Self-Cooling Windows Let In Sunlight With-Out The Heat

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Abstract -***A bio-inspired micro-fluid circulatory system for windows saves energy and cut cooling costs. The new window-cooling system contains an extensive network of ultrathin channels near the window—the pane—through which water can be pumped when the window is hot. Using temperature sensor interfaced with PSoc3. This system can be controlled manually or automatically. Temperature sensors like LM35, sensors used in vehicles etc can be used. As TMP05 sensor can be easily interfaced with PSoC3 we consider TMP05. Here we have applied automatically using temperature sensor TMP05 interfaced with PSoC3 kit. The TMP05 is monolithic temperature sensors that generate a modulated serial digital output (PWM), which varies in direct proportion to the temperature of the devices. The high period (TH) of the PWM remains static over all temperatures, while the low period (TL) varies. PSoC is the world's only programmable embedded system-on-chip integrating high-performance analog, PLD-based programmable logic, memory and a microcontroller on a single chip. PSoC (Programmable System on Chip) is a mixed-signal array internally composed of a processor core, configurable analog& digital blocks, programmable routing and interconnects. Unlike other Microcontrollers, which typically consist of only the processor core. A PSoC uses SRAM to store data, Flash Memory to store instructions and data and I/O registers to control internal logic blocks. On boot-up, the chip typically loads instructions/configuration from internal flash memory.***

Key Words: *PSoC, TMP05/TMP06, MOSFET, development kit.*

1. INTRODUCTION

Sun-drenched rooms make for happy residents, but large glass windows also bring higher air-conditioning bills. Now a bio-inspired micro-fluidic circulatory system for windows could save energy and cut cooling costs dramatically—while letting in just as much sunlight. The same circulatory system could also cool rooftop solar panels, allowing them to generate electricity more efficiently.[2] The channels consist of long, narrow troughs that are moulded into a thin sheet of clear silicone rubber that, when stretched over a flat pane of glass, create sealed channels. Micro-fluidics is the science that deals with the flow of liquids in channels of micrometer size. At least one dimension of the channel is of the order of a micrometer or tens of micrometers. Micro-fluidics can be considered both as a science (study of the behaviour of fluids in micro-channels) and a technology (manufacturing of micro-fluidic devices for applications such as lab-on-a-chip).This system can be controlled manually or automatically. Temperature sensors like LM35, sensors used in vehicles etc can be used. As TMP05 sensor can be easily interfaced with PSoC3 we consider TMP05. Here we have applied automatically using temperature sensor TMP05 interfaced with PSoC3 kit.

2. TEMPERATURE SENSOR TMP05

TMP05 is monolithic temperature sensors that generate a modulated serial digital output (PWM), which varies in direct proportion to the temperature of the devices. The high period (TH) of the PWM remains static over all temperatures, while the low period (TL) varies. The B Grade version offers a high temperature accuracy of ±1°C from 0°C to 70°C with excellent transducer linearity. The digital output of the TMP05 is CMOS-/TTL-compatible and is easily interfaced to the serial inputs of most popular microprocessors. The flexible open-drain output of the TMP06 is capable of sinking 5 mA. The TMP05 is specified for operation at supply voltages from 3 V to 5.5 V. Operating at 3.3 V, the supply current is typically 370 μA. The TMP05 is rated for operation over the −40°C to +150°C temperature range. It is not recommended to operate these devices at temperatures above 125°C for more than a total of 5% (5,000 hours) of the lifetime of the devices. The TMP05 has three modes of operation: Continuously converting mode, daisy-chain mode, and one shot mode. A three-state FUNC input determines the mode in which the TMP05 operates.

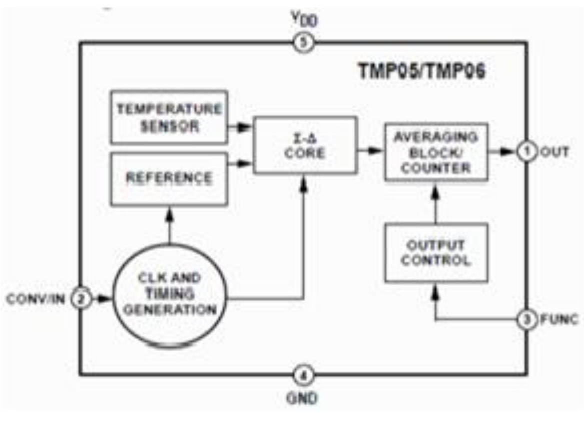

Fig -1: Functional block of TMP05/06

The CONV/IN input pin is used to determine the rate at which the TMP05/TMP06 measure temperature in continuously converting mode and one shot mode. In daisy-chain mode, the CONV/IN pin operates as the input to the daisy chain.

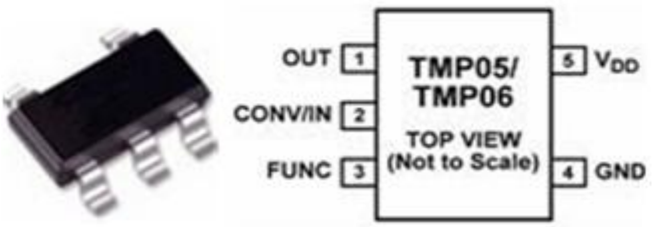

Fig -2: A temperature sensor TMP05

2.1 Pin Description:

1. *Pin No. 1(OUT):* Digital Output. Pulse-width modulated (PWM) output gives a square wave whose ratio of high-to-low period is proportional to temperature.
2. *Pin No. 2(CONV/IN):* Digital Input. In continuously converting and one shot operating modes, a high, low, or float input determines the temperature measurement rate. In daisy-chain operating mode, this pin is the input pin for the PWM signal from the previous part on the daisy chain.
3. *Pin No. 3(FUNC):* Digital Input. A high, low, or float input on this pin gives three different modes of operation. For details, see the Operating Modes section.
4. *Pin No. 4(GND):* Analog and Digital Ground.
5. *Pin No. 5(VDD):* Positive Supply Voltage, 3.0 V to 5.5 V. Using a decoupling capacitor of 0.1 μF as close as possible to this pin is strongly recommended.

2.2 Highlights:

1) The TMP05/TMP06 have an on-chip temperature sensor that allows an accurate measurement of the ambient temperature. The measurable temperature range is –40°C to +150°C.
2) Supply voltage is 3 V to 5.5 V.
3) Space-saving 5-lead SOT-23 and SC-70 packages.
4) Temperature accuracy is typically ±0.5°C. Each part needs a decoupling capacitor to achieve this accuracy.
5) Temperature resolution of 0.025°C.
6) The TMP05 feature a one shot mode that reduces the average power consumption to 102 μW at 1 SPS.

3. DAISY-CHAIN MODE

Setting the FUNC pin to a high state allows multiple TMP05/ TMP06s to be connected together and, therefore, allows one input line of the microcontroller to be the sole receiver of all temperature measurements. In this mode, the CONV/IN pin operates as the input of the daisy chain. In addition, conversions take place at the nominal conversion rate of TH/TL = 34 ms/65 ms at 25°C.

Therefore, the temperature equation for the daisy-chain mode of operation is

$$\text{Temperature } (°C) = 421 - (751 \times (TH/TL))$$

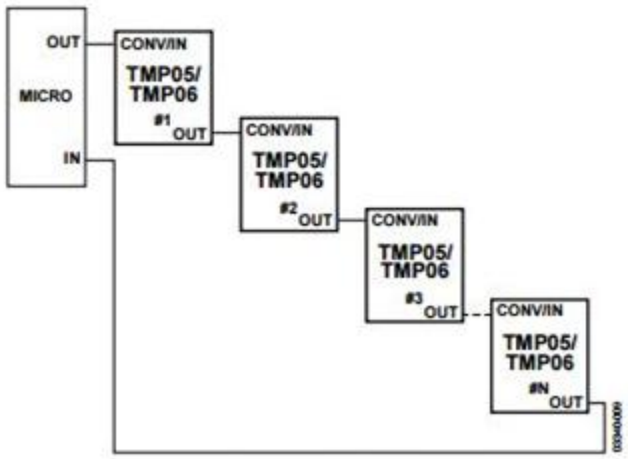

Fig -3: Daisy-Chain Structure

A second microcontroller line is needed to generate the conversion start pulse on the CONV/IN pin. The pulse width of the start pulse should be less than 25 μs but greater than 20 ns. The start pulse on the CONV/IN pin lets the first TMP05/TMP06 part know that it should now start a conversion and output its own temperature. Once the part has output its own temperature, it outputs a start pulse for the next part on the daisy-chain link. The pulse width of the start pulse from each TMP05/TMP06 part is typically 17 μs.

Fig -4 shows the start pulse on the CONV/IN pin of the first device on the daisy chain.
Fig -5 shows the PWM output by this first part.

Before the start pulse reaches a TMP05/TMP06 part in the daisy chain, the device acts as a buffer for the previous temperature measurement signals. Each part monitors the PWM signal for the start pulse from the previous part. Once the part detects the start pulse, it initiates a conversion and inserts the result at the end of the daisy-chain PWM signal. It then inserts a start pulse for the next part in the link. The final signal input to the microcontroller should look like Fig -6. The input signal on

Pin 2 (IN) of the first daisy-chain device must remain low until the last device has output its start pulse. If the input on Pin 2 (IN) goes high and remains high, the TMP05/TMP06 part powers down between 0.3 sec and 1.2 sec later. The part, therefore, requires another start pulse to generate another temperature measurement. Note that to reduce power dissipation through the part, it is recommended to keep Pin 2 (IN) at a high state when the part is not converting. If the IN pin is at 0 V, the OUT pin is at 0 V (because it is acting as a buffer when not converting), and is drawing current through either the pull-up MOSFET (TMP05) or the pull-up resistor (TMP06).

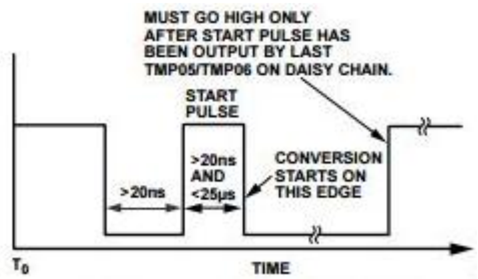

Fig -4: Start pulse at CONV/IN pin of first TMP05/06 device on Daisy-Chain.

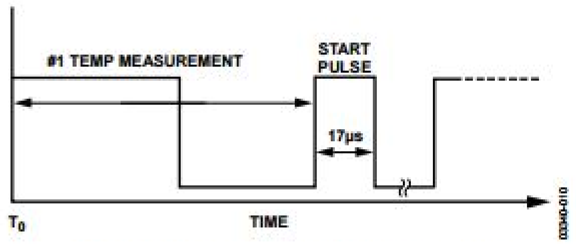

Fig -5: Daisy-Chain temperature measurement and start pulse output from first TMP05/TMP06.

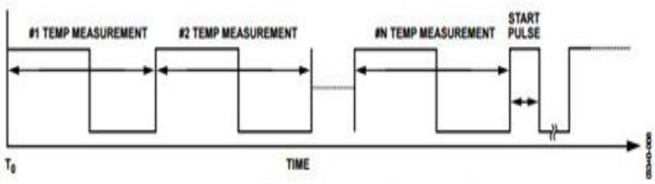

Fig -6: Daisy –Chain signal at input to the Microcontroller

4. PSoC

PSoC is the world's only programmable embedded system-on-chip integrating high-performance analog, PLD-based programmable logic, memory and a microcontroller on a single chip. PSoC (Programmable System on Chip) is a mixed-signal array internally composed of a processor core, configurable analog & digital blocks, programmable routing and interconnects. Unlike other Microcontrollers, which typically consist of only the processor core. A PSoC uses SRAM to store data, Flash Memory to store instructions and data and I/O registers to control internal logic blocks. On boot-up, the chip typically loads instructions/configuration from internal flash memory.

PSoC Creator is the second generation software IDE to design debug and program the PSoC 3 and PSoC 5 devices[1]. The development IDE is combined with an easy to use graphical design editor to form a powerful hardware/software co-design environment. PSoC Creator consists of two basic building blocks. The program that allows the user to select, configure and connect existing circuits on the chip and the components which are the equivalent of peripherals on MCUs. What makes PSoC intriguing is the possibility to create own application specific peripherals in hardware. On top of that, Cypress publishes component packs several times a year. Basically PSoC users get new peripherals for their existing hardware without being charged or having to buy new hardware. PSoC Creator also lets users connect any peripheral to any pin (except supply pins).

Fig -7: PSoC3 Kit

5. INTERFACE OF PSOC3

The traditional chips consist only of CPU cores whereas configurable blocks can be found in FPGA, CPLD and ASIC. A PSoC(Programmable system on chip) combines the architecture of both making it one of a kind. A System on Chip is a single chip performing functions of several chips put together[3]. PSoC devices integrate configurable analog and digital circuits. These are controlled by an on-chip microcontroller, thus, providing both enhanced design revision capability and component count savings. These devices occupy minimum board space, consume less power, provide high efficiency and reduce system cost. They can provide up to 100 peripherals. Peripherals allow interaction with the physical world. They also utilize fewer components to perform a task. Digital temperature sensors are widely used in systems where multiple temperature measurements are required in specific locations on a large board (such as a line card in a switch or router) or in a remote location. The use of digital temperature sensors frees the designer from worrying about digital noise coupling on to sensitive analog signals on the PCB layout because the digital temperature sensor does the analog to digital conversion within its own package, at the location where the temperature measurement is needed. The most common digital temperature sensors use industry-standard communications interfaces such as I2C or SPI. These interfaces are well known and need no description here. For applications in which the thermal management controller has no I2C or SPI interfaces available, an alternative is Analog Devices‟ TMP05 and TMP06 monolithic temperature sensors that generate a Pulse-width modulated (PWM) serial digital output.

The duty cycle of the PWM output varies in direct proportion to the ambient temperature of the devices. The high period (TH) of the PWM remains static over all temperatures, while the low period (TL) varies. It offers a high temperature accuracy of ±1 °C from 0 °C to 70 °C with excellent transducer linearity. The digital output of the TMP05 is CMOS/TTL-compatible and, therefore, can be interfaced directly to PSoC. The digital output of the TMP06 is open-drain and requires a pull-up resistor for proper operation, which can be integrated inside PSoC.

The TMP05 Digital Temperature Sensor Interface component makes it extremely easy for designers to develop thermal monitoring and management solutions using multiple TMP05 sensors. The component requires just one input and one output pin from PSoC[6]. The TMP05 Digital Temperature Sensor Interface component can be used in thermal management solutions for base stations, telecommunications, and in server and storage applications. Typical applications may include, but are not limited to, areas where remote temperature sensing, environmental control systems, computer thermal monitoring, thermal protection, industrial process control, and power-system monitoring and management are required.

6. TYPICAL SYSTEM ARCHITECTURE

The TMP05 sensor has three modes of operation:

- Continuously converting mode
- Daisy-chained mode
- One-shot mode

A three-state function control input pin (FUNC) sampled at power-up determines the mode in which the device operates. Setting the FUNC pin to a high state allows multiple TMP05s to be connected in daisy-chained mode. In that mode, multiple TMP05 temperature sensors can be connected, which enables PSoC to read all the sensors through the same two-wire interface. In this configuration, PSoC generates a "Start" pulse to begin a new temperature-to-PWM conversion cycle. The output of the first TMP05 sensor begins with its own PWM output, followed by a new Start pulse that it generated internally. The output of the second TMP05 sensor begins with the PWM output of the previous sensor, followed by its own PWM output and terminated by a new Start pulse that it generated internally. When more sensors are daisy chained[5].

In this fashion, the final return signal to PSoC contains the PWM outputs from all sensors starting with the output of the first sensor, followed by the output from the second sensor and so on until the terminating start pulse is detected. Temperature-to-PWM conversion then stops until PSoC generates another Start pulse. The system-level connection scheme and expected waveforms are shown in Fig -8. PSoC is an ideal choice for interfacing to TMP05 sensors because it has the programmable universal digital block resources available to implement the required custom interface logic with minimal firmware. This application focuses on how to use the TMP05 Digital Temperature Sensor Interface component with PSoC by working through some example projects on the CY8CKIT-001 PSoC Development Kit (DVK)[4]. The examples will show how to operate the component and monitor the temperature of multiple TMP05 devices reliably.

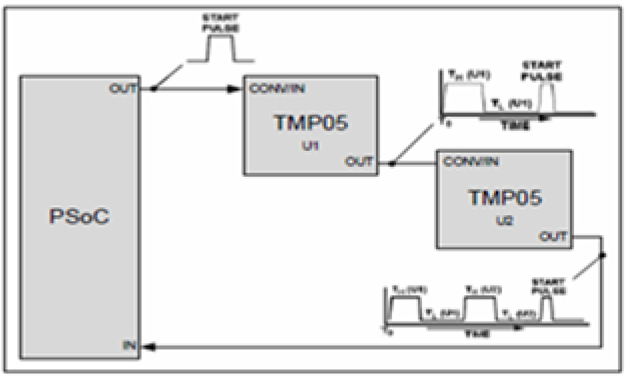

Fig -8: Multiple TMP05 sensors Daisy-Chained

Design Considerations when using TMP05 Sensors in Daisy-Chain Mode certain timing constraints must be observed when operating TMP05 sensors in daisy-chain mode. PSoC needs to generate the conversion start pulse on the CONV/IN pin of the first sensor. The start pulse lets the first TMP05 part know that it should now start a conversion and output its own temperature. The pulse width of the start pulse should be less than 25 µs but greater than 20 ns. These constraints are handled automatically by the component design and are mentioned in this application note for reference purposes only. Fig -4 and Fig -5 show the input and output waveforms for the first sensor in the daisy-chain (taken from the TMP05 device datasheet).

7. WORKING MECHANISM

The circulatory system used here functions like those of living animals, including humans, which contain an extensive network of tiny blood vessels near the surface of the skin that dilate when we are hot. This allows more blood to circulate, which promotes heat transfer through our skin to the surrounding air. Similarly, the new window-cooling system contains an extensive network of ultrathin channels near the "skin" of the window—the pane—through which water can be pumped when the window is hot. The channels consist of long, narrow troughs that are molded into a thin sheet of clear silicone rubber that, when stretched over a flat pane of glass, create sealed channels. The water comes in at a low temperature, runs next to a hot window, and carries that thermal energy away.

As described above in this system we are making use of micro fluid, TMP05and PSoC3 PLD. During interface of TMP05 a default temperature is set. If the temperature exceeds the default temperature it automatically opens the valve. As the valve opens the micro-fluids runs through the window panel. The heat exchange between the micro-fluid and the surrounding takes place, this leads to decrease in room temperature. Here the output of the temperature sensor is in voltage form. In the program, a default voltage value is set. If the voltage exceeds the default value an interrupt is generated. The PSoC3 lets the valve open and lets in the water. In order to cool the fluid we make use of glass wool. The fluid after absorbing the heat gets collected in a tank. This tank will be surrounded with glass wool; this brings down the temperature of the hot fluid[2].

Glass wool is a thermal insulation that consists of intertwined and flexible glass fibers, which causes it to "package" air, resulting in a low density that can be varied through compression and binder content. It can be a loose fill material, blown into attics, or, together with an active binder sprayed on the underside of structures, sheets and panels that can be used to insulate flat surfaces such as cavity wall insulation, ceiling tiles, curtain walls as well as ducting. It is also used to insulate piping and for sound proofing.

8. ADVANTAGES

1. CFC's (Chloro Fluro Carbons) letting out into environment and the damages caused to the environment can be avoided.
2. It is reliable in its performance.
3. When compared the implementation of it cheaper and hence its considered as cost effective.
4. The amount of energy consumed for the cooling when compared to the regular air conditioners is very much reduced and the performance factor of cooling is considerably increased, hence said to have reduced power consumption.

9. CONCLUSION

The new window-cooling system contains an extensive network of ultrathin channels near the "skin" of the window—the pane—through which water can be pumped when the window is hot. The PSoC3 lets the valve open and lets in the water. In order to cool the fluid we make use of glass wool. Thereby, glass wool helps with thermal insulation. This type of cooling is reliable, cost effective and helps in reducing power consumption.

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BIOGRAPHIES

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