P1 Quad-Socket ADC ASIC Board Production Test Procedure

Board Overview
Schematics

Test Board Components:
-FPGA mezzanine
-Ethernet transceiver
-quad-socket ADC ASIC board

Cabling:
-1 main power cable
-1 intermediate power cable
-1 LEMO analog signal cable
-1 ethernet cable

Test Stand Hardware:
-1 DAQ PC with ethernet card, keyboard, mouse, monitor
-1 power supply with 4.5V output, 3A current limit
-1 function generator (using Agilent 33600a)
-1 metal bucket
-pulley + hoist assembly
-dewar

Test Stand Software :
femb_python package release X

Quad-socket P1 ADC ASIC Test Board with Main Components Identified
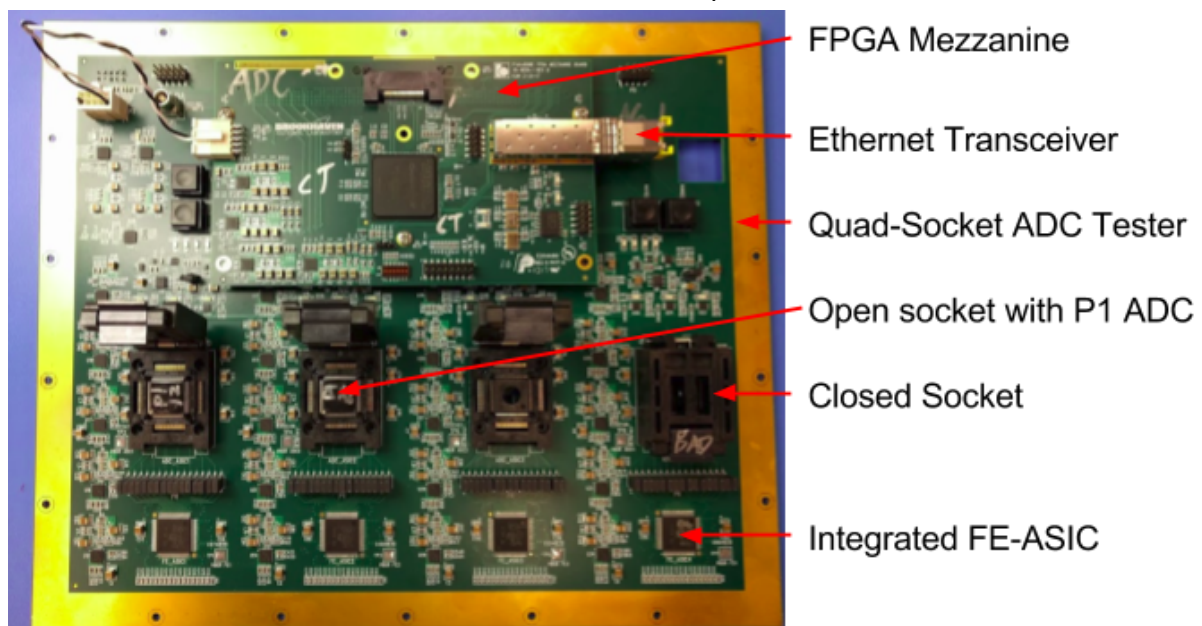
Socket Status LED Overview
The power supply for each ADC ASIC and electronic devices associated with its socket can be individually turned on or off by the FPGA. On power up the ADC sockets are not powered and need to be turned on before configuration and data taking can start. Socket power status LEDs provide a visual reference for the state of each socket. The LEDs are green when the ADC and socket electronics are turned off and turn red when power is enabled by the FPGA. The shifter can use these LEDs to confirm that the ADCs have been powered on or off.

The shifter should not directly handle the board when the test board is on. The shifter should only touch or handle the board when the 4.5V power supply output is off. At this point the status LEDs are off.
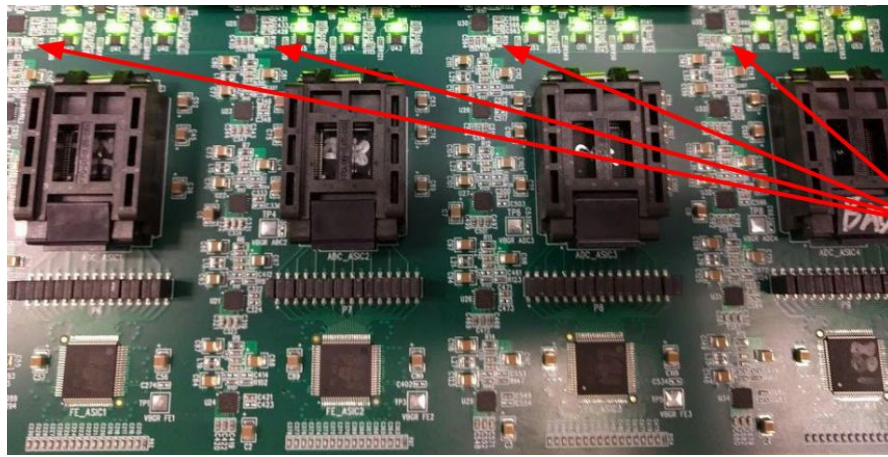
Socket Power Status LEDs

Test Stand Setup (for shift leader or expert)

Setup the test stand with the following configuration:

-HIGH Z function generator output impedance

-4.5V output on one power supply channel, all others 0V (to avoid mistakes)

-power supply negative outputs tied to ground

-verify correct intermediate power cable orientation (refer to images)

-ensure correct software on operator account, GUI is ready for shifter

-verify function generator control is working correctly

Procedure Overview

Preparation
1) Verify test board hardware status
2) Place ADC ASICs in test board sockets
3) Move test board to quad ADC ASIC test stand
4) Verify power supply 4.5V output is off, configuration is correct
5) Attach required cables to test board
6) Start quad-socket ADC production test GUI if not already started
7) Enter requested information into GUI
8) Turn power supply 4.5V output ON
9) Check ADC ASIC status using waveform viewer and terminal information
10) Reseat or replace ADC ASICs if necessary (several step procedure)

Liquid Nitrogen Immersion
11) Turn power supply 4.5V output OFF
12) Insert test board into basket
13) Hang basket on hoist + pulley system
14) Turn power supply 4.5V output ON
15) Verify ADC ASICs are still working well using waveform viewer and terminal information
16) Immerse ASICs board in liquid nitrogen (several step procedure)
17) Make final adjustments if necessary
18) Close waveform viewer window

Cryogenic Production Test
19) Press GUI button "Start Tests"
20) Monitor test progress with terminal output
21) Check summary plots that display after test finishes
22) Enter test results in spreadsheet
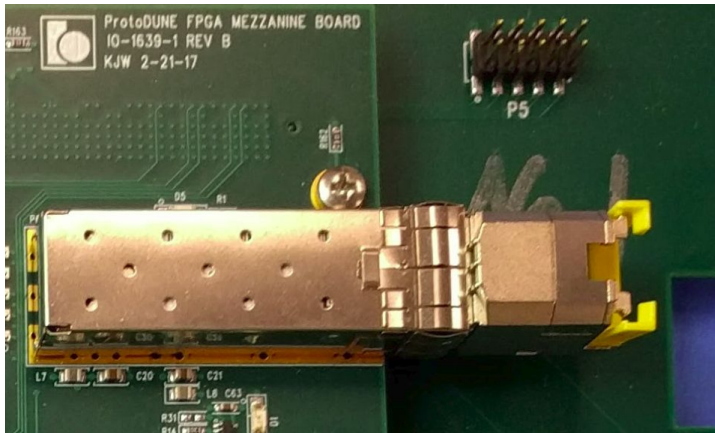23) Press GUI button "Reset"

Warm Up and Drying
24) Turn power supply 4.5V output OFF
25) Disconnect test-board cables from power supply
26) Raise board out of liquid nitrogen and bag
27) Leave basket hanging in air for ~20 minutes to warm up
28) Move basket + cables to unbagging area
29) Remove test board from basket
30) Remove ADC ASICs and place in appropriate containers
31) Dry board (several step procedure)

Procedure Step 1: Verify test board hardware

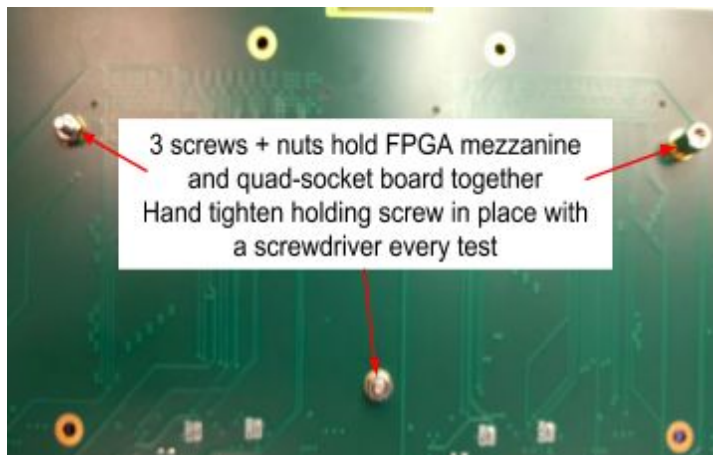Check that the integrated FPGA + quad-socket test board has the following:

1) Ethernet transceiver inserted and well seated
2) 3 screws holding FPGA board to ASIC board, hand tighten if necessary
3) Standoffs on top of board
4) Intermediate power cable between quad-socket and FPGA boards

Ethernet Transceiver

Tighten Screws

3 screws + nuts hold FPGA mezzanine and quad-socket board together Hand tighten holding screw in place with a screwdriver every test

Stand offs: protect power cable and prevent bottom of board getting dirty

Procedure Step 2: ASIC placement

Place three ADC ASICs in test board sockets

1. Move test board to staging area
2. Place box of ASICs to be tested beside test board
3. Open test board sockets 1,2,3. Do not open socket 4, which should be labelled "BAD" or similar
4. Use suction pen to place 3 P1 ADC ASICs in sockets. The large dot imprint on the ASIC top surface must be in the top-right of the socket. See image below for orientation.
5. Close sockets. Verify that latch is secure before moving board in next step

Quad-Socket Test Board in Preparation Area
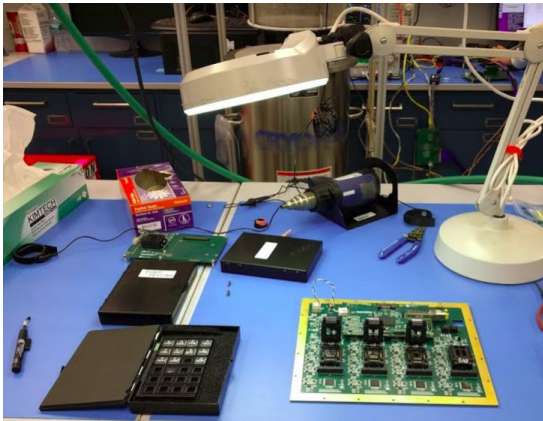
P1 ASIC in Test Board Socket

-ensure large dot imprint is to the top right when looking into the open socket of the FE-ASIC
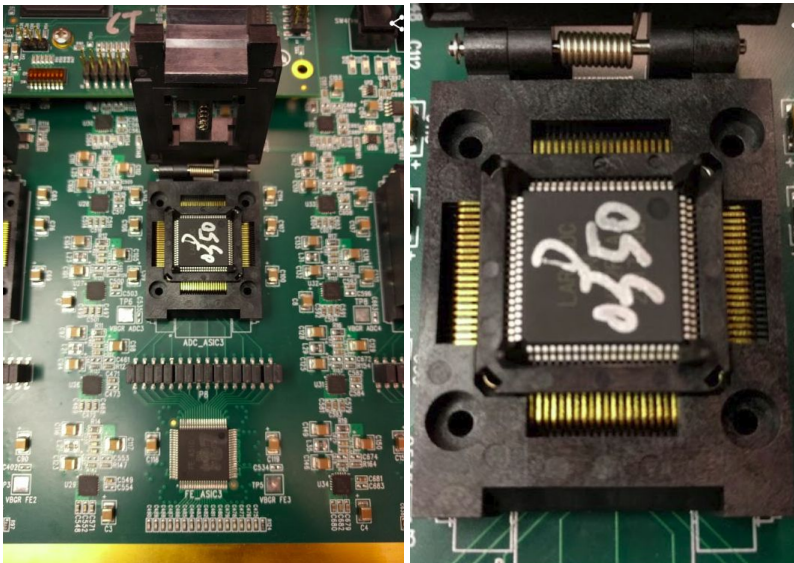
Procedure Step 3: Move test board to quad-socket ADC test stand
Carefully move uncabled board to test stand and place in marked position on lab bench top
-Need to mark position on bench top
-add picture of board in correct position pre-cabling HERE

Procedure Step 4: Verify power supply 4.5V output is off, configuration is correct
Look at the low voltage power supply and verify the following:
1. The power supply is configured to supply 4.5V output voltage
2. The power supply outputs are OFF.

Procedure Step 5: Attach required cables to test board

Attach the three required cables to the test board:

1. Low voltage power supply cable: connect to connector on bottom of board and to 4.5V power supply output. White plug goes to positive (+) voltage output and black plug to negative ((-) voltage output
2. Insert ethernet cable into transceiver on test board FPGA mezzanine
3. Insert LEMO cable into external signal input connector on test board and function generator channel 1 output
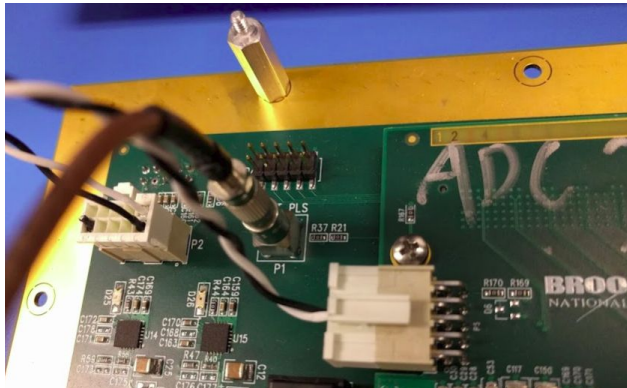
Low Voltage Power Cable Plugs in Power Supply Outputs

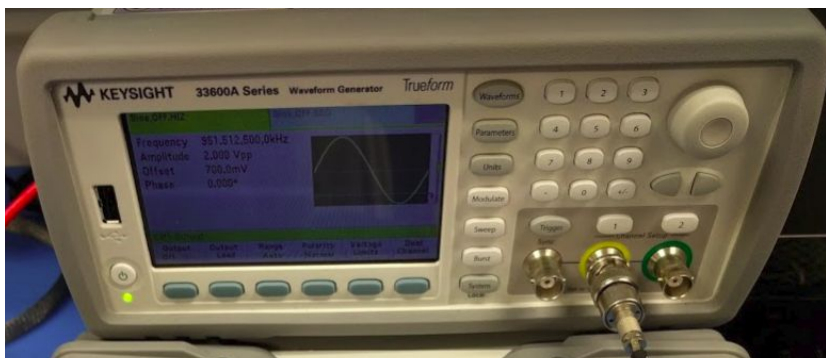Low Voltage Power Connector on Back of Quad-Socket Test Board

Ethernet Cable in Transceiver

LEMO Cable Inserted into Test Board External Signal Input Connector

LEMO Cable Attached to Function Generator Channel 1 Output

Fully Cabled Test Board on Test Stand Cabling

Procedure Step 6: Start quad-socket ADC production test GUI if not already started
Verify that the test-stand PC is running has the production test GUI pictured below. If the
GUI is not running then rerun the terminal command "quadadc_prod_gui"

Procedure Step 7: Enter requested information into GUI

Quad-Socket ADC ASIC Production Test GUI
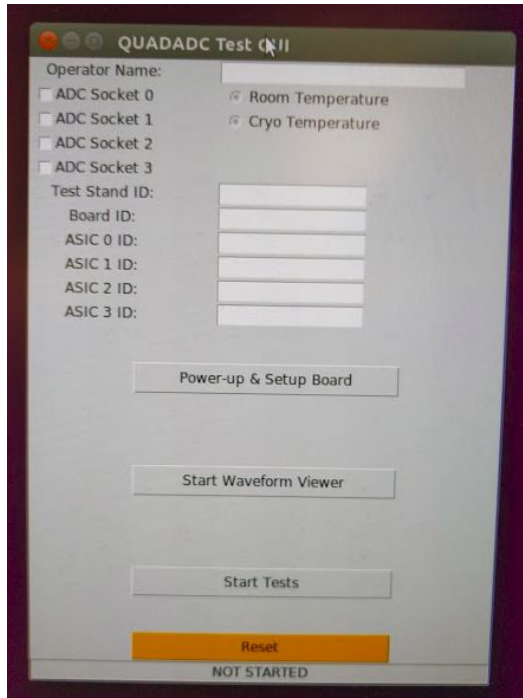
Production Step 8: Turn power supply 4.5V output ON

Turn the 4.5V power supply output ON.

1. For the RIGOL DP832 and DP832A model power supplies, press the "On" button for the appropriate power supply channel.
2. Verify that the channel status indicator shows the channel is ON. For the RIGOL supplies this means the "On" button is illuminated green
3. Read the current draw of the power supply 4.5V output from the display. For the single channel output configuration it should slowly reach 1.8A over

RIGOL Power Supply with 4.5V Output ON

Production Step 9: Check ADC ASIC status using waveform viewer and terminal information

1. Press the GUI "Power Up & Setup Board" button and view the information printed to the terminal window.
2. Check the terminal for a "Setup Initialized" and ASIC status messages
3. Press the "Start Waveform Viewer" button and verify a sinusoidal waveform is clearly visible for each channel on each ASIC

Quad-Socket ADC ASIC Production Test GUI
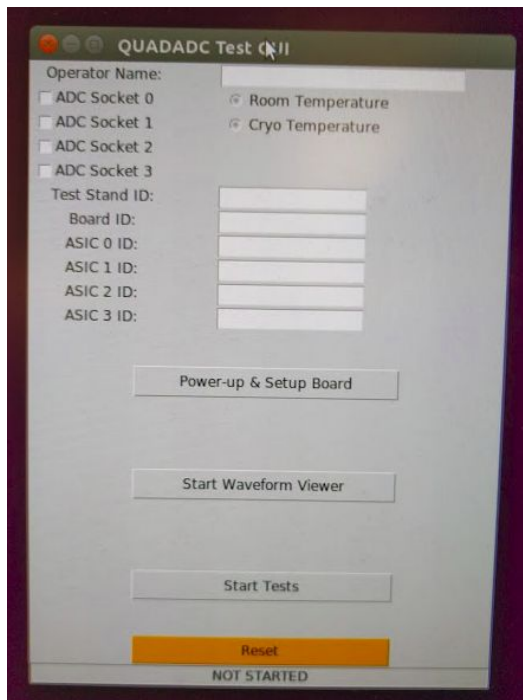
Production Step 10: Reseat or replace ADC ASICs if necessary

If an ASIC is not functioning correctly, the shifter should follow current shift guidelines about whether to replace it. Use the following procedure to replace the ASIC:

1. Close the waveform viewer window by pressing the "x" button on the top left of the window.
2. Turn power supply 4.5V output OFF. For the RIGOL DP832 supplies this means pressing the "On" button and verifying it's no longer illuminated and the display states the output is OFF
3. Uncable the quad-socket test-board. Remove the cables listed in Step 5
4. Move the test board to the ASIC installation area
5. Remove the non-functioning ASIC and replace with a new ASIC to be tested. Follow shift guidelines for what to do with the non-functioning ASIC.
6. Repeat Steps 3-9.

Production Step 11: Turn power supply 4.5V output OFF

Turn the 4.5V power supply output OFF.

1. For the RIGOL DP832 and DP832A model power supplies, press the "On" button for the appropriate power supply channel.
2. Verify that the channel status indicator shows all power supply channels are OFF. For the RIGOL DP832 supplies this means pressing the "On" button and verifying it's no longer illuminated and the display states the output is OFF
3. Read the current draw of the power supply 4.5V output from the display. It should display 0A on all channels.

RIGOL Power Supply with 4.5V Output OFF

**Production Step 12:** Insert test board into basket

Insert the cabled and unpowered test board into the immersion basket.

1. Place the immersion basket in front of the test stand (see picture)
2. Pick up the test board and hold it vertically with the FPGA board defining the top.
3. Insert the board test board into the basket, aligning the board edges with the black marks on the rim of the basket (see picture)

Immersion Basket Placed in Front of Test Stand
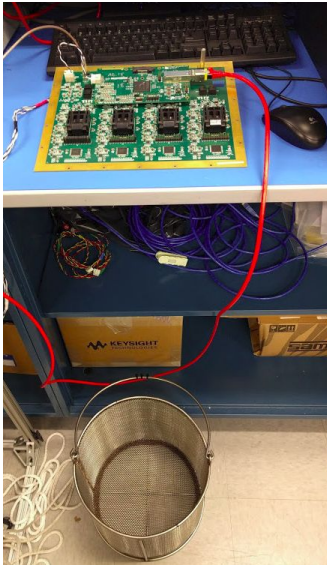
Test Board Inserted into Immersion Basket
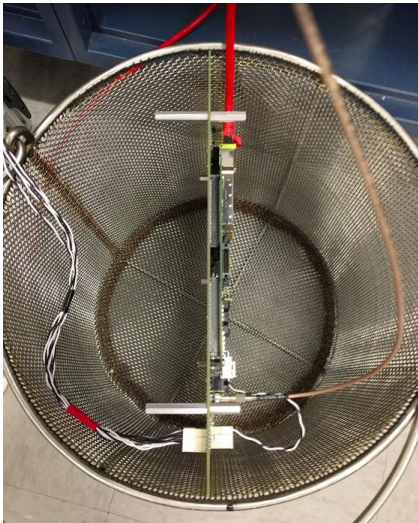
Production Step 13: Hang basket on hoist + pulley system
Pick up basket handle and attach to hook on tower hoist and pulley system.

Production Step 14: Turn power supply 4.5V output ON

Turn the 4.5V power supply output ON.

1.   For the RIGOL DP832 and DP832A model power supplies, press the "On" button for the appropriate power supply channel.
2.   Verify that the channel status indicator shows the channel is ON. For the RIGOL supplies this means the "On" button is illuminated green
3.   Read the current draw of the power supply 4.5V output from the display. For the single channel output configuration it should slowly reach 1.8A over.
4.   If the current draw is higher than 3A or the voltage output drops significantly below 4.5V turn off the power supply immediately inform the shift leader.

RIGOL Power Supply with 4.5V Output ON

Production Step 15: Verify ADC ASICs are still working well using waveform viewer and terminal information

1. Press the GUI "Power Up & Setup Board" button and view the information printed to the terminal window.
2. Check the terminal for a "Setup Initialized" and ASIC status messages
3. Press the "Start Waveform Viewer" button and verify a sinusoidal waveform is clearly visible for each channel on each ASIC

Quad-Socket ADC ASIC Production Test GUI
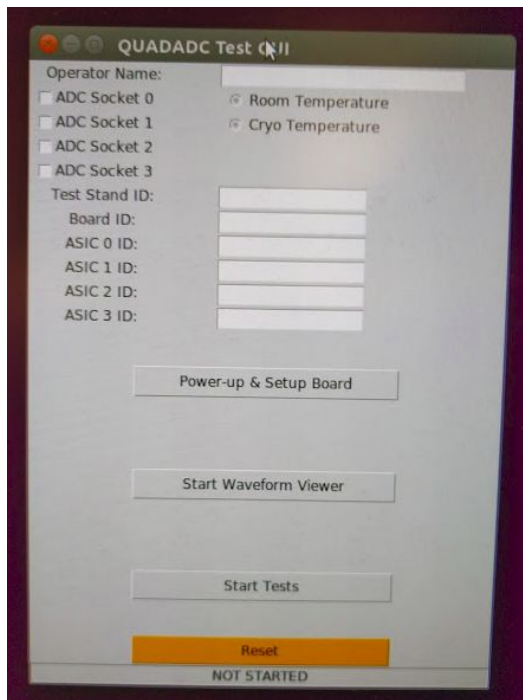
Production Step 16: Immerse ADC ASICs in liquid nitrogen (several step procedure, similar to single-socket procedure)

Slowly lower the test board into liquid nitrogen until the ADC ASICs are fully immersed. View the waveform viewer to ensure ADC ASICs continue to function while being immersed.

1. Lower the basket until the bottom is immersed. Stop and wait until liquid nitrogen stops boiling.
2. Lower basket until bottom of test board to just below ASIC sockets is immersed in liquid nitrogen. Stop and wait until liquid nitrogen stops boiling.
3. Slowly lower basket and immerse ADC ASIC sockets. View the waveform viewer to monitor ADC ASIC performance. Lower the basket until socket status LEDs are level with the liquid nitrogen surface.

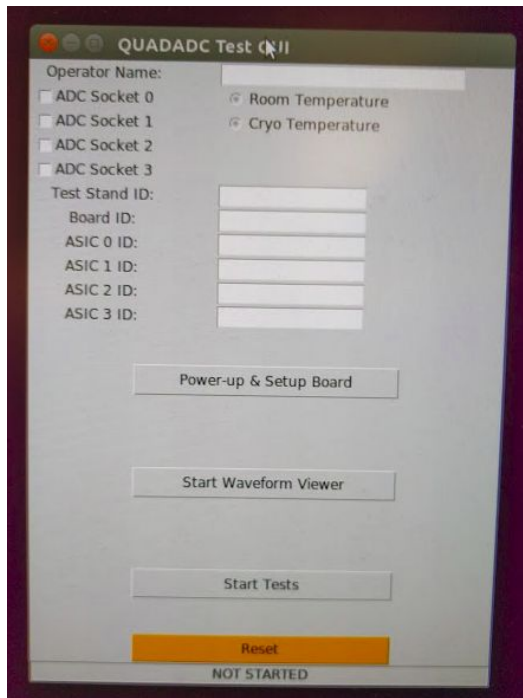**Production Step 17:** Make final adjustments if necessary

Depending on ADC ASIC status follow current shift guidelines about how to recover non-functioning ASICs.

Production Step 18: Close waveform viewer window
Close the waveform viewer window by pressing the "x" button on the top left of the window.

**Production Step 19:** Press GUI button "Start Tests"

Production Step 20: Monitor test progress with terminal output

View the terminal text and look for error messages. New text should appear at least every 30 seconds. The test is complete when summary plots are displayed.

Production Step 21: Check summary plots that display after test finishes
Verify that the test completed and whether each ADC ASIC passed quality cuts.

Production Step 22: Enter test results in spreadsheet
Enter results of test into cold electronics results spreadsheet

Production Step 23: Press GUI button "Reset"
Reset fields in GUI by pressing "Reset" button.
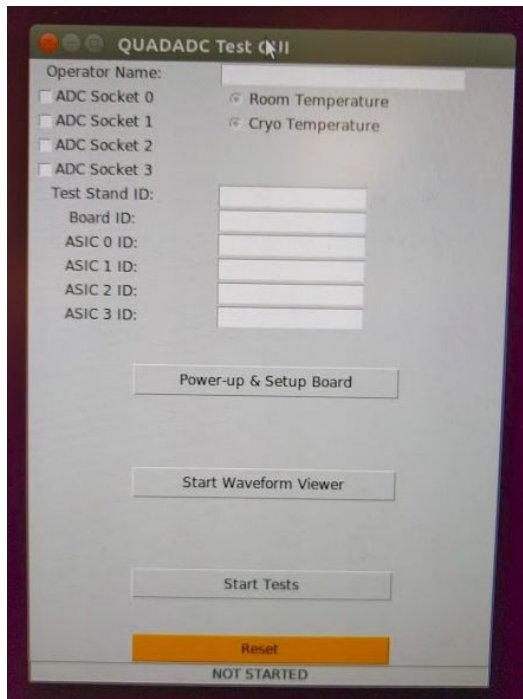
Production Step 24: Turn power supply 4.5V output OFF

Turn the 4.5V power supply output OFF.

4. For the RIGOL DP832 and DP832A model power supplies, press the "On" button for the appropriate power supply channel.
5. Verify that the channel status indicator shows all power supply channels are OFF. For the RIGOL DP832 supplies this means pressing the "On" button and verifying it's no longer illuminated and the display states the output is OFF
6. Read the current draw of the power supply 4.5V output from the display. It should display 0A on all channels.

RIGOL Power Supply with 4.5V Output OFF

Production Step 25: Disconnect test-board cables from power supply
Unplug test board cables from power supply output, and function generator.

Production Step 26: Raise board out of liquid nitrogen and place bag.
Quickly raise board out of liquid nitrogen and place bag around basket. The bag limits frost appearing on board surface, so the bag should be reasonably air tight.

Production Step 27: Leave basket hanging in air for ~20 minutes to warm up

Production Step 28: Move basket + cables to unbagging area.

Production Step 29: Remove test board from basket
Remove test board from basket and place in ASIC staging area

Production Step 30: Remove ADC ASICs and place in appropriate containers
Use the vacuum pen to remove ADC ASICs from test board sockets. Follow shift guidelines regarding where to place ASICs given the results of the production test.

Production Step 31: Dry the test board
Dry the test board to remove condensation. Follow shift guidelines regarding current drying procedures.

Common Test Stand Problems, Debugging and Solutions

Receive "register read error" message during room temperature test board setup or when running waveform viewer at room temperature
-check that test board is correctly cabled
-check that transceiver is seated correctly in FPGA transceiver socket
-check the 4.5V power supply output is ON and current draw is normal. If current draw is >100mA below normal value the FPGA board may not be receiving power
-try running terminal command "sudo restart-network" and check if problem persists. Attempt this several times
-ask the shift leader to check network card configuration
-try a different board and check if problem persists

Receive "register read error" message in the middle of a cryogenic production test
-check the 4.5V power supply output is ON and current draw is normal.
-it is possible that transceiver has become too cold to function. The production test should end, and the board powered down then removed from LN2 following the standard shift procedure. Check if the board works correctly at room temperature.

An error message causes the test to stall or crash. Test summary plots are not displayed at the end of the test
-this is a major error. Inform the shift leader and copy and paste terminal information for entire test into a new ELOG post.