TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

ARBITRARY WAVEFORM GENERATOR

33220A

(AGILENT)

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ARBITRARY WAVEFORM GENERATOR

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1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Frequency	Range: Sine: 1 µHz to 20 MHz; Triangle, Ramp: 1 µHz to 200 kHz; Square: 1 µHz to 20 MHz; Pulse: 500 µHz to 5 MHz Accuracy: ±20 ppm; *[1] Aging/year: ±20 ppm; Aging/ 90 days: ±10 ppm	Compared to an Electronic Counter
AC Amplitude	Range: (at 1 kHz) 20 mV to 20 V p-p into open circuit; 10 mV to 10 V p-p into 50 Ω Accuracy: ±(1% of setting + 1 mV p-p) *[2]	Measured with an AC Measurement Standard
Flatness	Range: 1 µHz to 20 MHz Accuracy: *[2] Referenced to 1 kHz: ±0.1 dB, <100 kHz; ±0.15 dB, 100 kHz to 5 MHz; ±0.3 dB, 5 to 20 MHz	
DC Offset	Range: (peak AC + DC) ±10 V into open circuit; ±5 V into 50 Ω Accuracy: ±(2% of offset setting + 0.5% of ampl + 2 mV) *[2]	Measured with a Digital Multimeter

See footnotes at end of Table.

Table 1. (Cont.)

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Harmonic Distortion	Range: DC to 20 MHz Accuracy: *2, *3 <1 V p-p: DC to 20 kHz, ≤-70 dBc; 20 to 100 kHz, ≤-65 dBc; 100 kHz to 1 MHz, ≤-50 dBc; 1 to 20 MHz, ≤-40 dBc; ≥1 V p-p: DC to 20 kHz, ≤-70 dBc; 20 to 100 kHz, ≤-60 dBc; 100 kHz to 1 MHz, ≤-45 dBc; 1 to 20 MHz, ≤-35 dBc	Measured with a Spectrum Analyzer
Squarewave Rise Time, Fall Time & Asymmetry	Range: 1 µHz to 20 MHz Accuracy: Rise Time, <13 ns; Fall Time, <13 ns; Asymmetry (at 50% Duty), ≤(1% of period + 5 ns)	Measured with an Oscilloscope and Electronic Counter

*1 The accuracy is the manufacturers calculated specification after one year. The accuracy specification is found by multiplying the longest term aging rate by the appropriate time interval to obtain one year.

*2 Autorange enabled.

*3 DC offset set to 0 VDC.

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	ELECTRONIC COUNTER	Range: 9 Hz to 21 MHz Accuracy: ±5 ppm	Agilent 53132A	
2.2	AC MEASUREMENT STANDARD	Range: 10 Hz to 20 MHz, 6.0 mV to 7.2 V rms Accuracy: ±0.25% of indication	Fluke 5790A/AF03	
2.3	DIGITAL MULTIMETER	Range: -10 to +10 VDC Accuracy: ±0.5% of indication	Hewlett-Packard 3458A	

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.4	SPECTRUM ANALYZER	Range: 2 to 80 MHz, ≤-70 dBm to +4 dBm Accuracy: Scale Fidelity ±1.6 dB	Hewlett-Packard 8563E	
2.5	OSCILLOSCOPE	Range: 110 MHz Accuracy: ≤3.25 ns	Tektronix 2465B	
2.6	FEEDTHROUGH TERMINATION	Range: 50 Ω, 10 kHz Accuracy: N/A	Tektronix 011-0049-01	
2.7	SPECTRUM ANALYZER	Range: 100 Hz to 4 MHz, ≤-70 to +4 dBm Accuracy: Scale Fidelity ±1.0 dB	Hewlett-Packard 3585A	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with the 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 test equipment to appropriate power source. Set all POWER switches to ON and allow warm-up as required by the manufacturer.

3.3 Connect the TI to appropriate power source. Press the ⏻ key. Allow for a one hour warm-up.

3.4 Throughout the Calibration Procedure, all hard keys will be **Bold**, soft keys will be underlined and menu values will be in *Italics*.

3.5 Perform the TI self test by pressing **Utility**, Test/Cal then Self Test.

3.6 After completion of the self test (about 15 s) the TI will display Self Test Passed or Self Test Failed. If the self test fails, perform required maintenance and rerun the self test.

NOTE

Step 3.7 should only be completed when an output impedance change is required for the TI.

3.7 To select the TI output termination proceed as follows: press **Utility**, Output Setup then Load, as required, to select *High Z* or *50 Ω*.

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 FREQUENCY CALIBRATION:

4.1.1 Connect the TI Output connector to the Electronic Counter CH 1 input. Set the Electronic Counter, as required, to make a frequency measurement.

4.1.2 Perform step 3.7 to select the TI *50 Ω* output termination, then set as follows:

Sine	
Freq	*10 Hz*
Ampl	*1.00 Vpp*
Output	on

4.1.3 Adjust the Electronic Counter controls, as required, for a stable indication. Verify the Electronic Counter indication is within the values listed in the Limits column of Table 2.

Table 2.

Applied (Hz)	Limits (Hz)
10	9.9998 to 10.0002
1.000 k	999.98 to 1000.02
10.000 M	9.9998 to 10.0002 M
20.000 M	19.9996 to 20.0004 M

4.1.4 Set the TI Freq to the next value listed in the Applied column of Table 2. Repeat step 4.1.3.

4.1.5 Repeat step 4.1.4 for the remaining value listed in the Applied column of Table 2.

4.1.6 Set the TI **Output** to off and disconnect test setup.

4.1.7 To ensure reliability of the TI, the following action will be taken: If the TI passed the above steps, perform the applicable adjustment steps in the appropriate section of the Commercial Data and enter NO ADJUSTMENT ACTION into the Maintenance Data Collection System. If the TI failed, perform the applicable adjustment steps in the appropriate section of the Commercial Data and enter appropriate ADJUSTMENT ACTION into the Maintenance Data Collection System.

4.2 AC AMPLITUDE CALIBRATION:

4.2.1 Connect the TI Output connector to the AC Measurement Standard INPUT 2.

4.2.2 Perform step 3.7 to select the TI *High Z* output termination, then set as follows:

Sine	
Freq	*1 kHz*
Ampl	*20 Vpp*
Output	on

4.2.3 Verify the AC Measurement Standard indication is within the values listed in the Limits column of Table 3.

4.2.4 Set the TI Ampl to the next value listed in the Applied column of Table 3. Repeat step 4.2.3.

4.2.5 Repeat step 4.2.4 for the remaining values listed in the Applied column of Table 3.

Table 3.

Applied (V p-p)	Limits (V rms)
20.0	7.000 to 7.142
18.0	6.300 to 6.428
16.0	5.600 to 5.714
14.0	4.900 to 5.000
12.0	4.200 to 4.285
10.0	3.500 to 3.571
7.0	2.450 to 2.500
4.4	1.540 to 1.572
2.0	699.7 to 714.5 m
670 m	234.2 to 239.6 m
200 m	69.65 to 71.77 m
67 m	23.10 to 24.28 m
20 m	6.65 to 7.50 m

4.2.6 Set the TI **Output** to off and disconnect test setup.

4.3 FLATNESS CALIBRATION:

4.3.1 Connect the TI Output connector to the AC Measurement Standard WIDEBAND input.

4.3.2 Perform step 3.7 to select the TI *50 Ω* output termination, then set as follows:

Sine	
Freq	*1 kHz*
Ampl	*3.00 V rms*
Output	on

4.3.3 Adjust the TI Ampl for an AC Measurement Standard indication of 3.00 V rms. Set the AC Measurement Standard to SET REF and select %.

NOTE

Do not adjust the TI Ampl from this point on.

4.3.4 Set the TI Freq to the first value listed in the Applied column of Table 4.

4.3.5 Verify the AC Measurement Standard indication is within the values listed in the Limits column of Table 4.

4.3.6 Repeat steps 4.3.4 and 4.3.5 for the remaining values listed in the Applied column of Table 4.

Table 4.

Applied (Hz)	Limits (%)
10	-1.1447 to 1.1579
100	-1.1447 to 1.1579
10.000 k	-1.1447 to 1.1579
100.000 k	-1.7121 to 1.7419
200.000 k	-1.7121 to 1.7419
500.000 k	-1.7121 to 1.7419
2.000 M	-1.7121 to 1.7419
3.000 M	-1.7121 to 1.7419
4.000 M	-1.7121 to 1.7419
5.000 M	-1.7121 to 1.7419
8.000 M	-3.3949 to 3.5142
10.000 M	-3.3949 to 3.5142

Table 4. (Cont.)

Applied (Hz)	Limits (%)
12.500 M	-3.3949 to 3.5142
14.000 M	-3.3949 to 3.5142
16.000 M	-3.3949 to 3.5142
17.500 M	-3.3949 to 3.5142
20.000 M	-3.3949 to 3.5142

4.3.7 Set the TI **Output** to off and disconnect test setup.

4.4 DC OFFSET CALIBRATION:

4.4.1 Connect the TI Output connector to the Digital Multimeter HI and LO input observing polarity. Set the Digital Multimeter controls, as required, to measure VDC.

4.4.2 Perform step 3.7 to select the TI *High Z* output termination, then set as follows:

Sine	
Freq	*1 kHz*
Ampl	*2.0 Vpp*
Offset	*9 VDC*
Output	on

4.4.3 Verify the Digital Multimeter indication is within 8.813 to 9.187 VDC.

4.4.4 Set the TI Offset for -9.0 VDC. Verify the Digital Multimeter indicates within –9.187 to –8.813 VDC.

4.4.5 Set the TI **Output** to off and disconnect test setup.

4.5 HARMONIC DISTORTION CALIBRATION:

4.5.1 Connect the TI Output connector to the Spectrum Analyzer (2.7) 50-75Ω input.

4.5.2 Perform step 3.7 to select the TI *50 Ω* output termination, then set as follows:

Sine	
Freq	*200 Hz*
Ampl	*900 mVpp*
Offset	0 VDC
Output	on

4.5.3 On the Spectrum Analyzer (2.7), press the INSTR PRESET key. Set the Spectrum Analyzer (2.7) controls, as required, to display the fundamental frequency and several harmonics.

4.5.4 Adjust the Spectrum Analyzer (2.7) controls to set the peak of the fundamental signal at a convenient reference point.

4.5.5 The peaks of all harmonics must be ≤-70 dBc.

4.5.6 Set the TI Freq to 10 kHz and repeat steps 4.5.3 through 4.5.5.

4.5.7 Set the TI Freq to 90 kHz and repeat steps 4.5.3 and 4.5.4.

4.5.8 The peaks of all harmonics must be ≤-65 dBc (≤-60 dBc for ≥1 Vpp).

4.5.9 Set the TI Freq to 900 kHz and repeat steps 4.5.3 and 4.5.4.

4.5.10 The peaks of all harmonics must be ≤-50 dBc (≤-45 dBc for ≥1 Vpp).

4.5.11 Set the TI Ampl to *1 Vpp*, Freq to *200 Hz* and repeat steps 4.5.3 through 4.5.10.

4.5.12 Set the TI **Output** to off and disconnect the test setup.

4.5.13 Connect TI Output connector to the Spectrum Analyzer (2.4) INPUT 50 Ω.

4.5.14 Set the TI Ampl to *900 mVpp*, Freq to *1.8 MHz* and **Output** to on.

4.5.15 Set the Spectrum Analyzer (2.4) controls, as required, to display the fundamental frequency and several harmonics.

4.5.16 Adjust the Spectrum Analyzer (2.4) controls to set the peak of the fundamental signal at a convenient reference point.

4.5.17 The peaks of all harmonics must be within the value listed in the Limits column of Table 5.

4.5.18 Set the TI Freq to the next value listed in the Applied column of Table 5. Repeat steps 4.5.15 through 4.5.17.

4.5.19 Repeat step 4.15.18 for the remaining values listed in the Applied column of Table 5.

Table 5.

Applied (MHz)	Limits (dBc)
1.8	≤-40
5	≤-40
10	≤-40
20	≤-40

4.5.20 Set the TI Ampl to *1 Vpp*, Freq to *1.8 MHz* and repeat steps 4.5.15 through 4.5.19 using Table 6.

Table 6.

Applied (MHz)	Limits (dBc)
1.8	≤-35
5	≤-35
10	≤-35
20	≤-35

4.5.21 Set the TI **Output** to off and disconnect test setup.

4.6 SQUAREWAVE RISE TIME, FALL TIME & ASYMMETRY CALIBRATION:

4.6.1 Connect the TI Output connector through the Feedthrough Termination to the Oscilloscope CH 1 input.

4.6.2 Set the TI as follows:

Square	
Freq	*10 kHz*
Ampl	*1 Vpp*
Duty Cycle	*50.0 %*
Output	on

4.6.3 Adjust Oscilloscope controls, as required, to view the leading edge of the output squarewave.

4.6.4 Measure the Rise Time of the leading edge between the 10 and 90% points. Verify the Rise Time is <13 ns.

4.6.5 Adjust the Oscilloscope controls, as required, to view the falling edge of the output squarewave.

4.6.6 Measure the Fall Time of the signal between the 90 and 10% points. Verify the Fall Time is <13 ns.

4.6.7 Disconnect the Oscilloscope and Feedthrough Termination from the TI Output connector.

4.6.8 Connect the TI Output to Electronic Counter CH 1 Input.

4.6.9 Set Electronic Counter to PERIOD 1. Set other controls as necessary to measure Period. Adjust the TI Ampl, if required, for a stable Electronic Counter indication.

4.6.10 Record Electronic Counter indication as P.

4.6.11 Set Electronic Counter to TI 1 TO 2, Channel 1 for - (negative) triggering and Channel 2 for + (positive) triggering. Set other controls as necessary to measure Time Interval. Adjust the TI Ampl, if required, for a stable Electronic Counter indication.

4.6.12 Record Electronic Counter indication as W.

4.6.13 Calculate the % of Squarewave Asymmetry using the following formula:

$$\%TS = \frac{P \div 2 - W}{P} \times 100$$

Where TS = TI Squarewave Asymmetry

P = Value recorded in step 4.6.10

W = Value recorded in step 4.6.12

4.6.14 Verify the result of step 4.6.13 is ≤1.0% +5 ns.

4.6.15 Set the TI **Output** to off. Set all STANDBY/POWER switches to STANDBY or OFF. Disconnect and secure all equipment.

CALIBRATION PERFORMANCE TABLE

4.1 FREQUENCY CALIBRATION:

Applied (Hz)	Limits (Hz)
10	9.9998 to 10.0002
1.000 k	999.98 to 1000.02
10.000 M	9.9998 to 10.0002 M
20.000 M	19.9996 to 20.0004 M

4.2 AC AMPLITUDE CALIBRATION:

Applied (V p-p)	Limits (V p-p)
20.0	19.799 to 20.201
18.0	17.819 to 18.181
16.0	15.839 to 16.161
14.0	13.859 to 14.141
12.0	11.879 to 12.121
10.0	9.899 to 10.101
7.0	6.929 to 7.071
4.4	4.355 to 4.445
2.0	1.979 to 2.021

CALIBRATION PERFORMANCE TABLE *(Cont.)*

4.2 AC AMPLITUDE CALIBRATION: *(Cont.)*

Applied (V p-p)	Limits (V p-p)
670 m	662.3 to 677.7 m
200 m	197.0 to 203.0 m
67 m	65.33 to 68.67 m
20 m	18.8 to 21.2 m

4.3 FLATNESS CALIBRATION:

Applied (Hz)	Limits (dB) Reference 1 kHz @ 3.0 V rms
10	-0.1 to 0.1
100	-0.1 to 0.1
10.000 k	-0.1 to 0.1
100.000 k	-0.15 to 0.15
200.000 k	-0.15 to 0.15
500.000 k	-0.15 to 0.15
2.000 M	-0.15 to 0.15
3.000 M	-0.15 to 0.15
4.000 M	-0.15 to 0.15
5.000 M	-0.15 to 0.15
8.000 M	-0.3 to 0.3
10.000 M	-0.3 to 0.3
12.500 M	-0.3 to 0.3
14.000 M	-0.3 to 0.3
16.000 M	-0.3 to 0.3
17.500 M	-0.3 to 0.3
20.000 M	-0.3 to 0.3

CALIBRATION PERFORMANCE TABLE *(Cont.)*

4.4 DC OFFSET CALIBRATION:

Applied (VDC)	Limits (VDC)
+9.0	8.813 to 9.187
-9.0	-9.187 to -8.813

4.5 HARMONIC DISTORTION CALIBRATION:

	Limits (dBc)	
Applied (Hz)	<1 V p-p	≥1 V p-p
200	≤-70	≤-70
10 k	≤-70	≤-70
90 k	≤-65	≤-60
900 k	≤-50	≤-45
1.8 M	≤-40	≤-35
5 M	≤-40	≤-35
10 M	≤-40	≤-35
20 M	≤-40	≤-35

4.6 SQUAREWAVE RISE TIME, FALL TIME & ASYMMETRY:

Applied	Limits
10.0 kHz, squarewave	Rise Time, <13 ns
	Fall Time, <13 ns
	Asymmetry, ≤1.0% of period + 5 ns