Interfacing KY-026 FLAME DETECTION SENSOR with nrf52840dk Microcontroller

KY026 Pin configuration:

- KY-026 Flame Sensor module **detects infrared light emitted by fire**.
- This module has both **digital and analog outputs** and a **potentiometer** to adjust the **sensitivity.**
- Used in **fire detection applications.**

KY-026 SPECIFICATIONS:

Module consist of:

1. 5mm infra-red receiver **LED**.
2. LM393 **dual differential comparator**.
3. 3296W trimmer **potentiometer**.
4. 6 resistors,2 indicator LEDs and 4 male header pins.

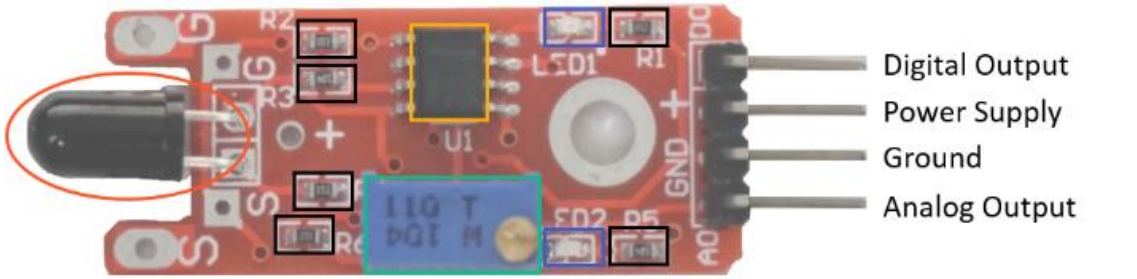
TECHNICAL DATA OF KY026

Operation Voltage	3.3V to 5V
Infrared Radiation Sensitivity	**0.76µm to 1.1µm**
Peak Wavelength (1/resonance frequency)	0.94µm
Detection Angle	0° to 60°

- Build in YG1006 infrared diode is sensitive to infrared radiation between 0.76µm and 1.1µm. When a fire burns, small amounts of infrared light are emitted. This light is received by the photodiode (IR receiver) on the sensor module.

- The detection angle of the phototransistor is between 0 and 60 degrees. Therefore, a fire is detected in a large angle around the sensor.

KY-026 Flame Sensor Module Pinout and Electronic Components:



Potentiometer | LEDs | Resistors | LM393 dual comparator | YG1006 Infrared Diode

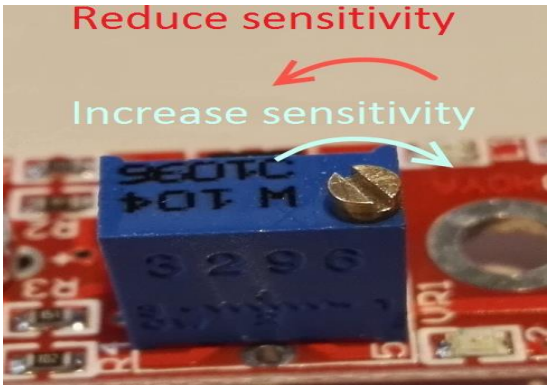
4 output pins that connect the KY-026 flame sensor module to a microcontroller.

- **A0:** Analog pin to transfer an analog signal.
- **GND**: Ground to connect the flame sensor to ground with the microcontroller.
- **+**: Pin for the 3.3V or 5V operation voltage regarding the technical datasheet.
- **D0**: Digital output based on a predefined threshold through the potentiometer and the operation voltage of the microcontroller.

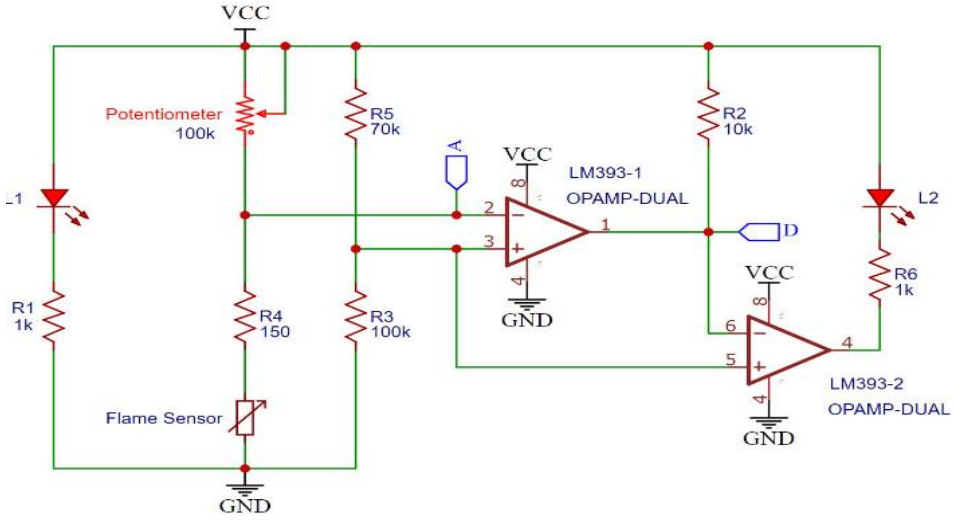
- **Potentiometer** to define a threshold for the digital output pin.
- **2 LEDs** to indicate that the module is operating (LED1) and to indicate the status of the digital pin (LED2).
- **6 Resistors** to prevent LEDs from high voltages and to operate as voltage dividers.
- **LM393 dual comparator** to compare the signal created by the infrared diode with the predefined value through the potentiometer and to control the status of the LED that indicates the status of the digital output.
- **YG1006 Infrared Diode** to recognize flames around the sensor module.

Sensitivity of Potentiometer:

This sensor doesn't show absolute values (like exact temperature in °C or magnetic field strength in mT). It is a relative measurement: you define an extreme value to a given normal environment situation, a signal will be sent if the measurement exceeds the extreme value.



Schematic of the KY-026 Flame Sensor Module:



- **LED1** in series with resistor R1 (1kΩ) to indicate that the KY-026 flame sensor module has a valid **power supply**.
- **Resistor R4 (150Ω)** and the **YG1006 infrared diode** as flame sensor build a voltage divider that relates to the reverence voltage of the **LM393-1 dual comparator (2).** The potential on this voltage divider is also the analog output **(A0)** of the KY-026 sensor module.
- Output of the first comparator of the **LM393 (1)** is connected to the **digital output (D0)** of the KY-026 flame sensor module.
- **Resistor R2** (10kΩ) disconnects the digital output **(D0)** from the operation voltage, otherwise D0 would be equal to the operation voltage and independent of the status of the flame sensor.

Functionality of the KY-026 Flame Sensor Module:

- If there is an operation voltage between 3.3V to 5V, **LED1 turns ON,** voltage divider between R5 and R3 creates a stable voltage of **V = VCC * R3 / (R3+R5) = VCC * 100/170 = 0.6*VCC.**

- This voltage is i/p voltage for pin (3) and (5) comparators.
- Other voltage divider created by the potentiometer and the resistor R4 in series to the YG1006 infrared diode is the input voltage of to first comparator pin (2) and the **A0** of the sensor.
- Potential on the **analog output (A0)** depends on the **resistance of the potentiometer** and **the voltage drop over the infrared diode**.

The voltage drop over the infrared diode depends on the infrared radiation and is

1) lower if there is a flame detected -> lower analog output
2) higher if there is no flame detected -> higher analog output

CASE 1: Potentiometer to be adjusted such that flame detected, potential of (A0) and pin (2) of comparator is **lower than i/p voltage 0.6*VCC.**

Therefore **LM393-1 (1) output is HIGH** and **D0 HIGH.**

Vcc pin (6) > 0.6*VCC pin (5), **LM393-2 (4) output is LOW.**

Potential difference between the **LED2 and resistor R6** and the output of the second comparator **LM393-2** (4), that turns **LED2 ON.**

RESULTS OF CASE-1 (When Flame Detected)

(A0) Analog output	LOW
(D0) Digital output	HIGH
LM393-1 (Comparator -1)	HIGH
LM393-2 (Comparator -2)	LOW
LED2	ON

CASE 2: If no flame detected, the potential on the analog output(A0) must be higher than the reference voltage(0.6*VCC) to set the output of the first comparator (1) to GND (LOW).

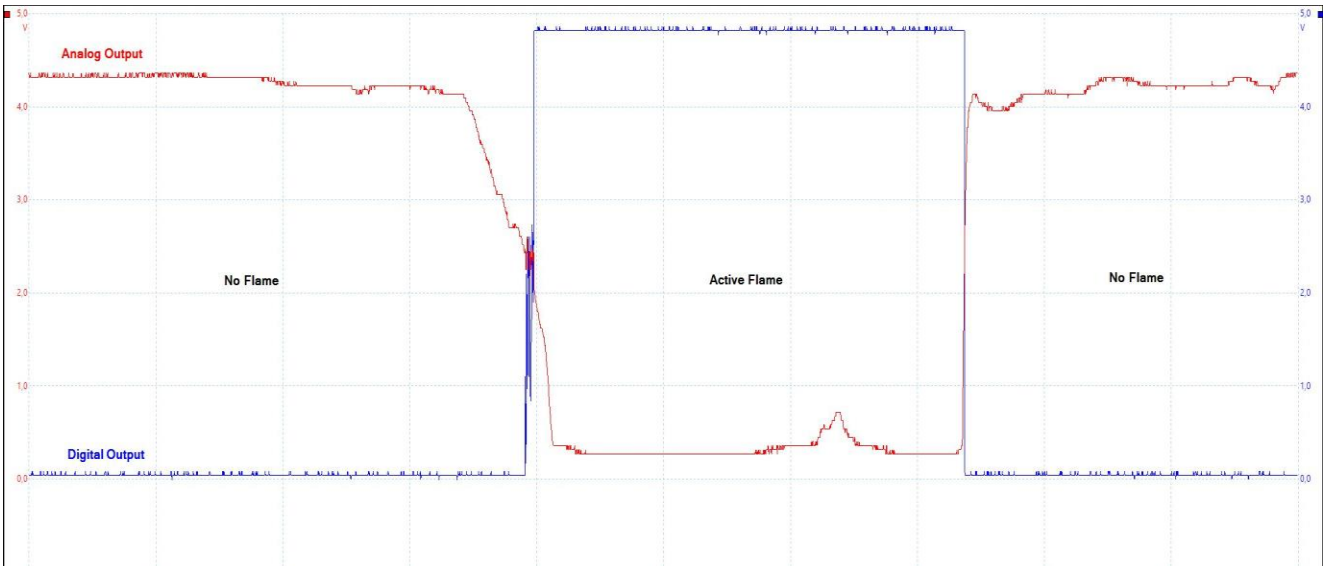
In this case the digital output**(D0) is GND** and input voltage of the second comparator PIN (5) 0.6*VCC is greater than the reference voltage GND PIN(6).

The output of the second comparator (4) is VCC and because there is no potential difference over the resistor R6 and LED2, **LED2 is OFF**.

RESULTS OF CASE-2 (When Flame not Detected)

(A0) Analog output	HIGH
(D0) Digital output	LOW
LM393-1 (Comparator -1)	LOW
LM393-2 (Comparator -2)	HIGH
LED2	OFF

Analog output(A0) and Digital output(D0) GRAPHICAL REPRESENTATION:



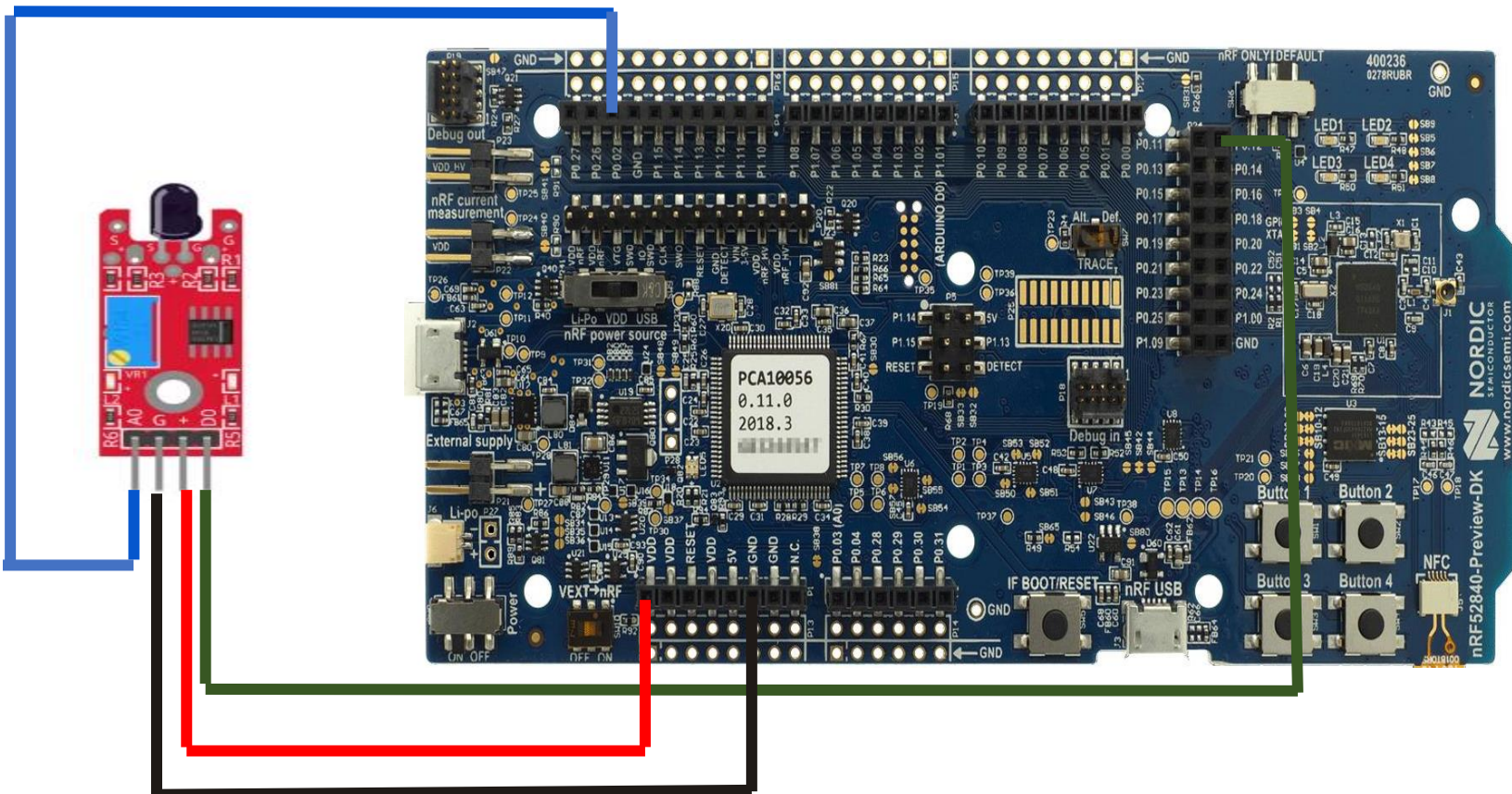
Summarized Functionality of the KY-026 Flame Sensor Module

Active Flame	Infrared Radiation	Analog Output	Digital Output	LED2
Yes	High	Low Value	VCC (HIGH)	On
No	Low	High Value	GND (LOW)	OFF

Conclusion obtained:

- If the measured infrared radiation increases due to a detected flame, the analog output (A0) decreases.
- To increase or decrease the sensitivity of the digital output (D0) of the KY-026 flame sensor module, adjust the potentiometer.
- If the threshold of the potentiometer is not exceeded, the digital output is HIGH and LED2 is ON.
- If there is no flame and therefore no infrared radiation, the threshold of the potentiometer is exceeded, the digital output (D0) is LOW and LED2 is OFF.

Interfacing nrf52840dk with KY-026 FLAME SENSOR:



PIN Configuration:

KY-026	Nrf52840dk
A0	P0.02
G	GND
+	+5V
D0	P0.12

SAADC:

- In nrf52840dk, ADC is known as **SAADC (Successive Approximation Analog-to-Digital Converter).**
- Supports up to **eight external analog input channels**, depending on package variant.

Lists the **main features of the SAADC**:

• Multiple input channels

• Each channel can use pins AIN0 through AIN7, the VDD pin, or the VDDH pin as input

• Eight channels for single-ended inputs and four channels for differential inputs

• Full scale input range

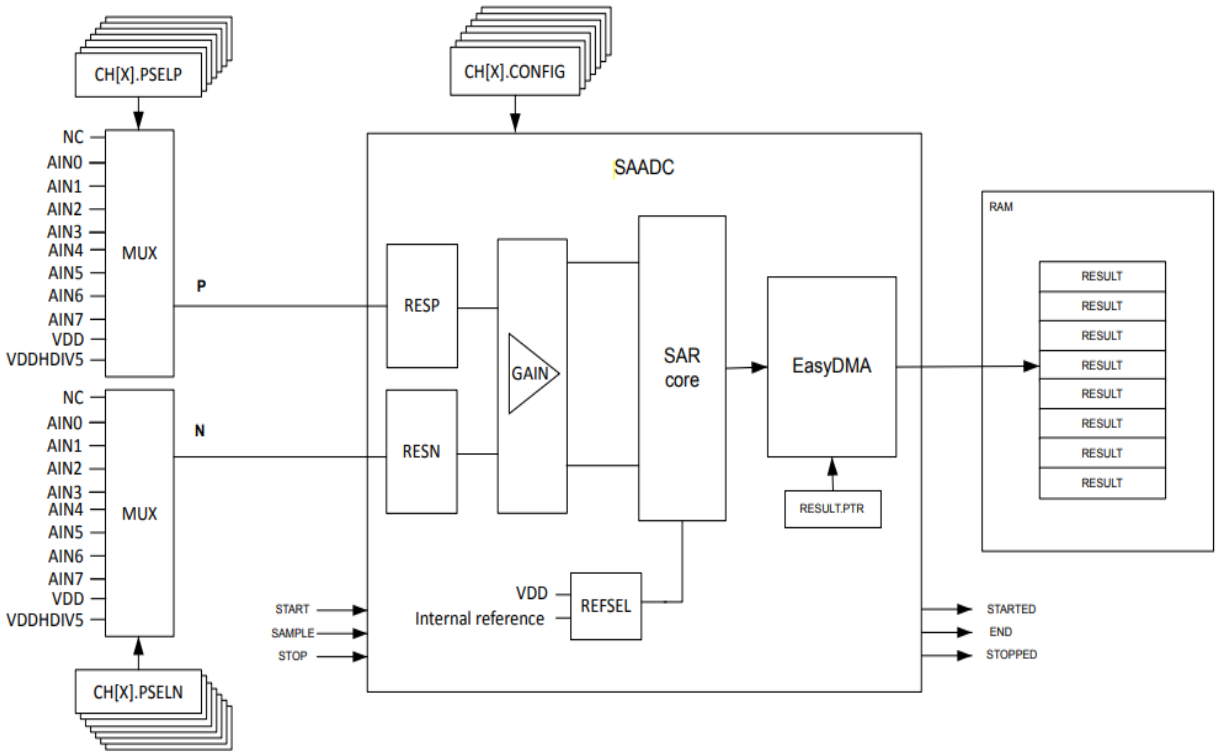
• Individual reference selection for each channel -> • VDD • Internal reference

• Continuous sampling

• Output samples are automatically written to RAM using EasyDMA

• Samples are stored as 16-bit 2's complement values

• 8/10/12-bit resolution, 14-bit resolution with oversampling



- **The input channel** is enabled and connected to an analog input pin using the registers CH[n]. PSELP (n=0...7)

AnalogInput0	1	AIN0
AnalogInput1	2	AIN1
AnalogInput2	3	AIN2
AnalogInput3	4	AIN3
AnalogInput4	5	AIN4
AnalogInput5	6	AIN5
AnalogInput6	7	AIN6
AnalogInput7	8	AIN7
VDD	9	VDD

Reference voltage and gain settings:

Each SAADC channel can have individual reference and gain settings. This is configured in registers CH[n].CONFIG (n=0...7).

Available configuration options are:

- **VDD/4 or internal 0.6 V reference**

- **Gain ranging from 1/6 to 4**

Input range = (±0.6 V or ±VDD/4)/gain

- Selecting VDD as reference, single-ended input (grounded negative input), and a gain of 1/4 will result in the following input range:

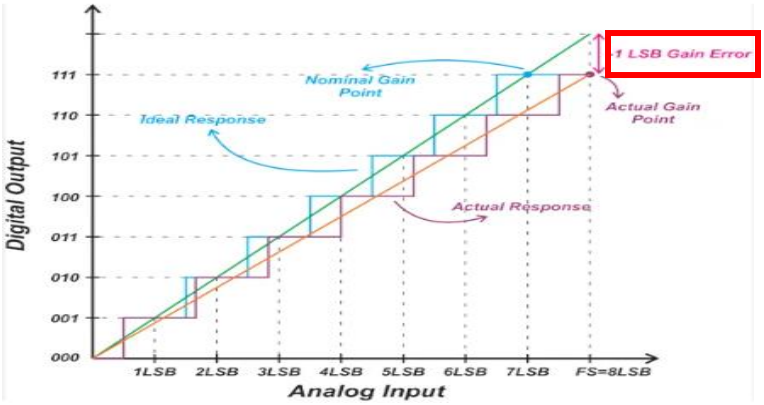
  Input range = (VDD/4)/(1/4) = VDD

- With internal reference, single-ended input (grounded negative input) and a gain of 1/6, the input range will be:

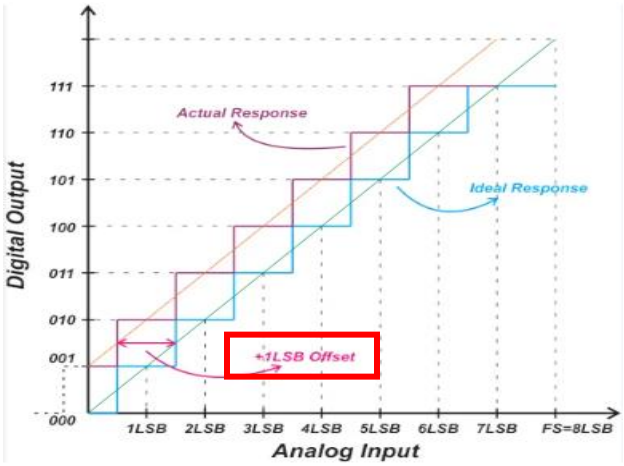
  Input range = (0.6 V)/(1/6) = 3.6 V

Important parameters of ADC:

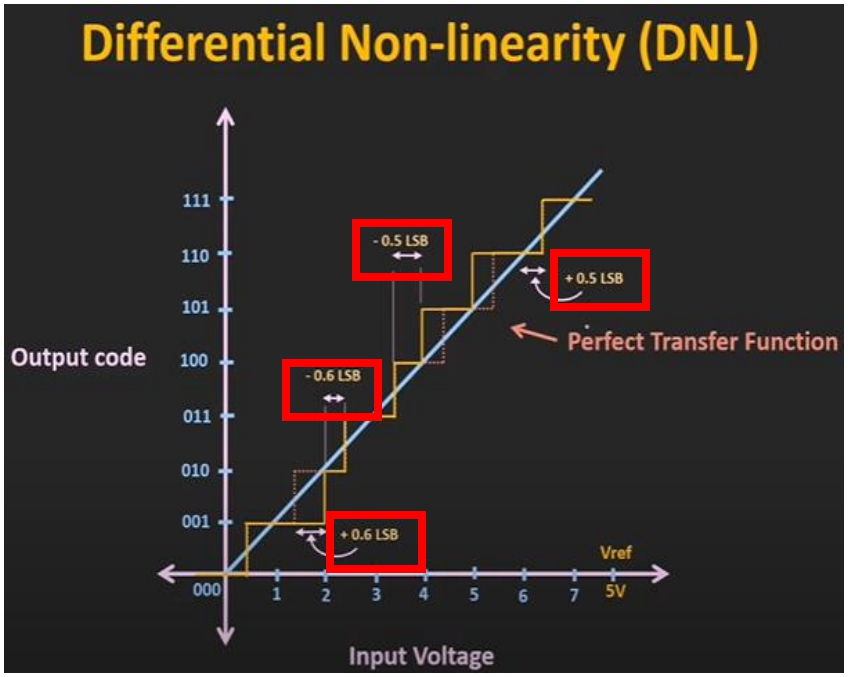
1. **Resolution:** the smallest incremental voltage that can be recognized and thus causes a change in the digital output. It is expressed as the number of bits output by the ADC. Denoted by **n**.
2. **Reference voltage/ Full scale Range**: The reference voltage by which the ADC computes digital values, many ADCs can use chip voltage supply as your reference voltage. Denoted by **Vref**.
3. **Gain:** gain is used to increase the signal and improve the signal-to-noise ratio (SNR).
4. **Gain Error:** the difference between the actual and ideal output slopes. It's also known as full-scale error.



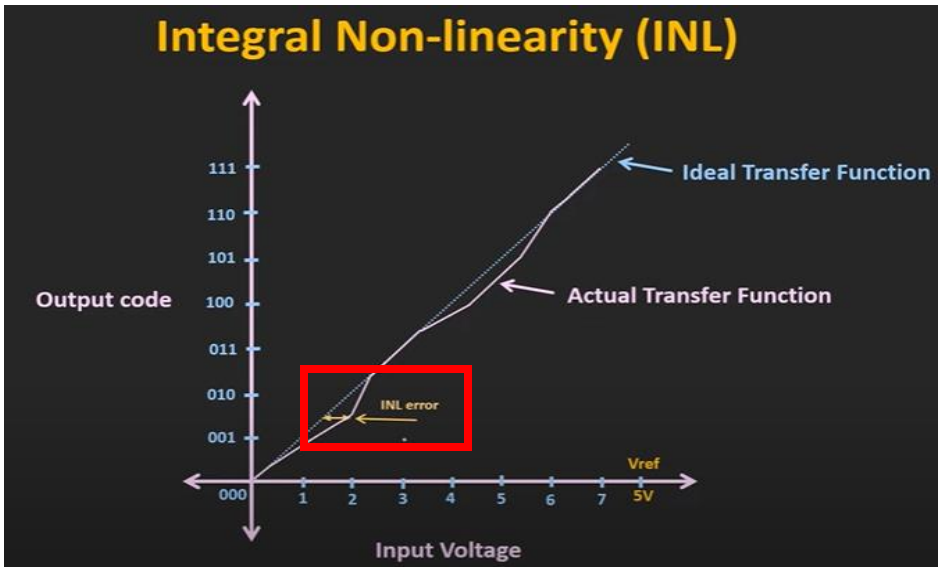
5. **Offset Error:** difference between the actual transfer function and the ideal transfer function at the zero transition.



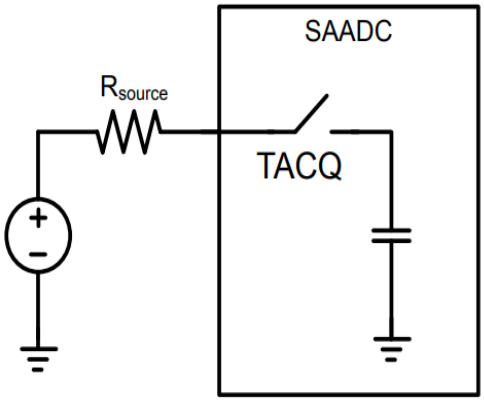
6. **Differential Non linearity error (DNL):** a measure of deviation from the ideal 1 LSB step.



7. **Integral Non-Linearity error (INL**): Difference between Ideal Transfer function and a straight line drawn from 0 to the points obtained from DNL.



8. **Acquisition time:** the time ADC takes to capture the input voltage during sampling.



In SAADC acquisition time means indicates how long the capacitor (TACQ)is connected (in closed state). For high source resistance the acquisition time should be increased

Digital output:

The digital output value from the SAADC is calculated using a formula.

RESULT = (V(P) – V(N)) * (GAIN/REFERENCE) * 2(RESOLUTION - m)

- where V(P) is the voltage at input P
- V(N) is the voltage at input N.
- GAIN is the selected gain.

- REFERENCE is the selected reference voltage.
- RESOLUTION is output resolution in bits, as configured in register RESOLUTION
- m is 0 for single-ended channels, 1 for differential channels
- Results are sign extended to 16 bits and stored as little-endian byte order in RAM.

SAADC is uses EasyDMA (Direct memory access) to store results in a result buffer in RAM.

Registers:

Base address	Peripheral	Instance	Description
0x40007000	SAADC	SAADC	Analog to digital converter

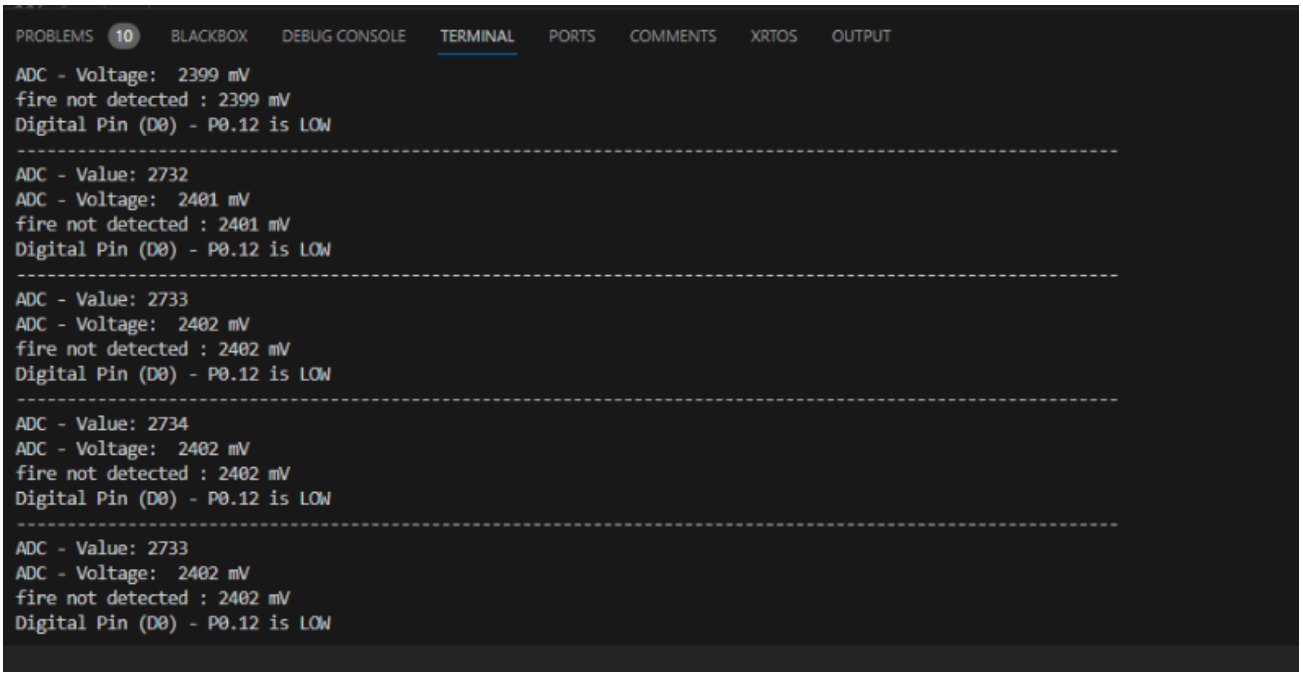
In my project I have set a Threshold of 1500 milli volts.

Detection parameter:

if (mv_value) is < 1500 mv -> FIRE DETECTED**, LED ON**

else -> FIRE NOT DETECTED, **LED OFF**

Serial output:



Logic analyzer output:

Channel 0 – Analog output of ADC

Channel 1 – Digital output of ADC

When Channel 0 is HIGH (High A0) no fire detected and Channel 1 will be LOW (D0 =0) and vice versa.