Operator's Manual

Integrating Signal Conditioner

M67i

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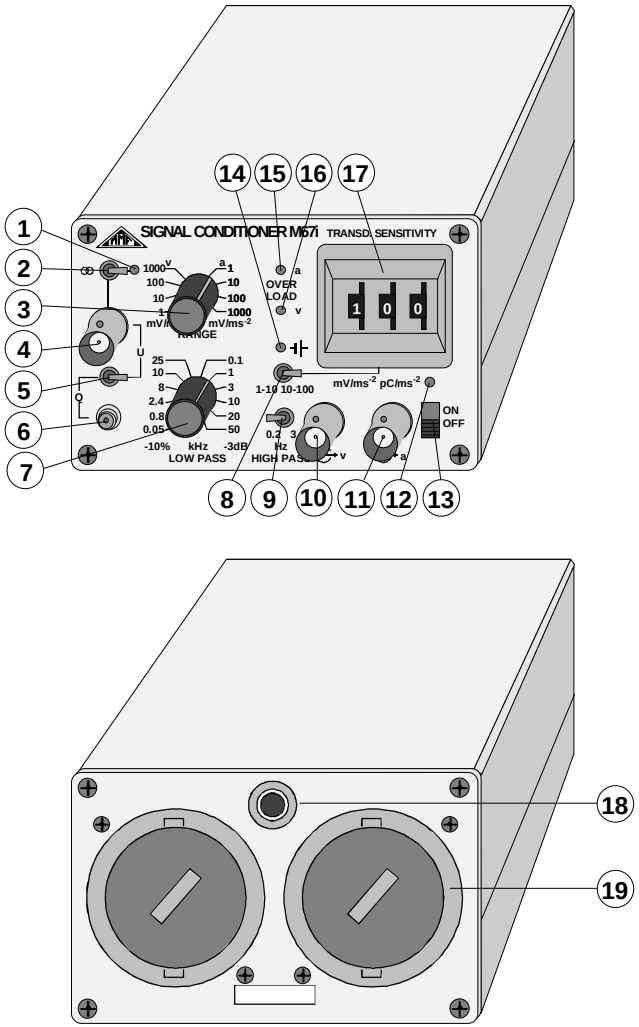

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1. Application

The Integrating Signal Conditioner M67i has been developed especially for signal conditioning at dynamic measurements of acceleration, force or pressure by means of piezoelectric transducers. The outputs are intended for connection of indicating or recording instruments, diagnostic equipment or data acquisition systems.

Typical applications are vibration measurements on machinery, measurements at mechanical structures in laboratories or low frequency vibration measurements at buildings or in seismology.

You can connect use piezoelectric transducers with charge output as well as transducers with integrated impedance converter (ICP® -transducers). Besides the amplification of the signal the M67i provides a low pass filter with 6 switchable frequencies. Therefore, in general, an additional anti-aliasing filter for digital processing is not necessary. Furthermore the M67i has two lower limiting frequencies.

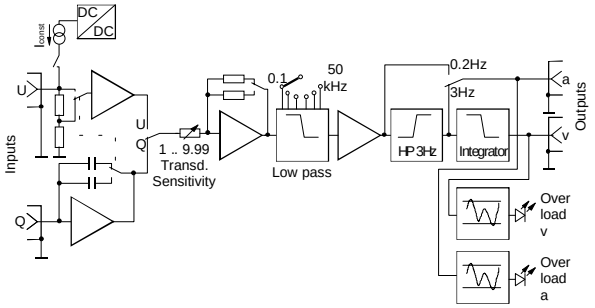
The instrument has two outputs: One with the linear, nonintegrated signal and the second with the integrated signal. By means of these two outputs you can, for instance, determine acceleration and velocity of a measured vibration signal simultaneously.

The M67i can be operated either by internal batteries or by an external power supply. So it can be used it in the field as well as in the laboratory.

2. Function

Figure 1 shows the block diagram of the M67i.

Figure 1: Block diagram



In the left part you see the two input stages. The charge input (Q) can be used for connection of capacitive sources, especially piezoelectric transducers with charge signal. The voltage input (U) in principle allows the connection of all kinds of voltage signals. Its typical application, however, is the connection of piezoelectric transducers with integrated impedance converter. This impedance converter is supplied by a constant current, which is fed through the measuring cable. For this purpose the voltage input has a constant current source, which can be switched on or off. This kind of sensor supply is called ICP®.

The gain range can be selected in four decade steps. The fine setting of the gain is carried out by a three digit thumb wheel switch.

The M67i has a four-pole low pass filter. By means of a rotary switch you have the choice of 5 lowpass frequencies. If necessary, the low pass can be switched off when the full bandwidth of the amplifier is needed.

The instrument has a non-integrating output “a” (measurement of acceleration) and an integrating output “a” (measurement of velocity). Both outputs can be used simultaneously. Each of the outputs has its own overload indicator. In addition the instrument features a high pass filter. For the non-integrating output this high pass filter can be switched off.

The M67i can be operated by internal batteries or an external power supply, for instance by the included mains plug adapter or a car battery.

3. Operation

Power Supply

The M67i is powered by two batteries Type R20, which have to be inserted into a battery compartment. The two battery compartments are located at the rear of the instrument case. The covers are opened with a coin by turning them left up to the stop. Inserting the batteries, they have to be oriented with the minus pole (flat side) towards the compartment. For a long battery life it is recommended to use alkaline batteries. Rechargeable Nickel-Cadmium (NC) or nickel-metal-hydride (NMH) batteries may also be employed. If the LED for battery control starts glowing, the operating voltage is too low and the batteries should be changed as soon as possible. The battery control starts glowing at 2.1 V. Down to 2 V the instrument works properly.

The instrument may also be powered through the power supply socket at the rear of the case. The socket complies with DIN 45323. The plus pole is connected to the tip. The instrument is protected against faulty polarization.

As external power supply you may use, for instance, the included mains plug adapter, a car battery or the supply voltage of a PC data acquisition board. The voltage may vary within the range of 8 V ... 18 V. The maximum current consumption amounts to 250 mA at 8 V.

Hints for Battery Operation

The current consumption reaches its maximum at the lowest supply voltage, with switched on constant current source and overload of the amplifier (overload LED glows). In the interest of a long battery life it is recommended to switch on the constant current source only if required and to avoid an overload of the amplifier. If you switch on the instrument in overload condition with nearly discharged batteries it may happen that the battery voltage does not reach the minimum voltage. In this case the instrument does not work correctly. Therefore, the M67i should be switched on always with its lowest gain (position 1 mV/ms^{-2}).

Switching on the instrument at battery operation, sometimes the LED for battery control glows red for some seconds. The reason for this event is the higher current consumption at overload, which depends from the transient response of the amplifier circuit.

Inputs The toggle switch for the inputs switches on the charge input (Q) or the voltage / ICP® input (U). The inputs cannot be operated simultaneously. Both inputs are single-ended (connected with ground o the supply voltage).

Charge (Q) In position "Q" the charge input is activated. This input may be used for connection of capacitive sources. The advantage of charge measurement is the low influence of cable capacitance and insulation resistance to the measuring result. Transducers with charge output, however, should be operated only with special low-noise cable. Ordinary coaxial cable causes at mechanical tension or bending, by reason of the triboelectrical effect, considerable influence to the accuracy of the measurement. In general, the length of the cable to this input should not exceed 10 m.

Voltage (U) In position "U" the voltage input is activated. This input is well suited for connection of ICP® compatible transducers with integrated impedance converter and low output impedance. The advantage of these transducers is their low sensitivity against interference caused by the measuring cable. The length of ordinary measuring cable to this input may be more than some hundred meters.

The toggle switch with the constant current symbol ⨀ connects a current source of 4.5 mA to this input for supplying the ICP® electronics of the transducer. The ICP® supply LED glows yellow as soon as the constant current flows correctly through the sensor. If this is not the case a broken cable, bad contact at the connector or a defect of the transducer may be the reason. The dimensioning of the sensor supply allows the connection of all customary ICP® compatible sensors.

With the constant current source switched off, the M67i may be used as amplifier for AC voltage signals from other sources.

For protection of the constant current source, when switched on, the peak value of the voltage input is limited to 22 V. Higher voltages will be cut off.

The two inputs are protected against overvoltage pulses up to 500 V, which may occur, for instance, at shock load of the piezoelectric transducer.

Gain

The output voltage of the M67i is scaled by adjustment of its gain in units of acceleration or velocity, depending on the used output. Therefore, you can read the mechanical value directly from the output voltage, without any conversion via electrical terms. So you may adjust the output voltage, for instance, to:

„1 mV corresponds to 1 m/s²“

„1 V corresponds to 1 mm/s“.

Transducer Sensitivity

For this purpose in the first step the sensitivity of the used sensor needs to be adjusted by means of the toggle switch for the sensitivity range and the three digit thumb wheel switch. Accelerometers with charge output will be adjusted in pC/ms^{-2}, ICP® compatible transducers in mV/ms^{-2}. The instrument has two ranges of transducer sensitivity. In the left position of the toggle switch “1 – 10” transducer sensitivity can be set by the thumb wheel switch in the range of 1.00 to 9.99 pC/ms^{-2} (or mV/ms^{-2}). For accelerometers with higher sensitivity (more than 10 pC/ms^{-2} or 10 mV/ms^{-2}) the toggle switch has to be positioned to “10 - 100”. Now the adjustment range of the thumb wheel switch reaches from 10.0 to 99.9 pC/ms^{-2} (or mV/ms^{-2}), i.e. one decade higher.
This adjustment has to be carried out only once after connecting the sensor.

Measuring Range

The measuring range can be changed in decade steps by the rotary switch “RANGE”. The right half of the scale of this switch is divided in units of acceleration (mV/ms^{-2}) for the voltage at the non-integrating output. The left half of the scale shows the measuring ranges of velocity (mV/mms^{-1}) for the integrating output. Both values may be measured simultaneously.

Transducers with Very High or Very Low Sensitivity

Transducer sensitivities outside the range of 1 to 100 pC/ ms^{-2} (or mV/ms^{-2}) can be balanced by the help of the measuring range. In case the sensitivity is too high, you have to set a tenth of its value at the toggle switch and the thumb wheel switch and multiply the measuring range by ten.
Example:
The Accelerometer model KB12V of Metra has a sensitivity of 300 mV/ ms^{-2}. The toggle switch has to be put into the position “10 - 100” and the thumb wheel switch has to be set to
“3-0-0”. The corrected measuring ranges are now: 10 mV/ ms^{-2} in position “1 mV/ ms^{-2}” 100 mV/ ms^{-2} in position “10 mV/ ms^{-2}” etc.
The inverse procedure has to be carried out when using sensors with a sensitivity lower than 1 pC/ ms^{-2} or 1 mV/ ms^{-2}. The ten times enlarged sensitivity value has to be adjusted

with the two switches and the measuring range has to be divided by ten.

Other Units and Other Mechanical Units

Besides the vibration measurement in units of acceleration (ms^{-2}) and velocity (mms^{-1}), like printed on the range scale, the M67i allows to measure vibration in other units or to determine other physical quantities, too, so, for instance, acceleration in g, pressure in bar or force in Newton.

For this purpose you have to set the sensitivity by the toggle switch and the thumb wheel switch in the same order of digits, like it is given in the data sheet of the manufacturer. An ICP®-compatible accelerometer, calibrated in g, for instance, has to be set in mV/g, a pressure transducer with charge output in pC/bar or a force sensor with ICP®-compatible output in mV/N. In the same way you have to deal with the measuring range. The units of the scale are now read in mv/g, mV/bar or mV/N.

Integrator

The M67i has a built-in integrator. It may be used to measure velocity (v) from a signal proportional to acceleration (a). The relation between the integrated (u_v) and the nonintegrated output voltage (u_a) can be described as follows:

$$u_v(t) = \int u_a(t)dt$$

For a sinusoidal voltage

$$u_a(t) = U_a \sin 2\pi ft$$

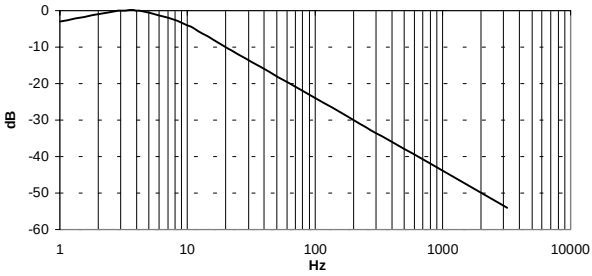
results after integration

$$u_v(t) = \frac{U_a}{2\pi f}\cos 2\pi ft\,.$$

This shows, that the integrated output voltage u_a is inversely proportional to the frequency. Therefore, the level of the voltage at the integrating output decreases by 20 dB per frequency decade.

The diagram in Figure 2 shows the characteristic of the integrator. The lower limiting frequency of the integrating output is set to 3 Hz.

Figure 2: Amplitude response of the integrator



Testing the Outputs

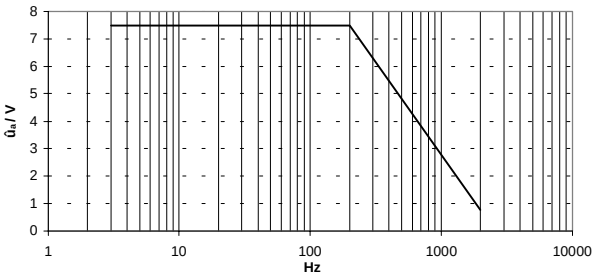
The M67i is designed for measurement of velocity in units of mms^{-1} and acceleration in ms^{-2}. At a frequency of 159.2 Hz the term $2\pi f$ becomes 1000 Hz. Supplying a sinusoidal signal of this frequency into the input, both outputs will deliver the same output voltage (resulting from the divider of 1000 between the units m and mm). This offers a simple possibility to test the output voltage by the help of a Vibration Calibrator of Metra´s VC1x series. They generate a calibration frequency of 159.2 Hz at a vibration level of 10 ms^{-2} and 10 mms^{-1}. This way you can calibrate the entire measuring chain from the pick-up to the following measuring equipment.

Dynamic Range

The full dynamic range of the output is guaranteed, independent of the adjusted transducer sensitivity. The maximum peak value of the output voltage amounts to $\hat{u}_{amax} \geq 7.5$ V.

The dynamic range of the integrating output, however, is limited. As you learn from Figure 2, the integration demands a high dynamic of the signal. At 1000 Hz the level at the integrating output amounts only to 1/100 of the value at 10 Hz. Because of the limited dynamic range of the preceding circuits of the integrator, the full dynamic range of this output can be guaranteed only within a limited frequency range. The integrator is rated to reach the maximum modulation of $\hat{u}_{amax} \geq 7.5$ V at frequencies up to 200 Hz. From this point the maximum modulation decreases proportional to the increasing frequency. At 2 kHz the maximum undistorted output level amounts to $\hat{u}_{amax} \geq 0.75$ V (Figure 3).

Figure 3: Dynamic range of the integrator output depending on frequency



Overload Indicators

To avoid distortion of the output signal due to overload, the M67i has an overload indication for each of the outputs. The overload indication responds to positive as well as to negative amplitudes of the signal. The LED starts glowing at a peak output voltage of > ± 6 V. From this point you still have a reserve up to the limiting value of ± 7.5 V.

Using the non-integrating output (a), the overload indicator

Output a

"a" is relevant, only. A signal of the LED "Overload v", which may appear at low frequencies, has no influence to the non-integrating output.

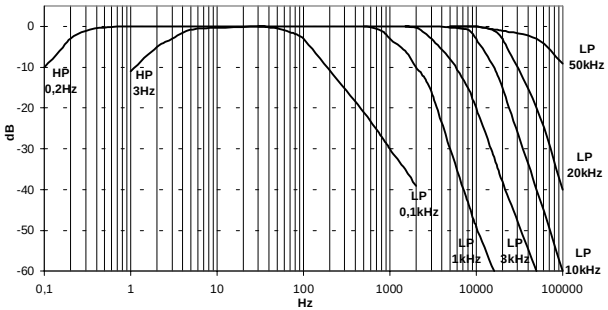
Output v

Using the integrating output (v), you have to pay attention to both overload indicator LEDs, however. At frequencies lower than 200 Hz at first the integrating output will overload, that means, the overload indication of this output ("Overload v") is glowing first. At frequencies higher than 200 Hz the stage preceding the integrator overloads first, as explained above (Figure 3). Therefore, the LED "Overload a" will glow first.

Filters

The M67i provides high pass and low pass filters with variable limiting frequencies. Figure 4 shows the frequency characteristic of the different filters.

Figure 4: Filter amplitude response



Low Pass Filter

The lowpass filter is set by the rotary switch "LOW PASS". The following limiting frequencies may be set:

100 Hz (-3 dB) or	50 Hz (-10 %)
1000 Hz (-3 dB) or	800 Hz (-10 %)
3000 Hz (-3 dB) or	2400 Hz (-10 %)
10 000 Hz (-3 dB) or	8000 Hz (-10 %)
20 000 Hz (-3 dB) or	16 000 Hz (-10 %)
50 000 Hz (-3 dB) or	25 000 Hz (-10 %).

By means of the different scales of the limiting frequencies with –3 dB and –10 % tolerances, you have the choice of two tolerance classes.

The 100 Hz-low pass is a two-pole filter with an attenuation of about –25 dB per frequency decade. The low pass filters of 1000 Hz, 3000 Hz, 10 kHz and 20 kHz are four-pole filters with an attenuation of about -50 dB / decade. In position 50 kHz the amplifier works with its full bandwidth.

Typical applications of the low pass filters are:

- Low pass 1000 Hz: Measurement of velocity on rotating machinery to VDI 2056 / ISO 10816.

- Low pass 100 Hz: Measurement of vibration exposure to the human body and vibration measurement on buildings to DIN 45699, ISO 4150, ISO 5349, ISO 8041.
- Anti-aliasing filtering for data acquisition systems.

High Pass Filter

The high pass filter has two switchable lower limiting frequencies of 0.2 Hz and 3 Hz. With the help of the 3 Hz high pass you may filter out low frequency disturbances from the measuring signal. Such disturbances may occur, for instance, by the influence of temperature variations to piezoelectric accelerometers, working on compression principle.
In position 0.2 Hz the amplifier uses its full bandwidth.
The 3 Hz high pass is a two-pole filter with an attenuation of about 25 dB per frequency decade.

4. Technical Data

Charge input	socket UNF 10-32
Voltage input	R_i >10 MΩ with switchable ICP constant current source, BNC socket
Constant current supply for ICP® compatible transducers	constant current 3.8 .. 5.6 mA compliance voltage > 17 V
Overvoltage protection of inputs	>500V, voltage input cuts off for signals >22 V
Measuring ranges	
Vibration acceleration	1 / 10 / 100 / 1000 mV/ms^{-2} ±2%
Vibration velocity	1 / 10 / 100 / 1000 mV/mms^{-1} ±2%
Transducer sensitivity adjustment	1.00 to 9.99 and 10.0 .. 99.9, 3 digits, decimal
Outputs	non-integrating and integrating $\hat{u}_{out} \geq \pm 7.5$ V, R_{out} = 50 Ω, 2 BNC sockets
Overload indicators	LEDs for non-integrating and integrating output, threshold voltage $U_{OVL} \geq \pm 6$ V
Frequency range, unfiltered	0.2 .. 50 000 Hz (-3 dB) at non-integrating output
High pass filter	3 Hz (-3 dB)
Low pass filters	100 Hz (-3 dB) / 50 Hz (-10 %) 1000 Hz (-3 dB) / 800 Hz (-10 %) 3000 Hz (-3 dB) / 2400 Hz (-10 %) 10 000 Hz (-3 dB) / 8000 Hz (-10 %) 20 000 Hz (-3 dB) / 16 000 Hz (-10 %) 50 000 Hz (-3 dB) / 25 000 Hz (-10 %)
Accuracy of filter frequencies	± 10 % from nominal value
Intrinsic noise	
Charge input	< 8 fC_{rms} with 1 nF at input, low pass 20kHz, range 1000 mV/ms^{-2}, sensitivity 1.00
Voltage input	< 8 μV_{eff} with ICP® compatible transducer at input, low pass 20kHz, range 1000 mV/ms^{-2}, sensitivity 1.00

Battery supply	2 R20 batteries (size D / Mono / UM1) life time: > 60 h with Alkaline batteries
Battery indicator	LED, threshold voltage: 2.1 V
External power supply	DC 8 .. 18V, <250 mA, DIN 45323 power supply jack, plus pole on tip
Dimensions	185 x 105 x 75 mm^3

Limited Warranty

Metra warrants during a period of
12 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 purchase.
Customer has to provide the dated bill of sale as evidence.
The warranty period ends after 12 months.

Repairs do not extend the warranty period.

This limited warranty covers only defects which arise as a result from 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 has to be paid by the customer.
The repaired or replaced product will be sent back at Metra's expense.

CE

Declaration of Conformity

Product: Integrating Signal Conditioner
Model: M67i

Hereby is certified that
the above mentioned product
complies with the demands
of the following standards:

- EN 50081-1
- EN 50082-1

Responsible for this declaration is the producer

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Meißner Str. 58
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Declared by
Manfred Weber
Radebeul, 9th November, 1999