

## 1. Tools

- Service engineer mechanical tool kit
- mAs meter
- Multimeter
- Digital oscilloscope with 2-beam memory
- PC incl. 3.5" FDD, HW-dongle, serial interface cable, free RAM  $\geq$  590 KB
- Service software "XRG SCOPE" Version 2.2 or higher
- Recommended PLCC extraction tool (AMP 822154-1) 2422 487 89772

## 2. Notes

### Caution!

**After the generator has been switched off, hazardous voltages are still applied to the d.c. intermediate circuits of the converter, the rotor control and the mA control.**

**These voltages are usually discharged within 1 minute to values which are no longer dangerous.**

## 3. Strategy

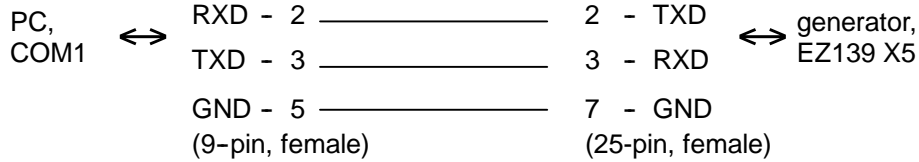
There are 3 categories of errors:

- The generator cannot be switched on at all or only for a short time.
  - See  $\Rightarrow$  5. "Initialization phase of the generator"
  - $\Rightarrow$  6. "Switch-on not possible"
- The generator can be switched on but no error numbers are displayed on the operating desk.
  - For fault finding use the service PC.
  - See  $\Rightarrow$  4. "Connecting the service PC"
  - $\Rightarrow$  5. "Initialization phase of the generator"
  - $\Rightarrow$  7. "Error numbers"
- Error messages are displayed on the desk.
  - For fault finding use the service PC.
  - See  $\Rightarrow$  4. "Connecting the service PC"
  - $\Rightarrow$  7. "Error numbers"

## 4. Service-PC

### 4.1. Connection

- S Switch the generator on.
- S Provide the PC with the HW key and switch it on.
- S Connect the PC to X5 on EZ139 CENTRAL UNIT CU via a serial data cable.



### 4.2. Operation

For installation of generator firmware and newest service tools see "REPLACEMENT" chapter "Exchange of firmware ...".

- S Call the program with **xrgscope** or with **xrgscope lcd** for PC's with LCD screen.
  - S Enter you password
- The following menu line appears:

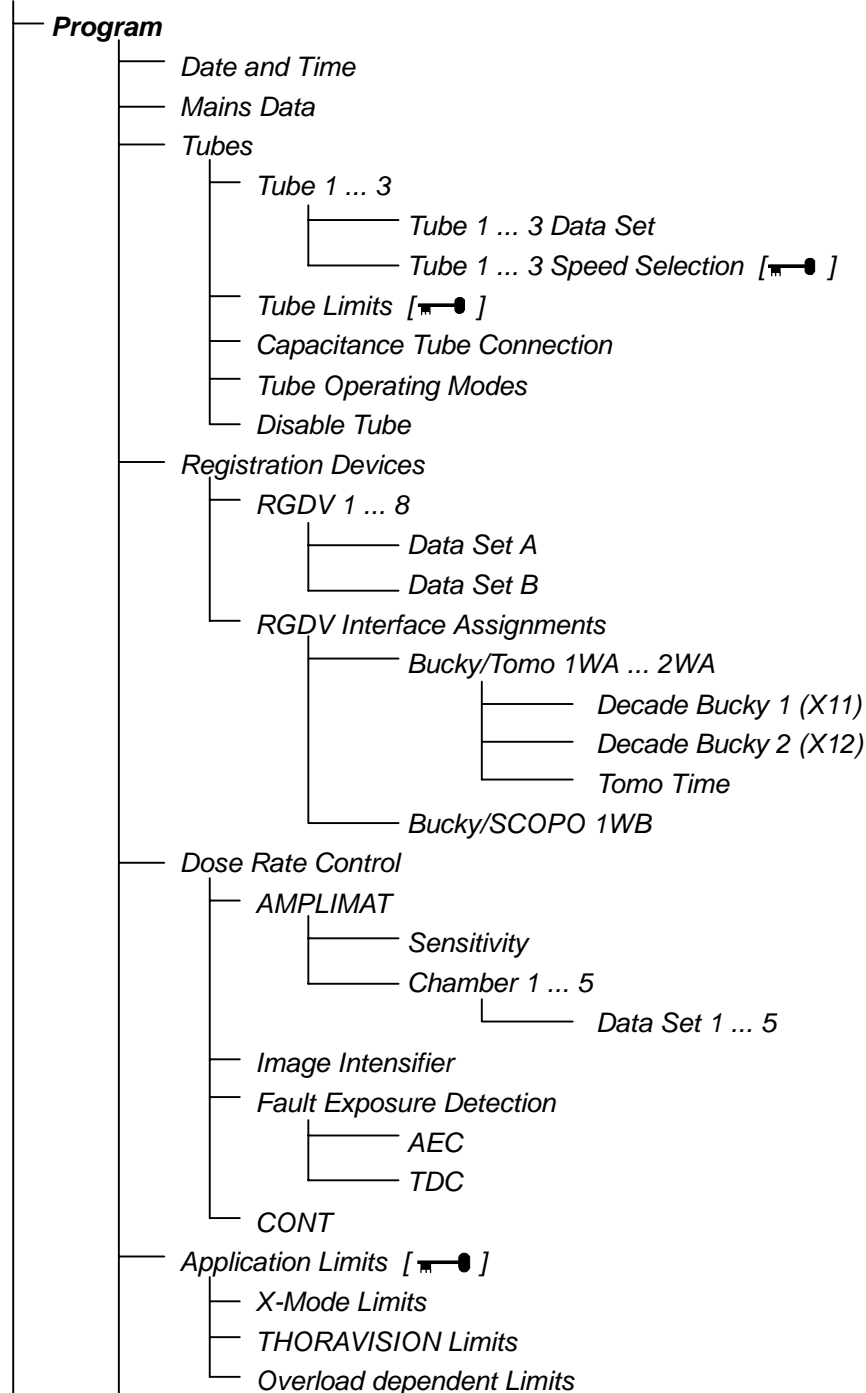
| <i>File</i> | <i>OPTIMUS</i> | <i>Select Unit</i> | <i>Options</i> | <i>Help</i> |
|-------------|----------------|--------------------|----------------|-------------|
|-------------|----------------|--------------------|----------------|-------------|

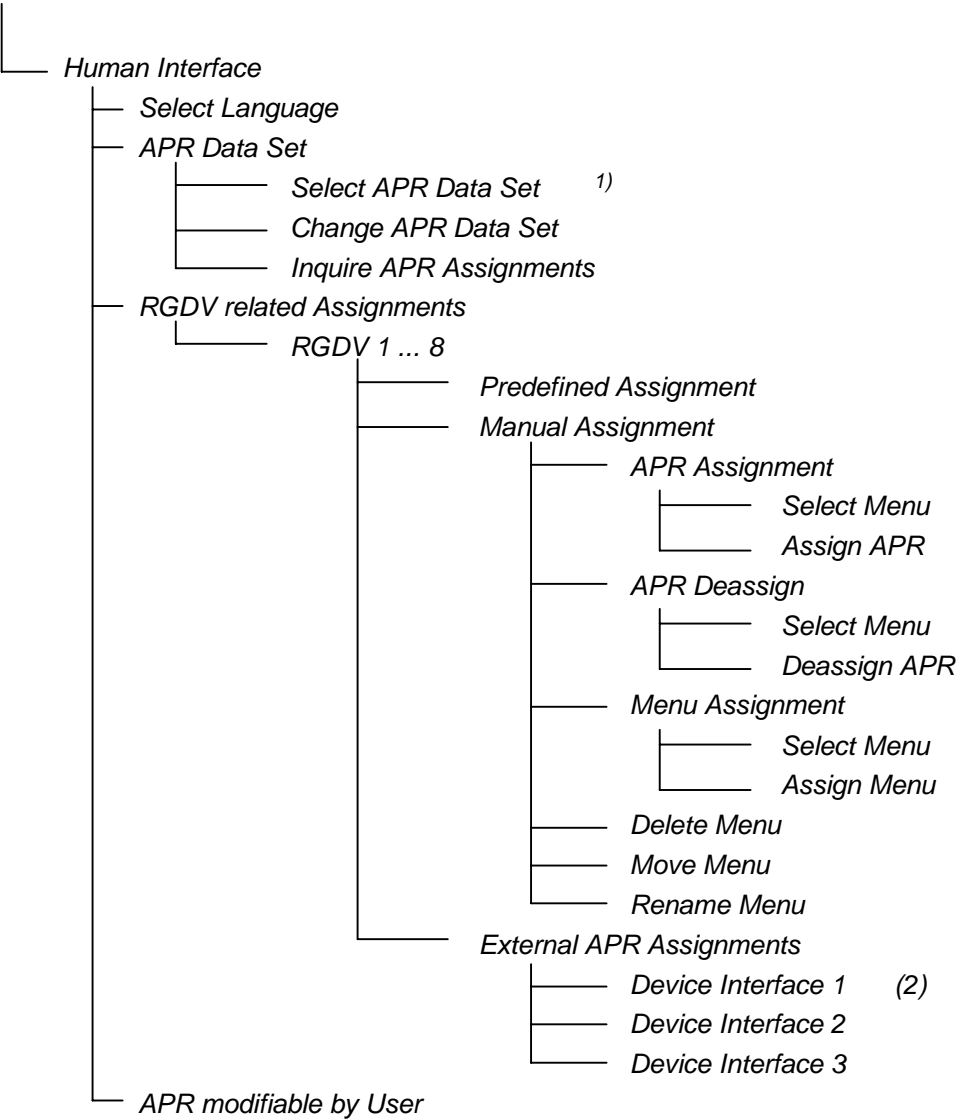
#### Note

- Current data files, for instance, for online help, tube types, APR programming are available in BBS.  
 Product: Generatoren Hamburg  
 Download area: OPTIMUS
- If you call the installation program with **xrgscope ?** the possible starting parameters for the service program will be listed.





### 4.3. Menu structure

#### OPTIMUS (Release 3)






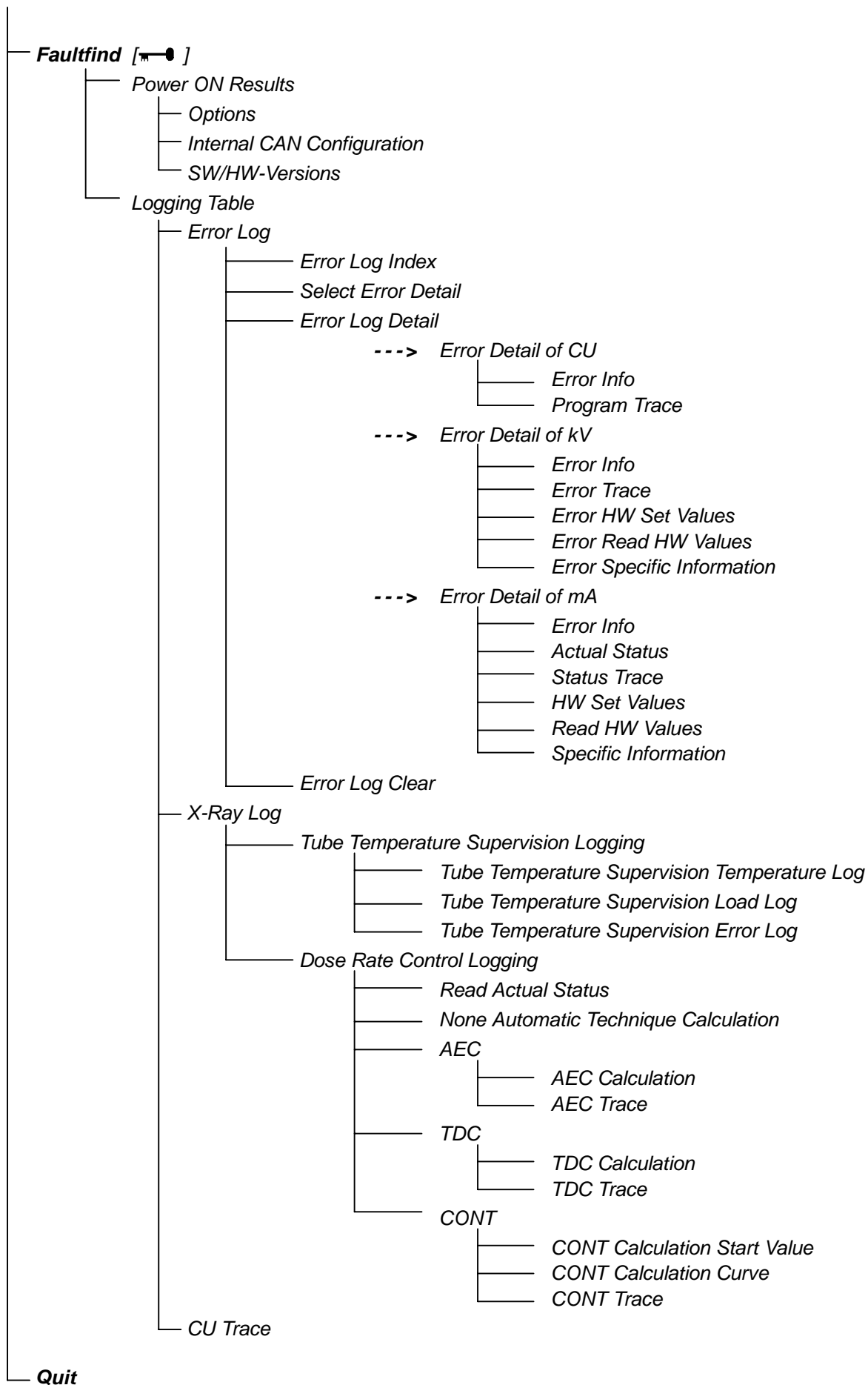


**Adjust**

- Tube Adaptation
- CAN Auto Configuration [  ]
- Area Exposure Product [  ]
  - Specific Yield of Tubes
    - Specific Yield of Tubes 1 ... 3
  - Add Filter Correction Tables
    - 2 mm Al
    - 1 mm Al + 0.1 mm CU
    - 1 mm Al + 0.2 mm CU
  - Wedge Filter Correction Table
    - Wedge 1
    - Wedge 2
    - Finger Wedge
- Dose Rate Control [  ]
  - TDC AMPLIMAT (Do not change the values without order from DMC Hamburg!)
  - Amplification Gain
    - TDC
    - CONT
  - CONT kV mA manual
- Boost Adaptation [  ]

**Accept**

- Backup [  ]
  - RGDV related Assignments
    - RGDV 1 ... 8
      - APR Assignments
  - CU Complete
- Restore [  ]
  - RGDV related Assignments
    - RGDV 1 ... 8
      - APR Assignments
  - CU Complete
- Inspect
  - Tube Statistic
    - Tube 1 ... 3 Statistic
  - Generator Statistic
  - Type of Tube 1 ... 3 [  ]



**FU-kV [ ]****Faultfind**

Power ON Results

Read Configuration

Logging Tables

Read Trace

Read Error

(Only at current error with contents)

Error: Info

Error: Trace

Error: HW Set Values

Error: Read HW Values

Error: Specific Information

Functional Test

Test Watchdog

Test DAC-ADC

Test Converter

Switch Error Handling

Monitoring

Measure Temperatures

kV Measurements

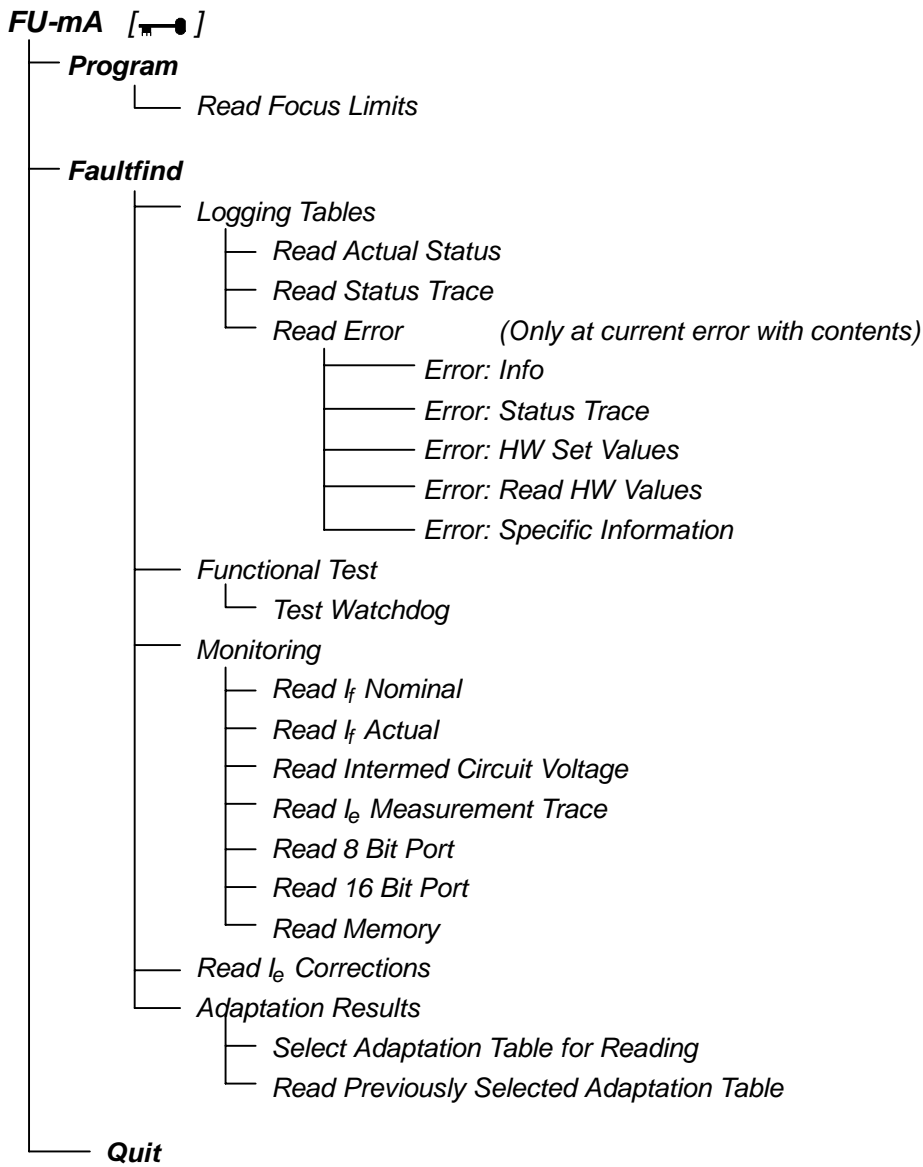
Converter Measurements


Read 8 Bit Port

Read 16 Bit Port

Read Memory

**Quit**



[  ] = A hardware key is required



#### 4.4. Saving data on disk and restoring data

All configurations data and logging tables are stored in battery-buffered CMOS areas.

Therefore, these data should be saved on disk as a backup.

In case data get lost they can easily be restored in the CMOS areas after the error source has been eliminated.

##### Saving of data:

S Select menu **"Accept/ Backup/ CU Complete"**.

S Store the data on floppy disk "Generator configuration data" found in the service documentation.

Default file name: cubackup.tdl

Recommended file name: s/n of the generator, e.g. 960007.tdl

File size: approx. 500–700 kB

Transfer time: approx. 8 min.

S Recommendation:

In addition, save the APR programming individually for each RGDV via the menu **"Accept/ Backup/ RGDV related Assignments/ RGDV 1...8/ APR Assignment"** on floppy disk.

File name: apr\_bak#.tdl    # = RGDV - number

Assignment of film/screen combinations to the individual APRs is not saved in this procedure!

S Recommendation:

In addition, save the programmings for the film/screen combinations via the menu **"Program/ Dose Rate Control/ AMPLIMAT/ Chamber 1...5/ Data Set 1...5"** (manual processing) and store them with the SAVE function (F3 key) on floppy disk.

Recommended file name: drc##.tdl    ## = chamber and data set number

Assignment of film/screen combinations to the individual APRs is not saved in this procedure!

##### Restoring of data:

##### Note

*Before starting this procedure the CAN interface on EZ X43 must be disconnected if present (THORAVISION or Bucky TH with bucky controller). Wait 2 minutes for the generator to be ready to communicate with the PC.*

S Select menu **"Accept/ Restore/ CU Complete"**.

S Restore the data from floppy disk.

Transfer time: approx. 15 min ... 50 min.

S Reset the generator.

S Program date and time.

Most of the programmings and logging tables can also be stored via the SAVE-function (button F3) of XRG SCOPE.

Some programmings can be restored via the LOAD-function (button F4).

- For service use, only keep the latest version of the backup.

- Never use a complete backup for a different generator.

- APR backups can also be loaded into other generators.

Since specific kV and mA reductions are also transferred, one should load APR backups only in generators of the same or a lower power class.

## 5. Initialization phase of the generator

### 5.1. Start-up sequence

Switch-on of the generator

|

Pulling-up of ENK 2

|

Selftest of ...

|                     |  |
|---------------------|--|
| ... control desk C: | All display elements are switched on for a short moment. |
|---------------------|--|

|                         |  |
|-------------------------|--|
| ... central unit EZ139: |  |
|-------------------------|--|

|                       |   |
|-----------------------|---|
| ... kV control EZ130: | voltage E is measured in the d.c. intermediate circuit. |
|-----------------------|---|

|

|                       |  |
|-----------------------|--|
| ... mA control EZ119: |  |
|-----------------------|--|

|                            |  |
|----------------------------|--|
| ... basic interface EZ150: |  |
|----------------------------|--|

|                       |  |
|-----------------------|--|
| ... rotor control EY: |  |
|-----------------------|--|

|                              |  |
|------------------------------|--|
| ... universal I/O EWA/B 102: |  |
|------------------------------|--|

|                    |  |
|--------------------|--|
| Indicating device: | The red status LED of the associated printed-circuit board or assembly is illuminated. |
|--------------------|--|

|

|

When the selftests have successfully been completed, the status LED's are blinking.

|

The central unit establishes connection to each functional unit via the CAN bus.

|

|                    |  |
|--------------------|--|
| Indicating device: | The red status LED of the associated printed-circuit board or assembly grows dark. |
|--------------------|--|

|

ENK1 is switched on.

|

The generator is internally ready.

|

The external ready circuits are checked (unit ready, door contact closed, thermal contact of the tube closed, tube not overloaded).

|

The green READY lamp in the operating desk is illuminated.

The generator is in the READY state.

## 5.2. Program status displayed on the operating panel

|                 |          |              |  |
|-----------------|----------|--------------|--|
| PHILIPS OPTIMUS |          |              | <ul style="list-style-type: none"><li>- No tube data loaded yet.</li><li>- No RGDVs programmed yet.</li><li>- No communication between desk and CU.</li><li>- Possible error entries:<br/>00B3, 00B6, 00BA ... F, 00B0, 00BT, 00BX, 00CJ, 00L1, 00PE, 00XB, 00XL, 03FD</li></ul> |
| 70 kV           | 32.0 mAs | Test         | <ul style="list-style-type: none"><li>- Tube data loaded.</li><li>- Selected focus not adapted.</li></ul>  |
| 70 kV           | 32.0 mAs | Adap         | <ul style="list-style-type: none"><li>- Status after calling up the adaptation mode.</li></ul>   |
| 40 kV           | 00.0 mAs | Adap         | <ul style="list-style-type: none"><li>- Start phase of adaptation mode.<br/>After the Ready signal appears the adaptation can be started up with the release switch.</li><li>- Possible error entries after adaptation:<br/>00BU, 00BV, 00X6</li></ul>                           |
| 70 kV           | 320 mAs  | 100 ms       | <ul style="list-style-type: none"><li>- Selected focus is adapted.</li><li>- AEC/TDC technique:<br/>For the selected RGDV no measuring unit has been assigned yet.</li></ul>   |
| 70 kV           | 0 ▲      | def1         | <ul style="list-style-type: none"><li>- For the selected RGDV no film/screen combination has been programmed yet.</li></ul>  |
| Test APR        |          |              | <ul style="list-style-type: none"><li>- No APR data have yet been loaded onto the selected RGDV.</li></ul>   |
| 81 kV           | 0 ▲      | B100         | <ul style="list-style-type: none"><li>- Ready status.<br/>An APR with AEC technique has been selected.</li></ul>   |
| skull axial     |          | crâne axial  |  |
| Schädel ax.     |          | cráneo axial |  |
|                 |          |              |  |
|                 |          |              |  |

## 6. Switch-on problems

### 6.1. Switch-on not possible

See drawings: Z1-2.1 / 2.2 / 2.3  
Z2-2

H1 on PCB EN100 is not illuminated.

- Error sources:
- ENF1 was released.  
For fault-finding look in the error buffer.
  - ENF1 is not switched on.
  - Mains voltage, especially phase L3, is not present.
  - ENF2 was released.  
Check: Low-voltage supply  
Filament circuit  
Tube extension  
Rotor control  
External current consumers
  - ENF2 is not switched on.
  - PCB EN100 or its connections are not okay.

H1 on PCB EN100 is illuminated.

- Error sources:
- The EMERGENCY-OFF circuit is open.
  - The operating desk is not connected.

### 6.2. No start up

- Error sources:
- EN 100 V1 is defective.  
The generator receives a continuous reset via signal: reset sw/.  
All red LEDs of the generator are illuminated.  
Also see Z1-2.1.  
Test: Remove link EZX44:14 --- EZX44:6.
  - No boot PROM present: EZ 139 D3 (see 5Z-1)
  - Flash PROMs EZ139 D4/D5 not correctly loaded.

## 7. Error numbers

### 7.1. Error classification

#### Errors:

- Errors are indicated by 4 digits.
- The first two digits indicate the functional unit FU reporting the error.
  - 00xx = CU-functional unit is concerned
  - 02xx = kV-functional unit is concerned
  - 03xx = mA-functional unit is concerned
- The last two letters indicate the error symptom.

#### Displayed errors (Errors and Fatal errors) :

- These errors are indicated on the display of the operating desk for the customer.
- The customer must call the service.
 

The customer can inform the service about the respective error number and the service can order the spare parts needed at an early stage of the maintenance procedure.

#### Not displayed errors (Warnings) :

- These errors are not relevant for the customer.
- In case an error of this category occurs frequently within a certain period of time, a displayed error can be generated.

### 7.2. Error list

Sources of error codes indicated in the first two digits (hex):

|               |           |   |
|---------------|-----------|---|
| 00 ..         | CU        | central unit EZ139  |
| 01 ..         | FU_DRC    | dose rate control, control physically located on CU EZ139, parts of basic interface<br>FU_CIE EZ150 also involved (Amplimat), FU_DRC also handles fluoro  |
| 02 ..         | FU_kV     | kV control EZ130  |
| 03 ..         | FU_mA_a   | 1st mA control EZ119, handles 2 filaments   |
| 04 ..         | FU_mA_b   | 2nd mA control, has been foreseen <ul style="list-style-type: none"> <li>- to drive the third filament of a 3 focus tube (does not yet exist)</li> <li>- to feed a MRC tube in a mixed configuration SRO-MRC</li> </ul> |
| 05 ..         | FU_mA_c   | 3rd mA control  |
| 06 ..         | FU_mA_d   | 4th mA control  |
| 07 ..         | FU_CIE    | central interface extension EZ150   |
| 08 ..         | FU_HI_a   | human interface 1 C300  |
| 09 ..         | FU_HI_b   | 2nd human interface   |
| 0A ..         | (HEX)     | will be changed to 10 .. (this is how they appear and how they are listed in the error list, same with 0B .. = 11 .. etc.   |
| 0A .. = 10 .. | FU_RC_a   | 1st rotor control high speed EY100  |
| 0B .. = 11 .. | FU_RC_b   | 2nd rotor control high speed (mixed use of SRO and MRC tubes, not yet foreseen<br>Release 2 and 3)  |
| 0C .. = 12 .. | FU_RC_c   | 3rd rotor control high speed  |
| 0D .. = 13 .. | FU_ADAP_a | adapter decade cable for 4 aux. units RAD WA/1WA<br>WA/1WA102   |
| 0E .. = 14 .. | FU_ADAP_b | ditto 2WA 2WA102  |
| 0F .. = 15 .. | FU_ADAP_c | ditto WB/1WB WB/1WB102  |
| 10 .. = 16 .. | FU_ADAP_d | ditto 2WB (not yet available) 2WB102  |
| 11 .. = 17 .. | FU_MDO    | monitor data overlay (not yet available)  |
| 12 .. = 18 .. | FU_ANA    | analog I/O interface  |

Class: Fatal error, Error, Warning

**Error class explanation**

|      |     |        |   |
|------|-----|--------|---|
| 00B0 | E/W | CPU:   | Error in application data service interface         |
| 00B1 | E/W | CPU:   | IIM was not expected by gen_order_list              |
| 00B2 | E/W | CPU:   | HI order is not expected - NO Member in display_tab |
| 00B3 | E/W | NVRAM: | data language selector is invalid                   |
| 00B4 | E/W | CPU:   | message invalid in ADopmes                          |
| 00B5 | E/W | CPU:   | Inputparameter out of range in ADSynta              |
| 00B6 | E/W | NVRAM: | FU adap data for DI are invalid                     |
| 00B7 | E/W | CPU:   | Message can not be send                             |
| 00B8 | E/W | NVRAM: | tomo mode switch can not be enabled                 |
| 00BA | E/W | NVRAM: | data of RGDV are invalid                            |
| 00BB | E/W | NVRAM: | basedata of RGU are invalid                         |
| 00BC | E/W | NVRAM: | statedata of RGU are invalid                        |
| 00BD | E/W | NVRAM: | data of APR are invalid                             |
| 00BE | E/W | NVRAM: | data of active RGU are invalid                      |
| 00BF | E/W | NVRAM: | data of RGKeys are invalid                          |
| 00BG | E/W | APR:   | no more lowest level menus available                |
| 00BH | E/W | APR:   | display position collision                          |
| 00BI | E/W | APR:   | menu/APR mismatch in same level                     |
| 00BJ | E/W | APR:   | menu name not found                                 |
| 00BK | E/W | APR:   | APR is assigned to a different RGDV                 |
| 00BL | E/W | APR:   | menu name already exists                            |
| 00BM | E/W | APR:   | max display position reached                        |
| 00BN | E/W | APR:   | APR not found in this menu                          |
| 00BO | E/W | NVRAM: | data of menu tree are invalid                       |
| 00BQ | E/W | CPU:   | APR can not be modified                             |
| 00BR | E/W | CPU:   | APR is not assigned to an RGDV                      |
| 00BS | E/W | APR:   | The RGDV of the APR is not ready for operation      |
| 00BT | E/W | NVRAM: | data of APR characteristics are invalid             |
| 00BU | E/W |        | Adaptation paused due to missing load               |
| 00BV | E/W | CPU:   | TTS status message during adaptation                |
| 00BW | E/W | APR:   | APR not accepted by general calculation             |
| 00BX | E/W | NVRAM: | variofocus allowed invalid                          |
| 00BY | E/W |        | RGDV order without active RGDV                      |

| Error | class | explanation |
|-------|-------|-------------|
|-------|-------|-------------|

|      |     |  |
|------|-----|--|
| 00CB | W   | CONF: Received IIM #1#2H unknown                   |
| 00CC | W   | CAN: frame-repeat-counter overflow (IIM #1#2H)     |
| 00CD | W   | CAN: FU #1H not addressable                        |
| 00CE | W   | CAN: rx-signal conflict (FU #1H)                   |
| 00CF | W   | CAN: no RTR from FU #1H                            |
| 00CG | W   | CPU: domain tx response Mailbox type wrong         |
| 00CH | W   | CPU: Invalid tbdor-Parameter FU_type               |
| 00CJ | W   | CAN auto configuration successful (#1H)            |
| 00CK | W   | CAN auto configuration without success (#1H)       |
| 00CL | W   | CAN: FU #1H not addressable                        |
| 00CM | W   | CAN: FU #1H sent event and did not answer RTR      |
| 00CP | W   | CAN: Max FU count exceeded                         |
| 00CQ | W   | SYSCAN: Radiography system is not responding       |
| 00CR | W   | SYSCAN: Guarded connection failed                  |
| 00CX | W   | CAN: last-only-repeat-counter overflow (IIM #1#2H) |
| 00CY | W   | CAN: abort of rx of IIM #1#2H (unexp frame)        |
| 00CZ | W   | CAN: unexpected frame received after IIM #1#2H     |
| 00DA | E/W | No CPU-Access to CAN-chip                          |
| 00DB | W   | CAN-chip reset not acknowledged                    |
| 00DC | W   | CAN-chip reset release not acknowledged            |
| 00DD | W   | CAN-chip DPRAM check failed                        |
| 00DE | E/W | unexpected CAN-chip int-pointer                    |
| 00DF | W   | CAN-chip state undefined                           |
| 00DG | W   | CAN-chip error-active after passive #1H            |
| 00DH | W   | CAN-chip state error-passive #1H                   |
| 00DI | E   | CAN-chip state bus-off #1H                         |
| 00DJ | W   | CAN-chip state DPRAM-error                         |
| 00DK | W   | CAN-chip state DPRAM-error&passive                 |
| 00DL | W   | unexpected CAN-chip interrupt                      |
| 00DM | W   | CAN: frame error (code #1H)                        |
| 00E0 | E/W | iRMX exception #2#1H occurred.                     |
| 00G0 | E/W | variable in case statement has undefined value     |
| 00G1 | E/W | condition_code <> OK after CALL to send            |
| 00G2 | E/W | condition_code <> OK after CALL to init            |
| 00I1 | E/W | CPU: Index to I/O-table is wrong                   |
| 00I2 | E/W | No interrupt reason on sig-bus                     |

| Error | class   | explanation  |
|-------|---------|--|
| 00I3  | E/W     | No interrupt reason on XS-bus  |
| 00I4  | E/W     | One FU has a WD-error, scantime_TV is not programmed correctly<br>See: XRGSCOPE --> OPTIMUS --> Program --> Dose rate control --> CONT: scantime_TV = 20.00 ms |
| 00L1  | E/W     | GC: checksum error   |
| 00L2  | E/W     | GC: data access error  |
| 00L3  | E/W     | GC: limit data error   |
| 00L4  | E/W     | GC: limits inconsistent  |
| 00L5  | E/W     | GC: calculation error  |
| 00L6  | E/W     | GC: function not implemented   |
| 00M0  | E/W     | Unable to initialize FU(s) #1H, #2H, #3H, #4H, #5H, #6H  |
| 00M1  | E/W     | Configuration key is missing or defective  |
| 00M2  | E/W     | Unable to initialize the FU mA   |
| 00M3  | E/W     | No response at all from FU(s) #1H, #2H, #3H, #4H, #5H, #6H   |
| 00PA  | E/W     | CPU: IIM/MSD number unknown  |
| 00PB  | E/W     | CPU: technic mode unknown  |
| 00PC  | E/W     | CPU: value limit overflow  |
| 00PD  | E/W     | PC comm: unknown TDL proc id   |
| 00PE  | E/W     | NVRAM: DRC NV checksum error   |
| 00PF  | E/W     | CPU: equal kV-sets from CU comes twice   |
| 00PG  | E/W     | CPU: kV sequence don t increase  |
| 00PH  | E/W     | CPU: EDL isn t possible min_mA limit   |
| 00PI  | E/W     | CPU: DCALC Dr_curve has only one element   |
| 00PJ  | E/W     | CPU: DCALC Dr_curve has strange values   |
| 00PK  | E/W     | CPU: equal kV-sets from CU with equal mA   |
| 00PL  | E/W     | CPU: dose digits disturbance   |
| 00S*  | Service | PCcomm: Service access trace   |
| 00S?  | E       | PCcomm: Unexpected error   |
| 00SA  | E       | PCcomm: Not enough space at destination segment  |
| 00SB  | E       | PCcomm: Base out of range  |
| 00SC  | E       | PCcomm: Value too large  |
| 00SD  | E       | PCcomm: Terminator not found   |
| 00SE  | E       | PCcomm: Error in description   |
| 00SF  | E       | PCcomm: Item type unknown  |
| 00SG  | E       | PCcomm: Internal type unknown  |
| 00SH  | W       | PCcomm: Value negative   |
| 00SI  | E       | PCcomm: Not enough space at destination buffer   |
| 00SJ  | E       | PCcomm: Syntax wrong   |



| Error | class | explanation |
|-------|-------|-------------|
|-------|-------|-------------|

|      |     |  |
|------|-----|--|
| 00SK | E   | PCcomm: String too long  |
| 00SL | W   | PCcomm: String truncated   |
| 00SM | E   | PCcomm: TDL segment overflow   |
| 00SN | E   | PCcomm: FU Reference Table full  |
| 00SO | E   | PCcomm: Node ID unknown  |
| 00SP | E   | PCcomm: FU Code unknown  |
| 00SQ | E   | PCcomm: Syntax error in node ID  |
| 00SR | W   | PCcomm: No node ID found   |
| 00SS | E   | PCcomm: Request not performed  |
| 00ST | E   | PCcomm: RMX error  |
| 00SU | W   | PCcomm: Enumeration element not found  |
| 00SV | E   | PCcomm: Mail corrupted   |
| 00SW | E   | PCcomm: Procedure ID unknown   |
| 00SX | E   | PCcomm: FU mA incompatible   |
| 00SY | E   | PCcomm: FU Off request failed  |
| 00SZ | E   | PCcomm: Wrong response   |
| 00T? | E   | TTS: Unexpected Error  |
| 00TA | E   | TTS: Received Message unknown  |
| 00TB | E   | TTS: Tube Supervision Error from FU kV; thermal switch of tube housing okay? |
| 00TC | E   | TTS: Internal TTS Error  |
| 00TD | E   | TTS: Tube Number unknown   |
| 00TE | E   | TTS: NVRAM Checksum Error  |
| 00TF | E   | TTS: NVRAM unavailable   |
| 00TG | E   | TTS: Tube overheated   |
| 00TH | W   | TTS: Load Data Supply inconsistent   |
| 00X0 | E/W | CPU: wrong timer id  |
| 00X1 | E/W | CPU: wrong timer mode  |
| 00X2 | E/W | CPU: wrong message type  |
| 00X3 | E/W | CPU: DWORD does not fit into BYTE3   |
| 00X4 | E/W | timeout of X-ray backup timer  |
| 00X5 | E/W | timeout of X-ray rotation timer  |
| 00X6 | E/W | timeout setting FUs, response missing  |
| 00X7 | E/W | CPU: curve token is NO_TOKEN   |
| 00XA | E/W | NVRAM: switch table invalid  |
| 00XB | E/W | NVRAM: tube data rotation invalid  |
| 00XC | E/W | NVRAM: watch dog invalid   |

| Error | class | explanation   |
|-------|-------|---|
| 00XD  | E/W   | NVRAM: konfi table invalid                                      |
| 00XE  | E/W   | NVRAM: test data invalid  |
| 00XF  | E/W   | NVRAM: RoCo data invalid  |
| 00XG  | E/W   | CPU: received IIM is unknown                                    |
| 00XH  | E/W   | CPU: received FU-type is unknown                                |
| 00XI  | E/W   | init with FU-RoCo not OK  |
| 00XJ  | E/W   | exposure time too short   |
| 00XK  | E/W   | CPU: FUmA refuses set data                                      |
| 00XL  | E/W   | NVRAM: tube yield table invalid                                 |
| 00XM  | E/W   | NVRAM: add filter corr table invalid                            |
| 00XN  | E/W   | NVRAM: wedge filter corr table invalid                          |
| 00XO  | E/W   | exposure time too long  |
| 00XP  | E/W   | exposure time too long  |
| 00XQ  | E/W   | NVRAM: tube statistic data invalid                              |
| 00XR  | E/W   | NVRAM: gsta data invalid  |
| 00XS  | E/W   | tube no in CU and FUKV different                                |
| 00XT  | E/W   | rotation in CU and FURoCo FUCIE diff.                           |
| 02AB  | W     | procedure called with wrong parameter                           |
| 02AC  | E     | wrong index for table access                                    |
| 02AD  | E     | wrong do case entry   |
| 02AE  | W     | unknown IIM received  |
| 02AF  | W     | IIM parameter out of range                                      |
| 02CA  | W     | Error in CASE selector  |
| 02CB  | W     | A CAN message with wrong IIM-no (no recipient defined) received |
| 02CC  | W     | multiple reception of the same CAN frame (transmitter ill)      |
| 02CE  | W     | unexpected signal value in CAN rx task                          |
| 02CF  | W     | CAN bus timeout while domain transmission                       |
| 02CG  | W     | token of CAN response mailbox is not a mailbox token            |
| 02CX  | W     | multiple rx of the same CAN last/only frame (transmitter ill)   |
| 02CY  | W     | aborted CAN domain receive (because of timeout or wrong signal) |
| 02CZ  | W     | unexpected CAN domain frame received (outside IIM-reception)    |
| 02DA  | W     | no CPU access to the CAN controller                             |
| 02DB  | W     | reset or release of the CAN controller was not acknowledged     |
| 02DD  | W     | check of the DPRAM of the CAN controller failed                 |
| 02DE  | W     | unexpected interrupt pointer in the CAN controller              |
| 02DF  | W     | CAN controller state undefined                                  |

| Error | class | explanation  |
|-------|-------|--|
| 02DG  | W     | CAN controller state ERROR ACTIVE after ERROR PASSIVE  |
| 02DH  | W     | CAN controller state ERROR PASSIVE   |
| 02DI  | W     | CAN controller state BUS OFF   |
| 02DJ  | W     | CAN controller state DPRAM ERROR   |
| 02DK  | W     | CAN controller state DPRAM ERROR and ERROR PASSIVE   |
| 02EA  | E     | interrupt 0: divide by zero  |
| 02EB  | E     | interrupt 1: single step   |
| 02EC  | E     | interrupt 2: NMI   |
| 02ED  | E     | interrupt 3: breakpoint  |
| 02EE  | E     | interrupt 4: overflow exception  |
| 02EF  | E     | interrupt 5: array bounds exception  |
| 02EG  | E     | interrupt 6: unused opcode   |
| 02EH  | E     | interrupt 7: ESC opcode  |
| 02EI  | E     | CAN connection to CU lost  |
| 02GA  | W     | interpolation not possible   |
| 02HA  | W     | kV nominal value out of range: $\pm (4 \% + 1 \text{ kV})$ ; 3 detections within 30 ms   |
| 02HB  | E     | kV nominal value out of range: $0 \text{ kV} > U > 170 \text{ kV}$   |
| 02HC  | W     | Z nominal value out of range: $\pm 1 \% \pm 0.2$ ; 3 detections within 30 ms; duty cycle range 3 %...30 %                              |
| 02HD  | E     | Z nominal value out of range: $0 \% > Z > 50 \%$   |
| 02HE  | W     | kV value during standby too large: $> 3 \text{ kV}$ for $> 400 \text{ ms}$ after PREP  |
| 02HF  | E     | kV value during standby too large: $> 4 \text{ kV}$ for $> 400 \text{ ms}$ after PREP  |
| 02HG  | W     | kV actual value out of range: $\pm (4 \% + 1 \text{ kV})$ ; 2 detections within 20 ms  |
| 02HH  | E     | kV actual value out of range: $20 \text{ kV} > U > 170 \text{ kV}$ ; 3 detections within 30 ms   |
| 02HI  | W     | E value during standby out of range: $470 \text{ V} > E > 780 \text{ V}$ ; 3 detections within 30 ms                                   |
| 02HJ  | E     | E value during standby out of range: $450 \text{ V} > E > 800 \text{ V}$ ; 3 detections within 30 ms                                   |
| 02HK  | W     | E value during high tension out of range: $400 \text{ V} > E > 780 \text{ V}$ ; 3 detections within 30 ms                              |
| 02HL  | E     | E value during high tension out of range: $350 \text{ V} > E > 800 \text{ V}$ ; 3 detections within 30 ms                              |
| 02HM  | W     | converter 1 temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 85 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms       |
| 02HN  | E     | converter 1 temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 90 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms       |
| 02HO  | W     | converter 2 temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 85 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms       |
| 02HP  | E     | converter 2 temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 90 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms       |
| 02HQ  | W     | high tension tank temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 80 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms |
| 02HR  | E     | high tension tank temperature out of range: $0 \text{ }^{\circ}\text{C} > T > 85 \text{ }^{\circ}\text{C}$ ; 3 detections within 30 ms |
| 02HS  | W     | divider test cathode out of range: $45.5 \text{ kV} > U > 50.5 \text{ kV}$ ; 3 detections within 30 ms                                 |
| 02HT  | E     | divider test cathode out of range: $43 \text{ kV} \geq U > 53 \text{ kV}$ ; 3 detections within 30 ms                                  |

**Error class explanation**

|      |   |  |
|------|---|--|
| 02HU | W | divider test anode out of range: 45.5 kV > U > 50.5 kV; 3 detections within 30 ms  |
| 02HV | E | divider test anode out of range: 43 kV $\geq$ U > 53 kV; 3 detections within 30 ms |
| 02HW | W | kV anode out of range, asymmetric ? : $\pm$ 15%; 2 detections within 20 ms         |
| 02HX | E | kV anode out of range, asymmetric ? : $\pm$ 15%; 3 detections within 30 ms         |
| 02MA | E | state request not accepted because of grid mode                                    |
| 02MB | E | state request not accepted because of error state                                  |
| 02MC | W | state requested by CU unknown  |
| 02OA | E | RMX error: timeout   |
| 02OB | E | RMX error: memory  |
| 02OC | E | RMX error: busy  |
| 02OE | E | RMX error: limit   |
| 02OF | E | RMX error: context   |
| 02OG | E | RMX error: exist   |
| 02OH | E | RMX error: state   |
| 02OI | E | RMX error: not configured  |
| 02OJ | E | RMX error: interrupt saturation  |
| 02OK | E | RMX error: interrupt overflow  |
| 02OL | E | RMX error: transmission  |
| 02OM | E | RMX error: divide by zero  |
| 02ON | E | RMX error: overflow  |
| 02OO | E | RMX error: type  |
| 02OP | E | RMX error: parameter   |
| 02OQ | E | RMX error: bad call  |
| 02OR | E | RMX error: array bound   |
| 02OS | E | RMX error: NDP error   |
| 02OT | E | RMX error: illegal opcode  |
| 02OU | E | RMX error: emulator trap   |
| 02OV | E | RMX error: interrupt table limit   |
| 02OW | E | RMX error: CPU xfer data limit   |
| 02OX | E | RMX error: wrap around   |
| 02OY | E | RMX error: check exception   |
| 02OZ | E | RMX error: unknown   |
| 02RA | W | grid mode changeover requested during prep   |
| 02RB | W | tube switch requested during preparation   |
| 02RC | W | requested P out of range   |
| 02SA | W | Not enough space at the destination  |

| Error | class | explanation   |
|-------|-------|---|
| 02SB  | W     | Base out of range   |
| 02SC  | W     | PC comm.: Value too large   |
| 02SD  | W     | Terminator not found  |
| 02SE  | W     | PC comm.: Error in description                                    |
| 02SF  | W     | PC comm.: Item type unknown                                       |
| 02SG  | W     | PC comm.: Internal type unknown                                   |
| 02SH  | W     | PC comm.: Value negative  |
| 02SI  | W     | PC comm.: No space at dest. buffer                                |
| 02SJ  | W     | PC comm.: Syntax wrong  |
| 02SK  | W     | PC comm.: String too long   |
| 02SL  | W     | PC comm.: String truncated  |
| 02SO  | W     | PC comm.: Unknown Table ID Received                               |
| 02SP  | W     | PC comm.: Access Level to Low                                     |
| 02SQ  | W     | PC comm.: Unknown Action Requested                                |
| 02SR  | W     | PC comm.: Routing or Message Corrupt                              |
| 02SS  | W     | Source Buffer too Small for Incoming Message                      |
| 02ST  | W     | CAN Buffer too Small for Outgoing Message                         |
| 02SU  | W     | PC comm.: Access. level is N_A                                    |
| 02UA  | E     | HW configuration identifier wrong                                 |
| 02UB  | W     | Set Up request received during preparation                        |
| 02WA  | W     | wrong tube selected   |
| 02WB  | E     | wrong tube selected   |
| 02WC  | W     | EN X C signal faulty  |
| 02WD  | E     | EN X C signal faulty  |
| 02WE  | W     | wrong grid mode selected  |
| 02WF  | E     | wrong grid mode selected  |
| 02WG  | W     | tube arcing detected  |
| 02WH  | E     | tube arcing detected  |
| 02WI  | W     | kV over voltage detected  |
| 02WJ  | E     | kV over voltage detected  |
| 02WK  | W     | measuring not stable  |
| 02WL  | E     | Tube Supervision Error  |
| 02WM  | E     | Tube Supervision Error  |
| 03AA  | W     | Internal parameter error  |
| 03AB  | W     | Wrong parameter from CU   |
| 03AC  | W     | le-regulation active on two filaments; only in case of VARIOFOCUS |

**Error class explanation**

|      |   |   |
|------|---|---|
| 03AI | W | Wrong IIM received  |
| 03BA | W | Coordinates not monotonous; boost adaptation error              |
| 03BB | W | No measurement values for adap. found                           |
| 03CA | W | Error in CASE selector  |
| 03CB | W | A CAN message with wrong IIM-no (no recipient defined) received |
| 03CC | W | multiple reception of the same CAN frame (transmitter ill)      |
| 03CE | W | unexpected signal value in CAN rx task                          |
| 03CF | W | CAN bus timeout while domain transmission                       |
| 03CG | W | token of CAN response mailbox is not a mailbox token            |
| 03CX | W | multiple rx of the same CAN last/only frame (transmitter ill)   |
| 03CY | W | aborted CAN domain receive (because of timeout or wrong signal) |
| 03CZ | W | unexpected CAN domain frame received (outside IIM-reception)    |
| 03DA | W | no CPU access to the CAN controller                             |
| 03DB | W | reset or release of the CAN controller was not acknowledged     |
| 03DD | W | check of the DPRAM of the CAN controller failed                 |
| 03DE | W | unexpected interrupt pointer in the CAN controller              |
| 03DF | W | CAN controller state undefined                                  |
| 03DG | W | CAN controller state ERROR ACTIVE after ERROR PASSIVE           |
| 03DH | W | CAN controller state ERROR PASSIVE                              |
| 03DI | W | CAN controller state BUS OFF                                    |
| 03DJ | W | CAN controller state DPRAM ERROR                                |
| 03DK | W | CAN controller state DPRAM ERROR and ERROR PASSIVE              |
| 03EA | E | CPU interrupt 0   |
| 03EB | E | CPU interrupt 1   |
| 03ED | E | CPU interrupt 3   |
| 03EE | E | CPU interrupt 4   |
| 03EF | E | CPU interrupt 5   |
| 03EG | E | CPU interrupt 6   |
| 03EH | E | CPU interrupt 7   |
| 03EI | E | CAN is unable to send an error to CU                            |
| 03FA | W | NVRAM: Invalid checksum   |
| 03FB | W | NVRAM: Standby filament not found                               |
| 03FC | E | No NVRAM plugged in   |
| 03FD | W | NVRAM empty; battery?   |
| 03GA | E | Linint error  |
| 03GB | W | Real math. error: real underflow                                |

| Error | class | explanation                             |
|-------|-------|---|
| 03GC  | W     | Real math. error: real overflow         |
| 03GD  | W     | Real math. error: dword overflow        |
| 03GE  | W     | Real math. error: integer overflow      |
| 03GF  | W     | Real math. error: word overflow         |
| 03GG  | W     | Singular matrix                         |
| 03HA  | E     | Unknown hardware                        |
| 03HB  | E/W   | Intermediate circuit voltage < 200 V    |
| 03HF  | W     | Undefined analog input channel          |
| 03HG  | W     | If-actual out of tolerance              |
| 03HH  | E     | If setpoint too large                   |
| 03HI  | E     | If-actual out of tolerance              |
| 03HJ  | E     | If-actual out of tolerance              |
| 03HK  | W     | If-nominal out of tolerance             |
| 03HL  | E     | If-nominal out of tolerance             |
| 03HM  | E     | If-nominal out of tolerance             |
| 03HN  | E     | No retrigger received from CU           |
| 03IA  | W     | Adaptation can not be completed         |
| 03IC  | W     | No le-adaptation measurement values     |
| 03ID  | W     | le-adaptation values not evaluable      |
| 03KA  | W     | Condi.-X-ray mode without mAs parameter |
| 03MA  | W     | Undefined status                        |
| 03MB  | W     | Status change not allowed               |
| 03MC  | W     | FU init data not expected               |
| 03OA  | E     | RMX exception: E\$TIME                  |
| 03OB  | E     | RMX exception: E\$MEM                   |
| 03OC  | E     | RMX exception: E\$BUSY                  |
| 03OD  | E     | RMX exception: E\$LIMIT                 |
| 03OE  | E     | RMX exception: E\$CONTEXT               |
| 03OF  | E     | RMX exception: E\$EXIST                 |
| 03OG  | E     | RMX exception: E\$STATE                 |
| 03OH  | E     | RMX exception: E\$NOT\$CONFIGURED       |
| 03OI  | E     | RMX exception: E\$INTERRUPT\$SATURATION |
| 03OJ  | E     | RMX exception: E\$INTERRUPT\$OVERFLOW   |
| 03OK  | E     | RMX exception: E\$TRANSMISSION          |
| 03OL  | E     | RMX exception: E\$ZERO\$DIVIDE          |
| 03OM  | E     | RMX exception: E\$OVERFLOW              |

| Error | class | explanation   |
|-------|-------|---|
| 03ON  | E     | RMX exception: E\$TYPE  |
| 03OO  | E     | RMX exception: E\$PARAM   |
| 03OP  | E     | RMX exception: E\$BAD\$CALL   |
| 03OQ  | E     | RMX exception: E\$ARRAY\$BOUND  |
| 03OR  | E     | RMX exception: E\$NDP\$ERROR  |
| 03OS  | E     | RMX exception: E\$ILLEGAL\$OPCODE   |
| 03OT  | E     | RMX exception: E\$EMULATOR\$TRAP  |
| 03OU  | E     | RMX exception: E\$INTERRUPT\$TABLE\$LIMIT   |
| 03OV  | E     | RMX exception: E\$CPUXFER\$DATA\$LIMIT  |
| 03OW  | E     | RMX exception: E\$SEG\$WRAP\$AROUND   |
| 03OX  | E     | RMX exception: E\$CHECK\$EXCEPTION  |
| 03OY  | E     | unknown RMX exception   |
| 03PA  | E     | Ie zero measured  |
| 03PB  | W     | Ie out of tolerance: $\pm 10\%$ (Ie > 5 mA, exp. time $\leq 44$ ms) or $\pm 3\%$ (Ie > 5 mA, exp. time > 44 ms) |
| 03PC  | E     | Ie out of tolerance: $\pm 30\%$ (Ie > 5 mA, exp. time > 44 ms)  |
| 03PD  | W     | Setpoint for Ie-regulation incorrect  |
| 03PE  | E     | Emergency off! Grid not closed!   |
| 03PF  | E     | No kV discharged due to missing Ie  |
| 03SC  | W     | PC comm.: Value too large   |
| 03SE  | W     | PC comm.: Error in description  |
| 03SF  | W     | PC comm.: Item type unknown   |
| 03SG  | W     | PC comm.: Internal type unknown   |
| 03SH  | W     | PC comm.: Value negative  |
| 03SI  | W     | PC comm.: No space at dest. buffer  |
| 03SJ  | W     | PC comm.: Syntax wrong  |
| 03SK  | W     | PC comm.: String too long   |
| 03SL  | W     | PC comm.: String truncated  |
| 03SO  | W     | PC comm.: Unknown Table ID Received   |
| 03SP  | W     | PC comm.: Access Level to Low   |
| 03SQ  | W     | PC comm.: Unknown Action Requested  |
| 03SR  | W     | PC comm.: Routing or Message Corrupt  |
| 03SU  | W     | PC comm.: Access. level is N_A (not available)  |
| 07CA  | E     | CAN: case-selector error  |
| 07CB  | W     | CAN: invalid CAN ID %u  |
| 07CC  | E     | CAN: frame rep. overflow IIM%u  |



| Error | class | explanation                             |
|-------|-------|---|
| 07CD  | E     | CAN: no RTR from CU                     |
| 07CE  | E     | CAN: rx signal conflict IIM%u           |
| 07CF  | E     | CAN: tx timeout                         |
| 07CI  | W     | CAN: IMPOSSIBLE ERROR                   |
| 07CP  | W     | CAN: CPU: PXerr %d %s(%d)               |
| 07CR  | W     | CAN: CPU: message request fail          |
| 07CS  | W     | CAN: CPU: message send error            |
| 07CY  | E     | CAN: rx abort IIM%u                     |
| 07CZ  | W     | CAN: unexpected frame (IIM%u)           |
| 07DA  | E     | CAN: chip access error                  |
| 07DB  | E     | CAN: chip reset error                   |
| 07DC  | E     | CAN: chip reset release error           |
| 07DE  | W     | CAN: illegal interrupt pointer          |
| 07DF  | E     | CAN: chip state undefined               |
| 07DG  | W     | CAN: chip err act. after pass.          |
| 07DH  | W     | CAN: chip state error passive           |
| 07DI  | W     | CAN: chip state bus-off                 |
| 07DJ  | E     | CAN: chip DPRAM Error                   |
| 07DK  | W     | CAN: chip DPRAM Error&passive           |
| 07DL  | W     | CAN: unexpected interrupt               |
| 07LA  | W     | CV received IIM unknown                 |
| 07LB  | W     | RC Stator number out of range           |
| 07LC  | W     | RC Stator not available                 |
| 07LD  | E     | RC Stator 1 readback failed             |
| 07LE  | E     | RC Stator 2 readback failed             |
| 07LF  | E     | RC Stator 3 readback failed             |
| 07LG  | W     | RC Speed value out of range             |
| 07LH  | E     | RC Speed set timeout                    |
| 07LI  | W     | RC Maximal stator load exceeded         |
| 07LJ  | E     | RC Maximal rotation time exceeded       |
| 07LK  | W     | AM Amplimat chamber number out of range |
| 07LL  | W     | AM Amplimat field number out of range   |
| 07LM  | W     | AM Amplimat delay value out of range    |
| 08CA  | E     | CAN: case-selector error                |
| 08CB  | W     | CAN: invalid CAN ID %u                  |
| 08CC  | E     | CAN: frame rep. overflow IIM%u          |

| Error | class | explanation                           |
|-------|-------|---------------------------------------|
| 08CD  | E     | CAN: no RTR from CU                   |
| 08CE  | E     | CAN: rx signal conflict IIM%u         |
| 08CF  | E     | CAN: tx timeout                       |
| 08CI  | W     | CAN: IMPOSSIBLE ERROR                 |
| 08CP  | W     | CAN: CPU: PXerr %d %s(%d)             |
| 08CR  | W     | CAN: CPU: message request fail        |
| 08CS  | W     | CAN: CPU: message send error          |
| 08CY  | E     | CAN: rx abort IIM%u                   |
| 08CZ  | W     | CAN: unexpected frame (IIM%u)         |
| 08DA  | E     | CAN: chip access error                |
| 08DB  | E     | CAN: chip reset error                 |
| 08DC  | E     | CAN: chip reset release error         |
| 08DE  | W     | CAN: illegal interrupt pointer        |
| 08DF  | E     | CAN: chip state undefined             |
| 08DG  | W     | CAN: chip err act. after pass.        |
| 08DH  | W     | CAN: chip state error passive         |
| 08DI  | W     | CAN: chip state bus-off               |
| 08DJ  | E     | CAN: chip DPRAM Error                 |
| 08DK  | W     | CAN: chip DPRAM Error&passive         |
| 08DL  | W     | CAN: unexpected interrupt             |
| 08HA  | E     | no message receive displaytask        |
| 08HB  | E     | no message release displaytask        |
| 08HC  | E     | APR not found                         |
| 08HD  | E     | offset in menu structure out of range |
| 08HF  | E     | no message request for test task      |
| 08HG  | E     | no message send for test task         |
| 08HH  | E     | APR BUFFER FULL                       |
| 08HI  | E     | no message send for ODD task          |
| 08HJ  | E     | no send message to CU from ODD        |
| 08HJ  | E     | no message send for Service task      |
| 08HK  | E     | Data error in CAN message             |
| 08IE  | E     | wrong setup IIM                       |
| 08SA  | E     | no request domtxtask when scanning    |
| 08SB  | E     | no request domtxtask when testing     |
| 08SC  | E     | no send message to task2_sc           |
| 10CA  | E     | CAN: case-selector error              |

| Error | class | explanation |
|-------|-------|-------------|
|-------|-------|-------------|

|      |     |                                   |
|------|-----|-----------------------------------|
| 10CB | W   | CAN: invalid CAN ID %u            |
| 10CC | E   | CAN: frame rep. overflow IIM%u    |
| 10CD | E   | CAN: no RTR from CU               |
| 10CE | E   | CAN: rx signal conflict IIM%u     |
| 10CF | E   | CAN: tx timeout                   |
| 10CI | W   | CAN: IMPOSSIBLE ERROR             |
| 10CP | W   | CAN: CPU: PXerr %d %s(%d)         |
| 10CR | W   | CAN: CPU: message request fail    |
| 10CS | W   | CAN: CPU: message send error      |
| 10CY | E   | CAN: rx abort IIM%u               |
| 10CZ | W   | CAN: unexpected frame (IIM%u)     |
| 10DA | E   | CAN: chip access error            |
| 10DB | E   | CAN: chip reset error             |
| 10DC | E   | CAN: chip reset release error     |
| 10DE | W   | CAN: illegal interrupt pointer    |
| 10DF | E   | CAN: chip state undefined         |
| 10DG | W   | CAN: chip err act. after pass.    |
| 10DH | W   | CAN: chip state error passive     |
| 10DI | W   | CAN: chip state bus-off           |
| 10DJ | E   | CAN: chip DPRAM Error             |
| 10DK | W   | CAN: chip DPRAM Error&passive     |
| 10DL | W   | CAN: unexpected interrupt         |
| 10IF | W   | initialization failed             |
| 10LA | W   | acceleration count limit exceeded |
| 10LC | W   | current limit exceeded            |
| 10LH | E/W | intermediate current %u mA (>%u)  |
| 10LL | E/W | intermediate current %u mA (<%u)  |
| 10LO | E   | intermediate voltage %u V (>%u)   |
| 10LT | E   | temperature limit exceeded        |
| 10LU | E   | intermediate voltage %u V (<%u)   |
| 10OE | W   | CPU: PXROS error %d               |
| 10OF | W   | CPU: PXROS error %d %s(%d)        |
| 10RC | E   | rotation check failed             |
| 10RI | E   | invalid rotation request : %u     |
| 10RM | E   | rotation detector not present     |
| 10RT | W   | rotation request timeout          |

| Error | class | explanation                               |
|-------|-------|---|
| 10TD  | E     | invalid data for tube %u                  |
| 10TE  | W     | stator %u hardware error                  |
| 10TF  | E     | stator %u switching failed                |
| 10TI  | E     | invalid stator request : %u               |
| 10TR  | E     | stator change with rotating anode         |
| 10UI  | W     | unknown message from CU: IIM %u           |
| 10UM  | W     | unexpected message from CU: IIM %u        |
| 10WT  | W     | CPU: watchdog timeout                     |
| 10XX  | W     | IMPOSSIBLE ERROR                          |
| 13CA  | E     | CAN: case-selector error                  |
| 13CB  | W     | CAN: invalid CAN ID %u                    |
| 13CC  | E     | CAN: frame rep. overflow IIM%u            |
| 13CD  | E     | CAN: no RTR from CU                       |
| 13CE  | E     | CAN: rx signal conflict IIM%u             |
| 13CF  | E     | CAN: tx timeout                           |
| 13CI  | W     | CAN: IMPOSSIBLE ERROR                     |
| 13CP  | W     | CAN: CPU: PXerr %d %s(%d)                 |
| 13CR  | W     | CAN: CPU: message request fail            |
| 13CS  | W     | CAN: CPU: message send error              |
| 13CY  | E     | CAN: rx abort IIM%u                       |
| 13CZ  | W     | CAN: unexpected frame (IIM%u)             |
| 13DA  | E     | CAN: chip access error                    |
| 13DB  | E     | CAN: chip reset error                     |
| 13DC  | E     | CAN: chip reset release error             |
| 13DE  | W     | CAN: illegal interrupt pointer            |
| 13DF  | E     | CAN: chip state undefined                 |
| 13DG  | W     | CAN: chip err act. after pass.            |
| 13DH  | W     | CAN: chip state error passive             |
| 13DI  | W     | CAN: chip state bus-off                   |
| 13DJ  | E     | CAN: chip DPRAM Error                     |
| 13DK  | W     | CAN: chip DPRAM Error&passive             |
| 13DL  | W     | CAN: unexpected interrupt                 |
| 13LA  | W     | CV Received IIM unknown                   |
| 13LB  | W     | IO Wrong bidirectional lines output value |
| 13LC  | W     | TR TOMO value out of range                |
| 13LD  | W     | TR RGDV value out of range                |

| Error | class | explanation                               |
|-------|-------|---|
| 13LE  | E     | TR RGDV readback failed                   |
| 13LF  | W     | TR Wrong sync contact value               |
| 13LG  | W     | TR Wrong handswitch enable value          |
| 13LH  | E     | PR S1/S2 switch active during startup     |
| 14CA  | E     | CAN: case-selector error                  |
| 14CB  | W     | CAN: invalid CAN ID %u                    |
| 14CC  | E     | CAN: frame rep. overflow IIM%u            |
| 14CD  | E     | CAN: no RTR from CU                       |
| 14CE  | E     | CAN: rx signal conflict IIM%u             |
| 14CF  | E     | CAN: tx timeout                           |
| 14CI  | W     | CAN: IMPOSSIBLE ERROR                     |
| 14CP  | W     | CAN: CPU: PXerr %d %s(%d)                 |
| 14CR  | W     | CAN: CPU: message request fail            |
| 14CS  | W     | CAN: CPU: message send error              |
| 14CY  | E     | CAN: rx abort IIM%u                       |
| 14CZ  | W     | CAN: unexpected frame (IIM%u)             |
| 14DA  | E     | CAN: chip access error                    |
| 14DB  | E     | CAN: chip reset error                     |
| 14DC  | E     | CAN: chip reset release error             |
| 14DE  | W     | CAN: illegal interrupt pointer            |
| 14DF  | E     | CAN: chip state undefined                 |
| 14DG  | W     | CAN: chip err act. after pass.            |
| 14DH  | W     | CAN: chip state error passive             |
| 14DI  | W     | CAN: chip state bus-off                   |
| 14DJ  | E     | CAN: chip DPRAM Error                     |
| 14DK  | W     | CAN: chip DPRAM Error&passive             |
| 14DL  | W     | CAN: unexpected interrupt                 |
| 14LA  | W     | CV Received IIM unknown                   |
| 14LB  | W     | IO Wrong bidirectional lines output value |
| 14LC  | W     | TR TOMO value out of range                |
| 14LD  | W     | TR RGDV value out of range                |
| 14LE  | E     | TR RGDV readback failed                   |
| 14LF  | W     | TR Wrong sync contact value               |
| 14LG  | W     | TR Wrong handswitch enable value          |
| 15CA  | E     | CAN: case-selector error                  |
| 15CB  | W     | CAN: invalid CAN ID %u                    |

| Error | class | explanation                               |
|-------|-------|---|
| 15CC  | E     | CAN: frame rep. overflow IIM%u            |
| 15CD  | E     | CAN: no RTR from CU                       |
| 15CE  | E     | CAN: rx signal conflict IIM%u             |
| 15CF  | E     | CAN: tx timeout                           |
| 15CI  | W     | CAN: IMPOSSIBLE ERROR                     |
| 15CP  | W     | CAN: CPU: PXerr %d %s(%d)                 |
| 15CR  | W     | CAN: CPU: message request fail            |
| 15CS  | W     | CAN: CPU: message send error              |
| 15CY  | E     | CAN: rx abort IIM%u                       |
| 15CZ  | W     | CAN: unexpected frame (IIM%u)             |
| 15DA  | E     | CAN: chip access error                    |
| 15DB  | E     | CAN: chip reset error                     |
| 15DC  | E     | CAN: chip reset release error             |
| 15DE  | W     | CAN: illegal interrupt pointer            |
| 15DF  | E     | CAN: chip state undefined                 |
| 15DG  | W     | CAN: chip err act. after pass.            |
| 15DH  | W     | CAN: chip state error passive             |
| 15DI  | W     | CAN: chip state bus-off                   |
| 15DJ  | E     | CAN: chip DPRAM Error                     |
| 15DK  | W     | CAN: chip DPRAM Error&passive             |
| 15DL  | W     | CAN: unexpected interrupt                 |
| 15LA  | W     | CV Received IIM unknown                   |
| 15LB  | W     | IO Wrong bidirectional lines output value |
| 15LC  | W     | TR TOMO value out of range                |
| 15LD  | W     | TR RGDV value out of range                |
| 15LE  | E     | TR RGDV readback failed                   |
| 15LF  | W     | TR Wrong sync contact value               |
| 15LG  | W     | TR Wrong handswitch enable value          |
| 16CA  | E     | CAN: case-selector error                  |
| 16CB  | W     | CAN: invalid CAN ID %u                    |
| 16CC  | E     | CAN: frame rep. overflow IIM%u            |
| 16CD  | E     | CAN: no RTR from CU                       |
| 16CE  | E     | CAN: rx signal conflict IIM%u             |
| 16CF  | E     | CAN: tx timeout                           |
| 16CI  | W     | CAN: IMPOSSIBLE ERROR                     |
| 16CP  | W     | CAN: CPU: PXerr %d %s(%d)                 |

| Error | class | explanation |
|-------|-------|-------------|
|-------|-------|-------------|

---

|      |   |   |
|------|---|---|
| 16CR | W | CAN: CPU: message request fail            |
| 16CS | W | CAN: CPU: message send error              |
| 16CY | E | CAN: rx abort IIM%u                       |
| 16CZ | W | CAN: unexpected frame (IIM%u)             |
| 16DA | E | CAN: chip access error                    |
| 16DB | E | CAN: chip reset error                     |
| 16DC | E | CAN: chip reset release error             |
| 16DE | W | CAN: illegal interrupt pointer            |
| 16DF | E | CAN: chip state undefined                 |
| 16DG | W | CAN: chip err act. after pass.            |
| 16DH | W | CAN: chip state error passive             |
| 16DI | W | CAN: chip state bus-off                   |
| 16DJ | E | CAN: chip DPRAM Error                     |
| 16DK | W | CAN: chip DPRAM Error&passive             |
| 16DL | W | CAN: unexpected interrupt                 |
| 16LA | W | CV Received IIM unknown                   |
| 16LB | W | IO Wrong bidirectional lines output value |
| 16LC | W | TR TOMO value out of range                |
| 16LD | W | TR RGDV value out of range                |
| 16LE | E | TR RGDV readback failed                   |
| 16LF | W | TR Wrong sync contact value               |
| 16LG | W | TR Wrong handswitch enable value          |

### 7.3. Elimination of error numbers

#### 00PL:

The message 00PL (Error of the AEC signal) may be a "warning" or an error. This depends on the disturbance of the AEC signal. The AEC signal can be measured at pin EZ 150 X4 (signal) to EZ 150 X3 (see also Z1 " Basic interface ").

**With using measuring chambers there are three possibilities to get the error "00PL"**

1. The shielding of the measuring chamber has a connection to system ground  
(at the measuring chamber or interconnection)
2. In the cable to the measuring chamber is a missing ground connection.  
(This mistake is not possible with the ACL chamber type, PEI No. 9890 000 016xx.)
3. The measuring chamber is defective.

#### Localization and elimination of the error source:

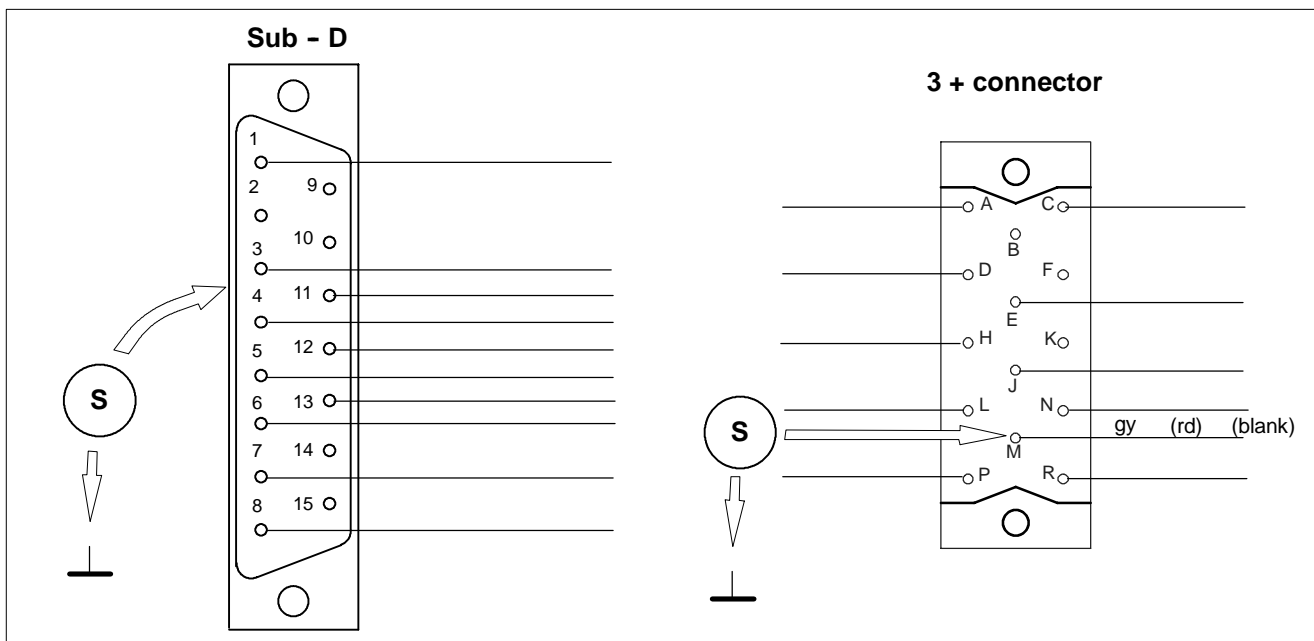
Re 1.)

S Remove the connector of the measuring chamber at generators side.

#### S Measure connection:

- "shielding" (sub - D connector) to system ground,
- or
- pin "M" (3+ connector, 14 pins) to system ground.

**No connection must be present!**



#### S Measure connection:

- "shielding" ( D-sub connector) to chamber shielding
- or
- pin "M" (3+ connector 14 pins) to chamber shielding

**The connection must be present.**



Re 2.)

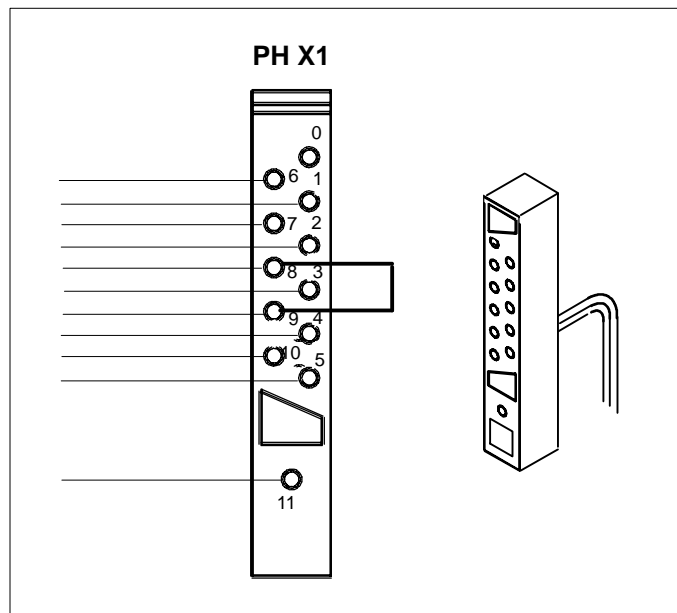
The connector of the measuring chamber at generators side has been removed.

- S Measure the connection between pin "8" and pin "13" (D-sub connector). The connection must be present.
- S If it is not, insert a link between pin "8" and "9" at the chamber cable at the chamber end as shown in the figure.

In this case the system is most probably operated with an old hybrid measuring chamber 9803 509 xxxxx instead of an ACL measuring chamber 9890 000 016xx. In hybrid measuring chambers the connection between pin 8 - 9 is missing.

In case a 3+ connector (AMP 14 pin) is used, the connection pin N --- J is most probably missing since this connection is not present in hybrid measuring chambers.

To increase the interference protection it is advisable to establish the above mentioned connection at the chamber end of the chamber cable pin 8 --- 9 in addition to the connection in the adapter for the AMPLIMAT cable (see Z1 Basic interface).

Re 3.):

Use a "test chamber" and compare the function.

## 8. Power supply

### Switch-on not possible:

- ENF1 not switched on (visual check).
  - ENF1 released
  - ENF2 not switched on (visual check).
  - ENF2 released by
    - low-voltage supply
    - filament circuit
    - tube extension
    - external components supply.
  - "ON" circuit EN100 defective.
- check for damage before reactivating ENF1/2  
(visual check, any smell ?)
- check for damage before reactivating ENF 1/2  
(visual check, any smell ?)

### Phase supervision

#### a) Without mains adaptation transformer:

- Phase L1 is missing: Mains contactors ENK2 and ENK1 cannot be activated.
- Phase L2 is missing: The generator can be switched on but does not go into the READY state.  
The filament-circuit supply is missing.  
There is an error message from function unit kV.
- Phase L3 is missing: "ON" circuit without supply voltage.

Fault tracing:

Check leads and fuses up to the mains supply.

#### b) With mains adaptation transformer:

In case at least one phase at the primary end is missing, the generator cannot be switched on. If there is a problem concerning the leads at the secondary end, refer to a).

### After switch-on or attempted switch-on:

The generator cannot be brought into the READY state (e.g. no desk display).

Check the low-voltage supply.

- ENF1 released:
  - Ground fault/short-circuit of one/several phase(s).
  - Check ENK2 and, if necessary, the contacts of ENK1.
  - Check the leads and the mains adaptation transformer.
  - Have contacts ENK2 or ENK1 dropped out?
  - Check visually. Be careful when doing so since the unit is still connected to mains.
- Missing voltage of intermediate circuit:
  - The damping resistors are unsoldered which was caused by overcurrent during switch-on.
  - Cause: Short-circuit in the converter, defective charging capacitors, mains-filter capacitors or rectifiers.
  - Unsoldering happens about 45 sec. after switch on.

The damping resistors are unsoldered because the converter was active and ENK1 was not switched on although activated by the software.

Probably termination of exposure.

This procedure can only happen once since the generator cannot go into STANDBY when intermediate-circuit voltage E is missing.

In case intermediate-circuit voltage E is present, ENK1 is activated by the software of the kV-control and remains activated for the complete time the unit is in operation.

In case of high impedance or when the tolerance of the symmetry resistors of the intermediate-circuit capacitor battery is too large, capacitors may be destroyed by overvoltage. In case ENK1 has already been activated, ENF1 will probably release.

ENF3 is released by the rotor control units.

The release of ENF2 switches the generator off since the supply voltage for the "ON" circuit and, consequently, the supply voltage of contactors ENK2 and ENK1 is interrupted.

## 9. Functional description of function unit mA

Tube data must be loaded as a data set from floppy disk via PC and central unit CU to into function unit mA.

The procedures described below cannot be carried out before the complete data set for the tube housing assembly is present in central unit CU.

Before the tube adaptation can be started, tube conditioning must be implemented.

With the present generator release the conditioning must be implemented manually.

Later on the conditioning program will take place automatically.

Before adaptation is started, the mA offset value of the mA measuring circuit will be determined.

This offset value consists of two components:

1. A current of 4 mA is impressed upon the mA measuring circuit which is used for continuous calibration (during STANDBY about once per minute).
2. In addition to this the kV measuring circuit delivers an offset current depending on the kV.

To measure this total value an exposure will be released with 40 kV with 500 mA filament current. The emission current measured is the correction value for all standard exposures (4 mA, measuring circuit current depending on the kV).

As opposed to the standby filament current value of the predecessor versions of generators, the standby filament current value of the OPTIMUS generator is not fixed.

It is determined for each focus individually. A 40 kV exposure is released with the focus to be measured while all other foci are switched off.

The filament current will be changed until an emission current of 100  $\mu$ A is obtained.

The associated filament current value is the individual standby filament current (1% to be subtracted so that the fluoroscopic current of any of the other foci is not affected).

The following adaptation program takes place fully automatically.

Based on 120 single exposures for each focus a data field is created in the CMOS of function unit mA. The adjustments for all other exposures are interpolated from this data field during operation.

During the adaptation procedure all limit values such as maximum filament current, maximum kV, maximum tube load, maximum output, current of the generator etc. are taken into account.

## Boost adaptation

Boost time determination (positive boosting).

With the predecessor versions of generators, a **calculated boost current** was added to the exposure filament current for a **fixed time** of 400 ms.

With OPTIMUS generators the boost current is always fixed but with a **variable time**.

The amount of the boost current is the sum of the maximum filament current (of the respective filament) plus 2000 mA.

To determine the time values an exposure must be started at a kV stage from which on the filament current does not have to be increased anymore to obtain the max. kV dependent emission current.

As soon as the 100% kV value is reached, the filament current jumps from the STANDBY value to the maximum filament current plus 2000 mA. The emission current is measured every 2 ms until the maximum tube current or the maximum possible tube current is reached.

In case this procedure takes too long (warming up of the tube), the measurement is continued with a second exposure after a sufficient period of time has passed.

The measurement starts again at the value obtained last.

An innovation of the OPTIMUS generator is the determination of the **negative boosting** (blanking of the filament current).

The measurement is started at the same kV stage as for the positive boost time but with maximum filament current.

As soon as the 100% kV value is reached, the maximum filament current of the filament jumps down to 500 mA.

Every 2 ms the emission current is measured until a value of 100  $\mu$ A is obtained.

The values for the blanking times are required for techniques such as, for instance, cine.

A filament current value of 500 mA must not be exceeded for otherwise the output to supply a gridswitch box (which might be present) is too low.

The following procedure takes place after the generator has been switched on:

Function unit mA initializes itself and afterwards establishes connection with central unit CU via CAN.

For 3 seconds every focus is boosted with the respective specified maximum filament current. Then blanking of the filament current (500 mA) takes place for a variable period of time (derived from negative boost adaptation) to bring the filament current to the STANDBY value (large focus first, then small).

The change of the filament current value upon a change of the focus which was the usual routine for the predecessor versions of the OPTIMUS generator does no longer take place – all STANDBY values remain constant.

During operation the following procedure takes place after the release of PREP:

- The filament current is raised from the individual STANDBY filament current to the boost current.

The switch-on time of the boost current depends on the difference between STANDBY and the exposure (single boost) or intermediate filament (double boost) current.

Double boost:

- The intermediate filament current is a calculated value. It is calculated in such a way that the filament current and thus the filament temperature is brought to exposure level when the boost current is switched on for another 50 ms which the exposure command.
- During exposure the filament current is regulated as required.
- At the end of exposure the filament current is reduced to the minimum value of 500 mA (negative boosting) for a calculated time to bring it from the exposure to the STANDBY value.
- In case preparation is released, negative boosting takes place until heating can go on with the STANDBY filament current.

## 10. CAN bus

All the intelligent assemblies/pc boards communicate via the CAN bus. There they are connected in parallel to the two lines CAN\_L (low) and CAN\_H (high).

The data are serially transmitted in the form of so-called frames.

Levels in quiescent state against chassis:

- CAN\_L: 2.5 V
- CAN\_H: 2.5 V

Levels during data transmission against chassis:

- CAN\_L: 0.50 ... 2.25 V
  - CAN\_H: 2.75 ... 4.50 V
- } Both levels are opposite.  
} The difference must be greater than 1.5 V!

Test points generator CAN:

- CAN\_L: EZX71
- CAN\_H: EZX72
- Chassis: EZX5

Test points system CAN:

- S\_CAN\_L: EZX42:2
- S\_CAN\_H: EZX42:7
- Chassis: EZX42:3

Reference: Z1-5.1, Z2-5.1/5.2

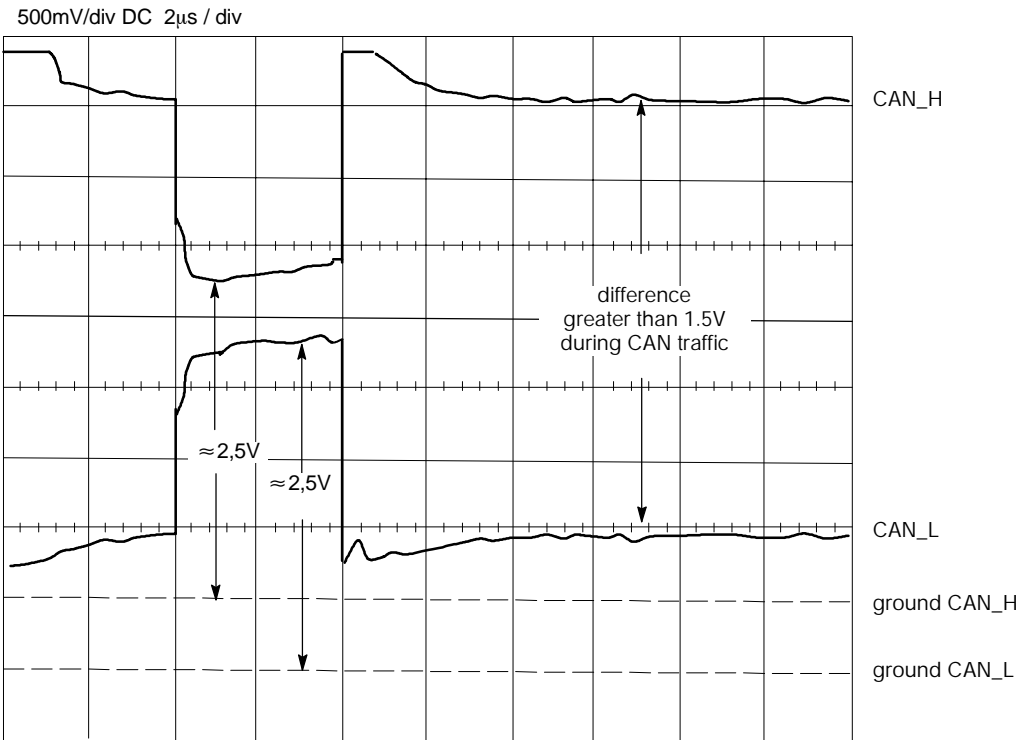
Symptoms of errors:

- The generator is inoperable.
- The red LED of one or more of the assemblies/pc boards is flashing.
- Parameter settings on the control desk are accepted and displayed with a considerable delay.
- In the error memory there are several entries which in the code begin with 00C (apart from 00CJ) or the error description contains a reference to signal conflicts.

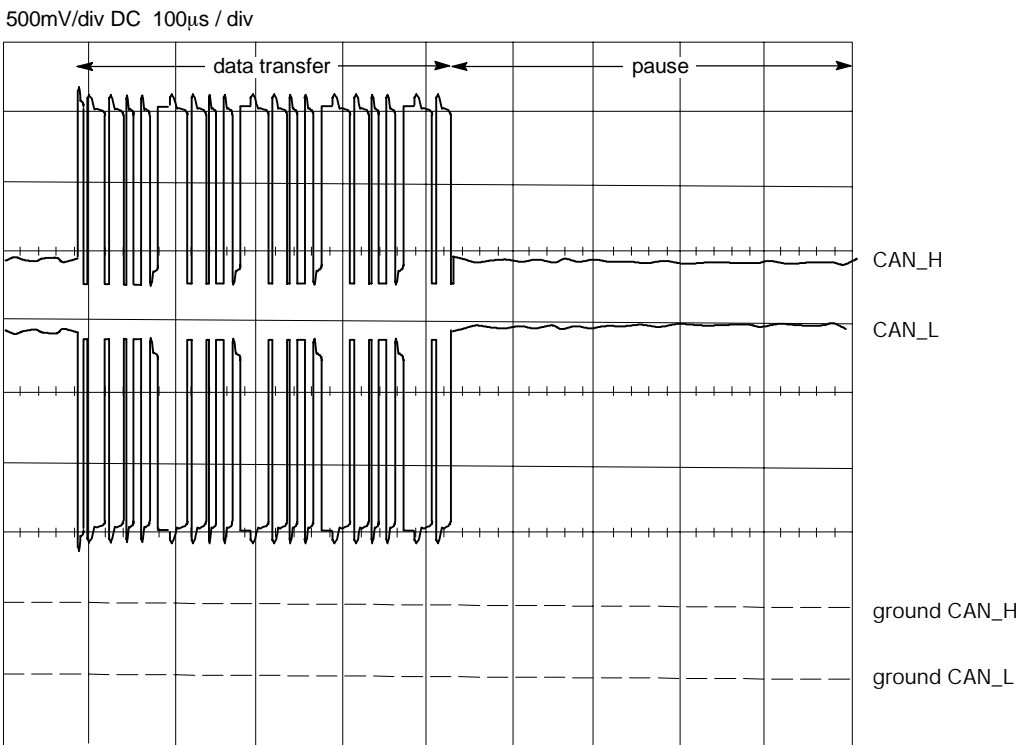
Error localization:

- Entries in the error memory clearly draw attention to the fact that the assembly and pcb are not communicating properly or not at all.
- Control measurement of CAN levels with an oscilloscope during data transmission and in the quiescent state.  
Data transmission is triggered by pressing any desk button.  
If the levels are outside the tolerance or are not symmetrical, the CAN driver of an assembly/pcb is faulty.  
Since all the users are connected to the bus in parallel, the troublemaker can only be found by disconnecting one user after another.  
Disconnection may only take place with the generator switched off.

CAN levels with a high temporal resolution:  
(Diagram 1)



CAN levels with low temporal resolution:  
(Diagram 2)



197H96

## 11. Incorrect exposure indicator

### General causes:

On the control desk an incorrect exposure is indicated if an exposure cannot be terminated according to the parameters set. Frequent causes of underexposure are the following:

- The operator has let go of the release switch prematurely.
- Tomography time of the unit does not coincide with the exposure time of the generator. Permissible tolerance:  $\pm 10\%$
- Measuring chamber incorrectly programmed, not connected or faulty.  
Check the following:
  - RGDV programming
  - Programming of AMPLIMAT sensitivity
  - Programming of EZ150 Basic Interface (Gain, 15 V/40 V supply)
  - Programming of screen-film combination (Data Sets 1...5)
- The APR selected is not matched to the technique used or the screen-film combination.  
Check the following:
  - APR programming

The standard APRs supplied have parameters which are generally matched to a 400-type screen-film combination. If the standard APRs are used, the exposure parameters will have to be changed according to the speed of the screen-film combination actually used.

This also applies if an automatic technique is programmed as the preferred technique. In automatic techniques the mAs and ms-parameters are used for Fault Exposure Detection.

### Fault exposure detection AEC/TDC:

To protect patients there are 3 monitoring systems for automatic techniques:

1. Maximum mAs product
2. Maximum exposure time or backup time
3. Fault Exposure Detection

The maximum mAs product can be set via xrgscope.

The fault exposure detection can be switched on or off via xrgscope. Irrespective of this, fault exposure detection is not performed if levels fall below certain limits.

### AEC/AECF limits:

- Maximum mAs product: 580 mAs (default)
- Maximum exposure time: 4 s
- Backup time AEC: Exposure time based on 10 times the mAs of the respective manual technique (kV-mAs). 4 s after overriding.
- Backup time AECF: 10 times the exposure time of the respective manual technique (kV-mAs).
- Fault Exposure Detection:  $\leq 4\%$  dose at 10% backup time

Fault Exposure Detection is ignored under the following circumstances:

- Backup time:  $\leq 100$  ms ( $\leq 10$  ms at 10%)
- Switch-off voltage (dose):  $\leq 610$  mV ( $\leq 24.4$  mV at 4%)

If there is a fault an exposure is aborted after about 10% of backup time. If the Fault Exposure Detection fails to respond in the event of a fault, shutdown takes place after reaching backup time or maximum exposure time or max. mAs product.

### TDC limits:

- Maximum mAs product: 580 mAs (default)
- Exposure time: 0.3 ... 6 s
- Fault Exposure Detection:  $\leq 10 \dots 4\%$  dose for 10 times the sample time  

$$\text{Dose minimum} = \frac{10 \times \text{sample time}}{\text{exposure time (corr.)}} \times 40\% \text{ nominal dose}$$
- Backup time: Exposure time
- Sample time: 25 ... 60 ms = 1% exposure time (corr.), min. 25 ms
- Sample steps: 12 ... 100

Fault Exposure Detection is ignored under the following circumstances:

- Exposure time: < 1 s

In the event of a fault the exposure is aborted after approx. 11 times Sample Time. If the Fault Exposure Detection fails to respond in the event of a fault, shutdown takes place after reaching the backup time or the max. mAs product.

The switch-off voltage should be at least 1.2 V to guarantee good TDC regulation. Program the higher gain factor on EZ150 BASIC INTERFACE ( $\geq 4512\ 108\ 05964$ ) if necessary.

### Programming possibilities:

- Menu "Program/ Application Limits/ **X-Mode Limits**":  
X-Ray Mode: AEC ... TDC      Max. Current Time Product Limit: 580 mAs
- Menu "Program/ Dose Rate Control/ Fault Exposure Detection/ **AEC ... TDC**": on - off

### Aids to fault finding:

Menu "Faultfind/ Logging Table/ X-Ray Log/ Dose Rate Control Logging/ ...

- .../ **Read Actual Status**": Technique and parameters of the last exposure
- .../ AEC/ **AEC Calculation**": Data of the selected APR with AEC or AECF
- .../ AEC/ **AEC Trace**": Control values of the last AEC exposure
- .../ TDC/ **TDC Calculation**": Data of the selected APR with TDC
- .../ TDC/ **TDC Trace**": Control values of the last TDC exposure

### Adjustment possibilities:

- Menu "Adjust / Dose Rate Control / TDC AMPLIMAT":  

|                  |                           |   |  |
|------------------|---------------------------|---|--|
| P gain factor    | (def. 50):                | } | Do not change any value here without order from DMC Hamburg! |
| i gain factor    | (def. 8):                 |   |  |
| d gain factor    | (def. 5):                 |   |  |
| min. sample time | (def. 40) [ms]: 25 ... 65 |   |  |



## 12. Mnemonic and routing list

Example:

| MNEMONIC | explanation     |
|----------|-----------------|
|          | chain           |
|          | value           |
|          | measuring point |
|          | trigger point   |
|          | remarks         |
|          | part of supply  |

---

|          |  |
|----------|--|
| AC_0V_XG | mains supply 0 V X-ray generator<br>ENX1102-EZX13:2-EZ102X1:DBZ4-EZ119X1:DBZ24<br>EZ14:2-<br>EZ15:2-EWRX21:2 |
|----------|--|

---

|            |  |
|------------|--|
| AC_230V_L1 | mains supply 230V AC phase 1<br>ENF3:L1-EZX13:1-EZX102X1:DBZ2<br>EZ14:1-<br>EZ15:1-EWRX21:1- |
|------------|--|

---

|            |   |
|------------|---|
| AC_230V_L2 | mains supply 230V AC phase 2<br>ENF3:L2-EZX13:3-EZ119X1:DBZ26 |
|------------|---|

---

|          |  |
|----------|--|
| AV_HT_AN | high tension actual value anode side<br>0V...+3.75V 1V $\approx$ 20kV<br>measuring point EZ130X4 |
|----------|--|

---

|          |  |
|----------|--|
| AV_HT_CA | high tension actual value cathode side<br>0V...+3.75V 1V $\approx$ 20kV<br>measuring point EZ130X5 |
|----------|--|

---

|       |   |
|-------|---|
| AV_HT | high tension actual value<br>0...+7.5V 1V $\approx$ 20kV<br>measuring point EZ130X3 |
|-------|---|

---

|       |  |
|-------|--|
| CAN_H | generator CAN high active<br>EZ119X2:C3-EZ130X2:C3-EZ139X2:C3-EZ150X2:C3-EZX44:10-EZX45:10-EZX46:10-<br>-C300X1:10-EZX51:3-EZX151:3-EZX52:7-EZX72-<br>EWAX51:10-EWAX52:10-EWA100X2:C3-<br>0V/5V<br>measuring point EZX72<br>part of: XRG bus |
|-------|--|

---

|       |   |
|-------|---|
| CAN_L | generator CAN low active<br>EZ119X2:A3-EZ130X2:A3-EZ139X2:A3-EZ150X2:A3-EZX44:2-EZX45:2-EZX46:2- -C300X1:2-EZX51:2-EZX151:2-<br>EZX52:2-EZX71- EWAX51:2-EWAX52:2-EWA100X2:A3-<br>0V/5V<br>measuring point EZX71<br>part of: XRG bus |
|-------|---|

---

|            |   |
|------------|---|
| CM_EX_SW_1 | common for exposure switch of release decade 1<br>EWA100X1:C5-EWAX1:10- |
|------------|---|

---

|            |   |
|------------|---|
| CM_EX_SW_2 | common for exposure switch of release decade 2<br>EWA100X1:C7-EWAX2:10-   |
| CM_EX_SW_3 | common for exposure switch of release decade 3<br>EWA100X1:C9-EWAX3:10-   |
| CM_EX_SW_4 | common for exposure switch of release decade 4<br>EWA100X1:C11-EWAX4:10-  |
| CM_SW      | common for radiation indication<br>EZ150X1:C29-EZX1:6-  |
| CM_TH      | common for thermal sensor of tube housing<br>EZ130X1:C12-EZX3:7- (generator basis 4512 104 70202/70601 only)<br>EZ130X1:C12-EZX3:4-   |
| CM_TH_SW   | common for tube housing switch<br>EZ130X1:C11-EZX3:4- (generator basis 4512 104 70202/70601 only)<br>EZ130X1:C11-EZX3:7-  |
| CTRL_X/    | control X-ray request command, system level<br>EZ139X1:A4-EZX23:4-EZX45:5-EWAX51:5-EWAX52:5-EWA100X2:C25-0V/15V<br>measuring point: EZX85<br>part of: system signal bus   |
| CTRL_X_C/  | control X-ray request command, internal generator level<br>EZ119X2:C6-EZ130X2:C6-EZ139X2:C6-EZ150X2:C6-EZX52:8-0V/5V<br>measuring point EZX74<br>driven by CU, active, if STOP_X_C/ not active, immediately inactive if STOP_X_C/ active, controls all non AEC exposures with exposure timer or AEC exposures with DRC timer<br>HTON high tension on command (internal generator command) resp. 20/21 signal<br>(external = old world)<br>part of: XS/XRG bus |
| CU_CT1_1   | cooling unit contact 1_1<br>EZ150X1:A22-EZX2:6-   |
| CU_CT1_2   | cooling unit contact 1_2<br>EZ150X1:C22-EZX2:7-   |
| CV1_GND    | converter power part 1 ground<br>EZ130X1:AC8-EZX24:8/21-EQ100X1:8/21  |
| CV1_GND_OL | converter power part 1 ground overload (generator basis $\geq$ 4512 104 70203/70602)<br>EZ130X1:A7-EZX24:20-EQ100X1:20  |
| CV1_ID/    | converter power part 1 identification<br>EQ100X1:19-EZX24:19-EZ130X1:A6-<br>open 5V, low active 0V  |

|            |  |
|------------|--|
| CV1_OL/    | converter power part 1 overload<br>EQ100X1:7-EZX24:7-EZ130X1:C7-<br>open +26V, low active 0V   |
| CV1_TM     | converter power part 1 temperature<br>EQ100X1:6-EZX24:6-EZ130X1:C6-<br>0.3...3.5V, 85 _C...0 _C  |
| CV2_GND    | converter power part 2 ground<br>EZ130X1:AC29-EZX34:8/21-E2Q100X1:8/21   |
| CV2_GND_OL | converter power part 2 ground overload (generator basis $\geq 4512\ 104\ 70203/70602$ )<br>EZ130X1:A28-EZX34:20-E2Q100X1:20  |
| CV2_ID/    | converter power part 2 identification<br>E2Q100X1:19-EZX34:19-EZ130X1:A27-<br>open 5V, low active 0V   |
| CV2_OL     | converter power part 2 overload<br>E2Q100X1:7-EZX34:7-EZ130X1:C28-<br>open +26V, low active 0V   |
| CV2_TM     | converter power part 2 temperature<br>EZ130X1:C27-E2Q100X1:6-EZX34:6-<br>0.3...3.5V, 85 _C...0 _C  |
| DR_BV_0V   | dose rate (signal) reference of image intensifier<br>EZX61:3-EZ139X2:C18-<br>negative potential of II unit, 0V $\pm 50$ mV against generator ground<br>differential signal with DR_BV_SG<br>part of: dose rate control |
| DR_BV_SG   | dose rate signal of image intensifier<br>EZX61:8-EZ139X2:A18-<br>positive potential, 0...10V<br>differential signal with DR_BV_0V<br>part of: dose rate control  |
| DR_FQ_NG   | dose rate signal (pulses) negative<br>EZX61:6-EZ139X2:C20-<br>0.1 $\mu$ R / pulse<br>optocoupled interface, dose rate signal = pulsed frequency<br>part of: dose rate control  |
| DR_FQ_PO   | dose rate signal (pulses) positive<br>EZX61:1-EZ139X2:A20-<br>0.1 $\mu$ R / pulse<br>optocoupled interface, dose rate signal = pulsed frequency<br>part of: dose rate control  |

|            |  |
|------------|--|
| DR_TV_NT   | dose rate of TV chain signal negative, fluoro regulation<br>EZ61:4-EZ139X2:C19-<br>± 12V minus polarity<br>dual voltage differential signal<br>+12V = 200% light, 0V = 100% light, - 12V = 50% light<br>part of: dose rate control   |
| DR_TV_PT   | dose rate of TV chain signal positive, fluoro regulation<br>EZ61:9-EZ139X2:A19-<br>± 12V positive polarity<br>dual voltage differential signal<br>-12V = 200% light, 0V = 100% light, +12V = 50% light<br>part of: dose rate control |
| DS_BV_0V   | dose (signal ramp) reference of image intensifier<br>EZ61:2-EZ139X2C17-<br>negative potential of II unit, 0V ± 50mV against generator ground<br>differential signal with DS_BV_SG<br>part of: dose rate control                      |
| DS_BV_SG   | dose signal ramp of image intensifier signal<br>EZ61:7-EZ139X2:A17-<br>0...10V, polarity positive<br>differential signal with DS_BV_0V<br>part of: dose rate control   |
| DS_MC_0V   | dose (signal ramp) reference of selected measuring chamber<br>EZ150X2:C16-EZ139X2:C16<br>negative potential of selected measuring chamber, 0V ± 50mV against generator ground<br>differential signal with DS_MC_SG                   |
| DS_MC_SG   | dose signal ramp of selected measuring chamber<br>EZ150X2:A16-EZ139X2:A16-<br>0...12V<br>differential signal with DS_MC_0V   |
| E_NG_CV1/2 | E value converter DC supply negative<br>converter 1: EQ100X1:5-EZX24:5-EZ130X1:C5-<br>converter 2: E2Q100X1:5-EZX34:5-EZ130X1:C26 (future releases)<br>0...-12V ≈ 0...-375V  |
| E_PO_CV1/2 | E value converter DC supply positive<br>converter 1: EQ100X1:18-EZX24:18-EZ130X1:A5-<br>converter 2: E2Q100X1:18-EZX34:18-EZ130X1:A26 (future releases)<br>0...+12V ≈ 0...+375V  |
| EN_X/      | enable X-ray, system level<br>EZ139X1:C2-EZX10:1/3-EZX23:15-EZX45:11-EZX46:11-C300X1:11- -EWAX51:11-EWAX52:11-EWA100X2:C26-<br>measuring point: EZX82, EZ139X9<br>part of: signal bus<br>0V/15V low active                           |

EN\_X\_C/ enable X-ray, internal generator level  
 EZ119X2:C7-EZ130X1:A9-EZ130X1:A30-EZ130X2:C7-EZ139X2:C7-EZ150X2:C7-EZX52:9-EZX76-  
 0V/5V low active  
 measuring point EZX76  
 driven by CU if EN\_X/ active (low)  
 part of: XS/XRG bus

CV1 EN/ converter 1/2 enable  
 CV2 EN/ converter 1: EZ130X1:A9-EZX24:22-EQ100X1:22-  
 converter 2: EZ130X1:A30-EZX34:22-E2Q100X1:22-

EX\_ON exposure on  
 EWA100X2:A9-EWAX14:7-  
 part of: exon old world

FD\_C\_CH1 central field measuring chamber 1  
 EZ150X1:C4-EZX21:12-  
 15V,  $R_i = 220 \Omega$

FD\_C\_CH2 central field measuring chamber 2  
 EZ150X1:A4-EZX22:12-  
 15V,  $R_i = 220 \Omega$

FD\_C\_CH3 central field measuring chamber 3  
 EZ150X1:C10-EZX31:12-  
 15V,  $R_i = 220 \Omega$

FD\_C\_CH4 central field measuring chamber 4  
 EZ150X1:A10-EZX32:12-  
 15V,  $R_i = 220 \Omega$

FD\_C\_CH5 central field measuring chamber 5  
 EZ150X1:C16-EZX41:12-  
 15V,  $R_i = 220 \Omega$

FD\_L\_CH1 left field measuring chamber 1  
 EZ150X1:C3-EZX21:11-  
 15V,  $R_i = 220 \Omega$

FD\_L\_CH2 left field measuring chamber 2  
 EZ150X1:A3-EZX22:11-  
 15V,  $R_i = 220 \Omega$

FD\_L\_CH3 left field measuring chamber 3  
 EZ150X1:C9-EZX31:11-  
 15V,  $R_i = 220 \Omega$

FD\_L\_CH4 left field measuring chamber 4  
 EZ150X1:A9-EZX32:11  
 15V,  $R_i = 220 \Omega$

|                   |  |
|-------------------|--|
| FD_L_CH5          | left field measuring chamber 5<br>EZ150X1:C15-EZX41:11-<br>15V, $R_i = 220\ \Omega$  |
| FD_R_CH1          | right field measuring chamber 1<br>EZ150X1:C5-EZX21:3<br>15V, $R_i = 220\ \Omega$  |
| FD_R_CH2          | right field measuring chamber 2<br>EZ150X1:A5-EZX22:3-<br>15V, $R_i = 220\ \Omega$   |
| FD_R_CH3          | right field measuring chamber 3<br>EZ150X1:C11-EZX31:3-<br>15V, $R_i = 220\ \Omega$  |
| FD_R_CH4          | right field measuring chamber 4<br>EZ150X1:A11-EZX32:3-<br>15V, $R_i = 220\ \Omega$  |
| FD_R_CH5          | right field measuring chamber 5<br>EZ150X1:C17-EZX41:3-<br>15V, $R_i = 220\ \Omega$  |
| FI_TF1_1          | filament transformer 1 line 1<br>EZ119X1:DBZ4-EZX12:1-EG106X15:1-<br>max. 300Veff or $\pm 150V$ against ground, 100...20kHz  |
| FI_TF1_2          | filament transformer 1 line 2<br>EZ119X1:DBZ6-EZX12:2-EG106X15:2-<br>max 300Veff or $\pm 150V$ against ground, 100...20kHz   |
| FI_TF2_1          | filament transformer 2 line 1<br>EZ119X1:DBZ8-EZX12:4-EG106X15:4<br>max. 300Veff or $\pm 150V$ against ground, 100...20kHz   |
| FI_TF2_2          | filament transformer 2 line 2<br>EZ119X1:DBZ10-EZX12:5-EG106X15:5-<br>max. 300Veff or $\pm 150V$ against ground, 100...20kHz |
| GND               |  |
| GND_15V           | ground (+15V) for desk handswitch<br>C300X3:1/2/6-   |
| GNDC<br>S_CAN_GND | CAN bus ground<br>EZ139X1:C17-EZX42:3/6-EZX43:3/6-EZX44:9-<br>part of: system CAN  |

GNDS signal bus ground  
 PO\_0V EZ139X1:AC1-EZX23:1/14-EZX44:15-EZX45:15-EWAX51:15-EWAX52:15-  
 part of: signal bus  
 negative

HT\_AN high tension anode side actual value  
 EG100X14:2-EZX35:2-EZ130X1:C17-  
 0...+10V  $\approx$  0...+100 kV

HT\_AN\_GND high tension anode side ground  
 EG100X14:10-EZX35:10-EZ130X1:A17-  
 0V

HT\_CA high tension cathode side actual value  
 EG100X14:1-EZX35:1-EZ130X1:C16-  
 0...-10V  $\approx$  0...-100kV

HT\_CA\_GND high tension cathode side ground  
 EG100X14:9-EZX35:9--EZ130X1:A16  
 0V

I1\_1 IGBT1 power part 1 EQ100 = 4512 108 05882  
 I1\_1/ IGBT1 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:C1-EZX24:1-EQ100X1:1-

I1\_1/ IGBT1 power part 1 EQ100 = 4512 108 05882  
 I1\_1 IGBT1 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:A1-EZX24:14-EQ100X1:14-  
 value: on = 3.7V off = 1.2V against ground \* = X10  
 measuring point EQ100 R25 end to X1 \* EQ100 X6

I1\_2 IGBT2 power part 1 EQ100 = 4512 108 05882  
 I1\_2/ IGBT2 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:C2-EZX24:2-EQ100X1:2-

I1\_2/ IGBT2 power part 1 EQ100 = 4512 108 05882  
 I1\_2 IGBT2 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:A2-EZX24:15-EQ100X1:15-  
 value: on = 3.7V off = 1.2V against ground \* = X10  
 measuring point EQ100 R27 end to X1 \* EQ100 X7

I1\_3 IGBT3 power part 1 EQ100 = 4512 108 05882  
 I1\_3/ IGBT3 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:C3-EZX24:3-EQ100X1:3-

I1\_3/ IGBT3 power part 1 EQ100 = 4512 108 05882  
 I1\_3 IGBT3 power part 1 EQ100  $\geq$  4512 108 08621 \*  
 EZ130X1:A3-EZX24:16-EQ100X1:16-  
 value: on = 3.7V off = 1.2V against ground \* = X10  
 measuring point EQ100 R29 end to X1 \* EQ100 X8

|       |  |          |                  |
|-------|--|----------|------------------|
| I1_4  | IGBT4 power part 1                                 | EQ100 =  | 4512 108 05882   |
| I1_4/ | IGBT4 power part 1                                 | EQ100 ≥  | 4512 108 08621 * |
|       | EZ130X1:C4-EZX24:4-EQ100X1:4-                      |          |                  |
| I1_4/ | IGBT4 power part 1                                 | EQ100 =  | 4512 108 05882   |
| I1_4  | IGBT4 power part 1                                 | EQ100 ≥  | 4512 108 08621 * |
|       | EZ130X1:A4-EZX24:17-EQ100X1:17-                    |          |                  |
|       | value: on = 3.7V off = 1.2V against ground * = X10 |          |                  |
|       | measuring point EQ100 R31 end to X1 * EQ100 X9     |          |                  |
| I2_1  | IGBT1 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_1/ | IGBT1 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:C22-EZX34:1-E2Q100X1:1-                    |          |                  |
| I2_1/ | IGBT1 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_1  | IGBT1 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:A22-EZX34:14-E2Q100X1:14                   |          |                  |
|       | value: on = 3.7V off = 1.2V against ground * = X10 |          |                  |
|       | measuring point EQ100 R25 end to X1 * E2Q100 X6    |          |                  |
| I2_2  | IGBT2 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_2/ | IGBT2 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:C23-EZX34:2-E2Q100X1:2-                    |          |                  |
| I2_2/ | IGBT2 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_2  | IGBT2 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:A23-EZX34:15-E2Q100X1:15-                  |          |                  |
|       | value: on = 3.7V off = 1.2V against ground * = X10 |          |                  |
|       | measuring point EQ100 R27 end to X1 * E2Q100 X7    |          |                  |
| I2_3  | IGBT3 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_3/ | IGBT3 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:C24-EZX34:3-E2Q100X1:3-                    |          |                  |
| I2_3/ | IGBT3 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_3  | IGBT3 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:A24-EZX34:16-E2Q100X1:16-                  |          |                  |
|       | value: on = 3.7V off = 1.2V against ground * = X10 |          |                  |
|       | measuring point EQ100 R29 end to X1 * E2Q100 X8    |          |                  |
| I2_4  | IGBT4 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_4/ | IGBT4 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:C25-EZX34:4-E2Q100X1:4-                    |          |                  |
| I2_4/ | IGBT4 power part 2                                 | E2Q100 = | 4512 108 05882   |
| I2_4  | IGBT4 power part 2                                 | E2Q100 ≥ | 4512 108 08621 * |
|       | EZ130X1:A25-EZX34:17-E2Q100X1:17-                  |          |                  |
|       | value: on = 3.7V off = 1.2V against ground * = X10 |          |                  |
|       | measuring point EQ100 R31 end to X1 * E2Q100 X9    |          |                  |
| IT_0V | emitter 0V exposure on signal                      |          |                  |
|       | EWA100X2:C9-EWAX14:9-                              |          |                  |
|       | part of: exon old world                            |          |                  |



|           |  |
|-----------|--|
| Iu        | stator current U of Low Speed Rotor Control low speed<br>measuring point EYAX22  |
| Iw        | stator current W of Low Speed Rotor Control low speed<br>measuring point EYAX21  |
| MN_EM_OF  | mains power emergency off<br>EZ4:1-EZ47:6-EN100X1:6-   |
| MN_ON     | mains on<br>C300X1:6-EZ46:6-EZ47:2-EN100X1:2-EZ44:14-  |
| NG_15V    | - 15 V supply Vee<br>EZ102X2:DBZ24-EZ119X2:AC12-EZ130X2:AC12-EZ139X2:AC12-EZ150C2:AC12-EZ21/22/31/32/41:6-EZ35:15-<br>EZ51:8-EZ151:8-EG100X14:15-<br>EZ31:6-EZ32<br>-14.5V ..... -15.5V  |
| NR_PR_X/  | not ready preparing for X-ray (low active)<br>EZ139X1:A3-EZ23:3-EZ45:4-EZ46:4-C300X1:4- -EWAX51:4-EWAX52:4-EWA100X2:A24-<br>driven by CU<br>measuring point: EZ83<br>part of: signal bus   |
| PO_12V    | + 12 V supply<br>EN100X1:1-EZ47:1-EZ46:7-C300X1:7-   |
| PO_15V    | + 15 V supply Vdd<br>EZ102X2:DBZ22-EZ119X2:AC11-EZ130X2:AC11-EZ139X2:AC11<br>-EZ150X2:AC11-EZ2:8/9-EZ35:7-EZ44:12/13-EZ46:5<br>-EZ51:7-EG100X14:7-C300X1:5<br>-EZ21/22/31/32/41:5 only generator basis 4512 104 70202/70601<br>-EZ151:7 generator basis $\geq$ 4512 104 70203/70602<br>+14.5V ..... +15.5V |
| PO_15/40V | + 15 V or + 40 V supply for measuring chamber<br>EZ150X1:A20-EZ21/22/31/32/41:5  |
| PO_26V    | + 26 V supply<br>EZ102X2:DBZ28-EZ119X2:AC14-EZ130X2:AC14-EZ139X2:AC14<br>-EZ150X2:AC14-EZ1:5-EZ2:3-EZ3:9-EZ11:1-EZ17:1-EZ18:1-EWAX1:4-<br>-EWAX2:4-EWAX3:4-EWAX4:4-EWAX41:1-EWAX23:9-EWAX24:5-EWA100X2:A14-EWA100X2:C14-<br>-EQ100X2:1-E2Q100X2:1-   |
| PO_26V_1  | + 26 V supply optional<br>EZ102X2:DBZ32-EZ19:1-EZ20:1-<br>EZ8:1 generator basis $\geq$ 4512 104 70203/70602  |
| PO_26V_RE | + 26 V supply reverse<br>EWA11-EWA12-EWAX1/2/3/4:4-EWAX42:1-<br>if generator and system release voltage are of the same polarity<br>PO_26V_RE = +26V, if not PO_26V_RE = 0V against -24V   |

|                     |   |
|---------------------|---|
| PO_26V_SW           | + 26 V supply switched<br>EZ102X1:D32-EZX7:1-EM1 generator basis $\geq$ 4512 104 70203/70602  |
| PO_400V             | + 400 V supply measuring chamber<br>EZ150X1:AC1-EZX21/22/31/32/41:1-<br>+400V , Ri=100k   |
| PO_5V               | + 5 V supply Vcc<br>EZ102X2:DBZ2/4/6-EZ119X2:AC1/2-EZ130X2:AC1/2-EZ139X2:AC1/2-EZ150X2:AC1/2-EZX46:9-C300X1:9-<br>EZX51:4/5/6-EZX151:4/5/6<br>+4.74V ..... +5.25V   |
| PO_V                | signal bus supply<br>EZX23:13/25-EZX44:5-EZX45:7-EWAX51/52:7-<br>EWA100X2:AC27-EZ139X1:AC6-<br>Vsgn<br>part of: signal bus  |
| POWERFAIL/          | power fail signal of power supply<br>EZ102X1:D30-EZ139X1:A10-   |
| PW_ON_NG            | DC supply relay power on negative<br>EZ130X1:A15-EZX47:9-EN100X1:9-<br>0V/+15V, low active  |
| PW_ON_PO            | DC supply relay power on positive<br>EZ130X1:C15-EZX47:4-EN100X1:4-<br>+15V   |
| RC_ON/              | rotor control on<br>EZ150X1:A25-EZX51:1-  |
| RC_RD/              | rotor control ready<br>EYAX1:9(low speed)-EXZ51:9-EZ150X1:C25-<br>measuring point EYAX25 low speed rotor control  |
| RC_ST_2/            | rotor control stator 2<br>EZ150X1:A26-EZX16:1(low speed)-EY100X3:1(high speed)-EWGX14:1   |
| RC_ST_3/            | rotor control stator 3<br>EZ150X1:C26-EZX16:2(low speed)-EY100X3:2(high speed)-EWGX14:2-EWGX15:1-E1WGX14:1  |
| RD_MN_ON            | ready mains power on<br>C300X1:14-EZX46:14-EZX47:7-EN100X1:7-   |
| RD_PR_X<br>NR_PR_X/ | ready preparing for X-ray or not ready preparing for X-ray (low active)<br>EZ139X1:A3-EZX23:3-EZX45:4-EZX46:4-C300X1:4- -EWAX51:4-EWAX52:4-EWA100X2:A24-<br>driven by CU<br>measuring point: EZX83<br>part of: signal bus |
| REL_CH1             | release (reset integrator) chamber 1<br>EZ150X1:C6-EZX21:4-   |

|           |   |
|-----------|---|
| REL_CH2   | release (reset integrator) chamber 2<br>EZ150X1:A6-EZX22:4-   |
| REL_CH3   | release (reset integrator) chamber 3<br>EZ150X1:C12-EZX31:4-  |
| REL_CH4   | release (reset integrator) chamber 4<br>EZ150X1:A12-EZX32:4-  |
| REL_CH5   | release (reset integrator) chamber 5<br>EZ150X1:C18-EZX41:4-  |
| RESET_C/  | system RESET command<br>EZ130X2:A6-EZ119X2:A6-EZ139X2:A6-EZ150X2:A6-EZX45:3-EZX46:3-C300X1:3-<br>-EZX51:10-EZX52:3-EZX73-EWAX51:3-EWAX52:3-EWA100X1:A6-<br>0V/5V<br>measuring point EZX73<br>driven by CU, active (low) if: EZ139 S1 activated, RESET_SW/ active,<br>threatening power supply drop in, watchdog alarm, switch on (button),<br>resets FU's<br>drop in, part of: XS/XRG bus |
| RESET_SW/ | signal bus reset, generator reset<br>EZX23:2-EZX44:6-EZ139X1:A2-<br>low active<br>$\tau \geq 200\text{ms}$ ( $\tau = 8.41 \text{ WP}$ )<br>resets CU<br>measuring point: EZX81<br>part of: signal bus   |
| RF_0V_CH1 | 0V reference value measuring chamber 1<br>EZX21:8-EZ150X1:C8-<br>differential signal with SIGN_CH1  |
| RF_0V_CH2 | 0V reference value measuring chamber 2<br>EZX22:8-EZ150X1:A8-<br>differential signal with SIGN_CH2  |
| RF_0V_CH3 | 0V reference value measuring chamber 3<br>EZX31:8-EZ150X1:C14-<br>differential signal with SIGN_CH3   |
| RF_0V_CH4 | 0V reference value measuring chamber 4<br>EZX32:8-EZ150X1:A14-<br>differential signal with SIGN_CH4   |
| RF_0V_CH5 | 0V reference value measuring chamber 5<br>EZX41:8-EZ150X1:C20-<br>differential signal with SIGN_CH5   |
| RG_DV_1   | registration device 1 selected<br>EWA100X1:C4-EWAX1:5-  |

|                    |   |
|--------------------|---|
| RG_DV_2            | registration device 2 selected<br>EWA100X1:A7-EWAX2:5-  |
| RG_DV_3            | registration device 3 selected<br>EWA100X1:A9-EWAX3:5-  |
| RG_DV_4            | registration device 4 selected<br>EWA100X1:A11-EWAX4:5-   |
| RM_DR_0V           | room door contact 0V<br>EZ150X1:C28-EZX1:10-  |
| RM_DR_CT           | room door contact<br>EZ1:8-EZ150X1:A28-   |
| RQ_SN_X/           | request synchronization of X-ray<br>EZ23:16-EZX45:12-EZX46:12-C300X1:12-EZ139X1:C3- -EWAX51:12-EWAX52:12-EWA100X2:A25-<br>measuring point: EZX84<br>part of: signal bus |
| RQ_XG_EX           | request X-ray generator for exposure<br>EWAX1/2/3/4:1-EWA100X1:A3   |
| RQ_XG_FL           | request X-ray generator for fluoroscopy<br>EWAX1/2/3/4:6-EWA100X1:A5  |
| RQ_XG_PR_1         | request X-ray generator for preparation<br>EWAX1:3-EWA100X1:A4-   |
| RQ_XG_PR_2         | request X-ray generator for preparation<br>EWAX2:3-EWA100X1:C6-   |
| RQ_XG_PR_3         | request X-ray generator for preparation<br>EWAX3:3-EWA100X1:C8-   |
| RQ_XG_PR_4         | request X-ray generator for preparation<br>EWAX4:3-EWA100X1:C10-  |
| RX_CAN_1           | system CAN 1 optional<br>EZ44:3-EZ139X1:C15-<br>part of: system CAN   |
| RX_CAN_2           | system CAN 2 optional<br>EZ43:1-EZ44:11-  |
| S_CAN_L<br>(CAN_N) | system CAN low active<br>EZ139X1:C16-EZX42:2-EZX43:2-<br>part of: system CAN  |

|                    |  |
|--------------------|--|
| S_CAN_H<br>(CAN_P) | system CAN high active<br>EZ139X1:A16-EZX42:7-EZX43:7-<br>part of: system CAN  |
| S_CAN_PO           | system CAN supply<br>EZ42:9-EZX43:9-EZX44:4-EZ139X1:A17-<br>Vcan<br>part of: system CAN  |
| SI_PH_ID<br>SI_PH/ | single phase identifier<br>EN100X1:5-EZX47:5-EZ130X1:C14-  |
| SIGN_CH1           | signal ramp of measuring chamber 1<br>EZ21:7-EZ150X1:C7-<br>0...12V (24V out of range possible)<br>differential signal with FR_0V_CH1  |
| SIGN_CH2           | signal ramp of measuring chamber 2<br>EZ22:7-EZ150X1:A7-<br>0...12V (24V out of range possible)<br>differential signal with RF_0V_CH2  |
| SIGN_CH3           | signal ramp of measuring chamber 3<br>EZ31:7-EZ150X1:C13-<br>0...12V (24V out of range possible)<br>differential signal with RF_0V_CH3 |
| SIGN_CH4           | signal ramp of measuring chamber 4<br>EZ32:7-EZ150X1:A13-<br>0...12V (24V out of range possible)<br>differential signal with RF_0V_CH4 |
| SIGN_CH5           | signal ramp of measuring chamber 5<br>EZ41:7-EZ150X1:C19-<br>0...12V (24V out of range possible)<br>differential signal with RF_0V_CH5 |
| SL_CO_1            | select correction 1 (thickness)<br>EWA100X1:A32-EWAX24:8-  |
| SL_CO_2            | select correction 2 (thickness)<br>EWA100X1:C32-EWAX24:9-  |
| SL_PG_1            | select ext APRT program 1<br>EWA100X1:A28-EWAX23:1-  |
| SL_PG_2            | select ext APRT program 2<br>EWA100X1:C28-EWAX23:2-  |
| SL_PG_3            | select ext APRT program 3<br>EWA100X1:A29-EWAX23:3-  |

|            |  |
|------------|--|
| SL_PG_4    | select ext APRT program 4<br>EWA100X1:C29-EWAX23:4-  |
| SL_PG_5    | select ext APRT program 5<br>EWA100X1:A30-EWAX23:5-  |
| SL_PG_6    | select ext APRT program 6<br>EWA100X1:C30-EWAX23:6-  |
| SL_PG_7    | select ext APRT program 7<br>EWA100X1:A31-EWAX23:7-  |
| SL_PG_8    | select ext APRT program 8<br>EWA100X1:C31-EWAX23:8-  |
| SL_TO_TM_1 | select tomo time 1<br>EWAX21:1-EWA100X1:A24-   |
| SL_TO_TM_2 | select tomo time 2<br>EWAX21:2-EWA100X1:C24-   |
| SL_TO_TM_3 | select tomo time 3<br>EWAX21:3-EWA100X1:A25-   |
| SL_TO_TM_4 | select tomo time 4<br>EWAX21:4-EWA100X1:C25-   |
| SL_TO_TM_5 | select tomo time 5<br>EWAX21:5-EWA100X1:A26-   |
| SL_TO_TM_6 | select tomo time 6<br>EWAX21:6-EWA100X1:C26-   |
| SL_TO_TM_7 | select tomo time 7<br>EWAX21:7-EWA100X1:A27-   |
| SL_TO_TM_8 | select tomo time 8<br>EWAX21:8-EWA100X1:C27-   |
| SL_XG_TO   | select X-ray generator for tomography<br>EWAX11:3-EWAX12:3-EWA100X1:C18-   |
| STOP_X_C/  | stop X-ray command, X-ray off from FU<br>EZ119X2:A7-EZ130X2:A7-EZ150X2:A7-EZX52:4-EZ139X2:A7-<br>0V/5V<br>measuring point EZX75<br>inactivates CTRL_X_C/<br>EXOF exposure off command<br>part of: XS/XRG bus |
| STU        | stator line U<br>EYAX2:2(low speed)-EY100X6:2/EY100X46:2(high speed)-EWGK11/K12:1<br>part of: low/high speed rotor control   |

|             |  |
|-------------|--|
| STV         | <p>stator line V = common<br/> EYAX2:3(low speed)-EY100X6:3/EY100X47:1(high speed)-EWGK11/K12:3<br/> part of: low/high speed rotor control</p> |
| STW         | <p>stator line W<br/> EYAX2:4(low speed)-EY100X6:4/EY100X47:2(high speed)-EWGK11/K12:5<br/> part of: low/high speed rotor control</p>          |
| SW_BU_1     | <p>switch bucky<br/> EWAX11:10-EWA100C1:C19-<br/> part of: bucky ready contact</p>   |
| SW_BU_2     | <p>switch bucky 2 (EWA or EWB) or 4 (EWB)<br/> EWAX12:10-EWA100X1:A21- -EWB100X1:A21-EWBX12:10-<br/> part of: bucky ready contact</p>          |
| SW_SF_CF_1  | <p>switch side field to central field bucky measuring chamber<br/> EWAX11:1-EWA100X1:A18-</p>  |
| SW_SF_CF_2  | <p>switch side field to central field bucky measuring chamber 2 (EWA or EWB) or 4 (EWB)<br/> EWAX12:1-EWA100X1:A20-</p>                        |
| SW_TO_1     | <p>switch tomography 1<br/> EWAX11:5-EWA100X1:A19-<br/> part of: tomo ready contact</p>  |
| SW_TO_2     | <p>switch tomography 2<br/> EWAX12:5-EWA100X1:C20-<br/> part of: tomo ready contact</p>  |
| SW_UN_EX    | <p>radiation indication<br/> EZ150X1:A29-EZX1:4-</p>   |
| TB_2/       | <p>tube 2 selected<br/> EZ130X1:A13-EZX11:2-EWGX11:2<br/> 0V/15V, low active</p>   |
| TB_2_RT     | <p>tube 2 selection check<br/> EWGX11:3-EZX11:3-EZ130X1:A10<br/> 0V/5V, low active</p>   |
| TB_3/       | <p>tube 3 selected<br/> EZ130X1:C13-EZX11:5-EWGX11:5-EWGX12:2<br/> 0V/15V, low active</p>  |
| TB_3_RT     | <p>tube 3 selection check<br/> E2WGX11:3-E1WGX12:3-E1WGX11:6-EZX11:6-EZ130X1:C10-<br/> 0V/5V, low active</p>                                   |
| TB_CU_FR_NG | <p>tube current frequency negative<br/> EG100X14:14-EZX35:14-EZ119X1:BZ32-<br/> -15V against ground</p>  |

|             |   |
|-------------|---|
| TB_CU_FR_PO | tube current frequency positive<br>EG100X16:6-EZX35:6-EZ119X1:BZ30-<br>15V against ground, frequency: 1 kHz $\approx$ 2 mA, 0...1500mA 500kHz/A |
| TH_OL       | tube housing overload<br>EZX3:6-EZ130X1:A12- (generator basis 4512 104 70202/70601 only)<br>EZX3:3-EZ130X1:A12-<br>0...5V                       |
| TH_OL_SW/   | tube housing overload switch<br>EZX3:3-EZ130X1:A11- (generator basis 4512 104 70202/70601 only)<br>EZX3:6-EZ130X1:A11-<br>0V/26V, low active    |
| TO_MO_PG    | tomo mode programmed<br>EWA100X1:A17-EWAX22:9-  |
| TO_PG_1     | tomo program 1<br>EWA100X1:A13-EWAX22:1-  |
| TO_PG_2     | tomo program 2<br>EWA100X1:C13-EWAX22:2-  |
| TO_PG_3     | tomo program 3<br>EWA100X1:A14-EWAX22:3-  |
| TO_PG_4     | tomo program 4<br>EWA100X1:C14-EWAX22:4-  |
| TO_PG_5     | tomo program 5<br>EWA100X1:A15-EWAX22:5-  |
| TO_PG_6     | tomo program 6<br>EWA100X1:C15-EWAX22:6-  |
| TO_PG_7     | tomo program 7<br>EWA100X1:A16-EWAX22:7-  |
| TO_PG_8     | tomo program 8<br>EWA100X1:C16-EWAX22:8-  |
| TO_PG_SL    | tomo program selected<br>EWA100X1:C17-EWAX22:10-  |
| TP_HT_GND   | temperature high tension tank ground<br>EZ130X1:A19-EZX35:12-EG100X14:4-  |
| TP_HT_SG    | temperature signal high tension tank<br>EG100X14:12-EZX35:4-EZ130X1:C19-<br>0...5V<br>+25 _C(12k $\Omega$ )...+100 _C(950 $\Omega$ )            |



|                  |  |
|------------------|--|
| V15C<br>S_CAN_PO | system CAN supply<br>EZ42:9-EZ43:9-EZ44:4-EZ139X1:A17-<br>Vcan<br>part of: system CAN  |
| V15S<br>PO_V     | signal bus supply<br>EZ23:13/25-EZ44:5-EZ45:7-EWAX51/52:7-<br>EWA100X2:AC27-EZ139X1:AC6-<br>Vsgn<br>part of: signal bus  |
| X_ACT/           | signal bus X-ray active<br>EZ139X1:A5-EZ23:5-EZ45:6-EWAX51/52:6-EWA100X2:C24-<br>driven by CU, X_ACT_S/ status dependent, old: EXON signal<br>measuring point: EZX86<br>part of: signal bus<br>0V/15V  |
| X_ACT_S/         | X-Ray active signal, kV > 75% nominal value or "fluoroscopy technique" high tension on<br>EZ119X2:A8-EZ130X2:A8-EZ139X2:A8-EZ150X2:A8-EZX52:5-<br>0V/5V<br>measuring point EZX77<br>HTON (high tension on) or FLON (fluoroscopy high tension on) signal<br>part of: XS/XRG bus, controls X_ACT/ status |
| XG_RD_EX_1       | X-ray generator ready for exposure request<br>EWA100X1:C3-EWAX1:2-   |
| XG_RD_EX_2       | X-ray generator ready for exposure request<br>EWA100X1:A6-EWAX2:2-   |
| XG_RD_EX_3       | X-ray generator ready for exposure request<br>EWA100X1:A8-EWAX3:2-   |
| XG_RD_EX_4       | X-ray generator ready for exposure request<br>EWA100X1:A10-EWAX4:2-  |

### 13. OPTIMUS AEC switch-off philosophy

The philosophy behind the switch-off behaviour in the Optimus Release 2.1 + 3 is the following (additional explanation to the graphics 3Z-20):

Every APR using the AEC technique as the preferred technique must have mAs, mA-s or mAs-s parameters in the background. These should almost match the typical organ related dose to the selected film-screen-combination. It is said that a film which got at least 40% of the desired density can be used for diagnosis.

If now the AEC exposure is started two supervisions are active with the aim of not giving unnecessary dose (or you simply get a proper AEC exposure):

- 1) The organ dependent background mAs value is multiplied with 10. If the exposure is not finished at  $10 \cdot \text{mAs}_{\text{backup}}$  the generator will stop. One must expect that something went wrong if the exposure exceeded 10 times the typical mAs value. This exposure has not been cut off by the supervision 2.
- 2) With the  $10 \cdot \text{mAs}_{\text{backup}}$  a kV and filament load dependent backup **time** is calculated by DRC (dose rate control). At 10% of this time value DRC checks if at least 4% of the desired dose has been detected by the measuring chamber. If the 4% limit will not be increased, the exposure will be switched off. The minimum of 40% density can not be obtained during the remaining backup time.

This 4% dose detection is automatically off, if the film-screen-combination is too sensitive (>400 speed systems). The 4% value will be too small to be reliable for a measurement.

With overriding the supervision will be switched off. Explanation see documentation.

How to test the limits of 600 mAs or 4000ms in AEC technique Release 2.1 Optimus:

One has to bypass the 4% detection and the background mAs value must be high enough to reach 600 mAs.

The 4% detection can be switched off with modifying the value Dose of FSC [ $\mu\text{Gy}$ ]:

- S Type in a value of 1 (which is equal to a 1000 speed system) in the Dose of FSC data field of any of the programmed film screen combinations.
- S Now select any APR and increase the background mAs value to 100 mAs.
- S Close the collimator or cover the chamber with led.

The AEC exposure will stop at a value which is always below 600 mAs, a typical limit is 588 mAs.

With the modified parameters the 4000 ms test can be carried out.

- S Select the modified APR on the control desk and go to Select APR and Change APR with the PC.
- S Reduce the le max factor: to 5% and transmit the APR screen.
- S Select the APR button again, the modified data are active now.
- S Select the small focal spot.
- S Switch an AEC exposure. It should last 4000 ms.
- S Change all modifications back to normal.

The supervision can be switched on or off, programming path:

XRGSCOPE - Optimus (XRG90) - Programming - Dose Rate Control - AMPLIMAT - Fault Exposure Detection - AEC or TDC - on/off.

Explanation see documentation.

Precalculation tables of the exposure which is actually displayed on the control desk can be seen on the PC under:

XRGSCOPE - Optimus (XRG90) - Faultfind - X-Ray Log - Dose Rate Control Logging - etc.

Explanation see documentation.

## 14. Explanation for table 3Z-22: AEC fault exposure detection strategy

The major intention having a fault exposure detection is to prevent from unnecessary radiation for the patient in case of a malfunction of the installation or a mistake in the use of the X-ray equipment.

### List of terms:

|         |   |  |
|---------|---|--|
| AEC     | = | Automatic Exposure Control   |
| APR100  | = | APR program with a less sensible film screen combination of 100 speed, originally parameters as programmed         |
| APR100* | = | same as APR100, but parameter(s) modified on the control desk (overriding)   |
| APR800  | = | APR program with a very sensible film screen combination of 800 speed, originally parameters as programmed         |
| APR800* | = | same as APR800, but parameter(s) modified on the control desk (overriding)   |
| 600mAs  | = | is the programmed mAs limit for AEC exposures (can be changed, should comply with the local regulations)           |
| 4000ms  | = | is the max time limit of AEC exposures (cannot be changed)   |
| 1       | = | point of the mAs dependent APR backup time, which is calculated from the 10 x (typical) organ mAs value of the APR |
| 2       | = | max mAs limit for AEC exposures (can be changed)   |
| 3       | = | max exposure time limit of 4000ms (cannot be changed)  |
| 4       | = | 10% (of the APR backup) time point   |
| 5       | = | 10% backup time point of the max exposure time limit (4000ms) = always 400ms                                       |

To explain the difference in switching the fault exposure detection **on** or **off** a very sensible (800 speed system) and a less sensible (100 speed system) film screen combination have been chosen.

### AEC fault exposure detection = ON

The factors determining whether the 4% dose value at 10% of the APR backup time will be checked are

- the 10% backup time value > 10ms
- the expected 4% density voltage value > 20mV.

In case of APR100 the check could be done, because the density voltage values are high enough.

The density voltage at 10% of the backup time would be too small to be measured for APR800, therefore the exposure will be continued up to the 10 x APR mAs value. The exposure will finally be terminated at 600mAs, if the APR mAs value is  $\geq 60$ mAs.

With APR100\* the exposure will be terminated at 10% of the max backup time, which is 4000ms for all AEC exposures after overriding of any APR parameters. (The 600 mAs limit will not switch off the exposure, 1500 mA emission current is not available).

With APR800\* the exposure will be terminated either at 600mAs or 4000ms, depending on which of the limits will be reached first.

### AEC fault exposure detection = OFF

APR100 and APR800 exposures have the same termination point at 10 x APR mAs. The exposure will finally be terminated at 600mAs, if the APR mAs value is  $\geq 60$ mAs.

APR100\* and APR800\* exposures will be terminated either at 600mAs or at 4000ms, depending on which of the limits will be reached first.

## 15. Explanations on programming the generator

### 15.1. OPTIMUS \ Program \ Dose Rate Control \ CONT:

**- scantime\_TV [ms]:** [ 20.000]:

20 ms = default. 20 ms must be programmed for all TV chains with a scantime  $\leq$  20 ms.

In case a TV chain has a longer scantime, program the actual scantime value:

scantime\_TV [ms]: [ 20.000] for scantime of TV chain  $\leq$  20 ms

scantime\_TV [ms]: [ xx.xxx] for scantime of TV chain = xx.xxx ms  $>$  20 ms

**- scantime\_TV valid:** Yes (default)

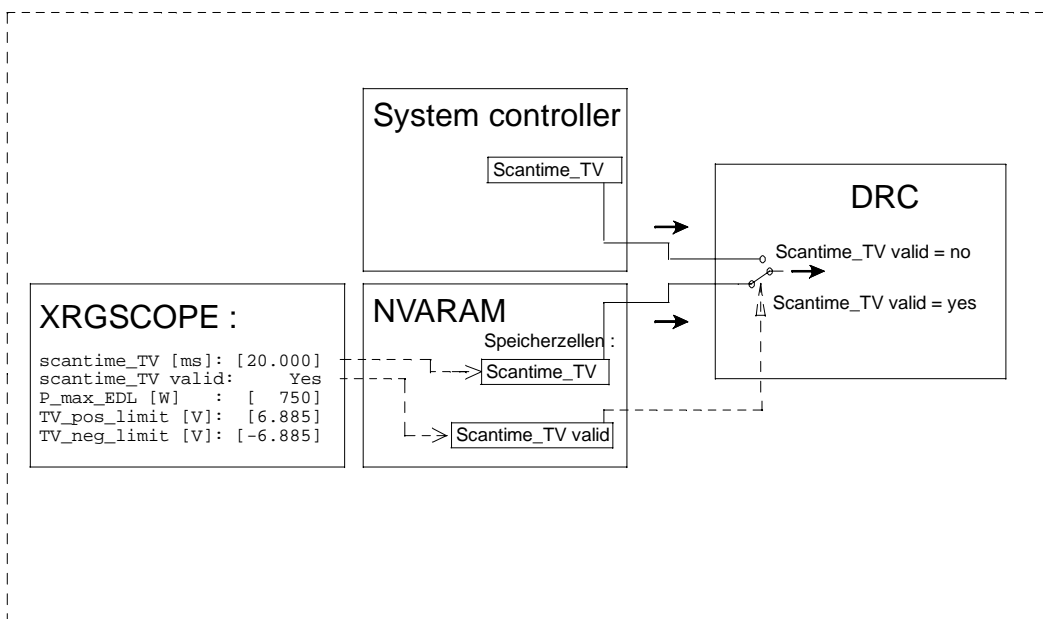
With Yes the programmed variable "scantime\_TV [ms]" is used for the control in functional unit dose-rate control (DRC).

At the moment only this value is possible.

With No the programmed variable "scantime\_TV [ms]" is **not** used for the control in functional unit dose-rate control (DRC). The variable is delivered by the system controller.

This version is a future option. At the moment it is not possible.

Also see the sketch explaining this program settings:



## 16. Printed-circuit boards

### 16.1. Low-voltage power supply / EZ 102

Also see Z1-2.3 "Low-voltage power supply".

LEDs H2 through H5 indicate whether the supply voltages are present.

The low-voltage power supplies of PCB EZ 102 are short circuit proof. Therefore it is most likely that in case one of the LEDs grows dark one of the external consumers and not the PCB itself is the cause of the error.

It is recommended that one after the other all consumers be disconnected from the respective power supply until the LED is illuminated again.

The last consumer that was removed has probably caused the short-circuit.