SKF Multilog On-line System IMx-R

User Manual

SKF

SKF Reliability Systems

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1
Introduction

This IMx-R User Manual is intended for all IMx-R versions 1.34.x, 1.35.x and 1.36.x.

System Overview

IMx-R is a part of the SKF Multilog On-line System product range which is the next generation of powerful, cost-effective solutions for railway vehicles. It is a robust measurement unit designed for tough industrial environment.

IMx-R works as a machine condition monitoring and protection system with several other units together in a network with the SKF @ptitude Observer Monitor Service.

In conjunction with SKF @ptitude Observer software, the IMx-R provides a complete system for early fault detection and prevention, automatic advice for correcting existing or impending conditions and advanced condition-based maintenance to improve machine reliability, availability and performance.
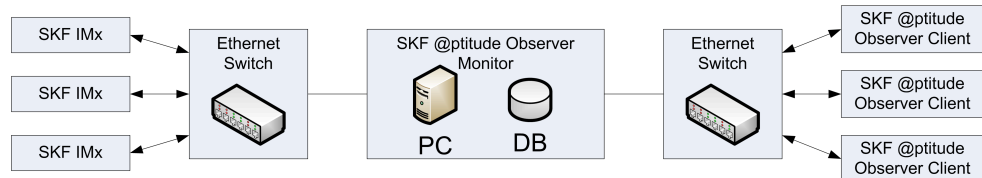
Figure 1-1: System overview of IMx-R and @ptitude Observer

The picture above illustrates how IMx-R units are linked together in a network that is connected via a LAN to a @ptitude Observer Monitor Service. The @ptitude Observer Monitor Service in turn can be connected to e.g. a LAN network making it possible for several of @ptitude Observer clients to link to this network.

@ptitude Observer clients can also be installed on the same computer as the @ptitude Observer Monitor Service software. Through a general interface, also known as ODBC (open database connectivity), it is possible to link the @ptitude Observer Monitor Service login computer to an existing database for an existing control or processing system, if desired. The @ptitude Observer Monitor Service, @ptitude Observer clients and the database can be separated from each other as long as they are on the same network where ODBC calls can travel freely.

IMx-R Unit

General Overview of IMx-R Unit

Figure 1-2: IMx-R front and rear view

An IMx-R unit is equipped with 20 analogue channels and four digital channels for dynamic signal inputs configurable for a variety of sensors.

Each IMx-R unit is consisted of two main parts;

- TSI (Technical Specifications for Interoperability) part for the safety related functions

- CM (Condition Monitoring) analysis part for non-safety related functions

The sensors of IMx-R are grouped as following:
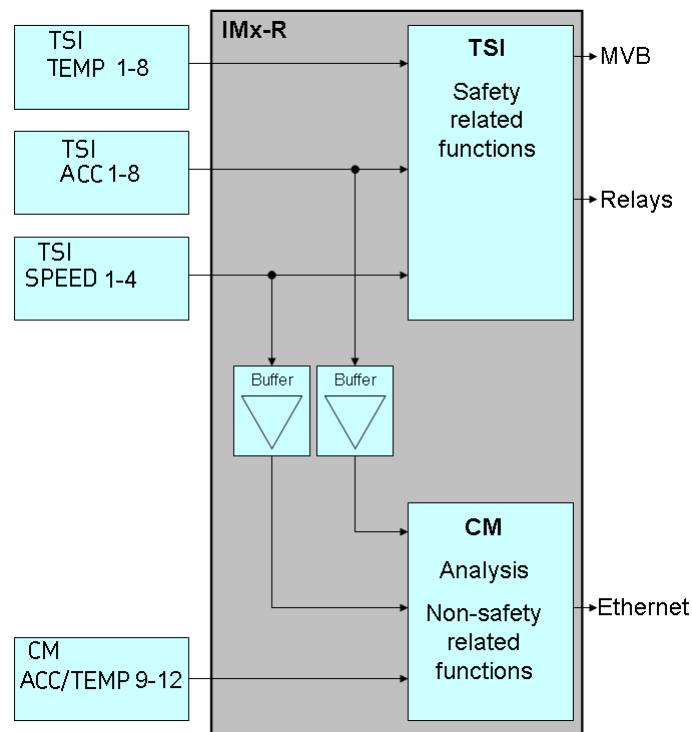
Figure 1-3: Sensor groups of IMx-R

- **TSI TEMP 1–8**: Eight analogue temperature sensors configurable for TSI part. Data are available to CM part via virtual channels.

- **TSI ACC 1–8**: Eight analogue acceleration sensors configurable for TSI part, but data are rerouted to CM part via buffer circuitry.

- **TSI SPEED 1–4**: Four digital speed sensors configurable for TSI part, but data are rerouted to CM part via buffer circuitry.

- **CM ACC/TEMP 9–12**: Four analogue combination (vibration, temperature, etc) sensors configurable for CM part.

IMx-R's unique features:

- The IMx-R unit monitors the condition of the train to detect faults of the train in order to prevent catastrophic failures from happening.

- Individual conditions for warning and alarm may be set for each channel. Warning and alarm levels may be controlled by machine speed or temperature.

- The unit's unique built-in hardware auto-diagnosis system continuously checks all sensors, cabling and electronics for faults, signal interruption, shortcuts or power failure.

Initiating an IMx-R is simple to carry out:

- The TSI part configuration is done through an initiating program called "IMx-R TSI Configurator" and a (portable) computer using RS232 serial interface located on the front panel of IMx-R unit. Refer to TSI Configuration in User Selectable Configuration chapter.

- The CM part configuration is done through @ptitude Observer software. Refer to CM User Selectable Configuration in User Selectable Configuration chapter.

- All initial CM part network configuration parameters, such as IP address, IMx identification number, etc. are done through "On-line Device Configurator" and stored first in a separate configuration file, then transferred to the IMx-R memory. Refer to CM Part Network Configuration chapter.

- The configuration is retained in the event of power losses, so that the IMx-R can start automatically when power returns.

TSI Part of IMx-R Unit

The TSI part monitors safety related functions including the following;

- Hot axle box detection (HABD)
- Bogie hunting detection (BHD)

The following sensors are configurable for TSI part.

- **TSI TEMP 1**–**8**: Eight analogue temperature sensors
- **TSI ACC 1**–**8**: Eight analogue acceleration sensors
- **TSI SPEED 1**–**4**: Four digital speed sensors

CM Part of IMx-R Unit

The CM part monitors the advanced condition monitoring functionalities such as following;

- Wheel condition
- Axle box bearing condition
- Gear box condition
- Traction motor condition

The following sensors are configurable for CM part.

- **CM ACC/TEMP 9**–**12**: Four general types of sensors (vibration, temperature, voltage, current, etc)

The following data are rerouted to CM part via buffer circuitry from TSI part.

- **TSI ACC 1**–**8**: Eight analogue acceleration sensors
- **TSI SPEED 1**–**4**: Four digital speed sensors

LED Indicators

The following table lists LED indicators available for each IMx-R unit. The LED indicators display the status of the system and sensors.

The LED indicators are located at the front panel of the unit. Refer to Front Connectors in IMx-R Drawings & Parts chapter.

LED Indicators			
Position	LED Indicator	Behaviour	Description
A1	TSI	On	Fault in TSI system
		Off	TSI system is Ok
A2	CM	On	Fault in CM system (service might be required)
		Flash	Fault in CM system (user correctable)
		Off	CM system is Ok
A3	ACT	Flash	Traffic on the network via J5 Ethernet2 connector
		Off	No traffic on the network via J5 Ethernet2 connector
A4	LNK	On	Ethernet link connection Ok via J5 Ethernet2 connector
		Off	Ethernet link not connected via J5 Ethernet2 connector
B1	MVB	On	MVB connected and Ok
		Slow flash	TSI-CM communication timeout, MVB configured but not connected or MVB configured but line error
		Fast flash	MVB configured but error in lifesign or safety layer
		Off	MVB not configured
B2	CAN	Flash	CAN communication indicator
		Off	CAN not connected
B3	CON	On	Connected to @ptitude Observer Monitor Service
		Slow flash	Trying to connect to @ptitude Observer Monitor Service
		Fast flash	@ptitude Observer Monitor Service forced the connection
		Unsymmetrical flash	No contact with the first gateway

LED Indicators			
Position	**LED Indicator**	**Behaviour**	**Description**
B4	ALR	On	Warning Indicator in CM
		Flash	Alarm indicator in CM
		Off	No alarm in CM
C1–C4	Digital (TSI SPEED sensor 1 to 4)	On	Input logic one
		Flash	Input toggle
		Off	Input logic zero
D1–D4 & E1–E4	Temp (TSI TEMP sensor 1 to 8)	On	Channel configured & running
		Slow flash	Channel cable fault
		Fast flash	Channel warning/alarm
		Off	Channel not configured
F1–F4 & G1–G4	Vib (TSI ACC sensor 1 to 8)	On	Channel configured & running
		Slow flash	Channel cable fault
		Fast flash	Channel warning/alarm
		Off	Channel not configured
H1–H4	Temp/Vib (CM ACC/TEMP sensor 9 to 12)	On	Channel configured & running
		Slow flash	Channel cable fault
		Fast flash	Channel warning/alarm
		Off	Channel not configured
J4 Ethernet 1	Ethernet connector	Green on	Ethernet link connection Ok via J4 Ethernet1 connector
		Yellow flash	Traffic on the network via J4 Ethernet1 connector

Table 1-1: LED indicators

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Installation

⚠️ *This tag indicates a safety related task.*

⚠️ *Important – The installation of an IMx-R must be carried out according to the instructions and advice given in this manual.*

Any deviation from these directions can be made only after consulting with SKF Condition Monitoring Center Luleå. Installation errors can lead to a situation where the system does not work as intended and machinery faults go undetected. Therefore, contact the IMx-R application engineer at the slightest doubt during the installation.

1. Connect the sensors according to Electrical Interfaces chapter.

2. Perform Cable Condition Test to ensure that the cables function properly. Cable condition test is described in Cable Condition Test under Every 59 000 Hours, General Check in Hardware Maintenance chapter.

3. Mount IMx-R unit according to General Mechanical Interface chapter and Mounting IMx-R in Hardware Maintenance chapter.

    Mounting IMx-R also includes the following which must be performed after IMx-R unit has been physically mounted on the rack:

    ✓ Download of IMx-R TSI configuration to the unit

    ✓ Validation of the IMx-R TSI configuration

    ✓ CM network configuration

4. Verify the IMx-R firmware version by following the instruction in TSI Firmware Update under Operation chapter.

5. Perform HABD functional test and check that HABD sensors are connected to IMx-R unit correctly. Follow the "Procedure for checking the temperature sensor after replacing" described in Replacing Temperature Sensor under Corrective Maintenance Tasks in Hardware Maintenance chapter.

6. Perform BDH functional test and check that BHD sensors are connected to IMx-R unit correctly. Follow "Procedure for checking the vibration sensor after replacing" described in Replacing Vibration Sensor under Corrective Maintenance Tasks in Hardware Maintenance chapter.

3

Electrical Interface

Electrical interfaces for IMx-R unit are grouped into three different types of interfaces; General Electrical Interface, TSI Part Electrical Interface and CM Part Electrical Interface.

General Electrical Interface

Sensor Inputs

The sensor inputs are located at Upper Rear Connector (J9) and Lower Rear Connector (J10) at the rear of the IMx-R unit. The pinout is listed in Pinout of Rear Connectors in IMx-R Drawings & Parts chapter, and the drawing of the rear connectors is found in Rear Connectors in IMx-R Drawings & Parts chapter.

All rear connectors are of the type F48 connectors complying with DIN 41612, HARTING 09061486901.

The sensor cables shall be a type of twisted pair and shielded with a capacitance of maximum 10 nF. The minimum cable dimension must be 0,5 mm^2.

All sensor cables shall be protected from any mechanical impact which might be expected depending on cable location. In addition, all sensors, sensor cables and junction box connectors must be protected from water ingress according to IP 66.

There are two pins for each sensor.

Sensor Type	Number of channels	Specification	Location in IMx-R unit
Analog Acceleration	8	ICP 100 mV/g	Lower Rear Connector (J10) TSI ACC 1 to 8
Analog Temperature	8	Pt1000, 1 kΩ @ 0 ºC 3,85 Ω/ºC	Lower Rear Connector (J10) TSI TEMP 1 to 8
Analog combination	4	ICP typically 10 or 100 mV/g Pt1000, 1 kΩ @ 0 ºC 3,85 Ω/ºC 0–20 V	Lower Rear Connector (J10) TSI ACC/TEMP 9 to 12
Digital Speed	4	Supply voltage 12 V, Current transition (low, high) 7 mA, 14 mA or Voltage Pulse 0–12 V	Upper Rear Connector (J9) TSI SPEED 1 to 4

Table 3-2: Sensor inputs

Important – In general, all sensor cables must be routed as far away as possible from the high voltage cables. If this cannot be done, care shall be taken to use high quality shielded cables.

Power Supply

The connection of the power supply of the IMx-R is located at Upper Rear Connector (J9) at the rear of the unit. The pinout is listed in [Pinout of Rear Connectors](#) in IMx-R Drawings & Parts chapter, and the drawing of Upper Rear Connector (J9) is found in [Rear Connectors](#) IMx-R Drawings & Parts chapter.

Power Consumption		
Component	**Typical (W)**	**Max (W)**
TSI board (without sensors)	5,2	5,7
CM board	5,0	5,3
IMx-R unit (without sensors)	13,1	13,7
IMx-R unit (including sensors and power supply)	14,1	14,7
PT1000 sensors (eight pieces)	0,03	0,03
Acceleration sensors (eight pieces)	0,4	1,0

Table 3-3: Power consumption

> *Important – The PE pins must be connected to the protective earth according to local regulations.*

Current Inrush

When the IMx-R unit is powered up, the current inrush has the following characteristics at 110 V.

- Maximum peak current at power up is 0,9 A
- Maximum current after 1 ms is 0,27 A
- Maximum current at worst case running condition is 0,14 A

> ⚠️ *Important – Circuit breakers of the power lines to the IMx-R units will break the circuit automatically when the current gets too high.*

Unit ID

The unit ID strapping is located at Upper Rear Connector (J9) at the rear of the IMx-R unit. It is consisted of six signals, IDPLUG0 to IDPLUG4 and IDPLUGP. The pinout is listed in [Pinout of Rear Connectors](#) in IMx-R Drawings & Parts chapter, and the drawing of Upper Rear Connector (J9) is found in [Rear Connectors](#) in IMx-R Drawings & Parts chapter.

The unit ID pins are of pull-up type which can be configured at Plug configuration interface within Configure MVB when configuring TSI . Refer to [TSI Configuration](#) in User Selectable Configuration chapter for detailed information.

Configurator (RS232) Interface

IMx-R has two RS232 interfaces which are located on the front panel of the IMx-R. Connector positions are found in [Front Connectors](#) in IMx-R Drawings & Parts chapter.

- **J6 RS232 TSI** is used only when TSI configuration is being done.
- **J7 RS232 CM** is used only when CM configuration is being done.

Use a serial null modem cable with a 9-pin D-SUB connector.

It is recommended to use a short length cable for RS232 interface in order to maintain full communication speed.

The pinout of both connectors is shown below.

Important – RS232 connectors are used only when the configuration is being done. Therefore, the cables shall not be connected to RS232 connectors at any other time.

RS232 Connectors Pinout

RS232 Connectors Pinout	
Pin	**Description**
1	NC (Not Connected)
2	Rx
3	Tx
4	NC (Not Connected)
5	GND
6	NC (Not Connected)
7	NC (Not Connected)
8	NC (Not Connected)
9	NC (Not Connected)

Table 3-4: RS232 connector pinout
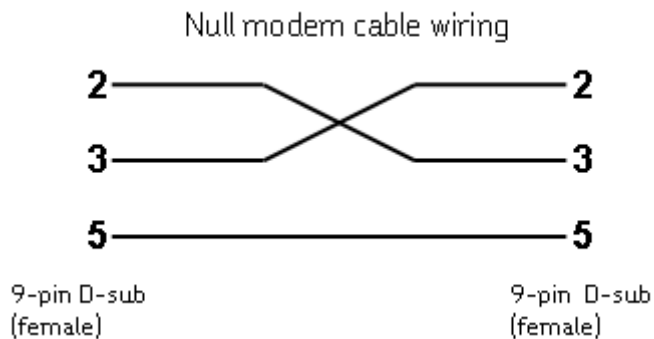
Figure 3-4: Null modem cable wiring

TSI Part Electrical Interface

TSI Part Sensor Inputs

This section is aimed especially for TSI part sensor inputs in addition to the information described for the general electrical interface sensor inputs.

The TSI part sensor cables shall be a type of twisted pair and shielded with a capacitance of maximum 10 nF, EN50306-4 3E 300 V 2x1 MM S 90.

Additional requirements for BHD sensors:

- Amplitude linearity ±1%

- Transverse sensitivity < 7%

- Mounting resonant frequency > 2 kHz

- Shock limit > 30 g (according to EN 61373, class 2)

- Operating temperature range −40 °C to +85 °C

- Sensitivity deviation versus temperature ±5% for the range of − 25 to +70 °C

- Sensitivity deviation versus temperature ±10% for the range of − 40 to +85 °C

- Electrical isolation 10^8 Ω

Additional requirements for HABD sensors:

- Precision* ±2 °C for the range of 0 to +150 °C

- Precision* ±5 °C for the range of −40 to 0 °C

- Shock limit > 100 g (according to EN 61373, class 3)

- Interface 2 wires + ground

- Operating temperature range −40 °C to +150 °C

*Precision includes sensor, cabling and connectors between IMx-R interface and sensor housing as illustrated below.
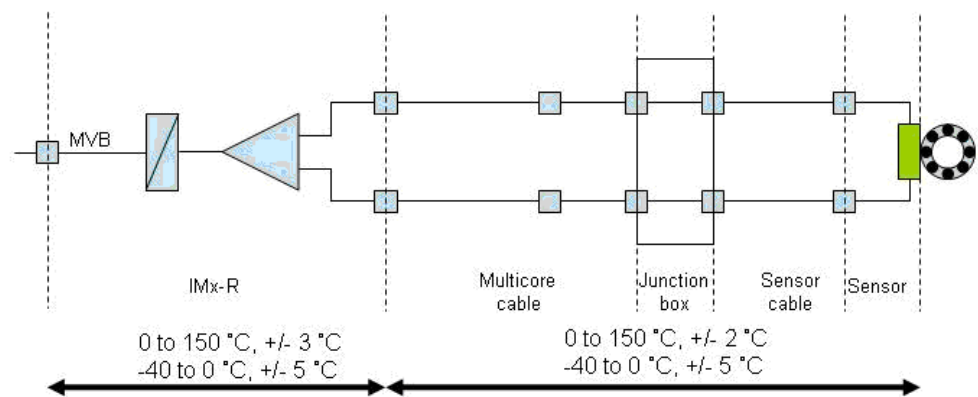
Figure 3-5: HABD sensor temperature precision

The train integrator is in charge of temperature sensors installation on the axle box. When setting the HABD alarm levels in the TSI Configuration, the temperature difference between the sensor and the bearing has to be taken into account.

MVB

The two MVB connectors, J3 MVB 1 and J2 MVB 2, are located at the front panel of the IMx-R unit. Connector positions are found in [Front Connectors](#) in IMx-R Drawings & Parts chapter.

The type of connector used is 9-pin D-SUB, one male and one female, according to the MVB standard.

MVB Male Connector Pinout

MVB Male Connector	
Pin	**Description**
1	A.data.P
2	A.data.N
3	NC (Not Connected)
4	B.data.P
5	B.data.N
6	A.term
7	A.term
8	B.term
9	B.term
Shell	MVB shield

Table 3-5: MVB male connector pinout

MVB Female Connector Pinout

MVB Female Connector	
Pin	**Description**
1	A.data.P
2	A.data.N
3	NC (Not Connected)
4	B.data.P
5	B.data.N
6	A.term
7	A.term
8	B.term
9	B.term
Shell	MVB shield

Table 3-6: MVB female connector pinout

Relay Outputs

The IMx-R has three relay outputs, two pins for each relay.

The relay outputs are located at Lower Rear Connector (J10) at the rear of the IMx-R unit. The pinout is listed in Pinout of Rear Connectors in IMx-R Drawings & Parts chapter, and the drawing of Lower Rear Connector (J10) is found in Rear Connectors in IMx-R Drawings & Parts chapter.

- **RELAY 1** for monitoring alarms of TSI functionalities (HABD and BHD). It is activated according to the configuration of TSI. Refer to Relays under Configure IMx-R in User Selectable Configuration chapter.

- **RELAY 2** for monitoring alarms of TSI functionalities (HABD and BHD). It is activated according to the configuration of TSI. Refer to Relays under Configure IMx-R in User Selectable Configuration chapter.

- **System OK** for monitoring the system status. It will be set to open state to signal any failure of TSI functionalities (HABD and BHD) and any failure of TSI sensors.

CM Part Electrical Interface

Ethernet

The IMx-R has two Ethernet connectors which are located at the front panel of the unit. Connector positions are found in <u>Front Connectors</u> in IMx-R Drawing & Parts chapter.

- **J4 Ethernet 1** is of type RJ45 which has an auto detection of crossover or a straight through Ethernet cable connection. Henceforth, IMx-R has two built-in Ethernet switches. It is possible to connect several IMx-R units in a daisy chain with up to eight units in a single cable layout.

  The states of J4 Ethernet 1 built-in LED indicators are listed in <u>LED Indicators</u> in Introduction chapter.

- **J5 Ethernet 2** is of type M12, D-coded. It shall not be the normal type of 4-pair but instead it shall be a type of 2-pair Cat5 (unshielded twisted pair) or better.

  The states of J5 Ethernet 2 connector are listed in <u>LED Indicators</u> in Introduction chapter via LED indicators ACT and LNK (position A3 and A4, respectively).

J4 Ethernet 1 (RJ45) Connector Pinout

J4 Ethernet 1 (RJ45) Connector	
Pin	**Description**
1	Tx+
2	Tx-
3	Rx+
4	NC (Not Connected)
5	NC (Not Connected)
6	Rx-
7	NC (Not Connected)
8	NC (Not Connected)

Table 3-7: J4 Ethernet 1 (RJ45) Connector

J5 Ethernet 2 (M12) Connector Pinout

J5 Ethernet 2 (M12) Connector	
Pin	**Description**
1	Tx+
2	Rx+
3	Tx-
4	Rx-

Table 3-8: J5 Ethernet 2 (M12) Connector

Ethernet Ports Used for Ethernet Communication

Ethernet Ports	
Port	**Description**
1000	IMx-R to @ptitude Observer Monitor Service communication (user configurable)
UDP 123	IMx-R to @ptitude Observer Monitor Service time synchronization (Windows standard time synchronization port)

Table 3-9: Ethernet ports

RS485 Field Bus

The RS485 field bus is located at Upper Rear Connector (J9) at the rear of the IMx-R unit. The pinout is listed in Pinout of Rear Connectors in IMx-R Drawings & Parts chapter, and the drawing of Upper Rear Connector (J9) is found in Rear Connectors in IMx-R Drawings & Parts chapter.

CAN Field Bus

The CAN field bus is located at Upper Rear Connector (J9) at the rear of the IMx-R unit. CAN bus is not activated currently but is reserved for future use.

4

General Mechanical Interface

Plug-in Unit

The IMx-R is a plug-in unit. Its enclosure material is aluminum and the rear cover is stainless steel. The front panel, upper panel and lower panel are Alodine for improved oxidation resistance as well as for improved shielding and grounding. The upper and lower cover plates are perforated to approximately 25% of the surface.

The detailed unit size is listed in Environmental section of Technical Data chapter.

The mounting screws are M2,5 and the torque value shall be 38 Ncm.

For the position of mounting screws, see Front Panel with Dimensions in IMx-R Drawings & Parts chapter.

Grounding/Shielding

Grounding is understood as the lowest impedance connection of all metallic parts of a vehicle (and car body) with the rail potential.

The grounding in rail vehicles serves the following three purposes:

- Protective grounding
- Operating grounding
- Improvement of the EMC

The ground connection is provided through the front panel mounting screws as well as the PE pins at Upper Rear Connector (J9).

The IMx-R unit shall be grounded in the counter rack, which in turn shall be grounded to the vehicle ground.

The following are the methods for grounding and shielding which comply with EMC tests.

- Single shielded cable connected to IMx-R end only.
- Double shielded cable with each shield connected to ground in one end of the sensor cable.

Important – The cable shields must be connected to the metallic housing of the rear F48 connectors in a 360º fashion. Each cable shield must run uninterrupted (DC block capacitor and/or junction box allowed) from the sensor. Pigtail connector shall be avoided.

Important – Shielding and grounding methods must be in agreement with the train manufacturer.

5

CM Part Unit Configuration

CM Part Network Configuration

CM part network configuration settings are done by using **On-line Device Configurator** tool.

- Note that CM part network configuration of IMx-R units is done by "Software" interface only.

- Each IMx-R unit must have an identity number between 1 and 255, unique to the database to which it is connected.

- It also requires network settings and the IP number and port number of the @ptitude Observer Monitor Service to which it should be connected.

- Keep in mind that most of the time, all IMx-R units are on the same network and database, therefore units can NOT have a same IP address or a same unit ID.

Refer to **CM Network Configuration File** section in **@ptitude Observer On-line Device Configurator User Manual** for detailed information**.**

IMx-R Time

IMx-R has a backup power capacitor which keeps the time for at least a month if IMx-R was disconnected from a power inlet.

To correct or set IMx-R time, use one of the following methods.

- **Automatic time synchronization**

  This method is preferable since IMx-R will continuously synchronize the time with the computer that has @ptitude Observer Monitor Service running.

  IMx-R uses a built-in function (NTP) in Windows for time synchronization.

  In order to activate time synchronization, refer to Time Synchronization chapter in "@ptitude Observer Installation Manual".

- **Manual set time**

  Use "Set time" function in @ptitude Observer which is found under a tab menu called "On-line", then "MasCon/IMx units" interface.

6
User Selectable Configuration

The IMx-R unit is designed to handle the following signals on board a railway vehicle;

- Up to **eight acceleration sensors** (TSI ACC 1–8)

- Up to **eight temperature sensors** (TSI TEMP 1–8)

- Up to **four digital sensors** (TSI SPEED 1–4) for speed, oil level, etc. onboard a railway vehicle

- Up to **four general analogue sensors** (CM ACC/TEMP 9–12) for vibration, temperature, etc.

These signals are processed using pre-defined algorithms and extracted values are checked against user defined alarm conditions.

If a fault is detected, an alarm will be triggered to notify the conductor of the train as well as ground based maintenance personnel in order for them to take an appropriate action.

In addition, measurement data will be recorded and stored in a database for further analysis.

Configuration errors can lead to a situation where the system does not work as intended and machinery faults go undetected. Therefore, contact the IMx-R application engineer at the slightest doubt during the configuration.

⚠ *Important – It is strongly recommended that the configuration of IMx-R software must be carried out according to the instructions and advice given in this manual. Any deviation from these directions can be made only after consulting with SKF Condition Monitoring Center Luleå.*

⚠ *Important – The modification of IMx-R TSI configuration shall be done by a person with the knowledge of IMx-R system. And after each modification, it shall be verified by following the instruction in TSI Configuration Update in Operation chapter.*

TSI Configuration

Start **IMx-R TSI Configurator** located in the latest release package, **IMx-R release x.x.x \ IMx-R TSI Configurator \ IMXRConfig x.x.x.exe**.
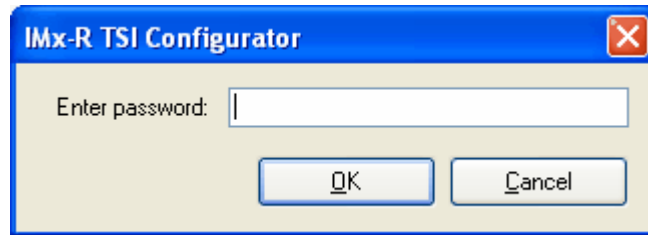
Figure 6-6: IMx-R TSI configurator password

Enter the password "secret".
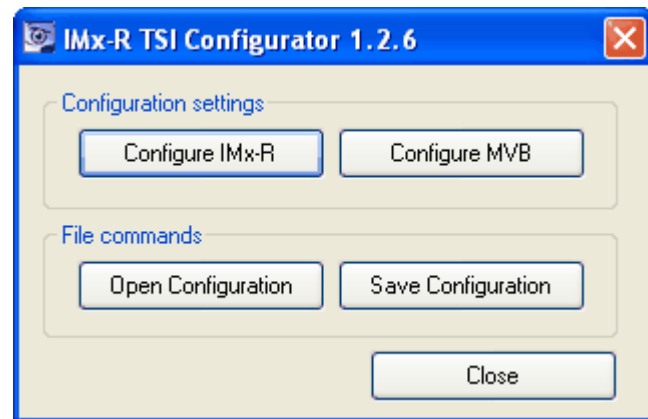
Figure 6-7: IMx-R TSI configurator settings

Click on an interface;

- Configure IMx-R to configure vibration channels, temperature channels, speed channels and relays.

- Configure MVB to configure MVB protocol.

- Open Configuration to load a saved configuration data file to the application.

- Save Configuration to save configuration data to a file.

Configure IMx-R

Configure IMx-R allows to configure vibration channels (TSI ACC 1 to 8), temperature channels (TSI TEMP 1 to 8), speed channels (TSI SPEED 1 to 4) and relays (RELAY 1 to 2).

The following attributes apply to all three settings of Vibration channels, Temp/Speed channels, and Relays. The attributes appear on the bottom of each screen.

- **Customer Config Version** is a 3-character string consists of A to Z and 0 to 9.

- **Version** is the TSI configuration version which consists of three sperate parts (X.Y.Z). Each part can be between 0 and 128.

  o X represents the major release which is a configuration format stepping.

  o Y represents the MVB configuration version.

  o Z represents IMx-R channel configuration version which is defined by the user.

- **IMx Unit ID** is used to link the configuration to a unit which has the matching unit ID, determined from the physical ID plug setting. If there is a mismatch, the configuration is not used and an error is set. The translation of the physical ID plug setting is configured at Plug configuration interface within Configure MVB.

Vibration Channels (TSI ACC 1 to 8)
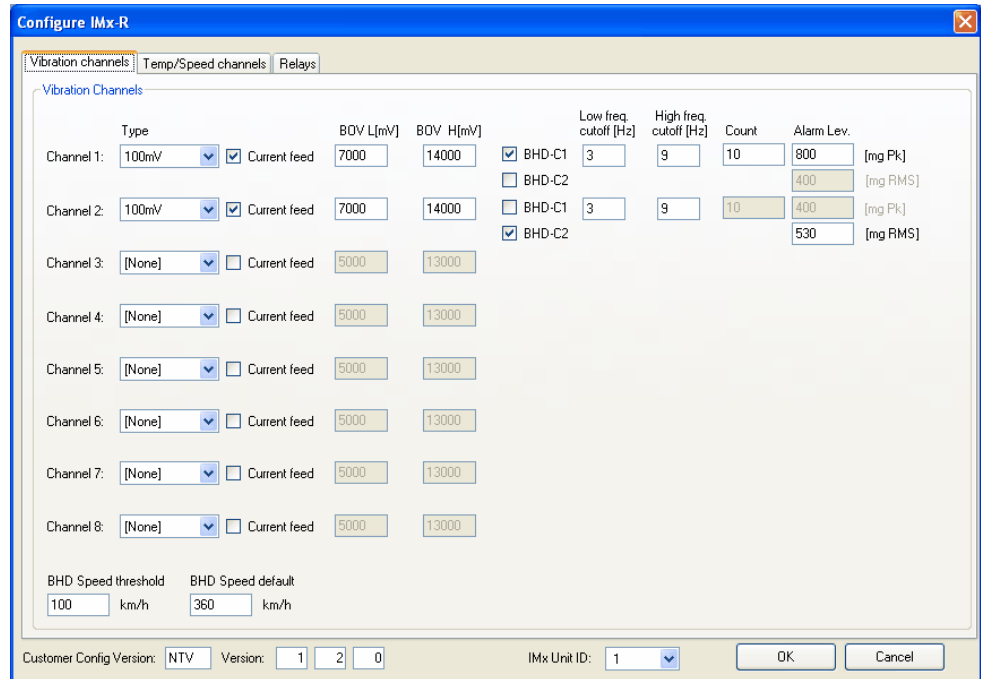
Figure 6-8: Example of Vibration channels configuration

- **Type** is the vibration sensor type for the channel. 100 mV represents a 100 mV/g. It can be "None" for not configured sensor.

- **Current feed** activates current feed (4 mA), if checked.

- **BOV L [mV]** is the lower range of Bias output voltage. The value should be between 5 000 and 10 000 mV.

- **BOV H [mV]** is the upper range of Bias output voltage. The value should be between 10 000 and 15 000 mV.

- **BHD-C1 (Bogie Hunting Detection Criterion 1)** activates BHD detection criterion 1, if checked.

- **BHD-C2 (Bogie Hunting Detection Criterion 2** according to EN 14363**)** activates BHD detection criterion 2, if checked.

- **Low freq. cutoff [Hz]** is the lower cutoff frequency for BHD. Only certain combinations of low freq. cutoff values and high freq. cutoff values are supported. Refer to the table "Low and High freq. cutoff value combinations", below.

- **High freq. cutoff [Hz]** is the upper cutoff frequency for BHD. Only certain combinations of low freq. cutoff values and high freq. cutoff values are supported. Refer to the table "Low and High freq. cutoff value combinations", below.

Low freq. cutoff value (Hz)	High freq. cutoff value (Hz) ("x" is supported)									
	6	7	8	9	10	11	12	13	14	15
2	x		x		x		x		x	
3		x		x		x		x		x
4			x		x		x		x	
5				x		x		x		x
6					x		x		x	
7						x				
8							x			

Table 6-10: Low and High freq. cutoff value combinations

- **Count** is the number of consecutive cycles with acceleration above the limit for instability detection needed to trigger alarm for criterion 1 (BHD-C1). Count should be between 6 and 20 cycles.

- **Alarm Lev.** (Alarm Level) is the limit acceleration value for instability detection.
  Alarm Level for BHD-C1 should be between 400 and 1 600 mg Peak.
  Alarm Level for BHD-C2 should be between 400 and 1 600 mg RMS.

- **BHD Speed threshold** is in km/hour. If the MVB train speed signal is greater or equal to this value, the BHD function will be activated. The value should be between 0 and 100 km/hour.

- **BHD Speed default** is in km/hour. If there is no valid train speed available, this value will be the default speed for BHD function. The value should be between 100 and 360 km/hour.

Temp/Speed Channels

Figure 6-9: Example of Temp/Speed channels configuration

Temperature Channels (TSI TEMP 1 to 8)

- **Type** is the temperature sensor type for the channel.

- **Power** activates power, if checked.

- **HABD (hot axle box detection)** activates HABD, if checked.

- **Warning [C]** is the temperature warning level in Celsius. Warning value should be between 60 and 130 ºC.

- **Danger [C]** is the temperature danger level in Celsius. Danger value should be between 80 and 150 ºC.

- **Hysteresis for ABS threshold** is the hysteresis for absolute temperature alarms. Its value should be between 2 and 15.

Speed Channels (TSI SPEED 1 to 4)

- **No. of Teeth** is the number of pulses per revolution. The value should be between 1 and 100.

- **Power** activates power, if checked.

- **TSI** should be remained unchecked. The functionality of this parameter is not implemented.

Relays (RELAY 1 to 2)
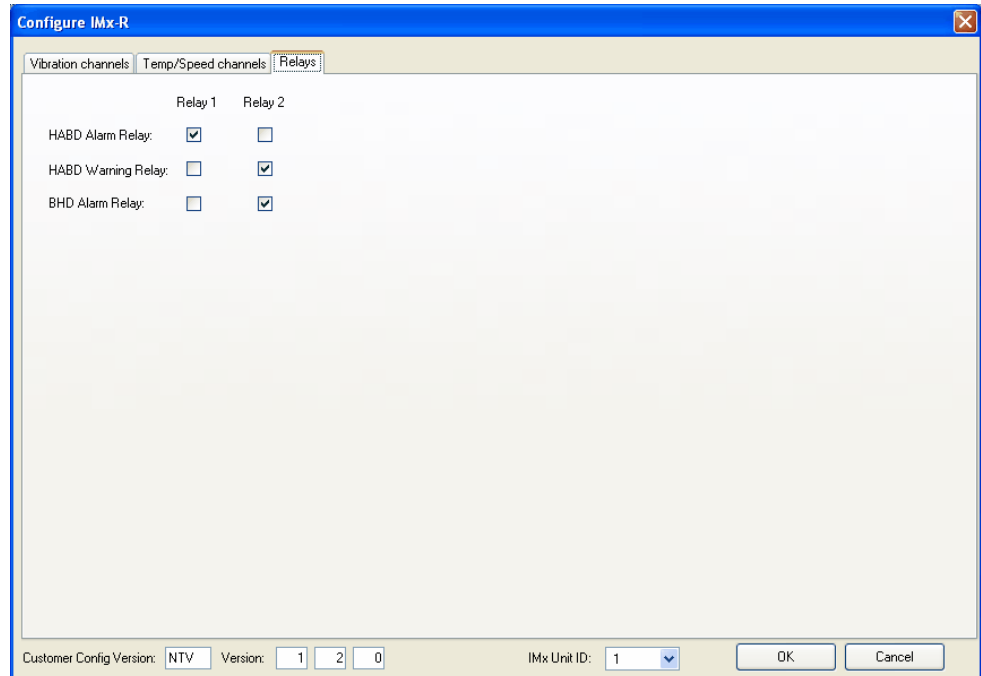
Figure 6‑10: Example of Relays configuration

- **HABD Alarm Relay** is for sending HABD danger information to the train control system via Relay 1 or Relay 2.

- **HABD Warning Relay** is for sending HABD warning information to the train control system via Relay 1 or Relay 2.

- **BHD Alarm Relay** is for sending BHD alarm information to the train control system via Relay 1 or Relay 2.

Configure MVB

MVB is for receiving process data and speed data from the train control system as well as to transmit alarm information to the train control system. The details of MVB protocol is application specific which can be configured in the following screen.

> *Important – Any modification of MVB configuration settings may lead to non-function of MVB communication and safety related alarm.*
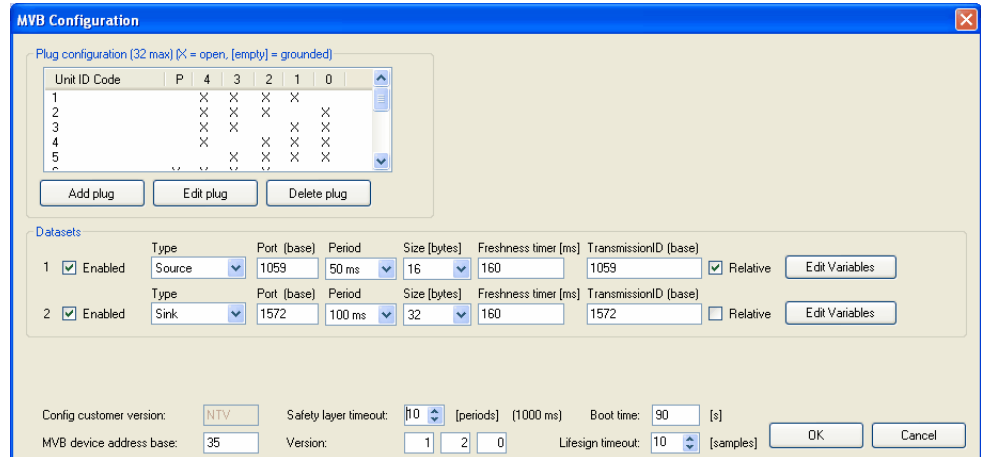
Figure 6-11: Example MVB configuration

Plug configuration (32 max) is the user configured code. The translation of this code is referred as the physical ID plug setting. The unit ID of this physical ID plug setting is compared to the unit ID entered in Configure IMx-R screen in order to link the right configuration to the unit.
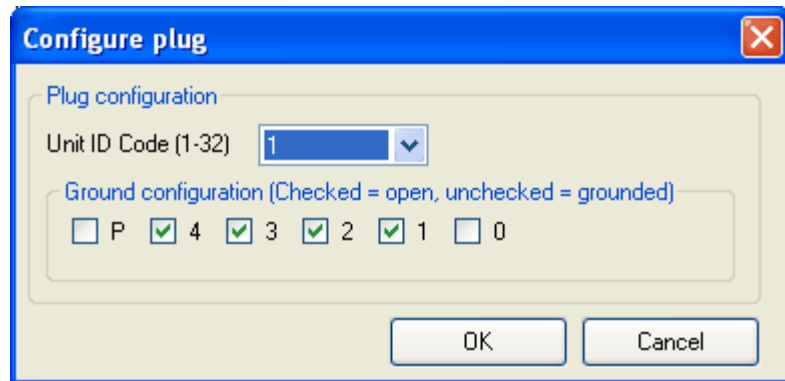
Figure 6-12: Example of Plug configuration for MVB

- **Unit ID Code** is a unique code which can be selected from the drop-down list , a number between 1 and 32. This unit ID code is used as a way to link to the corresponding configuration for the unit.

- **P** sets the ID plug's parity bit to "open" (not grounded), if checked.

- **4, 3, 2, 1, 0** sets each ID plug bit 4, 3, 2, 1 and/or 0 to "open" (not grounded), if checked.

Datasets

- **Enabled** enables the selected dataset, if checked.

- **Type** indicates the direction of the data flow; sink or source (only one sink and one source allowed).

- **Port (base)** is the port base number.

- **Period** is the dataset period in millisecond.

- **Size** is the dataset size in byte.

- **Freshness timer [ms]** is the range of time that data is acceptable since the last data.

- **Transmission ID (base)** is the base transmission ID.

- **Relative** allows the customer code to be added to the base port and to the base transmission ID, if checked.

- **Edit Variables** allows to edit the following attributes of the selected dataset.

Figure 6-13: Example of Edit variable for MVB configuration

- o **Byte offset** is the MVB byte offset of the MVB variable.

- o **Bit number** is the MVB bit number of the MVB variable.

- o **Type** is the MVB variable type.

- o **Source ID (1-15)** is the variable's source ID in the system which can be between 1 and 15.

- o **Index/Channel (1-16)** is the variable's index/channel in the system which can be between 1 and 16.

- o **Sink Default value** is the variable defaults if a variable belongs to a sink dataset.

- o **SIL2** indicates that the variable is SIL2, if marked. Otherwise the variable is SIL0. SIL0 and SIL2 have different criteria on variable defaults and variable validities.

- **Config customer version** is a 3-character string consists of A to Z and 0 to 9.

- **Safety layer timeout** is the period before the safety layer timeout. It can be between 3 and 15 sink dataset periods.

- **Boot time** is the time between the start of MVB and when sink dataset becomes available. During this time there will be no error reported by IMx-R due to sink dataset unavailability. MVB start time is stated in Startup under Operation chapter.

- **MVB device address base** is added to the customer code.

- **Version** is the MVB configuration version which consists of three sperate parts (X.Y.Z). Each part can be between 0 and 128.

  o X represents the major release which is a configuration format stepping.

  o Y represents the MVB configuration version.

  o Z represents IMx-R channel configuration version which is defined by the user.

- **Lifesign timeout** is the number of consecutive sink dataset lifesign samples before the timeout. It can be between 3 and 20 samples.

File Commands

- **Open Configuration** loads a saved configuration data file to the application.

- **Save Configuration** allows to save the configuration data to a file.

  Now that the configuration is done and saved, this configuration file should be loaded in the IMx-R unit. The downloading of a TSI configuration file to a unit is done through **On-line Device Configurator** tool. Refer to @ptitude Observer On-line Device Configurator User Manual.

CM User Selectable Configuration

The user selectable configuration of CM part which allows to configure up to four general analogue sensors (CM ACC/TEMP 9–12) is done through @ptitude Observer software.

Refer to **@ptitude Observer User Manual**.

7
TSI Commands

The following TSI commands are used to obtain information on various conditions when performing installation tests for IMx-R units. These commands can be performed by using the tool "**Serial Interface for IMx-R TSI**" provided by @ptitude Observer On-line Device Configurator.

Note that the commands can be different for each firmware version.

TSI Commands					
Description	**Firmware Version 1.0.0**	**Firmware Version 1.1.0**	**Firmware Version 1.2.0**	**Firmware Version 1.3.0**	**Firmware Version 1.4.0**
Display dataset[1]	ds	ds	ds	ds	ds
Display variable store (read variables)[2]	rv	rv	rv	rv	rv
Train bus time (MVB)	-	-	time	time	time
Display MVB device number	-	-	mvbdn	mvbdn	mvbdn
Fault injection[3]	-	fi	fi	fi	fi
Display TSI firmware version	-	-	ver	ver	ver
Display TSI configuration version	-	-	vercfg	vercfg	vercfg
Display sensor self-test diagnostics[4]	-	ssr	ssr	ssr	ssr
Display unit self-test diagnostics	-	systf	systf	systf	systf
Restart TSI part	reboot	reboot	reboot	reboot	reboot

TSI Commands					
Description	Firmware Version 1.0.0	Firmware Version 1.1.0	Firmware Version 1.2.0	Firmware Version 1.3.0	Firmware Version 1.4.0
Print information of current relay status	–	–	–	rel	rel
Print information of current unit ID and HW plug[5]	–	–	–	plug	plug
Print system information	–	–	–	sys	sys
Print information of current run mode	–	–	–	sstate	sstate
Read back the configuration commands used by IMx–R Online Device Configurator	–	–	–	dumpcfg	dumpcfg
MVB safety layer description[6]	–	–	–	–	mvbsl

Table 7-11: TSI commands

[1] More information on dataset command is described in "Display Dataset" section of this chapter.

[2] More information on variable store (read variables) command is described in "Read Variables" section of this chapter.

[3] More information on fault injection command is described in "Fault Injection" section of this chapter.

[4] More information on sensor self-test diagnostics command is described in "Sensor Self-test Diagnostics" section of this chapter.

[5] More information on current unit ID and HW plug command is described in "Unit ID and HW Plug Information" section of this chapter.

[6] More information on MVB safety layer description is described in "MVB Safety Layer Description" section of this chapter.

Display Dataset

The following Display Dataset commands, "ds", is used to present datasets and MVB/safety layer flags. The dataset command gives a snap shot of the current internal state. The dataset is internally built within different phases.

ds command	Description
dsax (x is a number between 0 and 3)	Show TSI configuration dependent datasets
dsbx (x is a number between 0 and 7)	Show CM configuration dependent datasets

Table 7-12: ds commands

The following are ds fields resulted by the display dataset (ds) commands from above.

ds fields	Description
port	dataset port in hexadecimal
flags	MVB/safety layer flag in hexadecimal (for firmware version 1.2.0 and 1.3.0, refer to the table "ds flags of firmware version 1.2.0 and 1.3.0", below)
freshness	dataset age in hexadecimal. Updates with 16 ms resolution (0x0010)
port data	First row is bytes 0 to 15. Second row is bytes 16 to 31

Table 7-13: ds fields

Example of ds fields: port 0x0624, flags 0xfa04, freshness 0xffff
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Descriptions of ds flags for firmware version 1.2.0 and later	
Bit	**Description**
0	–
1	MVB – communications error
2	MVB – unfresh
3	MVB – dataset has been received
4	–
5	–
6	–
7	–
8	Safety layer – validation status (see bit 15)
9	Safety layer – communications error
10	Safety layer – 0
11	Safety layer – authenticity error
12	Safety layer – timeliness error
13	Safety layer – integrity error
14	Safety layer – degraded mode
15	Safety layer – invalid (see bit 8)

Table 7-14: ds flags for firmware version 1.2.0 and later

If bits 8 to 15 are all zero, it is indicating an internal phase of "Waiting for next MVB message".

Read Variables

Read variables (rv) command displays the variable store in hexadecimal.

Row	**Description** (Column 0 is the left-most data column)							
	Column 0	**Column 1**	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Column 7**
00								
01								
02								
03								
04								
05	HABD device failure	BHD device failure						
06	HABD channel 1 invalidity	HABD channel 2 invalidity	HABD channel 3 invalidity	HABD channel 4 invalidity	HABD channel 5 invalidity	HABD channel 6 invalidity	HABD channel 7 invalidity	HABD channel 8 invalidity
07	HABD channel 1 alarm	HABD channel 2 alarm	HABD channel 3 alarm	HABD channel 4 alarm	HABD channel 5 alarm	HABD channel 6 alarm	HABD channel 7 alarm	HABD channel 8 alarm
08	HABD channel 1 warning	HABD channel 2 warning	HABD channel 3 warning	HABD channel 4 warning	HABD channel 5 warning	HABD channel 6 warning	HABD channel 7 warning	HABD channel 8 warning
09	BHD channel 1 invalidity	BHD channel 2 invalidity	BHD channel 1 alarm	BHD channel 2 alarm				
0a								
0b								
0c								
0d								
0e*	Safety layer certification failure of sink (received) dataset							
0f	Sink lifesign data (received)*	Train speed (received) in km/h						
10								
11								

Row	Description (Column 0 is the left-most data column)							
---	Column 0	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
12								

* available for firmware 1.4.0 only

Table 7-15: rv and descriptions - columns 0 to 7

Row	Description (Column 0 is the left-most data column)							
---	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15
00								
01								
02								
03								
04								
05								
06								
07								
08								
09								
0a								
0b								
0c								
0d								
0e*					SIL0 data valid		Failure of sink dataset lifesign	SIL2 data valid
0f					Source lifesign data (transmitted)*			
10								
11								
12								

* available for firmware 1.4.0 only

Table 7-16: rv and descriptions - columns 8 to 15

Fault Injection

The fault injection commands are applied to J6 RS232 TSI serial port.
The commands allow simulation of alarms and fault conditions which can be useful when performing communication tests on installations.

Fault Injection Commands for Firmware Version 1.1.0	
Command	**Description**
fih	Fault injection system bits – HABD device failure
fib	Fault injection system bits – BHD device failure

Table 7-17: Fault injection commands for firmware version 1.1.0

Once a command "fih" or "fib" has been issued, the successive issue of the same command forces or un-forces the device failure with toggling action. The commands are cleared at boot-up.

Fault Injection Commands for Firmware Version 1.2.0 and later	
Command	**Description**
fi5 00	Fault injection system bits – None
fi5 01	Fault injection system bits – HABD device failure
fi5 02	Fault injection system bits – BHD device failure
fi5 03	Fault injection system bits – HABD/BHD device failure
fi6 00	Fault injection HABD fault – None
fi6 01	Fault injection HABD fault – Channel 1
fi6 02	Fault injection HABD fault – Channel 2
fi6 04	Fault injection HABD fault – Channel 3
fi6 08	Fault injection HABD fault – Channel 4
fi6 10	Fault injection HABD fault – Channel 5
fi6 20	Fault injection HABD fault – Channel 6
fi6 40	Fault injection HABD fault – Channel 7
fi6 80	Fault injection HABD fault – Channel 8
fi6 ff	Fault injection HABD fault – All channels
fi7 00	Fault injection HABD alarm – None
fi7 01	Fault injection HABD alarm – Channel 1
fi7 02	Fault injection HABD alarm – Channel 2
fi7 04	Fault injection HABD alarm – Channel 3
fi7 08	Fault injection HABD alarm – Channel 4
fi7 10	Fault injection HABD alarm – Channel 5
fi7 20	Fault injection HABD alarm – Channel 6
fi7 40	Fault injection HABD alarm – Channel 7
fi7 80	Fault injection HABD alarm – Channel 8
fi7 ff	Fault injection HABD alarm – All channels
fi8 00	Fault injection HABD warning – None
fi8 01	Fault injection HABD warning – Channel 1

Fault Injection Commands for Firmware Version 1.2.0 and later	
Command	**Description**
fi8 02	Fault injection HABD warning – Channel 2
fi8 04	Fault injection HABD warning – Channel 3
fi8 08	Fault injection HABD warning – Channel 4
fi8 10	Fault injection HABD warning – Channel 5
fi8 20	Fault injection HABD warning – Channel 6
fi8 40	Fault injection HABD warning – Channel 7
fi8 80	Fault injection HABD warning – Channel 8
fi8 ff	Fault injection HABD warning – All channels
fi9 00	Fault injection BHD – None
fi9 01	Fault injection BHD loss of sensor – Channel 1
fi9 02	Fault injection BHD loss of sensor – Channel 2
fi9 04	Fault injection BHD alarm – Channel 1
fi9 08	Fault injection BHD alarm – Channel 2

Table 7-18: Fault injection commands for firmware version 1.2.0 and later

Additional Fault Injection Commands for Firmware Version 1.4.0	
Command	**Description**
fie 00	Fault injection MVB – None
fie 0c	Fault injection MVB – Source (transmitted) lifesign stop

Table 7-19: Additional fault injection commands for firmware version 1.4.0

Sensor Self-test Diagnostics

When TSI temperature sensor problems are suspected, you can connect a serial cable to the IMx-R TSI part after the fact, but before it has been power cycled or booted, and perform "ssr" commands to analyze the problems.

There are three "ssr" commands which display the minimum average and the maximum average for the eight TSI temperature channels since boot up. The left-most column represents channel 1 where as the right-most column represents channel 8. The statistics are cleared at boot up.

If a minimum average or maximum average is below or above the valid range, the corresponding self-test has failed.

Command	Description	Valid range of minimum and maximum average	
		FW 1.1.0, 1.2.0 and 1.3.0	FW 1.4.0
ssr0	Signal during self-test when sensor feed is disabled	0–1280	0–1280
ssr1	Sensor feed during self-test when reference is off	0–640	0–640
ssr2	Sensor feed during self-test measurement	55360-63296	55936–62592

Table 7-20: Sensor self-test diagnostics commands

Unit ID and HW Plug Information

"plug" command displays the current unit ID and hardware plug information.

Display	Description
ID: xx	Startup unit ID in hexadecimal if the unit has determined a correct unit ID. ID: 00 if system did not determine a correct unit ID.
Err: 00xx	A hexadecimal diagnostic code when the unit has not determined a correct unit ID. It may display further information on Range, Unique and/or Parity.
Plug: xx	Current hardware plug trapping bit 0 to 5 in hexadecimal
BC: xx	Bit 0 to 4 corresponding to ID plug 0 to 4 (IDPLUG0 to IDPLUG4). An unset bit indicates unstrapped as a set bit indicates strapped
P: x	Bit 5 corresponding to parity bit (IDPLUG0)
xx:	Customer Code in hexadecimal

Table 7-21: Plug TSI command

The following is an example and its descriptions;

ID: 0A   The correct unit ID is 10

PLUG: 35   Binary bit 5 4 3 2 1 0
                1 1 0 1 0 1   Plug configuration

BC: 15   Binary bit   4 3 2 1 0
                1 0 1 0 1   Bit 0, 2 and 4 are not grounded (open)
                Bit 1 and 3 are grounded

P: 1   Binary bit 5
                1   Parity bit not grounded (open)

01: 1E   Customer code in hexadecimal

MVB Safety Layer Description

MVB safety layer description is available with firmware 1.4.0.

The "mvbsl" command displays three lines consisting of a circular buffer (overwriting data to the right, then starting over from the leftmost position).

The initialization value of the buffer is "–" which means that there is no value yet.
The buffer's current position is also "–".
The value immediately to the left of "–" is the most current value, and the value immediately to the right of "–" is the oldest value.

Row	Description		
1. Safety layer state	This is the state of the safety layer (range 1 to 5)		
	1: Valid, unpack.	Certified OK	
	2: Reuse.	Time counter range switch	
	3: Invalid, defaults.	First received	
	4: Reuse.	Time-out pending	
	5: Invalid, default.	Time-out	
2. Safety layer SIL2 unpack status	This is the safety layer decision whether to unpack the dataset or not. 0: Invalid, set default 1: Reuse 2: Unpack, valid		
3. Validity of SIL2 data	This is the ultimate IMx-R decision on the validity of SIL2 data. 0: invalid 1: valid		

Table 7-22: mvbsl TSI command

Example:
mvbsl
5555555555555555-5555555555555555555555555555555555555555555
0000000000000000-0000000000000000000000000000000000000000000
0000000000000000-0000000000000000000000000000000000000000000

8
CM Event Messages

IMx-R system creates an event message on CM part when an alarm occurs.

The event messages are displayed in Event Log under On-Line interface in @ptitude Observer. Refer to @ptitude Observer User Manual on how to access Event Log.

CM Event Messages				
Type	**Class***	**Sub type**	**ID**	**Comments**
System fault	S	–	–	CM system fault
TSI Acceleration sensor fault	S	–	ch number 1 or 2	
TSI BHD danger	A	–	ch number 1 or 2	
TSI Configuration fault	S	1 = missing	None	Status of configuration
		2 = integrity error		
		3 = version error		
		4 = address error (not matching plug)		
		5 = parameter error		
TSI Environment fault	S	–	4	Internal temperature
TSI HABD danger	A	–	ch number 1 thru 8	
TSI HABD warning	A	–	ch number 1 thru 8	
TSI HW fault	S	–	–	Contact SKF CMC Luleå.
TSI ID plug fault	S	–	None	Plug parity failure
TSI MVB communication fault	S	–	0 = MVB not configured or not initialized	Status of MVB data
			1 = MVB line A inactive	
			2 = MVB line B inactive	
			3 = Lifesign error	
			4 = Safety layer, timeliness error	
			5 = Safety layer, authenticity error	
			6 = Safety layer, integrity error	

CM Event Messages				
Type	**Class***	**Sub type**	**ID**	**Comments**
TSI SW fault	S	-	-	Contact SKF CMC Luleå.
TSI Temperature sensor fault	S	-	ch number 1 thru 8	
TSI Unavailable	S	-	-	

Table 8-23: CM event messages

* S = system, A = alarm

9

CM Virtual Channels

CM virtual channels are used to transmit data from TSI part to CM part.

The configuration of CM virtual channels is done via **SKF @ptitude Observer** software when creating analogue channels for IMx-R unit with CM board.

- First, initiate an IMx-R unit with CM board via **On-line** under **MasCon/IMx units** interface of **SKF @ptitude Observer** software.

- When initiating an IMx-R unit, set the external communication type of the unit to "**TSI**".

- Create analogue channels for the unit.

- When creating analogue channels, configuration of CM virtual channels are done by selecting CM virtual channel numbers.

- For more information on initiating IMx-R units and creating analogue channels, see "@ptitude Observer User Manual".

CM virtual channels will present the following data from the TSI part.

CM Virtual Channels and Corresponding TSI Data		
Virtual Channel Number	Scale	Data description
101	1/65 536	Temperature channel 1 Vin/Vref
102	1/65 536	Temperature channel 2 Vin/Vref
103	1/65 536	Temperature channel 3 Vin/Vref
104	1/65 536	Temperature channel 4 Vin/Vref
105	1/65 536	Temperature channel 5 Vin/Vref
106	1/65 536	Temperature channel 6 Vin/Vref
107	1/65 536	Temperature channel 7 Vin/Vref
108	1/65 536	Temperature channel 8 Vin/Vref
109	0,01 ºC	Temperature channel 1 degrees
110	0,01 ºC	Temperature channel 2 degrees
111	0,01 ºC	Temperature channel 3 degrees
112	0,01 ºC	Temperature channel 4 degrees
113	0,01 ºC	Temperature channel 5 degrees
114	0,01 ºC	Temperature channel 6degrees
115	0,01 ºC	Temperature channel 7 degrees
116	0,01 ºC	Temperature channel 8 degrees
117	1 km/h	Train speed
118	-	Reserved
119	-	Reserved

CM Virtual Channels and Corresponding TSI Data		
Virtual Channel Number	**Scale**	**Data description**
120	–	Reserved
121	–	Reserved
122	–	Reserved
123	–	Reserved
124	project specific	ID number
125	0,005 g	Vibration channel 1 BHD C2 level
126	0,005 g	Vibration channel 2 BHD C2 level
127	1 count	Vibration channel 1 BHD C1 count
128	1 count	Vibration channel 2 BHD C1 count
129	1 mV	Vibration channel 1 DC
130	1 mV	Vibration channel 2 DC
131	0,01 ºC	System temperature
132	–	System status

Table 9-24: CM virtual channels and corresponding TSI data

10

Operation

Startup

System Startup

The IMx-R system initialization period at power on or reboot is maximum 30 seconds.

MVB Startup

The earliest time for MVB start is 20 seconds after the system power on or reboot. This time is needed to initialize MVB.

Safety Related Operation Recommendations

⚠️ The following operation recommendations are safety related.

- As soon as at least one of the IMx-R boxes issues a HABD alarm, a HABD condition has to be assumed and correct action needs to be taken.

- As soon as at least one of the IMx-R units on the train issues a BHD alarm, a BHD condition has to be assumed and correct action needs to be taken.

- If both IMx-R units, monitoring one bogie, are unavailable, measures have to be taken. A strong recommendation is to take the same action in this case as if BHD or HABD alarm condition has occurred.

- If HABD monitoring of a certain axle box is lost due to loss of sensor, reported HABD system fault or unavailability of corresponding IMx-R unit(s), measures have to be taken. A strong recommendation is to take the same action in this case as if HABD alarm condition has occurred.

- If BHD monitoring of a certain bogie is lost due to loss of sensor, reported BHD system fault or unavailability of corresponding IMx-R unit(s), measures have to be taken. A strong recommendation is to take the same action in this case as if BHD alarm condition has occurred.

Reliability Related Operation Recommendations

If at least one of the IMx-R units on the train issues a HABD alarm or BHD alarm, it is recommended that measures are taken in order to determine if the alarm condition is true or not (false alarm).

- HABD alarms can be checked with a hand held temperature monitoring unit. If the alarm is not verified as being false, the alarm has to be declared as true. For a true alarm condition, a HABD condition has to be assumed and correct action needs to be taken.

- BHD alarms are always declared as true since BHD alarms cannot be checked. Therefore, a BHD condition has to be assumed and correct action needs to be taken.

TSI Firmware Update

> ⚠️ *Important – The update of IMx-R TSI firmware shall be done by a person with the knowledge of IMx-R system.*

The update of TSI firmware on IMx-R units is done through **@ptitude Observer On-line Device Configurator** tool. Refer to @ptitude Oberserver On-line Device Configurator User Manual.

When a update of a TSI firmware is successfully done, the unit will reboot and display firmware information. Make sure to check the the version and checksum of the firmware.

The firmware version can also be obtained by a TSI command, "ver" using @ptitude Observer On-line Device Configurator.

In order to verify that the IMx-R is able to report alarms and system failures, a fault injection check shall be done and documented according to Fault Injection in TSI Commands chapter.

TSI Configuration Update

> ⚠️ *Important – The update of IMx-R TSI configuration shall be done by a person with the knowledge of IMx-R system.*

The TSI configuration is defined using the IMx-R TSI Configurator as described in User Selectable Configuration chapter of this manual. The download of the configuration to IMx-R units is done through @ptitude Observer On-line Device Configurator as described in the @ptitude Observer On-line Device Configurator User Manual.

When a new TSI configuration has been created or an existing TSI configuration has been updated, it has to be validated as following:

- The TSI configuration, including the configuration file name, has to be documented and stored in a text readable format.

- Each parameter has to be checked by the operator and another person, and the configuration document has to be signed by both persons.

- The TSI configuration has to be downloaded to the IMx-R unit and the start-up procedure shall end with the IMx-R entering a normal run mode.

- This start-up procedure has to be documented by copying the readout from the RS 232 port into a text document.

- The start-up procedure document shall be reviewed and signed by the operator. This review shall also contain a cross check of the name of the configuration file downloaded and the name of the configuration file reported by the IMx-R unit.

- The TSI configuration version can also be obtained by a TSI command, "vercfg" using @ptitude Observer On-line Device Configurator.

- In order to verify that the IMx-R is able to report alarms and system failures, a fault injection check shall be done and documented according to Fault Injection in TSI Commands chapter.

11

Hardware Maintenance

This chapter describes the hardware maintenance plan which should be performed on IMx-R units and sensors in order to maintain a reliable and safe system.

The maintenance plan is grouped by two different time intervals; every 29 500 hours for limited check and every 59 000 hours for general check.

The chapter also includes hardware maintenance recommendations, corrective maintenance tasks along with instructions on how to dismantle and mount IMx-R units.

⚠️ *Important – Equipment delivered by SKF must only be repaired by SKF or a SKF authorized company.*

⚠️ *Important – The hardware maintenance must be carried out in order to meet the result of reliability calculation on the IMx-R units which is done by applying the Reliability Fault Tree Analysis and Safety Fault Tree Analysis.*

Maintenance Schedule Table

Title	Task	Interval
⚠️ Visual Inspection	Visual check for damages and that cables and sensors are firmly fixed. Duration: 30 minutes Number of operators: 1 operator Tools needed: A torch	Every 29 500 Hours, Limited Check
⚠️ IMx-R Full Check	The IMx-R unit has to undergo a full routine test procedure at the workshop in Luleå in order to maintain a reliable and safe system. Duration: The IMx-R unit has to be in SKF CMC Luleå for 1 week	Every 59 000 Hours, General Check
⚠️ Temperature Sensor Test	Each temperature sensor should be controlled against an external temperature meter and against the redundant temperature sensor on each position. Duration: 30 minutes Number of operators: 2 operators Tools needed: • A laptop running SKF @ptitude Observer software with connection to the IMx-R units. • One external temperature meter, such as ThermoLaser TMTL 260	Every 59 000 Hours, General Check
⚠️ Vibration Sensor Test	This test has to be done to ensure a safe and reliable system for bogie hunting. Duration: 30 minutes Number of operators: 2 operators Tools needed: • A laptop with SKF @ptitude Observer software running with connection to the IMx-R • A Shaker • A 13 mm spanner	Every 59 000 Hours, General Check
Cable Condition Test	This test is to check if the sensor cables are electrically isolated from the cable shields. Duration: 30 minutes Number of operators: 1 operator Tools needed: • A "SKF Adapter for Cable Condition Test" tool • An ohmmeter (multimeter) • A screw driver	Every 59 000 Hours, General Check

Table 11-25: Maintenance schedule

Every 29 500 Hours, Limited Check

Visual Inspection

⚠️ A visual inspection of one IMx-R unit and cables will take about 30 minutes for one operator. No special qualification of operator is needed. A torch is needed for visual inspection so dark areas can also be inspected.

Summary

- Task: Visual inspection

- LRU: IMx-R

- Qualification of operator: No special qualification is needed.

- Time: 30 minutes

- Number of operators: 1

- Tools: A torch

1. Confirm that IMx-R units are firmly attached to the rack by the four corner screws which hold the IMx-R unit in place. Refer to Front Panel with Dimensions in IMx-R Drawings & Parts chapter for the exact locations of the mounting screws.

2. Confirm that MVB cables are firmly attached to J3 MVB1 and J2 MVB2 on the front panel of IMx-R unit.

3. Confirm that Ethernet M12 connectors are firmly attached to J5 Ethernet2 on the front panel of IMx-R unit.

4. Visual inspection shall be done on all temperature and vibration sensor cables and sensors for any damages and to confirm that all the sensors and cables are firmly fixed. Do this by inspecting each cable from the IMx-R unit to the sensor.

    - Check for any damaged cables, for example damages done by stones hitting the cables. Damaged cables must be replaced.

    - To replace a temperature sensor refer to Replacing Temperature Sensor under Corrective Maintenance Tests in this chapter.

    - To replace a vibration sensor including the integrated cable, refer to Replacing Vibration Sensor under Corrective Maintenance Tasks in this chapter.

    - Check for any loose cables such as loose cables caused by broken cable attachments. Loose cables have to be firmly attached again.

Every 59 000 Hours, General Check

IMx-R Full Check

⚠️ The full check of the IMx-R has to be done every 59 000 hours on all IMx-R units in operation.

The test of the IMx-R unit in SKF CMC Luleå will take 1 week.

- Dismount the IMx-R unit as described in <u>Dismantling IMx-R</u> in this chapter.

- Send the IMx-R unit to CMC Luleå.

- The IMx-R unit will undergo the full routine test procedure at the workshop in Luleå.

If the unit passes the test, it will be sent back to the operator.

If the unit does not pass the test, a recommendation will be to replace cards or components to the point where the unit will be fully ok and pass the test. If it is not possible to replace cards or components in order to pass the unit test, a strong recommendation will be to discard the unit and replace it with a new unit.

Temperature Sensor Test

⚠ All temperature sensors shall be tested against two independent sources. Each temperature sensor should be controlled against an external temperature meter and against the redundant temperature sensor on each position. The aim of the test is to identify any temperature sensor that has been drifted.

Summary

- Task: Temperature sensor test

- LRU: IMx-R

- Qualification of operator: Knowledge of how to use SKF @ptitude Observer software

- Time: 30 minutes

- Number of operators: 2

- Tools: A laptop with SKF @ptitude Observer software and an external temperature meter

Descriptions of the tools needed for performing the temperature sensor test:

- A laptop running SKF @ptitude Observer software with connection to the IMx-R units. SKF @ptitude Observer software can be purchased from SKF CMC Luleå.

- One external temperature meter such as a ThermoLaser TMTL 260. See the picture below. This ThermoLaser can be purchased at any local SKF office throughout European countries.

Figure 11-14: Example of ThermoLaser TMTL 260 in use

It will take about 30 minutes for two people to complete the temperature sensor test per IMx-R unit. The operators performing this test should be comfortable using SKF @ptitude Observer software for checking the data coming from the IMx-R unit. At least one of the operators performing this task needs to have the IMx-R and SKF @ptitude Observer software training. The IMx-R and SKF @ptitude Observer software training can be provided by SKF CMC Luleå.

To perform the test, one of the operators has to be inside of the train monitoring the sensor values in SKF @ptitude Observer software and the other operator has to be outside of the train with the temperature meter pointing to the sensor which should be checked.
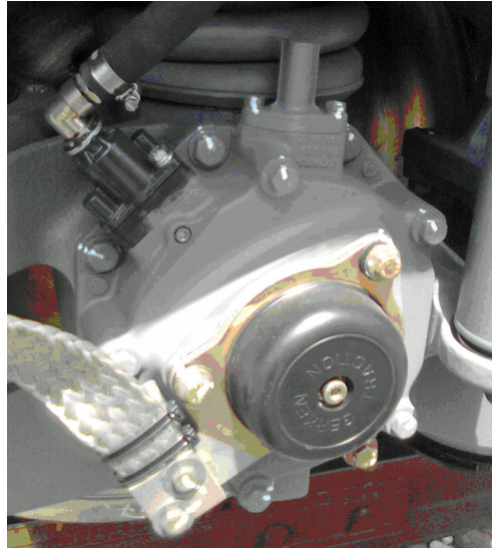

Figure 11-15: Example of a bearing house

It is important that if the sensor is located inside a bearing house (as shown in the picture above, for example), the temperature of the sensor and the temperature of the surface of the bearing house must be the same. Therefore, if the train was in operation right before the test, it is required to let the train stand still for at least three hours in order to even out the temperature differences.

However, if three hours of stand still cannot be reached before the test, then it is required to remove the cover in order to get to the sensor as close as possible. In this case, the laser beam from the temperature meter must be pointed directly towards the sensor.

- In SKF @ptitude Observer software, check the values for both redundant temperature sensors on one axle box.

- At the same time the temperature of the surface of the axle box should be checked with the ThermoLaser.

- Maximum allowed deviation is ±5 ºC for all three sensors.

- The aim of this test is to identify if any of the temperature sensors has been drifted

If one temperature sensor/cable does not pass the test, it will have to be replaced. See Replacing Temperature Sensor under Corrective Maintenance Tasks in this chapter.

Vibration Sensor Test

⚠️ The vibration sensor test shall be performed on all vibration sensors. This test has to be carried out in order to meet the result of reliability calculations on the IMx-R which is done by applying the Reliability Fault Tree Analysis and Safety Fault Tree Analysis.

Summary

- Task: Vibration sensor test

- LRU: IMx-R

- Qualification of operator: Knowledge of how to use SKF @ptitude Observer software

- Time: 30 minutes

- Number of operators: 2

- Tools: A laptop with SKF @ptitude Observer software, a portable Shaker and a 13 mm spanner

Descriptions of the tools needed for performing the vibration sensor:

- A laptop running SKF @ptitude Observer software with connection to the IMx-R units. SKF @ptitude Observer software can be purchased from SKF CMC Luleå.

- A portable Shaker. This Shaker is a tool which creates a known frequency at a known amplitude. The vibration sensor to be tested can be mounted on the Shaker and the values presented in SKF @ptitude Observer software should be according to what the Shaker creates. The recommended Shaker for this test is from PCB Piezotronics Inc which can be purchased from SKF CMC Luleå. The part number for this Shaker is "9100C". It needs to be ordered with a mounting base for M8.

- A 13 mm spanner to loosen the sensor from the bogie frame

It will take about 30 minutes for two people to perform the vibration sensor test per IMx-R unit. The operators performing this test should be comfortable using the SKF @ptitude Observer software for checking the data coming from the IMx-R. At least one of the operators performing this task needs to have the IMx-R and SKF @ptitude Observer software training. This IMx-R and SKF @ptitude Observer software training can be provided by SKF CMC Luleå.

To perform the test, one of the operators has to be inside of the train monitoring the sensor values in SKF @ptitude Observer software and the other operator has to be outside of the train with the Shaker where the vibration sensor can be mounted.

- To check a sensor, start with disconnecting the vibration sensor from the frame. Do this by unscrewing the bolt that holds the sensor to the surface. Use the 13 mm spanner to loosen the bolt.

- Mount the sensor to the Shaker. It should only be hand tightened. No tools should be used for mounting the sensor to the Shaker.

- The recommended output frequency for this test is 100 Hz at 5 g peak.

- One of the operators has to be outside of the train operating the Shaker and making sure that the Shaker stands still on a stable flat piece of ground or floor.

- The other operator needs to monitor sensor values in SKF @ptitude Observer software.

- In SKF @ptitude Observer software, a spectrum from the sensor should be opened in live mode so that the 100 Hz peak can be viewed.

- The peak in SKF @ptitude Observer software at 100 Hz should be 5 g peak according to the chosen parameter on the Shaker.

- Maximum allowed deviation is ±10%.

- The BOV from the sensor should also be between 8 and 13 Volts. If the BOV is outside of this range, then it is something wrong with the sensor or the cable.

- After the sensor has been tested, mount the sensor back to its original place.

If a vibration sensor does not pass the test, then it has to be replaced. Refer to Replacing Vibration Sensor under Corrective Maintenance Tasks in this chapter.

Cable Condition Test

Cable condition test should be done on all cables. This is done to ensure that there is no electrical connection between cable shield and the sensor + and – wires inside of the cable.

Summary

- Task: Cable condition test

- LRU: IMx-R

- Qualification of operator: Knowledge of how to operate an ohmmeter

- Time: 30 minutes

- Number of operators: 1

- Tools: A "SKF Cable Adapter for Cable Condition Test", one ohmmeter and a screw driver

Descriptions of the tools needed for performing the cable condition test:

- One SKF Cable Adapter for Cable Condition Test. This tool can be purchased from SKF CMC Luleå. The part number is "I429.1303".

Figure 11-16: A SKF Cable Adapter for Cable Condition Test

- One ohmmeter (multimeter).

- A screw driver to loosen four screws that hold the IMx-R to the rack.

It will take 30 minutes for one operator to complete the cable condition test for one IMx-R unit. The operator needs to know how to operate an ohmmeter.

- To do the cable condition test, start by removing the IMx-R from the rack. Follow the dismantling procedure described in Dismantling IMx-R section in this chapter.

- Insert the SKF Adapter for Cable Condition Test to the empty rack slot.

- Then use the ohmmeter to check that there is no electrical connection between any of the cable wires and the PE which is the same as cable shield.

Figure 11-17: Recommended ohmmeter setup

- Set the ohmmeter to beep if there is a connection as shown in the picture, above.

- Measure if there is any connection between TSI ACC 1+ to TSI ACC 8+, CM ACC/TEMP 9+ to CM ACC/TEMP 12+, TSI TEMP 1+ to TSI TEMP 8+, TSI SPEED 1A to TSI SPEED 4A, TSI SPEED 1B to TSI SPEED 4B, GND and the PE (shield). Refer to Pinout of Rear Connectors in IMx-R Drawings & Parts chapter for the position of connectors.

- This is done by inserting one of the cables from the ohmmeter to the connector marked PE (shield) on "SKF Adapter for Cable Condition Test". The other cable from the ohmmeter should be placed in the connector for all other wires TSI ACC 1+ to TSI ACC 8+ and so on. When both cables from the ohmmeter are inserted to the "SKF Adapter for Cable Condition Test", the rotating switch on the Adapter can be turned to check all TSI ACC 1+ to TSI ACC 8+ and so on. During this test, there should not be any connection between PE (shield) and the other wires.

- When all wires are checked the "SKF Adapter for Cable Condition Test" should be removed from the slot.

- Mount the IMx-R unit according to the procedure described in Mounting IMx-R in this chapter.

If a cable fails the test, it needs to be investigated as to where the problem lies.

- Do this by first performing a Visual Inspection according to Every 29 500 Hours, Limited Check maintenance.

- If a broken cable is found, then it should be replaced.

- If no broken cables are found in the visual inspection, cables can be replaced until the cable condition test is done with positive result. Follow the procedure Replacing Vibration Sensor and Replacing Temperature Sensor under Corrective Maintenance Tasks in this chapter when replacing sensors and cables.

Maintenance Recommendations

> ⚠️ *Important – If one IMx-R becomes unavailable for HABD, BHD or both HABD and BHD due to sensor failure or internal IMx-R failure, the IMx-R unit and/or sensor must be replaced at the next inspection.*

> ⚠️ *Important – A train is not allowed to be in operation for more than 74 hours with a faulty sensor or a faulty IMx-R unit.*

Sensor Functionality Check

It is recommended that the functionality of HABD and BHD sensors be validated periodically, at least once every three months or whenever a sensor has been installed or replaced, in order to detect drift failures.

IMx-R unit including CM part and @ptitude Observer are required to fulfill this sensor functionality check.

The sensor functionality check can be done through @ptitude Observer. Information on how to create measurement points in the CM part is described in the @ptitude Observer User Manual.

BHD Sensor Functionality Check

Measurement of all enabled BHD channels will be checked for acceptable active range. If a measurement is out of the acceptable active range, a system alarm will be triggered and an error will be reported in the @ptitude Observer System Alarm Log.

This check is done to detect a failure rate originated by a failure mode "no signal" when BOV measurement indicates normal.

Each BHD sensor functionality check shall be recorded as a document containing a printout of the System Alarm Log.

To enable BHD sensor check, do as following:

- For each IMx-R unit, create a Speed measurement point reading the train speed.

- For each enabled BHD channel, create a "Vibration" measurement point in the CM part with the following key parameter settings;

  - ✓ Trend RMS frequency range: 2 to 2 000 Hz
  - ✓ Active Range: 100 to 360 km/h
  - ✓ Measurement Range: 0,005 to 50 g

HABD Sensor Functionality Check

Each pair of HABD sensors, located on the same axle box, will be checked for temperature deviance. If the temperature measurements differ too much, an alarm will be triggered and a warning/danger message will be reported in the @ptitude Observer Alarm List.

The result of each HABD sensor's functionality check shall be recorded as a document containing a printout of the HABD Sensor Check part of the Alarm List.

To enable HABD sensor check, do the following:

- For each train, create a node called "HABD Sensor Check" in @ptitude Observer.

- For each pair of HABD sensors, located on the same axle box, create a "Derived point" measurement point that calculates the temperature difference between the two temperature measurements with the following key parameters;

  ✓ High alarm: 20 ºC
  ✓ High warning: 10 ºC
  ✓ Low warning: –10 ºC
  ✓ Low alarm: –20 ºC

Cable Grounding and Shielding Check

The validation of cables is recommended to be done whenever a cable has been installed or replaced in order to detect drift failures.

This check is divided into five sub tests.

The test equipment needed is an Insulation and Continuity Tester, set to measure resistance.

Test 1 – Ground Loop

This test is to verify that the shielding is not connected in a "ground loop".

- The cables/IMx-R inputs to be checked are the following. See Pinout of Lower Rear Connector (J10) for physical locations.

  ✓ TSI TEMP 1 to 8: eight analogue temperature sensors
  ✓ TSI ACC 1 to 8: eight analogue acceleration sensors
  ✓ TSI SPEED 1 to 4: four digital speed sensors
  ✓ CM ACC/TEMP 9 to 12: four analogue combination sensors

- To perform this test, the cable shielding is isolated by opening the cabinet connector and isolate it.

- Then the resistance is measured between ground and shield.

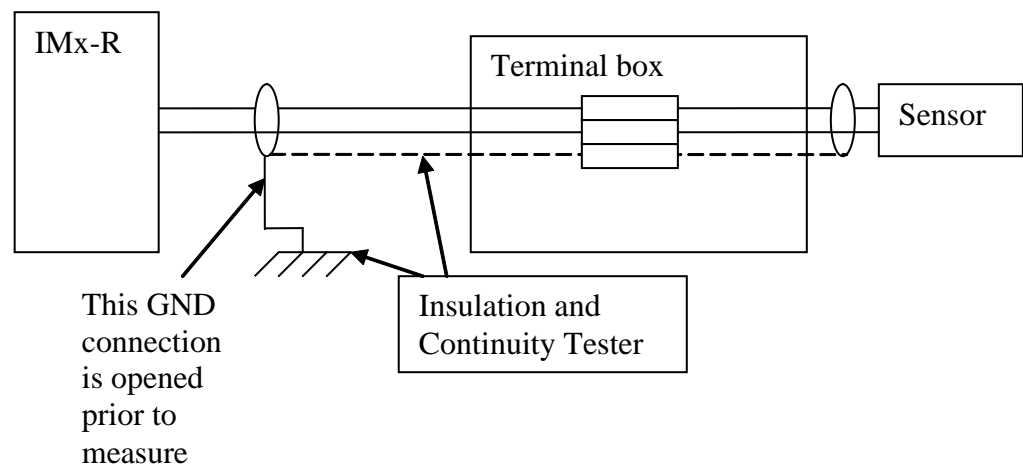- The expected result should be a very high resistance value, > 1 MΩ, showing no connection.

Figure 11-18: Cable grounding and shielding check – Ground loop test

Test 2 – Shield Continuity

This test is to verify that the shielding is not discontinued in a terminal box or connector.

- The cables/IMx-R inputs to be checked are the following. See Pinout of Lower Rear Connector (J10) for physical locations.

  - ✓ TSI TEMP 1 to 8: eight analogue temperature sensors
  - ✓ TSI ACC 1 to 8: eight analogue acceleration sensors
  - ✓ TSI SPEED 1 to 4: four digital speed sensors
  - ✓ CM ACC/TEMP 9 to 12: four analogue combination sensors

- To perform this test, the cable shielding is isolated by opening the cabinet connector and isolate it.

- Then the resistance is measured between the shield close to the IMx-R and the shield close to the sensor (at sensor connection in junction box close to sensor).

- The expected result should be a very low resistance value, < 5 Ω, showing connection.

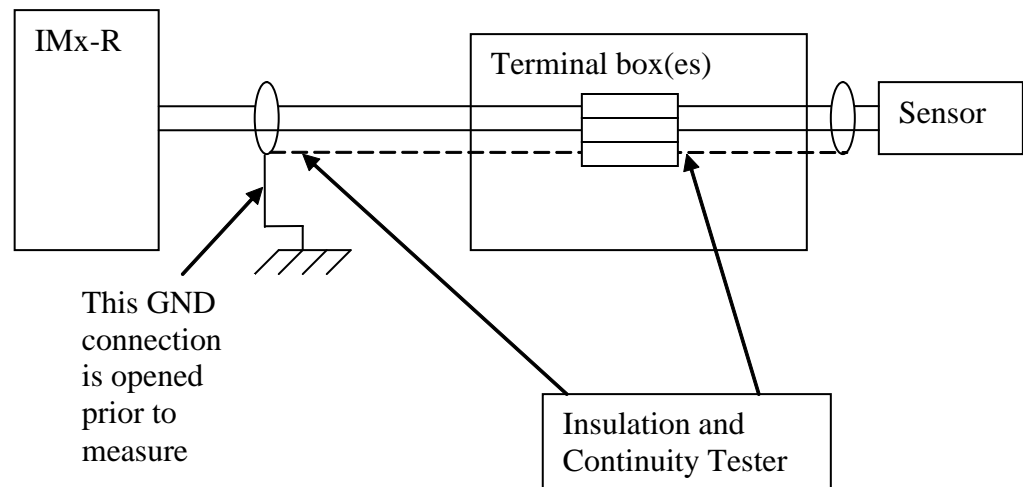Figure 11-19: Cable grounding and shielding check – Shield continuity test

Test 3 – Sensor Wire Isolation

This test is to verify that the sensor wires are not in connection with the cable shielding.

- The cables/IMx-R inputs to be checked are the following. See Pinout of Lower Rear Connector (J10) for physical locations.

  ✓ TSI TEMP 1 to 8: eight analogue temperature sensors
  ✓ TSI ACC 1 to 8: eight analogue acceleration sensors
  ✓ TSI SPEED 1 to 4: four digital speed sensors
  ✓ CM ACC/TEMP 9 to 12: four analogue combination sensors

- To perform this test, the sensor wires should be disconnected from the IMx-R.

- Then the resistance is measured between the shield and the sensor wires, first measure one wire to the shielding then the other wire to the shielding.

- The expected result should be a very high resistance value, > 1 MΩ, showing no short circuit.
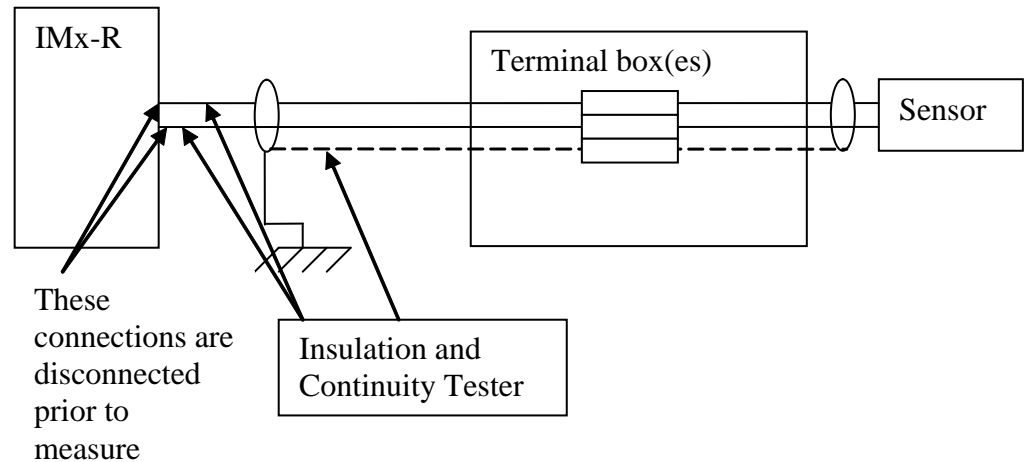

Figure 11-20: Cable grounding and shielding check – Sensor wire isolation test

Test 4 – Sensor Return Isolation

This test is to verify that the sensor "–" wire is not in connection with the train ground.

- The cables/IMx-R inputs to be checked are the following. See Pinout of Lower Rear Connector (J10) for physical locations.

  ✓ TSI TEMP 1 to 8: eight analogue temperature sensors
  ✓ TSI ACC 1 to 8: eight analogue acceleration sensors
  ✓ TSI SPEED 1 to 4: four digital speed sensors
  ✓ CM ACC/TEMP 9 to 12: four analogue combination sensors

- To perform this test, the sensor wires should be connected to the IMx-R. To access sensor wires it can be done at the rear connector or by using an extension board/box.

- Then the resistance is measured between the shield and the sensor "–" wire.

- The expected result should be a very high resistance value, > 1 MΩ, showing no connection between instrument ground and train ground.
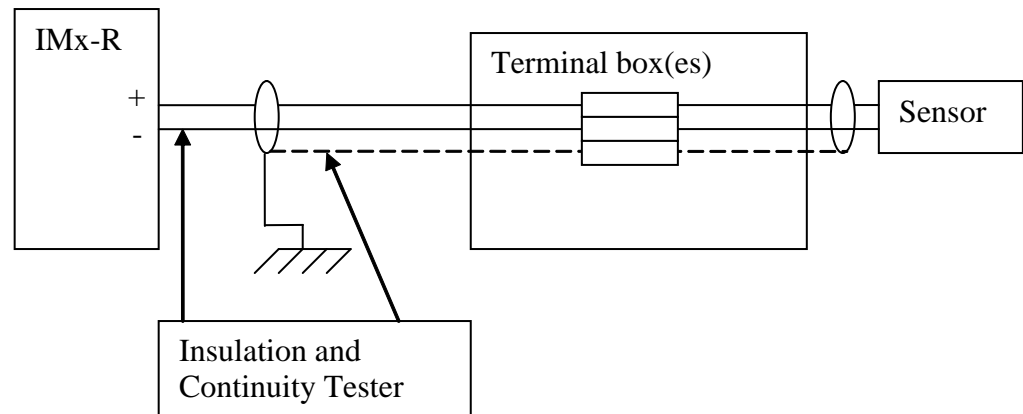
Figure 11-21: Cable grounding and shielding check – Sensor return isolation test

Test 5 – Cable Resistance for HABD Sensors

This test is to verify that the signal wires provide a good connection between the IMx-R unit and the sensor, through all connectors and junction boxes.

- The cables/IMx-R inputs to be checked are the following. See <u>Pinout of Lower Rear Connector (J10)</u> for physical locations.
  - ✓ TSI TEMP 1 to 8: eight analogue temperature sensors

- To perform this test, the sensor has to be disconnected from the axle box and the signal wires have to be connected to each other.

- Then the resistance is measured between the "+" wire and the "-" wire.

- The expected result should be a resistance < 6 Ω.

- A resistance > 6 Ω will lead to a measurement result showing a higher temperature than the actual temperature of the axle box.
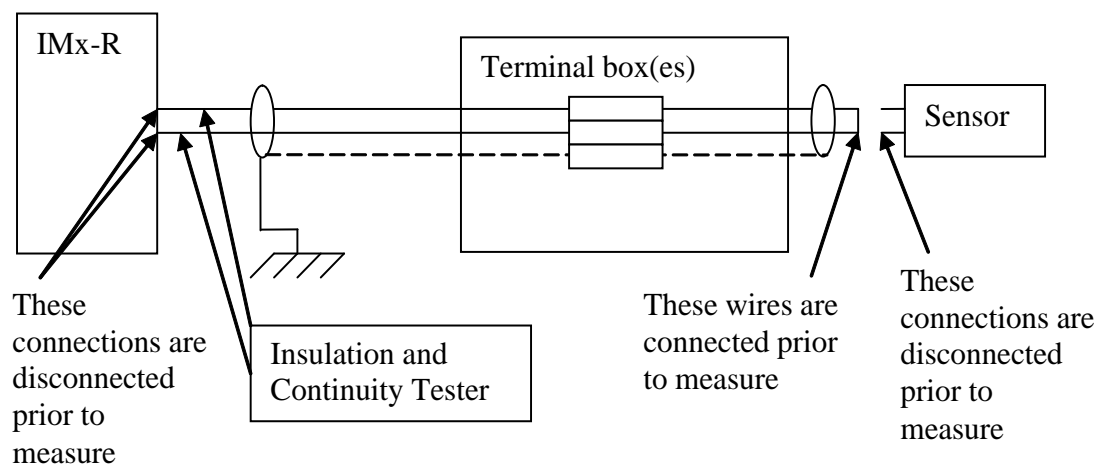
Figure 11-22: Cable grounding and shielding check – Cable resistance for HABD sensors

Corrective Maintenance Tasks

Replacing Temperature Sensor

Replacing Temperature Sensor Including Cable

For TBU temperature sensors, perform the instructions described in "Mounting Manual TBU Sensor" which is as an external document.

To ensure that the temperature sensor is operating properly after the mounting, the temperature sensors have to be tested against the redundant temperature sensor on each position.

Summary for checking if the temperature sensor has been mounted and wired correctly:

- LRU: IMx-R

- Qualification of Operator: Knowledge of how to use SKF @ptitude Observer software

- Time: 10 minutes

- Number of operators: 1

- Tools: A laptop with SKF @ptitude Observer software

Description of the tools needed to do a check on the temperature sensor after a replacement of the sensor:

- A laptop running SKF @ptitude Observer software with connection to the IMx-R unit. SKF @ptitude Observer software can be purchased from SKF CMC Luleå.

Procedure for checking the temperature sensor after replacing:

- Start SKF @ptitude Observer software and establish a connection to the IMx-R unit.

- Open a SKF @ptitude Observer software window with both redundant sensors on one axle box.

- View the readings in live mode.

- The values have to be within ±5 ºC for all three sensors.

- Perform HABD Sensor Functionality Check described in Sensor Functionality Check under Maintenance Recommendations in Hardware Maintenance chapter.

Replacing Vibration Sensor

Replacing Vibration Sensor Including Integrated Cable from Sensor to First Junction Box

If a vibration sensor or cable is broken, it is necessary to replace the sensor with integrated cable. It will take about 30 minutes for two operators to replace one sensor including integrated cable. The operators need to have knowledge about IMx-R and the sensor system. The IMx-R training is a must for one of the operators performing this task.

Summary

- Task: Replacing of Vibration sensor

- LRU: IMx-R

- Qualification of Operator: Knowledge of IMx-R and sensor system. IMx-R training is a must.

- Time: 30 minutes

- Number of operators: 2

- Tools: One 13 mm spanner, a torch, a laptop with SKF @ptitude Observer software and a rubber hammer

- The train needs to be in a pit to be able to replace a vibration sensor

Descriptions of the tools needed for replacing vibration sensor:

- One 13 mm spanner

- A torch can be good to have if the sensor is located at a dark place

- A laptop running the software SKF @ptitude Observer software with connection to the IMx-R units. SKF @ptitude Observer software can be purchased from SKF CMC Luleå.

- A rubber hammer

To replace the sensor and integrated cable:

- Start by locating the sensor.

- With the 13 mm spanner unscrew the bolt that holds the sensor to the surface of the frame.

- Detach the integrated sensor cable from the first junction box.

- If the cable is attached to surrounding material, unhook it from its attachments and pull it out of the train.

- Then take the new sensor with integrated cable and attach it to the junction box and the sensor to the same location on the frame as the previous sensor.

- Use the same type of attachments for the cable as was for the previous sensor cable.

- To check that the sensor is correctly attached to its position, place one hand on the sensor and make sure it is not loose.

Procedure for checking the vibration sensor after replacing:

- To make sure that the signal from the sensor is coming into the IMx-R, check SKF @ptitude Observer software that BOV is in the range of 8 to 13 Volts.

- Also in SKF @ptitude Observer software, open a live time signal for the newly replaced sensor. One operator should be outside the train hitting close to the sensor with a rubber hammer and the other operator should be inside the train viewing SKF @ptitude Observer software live time signal. The hits should be in the frequency of 2 to 3 Hz. Check that these hits are presented in the time signal for the sensor to assure that the sensor is working and attached to the correct channel in the IMx-R unit.

- Perform BHD Sensor Functionality Check described in Sensor Functionality Check under Maintenance Recommendations in Hardware Maintenance chapter.

Spare vibration sensors can be ordered from SKF CMC Luleå

- A vibration sensor with 1,25 meter integrated cable has a part number "I429.1250".

- A vibration sensor with 3,05 meter integrated cable has a part number "I429.3050".

Replacing IMx-R Unit

Refer to Dismantling IMx-R and Mounting IMx-R in this chapter.

Dismantling IMx-R

Summary

- Task: Dismantling an IMx-R unit

- LRU: IMx-R

- Qualification of Operator: Knowledge of IMx-R and sensor system. IMx-R training is a must.

- Time: About 15 minutes to dismantle an IMx-R unit

- Number of operators: 1

- Tools: A screwdriver, a laptop with SKF @ptitude Observer software and a null modem serial cable

Descriptions of the tools needed for dismantling an IMx-R:

- A screw driver to unscrew the four mounting screws that hold the IMx-R unit to the rack.

- A laptop running SKF @ptitude Observer software with connection to the IMx-R unit.

- A null modem serial cable. This cable is needed for the serial interface to save the currently running TSI configurations to the laptop. For the description of the null modem serial cable, see RS232 under General Electrical Interface in Electrical Interface chapter.

A spare IMx-R unit can be purchased from SKF CMC Luleå which has a part number "CMON 2004".

Before the dismantling of IMx-R, it is necessary to store the configuration running in the TSI part of the IMx-R if the same configuration is going to be used for the newly mounted IMx-R unit.

- Approach the IMx-R unit that is going to be replaced.

- Insert the RS232 null modem serial cable to the J6 RS232 TSI (position shown in Front Connectors in IMx-R Drawing & Parts chapter) and the other end of the cable to the laptop.

- Start **SKF @ptitude On-line Device Configurator** in the laptop. You may refer to the documentation "SKF @ptitude On-line Device Configurator User Manual" for more information.

- Click on **Start IMx-R TSI serial interface**.

- Choose a serial port for **Select COM port**. Usually the port number is 1. However, if port number 1 is in use by another program, any other port number can be used.

- Click on **Get Config**.

- Store this configuration on any of the drives in the laptop.

- When the configuration is stored, remove the RS232 null modem cable from the IMx-R unit.
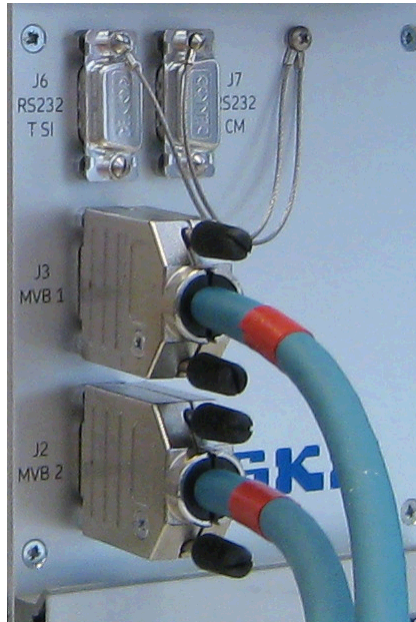
Now the dismantling of the IMx-R can start:

Figure 11-23: MVB serial communication cables

1. Detach both MVB serial communication cables from J3 MVB 1 and J2 MVB 2 connectors located in the lower left corner of the IMx-R front panel (positions shown in Front Connectors in IMx-R Drawing & Parts chapter).

Figure 11-24: Ethernet cable

2. Detach the Ethernet cable from J4 Ethernet 1 connector located in the upper left corner of the IMx-R front panel (position shown in Front Connectors in IMx-R Drawing & Parts chapter).

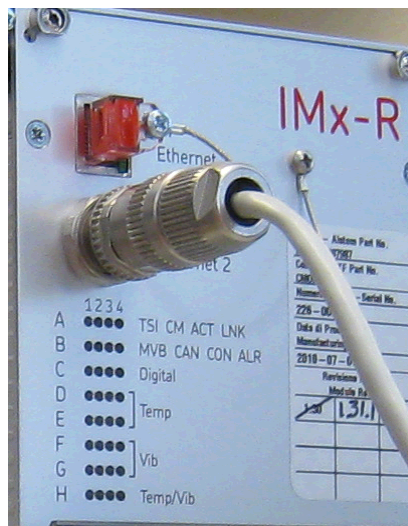3. Unscrew the 4 screws on the corners of the front panel. These screws hold the IMx-R unit to the rack. For the exact locations of the four mounting screws, see Front Panel with Dimensions in IMx-R Drawing & Parts chapter.
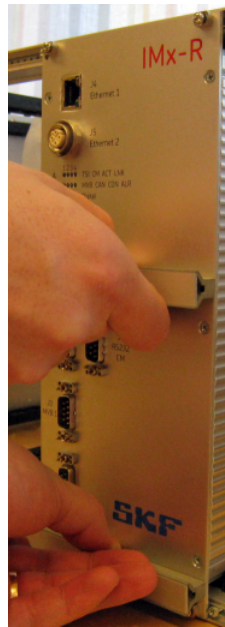
Figure 11-25: IMx-R front panel handles

4. When the 4 screws are loose, use both hands, one hand on each handle of the IMx-R front panel, and pull the IMx-R unit out. Pull the unit all the way out and away from the rack.

5. Inspect the IMx-R unit while still holding the unit. Look after mechanical damages, dirt, corrosion or anything that seems unusual.

Figure 11-26: IMx-R pins on the backside

6. Inspect the pins on the backside of the IMx-R unit. Also inspect the rack mounting position where the IMx-R should be mounted so that nothing unusual can be seen there.

Mounting IMx-R

Summary

- Task: Mounting an IMx-R unit

- LRU: IMx-R

- Qualification of Operator: Knowledge of IMx-R and sensor system. IMx-R training is a must.

- Time: About 30 minutes including tests

- Number of operators: 1

- Tools: A screwdriver, a laptop with SKF @ptitude Observer software and a null modem serial cable

Descriptions of the tools needed for mounting an IMx-R:

- A screw driver to screw the four mounting screws that hold the IMx-R unit to the rack.

- A laptop running SKF @ptitude Observer software with connection to the IMx-R unit.

- A null modem serial cable. This cable is needed for the serial interface to download TSI configurations to IMx-R from the laptop. For the description of the null modem serial cable, see RS232 under General Electrical Interface in Electrical Interface chapter.

It will take about 15 minutes for one operator to mount one IMx-R unit. In addition, it will take about 15 minutes for one operator to complete the tests indicated at the end of the mounting procedure for one IMx-R unit.

A spare IMx-R unit can be purchased from SKF CMC Luleå which has a part number "CMON 2004".

1. Take out the IMx-R unit from its cover. IMx-R units are usually shipped in a carton from SKF CMC Luleå.

2. Hold the unit with both hands, one hand on each handle.

3. Inspect the unit so that no mechanical damages, dirt, corrosion or anything unusual can be seen on the IMx-R unit. Specially, inspect the pins on the back of the IMx-R unit that all of them are straight and clean.

4. Inspect the rack slot where the IMx-R unit is going to be installed.

5. While holding the IMx-R unit with both hands, insert it gently into the rack position. Make sure it is inserted all the way in by pushing it with your hands. If the unit gets stuck half way in, do not force it further. Instead, take the unit out and inspect the rack before trying it again.

Figure 11-27: IMx-R unit last mm pushed by hand

6. The last mm should be pushed with hands without using the screws. The screws or the rack may get damaged if the screws are used to push the unit into the position.

7. When the IMx-R unit is inserted all the way in, screw in the 4 screws located on each corner of the front panel of the IMx-R. This secures the IMx-R unit in the correct position. Refer to 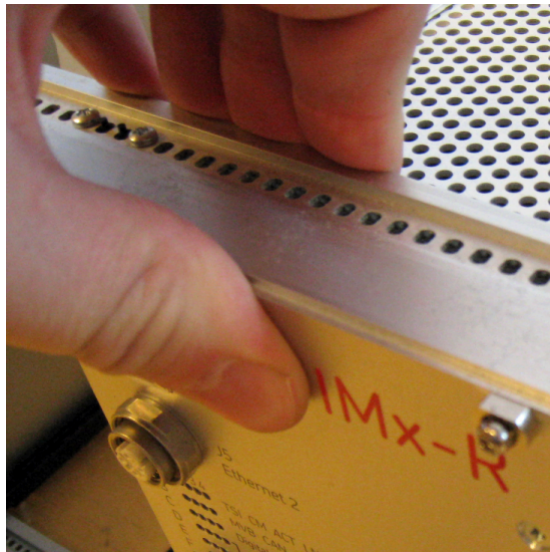Front Panel with Dimensions in IMx-R Drawing & Parts chapter for the exact locations of mounting screws and the torque value.

8. Attach both MVB serial communication cables to the MVB sockets, J3 MVB1 and J2 MVB2, located on the lower left part of the IMx-R front panel

9. Attach the Ethernet to the Ethernet socket, J4 Ethernet 1 located on the upper left corner of the IMx-R front panel.

10. After the IMx-R is mounted and all the cables are attached, the TSI configuration file must be downloaded to the IMx-R unit.

- Insert the RS232 null modem serial cable to the J6 RS232 TSI port and the other end of the cable to the laptop.

- Start **SKF @ptitude On-line Device Configurator** in the laptop. You may refer to "SKF @ptitude On-line Device Configurator User Manual" for more information.

- Click on **Start IMx-R TSI serial interface**.

- Choose a serial port for **Select COM port**.

- Click on **Download Config**.

- Chose the correct configuration file. If this is a replacement, then the configuration file which was stored before the dismantling should be downloaded to this new unit.

- The condition monitoring part of the IMx-R will get the firmware and configuration file from the database when the new IMx-R unit gets connected to SKF Observer @ptitude Monitor.

- Check the validity of the TSI configuration update by following the instruction given in TSI Configuration Update under Operation chapter.

11. After the TSI configuration is inserted to the new IMx-R unit, insert <u>network configuration</u> (described in CM Part Network Configuration chapter) parameters such as IP address to the CM part of the IMx-R unit.

- Insert the RS232 null modem serial cable to <u>J7 RS232 CM</u> port and the other end of the cable to the laptop.

- In the laptop start **SKF @ptitude Online Device Configurator**.

- Click on **Create a Network and ID configuration file for IMx**.

- Set configure by **Software** and the device number.

- Then type in the correct IP address for the unit. If this is a replacement of a unit then insert the same parameters of the old unit in the new unit.

- Save the file.

- Click on **Start serial interface for IMx.**

- Choose serial port in the upper left corner.

- Click on **Update network config**.

- Choose the correct file for this IMx unit.

- It will take about 30 seconds to download the file.

- The unit will be rebooted and the new IP address will be displayed in the startup procedure.

When the IMx-R CM part starts up with the correct IP address and gets connected to the @ptitude Observer Monitor application and the database, the latest firmware present in the database will be downloaded to the CM part of the IMx-R.

12. Check the following LED states on the newly mounted IMx-R unit to see if everything is ok. Refer to LED indicators in "IMx-R User Manual" for more information.

- TSI LED must be OFF

- CM LED must be OFF

- LINK LED should be ON

- ACT LED can be flashing if there is a connection to Monitor and traffic is on the network between IMx-R and SKF Observer @ptitude Monitor

- MVB LED must be ON if IMx-R is using MVB for communication

- CON LED should be ON if there is connection to SKF Observer @ptitude Monitor

- ALR LED should be OFF. If it is ON, investigate and find out why it is in alarm.

- All temperature channels in use must have the LED ON

- All vibration channels in use must have the LED ON

- All vibration/temp channels in use must have the LED ON

If any LED status on the IMx-R unit differs from the above listed states, the problems must be solved in order to achieve the correct LED states.

13. A check should be done in @ptitude Observer software to see that the new unit is correctly configured.

- Open **@ptitude Observer software** program

- Click on **On-line** in the menu bar and select **MasCon/IMx units** which will display all the configured MasCon and IMx units.

- Check that the new unit is enabled. If it is not enabled, select the new unit then press the **Edit** button and enable it.

- Check that the new unit is synchronized. If it is not synchronized, select the new unit then press the **Synchronize** button to synchronize it.

- Check that the new unit is connected. If it is not connected, start by checking the network cable between the unit and the laptop/network. Then check that the correct IP address was inserted to the new unit and that the correct unit ID is inserted to the IMx-R CM part.

12
Technical Data

Environmental

- 19" rack mounted according to IEC 60297
- Size (H x W x D): 262 × 107 × 232 mm (*10.3 x 4.2 x 9.1 in.*)
- Weight: 3 kg (*6.6 lb.*)
- Ambient temperature according to EN 50155, class TX
- EMC according to EN 50121-3-2
- Vibration and shock according to EN 61373, category 1B
- Encapsulation IP 20
- Humidity maximum 95% condensed according to EN 50125-1, class T3
- Altitude according to EN 50155 and EN 50125-1, usage up to 1 400 m (*4 593 ft.*)

Power Supply

- 24 to 120 V DC according to EN 50155

Analogue Inputs - TSI

- 16 analogue inputs:
  - Eight acceleration sensors
  - Eight temperature sensors
- Selectable standard accelerometer power supply (4 mA)
- Input range: 0 to 20 V
- Impedance: >40 kΩ for acceleration inputs

Analogue Inputs - CM

- 20 analogue inputs:
  - Eight acceleration sensors (TSI analogue inputs)
  - Eight temperature sensors (TSI analogue inputs)
  - Four general type of sensors (vibration, temperature, voltage, current, etc)
- Selectable standard accelerometer power supply (4 mA)
- Input range: 0 to 25 V
- Impedance: >40 kΩ for acceleration inputs

Digital Inputs - TSI & CM

- Four digital isolated inputs
- Individual 24 V power supply, maximum 40 mA/channel

Outputs - TSI

- Two relay outputs for monitoring alarm
- One relay output for system status

Analogue Measurement - TSI

- 16-bit AD conversion, acceleration input 0 to 2 kHz (no gain or AC/DC switching necessary)
- 10-bit AD conversion, temperature input (NTC/PT1000)

Analogue Measurement - CM

- 24-bit AD conversion enabling continuous transient capture (no gain or AC/DC switching necessary)
- True simultaneous sampling of all 12 vibration channels (no multiplexing)
- Simultaneous sampling of different channels with different sampling rates
- Frequency range: DC to 40 kHz
- Dynamic range: 120 dB
- Signal to noise ratio: 90 dB
- Cross-talk rejection: 100 dB
- Accuracy amplitude: ±2%, phase ±3° (up to 100 Hz)

Digital Measurement - TSI & CM

- Frequency range: 0,1 Hz to 20 kHz
- Accuracy frequency: 0,01%
- Pulse counting

Signal Processing - TSI

- BHD (bogie hunting detection) according to EN 14363:2005
- HABD (hot axle box detection) according to prEN 15437-2
- Watchdog and self testing

Signal Processing - CM

- Time waveform
- Vector analysis with circular alarms
- FFT: 100 to 6 400 lines
- DPE (Digital Peak Enveloping) and SKF Acceleration Enveloping
- Integration/derivation in frequency domain
- Window function: Hanning
- Customer formulated mathematical equations
- Dynamic alarm levels, active range determined on multiple parameters
- Data storage on time, event or alarm condition
- Data buffering in flash memory when communication link is down
- Detection of sensor and cable fault

Interface - TSI

- RS232 service interface
- MVB

Interface - CM

- Ethernet:
  - 100 Mbit RJ45 and M12 connectors
  - TCP/IP, switch functionality, auto crossover
- RS232 service interface
- RS485/Modbus
- CAN bus (not implemented)

Miscellaneous

- Calibration, traceable to BIPM
- CE certified according to EN 61000-6-3 and EN 61000-6-2
- SIL2 certification on request

Quality Control

SKF Condition Monitoring Center Luleå is ISO 9001:2008 certified.

13

IMx-R Drawings & Parts

Front Connectors

The following diagram is the front plate showing the positions of connectors.
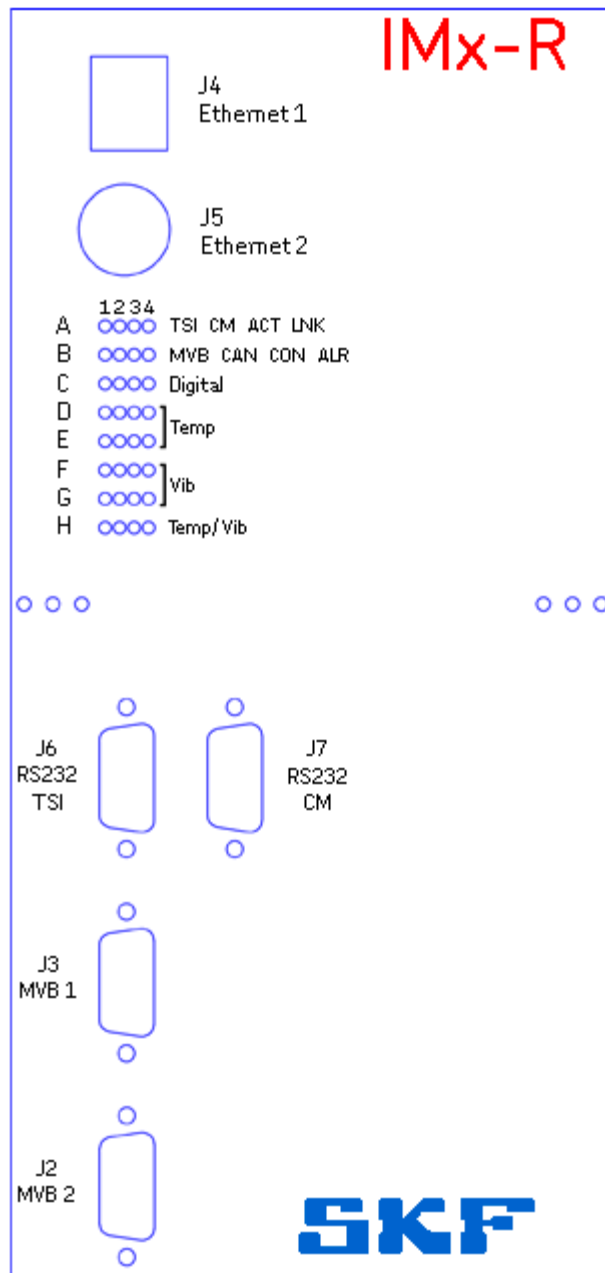

Figure 13-28: Front connectors

Front Panel with Dimensions

The following diagram is the front panel showing the positions the mounting screws and dimensions in mm.

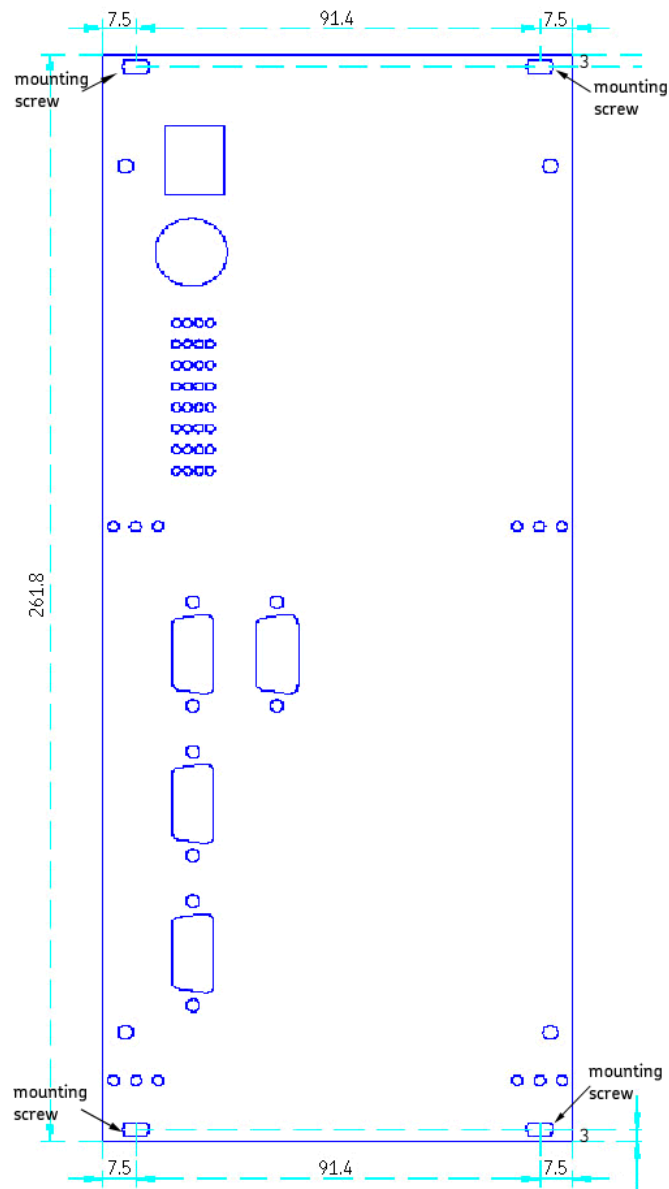The mounting screws are M2,5 and the torque value shall be 38 Ncm.

Figure 13-29: IMx-R front panel with dimensions

Rear Connectors

The following picture shows the positions of Upper Rear Connector (J9) and Lower Rear Connector (J10) at the rear plate of the unit along with dimensions in mm.

Note that the measurements on the drawing reflect the rear plate without encapsulation. The size of IMx-R unit including encapsulation is listed in Environmental, Technical Data section.
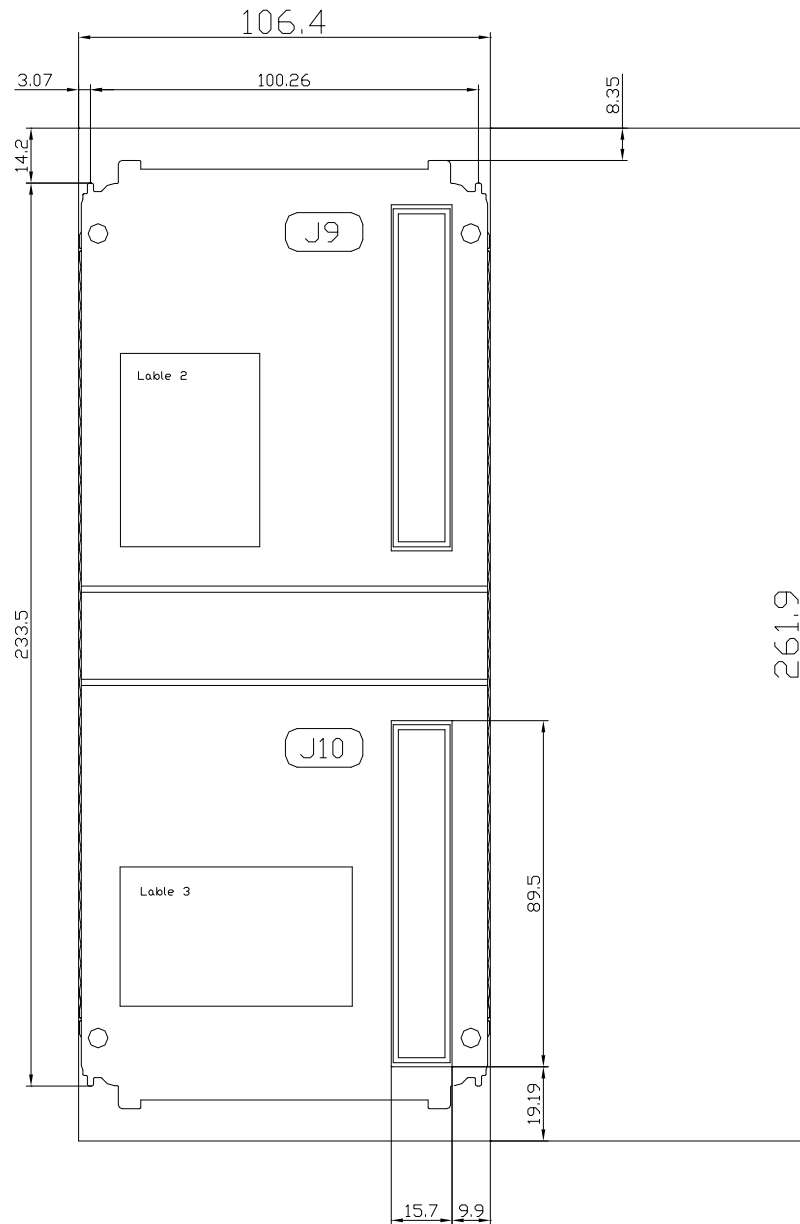

Figure 13-30: Rear connectors

Pinout of Rear Connectors

Upper Rear Connector (J9)

Upper Rear Connector (J9)					
Pin	Description	Pin	Description	Pin	Description
D2	PE (Protective Earth)	B2	PE (Protective Earth)	Z2	PE (Protective Earth)
D4	NC (Not Connected)	B4	NC (Not Connected)	Z4	NC (Not Connected)
D6	UIN–	B6	UIN–	Z6	UIN–
D8	NC (Not Connected)	B8	NC (Not Connected)	Z8	NC (Not Connected)
D10	UIN+	B10	UIN+	Z10	UIN+
D12	NC (Not Connected)	B12	NC (Not Connected)	Z12	NC (Not Connected)
D14	CAN H	B14	CAN L	Z14	GND
D16	IDPLUG PARITY	B16	IDPLUG GND	Z16	NC (Not Connected)
D18	IDPLUG BIT4	B18	IDPLUG GND	Z18	TSI SPEED 4B
D20	IDPLUG BIT3	B20	IDPLUG GND	Z20	TSI SPEED 4A
D22	IDPLUG BIT2	B22	IDPLUG GND	Z22	TSI SPEED 1B
D24	IDPLUG BIT1	B24	IDPLUG GND	Z24	TSI SPEED 1A
D26	IDPLUG BIT0	B26	IDPLUG GND	Z26	TSI SPEED 3B
D28	RS485 B OUT	B28	GND	Z28	TSI SPEED 3A
D30	RS485 A OUT	B30	GND	Z30	TSI SPEED 2B
D32	+12 V OUT	B32	GND	Z32	TSI SPEED 2A

Table 13-26: Upper rear connector pinout

Lower Rear Connector (J10)

Pin	Description	Pin	Description	Pin	Description
	Lower Rear Connector (J10)				
D2	RELAY 1A	B2	RELAY 2B	Z2	RELAY 2A
D4	RELAY 1B	B4	SYSTEM OK A	Z4	SYSTEM OK B
D6	GND	B6	TSI TEMP 8+	Z6	TSI TEMP 7+
D8	GND	B8	TSI TEMP 8- (GND)	Z8	TSI TEMP 7- (GND)
D10	TSI TEMP 6+	B10	TSI TEMP 5+	Z10	TSI TEMP 4+
D12	TSI TEMP 6- (GND)	B12	TSI TEMP 5- (GND)	Z12	TSI TEMP 4- (GND)
D14	TSI TEMP 3+	B14	TSI TEMP 2+	Z14	TSI TEMP 1+
D16	TSI TEMP 3- (GND)	B16	TSI TEMP 2- (GND)	Z16	TSI TEMP 1- (GND)
D18	CM ACC/TEMP 12+	B18	CM ACC/TEMP 11+	Z18	CM ACC/TEMP 10+
D20	CM ACC/TEMP 12- (GND)	B20	CM ACC/TEMP 11- (GND)	Z20	CM ACC/TEMP 10- (GND)
D22	CM ACC/TEMP 9+	B22	TSI ACC 8+	Z22	TSI ACC 7+
D24	CM ACC/TEMP 9- (GND)	B24	TSI ACC 8- (GND)	Z24	TSI ACC 7- (GND)
D26	TSI ACC 6+	B26	TSI ACC 5+	Z26	TSI ACC 4+
D28	TSI ACC 6- (GND)	B28	TSI ACC 5- (GND)	Z28	TSI ACC 4- (GND)
D30	TSI ACC 3+	B30	TSI ACC 2+	Z30	TSI ACC 1+
D32	TSI ACC 3- (GND)	B32	TSI ACC 2- (GND)	Z32	TSI ACC 1- (GND)

Table 13-27: Lower rear connector pinout

14

Troubleshooting Guide

Troubleshooting Guide is intended as an aid when IMx-R system is not functioning correctly.

It is designed for instrumentation engineers and others with sufficient knowledge of IMx-R system and electrical troubleshooting in electronic systems with 110 VDC power supply and of the risks what this can mean in case of incorrect procedure.

SKF Condition Monitoring Center Luleå strives to provide information that is as accurate as possible. However, SKF Condition Monitoring Center Luleå cannot be held responsible for any injury or damage to persons or material that can occur in the interpretation of, or due to actions taken on the basis of information in this document.

Note – The guarantee becomes void if IMx-R units are damaged through incorrect intervention in the hardware, or a patently incorrect connection in contravention of directions given.

Problems and Symptoms

Sensor signal disappears or is abnormally changed for single channels

Possible causes:
- Broken sensor cable
- Short circuit in sensor cable
- Sensor fault
- Hardware fault with IMx-R input stage
- Grounding loop

Suggested solution:
- Carry out sensor/cable test. Refer to Cable Condition Test.

A sensor repeatedly generates a false alarm or varies abnormally

Possible causes:
- Broken sensor cable/contact
- Incorrectly mounted sensor
- Hardware fault with IMx-R input stage
- Signal disturbed by external noise
- Grounding loop

Suggested solution:
- First carry out sensor/cable test by referring to Cable Condition Test.
  In addition, check the sensor mounting by referring to Cable Grounding and Shielding Check.
  If these yield no result, contact SKF Condition Monitoring Center Luleå.

Temperature signal unobtainable/faulty for a certain machine

Possible causes:
- Cable fault (short circuit/broken) to temperature sensor
- Faulty temperature sensor, or faulty installation
- Temperature signal too weak/impedance too high for IMx-R
- Faulty IMx-R temperature input
- Incorrect setting in hardware

Suggested solution:
- Test temperature input. Refer to [Temperature Sensor Test](#).

Vibration input gives faulty/no signal

Possible causes:
- Cable fault (short circuit/break/reverse polarity) to sensor
- Faulty sensor
- Faulty earthing
- Incorrect setting in hardware
- Faulty IMx-R input

Suggested solution:
- Carry out control of sensor and cabling. Refer to [Vibration Sensor Test](#).

IMx-R alarm relay does not activate despite of warning or alarm

Possible causes:
- Cabling fault from IMx-R to alarm panel
- Configuration error in software
- Hardware fault in IMx-R unit

Suggested solution:
- Carryout "Checking relay signal" section in Component Check of this chapter.

Monitor ceases to work with a certain IMx-R unit

Possible causes:
- Loss of voltage in IMx-R unit
- Hardware fault in IMx-R unit, such as power supply or processor module
- Break in Ethernet network

Suggested solution:
- Check the voltage in IMx-R unit, first. In addition, check the Ethernet built-in LED indicator behavior. LED indicator behavior can be found in [LED Indicators](#) table.
- If the problem continues, you may also refer to "Application Note Testing and troubleshooting IMx network connections" in Application notes which is accessible at the top right hand corner of News in Observer screen of @ptitude Observer.

Monitor completely ceases to function

Possible causes:
- Monitor PC non-functional
- Monitor software incorrectly set
- Ethernet switch non-functional
- Cable break in Ethernet network
- Firewall configuration incorrect
- Database non-functional

Suggested solution:
- Carry out "Checking monitor" section in Component Check of this chapter.

Component Check

Checking vibration sensor and sensor cabling

Follow the instructions listed in <u>Vibration Sensor Test</u>.

Checking temperature sensor and sensor cabling

Follow the instructions listed in <u>Temperature Sensor Test</u>.

Checking relay signal

1. Determine the unit number of the alarming channel through the software measurement point setting or though the list of terminal blocks.

2. Disconnect the relay connection from the IMx-R unit in question. Carefully check to see if the relay output caused to trip the machines. Measure the resistance between the alarm relay poles with an ohmmeter.

3. Has the relay been activated (approximately 0 Ω)?

   YES: The fault is in the cabling or output connections from IMx-R.

   NO: Check the software configuration for measurement point settings to find out whether the channel in question is allowed to activate the alarm relay. If this is not the case, then change the setting. Contact SKF Condition Monitoring Center Luleå, if the channel is permitted to activate the relay, but does not do so.

Checking monitor

1. Check first, whether the @ptitude Observer Monitor Service PC is functioning as it should be.

2. Try restarting the computer, if there is any doubt as to the status of the @ptitude Observer Monitor Service software.

3. Check also that the Ethernet network is functioning and that the @ptitude Observer Monitor Service computer can write to the server disk.

4. Check Firewall for correct configuration.

Checking Modbus (RS485) sensor

1. Start @ptitude Observer On-line Device Configurator program located in the @ptitude Observer directory.

2. Click **Start serial interface.**

3. On the Serial interface screen, enter the COM port number and type in the word "modbus" in the command box.

4. Statistics on communication and the contents of the import registers will appear on the screen.

   The statistics are:
   • Frame errors (short and long)
   • Checksum errors
   • The number of messages sent
   • The number of messages received
   • The number of timeouts of requests

5. A properly working Modbus communication should exhibit increasing sent and received messages, but not exhibit significant increase of errors or timeouts.

6. In case of errors or timeouts, check that all of the following are correctly installed:

   - Physical connections of RS485 cable wires are done correctly
   - Transmission characteristics are defined correctly
   - The Modbus Master–Slave pair address is entered correctly
   - RS485 termination is done correctly

7. This process of checking Modbus sensor can be done several times during the test to diagnose the communications or lack of it.