8 Bit PXI/PCI/VXI/LXI Digital Storage Oscilloscope Calibration Manual

M-Class Oscilloscope
Models ZT4211 and ZT4212

User's Manual: 0004-000070
Revision 1B

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Contact

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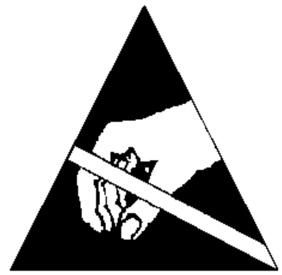

Handling Precautions for Electronic Devices Subject to Damage by Static Electricity

This instrument is susceptible to Electronic Static Discharge (ESD) damage. When transporting, place the instrument or module in conductive (anti-static) envelopes or carriers. Open only at an ESD-approved work surface. An ESD safe work surface is defined as follows:

- The work surface must be conductive and reliably connected to an earth ground with a safety resistance of approximately 250 kilo Ohms.
- The surface must NOT be metal. A resistance of 30–300 kilo Ohms per square inch is suggested.

Ground the frame of any line-powered equipment, chassis, test instruments, lamps, soldering irons, etc., directly to the earth ground. To avoid shorting out the safety resistance, ensure that the grounded equipment has rubber feet or other means of insulation from the work surface.

Avoid placing tools or electrical parts on insulators. Do NOT use any hand tool that can generate a static charge, such as a non-conductive plunger-type solder sucker. Use a conductive strap or cable with a wrist cuff to reliably ground to the work surface. The cuff must make electrical contact directly with the skin; do NOT wear it over clothing.

Note: Resistance between the skin and the work surface is typically 250 kilo Ohms to 1 mega Ohm using a commercially-available personnel grounding device.

Avoid circumstances that are likely to produce static charges, such as wearing clothes of synthetic material, sitting on a plastic-covered stool (especially when wearing woolen material), combing the hair, or making extensive pencil erasures. These circumstances are most significant when the air is dry.

When testing static sensitive devices, ensure DC power is ON before, during, and after application of test signals. Ensure all pertinent voltages are switched OFF while circuit boards or components are removed or inserted.

Revision History

Rev	Date	Section	Description
1	4-11-08	All	Initial Release
1A	6-12-08	Noise Validation Zero Offset Validation Offset Validation	Updated specification and values
1B	9-25-09	Calibration API	Added SCPI command information

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Test Setup

Environment

Validation and adjustment of the ZT4210 performance should be done under the following conditions.

Operating Conditions	
Ambient temperature	0 °C to 40°C
Humidity	10 to 90%, non-condensing, up to +40 °C
Warm up time	30 minutes

Table 1.1: Operating Conditions

Recommended Equipment

All equipment should be properly calibrated prior to running any of the tests described in this document.

Test Equipment	Key Specifications
Digital Multimeter	
DC Source Measurement Unit	4 Wire Sense Mode 200 V Range Accuracy: ± 0.02% of range RMS Noise: 200.0 mV < 500 µV 2.0 V < 1.8 mV 20.0 V < 20 mV 200.0 V < 150 mV
AC Voltage Source	Frequency Range 1 Hz to 1.2 GHz Output Power -127 dBm to +13 dBm Harmonics: less than -35 dBc

Table 1.2: Recommended Equipment

Validation Tests

The validation tests described in this document will validate the performance the ZT4210. The tests can be performed in any order. The ZT4210 Validation Checklist spreadsheet has been provided in which to record test results.

The Trigger Level, Zero Offset, Zero Bias, DC Offset and DC Range tests validate calibrated components. The instrument automatic calibration along with the calibration procedures defined in this document can be used to correct for variation in the components over time.

The Impedance, Noise, Internal 10 MHz Clock, Sample Rate, AC Coupling, Input Range Bandwidth, Filter Bandwidth, Trigger Bandwidth, and Channel to Channel Skew tests validate fundamental components of the instrument which are not calibrated. These components do not vary over time, but can be damaged by misuse.

Any validation test which repeatedly does not fall within the documented specification will require ZTEC Instruments Inc. warranty work to correct.

Calibration Tests

The calibration tests described in this document can be used to adjust the ZT4210. Prior to running any of the calibration tests the full suite of validation tests should be performed to baseline the performance of the instrument. If any of the validation tests documented above as fundament component tests do not perform within the documented specification do NOT attempt to calibrate the instrument.

The Internal 10 MHz calibration should be performed prior to the Input Range calibration. The Input Range calibration should be followed by an External Level calibration. An automatic calibration of the instrument should be performed immediately following each of calibration procedures.

The ZT4210 Calibration Checklist has been provided to record test results.

Calibration API

The following functions are provided in the class level drivers in order to adjust the ZT4210. Calibration commands are provided by their SCPI syntax as well as their class driver call.

Calibration Save Command

The Calibration Save Command saves the calibration codes in the factory calibration EEPROM location. Note: You should only use this command if you have successfully completed a set of calibration and validation tests. You will be overwriting the existing factory defaults.

SCPI

Command Syntax

CALibration:SAVE #HBEAD

Query Syntax

None

Parameters

None

Class Driver Call

ZT_ERROR ztscopeM_calibrate_save (ZT_HANDLE instr_handle)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

None

Calibration Default Command

The Calibration Default Command returns the instrument calibration data to default values. This command will set all calibration codes on the instrument to fundamental hardware defaults. Using this command will put your instrument into a known state from which calibration can proceed.

SCPI

Command Syntax

CALibration:DEFault #HBEAD

Query Syntax

None

Parameters

None

Class Driver Call

ZT_ERROR ztscopeM_calibrate_default (ZT_HANDLE instr_handle)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

None

Calibration Restore Command

The Calibration Restore Command returns the instrument to factory default calibration. This will reset all self-calibration data resulting from the *Calibrate Query* that is used to automatically calibrate the zero DC offset, the DC offset adjust scale factor, and the ADC balance.

SCPI

Command Syntax

CALibration:RESTore

Query Syntax

None

Parameters

None

Class Driver Call

ZT_ERROR ztscopeM_calibrate_restore (ZT_HANDLE instr_handle)

Returns:
ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:
instr_handle – The handle to the instrument being calibrated.

Outputs:
None

Calibrate External Default Command

The Calibrate External Default Command returns the instrument’s external trigger calibration settings to default values.

SCPI

Command Syntax

CALibration:EXTernal:DEFault #HFACE

Query Syntax

None

Parameters

None

Class Driver Call

ZT_ERROR ztscopeM_calibrate_external_default (ZT_HANDLE instr_handle)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

None

Calibrate Reference Oscillator Default Command

The Calibration Reference Oscillator Default Command sets the instrument's reference oscillator code to a default value.

SCPI

Command Syntax

CALibration:ROSCillator:DEFault #HFACE

Query Syntax

None

Parameters

None

Class Driver Call

ZT_ERROR ztscopeM_calibrate_reference_oscillator_default (ZT_HANDLE instr_handle)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

None

Calibration Gain Adjust Command

The Calibration Gain Adjust Command adjusts the instrument's gain calibration settings. The settings are calibrated for the current range, impedance and filter settings.

SCPI

Command Syntax

CALibration:GAIN<n>:ADJust #HBEAD,<range>,<impedance>,<filter_state>, <error>

Query Syntax

None

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<range>	Float	Range in Vpp
<impedance>	Discrete	50 50 Ω 1e6 1 MΩ
<filter_state>	Discrete	0 Bypass 1 20 MHz LPF
<error>	Float	0.0 to 1.0 fraction of full scale

Class Driver Call

```
ZT_ERROR ztscopeM_calibrate_gain_adjust (ZT_HANDLE instr_handle,
                                          u16 channel,
                                          f64 range,
                                          f32 impedance,
                                          u16 filter,
                                          f32 frac_err);
```

Returns:

ZT_SUCCESS if gain code is changed.
ZT_FAILURE if gain code can not be changed.

Inputs:

instr_handle – The handle to the instrument being calibrated.
channel – The input channel being calibrated.
range – The input range being calibrated.
imped – The input impedance setting being calibrated.
filter – The input filter setting being calibrated.
frac_err – The gain error to correct, fraction of full scale

Outputs:

None

Calibration External Adjust Command

The Calibration External Adjust Command adjusts the instrument's external trigger calibration settings. The passed in error is the amount of fractional error to adjust for.

SCPI

Command Syntax

CALibration:EXTernal:ADJust #HFACE,<error>

Query Syntax

None

Parameters

Name	Type	Range
<error>	Float	0.0 to 1.0 fraction of full scale

Class Driver Call

ZT_ERROR ztscopeM_calibrate_external_adjust (ZT_HANDLE instr_handle,
s32 frac_error);

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
frac_error – The amount of fractional error to adjust for

Outputs:

None

Calibrate Reference Oscillator Adjust Command

The Calibrate Reference Oscillator Adjust Command adjusts the instrument's reference oscillator calibration settings.

SCPI

Command Syntax

CALibration:ROSCillator:ADJust #HFACE,<error>

Query Syntax

None

Parameters

Name	Type	Range
<error>	Integer	Parts per million (PPM) adjustment

Class Driver Call

ZT_ERROR ztscopeM_calibrate_reference_oscillator_adjust (ZT_HANDLE instr_handle, s32 clk_error)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
clk_error – The amount of error to adjust for in PPM

Outputs:

None

Calibration ADC Data Query

The Calibration ADC Data Query returns the instrument's ADC calibration codes for the submodule(s) dependent on the interleave mode. ADCs 3 and 4 are only available for 4-channel instruments.

Independent Module 0 returns offset and full scale adjustment values for the independent operation of Input Channels 1 and 2.

Interleave Channel 1 returns offset and full scale adjustment values for the interleaved operation of Input Channel 1.

Interleave Channel 2 returns offset and full scale adjustment values for the interleaved operation of Input Channel 2.

Independent Module 1 returns offset and full scale adjustment values for the independent operation of Input Channels 3 and 4.

Interleave Channel 3 returns offset and full scale adjustment values for the interleaved operation of Input Channel 3.

Interleave Channel 4 returns offset and full scale adjustment values for the interleaved operation of Input Channel 4.

The <i_zero_code> is the zero offset for the I ADC. The <i_gain_code> is the full scale gain adjustment for the I ADC.

The <q_zero_code> is the zero offset for the Q ADC. The <q_gain_code> is the full scale gain adjustment for the Q ADC.

SCPI

Command Syntax

None

Query Syntax

CALibration:ADC:DATA? <interleave> → <zero_code>,<gain_code>

Parameters

Name	Type	Range
<interleave>	Discrete	0: Independent Module 0 1: Interleaved Channel 1 2: Interleaved Channel 2 3: Independent Module 1 4: Interleaved Channel 3 5: Interleaved Channel 4
<i_zero_code>	Integer	0 to 65535
<i_gain_code>	Integer	0 to 65535
<q_zero_code>	Integer	0 to 65535
<q_gain_code>	Integer	0 to 65535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_adc_data_query (ZT_HANDLE instr_handle,
s32 interleave,
u16 *i_zero_code,
u16 *i_gain_code,
u16 *q_zero_code,
u16 *q_gain_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
interleave – The interleave method:

0: Independent Module 0
1: Interleaved Channel 1
2: Interleaved Channel 2
3: Independent Module 1
4: Interleaved Channel 3
5: Interleaved Channel 4

Outputs:

i_zero_code – The zero offset for the I ADC.
i_gain_code – The full scale gain adjustment for the I ADC.
q_zero_code – The zero offset for the Q ADC.
q_gain_code – The full scale gain adjustment for Q ADC.

Calibration Gain Data Query

The Calibration Gain Data Query returns the instrument's gain calibration settings. The <gain_code> is the full scale adjustment at the passed in range, impedance and filter settings.

SCPI

Command Syntax

None

Query Syntax

CALibration:GAIN<n>:DATA? <range>,<impedance>,<filter_state> → <gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<range>	Float	Range in Vpp
<impedance>	Discrete	50 50 Ω 1e6 1 MΩ
<filter_state>	Discrete	0 Bypass 1 20 MHz
<gain_code>	Integer	0 to 65535

Class Driver Call

```
ZT_ERROR ztscopeM_calibrate_gain_data_query (ZT_HANDLE instr_handle,
                                             s32 input_channel,
                                             f64 range,
                                             f64 impedance,
                                             s32 filter,
                                             u16 *gain_code)
```

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
range – The calibration range to be queried.
impedance – The calibration impedance to be queried.
filter – The calibration filter state to be queried.

Outputs:

gain_code – The full scale adjustment.

Calibration Offset Data Query

The Calibration Offset Data Query returns the instrument's offset calibration settings. The <gain_code> is the full scale adjustment. Settings depend on the passed in range, impedance and filter settings.

SCPI

Command Syntax

None

Query Syntax

CALibration:OFFSet<n>:DATA? <range>,<impedance>,<filter_state> →
<zero_code>,<gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<range>	Float	Range in Vpp
<impedance>	Discrete	50 50 Ω 1e6 1 MΩ
<filter_state>	Discrete	0 Bypass 1 20 MHz
<zero_code>	Integer	0 to 65535
<gain_code>	Integer	0 to 65535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_offset_data_query (ZT_HANDLE instr_handle,
s32 input_channel,
f64 range,
f64 impedance,
s32 filter,
u16 *zero_code,
u16 *gain_code)

Returns:
ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:
instr_handle – The handle to the instrument being calibrated.
range – The calibration range to be queried.
impedance – The calibration impedance to be queried.
filter – The calibration filter state to be queried.

Outputs:
zero_code – The offset.
gain_code – The full scale adjustment.

Calibration Trigger Data Query

The Calibration Trigger Data Query returns the instrument's trigger calibration settings. The <zero_code> is the offset. The <gain_code> is the full scale adjustment.

SCPI

Command Syntax

None

Query Syntax

CALibration:TRIGger<n>:DATA? → <zero_code>,<gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<zero_code>	Integer	0 to 65535
<gain_code>	Integer	0 to 65535

Class Driver Call

**ZT_ERROR ztscopeM_calibrate_trigger_data_query (ZT_HANDLE instr_handle,
s32 input_channel,
u16 *zero_code,
u16 *gain_code)**

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

zero_code – The offset.
gain_code – The full scale adjustment.

Calibration External Data Query

The Calibration External Data Query returns the instrument's external trigger calibration settings. The <zero_code> is the offset. The <gain_code> is the full scale adjustment.

SCPI

Command Syntax

None

Query Syntax

CALibration:EXTernal:DATA? → <zero_code>,<gain_code>

Parameters

Name	Type	Range
<zero_code>	Integer	0 to 65535
<gain_code>	Integer	0 to 65535

Class Driver Call

**ZT_ERROR ztscopeM_calibrate_external_data_query (ZT_HANDLE instr_handle,
u16 *zero_code,
u16 *gain_code)**

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

zero_code – The offset.
gain_code – The full scale adjustment.

Calibration Reference Oscillator Data Query

The Calibration Reference Oscillator Data Query returns the instrument's reference oscillator calibration code.

SCPI

Command Syntax

None

Query Syntax

CALibration:ROSCillator:DATA? → <vcxo_code>

Parameters

Name	Type	Range
<vcxo_code>	Integer	0 to 65535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_reference_oscillator_data_query (
ZT_HANDLE instr_handle,
u16 *vcxo_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

vcxo_code – Reference oscillator calibration code.

Validation Tests

Impedance Validation

Specification: 50 Ohm ± 1% (Channels 1-4)
1 MOhm ± 1% (Channels 1-4)
± 2% (External Input)

Procedure:
1. Reset the instrument.
2. Set the instrument channel, impedance, and range to the value specified by the experiment table below.
3. Use a digital multimeter to measure impedance on the input connector.
4. Verify that the measured value is within the tolerance specified by the experiment table.

Experiment Table:

Channel	Impedance Setting (Ohms)	Range Setting (Vpp)	Minimum Acceptable Impedance (Ohms)	Maximum Acceptable Impedance (Ohms)
1 - 4	50	5.0	49.5	50.5
	1M	5.0	9.90E+05	1.01E+06
		10.0		
External Input	50	NA	49	51
	1M		9.80E+05	1.02E+06

Table 2.1: Impedance Test Setup and Tolerances

DC Range Validation

Specification: ± 1% of full scale range

Procedure:

1. Disconnect all cables from the instrument.
2. Reset the instrument.
3. Run an automatic calibration of the instrument.
4. Disable the instrument channels which will not be tested.
5. Connect a 10 MHz clock to the external input of the instrument.
6. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Average
Number of Acquisitions	64
Trigger Mode	Normal
Trigger Source	External Input
Trigger Level	0.0
Trigger Polarity	Rising Edge
Sample Points	100k
Offset	0
Coupling	DC
Attenuation	1.0

Table 2.2: DC Range Validation Settings

7. Use the experiment table below to determine the remaining instrument settings.
8. Use a voltage source to apply the voltage specified by the experiment table below.
9. Capture a waveform. Measure the average value of the waveform.
10. Verify that the measured value is within the tolerance specified by the experiment table.

Experiment Table:

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
1 - 4	1	10us	50us	Off	50	0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	2	1.9	2.1
							-2	-2.1	-1.9
	0.5	20us	100us			0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	2	1.9	2.1
							-2	-2.1	-1.9
	1	10us	50us		1M	0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	4	3.9	4.1
							-4	-4.1	-3.9
						20.00	8	7.8	8.2
							-8	-8.2	-7.8
						40.00	16	15.6	16.4
							-16	-16.4	-15.6
						80.00	32	31.2	32.8
							-32	-32.8	-31.2
						200.0	80	78	82
							-80	-82	-78
						400.0	80	76	84
							-80	-84	-76
	0.5	20us	100us			0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	4	3.9	4.1
							-4	-4.1	-3.9

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
						20.00	8	7.8	8.2
							-8	-8.2	-7.8
						40.00	16	15.6	16.4
							-16	-16.4	-15.6
						80.00	32	31.2	32.8
							-32	-32.8	-31.2
						200.0	80	78	82
							-80	-82	-78
						400.0	80	76	84
							-80	-84	-76
	1	10us	50us	On	50	0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	2	1.9	2.1
							-2	-2.1	-1.9
	0.5	20us	100us			0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	2	1.9	2.1
							-2	-2.1	-1.9
	1	10us	50us		1M	0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	4	3.9	4.1
							-4	-4.1	-3.9
						20.00	8	7.8	8.2
							-8	-8.2	-7.8
						40.00	16	15.6	16.4
							-16	-16.4	-15.6
						80.00	32	31.2	32.8
							-32	-32.8	-31.2
						200.0	80	78	82
							-80	-82	-78

Chan	Sample Rate (GS/s)	Time / Div	Offset Time	Filter	Imped (Ohm)	Range (V)	Applied Voltage(V)	Min. Average Value (V)	Max. Average Value (V)
						400.0	80	76	84
							-80	-84	-76
	0.5	20us	100us			0.05	0.02	0.0195	0.0205
							-0.02	-0.0205	-0.0195
						0.10	0.04	0.039	0.041
							-0.04	-0.041	-0.039
						0.25	0.1	0.0975	0.1025
							-0.1	-0.1025	-0.0975
						0.50	0.2	0.195	0.205
							-0.2	-0.205	-0.195
						1.00	0.4	0.39	0.41
							-0.4	-0.41	-0.39
						2.00	0.8	0.78	0.82
							-0.8	-0.82	-0.78
						5.00	2	1.95	2.05
							-2	-2.05	-1.95
						10.00	4	3.9	4.1
							-4	-4.1	-3.9
						20.00	8	7.8	8.2
							-8	-8.2	-7.8
						40.00	16	15.6	16.4
							-16	-16.4	-15.6
						80.00	32	31.2	32.8
							-32	-32.8	-31.2
						200.0	80	78	82
							-80	-82	-78
						400.0	80	76	84
							-80	-84	-76

Table 2.3: DC Range Setup and Tolerances Settings

Zero Offset Validation

Specification:	< ±(1% full scale range + 2 mV) @ +25 °C	(50 Ω, ≤0.1 Vpp)
	< ±(1% full scale range + 1 mV) @ +25 °C	(50 Ω, ≥0.25 Vpp)
	< ±(1% full scale range + 2 mV) @ +25 °C	(1MΩ, ≤0.1 Vpp)
	< ±(1% full scale range + 1 mV) @ +25 °C	(1MΩ, ≤5Vpp, ≥0.25 Vpp)
	< ±(1% full scale range + 50 mV) @ +25 °C	(1MΩ, ≥10 Vpp)

Procedure:

1. Disconnect all cables from the input channels.
2. Reset the instrument.
3. Run an automatic calibration of the instrument.
4. Disable all channels which are not being tested.
5. Connect a 10MHz clock to the external input of the instrument.
6. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Average
Number of Acquisitions	64
Trigger Mode	Normal
Trigger Source	External Input
Trigger Level	0.0
Trigger Polarity	Rising Edge
Sample Points	100k
Time/Div	10 µs
Offset Time	0.0
Offset	0.0
Coupling	DC
Attenuation	1.0

Table 2.4: Zero Offset Validation Settings

7. Use the experiment table below to determine the remaining instrument settings.
8. Capture a waveform. Measure the average value of the waveform.
9. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Filter	Impedance (Ohm)	Range (V)	Min. Average Value (V)	Max. Average Value (V)
1 - 4	Off	50	0.05	-0.0025	0.0025
			0.10	-0.003	0.003
			0.25	-0.0035	0.0035
			0.50	-0.0060	0.0060
			1.00	-0.0110	0.0110

Channel	Filter	Impedance (Ohm)	Range (V)	Min. Average Value (V)	Max. Average Value (V)
			2.00	-0.0210	0.0210
			5.00	-0.0510	0.0510
			10.00	-0.1010	0.1010
		1M	0.05	-0.0025	0.0025
			0.10	-0.003	0.003
			0.25	-0.0035	0.0035
			0.50	-0.0060	0.0060
			1.00	-0.0110	0.0110
			2.00	-0.0210	0.0210
			5.00	-0.0510	0.0510
			10.00	-0.1500	0.1500
			20.00	-0.2500	0.2500
			40.00	-0.4500	0.4500
			80.00	-0.8500	0.8500
			200.00	-2.0500	2.0500
			400.00	-4.0500	4.0500
	On	50	0.05	-0.0025	0.0025
			0.10	-0.003	0.003
			0.25	-0.0035	0.0035
			0.50	-0.0060	0.0060
			1.00	-0.0110	0.0110
			2.00	-0.0210	0.0210
			5.00	-0.0510	0.0510
			10.00	-0.1010	0.1010
		1M	0.05	-0.0025	0.0025
			0.10	-0.003	0.003
			0.25	-0.0035	0.0035
			0.50	-0.0060	0.0060
			1.00	-0.0110	0.0110
			2.00	-0.0210	0.0210
			5.00	-0.0510	0.0510
			10.00	-0.1500	0.1500
			20.00	-0.2500	0.2500
			40.00	-0.4500	0.4500
			80.00	-0.8500	0.8500
			200.00	-2.0500	2.0500
			400.00	-4.0500	4.0500

Table 2.5: Zero Offset Setup and Tolerances

Offset Validation

Specification:

< ±(1% full scale range + 1% offset + 2 mV) @ +25 °C	(50 Ω, ≤0.1 Vpp)
< ±(1% full scale range + 1% offset + 1 mV) @ +25 °C	(50 Ω, ≥0.25 Vpp)
< ±(1% full scale range + 1% offset + 2 mV) @ +25 °C	(1 MΩ, ≤0.1 Vpp)
< ±(1% full scale range + 1% offset + 1 mV) @ +25 °C	(1 MΩ, ≤5Vpp, ≥0.25 Vpp)
< ±(1% full scale range + 1% offset + 50 mV) @ +25 °C	(1 MΩ, ≥10 Vpp)

Procedure:

1. Disconnect all cables from the input channels.
2. Reset the instrument.
3. Run an automatic calibration of the instrument.
4. Disable all channels that are not being tested.
5. Connect a 10 MHz clock to the external input of the instrument
6. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Average
Number of Acquisitions	64
Trigger Mode	Normal
Trigger Source	External Input
Trigger Level	0.0
Trigger Polarity	Rising Edge
Sample Points	100k
Time/Div	10 µs
Offset Time	0.0
Coupling	DC
Attenuation	1.0

Table 2.6: Offset Validation Settings

7. Use the experiment table below to determine the remaining settings of the instrument.
8. Capture a waveform. Measure the average value of the waveform.
9. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Filter	Impedance (Ohm)	Range (V)	Offset Value (V)	Min. Average Value (V)	Max. Average Value (V)
1 - 4	Off	50	0.05	0.02	-0.0027	0.0027
				-0.02		
			0.10	0.04	-0.0034	0.0034
				-0.04		
			0.25	0.10	-0.0045	0.0045
				-0.10		

Channel	Filter	Impedance (Ohm)	Range (V)	Offset Value (V)	Min. Average Value (V)	Max. Average Value (V)
			0.50	0.20	-0.0080	0.0080
				-0.20		
			1.00	0.40	-0.0150	0.0150
				-0.40		
			2.00	0.80	-0.0290	0.0290
				-0.80		
			5.00	2.00	-0.0710	0.0710
				-2.00		
			10.00	0.0	-0.1010	0.1010
				0.0		
		1M	0.05	0.02	-0.0027	0.0027
				-0.02		
			0.10	0.04	-0.0034	0.0034
				-0.04		
			0.25	0.10	-0.0045	0.0045
				-0.10		
			0.50	0.20	-0.0080	0.0080
				-0.20		
			1.00	0.40	-0.0150	0.0150
				-0.40		
			2.00	0.80	-0.0290	0.0290
				-0.80		
			5.00	2.00	-0.0710	0.0710
				-2.00		
			10.00	4.00	-0.1900	0.1900
				-4.00		
			20.00	8.00	-0.3300	0.3300
				-8.00		
			40.00	16.00	-0.6100	0.6100
				-16.00		
			80.00	32.00	-1.1700	1.1700
				-32.00		
			200.0	80.00	-2.8500	2.8500
				-80.00		
			400.0	0.0	-4.0500	4.0500
				0.0		
	On	50	0.05	0.02	-0.0027	0.0027
				-0.02		
			0.10	0.04	-0.0034	0.0034
				-0.04		
			0.25	0.10	-0.0045	0.0045

Channel	Filter	Impedance (Ohm)	Range (V)	Offset Value (V)	Min. Average Value (V)	Max. Average Value (V)
				-0.10		
			0.50	0.20	-0.0080	0.0080
				-0.20		
			1.00	0.40	-0.0150	0.0150
				-0.40		
			2.00	0.80	-0.0290	0.0290
				-0.80		
			5.00	2.00	-0.0710	0.0710
				-2.00		
			10.00	0.0	-0.1010	0.1010
				0.0		
		1M	0.05	0.02	-0.0027	0.0027
				-0.02		
			0.10	0.04	-0.0034	0.0034
				-0.04		
			0.25	0.10	-0.0045	0.0045
				-0.10		
			0.50	0.20	-0.0080	0.0080
				-0.20		
			1.00	0.40	-0.0150	0.0150
				-0.40		
			2.00	0.80	-0.0290	0.0290
				-0.80		
			5.00	2.00	-0.0710	0.0710
				-2.00		
			10.00	4.00	-0.1900	0.1900
				-4.00		
			20.00	8.00	-0.3300	0.3300
				-8.00		
			40.00	16.00	-0.6100	0.6100
				-16.00		
			80.00	32.00	-1.1700	1.1700
				-32.00		
			200.0	80.00	-2.8500	2.8500
				-80.00		
			400.0	0.0	-4.0500	4.0500
				0.0		

Table 2.7: Offset Setup and Tolerances

Zero Bias Validation

Specification: ≤ ± 10 μA (50 Ohm)
≤ ± 1 nA (1 MOhm)

Procedure:

1. Disconnect all cables from the input channels.
2. Reset the instrument.
3. Perform an automatic calibration of the instrument.
4. Use the experiment table below to determine the settings of the instrument.
5. Use a digital multimeter to measure the current at the input connector.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Note: Bias current measurements will be limited by the accuracy of the digital multimeter.

Experiment Table:

Channel	Impedance (Ohm)	Range (V)	Min. Measured Value (Amp)	Max. Measured Value (Amp)
1 - 4	50	0.05	-1.00E-05	1.00E-05
	1M	0.05	-1.00E-09	1.00E-09
		10.0	-1.00E-09	1.00E-09

Table 2.8: Zero Bias Setup and Tolerances

Noise Validation

Specification:

RMS Noise Full Scale ≥ 100mVpp	≤ (0.3% of full scale range + 400 μV) ≤ (0.3% of full scale range) ≤ (0.5% of full scale range + 700 μV) ≤ (0.5% of full scale range)	(50 Ω Full Bandwidth) (50 Ω + 20 MHz Filter) (1 MΩ Full Bandwidth) (1 MΩ + 20 MHz Filter)
RMS Noise Full Scale < 100mVpp	≤ (0.5% of full scale range + 400 μV) ≤ (0.5% of full scale range) ≤ (0.5% of full scale range + 700 μV) ≤ (0.5% of full scale range + 50 μV)	(50 Ω Full Bandwidth) (50 Ω + 20 MHz Filter) (1 MΩ Full Bandwidth) (1 MΩ + 20 MHz Filter)

Procedure:

1. Reset the instrument.
2. Connect a 10 MHz clock to the external input of the instrument.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Trigger Source	External Input
Trigger Level	0.0
Trigger Polarity	Rising Edge
Sample Points	1M
Time/Div	20 ms
Offset Time	0.0
Coupling	DC
Attenuation	1.0
Offset	0.0

Table 2.9: Noise Validation Settings

4. Use the experiment table below to determine the settings of the instrument.
5. Capture a waveform. Measure the AC RMS of the waveform.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Note: For PCI and PXI units the RMS noise of the 50 mVpp range will be determined by the power supply noise rejection specification.

Experiment Table:

Channel	Filter	Impedance (Ohm)	Range (V)	Max. Measured Value (Vrms)
1 - 4	Off	50	0.05	0.00065
			0.10	0.00070
			0.25	0.00115
			0.50	0.00190
			1.00	0.00340
			2.00	0.00640
			5.00	0.01540
			10.00	0.03040
		1M	0.05	0.00095
			0.10	0.00120
			0.25	0.00195
			0.50	0.00320
			1.00	0.00570
			2.00	0.01070
			5.00	0.02570
			10.00	0.05070
			20.00	0.10070
			40.00	0.20070
			80.00	0.40070
			200.0	1.00070
			400.0	2.00070
	On	50	0.05	0.00025
			0.10	0.00030
			0.25	0.00075
			0.50	0.00150
			1.00	0.00300
			2.00	0.00600
			5.00	0.01500
			10.00	0.03000
		1M	0.05	0.00030
			0.10	0.00050
			0.25	0.00125
			0.50	0.00250
			1.00	0.00500
			2.00	0.01000
			5.00	0.02500
			10.00	0.05000
			20.00	0.10000
			40.00	0.20000
			80.00	0.40000

Channel	Filter	Impedance (Ohm)	Range (V)	Max. Measured Value (Vrms)
			200.0	1.00000
			400.0	2.00000

Table 2.10: Noise Setup and Tolerances

External Input Trigger Level Validation

Specification: ± 20 mV

Procedure:

1. Reset the instrument.
2. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic

Table 2.11: External Input Validation Settings

3. Use a voltage source to apply the voltage indicated in the experiment table below to the external input.
4. Capture a waveform. Measure the average value of the waveform.
5. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Applied Voltage (V)	Min. Measured Value (V)	Max. Measured Value (V)
External Input	1.00	0.98	1.02
	-1.00	-1.02	-0.98

Table 2.12: External Input Setup and Tolerances

Internal 10MHz Clock Validation

Specification: ± 2.5 ppm accuracy

Procedure:

1. Connect a precision 10 MHz clock to channel 1 of the instrument.
2. Reset the instrument.
3. Enter the following settings for the test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Sample Points	10k
Time/Div	10 ms
Offset Time	0 s
Trigger Source	Channel 1
Trigger Level	1.0
Trigger Polarity	Rising Edge
Channel 1	Enabled
Channel 1 Range	5.0 Vpp
Channel 1 Offset	0
Channel 1 Coupling	DC
Channel 1 Impedance	50 Ohm
Channel 1 Filter	Off
Channel 1 Attenuation	1.0
External Output	Enabled
External Output Source	Reference Event
External Output Polarity	Positive

Table 2.13: 10MHz Clock Validation Settings

4. Capture a waveform. Measure the frequency of the waveform.
5. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Min. Measured Value (Hz)	Max. Measured Value (Hz)
External Output	0	25

Table 2.14: 10MHz Clock Validation Tolerances

Sample Rate Validation

Specification: ± 0.5%

Procedure:
1. Reset the instrument.
2. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Normal
Sample Points	10k
Offset Time	0.0
Trigger Level	0.0
Trigger Polarity	Rising Edge
Range	2 Vpp
Offset	0.0
Coupling	DC
Impedance	50 Ohm
Filter	Off
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.15: Sample Rate Validation Settings

3. Use the experiment table below to determine the remaining instrument settings.
4. Use an AC voltage source to apply a +8 dBm signal to the channel being tested at the frequency indicated by the experiment table below.
5. Capture a waveform. Measure the frequency of the waveform.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Trigger & Capture Channel	Sample Rate (S/s)	Time/Div	Signal Frequency (Hz)	Minimum Measured Frequency (Hz)	Maximum Measured Frequency (Hz)
1 - 4	1.0000E+09	1us	1.0100E+06	1.0050E+06	1.0151E+06
	5.0000E+05	2ms	1.0000E+03	0.9950E+03	1.0050E+03

Table 2.16: Sample Rate Setup and Tolerances

AC Coupling Validation

Specification: 200 kHz High Pass (50 Ohm)
10 Hz High Pass (1 MOhm)

Procedure:

1. Reset the instrument.
2. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Sample Points	10k
Offset Time	0.0
Range	2 Vpp
Offset	0.0
Coupling	AC
Impedance	50 Ohm
Filter	Off
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.17: AC Coupling Validation Settings

3. Use the experiment table below to determine the remaining instrument settings.
4. Use an AC voltage source to apply a +8 dBm signal to the channel being tested at the frequency indicated by the experiment table below.
5. Capture a waveform. Measure the AC RMS of the waveform.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Sample Rate (S/s)	Time/Div	Signal Frequency (Hz)	Minimum Measured Value (Vrms)	Maximum Measured Value (Vrms)
1 - 4	2.0000E+08	5us	1.0000E+06	0.5457	0.5781
	2.0000E+07	50us	1.0000E+05	0.3158	0.4092
	2.0000E+06	0.5ms	1.0000E+04	0.0000	0.0892

Table 2.18: AC Coupling Setup and Tolerances

Trigger Level Validation

Specification: ± (2% full scale range + 5 mV + offset accuracy)

Procedure:

1. Reset the instrument.
2. Disable all channels not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Average
Number of Acquisitions	32
Trigger Mode	Normal
Sample Points	100
Time/Div	10ns
Offset Time	50 ns
Range	2 Vpp
Impedance	50 Ohms
Offset	0.0
Coupling	DC
Filter	Off
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.19: Trigger Level Validation Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Use an AC voltage source to apply a 100 Hz signal at the voltage indicated in the experiment table to the channel being tested.
6. Capture a waveform. Measure the average value of the waveform.
7. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Signal Power (dBm)	Trigger Polarity	Trigger Level	Minimum Average Value (V)	Maximum Average Value (V)
1 - 4	10	Falling Edge	0.7071	0.641107	0.773107
		Rising Edge	-0.7071	-0.773107	-0.641107

Table 2.20: Trigger Level Setup and Tolerances

Trigger Bandwidth Validation

Specification: DC to 250 MHz minimum

Procedure:
1. Reset the instrument.
2. Disable all channels not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Normal
Sample Points	1000
Offset Time	0
Range	5 Vpp
Offset	0.0
Coupling	DC
Impedance	50 Ohm
Filter	Off
Attenuation	1.0
Trigger Polarity	Rising Edge

Table 2.21: Trigger Bandwidth Validation Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Set the instrument to trigger on the channel under test.
6. Use an AC voltage source to apply the signal specified in the experiment table to the channel being tested.
7. Set the instrument to capture a waveform asynchronously.
8. Verify that the instrument captures a waveform.

Experiment Table:

Channel	Time/ Div	Trigger Level (V)	Signal Frequency (Hz)	Signal Magnitude (dBm)
1 - 4	100ns	0.25	1.00E+06	5.0
			1.00E+07	5.0
			1.00E+08	5.0
			2.50E+08	5.0
External Input	N/A	0.1	1.00E+07	-8.0
			1.00E+08	-8.0
			2.50E+08	-5.0

Table 2.22: Trigger Bandwidth Setup

Range Bandwidth Validation

Specification: 50Ohm: DC to 300 MHz typical, 250 MHz minimum (-3 dB)
1MOhm: DC to 300 MHz typical, 250 MHz minimum (-3 dB)

Procedure:

1. Reset the instrument.
2. Disable all channels not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Sample Points	100k
Time/Div	100 μs
Offset Time	0
Offset	0.0
Coupling	DC
Filter	Off
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.23: Range Bandwidth Validation Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Use an AC voltage source to apply the signal specified in the experiment table to the channel being tested.
6. Capture a waveform. Measure the AC RMS of the waveform.
7. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Chan	Imped (Ohm)	Range (Vpp)	Signal Volt (mVrms)	Signal Freq. (Hz)	Min. Measured Value (Vrms)	Max. Measured Value (Vrms)
1 - 4	50	10	999	2.500E+08	0.7071	1.0581
		5	999	2.500E+08	0.7071	1.0581
		2	500	2.500E+08	0.3540	0.5610
		1	200	2.500E+08	0.1416	0.2119
		0.5	100	2.500E+08	0.0707	0.1059
		0.25	50	2.500E+08	0.0353	0.0529
		0.1	25	2.500E+08	0.0177	0.0265
		0.05	10	2.500E+08	0.0070	0.0106
	1M	10.0	999	2.500E+08	0.7079	1.0581
		2.0	500	2.500E+08	0.3539	0.5296

Table 2.24: Range Bandwidth Setup and Tolerances

Filter Bandwidth Validation

Specification: Stopband rejection approx. 3 dB at 20 MHz

Procedure:
1. Reset the instrument.
2. Disable all channels not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Sample Points	100k
Sample Rate	500 MHz
Time/Div	20us
Offset Time	0
Range	5 Vpp
Offset	0.0
Coupling	DC
Impedance	50 Ohm
Filter	On
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.25: Filter Bandwidth Validation Settings

4. Use an AC voltage source to apply the signal specified in the experiment table to the channel being tested.
5. Capture a waveform. Measure the AC RMS of the waveform.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Signal Voltage (mVrms)	Signal Frequency (Hz)	Minimum Measured Value (Vrms)	Maximum Measured Value (Vrms)
1 – 4	800	2.0100E+07	0.5047	0.6354

Table 2.26: Filter Bandwidth Setup and Tolerances

Harmonics & Distortion Validation

Specification: Typical results

Input Range & Signal Frequency	Signal-to Noise Ratio (SNR)	Total Harmonic Distortion (THD)	Signal-to-Noise + Distortion (SINAD)
10 Vpp, 10.7 MHz	41.21 dBc	-53.15 dBc	40.94 dBc
1 Vpp, 10.7 MHz	41.93 dBc	-59.53 dBc	41.86 dBc
0.1 Vpp, 10.7 MHz	33.48 dBc	-57.59 dBc	33.47 dBc
10 Vpp, 60.1 MHz	41.24 dBc	-48.68 dBc	40.51 dBc
1 Vpp, 60.1 MHz	41.36 dBc	-49.93 dBc	40.79 dBc
0.1 Vpp, 60.1 MHz	33.16 dBc	-48.12 dBc	33.02 dBc

Table 2.27: Dynamic Range Specifications

Procedure:

1. Reset the instrument.
2. Disable all channels not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Normal
Sample Points	100k
Range	2 Vpp
Offset	0.0
Coupling	DC
Impedance	50 Ohm
Filter	Off
Attenuation	1.0

Table 2.28: Harmonics and Distortion Validation Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Use an AC voltage source to apply +9 dB 10.7 MHz signal to the channel being tested. ZTEC suggest filtering the signal at the input to the instrument in order to eliminate any noise from the AC source.
6. Capture a waveform.
7. Enable calculation channel 1. Set calculation channel 1 to perform an FFT of the captured waveform using a Hanning window.
8. Measure the SNR and THD of the FFT in calculation channel 1.
9. Verify that the measurement meets the minimum requirements specified by the experiment table below.

Experiment Table:

Channel	Sample Rate(Hz)	Time/Div	Offset Time (s)	Measurement	Minimum Measured for SNR, Maximum Measured for THD Value (dB)
1 & 3	1.00E+09	10us	1.2500E-05	SNR	40.0
				THD	-40.0
2 & 4	0.50E+09	20us	2.5000E-05	SNR	40.0
				THD	-40.0

Table 2.29: Harmonics & Distortion Setup and Tolerances

Calibration Tests

Internal 10 MHz Calibration

Procedure:

1. Reset the instrument.
2. Connect a precision 10 MHz +10 dBm signal to the external input of the instrument.
3. Set the reference oscillator source to external.
4. Use the zbind_blkin function to read an unsigned 32 bit integer value from the memory address 0x9010007C. (F_{EXT})
5. Set the reference oscillator source to internal.
6. Use the zbind_blkin function to read an unsigned 32 bit integer value from the memory address 0x9010007C. (F_{INT})
7. Calculate the error by subtracting the measured internal rate from the measured external rate.

$$\text{error} = F_{INT} - F_{EXT}$$

8. Use the ztscopeM_calibrate_reference_oscillator_adjust function to adjust the codes.
9. Repeat steps 6 through 8 until the error is less than 5.

Implementation Notes:

1. Each code should converge to an acceptable value within 10 iterations of the process.

Range Calibration

Procedure:

1. Reset the instrument.
2. Disable the channel not being tested.
3. Enter the following settings for each test.

Setup Item	Setting
Sample Points	524,288
Sample Rate	500 MS/s
Time/Div	105 µs
Offset Time	0.0
Acquisition Mode	Normal
Trigger Mode	Normal
Measure Method	Entire Waveform
Measure Edge	1
Offset	0.0
Coupling	DC
Attenuation	1.0

Table 3.1: Range Calibration Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Using a DC voltage source apply the positive voltage specified in the experiment table. (Va)
6. Capture a waveform. Measure the average of the waveform (Vp).
7. Using a DC voltage source apply the negative voltage specified in the experiment table. (-Va)
8. Capture a waveform. Measure the average of the waveform (Vn).
9. Calculate the gain error by subtracting one from the average of the quotients of the applied positive voltage and the measured positive voltage and the applied negative voltage and the measured negative voltage.

$$gain\_error = 1 - Va(Vn-Vp)/2VpVn$$

10. Use the ztscopeM_calibrate_gain_adjust function to adjust the gain codes.
11. Repeat steps 5 through 10 until the gain error is less than 0.5%.
12. Repeat procedure for each combination of channel, range, impedance, and filter settings specified in the experiment table below.

Experiment Table:

Channel	Impedance (Ohm)	Filter	Range (Vpp)	Positive Applied Voltage (V)	Negative Applied Voltage (V)
1 – 2	1.00E+06	Off	400.00	80.00	-80.00
			200.00	80.00	-80.00

			80.00	32.00	-32.00
			40.00	16.00	-16.00
			20.00	8.00	-8.00
			10.00	4.00	-4.00
			5.00	2.00	-2.00
			2.00	0.80	-0.80
			1.00	0.40	-0.40
			0.50	0.20	-0.20
			0.25	0.10	-0.10
			0.10	0.04	-0.04
			0.05	0.02	-0.02
		On	400.00	80.00	-80.00
			200.00	80.00	-80.00
			80.00	32.00	-32.00
			40.00	16.00	-16.00
			20.00	8.00	-8.00
			10.00	4.00	-4.00
			5.00	2.00	-2.00
			2.00	0.80	-0.80
			1.00	0.40	-0.40
			0.50	0.20	-0.20
			0.25	0.10	-0.10
			0.10	0.04	-0.04
			0.05	0.02	-0.02
	50	Off	10.00	2.00	-2.00
			5.00	2.00	-2.00
			2.00	0.80	-0.80
			1.00	0.40	-0.40
			0.50	0.20	-0.20
			0.25	0.10	-0.10
			0.10	0.04	-0.04
			0.05	0.02	-0.02
		On	10.00	2.00	-2.00
			5.00	2.00	-2.00
			2.00	0.80	-0.80
			1.00	0.40	-0.40
			0.50	0.20	-0.20
			0.25	0.10	-0.10
			0.10	0.04	-0.04
			0.05	0.02	-0.02

Table 3.2: Range Calibration Setup and Tolerances

Implementation Notes:

1. Each range except the maximums is calibrated at 80% of the maximum peak to peak range. (Note: This translates to 40% of the maximum and minimum range values.) This ensures that the gain accuracy is better than 1% of full scale.
2. Each gain code should converge to an acceptable value within 10 iterations of the process.
3. In order to more accurately determine the gain error, use the DC source to determine the exact voltage applied to the device in place of the expected voltage.
4. Perform an external level calibration immediately following a range calibration.

External Level Calibration

Procedure:

1. Reset the instrument.
2. Enter the following settings for each test.

Setup Item	Setting
Acquisition Mode	Normal
Trigger Mode	Normal
Trigger Source	External Input
Trigger Polarity	Rising Edge
Trigger Impedance	50 Ohms

Table 3.3: Trigger Offset Calibration Settings

3. Use the experiment table below to determine the remaining instrument settings.
4. Set the instrument to capture a waveform asynchronously on a falling edge trigger.
5. Using a DC voltage source apply a -0.5 V signal to the channel under test.
6. Increase the signal voltage by the increment value specified in the experiment table below until the instrument triggers.
7. Record the signal voltage which triggered the instrument (V_L).
8. Send an abort command to the instrument.
9. Set the instrument to capture a waveform asynchronously on a rising edge trigger.
10. Using a DC voltage source apply a 0.5V signal to the channel under test.
11. Decrease the signal voltage by the increment value specified in the experiment table below until the instrument triggers.
12. Record the signal voltage which triggered the instrument (V_H).
13. Send an abort command to the instrument.
14. Calculate the gain error by subtracting averaging the voltages at which the instrument triggered from one.

$$gain\_error = 1 - (V_H - V_L)/ 2$$

15. Use the function ztscopeM_calibrate_external_adjust to adjust the gain code based on the gain error.
16. Repeat steps 4 through 15 until the gain error is less than 1%.

Experiment Table:

Trigger Source	Trigger Level (V)	Trigger Polarity	Applied Signal Voltage (V)	Signal Increment Value (V)
External Input	1.0	Falling Edge	-0.50	1.560E-03
	-1.0	Rising Edge	0.50	-1.560E-03

Table 3.4: Trigger Offset Calibration Setup and Tolerances

Implementation Notes:

1. Perform an automatic calibration of the instrument immediately following the completion of external level calibration.
2. After the automatic calibration completes use the ztscopeM_save_calibration function to store the range gain codes and interleave gain codes permanently.

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