SUBJECT: HIGH-SPEED (5965) FLIP-FLOP

To: Group 62 Engineers and Group 63 Engineers

From: Hal Boyd

Date: February 24, 1953

Abstract: In this E-Note is presented a collection of data taken on the preliminary circuit of a high-speed, high-reliability, 5965 duo-triode flip-flop that was designed to drive 7AK7 gate tubes. The procedure used in the design of this flip-flop is explained in E-525 entitled "The Normalized Flip-Flop Chart." A circuit schematic of the flip-flop, from which all data was taken, is shown in Figure 1, attached.

1.0 P.R.F. Response Characteristics

The curves shown in Figure 2 were obtained by complementing the flip-flop with a continuous train of 0.1 µsec pulses with various loads on both flip-flop outputs. The lower curves define the transition from the region of either inoperation or frequency division, to the region of absolute operation. The upper curve (45° line at 5 megacycles) defines the transition from the region of operation to the region in which both output levels coincide. In this latter region the flip-flop's memory is destroyed and the flip-flop assumes a third stable state in which counting is not reliable.

For 20-volt triggers with a range from 13 to 30 volts, the flip-flop can drive up to 100 µf/side (6-7, 7AK7 gate tubes per side) up to a maximum continuous p.r.f. of 4 megacycles.

2.0 Counting Characteristics

Figure 3 was read directly from the output waveforms of the flip-flop while complementing at 1 Kc with 0.1 µsec pulses. 15-volt and 25-volt negative triggers were used for complementing the flip-flop, and the output waveforms were observed with no load and with a load of 100 µf on each output of the flip-flop. Note that no additional delay would be necessary for use of the flip-flop in counting applications.
3.0 Variation of critical voltages with low I_b tubes

The worst combination of tube sides for the flip-flop tube is with one side of high I and the other of low I_b. The most critical voltages are the output levels, E_L and E_H, the flip-flop tube's cathode voltage, E_k, the "on" tube's grid voltage, E_gon, and the "off" tube's grid voltage, E_goff. The manner in which these voltages vary as one tube side's I_b varies is shown in Figure 4.

The I_b of the tube side in question was varied by its filament voltage. In the experiment, provision was made for switching the tube side from a tube testing circuit to the flip-flop circuit. Hence, at each filament voltage the I_b at 120 volts E_L and E_H = 0 was measured, and, at that same filament voltage, the behavior of the tube in the flip-flop was noted and the critical voltages were measured. The results were verified when, later, low I_b 5965's were available.

4.0 Supply Voltage Variations

<table>
<thead>
<tr>
<th>Nominal Voltage</th>
<th>Limits</th>
<th>% Change</th>
<th>Output Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>+150</td>
<td>+210</td>
<td>40%</td>
<td>+5 to -25</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>100%</td>
<td>0 to -48</td>
</tr>
<tr>
<td>-150</td>
<td>-300</td>
<td>100%</td>
<td>+5 to -50</td>
</tr>
<tr>
<td></td>
<td>-25</td>
<td>16.7%</td>
<td>+2.5 to -25</td>
</tr>
<tr>
<td></td>
<td>-100</td>
<td>33.3%</td>
<td>+2.5 to -15</td>
</tr>
</tbody>
</table>

The above data is presented in terms of output voltage levels because failure of the flip-flop was arbitrarily taken as the point at which either output level falls within the range of from 0 to -25 volts, whereas flip-flop failure with respect to gate tubes defines a range of from 0 to -15 volts.

5.0 Resistor and diode tolerances

Tolerances on resistors and diodes were taken one at a time, and the limits were defined by the point at which either output level falls within a range of from 0 to -25 volts. Figure 5 gives the maximum tolerance of each component, all others being held constant and within the tolerances shown on Figure 1.

6.0 Marginal Checking

Various components of the flip-flop were varied one at a time, and marginal checking voltages were determined for a number of values of
each component. The marginal check voltage was inserted in the flip-flop at the spot marked "marginal check voltage" on Figure 1. The marginal checking voltage is centered, or has its base line, at -150 volts, and is taken to be the displacement from -150 volts. The manner in which the marginal checking voltage varies with percentage variations of each component is shown in Figures 6-12 inclusive. The solid curves indicate the picking up of a component on the same side of the flip-flop as the marginal checking voltage; whereas, the dotted curves are for components on the opposite side of the flip-flop.

Drawings:
SA-53718-1
SA-54002
SA-48396-G to 48405-G incl.

Signed

Hal Boyd

Approved
R. L. Best, Section Leader

Approved
N.H. Taylor, Group Leader

HB/cs
4 MEGACYCLE 59G5 FLIP-FLOP for GATE TUBE LOADING

20 volt negative 0.1usec trigger, nominal, range: 13-30 volts
Output levels: upper = 0.7+3, lower = -25+3
Maximum loading (for 20v triggers at 4mc): 100pF/side (6-7, 7AK7 GT's)

Complement

All resistors ±10% except as otherwise specified
RESISTOR & DIODE TOLERANCES

** ** +15% ** -30%  
± 15%  **  +30%  
R_b = 15K  

** ** +15% ** -30%  
± 22% at R_b = 50K  

NOTES: (K) If all four resistors vary in the worst directions, then each can vary ±2.5% before failure.

(*** ) These limits (as are all others) are defined by output levels of 0 to +3, and/or -25 to -35 volts.  
If -40 volts were taken as one of the limits instead of -35, then the +15% tolerance would be increased to +60%.  
Also, as the plate-circuit-diode's back resistance decreases, the upper limit increases and the lower limit decreases.
P.R.P. RESPONSE CHARACTERISTICS VS LOAD

Complementing Continuously

NOTE: (a) A 1000 OHM load resistance.
      * 2000 OHM side or loopoff on one side

Region of positive operation

Region of operation & division

PULSE REPETITION FREQ. — megacycles
MARGINAL CHECKING in TUBES

(---) Picking up tube on same side as.
(---) Picking up tube on opposite side.

Marginal check voltage.

-20 -15 -10 -5 0 5 10 15 20 25 30 35

Ib @ 15V, Cc 300.

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Redrawn
MARGINAL CHECKING THE DIVIDER RESISTORS

NOTE: 10K & 5K lines reverse after checking from other side.

SA-4Y4G0-5
Marginal Checking the Cathode Resistor

Checking on Either Side

Curve moves to right with poor tubes

Resistor Tolerance ± Percent

Marginal Voltage Volt

Note: Peaks being to the left of origin allows poor tubes.

SA-48401-G

[Signature]
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MARGINAL CHECKING THE G.E.E. PLATE RESISTOR

On high side due to using too fast plate diode back resistance in design and having Rs soak during test.

You see and understand wave to right when low diode Rs.

less than 35 volts output

greater than 35 volts output

Picking up resistor on same side as,

Picking up resistor on opposite side of MARGINAL CHECK VOLTAGE.

SA-48402-G

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20-FEB-53
Marginal Check on Plate-Circuit-Diode Back-Resistance

- Less than 20 volts output
- Greater than 20 volts output, but not greater than 30 volts

Figure 11

Marginal Check Voltage - Volts

18K 20K 50K 100K 200K 500K

Back Resistance - K ohms

Marginal Check Voltage -

(-) Picking up diode on one side only

(-) Picking up diode on opposite side of marginal check voltage.

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