PHILIPS

SPD

Service Procedure Document
Gradient amplifier Copley 274

PROPRIETARY NOTICE

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Section Gradient amplifier Copley 274

Contents

1 INTRODUCTION

NOTE

*The new systems Intera **Power** and Intera **Master** are the successors of NT PT3000 and NT PT6000 respectively. Be aware of the name Intera **MASTER** being very confusing, since we have a **master** gradient cabinet and a **slave** gradient cabinet in that system. Furthermore there is a **master** DC power supply and a **slave** DC power supply within each Copley 274 cabinet.*

WARNING

Be aware of the high voltage (420 Volt) present inside the gradient amplifier cabinet(s), on the connections at the gradient coil and in the system filter box. Make sure that the AC power has been switched off for at least 2 minutes before starting to work on the gradient chain. It is advised to watch the high voltage value on the EMI 20kW/420V DC power supply meters and make sure that the supply capacitors have discharge to less than 2 Volt.

1.1 CONFIGURATION OF THE GRADIENT AMPLIFIER CABINETS

PT1000A, PT3000 and Intera POWER:
The gradient system of a PT1000A, PT3000 and Intera POWER consists of one cabinet (a master cabinet).
This PT1000A, PT3000 or Intera POWER master cabinet contains:

- The gradient interface cabinet (DI) with:
  - The gradient interface controller (mother and daughter board)
  - 3 waveform generator WFG/ECC 2 boards
- 3 Copley 274 axis amplifiers;
- A power distribution unit (PDU);
- Two parallel switched EMI 20 kW/420 V DC power supplies (a master and a slave DC power supply).

PT6000 and Intera MASTER:
The gradient system of a PT6000 and Intera MASTER consists of two cabinets: a master cabinet and a slave cabinet.
This PT6000 or Intera MASTER master cabinet contains:

- The gradient interface cabinet (DI) with:
  - the gradient interface controller (mother and daughter board)
  - the 3 waveform generator WFG/ECC 2 boards
  - the interconnection board (master slave connection)
- 3 Copley 274 axis amplifiers;
- A power distribution unit (PDU);
- Two parallel switched EMI 20 kW/420 V DC power supplies (a master and a slave DC power supply).

The slave gradient cabinet has the same configuration as the master cabinet but does not contain a gradient interface cabinet.

Gradient coils:
The PT1000A uses the air-cooled gradient coil.
The systems PT 3000, Intera Power, PT6000 and Intera Master all use the same water-cooled gradient coil.

2 PROGRAMMING

2.1 BEFORE SWITCHING ON

Before switching on the cabinet(s) first check all DIP switches and jumper settings:

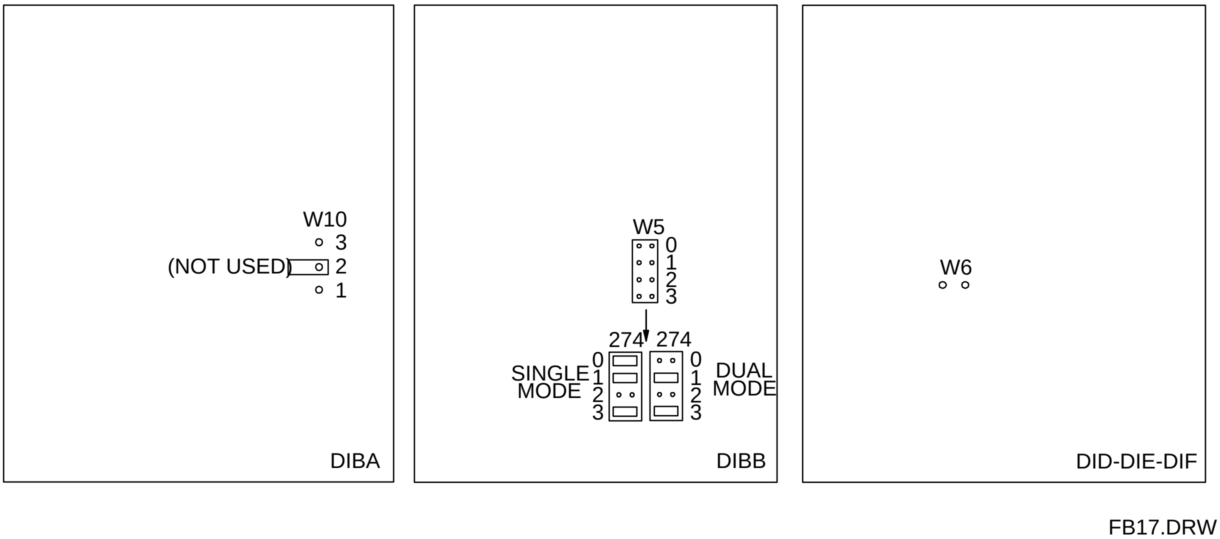
1. The DIP switch settings of the power modules and the controllers.
   See Table 1, Table 2, Table 3 and Table 4. The power module DIP switches are accessible from the rear of the cabinets. For the location of the DIP switches see Figure 2.
2. The jumper setting of the gradient interface controller (DIBA/DIBB).
   See Figure 1.
   For the Copley 274 jumper W10 is not required: the clock signal is directly connected from the gradient interface controller daughter board to the Copley controller via a separate coaxial cable. The clock signal does not go through the gradient interface controller mother board and waveform boards, as with the Copley 234 gradient amplfiers.
   If the jumper is accidentally installed, it can generate signal interference, which can affect the image quality.
3. For all system configurations with a Copley 274 gradient amplifier, the jumper W6 on all three WFG/ECC2 boards (DID/DIE/DIF) is not installed.
   See Figure 1.

Notice that every controller inside a Copley 274 axis has a set of '1' and a set of '2' potentiometers.
The set of '1' potentiometers is used in PT3000 and Intera POWER systems.
The set of '2' potentiometers is used in PT1000A, PT6000 and Intera MASTER systems.

These potentiometer sets are selected with the DIP switches ‘M1’ and ‘M0’ on each controller.
These different potentiometer sets are necessary, because of the difference in gradient coil load (one or two coil-halves).

A PT1000A system uses an air-cooled gradient coil, of which the load is only slightly different from one half of a water-cooled gradient coil. This is the reason that PT1000A systems use the set of '2' potentiometers.

Figure 1 - Jumper settings of the gradient interface boards



4. The gradient system interconnections are tightened properly.
5. The grounding straps of the side panels and doors of the cabinets have been checked.
6. All power module fan assemblies are properly mounted.
7. The rear door(s) are closed. Notice the door switch in the upper right corner of the cabinet. It should be pushed inwards properly. If you want to operate the gradient amplifier with opened doors or without doors, for troubleshooting, you have to pull the switch pin outwards.

CAUTION

Before switching on the cabinets, all magnet covers must be mounted, the water-cooling must be operational, and the temperature sensor on the gradient coil must be connected.
If the magnet covers are not yet mounted or the RF room is not yet operational, overrule the gradient air-pressure sensor temporarily. To do so, just short-circuit the two wires connected directly to the air-pressure sensor.

Figure 2 - DIP switches location at the Copley 274 power module

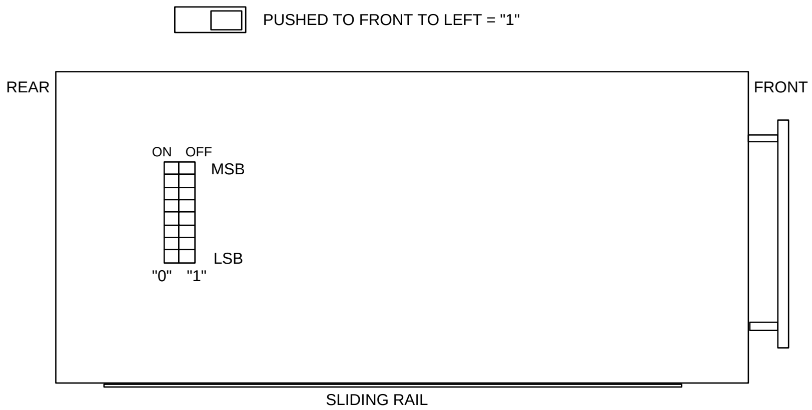


Table 1 - Address selection of the master cabinet (PT1000A, PT3000, PT6000, Intera POWER and Intera MASTER).

DIP switches on the Copley 274 Power Module		
FUNCTION	Master cabinet	DIP switches (MSB-LSB)
address	Power module 1	00000001
address	Power module 2	00000010
address	Power module 3	00000011
address	Power module 4	00000100
address	Power module 5	00000101
address	Power module 6	00000110
address	Power module 7	00000111
address	Power module 8	00001000
address	Power module 9	00001001
address	Power module 10	00001010
address	Power module 11	00001011
address	Power module 12	00001100
Address DIP switches located on the Copley 274 Controller * **see remark**		
address	Controller X 13	dddduudu
address	Controller Y 14	dddduuud

address	Controller Z 15	dddduuuu

Remark: In some controllers the DIP switches of the address selection are reversed (MSB - LSB, M1-M0), see Figure 4.
Always check the label, behind the 'hatch' of the controller panel.

Table 2 - Address selection of the slave cabinet (PT6000 and Intera MASTER).

DIP switches located on the Copley-274 Power Module		
FUNCTION	Slave cabinet	DIP switches (MSB-LSB)
address	Power module 17	00010001
address	Power module 18	00010010
address	Power module 19	00010011
address	Power module 20	00010100
address	Power module 21	00010101
address	Power module 22	00010110
address	Power module 23	00010111
address	Power module 24	00011000
address	Power module 25	00011001
address	Power module 26	00011010
address	Power module 27	00011011
address	Power module 28	00011100
Address DIP switches located on the Copley 274 Controller * **see remark**		
address	Controller X 29	ddduuudu
address	Controller Y 30	ddduuuud
address	Controller Z 31	ddduuuuu

Table 3 - Coil_1 mode and the clock signal selection of the PT3000 and Intera POWER cabinet

FUNCTIONS	POWER	Copley-274 Controller DIP switches M1,M0,OSC S/M,OSC ON,3/4 MOD
coil mode(s), clock	Controller X,Y and Z	dduud

Table 4 - Coil_2 mode and the clock signal selection of the PT1000A, PT 6000 and Intera MASTER master and slave cabinets

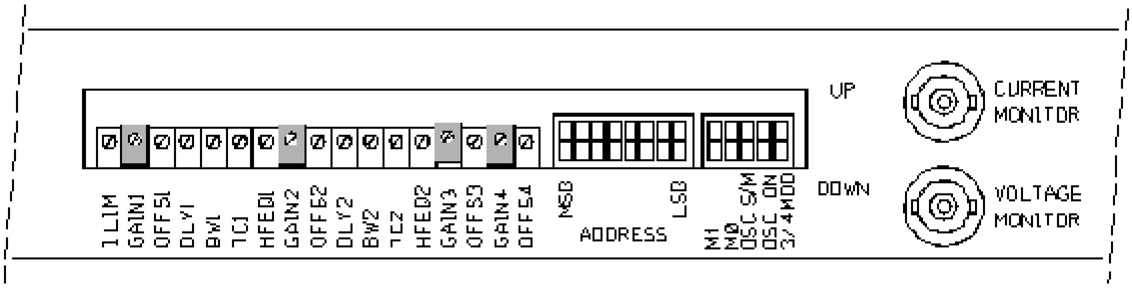
FUNCTIONS	MASTER Master and Slave	Copley-274 Controller DIP switches M1,M0,OSC S/M,OSC ON,3/4 MOD
coil mode(s), clock	Controller X,Y and Z	duuud * **see remark**

Remark: In some controllers the DIP switches of the address selection are reversed (MSB - LSB, M1-M0), see Figure 4.

Always check the label, behind the 'hatch' of the controller panel.

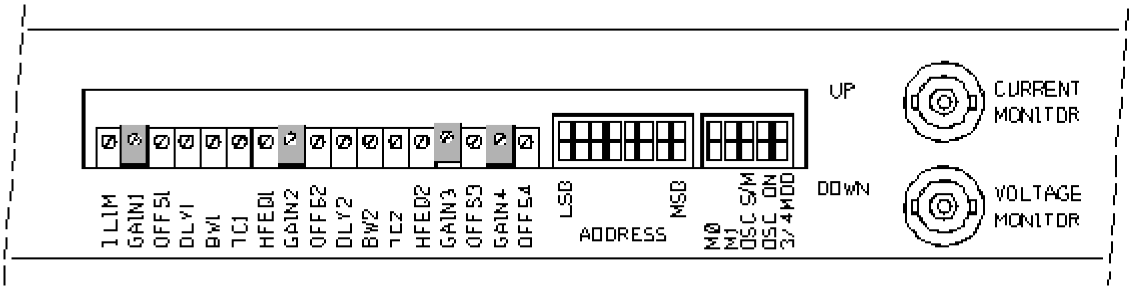
See Figure 3, for the lay-out of the DIP switches of the address selection for the majority of the controllers in the installed base.

Figure 3 - DIP switch location Copley-274 Controller



Some controllers however, have a different lay-out.
With these controllers the DIP switches M0 and M1 are reversed; also the DIP switches for the address selection are reversed. See Figure 4.

Figure 4 - DIP switch location Copley 274 Controller (reversed)



To make sure that you set the DIP switches correctly, ALWAYS check the label behind the hatch of the controller. If, for instance, a controller has been exchanged, the DIP switch label on the fan unit is not changed.

2.2 VERIFY GRADIENT AMPLIFIER PARAMETERS AND DRIVERS IN ASW AND TSW

Procedure:

1.	Login	GYROTOOL	
2.	Enter	<RETURN>	To enter the main menu.
3.	Select	Modify system configuration	
4.	Select	Scanner hardware configuration	
5.	Check	Gradient amplifier type	COPLEY-274S or COPLEY-274D
6.	Check	Grad. coil type	Water-cooled
7.	Select	<Proceed>	
8.	Select	<Exit>	

Check the gradient amplifier drivers in TSW:

1. Login TSW
2. Select CONF
3. Select EDIT
4. Check Line 696
5. 696 Gradient amplifier type = COPLEY-274S or COPLEY-274D
6. Press <CTRL> Z
7. Enter <Exit>
8. Select <Quit>

If gradient amplifier type has been changed, you have to perform a GYRORESTART, before you continue scanning.

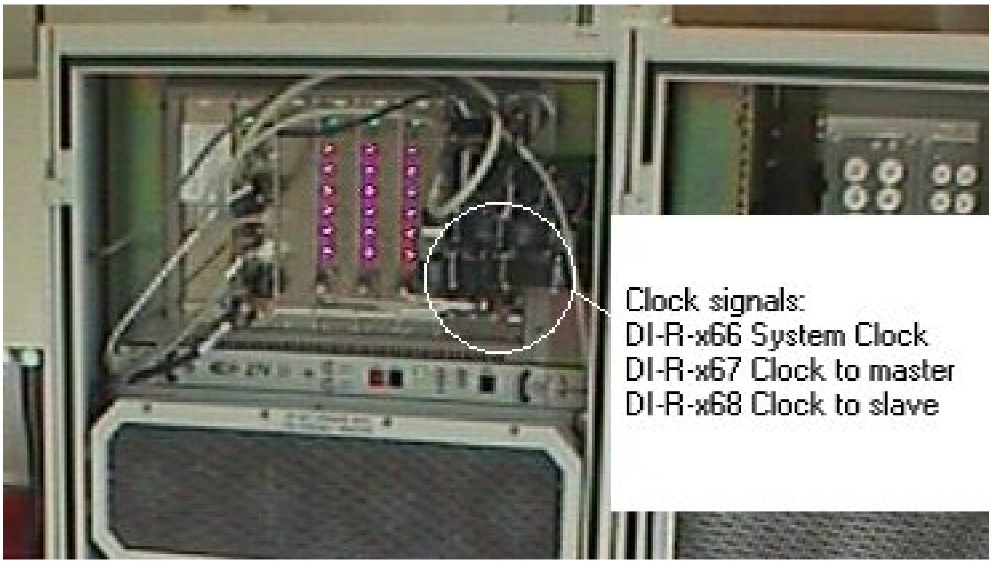
1. Login GYRORESTART
2. Enter YES

2.3 SETTING TO INTERNAL CLOCK FOR TEST PURPOSES

Introduction:
The clock for the Copley 274 gradient amplifier(s), is generated on the transceiver board inside the NTDAC and supplied to the gradient interface through the BCP board inside the NTDAC.
When you have clock problems, you can configure the gradient amplifier to internal clock for test purposes.
Operating the gradient amplifiers on the internal clock can slightly decrease the image quality of the system. In order to verify the behavior of the gradient amplifier over a longer time span, with the clock set to internal, you can decide to give the system back to the customer and continue with trouble-shooting at a more convenient time.

Procedure:

Figure 5 - Clock signals on the PT6000 / Intera MASTER

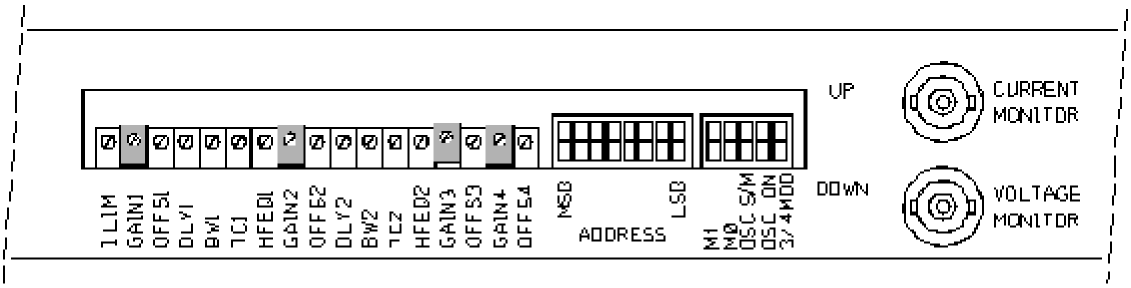


For a PT1000A, PT3000 and Intera POWER disconnect DIB-X58 on the gradient interface controller daughter board.

For a PT6000 / Intera MASTER:
1. Disconnect the coax cable from DIR-X66 (now the system clock is disconnected)
2. Disconnect the cable from DIR-X67 (clock to master cabinet) and connect it to DIR-X66.

Now all master and slave amplifier clocks are connected together.

Figure 6 - DIP switches



3. To activate the internal clock of the master X controller set the ‘OSC S/M’ and ‘OSC ON’ DIP switches to ‘down’.

The DIP switches ‘OSC S/M’ and ‘OSC ON’ have to be set like xx**DD**x.

- Now the master X controller generates the clock for all master and slave controllers.

If this does not work, it is likely that you have a problem with the interconnect board.

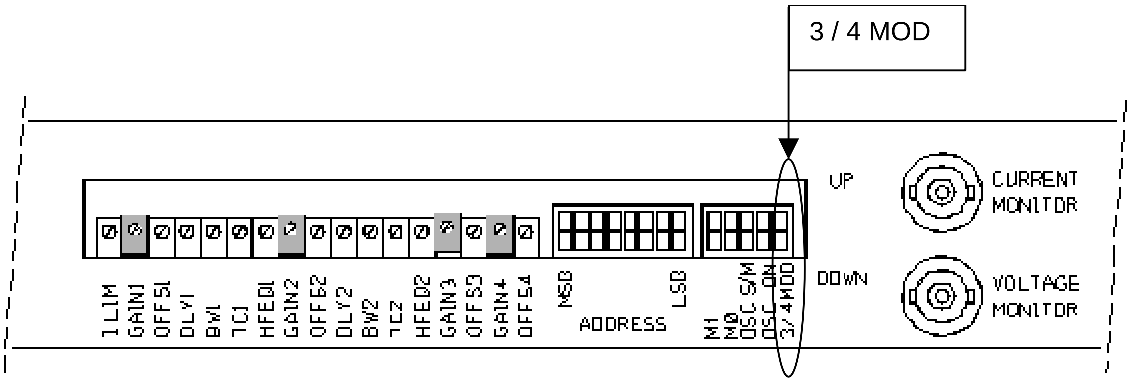
- To check this, disconnect the cable from DIR-X67 (clock to master cabinet) and disconnect the cable from DIR-X68 (clock to slave cabinet).
- Connect these two cables together with a coaxial I-piece or T-piece.
- Now you have skipped the interconnect board for the clock signal.

2.4 CONFIGURE 3 POWER MODULES FOR TEST PURPOSE

Introduction:
If there is one power module defective in an axis amplifier, the corresponding controller can be configured for operating with just 3 power modules. However this results in a 25% performance reduction of the gradient orientation. Therefore the system can have scan aborts, simply because the gradient amplifier cannot supply enough current in this configuration.

1. Switch off the gradient amplifier(s)
2. Open the small front cover of the controller of the affected axis amplifier.
3. Set the ‘3/4 MOD’ dip switch from ‘down’ to ‘up’. See Figure 7.
4. Switch on the gradient amplifier(s)

Figure 7 - DIP switch location Copley-274 Controller



NOTE

Do not for get to configure the controller for 4 power modules again after repair of the system! Otherwise the gradient system will not be able to supply the maximum gradient strength.

3 TEST PROCEDURES

To diagnose faults in the Copley 274 gradient amplifier, there are several tools available for the service engineer:

Test software (TSW): TSW is available for R5.X and R10.X systems
The TSW contains:
- Automatic tests, no operator actions are required after this test has been started.
- Interactive tests, the operator is requested and instructed to perform actions during the test.

System Tuning Tools (STT): STT is embedded in ASW for R5.X and R10.X systems.
The STT contains:
- System Tuning Tools (STT) diagnostic tests (service dongle level 1 required).

Application software (ASW) ASW contains:
- Logging in the application software (ASW). The ASW logging monitors the system, included the Gradient amplifiers. Any error in the gradient amplifier can be found in the ASW logging.
- In case of gradient errors, also a 'gradient dump file' is logged. This log file lists detail information about the error and the status in general of the gradient amplifier.

Displays: A display on each gradient amplifier axis and on each DC power supply shows the actual status of the unit.

Procedure to start ASW (R5.x to R9.x):
1. Logon: **Gyroscan**
2. **Continue with the required test.**

Procedure to start ASW (R10 ->)
1. Logon: **MR Service** + **Password** (Case sensitive)
2. Select: **Intera** in the MR Boot Configuration manager and press **Start**
3. **Continue with the required test.**

Additional for R11:
When the ASW is started up set the scan definition context to scan list.
4. Select: **System → Scan Definition Context → Scan List**

NOTE

For monitor setup in the technical room, refer to paragraph 6.8.

3.1 HOW TO VERIFY THE GRADIENT CABLE CONNECTIONS

3.1.1 PT3000 / INTERA POWER

Before switching the gradient amplifier on, you must check the gradient cable connections for possible shorts.
Checks are done with a digital multi meter (DMM) with an Ohms range.
See Table 5, where the measurement points are given.
The following measurements are made:

- The resistance of the X, Y and Z gradient coils ;
- The resistance between the X, Y and Z gradient coils;
- The resistance between each coil and ground.

WARNING

For this measurement the gradient amplifier must be switched OFF. Make sure that the AC power has been switched off for at least 2 minutes before starting to work on the gradient chain. It is advised to watch the high voltage value on the EMI 20kW/420V DC power supply meters and make sure that the buffer capacitors have discharged to less than 2 Volt.

Figure 8 - Gradient cable connections at rear of the gradient amplifier

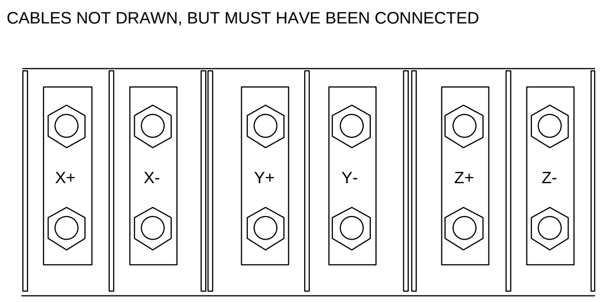


Table 5 - PT3000 / Intera POWER gradient cable connection checks

Measuring points:		Spec. [Ω]	Measured [Ω]
X+	X-	< 10	
Y+	Y-	< 10	
Z+	Z-	< 10	
X+	Y+	> 1000	
X+	Z+	> 1000 *	
Y+	Z+	> 1000 *	
X+	ground	> 1000 *	
Y+	ground	> 1000 *	
Z+	ground	> 1000 *	

*) If measurement results are slightly out of spec, retry the measurement with a different DMV or disconnect the positive gradient cable and measure between the gradient cable and ground.

3.1.2 PT6000 / INTERA MASTER

Before switching the gradient amplifiers on, you must check the gradient cable connections for possible shorts.
Checks are done with a digital multi meter (DMM) with an Ohms range. See Table 6, where the measurement points are given. The following measurements are made:

- The resistance of the X, Y and Z gradient coils ;
- The resistance between the X, Y and Z gradient coils;
- The resistance between each coil and ground.

WARNING

For this measurement the gradient amplifier must be switched OFF. Make sure that the AC power has been switched off for at least 2 minutes before starting to work on the gradient chain. It is advised to watch the high voltage value on the EMI 20kW/420V DC power supply meters and make sure that the buffer capacitors have discharged to less than 2 Volt.

Figure 9 - Gradient cables connections at rear of the gradient amplifier cabinets

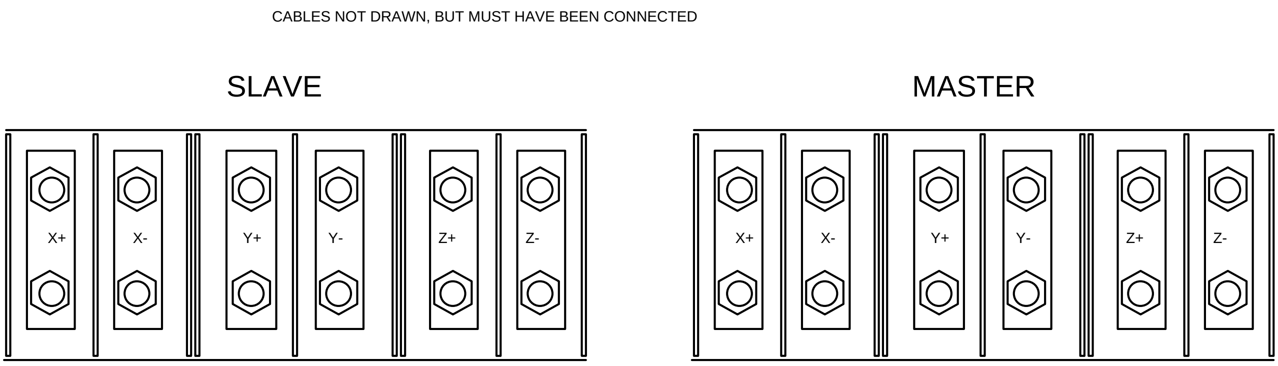


Table 6 - PT6000/ Intera MASTER gradient cable connections checks

Measuring points:		Spec.[Ω]	Measured[Ω]
X+ master	X- master	< 10	
Y+ master	Y- master	< 10	
Z+ master	Z- master	< 10	
X+ slave	X- slave	< 10	
Y+ slave	Y- slave	< 10	
Z+ slave	Z- slave	< 10	
X+ master	Y+ master	> 1000	
X+ master	Z+ master	> 1000	
Y+ master	Z+ master	> 1000	
X+ slave	Y+ slave	> 1000	
X+ slave	Z+ slave	> 1000	
Y+ slave	Z+ slave	> 1000	
X+ master	Y+ slave	> 1000	
X+ master	Z+ slave	> 1000	
Y+ master	X+ slave	> 1000	
Y+ master	Z+ slave	> 1000	
Z+ master	X+ slave	> 1000	
Z+ master	Y+ slave	> 1000	
X+ master	X+ slave	> 1000	
Y+ master	Y+ slave	> 1000	
Z+ master	Z+ slave	> 1000	
X+ master	ground	> 1000 *	
Y+ master	ground	> 1000 *	
Z+ master	ground	> 1000 *	
X+ slave	ground	> 1000 *	
Y+ slave	ground	> 1000 *	
Z+ slave	ground	> 1000 *	

*) If measurement results are slightly out of spec, retry the measurement with a different DMV or disconnect the positive gradient cable and measure between the gradient cable and ground.

3.2 GRADIENT INTERFACE (TSW)

1. Login: TSW
2. Select: TBDAS
3. Enter: RUN FUNCTIONAL GRADIENT AUTOMATIC
   No errors are allowed.
   When finished:
4. Enter: RUN FUNCTIONAL GRADIENT INTERACTIVE
   'GRADIENT INTERACTIVE' test started
   'CONTROLLER: sub-channels presence' test function started
   Follow the instructions on the screen.
5. Enter: QUIT to exit TBDAS test.

3.3 FIRST TIME POWER-ON CHECKS

1. Make sure that the NTDAC has been switched on (otherwise the sync_clock is missing).
2. Switch on the gradient amplifier in the MDU (MDE).
3. Switch on the MAINS and AUX of the master and, if applicable, the slave gradient amplifier cabinets.
4. The switches can be found on both PDU's in each cabinet.
5. All power module fan units should run.
6. Switch on both EMI 20 kW/420V DC power supplies in the master and, if applicable, the slave gradient amplifier cabinets.
7. The heat exchanger of the gradient coil must be switched on (PT3000/ Intera POWER and PT6000/ Intera MASTER only).
8. Verify the status of the heat exchanger (PT3000/ Intera POWER and PT6000/ Intera MASTER only):
   - Temp. control dial: 25 º C
   - Recirculation temperature: equal to the dial setting (tolerance)
   - Recirculation pressure: 43.5 PSI - 79.8 PSI (3 - 5 bar)
   - Pressure fluctuation: 7.2 PSI (0.5 bar)
   - Water purity indicator: After (re)filling the secondary circuit, this indicator will be red for a couple of days. This indicates that the ion-level is not yet within specification. The color should change to green within one week. Note that during this first week, it is allowed to operate the system with the indicator being red.
     When, after normal operation, the indicator changes to steady red the cartridge should be replaced. If the light is periodically changing between red and green, the purity is still adequate but replacement should be anticipated.
   - Idle- & cool light: The amber IDLE and the green COOL indicators show the status of the control valve. When the temperature control valve is fully open (for maximum cooling), the COOL indicator is on continuously. When the control valve is fully closed the IDLE indicator is on. As the control valve moves between these two extremes, the two indicators will flash with variable on-times to indicate the approximate position of the control valve.

3.4 CHECKING THE GRADIENT ORIENTATION

The gradient system must function properly before performing this procedure.
The shim gantry must be mounted and the Tesla meter must have been set up.

1. Measure the field strength with the Tesla meter. See Table 7.

   - Select: Scan Control
   - Select: Scan Utilities

- Select: Enter service mode
- Select: System tuning
- Select: System tuning tools
- Select: Installation procedures
- Select: Gradient adjustment procedures
- Select: Shim probe position
- Select; <proceed>

2. Change the parameter 'Gradient coil' to X, Y or Z, depending on the gradient under test. Measure the field strength in each position as indicated in the table below.

If the gradient orientation is correct then the following statements are true:
(Numbers refer to the values entered in the table)

X-gradient: (2-1) >0 ; (6-5) <0
Y-gradient: (11-9) >0 ; (15-13) <0
Z-gradient: (20-17) >0 ; (24-21) <0

Table 7 - Field strength measuring points

Probe position	demand input			
	x=y=z=0	x=on	y=on	z=on
p6, 0 degree p6, 180 degree	1 5	2 6		
p6, 90 degree p6, 270 degree	9 13		11 15	
p1, 0 degree p12, 0 degree	17 21			20 24

3. If any of the gradients have the wrong orientation, correct it.
4. Repeat the procedure.
5. Remove the shim gantry and Tesla meter when all is okay.

3.5 EDDY CURRENT COMPENSATION

3.5.1 DRIFT COMPENSATION FLUX METER

Condition: Place the pick-up coil holder, with the pick-up coils mounted in the direction of the gradient being tested, close to the iso-center, directly on the bridge section.
Notice that the axis of the pick-up coils is always parallel to the Z-axis of the magnet!

Procedure:

1. Set the remote/manual switch on flux meter to remote.
   The flux meter has to be switched **ON** for **at least 30 minutes**, before adjusting the offset **drift** of the flux meter.
2. Select: Scan Control
3. Select: Scan Utilities
4. Select: Enter service mode
5. Select: System tuning
6. Select: System tuning tools
7. Select: Installation procedures
8. Select: Gradient adjustment procedures
9. Select: Drift compensation flux meter.
   An information screen is displayed.
10. Select: <Proceed> To start the measurement.
11. Select: <Mod display>
12. Change/check:

monitoring mode	both
Raw data file logging	no
identifier of signal 1	Tr
sig 1: horizontal min	1.0
sig 1: horizontal max	4990
sig 1: vertical min	-0.1
sig 1: vertical max	0.1
sig 1: marker line	no
identifier of signal 2	Ti
sig 2: horizontal min	1.0
sig 2: horizontal max	4990
sig 2: vertical min	-0.1
sig 2: vertical max	0.1
sig 2: marker line	no

13. Select: <Proceed>
14. Select: <Display grid>
15. Select: <Display min/max>

At this point the signal from both pick-up coils is displayed on the monitor.
The value of each signal at the start of the measurement is not important. Important is that this value does not change during this 5 seconds measurement. This change is called DRIFT.
The drift of both signals (channels) during the 5 seconds measurement should be smaller than +/- 10 mV.

16. Adjusting the drift:
    - Temporarily disconnect the cable from the ‘Integrator 1’ output.
    - Connect a DMV to the ‘Integrator 1’ output via a BNC – to –banana adapter.
    - Set the remote /manual switch at the flux meter to ‘manual’.
    - Toggle the RESET switch on the flux meter.
      The value that you measure now at the DVM is the starting value, which is not necessarily 0 mV.
      However, whatever value it is, it should not change during the 5 seconds measurement.

- If the value changes, adjust the ‘Integrator 1’ output with the corresponding ‘Integrator 1’ (drift) potentiometer, until the drift is within spec (does not change during the 5 seconds measurement).
- Every time after you have changed the setting of the ‘Integrator 1’ (drift) potentiometer, reset the flux meter by toggling the RESET switch.
- If the drift is in spec, disconnect the DVM from the ‘Integrator 1’ output and connect the cable again.
- Repeat the drift adjustment for the ‘Integrator 2’ output.
- If the drift of both integrators is in specification, proceed as follows:
  * Make sure both signal cables are connected to the flux meter ;
  * **Set the remote/manual switch on the flux meter to ‘automatic’.**

At this point both signals can be viewed again on the monitor for visual inspection.
If one or both of the channels, still shows a drift out of specification, repeat the drift adjustment, until it is in specification.

17. Select: <Stop scan> To stop the measurement.

It is strongly advised to check and, if required, adjust the offset drift several times during the eddy current adjustment procedure!

3.5.2 POSITIONING EDDY CURRENT PICK-UP COILS

Condition: Place the pick-up coil holder, with the pick-up coils mounted in the direction of the gradient being tested, close to the iso-center, directly on the bridge section.
Notice that the axis of the pick-up coils is always parallel to the Z-axis of the magnet.
See paragraph 6.2.1.

1. Select: Position eddy current pick-up coils
   An information screen is displayed.
2. Select: <Proceed>
3. Change/check: gradient coil Z
4. Select: <Proceed> To start the measurement.
   If pick-up coils are positioned for the X or Y gradient adjustment:
5. Select: <Mod display>
6. Change/check:

monitoring mode	both
Raw data file logging	no
identifier of signal 1	Tr
sig 1: horizontal min	1.0
sig 1: horizontal max	150
sig 1: vertical min	-0.1
sig 1: vertical max	0.1
sig 1: marker line	no
identifier of signal 2	Ti
sig 2: horizontal min	1.0
sig 2: horizontal max	150
sig 2: vertical min	-0.1
sig 2: vertical max	0.1
sig 2: marker line	no
Select:	<Proceed>

7. If pick-up coils are positioned for the X or Y gradient adjustment:
   Move the holder with the pick-up coils in Z direction, until the response of the two channels is:
   - 50 mV < V < + 50 mV.
   If the pick-up coils are positioned for the Z gradient adjustment:
   Move the holder with the pick-up coils in Z direction, until the response of the two channels is:
   two signals with the same amplitude (absolute).
8. Select: <Stop scan>
9. To reduce the positioning time for the other gradients, mark the position of the pick-up coil holder on the bridge section.

3.5.3 EDDY CURRENT REFERENCE MEASUREMENT

Condition: The pick-up coils are positioned symmetrically around the iso-center in the direction of the gradient under test.

Procedure:

1. Select: Eddy current reference measurement
   An information screen is displayed.
2 Select: <Proceed>
3. Change/check:

Measuring type	Reference	
Gradient coil	Gradient under test	(Corresponds with the position of the pick-up coils)
Gradient ampl. faults	enabled	

4. Select: <Proceed> to start the measurement.
   The reference measurement is performed and the maximum gradient strength is measured.
   The program will display the result.

The maximum gradient strength should be: **> 4.5 mT/m**

5. Enter: <RETURN> to accept this condition.

3.5.4 EDDY CURRENT CHECK

Because the eddy currents have been adjusted in the factory, it is advised to check the actual behavior before starting to make any readjustments. For this check, the 'eddy current final measurement' procedure will be used. During the final measurement the specific channel delay deviation is changed **till the three- quarter point specification is reached.** The flatness of the average values is measured for the specified ranges. After completion of the final measurement the measured parameters will be checked against the specifications. An MRL will be displayed. If all values are within the limits the values are stored automatically into the tuned hardware parameter archive.

Make sure you are in the 'Gradient adjustment procedures' menu.

1. Select: Eddy current final measurement
   An information screen is displayed.
2. Select: <Proceed>
3. Change/check: gradient coil xxx
   'xxx' stands for gradient under test.
4. Change/check: Current ECC settings
   Activate all filters:

1	ON	2	ON	3	ON
4	ON	5	ON	6	ON

5. Select: <Proceed> To start the measurement.

At the end of the measurement, a measurement result list (MRL) will be displayed.
See paragraph 6.2.3.

ECC adjustment specifications:

		POWER	MASTER	Specification
ECC:	Three-quarter point	0.30 ms		69.0 % ± 3.0 %
ECC:	Three-quarter point		0.15 ms	63.0 % ± 6.0 %
ECC:	EOS point	0.4 ms		95.0 % ± 0.5 %
ECC:	EOS point		0.224 ms	91.5 % ± 0.5 %
ECC:	Flatness 1	0.7 -> 3.4 ms	0.5 ms -> 3.2 ms	< 0.15 % *)
ECC:	Flatness 2	3.4 -> 990 ms	3.3 ms -> 990 ms	< 0.1 % *)
ECC:	Difference 1	1.0 -> 5.4 ms	0.8 -> 5.2 ms	< 0.45 % **)
ECC:	Difference 2	5.8 -> 990 ms	5.2 -> 990 ms	< 0.42 % **)

*) [(max.value) - (min.value)]
**) [(max.value) - (min.value)]

- If the system does not pass the flatness tests: See paragraph 4.8. If it is okay, change the position of the pick-up coils for another axis. Repeat the pick-up coils positioning and start the final measurement again.
- If the system does not pass the difference tests, the most likely cause is the flux meter. To exclude the flux meter, interchange the eddy current pick-up coil connections at the front of the flux meter. Check the final measurement again. If the difference is still not within the specification, contact the MR helpdesk. In the meantime change the position of the pick-up coils for another axis. Repeat the pick-up coils positioning and start the final measurement again.

<u>SUMMARY of eddy current compensation check:</u>

X axis
- Place the two pick-up coils in position 2 and 4 on the X axis.
  See paragraph 3.5.2.
- Select the Z gradient and move the holder with the pick-up coils in Z direction, until the response of the two channels is < ± 50 mV.
- Perform the final eddy current measurement. See paragraph 4.8.2 for the X gradient'.

Y axis
- Place the two pick-up coils in position 3 and 5 on the Y axis.
  See paragraph 3.5.2.
- Select the Z gradient and move the holder with the pick-up coils in Z direction, until the response of the two channels is < ± 50 mV.
- Perform the final eddy current measurement. See paragraph 4.8.2 for the Y gradient'.

Z axis
- Place the two pick-up coils in position 1 and 1 on the Z axis.
  See paragraph 3.5.2.
- Select the Z gradient and move the holder with the pick-up coils in Z direction, until the response of the two channels are equal: tolerance 100 mV.
- Perform the final eddy current measurement. See paragraph 4.8.2 for the Z gradient'.

If the eddy current adjustment does not meet the specifications:
See paragraph 4.8.

3.6 DIAGNOSTIC TOOLS

3.6.1 ANALOG FUNCTION TEST

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient chain measurements
8. Select: Analog functions test
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.2 GRADIENT LOAD TEST

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient chain measurements
8. Select: Gradient load test (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.3 STATUS CHECK

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Status check (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.4 POWER MODULE DIGITIZED SIGNALS

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Pwr mod digitized signals (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

The numbers in the MRL refer to the listed test points:

1	=	+16V supply value
2	=	+15V supply value
3	=	High voltage supply value
4	=	IGBT1 temperature
5	=	Ambient temperature
6	=	Filter coil temperature of the power module
7	=	RMS current positive output
8	=	RMS current negative output
9	=	-15V supply value
10	=	+5V supply value
11	=	IGBT2 temperature
12	=	Airflow (not applicable)
13	=	Output rectifier temperature
14	=	+28V supply value
15	=	Predicted junction temperature
16	=	Reference temperature

3.6.5 POWER MODULE CM VOLTAGE, VFB

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Pwr mod CM voltage, VFB (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.6 POWER MODULE 60 A CURRENT SHARING

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Pwr mod 60A current sharing (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.7 POWER MODULE 600 A CURRENT SHARING

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Pwr mod 600A current sharing (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.8 CONTROLLER VOLTAGES

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Controller voltages (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.9 CONTROLLER GAIN AND OFFSET

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Controller gain/offset (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values, not within the specifications are marked in the displayed MRL listing.
For the adjustment of the controller offset, see paragraph 4.2 or 4.3.

3.6.10 CONTROLLER DIAGNOSTICS

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Controller diagnostics (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.11 POWER SUPPLY HIGH VOLTAGE

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Power supply high voltage (master or slave)
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.
   At the end of the test a MRL is displayed. No errors are allowed.
10. Select: <Proceed>
11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.6.12 SETTLING

Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Diagnostic measurements
7. Select: Gradient amplifier measurements
8. Select: Settling (master or slave)

An information screen is displayed.

9. Select: <Proceed> To start the measurement.

At the end of the test a MRL is displayed. No errors are allowed.

10. Select: <Proceed>

11. Select: <Cancel> twice

The test will start. At the end of the test the status of the amplifier is displayed.
Values not within the specifications are marked in the displayed MRL listing.

3.7 THE 100 A FUSE AND THE IGBTS IN THE POWER MODULE

Introduction

The DC voltage output of the two EMI 20 kW DC power supplies is routed to the power modules via the high voltage and ground bus bars and the backplane. See Figure 10 and Figure 11.

The + and – output of the power modules are routed to the gradient cable terminal block via the + out and – out bus bars. In each axis there are four power modules connected in parallel.

Figure 10 - the bus bars

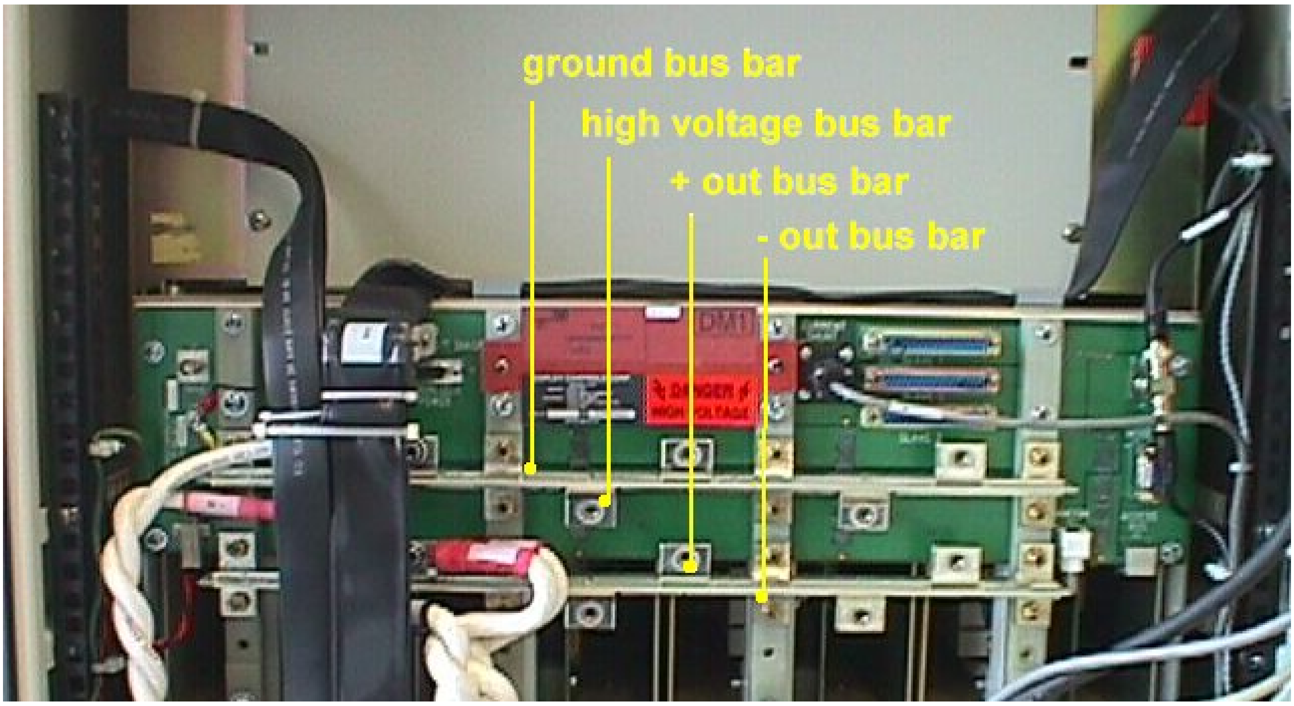
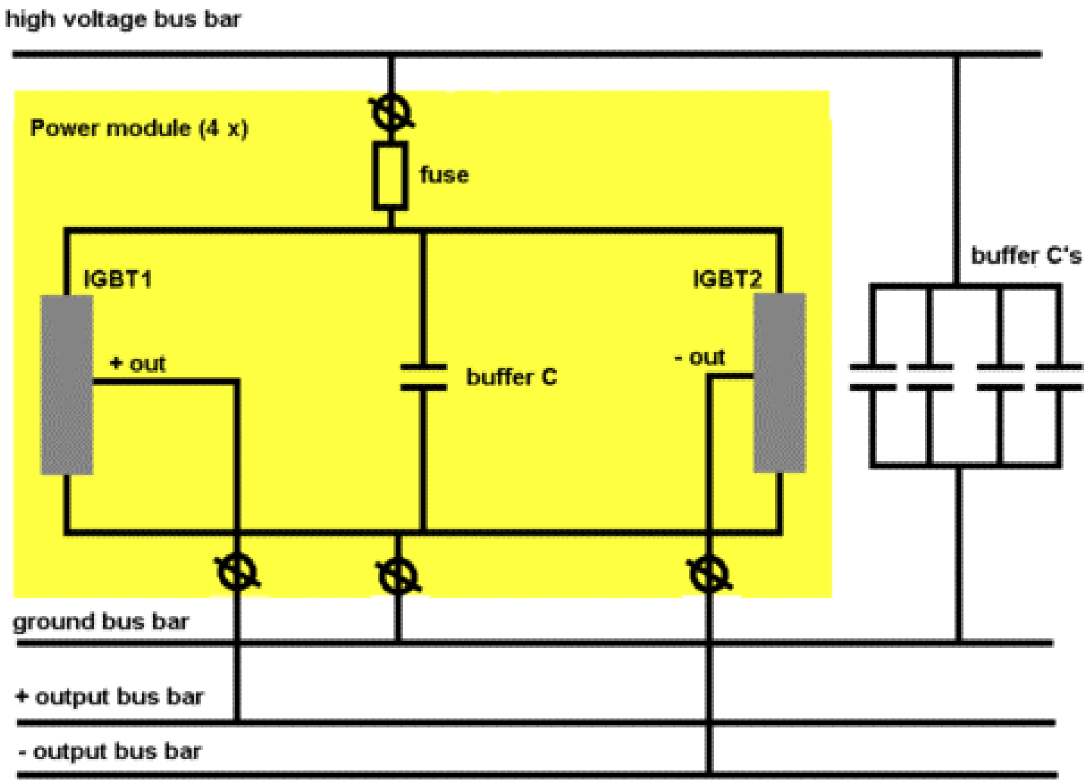


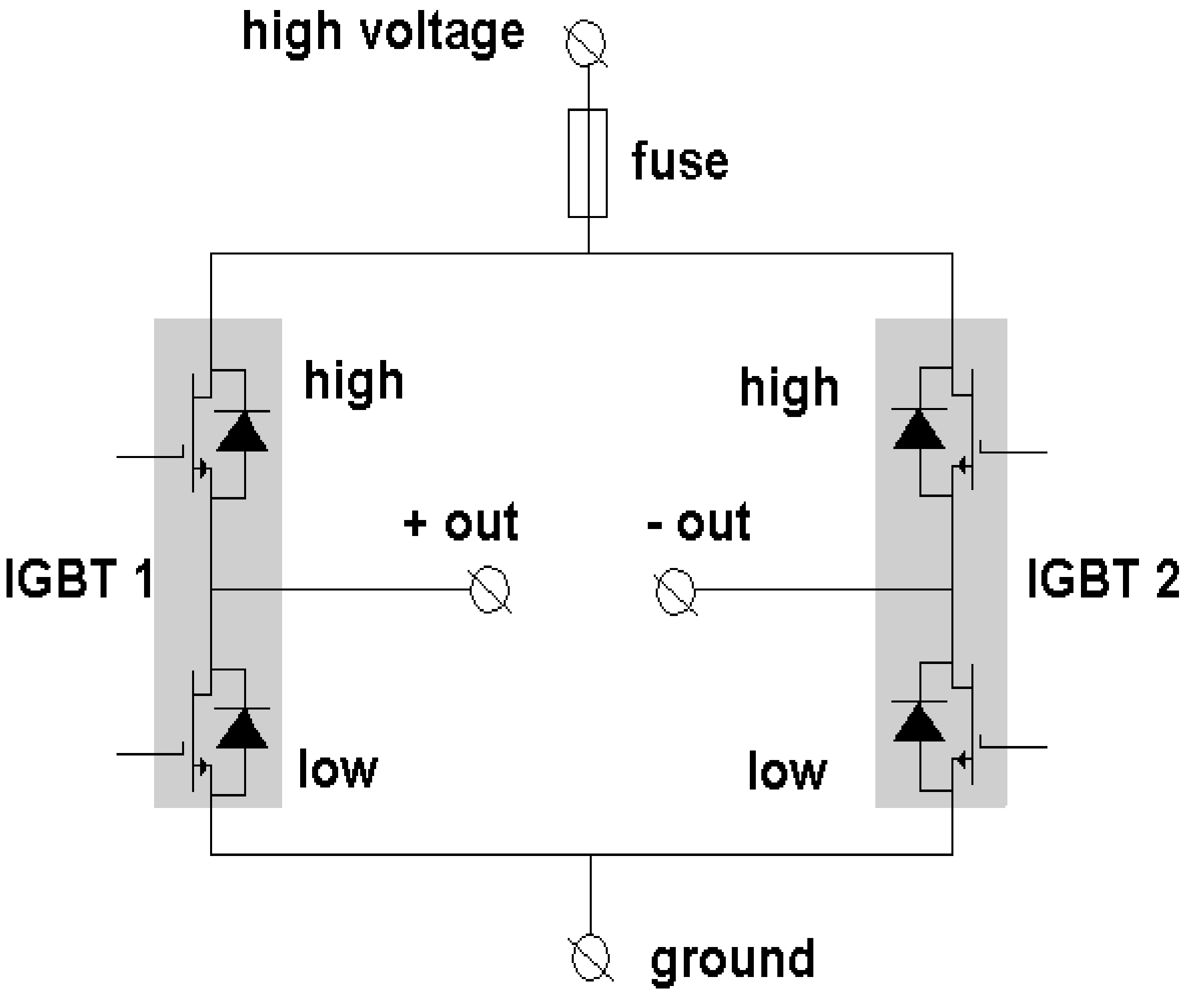
Figure 11 - the bus bar connections



At the bottom of each gradient cabinet (left side), extra buffer capacitors are mounted that smoothen the high voltage generated by the two EMI 20 kW DC power supplies. See Figure 12.
Each power module is connected to the high voltage bus bar via a build-in fuse. Extra buffer capacitors inside the power module provide additional smoothening of the high voltage.

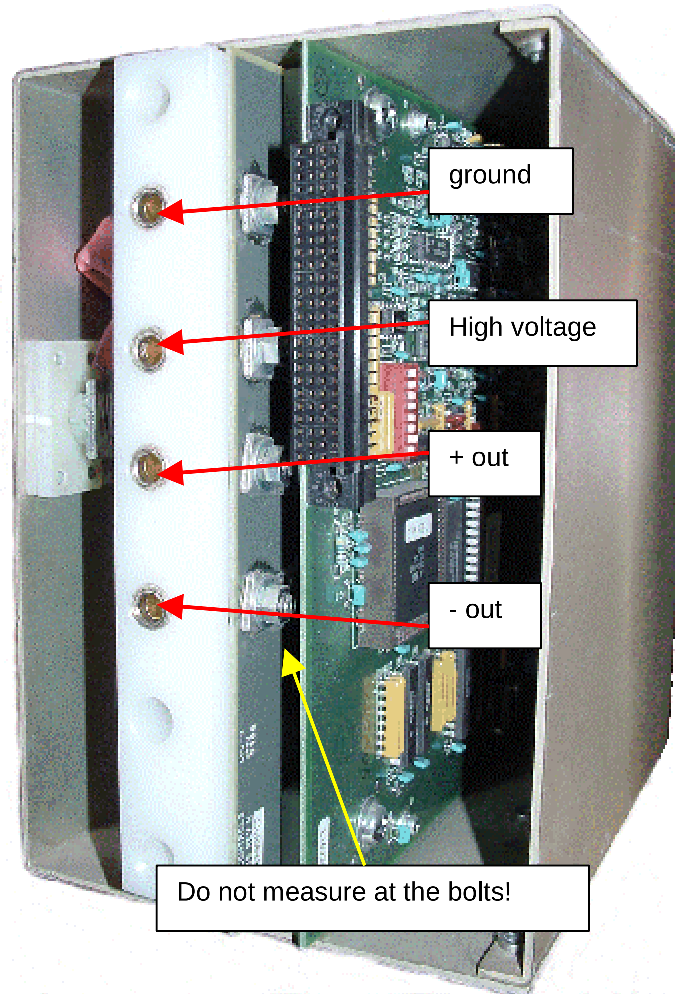
Figure 12 - buffer capacitors in the cabinet

Figure 13 - overview of the high power interface of the power module



3.7.1 CHECK THE FUSE

Figure 14 - the high power interface of the power module



The connections ground, high voltage, + out and – out of each power module are connected to the corresponding bus bars on the back plane.

Procedure:
- Switch off the gradient amplifier, check the high voltage on the EMI 20kW/420V DC power supply meters and make sure that the buffer capacitors have discharged to less than 2 Volt before you proceed.
- Remove the suspected power module from the cabinet.
- Measure the resistance between the bolt in front of the fuse and the high voltage connector pin, using a multi meter (DVM). See Figure 13 and Figure 14.

The resistance should be: < 1 Ohm (= short).

If the fuse is defective, continue with checking the IGBT's.

Conditions when to replace the 100 A fuse in the field:
- IGBT's are OK (See paragraph 3.7.2.)
- +16V supply voltage, +15V supply voltage and +28 supply voltage for the affected power module are within specification. (check the graddump file)
- The graddump shows an overload for the affected power module.
- Depending of the timing of the graddump generation (after the fuse was blown), the high voltage value in the graddump file is zero for the affected power module.

3.7.2 CHECK THE IGBTS

Procedure:

- Switch off the gradient amplifier, check the high voltage on the EMI 20kW/420V DC power supply meters and make sure that the buffer capacitors have discharged to less than 2 Volt before you proceed.
- First measure at the bus bars with all power modules in parallel.
- If there is a defective IGBT, remove the power modules one by one and repeat the measurement each time a power module has been removed. For the measurement refer to Table 8.

Notice that while measuring the IGBTs, you will load the buffer capacitors. Therefore you will not get a stable readout on your DVM, even if the IGBTs are okay.

You can check the IGBTs with a DMM measuring ‘resistance’ or perform 'diode check mode'.
The measured resistance must be higher than 100 Ohm.
The IGBTs are defective when you measure a short < 1 Ohm.

It is preferred to check the IGBTs, with a DMM in diode check mode (with a beep). Measure at the connector pins. Refer to Figure 14 for the connector pinning.

The results should be:

Table 8

IGBT	Measuring points	Diode check mode	Ohms mode
IGBT 1 high	+ out to high voltage	Short beep	> 100 Ohm = OK
IGBT 1 low	+ out to ground	Short beep	> 100 Ohm = OK
IGBT 2 high	- out to high voltage	Short beep	> 100 Ohm = OK
IGBT 2 low	- out to ground	Short beep	> 100 Ohm = OK

If one or more measurements don’t meet the requirements, you have to replace that power module, since the involved IGBT is defective and the IGBTs are not an FRU.

3.8 GRADIENT PARAMETERS DETERMINATION

The gradient parameters determination is necessary for optimizing the gradient performance.

3.8.1 GRADIENT PARAMETERS DETERMINATION (R5 TO R9)

Condition: The gradient cabinet must have been switched on for at least 15 minutes.
1. Select: Scan control
2. Select: Scan utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient parameters determination

Answer the question : Run all subsequent tools successively [No,Yes]: with Yes

8. Select: <Proceed> to start all three measurements

Follow the instructions on the screen.

3.8.2 GRADIENT PARAMETERS DETERMINATION (R10.X AND HIGHER)

Condition: The gradient cabinet must have been switched on for at least 15 minutes.
1. Select: Scan control
2. Select: Scan utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient params. Determination.
8. Select: Channel delay and shimming
   Follow the instructions on the screen.
9. Select: <Proceed> to start the measurements
   Channel delay and shimming will automatically be performed subsequently.

3.8.3 EDDY CURRENT ANALYSIS (R7.1 AND HIGHER)

The eddy current analysis tool analyzes the eddy current effects on the linear shim currents, generated by the gradients. With the determined parameters, the compensation for eddy current irregularities in the system is calculated and used to improve image quality for EPI – diffusion measurements.

NOTE

With this measurement, the 3 liter bottle must be placed vertically on the table-top and not horizontally!

1. Select: Scan utilities
2. Select: Enter service mode
3. Select: System tuning
4. Select: System tuning tools
5. Select: Installation procedures
6. Select: Eddy current analysis
7. Select: <Proceed> to start all three measurements

Follow the instructions on the screen.

3.9 FINE ADJUSTMENT OF THE GRADIENT STRENGHT

Procedure:
1. Select: Scan control
2. Select: Scan utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: Tuned hardware parameters
6. Check the present value for the parameters: ‘grad. gain adjust’ X, Y and Z
7. Set the values to 0.
8. Select: Store to save the changes (you have to enter a reason for changing the parameters).

3.9.1 FINE ADJUSTMENT X AND Y GRADIENT STRENGTH

1. Select: Scan control
2. Select: Spt scanning
3. Select: Service mode
4. Select: Perform iqp/est measurements
5. Select: Analysis principle: iqp
6. Select: xx misc
7. Select: GA_XY (scan name: ADJ:XY)
8. Position the head performance phantom, with the holder, for transversal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
9. Start the batch with <Proceed> (2x)
10. In the batch, SCOUT scans and the scans 'GA1:X_grad' and 'GA2:Y_grad' are performed automatically.

3.9.2 EVALUATION OF THE X AND Y SCANS

1. After the scans have finished select the SPT icon.
2. Select: Service mode
3. Select: IQ parameter/data evaluation tools
4. Select: Spatial linearity measurements
5. Select: Examination
6. Select: Examination GRAD_ADJ
7. Select: Scan: GA1:X_grad
8. Select: Image: Slice 1 SE_M
9. Select: Philips quality procedure
   Write down the value: Size vertical
   - Specification: 149.5 < size < 150.5 mm.
10. Select: Scan: GA2:Y_grad
11. Select: Image: Slice 1 SE_M
12. Select: Philips quality procedure.
    Write down the value: Size horizontal.
    - Specification: 149.5 < size < 150.5 mm.

3.9.3 MODIFY THE X AND Y 'GRAD. GAIN ADJUST' PARAMETERS

See Paragraph 3.9.6, if both measured values meet the specifications.
For the gradients that do not meet the specifications, calculate the new ‘grad. gain adjust parameters.

1. Select: Scan utilities
2. Select: Enter service mode
3. Select: System tuning
4. Select: Tuned hardware parameters

The new value can be calculated with the following formula (1 mm = 0.66%):

% new = (150 – Measured size) x 0.66% + old value

5. Modify the parameters: ‘grad. gain adjust’ X and Y to the calculated values.
   (The values must be between - 4.10 % and + 4.09 %)
6. Select: Store to save the changes (you have to enter a reason for changing the parameters).

3.9.4 CHECKING THE X AND Y FINE ADJUSTMENT

1. Select: Scan control
2. Select: Spt scanning
3. Select: Service mode
4. Select: Perform IQP/EST measurement
5. Select: Analysis principle: IQP
6. Select: xx misc
7. Select: GA_XY (scan name ADJ:XY)
   If not already done: Position the head performance phantom, with the holder, for transversal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
8. Start the batch with <Proceed> (2x)

In the batch, SCOUT scans and the scans 'GA1:X_grad' and 'GA2:Y_grad' are performed automatically.

3.9.5 FINAL EVALUATION OF THE X AND Y SCANS

1. After the scans have finished select the SPT icon.
2. Select: Service mode
3. Select: IQ parameter/data evaluation tools
4. Select: Spatial linearity measurements
5. Select: Examination
6. Select: Examination GRAD_ADJ
7. Select: Scan: GA1:X-grad
8. Select: Image: Slice 1 SE_M
9. Select: Philips quality procedure
   Write down the value: Size vertical
   - Specification: 149.5 < size < 150.5 mm
10. Select: Scan: GA2:Y_grad
11. Select: image: Slice 1 SE_M
12. Select: Philips quality procedure
    Write down the value: Size horizontal
    - Specification: 149.5 < size < 150.5 mm
13. Repeat the procedure if not within specification. See paragraph 3.9.3.

3.9.6 Fine adjustment Z gradient strength

1. Select: Scan Control
2. Select: Spt scanning
3. Select: Service mode
4. Select: Perform iqp/est measurement
5. Select: Analysis principle: iqp
6. Select: xx misc
7. Select: GA_Z (Scan name ADJ:Z)
8. Position the head performance phantom, with the holder, for coronal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
9. Start the batch with <Proceed> (2x)

In the batch, SCOUT scans and the scan 'GA1:Z_grad' will be performed automatically.

3.9.7 Evaluation of the Z scan

1. After the scans have finished select the SPT icon.
2. Select: Service mode
3. Select: IQ parameter/data evaluation tools
4. Select: Spatial linearity measurements
5. Select: Examination
6. Select: Examination GRAD_ADJ
7. Select: Scan: GA1:Z_grad
8. Select: Image slice 3 SE_M
9. Select: Philips quality procedure
   Write down the value: size vertical
   - Specification: 149.5 < size < 150.5 mm

3.9.8 Modify the Z 'grad. gain adjust' parameter

When the value for the Z gradient is not in specifications, calculate the new 'grad. gain adjust' parameter.
1. Select: Scan Utilities
2. Select: Enter service mode
3. Select: System tuning
4. Select: Tuned hardware parameters

The new value can be calculated with the following formula (1 mm = 0.66%):

% new = (150 – Measured size) x 0.66% + old value

5. Modify the parameters: 'grad gain adjust' Z to the calculated value. (The value must be between - 4.10 % and + 4.09 %)
6. Select: Store to save the changes (you have to enter a reason for changing the parameters).

3.9.9 Checking the Z fine adjustment

1. Login: Gyroscan
2. Select: Scan Control
3. Select: Spt scanning
4. Select: Service mode
5. Select: Perform IQP/EST measurements

6. Select: Analysis principle: IQP
7. Select: xx misc
8. Select: GA_Z (Scan name: ADJ:Z)
9. If not already done: Position the head performance phantom with the holder for coronal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
10. Start the batch with <Proceed> (2x)

In the batch, SCOUT scans and the scan 'GA1:Z_grad' will be performed automatically.

3.9.10 FINAL EVALUATION OF THE Z SCAN

1. After the scans have finished select the SPT icon.
2. Select: Service mode
3. Select: IQ parameter/data evaluation tools
4. Select: Spatial linearity measurements
5. Select: Examination
6. Select: Examination GRAD_ADJ
7. Select: Scan: GA1:Z_grad
8. Select: Image: Slice 3 SE_M
9. Select: Philips quality procedure.
10. Write down the value: size vertical.
    - Specification: 149.5 < size < 150.5 mm.
11. Repeat the procedure if not within specification. See paragraph 3.9.8.

3.10 FINE ADJUSTMENT OF THE GRADIENT STRENGHT (R10.X - R11.X)

Additional note when using R11:
When the ASW is started up set the scan definition context to scan list.

1. Select: **System → Scan Definition Context → Scan List**

NOTE

When ExamCards (Scan Definition Context) is selected in ASW, it is not possible to run SPT-batches!

NOTE

When nothing is displayed and happens after starting the scan batch,
select 'scan control' to enable the scan control window.

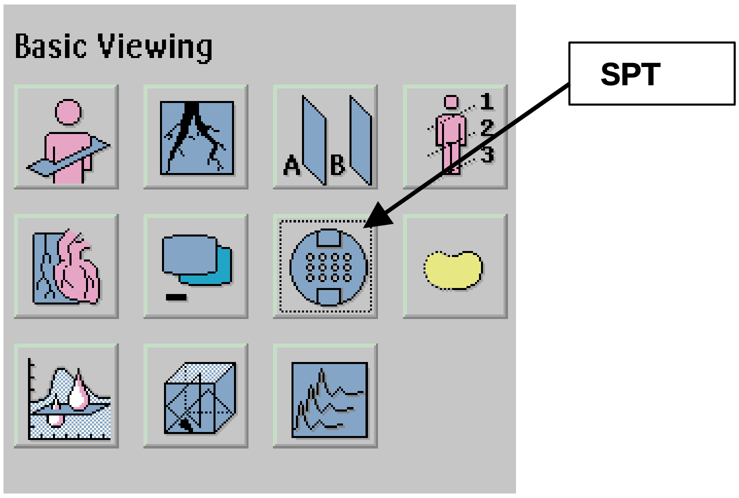
Procedure:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter Service Mode
4. Select: System Tuning
5. Select: Tuned Hardware Parameters
6. Check the present value for the parameters: 'grad. gain adjust' X, Y and Z
7. Set the values to 0 and press <Proceed>
8. Select: Store to save the changes (you have to enter a reason for changing the parameters).
9. Enter: Yes
10. Enter: Reason e.g. initial installation and press <Enter> 2x
11. Select: <Proceed>

3.10.1 FINE ADJUSTMENT X AND Y GRADIENT STRENGTH

11. Press <Windows> key on keyboard
12. Login: FSF with Service access (Refer to section 21)
    Start → MR System Management → Configuration → Configuration Application
13. Minimize the 2 FSF windows (do not close them!)
14. Select: SPT icon see Figure 15.

Figure 15 - SPT icon



15. Select: Batch View tab
16. Expand: Batch Files folder
17. Expand: IQT folder
18. Expand: Miscellaneous folder
19. Select: GA_XY
20. Right mouse click and select Run batch
21. Position the head performance phantom, with the holder, for transversal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
22. Press: <Proceed> in the SPT window
23. Press: <Proceed> in the Scan Control window
    In the batch, SCOUT scans and the scans 'GA1:X_grad' and 'GA2:Y_grad' are performed automatically
24. Press: Ok after the batch has finished successfully.

3.10.2 Evaluation of the X and Y scans

1. Select: SPT icon
2. Select: Image View tab
3. Select: Examination GRAD_ADJ
4. Select: Scan: GA1:X_grad
5. Select: Image: Slice 1 SE_M
6. Select: Manual Analysis → Spatial Linearity
7. Write down the value: Size vertical
   Specification: 149.5 < size < 150.5 mm.
8. Select: Scan: GA2:Y_grad
9. Select: Image: Slice 1 SE_M
10. Write down the value: Size horizontal.
    Specification: 149.5 < size < 150.5 mm.

3.10.3 Modify the X and Y 'grad. gain adjust' parameters

For the gradients that do not meet the specifications, calculate the new ‘grad. gain adjust parameters.

1. Select: **Start → MR Applications → Scan Applications → STT application**
2. Select: **Expert Tools**
3. Select: **Parameter administration**
4. Select: **Tuned HW-parameter administration**

The new values can be calculated with the following formula (1 mm = 0.66%):
% new = (150 – Measured size) x 0.66% + the old value

5. Select: **Grad. Gain adjust**[%] and press <**return**>
   Three values are shown (X, Y and Z).
   Enter at the left (1st) position the new value for the gradient gain X and at the middle (2nd) position the new value for the gradient gain Y. (The values must be between - 4.10 % and + 4.09 %)
6. Press: <**Proceed**>
7. Select: **Store** to save the changes
8. Enter: **Yes**
9. Press: <**Return**> (2x)
10. Press: <**Proceed**>

3.10.4 Checking the X and Y fine adjustment

1. Select: Batch View tab
2. Select: GA_XY from the Miscellaneous folder
3. Right mouse click and select Run batch
4. Press: <Proceed> in the SPT window
5. Press: <Proceed> in the Scan Control window
6. In the batch, SCOUT scans and the scans 'GA1:X_grad' and 'GA2:Y_grad' are performed automatically.
7. Press: Ok after the batch has finished successfully.

3.10.5 Final evaluation of the X and Y scans

1. After the scans have finished select the SPT icon.
2. Select: Image View tab
3. Select: Examination GRAD_ADJ
4. Select: Scan: GA1:X_grad
5. Select: Image: Slice 1 SE_M
6. Select: Manual Analysis → Spatial Linearity
7. Write down the value: Size vertical
   Specification: 149.5 < size < 150.5 mm.
8. Select: Scan: GA2:Y_grad
9. Select: Image: Slice 1 SE_M
10. Write down the value: Size horizontal.
    Specification: 149.5 < size < 150.5 mm.
11. Repeat the procedure if not within specification. Start with paragraph 3.10.3.

NOTE

If you decide to repeat this procedure, make sure that you add the new found value to the previous value present in the hardware parameters.

3.10.6 FINE ADJUSTMENT Z GRADIENT STRENGTH

1. Select: SPT icon
2. Select: Batch View tab
3. Expand: Batch Files folder
4. Expand: IQT folder
5. Expand: Miscellaneous folder
6. Select: GA_Z
7. Right mouse click and select Run batch
8. Position the head performance phantom, with the holder, for coronal scans in the head coil. Connect the head coil to one of the surface coil connectors. Move the head coil to the iso-center of the magnet by using the light visor and pressing <Travel to scan-plane>.
9. Press: <Proceed> in the SPT window
10. Press: <Proceed> in the Scan Control window
    In the batch, SCOUT scans and the scan 'GA1:Z_grad' will be performed automatically
11. Press: Ok after the batch has finished successfully.

3.10.7 EVALUATION OF THE Z SCAN

1. Select: SPT icon
2. Select: Image View tab
3. Select: Examination GRAD_ADJ
4. Select: Scan: GA3:Z_grad
5. Select: Image: Slice 3 SE_M
6. Select: Manual Analysis → Spatial Linearity
7. Write down the value: Size vertical
    Specification: 149.5 < size < 150.5 mm.

3.10.8 MODIFY THE Z 'GRAD. GAIN ADJUST' PARAMETER

When the value for the Z gradient is not in specifications, calculate the new 'grad. gain adjust' parameter.

1. Select: **Start → MR Applications → Scan Applications → STT application**
2. Select: **Expert Tools**
3. Select: **Parameter administration**
4. Select: **Tuned HW-parameter administration**
    The new values can be calculated with the following formula (1 mm = 0.66%):
    % new = (150 – Measured size) x 0.66% + the old value
5. Select: **Grad. Gain adjust**[%] and press <**return**>
    Three values are shown (X, Y and Z).
    Enter at the right (3st) position the new value for the gradient gain Z. (The values must be between -4.10 % and +4.09 %)
6. Press: <**Proceed**>
7. Select: **Store** to save the changes
8. Enter: **Yes**
9. Press: <**Return**> (2x)
10. Press: <**Proceed**>

3.10.9 CHECKING THE Z FINE ADJUSTMENT

1. Select: Batch View tab
2. Select: GA_Z from the Miscellaneous folder
3. Right mouse click and select Run batch
4. Press: <Proceed> in the SPT window
5. Press: <Proceed> in the Scan Control window

6. In the batch, SCOUT scans and the scan 'GA1:Z_grad' will be performed automatically.
7. Press: Ok after the batch has finished successfully.

3.10.10 FINAL EVALUATION OF THE Z SCAN

1. After the scans have finished select the SPT icon.
2. Select: Image View tab
3. Select: Examination GRAD_ADJ
4. Select: Scan: GA1:Z_grad
5. Select: Image: Slice 3 SE_M
6. Select: Manual Analysis → Spatial Linearity
7. Write down the value: Size vertical
   Specification: 149.5 < size < 150.5 mm.
8. Repeat the procedure if not within specification. Start with paragraph 3.10.9.

NOTE

If you decide to repeat this procedure, make sure that you add the new found value to the previous value present in the hardware parameters.

3.11 EXPERT TOOLS / GRADIENT CHAIN TEST

Next tool can be used to control the Copley 274 gradient amplifier by setting parameters. Several signals from the controller and separate axis amplifiers can be monitored.

To use this expert tool, a dongle access level 2 is required.
1. Select: Scan Control
2. Select: Scan Utilities
3. Enter: Service mode
4. Select: System Tuning
5. Select: System tuning tools
6. Select: Expert tools

If you are running R6.1.2 or higher the system responds with the following message:

You enter a service protected function.

Performing checks and/or adjustments and/or modifying any of the involved parameters affects the imaging capabilities of the Gyroscan system. This may only be performed by persons licensed by Philips Medical Systems.

When you have the right dongle access level to enter expert tools, continue:

7. Select: Analyse tools
8. Select: Gradient chain tests

The following appears on the screen (default):

GCT: meas mode	Test	_______________	status, test, expert
GCT: test list	->	no_test ... load_R_&_L	

Change GCT: meas mode test into expert <return>

The following appears on the screen (default):

GCT: meas mode	expert	_______________	status, test, expert
GCT: view mode	monitor	_______________	monitor, test
GCT: test	no_test	_______________	user_define ... load_R_&_L

Now change GCT: test no_test into user_define <return>

NOTE

Gradient configuration dependent parameters (e.g. 'gradient strength' and 'grad. slopes') are automatically set to the corresponding default value. Therefore some parameters can differ from the list below.

Change of the **bold** printed parameters like this:

GCT: meas mode	expert	_______________	status, test, expert
GCT: view mode	monitor	_______________	monitor, test
GCT: test	user_define	_______________	user_define ... load_R_&_L
GCT: test meas nr	0	_______________	0 - 3
GCT: power mode	**Low**	_______________	**Low, High**
GCT: amplifiers enabled	All	_______________	None, All
select the channel under test: X, Y or Z			
GCT: channel	**x only**	_______________	**x only, y only ..simultaneous**
GCT: strength [mT/m]	0.0000	_______________	-15.0000 - 15.0000
GCT: demand input [V]	0.0000	_______________	-8.6364 - 8.6364
GCT: output current [A]	0.0000	_______________	-427.5000 - 427.5000

GCT: grad. duration [ms]	**5.00**	________________	**2.00 - 10000.00**
GCT: grad. slopes [ms]	0.60	________________	0.10 - 1.25
GCT: repetition time [ms]	**170.00**	________________	**155.00 - 20000.00**
GCT: meas. start [ms]	0.00	________________	-2.00 - 10000.00
GCT: meas. duration [ms]	54.00	________________	2.05 - 1000.00
GCT: signal	**none**	________________	**none ... module temp**
GCT: section	**none**	________________	**none, controller, x, y, z, x/y/z**
GCT: signal filter	OFF	________________	OFF, ON
GCT: signal gain	OFF	________________	OFF, ON
GCT: signal reference	none	________________	none, dac x, dac y, dac z
GCT: signal averages	1	________________	1 - 100
GR ampl. faults?	disabled	________________	enabled, disabled
Grad. Amplifier reset?	yes	________________	no, yes

9. Select: <Proceed>
10. Press: <Return> to start the measurement

4 ADJUSTMENT PROCEDURES

Procedure to start ASW (R5.x to R9.x):
1. Logon: **Gyroscan**
2. **Continue with the required test.**

Procedure to start ASW (R10 ->)
1. Logon: **MR Service** + **Password** (Case sensitive)
2. Select: **Intera** in the MR Boot Configuration manager and press **Start**
3. **Continue with the required test.**

Additional for R11:
When the ASW is started up set the scan definition context to scan list.
4. Select: **System → Scan Definition Context → Scan List**

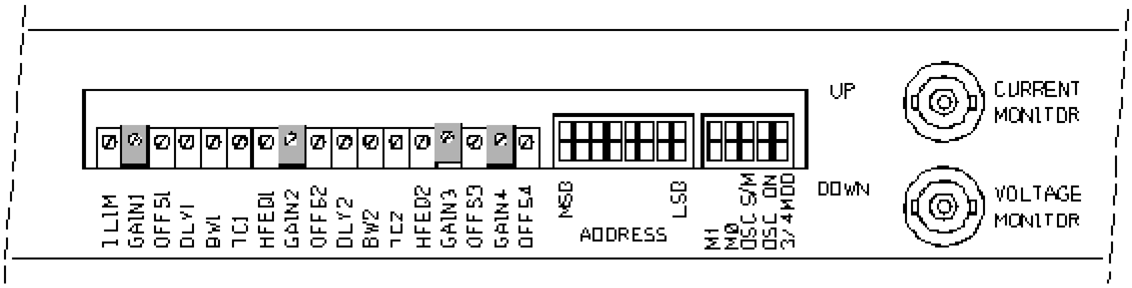
NOTE

For monitor setup in the technical room, refer to paragraph 6.8.

4.1 ILIM CURRENT ADJUSTMENT POTENTIOMETER

With the Ilim potentiometer you can adjust the maximum output current of an axis amplifier.
The Ilim potentiometer in all the Copley 274 controllers, should always be set **fully clockwise** for all system configurations. This to ensure the maximum possible output current of the gradient amplifier.

Figure 16 – The ILIM potentiometer



4.2 COPLEY 274 OFFSET (RELEASE 5.X – 8.X)

To do this adjustment, a dongle access level 2 is required.
11. Select: Scan Control
12. Select: Scan Utilities
13. Enter: Service mode
14. Select: System Tuning
15. Select: System tuning tools
16. Select: Expert tools

If you are running R6.1.2 or higher the system responds with the following message:

....

You enter a service protected function.

Performing checks and/or adjustments and/or modifying any of the involved parameters affects the imaging capabilities of the Gyroscan system. This may only be performed by persons licensed by Philips Medical Systems.

When you have the right dongle access level to enter expert tools, continue:

17. Select: Analyse tools
18. Select: Gradient chain tests

The following appears on the screen (default):

GCT: meas mode	Test	______________	status, test, expert
GCT: test list	->	no_test ... load_R_&_L	

Change GCT: meas mode test into expert <return>

The following appears on the screen (default):

GCT: meas mode	expert	______________	status, test, expert
GCT: view mode	monitor	______________	monitor, test
GCT: test	no_test	______________	user_define ... load_R_&_L

Now change GCT: test no_test into user_define <return>

NOTE

Gradient configuration dependent parameters (e.g. 'gradient strength' and 'grad. slopes') are automatically set to the corresponding default value. Therefore some parameters can differ from the list below.

Change of the **bold** printed parameters like this:

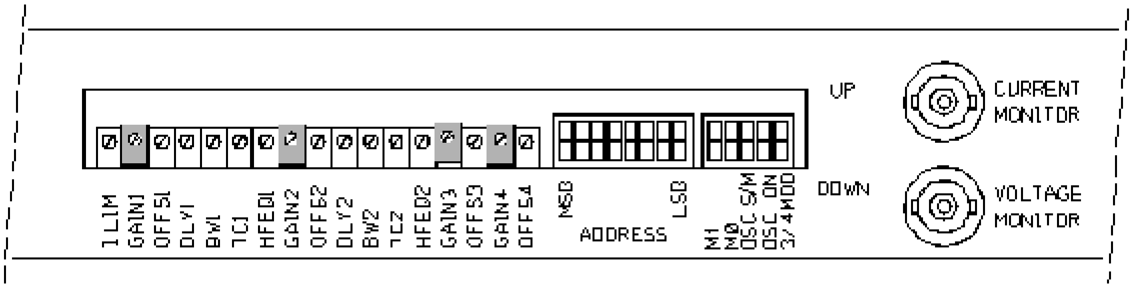
GCT: meas mode	expert	______________	status, test, expert
GCT: view mode	monitor	______________	monitor, test
GCT: test	user_define	______________	user_define ... load_R_&_L
GCT: test meas nr	0	______________	0 - 3
GCT: power mode	**Low**	______________	**Low, High**
GCT: amplifiers enabled	All	______________	None, All
select the channel under test: X, Y or Z			
GCT: channel	**x only**	______________	**x only, y only ..simultaneous**
GCT: strength [mT/m]	0.0000	______________	-15.0000 - 15.0000
GCT: demand input [V]	0.0000	______________	-8.6364 - 8.6364
GCT: output current [A]	0.0000	______________	-427.5000 - 427.5000
GCT: grad. duration [ms]	**5.00**	______________	**2.00 - 10000.00**
GCT: grad. slopes [ms]	0.60	______________	0.10 - 1.25
GCT: repetition time [ms]	**170.00**	______________	**155.00 - 20000.00**
GCT: meas. start [ms]	0.00	______________	-2.00 - 10000.00
GCT: meas. duration [ms]	54.00	______________	2.05 - 1000.00
GCT: signal	**none**	______________	**none ... module temp**
GCT: section	**none**	______________	**none, controller, x, y, z, x/y/z**
GCT: signal filter	OFF	______________	OFF, ON
GCT: signal gain	OFF	______________	OFF, ON
GCT: signal reference	none	______________	none, dac x, dac y, dac z
GCT: signal averages	1	______________	1 - 100
GR ampl. faults?	disabled	______________	enabled, disabled
Grad. Amplifier reset?	yes	______________	no, yes

19. Select: <Proceed>
20. Press: <Return> to start the measurement

Measure the offset of the selected axis on the BNC connector 'current monitor' of the Copley controller with a DVM.
Adjust the offset value to 0 +/- 1mV.

For PT1000A, PT6000 and Intera Master, use the offs2 potentiometer on the Copley controller.
For PT3000 and Intera Power, use the offs1 potentiometer on the Copley controller.

Figure 17 - offs1 and offs2 potentiometers



4.3 COPLEY 274 GAIN (OUTPUT CURRENT) (RELEASE 5.X – 8.X)

WARNING

The noise level in front of the Copley 274 is very high (approximately 84 dB).
Hearing protection must be used !

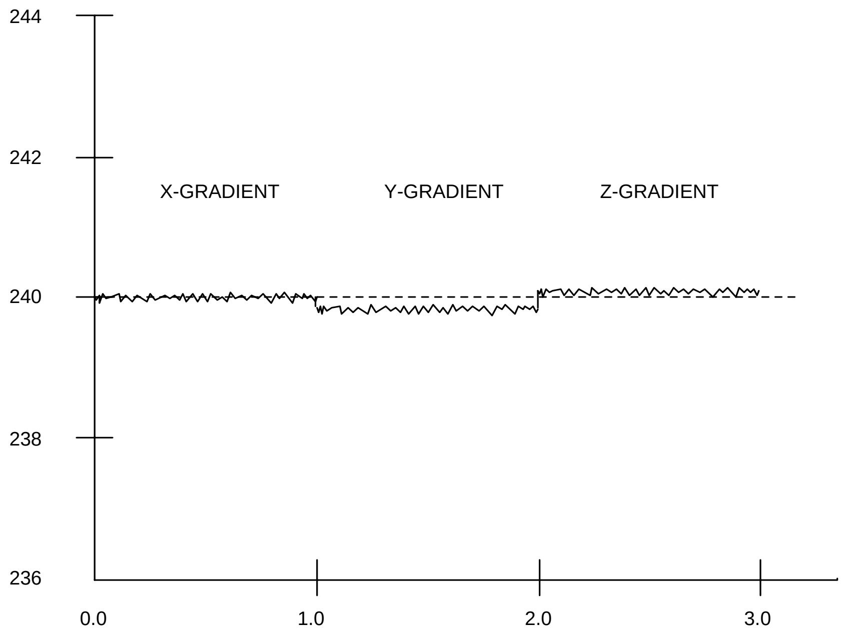
4.3.1 PT1000A / PT3000 / INTERA POWER GRADIENT GAIN (OUTPUT CURRENT)

The 'gradient current adjustment' procedure is used to check/adjust the gain of each Copley 274 axis amplifier. The test uses a demand signal that produces a coil current of 240 A with a tolerance of ± 3.6 A in each channel. The three axis currents are measured and the results are displayed on the console monitor.

Condition: The RF door should be closed.

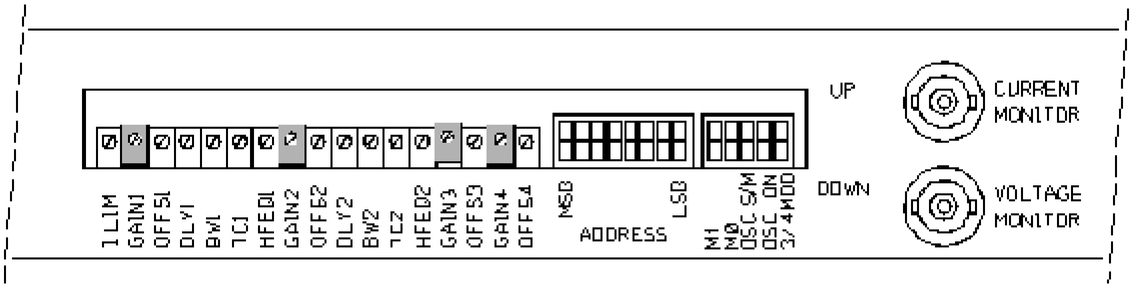
Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures
8. Select: Gradient current adjustment.
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.

Figure 18 - Gradient current output for a single mode system



The adjustment of the currents is done with the 'GAIN1' potentiometer of the corresponding Copley 274 controller. See Figure 19.

Figure 19 - 'GAIN1' potentiometer location Copley-274 Controller



When the three currents are in specification, preferably as close as possible to the 240 A value:
10. Enter: Exit
11. Select: <Cancel> Twice To exit the 'gradient adjustment procedures' menu.

4.3.2 PT6000 / INTERA MASTER GRADIENT GAIN (OUTPUT CURRENT)

The 'gradient current adjustment' procedure is used to check/adjust the gain setting of the Copley 274 axis amplifiers. The test uses a demand signal that should produce a coil current of 240 A with a tolerance of ± 3.6 A in each channel. The six axis currents are measured and the results are displayed on the console monitor.

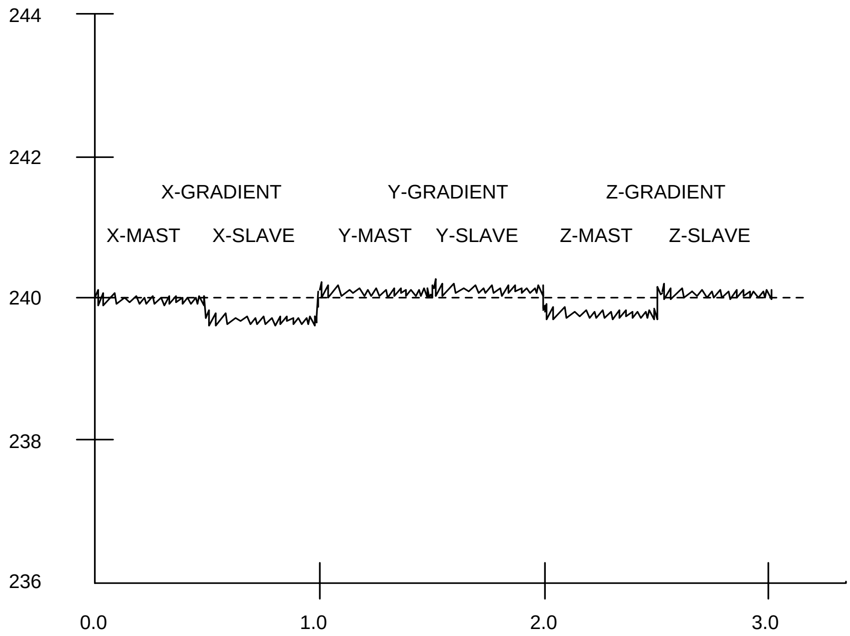
NOTE

It is advised to adjust the output current of the master axis and the slave axis (for X,Y and Z) as close as possible to the same level of output current. See the Y-gradient in Figure 20*, which is adjusted correctly. This will make it much easier to adjust the settling and dual delay. These two adjustments are described later on in this document.*

Condition: The RF door should be closed.

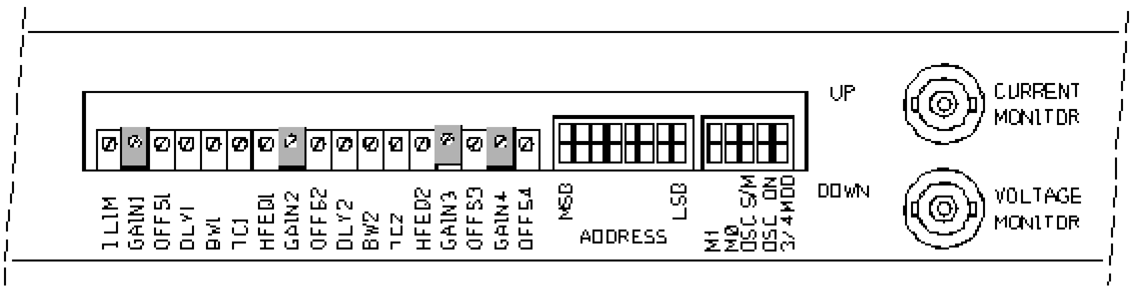
Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures
8. Select: Gradient current adjustment.
   An information screen is displayed. Follow the screen messages.
9. Select: <Proceed> To start the measurement.

Figure 20 – The gradient current output for a dual mode system



The adjustment of the currents is done with the 'GAIN2' potentiometer of the corresponding Copley 274 controller. See Figure 21.

Figure 21 - 'GAIN2' potentiometer location Copley-274 Controller



When the six currents are in specification, preferably as close as possible to the 240 A value:

10. Enter: Exit
11. Select: <Cancel> Twice To exit the 'gradient adjustment procedures' menu.

4.4 COPLEY 274 GAIN & OFFSET, RELEASE 9.X, ->

WARNING

The noise level in front of the Copley 274 is very high (approximately 84 dB).
Hearing protection must be used !

This procedure is used to check/adjust the gain and offset settings of the gradient amplifier. A bipolar gradient pulse is generated while the input and the output signal of the gradient amplifier are measured.
For each channel the offset and the gain is calculated and shown at the measurement information window.
At the monitoring windows resp. the measured gains and the measured offsets are displayed from left to right: X, Y and Z.

NOTE

During the measurement the eddy current compensation, filters are switched off.
No SW compensation for gradient gain and gradient offset will be done, i.e. the corresponding tuned HW parameters are NOT used.

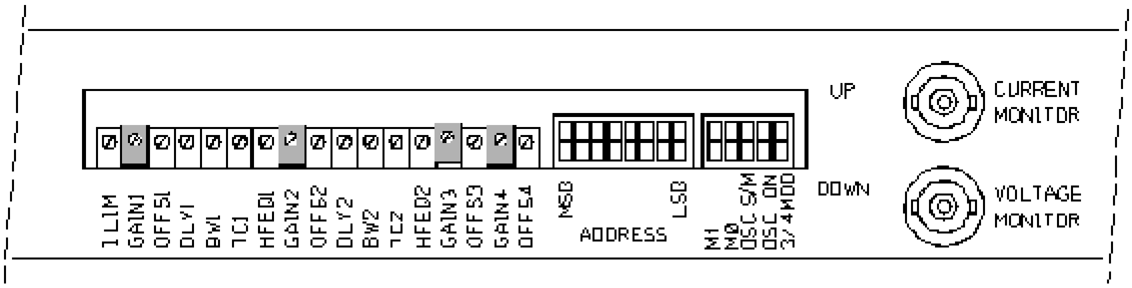
4.4.1 INTERA POWER GRADIENT GAIN & OFFSET ADJUSTMENT

Condition: The RF door should be closed.

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures
8. Select: Gradient ampl. gain/offset adjustment
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.

The adjustment of the gain is done with the 'GAIN1' potentiometer and the adjustment of the offset is done with the 'OFFS1' potentiometer, both of the corresponding Copley 274 controller. See Figure 22.

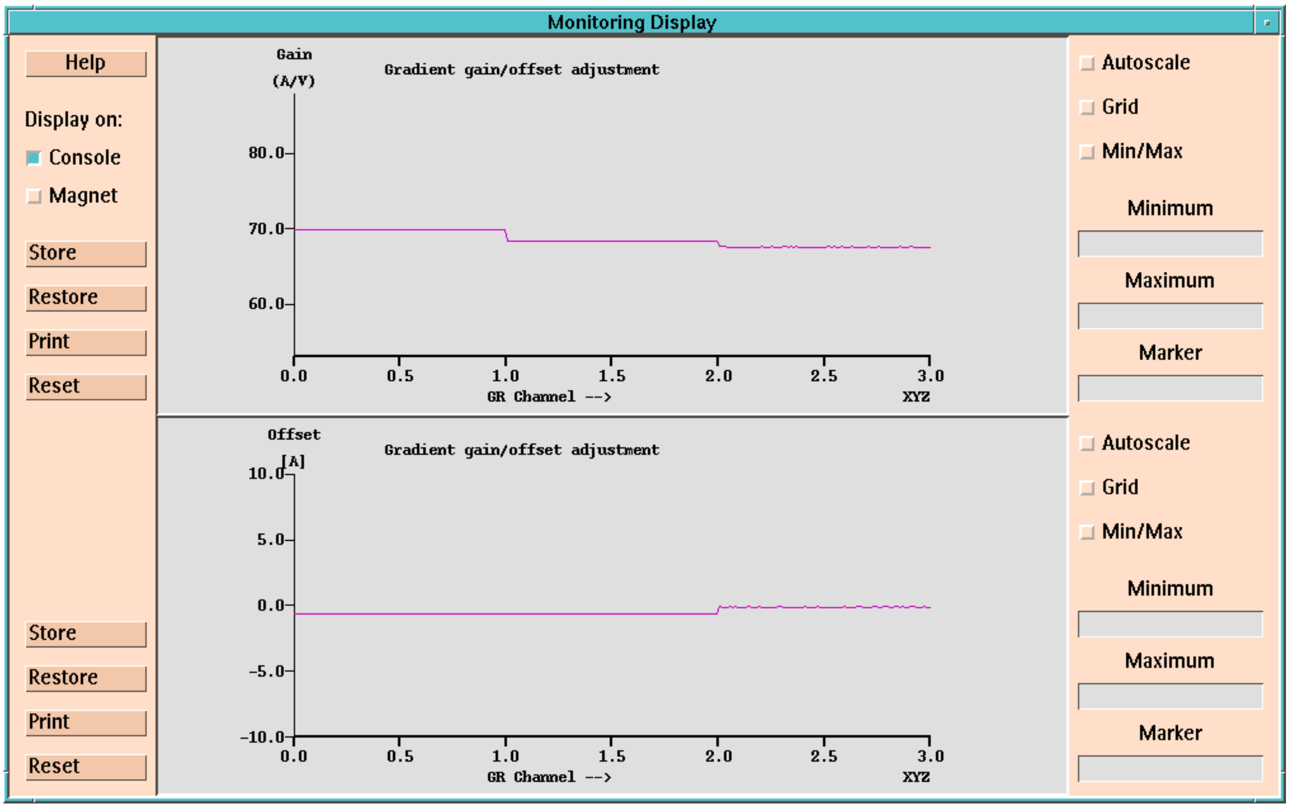
Figure 22 - 'GAIN1' and 'OFFS1" potentiometer location Copley-274 Controller



For all channels, the gain values must be adjusted to 70 A/V +/- 1 A/V the offset must be adjusted to 0 A +/- 0.5 A. See Figure 23.

When the three gains and offsets are within specification, continue:
10. Enter: Exit
11. Select: <Cancel> Twice To exit the 'gradient adjustment procedures' menu.

Figure 23 - Gradient gain and offset for a single mode system



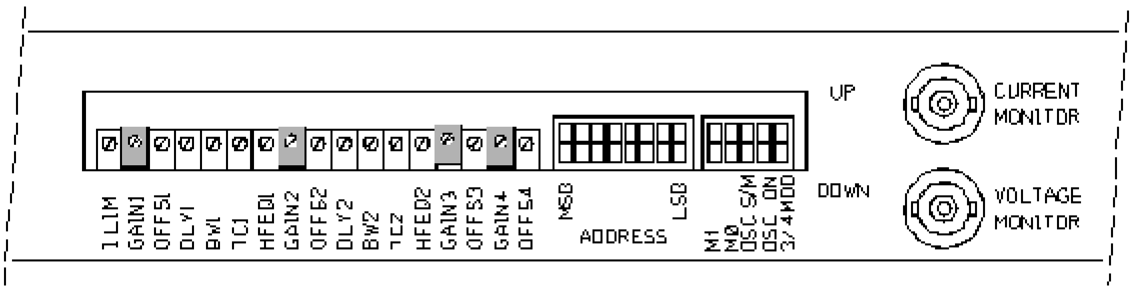
4.4.2 INTERA MASTER GRADIENT GAIN & OFFSET ADJUSTMENT

Condition: The RF door should be closed.

Procedure:
1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures
8. Select: Gradient ampl. gain/offset adjustment
   An information screen is displayed.
9. Select: <Proceed> To start the measurement.

The adjustment of the gain is done with the 'GAIN2' potentiometers and the adjustment of the offset is done with the 'OFFS2' potentiometers, both of the corresponding Copley 274 controllers in the master rack and in the slave rack. See Figure 24.

Figure 24 - 'GAIN2' and ‘OFFS2” potentiometer location Copley-274 Controller



For all channels, the gain values must be adjusted to 70 A/V +/- 1 A/V the offset must be adjusted to 0 A +/- 0.5 A. See Figure 25 and Figure 26.

NOTE

It is advised to adjust the output current of the master axis and the slave axis (for X,Y and Z) as close as possible to the same level of output current. See Figure 26*. This will make it much easier to adjust the settling and dual delay, which are described later on in this document.*

When the three gains and offsets are within specification, continue:
10. Enter: Exit
11. Select: <Cancel> Twice To exit the 'gradient adjustment procedures' menu.

Figure 25 – Gain and offset before adjustment

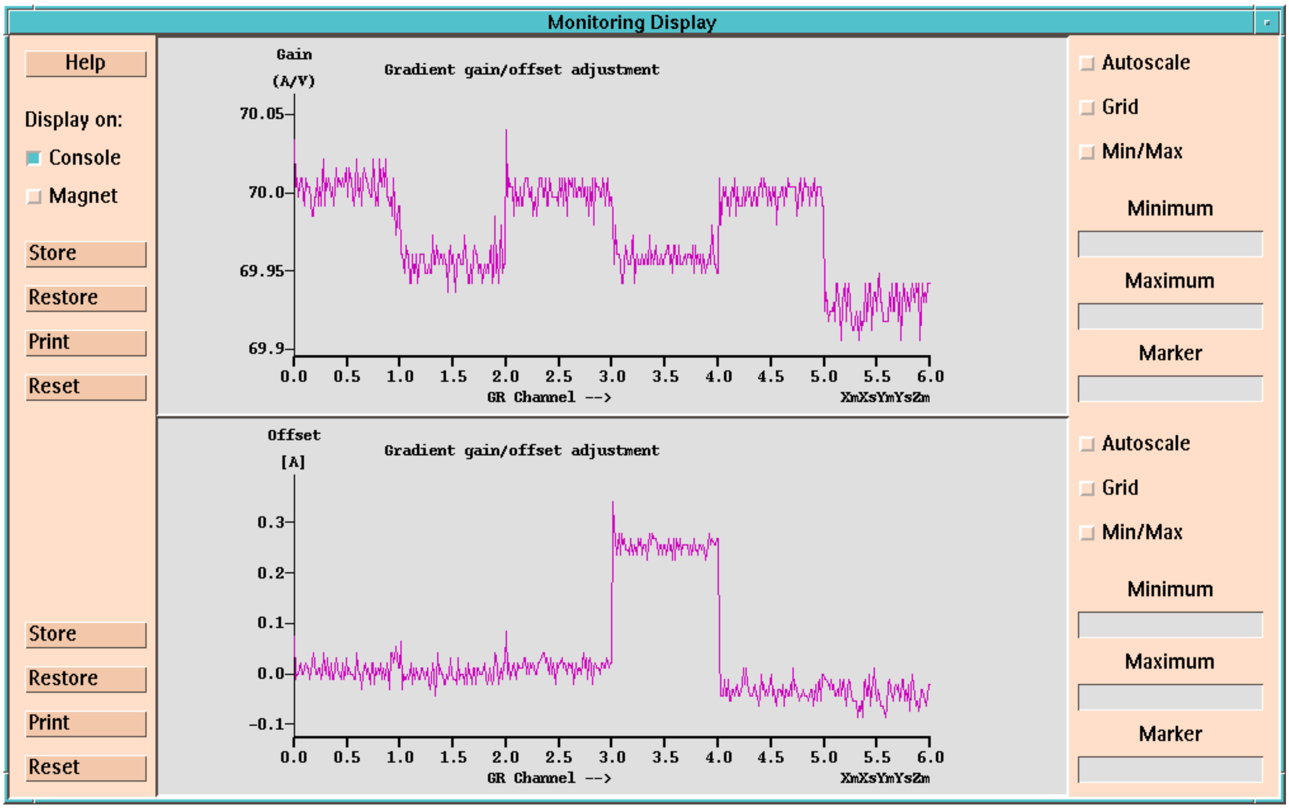
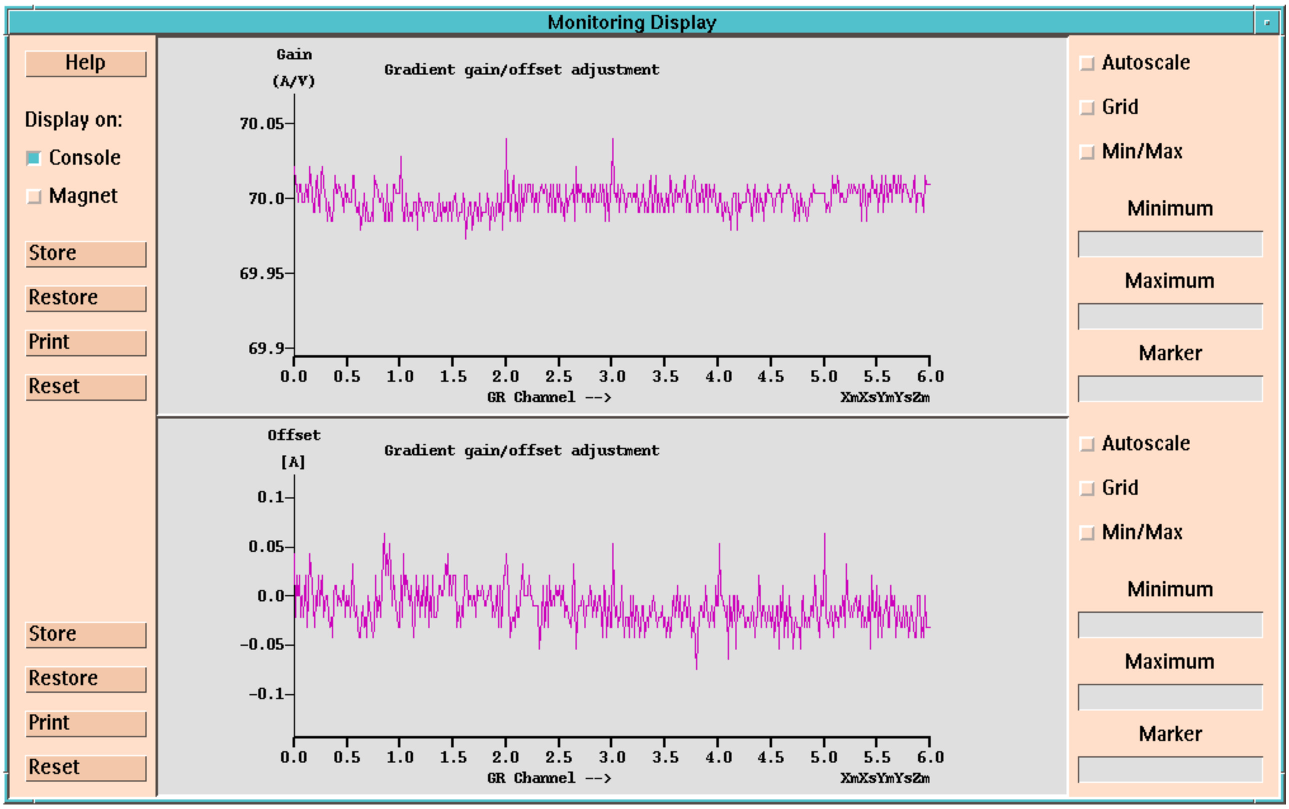


Figure 26 - Gain and offset adjusted

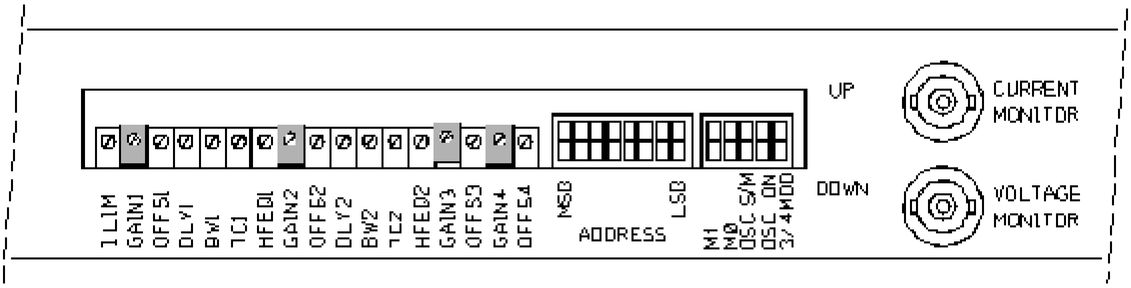


4.5 SETTLING PT1000A

The settling adjustment procedure is not applicable for the PT1000A. Only check the following potentiometers on the X,Y and Z Copley 274 controllers (see Figure 27):

1. Potentiometer DLY2 fully clockwise (20 turns potentiometer, no end stop).
2. Potentiometer BW2 fully clockwise (20 turns potentiometer, no end stop).
3. Potentiometer TC2 fully clockwise (20 turns potentiometer, no end stop).
4. Potentiometer HFEQ2 fully clockwise (20 turns potentiometer, no end stop).

Figure 27 - DLY2, HFEQ2, TC2 and BW2 potentiometers location Copley 274 Controller



4.6 SETTLING PT3000 / INTERA POWER OR PT6000 / INTERA MASTER

Condition: Both the offset and the gain must be in specification.
See paragraph 4.2, 4.3 and 4.4.

The settling procedure monitors the gradient current and the difference between the actually measured gradient current value and a reference gradient current curve.

Procedure:
Place the monitor or the LCD screen inside the technical room near the gradient amplifier.
Extend the mouse and keyboard cables, so that you can operate the system directly from the technical room.

WARNING

The noise level in front of the Copley 274 is very high (approximately 84 dB).
Hearing protection must be used !

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures
8. Select: Settling adjustment
   An information screen is displayed. Follow the screen messages.
9. Select: <Proceed> To start the measurement.

   Two signals are displayed:
   - The real gradient response (upper half = signal 1).
   - The difference signal (lower half = signal 2).
   The difference signal is calculated by the computer as the difference between a **reference** gradient response and the **real** gradient response.
   See figures:
   Figure 30 and Figure 33.
   The purpose of this adjustment is to adjust this difference signal as good as possible to ‘0’ over the entire range.

10. Select: <Display grad>
11. Select: <Mod display>
    Change/check

monitoring mode	both
Raw data file logging	no
identifier of signal 1	Tr
sig 1: horizontal min	0
sig 1: horizontal max	2.1
sig 1: vertical min	98.0
sig 1: vertical max	101.0
sig 1: marker line	no

Changing sig. 2 settings here is not possible.
(lines are overwritten by the test results from the running test).
Select: <Proceed>

To zoom in on a part of the signal 2 display, drag the desired window by moving the mouse, with the left mouse button pressed, over the signal part of interest, or just toggle the auto scale button on and off again.

By clicking the reset button, your original signal will return on the screen.

Depending on the gradient configuration, continue with one of the following adjustment procedures:
See paragraph 4.6.1.

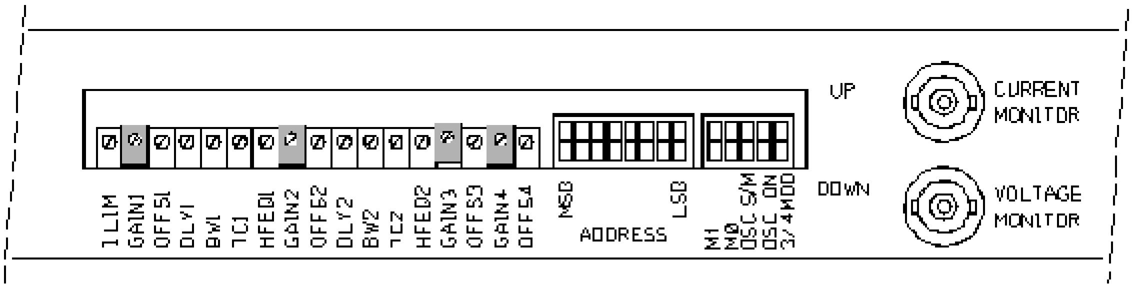
4.6.1 SETTLING PT3000 / INTERA POWER

1. Set the following X (Y, Z) controller potentiometers in their initial position (all are 20 turns potentiometers, no end stop). See Figure 28:
   - Turn the potentiometer ILIM fully clockwise (if not already done).
   - Turn the potentiometer DLY1 fully counter-clockwise .
   - Turn the potentiometer HFEQ1 fully clockwise, then 2 turns counter-clockwise.
   - Turn the potentiometer TC1 fully clockwise.
   - Turn the potentiometer BW1 fully clockwise.

To start the measurement:

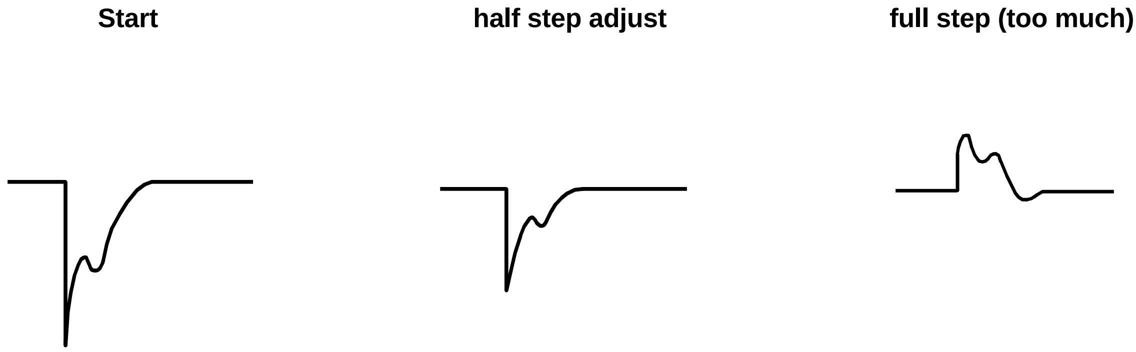
2. Enter: X (Y, Z)

Figure 28 - 'BW1', 'TC1' and 'HFEQ1' potentiometers location Copley 274 Controller



3. Adjust the difference signal, with potentiometers TC1 and BW1 on the X Copley 274 controller. See Figure 29.

Figure 29 - Adjustment principle



Adjustment information:
Notice that it is very easy to 'over-adjust' the settling signal if you adjust in larger steps. The signal can be decreased until an optimum; beyond this point the signal will increase again and you will have to start over from the default settings.

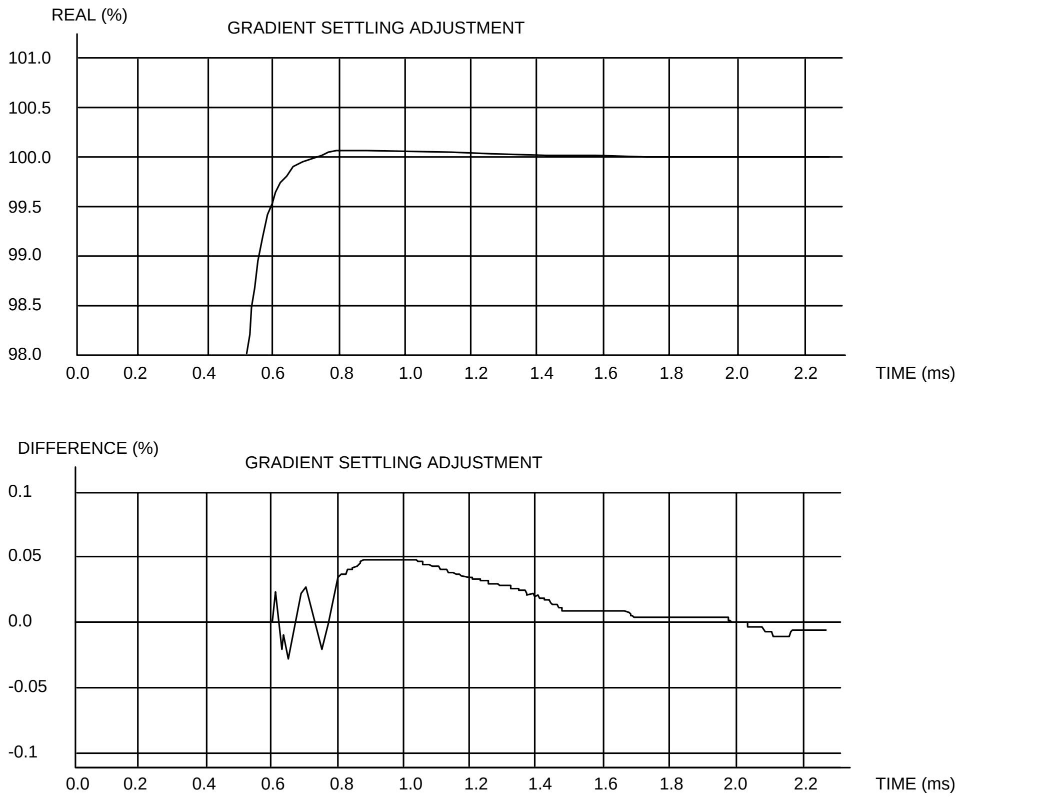
Start with potentiometer BW1 and adjust the flat line to almost 0% by turning it slightly counter-clockwise, while the other part of the signal will increase. Throughout the adjustment try to keep the negative peak in the

negative zone, otherwise the signal flips into the positive zone. Work in 'half steps' and stay in the negative zone.
Turn potentiometer TC1 slightly counter-clockwise until the corresponding other part of the signal is halved ('halve step'). The BW1-affected part of the signal will increase, but will stay below the starting value. Now adjust the signal further down with 'half steps' using potentiometers BW1 and TC1 subsequently until both signal parts are smaller than 0.10%. Try to get the signal within half spec, if possible within reasonable time. If you cannot meet the specification, adjust potentiometer HFEQ1 just one turn counter-clockwise. Repeat the adjustment of the potentiometers BW1 and TC1.
Refer to the text on the screen for the actual values.
These values are displayed in the line starting with: 'Small spec.'.

Now you have to check the 'real' signal (see the upper signal in Figure 30).
Overshoots above 100% level near the end of the slope, can result in a scan abort, followed by a shutdown of the gradient amplifier because of signal errors. A too slow response can cause gradient strength performance problems, which also can result in a scan abort, followed by a shutdown of the gradient amplifier because of signal errors. You cannot see this part of the signal in the difference signal, because the software does not display the slope information in the difference signal.

4. Verify that the real signal is more or less alike the upper signal in Figure 30.
   If not, use the potentiometer HFEQ1 to adjust the real signal more or less alike the upper signal in Figure 30 and keep the difference signal within spec with the potentiometers BW1 and TC1.

Figure 30 - monitoring screen Intera POWER



If the X settling is within specification, repeat the entire procedure for the two remaining axis from point ‘1’, by entering ‘Y’ or ‘Z’.

When all three axes are adjusted:

5. Enter: Exit

6. The final settling adjustment check will check each channel successively.
   In case of an error message, the operator must enter: <RETURN>.
   The program will continue the check until the next error message appears or all channels are done.
   The program is ready, when the 'gradient adjustment procedures' menu is displayed again.
7. If no error messages were seen, the adjustment was done successfully. An MRL is available.
   If an error message was seen, repeat the adjustment for the failing channel(s).

4.6.2 SETTLING PT6000 / INTERA MASTER

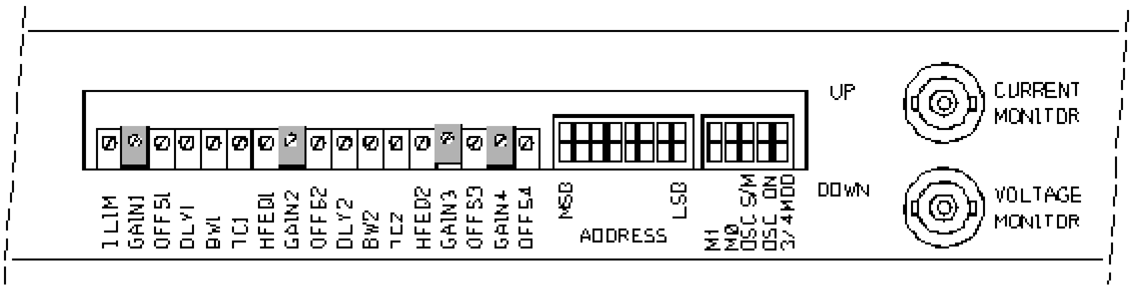
The following initial potentiometer settings are to be set on both the master cabinet and the slave cabinet. Start the adjustments however, **on the master cabinet** of the Intera MASTER configuration. This is the cabinet with the gradient interface rack.

1. Set the following X (Y, Z) master controller potentiometers **AND** slave controller potentiometers in their initial position (all are 20 turns potentiometers, no end stop). See Figure 31:
   - Turn the potentiometer ILIM fully clockwise (if not already done).
   - Turn the potentiometer DLY2 fully counter-clockwise .
   - Turn the potentiometer HFEQ2 fully clockwise, then 2 turns counter-clockwise.
   - Turn the potentiometer TC2 fully clockwise.
   - Turn the potentiometer BW2 fully clockwise.

To start the measurement:

2. Enter: X (Y, Z)
3. Enter: Master (The adjustments are now done on the X master Copley-274 controller).

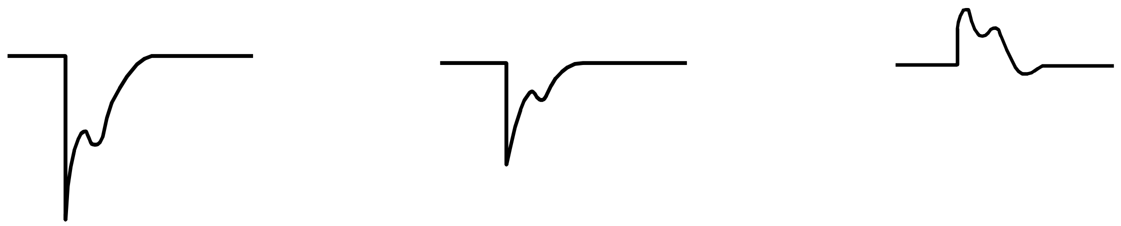
Figure 31 - 'BW2', 'TC2' and 'HFEQ2' potentiometers location Copley-274 Controller



4. Adjust the difference signal, with potentiometers TC2 and BW2 on the X master Copley 274 controller. See Figure 32 for the adjustment principle.

Figure 32 - Adjustment principle

Start	half step adjust	full step (too much)



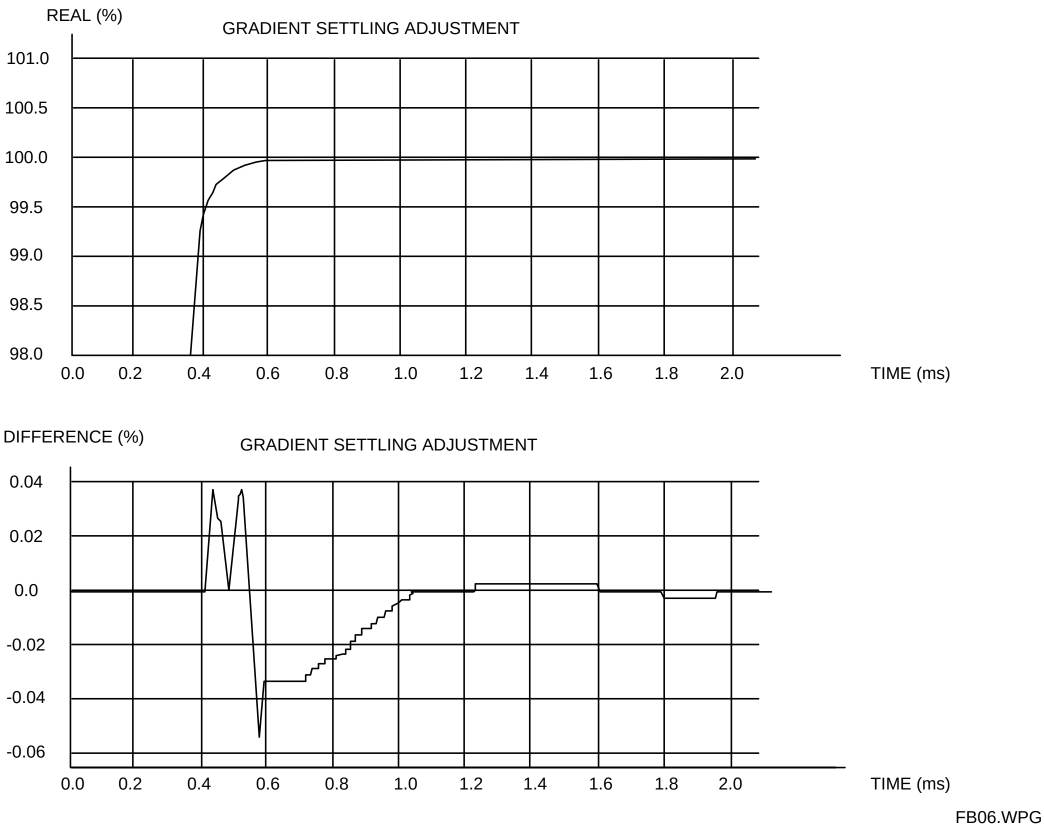
Adjustment information:
Notice that it is very easy to 'over-adjust' the settling signal if you adjust in larger steps. The signal can be decreased until an optimum; beyond this point the signal will increase again and you will have to start over from the default settings.

Start with potentiometer BW2 and adjust the flat line to almost 0% by turning it slightly counter-clockwise, while the other part of the signal will increase. Throughout the adjustment try to keep the negative peak in the negative zone, otherwise the signal flips into the positive zone. Work in 'half steps' and stay in the negative zone.
Turn potentiometer TC2 slightly counter-clockwise until the corresponding other part of the signal is halved ('halve step'). The BW2-affected part of the signal will increase, but will stay below the starting value. Now adjust the signal further down with 'half steps' using potentiometers TC2 and BW2 subsequently until both signal parts are smaller than 0.10%. Try to get the signal within half spec, if possible within reasonable time. If you cannot meet the specification, adjust potentiometer HFEQ2 just one turn counter clockwise. Repeat the adjustment of the potentiometers BW2 and TC2.
Refer to the text on the screen for the actual values.
These values are displayed in the line starting with: 'Small spec.'.

Now you have to check the 'real' signal (see the upper signal in Figure 33).
Overshoots above 100% level near the end of the slope, can result in a scan abort, followed by a shutdown of the gradient amplifier, because of signal errors. A too slow response can cause gradient strength performance problems, which also can result in a scan abort, followed by a shutdown of the gradient amplifier, because of signal errors. You cannot see this part of the signal in the difference signal, because the software does not display the slope information in the difference signal.

5. Verify that the real signal is more or less alike the upper signal in Figure 33.
   If not, use the potentiometer HFEQ2 to adjust the real signal more or less alike the upper signal in Figure 33 and keep the difference signal within spec with the potentiometers BW2 and TC2.

Figure 33 - monitoring screen Intera MASTER



NOTE

If it is not possible to adjust the settling for the master within specification, continue with the slave and return to the master afterwards. After you have adjusted the master check the slave adjustment again!

If the settling for the X master is within specification, proceed with the slave.
The following adjustments are to be done **on the slave cabinet** of the Intera MASTER configuration.

6. Enter: Slave (The adjustments are now done on the X slave Copley-274 controller.)

When done, repeat this procedure for the other axes:

7. The Y master and slave axis.
8. The Z master and slave axis.

When all channels are adjusted:

9. Enter: Exit
10. The final settling adjustment check will check each channel successively.
    In case of an error message, the operator must enter: <RETURN>.
    The program will continue the check until the next error message appears or all channels are done.
    The program is ready, when the 'gradient adjustment procedures' menu is displayed again.
    If no error messages were seen, the adjustment was done successfully. An MRL is available.
    If an error message was seen, repeat the adjustment for the failing channel(s).

4.7 DUAL DELAY PT6000 / INTERA MASTER

4.7.1 INTRODUCTION

The purpose of the 'dual delay adjustment' is to make the output of each slave axis amplifier **identical** to the output of the corresponding master axis amplifier. This is done by measuring the difference in output current of the master and slave amplifier with a dedicated Dual Mode Adjustment Tool (DMAT). This tool is basically a very accurate dual **current probe**. The current difference can be minimized by adjusting the gain2 and the delay potentiometer DLY2 on the **slave cabinet** and, if necessary, on the master cabinet.

Tools:

- Dual Mode Adjustment Tool (DMAT), code number: 8122 102 6441.

Conditions for this adjustment are:

1. The gradient amplifier offset must be in specification.
2. The gradient current has been adjusted.
3. The gradient settling behavior has been adjusted.
4. The gradient orientation must be correct. See paragraph 3.4.
5. The offset of the DMAT is adjusted and stable for at least 15 minutes. (Keep the unit switched on!)

4.7.2 DUAL DELAY MEASUREMENT SET-UP

WARNING

Be aware of the high voltage (420 Volt) present inside the gradient amplifier cabinet(s), on the connections to the gradient coil and the system filter box. Make sure that the AC power has been switched off for at least 2 minutes before starting to work on the gradient chain. It is advised to watch the high voltage value on the EMI 20kW/420V DC power supplies meters and make sure that the supply capacitors have discharged to less than 2 Volt.

1. Place the monitor or the LCD screen inside the technical room near the gradient amplifier.
   Extend the mouse and keyboard cables, so that you can operate the system directly from the technical room.

WARNING

The noise level in front of the Copley 274 is very high. (approximately 84dB).
Hearing protection must be used!

NOTE

Check the mechanical alignment of the knob of the sensitivity switch on the DMAT before you start any adjustment, by trying all possible knob positions!
Misalignment will influence the adjustments!

2. Switch off the gradient amplifiers inside the Mains Distribution Extension (MDE).

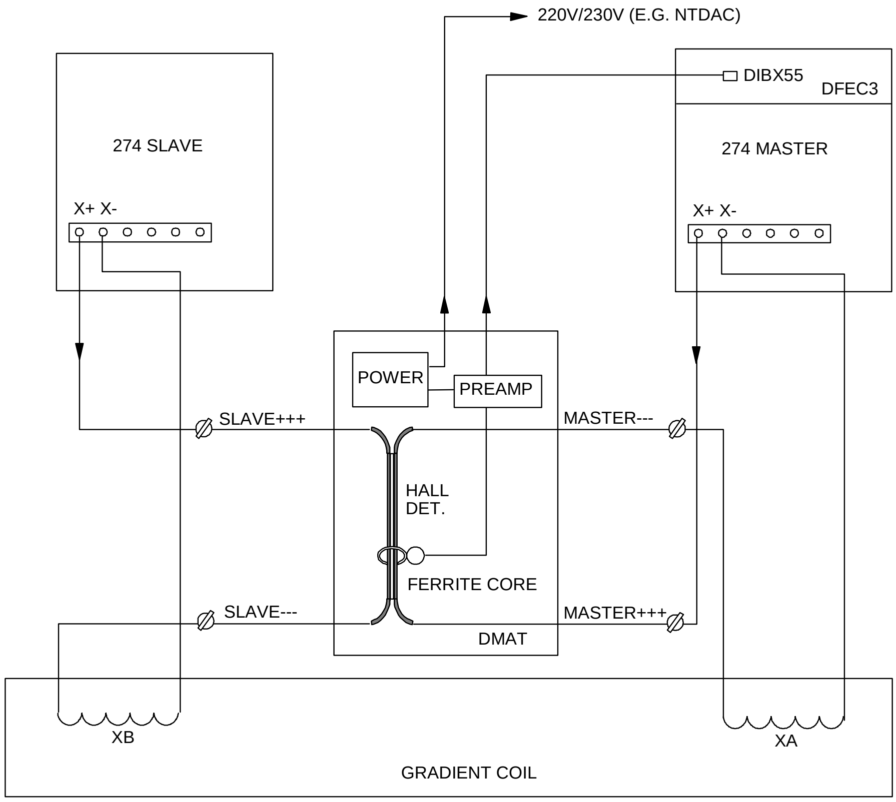
Before starting with the actual measurement, the offset of the DMAT has to be set to zero:

3. Connect the mains cable of the DMAT to a 220V/230V mains supply that is not switched off together with the gradient amplifier (e.g. in the NTDAC).
4. Put the sensitivity switch into position 200 mV/A.
5. Make sure that the 'gradient' cables, belonging to the DMAT, are 'open'. This means that the cable ends do not touch each other.
6. Measure the voltage on the coax output cable with a DMV.
7. Adjust the potentiometer, located on top of the DMAT, until the offset value of the probe is 0 mV +/- 2 mV, with the sensitivity set to 200 mV/A.

WARNING

Be aware of the high voltage (420V) present on the external cables of the DMAT.
Make sure that all connections are insulated before switching on the gradient amplifier.

Figure 34 - Dual Mode Adjustment Tool (DMAT) connections



8. Connect the DMAT in the X chain. See Figure 34.
   - Disconnect the gradient cables from X+ on the master gradient amplifier cabinet.
   - Connect the DMAT cable, marked **master+++**, to X+ on the master gradient amplifier.
   - Slide the delivered rubber sleeve over the cable, marked with green label **master---**. Connect this cable to the gradient cable, which leads to the X coil (already disconnected).
   - Slide the sleeve across the just made connection.
   - Put the test cables in such a way that the rear door of the master cabinet can be closed. Close the rear door of the master cabinet.
   - Disconnect the gradient cables from X+ on the slave gradient amplifier.
   - Connect the DMAT cable, marked **slave+++**, to X+ on the slave gradient amplifier.
   - Slide the delivered rubber sleeve over the cable, marked with blue label **slave---**. Connect this cable to the gradient cable, which leads to the X coil (already disconnected).
   - Slide the sleeve across the just made connection.
   - Put the test cables in such a way that the rear door of the slave cabinet can be closed. Close the rear door of the slave cabinet.
   - Connect the DMAT output BNC cable to DIBX55 at the gradient interface controller board.
9. Switch on the gradient amplifier inside the Mains Distribution Extension (MDE).
10. The gradient amplifiers cabinets are enabled after about 10 seconds.
11. Startup the dual delay adjustment:
    - Select: Scan Control
    - Select: Scan Utilities
    - Select: Enter service mode
    - Select: System tuning
    - Select: System tuning tools
    - Select: Installation procedures
    - Select: Gradient adjustment procedures
    - Select: Dual delay adjustment

    An information screen is displayed.
    - Select: <Proceed>

    Change/check:
    GCA: channel X

NOTE

The DMAT should be switched on for at least 15 minutes, before you start the adjustment, or check the adjustment.

4.7.3 PRE-ADJUSTMENT CHECK

Before starting to adjust the **slave** amplifiers, check if an adjustment is required.
When all specifications are met no adjustments are required.

Procedure:
1. Put the sensitivity switch of the DMAT in position 50 mV/A.
2. Select <Proceed> To start the measurement.
3. Switch on the grid in the monitor display, if not already done.
4. Compare the measured signal with Figure 38.

The signals measured at 0.5, 3.0 and 5.5 ms should have the same amplitude. It is normal to see some small differences (= gain mismatch).

Specification:	gain mismatch	< 10 mV	(Sensitivity switch: 50 mV/A)

Some peaks will be visible. These peaks have a typical amplitude < 60 mV and should be symmetrical around the baseline.

Specification:	slope1_integr.	0 ± 6 uVs	(Sensitivity switch: 50 mV/A)
	slope2_integr.	0 ± 6 uVs	(Sensitivity switch: 50 mV/A)
	max. peak in slope	< 95 mV	(Sensitivity switch: 50 mV/A)

4.7.4 DUAL DELAY

1. Put the sensitivity switch of the DMAT in position 100 mV/A.
   The gain mismatch (= amplitude at 0.5, 3.0 and 5.5 ms) should be visible.

NOTE

Don't use automatic display scaling. Use the 'sensitivity' switch on the current probe to change the amplitude of the monitor signal.

2. Adjust the **slave cabinet** GAIN2 potentiometer in such away that the signal has the same amplitude at 0.5, 3.0 and 5.5 ms. Gain mismatch is then minimal. Increase the sensitivity of the current probe. See Figure 36 and Figure 37 and continue the adjustment. Repeat the adjustment until a sensitivity of 50 mV/A has been reached and the gain mismatch is:
   < 10 mV. (Sensitivity switch: 50 mV/A)

3. Adjust the slope1 integr. and the max. peak values.
   Try to reduce the slope1 integr. (is area of the pulse). Make sure that the signal is symmetrically around the base-line. Differences are caused by the settling behavior of the slave.
   Start the adjustment with the probe sensitivity switch in a position which shows the complete pulse (10 mV/A till 50 mV/A). During the adjustment, the sensitivity can be increased.
   Final adjustment must be done with the switch in position 50 mV/A. Refer to Figure 38 for the final result.
   The adjustment is done with the delay DLY2 potentiometer at the **slave** controller, by turning it clockwise. The start position 'fully counter-clockwise' is already set at the settling adjustment.
   If the signal can not be optimized according to Figure 38, turn the delay potentiometer again fully counter-clockwise to its start position. Then change the setting of the HFEQ2 potentiometer by turning it one turn counter-clockwise and retry to optimize the signal by turning the delay DLY2 potentiometer clockwise at the **slave** controller. If this is still not possible perform this adjustment from the master controller. If adjustment from the master controller is not possible either, it is advised to return to the settling adjustment, verify the adjustment and try to improve the settling.
   Typical peak approx. 60 mV (sensitivity switch: 50 mV/A).

<u>Specification:</u>	gain mismatch	<10 mV	(Sensitivity switch: 50 mV/A)
	slope1_integr.	0 ± 6 uVs	(Sensitivity switch: 50 mV/A)
	slope2_integr.	0 ± 6 uVs	(Sensitivity switch: 50 mV/A)
	max. peak in slope	< 95 mV	(Sensitivity switch: 50 mV/A)

4. If the parameters 'gain mismatch', 'slope1_integr.', 'slope2_integr.' and 'max. peak in slope' are within the specification:
5. Enter: EXIT To stop the measurement.
6. Switch off the gradient amplifier in the MDE.
7. Disconnect the DMAT and connect the gradient coil cables to the gradient amplifier again.
8. Repeat the adjustment for the Y and Z gradient.

Figure 35 - Controller potentiometers

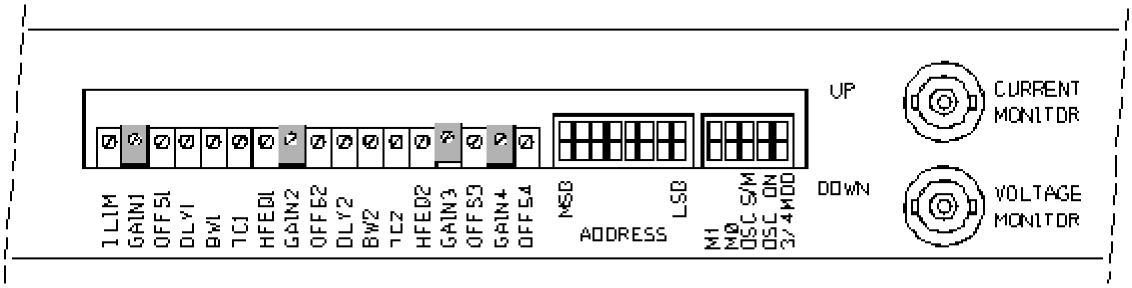


Figure 36 - Monitor signal before the 'GAIN2' adjusted

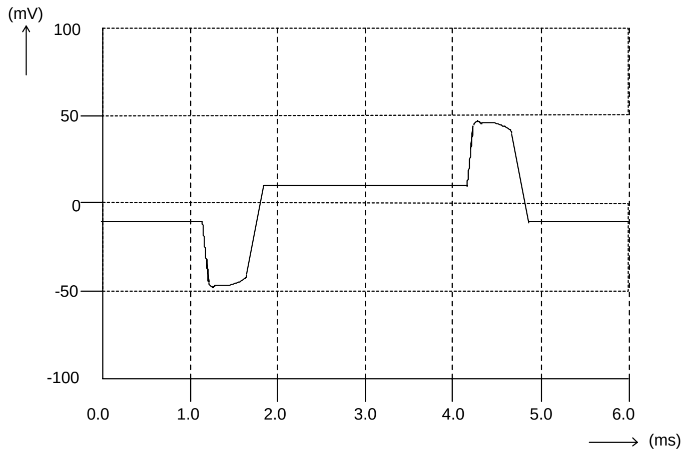


Figure 37 - Monitor signal after 'GAIN2' adjusted

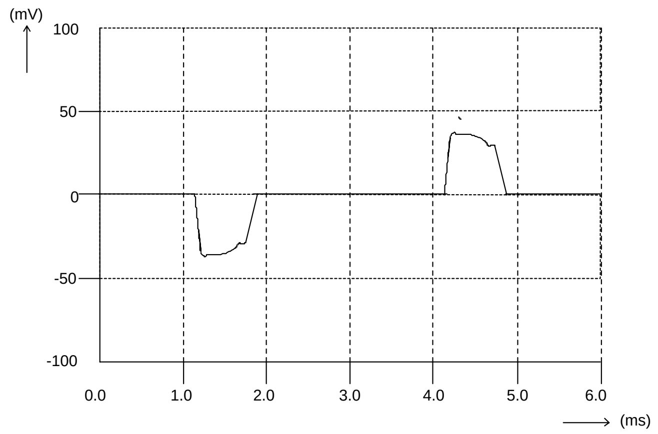
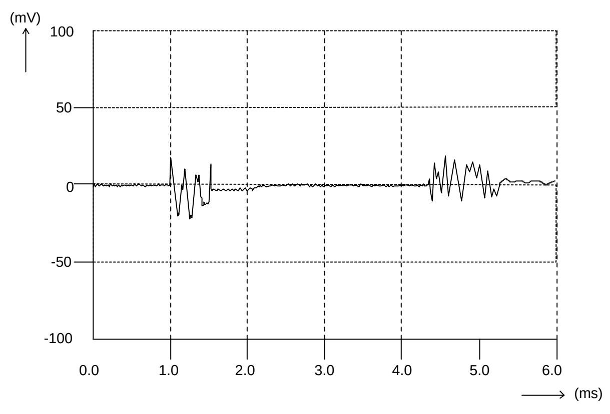


Figure 38 - Final monitor signal, current probe sensitivity set to 50 mV/A



4.8 EDDY CURRENT COMPENSATION

Condition:
1. BDAS and gradient amplifier must have been switched on for at least 30 minutes.
2. The RF amplifier should be switched on.
3. The offset drift of the flux meter is in spec. See 3.5.1.
4. The pick-up coils have been properly positioned. See 3.5.2.
5. A reference measurement has been made. See 3.5.3.

The start-up procedure for the following paragraphs:

1. Select: Scan Control
2. Select: Scan Utilities
3. Select: Enter service mode
4. Select: System tuning
5. Select: System tuning tools
6. Select: Installation procedures
7. Select: Gradient adjustment procedures

4.8.1 WFG/ECC

WARNING

The noise level in front of the Copley 274 is very high (approximately 84dB).
Hearing protection must be used !

NOTE

Do not leave any amplitude A(x) potentiometer in the center (zero) position. This to avoid problems with the next (shorter) time constant.

Try to adjust the eddy current response signal with a minimal use of the time constant (T) potentiometers.
It is advised to adjust the signals as good as possible within specification.

See also Table 9 and Figure 54.

1. Select: Compensate long term eddy current
2. Change/check: Gradient coil Xxx ('xxx' stands for gradient under test.)
   Current ECC settings

1	OFF	2	OFF	3	OFF
4	OFF	5	OFF	6	ON

   Repetition time [ms] 1500
   Pulse duration [ms] 750
   End sampling [ms] 700
3. Select: <Proceed> to start the adjustment of filter 6.
4. Select: <Mod display>
   Change/check:

monitoring mode	both
raw data logging	no
identifier of signal 1	Tavg
sig 1: horizontal min	5.0
sig 1: horizontal max	990
sig 1: vertical min	99.0
sig 1: vertical max	101.0
sig 1: marker line	no
identifier of signal 2	Tdif
sig 2: horizontal min	5.0
sig 2: horizontal max	990
sig 2: vertical min	-1.00
sig 2: vertical max	1.00
sig 2: marker line	no

5. Select: <Proceed>

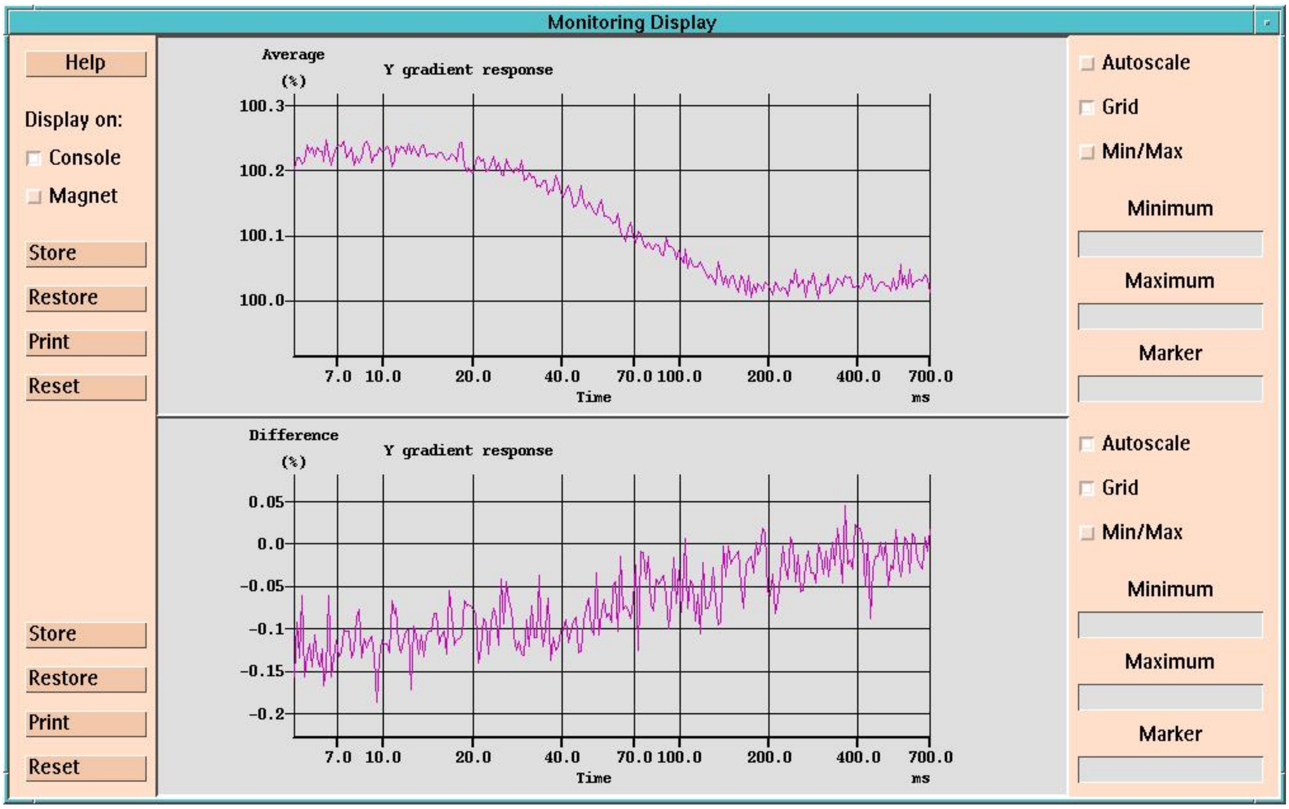
6. **Adjustment of the A6/T6 filter.**
   Check the flatness. **The range of the A6/T6 filter is from 150ms to 700ms.** If the flatness is not correct, improve it by turning only the potentiometer A6 a little bit. **Do not use potentiometer T6 for adjustment, keep it CCW.**
   The flatness should be **< 0.1 %**.

While turning A6 clockwise you are only able to lift the curve up. If already an overshoot exists, use negative compensation by turning A6 counter-clockwise.
If within specifications, continue with the next amplitude and time constant.

NOTE

The shown images are copied from an INTERA MASTER system and are only intended as an example. Do not try to adjust the ECC by copying these shown signals for 100%.

Figure 39 - A6, T6 (150 - 700ms)



When zooming in with the mouse, make sure to zoom in only in the vertical direction. By clicking the reset button, your original signal will return on the screen. This applies to all filter combinations.

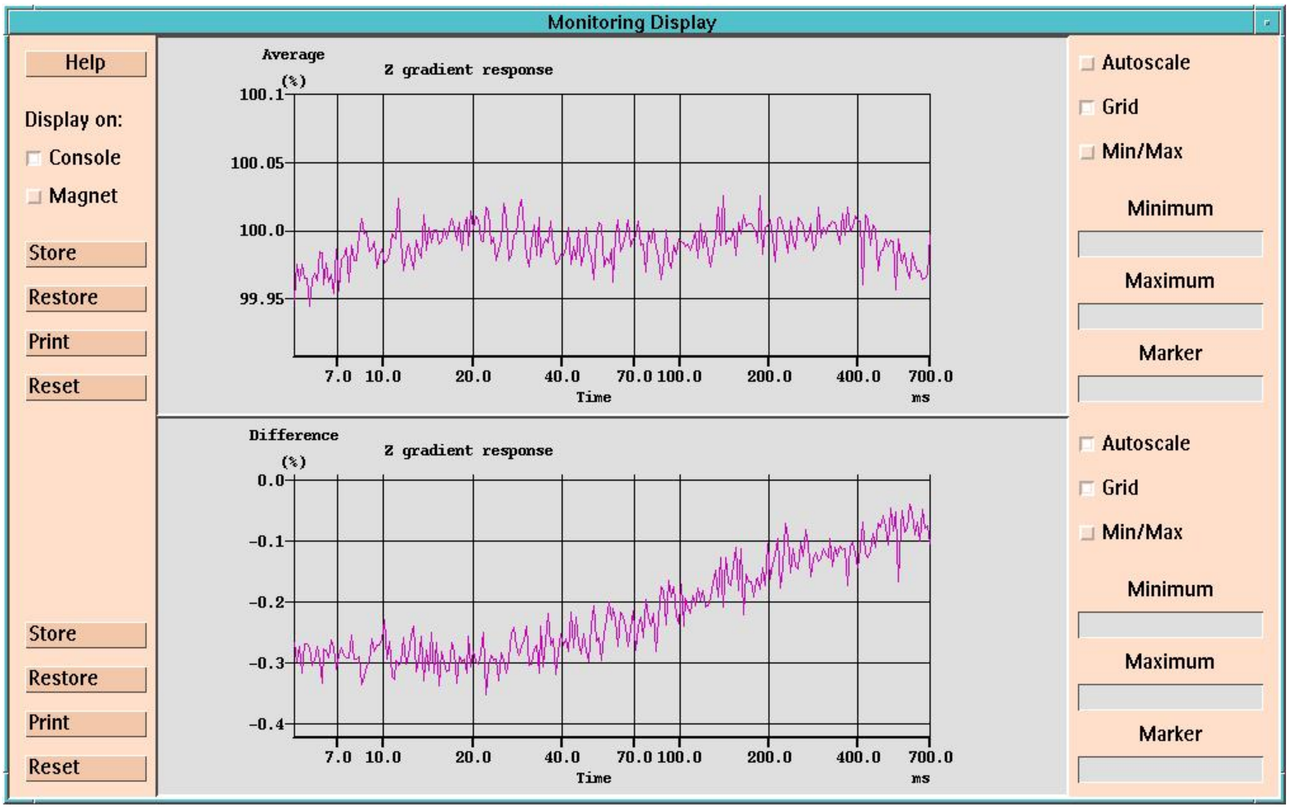
7. Select: <Stop scan>
8. Change/check: Current ECC settings

1	OFF	2	OFF	3	OFF
4	OFF	5	ON	6	ON

9. Select: <Proceed> twice to start the adjustment of filter 5.

10. **Adjustment of the A5/T5 filter.**
Check the flatness. **The range of the A5/T5 filter is from 40 - 150 ms.** If the flatness is not correct try to improve it by turning only the potentiometer A5 a little bit.
Use the potentiometer T5 as minimal as possible.
The flatness should be **< 0.1 %**.
When you do not succeed with this adjustment, turn T5 a half turn bit clockwise and turn A5 clockwise till the last part of the displayed curve is as flat as possible, but at least within the specifications. While turning A5 clockwise you are only able to lift the curve up. If already an overshoot exists, use negative compensation by turning A5 counter-clockwise.
If within specifications, continue with the next amplitude and time constant.

Figure 40 - A5, T5 (40 - 150 ms)



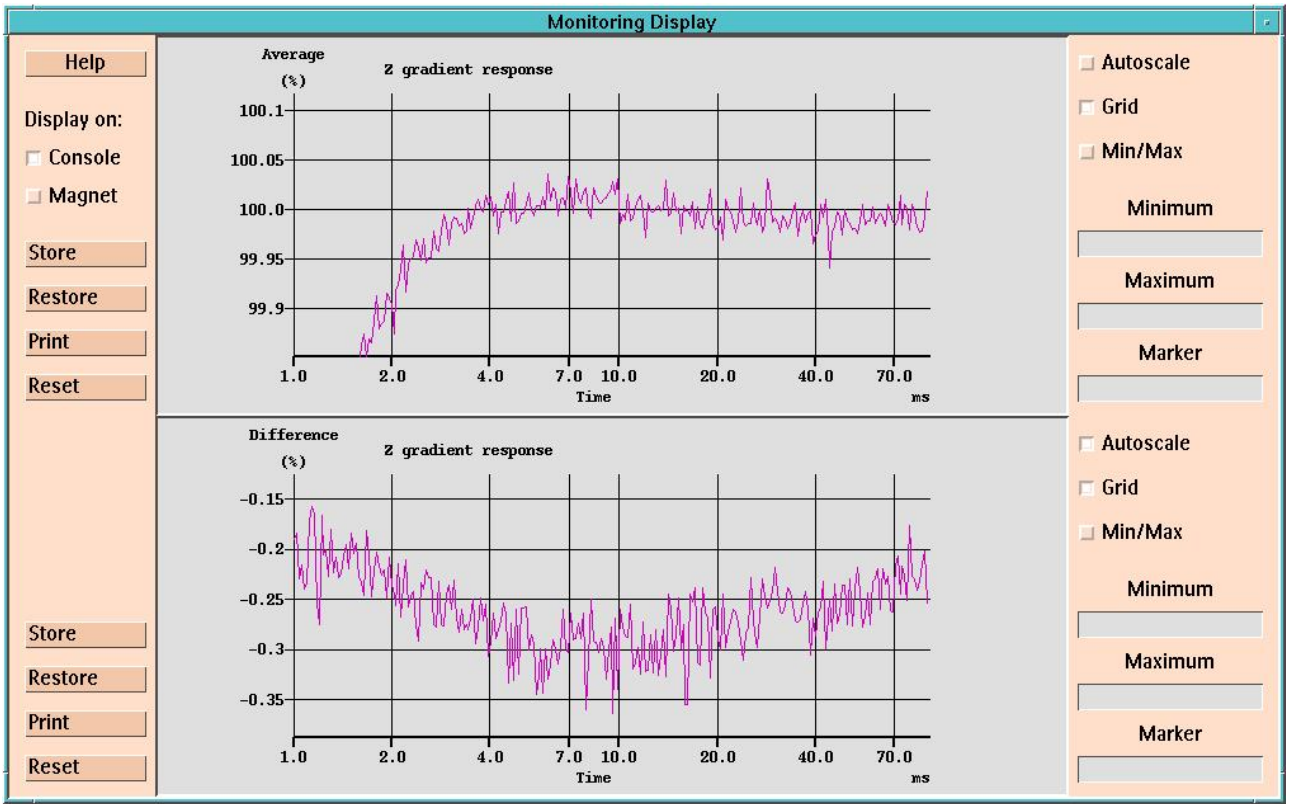
11. Select: <Stop scan>
12. Change/check: Current ECC settings

1	OFF	2	OFF	3	OFF
4	ON	5	ON	6	ON

13. Select: <Proceed> twice to start the adjustment of filter 4.

14. **Adjustment of the A4/T4 filter.**
Check the flatness. **The range of the A4/T4 filter is from 10 - 40 ms.** If the flatness is not correct try to improve it by turning only the potentiometer A4 a little bit. Do not yet touch T4.
The flatness should be **< 0.1 %.**
When you do not succeed with this adjustment, turn T4 a little bit clockwise and turn A4 clockwise till the last part of the displayed curve is flat as possible, but at least within the specifications. While turning A4 clockwise you are only able to lift the curve up. If already an overshoot exists, use negative compensation by turning A4 counter-clockwise.
If within specifications, continue with the next amplitude and time constant.

Figure 41 - A4, T4 (10 - 40 ms)



15. Select: <Stop scan>
16. Select: <Cancel>
17. Select: Compensate mid term eddy current
    An information screen is displayed.
18. Select: <Proceed>
19. Change/check: Current ECC settings

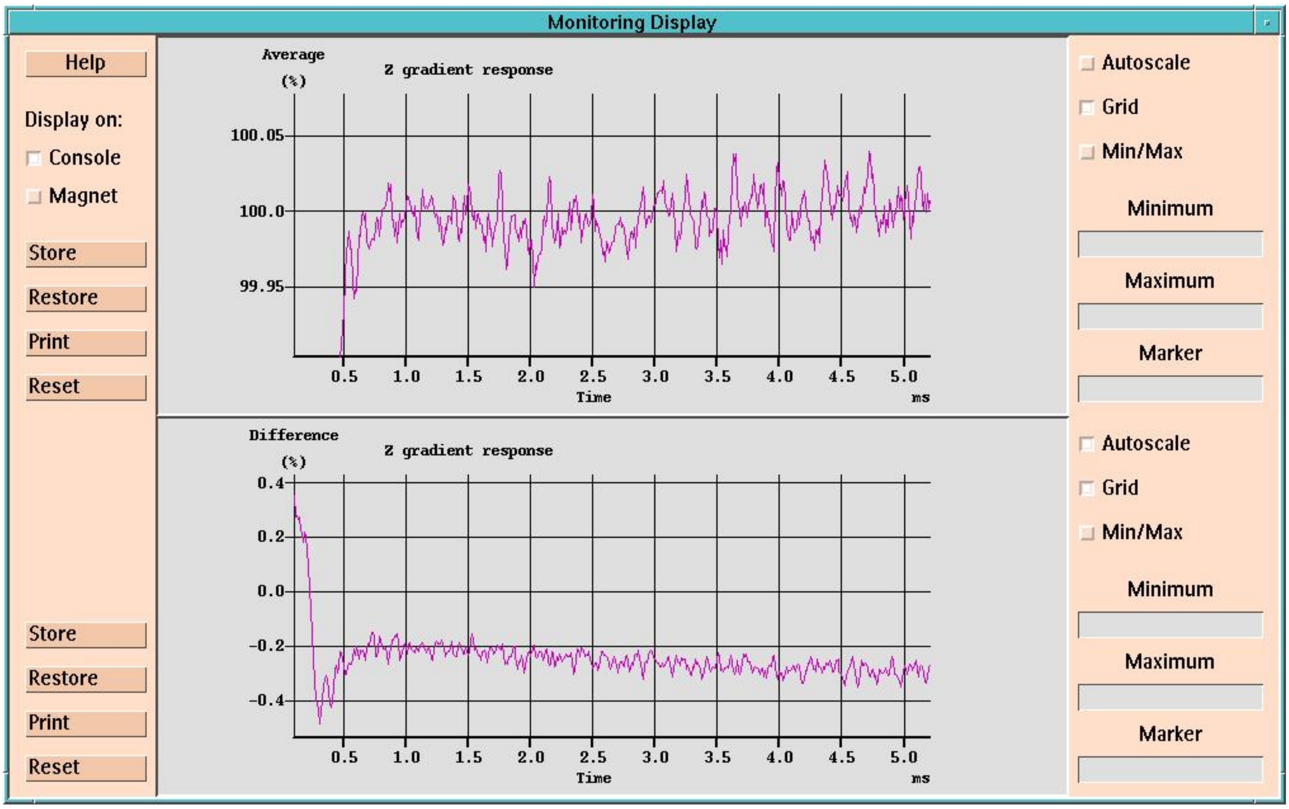
1	OFF	2	OFF	3	ON
4	ON	5	ON	6	ON

20. Select: <Proceed> twice to start the adjustment of filter 3.

21. **Adjustment of the A3/T3 filter.**
    Check the flatness. **The range of the A3/T3 filter is from 2 - 10 ms.** If the flatness is not correct try to improve it by turning only the potentiometer A3 a little bit. Do not yet touch T3.
    The flatness should be:
    - From 1 ms until 3.6 ms: **< 0.15 %**
    - From 3.6 ms onwards: **< 0.1 %**

    When you do not succeed with this adjustment then turn T3 a little bit clockwise and turn A3 clockwise till the last part of the displayed curve is flat as possible, but at least within the specifications. While turning A3 clockwise you are only able to lift the curve up. If already an overshoot exists use negative compensation by turning A3 counter-clockwise.
    If within specifications, continue with the next amplitude and time constant.

Figure 42 - A3, T3 (2 - 10 ms)



22.	Select:	<Stop scan>					
23.	Select:	<Cancel>					
24.	Select:	Compensate short term eddy current					
25.	Change/check:	Current ECC settings					
		1	OFF	2	ON	3	ON
		4	ON	5	ON	6	ON
26.	Select:	<Proceed> twice to start the adjustment of filter 2.					
27.	Select:	<Mod display>					

Change/check:

monitoring mode	one
raw data logging	no
identifier of signal 1	Tavg
sig 1: horizontal min	0.1
sig 1: horizontal max	5.00
sig 1: vertical min	99.8
sig 1: vertical max	100.2
sig 1: marker line	Yes
sig 1: marker position	0.7 ms for Intera POWER 0.5 ms for Intera MASTER

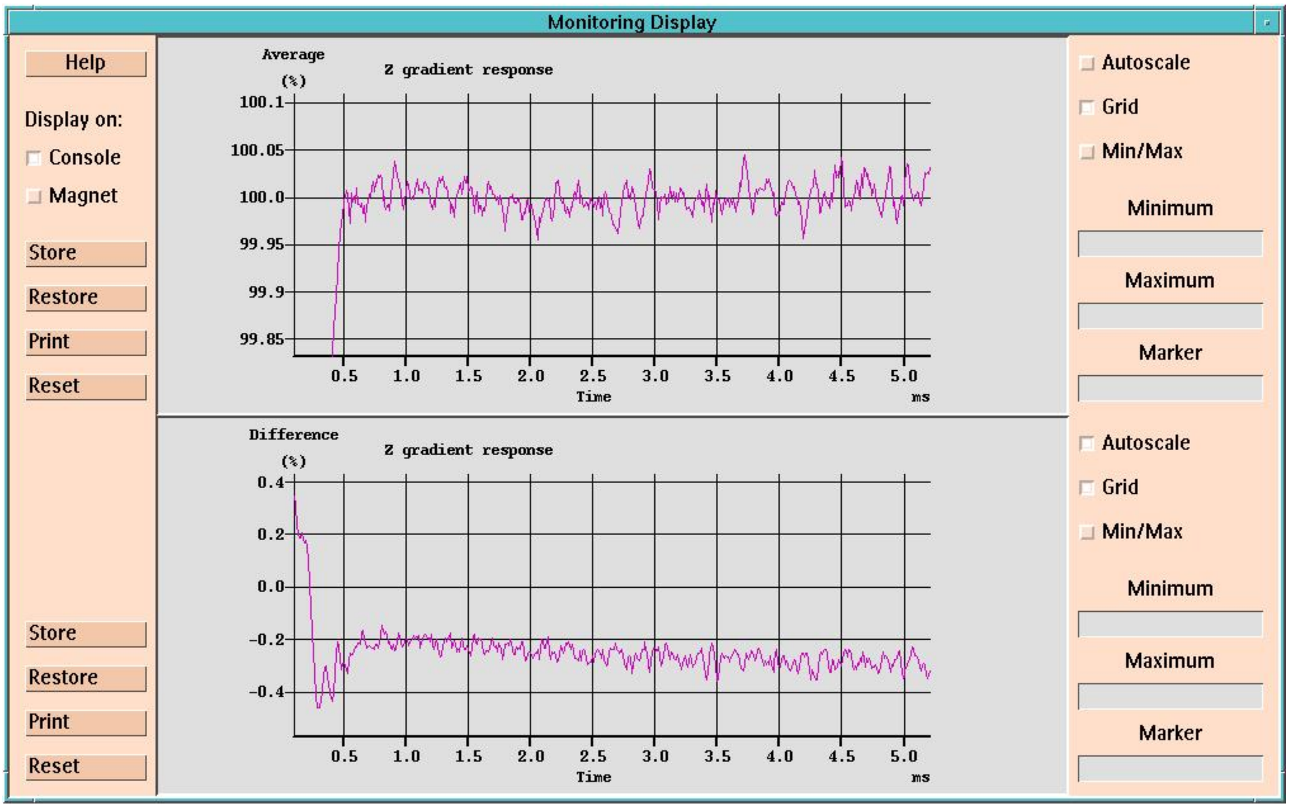
Select: <Proceed>

28. **Adjustment of the A2/T2 filter.**
Check the flatness. **The range of the A2/T2 filter is < 2 ms.** If the flatness is not correct try to improve it by turning only the potentiometer A2 a little bit. Do not yet touch T2.
The flatness should be:
- Intera POWER:
  From 0.7 ms until 3.4 ms: **< 0.15 %**
  From 3.4 ms onwards: **< 0.1 %**
- Intera MASTER:

From 0.5 ms until 3.2 ms: **< 0.15 %**
From 3.2 ms onwards: **< 0.1 %**

Above flatness range must be adjusted with A2 and T2. Because of the larger bandwidth of the Copley 274 this should not be a problem. If however a problem arises, this is probably caused by a bad adjustment of the settling.
When you do not succeed with this adjustment, turn T2 a little bit clockwise and turn A2 clockwise till the displayed curve is flat as possible, but at least within the specifications. While turning A2 clockwise you are only able to lift the curve up. If already an overshoot exists, use negative compensation by turning A2 counter-clockwise.
If within specifications, continue with the next amplitude and time constant.

Figure 43 - A2, T2 (< 2 ms)



29. Select: <Stop scan>
30. Change/check: Current ECC settings

1	ON	2	ON	3	ON
4	ON	5	ON	6	ON

31. Select: <Proceed> twice to start the adjustment of filter 1.
32. Select: <Mod display>
Change/check:

monitoring mode	one
raw data logging	no
identifier of signal 1	Tavg
sig 1: horizontal min	0.1
sig 1: horizontal max	5.00
sig 1: vertical min	99.8
sig 1: vertical max	100.2
sig 1: marker line	Yes
sig 1: marker position	0.7 ms for Intera POWER 0.5 ms for Intera MASTER

Select: <Proceed>

33. **Adjustment of the A1/T1 filter.**
Turn potentiometers A1 and T1 fully counter-clockwise. This means a maximum negative amplitude and a minimum time constant.

34. Turn T1 clockwise until its response 'reaches' the start of the flatness specification range. A small influence will be seen on the amplitude of A1. Correct this by adjusting A2 slightly. When done, turn A1 clockwise until the response at the 3/4-point reaches its specification.
The response is displayed in the 'menu' selection window.
The response value is RED if not within specifications.

Remark:
Each time the amplitude A1 is changed it affects the amplitude A2. To correct for this you must iterate the adjustment between A1 and A2. Where A1 is used to get the end-of-slope value at the marker within the specifications and A2 to correct the flatness of the signal. This procedure gets more difficult if one also changes T1 or T2 during the iterative adjustment.

The end-of-slope value:

Intera POWER:	95.0% +/- 0.5%
Intera MASTER:	91.5% +/- 0.5%

The flatness for all configurations with a Copley 274 should be:

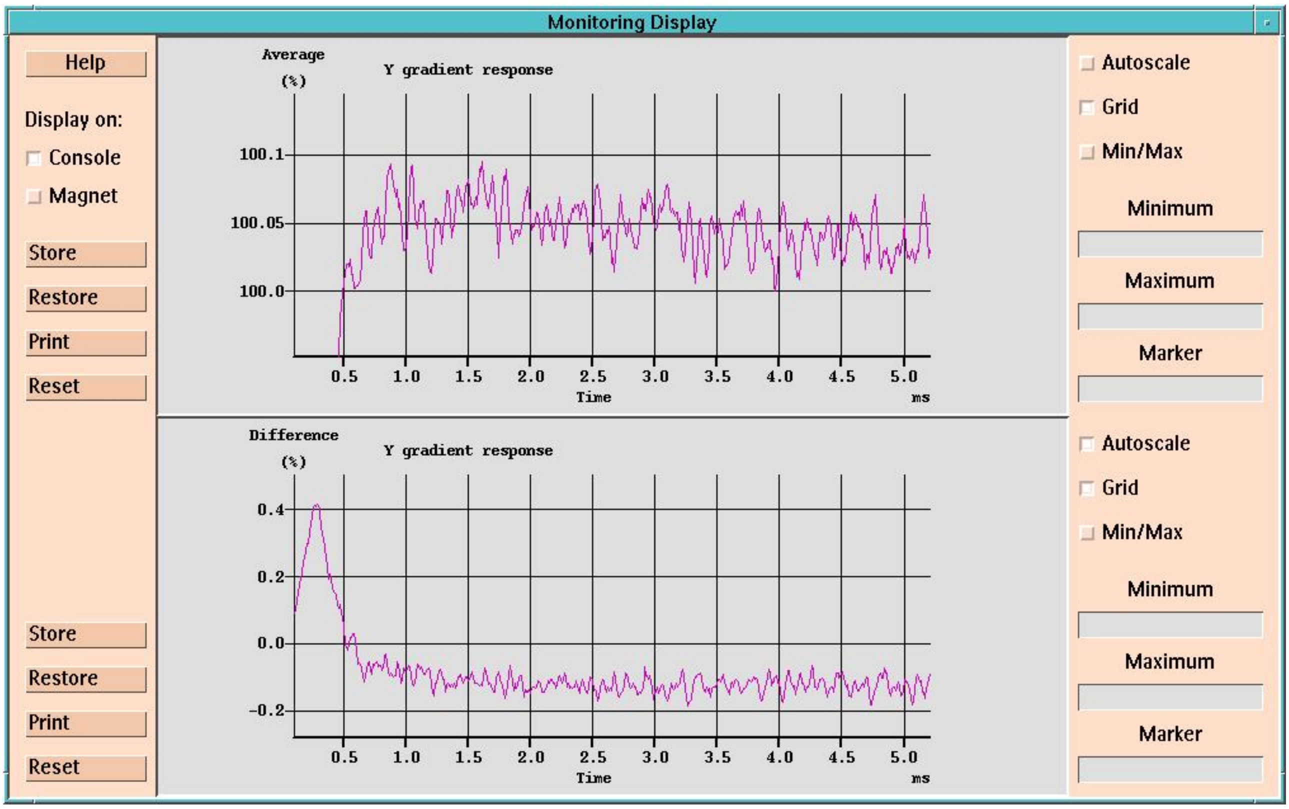
- Intera POWER:
  From 0.7 ms until 3.4 ms: **< 0.15 %**
  From 3.4 ms onwards: **< 0.1 %**
- Intera MASTER:
  From 0.5 ms until 3.2 ms: **< 0.15 %**
  From 3.2 ms onwards: **< 0.1 %**

35. Check also the response at the 3/4 point:
- Intera POWER at 0.30 ms, should be: 69.0 % +/- 3.0 %.
- Intera MASTER at 0.15 ms, should be: 63.0 % +/- 6.0 %.

The response is displayed in the 'menu' selection window.
Response value is RED if not within specifications.

36. Select: <Stop scan>
37. Select: <Cancel>

Figure 44 - A1, T1



4.8.2 EDDY CURRENT FINAL MEASUREMENT

1. Select: Eddy current final measurement
   An information screen is displayed.
2. Select: <Proceed>
3. Change/check: gradient coil xxx
   'xxx' stands for gradient under test.
4. Change/check: Settings

1	ON	2	ON	3	ON
4	ON	5	ON	6	ON

5. Select: <Proceed> To start the measurement.

At the end of the measurement a measurement result list (MRL) will be displayed.

- If the system does not pass the flatness tests, check the time on the extreme values. Depending on these times a part of the eddy current adjustment procedure must be repeated. See paragraph 4.8. Otherwise, change the position of the pick-up coils for another axis. Repeat the pick-up coils positioning and start the final measurement again.

If the system does not pass the **difference** tests, the most likely cause is the flux meter. To exclude the flux meter, interchange the pick-up coil connections at the front of the flux meter. Check the final measurement again. If the difference is still not within the specification, contact the MR helpdesk. In the mean time change the position of the pick-up coils for another axis. Repeat the pick-up coils positioning and start the final measurement again.

5 REPLACEMENT PROCEDURES

5.1 WFG/ECC BOARD

After installing a **new** board, it is advised to set the potentiometers in the starting position before you readjust the eddy currents.

This means:

- The 6 amplitude potentiometers A(x) should be turned fully counter-clockwise first and after that 7.5 turns clockwise (amplitude zero = center position).
- The 6 time constant potentiometers T(x) should be turned fully counter-clockwise.

NOTE

Of course it is also possible to copy the potentiometer settings from the defective board to the new board with the help of an Ohm meter. However, because of hysteresis in the mechanical part of the potentiometers, you still have to check the eddy current adjustment and most likely you will have to adjust the A2/T2 and A1/T1 filters.

See paragraph 4.8.

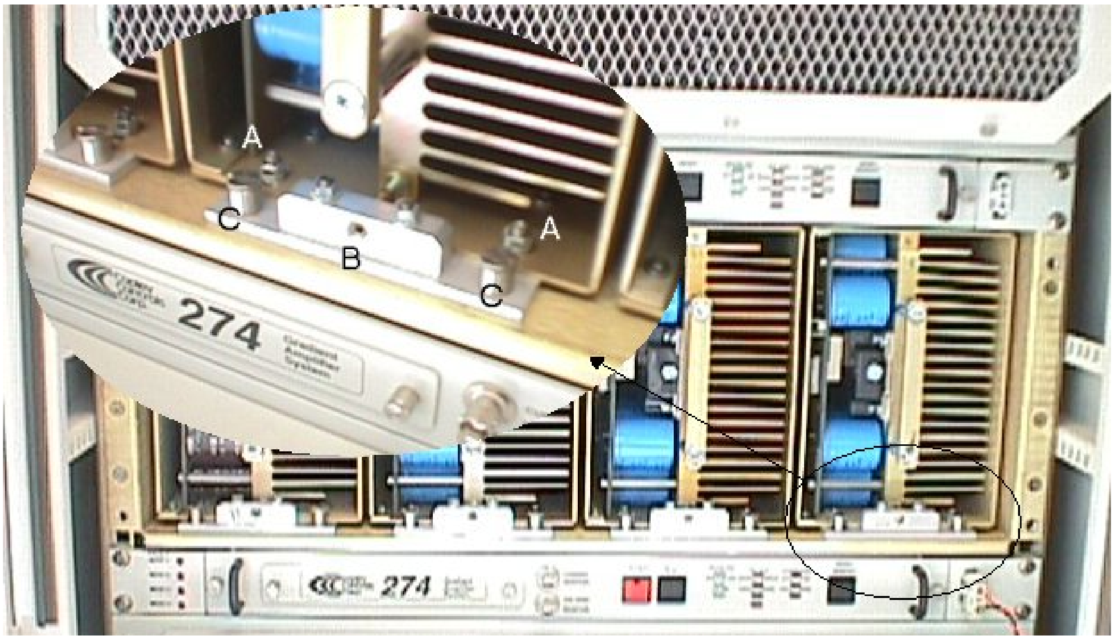
5.2 THE COPLEY 274 POWER MODULE

After replacement, check the system performance by repeating the failing scan and performing the PIQT batch.

5.2.1 PROCEDURE TO REMOVE A DEFECTIVE POWER MODULE

1. Power down the cabinet by switching off the main breaker at the front side;
2. Wait until the internal capacitor bank has completely discharged (check this at the output terminals with a DVM);
3. If open, for what ever reason, close the 274 controller(s) front hatch;
4. Remove the fan assembly (four screws and one connector);
5. Release the two screws (C), see Figure 45;
6. Take the power module by the handle and pull it out gently.

Figure 45 - Front side of the cabinet



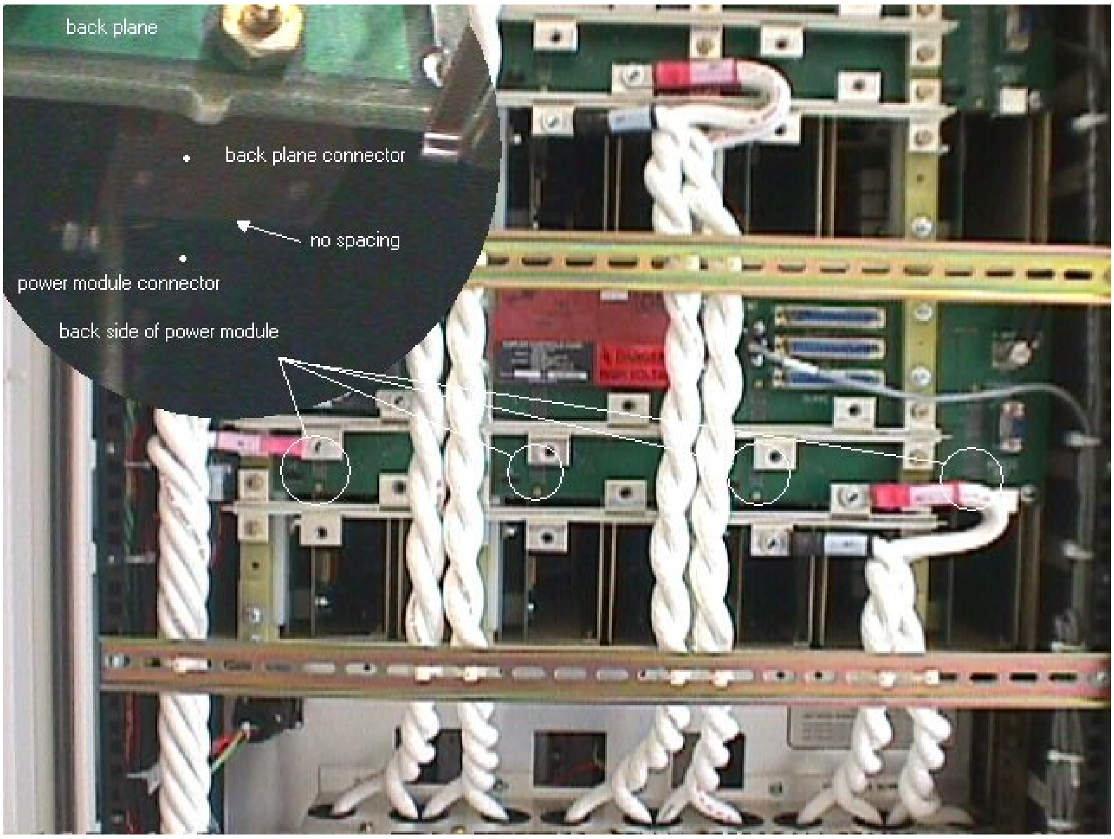
5.2.2 BEFORE YOU INSERT A NEW POWER MODULE

1. Release the two M5 nuts (A) with an 8 mm wrench, see Figure 45;
2. Unscrew the jackscrew (B) a little bit, with a 3 mm allen key, see Figure 45;
3. Copy the DIP switch address settings from the defective power module to the new power module.

5.2.3 INSERTING THE NEW POWER MODULE:

1. Insert the new power module in the axis and push it very gently into the back plane;
2. Check the connector seating at the back side of the back plane, see Figure 46;
3. Pull back the fastener without moving the power module and tighten the two screws (C), see Figure 45;
4. Now very gently (you could destroy the connector) turn the jackscrew (B) until the power module connector is properly seated into the back plane connector, see Figure 45;
5. Check again the connector seating at the back side of the back plane, see Figure 46;
6. Tighten the two locking M5 nuts (A), see Figure 45;
7. Remount the fan assembly;
8. Power up the cabinet by switching ON the main breaker at the front side.

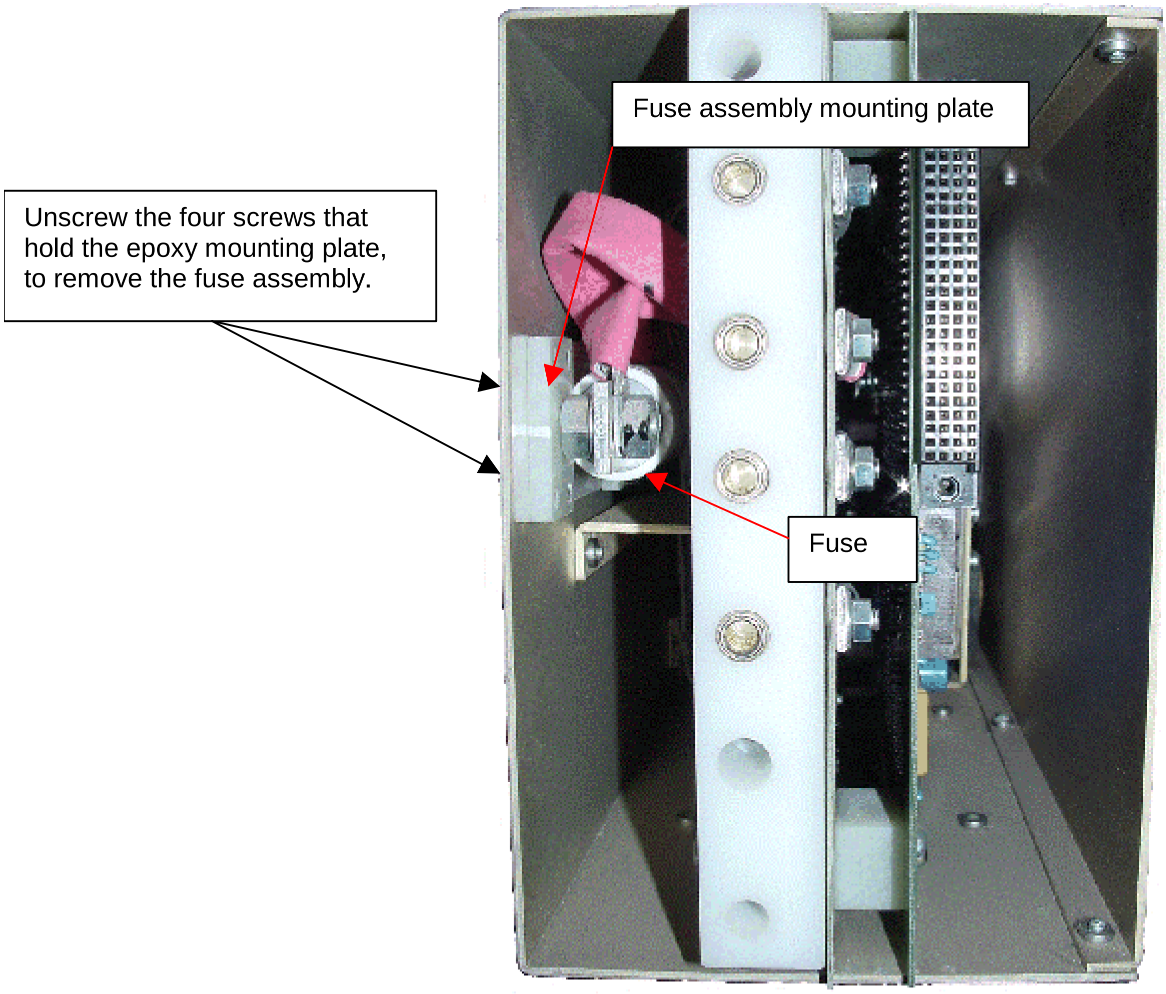
Figure 46 - Backside of the cabinet



5.2.4 THE 100 A FUSE

Precondition:
The fuse is defective and IGBT's are checked and ok. See paragraph 3.7.

Figure 47 – The power module fuse



The fuse is installed on an epoxy plate, which is mounted to the chassis with 4 screws (from the outside!). It is not necessary to de-assemble the power module for replacing the fuse.

Procedure:
1. Remove the power module from the cabinet and put it on a stable surface.
2. Remove the 4 screws that hold the epoxy mounting plate.
3. Gently pull out the fuse assembly.
4. Re-install the 4 screws temporarily, to ensure alignment of the epoxy parts.
5. Remove the power connections of the fuse by releasing the bolts (Use two wrenches.).
6. Replace the fuse.
7. Re-assemble the fuse assembly and install it back into the power module.
8. Be careful not to damage the cabling.
9. Install the power module in the cabinet.
10. Power on the gradient amplifiers, when all defective power modules are repaired.
11. Perform a PIQT to check the functioning of the system.

5.3 THE COPLEY 274 CONTROLLER

After replacement of a Copley 274 controller:

1. Check the Copley back plane revision level.
   If it is REV A, see paragraph 5.3.3.
2. Check the offset.
3. Adjust the gain.
4. Adjust the settling.
5. Adjust dual delay (only for PT6000 / Intera Master).
6. Check eddy current adjustment.
7. Check the gradient strength (head phantom size).

Check the system performance by repeating the failing scan and performing the PIQT batch.

5.3.1 DIP SWITCH SETTING

The controllers are delivered in two different versions, which cannot be recognized by the PHILIPS 12NC code number. These two versions have a different setting of the DIP switches.
The figures below show the dip switch settings of both controllers.
The majority of the controllers have a DIP switch setting according to Figure 49.

Procedure:
After replacement of a controller, set the DIP switches in accordance with the sticker on the controller.
Ignore the sticker on the 'four fan unit', when it differs from the one on the controller.

Figure 48 - The sticker on the controller

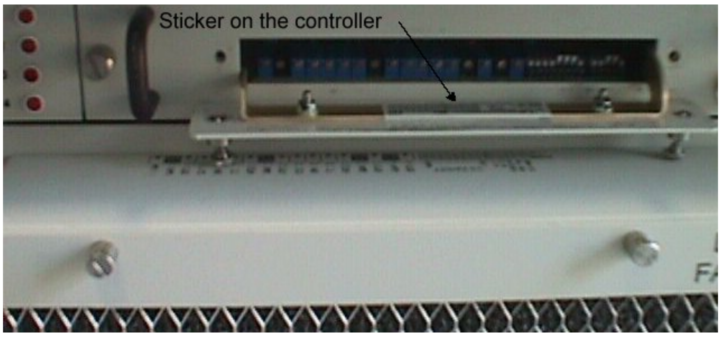
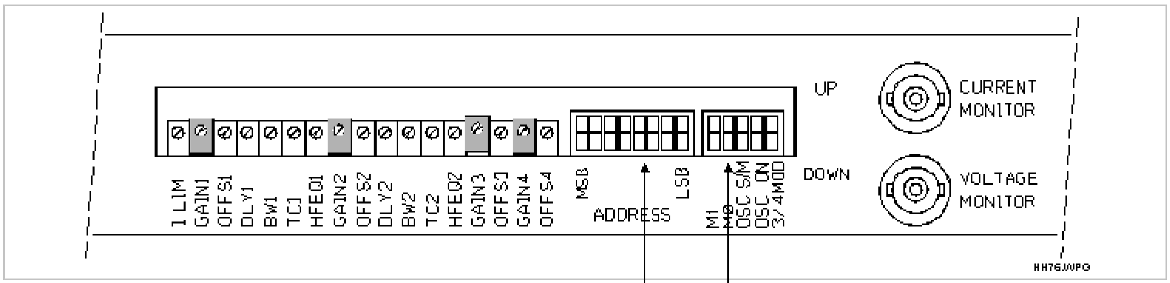
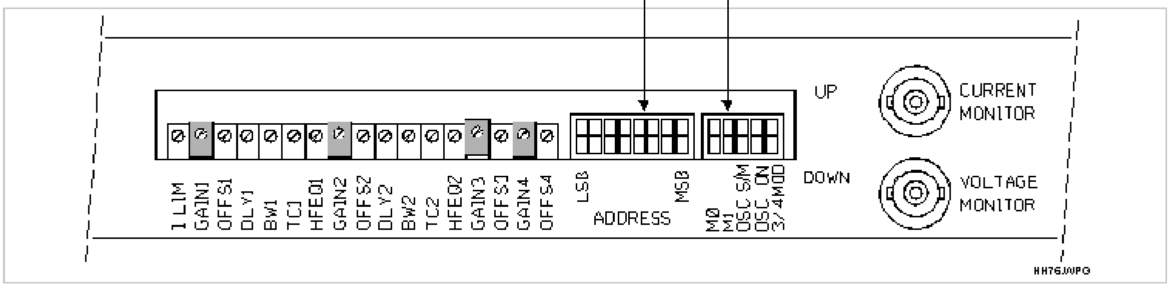


Figure 49 - DIP switches on the controller



Dipswitches normal.



Dipswitches reversed.

5.3.2 WRONG DIP SWITCH SETTINGS ERROR MESSAGES

If one or more of the DIP switches are accidentally set in the wrong position, error messages will be generated in the graddump.txt file. To demonstrate these error messages, the dip switches of the x-controller (MXC) were set in the wrong position on purpose.
This generated the following error messages in the graddump.txt file:

```
PROBLEM: Probably address-dipswitch wrong for unit MXC.
         Other data might be unreliable as a result.

---------------------------------------------------------------------
-----
TABLE 2: Complete status overview of the controllers:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  All status bits of reserved bit-names should be '0'.
  A '0' indicates a status fault (except for DanfyFlt, for which
1=fault).
---------------------------------------------------------------------
-----
     Faults A:          Faults B:          Faults C:
     C F . O O          D D .   B B B      . S   O D . . .
     h a . v v A I N    a a . B a a a      . i E p a . . .
     a u . e e i n o    n n . a d d d N    . g n e n . . .
     n l . r r r h      f f . d       o    . E a n f . . .
     S t . L T F i 5    + - .   + - +      . r b C y . . .
     t M . o e l b M    1 1 . + 1 1 2 E    . r l o F . . .
     o e . a m o S H    5 5 . 5 9 9 8 H    . o e n l . . .
     p m . d p w w z    V V . V V V V C    . r d n t . . .

MXC:
MYC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
MZC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
---------------------------------------------------------------------
-----
```

Notice the blank line after MXC: due to wrong dipswitch settings

Notice that this is just a part of the graddump.txt file.

BDASDUMP.LOG:
This logging can be 'boiled down' into a boildown.csv file. The boildown.com executable is available on the BBS. See paragraph: 6.6 for more information.

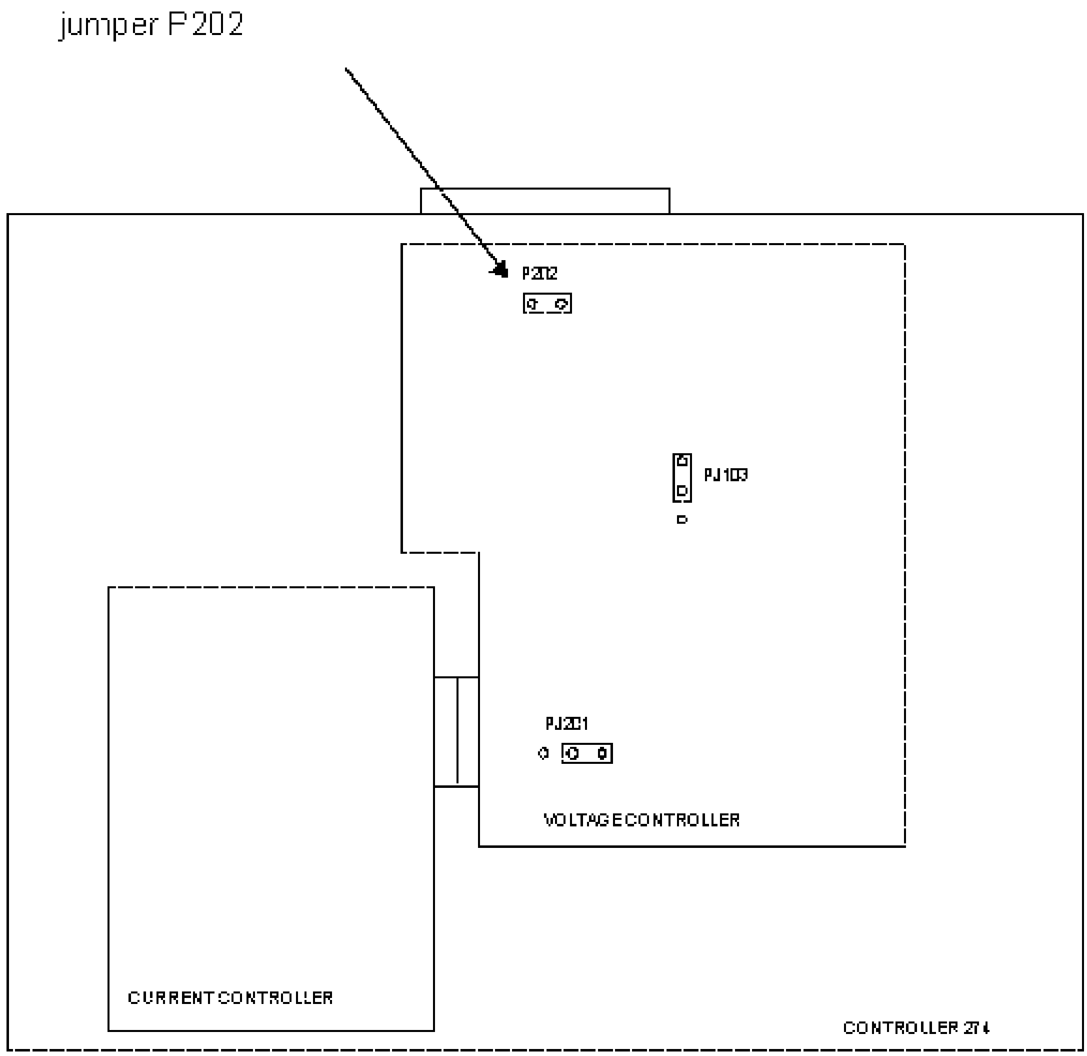
```
BOILDOWN.COM - version 981027/pbb - started at 30-MAR-1999
12:17:50.05
Now this file:
MMOTM7::DKA0:[SYS0.GYRODISK2.GYROSCAN.LOG]BDASDUMP.LOG;21
<30-MAR-1999 12:07:41.523 INFO>
, <30-MAR-1999 12:07:39.675 SEVE>, *** Exception raised in function,
check_gi_st
atus_cb, -GRADIENT-GCC: Fault on channel X.,
...we have found a total of 1 lines in this file
```

5.3.3 OPEN CONNECTION FAULT LATCHING

Via the controller, a detection is done on open connections to the backplane, if the backplane revision level is B or higher. When level B or higher, jumper P202 should not be installed.

When a new controller is installed and the gradient amplifier **backplane is revision level A**, you have to install the **jumper on P202** on the voltage controller board to disable open connection fault latching (use a jumper from the defective controller). An overview of the jumper setting is shown in **Figure 50.** The jumpers are reachable through holes in the top cover of the controller.

Figure 50 - Copley 274 controller jumper setting if backplane REV A



5.3.4 WRONG JUMPER P202 SETTING ERROR MESSAGES

If jumper P202 is not installed and the Copley 274 backplane is revision level A, the following error logging will be generated in the graddump file:

```
------------------------------------------------------------------------
Unit
name  Rank  Status text

MYC    9    Open connector (Interlock)
MYC    8    Overload: Too much current (peak and/or duration in a power module
       Or: Overcurrent in Danfysik sensor
MYC    7    Not enabled (due to fault or missing enable signal)
MYC    7    Overcurrent in Danfysik sensor. Line is visible only in case
       of a hard fault in sensor, because status is not latched
------------------------------------------------------------------------
```

Notice that this is just a part of the graddump.txt file.

Additional error logging will be generated in the bdasdump.log file:
This logging can be 'boiled down' into a boildown.csv file.
The boildown.com executable is available on the BBS and the PMS TechNet intranet site.

```
BOILDOWN.COM - version 981027/pbb - started at 19-MAR-1999 15:26:14.57
Now this file: MMOTM3::DKA0:[SYS0.GYRODISK2.GYROSCAN.LOG]BDASDUMP.LOG;29
<19-MAR-1999 15:18:50.938 INFO>
, <19-MAR-1999 15:18:50.919 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSC: Open Connector: one or more connectors not mated properly, Unit for
channel Y Control Master,
, <19-MAR-1999 15:18:50.919 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSC: Axis is disabled, Unit for channel Y Control Master,
, <19-MAR-1999 15:18:50.919 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSA: Power module is overloaded, Unit for channel Y Control Master,
, <19-MAR-1999 15:18:49.208 SEVE>, *** Exception raised in function,
AOGRAMP_set_on, -GRADIENT: Gradient amplifiers not enabled,
, <19-MAR-1999 15:18:47.793 SEVE>, *** Exception raised in function,
BDFE_set_gradamp, -GRADIENT:Gradient amp error, error-mask is 0x10.,
, <19-MAR-1999 15:18:47.793 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSC: Open Connector: one or more connectors not mated properly, Unit for
channel Y Control Master,
, <19-MAR-1999 15:18:47.793 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSC: Axis is disabled, Unit for channel Y Control Master,
, <19-MAR-1999 15:18:47.793 SEVE>, -GRADIENT:Error in Copley-274 amplifier,
FAULTSA: Power module is overloaded, Unit for channel Y Control Master,
...we have found a total of 8 lines in this file
```

6 EXPLANATIONS

6.1 SETTLING

'Settling' is the behavior of the actual gradient pulse, shortly after the rising slope. Compared with the demand pulse the actual gradient will trail and tend to oscillate (damped oscillation). In order to obtain a defined response of the gradient pulse the settling adjustment procedure is implemented. An incorrectly adjusted settling behavior will cause difficulties with the 'short-time' eddy current compensation adjustment and can cause gradient amplifier shutdowns. The cable length of the gradient cables influences this 'settling' behavior. In the factory the gradient amplifier has been adjusted with a certain length of the gradient cables. Because the length of the gradient cables on site is different from the factory-length, it is necessary to adjust the settling again.

Principle of adjustment
The 'settling' adjustment procedure uses three pulses:

- **Demand pulse**, this is the pulse sent to the Copley 274 amplifier;
- **Reference gradient response**, this is a pulse calculated by the computer. The wanted response from the gradient on a demand pulse is calculated. In order to calculate this reference a difference with respect to the demand pulse is used. The differences are:
  - at 100 usec after the end of slope: 99.5 %
  - at 150 usec after the end of slope: 99.8 %
  - at 250 usec after the end of slope: 99.9 %

  The demand pulse is considered to be 100% after the end of slope.
- **The actual gradient response**, which is scaled to 100%.

Figure 51 - Demand pulse and reference gradient pulse.

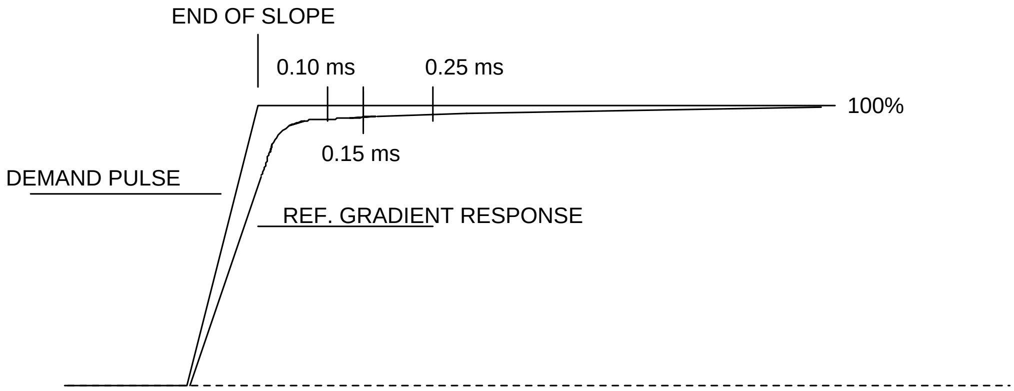
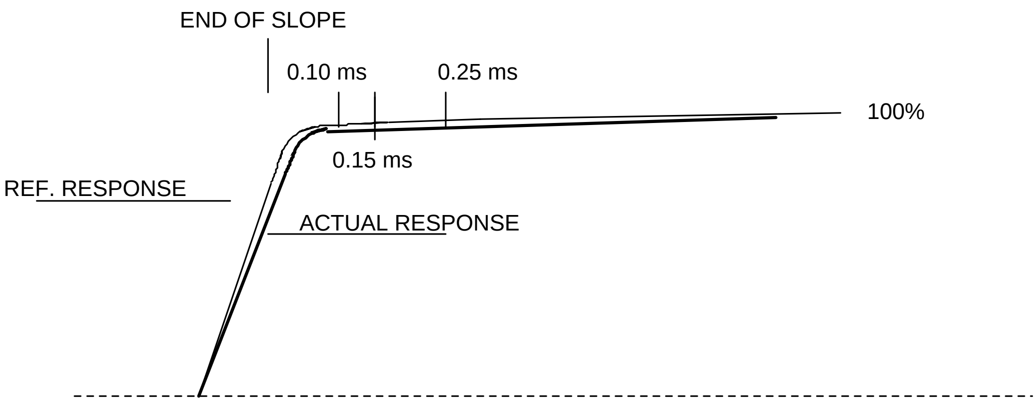
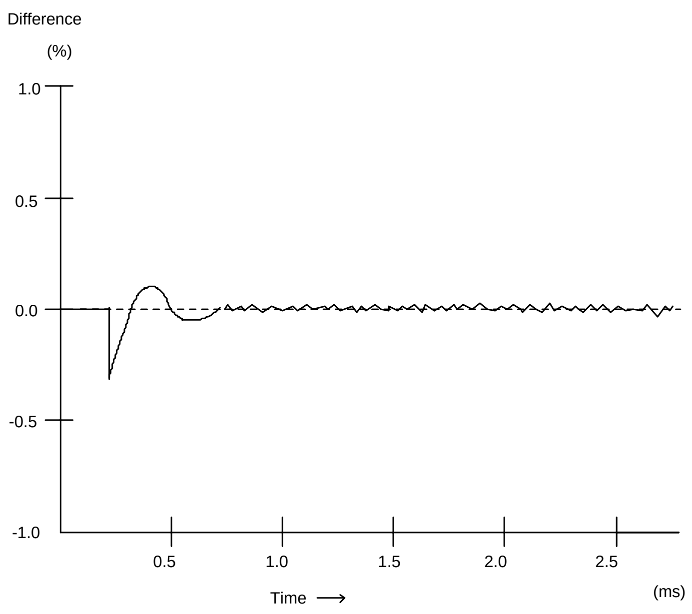


Figure 52 - Reference gradient response and actual gradient pulse.



The purpose of the settling adjustment is to adjust the actual gradient response as close as possible to the reference gradient response. During the adjustment the difference between the reference and the actual response signals is displayed and used for the settling adjustment. The adjustment is done with the potentiometers TC1, BW1 and HFEQ1 for PT3000 / Intera POWER, and with the potentiometers TC2, BW2 and HFEQ2 for PT6000 / Intera MASTER. These potentiometers are located on each Copley-274 Controller.

Figure 53 - Difference between actual and reference gradient response.



Text screen, as displayed during the adjustment procedure:
Besides the possible commands, the text screen also displays the measured values. These measured values are constantly updated during the adjustment. The **bold** printed line in the example, as shown below, is the line with the important values. The purpose of this adjustment is to adjust these three values below 0.10%.

Example:

```
Scan Util Scan Util     : Settling Adjustment                                   dd-mmm-yyy
------------------------------------------------------------------------------------------

----- GCA:  Gramp Settling Adjustment ----

      POSSIBLE COMMANDS:
   MASTER:      Selects the Master channels        SLAVE:     Selects the Slave channels
   X/Y/Z:       Selects channel for adjustment
   EXIT:        Stops measurement and returns measured output parameters
------------------------------------------------------------------------------------------

      MEASURED VALUES:
Adjusting channel:   X (Master)      Slope-End:   0.30 [ms]       Current:   412.5 [A]

Found mx. deviations at      :  >100   |   >150   |   >250   |   [usec]
- Small spec. (w.r.t. fit)   :  0.68   |   0.23   |   0.04   |   [%]
- Wide spec. (w.r.t. 100%)   :  1.08   |   0.35   |   0.07   |   [%]

      ENTER A COMMAND:

   Possibilities:      X,Y,Z,MASTER,SLAVE,EXIT
   Enter user input:   ____________________
```

Explanation measured values display:

- Small spec. line: The differences between the reference gradient response (on screen called ref. fit) and the actual gradient response are displayed. The displayed values are measured at 100 usec, 150 usec and 250 usec after the end-of-slope point. All values must be adjusted to: **< 0.10 %.**
- Wide spec. line: The differences between the demand pulse (on screen called ref. 100%) and the actual gradient response. The displayed values are measured at 100 usec, 150 usec and 250 usec after the end-of-slope point.
- Current: During the adjustment and during the final measurement the gradient current is set to 550 A.

Continue with paragraph 4.5 or paragraph 4.6.

6.2 EDDY CURRENTS

Pulsing the gradients results in a changing magnetic field, which induces eddy currents in the magnet cryostat, windings and shields.
This will make the gradient field response slow, compared to the demand signal for the gradient amplifier.
To get the required gradient field response, the demand signal for the gradient amplifier is adjusted in such a way that the influence of the eddy currents is compensated for.

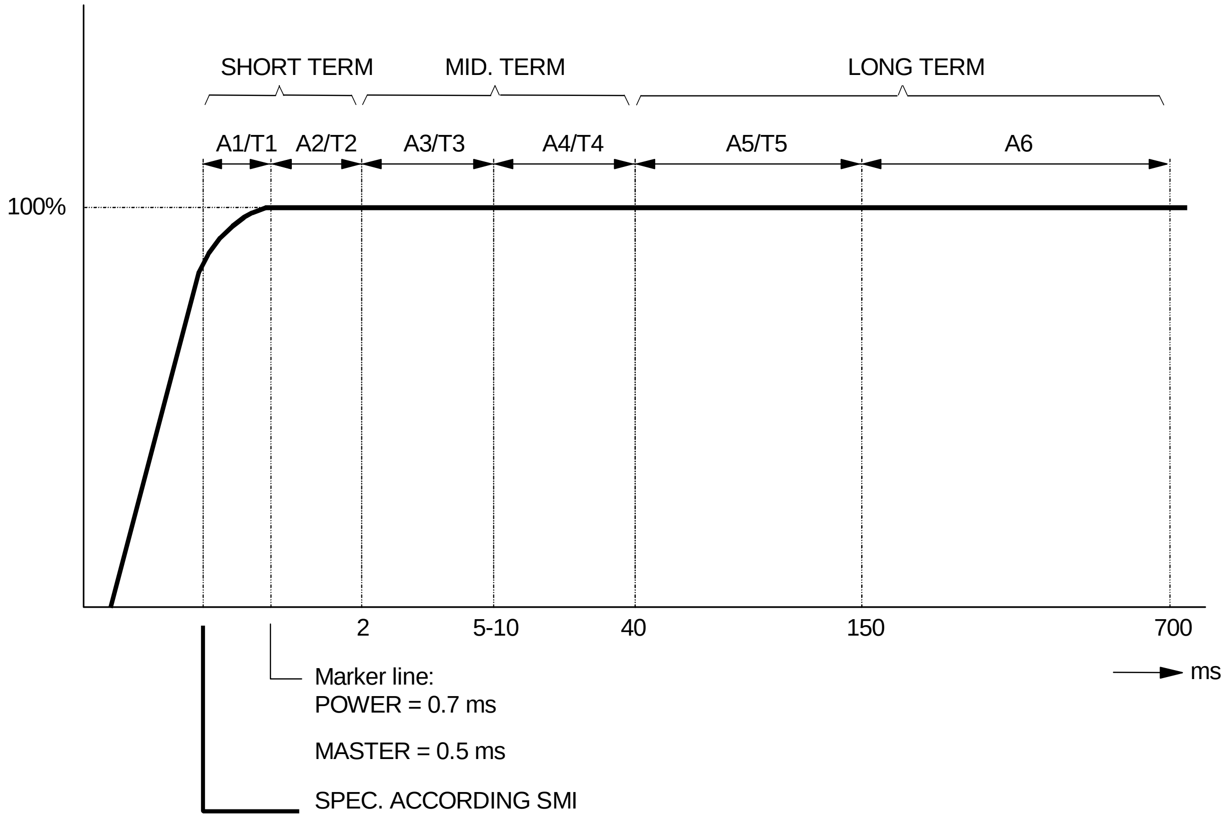
The gradient field response is measured at two points, located on the gradient axis corresponding with the gradient under test.
By adding the output from six adjustable filters to the original (uncompensated) gradient demand signal the gradient field response is compensated for eddy current effects. Each of these six filters can be enabled or disabled in the tuned hardware parameter archive of the application software. The response of each filter can be adjusted with an amplitude potentiometer A and a time constant potentiometer T.

The following table and figure shows the operational range of each filter.

Table 9 - The operational range of each filter

Potentiometers	Time constants
T6 A6	150 - 700ms
T5 A5	40 - 150ms
T4 A4	10 - 40ms
T3 A3	2 - 10ms
T2 A2	< 2ms
T1 A1	Used to decrease the rise time

Figure 54 - Time constants



All filters and their corresponding potentiometers are located on the WFG/ECC boards.
Each gradient channel (X,Y and Z) has its own WFG/ECC board.
Each WFG/ECC board has a seventh filter (A0/T0) which is not used with the Copley 274 amplifiers and has been disabled in the factory (jumper W6 is not installed, see Figure 1).
If a filter has been enabled in the application software, its corresponding red LED on the WFG/ECC board will be lit during a scan.

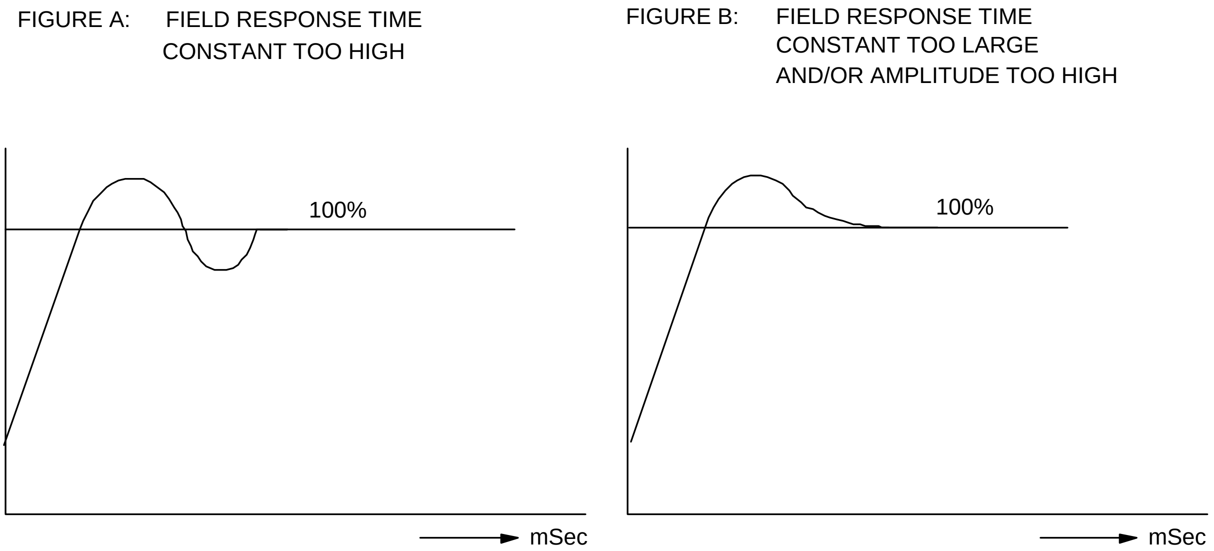
The amplitude potentiometers Ax have 15 turns with the zero effect setting in the middle. Clockwise turning of Ax (from the zero position) gives a higher amplitude, while counter-clockwise turning (from the zero position) gives a lower amplitude.
The time constant potentiometers Tx do not have a middle position.
Complete counter-clockwise turning of Tx gives the minimum time constant.
Clockwise turning of Tx increases the time constant.

The results of the eddy currents final measurement (for X, Y, and Z) are stored in the tuned hardware parameter archive. Notice that these results are only stored for archiving purposes: deleting or changing these results does not affect the eddy current behavior of the system.

The purpose of the eddy current compensation (ECC) adjustment, is twofold:
1. To adjust the amplitude of the field response (= gradient flux pulse) to 100%.
2. To adjust the rising slope.

With an eddy current **reference** measurement the 100% level is determined. It is assumed that the longest τ-time of the gradient system is 200 ms, after 5 τ-times (= 1s) the system is settled. So, one second after the end-of-slope the eddy current effects are faded out and at this point the eddy current **reference** measurement determines the 100% value.
The ECC adjustment always starts with the long term effects. From there you work your way back, via the mid term effects, to the short term effects. In the latter one also the rising slope is adjusted within specifications.
If, for whatever reason, you want to adjust the ECC all over again, place all potentiometers in their starting position again.
While adjusting the eddy currents, try to use the Tx potentiometers as little as possible.
Start with adjusting the amplitude Ax until a clear overshoot and a small undershoot can be seen. Then try to eliminate the undershoot with the time constant Tx. See Figure 55.
With the time constant Tx you can shift the overshoot over the time axis, with the effect that the undershoot will decrease or increase.

Figure 55 - Field response as a function of time



HH11.WPG

In part A of Figure 55, the time constant correction is too small: increase the time constant potentiometer by turning it clockwise.
In part B of Figure 55, the time constant is too big and/or the amplitude too high.
First try to decrease the time constant correction T(x) (counter-clockwise) until an undershoot becomes just visible again. If this is not possible, decrease the amplitude A(x) (counter-clockwise) until the undershoot becomes visible. Now increase T(x) (clockwise) until the undershoot meets the specifications. And so on.

For checking the ECC adjustment see paragraph3.5.

6.2.1 REQUIRED TOOLS

- Eddy current compensation set 8122 101 45004, which includes the eddy current pick-up coil holder.
- The eddy currents are adjusted on the WFG/ECC boards inside the gradient interface rack. Because the measured signal is displayed on the operator console, a temporary display must be in the technical room near the gradient amplifier cabinet(s).
- Extend both the keyboard and the mouse with extension cables so that you can operate the software from within the technical room.
- Take special care with positioning the flux meter: the drift strongly depends on environmental temperature variations.
- Keep the flux meter away from the gradient amplifier cabinet and gradient cables to eliminate possible induction. Take a minimum distance of 1 meter.
- Use the coax cables, delivered with the set, for the connection between the flux meter and the gradient interface cabinet DIB to minimize the noise:
  - The 'thick' coax cables for the signals
  - The 'thin' coax cable for the 'reset' signal

Figure 56 - Position Eddy current pick-up coils

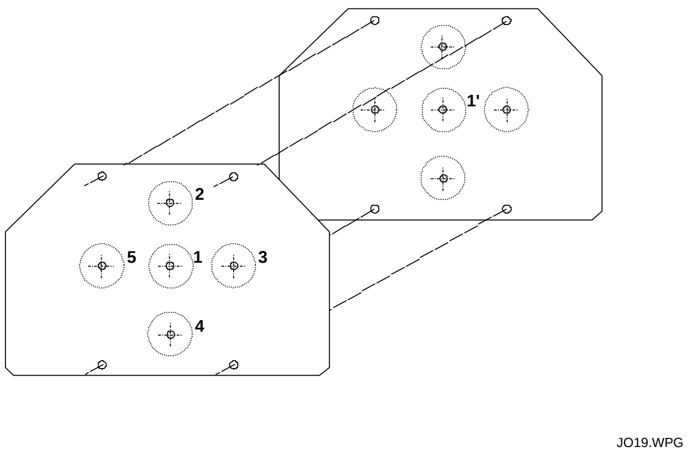
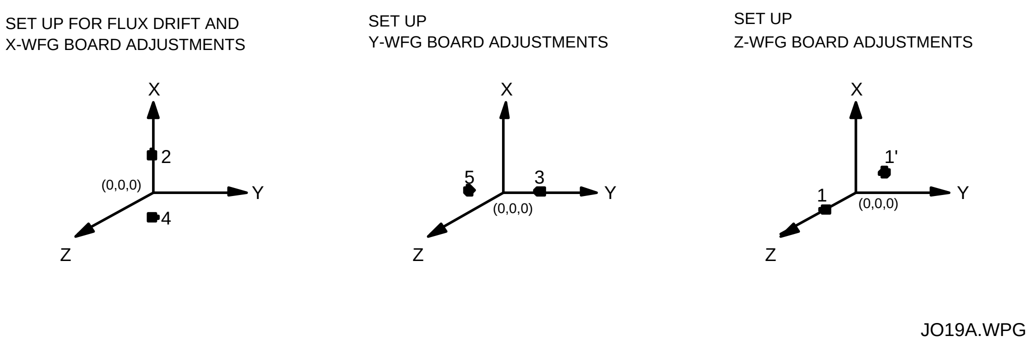


Figure 57 - Position pick-up coils related to X,Y and Z gradient axis.

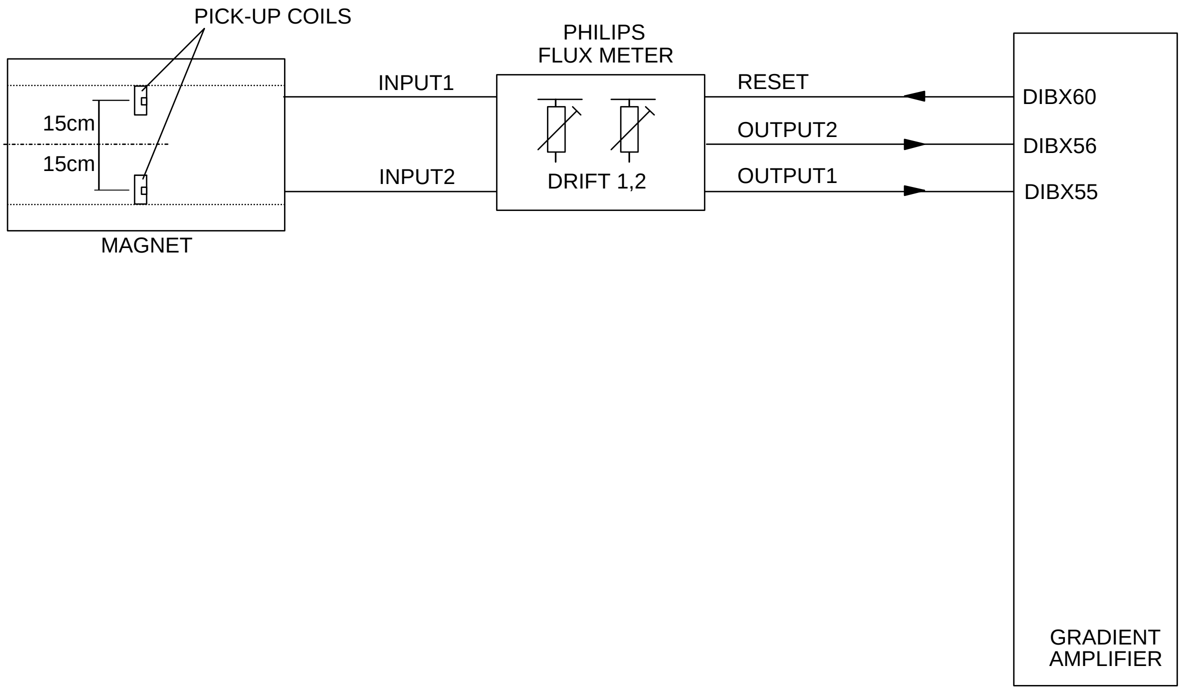


1. Mount the pick-up coils in the 15 cm positions for the 'gradient under test'.
   See Figure 56 and Figure 57.
2. Place the holder with the pick-up coils on the inner bed inside the the magnet.

Place it such that the pick-up coils are symmetrically by around the iso-center.
The axis of the pick-up coils must always be parallel to the Z direction (accuracy +/- 5 degrees).

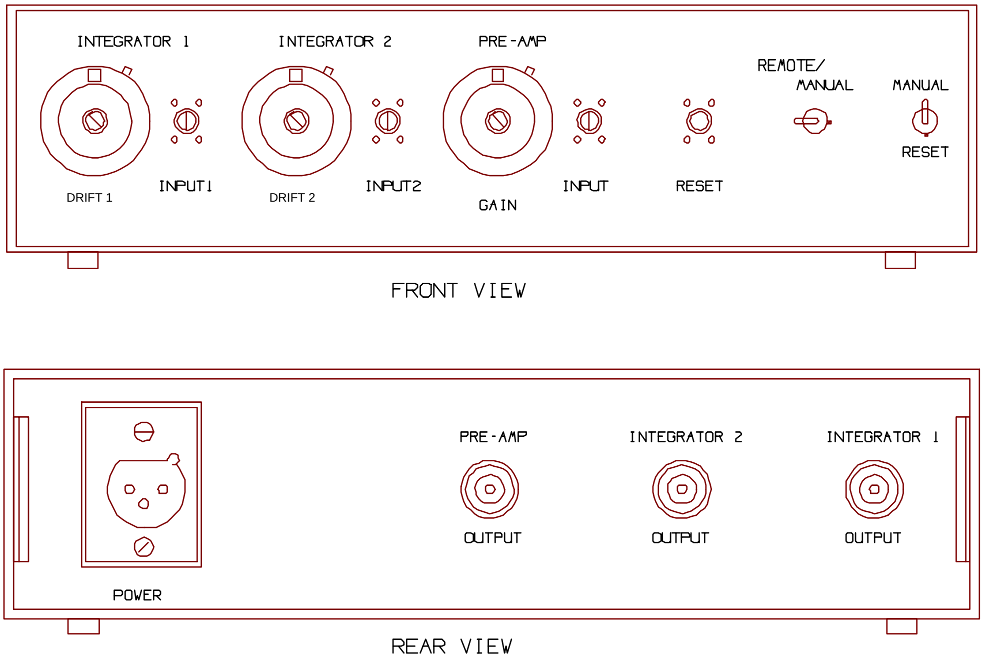
3. Switch on the flux meter and wait 30 minutes to allow the flux meter to stabilize.
4. Set up the measurement according to the shown figures.
   See Figure 58 and Figure 59.

Figure 58 - Measuring set-up for eddy current check



FB18.DRW

Figure 59 - Front and rear view of Philips flux meter



EDDY.DPF

6.2.2 PRINT THE MRL OF THE EDDY CURRENT FINAL MEASUREMENT

1. Make sure that there is enough paper in the printer.
2. Login : Gyroscan
3. Select: Scan control
4. Select: Scan utilities
5. Select: Enter service mode
6. Select: System tuning
7. Select: System tuning tools
8. Select: Measurement verification
9. Select: View measurement result lists

Now fill in the following bold printed parameters to select a MRL list:

Part of the filename	:	**ECA_FINAL**
Date specification	:	**No date**

10. Select: Proceed to continue
11. Choose the file to print.

Now set the print parameters: (the parameters to enter are printed bold)

View mode	:	Full
View file	:	Yes
Print file	:	**Yes**
Copy file	:	No

12. Select: Proceed to continue

With the 'next page' key and the 'previous page' key you can scroll through the MRL. Simultaneously, the MRL will be printed.

13. Select: Proceed to continue

14. Add the print-out of the Eddy current final measurement MRL to the system MRL.

6.2.3 EXAMPLE OF THE EDDY CURRENT MRL PRINT OUT

Example of an MRL print out for a PT3000 system and an Intera POWER system, with some comments added:

Line	Description				
1.	measurement type		Final	Nominal	Spec
2.	gradient coil X,Y or Z		Y		
3.	current ECC settings Y	1	<value>		
4.	current ECC settings Y	2	<value>		
5.	current ECC settings Y	3	<value>		
6.	current ECC settings Y	4	<value>		
7.	current ECC settings Y	5	<value>		
8.	current ECC settings Y	6	<value>		
9.	settings Y	1	<value>		
10.	settings Y	2	<value>		
11.	settings Y	3	<value>		
12.	settings Y	4	<value>		
13.	settings Y	5	<value>		
14.	settings Y	6	<value>		
15.	overall gradient delay (msec)		<value>		
16.	delay deviation (us)		<value>	0.0	[-12.0 - 12.0]
17.	three-quarter point (0.30 msec)		<value>	69.00	[66.00 - 72.00]
18.	EOS point (%)		<value>	95.0	[94.5 – 95.5]
19.	Flatness range 1 (%)		<value>	0.00	< 0.15
20.	Flatness range 2 (%)		<value>	0.00	< 0.10
21.	Difference 1 (%)		<value>	0.00	< 0.45
22.	Difference 2 (%)		<value>	0.00	< 0.42
23.	Extreme times (ms) 1		<value>		
24.	Extreme times (ms) 2		<value>		
25.	Extreme times (ms) 3		<value>		
26.	Extreme times (ms) 4		<value>		
27.	Extreme times (ms) 5		<value>		
28.	Extreme times (ms) 6		<value>		
29.	Extreme times (ms) 7		<value>		
30.	Extreme times (ms) 8		<value>		
31.	Spec. ranges (ms) 1		0.30		
32.	Spec. ranges (ms) 2		3.00		
33.	Spec. ranges (ms) 3		3.00		
34.	Spec. ranges (ms) 4		990.00		
35.	Spec. ranges (ms) 5		0.60		
36.	Spec. ranges (ms) 6		5.00		
37.	Spec. ranges (ms) 7		5.00		
38.	Spec. ranges (ms) 8		990.00		
39.	Measured-system delay [us]		24.00	24.00	[23.50 - 24.50]

Example of MRL print out for a PT6000 system or an Intera MASTER system, with some comments added:

Line	Description		Final	Nominal	Spec
1.	measurement type		Final	Nominal	Spec
2.	gradient coil X,Y or Z		Y		
3.	current ECC settings Y	1	<value>		
4.	current ECC settings Y	2	<value>		
5.	current ECC settings Y	3	<value>		
6.	current ECC settings Y	4	<value>		
7.	current ECC settings Y	5	<value>		
8.	current ECC settings Y	6	<value>		
9.	settings Y	1	<value>		
10.	settings Y	2	<value>		
11.	settings Y	3	<value>		
12.	settings Y	4	<value>		
13.	settings Y	5	<value>		
14.	settings Y	6	<value>		
15.	overall gradient delay (msec)		<value>		
16.	delay deviation (us)		<value>	0.0	[-12.0 - 12.0]
17.	three-quarter point (0.15 msec)		<value>	63.00	[57.00 - 69.00]
18.	EOS point (%)		<value>	91.5	[91.0 – 92.0]
19.	Flatness range 1 (%)		<value>	0.00	< 0.15
20.	Flatness range 2 (%)		<value>	0.00	< 0.10
21.	Difference 1 (%)		<value>	0.00	< 0.45
22.	Difference 2 (%)		<value>	0.00	< 0.42
23.	Extreme times (ms) 1		<value>		
24.	Extreme times (ms) 2		<value>		
25.	Extreme times (ms) 3		<value>		
26.	Extreme times (ms) 4		<value>		
27.	Extreme times (ms) 5		<value>		
28.	Extreme times (ms) 6		<value>		
29.	Extreme times (ms) 7		<value>		
30.	Extreme times (ms) 8		<value>		
31.	Spec. ranges (ms) 1		0.30		
32.	Spec. ranges (ms) 2		3.00		
33.	Spec. ranges (ms) 3		3.00		
34.	Spec. ranges (ms) 4		990.00		
35.	Spec. ranges (ms) 5		0.60		
36.	Spec. ranges (ms) 6		5.00		
37.	Spec. ranges (ms) 7		5.00		
38.	Spec. ranges (ms) 8		990.00		
39.	Measured system delay [us]		24.00	24.00	[23.50 - 24.50]

<u>Remarks:</u>

In the actual display of the result screen the line numbers are not shown.

Line

Line 23	Time at which the minimum of the averaged signal is measured for flatness 1	
Line 24	Time at which the maximum of the averaged signal is measured for flatness 1	
Line 25	Time at which the minimum of the averaged signal is measured for flatness 2	
Line 26	Time at which the maximum of the averaged signal is measured for flatness 2	
Line 27	Time at which the minimum of the difference signal is measured for difference 1	
Line 28	Time at which the maximum of the difference signal is measured for difference 1	
Line 29	Time at which the minimum of the difference signal is measured for difference 2	
Line 30	Time at which the maximum of the difference signal is measured for difference 2	
Line 31	Start time specification range for flatness 1.	
	POWER:	add 0.4 ms to find actual start time
	MASTER:	add 0.2 ms to find actual start time
Line 32	End time specification range for flatness 1.	
	POWER:	add 0.4 ms to find actual end time
	MASTER:	add 0.2 ms to find actual end time
Line 33	Start time specification range for flatness 2.	
	POWER:	add 0.4 ms to find actual start time
	MASTER:	add 0.2 ms to find actual start time
Line 34	End time specification range for flatness 2.	
Line 35	Start time specification range for difference 1	
	POWER:	add 0.4 ms to find actual start time
	MASTER:	add 0.2 ms to find actual start time
Line 36	End time specification range for difference 1	
	POWER:	add 0.4 ms to find actual start time
	MASTER:	add 0.2 ms to find actual start time
Line 37	Start time specification range for difference 2	
	POWER:	add 0.4 ms to find actual start time
	MASTER:	add 0.2 ms to find actual start time
Line 38	End time specification range for flatness difference 2	
Line 39	Measured system delay	

6.3 OVERVIEW OF THE GRADIENT DUMMY CONNECTOR.

Figure 60 - Top view gradient amplifier dummy connector.

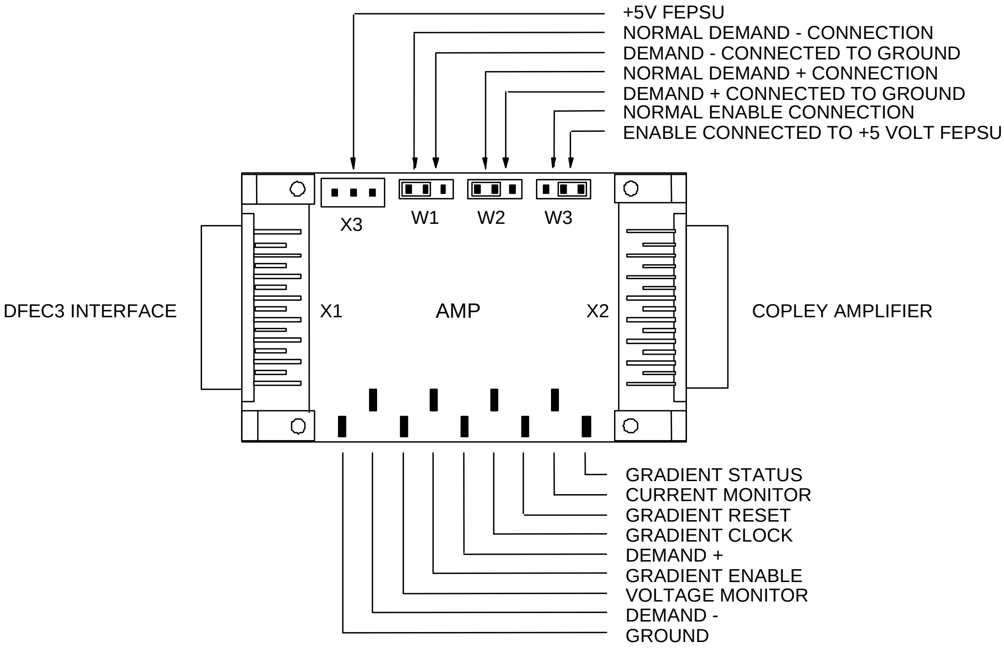
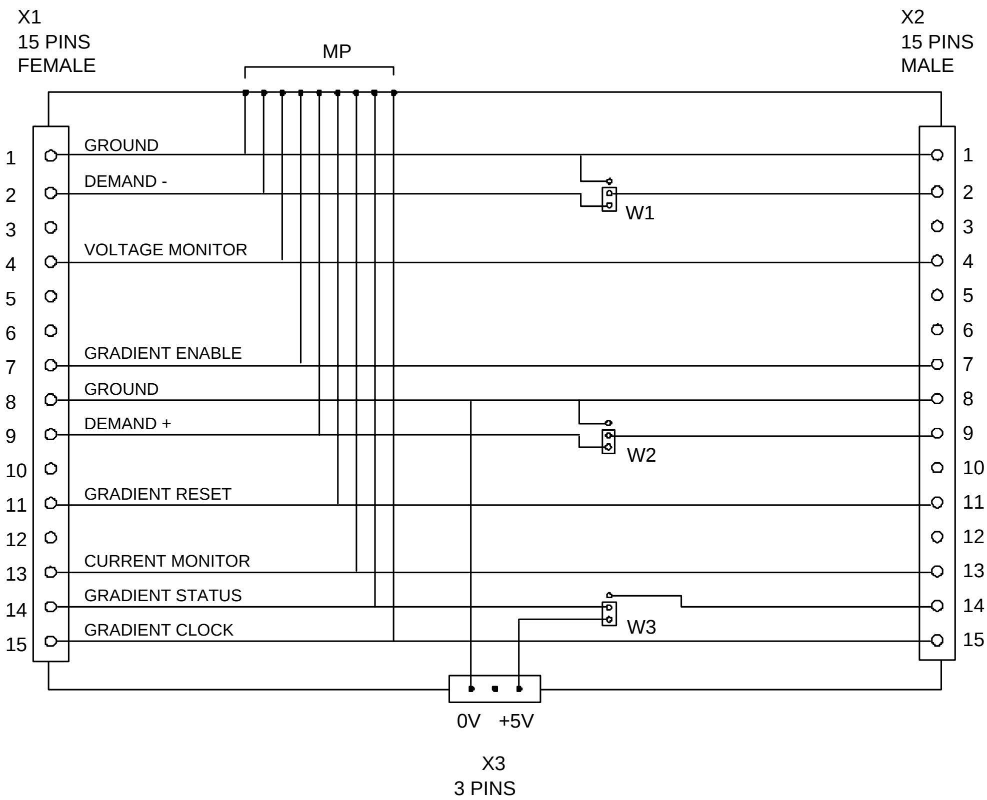


Figure 61 - Principle diagram Gradient Amplifier Dummy Connector



6.4 THE LED STATUS ON THE EMI 20KW/420V POWER SUPPLIES

When the gradient amplifier cabinet and both EMI power supplies are switched on the LED status on the EMI power supplies should be:

- For the master EMI power supply within the Copley 274 cabinet (DP1):
  - LED 'POWER ON' is lit.
  - LED 'VOLTAGE' is lit.

- For the slave EMI power supply within the Copley 274 cabinet (DP2):
  - LED 'POWER ON' is lit.
  - LED 'CURRENT' is lit.

All other LEDs on the EMI power supplies must be off after startup and all fans in the Copley 274 cabinet must be running.

Notice that the Copley 274 gradient amplifier cabinet can operate with only the master power supply installed. However, not all types of scans can be made.

The 25p D programming connector at the back of the power supply determines that a power supply is master or slave.

6.5 GRADDUMP FILE

Do not use the central log file for fault finding gradient amplifier related faults.
First use the graddump file to verify the gradient amplifier behavior.
Second, use the 'boiled down' bdasdump.log file for additional logging information concerning gradient faults. See paragraph 6.6.

Each time that a gradient error is detected during a scan, a scan abort is generated and the gradient amplifier will shutdown itself automatically. The status of the amplifier, just after the shutdown, is uploaded automatically to the host computer where it is written to a file called 'graddump.dmp' in the logging directory. This graddump.dmp file is not readable for a service engineer. Therefor a tool has been created that converts the hexadecimal information in this dump file into a readable text file. The conversion procedure for this graddump.dmp file is slightly different for each of the releases R6.1.2, R6.2.1 and R7.1.1.

6.5.1 HOW TO GENERATE A GRADDUMP.DMP FILE.

It is possible to generate a graddump.dmp file when ever you need to have one.

Procedure:

- Press the inhibit switch on one of the Copley 274 controllers (the red LED in the switch will be lit).
- Now start a scan and wait for the scan abort.
- Release the pressed inhibit switch again.

Because of the pressed inhibit switch, the scan will abort and the system will generate a graddump.dmp file. See Figure 62.

6.5.2 GRADDUMP: HOW TO USE / INSTALL THE CONVERSION TOOL FOR < R6.2

From the BBS or the PMS TechNet intranet site download the file 'graddump.zip' to your service computer. Unzip the file and upload the following two files into the logging directory of the host computer, e.g. with 'Proccomm Plus':

1. graddump.com upload as TEXT file;
2. grad_d.exe upload as BINARY file.

When done, login on the host computer with user 'gyrotest'.
Go to the logging directory by typing:
$ set def gyro$log

The command sequence for using the graddump tool is as follows:
$ @graddump [inputfile [outputfile]]

The input file is the gradient dump file and the output file is the file to which the converted data is written.
If you just type @graddump, the default input file 'gyro$log:graddump.dmp' will be used and the output file will be 'gyro$log:graddump.txt'.
It can be useful to rename the gyro$log:graddump.dmp file if you generate more graddump.dmp files in a trouble shoot session.
If you type @graddump followed by the input file name <name>.dmp, the output file will be <name>.txt.

Example 1:
$ @graddump

As input file the graddump.dmp file with the highest version number will be taken. This file will be converted into graddump.txt which can get a different version number depending on the number of existing files.

Example 2: (preferred procedure)
$ rename graddump.dmp;3 gd3.dmp;1
$ @graddump gd3.dmp;1

The output file will be gd3.txt;1.

6.5.3 GRADDUMP: HOW TO USE THE CONVERSION TOOL FOR R6.2 (ALSO R4.7.1, R5.7.1 AND R6.7.1)

Gyroscan systems with R6.2.1 software (also R4.7.1, R5.7.1 and R6.7.1) have the graddump file conversion program, this time called 'gradana', already on the system disk. So no additional download is required.

To use this conversion tool, login on the host computer with user 'gyrotest'.
Go to the logging directory by typing:
$ set def gyro$log

The command sequence for using the gradana tool is as follows:
$ gradana [inputfile [outputfile]]

The input file is the gradient dump file and the output file is the file to which the converted data is written.
If you just type gradana, the default input file 'gyro$log:graddump.dmp' will be used and the output file will be 'gyro$log:graddump.txt'.
It can be useful to rename the gyro$log:graddump.dmp file if you generate more graddump.dmp files in a trouble shoot session.
If you type gradana followed by the input file name <name>.dmp, the output file will be <name>.txt.

Example 1:
$ gradana

As input file the graddump.dmp file with the highest version number will be taken. This file will be converted into graddump.txt which can get a different version number depending on the number of existing files.

Example 2: (preferred procedure)
$ rename graddump.dmp;3 gd3.dmp;1
$ gradana gd3.dmp;1

The output file will be gd3.txt;1.

6.5.4 GRADDUMP: HOW TO USE THE CONVERSION TOOL FOR R7.1.1

The conversion of the graddump.dmp file to a readable text file is done automatically.
The readable text graddump file is called graddump.log.
The original graddump.dmp file with the hexadecimal information is also saved as 'graddump_dmp.log'.

NOTE

*Only when **no** graddump_dmp.log or graddump.log files have been deleted, will the version number of corresponding file types be identical.*

6.5.5 OVERVIEW OF THE GRADDUMP FOR ALL RELEASES.

The graddump file shows the logged status of the Copley 274 gradient amplifier just after a shutdown. This means that high voltage and output currents are already running downwards. See Figure 62. The system is in low power mode (note the graddump table 4 in Figure 62, the high voltage is 74 V) .

Besides error information, the graddump file also gives information about**:**
- Graddump table 1: Controller and power modules status summary (notice that the first line is the most important, the others are result faults).
- Graddump table 2: Complete status overview of the controllers.
- Graddump table 3: Complete status overview of the power modules.
- Graddump table 4: Read out of digitized signals of power modules. Just before table 4, you will find a summary of digitized signals being out of spec. Notice that it is empty when the graddump is created while the amplifier is standby.
- Miscellaneous data about power modules.

Miscellaneous data about power modules contains the following:
- Firmware versions.
- Total operational time (= the amplifier is switched on during days/hours/minutes).
- Operational time at current (= the amplifier is pulsing since days/hours/minutes).
- Percentage at current (= the amplifier is pulsing).
- Number of logged faults.
- Power-up count.
- Calibration dates (at Copley factory) (YY-MM-DD).
- Serial numbers and revision levels (here you can determine the swapping of power modules).
- IGBT power transistor type.
- TABLE: Complete overview of LAST-FAULTS status of the power modules faults
- In this overview all occurred faults from previous sessions are logged.

On the next pages several graddump examples are shown:
- The graddump file generated by trying to scan with one of the inhibit switches pressed. (Figure 62)
- This is a part of a graddump where the controller clock is disconnected. (Figure 63)
- This is a part of a graddump which shows wrong controller DIP switch settings. (Figure 64)
- This is a part of a graddump which shows wrong power module DIP switch settings. (Figure 65)
- This is a part of a graddump which shows a loose current sensor connection. (Figure 66)
- This is a part of a graddump which shows a short in the load. (Figure 67)

Figure 62 - The graddump file generated by trying to scan with one of the inhibit switches pressed.

```
Copley 274 Amplifier status file, processed Fri Mar 26 09:48:01 1999

Inputfile = INHIB.DMP;1
Original header:
>System Refence Number: 00001
>Hospital name: ASWT5X4 swid5054
>*** Gradient Amplifier dump.   Created: 99-03-26 09:46.56
>Copley-274D
>

--------------------------------------------------------------------------
TABLE 1: Controller and power modules status summary:

   Explanation of Unit names:
     The three characters make up the unit names as followed
       M = master, S = slave, X = x-axis, y = y-axis, z = z-axis
       C = controller, 1,2,3 or 4 = power module

   Explanation of the rank of the fault:
    10:   A 01 is found in a status byte this is possibly due to a
           random error in the reading of the status registers of the
           amplifier. If you need the status information of this part,
           then try to make another status-dump.
     9:   The unit showing this status fault is probably defective,
           or the shutdown reason is obvious (inhibit switch pressed?).
   8,7:   The unit showing this status fault might be defective
           or the status fault was introduced by another error.
   6,5:   Reserved status bits: If you see these, then there was either
           a logging problem or a new feature was added by the manufacturer
           of the gradient amplifier.
--------------------------------------------------------------------------
Unit
name  Rank  Status text

SXC    9    Inhibit switch pushed in (LED in switch is ON)
SXC    7    Not enabled (due to fault or missing enable signal)
--------------------------------------------------------------------------
```

```
---------------------------------------------------------------------------
TABLE 2: Complete status overview of the controllers:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  All status bits of reserved bit-names should be '0'.
  A '0' indicates a status fault (except for DanfyFlt, for which 1=fault).
---------------------------------------------------------------------------
     Faults A:         Faults B:         Faults C:
     C F . O O         D D .   B B B     . S   O D . . .
     h a . v v A I N   a a . B a a a     . i E p a . . .
     a u . e e i n o   n n . a d d d N   . g n e n . . .
     n l . r r r h     f f . d       o   . E a n f . . .
     S t . L T F i 5   + - .   + - +     . r b C y . . .
     t M . o e l b M   1 1 . + 1 1 2 E   . r l o F . . .
     o e . a m o S H   5 5 . 5 9 9 8 H   . o e n l . . .
     p m . d p w w z   V V . V V V V C   . r d n t . . .

MXC: 1 0 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
MYC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
MZC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0

SXC: 1 1 0 1 1 1 0 1   1 1 0 1 1 1 1 1   0 1 0 1 0 0 0 0
SYC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
SZC: 1 1 0 1 1 1 1 1   1 1 0 1 1 1 1 1   0 1 1 1 0 0 0 0
---------------------------------------------------------------------------
```

```
---------------------------------------------------------------------------
TABLE 3: Complete status overview of the power modules:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  A '0' indicates a status fault.
  All status bits of the reserved bit-names should be '1'.
---------------------------------------------------------------------------
     BusFaults:        AmpFaults:        AnalogErrors1:    AnalogErrors2:
     M F O O       .   . N     P N   N   B B   I   F . .   B   I   R B . .
     o a v v A     .   . v I I o e N o   a a B G A i . .   a B G A e a . .
     d u e e i N I .   . R G G s g o M   d d a B m l . .   d a B i c d . .
     F l r r r o 2 .   . a B B O O   o       d T b t . .     d T r t   . .
     a t T L F   l .   . m T T v v 1 d   + +   1 T T . .   -   2 F T + . .
     u M e o l E o .   . C 1 2 e e M C   1 1 + T e e . .   1 + T l e 2 . .
     l e m a o H n .   . o     r r H l   6 5 H m m m . .   5 5 m o m 8 . .
     t m p d w C g .   . r F F I I z k   V V V p p p . .   V V p w p V . .

MX1: 1 0 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MX2: 1 0 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MX3: 1 0 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MX4: 1 0 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MY1: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MY2: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MY3: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MY4: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MZ1: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MZ2: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MZ3: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
MZ4: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1

SX1: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SX2: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SX3: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SX4: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SY1: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SY2: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SY3: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SY4: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SZ1: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SZ2: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SZ3: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
SZ4: 1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1   1 1 1 1 1 1 1 1
---------------------------------------------------------------------------
```

```
--------------------------------------------------------------------------
Summary of digitized signals being 'out of spec':

--------------------------------------------------------------------------


--------------------------------------------------------------------------
TABLE 4: Read out of digitized signals of Power Modules:
  A '*' behind a number means 'out of spec'. (Error)
  A '!' behind a number means only 'out of spec' if the system
    was long enough in stand-by mode. (Warning)
  A '?' behind a number means the value deviates from typical
    value, but no spec is defined. (Informational)

  The estimated Ambient temperature is 21.2 degrees Celsius. If a system
  is in stand-by mode, all temperatures should be close to this temperature.
--------------------------------------------------------------------------
     X1    X2    X3    X4    Y1    Y2    Y3    Y4    Z1    Z2    Z3    Z4
--------------------------------------------------------------------------
+16V supply [V]  Spec=15.1:16.4  Shutdown limit=14.5:16.5
M:  15.8  15.8  15.9  15.8  15.8  16.0  15.8  15.8  15.8  15.7  15.6  15.8
S:  16.0  15.8  16.0  16.2  15.7  15.8  15.7  15.6  15.7  15.6  15.7  15.8

+15V supply [V]  Spec=14.9:16.3  Shutdown limit=13.5:16.5
M:  15.6  15.7  15.8  15.6  15.7  15.9  15.7  15.7  15.8  15.7  15.7  15.7
S:  15.6  15.6  15.7  15.8  15.7  15.7  15.8  15.7  15.7  15.6  15.7  15.8
```

```
 High Voltage (EMI supplies) [V]  Spec=70.0:433.0  Shutdown limit=61.0:440.0
 M:  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2
 S:  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2  74.2

 IGBT1 Temperature [degC]  Spec=18.7:25.2  Shutdown limit= <75.0
 M:  22.2  22.2  22.2  21.2  21.2  21.2  21.2  21.2  20.6  20.6  20.6  21.2
 S:  20.6  21.2  20.6  21.2  20.6  20.6  19.5  20.6  20.6  19.5  19.5  20.6

 Ambient Temperature [degC]  Spec=18.7:25.2  Shutdown limit= <45.0
 M:  22.2  21.2  22.2  21.2  20.6  21.2  22.2  21.2  20.6  19.5  20.6  20.6
 S:  21.2  21.2  22.2  20.6  20.6  20.6  21.2  21.2  20.6  20.6  21.2  21.2

 Inductor Temperature [degC]  Spec=18.7:25.2  Shutdown limit= <75.0
 M:  23.3  22.2  22.2  21.2  22.2  21.2  19.5  21.2  21.2  21.2  20.6  20.6
 S:  21.2  21.2  21.2  19.5  21.2  20.6  20.6  20.6  21.2  21.2  20.6  19.5

 Pos. RMS output current [A]  Spec=0.0:2.5  Shutdown limit= <175.0
 M:   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
 S:   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0

 Neg. RMS output current [A]  Spec=0.0:2.5  Shutdown limit= <175.0
 M:   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
 S:   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0

 -15V supply [V]  Spec=-16.3:-14.9  Shutdown limit=-16.5:-13.5
 M: -15.8 -15.9 -16.0 -15.8 -16.0 -16.0 -15.8 -16.0 -15.9 -15.9 -15.8 -15.8
 S: -15.8 -15.8 -16.0 -16.1 -15.9 -16.0 -16.0 -15.8 -15.9 -15.8 -16.0 -16.1

 +5V supply [V]  Spec=4.8:5.2  Shutdown limit=4.8:5.3
 M:   4.9   4.9   5.0   4.9   4.9   5.0   4.9   4.9   5.0   4.9   4.9   4.9
 S:   4.9   4.9   4.9   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.0   5.0

 IGBT2 Temperature [degC]  Spec=18.7:25.2  Shutdown limit= <75.0
 M:  22.2  21.2  22.2  21.2  21.2  21.2  21.2  22.2  20.6  20.6  21.2  20.6
 S:  21.2  21.2  21.2  21.2  21.2  20.6  21.2  20.6  20.6  19.5  20.6  21.2

 Airflow [-]  Spec=1.0:2.0  Shutdown limit=none
 M:   1.6   1.6   1.5   1.7   1.6   1.6   1.5   1.6   1.6   1.6   1.5   1.6
 S:   1.6   1.6   1.5   1.6   1.6   1.6   1.6   1.6   1.6   1.5   1.5   1.5

 Rectifier Temperature [degC]  Spec=18.7:25.2  Shutdown limit= <75.0
 M:  23.3  22.2  23.3  22.2  23.3  21.2  21.2  22.2  20.6  21.2  20.6  21.2
 S:  21.2  21.2  22.2  21.2  21.2  21.2  21.2  21.2  21.2  23.3  21.2  20.6


+28V supply [V]  Spec=27.0:29.0  Shutdown limit=26.5:29.5
M:  28.0  28.0  28.1  28.1  28.1  28.3  28.0  28.3  28.3  28.3  28.1  28.3
S:  28.0  28.1  27.9  28.3  28.1  28.4  28.1  28.3  28.1  28.1  28.3  28.3

Simulated JuncT rise [degC]  Spec=none  Shutdown limit=none
M:   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8
S:   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8   2.8

Reference temperature [degC]  Spec=none  Shutdown limit=none
M: 106.1 106.1 106.1 106.6 107.0 106.6 106.6 107.0 107.0 107.0 108.0 107.0
S: 106.6 107.0 106.1 107.0 106.6 107.0 107.0 107.0 107.0 107.5 107.0 106.6

Difference in temp. of IGBT 1 and 2 [degC]  Spec=-6.0:6.0  Shutdown limit=none
M:   0.0   1.1   0.0   0.0   0.0   0.0   0.0  -1.1   0.0   0.0  -0.5   0.5
S:  -0.5   0.0  -0.5   0.0  -0.5   0.0  -1.6   0.0   0.0   0.0  -1.1  -0.5
--------------------------------------------------------------------------
```

```
Miscellaneous data for power modules:

Firmware versions:
MX1:2.10            MX2:2.10            MX3:2.10            MX4:2.10
MY1:2.10            MY2:2.10            MY3:2.10            MY4:2.10
MZ1:2.10            MZ2:2.10            MZ3:2.10            MZ4:2.10

SX1:2.10            SX2:2.10            SX3:2.10            SX4:2.10
SY1:2.10            SY2:2.10            SY3:2.10            SY4:2.10
SZ1:2.10            SZ2:2.10            SZ3:2.10            SZ4:2.10


  Operational time (=Amplifier switched on)(days/hours/minutes):
  MX1:  73d 06h 41m    MX2:  73d 05h 34m    MX3:  73d 05h 52m    MX4:  73d 05h 44m
  MY1:  73d 05h 54m    MY2:  73d 05h 43m    MY3:  73d 05h 57m    MY4:  73d 06h 13m
  MZ1:  73d 05h 41m    MZ2:  73d 05h 50m    MZ3:  73d 06h 11m    MZ4:  73d 06h 03m

  SX1: 113d 08h 33m    SX2: 113d 07h 39m    SX3: 113d 08h 52m    SX4: 113d 07h 39m
  SY1: 113d 08h 11m    SY2: 113d 07h 37m    SY3: 113d 09h 05m    SY4: 113d 07h 51m
  SZ1: 113d 07h 35m    SZ2: 112d 16h 58m    SZ3: 113d 07h 45m    SZ4: 113d 09h 20m


  Operational time at current (days/hours/minutes):
  MX1:   4d 17h 06m    MX2:   4d 16h 57m    MX3:   4d 17h 05m    MX4:   4d 16h 43m
  MY1:   4d 10h 36m    MY2:   4d 10h 36m    MY3:   4d 10h 54m    MY4:   4d 10h 30m
  MZ1:   4d 23h 41m    MZ2:   4d 23h 30m    MZ3:   4d 23h 20m    MZ4:   4d 23h 32m

  SX1:   9d 23h 32m    SX2:   9d 23h 05m    SX3:   9d 23h 55m    SX4:   9d 22h 53m
  SY1:  10d 04h 56m    SY2:  10d 04h 45m    SY3:  10d 05h 08m    SY4:  10d 04h 55m
  SZ1:  10d 16h 46m    SZ2:  10d 16h 08m    SZ3:  10d 16h 42m    SZ4:  10d 16h 46m

       X1     X2     X3     X4     Y1     Y2     Y3     Y4     Z1     Z2     Z3     Z4
  -------------------------------------------------------------------------------------
  Percentage at current:
  M:  6.4    6.4    6.4    6.4    6.1    6.1    6.1    6.1    6.8    6.8    6.8    6.8
  S:  8.8    8.8    8.8    8.8    9.0    9.0    9.0    9.0    9.4    9.5    9.4    9.4

  Number of logged faults:
  M:  46     46     50     47     32     32     32     32     27     27     27     27
  S:  45     45     46     47     49     51     49     49     45     45     45     45

  Power-up count:
  M:  75     73     75     76     74     76     75     76     75     74     74     74
  S:  76     76     77     78     76     76     77     76     76     75     77     80


  Calibration dates (at Copley factory) (YY-MM-DD):
  MX1:98-08-17         MX2:98-08-17         MX3:98-08-17         MX4:98-08-17
  MY1:98-08-17         MY2:98-08-17         MY3:98-08-17         MY4:98-08-17
  MZ1:98-08-17         MZ2:98-08-17         MZ3:98-08-17         MZ4:98-08-17

  SX1:98-09-10         SX2:98-09-10         SX3:98-09-10         SX4:98-09-10
  SY1:98-09-10         SY2:98-09-10         SY3:98-09-10         SY4:98-09-10
  SZ1:98-09-09         SZ2:98-09-12         SZ3:98-09-09         SZ4:98-09-10
```

SerialNumbers and Revision levels:

	Module	Rev	ModBoard	Rev	DrvBoard	Rev	FiltBoard	Rev
MX1:	0496CB850	G	3398CC390	Q	3398CD792	M	3398AN507	I
MX2:	3398CB797	G	3398CC386	Q	3398CD778	M	3398AN496	I
MX3:	3398CB813	G	3398CC841	Q	3398CD786	M	3398AN923	I
MX4:	3398CB814	G	3398CC842	Q	3398CD789	M	3398AN936	I
MY1:	0596CB275	G	3398CC839	Q	3398CD780	M	3398AN922	I
MY2:	3398CB804	G	3398CC847	Q	3398CD783	M	3398AN021	I
MY3:	3398CB799	G	3398CC392	Q	3398CD777	M	3398AN494	I
MY4:	3398CB812	G	3398CC848	Q	3398?D984	M	3398AN929	I
MZ1:	3398CB795	G	3398CC009	Q	3398CD790	M	3398AN503	I
MZ2:	3398CB802	G	3398CC010	Q	3398CD986	M	3398AN508	I
MZ3:	3398CB810	G	3398CC844	Q	3398CD985	M	3398AN932	I
MZ4:	3398CB803	G	3398CC843	Q	3398CD787	M	3398AN920	I
SX2:	3798CB036	G	3798CC084	S	3698CD851	M	3798AN103	I
SX3:	3798CB029	G	3698CC732	S	3698CD849	M	3698AN971	I
SX4:	3698CB955	G	3698CC847	S	3698CD805	M	3698AN975	I
SY1:	3798CB030	G	3798CC078	S	3698CD807	M	3698AN982	I
SY2:	3798CB038	G	3798CC074	S	3698CD796	M	3798AN102	I
SY3:	3798CB046	G	3798CC076	S	3698CD913	M	3798AN112	I
SY4:	3798CB044	G	3798CC086	S	3698CD799	M	3798AN104	I
SZ1:	3798CB027	G	3698CC989	S	3698CD813	M	3698AN979	I
SZ2:	3698CB952	G	3798CC270	S	3698CD815	M	3698AN972	I
SZ3:	3698CB954	G	3698CC841	S	3698CD507	M	3698AN981	I
SZ4:	3798CB037	G	3698CC846	S	3698CD522	M	3798AN101	I

IGBT power transistor type:
'IRF' = International Rectifier,
'Mits' = Mitsubishi/PowerEx,
'Fuji' = Fuji,
'Semi' = Semikron.

MX1:Mits	MX2:Mits	MX3:Mits	MX4:Mits
MY1:Mits	MY2:Mits	MY3:Mits	MY4:Mits
MZ1:Mits	MZ2:Mits	MZ3:Mits	MZ4:Mits
SX1:Mits	SX2:Mits	SX3:Mits	SX4:Mits
SY1:Mits	SY2:Mits	SY3:Mits	SY4:Mits
SZ1:Mits	SZ2:Mits	SZ3:Mits	SZ4:Mits

```
------------------------------------------------------------------------------
TABLE: Complete overview of LAST-FAULTS status of the power modules:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  A '0' indicates a status fault.
  All status bits of the reserved bit-names should be '1'.
  The Last Faults tables contain reasons for the previous time every
  power module shut down. Depending upon usage, this will frequently
  just be the status logged during switching-off of the system.
------------------------------------------------------------------------------
     BusFaults:          AmpFaults:          AnalogErrors1:      AnalogErrors2:
     M F O O       .     . N     P N   N     B B   I   F . .     B   I   R B . .
     o a v v A     .     . v I I o e N o     a a B G A i . .     a B G A e a . .
     d u e e i N I .     . R G G s g o M     d d a B m l . .     d a B i c d . .
     F l r r r o 2 .     . a B B O O   o         d T b t . .       d T r t   . .
     a t T L F   l .     . m T T v v 1 d     + +   1 T T . .     -   2 F T + . .
     u M e o l E o .     . C 1 2 e e M C     1 1 + T e e . .     1 + T l e 2 . .
     l e m a o H n .     . o     r r H l     6 5 H m m m . .     5 5 m o m 8 . .
     t m p d w C g .     . r F F I I z k     V V V p p p . .     V V p w p V . .

MX1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 0     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1
MX2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 0     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1
MX3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 0     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1
MX4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 0     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1
MY1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MY2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MY3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MY4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MZ1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MZ2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MZ3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
MZ4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1

SX1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SX2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SX3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SX4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SY1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SY2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SY3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SY4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SZ1: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SZ2: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SZ3: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
SZ4: 0 0 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1     1 1 1 1 1 0 1 1
```

Figure 63 - This is a part of a graddump where the controller clock is disconnected.

```
------------------------------------------------------------------------
Unit
name  Rank  Status text
  The first line is the most important one, the others are result faults.
SYC    8    Master clock (5MHz) not received on controller
SY1    8    1MHz clock is missing or out of range
SY2    8    Module clock (20 or 25kHz) is missing or out of range
SY3    8    1MHz clock is missing or out of range
SY4    8    Module clock (20 or 25kHz) is missing or out of range
SYC    7    Not enabled (due to fault or missing enable signal)
-------------------------------------------------------------------------


-------------------------------------------------------------------------
TABLE 2: Complete status overview of the controllers:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  All status bits of reserved bit-names should be '0'.
  A '0' indicates a status fault (except for DanfyFlt, for which 1=fault).
-------------------------------------------------------------------------
     Faults A:              Faults B:              Faults C:
     C F . O O              D D .   B B B          . S   O D . . .
     h a . v v A I N        a a . B a a a          . i E p a . . .
     a u . e e i n o        n n . a d d d N        . g n e n . . .
     n l . r r r h          f f . d       o        . E a n f . . .
     S t . L T F i 5        + -     + - +          . r b C y . . .
     t M . o e l b M        1 1 . + 1 1 2 E        . r l o F . . .
     o e . a m o S H        5 5 . 5 9 9 8 H        . o e n l . . .
     p m . d p w w z        V V . V V V V C        . r d n t . . .

MXC: 1 1 0 1 1 1 1 1        1 1 0 1 1 1 1 1        0 1 1 1 0 0 0 0
MYC: 1 1 0 1 1 1 1 1        1 1 0 1 1 1 1 1        0 1 1 1 0 0 0 0
MZC: 1 1 0 1 1 1 1 1        1 1 0 1 1 1 1 1        0 1 1 1 0 0 0 0

SXC: 1 1 0 1 1 1 1 1        1 1 0 1 1 1 1 1        0 1 1 1 0 0 0 0
SYC: 0 0 0 1 1 1 1 0        1 1 0 1 1 1 1 1        0 1 0 1 0 0 0 0
SZC: 1 1 0 1 1 1 1 1        1 1 0 1 1 1 1 1        0 1 1 1 0 0 0 0
-------------------------------------------------------------------------
```

Note that the controller is not enabled.

Notice that all 6 listed faults are caused by a missing 5 MHz clock.
The first line is the most important, the others are result faults.

Possible causes:

- A missing 5 MHz clock at J6 at the back plane.
- A bad back plane, extender board or controller.

Because all four power modules (SY1, SY2, SY3, SY4) show the same error, it is very unlikely that there are power module problems.

Figure 64 - This is a part of a graddump which shows wrong controller DIP switch settings.

```
Original header:
>System Refence Number: 00001
>Hospital name: ASWT5X4 swid5054
>*** Gradient Amplifier dump.   Created: 99-03-26 11:16.26
>Copley-274D
>

PROBLEM: Probably address-dipswitch wrong for unit MYC.
         Other data might be unreliable as a result.

--------------------------------------------------------------------------
******** deleted some text here ***************

--------------------------------------------------------------------------
TABLE 2: Complete status overview of the controllers:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  All status bits of reserved bit-names should be '0'.
  A '0' indicates a status fault (except for DanfyFlt, for which 1=fault).
--------------------------------------------------------------------------
     Faults A:          Faults B:          Faults C:
     C F . O O          D D .   B B B      . S   O D . . .
     h a . v v A I N    a a . B a a a      . i E p a . . .
     a u . e e i n o    n n . a d d d N    . g n e n . . .
     n l . r r r h      f f . d       o    . E a n f . . .
     S t . L T F i 5    + - .   + - +      . r b C y . . .
     t M . o e l b M    1 1 . + 1 1 2 E    . r l o F . . .
     o e . a m o S H    5 5 . 5 9 9 8 H    . o e n l . . .
     p m . d p w w z    V V . V V V V C    . r d n t . . .

MXC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
MYC:
MZC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0

SXC: 1 0 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
SYC: 1 0 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
SZC: 1 0 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
--------------------------------------------------------------------------
```

Note the blank line.

NOTE

If you change the position of a controller inside the cabinet, you have to change the DIP switch settings according to the new position of the controller. If you don't do this, the graddump information is unreliable for diagnosis.

Figure 65 - This is a part of a graddump which shows wrong power module DIP switch settings.

```
PROBLEM: Probably address-dipswitch wrong for unit SX3.
         Other data might be unreliable as a result.

**** deleted some text ****
--------------------------------------------------------------------------
TABLE 3: Complete status overview of the power modules:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  A '0' indicates a status fault.
  All status bits of the reserved bit-names should be '1'.
--------------------------------------------------------------------------
     BusFaults:         AmpFaults:          AnalogErrors1:     AnalogErrors2:
     M F O O       .    . N     P N   N     B B   I   F . .    B   I   R B . .
     o a v v A     .    . v I I o e N o     a a B G A i . .    a B G A e a . .
     d u e e i N I .    . R G G s g o M     d d a B m l . .    d a B i c d . .
     F l r r r o 2 .    . a B B O O   o         d T b t . .      d T r t   . .
     a t T L F   l .    . m T T v v 1 d     + +   1 T T . .    -   2 F T + . .
     u M e o l E o .    . C 1 2 e e M C     1 1 + T e e . .    1 + T l e 2 . .
     l e m a o H n .    . o     r r H l     6 5 H m m m . .    5 5 m o m 8 . .
     t m p d w C g .    . r F F I I z k     V V V p p p . .    V V p w p V . .

MX1: 1 0 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MX2: 1 0 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MX3: 1 0 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MX4: 1 0 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MY1: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MY2: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MY3: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MY4: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MZ1: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MZ2: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MZ3: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
MZ4: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1

SX1: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SX2: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SX3:
SX4: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SY1: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SY2: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SY3: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SY4: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SZ1: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
SZ2: 1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1     1 1 1 1 1 1 1 1    1 1 1 1 1 1 1 1
```

Note the blank line.

NOTE

If you change the position of a power module inside the cabinet, you have to change the DIP switch settings according to the new position of the module. If you don't do this, the graddump information is unreliable for diagnosis.

Figure 66 - This is a part of a graddump which shows a loose current sensor connection.

```
---------------------------------------------------------------------------
Unit
name  Rank  Status text

SXC    9    Open connector (Interlock) The first line is the most important one, the others are result faults.
SXC    8    Overload: Too much current (peak and/or duration in a power module
                Or: Overcurrent in Danfysik sensor
SXC    7    Not enabled (due to fault or missing enable signal)
SXC    7    Overcurrent in Danfysik sensor. Line is visible only in case
                of a hard fault in sensor, because status is not latched
---------------------------------------------------------------------------


---------------------------------------------------------------------------
TABLE 2: Complete status overview of the controllers:
  Header-columns are the bit-names.
  Dots indicate the reserved bit-names.
  All status bits of reserved bit-names should be '0'.
  A '0' indicates a status fault (except for DanfyFlt, for which 1=fault).
---------------------------------------------------------------------------
     Faults A:          Faults B:          Faults C:
     C F . O O          D D .   B B B      . S   O D . . .
     h a . v v A I N    a a . B a a a      . i E p a . . .
     a u . e e i n o    n n . a d d d N    . g n e n . . .
     n l . r r r h      f f . d       o    . E a n f . . .
     S t . L T F i 5    + - .   + - +      . r b C y . . .
     t M . o e l b M    1 1 . + 1 1 2 E    . r l o F . . .
     o e . a m o S H    5 5 . 5 9 9 8 H    . o e n l . . .
     p m . H p w w z    V V . V V V V C    . r d n t . . .

MXC: 1 0 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
MYC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
MZC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0

SXC: 1 1 0 0 1 1 1 1    1 1 0 1 1 1 1 1    0 1 0 0 1 0 0 0
SYC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
SZC: 1 1 0 1 1 1 1 1    1 1 0 1 1 1 1 1    0 1 1 1 0 0 0 0
---------------------------------------------------------------------------
```

Notice that all four SXC (Slave X controller) faults are caused by only ONE problem: open connector (interlock). The others are result faults.

Possible causes:

- You have a REV A back plane and jumper P202 at the controller is not installed (only required for REV A back planes). See also paragraph 5.3.3.
- A loose current sensor connector (J19) at the back plane.
- A defective controller.
- A defective back plane or extender board.

Figure 67 - This is a part of a graddump which shows a short in the load.

```
---------------------------------------------------------------------------
Unit
name  Rank  Status text

SYC    8    Signal Error (Clipping), output current incorrect
SYC    7    Not enabled (due to fault or missing enable signal)
---------------------------------------------------------------------------
```

One of the faults that cause a 'signal error' is a short somewhere in the load of the amplifier.
For this particular fault there was a short between the gradient connection strips and the ring frame at the rear side of the magnet. The arcing could be seen in the dark examination room while the gradient amplifier tried to switch to high voltage mode.

By swapping coil connections you determine where to find the fault, inside the amplifier or at the coil side (filter box, cabling, strips or coil).

6.6 BOILDOWN PROGRAM

The boildown.com program (fits all software releases) is used to filter out the gradient amplifier related errors from the 'bdasdump.log' file.

From the BBS or the PMS TechNet intranet site download the file 'boildown.com' to your service computer. Upload this file into the logging directory of the host computer, e.g. with 'Procomm Plus' (upload as TEXT file).

Boildown procedure:

1. Login under GYROTEST/NOCOM (/NOCOM is used because of the purge command in the login command)
2. Go to the logfile directory:
   $ set def gyro$log:
3. Verify the number of bdasdump.log files:
   $ dir bdasdump.log
4. Run the boildown.com file to extract the relevant logging from the bdasdump.log files:
   $ @boildown

This command file generates a file named: boildown.csv. You can type this file on the host computer or you can copy this file to your note book (PC) into e.g. MS EXCEL.
Additional to the graddump, this file contains gradient amplifier logging, extracted from bdasdump.log.

6.7 APPENDIX: QUICK REFERENCE FOR ADJUSTMENTS

6.7.1 GRADIENT AMPLIFIER

Order of adjustments for the gradient amplifier:

	Adjustment	Paragraph	Affected unit
1.	Offset check	4.2	Copley 274 controller
2.	Gain adjustment	4.3	Copley 274 controller
3.	Settling adjustment	4.6	Copley 274 controller
4.	Dual mode adjustment (Intera MASTER only)	4.7	Copley 274 controller
5.	Eddy current adjustment	3.5 and 4.8	ECC/WFG board (in the gradient interface)

NOTE

If you have to redo one of these adjustments, e.g. because of failing hardware, you also have to check/adjust all adjustments followed after this re-done adjustment for the affected axis X, Y or Z.

Software adjustments for the gradient chain are in next paragraphs:

	Adjustment	Paragraph
1.	Gradient parameters determination	3.8.1
2.	Eddy current analysis	3.8.3
3.	Fine adjustment of the gradient strength	3.9

NOTE

After you have replaced a gradient amplifier Copley 274 controller or ECC/WFG board you have to perform these software adjustments from section 18.

6.7.2 EDDY CURRENT

NOTE

***Do NOT** use potentiometer T6, keep it counter clockwise!*

Adjustment order for Eddy current adjustment for each orientation X, Y or Z :

	Adjustment	**Paragraph**
1.	Drift adjustment of the integrator	3.5.1
2.	Positioning of the pick-up coils	3.5.2
3.	Reference measurement	3.5.3
4.	Long term eddy currents	4.8.1
5.	Mid term eddy currents	4.8.1
6.	Short term eddy currents	4.8.1
7.	Final measurement	4.8.2

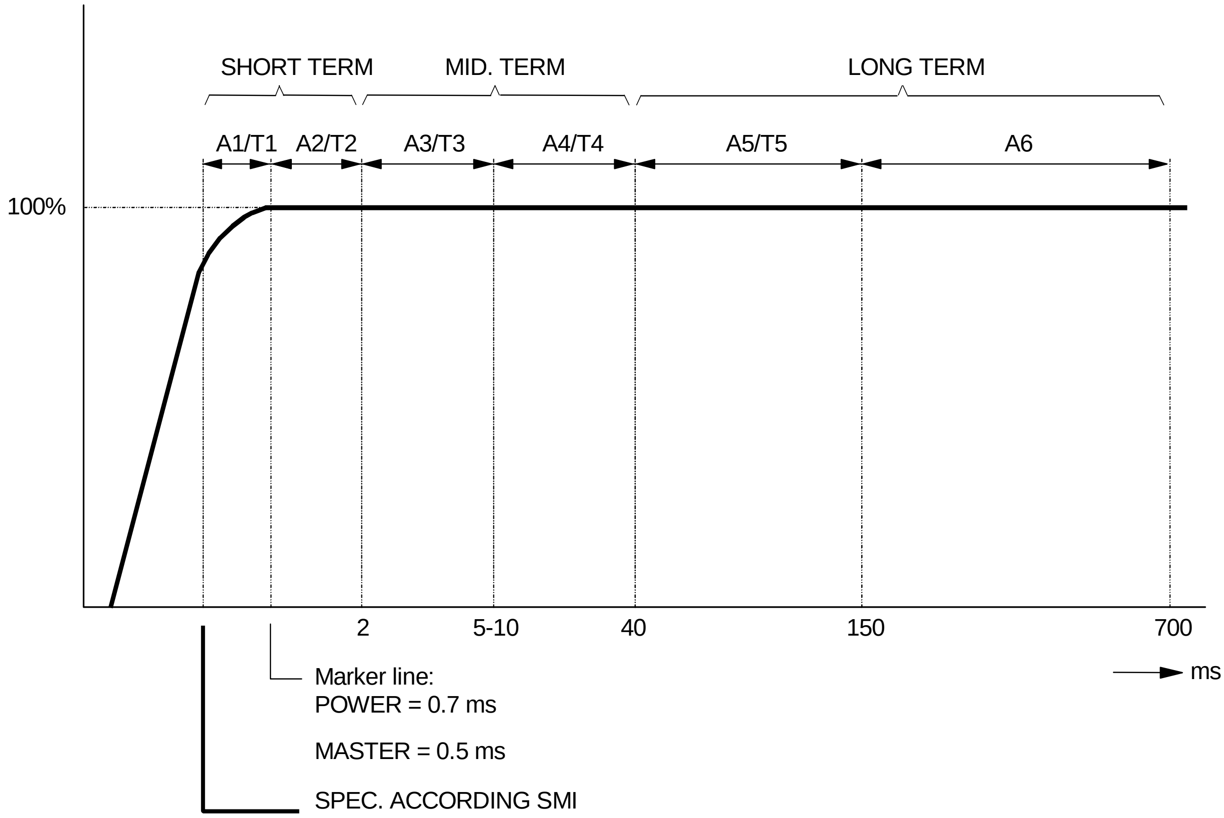
Before you start the **long term eddy currents**, **you have to change 3 parameters.**
Select "Compensate long term eddy currents" and change the following parameters from the default value:

- repetition time to 1500 ms
- pulse duration to 750 ms
- end sampling time 700ms

Table 10 - The operational range of each filter

Potentiometers	**Range**
T6 A6	150 - 700ms
T5 A5	40 - 150ms
T4 A4	10 - 40ms
T3 A3	2 - 10ms
T2 A2	< 2ms
T1 A1	Used to decrease the rise time

Figure 68 - Time constants



ECC adjustment specifications:

		POWER	MASTER	Specification
ECC:	Three-quarter point	0.30 ms		69.0 % ± 3.0 %
ECC:	Three-quarter point		0.15 ms	63.0 % ± 6.0 %
ECC:	EOS point	0.4 ms		95.0 % ± 0.5 %
ECC:	EOS point		0.224 ms	91.5 % ± 0.5 %
ECC:	Flatness 1	0.7 -> 3.4 ms	0.5 ms -> 3.2 ms	< 0.15 % *)
ECC:	Flatness 2	3.4 -> 990 ms	3.3 ms -> 990 ms	< 0.1 % *)
ECC:	Difference 1	1.0 -> 5.4 ms	0.8 -> 5.2 ms	< 0.45 % **)
ECC:	Difference 2	5.8 -> 990 ms	5.2 -> 990 ms	< 0.42 % **)

*) [(max.value) - (min.value)]
**) [(max.value) - (min.value)]

6.8 MONITOR SETUP IN THE TECHNICAL ROOM

6.8.1 RELEASE R5.X – R9.X

Setup the Barco or LCD monitor of the host computer, keyboard and mouse in the technical room.
Extend the video connection with 5 BNC cables + BNC I pieces or a 'VGA extension cable' 4522 150 20241.

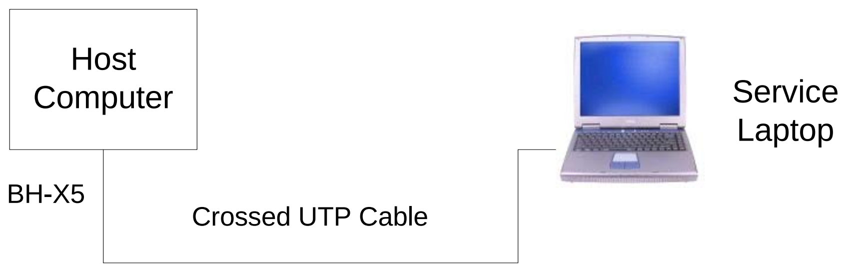
Also extend the keyboard and mouse connection both with two cables 'ext. cable keyboard/mouse' 4522 131 87551 (Totally 4 cables required).

6.8.2 RELEASE R10.1 AND ONWARDS

The host computer XW8000 is not capable to operate with a keyboard / mouse extension cable with a length above 5 meters. In order being able to setup a monitor (incl. the controls) in the technical room, especially required for the gradient amplifier adjustments, the Look Over The Shoulder application must be used.
Detailed information how to setup the Service PC using the Look Over The Shoulder application refer to the Remote Service manual.
TechNet: http://technet.best.ms.philips.com/mr/docdb/781/452298125401/452298125401.htm

Remote Service via network connection
The connection is established via BH-X5 on the host computer. Only the IP address of the host computer is required.

Figure 69 : Connection overview Service Laptop



The Field Service Framework
Before the FSF can be used Internet Explorer should be configured and a hardware key driver (dongle) should be installed on the Service PC. This configuration and installation should be performed once for every Service PC!
Refer to the Remote Service manual. for detailed information.
TechNet: http://technet.best.ms.philips.com/mr/docdb/781/452298125401/452298125401.htm