VSR-500-HBW

±500V HIGH-BANDWIDTH VOLTAGE SENSOR

HIGH-PERFORMANCE SOLUTIONS FOR
CONTROL DEVELOPMENT AND TESTING

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A solution serving as a precision sensor and a powerful tool for capturing transients in power electronics.

GENERAL DESCRIPTION

VSR-500-HBW is a high-performance voltage sensor for a wide range of applications in power electronics, providing accurate measurement of dynamic voltage events.

Featuring a bandwidth of 3 MHz, this device enables precise capture of quick voltage variations in power conversion systems. It is ideal for monitoring PWM ripple, short-duration transients, and other rapid signals. In addition, it supports AC mains and bus voltage measurement and system protection.

The measurement stage consists of a frequency-compensated high precision attenuator, followed by a fully-differential instrumentation amplifier. It offers high input impedance, low offset and noise, and excellent common-mode rejection in AC and DC voltage measurements.

The input range of ±500 V is scaled down to a ±5 V output, which corresponds to a sensitivity of 10 mV/V. The output is transmitted as a differential pair through the RJ45 connector. Inputs can be connected using laboratory banana plugs or wire terminals.

The sensor is optimized for use with imperix controllers, which provide the necessary ±15 V power supply through the RJ45 connector. It also supports other acquisition systems as long as the pinout is correctly configured.

KEY FEATURES AND SPECIFICATIONS

- Auto-configuration with B-Box 4 (1-wire link)
- ±500 V_{pk} measurement range
- 165 ns response time (typ.)
- 3 MHz bandwidth
- Outstanding CMTI over wide range of dV/dt
- Selectable bandwidth (3 MHz or 300 kHz)
- ±20mV input offset (typ.) – factory calibration available on B-Box 4
- ±0.2% gain error (typ.) – factory calibration available on B-Box 4
- Up to 1 kV_{RMS} permanent working voltage
- Self-powered from imperix controllers (±15 V)

TYPICAL APPLICATIONS

- High-performance current control (bandwidth, precision)
- Monitoring, scoping, debug
- System identification

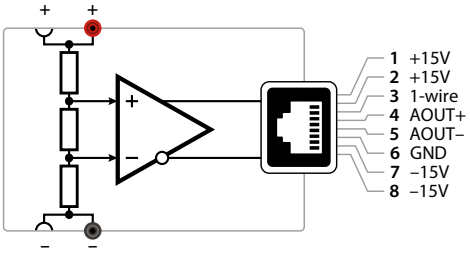
BENEFITS

This sensor, with its high bandwidth, paired with the 20 Msps oversampling capability of the B-Box 4, allows for accurate scoping of voltage waveforms, even during fast transient events. Thanks to the advanced precision and robust common-mode rejection, it operates effectively as a differential voltage probe, while the monitoring software Cockpit can substitute for an oscilloscope.

Due to its low noise level and minimal offset, it is well suited for measuring lower voltages. At the same time, its wide input range ensures flexibility. The unit is also mountable on a DIN rail, simplifying installation in laboratory and industrial setups.

Additionally, with the B-Box 4, this device can be calibrated through the 1-wire connection embedded in the RJ45 connector. This will further improve its accuracy and minimize the offset. Full plug-&-play compatibility with Imperix controllers is ensured, since measurement and calibration data, along with power supplies, are all handled over the RJ45 interface.

SIMPLIFIED SCHEMATIC



RELATED PRODUCTS

Sensor	Type	Range	BW	CMTI	Production
VSR-500-HBW	Differential	±500 V_{pk}	3 MHz	very high	Active
VSR-1000-ISO	Isolated	±1000 V_{pk}	100 kHz	very high	Active
CSR-25-HBW	Isolated	±25 A_{RMS}	1.5 MHz	very high	Active
DIN-800V	Isolated	±800 V_{pk}	100 kHz	medium	NRND
DIN-50A	Isolated	±50 A_{pk}	200 kHz	medium	NRND

TECHNICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Test conditions	Min.	Typ.	Max.	Unit
Maximum tolerable input voltage		IN+ to IN–	–	3.0	–	kV_{pk}
		IN+ or IN- to GND	–	1.5	–	kV_{pk}
Maximum repetitive peak voltage	V_{IORM}	60s, AC	–	1.5	–	kV_{pk}
Maximum working voltage	V_{IOWM}	OVCII, PD2, basic isolation	–	1100	–	V_{RMS}
		OVCII, PD2, reinforced isolation	–	550	–	V_{RMS}
ESD Human Body Model			–	±8	–	kV
Power supply voltage	$\pm V_{CC}$		±12	±15	±18	V

ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Test conditions	Min.	Typ.	Max.	Unit
Nominal input voltage, linear range	V_{NOM}		–	±500	–	V_{pk}
Maximum measurable voltage	V_{MAX}		–	±850	–	V_{pk}
Nominal sensitivity	G	Load resistance R_L = 5 kΩ	–	10.0	–	mV/V
Sensitivity error	G_E	Disregarding calibration data	–	–	±0.1	%
Input-referred offset	V_O	Disregarding calibration data	–	±20	±60	mV
	$V_{O,BB4}$	On B-Box 4 with calibration data enabled		±10	±30	mV
Response time	t_{resp}	To 90 % of final value		165		ns
Measurement bandwidth	$f_{3dB,High}$	Selector set to HIGH bandwidth		3	–	MHz
	$f_{3dB,Low}$	Selector set to LOW bandwidth		300	–	kHz
Input-referred noise, RMS		100 Hz - 3 MHz	–	104		mV
		100 Hz - 300 kHz	–	102		mV
Input series resistance	R_{IN}		–	6.4	–	MΩ
Output impedance, differential	R_{OUT}		19.8	20.0	20.2	Ω
Output short-circuit current	I_{SC}			±37		mA
Power consumption	P_{DD}		–	0.22		W

OFFSET

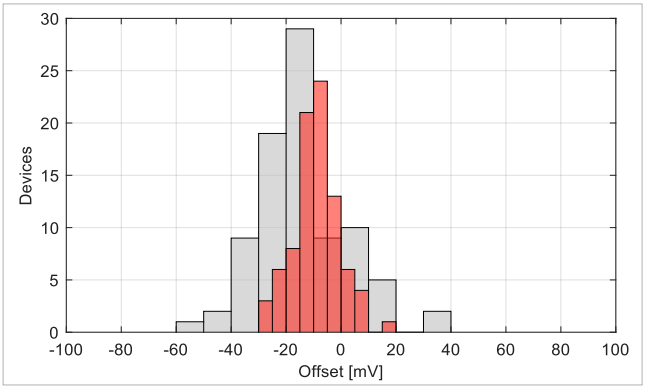


Fig. 1. Statistical distribution of input-referred offset (grey : uncalibrated, red : calibrated).

SENSITIVITY ERROR

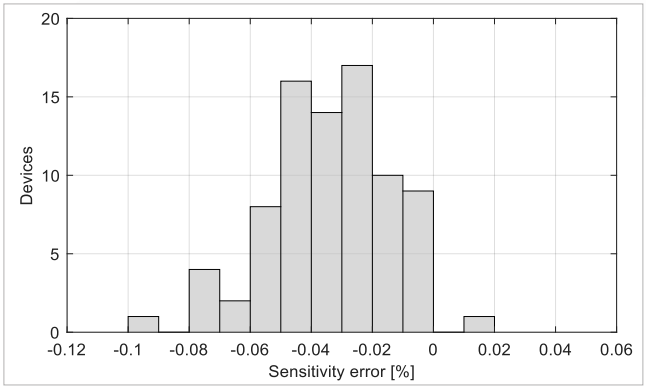


Fig. 2. Statistical distribution of sensitivity error (uncalibrated).

TYPICAL CHARACTERISTICS

LARGE SIGNAL STEP RESPONSE

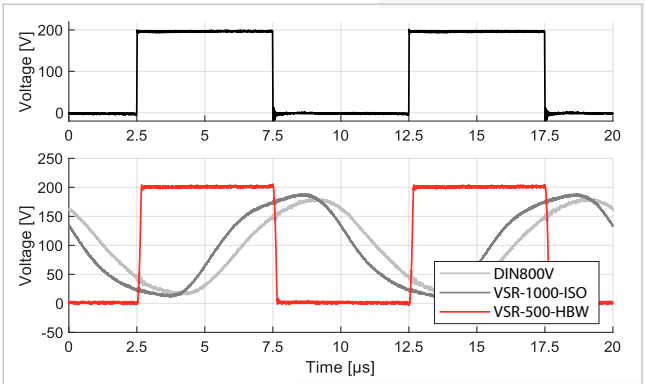


Fig. 3. Comparing VSR-500-HBW with other imperix voltage sensors.

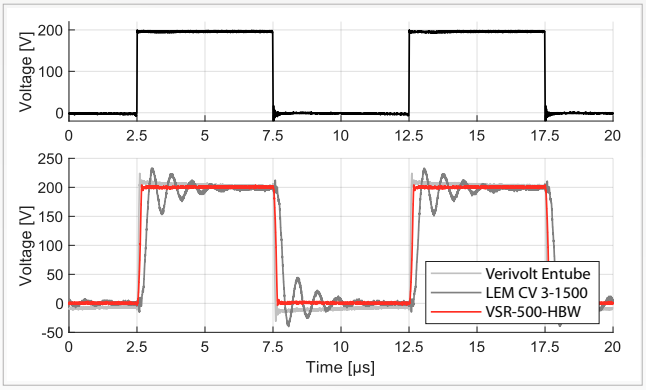


Fig. 4. Comparing VSR-500-HBW with competing solutions.

COMMON-MODE VOLTAGE REJECTION

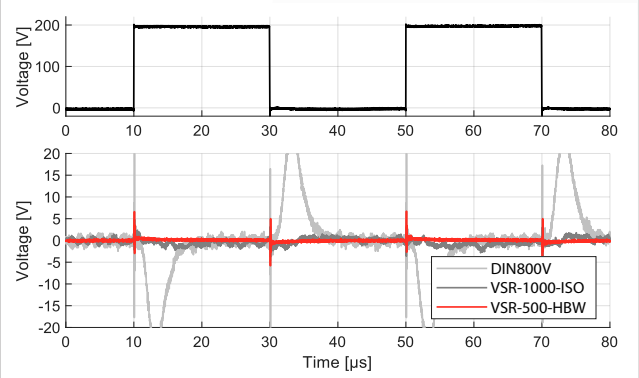


Fig. 5. Comparing-VS3-500-HBW with other imperix voltage sensors.

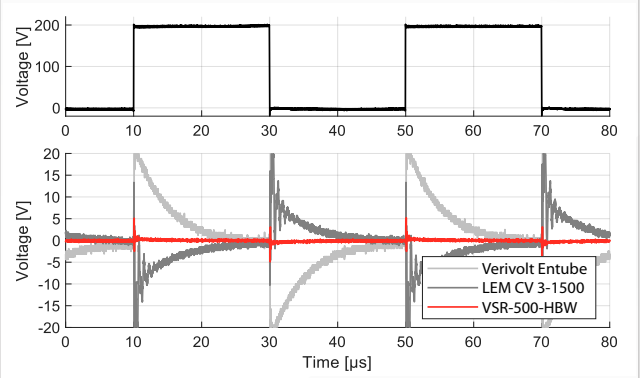


Fig. 6. Comparing VSR-500-HBW with competing solutions.

FREQUENCY RESPONSE

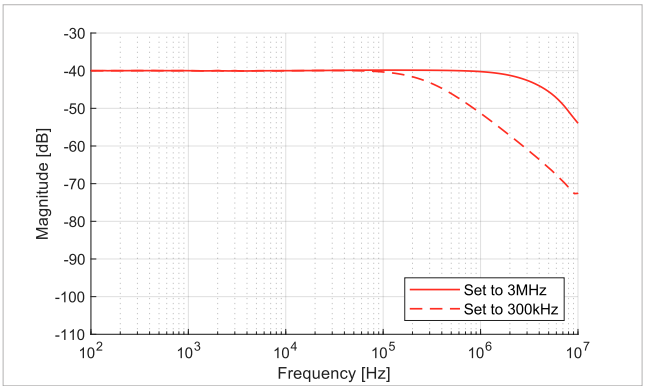


Fig. 7. Differential mode transfer function.

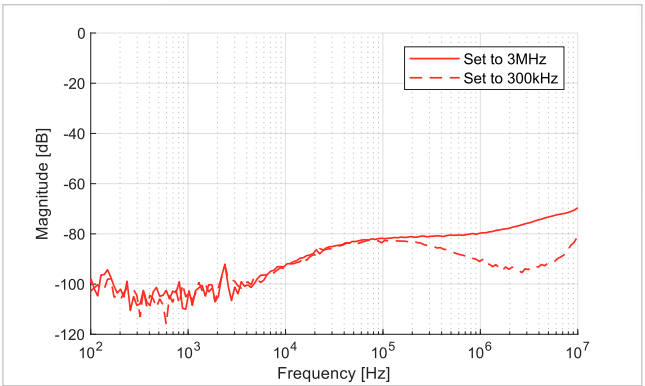


Fig. 8. Differential to common-mode transfer function.

NOISE

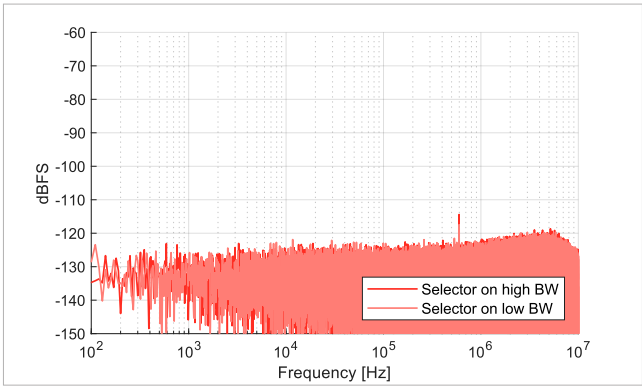


Fig. 9. Noise spectrum of the sensor, measured with B-Box 4

MECHANICAL SPECIFICATIONS

DIMENSIONS

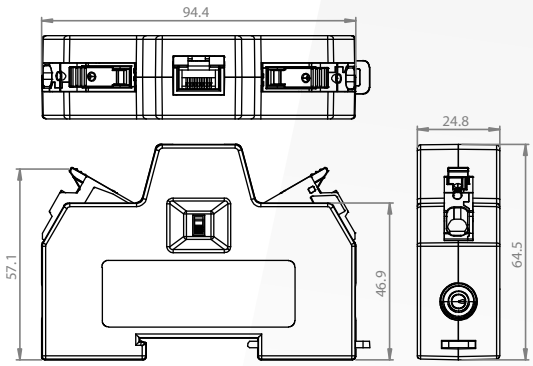


Fig. 10. Dimensions of the VSR-500-HBW sensors.

AUTO-IDENTIFICATION AND CALIBRATION

The VSR-500-HBW sensors embeds an EEPROM, which contains information on the sensor type as well as its calibration parameters. This data can be read from B-Box 4 and enable the auto-identification. The EEPROM is accessible over a 1-wire communication link present on pin 3 of the RJ45 connector.

FACTORY PARAMETERS

The following table lists the stored parameters. During factory testing, the offset is calibrated; however, the sensitivity is not calibrated.

Parameter	Value	User access from B-Box 4
Sensor type	VSR-500-HBW	Read only
Nominal sensitivity	0.01 [V/V]	Read only
Calibrated sensitivity	0.01 [V/V]	Read / write
Calibrated offset	0 [V]	Read / write

Table 1. Information stored in the EEPROM

CALIBRATION PROCEDURE

If the user wishes to update the calibration data present inside the EEPROM, this can be done by clicking the "edit" button in Cockpit:

- Switch from the "Projects" view to the "Targets" view.
- Select the correct target (if not already the case).
- Navigate to the "Analog I/Os" configuration tab.
- Select the correct channel.
- Click on the "edit" button, as shown in Fig. 13.

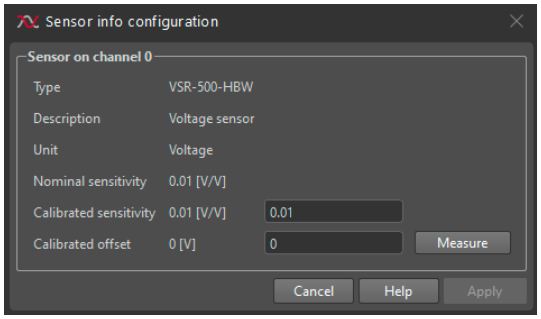


Fig. 11. Editing the calibration data in imperix Cockpit.

MOUNTING INSTRUCTIONS

VSR-500-HBW sensors are designed to be mounted on 35mm DIN rails. To correctly mount the device:

- Pull the black spring-type locker out.
- Place the sensor on the rail.
- Push back the spring-type locker.

WIRING INSTRUCTIONS

Beware of the limited current-carrying capacity of the 4 mm (banana) connectors. Their rating (24A) is similar to that of most laboratory cables. For higher-current applications, use the wire terminals.

Do not use wire sleeves with the wire terminals. Their internal surfaces are flat, preventing any risk of damage to stranded wires.

DISABLING CALIBRATION INFORMATION

By default, the B-Box 4 uses calibration parameters in order to improve the accuracy of the retrieved measurement. If, for any reason, the user wishes to bypass this behaviour, calibration can be disabled in the analog I/O configuration of the B-Box 4:

- Directly on B-Box 4, select the "analog I/O" configuration menu. Select the desired channel, and then "disable" in the relevant screen:

Fig. 12. Status message on the OLED screen of the B-Box 4.

- In Cockpit, uncheck the "USE CALIBRATION DATA" checkbox in the "analog I/O" tab of the "target" configuration.

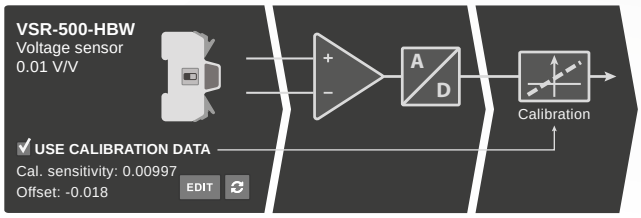


Fig. 13. Relevant section of the "analog I/O" configuration in Cockpit.

RELATED DOCUMENTATION

PRINT

- Datasheet of the B-Box 4 – link

ONLINE

- Sensor auto-identification on B-Box 4 – link
- Analog I/O configuration on B-Box 4 – link
- Architecture and operation of B-Box 4 – link
- Over-current and over-voltage protection – link
- Advanced sampling techniques – link

ENVIRONMENTAL CONDITIONS

Parameter	Value
System voltage	300 V, OVC II, PD2
Operating conditions (IEC/EN 60721-3-3)	Climate conditions for operation class 3K3 : – Temperature range: 0°C to +40°C – Relative humidity: < 95%, no condensation – Atmospheric pressure: 70KPa to 106KPa
Storage conditions (IEC/EN 60721-3-1)	Climate conditions for storage class 1K3 : – Temperature range: -25°C to +55°C – Relative humidity: < 95%, no condensation – Atmospheric pressure: 70KPa to 106KPa
IP rating	IP 20
Protection class	Class II

Table 2. Rated environmental conditions

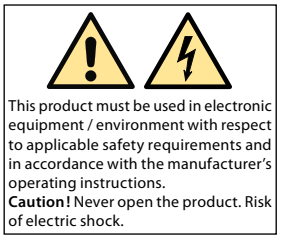
PINOUT

Pin	Pair	Color	Description
1	2	orange stripe	+15 V
2	2	orange solid	+15 V
3	3	green stripe	1-WIRE data
4	1	blue solid	Positive input / current input
5	1	blue stripe	Negative input / ground
6	3	green solid	GND
7	4	brown stripe	- 15 V
8	4	brown solid	- 15 V

Table 3. Pinout of the RJ45 connector.

REVISION HISTORY

- 26.09.25 : Preliminary version
- 10.03.26 : Added statistics on offset and sensitivity error.



This product must be used in electronic equipment / environment with respect to applicable safety requirements and in accordance with the manufacturer's operating instructions.
Caution! Never open the product. Risk of electric shock.

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ABOUT US

Imperix develops high-end control equipment and prototyping hardware for power electronics, motor drives, smart grids, and related applications. Our products are designed to accelerate the implementation of laboratory-scale power converters and facilitate the acquisition of high-quality experimental results.

NOTE

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