# PYRE

## Analog TO Flame Detection Evaluation Kit PY-DK-FLA01 (PY1377)

with three Pyreos analog TO-39 flame sensors (PY0573, PY0575, PY1601)

User Guide Rev. 2.0

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### 1 Introduction

This document describes the Pyreos IR Flame Sensor Evaluation Kit. The purpose of this kit is to enable engineers and technicians to carry out simple and effective evaluation of Pyreos flame sensors, experiment with a sample flame detection algorithm, and to capture measured data to a PC.

The kit is based on the Silicon Labs C8051F350 microcontroller with 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

#### 2.1 Kit contents

- 1. PY-DK-FLA01 Pyreos Flame Sensor Demonstrator Kit
- 2. 9V DC power supply
- 3. Micro USB cable
- 4. PYDK\_FLA software (supplied on CD, USB or by email)

#### 2.2 Minimum system requirements

- 1. Microsoft® Windows PC (all versions supported currently)
- 2. Local administrative rights to install device drivers
- 3. .NET Framework 4.0 (can be installed during setup procedure)
- 4. 1 free USB port



### 3 Installation

#### 3.1 Install Pyreos PYDK-FLA Software

From the installation folder Select PYDK\_FLA.msi . This will start the installation process.



Figure 1 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 4.0 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 4.0 can be downloaded from Microsoft's website. The framework can take a while to install but the software requires it.

#### 3.2 Connect PY-DK-FLA01 Demo Kit

Start using the Demo Kit by connecting it to a PC first.

- 1. Connect the power supply provided to the Demo Kit
- 2. Connect the USB cable to the Demo Kit and Windows PC
  - a. 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.

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#### 4 Software user guide

The PYDK-FLA Pyreos Flame Detection Demo software runs on Microsoft Windows PCs and communicates with the PY-DK-FLA01 Demo Kit, which enables easy testing of Pyreos flame sensors. The software provides an interface to the analogue circuits and A-D (Analogue to Digital) converter, which are provided by a 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:

```
All Programs -> Pyreos Ltd -> PYDK-FLA - > PYDK-FLA
```

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

🗘 Pyreos Flame Detection Demo				
File Detector Options About				
		5000 Ch0: CWL = 3.91 um, BW = 90 nm		
	RCŲJ		_	
Flam	e Detection Demo			
		-5000		
	· · · · · · · · · · · · · · · · · · ·	0 <	•	
Hame Algorithm Settings	Signal Visualisation Mode	5000 Ch1: CWL = 4.48 um, BW = 620 nm	Ē	
Algorithm : Disabled V	(@) Raw Signal 🔘 Founer Tranform 🔘 10 Hz Signal	*		
Window Size : 128 -	10 Hz Response		_	
Threshold Overall	Overall Threshold: Indicator Bar Scale: 5000			
Multiplier Threshold	r)	-5000		
Ch0 Threshold: 0 👻 0	0	0 <	•	
Ch1 Threshold: 3 - 0	0	5000 Ch2: 5.0 um Long Pass	- I	
Ch2 Threshold: 0 👻 0	0	*		
Ch3 Threshold: 0 👻 0	0		_	
	Live Data	-5000		
Flama		0 <	•	
Flame	Ch 0 : - Ch 1 : - Ch 2 : - Ch 3 : -	5000 Ch3: None	- I	
Algorithm		·		
Disabled			_	
		-5000		
		0 4	Þ	
N. N		No Connec	tion	

Figure 2 PYDK-FLA software - main application window

#### 4.2 Connecting software to the Demo Kit

To connect to the PY-DK-FLA01 Demo 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 3.

🖞 Pyreos Flame Detection Demo					
File Detector Options About					
Connect		5000	Ch0: CWL = 3.91 um, BW = 90 nm		
		·			
	REYJ				
Flan	ne Detection Demo				
		-5000			
		0 <	•		
Hame Algorithm Settings	Signal Visualisation Mode	5000	Ch1: CWL = 4.48 um, BW = 620 nm		
Algorithm : Disabled 👻	Raw Signal O Fourier Tranform O 10 Hz Signal	•			
Window Size : 128 -	10 Hz Response				
Treshold Over	Overall Threshold: Indicator Bar Scale: 5000				
Multiplier Threshold	r()	-5000			
Ch0 Threshold: 0 🔻 0	0	0 <	•		
Ch1 Threshold: 3 - 0	0	5000	Ch2: 5.0 um Long Pass		
Ch2 Threshold: 0 - 0	0	•			
Ch3 Threshold: 0 - 0	0				
	Live Data	-5000			
<b>Flama</b>		0 <	•		
Flame	Ch 0 : - Ch 1 : - Ch 2 : - Ch 3 : -	5000	Ch3: None		
Algorithm		*			
Disabled					
		-5000			
		0 <	Þ		
1			No Connection		

#### **Figure 3 Demo 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 4.

Select Com Port	
COM3	
COM4	
Cancel Refresh Ok	
	44

Figure 4 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.

Pyreos Flame Detection Demo				
File Detector Options About				
P) Flarr		5000	Ch0: CWL = 3.91 um, BW = 90 nm	
Flame Algorithm Settings	Signal Visualisation Mode	-5000		
Algorithm : Disabled  Vindow Size : 128	Naw Signal Pouner trantom 10 Hz Signal	5000	► Ch1: CWL = 4.48 um, BW = 620 nm	
Threshold Overall Multiplier Threshold	Overall Threshold: Indicator Bar Scale: 5000	*		
Ch0 Threshold: 0 💌 0	0			
Ch1 Threshold: 3 V 0	0			
Ch2 Threshold: 0   0	0	-		
Ch3 Threshold: 0 V	0	-5000	*	
	Live Data	5000	Ch2: 5.0 um Long Pass	
Flame Algorithm Disabled	Ch 0 : -246 Ch 1 : -142 Ch 2 : 170 Ch 3 : 0 Sample Frequency (Hz) = 104.17			
		-5000		
. Purent Flame Sensor v0.1				
$\mathbf{X}$	Figure 5 Software ma	ain 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 Demo 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 Demo Kit settings

Demo Kit 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 6. The settings can only be changed when the software is successfully connected to the Demo Kit.



File Detector Options About
Show Settings
Oscilloscope Full View
Oscilloscope Normal View

#### Figure 6 Finding the Demo Kit settings

C Pyreos Flame Detection Demo	
File Detector Options About	
<b>PYREO</b> S	5000 Ch0: CWL = 3.91 um, BW = 90 nm
Flame Detection Demo	
Connection Status : Connected on COM12 Firmware Version : Pyreos Flame Sensor v0.1	
Demo Kit Type Number of Channels : 3	5000 Ch1: CWL = 4.48 um, BW = 620 nm
Signal Gain Settings     Optical Filters       Channel 0 :     1       Channel 1 :     1       Channel 1 :     1	-5000
Channel 2: 1  Channel 3: 1  Ch	0      Ch2: 5.0 um Long Pass
Live Data Ch 0 : -104 Ch 1 : -114 Ch 2 : -29 Ch 3 : 0	
Close Settings	-5000 0 <
Hyreos Flame Sensor VU.1	Connected on COM12

#### Figure 7 Demo Kit settings page

**Number of Channels** drop-down box has 2 options – 3 channels (aimed for 3 TO5/TO39 flame sensor operation) and 4 channels (aimed for quad flame sensor operation).

**Signal Gain Settings** allow amplification level selection for each channel. Gain of 1 means no additional amplification is applied to the sensor signal, i.e. 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** allow 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.

Note: Changes on the Settings page will disable the flame detection algorithm, if running. The algorithm can be re-enabled on the main page.



#### 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 8.

📮 Pyreos Flame Detection Demo					
File Detector Options About					
		5000 Ch0: CWL = 3.91 um, BW = 90 nm			
		A			
	RLŲJ				
Flam	e Detection Demo	· · · · · · · · · · · · · · · · · · ·			
Davis Alasahan Sattinas	Since Manager Made	-			
	Revise Texter     10 Ha Signal	-5000			
Algorithm : Disabled	Pouner transform O To Hz Signal	۰ ۲			
Window Size : 128 -	10 Hz Response	5000 Ch1: CWL = 4.48 um, BW = 620 nm			
Threshold Overall	Overall Threshold: Indicator Bar Scale: 5000	A			
Multiplier Threshold					
Ch0 Threshold: 0 👻 0	0				
Ch1 Threshold: 3 💌 0	0				
Ch2 Threshold: 0 👻 0	0	-			
Ch3 Threshold: 0 💌 0	0	-5000			
	Live Data	۰ ۲ ( ) 1 ( ) 1 (			
	Live Data	5000 Ch2: 5.0 um Long Pass			
Flamo		A			
	Ch 0 : -86 Ch 1 : -95 Ch 2 : -95 Ch 3 : 0				
Algorithm	Sample Frequency (Hz) = 104.71	A har party and			
Disabled					
		-5000			
Pyreos Flame Sensor v0.1 Connected on COM12					

#### **Figure 8 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

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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. Signal Visualisation Modes (see paragraph 4.5.1) enable selection of each of these stages to better understand the detection process.



#### Figure 9 Flame detection

**Window Size** controls the speed of the algorithm vs. 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** 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 selects what proportion of the overall threshold is applied to each channel.

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**Overall Threshold** 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 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 (i.e. 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 paragraph 3.1.
- 2. Connect the Demo Kit see paragraph 3.2.
- 3. Go to Demo Kit settings (paragraph 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
  - n.b. In case of detection result not being as expected, see paragraph 5.1.
- 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
  - n.b. In case of detection result not being as expected, see paragraph 5.1.

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#### 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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