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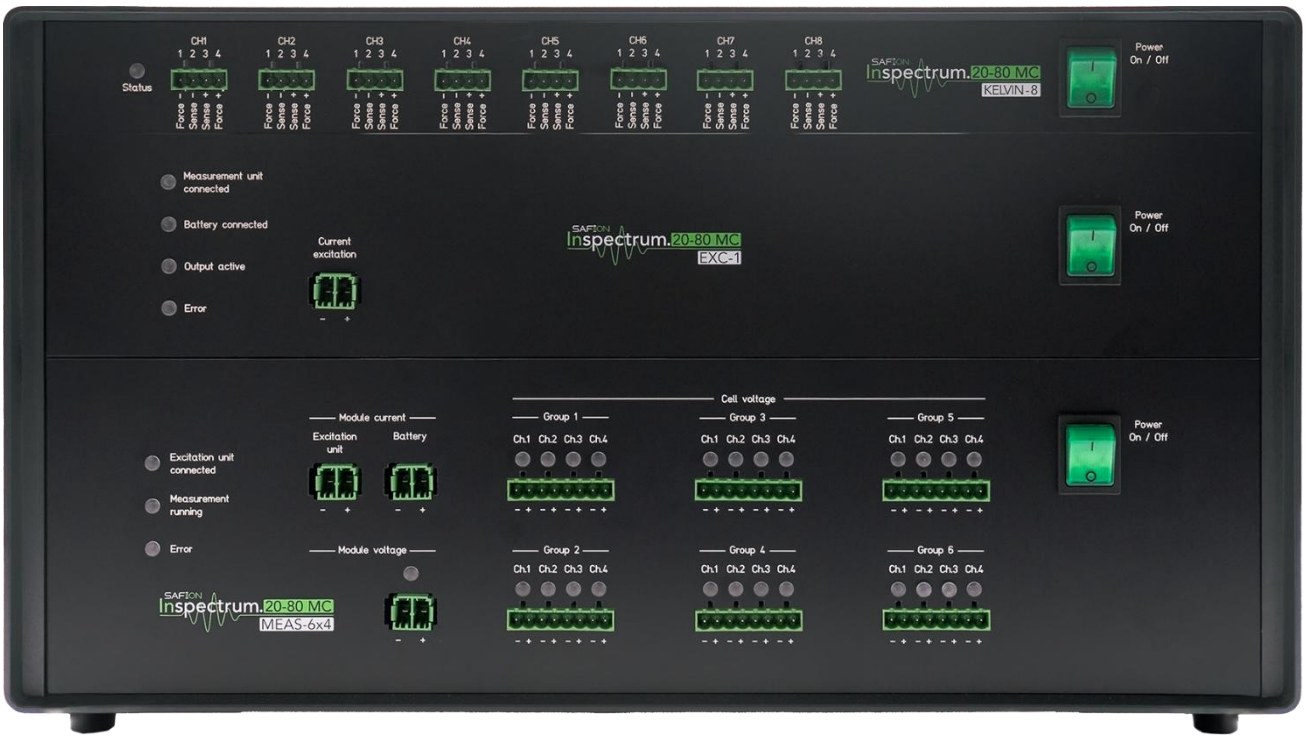
# Inspectrum.20-80 MC

## Hardware Manual

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# 1. General Information

## 1.1. Safety Instructions

Read the following safety instructions carefully before operating the product. Follow the instructions to avoid the risk of injury to the operating personnel and damage to the product. The safety precautions must be observed during the entire system operation.

**Never connect a battery module or any other device under test (DUT) with a voltage outside the specified voltage range to the Inspectrum.20-80 MC. Connecting a device not compliant to the specification of the Inspectrum device will cause severe damage to the Inspectrum and/or to the battery module. Do note that Measurement Unit and Excitation Unit may have different allowed voltage ranges.**

**Never connect a battery module or any other DUT which shows optical damage.**

**Only use cables that have been approved by Safion. Never use damaged cables. It is essential that the cable insulation is intact. Otherwise, serious damage to both the measuring device and the battery can occur. If you notice any damage to the cables, do not continue to operate the device until the cables have been replaced with ones that are intact. Contact support immediately if you notice any such defect.**

**Depending on their size, battery cells or battery modules can store an enormous amount of energy and deliver high power outputs. Be sure to avoid any short circuits.**

**Battery modules typically exhibit higher voltage voltages than individual cells. Ensure that appropriate safety precautions are taken in accordance with the voltage.**

**Never remove or plug in any cables while a measurement is in progress or the “Battery connected”-LED is lighting up.**

**The mains connection must be carried out by qualified personnel. Please note that the connection varies depending on the mains voltage.**

**Do not turn the Inspectrum device off or remove grid voltage while a measurement is in progress.**

**The excitation cables used must have a cross-section A ≥ 1.0 mm$^2$, corresponding to the excitation current in the device specifications.**

**Do not spill any liquid on the device. Also make sure to operate and store the device at non-condensing humidity to avoid damaging the internal components.**

**Never cover the ventilation slots on the back of the excitation unit and ensure that the outgoing air flow is not blocked.**

**Ensure a sufficiently large bending radius for both copper cables and fiber optic cables.**

**The Inspectrum.20-80 MC devices are high-precision measurement instruments. To obtain accurate and reproducible results, the devices should not be exposed to vibration during measurement operation.**

**Always ensure a correct polarity of excitation and measurement connections.**

**Remove all grid connections before changing any back panel connections.**

## 1.2. Intended Use

The product may only be used for development, research and test purposes, as well as in a production environment. Improper use or use not in accordance with the intended purpose is not permitted.

## 1.3. Liability

The operation of SAFION products is the exclusive responsibility of specially trained and qualified personnel. SAFION accepts no liability for damage to property or personal injury resulting from improper use of this product or use for other than the intended purpose or incorrect operation by insufficiently qualified personnel.

## 1.4. Qualifications of the User

Only qualified electricians may work on the product and the connected components or instructed persons under the supervision and guidance of a qualified electrician and in compliance with the regulations and standards applicable in the electrical field. A qualified electrician has technical training, specialist knowledge, and experience as well as knowledge of relevant rules to be able to assess the tasks assigned to him and to recognize associated potential dangers.

# 2. Device Specifications

The device specifications for each sub-module can be found in the following tables:

| **Measurement Unit MEAS-6x4** | | |
|---|---|---|
| Signal generation | Simultaneous excitation frequencies | Up to 32 (multi-sine operation) |
| | Frequency range | 10 mHz – 10 kHz |
| Measurement channels (*) | Module voltage | 1 |
| | Module current | 1 |
| | Cell voltage (total) | 24 |
| | Cell voltage (simultaneous) | 6 |
| Voltage input range | Module voltage | 0 V – 100 V |
| | Cell voltage | 0 V – 5 V |
| Current input range | | ±10 A |
| Channel to channel voltage (*) | | ±100 V |
| Measurement resolution | Module voltage (DC) | < 4 mV |
| | Module voltage (AC) | < 20 µV |
| | Cell voltage (DC) | < 500 µV |
| | Cell voltage (AC) | < 2 µV |
| | Module current | < 400 µA |
| Combined analog processing data rate | | > 110 Mb/s |
| Input voltage | | 100 V – 250 V / 50 Hz – 60 Hz |
| Dimensions (L x W x H) | | 450 mm x 483 mm x 134 mm (3U) |
| Input power | | < 50 W |
| Ambient temperature | | 10 °C – 30 °C, non-condensing |
| User interface | | USB |
| Additional data ports | | - Inspectrum excitation interface (**)<br>- Inspectrum extension interface (***) |

(*) Cell voltage channels are divided into 6 groups. Each group features 4 multiplexed channels. Each group, module current and voltage measurement are galvanically isolated.

(**) The excitation interface provides a fiber-optic high-speed data path between the measurement and the excitation unit.

(***) The extension interface provides a fiber-optic low-speed data path between the measurement unit and connected extension units (e.g. Temperature Extension Unit).

| Excitation Unit EXC-1 | |
|---|---|
| Maximum output current | ±10 A |
| Bandwidth (-3dB) | 10 kHz |
| Battery voltage range | 30 V – 80 V |
| Input voltage | 200 V – 250 V / 50 Hz – 60 Hz |
| Input power | < 1 kW |
| Dimensions (L x W x H) | 450 mm x 483 mm x 89 mm (2U) |
| Ambient temperature | 10 °C – 30 °C, non-condensing |
| Data ports | ▪ Inspectrum excitation interface (*)<br>▪ USB (for firmware updates, etc.) |

(*) The excitation interface provides a fiber-optic high-speed data path between the measurement and the excitation unit.

| Temperature Extension Unit | |
|---|---|
| Analog temperature channels (*) | 8 |
| Sensor types | PT100, PT1000<br>NTC 1k, NTC 4k7, NTC 10k |
| Measurement configuration | 4-wire<br>2-wire |
| Measurement resolution | Sensor dependent (**) |
| Measurement accuracy | Sensor dependent (**) |
| Channel to channel voltage (*) | ±100 V |
| Input voltage | 100 V – 250 V / 50 Hz – 60 Hz |
| Input power | < 50 W |
| Dimensions (L x W x H) | 250 mm x 483 mm x 45 mm (1U) |
| Ambient temperature | 10 °C – 30 °C, non-condensing |
| Data ports | ▪ Inspectrum extension interface (***)<br>▪ USB (for firmware updates, etc.) |

(*) All temperature measurement channels are galvanically isolated.

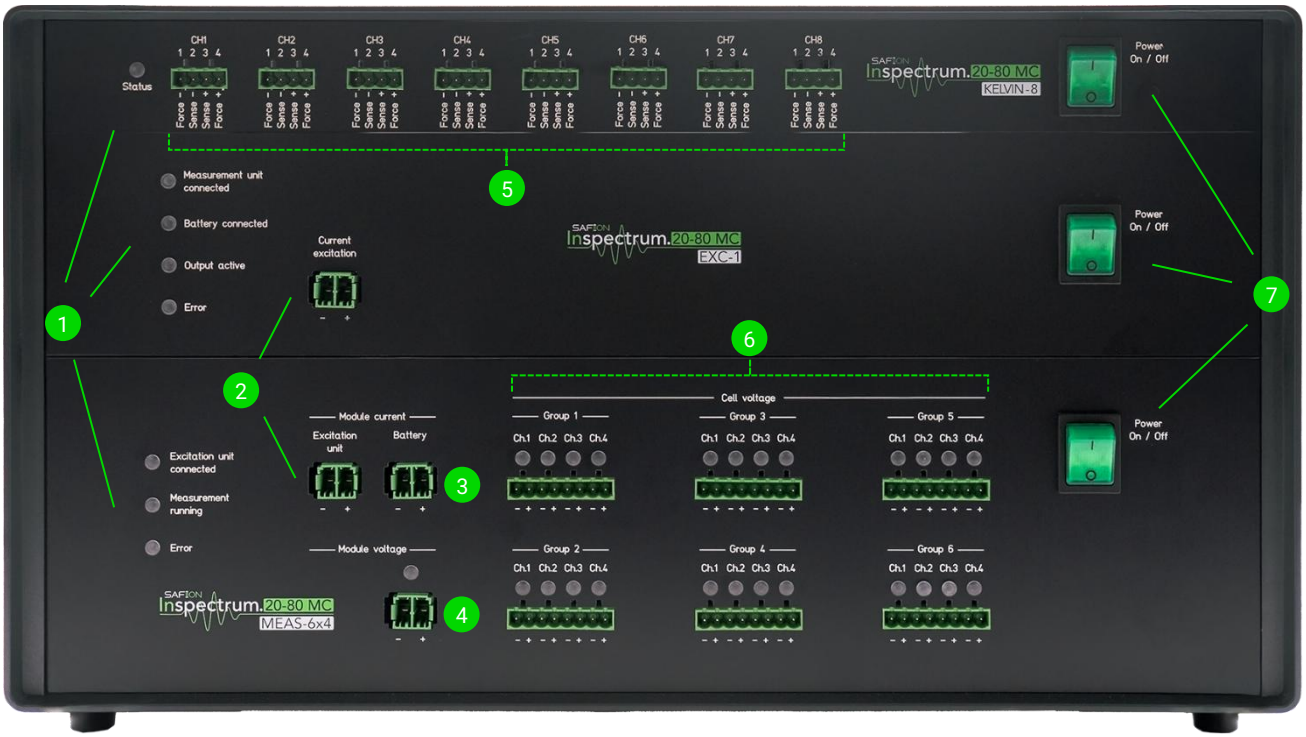
(**) Measurement resolution and accuracy depend on different factors. The resolution depends on the sensor type and the current temperature. The temperature sensor itself as well as the measurement configuration (4-wire vs. 2-wire) have a significant impact on the over-all measurement accuracy. A 4-wire connection is always preferred when high-accuracy temperature data is required.

(***) The extension interface provides a fiber-optic low-speed data path between the measurement unit and connected extension units (e.g. Temperature Extension Unit).

# 3. System Overview

The different front and back panel elements of the measurement system including temperature measurement extension are described in the following chapter. Please make yourself familiar with these elements before connecting the system and bringing it into operation.

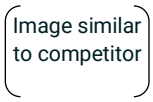
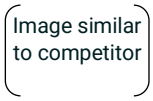
## 3.1. Front Panel



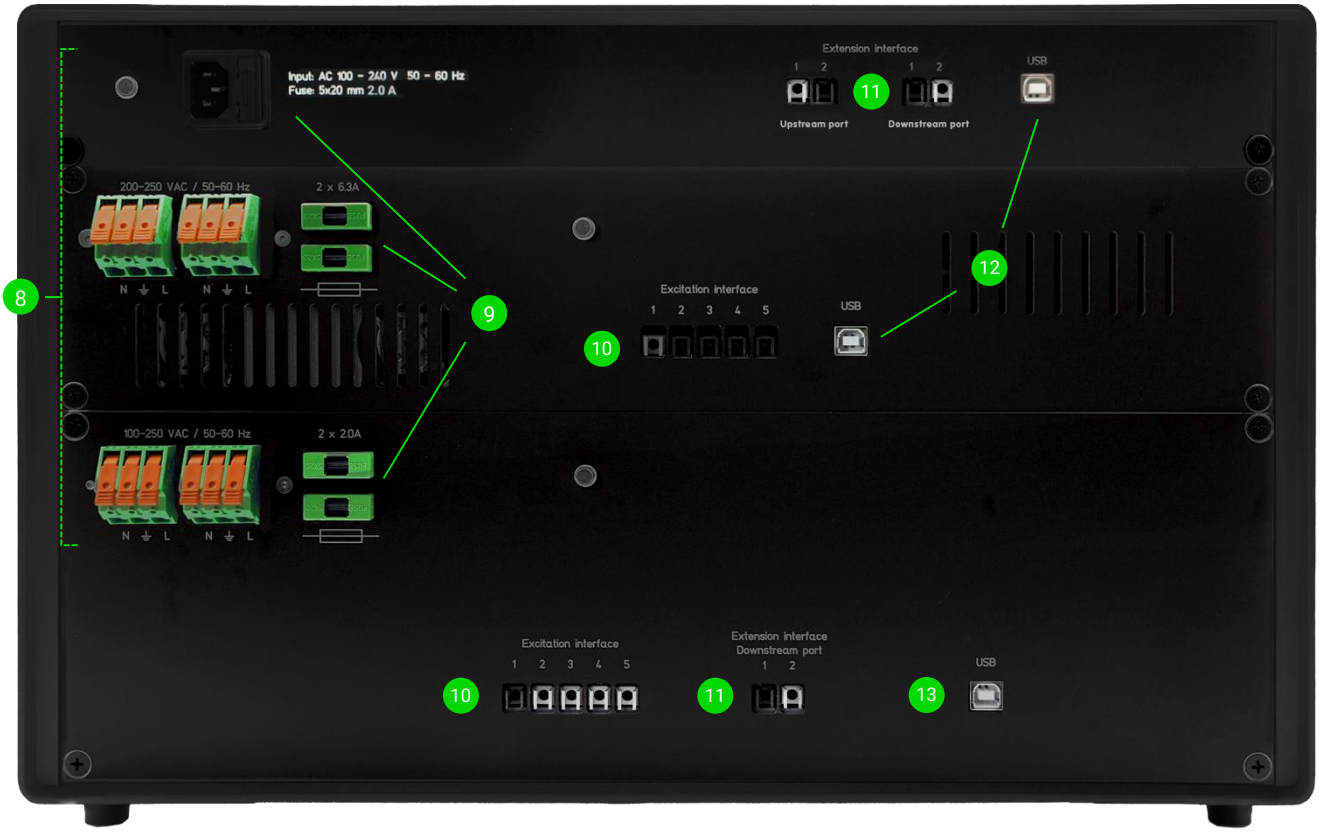

| Number | Description |
|---|---|
| **1** | Status LEDs |
| **2** | Excitation to measurement unit interconnect |
| **3** | Battery module current excitation output |
| **4** | Battery module voltage measurement input |
| **5** | Temperature sensor connections |
| **6** | Cell voltage measurement inputs |
| **7** | Power switches |

## 3.2. Cable Connector Types

The Inspectrum.20-80 MC includes high quality measurement cables for module and cell measurement applications. Information on the cable-side connectors for all front panel connections can be found in the following table:

| Cable type | Connector type | Amount |
|---|---|---|
| Module current excitation | Phoenix Contact Combicon Connectors L<br>SPC 5/ 2-STCL-7,62<br>Mfr. part number: 1718481  | 1 |
| Module voltage measurement | | 1 |
| Current excitation interconnect | | 2 |
| Cell voltage measurement | Phoenix Contact Combicon Connectors M<br>MSTB 2,5/ 2-ST-5,08<br>Mfr. part number: 1757019   | 4 x 6 |
| or | Würth Elektronik<br>WR-TBL Series 351 – 5.08 mm Vertical<br>Mfr. part number: 691351500002  | 4 x 6 |
| Temperature measurement | Phoenix Contact Combicon Connectors M<br>MSTB 2,5/ 4-ST-5,08<br>Mfr. part number: 1757035   | 8 |
| or | Würth Elektronik<br>WR-TBL Series 351 – 5.08 mm Vertical<br>Mfr. part number: 691351500004  | 8 |

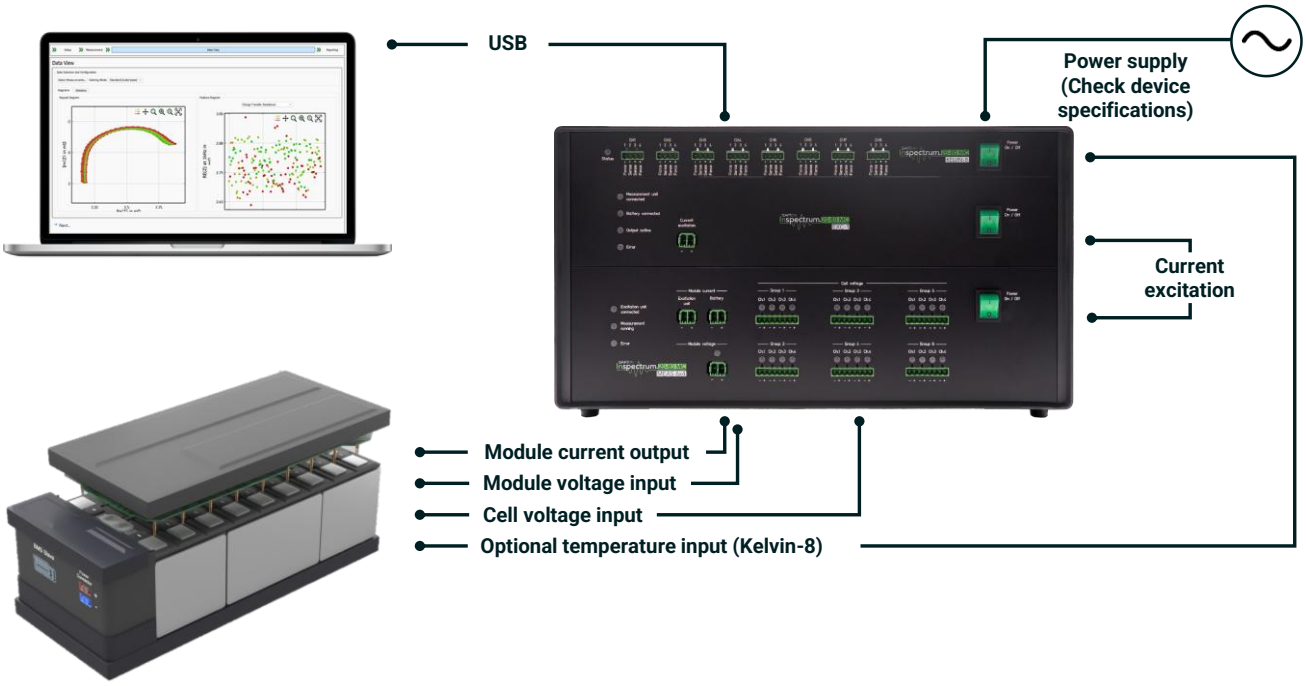
## 3.3. Back Panel




| Number | Description |
|---|---|
| **8** | Power supply connectors |
| **9** | Fuses |
| **10** | Excitation interface |
| **11** | Extension interface |
| **12** | USB service ports (for firmware updates, etc.) |
| **13** | Main USB port (connect to host PC) |

# 4. Hardware Setup and Connections

The following chapter describes the basic hardware setup and which physical connections have to be established before impedance measurements can be conducted. Please make sure you follow the instructions carefully before switching on the measurement system.




## 4.1. Back Panel Connections

**Remove all grid connections before changing any back panel connections.**

Please establish the following connections on the back panel of the measurement system:

- Connect the excitation interface fiber-optic cables to the excitation unit and the measurement unit. Connect each port (1 – 5) of the one unit the corresponding port (1 – 5) on the other unit. For all fiber-optic connections: Always insert connectors in sockets of the same color.
- Optional: Integrate a temperature measurement unit by connecting the interface extension fiber-optic cables to the measurement unit and the extension unit. Connect the downstream port of the measurement unit to the upstream port of the temperature measurement extension. Connect port 1 of the one unit to port 1 of the other unit. Repeat for port 2.
- Mains connection: A detailed description of how the mains connection has to be established is given in the next section.
- Connect the main USB port (measurement unit) to a host PC running the Inspectrum.Suite software.

## 4.2. Mains Connection

The excitation unit needs a minimum grid voltage of 200 V. Therefore, the grid connection differs for 230 V / 50 Hz and 120 V / 60 Hz grids. For European grids with 230 V and 50 Hz, a single phase is sufficient. For US grids with 120 V and 60 Hz, two phases with a phase shift of 180° are required. The following illustrations show the differences between the different grid voltages and frequencies.

**The mains connection must be carried out by qualified personnel. Please note that the connection varies depending on the mains voltage.**

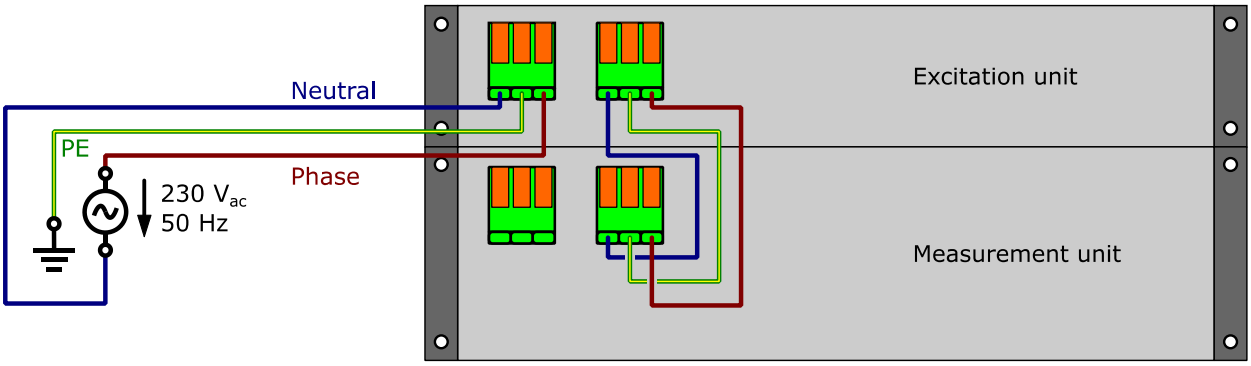
**There is a direct connection without fuses between the two power sockets of each unit.**

**Do not connect any other device to an unused power port.**

**Remove all grid connections before changing any back panel connections.**

### 4.2.1 Mains Connection for a 230 V / 50 Hz Grid

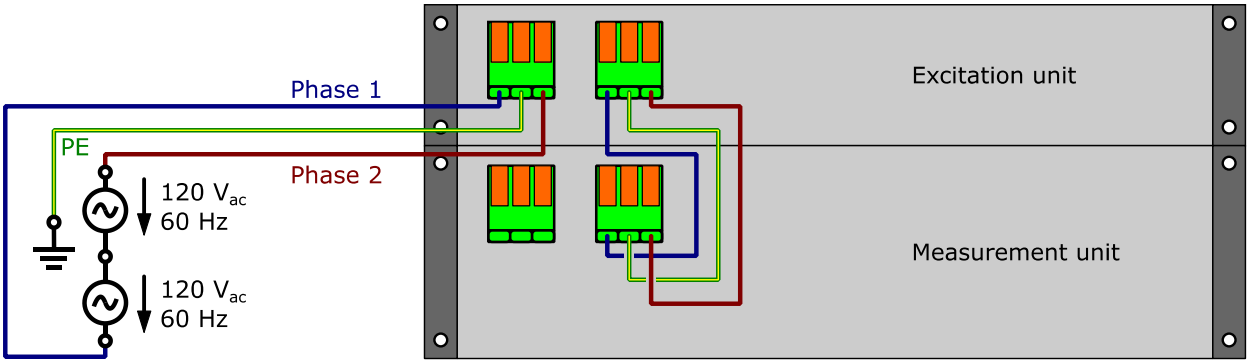
The following illustration depicts the correct mains connection in case the measurement system should be connected to a 230 V / 50 Hz grid:




Connect the measurement unit to the excitation unit. Connect PE first and repeat for neutral and phase. Now connect the remaining power socket of the excitation unit to the mains. The remaining power socket of the measurement unit can be used to power the optional temperature measurement extension unit. Do not connect any other device to an unused power port.

### 4.2.2 Mains Connection for a 120 V / 60 Hz Grid

The following illustration depicts the correct mains connection in case the measurement system should be connected to a 120 V / 60 Hz grid:



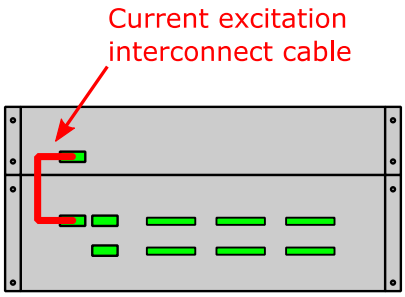

Connect the measurement unit to the excitation unit. Connect PE first and repeat for phase one and phase two. Now connect the remaining power socket of the excitation unit to the mains. Please remember that two phases with a phase shift of 180° are required to reach the minimum supply voltage. The remaining power socket of the measurement unit can be used to power the optional temperature measurement extension unit. Do not connect any other device to an unused power port.

## 4.3. Front Panel

**Always make sure the polarity of each connection is correct.**

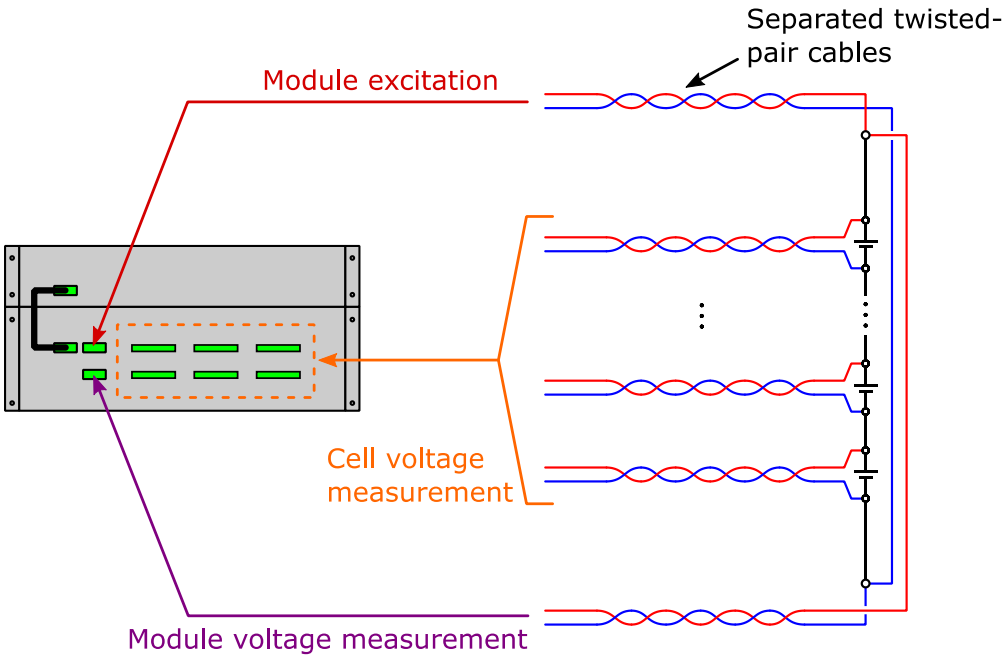
Please establish the following connections on the front panel of the measurement system:

- Connect the current excitation interconnect cable between the excitation unit and the measurement unit.




- Connect the voltage measurement cables to the correct front connectors of the measurement unit for each cell voltage measurement channel as well as for the battery module. Shielded twisted-pair cables are mandatory to ensure precise impedance measurements. The Inspectrum.20-80 MC offers simultaneous measurements of up to six channels and 4:1 multiplexing

capabilities for each channel. Connect the current excitation cable to the corresponding front connector of the measurement unit. Always make sure the polarity of each connection is correct.




- To integrate the optional temperature measurement extension, connect compatible temperature sensors to the corresponding connectors. This extends the Inspectrum.20-80 MC with temperature measurement capabilities for up to eight channels. The eight temperature measurement channels are hot-pluggable and can be plugged in or removed any time. 2-wire as well as 4-wire connections are supported while a 4-wire connection is highly recommended. In case a 2-wire connection should be used, connect the force pin to the sense pin for each polarity right at the connector.

# 5. Measurement System Turn-On and Turn-Off Process

**Make sure you have properly carried out all the steps from chapter 4.**

## 5.1. Turn-On Process

In order to turn the measurement system on, please follow these steps:

- Switch on the measurement unit by setting the corresponding power switch to on
- Switch on the excitation unit by setting the corresponding power switch to on
- Wait for status LEDs on the measurement unit and the excitation unit to indicate an established connection between the two sub-modules

If the optional temperature measurement extension is connected add the following steps:

- Switch on the temperature measurement extension by setting the corresponding power switch to on
- Wait for status LEDs on the temperature measurement extension to indicate an established connection to the measurement unit

## 5.2. Turn-Off Process

In order to turn the measurement system off, switch each off. Do not turn the measurement system off while an EIS measurement is running or the excitation output is active. It is recommended but not necessary to turn off the measurement unit first. When the excitation unit is switched off, it is normal that the error LED indicates a loss of power.

# 6. Maintenance

The following chapter describes the different maintenance steps. It is highly recommended to have the device calibrated within the proposed intervals and to run the latest firmware version.

## 6.1. Calibration

The Device is factory calibrated on delivery. SAFION recommends recalibrating the device every 12 months. Please contact the SAFION customer service for more information about the calibration process.

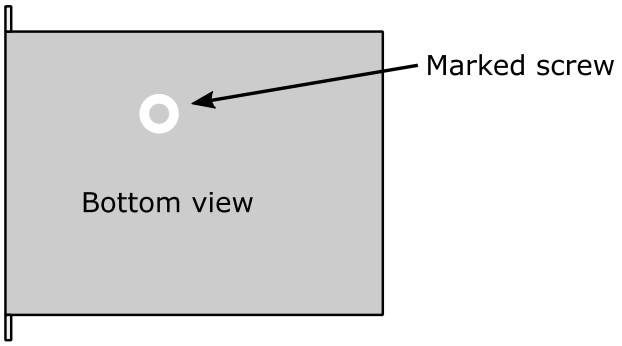
## 6.2. Firmware Update

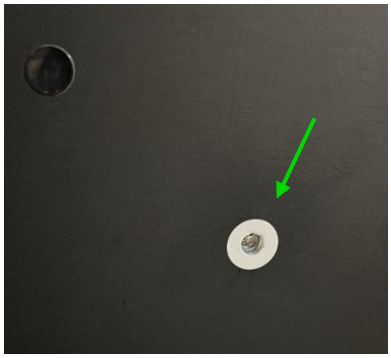
Each sub-unit is equipped with an USB port. For the excitation unit and the temperature measurement extension, the USB port is only for service purposes like a firmware update. In order to update the current firmware, turn off all other sub-units and connect the USB port to a PC. Safion provides a firmware update tool which is available for Windows PCs.

**Before the first commission of the device, make sure the firmware is updated to the most recent available version.**

## 6.3. Line Isolation Testing

The internal power supply is equipped with an over voltage protection to prevent impermissibly high voltages that can damage the device. During line isolation testing, which should be conducted in regular intervals, it might be necessary to bypass the over voltage protection of the power supply. To do so, remove the excitation unit (EXC-1) from the 19” rack, turn it around so that you have access to the bottom side of the excitation unit and take out the screw which is marked by a white marking as shown below. make sure to remove the connections on the back side of the device before removing it from the rack.
After testing is done, put the screw back in again before placing the excitation unit back inside the 19” rack. Re-establish all connections on the back side. Follow safety instructions.



## 6.4. Fuse replacement

Each unit of the Inspectrum.20-80 MC has externally accessible fuses for easy replacement next to the power supply connector on the respective back panel. The fuses protect the devices against impermissibly high currents. In the unexpected case that the fuses trip, they must be replaced by simply removing them from the compartment and inserting the respective new fuses according to the following specifications:

| **Measurement Unit** | |
|---|---|
| Amount | 2 |
| Type | 5x20 mm |
| Current / Voltage Rating | 2.0 A / 250 V AC |
| Characteristic | T (“Slow blow”) |
| **Excitation Unit** | |
| Amount | 2 |
| Type | 5x20 mm |
| Current / Voltage Rating | 6.3 A / 250 V AC |
| Characteristic | T (“Slow blow”) |
| **Temperature Extension Unit** | |
| Amount | 1 |
| Type | 5x20 mm |
| Current / Voltage Rating | 2.0 A / 250 V AC |
| Characteristic | T (“Slow blow”) |

The Inspectrum measurement system features fuses on all inputs and outputs which are to be connected to the battery module or DUT, which should never trigger in normal operation. If you think one of these fuses has been triggered, please contact the customer support.

## 6.5. Cleaning

Disconnect the Inspectrum.20-80 MC from the mains and disconnect any device-under-test before cleaning. It is recommended to use a damp cloth for cleaning. Do not use any reactive cleaning agents or alcohols.