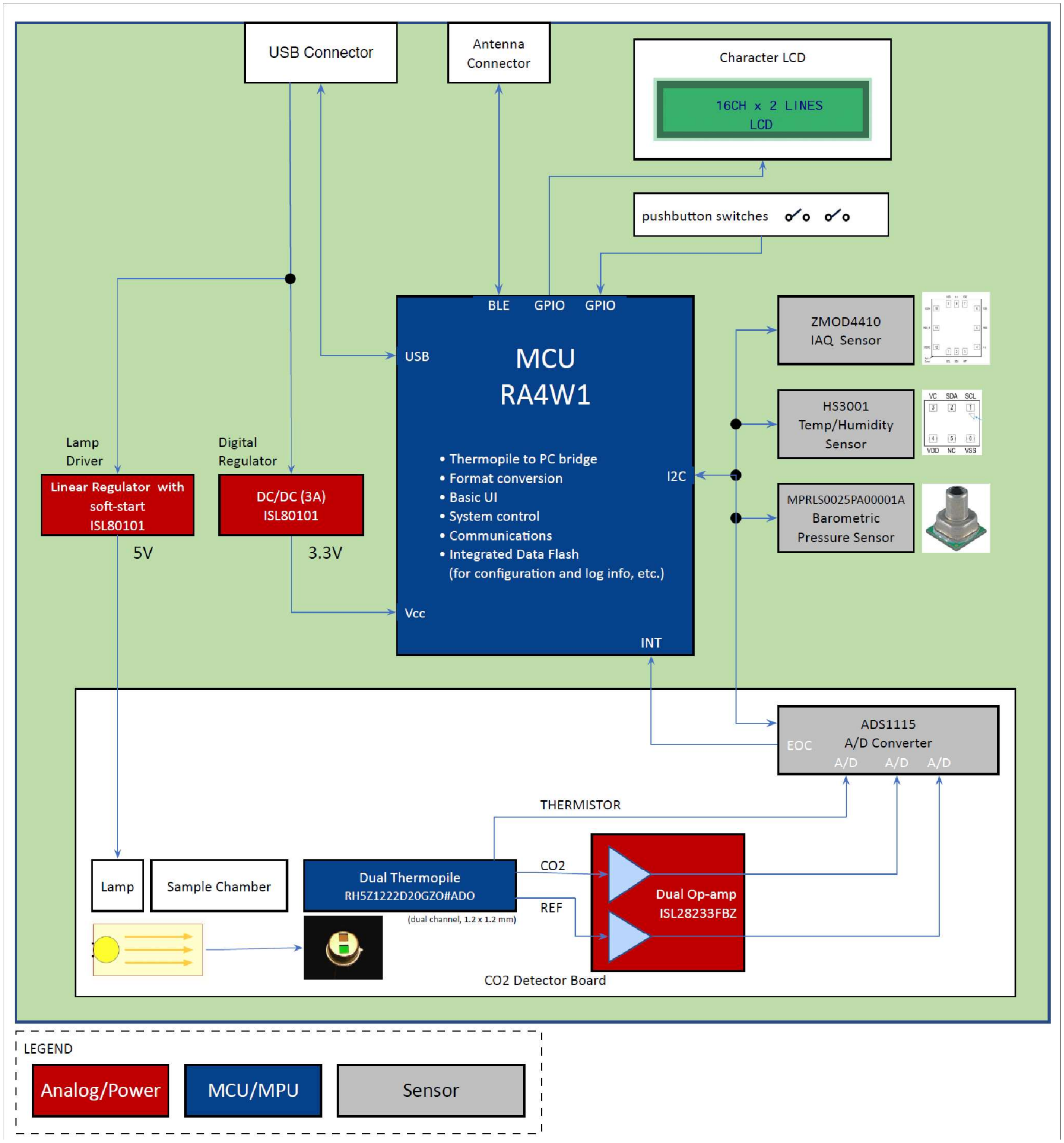
3. Working Principle of NDIR CO_2 Sensing

In general, a NDIR technology is a type of spectroscopy based on the principle that gas molecules absorb IR light and that absorption of certain gas occurs at a specific wavelength. In the case of Carbon dioxide, CO_2 strongly absorbs energy with a wavelength of 4.26µm. This makes CO_2 a good absorber of wavelengths falling in the infrared radiation region of the spectrum

The Renesas EVK for CO_2 Detector consists of an infrared light source, gas measurement chamber, dual thermopile detector, low noise amplifier,16-bit ADC, micro-controller (Renesas RA4W1), LCD user interface and power conversion electronics.



With reference to the above block diagram: gas enters from the openings in the sample chamber, and the infrared light source, in our case a lamp driven by a lamp driver circuit (a linear regulator with soft-start feature) emits infrared light intermittently to penetrate the gas being measured. The dual channel thermopile sensor is used to simultaneously measure the infrared light intensity of both the sensitive wavelength of CO_2, and of the reference wavelength. The reference light is not affected by CO_2.

3.1 Principle of Thermopile Measurement

The EVK includes a Renesas RTD120D dual thermopile. Each thermopile in the RTD120D package consists of a series connection of a large number of thermocouples. Since such a combination of thermocouples generates much higher thermoelectric voltage than a single thermocouple, the thermopile's sensitivity is increased.

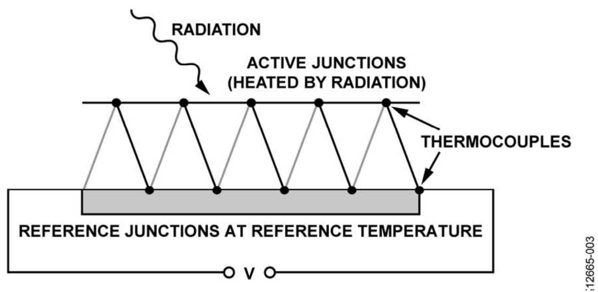


Figure 4. Each Thermopile is Constructed of Multiple Thermocouples

The IR light is applied to the dual thermopile detector fitted with a pair of optical filters. The filter pass band wavelengths are centered at 4260nm and 3910nm, and the concentration of carbon dioxide is measured from the ratios of the two thermopile voltages. The optical filter within the absorption channel serves as the detection channel and the optical filter outside the absorption spectrum serves as the reference channel. Measuring errors caused by dust or diminishing radiation intensity are removed using the reference channel.

3.2 Mathematical Derivation to Find the CO_2 Concentration

We use Beer-Lambert law to find the concentration 'x' of CO_2. Beer-Lambert law states that the intensity of IR in CO_2 gas decreases exponentially with the concentration 'x', Mathematically it can be represented as:

$$I = I_0 e^{-klx}$$

Here,

I = intensity of IR in CO_2 gas

I_0 = Intensity of IR in Reference gas (zero gas)

k = absorption coefficient for the specific gas and filter combination

l = equivalent optical path length between the lamp and detectors

x = concentration of CO_2

Re-arranging:

$$I/I_0 = e^{-klx}$$

Taking natural log on both sides:

$$\log(I/I_0) = (-klx)$$