

# PCUHCU Calibration Techniques for the AARTS System

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Accel-RF Corporation specializes in the design, development, manufacture, and sales of accelerated life-test/burn-in test systems for RF and Microwave semiconductor devices. This white paper describes technical information related to the AARTS Hardware. For more information contact:

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#### 1 Overview

The AARTS station utilizes several custom boxes manufactured by Accel-RF Corporation, including the Power/Heater Control Unit (PCUHCU). This box employs circuitry that must be calibrated. Digital-to-Analog Converters (DACs) drive the voltage- and current-control loops. Analog-to-Digital Converters (ADCs) are used to measure pre-switch voltage, DUT voltage, and DUT current. These devices employ calibration factors to optimize accuracy. This application note describes the technique used to calibrate both sets of devices.

# 2 ADC/DAC Calibrations

This document describes how to perform a full calibration of a PCUHCU brick. The brick should come from the factory already calibrated, but on occasion re-calibration may be desired. The calibration factors are stored on-board the PCUHCU motherboard in non-volatile memory. Hence, bricks may be moved between channels, or even completely replaced without the need to transfer calibration files like legacy PCU units required.

This process assumes the operator has access to either an Agilent 34401 or 34410 digital multimeter (DMM). Note, all AARTS systems have built-in DMMs, and that may be used for calibration purposes if a lab-version is not available. The USBControl software program must be used to calibrate the bricks.

#### 2.1 Accessing the Calibration Form

The USBControl program is used to determine all DAC and ADC calibration factors. There are two communication avenues available to access the PCUHCU motherboard processor: USB and/or GPIB. There is a USB port on the brick itself, and a unique one for each brick located on the back of the PCUHCU mainframe. The PCUHCU brick requires a 48-V power supply for powering its internal circuitry. The PCUHCU mainframe contains such a source and it is recommended that any customer-based calibration be performed in situ using such a mainframe.

The easiest way to access the PCUHCU motherboard is via the GPIB interface since it is already connected to the main AARTS computer for life-testing purposes. The main concern in this case is to correctly identify the proper GPIB address for the box (channel) being calibrated. Note: some systems have more than one PCUHCU mainframe. The rest of this app note presumes the GPIB interface is being utilized, and not the USB interface.

First, the LifeTest program must NOT be running to use the USBControl program as they may try to access the GPIB and./or USB buses simultaneously. Hence, stop the LifeTest program if it is running, then launch the USBControl program. A Form similar to that of Figure 2-1 should appear. Since the USB interface is not being employed, no PCUHCU devices are displayed in the main windows. Note, the HPS\_Pulser devices (i.e. fixtures) may be displayed, but they are different device types. There will be no PCUHCU item in the menu list at the top. Click CTRL-F2 to force all device types to become available. A Form similar to Figure 2-2 should appear. Click on the PCUHCU menu item to launch the PCUHCU interface.

A Form similar to Figure 2-3 is presented. Note that there are no entries in the device information box at the top. That is because the USB interface mode is selected as default. To establish a communication link to the PCUHCU brick, the operator must enter the proper GPIB card number, GPIB address, and slave address in the right hand "Interface" control box. Except for some DC systems with large numbers of channels, the GPIB card number will always be "0". The GPIB addresses will generally start with "1". Right Click in the Top menu of the LifeTest program and select "Display GPIB Card and Address Info" option to see which channels correspond to which addresses.

	USB Interface Accel-RF Corporation San Diego, CA Version = 2.1.2012220 Number of USB Devices = 0
Arsign S/N	dD Model S.N. Finnesse FPGA/CPLD Channel Driver Chip
Rest Bostoader PFGA Load Info Type Address ModelNumber > 255 x	EEPROM Data Start Stop 0 v 67 v Read ADDR 00 01 02 03 04 05 06 07 08 03 04 08 00 00 08 0F ASDI
Value Program Read	

Figure 2-1: USBControl Program





Interface       Determine       Select Device       PCUHCU Control         Interface       Read Reg       Read Reg       Interface         DeterTime       Read Reg       Read Reg       Interface         DeterTime       Read Reg       Read Reg       Interface         Program       MUX Control       MUX Connel       Interface         Vitte Register       Read Reg       Interface       Interface         Vitte Register       Vitte Register       Vitte Register       Interface         Value       Nate Cannel       Interface       Interface         Value       Interface       Interface       Interface         Interface       Interface       Interface       Interface         Value       Interface       Interface       Interface         Interface       Interface       Interface       Interface <td< th=""><th>PCUHCU Control</th><th></th><th></th><th></th><th></th></td<>	PCUHCU Control				
ECUHCU Control         Select Device       PECA/CIPLD Channel         Instance       Instance         Date/Time         Model         Select Device       PECA/CIPLD Channel         Instance         Instance         NUTCE Register         NUTCE Register         NUXCOmmed         PECA/CIPLD Channel         Instance         Value	e Plot				
FPGA Reg Control       -ran         Write Register       WUX Channel         Value	Date/Time Control Set Time Read Time Date/Time	Hect Device PCU Instance Board(D Model	HCU Control S/N Firmware FPGA/C	PLD Channel Gut GPL Card Addr	a Interface 3 0 SlaveAddr 1 0 ▼
Channel 1 Channel 2 ADC PIC Calculate     VI Control     Other Calculate     VI Control     Other Calculate     VI Control     Other Calculate     VI Control     Other Calculate     Other Calculate	FPGA Reg Control Sfan Write Register CH_5L0BAL_CTRL V Program Hex Read Register PCUHCU_BOARD_D V Read 00 Hex Contread	MUX Control         Mux on           Bias Select         MUX Channel           CH1_B1_y         0	ADC Control CH1_B1 Reg Addr 00 • CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1 CH1_B1	Read           Article         Tend Strapp         Actual           V_Pre         20130165 H22200         000000           V_CNR         20130165 H22200         000000           V_CRVR         20130165 H22200         000000           Tenp         20130165 H22200         000000           Interp         20130165 H22200         000000	Cont Read Value 000000 V 000000 V 000000 A 000000 °C 000000 °C me
Over Voltage         Over Current         Over Voltage         Over Voltage<	Channel 1 Channel 2	ADC PIC Calculate         Mill           DAC PIC Calculate         Switch OH           Clear         -DAC           Ext FB         Switch OH           Clear         OH           Current         OH           V 500.0E-03 A         3.000           under Voltage         OH A           V 4.000 A         5.000           V 4.000 A         Program           V 4.000 A         Program	Control Channel 1 Bias2 Elias1 DACC Ext FB Override Shunt Enable Current V 150 0E-03 A e UnderCurrent V 150 0E-03 A m Read	VI DAC Stat	e CHCU CAL

Figure 2-3: PCUHCU Form (USB Interface)

Figure 2-4: PCUHCU Form (GPIB Interface)



The SlaveAddr represents which slot in the PCUHCU mainframe the PCUHCU brick is plugged into. Slot 0 is the farthest left, and slot 5 is the farthest right. Each brick contains two channels. Slot 0 contains channels 1 and 2, slot 1 contains channels 3 and 4, and so on. Choose the proper SlaveAddr in the box that contains the channel of interest. Note that the PCUHCU Form only refers to channels "1" and "2" - these refer to the appropriate channels associated with the channel of interest based on the SlaveAddr.

The lower boxes contain several radio button options. Click on the "Cal" button and then "Load All" to load the existing calibration factors in the brick into memory. A form similar to Figure 2-5 should appear. Select the channel of interest and the Bias of Interest. Check the "ADC\_PIC\_Calculate" and "DAC\_PIC\_Calculate" check boxes to force the processor of the motherboard to apply calibration factors to all readings and settings. The following sections discuss calibration of ADC and DAC values.



Figure 2-5: PCUHCU Cal Interface

The connection configuration for all ADC and DAC voltage measurements is shown in Figure 2-6. If the AARTS system internal DMM is used, the FRONT/BACK switch should be set to "Front" and long cables connected between the fixture of interest and the DMM. Do not forget to set the switch to "Back" for normal LifeTest operation later.

The connection configuration for all ADC and DAC current measurements is shown in Figure 2-7. Note that the PCUHCU stimulus will be limited to ~2.5A as the limit of the Agilent meter is 3A. The internal DMM current monitoring mode will effectively short the output. Hence, the current calibrations will occur in current-limit mode of the respective supplies.

If only one DMM is available, the operator will need to switch between voltage and current mode as required for the parameter of interest. If two meters are available, the operator may set the GPIB addresses to unique values (ones that do not conflict with any instruments used by the system of course), and then define one for voltage and one for current.

It should be noted that this current calibration is different from that of the legacy PCU boxes and does not require external load resistors.



#### Figure 2-6: Voltage Measurement Configuration





#### 2.2 Calibrating DAC Factors

DACs are used in a variety of ARF instruments to control stimulus. Within the PCUHCU DACs are employed to set the voltage and current values. They are also used in the trip comparator circuits for fast shutdown of the supplies upon over/under voltage and current conditions. This section describes the technique used to calibrate these factors.

First, note (as shown in Figure 2-5) that the bias Type is displayed in Red in the ADC and DAC control boxes. This should match the expected type in the brick.

The parameters of interest for DAC values are:

VSET (target Voltage) P\_CURR (target Positive Current) N\_CURR (target Negative Current) V\_HI\_TRIP (high trip value of Voltage) V\_LO\_TRIP (low trip value of Voltage) I\_HI\_TRIP (high trip value of Current) I\_LO\_TRIP (low trip value of Current)

Note that Negative Current for standard Bias1-type sources is not valid and is disabled when that type supply is selected. It is active for Bias2-type sources.

Set the measurement system to Voltage Mode (Figure 2-6) and click on "Cal Voltages" in the DAC section. The first time a "Voltage" type measurement is performed, message boxes similar to Figure 2-8 are presented to configure the voltage meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 22, but the internal AARTS DMM is typically set to 28).

USB Control Message	×
Enter DVM Type for Voltage Measurement [34401 or 34410]:	OK Cancel
34401	
USB Control Message	x
Enter DVM GPIB Card Number:	OK Cancel
USB Control Message	×
Enter DVM GPIB Address:	OK Cancel
22	

Figure 2-8: Voltage Setup Inputs

A message box similar to that shown in Figure 2-9 indicates what stimulus will be applied to the channel. Click OK to continue the process. A Form similar to Figure 2-10 will show progress. When complete the values will be populated in the appropriate text boxes. The program will continue automatically through all voltage measurements. When complete, click on the "Store" button in the DAC control box area to write and store the values in the PCUHCU non-volatile memory.

#### Figure 2-9: DAC Voltage Measurement Information Box

USB Control Message
WARNING: This will calibrate Voltage for the PCUHCU_DAC Voltage!!!
Connect the external DVM in VOLTAGE Mode from the DUT Bias Force posts to ground at the DUT location.
The program will activate the series switch and then program a variety of stimulus conditions between 0V at 0.1A and 52V at 0.1A, and then compare the internal measurements to the external DVM readings. It will use that information to determine the offset and gain for current calibration. All trip signals will be disabled during this process.
NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.
Continue?
<u> </u>

### Figure 2-10: DAC Voltage Calibration Informational Box

				PCU	HCIL Control					
Date/Tin Set Time Date	Read Time	Select Device Instance Bo	ardID UHCU	Model PH2X3_000 00	S/N Firmwa 000000-000 3.32	ire FPGA/CF 5	PLD SlaveAddr O		USB Inte GPIB Card 0 S Addr 1	laveAddr
FPGA Re Wr CH1_GLOB Program Re PCUHCU_E Read Cont ret	a Control →Fan tie Register N_CTRL ↓ Value Hex ad Register UARD_10 ↓ Value 0.00 Hex d 1 Channel 2 ↓ Biast ∩ Bia	MUX C Bias Sele CH1_B1 CH1_B1 CH1 Timeout Tripped ADC PIC Calcu Ø DAC PIC Calcu Ø DAC PIC Calcu	Dentrol et MUX U Watchdog Read min Cont Pulse late	MUX ON Channel	ADC Control Reg Addr DO V Prog Reg Ibrating!! Arace Wait! (11 81 VUITABE Meas Voltage	CH1_B1 Board P2 CH1_B1 CH1_B1 CH1_B1 CH1_B1 1 In teset	V         Pre         2013010           _sense         2013010	Read           \$ Stamp         A           \$ 5 14:22:00         C           \$ Full Path         Full Path	Cont Columna Column	Read V V A °C °C °C
		ADC			Stop		DAC		[Bias1]	
	VPRE 59.63E VSENSE 19.43E VCVR -99.33E TEMP 0.000E NT_TEMP 0.000E	ET         GAIN           -06         15.17E-03           -06         15.16E-03           E-06         313.9E-03           +00         0.000E+00           +00         0.000E+00	Cal Cal Cal Cal Cal	ADC Voltages ADC Current Clear All Read Write Store	VSI P_CUR N_CUR V_H_TR V_LO_TR LH_TR LLO_TR	FSET 32.77E+03 R -18.131 R 65.54E+03 P 32.79E+03 P 32.81E+03 P 32.77E+03 P 32.77E+03 A	GAIN -298.309 8.227E+03 8.233E+03 -298.275 -297.866 -4.118E+03 -4.118E+03	Stop Cal Cal Cal Cal Cal Cal Cal	Stop DAC Currents Clear All Read Write Store	

To calibrate DAC currents, setup the measurement system for Current Mode (Figure 2-7) and click on "Cal Currents" in the DAC section. The first time a "Current" type measurement is performed, message boxes similar to Figure 2-8 are presented to configure the current meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 23, but the internal AARTS DMM is typically set to 28).

A message box similar to that shown in Figure 2-11 indicates what stimulus will be applied to the channel. Click OK to continue the process. A Form similar to Figure 2-12 will show progress. When complete the values will be populated in the appropriate text boxes. The program will continue automatically through all current measurements. When complete, click on the "Store" button in the DAC control box area to write and store the values in the PCUHCU non-volatile memory.

#### Figure 2-11: DAC Current Measurement Information Box

ſ	USB Control Message
	WARNING: This will calibrate Current for the PCUHCU_DAC Current!!!
	Connect the external DVM in CURRENT Mode from the DUT Bias Force posts to ground at the DUT location.
	The program will activate the series switch and then program a variety of stimulus conditions between 3V at 2.5A and 3V at 0.01A, then compare the internal measurements to the external DVM readings. It will use that information to determine the offset and gain for current calibration. All trip signals will be disabled during this process.
	NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.
	Continue?
	<u> </u>

#### Figure 2-12: DAC Current Calibration Informational Box

Date/Time Control Set Time Read Time Date/Time	Select Device Instance BoardID	PCL	HCU Control		
	0 PCUHCU	Model PH2X3_000 0	S/N Firmware 0000000-000 3.32	FPGA/CPLD SlaveAddi 5 0	O USB     Interface       • GPIB     GPIB       Card     0       SlaveAddr     0
FPGA Reg Control Srf. Write Register CH1_GLOBAL_CTRL ~ Program Nex Read Register PCUHCU_BOARD_ID ~ Value Read 00 Nex	m MUX Contro Bias Select CH1_B1	Mux Channel Mux Channel D sad ont lise DAC	ADC Control Reg Addr P 0 C Prog Reg C C C C AllDrating!!! tease Walt! C C C C C C C C C C C C C	CHI_BI Temp 2013005 442 H_BI V_Pre 20130105 442 H_BI V_CR2 20130105 442 H_BI V_CR2 20130105 442 H_BI V_CR2 20130105 442 H_III_Temp 20130105 442 Store Run	Read         Cont Read           p         Actual         Value           2x00         000000         V00000           2x00         000000         V           2x00         000000         V           2x00         000000         V           2x00         000000         V           2x00         000000         °C           2x00         000000         °C           2x00         000000         °C           2x00         000000         °C           ull Path Filename         V
Channel 1 Channel 2	✓ A0C PR. Calculate     ✓ DAC PR. Calculate     ✓ DAC PR. Calculate     ✓ ADC PR. ADC PR	ADC Current	Meas Current	Store All         VI           DAC         0           FSET         0AM           12.77E+03         -298.309           Call         -0.11           B1311         8.277E+03	DAC © State © HCU © CAL
VCVR 99.3 TEMP 0.00 NT_TEMP 0.00	13E-06 313.9E-03 Ca DE+00 0.000E+00 Ca DE+00 0.000E+00 Ca	Clear All Read Write Store Load	IL_CURR [ V_HL_TRIP ] V_LO_TRIP ] L_H_TRIP ] I_LO_TRIP ] INA	5.54±03         8.233±03         Cal           12.79±03         -298.275         Cal           12.81±403         -297.966         Cal           12.77±03         -4.118±03         Cal           12.76±03         -4.118±03         Cal           12.76±04         -4.118±03         Cal           12.76±05         -6.118±03         Cal	Clear All Read Write Store Load

#### 2.3 Calibrating ADC Factors

ADCs are used for voltage and current measurements. This section describes the technique used to calibrate these factors.

First, note (as shown in Figure 2-5) that the bias Type is displayed in Red in the ADC and DAC control boxes. This should match the expected type in the brick.

The parameters of interest for ADC values are:

VPRE (Pre-Switch Voltage) VSENSE (DUT Voltage) VCVR (DUT Current)

Set the measurement system to Voltage Mode (Figure 2-6) and click on "Cal Voltages" in the ADC section. The first time a "Voltage" type measurement is performed, message boxes similar to Figure 2-8 are presented to configure the voltage meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 22, but the internal AARTS DMM is typically set to 28).

A message box similar to that shown in Figure 2-13 indicates what stimulus will be applied to the channel. Click OK to continue the process. A Form similar to Figure 2-14 will show progress. When complete the values will be populated in the appropriate text boxes. The program will continue automatically through all voltage measurements. When complete, click on the "Store" button in the ADC control box area to write and store the values in the PCUHCU non-volatile memory.

#### Figure 2-13: ADC Voltage Measurement Information Box

U	SB Control Message
	WARNING: This will calibrate Voltage for the PCUHCU_ADC Voltage!!!
	Connect the external DVM in VOLTAGE Mode from the DUT Bias Force posts to ground at the DUT location.
	The program will activate the series switch and then program a variety of stimulus conditions between 0V at 0.1A and 52V at 0.1A, and then compare the internal measurements to the external DVM readings. It will use that information to determine the offset and gain for current calibration. All trip signals will be disabled during this process.
	NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.
	Continue?
	<u> </u>



Figure 2-14: ADC Voltage Calibration Informational Box

To calibrate ADC current, setup the measurement system for Current Mode (Figure 2-7) and click on "Cal Currents" in the ADC section. The first time a "Current" type measurement is performed, message boxes similar to Figure 2-8 are presented to configure the current meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 23, but the internal AARTS DMM is typically set to 28).

A message box similar to that shown in Figure 2-15 indicates what stimulus will be applied to the channel. Click OK to continue the process. A Form similar to Figure 2-16 will show progress. When complete the values will be populated in the appropriate text boxes. Click on the "Store" button in the ADC control box area to write and store the values in the PCUHCU non-volatile memory.

#### Figure 2-15: ADC Current Measurement Information Box

U	SB Control Message
	WARNING: This will calibrate Current for the PCUHCU_ADC Current!!!
	Connect the external DVM in CURRENT Mode from the DUT Bias Force posts to ground at the DUT location.
	The program will activate the series switch and then program a variety of stimulus conditions between 2V at 0.0005A and 2V at 1A, then compare the internal measurements to the external DVM readings. It will use that information to determine the offset and gain for current calibration. All trip signals will be disabled during this process.
	NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.
	Continue?
	<u> </u>



Figure 2-16: ADC Current Calibration Informational Box

# **3** Verifying the Calibrations

There are several ways to check calibration values. One way would be to set up an appropriate stimulus (with or without a load), program it into the supply using the VI Interface (see Figure 2-4), select the ADC of interest using the pull-down box in the "ADC Control" area, and clicking the Read button. The values displayed should properly read what an external meter should read. This is fine for a few points, but is time consuming for verifying performance over a large range.

An interface exists in the USBControl program to assist automated characterize the calibration over a wide operating range. Click the "Sweep" command button in the "Cal" Section to launch the Form shown in Figure 3-1. Select the Channel/Bias and Parameter of interest and then click on "Create Defaults". This sets up a set of stimulus values to cover a wide range of operating points. Then click on "Run Sweep" to take measurements.

#### 3.1 Verify Voltage Settings and Measurements

Set the measurement system to Voltage Mode (Figure 2-6) and click the "Run Sweep" command button. The first time a "Voltage" type measurement is performed, message boxes similar to Figure 2-8 are presented to configure the voltage meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 22, but the internal AARTS DMM is typically set to 28).

An informational box similar to Figure 3-2 reminds the operator what mode to set up. Click OK to Continue.

			PCU	HCU: ADC/DAC C	haracterization		,	
CUL	Diac	Daramotor				Read Results	Store Results	Plot
CH1B	Dias Vo							
1			DMM Delta	Worst-Case DMM %	ADC Delta	Worst-Case ADC %	Worst-Case ADC/DMM Diff	Worst-Case ADC/DIMM %
reate Defaults		Run Sweep		V 5	V	%	V	<u> </u>
Targets	Programme	d DMM Measured	DMM Delta DMN	M & Error ADC Actua	ADC Measured	ADC Delta ADC 2	Error ADC/DMM	Diff_ADC/DMM %
0.000E+00 ^								
1.000E-03								
1.778E-03								
3.162E-03								
5.623E-03								
10.00E-03								
17.78E-03								
31.62E-03								
56.23E-03								
100.0E-03								
177.8E-03								
316.2E-03								
1 000								
1 778								
3,162								
5.623								
10.000								
16.000								
22.000								
28.000								
34.000								
40.000								
46.000								

Figure 3-1: PCUHCU ADC/DAC Characterization Form

#### Figure 3-2: Voltage Characterization Informational Box

USB Control Message
WARNING: This will sweep the PCUHCU VOLTAGE : Bias Type = Bias1 !!!
Connect the external DVM in VOLTAGE Mode from the DUT Bias Force posts to ground at the DUT location.
NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.
Continue?
<u> </u>

The results are populated in the center list box as the measurements are being made. The target programmed value, the DMM measured value, and the ADC measured values are displayed; along with the deviation from ideal values. The worst case deviation values are also presented. Further, the deviation as percentage of Full Scale Range (FSR) is calculated (note: this is the value against which most power supplies are specified). Figure 3-3 illustrates typical results for a Bias1 voltage sweep. Click on the "Plot" command button to plot the results (similar to that shown in Figure 3-4).

ESR = 100.0V			F	PCUHCU: AE	C/DAC Ch	aracterization					
		CH1B1 Voltage.PCUHCUData.xls			Read Results Store Results Plot						
CH/I	Bias Para	imeter		_							
CH1B1 Voltage V		Worst-Case Worst-Case		Worst-Case	Worst-Case	Wors	Worst-Case Worst-Case				
Create Defaulte	Run Sween		DMM Delta DMM %		ADC Delta	ADC %	ADC/E	ADC/DIMM Diff ADC/DIMM %			
Cleate Delauits	10	Toweep	-26.03E	-03 V ∣-26.0.	SE-03 %	-37.54E-03 V	-37.54E-03	• ]-25.5	4E-03 V  -2	5.54E-03 %	
Targets	Programmed	DMM Measured	DMM Delta	DMM & Error	ADC_Actual	ADC Measured	ADC Delta	ADC % Error	ADC/DMM Diff	ADC/DMM %	
	-100.000	-99.998	1.740E-03	1.740E-03	000000	-100.024	-23.80E-03	-23.80E-03	-25.54E-03	-25.54E-03	^
	-94.000	-94.016	-16.31E-03	-16.31E-03	000000	-94.038	-37.54E-03	-37.54E-03	-21.23E-03	-21.23E-03	
	-88.000	-88.006	-5.768E-03	-5.768E-03	000000	-88.025	-24.73E-03	-24.73E-03	-18.96E-03	-18.96E-03	
	-82.000	-82.020	-19.84E-03	-19.84E-03	000000	-82.037	-36.79E-03	-36.79E-03	-16.95E-03	-16.95E-03	
	-76.000	-76.007	-7.019E-03	-7.019E-03	000000	-76.023	-22.68E-03	-22.68E-03	-15.66E-03	-15.66E-03	
	-70.000	-70.019	-19.20E-03	-19.20E-03	000000	-70.034	-34.10E-03	-34.10E-03	-14.91E-03	-14.91E-03	=
	-64.000	-64.009	-8.621E-03	-8.621E-03	000000	-64.022	-22.47E-03	-22.47E-03	-13.85E-03	-13.85E-03	
	-58.000	-58.021	-21.30E-03	-21.30E-03	000000	-58.034	-33.76E-03	-33.76E-03	-12.46E-03	-12.46E-03	
	-52.000	-52.014	-13.52E-03	-13.52E-03	000000	-52.024	-24.31E-03	-24.31E-03	-10.80E-03	-10.80E-03	
	-46.000	-46.026	-26.03E-03	-26.03E-03	000000	-46.035	-35.21E-03	-35.21E-03	-9.186E-03	-9.186E-03	
	-40.000	-40.010	-9.575E-03	-9.575E-03	000000	-40.018	-17.69E-03	-17.69E-03	-8.118E-03	-8.118E-03	
	-34.000	-34.021	-20.94E-03	-20.94E-03	000000	-34.028	-27.94E-03	-27.94E-03	-6.996E-03	-6.996E-03	
	-28.000	-28.011	-11.36E-03	-11.36E-03	000000	-28.017	-17.15E-03	-17.15E-03	-5.791E-03	-5.791E-03	
	-22.000	-22.022	-21.69E-03	-21.69E-03	000000	-22.027	-26.60E-03	-26.60E-03	-4.910E-03	-4.910E-03	
	-16.000	-16.009	-8.791E-03	-8.791E-03	000000	-16.012	-12.13E-03	-12.13E-03	-3.338E-03	-3.338E-03	
	-10.000	-10.020	-19.53E-03	-19.53E-03	000000	-10.022	-21.89E-03	-21.89E-03	-2.357E-03	-2.357E-03	
	-5.623	-5.628	-5.259E-03	-5.259E-03	000000	-5.630	-6.758E-03	-6.758E-03	-1.499E-03	-1.499E-03	
	-3.162	-3.181	-19.45E-03	-19.45E-03	000000	-3.182	-20.46E-03	-20.46E-03	-1.011E-03	-1.011E-03	
	-1.778	-1.787	-9.420E-03	-9.420E-03	000000	-1.788	-10.20E-03	-10.20E-03	-779.4E-06	-779.4E-06	
	-1.000	-1.015	-15.28E-03	-15.28E-03	000000	-1.016	-15.85E-03	-15.85E-03	-575.5E-06	-575.5E-06	
	-562.3E-03	-569.1E-03	-6.837E-03	-6.837E-03	000000	-569.7E-03	-7.435E-03	-7.435E-03	-597.3E-06	-597.3E-06	
	-316.2E-03	-322.5E-03	-6.288E-03	-6.288E-03	000000	-323.0E-03	-6.801E-03	-6.801E-03	-513.3E-06	-513.3E-06	
	-177.8E-03	-185.6E-03	-7.808E-03	-7.808E-03	000000	-186.2E-03	-8.379E-03	-8.379E-03	-571.0E-06	-571.0E-06	
	-100.0E-03	-105.7E-03	-5.738E-03	-5.738E-03	000000	-105.9E-03	-5.916E-03	-5.916E-03	-177.4E-06	-177.4E-06	
	-56.23E-03	-64.63E-03	-8.403E-03	-8.403E-03	000000	-65.43E-03	-9.200E-03	-9.200E-03	-797.0E-06	-797.0E-06	

Figure 3-3: Voltage Measurement Results

The top plot contains the ADC Measurement Accuracy (as compared to the external reference DMM). The horizontal axis is the external DMM values. The primary vertical axis is the difference between internal and external measurements in real magnitude. The secondary axis presents the deviation in percentage of FSR.

The bottom plot presents the DAC Settability Accuracy. The horizontal axis contains the programmed target. There are two primary plots, one for ADC measurements and one for external DMM measurements. The two secondary plots provide the value as a percentage of FSR.

It should be noted that, while it is nice to have close settability values, the LifeTest program will use its internal iteration controls to drive the supply to that required to yield the use-defined targets. For instance, if there is a large current in the device (e.g. Bias1 drain current = 1A), there will be an I\*R voltage drop between the supply and the load. The LifeTest program will iterate the supply up by whatever value is required to overcome that drop. Hence, it is the measurement accuracy that is more important.

Where the settability accuracy comes into play is the value of compliance defined. There is no iteration process in the LifeTest program that accommodates compliance levels – they are whatever the calibration accuracy determines. In practice, the operator should be giving some headroom such that the supply does not hit compliance under normal device degradation operation. Hence, this accuracy is less critical.



#### Figure 3-4: Voltage Measurement Results (Plotted)

#### 3.2 Verify Current Settings and Measurements

Set the measurement system to Current Mode (Figure 2-7) and click on "Run Sweep". The first time a "Current" type measurement is performed message boxes similar to Figure 2-8 are presented to configure the current meter. Enter the appropriate values for DMM type, GPIB Card, and GPIB Address of the measurement device (Note: the default address for external DMMs is typically 23, but the internal AARTS DMM is typically set to 28).

An informational box similar to Figure 3-5 reminds the operator what mode to set up. Click OK to Continue.

## Figure 3-5: Current Characterization Informational Box

USB Control Message									
WARNING: This will sweep Current for the PCUHCU POS_CURRENT : Bias Type = Bias1 !!!									
Connect the external DVM in CURRENT Mode from the DUT Bias Force posts to ground at the DUT location.									
NOTE: The bias state will not be reset on completion. Click the Program buttons to reset all parameters when complete.									
Continue?									
<u> </u>									

Figure 3-6: Current Measurement Results

FSR = 4.0A PCUHCU: ADC/DAC Characterization											
			SN15336-02 CH1B1 Pos Current.PCUHCUData.xls				Read Results Store Results Plot				
CH/I	Bias Par	ameter		-							
CH1B1 - Pos_Current -		Worst-Case Worst-Case Worst-Case				Worst-Case Worst-Case Worst-Case					
			DMM Delta DMM % ADC Delta ADC % ADC/DMM Diff ADC/DIMM %							DC/DIMM %	
eate Defaults	Ru	in Sweep	1.5418	-03 A   38.52	2E-03 %	1.903E-03 A	47.58E-03	% 675.	2E-06 A   1	6.88E-03 %	
Targets	Programmed	DMM Measured	DMM Delta	DMM & Error	ADC_Actual	ADC Measured	ADC Delta	ADC % Error	ADC/DMM Di	IF ADC/DMM %	
1.000E-03	1.000E-03	2.541E-03	1.541E-03	38.52E-03	000CFE	2.903E-03	1.903E-03	47.58E-03	362.7E-06	9.067E-03	
1.214E-03	1.214E-03	2.527E-03	1.313E-03	32.82E-03	000CFD	2.903E-03	1.689E-03	42.21E-03	375.5E-06	9.389E-03	
1.475E-03	1.475E-03	2.497E-03	1.022E-03	25.56E-03	000CEA	2.888E-03	1.413E-03	35.32E-03	390.2E-06	9.756E-03	
1.791E-03	1.791E-03	2.512E-03	721.5E-06	18.04E-03	000D05	2.909E-03	1.118E-03	27.94E-03	396.2E-06	9.906E-03	
2.175E-03	2.175E-03	2.492E-03	317.0E-06	7.925E-03	000CFE	2.903E-03	728.3E-06	18.21E-03	411.3E-06	10.28E-03	
2.641E-03	2.641E-03	2.820E-03	179.1E-06	4.477E-03	000EC7	3.259E-03	617.7E-06	15.44E-03	438.6E-06	10.97E-03	
3.207E-03	3.207E-03	3.435E-03	227.9E-06	5.697E-03	00119A	3.821E-03	614.1E-06	15.35E-03	386.2E-06	9.654E-03	
3.894E-03	3.894E-03	3.982E-03	88.29E-06	2.207E-03	00146C	4.383E-03	488.6E-06	12.21E-03	400.3E-06	10.01E-03	
4.729E-03	4.729E-03	4.822E-03	93.21E-06	2.330E-03	00188A	5.202E-03	473.4E-06	11.83E-03	380.2E-06	9.504E-03	
5.742E-03	5.742E-03	5.832E-03	89.95E-06	2.249E-03	001DDC	6.262E-03	519.7E-06	12.99E-03	429.7E-06	10.74E-03	
6 9725 02	6.973E-03	7.066E-03	92.76E-06	2.319E-03	0023EC	7.469E-03	495.8E-06	12.39E-03	403.0E-06	10.08E-03	
0.3732-03	8.468E-03	8.502E-03	33.81E-06	845.2E-06	002B1D	8.901E-03	432.6E-06	10.82E-03	398.8E-06	9.971E-03	
8.468E-03	10.28E-03	10.36E-03	77.29E-06	1.932E-03	00343C	10.72E-03	436.7E-06	10.92E-03	359.4E-06	8.986E-03	
10.28E-03	12.49E-03	12.54E-03	54.68E-06	1.367E-03	003F5F	12.93E-03	444.1E-06	11.10E-03	389.5E-06	9.736E-03	
12.49E-03	15.10E-03	15.21E-03	49.32E-06	1.233E-03	004CBD	15.00E-03	435.66-06	10.09E-03	402 SE 06	9.6562-03	
15.16E-03	10.41E-03	10.50E-03	58 45E 06	2.209E-03	005057	22 83E 03	451.12-00	12.20E-03	402.0E-00	10.072-03	
18.41E-03	27 155-03	27.33E-03	176 6E-06	4 416E-03	0089BF	27.74F-03	592 8F-06	14.82E-03	416 25-06	10.405-03	
22.36E-03	32 97F-03	33 23E-03	263 5E-06	6 588F-03	004764	33.655-03	679 9F-06	17.00E-03	416 4E-06	10.41E-03	
27.15E-03	40.04F-03	40.36E-03	322.0E-06	8.050E-03	00CB66	40.81E-03	774.7E-06	19.37E-03	452.7E-06	11.32E-03	
32.97E-03	48.62E-03	49.01E-03	387.0E-06	9.675E-03	00F699	49.42E-03	796.0E-06	19.90E-03	409.0E-06	10.23E-03	
40.04E-03	59.05E-03	59.43E-03	384.4E-06	9.610E-03	012B0E	59.86E-03	810.6E-06	20.27E-03	426.2E-06	10.66E-03	
48.62E-03	71.70E-03	71.69E-03	-13.29E-06	-332.3E-06	0168B6	72.14E-03	436.9E-06	10.92E-03	450.2E-06	11.25E-03	
59.05E-03	87.07E-03	87.22E-03	148.7E-06	3.717E-03	01B696	87.64E-03	572.4E-06	14.31E-03	423.7E-06	10.59E-03	
71.70E-03	105.7E-03	106.1E-03	371.9E-06	9.299E-03	021521	106.5E-03	766.7E-06	19.17E-03	394.7E-06	9.868E-03	
87 07E-03	128.4E-03	128.6E-03	155.3E-06	3.884E-03	028655	129.0E-03	606.3E-06	15.16E-03	451.0E-06	11.27E-03	

The results are populated in the center list box as the measurements are being made. As with voltage measurements, the results may be plotted by clicking on the Plot command button. Figure 3-7 presents a typical set of measured values.



#### Figure 3-7: Current Measurement Results (Plotted)

#### 3.3 Storing Results

The measurement results can be stored using the "Store Results" command button. They may also be retrieved by clicking the "Read Results" command. This is useful for future reference.