Application Notes

Using KEMET Analog Flame Sensors

Dealing with Analog Circuits

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DOCUMENT HISTORY

Version	Date	Change Ref.	Change Details
01	02 June 2021	N/A	First Release

1 INTRODUCTION

General IR flame detectors must have a long detection distance.

To detect flames at a long distance the amplifier gain must be extremely high.

To reduce signal to noise ratios within the circuit, it is common practice to use multiple amplifiers rather than just a single amplifier with high gain. Also, the use of multiple amplifier circuits allows signal conditioning to be applied.

If the signal conditioning takes the form of a Bandpass filter. The Bandpass filter conditions the output signal from the Flame detector, so that each stage of the amplifier ONLY amplifies the signal of interest and not amplifies the surrounding electrical noise. In this way we are able to reduce the signal to noise ratio (SNR) of the circuit while also applying a high gain to the electrical signal.

This application note explains how to calculate the gain and flicker frequency of the band pass filter circuit.

2 GENERAL IR FLAME DETECTOR TEST CONDITIONS

When testing IR flame detectors, the source fuel was n-Heptane.

The flame source container size was 33 cm x 33 cm x 4 ~ 5 cm.

The main flame flicker frequency of the test condition was normally between 2 ~ 4 Hz.

This implies a 2~4 Hz amplifier is required for IR flame detection.

3 SIMPLE NON-INVERTING AMPLIFIER AND ITS PROBLEM

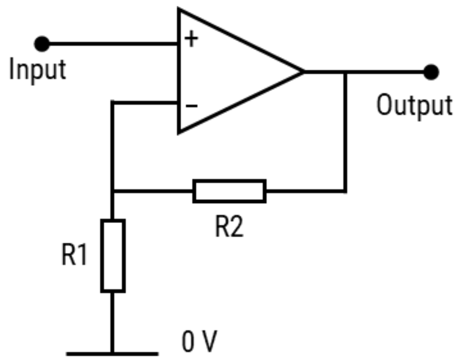

Figure 1 – Non-Inverting Amplifier

This type of amplifier circuit can be used for dual power supply circuits, (for example ±15 V), where the input signal can swing both negative and positive as long as it does not exceed the input supplies of the amplifier. For proper signal amplification, the bias voltage of the input signal and the reference voltage of the amplifier should be the same. If not, the difference between input bias and amplifier reference itself will be amplified.

4 AC COUPLED AMPLIFIER FOR PYROELECTRIC SENSOR

Today many engineers prefer to use single supply analog circuits as they reduce circuit complexities such as PCB layout and power supply considerations. However, single supply circuits do bring other considerations, such as ensuring the input signal does not meet or exceed the supply voltage. Often the way around this issue is to AC couple the input signal and to ensure the input is biased at 50% of the input supply.

All pyroelectric sensors detect variations in IR signal received. Therefore, a pyroelectric sensors output is an AC signal, for this reason all amplifier circuits connected to a pyroelectric sensor should be AC coupled (see Figure 2 below).

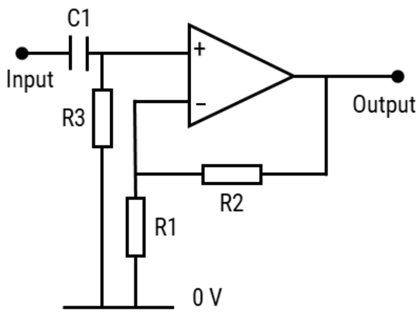

Figure 2 – Basic AC Coupled Amplifier

Figure 2 is an AC coupled amplifier for a dual power supply op amp. However, because of the zero-reference voltage, we cannot apply this circuit for single power supply operational amplifier.

Figure 3 is the AC coupled non-inverting amplifier for single supply operational amplifier. This circuit can control reference voltage at R_b, and the bandpass signal frequency can be tuned by changing the value of R_g, R_f, C_g and C_f.

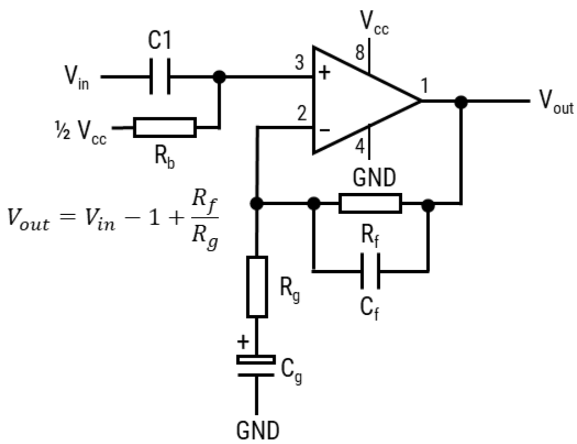

Figure 3 – Single Rail, AC Coupled Amplifier

5 PASS BAND FILTERING

What is a bandpass filter ? Since we require the flame sensor to detect only those signals which pertain to flames or " flicker" and to ignore potential false triggers, we must employ a signal filter that only allows signals of the correct frequency to pass. Earlier on in this document, the detection frequency of 2 Hz to 4 Hz was outlined. This means the filter has a start frequency of 2 Hz and a stop frequency of 4 Hz.

5.1 Pass Band Calculations

5.1.1 Roll-On Filter

Filter characteristics are usually defined by "the 3 dB point", so if we want to pass 2 Hz we should calculate a filter value where the 3 dB point is roughly 1.5 Hz.

$$F_1 = \frac{1}{2\pi \times R_g \times C_g}$$

Equation 1 - Roll-On Frequency 'F_1'

5.1.2 Roll-Off Filter

To ensure our 4 Hz frequency is also passed by our filter, we need to define and calculate the 3 dB point greater than 4.5 Hz.

$$F_2 = \frac{1}{2\pi \times R_f \times C_f}$$

Equation 2 – Roll-Off Frequency 'F_2'

5.2 Circuit Considerations

Figure 4 is an example amplifier circuit for long distance flame detection.

To expand the low-side cut-off frequency, the user can increase C_g and R_g.

To expand the high-side cut-off frequency, user can decrease C_f and R_f.

However, to keep the signal gain, the user should make a balance among these component values. The user also should verify this band-pass operation with a frequency sweep generator or simulations using PSPICE.

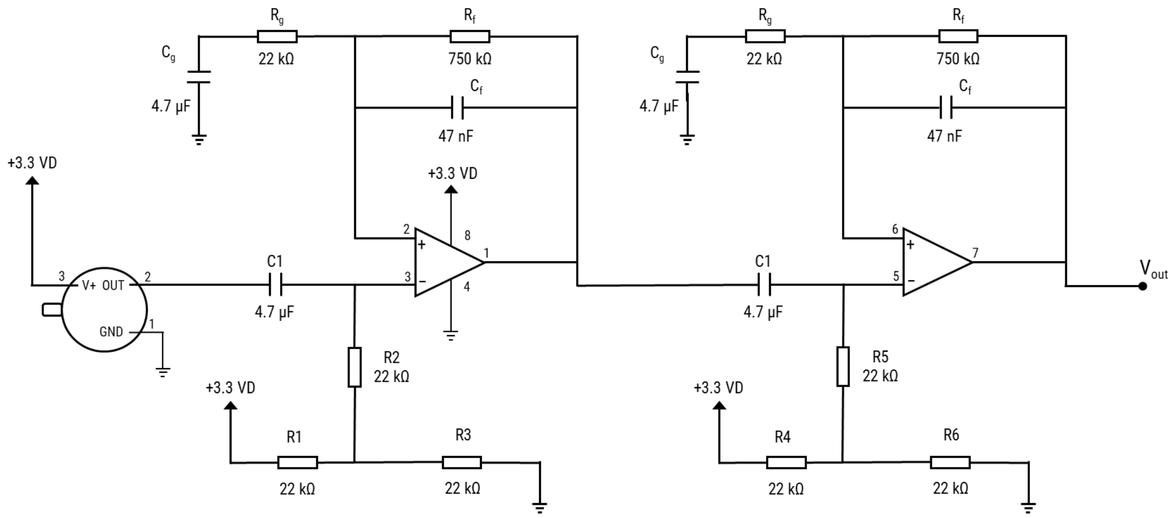

Figure 4 – Two Stage Amplification with Roll-On and Roll-Off Filtering (Band Pass Filtering)

5.3 Working Calculations

$$F_1 = \frac{1}{2\pi \times 22\ k\Omega \times 4.7\mu F} = 1.53\ Hz$$

Also

$$F_2 = \frac{1}{2\pi \times 750\ k\Omega \times 47nF} = 4.51\ Hz$$

Finally gain can be calculated

$$V_{out} = V_{in} \times \frac{R_f}{R_g}$$

$$V_{out} = 1.65 \times \frac{750\ k\Omega}{22\ k\Omega}$$

Gain is roughly 57 for each amplifier; or 3,250 in total.