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| SRON<br>**HIFI** | TEST-EQUIPMENT INTERFACE URD | **Doc. no.** : **SRON-U/HIFI/SP/2001-009**<br>**Issue** : **1.0 (=Draft 4.0)**<br>**Date** : **Dec 17, 2001**<br>**Category** :<br>**Page** : **1 of 23** |

**Title** **Test-equipment interface URD**

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**Contents**

**1 SCOPE OF WORK ..... 3**

**2 DOCUMENT REFERENCES ..... 3**

**2.1 Applicable Documents ..... 3**
**2.2 Reference Documents ..... 3**

**3 REQUIREMENTS ..... 4**

**3.1 Interface with the Router ..... 4**
**3.2 TC interface with the EGSE ..... 5**
**3.3 Telecommand verification ..... 5**
**3.4 Observation Identifier and Building Block Identifier ..... 5**
**3.5 Connection test ..... 6**
**3.6 Time synchronization ..... 6**
**3.7 TM Interface with the EGSE ..... 6**

**4 TEI SPECIFIC REQUIREMENTS ..... 7**

**4.1 TEI-PDU ..... 8**
*4.1.1 Monitor function ..... 8*
*4.1.2 Command interface ..... 8*
*4.1.3 Startup ..... 9*
**4.2 TEI-FPU ..... 10**
*4.2.1 Monitor function ..... 10*
*4.2.2 Heat switches ..... 12*
*4.2.3 Anomalies ..... 12*
*4.2.4 Shutter function ..... 12*
*4.2.5 Startup ..... 13*
**4.3 TEI-LOU ..... 14**
**4.4 TEI-LSU ..... 15**
*4.4.1 Monitoring ..... 15*
*4.4.2 Command Interface ..... 16*
*4.4.3 Interface to LSU ..... 17*
*4.4.4 Startup ..... 17*
**4.5 TEI-scanner ..... 18**
*4.5.1 Interface to scanner ..... 18*
*4.5.2 Telecommands and Telemetry ..... 18*
*4.5.3 Startup: ..... 19*
**4.6 TEI-VNA ..... 20**
*4.6.1 Interface to VNA ..... 20*
*4.6.2 Telecommands and Telemetry ..... 20*
*4.6.3 Startup ..... 20*
**4.7 TEI-SRC ..... 21**
*4.7.1 Interface to equipment ..... 21*
*4.7.2 Manual settings report ..... 22*
**4.8 TEI-PDU ..... 23**

## 1 SCOPE OF WORK

The purpose of the this document is to specify the user-requirements of the Test-equipment interface.

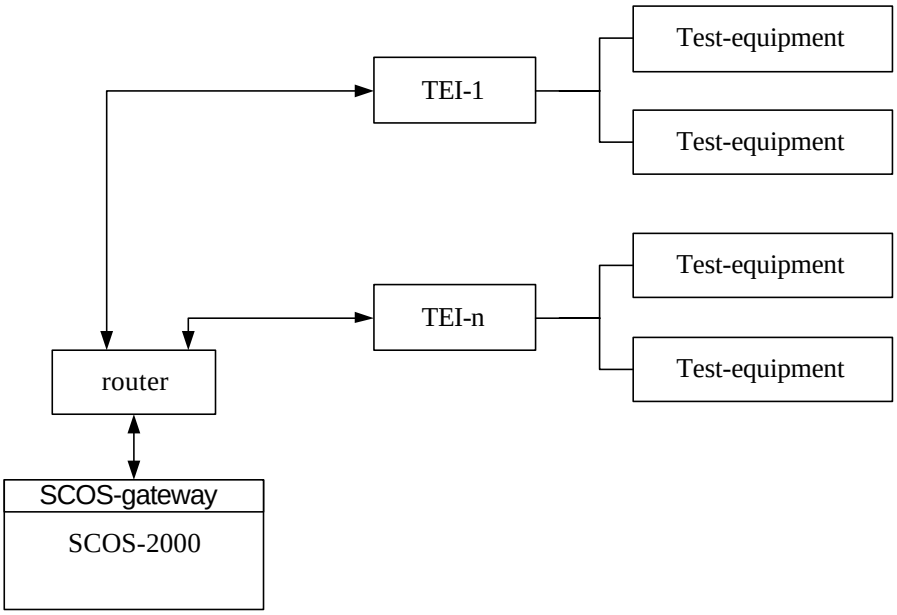



Figure 1 TEI applications connected to SCOS-2000

## 2 DOCUMENT REFERENCES

### 2.1 Applicable Documents

AD 1. Packet Structure ICD SCI-PT-ICD-7527 issue 2.0 Draft 2
AD 2. Herschel EGSE packet router ICD
AD 3. Test-equipment Interface SOW SRON-U/HIFI/SP/2001-008
AD 4. TEI TM/TC packet ICD SRON-U/HIFI/SP/2001-011

### 2.2 Reference Documents

RD 1. Herschel Router SOW SRON-U/HIFI/SP/2000-005

# 3 REQUIREMENTS

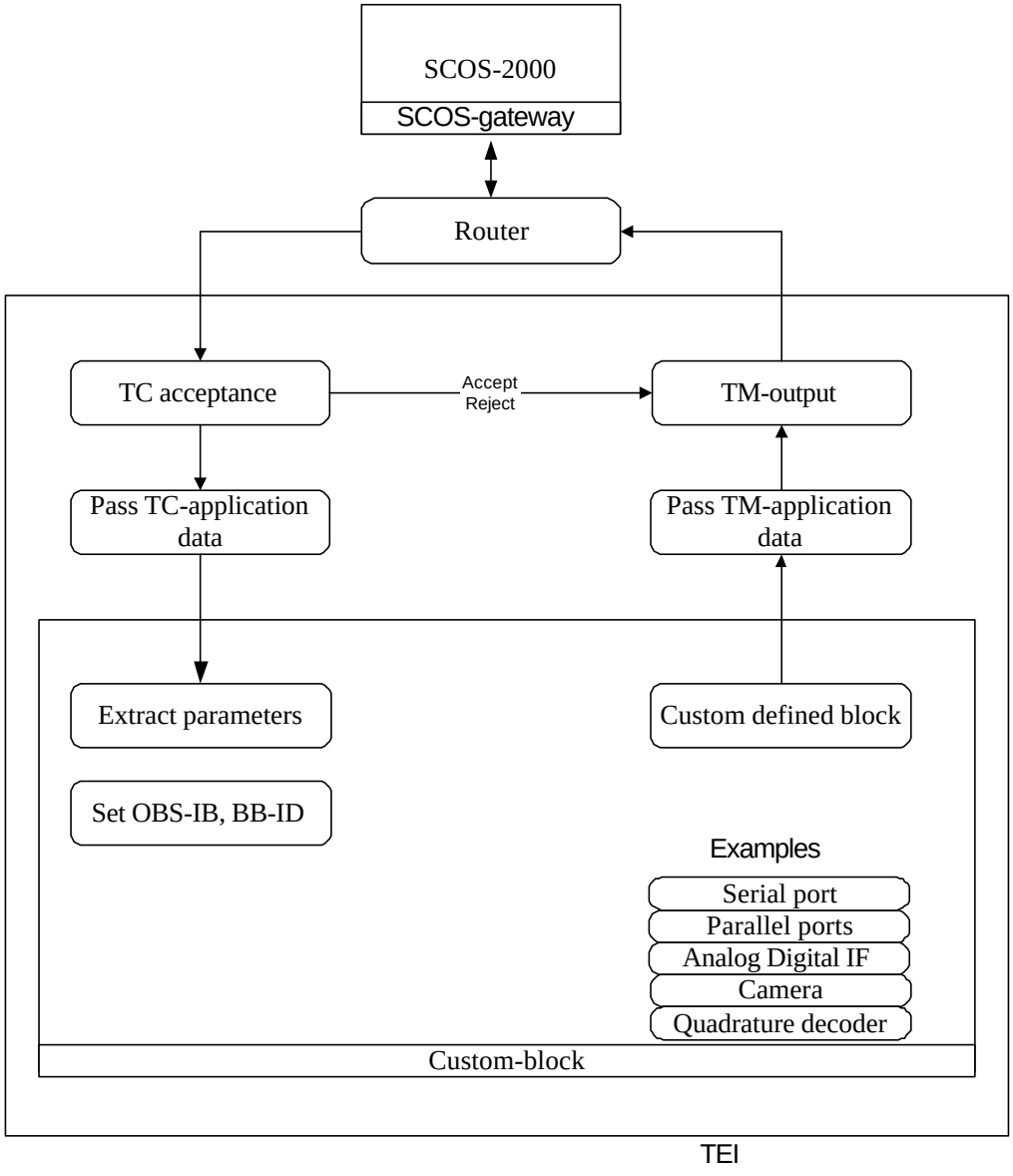



Figure 2 Overview of TEI software building blocks

## 3.1 Interface with the Router

Req 3.1.-1 The application shall exchange messages with the Router.
The communication protocol is described in AD 2.

Req 3.1.-2 Upon startup the application shall connect to the Router

Req 3.1.-3 The application shall register its name to the Router

Req 3.1.-4 The application shall only ask for the Packets with its own APID.

Req 3.1.-5 The application shall try to reconnect when the connection with the Router gets lost. The attempt to reconnect shall repeat until success.

Req 3.1.-6 The application shall receive messages from the Router
Req 3.1.-7 The application shall send messages to the Router.

### 3.2 TC interface with the EGSE

Req 3.2.-1 The application shall interpret USER_DATA (i.e. Herschel EGSE router messages of type=1) as TC-packets as per AD 1.

### 3.3 Telecommand verification

Req 3.1.-1 Upon receipt of a TC the application shall issue an acceptance report immediately.

Req 3.1.-2 The telecommand acceptance reports (both succes and failure) shall contain the telecommand ID and the packet sequence control field of the corresponding telecommand

Req 3.1.-3 A failure report shall be issued in the following cases:
- Illegal APID
- incomplete or invalid packet length
- incorrect checksum
- illegal packet type
- illegal packet subtype
- illegal or inconsistent application data

Notice:
- An APID is illegal when it is different form the unique APID that belongs to the TEI-unit
- A Type is illegal when the APID is legal and no telecommand of this type is known by the specified application
- A Subtype is illegal when the type is legal and no telecommand of this (type, subtype) is known by the specified application
- The length is invalid when **??**

Req 3.1.-4 The failure report shall contain an error code as shown in the table:

Table Error codes used in Acceptance report - Failure

| error code | Description |
|---|---|
| 0 | Illegal APID |
| 1 | incomplete or invalid packet length |
| 2 | incorrect checksum |
| 3 | illegal packet type |
| 4 | illegal packet subtype |
| 5 | illegal or inconsistent application data |
| 16-255 | Application specific error codes |

Notice: It is not foreseen that the TC-acceptor passes the ACK-field to the application. This implies that requests for start-execution reports, progress reports and completion reports can not be accomodated.

### 3.4 Observation Identifier and Building Block Identifier

Req 3.4.- 1 The Application shall maintain to Identifiers: Observation-ID and Building Block ID.
Req 3.4.- 2 The Application shall accept a telecommand that sets both Identifiers
Req 3.4.- 3 The Application shall accept telecommands that include the Building Block ID in the parameter field. Upon receipt of such a telecommand the Building Block ID shall be set accordingly.

Notice:

The Observation Identifier is a 32-bits field.
The BB-ID is a 32-bits field and can be split into three sub-fields:

| BB-ID | | |
|---|---|---|
| Instrument | BB-type | BB execution counter |
| HIFI=00(2 bits) | (14 bits) | (16 bits) |

Req 3.4.- 4 Unpon startup the OBS-ID, BB-type and BB execution counter shall be set to 0.

### 3.5 Connection test

Req 3.5- 1 The application shall accept a “perform connection test” telecommand

The purpose of this packet is to perform a connection test. Upon receipt of this command a Link Connection Report shall be issued.

### 3.6 Time synchronization

Req. 3.6-1 The TEIs shall be synchronized with each other with NTP

Req. 3.6-2 By default, the TM-generator shall use this time in the TM data field header.

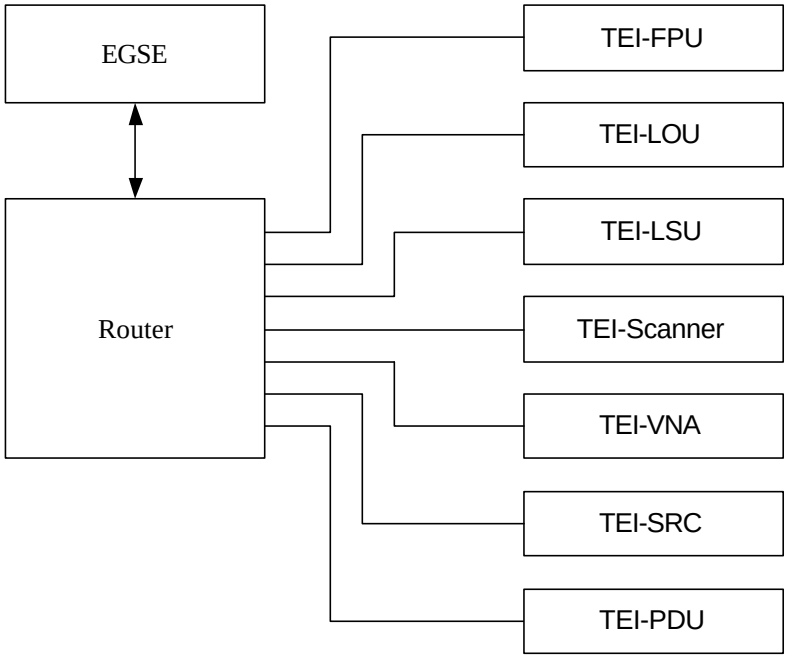
### 3.7 TM Interface with the EGSE

Req 3.7.- 1 The application shall generate TM-packets and send them in USER_DATA (i.e. Herschel EGSE router messages of type=1) to the Router
Req 3.7.- 2 The application shall include one unique APID in the TM-packet-header
Req 3.7.- 3 The application shall maintain a packet sequence counter. Upon startup the packet sequence counter starts at 0
Req 3.7.- 4 The application shall include a time field in the TM-packet-header.
Req 3.7.- 5 The application shall append a checksum field.
Req 3.7.- 6 Two fields of the application data field shall be used for the Observation Identifier and the Building block Identifier.

### 3.8 Error handling

Errors occuring in the TEI SW shall be reported using event-reports. The content of these reports is TBD

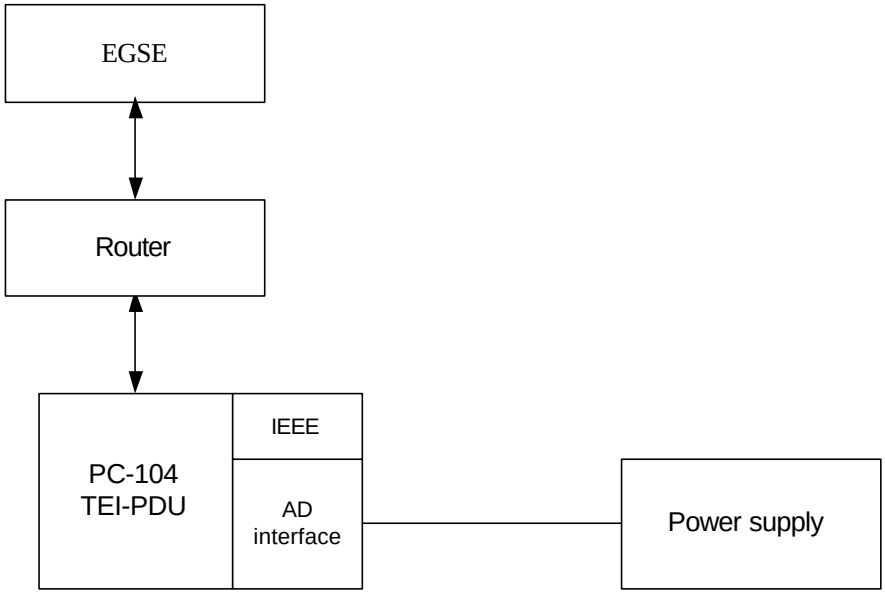
## 4 TEI SPECIFIC REQUIREMENTS




TEI-Overview

### 4.1 TEI-PDU

The TEI-PDU controls the power-distribution unit (PDU) for the HIFI subsystems.




TEI-PDU

The PDU is the power distribution unit for the HIFI-units. It supplies powerlines to the following units:

- LSU
- HRS-V
- HRS-H
- WBS-H
- WBS-V
- LCU

The voltage and the current supplied can be measured with the Analog interface card.

#### *4.1.1 Monitor function*

Req. 4.1.1.1 The TEI-PDU shall have an monitor function

Req. 4.1.1.2 The function shall monitor the voltage, and current supllied on each output line

Req. 4.1.1.3 The TEI-PDU shall generate an HK-packet each second

Req. 4.1.1.4 This HK packet shall contain:

- The status of the switches
- The measured values

#### *4.1.2 Command interface*

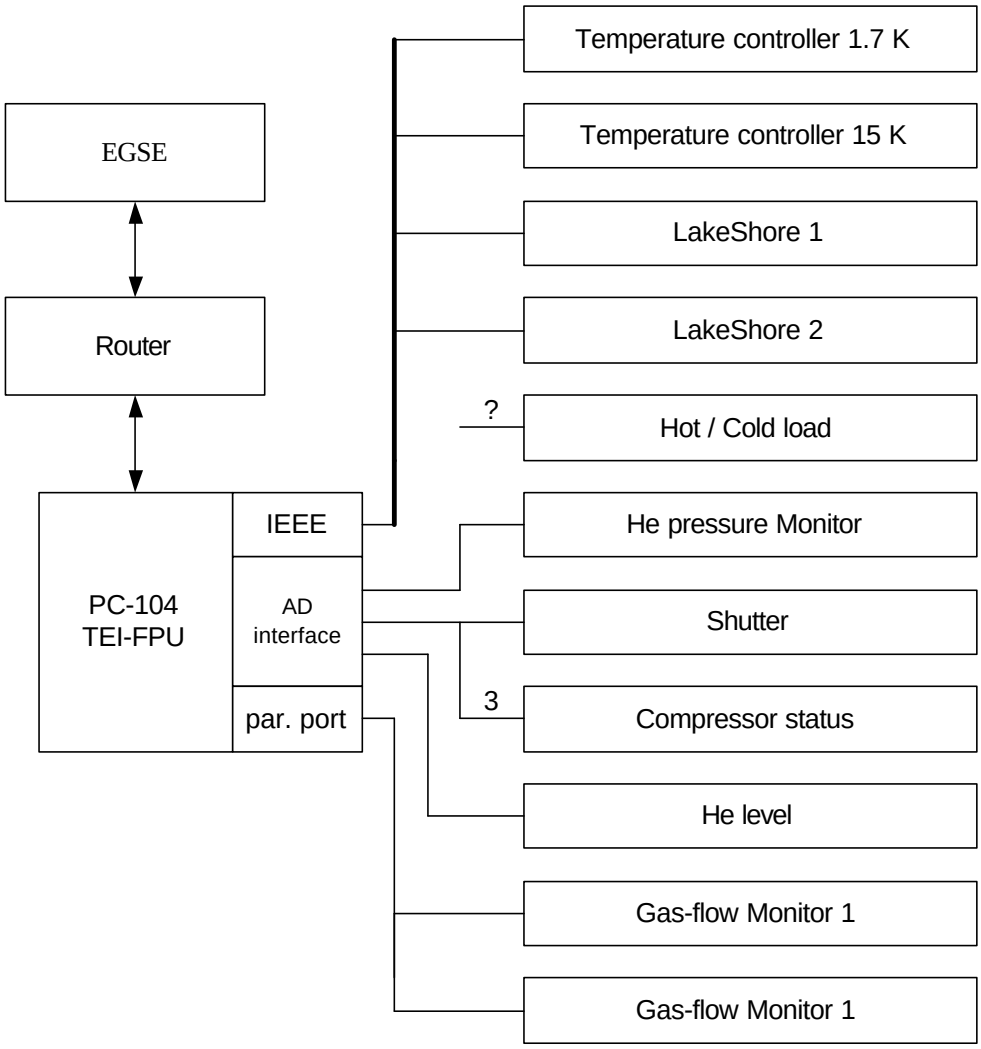
Req. 4.1.2.1 The TEI-PDU shall have a function to switch one power-line on.
Req. 4.1.2.2 The TEI-PDU shall have a function to switch one power-line off.
Req. 4.1.2.3 A parameter of these functions shall indicate which line to switch.

### *4.1.3 Startup*

Req. 4.1.3.1 The TEI-PDU shall configure the connected equipment at startup
Req. 4.1.3.2 The TEI-PDU shall start the monitor function at startup

### 4.2 TEI-FPU

The TEI-FPU is the interface to the equipment for the Focal Plane Unit (FPU) cryostat.




TEI-FPU

**Overview of connected equipment**:

1. Temperature controller 1.7 K
   - Type: Cryovac TIC304MA
   - Interface: IEEE-488
   - Commands: on/off
     set temperature
   - Readout: read temperature

2. Temperature controller 15 K
   - Type: Cryovac TIC304MA
   - Interface: IEEE-488
   - Commands: on/off
     set temperature
   - Readout: read temperature

3. A LakeShore temperature unit #1
   - Type: Lakeshore 218S
   - Interface: IEEE-488
   - Commands: None
   - Readout: Read 8 temperatures in K

4. A LakeShore temperature unit #2
   - Type: Lakeshore 218S
   - Interface: IEEE-488
   - Commands: None
   - Readout: Read 8 temperatures in K

5. He Pressure Monitor
   - Type: To be specified
   - Interface: 0-10V analog / A/D converter card, channel ?
   - Commands: None
   - Readout: Read pressure

6. He Level Monitor
   - Type: American Magnetics 135/136
   - Interface: 0-10V analog / A/D converter card, channel 1
   - Commands: None
   - Readout: Read level

7. Hot/Cold load
   - Type: temp sensors + temp controller
   - Interface: To be specified
   - Commands: set temperatures
   - Readout: Read temperatures

8. Shutter
   - Type: MicroKinetics DM4050 motor drive, two limit switch contacts
   - Interface: 2 bits digital output step/direction -> AD converter DO-0 DO-1
     2 bits digital motor drive status -> AD converter DI-0 DI-1
     2 bits limit switch readout -> AD converter DI-2 DI-3

9. Input from compressor
   Type NA
   Interface 3 status switch contacts readout -> AD converter DI-4 DI-5 DI-6
   Command None
   Readout Poll at < 100 ms. Generate event packet with time of change

10. Gas flow monitor 1 and 2
    Type: To be specified
    Interface: switch contact each 1 pulse/liter -> parallel port port pin 1/18 cq 14/18 Maximum puls rate 1/s, pulse duty cycle 0.2 – 0.8, level transition < 50 ms
    Voorstel uitlezing: poll, interval 50-100 ms
    Gebruik printer control lines -> noodzaak voor pull-up weerstand vervalt

### *4.2.1 Monitor function*

Req. 4.2.1.1 The TEI-FPU shall have a monitor function.

Req. 4.2.1.2 This function shall monitor the temperature of both temperature controllers, the temperatures of the LakeShore units, the He-pressure, the He-level, the current through both heat-switches.

Req. 4.2.1.3 The TEI-FPU shall generate a HK-packet each second

Req. 4.2.1.4 This HK-packet shall contain:
- The status of both temperature controllers (active/standby and setpoint)
- All monitored values
- The status of the shutter (open/close/wobble)

### *4.2.2 Heat switches (deleted)*

~~The Cryostate is equipped with two heat switches. These are manually operated.~~
~~The current is monitored by an analog monitor.~~

~~Req. 4.2.2.1 Both values shall appear in the HK-packet~~

### *4.2.3 Anomalies*

Req. 4.2.3.1 The TEI-FPU shall monitor three digital inputs. These will be low (TBC) in nominal state. When one or more inputs change this shall be reported in an event report. The status shall also be reported in the HK-packet.

### *4.2.4 Shutter function*

The Cryostate is equipped with a shutter, controlled by a stepper-motor. The shutter can be open, closed. When closed there is an option to keep the shutter wobbling in order to cancel emissive effects.
The shutter is controlled by two bits: step & direction
The shutter has two limit switches: two bits.
The shutter is equipped with a temperature sensor, connected to a LakeShore Unit.
The shutter is equipped with a heater which is operated manually.

Req. 4.2.4.1 The TEI-FPU shall accept commands to change the status of the shutter:
(1= open, 2= closed, 3= wobbling)

Req. 4.2.4.2 Upon receipt of the open-command the TEI-FPU shall control the door to the open-position in TBD ms

Req. 4.2.4.3 Upon receipt of the close-command the TEI-FPU shall control the door to closed-position in TBD ms

Req. 4.2.4.4 Upon receipt of the wobble-command the TEI-FPU shall control the door according to a sine-wave with frequency 1 s in TBD steps between position TBD to position TBD

Req. 4.2.4.5 The TEI-FPU shall control each step of the stepper moter

Exclusions:
The positions of the wobble open and closed shall be fixed and not commandable
The positions of the shutter are not in the Housekeeping, The HK only contains the status.

### *4.2.5 Startup*

Req. 4.2.5.1 The TEI-FPU shall configure the connected equipment at startup.

Req. 4.2.5.2 The TEI-FPU shall start the monitor-function at startup

Req. 4.2.5.3 The TEI-FPU shall command the temperature-controllers to stand-by at startup

Req. 4.2.5.4 The TEI-FPU shall close the shutter at startup

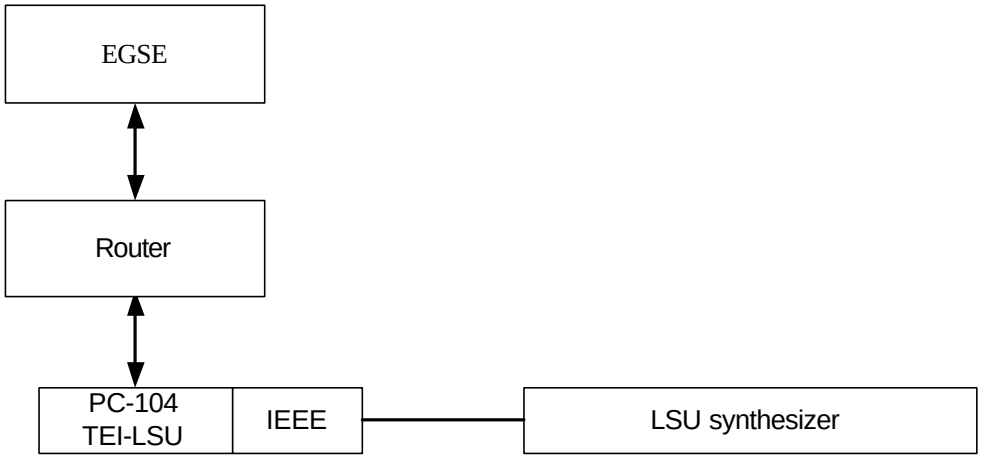
### 4.3 TEI-LOU

The TEI-FPU is the interface to the equipment for the Local Oscillator Unit (LOU) cryostat
The cryostate of the LOU contains a subset of elements as the one for the FPU
The TEI-FPU is connected to:

1. A LakeShore temperature control unit
   Connected with IEEE interface
2. He Pressure Monitor
   ? (To be specified by WL)
3. Input from compressor
   This is a digital line for anomaly monitoring

### 4.4 TEI-LSU

The TEI-FPU is the interface to the equipment that replaces the Local Oscillator Source Unit (LSU)




TEI-LSU

It is hazardous to increase the power with large steps, to switch the synthesizer on when to power level is high and to change the frequency when the synthesizer is on.
To prevent handling errors some pre-execution checks will be performed by SCOS-2000.

When the synthesizer is switched on it returns in the same state as before it was switched off.

A nominal switch-on procedure is as follows:
- The power should be "low" and the power must be "off".
- If the status is undefined: do nothing
- If the power is not below a TBD level the power must not be switched on.
- If the power is already on: do nothing.

Continuing from the low-power and off mode:
- Switch power on
- increase the power-level 0.1 dBm. Maintain the "current set-value"
- wait for an HK-packet that contains the new set-value and the new power level
- repeat last two steps until the desired level has been reached

A nominal switch-off procedure is as follows:
- decrease the power-level 0.1 dBm. Maintain the "current set-value"
- Repeat this step until the setvalue is at TBD level.
- Switch power off.

The TEI-LSU is connected to a synthesizer through an IEEE interface.

#### *4.4.1 Monitoring*

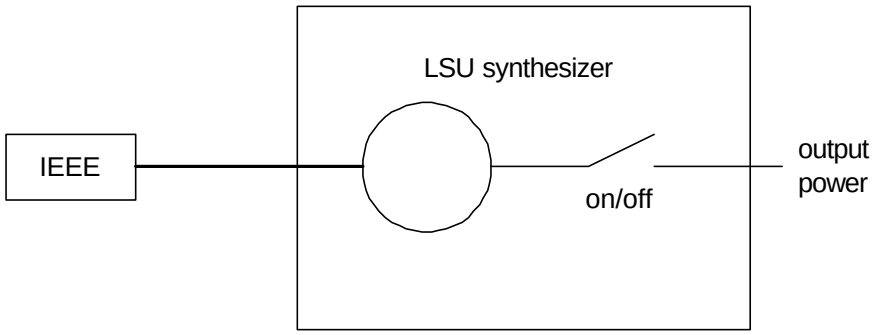
Req. 4.4.1.1 The power-status is on or off. As long as the first measurement has not been taken, the status shall be undefined.

Req. 4.4.1.2 The TEI-LSU shall generate house-keeping packets containing:

- set values for status, power, frequency
- measured values

Req. 4.4.1.3 The HK-packets shall be generated every 10 s. This period will be shorter after a command that changes the power-level.

### *4.4.2 Command Interface*




Req. 4.4.2.1 The TEI-LSU shall receive Telecommands to switch power on/off

Req. 4.4.2.2 The TEI-LSU shall receive Telecommands to set the frequency

This command will only be released by SCOS-2000 when the power is off.

Req. 4.4.2.3 The TEI-LSU shall receive Telecommands to increase the power with 0.1 dBm

This command shall be checked by SCOS-2000

The following activities shall take place upon receipt of the increase power level command:
1. Send a packet with LSU power = unknown
2. Increase the SET-power with 0.1 dBm
3. Send the set-power command to the synthesizer
4. Wait delay (to be specified)
5. Trigger the Monitoring function to make a new measurement and generate a HK-packet.

Req. 4.4.2.4 The TEI-LSU shall receive Telecommands to decrease the power with 0.1 dBm

The following activities shall take place upon receipt of the decrease power level command:
1. Decrease the SET-power with 0.1 dBm
2. Send the set-power command to the synthesizer
3. Wait delay (to be specified)
4. Trigger the Monitoring function to make a new measurement and generate a HK-packet.

Notice that the status is not set to “unknown”. Therefore the decrease commands may be released without delay.

Req. 4.4.2.5 The TEI-LSU shall receive Telecommands to set the power

This command is not checked.
As such it should be considered as hazardous

### *4.4.3 Interface to LSU*

Req. 4.4.3.1 The TEI-LSU shall be able to issue the following commands:
- Set Continuous Wave (CW) mode
- Switch power on/off
- Set Power
- Set Frequency

Req. 4.4.3.2 The TEI-LSU shall not issue commands to the synthesizer before the status of the synthesizer has been determined. (No commanding while power-status=undefined)

Req. 4.4.3.3 The TEI-LSU shall be able to collect the following measurement data:
- get Frequency, power, power-status

Req. 4.4.3.4 The TEI-LSU shall maintain the power setting and report this in Housekeeping

Req. 4.4.3.5 The commands that change the power level shall trigger the measurement function to acquire new measurements and to generate a new HK-packet.

### *4.4.4 Startup*

Req. 4.4.4.1 The TEI-LSU shall start the monitor-function at startup.

Req. 4.4.4.2 As long as the power has not been set this shall be indicated in the house-keeping.

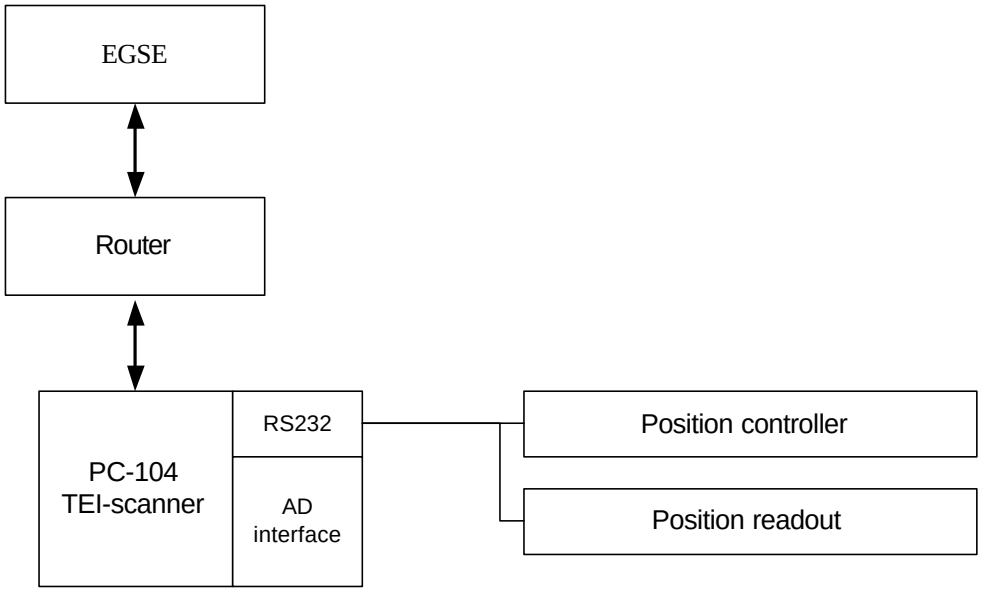
Req. 4.4.4.3 As long as the power has not been set, the power-set as reported in the house-keeping has no meaning and will be set to 0

Req. 4.4.4.4 As long as the frequency has not been set this shall be indicated in the house-keeping

Req. 4.4.4.5 As long as the frequency has not been set, the frequency -set as reported in the house-keeping has no meaning and will be set to 0

## 4.5 TEI-scanner

The TEI-scanner is connected to a scanner mechanism. This mechanism controls an x- and y- actuator




TEI-scanner

The position is readout with two Heidenhain LIP-481-R rulers (http://www.heidenhain.de/dt/lm_0_2.htm). These are incremental rulers with one point of reference for absolute position measurement. This point of reference must be found after startup.

### *4.5.1 Interface to scanner*

Req. 4.5.1.1 The TEI shall issue a command to the scanner to go to position (x2,y2) at velocity v. The exact SW-interface is to be specified.

### *4.5.2 Telecommands and Telemetry*

Req. 4.5.2.1 The TEI-scanner shall accept a command to find the point of reference.

Req. 4.5.2.2 From startup until the point of reference has been found two bits (one for each ruler) shall indicate the uncalibrated status of the ruler.

Req. 4.5.2.3 The TEI-scanner shall accept a command to go to position (x2,y2) in interval dt. The TEI-scanner shall maintain the current position (x1,y1) and derive the appropriate parameters that need to be passed to the scanner mechanism.

Req. 4.5.2.4 The TEI-scanner shall measure the position (xi,yi) every 30 ms during the interval [T0,T0+dt]

Req. 4.5.2.5 These positions shall be packed in a packet together with the time that corresponds to the first measurement in the packet.

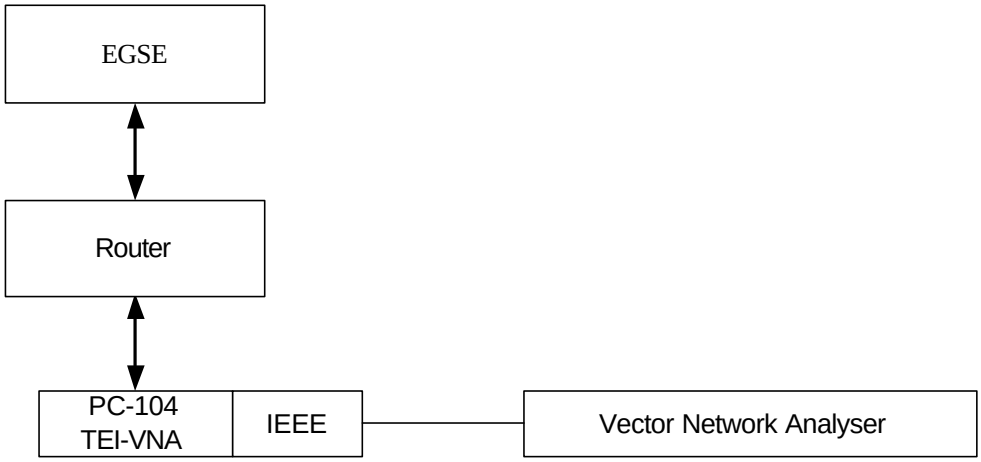
Req. 4.5.2.6 When more positions are measured than can be packed in one TM-packet a new independent packet shall be generated (i.e. no segmentation). All these packets have the same structure.

*4.5.3 Startup:*

Req. 4.5.3.1 The position-sensors must findtheir point of reference before a position measurement can be made. However, the search of these points will not be done automatically but upon command. At startup a calibration flag shall indicate that the reference point has not been found yet.

## 4.6 TEI-VNA

The TEI-VNA is connected to the Vector-Network Analyser.




TEI-VNA

### *4.6.1 Interface to VNA*

Req. 4.6.1.1 The TEI-VNA shall be able to collect measurement data from the VNA.

### *4.6.2 Telecommands and Telemetry*

Req. 4.6.2.1 The TEI-VNA shall accept a command to make N measurements in the next dT . These measurements are amplitude and phase.

Req. 4.6.2.2 These measurements shall be packed in a packet together with the time that corresponds to the first measurement in the packet.

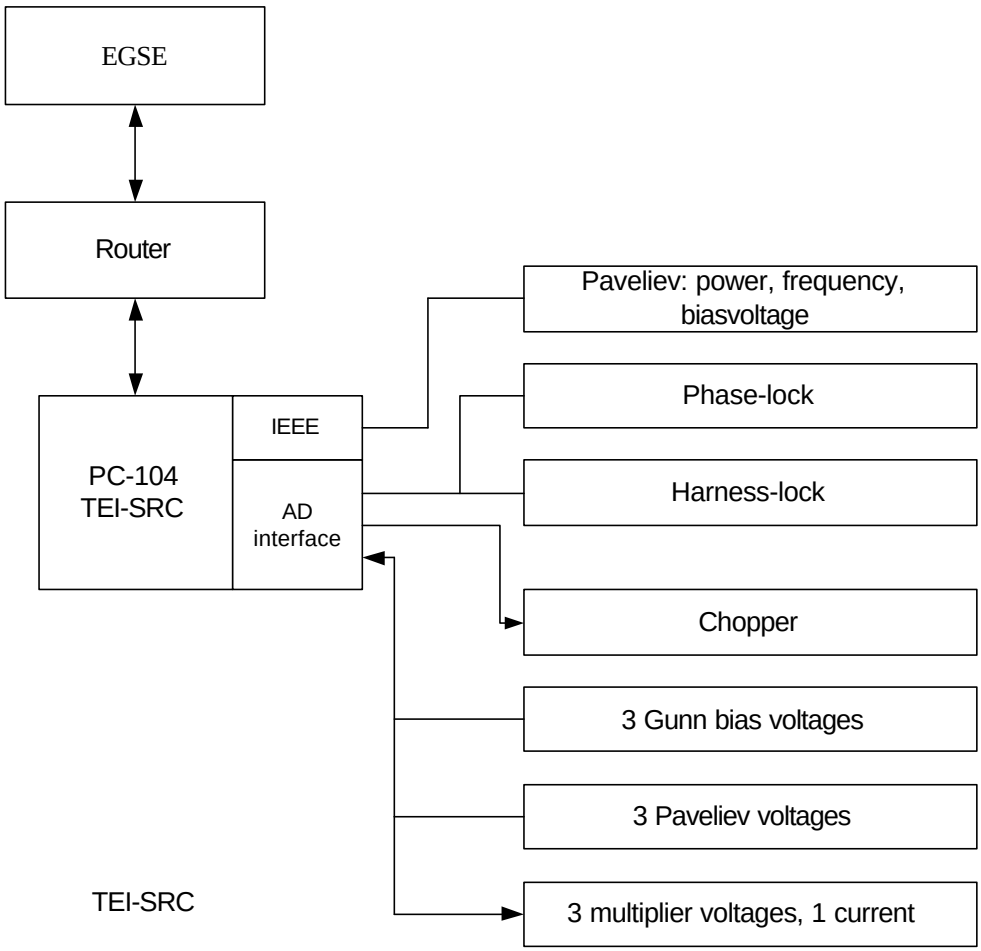
Req. 4.6.2.3 When more measurements are made than can be packed in one TM-packet a new independent packet shall be generated (i.e. no segmentation). All these packets have the same structure.

Req. 4.6.2.4 The TEI-VNA shall accept a telecommand to report the configuration of the VNA. This status shall be packet in a dedicated TM-packet.

### *4.6.3 Startup*

Req. 4.6.3.1 The TEI shall acquire and report the status of VNA at startup

### 4.7 TEI-SRC




The TEI sources is connected to one of three possible test-sources:
- a Gunn device
- a Paveliev device
- a JPL multiplier

The TEI has one output connector that can be connected to only one source. Each source comes with its own harness. A lock in the harness indicates which source is connected.

The TEI has a digital output that is connected to a chopper.

In case of JPL the same synthesizer will be controlled as used for the LSU-eq.

#### *4.7.1 Interface to equipment*

Req. 4.7.1.1 The TEI-SRC shall measure the lock-status of the harness. This status can be:

- Gunn
- Paveliev
- JPL
- undefined.

In case of Gunn device the TEI-source shall not command anything

Req. 4.7.1.2 In case of Paveliev device the TEI-source shall set power, frequency and bias-voltage

Req. 4.7.1.3 In case of JPL device the TEI-source shall set three bias-voltages and 1 current

Req. 4.7.1.4 The command that changes the bias-voltages for the JPL-configuration shall contain a parameter dt that indicates the ramp time. If dt=0 the voltage are set immediately

Req. 4.7.1.5 The TEI-SRC shall receive a command to increase the bias-voltages with 0.1 V. Each bias voltage has its own command.

These commands are hazardous in the sense that an increas in bias-voltage may result in too high an increase in power level which may cause damage to the device. Therefor a safety function shall be implemented to check if the power level is low enough to set a next step.

Upon receipt of any of the increase bias-voltages the following activities shall take place:

1. Send a packet with JPL-status = unknown
2. Increase the indicated SET-voltage with 0.1 V
3. Issue the indicated SET-voltage command.
4. Wait delay (to be specified)
5. Trigger the Monitoring function to make a new measurement and generate a HK-packet.
6. Evaluate the measured IF-power en determine if it is safe to increase the bias-voltages any further. Send the result in a packet.

Req. 4.7.1.6 TheTEI-SRC shall monitor:

- a bias voltage, a bias current, the IF power level by monitoring a voltage of the Gunn device
- power, frequency and bias-voltage of the Paveliev device
- three bias-voltages and 1 current of the JPL device

Notice that the monitor values of all devices appear in the HK-packets, irrespective of the configuration. The validity of the fields is given by the status parameter.

Req. 4.7.1.7 The TEI-SRC shall generate housekeeping packets that contain:

- the configuration
- all measured values
- all set values

Req. 4.7.1.8 The TEI-SRC shall accept a command to change the status of the chopper.

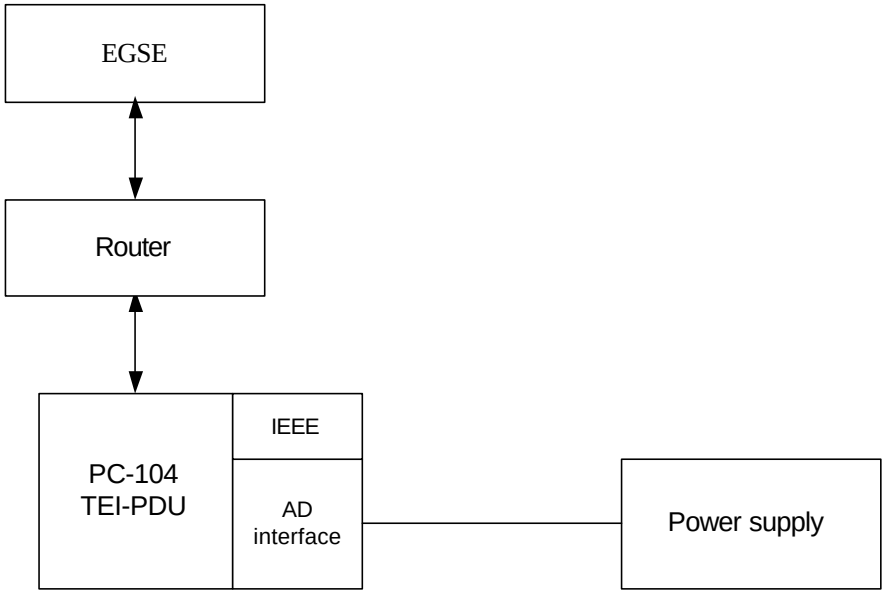
### *4.7.2 Manual settings report*

Req. 4.7.2.1 The TEI-source shall have a function to report manual settings.

Req. 4.7.2.2 This function shall consist of a two column table. Left the name of parameters, right fields to be lilled out by the operator. The fields shall be packed in a TM packet when a button is pushed. Fields are optional. The fields shall be cleared when sent.

### 4.8 TEI-PDU

The TEI-PDU controls the power-distribution unit (PDU) for the HIFI subsystems.




TEI-PDU