$$p = \frac{\rho R T}{m}$$

$$S(\lambda) = S_o(\lambda) e^{-m \cdot \delta(\lambda)}$$

$$B(T) = bT^4$$

$$e_w(T_i) = 0.62197 + \frac{f}{p - f}$$

$$\frac{du}{dt} = -\frac{uv\tan\phi}{a} + \frac{uw}{a} - \frac{1}{\rho}\frac{\partial p}{\partial x} + 2\Omega v \sin\phi - 2\Omega w \sin\phi + F_x$$

PMT-2005 Sensor

Description

The Model PMT-2005 is a complete precision ambient temperature measuring system designed for the meteorologist, climatologist, or atmospheric scientist. It provides a superior degree of accuracy and reliability, achieving an absolute accuracy of $\pm 0.05°C$ in measuring ambient temperature over the entire $\pm 50°C$ range. The system consists of an aspirated triple-shielded platinum resistance thermometer and it represents the state-of-the-art in ambient temperature monitoring.

Ambient temperature is highly variable in both time and space, and a single measurement reflects a limited space-time domain. Historically, techniques other than direct measurement of ambient temperature have provided support for the global warming issue, but precise knowledge of atmospheric ambient temperatures is a fundamental component to understanding the Earth's climatic mechanisms. As we continue collecting ambient temperature data for the climatological database, improvements in the basic measurement are required. While some of the problems of measuring ambient temperature cannot be easily eliminated, basic instrumental and observational errors in climatic temperature measurements can be significantly reduced by using the PMT-2005.

Features

- Highest accuracy available on the market
- "Smart" sensor, microprocessor-managed
- Analog and digital RS-232 outputs, inputs protected from polarity reversal and overvoltage
- Automatic detection and indication of fan failure
- Precision platinum resistance thermometer

Applications

The PMT-2005 offers nearly an order of magnitude more precision than existing ambient temperature measuring systems, making it ideally suited for:
- Professional grade meteorological stations
- Aviation weather system upgrades
- Field accuracy checks of other field sensors
- Industrial calibration laboratories
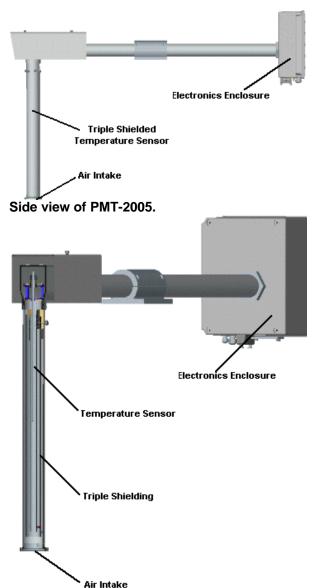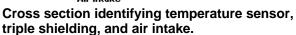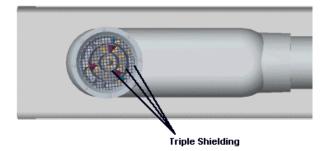- Agricultural and global climate change research

Mechanical Configuration

The PMT-2005 electronics are packaged in a weatherproof NEMA-type PVC enclosure. The thermometer radiation shields are manufactured of aluminum with an electrostatically-applied white powder coating for long life. Electrical and mechanical components are designed to operate over a temperature span of $\pm 50°C$; reduced aspirator motor life can be expected when system installation temperatures are below -50°C due to bearing lubricant degradation. The system typically mounts two meters above the ground to a customer tower or support and aimed into the prevailing wind.
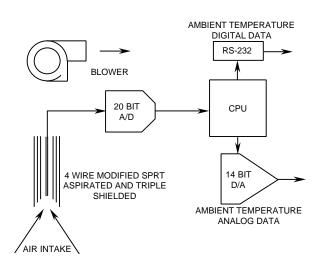
YES
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Side view of PMT-2005.

Cross section identifying temperature sensor, triple shielding, and air intake.

Detailed view of bottom of temperature sensor showing triple shielding, air intake, and screen.

PMT-2005 functional block diagram

Uncertainty Analysis

The ambient temperature measuring system employs a modification of the four-wire Standard Platinum Resistance Thermometer (SPRT) design. The modifications preserve the fundamental features of the SPRT, including minimum stem conduction error, strain-free mounting of the platinum element, and four-wire Kelvin readout. Features not required by the meteorological application are eliminated, bringing the thermometer within the range of affordability for field measurements. The PMT-2005's 100 Ohm platinum resistance thermometer element is calibrated after packaging in a NIST-traceable temperature bath (Hart Scientific Model 7025 high precision bath). The thermometer is then mounted in an aspirated, triple-walled aluminum radiation shield that has a worst case, full-sun, radiation error of less than +0.005°C. Readout of the 100Ω PRT element is achieved through the use of a 20-bit analog-to-digital converter which performs ratiometric conversions of an AC excited half- bridge, with a nominal current of 400 μAac. This results in a self-heating error of less than 0.0016°C and elimination of thermoelectric voltage errors.

Several potential sources of error should be considered in designing an ambient temperature measuring system that strives to offer absolute accuracy of ±0.05°C or better. The major contributors to the uncertainty analysis in an instrument of this type are the solar radiation shielding error (+0.005°C), the thermometer stem

conduction error ($\pm0.00003°$C), and the PRT self-heating error ($+0.0016°$C). A variety of other random RMS errors include the calibration limits of the thermometer bath ($\pm0.028°$C), reference resistor drift errors (±0.00607), amplifier gain errors ($\pm0.00729°$C), and the linearity error ($\pm0.0045°$C). The RMS uncertainty total is $< 0.03°$C, and the worst case bias error (positive bias) is $< 0.007°$C.

The PMT-2005 is therefore conservatively rated at an accuracy of $\pm0.05°$C.

Development History

The PMT-2005 is a subset of a Model MET-2010, itself the result of an intensive five-year R&D effort, sponsored in part by the United States Department of Agriculture, to develop and field test an improved means of measuring ambient temperature at climatological monitoring sites. It represents the first major improvement in air temperature measurement since the introduction in the 1970s of the Gill radiation shield.

The measurement of ambient air temperature is fundamental to the study of global climate and climate change mechanisms. Assessing the degree of global warming occurring from the increase of so-called "greenhouse gases" has been frustrated by variations in long-term temperature records due to earlier ambient temperature sensors that had calibration drifts. These variations stemmed from a variety of factors, including changes in the technology of measurement, methods of exposing the instrument, frequency of data collection, methods of calibration, and the training and dedication of the person collecting the data.
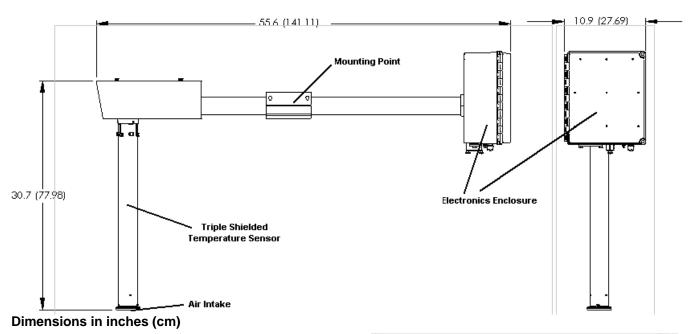
Internal CPU Operation

The PMT-2005 is controlled by an embedded microprocessor CPU that serves several functions:
- While monitoring the serial port for commands, continuous measurements of the ambient temperature are made by the ADC.
- Upon receipt of the query command (T), the CPU outputs a single data record, containing the ambient temperature and fan's status.

- The CPU performs digital filtering of the data to minimize measurement noise. It performs a quadratic fit to within $\pm0.001°$C of ITS-90 for converting PRT resistance values to $°$C.
- The D/A converter's analog output indicates the prevailing ambient temperatures.

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Mechanical Interface

Dimensions in inches (cm)

Digital Output Data Format

The RS-232 serial digital output is used to fully cover the resolution and precision of measurements. The PMT-2005 responds to a "T" string at the serial port with a constant length record. This includes a T echo; then a five-digit-long right-justified temperature value (selectable as °C or °F via an on-board jumper); followed by a blower status; terminating with CR and LF characters. An example of the PMT-2005 fixed length output record follows:
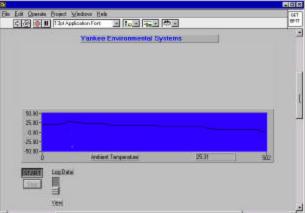
```
   T  22.54  FANFAIL=0
```


PMT-2005 software interface

Electrical Connections

Two foil-shielded 10' (3m) long cables are supplied with pig tails for interface to the user's junction box:
- DC power input; isolated return analog output
- RS-232 three-wire digital interface (no hardware handshaking is required) Cable runs are possible up to 50' via a user cable splice or junction box. Both DCE and DTE RS-232 serial interfaces can be interfaced.

Note: The PMT-2005 is also available with an optical chilled mirror hygrometer as model MET-2010.

Specifications

Power Required	11-14 Vdc, 4 Adc max, 1.3A nom;
Range	±50°C
Accuracy	±0.05°C
Analog output	±5.00 Vdc corresponding to ±50.0°C, (DAC yields 0.1°C res)
Digital output	RS-232, 9600 baud 8-N-1, ASCII (14-bit 0.01°C resolution)
Air flow	Approximately 400 FPM

YANKEE ENVIRONMENTAL SYSTEMS, INC.
Airport Industrial Park
101 Industrial Blvd., Turners Falls, MA 01376 USA
Tel: (413) 863-0200 Fax: (413) 863-0255
E-mail: info@yesinc.com http://www.yesinc.com