# External Potentiostats

# Installation & Operation Manual

# PP201/211/241

# XPOT

ZAHNER MESSSYSTEME

04/2019

# CAUTION

Prevent the inputs of the device from electrostatic discharge ! This may damage the device.

Do not connect active objects such as batteries or fuel cells to the power outputs of the device when the device is off !
This may damage the device.

# Unpacking

Zahner products are produced carefully, calibrated and tested to achieve a high quality standard. Also the assembling of the accessories and packing is done with great care. Therefore please check the shipment directly after receipt whether the device and all accessories are undamaged.

The shipment must contain the following parts:

## XPOT

- XPOT
- cable for connection of the EPC40/41/42 (Lemosa - Lemosa)
- cable for connection of a PC USB port (USB-A – D-Sub9) with build-in USB-serial converter
- 3 cables (red, black, blue) BNC – banana
- sense cable BNC (green marked) – banana (shielded)
- power cord
- this manual

## PP201/211/241

- PP201/211/241
- cable for connection of the EPC40/41/42 (D-Sub9 - Lemosa)
- cable for connection of a PC USB port (USB-A – D-Sub9) with build-in USB-serial converter
- 2 cables (red and black) with banana plugs (∅ 4mm) with a maximum rated current of 32 A
- 2 alligator clips (red and black)
- twisted sense cable (Lemosa plug, blue & green cables)
- power cord
- this manual

| | |
|---|---|
| ! | **To drive more than 32 A with the PP241 the customer has to use a high current cable and fix it to the front terminal CE and WE with suitable cable lugs.** |

# Basics

Today, dynamic measurements on electrochemical objects are of great interest. Modern instruments for impedance measurements, cyclic voltammograms and pulse response experiments provide a broad frequency range from µHz to MHz. At the same time, they provide a huge impedance range from µΩ to GΩ. Anyway: for most instruments there is one restriction left, they have a limited current range in the magnitude of some Amperes maximum. In the field of electrochemical power generation for example this is only sufficient for 'small' systems.

The electrochemical workstations of the *IM6* family provide a current range of ±2,5A (*Zennium*) and ±3A (*IM6*) and measure impedances down to some µΩ. Therefore we provide external potentiostats (*EL, PP-Series and XPOT*) which can extend the application field of the *IM* system.

The four quadrant power potentiostats *PP201/211/241* provides up to ±40A (PP241) or up to ±20V (PP211). These devices are designed to do charging/discharging experiments. The *XPOT* is an external potentiostat for up to ±500mA and ±10V (±25V compliance voltage) used e.g. for disk/ring electrode experiments, multi-cell experiments and light source supply for *CIMPS*.

The external potentiostats are easily integrated in the *IM6/Zennium* system using *EPC40/41/42* controller cards. All functions are controlled directly from the Thales software. Up to 16 external potentiostats may be controlled by one *IM6/Zennium* system using up to 4 *EPC40/41/42* cards.

With the *MultiCell* functionality of the *IM* systems the connected external potentiostats can be used in parallel. Up to 16 cells may be investigated at the same time.

## EPC4 / EPC40 / EPC41 / EPC42

The *EPC40/41/42* is able to control up to 4 external potentiostats like the *EL101/EL300/EL1000*, the *XPOT* and the *PP201/211/241*. Up to four *EPC40/41/42* for a total of 16 external devices can be installed in an *IM6* and the *Zennium* systems.

Each port provides analogue and digital interfaces for the communication of the external device with the *IM* system. The analogue part of the port feeds the device with the DC potential and the AC amplitude at a resolution of 16 bit. Measured current and potential are sent from the external device to the *IM* to be treated there in the same way as signals from the internal *IM* cards. The *EPC40/41/42* has a bandwidth of 250 kHz.

A bi-directional serial communication line allows to digitally control the external potentiostat functions and measuring ranges.

The *XPOT* and *PP*-Series potentiostats can be controlled by a Windows®-PC. In this case they provide the methods Test Sampling as well as U- and I-curves vs. time. They also work as a LabView® Virtual Instrument under the LabView® software.
Furthermore, you can control the *XPOT* and *PP*-Series potentiostats in a mixed mode with an *IM6/Zennium* and a PC in parallel. Both devices can be connected and disconnected in operation.

| ! | **Plug or unplug external devices only when both, IM6/Zennium AND the external device, are switched off. Otherwise the devices may be damaged.** |
|---|---|

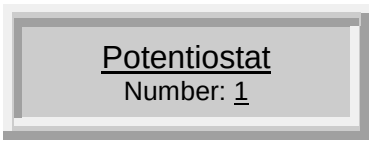
## Selecting an external device

All external *IM* devices are directly controlled by the Thales software. Each device has a unique device number which is identical with the *EPC40/41/42* port number. So, if a device is connected to *EPC* port 3, you address it with the device number 3. Device number '0' is reserved for the internal potentiostats of the *IM* system.

If an *RMUX* (relay multiplexer) card is installed, the device numbers of the *XPOT*s start with 17, not with 1, because the device numbers 1 to 16 are reserved for the 16 *RMUX* channels then.

To select a device, call the *Test Sampling* page and click one the # symbol next to the *Device Identity* box.


An input box will appear where you can input the device number.




Now the selected device type is shown in the *Device Identity* box, for example:


- If no device has been connected to the addressed *EPC40/41/42* port an error message is displayed and the software automatically selects the internal potentiostat.
- If the selected device is present but has not been activated yet the software starts to calibrate it automatically.
- If an external device is changed the new device has to be calibrated before use. The calibration is carried out only for the selected device. All other calibration data keep unchanged.

If a device number other than 0 is selected, the parameters of the *Test Sampling* page now are valid for this device.

The following methods are available for external devices:

| | |
|---|---|
| EIS | impedance measurement |
| C/E | parameter impedance measurement |
| I/E | current potential curve recording |
| MIE | Multiple parallel current potential curve recording |
| POL | polarisation measurements |
| C/V | cyclic voltammetry |
| AS | series measurements |

Specific parameters for these methods are to be edited in the pages related to the method.

## Changing devices

When changing the device number, the now inactive device will hold its DC conditions such as DC potential and on/off status as long as it is selected anew or the system is shut off. On the other hand only the selected device is internally connected to the FRA. Therefore only this device is able to output an AC signal superimposed to the DC potential.

# PP201 / PP211 / PP241

The *PP201/211/241* are external *Four-Quadrant-Potentiostats*. This means that they are able to sink and source current up to 20/10/40 A continuously, both positive and negative. Typical applications are charging/discharging experiments at batteries, accumulators and fuel cells. The *PP201/211/241* potentiostats can be operated in both potentiostatic and galvanostatic modes, controlled by the Thales software. The output as well as the input are electrically isolated up to a maximum difference potential against ground of ±12V.

## Measuring floating objects

On the rear of the *PP201/211/241* you will find two connectors with a jumper. If the jumper is set, the signal ground is connected to ground via a 100 Ω protective resistor. In contrary to the IM potentiostat (single output stage) the PP (bridge output stage) working electrode is NOT connected to signal ground. This is necessary, if the test object is floating (no metallic or electrolytic contact to ground). If any part of the cell is grounded, the jumper must be removed.

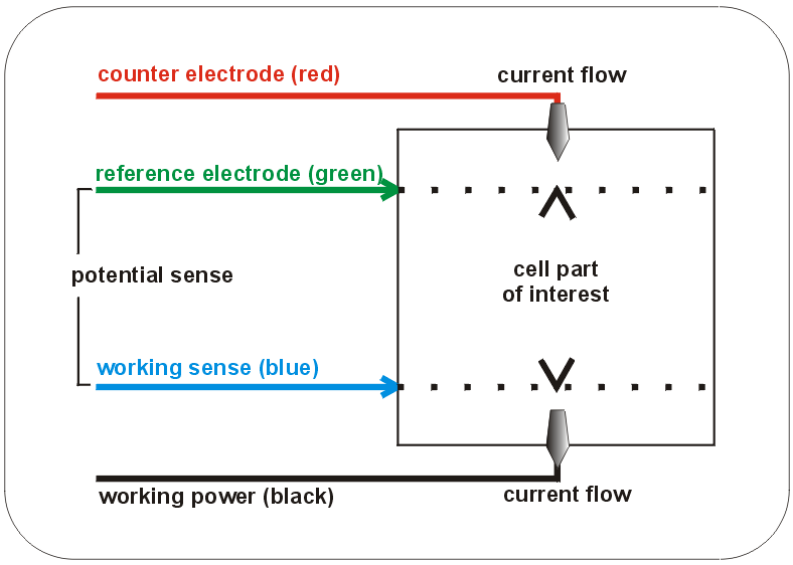
silver banana jack (protective ground) ⇔ black banana jack (system ground)

> **!** **When investigating floating objects the jumper must be set.**

## Stand-alone mode

Besides the usage of the *PP201/211/241* as an external potentiostat for an *IM6/Zennium* system, they also may be used in a stand-alone mode. The setup is done through an *IM* system or a PC.

## Cell Connections




As its functionality is identical with the main potentiostat, the meaning of the cell connections colours are the same at both devices. In order to minimize stray- and mutual inductance the power lines should be twisted.

Normally the *PP201/211/241* should only be connected or disconnected to the *IM* system if both, the *IM6/Zennium* and the *PP201/211/241* are switched off.

If you want to use the *PP201/211/241* as a stand-alone device, unselect it in the *Test Sampling* page of the *Thales* software (you may e.g. change the device number to the main potentiostat). Now you may unplug the *PP201/211/241* at the *EPC40/41/42* connector. For regaining access to the *PP201/211/241*, connect it to the *EPC40/41/42* and select it in the *Test Sampling* page of the *Thales* software.

> **!** **Never plug or unplug a *PP201/211/241* at the D-Sub9 connector at the backside of the device with the *IM* switched on. This may damage the system. It is recommended to fix the D-Sub9 connector with the screws to prevent accidental unplugging.**

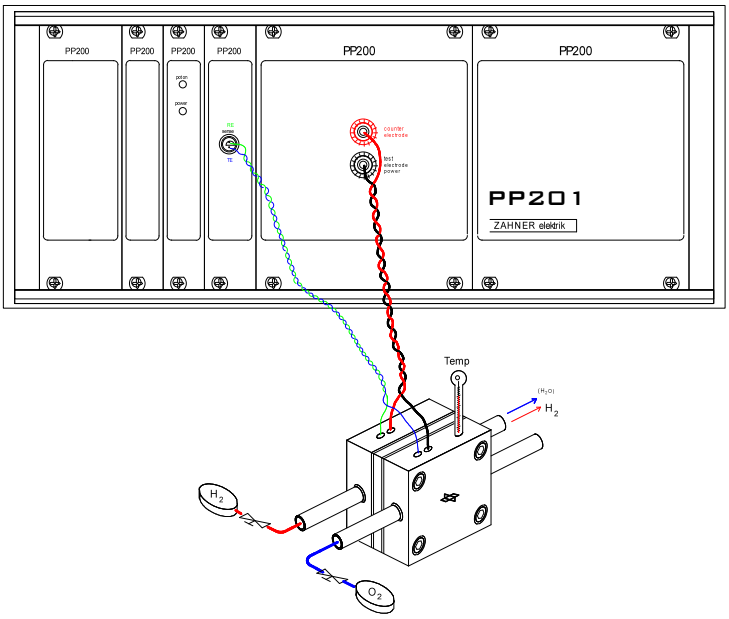
If the *PP201/211/241* are unplugged while being selected in the *Test Sampling* page of the *Thales* software, it will shut off the current. This is a precaution to prevent undefined situations.

The *PP201/211/241* need a warm-up time of about 15 minutes after power on. A calibration procedure is initiated automatically with the first access by the *IM* system. If you access a *PP201/211/241* during the warm-up time, please do a forced calibration (*EIS* menu -> *Calibrate*) after about 15 minutes.

As the *PP201/211/241* are optimised for high current (some 100 mA to 20 A) an erroneous current display of some µA is acceptable.

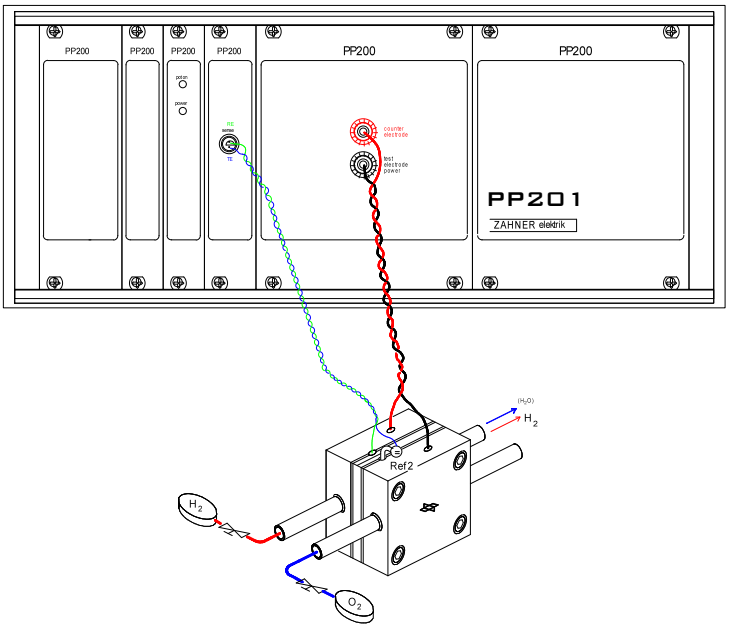
**! Never have a battery connected to the PP when the PP is switched off. This may damage the PP.**

## 1. Full Cell Configuration (Standard Kelvin Scheme)



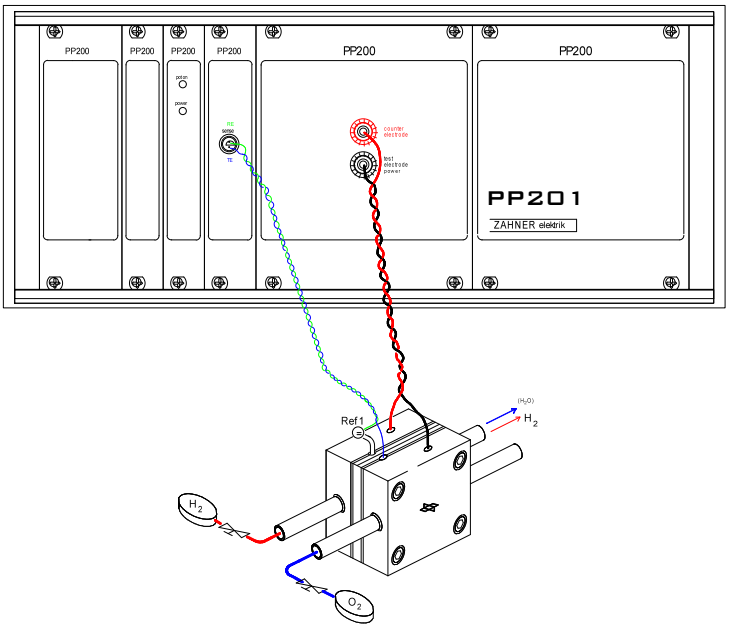

This configuration is used if a complete cell is to be investigated.

## 2.a. Half Cell Configuration – Anode



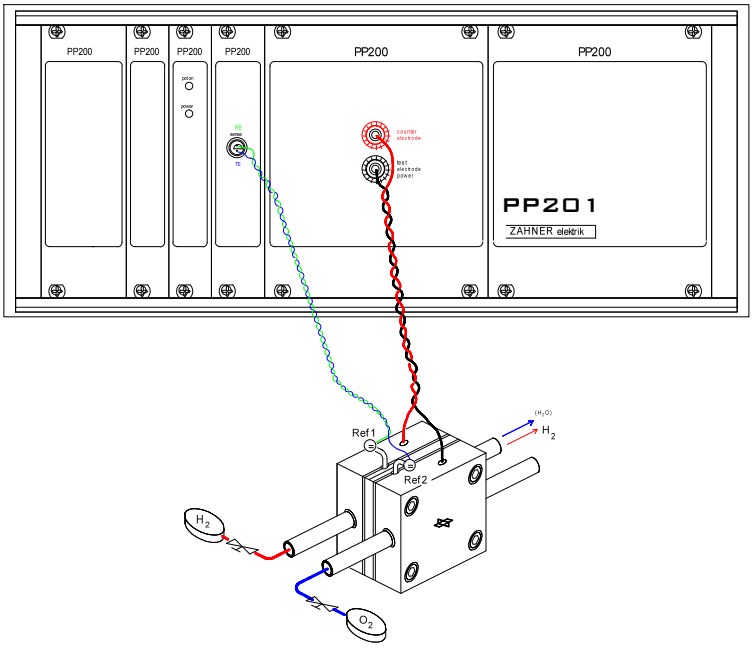

This configuration is used if the anodic part of the cell is to be investigated.

## 2.b. Half Cell Configuration – Cathode




This configuration is used if the cathodic part of the cell is to be investigated.

## 3. Partial Cell Configuration




This configuration may be used, if a certain part of a battery or fuel cell stack has to be investigated.

# XPOT

*XPOT* is a low power 4-quadrant potentiostat which may be used in connection with the impedance spectrometer IM6/Zennium. Using the *XPOT* allows parallel investigation of different objects. In such *multi-cell* arrangements, potentiostats which are not addressed, will hold their DC-conditions. *XPOT* provides a maximum current of ±500mA and a maximum potential of ±10V at a maximum frequency bandwidth of 100kHz. The compliance voltage is ±25 V.

## Connectors & LEDs


***Active* LED**
green = *XPOT* connected to *IM* system
orange = potentiostat on

**Probe I & E connectors**

**BNC Cell Connectors**
BNC plugs for connecting the cell:
Red = counter electrode
Green = reference electrode
Black = test (working) electrode
Blue = test (working) sense electrode

**The shields of the BNC connectors are connected to the test electrode (virtual ground) via a 2.2kΩ resistor.**

**!**

**The Probe I connector of the XPot is different from the Probe I connector of the IM6/Zennium. It is used for special XPot extensions such as CIMPS. Do not connect a UBuffer or a HiZ probe here.**

## Use of the built-in buffer

The built-in buffer amplifier may be used to increase the dynamic range of the *XPOT* up to +/-10V. To select the buffer amplifier mode, call the *Check Cell Connections* page of the *Thales* software, select any connection scheme *with buffer* and set the corresponding gain factor:

| gain factor | output potential range |
|---|---|
| 1 | -4V … +4V |
| 0.4 | -10 … +10V |

## Measuring floating objects

Floating and ground referenced objects demand different connections to the potentiostat. Usually, the ground of the *XPOT* will be connected to the system ground at its rear panel:

silver banana jack (protective ground) ⇔ black banana jack (system ground)

**!** **When investigating floating objects the jumper must be set.**

# Specifications

| | PP201 | PP211 | PP241 | XPOT |
|---|---|---|---|---|
| **Operating modes** | pot/gal | pot/gal | pot/gal | pot/gal |
| **Potential range** | ±4V / ±10V | ±4V / ±20V | ±4V / ±5V | ±4V / ±10V |
| **Pot. accuracy** | ±0.1% / ±1mV | ±0.1% / ±1mV | ±0.1% / ±1mV | ±0.1% / ±1mV |
| **Current range** | 0A … ±20A | 0A … ±10A | 0A … ±40A | ±10nA - ±500mA |
| **Current accuracy** | 0.25% / ±1mA | 0.25% / ±2mA | 0.25% / ±1mA | 0.2% / ±100pA |
| **Power dissipation** | 250W @ $T_a$ | 250W @ $T_a$ | 250W @ $T_a$ | 30W @ $T_a$ |
| **Output power** | 200W @ $T_a$ | 200W @ $T_a$ | 200W @ $T_a$ | 12W @ $T_a$ |
| **Frequency range*** | 10µHz - 200kHz | 10µHz – 200kHz | 10µHz – 200kHz | 10µHz – 200kHz |
| **Impedance range** | 1µΩ - 1kΩ** | 1µΩ - 1kΩ** | 1µΩ - 1kΩ** | 0.1Ω - 1GΩ |
| **Amb. temperature** | 0°C … 30°C | 0°C … 30°C | 0°C … 30°C | 0°C … 25°C |
| **System requirements** | IM6/Zennium + EPC42 or PC | IM6/Zennium + EPC42 or PC | IM6/Zennium + EPC42 or PC | IM6/Zennium + EPC42 or PC |

*Please note that the maximum frequency range only can be achieved with an IM6 or an Zennium equipped with EPC41 or EPC42. With an IM5d the maximum frequency range of external devices is 30kHz.

**Impedances below 1mΩ must be measured galvanostatically.