

Responsible division : PPC	Responsible unit : SET	Document type : Inspection/test instruction	Confidentiality status : Public	BOMBARDIER
Prepared : 2017-02-16 E Westrin	Title : Mitrac CM-C 1500 (ACM) Routine test instruction Customer test	Document state : Released	3EST000235-5976	
Checked : 2017-02-16 A-L Bergroth				
Approved : 2017-02-16 H-E Skalberg	File name : 3EST000235-5976_..doc	Revision : _	Language : en	Pages : 1/22

Reference Documents

Item	Document	Reg. No.
A	Fault finding instruction	3EST000235-5973
B	Product description ACM	3EST000235-5801
C	Maintenance instruction, ACM	3EST000235-5805
D	Technical description Customer Test Rack	3EST 93-196
E	User Manual DCUTerm	3EST000210-1000
F	Fault finding instruction for Routine test	3EST000235-5979
G	Setup files for converter test (see Propulsion Software CD, 3EST000235- 6333)	3EST000218-6311

Tests

No.	Test	Test equipment
1	I/O Test	2, 3, 4, 5, 6
2	Line trip test	3, 4, 5, 6
3	Fibre optical cable test	3, 4, 5, 6
4	Load Test	1, 3, 4, 5, 6

Test Equipment

No.	Designation/Data	Reg. No.	Qty.
1	Multimeter		2
2	Thermometer		1
3	Ethernet cable M12 to RJ45	3EST000212-3094	1
4	Testing rack	3EST 101-860	1
5	PC (min OS Windows XP), 1 Serial RS232 port (internal or with USB adapter), 1 Ethernet port		1
6	Testing device cables	3EST 000209-3171	1
7	Optical power meter	3EST 68-567	1
8	DCUTerm software	3EST000202-9542	-

TABLE OF CONTENTS

1 Description.....	3
1.1 Auxiliary converter module.....	3
1.2 Test equipment	3
1.2.1 General information	3
1.2.2 Description of automatic tests	4
1.3 Test rack	4
1.3.1 Front display	5
1.4 DCUTerm	9
1.5 Connection of the auxiliary converter module.....	10
1.6 General for automatic tests.....	13
2 Safety Recommendations.....	14
2.1 Static electricity	14
2.2 Working with Test rack connected 110 V DC	14
3 I/O Test	15
3.1 Temperature test.....	15
3.2 MVB	15
3.3 Digital I/O signals	16
4 Line trip test.....	17
4.1 General	17
4.2 Line trip test.....	17
5 Fibre optical cable test.....	18
General information	18
Preparations	18
Performing test	18
6 Load Test.....	21
6.1 General information	21
6.2 Load test	21

1 Description

1.1 Auxiliary converter module

The ACM is a complete converter module connected directly to the DC-link voltage. The ACM includes all the necessary control electronics. The control electronics are supplied from the battery system via the power supply.

The system voltage applied to the converter is 1500VDC.

For supervision and control, the ACM measures temperatures, currents and voltages.

Mechanically, the ACM consists of the following parts: the drive control unit containing DCU, DC/DC converter and a connection box, the gate drive unit containing GDU and voltage transformer and the heat sink unit containing IGBT modules and heat sink.

The ACM is designed as an air-cooled module to be mounted in a box. The cooling equipment is shared with other components in the box.

The control signals to the IGBTs are transmitted by optical cables from the computer to the Gate Drive Unit (GDU) which switch the IGBTs on and off.

The ACM communicates with the vehicle computer (VCU) via the Multifunctional Vehicle Bus (MVB).

The converter box is mounted under the vehicle.

A detailed description of the module is given in the product description of the auxiliary converter module (listed on the first page under “reference documents”).

1.2 Test equipment

1.2.1 General information

Testing is performed using a Test rack and a PC connected to the converter module. During the test the converter module is dismounted from the vehicle and placed on a workbench. The converter module is not cooled during the test. A detailed description of the dismounting and mounting of the converter module is given in the maintenance manual.

The PC communicates directly with the control computer (DCU) of the converter module.

DCUTerm is the test programme that is used to test converter modules. The programme runs in a Windows environment.

The control voltage and main supply can be checked via a volt meter. DC-link charging is ordered via the RS232 communication from the converter module DCU and no manual charging operation is possible.

The Test rack is the same for both types of modules: Auxiliary converter module (ACM) and Motor converter module (MCM).

	Language : en	Revision : _____	Page : 4	3EST000235-5976
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1.2.2 Description of automatic tests

Most testing and evaluation is performed automatically via a test program in the converter module DCU.

The status of the charging contactor, line circuit breaker (line contactor) and the DC-link voltage can be seen on the Test rack. There are test sockets for phase currents and line current on the Test rack. These are measured using a multimeter.

In case of any faults, the fault finding instructions according to the document list on first page should be used.

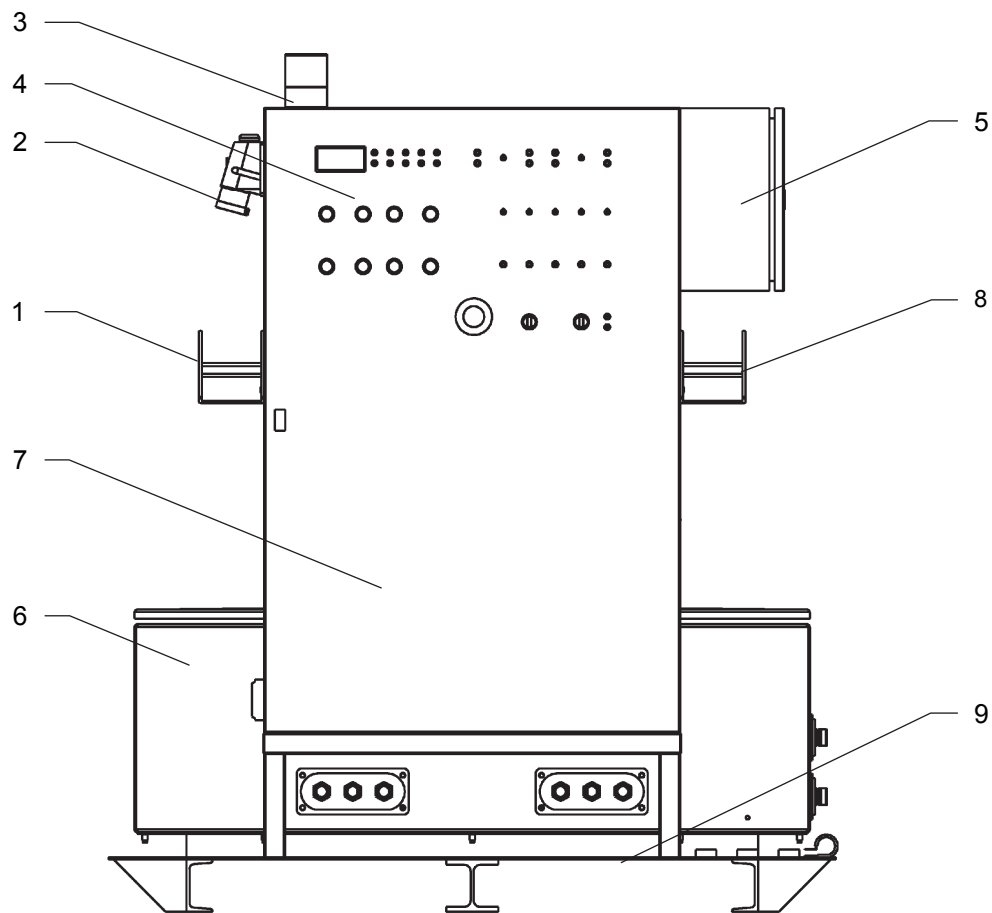
To facilitate fault finding, there are a number of test functions where the converter module can be operated so that manual checks can be performed via external measuring devices.

1.3 Test rack

The Test rack is mounted on a platform and consists of two parts, the cubicle at the front and the equipment case at the rear where the three phase transformer, load inductors and current shunts are mounted.

There is a display panel on the front of the cubicle where all manoeuvres and measurements are performed.

There is no forced cooling and the Test rack is cooled by self-convection.



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- | | |
|--|---|
| 1. Holder for signal cables to converter | 2. Power supply connection to test rack |
| 3. Warning light | 4. Front display |
| 5. Locker | 6. Equipment case |
| 7. Cubicle | 8. Holder for power cables to converter |
| 9. Platform | |

Figure 1 Customer test rack

1.3.1 Front display

When the front cover has been unlocked and opened all the components are easily accessible.

The figures below show the positions of various details on the Test rack. The explanation to the position numbers are listed after these two illustrations.

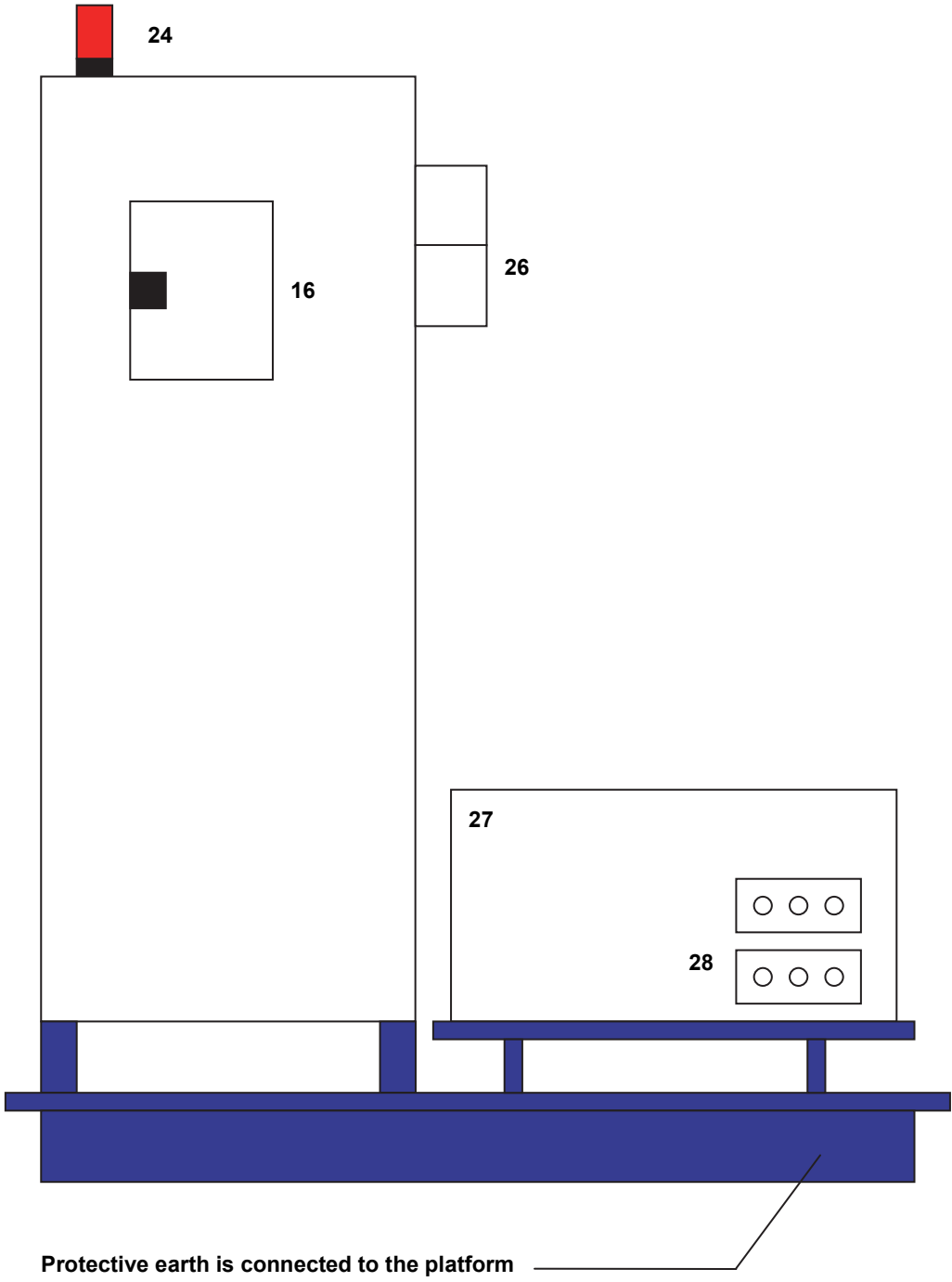


Figure 3 Test rack viewed from the right

Position	Description
1	Supply voltage connection to the Test rack (3 x 400 V / 50 Hz). NOTE: A 16 A cable plug (female) to fit the voltage connection socket is delivered with the Test rack.
2	Signal cables to the converter
3	Supply voltage; Green = on, Red = off.
4	Main contactor; Green = on, Red = off.
5	Charging contactor; Green = on, Red = off.
6	Line contactor; Green = on, Red = off.
7	Emergency shut-down button
8	Manual discharge knob (sprung); hold in place for at least 2 seconds at discharge.
9	AC simulator knob and status indication; supplies the converter with 25 V _{RMS} from the socket connector on the Test rack's front.
10	Line trip indication; Red = on, Unlit = off. NOTE! The converter cannot be used when line trip is on.
11	Switch S1; supplies 110 V _{DC} ; free (not used)
12	Switch S2; supplies 110 V _{DC} ; free (not used)
13	Switch S3; supplies 110 V _{DC} ; free (not used)
14	Switch S4; tests the LCM's "Earth Fault" by breaking the 24 V loop.
15	Switch S5; supplies 110 V _{DC} to the modules "Traction Safe" input.
16	Locker for load and chopper cables. NOTE! The door must be closed.
17	Speed simulator; switch S6 and S7 supplies 1000, 500, 250 and 125 Hz into the control computer; NOTE! Only applicable for Motor converter module (MCM); when the 2 green LEDs are lit it confirms that the supply unit in the converter module has supplied the DCU with the required voltage. If there is a problem with the supply, the two red LEDs are lit.
18	Output for measuring the DC link current, IDC
19	Output for measuring the phase current U/1U
20	Output for measuring the phase current V/2U
21	Output for measuring the phase current W/1V
22	Output for measuring the phase current 2V
23	DC link voltage display
24	Warning light - flashes when power to the converter is switched on.
25	Cubicle lock; must always be locked during testing.
26	Brake resistors (only used when testing modules with overvoltage chopper function)
27	Equipment case containing three phase transformer and the four load inductors. NOTE! Must be closed during tests.
28	Output cable lugs ; DC+/DC-, chopper and load

Table 1 Display and Test rack descriptions

1.4 DCUTerm

DCUTerm is the test program that is used to test the auxiliary converter module. The program runs in a Windows environment.

To be able to run the DCUTerm, the setup files (.txt and .dts) must be installed on the computer. These files are required to ensure functionality of bottom line buttons and left side menu items.

Information on how to configure DCUTerm is found in the DCUTerm user manual.

Tests to run are selected from the left side menu, first select “ACM test” and then the desired sub-test sorted under the “ACM test”, much like the tree structure in MS windows explorer.

When the desired test is selected, press “Start test” to commence testing.

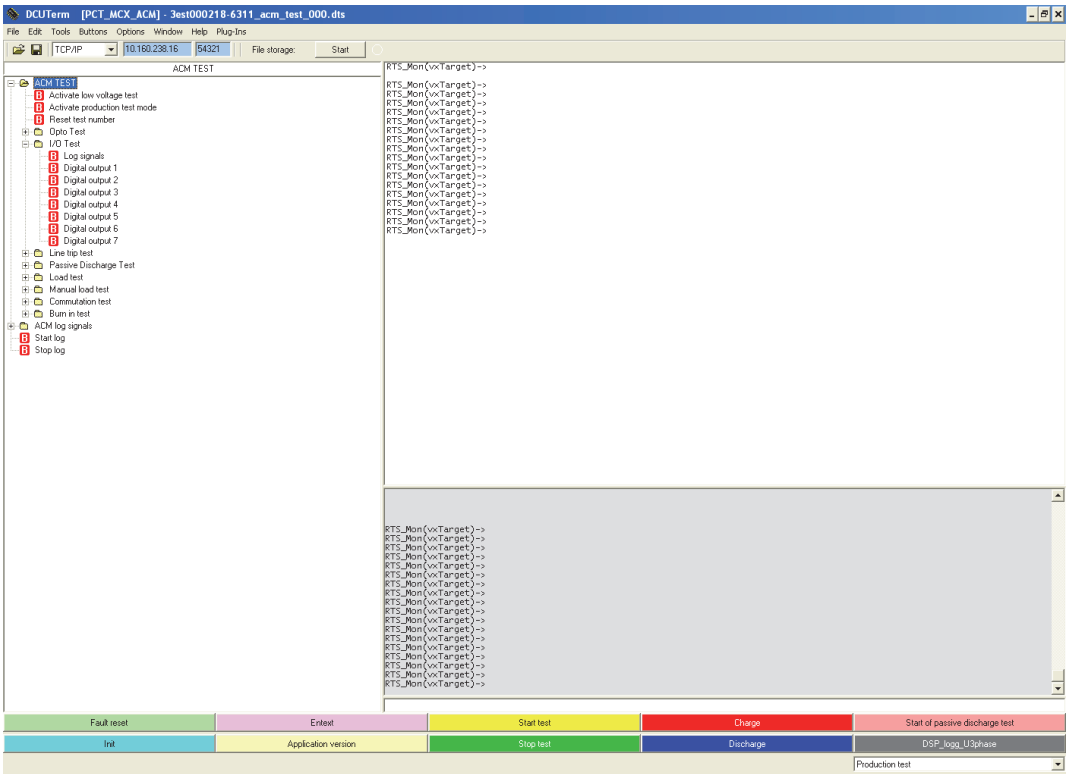


Figure 4 Main menu, DCUTerm

To log signals with fast log you can add those by clicking on “ACM log signals” and then expand the signal name that you want to add and click on right button on the mouse and select “Add to fast log”, see Figure 5.

Then choose ”Start log” to begin log or “Stop log”.

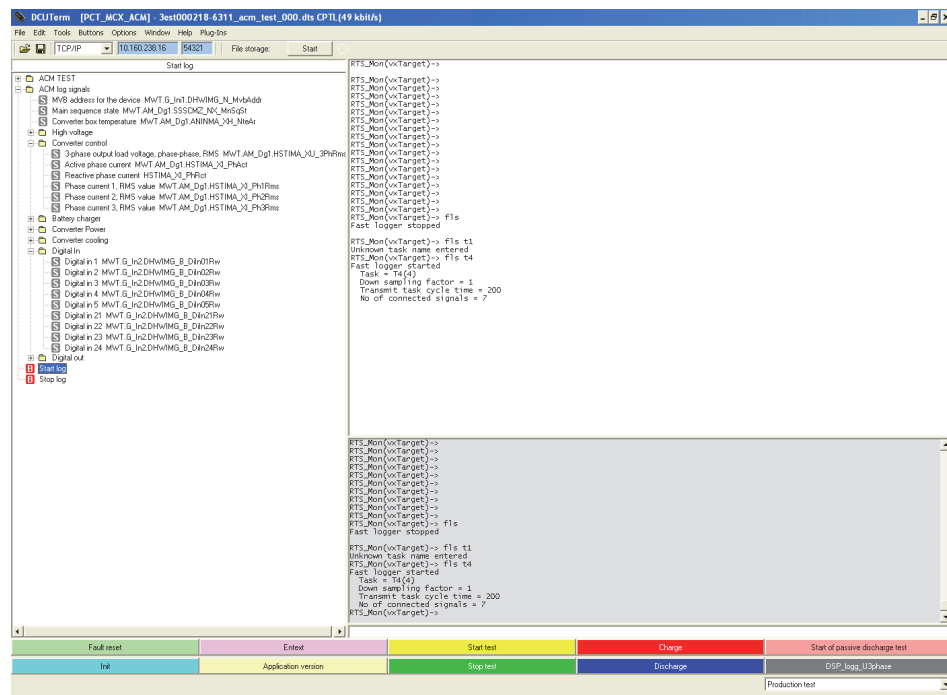


Figure 5 Example of adding signals with fast log

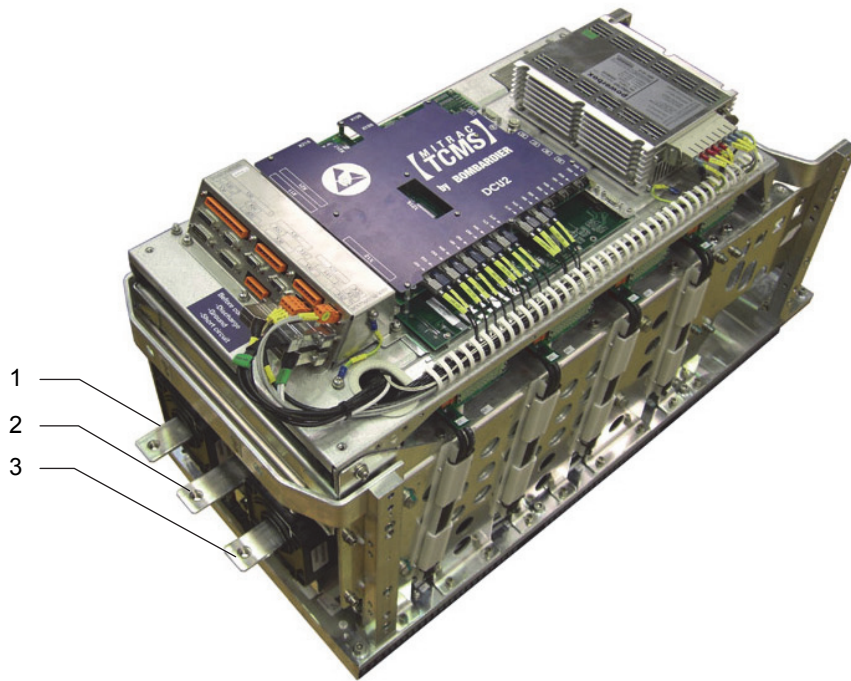
1.5 Connection of the auxiliary converter module

N.B. The testing cable unit is divided in two parts, cables which are marked MCM and cables marked ACM. Check that right cables are used and that connectors on not used cables are not in contact with the module.

Connect the following cabling:

- Test cable 3EST000209-3171 from X10 on the Test rack to X3, and X4 on the auxiliary converter module, see Figure 6 .
- Communication cable from COM1 on the PC to X3 on the Control computer (DCU/A), see Figure 8.
- DC+ and DC- to the DC-link capacitor on the auxiliary converter module, see Figure 7.
- Address plug ACM to X38 at the module.
- Protective earth to the earth point on the auxiliary converter module chassis

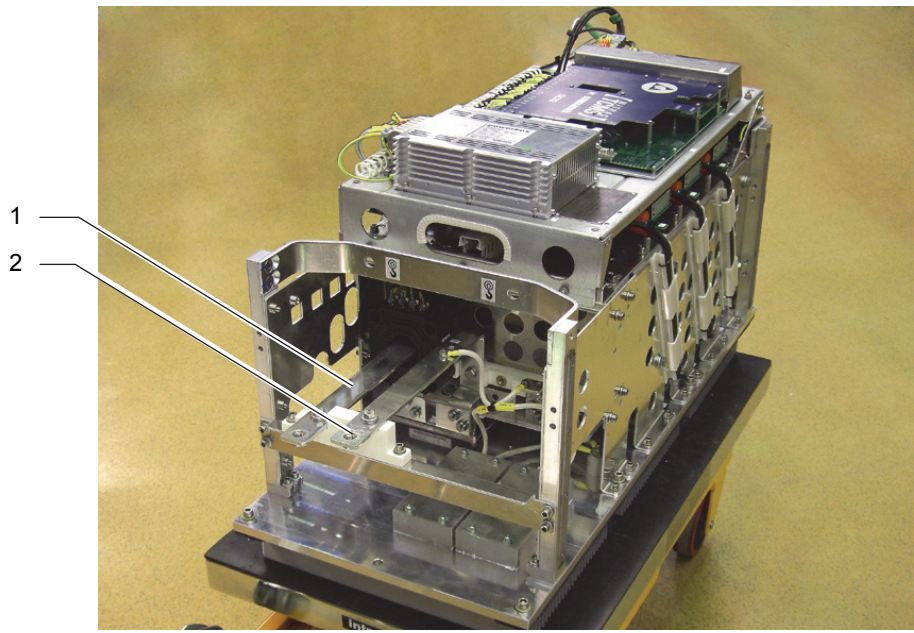
Leave the phase cables (designated as "U 1U", "V 2U", "W 1V", and "2V") still in the storage place at the side of the Test rack, see document 3EST 93-196. They will be connected later, as they disturb the "Fibre optic cable test".



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1. Phase U
2. Phase V
3. Phase W

Figure 6 Connections on the front of the ACM.

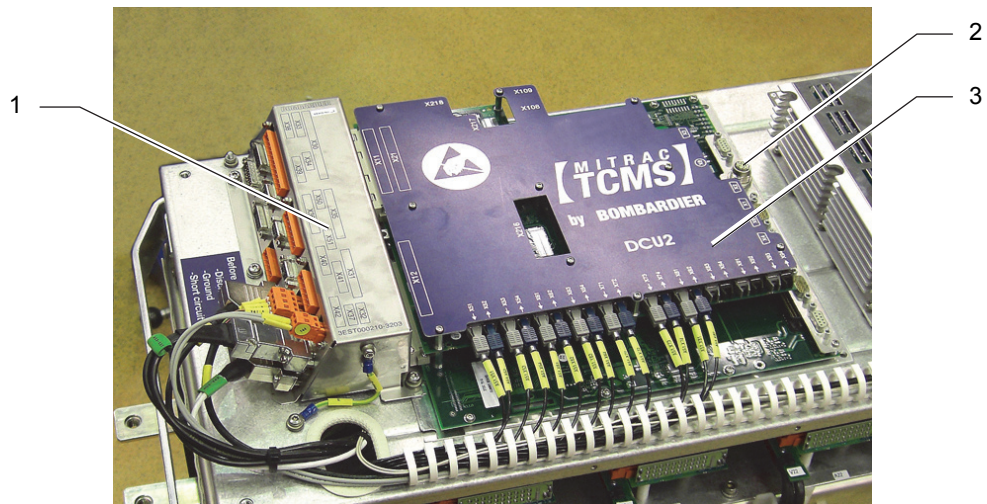


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1. DC+

2. DC-

Figure 7 Connections on the DC side of the ACM



3EST000260-1900

1. Connection box, all connections marked

2. Ethernet connection marked

3. DCU2, all connections well marked

Figure 8 Connections on the DCU and connection box

	Language : en	Revision : _____	Page : 13	3EST000235-5976
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1.6 General for automatic tests

1. Push "Supply voltage" button (Pos 3) on the Test rack and check that the Control computer is supplied with voltage (POW and OK LED's must lit).
2. Start DCUTerm on the PC connected to the DCU/A.
3. Click on the + sign beside "ACM test" to expand the section with the sub tests.
4. Double-click on "Activate low voltage test mode". Check on the PC-monitor that the commands are executed (text in the main window of DCUTerm).

2 Safety Recommendations

2.1 Static electricity



CAUTION – Static electricity

This component, or a component close to it, is ESD-sensitive. Static electricity can seriously damage circuit boards. Proceed as follows in order to avoid such damage:

1. Always keep the component in an ESD-protective package made of semi conducting plastics when handling these components as separate units.
 2. Always use an earthed wrist strap when handling these components.
 3. Always discharge the protective packaging at a well earthed point before the component is removed from or returned to the protective packaging.
 4. Always discharge yourself at a well-earthed point immediately before touching the component.
 5. Avoid touching contact pins and cable channels.
 6. Ensure that IGBT modules' gate and emitter are short-circuited all the time they are not connected in position.
-

2.2 Working with Test rack connected 110 V DC



CAUTION – Low test voltage 110 V DC

When a converter module is connected to the Test rack 110 V DC it is connected to the power circuits in the module during testing. To prevent accidents follow these instructions:

1. Extreme caution must be exercised during fault finding and testing activities.
 2. No unnecessary metallic objects (e.g. watch) should be introduced into the converter module.
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	Language : en	Revision : _____	Page : 15	3EST000235-5976
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3 I/O Test

Read through the Safety Recommendations in section 2 thoroughly, before commencing testing.

Preparations:

Set S5 to “ON” on the test rack (Pos 15).

3.1 Temperature test

This test checks that temperature sensors and cabling are working.

1. Don't forget to double-click on “Activate low voltage test” in DCUTerm.
2. Select “ACM log signals” in DCUTerm.
3. Click right button on mouse to add fast log signals – Temperature:
 - Transformer temperature - Transformer temperature
MWT.AM_Dg1.ANINMA_XH_Tf
 - Internal air temperature - Converter box temperature
MWT.AMX_Sv4.ANINMA_XH_Ai05
4. Check that Transformer temperature is 110 ± 5 °C
5. Check that Converter box temperature is environmental temperature ± 5 °C

3.2 MVB

This test checks that the MVB addressing is working in the control computer.

1. Select “ACM log signals” in DCUTerm.
2. Click right button on mouse to add fast log signal – MVB Address” to start logging:
 - MVB address - MVB address for the device
MWT.G_Ini1.DHWIMG_N_MvbAddr
3. Check that MVB is 81 dec- > 51 Hex”.

3.3 Digital I/O signals

This test checks that the digital I/O is functioning properly:

1. Select "I/O test" in DCUTerm
2. Double click on "Log Signals".
3. Double-click on "Digital output 4" and click on "Start".
4. Check that the green indication lamp corresponding to the "Charging contactor" on the Test rack become lit and that GHWIDI1 MWT.G_In2.DHWIMG_B_DiIn01Rw Digital in 1 becomes "1"
5. Click on "Stop" and check that the green indication lamp on the Test rack corresponding to the "Charging contactor" is turned off and that the red indication lamp become lit and that GHWIDI1 MWT.G_In2.DHWIMG_B_DiIn01Rw Digital in 1 becomes "0"
6. Double-click on "Digital output 5" and click on "Start".
7. Check that the green indication lamp corresponding to the "Line contactor" on the Test rack become lit and that GHWIDI2 MWT.G_In2.DHWIMG_B_DiIn02Rw Digital in 2 becomes "1"
8. Click on "Stop" and check that the green indication lamp on the Test rack corresponding to the "Line contactor" is turned off and that the red indication lamp become lit and that GHWIDI2 MWT.G_In2.DHWIMG_B_DiIn02Rw Digital in 2 becomes "0"

4 Line trip test

Read through the Safety Recommendations in section 2 thoroughly, before commencing testing.

4.1 General

This test closes the line trip relay on the DCU/A.

4.2 Line trip test

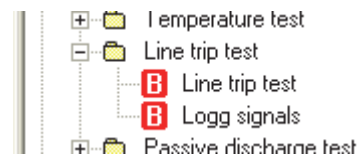


Figure 9 Menu in DCUTerm – Line strip test

1. Select “Line trip test” in DCUTerm.
2. Double-click on "Line trip test" and click on "Start".
3. Check that indication lamp corresponding to the “Line trip” on the Test rack becomes lit.
4. Click on "Stop" and check indication lamp corresponding to “Line trip” on the Test rack is turned off.

5 Fibre optical cable test

Read through the Safety Recommendations in section 2 thoroughly, before commencing testing.



CAUTION - To avoid damaging the optic cable proceed as follows:

Do not bend the optical cable. Minimum bending radius: 50 mm. When disconnecting or connecting the optical cable never pull or push on the cable itself. Always hold the black connector at the end of the cable.



CAUTION - Note:

As the gate drive units generate 24±5V on the DC-link, short-circuiting of the DC-link can result in material damage.

General information

In this test, light pulses are sent out on a selected fibre optic cable at a time with an optic cable tester. The wavelength (λ) shall be 630 nm.

Preparations

Mount the optic cables as stated below:

- 138(X51), 140(X53), 153(X61), 155(X63), 168(X71), 170(X73) **shall** be connected to the DCU but **not** connected to the GDU's.
- 139(X52), 141(X54), 154(X62), 156(X64), 169(X72), 171(X74) **shall** be connected to the GDU's but **not** connected to the DCU.

Performing test

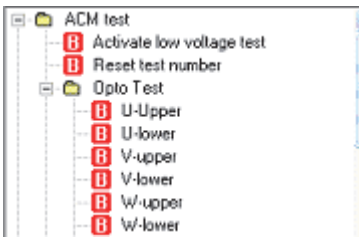


Figure 10 Part of menu, optical cable test

	Language : en	Revision : _____	Page : 19	3EST000235-5976
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1. Select: "Activate low voltage test" mode
2. Select "Optical fiber test"

Control signal

1. Select sub-test "U-upper" and click "Start".
2. Mount the receiver on optic cable 138 (phase U-upper pos .10) at the GDU end.
3. Check that the signal level is > -6 dBm.
4. Mount optic cable 138 on the GDU and check that the green LED on the GDU starts flashing.
5. Check that the corresponding feedback light signal at the DCU no longer exists, see Table 2 below.
6. Click "Stop" after each completed sub-test.

Feedback signal

1. Mount the receiver on optic cable 139 at the DCU end.
2. Check that the signal level is > -6 dBm.
3. Mount optic cable 139 to connector X52 on the DCU.

Control signal

1. Select sub-test "U-lower" and click "Start".
2. Mount the receiver on optic cable 140 (phase U-lower pos .10.6) at the GDU end.
3. Check that the signal level is > -6 dBm.
4. Mount optic cable 140 on the GDU and check that the green LED on the GDU starts flashing.
5. Check that the corresponding feedback light signal at the DCU no longer exists, see Table 2 below.
6. Click "Stop" after each completed sub-test.

Feedback signal

1. Mount the receiver on optic cable 141 at the DCU end.
2. Check that the signal level is > -6 dBm.
3. Mount optic cable 141 to the DCU connector X54.
4. Continue according to Table 2 below.

Cable	Phase	Connector	Signal type
153	V _{upper} .10.11	X61	Control
154	V _{upper} .10.11	X62	Feedback
155	V _{lower} .10.7	X63	Control
156	V _{lower} .10.7	X64	Feedback
168	W _{upper} .10.13	X71	Control
169	W _{upper} .10.13	X72	Feedback
170	W _{lower} .10.9	X73	Control
171	W _{lower} .10.9	X74	Feedback

Table 2 When all criteria are met, the test is completed.

6 Load Test

Read through the Safety Recommendations in section 2 thoroughly, before commencing testing.



CAUTION - Note!

If running this test repeatedly make sure not to overheat the IGBTs. This applies if no forced cooling is present.

6.1 General information

In this test the DC-link is charged to 110 V and a low DC current, 70 ± 10 A, is commutated through diagonal U-V and V-U for 2 seconds each, when the current sensor is checked. Then 160 ± 15 A is commutated through one diagonal at a time for 5 seconds in order to check the phases and current connections.

6.2 Load test

The following applies when measuring on the Test rack's test socket:
5 A corresponds to 1 mV.

Connect one multimeter to terminal U and another multimeter to terminal V on the Test rack.

When the test is running, check that the currents indicated on the multimeter and the currents in DCUTerm have the same direction and size.

1. Make sure that the supply voltage to the converter is turned off.
2. Connect the load cables to the converter terminals:

Cable marking	Converter terminal
U / 1U	U2
V / 2U	V2
W / 1V	W2

3. Apply the supply voltage by pushing the "Supply voltage" button (Pos 3) on Test rack.
4. Press the "Main contactor" on (Pos 4).
5. Select sub-test "Load test".

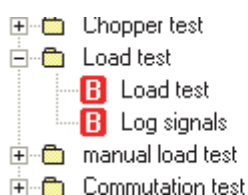


Figure 11 Menu in DCUTerm – Load test

	Language : en	Revision : _____	Page : 22	3EST000235-5976
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6. Click on button “Logg signals” to log signals.
7. Double-click on “Load test” and click on “Charge” in DCUTerm.
8. Check that the DC-link voltage rises to $110\pm 10V$.
9. Click on “Start” in DCUTerm.
10. If the test is OK, text below will be displayed:
 - Positive current
 - Low load test OK
 - High load test is selected
 - Positive current
 - High load test POA1 – POA3 ready
 - Positive current
 - High load test POA1 – POA2 ready
 - Positive current
 - Low load test is selected
 - High load test OK
 - PCT OK
 - Positive current
11. Select “Discharge” in DCUTerm and check that the line circuit breaker goes off.
12. Press the “Main contactor” off (Pos 4).
13. Turn “Discharge” switch on the Test rack.