# Thermal Sentry III

***Model TSN-3***

**– INSTALLATION AND OPERATION –**

*This documentation is valid for*
*Thermal Sentry III hardware version 1.0*

Sine Systems, inc

*Nashville, Tennessee • 615-228-3500*

# *Table of Contents*

# Section 1 — Safety Information

***WARNING!***

***The Thermal Sentry model TSN-3 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 TSN-3 or other equipment. Please ensure that proper safety precautions have been made before installing this device.***

The TSN-3, as any electronic device, can fail in unexpected ways and without warning. Do not use the TSN-3 in applications where a life-threatening condition could result if it were to fail.

The TSN-3 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 TSN-3 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:

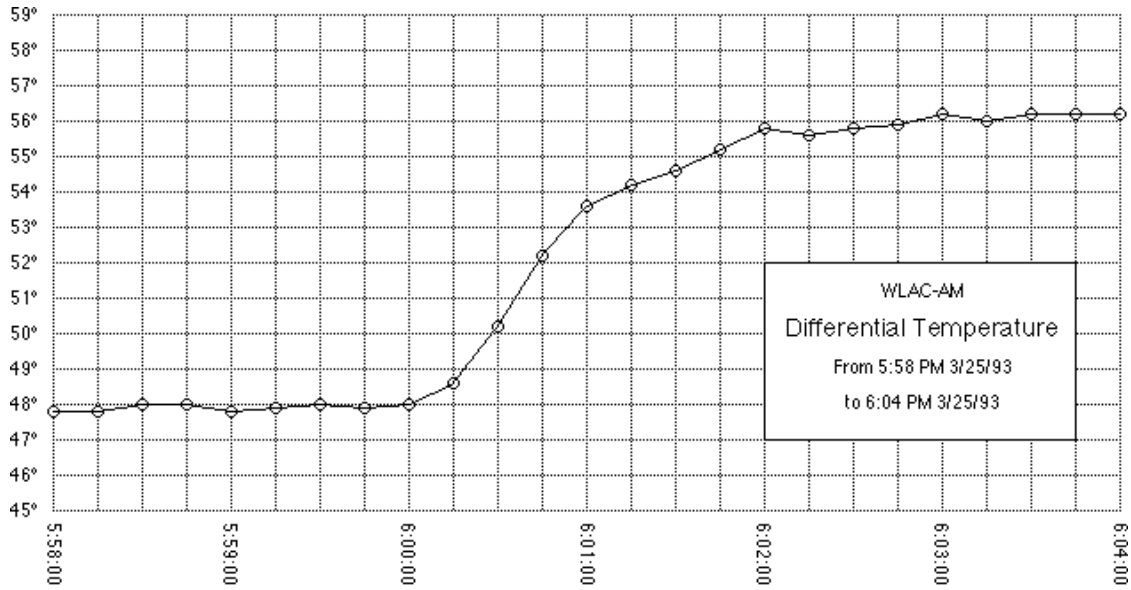



*Figure 2.1; Differential temperature over time*

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:

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

Plug in the data and we get the following results:

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

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 are observed before and during device installation.***

## 3.1 System Includes

The Thermal Sentry package contains these items:

- Thermal Sentry III model TSN-3
- temperature sensors (matched pair)
- 12 volt DC power supply
- Installation and 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.

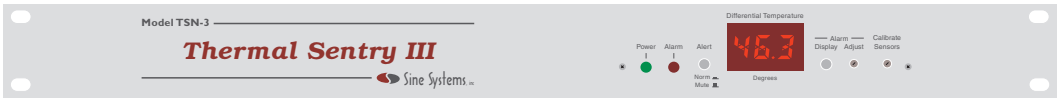



*Figure 3.1; TSN-3 front panel*

All electrical connections to the Thermal Sentry are made with 15 screw-terminals located on the rear of the unit. These connections include:

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

### 3.2.1 Temperature Sensor Calibration

The Thermal Sentry is supplied with two temperature sensors that consist of small PC boards with three screw-terminal connections. The air temperature sensors must be calibrated before they are installed. From the factory, the temperature sensors are matched within 1° F. This simple adjustment matches the sensors exactly.

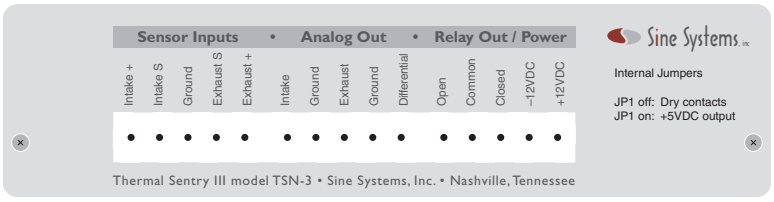



*Figure 3.2; TSN-3 rear panel*

Temporarily connect the two temperature sensors to the appropriate sensor inputs on the rear of the Thermal Sentry. The sensor outputs "+", "S" and "G" (ground) connect to the corresponding "+", "S" and "Ground" inputs on the Thermal Sentry main unit. It is not necessary to use the cables that will be used for the final installation. Once calibrated, cable length should have little or no effect on the accuracy of the sensors.

Place the sensors within an inch of each other and wait a few minutes for the temperature to stabilize. Locate the front panel adjustment labeled "Calibrate Sensors". Using a small screwdriver, turn the adjustment screw until the display reads "0.0" . Calibration is complete.

Note which sensor is connected to the intake inputs and which sensor is connected to the exhaust inputs. For maximum accuracy, the sensors should not be exchanged after they are calibrated.

### 3.2.2 Temperature Sensor Installation

*If the temperature sensors have not been calibrated, follow the procedure in section 3.2.1 before continuing.*

The temperature sensors may be located up to 100 feet from the Thermal Sentry main unit. The cable shield should connect to the ground (G) terminal, the black wire should connect to the sensor output (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.

***WARNING!***

***Two conductor foil shielded cable, such as Belden 8451, should be used for all connections. It is very important that foil shielded cable is used. Braid shielded cable is inadequate in this application.***

Place the intake temperature sensor in the air intake of the transmitter. Choose a position where the sensor will receive proper air flow but will not cause harm to or be harmed by any part of the transmitter.

Place the exhaust sensor in the air flow of the transmitter air exhaust. For the greater accuracy, the sensor should be located close to the output stack. The sensors can be used in air temperature up to 230°F. Again, choose a location for the sensor where it will not cause harm to or be harmed by any part of the transmitter.

When installing the sensors, be careful to avoid shorting the sensor by allowing the sensor board to come into contact with metal. Nylon wire ties can be used to restrain sensor leads and heat shrinkable tubing can be used to insulate the sensor board. If heat shrinkable tubing or any other insulator is used, do not restrict air flow around the top of the sensor component or the system will lose accuracy. The sensor component is the small, black component that looks like a transistor.

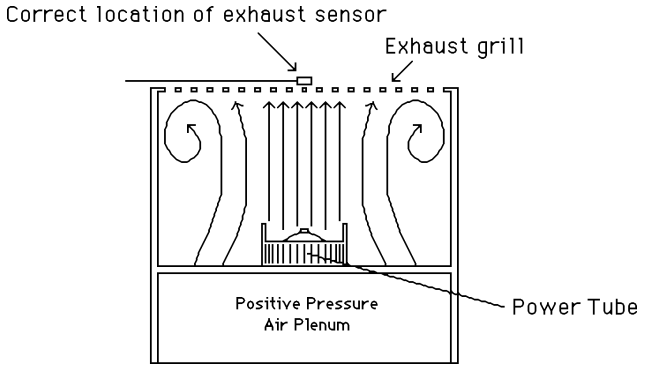



*Figure 3.3; Exhaust sensor location*

In order to obtain the most accurate and meaningful data from the Thermal Sentry, choose the temperature sensor locations carefully. 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. If the air intake draws in room air, the intake sensor could be located anywhere in the room but drafts in the room will cause reading variations that have nothing to do with the transmitter being measured.

Figure 3.2 shows the air-flow in a common broadcast transmitter stack. The exhaust sensor is shown directly over the power tube. If the sensor is 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. The temperature of this mixture is less stable in and significantly cooler than the undiluted air flowing through the tube. Cooling systems and amplifier types vary from transmitter to transmitter but the principal remains the same: locate the exhaust sensor as close as possible to the core of the airflow coming from the largest heat producer in the transmitter.

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

*Ignore references on the rear panel to JP2 for Celsius temperature--this jumper does not exist.* Contact Sine Systems for replacement sensors if Celsius temperature measurement is required.

### 3.2.3 Analog Outputs

The Thermal Sentry provides analog outputs for intake, exhaust and differential temperature. These voltage samples may be connected to the inputs of a remote metering device such as the RFC-1 Remote Facilities Controller. The outputs are linear and supply 10.0 millivolts DC per degree Fahrenheit referenced to the "Ground" terminal (0.0 volts= 0° F and 1.0 volts = 100.0°F).

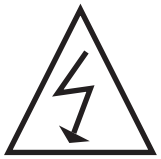
*The analog outputs should not be connected to a load of less than 1000 ohms.*

### 3.2.4 Alarm Threshold Adjustment

The alarm threshold is adjustable by a small set screw located on the front panel of the Thermal Sentry labeled "Alarm Set". To set the alarm threshold value, press and hold the Alarm Display button located to the left of the display. The display will show the alarm threshold value as long as the button is pressed. Using a small screwdriver, adjust the setting until the display reads the desired value and release the Alarm Display button.

### 3.2.5 Alarm Output

The Thermal Sentry alarm output activates when the differential temperature exceeds a preset limit. The alarm condition is indicated by a red LED on the front panel and a relay contact closure. The alarm relay outputs are labeled "Open", "Common" and "Closed" on the rear panel of the Thermal Sentry. Open, Closed and Common refer to the normally open, normally closed and common relay contacts respectively. The alarm relay output is used to signal outboard equipment of the alarm condition of the Thermal Sentry.



**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.***

As shipped from the factory, the alarm relay output contacts are dry and floating. If a jumper is installed at JP1, +5 volts DC will be supplied at the "Common" terminal of the relay output. The +5 volt supply can supply minimal current and is meant to be used as a signal to a remote metering device such as the RFC-1 Remote Facilities Controller.

### 3.2.6 Audible Alarm Alert

The audible alert is an internal piezo electric alert device that sounds when the alarm activates--when the differential temperature exceeds the threshold value. The audible alert can be muted by placing the front panel switch in the Mute position.

### 3.2.7 Power Supply Connection

***WARNING!***

***Do not ground either the "+12VDC" or the "-12VDC" power supply connections. Connect the supply leads only to the indicated terminals on the rear panel of the Thermal Sentry.***

The Thermal Sentry is powered by 12 volts DC. The power supply included with the system should be used for installations where 120VAC 60Hz wall current is available. If the power supply cable has a connector attached, cut it off and strip and tin the leads. The wire with the white stripe is positive and should be attached to the +12VDC terminal. The wire without a strip is negative and should be attached to the -12VDC terminal.

### 3.2.8 Multiple Temperature Sensor Pairs

In some installations it may be desirable to use the Thermal Sentry with more than one pair of temperature sensors. Examples of such installations are: monitoring both a main and alternate transmitter; monitoring a dual transmitter installation; or monitoring a transmitter having two or more major heat sources.

Switching between sensor pairs can be done manually with a switch or automatically with a relay. The sensors draw very little power from the Thermal Sentry so power and ground (+ and G) on multiple sensors can be connected at all times. The sensor output (S) must be switched as shown in Figure 3.4. Up to 20 pairs of sensors can be powered by one Thermal Sentry. Extra pairs of sensors are available from Sine Systems or through your dealer as model TS-1/MP (formerly TS-2).

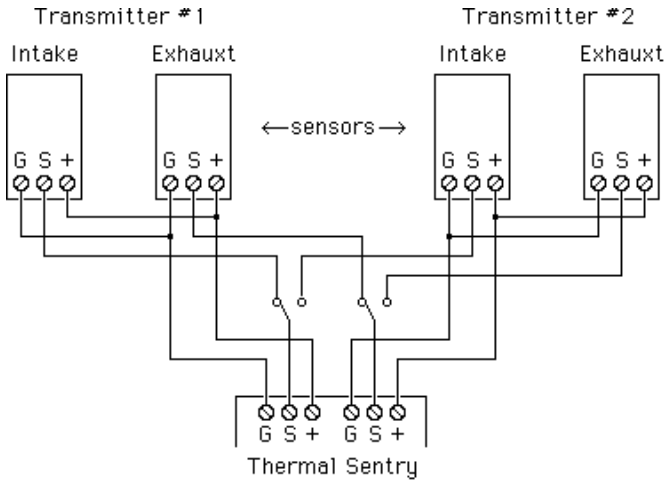



*Figure 3.4; Connecting multiple pairs of sensors to a Thermal Sentry*

The only limitation in using multiple pairs of temperature sensors is that the Thermal Sentry can only be calibrated for one pair of sensors. This is not normally a significant limitation because the sensor pairs are matched within one degree. This small degree of error is usually inconsequential in this application.

# 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 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. Replacement temperature sensors are available from Sine Systems. The system must be recalibrated when either sensor is replaced.

## 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 calibrated to 10.0 millivolts DC per degree Fahrenheit on a linear scale. Load impedance should be 1000 ohms or greater.

Alarm relay output is normally open or normally closed. Relay contacts are rated at 6 amperes.

*Switches*

Display mode (momentary pushbutton)
Audible alert Normal/Mute (latched pushbutton)

*Indicators*

Power indicator (green LED)
Alarm indicator (red LED)
3.5 digit temperature display (red)

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

*Adjustments*

Differential temperature sensor 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

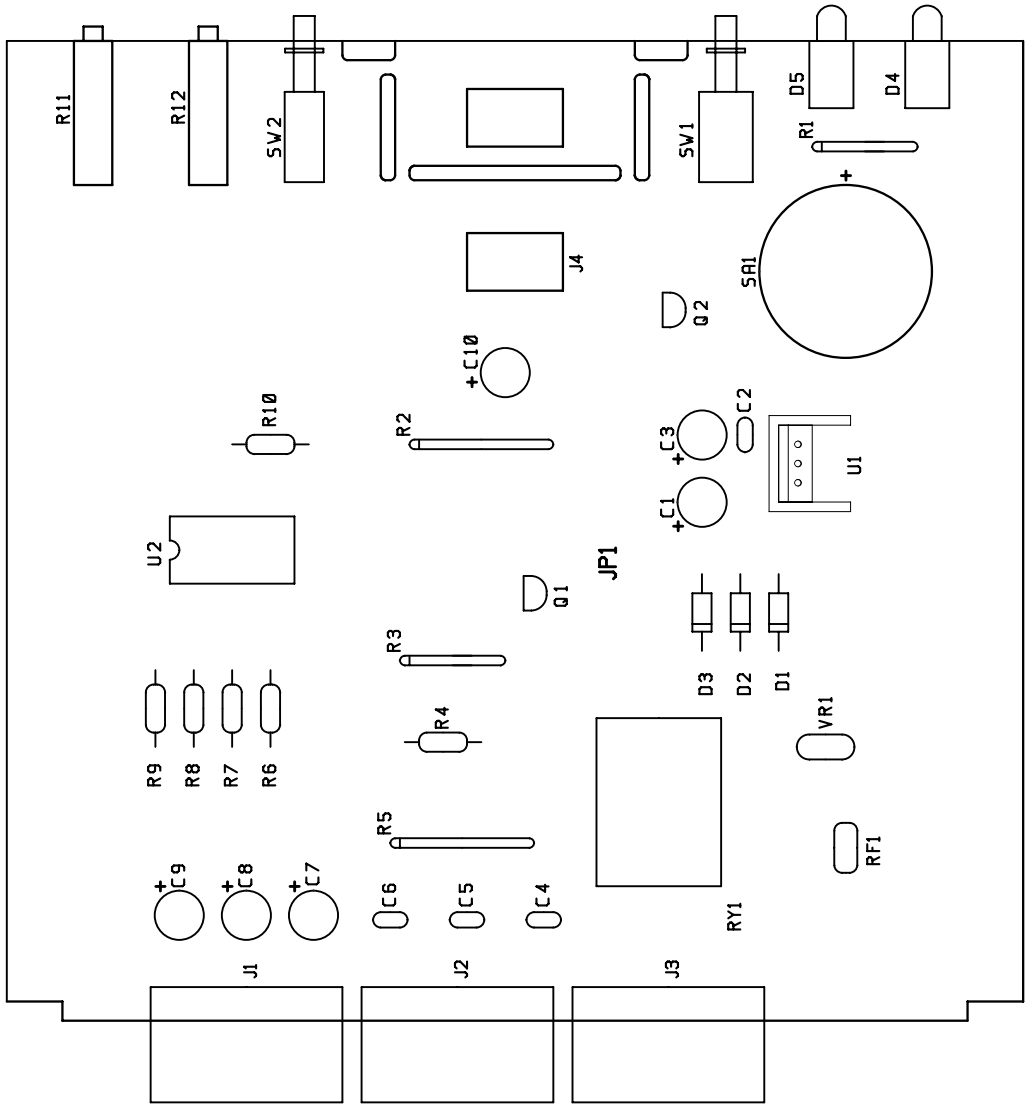
*Dimensions*

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

*Weight*

3 lbs.

## 5.4 Component Layout



## 5.5 Parts List (hardware revision 1.00)

| *Part Description and Value* | *Quantity* |
|---|---|
| board, PC, TSN-3, Rev. 0 | 1 |
| cable, wire/terminal, custom, black | 1 |
| cable, wire/terminal, custom, green | 1 |
| cable, wire/terminal, custom, red | 1 |
| capacitor, aluminum, radial, 100 µF, 16v/short | 6 |
| connector, pin-plug, female, 0.1", 2, shorting plug | 1 |
| connector, screw terminal, 5.0 mm, 5, plugable | 3 |
| connector pins, pin-plug, male, 0.1", 40 x 1, 0.24 gold up/.125 gold dn | 2 |
| connector pins, pin-plug, male, 0.156", 3, PCB, 0° | 1 |
| connector pins, screw terminal, 5.0 mm, 5 (5x1), PCB, 90° | 3 |
| diode, general purpose, 600 V/1 A, 1N4005 | 3 |
| enclosure, assembly, platinum, T1 MicroPak, 5.0" | 1 |
| enclosure part, overlay, lexan, printed for TSN-3 (rear) | 1 |
| enclosure part, rack panel, aluminum, painted for TSN-3 | 1 |
| enclosure part, rear panel, T1 MicroPak, punched for TSN-3 (overlay) | 1 |
| fuse, polyswitch, resettable, 0.4 amp, 60 V | 1 |
| hardware, nut, locknut, hex, 4-40, stainless | 1 |
| hardware, screw, pan head, 4-40 x 3/8", stainless | 1 |
| hardware, screw, pan head, thread rolling, 4-40 x 3/8", clear | 2 |
| hardware, screw, pan head, thread rolling, 4-40 x 5/8", clear | 2 |
| heatsink, TO-220, 0.52" x 0.375" x 0.75", vert, solder | 1 |
| integrated circuit, op amp, quad, LT1114CN, low power, DC | 1 |
| integrated circuit, transistor, NPN, PN2222A, TO-92 | 1 |
| integrated circuit, transistor, PNP, PN2907A, TO-92 | 1 |
| integrated circuit, voltage regulator, LM78M05FA, +5V DC/0.5 A | 1 |
| LED, 5mm, long, green, 90° | 1 |
| LED, 5mm, long, red, 90° | 1 |
| LED, display, 3.5 digits, meter, red, 2.0 VDC = full scale | 1 |
| miscellaneous, sonalert, piezo, 3-20 volt DC, 75dB @ 12V | 1 |
| relay, general purpose, 5A contact, 5 volt DC, form 1C | 1 |
| resistor, carbon film, 1/4W, 1M, 5% | 1 |
| resistor, carbon film, 1/4W, 22, 5% | 1 |
| resistor, cermet trimmer, 2K, 22 turn, horizontal | 2 |
| resistor, metal film, 1/4W, 20.0K, 1% | 4 |
| resistor, SIP, 3 x 1K, isolated | 1 |
| resistor, SIP, 3 x 220K, isolated | 2 |
| resistor, SIP, 3 x 330, isolated | 1 |
| resistor, SIP, 4 x 2.7K, isolated | 1 |
| resistor, SIP, 4 x 68, isolated | 1 |
| socket, DIP, 14, | 1 |
| switch, cap for C&K latched pushbutton, light gray, round | 2 |
| switch, pushbutton, latched, DPDT, PCB, 90° | 1 |
| switch, pushbutton, momentary, SPDT, PCB, 90° | 1 |

| *Part Description and Value* | *Quantity* |
|---|---|
| transformer, wall plug, 12V DC, 500 mA | 1 |
| varistor, metal oxide, 14 VDC, 11 VAC | 1 |