



HV Intelligent Battery Shunt Sensor

Battery Electronics

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1. Product Overview

The Intelligent Battery Shunt Sensor (IBSS) is based on Low TCR shunt resistor and high precision low tracing error voltage divider allowing high bandwidth, high accuracy current and voltage measurements over a wide range of temperatures without the need for temperature compensation.

The HV-IBSS-CAN/CANFD is available with multiple shunt values to match the user's measurement ranges Table 1.

Typical Application

- Automotive and industry
- Industrial and server computing
- Networking, telecom, and base station power supplies
- Battery management systems
- EV test environment
- Solar installations
- Home automation

Hardware Features

- I/O isolation test voltage 3.5 kVDC
- 9V to 24 V power supply
- CANFD interface
- NTC temperature measurement

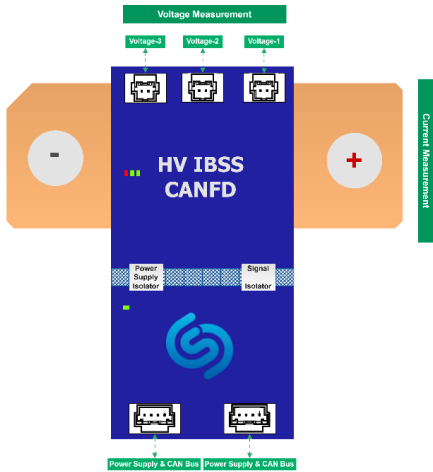
Features

- Current measurement
- Low TCR shunt resistor (down to $< \pm 10$ ppm)
- Low thermal EMF (as low as < 1.25 $\mu\text{V}/^\circ\text{C}$)
- Very low inductance (< 5 nH)
- Easy to connect to a busbar
- Continuous current rating up to 1800 A
- 5s overload up to 9000 A
- Three channel voltage measurement
- Voltage measurement up to 1200 V
- Precision to ± 0.5 % with low TCR tracking to 10 ppm/ $^\circ\text{C}$ utilizing thick film technology
- Analog frontend
- 24-bit analog-digital converter
- Up to 32 ksps output rate

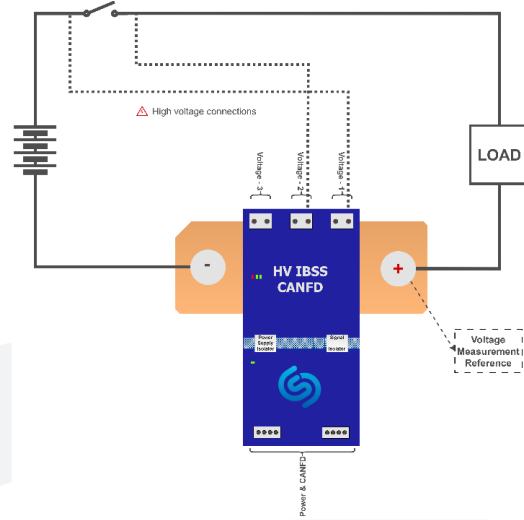
2. Available Current and Voltage Ranges

Order number	SSA001C06A	SSA001C05A	SSA001C04A	SSA001C03A	SSA001C02A	SSA001C01A
CURRENT MEASUREMENT						
Shunt resistance	100 $\mu\Omega$	50 $\mu\Omega$	30 $\mu\Omega$	50 $\mu\Omega$	25 $\mu\Omega$	15 $\mu\Omega$
Power rating (70 °C)	36 W	36 W	36 W	50 W	50 W	50 W
Continuous current	600 A	849 A	1095 A	1000 A	1414 A	1826 A
Short time overload (5x for 5 s)	3000 A	4245 A	5475 A	5000 A	7070 A	9130 A
Max. measurable current (ADC limit, gain 8)	1500 A	3000 A	5000 A	3000 A	6000 A	10000 A
Max. measurable current (ADC limit, gain 8)	3000 A	5000 A	5000 A	6000 A	6000 A	10000 A
Shunt resistance accuracy (%)	5%	5%	5%	5%	5%	5%
Shunt load life (resistance change over 1000 h)	1%	1%	1%	1%	1%	1%
Shunt TCR (max.)	± 10 ppm/K	± 10 ppm/K	± 10 ppm/K	± 10 ppm/K	± 10 ppm/K	± 10 ppm/K
Shunt thermal EMF (max.)	1.25 $\mu\text{V/K}$	1.25 $\mu\text{V/K}$	1.25 $\mu\text{V/K}$	1.25 $\mu\text{V/K}$	1.25 $\mu\text{V/K}$	1.25 $\mu\text{V/K}$
Shunt temperature operating range	-65 °C to +170 °C	-65 °C to +170 °C	-65 °C to +170 °C	-65 °C to +170 °C	-65 °C to +170 °C	-65 °C to +170 °C
VOLTAGE MEASUREMENT						
Resistor Range	8000 k Ω	8000 k Ω	8000 k Ω	8000 k Ω	8000 k Ω	8000 k Ω
Voltage divider ratio	0.001	0.001	0.001	0.001	0.001	0.001
Voltage divider accuracy	1%	1%	1%	1%	1%	1%
Voltage divider ratio accuracy	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Voltage measurement range	1200	1200	1200	1200	1200	1200

3. Pin Configuration



6. Typical Application Circuit



4. Power Supply and CAN Bus Pins

Pin	Name	Description
1	Ground	DC supply input / Vss (-)
2	CAN Bus High	CAN Bus communication pin
3	CAN Bus Low	CAN Bus communication pin
4	12V-24V	DC supply input / Vcc (+)



Power Supply and CAN Bus Connector (5600200420)

7. Led Indicators

- 3.3V power LED indicates availability of “hot” 3.3 V rail
- CAN bus frame TX LED indicates data transmission
- Measurement data ready LED indicates completion of ADC conversion

5. Voltage Measurement Pins

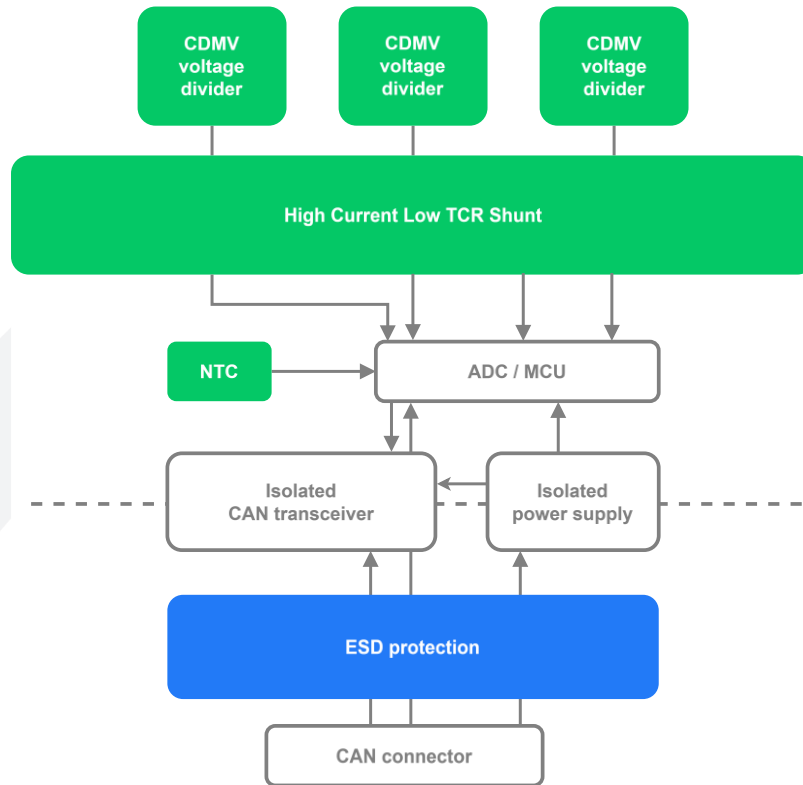
Pin	Name	Description
1, 2	Voltage Input-1	CH-1 Voltage Sensing
1, 2	Voltage Input-2	CH-2 Voltage Sensing
1, 2	Voltage Input-3	CH-3 Voltage Sensing



Voltage Measurement Connector (5600200220)



8. Overall Block Diagram



9. Operational Description

9.1 Device overview

The fundamental structure of this circuit comprises two domains: the high voltage domain (HV) and the low voltage domain (LV), which are galvanically isolated from each other.

To reduce the cost the number of data channels crossing the isolation barrier is minimized. Therefore, it was chosen to isolate the CAN interface and a single power supply. The isolated power supply supplies the 3.3 V rail on the HV side and supplies CAN TX and CAN RX signal to the MCU. The MCU interfaces with an SPI bus to transfer data from an SD-ADC which in turn is connected to a Vishay WSBE series of shunt for current measurement and three CDMV voltage dividers for voltage measurement.

9.2 Current Measurement

When the current flows through the shunt, the shunt's resistive element produces a voltage drop. This voltage is filtered (RC filter) and digitized using a 24-bit ADC. The

obtained digital value is transferred via SPI to the MCU and processed into data packages that are broadcasted on the CAN bus.

Due to the low thermal coefficient of resistance, the voltage drops over the shunt's resistive element is very stable with temperature (down to 10 ppm/K). Therefore, to reach industry standard deviations over the whole automotive temperature range and lifetime of the product temperature compensation is not required.

The WSBE series of shunts come with 5 % resistance accuracy. The accuracy of the final reading can be increased by calibration (two-point calibration since temperature compensation is not necessary) and hence is practically limited by the accuracy of the calibration standard used, the resolution and precision achieved by the ADC.

To keep offset errors to a minimum, the global chop mode of the ADCs is activated by default and should be kept active.

The sensor autonomously calibrates the ADC gain and samples at the maximum deviation rate permissible by the ADC corresponding to the relevant gain setting.

9.3 Voltage Measurement

To measure voltage, the HV source is connected to a CDMV voltage divider that reduces the input voltage at a ratio of 1000:1, producing voltages in a range the ADC can directly measure.

The accuracy of the voltage measurement is determined by multiple factors such as thermal drift between the upper and lower resistance in the divider as well as gain and offset errors in the ADC. Due to the unique construction of the CDMV thermal drift of the divider ratio is limited to 10 ppm and ADC offsets are reduced by global chop mode. This leaves the ADCs non-compensatable errors such as thermal and temporal gain error drifts as the main contributors to the measurement error.

9.4 Temperature Measurement

The HV intelligent battery shunt sensor (IBSS) uses NTC thermistors to measure the temperature of the shunt resistor. The NTC sensor is placed near the shunt resistor pin to accurately capture the thermal state. As the temperature increases, the resistance of the NTC decreases, and this change is converted into a voltage signal. The microcontroller reads this voltage via an embedded ADC and calculates the temperature, ensuring precise monitoring of the shunt temperature to prevent overheating and ensure system safety.

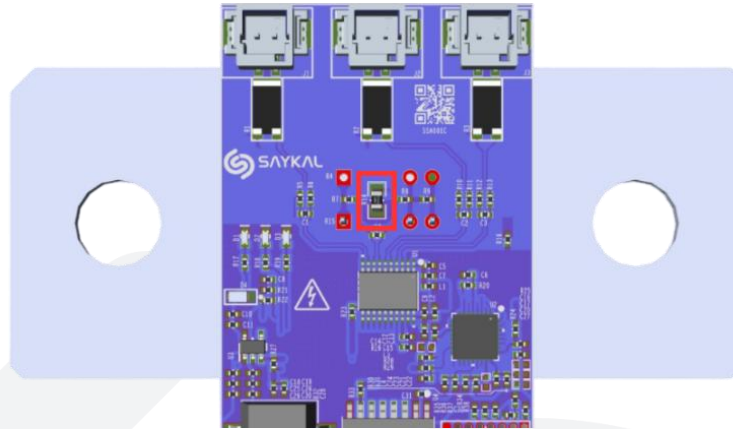


Figure 1 - NTC Placement on HV-IBSS-CAN/CANFD PCB

10. Power & Energy Measurement

Power and energy calculations are performed by the MCU and then transmitted over the CAN Bus. The device takes the voltage information from channel V1 as a reference for power and energy measurements. The direction of current flow through the shunt, whether positive or negative, does not affect the power calculation positively or negatively. In power calculation, the current channel is always taken as the absolute value by the device.

In energy calculation, the current channel is taken as negative or positive by the device and calculated.

11. Output Signals

SIGNAL	UNIT	MEASURED/CALCULATED
Voltage – 1	mV	Measured
Voltage – 2	mV	Measured
Voltage – 3	mV	Measured
Current	A	Measured
Temperature	C	Measured
Power	W	Calculated (1)
Energy	W μ s and Wh	Calculated (1)

Notes

- (1) By using the equations shown below, the IBSS provides calculated battery power and energy to track the energy flow. Power and energy values are provided on the CAN bus alongside the current and voltage measurements

$$\text{Power} = V1 \times I_{\text{shunt}} \text{ (W)}$$

- (2) Energy (W μ s) = Power (W) x Elapsed Time (μ s)
- (3) Energy (Wh) = [Energy W μ s to Wh conversion]

12. Anti-aliasing Filter

To properly drive the sigma delta ADC an anti-aliasing filter in accordance with the ADCs datasheet is used. Keep in mind that the input impedance between the voltage divider and current shunt are very different and require different capacitors to reach the same cutoff frequency. Failure to use proper filtering on the input of the ADC will result in noise and artefacts that can reduce accuracy and precision of the measurements below the ADC typical values.

13. CAN Bus Interface

13.1 CAN Bus Default Settings

- Protocol: CAN STD 2.0a
- Nominal baud rate: 500kbit/s
- Termination Resistors: Active (120 Ω)
- Measurement Data ID: 0x531
- Measurement Data cycle: 10ms

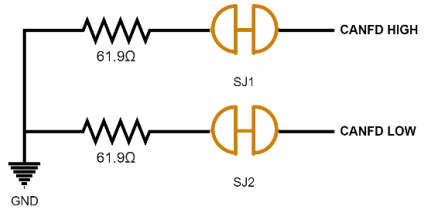
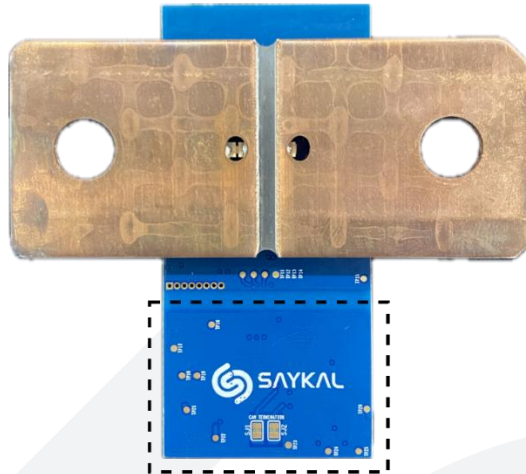
By default, the HV-IBSS-CANFD operates as a CAN device with bus termination resistors active, broadcasting readings and status messages periodically at a rate of 100 Hz.

A DBC file describing the CAN/CANFD protocol is available upon request. Please contact us directly to obtain the data sheet or additional documentation. CAN Bus communication can be configured. The CAN ID of measurement results can be changed via the CAN bus configuration message structure. CAN Bus Termination Resistors

13.2 CAN Bus Termination Resistors

By default, the CAN bus is terminated using termination resistors on CAN high and CAN low for easy evaluation in a point-to-point application. Bus termination resistors can be easily dis-engaged by cutting the copper connection in the middle of the two solder jumpers SJ1 and SJ2 found on the back of the PCB if needed.

To engage the termination resistors, use solder to close the jumper connection.



14. Measurement Message Structure

14.1 CANFD

- ID: 0x11223344 (Default)
- DLC: 32
- V1: Voltage – 1
- V2: Voltage – 2
- V3: Voltage – 3
- C: Current
- P: Power
- E: Energy
- T: Temperature (4)
- SED: System Error Data
- MED: Measurement Error Data
- CNT: Counter

Signal	V1	V2	V3	C	P	E	T	SED	MED	CNT
Bit	[0:31] Unsigned 4 Byte	[32:63] Unsigned 4 Byte	[64:95] Unsigned 4 Byte	[96:127] Signed 4 Byte	[128:159] Unsigned 4 Byte	[160:223] Signed 8 Byte	[224:231] Unsigned 1 Byte	[232:239] Unsigned 1 Byte	[240:247] Unsigned 1 Byte	[248:255] Unsigned 1 Byte
Unit	mV	mV	mV	mA	mW	Wh	°C			Message counter
Endianness	Big	Big	Big	Big	Big	Big	Big	Big	Big	Big

(4) Temperature value has +25°C offset and range is between 0(-25°C) and 255(230°C)

14.2 CAN STD 2.0a

14.2.1 Error Result Message

- ID: 0x530 (Default)
- DLC: 3

Signal	Temperature	SED	MED
Bit	[0:7] Unsigned 1 Byte	[8:15] Unsigned 1 Byte	[16:23] Unsigned 1 Byte
Unit	°C		
Endianness	Big	Big	Big

14.2.2 Current Result Message

- ID: 0x531 (Default)
- DLC: 8

Signal	Reserved	C
Bit	[0:31] Unsigned 4 Byte	[32:63] Signed 4 Byte
Unit		mA
Endianness		Big

14.2.3 Voltage 1 Result Message

- ID: 0x532 (Default)
- DLC: 8

Signal	Reserved	V1
Bit	[0:31] Unsigned 4 Byte	[32:63] Unsigned 4 Byte
Unit		mV
Endianness		Big

14.2.4 Voltage 2 Result Message

- ID: 0x533 (Default)
- DLC: 8

Signal	Reserved	V2
Bit	[0:31] Unsigned 4 Byte	[32:63] Unsigned 4 Byte
Unit		mV
Endianness		Big

14.2.5 Voltage 3 Result Message

- ID: 0x534 (Default)
- DLC: 8

Signal	Reserved	V3
Bit	[0:31] Unsigned 4 Byte	[32:63] Unsigned 4 Byte
Unit		mV
Endianness		Big

14.2.6 Energy Result Message

- ID: 0x536 (Default)
- DLC: 8

Signal	E
Bit	[0:63] Signed 8 Byte
Unit	mWH
Endianness	Big

14.2.7 Temperature Result:

- ID: 0x537 (Default)
- DLC: 1

Signal	T
Bit	[0:8] Unsigned 8 Byte
Unit	°C
Endianness	Big

14.2.8 Power Result Message

- ID: 0x535 (Default)
- DLC: 8

Signal	Reserved	P
Bit	[0:31] Unsigned 4 Byte	[32:63] Unsigned 4 Byte
Unit		mW
Endianness		Big

15. Error Data Structure

If the error is resolved or the device resets itself to default, these flags will be cleared.

15.1 SED: System Error Data		
BIT0	System Application Verification	If the device cannot verify the app upon startup, this flag will be set.
BIT1	System Calibration Verification	If the device cannot read or verify the calibration data upon startup, this flag will be set.
BIT2	System Configuration	If the device cannot read or verify the configuration data upon startup, this flag will be set.
BIT3	System CAN Bus RX	If the device receives a CAN Bus message that it cannot handle, this flag will be set.
BIT4	System CAN Bus TX	If the device cannot send a message via the CAN Bus, this flag is set. It cleared after the first successful transmission.
BIT5	System Temperature	If the device's temperature exceeds 200°C, this flag is set.
BIT6	Reserved	
BIT7	Reserved	

15.2 SED: Measurement Error Data		
BIT0	Meas. ADC Ready	If ADC data is not ready for 100ms, that bit occurs.
BIT1	Meas. ADC Lock	If ADC's PLL is not locked, this flag will be set.
BIT2	Meas. ADC Reset	If the ADC resets itself or remains in a reset state, this flag will be set.
BIT3	Meas. ADC Overvoltage	If any of the device's voltage measurement channels exceeds 1000V, this flag will be set.
BIT4	Meas. ADC Overcurrent	If any of the device's current measurement channels exceed the shunt resistor's maximum wattage, this flag will be set.
BIT5	Reserved	
BIT6	Reserved	
BIT7	Reserved	

16. CAN STD 2.0a Measurement Result ID Assignment Structure

CAN STD 2.0a Default Measurement ID: 0x531

	CH ID	Description
Measurement ID +	-1	Error Channel
	0	Current Channel
	1	Voltage 1 Channel
	2	Voltage 2 Channel
	3	Voltage 3 Channel
	4	Power Channel
	5	Energy Channel
	6	Temperature Channel

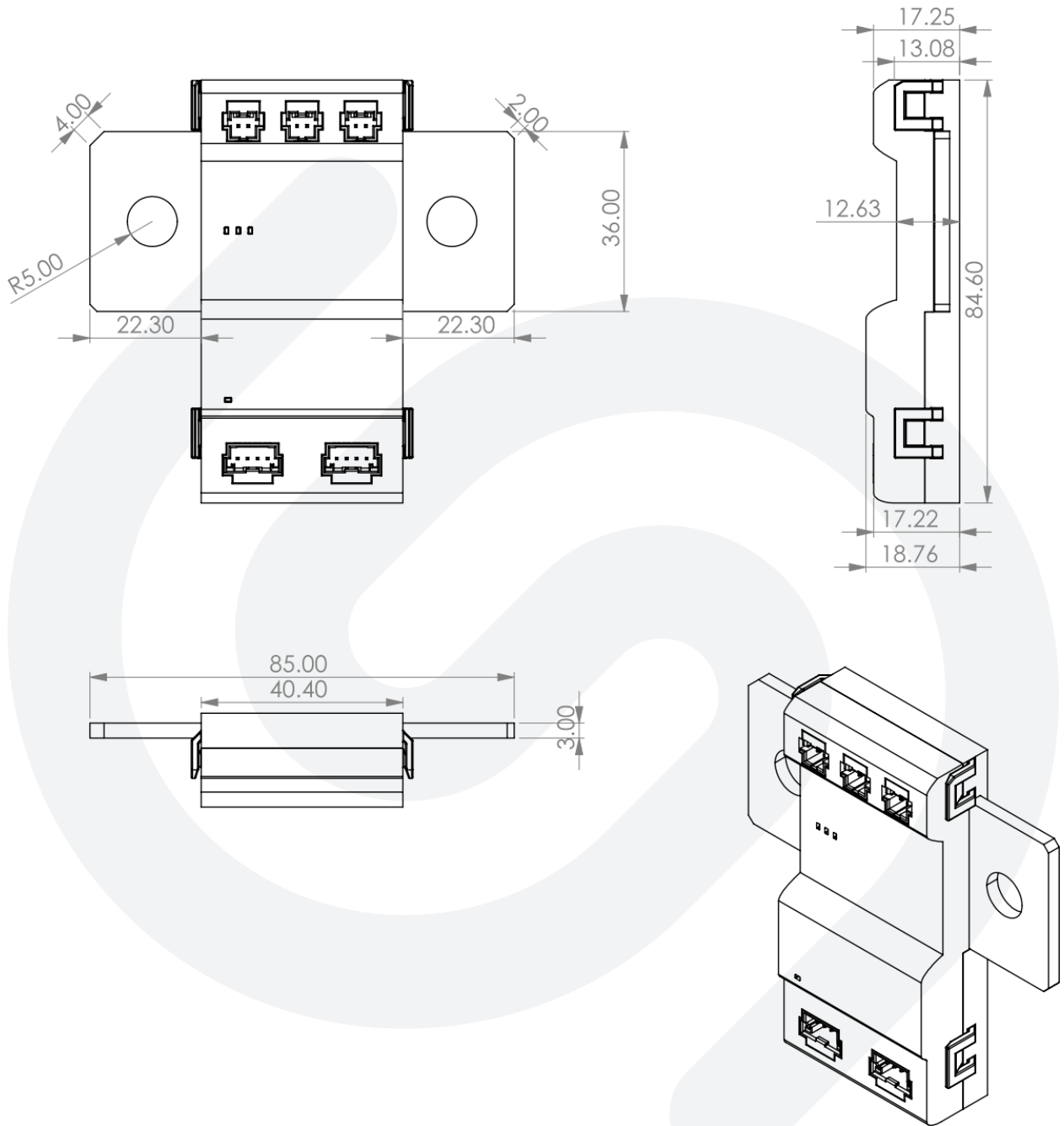
Measurement data will be sent as separate messages identified by their IDs. By default, or with the configured (Measurement ID + channel index), the measurement data will be sent sequentially. In the event of error handling, the error message will be sent as a 3-byte message with the ID decremented by 1.

If the CAN Measurement Result ID is changed with a command*, for example: 0x140, then the measurement results for CAN STD 2.0a will be as follows:

- 0x139: Error Result
- 0x140: Current Result
- 0x141: Voltage 1 Result
- 0x142: Voltage 2 Result
- 0x143: Voltage 3 Result
- 0x144: Power Result
- 0x145: Energy Result
- 0x146: Temperature Result

- A DBC file describing the CAN/CANFD protocol is available upon request. Please contact us directly to obtain the datasheet or additional documentation.

17. Mechanical



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