# Digital Flame Sensors

The structure of modern civilization rests on the foundation of electronics technology. Computers, the internet, mobile phones, and numerous other technologies owe their existence to electronics technology.

## Importance of Sensors in Electronics and Control Systems

Sensors are one of the essential components in an electronic or electromechanical system. Sensors enable electronic circuits to interact with their environment and collect valuable data from their surroundings. In a way, sensors act as the eyes and ears of an intelligent digital electronic system. The modern self-correcting feedback control systems rely entirely on sensing elements for their feedback loops, as shown in the following illustration.

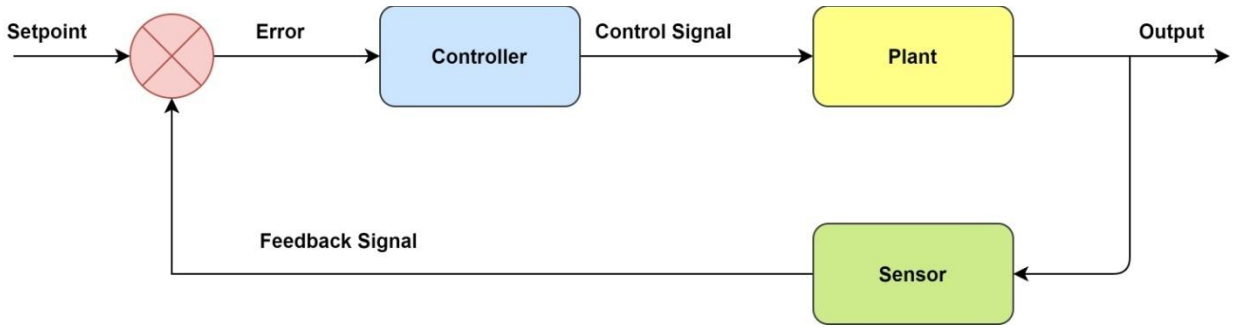


*Figure 1 – Feedback Control System*

To better understand this feedback control loop, let's take the example of an air conditioner. The user sets the desired temperature (setpoint) using a remote controller. The integrated temperature sensor provides the current room temperature measurement. If the setpoint and sensor signal difference is non-zero, the controller (microcontroller or digital circuit) turns on the compressor. When the room temperature (plant) equals the setpoint, the error signal becomes zero, and the compressor is turned off. The result is that the room temperature is maintained at the desired setpoint.

## Introduction to Flame Sensors

Flame or pyroelectric sensors are a crucial component of fire detection and fire protection systems. Fire protection systems are employed in commercial buildings and factories and are also widely used in residential facilities. Installation of residential fire safety systems is even mandatory in many first-world countries.

Pyroelectric sensors incorporate pyroelectric crystals whose polarization changes with temperature. As the intensity of incident infrared light increases, the temperature of the pyroelectric crystal rises, and a proportional electric charge is produced due to the pyroelectric effect.

Home and building automation is a leading sector actively adopting cutting-edge IoT (internet of things) technologies. Since fire protection systems play a critical role in the layout of any building, the importance of flame sensors has increased manifold.

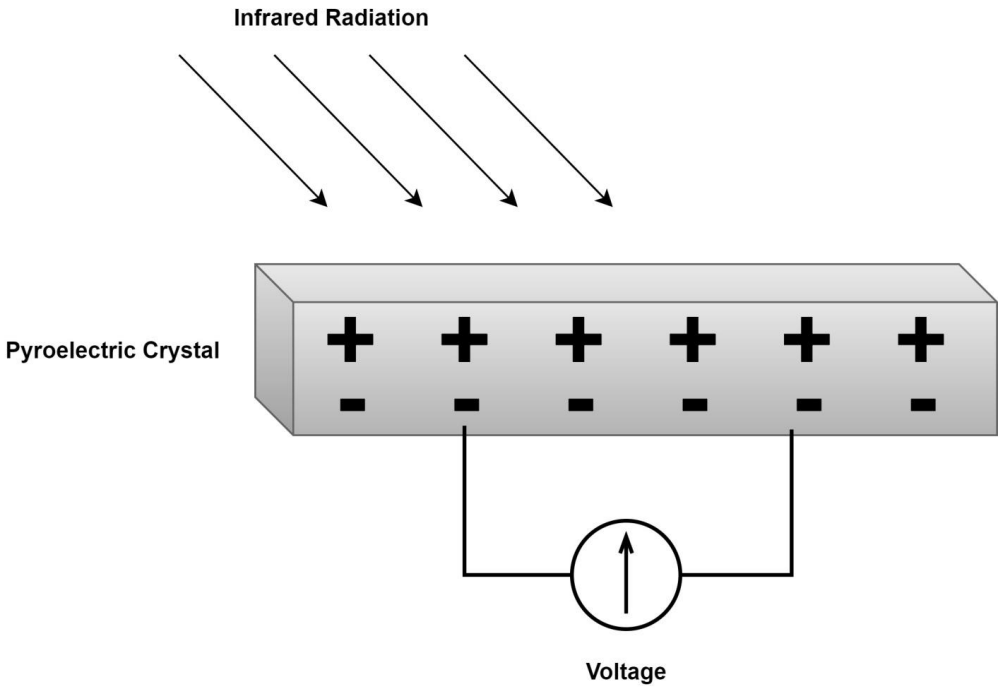


*Figure 2 – Pyroelectric Effect*

## Analog versus Digital Sensors

Historically, sensors have always been analog devices as the physical quantities measured are also analog, e.g., sound, light, temperature, pressure, etc. However, modern control systems use digital controllers such as microcontrollers, FPGAs and PLCs. Interfacing analog sensors to these digital devices require additional sub-systems (ADCs and signal conditioning circuitry) that add cost and complexity. To tackle this issue, manufacturers have now started to produce digital sensors that can readily be interfaced with digital controllers without the additional need for ADCs and signal conditioning circuitry. This development is especially beneficial for IoT systems as the node devices need to integrate microcontrollers and digital sensors on the same circuit board. Hence, a large number of low-cost smart digital sensors can be installed in the building for automation.

## KEMET Digital Pyroelectric Sensors

The QFS and QFCE series digital pyroelectric sensors from KEMET offer greater reliability, lower power consumption, and enhanced performance. These digital flame sensors combine high sensitivity with fast response times to ensure rapid and accurate detection of flames and fires. Thanks to the thin-film PZT material, these digital flame sensors can detect a cigarette lighter from a distance of up to 85 meters in outdoor conditions. These high-quality sensors are available in SMD (QFS) and TO-39 (QFCE) packages.

The KEMET QFCE & QFS digital flame sensors do not require additional conversion or conditioning circuitry as all the necessary analog circuitry is integrated into the sensor package. These sensors can easily be plugged into the digital controller IC. The $I^2C$ communication protocol ensures quick and easy communication with microcontrollers and microprocessors.

A simple block diagram of the QFCE series digital flame sensor is provided below. The diagram shows that the sensor package houses analog front-end, ADC, and digital filters in addition to the analog transducer. The digital flame sensor uses the $I^2C$ interface for digital communication and only requires two data lines (SDA, SCL).

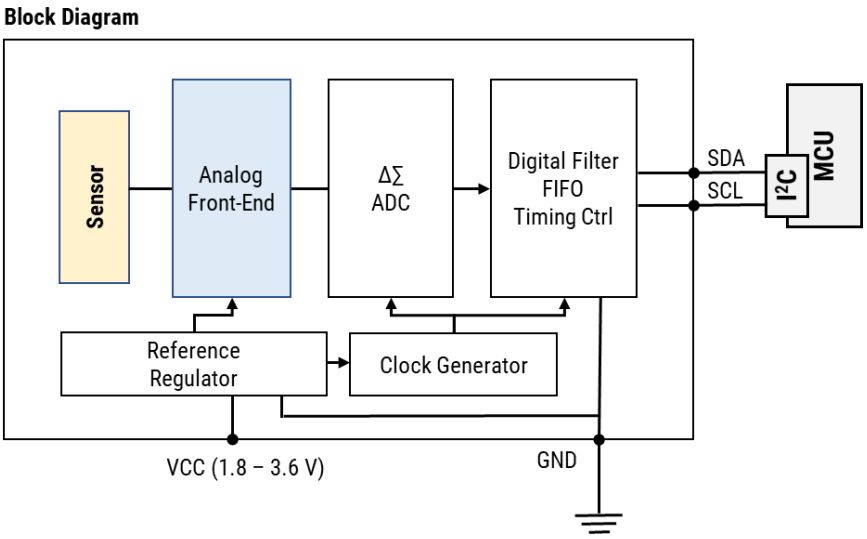


*Figure 3 – Block Diagram of QFCE Digital Flame Sensor*

In addition to digital output, the QFCE series digital flame sensors are also programmable. Thus, different sensor parameters are adjustable, including gain, flicker rate, sampling frequency, high and low pass filtering. Optical filtering is provided by selecting the related part number. This feature provides greater flexibility and control to system designers and engineers.

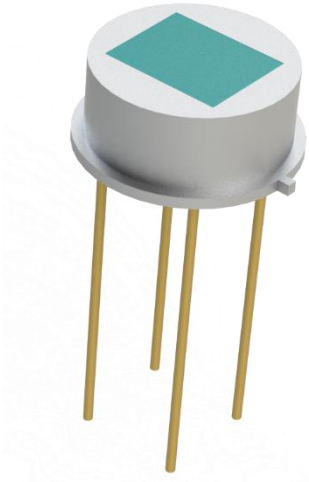

*Figure 4 – KEMET QFCE Digital Flame Sensor*

## Applications of QFCE Digital Flame Sensors

Due to their high sensitivity, reliability, high detection range, and integrated analog circuitry, QFCE digital flame sensors are ideal for IoT and industrial IoT applications. Some of the major application areas of these sensors include:

- Oil and gas
- Manufacturing
- Forest protection
- Smart homes
- Smart buildings
- Transportation
- Infrastructure protection

## Benefits of QFCE Digital Flame Sensors

QFCE digital flame sensors offer many advantages over analog flame sensors. Some of the salient features of these sensors are:

- High sensitivity
- 100$^{o}$ wide field of view
- Digital output and $I^2C$ interface
- Programmable gain and filtering
- Various optical filters available
- Integrated amplifier, ADC and digital filters
- Low power consumption

A comparison between analog (QFC), digital TO-39 (QFCE), and digital SMD (QFS) flame sensors are drawn in the following table:

| Feature | TO-39 Analog (QFC) | TO-39 Digital (QFCE) | SMD Digital (QFS) |
|---|---|---|---|
| **Key Strength** | High sensitivity up to 20 Hz<br>Fast response time<br>Compact TO-39 package<br>Wide field of view<br>Long range of detection | 40% better signal to noise ratio<br>No analog components<br>Digital I²C interface<br>Ultra fast response time<br>Programmable analog characteristics<br>Very long range of detection<br>Reduced current consumption<br>Wide field of view | No analog components<br>Digital I²C interface<br>Ultra fast response time<br>Programmable analog characteristics<br>Long range of detection<br>Low current consumption<br>Good field of view |
| **Typical Applications** | Industrial<br>Oil and gas<br>Infrastructure<br>Forest protection | Industrial<br>Oil and gas<br>Infrastructure<br>Forest protection | Industrial<br>Oil and gas<br>Infrastructure<br>Forest protection |
| **User Interface** | Analog interface | Digital I²C interface | Digital I²C interface |
| **Time Constant (10 - 20 Hz Peak)** | 12 ms | 10 ms | 10 ms |
| **Specific Detectivity (cm√Hz/W at 10 Hz/500 K)** | $3.5*10^8$ | $4.8*10^8$ | $2.5*10^8$ |
| **Field of View** | 100° | 100° | 90° |
| **Typical Range** | 65 meters | 85 meters | 40 meters |
| **Operating Current** | 65 µA | 23 µA | 23 µA |
| **Operating Voltage** | 2.7 to 8 V | 1.75 to 3.6 V | 1.75 to 3.6 V |
| **Operating Temperature** | -40° to +85°C | -40°C to +85°C | -40°C to +85°C |

*Figure 5 – Comparison Table*

The field-of-view diagram for the QFCE flame sensors is as follows:

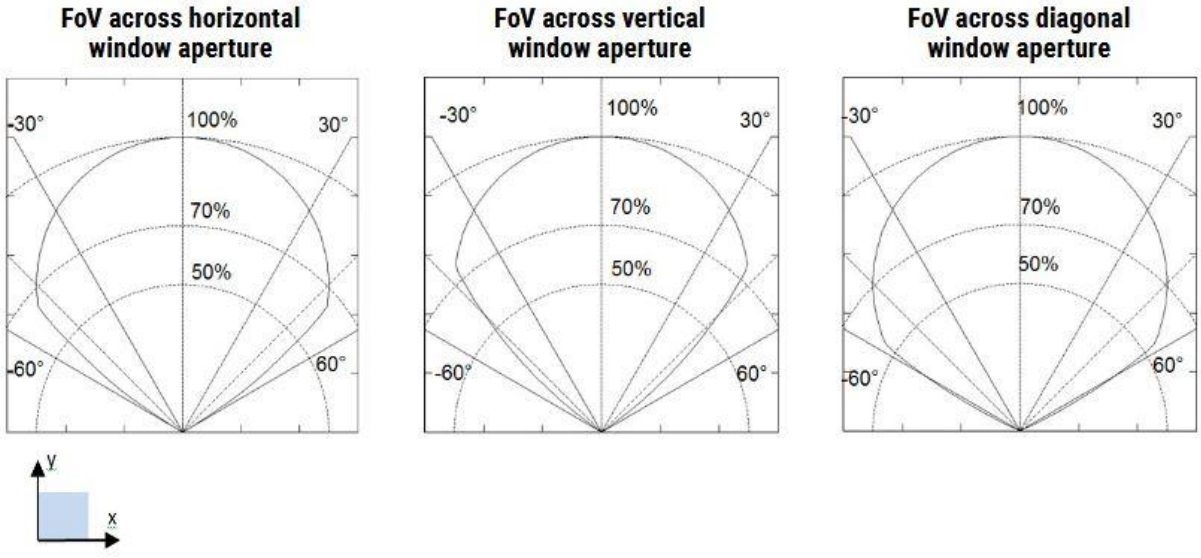


*Figure 6 – Field of View*

## Electrical Characteristics of QFCE Digital Flame Sensors

Important electrical characteristics of the digital flame sensor are listed as following:

- Nominal current consumption: 22 µA
- Operating voltage: 1.75 V to 3.60 V
- Digital I/O: $I^2C$
- Operating temperature: -40°C to +85ºC

## Conclusion

Sensors are among the most commonly used components in electronic and electromechanical control systems. Flame or pyroelectric sensors serve a crucial role in fire protection systems. Historically, flame sensors have always been analog and require ADCs and signal conditioning circuitry for microcontroller interfacing. However, with the advent of digital flame sensors, microcontroller interfacing has become dramatically simplified.

KEMET QFCE digital flame sensors offer low power consumption, high reliability, enhance field-of-view, programmable gain, programmable filtering, and $I^2C$ communication. These features make QFCE series sensors ideal for IoT and industrial IoT applications. Build the next-generation fire protection solutions with our high-quality QFCE series digital flame sensors. Contact a KEMET sales representative for more information, evaluation kits, and price quotations.