Batemika M100

Bridge mA-meter

User manual

Version 1.03.xx

Table of Contents

1 Introductions

Batemika M100 Bridge mA-meter is a specialised device used for the accurate and reliable measurement of excitation currents of all types of resistance bridges used in thermometry. Accurate determination of the excitation current is essential in order to increase the accuracy of the self-heating correction in SPRT measurements.

M100 measurement circuits were specifically designed to be extremely non-intrusive and have negligible effect on bridge operation. This was made possible by reducing the shunt resistance to only 4 Ω, while keeping the input leakage currents to minimum.

M100 features a serial and USB communication interface for connection to a computer, which enable acquisition of measured currents as well as individual ADC samples at up to 60 kHz sampling rate. This enables the visualization of the current waveform and can be used to perform diagnostics of resistance bridge operation.

M100 can measure DC, AC and arbitrary waveform currents with specified accuracy and can handle all types of measurement currents that can be encountered in common thermometry bridges.

M100 has two jumper-selectable measurement ranges, which are in compliance with commonly used measurement currents in thermometry.

M100 has specifically designed connectors, which enable seamless integration of the device in the measurement system. Connectors enable the connection of BNC, banana, spade lug and bare wire cables in four-wire configuration. M100 can be connected either between the resistance bridge and scanner or between the extension cable and SPRT, effectively replacing the passive connection box.

Figure 1: M100 Bridge mA-meter

2 Getting Started

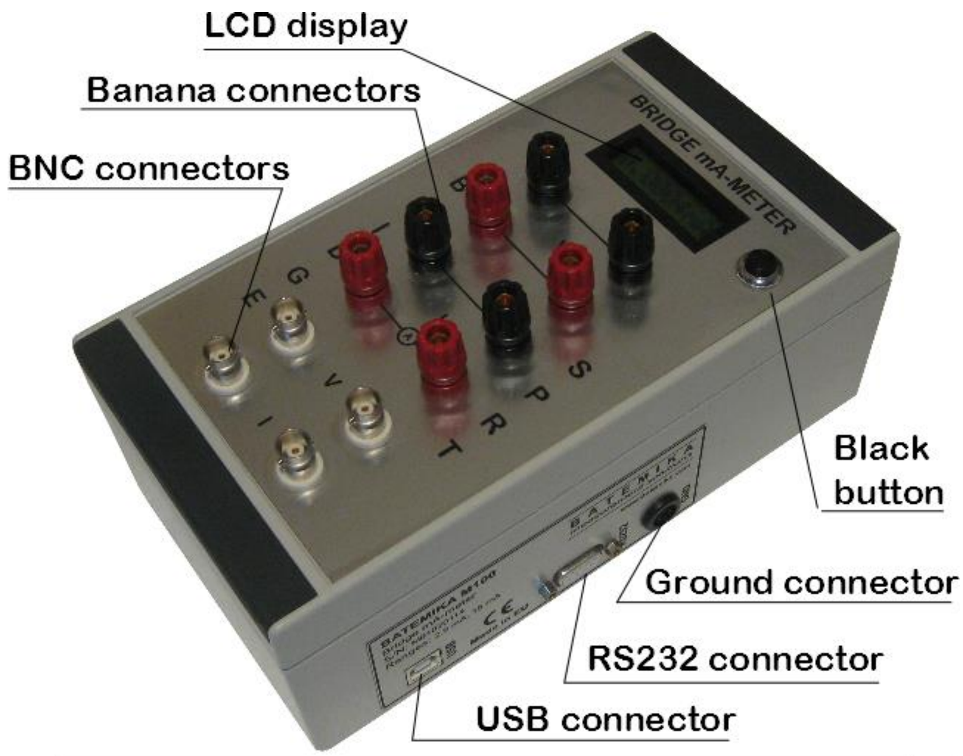
2.1 Warnings and cautions

Use the instrument only as specified in this manual. Keep a copy of this manual for future reference. Besides the general good practice for handling electronic equipment, follow these particular warnings and cautions:

- Read user manual before starting the M100 operation!
- M100 is designed for indoor use only. Prevent the use of instrument in wet or damp conditions, prolonged direct sunshine, vibrations, dust, water vapor, fumes and chemical residues.
- Use and store M100 according to environmental conditions as listed in Specifications.
- When moving the unit from a cold to warm and humid ambient, take measures to prevent condensation on and inside the instrument. If condensation occurs, do not start the instrument. Condensation may damage the instrument or cause drift of calibration values.
- Avoid using the instrument in environments prone to electrostatic discharges (ESD). ESD may disturb the normal operation of the instrument, and may cause permanent damage to electronic components, which may in long term cause instrument failure.
- Prevent electric contact between probes, cable leads and cable shields and the conductors which are electrically energized. This may result in severe shock, personal injury or death, fire hazard and damage to instruments.
- If instrument is damaged, do not use it. Secure the instrument and contact support for further instructions.
- Clean only with a damp cloth. Do not wet or allow water to penetrate the instrument. Do not use chemical solvents to clean the instrument.
- Do not place objects, liquid containers or other instrumentation on top of the M100. Handle the instrument carefully to prevent mechanical damage.
- M100 has two sets of connectors for the connection to the resistance bridge, but they are internally connected and only one should be used at any particular time. Connecting two resistance bridges (one on the banana connectors and the other on BNC connector) will create a short circuit on the bridge inputs and will result in a damaged resistance bridge. Therefore, always use one bridge with one M100 unit.
- M100 has a functional isolation between the connectors and digital interface rated at 1000 V, which prevents any damage from the M100 or remote interface to the connected resistance bridge. However, note that this is only functional isolation and not safety isolation, so voltages above 48 V between any connector or towards ground may result in personal injury, fire hazard and/or damage to equipment.
- M100 must be placed on a stable surface. If the device accidentally falls over, it may pull the cables of the SPRT and damage the SPRT, fixed-point cell, resistance bridge and the M100.
- M100 has a built-in rechargeable LiPo battery with 2000 mAh (7,4 Wh) capacity. Overcharging, puncturing and overheating may cause battery failure, which in extreme cases may result in fire or explosion.
- Changing the measurement range requires the top cover of the device to be removed. Before you do this, always remove all wires from the connectors, remove communication cables and switch off the device.
- M100 can safely handle currents of up to 50 mA, regardless of the selected measurement range. Exceeding this absolute limit may result in a drift of the calibration value or even permanently damaged device.

2.2 Overview

Batemika M100 Bridge mA-meter was specifically designed for straightforward integration in a measurement system for SPRT measurements in primary thermometry. The basic components of M100 are presented in the figure bellow.



2.3 Power supply

M100 is powered via the USB 2.0 interface at 5 V and 500 mA (max). Alternatively, M100 can be powered from the internal rechargeable LiPo battery, which provides approximately 24 hours of standalone operation. LiPo battery is automatically charged when USB interface is connected. LiPo battery will charge to 70% in approximately 4 hours and to full capacity in 16 hours. Charging is active also when the M100 is switched off.

Note that some USB ports may not be able to provide power for one standard USB load. This is a known issue on some portable devices. In this case, use of USB hub with external power supply is recommended.

2.4 Placement

M100 must be placed on a stable surface in order to prevent accidental falling and resulting damage. Use of draft shields is recommended, especially for the DC bridges. Avoid placing the M100 near sources of EMI. Avoid placing the M100 in electrical contact with metallic cases of other equipment, as this may result in ground loops and increased noise and interference.

2.5 Starting and stopping the M100

M100 can be switched on using the black button on the right hand side of the LCD display. After the device is started, the LCD display will briefly show the currently selected measurement mode, measurement range and the battery state of charge. M100 will then start to measure and display the measurement current.

The device can be switched off by pressing and holding the black button until the LCD display shows the *OFF* message. Release the button to complete the switch-off procedure.

In an unlikely case of firmware lockup, the device can be forced to switch off by pressing and holding the black button for more than 10 seconds. This will directly turn off power supplies, without a proper internal shutdown procedure.

M100 can also be switched off using the remote interface with the DX OF command. Note that M100 cannot be started using the remote interface commands.

2.6 USB device drivers

M100 is shipped with a set of USB device drivers, which support Windows XP and later. USB device drivers are located on the installation CD and are also available for download in the Downloads section on www.batemika.com.

After you connect your M100 Bridge mA-Meter using the USB interface to a computer for the first time, Windows will automatically try to search for the appropriate drivers. After the automatic search fails, the Windows will prompt you to locate the drivers. Manually select the location of the USB drivers on the installation CD or local directory. Please note that the driver for Windows XP is different from the drivers for higher versions of Windows, so choose the driver according to your operating system.

After the USB device drivers are successfully installed, the M100 device becomes visible in the Windows Device Manager. You may now start using the M100 with USB communication interface.

After the M100 USB interface is reconnected after successful first installation, Windows will automatically detect and recognize your M100 device and load appropriate drivers, without the need for user intervention.

M100 LabVIEW drivers require NI VISA runtime engine to be installed on target computer. NI VISA runtime engine is part of the M100 Applications installer, but a newer version can be manually downloaded from www.ni.com and installed on your computer.

2.7 Selecting the measurement mode

M100 has two internal measurement modes, which use two different algorithms to calculate the RMS value of the measurement current from the ADC samples.

- Asynchronous mode is using digital filtering to calculate the effective value of the measurement current. This is a very robust method that works with both periodic and non-periodic currents as well as noise signals. The disadvantage is long settling time (approximately 40 seconds). This mode is also less suitable for DC bridges with very slow current reversal rates.
- Synchronous mode is based on the detection of zero pass of signals, which is used to set the integration time to an integer number of signal periods. This mode requires periodic signals. The refresh time depends on the frequency of the signal and can be several tens of seconds for slow DC bridges. This mode is better for DC bridges with slow reversal rates. If the signal is not periodic or its frequency is above 1 kHz, the synchronisation algorithm may fail, resulting in low refresh rate and poor accuracy.

Measurement mode can be selected manually using the black button. If you press and immediately release the black button, the currently selected measurement mode and range are displayed. The letter

A indicates asynchronous mode and the letter S indicates synchronous measurement mode. To change the measurement mode, press and immediately release the black button again. The display will show the new setting. You may continue changing the measurement mode until the desired setting is displayed. To store the new setting, wait until the measurement mode is cleared from the display and the value of measurement current is displayed.

Measurement mode can also be changed using the remote interface command DM AM and DM SM.

Measurement mode is permanently stored in the EEPROM memory, so the setting will be preserved during the device shutdown.

2.8 Selecting the measurement range

M100 has two selectable measurement ranges. The low range is capable of measuring currents with RMS value up to 2,9 mA and the high range is capable of measuring currents with RMS value up to 15 mA. Note that this applies to the AC current with sine waveform. For other waveform shapes, observe the maximum input limits of 4 mA for the low range and 21 mA for the high range. Higher values of measurement current will be truncated and will result in large measurement errors. Exceeding the absolute limit of 50 mA may result in a drift of calibration value or even permanently damaged device.

Currently selected measurement range can be viewed by pressing and immediately releasing the black button. The procedure is the same as for viewing the measurement mode. Note that measurement range cannot be changed using the black button.

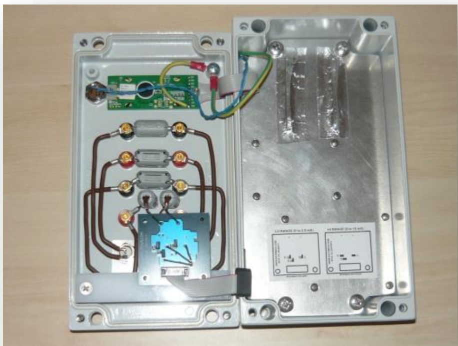
Changing the measurement range requires the change of jumpers under the top cover of the M100. Follow this step-by-step procedure to change the measurement range:

1. Place the M100 on a flat surface (empty table) and disconnect all connecting wires and communication cables. Switch off the device.

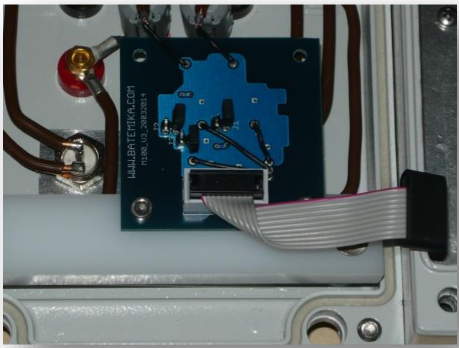
2. Remove the dark-gray plastic protection covers.

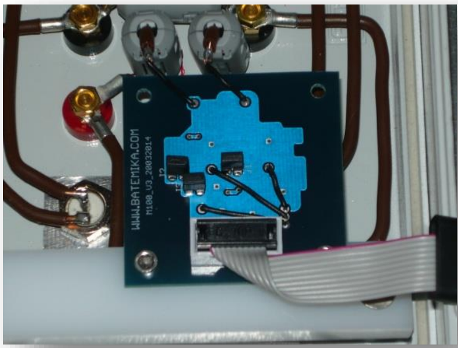
3. Unscrew the four screws in each corner of the top cover.

4. Remove the top cover and slowly roll the cover to the left (like opening a book). Pay attention to the cables.



5. Locate the jumpers J1, J2 and J3 on the small board on the bottom side of the cover. Before handling the jumpers, touch the metal case of M100 to release any static electricity. Place all jumpers in open (vertical) position for low range and closed (horizontal) position for high range. Always put all jumpers in the same position (open or closed).





Jumpers in low-range position

Jumpers in high-range position

6. Close the top cover, tighten the four screws in each corner and put the plastic covers back in place.
7. Start the M100 by pressing the black button. The LCD display will show the selected measurement range.

2.9 Overload conditions

M100 specifies two measurement ranges, which have nominal limits of 2.9 mA and 15 mA. These values apply to the RMS value of the AC current with sine waveform. Actual limits of the input ranges are therefore higher by the factor of √2, approximately 4 mA and 21 mA, respectively. If measurement current increases beyond specified maximum input limits, measured values are truncated at the maximum input limit value and an overload condition occurs. Overload condition is signalled by blinking the LCD display with the "OverLoad" message. Note that a single sample acquired out of input limits is sufficient to trigger overload condition. Overload condition is cleared approximately 5 seconds after the last overloaded sample was detected. Overload condition can be queried over communication interface with the "OL?" command.

The M100 will continue to normally acquire and display measurement current despite the overload condition, but as at least some samples were truncated, the accuracy of the measurement result is compromised.

DC current or square wave current can be measured normally with full accuracy up to the actual maximum input limits. For example, 4 mA DC current can be normally measured on LO range.

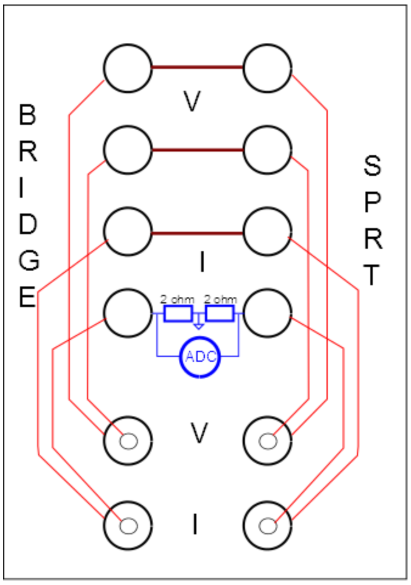
The M100 is capable of withstanding short-term overloads of up to 50 mA, regardless of selected measurement range. Higher currents may result in increased drift or even permanent damage to the device.

3 Connections

M100 connectors were specifically designed for easy connection of all types of resistance bridges and SPRTs.

3.1 Internal connections

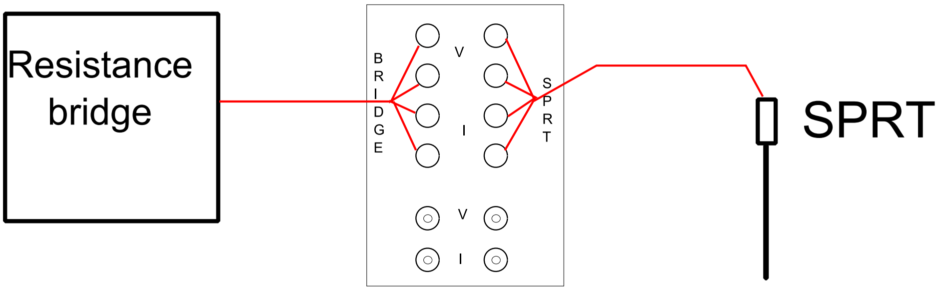
The internal connections are presented in the figure bellow. Note that BNC and banana connectors are not two independent sets of connectors, they are internally connected. The bridge current is measured in one of the current leads, which is marked with the A-meter symbol on the top cover. All other leads are completely passive and just provide means for simple four-wire connection of the SPRT. Note that connections are completely symmetrical and switching the SPRT and BRIDGE side of connections will have no effect on measurements. The SPRT and BRIDGE labels are printed on top cover just for reference.

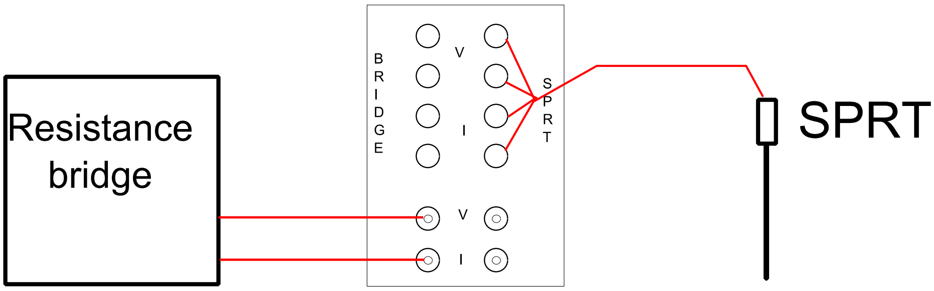


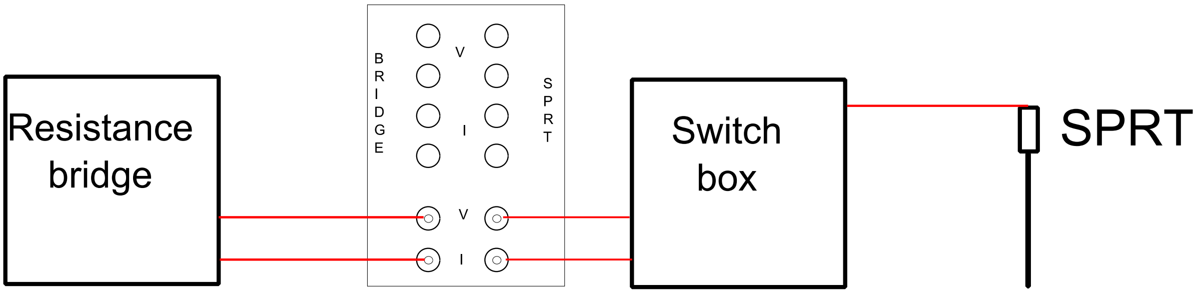
The current lead with the mA-meter circuit has an effective series resistance of 4 Ω. Tests on common thermometry bridges have shown that this resistance value has no observable influence on bridge operation.

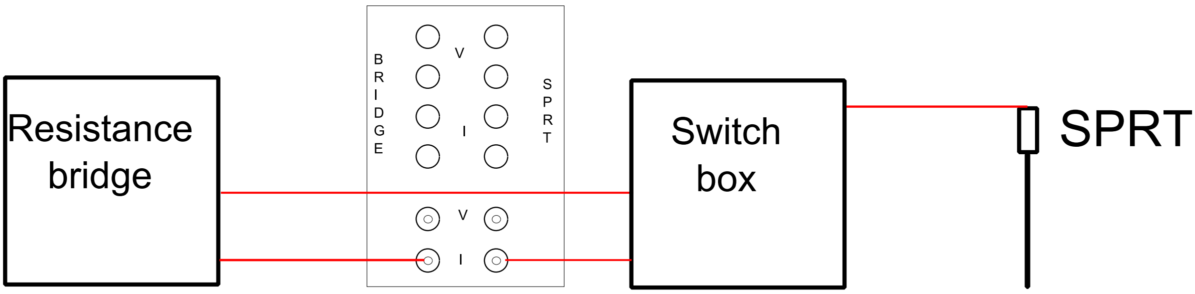
3.2 External connections

Examples of valid measurement connections are presented in figure bellow. The most common approach is to connect the resistance bridge on either banana connectors (common for DC bridges) or BNC connectors (common for AC bridges) and to connect the SPRT to banana connectors. In this case the M100 replaces the passive connection box, which acts as an adapter between extension cables and SPRT. The second approach is to place the M100 between the resistance bridge and scanner. In this case, the current can be measured on any of the SPRT connected to scanner. However, note that the M100 settling time is up to 40 seconds, so faster scanning rates can influence its accuracy. There are several other possibilities, such as connecting the voltage leads directly from resistance to scanner, mixing BNC and banana connector, etc.


Resistance bridge
BRIDGE
V
I
V
I
SPRT
SPRT


Resistance bridge
BRIDGE
V
I
V
I
SPRT
SPRT


Resistance bridge
BRIDGE
V
I
V
I
SPRT
Switch box
SPRT


Resistance bridge
BRIDGE
V
I
V
I
SPRT
Switch box
SPRT

3.3 Ground connection

M100 can operate in grounded or floating mode. Floating mode is only possible when operating from battery power and no communication interfaces are connected. In grounded mode, the digital board and the metallic chassis are electrically connected to ground potential via RS232 or USB communication interface or the dedicated ground connector.

The theoretical advantage of operating in grounded mode is the increased level of EMI (electromagnetic interference) protection. The metal chassis acts as a Faraday shield and should be grounded for best performance. If not grounded, the metal chassis can act as a receiving antenna for radiated EMI. Also, grounding the digital board sets the board potential, which can otherwise pick up static electricity.

The theoretical advantage of operating in floating mode is the decreased leakage current. Leakage current is the electrical current that flows from the current leads to analogue board and leaks to digital board and ground. As the analogue and digital board are galvanically isolated, the leakage current can only pass through parasitic capacitance and the EMI suppression capacitor. The total capacitance between the analogue and digital board is approximately 500 pF. This value is comparable to a parasitic capacitance of a few tens of meters of extension cable. Note that resistance bridges are to a large extent capable of compensating the capacitive leakage current, so the influence on measurement results should be minimal.

Initial evaluations showed that for a MI 6010 DC bridge there was no observable influence in both floating and grounded mode, while for the ASL F900 AC bridge the influence was significantly smaller in grounded mode. Refer to the Batemika M100 evaluation report for more details.

The recommended approach is to make a brief evaluation for a particular bridge by comparing results of different configurations to the reference laboratory setup, but the recommended operating mode is the grounded mode. The grounded mode is especially recommended in conditions of very low relative humidity, where static electricity may develop or in environments with high levels of radiated EMI, which could propagate through M100 and influence bridge operation.

4 M100 Calibration and adjustment

Calibration of the M100 bridge mA-meter consists of adjusting the offset and gain calibration constants. Note that for the purpose of self-heating correction, the only relevant quantity is current ratio and in this case the gain error is irrelevant. Offset error is typically irrelevant for AC bridges and has a small influence for DC bridges. When adjustment is performed, always perform the offset adjustment first and then proceed with gain adjustment. Note that changing the offset calibration constant will not invalidate the gain calibration constant.

Offset and gain calibration constants are adjusted separately for the low and high measurement range. Note that only the calibration constants for the currently selected measurement range are accessible. To access the other pair of calibration constants, change the measurement range by setting the range jumpers.

4.1 Offset adjustment

Offset is the parasitic DC value that is present in the measurement result when no inputs are connected. Note that offset may change with temperature, aging and other operating parameters. It is recommended that offset is checked and adjusted in regular intervals.

Offset adjustment is simple and requires no additional instruments. Follow this step-by-step procedure:

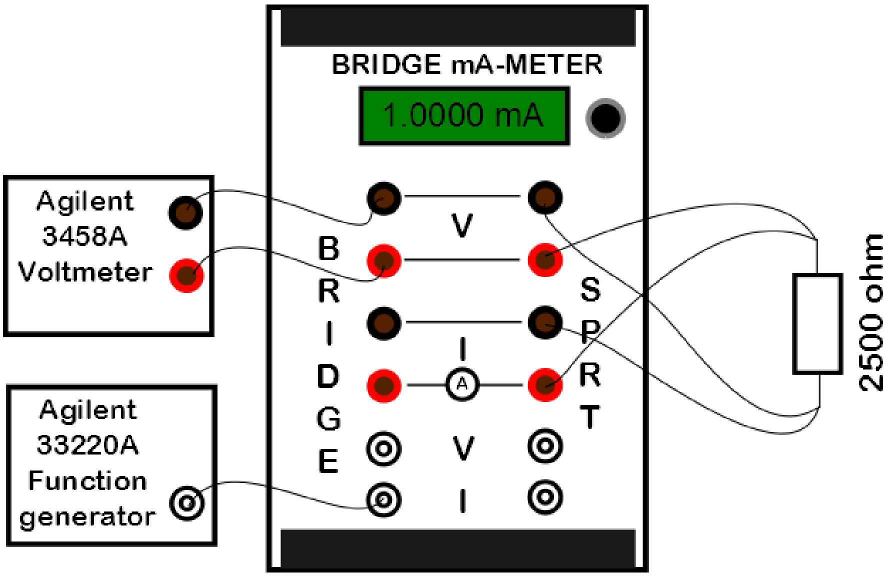
1. Disconnect all cables from the input connectors. The M100 LCD display should show the base noise level of approximately 0,4 µA for low range and 1,4 µA for high range
2. Connect the USB interface to a computer
3. Start the *M100 Readjustment* application and select the *Offset Calibration* tab. Click the Start Acquisition button. This application will continuously read samples from the M100 ADC and calculate the DC offset and new offset calibration constant. If offset exceeds 1 LSB (least significant bit of ADC resolution, equivalent to 0,03 µA for low range and 0,15 µA for high range), you may choose to apply the new calibration constant, which is permanently stored in the M100 EEPROM memory.
4. Click the Apply correction button to apply the currently measured offset correction or Stop Acquisition button to stop the offset calibration procedure

4.2 Gain adjustment

Gain represents the ratio between the measurement current in mA and ADC samples. Gain may be affected by the drift in internal reference resistors and voltage reference. As the gain has no direct influence on the accuracy of the self-heating correction and gain adjustment is not so straightforward, gain adjustment doesn’t have to be performed regularly.

Gain adjustment requires the accurate measurement of the reference value of the measurement current. Note that M100 is using the same range for DC and AC currents and the AC/DC transfer error is within the specified M100 accuracy, so the gain adjustment can be performed either with a DC or AC current. DC current measurement is simpler and more accurate, so this is the recommended method. If you are using the DC current, make sure you perform the measurement with both the positive and negative current in order to suppress any offset voltages.

The recommended measurement circuit for DC adjustment is presented in figure bellow. This method uses the indirect current measurement by measuring the voltage drop over a reference resistor with known resistance. Refer to the Batemika M100 Evaluation Report for more information and uncertainty analysis for this method. Note that this is only one possible approach for measuring the reference value of the current, other approaches including direct current measurement are also acceptable.



The recommended method for AC adjustment is the direct current measurement, where a current source (function generator), M100 and reference A-meter (Agilent 3458A) are connected in series.

The gain adjustment can be performed using the *M100 Readjustment* application. Select the *Gain Calibration* tab and start the application. The reference value of the current must be input manually in the application. The application then reads the measured value of current from M100 and calculates the new gain calibration constant. If the gain calibration constant is different than currently used gain calibration constant, you may choose to permanently store the new value in M100 EEPROM memory.

4.3 Manual adjustment

Offset and gain calibration constants can also be set manually, without using the calibration procedures in the *M100 Readjustment* application. This is especially useful if calibration procedure was not successful and you would like to restore factory default settings. Start the *M100 Readjustment* application and select the *Settings* tab. Click the *Manually Set Offset Correction* button *or Manually Set Gain Correction Button* to manually input and store offset and gain corrections.

5 Remote interface

Remote interface can be used to control the device from a computer using the RS232 or USB interface. Remote interface operation has no effect on the device measurement capabilities and both interfaces can be accessed independently at maximum supported speed.

5.1 RS232 interface

RS232 is a low-speed serial communication protocol, popular in measurement devices due to its simplicity, robustness and reliability.

RS232 protocol settings:

- Odd parity
- 8 data bits
- 1 stop bit
- Baud rate is software selectable (300, 600, 1200, 4800, 9600, 19200 or 38400)

Connection cable is a straight (not crossed) cable, also known as extension cable. Note that only pins 2, 3 and 5 are internally connected. Note that GND connection effectively connects the computer ground and the device digital ground. Use of dedicated cable with proper shielding and reasonable length is recommended. If a long cable is required, only three lines (2, 3 and 5) are required, but in this case the influence of non-standard cables on bridge operation must be re-evaluated.

Table 1: RS232 cable connection

Computer	Device	Function
1	1	Not connected
2	2	Transmit data from device to computer
3	3	Transmit data from computer to device
4	4	Not connected
5	5	GND
6	6	Not connected
7	7	Not connected
8	8	Not connected
9	9	Not connected

5.2 USB interface

USB interface is a fast and reliable communication protocol, readily available on most personal computers. USB interface is compatible with USB 2.0 standard and implements Full speed communication (12 Mbits/s).

For the USB interface it is recommended to use the LabVIEW drivers provided by manufacturer. These drivers internally implement the USB protocol, so the user can directly write and read message from the device.

In case the user chooses to implement the USB driver in another programming language, use the following protocol parameters:

- Vendor ID: 0x03EB
- Product ID: 0xC148
- Manufacturer name: BATEMIKA
- Model name: BRIDGE mA-METER

- Serial number: unique for each device (for example "mA-meter M01020114")
- Transfer type: bulk transfer on endpoint 1

Connection cable must be a dedicated double screened USB 2.0 compatible cable with standard 'A' plug on computer side and standard 'B' plug on device side. Use of ferrite cores on the connection cable is recommended. Never use unshielded USB 1.1 compatible cables or cables exceeding 3 meters in length.

USB remote interface requires device driver installation after the device is connected to the computer for the first time. Use the *.inf file provided by the manufacturer to install support for LabVIEW drivers.

5.3 Command set

Commands are identical for RS232 and USB interface. Command structure of the device remote interface constructed of a command message that is sent from the computer to the device and the response message that is sent from the device to the computer. Messages are case sensitive, only upper case letters must be used. Each message is terminated with a linefeed (LF) character with ASCII code 10. Termination character is not shown in the command descriptions. Messages have fixed structure and parameter length, so parsing messages by fixed indexes is possible.

Each response message starts with two status characters. 'OK' status indicates that the command was executed correctly, while the 'E1', 'E2' or 'E3' messages indicate command errors.

5.3.1 "B?" Get battery level

"B" command queries the internal battery state of charge, voltage and state of external power supply.

Command message: B?

Response message: *<Status> StateOfCharge, Voltage, ExternalPowerSupply*

Example:
```
B?
OK077.16, 4.0137, 1
```

5.3.2 "CP" Unlock calibration password

"CP" command enters the calibration password, which enables the setting of gain and offset calibration constants in the next command. Calibration password is valid for one "CG" or CO" command execution only and it is reset after the "CG" or CO" is executed. Calibration password is fixed and cannot be changed.

Command message: CP *CalibrationPassword*

Response message: *<Status>*

Example:
```
CP 23883
OK
```

5.3.3 "CG?" Get gain calibration constant

"CG?" command queries the gain calibration constant for the currently selected measurement range.

Command message: CG?

Response message: *<Status> GainCalibrationConstant*

Example:
```
CG?
OK41046
```

5.3.4 "CG" Set gain calibration constant

"CG" command seta the gain calibration constant for the currently selected measurement range. This value is permanently stored in the internal EEPROM. Note that EEPROM has a limited number of write cycles, so use this command with caution.

This command is password protected. Use the "CP" command to unlock the password first and then execute the "CG" command.

Command message: CG *GainCalibrationConstant*
Response message: <*Status*>
Example:
```
CG 41046
OK
```

5.3.5 "CO?" Get offset calibration constant

"CO?" command queries the offset calibration constant for the currently selected measurement range.

Command message: CO?
Response message: <*Status*> *OffsetCalibrationConstant*
Example:
```
CO?
OK-005
```

5.3.6 "CO" Set offset calibration constant

"CO" command sets the offset calibration constant for the currently selected measurement range. This value is permanently stored in the internal EEPROM. Note that EEPROM has a limited number of write cycles, so use this command with caution.

This command is password protected. Use the "CP" command to unlock the password first and then execute the "CO" command.

Command message: CO *OffsetCalibrationConstant*
Response message: <*Status*>
Example:
```
CO -005
OK
```

5.3.7 "DM?" Get measurement mode

"DM?" command queries the currently selected measurement mode. Measurement mode can be either asynchronous mode (AM) or synchronous mode (SM).

Command message: CM?
Response message: <*Status*> *MeasurementMode*
Example:
```
DM?
OKAM
```

5.3.8 "DM" Set measurement mode

"DM" command sets the measurement mode. Measurement mode can be either asynchronous mode (AM) or synchronous mode (SM).

Command message: DM *MeasurementMode*
Response message: <*Status*>
Example:
```
DM SM
OK
```

5.3.9 "DB?" Get currently selected baud rate

"DB?" command queries the currently selected baud rate for RS232 communication. Note that this parameter can be queried and/or set via USB interface, so guessing the baud rate via RS232 is avoided. Available baud rate settings are:

Setting	Baud rate
B0	300
B1	600
B2	1200

B3	2400
B4	4800
B5	9600
B6	19200
B7	38400

Command message: DB?
Response message: *<Status> BaudRateSetting*
Example:
```
DB?
OKB7
```

5.3.10 "DB" Set measurement mode

"DM" command sets queries the currently selected baud rate for RS232 communication. This value is permanently stored in the internal EEPROM. Note that EEPROM has a limited number of write cycles, so use this command with caution. If you are experiencing communication errors via RS232, lower the baud rate. 9600 bauds will work on most systems. The supplied cable (2 meters) supports also the top speed of 38400 bauds. The new baud rate setting will come into effect when you restart the device.

Command message: DB *BaudRateSetting*
Response message: *<Status>*
Example:
```
DB B6
OK
```

5.3.11 "DR?" Get measurement range

"DR?" command queries the currently selected measurement range. Note that measurement range can only be selected using the jumper selection within the device. Measurement range can be either low range (LO , 0 to 2,9 mA) or high range (HI, 0 to 15 mA).

Command message: DR?
Response message: *<Status> MeasurementRange*
Example:
```
DR?
OKLO
```

5.3.12"DS" Set digitizer mode

"DS" command starts the digitizer mode. In the digitizer mode, all acquired samples from the ADC are streamed directly to computer via the USB interface. Digitizer mode parameter can be either "ON" or "OF". Note that sending any additional command over the USB interface will immediately stop digitizer mode and will have the same effect as "DS OF" command

Command message: DS *DigitizerMode*
Response message: *<Status>*
Example:
```
DS ON
OK
```

5.3.13 "DF" set sampling frequency

"DF" command sets the sampling frequency of the ADC converter. Note that the default sampling frequency of 50 kHz (0480 setting) is the optimized value and that device calibration is valid only at this sampling frequency. Changing the sampling frequency is recommended only for advanced testing procedures in digitizer mode. Sampling frequency parameter is not stored permanently and will be restored to default value at next restart of the device. Sampling frequency is entered as sampling period and can be calculated as *SamplingPeriod* = 24000000/*SamplingFrequency*. Valid range of sampling period is 0400 (60 kHz) to 4800 (5 kHz).

Command message: DF *SamplingPeriod*

Response message: <*Status*>

Example:
```
DF 0400
OK
```

5.3.14 "DU" Set upgrade mode

"DU" command sets the upgrade flag, which will cause the device to enter the Upgrade mode during the next boot procedure of the device. In upgrade mode, device firmware can be upgraded via the RS232 interface.

Command message: DU ON

Response message: <*Status*>

Example:
```
DU ON
OK
```

5.3.15 "DX" Shut down

"DX" command starts the shutdown procedure, which stops the measurements and shuts down all power supplies of the device. Note that the device cannot be restarted using the remote interface, restarting requires manual intervention.

Command message: DX OF

Response message: <*Status*>

Example:
```
DX OF
OK
```

5.3.16 "DL" Turn of the LCD display

"DL" command enables or disables the power supply of the LCD display on the device. The measurement resumes normally and results can be retrieved via communication interface. Disabling the power supply reduces power consumption, processor workload and internal EMI. All these effects usually have an influence below the level of detection, so this command is normally used only for diagnostics purposes. Display status can be either ON or OF. After the device restart, LCD display is always enabled.

Command message: DL *DisplayStatus*

Response message: <*Status*>

Example:
```
DL OF
OK
```

5.3.17"I?" identify string

"I?" command queries the device for the identification string.

Command message: I?

Response message: <*Status*>*IdentificationString*

Example:
```
I?
OKBatemika, M100
```

5.3.18 "IV?" get firmware version

"IV?" command queries the device for the firmware version string.

Command message: IV?

Response message: <*Status*>*FirmwareVersionString*

Example:
```
IV?
OK1.02.02
```

5.3.19 "IS?" get serial number

"IS?" command queries the device for the serial number string.

Command message: IS?

Response message: *<Status>SerialNumberString*

Example:
```
IS?
OK1.02.02
```

5.3.20 "M?" get current measurement

"M?" command queries the device for the last value of the measurement current. Note that the resolution of the current measurement via remote interface has two additional digits when compared to LCD display.

Command message: M?

Response message: *<Status>CurrentMeasurement*

Example:
```
M?
OK1.000438
```

5.3.21"OL?" get overload status

"OL?" command queries the device for the overload status of acquired samples. Overload status is signalling if any recent samples were out of measurement range and were therefore truncated to the measurement limit. Note that a single overloaded sample will switch on the overload status, so in some cases overload status may be caused by spurious spikes or ESD events. Overload status may be signalled even if the RMS value is bellow the range limit. Overload status is cleared after the overload condition is absent for approximately 5 seconds. Command returns "0" if there are no recent overloaded samples and "1" if at least one overloaded sample was detected in the past 5 seconds.

Command message: OL?

Response message: *<Status>OverLoadStatus*

Example:
```
OL?
OK1
```

6 Digitizer mode

Digitizer mode enables the M100 to send all samples acquired by the M100 ADC to the computer where they can be analysed. Refer to the M100 Analyser application for an example of digitizer mode usage.

Digitizer mode can be started using the DS ON command via the remote interface. After this command is issued, further communication via USB interface is not possible. M100 immediately starts to send packages of 1023 bytes of data over USB interface. Each package consists of 339 samples, the package index and the M100 current measurement.

Each sample consists of 3 bytes with least significant byte first. As the ADC has 18 bit resolution, the least significant byte is padded with zeros on six least significant bits.

Package index is a consecutive sample number that identifies each package. Consecutive package indexes must differ by exactly 339 samples, otherwise a package was lost in communication.

M100 measurement current is the current value that is calculated by M100 and displayed in LCD display. The value consists of three bytes. The second and third bytes represent the measurement current divided by the display resolution for the selected measurement range. The first byte is the fractional part of this measurement current. For example:

1,012345 mA / 0,0001 mA = (39 * 256 + 139 + 115/256) -> 115, 139 , 39

Digitizer mode can be stopped using the DS OF command or by sending any command via USB remote interface. Note that sending of other commands via RS232 interface can be performed normally in digitizer mode.

7 M100 Applications

M100 Applications is a software package consisting of five applications for interfacing with your M100 Bridge mA-Meter.

M100 Applications installation is available for free-of-charge download at www.batemika.com. Please note that M100 Applications software is regularly upgraded with new features, so check our website News section. If you have a bug report or an idea for a new feature, contact us at info@batemika.com and we will consider implementing your suggestions in the new version.

M100 Applications includes also the Firmware Upgrade application, which performs the upgrade of the firmware inside your UT-ONE thermometer readout. After installing a new version of the M100 Applications, it is strongly recommended that you upgrade the firmware before using other applications. Unless otherwise noted, firmware upgrade will not affect your calibration history.

This software is licensed for use with M100 thermometer readout. LabVIEW source code for selected applications is available on request for qualified customers.

M100 Applications starts with the launch panel, which enables the launching of individual applications. Please note that the only one of the M100 applications can be active at the same time, otherwise communication collisions will occur.

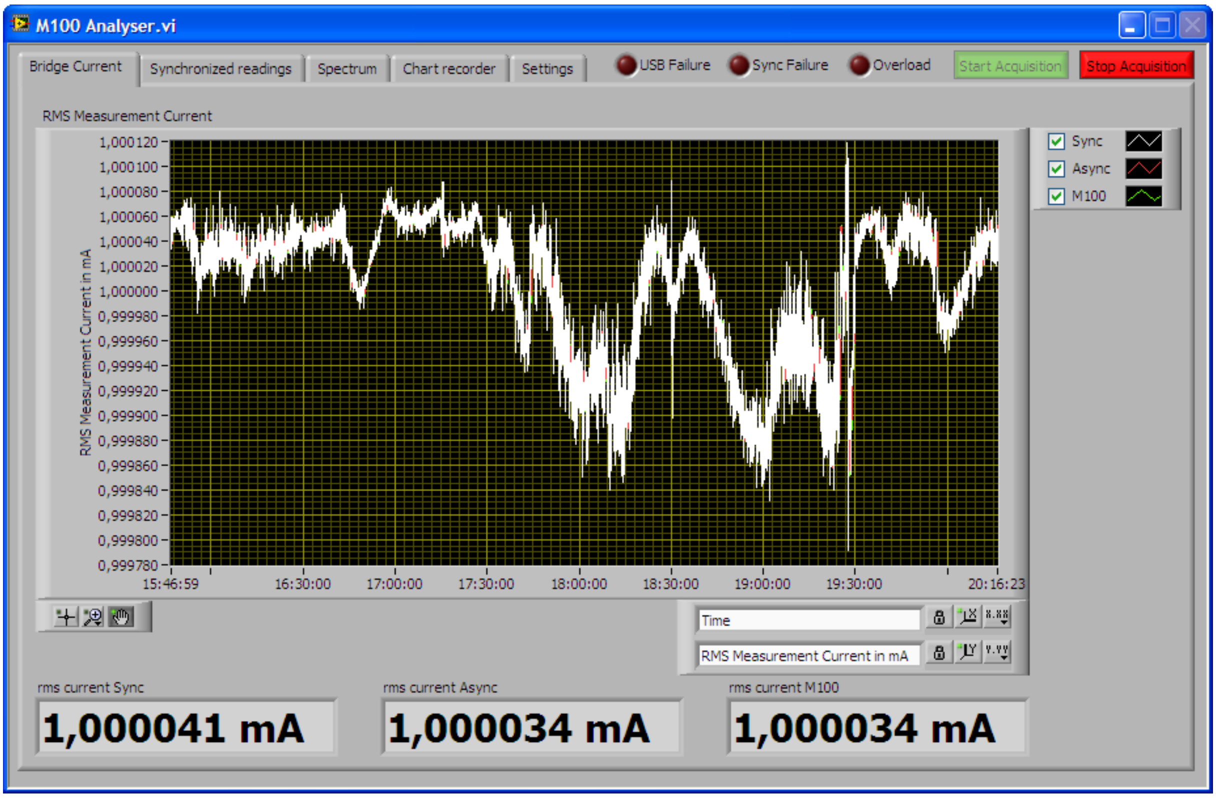
7.1 M100 Analyser

M100 Analyser is a support application which acquires samples from M100 ADC in digitizer mode and displays them on graphs. This application is useful for simple monitoring of the measurement current value as well as for the analysis of the measurement current shape and spectral analysis. These analyses are especially useful for the investigation of EMI and noise problems. In case there is a problem with bridge operation, M100 Analyser application can be used to record the measurement current in order to provide diagnostics and help locate the source of the problem.

M100 Analyser application requires the use of USB remote interface. RS232 interface does not provide sufficient speed for the operation in digitizer mode.

In the Bridge Current tab you can observe the value of the measurement current on the graph and on three large numeric indicators. Measurement current is calculated in application from acquired samples using the synchronous and asynchronous methods and acquired from M100 as calculated by its firmware using the currently selected measurement mode.

Acquisition is started using the Start Acquisition button and stopped using the Stop Acquisition button. If the Start Acquisition button is disabled, the connection to the M100 device was not successfully established. Check the connection cable and device, as well as parameters on the Settings tab.



The USB Failure indicator indicates that there was a failure during the transfer of samples via USB remote interface and that the results may be invalid. If USB failure occurs frequently, this is normally an indication that the computer is unable to process all data. Stop any USB devices, such as USB cameras, USB memory devices, USB printers, etc. Stop any other computation-intensive applications. Use a computer with a multi-core processor and at least 2 Gb of RAM.

The Sync Failure indicator indicates that the algorithm for zero-pass detection has failed to find the periodic signal. The accuracy of the synchronous method may be decreased. Sync failure usually occurs if there is no signal connected to the input connectors or if the frequency of the input signal is too high. You may click on the Sync Failure indicator or use the popup menu to force the synchronization event.

This will use the existing acquired samples and process them in the same way as if synchronization was successful. This is useful for displaying readings or spectrum of non periodic signals.

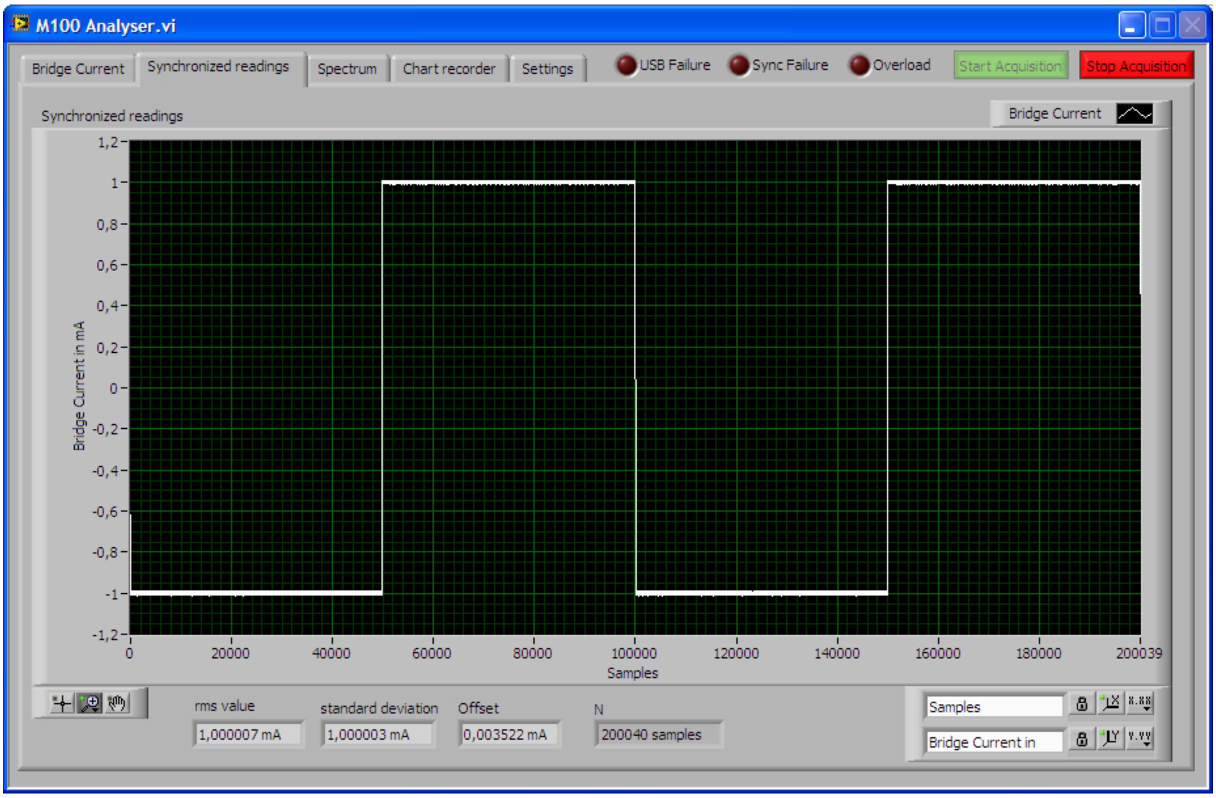
The Overload indicator indicates that at least some of the acquired readings are out of range. The Overload indicator is automatically cleared 5 seconds after the overload condition is no longer present.

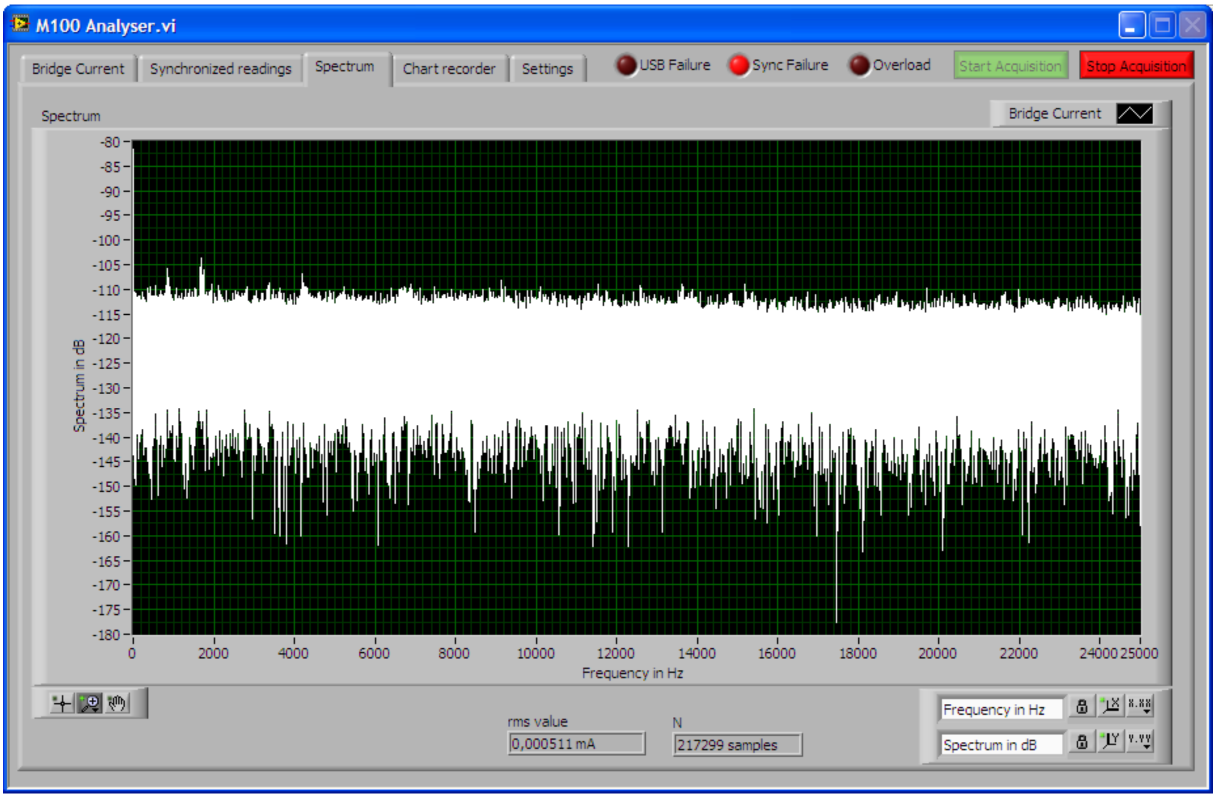
The data presented on graphs can be stored to measurement files using the commands on the graph popup menu. Note that all commands are not available for each of the graphs. Data can be stored in binary or text format. Binary format is intended primarily for reloading of captured data within the M100 Analyser application. Text format can be read directly in a text editor such as Notepad, or it can be imported in other applications (such as Excel or Matlab) for further analyses. Data in text files cannot be reloaded to M100 Analyser application. Note that measurement files can amount to several tens of Mb. Graph popup menu has the following menu commands:

- Save all to bin file will save all data on the graph to a binary file specified by the user.
- Save selection to bin file will save the data on the graph that is selected using the cursors in binary file. This command is available only for graphs with enabled cursors.
- Load from bin file will load the data from a previously saved bin file. Any existing data on the graph will be overwritten.
- Export all to text file will save all data on the graph to a text file.
- Export selection to text file will save the data on the graph that is selected using the cursors in text file. This command is available only for graphs with enabled cursors.

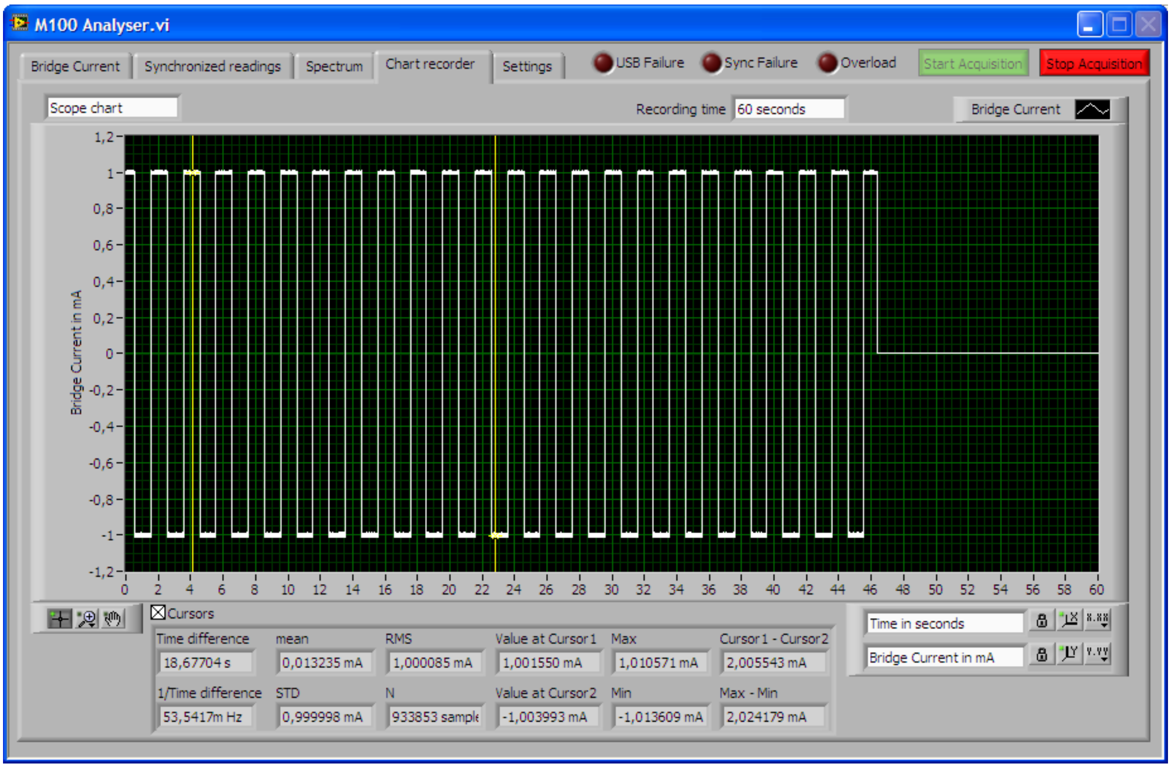
The Synchronized readings tab displays the graph with the current waveform shape. If algorithm for zero-pass detection was successful, a specified number of current periods will be displayed

If synchronization is not successful, you may click the Sync Failure indicator to override the algorithm for zero-pass detection and display all readings acquired so far and also calculate the measurement current using the synchronous method.





The Spectrum tab displays the spectrum calculated using the Fourier transformations. This spectrum can be used to detect undesired spectral components originating from EMI.



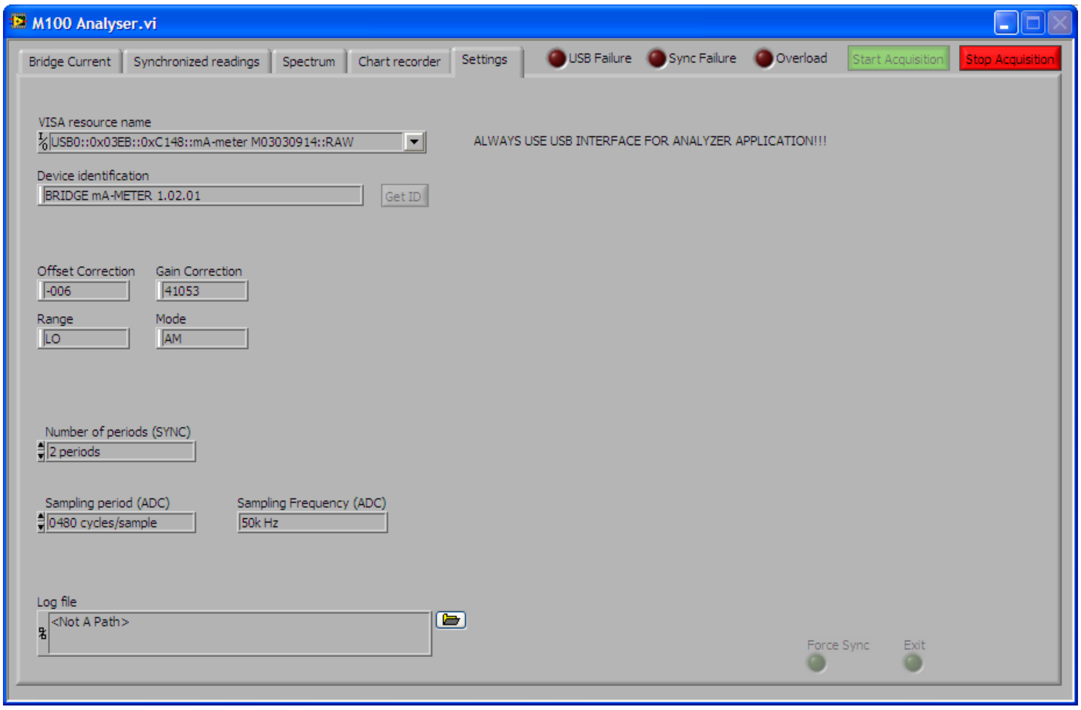
The Chart recorder tab is used to record long sequences of sampled measurement current. This tool is especially useful for diagnostics of resistance bridge problems and observation/evaluation of phenomena at particular conditions, such as the change of measurement channel on the scanner.

The length of recorded data is limited to 15 million samples, which is equivalent to 300 seconds at 50 kHz sampling frequency. You may decrease the sampling frequency by increasing the Sampling period parameter on the Settings tab to increase the maximum recording time. Recording time can be set in the Recording time input control. Recording time can be set with 10 seconds resolution.

The initial state of the chart recorder is Idle, and in this state no recording is occurring. Recording is started by selecting one of the other recording states:

- Single shot recording state will record one set of data with specified recording time and return to idle recording state.
- Scope chart recording state will records a set of data with specified recording time and when it is completed, it will clear the existing data and restart the recording.
- Sweep chart recording state will continuously record and overwrite data on the graph, without clearing the existing data.

The Cursors checkbox can be used to display cursors, which specify the interval of samples for calculation of statistical parameters. Note that this is a very computational intensive operation and should be avoided on low-performance computers.



The Settings tab can be used to specify the VISA resource name for the USB remote interface. Note that the use of RS232 interface is not supported in this application. The application displays the parameters from M100, including gain and calibration constants, measurement range and measurement mode.

The application will store the last selected VISA resource name and at next start, it will try to reconnect using the same resource name. If connection is successful, device identification is displayed and Start Acquisition button is enabled. If connection is not successful, Settings is automatically selected and Get ID button starts blinking. Check and select the correct VISA resource name and/or click the Get ID button to retry to connect.

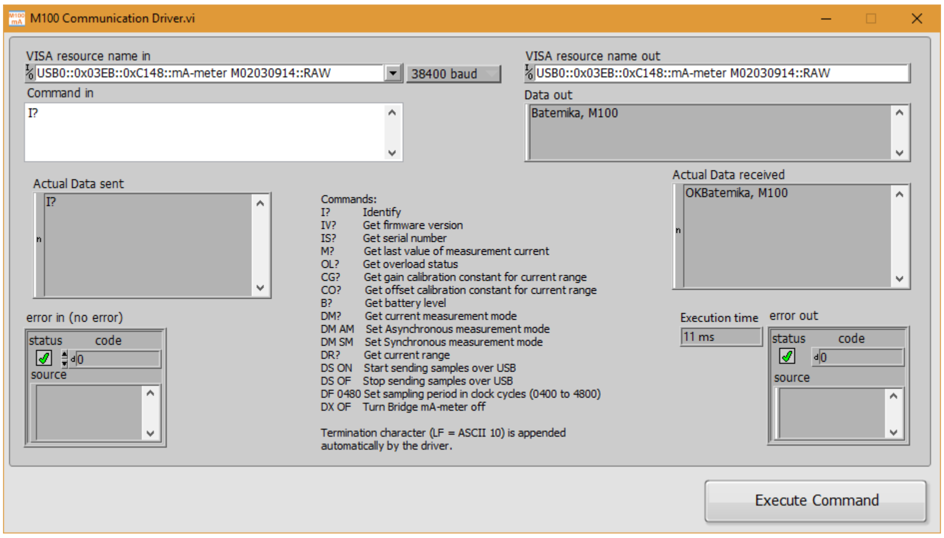
The user may specify the number of periods that will be used in the calculation of synchronous method and for the display on waveform and spectrum graphs. Note that the algorithm may override this setting if a low or high timeout occurs.

The user may also specify the sampling period of the ADC converter, which is translated directly to sampling frequency. This parameter must be set before acquisition is started with Start Acquisition button. Sampling period is specified in clock cycles, where one clock cycle is 1/24 μs. Note that the default setting is 480 cycles per sample, which translates to 50 kHz sampling frequency. Sampling period can be set from 400 to 4800 cycles per sample (60 kHz to 5 kHz sampling frequency). Note that sampling period is not permanently stored within M100 and will reset to default during next startup.

7.2 M100 Communication driver

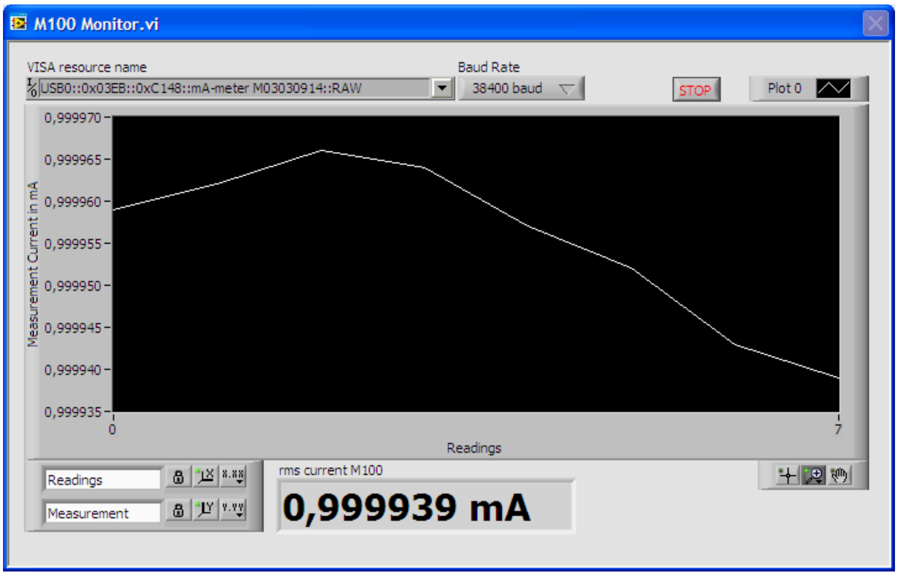
M100 Communication driver is a sample application that is primarily intended for testing the communication protocol and for integration in user applications. The driver supports both the RS232 and USB remote interface. For the USB remote interface, select the USB VISA resource name from the dropdown list. For RS232 remote interface, manually type the interface name (COM1, COM2, etc). The command message is entered in the *Command in* box. Note that the termination character (LF) is appended automatically. The command response can be read in the *Data out* box.

This application internally directly interfaces to the *AVR Simple driver.vi*, which is the basic LabVIEW communication driver for all Batemika products with USB, serial or GPIB interface.



7.3 M100 Monitor

M100 Monitor is a very simple sample application which uses *M100 Measurement Driver.vi* to acquire current and display it on a chart. This application can be used by users as a template for creating more sophisticated monitoring applications.

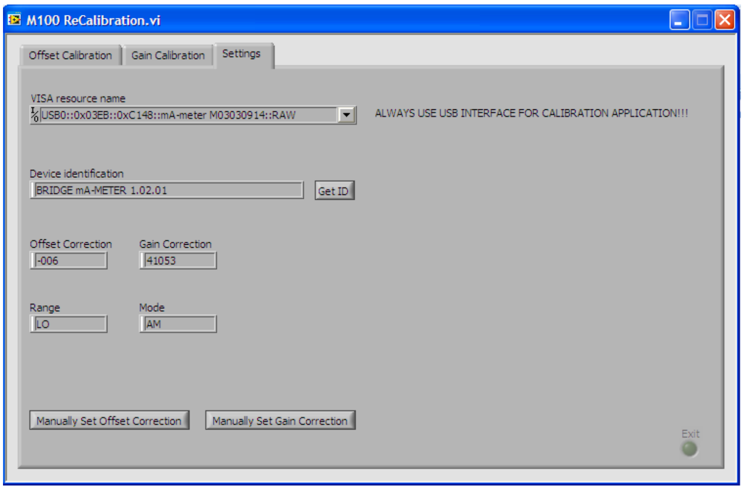


7.4 M100 Readjustment application

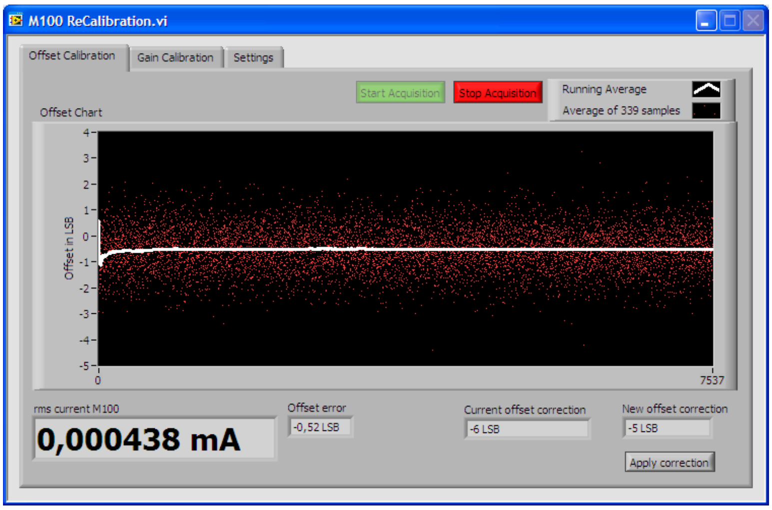
M100 Readjustment application is a support application which simplifies the measurement, calculation and storage of offset and gain calibration constants. Refer to *M100 Calibration and Adjustment* chapter for more information on adjustment procedure.

Adjustment is started with the selection of the communication interface in the *Settings* tab. Note that you can only use USB interface to perform adjustment. If communication is successfully established, the application will display device identification, and calibration coefficients for the currently selected measurement range.

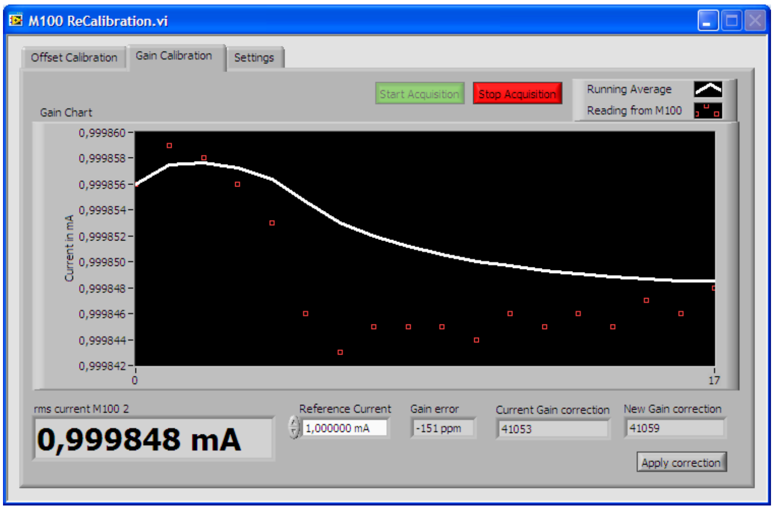
You can use the buttons in this tab to manually set offset and gain correction. This is useful if you would like to restore previous (factory default) values or if you prefer to calculate coefficients manually.



The second step in readjustment procedure is the offset calibration. Disconnect all cables from the M100 connectors and click the *Start Acquisition* button. M100 will acquire and present ADC samples, which represent the basic noise of the instrument. If there is any DC offset, the application will calculate new offset correction and you may use the *Apply correction* button to permanently store it to M100.



The third step in the readjustment procedure is the gain calibration. For the gain calibration, you will need to pass a current known value through M100. Current may be AC or DC. Enter the true value of the current in the *Reference Current* box and click the *Start Acquisition* button. Application will take measurements from M100, calculate their average value and determine the new gain correction. If the new gain correction is significantly different than the current gain correction, you may use the *Apply correction* button to permanently store new gain correction to M100.

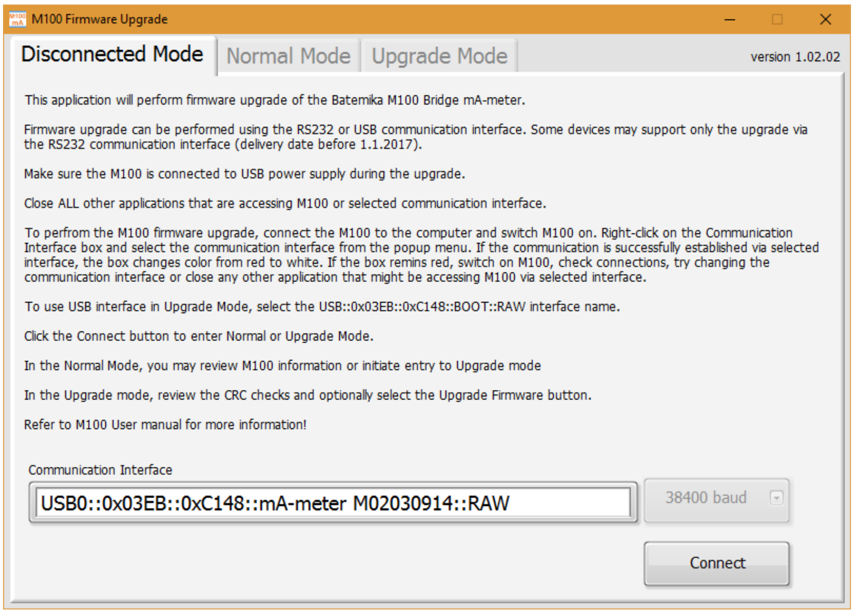


7.5 M100 Firmware Upgrade

M100 Firmware Upgrade is a support application used to upgrade the UT-ONE firmware. At Batemika we are constantly improving our products and this application allows you to update your existing unit with new features.

On some models, firmware upgrade can only be performed using the RS232 serial interface. Always use the communication cable supplied with the UT-ONE unit. Use the 38400 baud rate setting, lower settings are useful only if communication errors are detected.

Start the upgrade procedure by closing all other applications that are communicating with M100. To avoid confusion, connect only one M100 at a time during the upgrade.

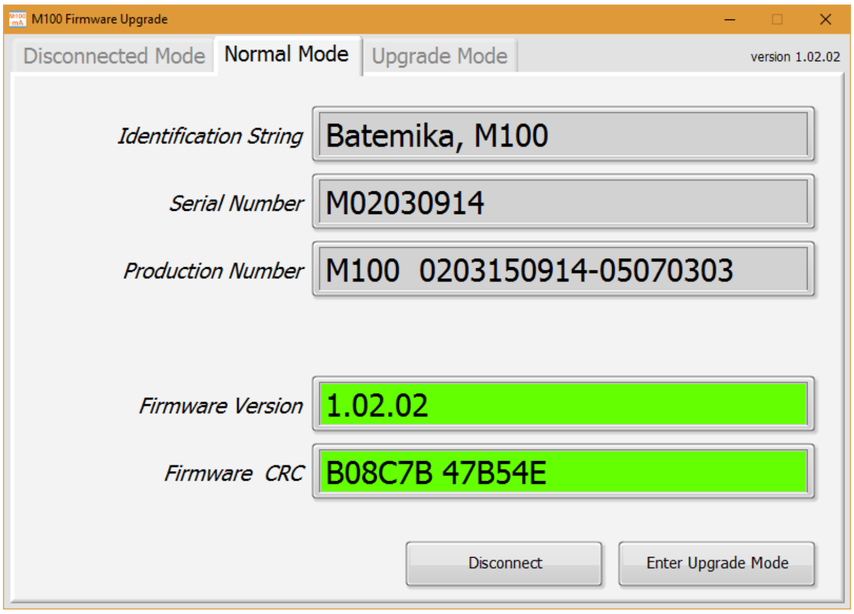


Upgrade starts in *Disconnected Mode*. Select the *VISA resource name* for your particular M100 and communication interface. If M100 is successfully detected on selected *VISA resource name*, the colour of the input box will change from red to white and the *Connect* button will be enabled.

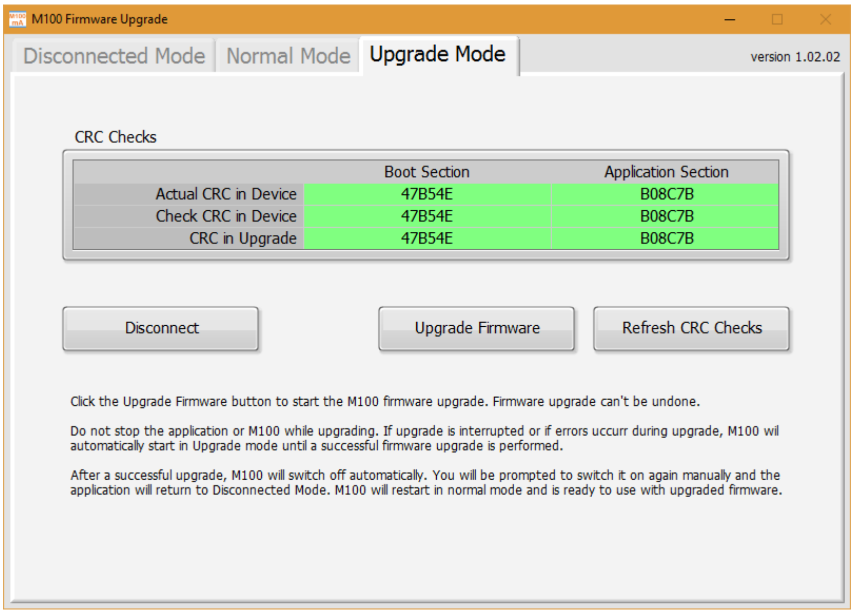
Click the *Connect* button to proceed to *Normal Mode* or *Upgrade Mode* screen. Note that you can safely connect, the application will ask you later to confirm any changes to M100 firmware.

If M100 is running normally, application will connect to *Normal Mode* and display the M100 information. Application also checks the firmware version in the device and compares it the version in the upgrade. If versions are identical, the box is coloured in green, otherwise in red. If you decide to proceed with the upgrade, click the *Enter Upgrade Mode* button. The application will set the upgrade flag in M100 and shut it down. You have to manually switch it back on. M100 starts in the upgrade mode, displaying the message "UPGRADE!". Click the *Connect* button to enter the *Upgrade mode*.

If you are using the USB interface, the VISA resource name of your UT-ONE device will change to "USB0::0x03EB::0xC148::BOOT::RAW". Select this entry to proceed with upgrade.



After the applications connects to upgrade mode, it checks the cyclic redundancy check (CRC) of the firmware in the device and in the upgrade and displays it in the table. Note that firmware consists of the boot section and application section, each having a separate CRC. Firmware upgrade will only update the application section. If there is a mismatch in the boot section CRC, upgrade may not be possible.



To start the upgrade, click the *Upgrade Firmware* button. After the upgraded is completed, click the *Disconnect* button to shut down the M100 unit. After you manually restart the device, it will launch with the upgraded firmware.

8 Specifications

This chapter provides detailed specifications for Batemika M100 Bridge mA-meter accuracy, operating conditions and other parameters.

Batemika is dedicated to constant improvement of our products and associated measurement procedures. We reserve the right to changes without prior notice.

Specification	Value
Measurement ranges	LO and HI (jumper selectable)
Measurement range limit	2.9 mA (LO) and 15 mA (HI) (RMS sine wave)
Maximum input limit	4 mA (LO) and 21 mA (HI) (higher values are truncated)
Absolute maximum current	50 mA short term (LO and HI)
Current absolute accuracy	500 ppm of range limit, 1.5 µA (LO) and 7.5 µA (HI)
*Current ratio accuracy**	200 ppm (currents higher than 10% of range limit)
	50 ppm (currents higher than 33% of range limit)
Display resolution	0.0001 mA (LO) and 0.001 mA (HI)
Remote interface resolution	Two additional digits compared to display resolution
ADC resolution	18 bits
ADC sampling frequency	50 kHz default, 5 kHz to 60 kHz adjustable
Base noise level	0.4 µA typical, 1 µA maximum (LO)
	1.4 µA typical, 4 µA maximum (HI)
DC offset	±5 LSB typical, ±20 LSB maximum, adjustable in 1 LSB steps
Temperature coefficient	±25 ppm/°C (within operating temperature range)
Frequency range	DC to 100 Hz
Bandwidth (-3dB)	15 kHz
Response time	30 seconds (asynchronous mode),
	one period or at least 2 seconds (synchronous mode)
Shunt resistance	4 Ω
Operating temperature	23 °C ± 3 °C
Operating relative humidity	40% to 60% relative humidity, non condensing
Power supply	USB 2.0 bus powered 5 V, 100 mA typical, 500 mA maximum
Rechargeable battery	Internal LiPo battery 2000 mAh (7.4 Wh)
Battery operating time	24 hours typical
Battery charging time	4 hours to 70%, 16 hours to full capacity
Battery lifetime	500 charging cycles typical, battery capacity degrades with use
Communication interfaces	RS232 and USB 2.0
Weight	1.75 kg
External dimensions (WxHxD)	120 x 100 x 220 mm
Warm up time	no warm up time required to achieve specified accuracy

*applicable to short-term measurements at the same frequency, waveform shape, measurement range, ambient conditions and measurement setup. The only parameter that is allowed to change is the value of current.

9 Troubleshooting

1. *Device will not start when I press the black button.*
   You are running on battery and your battery is fully discharged. Check if the external power supply or USB cable are attached and powered. If you are running on low battery, you may have to press the black button for a few seconds in order to start.
2. *The device stopped responding to communication interface and/or black button.*
   Press and hold the black button for more than ten seconds. This will execute a hardware shutdown of the power supplies and reset the device. Wait at least 30 seconds before restarting the device.
3. *The display is displaying OverLoad message.*
   Some of the acquired samples are over the input maximum limit. This may be a result of spikes during current switching or random electrical interference. If message persists than the measured current is too high and can't be measured on currently selected measurement range.
4. *The M100 was started, but there is no response on the screen.*
   Check the measurement mode. In synchronous mode, M100 may wait for periodic signals for several tens of seconds before producing a reading.
5. *The measurements are noisier than expected according to specifications.*
   Use the device away from sources of electromagnetic interference, such as electric motors, switched-mode power supplies, wireless communication devices, etc.
   Use a shielded and grounded cable for your probes.
   Cover the M100 connectors. Exposure to severe draft conditions may cause excessive parasitic emf variations, which results in noise increase.

10 Frequently Asked Questions

1. *Can I use the M100 both for AC and DC currents? Is there a switch/parameter to be set?*
   Yes, you may use the M100 to use any shape of the measurement current. There is no switch or parameter that can be set to select DC or AC operation. M100 will always measure true RMS value, which includes both the AC and DC component.
2. *Should I calibrate the M100 with DC or AC current?*
   You can calibrate the M100 with either DC or AC current. DC current calibration is usually simpler and a simple DC source and a DC voltmeter (used for measurement of thermocouples) can be used. If DC current is used, always reverse the current polarity and use mean value of both readings. This will eliminate the influence of any offset voltages.
3. *Can I use the M100 as a permanent connection box between the extension cable and SPRT?*
   Yes, the M100 is specifically designed for this purpose. A simple validation procedure is recommended, which compares the bridge readings with and without the M100.
4. *Can I use the M100 connected to the bridge and SPRT, without the M100 being switched on?*
   Yes, M100 can be used as a completely passive connection box.
5. *Should I connect the M100 to ground?*
   If M100 is connected to communication interface, it is grounded via communication interface and a separate ground connection is not recommended. If M100 is used as a standalone instrument, ground connection may improve EMI characteristics, but may also increase leakage currents. Ground connection is also beneficial from safety point of view and to reduce any static electricity accumulation. Although different connections have very small effect on measurements, some experimentation is recommended to find the best setup.
6. *Should I connect the shield connection from my bridge/extension cable to the GND connection on the M100?*
   If M100 is grounded, this connection is not recommended, as it will create a ground loop and may have significant influence on bridge operation. If M100 is not grounded, this connection may be beneficial for some types of bridges, but a validation procedure is recommended.
7. *Are any of the M100 inputs connected to system ground?*
   No, M100 input connectors are not connected to system ground, but there is a parasitic capacitance of approximately 500 pF to system ground. This equivalent to approximately 10 meters of shielded extension cable.
8. *Can I use M100 for other purposes, besides the measurement of measurement current of resistance bridges?*
   Although M100 was designed specifically for the use with resistance bridges, it can be readily used for any other application involving accurate measurement of small currents. Of course, observe the absolute maximum limits given in the specifications.
9. *What is the frequency range of M100?*
   Details about the M100 frequency characteristics can be found in M100 evaluation report. Nominal frequency range is from DC to 100 Hz. In this range, frequency dependency is within accuracy specifications. Currents at frequencies up to 10 kHz can be normally measured, but with increasing frequency error. M100 bandwidth is specified at 15 kHz. At this frequency, the output is reduced by 3 dB (input sinusoidal signal with 1 mA RMS will result in 0,707 mA measured value, 30% error). Measurement of currents with very high frequencies (> 1MHz) will result in increased leakage currents to GND and should be avoided.