Harris
INTEGRATED CIRCUITS
DATA BOOK

This DATA BOOK contains complete technical information on linear and memory integrated circuits presently available from Harris Semiconductor as standard products. A similar catalog dedicated to digital products specifies the complete line of Harris CMOS logic devices. By the use of the tear-out card provided in the back of this catalog, speciality information such as application notes, chip data sheets, and information about all new products introduced since publication of this catalog, are available directly through your local Harris sales office. They are also available from your nearest Harris representative or distributor.

For your convenience a complete index of Harris integrated circuits is provided in both an alpha-numeric sequence organized by major product categories such as linear and memory, and by a functional sequence. Although the alpha-numeric index tracks very closely with the organization of the data book, some exceptions do occur due to products combined on single data sheets. Warranting special attention for users of military product is the section on Harris Semiconductor's Dash 8 program. This section gives a complete description of processing used for 883 product available "off-the-shelf" from Harris. Complete physical dimensions of all packaging options are detailed in the section on package outlines. For ease of use, each major product section of this data book includes a complete industry cross reference index identifying industry cross reference numbers.

Harris is pleased that you would take this time to review our product line. We stand ready to support your production with world wide points of distribution. For your design convenience we offer a complete capability in applications assistance. Just call your local Harris office.

Thank you for thinking Harris.

AUGUST 1975

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

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HARRIS SEMICONDUCTOR

HISTORY
A look at Harris Semiconductor is a look at one of the Semiconductor success stories of the past two decades. Originally a three man laboratory organized to develop proprietary and custom circuits, this small nucleus increased in size until by 1966 it was known throughout the industry as the Microelectronics Division (MED) of Radiation, Inc., a military systems house located in Melbourne, Florida. As MED, the division fostered high technology and was an industry leader in the manufacturing of hardened devices.

In many respects, the Division, as it is known today, was born in July 1967. It was then that the entire 320 acre Melbourne complex became part of Harris-Intertype Corporation. With a new corporate identity the semiconductor operation dedicated its proficiency in high technology to the development of a series of state-of-the-art devices aimed specifically at the industrial marketplace.

In September of 1970, the firm chose its present name of Harris Semiconductor, became an independent division reporting directly to corporate headquarters in Cleveland, Ohio, and was well entrenched as a leading supplier of sophisticated industrial ICs as well as of ICs used on major military and NASA programs.

The past few years has been a major growth in Harris Semiconductor's participation within the industrial IC marketplace. While continuing as a major supplier of military and DoD products, efforts to penetrate the industrial marketplace has grown to where industrial customers now constitute approximately 80 percent of the Division's total effort.

To support its present position within the industrial marketplace, Harris Semiconductor has developed highly refined national and international lines of distribution. Included is a network of OEM sales offices, technically proficient manufacturers' representatives, and a family of distributors consisting of leaders within the electronic industry.

The Division now provides multiple product and service outlets within each significant market location and has opened direct sales offices in both Brussels, Belgium and Tokyo, Japan. Each outlet, through the combined efforts of OEM, manufacturer's representatives, and distributors, offers a complete line of complimenting product, literature and applications support.

FOR THE FUTURE
Harris Semiconductor now occupies over 225,000 square feet of floor space in five modern buildings located on the corporations's 320 acre site in Palm Bay, Florida. These facilities are equipped to perform the entire scope of Harris Semiconductor's operations but are augmented by offshore assembly facilities. Each operational site is designed for expansion. A recently completed 8 million dollar expansion and refurbishment program resulted in three-inch wafer processing across all product lines assuring customers with optimum in both pricing and delivery. Every effort is being made to guarantee that your association with Harris Semiconductor represents the finest in quality, reliability, delivery and price considerations.

TECHNOLOGY
Harris Semiconductor's significant contributions in process technology serve both the industrial and the military markets. In addition to pioneering the dielectric isolation process, Harris wields expertise in thin-film deposited on silicon dioxide, selective gold doping, buried n+ and p+ epitaxial layers, junction FETs, vertical npn and pnp transistors in the same monolithic structure, metallic aluminum bonding, multilevel interconnect processes, complementary MOS, junction isolated complementary MOS and p-channel MOS processes.

PRODUCTS
Harris produces a wide family line of devices embracing linear, digital and memory functions. Within the family of operational amplifiers, Harris has long offered state-of-the-art parameters without peer in monolithic circuitry. Now, this rapidly expanding linear line includes: phase locked loops, A/D and D/A encoders, and a rapidly expanding line of interface circuits. Harris is the largest single industry source of CMOS analog switches and multiplexers with a complete complement of alternate sources in addition to a strongly established proprietary line.

For the Digital world Harris Semiconductor is a leading supplier of standard logic CMOS. Nearly 100 devices are included to offer designers as comprehensive a CMOS logic selection as is available from industry. In addition to full alternate sourcing of the 54/74C family, product selection includes viable product from both the 4000 and 14500 families. Harris is actively pursuing JAN qualification of the entire CMOS product line. In the field of memories Harris pioneered and developed the concept of field programmable read only memories (PROM). Now available as a Harris exclusive is the complete family of "Generic" PROMs featuring a wide selection of organizations with identical programming requirements, input/output characteristics, fuse geometries and technology, as well as circuit configuration. The company is also aggressively pursuing development of a family of RAM products in both bipolar and MOS technology.

CHIP POLICY
Wherever practical the Harris product line is also made available in chip form. For further detail, contact either the Digital, Linear or Memory Product Marketing Managers respectively.

DASH 8 NOTICE
As a special service to users of high reliable products Harris makes instantly available high reliability on many of our product lines. Simply by adding its postscript -8 to appropriate Harris part numbers "off the shelf" delivery can be obtained of product screened to MIL-STD-883 Method 5004 Class B. For details concerning this special Harris program for High Rel users, see the Dash 8 section of this catalog.

EXPLANATION OF HARRIS PRODUCT CODE

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TEMPERATURE: (1)

2 | -55°C to 125°C |
4 | -25°C to 85°C |
5 | 0°C to 75°C |
6 | 100% 25°C Probe (Dice Only) |
8 | Dash 8 Program MIL-STD-883 Class B |
9 | -40°C to 85°C (4000 Series CMOS) |

Note 2:
The 54C/74C CMOS Family temperature designation is contained in the Part Number:
54CXX | -55°C to 125°C |
74CXX | 0°C to 70°C |

Harris products are designated by "Product Code". When ordering, please refer to products by the full code. Harris products will always begin with "H", except in the case of chip products. Specific device numbers will always be isolated by hyphens.
**HARRIS ALPHA-NUMERIC INDEX**

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*All Listed 74C Devices Are Available Also As 54C
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*All Listed 74C Devices Are Also Available As 54C.

**All Listed 80C Devices Are Also Available As 70C.
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*All Listed 74C Devices Are Available Also As 54C.

**Pin Compatible with 54C/74C.
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*All listed 74C devices are also available as 54C.

**All listed 80C devices are available also as 70C.

**Pin compatible with 54C/74C.
The Harris family of analog devices ... a select line of linears featuring state-of-the-art performance and monolithic reliability at realistic prices.

Harris Semiconductor has long been synonymous with high performance state-of-the-art linear integrated circuits. And, indeed, wherever monolithic performance is measured in terms of slew rate, bandwidth, and power consumption, Harris operational amplifiers still represent the leading edge of monolithic technology.

Linears from the Harris family can also lower your instrumentation systems costs substantially, improve performance, lower parts count, reduce design time, and increase system reliability. In the past, the speed and accuracy of most of these linears could only be approached with discrete devices, hybrids, or modules.

Excellent applications for Harris linears include: data acquisition, test equipment, telemetry, medical instruments, and process control.

Harris is now the industry’s leading manufacturer of CMOS analog switches and multiplexers featuring devices both with and without built-in overvoltage protection. All Harris switches and multiplexers utilize a special process that completely eliminates latchup while greatly reducing chances of channel interaction.

Technical advantage and volume production are both backed up by immediate nationwide applications support. When you think linears ... think Harris.
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<td>HA-2510/2512/2515, High Slew Rate Operational Amplifiers</td>
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<td>HA-2530/2535, High Slew Rate, Wideband Inverting Amplifier</td>
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<td>HA-2620/2622/2625, Wide Band, High Impedance Operational Amplifiers</td>
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<td>HA-2650/2655, Dual High Performance Operational Amplifier</td>
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<td>HA-2700/2704/2705, High Performance Operational Amplifiers</td>
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<td>HD-245/545, Triple Line Transmitter</td>
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<td>Li-107</td>
<td>HD-246/546/249/549, Triple Line Receivers</td>
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<td>HI-200, Dual SPST CMOS Analog Switch</td>
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<td>HI-506A/507A, 16 Channel Analog Multiplexer with Overvoltage Protection</td>
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<td>HI-508A/509A, 8 Channel Analog Multiplexers with Overvoltage Protection</td>
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<td>HI-1080/1085, 8-Bit D to A Converter High Speed Monolithic</td>
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<td>HI-5046A/5047A, CMOS Analog Switch</td>
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## Harris Operational Amplifiers

### Selection Guide for Military Applications

## HARRIS OPERATIONAL AMPLIFIERS

### Selection Guide

**For Commercial/Industrial Applications**

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<th>OP to +75°C</th>
<th>-25°C to +85°C</th>
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### INPUT CHARACTERISTICS

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<td>Offset Voltage</td>
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<td>Drift (Typ.)</td>
<td>55 μV/°C</td>
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<tr>
<td>Bias Current</td>
<td>65 μA</td>
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<tr>
<td>Offset Current</td>
<td>15 mA</td>
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<td>Common Mode Range</td>
<td>±12 V</td>
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### TRANSFER CHARACTERISTICS

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<td>15K V</td>
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<tr>
<td>Common Mode Rejection Ratio</td>
<td>70K V</td>
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<td>Bandwidth (Typ.)</td>
<td>700 MHz</td>
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<td>Full Power Bandwidth (Typ.)</td>
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<td>Output Voltage Swing</td>
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<td>Output Current (1)</td>
<td>±10 mA</td>
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<td>Full Power Bandwidth (Typ.)</td>
<td>±10 V</td>
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### TRANSIENT RESPONSE

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<td>Rise Time</td>
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<td>Overshoot</td>
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<td>Slow Rate</td>
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<td>Setting Time (Typ.)</td>
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### POWER SUPPLY CHARACTERISTICS

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<td>Power Supply Voltage</td>
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### FUNCTIONAL CHARACTERISTICS

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<td>Output Protection</td>
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---

(1) At +25°C
(2) Not applicable or not specified
(3) Typical
(4) Voltage supply = ±40V
(5) Dependent upon Is value

* TO-88 only

† Guaranteed for ±15V supplies and applicable temperature range unless otherwise specified.
**SELECTION GUIDE**

*Interface Circuits*

### COMPARATORS

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<th>PARAMETER +</th>
<th>-55°C to +125°C</th>
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<td>Supply Current (1)</td>
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### DIGITAL TO ANALOG CONVERTERS

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<td>Full Scale Output</td>
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<td>-5, +5, ±5</td>
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### PHASE LOCKED LOOPS

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<td>Frequency Range</td>
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<td>Tracking Range (TYP)</td>
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<td>Drift of f0 (TYP)</td>
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</table>

* Guaranteed for Applicable Temperature range, unless otherwise specified

(1) At +25°C

### PRAM PROGRAMMABLE AMPLIFIER

**HA - 2400/2404/2405**

One of four op amp input stages may be digitally selected to be connected to a single output. Replaces 5 op amps and a four channel multiplexer to obtain programmable gain, signal selection or countless other functions.

### SAMPLE – AND – HOLD/GATED OP AMP

**HA - 2420/2425**

Replaces two high performance op amps and a digitally controlled analog switch to form a high accuracy, versatile sample – and – hold, or a switchable op amp.

### CURRENT BOOSTER AMPLIFIER

**HA - 2630/2635**

A unity gain amplifier with output current up to ±400 mA, and 600V/μS slew rate, designed for use in series with any op amp output. For Coax line drivers, servo amps, audio amps, clock drivers, etc.

### DIGITAL LINE DRIVERS/RECEIVERS

**HD - 245/246/248/249** (-55°C to +125°C)

**HD - 545/546/548/549** (0°C to +75°C)

Triple-balanced line current mode drivers/receivers with party line capability for high speed (to 15 MHz) or long distance (to 3,000 feet) with superior noise immunity.

**HD - 1488/1489/1489A**


### KEYBOARD ENCODER

**HD - 0165**

Universal 16 key inputs, 4 parallel outputs with strobe and Key rollover output.
## CROSS-REFERENCE
### Linear and Interface Devices

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* "K" equivalent is either military device or selected commercial device

**NOTES:**
A. Pin-for-pin replacement
B. Minor pin-out difference (offset adj., compensation, etc.)
C. Not pin compatible — consult data sheets.

1. Identical electrical specifications
2. Harris part superior in most parameters
3. Parameter tradeoffs — consult data sheets
<table>
<thead>
<tr>
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* Part Numbers: Siliconix

**Harris**

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<td>C2</td>
</tr>
<tr>
<td></td>
<td>75152</td>
<td>HD-1489/A</td>
<td>C2</td>
</tr>
<tr>
<td></td>
<td>75154</td>
<td>HD-1489/A</td>
<td>C2</td>
</tr>
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<td>Transitron</td>
<td>TOA7709</td>
<td>HA-2600</td>
<td>B2</td>
</tr>
<tr>
<td></td>
<td>TOA8709</td>
<td>HA-2605</td>
<td>B2</td>
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<tr>
<td></td>
<td>TOA7809</td>
<td>HA-2060A</td>
<td>B2</td>
</tr>
<tr>
<td></td>
<td>TOA8809</td>
<td>HA-2065A</td>
<td>B2</td>
</tr>
</tbody>
</table>

NOTES:  
A. Pin-for-pin replacement  
B. Minor pin-out difference (offset adj., compensation, etc.)  
C. Not pin compatible — consult data sheets.  
1. Identical electrical specifications  
2. Harris part superior in most parameters  
3. Parameter tradeoffs — consult data sheets.
GENERAL DESCRIPTION

The integrated circuit covered by this data sheet forms a part of Harris' family of linear circuits intended for use as universal building blocks for analog circuitry. This Low Noise Operational Amplifier provides the 6dB per octave high frequency roll-off required for unconditional stability in operational feedback connections without the use of external compensation networks.

Simple resistive trim adjustment for zeroing input offset voltage is provided on the TO-86 package. The circuit is comprised of vertical NPN and PNP transistors in separate dielectrically isolated islands using advanced isolation techniques. These advanced production processes give the designer access to high performance integrated circuits without the technical compromises necessary with conventional junction isolation and lateral PNP fabrication methods.

The circuit is designed to meet or exceed the mechanical and environmental requirements of MIL-STD-883.

PACKAGES

CODE 9V  TO-86 (METAL BOTTOM)

All dimensions are in inches. All dimensions ± .010 unless otherwise shown.

PIN OUT

TO-86

TO-99
# Specifications

## Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-909</th>
<th>HA-911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>50.0V</td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±7.0V</td>
<td></td>
</tr>
<tr>
<td>Peak Output Current</td>
<td>±50mA</td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation (Note 10)</td>
<td>300mW</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range – HA-909</td>
<td>-55°C ≤ TA ≤ +125°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0°C ≤ TA ≤ +75°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
</tr>
</tbody>
</table>

## Electrical Characteristics

**Test Conditions:** $V_{\text{Supply}} = \pm 15.0V$ unless otherwise specified.

### Input Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-909 -55°C to +125°C</th>
<th>HA-911 0°C to +75°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Offset Voltage</td>
<td>+25°C</td>
<td>2.0</td>
<td>2.0</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>5.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Equivalent Input Noise (Note 9)</td>
<td>+25°C</td>
<td>1.0</td>
<td>1.0</td>
<td>μV</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>* Bias Current</td>
<td>+25°C</td>
<td>87</td>
<td>200</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>300</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>* Offset Current</td>
<td>+25°C</td>
<td>25</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>150</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Offset Current Average Drift</td>
<td>Full</td>
<td>1.0</td>
<td>1.0</td>
<td>nA/°C</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>200</td>
<td>100</td>
<td>KΩ</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>600</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±12.0</td>
<td>±12.0</td>
<td>V</td>
</tr>
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</table>

### Transfer Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-909 -55°C to +125°C</th>
<th>HA-911 0°C to +75°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Large Signal Voltage Gain (Notes 1, 4)</td>
<td>+25°C</td>
<td>25K</td>
<td>20K</td>
<td>V/V</td>
</tr>
<tr>
<td>(Note 1, 4)</td>
<td>Full</td>
<td>45K</td>
<td>45K</td>
<td></td>
</tr>
<tr>
<td>* Common Mode Rejection Ratio (Note 2)</td>
<td>Full</td>
<td>80</td>
<td>74</td>
<td>dB</td>
</tr>
<tr>
<td>Unity Gain Bandwidth (Note 3)</td>
<td>+25°C</td>
<td>7</td>
<td>7</td>
<td>MHz</td>
</tr>
</tbody>
</table>

### Output Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-909 -55°C to +125°C</th>
<th>HA-911 0°C to +75°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Swing (Note 1)</td>
<td>Full</td>
<td>±12.0</td>
<td>±11.0</td>
<td>V</td>
</tr>
<tr>
<td>* Output Current (Note 4)</td>
<td>+25°C</td>
<td>±20</td>
<td>±15</td>
<td>mA</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>+25°C</td>
<td>150</td>
<td>500</td>
<td>Ohms</td>
</tr>
</tbody>
</table>

### Transient Response

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-909 -55°C to +125°C</th>
<th>HA-911 0°C to +75°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (Notes 1, 5, 6 &amp; 8)</td>
<td>+25°C</td>
<td>40</td>
<td>40</td>
<td>ns</td>
</tr>
<tr>
<td>Overshoot (Notes 1, 5, 6 &amp; 8)</td>
<td>+25°C</td>
<td>15</td>
<td>15</td>
<td>%</td>
</tr>
<tr>
<td>* Slew Rate (Notes 1, 5 &amp; 8)</td>
<td>+25°C</td>
<td>+3.5</td>
<td>+5.0</td>
<td>V/µs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1.2</td>
<td>-2.0</td>
<td></td>
</tr>
</tbody>
</table>

### Power Supply Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-909 -55°C to +125°C</th>
<th>HA-911 0°C to +75°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Supply Current</td>
<td>+25°C</td>
<td>1.8</td>
<td>1.8</td>
<td>mA</td>
</tr>
<tr>
<td>* Power Supply Rejection Ratio (Note 7)</td>
<td></td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

1. $R_L = 2K\Omega$
2. $V_{CM} = \pm 5.0V$
3. $V_O < 90mV$
4. $V_O = \pm 10.0V$
5. $C_L = 100pF$
6. $V_O = \pm 200mV$
7. $V_{Sup} = \pm 9.0V$ to ±15.0V
9. 10 - 1000Hz, $R_S = 10K\Omega$
10. Derate by 6.6mW/°C above 106°C

*100% Tested For DASH 8
**DEFINITIONS**

Input Offset Voltage — That voltage which must be applied between the input terminals through two equal resistances to force the output voltage to zero.

Input Offset Current — The difference in the currents into the two input terminals when the output is at zero voltage.

Input Bias Current — The average of the currents flowing into the input terminals when the output is at zero voltage.

Input Common Mode Voltage — The average referred to ground of the voltages at the two input terminals.

Input Common Mode Range — The range of voltages which if exceeded at either input terminal will cause the amplifier to cease operating.

Common Mode Rejection Ratio — The ratio of a specified range of input common mode voltage to the peak to peak change in input offset voltage over this range.

Output Voltage Swing — The peak symmetrical output voltage swing, referred to ground, that can be obtained without clipping.

Input Resistance — The ratio of the change in input voltage to the change in input current.

Output Resistance — The ratio of the change in output voltage to the change in output current.

Positive Output Voltage Swing — The peak positive output voltage swing, referred to ground, that can be obtained without clipping.

Negative Output Voltage Swing — The peak negative output voltage swing, referred to ground, that can be obtained without clipping.

Voltage Gain — The ratio of the change in output voltage to the change in input voltage producing it.

Bandwidth — The frequency at which the voltage gain is 3 dB below its low frequency value.

Unity Gain Bandwidth — The frequency at which the voltage gain of the amplifier is unity.

Power Supply Rejection Ratio — The ratio of the change in input offset voltage to the change in power supply voltage producing it.

Transient Response — The closed loop step function response of the amplifier under small signal conditions.

Phase Margin — \[180° - (\phi_2 - \phi_2)\] where \(\phi_2\) is the phase shift at the frequency where the absolute magnitude of gain is unity and \(\phi_2\) is the phase shift at a frequency much lower than the open loop bandwidth.

**F.E.T. Input Preamplifier**

## Features

- Converts any op amp or comparator to F.E.T. input
- **Input Bias Current:** 1pA
- **Input Resistance:** $10^{12}$ OHMS
- **Slew Rate:** 100 V/µS
- **Bandwidth:** 10 MHz
- Meets MIL-STD-883 requirements

## Description

The HA-2000/2005 is a monolithic unity gain differential amplifier stage with J.F.E.T. inputs and bipolar transistor outputs. It is intended for use as a preamplifier for operational amplifiers and comparators to produce high input resistance and low bias currents without sacrificing high speed performance. The circuit has a much wider common mode range than simple F.E.T. pairs, allowing op amps to be connected as voltage followers with full output swing. The circuit can also be used as a high impedance unity gain buffer for differential or two single-ended signals for frequencies from D.C. to R.F.

The HA-2000 is guaranteed for operation from -55°C to +125°C while the HA-2005 is guaranteed from 0°C to +75°C.

## Packages

**Code 2A**

### Bottom View

- T-99
- All dimensions are in inches.
- All dimensions ±0.010 unless otherwise shown.

### Pin-Out

- Offset Adj.
- Output B
- Output A
- Input B
- Input A
- Offset Adj.

## Schematic

![Schematic Diagram](image-url)
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>±35V</td>
<td>±35V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±VSupply</td>
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<tr>
<td>Output Current</td>
<td>30mA</td>
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<tr>
<td>Internal Power Dissipation (Note 8)</td>
<td>300mW</td>
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</tr>
<tr>
<td>Operating Temp. Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temp. Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VOLTAGE BETWEEN V+ AND V- TERMINALS</strong></td>
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</tr>
<tr>
<td><strong>DIFFERENTIAL INPUT VOLTAGE</strong></td>
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</tr>
<tr>
<td><strong>INTERNAL POWER DISSIPATION (NOTE 8)</strong></td>
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<tr>
<td><strong>OPERATING TEMP. RANGE</strong></td>
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<tr>
<td><strong>STORAGE TEMP. RANGE</strong></td>
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### ELECTRICAL CHARACTERISTICS

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<thead>
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<tbody>
<tr>
<td><strong>OFFSET VOLTAGE (NOTE 1)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-2000A / HA-2005A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BIOAS CURRENT</strong></td>
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<td></td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OFFSET CURRENT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INPUT RESISTANCE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td><strong>INPUT RESISTANCE</strong></td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td><strong>COMMON MODE RANGE</strong></td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td><strong>TRANSFER CHARACTERISTICS</strong></td>
<td></td>
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</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>.98 V/V</td>
<td>.98 V/V</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
<td>.98 dB</td>
<td>.98 dB</td>
</tr>
<tr>
<td>Full Bandwidth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3 dB Bandwidth</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td>±10Ω</td>
<td>±10Ω</td>
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<tr>
<td><strong>OUTPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td>HA-2005A / HA-2005A</td>
<td>±10Ω</td>
<td>±10Ω</td>
</tr>
<tr>
<td><strong>OUTPUT CURRENT SOURCE</strong></td>
<td>±5 mA</td>
<td>±5 mA</td>
</tr>
<tr>
<td>Sink</td>
<td>±65 μA</td>
<td>±65 μA</td>
</tr>
<tr>
<td>Full Power Bandwidth (Notes 4,5)</td>
<td>1,000 kHz</td>
<td>1,000 kHz</td>
</tr>
<tr>
<td>Full Power Bandwidth (Notes 4,5)</td>
<td>1,000 kHz</td>
<td>1,000 kHz</td>
</tr>
<tr>
<td><strong>TRANSIENT RESPONSE</strong></td>
<td></td>
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</tr>
<tr>
<td>Rise Time (Notes 4,6)</td>
<td>±25Ω</td>
<td>±25Ω</td>
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<tr>
<td>Overshoot (Notes 4,6)</td>
<td>±25Ω</td>
<td>±25Ω</td>
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<tr>
<td>Slew Rate (Notes 4,5)</td>
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<td>±25Ω</td>
</tr>
<tr>
<td>Full Power Bandwidth (Notes 4,5)</td>
<td>100 V/μs</td>
<td>100 V/μs</td>
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<tr>
<td>Full Power Bandwidth (Notes 4,5)</td>
<td>100 V/μs</td>
<td>100 V/μs</td>
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<tr>
<td><strong>POWER SUPPLY CHARACTERISTICS</strong></td>
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</tr>
<tr>
<td>Supply Current</td>
<td>±25Ω</td>
<td>±25Ω</td>
</tr>
<tr>
<td>Power supply Rejection Ratio</td>
<td>±0.7 mA</td>
<td>±0.7 mA</td>
</tr>
<tr>
<td><strong>NOTES:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Adjustable to 0 with 100Ω pot between pins 1 and 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. R&lt;sub&gt;L&lt;/sub&gt; = 1MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. V&lt;sub&gt;CM&lt;/sub&gt; = ±5.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. R&lt;sub&gt;L&lt;/sub&gt; = 10KΩ to V-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. V&lt;sub&gt;Q&lt;/sub&gt; = ±1.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. V&lt;sub&gt;Q&lt;/sub&gt; = ±200mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. V&lt;sub&gt;Q&lt;/sub&gt; = ±9V to ±15V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Derate by 6.6 mW/°C above 105°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**PERFORMANCE CURVES**

V+ = 15 VDC, V- = 15 VDC, TA = 25°C UNLESS OTHERWISE STATED.

**INPUT BIAS AND OFFSET CURRENT VS. TEMPERATURE**

**EQUIVALENT INPUT NOISE VS. BANDWIDTH**

Upper 3dB Frequency
Lower 3db Frequency = 10 Hz

**D.C. GAIN VS. TEMPERATURE**

**GAIN, PHASE ANGLE VS. FREQUENCY**

**POWER SUPPLY CURRENT VS. TEMPERATURE**

**TRANSIENT RESPONSE, SLEW RATE TEST HOOK-UP**

**TYP. TRANSIENT RESPONSE WAVEFORM**

**TYP. SLEWING RESPONSE WAVEFORM**

Typical Transient Response Waveforms
Upper Trace: Input
Lower Trace: Output
Vertical Scale: 100mV/Div.
Horizontal Scale: 100ns/Div.

Typical Slewing Response Waveforms
Upper Trace: Input
Lower Trace: Output
Vertical Scale: 5V/Div.
Horizontal Scale: 100ns/Div.
TYPICAL APPLICATIONS

**F.E.T. VOLTMETER**

![F.E.T. Voltmeter Circuit Diagram]

**BALANCED LINE AMPLIFIER FOR AUDIO TO 100MHz SIGNALS**

![Balanced Line Amplifier Circuit Diagram]

**HOOKUP TO CREATE F.E.T. INPUT OP AMP OR COMPARATOR**

![Hookup to Create F.E.T. Input Op Amp or Comparator Circuit Diagram]

**ALTERNATE HOOKUP TO ADJUST FOR MINIMUM OFFSET VOLTAGE TEMPERATURE COEFFICIENT**

Adjust R₁ to point of minimum offset voltage change over temperature range. Adjust R₂ to zero offset voltage. Drifts of less than 10μV/°C can typically be achieved.
### HA-2050/2055/2050A/2055A

**High Slew Rate F.E.T. Input Operational Amplifiers**

#### FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>• HIGH SLEW RATE</td>
<td>120V/μs</td>
</tr>
<tr>
<td>• FAST SETTLING</td>
<td>400ns</td>
</tr>
<tr>
<td>• WIDE POWER BANDWIDTH</td>
<td>2 MHz</td>
</tr>
<tr>
<td>• HIGH GAIN BANDWIDTH</td>
<td>20 MHz</td>
</tr>
<tr>
<td>• HIGH INPUT IMPEDANCE</td>
<td>10^{12} OHMS</td>
</tr>
<tr>
<td>• LOW BIAS CURRENT</td>
<td>1 pA</td>
</tr>
<tr>
<td>• TRUE OP AMP – CAN BE OPERATED INVERTING OR NON-INVERTING</td>
<td></td>
</tr>
<tr>
<td>• MEETS MIL-STD-883 REQUIREMENTS</td>
<td></td>
</tr>
</tbody>
</table>

The HA-2050/2055 is an operational amplifier combining the advantages of very high slew rate and wide bandwidth with ultra-low input current and high input resistance. These devices are ideal for use in sample-and-hold circuits, A/D, D/A and sampled data systems; and for use in wide band R.F. or video systems where wide bandwidth at high output levels is required. The device may be operated inverting or non-inverting; and external compensation is required only when operated at closed loop gains less than three. An internal feedback capacitor is provided to cancel phase shift in the feedback loop due to input capacitance.

The HA-2050 is guaranteed for operation from -55°C to +125°C and the HA-2055 is guaranteed from 0°C to +75°C.

#### PACKAGE

**CODE 2A**

**TO-99**

**SLEWING WAVEFORM**

Horizontal Scale: 100μs/Div.

Upper Trace: Input; 1.67V/Div.

Lower Trace: Output; 5.0V/Div.

Gain = +3, R_L = 2K Ohms, C_L = 50pF
### Specifications

#### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>35.0V Internal Power Dissipation (Note 10)</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
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<tr>
<td>Output Current</td>
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</tr>
<tr>
<td>Operating Temp. Range</td>
<td>-55°C ≤ TA ≤ +125°C</td>
</tr>
<tr>
<td>Storage Temp. Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
</tr>
</tbody>
</table>

#### Electrical Characteristics

Test Conditions: $V_{Supply} = \pm 15.0V$ unless otherwise specified.

### Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limits</th>
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<tbody>
<tr>
<td><strong>HA-2050/HA-2050A</strong></td>
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<tr>
<td><strong>HA-2055/HA-2055A</strong></td>
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<tr>
<td><strong>-55°C to +125°C</strong></td>
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</tr>
<tr>
<td><strong>0°C to +75°C</strong></td>
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</tr>
<tr>
<td><strong>MIN.</strong></td>
<td><strong>TYP.</strong></td>
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<tr>
<td><strong>HA-2050/HA-2055</strong></td>
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<tr>
<td>Offset Voltage (Note 1)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
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<td>Bias Current</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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</tr>
<tr>
<td>Offset Current</td>
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</tr>
<tr>
<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
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<tr>
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<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
<td>+25°C</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td></td>
</tr>
<tr>
<td>HA-2050 / HA-2055</td>
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</tr>
<tr>
<td>HA-2050A / HA-2055A</td>
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<tr>
<td>Large Signal Voltage Gain (Note 2,5)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<td>HA-2050A / HA-2055A</td>
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<tr>
<td>Common Mode Rejection Ratio (Note 3)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
<td>+25°C</td>
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<tr>
<td>Gain Bandwidth Product (Note 4)</td>
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<tr>
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<tr>
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<tr>
<td>Full Power Bandwidth (Note 5)</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
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<tr>
<td><strong>TRANSMISSION RESPONSE</strong> (NOTES 2, 8, 9)</td>
<td></td>
</tr>
<tr>
<td>Rise Time (Note 6)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
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<tr>
<td>Overshoot (Note 6)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<td>HA-2050A / HA-2055A</td>
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<tr>
<td>slew Rate (Note 5)</td>
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<tr>
<td>HA-2050 / HA-2055</td>
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<tr>
<td>HA-2050A / HA-2055A</td>
<td>+25°C</td>
</tr>
<tr>
<td>Settling Time</td>
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</tr>
<tr>
<td>HA-2050 / HA-2055</td>
<td>+25°C</td>
</tr>
<tr>
<td>HA-2050A / HA-2055A</td>
<td>+25°C</td>
</tr>
<tr>
<td><strong>POWER SUPPLY CHARACTERISTICS</strong></td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>+25°C</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio (Note 7)</td>
<td></td>
</tr>
<tr>
<td>HA-2050 / HA-2055</td>
<td>Full</td>
</tr>
<tr>
<td>HA-2050A / HA-2055A</td>
<td>Full</td>
</tr>
</tbody>
</table>

**Notes:**
1. Adjustable to zero with 100KΩ pot between pins 1 and 5; wiper to V+.
2. $RL = 2KΩ$
3. $V_{CM} = ± 5.0V$
4. $AV > 10$
5. $V_{O} = ± 10V$
6. $V_{O} = ± 200mV$
7. $ΔV = ± 5.0V$
8. $C_{L} = 50pF$
10. Derate by 6.6mW/°C above 105°C
PERFORMANCE CURVES

V+ = 15 VDC, V- = 15 VDC, TA = 25°C UNLESS OTHERWISE STATED.

INPUT BIAS AND OFFSET CURRENT VS. TEMPERATURE

EQUIVALENT INPUT NOISE VS. BANDWIDTH

NORMALIZED AC PARAMETERS VS. TEMPERATURE

NORMALIZED AC PARAMETERS VS. SUPPLY VOLTAGE AT +25°C

OPEN-LOOP FREQUENCY AND PHASE RESPONSE

OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM BANDWIDTH CONTROL PIN TO GROUND

OPEN LOOP VOLTAGE GAIN VS. FREQUENCY AT +25°C

OUTPUT VOLTAGE SWING VS. FREQUENCY AT +25°C
PERFORMANCE CURVES (continued)

POWER SUPPLY CURRENT VS. TEMPERATURE

TRANSPORT RESPONSE: $A_V = +3$

$R_L = 2K$ Ohms, $C_L = 50pF$
Upper Trace: Input; 33mV/Div.
Lower Trace: Output; 100mV/Div.
Horizontal = 100ns/Div.
$T_A = +25^\circ C, V_S = \pm 15V$

SLEW RATE AND SETTLING TIME

TRANSIENT RESPONSE

SLEW RATE AND TRANSIENT RESPONSE

SUGGESTED OFFSET ZERO ADJUST HOOK-UP

TYPICAL APPLICATIONS

COMPENSATION CIRCUIT FOR UNITY GAIN

Slew Rate $\approx 40V/\mu s$
Bandwidth $\approx 8$ MHz
HA-2060/2065/2060A/2065A
Wide Band F.E.T. Input Operational Amplifier

**FEATURES**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GAIN BANDWIDTH PRODUCT</strong></td>
<td>100 MHz</td>
</tr>
<tr>
<td><strong>HIGH INPUT IMPEDANCE</strong></td>
<td>$10^{12}$ OHMS</td>
</tr>
<tr>
<td><strong>LOW BIAS CURRENT</strong></td>
<td>1 pA</td>
</tr>
<tr>
<td><strong>HIGH SLEW RATE</strong></td>
<td>35V/μs</td>
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<tr>
<td><strong>WIDE POWER BANDWIDTH</strong></td>
<td>600 kHz</td>
</tr>
<tr>
<td><strong>TRUE OP AMP - CAN BE OPERATED INVERTING OR NON-INVERTING</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MEETS MIL-STD-883 REQUIREMENTS</strong></td>
<td></td>
</tr>
</tbody>
</table>

**DESCRIPTION**

The HA-2060/2065 is an operational amplifier combining the advantages of very wide bandwidth and high slew rate with ultra-low input current and high input resistance. These devices are ideal for use in sample-and-hold circuits, active filters, wide band amplifiers, high gain amplifiers with superior bandwidth, and wherever very low closed loop gain and phase shift errors are required. The device may be operated inverting or non-inverting; and external compensation is required only when operated at closed loop gains less than five. An internal feedback capacitor is provided to cancel phase shift in the feedback loop due to input capacitance.

The HA-2060 is guaranteed for operation from -55°C to +125°C and the HA-2065 is guaranteed from 0°C to +75°C.

**PACKAGE**

CODE 2A

**SLEWING WAVEFORM**

Horizontal Scale: 200ns/Div.
Upper Trace: Input; 1.0V/Div.
Lower Trace: Output; 5.0V/Div.
Gain = +5, $R_L = 2$K Ohms, $C_L = 50pF
**SPECIFICATIONS**

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>35.0V</td>
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<td></td>
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<td>Differential Input Voltage</td>
<td>±12V</td>
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<td>Output Current / Full Short Circuit Protection</td>
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<table>
<thead>
<tr>
<th>Temperature</th>
<th>HA-2060/HA-2065A</th>
<th>HA-2065/HA-2065A</th>
</tr>
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<tbody>
<tr>
<td>-55°C to +125°C</td>
<td>-55°C to +125°C</td>
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</tr>
<tr>
<td>0°C to +75°C</td>
<td>0°C to +75°C</td>
<td></td>
</tr>
</tbody>
</table>

- Maximum Internal Power Dissipation: 300mW

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temp. Range</td>
<td>-55°C ≤ TA ≤ +125°C</td>
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<td></td>
</tr>
<tr>
<td>Storage Temp. Range</td>
<td>0°C ≤ TA ≤ +75°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-65°C ≤ TA ≤ +150°C</td>
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<td></td>
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</table>

**ELECTRICAL CHARACTERISTICS**

Test Conditions: VSupply = ±15.0V unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2060/HA-2065A</th>
<th>HA-2065/HA-2065A</th>
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<tbody>
<tr>
<td>-55°C to +125°C</td>
<td>-55°C to +125°C</td>
<td></td>
</tr>
<tr>
<td>0°C to +75°C</td>
<td>0°C to +75°C</td>
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</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Limits</th>
<th>Limits</th>
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</thead>
<tbody>
<tr>
<td><strong>INPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Voltage (Note 1)</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-2060 / HA-2065</td>
<td>15 to 25</td>
<td>15 to 50</td>
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<tr>
<td>Full</td>
<td>30 to 65</td>
<td>7 to 12</td>
<td></td>
</tr>
<tr>
<td>HA-2060A / HA-2065A</td>
<td>15 to 15</td>
<td>15 to 15</td>
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</tr>
<tr>
<td>Bias Current</td>
<td>nA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25°C</td>
<td>1 to 20</td>
<td>1 to 20</td>
<td></td>
</tr>
<tr>
<td>Full</td>
<td>0.5 to 10</td>
<td>0.02 to 1</td>
<td></td>
</tr>
<tr>
<td>Offset Current</td>
<td>nA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25°C</td>
<td>0.5 to 20</td>
<td>0.5 to 20</td>
<td></td>
</tr>
<tr>
<td>Full</td>
<td>0.1 to 5</td>
<td>.005 to .5</td>
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</tr>
<tr>
<td>Input Resistance</td>
<td>Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25°C</td>
<td>10 to 12</td>
<td>10 to 12</td>
<td></td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>pF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25°C</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full</td>
<td>±10.0</td>
<td>±10.0</td>
<td></td>
</tr>
</tbody>
</table>

| **TRANSFER CHARACTERISTICS**     |               |                 |                 |
| Large Signal Voltage Gain        | V/V           |                 |                 |
| (Note 2, 5)                      | 80K to 150K   | 80K to 150K     |                 |
| Full                             | 60K to 70K    | 70K to 90K      |                 |
| Common Mode Rejection Ratio      | dB            |                 |                 |
| (Note 3)                         | 74 to 90      | 70 to 90       |                 |
| Gain Bandwidth Product           | MHz           |                 |                 |
| (Note 4)                         | 100           | 100             |                 |

| **OUTPUT CHARACTERISTICS**       |               |                 |                 |
| Output Voltage Swing             | V             |                 |                 |
| (Note 2)                         | ±10 to ±12    | ±10 to ±12     |                 |
| Full                             |               |                 |                 |
| Output Current                   | mA            |                 |                 |
| +25°C                            | ±10 to ±18    | ±10 to ±18     |                 |
| Full                             | 600 to 600    | 600 to 600     |                 |

| **TRANSIENT RESPONSE**           |               |                 |                 |
| (NOTES 2, 3, 9)                   |               |                 |                 |
| Rise Time (Note 6)               | ns            |                 |                 |
| +25°C                            | 50            | 50              |                 |
| Overshoot (Note 6)               | %             |                 |                 |
| +25°C                            | 25            | 25              |                 |
| Slew Rate (Note 5)               | V/µs          |                 |                 |
| +25°C                            | 35            | 35              |                 |

| **POWER SUPPLY CHARACTERISTICS** | mA            |                 |                 |
| Supply Current                   | 4.0 to 6.0    | 4.0 to 6.0     |                 |
| Full                             | 74 to 90      | 70 to 90       |                 |

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2065/HA-2065A</th>
<th>HA-2060/HA-2065A</th>
</tr>
</thead>
<tbody>
<tr>
<td>-55°C to +125°C</td>
<td>-55°C to +125°C</td>
<td></td>
</tr>
<tr>
<td>0°C to +75°C</td>
<td>0°C to +75°C</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. Adjustable to zero with 100KΩ pot between pins 1 and 5; wiper to V+.
2. R L = 2kΩ
3. VCM = ±5.0V
4. AV > 10
5. VO = ±10V
6. VO = ±200mV
7. AV = ±5.0V
8. CL = 50pF
10. Derate by 6.6mW/°C above 105°C

**Li - 24**
PERFORMANCE CURVES

\[ V^+ = 15 \text{VDC}, \ V^- = 15 \text{VDC}, \ T_A = 25^\circ \text{C} \text{ UNLESS OTHERWISE STATED} \]

**INPUT BIAS AND OFFSET CURRENT VS. TEMPERATURE**

**EQUIVALENT INPUT NOISE VS. BANDWIDTH**

Upper 3dB Frequency
Lower 3dB Frequency - 10 Hz

**NORMALIZED AC PARAMETERS VS. TEMPERATURE**

**OPEN-LOOP FREQUENCY AND PHASE RESPONSE**

**OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM BANDWIDTH CONTROL PIN TO GROUND**

**OUTPUT VOLTAGE SWING VS. FREQUENCY AT +25^\circ \text{C}**

**OPEN LOOP VOLTAGE GAIN VS. TEMPERATURE**
**PERFORMANCE CURVES (continued)**

**POWER SUPPLY CURRENT VS. TEMPERATURE**

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Current (mA)</th>
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</thead>
<tbody>
<tr>
<td>-50</td>
<td>3.4</td>
</tr>
<tr>
<td>-25</td>
<td>3.5</td>
</tr>
<tr>
<td>0</td>
<td>3.8</td>
</tr>
<tr>
<td>25</td>
<td>4.0</td>
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</tbody>
</table>

**TRANSIENT RESPONSE: A_V = +5**

- R_L = 2K Ohms, C_L = 50pF
- Upper Trace: Input; 20mV/Div.
- Lower Trace: Output; 100mV/Div.
- Horizontal = 100ns/Div.
- T_A = +25°C, V_S = ±15V

**SLEW RATE AND SETTLING TIME**

- **Input:** +1.67V
- **Output:** -1.67V
- **Error Band:** ±10mV from Final Value
- **Slew Rate:** ±500mV/μs
- **Settling Time:** +10% Output

**TRANSIENT RESPONSE**

- **Input:** ±200mV
- **Output:** ±100mV
- **OverShoot:** ±10%
- **Rise Time:** ±10%
- **Settling Time:** +10%

**SUGGESTED OFFSET ZERO ADJUST HOOK-UP**

**TYPICAL APPLICATIONS**

**COMPENSATION CIRCUIT FOR UNITY GAIN**

- **Slew Rate:** ≈ 5 V/μs
- **Bandwidth:** ≈ 10 MHz
HA-2111/2211
Voltage Comparators

FEATURES

- INPUT BIAS CURRENT: 60nA
- INPUT OFFSET CURRENT: 4nA
- DIFFERENTIAL INPUT VOLTAGE: ±30.0V
- POWER SUPPLY VOLTAGES: A SINGLE 5.0V SUPPLY TO ±15.0V
- OFFSET VOLTAGE NULL CAPABILITY
- STROBE CAPABILITY

GENERAL DESCRIPTION

The HA-2111 and HA-2211 are voltage comparators which have low input bias currents. They operate over a wide range of power supply voltages, from the standard ±15.0V down to a single 5.0V power supply. A very flexible output stage is employed, which is compatible with RTL, DTL, TTL and MOS logic circuits.

SCHEMATIC

The schematic diagram shows the internal circuitry of the HA-2111/2211 voltage comparators. It includes components such as resistors (R1, R2, R3), capacitors, and diodes, which are essential for the proper operation of the comparators.

PACKAGES

- CODE 2A: T0-99

The packaging diagrams illustrate the physical layout of the comparators. They show the pin configuration and the footprint for the different package types (T0-99, T0-116), which are crucial for integrating the comparators into a circuit board design.

Pinout Details:

- **Case Connected to V-**

Pin Descriptions:

- NC: No Connection
- GROUND: Ground
- INPUT+: Positive Input
- INPUT-: Negative Input
- V+: Positive Supply
- V-: Negative Supply
- BALANCE: Balance Input
- OUTPUT: Comparator Output
- STROBE: Strobe Input
- BALANCE/STROBE: Balance/Strobe Input

Dimensions: All dimensions are in inches, unless otherwise noted.

**CODE 1S**

- Pinout for TO-99
- Pinout for TO-116
# Specifications

## Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>36.0V</td>
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<td></td>
</tr>
<tr>
<td>Output to V-</td>
<td>50.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground to V-</td>
<td>30.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±30.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage (Note 1)</td>
<td>±15.0V</td>
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</tr>
<tr>
<td>Internal Power Dissipation (Note 7)</td>
<td>500mW</td>
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<td></td>
</tr>
<tr>
<td>Output Short Circuit Duration</td>
<td>10 sec.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C to +150°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Electrical Characteristics

### V+ = +15.0 V.D.C.  
### V- = −15.0 V.D.C.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-211 -55°C to +125°C</th>
<th>HA-2211 -25°C to +85°C</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Offset Voltage (Note 2)</td>
<td>+25°C</td>
<td>0.7</td>
<td>0.7</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>* Bias Current</td>
<td>+25°C</td>
<td>60</td>
<td>60</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>* Offset Current (Note 2)</td>
<td>+25°C</td>
<td>4.0</td>
<td>4.0</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>10.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±14.0</td>
<td>±14.0</td>
<td>V</td>
</tr>
<tr>
<td>Strobe Current</td>
<td>+25°C</td>
<td>3.0</td>
<td>3.0</td>
<td>mA</td>
</tr>
</tbody>
</table>

| **Transfer Characteristics**             |             |                         |                        |       |
| Large Signal Voltage Gain                | +25°C       | 200K                    | 200K                   | V/V   |
| Response Time (Note 3)                   | +25°C       | 200                     | 200                    | ns    |

| **Output Characteristics**               |             |                         |                        |       |
| * Leakage Current (Note 4)               | +25°C       | 0.2                     | 0.2                    | nA    |
|                                          | Full        | 10.0                    | 10.0                   |       |
| * Saturation Voltage (Note 5)            | +25°C       | 0.75                    | 0.75                   | V     |
|                                          | Full        | 1.5                     | 1.5                    |       |

| **Power Supply Characteristics**         |             |                         |                        |       |
| * Positive Supply Current                | +25°C       | 5.1                     | 5.1                    | mA    |
|                                          |             | 6.0                     | 6.0                    |       |
| * Negative Supply Current                | +25°C       | 4.1                     | 4.1                    | mA    |
|                                          |             | 5.0                     | 5.0                    |       |

### Notes:

1. This rating applies for ±15.0V supplies. The positive input voltage limit is 30.0V above the negative supply. The negative input voltage is equal to the negative supply voltage or 30.0V below the positive supply, whichever is less.

2. The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.

3. 100mV input step; 5mV overdrive.

4. $V_{OUT} = 35.0V; V_{IN} = 5mV$

5. $I_{OUT} = 50mA; V_{IN} = -5mV$

6. $I_{Sink} = 8mA; V^+ = 4.5V; V^- = 0V; V_{IN+} = +1.00V; V_{IN-} = +1.006V$

7. Derate by 6.6mW/°C above 105°C

*100% Tested For DASH B
TYPICAL PERFORMANCE CURVES (continued)

**SUPPLY CURRENT**

- TA = 25°C
- Positive Supply: Output Low
- Negative Supply: Output High

**SUPPLY VOLTAGE (V)** vs. **TEMPERATURE (°C)**

**LEAKAGE CURRENTS**

**APPLICATION INFORMATION**

**OFFSET BALANCING**

- 3K
- +V

**GROUND REFERRED LOAD**

- +V

**OUTPUT FOR DTL/TTL LOAD**

- +5V

**TTL STROBE**

- 1K

**NOTE:** INPUT POLARITIES REVERSED
The HA-2311 is a voltage comparator which has low input bias currents. It operates over a wide range of power supply voltages, from the standard ±15.0V down to a single 5.0 V power supply. A very flexible output stage is employed which is compatible with RTL, DTL, TTL and MOS logic circuits.
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>36.0V</td>
</tr>
<tr>
<td>Output to V-</td>
<td>40.0V</td>
</tr>
<tr>
<td>Ground to V-</td>
<td>30.0V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±30.0V</td>
</tr>
<tr>
<td>Input Voltage (Note 1)</td>
<td>±15.0V</td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>500mW</td>
</tr>
<tr>
<td>Output Short Circuit Duration</td>
<td>10 sec.</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

#### ELECTRICAL CHARACTERISTICS

**V+ = +15.0 V.D.C.  V- = -15.0 V.D.C.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>HA-2311</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td>0°C to +75°C</td>
<td></td>
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<tr>
<td>Offset Voltage (Note 2)</td>
<td>+25°C</td>
<td>2.0</td>
<td>mV</td>
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<td></td>
<td>0°C to +75°C</td>
<td>7.5</td>
<td>mV</td>
</tr>
<tr>
<td>Bias Current</td>
<td>+25°C</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>0°C to +75°C</td>
<td>250</td>
<td>nA</td>
</tr>
<tr>
<td>Offset Current (Note 2)</td>
<td>+25°C</td>
<td>6.0</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>0°C to +75°C</td>
<td>50.0</td>
<td>nA</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td></td>
<td>±14.0</td>
<td>V</td>
</tr>
<tr>
<td>Strobe Current</td>
<td>+25°C</td>
<td>3.0</td>
<td>mA</td>
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#### TRANSFER CHARACTERISTICS

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<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>Value</th>
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<tbody>
<tr>
<td>Large Signal Voltage Gain</td>
<td>+25°C</td>
<td>200K</td>
</tr>
<tr>
<td>Response Time (Note 3)</td>
<td>+25°C</td>
<td>200 ns</td>
</tr>
</tbody>
</table>

#### OUTPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leakage Current (Note 4)</td>
<td>+25°C</td>
<td>0.2</td>
</tr>
<tr>
<td>Saturation Voltage (Note 5)</td>
<td>+25°C</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>0°C to +75°C</td>
<td>1.5</td>
</tr>
</tbody>
</table>

#### POWER SUPPLY CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Supply Current</td>
<td>+25°C</td>
<td>5.1</td>
</tr>
<tr>
<td>Negative Supply Current</td>
<td>+25°C</td>
<td>4.1</td>
</tr>
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</table>

**NOTES:**
1. This rating applies for ±15.0V supplies. The positive input voltage limit is 30.0V above the negative supply. The negative input voltage is equal to the negative supply voltage or 30.0V below the positive supply, whichever is less.
2. The offset voltages and offset currents given are the maximum values required to drive the output within a volt of either supply with a 1mA load. Thus, these parameters define an error band and take into account the worst case effects of voltage gain and input impedance.
3. 100mV input step; 5mV overdrive.
4. $V_{OUT} = 35.0V; V_{IN} = 10mV$
5. $I_{OUT} = 50mA; V_{IN} = -10mV$
6. $I_{SINK} = 8mA, V^+ = 4.5V, V^- = 0.0V, V_{IN+} = +1.0V, V_{IN-} = +1.0V$
TYPICAL PERFORMANCE CURVES (continued)

SUPPLY CURRENT

<table>
<thead>
<tr>
<th>SUPPLY VOLTAGE (V)</th>
<th>SUPPLY CURRENT (mA)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>6</td>
</tr>
</tbody>
</table>

- Positive supply current - output low
- Positive and negative supply - output high

SUPPLY CURRENT

<table>
<thead>
<tr>
<th>TEMPERATURE (°C)</th>
<th>SUPPLY CURRENT (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
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<tr>
<td>20</td>
<td>3</td>
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<td>30</td>
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</tr>
<tr>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
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</tbody>
</table>

- Positive supply current - output low
- Positive and negative supply - output high

LEAKAGE CURRENTS

<table>
<thead>
<tr>
<th>TEMPERATURE (°C)</th>
<th>LEAKAGE CURRENT (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>10^-8</td>
</tr>
<tr>
<td>35</td>
<td>10^-9</td>
</tr>
<tr>
<td>45</td>
<td>10^-10</td>
</tr>
<tr>
<td>55</td>
<td>10^-11</td>
</tr>
<tr>
<td>65</td>
<td>10^-12</td>
</tr>
<tr>
<td>75</td>
<td>10^-13</td>
</tr>
</tbody>
</table>

- Positive supply
- Output V_out: 40V
- Input V_in: 15V

APPLICATION INFORMATION

OFFSET BALANCING

GROUND REFERRED LOAD

OUTPUT FOR DTL/TTL LOAD

TTL STROBE

NOTE: INPUT POLARITIES REVERSED
HA-2400/2404/2405

PRAM™ Four Channel Programmable Amplifier

FEATURES

- THOUSANDS OF NEW APPLICATIONS; PROGRAM:
  - SIGNAL SELECTION/MULTIPLEXING
  - OP AMP GAIN
  - OSCILLATOR FREQUENCY
  - FILTER CHARACTERISTICS
  - ADD-SUBTRACT FUNCTIONS
  - INTEGRATOR CHARACTERISTICS
  - COMPARATOR LEVELS
  - ETC., ETC.

- HIGH SLEW RATE 50V/μs
- WIDE GAIN BANDWIDTH 40MHz
- HIGH GAIN 150,000
- LOW OFFSET CURRENT 5nA
- HIGH INPUT IMPEDANCE 30MΩ
- SINGLE CAPACITOR COMPENSATION
- DTL/TTL COMPATIBLE INPUTS

GENERAL DESCRIPTION

The HA-2400 is an operational amplifier with four identical input stages, any one (or none) of which may be electronically connected to the single output stage. The “ON” channel is selected through DTL/TTL compatible address inputs. The amplifier formed by the output and the selected pair of amplifier inputs is a high performance operational amplifier which can be operated with suitable feedback networks in any of the well known op amp configurations. The device is an extremely versatile analog building block. It can be used as an analog signal selector, sampler, or multiplexer with built in buffering or signal conditioning. By connecting different feedback networks from the output to each input pair, it can be used as a single or multiple channel amplifier with programmable feedback characteristics. The device is packaged in a hermetic 16 pin dual in-line package. The HA-2400 operates over the temperature range of -55°C to +125°C, the HA-2404 operates over -25°C to +85°C, while the HA-2405 operates over 0°C to +75°C.

FUNCTIONAL DIAGRAM

TRUTH TABLE

<table>
<thead>
<tr>
<th>D1</th>
<th>D0</th>
<th>EN</th>
<th>SELECTED CHANNEL</th>
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<td>L</td>
<td>L</td>
<td>H</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>H</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
<td>4</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>L</td>
<td>NONE</td>
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</table>

PACKAGE

CODE 1F TO-99

ALL DIMENSIONS ARE IN INCHES. ALL DIMENSIONS .010 UNLESS OTHERWISE SHOWN.

Case Connected to V−
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Input Voltage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Differential</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>±V Supply</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Digital Input Voltage</td>
<td>-0.76V to +10.0V</td>
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<tr>
<td>Output Current</td>
<td>Short Circuit Protected</td>
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<td></td>
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<td><strong>Output Current</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Power Dissipation</strong></td>
<td>Internal</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-55°C ≤ TA ≤ +125°C (HA-2400)</td>
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<tr>
<td>Storage Temperature Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

Digital inputs: VIL = +0.5V, VIH = +2.4V

**Limits apply to each of the four channels, when addressed.**

<table>
<thead>
<tr>
<th></th>
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<tr>
<td><strong>Input Characteristics</strong></td>
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</tr>
<tr>
<td>Offset Voltage</td>
<td>+25°C</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>mV</td>
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<tr>
<td>Bias Current (Note 12)</td>
<td>+25°C</td>
<td>50</td>
<td>200</td>
<td>50</td>
<td>250</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>Offset Current (Note 12)</td>
<td>+25°C</td>
<td>5</td>
<td>50</td>
<td>5</td>
<td>50</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±10.0</td>
<td>±10.0</td>
<td></td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td><strong>Transfer Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Signal Voltage Gain (Note 1,5)</td>
<td>+25°C</td>
<td>50K</td>
<td>150K</td>
<td>50K</td>
<td>150K</td>
<td>V/V</td>
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<tr>
<td>Common Mode Rejection Ratio (Note 2)</td>
<td>Full</td>
<td>25K</td>
<td>74</td>
<td>100</td>
<td>100</td>
<td>dB</td>
<td></td>
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<tr>
<td>Gain Bandwidth (Note 3)</td>
<td>+25°C</td>
<td>80</td>
<td>100</td>
<td>74</td>
<td>100</td>
<td>MHz</td>
<td></td>
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<tr>
<td>(Note 4)</td>
<td>+25°C</td>
<td>40</td>
<td>40</td>
<td></td>
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<td></td>
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<tr>
<td><strong>Output Characteristics</strong></td>
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<tr>
<td>Output Voltage Swing (Note 1)</td>
<td>Full</td>
<td>±10.0</td>
<td>±12.0</td>
<td>±10.0</td>
<td>±12.0</td>
<td>V</td>
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<tr>
<td>Output Current</td>
<td>+25°C</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td>mA</td>
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<td>Full Power Bandwidth (Notes 3, 5)</td>
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<td>500</td>
<td>500</td>
<td></td>
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<td>kHz</td>
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<tr>
<td>(Notes 4, 5)</td>
<td>+25°C</td>
<td>200</td>
<td>200</td>
<td></td>
<td></td>
<td>kHz</td>
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<td><strong>Transient Response</strong></td>
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<tr>
<td>Rise Time (Notes 4, 6)</td>
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<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td>ns</td>
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<tr>
<td>Overshoot (Notes 4, 6)</td>
<td>+25°C</td>
<td>25</td>
<td>25</td>
<td></td>
<td></td>
<td>%</td>
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<tr>
<td>Slew Rate (Notes 3, 7)</td>
<td>+25°C</td>
<td>50</td>
<td>50</td>
<td></td>
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<td>V/µs</td>
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<tr>
<td>(Notes 4, 7)</td>
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<td>V/µs</td>
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<td>Setting Time (Notes 4, 7, 8)</td>
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<td>1.5</td>
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<td>µs</td>
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<td><strong>Channel Select Characteristics</strong></td>
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<td>Digital Input Current (VIN = 0V)</td>
<td>Full</td>
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<td>1</td>
<td></td>
<td></td>
<td>mA</td>
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<tr>
<td>Digital Input Current (VIN = +5.0V)</td>
<td>Full</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
<td>nA</td>
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<tr>
<td>Output Delay (Note 9)</td>
<td>+25°C</td>
<td>100</td>
<td>100</td>
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<td>ns</td>
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<td>Crosstalk (Note 10)</td>
<td>+25°C</td>
<td>80</td>
<td>-110</td>
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<td>-110</td>
<td>dB</td>
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<td><strong>Power Supply Characteristics</strong></td>
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<td>Supply Current</td>
<td>+25°C</td>
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<td>6.0</td>
<td>4.8</td>
<td>6.0</td>
<td>mA</td>
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<tr>
<td>Power Supply Rejection Ratio (Note 11)</td>
<td>+25°C</td>
<td>80</td>
<td>90</td>
<td>74</td>
<td>90</td>
<td>dB</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. RL = 2KΩ
2. VCM = ±5 V.D.C.
3. AV = ±10, CCOMP = 0, RL = 2KΩ, CL = 50pF
4. AV = ±1, CCOMP = 15pF, RL = 2KΩ, CL = 50pF
5. VOUT = 20V peak-to-peak
6. VOUT = 400 mV peak-to-peak
7. VOUT = 10.0V peak-to-peak
8. To 0.1% of final value
9. To 10% of final value; output then slews at normal rate to final value.
10. Unselected input to output; VIN = ±10 V.D.C.
11. VSUPP = ±10V.D.C. to ±20V.D.C.
12. Unselected channels have approximately the same input parameters.
13. Derate by 4.3mW/°C above 105°C

*100% Tested For DASH 8
CHARACTERISTIC CURVES

V+ = 15VDC, V- = 15VDC, TA = 25°C UNLESS OTHERWISE STATED.

INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE

NORMALIZED A.C. PARAMETERS VS. TEMPERATURE

POWER SUPPLY CURRENT DRAIN AS A FUNCTION OF TEMPERATURE

OPEN LOOP FREQUENCY AND PHASE RESPONSE

NORMALIZED A.C. PARAMETERS VS. SUPPLY VOLTAGE

OPEN LOOP VOLTAGE GAIN VS. TEMPERATURE

FREQUENCY RESPONSE VS. CCOMP

OPEN LOOP FREQUENCY GAIN (dB)

Frequency (Hz)

Phase Angle Degrees

Temperature (°C)

Frequency (Hz)

Gain (dB)

Supply Voltage

Temperature (°C)

Temperature (°C)
**CHARACTERISTIC CURVES (continued)**

**OUTPUT VOLTAGE SWING VS. FREQUENCY**

Output Swing Volts Peak-to-Peak

- 0 to 20
- 0.1 to 20
- 1 to 2

Frequency (Hz)

10K 100K 1M 10M

**EQUIVALENT INPUT NOISE VS. BANDWIDTH**

Input Noise (μV)

- 0.1 to 10
- 0.01 to 1

Upper 3dB Frequency
Lower 3dB Frequency - 10Hz
Broadband Noise Characteristics

**TYPICAL APPLICATIONS**

**AMPLIFIER, NON-INVERTING PROGRAMMABLE GAIN**

**SAMPLE AND HOLD**

Sample charging rate = \( \frac{I_1}{C} \) V/sec.

Hold drift rate = \( \frac{I_2}{C} \) V/sec.

Switch pedestal error = \( \frac{Q}{C} \) Volts

1. \( I_1 \approx 150 \times 10^{-9} \) A
2. \( I_2 \approx 200 \times 10^{-9} \) A @ +25°C
3. \( Q \approx 600 \times 10^{-9} \) A @ -55°C
4. \( Q \approx 100 \times 10^{-9} \) A @ +125°C
5. \( Q \approx 2 \times 10^{-12} \) Coul.

FOR MORE EXAMPLES, SEE HARRIS APPLICATION NOTE 514.
### FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Current/Hold Current Ratio:</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Slew Rate:</td>
<td>5V/µs</td>
</tr>
<tr>
<td>Bandwidth:</td>
<td>2MHz</td>
</tr>
<tr>
<td>Aperture Time:</td>
<td>50ns</td>
</tr>
<tr>
<td>Low Charge Transfer:</td>
<td>10pC</td>
</tr>
<tr>
<td>Connect in Any Op Amp Configuration:</td>
<td></td>
</tr>
<tr>
<td>Also Use as Gated Op Amp:</td>
<td></td>
</tr>
<tr>
<td>DTL/TTL Compatible Control Input:</td>
<td></td>
</tr>
</tbody>
</table>

### DESCRIPTION

The HA-2420/2425 is a monolithic circuit consisting of a high performance operational amplifier with its output in series with an ultra-low leakage analog switch and a MOSFET input unity gain amplifier. With an external holding capacitor connected to the switch output, a versatile, high performance sample-and-hold or track-and-hold circuit is formed. When the switch is closed, the device behaves as an operational amplifier, and any of the standard op amp feedback networks may be connected around the device to control gain, frequency response, etc. When the switch is opened, the output will remain at its last level.

The device may also be used as a versatile operational amplifier with a gated output for applications such as analog switches, peak holding circuits, etc.

### FUNCTIONAL DIAGRAM

![Functional Diagram](image)

### PACKAGE

**CODE 1S**

14 LEAD BRAZED D.I.P.

**Pin One Ident.**

**Bottom View**

All dimensions in inches.

All dimensions ± 0.010 unless otherwise shown.
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>40V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±30V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Input Voltage (Pin 14)</td>
<td>±8V, -15V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>Short Circuit Protected</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW (note 8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>HA-2420</td>
<td>-55°C ≤ TA ≤ +125°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HA-2425</td>
<td>0°C ≤ TA ≤ +75°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
<td></td>
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</tr>
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</table>

#### ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>VSupply = ±15.0V</th>
<th>CH = 1000pF</th>
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</thead>
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<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>HA-2420 LIMITS</th>
<th>HA-2425 LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
</tr>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Voltage</td>
<td>+25°C</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>3</td>
</tr>
<tr>
<td>*Bias Current</td>
<td>+25°C</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>400</td>
</tr>
<tr>
<td>Offset Current</td>
<td>+25°C</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>100</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>±10</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRANSFER CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Large Signal Voltage Gain (Note 1, 4)</td>
<td>Full</td>
<td>25K</td>
</tr>
<tr>
<td>*Common Mode Rejection (Note 2)</td>
<td>Full</td>
<td>80</td>
</tr>
<tr>
<td>Gain Bandwidth Product (Note 3)</td>
<td>+25°C</td>
<td>2</td>
</tr>
<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Output Voltage Swing (Note 1)</td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>*Output Current</td>
<td>+25°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>Full Power Bandwidth (Note 3, 4)</td>
<td>+25°C</td>
<td>70</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>+25°C</td>
<td>5</td>
</tr>
<tr>
<td>TRANSIENT RESPONSE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise Time (Note 3, 5)</td>
<td>+25°C</td>
<td>100</td>
</tr>
<tr>
<td>Overshoot (Note 3, 5)</td>
<td>+25°C</td>
<td>20</td>
</tr>
<tr>
<td>Slew Rate (Note 3, 6)</td>
<td>+25°C</td>
<td>5</td>
</tr>
<tr>
<td>DIGITAL INPUT CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Input Current (Vyn = 0V)</td>
<td>Full</td>
<td>0.8</td>
</tr>
<tr>
<td>Digital Input Current (Vyn = +5.0V)</td>
<td>Full</td>
<td>20</td>
</tr>
<tr>
<td>Digital Input Voltage (Low)</td>
<td>Full</td>
<td>0.8</td>
</tr>
<tr>
<td>Digital Input Voltage (High)</td>
<td>Full</td>
<td>2.0</td>
</tr>
<tr>
<td>SAMPLE/HOLD CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition Time (Note 3, 7)</td>
<td>+25°C</td>
<td>4</td>
</tr>
<tr>
<td>Aperture Time</td>
<td>+25°C</td>
<td>50</td>
</tr>
<tr>
<td>*Drift Current</td>
<td>+25°C</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>0.5</td>
</tr>
<tr>
<td>*Charge Transfer</td>
<td>+25°C</td>
<td>10</td>
</tr>
<tr>
<td>POWER SUPPLY CHARACTERISTICS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Supply Current</td>
<td>+25°C</td>
<td>2.5</td>
</tr>
<tr>
<td>*Power Supply Rejection Ratio</td>
<td>Full</td>
<td>80</td>
</tr>
</tbody>
</table>

**NOTES:**
1. RL = 2KΩ
2. VCM = ±5 V.D.C.
3. AV = +1, RL = 2K, CL = 50pF
4. VOUT = 20V peak-to-peak (Note 1)
5. VOUT = 400mV peak-to-peak (Note 2)
6. VOUT = 10.0V peak-to-peak (Note 3)
7. Tested For DASH 8
8. Derate Power Dissipation by 4.3mW/°C Above +105°C Ambient Temperature.
9. 100% Tested For DASH 8
PERFORMANCE CURVES

V\text{SUPPLY} = \pm 15\text{VDC}, T_A = +25\degree\text{C}, C_H = 1,000\text{pF} UNLESS OTHERWISE SPECIFIED

**TYPICAL SAMPLE-AND-HOLD PERFORMANCE AS A FUNCTION OF HOLDING CAPACITANCE**

- **Drift during hold at \(+25\degree\text{C}\)**
- **Unity Gain Phase Margin (Degrees)**
- **Unity Gain Bandwidth (MHz)**
- **Slew Rate/Charge Rate (Volts/Second)**
- **Minimum sample time for \(0.1\%\) accuracy, 10 Volts swings (Microseconds)**
- **Sample to Hold offset error (Millivolts)**

**DRIFT CURRENT vs TEMPERATURE**

- **Drift Current (pA)**
- **Temperature, (Degrees C)**

**BROADBAND NOISE CHARACTERISTICS**

- **1\text{V RMS}**
- **Bandwidth (Lower 3db Frequency = 10Hz)**
- **Open Loop Voltage Gain, dB**
- **Open Loop Phase Response, Degrees**

**OPEN LOOP FREQUENCY RESPONSE**

**OPEN LOOP PHASE RESPONSE**

<table>
<thead>
<tr>
<th>C_H Value</th>
<th>Drift Current (pA)</th>
<th>Temperature, (Degrees C)</th>
<th>Frequency, Hz</th>
<th>Open Loop Voltage Gain, dB</th>
<th>Open Loop Phase Response, Degrees</th>
</tr>
</thead>
</table>

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NOTES: 1) Figure 1 shows a typical unity gain circuit, with offset zeroing. All of the other normal op amp feedback configurations may be used with the HA-2420/2425. The input amplifier may be used as a gated amplifier by utilizing Pin 11 as the output. This amplifier has excellent drive capabilities along with exceptionally low switch leakage.

2) The method used to reduce leakage paths on the P.C. board and the device package is shown in Figure 2. This guard ring is recommended to minimize the drift during hold characteristic.

3) The holding capacitor should have extremely high insulation resistance and low dielectric absorption. Polystyrene (below +85°C), Teflon, or Mica types are recommended.

For more applications, consult Harris Application Note 517.

GLOSSARY OF TERMS

AQUISITION TIME:
The time required by the device after the “sample” command to reach its final value within ±0.1%. This time includes switch delay time, slewing time and settling time. This is the minimum sample time required to obtain a given accuracy.

CHARGE TRANSFER:
The small charge transferred to the holding capacitor from the inter-electrode capacitance of the switch when the unit is switched to the Hold mode. Sample-to-Hold offset error is directly proportional to this charge, where:

\[
\text{Offset Error (V)} = \frac{\text{Charge (pC)}}{C_H (pF)}
\]

APERTURE TIME:
The time required after the “hold” command until the switch is fully open. This delays the effective sample timing with rapidly changing input signals.

DRIFT CURRENT:
Leakage currents from the holding capacitor during the Hold mode which cause the output voltage to drift. Drift rate (droop rate) can be calculated from drift current values using the formula:

\[
\frac{\Delta V}{\Delta T} \text{(Volts/Sec)} = \frac{I (pA)}{C_H (pF)}
\]
HA-2500/2502/2505
High Slew Rate Operational Amplifiers

FEATURES

- **HIGH SLEW RATE**: 30V/μs
- **FAST SETTLING**: 330ns
- **WIDE POWER BANDWIDTH**: 500kHz
- **HIGH GAIN BANDWIDTH**: 12MHz
- **HIGH INPUT IMPEDANCE**: 100MΩ
- **LOW OFFSET CURRENT**: 10nA
- **TRUE OP-AMP** – CAN BE OPERATED NON-INVERTING OR INVERTING
- **MEETS OR EXCEEDS MIL-STD-883 REQUIREMENTS**

GENERAL DESCRIPTION

An operational amplifier with excellent D.C. characteristics, featuring high slew rate and fast settling time. Ideal for use in A/D, D/A, and sampled data systems; and for use in wide band R.F. or video systems where wide bandwidth at high output levels is required. The HA-2500/02/05 is internally compensated.

SCHEMATIC

PACKAGES

CODE 2A

CODE 9V

(METAL BOTTOM)

PIN OUT

NOTES:
1. All leads gold plated KOVAR
2. All dimensions in inches.

ALL DIMENSIONS ARE IN INCHES. ALL DIMENSIONS ±.010 UNLESS OTHERWISE SHOWN.
## SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2500/HA-2502</th>
<th>HA-2505</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature Range</td>
<td>-55°C ≤ TA ≤ +125°C</td>
<td>0°C ≤ TA ≤ +75°C</td>
</tr>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>40.0V ±15.0V</td>
<td>40.0V ±15.0V</td>
</tr>
<tr>
<td>Peak Output Current</td>
<td>50mA</td>
<td>50mA</td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW</td>
<td>300mW</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

**V+ = +15V D.C., V- = -15V D.C.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2500 -55°C to +125°C</th>
<th>HA-2502 -55°C to +125°C</th>
<th>HA-2505 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LIMITS</strong></td>
<td>MIN.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
<tr>
<td><strong>LIMITS</strong></td>
<td>MIN.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
<tr>
<td><strong>LIMITS</strong></td>
<td>MIN.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
</tbody>
</table>

#### INPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset Voltage</td>
<td>+25°C</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Offset Voltage Average Drift</td>
<td>Full</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>μV/°C</td>
<td></td>
</tr>
<tr>
<td>Bias Current</td>
<td>+25°C</td>
<td>100</td>
<td>200</td>
<td>125</td>
<td>250</td>
<td>125</td>
<td>250</td>
<td>500</td>
<td>500</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>Offset Current</td>
<td>+25°C</td>
<td>10</td>
<td>25</td>
<td>20</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>100</td>
<td>100</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>20</td>
<td>50</td>
<td>MΩ</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>+10.0</td>
<td>±10.0</td>
<td>±10.0</td>
<td>±10.0</td>
<td>±10.0</td>
<td>V</td>
<td></td>
<td></td>
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<td></td>
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</table>

#### TRANSFER CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Signal Voltage Gain (Note 1,4)</td>
<td>+25°C</td>
<td>20K</td>
<td>30K</td>
<td>15K</td>
<td>25K</td>
<td>15K</td>
<td>25K</td>
<td>10K</td>
<td>10K</td>
<td>V/V</td>
<td></td>
</tr>
<tr>
<td>Common Mode Rejection Ratio (Note 2)</td>
<td>Full</td>
<td>80</td>
<td>90</td>
<td>74</td>
<td>90</td>
<td>74</td>
<td>90</td>
<td>V/V</td>
<td></td>
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<tr>
<td>Gain Bandwidth Product (Note 3)</td>
<td>+25°C</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>MHz</td>
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#### OUTPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Swing (Note 1)</td>
<td>Full</td>
<td>±10.0</td>
<td>±12.0</td>
<td>±10.0</td>
<td>±12.0</td>
<td>±10.0</td>
<td>±12.0</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current (Note 4)</td>
<td>+25°C</td>
<td>±10</td>
<td>±20</td>
<td>±10</td>
<td>±20</td>
<td>±10</td>
<td>±20</td>
<td>mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Power Bandwidth (Note 4)</td>
<td>+25°C</td>
<td>350</td>
<td>500</td>
<td>300</td>
<td>500</td>
<td>300</td>
<td>500</td>
<td>kHz</td>
<td></td>
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#### TRANSIENT RESPONSE

<table>
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<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (Notes 1, 5, 6 &amp; 8)</td>
<td>+25°C</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overshoot (Notes 1, 5, 7 &amp; 8)</td>
<td>+25°C</td>
<td>25</td>
<td>40</td>
<td>25</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slew Rate (Notes 1,4,5 &amp; 8)</td>
<td>+25°C</td>
<td>±25</td>
<td>±30</td>
<td>±20</td>
<td>±30</td>
<td>±20</td>
<td>±30</td>
<td>V/μs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settling Time to 0.1% (Notes 1,4,5 &amp; 8)</td>
<td>+25°C</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
<td>μs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### POWER SUPPLY CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current</td>
<td>+25°C</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Supply Rejection Ratio (Note 5)</td>
<td>Full</td>
<td>80</td>
<td>90</td>
<td>74</td>
<td>90</td>
<td>74</td>
<td>90</td>
<td>dB</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. $R_L = 2K$
2. $V_{CM} = ±5.0V$
3. $A_v > 10$
4. $V_o = ±10.0V$
5. $C_L = 50pF$
6. $V_o = ±400mV$
7. $V_o = ±600mV$
8. See transient response test circuits and waveforms page four.
9. $\Delta V = ±5.0V$

*100% Tested For DASH B
V+ = 15VDC, V- = 15VDC, TA = 25°C UNLESS OTHERWISE STATED

INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

NORMALIZED AC PARAMETERS vs TEMPERATURE

NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE AT +25°C

OPEN LOOP VOLTAGE GAIN vs TEMPERATURE

OUTPUT VOLTAGE SWING vs FREQUENCY AT +25°C

NOTE: External compensation components are not required for stability, but may be added to reduce bandwidth if desired.
**PERFORMANCE CURVES (continued)**

**POWER SUPPLY CURRENT vs TEMPERATURE**

- Vertical Scale: 5 mA
- Horizontal Scale: -50 to +125°C

**VOLTAGE FOLLOWER PULSE RESPONSE**

- Vertical Scale: V = 5 V/Div.
- Horizontal Scale: t = 200 ns/Div.
- R_L = 2 kΩ, C_L = 50 pF
- T_A = +25°C, V_S = ±15.0V

**SLEW RATE AND SETTLING TIME**

- +5.0V Input
- -5.0V Input
- +5.0V Output
- -5.0V Output
- Error Band (10 mV from Final Value)
- Slew Rate
- Settling Time

**TRANSIENT RESPONSE**

- Input
- Output
- Overshoot
- Rise Time

**SLEW RATE AND TRANSIENT RESPONSE**

- Suggested Offset Zero Adjust Hook-Up

<table>
<thead>
<tr>
<th>DEFINITIONS</th>
</tr>
</thead>
</table>

**INPUT OFFSET VOLTAGE**—That voltage which must be applied between the input terminals through two equal resistances to force the output voltage to zero.

**INPUT OFFSET CURRENT**—The difference in the currents into the two input terminals when the output is at zero voltage.

**INPUT BIAS CURRENT**—The average of the currents flowing into the input terminals when the output is at zero voltage.

**INPUT COMMON MODE VOLTAGE**—The average referred to ground of the voltages at the two input terminals.

**COMMON MODE RANGE**—The range of voltages which is exceeded at either input terminal will cause the amplifier to cease operating.

**TRANSIENT RESPONSE**—The closed loop step function response of the amplifier under small signal conditions.

**GAIN BANDWIDTH PRODUCT**—The product of the gain and the bandwidth at a given gain.

**SLEW RATE (Rating Limiting)**—The rate at which the output will move between full scale stops, measured in terms of volts per unit time. This limit to an ideal step function response is due to the non-linear behavior in an amplifier due to its limited ability to produce large, rapid changes in output voltage (slewing)... restricting it to rates of change of voltage lower than might be predicted by observing the small signal frequency response.

**SETTLING TIME**—Time required for output waveform to remain within 0.1 percent of final value.
**FEATURES**

- **HIGH SLEW RATE**
  - 60V/μs
- **FAST SETTLING**
  - 250ns
- **WIDE POWER BANDWIDTH**
  - 1,000 kHz
- **HIGH GAIN BANDWIDTH**
  - 12 MHz
- **HIGH INPUT IMPEDANCE**
  - 100mΩ
- **LOW OFFSET CURRENT**
  - 10nA
- **TRUE OP AMP – CAN BE OPERATED NON-INVERTING OR INVERTING**
- **MEETS OR EXCEEDS MIL-STD-883 REQUIREMENTS**

**GENERAL DESCRIPTION**

An operational amplifier with excellent D.C. characteristics, featuring high slew rate and fast settling time. Ideal for use in A/D, D/A and sampled data systems; and for use in wide band R.F. or video systems where wide bandwidth at high output levels is required. The HA-2510/12/15 is internally compensated.

**SCHEMATIC**
## SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitations</th>
</tr>
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<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>40.0V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±15.0V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>HA-2510/HA-2512</td>
</tr>
<tr>
<td></td>
<td>-55°C ≤ TA ≤ +125°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>HA-2515</td>
</tr>
<tr>
<td></td>
<td>0°C ≤ TA ≤ +75°C</td>
</tr>
<tr>
<td>Peak Output Current</td>
<td>50mA</td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

\( V^+ = +15 \text{ V D.C.}, V^- = 15 \text{ V D.C.} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2510</th>
<th>HA-2512</th>
<th>HA-2515</th>
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<tr>
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<td>-55°C to +125°C</td>
<td>0°C to +75°C</td>
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<td>LIMITS</td>
<td>LIMITS</td>
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<td></td>
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<td>MIN.</td>
<td>TYP.</td>
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<tr>
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<td>4</td>
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<tr>
<td></td>
<td></td>
<td>Full</td>
<td>11</td>
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<tr>
<td>Offset Voltage Average Drift</td>
<td></td>
<td>Full</td>
<td>20</td>
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<tr>
<td>Bias Current</td>
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<td>+25°C</td>
<td>100</td>
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<tr>
<td></td>
<td></td>
<td>Full</td>
<td>400</td>
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<tr>
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<td></td>
<td>+25°C</td>
<td>10</td>
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<td></td>
<td></td>
<td>Full</td>
<td>50</td>
</tr>
<tr>
<td>Input Resistance</td>
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<td>+25°C</td>
<td>50</td>
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<tr>
<td>Common Mode Range</td>
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<td>Full</td>
<td>±10.0</td>
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<tr>
<td>TRANSFER CHARACTERISTICS</td>
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<td>+25°C</td>
<td>10K</td>
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<tr>
<td></td>
<td></td>
<td>Full</td>
<td>7.5K</td>
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<tr>
<td>Large Signal Voltage Gain</td>
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<td>+25°C</td>
<td>80</td>
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<tr>
<td>(Note 1)</td>
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<td>Full</td>
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</tr>
<tr>
<td>Common Mode Rejection Ratio</td>
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<td>+25°C</td>
<td>12</td>
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<tr>
<td>(Note 2)</td>
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<td>Full</td>
<td></td>
</tr>
<tr>
<td>Gain Bandwidth Product</td>
<td></td>
<td>+25°C</td>
<td>12</td>
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<tr>
<td>(Note 3)</td>
<td></td>
<td>Full</td>
<td></td>
</tr>
<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td>+25°C</td>
<td>±10</td>
</tr>
<tr>
<td>Output Voltage Swing (Note 1)</td>
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<td>Full</td>
<td>±10.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+25°C</td>
<td></td>
</tr>
<tr>
<td>Output Current (Note 4)</td>
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<td>+25°C</td>
<td>750</td>
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<tr>
<td>Full Power Bandwidth (Note 4)</td>
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<td>+25°C</td>
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</tr>
<tr>
<td>TRANSIENT RESPONSE</td>
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<td>+25°C</td>
<td>25</td>
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<td>Rise Time (Notes 1, 5, 6 &amp; 8)</td>
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<td>+25°C</td>
<td>25</td>
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<tr>
<td>Overshoot (Notes 1, 5, 7 &amp; 8)</td>
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<td>+25°C</td>
<td>±50</td>
</tr>
<tr>
<td>Slew Rate (Notes 1, 4, 5 &amp; 8)</td>
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<td>+25°C</td>
<td>0.25</td>
</tr>
<tr>
<td>Settling Time (Notes 1, 4, 5 &amp; 8)</td>
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<td>+25°C</td>
<td></td>
</tr>
<tr>
<td>POWER SUPPLY CHARACTERISTICS</td>
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<td>+25°C</td>
<td>4</td>
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<tr>
<td>Supply Current</td>
<td></td>
<td>Full</td>
<td>80</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Note 9)</td>
<td></td>
<td>*100% Tested For DASH 8</td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
1. RL = 2K
2. \( V_{CM} \) = ±5.0V
3. \( A_V \) > 10
4. \( V_O \) = ±10.0V
5. \( C_L \) = 50pF
6. \( V_O \) = ±400mV
7. \( V_O \) = ±600mV
8. See transient response test circuits and waveforms page four.
9. \( \Delta V \) = ±5.0V
PERFORMANCE CURVES

V+ = 15VDC, V- = 15VDC, TA = 25°C UNLESS OTHERWISE STATED.

INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

NORMALIZED AC PARAMETERS vs TEMPERATURE

NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE

OPEN LOOP VOLTAGE GAIN vs TEMPERATURE

EQUIVALENT INPUT NOISE vs BANDWIDTH

OPEN LOOP FREQUENCY AND PHASE RESPONSE

OPEN-LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM BANDWIDTH CONTROL PIN TO GROUND

OUTPUT VOLTAGE SWING vs FREQUENCY AT +25°C

NOTE: External compensation components are not required for stability, but may be added to reduce bandwidth if desired.
PERFORMANCE CURVES (continued)

POWER SUPPLY CURRENT vs TEMPERATURE

VOLTAGE FOLLOWER PULSE RESPONSE

R_L = 2KΩ, C_L = 50pF
Vertical = 5V/Div.
Upper Trace: Input
Lower Trace: Output
T_A = +25°C, V_S = ±15.0V

SLEW RATE AND SETTLING TIME

TRANSIENT RESPONSE

SLEW RATE AND TRANSIENT RESPONSE

SUGGESTED OFFSET ZERO ADJUST HOOK-UP

DEFINITIONS

INPUT OFFSET VOLTAGE—That voltage which must be applied between the input terminals through two equal resistances to force the output voltage to zero.

INPUT OFFSET CURRENT—The difference in the currents into the two input terminals when the output is at zero voltage.

INPUT BIAS CURRENT—The average of the currents flowing into the input terminals when the output is at zero voltage.

INPUT COMMON MODE VOLTAGE—The average referred to ground of the voltages at the two input terminals.

COMMON MODE RANGE—The range of voltages which is exceeded at either input terminal will cause the amplifier to cease operating.

COMMON MODE REJECTION RATIO—The ratio of a specified range of input common mode voltage to the peak-to-peak change in input offset voltage over this range.

OUTPUT VOLTAGE SWING—The peak symmetrical output voltage swing, referred to ground, that can be obtained without clipping.

INPUT RESISTANCE—The ratio of the change in input voltage to the change in input current.

OUTPUT RESISTANCE—The ratio of the change in output voltage to the change in output current.

VOLTAGE GAIN—The ratio of the change in output voltage to the change in input voltage producing it.

UNITY GAIN BANDWIDTH—The frequency at which the voltage gain of the amplifier is unity.
HA-2520/2522/2525

High Slew Rate
Operational Amplifiers

FEATURES

- HIGH SLEW RATE
  120V/μs
- FAST SETTLING
  200ns
- WIDE POWER BANDWIDTH
  2,000 kHz
- HIGH GAIN BANDWIDTH
  100mΩ
- LOW OFFSET CURRENT
  10nA
- TRUE OP AMP — CAN BE OPERATED NON-INVERTING OR INVERTING
- MEETS OR EXCEEDS MIL-STD-883 REQUIREMENTS

GENERAL DESCRIPTION

An operational amplifier with excellent D.C. characteristics, featuring high slew rate and fast settling time. Ideal for use in A/D, D/A and sampled data systems; and for use in wide band R.F. or video systems where wide bandwidth at high output levels is required. The HA-2520/22/25 is stable for closed loop gains greater than 3 without external compensation.

SCHEMATIC

PACKAGES

CODE 2A

TO-99

Bottom View

CODE 9V

TO-86 (METAL BOTTOM)

PIN OUT

BANDWIDTH CONTROL
OFFSET ADJ
IN
IN-
OUT
OFFSET ADJ

TO-99

Top View

TO-86
### Specifications

**Absolute Maximum Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2520/2522</th>
<th>HA-2525</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>40.0V</td>
<td>0°C ≤ TA ≤ +75°C</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±15.0V</td>
<td>-65°C ≤ TA ≤ +150°C</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-55°C ≤ TA ≤ +125°C</td>
<td></td>
</tr>
</tbody>
</table>

**Electrical Characteristics**

- **V+ = +15V D.C., V- = -15V D.C.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2520 -55°C to +125°C</th>
<th>HA-2522 -55°C to +125°C</th>
<th>HA-2525 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Output Current</td>
<td>50mA</td>
<td>250mA</td>
<td>100mA</td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW</td>
<td>500mW</td>
<td>100mW</td>
</tr>
</tbody>
</table>

**Input Characteristics**

- **Offset Voltage**
  - +25°C: 4 mV, Full: 10 mV
  - +25°C: 11 mV, Full: 14 mV

- **Bias Current**
  - +25°C: 100 nA, Full: 200 nA
  - +25°C: 200 nA, Full: 500 nA

- **Offset Current**
  - +25°C: 10 nA, Full: 25 nA
  - +25°C: 25 nA, Full: 50 nA

- **Input Resistance**
  - +25°C: 50 MΩ, Full: 100 MΩ

- **Common Mode Range**
  - Full: ±10.0 \( \mu \text{V} \)

**Transfer Characteristics**

- **Large Signal Voltage Gain (Note 1, 4)**
  - +25°C: 10K, Full: 7.5K

- **Common Mode Rejection Ratio (Note 2)**
  - Full: 80, 90 dB

- **Gain Bandwidth Product (Note 3)**
  - +25°C: 20 MHz

**Output Characteristics**

- **Output Voltage Swing (Note 1)**
  - Full: ±10.0, ±12.0 V

- **Output Current (Note 4)**
  - +25°C: ±10, ±20 mA

- **Full Power Bandwidth (Note 4)**
  - +25°C: 1500 kHz

**Transient Response**

- **(AV = +3)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2520 -55°C to +125°C</th>
<th>HA-2522 -55°C to +125°C</th>
<th>HA-2525 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (Notes 1, 5, 6 &amp; 8)</td>
<td>25 ns</td>
<td>25 ns</td>
<td>25 ns</td>
</tr>
<tr>
<td>Overshoot (Notes 1, 5, 6 &amp; 8)</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Slew Rate (Notes 1, 4, 5 &amp; 8)</td>
<td>±100 V/( \mu \text{s} )</td>
<td>±120 V/( \mu \text{s} )</td>
<td>±120 V/( \mu \text{s} )</td>
</tr>
<tr>
<td>Settling Time (Notes 1, 4, 5 &amp; 8)</td>
<td>0.20 ( \mu \text{s} )</td>
<td>0.20 ( \mu \text{s} )</td>
<td>0.20 ( \mu \text{s} )</td>
</tr>
</tbody>
</table>

**Power Supply Characteristics**

- **Supply Current**
  - +25°C: 4 mA, Full: 80 mA

- **Power Supply Rejection Ratio (Note 7)**
  - Full: 80 dB

**Notes:**
1. \( R_L = 2K \)
2. \( V_{CM} = \pm 5.0V \)
3. \( A_V > 10 \)
4. \( V_O = \pm 10.0V \)
5. \( C_1 = 50\mu \text{F} \)
6. \( V_{O} = \pm 200\text{mV} \)
7. \( \Delta V = \pm 5.0V \)
8. See transient response test circuits and waveforms page four.

*100% Tested For DASH B
PERFORMANCE CURVES

V+ = 15VDC, V- = 15VDC, T_A = 25°C UNLESS OTHERWISE STATED

INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

NORMALIZED AC PARAMETERS vs TEMPERATURE

NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE AT +25°C

OPEN LOOP FREQUENCY AND PHASE RESPONSE

OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM BANDWIDTH CONTROL PIN TO GROUND

OUTPUT VOLTAGE SWING vs FREQUENCY AT +25°C
PERFORMANCE CURVES (continued)

POWER SUPPLY CURRENT vs TEMPERATURE

VOLTAGE FOLLOWER PULSE RESPONSE

\[ R_L = 2K \Omega, \quad C_L = 50pF \]

Upper Trace: Input; 1.33V/Div.
Lower Trace: Output; 5V/Div.

SLEW RATE AND SETTLING TIME

TRANSIENT RESPONSE

SLEW RATE AND TRANSIENT RESPONSE

SUGGESTED OFFSET ZERO ADJUST HOOK-UP

TYPICAL APPLICATIONS

COMPENSATION CIRCUIT FOR INVERTING UNITY GAIN

| Slew Rate | \( \approx 120V/\mu s \) |
| Bandwidth | \( \approx 10MHz \) |
| Settling Time | \( \approx 500ns \) |
HA-2530/2535
High Slew Rate, Wideband Inverting Amplifier

**Features**

- **High Slew Rate**: ±320V/μs
- **Fast Settling Time**: 550ns
- **Wide Power Bandwidth**: 5MHz
- **High Gain Bandwidth Product**: 70MHz
- **Low Offset Voltage**: 0.8mV
- **Low Power Supply Current**: 3.5mA

**Description**

The HA-2530/2535 is a monolithic wideband inverting amplifier whose performance characteristics are superior to any other monolithic in its class. The device uses a feedforward amplifier technique to achieve widepower bandwidth and high slew rate at no expense to noise or DC parameters. It is excellent for use in pulse circuits requiring high slew rate and fast settling, such as high speed integrators, A/D, D/A and sampled data systems. Also recommended for many video applications where wideband response at high output current levels are required. For gains less than 10 a small capacitor is required for stability.

**Packages**

<table>
<thead>
<tr>
<th>Code</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>TO-99</td>
</tr>
</tbody>
</table>

**Notes:**

1. All leads gold plated KOVAR
2. All dimensions in inches

**Pin-Out and Typical Hook-up**

**Schematic**

Bottom View

Top View

NOTE: Case tied to V−
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS
- Voltage Between V+ and V- Terminals: 40V
- Internal Power Dissipation (Note 1): 550mW
- Operating Temperature Range: -55°C ≤ TA ≤ +125°C (HA-2530)
- Peak Output Current: ±100mA
- Storage Temperature Range: -65°C ≤ TA ≤ +150°C (HA-2535)

#### ELECTRICAL CHARACTERISTICS

Test Conditions: \( V_{\text{Supply}} = \pm 15.0V \) Unless Otherwise Specified.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>HA-2530 -55°C to +125°C</th>
<th>HA-2535 0°C to +75°C</th>
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<tbody>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LIMITS</td>
<td>LIMITS</td>
</tr>
<tr>
<td>Offset Voltage</td>
<td>+25°C</td>
<td>0.8</td>
<td>3</td>
<td>0.8</td>
<td>5</td>
<td>mV</td>
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<tr>
<td>Average Offset Voltage Drift</td>
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<td>5</td>
<td></td>
<td>5</td>
<td></td>
<td>( \mu V/°C )</td>
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<tr>
<td>Bias Current</td>
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<td>15</td>
<td>100</td>
<td>15</td>
<td>200</td>
<td>nA</td>
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<tr>
<td>Offset Current</td>
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<td>20</td>
<td>5</td>
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<td>nA</td>
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<td>pF</td>
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<td></td>
<td>V/V</td>
<td>V/V</td>
</tr>
<tr>
<td>Large Signal Voltage Gain</td>
<td>+25°C</td>
<td>10⁵</td>
<td>2X10⁶</td>
<td>10⁵</td>
<td>2X10⁶</td>
<td>V/V</td>
</tr>
<tr>
<td>Common-Mode Rejection Ratio</td>
<td>Full</td>
<td>86</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>dB</td>
</tr>
<tr>
<td>Gain Bandwidth Product</td>
<td>+25°C</td>
<td>70</td>
<td></td>
<td>70</td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V</td>
<td>mA</td>
</tr>
<tr>
<td>Output Voltage Swing</td>
<td>Full</td>
<td>±10</td>
<td>±12</td>
<td>±10</td>
<td>±12</td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>+25°C</td>
<td>±25</td>
<td>±50</td>
<td>±25</td>
<td>±50</td>
<td>mA</td>
</tr>
<tr>
<td>Full Power Bandwidth</td>
<td>+25°C</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>MHz</td>
</tr>
<tr>
<td>TRANSIENT RESPONSE (NOTES 6 &amp; 7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>+25°C</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>ns</td>
</tr>
<tr>
<td>Overshoot</td>
<td>+25°C</td>
<td>30</td>
<td>45</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slew Rate</td>
<td>+25°C</td>
<td>±280</td>
<td>±320</td>
<td>±250</td>
<td>±320</td>
<td>V/( \mu )s</td>
</tr>
<tr>
<td>Settling Time</td>
<td>+25°C</td>
<td>500</td>
<td></td>
<td>500</td>
<td></td>
<td>ns</td>
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<tr>
<td>POWER SUPPLY CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>+25°C</td>
<td>3.5</td>
<td>6</td>
<td>3.5</td>
<td>6</td>
<td>mA</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>Full</td>
<td>86</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>dB</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Derate at 5.5mW/°C for Operation
2. RA = 2K
3. VCM = ±5.0V
4. AV >10
5. VAV = ±10V
6. C1 = 50pF
7. See Transient Response Test Circuit and Wave Forms, Page 4.
8. ΔV = ±5.0V
9. 100% Tested For DASH 8
PERFORMANCE CURVES

V+ = 15VDC, V- = 15VDC, $T_A = 25^\circ C$ UNLESS OTHERWISE STATED

INPUT BIAS AND OFFSET CURRENT vs. TEMPERATURE

NORMALIZED AC PARAMETERS vs. TEMPERATURE

NORMALIZED AC PARAMETERS vs. SUPPLY VOLTAGE AT +25°C

EQUIVALENT INPUT NOISE vs. BANDWIDTH

Upper 3dB Frequency
Lower 3dB Frequency - 10Hz

OPEN-LOOP FREQUENCY AND PHASE RESPONSE

POWER SUPPLY CURRENT vs. TEMPERATURE

OUTPUT VOLTAGE SWING vs. FREQUENCY AT +25°C
**PERFORMANCE CURVES (continued)**

**SETTLING TIME MEASUREMENT**

- Vertical: 5mV/DIV.
- Horizontal: 100ns/DIV.
- $T_A = +25^\circ C$, $V_S = \pm 15V$

**UNITY GAIN PULSE RESPONSE**

- Upper Trace: Input Vertical = 5V/DIV.
- Lower Trace: Output Horizontal = 50ns/DIV.
- $T_A = +25^\circ C$, $V_S = \pm 15V$

**SLEW RATE/SETTLING TIME/TRANSIENT RESPONSE TEST CIRCUIT**

*1 Settling time ($T_S$) is measured using a high speed high recovery oscilloscope to display the error voltage $V_E$. When $V_E$ is within ±5mV of final value the output $V_O$ will be within ±10mV (0.1%).

*2 $S_1$ closed for settling time.

**SLEW RATE**

- $+4.5V$ Input
- $-4.5V$ Input
- Slew Rate $\frac{\Delta V}{\Delta t}$
- Output $\Delta V$ $\Delta t$

**SETTLING TIME**

- $+5V$ Input
- $-5V$ Input
- Error Band $\pm 10mV$ from final value

**TRANSIENT RESPONSE**

- 0V Input
- 400mV Overshoot

* Measured on both positive and negative excursions.

**5MHz VIDEO AMPLIFIER ($A_V = 10$)**

- Input $V_1$
- 500Ω
- 5kΩ
- 455Ω
- 3pF
- 50pF
- Output
HA-2600/2602/2605

High Impedance Operational Amplifier

**FEATURES**

- HIGH INPUT IMPEDANCE
- LOW INPUT BIAS CURRENT
- LOW INPUT OFFSET CURRENT
- LOW INPUT OFFSET VOLTAGE
- HIGH GAIN
- HIGH SLEW RATE
- FAST RESPONSE TIME
- OUTPUT SHORT CIRCUIT PROTECTION
- MEETS OR EXCEEDS MIL-STD-883 REQUIREMENTS

**GENERAL DESCRIPTION**

Internally compensated high impedance, high performance monolithic operational amplifier intended for use as a general purpose operational amplifier in precision instrumentation and signal processing.

**SCHEMATIC**

**PACKAGES**

**CODE 2A**

TO-99

**CODE 9W**

TO-91

**PIN OUT**

TO-99

Case Connected to V-

TO-91

Case Connected to V-
## SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limits</th>
<th>HA-2600 -55°C to +125°C</th>
<th>HA-2602 -55°C to +125°C</th>
<th>HA-2605 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>±45.0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±12.0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Output Current</td>
<td>Full Short Circuit Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range – HA-2600/HA-2602</td>
<td>-55°C ≤ TA ≤ +125°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-2605</td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-55°C to +125°C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

V+ = +15VDC, V- = -15VDC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2600 -55°C to +125°C</th>
<th>HA-2602 -55°C to +125°C</th>
<th>HA-2605 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFFSET VOLTAGE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Voltage</td>
<td>0.5 mV</td>
<td>2 mV</td>
<td>3 mV</td>
</tr>
<tr>
<td>Offset Voltage Average Drift</td>
<td>4 mV</td>
<td>6 mV</td>
<td>5 mV</td>
</tr>
<tr>
<td><strong>BASIC CURRENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bias Current</td>
<td>1.0 mA</td>
<td>10 mA</td>
<td>15 mA</td>
</tr>
<tr>
<td>Offset Current</td>
<td>1.0 mA</td>
<td>10 mA</td>
<td>15 mA</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>100 MΩ</td>
<td>500 MΩ</td>
<td>400 MΩ</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>+11.0 MΩ</td>
<td>+11.0 MΩ</td>
<td>+11.0 MΩ</td>
</tr>
<tr>
<td><strong>TRANSFER CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Signal Voltage Gain (Notes 1, 4)</td>
<td>100 V/V</td>
<td>70 V/V</td>
<td>60 V/V</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio (Note 2)</td>
<td>80 V/V</td>
<td>74 V/V</td>
<td>74 V/V</td>
</tr>
<tr>
<td>Unity Gain Bandwidth (Note 3)</td>
<td>12 dB</td>
<td>12 dB</td>
<td>12 dB</td>
</tr>
<tr>
<td><strong>OUTPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Swing (Note 1)</td>
<td>100 MΩ</td>
<td>75 MΩ</td>
<td>75 MΩ</td>
</tr>
<tr>
<td>Output Current (Note 4)</td>
<td>±15 mA</td>
<td>±22 mA</td>
<td>±18 mA</td>
</tr>
<tr>
<td>Full Power Bandwidth (Note 4)</td>
<td>50 MΩ</td>
<td>75 MΩ</td>
<td>50 MΩ</td>
</tr>
<tr>
<td>Rise Time (Notes 1, 5, 6 &amp; 8)</td>
<td>30 ns</td>
<td>60 ns</td>
<td>60 ns</td>
</tr>
<tr>
<td>Overshoot (Notes 1, 5, 7 &amp; 8)</td>
<td>25 %</td>
<td>40 %</td>
<td>40 %</td>
</tr>
<tr>
<td>Slew Rate (Notes 1, 4, 5 &amp; 8)</td>
<td>±4 V/μs</td>
<td>±7 V/μs</td>
<td>±4 V/μs</td>
</tr>
<tr>
<td>Settling Time (Notes 1, 4, 5 &amp; 8)</td>
<td>1.5 μs</td>
<td>1.5 μs</td>
<td>1.5 μs</td>
</tr>
<tr>
<td><strong>POWER SUPPLY CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Current (Note 9)</td>
<td>3.0 mA</td>
<td>3.0 mA</td>
<td>3.0 mA</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio (Note 9)</td>
<td>80 mA</td>
<td>90 mA</td>
<td>74 mA</td>
</tr>
</tbody>
</table>

### TEST CONDITIONS

Notes:
1. R_L = 2K
2. V_CM = ±5.0V
3. V_O = ±90mV
4. V_O = ±110V
5. C_L = 1000F
6. V_D = ±200mV
7. V_R = ±40mV
8. See Transient response test circuits and waveforms page three.
9. V_R = ±9.0V to ±18V
10. 100% Tested For DASH 8
PERFORMANCE CURVES

**V+ = 15VDC, V- = 15VDC, T_A = 25°C UNLESS OTHERWISE STATED.**

- **Input Bias Current and Offset Current** as a Function of Temperature
- **Equivalent Input Noise** vs. Bandwidth
- **Open Loop Frequency and Phase Response**
- **Input Impedance** vs. Temperature, 100Hz
- **Peak Voltage Swing** vs. Frequency
- **Output Voltage Swing** vs. Frequency
- **Open-Loop Voltage Gain** vs. Temperature
- **Common Mode Voltage Range** as a Function of Supply Voltage
- **Open-Loop Voltage Gain** vs. Temperature

**SUGGESTED OFFSET ZERO ADJUST HOOK-UP**

**NOTE:** Measured on both positive and negative transitions.

**INPUT:**

- Overshoot
- Rise Time
- 90% Output

**OUTPUT:**

- 10% Final Value

**SLEW RATE AND SETTLING TIME**

- Error Band
- 10V from Final Value

**TRANSIENT RESPONSE**

- 5V
- 10V
- 15V

**SUPPLIED BY:**

- 20V SUPPLY
- +15V SUPPLY
- +10V SUPPLY
- +5V SUPPLY

**Note:** External Compensation Components are not Required for Stability. But May be Added to Reduce Bandwidth if Desired. If External Compensation is Used, Also Connect 100pF Capacitor From Output to Ground.
TYPICAL APPLICATIONS

PHOTO-CURRENT TO VOLTAGE CONVERTER

FEATURES:
1. CONSTANT CELL VOLTAGE
2. MINIMUM BIAS CURRENT ERROR

SAMPLE – AND – HOLD

REFERENCE VOLTAGE AMPLIFIER

VOLTAGE FOLLOWER

DEFINITIONS

INPUT OFFSET VOLTAGE – That voltage which must be applied between the input terminals through two equal resistances to force the output voltage to zero.

INPUT OFFSET CURRENT – The difference in the currents into the two input terminals when the output is at zero voltage.

INPUT BIAS CURRENT – The average of the currents flowing into the input terminals when the output is at zero voltage.

INPUT COMMON MODE VOLTAGE – The average referred to ground of the voltages at the two input terminals.

COMMON MODE RANGE – The range of voltages which is exceeded at either input terminal will cause the amplifier to cease operating.

COMMON MODE REJECTION RATIO – The ratio of a specified range of input common mode voltage to the peak-to-peak change in input offset voltage over this range.

OUTPUT VOLTAGE SWING – The peak symmetrical output voltage swing, referred to ground, that can be obtained without clipping.

INPUT RESISTANCE – The ratio of the change in input voltage to the change in input current.

OUTPUT RESISTANCE – The ratio of the change in output voltage to the change in output current.

VOLTAGE GAIN – The ratio of the change in output voltage to the change in input voltage producing it.

BANDWIDTH – The frequency at which the voltage gain is 3 dB below its low frequency value.

UNITY GAIN BANDWIDTH – The frequency at which the voltage gain of the amplifier is unity.

POWER SUPPLY REJECTION RATIO – The ratio of the change in input offset voltage to the change in power supply voltage producing it.

TRANSIENT RESPONSE – The closed loop step function response of the amplifier under small signal conditions.

PHASE MARGIN – \( \phi_2 - \phi_1 \) \( \phi_1 \) is the phase shift at the frequency where the absolute magnitude of gain is unity. \( \phi_2 \) is the phase shift at a frequency much slower than the open-loop bandwidth.

SLEW RATE (Rate Limiting) – The rate at which the output will move between full scale stops, measured in terms of volts per unit time. This limit to an ideal step function response is due to the non-linear behavior in an amplifier due to its limited ability to produce large, rapid changes in output voltage (slew) restricting it to rates of change of voltage lower than might be predicted by observing the small signal frequency response.

SETTLING TIME – Time required for output waveform to remain within 0.1 percent of final value.

*A small load capacitance is recommended in all applications where practical to prevent possible high frequency oscillations resulting from external wiring parasitics. Capacitance up to 100pF has negligible effect on the bandwidth or slew rate.
HA-2620/2622/2625
Wide Band, High Impedance
Operational Amplifiers

FEATURES

- Gain Bandwidth Product: 100MHz
- High Input Impedance: 500MΩ
- Low Input Bias Current: 1nA
- Low Input Offset Current: 1nA
- Low Input Offset Voltage: 1mV
- High Gain: 150K
- High Slew Rate: 35V/μs
- Output Short Circuit Protection

GENERAL DESCRIPTION

The HA-2620 family of operational amplifiers has very low input bias current and intended for use as high impedance comparators and wide band amplifiers. The HA-2620 family features very high gain, very high slew rate and output short circuit protection. The HA-2620 and HA-2622 operate over the full military temperature range from -55°C to +125°C. The HA-2625 operates over the temperature range of 0°C to +75°C.

SCHEMATIC

PACKAGES

CODE 2A

PACKAGES

CODE 1S

PIN OUT

TO-99

OFFSET ADJ.

Case Connected to V-

TO-116

OFFSET ADJ.

Case Connected to V-
# SPECIFICATIONS

## ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>TYP.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>45.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±12.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Output Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td>300mW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## ELECTRICAL CHARACTERISTICS

### INPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Offset Voltage (Note 1)</td>
<td>+25°C</td>
<td>0.5</td>
<td>4</td>
<td>3</td>
<td>mV</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>mV</td>
</tr>
<tr>
<td>* Bias Current</td>
<td>+25°C</td>
<td>1</td>
<td>15</td>
<td>5</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>10</td>
<td>35</td>
<td>60</td>
<td>nA</td>
</tr>
<tr>
<td>* Offset Current</td>
<td>+25°C</td>
<td>1</td>
<td>15</td>
<td>5</td>
<td>nA</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>5</td>
<td>35</td>
<td>60</td>
<td>nA</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>65</td>
<td>500</td>
<td>40</td>
<td>Ω</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±11.0</td>
<td></td>
<td>±11.0</td>
<td>V</td>
</tr>
</tbody>
</table>

### TRANSFER CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Large Signal Voltage Gain</td>
<td>+25°C</td>
<td>100K</td>
<td>150K</td>
<td>80K</td>
<td>V/V</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>70K</td>
<td>150K</td>
<td>60K</td>
<td>V/V</td>
</tr>
<tr>
<td>* Common Mode Rejection Ratio</td>
<td>Full</td>
<td>80</td>
<td>100</td>
<td>74</td>
<td>dB</td>
</tr>
<tr>
<td>Gain Bandwidth Product</td>
<td>+25°C</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>MHz</td>
</tr>
</tbody>
</table>

### OUTPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Swing (Note 2)</td>
<td>Full</td>
<td>±10.0</td>
<td>±12.0</td>
<td>±10.0</td>
</tr>
<tr>
<td>* Output Current (Note 3)</td>
<td>+25°C</td>
<td>±15</td>
<td>±22</td>
<td>±10</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>±20</td>
<td>±20</td>
<td>±20</td>
</tr>
</tbody>
</table>

### TRANSIENT RESPONSE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise Time (Notes 2, 5, 7 &amp; 8)</td>
<td>+25°C</td>
<td>17</td>
<td>45</td>
<td>17</td>
</tr>
<tr>
<td>* Slew Rate (Notes 2, 7, 8 &amp; 10)</td>
<td>+25°C</td>
<td>±25</td>
<td>±35</td>
<td>±20</td>
</tr>
</tbody>
</table>

### POWER SUPPLY CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Supply Current</td>
<td>+25°C</td>
<td>3.0</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td>* Power Supply Rejection Ratio</td>
<td>Full</td>
<td>80</td>
<td>90</td>
<td>74</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Offset may be externally adjusted to zero.
2. $R_L = 2KΩ$, $C_L = 50pF$
3. $V_O = 10.0V$
4. $V_{CM} = ±5.0V$
5. $V_O < 90mV$
6. 40dB Gain
7. See transient response test circuits and waveforms page 3.
8. $A_V = 5.0V$ (The HA-2620 family is not stable at unity gain without external compensation.)
9. $V_{Sup} = ±9.0V$ to ±15.0V
10. $V_O = 5.0V$

*100% Tested For DASH 8
TYPICAL PERFORMANCE CURVES

V+ = 15VDC, V- = 15VDC, T_A = 25°C UNLESS OTHERWISE STATED.

INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE

EQUIVALENT INPUT NOISE VS. BANDWIDTH

UPPER 3dB FREQUENCY - 10Hz
LOWER 3dB FREQUENCY - 1kHz
BROADBAND NOISE CHARACTERISTICS

OPEN LOOP VOLTAGE GAIN VS. FREQUENCY AND PHASE RESPONSE

Note: External Compensation is Required For Closed Loop Gain < 5. If External Compensation is Used, Also Connect 100 pf Capacitor From Output to Ground.

INPUT IMPEDANCE VS. TEMPERATURE, 100Hz

PEAK VOLTAGE SWING VS. FREQUENCY

OUTPUT VOLTAGE SWING VS. FREQUENCY

COMMON MODE RANGE VS. SUPPLY VOLTAGE

COMMON MODE VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE

OPEN-LOOP VOLTAGE GAIN VS. TEMPERATURE

TRANSIENT RESPONSE

SLEW RATE

SLEW RATE AND TRANSIENT RESPONSE

SUGGESTED OFFSET ZERO ADJUST AND BANDWIDTH CONTROL HOOK-UP

NOTE: MEASURED ON BOTH POSITIVE AND NEGATIVE TRANSITIONS.

100kHz

1kHz

10kHz

100kHz

1MHz

10MHz

500mV

90%

10%

0V

100mV

0V

1V

OUTPUT

OUTPUT

SLEW RATE

ΔV/ΔT

1.6k

490Ω

100kΩ

OFFSET

BANDWIDTH CONTROL

V

- V

IN

IN

OUT

OUT
**TYPICAL APPLICATIONS**

**HIGH IMPEDANCE COMPARATOR**

![Diagram of a high impedance comparator]

**DEFINITIONS**

**INPUT OFFSET VOLTAGE**—That voltage which must be applied between the input terminals through two equal resistances to force the output voltage to zero.

**INPUT OFFSET CURRENT**—The difference in the currents into the two input terminals when the output is at zero voltage.

**INPUT BIAS CURRENT**—The average of the currents flowing into the input terminals when the output is at zero voltage.

**INPUT COMMON MODE VOLTAGE**—The average referred to ground of the voltages at the two input terminals.

**COMMON MODE RANGE**—The range of voltages which is exceeded at either input terminal will cause the amplifier to cease operating.

**COMMON MODE REJECTION RATIO**—The ratio of a specified range of input common mode voltage to the peak-to-peak change in input offset voltage over this range.

**OUTPUT VOLTAGE SWING**—The peak symmetrical output voltage swing, referred to ground, that can be obtained without clipping.

**INPUT RESISTANCE**—The ratio of the change in input voltage to the change in input current.

**OUTPUT RESISTANCE**—The ratio of the change in output voltage to the change in output current.

**VOLTAGE GAIN**—The ratio of the change in output voltage to the change in input voltage producing it.

**UNITY GAIN BANDWIDTH**—The frequency at which the voltage gain of the amplifier is unity.

**POWER SUPPLY REJECTION RATIO**—The ratio of the change in input offset voltage to the change in power supply voltage producing it.

**TRANSIENT RESPONSE**—The closed loop step function response of the amplifier under small signal conditions.

**GAIN BANDWIDTH PRODUCT**—The product of the gain and the bandwidth at a given gain.

**SLEW RATE (Rate Limiting)**—The rate at which the output will move between full scale stops, measured in terms of volts per unit time. This limit to an ideal step function response is due to the non-linear behavior in an amplifier due to its limited ability to produce large, rapid changes in output voltage (slewing)...restricting it to rates of change of voltage lower than might be predicted by observing the small signal frequency response.

* A small load capacitance of at least 30pF (including stray capacitance) is recommended to prevent possible high frequency oscillations.
# HA-2630/2635

## High Performance Current Booster

### FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Current</td>
<td>±600mA</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>500V/μs</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>8MHz</td>
</tr>
<tr>
<td>Full Power Bandwidth</td>
<td>8MHz</td>
</tr>
<tr>
<td>Input Resistance</td>
<td>2.0 X 10^6Ω</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>2.0Ω</td>
</tr>
<tr>
<td>Power Supply Range</td>
<td>±5 V to ±20V</td>
</tr>
<tr>
<td>Package is Electrically Isolated</td>
<td></td>
</tr>
</tbody>
</table>

### DESCRIPTION

The HA-2630/2635 is a unity voltage gain, current amplifier intended to be used in series with an operational amplifier, inside the feedback loop, wherever additional output current capability is required. Wide bandwidth and exceptionally high slew rate allow it to be used with high performance op amps without producing instability or signal distortion. Current delivered to the load may be limited to a predetermined level by choice of two optional external limiting resistors. This device is packaged in an electrically isolated TO-8 type can allowing it to be conveniently mounted with or without a heat sink. The HA-2630 has guaranteed operation over -55°C to +125°C, while the HA-2635 is guaranteed over 0°C to +75°C.

### SCHEMATIC DIAGRAM

![Schematic Diagram](image)

### PACKAGE

#### Code 2G TO-8

![Package Diagram](image)

#### PIN OUT

![PIN OUT](image)
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>40V</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>± V Supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current (Note 2)</td>
<td>±700mA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation (Note 6)</td>
<td>Free Air: 1W</td>
<td>In Heat Sink: 4W</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-55°C ≤ TA ≤ +125°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0°C ≤ TA ≤ +75°C</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Storage Temperature Range:</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-65°C ≤ TA ≤ +150°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

V<sub>Supply</sub> = ±15 Volts  \quad R<sub>L</sub> = 50 Ohms  \quad R<sub>1</sub> = R<sub>2</sub> = 0 Ohms  \quad Unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HA-2630 -55°C to +125°C</th>
<th>HA-2635 0°C to +75°C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Bias Current</td>
<td>+25°C</td>
<td>30</td>
<td>30</td>
<td>150</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>2.0</td>
<td>2.0</td>
<td>200</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>+25°C</td>
<td>5.0</td>
<td>5.0</td>
<td>2.0</td>
</tr>
<tr>
<td>TRANSFER CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Gain (Note 1)</td>
<td></td>
<td>.85</td>
<td>.85</td>
<td>.95</td>
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<tr>
<td>Full</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>* Offset Voltage (V&lt;sub&gt;OUT&lt;/sub&gt; - V&lt;sub&gt;IN&lt;/sub&gt;)</td>
<td>+25°C</td>
<td>70</td>
<td>±200</td>
<td>70</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandwidth (-3dB)</td>
<td>+25°C</td>
<td>8.0</td>
<td>8.0</td>
<td>200</td>
</tr>
<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Output Voltage Swing</td>
<td></td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td>* Output Current (Note 1)</td>
<td>+25°C</td>
<td>±400</td>
<td>±300</td>
<td>±400</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Resistance</td>
<td>+25°C</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Full Power Bandwidth (Note 1)</td>
<td>+25°C</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>TRANSIENT RESPONSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise Time (Note 3)</td>
<td>+25°C</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Slew Rate (Note 4)</td>
<td>+25°C</td>
<td>200</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>POWER SUPPLY CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Supply Current</td>
<td></td>
<td>15</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Supply Voltage Range</td>
<td></td>
<td>±5</td>
<td>±5</td>
<td>±5</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio (Note 5)</td>
<td></td>
<td>66</td>
<td>66</td>
<td>66</td>
</tr>
</tbody>
</table>

**NOTES:**

1. V<sub>O</sub> = ±10V
2. Heat sink is required for continuous short circuit protection, regardless of current limit setting.
3. V<sub>O</sub> = 0.4V p-p.
5. ΔV<sub>supply</sub> = ±5V.
6. Without heat sink, derate by 14mW/°C ambient temperature above 100°C ambient, with heat sink, derate by 67mW/°C case temperature above 115°C case.

*100% Tested For DASH 8*
PERFORMANCE CURVES

V+ = 15VDC, V- = 15VDC, TA = 25°C UNLESS OTHERWISE STATED

OUTPUT SWING (RLIMIT = 0Ω)

NORMALIZED AC PARAMETERS vs. TEMPERATURE (RL = 50Ω)

OUTPUT CURRENT LIMITING vs. LIMITING RESISTANCE

POWER DISSIPATION vs. LIMITING RESISTANCE WITH OUTPUT SHORTED TO GROUND, VIN = +10V

OPEN LOOP FREQUENCY AND PHASE RESPONSE (RL = 50Ω, C_L = 10pF)

NORMALIZED AC PARAMETERS vs. SUPPLY VOLTAGE (RL = 50Ω)

OUTPUT CURRENT CHARACTERISTIC

MAXIMUM ALLOWABLE INTERNAL POWER DISSIPATION vs. TEMPERATURE

SUPPLY VOIt,, Volts)

NORMALIZED AC PARAMETERS vs. TEMPERATURE (RL = som)

LIMITING RESISTANCE

OUTPUT LOAD CURRENT (mA)

CASE TEMPERATURE

AMBIENT TEMPERATURE (NO HEAT SINK)
TYPICAL APPLICATION

20db, 5MHz VIDEO COAXIAL LINE DRIVER

HA-2530

HA-2630

3pF

RF
5K

+V

- V (-15V)

R2
2.5 Ω

R1
2.5 Ω

50 Ω COAX

50 Ω

NOTE: R1 and R2 lead length should be minimal.

LINE DRIVER PULSE RESPONSE

Horizontal Scale = 200ns/Div.
Upper Trace: Input, 200mV/Div.
Lower Trace: Output, 2V/Div.

SOME OTHER APPLICATIONS

• BIPOLAR POWER SUPPLY
• FUNCTION GENERATOR OUTPUT
• DEFLECTION COIL DRIVE
• AUDIO OUTPUT AMPLIFIER
**HA-2640/2645**

*High Voltage Operational Amplifier*

**FEATURES**

- **OUTPUT VOLTAGE SWING**: ±35V
- **SUPPLY VOLTAGE**: ±10V to ±40V
- **OFFSET CURRENT**: 5nA
- **BANDWIDTH**: 4MHz
- **SLEW RATE**: 5V/μs
- **COMMON MODE INPUT VOLTAGE SWING**: ±35V
- **OUTPUT OVERLOAD PROTECTION**

**DESCRIPTION**

The HA-2640/2645 is a high voltage, high performance, internally compensated monolithic operational amplifier.

It is intended for use wherever a high output voltage range is required, or where high supply voltages (up to 80 Volts total) are encountered. Output current is limited by a chip temperature sensing circuit, providing positive protection against damage under any overload or output short circuit condition. The device may also be used as a pin for pin replacement for many general purpose op amps to achieve superior input current, bandwidth, and slew rate.

The HA-2640 has guaranteed operation over -55°C to +125°C, while the HA-2645 is guaranteed over 0°C to +75°C.

**SCHEMATIC DIAGRAM**
### ABSOLUTE MAXIMUM RATINGS

- **Voltage Between V+ and V- Terminals**: 100V
- **Input Voltage Range**: ±37V
- **Output Current/Full Short Circuit Protection**: Internal
- **Internal Power Dissipation**: 680mW*

*Derate by 4.6mW/°C above +25°C

### ELECTRICAL CHARACTERISTICS

VS\text{Supply} = \pm 40V, \quad RL = 5K, \quad Unless Otherwise Specified.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEMP.</th>
<th>HA-2640 -55°C to +125°C</th>
<th>HA-2645 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT CHARACTERISTICS</td>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
</tr>
<tr>
<td>*Offset Voltage</td>
<td>+25°C</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Voltage Average Drift</td>
<td>Full</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>*Bias Current</td>
<td>+25°C</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>*Offset Current</td>
<td>+25°C</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Input Resistance</td>
<td>+25°C</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td>±35</td>
<td></td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±35</td>
<td></td>
</tr>
<tr>
<td>TRANSFER CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Large Signal Voltage Gain (Note 8)</td>
<td>+25°C</td>
<td>100K</td>
<td>200K</td>
</tr>
<tr>
<td>Full</td>
<td></td>
<td>75K</td>
<td></td>
</tr>
<tr>
<td>*Common Mode Rejection Ratio (Note 1)</td>
<td>Full</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Unity Gain Bandwidth (Note 2)</td>
<td>+25°C</td>
<td>8</td>
<td></td>
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<tr>
<td>OUTPUT CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Output Voltage Swing</td>
<td>Full</td>
<td>±35</td>
<td></td>
</tr>
<tr>
<td>*Output Current (Note 9)</td>
<td>+25°C</td>
<td>±12</td>
<td>±15</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>+25°C</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Full Power Bandwidth (Note 3)</td>
<td>+25°C</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>TRANSIENT RESPONSE (Note 7)</td>
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<td></td>
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</tr>
<tr>
<td>Rise Time (Notes 4, 6)</td>
<td>+25°C</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Overshoot (Notes 4, 6)</td>
<td>+25°C</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Slew Rate (Note 6)</td>
<td>+25°C</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>POWER SUPPLY CHARACTERISTICS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Supply Current</td>
<td>+25°C</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Supply Voltage Range</td>
<td>Full</td>
<td>±10</td>
<td>±40</td>
</tr>
<tr>
<td>*Power Supply Rejection Ratio (Note 5)</td>
<td>Full</td>
<td>80</td>
<td>90</td>
</tr>
</tbody>
</table>

NOTES:
1. V\text{CM} = \pm 30V
2. V\text{O} = 90mV
3. V\text{O} = \pm 35V
4. V\text{O} = \pm 200mV
5. V\text{S} = \pm 10V to \pm 40V
6. A\text{V} = 1
7. C\text{L} = 50pF
8. ΔV\text{O} = \pm 30.0V
9. R\text{L} = 1KΩ

*100% Tested For DASH 8
**PERFORMANCE CURVES**

\[ V^+ = V^- = 40\text{VDC}, \quad T_A = +25^\circ\text{C UNLESS OTHERWISE STATED} \]

**INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE**

- Current, nA vs Temperature, \(^\circ\text{C}\)

**INPUT NOISE CHARACTERISTICS**

- Voltage Noise
- Current Noise

**NORMALIZED AC PARAMETERS vs TEMPERATURE**

- Normalized Value Referred to +25°C
- Slew Rate
- Bandwidth

**OPEN LOOP FREQUENCY AND PHASE RESPONSE**

- Open Loop Voltage Gain, dB
- Phase Angle

**NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE AT +25^\circ\text{C}**

- Normalized Value Referred to ±30V
- Slew Rate
- Bandwidth

**OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM BANDWIDTH CONTROL PIN TO GROUND**

- Open Loop Gain, dB

**NOTE:** External Compensation Components are not Required for Stability. But May be Added to Reduce Bandwidth if Desired. \( C_L = 100\text{pF} \) is Also Required for Stability Only if External Compensation Capacitor is Used.
**PERFORMANCE CURVES (continued)**

**OUTPUT VOLTAGE SWING vs FREQUENCY AT +25°C**

- **AV = 1, V_{SUPPLY} = ±40V**
- **V_{SUPPLY} = ±20V**
- **V_{SUPPLY} = ±10V**

<table>
<thead>
<tr>
<th>Frequency, Hz</th>
<th>1K</th>
<th>10K</th>
<th>100K</th>
<th>1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak-to-Peak Voltage Swing</td>
<td>10.0</td>
<td>0.1</td>
<td>0.01</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**OUTPUT CURRENT CHARACTERISTIC**

- **AV = 1, V_{SUPPLY} = ±40V**
- **V_{IN} = +35V**

<table>
<thead>
<tr>
<th>Output Voltage, mA</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Load Current, mA</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
</tr>
</tbody>
</table>

**SWITCHING WAVEFORM AND TEST CIRCUIT**

**VOLTAGE FOLLOWER PULSE RESPONSE**

- **R_L = 5K, C_L = 50pF**
- **Vertical = 10V/Div.**
- **Horizontal = 5μs/Div.**
- **T_A = +25°C**
- **V_S = ±40V**

**SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT**

![Slew Rate and Transient Response Test Circuit Diagram]
HA-2650/2655
Dual High Performance Operational Amplifier

FEATURES

- Slew Rate: 5 V/μS
- Bandwidth: 8 MHz
- Bias Current: 35 nA
- Av. Offset Voltage Drift: 8 μV/°C
- Power Consumption: 75 mW
- Supply Voltage Range: ±2 V to ±20 V

DESCRIPTION

The HA-2650/HA-2655 contains two internally compensated operational amplifiers on a single chip offering high slew rate and high frequency performance at no expense to DC performance. Applications of the device range from DC to high frequency video circuits; such as tone generators, active filters, integrators, high impedance buffers, etc. The device is available in the TO-116 DIP and the TO-99 metal can, in either the military or commercial temperature range.

PACKAGE/PINOUTS

<table>
<thead>
<tr>
<th>PACKAGE/PINOUTS</th>
<th>CODE 1S</th>
<th>CODE 2A</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO-116 DIP</td>
<td><img src="image1" alt="TOP VIEW" /></td>
<td><img src="image2" alt="TOP VIEW" /></td>
</tr>
<tr>
<td>TO-99 Metal Can</td>
<td><img src="image3" alt="TOP VIEW" /></td>
<td><img src="image4" alt="TOP VIEW" /></td>
</tr>
</tbody>
</table>

SCHEMATIC DIAGRAM

[Diagram of the HA-2650/2655 operational amplifier]
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th></th>
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<td>Voltage Between V+ and V- Terminals</td>
<td>( V_+ ) = 15V ( V_- = -15V )</td>
<td>±30.0V</td>
<td>±30.0V</td>
<td>±30.0V</td>
<td>±30.0V</td>
<td>±30.0V</td>
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<td>Operating Temperature Range</td>
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<td>HA-2650</td>
<td>-55°C ( \leq T_A \leq +125°C )</td>
<td>HA-2655</td>
<td>0°C ( \leq T_A \leq +75°C )</td>
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#### ELECTRICAL CHARACTERISTICS

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<td>Input Characteristics</td>
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<td>*Offset Voltage</td>
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<td>1.5</td>
<td>3</td>
<td>2</td>
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<td>*Bias Current</td>
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<td>20</td>
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<td>( \Omega )</td>
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<td>( \mu F )</td>
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<td>Transfer Characteristics</td>
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<td>*Large Signal Voltage Gain (Note 3ab)</td>
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<td>25K</td>
<td>40K</td>
<td>20K</td>
<td>40K</td>
<td>V/V</td>
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<td>*Common Mode Rejection Ratio (Note 4)</td>
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<td>74</td>
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<td>dB</td>
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<td>Output Characteristics</td>
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<td>*Output Voltage Swing (Note 3c)</td>
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<td>±13</td>
<td>±14</td>
<td>±13</td>
<td>±14</td>
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<td>Full Power Bandwidth (Note 5)</td>
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<td>V</td>
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<td>Output Current (Note 3a)</td>
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<td>30</td>
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<td>( \text{KHz} )</td>
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<td>( \text{mA} )</td>
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<td>Transient Response (Note 6)</td>
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<td>( \text{ns} )</td>
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<td>Rise Time (Note 7)</td>
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<td>Overshoot (Note 7)</td>
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<tr>
<td>slew Rate</td>
<td></td>
<td>±2</td>
<td>±5</td>
<td>±2</td>
<td>±5</td>
<td>( \text{V/\mu s} )</td>
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#### POWER SUPPLY CHARACTERISTICS

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<td>*Supply Current</td>
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<td>2.5</td>
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<td>4</td>
<td>mA</td>
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<td>*Power Supply Rejection Ratio (Note 8)</td>
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<td>80</td>
<td>100</td>
<td>74</td>
<td>100</td>
<td>dB</td>
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<td>NOTES:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2. Derate at 4.7mW/°C at ambient temperatures above +110°C.</td>
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<td></td>
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</tr>
<tr>
<td>3. (a) ( V_O = \pm 10V ) (b) ( R_L = 2K ) (c) ( R_L = 10K )</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
V+ = +15V, V- = -15V, T_A = +25°C Unless Otherwise Stated.
PERFORMANCE CHARACTERISTICS

TRANSIENT RESPONSE/SLEW RATE CIRCUIT

SLEWING WAVEFORM

Note: Numbers in parentheses refer to the second half of TO-116 package.

TYPICAL APPLICATIONS

LOW COST HIGH FREQUENCY GENERATOR

ABSOLUTE-VALUE CIRCUIT

HIGH IMPEDANCE
HIGH GAIN
HIGH FREQUENCY INVERTING AMP

Vertical: 5V/DIV.
Horizontal: 1μs/DIV.
HA-2700/2704/2705
High Performance Operational Amplifiers

FEATURES
- HIGH SLEW RATE 20V/μs
- LOW POWER DISSIPATION 2.25mW AT ±15.0V
- HIGH OPEN LOOP GAIN 300K (R_L = 2K Ω)
- LOW INPUT BIAS CURRENT 5nA
- LOW OFFSET VOLTAGE 0.5mV
- HIGH CMRR 106dB
- WIDE POWER SUPPLY RANGE ±5.5V TO ±20.0V
- FULLY INTERNALLY COMPENSATED
- OUTPUT SHORT CIRCUIT PROTECTED
- OFFSET NULL CAPABILITY

GENERAL DESCRIPTION
The HA-2700 is a general purpose amplifier which utilizes a revolutionary input circuit concept that makes possible operation at very low power levels without compromising large signal response characteristics or output drive capability. Advanced circuit design techniques and the use of vertical NPN and PNP transistors make possible the attainment of very high gain with a single stage of voltage amplification, thus ensuring closed loop stability even in the critical unity gain follower mode, without the use of external compensation components.

The circuit is intended for use in applications that require fast large signal response with low power dissipation and for instrumentation applications in which low offset voltage, current drift, large voltage gain and high common mode rejection are necessary. Full output short circuit protection and the large differential input breakdown enable the device to withstand a variety of fault conditions.

PACKAGES

CODE 2A

TO-99

Bottom View

NOTES:
1. All leads gold plated Kovar.
2. All dimensions in inches.

CODE 1S

TO-116

ALL DIMENSIONS ARE IN INCHES. ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.

PIN OUT

TO-99:
HA2-2700/HA2-2704/HA2-2705

Case Connected to V-

TO-116:
HA1-2700/HA1-2704/HA1-2705

Case Connected to V-
### Specifications

**Absolute Maximum Ratings**
- Voltage Between $V^+$ and $V^-$ Terminals: 44.0V
- Differential Input Voltage: $\pm$18.0V
- Internal Power Dissipation (Note 7): 300mW
- Storage Temperature: $-65^\circ C \leq T_A \leq +150^\circ C$

**Electrical Characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$V^+ = 15.0, \text{V.D.C.}$</th>
<th>$V^- = -15.0, \text{V.D.C.}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset Voltage (Note 1)</td>
<td>+25°C</td>
<td>Full</td>
</tr>
<tr>
<td>Bias Current</td>
<td>+25°C</td>
<td>Full</td>
</tr>
<tr>
<td>Offset Current</td>
<td>+25°C</td>
<td>Full</td>
</tr>
<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±11.0</td>
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<tr>
<td><strong>Transfer Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Signal Voltage Gain (Notes 2 &amp; 3)</td>
<td>+25°C</td>
<td>Full</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio (Note 4)</td>
<td>Full</td>
<td>86</td>
</tr>
<tr>
<td>Gain Bandwidth Product (Note 2)</td>
<td>+25°C</td>
<td>1.0</td>
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<tr>
<td><strong>Output Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage Swing (Note 2)</td>
<td>+25°C</td>
<td>Full</td>
</tr>
<tr>
<td>Output Current (Note 3)</td>
<td>+25°C</td>
<td>10</td>
</tr>
<tr>
<td><strong>Transient Response Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slew Rate (Notes 2 &amp; 6)</td>
<td>+25°C</td>
<td>10</td>
</tr>
<tr>
<td><strong>Power Supply Characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>+25°C</td>
<td>75</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio (Note 5)</td>
<td>Full</td>
<td>86</td>
</tr>
</tbody>
</table>

**Notes:**
1. Can be adjusted to zero with 1 megohm pot between Pins 1 and 8 with the tap to Pin 7.
2. $R_L = 2K, \quad C_L = 100\mu F$
3. $V_C = \pm 10.0\text{V}$
4. $V_{CM} = \pm 15.0\text{V}$
5. $V_S = \pm 10.0\text{V} \pm 20.0\text{V}$
6. $A_V = 5$
7. Derate by 6.6 mW/°C above 105°C.

*100% Tested For DASH 8*
TYPICAL PERFORMANCE CURVES

OFFSET VOLTAGE AS A FUNCTION OF TEMPERATURE

INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE

BIAS CURRENT AS A FUNCTION OF COMMON MODE VOLTAGE

BIAS CURRENT AS A FUNCTION OF DIFFERENTIAL INPUT VOLTAGE

POWER SUPPLY CURRENT AS A FUNCTION OF DIFFERENTIAL INPUT VOLTAGE

POWER SUPPLY CURRENT AS A FUNCTION OF TEMPERATURE

VOLTAGE GAIN AS A FUNCTION OF TEMPERATURE

NOTE: Open loop ( comparator) applications are not recommended, because of the above characteristic.
TYPICAL PERFORMANCE CURVES (continued)

PHASE-FREQUENCY RESPONSE FOR THE HA-2700

TYPICAL APPLICATIONS

HIGH GAIN AMPLIFIER (100 V/V)

DIFFERENTIAL INPUT INSTRUMENTATION AMPLIFIER

THE GAIN IS GIVEN BY: \( G = \frac{R_1 + R_2 + R_3}{R_2} \)

UNITY GAIN VOLTAGE FOLLOWER

Non-inverting unity gain with a 2KΩ and 100pF load
TOP: \( V_{IN} = 10.0V \) Peak to Peak
BOTTOM: \( V_{OUT} \)
SCALE: Horizontal -1 μs/division
Vertical -5.0V/division

NOTE: Faster increase rise and fall time and increase distortion on output wave form.
# HA-2720/2725

**Wide Range Programmable Operational Amplifier**

## Features

<table>
<thead>
<tr>
<th><strong>Features</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>WIDE RANGE A.C. PROGRAMMING</td>
<td>The HA-2720/2725 Programmable Operational Amplifier is an internally compensated monolithic device offering wide range performance specifications. Parameters such as power dissipation, slew rate, bandwidth, noise and input DC parameters are programmed by selecting an external resistor or current source. Supply voltage as low as ±3 volts may be used with little degradation of AC performance. Applications such as current controlled oscillators, active filters, modulators and sample and hold circuits can be derived easily by modulating the set current. The HA-2720 is guaranteed for operation from -55°C to +125°C while the HA-2725 is guaranteed from 0°C to +75°C.</td>
</tr>
<tr>
<td>SLEW RATE: 0.06 TO 6V/μS</td>
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<tr>
<td>GAIN X BANDWIDTH: 5KHz TO 10MHz</td>
<td></td>
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<tr>
<td>WIDE RANGE D.C. PROGRAMMING</td>
<td></td>
</tr>
<tr>
<td>POWER SUPPLY RANGE: ±1.2V TO ±18V</td>
<td></td>
</tr>
<tr>
<td>SUPPLY CURRENT: 1μA TO 1.5mA</td>
<td></td>
</tr>
<tr>
<td>BIAS CURRENT: 0.4 TO 50mA</td>
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<tr>
<td>LOW NOISE</td>
<td></td>
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<tr>
<td>SHORT CIRCUIT PROTECTION</td>
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## Package

**TO-99**

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<thead>
<tr>
<th><strong>Code 2A</strong></th>
<th><strong>Pin Out</strong></th>
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<tbody>
<tr>
<td>Top View</td>
<td>Offset NULL</td>
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<tr>
<td>Inverting Input</td>
<td>V+</td>
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<tr>
<td>Non-Inverting Input</td>
<td>V-</td>
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<tr>
<td>Output</td>
<td>SET</td>
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<tr>
<td>Offset NULL</td>
<td>V-</td>
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<tr>
<td>V+</td>
<td>V-</td>
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**Code 2A**

## Schematic

[Diagram of the schematic]
**SPECIFICATIONS**

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>45.0V</td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>±30.0V</td>
</tr>
<tr>
<td>Input Voltage (Note 1)</td>
<td>±15.0V</td>
</tr>
<tr>
<td>ISET (Current at ISET)</td>
<td>500μA</td>
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<tr>
<td>VSET (Voltage to Gnd. at ISET)</td>
<td>V+ - 2.0V ≤ VSET ≤ V+</td>
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<tr>
<td>Power Dissipation (Note 2)</td>
<td>300mW</td>
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<td>Operating Temperature Range:</td>
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<tr>
<td>HA-2720 -55°C ≤ TA ≤ +125°C</td>
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</tr>
<tr>
<td>HA-2725 0°C ≤ TA ≤ +75°C</td>
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</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-65°C ≤ TA ≤ +150°C</td>
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</table>

**ELECTRICAL CHARACTERISTICS**

V+ = +3.0V, V- = -3.0V

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2720 -55°C to +125°C</th>
<th>HA-2725 0°C to +75°C</th>
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<tbody>
<tr>
<td>ISET = 1.5μA</td>
<td>ISET = 15μA</td>
<td>ISET = 1.5μA</td>
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<td>INPUT CHARACTERISTICS</td>
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<td>Offset Voltage</td>
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<tr>
<td>Offset Current</td>
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<tr>
<td>Bias Current</td>
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<tr>
<td>Input Resistance</td>
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<tr>
<td>Input Capacitance</td>
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<td>Bias Current</td>
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<tr>
<td>Input Capacitance</td>
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<td>TRANSFER CHARACTERISTICS</td>
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<td>Large Signal Voltage Gain (Note 9)</td>
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<tr>
<td>Common Mode Rejection Ratio (Note 4)</td>
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<td>OUTPUT CHARACTERISTICS</td>
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<tr>
<td>Output Voltage Swing (Note 3)</td>
<td>25°C</td>
<td>±2.0</td>
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<tr>
<td>Output Current (Note 5)</td>
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<td>Output Resistance</td>
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<td>2K</td>
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<tr>
<td>Output Short-Circuit Current</td>
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<td>TRANSIENT RESPONSE</td>
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<td>Rise Time (Note 6)</td>
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<td>Overshoot (Note 6)</td>
<td>25°C</td>
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<tr>
<td>Slew Rate (Note 7)</td>
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<td>POWER SUPPLY CHARACTERISTICS</td>
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<td>Supply Current</td>
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<td>Power Supply Rejection Ratio (Note 8)</td>
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</tbody>
</table>

*100% Tested For DASH B
**ELECTRICAL CHARACTERISTICS**

\[ V^+ = +15.0 \text{V}, \quad V^- = -15.0 \text{V} \]

<table>
<thead>
<tr>
<th>SPECIFICATIONS</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
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</tr>
<tr>
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<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
<td>5.0</td>
<td>7.0</td>
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<td>7.0</td>
<td>mV</td>
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<td>7.5</td>
<td>7.5</td>
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<td>Rise Time (Note 6)</td>
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<td>Overshoot (Note 6)</td>
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<td>Slew Rate (Note 7)</td>
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<td>POWER SUPPLY CHARACTERISTICS</td>
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<tr>
<td>*Supply Current</td>
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<td>210</td>
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<tr>
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<td>100</td>
<td>100</td>
<td>150</td>
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<td>150</td>
<td>150</td>
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<td>μV/V</td>
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</tbody>
</table>

**NOTES:**
1. For supply voltages less than ±15.0 V, the absolute maximum input voltage is equal to supply voltage.
2. Derate at 6.8 mW/°C for operation ambient temperatures above 75°C.

\[
V_{\text{SUPPLY}} = ±13.0 \text{V} \\
V_{\text{SUPPLY}} = ±15.0 \text{V} \\
V_{\text{CM}} = ±1.5 \text{V} \\
V_{O} = ±2.0 \text{V} \\
A_{V} = +1, \quad V_{IN} = 400 \text{mV}, \quad R_{L} = 5K, \quad C_{L} = 100 \text{pF} \\
\Delta V = ±1.5 \text{V} \\
\Delta V = ±1.0 \text{V} \\
V_{O} = ±1.5 \text{V} \\
V_{O} = ±1.0 \text{V} \\
V_{O} = ±0.5 \text{V} \\
V_{O} = ±0.0 \text{V} \\
V_{O} = ±1.0 \text{V} \\
R_{L} = 20K \\
R_{L} = 5K \\
R_{L} = 5K \\
*100% Tested For DASH 8
UNLESS OTHERWISE NOTED: $T_A = +25^\circ C, V_S = \pm 15VDC$

- **Input Bias Current vs. Set Current**
- **Input Bias Current vs. Temperature**
- **Input Offset Current vs. Temperature**
- **Change in Offset Voltage vs. $I_{SET}$ (UNNULLED)**
- **Input Noise Current vs. $I_{SET}$**
- **Input Noise Voltage vs. $I_{SET}$**
- **Input Noise Voltage and Current vs. Frequency**
- **Optimum Set Current for Minimum Noise vs. Source Resistor**
UNLESS OTHERWISE NOTED: \( T_A = +25\,^\circ\text{C},\, V_S = \pm 15\,\text{VDC} \)

**PERFORMANCE CURVES**

**MAXIMUM OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE**

**GAIN BANDWIDTH PRODUCT vs. \( I_{\text{SET}} \)**

**OPEN LOOP VOLTAGE GAIN vs. TEMPERATURE**

**OPEN LOOP VOLTAGE GAIN vs. \( I_{\text{SET}} \)**

**POWER SUPPLY REJECTION vs. \( I_{\text{SET}} \)**

**STANDBY SUPPLY CURRENT vs. \( I_{\text{SET}} \)**

**SUPPLY CURRENT vs. TEMPERATURE**

**NORMALIZED BANDWIDTH vs. TEMPERATURE**
**Performance Curves**

**Slew Rate vs. ISet**

**Phase Margin vs. Set Current**

**Typical Biasing Circuits**

**Suggested Offset Null**

**Set Current vs. Set Resistor**

**Transient Response/Slew Rate Circuit**

**Slewing Waveform**

**Linear**
# HA-2730/2735

## Wide Range Dual Programmable Operational Amplifier

### FEATURES

- **WIDE RANGE A.C. PROGRAMMING**
  - SLEW RATE: 0.06 TO 6V/\mu s
  - GAIN X BANDWIDTH: 5kHz TO 10MHz

- **WIDE RANGE D.C. PROGRAMMING**
  - POWER SUPPLY RANGE: ±1.2V TO ±18V
  - SUPPLY CURRENT: 1\mu A TO 1.5mA
  - BIAS CURRENT: 0.4 TO 50nA

- **LOW NOISE**
- **MONOLITHIC CONSTRUCTION**
- **SHORT CIRCUIT PROTECTION**

### DESCRIPTION

The HA-2730/2735 Dual Programmable Operational Amplifiers consist of two HA-2720 type op amps on a single monolithic chip. It features the same performance characteristics as the HA-2720/2725 and in addition offers closer thermal tracking, reduced size weight, and greater reliability than two single devices. The HA-2730/2735 is programmed by selecting two external bias resistors or current sources for independent control of each side. Applications such as current controlled oscillators, active filters, modulators and sample and hold circuits can be derived easily by modulating the set current.

The HA-2730 is guaranteed for operation from -55°C to +125°C while the HA-2735 is guaranteed form 0°C to +75°C.

### PACKAGE

**CODE 1S**

![Package Diagram]

14 LEAD BRAZED D.I.P.

**PIN OUT**

![Pin Diagram]

**SCHEMATIC**

![Schematic Diagram]
### ABSOLUTE MAXIMUM RATINGS

- Voltage Between V+ and V- Terminals: 45.0V
- Differential Input Voltage: ±30.0V
- Input Voltage (Note 1): ±15.0V
- I_SET (Current at I_SET): 500μA
- V_SET (Voltage to Gnd. at I_SET): V+ - 2.0V ≤ V_SET ≤ V+

### ELECTRICAL CHARACTERISTICS

**V+ = +3.0V, V- = -3.0V**

**PARAMETER** | **TEMP.** | **HA-2730** | **HA-2735**  
| | **I_SET = 1.5μA** | **I_SET = 15μA** | **I_SET = 1.5μA** | **I_SET = 15μA** | **I_SET = 1.5μA** | **I_SET = 15μA** | **UNITS**
| | **MIN.** | **TYP.** | **MAX.** | **MIN.** | **TYP.** | **MAX.** | **MIN.** | **TYP.** | **MAX.** |
| INPUT CHARACTERISTICS | | | | | | | | | | |
| *Offset Voltage | 25°C | 2.0 | 3.0 | 2.0 | 3.0 | 2.0 | 5.0 | 5.0 | mV |
| | Full | 5.0 | 5.0 | 7.0 | 7.0 | |
| Offset Current | 25°C | 0.5 | 3.0 | 1.0 | 10 | 0.5 | 5.0 | 1.0 | nA |
| | Full | 7.5 | 20 | 7.5 | 20 | |
| Bias Current | 25°C | 2.0 | 5.0 | 8.0 | 20 | 2.0 | 10 | 8.0 | 30 | nA |
| | Full | 10 | 40 | 10 | 40 | |
| Input Resistance | 25°C | 50 | 5 | 50 | 5 | MΩ |
| Input Capacitance | 25°C | 3.0 | 3.0 | 3.0 | 3.0 | pF |
| TRANSFER CHARACTERISTICS | | | | | | | | | | |
| *Large Signal Voltage Gain (Notes 3 & 9) | 25°C | 20K | 40K | 20K | 40K | 15K | 40K | 15K | 40K | V/V |
| | Full | 15K | 15K | 10K | 10K | |
| *Common Mode Rejection Ratio (Note 4) | Full | 80 | 80 | 74 | 74 | dB |
| OUTPUT CHARACTERISTICS | | | | | | | | | | |
| *Output Voltage Swing (Note 3) | 25°C | ±2.0 | ±2.2 | ±2.0 | ±2.2 | ±2.0 | ±2.2 | ±2.0 | ±2.2 | V |
| | Full | ±2.0 | ±1.9 | ±2.0 | ±2.0 | |
| Output Current (Note 5) | 25°C | ±0.2 | ±2.0 | ±0.2 | ±2.0 | mA |
| Output Resistance | 25°C | 2K | 500 | 2K | 500 | Ω |
| Output Short-Circuit Current | 25°C | 2.8 | 14 | 2.8 | 14 | mA |
| TRANSIENT RESPONSE | | | | | | | | | | |
| Rise Time (Note 6) | 25°C | 2.5 | 0.25 | 2.5 | 0.25 | μs |
| Overshoot (Note 6) | 25°C | 5 | 10 | 5 | 10 | % |
| Slew Rate (Note 7) | 25°C | 0.07 | 0.70 | 0.07 | 0.70 | V/μs |
| POWER SUPPLY CHARACTERISTICS | | | | | | | | | | |
| *Supply Current (Each Amp) | 25°C | 15 | 20 | 170 | 200 | 15 | 20 | 170 | 200 | μA |
| | Full | 15 | 20 | 170 | 200 | |
| *Power Supply Rejection Ratio (Note 8) | Full | 100 | 100 | 150 | 150 | μV/V | |

*100% Tested For DASH B*
## Specifications

### Electrical Characteristics

- **V+ = +15.0V, V- = -15.0V**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>ISET = 1.5μA</th>
<th>ISET = 15μA</th>
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<td>HA-2730 -55°C to +125°C</td>
<td>HA-2735 0°C to +75°C</td>
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<td>Full</td>
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<tr>
<td>Input Capacitance</td>
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<tr>
<td></td>
<td>Full</td>
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<td>Output Current (Note 5)</td>
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<td>Output Resistance</td>
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<td>Output Short-Circuit Current</td>
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<td><strong>Transient Response</strong></td>
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<td>Rise Time (Note 6)</td>
<td>25°C</td>
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<td>Overshoot (Note 6)</td>
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<td>Slew Rate (Note 7)</td>
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<td><strong>Power Supply Characteristics</strong></td>
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<td>*Supply Current (Each Amp)</td>
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<td>Full</td>
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<tr>
<td>*Power Supply Rejection Ratio</td>
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</table>

### Notes:

1. For supply voltages less than ±15.0V, the absolute maximum input voltage is equal to supply voltage.
2. Derate at 4.7mW/°C at ambient temperatures above 65°C.
3. \( V_{\text{SUPPLY}} = \pm 0.0V \)
4. \( V_{\text{CM}} = \pm 1.5V \)
5. \( V_{O} = \pm 2.0V \)
6. \( A_{V} = \pm 1, V_{IN} = 400mV, R_{L} = 5K, C_{L} = 100pF \)
7. \( V_{O} = \pm 2.0V \)
8. \( \Delta V = \pm 1.5V \)
9. \( V_{O} = \pm 1.0V \)

*100% Tested For DASH 8*
UNLESS OTHERWISE NOTED: $T_A = 25^\circ C$, $V_{S} = \pm 15\text{VDC}$
UNLESS OTHERWISE NOTED: $T_A = 25^\circ C$, $V_S = \pm 15VDC$
PERFORMANCE CURVES

SLEW RATE vs. I_SET

PHASE MARGIN vs. SET CURRENT

CHANNEL SEPARATION vs. FREQUENCY

TYPICAL BIASING CIRCUITS

SUGGESTED OFFSET NULL

V +
1/2
HA-2730
I_SET

SUGGESTED NULL

1/2
HA-2730
V_B
R_I

NOTE: Numbers in parentheses refer to the second half.

SET CURRENT vs. SET RESISTOR

TRANSIENT RESPONSE/SLEW RATE CIRCUIT

SLEWING WAVEFORM

NOTE: Numbers in parentheses refer to the second half.

V_IN
500 kΩ
100 pF

V_OUT

INPUT

OUTPUT

VERTICAL: 5V/DIV
HORIZONTAL: 1/5S/DIV

I_SET = 100 μA
HA-2820/2825
Phase Locked Loop

**Features**

- Frequency range: 0.01 Hz to 3 MHz
- Independent phase detector and oscillator for versatility
- Two isolated phase detector outputs
- DTL/TTL compatible oscillator output
- Oscillator stability: 100 ppm/°C, 0.01%/Volt

**Description**

The HA-2820/2825 Phase Locked Loop is useful for many operations in the frequency domain in the sub-audio to low R.F. bands. It features a number of functional and parametric improvements over other similar monolithic circuits.

A major feature is a high impedance current source phase detector output with provisions for external connection to the oscillator input which is a low impedance current sink. This allows connection of complex passive or active filters, amplifiers, sweep circuits, etc. within the loop. Also, the two phase detector outputs are isolated from one another so that different filter functions can be connected at the two outputs without interaction. The capability of independently adjusting loop bandwidth and demodulated output bandwidth allows phase modulation detectors to be constructed.

Applications include modulators and demodulators for F.M., phase modulation, and F.S.K.; frequency multiplication; data synchronization; tracking filters; and speed controls.

**Functional Diagram**

**Package**

14 lead brazed D.I.P.
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>TYP.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>27.0V</td>
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<tr>
<td>Input Voltage</td>
<td>2 V RMS</td>
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<tr>
<td>Output Current, Pin 7</td>
<td>10mA</td>
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</tbody>
</table>

**ELECTRICAL CHARACTERISTICS**

- **V+ = +6.0V**
- **V- = -6.0V**
- **F₀ ≈ 50kHz**
- **Pin 5 = Ground**

**PARAMETER TEMPERATURE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HA-2820 -55°C to +125°C</th>
<th>HA-2825 0°C to +75°C</th>
<th>UNITS</th>
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</thead>
<tbody>
<tr>
<td>Input Impedance, Pins 1 - 2</td>
<td>+25°C</td>
<td>MIN. 10K TYP. 5 MAX. 10K</td>
<td>MIN. 10 TYP. 5 MAX. 10</td>
<td>Ω</td>
</tr>
<tr>
<td>Input Voltage Range, Pins 1 - 2 (Note 1)</td>
<td>Full</td>
<td>MIN. 5 TYP. 5 MAX. 10</td>
<td>MIN. 5 TYP. 5 MAX. 10</td>
<td>mV RMS</td>
</tr>
<tr>
<td>Output Impedance, Pins 4 &amp; 14</td>
<td>+25°C</td>
<td>MIN. 10 TYP. 15 MAX. 10</td>
<td>MIN. 10 TYP. 20 MAX. 20</td>
<td>μΩ</td>
</tr>
<tr>
<td>Output Offset Current, Pins 4 &amp; 14</td>
<td>+25°C</td>
<td>MIN. 20 TYP. 20 MAX. 20</td>
<td>MIN. 20 TYP. 20 MAX. 20</td>
<td>μA</td>
</tr>
<tr>
<td>Conversion Gain, Pins 4 &amp; 14</td>
<td>+25°C</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>μA/Radian</td>
</tr>
</tbody>
</table>

**CURRENT CONTROLLED OSCILLATOR**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HA-2820 -55°C to +125°C</th>
<th>HA-2825 0°C to +75°C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Frequency</td>
<td>Full</td>
<td>MIN. 3 TYP. 5 MAX. 5</td>
<td>MIN. 3 TYP. 5 MAX. 5</td>
<td>MHz</td>
</tr>
<tr>
<td>Frequency Drift</td>
<td>Full</td>
<td>MIN. 100 TYP. 100</td>
<td>MIN. 100 TYP. 100</td>
<td>ppm/°C</td>
</tr>
<tr>
<td>Frequency Change with Supply Voltage (Note 4)</td>
<td>Full</td>
<td>MIN. .01 TYP. .01</td>
<td>MIN. .01 TYP. .01</td>
<td>%/V</td>
</tr>
<tr>
<td>Input Resistance, Pin 9</td>
<td>+25°C</td>
<td>MIN. 500 TYP. 500</td>
<td>MIN. 500 TYP. 500</td>
<td>Ω</td>
</tr>
<tr>
<td>Input Open Circuit Voltage, Pin 9</td>
<td>+25°C</td>
<td>MIN. -3.5 TYP. -3.5</td>
<td>MIN. -3.5 TYP. -3.5</td>
<td>V</td>
</tr>
<tr>
<td>Conversion Gain</td>
<td>+25°C</td>
<td>MIN. 1.0 TYP. 1.0</td>
<td>MIN. 1.0 TYP. 1.0</td>
<td>% Δf/μA</td>
</tr>
<tr>
<td>Output Voltage, High</td>
<td>+25°C</td>
<td>MIN. +1.9 TYP. +1.9</td>
<td>MIN. +1.9 TYP. +1.9</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage, Low</td>
<td>+25°C</td>
<td>MIN. +0.4 TYP. +0.4</td>
<td>MIN. +0.4 TYP. +0.4</td>
<td>V</td>
</tr>
<tr>
<td>Output Rise Time</td>
<td>+25°C</td>
<td>MIN. 100 TYP. 100</td>
<td>MIN. 100 TYP. 100</td>
<td>ns</td>
</tr>
<tr>
<td>Output Fall Time</td>
<td>+25°C</td>
<td>MIN. 125 TYP. 125</td>
<td>MIN. 125 TYP. 125</td>
<td>ns</td>
</tr>
</tbody>
</table>

**CLOSED LOOP CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HA-2820 -55°C to +125°C</th>
<th>HA-2825 0°C to +75°C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Gain</td>
<td>+25°C</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>% Δf/Radian</td>
</tr>
<tr>
<td>Tracking Range</td>
<td>+25°C</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>MIN. 50 TYP. 50 MAX. 50</td>
<td>%Δf</td>
</tr>
<tr>
<td>Demod. Output Swing, Pin 4</td>
<td>+25°C</td>
<td>MIN. ±700 TYP. ±700</td>
<td>MIN. ±700 TYP. ±700</td>
<td>mV</td>
</tr>
<tr>
<td>Frequency Drift</td>
<td>Full</td>
<td>MIN. 100 TYP. 100</td>
<td>MIN. 100 TYP. 100</td>
<td>ppm/°C</td>
</tr>
</tbody>
</table>

**POWER SUPPLY CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HA-2820 -55°C to +125°C</th>
<th>HA-2825 0°C to +75°C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Current, V+</td>
<td>Full</td>
<td>MIN. 3 TYP. 5 MAX. 5</td>
<td>MIN. 3 TYP. 5 MAX. 5</td>
<td>mA</td>
</tr>
<tr>
<td>Supply Current, V-</td>
<td>Full</td>
<td>MIN. 7 TYP. 10 MAX. 10</td>
<td>MIN. 7 TYP. 10 MAX. 10</td>
<td>mA</td>
</tr>
<tr>
<td>Supply Voltage Range (Notes 2, 3)</td>
<td>Full</td>
<td>MIN. ±6 TYP. ±12 MAX. ±6</td>
<td>MIN. ±6 TYP. ±12 MAX. ±6</td>
<td>V</td>
</tr>
</tbody>
</table>

**NOTES**

1. For ±10% tracking range.
2. +5.0V, -7.0V may be used alternatively.
3. Derate power dissipation by 6.6mW/°C above +105°C ambient temperature.
4. $\Delta V_S = \pm 2V$
TEST CIRCUIT

Unless otherwise specified: \( V^+ = +6.0V; \) \( V^- = -6.0V; \) \( R_1 = R_3 = 10K\Omega; \) \( R_2 = 1K\Omega; \) \( R_4 = R_5 = 300\Omega; \) \( R_T = 540\Omega; \) \( C_1 = .015\mu F; \) \( C_2 = C_3 = C_4 = 0.1\mu F; \) \( C_T = 0.01\mu F \) \( (f_0 \approx 50kHz); \) \( V_{IN} = 100mV \text{ RMS}; \) \( T_A = +25^\circ C \)

PERFORMANCE CURVES

CENTER FREQUENCY, \( f_0 \) vs. TIMING CAPACITOR, \( C_T \) \( (R_T = 540\Omega) \)

CENTER FREQUENCY, \( f_0 \) vs. TIMING RESISTOR, \( R_T \) \( (C_T = .01\mu F) \)
HA-2900/2904/2905
Chopper Stabilized Operational Amplifier

**FEATURES**

- **OFFSET VOLTAGE DRIFT:** 0.2μV/°C
- **OFFSET CURRENT DRIFT:** 1pA/°C
- **OPEN LOOP GAIN:** 5 × 10^8
- **BANDWIDTH:** 3MHz
- **SLEW RATE:** 2.5V/μS
- **TRUE DIFFERENTIAL INPUTS**

**DESCRIPTION**

The HA-2900/2904/2905 is the first monolithic chopper stabilized operational amplifier. It features superior offset drift characteristics, extremely low input currents, and excellent AC performance. Its inputs are symmetrical and differential, meaning that the device may be operated in any op amp feedback configuration; inverting, non-inverting, or balanced. Applications include high gain DC instrumentation, precision integrators, and as a substitute for other op amps wherever much lower errors without external adjustments are required. The device is packaged in a hermetic can with standard pin out, and requires only three external capacitors for operation.

**FUNCTIONAL DIAGRAM**

**PACKAGE**

**CODE 2A**

**ALL DIMENSIONS ARE IN INCHES**

**NOTES:**

1. All leads gold plated KOVAR.

2. All dimensions in inches.

**PIN OUT AND SUGGESTED HOOKUP**

![Top View](image)

![Bottom View](image)
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HA-2900 -55°C to +125°C</th>
<th>HA-2904 -25°C to +85°C</th>
<th>HA-2905 0°C to +75°C</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Between V+ and V- Terminals</td>
<td>42.0V</td>
<td>Operating Temperature Range</td>
<td>-55°C ≤ TA ≤ +125°C (HA-2900)</td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage (Note 1)</td>
<td>±15V</td>
<td>Storage Temperature Range</td>
<td>-25°C ≤ TA ≤ +85°C (HA-2904)</td>
<td></td>
</tr>
<tr>
<td>Output Current/Full Short Circuit Protection</td>
<td></td>
<td></td>
<td>0°C ≤ TA ≤ +75°C (HA-2905)</td>
<td></td>
</tr>
<tr>
<td>Internal Power Dissipation</td>
<td></td>
<td></td>
<td>-65°C ≤ TA ≤ +150°C</td>
<td>300mW*</td>
</tr>
</tbody>
</table>

*Derate by 6.6mW/°C above +105°C

#### ELECTRICAL CHARACTERISTICS

Test Conditions: C1 = C2 = 0.1μF, C3 = 1500pF, VSupply = ±15.0V unless otherwise specified.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>HA-2900 MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>HA-2904 MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>HA-2905 MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Offset Voltage | ±25°C | 20 | 60 | 20 | 50 | 20 | 80 | μV/
| Full | | | | | | | | | |
| Offset Voltage Average Drift | ±25°C | 0.2 | 0.4 | 0.2 | μV/°C | | | | |
| Full | | | | | | | | | |
| Bias Current | ±25°C | 150 | 1,000 | 150 | 1,000 | 150 | 1,000 | pA |
| Full | | | | | | | | | |
| Offset Current | ±25°C | 50 | 500 | 50 | 500 | 50 | 500 | pA |
| Full | | | | | | | | | |
| Offset Current Average Drift | ±25°C | 1 | 3 | 1 | pA/°C | | | | |
| Full | | | | | | | | | |
| Input Resistance | ±25°C | 100 | 100 | 100 | | | | MΩ |
| | | | | | | | | | |
| Input Capacitance | ±25°C | 10 | 10 | 10 | | | | pF |
| | | | | | | | | | |
| Common Mode Range | Full | ±10 | ±10 | ±10 | | | | V |
| | | | | | | | | | |
| **TRANSFER CHARACTERISTICS** | | | | | | | | | |
| *Large Signal Voltage Gain (Note 2) | ±25°C | 5x10^6 | 10^7 | 5x10^6 | 10^7 | 5x10^8 | V/V |
| Full | | | | | | | | | |
| Chopper Frequency | ±25°C | 750 | 750 | 750 | | | | Hz |
| | | | | | | | | | |
| *Common Mode Rejection Ratio (Note 3) | Full | 120 | 160 | 130 | 160 | 120 | 160 | dB |
| | | | | | | | | | |
| Gain Bandwidth Product (Note 4) | +25°C | 3 | | 3 | | | | MHz |
| | | | | | | | | | |
| **OUTPUT CHARACTERISTICS** | | | | | | | | | |
| *Output Voltage Swing (Note 2) | ±25°C | ±12 | ±12 | ±12 | ±12 | V |
| Full | | | | | | | | | |
| *Output Current | ±25°C | ±7 | | | | | mA |
| | | | | | | | | | |
| Output Resistance | Full | 200 | | 200 | | 200 | Ω |
| | | | | | | | | | |
| Full Power Bandwidth (Note 5) | ±25°C | 40 | | 40 | | 40 | kHz |
| | | | | | | | | | |
| **TRANSIENT RESPONSE** | (NOTES 2, 8, and 9) | | | | | | | | |
| Rise Time (Note 6) | ±25°C | 200 | 200 | 200 | ns |
| | | | | | | | | | |
| Overshoot (Note 6) | ±25°C | 20 | 20 | 20 | % |
| | | | | | | | | | |
| Slew Rate (Note 5) | ±25°C | 2.5 | 2.5 | 2.5 | V/μs |
| | | | | | | | | | |
| **POWER SUPPLY CHARACTERISTICS** | | | | | | | | | |
| *Supply Current | ±25°C | 3.5 | 5.0 | 3.5 | 5.0 | 3.5 | 5.0 | mA |
| | | | | | | | | | |
| *Supply Voltage Range | Full | ±12 | ±20 | ±10 | ±20 | ±12 | ±20 | V |
| | | | | | | | | | |
| *Power Supply Rejection Ratio (Note 7) | Full | 120 | 160 | 130 | 160 | 120 | 160 | dB |

**NOTES:**
1. Input terminals should be protected against static discharge during handling and installation. Input voltage should never exceed supply voltages.
2. Jn = 2K
3. VCM = ±5.0V
4. AV = 1
5. VD = ±10V
6. VS = ±200mV
7. AV = ±5V
8. CL = 50pF

*100% Tested For DASH 8
V+ = V- = 15VDC, TA = 25°C UNLESS OTHERWISE STATED

INPUT VOLTAGE NOISE

Frequency (Hz)

Open Loop Frequency and Phase Response

Frequency (Hz)

OUTPUT VOLTAGE SWING vs. FREQUENCY

Peak-to-Peak VoltageSwing

Frequency (Hz)

TYPICAL INPUT CHARACTERISTICS vs. TEMPERATURE

Offset Voltage

Input Bias Current, Offset Current (pA)

Temperature (°C)

NORMALIZED A.C. PARAMETERS vs. SUPPLY VOLTAGE

Normalized Parameters Referred to Values at ±15V

Supply Voltage

NORMALIZED A.C. PARAMETERS vs. TEMPERATURE

Normalized Parameters Referred to Values at +25°C

Temperature (°C)
**APPLICATION TIPS**

(1) Device inputs should be protected against exceeding either supply voltage from static discharge or inadvertent connection, particularly when wired directly to a connector or instrument panel.

(2) External capacitors C1, C2, and C3 should have good temperature stability, low leakage, and low dielectric absorption. Polyethylene (below +85°C), teflon types or polycarbonate are recommended. C3 could also be silver mica.

(3) Particular care must be exercised in system layout and material and component selection to realize the full performance potential of the HA-2900/2904/2905. External sources of drift error may include the thermocouple and electrochemical EMF's generated at junctions of dissimilar metals, leakage across insulating materials, static charges created by moving air, and improper grounding and shielding practices.

(4) Chopper noise is present chiefly as a common mode input current signal, and may be minimized by matching the impedances at the two inputs. Random noise may be reduced at the expense of bandwidth using active or passive filtering.

(5) Input frequencies near the chopper frequency (750Hz) or its harmonics may result in small components of difference frequency in the output. This effect should be checked in the individual application, and if objectionable, a low pass filter may be added in series with the input.

(6) When operating at closed loop gains between 70 dB and 140 dB, compensation networks may be required, because of open loop phase shift in this gain region. In most cases, a capacitor placed in parallel with the feedback resistor to yield a gain-bandwidth product < 2 MHz will be sufficient.
The HD-0165 Keyboard Encoder is a 16 line to four-bit parallel encoder intended for use with manual data entry devices such as calculator or typewriter keyboards. In addition to the encoding function, there is a Strobe output and a Key Rollover output which energizes whenever two or more inputs are energized simultaneously. Any four-bit code can be implemented by proper wiring of the input lines. Inputs are normally wired through the key switches to the +5.0V power supply. Full typewriter keyboard encoding up to eight bits can be accomplished with two Encoder circuits by the use of double pole key switches or single pole switches with two isolation diodes per key. Outputs will interface with all popular DTL and TTL logic families. The circuit is packaged in a hermetic 24-pin dual in-line package and operates over the temperature range of 0°C to +75°C.

**EQUIVALENT CIRCUITS**

**PACKAGE**

<table>
<thead>
<tr>
<th>CODE 1J</th>
<th>24 LEAD CERAMIC D.I.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL DIMENSIONS ARE IN INCHES</td>
<td></td>
</tr>
<tr>
<td>ALL DIMENSIONS ±.010 UNLESS OTHERWISE SHOWN</td>
<td></td>
</tr>
</tbody>
</table>
**SPECIFICATIONS**

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>+7.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>+5.5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>+5.5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>30mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature (Case)</td>
<td>0°C to +75°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ELECTRICAL CHARACTERISTICS**

Test Conditions:  

\[ V_{CC} = +5.0V \pm 5\% \]  
\[ T_{Case} = 0°C to +75°C \]

Unless otherwise specified

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym.</th>
<th>Limits</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Current</td>
<td>&quot;1&quot;</td>
<td>I_{IH}</td>
<td>mA</td>
<td>V_{IN} = +5.0V</td>
</tr>
<tr>
<td>D.C. Output Voltage</td>
<td>&quot;0&quot;</td>
<td>V_{OL}</td>
<td>+0.2</td>
<td>V_{IH} = +4.5V, I_{OL} = 10mA</td>
</tr>
<tr>
<td></td>
<td>&quot;1&quot;</td>
<td>V_{OH}</td>
<td>+2.4</td>
<td>V_{IH} = +3.5V, I_{OL} = 3.2mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>V_{IL} = Open Circuit, I_{OH} = -240μA</td>
</tr>
<tr>
<td>Operating Power Supply Current</td>
<td></td>
<td>I_{CC}</td>
<td>mA</td>
<td>One Input at +5.25V</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td>I_{CCM}</td>
<td>88</td>
<td>All Inputs at +5.25V</td>
</tr>
</tbody>
</table>

A.C. Skew Time (Note 1)  

\[ T_{SK} = 80 \text{ to } 200 \text{ ns} \]

\[ T_{Case} = 25°C \]

\[ V_{CC} = V_{IN} = +5.0V \]

\[ C_L < 50 \text{pF} \]

**NOTE:**  

(1) Skew time is the maximum time differential between propagation delay times of any outputs including \( \text{STROBE} \) and \( K_{RO} \).

**TRUTH TABLE**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>L L L L L L L L L L L L L L L L L L</td>
<td>H H H H H H H H H H H H H H H H H H</td>
</tr>
<tr>
<td>H L L L L L L L L L L L L L L L L L</td>
<td>H H H H H H H H H H H H H H H H H H</td>
</tr>
<tr>
<td>L H L L L L L L L L L L L L L L L L</td>
<td>L H H H L H H L L H H H H H H H H H</td>
</tr>
<tr>
<td>L L H L L L L L L L L L L L L L L L</td>
<td>L L H L H L L H H L L H L H L H L H</td>
</tr>
<tr>
<td>L L L H L L L L L L L L L L L L L L</td>
<td>L L L H H L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L H L L L L L L L L L L L L L</td>
<td>L L L L H L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L H L L L L L L L L L L L</td>
<td>L L L L L L L L H L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L H L L L L L L L L L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L L H L L L L L L L L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L L L L H L L L L L L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L L L L L L L H L L L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L L L L L L L L L H L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>L L L L L L L L L L L L L L L L L L</td>
<td>L L L L L L L L L L L L L L L L L L</td>
</tr>
<tr>
<td>ANY TWO OR MORE HIGH</td>
<td>X X X X X L L</td>
</tr>
</tbody>
</table>

**Inputs:**  

- L = Open Circuit or \(< +1.0 \text{V} \)
- H = \( > +4.6 \text{V} \) Current Source

**Outputs:**  

- L = \(< +0.4 \text{V} \)
- H = \( > +2.4 \text{V} \)
- X = Erroneous Data
Figure 1. GENERAL CONFIGURATION FOR ENCODING TWO TO SIXTEEN KEYS

The Truth Table is used to determine wiring from the key switches to Encoder inputs to produce desired output codes.

Figure 2. SWITCH BOUNCE ELIMINATION

This circuit generates a delayed Strobe pulse (St'). Delay time is determined by first monostable and should be about 10ms. Pulse width is determined by second monostable and should be set according to system requirements. Effect of switch bounce or arcing on make or break is positively eliminated and proper encoding will take place under two key rollover conditions.
APPLICATIONS (continued)

+5.0V SUPPLY

DOUBLE POLE KEY SWITCHES

INPUTS

OUTPUTS

M.S.B.

ALTERNATE ISOLATION METHOD:
SINGLE POLE KEY SWITCH WITH
TWO DIODES.

NOTE: Reduce Encoder fanout to two TTL loads maximum.

Figure 3. ENCODING UP TO 256 KEYS

Use upper Encoder to produce the four most significant output bits; the lower to produce the least significant bits. Use Truth Table and required output codes to determine wiring from each key to the two Encoders.

SHIFT and CONTROL functions can be implemented by logic gates in series with the output lines.
HARRIS SEMICONDUCTOR

HD-245/545 Triple Line Transmitter
HD-246/546/249/549 Triple Line Receivers
HD-248/548 Triple Party Line Receiver

FEATURES:

- CURRENT MODE OPERATION
- HIGH SPEED: 15MHz WITH 50FT. CABLE; 2MHz WITH 1,000FT. CABLE
- HIGH NOISE IMMUNITY
- LOW EMI GENERATION
- LOW POWER DISSIPATION
- HIGH COMMON MODE REJECTION
- TRANSMITTER AND RECEIVER PARTY LINE CAPABILITY
- TOLERATES -2.0V TO +20.0V GROUND DIFFERENTIAL (Transmitter with respect to receiver)
- TRANSMITTER INPUT/RECEIVER OUTPUT TTL/DTL COMPATIBLE

GENERAL DESCRIPTION

Each transmitter-receiver combination provides a digital interface between systems linked by 100 Ω twisted pair, shielded cable. Each device contains three circuits fabricated within a single monolithic chip. Data rates greater than 15MHz are possible depending on transmission line loss characteristics and length.

The transmitter employs constant current switching which provides high noise immunity along with high speeds, low power dissipation, low EMI generation and the ability to drive high capacitance loads. In addition, the transmitters can be turned "off", allowing several transmitters to time-share a single line.

Receiver input/output differences are shown in the following table:

<table>
<thead>
<tr>
<th>INPUT</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-246 / 546</td>
<td>100 Ω OPEN COLLECTOR</td>
</tr>
<tr>
<td>HD-248 / 548</td>
<td>HI-Z 6K PULL-UP RES.</td>
</tr>
<tr>
<td>HD-249 / 549</td>
<td>100 Ω 6K PULL-UP RES.</td>
</tr>
</tbody>
</table>

The internal 100 Ω cable termination consists of 50 Ω from each input to ground.

HD-248/548 "party line" receivers have a high-Z input such that as many as ten of these receivers can be used on a single transmission line.

Each transmitter input and receiver output can be connected to TTL and DTL systems. When used with shielded transmission line, the transmitter-receiver system has very high immunity to capacitive and magnetic noise coupling from adjacent conductors. The system can tolerate ground differentials of -2.0 V to +20.0V (transmitter with respect to receiver).

PACKAGES

CODE 1S 14 LEAD BRAZED C.I.P.

CODE 9V TO-86 (METAL BOTTOM)

ALL DIMENSIONS ARE IN INCHES.
ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.
SPECIFICATIONS HD-245/545 TRANSMITTERS

ABSOLUTE MAXIMUM RATINGS

Input Voltage Range: -0.5V to +10V
Output Voltage Range: -30V to +0.5V with respect to VCC
VCC Range: -0.5V to +10V
Storage Temperature Range: -65°C to +150°C

ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEMP.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
<th>VCC</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT LOW CURRENT</td>
<td>IIL</td>
<td>25°C Full</td>
<td>-1.5</td>
<td>-2.2</td>
<td>-2.5</td>
<td>-1.5</td>
<td>-2.3</td>
<td>-2.4</td>
<td>mA</td>
<td>5.5</td>
<td>1</td>
</tr>
<tr>
<td>&quot;ON&quot; OUTPUT CURRENT</td>
<td>IOUT &quot;ON&quot;</td>
<td>25°C Full</td>
<td>-2.3</td>
<td>-1.9</td>
<td>-1.8</td>
<td>-1.5</td>
<td>-1.5</td>
<td>-1.5</td>
<td>mA</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>&quot;OFF&quot; OUTPUT CURRENT</td>
<td>IOUT &quot;OFF&quot;</td>
<td>25°C Full</td>
<td>-30</td>
<td>-100</td>
<td>-100</td>
<td>-30</td>
<td>-100</td>
<td>-100</td>
<td>μA</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>DC OUTPUT CURRENT UNBALANCE</td>
<td>ΔIOUT</td>
<td>25°C Full</td>
<td>0.1</td>
<td>0.25</td>
<td>0.3</td>
<td>0.1</td>
<td>0.25</td>
<td>0.3</td>
<td>mA</td>
<td>5.5</td>
<td>3</td>
</tr>
<tr>
<td>OUTPUT BREAKDOWN</td>
<td>BV CER</td>
<td>25°C</td>
<td>-30</td>
<td>-50</td>
<td>-30</td>
<td>-50</td>
<td>-30</td>
<td>-50</td>
<td>V</td>
<td>V</td>
<td>GND</td>
</tr>
<tr>
<td>POWER SUPPLY CURRENT-TOTAL</td>
<td></td>
<td>25°C</td>
<td>15</td>
<td>18.6</td>
<td>18.6</td>
<td>15</td>
<td>24</td>
<td>24</td>
<td>mA</td>
<td>5.0</td>
<td>5</td>
</tr>
<tr>
<td>PROPIAGATION DELAY</td>
<td>tPLH</td>
<td>25°C Full</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>ns</td>
<td>5.0</td>
<td>3</td>
</tr>
<tr>
<td>TEST CIRCUIT PAGE 4</td>
<td>tPHL</td>
<td>25°C Full</td>
<td>3.2</td>
<td>10</td>
<td>10</td>
<td>3.2</td>
<td>10</td>
<td>10</td>
<td>ns</td>
<td>5.0</td>
<td>3</td>
</tr>
</tbody>
</table>

NOTES:
1. One input at Gnd, one input open, each output at Gnd.
2. One input at 0.45V, one input open, each output at Gnd.
3. Difference between φ1 and φ2 "ON" output data current.
4. Each input at Gnd, one output at Gnd.
5. One input of each transmitter at Gnd and the other input open. All six output lines at Gnd.
6. All six input lines open, all six output lines at Gnd.

I Limit ≥ 100 μA on output tested with -30V applied.

BLOCK DIAGRAM

SCHEMATIC
SPECIFICATIONS HD-246/546; HD-248/548; HD-249/549 RECEIVERS

ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>HD-246 / 546</th>
<th>HD-248 / 548</th>
<th>HD-249 / 549</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range</td>
<td>-1.0V to +1.0V</td>
<td>-0.5V to +6.0V</td>
<td>-0.5V to +8.0V</td>
</tr>
<tr>
<td>Output Voltage Range</td>
<td>-8.0V to +0.5V</td>
<td>-8.0V to +0.5V</td>
<td>-8.0V to +0.5V</td>
</tr>
<tr>
<td>VCC Range</td>
<td>-0.5V to +6.0V</td>
<td>-0.5V to +6.0V</td>
<td>-0.5V to +6.0V</td>
</tr>
<tr>
<td>VEE Range</td>
<td>-6.0V to +0.5V</td>
<td>-6.0V to +0.5V</td>
<td>-6.0V to +0.5V</td>
</tr>
<tr>
<td>Input Current</td>
<td>25mA</td>
<td>50mA</td>
<td>NA</td>
</tr>
<tr>
<td>Output Current</td>
<td>NA</td>
<td>50mA</td>
<td>NA</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
<td>-65°C to +150°C</td>
<td>-65°C to +150°C</td>
</tr>
</tbody>
</table>

ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>HD-246 / 248 / 546 / 548</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Resistance</td>
<td>RIN (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Pull-Up Resistor</td>
<td>R8 (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Output Voltage (HIGH)</td>
<td>VOH (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Output Voltage (LOW)</td>
<td>VOL (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Output Voltage (LOW) [Input Short-Circuit]</td>
<td>VOLSC (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Icc</td>
<td>5.1 mA</td>
</tr>
<tr>
<td>IEE</td>
<td>6.3 mA</td>
</tr>
<tr>
<td>Power Supply Current (Total)</td>
<td>5.1 mA</td>
</tr>
<tr>
<td>Voltage (High)</td>
<td>4.8 V</td>
</tr>
<tr>
<td>Voltage (Low)</td>
<td>0.4 V</td>
</tr>
<tr>
<td>Propagation Delay</td>
<td>tPLH (HD-246/546 &amp; HD-249/549)</td>
</tr>
<tr>
<td>Test Circuit 2 Page 4</td>
<td>25 ns</td>
</tr>
</tbody>
</table>

NOTES:
1. (+) IIN = 1.5mA; (-) Input = open (For HD-248/548; Ext. 50Q Res. or 75mV).
2. (+) Input = open; (-) IIN = 3mA. (For HD-248/548; Ext. 50Q Res. or 75mV)
3. Both inputs shorted to Gnd; or both inputs open such that 50Ω termination resistors are in the circuit.
4. (+) Input = open; (-) IIN = 3mA.
5. (+) IIN = 3mA; (-) Input = open.

BLOCK DIAGRAM

SCHEMATIC

NOTES:
1. HD-248/548 is as shown
2. HD-248/548 does not have 6K output pull-up resistors.
3. HD-248/548 does not have 50Ω input termination resistors.
4. Resistor values are nominal.
TEST CIRCUITS

TEST CIRCUIT 1 - TRANSMITTER PROPAGATION DELAY

INPUT:

\[ t_{TLH} \leq 10 \text{ ns} \]
\[ t_{THL} \]
\[ pw = 500 \text{ ns} \]
\[ f = 1 \text{ MHz} \]

\[ \phi_1 \text{ IN} \rightarrow \text{ OPEN (3.2V)} \]
\[ \phi_2 \text{ IN} \rightarrow \text{ OPEN(3.2V)} \]
\[ \phi_1 \text{ OUT} \rightarrow t_{PLH} \approx 0.15\text{V (3mA)} \]
\[ \phi_2 \text{ OUT} \rightarrow \approx 0.15\text{V (3mA)} \]

All measurements referenced to 50% V points.

TEST CIRCUIT 2 - RECEIVER PROPAGATION DELAY

INPUT:

\[ t_{TLH} \leq 10 \text{ ns} \]
\[ t_{THL} \]
\[ pw = 500 \text{ ns} \]
\[ f = 1 \text{ MHz} \]

\[ (+) \text{ IN} \rightarrow 150 \text{ MV} \]
\[ (-) \text{ IN} \rightarrow 150 \text{ MV} \]
\[ (-) \text{ OUT} \rightarrow 5\text{V} \]

All measurements referenced to 50% V points.

NOTE: External 50Ω resistors needed for HD-248/548.

APPLICATIONS

TYPICAL APPLICATION

HD-245/545 should be driven by open-collector gates. (Totem-pole output may cause slight reduction in "on" data current.) For more detailed information, refer to Harris Semiconductor application notes 205 and 207.
**FEATURES**

- ±6.0V OUTPUT LEVELS
- SHORT CIRCUIT PROTECTED
- USEFUL AS LOGIC LEVEL SHIFTER
- MONOLITHIC RELIABILITY

**DESCRIPTION**

The Harris HD-1488 is a quadruple line driver monolithic integrated circuit meeting the electrical requirements of EIA standard RS-232-C for interface between data terminal equipment and data communication equipment. This standard assures electrical interface compatibility between data equipment made by different manufacturers. The driver circuit is useful in any application requiring transfer of digital signals up to 20K bits per second using common-return signal lines over relatively short distances. The circuit inputs can be driven from any of the popular DTL or TTL logic families. It is available in a 14-pin hermetic dual in-line package for operation from 0°C to +75°C. The companion quad line receiver circuit is the Harris HD-1489.

**PACKAGE**

CODE 1A  TO-116 (14 LEAD CERAMIC D.I.P.)

**SCHEMATIC**

![Schematic Diagram]

**CONNECTION DIAGRAM**

![Connection Diagram]
# Specifications

## Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage, (V_+), (V_-) at (+25^\circ C)</td>
<td>(\pm 15.0) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>(V_- \leq V_{IN} \leq 7.0) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>(V_{OUT} \geq V_+ +5) V</td>
<td>(\leq V_- -5) V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature, (T_A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Dissipation at (+25^\circ C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Electrical Characteristics

Test Conditions: \(V_+ = +9.0V, V_- = -9.0V, T_A = 0^\circ C\) to \(+75^\circ C\) unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Limits</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Current</td>
<td>(I_F)</td>
<td>1.0 mA</td>
<td>(I_R)</td>
<td>10 (\mu A)</td>
</tr>
<tr>
<td></td>
<td>(V_{OL})</td>
<td>-6.0 V</td>
<td>(V_{OH})</td>
<td>+6.0 V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>(I_{SC+})</td>
<td>+6 mA</td>
<td>(I_{SC-})</td>
<td>-6 mA</td>
</tr>
<tr>
<td></td>
<td>(R_O)</td>
<td>300 Ohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>(I_+)</td>
<td>+15 mA</td>
<td>(I_-)</td>
<td>-13 mA</td>
</tr>
<tr>
<td></td>
<td>(I_{PD})</td>
<td>333 mW</td>
<td>(I_{PD})</td>
<td>576 mW</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>(T_{PD+})</td>
<td>250 ns</td>
<td>(T_{PD-})</td>
<td>30 ns</td>
</tr>
<tr>
<td></td>
<td>(T_{r})</td>
<td>50 ns</td>
<td>(T_{f})</td>
<td>25 ns</td>
</tr>
<tr>
<td></td>
<td>(R_L = 3K) (\Omega)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(C_L = 15pF)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(T_A = +25^\circ C)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:
1. To maintain a maximum rate of voltage change of \(30V/\mu s\), the load capacitance, including transmission line, should be at least 330pF.
The Harris HD-1489 is a quadruple line receiver monolithic integrated circuit meeting the electrical requirements of EIA Standard RS-232-C for interface between data terminal equipment and data communication equipment. This standard assures electrical interface compatibility between data equipment made by different manufacturers. The receiver circuit is useful in any application requiring transfer of digital signals up to 20K bits per second using common-return signal lines over relatively short distances. The circuit outputs can drive any of the popular DTL or TTL logic families. It is available in a 14-pin hermetic dual in-line package for operation from 0°C to +75°C. The companion quad line driver circuit is the Harris HD-1488.
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>±10.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>±30.0V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>20mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C to +150°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>0°C to +75°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Dissipation at +25°C</td>
<td>1000mW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### ELECTRICAL CHARACTERISTICS

**Test Conditions:** $V_{CC} = +5.0V$, $T_A = 0°C$ to $+75°C$

Response control pin open unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYM: MIN. TYP. MAX. UNITS</td>
<td>TEST CONDITIONS</td>
</tr>
</tbody>
</table>
| Input Current |                  | $V_{IN} = -3.0V$
| "0" $I_{IL}$ | -0.43 | 0.43 | mA |
| "1" $I_{IH}$ | -3.6 | -8.3 | |
| Input Threshold Voltage (Note 1) |        | $V_{IN} = +25.0V$
| "0" $V_{IL}$ | 0.75 | 1.25 | V |
| "1" $V_{IH}$ | 1.0 | 1.5 | |
| Output Voltage (Note 2) |                  | $V_{IN} = +1.5V$, $I_{OL} = 10mA$
| "0" $V_{OL}$ | 0.2 | 0.45 | V |
| "1" $V_{OH}$ | 2.6 | 5.0 | |
| Output Short Circuit Current | $I_{SC}$ | 3.0 | mA |
| Supply Current | $I_{CC}$ | 20 | 26 | mA |
| Power Dissipation | $P_D$ | 100 | 130 | mW |
| Propagation Delay | $T_{PD+}$ | 60 | 85 | ns |
|                  | $T_{PD-}$ | 25 | 50 | |
| Rise Time | $T_r$ | 90 | 175 | ns |
| Fall Time | $T_f$ | 8.0 | 20 | |

**NOTES:**

1. Hysteresis is typically 250mV to prevent output chatter as input signal passes through the threshold region. If desired, thresholds can be made more positive by connecting a resistor from the response control pin to a negative supply; or more negative by connecting the resistor to a positive supply. A capacitor up to 500pF may be connected from the response control pin to ground, making the circuit output less sensitive to narrow noise spikes.

2. This assures that the output will be in the “1” state if the input line is open or shorted to ground.
**FEATURES**

- INPUT HYSTERESIS 1.15V TYP.
- INPUTS WITHSTAND ±30.0V
- PROVISION FOR THRESHOLD ADJUSTMENT AND/OR NOISE FILTERING
- MONOLITHIC RELIABILITY

**GENERAL DESCRIPTION**

The Harris HD-1489A is a quadruple line receiver monolithic integrated circuit meeting the electrical requirements of EIA Standard RS-232-C for interface between data terminal equipment and data communication equipment. This standard assures electrical interface compatibility between data equipment made by different manufacturers. The receiver circuit is useful in any application requiring transfer of digital signals up to 20K bits per second using common-return signal lines over relatively short distances. The circuit outputs can drive any of the popular DTL or TTL logic families. It is available in a 14-pin hermetic dual in-line package for operation from 0°C to +75°C. The companion quad line driver circuit is the Harris HD-1488.

**PACKAGE**

<table>
<thead>
<tr>
<th>CODE 1A</th>
<th>TO-116 (14 LEAD CERAMIC D.I.P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL DIMENSIONS IN INCHES</td>
<td>ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.</td>
</tr>
</tbody>
</table>

**SCHEMATIC**

![Schematic Diagram](image1.png)

**CONNECTION DIAGRAM**

![Connection Diagram](image2.png)
### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>TYP.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>+10.0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>±10.0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Dissipation at +25°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derate by 5mW/°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

**Test Conditions:** $V_{CC} = +5.0V$, $T_A = 0°C$ to $+75°C$,
Response control pin open unless otherwise specified.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYM:</th>
<th>LIMITS</th>
<th>UNITS</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>IIL</td>
<td>-0.43</td>
<td>mA</td>
<td>$V_{IN} = -3.0V$</td>
</tr>
<tr>
<td>&quot;1&quot;</td>
<td>IIH</td>
<td>+0.43</td>
<td></td>
<td>$V_{IN} = +3.0V$</td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>IIL</td>
<td>-3.6</td>
<td>mA</td>
<td>$V_{IN} = -25.0V$</td>
</tr>
<tr>
<td>&quot;1&quot;</td>
<td>IIH</td>
<td>+3.6</td>
<td></td>
<td>$V_{IN} = +25.0V$</td>
</tr>
<tr>
<td>Input Threshold Voltage (Note 1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>VIL</td>
<td>0.75</td>
<td>V</td>
<td>$V_{OH} \geq 2.5V$</td>
</tr>
<tr>
<td>&quot;1&quot;</td>
<td>VIH</td>
<td>1.75</td>
<td></td>
<td>$V_{OL} \leq 0.45V$</td>
</tr>
<tr>
<td>D.C.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage (Note 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>VOH</td>
<td>2.6</td>
<td>V</td>
<td>$V_{IN} = +1.5V$, $I_{OL} = 10mA$</td>
</tr>
<tr>
<td>&quot;1&quot;</td>
<td>VOH</td>
<td>2.6</td>
<td></td>
<td>$V_{IN} = +0.75V$, $I_{OH} = -0.5mA$</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>I_SC</td>
<td>3.0</td>
<td>mA</td>
<td>$V_{IN} = +0.75V$</td>
</tr>
<tr>
<td>Supply Current</td>
<td>I_CC</td>
<td>20</td>
<td>26</td>
<td>mA</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>P_D</td>
<td>100</td>
<td>130</td>
<td>mW</td>
</tr>
<tr>
<td>Propagation Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{PD+}$</td>
<td>60</td>
<td>85</td>
<td>ns</td>
<td>$R_L = 3.9K\Omega$</td>
</tr>
<tr>
<td>$T_{PD-}$</td>
<td>25</td>
<td>50</td>
<td></td>
<td>$R_L = 390\Omega$</td>
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<tr>
<td>A.C.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>TR</td>
<td>90</td>
<td>175</td>
<td>ns</td>
</tr>
<tr>
<td>Fall Time</td>
<td>TF</td>
<td>8.0</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

1. Hysteresis is typically 1.15V to prevent output chatter as input signal passes through the threshold region. If desired, thresholds can be made more positive by connecting a resistor from the response control pin to a negative supply; or more negative by connecting the resistor to a positive supply. A capacitor up to 500pF may be connected from the response control pin to ground, making the circuit output less sensitive to narrow noise spikes.

2. This assures that the output will be in the "1" state if the input line is open or shorted to ground.
HI-200
Dual SPST CMOS Analog Switch

**FEATURES**

- ANALOG SIGNAL RANGE: ±15V
- TURN-ON TIME (TYP): 240ns
- $R_{ON} < 50\Omega$ (TYP) AT +25°C
- SWITCH CURRENT AT +25°C: 80mA
- LOW POWER DISSIPATION: 15mW
- DTL/TTL AND CMOS COMPATIBLE
- NO LATCH-UP

**DESCRIPTION**

The HI-200 is a monolithic device consisting of two independently selectable SPST switches. High switching speeds at low power levels are simultaneously achieved using the Harris Dielectric Isolation, Complementary MOS process. Latch-up or SCR phenomenon is inherently non-existent with this process. The device is packaged in a 10 pin TO-100 hermetic can and is available in both military and commercial temperature ranges.

**PIN OUT**

**PACKAGE**

**FUNCTIONAL DIAGRAM**

SWITCH OPEN FOR LOGIC HIGH
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Supply Voltage Between Pins 6 and 10</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>$V_{REF}$ to Ground</td>
<td>+20V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5V</td>
<td>V</td>
</tr>
<tr>
<td>Digital Input Voltage:</td>
<td>$+V_{Supply} +4V$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>$-V_{Supply} -4V$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog Input Voltage (One Switch)</td>
<td>$+V_{Supply} +2.0V$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>$-V_{Supply} -2.0V$</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

#### ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified

Supplies = +15V, -15V; $V_{REF}$ (Pin 7) = Open; $V_{AH}$ (Logic Level High) = 3.0V $V_{AL}$ (Logic Level Low) = 0.8V

For Test Conditions, consult Performance Characteristics

### ANALOG SWITCH CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>$V_S$, Analog Signal Range</td>
<td>Full</td>
<td>-15</td>
<td></td>
<td>15</td>
<td>-15</td>
<td>15</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$R_{ON}$, On Resistance (Note 1)</td>
<td>$+25°C$</td>
<td>55</td>
<td>70</td>
<td>55</td>
<td>80</td>
<td></td>
<td></td>
<td>Ω</td>
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<tr>
<td>$R_{OFF}$, Off Input Leakage Current (Note 2)</td>
<td>$+25°C$</td>
<td>1</td>
<td>500</td>
<td>1</td>
<td>500</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>$I_D{OFF}$, Off Output Leakage Current</td>
<td>$+25°C$</td>
<td>1</td>
<td>500</td>
<td>1</td>
<td>500</td>
<td></td>
<td></td>
<td>nA</td>
</tr>
<tr>
<td>$I_D{ON}$, On Leakage Current</td>
<td>$+25°C$</td>
<td>0.02</td>
<td>500</td>
<td>0.02</td>
<td>500</td>
<td></td>
<td></td>
<td>nA</td>
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### DIGITAL INPUT CHARACTERISTICS

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<tr>
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</thead>
<tbody>
<tr>
<td>$V_{IH}$, Input Low Threshold</td>
<td>Full</td>
<td></td>
<td>3.0</td>
<td></td>
<td></td>
<td>0.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$V_{IH}$, Input High Threshold</td>
<td>Full</td>
<td></td>
<td>3.0</td>
<td></td>
<td></td>
<td>0.8</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>$I_{IH}$, Input Leakage Current (High or Low) (Note 2)</td>
<td>Full</td>
<td>1.0</td>
<td></td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td>μA</td>
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</table>

### SWITCHING CHARACTERISTICS

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>$t_{OPEN}$, Break - Before Make Delay (Note 3)</td>
<td>$+25°C$</td>
<td>60</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_{ON}$, Switch on Time</td>
<td>$+25°C$</td>
<td>240</td>
<td>500</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>$t_{OFF}$, Switch off Time</td>
<td>$+25°C$</td>
<td>330</td>
<td>500</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td>ns</td>
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<tr>
<td>&quot;Off Isolation&quot; (Note 4)</td>
<td>$+25°C$</td>
<td>70</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>$C_{S{OFF}}$, Input Switch Capacitance</td>
<td>$+25°C$</td>
<td>5.5</td>
<td>5.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{D{OFF}}$, Output Switch Capacitance</td>
<td>$+25°C$</td>
<td>5.5</td>
<td>5.5</td>
<td></td>
<td></td>
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<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{D{ON}}$, Drain-To-Source Capacitance</td>
<td>$+25°C$</td>
<td>11</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{A}$, Digital Input Capacitance</td>
<td>$+25°C$</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pF</td>
</tr>
<tr>
<td>$C_{D{OFF}}$, Drain-To-Source Capacitance</td>
<td>$+25°C$</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
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<td>pF</td>
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### POWER REQUIREMENTS (Note 5)

<table>
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<tr>
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<tbody>
<tr>
<td>$P_{DD}$, Power Dissipation</td>
<td>$+25°C$</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mW</td>
</tr>
<tr>
<td>$I_D^+$, Current (Pin 10)</td>
<td>Full</td>
<td>0.5</td>
<td>0.5</td>
<td>2.0</td>
<td>0.5</td>
<td>2.0</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$I_D^-$, Current (Pin 6)</td>
<td>Full</td>
<td>0.5</td>
<td>0.5</td>
<td>2.0</td>
<td>0.5</td>
<td>2.0</td>
<td></td>
<td>mA</td>
</tr>
</tbody>
</table>

### NOTES:

1. $V_{OUT} = +10V, I_{OUT} = 1mA$
2. Digital Inputs Are MOS Gates
3. Typical Leakage is Less Than 1mA
4. $V_A = +3V, R_L = 1kΩ, C_L = 10pF, V_S = 3V RMS, f = 100 kHz$
5. $V_A = +3V$ or $V_A = 0V$ For Both Switches

*100% Tested For DASH 8
SCHEMATIC DIAGRAMS

TTL/CMOS REFERENCE CIRCUIT

V+ 10

Q1

Q2

R2

V- 6

Q3

Q6

Q8

Q9

Q14

V- 5V

INPUT

OUTPUT

A'

N11

N12

N13

P11

P12

V+

V-

A'

SWITCH CELL

DIGITAL INPUT BUFFER AND LEVEL SHIFTER

V+ 0

V-

200Ω

D1

D2

N1

N2

N3

N4

N5

N6

N7

N8

N9

N10

P1

P3

P4

P5

P6

P7

P8

P9

P10

V+ 0

V-

V-

A'

A'

ALL N-CHANNEL BODIES TO V-
ALL P-CHANNEL BODIES TO V+ EXCEPT AS SHOWN.
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

(UNLESS OTHERWISE SPECIFIED $T_A = 25^\circ C$, $V_{SUPPLY} = \pm 15V$, $V_{AH} = 3.0V$ $V_{AL} = 0.8V$ AND $V_{REF} = OPEN$).

ON RESISTANCE vs. ANALOG SIGNAL LEVEL, SUPPLY VOLTAGE AND TEMPERATURE

ON RESISTANCE vs. TEMPERATURE

(HI-200)
ON RESISTANCE vs. ANALOG SIGNAL LEVEL AND POWER SUPPLY VOLTAGE
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS (continued)

SWITCH LEAKAGE CURRENT vs. TEMPERATURE (HI-200)

OFF LEAKAGE CURRENT vs. TEMPERATURE

ON LEAKAGE CURRENT vs. TEMPERATURE

SWITCH CURRENT vs. VOLTAGE

SWITCH CURRENT vs. VOLTAGE
**PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS** (continued)

**SWITCHING WAVEFORMS**

**DIGITAL INPUT**

\[ V_{AH} \]

\[ V_{AL} = 0.8V \]

\[ t_{ON} \]

\[ t_{OFF} \]

**SWITCH OUTPUT**

\[ 0V \]

\[ 90\% \]

\[ 90\% \]

**t_{ON}, t_{OFF} (TTL INPUT)**

\[ V_{AH} = +4.0V \]

**t_{ON}, t_{OFF} (CMOS INPUT)**

\[ V_{REF} = \text{OPEN}, V_{AH} = +15V \]

**Top:** TTL Input  \n**Vertical:** 2V/Div.  \n**Bottom:** Output  \n**Horizontal:** 200ns/Div.

**Top:** CMOS Input  \n**Vertical:** 5V/Div.  \n**Bottom:** Output  \n**Horizontal:** 200ns/Div.
HI-201
Quad SPST CMOS Analog Switch

FEATURES

- ANALOG SIGNAL RANGE
- TURN-ON TIME (TYP)
- ON RESISTANCE (TYP)
- NO LATCH-UP
- NO DIGITAL INPUT CURRENT SPIKE
- DTL/TTL AND CMOS COMPATIBLE

DESCRIPTION

The HI-201 is a monolithic device consisting of four independently selectable SPST switches. High switching speeds at low power levels are simultaneously achieved using the Harris Dielectric Isolation, Complementary MOS process. Latch-up or SCR phenomenon is inherently non-existent with this process. The device is packaged in a 16 pin hermetic Dual In-Line and is available in both military and commercial temperature ranges.

FUNCTIONAL DIAGRAM

TYPICAL SWITCH

SWITCH OPEN FOR LOGIC HIGH
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

- Supply Voltage Between Pins 4 and 13
  - $V_{	ext{REF}}$ to Ground
- Digital Input Voltage
  - $V_{	ext{Supply,}}(+)$: 4V
  - $V_{	ext{Supply,}}(-)$: 4V
- Analog Input Voltage (One Switch)
  - $+V_{	ext{Supply}} +2.0V$
  - $-V_{	ext{Supply}} -2.0V$
  - 40V
  - +20V, -5V

#### ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified

- Supplies = +15V, -15V; $V_{	ext{REF}}$ (Pin 7) = Open; $V_{	ext{AH}}$ (Logic Level High) = 3.0V; $V_{	ext{AL}}$ (Logic Level Low) = +0.8V
- For Test Conditions, consult Performance Characteristics

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>HI-201-2</th>
<th>HI-201-5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-55°C to +125°C</td>
<td>0°C to +75°C</td>
</tr>
<tr>
<td>PARAMETER</td>
<td>TEMP.</td>
<td>MIN.</td>
</tr>
<tr>
<td>ANALOG SWITCH CHARACTERISTICS</td>
<td>Full</td>
<td>-15</td>
</tr>
<tr>
<td>*$V_S$, Analog Signal Range</td>
<td>Full</td>
<td>65</td>
</tr>
<tr>
<td>*$R_{ON}$, On Resistance (Note 1)</td>
<td>+25°C</td>
<td>85</td>
</tr>
<tr>
<td>*$I_{S(OFF)}$, Off Input Leakage Current</td>
<td>+25°C</td>
<td>2</td>
</tr>
<tr>
<td>*$I_{D(OFF)}$, Off Output Leakage Current</td>
<td>+25°C</td>
<td>500</td>
</tr>
<tr>
<td>*$I_{D(ON)}$, On Leakage Current</td>
<td>+25°C</td>
<td>2</td>
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<table>
<thead>
<tr>
<th>DIGITAL INPUT CHARACTERISTICS</th>
<th>HI-201-2</th>
<th>HI-201-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{AL}$, Input Low Threshold</td>
<td>Full</td>
<td>0.8</td>
</tr>
<tr>
<td>$V_{AH}$, Input High Threshold</td>
<td>Full</td>
<td>3.0</td>
</tr>
<tr>
<td>*$I_A$, Input Leakage Current (High or Low) (Note 2)</td>
<td>Full</td>
<td>1.0</td>
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<table>
<thead>
<tr>
<th>SWITCHING CHARACTERISTICS</th>
<th>HI-201-2</th>
<th>HI-201-5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>+25°C</td>
<td>30</td>
</tr>
<tr>
<td>tOPEN, Break - Before Make Delay (Note 3)</td>
<td>+25°C</td>
<td>185</td>
</tr>
<tr>
<td>tON, Switch ON Time</td>
<td>+25°C</td>
<td>220</td>
</tr>
<tr>
<td>tOFF, Switch OFF Time</td>
<td>+25°C</td>
<td>80</td>
</tr>
<tr>
<td>&quot;Off Isolation&quot; (Note 4)</td>
<td>+25°C</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_{S(OFF)}$, Input Switch Capacitance</td>
<td>+25°C</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_{D(OFF)}$, Output Switch Capacitance</td>
<td>+25°C</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_{D(ON)}$, Digital Input Capacitance</td>
<td>+25°C</td>
<td>5</td>
</tr>
<tr>
<td>$C_{DS(OFF)}$, Drain-To-Source Capacitance</td>
<td>+25°C</td>
<td>0.5</td>
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</table>

<table>
<thead>
<tr>
<th>POWER REQUIREMENTS (Note 5)</th>
<th>HI-201-2</th>
<th>HI-201-5</th>
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</thead>
<tbody>
<tr>
<td>*$I^+$, Current (Pin 13)</td>
<td>+25°C</td>
<td>15</td>
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<tr>
<td>Po, Power Dissipation</td>
<td>+25°C</td>
<td>60</td>
</tr>
<tr>
<td>*$I^+$, Current (Pin 4)</td>
<td>+25°C</td>
<td>0.5</td>
</tr>
<tr>
<td>$V_{A}$ = 5V, $R_L = 1 \Omega$, $C_L = 10pF$, $V_S = 3V$, $f = 100kHz$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NOTES:

1. $V_{OUT} = +10V$, $I_{OUT} = 1mA$
2. Digital Inputs Are MOS Gates - Typical Leakage is Less Than 1nA
3. $V_{AH} = +4.0V$
4. *100% Tested For DASH 8
SCHEMATIC DIAGRAMS

TTL/CMOS REFERENCE CIRCUIT

DIGITAL INPUT BUFFER AND LEVEL SHIFTER

ALL N-CHANNEL BODIES TO V-
ALL P-CHANNEL BODIES TO V+
EXCEPT AS SHOWN.
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

(UNLESS OTHERWISE SPECIFIED $T_A = 25^\circ C$, $V_{\text{SUPPLY}} = \pm 15V$, $V_{\text{AH}} = 3.0V$ $V_{\text{AL}} = 0.8V$ AND $V_{\text{REF}} = \text{OPEN}$).

**ON RESISTANCE vs. ANALOG SIGNAL LEVEL, SUPPLY VOLTAGE AND TEMPERATURE**

**ON RESISTANCE vs. TEMPERATURE**

(Ambient Temperature - °C)

**ON RESISTANCE vs. ANALOG SIGNAL LEVEL AND POWER SUPPLY VOLTAGE**

(HT-201)
SWITCHING WAVEFORMS

DIGITAL INPUT

V_{AH} 50% V_{AL} = 0V

ON OFF

SWITCH OUTPUT 0V

\[ \text{TON, TOFF (TTL INPUT)} \]
\[ V_{IN} = 3.5V \]

Top: TTL Input
Bottom: Output
Horizontal: 100ns/Div.
Vertical: 2V/Div.

\[ \text{TON, TOFF (CMOS INPUT)} \]
\[ V_{REF} = \text{OPEN}, V_{IN} = +15V \]

Top: CMOS Input
Bottom: Output
Vertical: 5V/Div.
Horizontal: 100ns/Div.
HI-506A/HI-507A
16 Channel Analog Multiplexer with Overvoltage Protection

**FEATURES**
- Analog/Digital Overvoltage Protection
- Fail Safe with Power Loss (No Latchup)
- Break Before Make Switching
- DTL/TTL and CMOS Compatible
- Analog Signal Range ±15V
- Access Time 500ns TYP.
- Supply Current at 1MHz 4mA TYP.
- Standby Power 7.5mW TYP.

**DESCRIPTION**
The HI-506A and HI-507A analog multiplexers are constructed with the Harris Dielectric Isolation, Complementary MOS process. Digital and Analog inputs are protected from overvoltage inputs that exceed either supply voltage with no channel interaction. Channel interaction is also eliminated in the event of power loss. The HI-506A is a single-ended 16 channel multiplexer while the HI-507A is a differential 8 channel version. The devices are packaged in a 28 pin dual-in-line package and are available in both military and commercial temperature ranges.

**PACKAGE**

**CODE 1L**

**PIN OUT/TRUTH TABLE**

### HI-506A

<table>
<thead>
<tr>
<th>A3</th>
<th>A2</th>
<th>A1</th>
<th>A0</th>
<th>EN</th>
<th>&quot;ON&quot; CHANNEL</th>
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### HI-507A

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# SPECIFICATIONS

## ABSOLUTE MAXIMUM RATINGS

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<td>Supply Voltage Between Pins 1 and 27</td>
<td>40V</td>
<td>40V</td>
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<td>V&lt;sub&gt;REF&lt;/sub&gt; to Ground</td>
<td>+20V</td>
<td>0V</td>
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<tr>
<td>V&lt;sub&gt;EN&lt;/sub&gt;, V&lt;sub&gt;A&lt;/sub&gt;, Digital Input Overvoltage:</td>
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<tr>
<td>V&lt;sub&gt;A&lt;/sub&gt;</td>
<td>V&lt;sub&gt;Supply&lt;/sub&gt;(+) +4V</td>
<td>V&lt;sub&gt;Supply&lt;/sub&gt;(-) -4V</td>
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<tr>
<td>Analog Input Overvoltage:</td>
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<tr>
<td>V&lt;sub&gt;S&lt;/sub&gt;</td>
<td>V&lt;sub&gt;Supply&lt;/sub&gt;(+) +20V</td>
<td>V&lt;sub&gt;Supply&lt;/sub&gt;(-) -20V</td>
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<tr>
<td>Analog Channel Characteristics</td>
<td></td>
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<tr>
<td>*V&lt;sub&gt;S&lt;/sub&gt;, Analog Signal Range</td>
<td>Full</td>
<td>-15</td>
</tr>
<tr>
<td>*R&lt;sub&gt;ON&lt;/sub&gt;, On Resistance (Note 1)</td>
<td>+25°C</td>
<td>1.2</td>
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<td>1.5</td>
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<tr>
<td>*I&lt;sub&gt;S&lt;/sub&gt;(OFF), Off Input Leakage Current</td>
<td>+25°C</td>
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<tr>
<td></td>
<td>Full</td>
<td></td>
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<tr>
<td>*I&lt;sub&gt;D&lt;/sub&gt;(OFF), Off Output Current</td>
<td>+25°C</td>
<td>1.0</td>
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<tr>
<td>HI-506A</td>
<td>Full</td>
<td></td>
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<tr>
<td>HI-507A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*I&lt;sub&gt;D&lt;/sub&gt;(OFF) with Input Overvoltage Applied (Note 2)</td>
<td>+25°C</td>
<td>4.0</td>
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<tr>
<td>HI-506A</td>
<td>Full</td>
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<tr>
<td>HI-507A</td>
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<tr>
<td>*I&lt;sub&gt;ON&lt;/sub&gt;, On Channel Leakage Current</td>
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<td>HI-506A</td>
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## ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified.

<table>
<thead>
<tr>
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<tr>
<td>Power Requirements</td>
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<td>P&lt;sub&gt;0&lt;/sub&gt;, Power Dissipation</td>
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<td>7.5</td>
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<tr>
<td>*I&lt;sub&gt;+&lt;/sub&gt;, Current Pin 1 (Note 5)</td>
<td>Full</td>
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<tr>
<td>*I&lt;sub&gt;-&lt;/sub&gt;, Current Pin 27 (Note 5)</td>
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<td>0.02</td>
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<tr>
<td>*I&lt;sub&gt;+&lt;/sub&gt;, Standby (Note 6)</td>
<td>Full</td>
<td>0.5</td>
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<tr>
<td>*I&lt;sub&gt;-&lt;/sub&gt;, Standby (Note 6)</td>
<td>Full</td>
<td>0.02</td>
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</tbody>
</table>

**Notes:**
1. V<sub>OUT</sub> = ±10V, I<sub>OUT</sub> = ±100 μA
2. Analog Overvoltage = ±33V
3. V<sub>REF</sub> = ±10V
4. V<sub>EN</sub> = 0.8V, RL = 1K, CL = 7pF, V<sub>S</sub> = 3VRMS, f = 500kHz
5. V<sub>EN</sub> = +4.0V
6. V<sub>EN</sub> = 0.8V
7. To drive from DTL/TTL circuits, 1KΩ pull-up resistors to +5.0V supply are recommended

*100% Tested For DASH B
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

(UNLESS OTHERWISE SPECIFIED \( T_A = 25^\circ C, V_{SUPPLY} = \pm 15V, V_{AH} = +4V, V_{AL} = 0.8V \) AND \( V_{REF} = \) OPEN.)

ON RESISTANCE vs. INPUT SIGNAL LEVEL, SUPPLY VOLTAGE

Normalized On Resistance

LEAKAGE CURRENT vs. TEMPERATURE

ON LEAKAGE CURRENT \( I_{ON} \)

OFF LEAKAGE CURRENT \( I_{OFF} \)

ANALOG INPUT OVERVOLTAGE CHARACTERISTICS

TEST CIRCUIT NO.4

Output Off Leakage Current \( I_{OFF} \)
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

ON CHANNEL CURRENT vs. VOLTAGE

TEST CIRCUIT NO. 5

ON CHANNEL CURRENT vs. VOLTAGE

TEST CIRCUIT NO. 6

SUPPLY CURRENT vs. TOGGLE FREQUENCY

TEST CIRCUIT NO. 6

SUPPLY CURRENT vs. TOGGLE FREQUENCY

TEST CIRCUIT NO. 7

ACCESS TIME vs. LOGIC LEVEL (HIGH)

TEST CIRCUIT NO. 7

ACCESS TIME vs. LOGIC LEVEL (HIGH)

SWITCHING WAVEFORMS

ACCESS TIME

ACCESS TIME
SWITCHING WAVEFORMS (continued)

TEST CIRCUIT NO.8
BREAK BEFORE MAKE DELAY (OPEN)

TEST CIRCUIT NO.9
ENABLE DELAY (TON(EN) - TOFF(EN))

SIMILAR CONNECTION FOR HI-507A

SCHEMATIC DIAGRAMS

FUNCTIONAL BLOCK DIAGRAM HI-506A

FUNCTIONAL BLOCK DIAGRAM HI-507A
SCHEMATIC DIAGRAMS (continued)

DELETE A3 or \( \overline{A_3} \)
INPUT FOR HI-507A

ADDRESS INPUT BUFFER
AND LEVEL SHIFTER

LEVEL SHIFTER

OVERVOLTAGE
PROTECTION

ADDRESS DECODER

MULTIPLEX SWITCH

Li-134
HI-508A/509A
8 Channel Analog Multiplexers with Overvoltage Protection

FEATURES
- ANALOG/DIGITAL OVERVOLTAGE PROTECTION
- FAIL SAFE WITH POWER LOSS
- BREAK BEFORE MAKE SWITCHING
- DTL / TTL AND CMOS COMPATIBLE
- ANALOG SIGNAL RANGE ±15V
- ACCESS TIME 500ns TYP.
- SUPPLY CURRENT AT 1MHz 4mA TYP.
- STANDBY POWER 7.5mW TYP.

DESCRIPTION
The HI-508A and HI-509A analog multiplexers are constructed with the Harris Dielectric Isolation, Complementary MOS process. Digital and Analog inputs are protected from overvoltage inputs that exceed either supply voltage with no channel interaction. Channel interaction is also eliminated in the event of power loss. The HI-508A is a single-ended 8 channel multiplexer while the HI-509A is a differential 4 channel version. The devices are packaged in a 16 pin dual-in-line package and are available in both military and commercial temperature ranges.

PACKAGE
CODE 1F
16 LEAD D.I.P.

PIN OUT/TRUTH TABLE

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<tr>
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<tbody>
<tr>
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<td>IN4A</td>
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<tr>
<td>OUTA</td>
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ALL DIMENSIONS IN INCHES.
ALL DIMENSIONS ±.010 UNLESS OTHERWISE SHOWN.
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
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<tbody>
<tr>
<td>Voltage between Supply Pins</td>
<td>40V</td>
<td>Total Power Dissipation*</td>
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V<sub>EN</sub>, V<sub>A</sub>, Digital Input Overvoltage:
- V<sub>A</sub> = V<sub>Supply(+)</sub> +4V
- V<sub>A</sub> = V<sub>Supply(-)</sub> -4V

Analog Input Overvoltage:
- V<sub>S</sub> = V<sub>Supply (+)</sub> +20V
- V<sub>S</sub> = V<sub>Supply (-)</sub> -20V

#### ELECTRICAL CHARACTERISTICS

Unless Otherwise Specified.

Supplies = +15V, -15V; V<sub>REF</sub> (Pin 13) = Open; V<sub>AH</sub> (Logic Level High) = +4.0V; V<sub>AL</sub> (Logic Level Low) = +0.8V

For Test Conditions, consult Performance Characteristics section.

### PARAMETER

#### ANALOG CHANNEL CHARACTERISTICS

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<tr>
<th>Parameter</th>
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<th>MAX.</th>
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<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
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<tr>
<td>*V&lt;sub&gt;S&lt;/sub&gt;, Analog Signal Range</td>
<td>Full</td>
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<td>+15</td>
<td>-15</td>
<td>+15</td>
<td>V</td>
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<td></td>
<td>Full</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>KΩ</td>
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<tr>
<td></td>
<td>Full</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>KΩ</td>
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<td>1.0</td>
<td>nA</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Full</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>KΩ</td>
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<td>μA</td>
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<td></td>
<td>Full</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
<td>KΩ</td>
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#### DIGITAL INPUT CHARACTERISTICS

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<td>V&lt;sub&gt;AL&lt;/sub&gt;, Input Low Threshold</td>
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<td>*I&lt;sub&gt;A&lt;/sub&gt;, Input Leakage Current (High or Low)</td>
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<td>1.0</td>
<td>μA</td>
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<tr>
<td></td>
<td>Full</td>
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<td>1.0</td>
<td>μA</td>
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#### SWITCHING CHARACTERISTICS

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<th>MAX.</th>
<th>UNITS</th>
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<tbody>
<tr>
<td>t&lt;sub&gt;A&lt;/sub&gt;, Access Time</td>
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<tr>
<td>t&lt;sub&gt;OPEN&lt;/sub&gt;, Break - Before Make Delay</td>
<td>+25°C</td>
<td>80</td>
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<tr>
<td>t&lt;sub&gt;ON&lt;/sub&gt;(EN), Enable Delay (ON)</td>
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<td>ns</td>
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<td>t&lt;sub&gt;OFF&lt;/sub&gt;(EN), Enable Delay (OFF)</td>
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<td>ns</td>
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<td>t&lt;sub&gt;OFF Isolation&lt;/sub&gt;” (Note 3)</td>
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<td>pF</td>
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<tr>
<td>C&lt;sub&gt;D&lt;/sub&gt;(OFF), Channel Output Capacitance</td>
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<td>25</td>
<td>pF</td>
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<tr>
<td>C&lt;sub&gt;G&lt;/sub&gt;, Digital Input Capacitance</td>
<td>+25°C</td>
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<td>12</td>
<td>pF</td>
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<tr>
<td>C&lt;sub&gt;D&lt;/sub&gt;(OFF), Input to Output Capacitance</td>
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#### POWER REQUIREMENTS

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<th>MAX.</th>
<th>UNITS</th>
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<tr>
<td>P&lt;sub&gt;D&lt;/sub&gt;, Power Dissipation</td>
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<td>7.5</td>
<td>mW</td>
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<tr>
<td>*I&lt;sub&gt;+&lt;/sub&gt;, Current (Note 4)</td>
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<td>2.0</td>
<td>5.0</td>
<td>mA</td>
</tr>
<tr>
<td>*I&lt;sub&gt;-&lt;/sub&gt;, Current (Note 4)</td>
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<td>0.02</td>
<td>1.0</td>
<td>0.02</td>
<td>mA</td>
</tr>
<tr>
<td>*I&lt;sub&gt;+&lt;/sub&gt;, Standby (Note 5)</td>
<td>Full</td>
<td>0.5</td>
<td>2.0</td>
<td>5.0</td>
<td>mA</td>
</tr>
<tr>
<td>*I&lt;sub&gt;-&lt;/sub&gt;, Standby (Note 5)</td>
<td>Full</td>
<td>0.02</td>
<td>1.0</td>
<td>0.02</td>
<td>mA</td>
</tr>
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</table>

### NOTES:

1. V<sub>OUT</sub> = ±10V, I<sub>OUT</sub> = -100μA
2. Analog Overvoltage = ±33V
3. V<sub>EN</sub> = 0.6V, P<sub>L</sub> = 1K, C<sub>L</sub> = 7pF, V<sub>S</sub> = 3V RMS, f = 500KHz
4. V<sub>EN</sub> = +4.0V
5. V<sub>EN</sub> = 0.8V
6. To drive from DTL/TTL Circuits, 1KΩ pull-up resistors to +5.0V supply are recommended

*100% Tested For DASH 8
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

(UNLESS OTHERWISE SPECIFIED $T_A = 25^\circ C$, $V_{SUPPLY} = \pm 15V$, $V_{AH} = +4V$, $V_{AL} = 0.8V$

TEST CIRCUIT NO. 1

ON RESISTANCE vs. INPUT SIGNAL LEVEL, SUPPLY VOLTAGE

ON RESISTANCE vs. ANALOG INPUT VOLTAGE

NORMALIZED ON RESISTANCE vs. SUPPLY VOLTAGE

LEAKAGE CURRENT vs. TEMPERATURE

TEST CIRCUIT NO. 2

OFF LEAKAGE CURRENT vs. TEMPERATURE

ON LEAKAGE CURRENT vs. TEMPERATURE

TEST CIRCUIT NO. 3

ANALOG INPUT OVERVOLTAGE CHARACTERISTICS

TEST CIRCUIT NO. 4

ANALOG INPUT OVERVOLTAGE CHARACTERISTICS
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

ON CHANNEL CURRENT vs. VOLTAGE

TEST CIRCUIT NO.5

ON CHANNEL CURRENT vs. VOLTAGE

TEST CIRCUIT NO.6

SUPPLY CURRENT vs. TOGGLE FREQUENCY

TEST CIRCUIT NO.7

ACCESS TIME vs. LOGIC LEVEL (HIGH)

ACCESS TIME vs. LOGIC LEVEL (HIGH)

*SIMILAR CONNECTION FOR HI-509A

SWITCHING WAVEFORMS

ACCESS TIME

* SIMILAR CONNECTION FOR HI-509A

0.1 sec/Div

200 ms/Div
SWITCHING WAVEFORMS (continued)

TEST CIRCUIT NO. 8
BREAK BEFORE MAKE DELAY (t_{OPEN})

V_{AH} = 4.0
0.8 = V_{AL}

ADDRESS DRIVE (V_{A})

OUTPUT

50%

50%

'OPEN

BREAK BEFORE MAKE DELAY (t_{OPEN})

TEST CIRCUIT NO. 9
ENABLE DELAY (t_{ON(EN)}, t_{OFF(EN)})

V_{AH} = 4.0

V_{AL} = 0.8V

90%

90%

'ON(EN)

'OFF (EN)

ENABLE DELAY (t_{ON(EN)}, t_{OFF(EN)})

FUNCTIONAL BLOCK DIAGRAM HI-508A

FUNCTIONAL BLOCK DIAGRAM HI-509A

SCHEMATIC DIAGRAMS

*SIMILAR CONNECTION FOR HI-509A

*SIMILAR CONNECTION FOR HI-509A
SCHEMATIC DIAGRAMS (continued)

ADDRESS INPUT BUFFER AND LEVEL SHIFTER

LEVEL SHIFTER

ADDRESS DECODER

DELETE A2 OR \bar{A}_2
INPUT FOR HI-509A

MULTIPLEX SWITCH
HI-1080/HI-1085
8-Bit D to A Converter
High Speed Monolithic

FEATURES

- **ACCURACY** - (HI-1080) Guaranteed -55° to +125°C
  (HI-1085) or 0° to +75°C
- **SPEED** - 1.5 Microseconds settling to 1/2 L.S.B.
- **VERSATILITY** - Unipolar, Bipolar, Offset Operation
  Positive or Negative External Reference
  Taps Provided for Scale Factor Adjustment
  Provision for Cascading Converters
  Matched Amplifier Feedback Resistors
  Inputs DTL/TTL Compatible
- **RELIABILITY** - Monolithic Construction
  Meets Requirements of MIL-STD-883

GENERAL DESCRIPTION

The HI-1080/1085 is a current switching converter complete
with a precision thin film R-2R ladder resistor network on a
single monolithic chip. It is ideal for general purpose high
speed, moderate accuracy digital-analog interfaces. It is
particularly suitable as part of a high speed successive
approximation or up-down counter type A to D converter.

PACKAGES

<table>
<thead>
<tr>
<th>CODE 9M</th>
<th>24 LEAD FLAT PACK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CODE 1H</th>
<th>24 LEAD D.I.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PIN CONFIGURATION

ALL DIMENSIONS ARE IN INCHES.
ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.
**SPECIFICATIONS**

**ABSOLUTE MAXIMUM RATINGS**

Maximum ratings are limiting values above which permanent circuit damage may occur.

Voltage
- \( V^+ : +8.0\text{V} \)
- \( V^- : -18.0\text{V} \)

Digital Inputs: \(+5.5\text{V}\)

*Derate at \(4\text{mW/°C}\) above \(85\text{°C}\) ambient.

**ELECTRICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>HI-1080 TEMP</th>
<th>LIMITS MIN</th>
<th>LIMITS TYP</th>
<th>LIMITS MAX</th>
<th>LIMITS UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>8</td>
<td>Bits</td>
<td>8</td>
<td>Bits</td>
</tr>
<tr>
<td><strong>Accuracy</strong> (Calibrated at 25°C)</td>
<td>+25°C</td>
<td>-55°C to +125°C</td>
<td>1/4</td>
<td>1/2</td>
</tr>
<tr>
<td><strong>V_{Full Scale}</strong> (Note 2) (Uncalibrated)</td>
<td>+25°C</td>
<td>-4.5</td>
<td>-4.98</td>
<td>-5.5</td>
</tr>
<tr>
<td><strong>Power Supply Rejection</strong> (Note 3)</td>
<td>-55°C to +125°C</td>
<td>.05</td>
<td>.001</td>
<td>L.S.B. per Volt</td>
</tr>
<tr>
<td><strong>Settling Time</strong> (Note 4)</td>
<td>+25°C</td>
<td>1.5</td>
<td>3.0</td>
<td>(\mu\text{s})</td>
</tr>
<tr>
<td><strong>Digital Inputs:</strong> High Threshold</td>
<td>0.8</td>
<td>2.0</td>
<td>Volts</td>
<td>Volts</td>
</tr>
<tr>
<td></td>
<td>(I_{\text{High}})</td>
<td>55°C to +125°C</td>
<td>.01</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Low Threshold</td>
<td>-55°C to +125°C</td>
<td>-0.7</td>
<td>-1.0</td>
</tr>
<tr>
<td><strong>Supply Current:</strong> (I^+)</td>
<td>-55°C to +125°C</td>
<td>8</td>
<td>10</td>
<td>(\text{mA})</td>
</tr>
<tr>
<td>(I^-)</td>
<td>-55°C to +125°C</td>
<td>8</td>
<td>10</td>
<td>(\text{mA})</td>
</tr>
<tr>
<td>(I_{\text{REF}}) (Note 7)</td>
<td>-55°C to +125°C</td>
<td>0.5</td>
<td>0.6</td>
<td>(\text{mA})</td>
</tr>
</tbody>
</table>

**NOTES:** Test Conditions –

1. Any Input Combination
2. Inputs all low
3. \(\Delta V_{\text{OUT}}/\Delta V_{\text{SUPPLY}}\)
   - \(V^+ = +5 \pm 0.5\text{V}\)
   - \(V^- = -15 \pm 3\text{V}\)
4. To ±0.2% of full scale after full scale input step
5. \(V^+ = 4.5\text{V}\)
6. \(V_{\text{in}} = 2.4\text{Volts}\)
   - \(V^+ = 5.5\text{V}\)
   - \(V_{\text{in}} = 0.4\text{Volts}\)
   - \(V^+ = 5.5\text{V}\)
7. \(V^+ = +6.0\text{V}\)
   - \(V^- = -15.0\text{V}\)
   - \(V_{\text{REF}} = +5.0\text{V}\)
   - Inputs all low

*100% Tested For DASH 8
PERFORMANCE CURVES

TYPICAL OUTPUT ACCURACY VS. TEMPERATURE

Figure 1

TYPICAL SETTLING TIME

Figure 2

OPERATION MODES

D/A CONVERTER OPERATION MODES

Figure 3

MODE | OUTPUT RANGE INPUTS: ALL HIGH TO ALL LOW | CONNECTIONS
--- | --- | ---
UNIPOLAR ZERO REFERENCE | $0 \to -V_R^+ - 1 \text{ L.S.B.}$ | $V_R^+$ N.C. GND GND
UNIPOLAR ZERO F.S. | $+/V_R^+/-0 + 1 \text{ L.S.B.}$ | $V_R^+$ N.C. GND $V_R$
BIPOLAR | $/V_R^+/0 -V_R + 1 \text{ L.S.B.}$ | N.C. $V_R^+$ GND $V_R^+$

OPERATING MODES

Figure 3

* Tap 1 or Tap 3 with selected external series resistor may be substituted for points A or B, respectively, for fine adjustment of output range.
TYPICAL APPLICATIONS

BUFFER AMPLIFIER CONNECTION

NON-INVERTING OUTPUT
(MORE NEGATIVE WITH INCREASING
COMPLEMENT OF INPUT NUMBER)

OUTPUT RANGE: SAME AS SHOWN
ON 'CHART 'OPERATING MODE' CHART
MULTIPLIED BY \( \frac{R_2}{R_1 + R_2} \)

INVERTING OUTPUT
(MORE POSITIVE WITH INCREASING
COMPLEMENT OF INPUT NUMBER)

<table>
<thead>
<tr>
<th>FULL SCALE OUTPUT</th>
<th>OUTPUT FEEDBACK CONNECTED TO</th>
<th>( R_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4.98V</td>
<td>SUM</td>
<td>2.5k</td>
</tr>
<tr>
<td>+9.96V</td>
<td>2R SUM</td>
<td>3.3k</td>
</tr>
</tbody>
</table>

Figure 4

CASCADED UNITS FOR 12 BIT RESOLUTION

DIGITAL INPUTS

Figure 5
HI-1800A
Analog Switch Four-Channel

FEATURES

- SIGNAL RANGE ±15V
- "ON" RESISTANCE 125Ω TYP.
- LEAKAGE AT +125°C 40 nA TYP.
- ACCESS TIME 500 ns TYP.
- DTL/TTL COMPATIBLE ADDRESS
- -55°C to +125°C OPERATION

DESCRIPTION

The HI-1800A is a general purpose analog switch which may be used as a signal selector, multiplexer, chopper, or cross-point switch for signals from D.C. to R.F. The configuration is two independent DPST switches with versatile TTL compatible addressing logic which allows connection as two SPDT, or a single DPDT, SPDT, or SPST switch by connection of external jumpers. ON resistance decreases correspondingly when switching elements are connected in parallel. The HI-1800A is fabricated on a single dielectrically isolated chip using complementary N and P channel MOS devices. This unique process produces exceptionally low leakage currents (even at +125°C), constant ON resistance, low power dissipation, and fast switching. The HI-1800A is available in a hermetic 16 pin dual-in-line package.

TRUTH TABLE

<table>
<thead>
<tr>
<th>INPUT ADDRESS</th>
<th>SWITCH CHANNELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 A2 A3 EN</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>L X X L</td>
<td>ON ON</td>
</tr>
<tr>
<td>H X X L</td>
<td>OFF OFF</td>
</tr>
<tr>
<td>X L X L</td>
<td>ON ON</td>
</tr>
<tr>
<td>X X H L</td>
<td>ON ON</td>
</tr>
<tr>
<td>X H L L</td>
<td>OFF OFF</td>
</tr>
<tr>
<td>X X X H</td>
<td>OFF OFF OFF</td>
</tr>
</tbody>
</table>

H≥+4.0V L≤+0.4V

PIN FUNCTIONS

ADDRESS 1 16
15 NEG. SUPPLY 11 OUT 1
14 POS. SUPPLY 10 IN 2
13 N.C. 9 OUT 2
12 IN 1
8 IN 3
7 OUT 3
6 IN 4
5 OUT 4
3 ENABLE
2 +5.0V SUPPLY
1 ADDRESS 2
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS (Note 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HI-1800A-2</th>
<th>HI-1800A-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage Between Pins 14 and 15</td>
<td>40.0V</td>
<td>30.0V</td>
</tr>
<tr>
<td>Logic Supply Voltage, Pin 2</td>
<td>30.0V</td>
<td>20.0V</td>
</tr>
<tr>
<td>Analog Input Voltage: V+Supply +2V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V-Supply -2V</td>
<td>780 mW (Note 2)</td>
<td></td>
</tr>
</tbody>
</table>

#### ELECTRICAL CHARACTERISTICS

**Supplies = +15V, -15V, +5.0V**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP.</th>
<th>HI-1800A-2 -55°C to +125°C</th>
<th>HI-1800A-5 0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALOG CHANNEL CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*V_{IN}, Analog Signal Range</td>
<td>Full</td>
<td>-15</td>
<td>-15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+15</td>
<td>+15</td>
</tr>
<tr>
<td>*Ron, ON Resistance (Note 3)</td>
<td>+25°C</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>*I_S (OFF), Input Leakage Current</td>
<td>Full</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>*I_D (OFF), Output Leakage Current</td>
<td>Full</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>*I_D (ON), On Channel Leakage Current</td>
<td>Full</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>DIGITAL INPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V_{IL}, Input Low Threshold</td>
<td>Full</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>V_{IH}, Input High Threshold (Note 4)</td>
<td>Full</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>*I_{IN}, Input Leakage Current</td>
<td>Full</td>
<td>.01</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>SWITCHING CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t_A, Access Time (Note 5)</td>
<td>+25°C</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Break-Before-Make Delay</td>
<td>+25°C</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>C_{IN}, Channel Input Capacitance</td>
<td>+25°C</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>C_{OUT}, Channel Output Capacitance</td>
<td>+25°C</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>C_{D}, Digital Input Capacitance</td>
<td>+25°C</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>POWER REQUIREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P_{D}, Power Dissipation</td>
<td>Full</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>P_{DS}, Standby Power (Note 6)</td>
<td>Full</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>*I_{+, Current Pin 14}</td>
<td>Full</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>*I_{-, Current Pin 15}</td>
<td>Full</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>*I_{L}, Current Pin 2</td>
<td>Full</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Voltage ratings apply when voltages at all other pins are within their nominal operating ranges.
2. Derate 9.25 mW/°C above t_A = +75°C
3. V_{OUT} = \pm 10V, I_{OUT} = \pm 100μA.
4. To drive from DTL/TTL circuits, 1K pullup resistors to +5.0V supply are recommended.
5. Time measured to 90% of final output level; V_{OUT} = -5.0V to +5.0V, Digital Inputs = 0.4V to +4.0V.
6. Voltage at Pin 3, ENABLE ≥ +4.0V.

*100% Tested For DASH 8
PERFORMANCE CHARACTERISTICS

ON RESISTANCE vs ANALOG SIGNAL LEVEL

\[ R_{ON} = \frac{V_2}{100 \mu A} \]

ON CHANNEL CURRENT vs VOLTAGE

ON/OFF LEAKAGE CURRENTS vs TEMPERATURE

ACCESS TIME
HI-1818A/1828A
8 Channel Analog Multiplexers

FEATURES

- SIGNAL RANGE: ±15V
- "ON" RESISTANCE: 250 Ω TYP.
- INPUT LEAKAGE AT +125°C: 20nA TYP.
- ACCESS TIME: 350ns TYP.
- POWER CONSUMPTION: 5mW TYP.
- DTL/TTL COMPATIBLE ADDRESS
- -55°C TO +125°C OPERATION

GENERAL DESCRIPTION

The Harris HI-1818A and HI-1828A Analog Multiplexers represent a significant breakthrough in analog switch performance. Vastly superior characteristics are obtained through the unique process of forming complementary MOS transistors in a dielectrically isolated substrate. These devices are useful as multiplexers, signal selectors, and choppers over a wide range of signal levels and switching frequencies. The HI-1818A is a single 8 channel multiplexer while the HI-1828A is a differential 4 channel version. The devices are packaged in a standard 16 pin dual in-line hermetic case and are available in the full military or commercial temperature ranges.

PIN OUT/TRUTH TABLE

HI-1818A

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>16 ADDRESS A0</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>±15V</td>
</tr>
<tr>
<td>+5.0V SUPPLY</td>
<td>15-15V SUPPLY</td>
</tr>
<tr>
<td>ENABLE</td>
<td>14+15V SUPPLY</td>
</tr>
<tr>
<td>ADDRESS</td>
<td>13 IN 1</td>
</tr>
<tr>
<td>A2</td>
<td>12 OUT</td>
</tr>
<tr>
<td>IN 8</td>
<td>11 IN 2</td>
</tr>
<tr>
<td>IN 7</td>
<td>10 IN 3</td>
</tr>
<tr>
<td>IN 6</td>
<td>9 IN 4</td>
</tr>
</tbody>
</table>

ADDRESS

A2 A1 A0 EN "ON" CHANNEL
L L L L 1
L L H L 2
L H L L 3
L H H L 4
H L L L 5
H L H L 6
H H L L 7
H H H L 8
X X X H NONE

HI-1828A

ADDRESS A1 A0 EN "ON" CHANNEL
L L L L 1 and 5
L H L L 2 and 6
H H L L 4 and 8
H H H L NONE

ADDRESS

A1 A0 EN "ON" CHANNEL
L L L L 13 IN 1
L H L L 12 OUT 1 THROUGH 4
IN 8 5
IN 7 6
IN 6 7
IN 5 8
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS (NOTE 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage Between Pins 14 and 15</td>
<td></td>
<td></td>
<td>40.0V</td>
<td></td>
</tr>
<tr>
<td>Logic Supply Voltage, Pin 2</td>
<td></td>
<td></td>
<td>30.0V</td>
<td></td>
</tr>
<tr>
<td>Analog Input Voltage: V&lt;sub&gt;Supply&lt;/sub&gt; +2V</td>
<td></td>
<td></td>
<td>5.0V</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;Supply&lt;/sub&gt; -2V</td>
<td></td>
<td></td>
<td>-5.0V</td>
<td></td>
</tr>
<tr>
<td>Digital Input Voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Power Dissipation (Note 2)</td>
<td></td>
<td></td>
<td>780mW</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td></td>
<td></td>
<td>-65°C to +150°C</td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

Supplies = +15V, -15V, +5V

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-55°C to +125°C</td>
<td>0°C to +75°C</td>
</tr>
<tr>
<td><strong>ANALOG CHANNEL CHARACTERISTICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* V&lt;sub&gt;IN&lt;/sub&gt;, Analog Signal Range</td>
<td>Full -15 15</td>
<td>Full -15 15</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>* R&lt;sub&gt;ON&lt;/sub&gt;, ON Resistance (Note 3)</td>
<td>+25°C 250 400</td>
<td>+25°C 250 400</td>
</tr>
<tr>
<td></td>
<td>Ω</td>
<td>Ω</td>
</tr>
<tr>
<td>* I&lt;sub&gt;G&lt;/sub&gt;(OFF), Input Leakage Current</td>
<td>Full 20 50</td>
<td>Full 20 50</td>
</tr>
<tr>
<td></td>
<td>nA</td>
<td>nA</td>
</tr>
<tr>
<td>* I&lt;sub&gt;D&lt;/sub&gt;(ON), On Channel Leakage (HI-1818A)</td>
<td>Full 100 250</td>
<td>Full 100 250</td>
</tr>
<tr>
<td>Current (HI-1828A)</td>
<td>nA</td>
<td>nA</td>
</tr>
<tr>
<td>* I&lt;sub&gt;D&lt;/sub&gt;(OFF) Output Leakage Current (HI-1818A)</td>
<td>Full 100 250</td>
<td>Full 100 250</td>
</tr>
<tr>
<td>(HI-1828A)</td>
<td>nA</td>
<td>nA</td>
</tr>
<tr>
<td><strong>DIGITAL INPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;L&lt;/sub&gt;, Input Low Threshold</td>
<td>Full 0.4</td>
<td>Full 0.4</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;H&lt;/sub&gt;, Input High Threshold (Note 4)</td>
<td>Full 4.0</td>
<td>Full 4.0</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>V</td>
</tr>
<tr>
<td>* I&lt;sub&gt;IN&lt;/sub&gt;, Input Leakage Current</td>
<td>Full .01 1</td>
<td>Full .01 1</td>
</tr>
<tr>
<td></td>
<td>μA</td>
<td>μA</td>
</tr>
<tr>
<td><strong>SWITCHING CHARACTERISTICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T&lt;sub&gt;S&lt;/sub&gt;, Access Time (Note 5)</td>
<td>+25°C 350</td>
<td>+25°C 350</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Break-Before-Make Delay</td>
<td>+25°C 100</td>
<td>+25°C 100</td>
</tr>
<tr>
<td></td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>C&lt;sub&gt;IN&lt;/sub&gt;, Channel Input Capacitance</td>
<td>+25°C 4</td>
<td>+25°C 4</td>
</tr>
<tr>
<td></td>
<td>pF</td>
<td>pF</td>
</tr>
<tr>
<td>C&lt;sub&gt;OUT&lt;/sub&gt;, Channel Output Capacitance (HI-1818A)</td>
<td>+25°C 20</td>
<td>+25°C 20</td>
</tr>
<tr>
<td>(HI-1828A)</td>
<td>pF</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td>+25°C 10</td>
<td>+25°C 10</td>
</tr>
<tr>
<td></td>
<td>pF</td>
<td>pF</td>
</tr>
<tr>
<td>C&lt;sub&gt;D&lt;/sub&gt;, Digital Input Capacitance</td>
<td>+25°C 5</td>
<td>+25°C 5</td>
</tr>
<tr>
<td></td>
<td>pF</td>
<td>pF</td>
</tr>
<tr>
<td><strong>POWER REQUIREMENTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&lt;sub&gt;D&lt;/sub&gt;, Power Dissipation</td>
<td>Full 5</td>
<td>Full 5</td>
</tr>
<tr>
<td></td>
<td>mW</td>
<td>mW</td>
</tr>
<tr>
<td>P&lt;sub&gt;DS&lt;/sub&gt;, Standby Power (Note 6)</td>
<td>Full 5</td>
<td>Full 5</td>
</tr>
<tr>
<td></td>
<td>mW</td>
<td>mW</td>
</tr>
<tr>
<td>* I&lt;sub&gt;+. Current Pin 14</td>
<td>Full 0.1 0.5</td>
<td>Full 0.1 0.5</td>
</tr>
<tr>
<td></td>
<td>mA</td>
<td>mA</td>
</tr>
<tr>
<td>* I&lt;sub&gt;- Current Pin 15</td>
<td>Full 0.3 1</td>
<td>Full 0.3 1</td>
</tr>
<tr>
<td></td>
<td>mA</td>
<td>mA</td>
</tr>
<tr>
<td>* I&lt;sub&gt;L&lt;/sub&gt;, Current Pin 2</td>
<td>Full 0.3 1</td>
<td>Full 0.3 1</td>
</tr>
<tr>
<td></td>
<td>mA</td>
<td>mA</td>
</tr>
<tr>
<td><strong>NOTES:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Voltage ratings apply when voltages at all other pins are within their nominal operating ranges.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Derate 9.25 mW/°C above 75°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. V&lt;sub&gt;OUT&lt;/sub&gt; = ±10V I&lt;sub&gt;OUT&lt;/sub&gt; = -100 μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. To drive from DTL/TTL circuits, 1KΩ pullup resistors to +5.0V supply are recommended.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Time measured to 90% of final output level; V&lt;sub&gt;OUT&lt;/sub&gt; = -5.0V to +5.0V, Digital Inputs = 0V to +4.0V.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Voltage at Pin 3, ENABLE = +4.0V.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*100% Tested For DASH 8
PERFORMANCE CHARACTERISTICS

ON RESISTANCE vs ANALOG SIGNAL LEVEL

ON CHANNEL CURRENT vs VOLTAGE

ON/OFF LEAKAGE CURRENTS vs TEMPERATURE

ACCESS TIME

Test Circuit

Test Circuit

Test Circuit
HI-5040 thru HI-5051
HI-5046A and HI-5047A
CMOS Analog Switches

FEATURES

- WIDE ANALOG SIGNAL RANGE
- LOW "ON" RESISTANCE (TYP)
- HIGH CURRENT CAPABILITY (TYP)
- BREAK-BEFORE-MAKE SWITCHING
  TURN-ON TIME (TYP)
  TURN-OFF TIME (TYP)
- NO LATCH-UP
- INPUT MOS GATES ARE PROTECTED FROM ELECTROSTATIC DISCHARGE
- DTL, TTL, CMOS, PMOS COMPATIBLE

DESCRIPTION

This family of CMOS ANALOG SWITCHES offers high performance at analog levels up to the supply rails. Low leakages, low "ON" resistance and high "OFF ISOLATION" characteristics are achieved using the latch-free, high reliability, Harris Dielectric Isolation process. These monolithic chips incorporate bipolar with MOS devices for minimizing power consumption when CMOS logic levels are used. The HI-5040 series replaces the IH-5040 family and is functionally compatible to the DG 180/190 family. The HI-5046A/5047A are proprietary 30 ohm versions of the HI-5046/5047. All are available in both commercial and military temperature ranges.

PACKAGES

CODE 1D 16 LEAD CERAMIC D.I.P.

CODE 9H 14 LEAD FLAT PACK (TO–86)

FUNCTIONAL DIAGRAM

TYPICAL SWITCH

FUNCTIONAL DESCRIPTION

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>TYPE</th>
<th>RQN</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI-5040</td>
<td>SPST</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5041</td>
<td>DUAL SPST</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5042</td>
<td>SPDT</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5043</td>
<td>DUAL SPDT</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5044</td>
<td>DPST</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5045</td>
<td>DUAL DPST</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5046</td>
<td>DPDT</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5046A</td>
<td>DPDT</td>
<td>30Ω</td>
</tr>
<tr>
<td>HI-5047</td>
<td>4PST</td>
<td>75Ω</td>
</tr>
<tr>
<td>HI-5047A</td>
<td>4PST</td>
<td>30Ω</td>
</tr>
<tr>
<td>HI-5048</td>
<td>DUAL SPST</td>
<td>30Ω</td>
</tr>
<tr>
<td>HI-5049</td>
<td>DUAL DPST</td>
<td>30Ω</td>
</tr>
<tr>
<td>HI-5050</td>
<td>SPDT</td>
<td>30Ω</td>
</tr>
<tr>
<td>HI-5051</td>
<td>DUAL SPDT</td>
<td>30Ω</td>
</tr>
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</table>
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>36V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_R$ to Ground</td>
<td>$V^+,-V^-$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital and Analog Input Voltage</td>
<td>$V^+ +4V$</td>
<td></td>
<td>$V^- -4V$</td>
</tr>
</tbody>
</table>

Analog Current (S to D) 80mA
Total Power Dissipation* 450mW

**Operating Temperature**
- HI-50XX-2 -55°C to +125°C
- HI-50XX-5 0°C to +75°C

Storage Temperature -65°C to +150°C

*Derate 6mW/°C above $T_A = 75°C$

### ELECTRICAL CHARACTERISTICS

#### Unless Otherwise Specified

Supplies = +15V, -15V; $V_R = 0V$; $V_{AH}$ (Logic Level High) = 3.0V; $V_{AL}$ (Logic Level Low) = +0.8V, $V_L = +5V$

For Test Conditions, consult Performance Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP</th>
<th>-55°C to +125°C</th>
<th>0°C to +75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALOG SWITCH CHARACTERISTICS</strong></td>
<td></td>
<td>MIN</td>
<td>TYP</td>
</tr>
<tr>
<td>Analog Signal Range</td>
<td>Full</td>
<td>-15</td>
<td>+15</td>
</tr>
<tr>
<td>Ron, &quot;ON&quot; Resistance (Note 1a)</td>
<td>$+25°C$</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Ron, &quot;ON&quot; Resistance (Note 1b)</td>
<td></td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Ron, Channel-to-Channel Match (Note 1a)</td>
<td>$+25°C$</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Ron, Channel-to-Channel Match (Note 1b)</td>
<td>$+25°C$</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>$I_{G(OFF)} = I_{D(OFF)}$, Off Input or Output Leakage Current</td>
<td>$+25°C$</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>$I_{D(OFF)}$, On Leakage Current</td>
<td>$+25°C$</td>
<td>0.01</td>
<td>500</td>
</tr>
</tbody>
</table>

| **DIGITAL INPUT CHARACTERISTICS** |       |     |     |     |     |     |     |       |
| $V_{AL}$, Input Low Threshold    | Full  | 0.8 | 0.8 | V   |     |     |     |       |
| $V_{AH}$, Input High Threshold   | Full  | 3.0 | 3.0 | V   |     |     |     |       |
| $I_A$, Input Leakage Current (High or Low) | Full | .01 | 1.0 | .01 | 1.0 | μA |     |       |

| **SWITCHING CHARACTERISTICS** |       |     |     |     |     |     |     |       |
| $t_{ON}$, Switch "ON" Time      | $+25°C$ | 370 | 1000 | 370 | ns |     |     |       |
| $t_{OFF}$, Switch "OFF" Time    | $+25°C$ | 280 | 500  | 280 | ns |     |     |       |
| Charge Injection (Note 2)       | $+25°C$ | 5   | 20   | 5   | mV |     |     |       |
| "OFF Isolation" (Note 3)        | $+25°C$ | 75  | 80   | 80  | dB |     |     |       |
| "Crosstalk" (Note 3)            | $+25°C$ | 80  | 88   | 88  | dB |     |     |       |
| $C_{S(OFF)}$, Input Switch Capacitance | $+25°C$ | 11  | 11   | pF  |     |     |     |       |
| $C_{D(OFF)}$, Output Switch Capacitance | $+25°C$ | 11  | 11   | pF  |     |     |     |       |
| $C_{A}$, Digital Input Capacitance | $+25°C$ | 22  | 22   | pF  |     |     |     |       |
| $C_{DS(OFF)}$, Drain-To-Source Capacitance | $+25°C$ | 5   | 5    | pF  |     |     |     |       |

#### POWER REQUIREMENTS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TEMP</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_D$, Quiescent Power Dissipation</td>
<td>$+25°C$</td>
<td>1.5</td>
<td>1.5</td>
<td>mW</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$I^+ +15V$ Quiescent Current</td>
<td>Full</td>
<td>0.3</td>
<td>0.5</td>
<td>mA</td>
<td></td>
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<td></td>
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<tr>
<td>$I^-, -15V$ Quiescent Current</td>
<td>Full</td>
<td>0.3</td>
<td>0.5</td>
<td>mA</td>
<td></td>
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<tr>
<td>$I_L$, +5V Quiescent Current</td>
<td>Full</td>
<td>0.3</td>
<td>0.5</td>
<td>mA</td>
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<tr>
<td>$I_R$, Gnd Quiescent Current</td>
<td>Full</td>
<td>0.3</td>
<td>0.5</td>
<td>mA</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**NOTES:**
1. $V_{OUT} = ±10V$, $I_{OUT} = 1mA$
2. For HI-5040 thru HI-5047
3. For HI-5048 thru HI-5051, HI-5046A/5047A
4. $V_{IN} = 0V$, $C_L = 10,000pF$
5. $R_L = 100Ω$, $f = 100KHz$, $V_{IN} = 2V_{pp}$, $C_L = 5pF$

Li-154
## Switch Functions

### Switch States Are for Logic "1" Input

<table>
<thead>
<tr>
<th>Switch Type</th>
<th>Model</th>
<th>Function</th>
<th>Flatpack</th>
<th>Cerdip</th>
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</thead>
<tbody>
<tr>
<td>SPST</td>
<td>HI-5040 (75Ω)</td>
<td>Flatpack</td>
<td><img src="image" alt="Flatpack SPST" /></td>
<td><img src="image" alt="Cerdip SPST" /></td>
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<tr>
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<td>Cerdip</td>
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<td>SPDT</td>
<td>HI-5042 (75Ω)</td>
<td>Flatpack</td>
<td><img src="image" alt="Flatpack SPDT" /></td>
<td><img src="image" alt="Cerdip SPDT" /></td>
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<tr>
<td>DPST</td>
<td>HI-5044 (75Ω)</td>
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<td>DPDT</td>
<td>HI-5046 (75Ω)</td>
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<tr>
<td></td>
<td>HI-5046A (30Ω)</td>
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<tr>
<td>Dual SPST</td>
<td>HI-5048 (30Ω)</td>
<td>Flatpack</td>
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<tr>
<td>Dual SPDT</td>
<td>HI-5049 (30Ω)</td>
<td>Flatpack</td>
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<td>SPDT</td>
<td>HI-5050 (30Ω)</td>
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<tr>
<td>Dual SPDT</td>
<td>HI-5051 (30Ω)</td>
<td>Flatpack</td>
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</tr>
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<td></td>
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<td>Cerdip</td>
<td><img src="image" alt="Cerdip Dual SPDT" /></td>
<td><img src="image" alt="Cerdip Dual SPDT" /></td>
</tr>
</tbody>
</table>
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS

(UNLESS OTHERWISE SPECIFIED TA = 25°C, V^+ = +15V, V^- = -15V, VL = +5V, VR = 0V, VAH = 3.0V and VAL = 0.8V)

ON RESISTANCE vs. ANALOG SIGNAL LEVEL, SUPPLY VOLTAGE AND TEMPERATURE

R_{ON} = \frac{V_2}{1mA}

ON’” RESISTANCE vs. ANALOG SIGNAL LEVEL AND POWER SUPPLY VOLTAGE

NORMALIZED "ON" RESISTANCE vs. TEMPERATURE

V_{IN} = 0V
ON/OFF LEAKAGE CURRENT vs. TEMPERATURE

- $I_{S(OFF)} = I_{D(OFF)}$
- $I_{D(ON)}$

 OFF LEAKAGE CURRENT vs. TEMPERATURE

 ON LEAKAGE CURRENT vs. TEMPERATURE

NORMALIZED "ON" RESISTANCE vs. ANALOG CURRENT

- $R_{ON} = \frac{V_{IN}}{I}$

"ON" RESISTANCE vs. ANALOG CURRENT

NORMALIZED "ON" RESISTANCE (REFERRED TO 1mA)

- 1.4
- 1.3
- 1.2
- 1.1
- 1.0

ANALOG CURRENT - mA
PERFORMANCE CHARACTERISTICS AND TEST CIRCUITS (continued)

"OFF" ISOLATION vs. FREQUENCY

"OFF" ISOLATION = 20 \log \left( \frac{V_{IN}}{V_{OUT}} \right)

CROSSTALK vs. FREQUENCY

"CROSSTALK" = 20 \log \left( \frac{V_{IN}}{V_{OUT}} \right)

POWER CONSUMPTION vs. FREQUENCY

TOGGLE FREQUENCY (50% DUTY CYCLE) - Hz

RL = 100Ω
RL = 10KΩ
RL = 1KΩ
RL = 10KΩ
SWITCHING CHARACTERISTICS

ON/OFF SWITCH TIME
vs. LOGIC LEVEL

SWITCHING TIMES FOR POSITIVE DIGITAL TRANSITION

SWITCHING TIMES FOR NEGATIVE DIGITAL TRANSITION

SWITCHING WAVEFORMS

TOP: TTL INPUT (1V/DIV)
V_{AH} = 3V, V_{AL} = 0.8V
BOTTOM: OUTPUT (5V/DIV)

TOP: CMOS INPUT (5V/DIV)
V_{AH} = 10V, V_{AL} = 0V
BOTTOM: OUTPUT (5V/DIV)

200ns/DIV
*Connect $V^+$ to $V_L$ for minimizing power consumption when driving from CMOS circuits.

**TTL/CMOS Reference Circuit**

**Switch Cell**

**Digital Input Buffer and Level Shifter**

**ALL N-CHANNEL BODIES TO V-**

**ALL P-CHANNEL BODIES TO V+**

EXCEPT AS SHOWN
On the subject of field programmable read-only memories the words PROM and Harris Semiconductor are virtually inseparable. The first effort to produce user programmable logic was ushered in by Harris in 1967 with the introduction of the diode matrix family. Again, in 1969, the advent of the HPR0M-0512 heralded the world's first monolithic field programmable read-only memory. This prototype, featuring nichrome fuse technology paved the way for future PROM generations establishing unprecedented reliability attested to by the fact that the HPR0M-0512, as of the printing of this catalog, is still the only field programmable read-only memory to receive full JAN 38510 certification.

After six years of high volume PROM manufacturing Harris Semiconductor remains today the world's largest single manufacturer of PROMs. Now, this high volume experience, coupled with continuing reliability, introduces the next generation in PROM development, the "GENERIC" family of PROMs. With design controlled by a family concept, each GENERIC PROM features identical programming, improved AC performance guaranteed over full temperature and voltage ranges, common circuit design and process technology. We invite you to study our GENERIC data sheets. You will soon see that "to know one GENERIC PROM is to know them all". Simplified device qualification, simplified system redesign and upgrading, maximum standardization and minimum costs; they're all in the family with GENERIC PROMs.
<table>
<thead>
<tr>
<th>PAGE</th>
<th>ITEM</th>
<th>ITEM DESCRIPTION</th>
</tr>
</thead>
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<tr>
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<td>HD-234/534</td>
<td>Hex Interface Inverters</td>
</tr>
<tr>
<td>Me-3</td>
<td>HD-235/535</td>
<td>Hex Interface Drivers</td>
</tr>
<tr>
<td>Me-9</td>
<td>HD-6600</td>
<td>Quad Power Strobe</td>
</tr>
<tr>
<td>Me-9</td>
<td>HD-6605</td>
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</tr>
<tr>
<td>Me-13</td>
<td>HM-010/030/040/050/074/080/090</td>
<td>MIL Temperature Diode Matrices</td>
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<td>Me-21</td>
<td>HM-0110/0168/0104/0186</td>
<td>Commercial Diode Matrices</td>
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<tr>
<td>Me-23</td>
<td>HM-7202</td>
<td>1024 x 7 N-Channel MOS RAM</td>
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<tr>
<td>Me-27</td>
<td>Generic Prom Product Chart</td>
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<tr>
<td>Me-28</td>
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<td>256-Bit Field Programmable Bipolar PROM</td>
</tr>
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<td>Me-32</td>
<td>HM-7610/7611</td>
<td>1024-Bit Field Programmable Bipolar PROM</td>
</tr>
<tr>
<td>Me-36</td>
<td>HM-7620/7621</td>
<td>2048-Bit Field Programmable Bipolar PROM</td>
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<tr>
<td>Me-40</td>
<td>HM-7640/7641</td>
<td>4096-Bit Field Programmable Bipolar PROM</td>
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<td>Me-44</td>
<td>Harris Bipolar Prom Cross-Reference</td>
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<td>Me-45</td>
<td>HPROM-0512</td>
<td>512- Bit Field Programmable Bipolar PROM</td>
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<td>HPROM-1024/1024A</td>
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<td>Me-55</td>
<td>HPROM-8256</td>
<td>256-Bit Field Programmable Bipolar PROM</td>
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</table>
**GENERAL DESCRIPTION**

The integrated circuits covered by this data sheet form a part of Harris' family of Military and Industrial Monolithic Interface Circuits intended for use as universal inverters, translators between logic families, as logic drivers in Monolithic Diode Matrix logic and in high voltage applications. The interface circuit with the node-input is compatible with all logic families, RTL, DTL, T2L and CML. The circuits are fabricated within a single monolithic silicon chip using passivated epitaxial techniques and Harris' Dielectric Isolation method. Each circuit type consists of six node-input inverters as shown in the circuit schematic. Use of Dielectric Isolation provides parasitic-free operation with electrical performance surpassing that of conventionally constructed integrated circuits. Harris' Interface Circuits are designed to meet or exceed the mechanical and environmental requirements of MIL-STD-883.

### MILITARY 200 SERIES

### INDUSTRIAL 500 SERIES

**BASIC TYPES OF INTERFACE CIRCUITS**

<table>
<thead>
<tr>
<th>Type</th>
<th>200 Series</th>
<th>500 Series</th>
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</thead>
<tbody>
<tr>
<td><strong>HEX INTERFACE INVERTER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROPAGATION DELAY</td>
<td>10ns</td>
<td></td>
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<tr>
<td>POWER DISSIPATION</td>
<td>10mW</td>
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</tr>
<tr>
<td>OUTPUT BREAKDOWN VOLTAGE</td>
<td>6V</td>
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</tr>
<tr>
<td><strong>HIGH VOLTAGE HEX INTERFACE DRIVER</strong></td>
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<td></td>
</tr>
<tr>
<td>PROPAGATION DELAY</td>
<td>35ns</td>
<td></td>
</tr>
<tr>
<td>POWER DISSIPATION</td>
<td>10mW</td>
<td></td>
</tr>
<tr>
<td>OUTPUT BREAKDOWN VOLTAGE</td>
<td>35V</td>
<td></td>
</tr>
<tr>
<td><strong>HIGH VOLTAGE HEX INDICATOR DRIVER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TURN-ON OR TURN-OFF DELAY</td>
<td>0.8μs</td>
<td></td>
</tr>
<tr>
<td>PROPAGATION DELAY</td>
<td>35ns</td>
<td></td>
</tr>
<tr>
<td>POWER DISSIPATION</td>
<td>12mW</td>
<td></td>
</tr>
<tr>
<td>OUTPUT BREAKDOWN VOLTAGE</td>
<td>55V</td>
<td></td>
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</tbody>
</table>

**SELECTION GUIDE**

**HEX INTERFACE INVERTER**
- 200 SERIES: PAGES Di - 9, Di - 10
- 500 SERIES: PAGES Di - 9, Di - 12

**HEX INTERFACE DRIVER**
- 200 SERIES: PAGES Di - 9, Di - 11
- 500 SERIES: PAGES Di - 9, Di - 13

**HEX INDICATOR DRIVER**
- 500 SERIES: PAGES Di - 9, Di - 14
### Absolute Maximum Ratings

- **Input Voltage**: +6 Volts
- **Output Voltage**: +6 Volts
- **Operating Temp.**: -55°C to +125°C
- **Vcc**: +8 Volts
- **Storage Temp.**: -65°C to +150°C

Maximum ratings are limiting values above which permanent circuit damage may occur.

### Static Electrical Characteristics (Notes 1, 4)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
</tr>
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<td>&quot;1&quot; OUTPUT VOLTAGE</td>
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<td></td>
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<td>4.5</td>
</tr>
<tr>
<td>node Input</td>
<td>4.0</td>
<td>4.5</td>
</tr>
<tr>
<td>node Input</td>
<td>3.7</td>
<td>4.4</td>
</tr>
<tr>
<td>&quot;0&quot; OUTPUT VOLTAGE</td>
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<td></td>
</tr>
<tr>
<td>node Input</td>
<td>.25</td>
<td>.45</td>
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<td>node Input</td>
<td>.25</td>
<td>.40</td>
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<td>.25</td>
<td>.45</td>
</tr>
<tr>
<td>&quot;0&quot; INPUT CURRENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>2.55</td>
<td>3.45</td>
</tr>
<tr>
<td>node Input</td>
<td>1.80</td>
<td>2.70</td>
</tr>
<tr>
<td>node Input</td>
<td>2.30</td>
<td>3.45</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
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</tr>
<tr>
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<tr>
<td></td>
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<td>17.5</td>
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<tr>
<td></td>
<td>8</td>
<td>11.0</td>
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<tr>
<td>OUTPUT CAPACITANCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.0</td>
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</tr>
<tr>
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### Switching (Dynamic) Characteristics

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>TEST CONDITIONS</th>
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<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
</tr>
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<td>Turn On Delay</td>
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<tr>
<td>t_on</td>
<td>20</td>
<td>35</td>
</tr>
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<td>13</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Turn Off Delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t_off</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Propagation Delay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t pd</td>
<td>8</td>
<td>12</td>
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</table>
## ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Temp.</th>
<th>Vcc</th>
<th>Driven Input</th>
<th>Output</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>+6</td>
<td></td>
<td></td>
<td>Volt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>+35mA</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-55°C</td>
<td>+125°C</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-65°C</td>
<td>+150°C</td>
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<td></td>
<td></td>
<td></td>
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</table>

Maximum ratings are limiting values above which permanent circuit damage may occur.

## STATIC ELECTRICAL CHARACTERISTICS (Notes 1, 4)

### CHARACTERISTIC

#### LIMITS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Temp.</th>
<th>Vcc</th>
<th>Driven Input</th>
<th>Output</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>29</td>
<td></td>
<td></td>
<td>V</td>
<td>-55°C</td>
<td>4.5V</td>
<td></td>
<td>2.2V</td>
<td>SEE</td>
</tr>
<tr>
<td>node Input</td>
<td>29</td>
<td></td>
<td></td>
<td>V</td>
<td>+25°C</td>
<td>4.5V</td>
<td></td>
<td>1.8V</td>
<td>NOTE</td>
</tr>
<tr>
<td>node Input</td>
<td>28</td>
<td></td>
<td></td>
<td>V</td>
<td>+125°C</td>
<td>4.5V</td>
<td></td>
<td>1.2V</td>
<td>2b</td>
</tr>
<tr>
<td>&quot;0&quot; Output Voltage</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>.55</td>
<td>1.0</td>
<td></td>
<td>V</td>
<td>-55°C</td>
<td>4.5V</td>
<td></td>
<td>5mA</td>
<td>3</td>
</tr>
<tr>
<td>node Input</td>
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<td>3.45</td>
<td>mA</td>
<td>V</td>
<td>+25°C</td>
<td>5.0V</td>
<td></td>
<td>10mA</td>
<td>3</td>
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<tr>
<td>node Input</td>
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<td>3.45</td>
<td>mA</td>
<td>V</td>
<td>+125°C</td>
<td>5.5V</td>
<td></td>
<td>10mA</td>
<td>3</td>
</tr>
<tr>
<td>&quot;0&quot; Input Current</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>node Input</td>
<td>2.55</td>
<td>3.45</td>
<td>mA</td>
<td>V</td>
<td>-55°C</td>
<td>5.5V</td>
<td></td>
<td>.35V</td>
<td>3</td>
</tr>
<tr>
<td>node Input</td>
<td>2.70</td>
<td>3.45</td>
<td>mA</td>
<td>V</td>
<td>+25°C</td>
<td>5.5V</td>
<td></td>
<td>.35V</td>
<td>3</td>
</tr>
<tr>
<td>node Input</td>
<td>2.30</td>
<td>3.45</td>
<td>mA</td>
<td>V</td>
<td>+125°C</td>
<td>5.5V</td>
<td></td>
<td>.35V</td>
<td>3</td>
</tr>
<tr>
<td>&quot;1&quot; Output Current</td>
<td>.025</td>
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<td>µA</td>
<td>V</td>
<td>+25°C</td>
<td>4.5V</td>
<td></td>
<td>GND</td>
<td>30V</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>50</td>
<td>µA</td>
<td>V</td>
<td>+125°C</td>
<td>4.5V</td>
<td></td>
<td>GND</td>
<td>30V</td>
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</table>

### SWITCHING (DYNAMIC) CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Temp.</th>
<th>Vcc</th>
<th>Test Circuit</th>
</tr>
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<tbody>
<tr>
<td>Propagation Delay</td>
<td>35</td>
<td>70</td>
<td>ns</td>
<td></td>
<td>-55°C</td>
<td>5.0V</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>80</td>
<td>ns</td>
<td></td>
<td>+25°C</td>
<td>5.0V</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>80</td>
<td>ns</td>
<td></td>
<td>+125°C</td>
<td>5.0V</td>
<td>3</td>
</tr>
</tbody>
</table>

### NOTES:

1. This specification is written for one gate element. With multiple element packages, all elements within the package must qualify for the package to obtain “type” classification.
2a. The output is to be returned to Vcc through 5.6kΩ for these tests.
2b. The output is to be returned to +30V through 5.6kΩ for these tests.
3. “NAND” Logic Definitions: “UP” Level = “1”, “DOWN” Level = “0”.
4. All measurements made with Pin 7 at zero volts. All voltage and capacitance measurements are referenced to pin 7. Terminals not specifically mentioned are left electrically open.
5. These measurements must be made using current forcing, voltage measuring techniques.
### Absolute Maximum Ratings

- **Input Voltage**: +6 Volts
- **Output Current**: +50mA
- **Output Voltage**: +8 Volts
- **Operating Temp.**: 0°C to +75°C
- **Storage Temp.**: -65°C to +150°C

Maximum ratings are limiting values above which permanent circuit damage may occur.

### Static Electrical Characteristics (Notes 1, 4)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“1” Output Voltage</strong></td>
<td></td>
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</tr>
<tr>
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<td>MIN.</td>
<td>TYP.</td>
</tr>
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<tr>
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<td>3.8</td>
</tr>
<tr>
<td>node Input</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>“0” Output Voltage</strong></td>
<td></td>
<td></td>
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<tr>
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<td>.45</td>
</tr>
<tr>
<td>node Input</td>
<td>.30</td>
<td>.45</td>
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<td>node Input</td>
<td>.30</td>
<td>.45</td>
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<td></td>
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<td>3.45</td>
</tr>
<tr>
<td>node Input</td>
<td>2.70</td>
<td>3.45</td>
</tr>
<tr>
<td>node Input</td>
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<td>3.45</td>
</tr>
<tr>
<td><strong>“1” Output Current</strong></td>
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<td>.05</td>
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<td><strong>Power Dissipation</strong></td>
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<td></td>
<td>14.8</td>
<td>17.5</td>
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<td>10.0</td>
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<tr>
<td><strong>Output Capacitance</strong></td>
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<tr>
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<td>2.0</td>
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### Switching (Dynamic) Characteristics

<table>
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<th>LIMITS</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
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<td>MIN.</td>
<td>TYP.</td>
</tr>
<tr>
<td>Propagation Delay ( t_{pd} )</td>
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### Absolute Maximum Ratings

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</thead>
<tbody>
<tr>
<td>+6 Volts</td>
<td>+35mA</td>
<td>-0°C to +75°C</td>
<td>-65°C to +150°C</td>
</tr>
<tr>
<td>+35 Volts</td>
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</tbody>
</table>

Maximum ratings are limiting values above which permanent circuit damage may occur.

### Static Electrical Characteristics (Notes 1, 4)

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<thead>
<tr>
<th>Characteristic</th>
<th>Limits</th>
<th>Test Conditions</th>
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<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Typ.</td>
</tr>
<tr>
<td>“1” Output Voltage</td>
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<td></td>
</tr>
<tr>
<td>node Input</td>
<td>29</td>
<td>V</td>
</tr>
<tr>
<td>node Input</td>
<td>29</td>
<td>V</td>
</tr>
<tr>
<td>node Input</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>“0” Output Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>.65</td>
<td>1.0</td>
</tr>
<tr>
<td>node Input</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>node Input</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>“0” Input Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>2.95</td>
<td>3.45</td>
</tr>
<tr>
<td>node Input</td>
<td>1.80</td>
<td>2.95</td>
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<tr>
<td>node Input</td>
<td>2.95</td>
<td>3.45</td>
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<tr>
<td>“1” Output Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>.1</td>
<td>1</td>
</tr>
<tr>
<td>node Input</td>
<td>1</td>
<td>50</td>
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<tr>
<td>Power Dissipation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>node Input</td>
<td>14.8</td>
<td>17.5</td>
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<tr>
<td>node Input</td>
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<td>11.0</td>
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<tr>
<td>Output Capacitance</td>
<td></td>
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<tr>
<td>node Input</td>
<td>5.0</td>
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### Switching (Dynamic) Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Limits</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Typ.</td>
</tr>
<tr>
<td>Propagation Delay ( t_{pd} )</td>
<td>35</td>
<td>70</td>
</tr>
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</table>
**TEST CIRCUITS**

Test Circuit No. 1

```
\[
\begin{align*}
\text{INPUT PULSE} & \quad t_o = t_i = 5ms \\
& \quad f = 1MHz \\
& \quad pw = 100ns
\end{align*}
\]

Test Circuit No. 2

```

Test Circuit No. 3

```

Test Circuit No. 4

```

**PACKAGING**

Package outline drawings for Harris Integrated Circuits products are illustrated below. For each package, a particular Harris protective carrier is used in production, testing, and handling. If desired, this protective carrier may be specified for shipping purposes. Harris can also furnish custom designed packages from its in-house facility. The package Carriers and their relationship to corresponding test contactors are shown.

**CODE 9V**  TO-86 (METAL BOTTOM)

**CODE 1S**  14 LEAD BRAZED D.I.P.

---

ALL DIMENSIONS ARE IN INCHES.
ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.
FEATURES

- HIGH DRIVE CURRENT – 200mA
- HIGH SPEED 50ns TYPICAL
- TTL COMPATIBLE INPUTS
- DIELECTRIC ISOLATION
- QUAD MONOLITHIC CONSTRUCTION
- POWER SUPPLY FLEXIBILITY
- LOW POWER STANDBY 30mW/CIRCUIT
- ACTIVE 95mW/CIRCUIT

DESCRIPTION

The HD-6600 Quad Power Strobe and HD-6605 Quad Logic Strobe are constructed with Harris Dielectric Isolation Bipolar Monolithic Process. The design incorporates power supply flexibility with TTL compatible inputs and high current outputs.

CIRCUIT DIAGRAM

LOGIC DIAGRAM
# SPECIFICATIONS

## ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage</td>
<td>$V_{CC1}$</td>
<td>$5.0$</td>
<td>$-10$</td>
<td>$0$</td>
<td>VDC</td>
</tr>
<tr>
<td>$V_{CC2}$</td>
<td></td>
<td>$5.0$</td>
<td>$-15$</td>
<td>$0$</td>
<td>VDC</td>
</tr>
<tr>
<td>$V_{CC3}$</td>
<td></td>
<td>$5.0$</td>
<td>$-20$</td>
<td>$0$</td>
<td>VDC</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>$V_{IN}$</td>
<td>$-0.5$</td>
<td>$+5.5$</td>
<td>$V$</td>
<td>DC</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{STG}$</td>
<td>$-65$</td>
<td>$+150$</td>
<td>$C$</td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>$I_L$</td>
<td>$-300$</td>
<td></td>
<td>$mA$</td>
<td></td>
</tr>
<tr>
<td>Power Dissipation at $25^\circ C$</td>
<td></td>
<td>$1000$</td>
<td></td>
<td>$mW$</td>
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## RECOMMENDED OPERATING CONDITIONS

<table>
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<tr>
<th>Power Supplies: $V_{CC1}$</th>
<th>$V_{CC2}$</th>
<th>$V_{CC3}$</th>
<th>Conditions</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$5$ VDC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$12$ VDC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$5$ VDC</td>
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## ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Test Conditions</th>
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</thead>
<tbody>
<tr>
<td>DC-turn on delay</td>
<td>$t_{on}$</td>
<td>$50$</td>
<td>$75$</td>
<td>$ns$</td>
<td></td>
<td>$V_{CC1} = 5.0$ VDC</td>
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<tr>
<td></td>
<td>$t_{off}$</td>
<td>$50$</td>
<td>$75$</td>
<td>$ns$</td>
<td></td>
<td>$V_{CC1} = 12$ VDC</td>
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<tr>
<td></td>
<td>$I_r$</td>
<td>$40$</td>
<td>$65$</td>
<td>$ns$</td>
<td></td>
<td>$R_L = 31.6 \Omega$</td>
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<tr>
<td></td>
<td>$C_L$</td>
<td>$620$</td>
<td></td>
<td></td>
<td></td>
<td>$C_L = 620$ pf</td>
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</tbody>
</table>

## SWITCHING TIME DEFINITIONS

![Diagram of switching time definitions]
TYPICAL CHARACTERISTICS

**TYPICAL OUTPUT VOLTAGE vs. LOAD CURRENT AND NUMBER OF STROBES ENABLED**

- TA = 25°C
- VCC1 = 5 VDC
- VCC2 = 12 VDC
- VCC3 = 5 VDC

**TYPICAL OUTPUT VOLTAGE vs. VCC3 SUPPLY VOLTAGE**

- TA = 25°C
- VCC1 = 5 VDC
- VCC2 = 12 VDC
- VCC3 = 5 VDC

**TYPICAL OUTPUT VOLTAGE vs. AMBIENT TEMPERATURE**

- VCC1 = 5 VDC
- VCC2 = 12 VDC
- VCC3 = 5 VDC
- RL = 31.6Ω

**TYPICAL DELAY t_{off} AND t_f vs. AMBIENT TEMPERATURE**

- TA = 25°C
- VCC1 = 5 VDC
- VCC2 = 12 VDC
- VCC3 = 5 VDC
- RL = 31.6Ω

**TYPICAL DELAY t_{on} AND t_f vs. LOAD CAPACITANCE**

- TA = 25°C
- VCC1 = 5 VDC
- VCC2 = 12 VDC
- VCC3 = 5 VDC
- RL = 31.6Ω
LED MULTIPLEXING

The HD-6600 Quad Power Strobe and HD-6605 Quad Logic Strobe, when used in conjunction with the HD-0140 Quad Latch/7 Segment Display Driver, provides a flexible multiplexed display system. The 150mA drive capability of the Power Strobe matches the current requirements of most 7 segment LED's presently available.

HD-6600 POWER STROBE
HD-6605 "PROM" LOGIC STROBE

The use of the HD-6600 Power Strobe or HD-6605 Quad Logic Strobe with the HPROM 1024A programmable memories allows expansion of a 256 word memory to a 1024 word memory with only a nominal increase in system power. Using the enable signal as the Power Strobe input optimizes the enable to output delay of the memory.
Harris Monolithic Diode Matrices consist of arrays of passivated silicon diodes, fabricated in dielectrically isolated moats. Use of improved epitaxial techniques allow construction of arrays using the epitaxial layer as the common cathode connection for all diodes in a row. Column connection to the anode side of the diodes are made to metalized interconnect lines via fusible links. By selectively opening fuses, diodes are effectively removed from the circuit to form any desired matrix pattern. Harris automatic production test equipment provides instantaneous code pattern customizing from finished goods inventory.

Combining the fusing technique with the availability of various matrix sizes and the possibility of assembling several matrices to form larger arrays, provides designers with the necessary flexibility in system design.

The matrices meet full military temperature range operation (-55°C to +125°C) and the circuits are designed to meet or exceed the mechanical and environmental requirements of MIL-STD-883.

**TYPICAL 6 x 8 CIRCUIT SCHEMATIC**

<table>
<thead>
<tr>
<th>COLUMN CONNECTION PIN NO.</th>
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<tr>
<td>1</td>
</tr>
<tr>
<td>7</td>
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</tbody>
</table>

Harris matrices are ideally suited for applications in logic generation, coding, decoding, and addressing type networks. For further information refer to Harris Diode Matrix Technical Information and Application Bulletin.

**MONOLITHIC INTERFACE CIRCUITS**

When the Harris family of Monolithic Diode Matrices are used with Harris Monolithic Interface circuits, complex logic generation is possible with simple diode-inverter logic. A product selection guide for the monolithic interface circuits is given to help designers select the best interface circuit and matrix for his application. The interface circuits can be used for input to or output from any diode matrix.
### PRODUCT SELECTION GUIDE

<table>
<thead>
<tr>
<th>MATRIX SIZE</th>
<th>FAST RECOVERY</th>
<th>MEDIUM RECOVERY</th>
<th>GENERAL PURPOSE</th>
<th>PACKAGE OUTLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x 10</td>
<td>HM1-090</td>
<td>HM1-091</td>
<td>HM1-093</td>
<td>1A</td>
</tr>
<tr>
<td>4 x 10</td>
<td>HM9-090</td>
<td>HM9-091</td>
<td>HM9-093</td>
<td>9H</td>
</tr>
<tr>
<td>10 x 4</td>
<td>HM1-050</td>
<td>HM1-051</td>
<td>HM1-055</td>
<td>1A</td>
</tr>
<tr>
<td>10 x 4</td>
<td>HM9-050</td>
<td>HM9-051</td>
<td>HM9-055</td>
<td>9H</td>
</tr>
<tr>
<td>5 x 5</td>
<td>HM1-074</td>
<td>HM1-075</td>
<td>HM1-077</td>
<td>1A</td>
</tr>
<tr>
<td>5 x 5</td>
<td>HM9-074</td>
<td>HM9-075</td>
<td>HM9-077</td>
<td>9H</td>
</tr>
<tr>
<td>5 x 8</td>
<td>HM1-010</td>
<td>HM1-012</td>
<td>HM1-013</td>
<td>1A</td>
</tr>
<tr>
<td>5 x 8</td>
<td>HM9-010</td>
<td>HM9-012</td>
<td>HM9-013</td>
<td>9H</td>
</tr>
<tr>
<td>8 x 5</td>
<td>HM1-080</td>
<td>HM1-081</td>
<td>HM1-084</td>
<td>1A</td>
</tr>
<tr>
<td>8 x 5</td>
<td>HM9-080</td>
<td>HM9-081</td>
<td>HM9-084</td>
<td>9H</td>
</tr>
<tr>
<td>6 x 8</td>
<td>HM1-030</td>
<td>HM1-031</td>
<td>HM1-034</td>
<td>1A</td>
</tr>
<tr>
<td>6 x 8</td>
<td>HM9-030</td>
<td>HM9-031</td>
<td>HM9-034</td>
<td>9H</td>
</tr>
<tr>
<td>8 x 6</td>
<td>HM1-040</td>
<td>HM1-041</td>
<td>HM1-044</td>
<td>1A</td>
</tr>
<tr>
<td>8 x 6</td>
<td>HM9-040</td>
<td>HM9-041</td>
<td>HM9-044</td>
<td>9H</td>
</tr>
</tbody>
</table>

### DIODE PIN OUT CONFIGURATION

When ordering a matrix with a custom pattern take a matrix pattern and circle out those diodes to be removed from the matrix. Another method to clearly identify pattern is to call out row and column pins for each diode to be removed.
FAST RECOVERY MATRICES

HM-074 5 x 5  HM-050 10 x 4
HM-010 5 x 8  HM-080 8 x 5
HM-030 6 x 8  HM-090 4 x 10
HM-040 8 x 6

ABSOLUTE MAXIMUM RATINGS

Forward Current : 100 mA
Surge Current (100 μs max.) : 200 mA  Operating Temp. (ambient) : -55°C to +125°C
Total Ckt. Dissipation (still air) : 450 mW  Storage Temp. (ambient) : -65°C to +150°C

Maximum ratings are limiting values above which permanent circuit damage may occur.

ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>UNIT</th>
<th>TEST CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
<tr>
<td>FORWARD DROP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{F\text{20}}$</td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>$V_{F\text{1}}$</td>
<td>0.7</td>
<td>.95</td>
<td>.75</td>
</tr>
<tr>
<td>REVERSE BREAKDOWN</td>
<td>40</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>$BV_{R}$</td>
<td>45</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>REVERSE CURRENT</td>
<td>7</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>$I_R$</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>REVERSE RECOVERY</td>
<td>7</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$t_{rr}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CROSSPOINT</td>
<td>1.9</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>CAPACITANCE</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$C_{\text{cp}}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COUPLING COEFFICIENT</td>
<td>20</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>$I_{CL}$</td>
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</tbody>
</table>

PERFORMANCE CURVES

(See Page Me-18 for Performance Characteristic Curves)

$V_F$  Figure 1
$I_R$  Figure 2
$C_{\text{cp}}$ Figure 5
### MEDIUM RECOVERY MATRICES

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>HM-075</td>
<td>5 x 5</td>
<td>HM-051</td>
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<td>HM-012</td>
<td>5 x 8</td>
<td>HM-081</td>
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<td>HM-031</td>
<td>6 x 8</td>
<td>HM-091</td>
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<tr>
<td>HM-041</td>
<td>8 x 6</td>
<td></td>
</tr>
</tbody>
</table>

### ABSOLUTE MAXIMUM RATINGS

- **Forward Current**: 100 mA
- **Surge Current (100 μs max.)**: 200 mA
- **Operating Temp. (ambient)**: -55°C to +125°C
- **Total Ckt. Dissipation (still air)**: 450 mW

Storage Temp. (ambient): -65°C to +150°C

Maximum ratings are limiting values above which permanent circuit damage may occur.

### ELECTRICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>TEST CONDITIONS</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
</tr>
<tr>
<td>FORWARD DROP</td>
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<tr>
<td>$V_{F20}$</td>
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<tr>
<td>$V_{F1}$</td>
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<td>1.5</td>
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<td>REVERSE BREAKDOWN</td>
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<td>40</td>
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<tr>
<td>$B_{Vr}$</td>
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<td>$I_r$</td>
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<td>50</td>
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<td>25</td>
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<td>REVERSE RECOVERY</td>
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<td>$t_{rr}$</td>
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<tr>
<td>CROSSPOINT CAPACITANCE</td>
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<tr>
<td>$C_{op}$</td>
<td>1.9</td>
<td>4.0</td>
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<tr>
<td>COUPLING COEFFICIENT</td>
<td>20</td>
<td>50</td>
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### PERFORMANCE CURVES

(See Page Me-18 for Performance Characteristic Curves)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>FIGURE</th>
</tr>
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<tbody>
<tr>
<td>$V_F$</td>
<td>Figure 1</td>
</tr>
<tr>
<td>$I_r$</td>
<td>Figure 3</td>
</tr>
<tr>
<td>$C_{op}$</td>
<td>Figure 5</td>
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</table>
GENERAL PURPOSE MATRICES

HM-077 5 x 5  HM-055 10 x 4
HM-013 5 x 8  HM-084 8 x 5
HM-034 6 x 8  HM-093 4 x 10
HM-044 8 x 6

ABSOLUTE MAXIMUM RATINGS

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Total Ckt. Dissipation (still air) : 450 mW  Storage Temp. (ambient) : −65°C to +150°C

Maximum ratings are limiting values above which permanent circuit damage may occur.

ELECTRICAL CHARACTERISTICS

HM-013  HM-055  HM-084
HM-034  HM-077  HM-093
HM-044

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>UNIT</th>
<th>TEST CONDITIONS</th>
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<tr>
<td></td>
<td>MIN.</td>
<td>TYP.</td>
<td>MAX.</td>
</tr>
<tr>
<td>FORWARD DROP</td>
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</tr>
<tr>
<td>Vf, 20</td>
<td>0.95</td>
<td>1.3</td>
<td>1.5</td>
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<tr>
<td>Vf, 1</td>
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<td>.75</td>
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<td>50</td>
<td></td>
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<tr>
<td>BV, x</td>
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<td>REVERSE CURRENT</td>
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<td>IR</td>
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<td>t, r</td>
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<td>4.0</td>
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<td>IcL</td>
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PERFORMANCE CURVES

(See Page Me-18 for Performance Characteristic Curves)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>CURVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vf</td>
<td>Figure 1</td>
</tr>
<tr>
<td>IR</td>
<td>Figure 4</td>
</tr>
<tr>
<td>C, p</td>
<td>Figure 5</td>
</tr>
</tbody>
</table>
TYPICAL PERFORMANCE CHARACTERISTICS

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5
DIODE MATRIX FUSING

A simple ramp current generator is used to provide the fusing current. With switch SLA in the position shown the capacitor C1 is discharged to ground through R2. The diode to be eliminated is selected by setting the row and column switches S2 and S3 respectively as required. When switch SLA is activated to position 2, capacitor C1 charges up through R1 forming a ramp voltage that drives the base of Q1. The darlington transistor pair of Q1 and Q2 transforms the voltage ramp to a current ramp that provides current to the column contacts on the matrix. This current, through the fuse, opens the fusible link in series with the selected diode. The peak fusing current required to open a fusible link, is approximately 750 milliamperes. As the temperature of the fuse is raised, the aluminum begins to melt. This melting continues until the fuse link separates. The cohesive forces of the melting aluminum retracts the remaining portions of the metal, thereby preventing formation of loose aluminum residues. The melting temperature of aluminum at approximately 650°C will not affect the passivating layer of silicon dioxide whose melting temperature is about 1350°C. Test verification is obtained by an indicating device placed in series with the column and row switches through the contacts SLB to give visual indication of the condition of each diode in the matrix before and after fusing.

MONOLITHIC INTERFACE CIRCUITS

Harris interface circuits and monolithic diode matrices form a compatible family of integrated circuits to complement any logic design. These circuits in combination can perform AND, OR, INVERT, AND-OR, NAND/NOR logic functions. The versatility of these circuits is unsurpassed when control, coding and decoding logic functions are performed.

PRODUCT SELECTION GUIDE FOR INTERFACE CIRCUITS

200/300 SERIES MILITARY -55°C to +125°C
TYPICAL CHARACTERISTICS AT VCC = 5.0V and TA = +25°C

<table>
<thead>
<tr>
<th>TYPE NUMBER</th>
<th>DESCRIPTION</th>
<th>FAN-OUT</th>
<th>$t_{pd}$ (ns)</th>
<th>POWER DISSIPATION (mW)</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-234</td>
<td>Hex Interface Inverter</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>HD-235</td>
<td>Hex Interface Driver</td>
<td>35V</td>
<td>35</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

NOTE: Parts available in flat pack and dips

500 SERIES INDUSTRIAL 0°C to +75°C
TYPICAL CHARACTERISTICS AT VCC = 5.0V and TA = +25°C

<table>
<thead>
<tr>
<th>TYPE NUMBER</th>
<th>DESCRIPTION</th>
<th>FAN-OUT</th>
<th>$t_{pd}$ (ns)</th>
<th>POWER DISSIPATION (mW)</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD-534</td>
<td>Hex Interface Inverter</td>
<td>5</td>
<td>18</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>HD-535</td>
<td>Hex Interface Driver</td>
<td>35V</td>
<td>35</td>
<td>12</td>
<td>2</td>
</tr>
</tbody>
</table>

NOTE: Parts available in flat pack and dips

NOTES:
1. Fan-out is defined for Harris DTL logic of the same series number.
2. Voltage given in fan-out column is the minimum output breakdown voltage for this gate element.
PACKAGING

CODE 1A  TO-116 (14 LEAD CERAMIC D.I.P.)

ALL DIMENSIONS ARE IN INCHES
ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.

INDEX NOTCH

CODE 9H  TO-86 (CERAMIC)

ALL DIMENSIONS IN INCHES
The commercial diode matrices are arrays of passivated silicon diodes, fabricated in dielectrically isolated moats. An epitaxial layer is used as the common cathode connection for all diodes in a row. Column connections to the anode side of the diodes are made through metal interconnect lines via fusible links. By selectively opening the links, diodes can be removed from the circuit to form any desired matrix pattern. This device is available in a 14-lead dual in-line CERDIP package. These parts are also available in a MIL-Temperature performance range.

### Matrix Patterns

<table>
<thead>
<tr>
<th>Description</th>
<th>Package</th>
<th>Code 1A</th>
</tr>
</thead>
<tbody>
<tr>
<td>HM-0110 (4x10)</td>
<td>TO-116(14 LEAD CERAMIC D.I.P)</td>
<td></td>
</tr>
<tr>
<td>HM-0168 (6x8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM-0104 (10x4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM-0186 (8x6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When ordering a matrix with a custom pattern take a matrix pattern and circle out those diodes to be removed from the matrix. Another method to clearly identify pattern is to call out row and column pins for each diode to be removed.
SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

- Forward Current: 100 mA
- Surge Current (100 μs Max.): 200 mA
- Total Circuit Dissipation (Still Air): 450 mW
- Operating Temperature (Ambient): 0°C to 70°C

ELECTRICAL CHARACTERISTICS AT 25°C

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>LIMITS</th>
<th>LIMITS</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN.</td>
<td>MAX.</td>
<td>MIN.</td>
</tr>
<tr>
<td>Forward Drop V_F20</td>
<td>1.5V</td>
<td>1.8V</td>
<td>I_F = 20mA</td>
</tr>
<tr>
<td>Forward Drop V_F1</td>
<td>0.9V</td>
<td>1.0V</td>
<td>I_F = 1mA</td>
</tr>
<tr>
<td>Rev. Breakdown Volt. B_VR</td>
<td>20V</td>
<td>20V</td>
<td>I_R = 100μA</td>
</tr>
<tr>
<td>Rev. Current I_R</td>
<td>1μA</td>
<td>1μA</td>
<td>V_R = 15V</td>
</tr>
<tr>
<td>Rev. Rec. Time</td>
<td>100ns</td>
<td>100ns</td>
<td>I_F = 10mA</td>
</tr>
<tr>
<td>Coupling Capacitance C_CCP</td>
<td>8pF</td>
<td>8pF</td>
<td>V_R = 5V</td>
</tr>
</tbody>
</table>

NOTE: When ordering a matrix with a custom pattern either obtain copies of Harris patternizing forms from your local sales representative or contact headquarters, Marketing, Melbourne, Florida.

On all orders less than 100 units there will be a one time charge for each special pattern formed by Harris.
**FEATURES**

- MIL And Commercial Versions
- Access Times From 350 TO 1000 NS
- Static – Easy To Use
- 1024 x 1 Organization
- Pinout Compatible With Industry Standard 2102
- Single +5V Power Supply
- TTL Compatible I/O
- No Clocks, No Refresh
- Two TTL Loads
- Three-State Output
- Output Can Be Or -Tied
- Inputs Protected From Static Change

**DESCRIPTION**

The HM-7202 is a 1024 Word X 1-Bit static N-Channel Random Access Read/Write Memory. Its TTL-Compatible I/O, single +5V supply, and static circuitry allow ease of operation without refresh or clocking.

Data Out is non-inverted from Data In.

A chip select and three-state output allow easy memory array expansion. Input protection and 2 full TTL load drive capability round out the features of this easy-to-use-device.

The HM-7202 is compatible with the industry standard 2102-type devices, and is available in commercial and military temperature range, in a number of speed categories.

**PACKAGING**

- A6 16 A1
- AS 15 A9
- RiW 14 A9
- Ag 13 CE
- A2 12 DO
- A3 11 DI
- A4 10 VCC
- A0 8 GND

**DIMENSIONS**

- ALL DIMENSIONS IN INCHES.
- ALL DIMENSIONS ±.003 UNLESS OTHERWISE SHOWN.

- θ JA - 100°C/Watt (Still Air)
- θ JC - 30°C/Watt (Still Air)

- θ JA - 95°C/Watt (Still Air)
- θ JC - 55°C/Watt (Still Air)

**BLOCK DIAGRAM**
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

- **Storage Temperature:** -65°C to +150°C
- **Ambient Operating Temperature:** 0°C to +70°C (7202-5) / -55°C to +125°C (7202-2)
- **Maximum Power Dissipation:** 500mW
- **VCC To Ground (Continuous):** -0.5V to +7.0V
- **Voltage To Ground On Any Input Or Output:** -0.5V to +7.0V
- **Maximum Current Into Output:** ±50mA

#### ELECTRICAL CHARACTERISTICS:

**NOTE:** $V_{CC} = +5.0V \pm 5\%$ (7202-5)  
$V_{CC} = +5.0V \pm 10\%$ (7202-2)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>HM-7202-5</th>
<th>HM-7202-2</th>
<th>UNITS</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$T_A = 0°C$ To $+70°C$</td>
<td>$T_A = -55°C$ To $+125°C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
<td>MIN</td>
<td>TYP</td>
</tr>
<tr>
<td>Address/Enable &quot;1&quot;</td>
<td>$I_{FA}$</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Forward Current &quot;1&quot;</td>
<td>$I_{FE}$</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Address/Enable &quot;0&quot;</td>
<td>$I_{RA}$</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Reverse Current &quot;0&quot;</td>
<td>$I_{RE}$</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Input Threshold &quot;1&quot; Voltage</td>
<td>$V_{IH}$</td>
<td>2.0</td>
<td>0.65</td>
<td>2.0</td>
<td>0.65</td>
</tr>
<tr>
<td>(Three-State)</td>
<td>$V_{IL}$</td>
<td>2.4</td>
<td>0.45</td>
<td>2.4</td>
<td>0.45</td>
</tr>
<tr>
<td>Output Voltage &quot;1&quot;</td>
<td>$V_{OH}$</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>$V_{OL}$</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Output Leakage &quot;1&quot;</td>
<td>$I_{OHL}$</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>$I_{OLL}$</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>$I_{CC}$</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### READ CYCLE:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIL/COMM HM-7202</th>
<th>MIL/COMM HM-7202A</th>
<th>MIL/COMM HM-7202B</th>
<th>MIL HM-7202C</th>
<th>COMM HM-7202C</th>
<th>UNITS</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Access Time</td>
<td>$t_{AA}$</td>
<td>1000</td>
<td>650</td>
<td>500</td>
<td>400</td>
<td>350</td>
<td>NS</td>
<td>$C_L = 50pF$</td>
</tr>
<tr>
<td>Chip Enable Access Time</td>
<td>$t_{CE}$</td>
<td>500</td>
<td>400</td>
<td>350</td>
<td>300</td>
<td>180</td>
<td>NS</td>
<td>Reference = 1.5V</td>
</tr>
<tr>
<td>Address-Output Hold Time</td>
<td>$t_{DH1}$</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>40</td>
<td>NS</td>
<td>Input Pulse Levels +0.65V to +2.2V</td>
</tr>
<tr>
<td>CE-Output Hold Time</td>
<td>$t_{DH2}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NS</td>
<td>$t_{R} = t_{F} = 20NS$</td>
</tr>
<tr>
<td>Read Cycle Time</td>
<td>$t_{RC}$</td>
<td>1000</td>
<td>650</td>
<td>500</td>
<td>400</td>
<td>350</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

#### WRITE CYCLE:

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIL/COMM HM-7202</th>
<th>MIL/COMM HM-7202A</th>
<th>MIL/COMM HM-7202B</th>
<th>MIL HM-7202C</th>
<th>COMM HM-7202C</th>
<th>UNITS</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Write Setup Time</td>
<td>$t_{AW}$</td>
<td>200</td>
<td>200</td>
<td>150</td>
<td>120</td>
<td>20</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Write Pulse Width Time</td>
<td>$t_{WP}$</td>
<td>750</td>
<td>400</td>
<td>300</td>
<td>220</td>
<td>200</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Write Recovery Time</td>
<td>$t_{WR}$</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Data Setup Time</td>
<td>$t_{DW}$</td>
<td>800</td>
<td>450</td>
<td>330</td>
<td>250</td>
<td>250</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Data Hold Time</td>
<td>$t_{DH}$</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>CE-Write Setup Time</td>
<td>$t_{CW}$</td>
<td>900</td>
<td>550</td>
<td>400</td>
<td>300</td>
<td>250</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Write Cycle Time</td>
<td>$t_{WC}$</td>
<td>1000</td>
<td>650</td>
<td>500</td>
<td>400</td>
<td>350</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>
### Capacitance

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>TYP</th>
<th>MAX</th>
<th>LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input</td>
<td>C_A</td>
<td></td>
<td>3</td>
<td>5</td>
<td>pF</td>
</tr>
<tr>
<td>Read/Write</td>
<td>C_R/W</td>
<td>( V_{CC} = +5.0V; T_A = +25^\circ C )</td>
<td>7</td>
<td>10</td>
<td>pF</td>
</tr>
<tr>
<td>Input/Output</td>
<td>C_I/O</td>
<td>( V_T = 0V; f = 1MHz )</td>
<td>7</td>
<td>10</td>
<td>pF</td>
</tr>
</tbody>
</table>

**NOTE 1.** Capacitance is guaranteed, and sampled, but is not 100% tested.
<table>
<thead>
<tr>
<th>ORGANIZATION</th>
<th>PART NUMBER</th>
<th>OUTPUT TYPE</th>
<th>PINOUT</th>
<th>MAXIMUM ACCESS OVER VOLTAGE AND TEMP.</th>
<th>TYPICAL PROGRAMMING TIME (ALL BITS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256 X 4</td>
<td>HM-7610</td>
<td>(OC)</td>
<td>A6-1</td>
<td>60ns</td>
<td>1 SECOND</td>
</tr>
<tr>
<td></td>
<td>HM-7611</td>
<td>(TS)</td>
<td>A5-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A4-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A2-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GND-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A1-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A0-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>512 X 4</td>
<td>HM-7620</td>
<td>(OC)</td>
<td>A6-1</td>
<td>70ns</td>
<td>2 SECONDS</td>
</tr>
<tr>
<td></td>
<td>HM-7621</td>
<td>(TS)</td>
<td>A5-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A4-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A3-4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>A2-7</td>
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<td>GND-8</td>
<td></td>
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<td>A1-6</td>
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<td></td>
<td></td>
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<td>A0-5</td>
<td></td>
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</tr>
<tr>
<td>512 X 8</td>
<td>HM-7640</td>
<td>(OC)</td>
<td>A7-1</td>
<td>70ns</td>
<td>4 SECONDS</td>
</tr>
<tr>
<td></td>
<td>HM-7641</td>
<td>(TS)</td>
<td>A6-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A5-3</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>A4-4</td>
<td></td>
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<td></td>
<td>A3-5</td>
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<td></td>
<td>A2-6</td>
<td></td>
<td></td>
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<td>A1-7</td>
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<td></td>
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<td>A0-8</td>
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<td>01-9</td>
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<td></td>
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<td>02-10</td>
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<td>03-11</td>
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<td></td>
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<td>04-12</td>
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<td></td>
</tr>
<tr>
<td>1024 X 4</td>
<td>HM-7644</td>
<td>ACTIVE</td>
<td>A6-1</td>
<td>70ns</td>
<td>4 SECONDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PULLUP</td>
<td>A5-2</td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>A4-3</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A2-7</td>
<td></td>
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</tr>
<tr>
<td></td>
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<td></td>
<td>GND-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1024 X 4</td>
<td>HM-7642</td>
<td>(OC)</td>
<td>A6-1</td>
<td>70ns</td>
<td>4 SECONDS</td>
</tr>
<tr>
<td></td>
<td>HM-7643</td>
<td>(TS)</td>
<td>A5-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A4-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A3-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A2-7</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>GND-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 X 8</td>
<td>HM-7602</td>
<td>(OC)</td>
<td>01-1</td>
<td>40nsec</td>
<td>&lt;1 SECOND</td>
</tr>
<tr>
<td></td>
<td>HM-7603</td>
<td>(TS)</td>
<td>02-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>03-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>04-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>05-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>06-6</td>
<td></td>
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<td></td>
<td>07-7</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>GND-8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**HM-7602/7603**

256–Bit Field Programmable
Bipolar PROM

### FEATURES

- **32 Words, 8-Bits per Word**
- **Simple, High Speed Programming Procedure (less than 1 second Typical)**
- **Inputs and Outputs TTL Compatible**
  - Low Input Current – 400μA Logic “0”, 40μA “1”
  - Full Output Drive – 15mA Sink/2mA Source
- **Fast Access Time** – 40ns Over Commercial Temperature and Voltage; 50ns Over Military Temperature and Voltage
- **Expandable** – “Wired-Or” Outputs with Chip Select

### DESCRIPTION

The HM-7602 (open collector) and HM-7603 (three-state) are fully decoded, high speed, 256-bit programmable ROM'S organized as 32 words by 8-bits per word. They are supplied with all bits storing a logical “1” (outputs high), and can be selectively programmed for a logical “0” (outputs low).

The nichrome fuse technology is the same as is used in the JAN approved MIL 38510/201 PROM, and in all other Harris PROMs.

The field programmable PROM can be custom programmed to any pattern using a simple programming procedure. Schottky Bipolar circuitry provides extremely fast access time, and features temperature and voltage compensation to minimize variations in access time.

In addition to the conventional storage array, two test rows and one test column are included to assure high programmability, and guarantee parametric and A.C. performance. Fuses in these test rows and columns are blown prior to shipment.

### PACKAGE

**CODE 1D**

![Package Diagram]

All dimensions in inches. All dimensions ± .010 unless otherwise shown. 

$T_A = 80^\circ C$; W/STILL AIR

### BLOCK DIAGRAM

![Block Diagram]

- $V_{CC} = \text{Pin (16)}$
- $\text{GND} = \text{Pin (8)}$

$A_0 (10)$
$A_1 (11)$
$A_2 (12)$
$A_3 (13)$
$A_4 (14)$
$A_5 (15)$

$\text{Address Buffers}$

$0$

$1 \text{OF} 32 \text{Row Decoder}$

$32 \times 8 \text{ Memory Array}$

$0_0 \ 0_1 \ 0_2 \ 0_3 \ 0_4 \ 0_5 \ 0_6 \ 0_7$
### SPECIFICATIONS

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output or Supply Voltage (Operating)</td>
<td>7.0V</td>
</tr>
<tr>
<td>Address/Enable Input Voltage</td>
<td>5.5V</td>
</tr>
<tr>
<td>Address/Enable Input Current</td>
<td>-20mA</td>
</tr>
<tr>
<td>Output Sink Current</td>
<td>70mA</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>+150°C</td>
</tr>
<tr>
<td>Operating Temperature (Ambient)</td>
<td>+125°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>+175°C</td>
</tr>
</tbody>
</table>

Stresses above those listed under the "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress only rating and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied. (While programming, follow the programming specifications.)

#### ELECTRICAL CHARACTERISTICS (OPERATING)

- **HM-7602-5**
- **HM-7603-5**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable Input Current</td>
<td>IA, IE</td>
<td>IIP</td>
<td>0</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>VIL</td>
<td>VX, VTHL</td>
<td>0</td>
<td>-0.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>VOH, VOL</td>
<td>V1</td>
<td>0.35</td>
<td>0.45</td>
<td>0.35</td>
</tr>
<tr>
<td>Output Discharge Current</td>
<td>IOL</td>
<td>-100</td>
<td>-100</td>
<td>mA</td>
<td>VDD, VCC = VCC Max</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>ICC</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>VCL</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>IIN = -10mA</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>IOS</td>
<td>N/A</td>
<td>N/A</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Address Access Time</td>
<td>tAA</td>
<td>25</td>
<td>40</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>tEA</td>
<td>20</td>
<td>30</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

**D.C.**

- **HM-7602-5**
- **HM-7603-5**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable Input Current</td>
<td>IA, IE</td>
<td>IIP</td>
<td>0</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>VIL</td>
<td>VX, VTHL</td>
<td>0</td>
<td>-0.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>VOH, VOL</td>
<td>V1</td>
<td>0.35</td>
<td>0.45</td>
<td>0.35</td>
</tr>
<tr>
<td>Output Discharge Current</td>
<td>IOL</td>
<td>-100</td>
<td>-100</td>
<td>mA</td>
<td>VDD, VCC = VCC Max</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>ICC</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>VCL</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>IIN = -10mA</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>IOS</td>
<td>N/A</td>
<td>N/A</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Address Access Time</td>
<td>tAA</td>
<td>25</td>
<td>40</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>tEA</td>
<td>20</td>
<td>30</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

**A.C.**

- **HM-7602-5**
- **HM-7603-2**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable Input Current</td>
<td>IA, IE</td>
<td>IIP</td>
<td>0</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>VIL</td>
<td>VX, VTHL</td>
<td>0</td>
<td>-0.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>VOH, VOL</td>
<td>V1</td>
<td>0.35</td>
<td>0.45</td>
<td>0.35</td>
</tr>
<tr>
<td>Output Discharge Current</td>
<td>IOL</td>
<td>-100</td>
<td>-100</td>
<td>mA</td>
<td>VDD, VCC = VCC Max</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>ICC</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>VCL</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>IIN = -10mA</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>IOS</td>
<td>N/A</td>
<td>N/A</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Address Access Time</td>
<td>tAA</td>
<td>25</td>
<td>40</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>tEA</td>
<td>20</td>
<td>30</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

**Typical Measurements are at TA = 25°C, VCC = +5V**

#### CAPACITANCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add. Input Cap.</td>
<td>CIN, CS</td>
<td>8 pF</td>
<td>VCC = 5V, VIN = 2.0V, f = 1MHz</td>
</tr>
<tr>
<td>Output Cap.</td>
<td>COUT</td>
<td>8 pF</td>
<td>VCC = 5V, VOUT = 2.0V, f = 1MHz</td>
</tr>
</tbody>
</table>

**NOTE:** These parameters are only periodically sampled and are not 100% tested.
**PROGRAMMING**

The HM-7602/7603 is manufactured with all bits/outputs Logical “1” (Output High). Any desired bit/output can be programmed to a Logical “0” (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HM-7602/7603 can be programmed automatically or by the manual procedure shown below.

**PROGRAMMING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input Voltage (1)</td>
<td>V_{IH}</td>
<td>2.4</td>
<td>5.0</td>
<td>V</td>
</tr>
<tr>
<td>Voltage</td>
<td>V_{IL}</td>
<td>0.0</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>Programming/Verify Voltage to V_{CC} (2)</td>
<td>V_{PH}</td>
<td>11.5</td>
<td>12.0</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>V_{PL}</td>
<td>3.75</td>
<td>4.0</td>
<td>4.25</td>
</tr>
<tr>
<td>Programming Voltage Current Limit</td>
<td>I_{CCP}</td>
<td>600</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Programming (V_{CC}) Voltage Rise and Fall Time</td>
<td>t_{R}</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>t_{F}</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Programming Delay</td>
<td>t_{D}</td>
<td>10</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Programming Pulse Width – First Attempts</td>
<td>t_{P1}</td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Programming Pulse Width – Subsequent</td>
<td>t_{P2}</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Programming Duty Cycle</td>
<td>D.C.</td>
<td>–</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Output Voltage Enable</td>
<td>V_{OPE}</td>
<td>9.5</td>
<td>10.0</td>
<td>10.5</td>
</tr>
<tr>
<td>Disable (3)</td>
<td>V_{OPD}</td>
<td>0</td>
<td>.45</td>
<td>5.5</td>
</tr>
<tr>
<td>Output Voltage Enable Current Limit</td>
<td>I_{OPE}</td>
<td>10</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Case Temp</td>
<td>T_{C}</td>
<td>75</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

1. Address and chip select should not be left open for V_{IH}.
2. Verification at V_{CC} = 4.0 ± .25 Volts, T_{A} = 25°C is recommended to guardband performance over full temperature and voltage range.
3. Disable condition will be met with output open circuit.
PROGRAMMING PROCEDURE

1. Address the PROM with the binary address of the selected word to be programmed. Address inputs are TTL compatible. An open circuit should not be used to address the PROM.

2. Disable the chip by applying input high \( (V_{IH}) \) to the chip select input. The chip select input is TTL compatible. An open circuit should not be used to disable the chip.

3. Disable the programming circuitry by applying an Output Voltage Disable of less than \( V_{PD} \) to the output of the PROM. The output may be left open circuit to achieve the disable.

4. Raise \( V_{CC} \) to \( V_{PH} \) with rise time equal to \( t_r \).

5. After a delay equal to or greater than \( t_d \), apply a pulse with amplitude equal to \( V_{PPE} \) and duration of \( t_p1 \) to the output selected for programming. Note that the PROM is supplied with fuses intact generating an output high. Programming a fuse will cause the output to go low in the verify mode.

6. Other bits in the same word may be programmed while the \( V_{CC} \) input is raised to \( V_{PH} \) by applying output enable pulses to each output which is to be programmed. The output enable pulses must be separated by a minimum interval of \( t_d \).

7. Lower \( V_{CC} \) to \( 4.0 \pm 0.25 \) Volts following a delay to \( t_d \) from the last programming enable pulse applied to an output.

8. Enable the PROM for verification by applying a logic "0" \( (V_{IL}) \) to the \( CS \) input.

9. If any bit does not verify as programmed, repeat steps 2 through 8 using an output pulse enable width of \( t_p1 \) for up to 15 additional pulses to enhance programming speed. If the bit is still unprogrammed, follow with at least 16 repetitive pulses of \( t_p2 \) in width, to achieve high programming yield. In the event that the bit is still unprogrammed, the part is considered a programming reject and should be returned to the factory. The address and incorrect and desired contents of a location in which a programming failure has occurred in any returned device must be included with that return.

10. Repeat steps 1 thru 9 for all other bits to be programmed in the PROM.

RECOMMENDED PROGRAMMING CIRCUIT

The circuit and timing diagram shown in Figures 1 and 2 will establish the proper programming condition for the output enable pulse. This allows the use of standard TTL parts for all logic inputs to the PROM. Note the gate which senses the output must be input protected to withstand input up to 12.5 Volts during programming.
**HM-7610/7611**

**1024-Bit Field Programmable Bipolar PROM**

### FEATURES

- 256 Words, 4-Bits per Word
- Simple, High Speed Programming Procedure (less Than 1 Second Typical)
- Inputs and Outputs TTL Compatible
  - Low Input Current \(-400 \mu A\) Logic "0", \(40 \mu A\) Logic "1"
  - Full Output Drive \(-15mA\) Sink/\(2mA\) Source
- Fast Access Time—60NS Over Commercial Temperature & Voltage, 75NS Over Military Temperature & Voltage
- Expandable—“Wired-Or” Outputs With Chip Select
- Pin Compatible With Industry Standard 256 X 4 Proms

### DESCRIPTION

The HM-7610 (open collector) and HM-7611 (three-state) are fully decoded, high speed, 1024-bit programmable ROM'S organized as 256 words by 4 bits per word. They are supplied with all bits storing a logical “1” (outputs high), and can be selectively programmed for a logical “0” (outputs low).

The nichrome fuse technology is the same as is used in the JAN approved MIL 38510/201 PROM, and in all other Harris PROMs.

The field programmable PROM can be custom programmed to any pattern using a simple programming procedure. Schottky Bipolar circuitry provides extremely fast access time, and features temperature and voltage compensation to minimize variations in access time.

The pinout is compatible with the industry standard 256X4 PROM.

In addition to the conventional storage array, two test rows and two test columns are included to assure high programmability, and guarantee parametric and A.C. performance. Fuses in these test rows and columns are blown prior to shipment.

### BLOCK DIAGRAM

![Block Diagram](image-url)
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HM-7610-5</th>
<th>HM-7611-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output or Supply Voltage (Operating)</td>
<td>7.0V</td>
<td>7.0V</td>
</tr>
<tr>
<td>Address/Enable Input Voltage</td>
<td>5.5V</td>
<td>5.5V</td>
</tr>
<tr>
<td>Address/Enable Input Current</td>
<td>-20mA</td>
<td>-20mA</td>
</tr>
<tr>
<td>Output Sink Current</td>
<td>70mA</td>
<td>70mA</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>+150°C</td>
<td>+150°C</td>
</tr>
<tr>
<td>Operating Temperature (Ambient)</td>
<td>+125°C</td>
<td>+125°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>+175°C</td>
<td>+175°C</td>
</tr>
</tbody>
</table>

Stresses above those listed under the "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress only rating and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied. (While programming, follow the programming specifications.)

### ELECTRICAL CHARACTERISTICS (OPERATING)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HM-7610-5</th>
<th>HM-7611-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>5V ±5%</td>
<td>5V ±5%</td>
</tr>
<tr>
<td>TA (°C) to 25°C or 25°C to +70°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PARAMETER</strong></td>
<td><strong>SYMBOL</strong></td>
<td><strong>MIN.</strong></td>
</tr>
<tr>
<td>Address/Enable</td>
<td>&quot;I&quot;</td>
<td>TπA, VLE</td>
</tr>
<tr>
<td>Input Current</td>
<td>&quot;0&quot;</td>
<td>TπA, VLE</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>&quot;I&quot;</td>
<td>VIL</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>&quot;0&quot;</td>
<td>VOH, VOL</td>
</tr>
<tr>
<td>Output Disabled Current</td>
<td>&quot;I&quot;</td>
<td>DLE</td>
</tr>
<tr>
<td>Output Leakage</td>
<td>&quot;0&quot;</td>
<td>DLE</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>&quot;I&quot;</td>
<td>ICC</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>&quot;I&quot;</td>
<td>VCL</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>&quot;I&quot;</td>
<td>IOS</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>&quot;I&quot;</td>
<td>TEA</td>
</tr>
<tr>
<td>Address Access Time</td>
<td>&quot;I&quot;</td>
<td>TAA</td>
</tr>
</tbody>
</table>

Typical Measurements are at TA = 25°C, VCC = +5V

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HM-7610-2</th>
<th>HM-7611-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>5V ±10%</td>
<td>5V ±10%</td>
</tr>
<tr>
<td>TA (°C) to 25°C or 25°C to +125°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PARAMETER</strong></td>
<td><strong>SYMBOL</strong></td>
<td><strong>MIN.</strong></td>
</tr>
<tr>
<td>Address/Enable</td>
<td>&quot;I&quot;</td>
<td>TπA, VLE</td>
</tr>
<tr>
<td>Input Current</td>
<td>&quot;0&quot;</td>
<td>TπA, VLE</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>&quot;I&quot;</td>
<td>VIL</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>&quot;0&quot;</td>
<td>VOH, VOL</td>
</tr>
<tr>
<td>Output Disabled Current</td>
<td>&quot;I&quot;</td>
<td>DLE</td>
</tr>
<tr>
<td>Output Leakage</td>
<td>&quot;0&quot;</td>
<td>DLE</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>&quot;I&quot;</td>
<td>ICC</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>&quot;I&quot;</td>
<td>VCL</td>
</tr>
<tr>
<td>Output Short Circuit Current</td>
<td>&quot;I&quot;</td>
<td>IOS</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>&quot;I&quot;</td>
<td>TEA</td>
</tr>
<tr>
<td>Address Access Time</td>
<td>&quot;I&quot;</td>
<td>TAA</td>
</tr>
</tbody>
</table>

Typical Measurements are at TA = 25°C, VCC = +5V

### CAPACITANCE (1): TA = 25°C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SYMBOL</th>
<th>TYP.</th>
<th>UNITS</th>
<th>TEST CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add. Input Cap.</td>
<td>CIN, COUT</td>
<td>8</td>
<td>pF</td>
<td>VCC = 5V, VIN = 2.0V I = 1MHz</td>
</tr>
</tbody>
</table>

Note: (1) These parameters are only periodically sampled and are not 100% tested.
PROGRAMMING

The HM-7610/7611 is manufactured with all bits/outputs Logical "1" (Output High). Any desired bit/output can be programmed to a Logical "0" (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HM-7610/7611 can be programmed automatically or by the manual procedure shown below.

PROGRAMMING SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>RECOMMENDED VALUE</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input Voltage (1)</td>
<td>V_H</td>
<td>2.4</td>
<td>5.0</td>
<td>5.0</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>V_L</td>
<td>0.0</td>
<td>0.4</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>Programming/Verify Voltage to V_CC (2)</td>
<td>V_P_H</td>
<td>11.5</td>
<td>12.0</td>
<td>12.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>V_P_L</td>
<td>3.75</td>
<td>4.0</td>
<td>4.25</td>
<td>V</td>
</tr>
<tr>
<td>Programming Voltage Current Limit</td>
<td>I_CC</td>
<td>600</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming Voltage Rise and Fall Time</td>
<td>t_R</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>t_F</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>µs</td>
</tr>
<tr>
<td>Programming Delay</td>
<td>t_D</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>µs</td>
</tr>
<tr>
<td>Programming Pulse Width – First Attempts</td>
<td>t_P1</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>µs</td>
</tr>
<tr>
<td></td>
<td>t_P2</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>ms</td>
</tr>
<tr>
<td>Programming Duty Cycle</td>
<td>D.C.</td>
<td>–</td>
<td>10</td>
<td>10</td>
<td>%</td>
</tr>
<tr>
<td>Output Voltage Enable</td>
<td>V_O_P_E</td>
<td>9.5</td>
<td>10.0</td>
<td>10.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>V_O_P_D</td>
<td>0</td>
<td>0.45</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Enable Current Limit</td>
<td>T_O_P_E</td>
<td>10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Temp</td>
<td>T_C</td>
<td>75</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Address and chip select should not be left open for V_H.
2. Verification at V_CC = 4.0 ±0.25 Volts, T_A = 25°C is recommended to guardband performance over full temperature and voltage range.
3. Disable condition will be met with output open circuit.
PROGRAMMING PROCEDURE

1. Address the PROM with the binary address of the selected word to be programmed. Address inputs are TTL compatible. An open circuit should not be used to address the PROM.

2. Disable the chip by applying input highs (VIH) to both chip select inputs. The chip select inputs are TTL compatible. An open circuit should not be used to disable the chip.

3. Disable the programming circuitry by applying an Output Voltage Disable of less than VOPD to the output of the PROM. The output may be left open circuit to achieve the disable.

4. Raise Vcc to VPH with rise time equal to tR.

5. After a delay equal to or greater than td, apply a pulse with amplitude equal to VOP and duration of tp1 to the output selected for programming. Note that the PROM is supplied with fuses intact generating an output high. Programming a fuse will cause the output to go low in the verify mode.

6. Other bits in the same word may be programmed while the Vcc input is raised to VPH by applying output enable pulses to each output which is to be programmed. The output enable pulses must be separated by a minimum interval of td.

7. Lower Vcc to 4.0 ± 0.25 Volts following a delay to td from the last programming enable pulse applied to an output.

8. Enable the PROM for verification by applying a logic "0" (VIL) to the CS1 and CS2 inputs.

9. If any bit does not verify as programmed, repeat steps 2 through 8 using an output pulse enable width of tp1 for up to 15 additional pulses to enhance programming speed. If the bit is still unprogrammed, follow with at least 16 repetitive pulses of tp2 in width, to achieve high programming yield. In the event that the bit is still unprogrammed, the part is considered a programming reject and should be returned to the factory. The address and incorrect and desired contents of a location in which a programming failure has occurred in any returned device must be included with that return.

10. Repeat steps 1 thru 9 for all other bits to be programmed in the PROM.

RECOMMENDED PROGRAMMING CIRCUIT

The circuit and timing diagram shown in Figures 1 and 2 will establish the proper programming condition for the output enable pulse. This allows the use of standard TTL parts for all logic inputs to the PROM. Note the gate which senses the output must be input protected to withstand input up to 12.5 Volts during programming.

FIGURE 1

FIGURE 2
The HM-7620 (open collector) and HM-7621 (three-state) are fully decoded, high speed, 2048-bit programmable ROM's organized as 512 words by 4 bits per word. They are supplied with all bits storing a logical "1" (outputs high), and can be selectively programmed for a logical "0" (outputs low).

The nichrome fuse technology is the same as is used in the JAN approved MIL 38510/201 PROM, and in all other Harris PROMS.

The field programmable PROM can be custom programmed to any pattern using a simple programming procedure. Schottky Bipolar circuitry provides extremely fast access time, and features temperature and voltage compensation to minimize variations in access time.

The pinout is compatible with the industry standard 256 x 4 PROM with the exception that the CS2 input on pin 14 is replaced by Address Input A8. Systems using 256 x 4 PROMS can be upgraded to store twice the number of bits within the same board area, while maintaining the same system power requirements. Alternatively, both the package count and the system power can be halved by using the HM-7620/HM-7621 in place of the 256 x 4 PROM.

In addition to the conventional storage array, two test rows and two test columns are included to assure high programmability, and guarantee parametric and A.C. performance. These fuses are blown prior to shipment.
## SPECIFICATIONS

### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output or Supply Voltage (Operating)</td>
<td>7.0V</td>
</tr>
<tr>
<td>Address/Enable Input Voltage</td>
<td>5.5V</td>
</tr>
<tr>
<td>Address/Enable Input Current</td>
<td>-20mA</td>
</tr>
<tr>
<td>Output Sink Current</td>
<td>70mA</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>+150°C</td>
</tr>
<tr>
<td>Operating Temperature (Ambient)</td>
<td>+125°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>+175°C</td>
</tr>
</tbody>
</table>

Stresses above those listed under the "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress only rating and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied. (While programming, follow the programming specifications.)

### ELECTRICAL CHARACTERISTICS (OPERATING)

#### HM-7620-5

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable</td>
<td>V_{IH}</td>
<td>2.0</td>
<td>0.8</td>
<td>2.0</td>
<td>0.8</td>
<td>V</td>
<td>V_{CC} + V_{CC Min}</td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>V_{IL}</td>
<td>0.35</td>
<td>0.45</td>
<td>3.4</td>
<td>0.35</td>
<td>V</td>
<td>V_{CC} + V_{CC Min}</td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V_{OH}</td>
<td>100</td>
<td>N/A</td>
<td>100</td>
<td>N/A</td>
<td>V</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V_{OL}</td>
<td>100</td>
<td>N/A</td>
<td>100</td>
<td>N/A</td>
<td>V</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
</tbody>
</table>

#### HM-7621-5

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable</td>
<td>I_{IA}</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>40</td>
<td>μA</td>
<td>V_{IH} = V_{CC Max}</td>
<td></td>
</tr>
<tr>
<td>Input Current</td>
<td>I_{JE}</td>
<td>-0.1</td>
<td>-0.4</td>
<td>-0.1</td>
<td>-0.4</td>
<td>mA</td>
<td>V_{IL} = 0.45V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I_{FE}</td>
<td>-0.1</td>
<td>-0.4</td>
<td>-0.1</td>
<td>-0.4</td>
<td>V</td>
<td>V_{CC} = V_{CC Min}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I_{FE}</td>
<td>-0.1</td>
<td>-0.4</td>
<td>-0.1</td>
<td>-0.4</td>
<td>V</td>
<td>V_{CC} = V_{CC Max}</td>
<td></td>
</tr>
</tbody>
</table>

#### D.C.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Input Current</td>
<td>I_{DS}</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
<td>mA</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>I_{DS}</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
<td>mA</td>
<td>All Inputs Grounded</td>
<td></td>
</tr>
<tr>
<td>clamp Voltage</td>
<td>V_{CL}</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>I_{CL} = -10mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Circuit</td>
<td>V_{CL}</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>I_{CL} = -10mA</td>
<td></td>
<td></td>
<td></td>
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</table>

#### A.C.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Access Time</td>
<td>t_{AA}</td>
<td>40</td>
<td>70</td>
<td>40</td>
<td>70</td>
<td>ns</td>
<td>V_{CC} and TA Over Full Range</td>
<td></td>
</tr>
<tr>
<td>Enable Time</td>
<td>t_{EA}</td>
<td>15</td>
<td>25</td>
<td>15</td>
<td>25</td>
<td>ns</td>
<td>V_{CC} and TA Over Full Range</td>
<td></td>
</tr>
</tbody>
</table>

**Typical Measurements are at TA = 25°C, V_{CC} = +5V**

#### HM-7620-2

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Address/Enable</td>
<td>V_{IH}</td>
<td>2.0</td>
<td>0.8</td>
<td>2.0</td>
<td>0.8</td>
<td>V</td>
<td>V_{CC} + V_{CC Min}</td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>V_{IL}</td>
<td>0.35</td>
<td>0.45</td>
<td>3.4</td>
<td>0.35</td>
<td>V</td>
<td>V_{CC} + V_{CC Min}</td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>V_{OH}</td>
<td>100</td>
<td>N/A</td>
<td>100</td>
<td>N/A</td>
<td>V</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>V_{OL}</td>
<td>100</td>
<td>N/A</td>
<td>100</td>
<td>N/A</td>
<td>V</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
</tbody>
</table>

#### D.C.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Current</td>
<td>I_{DS}</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
<td>mA</td>
<td>V_{CC} + V_{CC Max}</td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>I_{DS}</td>
<td>90</td>
<td>130</td>
<td>90</td>
<td>130</td>
<td>mA</td>
<td>All Inputs Grounded</td>
<td></td>
</tr>
<tr>
<td>clamp Voltage</td>
<td>V_{CL}</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>I_{CL} = -10mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Circuit</td>
<td>V_{CL}</td>
<td>-1.5</td>
<td>-1.5</td>
<td>V</td>
<td>I_{CL} = -10mA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### A.C.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Access Time</td>
<td>t_{AA}</td>
<td>40</td>
<td>85</td>
<td>40</td>
<td>85</td>
<td>ns</td>
<td>V_{CC} and TA Over Full Range</td>
<td></td>
</tr>
<tr>
<td>Enable Time</td>
<td>t_{EA}</td>
<td>15</td>
<td>30</td>
<td>15</td>
<td>30</td>
<td>ns</td>
<td>V_{CC} and TA Over Full Range</td>
<td></td>
</tr>
</tbody>
</table>

**Typical Measurements are at TA = 25°C, V_{CC} = +5V**

*100% Tested For DASH 8

### CAPACITANCE (1): TA = 25°C

#### Add. Input Cap.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Typ.</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Cap.</td>
<td>C_{IN} A. CS</td>
<td>8</td>
<td>pF</td>
<td>V_{CC} = 5V, V_{IN} = 2.0V, f = 1MHz</td>
</tr>
</tbody>
</table>

**NOTE:** These parameters are only periodically sampled and are not 100% tested.
**SWITCHING TIME DEFINITIONS**

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>1.5V</th>
<th>3.0V</th>
<th>0.0V</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT</td>
<td>1.5V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A.C. TEST LOAD**

\[ 5.0V \]

\[ 0_x \]

\[ 300\Omega \]

\[ \text{TEST POINT} \]

\[ 600\Omega \]

\[ 3pF \]

*Includes jig & probe total capacitance

---

**PROGRAMMING**

The HM-7620/7621 is manufactured with all bits/outputs Logical "1" (Output High). Any desired bit/output can be programmed to a Logical "0" (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HM-7620/7621 can be programmed automatically or by the manual procedure shown below.

---

**PROGRAMMING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN</th>
<th>RECOMMENDED VALUE</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input Voltage</td>
<td>( V_{IH} )</td>
<td>2.4</td>
<td>5.0</td>
<td>5.0</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>( V_{IL} )</td>
<td>0.0</td>
<td>0.4</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>Programming/Verify Voltage to ( V_{CC} )</td>
<td>( V_{PH} )</td>
<td>11.5</td>
<td>12.0</td>
<td>12.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>( V_{PL} )</td>
<td>3.75</td>
<td>4.0</td>
<td>4.25</td>
<td>V</td>
</tr>
<tr>
<td>Programming Voltage Current Limit (1)</td>
<td>( I_{CCP} )</td>
<td></td>
<td></td>
<td>600</td>
<td>mA</td>
</tr>
<tr>
<td>Programming (( V_{CC} )) Voltage Rise and Fall Time</td>
<td>( t_r )</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>( \mu )s</td>
</tr>
<tr>
<td></td>
<td>( t_f )</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>Programming Delay</td>
<td>( t_d )</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>Programming Pulse Width – First Attempts</td>
<td>( t_{pl} )</td>
<td>100</td>
<td>100</td>
<td>200</td>
<td>( \mu )s</td>
</tr>
<tr>
<td>Programming Pulse Width – Subsequent</td>
<td>( t_{p2} )</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>ms</td>
</tr>
<tr>
<td>Programming Duty Cycle</td>
<td>D.C.</td>
<td>–</td>
<td>10</td>
<td>10</td>
<td>%</td>
</tr>
<tr>
<td>Output Voltage Enable</td>
<td>( V_{OPE} )</td>
<td>9.5</td>
<td>10.0</td>
<td>10.5</td>
<td>V</td>
</tr>
<tr>
<td>Disable (3)</td>
<td>( V_{OPD} )</td>
<td>0</td>
<td>45</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Enable Current Limit</td>
<td>( I_{OPE} )</td>
<td></td>
<td></td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Case Temp</td>
<td>( T_C )</td>
<td></td>
<td></td>
<td>75</td>
<td>°C</td>
</tr>
</tbody>
</table>

1. Address and chip select should not be left open for \( V_{IH} \).
2. Verification at \( V_{CC} = 4.0 \pm 0.25 \) Volts, \( T_A = 25^\circ C \) is recommended to guardband performance over full temperature and voltage range.
3. Disable condition will be met with output open circuit.

---

**SCHEMATIC DIAGRAMS**

**HM-7620**

**HM-7621**

---

The HM-7620/7621 is manufactured with all bits/outputs Logical "1" (Output High). Any desired bit/output can be programmed to a Logical "0" (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HM-7620/7621 can be programmed automatically or by the manual procedure shown below.
PROGRAMMING PROCEDURE

1. Address the PROM with the binary address of the selected word to be programmed. Address inputs are TTL compatible. An open circuit should not be used to address the PROM.

2. Disable the chip by applying an input high (VIH) to the chip select input. The chip select input is TTL compatible. An open circuit should not be used to disable the chip.

3. Disable the programming circuitry by applying an Output Voltage Disable of less than VOPD to the output of the PROM. The output may be left open circuit to achieve the disable.

4. Raise VCC to VPH with rise time equal to tR.

5. After a delay equal to or greater than td, apply a pulse with amplitude equal to VOPE and duration of tP1 to the output selected for programming. Note that the PROM is supplied with fuses intact generating an output high. Programming a fuse will cause the output to go low in the verify mode.

6. Other bits in the same word may be programmed while the VCC input is raised to VPH by applying output enable pulses to each output which is to be programmed. The output enable pulses must be separated by a minimum interval of td.

7. Return VCC to 4.0 ± .25 V following a delay of td from the last programming enable pulse applied to an output.

8. Enable the PROM for verification by applying a logic "0" (VIL) to the CS1 input.

9. If any bit does not verify as programmed, repeat steps 2 through 8 using an output pulse enable width of tP1 for up to 15 additional pulses to enhance programming speed. If the bit is still unprogrammed, follow with at least 16 repetitive pulses of tP2 in width, to achieve high programming yield. In the event that the bit is still unprogrammed, the part is considered a programming reject and should be returned to the factory. The address and incorrect and desired contents of a location in which a programming failure has occurred in any returned device must be included with that return.

10. Repeat steps 1 thru 9 for all other bits to be programmed in the PROM.

RECOMMENDED PROGRAMMING CIRCUIT

The circuit and timing diagram shown in Figures 1 and 2 will establish the proper programming condition for the output enable pulse. This allows the use of standard TTL parts for all logic inputs to the PROM. Note the gate which senses the output must be input protected to withstand input up to 12.5 Volts during programming.

FIGURE 1

FIGURE 2
The HM-7640 (open collector) and HM-7641 (three-state) are fully decoded, high speed, 4096-bit programmable ROM's organized as 512 words by 8 bits per word. They are supplied with all bits storing a logical "1" (outputs high), and can be selectively programmed for a logical "0" (outputs low).

The nichrome fuse technology is the same as is used in the JAN approved MIL 38510/201 PROM, and in all other Harris PROMS.

The field programmable PROM can be custom programmed to any pattern using a simple programming procedure. Schottky Bipolar circuitry provides extremely fast access time, and features temperature and voltage compensation to minimize variations in access time.

In addition to the conventional storage array, two test rows and four test columns are included to assure high programmability, and guarantee parametric and A.C. performance. Fuses in these test rows and columns are blown prior to shipment.
### SPECIFICATIONS

**ABSOLUTE MAXIMUM RATING**

- Output or Supply Voltage (Operating): 7.0V
- Address/Enable Input Voltage: 5.5V
- Address/Enable Input Current: -20mA
- Output Sink Current: 70mA
- Storage Temperature: +150°C
- Operating Temperature (Ambient): +125°C
- Maximum Junction Temperature: +175°C

Stresses above those listed under the "Absolute Maximum Rating" may cause permanent damage to the device. This is a stress only rating and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied. (While programming, follow the programming specifications.)

### ELECTRICAL CHARACTERISTICS (OPERATING)

#### SYMBOLS

- \( V_{IH}, V_{IL} \)
- \( V_{OH}, V_{OL} \)
- \( I_{IH}, I_{IL} \)
- \( I_{OH}, I_{OL} \)
- \( V_{CC}, V_{EE} \)
- \( I_{CC} \)
- \( V_{CL}, V_{LS} \)
- \( V_{IL}, V_{LS} \)
- \( I_{EA}, I_{AA} \)
- \( t_{EA}, t_{AA} \)
- \( C_{IN}, C_{OUT} \)

#### Units

- Microamperes (µA)
- Milliamperes (mA)
- Volts (V)
- Nanoseconds (ns)
- PicoFarads (pF)

#### Test Conditions

- TA: 25°C, \( V_{CC} = +5V \)

#### Typical Measurements

- \( t_{EA} = 15 \pm 25 \) ns
- \( t_{AA} = 40 \pm 70 \) ns

#### Capacitance (1):

- \( T_A = 25°C \)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOLS</th>
<th>UNITS</th>
<th>TEST CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Enable Input Current</td>
<td>( I_{RA}, I_{RE}, I_{IA}, I_{IE} )</td>
<td>8 pF</td>
<td>( V_{CC} = 5V, 10H = 0.1MHz )</td>
</tr>
<tr>
<td>Output Capac.</td>
<td>( C_{OUT} )</td>
<td>8 pF</td>
<td>( V_{CC} = 5V, VOL = 2.0V, f = 1MHz )</td>
</tr>
</tbody>
</table>

**NOTE:** (1) These parameters are only periodically sampled and are not 100% tested.
**SWITCHING TIME DEFINITIONS**

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5V</td>
<td>1.5V</td>
</tr>
<tr>
<td>3.0V</td>
<td>0.0V</td>
</tr>
</tbody>
</table>

**A.C. TEST LOAD**

- **CS1**
- **CS2**
- **TEA**
- **TEA**
- **OE**
- **OE**
- **1R, 1f < 5NS**

**PROGRAMMING**

The HM-7640/7641 is manufactured with all bits/outputs Logical "1" (Output High). Any desired bit/output can be programmed to a Logical "0" (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HM-7640/7641 can be programmed automatically or by the manual procedure shown below.

**PROGRAMMING SPECIFICATIONS**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNITS</th>
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</thead>
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<tr>
<td>Address Input Voltage (1)</td>
<td>VIH</td>
<td>2.4</td>
<td>5.0</td>
<td>V</td>
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<tr>
<td>Programming Voltage to VCC (2)</td>
<td>VPH</td>
<td>1.15</td>
<td>12.0</td>
<td>V</td>
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<tr>
<td></td>
<td>VPL</td>
<td>3.75</td>
<td>4.0</td>
<td>V</td>
</tr>
<tr>
<td>Programming Voltage Current Limit</td>
<td>ICCP</td>
<td></td>
<td>600</td>
<td>mA</td>
</tr>
<tr>
<td>Programming Voltage Rise and Fall Time</td>
<td>tr, tf</td>
<td>1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Programming Delay</td>
<td>td</td>
<td>10</td>
<td>100</td>
<td>μs</td>
</tr>
<tr>
<td>Programming Pulse Width – First Attempts</td>
<td>tp1</td>
<td>100</td>
<td>200</td>
<td>μs</td>
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<tr>
<td>Programming Pulse Width – Subsequent</td>
<td>tp2</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Programming Duty Cycle</td>
<td>D.C.</td>
<td>10</td>
<td>10</td>
<td>%</td>
</tr>
<tr>
<td>Output Voltage Enable (3)</td>
<td>VOPe</td>
<td>9.5</td>
<td>10.0</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Disable</td>
<td>VOPD</td>
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<td>.45</td>
<td>5.5</td>
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<td>Enable Current Limit</td>
<td>IOPe</td>
<td></td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Case Temp</td>
<td>Tc</td>
<td>75</td>
<td>0°C</td>
<td></td>
</tr>
</tbody>
</table>

1. Address and chip select should not be left open for VIH.
2. Verification at VCC = 4.0 ± .25 Volts, TA = 25°C is recommended to guardband performance over full temperature and voltage range.
3. Disable condition will be met with output open circuit.

**SCHEMATIC DIAGRAMS**

**HM-7640**

- **FROM 1 OF 8 COLUMN DECODE**
- **TO DR-TIE OF 1 TO 8 COLUMN DECODE**
- **OPEN COLLECTOR OUTPUT**
- **PROGRAMMING CIRCUITRY**

**HM-7641**

- **FROM 1 OF 8 COLUMN DECODE**
- **TO DR-TIE OF 1 TO 8 COLUMN DECODE**
- **THREE-STATE OUTPUT**
- **TO CHIP SELETS**
- **OPEN COLLECTOR OUTPUT**
- **PROGRAMMING CIRCUITRY**
PROGRAMMING PROCEDURE

1. Address the PROM with the binary address of the selected word to be programmed. Address inputs are TTL compatible. An open circuit should not be used to address the PROM.

2. Disable the chip by applying input highs (VIH) to both CS1 and CS2 chip select inputs. The chip select inputs are TTL compatible. An open circuit should not be used to disable the chip.

3. Disable the programming circuitry by applying an Output Voltage Disable of less than VOPD to the output of the PROM. The output may be left open circuit to achieve the disable.

4. Raise VCC to VPH with rise time equal to tr.

5. After a delay equal to or greater than td, apply a pulse with amplitude equal to VOPE and duration of tpl to the output selected for programming. Note that the PROM is supplied with fuses intact generating an output high. Programming a fuse will cause the output to go low in the verify mode.

6. Other bits in the same word may be programmed while the VCC input is raised to VPH by applying output enable pulses to each output which is to be programmed. The output enable pulses must be separated by a minimum interval of td.

7. Lower VCC to 4.0 ± 0.25 Volts following a delay to td from the last programming enable pulse applied to an output.

8. Enable the PROM for verification by applying a logic '0' (VIL) to the CS1 and CS2 inputs.

9. If any bit does not verify as programmed, repeat steps 2 through 8 using an output pulse enable width of tpl for up to 15 additional pulses to enhance programming speed. If the bit is still unprogrammed, follow with at least 16 repetitive pulses of tp2 in width, to achieve high programming yield. In the event that the bit is still unprogrammed, the part is considered a programming reject and should be returned to the factory. The address and incorrect and desired contents of a location in which a programming failure has occurred in any returned device must be included with that return.

10. Repeat steps 1 thru 9 for all other bits to be programmed in the PROM.

RECOMMENDED PROGRAMMING CIRCUIT

The circuit and timing diagram shown in Figures 1 and 2 will establish the proper programming condition for the output enable pulse. This allows the use of standard TTL parts for all logic inputs to the PROM. Note the gate which senses the output must be input protected to withstand input up to 12.5 Volts during programming.
### HARRIS BIPOLAR PROM CROSS-REFERENCE

<table>
<thead>
<tr>
<th>NO. OF BITS</th>
<th>ORGANIZATION AND NO. OF OUTPUTS</th>
<th>HARRIS</th>
<th>AMD</th>
<th>FAIRCHILD</th>
<th>INTEL</th>
<th>INTERSIL</th>
<th>MMI</th>
<th>MOTOROLA</th>
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</tbody>
</table>

**NOTE:** Compatible pin-for-pin in read mode, but require different programming conditions for entering data into the memory.
**FEATURES**

- FIELD PROGRAMMABLE
- 64 WORDS/8 BITS PER WORD
- FULLY DECODED
- DTL/TTL COMPATIBLE
- 55 NS ACCESS TIME
- SINGLE 5 VOLT POWER SUPPLY
- STATIC OUTPUT WITH FANOUT OF 10
- AVAILABLE IN EITHER MILITARY OR COMMERCIAL TEMPERATURE RANGE
- EXPANDABLE - "WIRED-OR" OUTPUTS "AND" ENABLE INPUTS

**BLOCK DIAGRAM**

**HPROM-0512**

**512-Bit, Bipolar PROM™**

**TABLE**

<table>
<thead>
<tr>
<th>Word Number</th>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) E</td>
<td>A5 A4 A3 A2 A1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0 1 0 0 0 0 0 0</td>
</tr>
<tr>
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<tr>
<td>63</td>
<td>63</td>
<td>1 1 1 1 1 1 1 1</td>
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</tbody>
</table>

**NOTE:** (1) E = E1, E2 (2) X = "Don't Care"

**FIELD PROGRAMMING**

The HPROM-0512 is the first read-only memory which can be programmed electronically after manufacture and packaging. Most semiconductor read-only memories are programmed during manufacturing by designing the final metallization to correspond to the desired memory configuration. This process requires a different mask for each unique design and once the device is packaged, no further changes can be made. In contrast, the technique for programming the HPROM-0512 (see page 5) is straightforward and can be implemented at the user's facility with little difficulty.

Referring to the block diagram above, the status of any bit is determined by the condition of the 512 "Memory Elements" which connect the input word lines to each of eight (8) output bit buffers. In an unprogrammed memory, all "Memory Elements" are short circuits so that logical "zeros" appear at each output bit position for any address input. "Electronic Programming" involves the alteration of specific "Memory Elements" to create logical "ones" in selected bit positions. This alteration is irreversible and cannot be accomplished under normal operating conditions — thus, the HPROM-0512 is a true permanent memory when inserted in a system.

PROM is a trademark of Harris Semiconductor for its family of field programmable read-only memories.
**SPECIFICATIONS**

### ABSOLUTE MAXIMUM RATINGS

- **Supply Voltage, \( V_{CC} \)**: 7.0V
- **Address/Enable Input Voltage, \( V_A, V_E \)**: -1.5V to +5.5V
- **Output Supply Voltage, \( V_{BS} \)**: -0.5V to +7.0V
- **Output Sink Current, \( I_{OL} \)**: -30mA
- **Input Current**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sym</th>
<th>Limits</th>
<th>Units</th>
<th>Test Condition</th>
</tr>
</thead>
</table>
| **Enable Current**               | RE  | 10 \* 60  | \( \mu A \) | \( V_E = 2.4V \)  
|                                  |     | 30 \* 100 |         | \( V_E = 5.25V \)  
|                                  | FE  | -1.0 \* 1.6 | mA      | \( V_E = 0.4V \)  
|                                  |     |            |         | \( V_{CC} = 5.25V \) |
| **Address Current**              | RA  | 10 \* 60  | \( \mu A \) | \( V_A = 2.4V \)  
|                                  |     | 30 \* 100 |         | \( V_A = 5.25V \)  
|                                  | FA  | -1.0 \* 1.6 | mA      | \( V_A = 0.4V \)  
|                                  |     |            |         | \( V_{CC} = 5.25V \) |
| **Input Threshold Voltage**      | IH  | 2.0       | V       | \( V_{CC} = 4.75V \) |
|                                  |     | 0.25 \* 0.45 | V       | \( V_{CC} = 5.25V \) |
| **D.C. Output "0" Voltage**      | ODL | 0.25 \* 0.45 | V       | \( V_{CC} = 4.75V \)  
|                                  |     |            |         | \( V_{OL} = 10mA \)  
| **Output "1" Leakage Current**   | OH  |          | \( \mu A \) | \( V_{OH} = 2.4V \)  
|                                  |     | *100      |         | \( V_{IL} = 0.8V \)  
|                                  |     | *200      |         | \( V_{CC} = 5.25V \)  
| **Power Supply Current**         | ICC | 70 \* 95  | mA      | \( V_{CC} = 5.25V \)  
| (Quiescent)                      |     | 80        | mA      | \( V_E = V_A = 0V \)  
| (Operating)                      |     |           |         | \( f = 4MB/s \)⁴²   
| **Output Capacity**              | COUT | 5        | pF      | \( V_{OUT} = 2.0V \)  

### ELECTRICAL CHARACTERISTICS

**Test Conditions:**

- \( V_{CC} = 5.0 \pm 5\% \), \( G_1 = G_2 = G_2' = \text{Ground} \)
- \( T_{CASE} = -55°C \) to +125°C for HPROM-0512-2
- \( 0°C \) to +75°C for HPROM-0512-5
- unless otherwise specified.

### Notes:

1. Threshold voltages are defined as the limits on the input levels which ensure that the desired input state is achieved.
2. A typical device is one programmed to output 50% "ones".
3. Output terminals left open — see Test Circuit 1.
**TEST CIRCUITS**

**Figure 1.**
OPERATING POWER SUPPLY CURRENT

**Figure 2.**
PROPAGATION DELAYS

**SWITCHING TIME DEFINITIONS**

**NOTES:**
1. $E_1 = E_2 = "1"$
2. All measurements referenced to +1.5V level.
3. Address rise and fall times $\leq 10$ns.
CHARACTERISTIC CURVES

OUTPUT CHARACTERISTICS

OUTPUT CURRENT VS. TEMPERATURE

POWER SUPPLY CURRENT VS. TEMPERATURE

POWER SUPPLY CURRENT VS. DATA RATE

OUTPUT LEAKAGE CURRENT VS. TEMPERATURE

PROPAGATION DELAY VS. TEMPERATURE

TEST CONDITIONS: \( V_{CC} = 5.0V \) UNLESS OTHERWISE SPECIFIED.
PROGRAMMING

PROGRAMMING SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYM.</th>
<th>RECOMMENDED VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input Voltage &quot;1&quot;</td>
<td>VAH</td>
<td>(1) Open Circuit</td>
</tr>
<tr>
<td>&quot;0&quot;</td>
<td>VAL</td>
<td>-5.0V</td>
</tr>
<tr>
<td>Address Input low Current</td>
<td>IAL</td>
<td>-3.0mA</td>
</tr>
<tr>
<td>Power Supply Voltage</td>
<td>VCC</td>
<td>5.0V +5%-0%</td>
</tr>
<tr>
<td>G1 Voltage (2)</td>
<td>VG1</td>
<td>-5.0V</td>
</tr>
<tr>
<td>G2 Voltage</td>
<td>VG2</td>
<td>0V</td>
</tr>
<tr>
<td>Programming Voltage (MAX)</td>
<td>VBP</td>
<td>-7.0V</td>
</tr>
<tr>
<td>Programming Current (MAX)</td>
<td>Ip</td>
<td>100mA</td>
</tr>
<tr>
<td>Maximum Programming T_CASE</td>
<td>T_CASE</td>
<td>75°C</td>
</tr>
<tr>
<td>Programming Pulse widths</td>
<td>PW</td>
<td>400 ms</td>
</tr>
<tr>
<td>Duty Cycle T A 25°C</td>
<td>DC</td>
<td>20%</td>
</tr>
</tbody>
</table>

(1) An open collector TTL gate meets this specification.
(2) G1 must be connected to -5.0V prior to applying VCC or programming voltage.

PROGRAMMING

Programming the HPROM-0512 is a simple operation which can be accomplished with a minimum of equipment. A negative going voltage pulse is applied to each output terminal where the initial logic “zero” is to be changed to a logic “one.” The power supply and ground connections described below ensure that alteration of a specific logic element will not occur under normal operating conditions.

The following is the recommended procedure for reliably programming the HPROM-0512.

1. Connect the HPROM-0512 as shown in Figure 1. To address a particular word in memory, set the input switches to the binary equivalent of that word, where a logic “zero” is -5.0V and a logic “one” is an open circuit. (Do not return to supply.) All output bits (B0, B1, . . . , B7) of this word are now available for programming.

2. With the output of the current generator limited to 100mA, apply a negative going pulse to the pin associated with the first bit to be changed from a “zero” to a “one”. This is most easily accomplished by connecting the negative terminal of a variable power supply to the proper output pin and manually increasing the voltage to approximately 6.0V.

(The circuit shown in Figure 2 can be used in more automated programming systems. This circuit generates a fusing pulse which is at the proper voltage and current levels for fast, reliable programming. Most devices will program with input pulse widths (PW) as low as 200ms.)

Verify the bit programmed by returning the device to the read mode and connecting a load resistor to +5V.

3. Skipping any bit which is to remain a “zero,” repeat Step 2 for each “one” in the word being addressed. (For maximum reliability, program only one bit at a time.)

4. Set the next input address and repeat Steps 2 and 3. This procedure repeated for each input address for which a specific output word pattern is desired. Note that all addresses do not have to be programmed at the same time, nor do all output bits for a given address. A “zero” can always be changed to a “one” simply by repeating Steps 1 and 2. A “zero” once programmed to “one” cannot be reprogrammed to “zero.”

The procedure given above is intended merely to convey the mechanics of programming the HPROM-0512. Obviously, more sophisticated electronic methods can be devised to automate the process and minimize the time required for programming. Such a system is used by Harris to custom-program ROM’s for customers whose memory configurations are already established and also for certain standard patterns. This particular system operates with punched card inputs which convey the programming information and also provide the test conditions for each programmed ROM.
POWER STROBE

Since the HPROM-0512 is a permanent memory, $V_{CC}$ may be removed from the chip during periods when the memory is not being accessed thus reducing the average power consumption. A circuit which performs this function is shown in Figure 1. Using the components shown, the propagation delay from the power strobe to the first output word ($t_{SL}$) becomes $\sim 140$ns. Figure 2 shows the variation in $t_{SL}$ as a function of temperature.

EXPANDABILITY

The HPROM-0512 is easily expanded in both bit and word dimensions. Expanding in the word dimension is accomplished by using the E1 and E2 Enable Inputs as further decoding elements for the input address and wiring together (WIRE-OR) two or more output pins from corresponding bits of different words. The "WIRE-OR" connection results in increased capacitance and leakage at the output node as each additional package is connected. Expansion in the bit dimension is accomplished by paralleling corresponding address pins on two or more units. The Block Diagram above depicts a 256 word by 16-bit system.
**FEATURES**

- FIELD PROGRAMMABLE
- 256/4 BITS PER WORD
- FULLY DECODED
- DTL/TTL COMPATIBLE
- 50ns ACCESS TIME
- PROVEN RELIABLE NICHROME FUSES
- LOW INPUT CURRENT ≤ 0.25mA
- SINGLE 5.0V POWER SUPPLY
- EXPANDABLE – "WIRED-OR" OUTPUTS WITH CHIP SELECT INPUT
- AVAILABLE IN MILITARY AND COMMERCIAL TEMPERATURE RANGES

**DESCRIPTION**

The HPROM-1024 (3-State) and the HPROM-1024A (Open Collector) are fully decoded, high speed, 1024-bit, field programmable ROM's organized as 256 words by 4 bits per word. Field programmable implies that, by following a simple programming procedure, users are able to program the PROM to any custom pattern to satisfy their system requirements.

The HPROM-1024 and the HPROM-1024A are identical except for the output stage. The HPROM-1024A has an Open Collector output while the HPROM-1024 has a third high impedance state output, allowing the device to work in a "Wire – OR" configuration. The third state is activated by disabling the device (CS1 or CS2 High).

The HPROM-1024/1024A are supplied with all bits storing a Logical "1" (Output High) and can be selectively programmed for a Logical "0" (Output Low). The addressing scheme for programming and reading the information in the system is the same.

**INPUT/OUTPUT SCHEMATICS**

**BLOCK DIAGRAM**

**PACKAGE**

<table>
<thead>
<tr>
<th>CODE 1D</th>
<th>16 LEAD CERAMIC D.I.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND A2 A1 A0 A3 A4 A5 A6</td>
<td></td>
</tr>
<tr>
<td>9 10 11 12 13 14 15 16</td>
<td></td>
</tr>
<tr>
<td>04 03 02 01 CST/CSP A7 VCC</td>
<td></td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE 1 INCHES. ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.
SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Note:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output or Supply Voltage</td>
<td></td>
<td>7.0V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address/Enable Input Voltage</td>
<td></td>
<td>5.5V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address/Enable Input Current</td>
<td></td>
<td>-20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Sink Current</td>
<td></td>
<td>70mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Temperature</td>
<td></td>
<td>+150°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Temperature (Case)</td>
<td></td>
<td>+125°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td></td>
<td>+175°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theta Jc (Cerdip)</td>
<td></td>
<td>25°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theta JA (Cerdip)</td>
<td></td>
<td>80°C/W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:

Stresses above those listed under the “Absolute Maximum Rating” may cause permanent damage to the device. This is a stress only rating and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied. (While programming, follow the programming specifications.)

ELECTRICAL CHARACTERISTICS (Operating Mode)

Test Condition: 1) VCC = 5.0± 5%, TA = -55°C to +125°C (HPROM-1024-2, HPROM-1024A-2)

2) VCC = 5.0± 5%, TA = 0°C to +75°C (HPROM-1024-5, HPROM-1024A-5) unless otherwise specified.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address/Chip Select &quot;1&quot;</td>
<td>IRE, IRE</td>
<td>*40</td>
<td>*40</td>
<td>µA</td>
<td>VIH = VCC Max.</td>
</tr>
<tr>
<td>Input Current &quot;0&quot;</td>
<td>IFA, IFE</td>
<td>*-0.25</td>
<td>*-0.25</td>
<td>mA</td>
<td>VIL = 0.45V</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>VClamp</td>
<td>-0.7</td>
<td>-1.0</td>
<td>-0.7</td>
<td>-1.5 VCC = VCC Min.</td>
</tr>
<tr>
<td>Input Threshold &quot;1&quot; Voltage &quot;0&quot;</td>
<td>VIH, VIL</td>
<td>2.0</td>
<td>2.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Output Voltage &quot;1&quot; &quot;0&quot;</td>
<td>VOH, VOL</td>
<td>*2.4</td>
<td>*0.45</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Output Leakage &quot;1&quot;</td>
<td>IOH, N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>*100</td>
<td>µA</td>
</tr>
<tr>
<td>Output Disabled Current</td>
<td>IOE</td>
<td>*100</td>
<td>*100</td>
<td>mA</td>
<td>VOH = 2.4V, VEH/VEl/V2 = 2.0V</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>ICC</td>
<td>*130</td>
<td>*130</td>
<td>mA</td>
<td>All Inputs Grounded. VCC = VCC Max.</td>
</tr>
<tr>
<td>Address to Output</td>
<td>tA+, tA-</td>
<td>50</td>
<td>*70</td>
<td>50</td>
<td>*70 ns</td>
</tr>
<tr>
<td>Enable Access Time</td>
<td>tE-, tOFF+</td>
<td>20</td>
<td>*35</td>
<td>20</td>
<td>*35 ns</td>
</tr>
</tbody>
</table>

*100% Tested For DASH 8

CAPACITANCE (1): TA = 25°C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add. Input Cap.</td>
<td>CINA, CS2</td>
<td>7</td>
<td>15</td>
<td>pf</td>
<td>VCC = 5V, VIN = 2.0V</td>
</tr>
<tr>
<td>Chip Select Input Cap.</td>
<td>CS1</td>
<td>10</td>
<td>20</td>
<td>pf</td>
<td>VCC = 5V, VIN = 2.0V</td>
</tr>
<tr>
<td>Output Cap.</td>
<td>COUT</td>
<td>6</td>
<td>12</td>
<td>pf</td>
<td>VCC = 5V, VOUT = 2.0V</td>
</tr>
</tbody>
</table>

NOTE (1): These parameters are only periodically sampled and are not 100% tested.

SWITCHING TIME DEFINITIONS

A.C. TEST LOADS

5.0V

300Ω

Test Point

0Ω

600Ω

30pf
The HPROM-1024/1024A is manufactured with all bits/outputs Logical "1" (Output High). Any desired bit/output can be programmed to a Logical "0" (Output Low) by following the simple procedure shown below. One may build his own programmer to satisfy the specifications described in Table 1, or buy any of the commercially available programmers which meet these specifications. The HPROM-1024/1024A can be programmed automatically or by the manual procedure shown below.

### PROGRAMMING SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN. VALUE</th>
<th>RECOMMENDED VALUE</th>
<th>MAX. VALUE</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Input Voltage</td>
<td>$V_{IH}$</td>
<td>2.4</td>
<td>5.0</td>
<td>5.0</td>
<td>V</td>
<td>Address inputs should not be left open for $V_{IH}$</td>
</tr>
<tr>
<td></td>
<td>$V_{IL}$</td>
<td>0.0</td>
<td>0.0</td>
<td>0.4</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Chip Select 2 Voltage</td>
<td>$V_{CS2}$</td>
<td>2.4</td>
<td>5.0</td>
<td>5.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Programming Voltage</td>
<td>$V_{CS1}$ (Pin 13)</td>
<td>24.0</td>
<td>25</td>
<td>25.5</td>
<td>V</td>
<td>*Including overshoot</td>
</tr>
<tr>
<td>Programming Current Limit</td>
<td>$I_{CS1}$ (Pin 13)</td>
<td>125mA</td>
<td>200</td>
<td>300</td>
<td>mA</td>
<td>125mA is the typical programming current requirement.</td>
</tr>
<tr>
<td>Programming Pulse Width</td>
<td>$T_{PW}$</td>
<td>1</td>
<td>10</td>
<td>100</td>
<td>mS</td>
<td>$\text{RISE} = 200 \ SECS; \text{SLEW} = 200%$</td>
</tr>
<tr>
<td>Output Select Voltage</td>
<td>$V_{OS}$</td>
<td>10.5</td>
<td>11</td>
<td>11.5</td>
<td>V</td>
<td>2mA is the typical current requirement.</td>
</tr>
<tr>
<td>Output Select Current limit</td>
<td>$I_{OS}$</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Power Supply Voltage</td>
<td>$V_{CC}$</td>
<td>5.0</td>
<td>5.0</td>
<td>5.25</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Case Temperature</td>
<td>$T_{C}$</td>
<td>-25</td>
<td>25</td>
<td>75*</td>
<td>°C</td>
<td>*20% duty cycle with $T_{A} = 25^\circ \text{C}$</td>
</tr>
</tbody>
</table>

### MANUAL PROGRAMMING

The HPROM-1024/1024A may be programmed using the method shown in the figure on the left.

(1) Select the word to be programmed by applying the appropriate voltages to the address pins $A_0$ through $A_7$.

(2) Apply 11.0 volts to the output associated with the bit to be programmed. The other outputs may be left open or connected to any normal circuitry which does not apply more than 5 volts to these outputs. Only one output is programmed at a time.

(3) Apply the 25 volt programming pulse to the Input Pin $CS_1$ (Pin 13). The recommended programming pulse width is 10ms. However, programming speed may be enhanced by making initial attempts at 1msec. Bits which do not program with these pulse widths may be programmed either by repeating with 10ms pulses or by increasing the programming pulse width to 100ms. The multiple application of the programming pulse or the increased pulse width in no way affects the reliability of the device. The case temperature of the device being programmed, however, must not exceed 75°C. The 20% duty cycle at $T_{A} = 25^\circ \text{C}$ generally maintains a $T_{CASE}$ of 75°C. Bits which do not program when subjected to multiple pulses totaling 500 msec may be returned for replacement. Returned units should be accompanied with word and bit location of fuse which did not program.

(4) To verify that the output has been programmed following each application of the programming pulse, being Pin 13 and Pin 14 to 0.4 volts or less. $V_{CC}$ should be reduced to 4.0 + .2 volts to guardband full temperature and volume range operations.

(5) The above procedure is repeated to program other bits on the chip.
The HPROM-8256 is another in a series of field programmable read-only memories from Harris Semiconductor. Field programming implies that the device (packaged with logical "0's" in all 256 memory locations) can be programmed electronically by the user to any specific pattern using the simple procedure shown on page 4.

Referring to the circuit diagram below, the status of any bit is determined by the condition of the "memory element" in that bit location. For a logical "0" output, the memory element is in the conducting state and the output transistor is turned "on". Programming, then, involves opening selected memory elements to prevent current flow to the output transistor, creating a logical "1" in each programmed bit location.

**Note:** X = DON'T CARE

---

**FEATURES**

- FIELD PROGRAMMABLE
- 32 WORDS/8BITS PER WORD
- FULLY DECODED
- DTL/TTL COMPATIBLE
- 40NS ACCESS TIME
- PROVEN RELIABLE NICHROME FUSES
- SINGLE 5V POWER SUPPLY
- STATIC OUTPUT WITH FANOUT OF 10
- AVAILABLE IN MILITARY AND COMMERCIAL TEMPERATURE RANGES
- EXPANDABLE – "WIRED-OR" OUTPUTS – CHIP ENABLE INPUT

---

**TRUTH TABLE**

<table>
<thead>
<tr>
<th>WORD NUMBER</th>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>E A4 A3 A2 A1 A0</td>
<td>B7 B6 B5 B4 B3 B2 B1 B0</td>
<td>1 1 1 1 1 1 1 1 1</td>
</tr>
<tr>
<td>X 1 X X X X</td>
<td>1 1 1</td>
<td>X</td>
</tr>
<tr>
<td>0 0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>X</td>
</tr>
<tr>
<td>1 0 0 0 0 0 1</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>X</td>
</tr>
<tr>
<td>2 0 0 0 0 0 1</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>X</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>31 0 1 1 1 1</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>X</td>
</tr>
</tbody>
</table>

---

**CIRCUIT DIAGRAM**

---

**PACKAGE**

**CODE 1D**

16 LEAD CERAMIC D.I.P.
### Specifications

#### Absolute Maximum Ratings

- **Supply Voltage (Operating), VCC**: 7.0V
- **Address/Enable Input Voltage, VA, VE**: -1.5V to +5.5V
- **Output Supply Voltage (Operating), VBS**: -1.5V to +7.0V
- **Output Sink Current, IOL**: 30mA
- **Input Current**: 30mA
- **Storage Temperature**: -65°C to +150°C
- **Operating Temperature**: -55°C to +125°C

#### Electrical Characteristics

**Test Conditions**

<table>
<thead>
<tr>
<th>HPROM-8256-2 (VCC=+5.0V ±10%, TA= -55°C to +125°C)</th>
<th>HPROM-8256-5 (VCC=+5.0V ±5%, TA= 0°C to +75°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PARAMETER</strong></td>
<td><strong>SYM</strong></td>
</tr>
<tr>
<td>ENABLE Current</td>
<td>“1”</td>
</tr>
<tr>
<td></td>
<td>“0”</td>
</tr>
<tr>
<td>Address Current</td>
<td>“1”</td>
</tr>
<tr>
<td></td>
<td>“0”</td>
</tr>
<tr>
<td>Input Threshold Voltage</td>
<td>“1”</td>
</tr>
<tr>
<td></td>
<td>“0”</td>
</tr>
<tr>
<td>Output “0” Voltage</td>
<td>VDL</td>
</tr>
<tr>
<td>Output “1” Leakage</td>
<td>IOH</td>
</tr>
<tr>
<td>Input Clamp Voltage</td>
<td>VC</td>
</tr>
<tr>
<td>Power Supply Current (Quiescent)</td>
<td>ICC</td>
</tr>
<tr>
<td></td>
<td>(Operating)</td>
</tr>
<tr>
<td>Address/Enable to Output Fall Delay</td>
<td>t-</td>
</tr>
<tr>
<td>Address/Enable to Output Rise Delay</td>
<td>t+</td>
</tr>
</tbody>
</table>

*100% Tested For DASH 8

#### Switching Time Definitions

1. All measurements referenced to +1.5V.
2. Address rise and fall times ≤ 10ns.
**PROGRAMMING**

**NOTE:** See Procedure No. 4 below.

**REQUIREMENTS**

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>RECOMMENDED VALUE</th>
<th>LIMITS</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable/Address Input Low Current</td>
<td></td>
<td>MIN. -6.0 mA</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Enable/Address Input Voltage low</td>
<td>GND</td>
<td>0.4 V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>high</td>
<td>OPEN</td>
<td>11.5 V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Programming Voltage (VCCp)</td>
<td>1</td>
<td>0.5 ms</td>
<td>800* ms</td>
<td>V</td>
</tr>
<tr>
<td>Programming Pulse Width (tp)</td>
<td>20</td>
<td>0.0 V</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Programming Output Voltage</td>
<td>-0.5</td>
<td>0.0 mA</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Non-Programming Output Current</td>
<td>4.0</td>
<td>0.0 %</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>TCASE</td>
<td></td>
<td>75 °C</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Duty Cycle (TA = 25°C)</td>
<td>60</td>
<td>80 %</td>
<td></td>
<td>V</td>
</tr>
</tbody>
</table>

**PROCEDURE**

1. Connect the PROM as shown in figure 1.
2. Address the desired word by applying an open circuit for Logic “1” and ground for Logic “0”. (High voltage open collector TTL inputs may also be used.)
3. Select first output bit to be programmed by taking that output to a negative 0.5V.
4. Disable device (E ≥ 2.5V). (Nonprogramming outputs will rise to approximately 8.3V) Raise supply to +11V and enable device (E ≤ 0.4V) to program the selected memory element. (Enable signal must not be applied prior to raising VCC to +11V.) Device should be enabled for tp milliseconds. For fastest programming results the first attempts should be one millisecond with subsequent attempts greater than 10 milliseconds to maximize programmability.
5. Verify the bit programmed by lowering the +15V to +4.5V and then enabling the device.
6. In the event the device does not verify, repeat steps 2 - 5. Bits which do not program with a total of 800 msec of programming time are considered unprogrammable and may be returned for replacement. Devices returned must contain word and bit numbers of bits which did not program.
7. Repeat steps 3 through 6 to complete programming the remaining bits in the selected word.
8. Repeat steps 2 through 7 to complete programming the remaining words in the device.
CHARACTERISTIC CURVES

POWER SUPPLY CURRENT vs TEMPERATURE

ADDRESS TO OUTPUT PROPAGATION DELAY vs TEMPERATURE

ENABLE TO OUTPUT PROPAGATION DELAY vs TEMPERATURE

INPUT THRESHOLD vs TEMPERATURE

INPUT CURRENT vs INPUT VOLTAGE

OUTPUT LOW V-I CHARACTERISTICS

EXPANDABILITY
MIL-STD-883/MIL-M-38510 Reliability Assurance Program

INTRODUCTION

STATEMENT OF SCOPE

This section establishes the detail requirements for Harris' Circuits screened and tested under the DASH 8 Program.

The Harris DASH 8 Devices pass the screening requirements of the latest issue of MIL-STD-883, Method 5004, Class B, and the requirements as specified in this document.

APPLICABLE DOCUMENTS

The following documents form a part of this section to the extent referenced herein:

- MIL-Q-9858A  "Quality Program Requirements"
- MIL-STD-883  "Test Methods and Procedures for Microelectronics"
- NASA Publication 200-3  "Inspection System Provisions"

Harris maintains a product assurance program (PAP) using MIL-M-38510 as a guide. Harris Product Assurance Program assures compliance with the requirements and quality standards of control drawings and the requirements of this specification.

Systems and procedures used are in accordance with NASA Publication 200-3, MIL-Q-9858A and MIL-M-38510.

The DASH 8 Program will also be found useful by those Harris customers who must generate their own procurement specifications. Use of the enclosed Harris Standard Test Tables, Test Parameters, and Burn-In Circuits will aid in reducing specification negotiation time. CMOS is also available in DASH 8, for further information on CMOS DASH 8 see our CMOS Catalog or contact your local sales representative.
MIL-STD-883, METHOD 5004, CLASS B, 100% SCREENING PROCEDURE

SCREEN

1. Internal Visual (Precap) 2010 Condition B
2. Stabilization Bake 1008, Condition C, 24 Hours minimum
3. Temperature Cycling 1010, Condition C
5. Seal, Fine Leak 1014, Condition (As applicable)
6. Seal, Gross Leak 1014, Omit Step 1, No vacuum Preconditioning Step 2
7. Initial Electrical Harris Specifications
8. Burn-In Method 1015, 168 hours @ 125°C (Burn-In Circuits Enclosed. See page Da-8.)
9. Final Electrical Per appropriate Harris DASH 8
   9.1 D. C. Tests at 25°C Data Sheet only those items
   Maximum and minimum identified by * are tested 100%. operating temperatures
   9.2 A. C. Tests at 25°C
10. External Visual Method 2009
11. Lot Acceptance Group A, Table 1, Subgroup 1, 2, 3 & 4

NOTE:
LOT DEFINITION: Production Lot and Inspection Lot shall be as defined in MIL-M-38510.
TRACEABILITY: All devices are assigned date code identification that provides traceability back to the inspection lot.
BRANDING: All devices are branded with the HX-XXX-8 and EIA data code.
AGED PRODUCT: Product that has been held for more than twelve months will be rescreened prior to shipment.
ADDITIONAL REQUIREMENTS: Attributes data will be supplied on Group A Lot Acceptance upon request.

Generic data from Harris’ Reliability Add-On Program is available upon request; The objective of Harris Reliability Add-On Program is to provide a continuous life and environmental monitor for all product families in manufacturing. This program provides life test performance results to fulfill customer reliability data requirements and to verify package integrity. The Reliability Add-On Program is supplemental to customer funded Lot Qualification.

For customers desiring Lot Qualification, Harris Semiconductor will perform the Group A, Group B and Group C test to MIL-STD-883, Method 5005 as defined herein for an additional charge.
Generic data from Harris’ Reliability Add-On Program is available upon request; The objective of Harris Reliability Add-On Program is to provide a continuous life and environmental monitor for all product families in manufacturing. This program provides life test performance results to fulfill customer reliability data requirements and to verify package integrity. The Reliability Add-On Program is supplemental to customer funded Lot Qualification.

The Harris Reliability Add-On Program is an on-going program that provides generic product and package testing data that can be equated to MIL-STD-883 Group B and Group C tests. The data derived from the Add-On Program forms the basis for the Harris Reliability Bulletins published under the cognizance of the Harris Reliability Manager.

The Reliability Add-On Program section that is applicable to the DASH 8 program is listed below.

<table>
<thead>
<tr>
<th>PRODUCT TYPE</th>
<th>SCHEDULE WITH SAMPLE SIZE</th>
<th>STRESS CONDITIONS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERIC STANDARD</td>
<td>a) 1,000 hours sample of each generic type per quarter.</td>
<td>a) $T_A = +125^\circ\text{C}$ operating life</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Extend to 5,000 hours - 1 sample per quarter.</td>
<td>b) $T_A = +175^\circ\text{C}$ storage life</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Extend to 10,000 hours - 1 sample per half year.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Sample size - 10 per stress medium for PROMs; 14/36 per stress medium for linears.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) Variables data points at 0, 168, 500, 1000, 2000, 5000, and 10,000 hours.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PACKAGE QUALIFICATION</td>
<td>a) One generic type per quarter per package type.</td>
<td>a) Reference Reliability Standard Operating Procedure (RSOP) -002 and -003</td>
<td>Reason: Verify continued package integrity.</td>
</tr>
<tr>
<td></td>
<td>b) Sample size - 50 good and 50 reject devices per package type for package qual;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPECIAL TESTS</td>
<td>a) One generic type, per month as a minimum</td>
<td>SEM Analysis</td>
<td>Reason: To verify aluminum coverage over oxide steps.</td>
</tr>
<tr>
<td>AI step coverage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# HARRIS DEVICE QUALIFICATION PROCEDURE

## MIL-STD-883, METHOD 5005, GROUP B (NOTE 1)

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>CONDITION</th>
<th>QUALITY CONFORMANCE INSPECTION (NOTE 2)</th>
<th>QUALIFICATION INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBGROUP 1</strong></td>
<td></td>
<td></td>
<td>CLASS B LTPD</td>
<td>CLASS B LTPD</td>
</tr>
<tr>
<td>Physical Dimensions</td>
<td>2016</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUBGROUP 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Resistance to solvents</td>
<td>2015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Internal Visual and mechanical</td>
<td>2014</td>
<td>Failure criteria from design and construction requirements of applicable procurement document</td>
<td>3 devices (no failures)</td>
<td>3 devices (no failures)</td>
</tr>
<tr>
<td>(c) Bond strength (NOTE 3)</td>
<td>2011 (see 3.8)</td>
<td>Test condition C or D</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Ultrasonic or wedge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUBGROUP 3</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Solderability (NOTE 4)</td>
<td>2003</td>
<td>Soldering temperature of 260 ±10°C.</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td><strong>SUBGROUP 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead integrity</td>
<td>2004</td>
<td>Test condition B&lt;sub&gt;2&lt;/sub&gt;</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Seal (NOTE 5)</td>
<td>1014</td>
<td>As applicable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Fine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Gross</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. Electrical reject devices from the same inspection lot may be used for all subgroups when end point measurements are not required.
2. Generic data from Harris Reliability Add-On Program available upon request.
3. Unless otherwise specified, at the manufacturer's option, test samples for bond strength may be selected randomly immediately following internal visual (method 5004) prior to sealing.
4. The LTPD applies to the number of leads inspected except in no case shall less than three devices be used to provide the number of leads required.
5. Omit step 1 and vacuum preconditioning of step 2.
### HARRIS DEVICE QUALIFICATION PROCEDURE

**MIL-STD-883, METHOD 5005, GROUP C**

<table>
<thead>
<tr>
<th>TEST</th>
<th>METHOD</th>
<th>CONDITION</th>
<th>QUALITY CONFORMANCE INSPECTION (NOTE 6)</th>
<th>QUALIFICATION INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CLASS B LTPD</td>
<td>CLASS B LPTD</td>
</tr>
<tr>
<td><strong>SUBGROUP 1 (NOTE 1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shock</td>
<td>1011</td>
<td>Test condition B as a minimum.</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Temperature cycling</td>
<td>1010</td>
<td>Test condition C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture resistance</td>
<td>1004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal (NOTE 5)</td>
<td>1014</td>
<td>As applicable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Fine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Gross</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Examination (NOTE 2)</td>
<td></td>
<td>As specified in the applicable procurement document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End point elec. parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUBGROUP 2 (NOTE 1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical shock</td>
<td>2002</td>
<td>Test condition B</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Vibration, variable frequency</td>
<td>2007</td>
<td>Test condition A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant acceleration</td>
<td>2001</td>
<td>Test condition E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal (NOTE 5)</td>
<td>1014</td>
<td>As applicable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Fine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Gross</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Examination (NOTE 3)</td>
<td></td>
<td>As specified in the applicable procurement document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End point elec. parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUBGROUP 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperature storage (NOTE 4)</td>
<td>1008</td>
<td>150 +50 °C storage, 1000 hours.</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>End point elec. parameters</td>
<td></td>
<td>As specified in the applicable procurement document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUBGROUP 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating life test (NOTE 4)</td>
<td>1005</td>
<td>Test condition to be specified in the applicable procurement document (1000 hours).</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>End point elec. parameters</td>
<td></td>
<td>As specified in the applicable procurement document.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. Devices used for environmental tests in subgroup 1 may be used for mechanical tests in subgroup 2.
2. Visual examination shall be in accordance with method 1010 or 1011 at a magnification of 5X to 10X.
3. Visual examination shall be performed at a magnification of 5X to 10X for evidence of defects or damage to case, leads, or seals resulting from testing (not fixturing). Such damage shall constitute a failure.
4. See applicable life test circuit enclosed herein.
5. Omit step 1 and vacuum preconditioning of step 2.
6. Generic data from Harris Reliability Add-On Program available upon request.
LINEAR

ANALOG MULTIPLEXERS AND SWITCHES

MULTIPLEXERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI-506</td>
<td>CMOS 16 Channel Analog Multiplexer</td>
<td>21</td>
</tr>
<tr>
<td>HI-506A</td>
<td>CMOS 16 Channel Analog Multiplexer</td>
<td>21</td>
</tr>
<tr>
<td>HI-507</td>
<td>Dual-8 CMOS Multiplexer</td>
<td>21</td>
</tr>
<tr>
<td>HI-507A</td>
<td>Dual-8 CMOS Multiplexer</td>
<td>21</td>
</tr>
<tr>
<td>HI-508A</td>
<td>8 Channel Analog Multiplexer</td>
<td>22</td>
</tr>
<tr>
<td>HI-509A</td>
<td>4-Channel Analog Multiplexer</td>
<td>23</td>
</tr>
<tr>
<td>HI-1818A</td>
<td>8 Channel Multiplexer</td>
<td>26</td>
</tr>
<tr>
<td>HI-1828A</td>
<td>4-Channel Multiplexer</td>
<td>27</td>
</tr>
</tbody>
</table>

SWITCHES

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI-200</td>
<td>Dual SPST Analog Switch</td>
<td>19</td>
</tr>
<tr>
<td>HI-201</td>
<td>Quad SPST Analog Switch</td>
<td>20</td>
</tr>
<tr>
<td>HI-1800A</td>
<td>DPDT–Low Leakage 4-Channel Analog Switch</td>
<td>25</td>
</tr>
</tbody>
</table>

OPERATIONAL AMPLIFIERS

F. E. T. INPUT

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-2000</td>
<td>F. E. T. Input Preamplifier</td>
<td>3</td>
</tr>
<tr>
<td>HA-2050</td>
<td>High Slew Rate F. E. T. Input Operational Amplifier</td>
<td>2</td>
</tr>
<tr>
<td>HA-2050A</td>
<td>High Slew Rate F. E. T. Input Operational Amplifier</td>
<td>2</td>
</tr>
<tr>
<td>HA-2080</td>
<td>Wide Band F. E. T. Input Operational Amplifier</td>
<td>2</td>
</tr>
<tr>
<td>HA-2080A</td>
<td>Wide Band F. E. T. Input Operational Amplifier</td>
<td>2</td>
</tr>
</tbody>
</table>

HIGH SLEW RATE

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-2500</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2502</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2510</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2512</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2520</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2522</td>
<td>High Slew Rate Operational Amplifiers</td>
<td>2, 8</td>
</tr>
<tr>
<td>HA-2530</td>
<td>Wide Band High Slew Inverting Amplifiers</td>
<td>9</td>
</tr>
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</table>

LOW NOISE WIDE BAND

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-909</td>
<td>Low Noise, Operational Amplifier</td>
<td>1, 2</td>
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</tbody>
</table>

LOW POWER

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-2700</td>
<td>Low Power, High Performance Operational Amplifiers</td>
<td>13, 14</td>
</tr>
<tr>
<td>HA-2720</td>
<td>Low Power, Current Programmable Operational Amplifiers</td>
<td>15</td>
</tr>
<tr>
<td>HA-2730</td>
<td>Low Power, Dual, Current Programmable Operational Amplifiers</td>
<td>16</td>
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</tbody>
</table>

PRECISION HIGH ZIN WIDE BAND

<table>
<thead>
<tr>
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<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-2600</td>
<td>High Impedance Operational Amplifiers</td>
<td>2, 10</td>
</tr>
<tr>
<td>HA-2602</td>
<td>High Impedance Operational Amplifiers</td>
<td>2, 10</td>
</tr>
<tr>
<td>HA-2610</td>
<td>Wide Band, High Impedance Operational Amplifiers</td>
<td>2, 10, 11</td>
</tr>
<tr>
<td>HA-2622</td>
<td>Wide Band, High Impedance Operational Amplifiers</td>
<td>2, 10, 11</td>
</tr>
<tr>
<td>HA-2650</td>
<td>Dual High Performance Operational Amplifiers</td>
<td>2</td>
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SPECIAL FUNCTION

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>HA-2400</td>
<td>PRAM Four Channel Operational Amplifiers</td>
<td>6</td>
</tr>
<tr>
<td>HA-2420</td>
<td>Sample and Hold, Gated Operational Amplifiers</td>
<td>7</td>
</tr>
<tr>
<td>HA-2530</td>
<td>High Performance Current Booster</td>
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</tr>
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</table>

ULTRA HIGH PRECISION

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<th>Description</th>
<th>DRAWING NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA-2900</td>
<td>Chopper Stabilized Operational Amplifiers</td>
<td>18</td>
</tr>
</tbody>
</table>

PHASE LOCKED LOOP

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
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<tbody>
<tr>
<td>HA-2820</td>
<td>Phase Locked Loop</td>
<td>17</td>
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SPECIAL INTERFACE CIRCUITS

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>HI-1080</td>
<td>8-Bit, D to A Converter High Speed Monolithic</td>
<td>24</td>
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VOLTAGE COMPARATOR

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
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<tbody>
<tr>
<td>HA-2111</td>
<td>Precision Voltage Comparator</td>
<td>4, 5</td>
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MEMORY

BIPOLAR MEMORY

GENERIC PROMS

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>DRAWING NO.</th>
</tr>
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<tbody>
<tr>
<td>HM-7610</td>
<td>1024-Bit, Bipolar Generic PROM (open collector)</td>
<td>29</td>
</tr>
<tr>
<td>HM-7611</td>
<td>1024-Bit, Bipolar Generic PROM (three state)</td>
<td>29</td>
</tr>
<tr>
<td>HM-7620</td>
<td>2048-Bit, Bipolar Generic PROM (open collector)</td>
<td>33</td>
</tr>
<tr>
<td>HM-7621</td>
<td>2048-Bit, Bipolar Generic PROM (three state)</td>
<td>33</td>
</tr>
</tbody>
</table>

HPROM

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>HPROM-0512</td>
<td>512-Bit, Bipolar PROM</td>
<td>30</td>
</tr>
<tr>
<td>HPROM-1024</td>
<td>1024-Bit, Bipolar PROM (three state)</td>
<td>32</td>
</tr>
<tr>
<td>HPROM-1024A</td>
<td>1024-Bit, Bipolar PROM (open collector)</td>
<td>32</td>
</tr>
<tr>
<td>HPROM-8256</td>
<td>256-Bit, Bipolar PROM</td>
<td>31</td>
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</table>

POWER/LOGIC STROBE

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tbody>
<tr>
<td>HD-6600</td>
<td>Quad Power Strobe</td>
<td>28</td>
</tr>
<tr>
<td>HD-6605</td>
<td>Quad Logic Strobe</td>
<td>28</td>
</tr>
</tbody>
</table>
1. **HA-909**

   - **Circuit Type:** TO-86 Flat Pack
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 1\text{ M}	ext{egohm}$
     - $C_1 = 0.01\mu F, 100V$


   - **Circuit Type:** TO-99
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 1\text{ M}	ext{egohm}$
     - $C_1 = 0.01\mu F, 100V$

3. **HA-2000**

   - **Circuit Type:** TO-99
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 300\Omega$
     - $D_{1,2} = \text{IN4002}$
     - Freq: $50\text{ KHz} @ 12\text{ V}$ peak to peak

4. **HA-2111**

   - **Circuit Type:** TO-99
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 300\Omega$
     - $D_{1,2} = \text{IN4002}$
     - Freq: $50\text{ KHz} @ 12\text{ V}$ peak to peak

5. **HA-2111**

   - **Circuit Type:** TO-116
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 300\Omega$
     - $D_{1,2} = \text{IN4002}$
     - Freq: $50\text{ KHz} @ 12\text{ V}$ peak to peak

6. **HA-2400**

   - **Circuit Type:** TO-99
   - **Bandwidth Control**
   - **Output**
   - **Notes:**
     - $T_A = +125^\circ C$
     - $R_1 = 100\kappa\Omega$
     - $C_1 = 910\mu F, 50V$
     - $D_{1,2} = \text{IN4002}$
     - Freq: $Q_1 = 100\text{ KHz}; Q_2 = 50\text{ KHz}; Q_3 = 25\text{ KHz}$
**BURN-IN CIRCUITS**

**7** HA-2420

![Diagram for HA-2420][1]

NOTE: $T_A = +125^\circ\text{C}$

**8** HA-2500, HA-2502, HA-2510, HA-2512, HA-2520, HA-2522

![Diagram for HA-2500, HA-2502, HA-2510, HA-2512, HA-2520, HA-2522][2]

NOTES:
- $T_A = +125^\circ\text{C}$
- $R_1 = 1\ \text{Megohm}$
- $C_1 = 0.01\ \mu\text{F}, 50\text{V}$

**9** HA-2530

![Diagram for HA-2530][3]

NOTE: $T_A = +125^\circ\text{C}$

**10** HA-2600, HA-2602, HA-2620, HA-2622

![Diagram for HA-2600, HA-2602, HA-2620, HA-2622][4]

NOTES:
- $T_A = +125^\circ\text{C}$
- $R_1 = 1\ \text{Megohm}$
- $C_1 = 0.01\ \mu\text{F}, 100\text{V}$

**11** HA-2620/2622

![Diagram for HA-2620/2622][5]

NOTES:
- $T_A = +125^\circ\text{C}$
- $R_1 = 1\ \text{Megohm}$
- $C_1 = 0.01\ \mu\text{F}, 100\text{V}$

**12** HA-2630

![Diagram for HA-2630][6]

NOTE: $T_A = +125^\circ\text{C}$
**BURN-IN CIRCUITS**

**13**

HA-2700

**14**

HA-2700

**15**

HA-2720

**16**

HA-2730

**17**

HA-2820

**18**

HA-2900

**NOTES:**

TA = +125°C
R1 = 1 Megohm

**NOTES:**

TA = +125°C
R1 = 1 Megohm

**NOTES:**

TA = +125°C
R1 = 10KΩ
R2 = 4.7KΩ
R3 = 600Ω
C1 = 0.1 μF
**BURN-IN CIRCUITS**

**HI-200**

- **INPUT DRIVER**
- **D1**
- **D2**
- **D3**
- **R1**
- **VREF**
- **OPEN**

**NOTES:**
- **TA = +125°C**
- **R1 = 10KΩ**
- **D1D2D3 = IN4002**
- **Freq: = 100KHz**

**HI-201**

- **INPUT DRIVE**
- **D1**
- **D2**
- **R1**
- **VREF**
- **OPEN**

**NOTES:**
- **TA = +125°C**
- **D1D2 = IN4002**
- **Freq: = 100KHz**

**HI-506/507/506A/507A**

- **+15VDC**
- **+5.0V**
- **A1**
- **A2**
- **A3**
- **A4**
- **10KΩ**
- **NC**

**NOTES:**
- **AO = 100KHz**
- **A1 = 50KHz**
- **A2 = 25KHz**
- **A3 = 12.5KHz**

**HI-508A**

- **+15VDC**
- **+15VDC**
- **1KΩ**
- **NC**

**NOTES:**
- **A0 = 100KHz**
- **A1 = 50KHz**
- **A2 = 25KHz**
- **Temp: +125°C**
- **Package: 16 pin dip**

**HI-509A**

- **+15VDC**
- **10K**
- **WATT**

**NOTES:**
- **AO = 100KHz**
- **A1 = 50KHz**
- **Temp: +125°C**
- **Package: 16 pin dip**

**HI-1080**

- **+18V**
- **-18V**
- **NC**
- **NC**
- **COMMON**
- **TAP 3**
- **TAP 2**
- **TAP 1**
- **LADDER TERM**
- **LADDER EXTL**
- **LADDER BUS**
- **LADDER OUTPUT**
- **R SUM**
- **2R SUM**
- **LOGIC SPLBY**

**NOTE:**
- **TA = +125°C**
BURN-IN CIRCUITS

**31** HPROM-8256

![Circuit Diagram]

**NOTES:**
- $T_A = +125^\circ C$
- $V_{CC} = 5.5V$
- ALL 'R' = 510Ω

**FREQ:**
- $Q_1 = 100$KHz, $Q_2 = 50$KHz
- $Q_3 = 25$KHz, $Q_4 = 12.5$KHz
- $Q_5 = 6.25$KHz, $Q_6 = 3.125$KHz

**32** HPROM-1024/1024A

![Circuit Diagram]

**NOTES:**
- $T_A = +125^\circ C$
- $V_{CC} = 5.5V$
- ALL 'R' = 300Ω
- $Q_1 = 100$KHz, $Q_2 = 50$KHz
- $Q_3 = 25$KHz, $Q_4 = 12.5$KHz
- $Q_5 = 6.15$KHz, $Q_6 = 3.125$KHz
- $Q_7 = 1.5625$KHz, $Q_8 = 781.25$Hz
- $Q_9 = 390.625$Hz

**33** HM-7620/7621

![Circuit Diagram]

**NOTES:**
- $V_{CC} = 5.0V$
- $GND = 5.0V$
- $R = 300Ω$

$F_0 = 100$KHz SQUARE WAVE
1. ALL DIMENSIONS IN INCHES.
2. ALL DIMENSIONS ± .010 UNLESS OTHERWISE SHOWN.

CODES 1A & 1U
TO-116 (14 LEAD CERAMIC D.I.P.)

CODES 1B & 1D
16 LEAD CERAMIC D.I.P.

CODE 1F
16 LEAD D.I.P.

CODE 1H
24 LEAD D.I.P.

CODE 1J
24 LEAD CERAMIC D.I.P.

CODE 1L
28 LEAD D.I.P.
PACKAGE DIMENSIONS

**CODE 1S**
14 LEAD BRAZED D.I.P.

**CODE 1W**
16 LEAD CERAMIC D.I.P.

**CODE 2A**
TO-99

**CODE 2B**
TO-78

**CODE 2D**
TO-100

**CODE 2E**
TO-99 (.230 PC)

**CODE 2G**
TO-8

**CODE 9H**
TO-86
CATALOGS
CONDENSED FORM (Integrated Circuits Catalog)
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</tr>
<tr>
<td>HA-2050/2055/2050A 2055A</td>
<td>High Slew Rate F.E.T. Input Op Amp</td>
</tr>
<tr>
<td>HA-2060/2065/2060A 2065A</td>
<td>Wide Band F.E.T. Input Op Amp</td>
</tr>
<tr>
<td>HA-2111/2211</td>
<td>Precision Voltage Comparator</td>
</tr>
<tr>
<td>HA-2311</td>
<td>Precision Voltage Comparator</td>
</tr>
<tr>
<td>HA-2400/2404/2405</td>
<td>PRAM, Four Channel Op Amp (See application note 514)</td>
</tr>
<tr>
<td>HA-2420/2425</td>
<td>Sample &amp; Hold, Gated Op Amp (See application note 515)</td>
</tr>
<tr>
<td>HA-2500/2502/2505</td>
<td>High Slew Rate Op Amp</td>
</tr>
<tr>
<td>HA-2510/2512/2515</td>
<td>High Slew Rate Op Amp</td>
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<tr>
<td>HA-2520/2522/2525</td>
<td>High Slew Rate Op Amp</td>
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<tr>
<td>HA-2530/2535</td>
<td>Wide Band High Slew Inverting Amp (See application note 509)</td>
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<tr>
<td>HA-2600/2602/2605</td>
<td>High Impedance Op Amp (See application note 508)</td>
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<tr>
<td>HA-2620/2622/2625</td>
<td>Wide Band, High Impedance Op Amp (See application note 508)</td>
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<tr>
<td>HA-2630/2635</td>
<td>High Performance Current Booster</td>
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<td>HA-2640/2645</td>
<td>High Voltage Op Amp</td>
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<td>HA-2650/2655</td>
<td>Dual High Performance Op Amp</td>
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<tr>
<td>HA-2700/2704/2705</td>
<td>Low Power, High Performance Op Amp (See application notes 601,602,605)</td>
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<tr>
<td>HA-2720/2725</td>
<td>Low Power, Current Programmable Op Amp</td>
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<tr>
<td>HA-2730/2735</td>
<td>Low Power, Dual, Current Programmable Op Amp</td>
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<tr>
<td>HA-2820/2825</td>
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DIGITAL

DIGITAL DATA SHEETS
(Refer to CMOS REFERENCE GUIDE in Digital Section this Catalog)

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<td>Hex Interface Inverters</td>
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<tr>
<td>HD-235/535</td>
<td>Hex Interface Inverters</td>
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<tr>
<td>HD-536</td>
<td>Hex Interface Driver</td>
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<td>HD-6600</td>
<td>Quad Power Strobe</td>
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<td>HD-6805</td>
<td>Quad Logic Strobe</td>
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<tr>
<td>HM-010/030/040/050 074/080/090</td>
<td>MIL-TEMP Range Diode Matrices</td>
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<tr>
<td>HM-0110/0168/0104 0186</td>
<td>Commercial Diode Matrices</td>
</tr>
<tr>
<td>HM-7220</td>
<td>4096 X 1 Dynamic N-Channel RAM</td>
</tr>
<tr>
<td>HM-7602/7603</td>
<td>32 X 8 Field Programmable Bipolar Generic PROM</td>
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<th>Description</th>
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<td>256 X 4 Field Programmable Bipolar Generic PROM</td>
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<tr>
<td>HM-7620/7621</td>
<td>512 X 4 Field Programmable Bipolar Generic PROM</td>
</tr>
<tr>
<td>HM-7640/7641/7642</td>
<td>1024 X 4 Field Programmable Bipolar Generic PROM</td>
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<tr>
<td>HM-7643/7644</td>
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<tr>
<td>HPROM-8256</td>
<td>256-Bit, Bipolar PROM</td>
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<td>HPROM-0512</td>
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<td>HPROM-1024/1024A</td>
<td>1024-Bit, Field Programmable Bipolar PROM</td>
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<tr>
<td>HM-7202</td>
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Issue 6  HA-2500 High Slew Rate Monolithic Op Amp
Issue 7  Complementary MOS Process
Issue 8  Field Programmable Read-Only Memory Devices
          HPROM-0512, HPROM-1024, HPROM-8256

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CF-1800A 4 Channel CMOS Analog Switch Monolithic Chip
CF-1818A 8 Channel CMOS Analog Multiplexer Monolithic Chip
CF-1828A 8 Channel CMOS Analog Multiplexer Monolithic Chip
CF-2005  F.E.T. Input Preamp Amplifier Monolithic Chip
CF-2311  Precision Voltage Comparator
CF-2405  PRAM™ 4 Channel Programmable Amplifier
           Monolithic Chip
CF-2425  Sample & Hold Gated Operational
           Amplifier Monolithic Chip
CF-2505  High Slew Rate Operational Amplifier
           Monolithic Chip
CF-2515  High Slew Rate Operational Amplifier
           Monolithic Chip
CF-2525  High Slew Rate Operational Amplifier
           Monolithic Chip
CF-2535  High Slew Rate, Wide Band Inverting Amplifier
           Monolithic Chip
CF-2605  High Input Impedance Operational Amplifier
           Monolithic Chip
CF-2625  Wide Band Operational Amplifier Monolithic
           Chip
CF-2635  Current Booster
CF-2645  High Voltage Operational Amplifier
CF-2655  Dual High Performance Operational Amplifier
CF-2705  Low Power, High Performance Operational
           Amplifier Monolithic Chip
CF-2725  Low Power, Current Programmable Operational
           Amplifier
CF-2735  Low Power, Dual Current Programmable
           Operational Amplifier
CF-2825  Phase Locked Loop Monolithic Chip
CF-2905  Chopper Stabilized Operational Amplifier
           Monolithic Chip
CF-200  Dual SPST CMOS Analog Switch
CF-201  Quad SPST CMOS Analog Switch
CF-506A  16 Channel Analog Multiplexer with Over Voltage
           Protection Monolithic Chip
CF-507A  Differential 8 Channel Analog Multiplexer with
           Over Voltage Protection Monolithic Chip
CF-508A  8 Channel Analog Multiplexer with Over
           Voltage Protection
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