TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

DIGITAL REAL-TIME OSCILLOSCOPE

TDS 210, TDS 220, TDS 224

(TEKTRONIX)

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DIGITAL REAL-TIME OSCILLOSCOPE

TDS 210, TDS 220, TDS 224

(TEKTRONIX)

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
DC Voltage Measurement	Range: 2 mV to 5 V/div Accuracy: Average of ≥16 waveforms: ±[3% X (reading + vertical position) + 1% of vertical position + 0.2 div]; Delta volts between any two averages of ≥16 waveforms: ±[(3% X reading) + 0.05 div]	Compared to a Voltage Standard
Bandwidth	Range: 10 mV to 5 V/div DC to 60 MHz (TDS 210); DC to 100 MHz (TDS 220 and TDS 224); 2 to 5 mV/div: DC to 20 MHz Accuracy: Down not more than 3 dB	Apply a constant amplitude signal while changing frequency. Vertical deflection compared to deflection at a referenced frequency
Sample Rate and Delay Time	Range: 5 ns to 5 s/div Accuracy: ±100 ppm over any ≥1 ms time interval	Checked with standard time mark signals
Trigger Sensitivity	Range: INT: 1 div, DC to 10 MHz; 1.5 div, 10 to 60 MHz (TDS 210); 1.5 div, 10 to 100 MHz (TDS 220 and TDS 224); EXT: (TDS 210 and TDS 220 Only): 100 mV, DC to 10 MHz; 150 mV, 10 to 60 MHz (TDS 210); 150 mV, 10 to 100 MHz (TDS 220) Accuracy: Minimum	Apply minimum signals and check for a stable display

2 EQUIPMENT REQUIREMENTS:

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1 VOLTAGE CALIBRATOR	Range: -7.0 to +7.0 VDC Accuracy: ±0.9%	Fluke 5700A	
2.2 LEVELED SINE WAVE GENERATOR	Range: 50 kHz to 100 MHz Accuracy: ±5%	Tektronix SG 503 P/O F5030A1	
2.3 TIME MARK GENERATOR	Range: 10 ms Accuracy: ±25 ppm	Tektronix TG 501A P/O F5030A1	
2.4 FEEDTHROUGH TERMINATION	Range: 50 Ω Accuracy: N/A	Tektronix 011-0049-01	
2.5 DUAL INPUT CABLE	Range: N/A Accuracy: N/A	Tektronix 067-0525-00	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning Calibration Process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

3.2 Connect the TI to an appropriate power source. Set TI POWER switch to ON and allow a 10 minute warm-up period.

3.3 Connect all equipment to an appropriate power source. Set all all POWER switches to ON or STBY and allow a warm-up time as required by manufacturer.

NOTE

An internal Self Test procedure is automatically performed every time the TI is powered on. No test hookups are required. Verify that no error messages are displayed before continuing with this procedure.

3.4 Instructions for menu selection follow this format: **FRONT PANEL** button, **Pop-Up** (if necessary), **Main Menu** button, **Side Menu** button. For example, press the TI **CH 1 Menu** button, select **Probe** and set to **1X**.

3.5 Perform the TI Self Calibration as follows:

3.5.1 Press the TI **UTILITY** button and select **Do Self Cal** to start the routine. Follow the display prompts. The routine takes about one minute to complete.

3.5.2 Verify the Self Calibration passes.

NOTE

The Self Calibration quickly optimizes the TI signal path for maximum measurement accuracy. The routine can be ran at any time but should always be ran if the ambient temperature changes by 5° C or more.

4 CALIBRATION PROCESS:

NOTE

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

4.1 DC VOLTAGE MEASUREMENT CALIBRATION:

4.1.1 Connect the Voltage Calibrator output to the TI CH 1 connector.

4.1.2 Press the TI **SAVE/RECALL** button, select **Recall/Factory**.

4.1.3 Press the TI **CH 1 MENU** button, select **Probe** and set to **1X**.

4.1.4 Press the TI **ACQUIRE** button, select **Average** and set to **16**.

4.1.5 Press the TI **MEASURE** button, select **Source** and set to **CH1**, select **Type** and set to **Mean**.

4.1.6 Set the TI CH 1 VOLTS/DIV to the first setting listed in the Volts/Div column of Table 2.

4.1.7 Set the Voltage Calibrator output level to the positive voltage, for the CH 1 VOLTS/DIV setting being tested, listed in the Applied column of Table 2.

4.1.8 Set the Voltage Calibrator OPR/STBY to OPR. Record the TI indication as V pos.

4.1.9 Set the Voltage Calibrator OPR/STBY to STBY.

4.1.10 Set the Voltage Calibrator output level to the negative voltage, for the CH 1 VOLTS/DIV setting being tested, listed in the Applied column of Table 2.

4.1.11 Set the Voltage Calibrator OPR/STBY to OPR. Record the TI indication as V neg.

4.1.12 Set the Voltage Calibrator OPR/STBY to STBY.

4.1.13 Calculate the difference by subtracting the V neg recorded in step 4.1.11 from the V pos recorded in step 4.1.8.

4.1.14 The result must be within the values listed in the Limits column of Table 2.

Example: V diff = V pos - V neg

4.1.15 Set the TI CH 1 VOLTS/DIV to each of the remaining settings listed in the Volts/Div column of Table 2 and repeat steps 4.1.7 through 4.1.14.

Table 2.

Volts/Div (V)	Applied (VDC)	Limits (V)
5 m	+17.5 m	33.7 to 36.3 m
	-17.5 m	
200 m	+700 m	1.348 to 1.452
	-700 m	
2	+7.00	13.48 to 14.52
	-7.00	

4.1.16 Disconnect the Voltage Calibrator from the TI CH 1 connector and connect to the TI CH 2 connector.

4.1.17 Press the TI **CH 1 MENU** button (twice) to turn off channel 1 display.

4.1.18 Press TI **CH 2 MENU** button, select **Probe** and set to **1X.**

4.1.19 Press the TI **ACQUIRE** button, select **Average** and set to **16**.

4.1.20 Press the TI **MEASURE** button, select **Source** and set to **CH2**, select **Type** and set to **Mean**.

4.1.21 Repeat steps 4.1.6 through 4.1.15 using TI Channel 2 controls.

4.1.22 For TDS 210 or TDS 220, proceed to step 4.1.29. For TDS 224 proceed to step 4.1.23.

4.1.23 Disconnect the Voltage Calibrator from the TI CH 2 connector and connect to the TI CH 3 connector.

4.1.24 Press the TI **CH 2 MENU** button (twice) to turn off channel 2 display.

4.1.25 Repeat steps 4.1.18 through 4.1.21 using TI Channel 3 controls and settings.

4.1.26 Disconnect the Voltage Calibrator from the TI CH 3 connector and connect to the TI CH 4 connector.

4.1.27 Press the TI **CH 3 MENU** button (twice) to turn off channel 3 display.

4.1.28 Repeat steps 4.1.18 through 4.1.21 using TI Channel 4 controls and settings.

4.1.29 Set the Voltage Calibrator OPR/STBY to STBY and disconnect test setup.

4.2 BANDWIDTH CALIBRATION:

4.2.1 Connect the Leveled Sine Wave Generator output through the Feedthrough Termination to the TI CH 1 connector.

4.2.2 Press the TI **SAVE/RECALL** button, select **Recall/Factory**.

4.2.3 Press the TI **CH 1 MENU** button, select **Probe** and set to **1X**.

4.2.4 Press the TI **ACQUIRE** button, select **Average** and set to **16**.

4.2.5 Press the TI **TRIGGER MENU** button, select **Coupling** and set to **Noise Reject**.

4.2.6 Press the TI **MEASURE** button, select **Source** and set to **CH1**, select **Type** and set to **Pk-Pk**.

4.2.7 Set the TI CH 1 VOLTS/DIV to 100 mV/div and SEC/DIV to 10 µs/div.

4.2.8 Set the Leveled Sine Wave Generator frequency to 50 kHz. Adjust the Leveled Sine Wave Generator output amplitude until the TI Pk-Pk indication is 600 mV.

4.2.9 Increase the Leveled Sine Wave Generator frequency controls to 60 MHz for the TDS 210 or 100 MHz for the TDS 220 and TDS 224.

4.2.10 Set the TI SEC/DIV to 10 ns/div.

4.2.11 The TI Pk-Pk indication must be ≥425 mV.

4.2.12 Set the Leveled Sine Wave Generator output to minimum.

4.2.13 Disconnect the Feedthrough Termination from the TI CH 1 connetor and connect to the TI CH 2 connector.

4.2.14 Press the TI **CH 1 MENU** button (twice) to turn off channel 1 display.

4.2.15 Press TI **CH 2 MENU** button, select **Probe** and set to **1X**.

4.2.16 Press the TI **TRIGGER MENU**, select **Source** and set to **CH2**.

4.2.17 Press the TI **MEASURE** button, select **Source** and set to **CH2**, select **Type** and set to **Pk-Pk**.

4.2.18 Repeat steps 4.2.7 through 4.2.11 using TI Channel 2 controls.

4.2.19 Set the Leveled Sine Wave Generator output to minimum.

4.2.20 For TDS 210 or TDS 220, proceed to step 4.2.27. For TDS 224, proceed to step 4.2.21.

4.2.21 Disconnect the Feedthrough Termination from the TI CH 2 connector and connect to the TI CH 3 connector.

4.2.22 Press the TI **CH 2 MENU** button (twice) to turn off channel 2 display.

4.2.23 Repeat steps 4.2.15 through 4.2.19 using TI Channel 3 controls and settings.

4.2.24 Disconnect the Feedthrough Termination from the TI CH 3 connector and connect to the TI CH 4 connector.

4.2.25 Press the TI **CH 3 MENU** button (twice) to turn off channel 3 display.

4.2.26 Repeat steps 4.2.15 through 4.2.19 using TI Channel 4 controls and settings.

4.2.27 Disconnect test setup.

4.3 SAMPLE RATE AND DELAY TIME CALIBRATION:

4.3.1 Connect the Time Mark Generator output through the Feedthrough Termination to the TI CH 1 connector.

4.3.2 Set the Time Mark Generator output for 10 ms markers.

4.3.3 Press the TI **SAVE/RECALL** button, select **Recall Factory**.

4.3.4 Press the TI **CH 1 MENU** button, select **Probe** and set to **1X**.

4.3.5 Set the TI CH 1 VOLTS/DIV to 500 mV/div and SEC/DIV to 1 ms/div.

4.3.6 Press the TI **SET LEVEL TO 50%** button, then use the VERTICAL POSITION control to center the test signal on the TI screen.

4.3.7 Press the TI **HORIZONTAL MENU** button, select **Window**, then set the Window SEC/DIV to 500 µs/div.

NOTE

The SEC/DIV control sets the Main timebase. Setting the Window SEC/DIV to a setting slower than the Main timebase setting resets the Main timebase. If this happens, reset the SEC/DIV and then the Window SEC/DIV settings.

4.3.8 Use the TI HORIZONTAL POSITION control to set the window position to 10.0 ms.

4.3.9 Set the TI Window SEC/DIV to 500 ns/div.

4.3.10 The rising edge of the TI marker must cross the center horizontal graticule line within -2 to +2 div of the center graticule.

NOTE

One div of displacement from graticule center corresponds to a 50 ppm time base error.

4.3.11 Disconnect the Time Mark Generator from the TI CH 1 connector.

4.4 TRIGGER SENSITIVITY CALIBRATION:

4.4.1 Connect the Leveled Sine Wave Generator output through the Feedthrough Termination to the TI CH 1 connector.

4.4.2 Press the TI **SAVE/RECALL** button, select **Recall/Factory**.

4.4.3 Press the TI **CH 1 MENU** button, select **Probe** and set to **1X**.

4.4.4 Press the TI **TRIGGER MENU** button, select **Mode** and set to **Normal**.

4.4.5 Press the TI **ACQUIRE** button, select **Sample**.

4.4.6 Press the TI **MEASURE** button, select **Source** and set to **CH1**, select **Type** and set to **Pk-Pk**.

4.4.7 Set the TI CH 1 VOLTS/DIV to 500 mV/div and the SEC/DIV to 10 ns/div.

4.4.8 Set the Leveled Sine Wave Generator frequency to 10 MHz.

4.4.9 Adjust the Leveled Sine Wave Generator output amplitude until the TI Pk-Pk indication is 500 mV. The measured amplitude can fluctuate around 500 mV.

4.4.10 Press the TI **SET LEVEL TO 50%** button.

4.4.11 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.12 Press the TI **TRIGGER MENU**, select **Slope** and set to **Falling**.

4.4.13 Press the TI **SET LEVEL TO 50%** button.

4.4.14 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.15 Press the TI **TRIGGER MENU**, select **Slope** and set to **Rising**.

4.4.16 Set the Leveled Sine Wave Generator frequency to 60 MHz for the TDS 210 or 100 MHz for the TDS 220 and TDS 224.

4.4.17 Press TI **MEASURE** button and adjust the Leveled Sine Wave Generator output amplitude until the TI Pk-Pk indication is 750 mV. The measured amplitude can fluctuate around 750 mV.

4.4.18 Press the TI **SET LEVEL TO 50%** button.

4.4.19 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.20 Press the TI **TRIGGER MENU**, select **Slope** and set to **Falling**.

4.4.21 Press the TI **SET LEVEL TO 50%** button.

4.4.22 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.23 Press the TI **TRIGGER MENU**, select **Slope** and set to **Rising**.

4.4.24 Set the Leveled Sine Wave Generator output to minimum.

4.4.25 Disconnect the Feedthrough Termination from the TI CH 1 connector and connect to the TI CH 2 connector.

4.4.26 Press the TI **CH 1 MENU** button (twice) to turn off channel 1 display.

4.4.27 Press the TI **CH 2 MENU** button, select **Probe** and set to **1X**.

4.4.28 Press the TI **TRIGGER MENU** button, select **Source** and set to **CH2**.

4.4.29 Press the TI **MEASURE** button, select **Source** and set to **CH2**, select **Type** and set to **Pk-Pk**.

4.4.30 Repeat steps 4.4.7 through 4.4.24 using TI Channel 2 controls and settings.

4.4.31 For TDS 210 or TDS 220, proceed to step 4.4.39. For TDS 224, proceed to step 4.4.32.

4.4.32 Disconnect the Feedthrough Termination from the TI CH 2 connector and connect to the TI CH 3 connector.

4.4.33 Press the TI **CH 2 MENU** button (twice) to turn off channel 2 display.

4.4.34 Repeat steps 4.4.27 through 4.4.30 using TI CH 3 controls and settings.

4.4.35 Disconnect the Feedthrough Termination from the TI CH 3 connector and connect to the TI CH 4 connector.

4.4.36 Press the TI **CH 3 MENU** button (twice) to turn off channel 3 display.

4.4.37 Repeat steps 4.4.27 through 4.4.30 using TI CH 4 controls and settings.

4.4.38 Disconnect test setup and proceed to step 4.4.59.

4.4.39 Disconnect test setup.

4.4.40 Press the TI **TRIGGER MENU** button, select **Source** and set to **Ext**.

4.4.41 Connect the Leveled Sine Wave Generator output through the Feedthrough Termination to the Dual Input Coupler.

4.4.42 Connect one end of the Dual Input Coupler to the TI CH 2 connector and the other end to the TI EXT TRIG connector.

4.4.43 Set the TI CH 2 VOLTS/DIV to 50 mV/div.

4.4.44 Set the TI SEC/DIV to 100 ns/div.

4.4.45 Set the Leveled Sine Wave Generator frequency to 10 MHz.

4.4.46 Press TI **MEASURE** button and adjust the Leveled Sine Wave Generator output amplitude until the TI Pk-Pk indication is 100 mV. The measured amplitude can fluctuate around 100 mV.

4.4.47 Press the TI **SET LEVEL TO 50%** button.

4.4.48 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.49 Press the TI **TRIGGER MENU**, select **Slope** and set to **Rising**.

4.4.50 Press the TI **SET LEVEL TO 50%** button.

4.4.51 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.52 Set the TI SEC/DIV to 10 ns/div.

4.4.53 Set the Leveled Sine Wave Generator frequency to 60 MHz for the TDS 210 or 100 MHz for the TDS 220.

4.4.54 Press TI **MEASURE** button and adjust the Leveled Sine Wave Generator output amplitude until the TI Pk-Pk indication is 150 mV. The measured amplitude can fluctuate around 150 mV.

4.4.55 Press the TI **SET LEVEL TO 50%** button.

4.4.56 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.57 Press the TI **TRIGGER MENU**, select **Slope** and set to **Falling**.

4.4.58 The TI must have a stable display. Adjust TI **TRIGGER LEVEL** as necessary.

4.4.59 Set all outputs to OFF or minimum. Set all POWER switches to STANDBY or OFF. Disconnect and secure all equipment.

CALIBRATION PERFORMANCE TABLE

4.1 DC VOLTAGE MEASUREMENT CALIBRATION:

Volts/Div (V)	Applied (VDC)	Limits (V)
5 m	+17.5 m, -17.5 m	33.7 to 36.3 m
200 m	+700 m, -700 m	1.348 to 1.452
2	+7.00, -7.00	13.48 to 14.52

4.2 BANDWIDTH CALIBRATION:

Applied	Limits
50 kHz	600 mV (Reference)
TDS 210, 60 MHz	≥425 mV
TDS 220 and TDS 224, 100 MHz	≥425 mV

4.3 SAMPLE RATE AND DELAY TIME CALIBRATION:

Applied	Limits
10 ms markers	-2 to +2 div (±100 ppm)

4.4 TRIGGER SENSITIVITY CALIBRATION:

Applied	Limits
INT: TDS 210, TDS 220, and TDS 224, 1 div at 10 MHz	Stable display
INT: TDS 210, 1.5 div at 60 MHz	Stable display
INT: TDS 220 and TDS 224, 1.5 div at 100 MHz	Stable display
EXT: TDS 210 and TDS 220, 100 mV at 10 MHz	Stable display
EXT: TDS 210, 150 mV at 60 MHz	Stable display
EXT: TDS 220, 150 mV at 100 MHz	Stable display