KEMET
a YAGEO company

TO Pyroelectric Infrared
Flame Sensing Evaluation Kit
USEQFCK4000000

User Guide
Rev. 2.2

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1   INTRODUCTION

This document describes the KEMET Flame Sensing Evaluation Kit USEQFCK4000000 that enables engineers and technicians to carry out simple and effective evaluation of KEMET TO-39 packaged flame sensors, experiment with the sample flame detection ratio based algorithm, and to capture measured data to a PC.

The kit is based on the Silicon Labs C8051F350 microcontroller with a high precision A-D converter and programmable gain amplifier. It is capable of sample rates above 100 Hz for 3 sensor channel and 75 Hz for 4 channel operation.

2   GETTING STARTED

Figure 1 – TO Flame Sensing Evaluation Kit USEQFCK4000000

2.1   Kit Contents

1. USEQFCK4000000 TO flame detection demonstrator kit
2. 3 sensors: USEQFCSA391100, USEQFCSA435100 and USEQFCSA500100
3. 9 VDC power supply
4. Micro USB cable
5. KEMET TO Flame Sensing Evaluation Tool (Analog) software
   click here for downloading the software

2.2   Minimum System Requirements

1. Microsoft® Windows PC
2. Local administrative rights to install device drivers
3. .NET Framework 4.5
4. 1 free USB port

3   INSTALLATION

3.1   Installing the KEMET Flame Sensing Evaluation Tool Software

From the software pack available to download <u>here</u>, select the **setup.exe** file that has this icon. This will start the installation process.
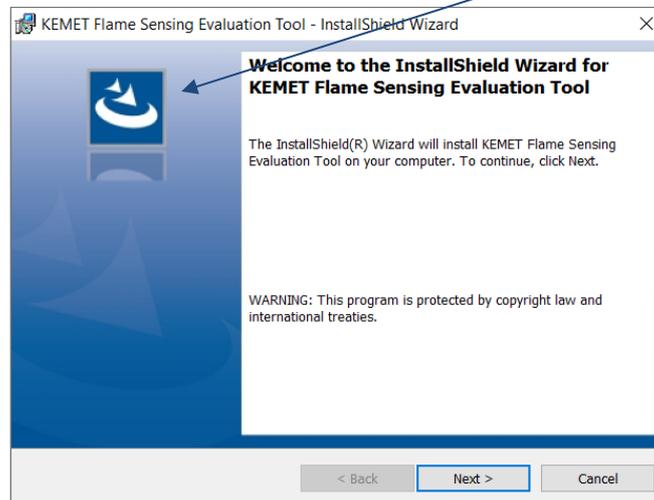

Figure 2 – Installer Screen

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, it can be installed as part of the setup routine or alternatively the setup routine can be cancelled and the .NET framework 4.5 can be downloaded from Microsoft's website. The framework can take a while to install but the software requires it.

3.2   Connecting the TO Flame Sensing Evaluation Kit

Connect the power supply provided to the KEMET Flame Detection Demonstrator Kit. Then connect the USB cable to the kit and Windows PC. You may see a message suggesting you are required to install a device driver. You can either. Follow the on-screen instructions and download a driver from Windows Update.

Your kit is now installed and ready to use.

4   SOFTWARE USER GUIDE

The KEMET Flame Sensing Evaluation Tool software runs on Microsoft Windows PCs and communicates with the Flame Detection Demonstrator Kit USEQFCK4000000, which enables easy testing of KEMET QFC TO packaged flame sensors. The software provides an interface to the analog circuits and A-D (Analog to Digital) converter, which are provided by the Silicon Labs C8051F350. Additional signal processing and analysis algorithms to filter and analyze sensor output for flame detection are provided. These include a simple flame detection algorithm using Fast Fourier Transform of sensor signals and threshold level based analysis of 10 Hz components of these signals.

4.1 Starting the Software

To start the software select the following from the windows start button in your task bar.
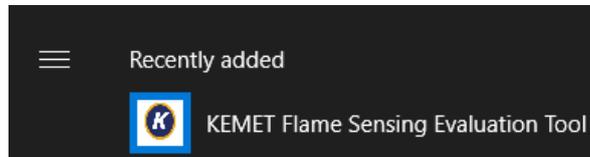
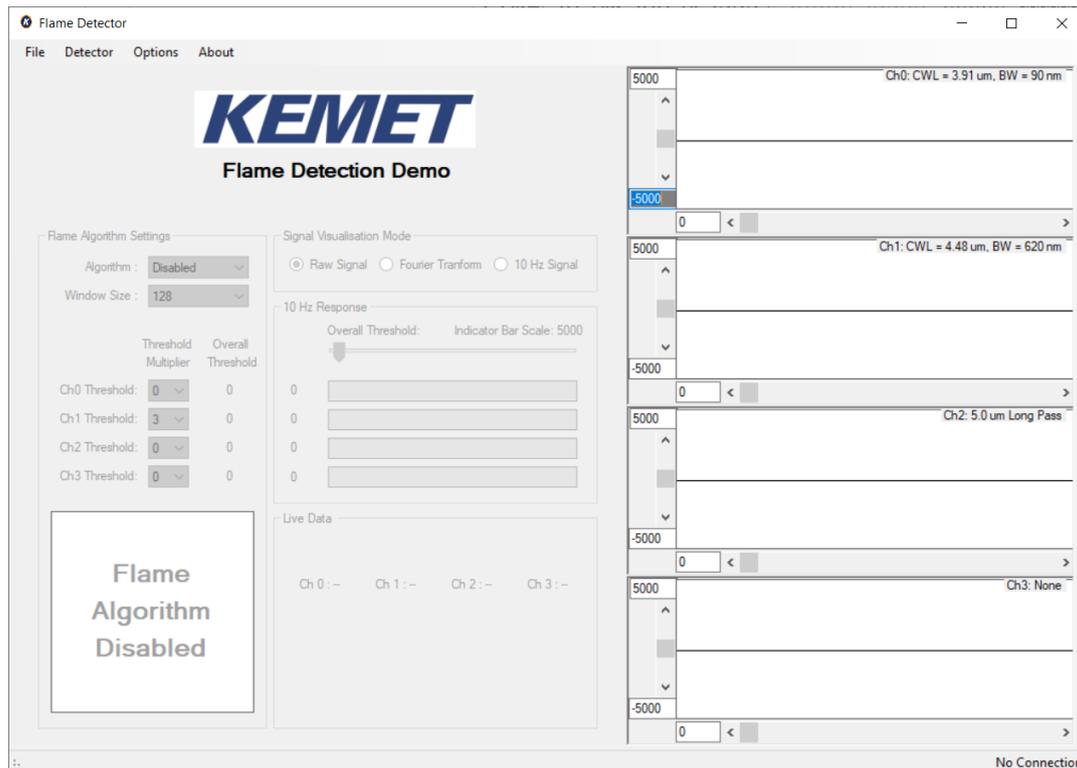This will open up the KEMET sensor data capture main screen as shown below.

Figure 3 – Flame Detector Main Application Window

4.2 Connecting Software to the Demo Kit

To connect to the flame detection demonstrator kit make sure the board is powered and connected to the PC through the USB cable.

From the menu bar select the **Detector** option and then **Connect** as shown in Figure 4.
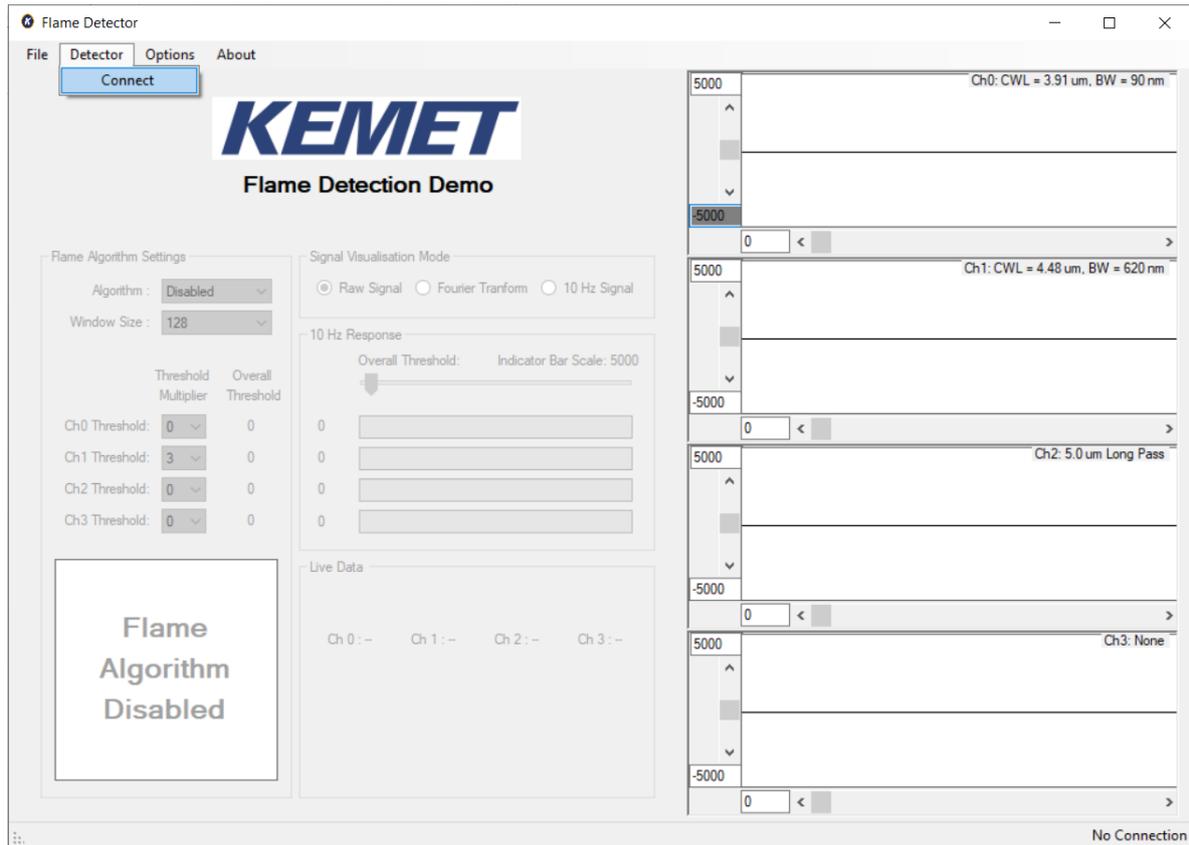
Figure 4 – Flame Detection Demonstrator Kit Connection

This will open up a further dialog box asking you to select on which com port the data capture board is using, as shown in Figure .
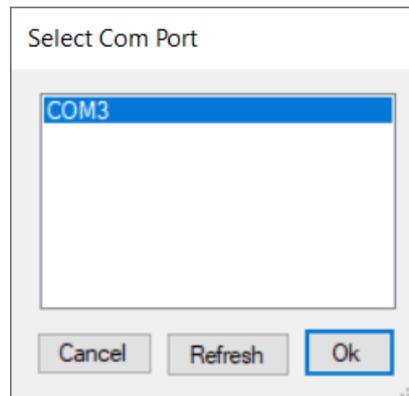

Figure 5 – Com Port Selection

Select the desired com port. If you are unsure which com port is assigned to your PCB, you can unplug the USB cable and click **Refresh** which will remove the port assigned to your board from the list. You can then re-connect the USB cable and when you click **Refresh** the correct port will return to the list.
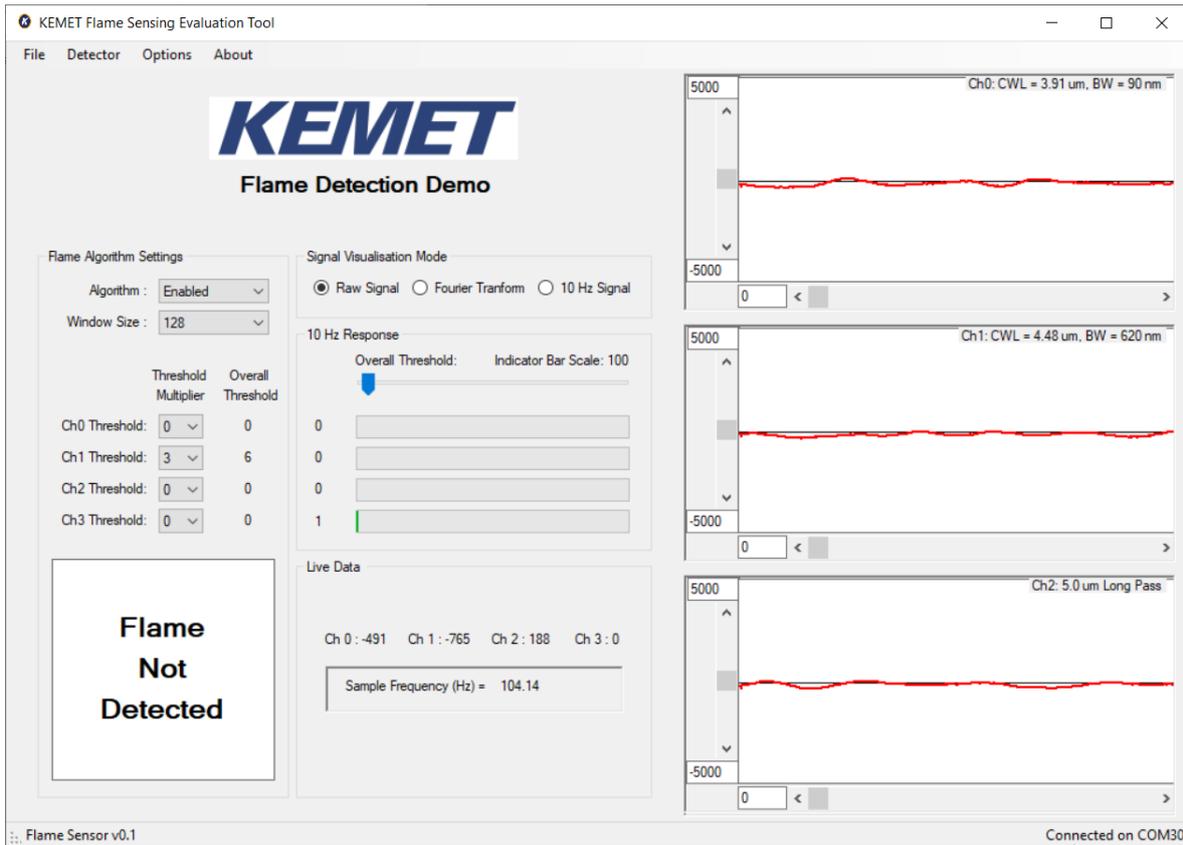
Figure 6 – Software Main Page

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 on COMXX" on the right side, and the left will show the Flame Detection Demonstrator Kit firmware version. Sensor signal will be visible on the signal viewers on the right.

If the program fails to make a connection to the data capture board, an error message is displayed and the screen returns to its initial screen. Check the USB and power connection and try to connect again.

4.3 Flame Detector Settings

This flame detector's specific settings allow for selection of the number of channels, and optical filters and gain on each channel. The settings can be accessed by selecting the **Show Settings** item in the **Options** menu, as shown in Figure 7. The settings can only be changed when the software is successfully connected to the Demo Kit.

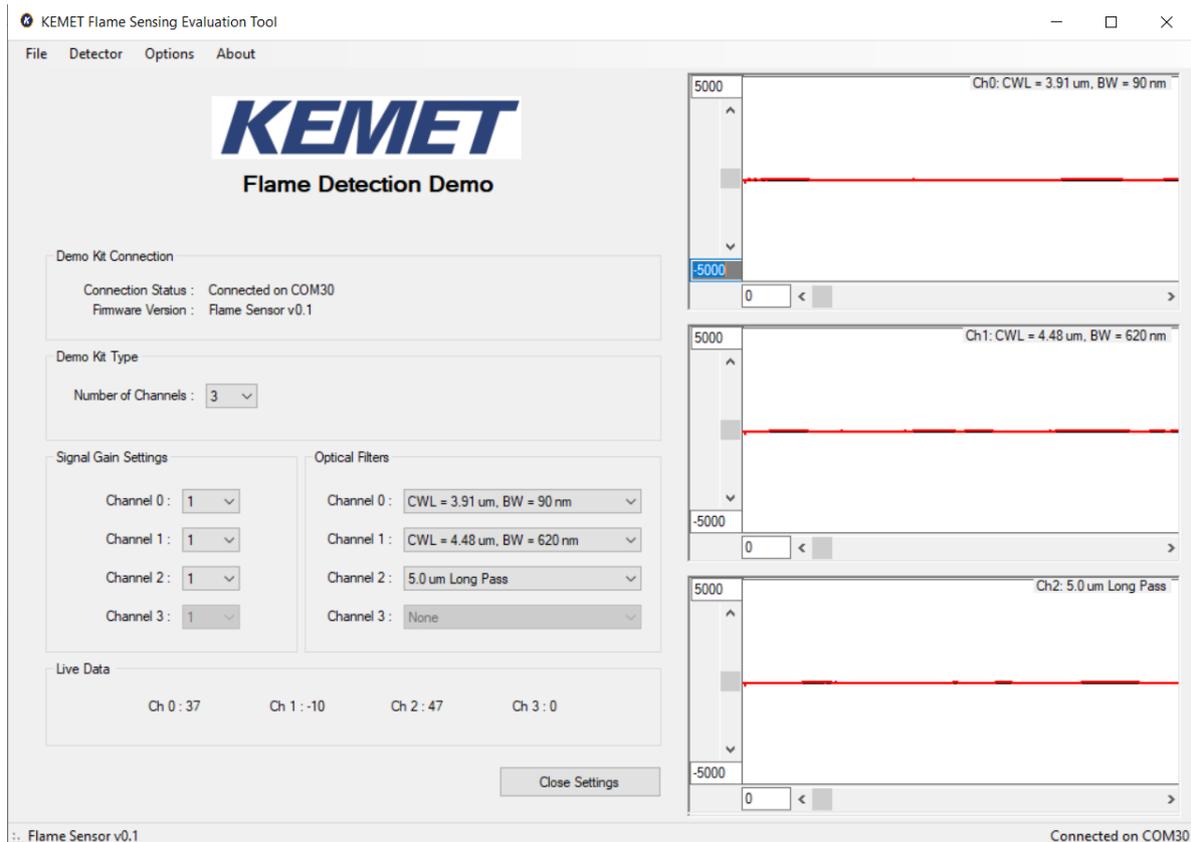*Figure 7 – Finding the Demo Kit Settings*

Figure 8 – Demo Kit Settings Page

Number of Channels: The drop-down box has 2 options – 3 channels (aimed for 3 TO-39 flame sensor operation) and 4 channels (aimed for quad flame sensor operation).

Signal Gain Settings: This allows for amplification level selection for each channel. Gain of 1 means no additional amplification is applied to the sensor signal, thus x1. The remaining settings of 'X' give multiples of the signal levels obtained at gain of 1. For example, gain selection of 8 gives signal 8 times larger than with gain selection of 1.

Optical Filters: This allows the user to select non-standard filter combinations for each sensor channel. Please note that not all combinations can be used by the flame detection algorithm successfully.[1]

4.4 Signal Viewing

After connection, raw signals from the sensors will be shown in the signal viewers on the right side of the software window, as shown in Figure 9.

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[1] Changes on the Settings page will disable the flame detection algorithm, if running. The algorithm can be re-enabled on the main page.
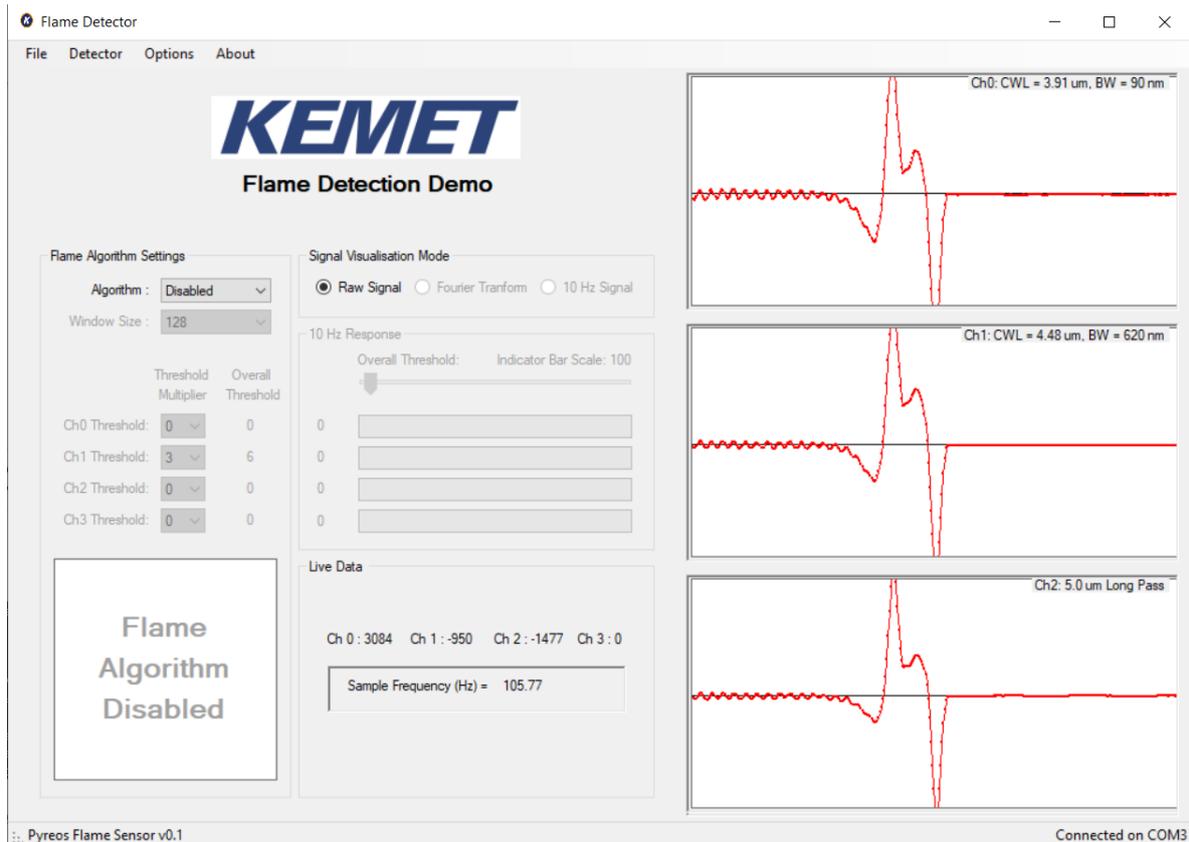
Figure 9 – Signal Viewers

4.5 Flame Detection Algorithm

For any operation beyond signal viewing, the flame detection algorithm needs to be enabled by selecting **Algorithm : Enabled** under **Flame Algorithm Settings** on the main page.

4.5.1 Additional Signal Viewing Features

The additional features which will be enabled with the algorithm are:

- Additional **Signal Visualisation Modes**:
  - **Fourier Transform:** Frequency domain representation of the signal useful for looking at dominant frequencies in signals (relative magnitude), for example comparison of flame flicker frequency and human motion frequency.
  - **10 Hz Signal:** The 10 Hz signal response from the Fourier Transform calculation representing the levels analysed by the flame detection algorithm.
- **10 Hz Response:** Live visualization of the 10 Hz Signal on bars, as seen on 10 Hz Signal Visualisation Mode, also representing the levels used by the flame detection algorithm.
- **Flame Detection Algorithm:** Adjustments and indication of flame detection status.

4.5.2 Algorithm Settings

The flame algorithm uses Fast Fourier Transform (FFT) of the signal to extract the 10 Hz magnitude, or more precisely the average magnitude between 9 Hz and 11 Hz. The above mentioned Signal Visualisation Modes enable selection of each of these stages to better understand the detection process.
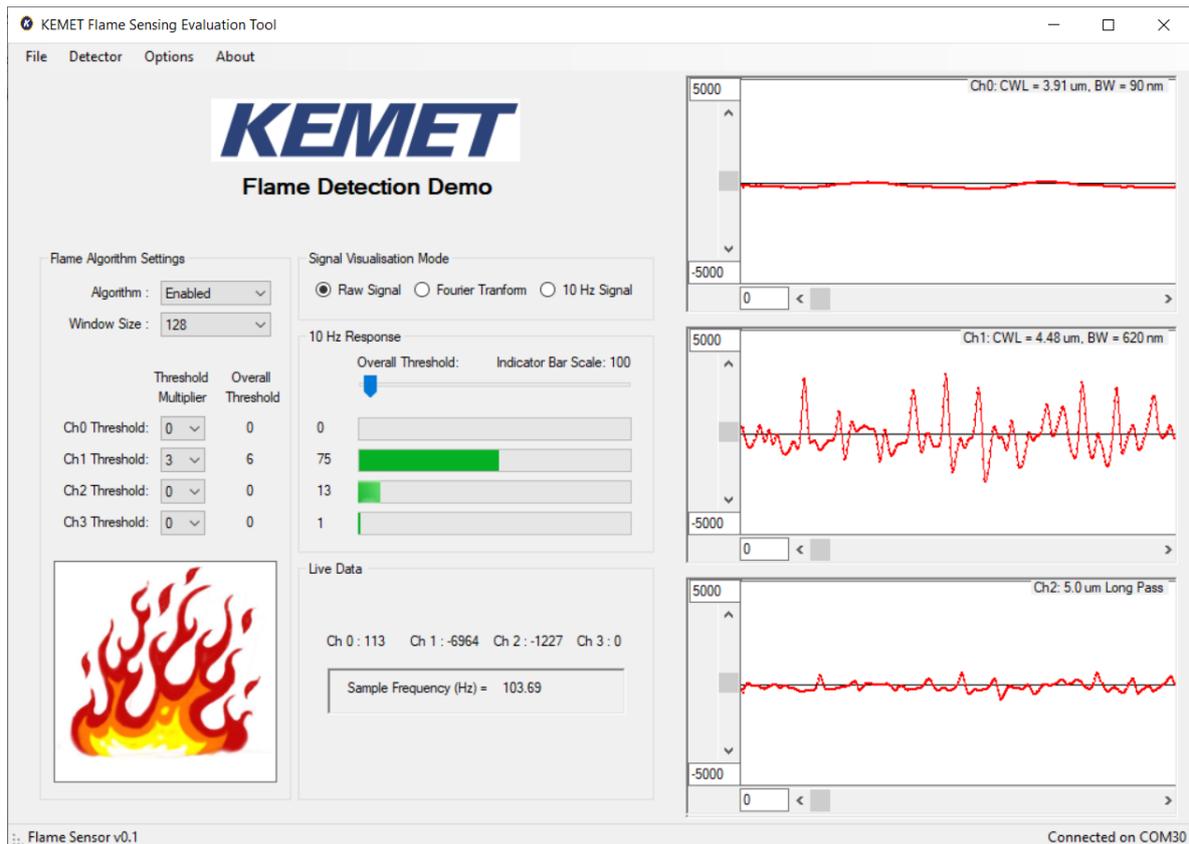
Figure 10 – Flame Sensing

Window Size: This controls the speed of the algorithm versus the stability to momentary fluctuations. A value of 128 can be treated as the middle setting. A lower value of window size gives faster response, but also less immunity to noise, both from the sensor and electronics and from the scene seen by the sensors. A higher value increases stability and glitch rejection. However detection time is increased to around 15 seconds with the highest setting.

10 Hz Response: This is the final result from the preprocessing for each channel. The relative levels from the channels are shown on the horizontal bars when the algorithm is enabled.

Threshold Multiplier: This selects what proportion of the overall threshold is applied to each channel.

Overall Threshold: This slider controls the algorithm detection level. The higher the threshold, the bigger flame is needed to trigger the flame detection algorithm. After moving the slider, check the **Overall Threshold** column next to the **Threshold Multipliers** for each channel. The detection is triggered when all channels **10 Hz Response** rises above their respective overall thresholds. For flame decision to be made and the flame icon to show, the flame channel (Ch1) needs to be above other channels by its threshold value also.

5   EXAMPLE DEMONSTRATION

Follow these steps to demonstrate flame detection using a lighter from around 0.5 meter distance.

1. Install the software – see Section 3.1.
2. Connect the Demo Kit – see Section **Error! Reference source not found.**.
3. Go to Demo Kit settings – see Section 4.3 and select gain of 16 on Channels 0, 1 and 2. Close the settings page.
4. On the main page, enable the flame detection algorithm.
5. Set the following thresholds multipliers: Ch0 = 0, Ch1 = 3, Ch2 = 0. This should result in **Overall Thresholds** of 0, 6 and 0 respectively.
6. Test by waving a hand in front of the sensors. Expected outcome:
    a. Signal viewer for Ch2 – "human" filter:
        i. in **Raw Signal** mode shows a wave as hand passes the sensor.
        ii. in **Fourier Transform** mode low frequency component increases.
        iii. in **10 Hz Signal** mode there is an increase in level.
    b. **10 Hz Response** bars for Channels 0 and 1 do not show much increase, but Channel 2 increases depending on the intensity of hand movement.
    c. Detection result – "Flame Not Detected" showing in bottom left corner of the application.[2]
7. Test by lighting a lighter in front of the sensors. Expected outcome:
    a. Signal viewer for Ch1 – "flame" filter:
        i. generally a higher response is shown on Ch1 for flame test at the moment of starting the flame than on Ch2 for hand waving test.
        ii. in **Raw Signal** mode shows a spike when lighter is lit, then shows ripple when the flame is on, and bigger oscillation if the lighter is shaken.
        iii. in **Fourier Transform** mode low frequency component increases.
        iv. in **10 Hz Signal** mode there is a sharp increase in level when the lighter is lit, followed by a drop when the flame is on.
    b. **10 Hz Response** bars for Channel 0 does not show much increase, Channel 1 shows significant response, while Channel 2 response depends on hand and other movement in the Field of View of the sensors.
    c. Detection result – flame icon showing in bottom left corner of the application.[3]

5.1   Key Adjustments

- If the algorithm is constantly triggering and the flame icon is showing in the bottom left corner of the application, increase the overall threshold. The **Overall Thresholds** of each channel can be set just above noise level as the starting point for adjustment.

- If the algorithm is not triggering when a flame is present, decrease the **Overall Threshold** and/or the **Threshold Multiplier** for the flame channel. The magnitude of 10 Hz response when the flame event occurs can be used to set the detection threshold on the flame channel to around half of this value as the starting point for adjustment.

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[2] In case of detection result not being as expected, see Section 5.1.
[3] In case of detection result not being as expected, see Section 5.1.