M-Class Waveform Generator Calibration Manual

Models ZT5211, ZT5212

User's Manual: 0004-000075
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Contact

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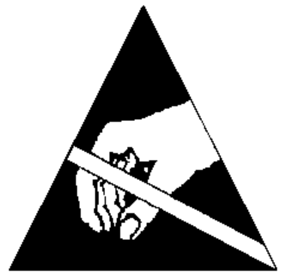

Handling Precautions for Electronic Devices Subject to Damage by Static Electricity

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	6-9-09	All	Initial Release
1A	12-7-2009	API	Corrections, added SCPI syntax

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Test Setup

Environment

Validation and adjustment of the ZT5210 should be done under the following conditions.

Operating Conditions	
Ambient temperature	20^{o}C to 30^{o}C
Humidity	5 to 95%, non-condensing, up to +30 °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	Bandwidth: 3 Hz to 300 kHz 1000V Range Accuracy: 0.06% basic acV
Spectrum Analyzer	Bandwidth: 1kHz – 1GHz Signal measurement -128dBm to 30dBm
DC Source Measurement Unit	4 Wire Sense Mode 200V Range Accuracy: ± 0.02% of range RMS Noise: 200.0mV < 500µV 2.0V < 1.8mV 20.0V < 20mV 200.0V < 150mV
AC Voltage Source	Frequency Range 1Hz to 1.2GHz Output Power -127dBm to +13dBm Harmonics: less than -35dBc

Table 1.2: Recommended Equipment

Validation Tests

The validation tests described in this document will validate the performance the ZT5210. The tests can be performed in any order. The ZT5210 Validation Checklist spreadsheet has been provided in which to record test results.

The External In Trigger Level, Internal 10MHz Clock, DC Offset and Gain test validate calibrated components. The instrument calibration procedures defined in this document can be used to correct for variation in the components over time.

The RMS Noise, Filter Bandwidth, Harmonics and Distortion 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 ZT5210. 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.

The Internal 10MHz calibration should be performed prior to the External Zero and External Level calibrations. The Filter Zero calibration followed by the Filter Gain adjust should be followed by the Offset and Gain calibrations.

The ZT5210 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 ZT5210. Calibration commands are provided by their SCPI syntax as well as their class driver call.

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 ztwaveM_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 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 ztwaveM_calibrate_external_adjust (ZT_HANDLE instr_handle,
s32 cal_error)**

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

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

Outputs:

None

Calibrate External Zero Command

The Calibrate External Zero Command adjusts the instrument's external trigger calibration zero code settings.

SCPI

Command Syntax

CALibration:EXTernal:ZERO #HFACE,<cal_error>

Query Syntax

None

Parameters

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

Class Driver Call

ZT_ERROR ztwaveM_calibrate_external_zero (ZT_HANDLE instr_handle, s32 cal_error)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

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

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, <error>

Query Syntax

None

Parameters

Name	Type	Range
<n>	Discrete	1 Output Channel 1 2 Output Channel 2 3 Output Channel 3 4 Output Channel 4
<error>	Float	0.0 to 1.0 fraction of full scale

Class Driver Call

ZT_ERROR ztwaveM_calibrate_gain_adjust (ZT_HANDLE instr_handle,
s32 channel,
f64 cal_error)

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 output channel being calibrated.
cal_error – The gain error to correct, fraction of full scale

Outputs:

None

Calibration Gain Voltage Command

The Calibration Gain Adjust Command sets the instrument's gain voltage to measured value. The instrument's programmed output voltage should exactly match the voltage you are attempting to calibrate from the AC Amplitude Calibration table in Appendix A.

SCPI

Command Syntax

CALibration:GAIN<n>:VOLTage #HBEAD, <actual_range>

Query Syntax

None

Parameters

Name	Type	Range	
<n>	Discrete	1	Output Channel 1
		2	Output Channel 2
		3	Output Channel 3
		4	Output Channel 4
<actual_range>	Float	Actual Measured Voltage	

Class Driver Call

ZT_ERROR ztwaveM_calibrate_gain_voltage (ZT_HANDLE instr_handle,
s32 channel,
f64 actual_range)

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 output channel being calibrated.
actual_range – The actual measured voltage.

Outputs:

None

Calibration Gain Voltage Query

The Calibration Gain Adjust Command sets the instrument's gain voltage to measured value. The instrument's programmed output voltage should exactly match the voltage you are attempting to calibrate from the AC Amplitude Calibration table in Appendix A.

SCPI

Command Syntax

CALibration:GAIN<n>:VOLTage? → <actual_range>

Query Syntax

None

Parameters

Name	Type	Range
<n>	Discrete	1 Output Channel 1 2 Output Channel 2 3 Output Channel 3 4 Output Channel 4
<actual_range>	Float	Actual Measured Voltage

Class Driver Call

ZT_ERROR ztwaveM_calibrate_gain_voltage_query (ZT_HANDLE instr_handle,
s32 channel,
f64 *actual_range)

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 output channel being calibrated.

Outputs:

actual_range – The actual measured voltage.

Calibration Gain Offset Adjust Command

The Calibration Gain Offset Adjust Command sets the instrument's offset voltage to the measured value. The instrument's programmed offset voltage should exactly match the voltage you are attempting to calibration from the DC Offset Calibration table in Appendix A.

SCPI

Command Syntax

CALibration:OFFSet<n>:ADJust #HBEAD, <actual_range>

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
<actual_range>	Float	Offset voltage

Class Driver Call

**ZT_ERROR ztwaveM_calibrate_offset_voltage (ZT_HANDLE instr_handle,
s32 channel,
f64 actual_range)**

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 output channel being calibrated.
actual_range – The output offset measured.

Outputs:

None

Calibration Offset Voltage Query

The Calibration Offset Voltage Query returns the instrument’s offset calibration voltage.

SCPI

Command Syntax

CALibration:OFFSet<n>:VOLTage? → <actual_range>

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
<actual_range>	Float	Offset voltage

Class Driver Call

ZT_ERROR ztwaveM_calibrate_offset_voltage_query (ZT_HANDLE instr_handle, s32 channel, f64 *actual_range)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
channel – The output channel being queried.

Outputs:

actual_range – The output offset voltage from the offset calibration breakpoint table.

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 _ZT_FUNC ztwaveM_calibrate_ref_osc_adjust (ZT_HANDLE instr_handle, f64 cal_error)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

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

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 gain scale factor, the ADC balance, the input trigger zero offset, the input trigger gain scale factor, and the external trigger zero offset.

SCPI

Command Syntax
CALibration:RESTore

Query Syntax
None

Parameters
None

Class Driver Call

ZT_ERROR ztwaveM_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

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 ztwaveM_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 Data Query

The Calibration Data Query returns the instrument's calibration settings. This function returns the Gain, Offset, External and Reference Oscillator calibration data.

SCPI

N/a – This function combines several queries

Class Driver Call

```
ZT_ERROR ztwaveM_calibration_data (ZT_HANDLE instr_handle,
                                   s32 channel,
                                   f64 *gain,
                                   u16 *external_gain_code,
                                   s16 *offset_zero_code,
                                   u16 *external_zero_code,
                                   u16 *vcxo_code)
```

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
channel - The output channel being queried.

Outputs:

gain – The instrument's gain code for the current filter setting.
external_gain_code – The instrument's gain code for the external output.
offset_zero_code – The instrument's zero offset adjust for the current filter setting.
external_zero_code – The instrument's zero code of the external output.
vcxo_code – The instrument's reference oscillator adjustment code.

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 ztwaveM_calibration_data_external (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 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 current range, impedance and filter settings.

SCPI

Command Syntax
None

Query Syntax
CALibration:GAIN<n>:DATA? → <gain_code>

Parameters

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

Class Driver Call

ZT_ERROR _ZT_FUNC ztwaveM_calibration_data_gain (ZT_HANDLE instr_handle,
s32 channel,
f64 *gain)

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

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

Outputs:
gain – The gain scale factor required for the current output filter.

Calibration Offset Data Query

The Calibration Offset Data Query returns the instrument's offset calibration settings. The <zero_code> is the full scale adjustment. Calibration settings depend on current output filter settings.

SCPI

Command Syntax

None

Query Syntax

CALibration:OFFSet<n>:DATA? → <zero_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

Class Driver Call

ZT_ERROR _ZT_FUNC ztwaveM_calibration_data_offset (ZT_HANDLE instr_handle,
s32 channel,
s16 *zero_code)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.
channel – The output channel being queried.

Outputs:

zero_code – The zero offset correction for the current output filter.

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 ztwaveM ztwaveM_calibration_data_rosc (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 Date Query

The Calibration Date Query returns the date instrument was last calibrated at the factory.

SCPI

Command Syntax

None

Query Syntax

CALibration:DATE? → <month>,<day>,<year>

Parameters

Name	Type	Range
<month>	Integer	1-12
<day>	Integer	1-31
<year>	Integer	0-65,535c.e.

Class Driver Call

ZT_ERROR ztwaveM ztwaveM_calibration_date (ZT_HANDLE instr_handle,
u16 *month,
u16 *day,
u16 *year)

Returns:

ZT_SUCCESS if command succeeds.
ZT_FAILURE if command fails.

Inputs:

instr_handle – The handle to the instrument being calibrated.

Outputs:

month – Month of the last factory calibration.
day – Day of the last factory calibration.
year – Year of the last factory calibration.

Validation Tests

Impedance Validation

Specification: ± 2% (External Input)

Procedure:

1. Reset the instrument.
2. Set the instrument external input 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)
External Input	50	49	51
	1M	9.80E+05	1.02E+06

Table 2.1: Impedance Test Setup and Tolerances

Offset Validation

Specification: < ±(0.5% of offset Setting + 2 mV)

Procedure:

1. Disconnect all cables from the output channels.
2. Reset the instrument.
3. Disable all channels that are not being tested.
4. Enter the following settings for each test.

Setup Item	Setting
Operation Mode	Continuous
Function Shape	DC

Table 2.2: Offset Validation Settings

5. Use the experiment table below to determine the remaining settings of the instrument.
6. Using a DMM to measure the offset voltage into a high impedance load.
7. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Bandwidth	Offset Voltage (V)	Min Value (V)	Max Value (V)
All	50MHz, 10MHz, 1MHz, 100kHz	-14.00	-14.072	-13.928
		-13.00	-13.067	-12.933
		-12.00	-12.062	-11.938
		-11.00	-11.057	-10.943
		-10.00	-10.052	-9.948
		-9.00	-9.047	-8.953
		-8.00	-8.042	-7.958
		-7.00	-7.037	-6.963
		6.00	5.968	6.032
		-5.00	-5.027	-4.973
		-4.00	-4.022	-3.978
		-3.00	-3.017	-2.983
		-2.00	-2.012	-1.988
		-1.00	-1.007	-0.993
		0.00	-0.002	0.002
		1.00	0.993	1.007
		2.00	1.988	2.012
		3.00	2.983	3.017
		4.00	3.978	4.022
		5.00	4.973	5.027
		6.00	5.968	6.032
		7.00	6.963	7.037
		8.00	7.958	8.042

		9.00	8.953	9.047
		10.00	9.948	10.052
		11.00	10.943	11.057
		12.00	11.938	12.062
		13.00	12.933	13.067
		14.00	13.928	14.072

Table 2.3: Offset Setup and Tolerances

Gain Validation

Specification: < ±(0.5% of Range + 10mVpp)
Procedure:

1. Disconnect all cables from the output channels.
2. Reset the instrument.
3. Disable all channels that are not being tested.
4. Enter the following settings for each test.

Setup Item	Setting
Operation Mode	Continuous
Function Shape	Sine
Frequency	1kHz
Vertical Offset	0V

Table 2.4: Gain Validation Settings

5. Use the experiment table below to determine the remaining settings of the instrument.
6. Using a DMM to measure the peak to peak output voltage into a high impedance load.
7. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Bandwidth	Output Voltage (Vp)	Output Amplitude (Vpp)	Min Value (Vpp)	Max Value (Vpp)
All	50MHz, 10MHz, 1MHz, 100KHz	1.00	2.00	1.980	2.020
		2.00	4.00	3.970	4.030
		3.00	6.00	5.960	6.040
		4.00	8.00	7.950	8.050
		5.00	10.00	9.940	10.060
		6.00	12.00	11.930	12.070
		7.00	14.00	13.920	14.080
		8.00	16.00	15.910	16.090
		9.00	18.00	17.900	18.100
		10.00	20.00	19.890	20.110
		11.00	22.00	21.880	22.120
		12.00	24.00	23.870	24.130
		13.00	26.00	25.860	26.140
		14.00	28.00	27.850	28.150

Table 2.5: Gain Validation Setup and Tolerances

RMS Noise Validation

Specification:

RMS Noise: ≤ 1mV into 50Ω (50MHz Filter)

Procedure:

1. Disconnect all cables from the output channels.
2. Reset the instrument.
3. Disable all channels that are not being tested.
4. Enter the following settings for each test.

Setup Item	Setting
Operation Mode	Continuous
Function Shape	DC
Vertical Offset	0V
DAC Clock Frequency	200MS/s

Table 2.6: RMS Noise Validation Settings

5. Use the experiment table below to determine the remaining settings of the instrument.
6. Using a DMM to measure the RMS voltage into a 50Ω load.
7. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Bandwidth	Maximum Measured Value (Vrms)
All	50MHz	0.0010

Table 2.7: Noise Setup and Tolerances

Note: The RMS noise determined by this test is bandwidth limited for a more complete procedure contact ZTEC Instruments Inc.

Filter Bandwidth Validation

Specification: DC to 10MHz (± 0.1dB passband flatness)
DC to 25MHz (-1 dB bandwidth)
DC to 50MHz (-3 dB bandwidth)

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	Sine
Vertical Amplitude	1.12Vpp (+5dBm)
Vertical Offset	0V

Table 2.8: Filter Bandwidth Validation Settings

4. Use a spectrum analyzer to measure the output power of the waveform.
5. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Bandwidth	Signal Frequency	Minimum Measured Value (dBm)	Maximum Measured Value (dBm)
All	50MHz	5MHz	4.9	5.1
		20MHz	3.75	4.25
		45MHz	1.5	2.5

Table 2.9: Filter Bandwidth Setup and Tolerances

Harmonics & Distortion Validation

Specification: Harmonic < -40 dBc
Non-harmonic distortion < -55 dBc

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	Sine
Vertical Amplitude	1.12Vpp (5dBm)
Vertical Offset	0V
Output frequency	50MHz

Table 2.10: Harmonics and Distortion Validation Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Use a spectrum analyzer to measure the harmonic and non-harmonic distortion.
6. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Output Frequency	Filter	Measurement	Maximum (dBc)
All	5.00E+07	5.00E+07	Non-harmonic	-52.0
			Harmonic	-38.0

Table 2.11: Harmonics and Distortion Setup and Tolerances

Internal 10MHz Clock Validation

Specification: ± 2.5ppm accuracy

Procedure:

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

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

8. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Min. Error Value (Hz)	Max. Error Value (Hz)
External Input	0	25

Table 2.12: 10MHz Clock Validation Tolerances

External Input Trigger Level Validation

Specification: ± 20mV

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

Setup Item	Setting
Operation Mode	Channel 1 Burst
Trigger Source	External
Trigger Impedance	50 Ohms
Initiate Mode	Single

Table 2.13: External Input Validation Settings

3. Use the experiment table below to determine the remaining instrument settings.
4. Use a voltage source to apply the voltage indicated in the experiment table below to the external input.
5. Initiate the instrument.
6. Read the operation status register condition to verify that the instrument has not triggered.
7. Increase (or decrease if testing the falling edge trigger) the applied voltage by 0.1V. Read the operation status register condition until the instrument triggers.
8. Record the voltage applied to the external input upon the trigger event.
9. Verify that the measurement is within the tolerances specified below by the experiment table.

Experiment Table:

Channel	Trigger Level (V)	Trigger Polarity	Applied Voltage (V)	Min. Measured Value (V)	Max. Measured Value (V)
External Input	1.00	Rising Edge	0.5	0.98	1.02
	-1.00	Falling Edge	-0.5	-1.02	-0.98

Table 2.14: External Input Setup and Tolerances

External Trigger Bandwidth Validation

Specification: DC to 250MHz minimum

Procedure:

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

Setup Item	Setting
Operation Mode	Channel 1 Burst
Trigger Source	External
Trigger Polarity	Rising Edge
Trigger Impedance	50 Ohms
Trigger Level	0.1V
Initiate Mode	Single

Table 2.15: Trigger Bandwidth Validation Settings

3. Use an AC voltage source to apply the signal specified in the experiment table to the external input being tested.
4. Initiate the instrument.
5. Read the operation status register to verify the trigger occurs.

Experiment Table:

Channel	Signal Level (dB)	Signal Frequency (Hz)
External Input	0	1.00E+07
		1.00E+08
		2.50E+08

Table 2.16: Trigger Bandwidth Setup

Calibration Tests

Zero Offset Adjust

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	DC

Table 3.1: Zero Offset Calibration Settings

4. Set the filter as 100kHz filter
5. Using a DMM to measure the offset voltage in a high impedance load.
6. Use the ztwaveM_calibrate_offset_adjust function to adjust the offset.
7. Repeat steps 5 through 6 until the error is less than 2mV.
9. Repeat for 1MHz, 10MHz and 50MHz filters

Implementation Notes:

Each code should converge to an acceptable value within 25 iterations of the process.

Offset Calibration

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	DC

Table 3.2: Offset Calibration Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Set the vertical offset specified in the experiment table.
6. Using a DMM to measure the offset voltage in a high impedance load
7. Use the ztwaveM_calibrate_offset_voltage function to encode the offset voltage.
8. Repeat procedure for each combination of channel and filter settings specified in the experiment table below.

Channel	Filter	Offset Voltage (V)
All	50MHz	14.1
		13.2
		12.3
		11.3
		10.4
		9.4
		8.5
		7.5
		6.6
		5.6
		4.7
		3.7
		2.8
		1.8
		0.9
		0
		-0.9
		-1.8
		-2.8
		-3.7
		-4.7
		-5.6
		-6.6
		-7.5
		-8.5

		-9.4
		-10.4
		-11.3
		-12.3
		-13.2
		-14.1

Table 3.3: Offset Calibration Setup and Tolerances

Filter Gain Adjust

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	Sine
Frequency	1kHz
Vertical Amplitude	6Vp

Table 3.4: Filter Gain Adjust Settings

4. Set the filter as 100kHz filter.
10. Measure the peak to peak voltage into a high impedance load.
11. Calculate the gain error using the formula below.
    gain error = 1.0 - ((expected amplitude – measured amplitude)/expected amplitude
12. Use the ztwaveM_calibrate_gain_adjust function to adjust the gain codes.
13. Repeat steps 4 through 6 until the error is less than 15mVpp.
14. Repeat for 1MHz, 10MHz and 50MHz filters

Implementation Notes:

Each code should converge to an acceptable value within 25 iterations of the process.

Gain Calibration

Procedure:

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

Setup Item	Setting
Operation Mode	Continuous
Function Shape	Sine
Frequency	1kHz
Vertical Amplitude	1Vpp

Table 3.5: Gain Calibration Settings

4. Use the experiment table below to determine the remaining instrument settings.
5. Set the vertical amplitude specified in the experiment table.
6. Measure the peak to peak voltage into a high impedance load.
7. Use the ztwaveM_calibrate_gain_voltage function to encode the gain voltage.
8. Repeat procedure for each combination of channel and filter settings specified in the experiment table below

Channel	Filter	Amplitude (Vpp)
All	50MHz	1.0
		2.0
		2.9
		3.9
		4.9
		5.8
		6.8
		7.8
		8.7
		9.7
		10.7
		11.6
		12.6
		13.6
		14.5
		15.5
		16.5
		17.5
		18.4
		19.3
		20.3
		21.2
		22.2
		23.1

		24.1
		25.0
		26.0
		27.0
		27.8

Table 3.6: Gain Calibration Setup

Internal 10MHz Calibration

Procedure:

1. Reset the instrument.
2. Connect a precision 10MHz clock 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 32bit 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 32bit integer value from the memory address 0x9010007C. (F_{INT})
7. Calculate the error by subtracting the measured internal rate from the measured external rate:

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

8. Use the ztwaveM_calibrate_reference_oscillator_adjust function to adjust the codes.
9. Repeat steps 6 through 8 until the error is less than 25.

Implementation Notes:

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

External Calibration

Procedure:

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

Setup Item	Setting
Operation Mode	Channel 1 Burst
Trigger Source	External Input
Trigger Polarity	Rising Edge
Trigger Impedance	50 Ohms

Table 3.7: Trigger Offset Calibration Settings

3. Use the experiment table below to determine the remaining instrument settings.
4. Using a DC voltage source apply a -0.5V signal to the external input.
5. Decrease the signal voltage by the increment value specified in the experiment table below until the instrument triggers. (Read the operational register trigger bit to check whether the trigger occurs).
6. Record the signal voltage which triggered the instrument (V_L).
7. Using a DC voltage source apply a 0.5V signal to the external input.
8. Increase the signal voltage by the increment value specified in the experiment table below until the instrument triggers.
9. Record the signal voltage which triggered the instrument (V_H).
10. Calculate the offset error and gain error.

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

$$offset\_error = (V_H + V_L)/ 2$$

11. Use the function ztwaveM_calibrate_external_adjust to adjust the gain code based on the gain error and use the function ztwaveM_calibrate_external_zero to adjust the offset code based on the offset error.
12. Repeat steps 4 through 11 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 3.8: Trigger Offset Calibration Setup and Tolerances

Implementation Notes:

After the calibration completes use the ztwaveM_save_calibration function to store the gain codes and offset codes permanently.

Calibration Tables

Filter Gain Adjust Table

Function	Default Value (f32 scale factor)
Filter scale factor for bypass (50 MHz)	1.0
Filter scale factor for 10 MHz	1.0
Filter scale factor for 1 MHz	1.0
Filter scale factor for 100 kHz	1.0

Table A1.1: Filter Gain Adjust Default Values

Filter Offset Adjust Table

Function	Default Value (s16 correction factor)
Filter correction factor for bypass (50 MHz)	0
Filter correction factor for 10 MHz	0
Filter correction factor for 1 MHz	0
Filter correction factor for 100 kHz	0

Table A1.2: Filter Offset Adjust Default Values

DC Offset Calibration Table

Function	Default Value (f32)
DC Voltage Offset for 0800_{16}	14.1
DC Voltage Offset for 1000_{16}	13.2
DC Voltage Offset for 1800_{16}	12.3
DC Voltage Offset for 2000_{16}	11.3
DC Voltage Offset for 2800_{16}	10.4
DC Voltage Offset for 3000_{16}	9.4
DC Voltage Offset for 3800_{16}	8.5
DC Voltage Offset for 4000_{16}	7.5
DC Voltage Offset for 4800_{16}	6.6
DC Voltage Offset for 5000_{16}	5.6

Function	Default Value (f32)
DC Voltage Offset for 5800_{16}	4.7
DC Voltage Offset for 6000_{16}	3.7
DC Voltage Offset for 6800_{16}	2.8
DC Voltage Offset for 7000_{16}	1.8
DC Voltage Offset for 7800_{16}	0.9
DC Voltage Offset for 8000_{16}	0.0
DC Voltage Offset for 8800_{16}	-0.9
DC Voltage Offset for 9000_{16}	-1.8
DC Voltage Offset for 9800_{16}	-2.8
DC Voltage Offset for $A000_{16}$	-3.7
DC Voltage Offset for $A800_{16}$	-4.7
DC Voltage Offset for $B000_{16}$	-5.6
DC Voltage Offset for $B800_{16}$	-6.6
DC Voltage Offset for $C000_{16}$	-7.5
DC Voltage Offset for $C800_{16}$	-8.5
DC Voltage Offset for $D000_{16}$	-9.4
DC Voltage Offset for $D800_{16}$	-10.4
DC Voltage Offset for $E000_{16}$	-11.3
DC Voltage Offset for $E800_{16}$	-12.3
DC Voltage Offset for $F000_{16}$	-13.2
DC Voltage Offset for $F800_{16}$	-14.1

Table A1.3: DC Offset Breakpoint Table Default Values

AC Amplitude Calibration Table

Function	Default Value (f32)
AC Voltage Amplitude for 0800_{16}	1.0
AC Voltage Amplitude for 1000_{16}	2.0
AC Voltage Amplitude for 1800_{16}	2.9
AC Voltage Amplitude for 2000_{16}	3.9
AC Voltage Amplitude for 2800_{16}	4.9
AC Voltage Amplitude for 3000_{16}	5.8
AC Voltage Amplitude for 3800_{16}	6.8
AC Voltage Amplitude for 4000_{16}	7.8

Function	Default Value (f32)
AC Voltage Amplitude for 4800_{16}	8.7
AC Voltage Amplitude for 5000_{16}	9.7
AC Voltage Amplitude for 5800_{16}	10.7
AC Voltage Amplitude for 6000_{16}	11.6
AC Voltage Amplitude for 6800_{16}	12.6
AC Voltage Amplitude for 7000_{16}	13.6
AC Voltage Amplitude for 7800_{16}	14.5
AC Voltage Amplitude for 8000_{16}	15.5
AC Voltage Amplitude for 8800_{16}	16.5
AC Voltage Amplitude for 9000_{16}	17.5
AC Voltage Amplitude for 9800_{16}	18.4
AC Voltage Amplitude for $A000_{16}$	19.3
AC Voltage Amplitude for $A800_{16}$	20.3
AC Voltage Amplitude for $B000_{16}$	21.2
AC Voltage Amplitude for $B800_{16}$	22.2
AC Voltage Amplitude for $C000_{16}$	23.1
AC Voltage Amplitude for $C800_{16}$	24.1
AC Voltage Amplitude for $D000_{16}$	25.0
AC Voltage Amplitude for $D800_{16}$	26.0
AC Voltage Amplitude for $E000_{16}$	27.0
AC Voltage Amplitude for $E800_{16}$	27.8
AC Voltage Amplitude for $F000_{16}$	28.6
AC Voltage Amplitude for $F800_{16}$	29.4

Table A1.4: AC Amplitude Breakpoint Table Default Values

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