11 3110A Calibration

11.1 Introduction

This section, along with the calibration tests found in **Appendix A,** provide 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 test tables in **Appendix A** are 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 necessarily 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.

3. Repeat for the other files.

Notes:

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

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

A 3110A Calibration Tests

AETECHRON GWA Worksheet Rev A

General Waveform Assessment

Used to verify various analog signal outputs behave as expected. Use with the GWA SWG file in the Calibration directory.

<u>General default settings</u>
Nominal Gain = 20
Nominal DC offset = 0 VDC
Phase = 0
Interface with Chart for voltage and frequency:
Vp1 100Vp
Vp2 200Vp
Duration = 1000 msec post Trigger segment

This test assumes that the oscilloscope used can measure voltage and frequency directly, or by using scales generated on the display.

<u>Checking the DC Voltage Output:</u>

1. Make sure the 3110A has been on for at least 20 minutes.
2. Make sure the system gain is set to 20 and the DC offset is set such that a commanded output of 0V generates an output of 0V.
3. Open the GWA SWG file.
4. Set the scope to measure the Vpp and frequency of the signal, with an attenuation of 1X.
5. Measure the Vpp and frequency.
6. Record the measured value.
7. Repeat steps 5 and 6 for the remaining waves.

Waveform	Start/End Amplitude, V_p	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V_{pp})	Measured (Vpp)	High Limit (Vpp)
Sine		20		9.9		10.1
		20		19.6		20.4
Square	Start/End Amplitude, V_p	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V_{pp})	Measured (Vpp)	High Limit (Vpp)
		20		9.9		10.1
		20		19.6		20.4
Triangle	Start/End Amplitude, V_p	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V_{pp})	Measured (Vpp)	High Limit (Vpp)
		20		9.9		10.1
		20		19.6		20.4
Sawtooth	Start/End Amplitude, V_p	Frequency (kHz)	Measured Frequency (kHz)	Low Limit (V_{pp})	Measured (Vpp)	High Limit (Vpp)
		20		9.9		10.1
		20		19.6		20.4

AETECHRON RFA Worksheet Rev D

Ripple Frequency Accuracy

Used to determine how close the 3110A's generated frequency is to the commanded value. Use with RFA SWG files in the Calibration directory.

<u>General default settings</u>
Nominal Gain = 20
Phase = 0
Interface Chart voltage amplitude:
50 kHz 50 Vp BNC output = 2.5 Vp
100 kHz 50 Vp BNC output = 2.5 Vp
500 kHz 50 Vp BNC output = 2.3 Vp
1 MHz 50 Vp BNC output = 1.7 Vp
Duration = 1000 sec

This test assumes that the oscilloscope used can measure frequency directly. If desired the time can be measured and frequency calculated.

<u>Checking the Frequency Accuracy:</u>

1. Make sure the 3110A has been on for at least 20 minutes.
2. Open the RFA SWG file.
3. Measure the frequency, taking both the maximum and minimum observed value for that wave.
4. Record the measured maximum and minimum frequencies.
5. Repeat steps 3 and 4 for the remaining frequencies.
6. If either the high or low frequency measurement is outside the listed limits then the unit fails that frequency.

Frequency	Range	Measured	Min Limit	Max Limit
50 kHz	Max Frequency		49.75 kHz	50.25 kHz
	Min Frequency			
100 kHz	Max Frequency		99 kHz	101kHz
	Min Frequency			
500 kHz	Max Frequency		495 kHz	505 kHz
	Min Frequency			
1 MHz	Max Frequency		.99 MHz	1.01 MHz
	Min Frequency			

Ripple Voltage Response Test

Used to determine how close the 3110A's generated voltage is to the expected response. Use with RVRT SWG files in the Calibration directory.

General default settings
Gain = 20
Phase = 0
Frequency varies.
NOTE: All voltage values are in Vpp.
Interface Chart voltage amplitude, 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. If desired the amplitude can be measured and peak-to-peak values 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. Begin the waveform and measure the first wave.
4. Record the maximum and minimum voltages observed.
5. Repeat steps 4-6 for the remaining trials.

	GUI 10 V_{pp}	BNC 0.50 V_{pp}	V_{ref} = 0.50 V_{pp}		
Frequency (Hz)	Range	Measured	Average	Lower Limit	Upper Limit
100	Max Voltage			0.5	0.561
	Min Voltage				
100000	Max Voltage			0.5	0.561
	Min Voltage				
1000000	Max Voltage			0.334	0.5
	Min Voltage				

	GUI 150 V_{pp}	BNC 7.50 V_{pp}	V_{ref} = 7.50 V_{pp}		
Frequency (Hz)	Range	Measured	Average	Lower Limit	Upper Limit
100	Max Voltage			7.5	8.415
	Min Voltage				
100000	Max Voltage			7.5	8.415
	Min Voltage				
1000000	Max Voltage			5.01	7.5
	Min Voltage				

AETECHRON RPFT Worksheet Rev A

Ripple Phase Functional Test

Used to determine how close the 3110A's phase shift is to the commanded value. Use with RPFT SWG file in the calibration directory.

General default settings
Gain = 20
Interface Chart voltage amplitude = 100 Vp, or BNC output = 5 Vp
Duration = 1000 sec

This test is designed to verify that the phase shift feature is functioning, it will not verify the accuracy of this feature. For accuracy verification, refer to the RPA test.

Checking the Phase Accuracy Procedure:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Open the RPFT SWG file.
3. Set oscilloscope to trigger once, at a level that will allow viewing from the start of waveform playback, similar to Figure 1.
4. Verify that playback of the first segment matches Figure 1, in which the sine wave output starts at 0V.
   a. If the output is dissimilar to figure 1 in terms of waveform start value, the device will fail the RPFT.
5. Verify that playback of the second segment matches Figure 2, in which the sine wave output starts at 0V but immediately goes negative (phase shift of 180°).
   a. If the output is dissimilar to figure 2 in terms of waveform start value, the device will fail the RPFT.

0° (Pass/Fail)	180° (Pass/Fail)

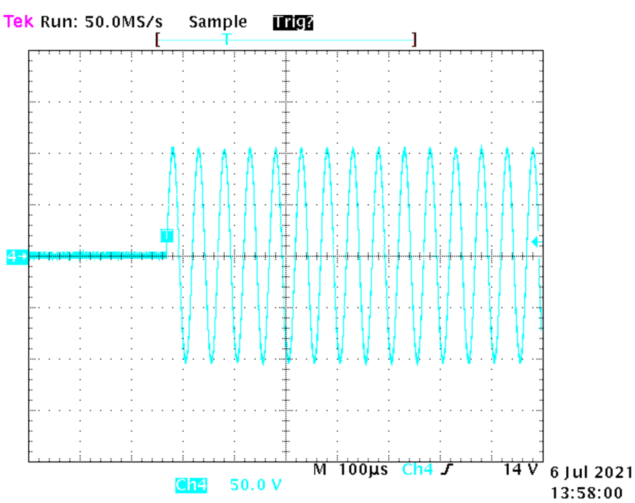


Figure 1

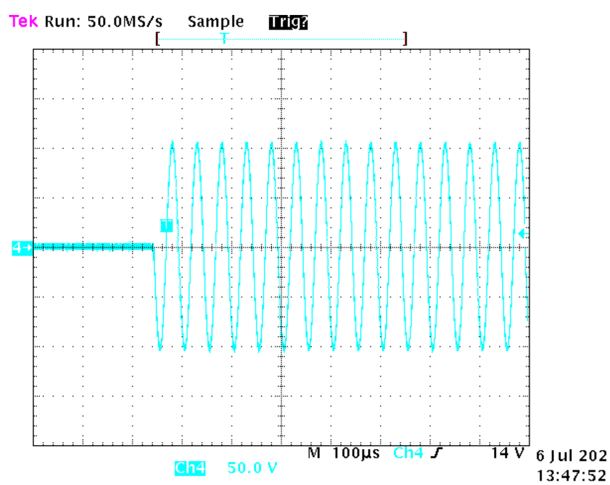


Figure 2

AETECHRON DC Worksheet Rev C

DC Voltage Accuracy

Used to determine the DC voltage output and compare to the commanded value. Use with DC SWG files in the Calibration directory. All transitions are from 0 VDC to a second DC voltage.

General default settings
Nominal Gain = 20
Nominal DC offset = 0 VDC
Phase = 0
Default three segment with trigger
Interface Chart voltage amplitude:
DC1 0 VDC to 13.5 VDC
DC2 0 VDC to 150 VDC
Duration = 1000 sec after trigger segment

This test assumes that the oscilloscope used can measure voltage directly, or by using scales generated on the display. A digital multimeter can also be used.

Checking the DC Voltage Output:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Make sure the system gain is set to 20 and the DC offset is set such that a 0V commanded output measures 0V.
3. Open the DC SWG file.
4. Set the scope to measure the voltage value and begin the waveform.
5. Measure the first DC value.
6. Record the measured value.
7. Repeat steps 5 and 6 for the remaining trials.

	Voltage	
Trial No.	DC1 (0.675 VDC)	DC2 (7.50 VDC)
1		
2		
3		
Average:		
Average Max Limit	0.6784	7.65
Average Min Limit	0.6716	7.35

AETECHRON RT Worksheet Rev C

Rise Time Frequency Accuracy

Used to determine the time for the 3110A to transition voltage states, this being the time required for the 3110A to go from one DC Voltage to another. Use with RT SWG files in the Calibration directory. All transitions are from one DC voltage to a second DC voltage.

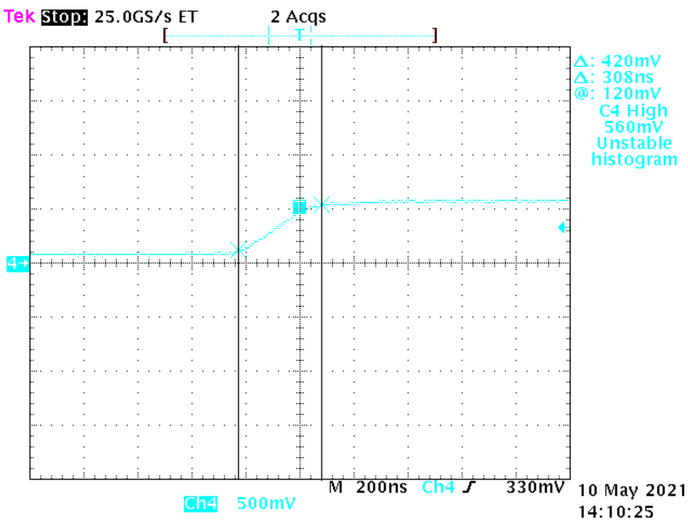
<u>General default settings</u>
Nominal Gain = 20
Phase = 0
Default two-segment with Trigger
Interface Chart voltage amplitude:
RT1 0 VDC to 10 VDC
RT2 -150 VDC to 150 VDC
Duration = 100 msec per segment

This test assumes that the oscilloscope used can measure time directly, or by using scales generated on the display. Measuring the time manually will also achieve the desired result. An example of the area to be measured is displayed in the oscilloscope shot below.

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

<u>Checking the Rise Time:</u>

1. Make sure the 3110A has been on for at least 20 minutes.
2. Open the RT SWG file.
3. Set scope to capture the transition, using a single rising-edge trigger.
4. Measure time to complete the transition.
5. Record in the table below.
6. Repeat steps 2-5 for the remaining trials.



	Rise Time	
Trial No.	RT1	RT2
1		
2		
3		
Average:		
Limit:	< 1 µsec	< 1 µsec

AETECHRON SD Worksheet Rev B

Minimum Step Duration Measurement

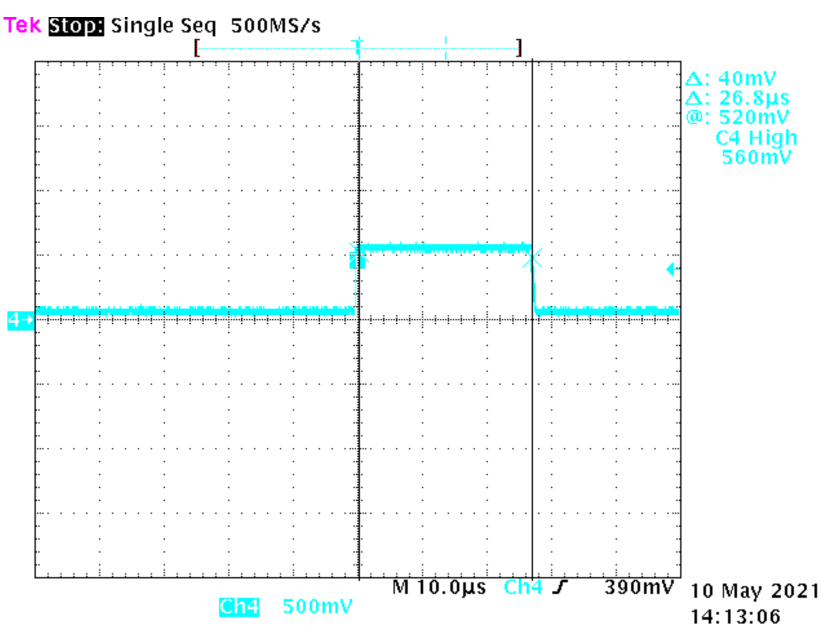
Used to determine the accuracy of timed voltage states, or how accurately the 3110A can output a signal for a set time
All transitions are from one DC voltage to a second DC voltage, then a return to the first voltage.

General default settings
Gain = 20
Phase = 0
Default three-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. Time measurements can be done manually if preferred, this will achieve the desired result.

Checking the Rise Time:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Set the oscilloscope to capture a similar area to the figure below, making use of a rising-edge single trigger.
3. Measure the time as indicated in the figure below.
4. Record the measure value.
5. Repeat steps 2-4 for the remaining trials.



	Step Duration Times		
Trial No.	SD1	SD2	SD3
1			
2			
3			
Average:			
Limit:	± 3 µsec	± 3 µsec	± 3 µse

AETECHRON ORAT Worksheet Rev A

Offset Ripple Accuracy Test

Used to determine the accuracy of a ripple with a DC offset. Use with ORAT SWG files in the Calibration directory.

General default settings
Nominal Gain = 20
Nominal DC offset = 0 VDC
Phase = 0

This test assumes that the oscilloscope used can measure voltage directly, or by using scales generated on the display. A digital multimeter can also be used.

Checking the offset ripple:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Make sure the system gain is set to 20 and the DC offset is set such that a commanded output of 0V generates an output of 0V.
3. Open the ORAT SWG file.
4. Set the scope to measure the offset, frequency, and Vpp of the wave with an attenuation of 1X.
5. Begin waveform playback.
6. Measure the values from step 4.
7. Record the measured values.
8. Repeat steps 6 and 7 for the remaining trials.

	Voltage (V_{pp})	Voltage Limits (V_{pp})	Offset (V)	Offset Limits (V)	Pass/Fail
OR1		0.09		0.6075	
		0.011		0.7425	
OR4		9		4.5	
		11		5.5	

Ripple Phase Accuracy

Used to determine how close the 3110A's phase shift is to the commanded value. Use with RPA SWG files in the Calibration directory. This test will only be used in the event that precise phase shifting is necessary, this test is not performed as part of the factory calibration procedure.

General default settings
Gain = 20
Interface Chart voltage amplitude = 100 V_p, or BNC output = 5 V_p
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 places where the wave equals zero and can be measured with an oscilloscope. Figure 2 shows an example of a phase shift. For a given n and phase shift φ, the time from $n = 0$ to the n^{th} crossing is given by

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

or

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

The error can be found from

$$\%error = \frac{|t_m - t_{exp}|}{t_m} * 100$$

Where t_m is the time measured and t_{exp} is the expected time, which are the values in the table on the next page.

Checking the Phase Accuracy Procedure:

1. Make sure the 3110A has been on for at least 20 minutes.
2. Open the RPA SWG file.
3. Set oscilloscope to a single trigger, causing the scope to trigger once such that you get an image similar to Figure 1.
4. Once you have the desired viewing window, measure the time from the beginning of the curve to each of the zero crossing points.
    a. Note: Only 4 zero-crossing points will be recorded. n=4, 5, 6, and 7
5. Record the measured times of zero crossing points and repeat for the remaining waveforms.

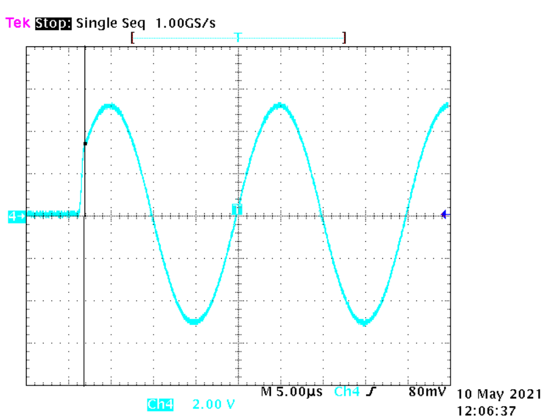


Figure 1 Example Oscilloscope Reading

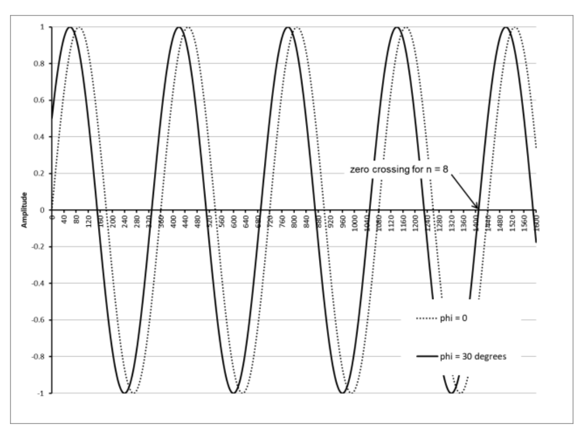


Figure 2 for ϕ = 30°

RPA1: 50 kHz ϕ = 30°

zeros (crossing) n =	time (µsec)	measured (µsec)	Variation %
4	38.33		
5	48.33		
6	58.33		
7	68.33		
		Average	
		Limit	0.5 %

RPA 2: 500 kHz ϕ = 30°

zeros (crossing) n =	time (µsec)	measured (µsec)	Variation %
4	3.833		
5	4.833		
6	5.833		
7	6.833		
		Average	
		Limit	2 %

RPA2: 50 kHz ϕ = 75°

zeros (crossing) n =	time (µsec)	measured (µsec)	Variation %
4	35.833		
5	45.833		
6	55.833		
7	65.833		
		Average	
		Limit	0.5 %

RPA4: 500 kHz ϕ = 75°

zeros (crossing) n =	time (µsec)	measured (µsec)	Variation %
4	3.5833		
5	4.5833		
6	5.5833		
7	6.5833		
		Average	
		Limit	3 %