Instruction Manual

Triaxial
Vibration
Monitor
VM40C

Valid from version xxx.012

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Dec/ 23

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VM40
Triaxial Vibration Monitor

```
███ ▶ 10.05.17 08:10:41
DIN4150-3
X:   12.69 mm/s
Y:    0.19 mm/s
Z:   12.55 mm/s
Max.: X @ 7Hz
ALARM↑
F1/F2: Info F3: Menu
```

```
1          100
           Hz
```

Warning   Alarm

F1   F2   F3

◀   OK
    ON-OFF   ▶

▼

Relay

USB/Ser.

Charge

Thank you for choosing a Metra Vibration Measurement Instrument

1. Purpose of Use

The VM40C is designed for measuring vibration in buildings, bridges, towers, pipelines and various other large structures.

The measurements serve to prevent possible structural damage or disturbance to people.

The VM40C contains a sensor, recording and evaluation electronics and an accumulator in its robust casing. It is especially suitable for autonomous operation over longer periods of time e.g. on construction sites.

2. Function

The instrument contains three highly sensitive piezoelectric systems for vibration measurement of all three spacial dimensions.

The signal processing is controlled by a micro processor. The VM40C is operated via its seven keypad buttons and illuminated LCD display.

The measurement data can be transferred to a PC via the USB interface. The instrument also has a port for connecting a charger and a relay output for the external signaling of vibration occurrences.

The VM40C can measure in accordance with to the following standards:

- **DIN 4150-3**: Structural Vibration – Effects of vibration on structures
- **BS 7385**: Evaluation and measurement for vibration in buildings
- **SN 640312a**: Effects of vibrations on buildings
- **Circulaire du 23/07/86** relative vibrations mécaniques émises dans l'environnement par les installations classées pour la protection de l'environnement

Through menu navigation, all information concerning the type and location of the measurement and the building type is requested and operational errors are avoided.

The display of the measurement values is carried out using the three peak values of vibration velocity (X/Y/Z) or the vector sum. Furthermore the main frequency and its coordinate are displayed for the highest amplitude.

Additionally the VM40C displays the FFT spectrum of the measured vibration quantity. The spectral graph also indicates the limit value curve of the chosen standard, which enables you to analyze potential damage at a glance.

If the limit value is exceeded, the measured value can be saved. The VM40C also contains two LEDs and a relay output for signaling alarm status.

The VM40C with the optional accessory VM40-MODEM can send its measuring data to the IoT data platform ThingSpeak. This enables remote data inspection using a web browser. In the case of vibration events the VM40C can send SMS alert messages.

Other accessories are the mobile report printer VM40-PRINTER and the alarm beacon VM40-L.

3. Measuring

3.1. Selecting the Measuring Mode

Switch on the VM40C by pressing the ON-OFF button. After the start screen, the measurement value display with the most recently selected settings appears.

Press F3 to open the main window and select "measuring mode" (Figure 1).

```
MEASURING MODE
>Non-standard
 DIN 4150-3
 BS 7385
 SN 640312a
 Circulaire
▲▼: Select F3: Quit
```

Figure 1: Measuring mode

You can choose between adjustable measured value (non-standardized) and the four supported standards, which are described in the following sections.

In the measurement value display you can view the selected settings by pressing the F1 button (Figure 2).

```
VIBRATION MONITOR
 BS 7385

 Unreinforced/Resident.

 1 /4 /15 /40  Hz
 3 /15 /20 /50  mm/s
F3: Back
```

Figure 2: Settings display

Here you will see your chosen standard with its specified settings as well as the four frequency and amplitude dots of the limit value curve.

Notice: The following chapters include abstracts of the most relevant standards for building vibration. For a compliant evaluation it is necessary to study the standard documents to the full extent.

Notice: Menus are closed automatically if no operation is done for 1 minute and the VM40C returns to the measuring screen.

3.2. Measuring in accordance with DIN 4150-3

3.2.1. Measurement Procedure

DIN 4150-3 is the most widely applied standard internationally for measuring structural vibrations. The measurement procedure can be found in a similar form in other national standards, for example the Italian UNI 9916.

The assessment parameter is the maximum value v_i of the three individual components (peak values) of vibration velocity at frequencies of 1 to 80 Hz. According to the 2016 edition of the standard the most significant measurement location is the <u>highest ceiling</u>. This measurement determines the horizontal response of the building to vibrations at the foundation. Only the higher value of the two horizontal components X/Y is evaluated.

Alternatively, measurements of short-time vibrations can be carried out at the foundation. In this case the highest value of X/Y/Z is used. For measurements at the foundation the evaluation is frequency weighted which reflects the transmission from the foundation to the upper ceiling.

The standard provides guide values for permissible vibration velocities for short-time and sustained vibrations in three types of buildings.

Guide values for vibration velocity v_i for analyzing the effects of transient vibration					
Building Type	Foundation Frequency of the Significant Vibration			Upper ceiling	
Frequency range	1 – 10 Hz	10 – 50 Hz	50 – 100 Hz	all Frequencies	
Direction	X / Y / Z	X / Y / Z	X / Y / Z	X / Y	Z
Reinforced or framed structures. Industrial and heavy commercial buildings	20 mm/s	20 – 40 mm/s	40 – 50 mm/s	40 mm/s	20 mm/s
Unreinforced or light framed structures/ Residential or light commercial type buildings	5 mm/s	5 – 15 mm/s	15 – 20 mm/s	15 mm/s	20 mm/s
Delicate, listed buildings e.g. historical monuments	3 mm/s	3 – 8 mm/s	8 – 10 mm/s	8 mm/s	20 mm/s

Table 1: Guide values for transient vibration

Notes from DIN 4150-3 about the guide values in Table 1:

- For engineering structures in massive scale construction, e.g. reinforced concrete for abutments or block foundations you can raise the guide values for industrial type buildings twofold.
- If short-time vibrations occur in ceilings at below 20 mm/s in vertical direction, a reduction in the serviceability is not to be expected.

The standard also gives guide values for short-time vibrations on pipelines of varying types:

Guide values for transient vibrations in pipelines	
Pipe material	Vibration Velocity v_i
Steel, welded	100 mm/s
Stoneware, concrete, reinforced concrete, pre-stressed concrete, metal	80 mm/s
Brickwork, plastic	50 mm/s

Table 2: Guide values for pipelines

For continuous vibrations the following guide values apply:

Guide values for vibration velocity v_i for analyzing the effects of continuous vibration		
Building Type	Upper ceiling level, all Frequencies	
Direction	X / Y (horizontal)	Z (vertical)
Reinforced or framed structures industrial and heavy commercial buildings	10 mm/s	10 mm/s
Unreinforced or light framed structures, residential or light commercial type buildings	5 mm/s	10 mm/s
Delicate buildings, listed buildings e.g. historical monuments	2.5 mm/s	-

Table 3: Guide values for continuous vibration

Vertical continuous vibrations with a vibration velocity below 10 mm/s normally do not cause damage to ceilings in houses. For delicate buildings there are no guide values available.

For sustained vibrations on pipelines, the guide values for short time vibrations, reduced by 50%, can be applied.

The following advice is given in DIN 4150-3 for the placement of sensors:

- In the upper ceiling level the sensor should be placed where the greatest horizontal vibration is expected. It may be necessary to perform comparison measurements along the outer walls. On concrete ceilings which are reinforced in both directions measurements can be taken in any place.
- For foundation vibrations the transducer should be placed on the lowest floor at the foundation or on the outer wall.
- For buildings without a basement the measurement location must not be higher than 0.5m above the ground level.
- One of the lateral coordinates (X/Y) should be parallel to an outside edge of the building.
- Buildings with larger ground areas should be measured at several points.
- In addition to measuring at the foundation and the upper ceiling, if required, measurements can be carried out in the vertical direction on the ceilings, where the strongest vibrations are to be expected (mostly central).
- When measuring pipelines, where possible, the sensor should be placed on the pipeline itself

3.2.2. Measuring with the VM40C

After choosing the operating mode „DIN 4150-3", please select whether you will be measuring short-time or sustained vibrations (Figure 3).
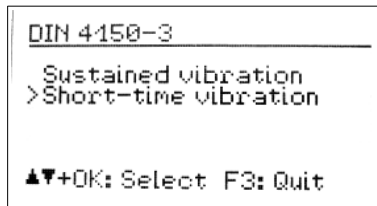

Figure 3: Short-time/Sustained vibration

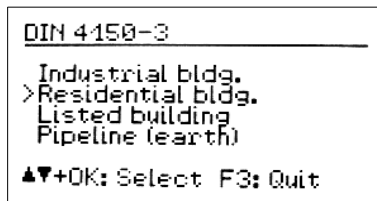Next, please select the building type:

Figure 4: Building type

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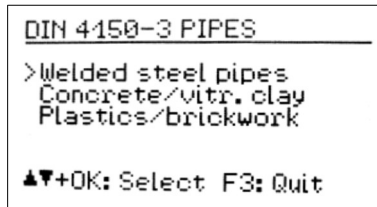When selecting "Pipeline" the following types are available:

Figure 5: Pipeline types

In the case of short-time vibrations the measurement location needs to be selected:
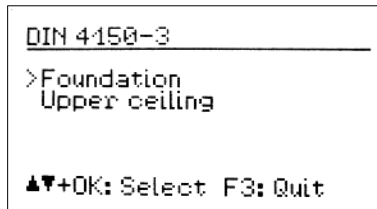
Figure 6: Measurement location

The standard frequency range is 1 to 80 Hz. In special cases, e.g. blasting operations, the frequency range can be increased to 1 to 315 Hz.
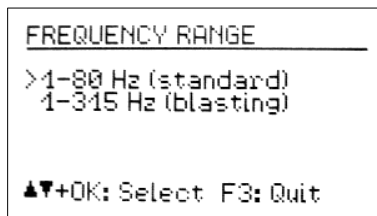
Figure 7: Frequency range

Press F3 to exit the menu to go to the measurement value display (Figure 8).
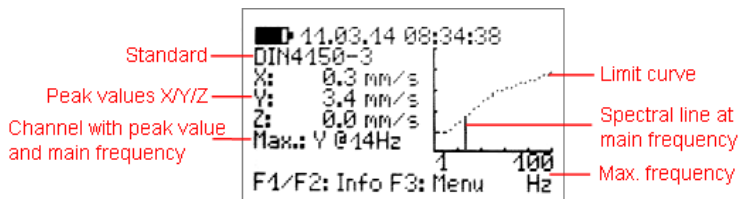
Figure 8: Measurement value display in accordance with DIN 4150-3

The three peak values X/Y/Z of the vibration velocity and the highest amplitude together with its main frequency are displayed every second. On the right side of the screen a graph displays the frequency spectrum (FFT) including the limit curve. The diagram is scaled to the limit curve. Higher magnitudes will be cut off.

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Notice: For ceiling vibrations (1 and 3) there are different guide values for the vertical (Z) direction. They are evaluated by the VM40C and considered for alarms. In the FFT and frequency display, however, only the horizontal directions (X / Y) are shown.

If the limit value curve is exceeded, "ALARM" is displayed below the main frequency. If the limit value is exceeded the following will happen:

- The red light will flash.
- The measurement values will be saved if the event recording has been activated.
- The relay output will switch, if it has been activated.
- A text message (SMS) will be sent, if this option has been set up and if the modem is connected.

Note: The alarm and recording functions will be activated after a delay of 30 seconds after leaving the menu.

Note: If the measured vibration is too low for a precise calculation of the main frequency the unit will display "???" instead of a frequency.

3.3. Measuring in accordance with BS7385

3.3.1. Measurement Procedure

The British Standard BS 7385 is mainly used in the Commonwealth countries. It is less complex than the DIN Standard. Similarly to the DIN standard, it also measures the peak value of the vibration velocity in all spacial dimensions. It is called "peak particle velocity" (ppv). The frequency range is not precisely specified. The VM40C uses the range 1 to 80 Hz and 1 to 315 Hz.

The Standard provides guide values for short-time vibrations, which are measured at the foundation (Table 4). The guide values mark the limit above which cosmetic damage may occur, such as cracks in the walls or ceilings. Lesser damage is to be expected at double the guide value and greater damage at fourfold the guide value. In the case of sustained vibrations or excitation from building resonance the guide values need to be reduced by by at least 50%.

Residential and Industrial buildings are differentiated.

Guide values for short-time vibrations without excitation of building resonances		
Main Frequency	Vibration Velocity for Residential Buildings	Vibration Velocity for Industrial Buildings
1 – 4 Hz	< 0.6 mm displacement	-
4 Hz	15 mm/s	50 mm/s
15 Hz	20 mm/s	50 mm/s
40 Hz	50 mm/s	50 mm/s
250 Hz	50 mm/s	50 mm/s

Table 4: Guide values in accordance with BS 7385

Figure 9: Graph: Guide values in accordance with BS 7385

3.3.2. Measuring with the VM40C

Once you have selected the measuring mode "BS7385", select the building type to be assessed (Figure 10).

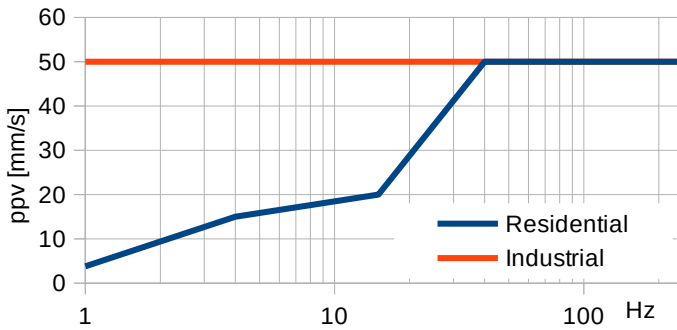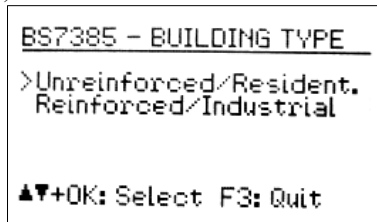Figure 10: Building Type
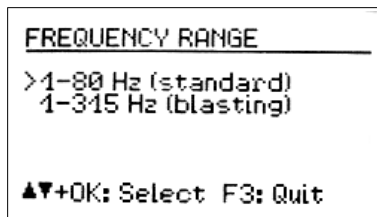
In the next menu select the frequency range:

Figure 11: Frequency range

Press F3 to exit the menu and to go the measurement value display (Figure 12).
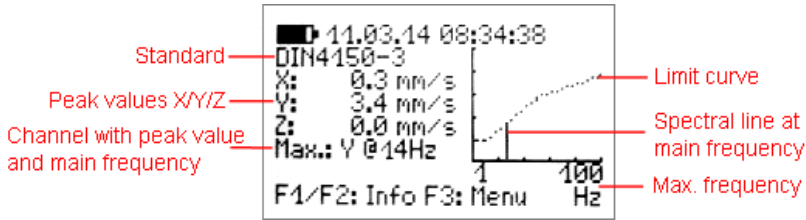
Figure 12: Measurement value display to BS7385

The three peak values X/Y/Z of the vibration velocity and the highest amplitude to-gether with its main frequency are displayed every second. On the right side of the screen a graph displays the frequency spectrum (FFT) including the limit curve. The diagram is scaled to the limit curve. Higher magnitudes will be cut off.

If the limit value is exceeded, "ALARM" is displayed below the main frequency and the following will happen:

• The red light will flash.
• The measurement values will be saved if the event recording has been activated.
• The relay output will switch off, if it has been activated.
• A text message (SMS) will be sent, if this option has been set up and if the mo-dem is connected.

Note: The alarm and recording functions will be activated after a delay of 30 sec-onds after leaving the menu.

Note: If the measured vibration is too low for a precise calculation of the main fre-quency the unit will display "???" instead of a frequency.

3.4. Measuring in accordance with SN 640312a

3.4.1. Measurement Procedure

The Swiss Standard SN 640312a is also based on the peak values of the vibration velocity. However, it uses the vector sum as assessment parameter:

$$v_i = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

It measures between 5 and 150 Hz. The frequency range is divided into three sec-tions: 8 to 30 Hz, 30 to 60 Hz and > 60 Hz. For frequencies below 8 Hz the guide value for 8 to 30 Hz reduced by one-third is applied.

As a basis for the guide values, four building types with different levels of sensitiv-ity, the occurrence of vibrations and the frequency with which the vibration influ-ence occurs are taken as a the basis for the guide values (5).

3.4.2. Measuring with the VM40C

After selecting the measuring mode "SN 640312a", define which sensitivity class the building belongs to:

| Occurance of vibrations	very low sensitivity			low sensitivity			normal sensitivity			increased sensitivity		
	occasio-nally	frequently	perma-nently	occasio-nally	frequently	perma-nently	occasio-nally	frequently	perma-nently	occasio-nally	frequently	perma-nently
1 Hz	45 mm/s	18 mm/s	9 mm/s	30 mm/s	12 mm/s	6 mm/s	15 mm/s	6 mm/s	3 mm/s	7,5 mm/s	3 mm/s	1,5 mm/s
30 Hz	60 mm/s	24 mm/s	12 mm/s	40 mm/s	16 mm/s	8 mm/s	20 mm/s	8 mm/s	4 mm/s	10 mm/s	4 mm/s	2 mm/s
60 Hz	90 mm/s	36 mm/s	18 mm/s	60 mm/s	24 mm/s	12 mm/s	30 mm/s	12 mm/s	6 mm/s	15 mm/s	6 mm/s	3 mm/s

Table 5: Guide values in accordance with SN 640312a
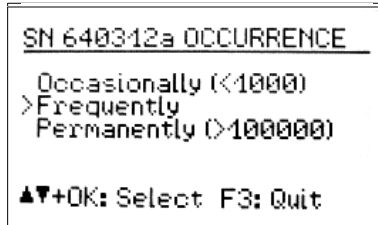
Figure 13: Occurrence

Once you have selected the building type, select the occurrence of the vibrations. The figures represent the vibration emissions, at which the velocity vector exceeds the 0,7-fold guide value. The assessment period is the time duration during which the building is exposed to vibrations.
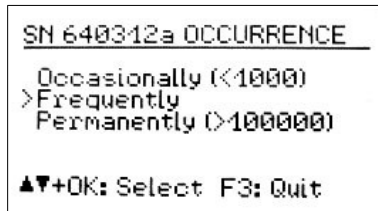
Figure 14: Occurrence

Press F3 to exit the menu and to go to the measurement value display (Figure 15).
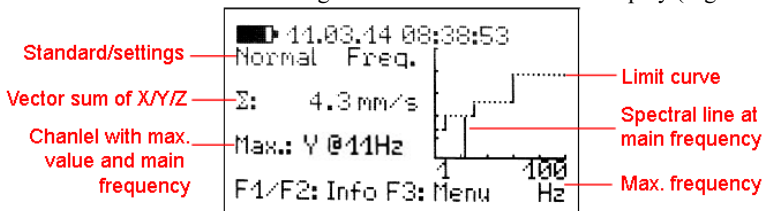
Figure 15: Measurement value display in accordance with SN 640312a

The vector sum of the vibration velocity in the three directions X/Y/Z and the highest amplitude together with its main frequency are displayed every second. On the right side of the screen a graph displays the frequency spectrum (FFT) including the limit curve. The diagram is scaled to the limit curve. Higher magnitudes will be cut off.

If the limit value is exceeded, "ALARM" is displayed below the main frequency and the following will happen:

- The red light will flash.
- The measurement values will be saved if the event recording has been activated.
- The relay output will switch off, if it has been activated.
- A text message (SMS) will be sent, if this option has been set up and if the modem is connected.

Note: The alarm and recording functions will be activated after a delay of 30 seconds after leaving the menu.

Note: If the measured vibration is too low for a precise calculation of the main frequency the unit will display "???" instead of a frequency.

3.5. Measurement in accordance with Circulaire 23/07/86

3.5.1. Measurement Procedure

The French guideline specifies a measuring method and limits for building vibration. It differentiates between methods for "fine analysis" and "monitoring". The VM40C supports the second method. Measurement is based on the peak values of vibration velocity in directions X/Y/Z between 4 and 150 Hz..

Relevant for evaluation is the maximum of the three peak values and its main frequency. The guideline gives limit values for resistant, sensitive and very sensitive structures and for permanent or short-time vibration. The limit values are found in figures 16 and 17.
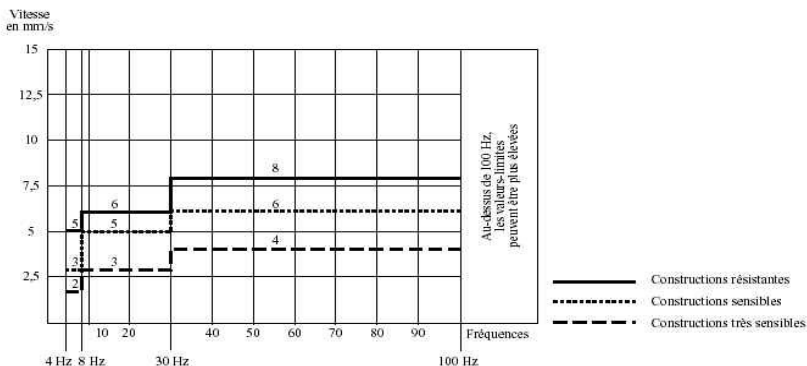

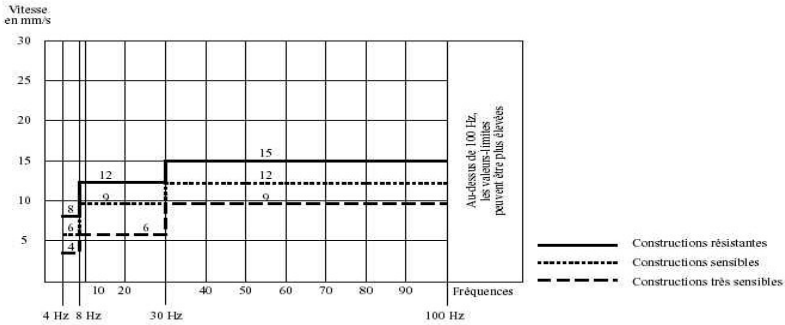Figure 16: Limits for permanent vibration (Circulaire 23/07/86)

Figure 17: Limits for short-time vibration (Circulaire 23/07/86)

3.5.2. Measuring with the VM40C

After selecting the measuring mode "Circulaire" you will be asked to enter the building type (resistant, sensitive or very sensitive). In the next step you select permanent or short-time vibration. Leave the menu by pressing OK.

The three peak values X/Y/Z of the vibration velocity and the highest amplitude together with its main frequency are displayed every second. On the right side of the screen a graph displays the frequency spectrum (FFT) including the limit curve. The diagram is scaled to the limit curve. Higher magnitudes will be cut off.

If the limit value is exceeded, "ALARM" is displayed below the main frequency and the following will happen:

- The red light will flash.
- The measurement values will be saved if the event recording has been activated.
- The relay output will switch off, if it has been activated.
- A text message (SMS) will be sent, if this option has been set up and if the modem is connected.

Note: The alarm and recording functions will be activated after a delay of 30 seconds after leaving the menu.

Note: If the measured vibration is too low for a precise calculation of the main frequency the unit will display "???" instead of a frequency.

3.6. Non-Standardized Measuring

If a standardized measurement is not desired, the vibration quantity (acceleration or velocity), the frequency range and the limit values can be entered manually. For this option select the measuring mode "Non-standardized".

Next you can select the vibration quantity and frequency range (Figure 18).
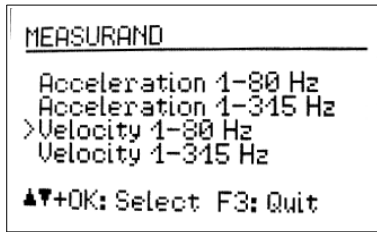
Figure 18: Non-standardized measurement

After this the points which define the limit value curve can be entered. The lowest and highest frequencies are fixed. The amplitudes and the two middle frequencies can be freely selected within the range limits. (Figure 19).
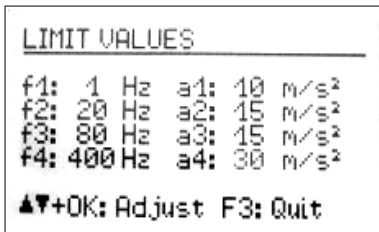
Figure 19: Entering limit values
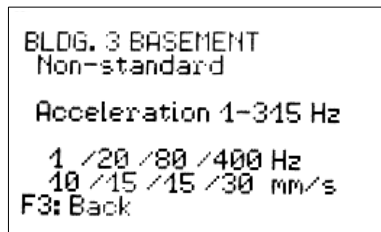
Figure 20: Display of limit values

As with the other measuring modes, your chosen measuring settings can be viewed during measuring by pressing F1 (Figure 20).

3.7. Overload Indication

If the vibration magnitude exceeds the limits shown in the Technical Data section, the VM40C will indicate "OVERLOAD" instead of the measuring value for the respective direction. (Figure 21).

In addition the warning and alarm LEDs flash simultaneously.

Due to integration the overload limit for velocity is frequency dependent (Figure 22).
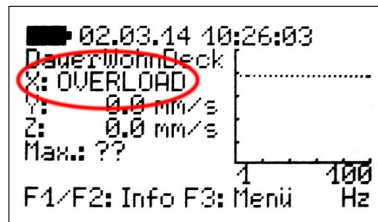
Figure 21: Overload indication

4. Saving Measurement Values

4.1. Introduction

The VM40C has memory space for 100,000 measurements. The saved data can be viewed via the instrument menu or transferred to the PC via the USB interface.

A measurement record includes:

* Date and time
* Measurement values X/Y/Z or the vector sum
* Main frequency
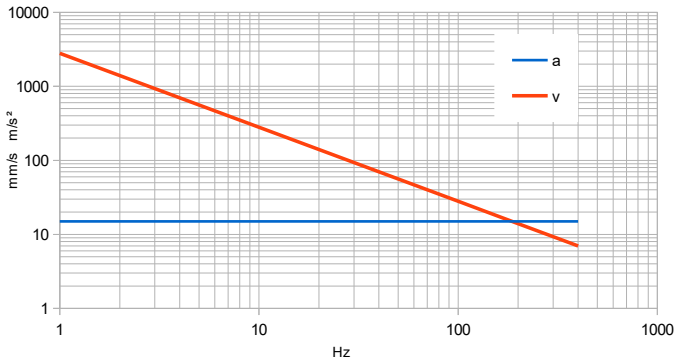
Figure 22: Overload limits for acceleration (a) and velocity (v)

* Trigger event

The instrument saves the data if any of the following events (triggers) occur:

* a warning or alarm event occurred
* a predefined time interval expired

Alarm events occur if the limits described in Section 3 are exceeded.

Warning events occur if the warning threshold is exceeded (see section 8.1).

The VM40C can also save measurements in fixed time intervals. In this case the highest X/Y/Z peak values since the last time step are saved[1]. Thereby no vibration event will be lost when recording in time intervals. This mode may be used if continuous recording is desired. It should be noted, however, that large amounts of data is accumulated withing short time. At 5 s recording interval, for example, the memory will be full after only 5 days. You should also be aware that it will take longer to transfer the data to a PC.

For most applications event controlled recording is sufficient. With carefully set alarm and warning limits all relevant vibration events are stored whereas time sections without vibration are ignored. This avoids the accumulation of useless data without information value. For verification purposes a combination of event and time controlled recording (e.g. with 5 minute intervals) may be useful. In any case the VM40C ensures continuous monitoring.

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1   from version 001.008, in earlier versions the current display value was saved

Notice: Saving measurements will start 30 seconds after leaving the menu.

Saved measurements are sorted in to data files in the VM40C. A file contains related measurements with the same settings.

4.2. Settings for Recording Data

To start recording open the main menu by pressing F3 and select "Recording" (Figure 23).

```
RECORDING
─────────────────────────
>Start recording
 View/edit/delete files
 Print report
 Delete all files

▲▼: Select  F3: Quit
```

Figure 23: Start Recording

Select "start". Now you can define the events (triggers), when the data should be saved. (Figure 24).

```
SAVING MODE
─────────────────────────
 At warning/alarm event
 Time-controlled
>Event and time control

▲▼+OK: Select  F3: Quit
```

Figure 24: Trigger selection

In the setting "Warning/Alarm" the measurement value is saved as soon as a change in status occurs, as follows:

• Normal to Warning
• Normal to Alarm
• Warning to Alarm
• Alarm to Warning
• Alarm to Normal
• Warning to Normal

If the warning or alarm status persists, no further measured values will be saved. This keeps the quantity of saved data down to a minimum. The type of status change is saved with the measurement.

The VM40C also offers you the possibility of saving measurements at pre-set time intervals. The time intervals are to be entered in seconds, for a minimum of 5 seconds. (Figure 25).
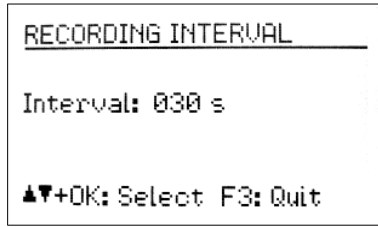
Figure 25: Recording interval

The time interval recording can also be combined with the status change recording ("Event and time control").

After determining the recording settings you will be asked to enter the name of the data record (Figure 26).
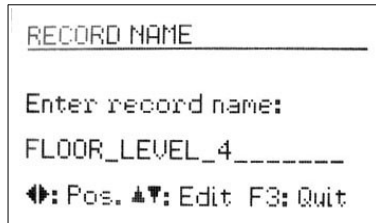
Figure 26: Record name

The record name identifies a block of related measurements with the same saved settings. Here you can enter, for example, the measurement location. With the arrow keys you can enter up to 20 upper case characters and digits. The last entered name appears as the default name. To exit the menu press OK.

Next you will be asked for SMS alarms. You may confirm if the modem is connected (see section 9.4).

After defining all the recording settings you can activate the keypad lock by pressing OK, to ensure that no unwanted interference occurs (see Section 8.2). You can also start recording without using the keypad lock by pressing F3 (27).
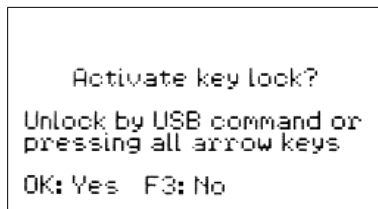
Figure 27: Key lock

The instrument will now display "Recording started". Thirty seconds later the evaluation of the recording trigger (event or time interval) will begin. The currently active recording can be seen in the measurement value display as a blinking text "Rec.# xxx", where xxx is the number of the previously saved measurements.

During recording the menu cannot be opened. If you press the menu button F3 you will be asked whether you wish to stop recording, the same will happen if you press OK/ON-OFF. The modem will also be switched off to save power.

After reaching the memory end the VM40C will display the error message "Memory full".

Notice: The transmission of data from the VM40C to the PC is not possible while recording is active.

4.3. Viewing saved Data

After recording you can view the saved measurements in the "Recording" menu. Select the menu point "View/edit/delete files" and then use the arrow keys ▲ ▼ to select the data file you wish to view (28).

```
File No. 2    of    3
FLOOR LEVEL 4
Start: 11.03.14  08:43:44
BS 7385 (1-80Hz)
unreinforced/Res.
5 s + events
F1: Edit name  ◀: Delete
▲▼+OK: Select  F3: Quit
```

Figure 28: Select file

A data file is displayed by its number and name, together with the start time, chosen standard and trigger source.

Note: The file numbers are not always in the order of saving. A previously erased file number will be re-assigned to the next saved file.

Pressing ◀ deletes the file together with all of its recorded measurements.

Press F1 to change the file name.

Press OK to open the file. The first saved record is then displayed (29). Below the file name you see the record number with the total number of records in the file, date and time and the trigger event. The abbreviations mean:

(T):   time interval controlled

0→W: normal to warning transition

0→A: normal to alarm transition

W→A: warning to alarm transition

W→0:   warning to normal transition

A→W: alarm to warning transition

A→0:   alarm to normal transition

END: recording stopped by the user, last record

BAT: recording terminated because of low battery, last record

MEM: recording terminated because of full memory, last record

CH1:   charging of the accumulator started

CH0:   charging of the accumulator finished

When the data was measured to SN 640312a you see the vector sum, otherwise the three measuring values of X / Y / Z. The significant frequency f(max) of the highest value is also displayed.

Figure 29: View record

Use keys ▲ ▼ to scroll between records. Press F3 to exit the menu.

4.4. Deleting the Data Memory

In the "Recording" menu the entire memory can be deleted by selecting "Delete all files". This can take several seconds, depending on the amount of data stored. The event counters (see chapter 4.5) are also reset.

4.5. Alarm Statistics

In the measurement value display, press F2 for an overview of the warning and alarm events that have occurred. These are displayed together with the number of saved measured values.

Figure 30: Event display

The sent messages and Connection error counters are useful in combination with VM40-MODEM. They count both SMS and ThingSpeak messages.

Press F1 to reset all counters.

4.6. Transferring the recorded data to a PC

For transferring saved data from the VM40C to a PC, a program is available (see section 10.2). It can found on our website https://mmf.de/en/produkt/vm40c.

The program enables you to display the measured data as table or time graph and generates reports according to your own requirements. It also convert the measurement data into a table of comma-separated values (CSV).

5. Printing a Report

The mobile printer VM40-PRINTER is offered as an optional accessory. It enables printing an immediate report on the site of measurement. The small printer uses thermo paper rolls. It is powered from an internal accumulator. It only needs to be connected to the VM40C via the supplied cable.

Figure 31: Printer VM40-PRINTER

To print a report, please open the menu "Recording" (Figure 32).
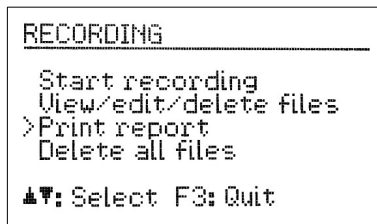
Figure 32: Printer menu

Select "Print report" and press OK. Next you will see the menu for the selection of a data file. Use the ▲▼ keys and OK to select a file. If the file contains more than 50 records a warning message will be issued to avoid excessive paper consumption (Figure 33).

Figure 33: Warning at more than 50 records

Figure 34: Start printing

You can continue printing all records by pressing F3 or filter the data before printing using the ▲ ▼ keys (Figure 35).

Figure 35: Selecting data to be printed

The following options are available:

- Only recordings triggered by the alarm limit
- Recordings triggered by the warning or alarm limit
- Only the recording with the highest measuring value

By this moment the printer needs to be connected and switched on pressing the ⏻ button for at least 1 s. Press OK at the VM40C to start printing.

Each recording fills two lines. The number after "No." indicates the position of the record in the VM40C memory. After "Event" you find the rea-

Figure 36: Example printout

son of recording. "A" stands for exceeding the alarm limit, "W" for exceeding the warning limit, "N" for dropping below the warning limit and "T" for recording in time intervals. In the last record "E" marks termination by the user, "B" because of battery discharge and "M" because of full memory. The recording event is followed by the time of recording.

The second line shows the measuring values. For triaxial measurement, e.g. to DIN 4150-3, there are the three axis values X/Y/Z. For vector sums, e.g. to SN 640312a there is only one value per record. The main frequency is also printed.

Each printout ends with a record "Event: E". This marks the end of recording.

In Figure 36 you see an example printout showing only alarm events. The header includes device data, settings and start time. Below you find the recordings.

The printout ends with "END OF REPORT".

The printer switches off automatically when not used for longer time. The included battery can be charged by the supplied mains adapter.

6. Relay Output and Alarm Beacon VM40-L

The VM40C has a relay output for controlling external signaling devices. These can be, for example, warning lights and acoustic signaling devices.

Please pay careful attention to the maximum contact load (see technical data, section 17). The relay output is not suitable for direct connection of mains operated devices.

To adjust the settings open the main menu and select "Alarms" and then "Relay output". You can pre-set the relay to energize or de-energize when warning status (see Section 8.1) or alarm status occurs. (37).


```
RELAY OUTPUT SETTINGS

>Switches at alarm
 Switches at warning
 Relay disabled

▲▼+OK: Select  F3: Quit
```

```
RELAY OUTPUT SETTINGS

>Non-latching
 Latching (reset by OK)



▲▼+OK: Select  F3: Quit
```

Figure 37: Relay output

In addition, you can determine whether the relay should stay energized ("Latching") or de-energize after the event finishes, until OK is pressed ("Non-latching").

Note: The relay function will be activated after a delay of 30 seconds after leaving the menu.

Figure 38 shows the output socket and its contact assignment. In neutral (de-energized) position the contacts "C" and "n.c." are connected, during warning or alarm status (energized) the contacts "C" and "n.o." are connected.

n.o. (o o) n.c.

C
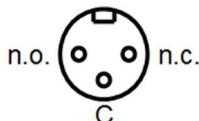
Figure 38: Relay output terminal assignment (external view of the socket)

Metra offers the alarm beacon VM40-L as accessory (Figure 39). It is supplied with 5 m connection cable to the VM40 relay output. Two LR20 batteries are included which last for approximately 180 hours of light. The battery compartment is opened by unscrewing the bottom lid.

Within the battery compartment there are also two switches. The white one enables a light sensor which switches off the beacon during day light. Since this will not be desired in most cases the white switch should be unlatched (off). The black push button selects the flashing pattern.

The switch outside the beacon is for testing.

Figure 39: Alarm beacon VM40-L

7. Radio-Controlled Beacon Light VM40R1/R2

The VM40-R2 radio-controlled beacon light (Figure 40) in combination with the VM40-R1 transmitter (Figure 41) is suitable for signaling limit value violations away from the measurement location, for example in construction machinery. Both components are optional accessories for the VM40C. They have a degree of protection of IP65.

Figure 41: Transmitter VM40-R1

Figure 40: Radio-controlled beacon light VM40-R2

Radio communication is based on LoRa standard. LoRa is license-free and is suitable for distances of several hundred meters in the free field with relatively good building penetration at very low power consumption. In the countries of the EU, the ISM band 868 MHz is used. In other regions, operation in the 868 MHz band may not be permitted. Other frequency variants are available on request for this purpose.

The radio beacon light can be supplied by three AA batteries (Figure 42). Alternatively, it can be powered from an external source of 5 to 36 V DC. This can be the on-board voltage of a vehicle, for example. A spiral cable for connection to a cigarette lighter is optionally available for this purpose. Depending on the voltage source, the rocker switch must be set to position I or II.

Note: Please remove the batteries if the VM40-R2 is not used for a longer period.

The VM40-R1 transmitter unit is connected to the 8-pin middle socket of the VM40C via the supplied 1 m cable. It is powered by the VM40C. The modem or a

Figure 42: VM40-R2 batteries

USB power supply can additionally be connected to the "Modem/Power" socket of the VM40-R1.

The VM40-R2 radio beacon light is controlled by the VM40C by means of an address. You can see the selected address on the VM40-R2 by the position of the coding switch. Addresses from 0 to 9 and A to F are possible. The addressing is used to assign the devices if several VM40-R2 units and several VM40C are in use at the same time. If you operate only one VM40C, you can keep the current address setting of the VM40-R2. It is also possible to couple several VM40C with one VM40-R2 which will then display the alarms of all vibration monitors operating with the same address.

To change the position of the coding switch, loosen the four screws of the transparent cover of the signal lamp if necessary.

First, the address of the radio beacon light must be set in the VM40C. To do this, open "IOT/SMS/Alarms" in the main menu, then "Relay & radio beacon" and "Radio beacon" (Figure 43).

```
MAIN MENU
_____

 Recording
 Measuring mode
>IoT/SMS/Alarms
 Key lock
 Device settings
▲▼: Select  F3: Quit
```

```
IoT/SMS/ALARM
_____

 ThingSpeak
 AskSensors
 SMS
 Warning threshold
>Relay & radio beacon
▲▼: Select  F3: Quit
```

```
RELAY/RADIO SETTINGS
_____

 Relay at alarm
 Relay at warning
 Relay disabled
>Radio beacon

▲▼: Select  F3: Quit
```

```
RADIO BEACON
_____

Address of VM40-R2: 4



F1: Test
▲▼: Select  F3: Quit
```
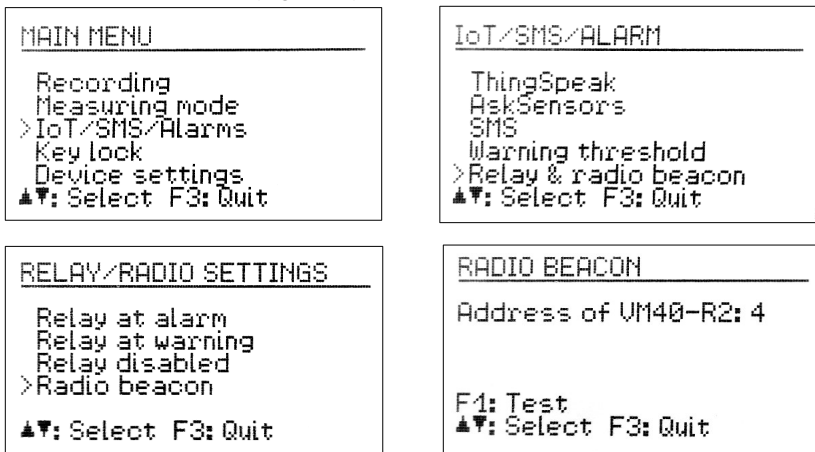
Figure 43: Selecting the address of the radio beacon light at the VM40C

Select the address using the ▲▼ buttons. You may test the connection to the VM40-R2 by pressing F1 (Figure 44). The VM40-R2 has to be switched on.

```
RADIO BEACON
_____

Address of VM40-R2: 4

Sending radio signal...
OK

F3: Quit
```
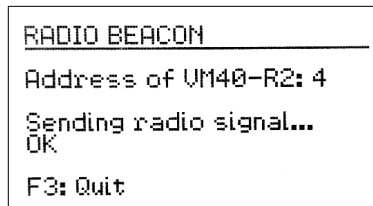
Figure 44: Testing the radio connection

If the transmitting part does not work properly, the message "VM40-R1: Error" is displayed. If the signal lamp does not respond, the device displays "VM40-R2: Error". The test is performed periodically until it is terminated with F3.

At the beacon light, the status LED in the center is green when there is a connection to the VM40C. For this purpose, the VM40C periodically sends a status message to the VM40-R2. If this fails to occur for more than 30 s, the LED turns red. Continuous red lighting of the status LED indicates an interruption of the radio connection.

If the battery voltage is too low, the LED lights up blue.

If the VM40C reports a warning event, all LEDs on the outer edges and two bright LEDs behind the front label flash yellow, and red in the event of an alarm. The minimum flashing duration is 30 s. If further vibration events occur the LEDs will flash longer.

In measuring mode, an active VM40-R1 transmitter is indicated by an "R" in the top right corner of the display.

Note: The VM40C does not receive a confirmation from the VM40-R2 to status messages (OK/warning/alarm). This helps to minimize transmission time and power consumption. If you want to check whether the VM40-R2 is within range, please carry out the connection test described above.

8. Miscellaneous Settings

8.1. Warning Threshold

The warning threshold is an adjustable percentage value, which relates to the Alarm threshold of the selected standard (see Section 3). This enables you to automatically save measurement values or activate signaling at below the alarm limit of the applied standard.

If the warning threshold is exceeded the yellow light next to the display will flash.

To adjust the warning threshold, open the main menu by pressing F3, then select "Alarm/SMS" and "Warning Threshold (Figure 45).
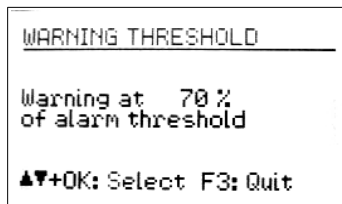

Figure 45: Warning Threshold

By pressing the keys ▲ ▼ you can set the value between 10 and 95 %.

8.2. Keypad Lock

To prevent manipulation during ongoing monitoring, it can be advantageous to activate the key lock. This function can be found in the main menu under "Key Lock" (Figure 46).
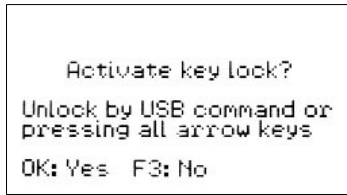
Figure 46: Key Lock

When the key lock has been activated, after leaving the menu you can only retrieve information using keys F1 and F2.

To release the key lock press all four arrow keys simultaneously, until the instrument displays "unlocked".

Alternatively, the key lock can be switched on and off by a command sent via the USB interface.

8.3. Adjusting the Axes

The VM40C contains a tilt sensor for adjusting and monitoring the vertical alignment. The axes adjustment is located in the main menu under "Device settings". There you will see a graph which resembles a spirit level (Figure 47). The moving point has to be located within the circle. If this is the case, "OK" will be displayed on the left of the screen.

To install/mount the VM40C on various floors or surfaces in conformity with a standard, Metra offers a tripod floor plate with adjustable feet.
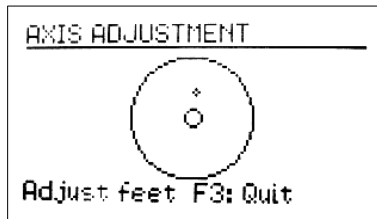

Figure 47: Axis adjustment

The axis adjustment is monitored during measurement operation. If the axes have been adjusted incorrectly, the flashing warning will appear in place of the standard "Adjust Axes!" (Figure 48).
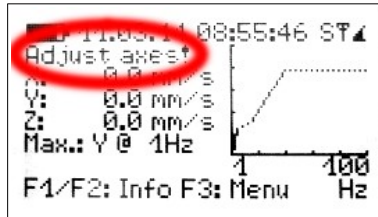
Figure 48: Warning "Adjust axes"

8.4. Date and Time

To retrace vibration events in the saved values the exact date and time are important. To set the data and time open the main menu, by pressing F3. From the main menu go to the menu option "Device settings" and press OK. From within this sub-menu go to "Date and time".

Use the keys ▲ ▼ to change the flashing value and with the keys ◄► move between second, hour, minute, month, day and year.

The date also takes the leap year in to account.

In the same menu you can also correct clock inaccuracy. This can be done using the setting at "Cal." in ppm (parts per million). The clock frequency can be increased with positive values and decreased with negative values. The sign changes to minus at +254 ppm.

Example: The clock is 5 seconds slow. There are 24 * 60 * 60 s = 86400 seconds in a day. The difference amounts to 5 s / 86400 s = $58 * 10^{-6}$ = 58 ppm. The adjustable value is -58 ppm. Press OK to apply the settings.
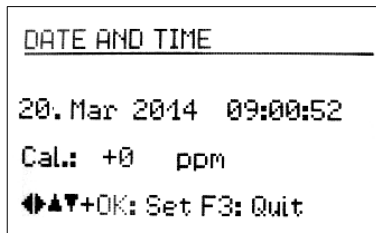
Figure 49: Date and Time

8.5. Instrument Name

The VM40C can be given an individual name, which, for example, identifies the location of installation. The instrument name is retrievable via the USB interface and is also used for the SMS alerts (VM40-MODEM) (see Section 9.4).

To enter the name open the main menu, go to "Device settings" and then to "Device name".
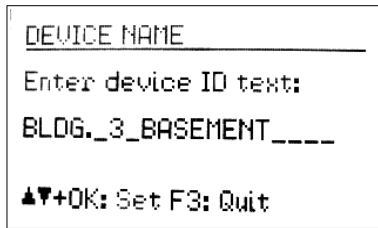
Figure 50: Device Name

Using the arrow keys you can enter us to 20 upper case characters and digits.

8.6. Menu Language

In the "Device settings" menu under "Menu language" you can choose between German and English. From our Download web page you may also install a firmware version in French and Italian (see section 11).

9. Cellular Modem (VM40-MODEM)

9.1. General Information

The optional mobile phone modem VM40-MODEM can be connected for sending measurement data to the IoT platform ThingSpeak and for sending SMS text message alerts when vibration events occur. In this way the VM40C can be used far away grid-bound infrastructures.

The modem supports the 4G (LTE) frequency bands 3, 8 and 20 for Europe, Middle East and Africa and 2G (E-GSM-900 and DCS-1800).

The modem is connected via a 5 m long cable to the 8 pin socket of the VM40C which helps to find a suitable location even in places with poor network coverage. Power supply for the modem is provided from the VM40C.

To provide the additional power for the modem (current consumption is about three times higher than without modem) it is recommended to connect a USB mains plug adapter with 5 V / >1500 mA via the "+5 V supply" socket of the modem using the supplied USB cable (see section 13).

Figure 51: VM40-MODEM

9.2. Inserting the SIM Card

To use the SMS functions a SIM card is needed. Open the case of the modem by loosening two cross-headed screws (Figure 52). Remove the cover and open the SIM card holder. Insert a Micro SIM card in the direction printed on the case and push it in until you hear a clicking sound.

Figure 52: SIM card holder

9.3. First Connection to a Mobile Phone Network

Once you have inserted the SIM card, open "ThingSpeak/SMS/Alarms" from the main menu and then select "SMS" and "Activate SMS alarms".

When you use the card for the first time, you will be asked to enter the PIN. If the card has been locked (e.g. due to entering the wrong PIN three times), you will additionally need to enter the PUK number (Personal Unblocking Key) (Figure 53).

```
SMS REGISTRATION

PUK: 19078419

PIN: _____


◀▶▲▼+OK: Set F3: Quit
```
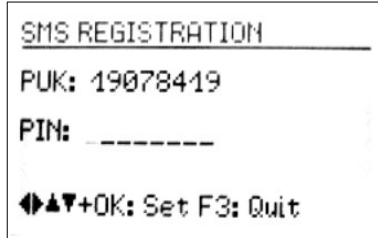
Figure 53: Entering the PUK and PIN

Note: The VM40C deactivates the password request after the first registration, so that the password does not need to be entered again.

Now the VM40C will try to connect to the mobile phone network. At the first time this can take more than one minute. If the registration was successful the name of the network provider will appear on the display (Figure 54). The green LED at the modem will be on.

```
REGISTRATION

Registered on ...
E-Plus
4G



```

Figure 54: Mobile Registration

9.4. SMS Alerts

The VM40C with connected VM40-MODEM can send SMS messages including measurement values and time stamp when a limit value is exceeded. The necessary settings are made in the menu "Recording" / "Start recording" / "SMS alarms?" (Figure 55).

```
SMS ALARM
>Activate SMS alarms
 SMS phone book


▲▼: Select  F3: Quit
```

Figure 55: SMS menu

If the phone book of the SIM card does not yet include a phone number for receiving an SMS, select the menu item "SMS pho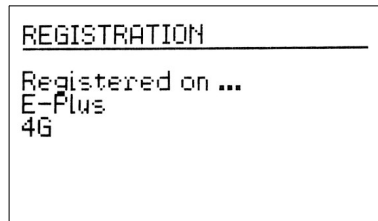ne book". Press F1 to create a new entry and use the arrow keys to enter a name and then the telephone number without spaces (Figure 56). Press OK to complete the entry. A maximum of 50 entries can be saved.

Use the ▲ ▼ keys to scroll through the existing entries.

Press ◄ to delete an entry.

With ► you can change an existing entry.

```
SMS PHONE BOOK

No.  1
015406946598
JAN

F1: New ▶: Edit
▲▼: Scroll ◀: Del. F3: Quit
```

Figure 56: SMS phone book

Now select "Activate SMS alarms". A menu with settings appears (Figure 57). You can accept the existing settings with OK or make changes with F1. The maximum number of sent SMS can be entered. Furthermore, the minimum time between two consecutive SMS can be defined in minutes. Finally, one or two numbers are selected from the phone book to which an SMS is to be sent. The entries are made with the arrow keys and confirmed with OK.
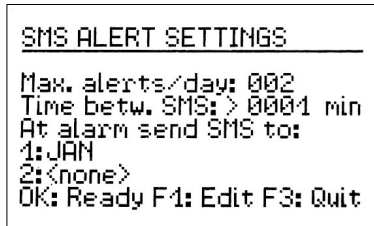
Figure 57: SMS settings

The VM40C finally confirms the activation of the SMS alarm function.

Figure 58: SMS function active

You can recognize the SMS function in measuring mode by an "S" at the top right of the display (Figure 59).
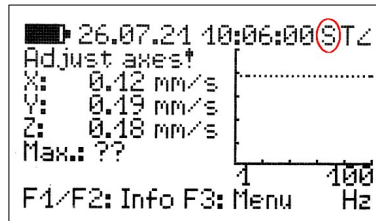
Figure 59: SMS indication

Note: The SMS function becomes active only after a delay of 10 seconds after the start of the measurement. Before that, the wait symbol Σ appears. The symbol is also shown when the entered number of SMS per day was reached.

Note: After the first exceeding of the alarm limit, the SMS function becomes active, but vibration is measured for another five seconds in order to transmit subsequent even higher amplitudes in the SMS, if necessary.

In measurement mode you can check the number of sent messages and possible errors by pressing F2 (see section 4.5).

On the receiving side, the SMS (with small phone-dependent differences) looks like in Figure 60.

Under the heading "!!VIBRATION ALERT!!" is the device name (see section 8.5). Below this, the date and time of the alarm event are displayed. This is followed by

the three vibration values at the time of the alarm, the main frequency and the battery charge status of the VM40C.

Figure 60: Example of received SMS message

A similar message including "!!LOW BATTERY ALERT!!", date and time is shown at 5 % battery charge. At full memory a warning message "!!MEMORY ALERT!!" is sent.

Note: As of software version 012, the modem is only switched on for sending. This has considerably extended the battery operating time. On the other hand this also eliminates the possibility of triggering the sending of an SMS by calling the device. Instead, the measurement data can now be retrieved via the ThingSpeak Internet platform.

Note: The IoT data platform AskSensors can send email messages at vibration events.

9.5. IoT Data connection

The VM40C in conjunction with the modem can send its measurement data to a sensor data platform on the Internet. This makes it possible to track the vibration remotely using an internet browser on any PC or mobile device.

The following IoT platforms are supported:

• AskSensors, a simply designed data visualization platform

• ThingSpeak, an online data interface for collecting, visualizing, and analyzing measurement data that is part of MathWorks' MATLAB software.

For more information, see the **VM40C-IoT Manual**, which is available for download on our website https://mmf.de/en/produkt/vm40c.

9.6. Modem Error Codes

If the connection was not successful the following error codes can be returned:

2   No modem found (SMS & IoT)

3   PIN or SIM card error (SMS & IoT)

4   APN sending error, APN may be correct (IoT)

5   CFG error of REST-API connection (IoT)

6   Timeout error of REST-API connection, APN may be wrong (IoT)

7   PDP Context sending error (IoT)

8   API connect error (IoT)

9   Error HTTP status code received from server (IoT)

10   No HTTP status code received from server (IoT)

11   Sending error (SMS)

10. Data Transfer via USB

10.1. Connection to a PC

The VM40C has a USB interface. For connecting to a PC the VM2x-USB cable is provided (Figure 73), which is connected to the second socket on the VM40C. As soon as the other end of the cable is connected to the computer USB socket, the device identification begins.

If the instrument is being connected to a PC for the first time you will be asked to carry out a driver installation. The required driver data MMF_VCP.zip can be found on our website:

https://mmf.de/en/produkt/vm40c/

Save both data files in a directory on your computer.

When Windows requests details of the source of the device driver, this directory should be entered.

The device driver is digitally signed and runs with Windows 7, 8 and 10.

If the VM40C is connected to a PC, the signal "USB" appears on the measurement screen in place of the battery symbol. The battery power is then switched off and the instrument obtains its power supply via the USB connection.

10.2. Software VM40MDB

The PC software VM40MDB is used to archive and display measuring data from the VM40C. In addition it generates reports in accordance with the relevant standards.

You can download the license-free software from the web page

https://mmf.de/en/produkt/vm40c/

VM40MDB runs under Windows 7, 8 and 10.

Connect the VM40C to the USB port of the PC, switch it on and install the device driver, if necessary (see chapter 10.1).

Install VM40MDB and start it from the Windows start menu (Programs / Metra Radebeul). The main window will appear. (Figure 61).

Note: On 64 bit systems it may be necessary to install manually "SQL Server Compact" which can be found under this link:

https://www.microsoft.com/en-us/download/details.aspx?id=5783
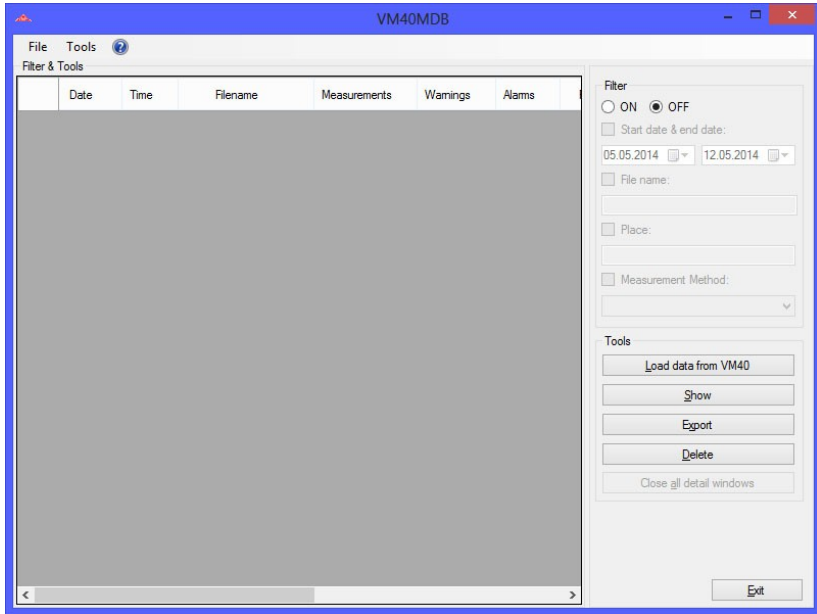
Figure 61: Main window without data

To start the transfer of data from the VM40C to the PC click "Load data from VM40". The software will read header data first. Now you can select the files to be loaded by clicking the check boxes (Figure 62).

Notice: The transmission of data from the VM40C to the PC is not possible while recording is active.

Figure 62: Selection of files

Click "Load selected data" to start the transfer. This may take up to some minutes for larger amounts of data. The progress is indicated above the list of header data.

Figure 63: Imported data

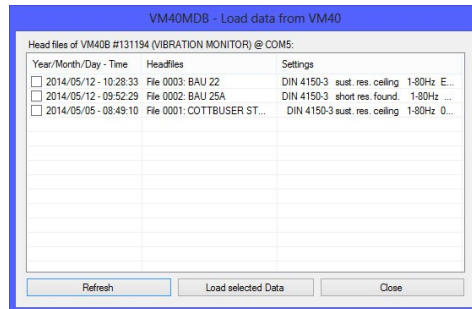VM40MDB can archive all measurements you have ever recorded with the VM40C. They can also come from different VM40C units.

To search in larger amounts of data there are filter functions on the right side of the header list. You may search for a certain range of calendar dates, parts of the file name or the "place" text or for the measurement mode. The wild-card character "*" is allowed.

Select a record with the mouse pointer and click "Show". A window showing "Properties" of the opened file will appear (Figure 64).

Figure 64: File properties

You find the following information:

- Record name which was entered in the VM40C (see page 17)
- Period of recording
- Device name and serial number
- Used standard with detailed settings
- Record settings (triggers and interval)
- Number of saved measurements, warnings and alarms (colored)
- Maximum values for X, Y and Z

You may manually enter a description of the place of measurement, measuring conditions, etc. Two text fields are available for this purpose.

Click "Open protocol" to generate a report to DIN 4150-3, Appendix A. Under several menu tabs the necessary information is gathered (Figure 65). These include:

• Purchaser and person in charge

• Details about the source of vibration

• Description of the monitored structure

• Information about the location and the measuring point

• Environmental and other conditions

• Measuring results to be included
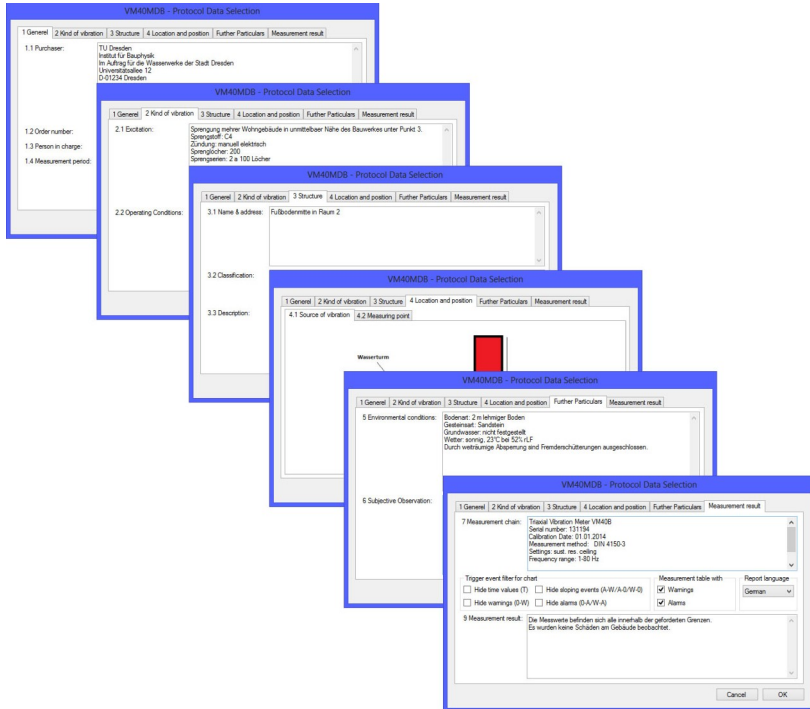
Figure 65: Entering data for the measuring report

In the menu "Location and position" pictures can be entered. Click inside the white space and load the image file from a specified storage position.

Press "OK" to complete the report. Figure 67 shows an example report.

The letter head of the protocol, including company address data and a logo, are entered in the menu "File" / "Settings" of the main window (Figure 66).
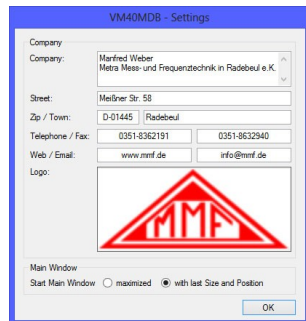

Figure 66: Protocol letter head

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Measurement protocol

1 General

1.1 Purchaser:	TU Dresden
	Institut für Bauphysik
	Im Auftrag für die Wasserwerke der Stadt Dresden
	Universitätsallee 12
	D-01234 Dresden
1.2 Order number:	EK-2014/2348
1.3 Person in charge:	Christian Richter
1.4 Measurement period:	05.05.2014 08:49:10 - 07.05.2014 15:51:26

2 Kind of vibration

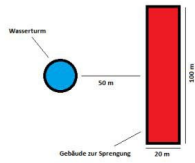|	
2.1 Excitation:	Sprengung mehrer Wohngebäude in unmittelbaer Nähe des Bauwerkes unter Punkt 3.
	Sprengstoff: C4
	Zündung: manuell elektrisch
	Sprenglöcher: 200
	Sprengserien: 2 a 100 Löcher
2.1 Operating conditions:	keine weiteren Erschütterungsquellen im Radius von 1 Kilometer.

3 Structure

3.1 Name and address:	Fußbodenmitte in Raum 2
3.2 Classification:	Baudenkmal nach DIN 4150-3
3.3 Description:	Bauart: Wasserturmgebäude
	Göße: Grundfläche 20m x 20 m / Höhe 30 m
	Gründung: 1889
	Baulicher Zustand: 1992 saniert, keine Schäden erkennbar.

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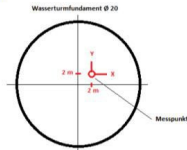
Radebeul, 17.07.2014

4 Location and postion

4.1 Source of vibration

4.2 Measuring point

5 Environmental conditions

Bodenart: 2 m lehmiger Boden
Gesteinsart: Sandstein
Grundwasser: nicht festgestellt
Wetter: sonnig, 23°C bei 52% rLF
Durch weiträumige Absperrung sind Fremderschütterungen ausgeschlossen.

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6 Subjective observations

An der Absperrgrenze (1 km von Sprengung entfernt) waren keine sekundären Nebeneffekte außer der Explosion an sich zu spüren.

7 Measuring chain

Triaxial Vibration Meter VM40B
Serial number: 131194
Calibration Date: 01.01.2014
Measurement method: DIN 4150-3
Settings: sust. res. ceiling
Frequency range: 1-80 Hz
Trigger mode: 005s + events
Measurement processing and report generation done with VM40MDB software.

8 Measurement result

8.1 Event chart
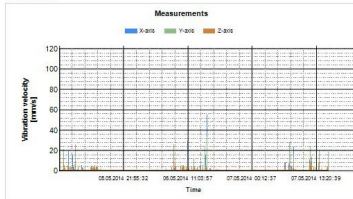
8.2 Single measurements

Date	Time	X-axis [mm/s]	Y-axis [mm/s]	Z-Axis [mm/s]	Frequency [Hz]	Trigger event
05.05.2014	09:35:49	1,79	5,8	1,79	11	Alarm (0-A)
05.05.2014	09:42:49	2,26	6,19	2,11	9	Alarm (0-A)
05.05.2014	10:22:57	4,7	20,47	7,32	9	Alarm (0-A)
05.05.2014	10:32:45	5,18	1,52	1,26	3	Alarm (0-A)
05.05.2014	10:33:51	19,42	4,33	2,46	5	Alarm (0-A)
05.05.2014	11:22:48	9,54	2,13	1,6	11	Alarm (0-A)
05.05.2014	11:22:59	15,62	1,97	1,98	2	Alarm (0-A)

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07.05.2014	12:19:35	0,99	5,77	13,42	11	Alarm (0-A)
07.05.2014	13:19:53	1,68	5,19	2,97	9	Alarm (0-A)
07.05.2014	13:41:33	5,55	8,75	2,97	11	Alarm (0-A)
07.05.2014	13:52:43	7,01	1,18	1,52	10	Alarm (0-A)
07.05.2014	13:53:51	5,44	3,09	2,55	9	Alarm (0-A)
07.05.2014	13:53:59	10,96	20,41	9,22	8	Alarm (0-A)
07.05.2014	15:44:36	8,57	18,34	4,08	2	Alarm (0-A)
07.05.2014	15:44:45	1,3	5,74	5,49	11	Alarm (0-A)
07.05.2014	15:47:31	1,94	6,11	5,04	8	Alarm (0-A)
07.05.2014	15:51:14	97,62	93,31	76,33	3	Alarm (0-A)
07.05.2014	15:51:25	7,84	4,69	1,12	2	Alarm (0-A)

9 Evaluation

Die Messwerte befinden sich alle innerhalb der geforderten Grenzen.
Es wurden keine Schäden am Gebäude beobachtet.

10 Signs

_____ _____
Person in charge & stamp Purchaser

Figure 67: Example report (4 pages)

Apart from the report function you may display the measuring data graphically by selecting the menu tab "Measurement chart" (Figure 68). You will see all measurements in a magnitude/time diagram. Displayed events can be filtered depending on their trigger event. For example, you may want to see alarm events only. By right mouse click axes can be disabled. You may also save the diagram as image or in CSV table format to be further processed in Excel, OpenOffice Calc etc.
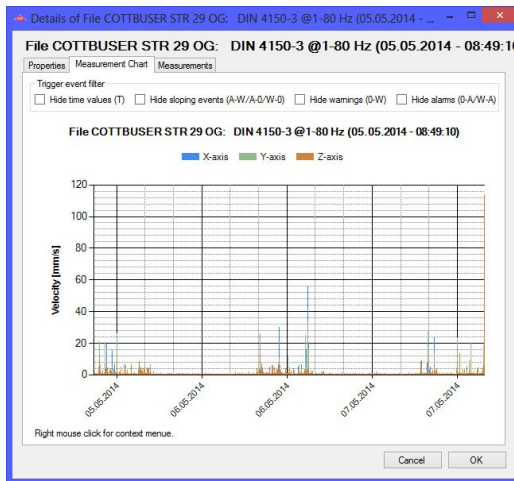

Figure 68: Measuring chart

Select the menu tab "Measurements" to switch to table view (Figure 69). Like in the diagram window you have the possibility to suppress certain kinds of events.

Figure 69: Table view

Notice: The frequency column shows "???" instead of a main frequency if the magnitude was too low to detect a main frequency.

If you click "Export" in the main window you will be asked to select the events to be saved into an export file (Figure 61). Available export formats are text and CSV.
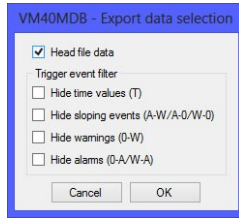

Figure 70: Selecting data for export

Finally, you may use the "Delete" button to erase data files from the VM40C memory.

11. Firmware Update

The device software (firmware) can be updated via the USB interface. First check whether an updated version of the currently installed software is available. This can be found on our website under:

https://mmf.de/en/produkt/vm40c/

There you will see the most recently updated firmware version. The version number is composed of three digits for the hardware and three for the software (hhh.sss). Only the last three digits are relevant for the Firmware.

The currently installed version is displayed on the VM40C start screen.

If firmware with a higher version number is available on the website, please proceed as follows:

1. Download the packed firmware file vm40c.zip from the above named internet address and unpack the contained file vm40c.hex to a folder of your choice Notice: The firmware file vm40c.zip is available in different menu languages.

2. Also download the program "Firmware Updater" from the above named internet address and install it on your PC.

3. Connect the VM40C to the PC using the supplied USB cable and switch it on, by doing this the PC recognizes it as a USB device.
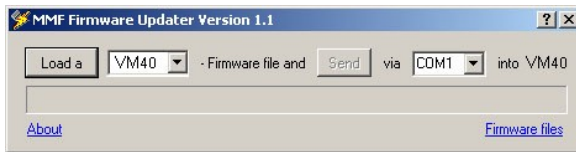
Figure 71: Firmware Updater

4. Start the "Firmware Updater", then select the instrument type "VM40" and the virtual COM port assigned by the PC. If you are not sure which of the available COM ports is correct, you can check in the Windows system control manager located within the device manager.

5. Click on "Load" in the "Firmware Updater" and enter the path to the file where the downloaded firmware file vm40.hex is located.

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6. Within the VM40C "Device settings" select the option "Update firmware" and confirm the subsequent warning by pressing OK (Figure 72). By carrying out this step the old Firmware is deleted. The VM40C will then indicate that it is awaiting new Firmware data from the USB interface ("Waiting for update").


```
FIRMWARE UPDATE

Erase old firmware and
prepare for update?
VM40 will restart and
wait for update via USB!

OK:Yes  F3:Quit
```

Figure 72: Start update

7. Click on "Send" in the "Firmware Updater" and confirm the subsequent hint. Transfer of the firmware data has now begun. The transfer progress is displayed as a time bar on the PC and also on the VM40C. When the update is finished the VM40C will carry out a new start and the "Firmware Updater" will close. Please do not interrupt the update process. After transfer failures the update can be restarted at point 3.

Important: Before starting an update please ensure that the battery is sufficiently charged. Otherwise the update may fail and can only be restored by the manufacturer.

12. Charging the Accumulator

The built-in NiMH accumulator has a capacity of 9 A h, which enables the VM40C to operate independently for more than 15 days. The usage of the mobile phone modem will approximately triple the current consumption and consequently shorten the operation time by two thirds.

NiMH accumulators have a self-discharge rate of 0,5 to 1 % per day.

The charge status is displayed in the top left corner of the display. Shortly after the battery symbol displays empty, the VM40C switches off. The device measures according to the specification until it reaches this state.

To recharge the accumulator please connect the charger provided to the device via the charge socket.

After connecting up the charger you need to switch the device on in order to start the charging process. After a few seconds "Chg" appears in the top left corner of the screen in place of the battery symbol. The accumulator has started charging, only when the "Chg" indicator appears and only while measurements are being displayed. If you open a menu or switch off the device the charging process will be interrupted.

If the accumulator is completely empty it takes approximately 10 hours to be fully recharged.

For longer measurements the charger can remain connected. The charge process will start automatically if the accumulator voltage drops under a minimum value. It is recommended, however, to support the accumulator by connecting a USB supply.

Note: If, after a long period of storage without charging, the battery is completely discharged so that the device can no longer be switched on, proceed as follows: Connect the charger. If the device does not start after this, additionally connect it to a PC or a USB charger via the USB cable. After that, the device should be able to be switched on. Remove the USB cable again. The charging indicator appears in the upper left corner of the display. After deep discharging, it may be necessary to re-connect the charging cable several times if the charging process stops after a few seconds.

13. External Power Supply

For measurements of long duration an external power supply is recommendable.

To operate the VM40C using an external power supply, connect the USB cable provided via the device USB socket. (Figure 73).

To operate the device via a USB power supply you may use a standard USB wall charger with a minimum output current of 1500 mA at 5 V (please check the power rating of the device). If the VM40C is connected via USB, the text "USB" appears on the measurement screen in place of the battery symbol. The internal accumulator then switches off and the VM40C receives its power via the USB connection.

If there is no mains available in the measurement location you can power the VM40C from a USB battery, also called "Power Bank". However, most of the commercially available power banks have an automatic switch-off function below a certain load current what makes them unsuited for powering the VM40C. There are some models with "Always On" feature which are suitable.

A source is https://voltaicsystems.com/always-on-batteries

If the modem is connected the VM40 can be powered externally via the modem connector (see section 9.1).

Notice: The battery charger VM40-CH is not recommended for permanent operation of the VM40C. Measurement can be continued with connected charger but for battery support during measurement a USB power source should be connected (see above).

Figure 73: USB Socket, USB power supply, power bank with Always-On feature

14. Reset

In rare cases the VM40C may not respond to key pressure. You can restart the firmware by pressing the internal reset button. For this purpose the case needs to be opened by unscrewing the four screws of plastic covers and then further four screws which are under the gray plastic parts. Please open the lid carefully.
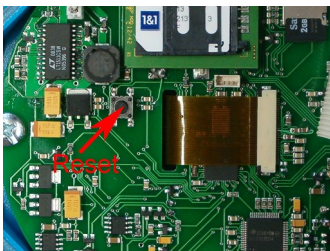

Figure 74: Reset button

Pressing the Rest button does not affect data in the memory. Only time and date need to be readjusted (chapter 8.4).

15. Mounting / Installation

The cast aluminum casing of the VM40C is suitable for direct mounting because of its weight. However, we recommend using the Tripod Floor Plate VM40-BP, available from Metra as a mounting accessory. (Figure 75). The VM40-BP has adjustable feet for aligning the axes, including exchangeable tips for different floor types.

At higher magnitudes the VM40C should be attached by screws. According to SN 640312a, free placement is not allowed at accelerations above 3 m/s². The corresponding velocity is, for example, 24 mm/s at 20 Hz or 12 mm/s at 40 Hz.

For screw attachment the VM40C has four through-holes for screws up to M5 with a maximum head diameter of 8 mm. It is not necessary to open the casing in order to mount the device. Only the two gray plastic panels need to be removed.

Figure 75: VM40C with Tripod Floor Plate VM40-BP

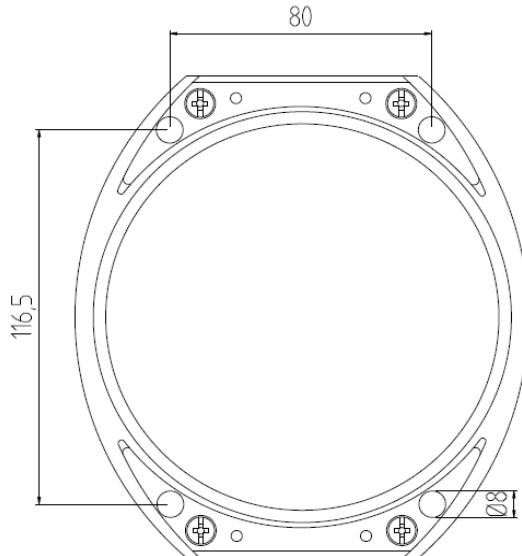Figure 76 shows a dimensional drawing of the mounting holes.

Figure 76: Dimensions of the mounting holes

16. Calibration

A VM40C distinguishing feature of the VM40C is its high long-term stability. Depending on the intensity with which it is used we recommend a recalibration after approximately 1 to 2 years. The month and year of the last calibration are displayed on the start screen.

The calibration is performed through mechanical excitation with known vibration amplitudes.

Due to the weight of the device and the required low frequencies and high amplitudes a particular kind of vibration exciter is needed.

The calibration menu is not accessible to the user in order to avoid manipulation

Metra offers a calibration service, if desired with DAkkS accreditation. For calibrations in other labs we also provide the necessary technical documentation, upon request.

17. Technical Data

Measured value	Peak value of vibration velocity or vibration acceleration
Supported standards	DIN 4150-3; BS 7385; SN 640312a, Circulaire du 23/07/86
Vibration Sensor	Triaxial piezoelectric shear type accelerometer
Display ranges (peak) Vibration acceleration: Vibration velocity:	0.001 – 15 m/s² 0.01 – 2400 mm/s at 1 Hz; 0.01 – 30 mm/s at 80 Hz (full-scale value frequency dependent)
Measurement accuracy	±3 % ±20 digits at reference frequency 16 Hz, 100 Hz low pass ±3 % ±40 digits at reference frequency 16 Hz, 395 Hz low pass
Frequency ranges	0.8- 100 Hz; 0.8 – 395 Hz, 5 – 150 Hz
Display	LCD, b/w, 128 x 64 pixels, back light 3 peak values (X/Y/Z) or vector sum significant frequency 50 lines FFT spectrum battery charge condition; date; time
Alarm signaling	Warning and Alarm LEDs next to the Display Relay output (change-over contact, max. 100 VDC / 2 A)
SMS alarm function (with VM40-MODEM)	SMS transmission at vibration events including X/Y/Z values, frequency, date, time, device name
Measurement value memory	Built-in Micro SD card max. 100 000 measurements (X/Y/Z, frequency, date, time, trigger event)
Analog/digital converter	24 Bit, Sigma-Delta
USB interface	USB 2.0 Full-Speed, CDC mode, via cable VM2x-USB
Accumulator	NiMH, 4.8 V / 9 Ah, charging duration: approx. 10 h; buffered operation without accumulator load by USB power; (e.g. USB mains adapter)
Battery operating life per charge	5 – 15 days, depending on temperature, mobile communication (VM40-MODEM) and display light duration
Menu language	English / German / Italian / French
Operating temperature range	- 20 – 60 °C
Protection grade	IP67
Dimensions	150 mm x 140 mm x 80mm
Weight	2 kg
Accessories included	USB Cable VM40 USB Battery charger VM40-CH
Optional Accessories	Tripod Floor Plate VM40-BP 2G/4G (GSM/LTE) modem VM40-MODEM* Portable battery-powered printer VM40-PRINTER

* For the supported frequency bands see section 9.1

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

According to EMC Directive 2014/30/EC and
UK Electromagnetic Compatibility Regulations 2016

Product: Triaxial Vibration Monitor
Type: VM40C (from Ser. no. 170000)

It is hereby certified that the above mentioned product complies
with the demands pursuant to the following standards:

DIN / BS EN 61326-1: 2013
DIN / BS EN 61010-1: 2011
DIN 45669-1: 2010

The producer is responsible for this declaration

Metra Mess- und Frequenztechnik in Radebeul e.K.

Meißner Str. 58, D-01445 Radebeul

declared by

Michael Weber