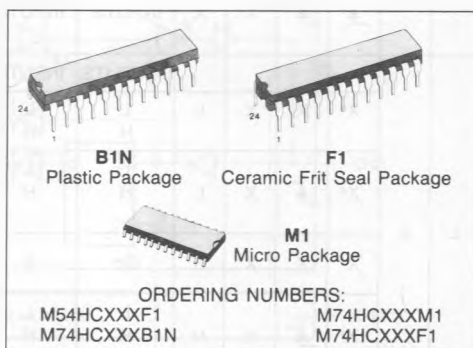


# HC651 OCTAL BUS TRANSCEIVER/REGISTER (3-STATE, INV.) HC652 OCTAL BUS TRANSCEIVER/REGISTER (3-STATE)

- **LOW POWER DISSIPATION**  
 $I_{CC} = 4 \mu A$  (MAX.) at  $T_A = 25^\circ C$
- **HIGH NOISE IMMUNITY**  
 $V_{NIH} = V_{NIL} = 28\% V_{CC}$  (Min)
- **OUTPUT DRIVE CAPABILITY**  
 15 LSTTL LOADS
- **SYMMETRICAL OUTPUT IMPEDANCE**  
 $|I_{OH}| = I_{OL} = 6 \text{ mA}$  (MIN.)
- **BALANCED PROPAGATION DELAYS**  
 $t_{PLH} = t_{PHL}$
- **WIDE OPERATING VOLTAGE RANGE**  
 $V_{CC}$  (OPR) = 2V to 6V
- **PIN AND FUNCTION COMPATIBLE**  
 WITH 54/74LS651/652



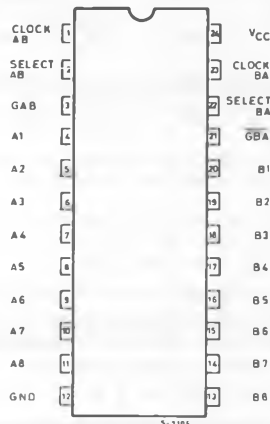
## DESCRIPTION

M54/74HC651/652 are high speed CMOS OCTAL BUS TRANSCEIVERS AND REGISTERS (3-STATE), fabricated in silicon gate C<sup>2</sup>MOS technology. They have the same high speed performance of LSTTL combined with true CMOS low power consumption. These devices consist of bus transceiver circuits, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the input bus or from the internal storage registers. Enable GAB and GBA are provided to control the transceiver functions.

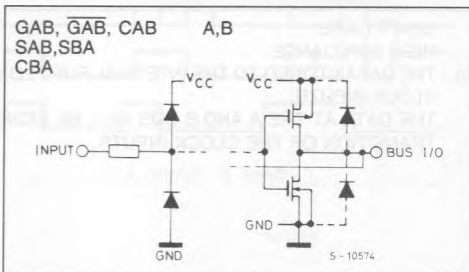
Select AB and Select BA control pins are provided to select whether real-time or stored data is transferred. A low input level selects real-time data, and a high selects stored data.

Data on the A or B bus, or both, can be stored in the internal D flip-flops by low-to-high transitions at the appropriate clock pins (CLOCK AB or CLOCK BA) regardless of the select or enable control pins. When select AB and select BA are in the real-time transfer mode, it is also possible to store data without using the internal D-type flip-flops by simultaneously enabling GAB and GBA. In this configuration each output reinforces its input. Thus, when all other data sources to the two sets of bus lines are at high impedance, each set of bus lines will remain at its last state. All inputs are equipped with protection circuits against static discharge and transient excess voltage.

## PIN CONNECTIONS (top view)



## INPUT AND OUTPUT EQUIVALENT CIRCUIT



**TRUTH TABLE**

M54/74HC652 (The truth table for M54/74HC651 is the same as this, but with the outputs inverted)

| GAB | GBA | CAB | CBA | SAB | SBA | A       | B       | FUNCTION  |
|-----|-----|-----|-----|-----|-----|---------|---------|---|
| L   | H   |     |     |     |     | INPUTS  | INPUTS  | Both the A bus and the B bus are inputs.  |
|     |     | X   | X   | X   | X   | Z       | Z       | The output functions of the A and B bus are disabled.   |
|     |     |     |     | X   | X   | INPUTS  | INPUTS  | Both the A and B bus are used for inputs to the internal flip-flops. Data at the bus will be stored on low to high transition of the clock inputs.                            |
| L   | L   |     |     |     |     | OUTPUTS | INPUTS  | The A bus are outputs and the B bus are inputs.   |
|     |     | X*  | X   | X   | L   | L<br>H  | L<br>H  | The data at the B bus are displayed at the A bus.   |
|     |     | X*  |     | X   | L   | L<br>H  | L<br>H  | The data at the B bus are displayed at the A bus. The data of the B bus are stored to the internal flip-flops on low to high transition of the clock pulse.                   |
|     |     | X*  | X   | X   | H   | Qn      | X       | The data stored to the internal flip-flops are displayed at the A bus.  |
|     |     | X*  |     | X   | H   | L<br>H  | L<br>H  | The data at the B bus are stored to the internal flip-flops on low to high transition of the clock pulse. The states of the internal flip-flops output directly to the A bus. |
| H   | H   |     |     |     |     | INPUTS  | OUTPUTS | The A bus are inputs and the B bus are outputs.   |
|     |     | X   | X*  | L   | X   | L<br>H  | L<br>H  | The data at the A bus are displayed at the B bus.   |
|     |     |     | X*  | L   | X   | L<br>H  | L<br>H  | The data at the B bus are displayed at the A bus. The data of the B bus are stored to the internal flip-flops on low to high transition of the clock pulse.                   |
|     |     | X   | X*  | H   | X   | X       | Qn      | The data stored to the internal flip-flops are displayed at the B bus.  |
|     |     |     | X*  | H   | X   | L<br>H  | L<br>H  | The data at the A bus are stored to the internal flip-flops on low to high transition of the clock pulse. The states of the internal flip-flops output directly to the B bus. |
| H   | L   |     |     |     |     | OUTPUTS | OUTPUTS | Both the A bus and the B bus are outputs.   |
|     |     | X   | X   | H   | H   | Qn      | Qn      | The data stored to the internal flip-flops are displayed at the A and B bus respectively.   |
|     |     |     |     | H   | H   | Qn      | Qn      | The output at the A bus are displayed at the B bus, the output at the B bus are displayed at the A bus respec.  |

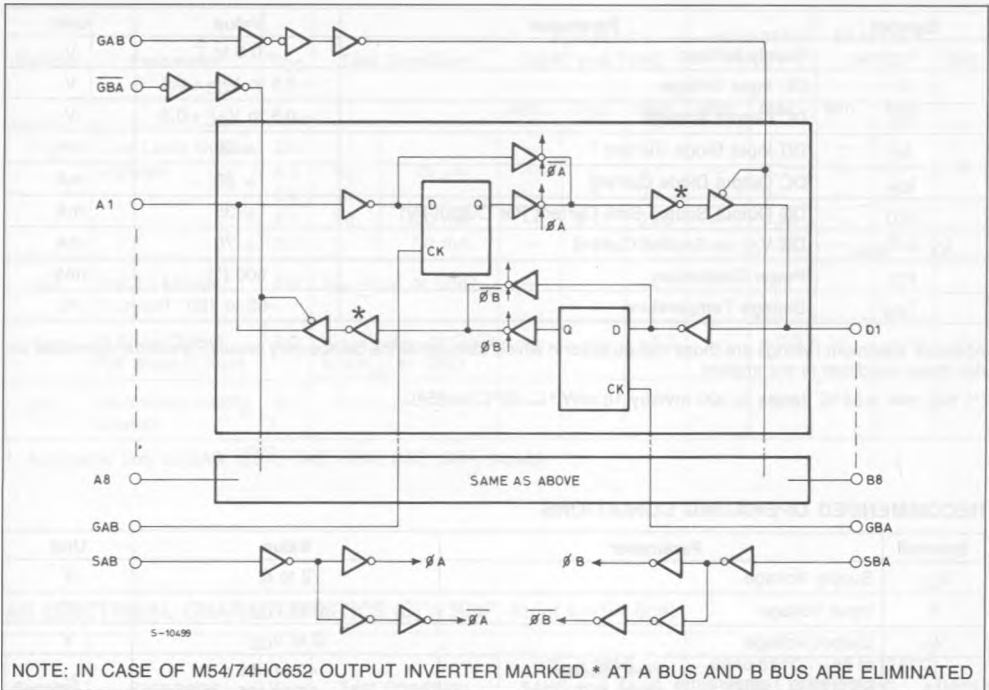
X : DON'T CARE.

Z : HIGH IMPEDANCE.

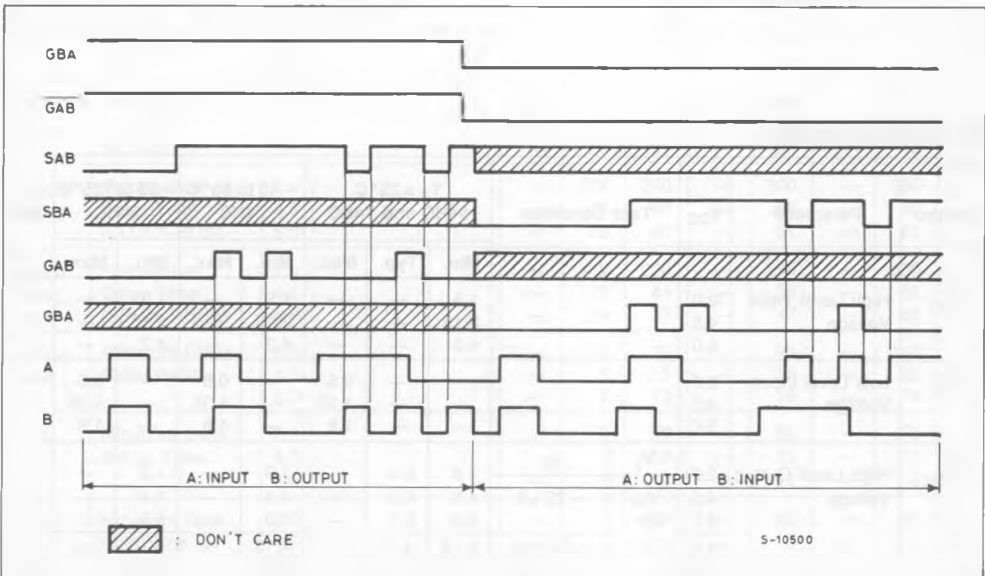
Qn: THE DATA STORED TO THE INTERNAL FLIP-FLOPS BY MOST RECENT LOW TO HIGH TRANSITION OF THE CLOCK INPUTS.

\* : THE DATA AT THE A AND B BUS WILL BE STORED TO THE INTERNAL FLIP-FLOPS ON EVERY LOW TO TRANSITION OF THE CLOCK INPUTS.

## LOGIC DIAGRAM (HC652)



## TIMING CHART



## ABSOLUTE MAXIMUM RATINGS

| Symbol                | Parameter                                    | Value                   | Unit |
|-----------------------|--|-------------------------|------|
| $V_{CC}$              | Supply Voltage                               | - 0.5 to 7              | V    |
| $V_I$                 | DC Input Voltage                             | - 0.5 to $V_{CC} + 0.5$ | V    |
| $V_O$                 | DC Output Voltage                            | - 0.5 to $V_{CC} + 0.5$ | V    |
| $I_{IK}$              | DC Input Diode Current                       | $\pm 20$                | mA   |
| $I_{OK}$              | DC Output Diode Current                      | $\pm 20$                | mA   |
| $I_O$                 | DC Output Source Sink Current Per Output Pin | $\pm 35$                | mA   |
| $I_{CC}$ or $I_{GND}$ | DC $V_{CC}$ or Ground Current                | $\pm 70$                | mA   |
| $P_D$                 | Power Dissipation                            | 500 (*)                 | mW   |
| $T_{stg}$             | Storage Temperature                          | - 65 to 150             | °C   |

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

(\*) 500 mW:  $\cong 65^\circ\text{C}$  derate to 300 mW by 10 mW/°C:  $65^\circ\text{C}$  to  $85^\circ\text{C}$

## RECOMMENDED OPERATING CONDITIONS

| Symbol     | Parameter   | Value   | Unit |
|------------|---|---|------|
| $V_{CC}$   | Supply Voltage                                      | 2 to 6  | V    |
| $V_I$      | Input Voltage                                       | 0 to $V_{CC}$   | V    |
| $V_O$      | Output Voltage                                      | 0 to $V_{CC}$   | V    |
| $T_A$      | Operating Temperature<br>74HC Series<br>54HC Series | - 40 to 85<br>- 55 to 125   | °C   |
| $t_r, t_f$ | Input Rise and Fall Time                            | $V_{CC} \begin{cases} 2 \text{ V} & 0 \text{ to } 1000 \\ 4.5 \text{ V} & 0 \text{ to } 500 \\ 6 \text{ V} & 0 \text{ to } 400 \end{cases}$ | ns   |

## DC SPECIFICATIONS

| Symbol          | Parameter                 | V <sub>CC</sub>   | Test Condition   |                      | T <sub>A</sub> = 25°C<br>54HC and 74HC |              |                    | – 40 to 85°C<br>74HC |                    | – 55 to 125°C<br>54HC |                    | Unit |        |
|-----------------|---------------------------|-------------------|--|----------------------|--|--------------|--------------------|----------------------|--------------------|-----------------------|--------------------|------|--------|
|                 |                           |                   |  |                      | Min.                                   | Typ.         | Max.               | Min.                 | Max.               | Min.                  | Max.               |      |        |
| V <sub>IH</sub> | High Level Input Voltage  | 2.0<br>4.5<br>6.0 |  |                      | 1.5<br>3.15<br>4.2                     | —<br>—<br>—  | —                  | 1.5<br>3.15<br>4.2   | —<br>—<br>—        | 1.5<br>3.15<br>4.2    | —<br>—<br>—        | V    |        |
| V <sub>IL</sub> | Low Level Input Voltage   | 2.0<br>4.5<br>6.0 |  |                      | —<br>—<br>—                            | —<br>—<br>—  | 0.5<br>1.35<br>1.8 | —<br>—<br>—          | 0.5<br>1.35<br>1.8 | —<br>—<br>—           | 0.5<br>1.35<br>1.8 | V    |        |
| V <sub>OH</sub> | High Level Output Voltage | 2.0               | V <sub>I</sub><br><br>V <sub>IH</sub><br>or<br>V <sub>IL</sub> | I <sub>O</sub>       | 1.9                                    | 2.0          | —                  | 1.9                  | —                  | 1.9                   | —                  | V    |        |
|                 |                           | 4.4               |  |                      | 4.5                                    | —            | 4.4                | —                    | 4.4                | —                     |                    |      |        |
|                 |                           | 6.0               |  | – 20 μA              |  | 5.9          | 6.0                | —                    | 5.9                | —                     | 5.9                |      | —      |
|                 |                           | 4.5<br>6.0        |  | – 6.0 mA<br>– 7.8 mA |  | 4.18<br>5.68 | 4.31<br>5.8        | —<br>—               | 4.13<br>5.63       | —<br>—                | 4.10<br>5.60       |      | —<br>— |

## DC SPECIFICATIONS (Continued)

| Symbol          | Parameter                        | V <sub>CC</sub> | Test Condition   |       | T <sub>A</sub> = 25°C<br>54HC and 74HC |      |       | – 40 to 85°C<br>74HC |       | – 55 to 125°C<br>54HC |      | Unit |
|-----------------|----------------------------------|-----------------|--|-------|--|------|-------|----------------------|-------|-----------------------|------|------|
|                 |                                  |                 |  |       | Min.                                   | Typ. | Max.  | Min.                 | Max.  | Min.                  | Max. |      |
| V <sub>OL</sub> | Low Level Output Voltage         | 2.0             | V <sub>IH</sub><br>or<br>V <sub>IL</sub>   | 20 μA | —                                      | 0    | 0.1   | —                    | 0.1   | —                     | 0.1  | V    |
|                 |                                  | 4.5             |  |       | —                                      | 0    | 0.1   | —                    | 0.1   | —                     | 0.1  |      |
|                 |                                  | 6.0             |  |       | —                                      | 0    | 0.1   | —                    | 0.1   | —                     | 0.1  |      |
|                 |                                  | 4.5             | 6.0 mA<br>7.8 mA   | —     | 0.17                                   | 0.26 | —     | 0.33                 | —     | 0.40                  |      |      |
|                 |                                  | 6.0             |  |       | 0.18                                   | 0.26 | —     | 0.33                 | —     | 0.40                  |      |      |
| I <sub>IN</sub> | Input Leakage Current*           | 6.0             | V <sub>IN</sub> = V <sub>CC</sub> or GND   |       | —                                      | —    | ± 0.1 | —                    | ± 1   | —                     | ± 1  | μA   |
| I <sub>OZ</sub> | 3-State Output Off State Current | 6.0             | V <sub>OUT</sub> = V <sub>CC</sub> or GND<br>V <sub>I</sub> = V <sub>CC</sub> or GND |       | —                                      | —    | ± 0.5 | —                    | ± 0.5 | —                     | ± 10 |      |
| I <sub>CC</sub> | Quiescent Supply Current         | 6.0             | V <sub>I</sub> = V <sub>CC</sub> or GND  |       | —                                      | —    | 4     | —                    | 40    | —                     | 80   |      |

\*: Applicable only to GAB, GBA, CAB, CBA, SAB, SBA, inputs.

AC ELECTRICAL CHARACTERISTICS (C<sub>L</sub> = 50pF, Input t<sub>r</sub> = t<sub>f</sub> = 6ns)

| Symbol                                 | Parameter                           | V <sub>CC</sub>   | Test Condition | T <sub>A</sub> = 25°C<br>54HC and 74HC |                 |                 | - 40 to 85°C<br>74HC |                 | - 55 to 125°C<br>54HC |                 | Unit |
|--|-------------------------------------|-------------------|----------------|--|-----------------|-----------------|----------------------|-----------------|-----------------------|-----------------|------|
|  |                                     |                   |                | Min.                                   | Typ.            | Max.            | Min.                 | Max.            | Min.                  | Max.            |      |
| t <sub>TLH</sub><br>t <sub>THL</sub>   | Output Transition Time              | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 25<br>7<br>6    | 60<br>12<br>10  | —<br>—<br>—          | 75<br>15<br>13  | —<br>—<br>—           | 90<br>18<br>15  | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub>   | Propagation Delay Time (BUS-BUS)    | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 92<br>23<br>20  | 180<br>36<br>31 | —<br>—<br>—          | 225<br>45<br>38 | —<br>—<br>—           | 270<br>54<br>46 | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub>   | Propagation Delay Time (CLOCK-BUS)  | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 124<br>31<br>26 | 240<br>48<br>41 | —<br>—<br>—          | 300<br>60<br>51 | —<br>—<br>—           | 360<br>72<br>61 | ns   |
| t <sub>PLH</sub><br>t <sub>PHL</sub>   | Propagation Delay Time (SELECT-BUS) | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 112<br>28<br>24 | 220<br>44<br>37 | —<br>—<br>—          | 275<br>55<br>47 | —<br>—<br>—           | 330<br>66<br>56 | ns   |
| t <sub>W(H)</sub><br>t <sub>W(L)</sub> | Minimum Clock Pulse Width           | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 30<br>8<br>7    | 75<br>15<br>13  | —<br>—<br>—          | 95<br>19<br>16  | —<br>—<br>—           | 110<br>22<br>19 | ns   |
| t <sub>s</sub>                         | Minimum Data Set-up Time            | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | 5<br>1<br>1     | 50<br>10<br>9   | —<br>—<br>—          | 65<br>13<br>11  | —<br>—<br>—           | 75<br>15<br>13  | ns   |
| t <sub>h</sub>                         | Minimum Data Hold Time              | 2.0<br>4.5<br>6.0 |                | —<br>—<br>—                            | —<br>—<br>—     | 25<br>5<br>5    | —<br>—<br>—          | 30<br>6<br>5    | —<br>—<br>—           | 40<br>8<br>7    | ns   |

### AC ELECTRICAL CHARACTERISTICS (Continued)

| Symbol                               | Parameter                        | V <sub>CC</sub>   | Test Condition       | T <sub>A</sub> = 25°C<br>54HC and 74HC |                 |                 | – 40 to 85°C<br>74HC |                 | – 55 to 125°C<br>54HC |                 | Unit |
|--------------------------------------|----------------------------------|-------------------|----------------------|--|-----------------|-----------------|----------------------|-----------------|-----------------------|-----------------|------|
|                                      |                                  |                   |                      | Min.                                   | Typ.            | Max.            | Min.                 | Max.            | Min.                  | Max.            |      |
| t <sub>PZL</sub><br>t <sub>PZH</sub> | 3-State Output<br>Enable Time    | 2.0<br>4.5<br>6.0 | R <sub>L</sub> = 1kΩ | —<br>—<br>—                            | 100<br>25<br>21 | 180<br>36<br>31 | —<br>—<br>—          | 225<br>45<br>38 | —<br>—<br>—           | 270<br>54<br>46 | ns   |
| t <sub>PZL</sub><br>t <sub>PZH</sub> | 3-State Output<br>Disable Time   | 2.0<br>4.5<br>6.0 | R <sub>L</sub> = 1kΩ | —<br>—<br>—                            | 88<br>22<br>19  | 170<br>34<br>29 | —<br>—<br>—          | 215<br>43<br>37 | —<br>—<br>—           | 255<br>51<br>43 | ns   |
| C <sub>IN</sub>                      | Input Capacitance                |                   |                      | —                                      | 5               | 10              | —                    | 10              | —                     | 10              | pF   |
| C <sub>OUT</sub>                     | Output<br>Capacitance            |                   | BUS I/O              | —                                      | 13              | —               | —                    | —               | —                     | —               | pF   |
| C <sub>PD</sub> (*)                  | Power Dissipation<br>Capacitance |                   |                      | —                                      | 46              | —               | —                    | —               | —                     | —               |      |

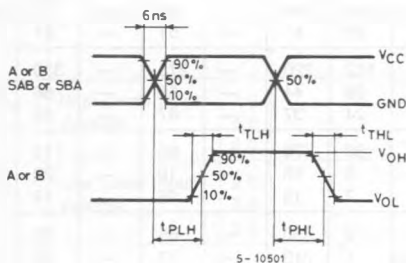
Note (\*)  $C_{PD}$  is defined as the value of IC's internal equivalent capacitance which is calculated from the operating current consumption without load (refer to Test circuit).

Average operating current can be obtained by equation hereunder.

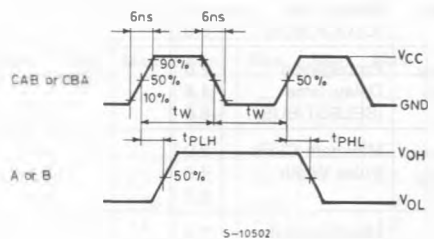
$$I_{CC(opr.)} = C_{PD} \cdot V_{CC} \cdot f_{IN} + I_{CC}/8 \text{ (per bit)}$$

### SWITCHING CHARACTERISTICS TEST CIRCUIT AND WAVEFORM

### WAVEFORM 1

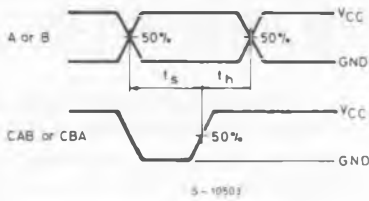


WAVEFORM 2

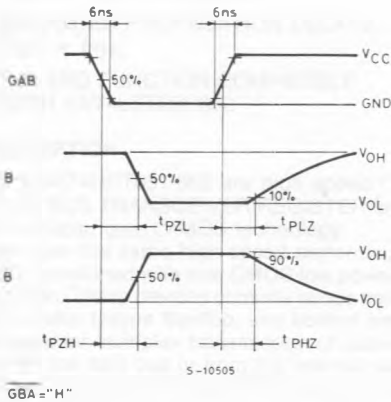


## SWITCHING CHARACTERISTICS TEST CIRCUIT AND WAVEFORM (Continued)

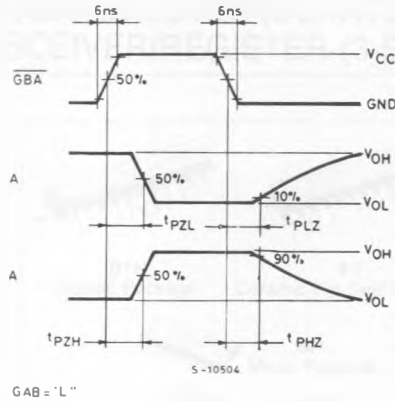
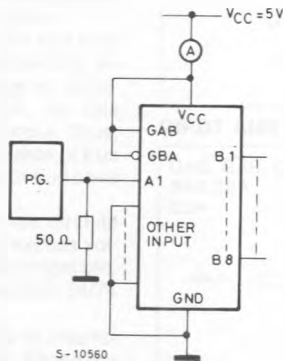
WAVEFORM 3



WAVEFORM 4



WAVEFORM 5

TEST WAVEFORM  $I_{CC}$  (Opr.)

INPUT TRANSITION TIME IS THE SAME AS THAT IN CASE OF SWITCHING CHARACTERISTICS TEST