Sensor auto-identification on B-Box 4

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This article describes the auto-identification feature for imperix's latest current and voltage sensors — including those embedded in power modules — when used with the B-Box 4. This capability ensures true plug-and-play compatibility between the controller and its sensors, offering the following benefits:

- **Mitigation of the risk of misconfiguration**, thanks to detailed warnings in case of incorrect settings. Furthermore, the direct configuration of the safety limits in the sensor's true value (e.g. Volts or Amperes) also contributes to reducing the risk of setting inadequate thresholds.
- **Use of factory calibration data** included inside the sensors for superior overall accuracy and precision.

Supported devices

Auto-identification is only possible from the newest imperix controller, namely the B-Box 4. On the sensor side, the supported devices are as follows:

Product	Pre-calibrated offset	Pre-calibrated sensitivity	Comment
VSR-500-HBW	yes	no	
VSR-1000-ISO	yes	no	
CSR-25-HBW	yes	no	
PEB-800-40	yes	no	
PEB4050*	no	no	* Products sold > 2026
PEH2015*	no	no	* Products sold > 2026
PEH4010*	no	no	* Products sold > 2026
PEN8018*	no	no	* Products sold > 2026

The following devices **do not support** auto-identification: B-Box RCP 3.0, B-Box Micro, B-Board PRO, TPI8032, DIN-800V, DIN-50A, PEB8024, PEB8038.

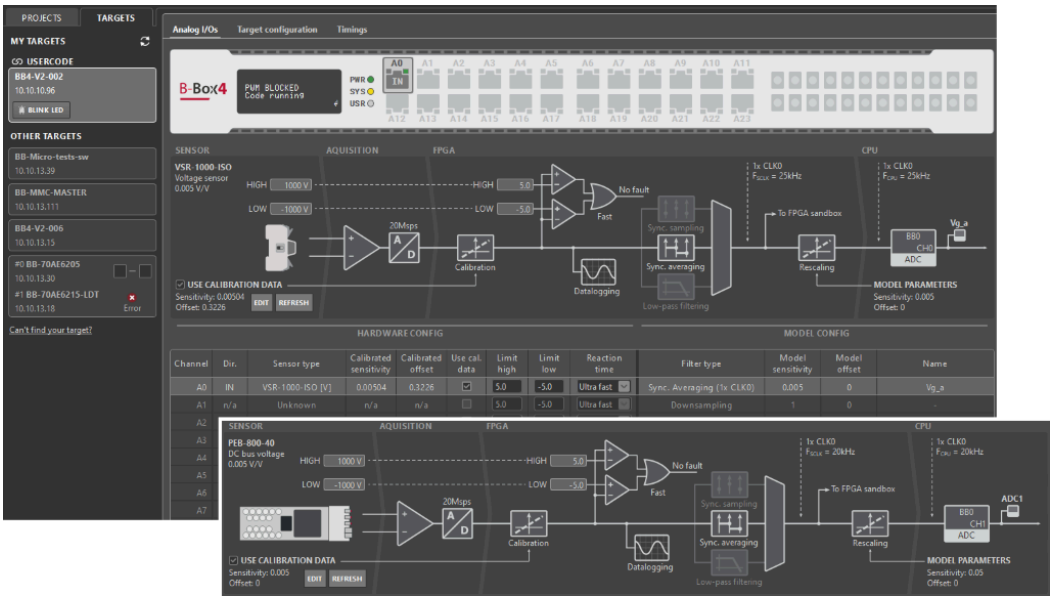
Principles of operation

The necessary data for the auto-identification process is stored within an EEPROM located inside the sensors. This memory stores information on the sensor type as well as its calibration parameters (see table below), which the B-Box 4 can read or update using a dedicated pin inside the RJ45 cable (1-wire communication). This mechanism is slow and entirely independent from that of the measurement, whose data remains carried over a differential pair of analog signals.

Parameter	Value example	User access from B-Box 4
Sensor type	CSR-25-HBW	read only
Nominal sensitivity	0.2 V/A	read only
Calibrated sensitivity	0.199 V/A	read/write
Calibrated offset	0.075 A	read/write

Information stored inside compatible imperix sensors.

Communication via the 1-Wire link is active exclusively during the B-Box 4 startup sequence, when a user code is started, or upon manual initiation by the user via the refresh command. Upon completion of the reading cycle, the retrieved data is populated and available for review within the *Analog I/Os* tab of the Cockpit software.



Analog I/Os tab in Cockpit when a sensor/power module is detected

The same information is also accessible on the LCD screen of the B-Box 4's front panel. In the menu under *ANALOG I/O* and the corresponding channel, the display shows the name of the connected sensor. If needed, the user can initiate a manual refresh of the connected devices.

Detected sensor type, as displayed on the front panel of the B-Box 4

Enabling/disabling the reading of the calibration data from the front panel of the B-Box 4

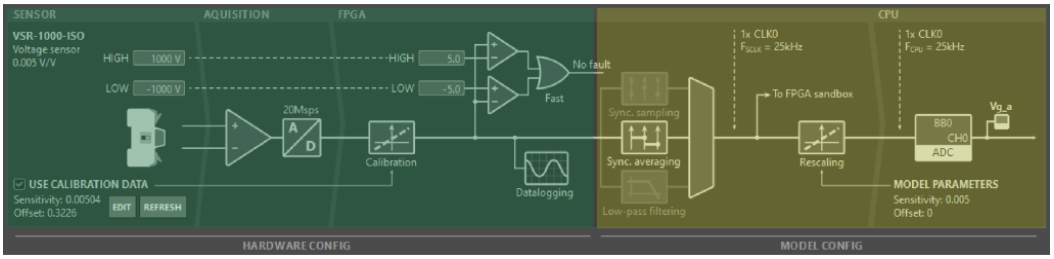
By default, calibration data is used in order to benefit from the related improvement of precision. However, if this is not desired for any reason, this option can be disabled either in Cockpit or using the front panel.

Coordination with analog channel parameters

Considering a complete analog I/O channel of B-Box 4, two parameter types should be distinguished:

- **Hardware parameters** (in green below) are stored on the hardware itself, namely the B-Box 4. Their configuration can be done using either Cockpit (Analog I/O tab) or through the front panel (LCD screen and button). These parameters are stored permanently, unless modified or reset. The safety limits as well as their reaction time are notable hardware parameters.
- **Model parameters** (in yellow below) are stored inside the Simulink/PLECS/C++ model. Their configuration must hence be done directly in the corresponding project files. These parameters are part of the control code (software), which are usually different for each project. The sampling method as well as the re-scaling gain of the corresponding measurement are notable model parameters.

More information regarding the configuration of the B-Box 4's analog inputs is given in PN252.



Architecture of an analog input channel on B-Box 4, hardware configuration section in green, model configuration section in yellow

Once a sensor is auto-identified, its associated characteristics (type, sensitivity and offset) are stored as part of the corresponding hardware parameters. This enables the following functions:

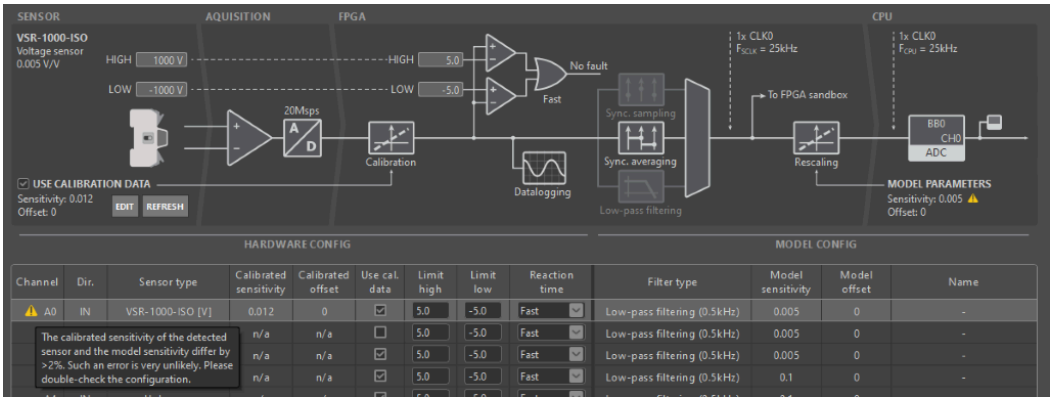
- Hardware and model parameters are automatically and systematically compared, so that possible inconsistencies are identified.
- The sensitivity of the connected sensor is known with sufficient confidence so that the protection thresholds can be safely configured in true value (e.g., tens

of amperes or hundreds of volts, at the sensor's input) as opposed to a voltage on the ADC (e.g. few volts at most, at the sensor's output).

Error messages and warnings

Several warnings may appear in Cockpit in relation to sensor auto-identification. These warnings, displayed in the *Logs* window and in the *Analog I/Os* tab, typically reveal probable misconfigurations, such as:

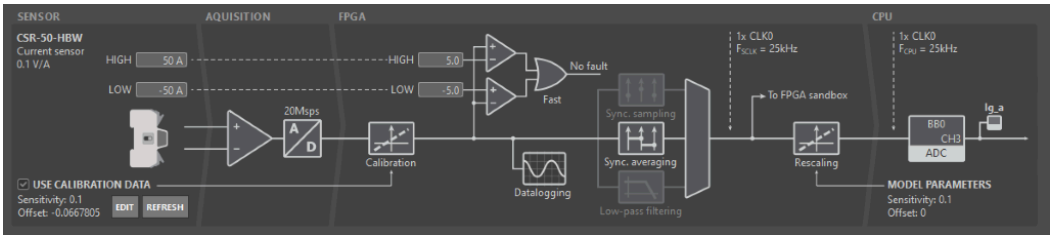
- The connected sensor type (model) differs from the one selected in the corresponding ADC block (if any).
- The sensitivity stored inside the detected sensor differs from that specified in the model (for that channel) by over 2%. This is unlikely to correspond to proper calibration, but rather indicates a wrong model configuration.
- A sensor is connected to a channel that is otherwise configured as an output, which doesn't make sense.



Example of a warning message displayed in the *Analog I/Os* tab of Cockpit

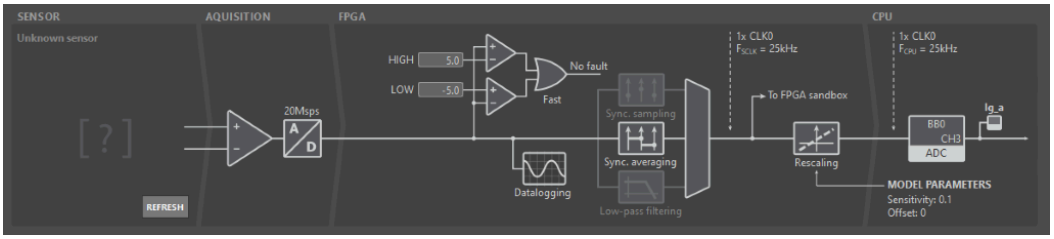
Configuration of the safety limits

Another benefit of sensor auto-identification is that it simplifies the configuration of the safety limits and, consequently, reduces the risk of incorrect settings. For example, the safety limits for a CSR-25-HBW sensor can be specified directly in amperes, so the user does not need to perform any conversion from the sensor's output voltage. In this case, the safety limits can be set in the text fields just above the displayed sensor on the corresponding channel. They can also be set using the B-Box 4's front panel.



Remote configuration of an analog input channel in Cockpit, with sensor auto-identification

When auto-identification is not available, safety limits must, however, be set considering the sensor's output voltage (i.e., the voltage applied to the ADC), rather than in the true measurement value.



Remote configuration of an analog input channel in Cockpit, without sensor auto-identification

More information about safety and protection is available in Over-current and over-voltage protection. Specific details about the configuration of the B-Box 4 are also given in PN252.

Factory calibration

Imperix products that are compatible with auto-identification (see table above) systematically undergo an **offset calibration** process, so that this information is identified and written on the EEPROM before shipping. This pre-calibration is expected to be vastly sufficient for most needs. Nonetheless, if re-calibration is necessary for any reason, it can also be easily re-executed during use. A basic, yet typical process is presented below.

The **sensitivity** is, however, not factory pre-calibrated, primarily for practical reasons. This parameter can nonetheless be updated afterward, for instance, using the procedure described below.

Manual offset calibration

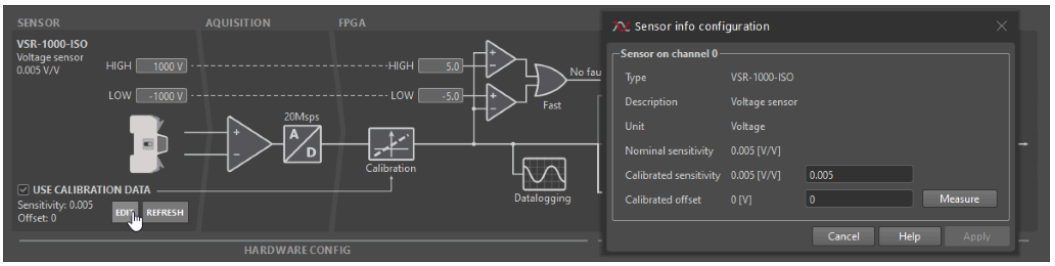
To calibrate the offset, no other equipment than the sensor and the B-Box 4 is required.

Before performing the offset compensation, it is important to ensure that the sensor is free of any residual voltage or current. Even small amounts of leakage current or remaining charge can nullify the calibration process. The most reliable way to properly avoid this is to disconnect the sensor from the rest of the circuit during calibration.

Once confidence is gained that the **measured value is truly zero**, the following basic procedure describes how to identify and store offset-related information with minimum effort:

1. Connect the sensor output to the desired ADC channel.
2. In the *Analog I/Os* tab of Cockpit, select the corresponding analog channel.
3. Next to the displayed sensor, click on *EDIT*.
4. In the sensor configuration pop-up, manually update the sensor offset (see image below).
5. Click *Apply* to save the changes.

If a Cockpit project exists for the selected target, and the model implements a measurement on the desired channel, the offset can be automatically measured. Step 4 is hence simplified:
4. Click on *Measure* to launch an averaging measurement over 2s. The offset is automatically updated.



Sensor configuration window in Cockpit

Manual sensitivity calibration

To correctly calibrate the sensitivity, a reference measurement provided by a higher precision device is required. A very basic, yet typical calibration procedure is described as follows:

1. Make sure that the offset is properly calibrated first (see procedure above).
2. Connect a precisely known voltage/current source to the sensor's input, serving as the reference measurement. Note down that reference value.
3. Observe the sensed value (e.g., using Cockpit). With the two results, calculate the new calibrated sensitivity:

$$S_{calibrated} = \frac{Val_{cockpit}}{Val_{reference}} \cdot S_{uncalibrated}$$

4. In the sensor configuration pop-up, manually update the sensitivity.

The above-described procedure leverages only one point to calibrate the sensitivity. This is reasonable with an excellent linearity and a reference measurement of very high precision. However, in practice:
– The calibration can only be as precise as the reference measurement, which is typically easier to achieve for a voltage than for a current.
– If reaching a high precision is possible and required, superior results can be obtained by making several (or numerous) points inside both the positive and negative sensor ranges, and deducing the offset and sensitivity using a least mean square linearisation method.

Further readings

- Analog I/O configuration on B-Box 4
- Over-current and over-voltage protections