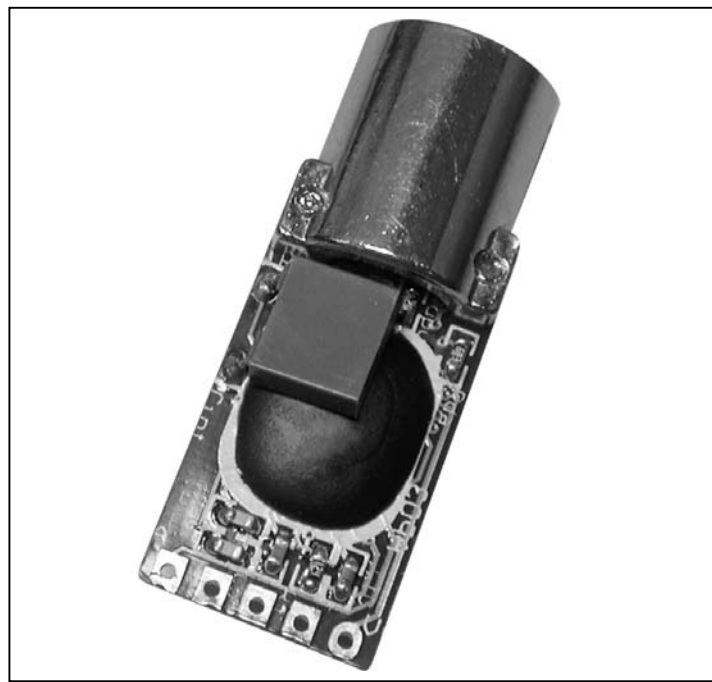


# TN9 Infrared Thermometer Module

## *User Manual*



# Contents

<b>1 GENERAL DESCRIPTION .....</b>	<b>3</b>
EDITION JULY 2004.....	3
<b>2 THEORY OF OPERATION.....</b>	<b>4</b>
2.1 PRINCIPLES OF OPERATION.....	4
2.2 FEATURES OF DESIGN.....	5
2.3 FIELD OF VIEW .....	6
2.4 EMISSIVITY .....	7
<b>3 SPECIFICATION .....</b>	<b>8</b>
3.1 ABSOLUTE MAXIMUM RATING .....	8
3.2 DC CHARACTERISTICS.....	8
3.3 MEASUREMENT SPECIFICATION .....	9
3.4 PIN ASSIGNMENT OF TN0; TN9.....	10
<b>4 SERIAL OUTPUT.....</b>	<b>11</b>
4.1 TYPICAL DIAGRAM.....	11
4.2 TIMING OF SPI .....	12
4.2.1 <i>Format of Message</i> .....	13
4.2.2 <i>Example</i> .....	13
4.2.3 <i>How to modify Emissivity? (How to write Emissivity into EEPROM)</i> .....	14
<b>5 INTERFACE DEMO BOARD: HUB-D.....</b>	<b>15</b>
<b>6 INTERFACE PROGRAM FOR PC.....</b>	<b>16</b>

## 1. General Description

This document describes the user guide of TNm Series (TN0; TN9).

**Edition July 2004**

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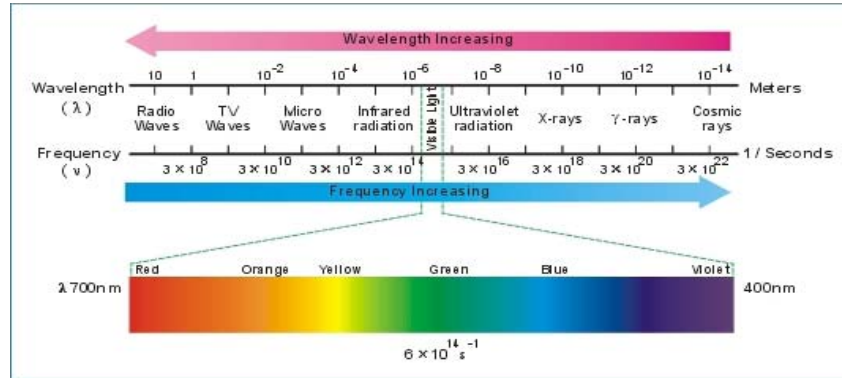
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## 2. Theory of Operation

### 2.1. Principles of Operation



**Fig 1. the Infrared Radiation Spectrum**

Infrared, just like any light ray, is an Electromagnetic Radiation, with lower frequency (or longer wavelength) than visual light. Anything above absolute zero (-273.15 degrees Celsius or 0 degrees Kelvin), radiates in the infrared. Even ice cube, snow, your refrigerator emit infrared.

The **Stefan-Boltzmann Law**, where the total radiation energy is proportional to the fourth power of the absolute temperature and **Wien Displacement Law**, the product of the peak wavelength and the temperature is found to be a constant, are implemented in the TNm infrared thermometer module. The infrared radiation of measure target is collected by a infrared mirror through a IR filter of 5 or 8um cut in frequency to the infrared thermopile detector. The detector signal will be amplified and digitalize by the low noise and high linearity OP and AD convertor. The ambient temperature sensor( usually included in the same package as the thermopile detector ) is set in the space near the optical system to detect the fast change of the ambient temperature. The signal processing section receives the signals from these temperature sensors to calculate the target surface temperature by a mathematical algorithm.

### 2.2. Features of Design

The TNm infrared thermometer module is specially designed for a high sensitivity, high accuracy, low noise and low power consumption. A number of design features contribute to the performance:

- MEMS thermopile detector and a high accurate ambient temperature compensation technics care used for the TNm infrared thermometer module.
- ZyTemp has developed a proprietary Infrared-System-On-Chip device that integrates all hardware items onto one IC. Using this innovative SoC technology, TNm infrared thermometer module has become a highly affordable and compact product.
- ZyTemp's products can faithfully withstand a thermal shock of 10degC/18degF. Our products are adept in maintaining accuracies under widely changing environmental conditions. For example, the errors from environmental changes of older IRTs can reach 1.6degC, requiring up to 30 minutes to stabilize, while ZyTemp's TNm error differential is only 0.7degC, needing only 7 minutes to restabilize.
- TNm products operate from a 3 Volt power supply, while many other older IRTs still require a 9 Volt supply.
- ZyTemp has maintained a NIST or National Measurement Laboratory traceable Temperature Primary Standard. All the TNm products are calibrated under traceable infrared standard sources. The calibration data and serial number are saved in a EEPROM on the module.

### 2.3. Field of View

What is D:S = 1:1  
 This device has a D:S = 1:1  
 Distance : Spot = 1:1

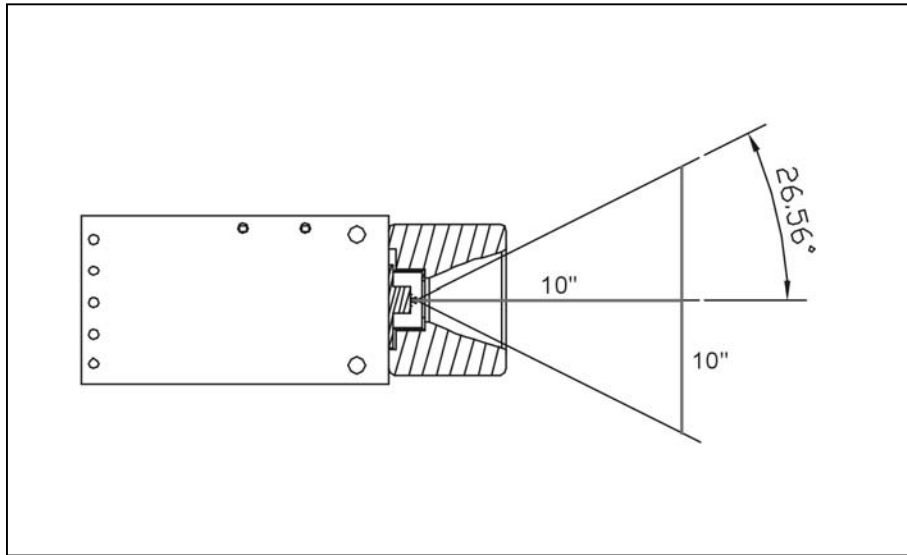


Fig 2. Field of View

When the Distance is 10 inch, then the measurement spot size is also 10 inch.  
 When the Distance is 20 inch, then the measurement spot size is also 20 inch.  
 In other words, the FOV(Field of View) is  $26.6 \times 2 = 53.2$  degree

Beware the Vignette  
 Good Design, No Vignette

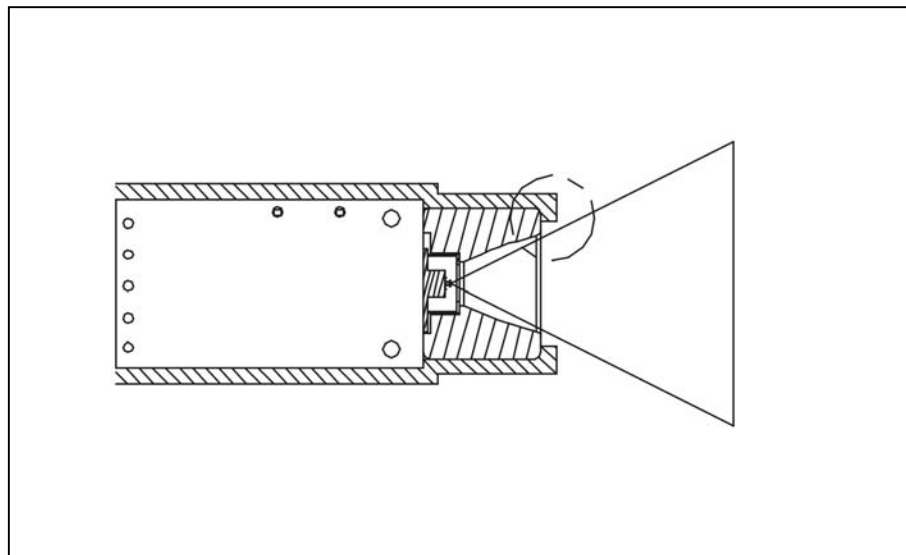
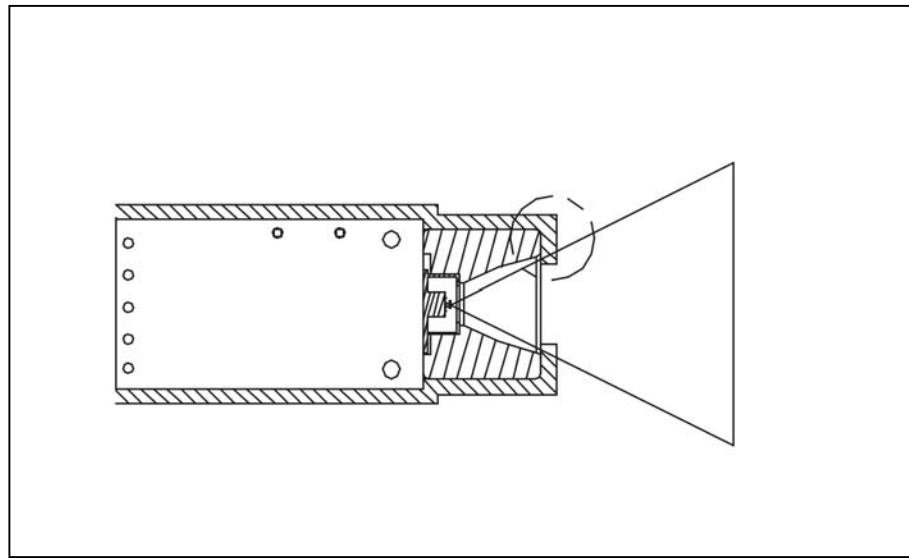


Fig 3. Good Design Field of View

## Bad Design Vignette

The Sensor “see” the edge of the housing

So the measurement in fact is the averaging of the real target and the edge of housing.



**Fig 4. Bad Design Field of View**

## 2.4. Emissivity

Understanding an object's emissivity, or its characteristic "radiance" is a critical component in the proper handling of infrared measurements. Concisely, emissivity is the ratio of radiation emitted by a surface or blackbody and its theoretical radiation predicted from **Planck's law**. A material's surface emissivity is measured by the amount of energy emitted when the surface is directly observed. There are many variables that affect a specific object's emissivity, such as the wavelength of interest, field of view, the geometric shape of the blackbody, and temperature. However, for the purposes and applications of the infrared thermometer user, a comprehensive table showing the emissivity at corresponding temperatures of various surfaces and objects is displayed.

Please visit ZyTemp's website: <http://www.zytemp.com/tutorial/emissivity.asp> to check the emissivity of the materials of interested.

### 3. Specification

#### 3.1. Absolute Maximum Rating

Characteristics	Symbol	Ratings
DC Supply Voltage	V <sub>+</sub>	<7.0V
Input Voltage Range	V <sub>IN</sub>	-0.5V to V <sub>+</sub> + 0.5V

**Note:** Stresses beyond those given in the Absolute Maximum Rating table may cause operational errors or damage to the device. For normal operational conditions see AC/DC Electrical Characteristics.

#### 3.2. DC Characteristics

(VDD = 3.0V, T<sub>A</sub> = 25°C)

Characteristics	Symbol	Limit			Unit	Test condition
		Min	Typ.	Max		
Operating Voltage	VDD	2.5	-	3.6	V	
Operating Current	I <sub>OP</sub>	-	4	6	mA	VDD = 3.0V, F <sub>CPU</sub> = 600KHz
Standby Current	I <sub>STBY</sub>	-	2	3	μA	VDD = 3.0V
Input High Level	V <sub>IH</sub>	2.0	-	-	V	VDD = 3.0V
Input Low Level	V <sub>IL</sub>	-	-	0.8	V	VDD = 3.0V
Output High I	I <sub>OH</sub>	-	-2.0	-	mA	VDD = 3.0V, V <sub>OH</sub> = 2.4V
Output Sink I	I <sub>OL</sub>	-	2.5	-	mA	VDD = 3.0V, V <sub>OH</sub> = 0.8V

(VDD = 4.5V, T<sub>A</sub> = 25°C)

Characteristics	Symbol	Limit			Unit	Test condition
		Min	Typ.	Max		
Operating Voltage	VDD	3.6	-	5.0	V	
Operating Current	I <sub>OP</sub>	-	6	9	mA	VDD = 4.5V, F <sub>CPU</sub> = 600KHz
Standby Current	I <sub>STBY</sub>	-	3	4.5	μA	VDD = 4.5V
Input High Level	V <sub>IH</sub>	3.0	-	-	μA	VDD = 4.5V
Input Low Level	V <sub>IL</sub>	-	-	0.8	μA	VDD = 4.5V
Output High I	I <sub>OH</sub>	-	-2.0	-	mA	VDD = 4.5V, V <sub>OH</sub> = 3.5V
Output Sink I	I <sub>OL</sub>	-	2.5	-	mA	VDD = 4.5V, V <sub>OL</sub> = 0.8V

### 3.3. Measurement Specification

Measurement Range	-33~220°C / -27~428°F
Operating Range	-10~50°C / 14~122°F
Accuracy Tobj=15~35°C, Tamb=25°C	+/-0.6°C
Full Range Accuracy #AC	+/-2%, 2°C
Resolution at -9.9~199.9°C	1/16°C=0.0625 (full range)
Response Time (90%)	1sec
D:S	1:1
Emissivity	0.01~1 step.01
Update Frequency	1.4Hz
Dimension	12x13.7x35mm
Wave Length	5um-14um
Weight (no battery)	9g
Power Supply	3V or 5V Option

## 3.4. Pin Assignment of TN0; TN9

Warning: The Dimension in this drawing is for reference only.

For actual dimension, please download from

<http://www.ZyTemp.com/products/download/ExtDrawing.asp>

V: Vdd

G: GND

D: Data (Serial Data)

C: Clock (Serial Clock)

A: Action Pin (*pull low* to measure, *floating* while to Write Data into the IRT)

Note: TN0; TN9 has the same pin assignment.

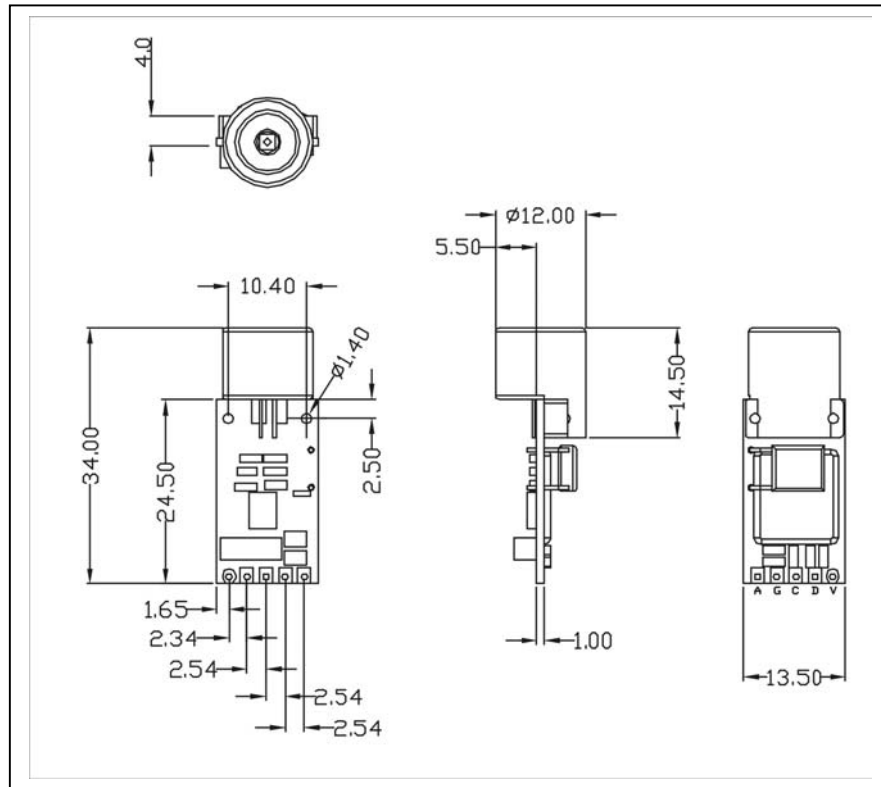
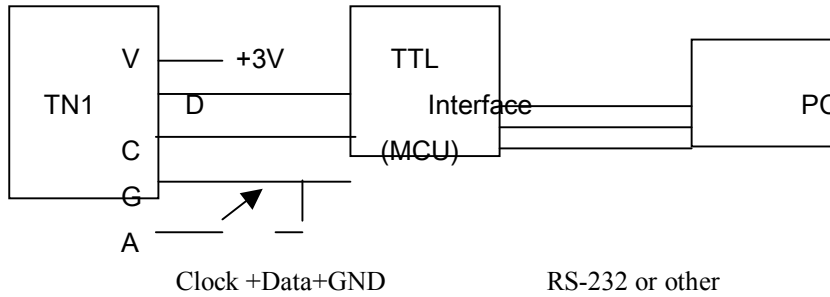


Fig 5. the Module External Drawing

## 4. Serial Output

### 4.1. Typical Diagram



**Fig 6. Typical Diagram**

DUT to TTL Interface (MCU)

V:Vcc

D:Data

C:Clock (2KHz)

G:GND

A:ActionKey (When Pull Low, the device will measure Tbb continuously.)

DUT is Output the data, while MCU is receiving the Data

Note: Data Pin is High when there is no data , Time Out > 2ms

### 4.2. Timing of SPI

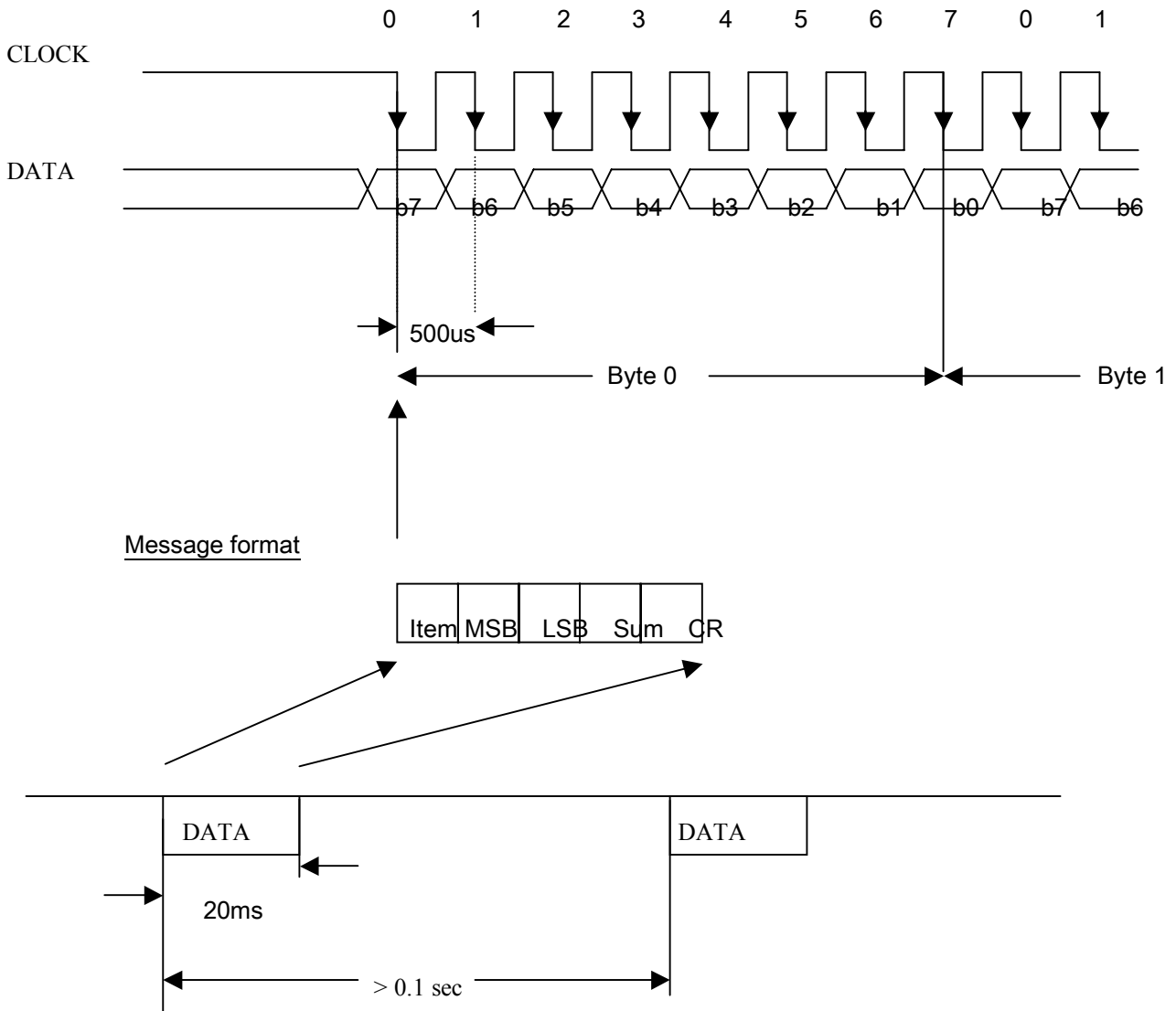


Fig 7. Timing of SPI

**4.2.1. Format of Message**

Item	MSB	LSB	Sum	CR
------	-----	-----	-----	----

**Item**            “L”(4CH): Tobj (Temperature of Obj)  
                       “P”(66H): Tamb (Ambient Temperature)  
**MSB**            8 bit Data Msb  
**LSB**            8 bit Data Lsb  
**Sum**            Item+MSB+LSB=SUM  
**CR**             0DH, End of the message

**4.2.2. Example**

1. Object Temperature

4C	14	2A	8A	0D
----	----	----	----	----

**Item**            4CH → “L” the item code of Object temperature  
**Data**            MSB        14H  
                       LSB        2AH  
                       Real Temperature Value  $[\text{Hex2Dec}(142\text{AH})]/16-273.15= 49.475 \text{ } ^\circ\text{C}$   
**Sum**            CheckSum  $4\text{CH}+14\text{H}+2\text{AH}=8\text{AH}$  (Only Low Byte)  
**CR**             0DH → ‘Carriage Return’ means End of Message

2. Ambiant Temperature

66	12	C3	3B	0D
----	----	----	----	----

**Item**            66H → “P” the item code of Ambient temperature  
**Data**            MSB        12H  
                       LSB        C3H  
                       Real Temperature Value  $[\text{Hex2Dec}(12\text{C}3\text{H})]/16-273.15= 27.03 \text{ } ^\circ\text{C}$   
**Sum**            CheckSum  $66\text{H}+12\text{H}+\text{C}3\text{H}=3\text{BH}$  (Only Low Byte)  
**CR**             0DH → ‘Carriage Return’ meas End of Message

### 4.2.3. How to modify Emissivity? (How to write Emissivity into EEPROM)

*Warning: misuse may result in EEPROM other data modified, this may destroy the calibration. the device may become useless!*

- 1) This Infrared Thermometer module is calibrated for Emissivity=0.95 defaultly. Most of Non-metal material have emissivity near to 0.95. But the infrared emissivity of normal metal is much lower and may have to modify the setting of the module for certain application.
- 2) The communication format and how to read data from DUT's CommuMode:  
ItemCode + HighByte + LowByte + CheckSum(ItemCode+HighByte+LowByte) + CR , total 40 clocks(& data).
- 3) For write Emissivity to DUT, the communication format is the same as read.  
=> "S"+ HighByte(Emissivity value) + 04H + CheckSum(ItemCode + HighByte + 04H) + CR  
Emissivity value = HighByte(hex)/100(dec),  
For example: HighByte = 5F(hex)=95(dec) -> emissivity = 95(dec)/100(dec) = 0.95.  
keep the LowByte data = 04(hex).
- 4) The trick for write data to DUT is as below
  - a. Action pin need to be floating when we want to write data to DUT.
  - b. As you know, DUT will do routine data out by 40 clocks & datas with communication format.  
After the 40th clock, DUT will pull the CLK & DATA pin to weak high for waiting if there is External CPU want write data to DUT.  
Please let External CPU start send 1st clock within the timing T1 after the 40th clock.  
: 5ms < T1 < 10ms
  - c. The frequency of CLK should be 2KHz.
  - d. DUT will latch the data at negative edge of CLK, so data should be ready before the negative edge of 1st writing clock.
- 5) For example,  
Emissivity = 0.95 ==> "S" + 5F(hex) + 04(hex) + B0(hex) + CR  
Emissivity = 0.80 ==> "S" + 50(hex) + 04(hex) + A7(hex) + CR
- 6) Finally, how do we know write emmissivity success.  
About 5 ms after you send CLK & DATA to DUT completely.  
DUT should have 3 kinds of response.
  - a. DUT will send out the same data whcih External CPU had write to DUT.  
(We call this ECHO). That means write emmissivity success.
  - b. DUT will send out "S" + FF(hex) + FF(hex) + CheckSum( "S" + FF + FF ) + CR.  
That means DUT find data checksum error = a wrong data receiving.  
DUT will forget the data, and you need to re-write again.
  - c. DUT have no response as above  
That means DUT don't get full 40 clocks.  
Please check the clock & data which control by External CPU.  
Especially, please make sure the T1 timing is right.

## 5. Interface Demo Board: Hub-D

### General Description:

Hub-D is an Interface box with LCD, for TN series.

This Box can work as an interface between the IRTm(IRT Module) and PC. see Fig.A

“Hub\_D” has a 2-column character type LCD Display, it can also work without the PC.

The Hub will show Tobj & Tamb (data from the IRTm) continuously.

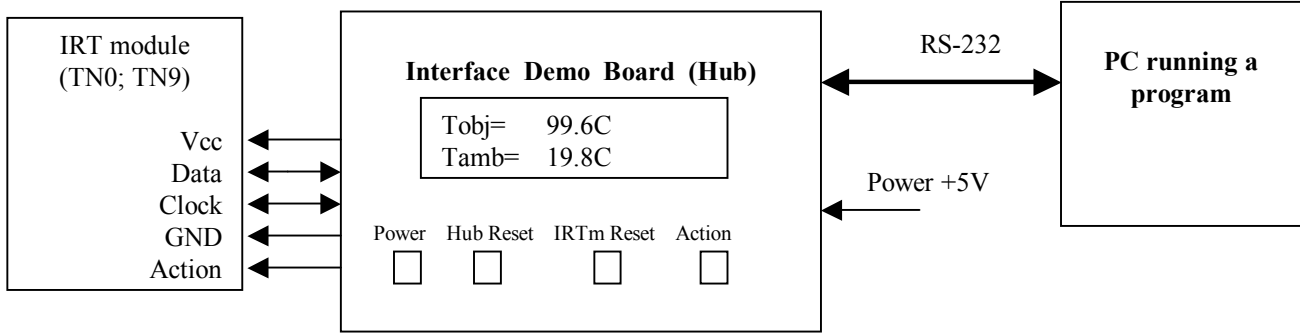


Fig 8. Typical Application of Hub

Model No:Hub-D

Program: TNmDB001.exe

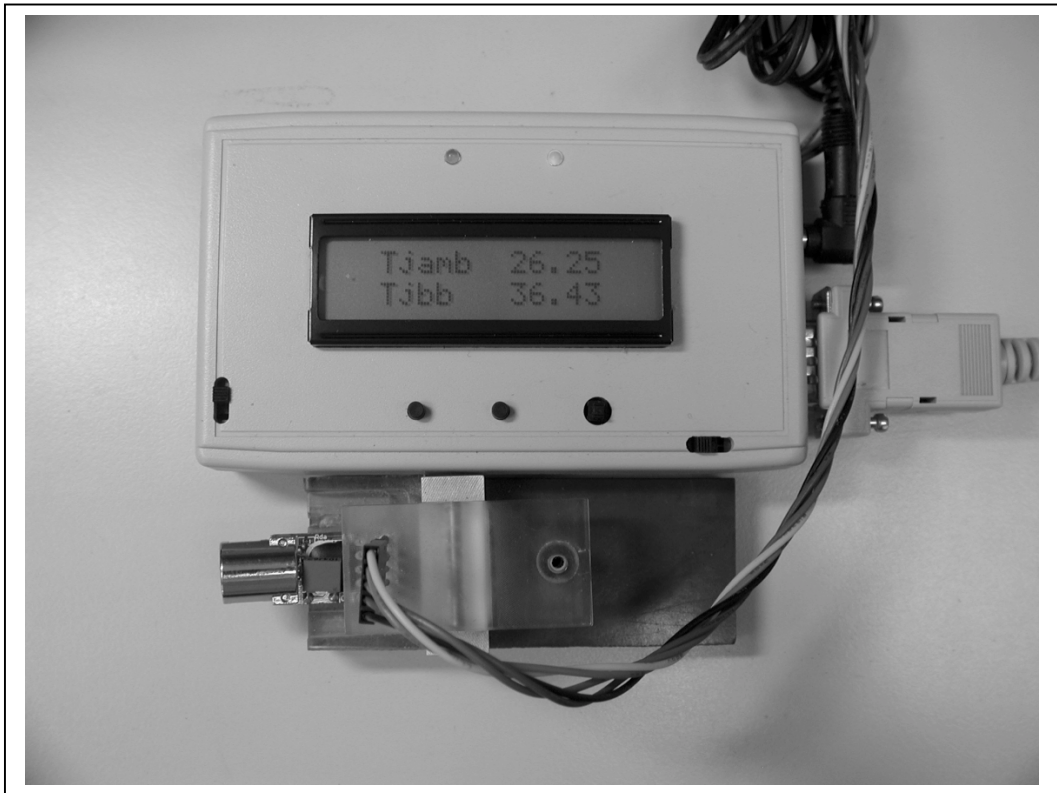


Fig 9. Hub-D

## 6. Interface Program for PC

Program: TNmDB001.exe

a Free version for demonstration can be download at <http://www.zytemp.com/download/default.asp>

- Running under a DOS window (in MS Windows environment)
- This program will show:  
Tbb (Tobj) ; Tamb in degC;degF continuously  
Status of IRT
- Modification of the Emissivity
- degC/degF unit change