Tempus
Lifecare Sensor

# Datasheet (Preliminary)

## Rev. 1.17 / Sep. 2020

# TU05

## High-end Thermopile Detector (Digital, TO46)

**MEMS thermopile module TU05**

## Brief Description

The "**TU05**" is the TEMPUS digital Far Infrared Thermopile sensor with read-out IC that measures the temperature of an object without the need to contact. This sensor uses a thermopile to measure the Far Infrared energy emitted from the object being measured and uses the corresponding change in thermopile voltage to determine the object temperature. This sensor detects the object temperature from -40℃ to +125℃ to enable use in a wide range of application. An I²C interface is used to communicate with this device for various applications.

## Features

- Fully Integrated Digital Far Infrared thermopile sensor
- TO-46 Package
- 1.8V to 3.6V single supply continuous operation
- Current consumption: 1.0mA (operating mode)

- I²C Interface
- Temperature resolution
- 3mK/LSB for body temperature sensing
- ±0.5 K for Object temperature sensing
- Operating temperature: -40℃~85℃
- Optical : Fresnel Lens

## Applications
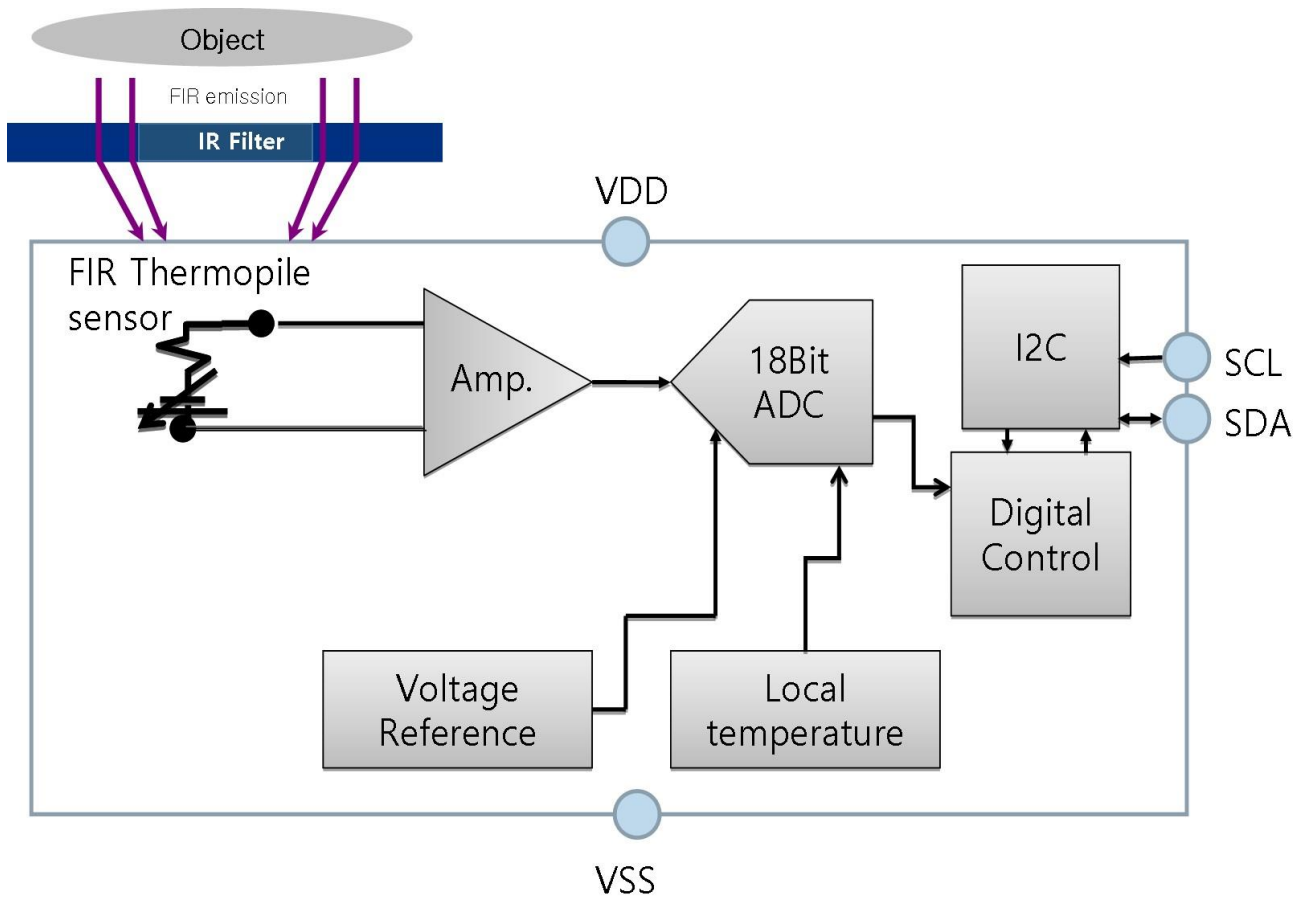
☐ **Non-contact Temperature sensing:**
- Temperature monitoring
- Comfort Index measurement
- Power Management system
- Thermometers
- Healthcare

☐ **Human Body Detection:**
- Interactive Power control
- Notebook monitor control
- Lighting unit control
- Display panel control

**Functional Block Diagram**



The sensor packaged in a hermetically sealed 4-pin metal can package is RoHS compatible and operates over -40~85℃ temperature range.

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## Sensor Electrical Specifications

| Parameter (units) | Conditions | Minimum | Typical | Maximum |
|---|---|---|---|---|
| Operating voltage range (V) | | 1.8 | 2.8 | 3.6 |
| Supply current (mA) | | | | 1.0mA |
| Operating Temperature Range (℃) | | -40 | | +85 |
| Storage temperature range(℃) | | -40 | | +125 |
| Junction temperature ($T_{J\,max,}$ ℃) | | | | +150 |
| VDD Rise Time (us) | | | | 200 |
| ESD rating: Human body model(V) | | | | +-4000 |

## Package Dimension (in mm)
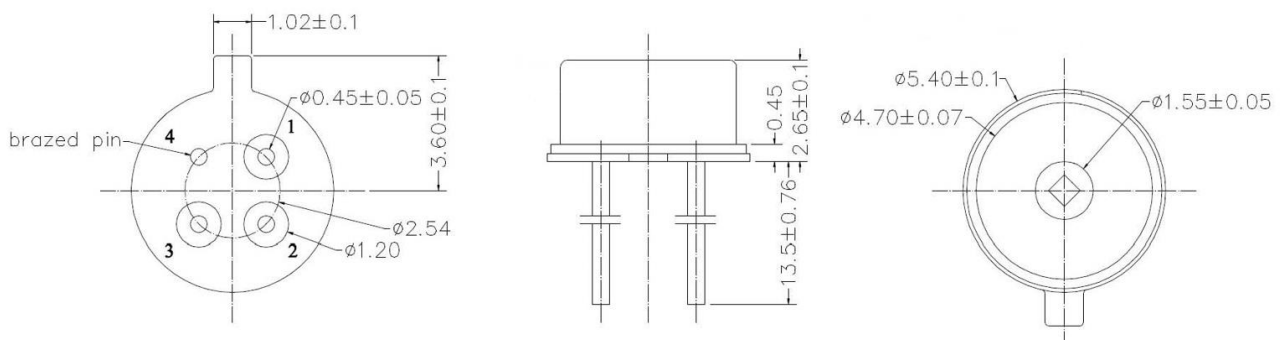


| PIN Number | PIN Name | Function | Note |
|---|---|---|---|
| 1 | SDA | Serial Communication | |
| 2 | VDD | 1.8 to 3.6V | Lower is better for power consumption |
| 3 | SCL | Serial Communication | |
| 4 | GND | Ground | |

Note :

This drawing is subject to change without notice for Quality Improvement

## Signal Conditioning Circuit

The **TU05** is a thermopile sensor module with a sensor signal conditioner (SSC) integrated circuit for high-accuracy amplification and analog-to-digital conversion of a differential or pseudo-differential input signal. Designed for variety high- resolution sensor module applications, the integrated signal conditioner of a **TU05** can perform offset, span, and 1st and 2nd order temperature compensation of the measured signal. The module is developed for correction of absolute voltage sensors, it can also provide a corrected temperature output measured with an internal sensor. The measured and corrected sensor values are provided at the digital output pins, which can be configured as $I^2C^{TM*}$ (≤ 3.4MHz). Digital compensation of signal offset, sensitivity, temperature, and non-linearity is accomplished via a 26-bit internal digital signal processor (DSP) running a correction algorithm. Calibration coefficients are stored on-chip in a highly reliable, non-volatile, multiple-time programmable (MTP) memory. Programming the **TU05** is simple via the serial interface. The interface is used for the PC-controlled calibration procedure, which programs the set of calibration coefficients in memory. The **TU05** provides accelerated signal processing, increased resolution, and

Improved noise immunity in order to support high-speed control, safety, and real-time sensing applications with the highest requirements for energy efficiency.

## Features

- An integrated high accuracy thermopile with its signal conditioning circuits
- Flexible, programmable analog front-end design; up to 18-bit analog-to-digital converter (ADC)
- Fully programmable gain amplifier for optimizing sensor signals: gain range 6.6 to 216 (linear)
- Internal auto-compensated temperature sensor
- Digital compensation of individual sensor offset;   1st and 2nd order digital compensation of sensor gain as well as 1st and 2nd order temperature gain and offset drift
- Programmable interrupt operation (Option)
- High-speed sensing: e.g. 16-bit conditioned sensor signal measurement rate >1/500s
- Typical sensor elements can achieve accuracy of better than ±0.10% FSO** at -40 to 85°C

## Benefits

- Integrated 26-bit calibration math digital signal processor (DSP)
- Fully corrected signal at digital output
- One-pass calibration minimizes calibration costs
- No external trimming, filter, or buffering components required
- Highly integrated CMOS design with cutting edge MEMS technology
- Integrated reprogrammable non-volatile memory
- Excellent for low-voltage and low-power battery applications

## Physical Characteristics

- Supply voltage range: 1.8V to 3.6V
- Current consumption: 1.0mA (operating mode)
- Temperature resolution: <0.003K/LSB
- Best-in-class energy-efficiency with 16-bit resolution: <140pJ/step with 18-bit resolution: <50pJ/step
- Operation temperature: –40°C～+85°C
- Delivery options: TO package

## IC Characteristics

Absolute Maximum Ratings

Note: The absolute maximum ratings are stress ratings only. The **TU05** might not function or be operable above the recommended operating conditions. Stresses exceeding the absolute maximum ratings might also damage the device. In addition, extended exposure to stresses above the recommended operating conditions might affect device reliability. TEMPUS does not recommend designing to the "Absolute Maximum Ratings."

Table 1.1 Maximum Ratings

| PARAMETER | SYMBOL | Min | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| Voltage Reference | VSS | 0 | | 0 | V |
| Analog Supply Voltage | VDD | -0.4 | | 3.63 | V |
| Input Current into any Pin except RES, SS [1), 2)] | IIN | 100 | | 100 | mA |
| Electrostatic Discharge Tolerance – Human Body Model (HBM1) [3)] | VHBM1 | ±4000 | | - | V |
| Storage Temperature | TSTOR | -40 | | 125 | °C |

1) Latch-up current limit for RES, TEMPUS-test and SS: ±70mA.

2) Latch-up resistance; reference for pin is 0V.

3) HBM1: C = 100pF charged to VHBM1 with resistor R = 1.5k in series based on MIL 883, Method 3015.7. ESD protection referenced to the Human Body Model is tested with devices in ceramic dual in-line packages (CDIP) during product qualification.

### Operating Conditions

The reference for all voltages is Vss.

Table 1.2 Operating Conditions

| PARAMETER | SYMBOL | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| Supply Voltage | VDD | 1.8 | - | 3.6 | V |
| VDD Rise Time | tVDD | | | 200 | µs |
| Operation Temperature Range | TAMB | -40 | - | 85 | °C |
| External (Parasitic) Capacitance between VDDB and VSS | CL | 0.01 | | 50 | nF |

## I²C™

I²C™ Mode will be selected if the very first interface activity after **TU05** power-up is an I²C™ command.

### Command Request (I²C™ Write)

| S | SlaveAddr | 0 | A | Command | A | P |
|---|-----------|---|---|---------|---|---|

| S | SlaveAddr | 0 | A | Command | A | CmdDat <15:8> | A | CmdDat | A | P |
|---|-----------|---|---|---------|---|---------------|---|--------|---|---|

### I²C™ Read Status

### Read Status (I²C™ Read)

| S | SlaveAddr | 1 | A | Status | N | P |
|---|-----------|---|---|--------|---|---|

### Read Data (I²C™ Read)

(a) Example: after the completion of a Full Measurement command (AAHEX)

| S | SlaveAddr | 1 | A | Status | A | SensorDat <23:16> | A | SensorDat <15:8> | A | Sensor Dat <7:0> | A | TempDat <23:16> | A | TempDat <15:8> | A | TempDat <7:0> | N | P |
|---|-----------|---|---|--------|---|-------------------|---|------------------|---|------------------|---|-----------------|---|----------------|---|---------------|---|---|

### I²C Slave address
TU05 I2C slave address : 0x00

## I²C™ Commands

The I²C™ commands supported by the **TU05** are listed in Table 3.1. The command to read an address in the user memory is the same as its address. The command to write to an address in user memory is the address plus 40HEX.

There is a TEMPUS-reserved section of memory that can be read but not over-written by the user.

Table 3.1 I²C™ Commands

Note: Every return starts with a status byte followed by the data word as described in section

| Command (Byte) | Return | Description |
|---|---|---|
| A9HEX | — | Start_CM Exit Normal Mode and transition to Command Mode (as very first command after power-up). |
| AAHEX | 24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data | Measure Trigger full measurement cycle (AZSM, SM, AZTM, and TM, as described in section 3.2) and calculation and storage of data in the output buffer using the configuration from MTP. |

Table 3.2 General Status Byte

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Meaning, Weight | RSV | RSV | Busy? | Mode | | RSV | RSV | RSV |

Busy[5]
1 : Busy
0 : Not busy

Status[4:3]
01 : Command mode
00 : Normal mode

**TU05 Read flow**

```
        ┌──────────────┐
        │   Power On   │
        └──────┬───────┘
               │
        ┌──────▼───────┐
        │   Start_CM   │
        │   (0xA9)     │
        └──────┬───────┘
               │
        ┌──────▼───────┐
        │ CMD_MEASURE  │
        │   (0xAA)     │
        └──────┬───────┘
               │
          ┌────▼────┐
    Y  ◄──│  BUSY?  │
          └────┬────┘
               │ N
        ┌──────▼───────┐
        │  Read Data   │
        └──────┬───────┘
               │
        ┌──────▼───────┐
        │  Calculate   │
        │ temperature  │
        └──────┬───────┘
               │
        ┌──────▼───────┐
        │   Standby    │
        └──────────────┘
```

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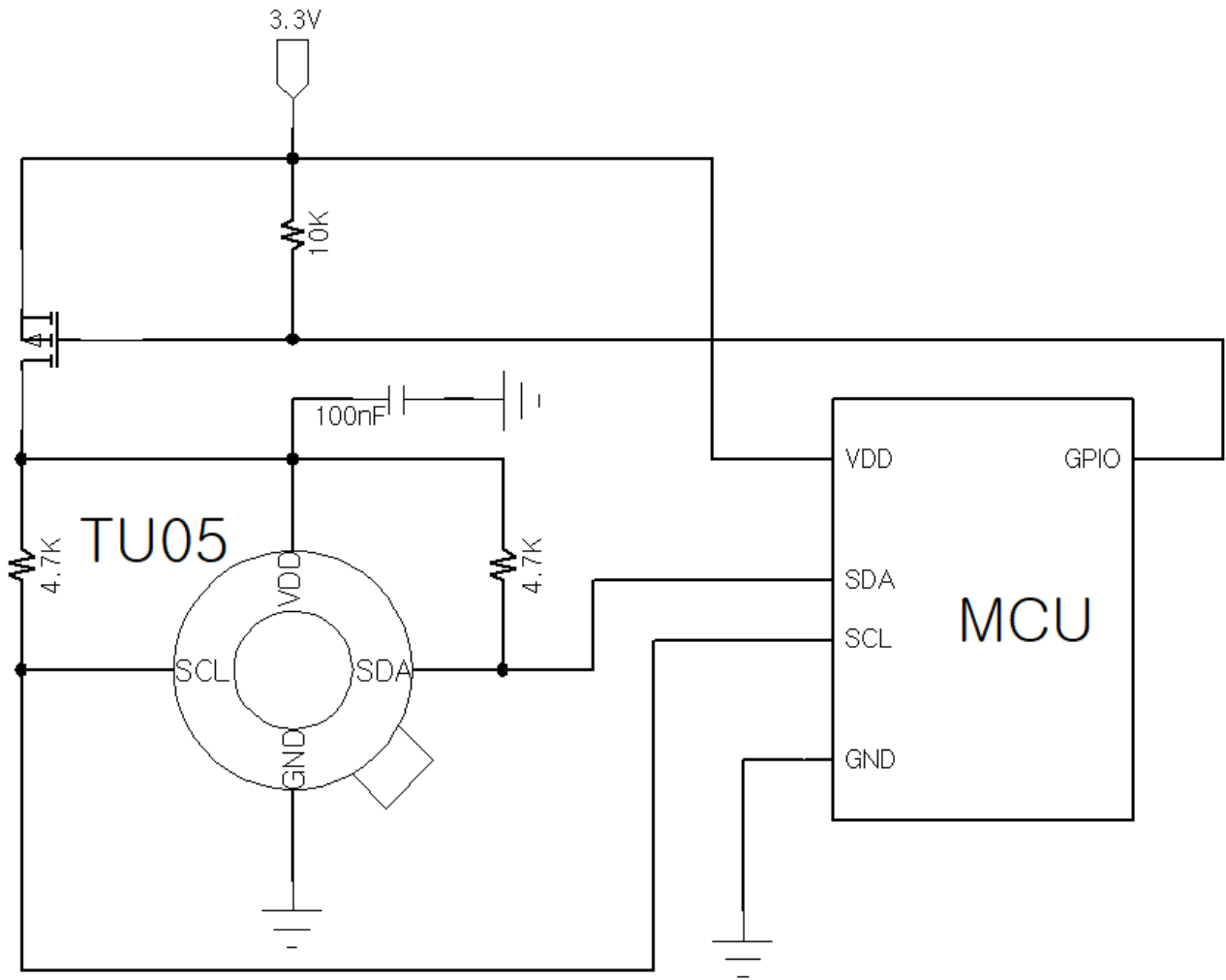*Lifecare Sensor*
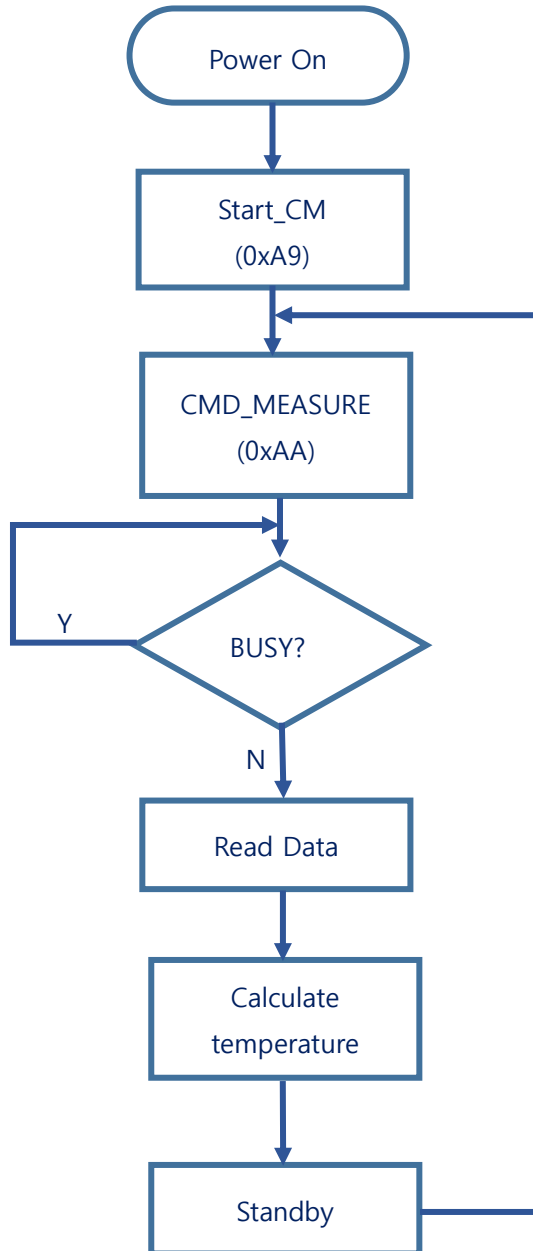
**Reference schematic of TU05**

## Packing Information

(It may differ depending on the situation and it is subject to change without notice)

| Tube | Inner Packing | Box |
|---|---|---|
| 50pcs | 500pcs | 20,000pcs |
|  |  |  |