

## DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

**CALIBRATION PROCEDURE FOR  
TDR/SAMPLER PLUG-IN TD-1160(P)/U  
(TEKTRONIX TYPE 7S12)**

Headquarters, Department of the Army, Washington, DC  
30 September 1976

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## SECTION I IDENTIFICATION AND DESCRIPTION

**1. Test Instrument Identification.** This bulletin provides instructions for the calibration of TDR/Sampler Plug-In, TD-1160(P)/U (Tektronix Type 7S12). The manufacturer's instruction manual was used as the prime data source in compiling the instructions. The equipment being calibrated will be referred to as the TI (test instrument) throughout this bulletin.

*a. Model Variations.* None.

*b. Time and Technique.* The time required for this calibration is approximately 4 hours, using the d.c. and low frequency technique.

**2. Calibration Data Card, (DA Form 2416).** *a.* Forms, records, and reports required for calibration personnel at all levels are prescribed by TM 38-750. DA Form 2416 must be annotated in accordance with TM 38-750 for each calibration performed.

*b.* Adjustments to be reported on DA Form 2416 are designated (R) at the end of the sentence in which they appear. Report only those adjustments made and designated with (R).

**3. Calibration Description.** TI parameters and performance specifications which pertain to this calibration are listed in table 1.

*Table 1. Calibration Description*

TI identification	Performance specifications		
Deflection factor Range Accuracy	2 to 500 unit/div in 1, 2, 5 sequence. Variable provides 1 to 700 unit/div (mv or mp). ±3%		
ρ CAL range	Allows calibrated reflection coefficient (ρ) with pulse generators supplying from 200 mv to 1 v pulse amplitude.		
DC OFFSET range	+1 v to - 1 v		
OFFSET OUT: Range Accuracy	+ 10 v to -10 v. OFFSET OUT = 10X (DC OFFSET). ±2%		
VERTICAL SIGNAL OUT: Amplitude Accuracy	200 mv/div of signal display ±2%		
SWEEP OUT: Range Accuracy	0 to greater than 10 v ±2%		
TIME/DIV: Range Accuracy	20 ps/div to 1 μs/div in 1, 2, 5 sequence. Variable provides to 8 ps/div. ±2%		
System performance with PL-1373/U (Tektronix Type S-6) and SG-1094/U (Tektronix Type S-52).			
Rise time	35 ps or less for incident step, 45 ps or less for displayed reflection from short-circuited 1 ns test line.		
Pulse amplitude	At least +200 mv		
Jitter	Less than 10 ps (without signal averaging)		
Aberrations	Not more than ±7%, total of 10% p-p within first 1.8 ns of step edge with reference level at 1.8 ns from step edge; not more than ±2%, total of 4% p-p after 2.5 ns from step edge with reference level at 0.3 μs from step edge.		
Time-distance scale: Accuracy	±1% fs TIME-DISTANCE Multiplier		
Time range	X.1	X1	X10
	.1μs	1μs	10μs
Air dielectric distance range.	Maximum of 150 ns one way cable delay		
	49 ft 15m	490 ft 150 m	4900 ft 1500 m
Poly dielectric distance range.	Max of 150 ft (46 m) cable length.		
	32 ft 9.75 m	320 ft 97.5 m	3200 ft 975 m.
	Max of 100 ft (30 m) cable length.		

## SECTION II EQUIPMENT REQUIREMENTS

**4. Equipment Required.** Table 2 identifies the specific equipment used in this calibration procedure. This equipment is issued with secondary transfer standards calibration set NSN 6695-00-621-7877 and is to be used in performing this procedure. Alternate items may be used by the calibrating activity when the equipment listed in table 2 is not available. The items selected must be verified to perform satisfactorily prior to use and must bear evidence of current calibration. The

equipment must meet or exceed the minimum use specifications listed in table 2. The accuracies listed in table 2 provide a four-to-one accuracy ratio between the standard and TI.

**5. Accessories Required.** The accessories listed in table 3 are issued as indicated in paragraph 4 above and are to be used in this calibration procedure. When necessary, these items may be substituted by equivalent items unless specifically prohibited.

*Table 2. Minimum Specifications of Equipment Required*

Item number	Common name	Minimum use specifications	Manufacturer, model, and part number *
A1	AC CALIBRATOR	Range: 4.11474 mv rms to 1.09231 vrms. Accuracy: $\pm 0.75$	Hewlett-Packard, Model 745AC90 (MIS-10342 Type 1).
A2	DELAY LINE	Time: 75 nsec delay Rise time: 175 psec	Tektronix Type 7M11
A3	OSCILLOSCOPE	Rise time: psec	Tektronix, Type 7000 series.
A4	PULSE GENERATOR	Must be compatible with TI.	Tektronix, Type S-52
A5	TIME-MARK GENERATOR.	Range: 1 $\mu$ S to 2 nS markers. Accuracy: $\pm 0.75\%$	Tektronix, Type 184 MOD 146B (7912042-2).
A6	TRIGGER RECOGNIZER.	Must be compatible with TI.	Tektronix, Type S-53
A7	SAMPLING HEAD	Must be supplied with TI	Tektronix, Type S-6
A8	VERTICAL AMPLIFIER.	Range: 9 to 11 mv	Tektronix, Type 7A series.

\*The calibration equipment utilized in this procedure was selected from those known to be available at Department of Defense facilities, and the listing by make or model number carries no implication of preference, recommendation, or approval by the Department of Defense for use by other agencies. It is recognized that equivalent equipment produced by other manufacturers may be capable of equally satisfactory performance in the procedure.

*Table 3. Accessories Required*

Item	Common name	Description and part number
B1	ADAPTER	SMA male to BNC female Tektronix, Type 015-1018-00.
B2	ADAPTER*	GR to BNC connector plug (10528559)
B3	CABLE	36-in., RG-58/U; BNC to double banana plug terminations (7907471).
B4	CABLE*	30-in., RG-58/U; BNC plug terminations (79046).
B5	CABLE	BSM to BNC connector Tektronix, Type 012-0126-00.
B6	CABLE	Coaxial cable, U-shaped Tektronix, Type 015-1017-00 (supplied with TI).
B7	CABLE	Coaxial; Tektronix, Type 015-1023-00
B8	Extender *	Flexible Tektronix, Type 067-0616-00
B9	Probe	Tektronix, Type P6006 (7911545)
B10	TERMINATION	Short-circuit, 3 mm female; Tektronix, Type 012-10210 (supplied with TI)
B11	TERMINATION	Short-circuit, GR connectors; Tektronix, Type 017-0087-00.

\*Two required

### SECTION III PRELIMINARY OPERATIONS

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**6. Preliminary Instructions.** a. The instructions outlined in this section are preparatory to the calibration process. Personnel should become familiar with the entire procedure before beginning the calibration.

b. Items of equipment used in this procedure are referenced within the text by common name and item identification number as listed in tables 2 and 3. For the identification of equipment referenced by item numbers prefixed with A, see table 2, and for prefix B, see table 3.

#### **WARNING**

**HIGH VOLTAGE is used during the performance of this calibration. DEATH ON CONTACT may result if personnel fail to observe safety precautions.**

**7. Equipment Setup.** a. Install two extenders (B8) into oscilloscope (A3) right and horizontal compartment.

Install vertical amplifier (A8) in oscilloscope left vertical compartment.

b. Connect TI to extenders. Do not cross cables.

c. Install sampling head (A7) in SAMPLING compartment of TI and pulse generator (A4) in PULSE GENERATOR compartment of TI.

d. Position TI controls as listed in (1) through (10) below:

- (1) mV switch to on position.
- (2) mV/DIV VARIABLE control to CAL IN.
- (3) mV/DIV switch to 100.
- (4) REP switch to on position.
- (5) TIME-DISTANCE multiplier switch to X1.
- (6) TIME/DIV switch to .1  $\mu$ s.
- (7) TIME-DISTANCE dial to 0 (zero).
- (8) FINE (ZERO SET) control fully clockwise.
- (9) SCAN control fully clockwise.
- (10) LOCATE switch to in position.

e. Set oscilloscope power switch to on position and allow 5 minutes for equipment to warm up.

SECTION IV  
CALIBRATION PROCESS

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met before continuing with the calibration.

head used and may not be properly adjusted for other sampling heads.

(3) Depress oscilloscope (A3) right vertical mode switch and right vertical trigger source switch.

(4) Adjust TI DC OFFSET control to display pulse on oscilloscope crt. If step is off oscilloscope crt, perform b(1) below.

(5) Adjust TI mV/DIV VARIABLE control for a 5-division step on oscilloscope crt. If first dot is not 4.5 divisions above 0-percent level on oscilloscope crt display, perform b(2) and (3) below.

(6) Turn TI mV/DIV VARIABLE switch to CAL IN and remove coaxial line from sampling head input and pulse generator output.

b. Adjustments.

(1) Adjust R592 (fig. 2) until pulse is displayed on oscilloscope crt.

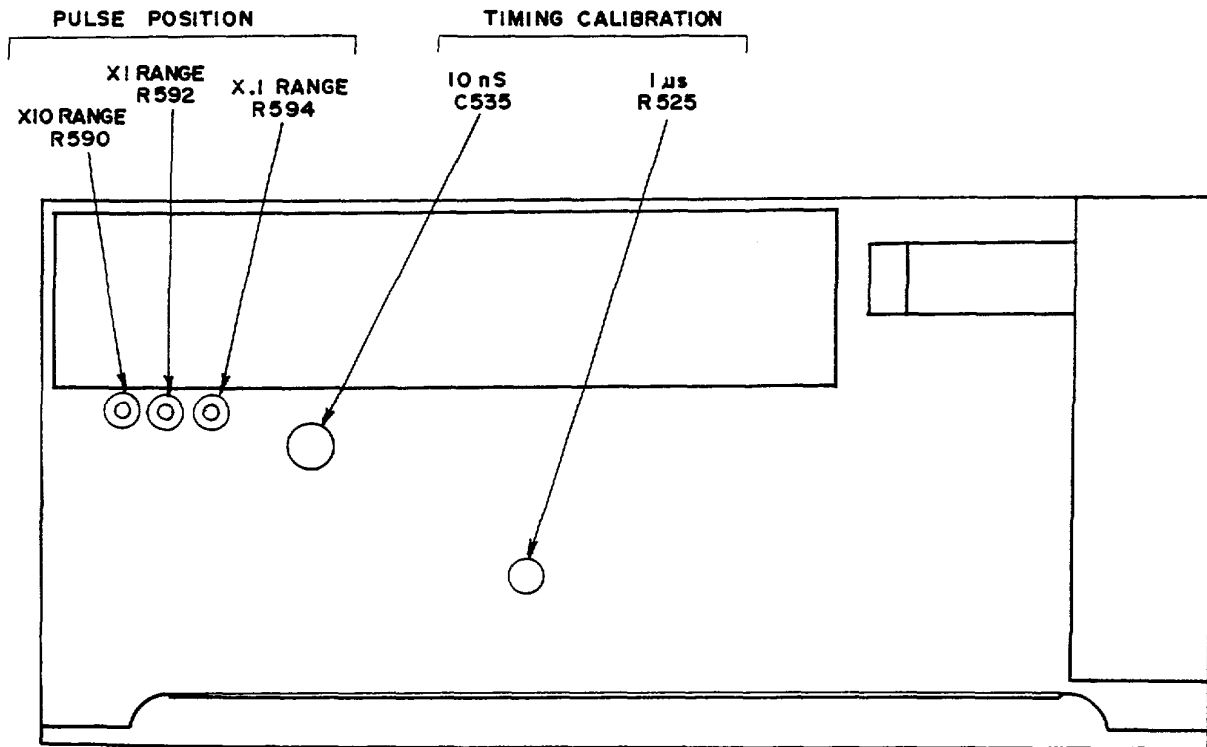
8. Memory Gate Width and Gain. a. Performance Check.

(1) Connect pulse generator (A4) PULSE OUTPUT to sampling head (A7) lower input, using cable (B6).

(2) Connect termination (B11) to sampling head upper input.

NOTE

TI memory gain is adjusted to compensate for gain of sampling



ELIOS001

Figure 1. Adjustment locations on right index card.

(2) Adjust R390 (fig. 2) to raise dot above step 0 percent level to its maximum amplitude (may overshoot

100 percent level. Refer to figure 3 for similar waveform).

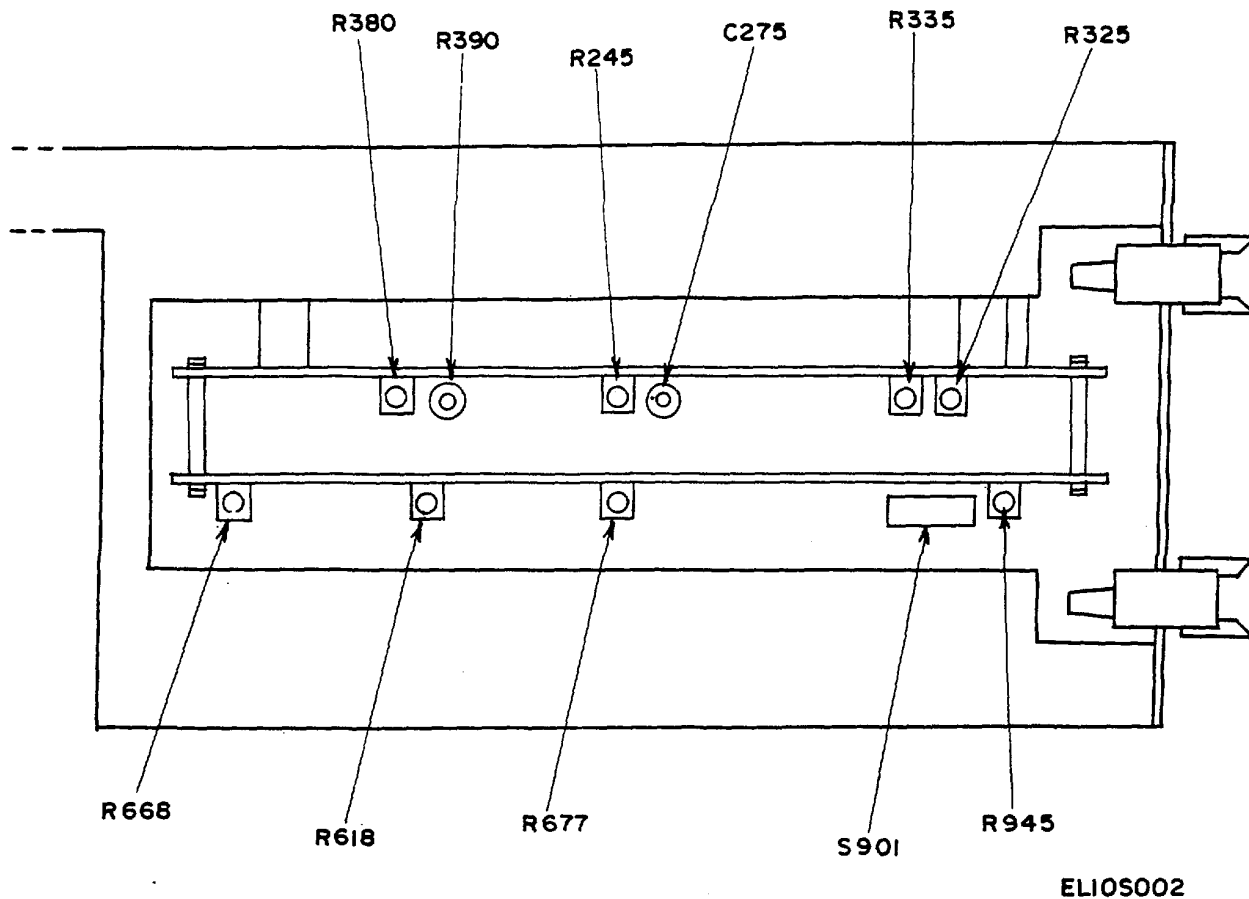
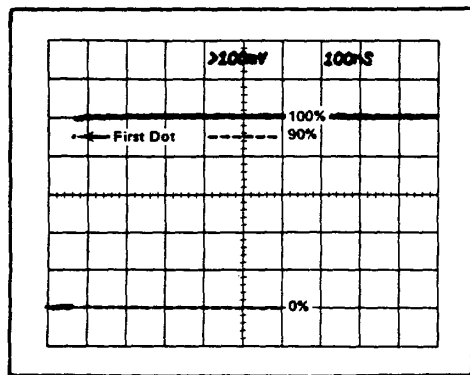


Figure 2. Adjustment locations - vertical and horizontal cards.

(3) Adjust C275 (fig. 2) to place first dot above 0-percent level at 90 percent level (4.5 divisions above 0 percent level) as shown in figure 3.



ELIOS003

Figure 3. Waveform for R390 and C275 adjustments.

**9. Memory, Variable, and Vertical Position Balance.**

*a. Performance Check.*

(1) Depress oscilloscope (A3) left vertical mode switch and connect probe (B9) to vertical amplifier (A8) CH1 input.

(2) Turn vertical amplifier VOLTS/DIV switch to 10 mV and set AC-GND-DC switch to GND.

(3) Adjust vertical amplifier position control to center trace on oscilloscope crt and set AC-GND-DC switch to DC.

(4) Connect probe tip to TI OFFSET OUT jack and adjust DC-OFFSET control to center trace on oscilloscope crt. Do not move DC OFFSET control during the remainder of this check.

(5) Connect probe tip to TI VERT SIG OUT jack. If trace is not centered on oscilloscope crt, perform b(1) below.

(6) Depress oscilloscope right vertical mode switch and turn mV/DIV VARIABLE control throughout its range. If trace on oscilloscope crt shifts, perform b(2) below.

(7) Turn TI mV/DIV VARIABLE control to CAL IN. If trace is not centered on oscilloscope crt, perform b(3) below.

*b. Adjustments.*

(1) Adjust R245 (fig. 2) until trace is centered on oscilloscope crt.

(2) Adjust R335 (fig. 2) for no trace shift when mV/DIV VARIABLE control is turned throughout its range.

(3) Adjust R325 (fig. 2) until trace is centered on oscilloscope crt.

**10. Vertical Gain. a. Performance Check.**

(1) Remove pulse generator (A4) from TI and install trigger recognizer (A6).

(2) Connect a calibrator (A1) to sampling head (A7), using cable and adapter (B1 and B3).

(3) Turn TI mV/DIV switch to 100.

(4) Adjust ac calibrator frequency for 1 kHz and amplitude for 6 divisions of vertical deflection on oscilloscope (A3) crt. If ac calibrator does not indicate between 0.205737 and 0.218463 volt rms, perform *b* below.

(5) Repeat technique of (3) and (4) above for TI mV/DIV switch settings and a calibrator indications listed in table 4. Ac calibrator will indicate within limits specified.

Table 4. Gain Accuracy Check

TI mV/DIV switch settings	Ac calibrator indications (rms)	
	min	Max
500	1.01868 v	1.092312 v
200	0.411474 v	0.436926 v
50	0.102868 v	0.1092312 v
20	41.1474 mv	43.6928 mv
10	20.5737 mv	21.8463 mv
5	10.2868 mv	10.9232 mv
2	4.11474 mv	4.36926 mv

*b. Adjustments.* Adjust ac calibrator for an indication of 0.21210 volt rms. Adjust TI VERTICAL GAIN (front panel) for 6 divisions of vertical deflection.

**11. Horizontal Position and SWEEP CAL. a. Performance Check.**

(1) Set TI mV/DIV switch to 50 and center trace on oscilloscope (A3) crt horizontal graticule centerline.

(2) Depress TI MAN switch and turn SCAN control fully counterclockwise and then fully clockwise. If dot does not align with left and right graticule lines, respectively, perform *b* below.

(3) Depress TI REP switch.

*b. Adjustments.* Adjust TI HORIZ POS and SWEEP CAL (front panel) to aline dot to left and then right graticule lines while performing *a*(2) above.

**12. Timing. a. Performance Check**

(1) Connect time-mark generator (A5) TRIGGER OUT to TI trigger recognizer (A6), using cable (B4).

(2) Connect time-mark generator MARKER OUT to TI sampling head (A7), using cable and adapter (B4 and B1).

(3) Position TI controls as listed in (a) through (e) below:

- (a) mV/DIV switch to 500.
- (b) TIME-DISTANCE control to .50 μs.
- (c) TIME-DISTANCE multiplier switch to

X10.

- (d) TIME/DIV switch to 1 μs.
- (e) DC OFFSET control to display trace on

crt.

(4) Set time-mark generator to 1 μS MARKER OUT and TRIGGER OUT for 10 μS. If oscilloscope (A3) crt does not display 1 marker per division between second and 10th graticule lines ±1 minor division, perform *b*(1) below.

(5) Set TI TIME-DISTANCE multiplier switch to X.1 and TIME/DIV switch to 10 ns.

(6) Set time-mark generator to 10 nS MARKER OUT. If oscilloscope crt does not display one sine wave per division between second and 10th graticule lines ±1 minor division, perform *b*(2) below.

(7) Repeat (4), (5), and (6) above for TI switch settings and time-mark generator indications listed in table 5.

Table 5. Time-Division Accuracy

Test Instrument		Time-Mark Generator setting	Markers per-div
TIME/DIV setting	TIME-DISTANCE multiplier switch setting		
.5μs	X10	.5μS	1
.2μs	X10	.1μS	2
.1μs	X10	.1μS	1
50 ns	X10	50 nS	1
20 ns	X10	10 nS	2

Table 5. Time-Division Accuracy - Continued

Test Instrument		Time-Mark Generator setting	Markers per/div
TIME/DIV setting	TIME-DISTANCE Multiplier switch setting		
10 ns	X10	10 nS	1
5 ns	X10	5nS	1
2 ns	X10	2 nS	1
.1 $\mu$ s	X1	.1 $\mu$ S	1
50 ns	X1	50 nS	1
20 ns	X1	10 nS	2
10 ns	X1	10 nS	1
5 ns	X1	5 nS	1
2 ns	X1	2 nS	1
1 ns	X1	2 nS	.5
5 ns	X1	5 nS	1
2 ns	X1	2 nS	1
1 ns	X1	2 nS	.5

*b. Adjustments.*

(1) Adjust R525 (fig. 1) for 1 marker per division between second and 10th graticule lines on oscilloscope crt (R).

(2) Adjust C535 (fig. 1) for 1 sine wave per division between second and 10th graticule lines on oscilloscope crt (R).

**13. TIME-DISTANCE Dial Accuracy.** *a. Performance Check.*

(1) Set time-mark generator (A5) to 1 $\mu$ S markers.

(2) Position TI controls as listed in (a) through (d) below:

(a) mV/DIV switch to 200.

(b) TIME-DISTANCE multiplier switch to X10.

(c) TIME/DIV switch to 20 ns.

(d) TIME-DISTANCE dial to 0 (zero).

(3) Turn trigger recognizer (A6) controls fully clockwise.

(4) Turn TI FINE control to align leading edge of marker on center vertical graticule line on oscilloscope (A3) crt. Note reference point.

(5) Turn TI TIME-DISTANCE control to align 10th marker on reference point noted in (4) above. If TIME-DISTANCE dial does not indicate between .90 and 1.1  $\mu$ s, perform *b* below.

*b. Adjustments.* Turn TIME-DISTANCE control to 1.00  $\mu$ s and adjust R668 (fig. 2) until 10th marker is aligned with reference point noted in *a*(4) above (R).

**14. Delay Calibrate Control.** *a. Performance Check.*

(1) Connect delay line (A2) output 1 to sampling head (A7) lower input, using cable and adapter (B4 and B2).

(2) Connect delay line input 1 to trigger recognizer (A6) TRIG OUT, using cable and adapter (B5 and B2).

(3) Position TI controls as listed in (a) through (f) below:

(a) mV/DIV switch to 500.

(b) TIME-DISTANCE multiplier switch to X.1.

(c) TIME/DIV switch to 5 ns.

(d) TIME-DISTANCE dial to 0 (zero).

(e) FINE control fully clockwise.

(f) DC OFFSET control to display pulse on oscilloscope (A3) crt.

(4) Turn delay line TRIGGER SELECTOR control to 1 and turn trigger recognizer STABILITY control fully clockwise; and turn LEVEL control to midrange. If leading edge of pulse level (10 to 20 percent) is not aligned with vertical graticule centerline on oscilloscope crt, perform *b* below.

*b. Adjustments.* Adjust R380 (fig. 2) to align the 10 to 20 percent level of leading edge of display with vertical graticule centerline on crt.

**15. Pulse Position.** *a. Performance Check.*

(1) Remove trigger recognizer (A6) and install pulse generator (A4) in TI.

(2) Connect pulse generator to sampling head (A7) LOWER INPUT, using cable (B6).

(3) Position TI controls as listed in (a) through (e) below:

(a) mV/DIV switch to 100.

(b) TIME-DISTANCE multiplier switch to X.1.

(c) TIME-DIV switch to 1 ns.

(d) TIME-DISTANCE control to 0 (zero).

(e) FINE (zero set) control fully clockwise.

(4) If leading edge of pulse is not aligned with vertical graticule centerline on oscilloscope (A3) crt, perform *b*(1) below.

(5) Set TI TIME-DISTANCE multiplier switch to X1. If pulse display is not aligned with vertical graticule centerline, perform *b*(2) below.

(6) Depress TI HIGH RESOLUTION switch and turn SCAN control fully counterclockwise. If oscilloscope crt does not display 1 sweep in 50 or more seconds, perform *b*(3) below.



(7) Depress TI HIGH RESOLUTION switch to out position and turn SCAN control fully clockwise.

(8) Set TI TIME-DISTANCE multiplier switch to X.1 and TIME/DIV switch to .2 ns.

(9) Position leading edge of trace on oscilloscope crt vertical graticule centerline, using TIME-DISTANCE control.

(10) Depress TI LOCATE switch to out position. If center of trace on leading edge is not bright, perform *b*(4) below.

*b. Adjustments.*

(1) Adjust R594 (fig. 1) to position pulse on oscilloscope crt vertical graticule centerline.

(2) Adjust R592 (fig. 1) to position pulse on oscilloscope crt vertical graticule centerline.

(3) Adjust R618 (fig. 2) for one sweep in 50 or more seconds.

(4) Adjust R677 (fig. 2) to center bright portion of trace on leading edge of trace.

**16. Correction Memory.** *a. Performance Check*

(1) Depress TI LOCATE switch to in position.

(2) Connect termination (B10) and cable (B7) to sampling head (A7)

(3) Position trace on horizontal graticule centerline on oscilloscope (A3) crt.

(4) Set TI switch S901 (fig. 2) from off (rear position) to normal (center position). If trace shifts on oscilloscope crt, perform *b* below.

(5) Set TI switch S901 to normal (center) position.

*b. Adjustments.* Adjust R945 (fig. 2) for no trace shift as S901 is switched from off to normal position.

**17. Risetime.** *a. Performance Check*

(1) Connect pulse generator (A4) to sampling head (A7), using cable (B6).

(2) Set TI TIME/DIV switch to 20 ps and TIME-DISTANCE control to display pulse on oscilloscope (A3) crt. Adjust mV/DIV VARIABLE control for suitable display.

(3) Measure rise time, using standard rise-time technique. Rise time will be 35 picoseconds or less.

*b. Adjustments.* No adjustments can be made.

**18. Final Procedure.** *a. Deenergize and disconnect all equipment.*

*b. In accordance with TM 38-750, annotate and affix DA Label 80 (US Army Calibration System). When the TI cannot be adjusted within tolerance, annotate and affix DA Form 2417 (Unserviceable or Limited Use) tag.*

By Order of the Secretary of the Army:

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