Temperature Sensor Board

User Manual

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ZILOGIC SYSTEMS

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Chapter 1. Temperature Sensor Board

1. Overview

The temperature sensor board is based on NXP's `SA56004` temperature sensor which can be interfaced through the I²C bus. Temperatures can be measured with an accuracy of ±1 °C.

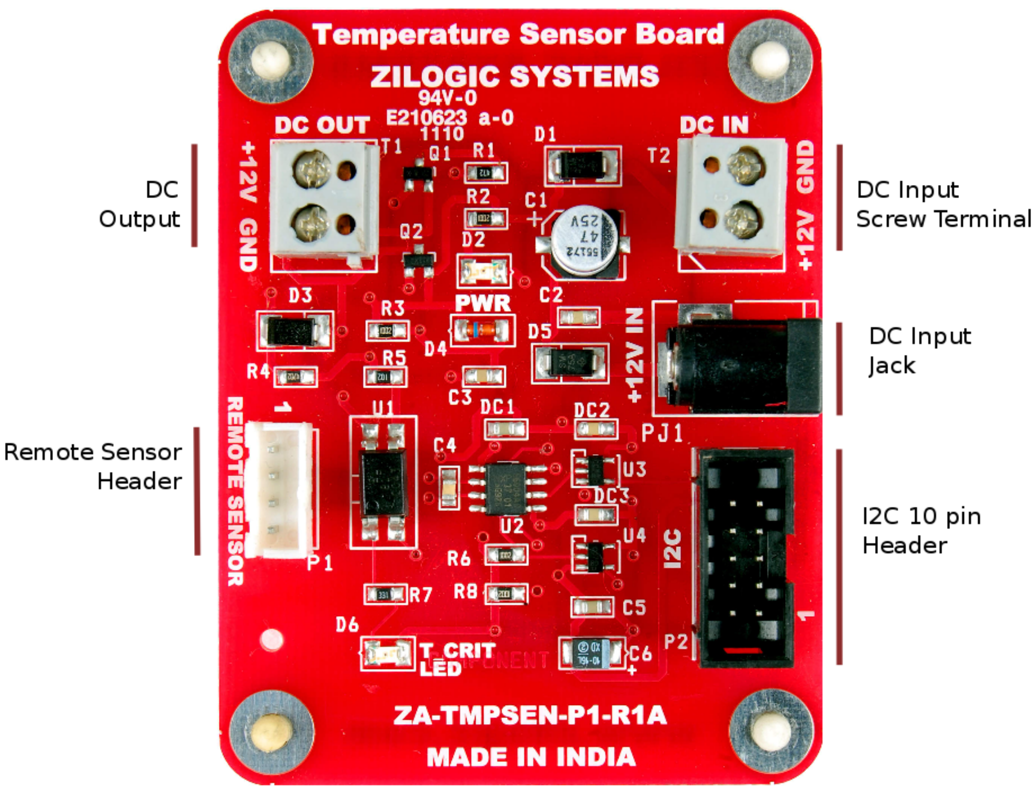
2. Board Features

- `SA56004`, I²C temperature sensor
- Remote temperature measurement
- Over temperature alert interrupt
- External device control, without software intervention
- LED indications for testing/debugging
- Can measure temperatures from -40 °C to 125 °C.

3. Locating Components

The location of the components on the board is indicated in the following diagrams.

Figure 1.1. Front View



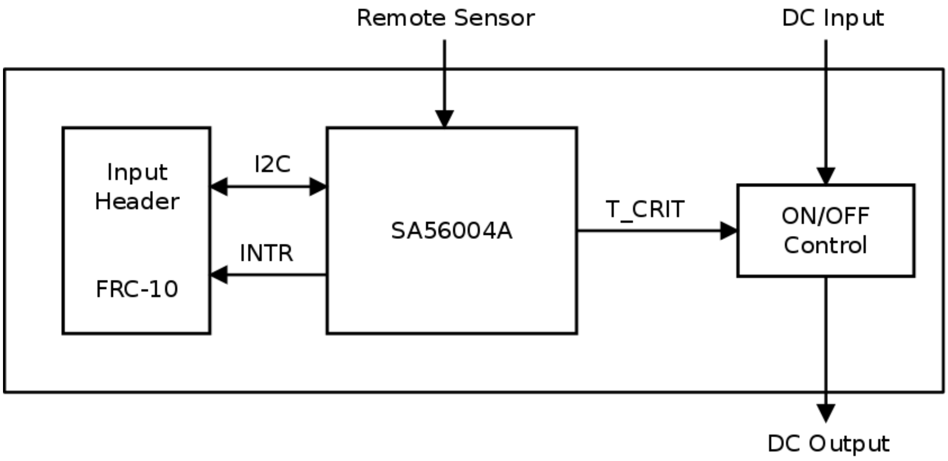
4. Description

A block diagram representation of the board is shown below. The I²C temperature sensor can be accessed through the 10 pin FRC connector from the motherboard. The temperature sensor can measure the local IC temperature, and a remote temperature. For measuring remote temperatures a transistor connected to the `REMOTE SENSOR` port is used as the sensing element.

An alert interrupt is raised when the temperature exceeds a configurable set point. The signal T_CRIT is raised when the temperature exceeds a configurable critical set point. This is useful for automatic temperature regulation applications, where the system is to be shutdown or a fan is to be switched ON, without software intervention.

The board provides a isolated 12V/1Amp power switching. The board switches ON the 12V/1Amp DC OUT on T_CRIT assertion and switches OFF the DC OUT on T_CRIT de-assertion. DC OUT can be connected to a 12V fan to switch it on and off automatically on thermal critical points.

Figure 1.2. Block Diagram



5. Power Supply

The temperature sensor board is powered from the motherboard through FRC-10 header.

The DC OUT can be used for controlling an external device, like a fan or a relay. If external device control is required, an external 12V/1Amp DC power should be provided through the DC IN screw terminal or through the +12V IN power jack. This will be driven out through DC OUT on T_CRIT assertion.

Output Voltage	12V
Output Current	1A
Polarity	

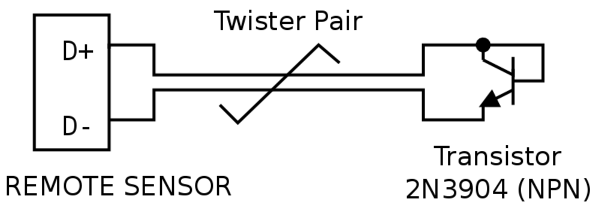
6. Remote Sensor

For remote temperature measurement, the Emitter-Base diode of a BJT, is used as the sensing element. Note that two-lead diodes cannot be used, since the ideal factor of two-lead diodes is incompatible with the temperature sensor. The recommended transistors are listed below.

- 2N3904 (NPN)
- 2N3906 (PNP)

An example of an 2N3904 NPN transistor connected to the REMOTE SENSOR connecter is shown in the following diagram.

Figure 1.3. Connecting Sensing Element



The wires connecting the sensing element can be 8 inches long. For longer wire lengths a shielded twisted pair is recommended. Please see the recommendations under the section "Mounting" of the SA56004X data sheet.

7. Connectors and Headers

7.1. `I2C` Connector

The temperature sensor board can be interfaced to a motherboard through the `I2C`, 10 pin FRC, connector. The signal details are given below.

Table 1.1. FRC-10 Pin Connector

Pin #	Signal	Signal Type
1	`VCC`	Supply from motherboard
2	Not Used	-
3	Not Used	-
4	`SCL`	Open collector
5	`SDA`	Open collector
6	Not Used	-
7	Not Used	-
8	Not Used	-
9	`INTR#`	TTL Out
10	`GND`	-

7.2. `REMOTE SENSOR` Connector

When a remote temperature has to be measured, the remote temperature sensing element is connected to the `REMOTE SENSOR` header.

Table 1.2. `REMOTE SENSOR` Connector

Pin #	Signal
1	`GND`
2	`D+`
3	`D-`
4	`GND`

7.3. `DC OUT` and `DC IN` Connector

This `DC OUT` connector provides a 12V DC from the `DC IN` connector when `T_CRIT` is asserted. This is typically used for controlling a fan, or triggering a system shutdown, when the temperature exceeds a configured critical set point.

Table 1.3. `DC OUT` and `DC IN` Connector

Pin #	Signal
1	`VCC`
2	`GND`

8. Specifications

Table 1.4. Specifications

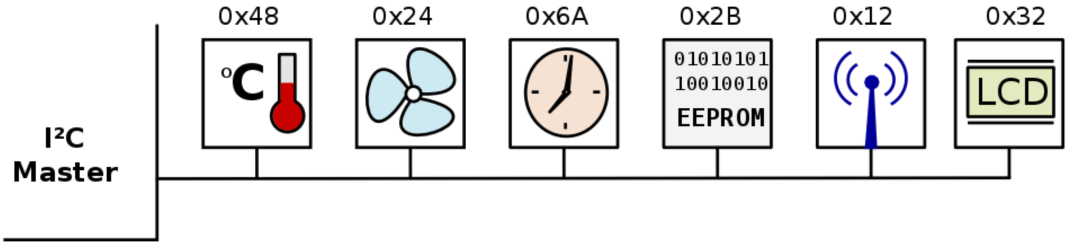
Parameter	Value	Condition
Power Supply		
Supply Voltage	5V	
Supply Current	550uA - 600uA	16Hz conversion rate FIXME
Temperature		
Measurement Range	-40 °C - 125 °C	
Local Temp. Error	±2 °C	+60 °C to +100 °C
	±3 °C	-40 °C to +125 °C
Remote Temp. Error	±1 °C	+60 °C to +100 °C
	±3 °C	-40 °C to +125 °C
I²C Bus		
Input High Voltage	2.2V - 5.0V	
Input Low Voltage	0.0V - 0.8V	
Max. SCL frequency	400kHz	
7-bit Device Address	0x48	

Chapter 2. Board Usage

1. I²C Bus Overview

The I²C is a simple two wire interface for on-board communication. One of the wires is data and the other is clock. The I²C is a master slave bus. The master is initiates the communication and the slaves respond to it. Each slave on the bus has an address to uniquely identify itself.

Figure 2.1. I²C Bus



There are typical two operations that the master can perform `i2c_read` and `i2c_write`. During the `i2c_read` operation the master specifies the slave address and the no. of bytes to read. During the `i2c_write` operation the master specifies the slave address and the bytes to be written.

2. Accessing Device Registers

The devices usually have a set of registers. Each register is given an address. When a register is to be read or written, the address is first written to the device and then data is read or written to the register.

The register address specified is stored within the device. For successive reads to the same register the address need not be specified again.

3. Common Usage Scenarios

This section shows the pseudo-code for various common usage scenarios. The I²C operations are represented by the following two functions.

```
data = i2c_read(dev_addr);
i2c_write(dev_addr, data);
```

The `dev_addr` is the 7-bit I²C address of the device to read/write. `data` is the byte to be read/written. In the case of `i2c_read()` the byte read from the device is returned. In the case of `i2c_write()` the byte to be written to the device is passed to the function.

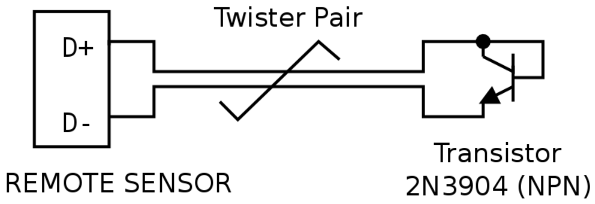
Scenario I: Measuring Local Temperature. To measure the local temperature the following pseudo code can be used.

```
lthb_reg = 0x0;
i2c_write(0x48, lthb_reg); ❶

temp = i2c_read(0x48); ❷
```

❶ Write the register address of the local temperature register (`LTHB`), 0x0.
❷ Read the contents of `LTHB`. The read byte is the local temperature in degree Celsius.

Scenario II: Measuring Remote Temperature. The temperature sensing element, is first connected to the `SENSOR PORT` as shown in the following diagram.

Figure 2.2. Connecting Sensing Element



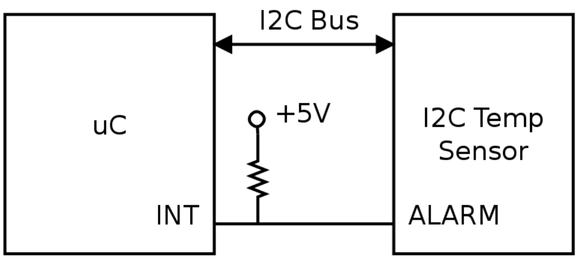
The following pseudo code is used to measure the remote temperature.

```
rthb_reg = 0x1;
i2c_write(0x48, rthb_reg); ❶

temp = i2c_read(0x48); ❷
```

❶ Write the register address of the remote temperature register (RTHB), 0x1.
❷ Read the contents of RTHB. The read byte is the remote temperature in degree Celsius.

Scenario III: Interrupt Notification. In certain applications, an action has to be taken when the temperature exceeds a specific temperature range. This can be done by periodically reading the temperature register. But a much more efficient method is possible. The temperature sensor can interrupt the CPU, when the temperature exceeds a specified range. The CPU then performs the required action, and acknowledges the interrupt.

Figure 2.3. Alert Interrupt



The temperature sensor has an ALERT signal that can be used as an interrupt signal. The set points for local and remote temperatures can be configured individually. An example circuit configuration is shown in Figure 2.3, “Alert Interrupt”. Note that since the ALERT is an open collector output a pull-up resistor (typically 10k) is required. The pseudo code for enabling interrupt notification when the local temperature exceeds the range 10 °C - 60 °C is given below.

```
lhs_reg = 0x0B;
i2c_write(0x48, lhs_reg); ❶

temp = 60;
i2c_write(0x48, temp); ❷

lls_reg = 0x0C;
i2c_write(0x48, lls_reg); ❸

temp = 10;
i2c_write(0x48, temp); ❹
```

❶ Write register address of the Local High Setpoint register (LHS), 0x0B.
❷ Write local high setpoint temperature 60 °C to LHS.

❸ Write register address of the Local Low Setpoint register (LLS), 0x0C.
❹ Write local low setpoint temperature 10 °C to LLS.

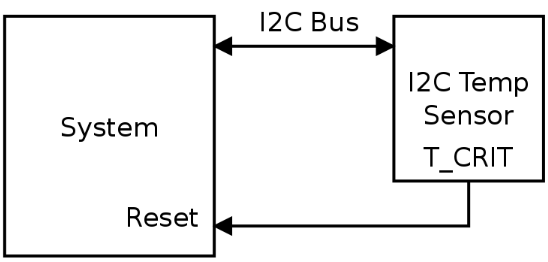
The pseudo code for the interrupt handler in given below.

```
lthb_reg = 0x0;
i2c_write(0x48, lthb_reg);

temp = i2c_read(0x48); ❶

sr_reg = 0x2;
i2c_write(0x48, sr, reg);

status = i2c_read(0x48); ❷
```

❶ Read the local temperature.
❷ Read the status register to acknowledge the interrupt.

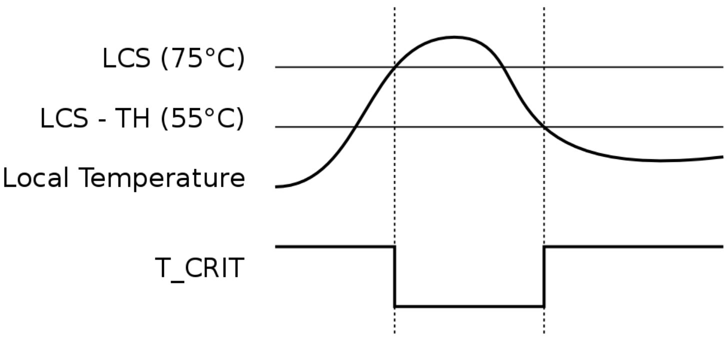
Scenario IV: Thermal Watchdog. In certain applications, the temperature sensor is required to autonomously control an external device, when the temperature exceeds a setpoint. This must be done without the intervention of the software. One such application is the thermal watchdog, where the temperature sensor shuts down the system being monitored or switches a cooling fan when the temperature over shoots the setpoint.

Figure 2.4. Thermal Watchdog



The temperature sensor can act like a thermal watchdog using the T_CRIT signal. The T_CRIT becomes low when the temperature exceeds the T_CRIT setpoint. The T_CRIT signal can in-turn control a cooling fan. The T_CRIT setpoint can be configured individually for local and remote temperatures. An example circuit configuration is shown in Figure 2.4, “Thermal Watchdog”. The T_CRIT is held low till the temperature drops by a configurable hysteresis amount. hysteresis on the T_CRIT signal is shown in the figure below.

Figure 2.5. Hysteresis



The default T_CRIT setpoint is 85 °C. The default T_CRIT hysteresis is 10 °C. The following pseudo-code sets the T_CRIT setpoint to 75 °C, and the hysteresis to 20 °C.

```
lcs_reg = 0x20;
i2c_write(0x48, lcs_reg); ❶

temp = 75;
i2c_write(0x48, temp); ❷

th_reg = 0x21;
i2c_write(0x48, th_reg); ❸

hyst = 20;
i2c_write(0x48, hyst); ❹
```

❶ Write the register address of the local `T_CRIT` register (`LCS`), 0x20.
❷ Write the setpoint to `LCS`. The local temperature setpoint in degree Celsius, is written to the register.
❸ Write the register address of the `T_CRIT` hysteresis register (`TH`), 0x21.
❹ Write the hysteresis amount to `TH`. The hysteresis amount in degree Celsius, is written to the register.

Appendix A. Legal Information

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2. Disclaimers

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