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LIQUID COOLED DELTA

REPAIRED TRANSISTOR MODULE

TEST PROCEDURE

ISSUED TO:	

AUTHORIZED FOR ISSUE:
(Signature and Date)

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Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
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Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 1/17



CONTENTS

1. INTRODUCTION	4
1.1 SAFETY	4
1.2 RELATED DOCUMENTS	4
1.3 USING TEST INSTRUCTIONS	4
1.4 MODELS COVERED	4
1.5 TEST EQUIPMENT	5
2. PRESSURE TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.1 and Delta Pressure Test WI 7.5-PITWI001)	5
3. INITIAL MECHANICAL/ELECTRICAL CHECKS (Ref. Test Specification MVDL 643-4701/TS Section 7.2)	5
4. FLASH TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.3)	6
5. VOLTAGE SHARING TESTS (Ref. Test Specification MVDL 643-4701/TS Section 7.4)	6
5.1.1 TEST CONNECTIONS	6
5.1.2 LOW VOLTAGE TEST	7
5.1.3 HIGH VOLTAGE TEST	8
6. BENCH PULSE TEST AND DIB CHECK (Ref. Test Specification MVDL 643-4701/TS Section 7.7)	8
7. INSTALLING THE UNIT INTO THE TEST CUBICLE (Ref. Test Specification MVDL 643-4701/TS Section 7.10 & 7.11)	9
8. PRESSURE, FLOW AND LEAK CHECK	9
9. OVER CURRENT TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.12)	9
9.1 SLOW SHORT CIRCUIT TESTS	10
9.1.1 INITIAL SETUP AND CHECKS	10
9.1.2 DC+ to Phase U	10
9.1.3 DC+ to Phase V	11
9.1.4 DC+ to Phase W	11
9.1.5 DC- to Phase W	11
9.1.6 DC- to Phase V	12
9.1.7 DC- to Phase U	12
9.2 FAST SHORT CIRCUIT TESTS	12
9.2.1 DC+ to Phase U	12
9.2.2 DC+ to Phase V	13
9.2.3 DC+ to Phase W	13
9.2.4 DC- to Phase W	13
9.2.5 DC- to Phase V	13
9.2.6 DC- to Phase U	13
10. OVER TEMPERATURE TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.13)	13
11. INDUCTIVE LOAD TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.14)	14

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 2/17



COMMERCIAL IN CONFIDENCE

12. MEGGER TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.15)	15
13. DISCREPANCY LOG	16
14. ACRONYMS AND ABBREVIATIONS	16
15. MODIFICATION RECORD.....	17

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 3/17



1. INTRODUCTION

This document provides test instructions for the Louisville Delta Repair Test Process to verify the functionality of liquid cooled delta transistor modules per Test Specification MVDL643-4701/TS. Both individual component functionality tests as well as the complete module tests are covered in this document. Test engineers must add information to the "LCD_TEST_LIST_PITT" spreadsheet to keep a record of component failures.

1.1 SAFETY

Test engineers shall wear appropriate PPE as described in the GE Health and Safety Manual while testing live components.

1.2 RELATED DOCUMENTS

MVDL643	Test Specification MVDL643-4701/TS
T1679EN	MV3000C Software Technical Manual
T1693EN	MV Liquid Cooled Delta Technical Manual
41Y8175/01	MVDL643-4701 General Assembly Drawings
41Y8277/01	MVDL800/1000 General Assembly Drawing
10E5437/01	Fan Speed Feedback Wiring Diagram
10E5510/01	MVDL800/MVDL1000 Wiring Diagram
KC3/4319/CD	Delta Interface Board Circuit Diagram
KC3/4338/CD	Fan Monitor Board Circuit Diagram
KC3/4381/CD	Enhanced DIB Circuit Diagram
KC3/4384/CD	PCB MV3K ENH DIB Circuit Diagram

1.3 USING TEST INSTRUCTIONS

Work through the test instructions carrying out each section in the order given. Pass on to the next section only on completion of the present section. Check off completed tests using the included LCD transistor module test certificate (V1P1C1S102) document. The test certificate follows the outline of this procedure. Record any discrepancies on the Test Discrepancy Record Sheet in Appendix A on the LCD transistor module test certificate. Upon successful completion of these test instructions, the LCD transistor module test certificate is to be signed and dated by the test engineer. Test Software is located in <https://3.75.190.20/svn/p80i/> folder under Tortoise SVN.

1.4 MODELS COVERED

This test procedure provides instructions for testing the following models of LCD transistor modules.

- i) MVDL643
- ii) MVDL800
- iii) MVDL1000



1.5 TEST EQUIPMENT

- a) Digital multi meter
- b) Tektronix high voltage probe with appropriate 1.1M Ω terminating resistor attached in between the + and – terminals of connector
- c) Oscilloscope
- d) 2 – 10x's probes for oscilloscope
- e) 2 – 100x's probes for oscilloscope
- f) 1- 1000x's current probe for oscilloscope
- g) High voltage DC voltage supply with over-current LEM protection
- h) Water cooling station
- i) Test enclosure
- j) Flash test equipment
- k) Meggar testing equipment
- l) Stop watch

2. PRESSURE TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.1 and Delta Pressure Test WI 7.5-PITWI001)

- a)
- b) Insert test hose with compressor fitting.
- c) Open valve.
- d) Connect compressor line.
- e) Bring to 90 psi
- f) Close valve and remove compressor line.
- g) Keep under pressure for 10 min.
- h) Verify unit doesn't drop .3 psi in 10 minutes.
- i) Open valve and remove test hose.
- j) Replace repair hose and tighten.
- k) Record the pass/fail in the test certificate

3. INITIAL MECHANICAL/ELECTRICAL CHECKS (Ref. Test Specification MVDL 643-4701/TS Section 7.2)

- a) Ensure that Manufacturing has signed off on MVDL Repair Checklist) that module is ready for test inspection
- b) Complete test inspection and sign off
- c) Check that all external metal components for earth continuity to the module earth terminal



COMMERCIAL IN CONFIDENCE

- d) Record the pass/fail in the test certificate

4. FLASH TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.3)

- a) Connect all pins of PL1 and PL3 on the 20X4381 or 20X4384 to the module earth and the ground probe on the High voltage tester
- b) Connect DC+, DC-, A,B and C power connections together and to the probe on the high voltage tester
- c) Connect the flash tester earth probe to the module earth and test for one minute at:
 - 2.5 kV ac rms (or 3.54 kV dc) for version MVD*** – 4401
 - 2.5 kV ac rms (or 3.54 kV dc) for version MVD*** – 4501
 - 2.7 kV ac rms (or 3.8 kV dc) for versions MVD*** – 4601
 - 2.7 kV ac rms (or 3.8 kV dc) for versions MVD*** – 470X
- i) Record the leakage current
- ii) The leakage current is less than 50 μ A
- iii) No flash over occurs
- d) Remove test jumpers and high voltage tester connections before installing the unit in the test cubicle
- e) Record the leakage and pass/fail in the test certificate

5. VOLTAGE SHARING TESTS (Ref. Test Specification MVDL 643-4701/TS Section 7.4)

5.1.1 TEST CONNECTIONS

- a) Use the DMM and verify that the DC link is at 0 volts
- b) Verify all 120 Vac power is off, and all switches on the control box are in the off position
- c) Verify the variac in the high voltage DC power supply is set to 0
- d) Clip the test sharing resistors and meters to the capacitor bank under test as described below (also in picture below).
 - Red wire to DC+ (horizontal buss work)
 - Black wire to DC- (vertical buss work)
 - Orange wire to – terminal of midpoint capacitor
 - Red wire with Grey stripe to + terminal of midpoint capacitor
 - Brown wire to DC+
 - Yellow wire to DC-
 - Connect ground

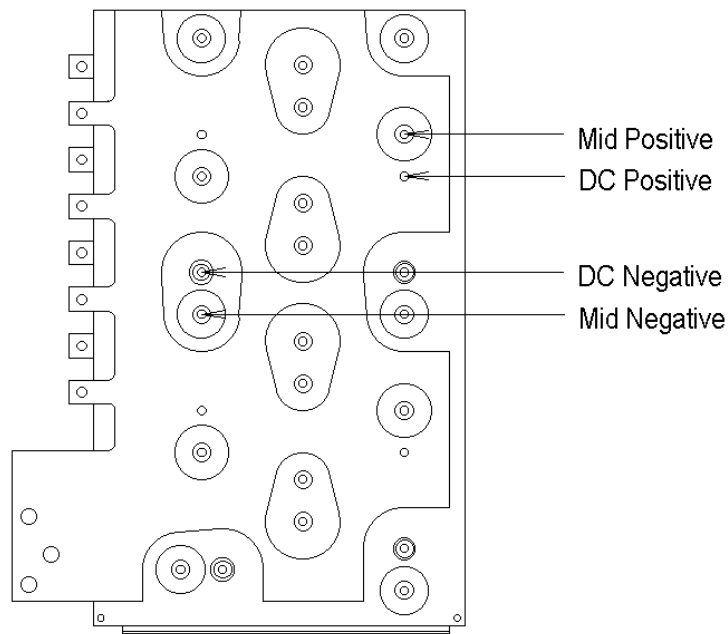
COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 6/17



COMMERCIAL IN CONFIDENCE



- e) Connect a Techtronic's P6015A High voltage probe with appropriate 1.1M Ω terminating resistor attached in between the + and – terminals to a DMM set to read DC volts
- f) Connect the probe's positive side to DC+ of the capacitor bank
- g) Connect the probe's negative side to DC- of the capacitor bank
- h) Turn on the three voltage monitors by holding the "RS232" button in on the front and turning on the switch in the back

5.1.2 LOW VOLTAGE TEST

- a) Turn the "cap bank select" switch to "EXT"
- b) Turn the "fast discharge" switch to "auto"
- c) Turn the "charge/ sharing" switch to "enable"
- d) Turn the "main power" switch to "on"
- e) Close the 2 and 10 amp circuit breakers in the high voltage DC power supply
- f) Slowly raise the voltage until the DMM with the High voltage probe reads .06V (probe divides voltage by 1000)
- g) Monitor the voltage across each leg of the capacitor bank while raising the voltage and verify that the voltage across each bank of capacitors is approximately equal and has not clamped at a lower voltage.
- h) Allow voltage to stabilize
- i) Slowly raise the capacitor bank to 300V and monitor as mentioned in g)

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 7/17



COMMERCIAL IN CONFIDENCE

- j) Verify that the voltage across each leg of the capacitor bank is approximately 1/3 of the total DC link voltage
- k) Record the volts in the test certificate

5.1.3 HIGH VOLTAGE TEST

- a) If the capacitor bank passes the previous test slowly raise the voltage until one or more capacitor circuits reaches 430V
- b) Leave on for 5 minutes. Verify that the volts are stable and that the voltage doesn't drift below 411V
- c) Record the three voltages in the test certificate
- d) Wind variac down
- e) Open 2 and 10 amp breakers
- f) Turn the Main Power switch to off
- g) Let the UUT sit until DC Link reaches zero

6. BENCH PULSE TEST AND DIB CHECK (Ref. Test Specification MVDL 643-4701/TS Section 7.7)

- a) Attach SMPS to UUT and connect ribbon and DC Auxiliary cable
- b) Connect CDC ribbon to DIB
- c) Attach Brown and Red probe leads to two of the three output phase bus plates
- d) Turn 120V Main Power switch to "on"
- e) Close 2 and 10 amp breakers
- f) Wind variac to 850V
- g) Verify DDM (keypad) turns on and is healthy (no trips)
- h) Verify three green LEDs (without fans) or five green LEDs (with fans) are lit on DIB
- i) Verify both fans are on and blowing towards capacitor bank
- j) Navigate to P11.03 and verify DC Link volts are close to meter volts
- k) Navigate to P99.05 and verify correct current rating (i.e. – MVDL800 says 800)
- l) Navigate to P1.02 and press green start button on DDM
- m) Verify green LED on DIB and DDM illuminates
- n) Verify current feedback is 1 to 3 amps
- o) Verify pulse output on o scope
- p) Verify temperature feedback in P45.00, P45.01 and P45.02
- q) Let run for 5 minutes and press red button on DDM to stop
- r) Wind down variac
- s) Open 2 and 10 amp breakers

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 8/17



COMMERCIAL IN CONFIDENCE

- t) Switch Main Power switch to "off" and switch down all other 120v switches on box.
- u) Remove power connections, SMPS, and ground once DC Link is at zero.

7. **INSTALLING THE UNIT INTO THE TEST CUBICLE** (Ref. Test Specification MVDL 643-4701/TS Section 7.10 & 7.11)

- a) Connect the heat exchanger system,
- b) Connect the DC terminals to the supply rectifier
- c) Connect the AC terminals to the load reactor
- d) Connect the short circuit test cables to the AC terminals
- e) Connect the short circuit test cables to DC+ and DC-
- f) Connect TB1 of the LCD to the SMPS
- g) Connect PL3 of the DIB to the SMPS
- h) Connect PL1 of the DIB to the MV3000C controller.
- i) Connect a suitably rated DVM to monitor the d.c. link voltage (High voltage probe)
- j) Connect an appropriately sized earth wire to the module's earth terminal

8. **PRESSURE, FLOW AND LEAK CHECK**

- a) Turn on 120V control power to variac and verify that it is wound down, (normally always on)
- b) Close 03Q1 (Variac Disconnect on Test Rig Drive)
- c) Around 12V should be read on the Fluke meter
- d) Make sure 120V is plugged in for variac motors
- e) Switch Power Source switch to VAR on Operator Station
- f) Raise Variac to 460V on Fluke meter
- g) Turn pump switch on side of drive to "Pump Motor"
- h) Verify flow is 6 GPM or greater on pump skid
- i) Check for leaks on Delta, coolant connections, rectifier, pump system
- j) Turn pump switch on side panel to off
- k) Close doors and verify good seal
- l) Wind Variac down until it says 12V

9. **OVER CURRENT TEST** (Ref. Test Specification MVDL 643-4701/TS Section 7.12)

CAUTION: Tests require voltages up to 874VAC & 1170 VDC appropriate PPE is to be worn

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 9/17



CAUTION: Short circuit testing is to be performed at 1150VDC remain the appropriate distance away from enclosure for arc flash safety

9.1 SLOW SHORT CIRCUIT TESTS

These tests use an inductor to limit the rise rate of current. Record pass/fail in the LCD Transistor module Test Record spreadsheet.

9.1.1 INITIAL SETUP AND CHECKS

- a) Turn the POWER SOURCE selector switch to “VAR” on the operator station
- b) Turn the MODULE selector switch to “XSTR” on the operator station
- c) Turn the DELTA selector switch to “LCD” on the operator station
- d) Turn the “PULSE” selector switch to “6”
- e) Verify that the voltage measured on the variac DMM that the voltage still reads approximately 12V
- f) Turn the MAIN POWER selector switch to “ON” on the operator station
- g) Slowly raise the variac’s voltage until the DMM measures 407 V
- h) When DC Link reaches ~600VDC
- i) Verify that the drive and the key pad turns on
- j) Verify no faults are present on the key pad
- k) Navigate to parameter P11.03 DC link voltage and verify it measures approximately 1100V
- l) Navigate to parameters P45.00, P45.01 and P45.02 and verify these temperatures read room temperature (between 20-25°C)

9.1.2 DC+ to Phase U



- a) Set parameter P2.01 to the value listed in the table below

Drive Model Number	Motor Voltage P2.01
MVDL643	92V
MVDL800	114V
MVDL1000	143V



- b) Press the “DC POS START” push button and verify the LED “DC POS CLOSED” is illuminated
- c) Press the “PHASE U START” push button and verify the LED “PHASE U CLOSED” is illuminated





COMMERCIAL IN CONFIDENCE

- d) Press run (RED BUTTON) on the keypad
- e) Verify that the drive trips and displays a fault, press  on the keypad and select option 2
- f) Verify that parameter P10.10 is fault code 31 for "Phase U over current fault"
- g) Press  on the keypad, and select option 3 to reset the fault
- h) Verify that the fault clears


9.1.3 DC+ to Phase V

- a) Press the "PHASE U STOP" push button and verify the LED "PHASE U CLOSED" turns off
- b) Press the "PHASE V START" push button and verify the LED "PHASE V CLOSED" is illuminated
- c) Press run on the keypad
- d) Verify that the drive trips and displays a fault, press  on the keypad and select option 2
- e) Verify that parameter P10.10 is fault code 33 for "Phase V over current fault"
- f) Press  on the keypad, and select option 3 to reset the fault
- g) Verify that the fault clears

9.1.4 DC+ to Phase W

- a) Press the "PHASE V STOP" push button and verify the LED "PHASE V CLOSED" turns off
- b) Press the "PHASE W START" push button and verify the LED "PHASE W CLOSED" is illuminated
- c) Press run on the keypad
- d) Verify that the drive trips and displays a fault, press  on the keypad and select option 2
- e) Verify that parameter P10.10 is fault code 35 for "Phase W over current fault"
- f) Press  on the keypad, and select option 3 to reset the fault
- g) Verify that the fault clears

9.1.5 DC- to Phase W

- a) Press the "DC POS STOP" push button and verify the LED "DC POS CLOSED" turns off
- b) Press the "DC NEG START" push button and verify the LED "DC NEG CLOSED" is illuminated
- c) Press run on the keypad
- d) Verify that the drive trips and displays a fault, press  on the keypad and select option 2


COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D



Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 11/17





COMMERCIAL IN CONFIDENCE

- e) Verify that parameter P10.10 is fault code 35 for "Phase W over current fault"
- f) Press  on the keypad, and select option 3 to reset the fault
- g) Verify that the fault clears

9.1.6 DC- to Phase V

- a) Press the "PHASE W STOP" push button and verify the LED "PHASE W CLOSED" turns off
- b) Press the "PHASE V START" push button and verify the LED "PHASE V CLOSED" is illuminated
- c) Press run on the keypad
- d) Verify that the drive trips and displays a fault, press  on the keypad and select option 2
- e) Verify that parameter P10.10 is fault code 33 for "Phase V over current fault"
- f) Press  on the keypad, and select option 3 to reset the fault
- g) Verify that the fault clears

9.1.7 DC- to Phase U

- a) Press the "PHASE V STOP" push button and verify the LED "PHASE V CLOSED" turns off
- b) Press the "PHASE U START" push button and verify the LED "PHASE U CLOSED" is illuminated
- c) Press run on the keypad
- d) Verify that the drive trips and displays a fault, press  on the keypad and select option 2
- e) Verify that parameter P10.10 is fault code 31 for "Phase U over current fault"
- f) Press  on the keypad, and select option 3 to reset the fault
- g) Verify that the fault clears

9.2 FAST SHORT CIRCUIT TESTS

CAUTION: Tests require voltages up to 874VAC & 1170 VDC appropriate PPE is to be worn

These tests use a contactor to bypass the short circuit inductor used in section 9.1. Enter pass/fail in the LCD Transistor Module Test Certificate

9.2.1 DC+ to Phase U

- a) Press the "DC NEG STOP" push button and verify the LED "DC NEG CLOSED" turns off
- b) Press the "DC POS START" push button and verify the LED "DC POS CLOSED" is illuminated

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 12/17



COMMERCIAL IN CONFIDENCE

- c) Press the "SHORT BYPASS START" push button on the LCD section of the operator station and verify the LED "LCD BYPASS CLOSED" is illuminated
- d) Follow the procedure listed in section 9.1.2

9.2.2 DC+ to Phase V

- a) Follow the procedure listed in section 9.1.3

9.2.3 DC+ to Phase W

- a) Follow the procedure listed in section 9.1.4

9.2.4 DC- to Phase W

- a) Follow the procedure listed in section 9.1.5

9.2.5 DC- to Phase V

- a) Follow the procedure listed in section 9.1.6


9.2.6 DC- to Phase U

- a) Follow the procedure listed in section 9.1.7
- b) Hit stop to all
- c) Turn the "Power source" selector switch to 690V. Drive turns off. Wait 2 minutes
- d) Increase the variac's voltage until it reads 460V on the DMM

10. OVER TEMPERATURE TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.13)

CAUTION: Tests require voltages up to 759VAC & 1060VDC appropriate PPE is to be worn

CAUTION: Test requires Drive to Operate at 100% FLC and Trip on Over Temperature, components can be at 95°C or greater

- a) Close Circuit breaker -03Q5 on drive
- b) Navigate to parameter P11.03 DC link voltage and verify it measures approximately 960V
- c) Navigate to P1.02 and press run on the keypad
- d) Wait 10 seconds for the drive to reach 60Hz and verify that the current feedback is +/- 5% of the Delta's current rating
- e) Navigate to P11.05 "Hottest SkiiP Reading" and start the stopwatch when the reading reaches 40 Deg. C
- f) Measure the time taken for the drive to trip and record in the test certificate
- g) Turn the "PUMP" selector switch to "ON"
- h) Verify that the keypad displays a trip and press  on the keypad and select option 2

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 13/17



COMMERCIAL IN CONFIDENCE

- i) Verify that parameter P10.10 is fault code 6 "Temperature Fault", and no other Faults present.
- j) Navigate to parameter P45.22 and verify it is "1" for over temperature
- k) Navigate to parameter P45.23 and see which phase caused the fault and record in certificate
 - A "3" = phase U delta 1
 - A "4" = phase V delta 1
 - A "5" = phase W delta 1
- l) Monitor parameters P45.00, P45.01 and P45.02 and allow the pump to run until the three temperatures measure ambient
- m) Reset Drive

11. INDUCTIVE LOAD TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.14)

CAUTION: Tests require voltages up to 759VAC & 1024VDC appropriate PPE is to be worn

CAUTION: Test requires Drive to Operate at 110% FLC

- a) Use a thermometer to measure ambient temperature

NOTE: Continuous operation in overload is achieved by setting development parameter D1522 = 1.

Set P99.06 = 3511 and P99.09 = 6329 to make the D-Tables available.

- b) Set parameter P2.01 and P35 to the value in the table below

Drive Model Number	Motor Voltage P2.01	110% FLC	P35 (FREQ)
MVDL643	100V	707 A _{RMS}	1.25KHz
MVDL800	125V	880A _{RMS}	2.5KHz
MVDL1000	155V	1100A _{RMS}	2.5KHz

- c) Verify that the pump is still running from the previous test
- d) Navigate to parameter P1.02 and press run on the key pad. Drive will go into warning with excessive current
- e) Wait 10 seconds for the drive to get up to speed
- f) Start Stop watch
- g) Verify the current measured is the value in the above table +/- 5%

*Note: Parameter P2.01 is set assuming inductance is only present in the load reactor and excludes cable inductance. Parameter P2.01 might need to be adjusted to account for the extra inductance added by the cable length. Adjust responsibly (I.E. A few volts per adjustment). If the unit under test starts to decrease in frequency, then the voltage entered into P2.01 is too high.

- h) Navigate to P1.04 and verify the motor volts is the value specified in the table above
- i) Let the drive run at 110% FLC for 10 minutes
- j) Record the following values in the LCD Transistor Module Test Certificate
 - i) Ambient Temperature

COMMERCIAL IN CONFIDENCE

Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 14/17



COMMERCIAL IN CONFIDENCE

- ii) P45.00
- iii) P45.01
- iv) P45.02
- v) P1.02
- vi) P11.03
- vii) Record Coolant Temps IN and OUT on Test Certificate
- viii) Record Time for Overtemperature on Test Certificate

The unit is considered to have passed the test if:

- (U Phase Temperature) – (V Phase Temperature) = range -6.5°C to +11.5°C
- (V Phase Temperature) – (W Phase Temperature) = range -6.5°C to +11.5°C
- The temperature rise of the hottest SkiiP above water inlet temperature should be in the range shown in the table 7.5

Temperature Rise for Drive sizes

Drive Type	Temperature rise above inlet water temperature at 2.5kHz switching frequency
MVDL643	13°C to 23°C
MVDL800	14°C to 31°C
MVDL1000	18°C to 37°C

If the unit fails this test, i.e. it trips before the test is complete, record the time to trip and the fault code. Investigate and fix the fault.

- k) Press stop on the keypad
- l) Let pumps run for ~15 minutes
- m) Switch “Main Power” switch to off
- n) Turn all selector switches to “OFF” on the operator station
- o) Wind down variac
- p) Open 03Q1 (Variac Disconnect on door of Test Rig) and 03Q5 (690V Disconnect on door of Test Rig)
- q) Voltage should be measured with appropriate test equipment. Verify the DC link reaches 0V on MVDL DC Link meter
- r) Disconnect all power cabling from the transistor module
- s) Disconnect cooling system
- t) Drain Delta. Take Delta out of enclosure

12. MEGGER TEST (Ref. Test Specification MVDL 643-4701/TS Section 7.15)

Connect the following to the module earth and the Megger ground probe:

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Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 15/17



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All pins of PL1 and PL3 on 20X4381

Or all pins of PL1 and PL3 on 20X4384

Connect DC+, DC-, A, B, and C power connections together, and to the high voltage probe of the Megger.

Test at 1kV for 30 seconds. Delta passes if greater than 600MΩ. Record the results in the test certificate.

*If the module passes ALL tests mentioned above, get drive ready for shipping and sign the LCD Transistor Module Test Certificate as well as filling out the appropriate work complete paper work

-END OF TEST-

13. DISCREPANCY LOG

14. ACRONYMS AND ABBREVIATIONS

LCD	<u>L</u> iquid <u>C</u> ooled <u>D</u> elta
SKiiP	<u>S</u> emikron <u>i</u> ntegrated <u>i</u> ntelligent <u>P</u> ower (IGBT modules)
SMPS	<u>S</u> witch <u>M</u> ode <u>P</u> ower <u>S</u> upply
CDC	<u>C</u> ommon <u>D</u> rive <u>C</u> ontroller
DMM	<u>D</u> igital <u>M</u> ulti <u>M</u> eter
DIB	<u>D</u> elta <u>I</u> nterface <u>B</u> oard
UUT	<u>U</u> nit <u>U</u> nder <u>T</u> est
DDM	<u>D</u> rive <u>D</u> ata <u>M</u> anager

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Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 16/17



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15. MODIFICATION RECORD

Version	Date	Author	Details
Ar1	22 Jun 10	Patrick Walter	Updated per new process
Ar2	27 Aug 10	Patrick Walter	Updated per new process
A	25 Oct 11	Patrick Walter	Updated per new process
B	20 Feb 14	Russ Steder	Edited per initial design review
C	19 Mar 15	Chris Florenz	Initial issue for review
D	25 Apr 15	Chris Florenz	Update per review
E	17 Jan 17	Jeff Barton	Update for Louisville Site / Richard Payne

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Customer : LIQUID COOLED DELTA
Project : REPAIRED TRANSISTOR MODULE
Document: TEST PROCEDURE
File : USEX000019 / LCD Transistor Module Test Instructions D

Ref : V1P1C1S101
Version : 2.0
Date : 19 Mar 15
Page : 17/17