MEGRAPHIC 7000

DISPLAY COMMAND FORMAT

MEGATEK
CORPORATION
GRAPHIC SYSTEMS

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MEGRAPHIC 7000

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INTRODUCTION

The MEGRAPHIC 7000 Graphics Display Unit is a self-refreshing high speed display system. Display commands are transferred between the 7000 and the host computer in either programmed I/O or DMA modes. Standard host computer interface modules are available for the most popular minicomputers and a universal interface module simplifies connection to others. Because the 7000 contains its own RAM refresh memory and a microcontroller for hardware-implemented graphics features, memory requirements and loading of the host computer are minimized. The 7000 display processor offers a full range of sophisticated graphics display capabilities such as scaling, rotation, translation, and clipping. In addition to the standard 96-character ASCII subset, the hardware character generator will accomodate special user-defined symbol sets.

Twelve-bit resolution is standard on the 7000, as are hardware translation, dashed lines, and blinking. Hardware rotation, scaling, and clipping are options which may added at any time. Sixteen levels of vector intensity allow precise control of shading and figure differentiation.

For maximum flexibility, speed, and resolution, the 7000 operates with a 32-bit display word. Refresh memory may be expanded up to 32K 32-bit words. An additional 32K is reserved for character and symbol sets as well as device addresses used in the 7000.

The screen is organized with the origin (0,0) at the center and a range of -2048 through +2047 for each axis. The origin may be translated under program control by the user.

The display list stored within the refresh memory of the 7000 specifies the vectors and characters to be drawn. In addition, the display list may specify scaling, translation, rotation, and clipping operations as well as means to alter display list execution and control images on several displays. The starting address of the display list is stored in location 000001. The microcontroller begins executing display commands at this starting address. It will execute commands sequentially until control is transferred by a branch command or until the end of the display list, signified by a stop bit set in a Special Function Command, is encountered. Upon receipt of the next refresh clock pulse, or immediately if in free run mode, the microcontroller will again begin execution at the display list starting address.

VECTOR COMMANDS

Vector information contained in a display command includes X and Y coordinates or displacements, vector intensity, and whether the vector is to be dashed and/or blinking.

Absolute Vectors

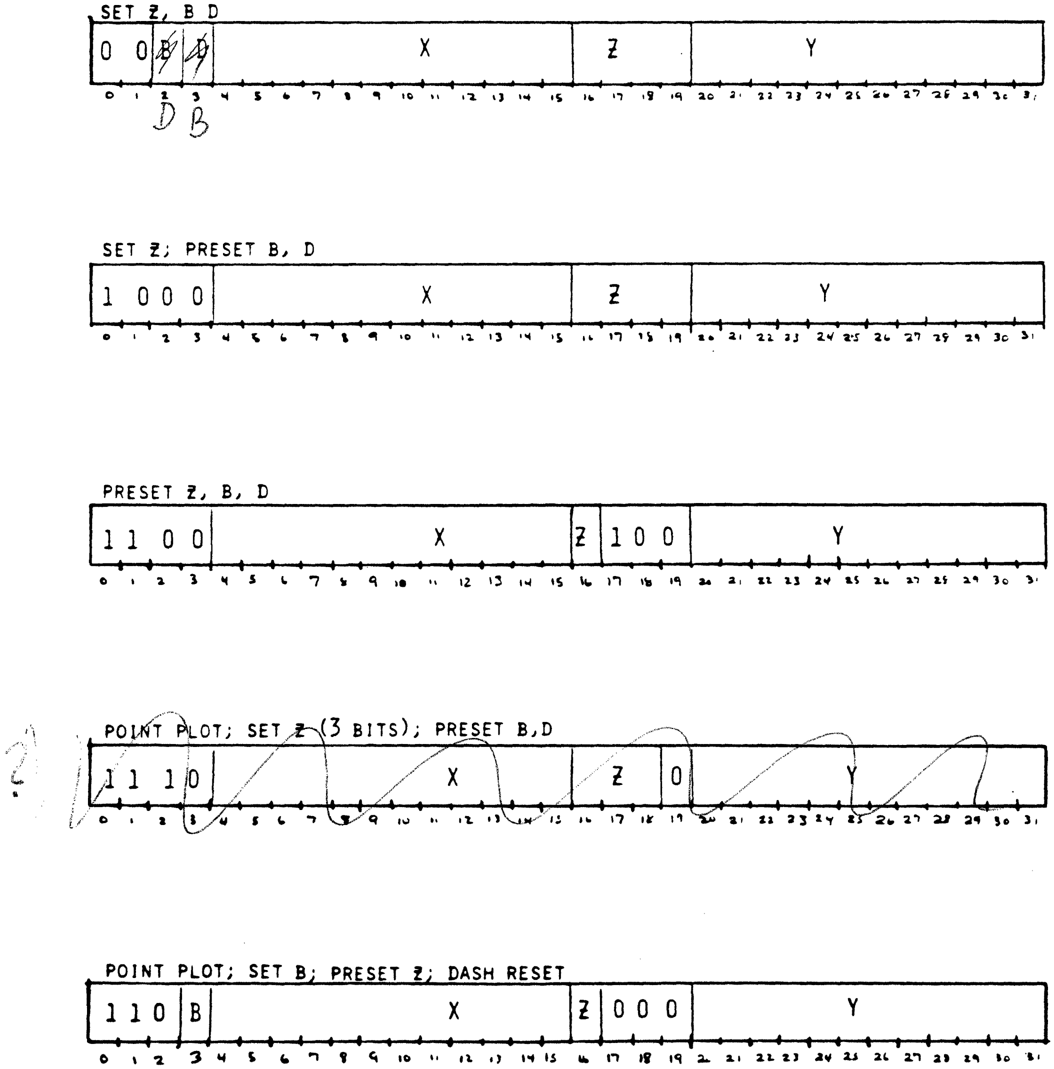
An absolute vector command denotes a vector from the current beam position to the new X-Y position in the command. X and Y coordinate fields for an absolute vector are each 12 bits long, resulting in a display resolution of 4096 points in X by 4096 points in Y. Coordinates are stored in two's complement form.

Vector intensity (Z) may be set to any of sixteen levels, including zero or no intensity. Blank vectors may be used to position figures on the screen and different levels used to differentiate objects or highlight the display information. Intensity may be stored as four bits in the vector command or preset, in which case the value currently stored in the intensity register is used for the new vector. This value may have been set by a previous vector command or the Special Function Command.

Hardware blinking and dashed lines are each controlled by a single bit (B or D) in the vector command or a vector format with preset B or D may be selected. When the preset functions are selected, the current values on the B and/or D registers are used for the new vector.

An absolute vector may also be drawn in point plot mode. In this mode the vector is blanked and only the endpoint will be intensified to the Z specified. This simplifies the display of user data which is best presented as a series of points (e.g.: experimentally derived points on a graph). Eight intensity levels (corresponding to levels 0, 2, 4, 6, 8, 10, 12 and 14) are available in point plot mode when Z is set within the command; the full sixteen levels are available if preset Z is used.

ABSOLUTE VECTORS


SET Z, B D

SET Z; PRESET B, D

PRESET Z, B, D

POINT PLOT; SET Z (3 BITS); PRESET B,D

POINT PLOT; SET B; PRESET Z; DASH RESET

Relative Vectors

A relative vector command specifies the number of resolution elements movement in X and in Y from the current been position. X and Y displacements are expressed in two's complement form and may be in the range -2048 through +2047.

Z, B, and D parameters and point plot mode may be specified as shown below.

RELATIVE VECTORS

Set Ƶ, B, D

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	1	D	B	ΔX												Ƶ				ΔY											

Set Ƶ: Preset B, D

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	0	0	1	ΔX												Ƶ				ΔY											

Preset Ƶ, B, D

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1	0	0	ΔX												Ƶ	1	0	1	ΔY											

Point Plot; Set B; Preset Ƶ; Dash Reset

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	1	0	B	ΔX												Ƶ	0	0	1	ΔY											

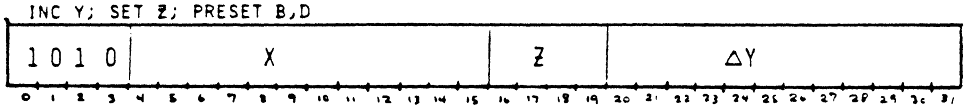
Incremental (Mixed) Vectors

An incremental or mixed vector has one coordinate specified in absolute terms, the other in relative. This allows certain graphics operations that are not otherwise easily accomplished. Both coordinates are expressed in two's complement form; the absolute coordinate denotes a screen position on the range -2048 through 2047 and the relative coordinate specifies a displacement in the range -2048 through 2047.

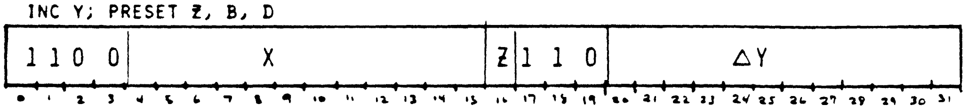
Z, B and D parameters and point plot mode may be specified as shown below.

INCREMENTAL VECTORS

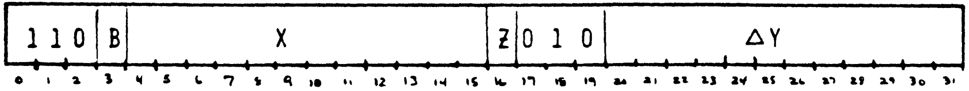
INC Y; SET Z; PRESET B,D



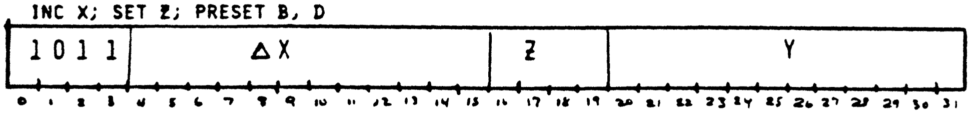
INC Y; PRESET Z, B, D



INC Y; POINT PLOT; SET B; PRESET Z DASH RESET

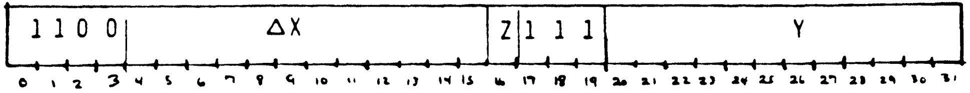


INC X; SET Z; PRESET B, D

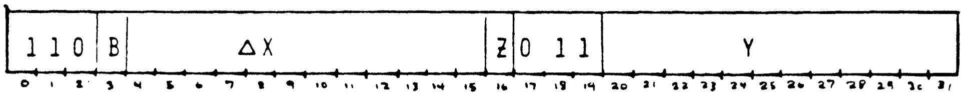


Incremental Vectors Continued

INC X; PRESET Z, B, D



INC S; POINT PLOT, SETB; PRESET Z; DASH RESET



Vector Strings

Many pictures consist of a connected series of similar short vectors. Vector string formats have been defined to permit packing multiple relative or incremental-X vectors into one 7000 refresh memory word, reducing buffer storage requirements. Absolute vectors, because they require a 12-bit X and a 12-bit Y, cannot be so packed.

Series relative vectors have 7-bit X and Y displacement fields. Longer vectors may be created with a 3-bit multiplication factor (SIZE), which scales every vector in the succeeding string. Values of SIZE from 000 through 111 produce multiplication factors of 1 through 8, respectively.

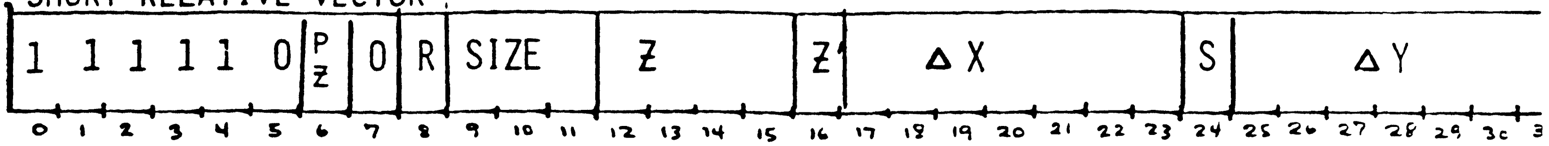
Series incremental-X vectors have 12-bit X and Y coordinate fields.

Each vector string begins with a word whose format defines intensity, whether to use this new intensity or the value currently stored in the Z register, whether this string will terminate a subroutine and cause a return, and the displacement multiplication factor (for relative vectors only).

The string of vectors following the format word may be of any length. Each vector in the series may be output with intensity or blanked by its Z' bit. A stop bit(S) is included for each vector. This is set for the final vector in the series and reset for all others.

VECTOR STRINGS

SHORT RELATIVE VECTOR



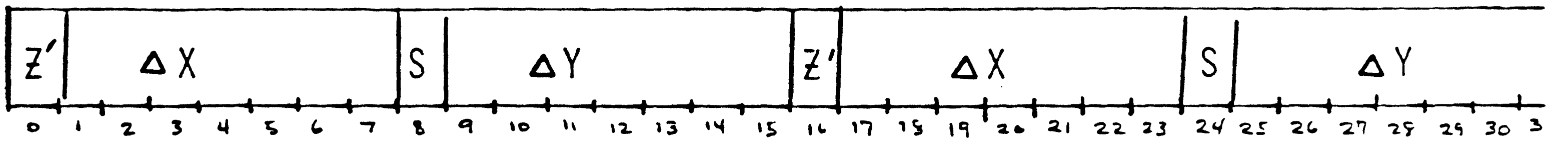
PZ; 0 USE NEW Z
1 USE PREVIOUS Z

R; 0 NO-OP
1 RETURN FROM SUBROUTINE AT END OF STRING

SIZE; 000-111 MULIPLY VECTOR BY FACTOR 1-8

Z'; 0 BLANK VECTOR
1 OUTPUT WITH INTENSITY

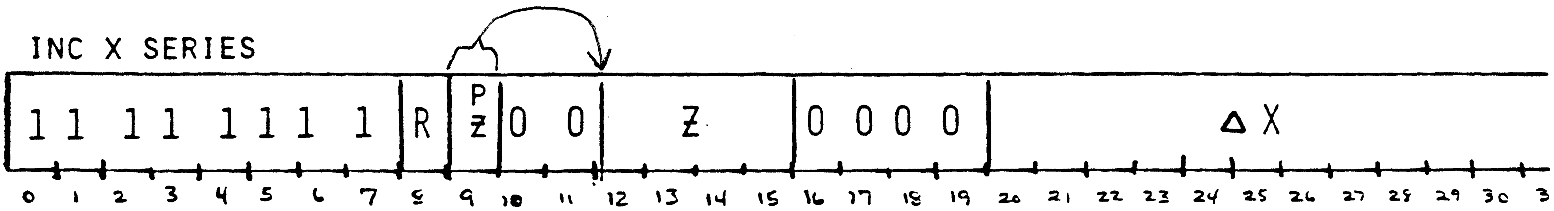
SHORT RELATIVE VECTOR STRING (FOLLOWS SH. REL. VECTOR COMMAND)



Z'; 0 BLANK CURRENT VECTOR
1 OUTPUT WITH INTENSITY

S; 0 CONTINUED WITH STRING
1 END OF VECTOR STRING

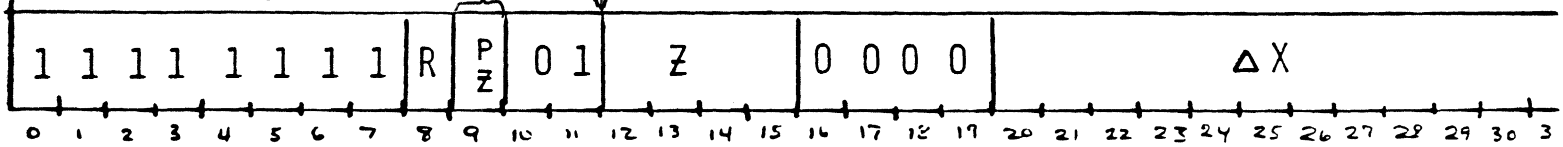
INC X SERIES



PZ; 0 USE NEW Z
1 USE PREVIOUS Z

R; 0 NO OP
1 RETURN FROM SUBROUTINE AT END OF STRING

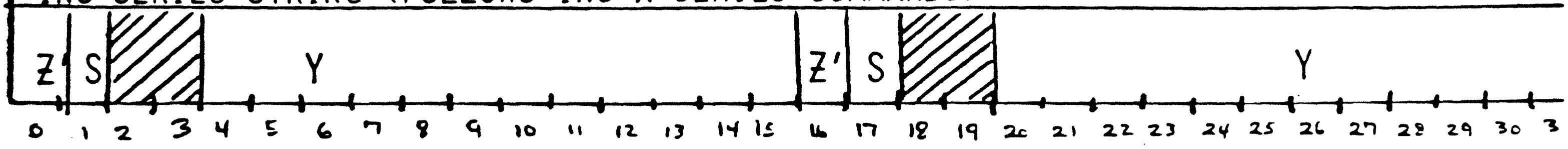
INC X SERIES; POINT PLOT



PZ; 0 USE NEW Z
1 USE PREVIOUS Z

R; 0 NO OP
1 RETURN FROM SUBROUTINE AT END OF STRING

INC SERIES STRING (FOLLOWS INC X SERIES COMMANDS)



CHARACTER COMMANDS

NOTE: To use these command formats, the optional hardware character generator is required.

The character commands cause display of characters and character strings form the standard MEGATEK character set, a 96-character subset of the ASCII set. The commands specify the characters to be displayed, their size, rotation, and intensity. Two formats are provided; one permits the associated characters to be rotated/scaled/clipped by the hardware transformations (see HARDWARE TRANSFORMATIONS), the other does not. Text connected with a figure, such as graph annotation, may be manipulated with the vector information in the figure, while status messages or menu information remains unmodified.

The character string defined in the command may be of any length. The ASCII code for each character is stored in the command. Codes for the first two characters are placed in the format definition word and succeeding codes are packed four per word thereafter. The actual vector strokes which make up each character are contained in ROM in the hardware character generator and will be accessed by the character code. The string is terminated by a null character (i.e.: all zeros).

All characters in the string have the attibutes assigned in the format word. Intensity (Z) may be set to any of sixteen levels and a preset-Z (PZ) bit selects either this new intensity or the intensity value currently in the Z register.

A three-bit multiplication factor (SIZE) scales the character to any of the eight standard character sizes. The eight sizes are successive integer multiples of the smallest size; values of SIZE fom 000 through 111 produce characters of 1 through 8 times the smallest size.

A two-bit rotation field (ROT) changes the angle at which characters are written on the screen in the following manner:

ROT	ANGLE	
00	0°	(HORIZONTAL)
01	90°	CCW
10	180°	CCW
11	270°	CCW

ROT and SIZE are both independent of the hardware transformations.

CHARACTERS

Character

1	1	1	1	0	0	PZ	ROT	SIZE	Z	CHAR	CHAR
0	1	2	3	4	5	6	7 8	9 10 11	12 13 14 15	16 17 18 19 20 21 22 23	24 25 26 27 28 29 30 31

PZ: 0 USE NEW Z
1 USE PREVIOUS Z

ROT: 00 0°
01 90°ccw
10 180°
11 270°

SIZE: 000-111 MULTIPLY CHARACTER BY FACTOR 1-8

zie 6 blz.en verderop

Character (No Hardware Transformations)

1	1	1	1	0	1	PZ	ROT	SIZE	Z	CHAR	CHAR
0	1	2	3	4	5	6	7 8	9 10 11	12 13 14 15	16 17 18 19 20 21 22 23	24 25 26 27 28 29 30 31

Character String (Follows Character Command)

CHAR	CHAR	CHAR	CHAR
0 1 2 3 4 5 6 7	8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23	24 25 26 27 28 29 30 31

ALL CHARACTER STRINGS TERMINATED BY NULL CHARACTER

HARDWARE TRANSFORMATIONS

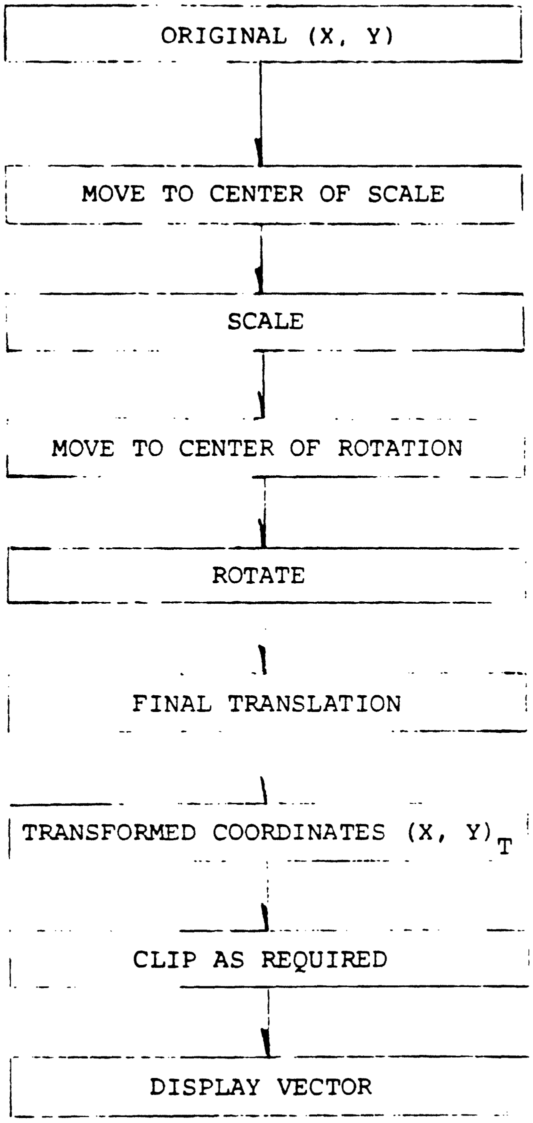
NOTE: To use these command formats, optional rotate/scale and clip hardware is required.

The hardware transformation consists of the application of scale factors, rotation angles, and translation to all vectors executed after the transformation commands in the display list. The transformation data is then clipped to the user specified display window (any rectangle on the screen). When any parameter (scale factor, angle, clip boundary, etc.) is changed, the transformation must be re-computed to generate new display list commands.

Because the scale/rotate/translate transformation can be reduced to a single matrix operation on a vector, MEGATEK has developed matrix multiply transformation hardware to implement these features. The elements of the transformation matrix must be supplied as display list commands. All vector information following the transformation commands will be subjected to the specified matrix operation. A given display may have several scale factors or rotation angles simply by executing the transformation commands required to change the matrix elements.

The generation of that matrix is described below. The parameters involved in the transformation are:

SCLX	- X SCALE FACTOR
SCLY	- Y SCALE FACTOR
STRX	- CENTER OF SCALE - X
STRY	- CENTER OF SCALE - Y
ROT	- ROTATION ANGLE
RTRX	- CENTER OF ROTATE - X
RTRY	- CENTER OF ROTATE - Y
TRX	- TRANSLATION - X
TRY	- TRANSLATION - Y



ORDER OF TRANSFORMATION

SCALE CALCULATION:

$$X' = \mathrm{SCLX} * (X - \mathrm{STRX}) + \mathrm{STRX}$$

$$Y' = \mathrm{SCLY} * (Y - \mathrm{STRY}) + \mathrm{STRY}$$

ROTATION CALCULATION:

$$X'' = \mathrm{COS}\Theta * (X' - \mathrm{RTRX}') - \mathrm{SIN}\Theta * (Y' - \mathrm{RTRY}') + \mathrm{RTRX}'$$

$$Y'' = \mathrm{SIN}\Theta * (X' - \mathrm{RTRX}') + \mathrm{COS}\Theta * (Y' - \mathrm{RTRY}') + \mathrm{RTRY}'$$

TRANSLATION CALCULATION:

$$X''' = X'' + \mathrm{TRX}$$

$$Y''' = Y'' + \mathrm{TRY}$$

TOTAL CALCULATION (COMBINED):

$$\begin{aligned} X''' = {} & X * (\mathrm{SCLX} * \mathrm{COS}\Theta) - Y * (\mathrm{SCLY} * \mathrm{SIN}\Theta) \\ & + \mathrm{TRX} - \mathrm{SCLX} * \mathrm{RTRX} * \mathrm{COS}\Theta + \mathrm{SCLY} * \mathrm{RTRY} * \mathrm{SIN}\Theta \\ & + \mathrm{SCLX} * (\mathrm{RTRX} - \mathrm{STRX}) + \mathrm{STRX} \end{aligned}$$

$$\begin{aligned} Y''' = {} & X * (\mathrm{SCLX} * \mathrm{SIN}\Theta) + Y * (\mathrm{SCLY} * \mathrm{COS}\Theta) \\ & + \mathrm{TRY} - \mathrm{SCLX} * \mathrm{RTRX} * \mathrm{SIN}\Theta - \mathrm{SCLY} * \mathrm{RTRY} * \\ & \mathrm{COS}\Theta + \mathrm{SCLY} * (\mathrm{RTRY} - \mathrm{STRY}) + \mathrm{STRY} \end{aligned}$$

TRANSFORMATION DERIVATION

- TRANSFORMATION

$$\begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}_T = \begin{bmatrix} M_1 & M_2 & M_3 \\ M_4 & M_5 & M_6 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix}_{SCREEN}$$

SCLX,Y = X, Y SCALE FACTORS

STRX,Y = X, Y CENTER OF SCALE

ROT = ROTATION ANGLE

RTRX,Y = X, Y CENTER OF ROTATION

TRX,Y = X, Y TRANSLATION

MATRIX ELEMENTS

M_1 = SCLX * COS (ROT)

M_2 = -SCLY * SIN (ROT)

M_3 = TRX - SCLX * RTRX * COS (ROT) + SCLY * RTRY * SIN (ROT)
+ SCLX * (RTRX - STRX) + STRX

M_4 = SCLX * SIN (ROT)

M_5 = SCLY * COS (ROT)

M_6 = TRY - SCLX * RTRX * SIN (ROT) - SCLY * RTRY * COS (ROT)
+ SCLY * (RTRY - STRY) + STRY

TRANSFORMATION MATRIX

It is these six matrix elements which are specified in the command formats. A software utility aids the 7000 user in converting his rotation, scaling, and translation parameters into the six matrix elements.

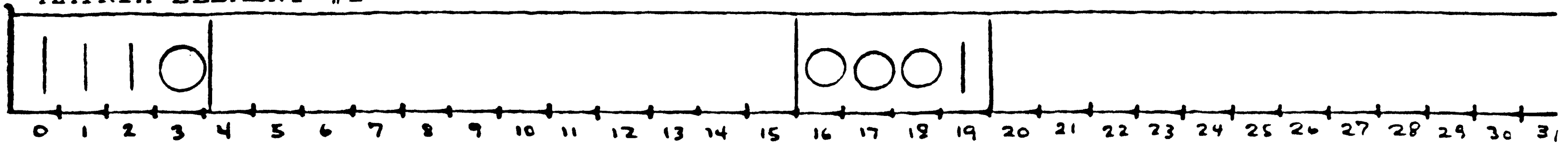
The transformed data is clipped to the display window specified in the Clip Boundary commands. All vector commands executed following the commands to set new boundaries are clipped to those boundaries. Multiple display windows may be defined by changing clip boundaries. Absolute X and Y screen coordinates define the lower left and upper right corners of the display window. Only vectors within this window, or the portions of vectors passing through this window, will be displayed. All other information will be blanked.

NOTE: Two character command formats have been defined. One permits the associated characters to be transformed and clipped, the other exempts them from these operations. The user may thus have text information relating to a figure move with the figure, while background, tabular, or menu information remains fixed. SEE CHARACTER COMMANDS.

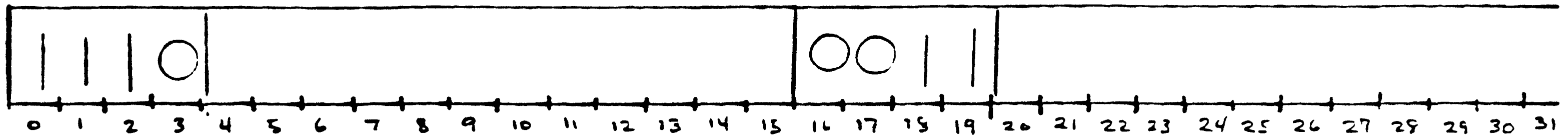
HARDWARE TRANSFORMATIONS

NB: DATA FORMAT FOR MATRIX
ELEMENTS IS CURRENTLY
UNSPECIFIED

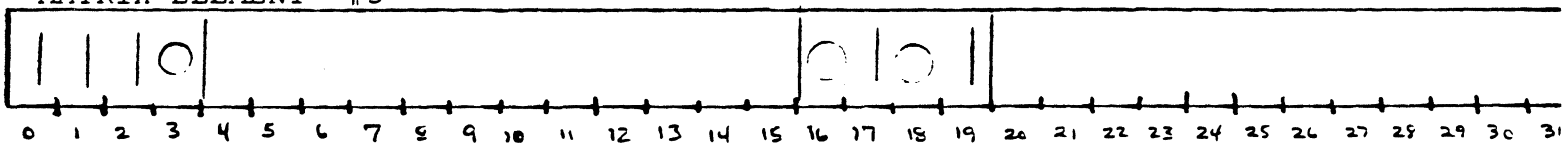
MATRIX ELEMENT #1



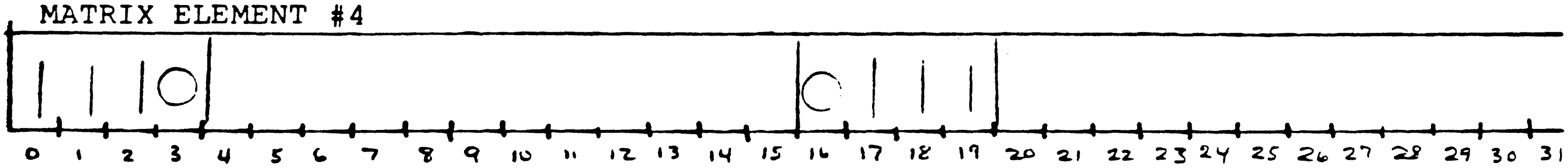
MATRIX ELEMENT #2



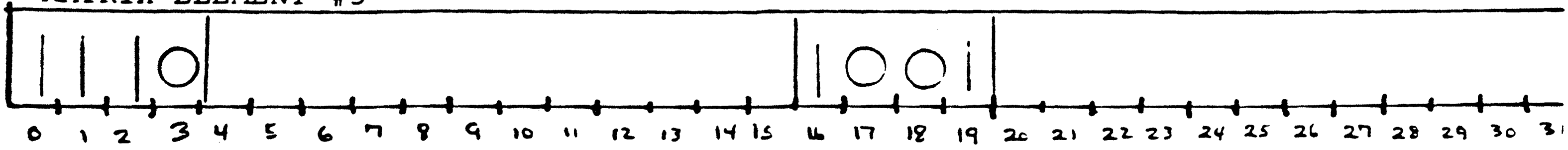
MATRIX ELEMENT #3



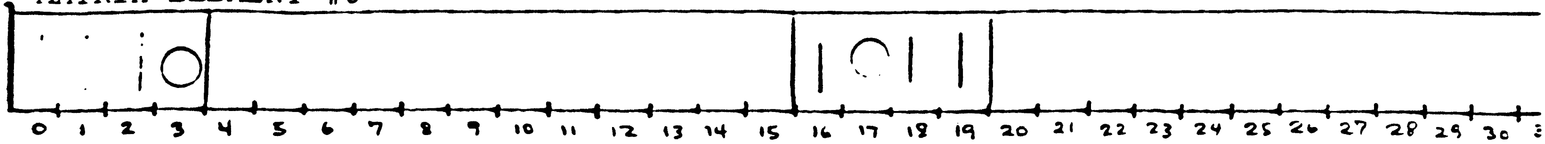
MATRIX ELEMENT #4



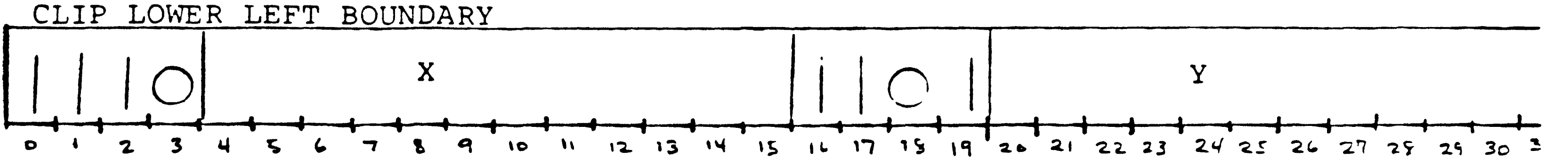
MATRIX ELEMENT #5



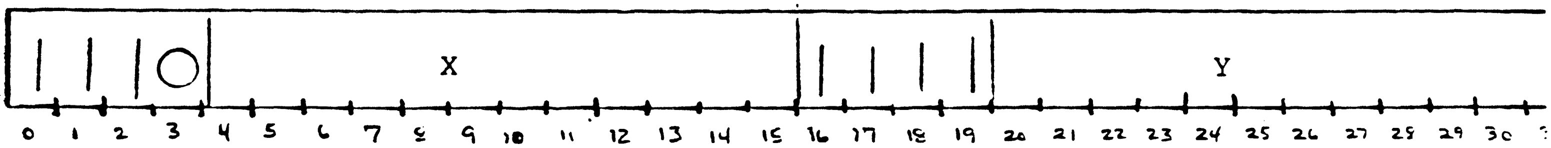
MATRIX ELEMENT #6

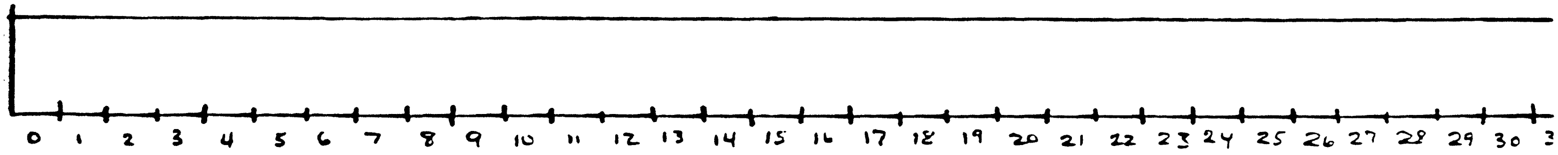


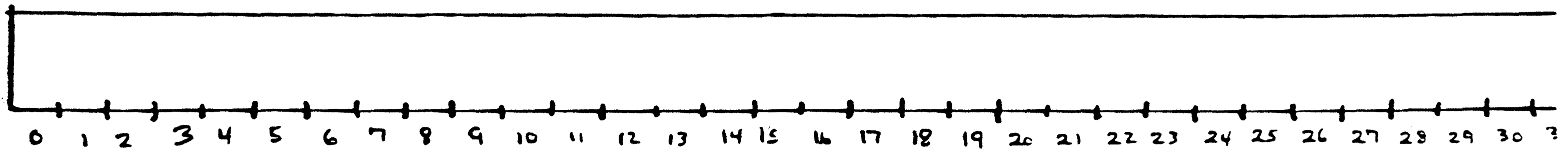
CLIP LOWER LEFT BOUNDARY



CLIP UPPER RIGHT BOUNDARY







BRANCH CONTROL

To alter execution of the display command list, branch capabilities are provided. These commands allow the user to create and modify display list information while other parts of the list are being shown. Graphics subroutines may be created, saving both programming effort and refresh memory.

Each branch command causes a jump to a new display list address. Three different formats are provided: JUMP, JUMP TO SUBROUTINE, and VECTORED JUMP.

Jump and Jump To Subroutine cause jumps based on the address information contained within the commands. Both types of jump may be made either to an absolute address in the display list or to an address relative to the current display list address. The Jump To Subroutine command, however, saves the current address so that display list execution control may be returned following the subroutine. An absolute jump has the range 0 through 65535 and a relative jump the range -32768 through +32767. Absolute jump coordinates are unsigned 12-bit integers, while relative displacements are expressed in two's complement form.

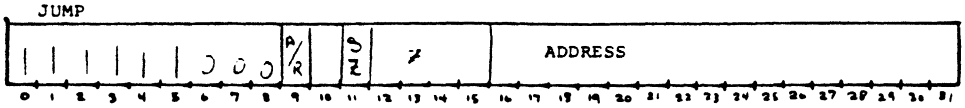
The Vectored Jump command causes a jump based on the contents of a "vector word" whose display list address is contained in the jump command. The low order 16 bits of the vector word are used as a displacement and are added to the address of the Vectored Jump command itself to determine the jump destination address. The low order 16 bits of the vector word are treated as an unsigned sixteen-bit binary integer (i.e.: only positive displacements are permitted).

A series of alternative actions or branches to alternative actions commonly follow the Vectored Jump command. Simply by changing the contents of the vector word, the jump destination is changed. This provides the user with a simple mechanism for implementing jumps based on logical decisions.

All branch command formats contain a four-bit intensity field and a set intensity (SZ) bit. This allows the user to change the contents of the intensity register at the time of branch execution. Display commands to be executed following the branch may be written to use the intensity set by the branch command.

BRANCH CONTROL

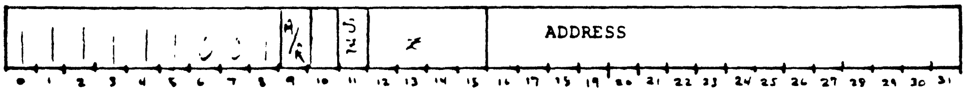
JUMP



A/R: 0 ABSOLUTE JUMP
1 RELATIVE TO CURRENT POSITION

SZ : SET INTENSITY

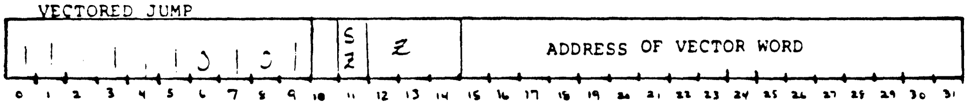
JUMP TO SUBROUTINE



A/R: 0 ABSOLUTE JUMP
1 RELATIVE TO CURRENT POSITION

SZ: SET INTENSITY

VECTORED JUMP



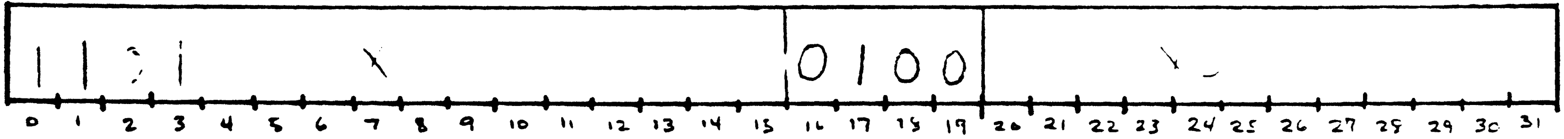
SZ: SET INTENSITY

ORIGIN TRANSLATION

In the 7000 series, the default origin (0,0) is at the center of the screen and the range of addressable points for each axis is -2048 through 2047. The user may redefine the origin's position to suit his application requirements with the Origin Translation command. The new X and Y coordinates for the origin, XORG and YORG, are stored in two's complement form and may take on any values in the range of addressable points. The X and Y coordinates of all vector commands executed after the Origin Translation command will have XORG and YORG, respectively, added to them.

Note that the new origin is defined in absolute terms. A translation command moves the origin to the new coordinates specified, not the former coordinates plus a displacement of XORG and YORG.

Origin Translation Format



SPECIAL FUNCTIONS

A Special Function Command may be placed in the display list to control any of several display functions:

RT - reset origin translation to the default value of (0,0) at screen center.

R - display list return. Effects a return from the last Jump To Subroutine executed.

I - generate interrupt. Upon execution of the Special Function Command, an interrupt is generated in the host CPU.

Z - a four-bit intensity field.

SZ - set Z. Causes the Z field to be loaded into the Z register.

FR - freeze processor. When set, FR causes the microcontroller to cease execution at the Special Function Command and examine FR repeatedly until FR is reset. Execution then continues with the next display command.

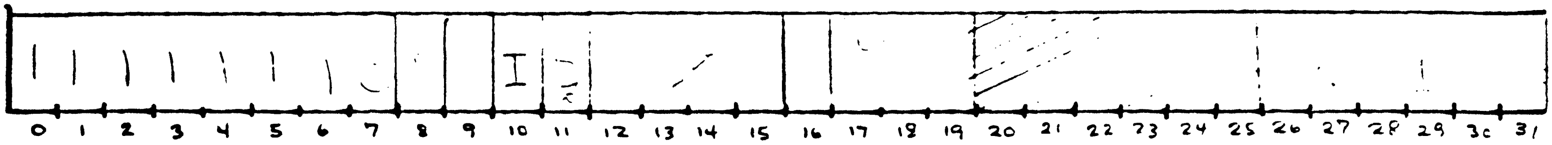
END - end of the display list. The microcontroller ceases executing successive display commands at this point. In a programmed refresh rate mode, the controller halts until the next refresh timing pulse[1], then returns to the beginning of the display list and executes the display list command found there. In free run mode it returns immediately to the begining of the list and begins execution.

D1 - two bits which determine the status of CRT monitor #1

D2 - two bits which determine the status of CRT monitor #2, if a second monitor is in use.

[1] line sync.

Special Function Format



SZ: Load Z From Z Field
R: Display List Return
I: Generate Interrupt
RT: Reset Translation

FR: Freeze Processor On This Word
END: End Of Display List

D1/D2: 00 No Op 01 Display Off
10 Display On 11 Toggle Display (On → Off, Off → On)

MEGATEK

DATE: FEBRUARY 5, 1979

TO: MEGRAPHIC 7000 DISPLAY COMMAND FORMAT USERS

FROM: JOHN MORELAND/MANAGER, MARKETING SERVICES JM

SUBJECT: REVISION OF DISPLAY LIST FORMATS

The attached manual describing the MEGRAPHIC 7000 Display Command Format specifies some formats which have been revised since publication. Attached is a copy of the revised formats. Please refer to these when reading the manual.

A revised document is being prepared.