

Operator's Manual

# Charge Amplifiers

**M68  
Series**



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# 1. Application

The Signal Conditioners of M68 series are intended for connection of piezoelectric acceleration, force or pressure transducers. The input is suitable for sensors with charge output as well as for ICP<sup>®</sup> compatible transducers or microphones.

By means of the M68 the sensor signal can be best possibly adapted to the existing measuring equipment or PC-based data acquisition systems. The Signal Conditioners provide the following functions:

- Adaptation of the sensor signal and sensor supply
- Amplification
- High- and low-pass filtering (for example anti-aliasing filter)
- Integration of the sensor signal, for instance, to measure velocity or displacement.

Models M68D1 and M68D3 are housed in a rugged aluminum case. Both models can be used in laboratory as well as under field conditions. Model M68D1 may also be operated from batteries. Model M68R1 has been developed for multichannel measuring systems. It fits into 19"-rack systems.

## 2. Function and Operation

### 2.1. Introduction

Fig. 2 shows the block diagram of Model M68 with its most important functional groups.

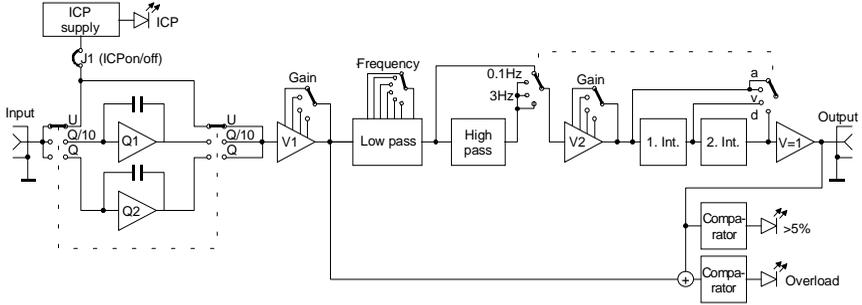


Fig. 2: Block diagram

**Description of the Signal Path** Depending on the position of the input switch, the input signal passes the impedance converter Q1 or Q2. If ICP operation is selected, the signal is directly connected to the amplifier. At ICP operation a constant current is fed into the input socket to supply the sensor electronics. The constant current source can be switched off by the internal jumper J1, in case an AC voltage shall be connected to the input.

The input circuit is followed by the first amplifier stage, low pass and high pass filters. The low pass filter has 6 selectable limiting frequencies. The high pass filter has a limiting frequency of 3 Hz, which can be bypassed by the switch "HIGH PASS / INTEGRATOR". In this case the full bandwidth down to 0.1 Hz comes into effect. The filters are followed by the second amplifier stage. The divided gain before and after filtering provides sufficient dynamic range, even for signal components outside the filter range. At the same time a high signal-to-noise ratio is achieved.

Before reaching the output driver the signal may pass one or two integrating stages. The output is DC coupled.

A control LED for the output modulation indicates an output signal higher than 5 % of full-scale modulation. An overload LED shows if the output signal exceeds

90 % of full-scale modulation. It also indicates overload before the filter stages.

Models M68D1, M68D3, and M68R1 have identical electronic circuits.

## 2.2. Power Supply

**External Supply** The Signal Conditioners M68 are powered by an external DC voltage

- Models M68D1 and M68D3 come with a mains plug adapter for 115/230 VAC. The power supply socket according to DIN 45323 is located at the rear of the instruments. Any other voltage of 5 V to 15 V DC and about 300 mA (for M68D1) or 1 A (for M68D3) may be connected to this socket. The positive supply terminal is connected to center pin (tip). The POWER ON/OFF switch is located at the rear.
- The M68R1 also has its power supply connector at the rear. It is a 4-pole frame connector type WAGO 232. The pin designation is shown in Fig. 3.

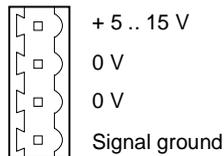


Fig. 3: Power supply socket of Model M68R1

The supply voltage is connected to the terminals “+ 5 .. 15 V” and “0 V”. A special plug with screwed contacts for the rear socket is delivered together with the instrument. This way the power supply can be wired manually. In case you use the offered 19”-mounting racks with internal power supply unit, this connection is realized by the backplane (see chapter 2.7). Model M68R1 has no power on/off switch.

**Battery Operation (M68D1)** Model M68D1 has a battery compartment for four “AA” size batteries (type LR 6). It is opened by unscrewing four plastic knobs and removing the cover. The right polarity is shown on the battery holder. To ensure long battery life it is recommended to use alkaline batteries. Accumulators may be used as well. You can operate the instrument on NiMH or NiCd. However, by reason of the lower voltage of accumulators, the battery control will not work.



Please take discharged batteries out of the instrument to avoid damage by leakage. Also, remove the batteries if the unit is not in use for a longer period.

**Voltage Control** All models of M68 series have an LED “BAT O.K.” indicating sufficient supply voltage. It lights up green, as long as the voltage is above 5 V. It works for battery operation as well as for external power supply.

**Fault Protection** The instruments are protected against false polarization and short-time excess voltage up to 60 V.

**Grounding Conception** The inputs and outputs of the signal conditioners are single ended, i.e. asymmetrical. In case an additional signal ground connection is required, ground is available via a separate connector at the rear of the instruments. For the Models M68D1 and M68D3 this connector is a 4 mm banana jack. The signal ground of Model M68R1 can be found at the 4-pole frame connector. The case of the instruments is internally connected to ground.

The power supply is separated from signal ground. In some cases it may be of advantage to connect the minus pole of the power supply to signal ground, to avoid ground loops. For this purpose you can plug in the 4 mm jumper (delivered with the instruments) at the rear of Models M68D1 and M68D3. At Model M68R1 the terminals of the power supply socket can be connected by a wire.

## 2.3. Inputs

The Signal Conditioners M68 are designed for both sensors with charge output and with integrated impedance converters to ICP<sup>®</sup> standard as well. You can switch from one to the other type of transducer by means of the slide switch next to the input socket. Both types use the same BNC input socket.

**Charge Mode** Capacitive signal sources, usually piezoelectric sensors with charge output, are connected to the charge input (Q). The input is fed to an amplifier with capacitive feedback. All M68 instruments have two input stages for charge. In the position “Q/10” of the switch the gain is divided by 10.

The advantage of charge measurement is, that cable capacitance and insulation resistance have almost no influence to the measuring result. For sensors with charge output it is strongly recommended to use special low-noise cables. Ordinary cable will cause a considerable measuring error at mechanical stress, as a result of the so-called triboelectrical effect. Cables with low insulation resistance, for example caused by humid connectors, reduce the accuracy of measurement at lower frequencies. A desirable insulation resistance is higher than 10 GΩ. Cables longer than 10 m are not recommended at the charge input.

**ICP<sup>®</sup> Mode** The abbreviation ICP means “Integrated Circuit Piezoelectric”. It has been established between many other names as industrial standard for piezoelectric transducers. The integrated sensor circuit transforms the charge signal of the piezo-ceramics, with its very high impedance and high EMI sensitivity, into a voltage signal with low impedance. The converted signal can be easier transmitted. The cable length at this input may be more than one hundred meters. Ordinary low cost coaxial cable can be used.

A peculiarity of ICP<sup>®</sup> is, that power supply and measuring signal use the same line. So, an ICP<sup>®</sup> transducer needs, like a transducer with charge output, only one single-ended line.

Fig. 4 shows the circuit diagram. To separate the low impedance sensor signal from the power supply, the integrated circuit is supplied with constant current.

This constant current must be fed into the measuring line and simultaneously separated from the following amplifier stages. The yellow LED “ICP ON” indicates the flow of constant current.

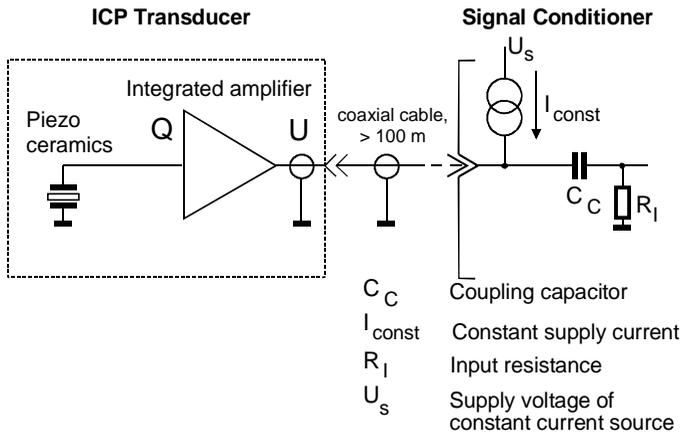


Fig. 4: ICP principle

By supplying the sensor with constant current a positive DC voltage arises over its terminals. This static bias voltage depends on manufacturer and specimen and amounts to about 5 through 14 V. The sensor signal is superposed on this bias voltage. The output voltage of the transducer never changes to negative values. Its minimum value is the saturation voltage of the integrated impedance converter (0.5 V to 1 V). The supply voltage of the constant current source determines the maximum value of the output voltage. For the M68 this voltage amounts up to 24 V and guarantees an optimum dynamic range for all available sensors. Fig. 5 shows these relations.

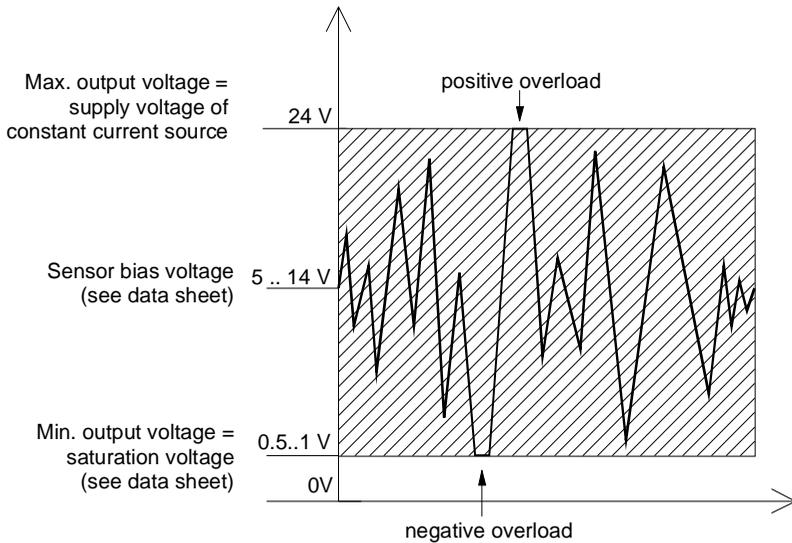


Fig. 5: Dynamic range of ICP<sup>®</sup> compatible transducers

**Switching Off the ICP Supply**

In some cases it may be necessary to switch off the constant current supply, in order to use the input for normal AC sources. For this purpose, please change the position of the jumper, which you will find at Models M68D1 and M68R1 behind the front panel. Remove the cover of Model M68D1 by unscrewing the four plastic screw heads. To remove the cover of Model M68R1, four screws at the side and two at the back are unscrewed. Jumper J1 is located left at the front side of the printed circuit board. Plug it into the position "OFF" to switch off the constant current source.

After removing the front cover of Model M68D3 you will see only the jumper of channel 1. To reach the jumpers of channels 2 and 3, please remove front and rear panel.

**Avoiding Ground Loops**

Earthing or ground loops are often the reason for measuring errors in multichannel measuring systems. In most cases you will find a superimposed 50 Hz or 100 Hz voltage on the measuring signal. One reason for this effect may be, that the transducers are connected to ground not only via their cable at the signal conditioner, but also in addition at the measuring point through their case. Vibration transducers are often mounted at

grounded machine parts. Within earthing systems transient currents may appear. These transient currents cause a potential drop across the earthing or grounding wires. Via the signal input of the amplifier they may result in a considerable measuring error.

To avoid this, insulated attachment of the transducers is recommended.

Metra offers several industrial vibration transducers with insulated mounting base and different insulating flanges for non-insulated sensors.

A star-shaped grounding network is the ideal solution to avoid ground loops. Star-shaped means that all grounding wires of the sensors and the amplifier outputs are tied to ground at the signal conditioners, without any transverse connections. In many cases this is more difficult to realize for the outputs than for the inputs, because the following measuring equipment may have single-ended, inputs. If you have the choice to use differential inputs, which can be found on many data acquisition boards, you should preferably use them.

## 2.4. Amplifier

The instruments of M68 Series have the following measuring ranges:

Charge mode: 0.1 / 1 / 10 / 100 / 1000 mV/pC

ICP mode: 1 / 10 / 100 / 1000 times

The gain selection switch "GAIN" has four positions. In position "Q/10" of the input selection slide switch the measuring range of all charge ranges is divided by 10. This may be advantageous for measurement with high sensitivity transducers or for shock measurement.



After connecting a sensor and occasionally after changing the measuring range, the amplifier needs a certain settling time because of a short term overload. Therefore it may take about 30 s, until the output voltage is free of DC components.

<b>Output</b>	The amplifier output is buffered and DC-coupled. Therefore, possible offset currents fed into the amplifier output by the following equipment (for instance a PC data acquisition board), do not cause a DC offset.
<b>Minimum Modulation and Overload Control</b>	<p>LEDs indicate minimum modulation and overload condition.</p> <p>The LED “&gt;5%” lights up at an output voltage higher than 0.7 V. The LED “OVL” lights up if the output voltage exceeds 9 V.</p> <p>The optimum gain range is selected, if the LED “&gt;5%” lights up and the LED “OVL” remains dark. If both LEDs remain dark, the gain should be increased. If both LEDs light up the gain should be reduced. The overload detector monitors both the amplifier output and the filter input (see Fig. 2). By that means overload condition will also be indicated when high signal components beyond the filter pass band occur.</p> <p> An overload detector at the integrator input is not provided. In some cases high level components at higher frequencies may overload the amplifier stage before the integrator while at the integrator output no overload condition can be detected. To avoid this, make sure to check the signal level in the switch position „ACC“ (integrator off) before switching on the integrators. When the LED indicates overload you can use the low pass filter to attenuate high frequencies.</p>

## 2.5. Filters

**Low Pass** To eliminate disturbing noise or to comply with the Shannon theorem: “Signal frequency should be less than half of the sampling frequency”, it can be advantageous, to use a low pass filter. For higher accuracy in the time domain it is recommended to set the low pass at  $\frac{1}{10}$  the sampling frequency.

The instruments of M68 series have 6 internal low pass filters. The scale at the positions of the filter switch “LOW PASS” is shows the 3 dB limiting frequencies in kHz. The following table shows the 3 dB and the 10 % limiting frequencies of the low pass filters:

**3 dB Frequency**

100 Hz  
 300 Hz  
 1 kHz  
 10 kHz  
 20 kHz  
 50 kHz

**10 % Frequency**

70 Hz  
 200 Hz  
 700 Hz  
 7 kHz  
 14 kHz  
 35 kHz

The slope of the low pass filters is 40 dB per decade.

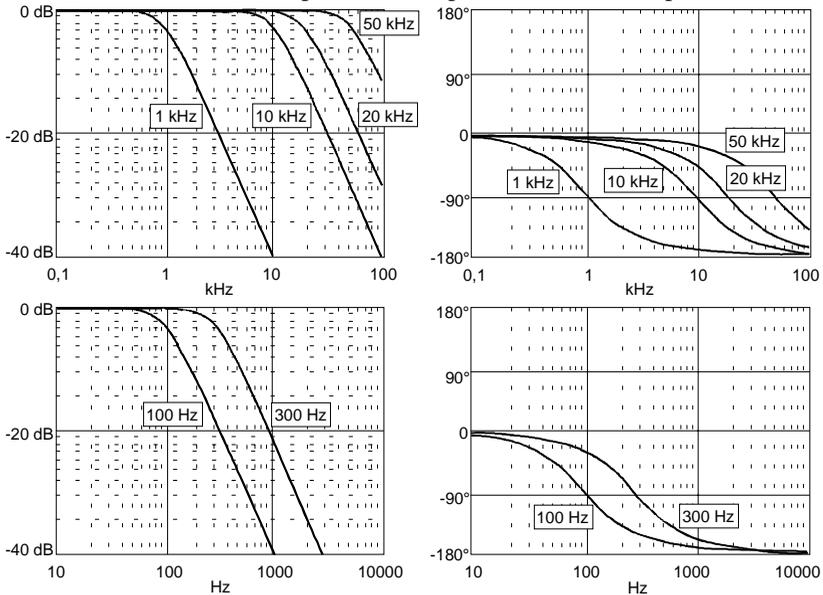


Fig. 6: Typical frequency and phase response of the low pass filters

**High Pass**

The M68 signal conditioners have a high pass filter with a lower limiting frequency of 3 Hz (-3 dB). By means of this filter low frequency noise can be removed. Low frequency noise may occur, for example, by the influence of temperature transients to piezoelectric compression type accelerometers. The slope of the 3 Hz high pass filter is 40 dB / frequency decade (Fig. 7). The 3 Hz high-pass filter is switched on by turning the “INTEGRATOR HIGH PASS” switch into position “ACC 3 Hz”. If the high pass filter is switched off (switch position “0.1 Hz ACC”), the lower limiting frequency of the amplifier is 0.1 Hz.



When using the integrators, the 3 Hz high pass filter is switched on in any case.

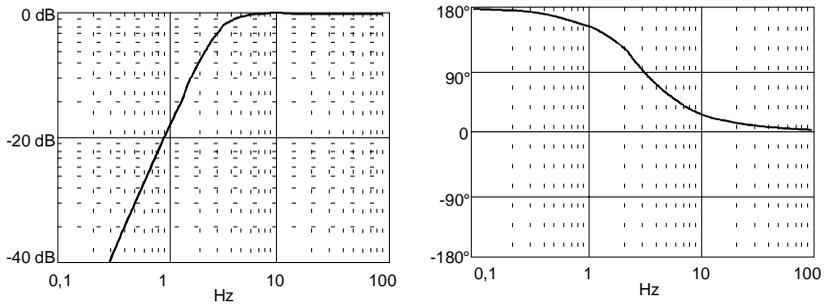


Fig. 7: Frequency and phase response of the high pass filter

As the filters are located between the amplifier stages (see Fig. 2) the instrument does not become overloaded, even if the measured signal has higher spectral components outside the filter range.

## 2.6. Integrators

The M68 can integrate the measuring signal one or two times. Integration can be useful for vibration measurement by means of accelerometers on rotating machinery.

Single integration of vibration acceleration results in velocity, double integration in displacement.

The „INTEGRATOR HIGH PASS“ switch activates the integrators. In position “ACC“ (acceleration) the measuring signal passes without integration. At the position “VEL” (velocity) the signal is integrated once, in position “DISP” (displacement) twice.

With switched on integrators the 3 Hz high pass filter is always activated.

**Relation Between Output Voltage and Vibration Quantity** The following calculations show how the output of the M68 ( $u_{out}$ ) corresponds to the three vibration quantities. The selected gain range of the M68 is  $G$  and the accelerometer sensitivity (see transducer data sheet) is  $B_{ua}$ .

**Vibration acceleration  $a$**  (without integration):

$$a = \frac{u_{out}}{G \cdot B_{ua}}$$

( $a$  in  $m/s^2$ ;  $u_{out}$  in mV;  $G$  in mV/mV;  $B_{ua}$  in mV/ $ms^{-2}$ )

**Vibration velocity  $v$**  (single integration):

$$v = \frac{u_{out}}{G \cdot B_{ua}} \cdot 10 \text{ s}$$

( $v$  in mm/s;  $u_{out}$  in mV;  $G$  in mV/mV;  $B_{ua}$  in mV/ $ms^{-2}$ )

**Vibration displacement  $d$**  (double integration):

$$d = \frac{u_{out}}{G \cdot B_{ua}} \cdot 100 \text{ s}^2$$

( $d$  in  $\mu m$ ;  $u_{out}$  in mV;  $G$  in mV/mV;  $B_{ua}$  in mV/ $ms^{-2}$ )

The equations above apply for ICP<sup>®</sup> compatible accelerometers. For accelerometers with charge output,  $G$  is replaced by the selected charge amplifier range in pC/g and  $B_{ua}$  is replaced by the transducer's charge sensitivity  $B_{qa}$ .

**Example** Vibration velocity is measured using an accelerometer with a sensitivity of  $B_{qa} = 5 \text{ pC}/ms^{-2}$ . The M68 is operated in the range  $G = 100 \text{ mV}/pC$ . Its output voltage is  $300 \text{ mV}_{rms}$ . What is the corresponding vibration velocity?

Solution:  $v = \frac{300 \text{ mV}}{100 \text{ mV}/pC \cdot 5 \text{ pC}/ms^{-2}} \cdot 10 \text{ s}^{-1} = 6 \text{ mm}/s_{rms}$

**Normalization of the Output Signal** Often a direct connection between the output voltage of the M68 and the measured physical quantity (for example "1 mV corresponds to 1 mm/s") is desired.

This can be achieved by adjusting the connected measuring equipment or by typing in a correction factor in a PC based data acquisition system. In the example given above this correction factor would be 0.02.

**Dynamic Range Over Frequency** At higher frequencies the output voltage will have only small amplitudes after integration. The dynamic range and the signal-to-noise ratio therefore become lower in the kHz-range (Fig. 8).

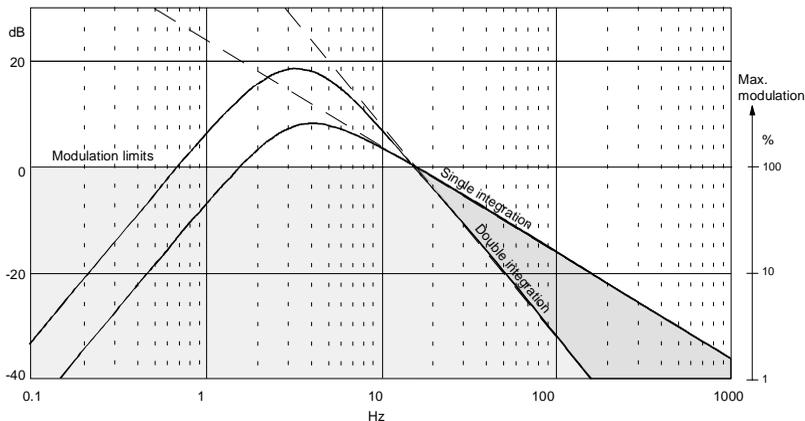


Fig. 8: Frequency response of the integrators

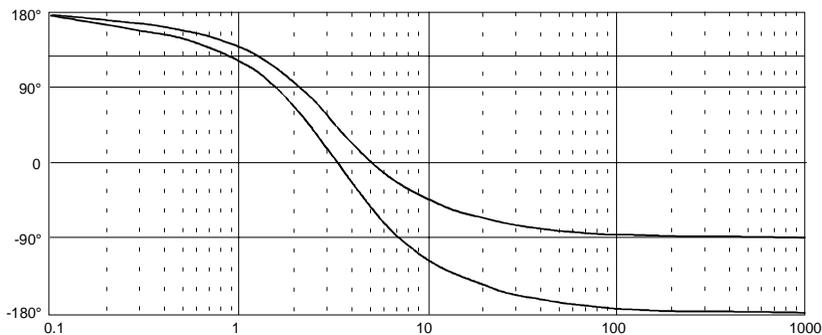


Fig. 9: Phase response of the integrators

**Overload at Integrator Input** In some cases signal components with high frequency and magnitude may overload the amplifier although no overload can be detected at the M68 output. The overload LED remains dark. This can occur due to the attenuation of higher frequencies by the integrator (compare Fig. 8). To avoid possible overload, make sure to check the signal level in the switch position „ACC“ (integrator off) before using the integrator. If an overload condition should be indicated, reduce high frequency components by an appropriate low pass frequency.

## 2.7. Rack Mounting Cases for Model M68R1

For the 19" unit M68R1 the following rack mounting cases are available:

<b>Model</b>	<b>Channels</b>	<b>Built-in power supply</b>
M68A6	6	no
M68A12	12	no
M68B6	6	yes
M68B12	12	yes



Fig. 10: Rack case M68A6 for 6 channels

The rack mounting cases without internal power supplies Model M68A6 and M68A12 have an open rear side (see Fig. 11). The rear terminals of the modules must be wired manually to an external DC power supply.

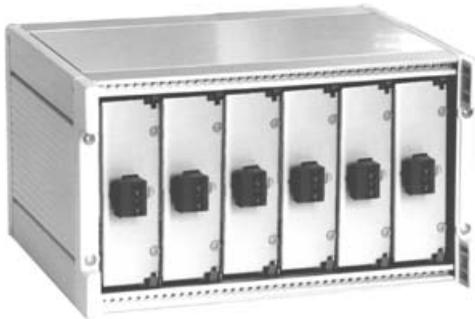


Fig. 11: Rear view of case Model M68A6

The rack cases with internal power supply Models M68B6 and M68B12 supply the plugged-in modules via a backplane. They can be operated with both 115 VAC and 230 VAC without changing any settings.

### Replacing the fuse

The fuse holder of the rack cases M68B6 and M68B12 with mains power supply is located inside the mains socket at the rear. It can be pulled out using a screw driver. The fuse facing to the back of the drawer is a spare fuse. The rear one is the mains fuse.



**Important:** Unplug the device from the mains voltage before replacing the fuse.

Make sure that the fuse to be replaced has the rating T 800 mA.

## 3. Technical Data

<b>Measuring inputs</b>	Charge and ICP <sup>®</sup> compatible, $R_i > 5 \text{ M}\Omega$ BNC socket, single-ended
<b>ICP<sup>®</sup> sensor supply</b>	3.8 .. 5.6 mA constant current, compliance voltage 24 V, switched off by internal jumper, LED indicator
<b>Gain</b>	0.1 / 1 / 10 / 100 / 1000 mV/pC (charge) 1 / 10 / 100 / 1000 (ICP)
<b>Accuracy</b>	$\pm 1 \%$ typical $\pm 2 \%$ maximum
<b>Low pass filter</b> (-3 dB)	0.1 / 0.3 / 1 / 10 / 20 / 50 kHz, two poles, 40 dB/decade
<b>High pass filter</b> (-3 dB)	3 Hz, two poles, 40 dB/decade, can be switched off
<b>Frequency range of integrators</b>	Single integration: 3 .. 1000 Hz Double integration: 3 .. 100 Hz
<b>Output</b>	$\pm 10 \text{ V}_{\text{PEAK}}$ , DC coupled, DC offset $< 10 \text{ mV}$ , $R_{\text{OUT}} = 50 \Omega$ , BNC socket, single-ended
<b>Cross-talk attenuation</b>	$> 60 \text{ dB}$ (M68D3 at 1 kHz / $V=1000$ )
<b>Output noise</b>	$< 10 \text{ mV}_{\text{RMS}}$ (50 kHz bandwidth), $< 6 \text{ mV}_{\text{RMS}}$ (20 kHz bandwidth)
<b>LED indicators</b>	Minimum modulation: $> 0.7 \text{ V}_{\text{PEAK}}$ Overload: $> 90 \%$ of full-scale output Battery: supply voltage $> 5 \text{ V}$

<b>External supply</b>	5 .. 15 VDC < 300 mA (M68D1, M68R1) < 1 A (M68D3) connector to DIN 45323 (M68D1 / M68D3) 4 pin frame connector (M68R1)
<b>Battery supply (only M68D1)</b>	4 x "AA" size (LR6) > 10 h lifetime with alkaline cells
<b>Mains supply (only M68B6 / M68B12)</b>	Wide range input 85 .. 264 VAC Socket for IEC 320 mains cord Grounding required Power consumption: < 40 W Fuse: 800 mA (slow) in mains socket
<b>Mains plug adapter (only M68D1 / M68D3)</b>	Wide range input 100 .. 240 VAC, 50 / 60 Hz with two pole Euro plug Output: 12 VDC / 0.5 A (M68D1) / 1 A (M68D3)
<b>Warm-up time</b>	15 minutes
<b>Operating temperature</b>	-10 .. 50 °C, 95 % rel. humidity without condensation
<b>Dimensions (width x height x depth)</b>	105 x 40 x 150 mm <sup>3</sup> (M68D1) 105 x 90 x 140 mm <sup>3</sup> (M68D3) 7 width units x 3 height units x 190 mm (M68R1)

## **Limited Warranty**

Metra warrants for a period of

**24 months**

that its products will be free from defects in material or workmanship and shall conform to the specifications current at the time of shipment.

The warranty period starts with the date of invoice.

The customer must provide the dated bill of sale as evidence.

The warranty period ends after 24 months.

Repairs do not extend the warranty period.

This limited warranty covers only defects which arise as a result of normal use according to the instruction manual.

Metra's responsibility under this warranty does not apply to any improper or inadequate maintenance or modification and operation outside the product's specifications.

Shipment to Metra will be paid by the customer.

The repaired or replaced product will be sent back at Metra's expense.



## **Declaration of Conformity**

Products: Charge Amplifiers  
Models: M68D1, M68D3, M68R1

It is hereby certified that  
the above mentioned products  
comply with the demands  
pursuant to the following standards:

- EN 50081-1
- EN 50082-1
- EN 61000-3
- EN 60950

Responsible for this declaration is the producer

Metra Mess- und Frequenztechnik

Meißner Str. 58

D-01445 Radebeul

Declared by

Manfred Weber

Radebeul, 29<sup>th</sup> of May, 2001