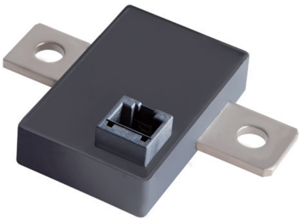
ISAscale® // HIGH PRECISION MEASUREMENT

IPC-MOD



Index

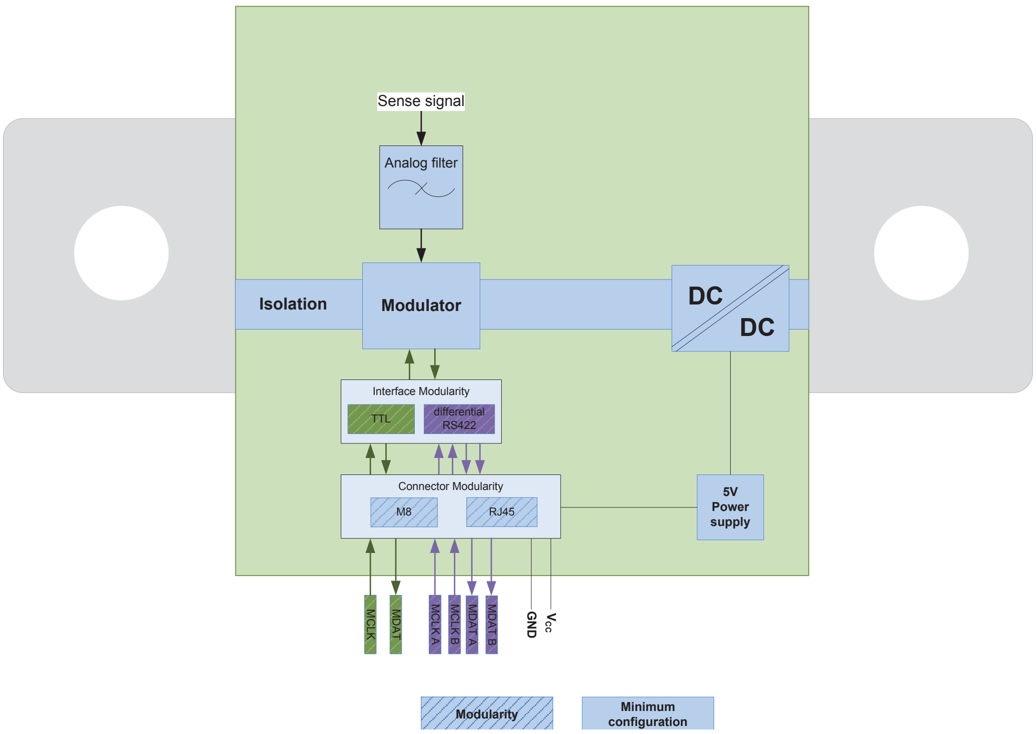
1. Description

The IPC-MOD is a high bandwidth precision current measurement system which provides a fully calibrated current sensing signal. Different types are available with several nominal current measurement ranges between ±100 A_{rms} and ±2500 A_{rms}. The ranges are based on the shunt resistor and are part of the modular system. The IPC sensor can also measure the flowing current in extended measurement ranges (see chapter 5 "Technical Data"). The modularity allows the fast adaptation on customer requirements.

2. Application i.e.

- Frequency AC/DC current measurement for drive technology
- Inverter technology
- Motion drive
- UPS systems

3. Functionality description



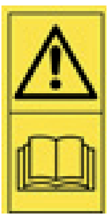
IPC-MOD

3.1 Isolation

IPC-MOD has an internal isolation of power suppy and signal path which allows usage of this sensor at operating working voltages up to 1,500 V.

Maximum working insulation voltage V_{IORM}	**1,000 V_{RMS} / 1,500 V_{DC}**	
Transient overvoltage V_{IOTM}	Type test: Unit test:	4,400 V_{RMS} (60 s) 4,400 V_{RMS} (1 s) / 6,223 V_{peak} (1 s)
Rated impulse voltage (1,2/50 µs)	8,000 V	
Rated mains voltage acc. to IEC 60664-1	Basic Insulation: ≤600 V_{RMS} (Class I – IV) ≤1000 V_{RMS} (Class I – III)	Reinforced Insulation: ≤300 V_{RMS} (Class I – IV) ≤600 V_{RMS} (Class I – III) ≤1000 V_{RMS} (Class I – II)
Minimum external creepage distance	≥30 mm	
Minimum internal clearance	6.8 mm	
CTI housing	Material Group IIIa	
CTI potting	Material Group II	
Fundamental frequency	<30 kHz	**Note:** According to DIN EN 60664-1-2008-01 the voltage insulation as shown above is only valid for fundamental frequencies below 30 kHz of the voltage potentials across the electrical insulation. For fundamental frequencies above 30 kHz the voltage insulation has to be evaluated and validated separately with high frequency tests.

Table 1: Isolation according to DIN EN 60664-1-2008-01



Depending on the application, there may be hazardous voltages on the connectors of IPC-MOD after installation and connection.
Please follow the safety instructions (to find on www.isabellenhuette.de)!

3.2 Digital communication interface

The digital communication interface of IPC-MOD consists only of one output and one input signal:
Input: Modulator Clock (MCLK)
Output: Modulator Datastream (MDAT)

Depending on version, the electrical voltage levels are single-ended TTL or differential RS-422.

3.3 Ranges

The IPC-MOD product family offers five different, customer selectable current measurement ranges. The selection of a required measurement range determines the shunt resistance.

Every shunt value has unique characteristics see chapter 5 "Technical Data". The resolution depends on the shunt resistance value. One limited characteristic is the maximum load of the shunt resistor. The limitation is based on the internal thermal resistance and a maximum tolerable increase of temperature caused by the flowing load current through the shunt.
To ensure that the limits are not exceeded, an effective heat dissipation over the bus bar and the environmental temperature must be provided.

IPC-MOD

4. Measurement description

The IPC-MOD uses a Δ-Σ-modulator to sample the analogue voltage drop caused by load current over the shunt (Ohm's law).

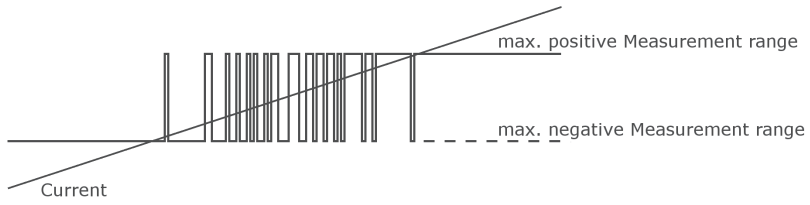
4.1 Bitstream

The output signal of the IPC-MOD is a serial 1-Bit Datastream, which is synchronous to the MCLK input signal of the module. At each falling edge of the MCLK signal the MDAT output of the IPC-MOD is updated.

The measurement value of the IPC-MOD is represented by the density of '1' and '0' of the bit stream. This means for example that with no current flowing through the shunt resistor the MDAT signal stays LOW for 50 % of the time and HIGH for the other 50%. However there are two exceptions concerning the density of the bit stream:

- If the primary current exceeds the negative measurement range of the IPC-MOD, the 1-Bit datastream is continuously LOW, whereas every 128 clocks of MCLK a '1' is generated to signalize that the module is still working
- If the primary current exceeds the positive measurement range of the IPC-MOD, the 1-Bit datastream is continuously HIGH, whereas every 128 clocks of MCLK a '0' is generated to signalize that the module is still working

Figure 1: Modulator output vs. flowing load current [1]

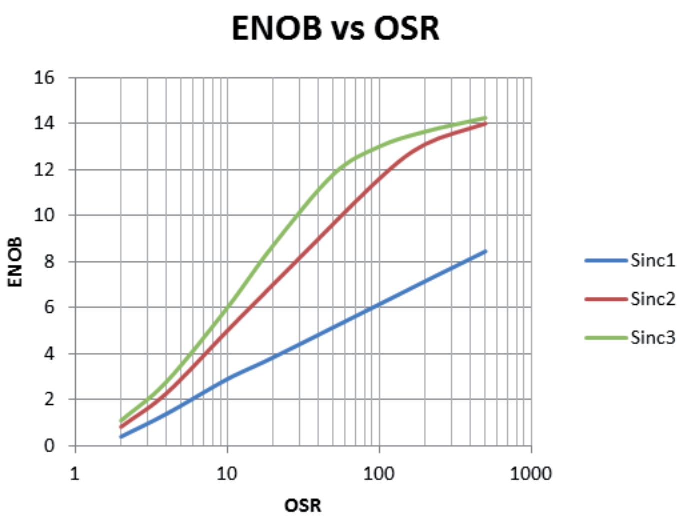


To 'translate' the 1-Bit Datastream into an n-bit measurement value, the datastream signal has to be decimated by a digital decimation filter.

The user is free to choose a digital filter suitable to his application. Typical decimation filter typologies are sincfast, sinc, sinc² or sinc³. As the IPC-MOD is equipped with a second order Δ-∑-modulator it is recommended to use a sinc³ filter topology.

By using higher oversampling ratios (OSR) of the decimation filter, the user can reach better (higher) measurement value accuracy, due to receiving higher Effective-Number-of-Bits (ENOB), but with lower output frequency. The following graph shows exemplarily the dependency between filter typology and OSR to ENOB.

Figure 2: ENOB vs. OSR [2]



[1,2] Source: Datasheet AMC1204 PRE VIEW RE V. 3.1– AUG, 2010; www.ti.com

IPC-MOD

4.2 Temperature calibration

Each measurement result can be influenced by changing temperatures. For this reason, the IPC-MOD includes an internal temperature compensation to provide an optimized result over the complete defined temperature range.

5. Technical Data

5.1 Operation conditions

Parameter	Min.	Typ.	Max.	Unit
Operating temperature	-40		+85	°C
Storage temperature	-40		+125	°C
Supply voltage	4.75	5	5.25	V
Current consumption	20	35	50	mA

5.2 Current measurement

Parameter						Unit
Nominal measurement range (depends from shunt)	± 100	± 300	± 500	± 1,000	± 2,500	A_{RMS}
Power loss	<3	<9	<9	<20	<32	W
Linear measurement range	±170	±520	±1,400	±2,450	±9,500	A
Maximum measurement range (nonlinear)	±210	±650	±1,750	±3,100	±12,500	A
Extended load 5 min	± 120	± 320	± 730	± 1,100	± 2,600	A
Extended load 30 sec	± 200	± 430	± 860	± 1,400	± 3,200	A
Extended load 10 sec	± 300	± 600	± 1,000	± 2,000	± 4,300	A
Extended load 1 sec	± 900	± 1,600	± 2,700	± 5,500	± 11,300	A
Extended load 200 ms	± 2,000	± 3,600	± 6,000	± 12,000	± 24,000	A
Physical Resolution [2]	7	20	55	95	380	mA
Parameter	**Min.**		**Typ.**		**Max.**	**Unit**
Initial accuracy (nominal range)			±0.2 (@ 20°C) ±0.5 over operating temperature			% rdg[3]
Total accuracy (nominal range)[4]			±1.0			% rdg
Bandwidth analog input filter (3dB)			400			kHz
Offset	±0.03		±0.05		±0.08	% rng[5]
Noise (RMS)[6, 7]			≤3			digit
Weight						
100 A…500 A version			max. 95			g
1,000 A…2,500 A version			max 165			g

[2] Depends on used decimation filter type (sinc / sinc² / sinc³), OSR and averaging

[3] Error of reading

[4] As per defined operating temperature range and lifetime

[5] Error of range

[6] Depends on supplied MCLK frequency and operating temperature; Measured by OSR = 256

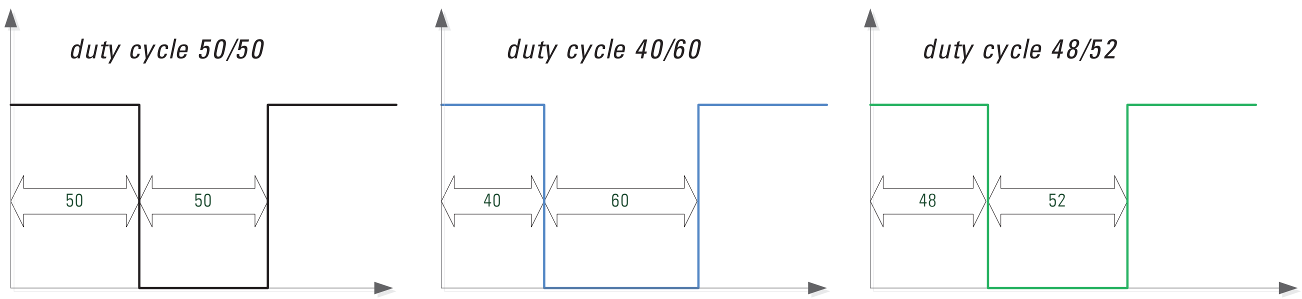
[7] As per defined MCLK range

IPC-MOD

5.3 Digital interface: Signal and timing specification

Parameter	Min.	Typ.	Max.	Unit
TTL				
MCLK High-level input voltage	0.75 * VCC		VCC + 0.3 V	Volts
MCLK Low-level input voltage	-0.3 V		0.25 * VCC	
RS422				
MCLK A/B input voltage	-7	-125	12	Volts
MCLK Differential Threshold voltage	-200		-50	mVolts
f_{MCLKIN} 40/60 to 60/40 for $f_{MCLKIN} \leq 16$ MHz 48/52 to 52/48 for 16 MHz $< f_{MCLKIN} <$ 20 MHz	5	20	20.1	MHz
Response Time MDAT 1-bit DataStream signal		3 * 1/(fMCLK)		
Propagation Delay[8] (between MDAT and MCLK)			0.25 * 1/(f_{MCLK})	µsec

Figure 3: Duty cycles

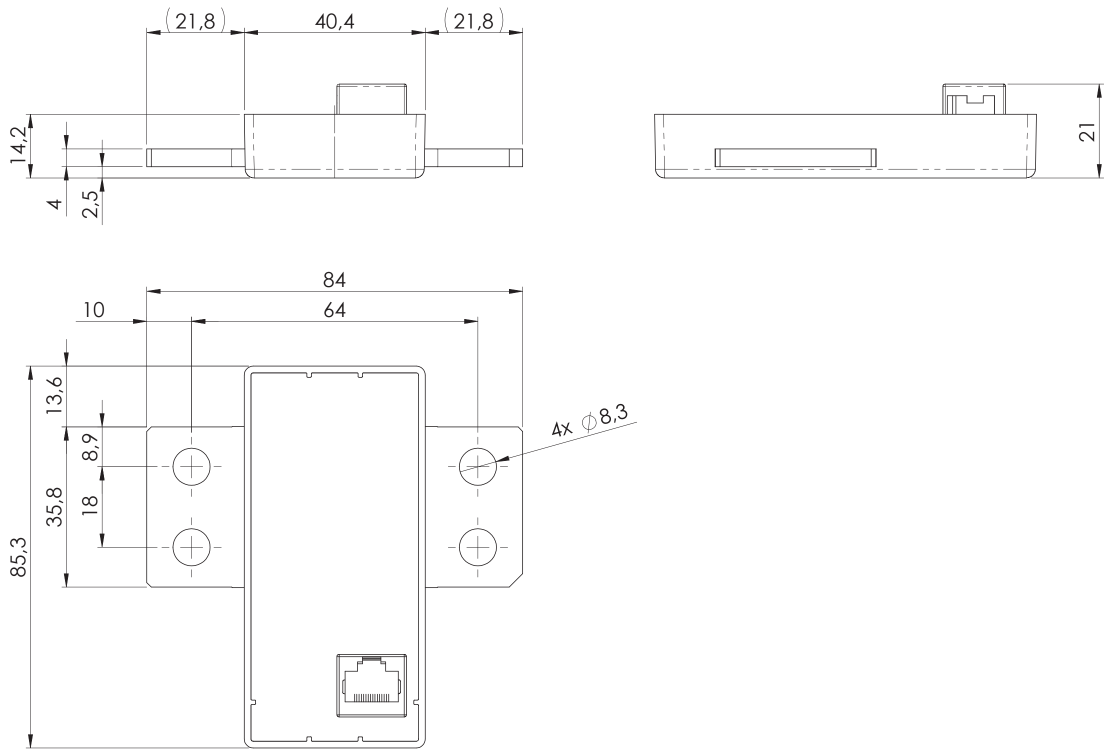


[8] **Important Note:** If level converters, level amplifiers, interface converters or similar are used, please be aware of the limitation for propagation delay between MDAT and MCLK as the received MDAT signal will be read according to the corresponding MCLK at the customers system.

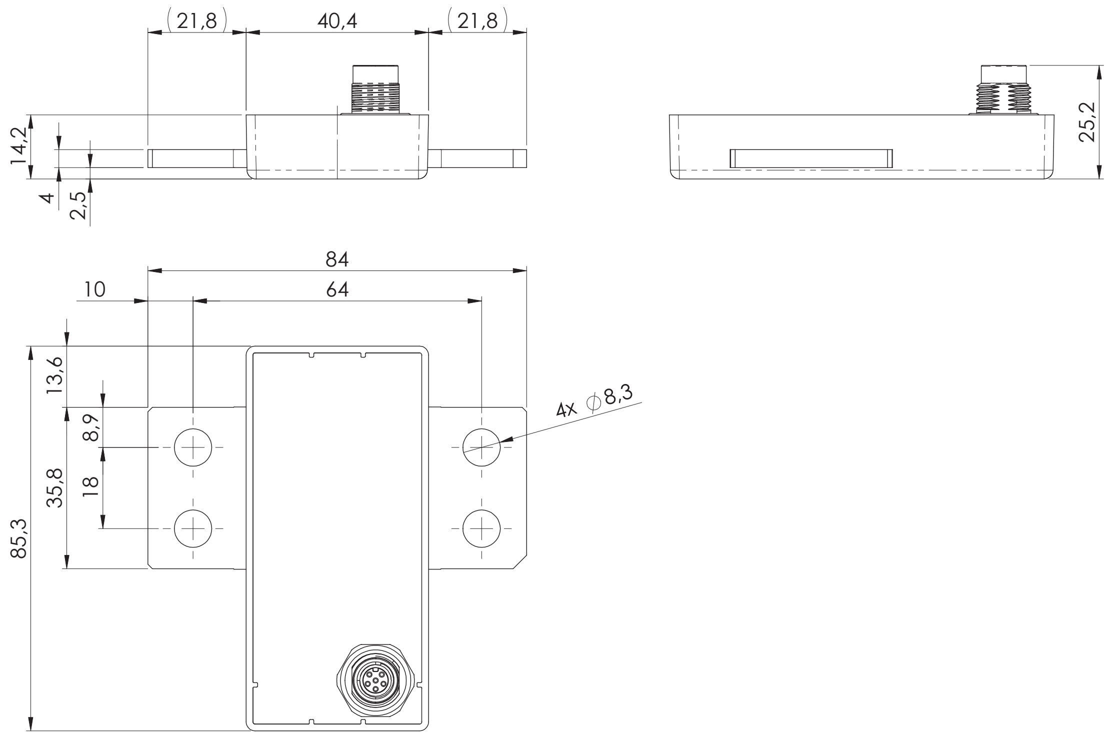
IPC-MOD

5.4 Mechanical dimension

IPC-MOD RJ45
2,500 / 1,000 A

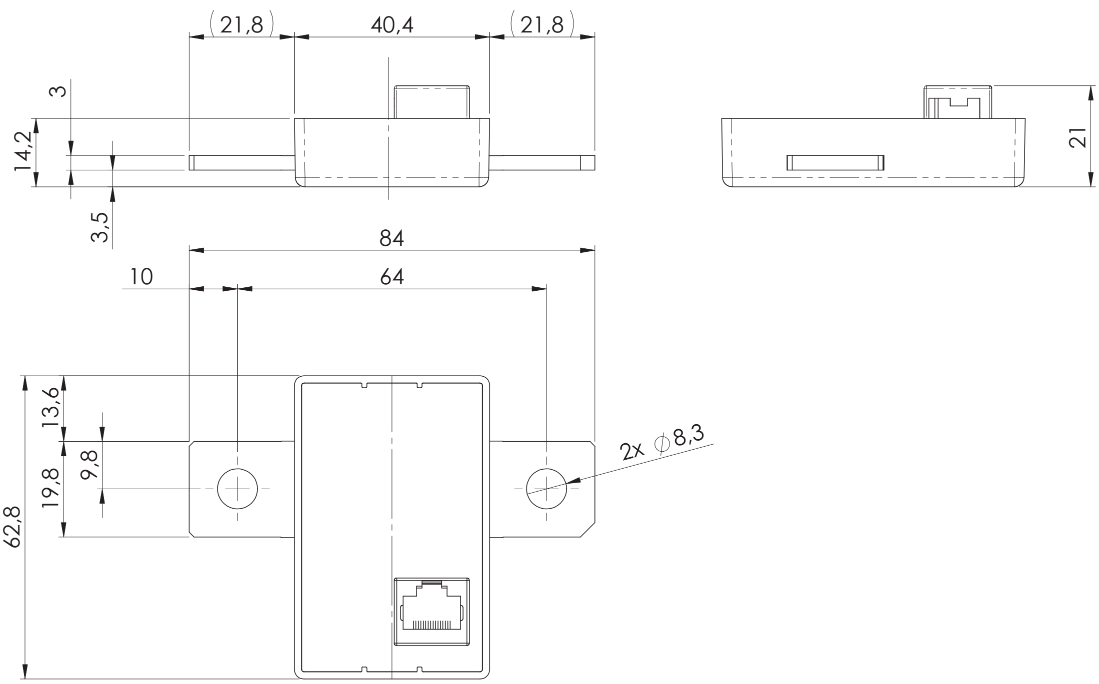


IPC-MOD M8
2,500 / 1,000 A

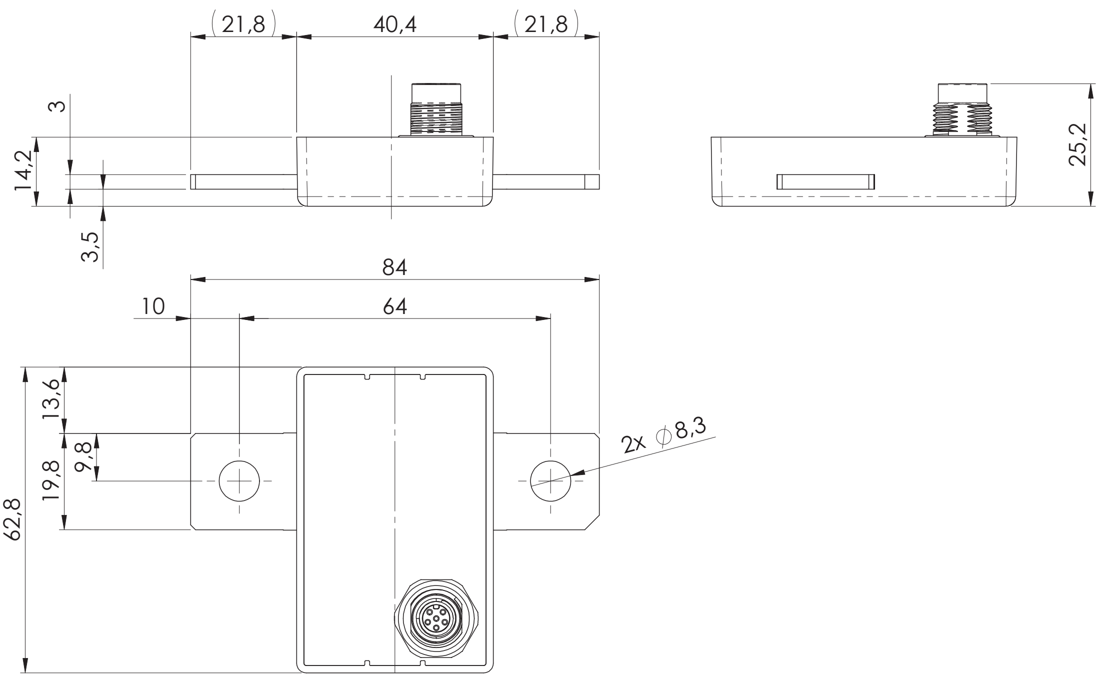


IPC-MOD

IPC-MOD RJ45
100 / 300 / 500 A



IPC-MOD M8
100 / 300 / 500 A



Important Note: To get best measurement performance and results, it is very important to ensure a homogenous and symmetric current flow through the shunt of IPC-MOD by screwing it with both holes on every side onto the bus bar. Connecting only one of the holes can cause high measuring errors!

IPC-MOD

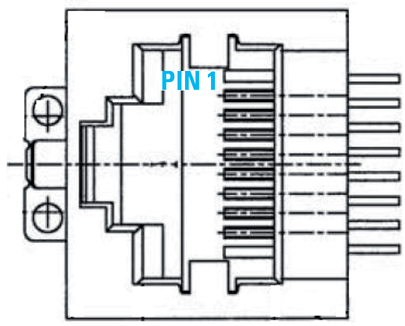
5.5 Bus bar connection

The accuracy and repeatability of current measurement depends from the quality of the connection between customer's bus bar and the shunt bus bar.

To ensure a good and useful connection between customer's bus bar and the shunt consider the following instructions:
(1) Mounting the IPC-MOD on a bus bar is highly recommended (instead of mounting a cable onto the shunt)
(2) Screwing the IPC-MOD on a bus bar by using all mounting holes, never use less then the available hole for screwing
(3) Always use screws with an outer diameter of 8 mm (M8), using smaller screws (e. g. M6 or M5) is NOT recommended
(4) Never use flat washers between the bus bar and the shunt!
(5) All screws using for mounting must be tightened with a torque as equal as possible!
(6) The recommended torque is 15 - 20 Nm

5.6 Pin configuration

Used PCB Header	**RJ45 Jack**
Qty. of Pins	1 x 8
Recommended Connector	Standard CAT5 or higher (shielded and twisted pair cable recommended)

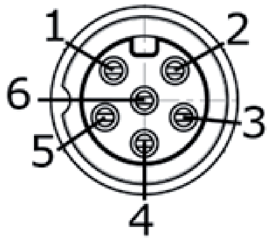


PIN	**TTL-Interface**		**RS422-Interface**	
1	MDAT	Output of 1-Bit Datastream	MDAT A	Output of 1-Bit Datastream +
2	GND	Ground	MDAT B	Output of 1-Bit Datastream -
3	MCLK	Clock-Input	MCLK A	Clock-Input +
4	VCC	Supply voltage	VCC	Supply voltage
5	VCC	Supply voltage	VCC	Supply voltage
6	GND	Ground	MCLK B	Clock-Input -
7	GND	Ground	GND	Ground
8	GND	Ground	GND	Ground

Important Note: All GND pins shall be connected to ensure signal integrity

IPC-MOD

Used PCB Header	**M8**
Qty. of Pins	6
Recommended Connector	Phoenix Contact SAC-6P-M 8MS/ 1,5-PUR SH - 1522299



PIN	**TTL-Interface**		**RS422-Interface**	
1	MDAT	Output of 1-Bit Datastream	MDAT A	Output of 1-Bit Datastream +
2	MCLK	Clock-Input	MCLK A	Clock-Input +
3	VCC	Supply voltage	VCC	Supply voltage
4	GND	Ground	GND	Ground
5	GND	Ground	MDAT B	Output of 1-Bit Datastream -
6	GND	Ground	MCLK B	Clock-Input -

Important Note: All GND pins shall be connected to ensure signal integrity

5.7 Connection Cable

The usable cable length depends mainly on the power and signal integrity of the used transceiver on customer electronic. When using ready-to-use assembled CAT5 cable (or higher), the communication was tested with a cable length up to 5 m.

- In principle, it is recommended to use a cable as short as possible for customer's application
- It is highly recommended to use a ready-to-use assembled CAT5 cable (or higher) with a RJ45-Jack on customer electronic, too
- If no RJ45-Jack on customer electronic is available and the CAT cable has to be cutted, stripped and assembled, we recommend to check the signal quality (curves, edges, voltage levels and timings, e. g. propagation delay)

Important Note: The used connection cable has to be applicable for the environmental conditions of the application, especially the ambient and bus bar temperature. Perhaps it is necessary to use special CAT cable for higher temperature environment.

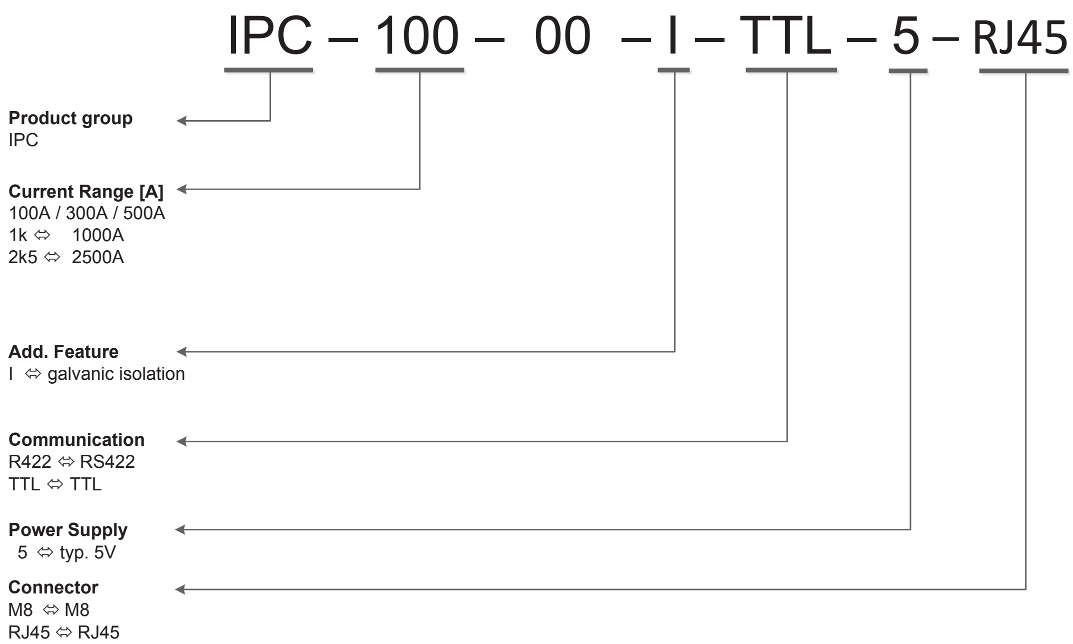
If an IP-protection or standard M12 connector is needed, it is recommended to use one of the following (or similar) 8P8C RJ-45 connecters (no guarantee for correctness and completeness, for more and updated information, please see manufacturer's website).

If an IP-protection or standard M12 connector is needed, it is recommended to use one of the following (or similar) 8P8C RJ-45 connectors (no guarantee for correctness and completeness, for more and updated information, please see manufacturer's website).

Manufacturer	**IP Protection**	**Source**
METZ CONNECT	up to IP67	http://www.metz-connect.com/de/rj45/plugs
3M	up to IP20	http://solutions.3mdeutschland.de/wps/portal/3M/de_DE/Industrie-Elektronik/ Industrie-Elektronik
Industrial-Amphenol	up to IP67 (IP68)	http://industrial-amphenol.com/archive/single/ new-industrial-m12-to-rj45-ethernet-adapters

IPC-MOD

5.8 Product configuration



6. Qualification

The sensor is qualified mainly in accordance to the industrial standards EN61000 and EN60068. The qualification was carried out with the modular encapsulation concept, which guarantees a maximum in flexibility and modularity. In case of very rough environmental conditions it may be necessary to adapt the encapsulation of the sensor. Depending on the special environmental conditions different encapsulation concepts are available, on customer request.

6.1 EMC Performance

The IPC-MOD current sensor complies with standard requirements and sustains its designed functionality for the following EMC tests.

Product type	Standard	Test description	Test parameter / Reached performance
IPC-300-00-I-TTL-5 / RJ45	EN 61000-4-2:2008	ESD: Direct - Indirect discharges	±4 kV
IPC-300-00-I-TTL-5 / RJ45	EN 61000-6-2:2006	E-Field immunity	3 V/m – 10 V/m
IPC-300-00-I-TTL-5 / RJ45	EN 61000-4-4:2012	Burst immunity	±2 kV
IPC-300-00-I-TTL-5 / RJ45	EN 61000-4-5:2005	Surge immunity	±1 kV
IPC-300-00-I-TTL-5 / RJ45	EN 55011:2011	Conducted emissions	Up to 18 MHz: Class A

IPC-MOD

6.2 Performance under climatic loads

IPC-MOD is able to sustain designed functionality under following climatic loads.

Product type	Standard	Test description	Test parameter
IPC-300-00-I-TTL-5 / RJ45	EN 60068-2-2:2008	High-temperature endurance	+85 °C / 1000 h
IPC-300-00-I-TTL-5 / RJ45	EN 60068-2-14:2010	Temperature change	-40 °C … +85 °C 20 cycles
IPC-300-00-I-TTL-5 / RJ45	EN 60068-2-14:2010	Temperature shock	-40 °C / +125 °C t_{hold}= 1h / 10 cycles
IPC-300-00-I-TTL-5 / RJ45	EN 60068-2-78:2014	Humid heat, constant	93% rel. humidity +40 °C / 96 h
IPC-300-00-I-TTL-5 / RJ45	EN 60664-3:2010	Insulation coordination: Withstand voltage Insulation resistance Partial discharge Insulation category II / III	4.5 kVAC 1.5 kVDC 2.188 kVAC / Q > 5 pF 9.847 kV
IPC-300-00-I-TTL-5 / RJ45	DIN EN 60529:2014	IP protection class	IP40
IPC-300-00-I-TTL-5 / M8	ISO 20653:2013	IP protection class	IP6K2