

# TEXAS INSTRUMENTS



X3T9.2/92-160

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FROM: DEAN WALLACE, TI  
SUBJECT: ACTIVE TERMINATION REQUIREMENTS

Depending on the system configuration active negation drivers are not always needed for fast SCSI. If the driver or receiver are at a terminated end of the cable and the cable length is reasonably close to the SCSI committees recommendation then in certain configurations the system can be operated at 10MHz even with cables that have impedances below 72 ohms. Figure one shows a comparison between a setup where the driver and receiver are in the middle of the cable and the same setup with the driver moved from the middle to a terminated end. The scope pictures show that being by the terminator add about an additional 600mV to the first step in this setup. This is due to the continued infeed of current from the termination.

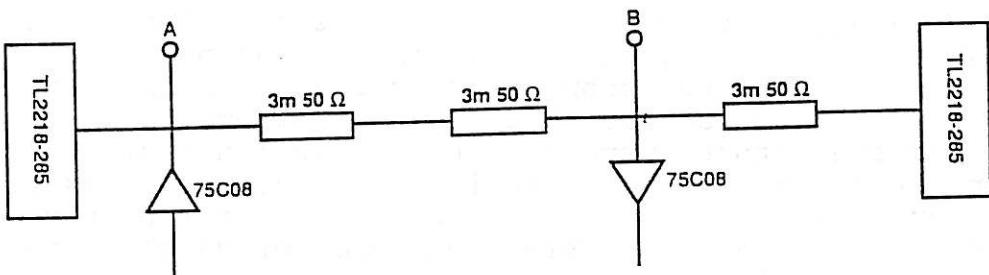
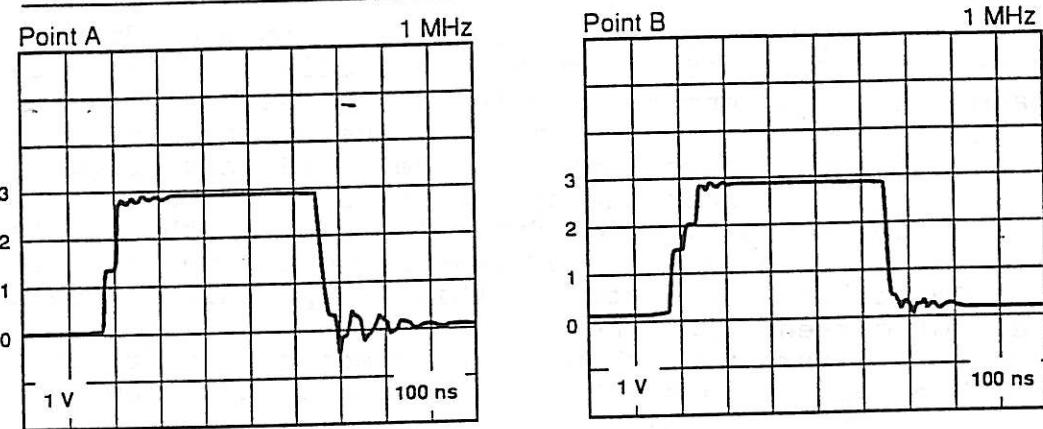
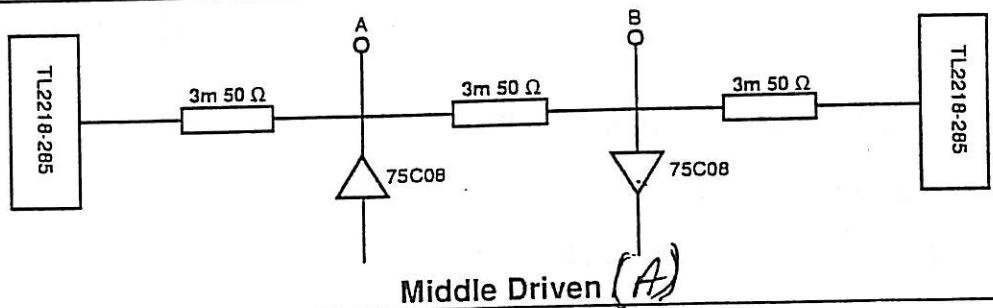
Figure two thru figure four show a comparison of end driven setups at 1MHz and 10MHz and cable impedances of 93 ohms, 75 ohms, and 50 ohms. The scope photographs show an acceptable high level in all instances with the exception of t' ~ Boulay termination with a cable impedance of 50 ohms. In this setup negation drivers were not needed for 10MHz operation. The negation drivers would give a higher first step and increased noise margin but the necessity of active negation (in these setups) for proper system operation is questionable. The negation drivers also require that the terminators be able to sink current without affecting the output current on the other lines of the terminator.

If the driver or the receiver are in the middle of a bus (away from an active terminator) then negation drivers are needed for proper operation. Figure six shows that even with cable impedances of 93 ohms these middle driven systems don't achieve sufficient high levels.

Figures 14 thru 16 show a resistor terminated setup with 50 ohm cable and the driver and receiver in the middle of the bus. Figure 15 shows that various short pulsedwidths of current do not increase the high level and introduce noise into the system. The same figure (figure 15) shows that a controlled negation driver that drives through the 2 volt threshold makes this setup operate properly, even at 10MHz (figure 16).

Systems with low impedance cable and weak terminators can still be used with active negation drivers. Systems with higher impedance cable and either the target or the initiator at the terminator probably don't need active negation drivers especially if the termination is some form of non-linear termination allowing a high level of current even at higher voltages resulting in a higher first step.

### END DRIVEN VS. MIDDLE DRIVEN ( $Z_C = 50 \Omega$ )



End Driven

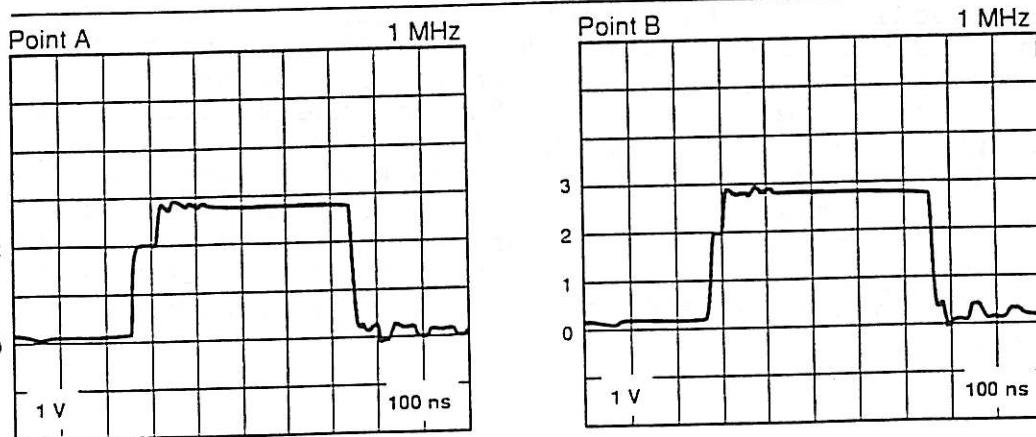
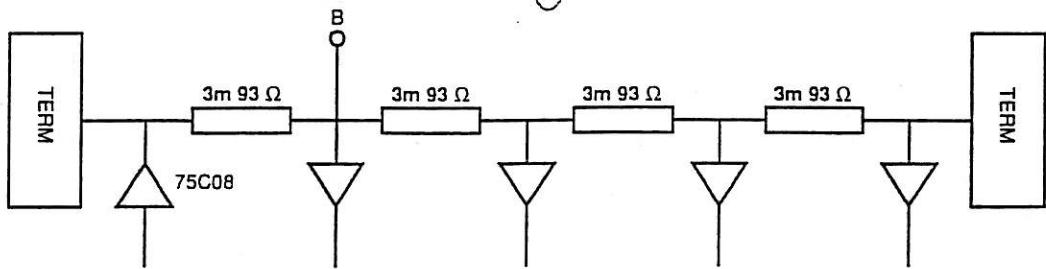


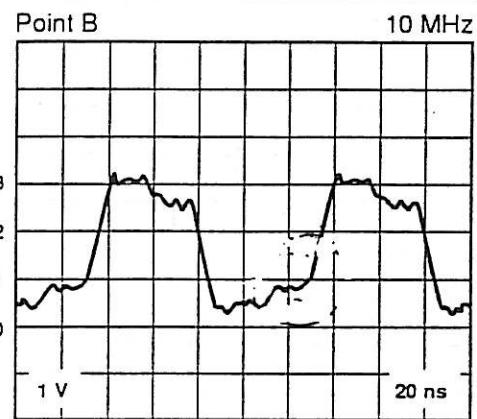
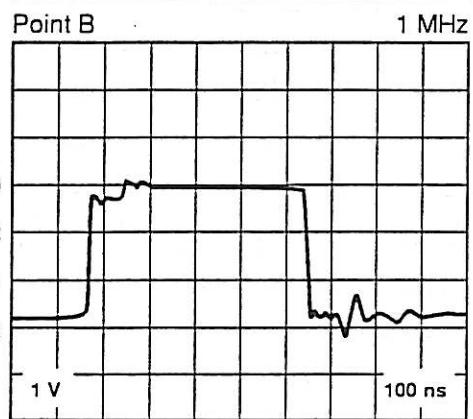
FIGURE 1



**END DRIVEN ( $Z_C = 93 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



**Boulay Terminator**

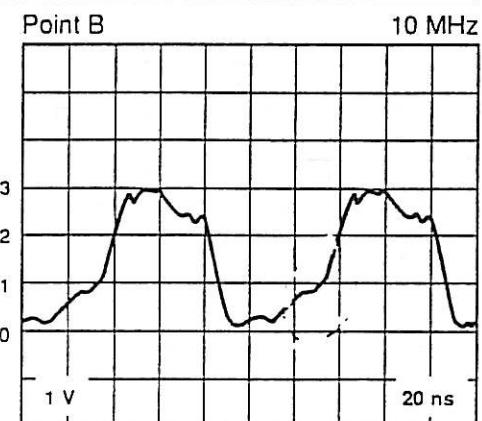
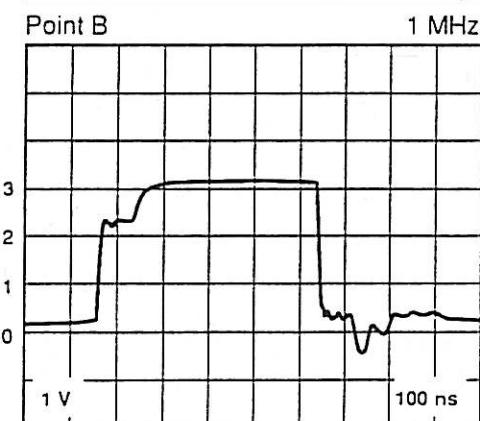
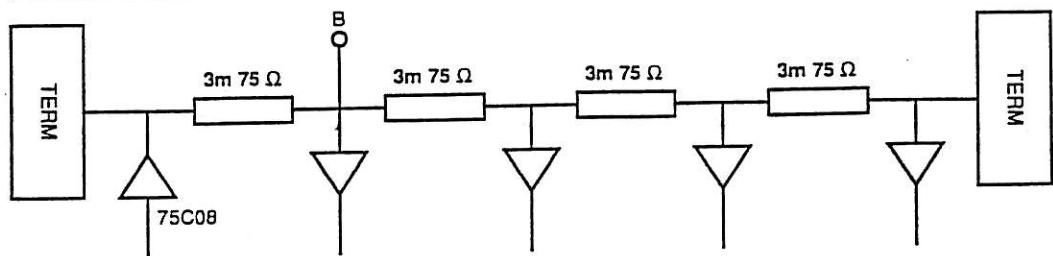


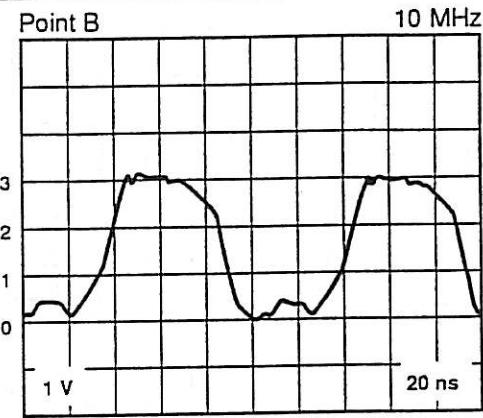
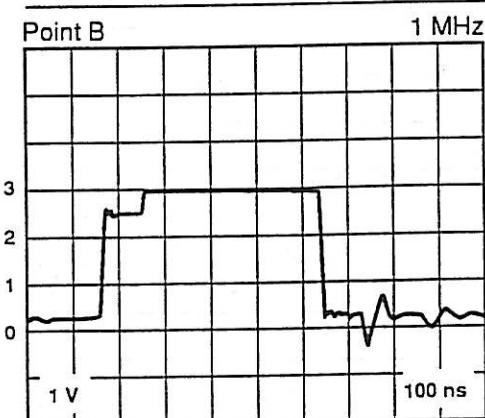
FIGURE 2



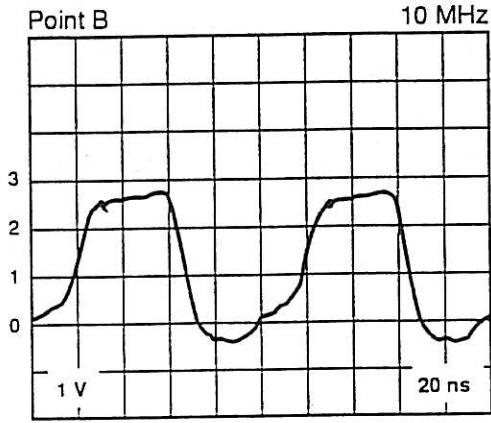
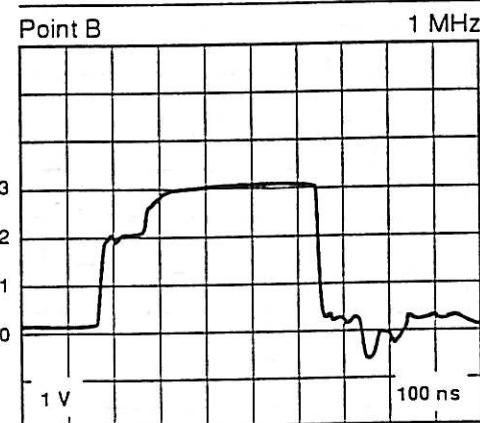
**END DRIVEN ( $Z_C = 75 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



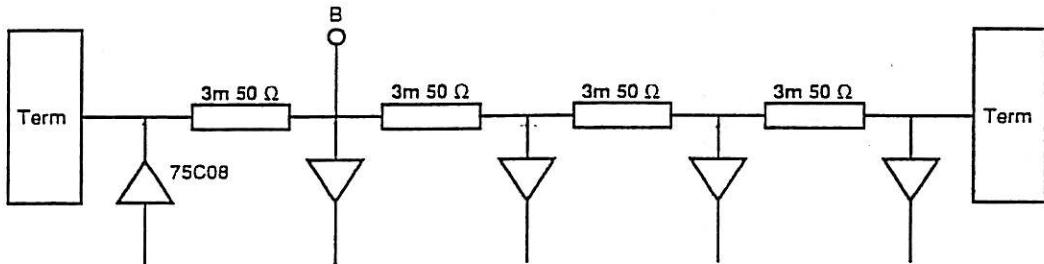
**Boulay Terminator**



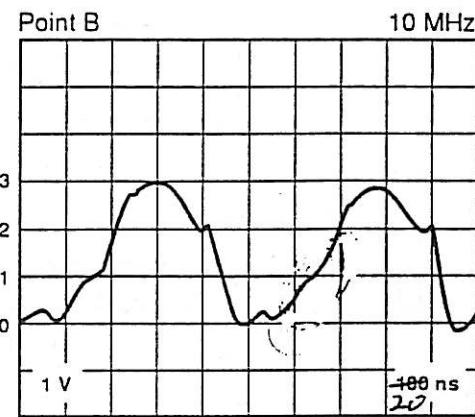
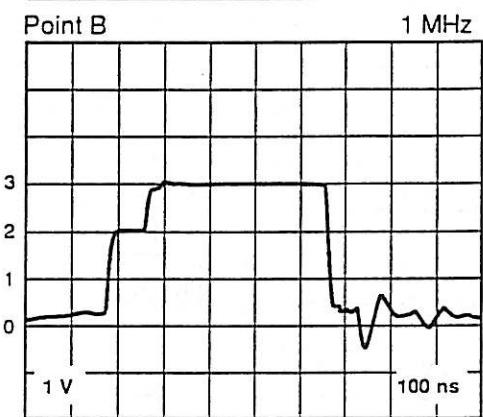
**FIGURE 3**



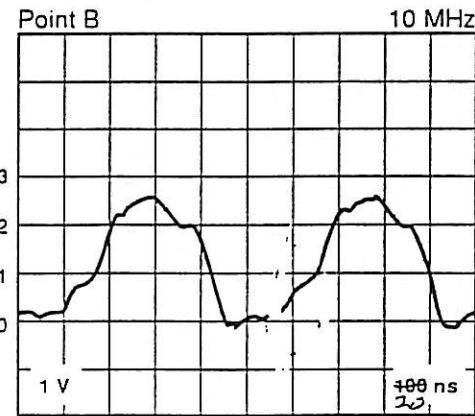
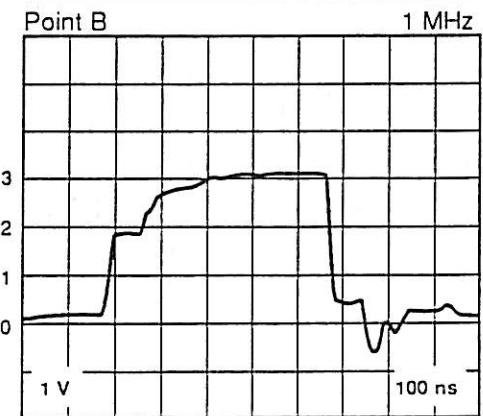
**END DRIVEN ( $Z_C = 50 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Probe Terminator**



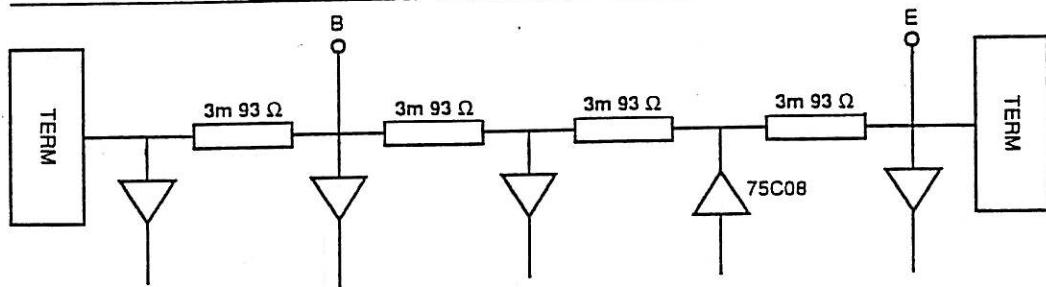
**Boulay Terminator**



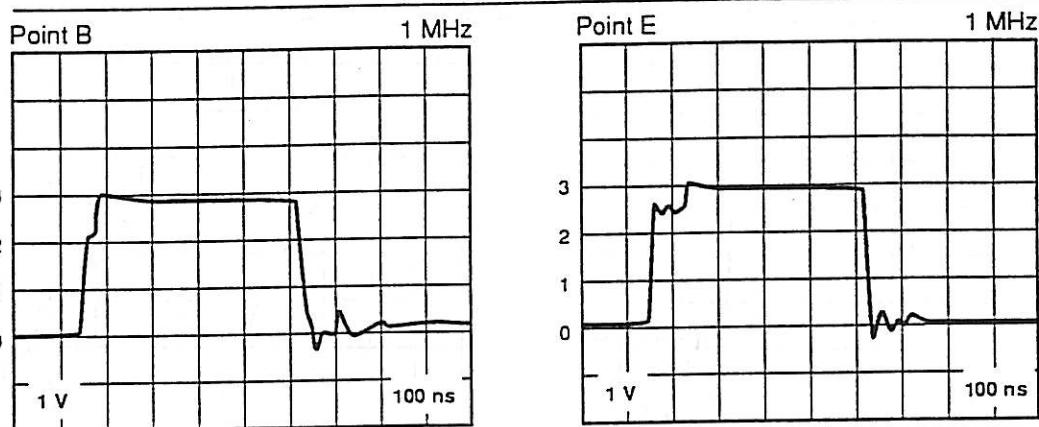
**FIGURE 4**



MIDDLE DRIVEN ( $Z_C = 93 \Omega$ , OPEN DRAIN)



TL2218-285 Current Mode Terminator



Boulay Terminator

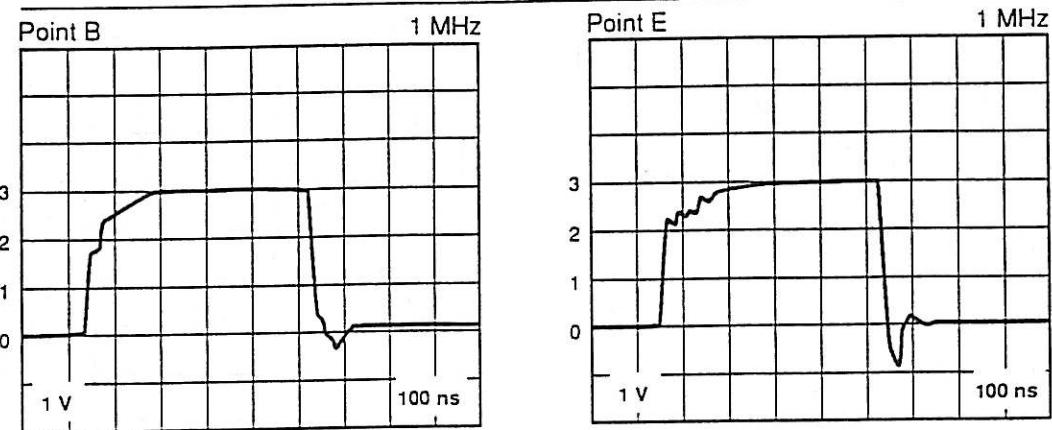
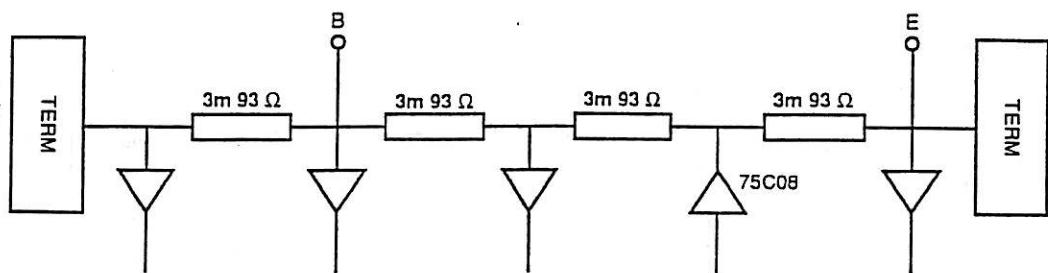


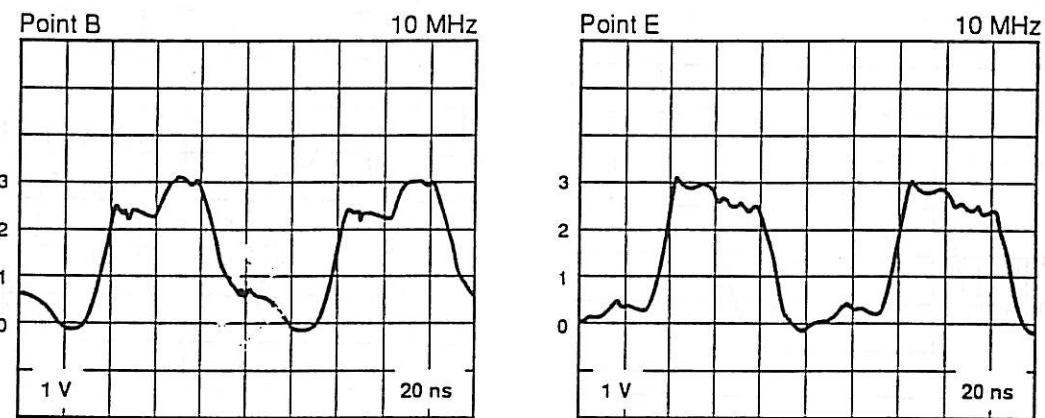
FIGURE 5



**MIDDLE DRIVEN ( $Z_C = 93 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



**Boulay Terminator**

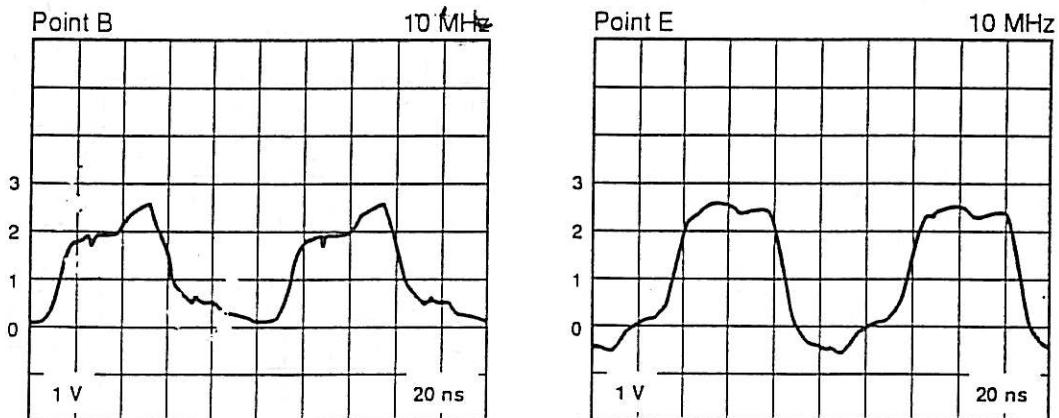
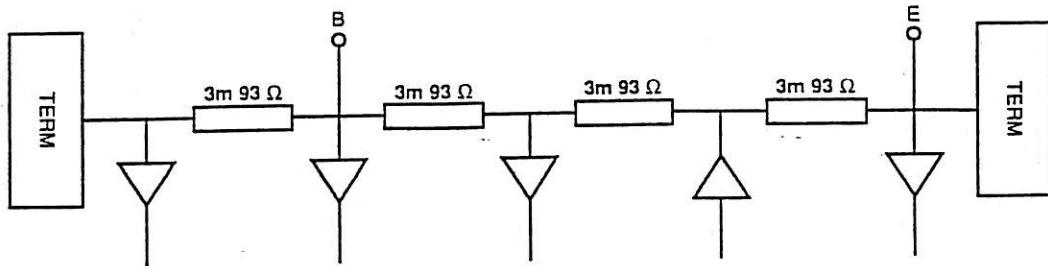


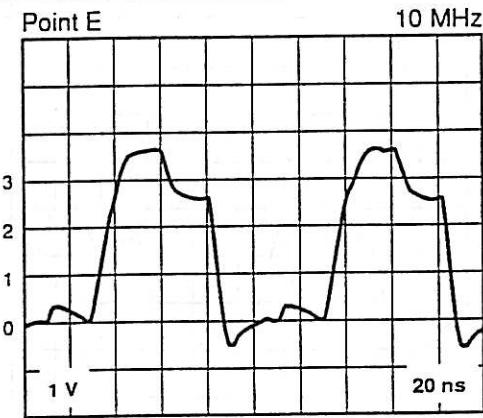
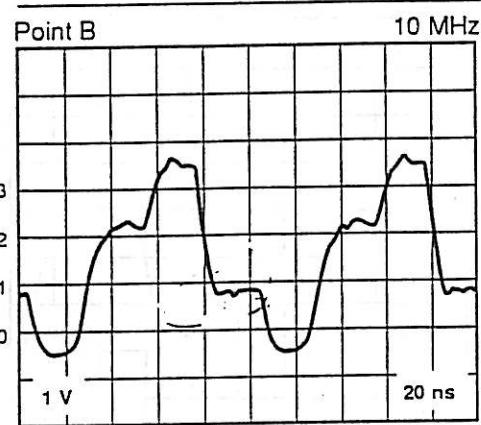
FIGURE 6



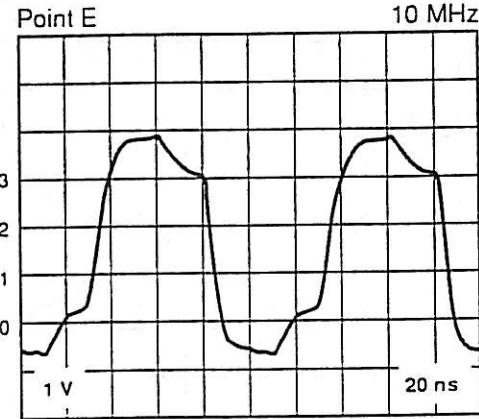
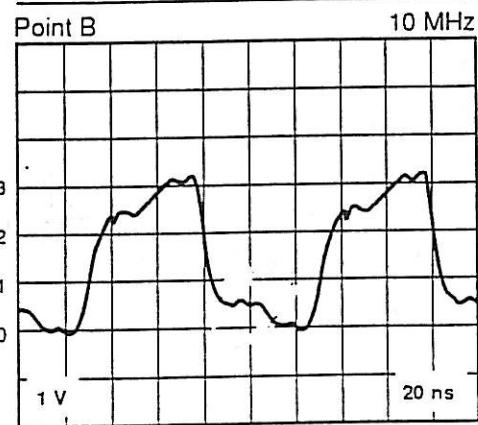
**MIDDLE DRIVEN ( $Z_C = 93 \Omega$ , NEGATION DRIVER, 20 mA)**



**TL2218-285 Current Mode Terminator**



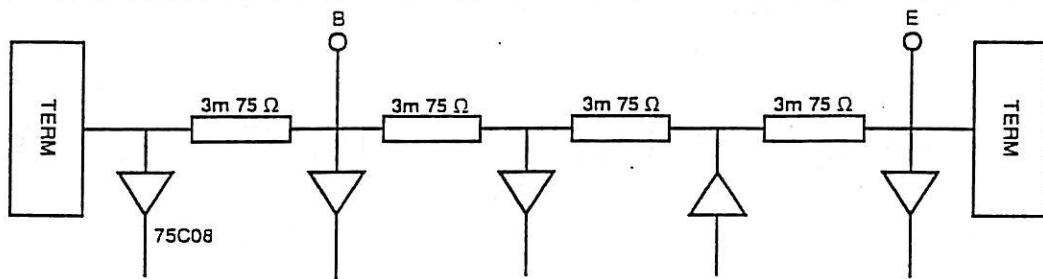
**Boulay Terminator**



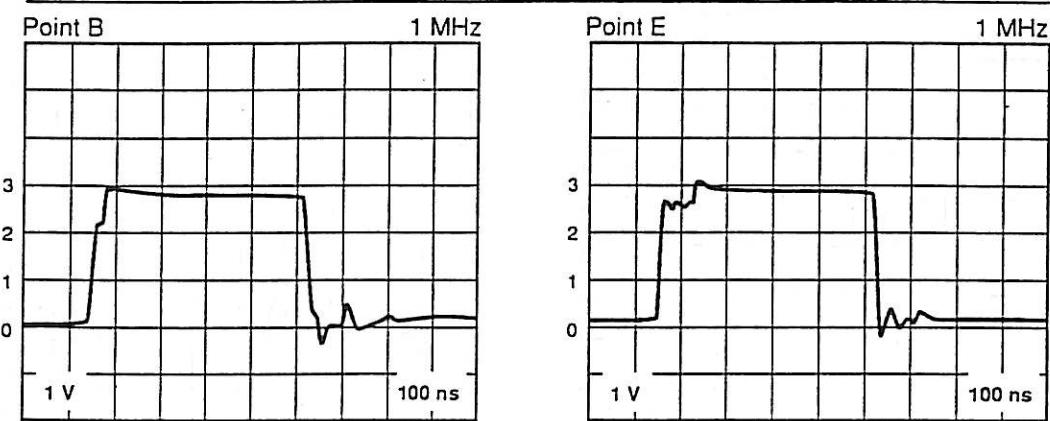
**FIGURE 7**



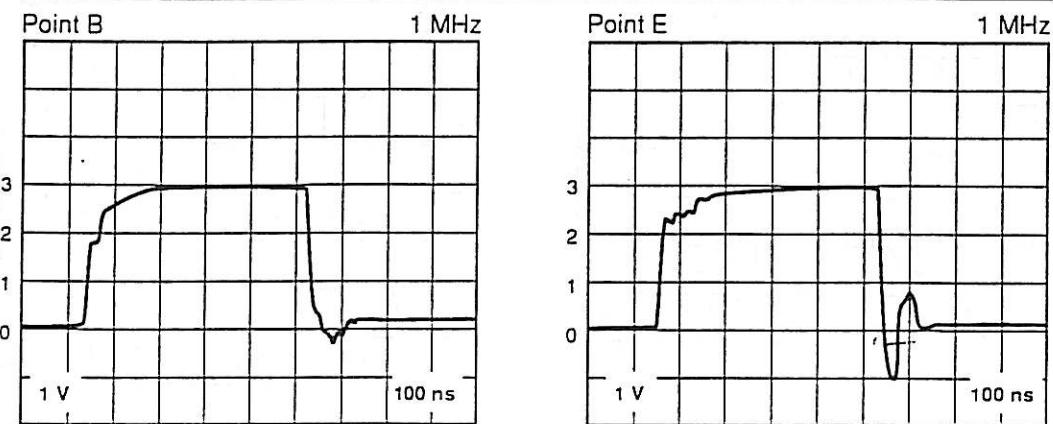
**MIDDLE DRIVEN ( $Z_C = 75 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



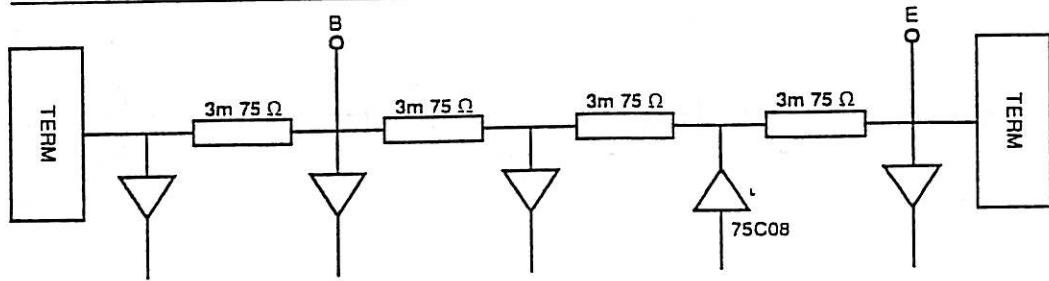
**Boulay Terminator**



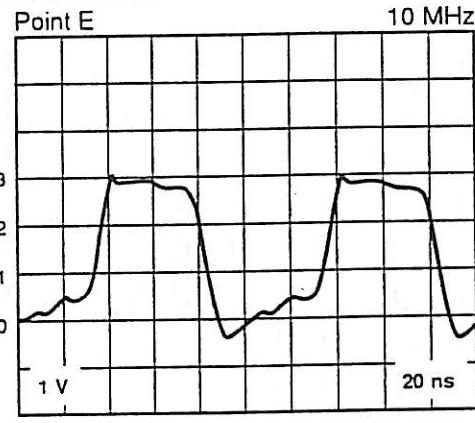
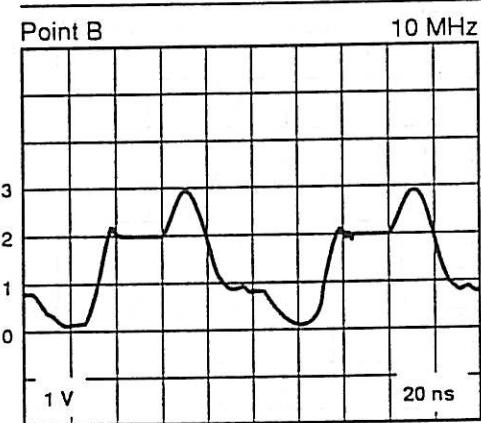
**FIGURE 8**



*MIDDLE*  
END DRIVEN ( $Z_C = 75 \Omega$ , OPEN DRAIN)



TL2218-285 Current Mode Terminator



Boulay Terminator

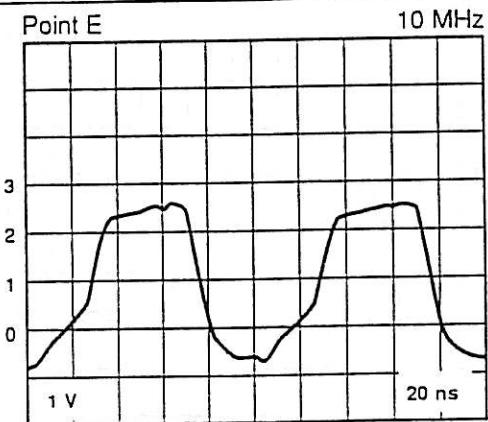
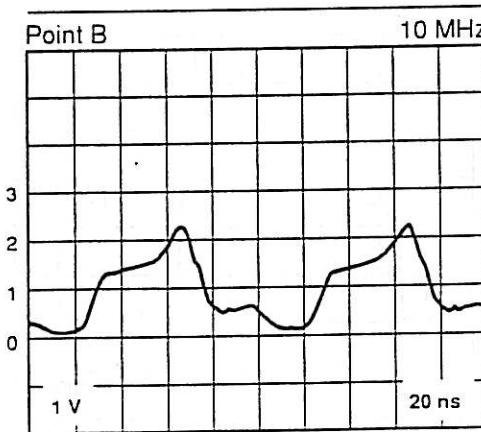
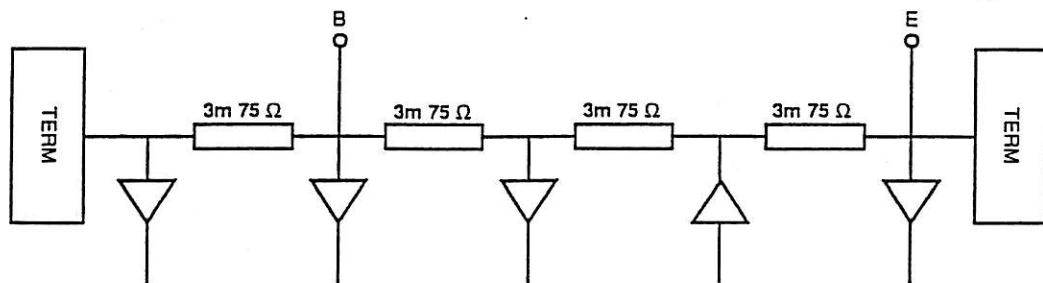


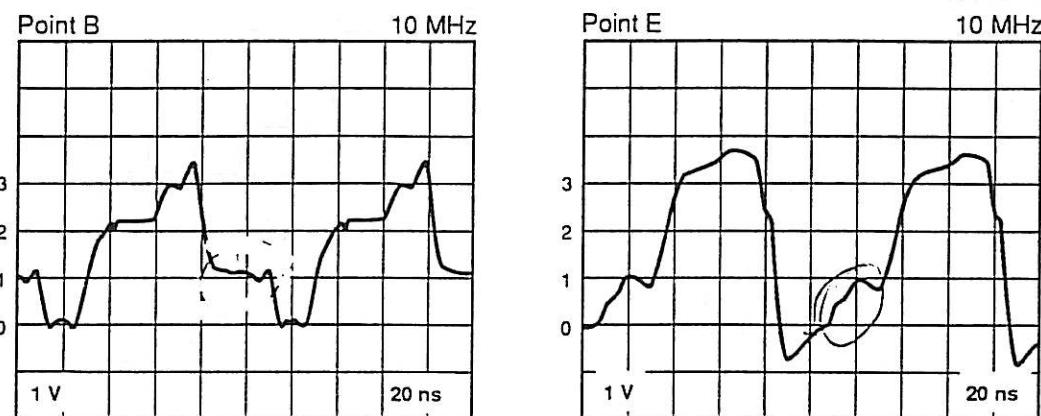
FIGURE 9



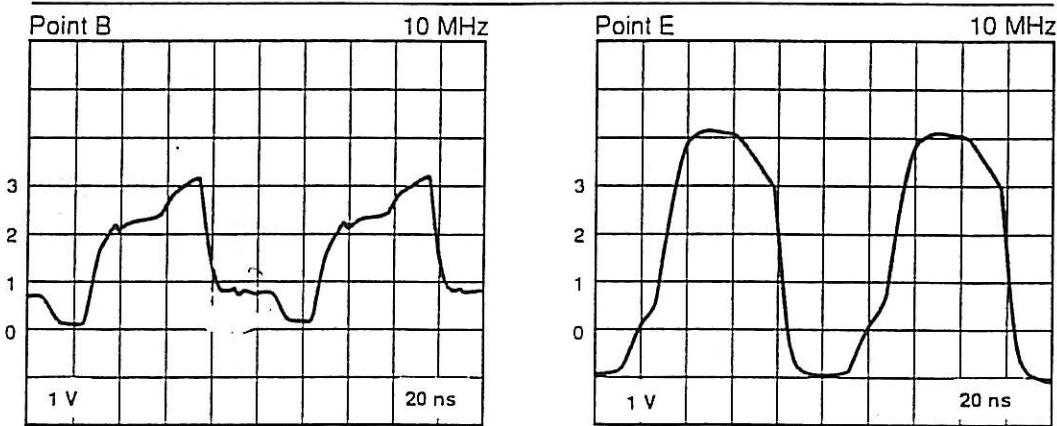
**MIDDLE DRIVEN ( $Z_C = 75 \Omega$ , NEGATION DRIVER, 20 mA)**



**TL2218-285 Current Mode Terminator**



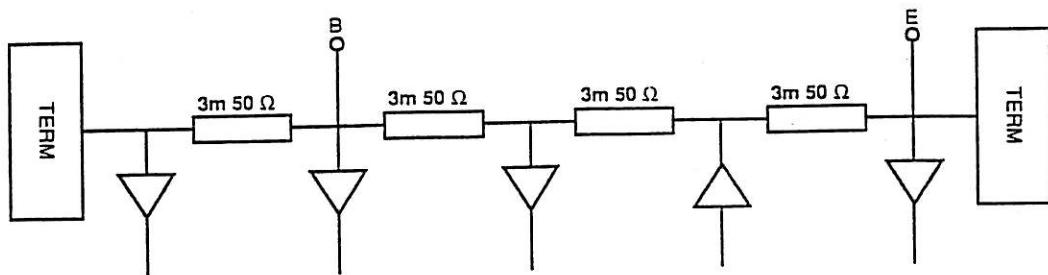
**Boulay Terminator**



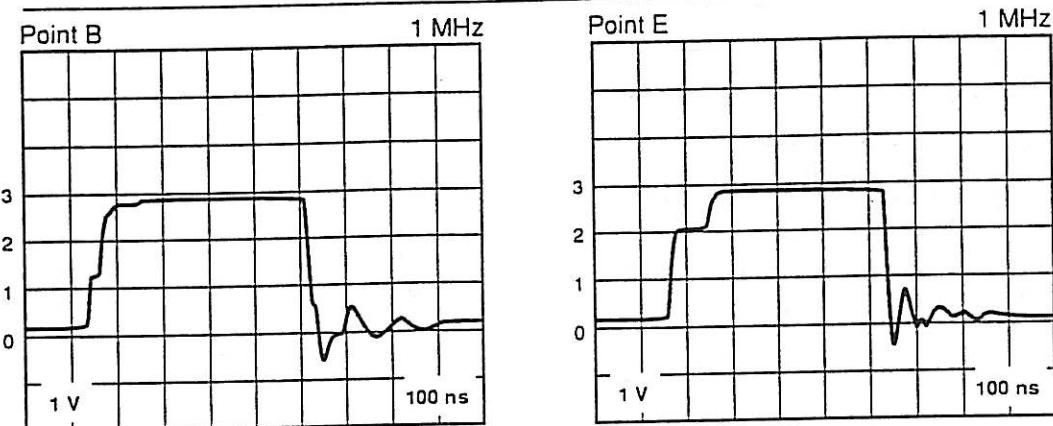
**FIGURE 10**



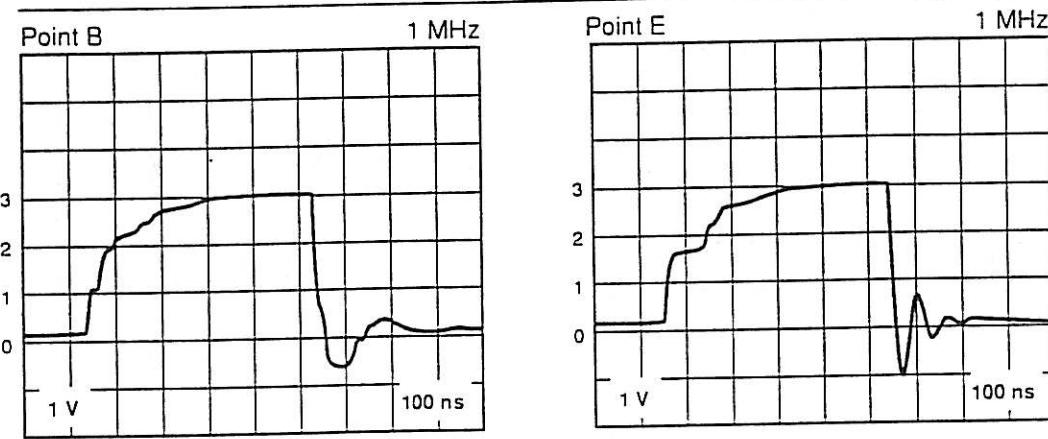
**MIDDLE DRIVEN ( $Z_C = 50 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



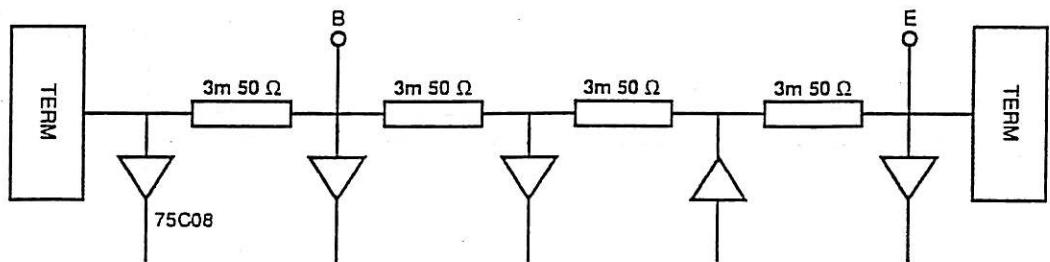
**Boulay Terminator**



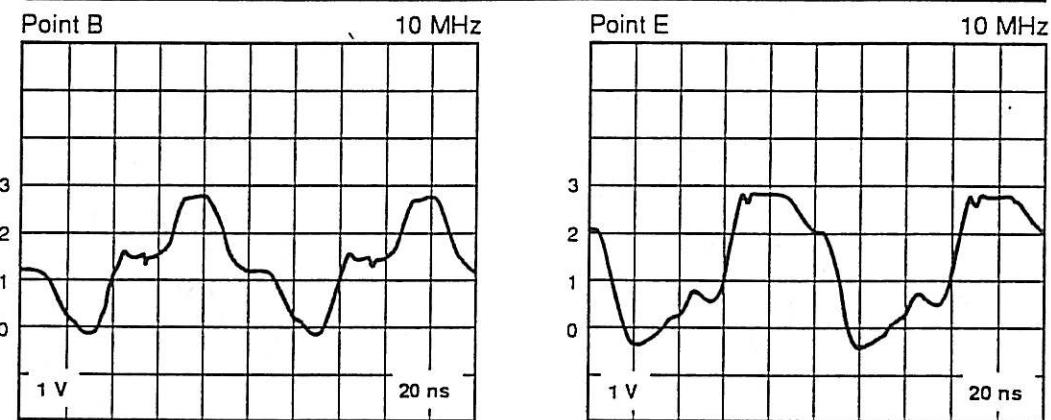
**FIGURE 11**



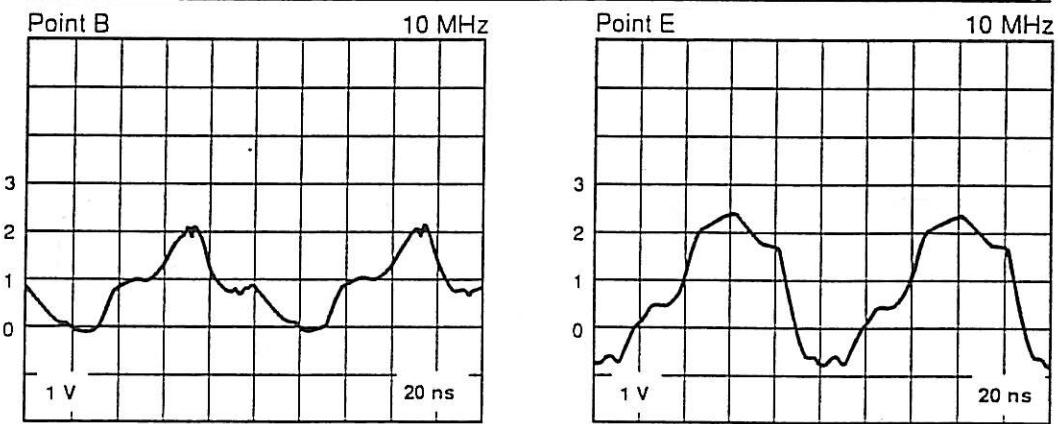
**MIDDLE DRIVEN ( $Z_C = 50 \Omega$ , OPEN DRAIN)**



**TL2218-285 Current Mode Terminator**



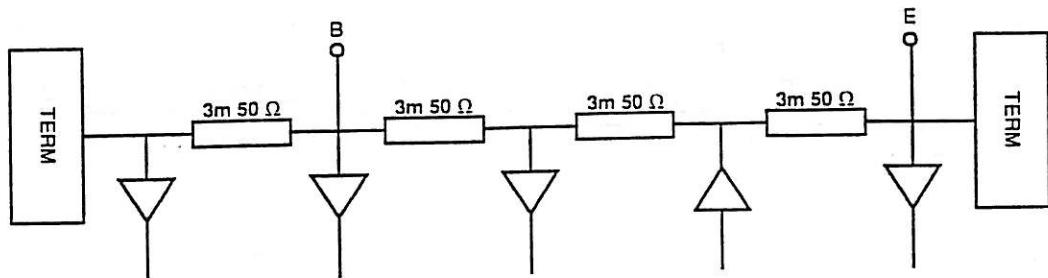
**Boulay Terminator**



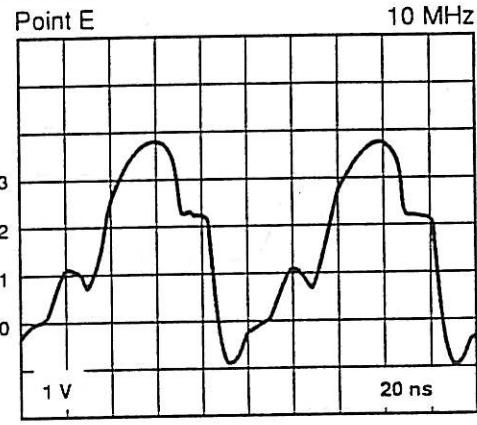
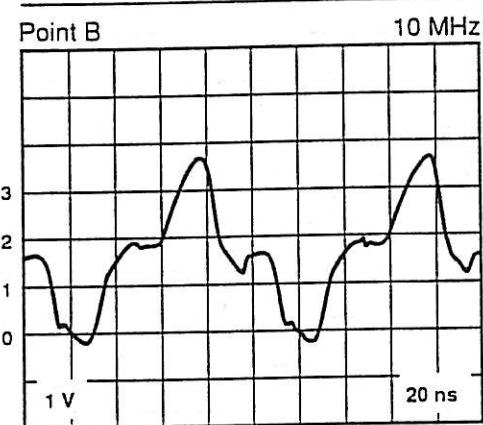
**FIGURE 12**



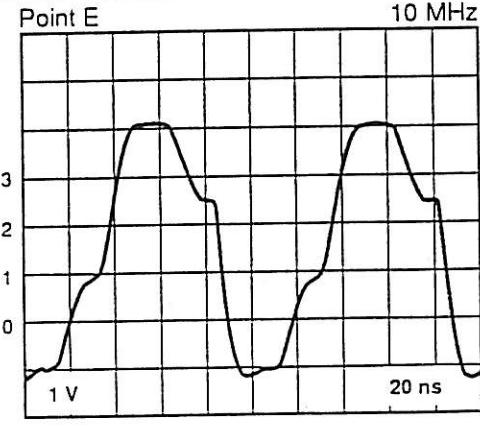
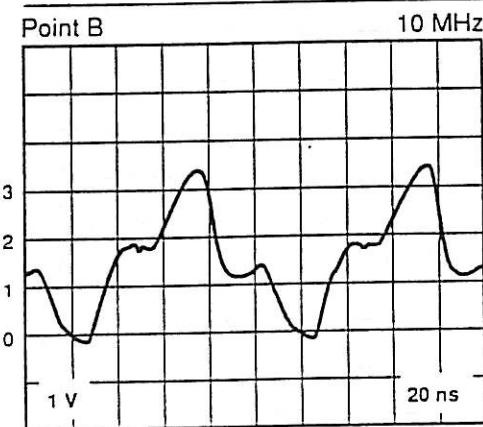
**MIDDLE DRIVEN ( $Z_C = 50 \Omega$ , NEGATION DRIVER, 20 mA)**



**TL2218-285 Current Mode Terminator**



**Boulay Terminator**



**FIGURE 13**



**MIDDLE DRIVEN ( $Z_C = 50 \Omega$ , OPEN DRAIN)**

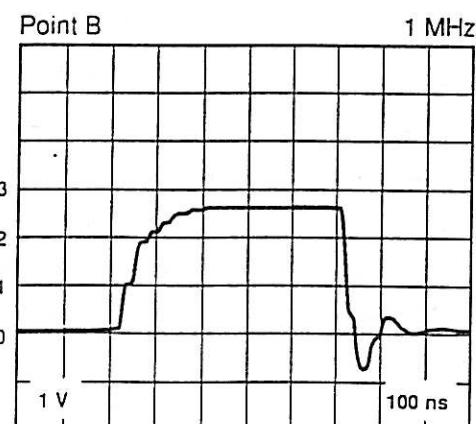
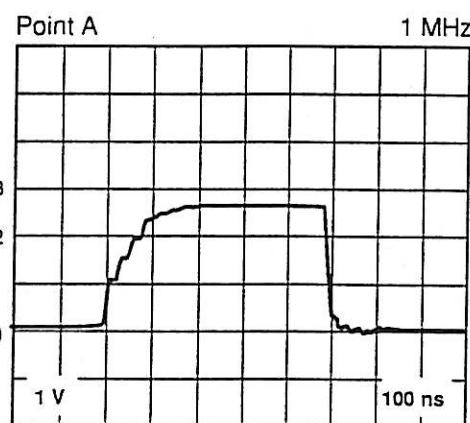
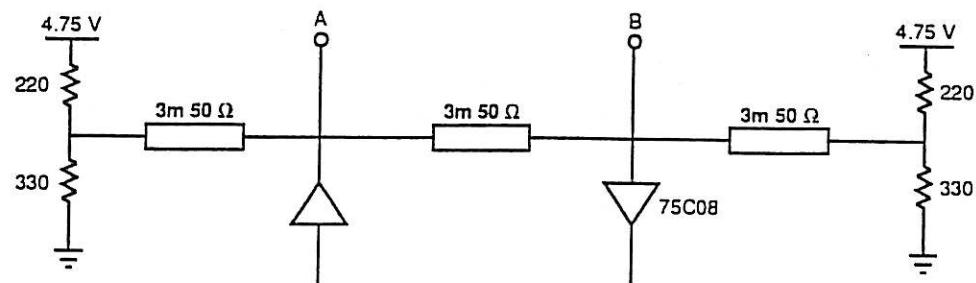
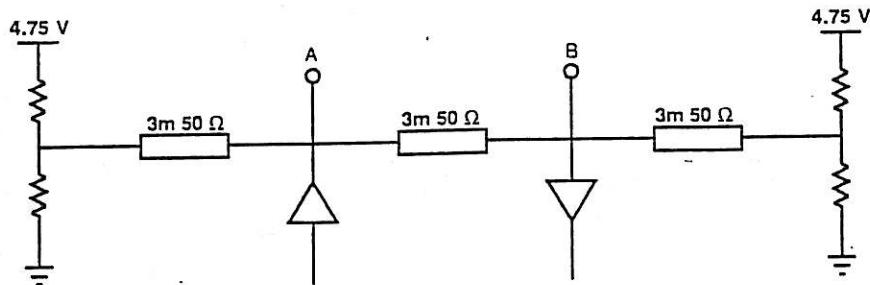


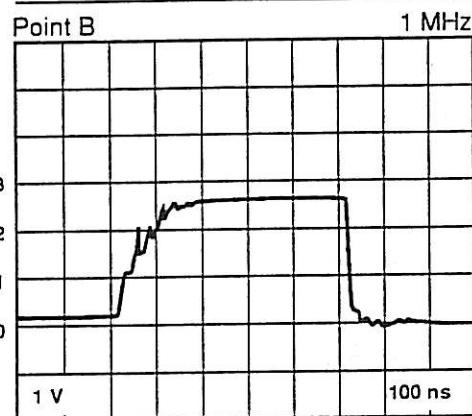
FIGURE 14



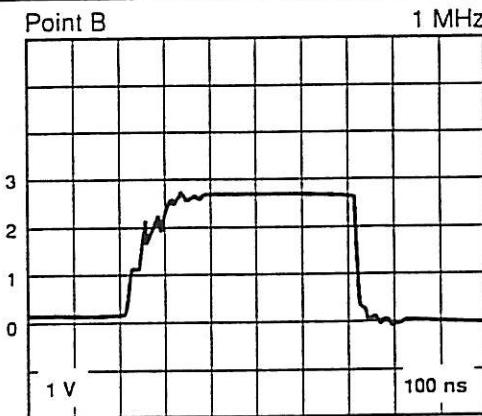
**MIDDLE DRIVEN ( $Z_C = 50 \Omega$ , CURRENT PULSE)**



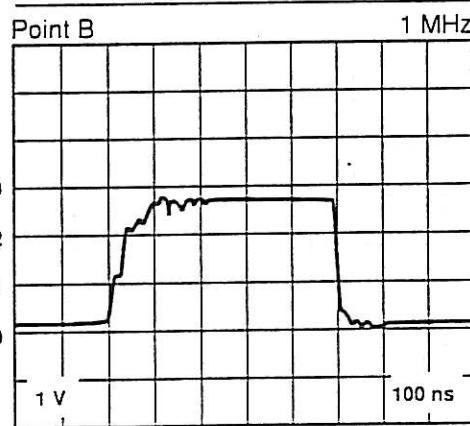
10 ns Pulse, 20 mA



50 ns Pulse, 20 mA



100 ns Pulse, 20 mA



Negation Driver

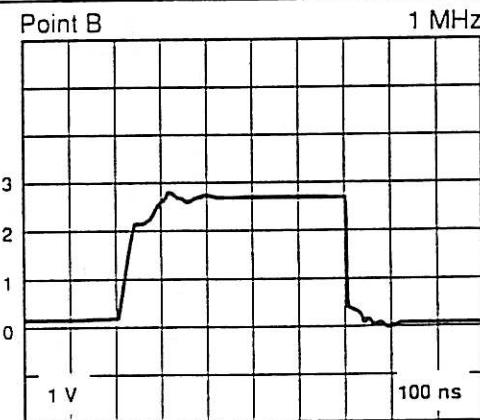
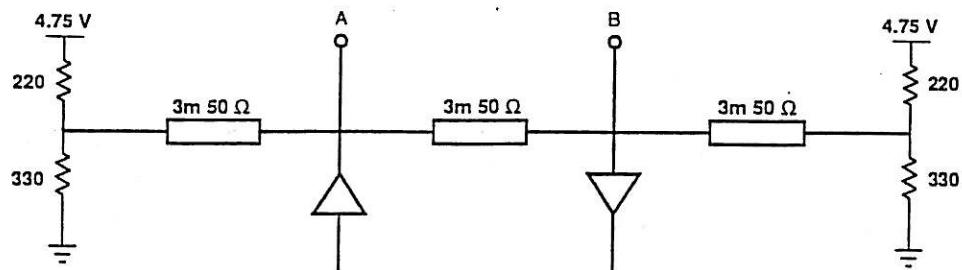


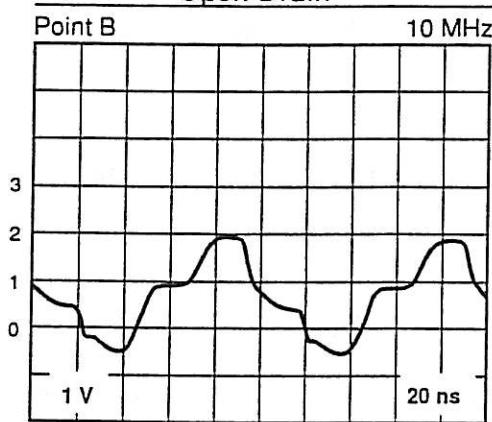
FIGURE 15



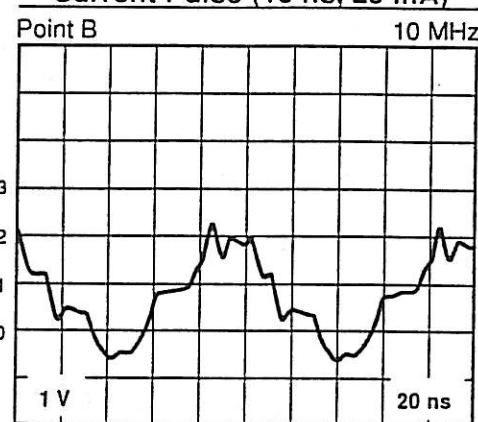
### MIDDLE DRIVEN ( $Z_C = 50 \Omega$ )



Open Drain



Current Pulse (10 ns, 20 mA)



Negation Driver

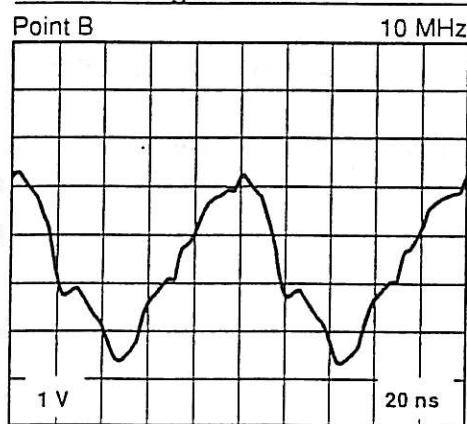


FIGURE 16



## ACTIVE NEGATION DRIVERS

- Systems with the driver or receiver at a terminated end probably don't need active negation drivers if:
  - \*  $Z_c$  is 72 ohms to 96 ohms (SCSI rec)
  - \* Driver/receiver are within 3 meters
- Negation drivers will give additional noise margin.
  - \* Termination needs to sink negation current without effecting output current on other lines.
- If the driver and receiver are in the middle of the cable then negation drivers are needed for low impedance cables or low current terminators.

## ACTIVE NEGATION DRIVERS

- Ⓐ Using a current pulse ('kicker') doesn't always work.
  - \* Depends on the pulselwidth
  - \* Output current
  
- Ⓑ Negation driver output a function of line voltage yields best results.
  - \* Pick a trip point for negation driver.
  - \* Required output current?

## TERMINATION ISSUES

### ⦿ Negation current sink capability

- \* Amount of current
- \* Channel separation

### ⦿ Termination capacitance

- \* Measure with terminator disabled
- \* Specific voltage (500mV)
- \* Specific frequency (10MHz)

### ⦿ Terminator output current of 24mA at 200mV

- \* Undershoot clamps could source current in the 0 to 200mV range.