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PIR Detector

1. Introduction

In recent years, as greenhouse effect brings about global climate abnormality, all products are designed to conform to be energy-saving and green energy. In order to achieve the above objects, all electronic product and household appliances cannot always be in operation, but should be activated to start their functions when people move close to them or pass them. For the reason, it is necessary to develop a detector capable of detecting human bodies by infrared lights. The pyro-electric infrared (PIR) detector is the best resolution because the housing of the PIR detector has a multi-layer coating film capable of blocking most infrared lights, but only allows the infrared lights with the waveforms whose temperatures are close to 36.5 ℃; thus, the detector is very suitable for movement detection of human bodies by infrared lights. The document mainly introduces the applications of the PIR detectors of HYCON HY10P-series MCUs.

2. Principle of PIR detector

When some crystals are heated, both ends of each of the crystals generate a plurality of charges; and the number of the charges of one end is equal to that of the other end, but the polarity of the charges of one end is inverse to that of the other end, which is so-call pyro-electric phenomenon. In general, the bound charges generated by the self-polarization of the crystals are neutralized by the free electrons from the air and attached to the surfaces of the crystals, and the self-polarization electric moments cannot be provided. When the temperature is changed, the self-polarization is also changed. Meanwhile, the charges of the surfaces of the crystals are exhausted. The situation of exhausting the charges is in proportion to the polarization level. FIG. 1 shows the principle of forming the pyro-electric phenomenon. The crystals which can generate the pyro-electric phenomenon is so-called pyro-electric body or pyro-electric component, and the most frequently-used materials include single crystals (e.g. LiTaO3, etc.), piezoelectric ceramics (e.g. PZT., etc.) and polymer thin films (e.g. PVFZ, etc.)

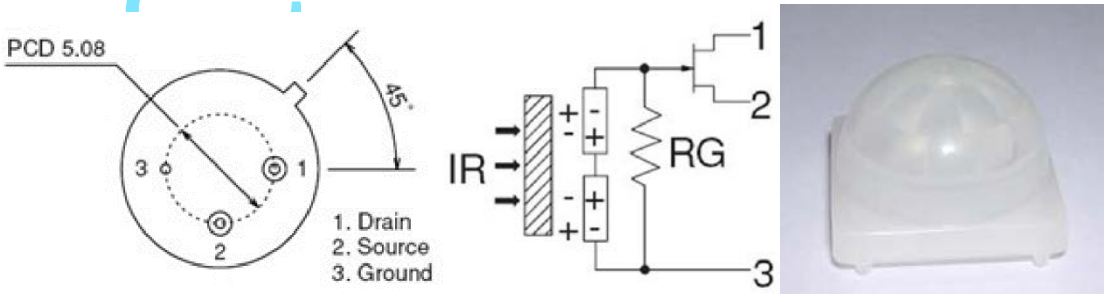

FIG. 1 FIG. 2 FIG. 3

The PIR detector is based on the pyro-electric phenomenon, which is a temperature sensor. The detector is composed of the ceramic oxides or piezoelectric crystal components; the both surfaces of the components serves as the electrodes; when the detector detects the change of the temperature of its monitoring range is “ΔT”; the pyro-electric phenomenon generates the charges “ΔQ” on both electrodes,

and there is a small voltage “ΔV” generated between the two electrodes. As its output impedance is very high, the detector has a field-effect transistor (FET) to perform the impedance change. The charges “ΔQ” generated by the pyro-electric phenomenon will be combined with the ions in the air and then disappear; when the environmental temperature is stable and unchanged, ΔT=0 and the detector does not output signals.When a person enters the monitoring area,“ΔT” is generated because the temperature of the human body is different from the environmental temperature; therefore, the detector outputs signals. If the person enters the monitoring area but does not move, the temperature remains unchanged; thus, the detector does not output signals. Therefore, the detector can detect the movement of the human bodies or animals. The structure and internal circuit of the PIR detector are as shown in FIG. 2. The detector mainly includes a housing, a spectral filer, a pyro-electric component “PZT” and a FET, etc. More specifically, the filer is disposed at the window to form a window for the infrared lights to pass through. The spectral filter is 6mm multi-layer film interference filter, which can effectively filter out the sun lights and the lights of fluorescent lamps with short waveforms (about lower than 5mm). The pyro-electric component “PZT” can transfer the small change between the infrared signals with the waveforms between 8mm~12mm into the electrical signals; in order to provide higher sensitivity for human bodies, its surfaces receiving the radiation usually are covered by the Fresnel filters, which can effectively suppress the interferences from the environment.The Fresnel lens (FIG. 3) is manufactured according to Fresnel principle, which can divide the infrared lights into the visible area and the blind zone, and also can provide the focusing effect; therefore, the sensitivity of the PIR detector can be significantly increased. The Fresnel lens can be classified into two types, including the refracting type and reflecting type. One of its functions is to provide the focusing effect in order to refract (reflect) the infrared lights generated from the pyro-electric phenomenon to the PIR detector; the other one of its functions is to divide the monitoring area into several light areas and dark areas in order to make the moving objects entering the monitoring area provide the temperature change to the PIR detector in order to generate the changing pyro-electric infrared signals; in this way, the PIR detector can generate the changing electrical signals. If we can connect a proper resistor to the pyro-electric component, the current passes through the resistor when the component is heated; then, the voltage signal can be obtained between the both ends of the resistor.

3. System structure and measurement description

Regarding HYCON HY10P-series integration high-precision Σ-Δ ADC MCU, its ADC output rate can be up to 1KHZ, so the MCU can swiftly measure instantaneous signal change; the conventional measurement method is to use two OPs to amplify the signals and make the comparison so as to monitor the changes of the detector. The system is to use the ADC to directly read the signal change, and then determine whether a heat source passes through or the signal change is caused by the environmental temperature change according to the signal change.The photoresistor is usually applied to the automatic detection lamp; however, the conventionalCDS photoresistor is gradually abandoned due to the environmental protection problem. Currently, most products adopt the photo transistor; since the transistor is a non-linear component, the conventional method using the OPs to amplify the signals or use

the I/O to provide the monitoring function can no longer be used for accurate applications; thus, it is necessary to use the ADC to measure the signals of the photo transistor. For the reason, the ADC measurement application must replace the conventional method using the OPs and the comparators.

Application circuit:

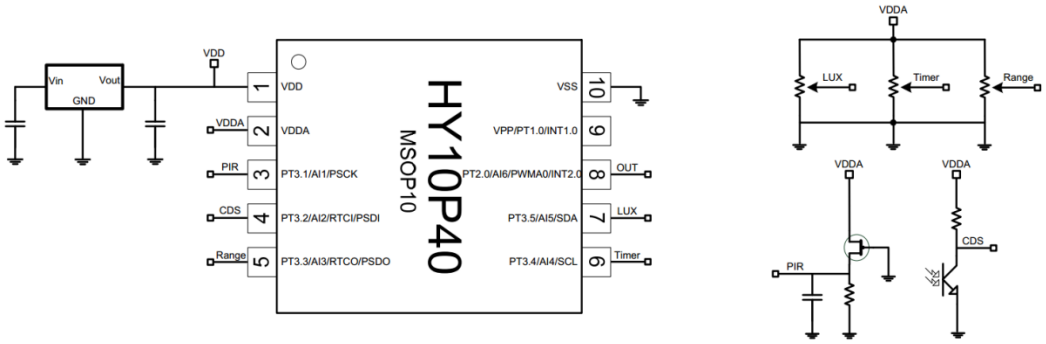

FIG. 4 Application circuit of HY10P40 PIR detector

ADC measurement waveform:

The configuration of the ADC is 250K sampling frequency and 1K output frequency;

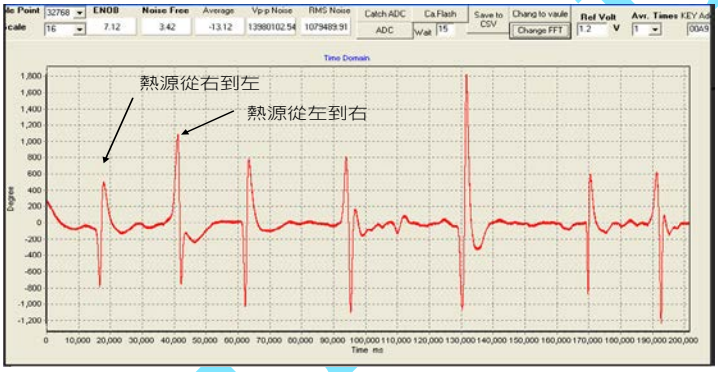

FIG. 5 The ADC output is 1KHZ, and the protrusion waves are the signals taking place when a heat source passes through.

4. Application structure

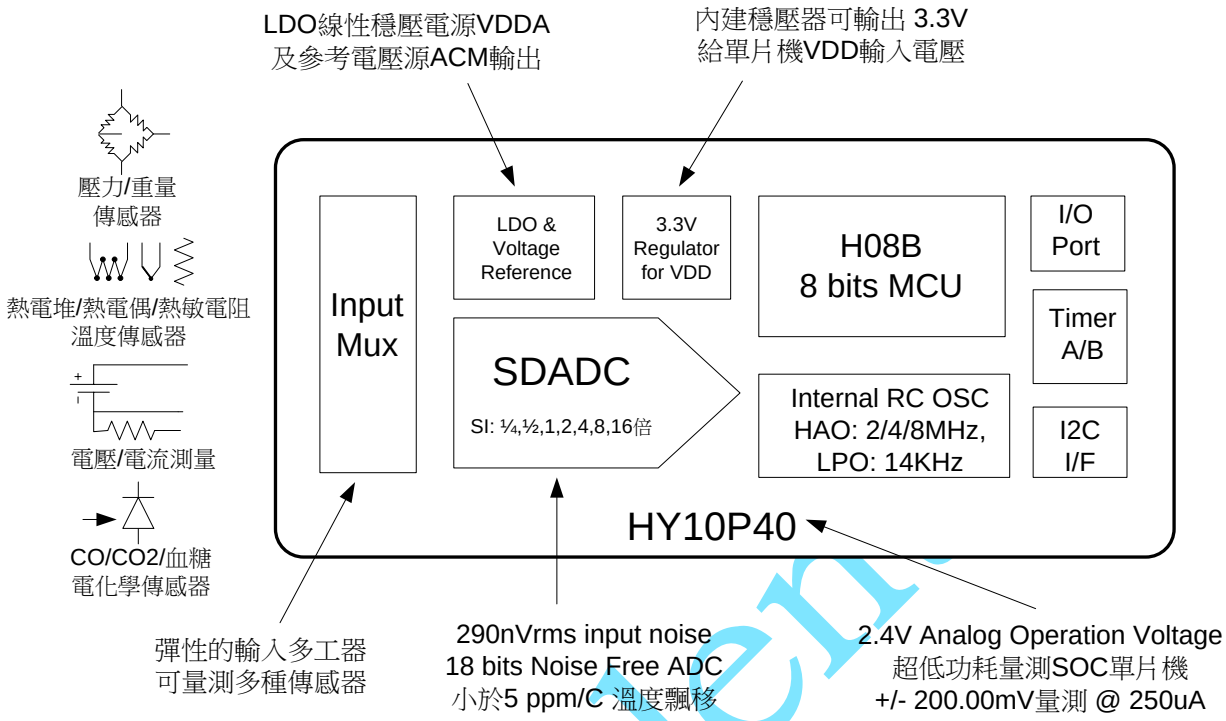

FIG. 6

HY10P-series 8-bit high-performance OTP MCU provided by HYCON is as shown in FIG. 5. The MCU not only includes the over sampling sigma delta analog-to-digital converter, but also can significantly simplify the peripheral circuit of the application; the chip is actually a MCU with high-performance specification and high integration:

- The input voltage range of the built-in V_{REGIN} regulator is up to 4V~24V, and can directly output 3.3V to the VDD to serve as the working voltage source of the MCU; in this way, the application can save the cost of a regulator.
- The range of the working voltage "VDD" of the MCU is 2.2V to 3.6V, which is suitable for battery-type products, and its working temperature range is between -40℃~85℃, which is more suitable for the industrial specification requirements.
- 8-Bit RISC-like MCU has 46 high-performance instruction sets "H08B"; besides, the chip has 2KWord OTP (One Time Programmable) Type program memory, and 128Byte data memory, which can satisfy the requirements of the algorithms.
- High-precision correctable RC oscillatoris provided, which can reduce the component requirements of connecting to external oscillators.
- The chip has the primary frequencynetwork which providing various working clocks for you to flexibly choose from, which allows users to achieve the best energy-saving planning; besides, the CPU also supports the instruction driving functions of the standby mode and the sleep mode so as to

effectively perform the power management, which can save more energy during the non-measurement mode. The power consumption of the chip is only 2.25mW even if under the consecutive measurement mode; further, the power consumption of the chip is only 2uW after entering the deep-sleep mode, which can further satisfy the energy-saving requirement.

- Multiple anti-failure function is provided; the function can active the chip reset function for the power source system to make the MCU can work normally; besides, the hardware full-stacking reset and the watchdog reset functions are further provided, which can reduce the chip failure phenomenon due to external interferences.
- Built-in high-resolution full-differential-input ΣΔADC:
  The main core of the chip is the built-in high-resolution full-differential-input ΣΔADC, the core can integrate the application system to achieve the system-on-chip (SOC). Under the setting of not amplifying inputted analog signals, the performance of the ADC can reach extra-high resolution, up to 20-bit ENOB. The ADC has the built-in programmable gain amplifier (PGA)function, which can indirectly save the conventional function of connecting to an external instrumentation pre-amplifier, and its magnifying power is up to 16, which is equal to the small signal resolution ability capable of resolving 290nV RMS noise. Under the setting of 250KHZ ADC sampling frequency, the chip can completely sample the data of the signals; thus, the oversampling structure of the ADC can increase the whole signal resolution; besides, the programmable digital oversampling function can also allow the decoding output rate of the ADC can be set to have the signal output speed of 8HZ-12HZ, which can completely satisfy various sampling bandwidth applications; further, the integration of the second-order comb filter at the rear end and the oversampling structure can also provide the function of low-pass filter.
- Support various digital functions to achieve a complete digital control product:
  Abundant multi-function digital peripheries can provide more application imaging space, including 8-bit Timer A, 16-bit Timer B modules, and built-in digital comparator module, capturing module, pulse-width modulation (PWM) module and pulse-frequency divider (PFD) function, etc. The built-in I2C serial communication module is suitable to server as the bridge to communication with other HOSTs.

5. Conclusion

The PIR measurement products adopting HY10P-series are of simple circuit and can provide flexible and diversified measurement functions, which can also allow users to change the parameters under different measurement environments.

6. References

[1] http://www.hycontek.com/attachments/MSP/DS-HY10P40_TC.pdf
HYCON HY10P40 Datasheet.
[2] http://www.hycontek.com/attachments/MSP/UG-HY10S40_TC.pdf

HYCON HY10P40 User Guide.