



NATIONAL  
OPTICAL  
ASTRONOMY  
OBSERVATORY

SYSTEM INSTRUMENTATION GROUP  
950 N. Cherry Ave.  
P. O. Box 26732  
Tucson, Arizona 85726-6732  
(520) 318-8000 FAX: (520) 318-8303

---

# Torrent

## Board Test and Calibration

NOAO Document TRNT-TS-01-0002

Revision: 0

Authored by:  
Ron George  
08/2/2010

Please send comments:  
[rgeorge@noao.edu](mailto:rgeorge@noao.edu)

## Revision History

Version	Date Approved	Sections Affected	Remarks
0	8/2/2010	All	Initial draft release - aro

# Table of Contents

<b>Revision History .....</b>	<b>2</b>
<b>Table of Contents.....</b>	<b>3</b>
<b>1.0 Introduction.....</b>	<b>5</b>
<b>2.0 Torrent Board Test System Hardware and Software Conceptual Overview ....</b>	<b>5</b>
<b>3.0 Torrent Test Platform Hardware Design .....</b>	<b>6</b>
3.1 USB Data Acquisition Modules.....	6
3.2 Power Supply Dynamic Load Board .....	6
3.3 Torrent PCB Test Fixture.....	7
<b>4.0 Torrent Test Platform Software Design .....</b>	<b>7</b>
4.1 Initial Test Page .....	7
4.2 Power Supply PSM Test Page .....	8
4.3 LCB Test Page .....	10
4.4 CCD AFE Test Page .....	13
4.5 Mezzanine Board Test Page.....	18
4.6 Pre-amp Board Test Page.....	19
4.7 Utility Transition Board Test Page .....	20
4.9 IR AFE Test Page .....	21
<b>5.0 Torrent PCB assembly test requirements .....</b>	<b>27</b>
5.1 Power Supply Board .....	27
5.2 Local Control Board (LCB).....	27
5.3 CCD AFE.....	28
5.4 IR AFE Board .....	30
5.5 Mezzanine Board .....	32
5.6 Pre-amp Board .....	32
5.7 Utility Transition Board.....	33

## **List of Figures**

## **List of Tables**

## 1.0 Introduction

This document details the functional test plan and requirements for the electronics hardware boards that make up a Torrent controller. It also describes and details implementation for the Torrent controller board test platform.

## 2.0 Torrent Board Test System Hardware and Software Conceptual Overview

The electronics hardware and software that will be used to test the printed circuit board assemblies that eventually make up a Torrent controller are based on commercial off-the-shelf USB-based data acquisition I/O devices under the control of a Lab View based test program. The USB DAQ devices will be mounted inside a test fixture with resident Torrent PCB assemblies and test-specific simulation load boards. Resident Torrent PCBs are necessary to test production PCBs. For example, an LCB needs a power supply to operate while under test. This power supply will be provided by the resident Torrent PCBs. The test fixture will first be configured by the operator to test a particular type of Torrent PCB. The Torrent PCBs that are supported for test are:

- Power supply board
- LCB
- AFE (IR and CCD)
- Mezzanine board
- Pre-Amplifier board
- Transition / Utility board

The stimulus and measurement of the PCB under test is done by the USB DAQ devices under Lab View program control. Control of the PCB under test, the resident PCBs, and the simulation load boards is also done under Lab View program control. There will be an interface between the PAN and the Lab View program for setting attributes, reading back telemetry and acquiring video channel test data.

The graphical user interface will begin with a form into which the test operator enters some basic information such as his or her name, the date and the location. The operator then selects from a menu the specific Torrent PCB requiring test. Menu selection will then take the operator to the appropriate PCB test screens where more specifics will be entered such as the serial number, type and revision of the PCB under test. Each PCB test screen will display instructions on how to configure the test fixture to test the selected PCB. Once the test fixture is configured and the PCB under test is installed in it, the operator may continue with the testing of the chosen PCB. From this point the test executes and provides results to the operator. The operator has the option of saving the test results or exiting without saving. If the PCB being tested uses calibration factors, these too will be stored in a calibration text file upon saving. The tests will all exit back to the initial screen.

For diagnostic purposes each PCB sub-test will have a diagnostic mode that will allow a technician to loop on a failure for failure analysis and troubleshooting. The test program shall be compiled to run stand-alone without the need for a Lab View installation to test Torrent PCBs.

### 3.0 Torrent Test Platform Hardware Design

The hardware necessary to fully test all of the Torrent PCBs listed in Section 1.0 is a combination of “off the shelf” USB 2.0 data acquisition modules, a USB 2.0 hub, a power supply dynamic load board, a 60W 24V Torrent power brick, resident boards and a fixture in which to contain the test hardware and provide an interface to the PCBs being tested.

#### 3.1 USB Data Acquisition Modules

There are a variety of USB 2.0 DAQ modules available. The specific minimum DAQ I/O requirements for testing the Torrent PCB’s are shown in Table 1.

**Table 1 – DAQ Requirements**

DAQ Type	Range	Resolution	Minimum Number of Channels
Analog Input	+/-10V	16 bit @1Mhz	25
Analog Output	+/-10V	16 bit	10
PWM output	0 – 3.3V Or TTL	16 bit @20Mhz (w/ external clock)	10
Counter Input	+/-15V	32 bit @20Mhz	2
Digital I/O	TTL	1 bit	33

#### 3.2 Power Supply Dynamic Load Board

A dynamic load to meet the test requirements of the PSM will be required. The design for the dynamic load is based on the 2SK1058 and 2SJ162 N or P type linear power MOSFETs. An analog output from the USB DAQ AO module will set the gate voltage on the load MOSFET for that particular voltage output of the power supply. This in turn sets the load current for that same power supply output. The gate voltage / load current can dynamically be varied independent of other power supply outputs or left in a static state while other outputs are being tested. Additionally the capability exists to dynamically vary all the analog voltage outputs of the power supply at the same time to ensure no cross coupling or pickup exists between the supplies as they each regulate to the changing loads.

### **3.3 Torrent PCB Test Fixture**

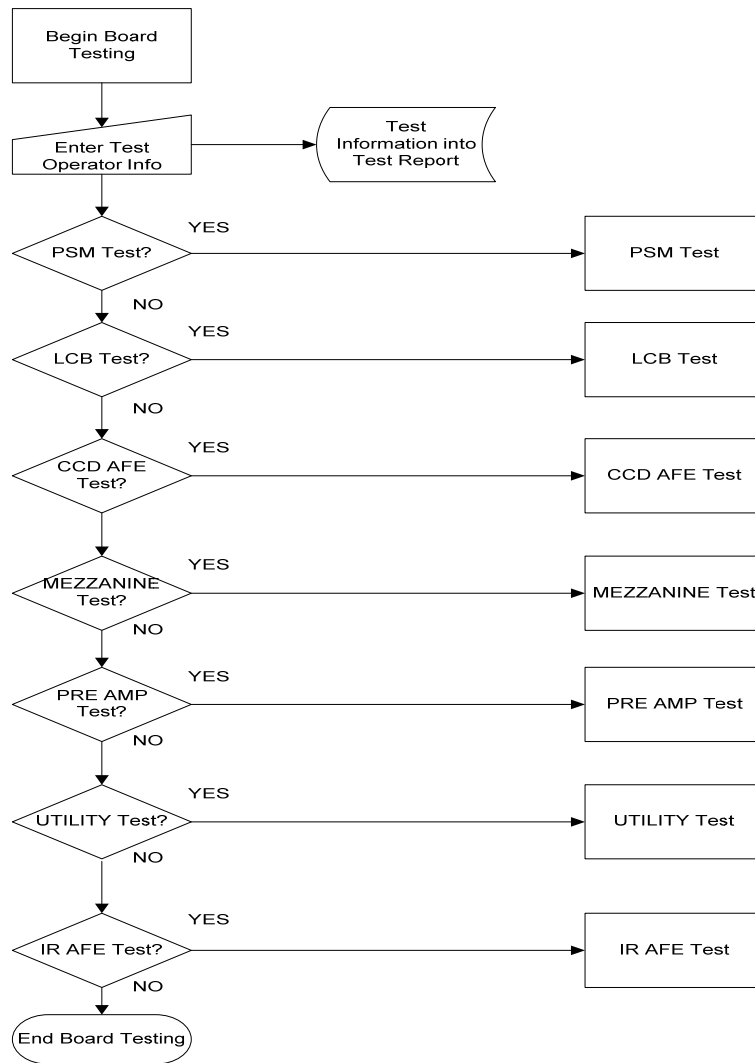
The test fixture will be a box in which all necessary USB DAQ, fixture power, dynamic load boards, USB hub, resident boards and unit under test interconnections are housed. The fixture will have location test sites for the particular PCB being tested. Test cabling will be connected with adaptors from the fixture interconnections to the PCB under test. The fixture shall have a USB feed-through for the software to communicate with the USB DAQ modules. The fixture is where the actual testing and troubleshooting are done.

## **4.0 Torrent Test Platform Software Design**

The test software to run the Torrent test platform will be coded in Lab View and must have the ability to pass values to and from the DHE via the PAN process. The overall design will consist of a page for each of the Torrent PCBs to be tested and the appropriate steps within each page to test the board. At the end of a test for a given board a report will be generated that contains the results of the test, the name of the person doing the testing, the date the test was performed and any calibration factors that are calculated as a result of the testing.

### **4.1 Initial Test Page**

The initial test page for the test program will consist of multiple text fields for the test operator to enter in their name, the date (automatic) and location. The initial page will have a menu that will bring up the subsequent board test page for the board being tested.

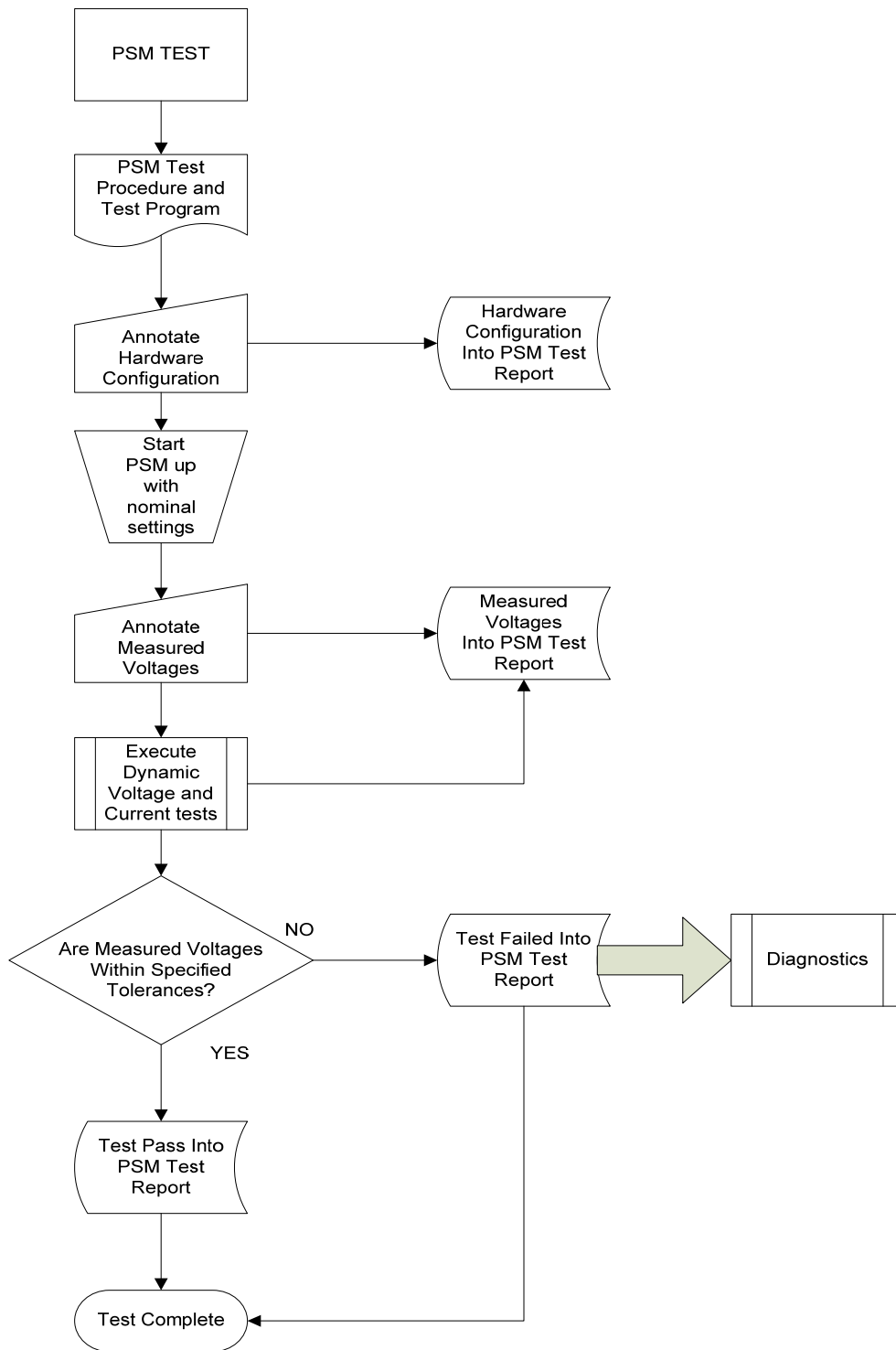


Initial Test Page  
Figure 1

## 4.2 Power Supply PSM Test Page

The power supply test page will have text fields to enter information such as the serial number of the power supply board under test. There will be sections for the measured results to be entered.

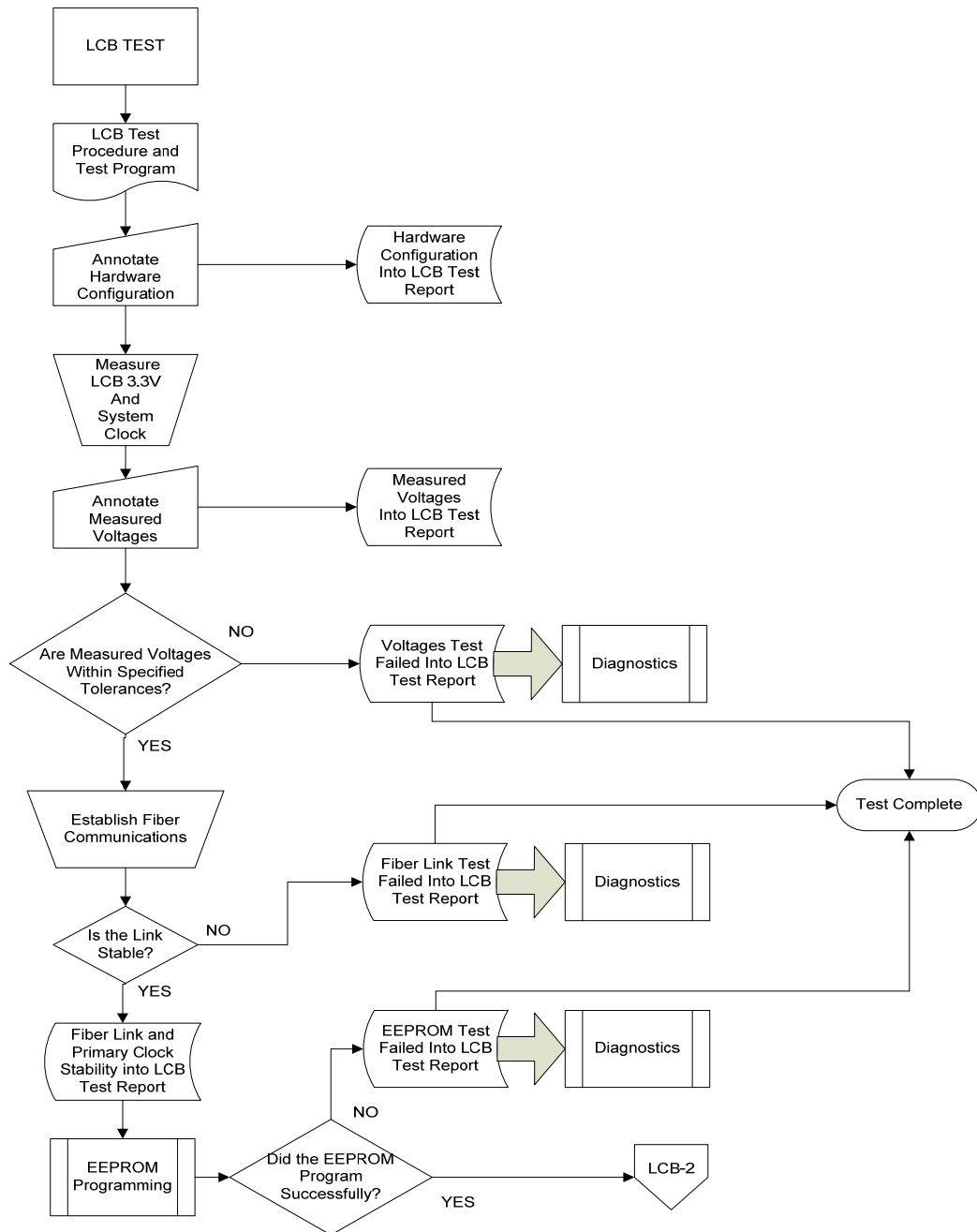




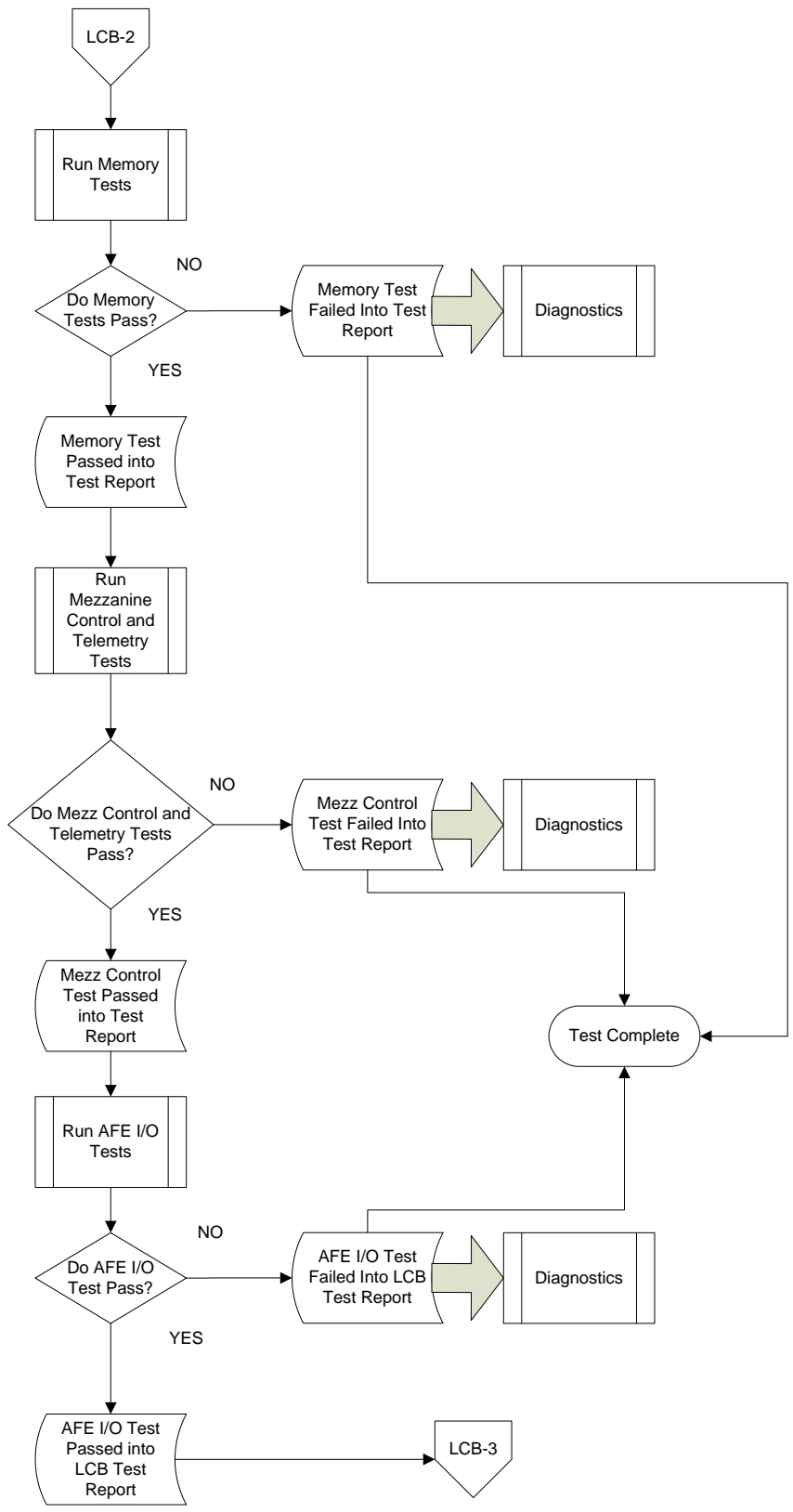
Power Supply PSM Test Page  
Figure 2

### 4.3 LCB Test Page

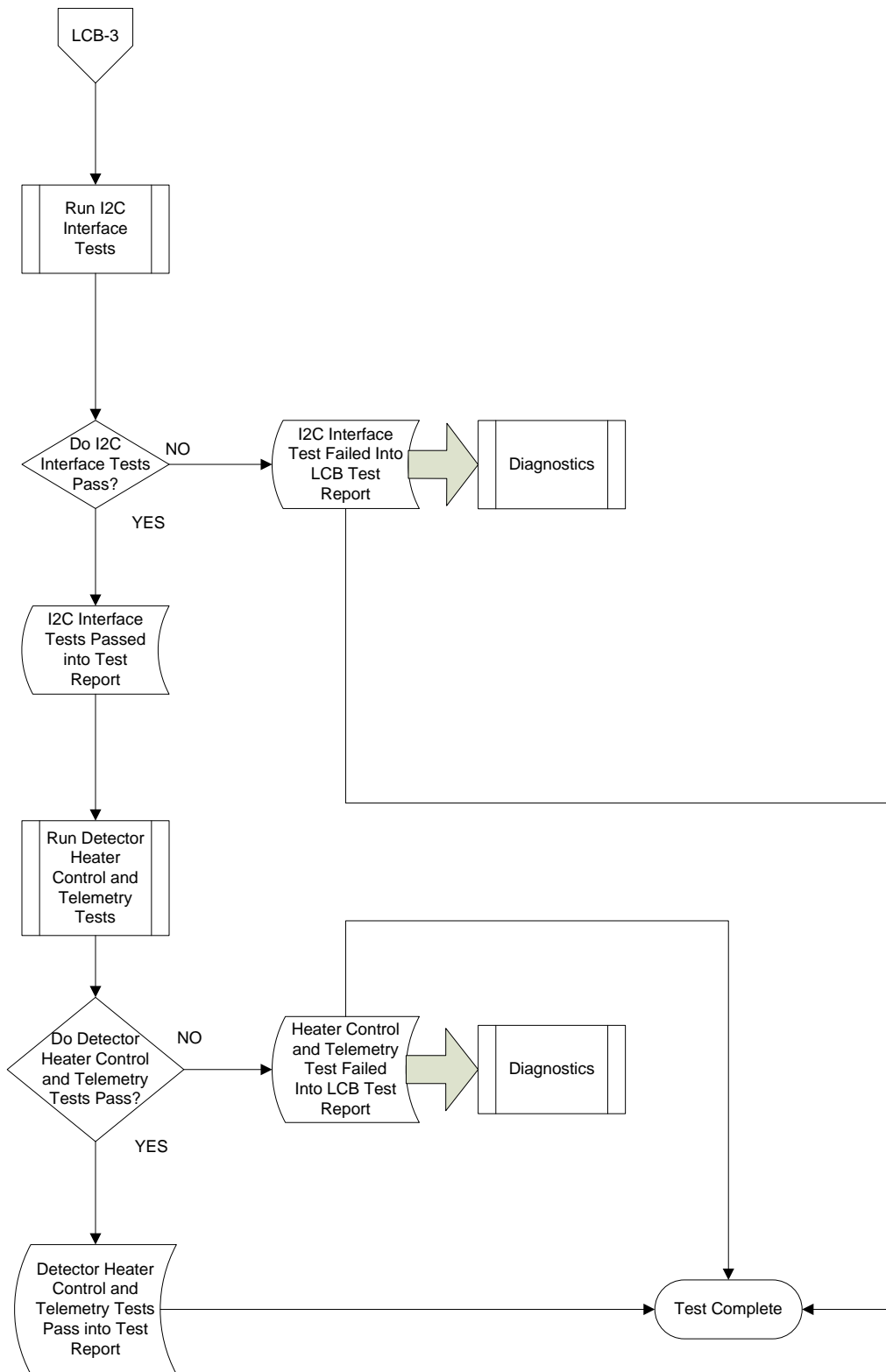
The LCB test page will have text fields to enter information such as the serial number and Hardware / Firmware configuration of the LCB under test. The rest of the LCB test page is shown in Figures 3, 4 and 5.



LCB Test Page  
Figure 3



LCB2 Test Page  
Figure 4

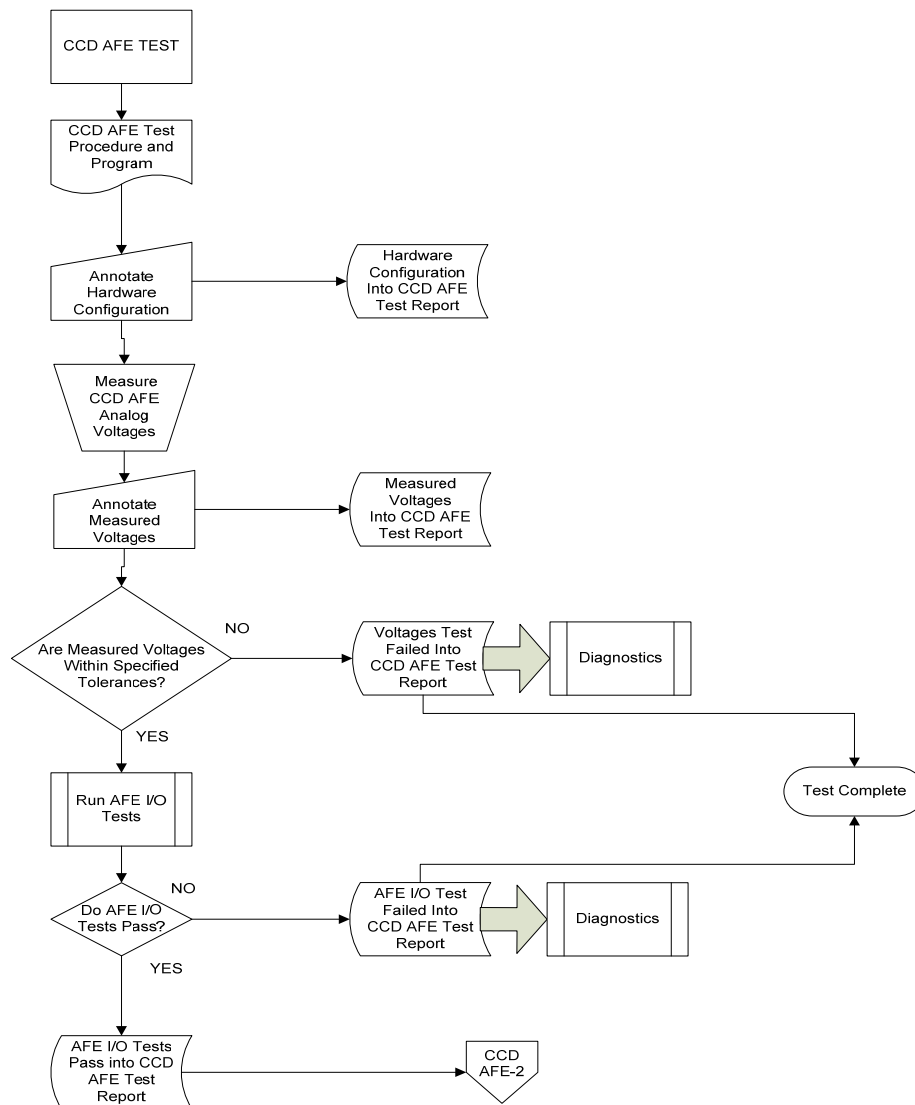


LCB3 Test Page  
Figure 5

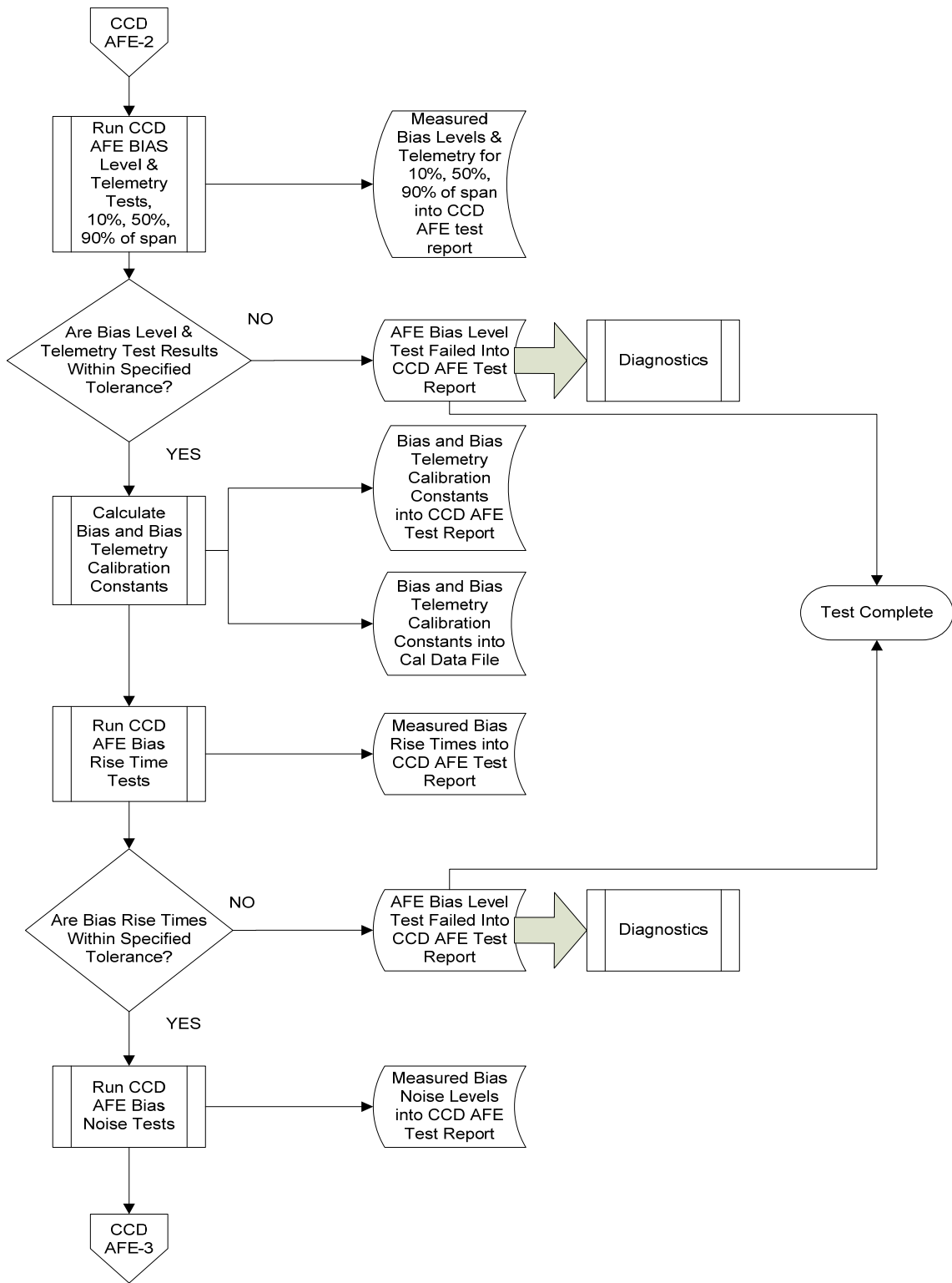
## 4.4 CCD AFE Test Page

The CCD AFE test page will have text fields to enter information such as the serial number of the CCD AFE board under test. There will be sections for the measured results that will be filled in automatically. The slope and offset calibrations will be calculated from these measured results.

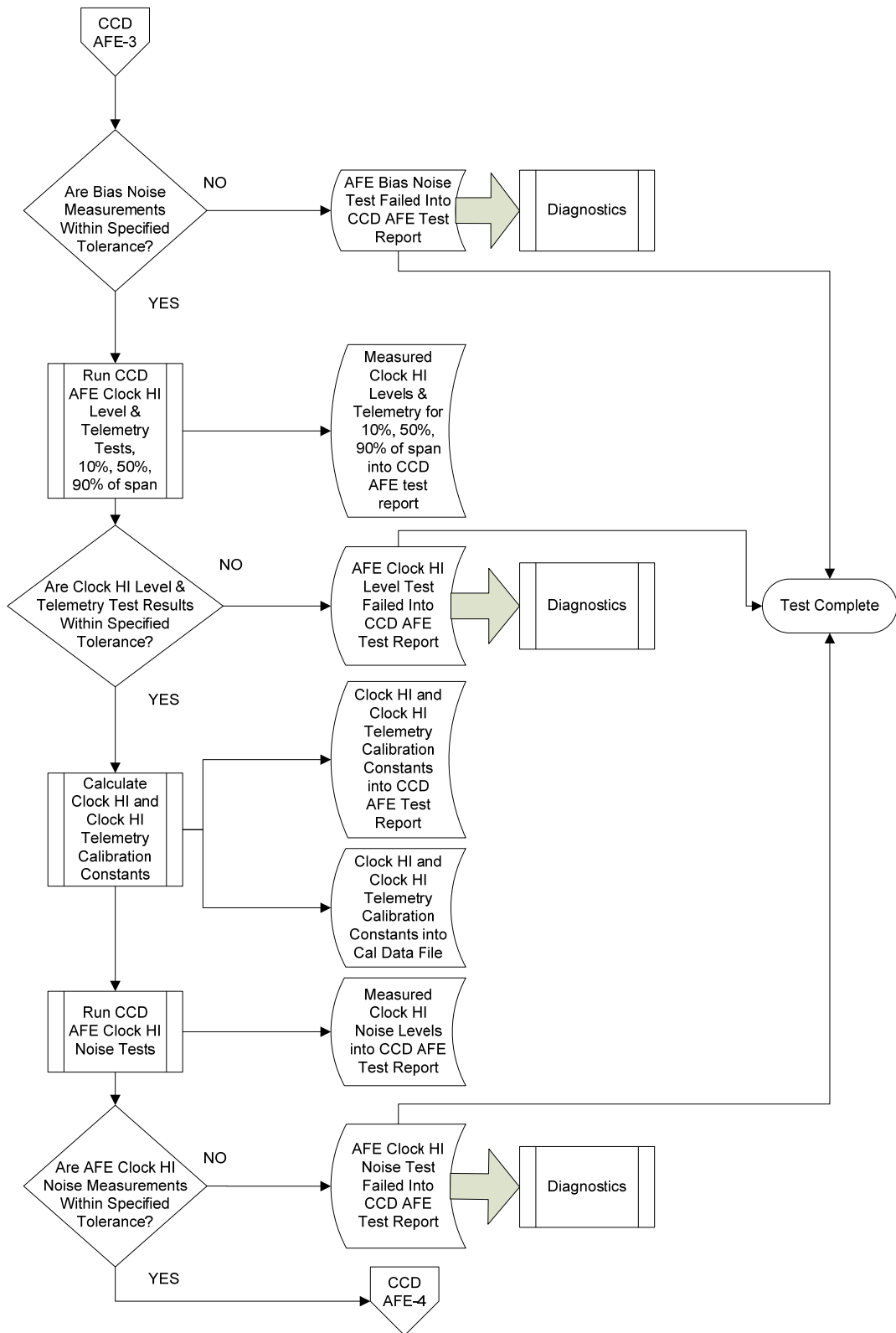
The ADC for each given channel will be used to measure the values for the offset voltage for that channel. The offset slope and offset calibrations will be calculated from these values. Finally, test data frames will be taken and the data evaluated for statistical values of merit. A histogram will be displayed that demonstrates the noise distribution of the data set. The rest of the CCDAFE test page I shown in Figures 6, 7, 8, 9 and 10.



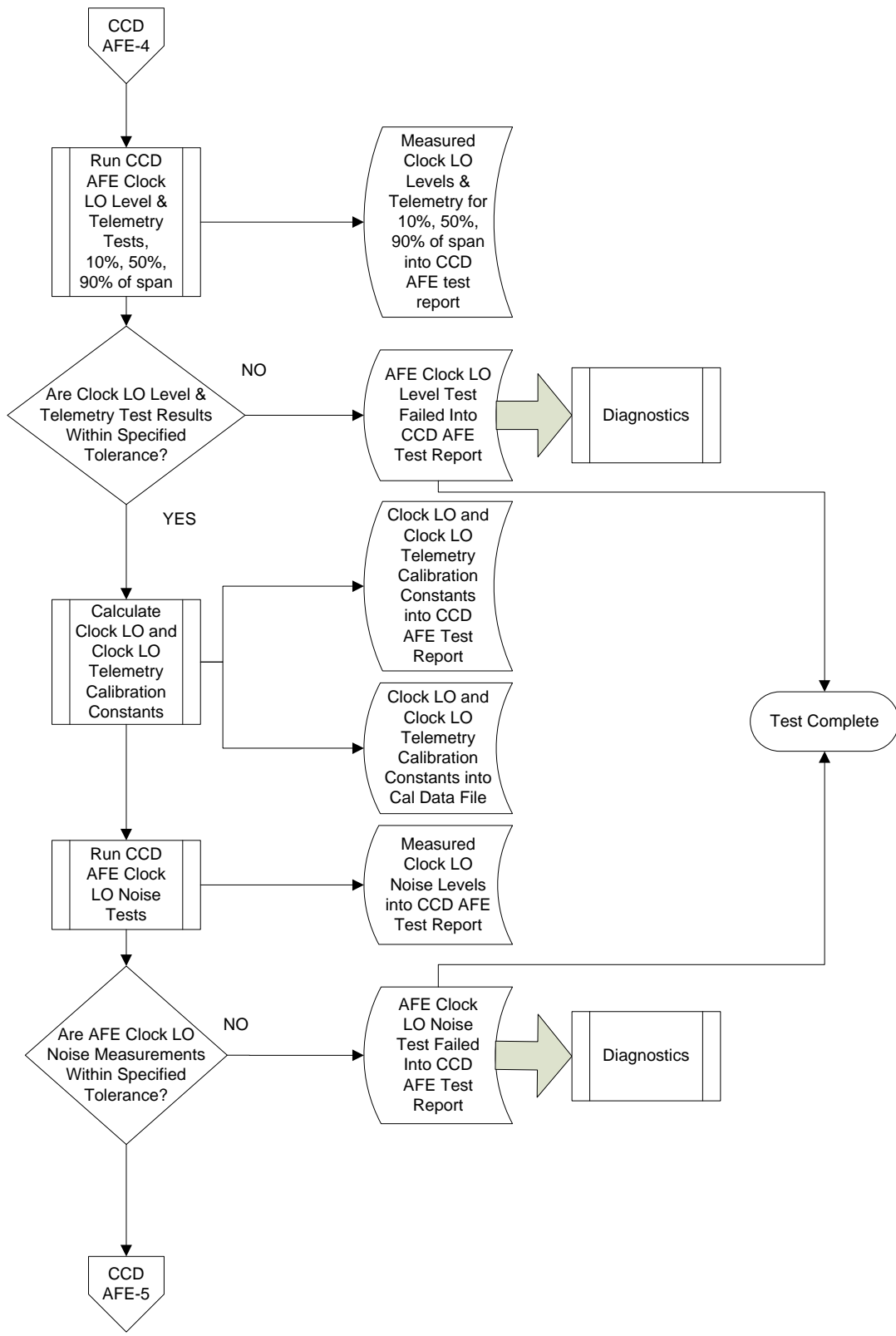
CCD AFE Test Page  
Figure 6



CCD AFE Test Page 2  
Figure 7

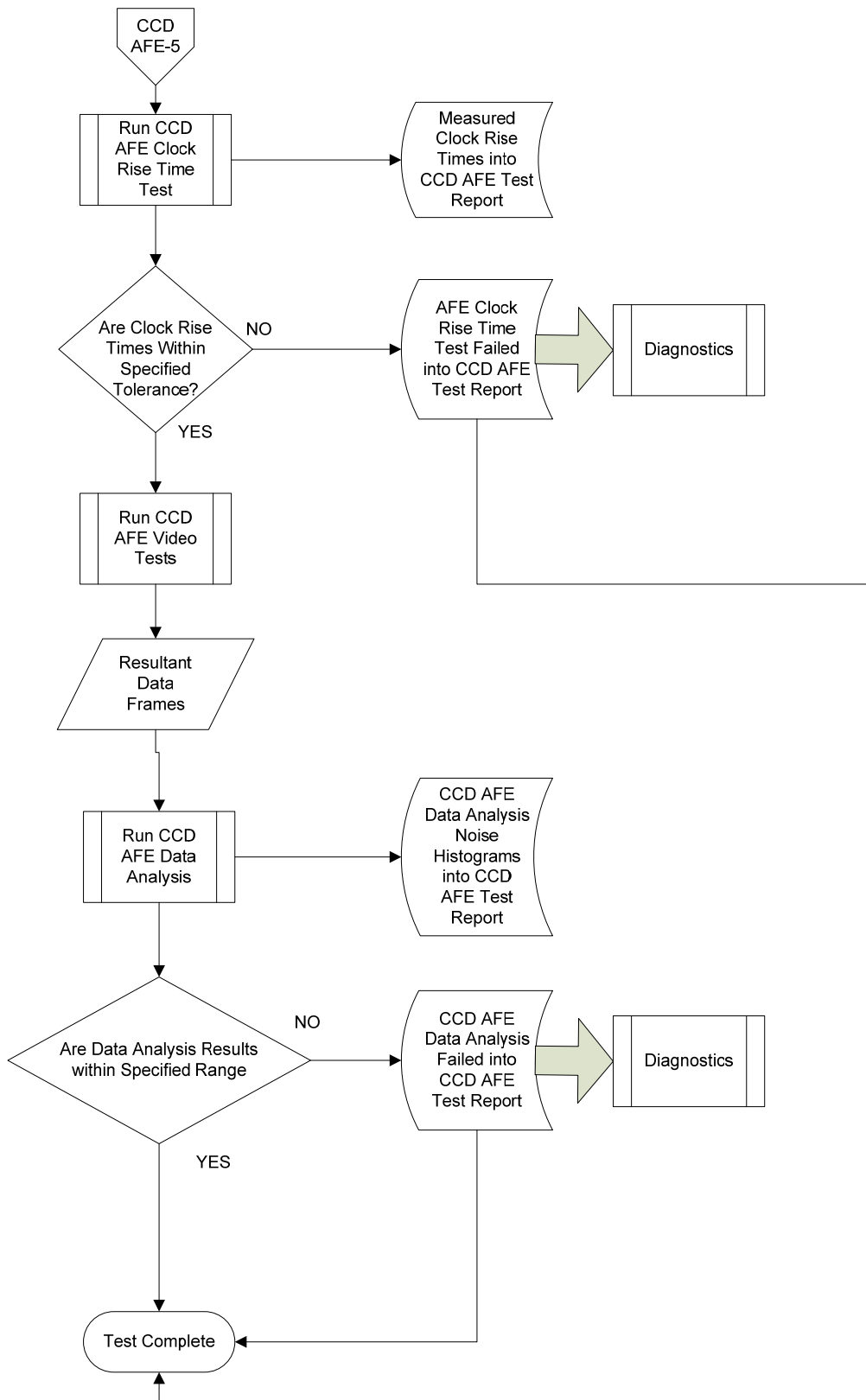


CCD AFE Test Page 3  
Figure 8



CCD AFGE Test Page 4  
Figure 9



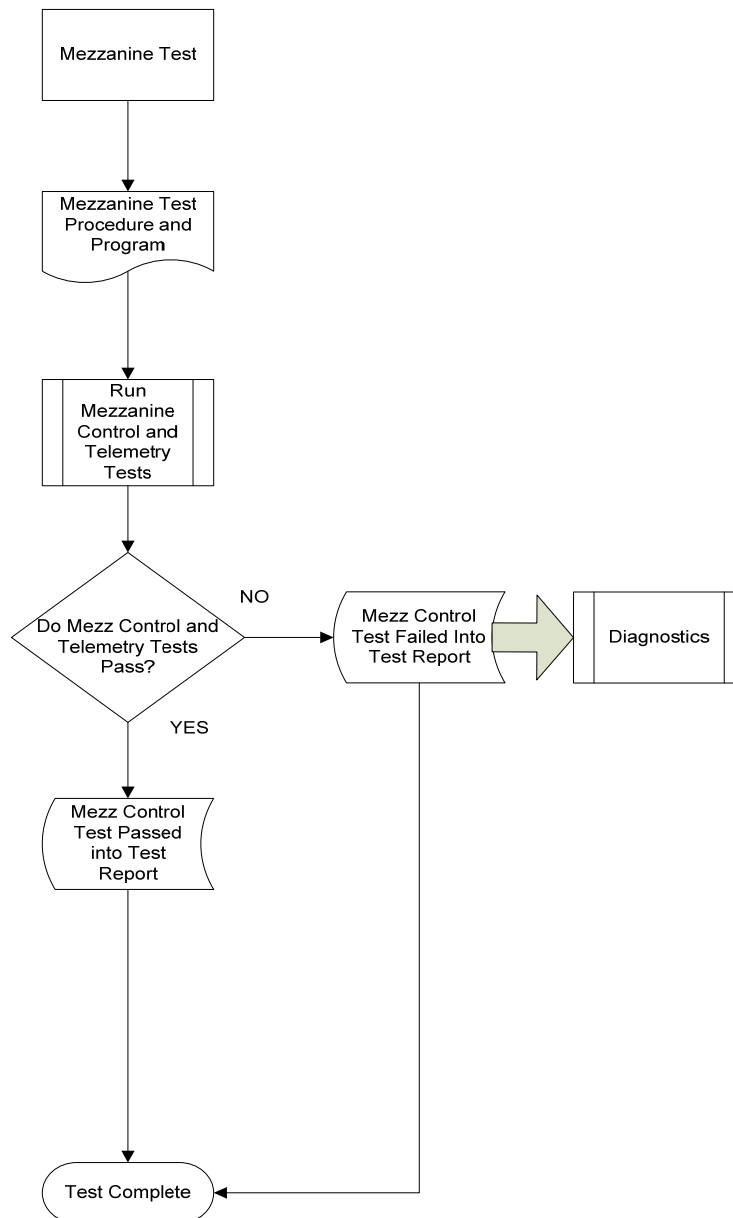


CCD AFE Test Page 5  
Figure 10

## 4.5 Mezzanine Board Test Page

The Mezzanine board test page will have text fields to enter information such as the serial number of the board under test. AFE voltage control shall be manipulated through radio buttons and the voltage telemetry read back as a first order verification of the control functionality.

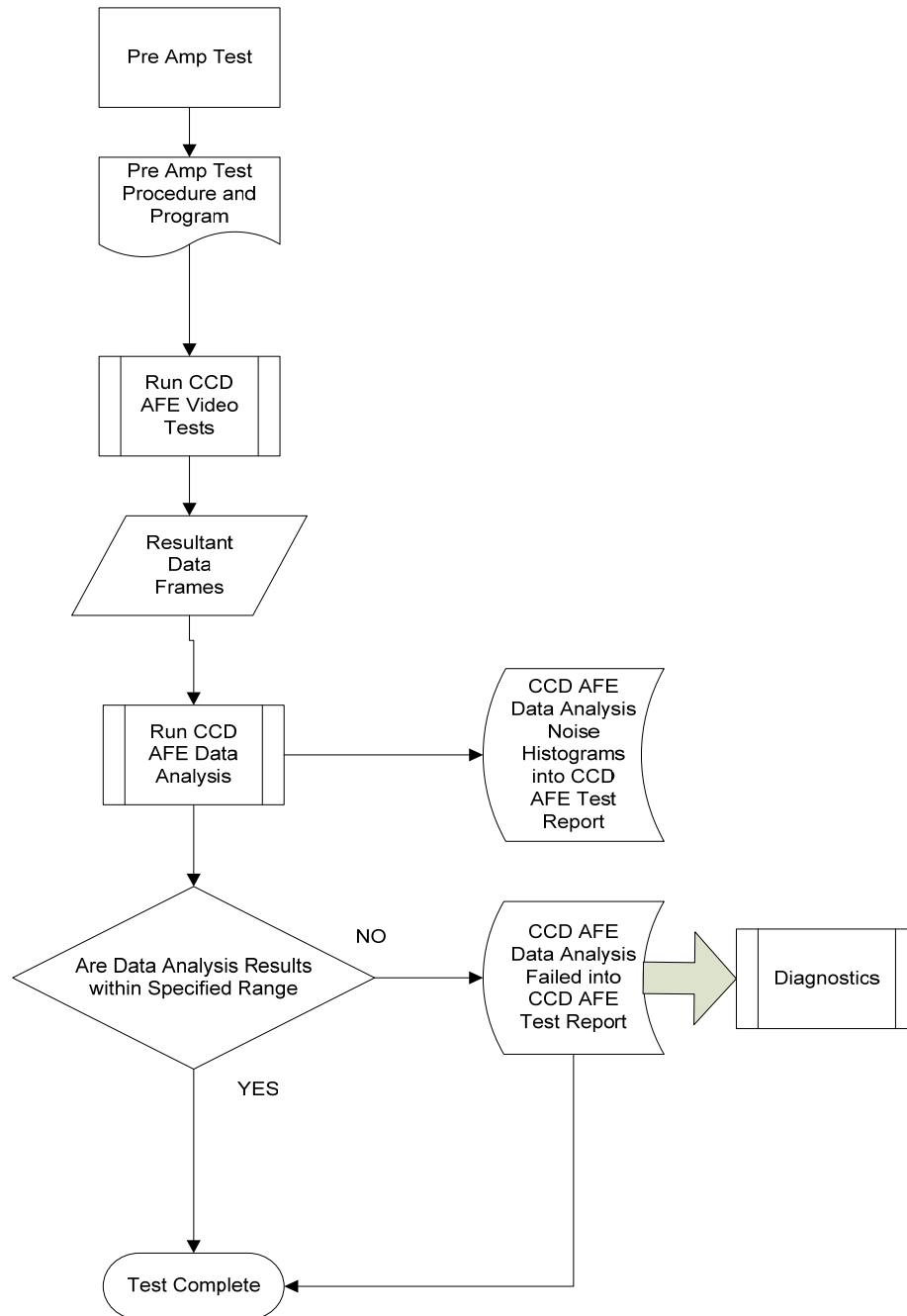
An AFE load board that simulates an over current condition will be used to verify the over current condition by reading the registers that trap this condition. This conceptual procedure is fouled at the very top.



Mezzanine Board Test Page  
Figure 11

## 4.6 Pre-amp Board Test Page

The pre amp test page will have text fields to enter information such as the serial number of the pre amp board under test. A subset of the CCD AFE test for the input channels will be used to verify proper operation of the pre amp board by taking test data frames and evaluating the data for statistical values of merit. A histogram will be displayed that demonstrates the noise distribution of the data set.

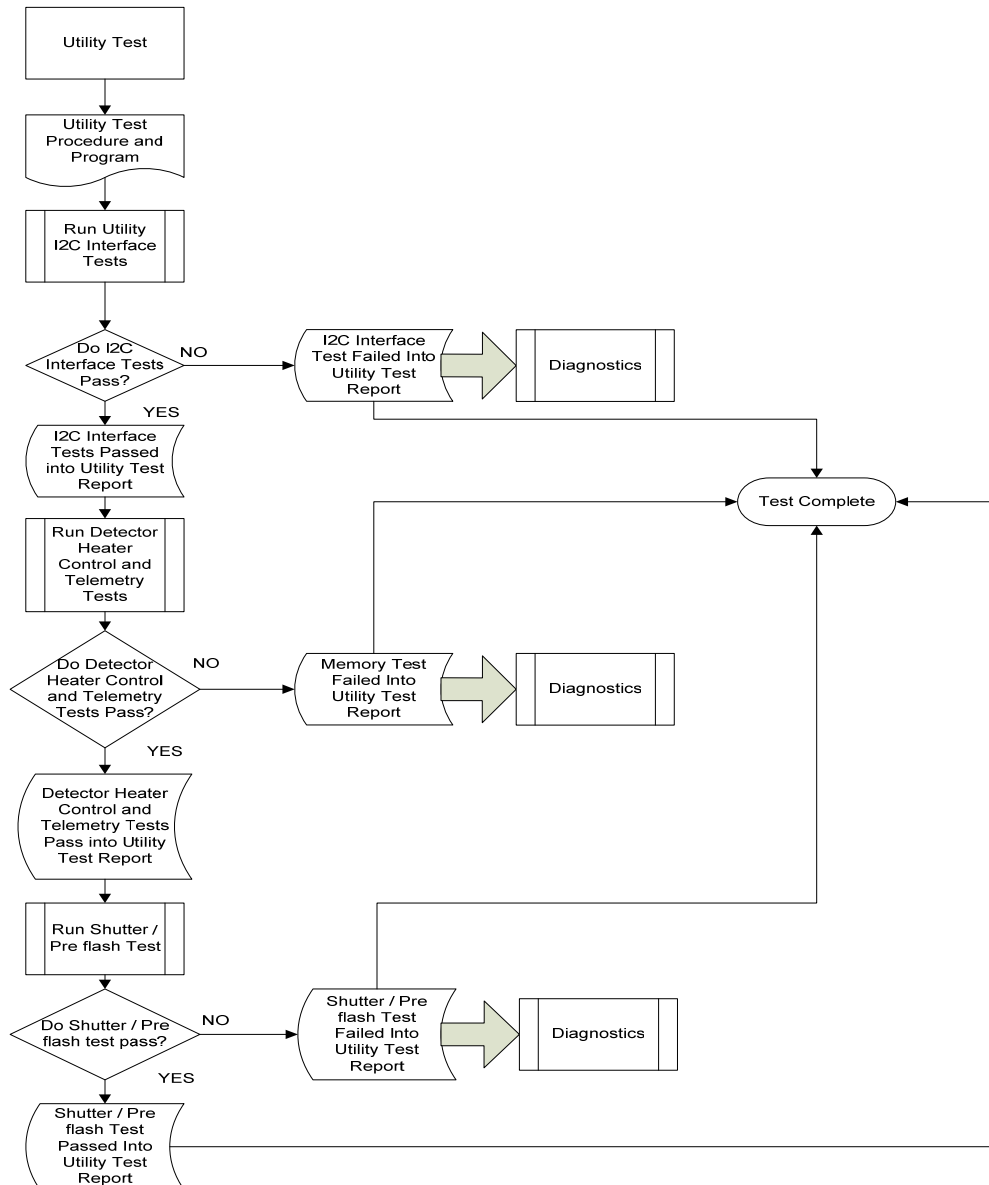


Pre-amp Board Test Page

Figure 12

## 4.7 Utility Transition Board Test Page

The utility transition board test page will have text fields to enter information such as the serial number of the utility transition board under test. Measurements of the temp sensor current sources and conditioning circuits will be entered into this page. The shutter control and pre-flash bits will be controlled on this page with radio buttons and proper operation will be verified with LED indicators in the test fixture. **NO UTILITY TRANSITION BOARDS WERE HARMED IN THE MAKING OF THIS DOCUMENT.**



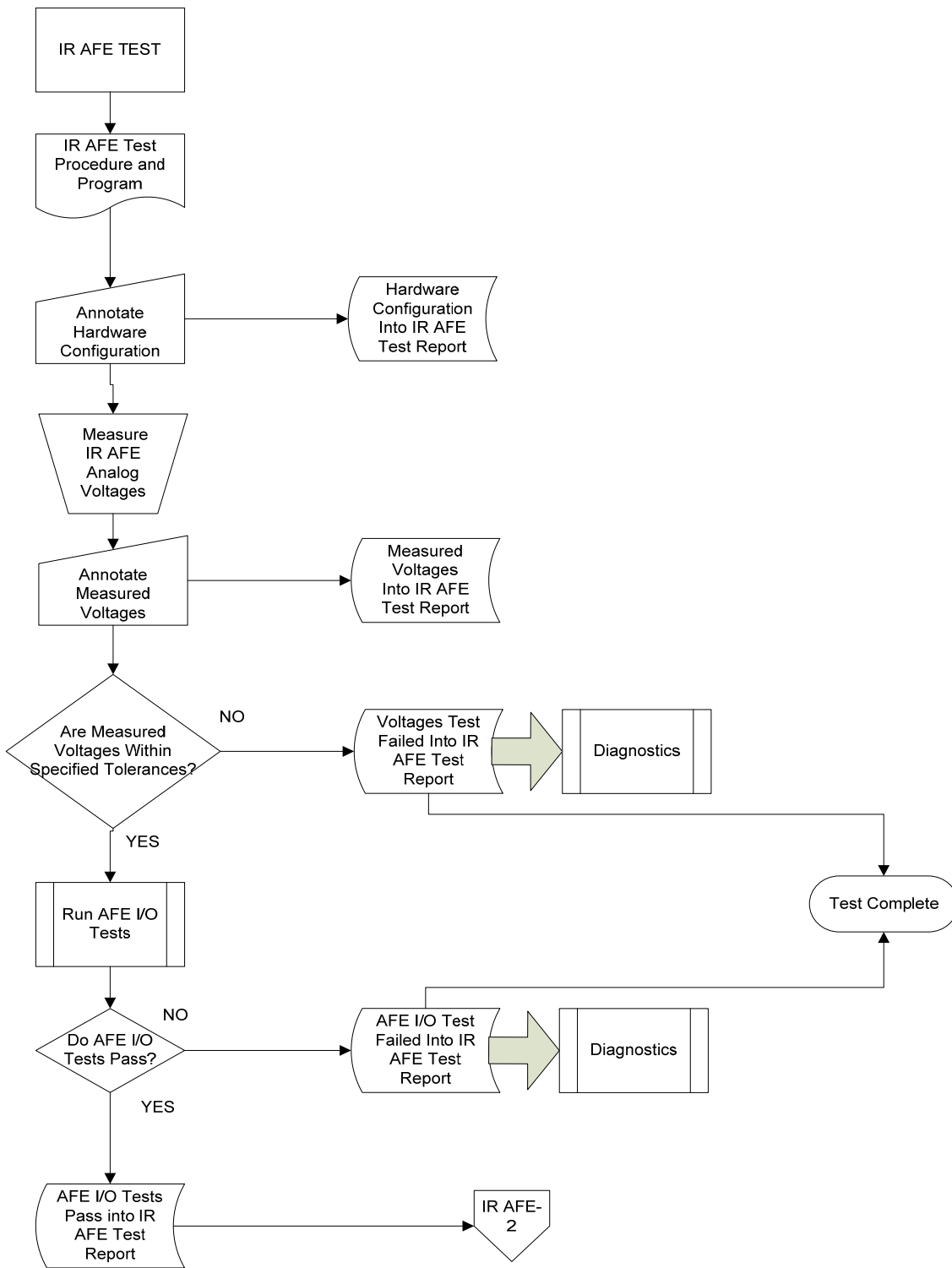
Utility Transition Board Test Page  
Figure 13

## **4.9 IR AFE Test Page**

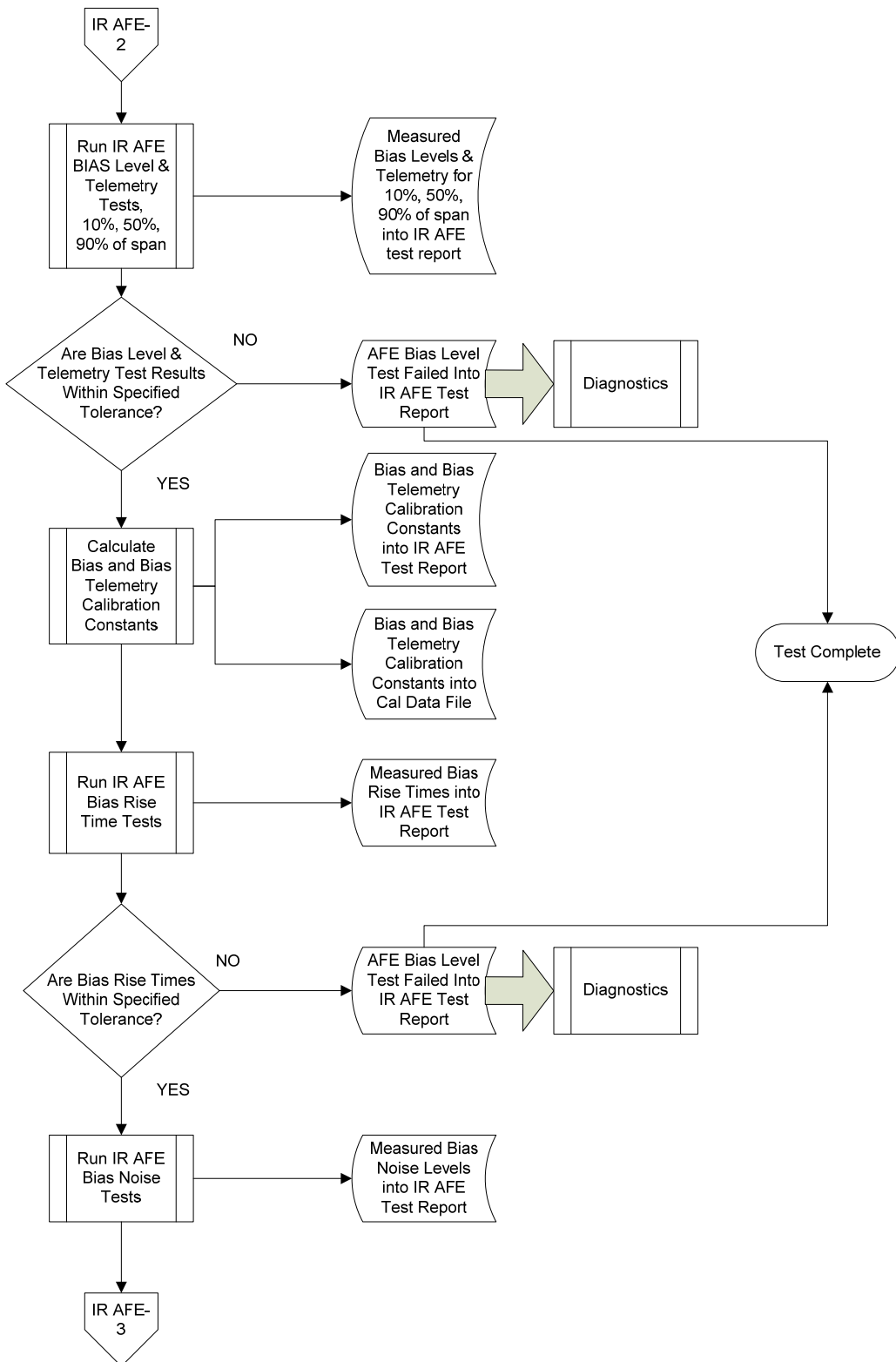
The IR AFE test page will have text fields to enter information such as the serial number of the IR AFE board under test. There will be sections for the measured results to be displayed automatically. The slope and offset calibrations will be calculated from these measured results.

The ADC for each given channel will be used to measure the values for the offset voltage for that channel. The offset slope and offset calibrations will be calculated from these values. Finally, test data frames will be taken and the data evaluated for statistical values of merit. A histogram will be displayed that demonstrates the noise distribution of the data set.

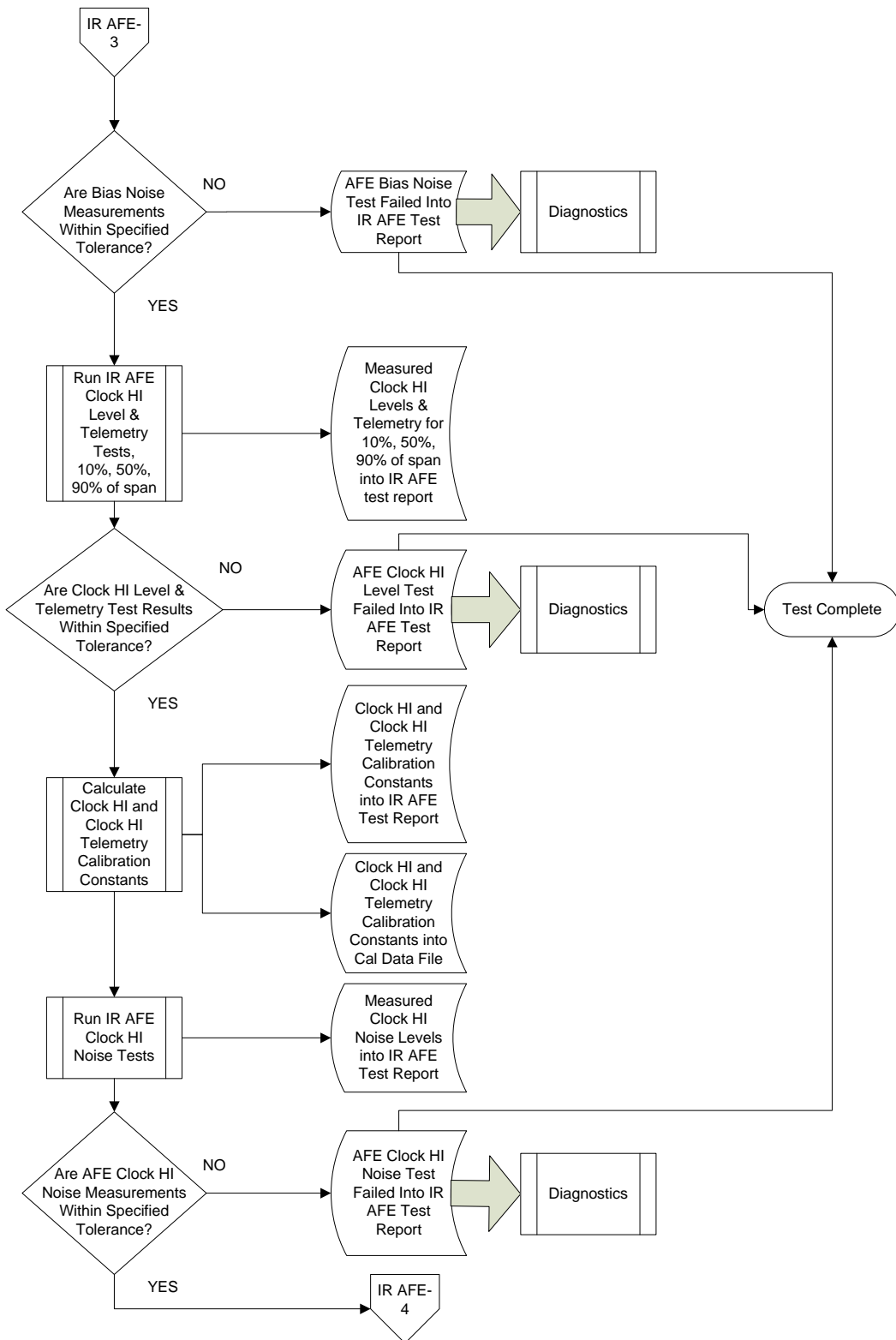
The test pages are shown in Figures 14, 15, 16, 17 and 18.



IR AFE Test Page  
Figure 14

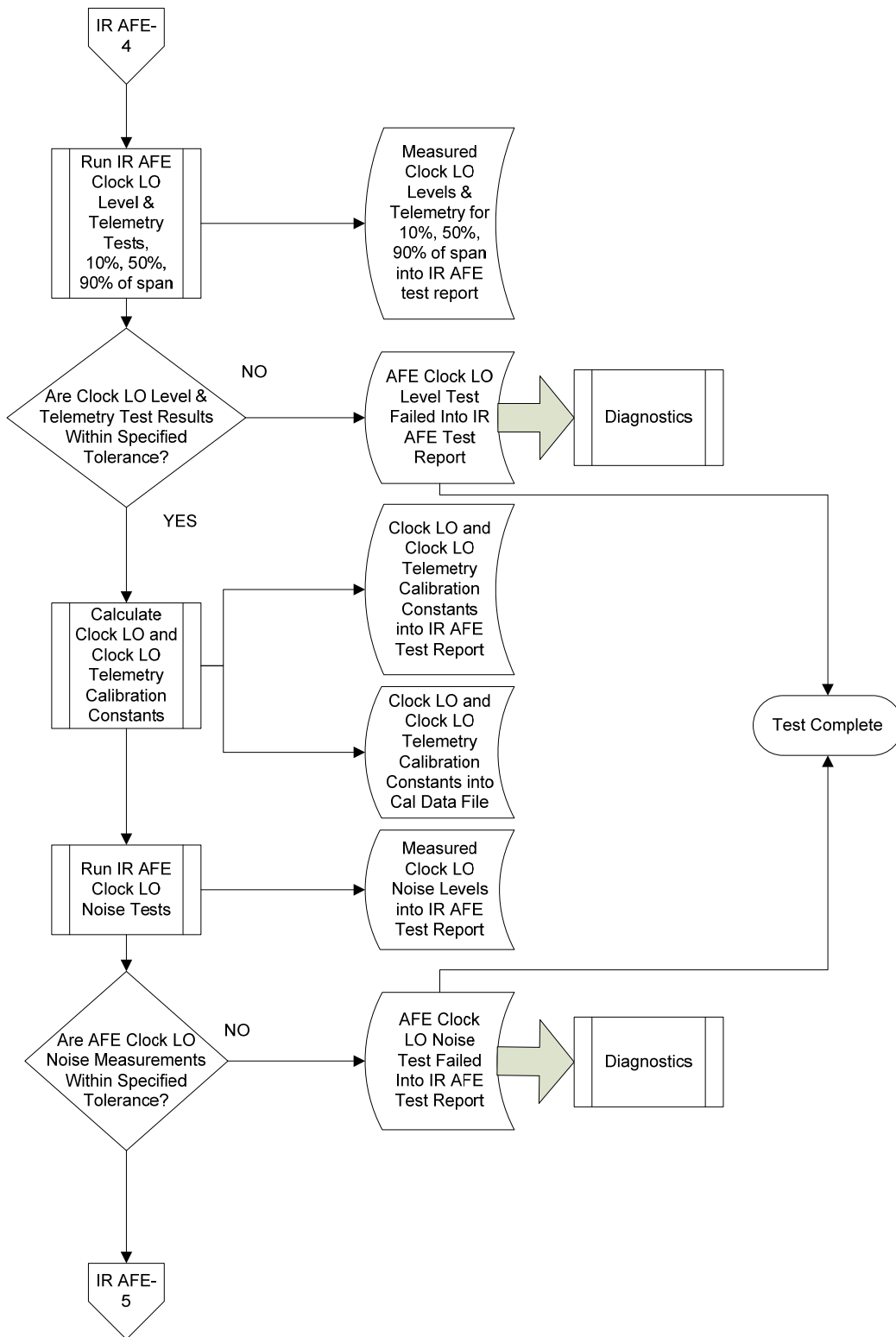


IR AFE Test Page 2  
Figure 15

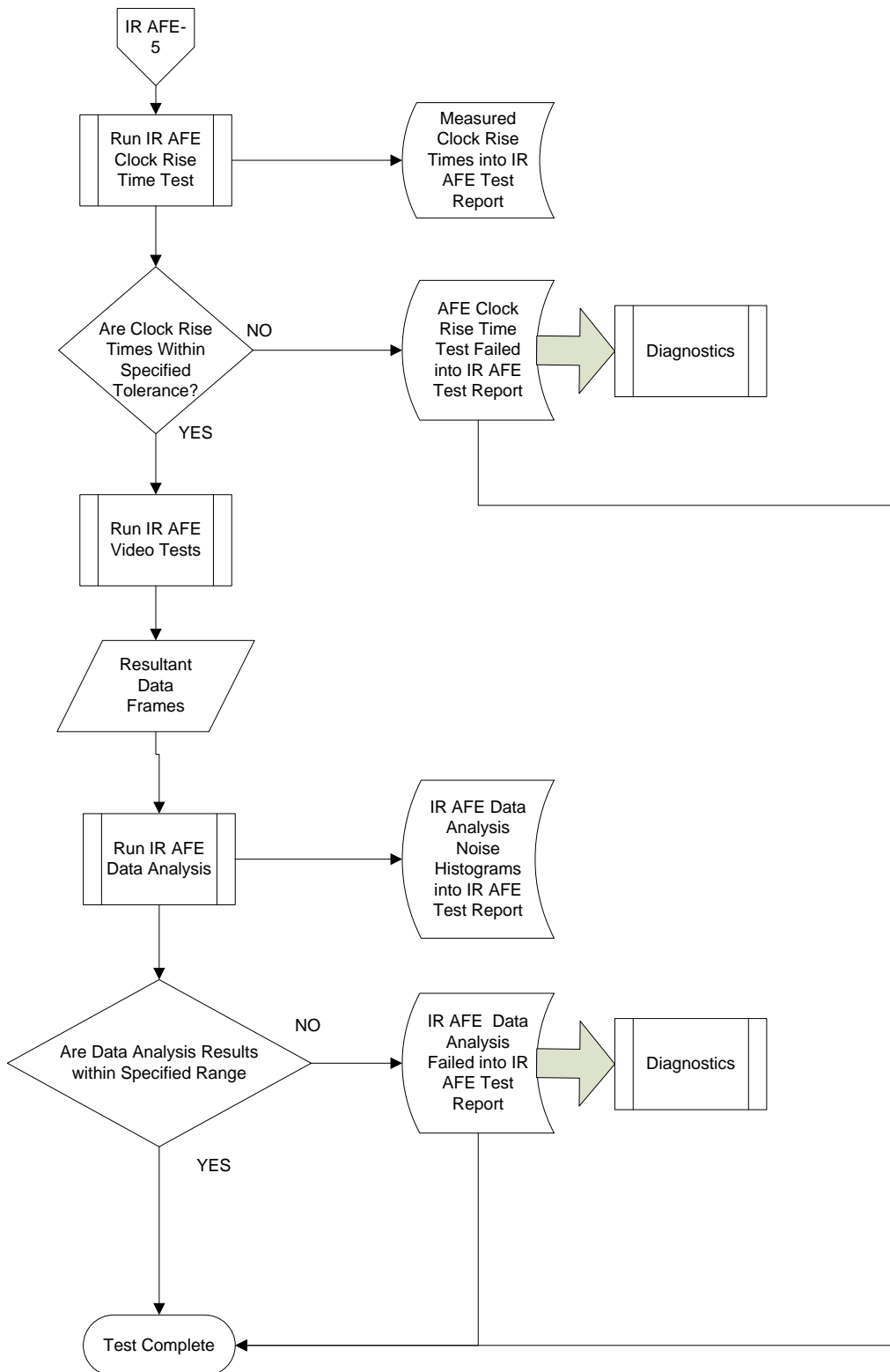


IR AFE Test Page 3  
Figure 16





IR AFE Test Page 4  
Figure 17



IR AFE Test Page 5  
Figure 18

## 5.0 Torrent PCB assembly test requirements

The Torrent Controller electronics boards are comprised of a power supply board, a Local Control Board (LCB), two AFEs (analog front end, IR or CCD), a mezzanine board, a preamp board and a utility transition board.

The test requirements for each of the Torrent electronics sub-boards are unique and are therefore broken out individually by board. The overall goal for the Torrent test architecture is to provide 100% functional testing of each board to the design specifications for each of the electronics boards.

### 5.1 Power Supply Board

The power supply board will be tested under the control of a Lab View based test system that controls the power supply (enables, syncs, and adjustments) and the dynamic / static loads for each power supply output. Each of the supply outputs +Vcc, +Vfan, +/-Vana, +/-Vcb, +/-Vhv, Vbb, and +Vhtr will be tested using a dynamic load. Test requirements<sup>1</sup> stipulate that all supplies operate simultaneously at nominal current and maximum voltage with no degradation of stability or noise. Additionally, with all supplies operating at nominal current and voltages, each individual supply must be tested to the maximum rated current with no degradation of noise or stability to any supply. Finally, with all supplies operating at nominal current and voltages, each individual supply must be tested to the minimum rated current with no degradation of noise or stability to any supply.

**Table 2 – Torrent PSM Test Performance Requirements**

PSM Sub-tests	Voltage Range (V)	Current Minimum (mA)	Current Nominal (mA)	Current Maximum (mA)
+Vcc	+3.3 (+/-2.5%)	250	1130	3000
+Vana	+5 to +10	6	400	720
-Vana	-10 to -5	6	250	720
+Vcb	+9 to +18	6	350	650
-Vcb	-18 to -9	6	350	650
+Vhv	+30 / +5	6	120	200
-Vhv	-5 / -30	6	120	200
+Vbb	+40 to +80	6	8	10
-Vbb	-80 to -40	6	8	10
Vfan	+7 to +14	180	300	400
Vheater	+22	0	275	500

### 5.2 Local Control Board (LCB)

The LCB will be tested using a test system dedicated power supply, AFEs, mezzanine and a test chassis. Upon programming and power on checks, all external interfaces such as fibers to the PAN computer, Ethernet and sync in/out will be exercised. Power through the LCB to the blower will be verified by running the test system dedicated blower. All other AFE and power supply control including mezzanine board power control and fault monitoring will be addressed in this test.

<sup>1</sup> Power Supply Functional Testing, TRNT-AD-11-xxxx, P. Moore, 03/03/2009

The on-board memory will be exercised using data from the digital data generator and then from the eight AFE channels. Finally, the ability to write to the AFE clock, bias and offset DACS and read from the AFE telemetry on both AFEs will be verified.

**Table 3 - Torrent LCB Test Performance Requirements**

<b>LCB Sub Tests</b>	<b>Voltage Range @ (+/-1%)</b>	<b>Current Maximum</b>	<b>Regulation / Stability / Success</b>
<b>+3.3Vdc digital (+VCC)</b>	>+3.27, < +3.33	<=3.0A	Regulation
<b>+2.5Vdc digital</b>	>+2.575, <+2.525	<.15A	Regulation
<b>+1.8Vdc digital</b>	>+1.782, <+1.818	<.3A	Regulation
<b>+1.2Vdc digital</b>	>+1.19, <+1.21	<???	Regulation
<b>+1.0Vdc digital</b>	>+0.99, <+1.1	<???	Regulation
<b>Fiber Link Tests</b>	NA	NA	Must Be Stable
<b>EEPROM programming</b>	NA	NA	Read data matches write data
<b>Memory Test</b>	NA	NA	Read data matches write data
<b>Mezz Control Tests</b>	All Controlled Voltages to AFE	Over current Telemetry	
<b>AFE I/O Tests</b>	NA	NA	Pass / Fail
<b>I2C Bus interface</b>	NA	NA	Read AFE and PSM temps / SSN / EEPROM
<b>Heater Control and Telemetry</b>	NA	NA	Ability to read temp sensors and control temperature

### 5.3 CCD AFE

Torrent's CCD AFE shall be tested using a test system dedicated power supply, LCB, mezzanine board, preamplifier board and a test chassis. All sixteen clock and sixteen bias outputs (per CCD AFE) are to be verified using an external measurement device that has sufficient resolution to ensure a valid measurement. The following metrics for each clock and bias output will be determined:

- Voltage output accuracy (max, min, midpoint)
- Typical output load drive capability
- DC stability – tolerance
- AC Noise – tolerance
- Rise time – tolerance

Calibration data such as the slope and offset for each clock or bias DAC output and its associated telemetry channel will be calculated and saved in a text format file for the later system calibration step of Torrent production and integration. Each input channel offset circuit will be challenged using the ADC for that channel. Similar slope and offset data for the offset circuits will be stored in the file, to be used later during production of a full-up system.

The ADC input channels (four per CCD AFE) will be tested by taking data with the ADC for the channel under test in a regime that adds in more front end circuit complexity in each successive step. Resultant data is then analyzed for the statistical mean, midpoint and standard deviation against predefined tolerances. A histogram distribution of sampled noise values shall be evaluated and compared against a typical acceptable noise distribution for final pass / fail determination.

**Table 3 - Torrent CCD AFE Test Performance Requirements**

<b>CCD AFE Sub Tests</b>	<b>Voltage Range @ (+/-1%)</b>	<b>Current Maximum</b>	<b>Noise</b>	<b>Regulation / Stability / Success / Rise Time</b>
<b>AFE I/O Tests</b>	See PSM test analog Voltages	See PSM test analog I max	TBD	
<b>I2C Bus interface</b>	NA	NA	NA	Pass / Fail
<b>CCD AFE Biases</b>				Read AFE and PSM temps / SSN / EEPROM
<b>CCD AFE LV Biases (0 →7)</b>	+/- 15Vdc	25mA	+/- .001% of value	Rise Time <100mS
<b>CCD AFE HV Biases (8→15)</b>	0Vdc → +/- 30Vdc	25mA	300uVrms max	Stable, Rise Time <100mS
<b>CCD AFE Clocks</b>			300uVrms max	Stable, Rise Time <100mS
<b>CCD AFE Clocks (0→15)</b>	+/- 15Vdc	30mA	Overshoot <.01%, noise .01% <5mVrms	Rise Time <150nS, Settling time <200nS
<b>CCD AFE Video Channels (1→4) Offsets</b>	Offset Range 0Vdc→5Vdc??	Offset noise <2ADU rms, calibration constants derived from offset test.		
<b>CCD AFE Video Channels (1→4) CDS Signals</b>	CDS signals compared against prescribed signal pattern.			
<b>CCD AFE Video Channels (1→4)</b>	Input Sensitivity	Max Conv. Rate = 500Kpix/sec.	Noise @100K pix/sec	Noise @500K pix/sec.
<b>CCD AFE Video Channels (1→4)</b>	0.5μV=>10μV / ADU	500K pixels / second	<2 ADU rms	
<b>CCD AFE Video Channels (1→4)</b>	IRAF histogram evaluation of noise performance compared against a “golden” histogram curve. IRAF imstat of the number of pixels in the sample, the mid point, and the standard deviation compared against “golden” statistics to a defined tolerance. This will be a predefined script called from the test and the results will be saved with the test.			

## 5.4 IR AFE Board

Torrent's IR AFE shall be tested using a test system dedicated power supply, LCB, mezzanine board and a test chassis. All 16 clock and 16 bias outputs (per IR AFE) are to be verified using an external measurement device that has sufficient resolution to ensure a proper measurement. The following metrics for each clock and bias output will be determined:

- voltage output accuracy (max, min, midpoint)
- Maximum output load capability
- DC stability
- AC Noise
- Rise time

Calibration data such as the slope and offset for each clock or bias DAC output and its associated telemetry channel will be calculated and saved in a text format file for the later system calibration step of Torrent production and integration. Each input channel offset circuit will be challenged using the ADC for that channel. Similar slope and offset data for the offset circuits will be stored in the file also to be used later during production of a full up system.

The ADC input channels (16 per IR AFE) will be tested by taking shorted input data with the ADC for the channel under test. Resultant data is then analyzed for the statistical mean, midpoint, and standard deviation against predefined tolerances. A histogram distribution of sampled noise values shall be evaluated and compared against a typical acceptable noise distribution for final pass / fail determination.

**Table 4 - Torrent IR AFE Test Performance Requirements**

<b>IR AFE Sub Tests</b>	<b>Voltage Range @ (+/-1%)</b>	<b>Current Maximum</b>	<b>Noise</b>	<b>Regulation / Stability / Success / Rise Time</b>
<b>IR AFE voltages</b>	See PSM test analog Voltages	See PSM test analog I max	TBD	
<b>AFE I/O Tests</b>	NA	NA	NA	Pass / Fail
<b>I2C Bus interface</b>	NA	NA	NA	Read AFE and PSM temps / SSN / EEPROM
<b>IR AFE Biases</b>			+/- .001% of value	Rise Time <100mS
<b>IR AFE LV Biases (0 →7)</b>	+/- 15Vdc	25mA	300uVr ms max	Stable, Rise Time <100mS
<b>IR AFE HV Biases (8→15)</b>	0Vdc → +/- 30Vdc	25mA	300uVr ms max	Stable, Rise Time <100mS
<b>IR AFE Clocks</b>			Overshoot <.01%, noise .01% <5mVrms	Rise Time <150nS, Settling time <200nS
<b>IR AFE Clocks (0→15)</b>	+/- 15Vdc	30mA	<5mVrms	Stable, Rise Time <150nS, Settling Time <200nS
<b>IR AFE Video Channels (1→16) Offsets</b>	Offset Range 0Vdc→5Vdc??	Offset noise	<2ADU rms, calibration constants derived from offset test.	
<b>IR AFE Video Channels (1→16)</b>	Input Sensitivity	Max Conv. Rate = 500Kpix/sec.	Noise @100K pix/sec	Noise @500K pix/sec.
<b>IR AFE Video Channels (1→16)</b>	4μV→40μV / ADU	500K pixels / second	<1.7 ADU rms	
<b>IR AFE Video Channels (1→16)</b>	IRAF Histogram evaluation of noise performance compared against a “golden” histogram curve. IRAF instat of the number of pixels in the sample, the mid point, and the standard deviation compared against “golden” statistics to a defined tolerance. This will be a predefined script called from the test and the results will be saved with the test.			

## 5.5 Mezzanine Board

The mezzanine board shall be tested using a test system dedicated power supply, LCB, AFE's, and a test chassis. The control functions for each of the analog power supplies that provide DC power to the AFE's shall be verified. Over current sensing telemetry will also be challenged using an AFE load simulation board that provides large enough loads to cause the over current circuit to actuate.

**Table 5 - Torrent Mezzanine Test Performance Requirements**

Mezzanine Sub Tests	Voltage Range @ (+/-1%)	Over Current Sense Ability?	Control / Telemetry
+Vana	+5 to +10	>1.0A	Control & Status
-Vana	-10 to -5	>1.0A	Control & Status
+Vcb	+9 to +18	>0.5A	Control & Status
-Vcb	-18 to -9	>0.5A	Control & Status
+Vhv	+30 / +5	>0.2A	Control & Status
-Vhv	-5 / -30	>0.2A	Control & Status

## 5.6 Pre-amp Board

Pre-amp boards are to be tested using a test system dedicated power supply, LCB, mezzanine board, AFEs and a test chassis. The preamplifier test will be some of the same tests performed on the CCD AFE board. The test will challenge the integrity and performance of all clock and bias signals that are passed through the pre-amp board. ADC video input channel performance will be evaluated by taking shorted input data with a known good AFE board and analyzing the data for standard deviation, mean value and histogram distribution.

**Table 6 - Torrent Pre-amp Board Test Performance Requirements**

Pre-amp Sub Tests	Voltage Range @ (+/-1%)	Current Maximum	Noise	Regulation / Stability / Success / Rise Time
Pre-amp Biases			+/- .001% of value	Rise Time <100mS
Pre-amp LV Biases (0 →7)	+/- 15Vdc	25mA	300uVrms max	Stable, Rise Time <100mS
Pre-amp HV Biases (8→15)	0Vdc → +/- 30Vdc	25mA	300uVrms max	Stable, Rise Time <100mS
Pre-amp Clocks			Noise .01% <5mVrms	Rise Time <150nS, Settling time <200nS
Pre-amp Clocks (0→15)	+/- 15Vdc	30mA	<5mVrms	Stable, Rise Time <150nS, Settling Time <200nS
Pre-amp Video Channels (1→4)	Input Sensitivity	Max Conv. Rate = 500Kpix/sec.	Noise @100K pix/sec	Noise @500K pix/sec.
CCD AFE Video Channels (1→4)	0.5μV=>10μV / ADU	500K pixels / second	<2 ADU rms	
CCD AFE Video Channels (1→4)	IRAF Histogram evaluation of noise performance compared against a "golden" histogram curve. IRAF imstat of the number of pixels in the sample, the mid point, and the standard deviation compared against "golden" statistics to a defined tolerance. This will be a predefined script called from the test and the results will be saved with the test.			



## 5.7 Utility Transition Board

The Torrent utility transition board is to be tested using a test system dedicated power supply and an LCB. Circuit functionality to be validated includes the temp sensor current sources / conditioning circuitry and the shutter and pre-flash signal paths through this board. Adjustments for the calibration of this circuit are to be made at this time.

**Table 7 - Torrent Utility Transition Board Test Performance Requirements**

<b>Utility Xistion Sub Tests</b>	<b>Read temp sensors and pass the shutter and pre-flash signals through.</b>
<b>Heater Control and Telemetry</b>	Must convert V→F accurately reading the temperature from test sensors. Must produce shutter control and pre-flash signals.
<b>I2C Bus Devices</b>	Read I2C devices and write / read I2C eeprom.
<b>Shutter and Pre-flash</b>	Shutter and Pre-flash LED's illuminate and extinguish based on the selected output state.