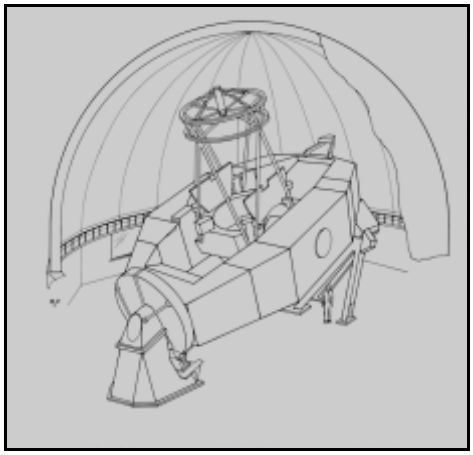
REV	DESCRIPTION	DATE	BY
-	Initial Release	7/22/09	EAW

T3-3003
Safety Board Test Procedure
Revision: -

SERIAL NUMBER TESTED _____ Rev D



T3-3003 Rev -

University of Hawaii
Institute for Astronomy

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1 Test Overview

This test procedure is for validating the operation of the TCS3 Safety Board. This procedure is primarily intended to be used for board level testing. However, since the TCS3 software and the lab setup are used during testing, some minor system level interface testing will also be included where it is convenient. Only after completing and passing this procedure is the Safety Board acceptable for operational use.

All fields with a *yellow background* are recordable data fields and must be completed.

Note: making a test procedure that is completely independent of the TCS3 lab setup was determined to be very cumbersome due to the number and types of interfaces. Therefore, it is important that the lab setup be maintained and functional for this test procedure.

Note: "SafetyBrd_Tach_Switch_is_off" will always appear in mcc1 during lab testing. This warning indicates that the board is set (via switches) for lab testing and not summit operation.

2 Equipment and Tools Required

The table below lists the equipment and tools required to complete this test procedure.

Item #	Qty	Model / Part Number	Description
1	2	Fluke 179 (or equivalent)	Fluke Multimeter
2	1	-	TCS3 Lab System
3	1	-	Latest TCS3 Software
4	1	TDS2014B (or equivalent)	Oscilloscope, 100 MHz, 4 channel
5	REF	TCS-T3	Safety Board Schematics
7	1	Rev D	Safety Board (unit under test)

Table 1 Required Test Equipment

3 Test Setup

Follow these steps to setup the lab system:

1. Power down the TCS3 motor amp supply. This is the big supply at the bottom of the rack.
2. Power down the TCS3 rack box containing the Safety Board.
3. Disconnect all connectors from the Safety Board in the rack box and remove the Safety Board. Install Safety Board that is to be tested and connect all connectors to it.
4. Set switches SW1 and SW2 to lab operation.
5. Power up the TCS3 rack box and motor amp power supply.
6. Turn on the "t9h" PC if it is not already running. This is the analog tachometer emulator.
7. Start up the latest version of the TCS3 software.
8. Bring up two mcc windows and display mcc1 and mcc2.
9. Press the "T3.Reset" button on mcc1.
10. Press the system power on button on mcc2.

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11. Select the track button on mcc1.

The lab unit should be tracking. If it is not, look for any errors listed in the mcc1 window. Most likely the error will be related to the limit switches on the test panel. If not, refer to the TCS3 lab unit documentation.

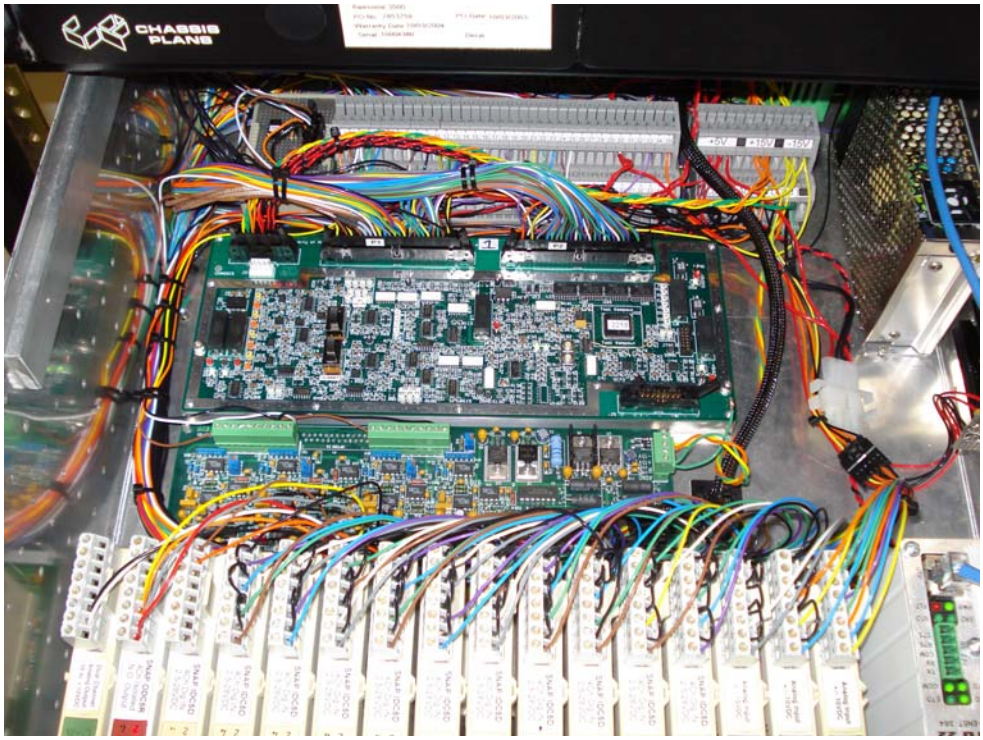

Figure 1 Safety Board Installed in Servo Box

Figure 2 TCS3 Lab Setup TO Control Panel

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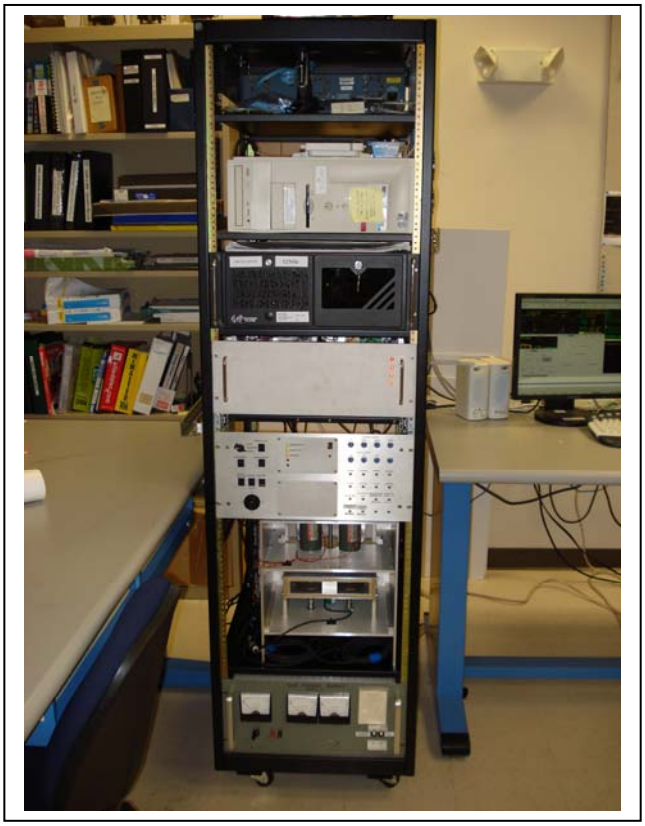

Figure 3 TCS3 Lab Rack

4 Testing

4.1 Limit & Stop Switches

Each switch in the table below will simulate a fault when it is switched. Start each test in tracking mode. After each fault, move the switch back to its non-fault position and push the "T3.Reset" (mcc1) button followed by the power on button (mcc2) and select racking again. Repeat this procedure for the next switch listed. In addition to testing the switches (simulated fault conditions), the testing below also tests the reset and brake signals by using theses functions in the procedure.

Check the conditions that apply to each switch. If all boxes are checked, then the fault that the switch simulates passes.

Switch	mcc1 display (✓)				Lab TO Panel LEDs (✓)			Final Result - All boxes checked (circle one)	Tester Initials	Date
	Unique mcc1 Error Message	Unique Error	"Safety Board Error Exist"	"System Power is off"	System Power = OFF	Brakes On = ON	Safety Board OK = OFF			
E stop	SafetyBrd_HA_Stop_E_Latch							PASS / FAIL		
E Emerg	SafetyBrd_HA_Emerg_E_Latch							PASS / FAIL		
W Stop	SafetyBrd_HA_Stop_W_Latch							PASS / FAIL		
W Emerg	SafetyBrd_HA_Emerg_W_Latch							PASS / FAIL		
N Stop	SafetyBrd_Dec_Stop_N_Latch							PASS / FAIL		
N Emerg	SafetyBrd_Dec_Emerg_N_Latch							PASS / FAIL		
S Stop	SafetyBrd_Dec_Stop_S_Latch							PASS / FAIL		
S Emerg	SafetyBrd_Dec_Emerg_S_Latch							PASS / FAIL		
Horizon Stop	SafetyBrd_Horizon_Stop_Latch							PASS / FAIL		
Hand Paddle Stop	SafetyBrd_DomeHP_Stop_Latch							PASS / FAIL		
Emergency Stop	Safety Brd_Emerg_Stop_Latch							PASS / FAIL		

Table 2 Limit Switch Tests

4.2 Limit Override Switch

Start tracking mode. Move the "Limit Override" switch to the up position. With this switch in the up position, activate each switch and record the data in the table below until all switches are active.

Switch	mcc1 display (✓)			Lab TO Panel LEDs (✓)			Final Result - All boxes checked (circle one)	Tester Initials	Date
	Unique mcc1 Error Message	Unique Error	Hardware Limit Override On	System Power = ON	Brake = OFF	Safety Brd OK =ON			
E stop	SafetyBrd_HA_Stop_E_Latch						PASS / FAIL		
E Emerg	SafetyBrd_HA_Emerg_E_Latch						PASS / FAIL		
W Stop	SafetyBrd_HA_Stop_W_Latch						PASS / FAIL		
W Emerg	SafetyBrd_HA_Emerg_W_Latch						PASS / FAIL		
N Stop	SafetyBrd_Dec_Stop_N_Latch						PASS / FAIL		
N Emerg	SafetyBrd_Dec_Emerg_N_Latch						PASS / FAIL		
S Stop	SafetyBrd_Dec_Stop_S_Latch						PASS / FAIL		
S Emerg	SafetyBrd_Dec_Emerg_S_Latch						PASS / FAIL		
Horizon Stop	SafetyBrd_Horizon_Stop_Latch						PASS / FAIL		

Table 3 Override Switch Tests #1

Deactivate all of the switches from the above table. Move the "Limit Override" switch to the up position. For each mode below, start in tracking mode. Unlike the test above, the tests in the table below should cause faults. Reset, turn on power, and start tracking after each fault. After the completion of the tests, move the Limit Override to the down position (off).

Switch	mcc1 display (✓)				Lab TO Panel LEDs (✓)			Final Result - All boxes checked (circle one)	Tester Initials	Date
	Unique mcc1 Error Message	Unique Error	"Safety Board Error Exist"	"System Power is off"	System Power = OFF	Brake = ON	Safety Brd OK = OFF			
Hand Paddle Stop	SafetyBrd_DomeHP_Stop_Latch							PASS / FAIL		
Emergency Stop	SafetyBrd_Emerg_Stop_Latch							PASS / FAIL		

Table 4 Override Switch Tests #2

4.3 Telescope Enable Switch

The telescope enable switch will not cause the TCS3 to remove system power. It simply disables the telescope (and applies brakes) as its name implies. Begin in tracking mode, move the switch down to disable the telescope, and record the data. After completion of the tests, move the switch to the up position.

Switch	mcc1 display (✓)		Lab TO Panel LEDs (✓)			Final Result - All boxes checked (circle one)	Tester Initials	Date
	Unique mcc1 Error Message	Unique Message	System Power = ON	Brake = ON	Safety Brd OK = ON			
Telescope Enable	TOP Tele Enable is OFF					PASS / FAIL		

Table 5 Telescope Enable Switch Tests

4.4 Overcurrent

There are several overcurrent telemetry points used to protect the amplifiers and motors for both the dome and the telescope axes. To test these points, the lab TO Panel has potentiometers that can vary the voltage, emulating the current feedback in the actual system.

NOTE: The current limits will be set fairly high relative to the average current usage. Based on the position of the telescope much higher current may be required during acceleration. If the dome "sticks" or binds at a certain point, maximum current may be required. Therefore, the dome current limits are set very high and may only trip under a catastrophic condition such as a short or amplifier malfunction.

Reset by pushing the "T3.Reset" (mcc1) button followed by the power on button (mcc2). While observing the amplifier current graph in the "Details->Graph1/2" tab, adjust the TO Panel potentiometer until the overcurrent error appears in mcc1. Record the requested values in the table. All measurements are referenced to "AGND".

Current Point and Polarity	Actual Trip Point in Details->Graph1/2 (A)	Trip Point SPEC		Unique mcc1 Error Message	Unique mcc1 Error Present	Tester Initials	Date
		Trip Point SPEC (A)	PASS/FAIL				
West+		34 to 38	PASS / FAIL	SafetyBrd_OC_West _Latch	PASS / FAIL		
West-		-34 to -38	PASS / FAIL	SafetyBrd_OC_West _Latch	PASS / FAIL		
East+		34 to 38	PASS / FAIL	SafetyBrd_OC_East _Latch	PASS / FAIL		
East-		-34 to -38	PASS / FAIL	SafetyBrd_OC_East _Latch	PASS / FAIL		
North+		34 to 38	PASS / FAIL	SafetyBrd_OC_North _Latch	PASS / FAIL		
North-		-34 to -38	PASS / FAIL	SafetyBrd_OC_North _Latch	PASS / FAIL		
South+		34 to 38	PASS / FAIL	SafetyBrd_South _Latch	PASS / FAIL		
South-		-34 to -38	PASS / FAIL	SafetyBrd_South _Latch	PASS / FAIL		
DOME 1+		46 to 50	PASS / FAIL	SafetyBrd_OC_Dome1 _Latch	PASS / FAIL		
DOME 1-		-46 to -50	PASS / FAIL	SafetyBrd_OC_Dome1 _Latch	PASS / FAIL		
DOME 2+		46 to 50	PASS / FAIL	SafetyBrd_OC_Dome2 _Latch	PASS / FAIL		
DOME 2-		-46 to -50	PASS / FAIL	SafetyBrd_OC_Dome2 _Latch	PASS / FAIL		
DOME 3+		46 to 50	PASS / FAIL	SafetyBrd_OC_Dome3 _Latch	PASS / FAIL		
DOME 3-		-46 to -50	PASS / FAIL	SafetyBrd_OC_Dome3 _Latch	PASS / FAIL		

Table 6 Overcurrent Testing

4.5 Overspeed

There are two overspeed circuits that prevent the HA or DEC axis from exceeding a set, maximum speed.

Note: the HA axis does not track perfectly in the lab setup. It has some oscillations and may cause an overspeed condition prematurely. Use best judgment as to when the overspeed error actually occurred.

Reset by pushing the "T3.Reset" (mcc1) button followed by the power on button (mcc2). While monitoring the "velocity telemetry" in "Details->Graph1", increment and execute the MV command until the "overspeed" error appears in mcc1. The overspeed circuit will be tested with both positive and negative velocities. Start the MV command at +1900 arcsec/s (-1900 arcsec/s) and increase magnitude in increments of 10 arcsec/s. Record the requested values in the table below. All measurements are referenced to "AGND".

Overspeed Axis	Last MV CMD @ Trip Point (arcsec/s)	Overspeed Trip Point SPEC (arcsec/s)	Overspeed Trip Point SPEC	Unique mcc1 Error Message	Unique mcc1 Error Present	Tester Initials	Date
HA Axis (positive)		1900 to 2050	PASS / FAIL	SafetyBrd_OS_Ha_Latch	PASS / FAIL		
HA Axis (negative)		-1900 to -2050	PASS / FAIL	SafetyBrd_OS_Ha_Latch	PASS / FAIL		
DEC Axis (positive)		1900 to 2050	PASS / FAIL	SafetyBrd_OS_Dec_Latch	PASS / FAIL		
DEC Axis (negative)		-1900 to -2050	PASS / FAIL	SafetyBrd_OS_Dec_Latch	PASS / FAIL		

Table 7 Overspeed Testing

4.6 Tachometer Gain

TCS3 uses filtered, averaged velocity from the two opposing motor tachometers. To verify that the velocity gain is correct, several points will be measured and the corresponding data will be used to calculate the gain. Use the MV command to set the velocity as indicated in the table. Record the required data. All measurements are referenced to "AGND" with the exception of tachometer testpoints. Measure from red (+) to black (-).

4.6.1 HA Axis

MV CMD Velocity	East Tach (V) (E+ to E- testpoint)	West Tach (V) (W+ to W- testpoint)	"HA Vel" Testpoint (V)	Tach_Gain= $\frac{"HAVel"}{(East \cdot 1.26 + West)/2}$	GAIN SPEC	GAIN PASS / FAIL	Tester Initials	Date
1000					0.18 to 0.20	PASS / FAIL		

Table 8 HA Axis Tachometer Gain Tests

4.6.2 DEC Axis

MV CMD Velocity	North Tach (V) (N+ to N- testpoint)	South Tach (V) (S+ to S- testpoint)	"HA Vel" Testpoint (V)	Tach_Gain= $\frac{"HAVel"}{(East + West)/2}$	GAIN SPEC	GAIN PASS / FAIL	Tester Initials	Date
1000					0.18 to 0.20	PASS / FAIL		

Table 9 DEC Axis Tachometer Gain Tests

4.7 Power & Miscellaneous Board Signals

Power and board level signals that do not fit into any specific category and are tested in this section. All measurements are referenced to "AGND".

Signal Name	Measure At	Measurement Reference	Value	Units	SPEC	PASS / FAIL	Tester Initials	Date
+5 V Reference	D8 / C19 Node	AGnd		V	4.980 to 5.020	PASS / FAIL		
-5 V Reference	D1 / R17 Node	AGnd	AGnd	V	-4.980 to -5.020	PASS / FAIL		
CLK OUT Frequency	U29 pin 3	DGnd		Hz	9.5 to 10.5 Hz	PASS / FAIL		
CLK OUT Vmax	U29 pin 3	DGnd		Vdc	4.5 to 5.1	PASS / FAIL		
CLK OUT Vmin	U29 pin 3	DGnd		mVdc	0 to 200 mV	PASS / FAIL		
+15V Power	Testpoint	AGnd		Vdc	14.0 to 15.0 V	PASS / FAIL		
-15V Power	Testpoint	AGnd		Vdc	-14.0 to -15.0 V	PASS / FAIL		
+5VDIG	Testpoint	DGnd		Vdc	4.8 to 5.2 V	PASS / FAIL		
+5VWD	Testpoint	WDGnd		Vdc	4.8 to 5.2 V	PASS / FAIL		
+5VSE	Testpoint	SEGnd		Vdc	4.8 to 5.2 V	PASS / FAIL		

Table 10 Miscellaneous Board Signal Testing

4.8 Watch Dog Timer

The Safety Board has two watch dog timers. The watchdog timer reset signal is sent from the TCS3 Control PC to the Safety Board. The other watchdog is for the on board CPLD clock. Clear any errors first. Push and hold the momentary contact switches located on the Safety Board. Record the results.

Condition	mcc1 Error Message	PASS / FAIL	Tester Initials	Date
SW4 Pressed	SafetyBrd_Watchdog_Tmr_Latch	PASS / FAIL		
SW3 Pressed	SafetyBrd_Clocking_Error_Latch	PASS / FAIL		

Table 11 Watchdog Timer Test

4.9 Telescope Brake Relay

To test these relays, start tracking (turns off brakes) and measure between the specified points in the table. Then enter idle mode (turns brakes on) and measure the specified points again.

NOTE: In the lab system the output drives a resistive load instead of an actual relay coil.

Condition	Relay Under Test	Measure Between	Value	Units	SPEC	PASS / FAIL	Tester Initials	Date
Tracking (brakes OFF)	Brake Enable	TB1-B49 to AGnd		V	23V to 25V	PASS / FAIL		
Idle (brakes ON)	Brake Enable	TB1-B49 to AGnd		V	Less than 100 mV	PASS / FAIL		

Table 12 Telescope Brake Relay

4.10 Telescope & Dome Amp Enable Lines

The amplifiers for the dome and telescope axes have enable lines. These lines are sensed to make sure that they are functioning correctly when the brakes are taken off or if the thermal fuse blows in the amplifier (disconnects enable line). Errors are created for the telescope axes and a warning is created for the dome.

The lab TO Panel contains switches for emulating error conditions.

Note: some combinations may not be possible in actual operation, however, they are used to test the logic.

Tracking	TO Panel System Power Break Switch	TO Panel HA & DEC Amp Enable Break Switch	SPEC	SPEC PASS / FAIL	Tester Initials	Date
Yes	down (break)	up (normal)	No Error - Tracking	PASS / FAIL		
Yes	up (normal)	down (break)	"Safety_Tel_Amp_Enable_Therm" error in mcc1.	PASS / FAIL		
Yes	down (break)	down (break)	No Error - Tracking	PASS / FAIL		
Yes	up (normal)	up (normal)	No Error - Tracking	PASS / FAIL		

Table 13 Telescope Amp Enable Line Testing

For the dome enable lines, set the dome control switch on the TO Panel to "software". Use "manual" mode on mcc1. Set "Manual Cntl" to 0.50. Click "Right". This will move the simulated dome. Ensure that system power is on (turned on via mcc2).

TO Panel System Power Break Switch	TO Panel Dome Amp Enable Break Switch	TO Panel Dome Brake Relay Break Switch	SPEC	SPEC PASS / FAIL	Tester Initials	Date
up (normal)	down (break)	up (normal)	Dome Moving & "SafetyBrd_Dome_Amp_Enable_Therm"	PASS / FAIL		
down (break)	down (break)	up (normal)	Dome Moving, no warning	PASS / FAIL		
down (break)	down (break)	down (break)	Dome Moving, no warning	PASS / FAIL		
up (normal)	down (break)	down (break)	Dome Moving, no warning	PASS / FAIL		

Table 14 Dome Amp Enable Line Testing

4.11 Overall Servo

The overall servo testing will consist of tracking, offsets, and slewing. Use the specified PID and velocity feed forward values with the appropriate command. When performing these tests, look for any abnormal signs, specifically large oscillations. A basic knowledge of using the TCS3 control software is assumed. If more information on using it is required, please contact someone who is familiar with it (software programmer, TO, etc).

Note: the HA axis is not well behaved and has oscillations. Use the best case results. Essentially these tests just check to make sure that the system is functional.

The measurements required for all the tables below come from the sub-tab "Graph1" in the "Details" tab.

Basic commands used in command line prompt:

pg.ferr 2	Zooms in on following error window.
beam.set 30 30	Sets beam switch to 30 arcsec for both HA and DEC.
next.hadec 1 40	Sets slew position to 1hr (HA) and 40 degrees (DEC).

Operation	HA Axis				DEC Axis			
	P	I	D	Vff	P	I	D	Vff
Tracking	100k	25k	2k	15k	100k	25k	2k	15k
SLEW	100k	100	2k	15k	100k	100	2k	15k

Table 15 Servo PID Settings for mcc3 window

Operation	Axis	Following Error - "pmac" plot				SPECS PASS / FAIL	Tester Initials	Date
		"range" arcsec peak-peak	SPEC "range" arcsec peak-peak	std dev arcsec	SPEC std dev arcsec			
Tracking	HA		0.5		0.1	PASS / FAIL		
Tracking	DEC		0.1		0.03	PASS / FAIL		

Table 16 Tracking Tests

Operation	Axis	Offset (arcsec)	Settling Time "pmac" plot (yellow)	SPEC Settling Time (back to within 0.2 arcsec p-p band)	SPECS PASS / FAIL	Tester Initials	Date
Tracking	HA	+/- 30		< 2 seconds	PASS / FAIL		
Tracking	DEC	+/- 30		< 2 seconds	PASS / FAIL		

Table 17 Offset Tests

Operation	Axis	Movement	Velocity Error - "pmac" plot (yellow) (during constant velocity portion of SLEW)				SPECS PASS / FAIL	Tester Initials	Date
			"range" arcsec/s peak-peak	SPEC "range" arcsec/s peak-peak	"std dev" arcsec/s	SPEC " std dev" arcsec/s			
SLEW	HA	+		150		20	PASS / FAIL		
SLEW	DEC	+		15		3	PASS / FAIL		

Table 18 Slew Tests

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5 Completion

1) Power down the TCS3 lab setup.

2) Remove the safety board.

3) Set SW1 and SW2 to summit on Safety Board.

4) Place “tested (date)” sticker on Safety Board.

5) Testing for the Safety Board is now complete and is acceptable for use in TCS3.

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