Reference DKW 07/29/2016

DKW 01-02-2019

T500/T600 Scrub Board Functional Test Procedure

PCA (with or without telemetry)

Revision 2 -- changes highlighted.

**Setup**:

A clamshell fixture has test probes that make connections with all necessary points when the board is placed in the fixture and the latch is closed over the board. Test commands are sent to the board using the CAN interface. The board executes the commands and returns status over the same interface.

All CAN communication is with CAN node ID #3 (main processor) and CAN node ID #12 (telemetry) except where indicated.

Rev 1 based off Revision 12 of Rhine FCT.

**Test Sequence**:

1. Install board in machine.
2. Turn power on. Power supply is set to 24.0V and should be capable of driving a 75A load. Power is applied as indicated: COM goes to large screw stud J1 and J7-8, J7-12, J12-8, J6-10. +24V goes to small screw stud J5, J7-1 and J7-10.

**Firmware Rev Check:**

1. Read the firmware revision by sending the following command: **read CAN index 0x100A subindex 0x00**. Check the returned value against latest revision.

**Initial Power/Switch Input Tests:**

1. Apply 24V to J6-1.
2. Read EC-water Circuit Breaker by sending the following command: **read CAN index 0x3085 subindex 0x01.** Bit 5 must be 0.
3. Remove 24V from J6-1.
4. Read EC-water Circuit Breaker by sending the following command: **read CAN index 0x3085 subindex 0x01.** Bit 5 must be 1.
5. J6-2 should be floating.
6. Read scrub head max downforce switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 2 must be 0.
7. Short J6-2 to ground.
8. Read scrub head max downforce switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 2 must be 1.
9. J6-3 should be floating.
10. Read orbital downforce 1 switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 4 must be 0.
11. Short J6-3 to ground.
12. Read orbital downforce 1 switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 4 must be 1.
13. J6-4 should be floating.
14. Read chemical tank switch by sending the following command: **read CAN index 0x3083 subindex 0x01.** Bit 5 must be 1.
15. Short J6-4 to ground.
16. Read chemical tank switch by sending the following command: **read CAN index 0x3083 subindex 0x01.** Bit 5 must be 0.
17. J6-5 should be floating.
18. Read scrub head middle switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 0 must be 1.
19. Short J6-5 to ground.
20. Read scrub head middle switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 0 must be 0.
21. J6-6 should be floating.
22. Read orbital downforce 2 switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 6 must be 0.
23. Short J6-6 to ground.
24. Read orbital downforce 2 switch by sending the following command: **read CAN index 0x3031 subindex 0x04.** Bit 6 must be 1.
25. J6-7 should be floating.
26. Read parking brake switch by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 6 must be 0.
27. Short J6-7 to ground.
28. Read parking brake switch by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 6 must be 1.
29. J6-8 should be floating.
30. Read squeegee down/ vac switch by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 2 must be 0.
31. Short J6-8 to ground.
32. Read squeegee down/ vac switch by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 2 must be 1.
33. Apply 24V to J7-10.
34. Read wand pump Circuit Breaker by sending the following command: **read CAN index 0x3071 subindex 0x01.** Bit 7 must be 0.
35. Remove 24V from J7-10.
36. Read wand pump Circuit Breaker by sending the following command: **read CAN index 0x3071 subindex 0x01.** Bit 7 must be 1.
37. Wait 10 seconds.
38. Read VBAT\_POWER\_MONITOR\_ANALOG by sending the following command: **read CAN index 0x3042 subindex 0x07 bytes 0 and 1.** Reading is measured voltage x 100. Reading must come back within ±4% of 24.0V. (2304 < reading < 2496)
39. Apply 24V to J12-2.
40. Read E-stop switch out by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 0 must be 0.
41. Turn off I-Drive enable by sending the following command: **write 0 to CAN index 0x30A0 subindex 0x01.** Measure pin J12-1 WRT common with a DMM. Must measure 0V±.5V.
42. Turn on I-Drive enable by sending the following command: **write 1 to CAN index 0x30A0 subindex 0x01.** Measure pin J12-1 WRT common with a DMM. Must measure 24V±2V.
43. Test current limiting on I-Drive enable output by applying a 100Ω 5W load between J12-1 and common.
44. Measure pin J12-1 WRT common with a DMM. Must measure 1.0V±0.4V.
45. Remove load from J12-1.
46. Remove 24V from J12-2.
47. Read E-stop switch out by sending the following command: **read CAN index 0x3080 subindex 0x01.** Bit 0 must be 1.
48. Apply 24V to J12-7.
49. Read I-Drive Circuit Breaker by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 7 must be 0.
50. Remove 24V from J12-7.
51. Read I-Drive Circuit Breaker Circuit Breaker by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 7 must be 1.
52. J12-3 should be floating.
53. Read I-drive Aux2 (“propel active”) by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 0 must be 0.
54. Short J12-3 to ground.
55. Read I-drive Aux2 by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 0 must be 1.
56. J12-4 should be floating.
57. Read I-drive Aux3 (“reverse”) by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 5 must be 0.
58. Short J12-4 to ground.
59. Read I-drive Aux3 by sending the following command: **read CAN index 0x30A1 subindex 0x01.** Bit 5 must be 1.

**RTC and Battery Backup Test: (done on telemetry board only)**

1. CAN communication in this section is done with CAN node ID #12.
2. Set Real time clock to current day and time by sending the following command: **Write four bytes to CAN index 0x2003 subindex 0x01: byte 0 is month (decimal), byte 1 is day of month, byte 2 is year, byte 3 is day of week (can be left as zero when writing and the software will compute the correct day). Write four bytes to CAN index 0x2003 subindex 0x02: byte 0 is hour (decimal), byte 1 is minutes, byte 2 is seconds, byte 3 is zero (unused)**
3. Turn off power for 10 seconds.
4. Turn on power.
5. Read RTC **by reading four bytes from CAN index 0x2003 subindex 0x01 and four bytes from CAN index 0x2003 subindex 0x02**. Date and time must come up correctly and clock must have incremented by approximately 10 to 20 seconds. (10 seconds plus bootup time.)

**FRAM Test: : (done on telemetry board only) CAN ID #12**

1. Write test data to FRAM by sending the following command: Write the value 55A5 into parameter 1998 as below:
   1. **Write object 0x2000 sub-index 0x02 with data { 00, 01, CE, 07, 02, 00, 00, 00, A5, 55}**
   2. **Read object 0x2000 sub-index 0x01 and verify array = { 00, 01, CE, 07, 00, 00, 00, 00}**
2. Read back the data by sending the following command: Read the value 55A5 from parameter 1998.
   1. **Write object 0x2000 sub-index 0x02 with data {00, 00, CE, 07, 02, 00, 00, 00, 00, 00 }**
   2. **Read object 0x2000 sub-index 0x01 and verify array = { 00, 00, CE, 07, 02, 00, 00, 00, A5, 55}**

**Serial Flash Test:**

1. Write the board serial number to the serial EEPROM by sending the following command: Write the serial number into parameter 2999. (ASCII is fine for the characters) as below:
   1. **Write object 0x2000 sub-index 0x02 with data { 00, 01, B7, 0B, 1E, 00, 00, 00, \_\_, \_\_, \_\_, …}**
   2. **Example serial number 123456 = {00, 01, B7, 0B, 1E, 00, 00, 00, 31, 32, 33, 34, 35, 36 }**
   3. **Read object 0x2000 sub-index 0x01 and verify array = { 00, 01, B7, 0B, 00, 00, 00, 00}}**
2. Read back the board serial number from the serial EEPROM by sending the following command: Read the serial number from parameter 2999 as below:
   1. **Write object 0x2000 sub-index 0x02 with data {00, 00, B7, 0B, 1E, 00, 00, 00}**
   2. **Read object 0x2000 sub-index 0x01 and verify array = { 00, 00, B7, 0B, 1E, 00, 00, 00, \_\_, \_\_, \_\_, …}**

**Actuator Bridge Driver Test:**

1. Commands will be sent to control the actuator driver on the UUT, which has resistive loads applied to its outputs (across J7-3 to J7-4).
2. Apply open load to the actuator driver.
3. Turn on the actuator driver by sending the following commands:
   1. **Write 500 to CAN index 0x3022 subindex 0x01 bytes 0 and 1. (sets current limit to 5.0A)**
   2. **Write to CAN index 0x3020 subindex 0x01, bytes 1 and 2 = 500, and byte 0 = 4. (sets PWM to 50%, sets extend direction)**
4. This “extends” the actuator at 50% duty cycle with a current limit of 5.0A, driving an open load.
5. **Write to CAN index 0x3020 subindex 0x01, bytes 1 and 2 = 500, and byte 0 = 2. (sets PWM to 50%, sets retract direction)**
6. This “retracts” the actuator at 50% duty cycle with a current limit of 5.0A, driving an open load.
7. Read actuator driver status by sending the following command: **read CAN index 0x3021 subindex 0x01 byte 0.** Bit 5 must be 0. (bit 5 = short) Bit 4 must be 0. (bit 4 = overcurrent) Bit 1 must be 1. (bit 1 = open circuit)
8. Read actuator current by sending the following command: **read CAN index 0x3021 subindex 0x05 bytes 0 and 1.** Actuator current must be 0A±0.2A. Reading is current x 100 so (0 < reading < 20)
9. Power cycle the UUT to clear the fault.
10. Apply an 8.5Ω 100W load to the actuator driver.
11. Turn on the actuator driver by sending the following commands:
    1. **Write 500 to CAN index 0x3022 subindex 0x01 bytes 0 and 1. (sets current limit to 5.0A)**
    2. **Write 500 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 50%, sets extend direction)**
12. This “extends” the actuator at 50% duty cycle with a current limit of 5.0A into a load that wants to draw 2.8A.
13. Read actuator driver status by sending the following command: **read CAN index 0x3021 subindex 0x01 byte 0.** Bit 5 must be 0. (bit 5 = short) Bit 4 must be 0. (bit 4 = overcurrent) Bit 0 must be 1. (bit 0 = moving)
14. Read actuator current by sending the following command: **read CAN index 0x3021 subindex 0x05 bytes 0 and 1.** Actuator current must be 2.8A±0.3A. Reading is current x 100 so (250 < reading < 310)
15. Stop the actuator motor driver by sending the following command: **Write 0 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 0%, sets extend direction)**
16. Apply a 4Ω 200W load to the actuator driver.
17. Turn on the actuator driver by sending the following commands:
    1. **Write 500 to CAN index 0x3022 subindex 0x01 bytes 0 and 1. (sets current limit to 5.0A)**
    2. **Write 500 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 50%, sets extend direction)**
18. This “extends” the actuator at 50% duty cycle with a current limit of 5.0A, with a load that wants to draw 6.0A.
19. Read actuator driver status by sending the following command: **read CAN index 0x3021 subindex 0x01 byte 0.** Bit 4 must be 1. (bit 4 = overcurrent)
20. Read actuator current by sending the following command: **read CAN index 0x3021 subindex 0x05 bytes 0 and 1.** Actuator current must be 0A±0.2A. Reading is current x 100 so (0 < reading < 20)
21. Power cycle the UUT to clear the fault.
22. Apply an 8Ω 100W load to the actuator driver.
23. Turn on the actuator driver by sending the following commands:
    1. **Write 500 to CAN index 0x3022 subindex 0x01 bytes 0 and 1. (sets current limit to 5A)**
    2. **Write 950 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 2 to byte 0. (sets PWM to 95%, sets retract direction)**
24. This “retracts” the actuator at 95% duty cycle with a current limit of 5A, with a load that wants to take 3.0A.
25. Read actuator driver status by sending the following command: **read CAN index 0x3021 subindex 0x01 byte 0.** Bit 5 must be 0. (bit 5 = short) Bit 4 must be 0. (bit 4 = overcurrent) Bit 0 must be 1. (bit 0 = moving)
26. Read actuator current by sending the following command: **read CAN index 0x3021 subindex 0x05 bytes 0 and 1.** Actuator current must be 3.0A±0.3A. Reading is current x 100 so (270 < reading < 330)
27. Read actuator output voltage with a meter at the output connector. J7-3 must be 22V ±2V WRT J7-4.
28. Stop the actuator motor driver by sending the following command: **Write 0 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 0%, sets extend direction)**
29. Apply an 8Ω 100W load to the actuator driver.
30. Turn on the actuator driver by sending the following commands:
    1. **Write 500 to CAN index 0x3022 subindex 0x01 bytes 0 and 1. (sets current limit to 5A)**
    2. **Write 950 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 95%, sets extend direction)**
31. This “extends” the actuator at 95% duty cycle with a current limit of 5A.
32. Read actuator driver status by sending the following command: **read CAN index 0x3021 subindex 0x01 byte 0.** Bit 5 must be 0. (bit 5 = short) Bit 4 must be 0. (bit 4 = overcurrent) Bit 0 must be 1. (bit 0 = moving)
33. Read actuator current by sending the following command: **read CAN index 0x3021 subindex 0x05 bytes 0 and 1.** Actuator current must be 3.0A±0.3A. Reading is current x 100 so (270 < reading < 330)
34. Read actuator output voltage. J7-3 must be -22V ±2V WRT J7-4.
35. Stop the actuator motor driver by sending the following command: **Write 0 to CAN index 0x3020 subindex 0x01 bytes 1 and 2, and 4 to byte 0. (sets PWM to 0%, sets extend direction)**

**Hour meter Test:**

1. Test the hour meter output by reading pin J7-11 WRT common with a DMM. Must read 0V.
2. The rest of the hour meter test is in the scrub motor test section.

**Chempump Speed Set Test:**

1. Connect J7-13 to ground.
2. Read the chempump pot by sending the following command: **read CAN index 0x3083 subindex 0x02 bytes 0 and 1.** Reading is a percentage of full scale, where full scale = 2.7V. Reading from the UUT must be 0 to 50.
3. Connect J7-13 to a source of 1.024V.
4. Read the chempump pot by sending the following command: **read CAN index 0x3083 subindex 0x02 bytes 0 and 1.** Reading from the UUT must be 379±5%.
5. Connect J7-13 to a source of 2.048V.
6. Read the chempump pot by sending the following command: **read CAN index 0x3083 subindex 0x02 bytes 0 and 1.** Reading from the UUT must be 759±5%.

**Valve LSD Test:**

1. Apply open load to the valve low side driver.
2. Turn on the valve driver by sending the following command: **Write 1 to CAN index 0x3050 subindex 0x01.**
3. This runs the valve driver at 100% duty cycle with a current limit of 1.0A into an open load.
4. Read valve driver status by sending the following command: **read CAN index 0x3051 subindex 0x01.** Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
5. Power cycle the UUT to clear the fault.
6. Apply a 30Ω 50W load to the valve driver, from J7-1 to J7-2.
7. Turn on the valve driver by sending the following command: **Write 1 to CAN index 0x3050 subindex 0x01.** This runs the valve driver at 100% duty cycle with a current limit of 1.0A.
8. Read valve driver status by sending the following command: **read CAN index 0x3051 subindex 0x01.** Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
9. Read valve current by sending the following command: **read CAN index 0x3051 subindex 0x03 bytes 0 and 1.** Valve current must be 0.8A±0.1A. Reading is current x 100 so (70 < reading < 90)
10. Turn off valve driver by sending the following command: **Write 2 to CAN index 0x3050 subindex 0x01.**
11. Read valve current by sending the following command: **read CAN index 0x3051 subindex 0x03 bytes 0 and 1.** Valve current must be 0.0A±0.1A. Reading is current x 100 so (0 < reading < 10)
12. Apply a 15Ω 50W load to the valve driver.
13. Turn on the valve driver by sending the following command: **Write 1 to CAN index 0x3050 subindex 0x01.** This runs the valve driver at 100% duty cycle with a current limit of 1.0A into a load that wants to take 1.6A.
14. Read valve driver status by sending the following command: **read CAN index 0x3051 subindex 0x01.** Bit 1 must be 1. (bit 1 is overcurrent) Bit 2 must be 0 (bit 2 is open load).
15. Read valve current by sending the following command: **read CAN index 0x3051 subindex 0x03 bytes 0 and 1.** Valve current must be 0.0A±0.1A. Reading is current x 100 so (0 < reading < 10)
16. Power cycle the UUT to clear the fault.

**Digital Power Monitor Circuit Test:**

1. This tests the circuit’s ability to shut down the drivers if the system power is low voltage. It uses the valve driver circuit to test this.
2. Lower the 24V supply to 15V.
3. Apply a 15Ω 50W load to the valve driver.
4. Turn on the valve driver by sending the following command: **Write 1 to CAN index 0x3050 subindex 0x01.** This runs the valve driver at 100% duty cycle with a current limit of 1.0A, however the power monitor circuit should inhibit operation.
5. Read valve driver status by sending the following command: **read CAN index 0x3051 subindex 0x01.** Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
6. Read valve current by sending the following command: **read CAN index 0x3051 subindex 0x03 bytes 0 and 1.** Valve current must be 0.0A±0.1A. Reading is current x 100 so (0 < reading < 10)
7. Power cycle the UUT to clear the fault.
8. Restore power to 24.0V.

**Chem Pump LSD Test:**

1. Apply open load to the chem pump low side driver.
2. Turn on the chem pump driver by sending the following command: **Write to CAN index 0x3090 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.** This runs the chem pump driver at 50% duty cycle with a current limit of 1.0A into an open load.
3. Read chem pump driver status by sending the following command: **read CAN index 0x3091 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
4. Power cycle the UUT to clear the fault.
5. Apply a 33Ω 50W load to the chem pump driver, from J7-1 to J7-6.
6. Turn on the chem pump driver by sending the following command: **Write to CAN index 0x3090 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.** This runs the chem pump driver at 50% duty cycle with a current limit of 1.0A into a load that wants to draw 0.72A.
7. Read chem pump status by sending the following command: **read CAN index 0x3091 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
8. Read chem pump current by sending the following command**: read CAN index 0x3091 subindex 0x03 bytes 0 and 1.** Chem pump current must be 0.72A±0.1A. Reading is current x 100 so (62 < reading < 82)
9. Read chem pump output voltage with a meter at the output connector. J7-6 must be 12V ±1V WRT J7-12. (8.5V±1V if not measured with a true RMS meter)
10. Turn off chem pump driver by sending the following command: **Write to CAN index 0x3090 subindex 0x01 byte0=2, bytes 1 and 2 = 00, byte 3 = 0.**
11. Read chem pump current by sending the following command**: read CAN index 0x3091 subindex 0x03 bytes 0 and 1.** Chem pump current must be 0.0A±0.1A. Reading is current x 100 so (0 < reading < 10)
12. Apply an 8Ω 50W load to the chem pump driver.
13. Turn on the chem pump driver by sending the following command: **Write to CAN index 0x3090 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.** This runs the chem pump driver at 50% duty cycle with a current limit of 2.0A into a load that wants to take 3.0A.
14. Read chem pump status by sending the following command: **read CAN index 0x3091 subindex 0x01.** Bit 1 must be 1 (bit 1 is overcurrent). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load).
15. Read chem pump current by sending the following command**: read CAN index 0x3091 subindex 0x03 bytes 0 and 1.** Chem pump current must be 0.0A±0.1A. Reading is current x 100 so (0 < reading < 10)
16. Power cycle the UUT to clear the fault.

**Wand Pump Test:**

1. Apply 24V to J7-10.
2. Apply open load to the wand pump low side driver.
3. Turn on the wand pump driver by sending the following command: : **Write 0x01D00700 to CAN index 0x3070 subindex 0x01 bytes 0 through 3.**
4. This runs the wand pump driver at approximately 83% duty cycle with a current limit of 16A into an open load.
5. Read wand pump driver status by sending the following command: **read CAN index 0x3071 subindex 0x01.** Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
6. Power cycle the UUT to clear the fault.
7. Apply a 2Ω 50W load to the wand pump driver, from J7-10 to J7-9.
8. Turn on the wand pump driver by sending the following command: : **Write 0x01D00700 to CAN index 0x3070 subindex 0x01 bytes 0 through 3.** This runs the wand pump driver at approximately 83% duty cycle with a current limit of 16.0A into a load that wants to draw approximately 12A.
9. Read wand pump driver status by sending the following command: **read CAN index 0x3071 subindex 0x01.** Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
10. Read wand pump current by sending the following command: **read CAN index 0x3071 subindex 0x03 bytes 0 and 1.** Valve current must be 12A±1.2A. Reading is current x 100 so (1080 < reading < 1320)
11. Turn off wand pump driver by sending the following command: : **Write to CAN index 0x3070 subindex 0x01: 0x02000000 (4 bytes)**
12. Read wand pump current by sending the following command: **read CAN index 0x3071 subindex 0x03 bytes 0 and 1.** Wand pump current must be 0.0A±0.4A. Reading is current x 100 so (0 < reading < 40)
13. Apply a 1.25Ω 200W load to the wand pump driver.
14. Turn on the wand pump driver by sending the following command: **Write 0x01D00700 to CAN index 0x3070 subindex 0x01 bytes 0 through 3.** This runs the wand pump driver at approximately 83% duty cycle with a current limit of 16A into a load that wants to take 19A.
15. Read wand pump driver status by sending the following command: **read CAN index 0x3071 subindex 0x01.** Bit 1 must be 1. (bit 1 is overcurrent) Bit 2 must be 0 (bit 2 is open load).
16. Read wand pump current by sending the following command: **read CAN index 0x3071 subindex 0x03 bytes 0 and 1.** Wand pump current must be 0.0A±0.4A. Reading is current x 100 so (0 < reading < 40)
17. Power cycle the UUT to clear the fault.

**Vac Fan Driver Test:**

1. Commands will be sent to control the vac fan driver on the UUT, which has resistive loads applied to its outputs (across J4-1 to J4-2).
2. Apply open load to the vac fan driver.
3. Turn on the vac fan driver by sending the following commands:
   1. **Write to CAN index 0x3042 subindex 0x01 bytes 0 and 1 = 500.**
   2. **Write to CAN index 0x3040 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.**
4. This runs the vac fan driver at 50% duty cycle with a current limit of 5.0A into an open load.
5. Read vac fan driver status by sending the following command: **read CAN index 0x3041 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
6. Read the vac fan current by sending the following commands**: read CAN index 0x3041 subindex 0x03 bytes 0 and 1.** Vac fan current must be 0.0A±0.5A. Reading is current x 100 so (0 < reading < 50)
7. Power cycle the UUT to clear the fault.
8. Apply a 1.25Ω 500W load to the vac fan driver.
9. Turn on the vac fan driver by sending the following commands:
   1. **Write to CAN index 0x3042 subindex 0x01 bytes 0 and 1 = 2500.**
   2. **Write to CAN index 0x3040 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.**
10. This runs the vac fan driver at 50% duty cycle with a current limit of 25.0A into a load that wants to draw 19.2A.
11. Read vac fan driver status by sending the following command: **read CAN index 0x3041 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
12. Read the vac fan current by sending the following commands**: read CAN index 0x3041 subindex 0x03 bytes 0 and 1.** Vac fan current must be 18±2A. Reading is current x 100 so (1700 < reading < 1900).
13. Stop the vac fan motor driver by sending the following command: **Write to CAN index 0x3040 subindex 0x01 byte0=2, bytes 1 and 2 = 00, byte 3 = 0.**
14. Read the vac fan current by sending the following commands**: read CAN index 0x3041 subindex 0x03 bytes 0 and 1.** Vac fan current must be 0.0A±0.5A. Reading is current x 100 so (0 < reading < 50)
15. Apply a 0.75Ω 1000W load to the vac fan driver.
16. Turn on the vac fan driver by sending the following command:
    1. **Write to CAN index 0x3042 subindex 0x01 bytes 0 and 1 = 2500.**
    2. **Write to CAN index 0x3040 subindex 0x01 byte0=1, bytes 1 and 2 = 1200, byte 3 = 0.**
17. This runs the vac fan driver at 50% duty cycle with a current limit of 25.0A into a load that wants to draw 32A.
18. Read vac fan driver status by sending the following command: **read CAN index 0x3041 subindex 0x01.** Bit 6 must be 1 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
19. Read the vac fan current by sending the following commands**: read CAN index 0x3041 subindex 0x03 bytes 0 and 1.** Vac fan current must be 0.0A±0.5A. Reading is current x 100 so (0 < reading < 50)
20. Power cycle the UUT to clear the fault.
21. Apply a 1.25Ω 500W load to the vac fan driver. Turn on the vac fan driver by sending the following command:
    1. **Write to CAN index 0x3042 subindex 0x01 bytes 0 and 1 = 2500.**
    2. **Write to CAN index 0x3040 subindex 0x01 byte0=1, bytes 1 and 2 = 2300, byte 3 = 0.**
22. This runs the vac fan driver at 95% duty cycle with a current limit of 25A.
23. Read vac fan driver status by sending the following command: **read CAN index 0x3041 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
24. Read vac fan output voltage with a meter at the output connector. J4-2 must be 22V ±2V WRT J4-1.
25. Stop the vac fan motor driver by sending the following command: **Write to CAN index 0x3040 subindex 0x01 byte0=2, bytes 1 and 2 = 00, byte 3 = 0.**

**Scrub Motor 1 Driver Test:**

1. Commands will be sent to control the scrub motor driver on the UUT, which has resistive loads applied to its outputs (across J3-1 through 12 to J3-13 through 24).
2. Apply open load to the scrub motor 1 driver.
3. Turn on the scrub motor 1 driver by sending the following command:
   1. **Write to CAN index 0x3002 subindex 0x01 bytes 0 and 1 = 50.**
   2. **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 1200.**
4. This runs the scrub motor 1 driver at 50% duty cycle with a current limit of 5.0A into an open load.
5. Read scrub motor 1 driver status by sending the following command: **read CAN index 0x3001 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
6. Read the scrub motor 1 current by sending the following commands**: read CAN index 0x3001 subindex 0x03 bytes 0 and 1.** Scrub motor 1 current must be 0.0A±0.5A. Reading is current x 10 so (0 < reading < 5)
7. Power cycle the UUT to clear the fault.
8. Apply a 0.625Ω 1000W load to the scrub motor 1 driver.
9. Turn on the scrub motor 1 driver by sending the following command:
   1. **Write to CAN index 0x3002 subindex 0x01 bytes 0 and 1 = 500.**
   2. **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 1200.**
10. This runs the scrub motor 1 driver at 50% duty cycle with a current limit of 50.0A into a load that wants to draw 38.4A.
11. Read scrub motor driver 1 status by sending the following command: **read CAN index 0x3001 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
12. Read the scrub motor 1 current by sending the following commands**: read CAN index 0x3001 subindex 0x03 bytes 0 and 1.** Scrub motor 1 current must be 34.2A+2A-4A. Reading is current x 10 so (302 < reading <362).
13. Test the hour meter output by reading pin J7-11 WRT common with a DMM. Must read over 4.0V. (hour meter runs only when the scrub motor does)
14. Stop the scrub motor 1 driver by sending the following command: **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 0000.**
15. Read the scrub motor 1 current by sending the following commands**: read CAN index 0x3001 subindex 0x03 bytes 0 and 1.** Scrub motor 1 current must be 0A±2A. Reading is current x 10 so (0 < reading < 20)
16. Apply a 0.375Ω 1500W load to the scrub motor 1 driver.
17. Turn on the scrub motor 1 driver by sending the following command:
    1. **Write to CAN index 0x3002 subindex 0x01 bytes 0 and 1 = 500.**
    2. **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 1200.**
18. This runs the scrub motor 1 driver at 50% duty cycle with a current limit of 50.0A into a load that wants to draw 64A.
19. Read scrub motor driver 1 status by sending the following command: **read CAN index 0x3001 subindex 0x01.** Bit 6 must be 1 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
20. Read the scrub motor 1 current by sending the following commands**: read CAN index 0x3001 subindex 0x03 bytes 0 and 1.** Scrub motor 1 current must be 0A±2A. Reading is current x 10 so (0 < reading < 20)
21. Power cycle the UUT to clear the fault.
22. Apply a 0.625Ω 1000W load to the scrub motor 1 driver.
23. Turn on the scrub motor 1 driver by sending the following command:
    1. **Write to CAN index 0x3002 subindex 0x01 bytes 0 and 1 = 500.**
    2. **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 2300.**
24. This runs the scrub motor 1 driver at 95% duty cycle with a current limit of 50A into a load that wants to draw 38.4A.
25. Read scrub motor 1 output voltage with a meter at the output connector. J3-1 must be 22V ±2V WRT J3-13.
26. Stop the scrub motor 1 driver by sending the following command: **Write to CAN index 0x3000 subindex 0x01 bytes 0 and 1 = 00.**

**Scrub Motor 2 Driver Test:**

1. Commands will be sent to control the scrub motor 2 driver on the UUT, which has resistive loads applied to its outputs (across J2-1 through 12 to J2-13 through 24).
2. Apply open load to the scrub motor 2 driver.
3. Turn on the scrub motor 2 driver by sending the following command:
   1. **Write to CAN index 0x3012 subindex 0x01 bytes 0 and 1 = 50.**
   2. **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 1200.**
4. This runs the scrub motor 2 driver at 50% duty cycle with a current limit of 5.0A into an open load.
5. Read scrub motor 2 driver status by sending the following command: **read CAN index 0x3011 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 1 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
6. Read the scrub motor 2 current by sending the following commands**: read CAN index 0x3011 subindex 0x03 bytes 0 and 1.** Scrub motor 2 current must be 0.0A±0.5A. Reading is current x 10 so (0 < reading < 5)
7. Power cycle the UUT to clear the fault.
8. Apply a 0.625Ω 1000W load to the scrub motor 2 driver.
9. Turn on the scrub motor 2 driver by sending the following command:
   1. **Write to CAN index 0x3012 subindex 0x01 bytes 0 and 1 = 500.**
   2. **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 1200.**
10. This runs the scrub motor 2 driver at 50% duty cycle with a current limit of 50.0A into a load that wants to draw 38.4A.
11. Read scrub motor driver 2 status by sending the following command: **read CAN index 0x3011 subindex 0x01.** Bit 6 must be 0 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
12. Read the scrub motor 2 current by sending the following commands**: read CAN index 0x3011 subindex 0x03 bytes 0 and 1.** Scrub motor 2 current must be 34.2A+2A-4A. Reading is current x 10 so (302 < reading <362).
13. Stop the scrub motor 2 driver by sending the following command: **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 0000.**
14. Read the scrub motor 2 current by sending the following commands**: read CAN index 0x3011 subindex 0x03 bytes 0 and 1.** Scrub motor 2 current must be 0A±2A. Reading is current x 10 so (0 < reading < 20)
15. Apply a 0.375Ω 1500W load to the scrub motor 2 driver.
16. Turn on the scrub motor 2 driver by sending the following command:
    1. **Write to CAN index 0x3012 subindex 0x01 bytes 0 and 1 = 500.**
    2. **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 1200.**
17. This runs the scrub motor 2 driver at 50% duty cycle with a current limit of 50.0A into a load that wants to draw 64A.
18. Read scrub motor driver 2 status by sending the following command: **read CAN index 0x3011 subindex 0x01.** Bit 6 must be 1 (bit 6 is shorted load). Bit 5 must be 0. (bit 5 is FET fault) Bit 2 must be 0 (bit 2 is open load). Bit 1 must be 0 (bit 1 is overcurrent).
19. Read the scrub motor 2 current by sending the following commands**: read CAN index 0x3011 subindex 0x03 bytes 0 and 1.** Scrub motor 2 current must be 0A±2A. Reading is current x 10 so (0 < reading < 20)
20. Power cycle the UUT to clear the fault.
21. Apply a 0.625Ω 1000W load to the scrub motor 2 driver.
22. Turn on the scrub motor 2 driver by sending the following command:
    1. **Write to CAN index 0x3012 subindex 0x01 bytes 0 and 1 = 500.**
    2. **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 2300.**
23. This runs the scrub motor 2 driver at 95% duty cycle with a current limit of 50A into a load that wants to draw 38.4A.
24. Read scrub motor 2 output voltage with a meter at the output connector. J2-1 must be 22V ±2V WRT J2-13.
25. Stop the scrub motor 2 driver by sending the following command: **Write to CAN index 0x3010 subindex 0x01 bytes 0 and 1 = 00.**

**Telemetry Test: (done on board with telemetry only) Send to Node ID 12**

1. Read the telemetry status bits by **reading CAN location 0x3811 subindex 0x01.**  Bit 0 must be 1. (installed)
2. Read the telemetry registration status by **reading CAN location 0x3811 subindex 0x02.**  The value read should be 01. (registered on home network). It may take up to 60 seconds to connect. If it returns 6, it is still initializing.
3. Read the SIM number by **reading 27 bytes from CAN location 0x3811 subindex 0x04.**  The value read should be a visible string of 20 ASCII characters followed by 7 more bytes (discard the trailing 7 bytes). Each of the 20 ASCII characters must fall in the range 0x30 to 0x39 (decimal digits 0 through 9). This corresponds to the 20 digit SIM number printed on the SIM card.

End of test. Power off.