# INFORMATION

# ON THE

# MEPHISTO SCOPE 1

# RUNNING OFFLINE

*Firmware Version 3.0x*
*27.07.2007*

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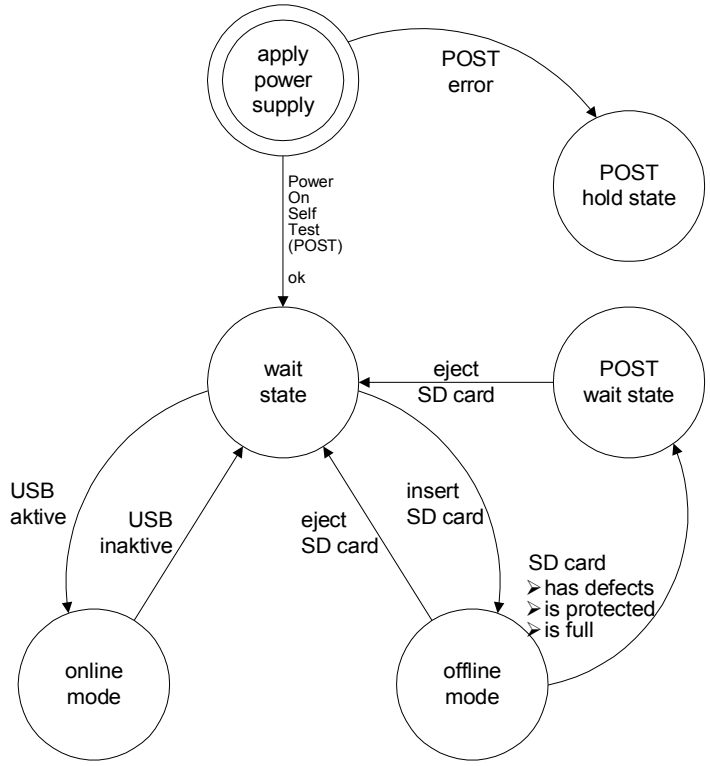
# Entering Online and Offline Modes

After powering on the MEphisto Scope 1 via USB- or DC-plug, the device starts searching for an USB connection for about two seconds. During this time the right LED is on. A PC can only be recognised, if the appropriate driver is installed. The physical link itself is not sufficient. After having found a proper connection, the devices switches to online mode. The MEphisto Scope 1 can be used with the MEphistoLab application.

If no valid USB connection can be found for the first two power on seconds, the device enters a wait state. It continues checking for an USB cannel and additionally watches the SD card socket. In wait state the two LEDs are flashing periodically. If an USB link is established, the device again switches to online state. During wait state insertion of an SD card will be recognised. Pushing in the card will force the device into offline mode. After a secure period of about two seconds the device starts recording. This time is inserted to make sure, the card is no longer toughed. If the card is inserted before powering on, it will not be recognised as start signal. It must be unlocked and pushed in again.

The MEphisto Scope 1 falls back into wait state, as soon as it cannot proceed any further. If the USB pipe is broken, e.g. because the PC is shut down, the device will recognise it. If it is still powerd by an active hub or the wall mount AC adapter it will enter wait state. Also pulling the SD card will force the MEphisto Scope into this state. If the card is full or faulty the wait state again will be the result.



# Configuring the Offline Mode

## *Choosing the right mode*

Within a few limitations there will be a sufficient setting for every problem. It is most important to choose the right mode. Desired reliability and post processing of the recorded data guides you to the preferable mode.

Regarding to safety, two criteria must be guaranteed. Using logger mode, the device must under all circumstances be able to work continuously. Power supply must be stable. The contact with the SD card must not be interrupted by vibration or shock. Under normal conditions these requirements are always met. However, in mobile use this must be kept in mind. In doubt the oscilloscope mode is preferable. Under worst case conditions one data set is lost, but the device continues recording. In oscilloscope mode the SD card is re-initialised before every write cycle. This insures a maximum of reliability. In data logger mode the whole card is reserved for one single file. No further recordings can be placed on this card after a fault. The table below lists up the particular security features of both modes.

| mode | oscilloscope | data logger |
|---|---|---|
| moment of saving | after acquisition period | immediately |
| worst case loss of data | one acquisition period<br>(100 – 131000 samples) | current sector<br>(128 samples) |
| resumption of recording | immediately | after changing the SD card |
| change the SD card while acquisition running | yes | yes (leaves the data set on the first card incomplete) |

If safety can be guaranteed, the job itself suggests the mode of operation. For recordings of slow signals over a long period, the data logger mode is the first choice. All samples will be acquired isochronously. As described above, the MEphisto Scope 1 first of all sets up a single file, spanning the whole card's memory. During recording, it is filled up continuously with sampling data. Of course the logging process can be started using a trigger criterion.

Recording the temperature of a running machine or the discharge of an accumulator are typical applications for the data logger.

If the goal is to record a parameter for a particular period or if measurement is to be repeated using triggers, the oscilloscope mode has to be chosen. It creates one file per period. Between two files there will be a gap of at least one or two seconds using the manual trigger. The time stamp of each file gives information on the moment of saving, that is the end of the acquisition period. The file name itself comprises this time stamp in hexadecimal notation and the suffix.

Oscilloscope mode is recommended for unattended recordings of certain situations. Voltage drops below a given threshold can be documented for example. Another application could be sequential recordings of a pre-set period. The room temperature of each day or power requirements of a machinery within a week can be documented easily.

## *Calculating acquisition periods in offline mode*

### Data logger

In data logger mode the whole capacity of the SD card is used. It can be checked using a PC. Usually it is about 90% up to 95% of the gross capacity printed on the label. Knowing the free capacity (m) and the given period (T) the sampling rate can be calculated.

$$t = \frac{4 \cdot T}{m}$$

Assuming there are 124654592 free bytes on the card and the period has to be one week, the result is 19.41ms/sample. The set time therefore has to be 20ms/sample. The calculated value has to be round up. Otherwise the actual set period is too short. The factor of 4 results from the amount of data of each sample. It consists of two synchronous channels with a resolution of 16 Bit per sample.

$$t = \frac{4\,\frac{byte}{sample} \cdot (7 \cdot 24 \cdot 60 \cdot 60)\,seconds}{124654592\,Byte} = 19.41\,\frac{ms}{sample}$$

### Oscilloscope

Trying to configure the oscilloscope mode, two approaches might be useful. The maximum number of files is the key value here. It could be 511 or 512, depending on whether the SD card has a volume label or not. To just repeat this issue: You can save a maximum amount of 512 files on the SD card, no matter how small they are.

In the first approach we have a given period (T) as in the logger mode. We assume one week. The directory can be filled with 511 entries (n). The time span is calculated this way:

$$t = \frac{T}{n}$$

With the given values, this is the result:

$$t = \frac{(7 \cdot 24 \cdot 60 \cdot 60)\ seconds}{511\ acquisitions} = 1183{,}6\,\frac{s}{acquisition}$$

The resolution (r) within the sample period can in most situations be freely chosen according the requirements. There might be a memory limit you have to check. The free space (N) on the card can not be exceeded.

$$N > r \cdot n \quad \text{or} \quad r < \frac{N}{n}$$

On SD cards of 256 MB and more this limit is rarely reached.

Coming back to the example above. If you choose a memory depth of 1000 samples, the period can be set to 1190s to cover the whole week on one SD card. The result will be 509 Files.

To get a better utilization of the card, you might try to use a memory depth of 131000 samples. The sample period will be 1184s. The MEphisto Scope 1 produces 511 in one week. The total size is 267764000 bytes. Typical card space on a 256 MB device is 256770000 bytes. So, this setting is just a little too big and requires a 512MB card.

Just the opposite way is the approach via the sample period. It could be useful to use t = 1h = 3600s to make post processing of the data easier. The setting has to be checked, if it is applicable.

$$n = \frac{T}{t} \leqslant 511$$

One week is 168 hours long, that is 168 files. This amount easily fits on the card. As above, you can chose each memory depth you want. In this case with the little number of files, you might even choose 131000 samples/file. The minimum depth is 2000 to get a time span of one hour.

Please note, that in both approaches the choice of memory depth sets the time resoulution within the file. If you choose a value of 2000 in the example above, the resolution will be 1.8s. With 100000 samples per file it increases to 36ms. On the other hand, many spread sheet applications can handle just 65500 lines. Limiting the value to 50000 samples is essential for post processing.

Please find some useful settings in the table below. Each acquisition period covers 511 files.

| **period [s]** | **memory depth [samples]** | **resolution [s/samples]** | **files/day** | **max. sample period [d]** |
|---|---|---|---|---|
| 60 | 100 | 600 m | 1140 | 8.52 h |
| 60 | 100k | 600 µ | 1140 | 8.52 h |
| 3600 | 100 | 36 | 24 | 21 |
| 3600 | 100k | 36 m | 24 | 21 |
| 21500 | 50k | 430 m | 4.019 | 127 |
| 20960 | 131k | 160 m | 4.122 | 124 |
| 43000 | 50k | 860 m | 2.009 | 254 |
| 43230 | 100k | 432,3 m | 1.999 | 255 |
| 86500 | 50k | 1,73 | 0.999 | 511 |
| 86460 | 131k | 660 m | 0.999 | 511 |
| 125000 | 50k | 2.5 | 1.447 d/file | 2.02 a |
| 327500 | 131k | 2.5 | 3.791 d/file | 5.31 a |

The last two lines show up the maximum settings. The MEphisto Scope 1 could in this case work for more than five years.

## More Configuration

All further configuration is made as if they were for online mode. Voltages, trigger mode etc. have to be set before starting offline. Every change is saved immediately in the device. Some control elements are on application level, not driven by the device itself. This includes display settings like channel on/off switches and display functionality. The device has no knowledge of these settings during offline mode. However, you can set them accordingly after reading out the card.

## Preservation of Configuration

Configuration as well as the running clock stay alive for many days, even without external power supply. The MEphisto Scope 1 does not use batteries or accumulators. It has a built in capacitor, that supplies the memory. Duration depends on the amount of charge in the capacitor. One hour charging covers at least one day without supply. Eight hours of charge last for at least one week. These periods were determined at about 25°C (77°F). Maximum charge is reached after 24 hours. Exceeding this period increases live time marginally. Nevertheless, you cannot overload the capacitor. At room temperature the charge may keep the clock and configuration running for several weeks. In case of loss of configuration the device will indicate this error, if you try to use it offline. The capacity decreases rapidly with increasing temperature. At 70°C (158°F) the time is about 10% as it would be at room temperature. On low temperatures capacity increases a little but charging times rise.

## Preparing for Measurements

If the MEphisto Scope is running an offline acquisition, it must be stopped first by powering off for at least 20 seconds. If it is in wait state external power from the AC adaptor may be left connected in online mode. A plugged SD card should be ejected.

1. connect the MEphisto Scope with the PC
   → LEDs are on constantly
2. start the MEphistoLab
   → the scope's clock is synchronised with the PC
3. choose the acquisition mode
4. make appropriate settings for channel/memory/timing
   → The device saves settings and mode in the clock chip.
5. close the MEphistoLab
6. remove the USB kable

## Running the Measurement

To use the MEphisto Scope without the PC you require the bundled AC adaptor and a SD card. If you have chosen a logging mode, the card must be empty.

1. Plug in the AC adaptor
   → The device enters wait state. Both LEDs flash.
2. insert SD card
   → LEDs show the progress:
   Oscilloscope modes: left acquisition, right saving
   Logger: right initialising, left logging and saving

# Changing the SD Card

The card may be changed while an acquisition is running. This has slightly different results in oscilloscope and logger modes.

The card must be ejected the usual way by pressing and springing. Pulling the card immediately might result in a blocked device.

## *Oscilloscope Mode*

If the device finishes an acquisition with no card plugged in, this data is lost. It is recommended to note the start time and the duration of each cycle. Please note, that each cycle will shift some seconds.

If the card is ejected during saving (right LED on), the current file is unusable and its data is lost. Please follow these guide lines:

1. Check the LEDs. The device has to be in acquisition mode (left LED on)
2. Eject the full card.
3. Insert an empty card.
4. To check the reliability, check the data. With manual trigger the newest file must not be older than one period. If for example a period of 3600s was chosen, the newest file must not be older than one hour. If it accidentally is, the device might have been disturbed by drops in supply, overvoltage, EMI or mechanical shock. In case of malfunction, please remove the power supply for at least 20 seconds. The card must be ejected and inserted later. Configuration is safe with this procedure.

## *Data Logger Mode*

In data logger modes worst case loss will be 512 bytes, that is 128 samples. If the device was already triggered, all previous data is available on the card. If the device is still waiting for the trigger during card change, the card just contains the setup information.

While logging data to SD card, the device will detect the removal of the card and will fall back into wait state. In this case a new card can be inserted. Acquisition will restart, waiting for a new trigger.

It is strongly recommended to not remove the card during initialisation. Initialisation is indicated with the right LED. If this has happened by accident, the card must be formatted.

# Troubleshooting

The MEphisto Scope 1 is very robust due to it's mechanical and electrical design. Nevertheless, malfunction can never be precluded. If the device works unattended for a very long time, malfunctions could happen undiscovered. Pecise analysis of the error can help to improve stability for further measurements.

## *Errors Occurring at the Beginning of a Measurement*

Some errors arise just at the beginning of the measurement. If the SD card is inserted and the devices blinks an power on self test (POST) code, there could be the following faults:

| error code | cause | solution |
|---|---|---|
| 4 | unreliable configuration memory<br><br>The device was stored too long without a power supply. | Please make a new configuration. Make sure to load the capacitor long enough. |
| 5 | error accessing the SD card<br><br>The device could not communicate with the card. | Re-insert the card. Please make sure it is not touched after insertion. If the error occurs again, the card is probably damaged seriously. In this case you have to change the card. |
| 6 | error while initialising the file system.<br><br>The device does not know how to handle the card's file system. | The Mephsito Scope 1 can only use FAT16 (FAT) and FAT32. Cards with 8MB or 16MB FAT12 is the standard. Format the card while choosing explicit FAT16. On small cards you can force FAT16 by choosing small block size (512-1024Byte). |
| 14 | wrong trigger mode for offline use<br><br>The combination of trigger mode and trigger point is unsupported in offline mode. | This error only comes up using logger modes. A trigger may start the logging but not terminate it. Please adjust the trigger point to 0%. |
| 15 | wrong acquisition mode for offline use<br><br>The device does not support this mode when running offline | In the first firmware revisions the digital data logger can not be used offline. Please look for new versions on the internet. Please update, when a new version is available.<br>Volt meter modes are not supported offline. |

Besides these apparent faults other trouble may hinder from measuring. Often simply the trigger conditions are not met. Run an online test to make sure, the configuration is chosen correctly for the real world.

## *Errors Occurring during Run Time*

After having successfully started a measurement, more trouble can lead to other symptoms. Different operating modes have significantly different sources. The first choice for diagnosis is the SD card. Its content might give an idea why the device stopped. Each file has a time stamp giving information on start or stop times of the last log or acquisition. Try to open the newest file with the MEphistoLab. Especially in the logger modes the contents might give a hint, what went wrong. Troubles or overvoltage can often be detected in the course of the trace.

## Logger Mode

In the logger modes most important is to watch the status LEDs. If they indicate an error of the file system (POST code 6), three errors might be taken into account.

1. The card is defective. Test the card at maximum speed of 100kHz. This can take up to six hours on a 2GB card. But this is the only way to make a safe diagnosis. SD card readers use different access methods than the MEphisto Scope 1 does.
2. There was a disturbance of the supply voltage.
3. The SD card has been moved. Heavy shock, drops or vibration at resonance frequency might be the cause. This needs not necessarily lead to obvious effects. The contact might be interrupted for just a moment, but the logging can not be resumed afterwards.

If the status LEDs do not lead to reliable diagnosis, the file might help to find the cause.

1. If an inconspicuous trace suddenly drops, this often is a result of a high energy glitch. This could for example couple through the ground connection of the probe. If the energy is high enough, the micro controller might be disturbed.
2. Induction loops with very high voltages from the signal or ground path to the mains supply can also disturb the communication within the device.
3. Sudden changes in the trace just before the drop usually indicate high overvoltage at the input.

## Oscilloscope Mode

The MEphisto Scope 1 can be disturbed in miscellaneous ways. The static causes have been discussed in the chapter above. In oscilloscope mode they almost lead to one corrupt or dropped file. The device usually continues its work afterwards. The error shows up by too little files and by an irregular time stamp sequence. However, you will notice these anomalies only in trigger mode “manual”, because it produces isochronous file sequences.

In oscilloscope mode, the status LEDs might be also useful. Nevertheless, little errors are indicated permanently. In most cases the device tries to restart rather than showing that there had been an error. Restarting will only fail if the SD card is damaged or full. In case of SD card failure a POST code will be shown. These errors are discussed in the chapter “Errors Occurring at the Beginning of a Measurement”. If the card is full, the device enters wait state. This condition is indicated as usual by both LEDs flashing. In both cases work can be continued by inserting a new card.

# Background Information

## *Common Topics*

Configuration and time of day are stored in a semiconductor, that is supplied by a so called “double layer capacitor”. This capacitor is charged via USB or the AC adaptor. Like an accumulator, full charge takes some time. Optimal charge is accumulated after about 12 hours, maximum charge takes 24 hours. Nevertheless, there is little difference in backup time. At room temperature configuration can be reliable for several weeks. At high temperatures, for example in cars, the time is reduced dramatically. Under extreme conditions it can drop below one day. Under such circumstances the device should be powered by a voltage converter from the car's supply.

## *Oscilloscope Mode*

In oscilloscope mode the device makes one acquisition. Then it creates a file and saves configuration and sample data within this file. During acquisition the left LED is on. While saving it is the left one. If the card is ejected during saving, the last file will be corrupted. The file system itself is always safe.

## *Logger Mode*

The strategy in the logging modes is quite different. After the card is inserted, the device proves it to be empty, having the right LED on. Duration depends on the card's size and file system. With FAT32 it will inevitably take between two and eight times longer than it would take with FAT16. But even with FAT16 the time can be reduced significantly by increasing the cluster size while formatting. If the card is not completely empty, the device falls back into wait state.

If the card is checked to be usable, the file is initialised to span the whole card. Its content is erased. The duration of this process also depends on the factors described in the last paragraph. After erasing, the device writes it's configuration into the file. Still the right LED is on. Until this moment, the card must not be removed. If this accidentally happens the card has to be re-formatted in any case.

If the file is completely initialised, the device enters the sampling mode. The samples are written immediately into the file. The right LED is on. The process may be interrupted from now on. After the card is filled up with data, the device enters wait sate.

The MEphisto Scope is a very low power device. It can not handle sampling data and work on the file system at the same time. Searching for free clusters on a FAT16 or FAT32 file system requires much performance that is exclusively tied up with the sampling. Therefore there is no other way to handle the file and the data stream. PCs solve this problem by buffering all media's management data in the RAM for quick access. The MEphisto Scope can not use this trick. If the card is removed from the device during logging, the modified data could not be written back in time. So the device opens one large file at the beginning and later fills it up continuously. This makes data reliable, even if the card is removed during writing. Later firmware versions will offer an option to pre-set the file size instead.

Because the file's content is erased, after a broken recording you can see both traces fall to the minimum. This step can be noticed quite well. If a large card contains little data, there seems to be no data at all. Not before zooming the left edge of the display the short valid period shows up.

Reading the data with the MEphistoLab the amount is limited to 200000 values. A file containing 250MB of data results in an average of 330 samples to build each shown value. Very high frequencies will be suppressed by this procedure. But if this compression would be omitted, many

PCs with 256MB or 512MB of RAM would be overstrained. This could lead to response times up to one hour.

## *SD Cards*

Usually the MEphisto Scope utilises all SD cards. On the other hand, even branded cards could contain faulty controller chips. The bundled cards are not affected by such problems. Every incoming batch is in-house tested for reliability.

We can not give advice were and what to buy, when additional cards are needed. Very often OEMs re-design cards even within active series. Looking at the outside, there is no change. So the “advice” is to buy a card and test it. The most effective test could be made using the data logger at maximum speed. Then the file has to be examined for drops or other incongruity. If the result is good, more cards can be bought from exactly the same shelf. If there are problems with the card, they will occur immediately and always. The card does not process the data temporarily or even not at all. But there is no such thing as a card that is working one day and then again not.

There are no problems with speed. Even oldest 16MB cards can handle the data. So it makes no sense to buy high speed cards. On the other hand there is nothing wrong with this. Every card designed according to the standard SD card specification can be used. The limit is 2GB. Cards based on the SD-HD specification beyond 4GB are currently not supported.

## *File contents*

The format of all files written by the MEphisto Scope 1 is the same. Files having the suffix “MSA” start with a short header, containing the configuration followed by the sample data. The header is the same in all modes. Nevertheless, the sample data vary, depending on the mode.

All header's entries have a length of 32 bit each. In the further discussion the meaning of “Float” is the 32 bit IEEE floating point format. “ULong” will paraphrase an unsigned integer with also 32 bit size. ASCII characters and single bytes will be referred to as “Char”. They will always be used as a field of 4. That also results in a size of 32 bit. The information in the header have this structure:

| Entry | Type | Function |
|---|---|---|
| 0 | Char[4] | Acquisition mode |
| 1 | Float | amplitude channel 0 |
| 2 | Float | amplitude channel 1 |
| 3 | Float | offset channel 0 |
| 4 | Float | offset channel 1 |
| 5 | Float | zero point correction channel 0 |
| 6 | Float | zero point correction channel 1 |
| 7 | Float | time base |
| 8 | Float | memory depth |
| 9 | Float | trigger point (1-99%) |
| 10 | ULong / Char[4] | trigger channel |
| 11 | ULong / Char[4] | trigger type |
| 12 | Float | upper trigger level |
| 13 | Float | lower trigger level |
| 14 | ULong / Char[4] | GPIO data |
| 15 | ULong / Char[4] | GPIO direction |

## Acquisition mode

This entry can be interpreted as required. regarding the Der Meßmodus kann je nach Wunsch interpretiert werden. The labels below are just mnemonics. The device handles them as ULong values.

| Meaning | Label |
|---|---|
| oscilloscope, analogue | OSA0 |
| data logger, analogue | DLA0 |
| logic analyser using IO ports | LAIO |
| data logger using IO ports | DLDI |

The mode DLDI will be available in future firmware versions.

## Amplitude

This is the voltage range. Each channel has its own entry in the header.

## Offset

This is obviously the centre shift of the voltage range. There is one entry for each channel.

## Zero Point Correction

This parameter is ascertained during calibration, one per channel.

## Time Base

This value represents the time between two samples.

## Memory Depth

The memory depth is relevant only in the oscilloscope modes “OSA0” and “LAIO”. This is the number of sampled data. In the logger modes this value is invalid. The number has to be determined by the file size.

## Trigger Point

The position of the trigger point within the sampling data is given by this value. The information is given as percentage of the memory depth. Assuming 1000 samples and a value of 10% for the trigger point, the trigger event can be found at sample number 100.

## Trigger Channel

Interpretation of this value depends on the mode. In analogue modes this value indicates the sensitive channel. The value is usually read as ULong. In the digital modes three out of four individual bytes have to be interpreted separately. Three bytes represent the five possible states of each corresponding bit on the port. Byte 0 is irrelevant with the digital modes. Each bit is a mask for the corresponding data bit.

| Byte | Function | Bit = 0 | Bit = 1 |
|---|---|---|---|
| 0 | - | - | - |
| 1 | relevance | bit is ignored | bit is tested |
| 2 | dynamics | bit is tested for its level | bit is tested for an edge |
| 3 | level/edge | level=low or edge=falling | level=high or edge=rising |

## Trigger Type

The type is preferably interpreted a a single ASCII character in byte 0. The table below lists up these characters. It also shows what other configuration values will be relevant.

| Type | Zeichen | genutzte Einstellung |
|---|---|---|
| level, above | T | upper trigger level |
| level, below | t | upper trigger level |
| window, entry | W | upper trigger level, lower trigger level |
| window, exit | w | upper trigger level, lower trigger level |
| edge, rising | E | upper trigger level |
| edge, falling | e | upper trigger level |
| derivative, positive slope | D | upper trigger level |
| derivative, negative slope | d | upper trigger level |
| external, positive edge | X | - |
| external, negative edge | x | - |
| pattern | P | bit pattern in the trigger channel |
| manual | M | - |

## Upper Trigger Level

This is one of two possible trigger levels. Most modes use just this value.

## Lower Trigger Level

This second level has to be interpreted, when window trigger was selected.

## GPIO Data

This information is necessary if and only if the digital port controls an analogue signal conditioner.

## GPIO Direction

This setting can be used as a mask for the GPIO data.

| direction | bit value |
|---|---|
| input | 0 |
| output | 1 |

## Sample data

This area consists of entries, each 32 bit in size. In the analogue modes two synced 16 bit samples are saved. The upper 16 bit contain the data from channel 0, the lower portions comes from channel 1. As the device saves the raw sample data, they have to be converted into the real voltage. It is calculated by the formula given below. Passive probes with an attenuation factor different from 1 have to be taken into account also. The MEphisto Scope 1 does not support auto sensing of this factor. Therefore the file does not contain such information.

$$U[V] = \left( \frac{n_{sample}}{32768} - 1 \right) \cdot \frac{amplitude}{2} + offset - zeropointcorrection$$

In the digital modes the sample data is also saved using two 16 bit values. The older sample is put in the two upper bytes, the newer one is in the lower half. Further processing of the data is not necessary. If you prefer you might read single 16 bit values in sequence to get the same result.