Thermal Sentry II

Model TSN-2

– INSTALLATION AND OPERATION –

This documentation is valid for
Thermal Sentry hardware version 2.0

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Section 1 — Safety Information

WARNING!

The Thermal Sentry should be installed only by qualified technical personnel. An attempt to install this device by a person who is not technically qualified could result in a hazardous condition to the installer or other personnel, and/or damage to the Thermal Sentry or other equipment. Please ensure that proper safety precautions have been made before installing this device.

The Thermal Sentry, as any electronic device, can fail in unexpected ways and without warning. Do not use the Thermal Sentry in applications where a life-threatening condition could result if it were to fail.

The Thermal Sentry is designed for indoor use in a dry location. Installation and operation in other locations could be hazardous. Use only the original wall-plug power supply supplied with the unit.

The purchaser and user of the Thermal Sentry bears the sole responsibility for determining suitability of this equipment for their intended use. Because this equipment can fail in an unpredictable or unexpected way, even in normal use, Sine Systems, Inc. cannot be held responsible for damages, either direct or indirect, resulting from use of this equipment.

Section 2 — System Description

2.1 General Description

The Thermal Sentry monitors the overall operating condition of a broadcast transmitter by measuring the temperature differential between the air intake and exhaust. This data can provide important, early-warning information about conditions that, if left uncorrected, could lead to costly damage.

While it is a common practice to monitor transmitter exhaust temperature, this information is of limited value. The exhaust temperature can vary over a wide range due to nothing more than changes in intake temperature. The differential temperature (intake to exhaust) provides information that is much more meaningful. The differential temperature can reveal even small changes in both the thermal-output and cooling-air volume of a transmitter.

The Thermal Sentry uses two precision temperature sensors. One is installed at the cooling-air intake and the other at the cooling-air exhaust of a transmitter. Data from these sensors is used to compute a differential temperature that is displayed on the bright, easy to read LED display. In addition, the Thermal Sentry has a warning output that activates whenever the temperature differential exceeds an adjustable, preset value. The alarm output can be used to generate an alarm by a dial out remote control system such as the RFC-1/B Remote Facilities Controller.

The key to interpreting the differential temperature data is to determine the "baseline" differential temperature of a normally operating transmitter. It only takes a short period of observation to establish the normal temperature range. This normal range is used as a basis for comparison so that variations in the differential temperature have significant meaning.

The differential temperature can be an early warning indication for a host of potential problems. Here are some of the conditions that can be detected:

- Dirty, blocked, ruptured, defective, or incorrectly installed air filters
- Blower motor problems, loose blower belts, dirty blower impellers, loss of power phase
- Missing, leaking, or incorrectly replaced panels in transmitter air plenum
- High feedline VSWR or antenna mismatch (antenna/feedline failures or antenna icing)
- Overheating components
- Faulty output power indicators
- Efficiency loss from tuning change, RF problems, loss of drive, screen or filament voltage change
- Improper power adjustment by operator
- Wind effects on intake and/or exhaust ports that are ducted to the building's exterior

The Thermal Sentry occupies a single rack space in a standard 19 inch wide equipment rack. The front panel contains a 3- digit LED display that shows the differential temperature from 0°F to 199.9°F and an “Alarm” condition indicator. All connections are made via removable screw terminal connectors. The two air temperature sensors can be located up to 100 feet from the control unit. The Thermal Sentry provides auxiliary analog outputs for intake, exhaust, and differential temperature. The output samples can be used for remote indicators such as an RFC-1/B Remote Facilities Controller.

2.2 Monitoring Differential Temperature

To illustrate how sensitive an indicator differential temperature can be, consider the following data recorded at a broadcast transmitter:

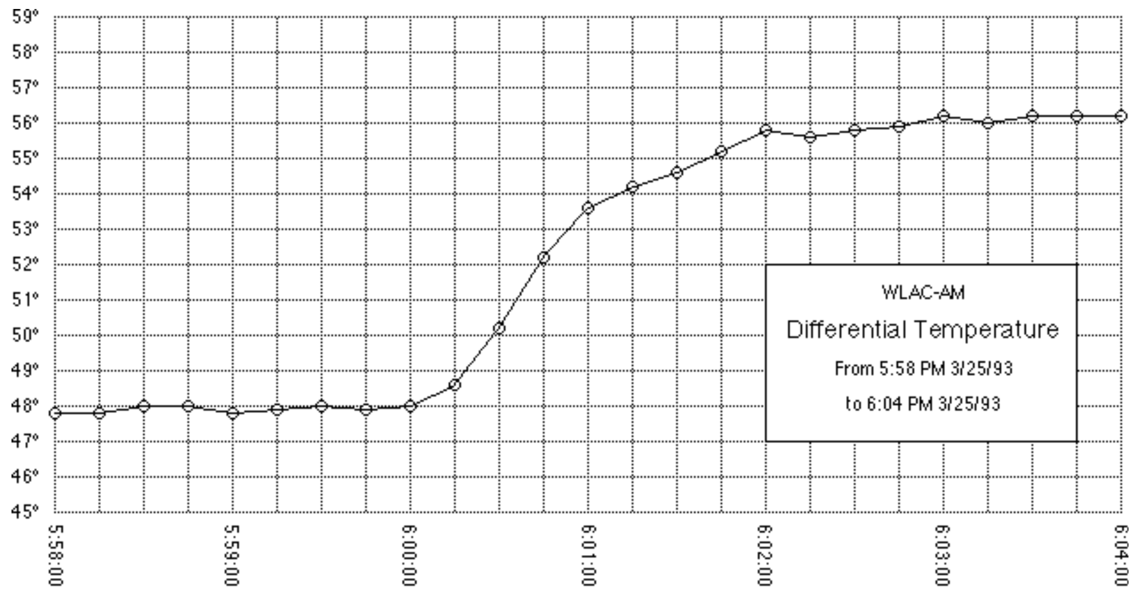


Figure 2.1; Differential temperature over time

The transmitter is a 50 kW AM, nondirectional day, directional night. The graph consists of differential temperature recorded every 15 seconds from 5:58 PM to 6:04 PM. The station switches to directional at 6:00 PM. The transmitter output increases somewhat in the directional mode due to losses in the antenna phasor. This is clearly and quickly indicated by the rise in differential temperature.

2.2.1 Primary Factors

The static factors which affect differential temperature, such as altitude and transmitter model, are inalterable and determine the "baseline" differential temperature. Other factors are variable and can be used as indicators of problems or potential problems. In interpreting differential temperature data, it is important to be aware of the variable factors which influence the data.

The primary controlling factors in temperature differential are thermal output of the transmitter and cooling-air volume. Either an increase in the first or a decrease in the second will cause the differential temperature to rise. It is this characteristic that gives the Thermal Sentry its power to detect so many problems.

Keep in mind that the thermal output of an AM transmitter can change with modulation. Also, the thermal output of all transmitters will change if the output power changes, due to either operator adjustment or line-voltage changes. This is why a short period of observation is needed to establish the "normal" range of differential temperature.

2.2.2 Secondary Factors

A smaller but not insignificant factor which influences temperature differential is intake-air temperature. This is because cool air is denser than warm air (at a given pressure) and is capable of transferring more heat for a given volume. The temperature differential of a typical transmitter will be about 12% less with 35° intake air as compared to 95° intake air, all other conditions being equal. This is observed as a slow, predictable, seasonal change in differential temperature, typically 2° to 7° depending on the power level of the transmitter. With the application of a simple formula, this effect can be eliminated and changes in a transmitter's thermal output or cooling-air volume as small as 2% can be detected.

Suppose, for example, an operator notices that a transmitter's differential temperature is running a little higher than it has been recently. He observes that the current temperature differential is 52.2° and the current intake temperature is 38°(F). He has previously established a baseline temperature differential of 53.5° at a reference intake temperature of 72°. The question is: What would the differential temperature be now if the intake temperature were 72°? To answer this question we can use the following simple formula:

$$\text{Converted Differential} = \text{Current Differential} \times \frac{\text{Reference Intake Temp} + 460}{\text{Current Intake Temp} + 460}$$

Plug in the data and we get the following results:

$$\text{Converted Differential} = 52.2 \times \frac{72 + 460}{38 + 460} = 55.76°$$

In other words, if the current intake temperature were 72° instead of the current 38°, we can predict that the differential temperature would be 55.76° instead of the current 52.2°. Since the baseline reference adjusted to 72° is 53.5°, we can see that the differential temperature is indeed running 2.26° over baseline and might warrant further investigation.

2.2.3 Tertiary Factors

Tertiary factors with still lessor effects on differential temperature are atmospheric pressure and relative humidity, which both effect cooling-air density. Also, because of the designed shape of the impeller (and other factors), the efficiency of the blower is optimum at a specific air density. Within the scope of the Thermal Sentry, these tertiary factors are small enough to be disregarded.

Section 3 — Installation

WARNING!

The Thermal Sentry should be installed only by qualified technical personnel. An attempt to install this device by a person who is not technically qualified could result in a hazardous condition to the installer or other personnel, and/or damage to the Thermal Sentry or other equipment. Please ensure that proper safety precautions have been made before installing this device.

3.1 System Includes

The Thermal Sentry package contains these items:

- Thermal Sentry II model TSN-2
- temperature sensors (matched pair)
- 12 volt DC power supply
- operation manual

3.2 Installing the Unit

The Thermal Sentry is designed to be mounted in a standard 19 inch EIA equipment rack. It is 1.75 inches high. The Thermal Sentry generates little heat and can be mounted in just about any convenient location where the ambient temperature does not exceed 140°F.

All electrical connections to the Thermal Sentry are made with 14 screw-terminals located on the rear of the unit. These connections include:

- Intake Sensor
- Exhaust Sensor
- Auxiliary Analog Output
- Alarm Output
- Power Supply

3.2.1 Temperature Sensor Location

The Thermal Sentry is supplied with two temperature sensors. These consist of small PC boards with three screw-terminals. The sensors are identical but once installed and calibrated, they should not be interchanged or system accuracy will suffer. The three terminals on each sensor should be connected to the corresponding terminals on the rear panel of the Thermal Sentry.

WARNING!

Two-conductor-with-foil-shield cable, such as Belden 8451, should be used for the connection. It is very important that foil-shielded cable be used. Braid-shielded cable is inadequate.

The air-temperature sensors may be located up to 100 feet from the Thermal Sentry. The length of the cable may be changed after calibration as the wire resistance (up to about a hundred feet) has no significant effect on calibration. The shield of the cable should connect to the ground (G) terminal, the black wire should connect to the sensor (S) terminal and the red wire should connect to the +5 volt (+) terminal. To reduce RF susceptibility, the unshielded portions of the wire at the end of the cable connected to the sensor should be as short as possible (one inch or less).

Before the air-temperature sensors are placed in their final positions, they will need to be calibrated. When this is done, the sensors should be placed within one inch of each other. See section 3.4 for the calibration procedure.

After calibration, the intake air-temperature sensor should be placed in the air flow at the transmitter's air intake, and the exhaust air-temperature should be placed in the air flow of the transmitter's air exhaust. The sensors can be used in air temperature up to 230°F. If the air-temperature sensor is installed in such a way that the lower side of the PC board could come in contact with metal, a piece of insulating tubing (supplied) should be installed over the sensor. This is heat-shrinkable tubing but it should not be shrunk in order to allow good air flow over the sensor.

In order to obtain the most accurate and meaningful data from the Thermal Sentry, care should be used in the placement of the air-temperature sensors. As an example, the following illustration shows the air-flow in a common broadcast transmitter:

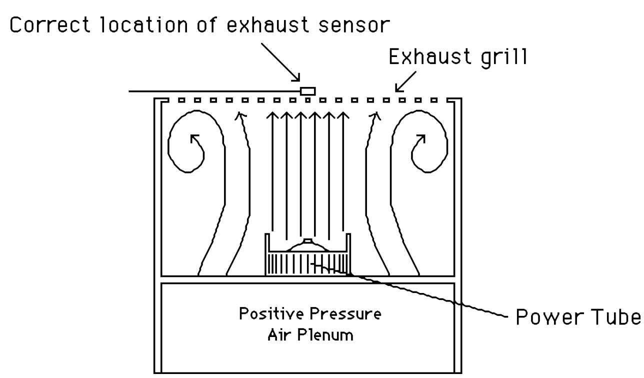


Figure 3.1; Exhaust sensor location

Here, the exhaust air-temperature sensor is shown directly over the power tube. If the sensor were located significantly off center, the air flowing across it will be a mixture of air flowing through the tube fins, leakage air, and circulating vortices cooled by the inside walls of the cabinet. This mixture is less stable in temperature and significantly cooler than the undiluted air flowing through the tube. The type of amplifier and cooling system varies from transmitter to transmitter but the principal remains the same: locate the exhaust air-temperature sensor as close as possible to the core of the airflow coming from the largest heat producer in the transmitter.

Care should also be used in the placement of the intake air-temperature sensor. If a transmitter is drawing-in room air, it might seem that the intake sensor could be located anywhere in the room. While this can be done, a short term variation of about ±1° to ±2° in differential temperature will be noticed having no correlation to the actual transmitter differential. This is because of random drafts within the room. The ideal location for the intake sensor is near the blower intake. Here the air is funneled and flowing rapidly. The next best location is on the outside of the air filters as close to the blower intake as possible.

When installing the air-temperature sensors, be sure there is no way they could fall into, or be sucked into, any portion of the transmitter where they could do harm. Nylon cable-ties are a good way to securely fasten the air-temperature sensors in place.

The Thermal Sentry is designed to operate properly in high RF fields. In extreme cases it may be necessary to connect the air-temperature sensor ground connections to the ground connection in the rack in which the Thermal Sentry is mounted.

3.2.2 Multiple Temperature Sensor Pairs

Sometimes it may be desirable to use the Thermal Sentry with more than one pair of temperature sensors. A main and alternate-main transmitter, a dual transmitter, or a transmitter having two or more major heat sources are examples where this might be needed. Additional pairs of air-temperature sensors may be ordered as part number TS-2. The only limitation in using multiple pairs of temperature sensors is that the "zero" calibration in the Thermal Sentry can be set to only one pair of sensors. This is normally not a significant problem because the calibration of any given pair of sensors is usually to within a degree of each other. Once this is accounted for in the "baseline" observations it is really of no consequence. Switching between pairs of sensors can be done manually with a switch or automatically with a relay. The air-temperature sensors require very little power from the Thermal Sentry and as a result can be connected to power and ground at all times. Only the sensor output needs to be switched. Up to 20 or so pairs of sensors can be powered by one Thermal Sentry. Here is an example of a system using two pairs of sensors:

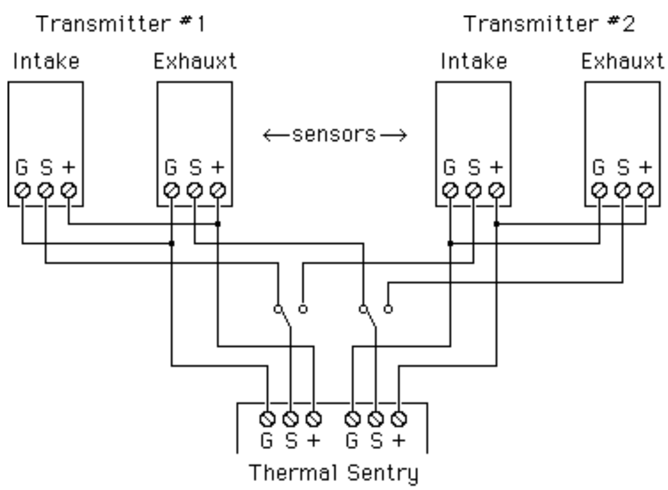


Figure 3.2; Connecting multiple pairs of sensors

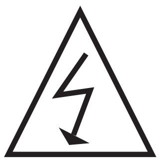
3.2.3 Temperature Sensor Calibration

The air-temperature sensors are precalibrated, typically within 1° of each other. In order to match the two sensors exactly to each other, a "Zero Set" adjustment is available on the front panel. Before setting the adjustment, locate the two air-temperature sensors within one inch of each other. Allow about 5 minutes for the sensors to stabilize. Then adjust the Zero Set control until the display reads 0.0.

3.2.4 Alarm Output

The Thermal Sentry has an alarm output that activates when the differential temperature exceeds a preset limit. The alarm condition is indicated by a red LED on the front panel and an alarm output on the rear panel. This can be used to alert a remote operator by means of a remote-control-system or it can be used to control equipment directly. The alarm output can be either a relay contact or a voltage source.

The “Alarm Set” adjustment is available on the front panel. To set the alarm value, switch the unit from the Operate mode to the Set mode with the front panel switch. Then, adjust the Alarm Set control until the desired Alarm temperature is indicated on the front panel display. Finally, place the switch back in the Operate position.



High Voltage!

Do NOT connect high voltage sources (such as 120 or 240 volts AC) to the Thermal Sentry. Because of the exposed terminals, a painful or lethal shock could be delivered to maintenance personnel.

The Alarm output is configured with two jumpers located inside the Thermal Sentry case. To open the case, remove the two Phillips-head screws on the rear panel. Remove the rear panel and bezel, and slide the top cover off the base. These are the four ways the Alarm output can be configured:

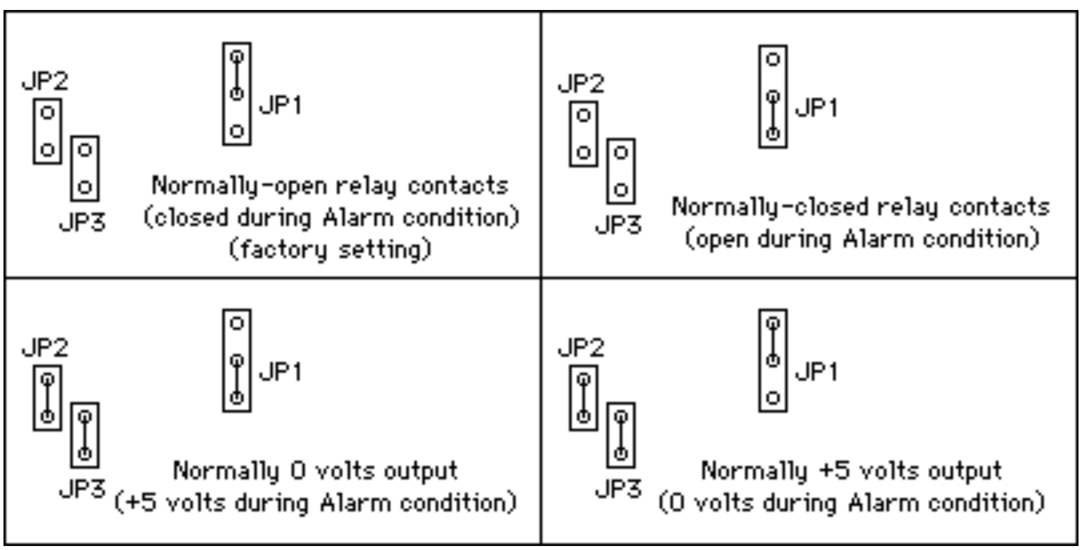


Figure 3.3; Alarm output configuration jumpers

'When the Alarm output is configured for 0 volts/+5 volts, the "A" terminal is ground and the "B" terminal is the output.

When the Alarm output is configured as a relay contact, the contacts are floating and are rated at 6 amperes. The "A" and "B" terminals are interchangeable.

3.2.5 Auxiliary Analog Outputs

The Thermal Sentry provides auxiliary analog outputs for intake temperature, exhaust temperature, and differential temperature. The outputs are linear and precalibrated to 10.0 millivolts per degree Fahrenheit (0.000 volts= 0° F; 1.000 volts = 100.0°F) referenced to the "G" terminal, and may be used for local or remote indication. The outputs may be checked with a digital multimeter set to 2 volts DC.

The auxiliary analog outputs should not be connected to a load of less than 1000 ohms.

3.3.6 Power Supply Connection

WARNING!

Do not ground either the "+" or the "-" power supply connections. Connect them only to the indicated terminals on the rear panel of the Thermal Sentry.

The Thermal Sentry is powered by 12 volts DC. The included wall-plug power supply should be used. If the power supply cord has a connector attached, cut it off and strip the leads. The wire with the white stripe is positive and should be attached to the "+" terminal. The other wire should be attached to the "-" terminal.

Section 4 — Circuit Description and Repair

4.1 Repair Safety Warnings

WARNING!

The Thermal Sentry should be installed or repaired only by qualified technical personnel. An attempt to repair this device by a person who is not technically qualified could result in a hazardous condition to the installer or other personnel, and/or damage to the Thermal Sentry or other equipment. Please ensure that proper safety precautions have been made before installing or repairing this device.

4.2 Circuit Description

The external 12 volt DC power supply is split by diodes D3 through D5 and U2 to form a dual voltage power supply. The negative supply is necessary to allow the op amp outputs to reach zero volts in the negative direction.

U1c forms a differential amplifier with a gain of unity. R2 provides a means to trim out DC offset and sensor miscalibration. This drives the analog input of the display board and U1a, a comparator, which uses the output of R11 as a reference. In the Alarm condition, the output of U1a is driven "low" to about 0 volts. This turns on Q1 which turns on RY-1 and the front panel Alarm LED, D1.

U1b and U1d are unity gain buffers for the Intake and Exhaust telemetry outputs.

There are no critical or unusual parts in the Thermal Sentry. All semiconductors can be replaced with EGC equivalents except the temperature sensors themselves. These, as well as all other parts are available from Sine Systems. If either temperature sensor is replaced, the Zero Set will need to be recalibrated.

4.3 Factory Service Policy

These policies are effective August 1999 and are subject to change without prior notice.

4.3.1 Factory Warranty

Sine Systems, Inc. guarantees our products to be free from manufacturing defect for a period of one year from the original date of purchase from Sine Systems, Inc. This warranty covers the parts and labor necessary to repair the product to factory specifications. This warranty does not cover damage by lightning, normal wear, misuse, neglect, improper installation, failure to follow instructions, accidents, alterations, unauthorized repair, damage during transit, fire, flood, tornado, hurricane or acts of God and/or nature.

4.3.2 Factory Return Policy

The factory return policy only applies to equipment purchased directly from Sine Systems, Inc. Equipment purchased through a third party (dealer) is subject to the return policy of the dealer and arrangements for return or exchange must be handled through the dealer.

Sine Systems policy on returns and exchanges with the factory is broken down according to the following schedule:

> *30 days "no questions asked"*
>
> During the first thirty days from the date that equipment ships from our factory we will accept it back for a full refund less shipping charges provided that the equipment is still in new, resellable condition with no cosmetic damage. This does not constitute an evaluation program. It is for legitimate purchases only.
>
> *less than 60 days, may be returned less 15% restocking fee*
>
> Between 31 and 60 days from the time we ship the equipment, we will accept unmodified equipment back for a refund less shipping charges and 15% of the invoice cost. This is to cover the cost of restocking the items which must then be sold at a discount as reconditioned instead of new.
>
> *no return after 60 days*
>
> We will recondition the equipment for you according to our repair rates but we will not accept it for refund or exchange after 60 days from the initial purchase.

4.3.3 Factory Service Policy

Sine Systems is proud to offer same day repair service on all of our products. When we receive damaged equipment, we will repair it and ship it back the same day it arrives. Because we offer immediate service, we do not send loaner equipment. If we cannot immediately repair equipment and return it, we may ship a loaner unit at our discretion.

While we do not require prior authorization on repairs, we suggest that you verify our shipping address before returning equipment for repair. Sine Systems is not responsible for items lost in transport or delivered to the wrong address. Emergency service may be made available on weekends or holidays, at our discretion, if arrangements are made with us in advance.

4.3.4 Warranty Service

There is no charge for repair service on items covered under warranty. You are responsible for shipping charges to return damaged equipment to us for repair. Damage due to negligence, lightning or other acts of nature are not covered under warranty.

4.3.5 Service Rates

For service not covered under warranty we have a flat rate repair fee. Flat rate repairs cover only components that fail electrically. Mechanical damage will be assessed on a per repair basis. Repair charges typically fall into one of these categories. Shipping fees are not covered in the repair rate.

Minor programming adjustments or no damage, $50 plus shipping

Sometimes a system works exactly like it is supposed to when we get it or it can be fixed through a simple adjustment in firmware. We will do our best to identify intermittent hardware problems and correct them. The fee covers the time it takes our technician to thoroughly inspect and test the equipment.

Minor repairs are up to $150 plus shipping

Five or fewer defective components are replaced in a minor to moderate repair. This accounts for most of our repairs. These repairs may cost less depending on the components replaced and the amount of time required to complete the repair.

Moderate repairs are $250 plus shipping

Six to ten defective components are replaced in a major repair. Again, we may charge less depending on the components replaced and the amount of time required to complete repairs.

Major repairs cost more than $250 plus shipping

This occurs rarely but it can happen. If the equipment has blown traces and scorch marks from burned components, it's a safe bet that it will take several components and quite a bit of bench time to repair. We assess this type of repair on a per incident basis.

Damaged beyond recognition, assessed on a per case basis

Hopefully you have insurance. In cases where the board is so badly damaged that it is not worth repairing we may, at our discretion, offer to replace the destroyed circuit board. The options and costs vary widely in these cases so we will call with options.

All repairs must be billed to a credit card or shipped COD. Specify which you prefer with your request for service. At your request, we will call with the total amount of the repair (including applicable shipping charges) so that suitable payment can be arranged before a COD shipment. If you need a COD total, do not forget to include a telephone number where you can be contacted.

4.3.6 Instructions for Factory Service

Please include a note with any specific information available about the equipment failure as an aid to our technicians. Pack equipment carefully to avoid further damage in shipping. We are not responsible for damage during transport.

When returning a system with multiple components, we strongly suggest that you return the entire system. We will repair the parts that are returned but lightning is rarely selective enough to damage only a single part of a system.

Be sure to include a street address for return shipping by UPS. The repair will be delayed if you neglect to give us enough information to return your equipment--this actually happens! If you prefer a carrier other than UPS or wish us to bill to your shipping account, we can usually accommodate these requests. Many carriers do not accept COD shipments so credit card billing may be required for carriers other than UPS. If you do not specify otherwise, return shipments will be made by the UPS equivalent of the received shipping method.

We suggest that you verify our shipping address before sending equipment for repair. Same day service does not apply if you ship to an incorrect address and/or the carrier delivers the equipment too late in the day for repairs to be completed. Sine Systems is not responsible for equipment that is not delivered to our factory. It will be your responsibility to contact the carrier to retrieve your improperly delivered equipment.

Section 5 — Specifications

5.1 Electrical Specifications

Ports

Temperature Sensors (5.0mm screw terminal connectors)
Analog Temperature Outputs (5.0mm screw terminal connectors)
Alarm Output (5.0mm screw terminal connectors)
Power Input (5.0mm screw terminal connectors)

Analog outputs are linear and precalibrated to 10.0 millivolts (DC) per degree Fahrenheit. Load impedance should be 1000 ohms or greater.

Alarm output can be configured as a normally-open or normally-closed relay contact rated at 6 amperes, or a normally-high or normally-low 5 volt logic-level using internal jumpers.

Switches

Operating/Setup Mode Selector (toggle switch)

Indicators

3.5 digit display (green)
Alarm LED (redn)

The digital display indicates from 0°F to 199.9°F differential temperature.

Adjustments

Differential temperature calibration
Differential temperature alarm set

Sensors

Operating range: 0°F to 230°F ambient air temperature
Absolute accuracy (at 72°F): ±2°F
Differential accuracy (0°F to 100°F difference): ±2°F

AC Power

Input: 100-240 Volts AC, 50-60 Hz, 5 watts
Output: 12 Volts DC, 200 mA max

5.2 Mechanical Specifications

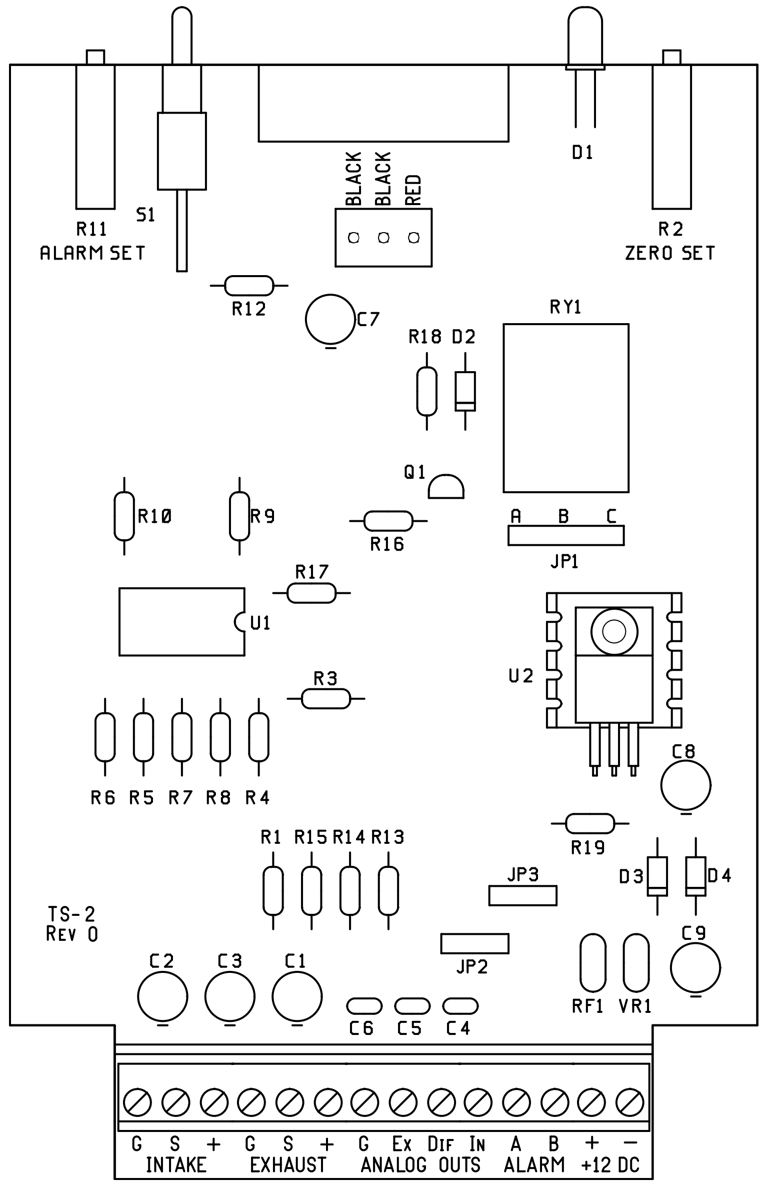
Dimensions

19.0” (w) x 6.0” (d) x 1.75” (h)
mounts in standard 19” EIA rack

Weight

3 lbs.

5.5 Component Layout



5.6 Parts List (hardware revision 1.00)

Part Description and Value	*Quantity*
board, PC, TS-1 Sensor (10/panel), Rev. 5	2
board, PC, TSN-2, Rev. 0	1
cable, wire/terminal, custom, black	2
cable, wire/terminal, custom, red	1
capacitor, aluminum, radial, 100 µF, 16v/short	6
capacitor, monolythic ceramic, 0.1 µF, .1" spacing	7
connector, screw terminal, 3.5 mm, 3, PCB, 0°	2
connector, screw terminal, 5.0 mm, 2, PCB, 0°	1
connector, screw terminal, 5.0 mm, 3, PCB, 0°	4
connector pins, pin-plug, male, 0.156", 3, PCB, 0°	1
diode, general purpose, 600 V/1 A, 1N4005	3
enclosure, assembly, black, Q1 MicroPak, 5.0"	1
enclosure part, rack panel, aluminum, anodized for TSen II	1
enclosure part, rear panel, cut, Q series MicroPak, 4.0" x 1.120	1
fuse, polyswitch, resettable, 0.4 amp, 60 V	1
hardware, nut, hex, 4-40,	1
hardware, screw, pan head, 4-40 x 3/8", stainless	1
hardware, screw, pan head, thread rolling, 4-40 x 5/8", black	2
hardware, washer, lockwasher, #6, split	1
heatsink, TO-220, 0.75" x 0.75" x 3.375", horiz, bolt, 2.5 watt	1
integrated circuit, op amp, quad, LT1114CN, low power, DC	1
integrated circuit, temperature sensor, analog, LM34DZ,	2
integrated circuit, voltage regulator, LM78M05FA, +5V DC/0.5 A	1
LED, display, 3.5 digits, meter, green, 2.0 VDC = full scale	1
LED, T1-3/4, orange, diffused	1
relay, general purpose, 5A contact, 5 volt DC, form 1C	1
resistor, carbon film, 1/4W, 1.0K, 5%	2
resistor, carbon film, 1/4W, 1M, 5%	1
resistor, carbon film, 1/4W, 2.7K, 5%	4
resistor, carbon film, 1/4W, 22, 5%	1
resistor, carbon film, 1/4W, 330, 5%	1
resistor, carbon film, 1/4W, 75, 5%	8
resistor, cermet trimmer, 2K, 22 turn, horizontal	2
resistor, metal film, 1/4W, 20.0K, 1%	4
socket, DIP, 14,	1
switch, toggle, latched, SPDT, PCB, 90°	1
transformer, wall plug, 12V DC, 500 mA	1
transistor, PNP, PN2907A, TO-92	1
varistor, metal oxide, 14 VDC, 11 VAC	1