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

M-Class Oscilloscope
Models ZT4628 and ZT4629

User's Manual: 0004-000086
Revision 1B

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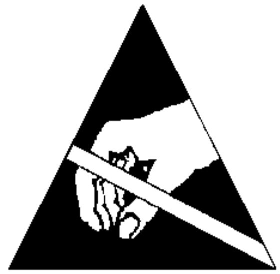

Handling Precautions for Electronic Devices Subject to Damage by Static Electricity

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	02-07-11	All	Initial Release
1A	08-16-11	All	Updates for modified calibration procedure
1B	09-02-11	Calibrations	Add skew cal

Table of Contents

List of Tables

Test Setup

Environment

Validation and adjustment of the ZT4620 performance should be done under the following conditions.

Operating Conditions	
Ambient temperature	20 °C to 30 °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 ZT4620. The tests can be performed in any order. The ZT4620 Validation Checklist spreadsheet has been provided in which to record test results.

The Internal 10 MHz Clock, Trigger Level, Offset, Path and 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, Coupling, Input Range Bandwidth, Filter Bandwidth, and Trigger Bandwidth 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 ZT4620. 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 fundamental component tests do not perform within the documented specification do not attempt to calibrate the instrument.

An automatic calibration must be performed before starting calibrations. The Skew calibration should flow the initial automatic calibration. The Internal 10 MHz calibration should be performed prior to the Input Range calibration. The Input Range calibration should be followed by an internal automatic self calibration. Finally, the Input Path calibration, Input Trigger Level, and External Trigger Level calibrations should be performed in that order. A final automatic self calibration of the instrument should be performed immediately following the successful completion of all calibration procedures. To ensure correctness the Internal 10 MHz Clock, Trigger Level, Offset, Path, and Range validation tests should be run to confirm the results of the calibrations.

The ZT4620 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 ZT4620. 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 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 calibration data resulting from the *Calibrate Query* that is used to automatically calibrate the offset, ADC full scale gain, and input trigger level.

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 input 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 ADC Set Gain Code Command

The Calibration ADC Set Gain Code Command sets the instrument's ADC gain code for the specified channel. This command does not modify the existing calibration codes.

SCPI

Command Syntax

CALibration:ADC<n>:CODE #HBEAD,<gain_code>

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
<code>	Integer	0 to 65535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_adc_set_code (ZT_HANDLE instr_handle,
s32 input_channel,
u16 gain_code);

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
input_channel – The input channel being calibrated.
gain_code – The gain code to apply to the ADC.

Outputs:

None

Calibration External Adjust Command

The Calibration External Adjust Command adjusts the instrument's external input trigger calibration settings.

SCPI

Command Syntax

CALibration:EXTernal:ADJust #HFACE,<error>

Query Syntax

None

Parameters

Name	Type	Range
<error>	Float	-0.25 to 0.25

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 Impedance Gain Adjust Command

The Calibration Impedance Gain Adjust Command adjusts the instrument's gain calibration settings compensating for variation introduced by the input impedance. The settings are calibrated for a single range using both 50 and 1M Ohm input impedances.

SCPI

Command Syntax

CALibration:IMPedance<n>:ADJust #HBEAD, <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
<error>	Float	0.78 to 1.22

Class Driver Call

ZT_ERROR ztscopeM_calibrate_impedance_adjust (ZT_HANDLE instr_handle,
u16 input_channel,
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.
input_channel – The input channel being calibrated.
frac_err – The gain error to correct, fraction of full scale

Outputs:
None

Calibration Input Gain Adjust Command

The Calibration Input Gain Adjust Command adjusts the instrument's gain calibration settings compensating for variations in the input path. The settings are calibrated for a single range across all coupling, impedance, and filter settings.

SCPI

Command Syntax

CALibration:INPut<n>:ADJust #HBEAD, <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
<error>	Float	-0.25 to 0.25

Class Driver Call

```
ZT_ERROR ztscopeM_calibrate_input_adjust (ZT_HANDLE instr_handle,
                                          u16 input_channel,
                                          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.
input_channel – The input channel being calibrated.
frac_err – The gain error to correct, fraction of full scale

Outputs:

None

Calibration Range Gain Adjust Command

The Calibration Range Gain Adjust Command adjusts the instrument's gain calibration settings compensating for all nominal ranges on a single input path. The settings are calibrated for the current nominal range using the default input path setting for coupling, impedance, and filter of DC, 1MOhm, and Bypass. There are thirty-four nominal ranges.

SCPI

Command Syntax

CALibration:RANGe<n>:ADJust #HBEAD, <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
<error>	Float	-0.25 to 0.25

Class Driver Call

ZT_ERROR ztscopeM_calibrate_range_adjust (ZT_HANDLE instr_handle,
u16 input_channel,
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.
input_channel – The input channel being calibrated.
frac_err – The gain error to correct, fraction of full scale

Outputs:

None

Calibration Trigger Gain Adjust Command

The Calibration Trigger Gain Adjust Command adjusts the instrument's input trigger gain calibration settings.

SCPI

Command Syntax

CALibration:TRIGger<n>:GADJust #HBEAD, <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
<error>	Float	0.5 to 1.5

Class Driver Call

ZT_ERROR ztscopeM_calibrate_trigger_gain_adjust (ZT_HANDLE instr_handle,
u16 input_channel,
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.
input_channel – The input channel being calibrated.
frac_err – The gain error to correct, fraction of full scale

Outputs:
None

Calibration Trigger Zero Adjust Command

The Calibration Trigger Zero Adjust Command adjusts the instrument's input trigger zero calibration settings.

SCPI

Command Syntax

CALibration:TRIGger<n>:ZADJust #HBEAD, <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
<error>	Float	-0.5 to 0.5

Class Driver Call

ZT_ERROR ztscopeM_calibrate_trigger_zerro_adjust (ZT_HANDLE instr_handle,
u16 input_channel,
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.
input_channel – The input channel being calibrated.
zero_error – The gain error to correct, fraction of full scale

Outputs:

None

Calibration ADC Gain Scale Data Query

The Calibration ADC Gain Scale Data Query returns a single entry in the instrument's gain scale table. There are thirty-three total entries in the gain scale table per instrument channel. The scale factor is the amount of full scale range adjustment multiplied by the ADC's default full scale value of 32,768. The amount of range adjustment possible at the ADC is limited to ± 20%.

SCPI

Command Syntax

None

Query Syntax

CALibration:ADC<n>:TDATa? <table_idx> → <scale_factor>, <adc_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<table_idx>	Integer	0 to 32
<scale_factor>	Integer	26,214 to 39,321
<adc_code>	Integer	0 to 65,535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_adc_table_data_query (ZT_HANDLE instr_handle,
s32 input_channel,
s32 table_idx,
u16 *scale_factor,
u16 *adc_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
input_channel – The input channel of interest.
table_idx – The requested table entry of interest.

Outputs:

scale_factor – The full scale range adjustment.
adc_code – The ADC gain code.

Calibration Offset Data Query

The Calibration Offset Data Query returns the instrument's offset gain calibration setting compensating for all nominal ranges on a single input path. The settings are returned for the current nominal range. There are thirty-four nominal ranges.

SCPI

Command Syntax

None

Query Syntax

CALibration:OFFSet<n>:DATA? → <gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<gain_code>	Integer	0 to 65,535

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.
input_channel – The input channel of interest.
range – Not applicable
impedance – Not applicable
filter – Not applicable

Outputs:

zero_code – Not applicable
gain_code – The offset gain adjustment.

Calibration Trigger Data Query

The Calibration Trigger Data Query returns the instrument's trigger calibration settings. A single pair of offset and gain calibration codes are used to compensate for all ranges and input paths. The <zero_code> is the offset correction. 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 65,535
<gain_code>	Integer	0 to 65,535

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 correction.
gain_code – The full scale adjustment.

Calibration External Data Query

The Calibration External Data Query returns the instrument's external input trigger calibration settings. The <zero_code> is the offset correction. 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 65,535
<gain_code>	Integer	0 to 65,535

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 correction.
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 65,535

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.

Calibration Reference Frequency Query

The Calibration Reference Frequency Query returns the frequency of the instrument’s reference clock code.

Class Driver Call

ZT_ERROR ztscopeM_calibrate_reference_frequency_query (ZT_HANDLE instr_handle, U32 *ref_frequency)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

ref_frequency – Frequency of the reference clock on the instrument.

Calibration Impedance Data Query

The Calibration Impedance Data Query returns the instrument's impedance calibration gain code. The calibration settings are dependant on the current input impedance.

SCPI

Command Syntax

None

Query Syntax

CALibration:INPut<n>:DATA? → <gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<gain_code>	Integer	0 to 65,535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_impedance_data_query (ZT_HANDLE instr_handle, s32 input_channel, u16 *path_gain_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
input_channel – The input channel of interest.

Outputs:

gain_code – Input impedance full scale range adjustment code.

Calibration Input Data Query

The Calibration Input Data Query returns the instrument's input path calibration settings. The calibration settings are dependant on the current coupling, impedance, and filter settings.

SCPI

Command Syntax

None

Query Syntax

CALibration:INPut<n>:DATA? → <path_offset_code>, <path_gain_code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<path_offset_code>	Integer	0 to 65,535
<path_gain_code>	Integer	0 to 65,535

Class Driver Call

ZT_ERROR ztscopeM_calibrate_input_data_query (ZT_HANDLE instr_handle,
s32 input_channel,
u16 *path_offset_code,
u16 *path_gain_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
input_channel – The input channel of interest.

Outputs:

path_offset_code – Input path offset correction code.
path_gain_code – Input path full scale range adjustment code.

Calibration Range Data Query

The Calibration Range Data Query returns the instrument's range calibration settings. The calibration settings are dependant on the current nominal range. There are thirty-four nominal ranges.

SCPI

Command Syntax

CALibration:RANGe<n>:DATA? → <zero_code>, <offset_code>

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
<zero_code>	Integer	0 to 65,535
<gain_code>	Integer	0 to 65,535

Class Driver Call

```
ZT_ERROR ztscopeM_calibrate_range_data_query (ZT_HANDLE instr_handle,
                                              s32 input_channel,
                                              u16 *zero_code,
                                              u16 *gain_code);
```

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.
input_channel – The input channel being calibrated.

Outputs:

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

Calibration Skew Query

The Calibration Skew Query performs an internal baseline measurement for channel to channel skew. The query returns the skew in picoseconds for each channel relative to Channel 1 using the internal fiducial signals.

SCPI

Command Syntax

CALibration:SKEW? → <ch1_skew>, <ch2_skew>,<ch3_skew>,<ch4_skew>

Query Syntax

None

Parameters

Name	Type	Range
< ch_x_skew >	Integer	-500 to 500

Class Driver Call

ZT_ERROR ztscopeM_calibrate_skew_query (ZT_HANDLE instr_handle,
s16 align_score[]);

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.

Outputs:

ch_x_skew – The amount of internal skew relative to channel 1 in picoseconds.

Calibration Delay Command and Query

The Calibration Delay Command and Query sets and returns the external skew compensation for channel to channel alignment.

SCPI

Command Syntax

CALibration:DELay<n>:CODE #HBEAD,<code>

Query Syntax

CALibration: DELay<n>:CODE? → <code>

Parameters

Name	Type	Range
<n>	Discrete	1 Input Channel 1 2 Input Channel 2 3 Input Channel 3 4 Input Channel 4
<code>	Signed Integer	-1 to 1

Class Driver Call

ZT_ERROR ztscopeM_calibrate_delay_code (ZT_HANDLE instr_handle,
s32 input channel
s16 code);

ZT_ERROR ztscopeM_calibrate_delay_code_query (ZT_HANDLE instr_handle,
s32 input channel
s16 *code);

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.
input_channel – The input channel being calibrated.
code – The desired amount of external skew.

Outputs:

code – The desired amount of external skew.

Validation Tests

Impedance Validation

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

Procedure:
1. Reset the instrument.
2. Set the instrument channel and impedance 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)	Minimum Acceptable Impedance (Ohms)	Maximum Acceptable Impedance (Ohms)
1 - 4	50	49.5	50.5
	1M	9.9E+05	1.01E+06
External Input	50	49	51
	1M	9.80E+05	1.02E+06

Table 2.1: Impedance Test Setup and Tolerances

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	Normal
Trigger Mode	Automatic
Trigger Source	External Input
Trigger Level	1.0 V
Trigger Polarity	Rising Edge
Sample Points	100 k
Sample Rate	50 MS/s
Sample Time	2 ms
Offset Time	1 ms
Offset	0.0 V
Coupling	DC
Impedance	1MOhm
Input Filter	Bypass
Attenuation	1.0

Table 2.2: 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:

Channel	Range (V)	Applied Voltage (V)	Minimum Average Value (V)	Maximum Average Value (Vavg)
	0.024	0.0096	0.00936	0.00984
		-0.0096	-0.00984	-0.00936
	0.032	0.0128	0.01248	0.01312
		-0.0128	-0.01312	-0.01248
	0.480	0.1920	0.18720	0.19680
		-0.1920	-0.19680	-0.18720
	0.560	0.2240	0.21840	0.22960
		-0.2240	-0.22960	-0.21840
	0.072	0.0288	0.02808	0.02952
		-0.0288	-0.02952	-0.02808
	0.088	0.0352	0.03432	0.03608
		-0.0352	-0.03608	-0.03432
	0.112	0.0448	0.04368	0.04592
		-0.0448	-0.04592	-0.04368
	0.144	0.0576	0.05616	0.05904
		-0.0576	-0.05904	-0.05616
	0.176	0.0704	0.06864	0.07216
		-0.0704	-0.07216	-0.06864
	0.224	0.0896	0.08736	0.09184
		-0.0896	-0.09184	-0.08736
	0.280	0.1120	0.10920	0.11480
		-0.1120	-0.11480	-0.10920
	0.352	0.1408	0.13728	0.14432
		-0.1408	-0.14432	-0.13728
	0.448	0.1792	0.17472	0.18368
		-0.1792	-0.18368	-0.17472
	0.560	0.2240	0.21840	0.22960
		-0.2240	-0.22960	-0.21840
	0.704	0.2816	0.27456	0.28864
		-0.2816	-0.28864	-0.27456
	0.896	0.3584	0.34944	0.36736
		-0.3584	-0.36736	-0.34944
	1.120	0.4480	0.43680	0.45920
		-0.4480	-0.45920	-0.43680
	1.408	0.5632	0.54912	0.57728
		-0.5632	-0.57728	-0.54912
	1.776	0.7104	0.69264	0.72816
		-0.7104	-0.72816	-0.69264
	2.232	0.8928	0.87048	0.91512
		-0.8928	-0.91512	-0.87048
	2.816	1.1264	1.09824	1.15456
		-1.1264	-1.15456	-1.09824
	3.544	1.4176	1.38216	1.45304
		-1.4176	-1.45304	-1.38216

Channel	Range (V)	Applied Voltage (V)	Minimum Average Value (V)	Maximum Average Value (Vavg)
	4.456	1.7824	1.73784	1.82696
		-1.7824	-1.82696	-1.73784
	5.608	2.2432	2.18712	2.29928
		-2.2432	-2.29928	-2.18712
	7.064	2.8256	2.75496	2.89624
		-2.8256	-2.89624	-2.75496
	8.896	3.5584	3.46944	3.64736
		-3.5584	-3.64736	-3.46944
	11.192	4.4768	4.36488	4.58872
		-4.4768	-4.58872	-4.36488
	14.096	5.6384	5.49744	5.77936
		-5.6384	-5.77936	-5.49744
	17.744	7.0976	6.92016	7.27504
		-7.0976	-7.27504	-6.92016
	22.336	8.9344	8.71104	9.15776
		-8.9344	-9.15776	-8.71104
	28.112	11.2448	10.96368	11.52592
		-11.2448	-11.52592	-10.96368
	35.400	14.1600	13.80600	14.51400
		-14.1600	-14.51400	-13.80600
	44.560	17.8240	17.37840	18.26960
		-17.8240	-18.26960	-17.37840

Table 2.3: Range Setup and Tolerances

Input Path Validation

Specification: <1% of Full Scale Range

Procedure:

1. Disconnect all cables from the instrument.
2. Reset the instrument.
3. Disable the instrument channels which will not be tested.
4. Enter the following settings for each test.

Setup Item	Setting
Acquisition Type	Normal
Sample Points	10 k
Trigger Mode	Automatic
Trigger Level	0.0 V
Range	5.608 Vpp
Offset	0.0 V
Attenuation	1.0

Table 2.4: Input Path Validation Settings

1. Use the experiment table below to determine the remaining instrument settings.
2. Using an AC signal source to apply the signal specified in the experiment table.
3. Capture a waveform. Measure the AC RMS value of the waveform.
4. Verify that the measured value is within the tolerance specified by the experiment table.

Experiment Table:

Trigger Source & Test Channel	Impedance (Ohms)	Signal Frequency & Power	Sweep Time & Offset Time	Coupling	Filter	Minimum Measured Voltage (mVrms)	Maximum Measured Voltage (mVrms)
1 - 4	1MOhm	10kHz 10dBm	10 ms 5 ms	DC	Bypass	699.0	715.3
					Low Pass	699.0	715.3
				AC LFR	Bypass	699.0	715.3
					Low Pass	699.0	715.3
				AC	Bypass	699.0	715.3
					Low Pass	699.0	715.3
	50Ohm	15MHz 13dBm	10 µs 5 µs	DC	Bypass	916.2	1028.0
					Low Pass	916.2	1028.0
				AC LFR	Bypass	916.2	1028.0
					Low Pass	916.2	1028.0
				AC	Bypass	916.2	1028.0
					Low Pass	916.2	1028.0

Table 2.5: Input Path Setup and Tolerances

Offset Validation

Specification: < ±(1% full scale range + 1% offset + 1 mV) @ +25 °C (50 Ω)
< ±(1% full scale range + 1% offset + 5 mV) @ +25 °C (1 MΩ)

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	32
Trigger Mode	Automatic
Trigger Source	External Input
Trigger Level	1.0 V
Trigger Polarity	Rising Edge
Sample Points	100 k
Sample Rate	1 GS/s
Sample Time	100 µs
Offset Time	50 µs
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 the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Coupling	Filter	Impedance (Ohms)	Range (V)	Offset (V)	Min. Average Value (V)	Max. Average Value (V)
1 - 4	DC	Bypass	50	0.008	0.0032	-0.001112	0.001112
					-0.0032	-0.001112	0.001112
				0.016	0.0064	-0.001224	0.001224
					-0.0064	-0.001224	0.001224
				0.024	0.0096	-0.001336	0.001336
					-0.0096	-0.001336	0.001336
				0.032	0.0128	-0.001448	0.001448
					-0.0128	-0.001448	0.001448

Channel	Coupling	Filter	Impedance (Ohms)	Range (V)	Offset (V)	Min. Average Value (V)	Max. Average Value (V)
				0.048	0.0192	-0.001672	0.001672
					-0.0192	-0.001672	0.001672
				0.056	0.0224	-0.001784	0.001784
					-0.0224	-0.001784	0.001784
				0.072	0.0288	-0.002008	0.002008
					-0.0288	-0.002008	0.002008
				0.088	0.0352	-0.002232	0.002232
					-0.0352	-0.002232	0.002232
				0.112	0.0448	-0.002568	0.002568
					-0.0448	-0.002568	0.002568
				0.144	0.0576	-0.003016	0.003016
					-0.0576	-0.003016	0.003016
				0.176	0.0704	-0.003464	0.003464
					-0.0704	-0.003464	0.003464
				0.224	0.0896	-0.004136	0.004136
					-0.0896	-0.004136	0.004136
				0.28	0.112	-0.00492	0.00492
					-0.112	-0.00492	0.00492
				0.352	0.1408	-0.005928	0.005928
					-0.1408	-0.005928	0.005928
				0.448	0.1792	-0.007272	0.007272
					-0.1792	-0.007272	0.007272
				0.56	0.224	-0.00884	0.00884
					-0.224	-0.00884	0.00884
				0.704	0.2816	-0.010856	0.010856
					-0.2816	-0.010856	0.010856
				0.896	0.3584	-0.013544	0.013544
					-0.3584	-0.013544	0.013544
				1.12	0.448	-0.01668	0.01668
					-0.448	-0.01668	0.01668
				1.408	0.5632	-0.020712	0.020712
					-0.5632	-0.020712	0.020712
				1.776	0.7104	-0.025864	0.025864
					-0.7104	-0.025864	0.025864
				2.232	0.8928	-0.032248	0.032248
					-0.8928	-0.032248	0.032248
				2.816	1.1264	-0.040424	0.040424
					-1.1264	-0.040424	0.040424
				3.544	1.4176	-0.050616	0.050616
					-1.4176	-0.050616	0.050616
				4.456	1.7824	-0.063384	0.063384
					-1.7824	-0.063384	0.063384
				5.608	2.2432	-0.079512	0.079512
					-2.2432	-0.079512	0.079512
				7.064	2.8256	-0.099896	0.099896

Channel	Coupling	Filter	Impedance (Ohms)	Range (V)	Offset (V)	Min. Average Value (V)	Max. Average Value (V)
					-2.8256	-0.099896	0.099896
				8.896	3.5584	-0.125544	0.125544
					-3.5584	-0.125544	0.125544
				11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
				14.096	5.6384	-0.198344	0.198344
					-5.6384	-0.198344	0.198344
				17.744	7.0976	-0.249416	0.249416
					-7.0976	-0.249416	0.249416
				22.336	8.9344	-0.313704	0.313704
					-8.9344	-0.313704	0.313704
				28.112	11.2448	-0.394568	0.394568
					-11.2448	-0.394568	0.394568
				35.4	14.16	-0.4966	0.4966
					-14.16	-0.4966	0.4966
				44.56	17.824	-0.62484	0.62484
					-17.824	-0.62484	0.62484
			1M	0.008	0.0032	-0.001112	0.001112
					-0.0032	-0.001112	0.001112
				0.016	0.0064	-0.001224	0.001224
					-0.0064	-0.001224	0.001224
				0.024	0.0096	-0.001336	0.001336
					-0.0096	-0.001336	0.001336
				0.032	0.0128	-0.001448	0.001448
					-0.0128	-0.001448	0.001448
				0.048	0.0192	-0.001672	0.001672
					-0.0192	-0.001672	0.001672
				0.056	0.0224	-0.001784	0.001784
					-0.0224	-0.001784	0.001784
				0.072	0.0288	-0.002008	0.002008
					-0.0288	-0.002008	0.002008
				0.088	0.0352	-0.002232	0.002232
					-0.0352	-0.002232	0.002232
				0.112	0.0448	-0.002568	0.002568
					-0.0448	-0.002568	0.002568
				0.144	0.0576	-0.003016	0.003016
					-0.0576	-0.003016	0.003016
				0.176	0.0704	-0.003464	0.003464
					-0.0704	-0.003464	0.003464
				0.224	0.0896	-0.004136	0.004136
					-0.0896	-0.004136	0.004136
				0.28	0.112	-0.00492	0.00492
					-0.112	-0.00492	0.00492
				0.352	0.1408	-0.005928	0.005928
					-0.1408	-0.005928	0.005928

Channel	Coupling	Filter	Impedance (Ohms)	Range (V)	Offset (V)	Min. Average Value (V)	Max. Average Value (V)
				0.448	0.1792	-0.007272	0.007272
					-0.1792	-0.007272	0.007272
				0.56	0.224	-0.00884	0.00884
					-0.224	-0.00884	0.00884
				0.704	0.2816	-0.010856	0.010856
					-0.2816	-0.010856	0.010856
				0.896	0.3584	-0.013544	0.013544
					-0.3584	-0.013544	0.013544
				1.12	0.448	-0.01668	0.01668
					-0.448	-0.01668	0.01668
				1.408	0.5632	-0.020712	0.020712
					-0.5632	-0.020712	0.020712
				1.776	0.7104	-0.025864	0.025864
					-0.7104	-0.025864	0.025864
				2.232	0.8928	-0.032248	0.032248
					-0.8928	-0.032248	0.032248
				2.816	1.1264	-0.040424	0.040424
					-1.1264	-0.040424	0.040424
				3.544	1.4176	-0.050616	0.050616
					-1.4176	-0.050616	0.050616
				4.456	1.7824	-0.063384	0.063384
					-1.7824	-0.063384	0.063384
				5.608	2.2432	-0.079512	0.079512
					-2.2432	-0.079512	0.079512
				7.064	2.8256	-0.099896	0.099896
					-2.8256	-0.099896	0.099896
				8.896	3.5584	-0.125544	0.125544
					-3.5584	-0.125544	0.125544
				11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
				14.096	5.6384	-0.198344	0.198344
					-5.6384	-0.198344	0.198344
				17.744	7.0976	-0.249416	0.249416
					-7.0976	-0.249416	0.249416
				22.336	8.9344	-0.313704	0.313704
					-8.9344	-0.313704	0.313704
				28.112	11.2448	-0.394568	0.394568
					-11.2448	-0.394568	0.394568
				35.4	14.16	-0.4966	0.4966
					-14.16	-0.4966	0.4966
				44.56	17.824	-0.62484	0.62484
					-17.824	-0.62484	0.62484
		Low Pass	50	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
			1M	11.192	4.4768	-0.157688	0.157688

Channel	Coupling	Filter	Impedance (Ohms)	Range (V)	Offset (V)	Min. Average Value (V)	Max. Average Value (V)
					-4.4768	-0.157688	0.157688
	AC LFR	Bypass	50	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
			1M	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
		Low Pass	50	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
			1M	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
	AC	Bypass	50	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
			1M	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
		Low Pass	50	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688
			1M	11.192	4.4768	-0.157688	0.157688
					-4.4768	-0.157688	0.157688

Table 2.7: Offset Setup and Tolerances

Noise Validation

Specification: ≤ (0.5% of full scale range + 350 µV) (50Ω Full Bandwidth)
≤ (0.5% of full scale range + 75 µV) (50Ω + 30 MHz Filter)
≤ (0.5% of full scale range + 350 µV) (1MΩ Full Bandwidth)
≤ (0.5% of full scale range + 125 µV) (1MΩ + 30 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	1.0 V
Trigger Polarity	Rising Edge
Sample Points	1 M
Sample Rate	1 GS/s
Sample Time	1 ms
Offset Time	0 ms
Coupling	DC
Attenuation	1.0
Offset	0.0 V

Table 2.8: 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.

Experiment Table:

Channel	Filter	Impedance (Ohms)	Range (Vpp)	Maximum Measured Value (Vrms)
1 - 4	Bypass	50	0.352	0.00211
			1.176	0.00623
			8.896	0.04483
			44.56	0.22315
		1M	0.352	0.00211
			1.176	0.00623
			8.896	0.04483
			44.56	0.22315
	Low Pass	50	0.352	0.001835
			1.176	0.005955
			8.896	0.44555
			44.56	0.222875
		1M	0.352	0.001885
			1.176	0.006005
			8.896	0.044605
			44.56	0.222925

Table 2.9: Noise Setup and Tolerances

External Input Trigger Level Validation

Specification: ±20mV

Procedure:

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

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Normal
Sample Points	1 k
Sample Rate	1 GS/s
Sample Time	1 µs
Offset Time	500 ns
Offset	0.0 V
Attenuation	1.0
Coupling	DC
Filter	Bypass
Impedance	50 Ohm

Table 2.10: External Input Validation Settings

3. Use a voltage source to sweep voltage from 0.75 V to 1.5 V in 1.5 mV steps for the positive trigger level and from -0.75 V to -1.5 V for the negative trigger level.
4. Verify the instrument triggers and capture the input voltage level.
5. Verify the input voltage is within the tolerances specified below by the External Input Setup and Tolerances table.

Experiment Table:

Trigger Source & Channel	Trigger Level (V)	Trigger Polarity	Min. Measured Value (V)	Max. Measured Value (V)
External Input	1.00	Rising edge	0.98	1.02
	-1.00	Falling Edge	-1.02	-0.98

Table 2.11: External Input Setup and Tolerances

Internal 10MHz Clock Validation

Specification: ±2.5ppm 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	10 k
Sample Time	1 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 V
Channel 1 Coupling	DC
Channel 1 Impedance	50 Ohm
Channel 1 Filter	Bypass
Channel 1 Attenuation	1.0
External Output	Enabled
External Output Source	Reference Event
External Output Polarity	Positive

Table 2.12: 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 2.13: 10MHz Clock Validation Tolerances

AC Coupling Validation

Specification: AC Coupling: 90Hz High pass (1MΩ)
1.8MHz High pass (50Ω)

AC Low Frequency Reject: 450Hz High pass (1MΩ)
9MHz High pass (50Ω)

Procedure:

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

Setup Item	Setting
Acquisition Type	Normal
Trigger Mode	Automatic
Sample Points	10 k
Offset Time	0 s
Range	2.00 Vpp
Offset	0.0 V
Filter	Bypass
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.14: 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	Coupling	Sample Rate (S/s)	Sample Time (s)	Signal Frequency (Hz)	Min Measured Value (mVrms)	Max Measured Value (mVrms)
1 - 4	AC	1.0E+9	10.0E-6	10.0E+6	530.3	595.0
		100.0E+6	100.0E-6	1.0E+6	354.4	500.6
		100.0E+3	100.0E-3	100.0E+3	50.1	89.0
	AC LFR	1.0E+9	10.0E-6	10.0E+6	530.3	595.0
		100.0E+6	100.0E-6	1.0E+6	99.9	141.1
		100.0E+3	100.0E-3	100.0E+3	10.0	17.8

Table 2.15: AC Coupling Setup and Tolerances

Trigger Level Validation

Specification: ±(2% full scale + 5mV + 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	1000
Sample Rate	2 GS/s
Sample Time	500 ns
Offset Time	250 ns
Range	2 Vpp
Impedance	1MOhm
Offset	0.0 V
Coupling	DC
Filter	Bypass
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.16: 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 6dBm signal 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	Trigger Polarity	Trigger Level	Minimum Average Value (V)	Maximum Average Value (V)
1 - 4	Rising Edge	0.5	0.434	0.566
	Falling Edge	-0.5	-0.566	-0.434

Table 2.17: Trigger Level Setup and Tolerances

Trigger Bandwidth Validation

Specification: DC to 500MHz, minimum (Channels 1 - 4)
DC to 250MHz, minimum (External Input)

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
Trigger Polarity	Rising Edge
Sample Points	1 k
Sample Rate	1 GS/s
Sample Time	1 μs
Offset Time	0.0
Range	5 Vpp
Offset	0.0
Coupling	DC
Impedance	50 Ohm
Filter	Bypass
Attenuation	1.0

Table 2.18: 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
			10E+06	5.0
			100E+06	5.0
			250E+06	5.0
			400E+06	5.0
External Input	N/A	0.1	10E+06	-8.0
			100E+06	-8.0
			250E+06	-5.0

Table 2.19: Trigger Bandwidth Setup

Range Bandwidth Validation

Specification: 50Ohm: DC to 500MHz typical (-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	10 k
Offset Time	0.0 s
Offset	0.0 V
Coupling	DC
Filter	Bypass
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.20: 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	Range (Vpp)	Signal Power (dBm)	Signal Frequency (Hz)	Sample Rate (S/s)	Minimum Measured Value (Vrms)	Maximum Measured Value (Vrms)
1 - 4	11.192	-8	1.00E+04	2.000E+05	0.0865	0.0916
			1.01E+06	5.000E+07	0.0840	0.0943
			3.01E+07	5.000E+08	0.0793	0.0999
			1.01E+08	1.000E+09	0.0793	0.0999
			2.01E+08	2.000E+09	0.0793	0.0999
			3.01E+08	2.000E+09	0.0630	0.1121
			5.01E+08	2.000E+09	0.0630	0.1121
	4.456	0	1.00E+04	2.000E+05	0.2173	0.2301
			1.01E+06	5.000E+07	0.2111	0.2369
			3.01E+07	5.000E+08	0.1993	0.2509
			1.01E+08	1.000E+09	0.1993	0.2509
			2.01E+08	2.000E+09	0.1993	0.2509
			3.01E+08	2.000E+09	0.1583	0.2815
			5.01E+08	2.000E+09	0.1583	0.2815
	0.896	13	1.00E+04	2.000E+05	0.9705	1.0280
			1.01E+06	5.000E+07	0.9429	1.0580
			3.01E+07	5.000E+08	0.8902	1.1207
			1.01E+08	1.000E+09	0.8902	1.1207
			2.01E+08	2.000E+09	0.8902	1.1207
			3.01E+08	2.000E+09	0.7071	1.2574
			5.01E+08	2.000E+09	0.7071	1.2574
	0.352	13	1.00E+04	2.000E+05	0.9705	1.0280
			1.01E+06	5.000E+07	0.9429	1.0580
			3.01E+07	5.000E+08	0.8902	1.1207
			1.01E+08	1.000E+09	0.8902	1.1207
			2.01E+08	2.000E+09	0.8902	1.1207
			3.01E+08	2.000E+09	0.7071	1.2574
			5.01E+08	2.000E+09	0.7071	1.2574

Table 2.21: Range Bandwidth Setup and Tolerances

Filter Bandwidth Validation

Specification: 30 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	1 k
Range	5.0 Vpp
Offset Time	0.0 V
Offset	0.0 V
Coupling	DC
Impedance	50 Ohm
Filter	Low Pass
Attenuation	1.0
Measure Method	Entire Waveform
Measure Edge	1

Table 2.22: Filter Bandwidth Validation Settings

4. Use an AC voltage source to apply a +13dBm signal at the frequency 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 Frequency (Hz)	Sample Rate (S/s)	Minimum Measured Value (Vrms)	Maximum Measured Value (Vrms)
1 – 4	10.0E+3	100.0E+3	0.9761	1.0221
	1.0E+6	50.0E+6	0.9429	1.0580
	30.1E+6	500.0E+6	0.7934	0.9988
	101.0E+6	1.0E+9	0.2236	0.3544

Table 2.23: Filter Bandwidth Setup and Tolerances

Calibration Tests

Skew Calibration

Procedure:

1. Use the ztscopeM_calibrate_delay_code driver function to set all external skew adjustments to zero.
2. Use the ztscopeM_calibrate_skew_query to perform an internal channel alignment and return the internal alignment variation between channels.
3. Reset the instrument.
4. Enter the following settings for each test.

Setup Item	Setting
Sample Points	1000
Sample Rate	2 GS/s
Sample Time	500 ns
Offset Time	250 ns
Acquisition Mode	Normal
Number of Acquisitions	32
Trigger Source	Input 1
Trigger Level	0.5 V
Trigger Slope	Rising Edge
Trigger Mode	Normal
Measure Method	Entire Waveform
Measure Edge	1
Range	2.0 V
Offset	0.5 V
Coupling	DC
Impedance	50Ohm
Filter	Bypass
Attenuation	1.0
Output State	Enable
Output Source	Pulse Event

Setup Item	Setting
Output Polarity	Positive
Output Pulse Mode	Clock
Output Period	1.0 us

Table 3.1: Skew Calibration Settings

5. Connect the instruments external output to all input channels simultaneously using signal Ts and equal length cables.
6. Capture a waveform.
7. Measure the rise crossing time on each channel. (RCTx)
8. Calculate the difference between the rise crossing times for channels 2 – 4 relative to channel 1. (RCT_delta_x = RCT0 – RCTx)
9. Determine the number of samples required for external skew compensation. (Adjx = RCT_delta_x / 500.0e-12)
10. Use the ztscopeM_calibrate_delay_code driver function to set all external skew adjustments to the value calculated in step 9.
11. Reset the instrument.
12. Repeat steps 4 through 8 to verify that the rise crossing times are less than the sample rate resolution. (|RCT_delta_x| < 250 pS)

Internal 10 MHz Calibration

Procedure:

13. Reset the instrument.
14. Connect a precision 10MHz +10dBm signal to the external input of the instrument.
15. Set the reference oscillator source to external.
16. Read the instrument's external reference oscillator DAC code (F_{EXT}) using the ztscopeM_calibrate_reference_frequency_query driver function.
17. Set the reference oscillator source to internal.
    Read the instrument's internal reference oscillator DAC code (F_{INT}) using the ztscopeM_calibrate_reference_frequency_query driver function.
18. Calculate the error by subtracting the measured internal rate from the measured external rate.

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

19. Use the ztscopeM_calibrate_reference_oscillator_adjust function to adjust the codes.
20. 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.
2. Perform an input range calibration immediately following an internal 10MHz calibration.

Range Calibration

Procedure:

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

Setup Item	Setting
Sample Points	100 k
Sample Rate	50 MS/s
Sample Time	2 ms
Offset Time	1 ms
Acquisition Mode	Average
Number of Acquisitions	32
Trigger Source	External Input
Trigger Level	1.0
Trigger Slope	Rising Edge
Trigger Mode	Automatic
Measure Method	Entire Waveform
Measure Edge	1
Offset	0.0 V
Coupling	DC
Impedance	1MOhm
Filter	Bypass
Attenuation	1.0

Table 3.2: Range Calibration Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Use the ztscopeM_calibrate_adc_set_code driver function to set the ADC gain code to a default value of 32,768 (or 0x8000).
6. Using a DC voltage source apply the positive voltage specified in the experiment table. (Va)
7. Capture a waveform. Measure the average of the waveform (Vpos).
8. Using a DC voltage source apply the negative voltage specified in the experiment table. (-Va)
9. Capture a waveform. Measure the average of the waveform (Vneg).
10. Calculate the gain error.

    Gain Error = (Va - -Va)/(Vpos – Vneg)
11. Use the ztscopeM_calibrate_range_adjust function to adjust the gain code and correct for the error.
12. Repeat steps 4 through 11 for each range specified in the experiment table below.
13. Set the input range to 5.608Vpp with 1MOhm input impedance.

14. Use the ztscopeM_calibrate_adc_set_code driver function to set the ADC gain code to a default value of 32,768 (or 0x8000).
15. Using a DC voltage source apply a 2.432V positive voltage (Va) to the input
16. Capture a waveform. Measure the average of the waveform (Vpos_1M).
17. Using a DC voltage source apply a -2.432V positive voltage (-Va) to the input
18. Capture a waveform. Measure the average of the waveform (Vneg_1M).
19. Set the input range to 5.608Vpp with 50Ohm input impedance.
20. Calculate the 1MOhm gain error as shown below.

    1MOhm Gain Error = (Vpos_1M – Vneg_1M) / (Va - -Va)
21. Use the ztscopeM_calibrate_adc_set_code driver function to set the ADC gain code to a default value of 32,768 (or 0x8000).
22. Using a DC voltage source apply a 2.432V positive voltage (Va) to the input
23. Capture a waveform. Measure the average of the waveform (Vpos_50).
24. Using a DC voltage source apply a -2.432V positive voltage (-Va) to the input
25. Capture a waveform. Measure the average of the waveform (Vneg_50).
26. Calculate the 50Ohm gain error as shown below.

    50Ohm Gain Error = (Vpos_50 – Vneg_50) / (Va - -Va)
27. Calculate the impedance gain error as shown below.

    Impedance Gain Error = 1MOhm Gain Error / 50Ohm Gain Error
28. Use the ztscopeM_calibrate_impedance_adjust function to adjust the gain code and correct for the error.

Experiment Table:

Channel	Range (V)	Positive Applied Value (Va)	Negative Applied Value (-Va)
	0.024	0.0096	-0.0096
	0.032	0.0128	-0.0128
	0.048	0.0192	-0.0192
	0.056	0.0224	-0.0224
	0.072	0.0288	-0.0288
	0.088	0.0352	-0.0352
	0.112	0.0448	-0.0448
	0.144	0.0576	-0.0576
	0.176	0.0704	-0.0704
	0.224	0.0896	-0.0896
	0.28	0.112	-0.112
	0.352	0.1408	-0.1408
	0.448	0.1792	-0.1792
	0.56	0.224	-0.224
	0.704	0.2816	-0.2816
	0.896	0.3584	-0.3584
	1.12	0.448	-0.448
	1.408	0.5632	-0.5632
	1.776	0.7104	-0.7104
	2.232	0.8928	-0.8928
	2.816	1.1264	-1.1264
	3.544	1.4176	-1.4176
	4.456	1.7824	-1.7824

	5.608	2.2432	-2.2432
	7.064	2.8256	-2.8256
	8.896	3.5584	-3.5584
	11.192	4.4768	-4.4768
	14.096	5.6384	-5.6384
	17.744	7.0976	-7.0976
	22.336	8.9344	-8.9344
	28.112	11.2448	-11.2448
	35.4	14.16	-14.16
	44.56	17.824	-17.824

Table 3.3: Range Calibration Setup

Implementation Notes:

1. Each range 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. 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.
3. Perform an internal automatic calibration immediately following a range calibration.

Input Path Calibration

Procedure:

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

Setup Item	Setting
Sample Points	10 k
Sample Rate	1 MS/s
Sample Time	10 ms
Offset Time	5 ms
Acquisition Mode	Normal
Trigger Level	0.0 V
Trigger Slope	Rising Edge
Trigger Mode	Automatic
Measure Method	Entire Waveform
Measure Edge	1
Range	5.608 Vpp
Offset	0.0 V
Attenuation	1.0

Table 3.4: Input Path Calibration Settings

4. Using an AC source to apply a 10kHz, 10dBm signal to the channel being calibrated.
5. Capture a waveform. Measure the AC RMS of the waveform (Vreference), this will be reference value for all other settings.
6. Use the experiment table below to determine the changes to the input path settings.
7. Capture a waveform. Measure the average of the waveform (Vmeasured).
8. Calculate the gain error.

   Gain Error = Vreference / Vmeasured
9. Use the ztscopeM_calibrate_input_adjust function to adjust the input path gain code to correct for the measured error.
10. Repeat steps 6 to 9 for each input path specified in the experiment table below.

Experiment Table:

Channel & Trigger Source	Coupling	Filter	Impedance (Ohms)
1-4	DC	Bypass	1M
		Low Pass	1M
	AC	Bypass	1M
		Low Pass	1M
	AC-LFR	Bypass	1M
		Low Pass	1M

Table 3.5: Input Path Calibration Setup

Implementation Notes:

1. Perform an input trigger level calibration immediately following an input path calibration.

Input Trigger Calibration

Procedure:

11. Reset the instrument.
12. Disable all channels not being tested.
13. Enter the following settings for each test.

Setup Item	Setting
Sample Points	1 k
Sample Rate	2 GS/s
Sample Time	500 ns
Offset Time	250 ns
Acquisition Mode	Average
Trigger Mode	Normal
Measure Method	Entire Waveform
Measure Edge	1
Range	1.776 Vpp
Offset	0.0 V
Attenuation	1.0

Table 3.6: Input Trigger Calibration Settings

14. Use the experiment table below to determine the remaining instrument settings.
15. Use an AC voltage source to apply a 100 Hz 6dBm signal to the channel being tested.
16. With the instrument set for a rising edge trigger at 0.0V capture a waveform. Measure the average value of the waveform (Vmeas_rise).
17. With the instrument set for a falling edge trigger at 0.0V capture a waveform. Measure the average value of the waveform (Vmeas_fall).
18. Calculate the voltage error for the zero trigger level as shown

    Voltage Error = (Vmeas_rise – Vmeas_fall)/ 2.0
19. Use the ztscopeM_calibrate_trigger_zero_adjust driver cal to adjust the trigger zero code for the measured error.
20. Repeat steps 16 through 19 until the voltage error is less than 0.1% of the range (or 1.776mV).
21. With the instrument set for a rising edge trigger at 0.444V capture a waveform. Measure the average value of the waveform (Vmeas_high_rise).
22. With the instrument set for a falling edge trigger at 0.444V capture a waveform. Measure the average value of the waveform (Vmeas_high_fall).
23. With the instrument set for a rising edge trigger at -0.444V capture a waveform. Measure the average value of the waveform (Vmeas_low_rise).
24. With the instrument set for a falling edge trigger at -0.444V capture a waveform. Measure the average value of the waveform (Vmeas_low_fall).
25. Calculate the gain error for the trigger level as shown

Gain Error = Vtrig / ((Vmeas_high_rise + Vmeas_high_fall – Vmeas_low_rist – Vmeas_low_fall)/ 4.0)

26. Use the ztscopeM_calibrate_trigger_gain_adjust driver cal to adjust the trigger gain code for the measured error.
27. Repeat steps 21 through 26 until the gain error is less than 0.1% of the range.

Implementation Notes:

1. Each code should converge to an acceptable value within 10 iterations of the process.
2. Perform an external trigger level calibration immediately following an input path calibration.

External Trigger Level Calibration

Procedure:

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

Setup Item	Setting
Acquisition Mode	Normal
Sample Points	1 k
Sample Rate	1 GS/s
Sample Time	1 µs
Offset Time	0.0
Trigger Mode	Normal
Trigger Source	External Input
Trigger Impedance	50 Ohms

Table 3.7: External Trigger Level Calibration Settings

3. Use the External Trigger Level Calibration Setup and Tolerances Experiment Table below to determine the remaining instrument settings.
4. Set the instrument to capture a waveform asynchronously on a rising 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_H).
8. Send an abort command to the instrument.
9. Set the instrument to capture a waveform asynchronously on a falling 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_L).
13. Send an abort command to the instrument.
14. Calculate the gain error by subtracting the average signal voltage at which the instrument triggered from one.

$$\text{gain\_error} = 1 - \frac{V_H - V_L}{2}$$

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	Rising Edge	0.50	1.560E-03
	-1.0	Falling Edge	-0.50	-1.560E-03

Table 3.8: External Trigger Level 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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