ABC-MEMS

User's Manual

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1 Introduction

ABC-MEMS is the third generation of ABC Instrument's smart vibration meter/datalogger. It includes It includes a 3-axis MEMS accelerometer, an accurate date/time clock, a non-volatile 128 Mb recording memory and *wireless* connectivity with fast USB and *WiFi*™ download. Depending on the settings it can record vibration/velocity signals and/or RMS vibration/velocity levels for months. Its very small size allows it to be attached to, or embedded within, the monitored equipment.

The ABC-Mems model is an evolution of the 1e model. It has the following new features:

- Can measure, record and trigger on velocity signals, in addition to acceleration signals.
- Has *WiFi*™ reporting and email alarms.
- Includes an accelerometer with exceptional noise floor (20 times better noise floor than the *Vibration Mems -16g).*
- Sampling rates up to 4 kHz.
- Improved anti-aliasing filter.

The ABC-Mems includes the following features:

- 3-Axis integral MEMS accelerometer
- Measures and records:
  - Raw acceleration or velocity signals
  - Acceleration or velocity signal statistics
  - Vibration or velocity RMS levels
  - Inclinations
- All-digital design.
- Integrated oscilloscope function that can show the vibration or velocity signals in real time.
- Allows the observation of recorded data while the recording is ongoing.
- Works standalone, or USB or *WiFi*™ connected for setup and data transfer to PC.
- Long life internal rechargeable battery that recharges from USB.
- Self-calibrated using the earth's gravity as a reference.
- Observes and records 100% of the acceleration signals (no missed samples).
- Editable individual custom ID for easier instrument management.
- Completely sealed weatherproof enclosure.

2 Applications

- Building-health monitoring on construction sites.
- Long-term seismic monitoring.
- Long-term inclination monitoring.
- Long-term measurement and recording of acceleration signals, velocity signals, signal statistics (peaks and average) and RMS levels.
- Continuous monitoring of machinery wear.

3 Warnings



Avoid over-discharging the battery

- *Recharge the instrument immediately if the LED indicates a low-battery condition.*
- *Even if the instrument is Idle all or most of the time, recharge it fully at least once every 6 months.*

Do not store or operate the instrument at temperatures exceeding the following limits

- *-20 °C to 60 °C (-4 °F to 140 °F)*

Do not mount on a metal plate. *That would drastically weaken the WiFi™ signal.*

4 Getting Started

4.1 Software Installation

- On the PC that is used to setup the instrument, run *Instrument_Manager_Installer.exe*. This installs the *Instrument_Manager* application, as well as its USB driver and documentation.
- On the PC that is used as a server, to collect data over the network, run *Instrument_Listener_Installer.exe*. This installs the listener application that is used to respond to instrument incoming connections, and create and fill the corresponding data files.

Note: The same PC can be used for both applications.

Note: Perform the software installation above BEFORE connecting the instrument to the PC for the first time. The installer includes a USB driver, which is required for the PC to recognize the instrument.

4.2 Hardware Installation

1. Connect the instrument to an available USB port on the PC.
2. Verify that the PC properly detects the instrument and loads the driver. In case of doubt see section ***Troubleshooting***. Note that it can take some time for the PC to load the driver, the first time the instrument is connected.

4.3 Initial Test and Configuration

1. Upon connection to the PC, the *charge* LED should immediately light-up yellow (charging) or green (charged). Once the PC has loaded the driver the *operating* LED should blink once per second.
2. Go into *Start\All Programs\ABC_Instruments\Instrument_Manager* and run *Instrument_Manager.exe*. The front-panel described in ***Figure 9*** appears, and the application tries to connect to the instrument. If it fails to find the instrument it indicates *No Device Found*. If this is the case see section ***Troubleshooting***
3. Otherwise the application switches-on the ABC-MEMS and starts communicating with it.

4. If the Time and Date in the upper right corner of the application window are not properly adjusted the application asks if you want the instrument time to be synchronized to the PC time. Only say YES if the PC time is correct.

5. In addition, the application detects if the time zone of the instrument is different from the time zone of the PC. If it is, the application asks to set the instrument to the same time zone as the PC.

> Note: If (in rare cases) the instrument is not intended to be used in the same time zone as that of the PC used to configure it, we suggest to temporarily change the PC's time zone to the time zone where the instrument will be recording, let the application set the instrument to the PC's time zone, and change the PC's time zone back after that initial setting. Afterwards if/whenever the application asks to change the instrument time zone back to the PC's time zone, simply choose to cancel the adjustment.

6. In the front-panel of the application you should see the acceleration or velocity signals display in real-time.

5 Instrument Functions and Description

The instrument connects to a PC on a USB port. The *Instrument_Manager* application is used to set its operating parameters and download recorded data.

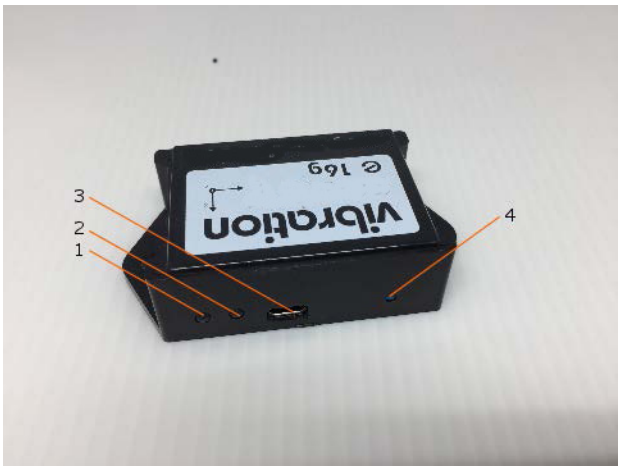


Figure 1 *ABC-Mems*

1. Charge LED
2. Operation LED
3. USB Connector
4. Reset Button

6 Principle of Operation

6.1 Power Consumption

The ABC-Mems is always on. However, when not in operation it only measures time, which only takes a tiny operating current. In that *Idle* state it can stay on for up to 6 months. When the meter is actively measuring, its power consumption is mostly affected by two factors:

- The accelerometer sampling rate.
- Whether it is recording raw signals or statistics.

The meter can be configured to connect to a server at regular intervals. When that function is enabled, the meter will activate its *WiFi*™ interface at the defined interval, and attempt to connect via *WiFi*™ for up to 1 minute. During that time, the instrument's power consumption will be increased. If the connection fails the meter will fall back to its previous state (Sleep or Recording).

Note: *WiFi*™ communications consume battery, so when leaving the meter unused for a long time, it is important to disable the *WiFi*™ periodic connection feature.

In order to minimize the power consumption due to *WiFi*™ reporting, choose a longer *WiFi*™ connection interval, for instance 1 hour. Make sure that the router is well within range of the instrument. *WiFi*™ consumption is greatly increased when the *WiFi*™ signal is weak.

The *Instrument_Manager* application automatically calculates and displays the cumulative number of days that the battery would last while recording, as a function of the instrument settings.

Note: That indication does not take into account any *WiFi*™ reporting.

In applications where the meter must record for longer periods of time, it can be connected to a USB charger. For outdoor-use, a USB-output solar panel, that will power the instrument indefinitely.

6.2 Battery Charging

The battery charges whenever the following conditions are met:

- The battery is not already fully charged.
- The instrument is connected to a PC's USB port and the PC is not in standby, or
- The instrument is connected to a USB charger.

Note: In order to charge the instrument properly, use a USB charger that is either compliant with the USB charging specification (most commercial dedicated USB chargers), or the Apple charging specification (most Apple chargers that have a USB output). We do not recommend using the USB outputs of cell-phone chargers, as many do not follow either standard.

While charging, the charge LED is orange. When fully charged, the LED changes to green.

The charge time from a completely discharged state varies with the amount of power the PC allows the instrument to draw. Charge time is normally around 2H30. If the PC does not allow the fast charge current, the charge time can increase up to 5 to 6 hours.

Note: When connected to a PC, battery charging stops while the PC is in standby.

Note: It is OK to leave the instrument connected to a PC or USB charger all the time. The smart charger inside the instrument will stop charging as soon as the battery reaches full-charge.

6.3 Modes of Operation

The meter has four modes of operation:

Mode	Operation	Power Consumption
Idle	Disconnected from USB and not actively recording - Only keeps time.	Minimal: Only needs to be recharged every 6 months.
Active	Connected to USB – Not recording – Instrument is fully on and measuring	Instrument draws power from USB to power itself, and if necessary recharge its battery. Battery is not depleted.
Recording or Auto-Rec	USB-connected or not - Fully on and recording.	If USB-connected, power comes from USB. If not, power comes from the internal battery. Power consumption depends on the instrument settings, and can go from days to months.
Periodic *WiFi*™ Connect	From any state, including *Idle* and *Recording*, the instrument can periodically wake up its *WiFi*™ interface and attempt to connect to a server. If the connection is not established after 1 minute it falls back to its original state until the next connection time.	If USB-connected, power comes from USB. If not, power comes from the battery. The *Periodic Connect* feature consumes battery. This is especially the case if the connection interval is set to be short so it occurs often.

Table 1

6.4 LED Indicators

The meter has two LED indicators:

6.4.1 Charge LED

The charge LED is always fully on or off.

LED State	Meaning
Off	Instrument is disconnected, or is connected to a PC that is in standby.
Green	Instrument is connected to a PC or USB charger, and the battery is full.
Orange	Instrument is connected to a PC or USB charger, and the battery is charging.

Table 2

6.4.2 Operation LED

The operation LED is always blinking.

LED State	Meaning
Off	Instrument is in *Idle* mode.
1-blink/second	Instrument is in *Active or Auto-Rec* mode, but is not actively recording.
2-blinks/second	Instrument is actively recording.
1-blink/second (off-beat)	Instrument is presently communicating with a server via *WiFi™.*
4-blinks/second	Battery is low. Recharge as soon as possible. If the battery level becomes critical the instrument will go to *Idle* mode (LED-off) in order to safeguard the battery against over-discharge as much as possible.

Table 3

6.5 Acceleration Sensor and Signal Processing

6.5.1 Measurement

The 3-axis MEMS accelerometer inside the ABC-Mems accurately measures static (DC) and dynamic (AC) acceleration signals with an adjustable sampling rate of up to 4 kHz.

Velocities are calculated in real-time from the acceleration sensor.

The accelerometer's dynamic range is +-8g.

When measuring accelerations an adjustable-frequency high-pass filter can be added to the measurement path. The high-pass filter is required to measure RMS vibration levels. Otherwise the measured RMS levels would be biased by the DC component. On the other hand, inclination measurements require the measurement of the DC component, so DO NOT use the high-pass filter for inclinations.

When measuring velocities, a high-pass filter is automatically placed in the signal path. The cutoff frequency is adjustable, and has an impact on velocity noise.

The instrument's power consumption is proportional to the sampling rate, and dependent upon whether the instrument is set to record raw signals or statistics.

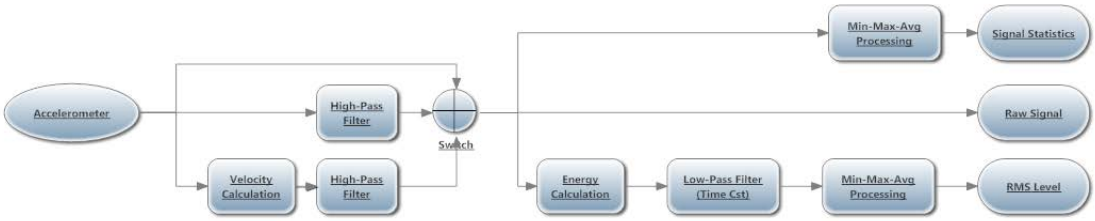


Figure 2 Signal Processing

Figure 2 shows the signal processing flow for one axis of the accelerometer.

The raw acceleration signal is sampled at an adjustable rate. The sampling rate can go up to 4 kHz.

The signal is then optionally high-pass filtered to remove the DC and low-frequency components. This is usually required to capture RMS vibration levels. The cutoff of the high-pass filter is adjustable. Alternately, the acceleration signal is digitally integrated to yield a velocity signal.

- In the *Raw-Signal* branch the signal (acceleration or velocity) is recorded at the sampling frequency.

- In the *Signal Statistics* branch *Min-Max-Avg* processing captures the min, max and average of the acceleration or velocity signal over an adjustable recording (log) interval. For each new interval the statistics are cleared, then the statistics are updated during the course of the interval, then at the end of the interval the statistics are recorded, and a new interval is started.

- In the *RMS-Level* branch the signal is squared to calculate the instantaneous power. The instantaneous power is low-pass-filtered with an adjustable time constant to produce an average. A short time constant provides an average that is capable of tracking fast transients, while a longer time constant provides a smoother and less noisy average. A typical fast time constant is around 100ms. While a typical long time constant is around 1s. Finally the square-root of the power is taken to present RMS vibration or velocity levels. The RMS vibration levels can be displayed in linear or dB scale.

- In the *Level-Statistics* branch *Min-Max-Avg* processing captures the min, max and average vibration levels over an adjustable recording interval. For each new interval the statistics are cleared, then the statistics are updated during the course of the interval, then at the end of the interval the statistics are recorded, and a new interval is started. The RMS vibration levels can be displayed in linear or dB scale.

Irrespective of the setting, the instrument always observes 100% of the acceleration samples.

6.5.2 Upper Frequency Limit

Figure 3 shows the response of the accelerometer structure and its acquisition chain, along the X and Y axes, at 4 kHz sampling rate.

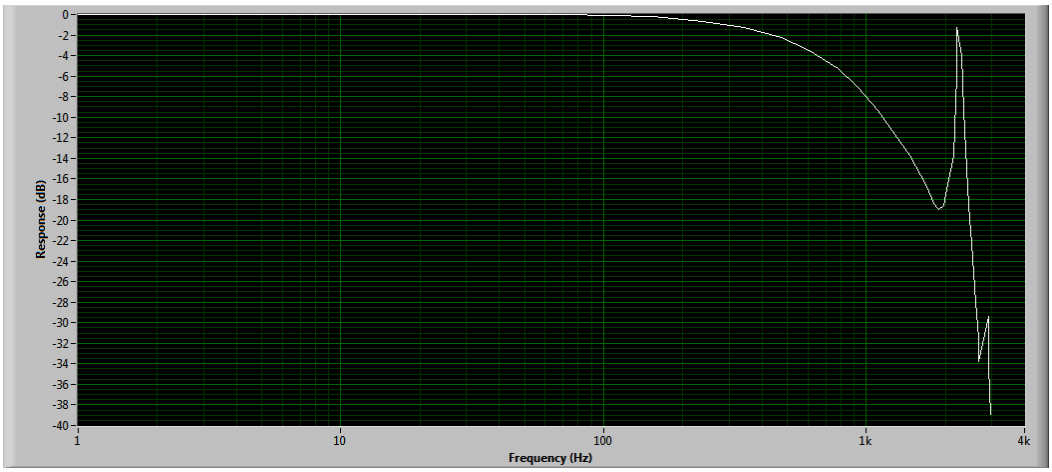


Figure 3 X and Y axes

Figure 4 shows the response of the accelerometer structure and its acquisition chain, along the Z axis, at 4 kHz sampling rate.

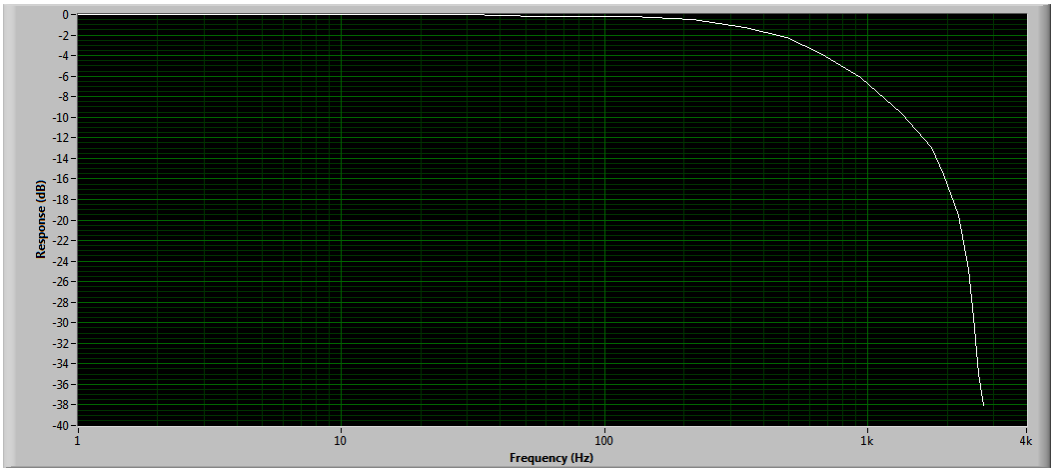


Figure 4 Z axis

6.5.3 Low-Frequency Limit

The low-frequency can optionally be limited by the digital high-pass filter. The cutoff frequency is adjustable, and can be adjusted to extremely low frequencies thanks to the filter's exceptionally high resolution. *Figure 5* shows the low-frequency response for a high-pass filter adjusted to 1 Hz, 5 Hz and 10 Hz, and operating at 4 kHz sampling frequency.

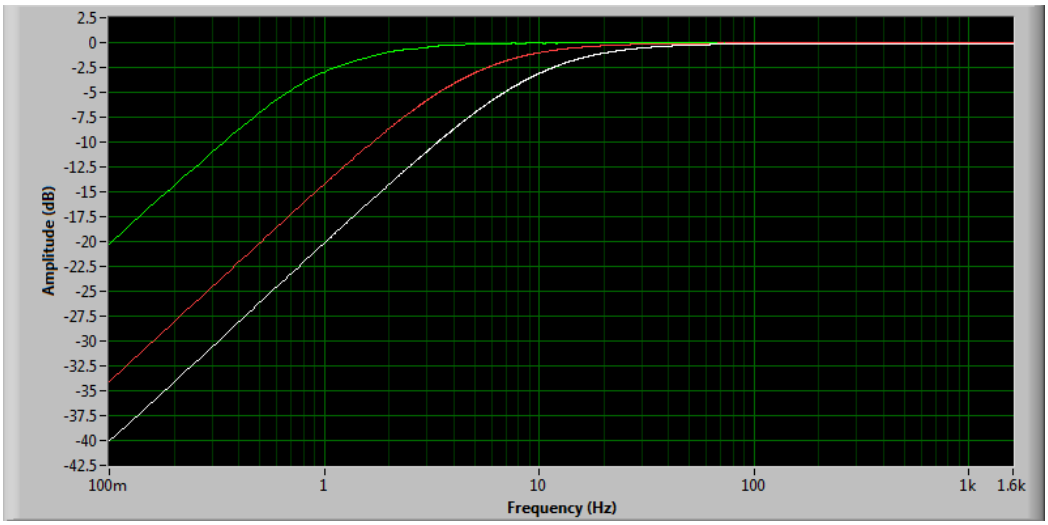


Figure 5 High-Pass Filter

6.5.4 Noise

6.5.4.1 Acceleration Noise

Figure 6 shows the RMS noise along the three axes, as a function of sampling frequency.

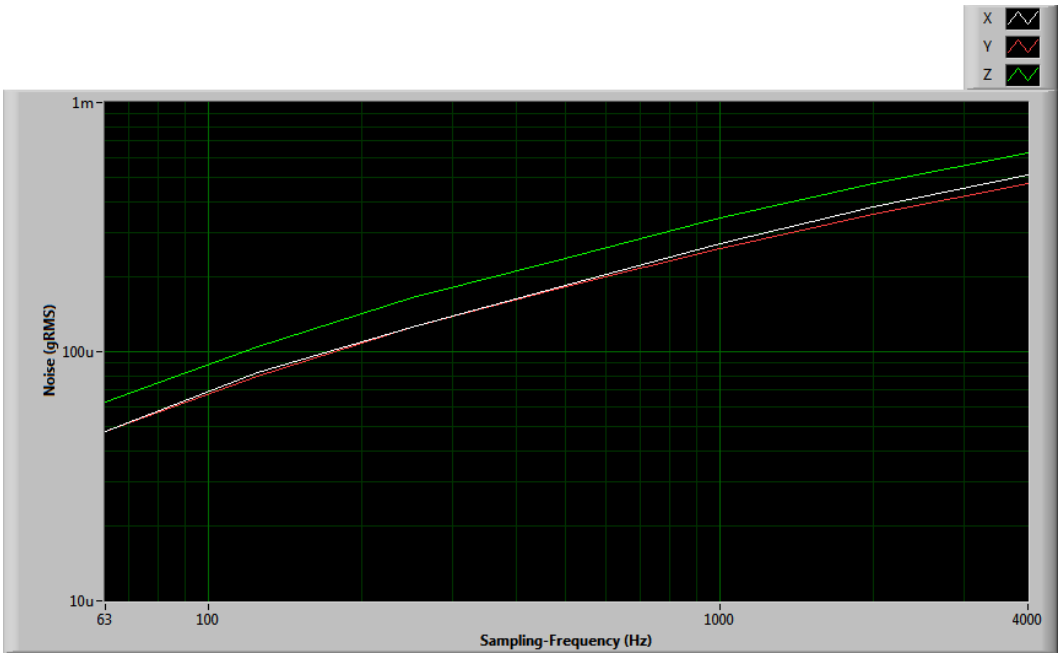


Figure 6

Figure 7 shows the acceleration noise spectrum when the accelerometer is sampling at 4 kHz.

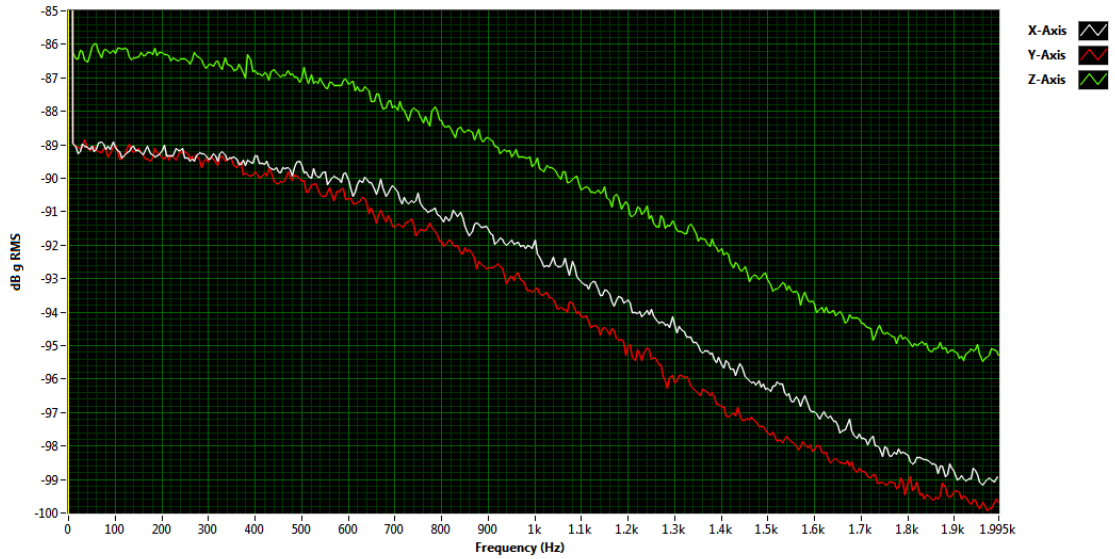


Figure 7

6.5.4.2 Velocity Noise

Figure 8 shows the RMS velocity noise as a function of the cutoff frequency of the high-pass filter. The velocity noise is not significantly influenced by sampling frequency.

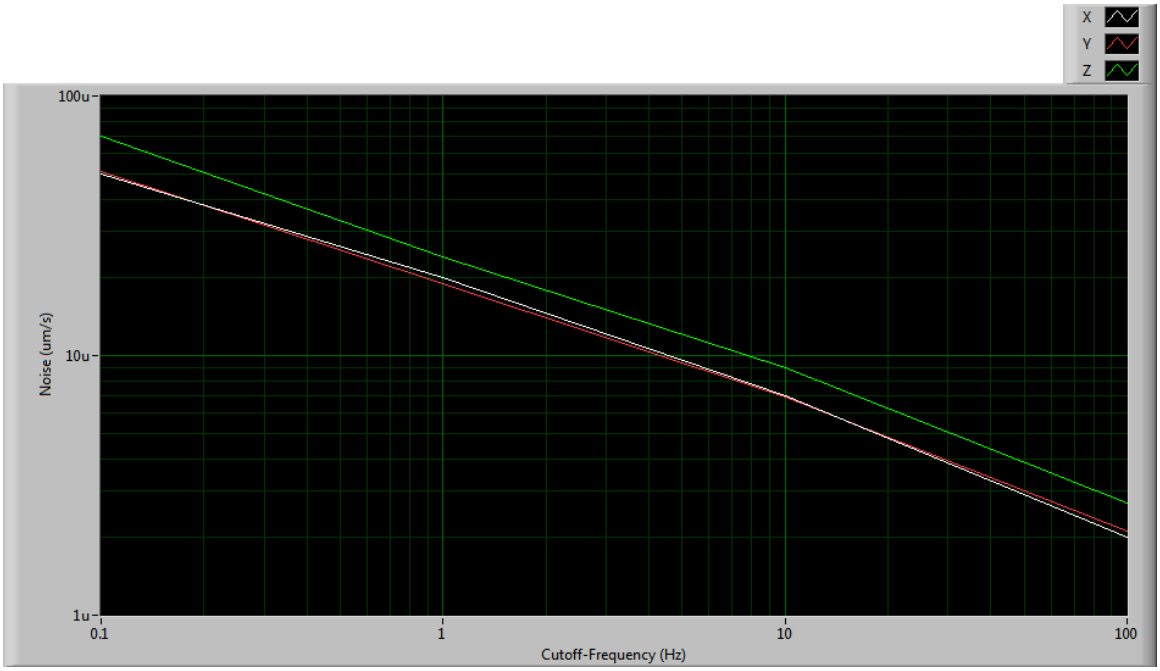


Figure 8

6.5.5 Sensor Dynamic Range

The sensor's dynamic range extends from -8 g to +8 g. The precise dynamic range is dependent upon the calibration and varies slightly from an individual instrument to the next.

6.6 Calibration

The calibration uses the earth's gravity as a 1g reference signal. The calibration procedure is completely automated and can be performed at any time. It requires the user to set the instrument in successive stable positions with its X, Y and Z axes aligned vertically while the instrument takes the reference measurements.

At any time the calibration can be checked by using the static acceleration measurements. The following procedure can be used to check the calibration:

1. Place the instrument in a position where the X axis is in the vertical position and axes Y and Z are horizontal. Read the static acceleration (Static tab in *Instrument_Manager*). If the calibration is correct the static acceleration along the X axis should be 1g. The static acceleration along the Y and Z axes should be 0g.

2. Place the instrument in a position where the Y axis is in the vertical position and axes X and Z are horizontal. Measure the static acceleration. If the calibration is correct the static acceleration along the Y axis should be 1g. The static acceleration along the X and Z axes should be 0g.

3. Place the instrument in a position where the Z axis is in the vertical position and axes X and Y are horizontal. Measure the static acceleration. If the calibration is correct the static acceleration along the Z axis should be 1g. The static acceleration along the X and Y axes should be 0g.

6.7 Scale

The records in a scale that is internal to the instrument. All data is re-scaled for display as selected by the user, whether it is g or m/s^2 for acceleration, or m/s for velocity, dB or linear. This way the data can be displayed in any scale irrespective of the scale selected at the time of the recording.

6.8 Inclinations

The instrument's inclination around the X and Y axes is not measured directly. It is calculated by the *Instrument_Manager* application, from the components of the earth's gravity along the three axes. So in order to display inclinations, the instrument must be setup to record acceleration statistics, and at least record the average accelerations along the X, Y and Z axes, with no high-pass filter.

After recording, the average accelerations along the X, Y and Z axes can be displayed by the *Instrument_Manager* application as individual-axis accelerations, or as inclinations.

Using the three components of acceleration along the X, Y and Z axes, the inclinations around the X and Y axes can be calculated. These are named:

- Tilt around the X axis: *Theta*

- Tilt around the Y axis: *Phi*

Theta and *Phi* are displayed in the *Static* tab, along with a graphical depiction of the instrument in real time.

In addition to the inclination angles, the application calculates the norm of the acceleration. If the instrument is stationary, and only subjected to slow changes in inclination, and is properly calibrated, the norm of the acceleration should always be constant and equal to 1*g.*

6.9 Manual Recording

A manual recording is started by pressing the *Record* button in the *Setup* tab of the *Instrument_Manager* application.

Every time a recording is started, a new record is created in memory and filled until the recording is stopped. That record is time-stamped, so the signals can be displayed with respect to absolute date/time. Records are stored sequentially in the instrument's memory. There is no limit to the number of records that the memory can contain, only a limit to the total size of the data recorded. The *Instrument_Manager* application displays the total memory recording time as a function of the various setup parameters.

After (or while) recording, the records contained in memory can be downloaded from the instrument and observed or exported. In case a recording is ongoing the last record is only displayed up to the present time.

The recording is stopped automatically when the recording memory is full. This way a new record will not overwrite an old one.

The recording memory is non-volatile, so there is no risk of losing the data that has already been recorded, even in the case of a battery failure.

Note: It is perfectly legal to find empty records in memory. That occurs typically when a recording is started and stopped quickly (for a time shorter than the log interval), before any data had time to be written to memory. In that case only the time-stamp is written to memory.

An empty record can also occur when a recording was started but no data was selected to be recorded.

To start a recording manually follow the steps below:

1. Select the type of signal (Acceleration or Velocity), and select the sampling frequency.

2. Select the type of data to record (raw signal, signal statistics or RMS levels). Select the axes and/or statistics to record.

3. Select the log-interval. Note that the total recording time is automatically calculated and displayed by the *Instrument_Manager* application, as a function of the log-interval and type of data selected. The log-interval is adjustable in 125 ms increments, from 125 ms up to 2H.

4. If recording RMS levels, select the time constant used to smooth the measured sound levels for *L-min* and *L-max*. Choose a time constant around 125 ms to be able to detect short transients. Choose a time constant around 1s to provide cleaner more stable RMS levels. Or adjust to another value, as required by the application.

5. When ready to start a recording immediately, simply press the *Record* button. Press *Record* again to stop the recording.

6.10 AutoRec Recording

AutoRec allows the recording to start when the signal measured passes a preset limit. The recording stops after the signal has been measured below the preset limit for at least equal the preset duration.

AutoRec is mainly used to record raw signals. When recording raw signals, the memory consumption grows very rapidly with time. So in order to monitor raw signals over a long time, only short segments can be captured at a time.

When statistics are being monitored, the instrument has enough memory to be able to record non-stop for weeks and months. So *AutoRec* is not really necessary.

AutoRec will capture a certain number of pre-trig samples (256 samples).

For instance *AutoRec* can be setup to:

- Start recording a raw acceleration signal whenever the acceleration passes 0.2g.
- Stop recording whenever the acceleration signal is < 0.2g for at least 10s.

AutoRec setup always requires two parameters:

- A threshold to start the recording (Acceleration or Velocity). The recording will start as soon as the signal passes the threshold.
- A minimum duration to stop the recording. The recording will stop after the preset duration has elapsed with the signal staying below the threshold.

The threshold is set in m/s^2 for accelerations, and in m/s for velocities.

The threshold applies to the raw signal if the instrument is set to record raw signal or signal statistics. In that case, the threshold value T defines a positive threshold $+T$ and a negative threshold $-T$. The recording starts whenever the raw signal goes outside of the interval $[-T, +T]$. When measuring acceleration signals without high-pass filter, the threshold is applied relative to the static acceleration at the time when *AutoRec* is started. This way it is also possible to trigger a recording when the tilt of the instrument changes by a predefined amount.

The threshold applies to the RMS level if the instrument is set to record RMS levels. In that case the threshold value defines a positive threshold $+T$. The recording starts whenever the RMS value goes outside of the interval $[0, +T]$

In order to trigger the recording, the signal must pass the threshold on any individual axis. For instance, if the instrument is set to record raw velocity signals the trigger value V represents a cube around the origin (0,0,0), with a side-length of $2V$.

7 *WiFi™* Connectivity

The ABC Mems supports a mode of operation where it periodically connects to a server (a Windows PC running the *Instrument_Listener* application) through *WiFi*™. This feature is designed to let the instrument record autonomously, periodically report the levels or signals recorded since the last connection, and optionally send emails with RMS-level or low-battery alerts. When set, this feature will work, even if the instrument is reset, or if it loses and regains battery power (for instance if the instrument is reconnected to a charger after the battery has been completely drained).

This PC-server being connected-to does not have to be in the vicinity of the instrument. It can be a continent apart, as long as it is reachable through the internet, and all firewalls have been set to allow the connection.

The instrument connects to a *WiFi*™ Router or *Access Point* that is in its vicinity. From there, it will find the server to connect to, either by its IP address, or by its domain name.

7.1 *WiFi™* Reporting

Note: When using the instrument with WiFi™ connectivity, do not start a recording manually, or via the timer. The instrument will be completely controlled by the server, including starting the recording, erasing memory if required, and resetting the time.

When using the *WiFi*™ feature, the instrument will try to connect to a known server at regular intervals, or immediately in case of alarm.

Whenever it connects the instrument will talk to a special *Instrument_Listener* application running on the server. That application will do the following:

- If the instrument is currently recording:
    - Upload the latest recorded data from the instrument and updates a growing file with that data (create the file if it was not already created).
- If the instrument is not currently recording (for instance if the recording was stopped earlier because the memory was full):
    - Upload the latest recorded data from the instrument (if any) and update the recording file.
    - Adjust the instrument time (does not adjust the time zone of the instrument, just precisely readjust the Universal-Time-Code running in the instrument).
    - Delete all data in the instrument's memory (all that data has already been safely stored in the recording file on the server).
    - Start a new recording, or Start the *AutoRec* mode.

7.2 Email Alarms

In addition to trying to connect to the server at regular intervals, the instrument will try to connect immediately to the email server in case of alarm. The alarm function does not require the use of a server or *Listener* application. The instrument will connect directly to an email server, such as a *gmail* account.

In order to be able to send an alarm email, the instrument must have the following setup:

- A *WiFi*™ Router or *Access Point* must be in the instrument's vicinity, and the instrument must have been configured with that router's connection parameters. That is part of the *WiFi Setup* of the instrument.
- The instrument must have been configured with an outgoing email account and connection parameters. That is part of the *Email Setup* of the instrument.

Two alarms can be enabled:

- A signal or level past a preset threshold. The threshold works exactly the same as the threshold used for *AutoRec,* but a different threshold can be specified. When the same threshold is used, the instrument will both:
    - Start a recording of the raw signal.

- Send an alert email.

- The battery is close to being depleted.

8 Instrument_Manager Application

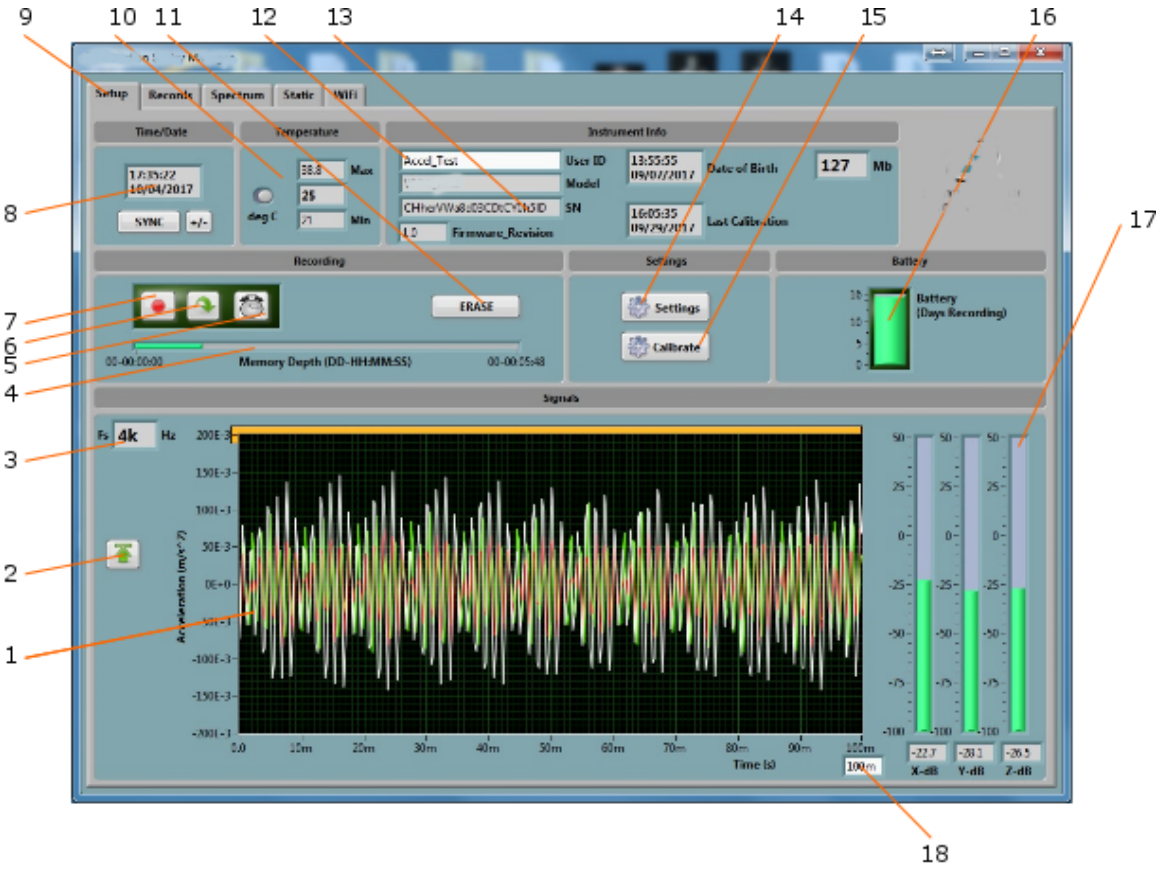


Figure 9 Setup Tab

1. Real-Time Signals
2. Auto-Range Button
3. Sampling Frequency Indicator
4. Memory Fill Indicator
5. Timer Button
6. AutoRec Button
7. Record Button
8. Instrument Time Indicator
9. Tab selector
10. Instrument Temperature Indicator
11. Erase Button
12. Instrument Custom ID
13. Instrument Information
14. Settings Button
15. Calibration Button
16. Battery Condition, Charge and Recording Time Field
17. RMS Level Indicators

18. Display Length

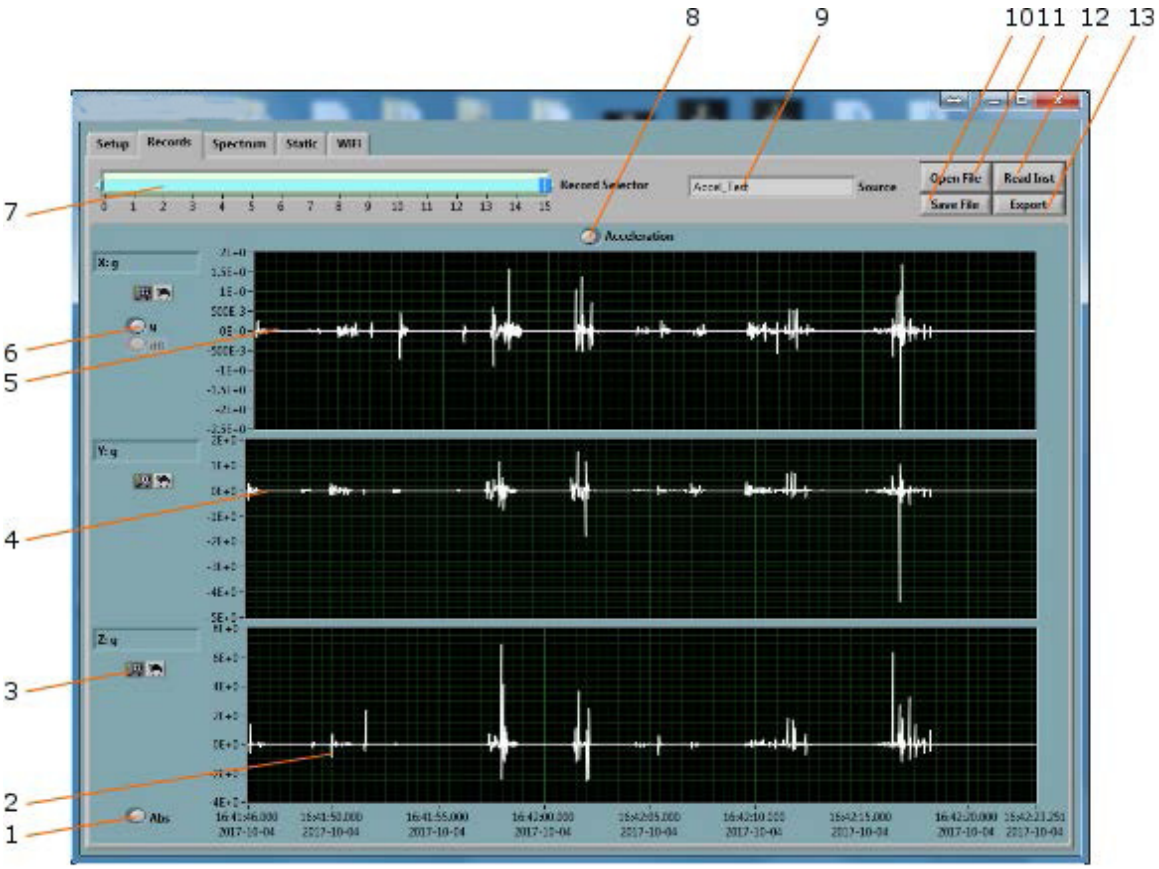


Figure 10 Record Tab

1. Absolute/Relative Time Scale Button
2. Z-Axis Recorded Data
3. Pan and Zoom Buttons
4. Y-Axis Recorded Data
5. X-axis Recorded Data
6. Scale Buttons
7. Record Number Selector
8. Acceleration/Inclination Display Mode
9. Data Source
10. File Save Button
11. File Open Button
12. Instrument Download Button
13. Export Button

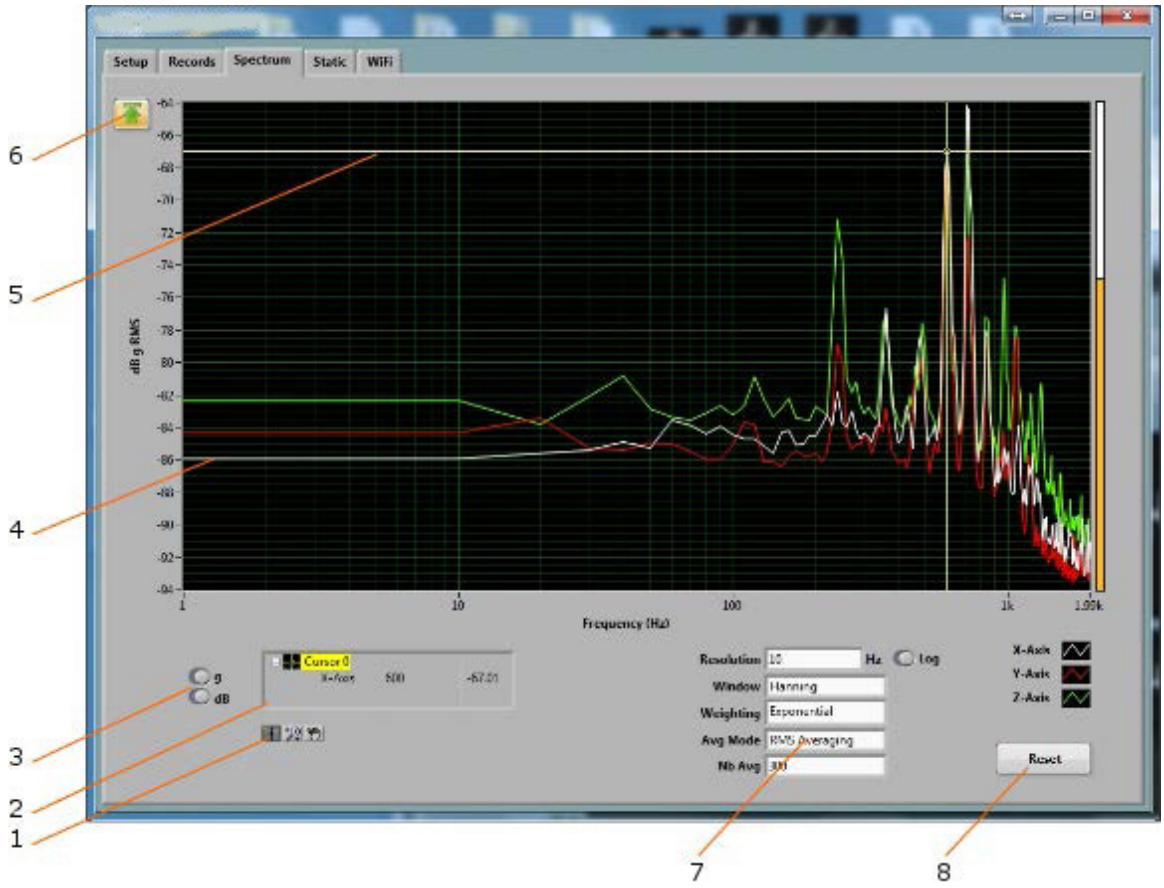


Figure 11 Spectrum Tab

1. Cursor, Zoom and Pan controls
2. Cursor values display
3. Scale buttons
4. Spectrum
5. Cursor
6. Auto-scale button
7. Spectral controls
8. Spectrum reset button

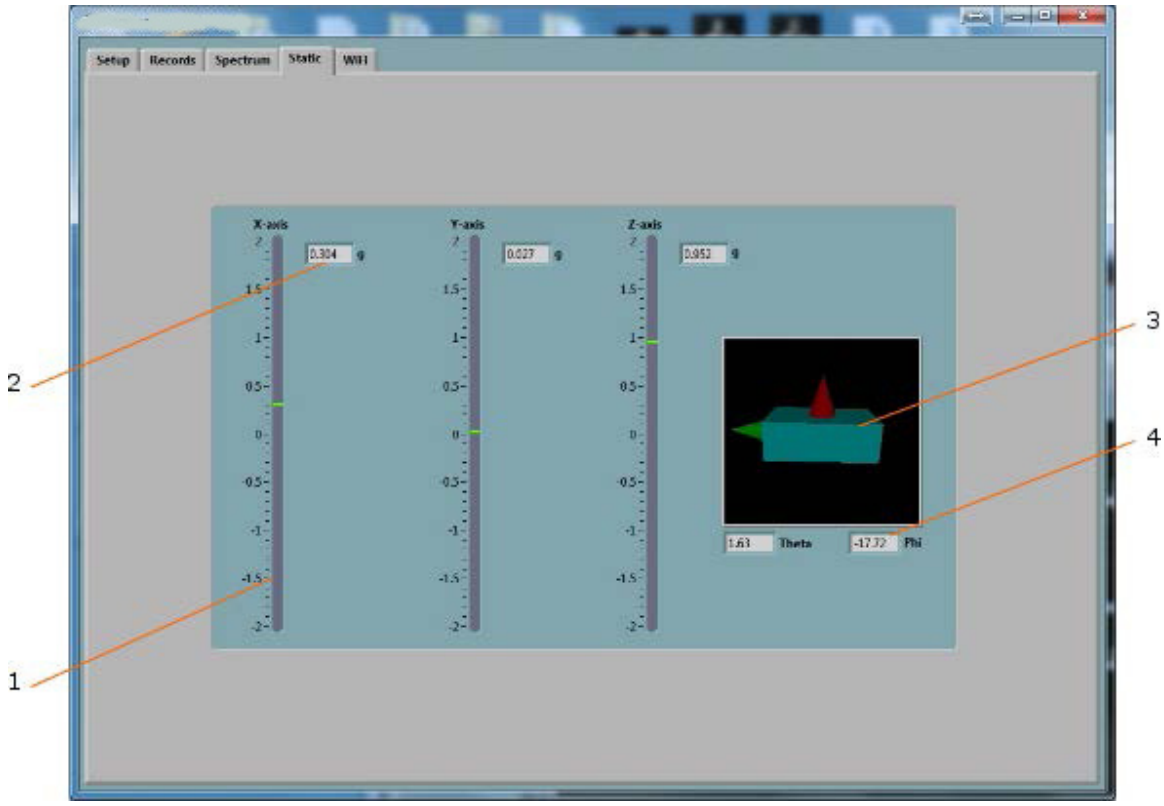


Figure 12 Static Tab

1. Static axis indicator
2. Static digital display
3. Inclinometer graphic display
4. Inclinometer angle displays

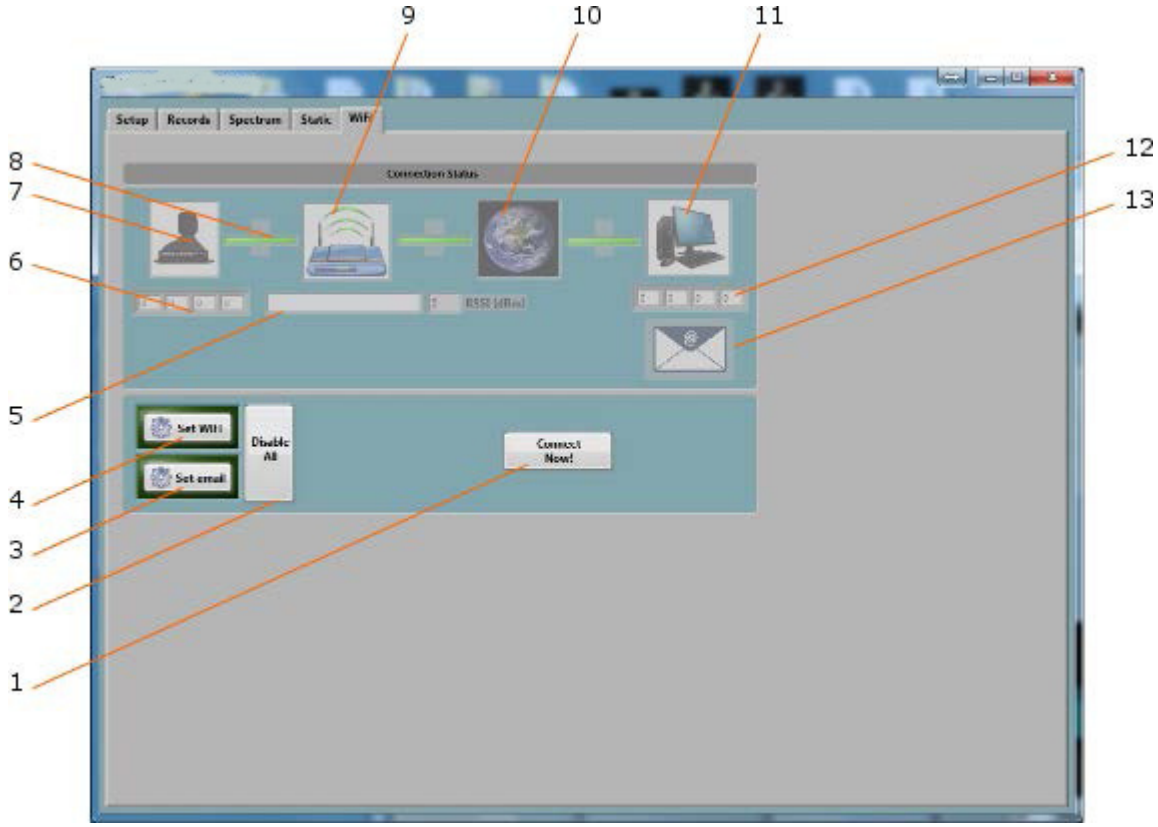


Figure 13 WiFi Tab

1. Connection Test Button
2. Disable All WiFi Button
3. Email Setup Button
4. WiFi Setup Button
5. Name (SSID) of WiFi Access Point or Router
6. IP Address of Instrument
7. Instrument WiFi Active Indicator
8. Link Indicator
9. Router or Access Point Connected Indicator
10. Network Connected Indicator
11. Server Connection Indicator
12. Server IP Address
13. Email Connection Indicator

8.1 Starting the Application

Note: The application can be run with or without an instrument connected. When an instrument is not connected the application can only be used to display and analyze a previously saved log file. All the controls and indicators related to the instrument are grayed out.

To control a ABC Mems using the *Instrument_Manager,* proceed as follows:

1. Connect the instrument to an available USB connector on the PC.

2. Make sure that the charge LED lights-up yellow or green, and that the operation LED starts blinking. If not, review the installation procedure, or see section ***Troubleshooting.***

3. Go to *Start\All-Programs\ABC_Instruments\Instrument_Manager*, and run *Instrument_Manager.exe*.

4. The front-panel described in ***Figure 9*** appears, and the application tries to connect to the instrument. If it fails to find the instrument it indicates *No Device Found*. If this is the case see section ***Troubleshooting***

5. Otherwise the application immediately starts communicating with the ABC Mems.

8.2 Main Functions

The application has five main tabs:

- **The *Setup* Tab:** Is used to setup the instrument and monitor real-time signal (see ***Figure 9***).
- **The Records Tab:** Is used to download, display and export the data from the meter (see ***Figure 10***).
- **The Spectrum Tab:** Is used to display a real-time power spectrum from the meter (see ***Figure 11***).
- **The Static Tab:** Is used to display static acceleration, inclination, and to check calibration against the acceleration of gravity (see ***Figure 12***).
- **The WiFi Tab:** Is used to display the present connection state of the meter and to setup its connection parameters (SSID, Security, Password…etc.) (see ***Figure 13***).

8.3 Setup Tab

The setup tab is seen in ***Figure 9***. It is divided into seven fields.

8.3.1 Time and Date Field

This field displays the internal time of the instrument. If the instrument time is not properly adjusted, press *Synchronize*. This synchronizes precisely the instrument time to the PC time. Make sure the PC time is accurate before synchronizing the instrument.

This field is also used to finely adjust the precision of the internal clock, if necessary.

Note: Time synchronization is not allowed while the instrument is recording.

8.3.2 Temperature Field

This field is used to display the instrument's internal temperature in ℃ or ℉. It is normal for the internal temperature to rise slightly while the instrument is charging.

8.3.3 Instrument Info Field

The instrument info field provides instrument information, such as instrument model, serial number and firmware revision. In addition the *User-ID* field may be used to assign a custom identifier to the instrument.

To set, modify or delete the *User-ID*, simply place the cursor in the *User-ID* box and write a new identifier or clear the text. The new identifier is written to the instrument's memory as soon as *return* or *enter* is pressed, or if the mouse is left-clicked outside of the box.

The *User-ID* is written to non-volatile memory, so it is retained even in the event of a reset or battery failure.

8.3.4 Recording Field

Note: When using the instrument with WiFi™ connectivity, do not use any of the controls in the Recording field. The instrument will be completely controlled by the server, including starting the recording, erasing memory if required, and resetting the time.

The recording field has three buttons:

- **Record** The *Record* button is used to immediately create a new record and start recording. The new record is placed in memory immediately after the last one. The recording stops when the memory is full, or when the *Record* button is pressed again. The recording parameters, such as number and types of values recorded…etc. must be adjusted prior to starting the recording.

- **AutoRec** The *Auto-Rec* button is used to place the instrument in or out of the *Auto-Rec* mode. In the *Auto-Rec* mode the instrument stays semi-dormant, sampling the acceleration or velocity in the background, as long as it does not detect an acceleration or velocity value beyond an adjustable threshold. When the signal value goes over the threshold, the instrument wakes up and starts recording, using the recording parameters in effect in the instrument's configuration. When the signal value goes and stays below the threshold for a set length of time, the recording stops and the instrument goes back to sleep. When the *Auto-Rec* mode is selected, the instrument will first wait for the signal to rise above the set threshold before starting the first recording. The next period of inactivity will stop the recording, and so on until the user exits the *Auto-Rec* mode, or the memory is exhausted. A new record is created every time the threshold is passed and the instrument is not already recording.

Note: The threshold is expressed in m/s^2 for acceleration and in m/s for velocity.

Note: The threshold T can only be positive. When recording raw signals or signal statistics the recording is triggered as soon as the signal goes higher than $+\mathrm{T}$, or lower than $-\mathrm{T}$. When recording RMS levels, the recording is started as soon as the RMS level goes higher than $+\mathrm{T}_{\mathrm{RMS}}$.

- **Timer** The *Timer* button is used to set a time and date to start the recording automatically. This is only allowed when a recording is not already in progress. To set the timer, press the *Timer* button. Then set the recording date and time, and press the *OK* button to arm the timer. The timer will start an immediate recording, or start the *AutoRec* mode, depending on the settings.

- **Erase** The *Erase* button erases unconditionally all the data that has been recorded in the instrument, making room for new records.

The *Memory Depth* bar provides two indications:

- The percentage of memory already used (indicated by the green bar). The bar is completely grey when the memory is empty and completely green when the memory is full.

- The total memory time, in Days-Hours-Minutes-Seconds. The total memory time is displayed at the right extremity of the scale. It is calculated as a function of the instrument settings, such as log interval, statistics recorded…etc. Therefore it will change dynamically as the settings are modified, to reflect the new overall memory time.

8.3.4.1 Timer Setting

When the *Timer* button is pressed, the timer settings panel appears.

Either use the direct entry field (***Figure 14*** (4)), or press the *Calendar View* button (***Figure 14*** (3)) to set the date and time when the recording must start.

Press the *OK* button to exit and arm the timer.

Press the *Cancel* button, or the *Window-Close* button to exit without arming the timer.

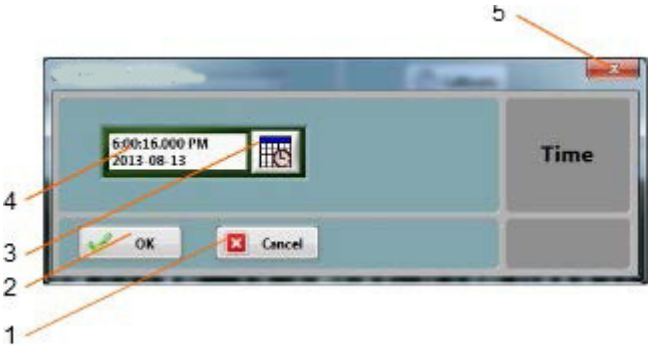


Figure 14 Timer Settings Panel

1. Cancel button – Closes the window without arming the timer
2. OK button – Closes the window and arms the timer
3. Calendar button – Brings the calendar view to enter date and time
4. Date/Time field – Can be used to enter date and time directly
5. Window close button - Closes the window without arming the timer

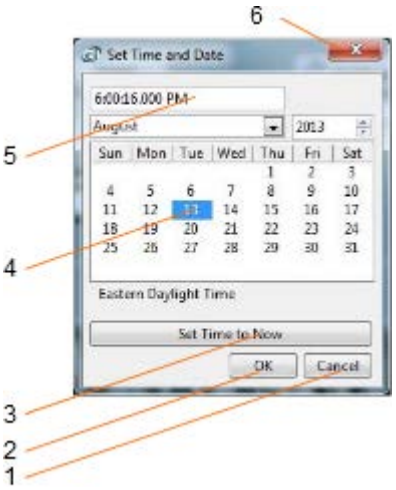


Figure 15 Calendar View

1. Cancel button – Closes the window without changing the date/time setting
2. OK button – Closes the window and accepts the newly set date/time
3. Set to Now button – Set the time and date to the present time

4. Date setting field – Click a date to set
5. Time setting field – Use the field to set a new time
6. Window close button - Closes the window without changing the date/time setting

8.3.5 Settings Field

The settings field contains the *Settings* and *Calibration* buttons.

8.3.5.1 Instrument Settings Panel

The instrument settings panel opens when the user presses the *Settings* button. Changing the settings is only allowed when the instrument is not actively recording.

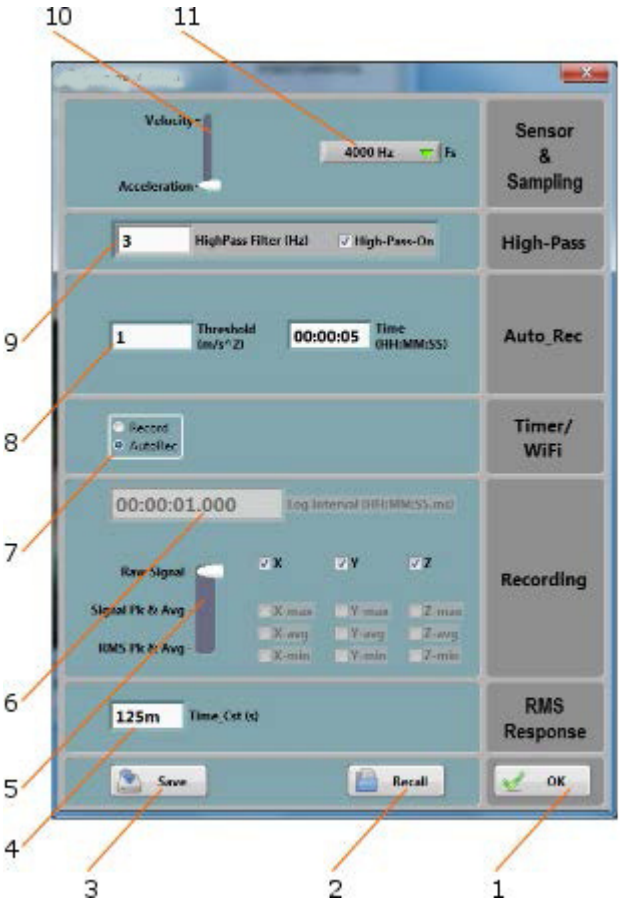


Figure 16 Instrument Settings Panel

1. OK button – Saves the settings and closes the window
2. Recall button – Calls back settings previously saved to a file
3. Save button – Saves to a file the settings presently displayed
4. Time constant for RMS level smoothing
5. Record type selector - Axes to record
6. Log interval setting
7. Timer action. This is also the action taken when the recording is triggered via *WiFi*™
8. Auto-Rec threshold and inactivity duration setting
9. High-Pass filter frequency and On/Off control
10. Signal type selector
11. Sampling frequency

8.3.5.1.1 Sampling Frequency

The sampling frequency can be adjusted up to 4 kHz. The power consumption while recording is roughly proportional to the sampling frequency. The *Battery* scale in the *Setup* panel indicates how long the instrument can record for as a function of sampling frequency.

When recording raw signals the amount of memory consumed is proportional to the sampling frequency. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the overall recording time as a function of the selection.

8.3.5.1.2 High-Pass Filter

The high-pass filter can be selected or deselected by clicking on the checkmark. The field on the left is used to adjust the cutoff frequency. Thanks to its very high resolution, the high-pass filter can be adjusted to frequencies that are extremely low relative to the sampling frequency.

8.3.5.1.3 Auto-Rec Settings

These settings adjust the trigger threshold and the inactivity period. Once the instrument is placed in *Auto-Rec* mode it switches between two states:

- **Waiting for activity** While in inactive mode the instrument waits for activity. Activity is defined as “signal that transitions through the threshold on at least one axis”. The signal must be below, then above the threshold to trigger the recording. When activity is detected the instrument creates a new record and starts recording. The threshold is the same on all axes.

- **Waiting for inactivity** While recording, the instrument waits for inactivity. Inactivity is defined as “signal that stays below the threshold on all three axes for a time longer than the inactivity period”. When inactivity is detected the instrument stops the ongoing recording. Therefore the inactivity time defines the minimum amount of time that the instrument will record, once triggered. The recording will keep going if the signal keeps passing the threshold while the recoding is ongoing.

8.3.5.1.4 Timer/ *WiFi™* Operation

This control defines the action to take when the timer is engaged, or if the recoding is started via *WiFi*™ through the server. The choices are:

- Record: The recording will start once the timer has reached the specified time and date.

- Auto-Rec: The instrument will go to Auto-Rec mode once the timer has reached the specified time and date.

8.3.5.1.5 Log Interval

The log interval defines the time between two successive recorded points when the instrument is recording signal statistics or RMS level statistics. When recording either type of statistics the min, max and average are reset at the beginning of each log interval. Then the instrument observes the signals or levels for the duration of the log interval, and updates the min, max and averages accordingly. At the end of the log interval the selected statistics are written to memory. Then the next log interval is started… and so on until the recording is stopped or the memory is exhausted.

The log interval is only relevant when recording statistics. When recording raw signals the time between two successive samples is simply the sampling period.

The log interval can be adjusted from 125 ms to 2 H in increments of 125 ms.

When recording statistics the amount of memory consumed is inversely proportional to the log interval. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the overall recording time as a function of the selection.

8.3.5.1.6 Signal Selectors

The *Record-Type* selector specifies whether raw signals, signal statistics or RMS level statistics are being recorded.

In either case the user must choose the axes, and optionally the types of statistics to record. To select or deselect an axis or statistic, simply press on the corresponding checkmark.

Note: In order to record inclinations select "Acceleration", then select "Signal Statistics" and select at least the X-avg, Y-avg and Z-avg selectors. The inclinations are calculated from those acceleration measurements.

The amount of memory consumed while recording is proportional to the number of channels and statistics selected. The *Memory-Depth* indicator in the *Setup* panel automatically calculates the total recording time as a function of the selection.

8.3.5.1.7 Low-Pass Time Constant

When recording RMS level statistics, the instantaneous RMS signal is low-pass-filtered with an adjustable time constant.

The time constant is only relevant when recording RMS level statistics, and is only used to detect min and max values. The average is calculated by a rectangular integration over the log interval. A shorter time constant should be chosen to detect sharp transients. Otherwise the measurements will be smoothed out. On the other hand, when the RMS levels are slowly varying, a longer time constant will provide more precise values.

Typical fast time constants are 100 ms and under.

Typical slow time constants are 1s and over.

8.3.5.1.8 Closing the Window

The adjustments are only implemented when the *OK* button is pressed. In order to forego any changes, simply close the window without pressing *OK*.

If any setting requires the user's attention a warning window is open to display the warning. The settings are still in effect though, and the user can either heed the warning and go back and modify the settings, or ignore the warning and leave them as they are.

8.3.5.2 Calibration

Pressing the *Calibrate* button launches the calibration procedure. Once the calibration is started simply follow the on-screen instructions to accurately calibrate the instrument. The calibration can be performed at any time. The calibration requires the instrument to be placed in three different positions, successively placing one of its axes in the vertical position, while the other two stay horizontal.

8.3.6 Battery Field

This battery condition field indicates the remaining battery capacity. The indicator is surrounded by a yellow indicator that lights-up when the battery is charging.

The battery condition indicator is scaled to indicate the approximate number of days of recording time remaining in the battery.

8.3.7 Signals Field

The vibration levels measurement field provides information about the current acceleration or velocity signals and RMS levels.

- The graph presents the instantaneous signals as they are measured in real-time. The *Fs* indicator to the left of the graph shows the sampling frequency in effect. The *duration* control on the right of the horizontal scale selects the duration of the time segment to display. The maximum is the equivalent of 2048 points.
- When pressed, the vertical auto-scale button allows the scale to be dynamically adjusted so that all the signals fit in the graph. When released, the scale is fixed. When using a fixed scale, the scale can be adjusted manually by double-clicking and writing new values directly in the top-most and bottom-most marker values of the vertical scale. Acceleration signals are displayed in m/s^2. Velocity signals are displayed in m/s. The effect of the high-pass filter, if it is in effect, is taken into account in the display. The orange bar at the top of the graph shows the progressive filling of the capture buffer. When operating at high sampling frequencies the bar is usually always full. However when operating at low sampling frequencies, with a large number of points it may take a long time to fill the buffer for display. The bar provides a visual indication that the buffer is filling-up.
- The three bars to the right of the graph show the RMS levels measured on the X, Y and Z axes. The RMS levels are presented in dBm/s^2 for acceleration, and in dBm/s for velocity. Note that the effect of the high-pass filter is taken into account in the displayed values. RMS levels should not normally include DC levels. In order to exclude the DC levels, the high-pass filter must be activated.

8.4 Records Tab

The *Records* tab is seen in ***Figure 10***. It is used to retrieve the recorded information from the meter or from a saved file, and to display and optionally export the recorded logs.

8.4.1 Instrument Download

To download data from the instrument press the *Read-Inst* button. The whole contents of the instrument's memory are downloaded, and the newest record is displayed in the graph.

The *Record Selector* at the top-left of the page (***Figure 10*** (7)) indicates how many records have been downloaded. It shows one separate tick per record downloaded. Use the blue slider to select the desired record. When selecting a record the indication *No-Data* is displayed on top of any empty graph.

Note: It is legal for a record to contain no data at all. This may mean that the recording was started and stopped before any data had time to be recorded. It can also be the case if no data type was selected to be recorded. In such a case the time-stamp is still valid and can be used to determine when that recording occurred.

The *Source* indicator shows the *User-ID* of the instrument, if any has been set.

The time scale can be displayed in absolute (date/time) or relative (fractional seconds) format. The absolute format exposes the time-stamp that was written in memory with the record. Relative time is more useful when examining raw signals.

When viewing acceleration data, the scale can be chosen as g or m/s^2, in linear or dB scale for RMS values.

When viewing velocity data the scale is m/s, in linear or dB scale for RMS values.

By default the graphs display signals or RMS levels on a per-axis basis. But when the *Acceleration/Inclination* button is set to *Inclination*, and if the recording includes the average acceleration along the three axes, the graphs combine the acceleration components and show:

- The norm of the acceleration on the top-most graph. This is normally 1g if the instrument is stationary and only subjected to changes in inclination.
- The *Theta* tilt around the X-axis on the middle graph. The inclination is presented in degrees.
- The *Phi* tilt around the Y-axis on the bottom-most graph. The inclination is presented in degrees.

8.4.2 File Save

Pressing the *Save File* button saves all the records downloaded from the instrument to a file on the PC. In addition to the whole contents of the recording memory the file also contains ancillary information, such as calibration, instrument information…etc.

The file is saved in a proprietary format with the extension *.cil*.

By default the file is saved with a name that contains the *User-ID* of the instrument, as well as the present date and time.

8.4.3 File Open

Pressing the *Open File* button recalls all the records previously saved to a *.cil* or *.wlg* file. The function works very much like the *Instrument Download* function, except that the data comes from a previously saved file.

Two types of files can be opened and displayed:

- **.cil** This type of file is created by the *Instrument_Manager* application. It contains all the data that has been downloaded from the instrument.
- **.wlg** This type of file is created by the *Instrument_Listener* application. It contains data that is sent by an instrument over the network.

The *Source* field shows the *User-ID* of the instrument the data comes from.

That function works even when no instrument is connected to the PC, so it can be used to examine data that was recorded elsewhere and sent to the user as a file.

8.4.4 Exporting Data

The data of the record being viewed can be exported for further display or processing. Depending on the type of record two formats can be chosen from:

- If the record contains raw signals, the data can be exported to either *.wav* or *tab-delimited text* format. The *.wav* format is preferred when dealing with a large quantity of data because it provides a smaller, more efficient storage. When exporting as *.wav* a separate file is created for every axis present in the record.

- If the record contains raw signals, the data can also be exported to a tab-delimited text format that can be easily opened by spreadsheet applications such as Excel. In that case the user should be mindful of the quantity of points contained in the record. The text formatting can easily produce files of huge sizes.

- If the record contains RMS levels or signal statistics the data can only be exported to a tab-delimited text format.

8.4.5 Graph Controls

All graphs can be adjusted using the following techniques:

8.4.5.1 Zoom Controls

To the left of each graph is a two-button control. The left-most looks like a magnifying glass. It is used to zoom-in and zoom-out the corresponding graph. To use it, simply press the button, and choose one of the following zoom functions:

- Zoom X-Y
- Zoom X
- Zoom Y
- Zoom-Extents

After choosing the function, the cursor changes to a magnifying glass. Click and drag on the graph to apply the required zoom.

Keep in mind that each graph has a separate zoom and pan function. Select the proper function for the particular graph you are interested in before applying it. Make sure that the cursor changes to the proper function when the mouse is hovered on top of the graph.

Note that all three graphs are always synchronized along the X scale. Whatever zoom is applied to the X-scale over one graph is always applied to the other two. This way the X-scale is always the same for the three graphs.

8.4.5.2 Pan Controls

To pan a graph left, right up or down, first press on the *Hand* button to the left of the particular graph you are interested in. Then position the mouse over the graph. Left-click to “grab” the graph, and move the mouse to pan the graph as desired.

8.4.5.3 X-Y-Scale Direct Modification

Another way to zoom a graph is to directly change its scale. To do that, simply click on the value for left-most or right-most marker of the X-scale, and select its value. Type a new value to replace the old one. The scale is adjusted so that that new value is used at the beginning or end of the scale.

The same technique can be applied to the bottom-most or top-most values of the Y-scale of each graph.

8.5 Spectrum Tab

The *Spectrum* tab is shown on ***Figure 11***. When that tab is selected the time-domain signals captured by the instrument are presented in the form of averaged power spectra. The processing is as follows:

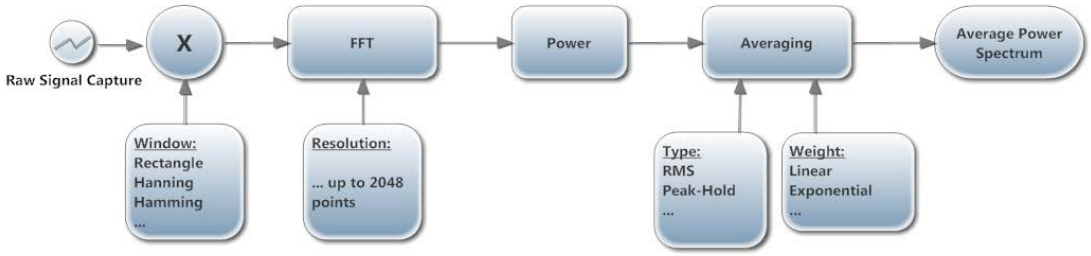


Figure 17

8.5.1 Resolution

The resolution is specified in terms of frequency separation between two adjacent spectrum points. The smaller the frequency resolution, the longer the time window will be. The actual resolution is chosen as the closest achievable value.

8.5.2 Window

The type of window chosen has an impact on the spectral resolution. The *Hanning* window is generally a good choice that provides good spectral selectivity.

8.5.3 Weighting

The weighting can be exponential or linear.

- **Exponential Averaging** is comparable to a low-pass time filtering of the spectrum. In other words each spectral line is low-pass filtered so that the resulting spectrum is smoothed out over time. In that case the *Nb_Avg* represents an equivalent averaging time constant, expressed in number of successive spectra. The averaging is continuous and does not stop. Each successive spectrum is taken into account in the calculation. A larger value of *Nb_Avg* produces a spectrum that is more stable, but also averages-out short-lived transients.

- **Linear Averaging** takes an equal-weight average of *Nb_Avg* successive spectra. After the *Nb_Avg* spectra have been observed the result is frozen.

In both cases the *Reset* button discards the present display and restarts the averaging from zero.

8.5.4 Avg Mode

The *Averaging Mode* can be chosen from several choices:

- **RMS Averaging** RMS averaging reduces signal fluctuations but not the noise floor. The noise floor is not reduced because RMS averaging averages the power of the signal. *RMS Averaging* is the most common type.

- **Peak-Hold** Peak hold averaging retains the peak levels of the measured spectra. Peak hold averaging is performed at each frequency line separately, retaining peak levels from one FFT record to the next.

Note: All the FFT calculations are performed on the PC. The raw time-signals are transferred from the instrument to the PC, where the FFT and averaging calculations are performed.

8.5.5 Scale

The power spectra can be displayed in *g* or m/s^2 scale for acceleration, and in *m/s* for velocity. The scale can be chosen linear or dB. Changing the scale does not restart the averaging It just displays the same data in a different scale.

8.5.6 Cursor, Zoom and Pan

A cursor can be used to precisely measure the frequency and amplitude of a particular spectral point. In order to use the cursor proceed as follows:

- Press on the button that looks like a cross (see ***Figure 11***(1))

- Place the mouse over the point where the X and Y cursor lines meet and left-click. This grabs the cursor.

- Drag the cursor to the spectrum curve and frequency of interest. The cursor can jump from one curve to the other.

- Read the X and Y values in the cursor field underneath the graph.

Zooming and Panning is done the same way as in the *Records* graphs. See section ***Graph Controls***. The auto-scale button can be pressed or released to obtain an automatic or fixed scale. When the graph is in fixed scale, writing directly in the values of the end-scale markers sets the scale to fit those values, in the X as well as Y scales.

8.6 Static Tab

The static tab is seen in ***Figure 12***. It displays the measured static acceleration along the three axes. This can be used to verify the calibration. When a particular axis is vertical and the instrument is not moving, the measured static acceleration along that axis should be precisely 1g.

The static tab also shows a graphic depiction of the instrument's inclination, as well as the tilt angles around the X and Y axes.

8.7 *WiFi* Tab

The *WiFi* tab has all the indicators showing the instrument's present state of connection, as well as controls to configure *WiFi*™and email settings.

8.7.1 Connection Status

8.7.1.1 Levels of Connection

When trying to connect, either at the preset interval, or for an email alarm, the instrument will do it in two stages:

- The instrument first tries to connect to a *WiFi*™ router or access-point in its vicinity.
- Once connected to the network through the router or access-point, the instrument will then try to connect to a server (either the specified email server, or the server running the *Listener* application, depending if it is for an alarm or part of the regular reporting of recorded data. The server connection can be done to a specified IP address, or to a domain name. Connecting using a domain name is preferable because IP addresses are often subject to change.

The instrument has a total time of 1 minute to go through the two stages. If the final stage is not established by the end of that minute, the instrument stops trying in order to preserve battery. It will then retry at the next preset interval, or if a new email alarm is triggered.

Note: In order to maximize data throughput and minimize power consumption, it is best to locate the router or access point close to the instrument so WiFi™ communications are reliable.

Note: If the Instrument_Listener application is not running on the server, the instrument will not be able to download any data. Email alarms however can still work because they rely on a different email server (gmail account for instance).

*Note: The panel shown in **Figure 13** will display the progression of the connection. It is designed to help debug connection problems*

The *Connection Status* field indicates graphically the different stages of connection. Each icon (7, 8, 9, 10 and 11 in ***Figure 13***) indicates a different connection stage:

- Indicator 11 or 13 blinking: The instrument is initiating a connection to report data or send an email respectively.
- Indicator 7 Active: The instrument is actively trying to connect to a Router or Access-Point.
- Indicators 7, 8, 9 Active: The instrument is connected to a Router or Access Point. In this case the SSID of the Router or Access Point is written in indicator 5.
- Indicators 7, 8, 9, 10 Active: The instrument is connected to the network.
- Indicators 7 to 11/13 Active: The instrument has connected to the server and is talking to the *Instrument_Listener* application or the specified email server. In that case the server's IP address is written in indicator 12.

8.7.2 WiFi Settings

The *WiFi*™ settings panel appears when the *Set WiFi* button is pressed. The *WiFi*™ settings are used to configure the Router(s) or Access Point(s) to connect to, the Server's IP address or domain name, and the periodic connection schedule.

Note: The Router and Access Point connection parameters must be set in order to send emails, even if no WiFi™ reporting is active or required.

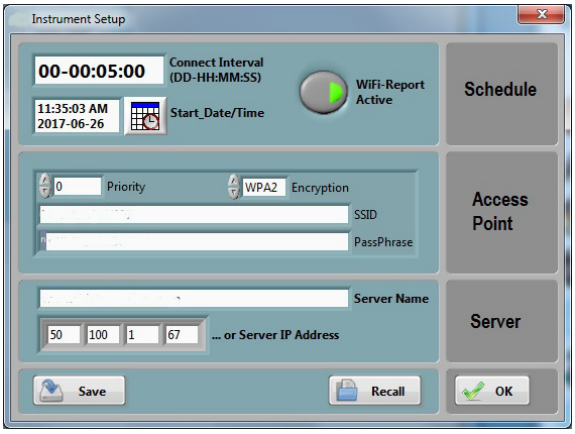


Figure 18 WiFi Settings

8.7.2.1 Schedule

Whether it is recording or idle, the instrument can activate its *WiFi*™ interface and try to connect to a server at regular intervals. The connection schedule is defined in that field. In order to enable that behavior, the following must be setup:

- The Connect Interval must be set: The interval is often chosen as once per hour, or once per 10 min. Setting too short an interval (lower than 5 min) will drain the battery faster. Setting too long an interval (several days, a week or more) will risk losing data if the connection cannot be established at its scheduled time. The interval must not be set to 0. We do not advise setting a schedule interval lower than 2 min.

- The *WiFi-Report-Active* button must be pressed: When the button is released the instrument will not try to connect at the set interval.

- A start date and time must be set sometime in the future: The periodic connection attempts will only begin at the set date and time.

8.7.2.2 Access Point

The coordinates of the access point or *WiFi*™ router can be set, with its security method, password, and priority. A router or access point is defined by its *SSID*.

When security is used, a password must be set and the proper security method in effect for that router must be set (WEP, WPA or WPA2). The security is often WPA or WPA2 nowadays because it offers improved security.

Note: By clicking on the little grey block at the left of the pass-phrase field, several input methods can be selected:

- *Password (P) is used to conceal the password being entered*
- *Hex (H) is normally used in conjunction with WEP security*
- *Normal (N) is normally used in conjunction with WPA and WPA2 security. This is the default.*

8.7.2.3 Server

The server can be defined by its IP address, or its domain name. This server can reside on the local network, or on the internet. Once the instrument is connected to the access point, it will attempt to contact the IP address or domain name of the server. A domain name is often used in conjunction with a DDNS service. This allows the IP address of the server to change over time, without affecting the connection.

Note: When the server is not on the local network, the configuration of the router it is connected to is more complicated. See section ***8.7.4****.*

8.7.3 Manual Connection

In order to test the *WiFi*™ connection, after setting up the Router or Access-Point and/or the server's IP address or domain name, but prior to setting a connection schedule, press the *Connect-Now* button. The connection status will show that the instrument is immediately trying to connect, and will show all the connection stages in sequence.

In order for the last stage (Server Connected) to be reached the server must be working, must be reachable, and must be running the *Instrument_Listener* application.

8.7.4 Setting Up the Server to Work in a Local or Wide Area Network.

Setting up a server to run on the same local network the instrument is in is relatively easy. In addition to the steps above, one should make sure of the following:

- If the server is contacted by its IP address, the IP address of the PC working as a server must be fixed. To that end, the router that the PC is connected to must be set to use "Static DHCP" for that PC. This way the IP address will not change over time.
- The PC working as a server must be always on, and must be running the *Instrument_Listener*. Otherwise the connection can't be established when the instrument tries to connect.

Setting up a server to work in a Wide Area Network (in a different city for instance) is a little more complicated. One option is to use a corporate server running the *Instrument_Listener*. In that case it usually makes sense to use a domain name to represent the server's address.

When the server is a simple PC in an office, the following configuration may be used:

- The router that the PC is connected to is configured for "Port Forwarding". Port Forwarding must be enabled on port 50 000, for TCP/IP, to the local IP address of the PC.
- Static DHCP must be configured on that PC, so its local IP address will not change.
- Ideally the router must be setup to use a DDNS service, such as *noip.com*. This way the instrument can use a domain name registered through the DDNS service in order to contact

the server. Alternately the instrument's server setup can use the WAN IP address of the router that the server is connected to. That is a less optimal solution because that WAN IP address is often subject to change by the internet provider, and when it changes the instrument won't be able to connect to the server anymore.

8.7.5 Email Setup

Email alarms can be setup by pressing the *Set* email button.

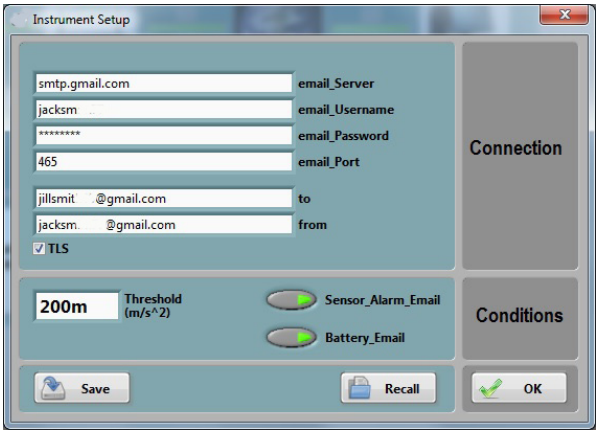


Figure 19 Email Setup

Email alarms require the following conditions:

- The *WiFi*™ setup must have already been done so the instrument can connect to a router or access point. However a connection schedule does not need to be in effect for the emails to work.
- That router or access point must be connected to the internet.
- The user must have an email account to use for outgoing email. A good solution is to use a *gmail* account.

The email setup is not always easy.

The complete email setup is similar to the configuration of any email application. It includes the following:

- **Email server** The internet name of the outgoing email server. For gmail this is *smtp.gmail.com*
- **Port number** The TCP port number of the email service. This is usually:
  - o **25** for an "open" (no security) account.
  - o **465** for SSL security
  - o **587** for TLS security

  For gmail this is port 587 or 465.
- **User-name** The account name. For gmail it is the user's account name (part of the email address to the left of the @ sign).

- **Password** The account password (leave blank for an “open” (no security) account). For *gmail,* this is the password to gain access to the account.
- **TLS** The encryption setting. This is the only secure mode supported. Uncheck for an “open” (no encryption) account. For *gmail* this should be set.

In addition to these settings, the email alarms settings let you set:

- **One Recipient** The recipient line (*to* line in ***Figure 19***).
- **The sender’s address**

The application by default shows the settings for a fictitious secure *gmail* account (see ***Figure 19***). These settings of course need to be changed to reflect the user’s own email account settings and recipient email address.

Two types of alarms can be sent:

- An alarm when a threshold is exceeded. That threshold works exactly the same way as the *AutoRec* threshold. If it is set to the same value as the *AutoRec* threshold, the instrument will both start a recording of the signals, and send an email when the signal goes above the threshold.

- An alarm when the battery level is too low. The level cannot be adjusted. It is set so the instrument has enough reserves to send the alarm.

8.7.6 *WiFi™* Battery Drain

Connecting to a network drains the battery. Even if the instrument is idle, if the periodic connection is enabled, the instrument will regularly wake up and attempt to connect to the server. Trying to connect at regular intervals will drain the battery in a short amount of time.

When that behavior is unwanted (for instance when the instrument is unused and in storage) pressing the *Disable All* button (see 4 ***Figure 13***) will completely disable *WiFi*™ and email connectivity. If the instrument is idle with all its *WiFi*™ connectivity disabled, it can keep its battery for at least 6 months.

9 Instrument_Listener Application

In order to report recorded data, and send alarm emails, the instrument must connect to a remote PC (a server) that is running the *Instrument_Listener* application. The *Instrument_Listener_Installer_Vxxx* must be installed on the PC (*Vxxx* represents the version number of that application).

The remote PC (the server) must:

- Be on
- Be reachable over the network, either by an instrument on the local network, or on a global network. All firewalls must allow the server to receive incoming connections.
- Be running the *Instrument_Listener* application. It may be useful to setup that application so that it runs automatically when the PC boots.

The *Instrument_Listener* application (see ***Figure 20***) always listens to incoming connection attempts from instruments in the field. Whenever an instrument tries to connect, it opens a *Server* window (see ***Figure 21***). That window briefly opens to show the communications with the instrument, battery level and temperature. It manages all operations that the instrument needs to perform and then closes back down.

Note: When several instruments try to connect at the same time, the Instrument_Listener application will open multiple ABC_Server windows.



Figure 20 Instrument_Listener Application

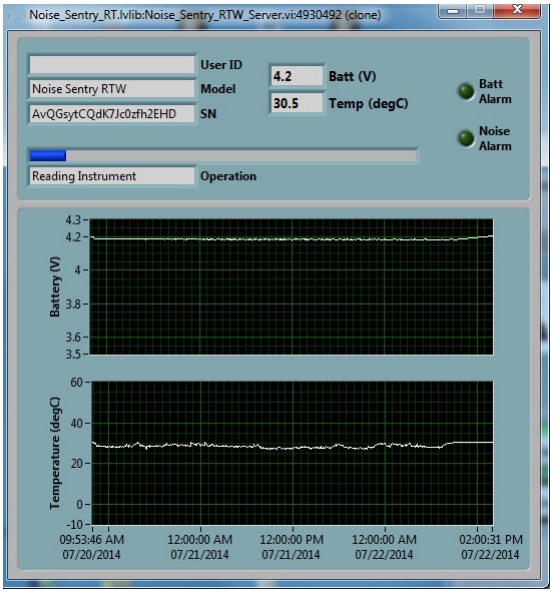


Figure 21 ABC_Server Window

The ABC_*Server* window performs the following operations:

- If data is in the instrument, it creates a *.wlg* file to hold that data, or appends the data to the file if one has already been created.
- If the instrument is not currently recording, it then erases the instrument's memory, adjusts the time, and starts recording. If the instrument is recording it closes as is and lets the recording continue.

9.1 File Storage

The *.wlg* files that are created by the ABC_Server are stored by default in *C:\Users\username\Documents\ABC_Instruments\All_Instruments\Records\ABC-Mems*,

where *username* is the name of the user currently logged. In the context of a particular user's account, this folder is normally designated:

Libraries\Documents\My Documents\ABC_Instruments\All_Instruments\Records\ABC-Mems

These *.wlg* files can be opened for viewing by the *Instrument_Manager* application.

10 Maintenance

10.1 Battery Care

The following factors affect battery life:

- Prolonged use at extreme temperatures (close to the limits of *-20 °C and +60 °C (-4 °F to 140 °F)* will shorten the life of the battery.
- Over-discharge of the battery will shorten the life of the battery. Always fully recharge the battery when it is low or at least every 6 months, whichever comes first.
- Never leave the instrument in storage with the *WiFi*™ set to periodically connect.

10.2 Reset Procedure

In the unlikely case where the instrument's firmware crashes a hardware reset can be performed by inserting a small rod into the reset hole and pushing until a slight click is felt. There is no risk of losing any recorded data or settings by resetting the instrument. However a hardware reset will reset the instrument's time and date to a value in year 1903.

10.3 Operation Outdoors

Thanks to its potted construction, the meter is weather-proof. It can safely be used outdoors provided that the temperature is always within the safe limits. However when using it outdoors with a risk of rain or snow, make sure its USB connector is facing down, so water will not accumulate in the connector and microphone port.

10.4 Dust

Dirt can accumulate into the USB connector. Tolerances on that connector are very tight. So if dirt and debris are in the connector, forcing the male part into it may damage the connector. Never force a micro-USB plug into the USB socket in the instrument. If resistance is felt, try to expel debris by blowing compressed air in the connector.

10.5 Cleaning

Use a damp sponge or soft cloth.

Note: Do not use solvents. *Do not submerge in water.*

10.6 Software and Firmware Upgrades

After upgrading the software, if a firmware upgrade is required it will be applied automatically when the upgraded *Instrument_Manager* application is started. In that case do not disconnect the instrument until the upgrade is completely over. Failure to do that will place the instrument in a state where it no longer works.

Note: A firmware upgrade will not lose any recorded data, but may reset some of the instrument's settings.

Note: When upgrading the instrument's firmware always make sure that only one instrument is connected to the PC at a time.

11 Troubleshooting

11.1 USB Power Limitation

In some instances a PC will not allow the instrument to connect to one of its USB ports because it cannot provide the battery charge current requested by the instrument. If you suspect that this may be a factor, try connecting the instrument to the output of an externally-powered USB hub that is capable of providing a full USB load (500 mA). Alternately, recharge the instrument using a USB charger.

11.2 USB Driver Installation

If the *Instrument_Manager* application is unable to communicate with the meter it may be because the USB driver failed to install properly. To check the USB driver installation follow the procedure below:

1. Disconnect the USB cable.
2. If necessary take the PC out of stand-by.
3. Reconnect the instrument to an available USB port on the PC.
4. Make sure the charge LED lights-up green (charged) or yellow (charging). If not, make sure that the PC's USB port is functional and that the USB cable is not damaged. If necessary try on a different PC, and/or with a different USB cable. The charge LED is just an indication that the port is powered. It should light-up, even if the USB driver is not installed properly.
5. Make sure that the operation LED starts blinking. If not go to step 6.
6. Open the *Device Manager* on the PC. This is usually found in *Control Panel – System and Maintenance*.
7. Just after connecting the instrument to the PC, observe that the *Device Manager* window refreshes.
8. Verify that an item named *DDCI Platform* or ABC-Mems has been created in the list of devices.
9. If an unknown item appears, or an item named *DDCI Platform* or ABC-Mems is found but has an exclamation mark (indicating a problem) beside it, disconnect the device and try re-installing the driver (see step 10).

10. To re-install the driver disconnect the *instrument from the PC*. Then Go into *Start\All Programs\Convergence_Instruments\Instrument_Manager\Driver*, and run *DDCI_Driver_Install.exe*. This re-installs the USB driver.

11.3 Connection Problems

Failure to communicate with the PC can also be caused by poor USB cable contacts. Make sure the USB connector is fully inserted into the socket of the meter. Inspect the inside of the socket in the instrument. If dirt is lodged in the socket, use dry compressed air to expel it.