



**SMD Pyroelectric Infrared  
CO<sub>2</sub> Gas Sensing Evaluation Kit  
USEQGSK3000000**

**User Guide  
Rev. 3.1**

**JUN 2020**

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## 1 INTRODUCTION

This document describes the KEMET SMD CO<sub>2</sub> Gas Sensing Evaluation Kit USEQGSK3000000 that enables simple and efficient data capture from KEMET SMD packaged sensor components USEQ\*S. These high performance thin film pyroelectric sensor products are typically used in NDIR gas sensing systems.

The purpose of the kit is to enable engineers and technicians to carry out a simple and effective evaluation of KEMET SMD sensors, to capture measured data and send it to a PC. The kit is based on the STM32F303K8T6 microcontroller.

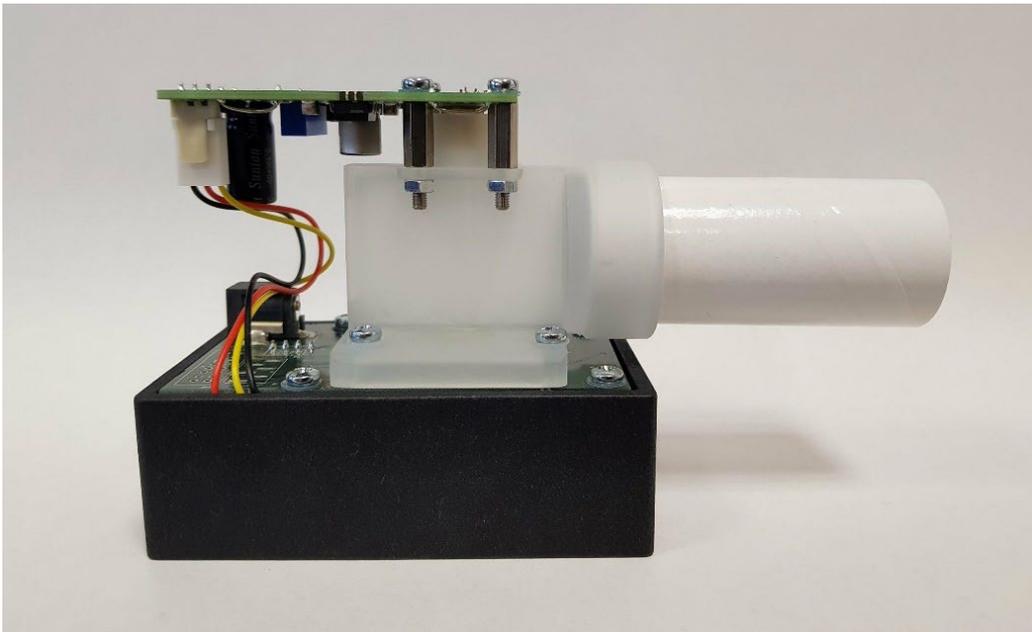


Figure 1 – SMD CO<sub>2</sub> Gas Sensing Evaluation Kit USEQGSK3000000

## 2 GETTING STARTED

### 2.1 Kit Contents

1. PCB with STM32F303K8T6 microcontroller
2. 2 sensors: USEQFSEA391180 and USEQGSEAC82180
3. KEMET emitter drive PCB, with KEMET TO39 emitter
4. 3d printed gas cell
5. Breathing tubes
6. 9V DC power supply
7. Micro USB cable
8. USB drive with software and documentation

### 2.2 Minimum System Requirements

1. Microsoft® Windows
2. 2 GB of RAM
3. 450 MB of available hard-disk space for installation, additional free space required for storing CSV files
4. 1024x768 display (1280x1024 recommended)
5. Local administrative rights to install device drivers
6. .NET Framework 4.5
7. 1 free USB port

### 3 INSTALLATION

#### 3.1 Installing the KEMET Gas Sensing Evaluation Tool Software

From the software pack included with the kit, select the “setup.exe” file that has this icon. This will start the installation process.

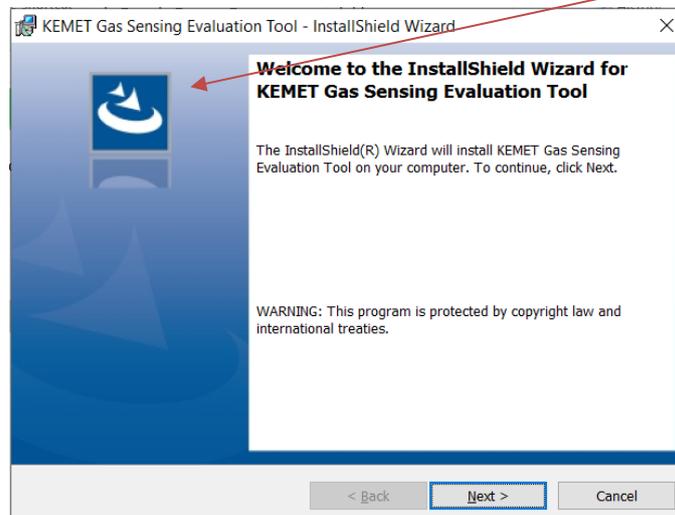


Figure 2 – Installer Screen

Follow the on screen instructions and enter the information required.

As part of the installation process a check will take place to see if .NET Framework 4.5 is present. If not, the setup routine can be cancelled and the .NET framework 4.5 can be downloaded from Microsoft’s website.

A driver is needed for the STM32F303K8T6 microcontroller. This is included in the software package.

#### 3.2 Installing the ST Microcontroller USB Driver

The USB supplied contains a folder called “en.stsw-link009.zip”. Extract the files and run either the application “dpinst\_amd64.exe” if you have a 64bit system or “dpinst\_x86.exe” if you have a 32 bit system. This will install the USB driver for the ST microcontroller that is connected to the SMD board.

Once the driver has been installed the USB cable can be connected between the SMD Board and the computer.

Once connected the green light on the SMD board will be on constantly and the red light will flash (The microcontroller is the inverse of this, red is on constantly and green flashes).

#### 3.3 Installing .NET 4.5 Framework

If you do not have the .NET 4.5 framework installed on your computer then use the installer provided (“dotnetfx45\_full\_x86\_x64”) in the software package.

#### 3.4 Connecting the SMD Gas Sensing Evaluation Kit

1. Connect the USB cable to the kit and Windows PC
2. Connect the power supply provided to the KEMET PCB

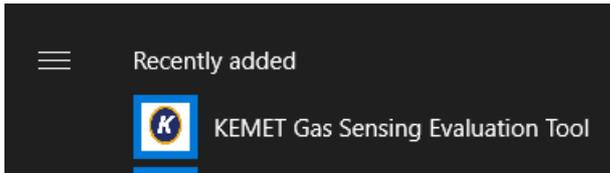
You may see a message suggesting you are required to install a device driver. Follow the on screen instructions and download a driver from Windows Update or install from the software package provided.

## 4 SOFTWARE USER GUIDE

The KEMET Gas Sensing Evaluation Tool Data Capture software runs on Microsoft Windows PCs and communicates with the evaluation PCB, which enables easy testing of KEMET USEQ\*S SMD packaged sensors. The software provides an interface to devices. Additional signal processing algorithms to filter and analyse sensor output for NDIR gas sensing are provided.

### 4.1 Starting the Software

To start the software select the following from the windows start button in your task bar:



This will open up the KEMET sensor data capture main screen as shown below:

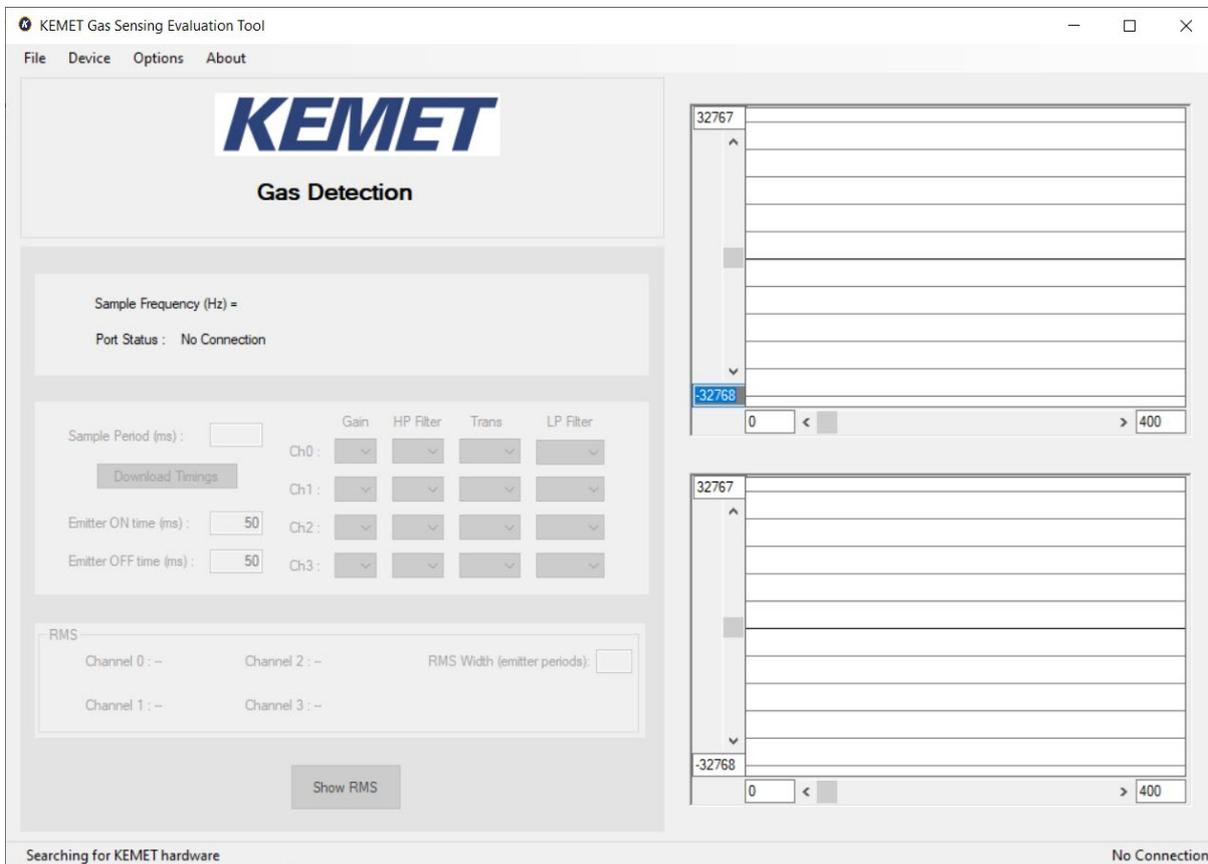


Figure 3 – Gas Sensing Evaluation Tool Main Application Window

## 4.2 Connecting Software to the Data Capture Board

To connect to the data capture board make sure the board is powered and connected to the PC through the USB cable.

From the menu bar select the “Device” option and then “COMXX : Sensor firmware vxxx” (or the current version number of firmware) as shown below.

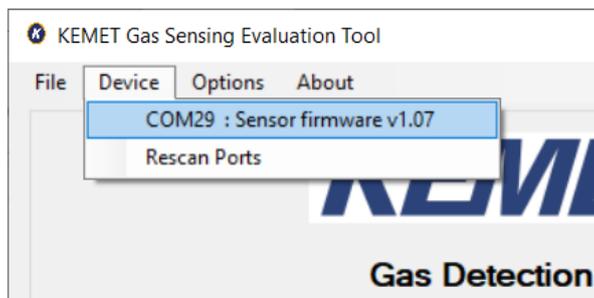


Figure 4 – Detector Connection

If the device does not show up then click Rescan Ports.

Select the device. If the device does not show up or connection fails then unplug both the USB cable and the 9 V supply and reconnect, then repeat the steps above.

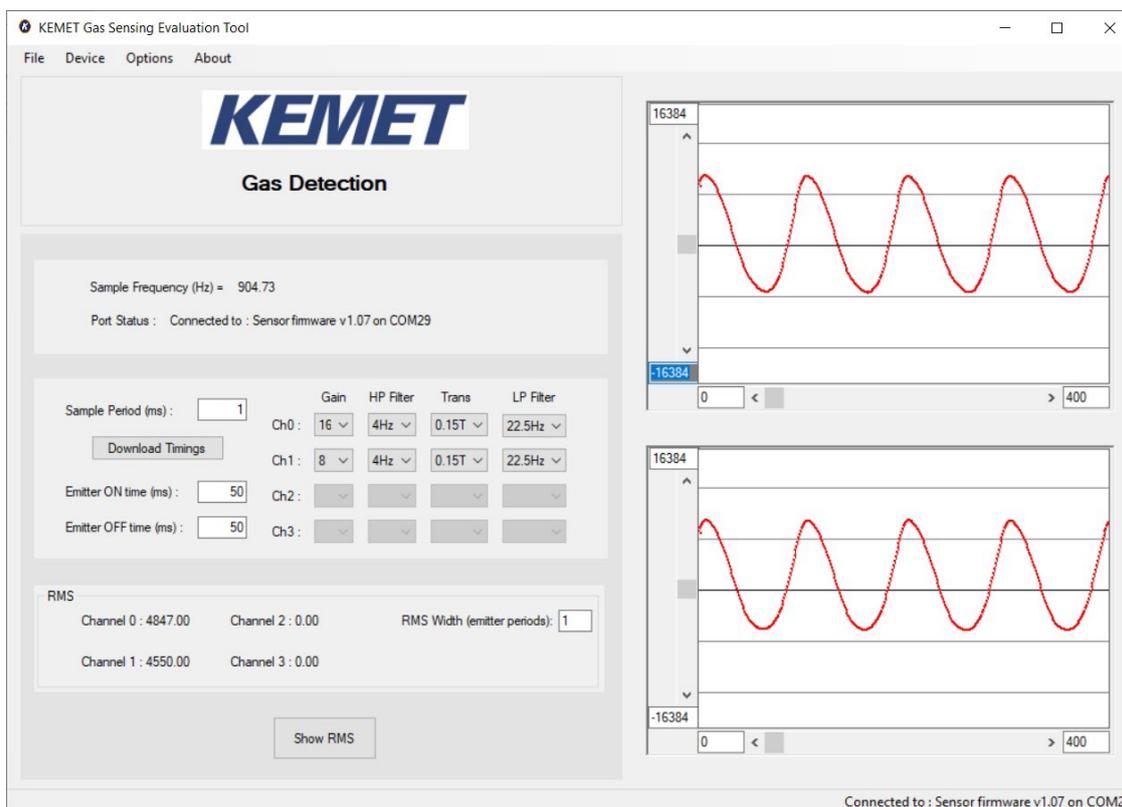


Figure 5 – Main Application Window

If the data capture board is connected to the required com port, the status bar at the bottom of the main display will show the message “Connected to: Sensor firmware Vxxx on COMXX” on the right side, and the left will show the data capture board firmware version.

### 4.3 Data Capture Board Control

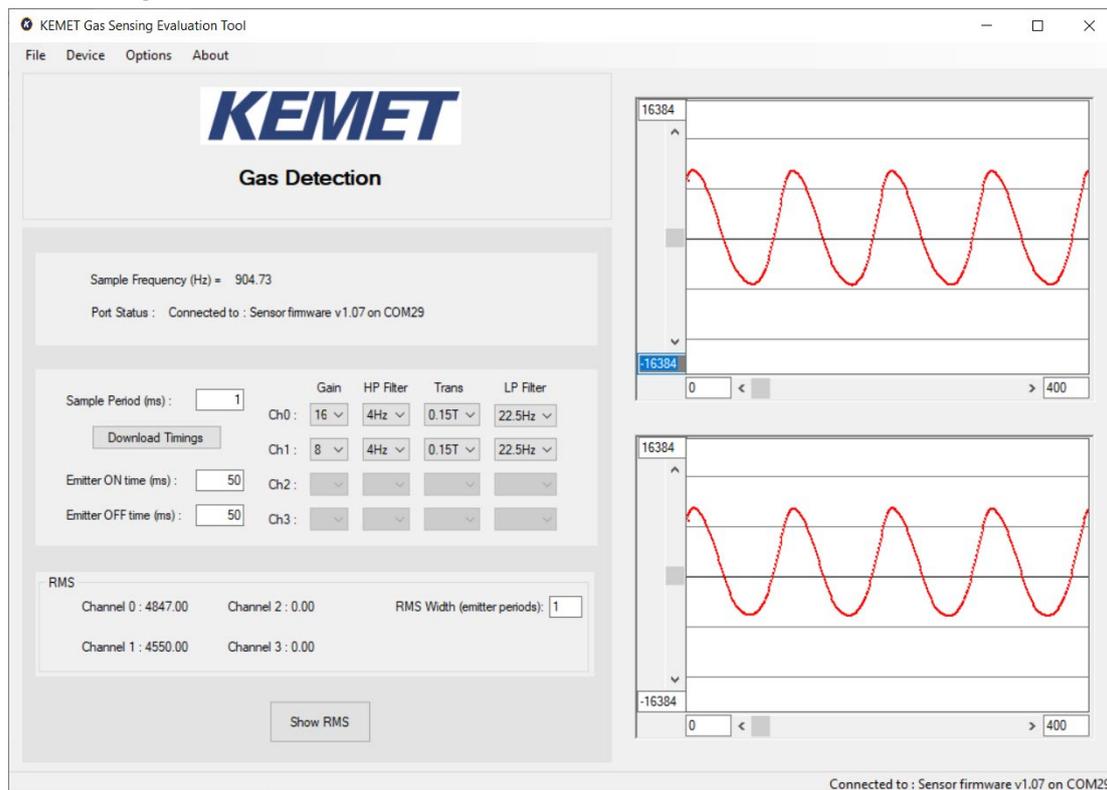


Figure 6 – Data Capture Board Control Window

The current settings used on the data capture board are displayed and the root mean square (RMS) values update at a rate depending on filter width and emitter frequency.

#### 4.3.1 Data Capture Settings

It is possible to change some of the settings on the data capture board and also the filter calculations through the interface. The settings from the drop-down lists update the board immediately once the change takes place and the settings in the boxes update when “Download Settings” is pressed. If the value is invalid or out of range, an error message is displayed and the text box is cleared.

The settings internal to the SMD are described below:

**Gain:** values from 1 to 64 are useable as the gains for each channel.

**High Pass Filter:** The hi-pass filter allows signal filtering within the SMD package before transmitting data to the MCU.

**Trans-impedance:** The trans-impedance setting is used to set the resistance of the feedback resistor in the gain amplifier. It works together with the capacitance value chosen to set the time constant of the amplifier through the RC response of the two parameters.

**Low Pass Filter:** The low-pass filter allows signal filtering within the SMD package before transmitting data to the MCU.

**Control board settings:**

**Emitter frequency:** The frequency is set by choosing the ON and OFF times for the emitter. The initial settings of 50 ms on both provides a 10 Hz emitter frequency.

**4.3.2 RMS Values**

This section displays the RMS (root mean square) output of each sensor channel calculated to the specified filter widths.



Figure 7 – RMS Result Section

The values are updated when the calculations are complete for each set of data, with a rate that should match the displayed response rate. The response rate is determined by the filter width over the emitter frequency and is displayed in seconds. Inactive channels simply show a value of 0.

**4.3.3 RMS Width Value**

Setting the RMS width larger will produce more stable but slower to respond output and conversely setting the RMS width smaller will create a less stable but faster responding output. Which one is best will depend on your application.

#### 4.4 Viewing Data on the Scope

While the software is connected to a data capture board, it is possible to view the data sampled in real time. Virtual oscilloscopes are provided for each channel and can be shown or hidden by selecting “Oscilloscope Full View” or “Oscilloscopes Normal View” respectively from “Options” in the menu bar.

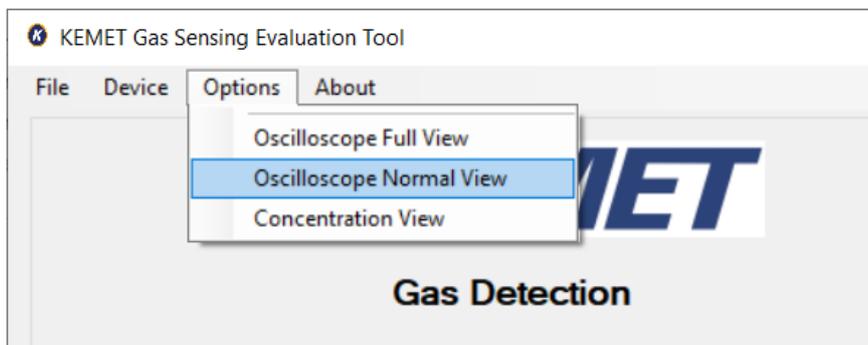


Figure 8 – View Options

The oscilloscope window has several features which emulate a basic oscilloscope for viewing live sampled data. It can be adjusted to display the desired range on both the y-axis (amplitude) and the x-axis (time domain).

The number of oscilloscope windows displayed is equivalent to the number of channels selected and will change every time the number of active channels changes.

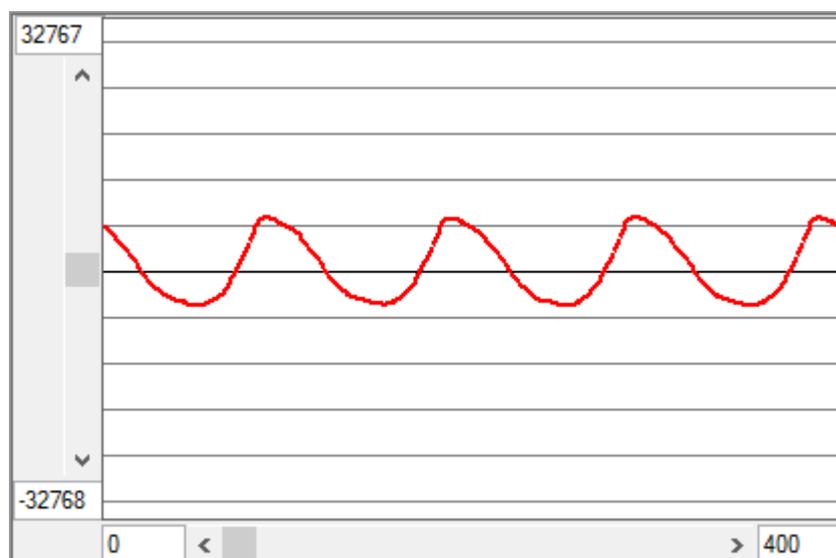


Figure 9: Oscilloscope Window Normal View

The scales can be changed by clicking on the x or y axis value and typing in a new value then pressing enter.

The properties option, which is accessed by right clicking on the scopes graphing area, allows the user to enable or disable the horizontal grid lines and also set the spacing in A-D counts.

## 4.5 Selecting CSV Options

The software allows the user to select which types of data processing to be performed on the raw data to then be written to files.

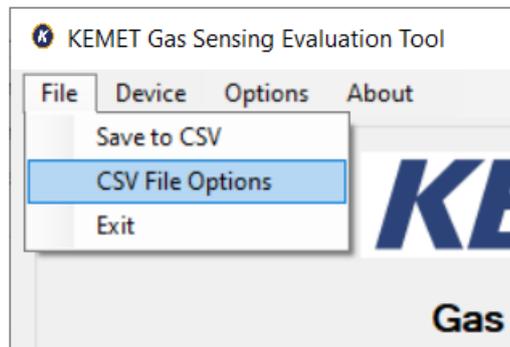


Figure 10 – CSV File Options

Clicking on this option in the drop-down menu will provide the user with a set of check boxes to allow them to choose which types of data processing are to be performed and the outputs written to files.

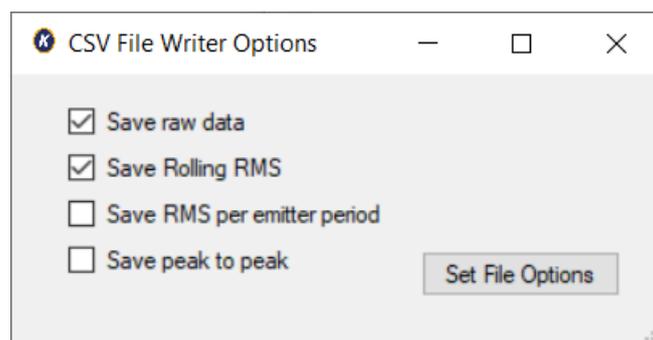


Figure 11 – CSV Choices

By checking a tick box the corresponding file will be written when saving commences.

## 4.6 Saving Data to CSV (Comma Separated Value) File

From the file menu on the main screen it is possible to save the captured data to Comma Separated Value files, for analysis in Matlab, Excel, etc. After selecting **Save to CSV**, a pop up window **Capture Data to CSV File** will appear requesting information about how long the software should save data for.

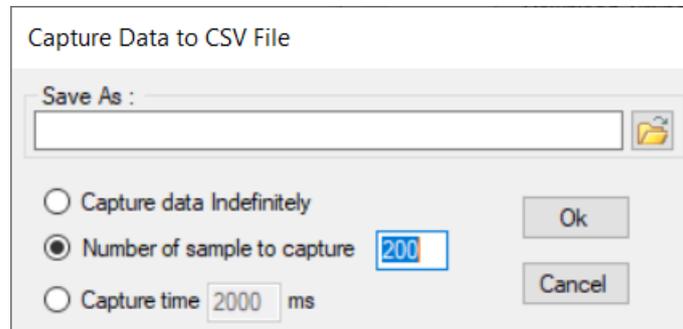


Figure 12 – CSV File Writing Settings

It is possible to choose:

- to capture data indefinitely; which will capture data until the software is instructed to stop, or the PC runs out of disk space.
- to specify the number of samples which the PC should capture data for.
- to specify the time period over which the software will capture samples.

After selecting the duration of data capture and entering the desired file name to **Save As**.

After choosing a file name and selecting **Ok** the software will automatically write the files specified by the options selected from the CSV file options window. By default this is the raw data and a rolling rms. The files are then saved in the location with the name you specified. The raw data will simply have the name of the file and the .csv file extension. The other files will be named with the addition of “.rms”, “.periodRMS” or “.pp” as appropriate then followed by .csv.

The software will also update its display on the status bar to show that it is capturing data to a file as seen in the bottom right of Figure 13.

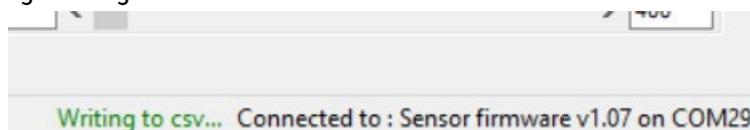


Figure 13 – Saving Data to CSV File in Process

At any time while the software is capturing data to a file it is possible to stop the data capture by selecting **Stop CSV Capture** from the file menu.

## 5 CONCENTRATION VIEW

The ability to turn the sensor signals into a known concentration of gas is of course the requirement of most gas detection systems. The gas concentration view of the Gas Sensing Evaluation Toolkit is available by selecting it from the drop down options menu on the top bar.

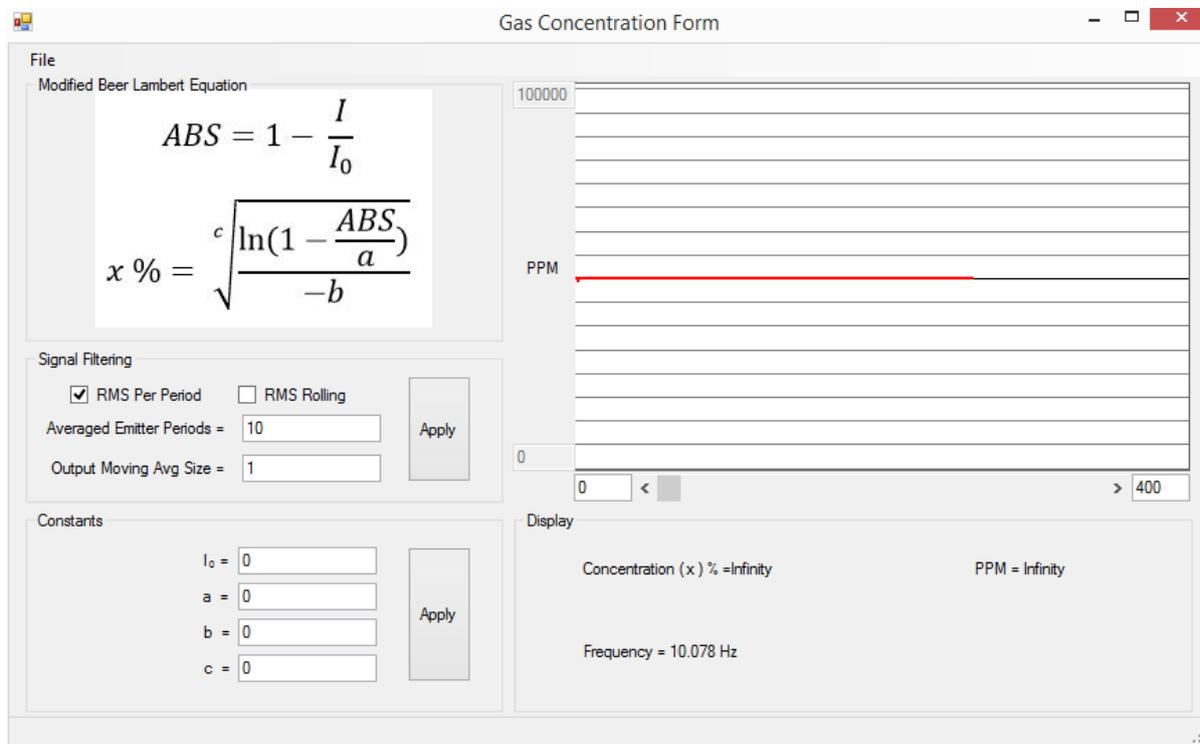


Figure 14 – Concentration View

Once opened the initial output of the concentration form will be nonsensical information as the system has not been calibrated. In order to calibrate the system please determine the co-efficients according to the Beer Lambert law.

Once the system has been calibrated then it is possible to save the coefficients of the modified Beer Lambert law by selecting file then “Save Coefficients”.

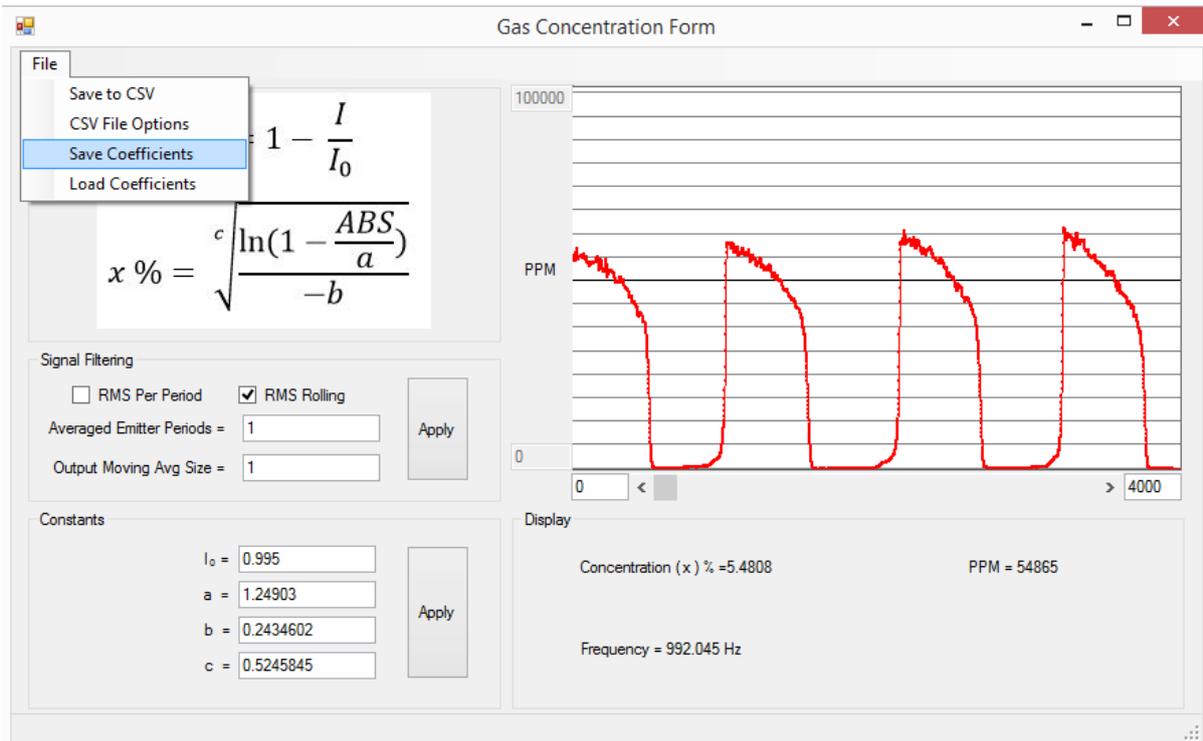


Figure 15 – Saving Coefficients

The next time this system is connected to the software the coefficients can be loaded from the file using the “Load Coefficients” option. It is worth mentioning that the same set of coefficients cannot be used for different systems. Each system must be calibrated individually as there are system differences such as sensor responsivity and emitter characteristics that vary from demo kit to demo kit.

The input to the modified Beer Lambert law equation is the RMS per emitter period. This is chosen for its stability. In order to provide greater stability a larger number of emitter periods can be averaged using the text box and apply button in the signal filtering section.

If the “CSV options” is selected from this view there is an additional option of saving the concentration values calculated. This must be opened and selected to save concentration data.

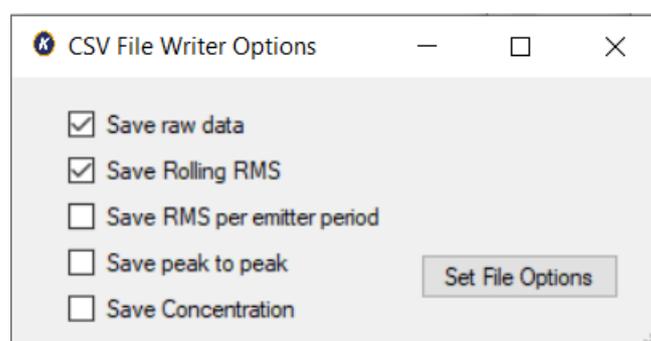


Figure 16 – CSV Options from Concentration View

## 5.1 Signal Processing

There are two options available for the data being fed in the concentration calculation – “RMS per Period” and “RMS Rolling”. The compromise being made between these two choices is speed of response and stability.

### **RMS Per Period – 10 Hz**

This data processing method only passes a single data point to the concentration calculation for every emitter period. This results in a 10Hz concentration update. This is the most stable but slowest responding method.

### **RMS Rolling – Sampling Frequency**

This calculates the RMS for a window of data every time a new data point arrives. This is the fastest updating but most unstable processing method.

### **Averaged Emitter Periods**

This applies to both the types of RMS calculation. It is simply the number of emitter periods being averaged to provide the RMS data point that is passed to the concentration calculations.

### **Output Moving Average Size**

This changes the moving average window size on the calculated concentration value.

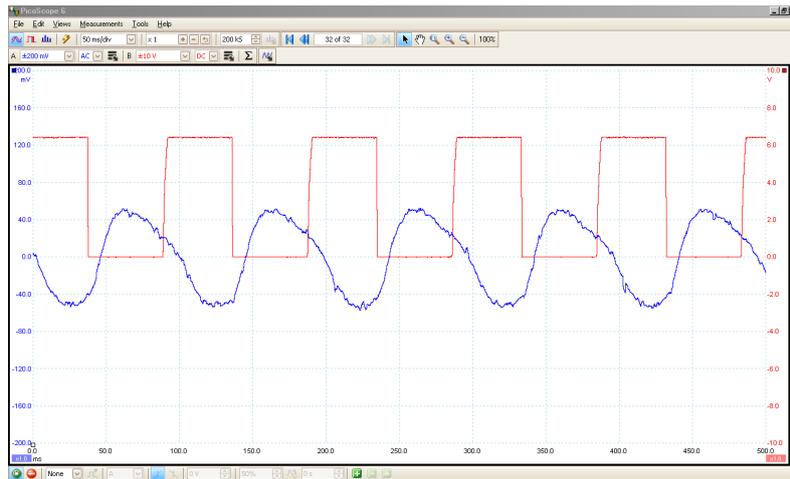
## 6 SAMPLING AND SIGNAL PROCESSING FOR KEMET SENSORS

KEMET thin film pyroelectric sensors have excellent response at higher modulation frequencies than many existing competitor sensors. This higher frequency performance has the benefit of reducing the impact of pink (1/F) noise that can plague both sensors and electronics at the low frequencies often used in infrared applications. Good system engineers will be aware that pink noise may be the dominant noise source when operating at below ~4 Hz. This is in stark contrast to most electronics applications where signals in excess of 1 KHz are examined, and pink noise is less significant. For many applications, including NDIR gas sensing and IR spectroscopy, by operating KEMET sensors at higher modulation frequencies the pink noise can be further suppressed, improving the signal to noise ratio. KEMET sensors will still outperform competitors sensors in the 1-4 Hz operational range in a circuit optimized for KEMET.

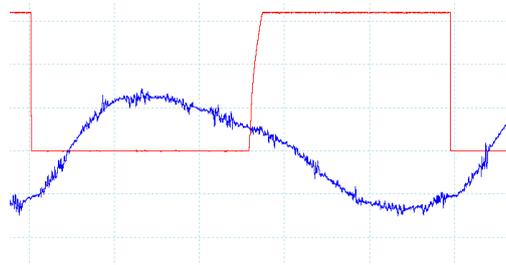
KEMET sensor products provide customers with a combination of class leading S/N and unparalleled temperature stability, as well as excellent part to part uniformity. These advantages are brought about by the combination of KEMET’ advanced MEMs based thin film device structure with a low noise trans-impedance amplifier, which includes a 31 Hz first order low pass filter.

To maximize the competitive advantage offered by our product it is recommended that sampling and filtering regimes are modified in accordance with the following diagrams.

The figure below shows a typical waveform from KEMET sensors when illuminated with a 10 Hz emitter pulsed with a square wave.

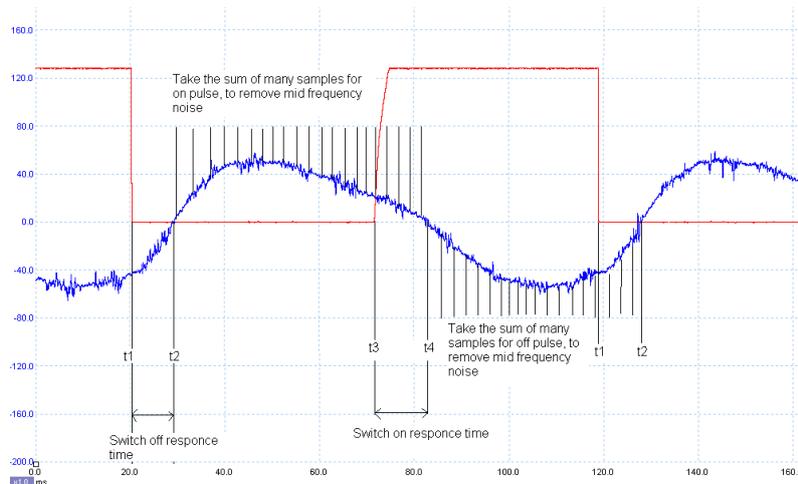


There are two points to note about the signal shown on the previous page, as highlighted by the figure below in more detail:



1. There is mid frequency noise present in the signal (This noise can easily be removed by oversampling)
2. Even at 10 Hz the waveform is not completely sinusoidal, demonstrating the higher speed performance of KEMET sensors

The diagram below illustrates how to sample the above waveform so as to minimize noise present in the signal:



1. For each different NDIR design the timings for switch on (t2-t1) and switch off (t4-t3) time will have to be measured, as they are more correlated to emitter design than KEMET sensors. The signal size = Sum (on samples) – Sum (off samples)

## 7 EMITTER VOLTAGE SETTING

As with all electronics there are tolerances for each of the components. The CO<sub>2</sub> Gas Sensing Evaluation Kit USEQGSK3000000 is no different and hence a calibration methodology is required to ensure optimal settings for maximum sensor output whilst not saturating the sensor. The method is best described by looking at the waveform on both the KEMET Software as well as using an external oscilloscope.

### 7.1 Saturation of Signal

The kits come set-up to provide consistent signal between kits however it may sometimes be required to alter the output. To see when the signal is saturated compare the output waveform you see with the following graphs.

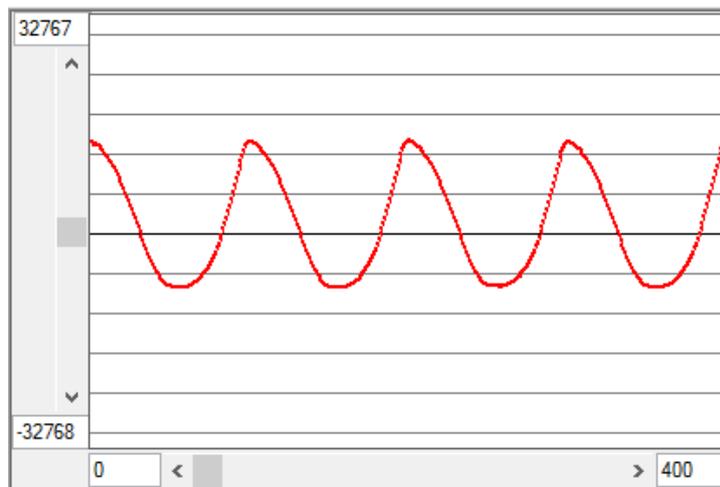


Figure 17 – Maximum Signal – No Saturation

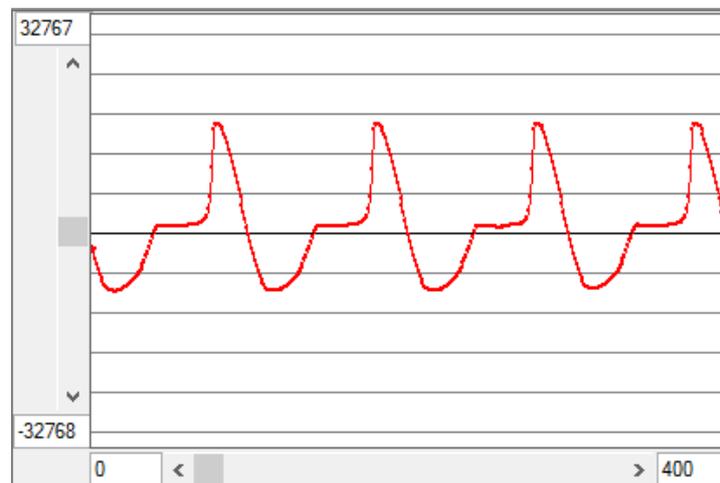


Figure 18 – Saturated Signal Output

## 7.2 Method

Starting with the emitter voltage set to the point of causing saturation of signal, slowly reduce the voltage until no saturation is occurring. For most applications this will be fine. For using the system in environments that have less CO<sub>2</sub> than average environmental CO<sub>2</sub> levels it will be necessary to reduce the voltage slightly further again to ensure that when the level of absorbing gas drops that the additional signal strength will not cause the output to saturate.

The emitter board has a potentiometer for altering the voltage across the emitter.

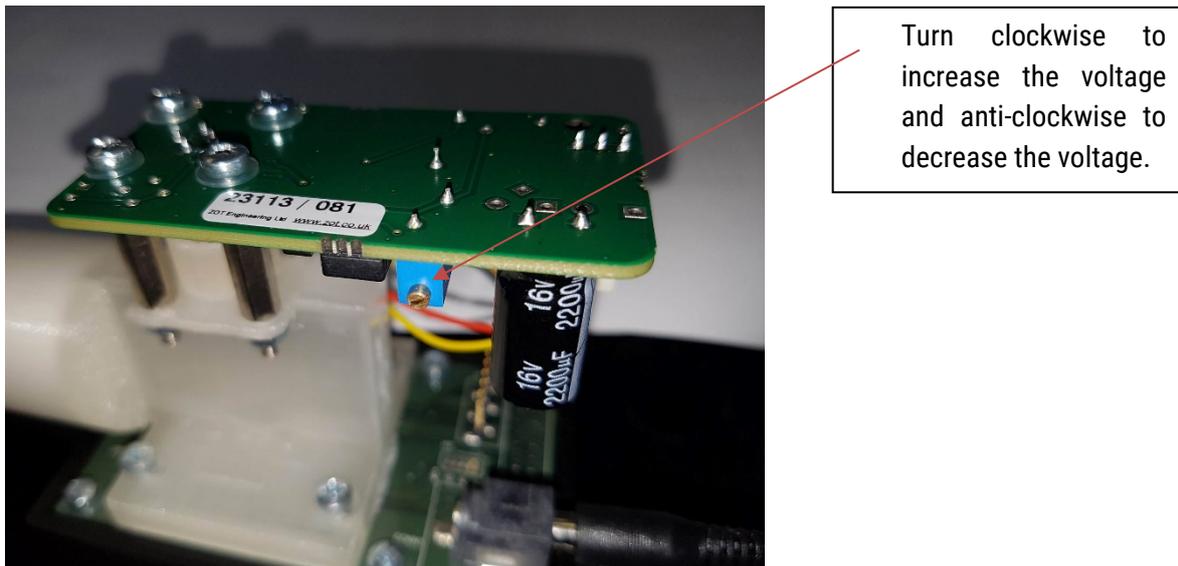


Figure 19 – Emitter Voltage Adjustment Point

1. Turn the voltage up until one of the signals has saturated, looking out for the waveforms listed above for saturation.
2. Slowly reduce the voltage until no evidence of saturation is detected.
3. Reduce slightly further if the application requires it.

Following these three steps will ensure maximum signal strength for your application.

Please note that the maximum emitter voltage is higher than is generally required, this is due to the different lengths of brass pipe for each gas detection application differing dramatically, and it should never need to be set to maximum for CO<sub>2</sub>. Running at higher voltages causes the emitter to deteriorate faster so should be avoided unless necessary due to a longer path length.

For use with the demo kit breathing cavity the voltage will not need to be maximum. If you create your own gas cell with a longer path then both the voltage on the emitter and the gain values for the channels will need to be adjusted to achieve maximum signal.