11 3110A Calibration

11.1 Introduction

This section provides the guidelines for establishing the performance of key parameters for the 3110A output. It provides instructions for the measurement of the various output signals the 3110A can provide. Although the output of the 3110A can be adjusted via the gain settings, this feature is intended for use in calibrating the system (both the 3110A and the associated amplifier) and not for calibrating the output of the isolated 3110A. For instructions on the calibration of a 3110A/amplifier system, please see the Help topic “System Calibration.”

For the output validation of an isolated 3110A, tolerances and ranges will be provided for a variety of measurements. The results of the measurements will be essentially a “Pass” or “Fail.” Tests conducted according to these instructions should be considered “functional tests” that are intended to confirm the function of the settings of the 3110A. Since fine adjustment of the test system can be accomplished via the 3110A/amplifier System Calibration, the calibration of the isolated 3110A will require only general instrumentation. The procedure should be carried out with the gain set at the anticipated gain to be used in testing. The default gain used in the assessment tables is 20.

11.2 Documentation

Standard SI units commonly found in electrical standard are used for checking the calibration of the 3110A. The minimum requirements for calibration documentation are that the instruments used should be able to accurately measure the quantities within the tolerances provided. Instruments should bear evidence (via a label on the instrument or similar documentation) that the measuring instrument is calibrated. The table shown below is provided to record the performance of the 3110A in key areas, and to facilitate interaction with the AE Techron when needed.

ANSI Z540 or ISO 17205 calibration with documentation is available as an option.

11.3 Required Instruments

Instruments required are an oscilloscope and a digital multimeter. All measurements should be made into high-impedance instruments. The measurements outlined here do not neccesarily require a probe. Using BNC connectors to both instruments is advised. It is assumed that the oscilloscope probe attenuation is set at 1X. Best performance will be attained if the measuring instruments are either isolated (battery powered) or grounded at the same point with the 3110A.

Instruments requirements are suggested requirements. Virtually any calibrated high impedance DMM and oscilloscope will serve. Observe any temperature corrections or other temperature-based requirements for the measuring instruments.

Oscilloscope:
Bandwidth: 50 MHz, minimum
Sample Rate: 1 GS/sec minimum
Automatic Measurements: Frequency, RMS, Peak-to-Peak
Input Impedance (DC): 10M ohm

DMM:
Frequency Range: ±(% of reading + # of counts)
50 Hz to 10 kHz: 0.3 + 20
10 to 20 kHz: 1 + 40
20 to 100 kHz: 2 + 150
Impedance: Up to 20 M ohm over available ranges

11.4 Connections and Settings

Test connections are made from the front panel Signal Out BNC connector to the test instrument.

Cables and connectors having minimal insertion loss over the bandwidth (DC to 1000 kHz) are required.

An amplifier may be connected to the 3110A, but must be turned off during this series of tests.

No other peripheral connections will affect these tests.

Use common ground or isolated instruments, if possible. Select an environment with minimal radiated noise.

Temperature and run time: Allow the 3110A to run for 20 minutes in a quiescent state.

Gain = Nominally 20.0 for all waveforms; however follow the preliminary steps indicated below. For the purpose of these tests, a specification of G = 20 will mean that the system gain value has been adjusted to deliver an output based on the System Gain Calibration routine.

Use 0 VDC for offset setting for varying waveforms

Sweep Type = LIN for all tests

Where applicable, frequency values should be within 2% of values selected

For the Square waveform, slew rate should be within 3 V/ms for each test

Settings and features not tested: Sweep functions, Control functions, Duration setting and the various Looping features

For all tests, perform the following preliminary steps:

1. Allow the 3110A to warm up for at least 20 minutes prior to performing any operations.
2. Once warmed up, under the Settings/System Calibration tab, run and adjust the DC offset to center the quiescent DC output of the 3110A. See ***"System Calibration."***

11.5 Output Assessments

The assessment of a waveform consists of setting up the 3110A SWG user interface with the values as indicated for each waveform type listed on the various tables. The duration may be set for several seconds, or more depending on the triggering selected. The standard tests included in the Calibration sub-directory are generally set for 1000 seconds, but this can be adjusted, if desired. The test varies voltage and, for alternating waveforms, a range of frequencies is given for each voltage level.

The test waveforms for specific tests can be found in the Standards Library in the Calibration directory.

11.5.1 Ripple Frequency Accuracy

Used to determine how close the 3110A generated frequency is to the commanded value. Use with RFA SWG files in the Calibration sub-directory in the Standards Library.

General default settings

Gain = 20
Phase = 0
Interface Chart voltage amplitude:

50 kHz	50 Vp	BNC output = 2.5 Vp
100 kHz	10 Vp	BNC output = 0.5 Vp
500 kHz	5 Vp	BNC output = 0.2 Vp
1 MHz	2 Vp	BNC output = 0.1 Vp

Duration = 1000 sec

This test assumes that the oscilloscope used can measure frequency directly. That is, the value of frequency is measured by direct measurement of frequency on the oscilloscope display. If desired, of course, the time can be measured and frequency calculated.

Checking the Frequency Accuracy:

3. Make sure the 3110A has been on for at least 20 minutes.
4. Set all probe and oscilloscope scales to 1X.
5. Open the SWG file corresponding to the table for which measurement is to be made. Four files are provided,
6. Run the Ripple sinusoidal waveform and record the high and low values for frequency
7. Determine the variation and compare with specifications
8. Repeat for the other files.

Notes:

1. Additional voltages and frequencies can be entered by changing the template SWG files.
2. Output depends on frequency; see frequency response curve.

Frequency	Range	Measured	Variation
50 kHz	Max Frequency		
	Min Frequency		
100 kHz	Max Frequency		
	Min Frequency		
500 kHz	Max Frequency		
	Min Frequency		
1 MHz	Max Frequency		
	Min Frequency		

11.5.2 Ripple Voltage Response Test

Used to determine how close the 3110A generated voltage is to the expected response. Use with RVRT SWG files in the Calibration sub-directory in the Standards Library.

General default settings

Gain = 20

Phase = 20

Frequency varies

NOTE: All voltage values are in Vpp

Interface Chart voltage amplitude is as indicated in the data table below.

10 Vpp BNC output = 0.5 Vp-p
50 Vpp BNC output = 2.5 Vp-p
100 Vpp BNC output = 5.0 Vp-p
150 Vpp BNC output = 7.5 Vp-p

Duration = 1000 sec

This test assumes that the oscilloscope used can measure voltage directly. That is, the value of voltage is measured by direct measurement of voltage on the oscilloscope display. If desired, of course, the amplitude can be measured and calculated.

Checking the Voltage Response:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Adjust the DC offset and Gain in the Settings/System Calibration tab for nominal 0 VDC offset and actual output gain = 20.
3. Set all probe and oscilloscope scales to 1X.
4. Open the SWG file corresponding to the table for which measurement is to be made. Four files are provided, one for each reference voltage,
5. Start at the lowest frequency, 100 Hz, and measure the variation in the voltages. Stop the output and add one zero to the frequency and repeat. Enter the next voltage and the lowest frequency, and repeat.
6. Determine the average if the values varied.
7. Determine the response by calculating the dB value (Vref is the expected BNC output voltage, in Vpp)

$$dB = 20\log\left(\frac{V_{meas}}{V_{ref}}\right)$$

8. Compare the values for the responses to the dB response range values

Notes:

1. Additional voltages and frequencies can be entered by changing the template SWG files.
2. Output depends on frequency; see frequency response curve

	GUI: 10 Vpp	BNC: 0.50 Vpp			
Frequency (Hz)	Range	Measured	Average	Response (dB)	dB range
100	Max Voltage				1
	Min Voltage				-0
1000	Max Voltage				1
	Min Voltage				-0
10000	Max Voltage				1
	Min Voltage				-0
100000	Max Voltage				1
	Min Voltage				-0
1000000	Max Voltage				0
	Min Voltage				-2.5

	GUI: 50 Vpp	BNC: 2.50 Vpp			
Frequency (Hz)	**Range**	**Measured**	**Average**	**Response (dB)**	**dB range**
100	Max Voltage				1
	Min Voltage				-0
1000	Max Voltage				1
	Min Voltage				-0
10000	Max Voltage				1
	Min Voltage				-0
100000	Max Voltage				1
	Min Voltage				-0
1000000	Max Voltage				0
	Min Voltage				-2.5

	GUI: 100 Vpp	BNC: 5.00 Vpp			
Frequency (Hz)	**Range**	**Measured**	**Average**	**Response (dB)**	**dB range**
100	Max Voltage				1
	Min Voltage				-0
1000	Max Voltage				1
	Min Voltage				-0
10000	Max Voltage				1
	Min Voltage				-0
100000	Max Voltage				1
	Min Voltage				-0
1000000	Max Voltage				0
	Min Voltage				-2.5

	GUI: 150 Vpp	BNC: 7.50 Vpp			
Frequency (Hz)	**Range**	**Measured**	**Average**	**Response (dB)**	**dB range**
100	Max Voltage				1
	Min Voltage				-0
1000	Max Voltage				1
	Min Voltage				-0
10000	Max Voltage				1
	Min Voltage				-0
100000	Max Voltage				1
	Min Voltage				-0
1000000	Max Voltage				0
	Min Voltage				-2.5

11.5.3 Ripple Phase Accuracy

Used to determine how close the 3110A phase shift is to the commanded value. Use with the RPA SWG files in the Calibration sub-directory in the Standards Library.

General default settings

Gain = 20

Interface Chart voltage amplitude = 100 Vp, or BNC output = 5 Vp

Duration = 1000 sec

One of the simplest ways to measure phase is to observe the time shift generated by a phase change. The change in phase changes the zero crossing times for a periodic wave and can be measured with an oscilloscope. Although the shift is the same for each cycle, more significant figures can be obtained by using a longer time interval. Thus, larger values of n (the nth crossing) will generate better measurements. See the example figure below. For a given n and phase shift φ, the time from t = 0 to the nth crossing is given by

$$t=\frac{1}{2\pi f}(n\pi-\phi);\phi\in radians\wedge n=1,2,3,\cdots$$

or

$$t=\frac{1}{2f}\left(n-\frac{\phi}{180}\right);\phi\in degrees\wedge n=1,2,3,\cdots$$

Checking the Phase Accuracy:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Open the SWG file corresponding to the table for which measurement is to be made. Four files are provided, two for 50 kHz and two for 500 kHz.
3. Set all probe and oscilloscope scales to 1X.
4. For each file, set up the oscilloscope to the pre-trigger setting, and set the time sweep sufficient to capture at least 8 crossing events, as well as the start. The time for the nth crossing event is shown in the tables, under the n column. Low values of n are shown for reference.
5. Start the waveform. It will run for several minutes (default is 1000 sec, but this can be adjusted as well)

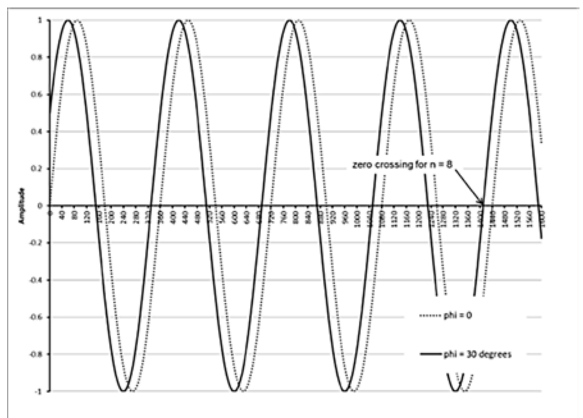

Figure 11.1 – Example Figure for ϕ=30°

SWG File RPA1:
50 kHz ϕ = 30°

Zeros		Measured
n	time (msec)	(msec)
0	-0.0017	
1	0.0083	
2	0.0183	
3	0.0283	
4	0.0383	
5	0.0483	
6	0.0583	
7	0.0683	
8	0.0783	
9	0.0883	
10	0.0983	

SWG File RPA2:
50 kHz ϕ = 75°

Zeros		Measured
n	time (msec)	(msec)
0	-0.0042	
1	0.0058	
2	0.0158	
3	0.0258	
4	0.0358	
5	0.0458	
6	0.0558	
7	0.0658	
8	0.0658	
9	0.0858	
10	0.0958	

SWG File RPA3:
500 kHz ϕ = 30°

Zeros		Measured
n	time (msec)	(msec)
0	-0.0002	
1	0.0008	
2	0.0018	
3	0.0028	
4	0.0038	
5	0.0048	
6	0.0058	
7	0.0068	
8	0.0078	
9	0.0088	
10	0.0098	

SWG File RPA4:
500 kHz ϕ = 75°

Zeros		Measured
n	time (msec)	(msec)
0	-0.0004	
1	0.0006	
2	0.0016	
3	0.0026	
4	0.0036	
5	0.0046	
6	0.0056	
7	0.0066	
8	0.0076	
9	0.0086	
10	0.0096	

6. Measure the time from t = 0 to the zero cross for n = 8. Record in the measurement column at the spacefor n = 8, and compare to commanded value in the green time column.
7. The reference value is given for n = 8 in each table, and there are other values that can be checked.
8. Repeat for the other files.

Notes:

1. Additional voltages and frequencies can be entered by changing the template SWG files.

11.5.4 General Waveform Assessment

Waveform	Start/End Offset (V)	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V)	Measured (V)	High Limit (V)
DC	100	NA	NA	4.95		5.05
	200	NA	NA	9.95		10
Sine	Start/End Amplitude, Vp	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (Vp)	Measured (V)	High Limit (Vp)
	100	1		4.90		5.10
		10		4.90		5.10
		20		4.90		5.10
	200	1		9.90		**10**
		10		9.90		**10**
		20		9.90		**10**
Square	Start/End Amplitude, Vp	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V)	Measured (V)	High Limit (V)
	100	1		4.90		5.10
		10		4.90		5.10
		20		4.90		5.10
	200	1		9.90		10
		10		9.90		10
		20		9.90		10
Triangle	Start/End Amplitude, Vp	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V)	Measured (V)	High Limit (V)
	100	1		4.90		5.10
		10		4.90		5.10
		20		4.90		5.10
	200	1		9.90		10
		10		9.90		10
		20		9.90		10
Sawtooth	Start/End Amplitude, Vp	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V)	Measured (V)	High Limit (V)
	100	1		4.90		5.10
		10		4.90		5.10
		20		4.90		5.10
	200	1		9.90		10
		10		9.90		10
		20		9.90		10

Notes:

1. The values in this table are referenced to peak volts.

11.5.5 Rise Time Accuracy

Used to determine the time to transition voltage states for the 3110A, from one commanded DC voltage to another. Use with RT SWG files in the Calibration sub-directory in the Standards Library. All transitions are from one DC voltage to a second DC voltage.

General default settings

Gain = 20

Phase = 0

Default two-segment with Trigger

Interface Chart voltage amplitude:

RT1	0 VDC to 10 VDC
RT2	0 VDC to 200 VDC
RT3	-150 VDC to 150 VDC

Duration = 100 msec per segment

This test assumes that the oscilloscope used can measure time directly, or by using scales generated on the display. That is, the value of time is measured by direct measurement of time on the oscilloscope display. If desired, of course, the time can be measured manually.

Also note that the rise time is taken as the industry standard time from 10% of the transition voltage to 90% of the transition voltage; that is a total of 80% of the ΔV.

Checking the Rise Time:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Set all probe and oscilloscope scales to 1X, and that the channel input is DC enabled.
3. Open the SWG file corresponding to the table for which measurement is to be made. Three files are provided.
4. Run the file and, when ready, actuate the trigger and capture the step signal. Make repeated measurement trials and average the results.
5. Compare with specifications.
6. Repeat for the other files.

Notes:

1. Additional voltages and times can be entered by changing the template SWG files.

Trial No.	Rise Time		
	RT1	RT2	RT3
1			
2			
3			
Average			

11.5.6 Minimum Step Duration Measurement

Used to determine the time of duration of a standard step signal transition between two DC voltage states for the 3110A, from one commanded DC voltage to another. Use with the SD SWG files in the Calibration sub-directory in the Standards Library. All transitions are from one DC voltage to a second DC voltage, then return to first voltage.

General default settings

Gain = 20

Phase = 0

Default four-segment with Trigger

Interface Chart voltage amplitude:

SD1	0 VDC to 10 VDC, back to 0 VDC
SD2	0 VDC to 100 VDC, back to 0 VDC
SD3	0 VD to 200 VDC, back to 0 VDC

Duration = 25 µsec per transition segment

This test assumes that the oscilloscope used can measure time directly, or by using scales generated on the display. That is, the value of time is measured by direct measurement of time on the oscilloscope display. If desired, of course, the time can be measured manually.

Checking the Rise Time:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Set all probe and oscilloscope scales to 1X, and make sure that the channel input is DC enabled.
3. Open the SWG file corresponding to the table for which measurement is to be made. Three files are provided.

4. Run the file and, when ready, actuate the trigger and capture the step signal. Make repeated measurement trials and average the results.
5. Compare with specifications.
6. Repeat for the other files.

Trial No.	Step Duration Times		
	SD1	SD2	SD3
1			
2			
3			
Average			

Notes:

1. Additional voltages and times can be entered by changing the template SWG files.

11.5.7 Quiescent Noise

Used to determine the noise present in a quiescent state. Requires no test SWG file.

General default settings

Gain = 20

Phase = 0

Duration = N/A

This test assumes that the oscilloscope used can measure voltage directly. This test is independent of DC offset, which can be trimmed and offset in the Settings/System Calibration dialog section.

Checking the noise level:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Set all probe and oscilloscope scales to 1X, the channel inputs can be set to AC enabled.
3. Use sufficiently fine V/div to resolve the noise.
4. Observe the noise levels in several trials
5. Compare with specifications

Notes:

1. Additional voltages and times can be entered by changing the template SWG files.
2. The noise present should be independent of overall system gain.

Trial No.	Noise (mV)		
1			
2			
3			
Average			

If you have any questions, please contact AE Techron Technical Support at 574-295-9495.