EMC-6B 1983

Fenwal® Electronics

THERMISTOR MANUAL

FENWAL ELECTRONICS
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About . . .
FENWAL ELECTRONICS

Fenwal Electronics was founded in 1955 to manufacture precision thermistors and thermistor sensor assemblies. It has pioneered in the work of applying the unique characteristics of these versatile semiconductors to a broad range of consumer, industrial, aerospace and military applications.

The manufacturing facility at 63 Fountain Street, Framingham, Massachusetts 01701, U.S.A., has been surveyed and approved by major contractors from every part of the world and by various government agencies including all branches of the military and NASA. Many types of testing required in the production of high reliability products is performed by Fenwal Electronics either at our main plant or through facilities at affiliate plants. The capability to meet and exceed rigid high reliability design requirements, enabled Fenwal Electronics to participate in virtually every major military and aerospace program. Quality control facilities comply with MIL-Q-9858A and have been Air Force approved to conduct QPL testing to MIL-T-23648A.

The ever increasing number of users and applications for thermistors demands that thermistor manufacturers provide high reliability and quality as an integral part of every thermistor purchased. Fenwal Electronics prides itself on being that kind of a company. Past and present performances tell the story of why Fenwal Electronics is one of the major thermistor manufacturers in the world and why we have always been a leader in the field of thermistor and thermistor assembly design applications.

At Fenwal Electronics, we prove daily . . . "Worldwide Thermistor Leadership through Quality"

®REGISTERED TRADEMARK

WHAT ARE THERMISTORS?

NTC TYPE

Thermistors are "thermal resistors" or resistors with a high negative temperature coefficent of resistance. As the temperature increases, the resistance decreases and as the temperature decreases, the resistance increases. This is just opposite to the effect of temperature changes on metals.

Thermistors are semiconductors of ceramic material made by sintering mixtures of metallic oxides such as manganese, nickel, cobalt, copper, iron and uranium. Although these materials and their semiconducting characteristics have been known for nearly 200 years, only in the last 30 years have techniques of producing thermistors been well enough developed to permit production of reproducible and stable units. Various mixtures of these metallic oxides are formed into useful shapes. Their electrical characteristics may be controlled by varying the type of oxide used and the physical size and configuration of the thermistor. Standard forms now available are:

BEADS: Beads are made by forming small ellipsoids of thermistor material on two fine wires tight and parallel about 0.01 inches apart. The material is sintered at high temperature and the leads become embedded tightly in the beads making good electrical contact inside the thermistors. Beads may be coated with glass for protection or they may be mounted in evacuated or gas-filled bulbs. Resistance values of 10 ohms to over 100 megohms can be obtained in beads ranging from 0.006 to 0.050 inches in diameter.

GLASS PROBES: Beads sealed into the tips of solid glass rods of up to 0.1 inches diameter and ¼ to 2 inches in length.

DISCS: Discs are made by pressing thermistor material under several tons of pressure in a round die to produce flat pieces like a coin. These pieces are sintered and then coated with silver on the two flat surfaces. Standard discs are from 0.05 inch to 1 inch in diameter and 0.010 to 0.25 inches thick. Resistance values of 1 ohm to 1 megohm can be produced in this way.

WASHERS: Washers are made like discs except that a hole is formed in the center so the unit can be mounted on a bolt. Several washers may be mounted together on a bolt with terminals between them so they may be connected either in series or parallel as desired. Standard washers are 0.77 inches in diameter.

RODS: Rods are extruded through dies to make long cylindrical units which are normally 0.053, 0.110, or 0.173 inches in diameter and from ½ to 2 inches long. Leads are attached to the end of the rods and resistance values can be provided from 1,000 ohms to 150,000 ohms. The major advantage of rods over other configurations is the ability to produce high resistance units with moderately high power handling capability.

E-I CURVE-MATCHED THERMISTOR PAIRS: Matched thermistor assemblies designed for use in gas Chromotographic equipment and other thermal conductivity gas analysis instruments. Each bead is mounted to a special hermetically sealed stem. For maximum sensitivity, the higher resistance units should be used at higher temperatures. Ask for E-I Curve Manual L-7.

VACUUM AND GAS FILLED ASSEMBLIES: Vacuum and gas filled assemblies are uniquely qualified as transducers because of two inherent characteristics: first, is their high sensitivity to small variations in their own temperature and second, is their ability to operate in the "self-heated mode." In thermal conductivity instrumentation, these units may be used in high accuracy flowmeters, anemometers and vacuum gauges for use as sensing thermistors to detect minute thermal changes caused by the presence or flow of a liquid or gas. Ask for E-I Curve Manual L-7.

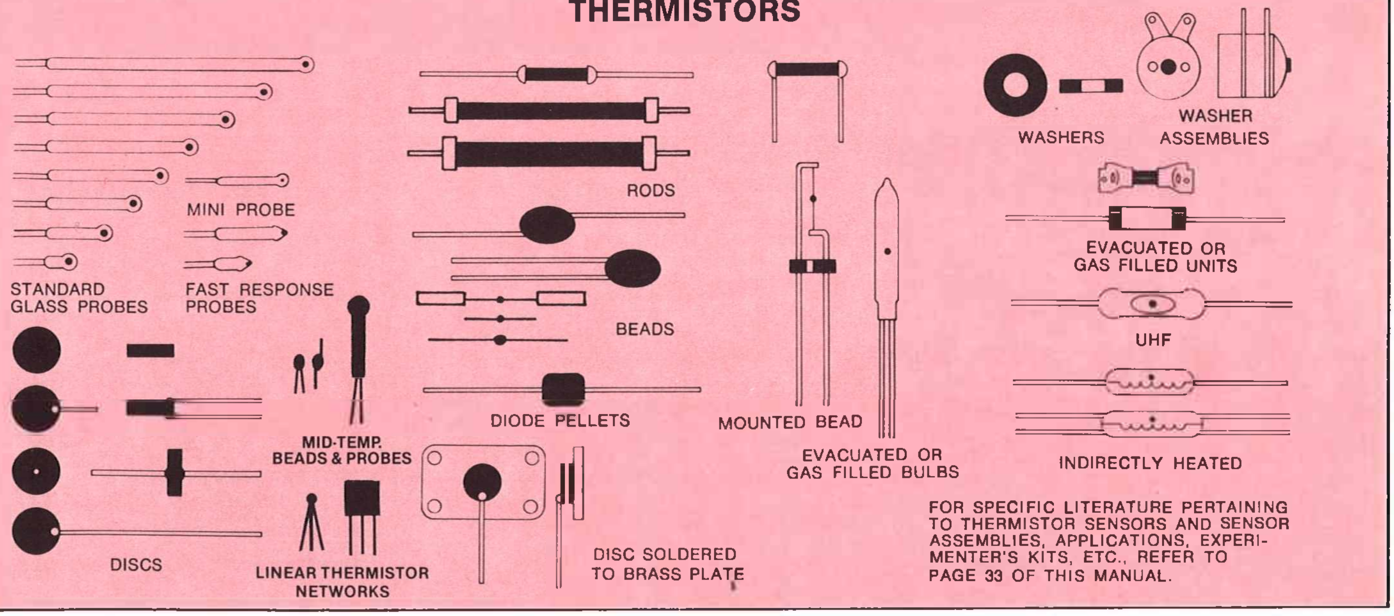
LINEAR THERMISTOR NETWORKS (LTN^{TM}): Precision resistors and thermistors which are designed to produce a resistance change or voltage output that varies linearly with temperature over the selected temperature range. Ask for Bulletin L-9A.

MID-TEMP. BEAD AND PROBE THERMISTORS: Useage at higher MID-TEMP. range from 200°C to 600°C now possible for thermistor users previously limited to temperature range of 300°C. Ask for Bulletin L-10.

THERMISTOR CONFIGURATIONS

FENWAL ELECTRONICS offers the broadest variety of Thermistor Sensors and Thermistor Sensor Assemblies in the world. We offer over 1,000 standard units and will provide engineering assistance to guarantee customized units that will satisfy your design applications. Listed below are basic thermistor configurations which are available in a broad range of resistances, temperature ranges, sizes, etc.

THERMISTORS



FOR SPECIFIC LITERATURE PERTAINING TO THERMISTOR SENSORS AND SENSOR ASSEMBLIES, APPLICATIONS, EXPERIMENTER'S KITS, ETC., REFER TO PAGE 33 OF THIS MANUAL.

WHAT ARE THERMISTORS?

(continued)

Precision
Interchangeable R-T Curve Matched
Thermistors

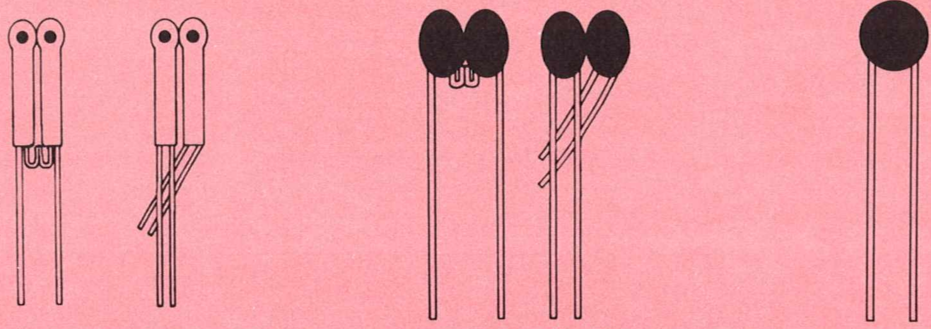
ISO-CURVE CURVE-MATCHED, INTERCHANGEABLE THERMISTORS: Special glass bead and glass probe thermistors that have been precision matched at the factory to standardized resistance-temperature curves and are designated for use at temperatures to 300°C. They have the unique and valuable characteristic of complete electrical interchangeability. In addition they offer all of the functional advantages associated with standard thermistors, including large resistance change per degree of temperature change which provides high accuracy and resolution. Thermistors are normally rated by the value of their resistance at 25°C. Standard units having the same rated resistance, however, will not exhibit identical resistance-versus-temperature characteristics over their full temperature range. ISO-CURVE thermistors, on the other hand, will match a specified R-T curve over the full temperature range required. ISO-CURVE thermistors are available at the present time in a number of standardized R-T curve values; 500, 1K, 2K, 4K, 15K, 16K, 25K, 100K and 400K ohms. These standard curves represent permanent specifications and an F. E. ISO-CURVE thermistor purchased five years from now will be perfectly interchangeable with one of the same value purchased today. Ask for ISO-CURVE Thermistor Manual L-2B.

UNI-CURVE INTERCHANGEABLE CURVE-MATCHED THERMISTORS: A companion to the famous ISO-CURVE units. UNI-CURVE thermistors are high quality, low cost epoxy coated R-T curve-matched interchangeable thermistors designed for use at temperatures to 150°C. They offer additional cost savings by eliminating the need for individual R-T calibration, as well as standardization of circuit components, and simplify design and replacement problems. They are particularly well suited for use in applications such as temperature measurement, indication and control, also for compensation of ambient temperature effects on copper coils, transistors, integrated circuits and other semiconductor devices. UNI-CURVES are available at the present time in a number of standard resistance values; 100, 300, 500, 1,000, 2252, 3K, 5K, 10K, 30K, 50K and 100K ohms. Fenwal Electronics high volume UNI-CURVE manufacturing capability provides availability of interchangeable thermistors at low cost with the quality and ruggedness to meet the rigid design requirements of MIL-T-23648. Ask for UNI-CURVE Thermistor Manual L-6A.

THERMISTOR PROBE ASSEMBLIES: Standardized or special customized thermistor assemblies, provided in complete, ready-to-mount housings, enable you to take advantage of the precision and interchangeability of Fenwal Electronics thermistors. A complete line of thermistor probe assemblies is available for a variety of missile, aircraft and industrial applications, including liquid level indication and control, temperature measurement and control of liquids, solids, gases and other applications. Calibration can be supplied with probe assemblies at desired temperatures. Thermistor probe assemblies with identical resistance-temperature curves are available to close tolerances over a wide temperature range. Most of these housings can be made to meet military specifications if required. Ask for Thermistor Housing Manual L-5A.

INTERCHANGEABLE R-T CURVE-MATCHED THERMISTORS

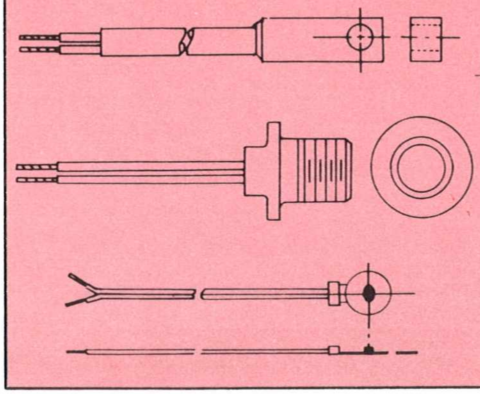
UNI-CURVE®



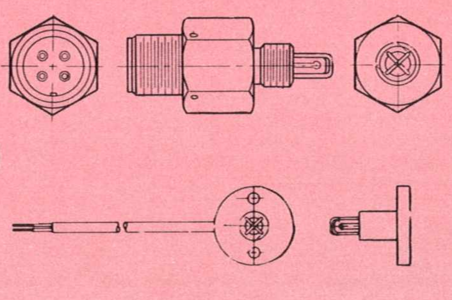
FOR ADDITIONAL DETAILED INFORMATION ON ISO-CURVE UNITS ASK FOR BULLETIN L-2A AND FOR UNI-CURVE UNITS ASK FOR OUR L-6A MANUAL. REFERENCE PAGES 25, 26, 30, 31 OF THIS MANUAL.

THERMISTOR PROBE ASSEMBLIES

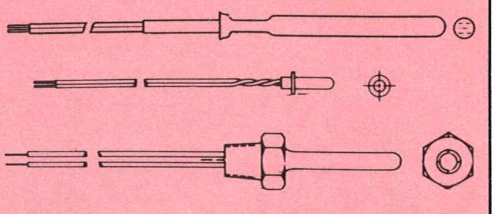
SURFACE TEMPERATURE



GAS TEMPERATURE



LIQUID TEMPERATURE



FOR ADDITIONAL INFORMATION ON FENWAL ELECTRONIC'S THERMISTOR PROBE ASSEMBLIES ALONG WITH DETAILED DATA CONCERNING HOUSINGS AND MOUNTING UNITS ASK FOR OUR COMPREHENSIVE THERMISTOR HOUSING MANUAL L-5A. REFERENCE PAGE 33 OF THIS MANUAL.

WHAT DO THERMISTORS DO?

There are three important characteristics of thermistors that make them useful in electronic and electrical circuits.

RESISTANCE-TEMPERATURE CHARACTERISTIC: The resistance of a thermistor is solely a function of its absolute temperature. Since electrical power being dissipated within a thermistor will heat it above its ambient temperature and thereby reduce its resistance, it is necessary to test for resistance with a very small amount of power so there will be no measurable increase in the thermistor temperature. The resistance so measured is called Ro, which means the resistance at essentially zero power.

*The typical theoretical mathematical expression which relates the resistance and the absolute temperature of a thermistor is as follows:

$$\frac{\mathrm{Ro}\ (T_1)}{\mathrm{Ro}\ (T_2)} = e^{\beta\left(\frac{1}{T_1}-\frac{1}{T_2}\right)}$$

Where:

Ro (T_1) is the resistance at absolute temperature T_1.
Ro (T_2) is the resistance at absolute temperature T_2.
e is 2.718.
β is a constant which depends on the material used to make the thermistor.

Unless otherwise specified all values of β are determined from measurements made at 0°C and 50°C. The range of β values for Fenwal Electronics' thermistor materials is typically 3000-5000.

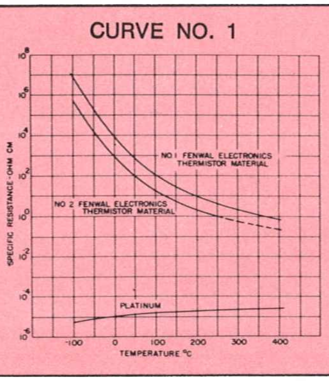
The temperature coefficient of a thermistor or alpha "α_T" is expressed in the following equation:

$$\alpha_T = \frac{1}{R_T}\ \frac{dR_T}{dT}\ \text{OHMS/OHM/°C}$$

which is approximately equal to $-\frac{\beta}{T^2}$

The value of α_T is more useful when expressed in %/°C. and in some cases is as high as —5.8% at room temperature as compared to .36% for platinum. αT is not a constant, but varies smoothly over the whole temperature range. This value is a useful measure of thermistor's sensitivity to temperature change and is higher at low temperatures while lower at high temperatures.

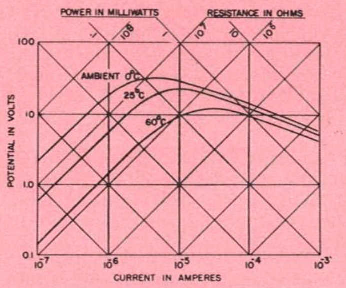
CURVE NO. 1



Curve No. 1 shows the resistance variation of two basic Fenwal Electronics' thermistor materials with temperature, and also shows the resistance variation of platinum for comparison. Between the temperatures of — 100°C. and 400°C., there is a change of ten million to one in resistance of thermistor materials whereas platinum resistance changes by only ten to one over the same temperature range.

VOLTAGE-CURRENT CHARACTERISTIC: If a very small voltage is applied to a thermistor, a small current will flow which does not produce enough heat in the thermistor to heat it measurably above its surroundings. Under these circumstances, Ohm's law will be followed and the current will be proportional to the applied voltage. However, if the voltage is gradually increased, the current will increase, and the heat generated in the thermistor will finally begin to raise its temperature above that of its surroundings. The resistance will consequently be lowered and more current will flow than if the resistance had remained constant.

CURVE NO. 2



STEADY-STATE VOLTAGE-CURRENT CHARACTERISTICS OF FENWAL ELECTRONICS BK65V1 THERMISTOR

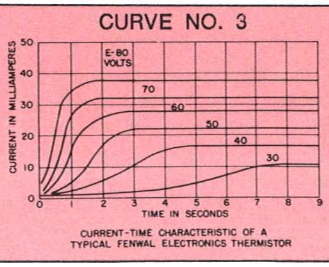
Curve No. 2 shows that the voltage drop across a thermistor increases as the current increases until it reaches a peak value beyond which the voltage drop decreases as the current increases. In this portion of the curve, the thermistor is exhibiting a negative resistance characteristic. Thus, under any fixed ambient conditions, the resistance of a thermistor is a function of the power being dissipated within itself, provided there is sufficient power to raise its temperature considerably above ambient. Under normal operating conditions the temperature may rise two to three hundred degrees Centigrade and the resistance may be lowered to 1/1000 of its value at low current. For temperature measurement and indication, or any other applications which require that the thermistor be operated with "negligible self-heat" reference should be made to the dissipation constant value for the particular thermistor. The "self-heat" in °C due to applied power will be a direct fraction or multiple of the dissipation constant. For example: For a thermistor with a D.C. of 1 mw/°C, 0.1 mw relates to 0.1°C self heat. 10mw=10°C self-heat.

CURRENT-TIME CHARACTERISTIC: If a voltage is applied to a thermistor and resistor in series, a current will flow which is determined by the voltage and the total circuit resistance. If the voltage is high enough, some heat will be generated in the thermistor which will lower its resistance and more current will flow. This, in turn, will heat the thermistor more and lower its resistance further.

This process will continue until the thermistor reaches the maximum temperature possible for the amount of power available in the circuit, at which time a steady state will exist.

Since the thermistor has a certain mass, it takes time for it to be heated to its maximum value and this is a function of the mass of the thermistor, the value of the series resistance and the applied voltage.

CURVE NO. 3



CURRENT-TIME CHARACTERISTIC OF A TYPICAL FENWAL ELECTRONICS THERMISTOR

Curve No. 3 shows that the time delay for the circuit to reach maximum current for a given thermistor is a function of the applied voltage. By suitable choice of thermistor and associated circuitry, it is possible to produce time delays from milliseconds to several minutes.

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*This is a Typical Theoretical Mathematical Expression used solely for this problem and should not be construed as a truism.

HOW ARE THERMISTORS USED?

HOW ARE THERMISTORS USED? There are many circuits in which thermistors have been used to great advantage. The number of successful applications has been growing rapidly in the last few years and the future use of thermistors is limited only by the imagination and enterprise of skilled engineers. A few of the more common applications are described below.

TEMPERATURE MEASUREMENT: A simple circuit (Fig. 1) for temperature measurement consists of a battery, a thermistor, and a microammeter. As the temperature changes, the resistance of the thermistor changes and the current flow through the meter can be calibrated in terms of temperature. In this circuit, the thermistor may be mounted at a great distance from the meter and ordinary copper wire may be used for connection. Since the thermistor may be of high resistance, such as 100,000 ohms or more, any change in resistance of the copper transmission line due to ambient temperature changes will be negligible. As long as the supply voltage remains constant, the current flow will be determined only by the absolute temperature of the thermistor. Changes in the transmission line length or changes in temperature of the meter will not affect the accuracy of the temperature indication.

A more sensitive temperature measuring circuit (Fig. 2) consists of a thermistor in one leg of a bridge circuit. The meter may be a center zero galvanometer. The more sensitive the galvanometer, the shorter the temperature range indicated on the full scale of the meter. Such indicators have been made with a full scale reading of 1°C. A similar circuit (Fig. 3) but with two thermistors instead of one may be used for making accurate temperature differential measurements. If the two thermistors are placed in different locations, the unbalance of the bridge will be dependent upon the difference of the two thermistors. A typical FE 4,000-ohm thermistor with a temperature coefficient of −3.9% /°C @ 25°C will exhibit a resistance change of 156 ohms per degree C change in temperature, compared to only 7.2 ohms for a platinum resistance bulb with the same basic resistance. Connected in a simple bridge circuit with an indicating galvanometer, a thermistor will readily indicate a temperature change of as little as 0.0005°C. It is a simple matter, with such a circuit, to obtain a 1°C full-scale output. This high sensitivity, together with the relatively high thermistor resistance which may be selected, makes the thermistor ideal for remote measurements or control, since changes in contact or transmission line resistance due to ambient temperature effects are negligible. For example, 400′ of #18 AWG copper wire transmission line, subjected to a 25°C temperature change, will affect the accuracy of measurement or control approximately 0.05°C.

Thermistor control systems are inherently sensitive, stable, and fast acting, and require relatively simple circuitry. Neither polarity nor lead length is significant, and no reference temperature or cold junction compensation is required, as with thermocouples.

Due to the large voltage outputs provided by a typical thermistor bridge (Fig. 4) or by a standard thermistor telemetering circuit (Fig. 5), no amplification is required. The voltage output of the standard thermistor bridge or telemetering circuit at 25°C will be 18 millivolts/°C using a 4,000 ohms GB34P92 thermistor; 450 times greater than that of a Chromel/Alumel thermocouple whose output is only 0.040 millivolts/°C.

TEMPERATURE COMPENSATION

Copper Coil Compensation — A properly selected thermistor, mounted against or near a circuit element such as a copper coil, (Fig. 6), and experiencing the same ambient changes, can be connected in the circuit in such a way as to compensate almost exactly for the electrical changes caused by the original element. For example, it may be desired to have a relay operate at the same voltage over a broad temperature range. Assume a unit with a copper coil of 5000Ω @ 25°C, which pulls in at 1 ma., used in a VR circuit where it must pull in at a constant voltage from 0°C to 60°C. Uncompensated, the coil resistance varies from 4555Ω at 0°C to 5623Ω @ 60°C, representing a change of about ±10½%. With a single thermistor compensation network, this variation can be reduced to about ±15Ω or ±¼%. Fig. 7 illustrates the effect of a compensation network. With double or triple compensation networks variations can be reduced even further.

It is desirable in such applications that there be good thermal coupling between thermistor and component so that both are at the same temperature at all times regardless of whether the temperature change is due to ambient temperature or current flow through either component.

Thermistors have been used to compensate magnetic amplifiers so their gain remains constant as temperature changes.

In addition, they are frequently used to temperature-compensate the copper coils in: METERS, to maintain proper indicator needle displacement — DEFLECTION YOKES, for constant impedance — SERVO MOTORS, GENERATORS and SYNCHRO RESOLVERS, to eliminate phase displacement errors — ELECTRIC MOTORS and GENERATORS, to maintain constant speed and output — VIBRATING REED CHOPPERS, to maintain steady make-break characteristics.

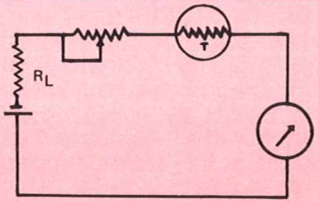


FIG. 1

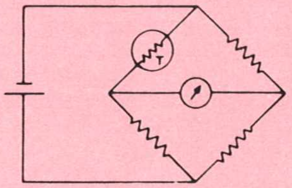


FIG. 2

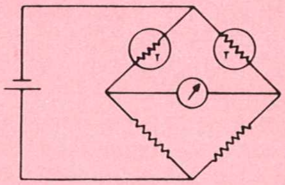


FIG. 3

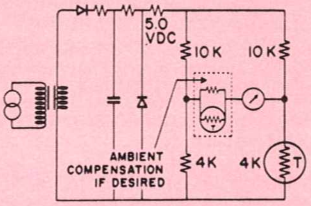


FIG 4 Typical Thermistor Temperature Indication Circuit.

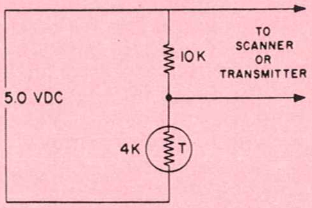


FIG. 5 Typical thermistor telemetry circuit.

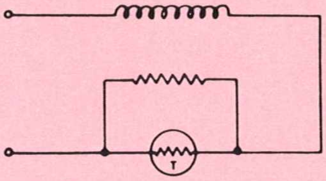


FIG. 6

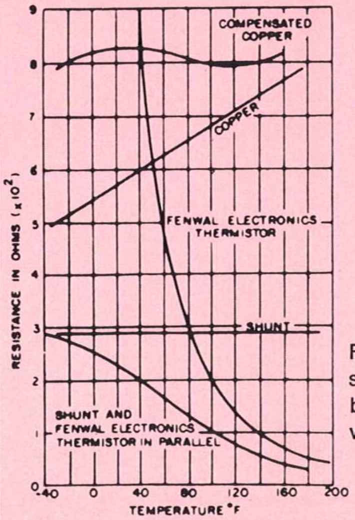


Fig. 7. Temperature compensation of a copper conductor by means of a thermistor network.

HOW ARE THERMISTORS USED?

(continued)

Transistor Compensation — Because transistor operation is thermal-sensitive, disc thermistors are often used to minimize temperature-caused variations in emitter and collector current. Fig. 8 illustrates the result of an effective compensation network, with three intersections-between desired and actual curves.

TEMPERATURE CONTROL: A simple temperature control can be made by placing a thermistor (Fig. 9) in series with a relay, a battery, and a variable resistor. It is possible to make the relay operate at any desired temperature of the thermistor. The relay will close when the thermistor gets warm and open when it gets cold.

A more sensitive temperature control may be made by placing a thermistor (Fig. 10) in one leg of a bridge circuit, a variable resistor in another leg, and a polarized relay across the output. When the thermistor becomes warm, the relay will operate in one direction and when the thermistor becomes cold, the relay will operate in the opposite direction. The point of operation may be adjusted by changing the value of the variable resistor.

A more sensitive control may be made by applying AC to the bridge and placing a high gain amplifier between the bridge and the relay. Such controls have operated to a precision of .001°F. with ease as per (Fig. 11).

LIQUID LEVEL MEASUREMENT: If a thermistor is placed in series with a light bulb and a battery, the light will operate if the thermistor is suspended in air. The thermistor heats up and the resistance drops permitting enough current to flow to light the bulb. If the thermistor is submerged in a liquid (Fig. 12) it will be cooled because of the greater thermal conductivity of the liquid and the thermistor resistance will increase and sufficiently reduce the current in the bulb to extinguish it. This device may be used as a liquid level indicator.

A liquid level control may be made by substituting a relay for the light bulb, the relay operating a valve to control the liquid flow.

TIME DELAY: By placing a thermistor and a variable resistor in series with a battery and a relay (Fig. 13) a variable time delay relay may be made. When the switch is closed, the current flow is limited by the high resistance of the thermistor which then heats up and permits sufficient current flow to close the relay. By increasing the series resistance, the delay time may be increased and by reducing the series resistance, the delay time may be decreased. Such delay circuits are used in many cases where variable or fixed delay is required.

CURRENT SURGE SUPPRESSION: A thermistor in series with a vacuum tube filament or in series with an incandescent light bulb (Fig. 14) will prevent an initial current surge when the devices are turned on from a cold start. By selecting a thermistor with the same time constant as the filaments, it is possible to have the current remain substantially constant during the initial warmup time.

SWITCHING: If several devices such as low voltage light bulbs are connected in series with a suitable thermistor connected in parallel with each unit (Fig. 15) very little current will pass through the thermistors because they are not appreciably heated by the small voltage drop across the bulbs. If one bulb burns out, the full line voltage appears across the parallel thermistor and heats it over its peak and the voltage quickly drops to the original value of the bulb voltage. The result is that the other bulbs remain lighted and only the burned out one is extinguished. The thermistor continues to carry the load of the bulb. When the bulb is replaced, it takes the current from the thermistor which cools off and returns to its original idle condition of high resistance and low current.

POWER MEASUREMENT: If a bead thermistor of 2000 ohms is placed in a 200 ohm bridge circuit with a variable resistor in series with the bridge, (Fig.16) the current may be increased gradually until the thermistor heats up enough to lower its resistance to 200 ohms at which point the bridge will be in balance. This current may be measured and the D.C. power in the thermistor calculated. If a source of high frequency power is applied to the thermistor through suitable capacitors, it will be still further heated and the bridge will be unbalanced. The D.C. power may then be reduced until the bridge balances again and the new D.C. power calculated. The difference in the two D.C. power calculations will be the H.F. power.

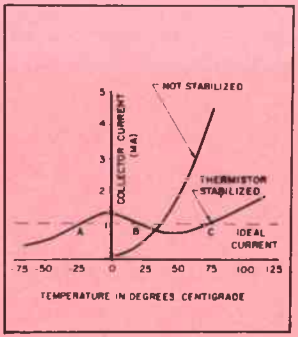


Fig. 8. Variation of collector current with temperature for non-stabilized and thermistor-stabilized transistor circuits.

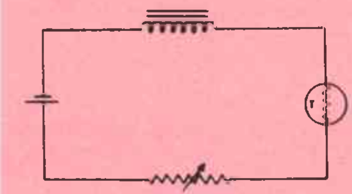


FIG. 9

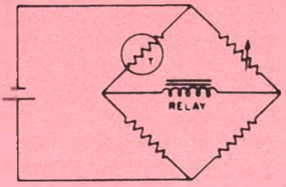


FIG. 10

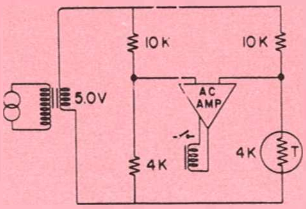


Fig. 11. Typical thermistor temperature control circuit.

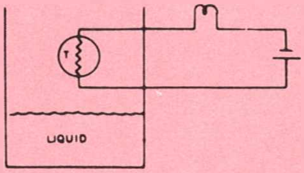


FIG. 12

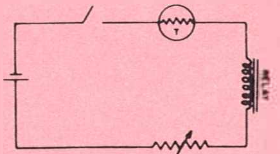


FIG. 13

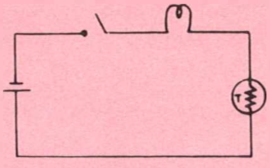


FIG. 14

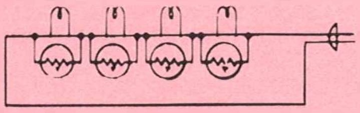


FIG. 15

HOW ARE THERMISTORS USED?
(continued)

VOLTAGE CONTROL: A thermistor with a suitable series resistor "A" may be placed in parallel (Fig. 17) with the load in a circuit to maintain constant voltage across the load. When the load resistance increases, the drop across resistor "B" tries to reduce and tends to raise the voltage across the load. The thermistor heats up and reduces its resistance so more current flows through the thermistor and through resistor "B" which brings the voltage across the load back to its original value. Such controls can maintain as close as 1% voltage regulation over a broad range of load resistance or over a broad range of supply voltages. Any voltage between ½ volt and 100 volts may be regulated in this way by suitable circuitry.

POWER LEVEL CONTROL: Automatic power level control can be obtained in amplifiers by many methods of applying thermistors to the circuit. The simplified schematic (Fig. 18) shows one such approach. A thermistor is placed in a negative feedback circuit so the thermistor is heated when the output level increases. The resistance therefore reduces the amplifier gain. Such controls have been used to control the output level of amplifiers to within ½ db. with as much as a 40 db. variation at the input.

THERMAL CONDUCTIVITY INSTRUMENTS: Fig. 19 depicts a bridge circuit with enough current flowing through the thermistors to heat them to about 150°C., they may be used in many instruments for measurement of various physical phenomena. If the two thermistors are placed in small cavities in a brass block so the gas in the cavities may be changed, the unit becomes a gas analyzer. If air is put in both cavities and the bridge is balanced by varying the setting of "A" then the air on one cavity is replaced by carbon dioxide, and the bridge will be unbalanced because the carbon dioxide has a lower thermal conductivity than air and that thermistor will become hotter and lower in resistance. The amount of unbalance will represent 100% CO2 in the analyzer. 50% CO2 will give just half the meter reading and the instrument may therefore be calibrated with a linear scale to read in % CO2 in air. Similar calibration may be made for any other mixture of two gases. Such an instrument has been made without using amplifiers to have a full scale reading of ½% CO2 in air.

If the same bridge is made with one thermistor sealed in a cavity in a brass block and the other mounted in a small pipe, it may be used as a flow meter. When no air is flowing through the pipe, the bridge may be balanced. When air flows through the pipe, the thermistor is cooled and its resistance increases which unbalances the bridge. The amount of cooling is proportional to the rate of flow of the air and the meter may be calibrated in terms of flow in the pipe. The same instrument may be used for measuring flow rate of any gas or liquid. Such instruments have been made to measure flow rates as low as .001 c.c. per minute. One instrument can measure flow rates over a range of 100,000 to 1 or more, merely by switching resistance in series with the output meter.

If this instrument is made with the sensing thermistor held in free air, it becomes an anemometer capable of measuring air velocity from the slightest breeze to a gale and can be calibrated in terms of miles per hour of wind velocity.

If one of the thermistors is mounted in a sealed, evacuated bulb, and the other is mounted in a chamber connected to a vacuum pump, it may be calibrated as a vacuum gauge in terms of mm of mercury. By pumping the chamber down to a high vacuum and balancing the bridge, output will be obtained when the chamber is not at high vacuum because the presence of air will cool the thermistor etc.

ALTIMETER: A very sensitive altimeter has been made by placing a thermistor at the surface of a liquid (Fig. 20) in an open container and applying heat to the liquid until it boils. The thermistor resistance may be measured by any convenient means and its resistance will be determined by the boiling point of the liquid which is determined by the pressure applied to the liquid which is a function of the altitude. Such a device is called a hypsometer and has been made capable of measuring altitude from sea level to over 125,000 feet with a precision of better than 1% of the measured pressure.

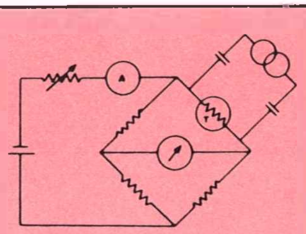


FIG. 16

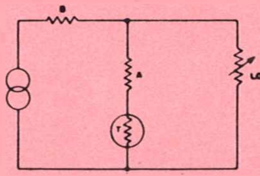


FIG. 17

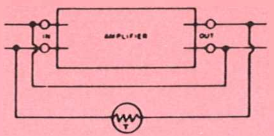


FIG. 18

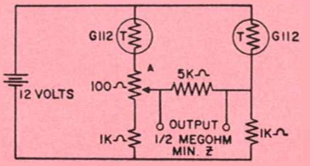


FIG. 19

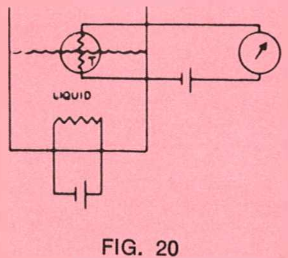


FIG. 20

SOLVING APPLICATIONS PROBLEMS WITH THERMISTORS

Much has been written concerning the general characteristics and applications of thermistors, but little on how-to-solve actual problems. Three application problems, each highlighting a different major characteristic are solved here.

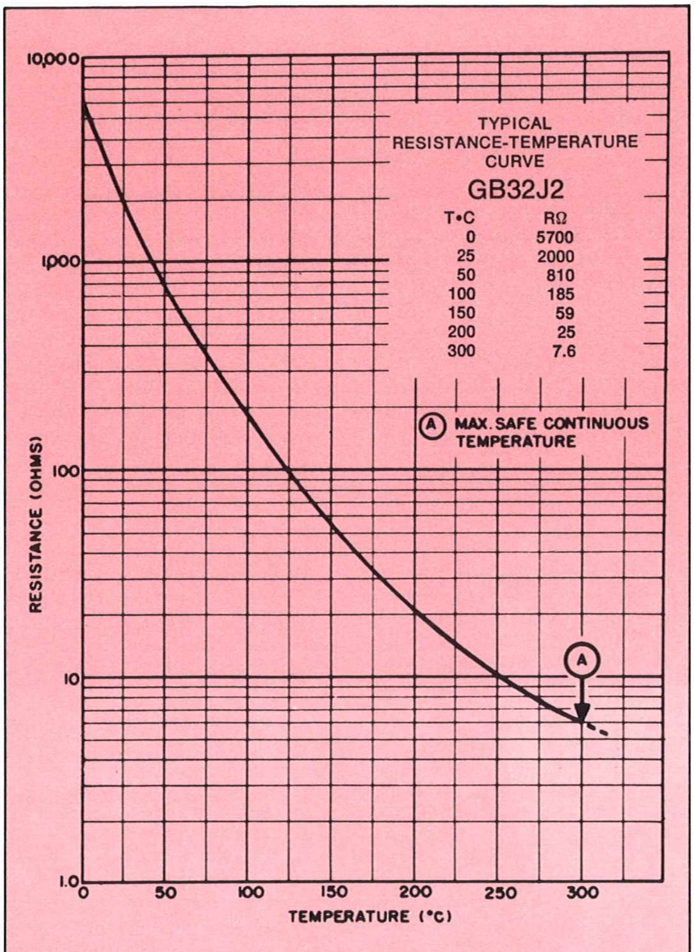


FIG. 1

BACKGROUND DATA

Although "thermistor" means "thermal resistor" and applies to devices with a positive or a negative temperature coefficient of resistance, the latter is the major thermistor industry today. We will limit our discussion to that field. The same techniques, slightly modified, may be used to solve problems involving thermistors with positive coefficients.

Thermistors really do only one thing: they change their electrical resistance with absolute temperature. The thermistors we are discussing here reduce resistance as temperature increases. The curve which represents this relationship is called the R-T (Resistance-Temperature) curve and is usually plotted in terms of the logarithm of resistance vs. temperature, Fig. 1.

Another common way of presenting this information is in tabular form where the ratio of the resistance at any temperature to the resistance at 25 deg. C. is tabulated against various temperatures (R-T Tables, page 28). This is the characteristic which is used in temperature measurement, temperature control, and temperature compensation. Most thermistors are rather small, ranging from tiny beads, a few thousandths of an inch in diameter, to discs about 1 inch in diameter and ¼ inch thick.

If an appropriate voltage is applied, a small current, not sufficient to heat the thermistor measurably above its surroundings, will flow. Under these circumstances, Ohm's law will be followed and the current will be proportional to the applied voltage.

SOLVING AN APPLICATIONS PROBLEM WITH THERMISTORS

However, if the voltage is gradually increased, the current will increase and the heat generated in the thermistor will finally begin to raise its temperature above that of its surroundings. The resistance will consequently be lowered and more current will flow than if the resistance had remained constant.

The curve which shows this characteristic is called the E-I (Voltage-Current) curve and is usually plotted in terms of the logarithm of the voltage vs. the logarithm of the current, Fig. 2. The advantage of this type of curve is that the thermistor power and resistance may also be read on the diagonal logarithmic scales. Fig. 2 shows that the voltage drop across a thermistor increases with the current until it reaches a peak value at "B" beyond which the voltage drop decreases as the current increases. In this portion of the curve, the thermistor is exhibiting a negative resistance characteristic.

POWER CONSIDERATIONS

Thus, under any fixed ambient conditions, the resistance of a thermistor is a function of the power being dissipated within itself, provided there is sufficient power to raise its temperature considerably above ambient. Under normal operating conditions, the temperature may rise to 200 deg. or 300 deg. C. and the resistance may be lowered to .001 of its value at low current. This characteristic is used in such devices as voltage regulators, microwave power meters, gas analyzers, and automatic volume and power level controls.

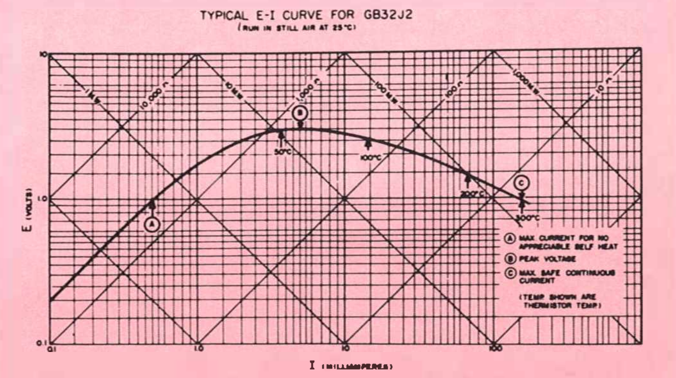


FIG. 2

If a voltage is applied to a thermistor and resistor in series a current will flow which is determined by the voltage and the total circuit resistance. If the voltage is high enough, some heat will be generated in the thermistor, lowering its resistance and permitting more current to flow. This, in turn, will heat the thermistor still more and lower its resistance further. The process will continue until the thermistor reaches the maximum temperature possible for the amount of power available in the circuit, at which time, a steady state will exist. The E-I curve described represents only these steady state conditions.

Fig. 3 shows the "Current-Time" or "dynamic" characteristic of a thermistor in a fixed circuit in which voltage is varied. Fig. 4 shows the same characteristic in which the voltage is fixed and the series resistance is varied. This is the function of thermistors normally used for time delay and surge suppression applications.

Specific Problems

Now that we have discussed the data normally published by manufacturers, let us solve a few specific problems. It would be very nice, if we could write a series of precise mathematical equations, with instructions to put in a few conditions, and solve for the answers. Unfortunately, this is not the case.

A thermistor appears to be a simple device, but the mathematical expression of all its electrical characteristics, in terms of its mechanical structure, is extremely complicated and involves a large number of independent parameters.

If you have tried to solve a thermistor problem by trial and error, do not be ashamed; it is still the easiest and quickest way to get an answer.

TEMPERATURE COMPENSATION PROBLEM

Let's design a temperature compensator for a copper relay coil, 5000 ohms at 25 deg. C., that pulls in at 1 ma. The relay should operate in a voltage regulation circuit where it must pull in at a constant voltage from 0 deg. to 60 deg. C. For a copper coil, $Rt=Ro\ (1+0.0039\ t)$. Rt at 25 deg. C. equals 5000 ohms so Ro at 0 deg. C.=4555 ohms. Every 10 deg. C., the resistance will increase about 178 ohms. The coil resistance vs. temperature is tabulated in Table 1 Column a.

Since the relay pulls in at 1 ma, it will require 4.56 v. at 0 deg. C. and 5.62 v. at 60 deg. C. to pull in. We know that the thermistor will have to be shunted and will be some resistance considerably lower than the coil resistance. Assume a value between 1000 and 4000 ohms. Assume also that we are short of space and would like to bury the thermistor right in the relay coil. A small glass coated bead or ¼ inch long glass probe would be convenient. Looking in a catalog, we find that such beads and probes are available in this resistance range and their R-T curve is the one shown in Fig. 1. Thermistor ratios have been added in Table 1, Column b, from R-T Curve 11 on Page 29.

If we subtract the last ratio from the 50 deg. ratio, we get .113 which is the amount of resistance change a 1 ohm thermistor would give between 50 °C. and 60. We need 178 ohms change so by dividing 178 by .11, we find we need a 1600 ohms thermistor at 25 °C. We make this calculation at the highest temperature end of the chart because the thermistor has the least sensitivity here. Also, we want to be sure to have enough thermistor to give the resistance change required. When the thermistor is shunted, at low temperature, the shunt will control the resistance; at high temperatures, the thermistor will control the resistance.

First Attempt

If we use a 1600 ohms thermistor, we can multiply the ratio at 50 deg. and 60 deg. C. by 1600 and find the thermistor resistance values will be 648 and 467 ohms respectively. The difference is very close to the 178 ohms required. The unshunted thermistor would compensate very nicely between 50 deg. and 60 deg. C. but of course, would way overcompensate at lower temperatures.

When we add the shunt, we will reduce the thermistor value about 50%. To make up for this loss, therefore, we want to try a thermistor of 1600X1.5 or 2400 ohms at 25 deg. C. Thermistor resistance values, Table 1, Column c, are obtained by multiplying 2400 by the thermistor ratios. By the time we shunt the thermistor at 60 deg. C., the compensation resistance will be in the order of 500 ohms which added to 5623 will give about 6100 ohms. This is about the value we should have at 0 deg. C. also. Therefore we must shunt the 6840 ohms thermistor to produce 6100-4555 or 1545 ohms. The shunt resistance will be

$$S = \frac{R_T\, R_{ST}}{R_T - R_{ST}} \text{ or } \frac{6840 \times 1545}{6840 - 1545}$$

which equals 2000 ohms, where Rt is the thermistor resistance, S is the shunt resistance, and the Rst the shunted thermistor resistance. We can now add two more columns to our chart, the compensator resistance, Table 1, Column d, which is the value of the thermistor shunted by 2000 ohms or $\frac{SRt}{S+Rt}$ and the total circuit resistance. Table 1, Column e, which is the copper coil resistance plus the compensation resistance.

Without compensation, the coil resistance is within ±10.5% of a nominal. On the first try, we have brought the variation down to 6112 ±30 or ±0.49%, Fig. 5.

Second Attempt

For a second try, we see that we need more negative resistance between 50 deg. and 60 deg. C. to reduce the positive slope in that range. Let's try about a 30% increase in thermistor resistance instead of a 2400 ohms unit, we will try a 3100 ohms unit. Column f is added to Table 1 by multiplying 3100 by the thermistor ratios. To get the best compensation, the peak point at 10 deg. C. must equal the peak point at 60 deg. C. If we use a 2000 ohms shunt with our 905 ohms thermistor at 60 deg. C., we get a total circuit resistance of 623 + 5623 or 6246 ohms. To get this same value at 10 deg. C. which is where our curve in Fig. 5 peaks, we must make the shunt and 5704 ohms thermistor equal 6246-4733 or 1513 ohms. Therefore, the shunt must be 2040 ohms. Columns g and h can now be added to Table 2. Plotting this curve in Fig. 5, we see the total circuit is 6231 ±19 ohms or ±0.31%. This is about the best compensation we can get without using a double or triple compensation network. This is more than 30 times as good as the uncompensated relay!

TABLE 1

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
			First Try: Rt = 2400 Ω at 25° C. Thermistor Resistance			Second Try: Rt = 3100 Ω at 25° C. Thermistor Resistance		
	Coil Resistance	Thermistor Ratio	Unshunted	w/2000 Ω shunt		Unshunted	w 2040 Ω shunt	
Temp.	R_c	p	R_t	R_{st}	$R_c + R_{st}$	R'_t	R'_{st}	$R_c + R'_{st}$
0° C.	4555 Ω	2.85	6840	1548	6103	8835	1657	6212 Ω
10	4733	1.84	4416	1377	6110	5704	1503	6236
20	4911	1.22	2930	1189	6100	3782	1325	6236
25	5000	1.00	2400	1090	6090	3100	1231	6231
30	5089	.827	1985	996	6085	2563	1136	6225
40	5267	.573	1375	815	6082	1776	949	6216
50	5445	.405	972	654	6089	1255	777	6222
60	5623	.292	700	518	6141	905	627	6250

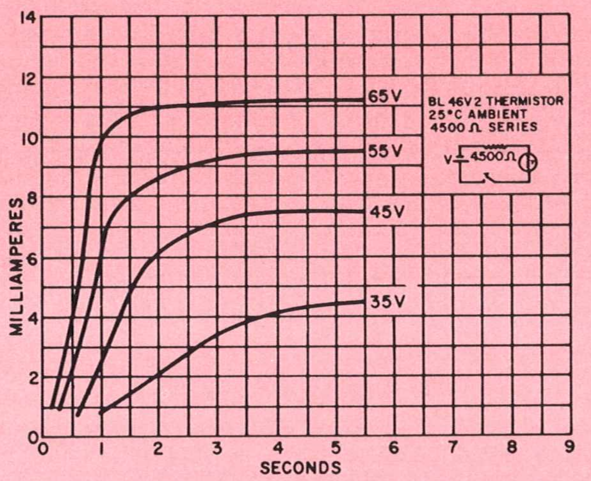


FIG. 3

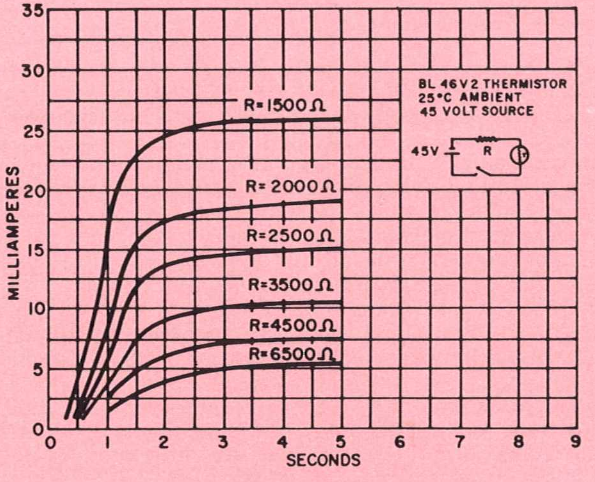


FIG. 4

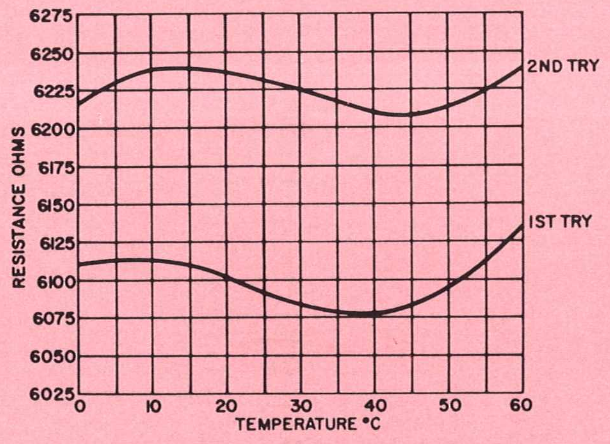


FIG. 5

Power in Thermistor

Maximum power exists when the thermistor and the shunt are of equal value, about 35 deg. C. A max. current of 0.5 ma flows which approximates 0.5 mw in 2040 ohms. A small glass probe embedded in the coil has a dissipation constant of about 1 mw/deg. C. So 0.5 mw raises the thermistor temperature about 0.5 deg. C. This lowers its resistance 1.7% or about 35 ohms. Instead of a 2040 ohms shunt and a 2040 ohms thermistor, we have a 2040 ohms shunt and a 2005 ohms thermistor because of self heat. This makes a compensator of 1012 ohms instead of 1020 ohms. This 8 ohms lower resistance decreases the overall error from ±0.31% to ±0.29%.

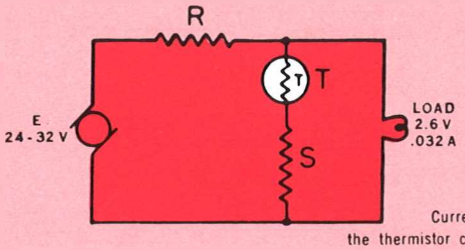
We now have the final answer. A bead type, glass probe thermistor, ¼ inch long with a standard B value of 3495, buried in the coil, and shunted by a 2040 ohms resistor will do an excellent job.

VOLTAGE REGULATION PROBLEM

For an automatic camera, a constant light source is needed as a reference for an automatic iris adjuster. The light is to be a 2.6 v., 32 ma bulb operating from a generator. The voltage varies from 24 to 32 v., depending upon load and speed of rotation.

In a voltage regulator circuit, Fig. 6, E is the supply voltage, R a series resistance for control, T the thermistor and S a series resistor with the thermistor. A thermistor voltage control works just like a gas tube control; current through the thermistor circuit varies widely but the voltage across it remains substantially constant. The voltage drop in R always balances out the variation in source voltage.

Looking at Fig. 2 we see a typical E-I curve of a thermistor. There is a short flat part to this curve at the peak, "B." This would give some voltage regulation but would not cover a very broad range of load or source variation. If we put a 10 Ω resistor in series with the thermistor and plot a new E-I curve including this resistor, we get curve D, Fig. 7. If we do the same with a 20 Ω resistor, we get curve E. A 30 Ω resistor gives curve F. In all 3 curves we find an extended flat section of the curve between X and X'.



Current through the thermistor circuit varies widely, but the voltage across it remains constant.

FIG. 6

TABLE 2

I_t	E_t	E_s	$E_t + E_s$
20 ma.	2.38 v.	.35 v.	2.73 v.
25	2.22	.44	2.66
30	2.09	.53	2.62
35	1.98	.62	2.60
40	1.88	.70	2.58
45	1.80	.79	2.59
50	1.72	.88	2.60
55	1.65	.97	2.62
60	1.58	1.06	2.64
65	1.53	1.15	2.68
70	1.48	1.23	2.71

SOLVING APPLICATIONS PROBLEMS WITH THERMISTORS

(continued)

Curve Selection

We want a curve which has a peak slightly above the 2.6 desired controlled voltage. The heavy curve Fig. 7, (similar to Fig. 2) should be about right. First make up a chart, Table 2, showing thermistor current in 5 ma steps from 20 ma to 70 ma. Then read the voltages across the thermistor from the curve.

At some nominal point like 50 ma what value of S do we need to make load voltage 2.6 v. ? Thermistor voltage is 1.72 so we need 2.60-1.72 or .88 v. across S. Therefore, S must be

$$\frac{0.88}{0.050} \text{ or } 17.6 \text{ ohms}$$

Multiplying 17.6 by various values of current, we can write down the voltage developed across S. Adding the thermistor and S voltage we get the total values.

The flattest part of the curve is between 30 and 55 ma. What value of R do we need to put 30 ma in the thermistor circuit when our source is minimum (24 v.)? The load current will be 32 ma, the thermistor current will be 30 ma so the total current through R will be 62 ma. The load voltage will be 2.6 v. so we must drop 21.4 v. in R.,

$$R = \frac{21.4}{0.062} = 345 \text{ ohms.}$$

What current will the thermistor take at maximum supply voltage? Load voltage of 2.6 means 29.4 v. must be dropped in R.

$$1 = \frac{29.4}{345} = 85 \text{ ma.}$$

Therefore the thermistor must take 85-32 or 53 ma.

Without voltage control, the load variation would be 28±4 or ±14.3%. With voltage control, the max. load voltage, between 30 and 55 ma, in the thermistor circuit is 2.62 and the min. is 2.58. This is a variation of 2.60 ±0.02 or ±.77% which is about 19 times as good. This could be improved by making a two stage regulator as shown in Figure 8. Here let T and S be the same values just worked out and recalculate R for a source voltage at point x of about ±.04 volts which can be obtained by calculating values of T', S', and R' as above. This will give an overall control of output to the load of about 2.600 ±.005 volts or ±2% which is 72 times as good as no control at all.

Thermistor Mounting

Since this E-I curve is data on a bead thermistor suspended in air, we would want to have it in a small air filled container like a glass bulb or a crystal can for easy mounting. Our thermistor is operating at about 50 ma and 1.7 v. or 34 ohms. The 25°C. resistance of this unit is 2100 ohms therefore the ratio of 34 to 2100 is 0.016. Looking this up on an R-T chart (Page 29, Curve 11) shows the operating temperature of the thermistor bead to be about 180°C. Because of this high operating temperature, small ambient variations will have little effect on our control. However, large ambient changes will affect the control so it would be a good idea to put the thermistor in a small crystal oven. The thermistor could be supplied in a crystal can for the purpose!

TIME DELAY PROBLEM

Problems of surge suppression and time delay are the most difficult to solve because there is very little published information available. Usually it boils down to trying a few thermistors until one is found that does the job. However, suppose we have data such as that shown in Figs. 3 and 4. Assume we have a relay that has 3000 ohms resistance and pulls in at 5 ma. We want to use it in a 60 v. circuit and want about 1 sec. delay. Can we do it with the thermistor described in Figs. 3 and 4?

Looking at Fig. 3, we see that a 60 v. source with 4500 ohms in circuit will reach 5 ma in 0.75 sec. so we must increase the time about 33% to get to 1 sec.

Obviously, we need more series resistance to increase the time delay.

We can assume that a 33% increase in time delay with 60 v. on the circuit will also give a 33% increase in time delay with 45 v. on the circuit. Therefore we look at Fig. 4 to determine what resistance change will give this much time change. With 45 v. on the circuit and 4500 ohms in series, we see that 5 ma will be reached in about 1.5 sec. A 33% time increase would bring this to 2.0 sec. Also in Fig. 4, we see that to reach 5 ma in 2.0 sec., we need a resistance about halfway between 4500 ohms and 6500 ohms or 5500 ohms.

Therefore 5500 ohms in series with the thermistor and 60 v. will take 1 sec. to reach 5 ma. Since the relay is 3000 ohms, we need 2500 ohms in series with the relay and the thermistor to give the desired time delay.

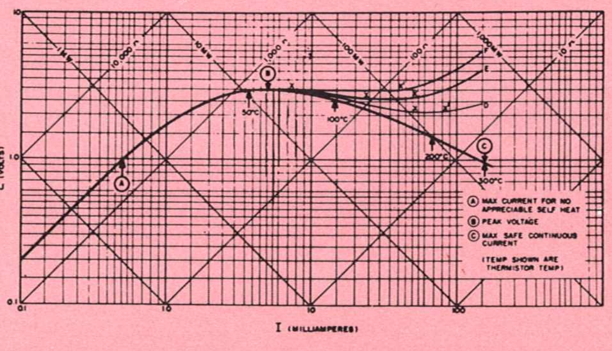


FIG. 7

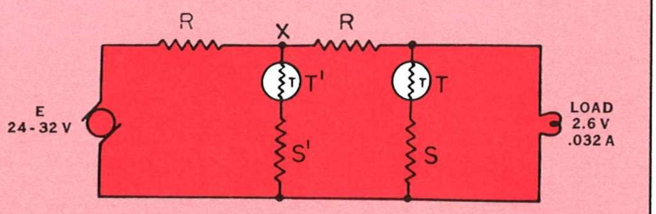


FIG. 8

LIQUID LEVEL CONTROL

PROBLEM: Using a thermistor as the sensor element, automatically maintain the liquid in a tank to a specified level, by control of the solenoid fill valve (S) when the liquid falls below the desired level. (Refer to Fig. 1.)

Known:

1. The ambient operating temperature of the liquid and air above the liquid is 25°C.
2. The solenoid pull in current is 10 ma. maximum and drop out current is 5 ma. minimum under worst conditions.
3. The voltage supply is 115 V.
4. Solenoid resistance (S_r) is 1000Ω.

Determine:

1. Thermistor configuration.
2. Thermistor Resistance at 25°C.
3. Series Resistance for Proper Solenoid Operation.
4. Circuit Sensitivity.

SOLUTION:

Step No. 1: Selecting the Thermistor

a. PHYSICAL CONFIGURATION — Generally, glass bead thermistors are used in gas or air applications. GLASS PROBES are best suited to liquid level control (immersion) applications, because of their extended glass body length, which prevents conductivity and circuit shorting with the media by the thermistor body leads. It is preferable to have the thermistor enclosed in a metal or plastic probe assembly housing for protection and convenience. (Refer to Thermistor Housing Manual L-5A and to the applicable sections of this handbook.)

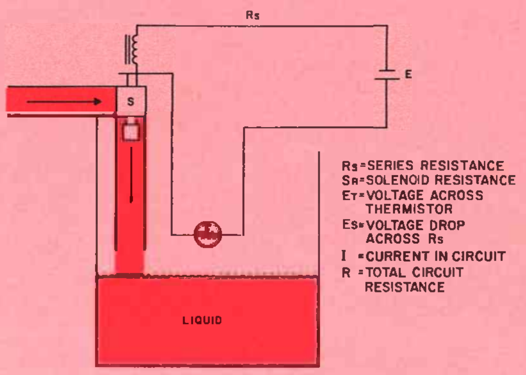
b. Select appropriate RESISTANCE VALUE and DISSIPATION CONSTANT compatible with the available voltage supply. To obtain maximum current sensitivity, the peak of the thermistor curve at 25°C should not be greater than 70% of the supply voltage. (Point "M" Fig. 2.)

The thermistor must be operated in the self-heat mode at as high a temperature as is compatible with the two mediums (air and liquid) to obtain the greatest sensitivity and still remain within the maximum temperature rating of the thermistor. The E-I CURVE which meets these fundamental requirements is the GA51P2 (Fig. 2). As may be seen, the peak value is about 28 volts and the mid-point of the negative resistance region (between the peak and the maximum operating temperature point) is approximately 10 ma., our chosen operating point in air.

Step No. 2: Selecting the Series Resistor

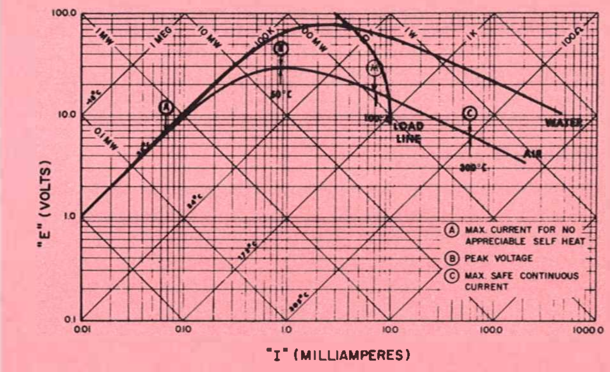
The series resistor serves a twofold purpose. It limits the self-heat factor in the thermistor in order to prevent thermal runaway and damage, and allows for the selection of the proper operating body temperature of the thermistor for the maximum sensitivity or change in current.

Inspecting the E-I CURVE for the GA51P2 thermistor, note that at 10 ma. the voltage drop across the thermistor is 15 v. Therefore, the difference of 100 v. must be dropped across the series resistor and the solenoid resistance combination $R_s + S_r$ is easily calculated through the use of Ohm's law.



LIQUID LEVEL CONTROL

FIG. 1



TYPICAL GA51P2 E-I CURVE

FIG. 2

WHERE:
R_s = Series Resistance
S_r = Solenoid Resistance
E_s = Voltage Drop Across R_s
I = Current in Circuit
R = Total Resistance of $R_s + S_r$

THEN: $$R = \frac{E_s}{I} = \frac{100}{.01} = 10000 \text{ ohms.}$$

AND: $$R_s = R - S_r \text{ or } 10000 - 1000 \text{ ohms.}$$
$$R_s = 9000 \text{ ohms.}$$

Step No. 3: Sensitivity Check

A sensitivity check of the circuit is necessary to assure that the desired or adequate decrease in current flow is attained when the thermistor is immersed in liquid for proper operation of the solenoid fill valve.

A method that can be used for determination of sensitivity utilizes two E-I CURVES, plotted on the same graph coordinates. One is the standard, using air as the medium at 25°C. The other curve is for the same thermistor in the other medium (water). A load line is then calculated and plotted through both curves to intersect the operating point on the E-I CURVE for the air medium and establishing the new operating point on the other curve. This second point indicates the new current and voltage operating points for the changed environment, indicating the measure of sensitivity, and satisfies the equation applicable to both curves. (Ref. Fig. 2.)

WHERE: $E_{in} = E_t + E_s$
AND: $E_t = E_{in} - E_s$
WHEN: $E_{in} = 115$ Volts
E_t = Voltage across the thermistor
E_s = Voltage across the series resistance

There are three separate and yet interrelated functions that must be performed whenever the two curve method is used to determine the sensitivity.

They are:

DETERMINATION OF THE NEW THERMISTOR D.C. IN THE NEW MEDIUM.

GENERATION OF A NEW E-I CURVE TO REFLECT THE D.C. CHANGE IN THE THERMISTOR FOR THE NEW MEDIUM.

COMPUTING AND PLOTTING A LOAD LINE TO LOCATE THE NEW OPERATING POINT IN THE NEW MEDIUM.

DETERMINING THE D.C.

Dissipation Constants in media other than air, may be determined by test. However, a good approximation of the dissipation constant for the thermistor in a changed medium can readily be made by referring to established standard thermal conductivity tables, and noting the increased or decreased ratio in relation to air. This same magnitude of change is then applied directly to the established D.C. for the thermistor in air.

As an example, a comparison of the thermal conductivity of air and water indicates that water has a conductivity approximately five times greater. If we apply this same magnitude of increase to the GA51P2 thermistor that has a D.C. of 1 milliwatt per degree Centigrade in air, then when immersed in water, its new D.C. will be 5 milliwatts per degree Centigrade.

GENERATING AN E-I CURVE FOR A DIFFERENT MEDIUM

After the new thermistor D.C. has been established, a new E-I CURVE for this new medium (liquid) can be calculated from the existing curve in a similar manner used for plotting a new E-I CURVE at temperatures other than 25° Centrigrade.

Observe the point of intersection of the constant resistance line at the 1 MW point on the power line applicable to the D.C. of the thermistor in air.

Locate and mark the 5 Mw point of intersection on the constant resistance line. Measure the distance between the 1 MW point and the 5 MW point on that resistance line. Proceed to plot the new E-I CURVE points for a thermistor in a liquid medium by keeping the measured distance constant and with one end of that distance, indexed on the existing curve. Keeping the measured distance parallel to the constant resistance lines, mark reference points arbitrarily, at close intervals, by following the contour of the existing curve.

LOAD LINE COMPUTATION AND PLOT

The equation used in locating a new operating point on the calculated E-I CURVE involves two variables: The current through the circuit and the voltage drop across the thermistor. Therefore, one variable must be eliminated. This is done by assuming fixed values of current through the circuit at three or four different current points equally spaced either in the current decade before or after the actual 10 milliampere current operating point of the thermistor in air.

NOTE: If the thermal conductivity of the new medium is greater than air, it effectively increases the D.C. of the thermistor and the current decade preceding the current operating point would be used. If the thermal conductivity is decreased, the current decade after the operating point should be used

In this sensitivity check, values in the current decade preceding the current operating point of 10 milliamperes in air will be used to calculate the voltage drop across the thermistor and plotted on the same coordinate as the two E-I CURVES to generate a load line that will locate the new operating point.

LET: E_t = Voltage drop across the thermistor
E_R = The total voltage drop across the series resistance combination $(R_s + S_r)$
E_{in} = Supply voltage
I = Current through circuit (amps)
R = Total resistance in series with thermistor $(R_s + S_r)$

THEN: $E_{in} = E_t + E_R$ - - - - (i)
AND: $E_R = I(R_s + S_r)$ - - - - (ii)

COMBINING EQUATION (i) AND (ii)
$E_{in} = E_t + I(R_s + S_r)$ - - - - (iii)
$\therefore\ E_t = E_{in} - I(R_s + S_r)$

IN THIS EXAMPLE
LET: $E_{in} = 115$ V
AND: $R = 10\text{K}\ \Omega$

SUBSTITUTING THESE VALUES IN EQUATION (iii)
$E_t = 115 - I(10^4)$

THUS IF:		THEN:	
	I = 8 ma		E_t = 35 Volts
	I = 6 ma		E_t = 55 Volts
	I = 4 ma		E_t = 75 Volts
	I = 2 ma		E_t = 95 Volts

Plotting these voltage points, we find that the load line intersects the E-I CURVE representing the water medium at the 5 milliampere current point, indicating that the current decreases in the circuit from 10 milliamperes when the thermistor is in air to 5 milliamperes when it is immersed in water, providing adequate circuit sensitivity. (Refer to Fig. 2.)

DESIGNING LINEAR TEMPERATURE READ OUT CIRCUITS

DESIGNING LINEAR TEMPERATURE READ OUT CIRCUITS

Selection of Thermistor (R_t)

Generally speaking, high resistance units (100k to 500k @ 77°F) are used for high temperatures (300°F to 600°F); intermediate resistance units (2k to 75k @ 77°F) at intermediate temperatures (150°F to 300°F); low resistance units (100 to 1k @ 77°F) at low temperatures (—100°F to 150°F).

The maximum Ro at low temperatures must not be excessive and must be compatible with the limits of the associated circuitry. If Ro is excessive, spurious signal pick-up can result. If high Ro is required and pick-up is a problem, shielded lines or the use of D.C. power must be considered.

The minimum resistance at high temperatures must not be too low. Generally, a resistance of a low order of magnitude at high temperatures will result in a decrease in sensitivity. Errors due to contact resistance, line resistance and line resistance variation with changes in ambient temperature may also result at high temperatures due to inadequate thermistor resistance.

Selection of Resistance Values for Associated Circuitry (R_1 R_2 R_3)

Thermistors used for temperature measurement are usually employed in one leg of a bridge circuit. If linearity in the bridge output voltage change over the temperature range is desired with a minimum decrease in thermistor sensitivity, the series resistor (R_2) and the opposite bridge leg resistor (R_3) should be equal to the thermistor resistance at the mid-point of the temperature range. The value of the adjacent bridge leg resistor (R_1) should be equal to the thermistor's resistance at the temperature where bridge null is desired.

Selection of Input Voltage (E)

The bridge voltage input must be compatible with the dissipation constant of the thermistor and the degree of accuracy or precision to which the temperature is to be measured. This will alleviate the necessity of providing a permanent offset in readout or control instrumentation to overcome the self-heating effects in the thermistor due to application of excessive power. Bridge voltage can be determined as follows:

$$E = \sqrt{PR}$$

Bridge Input Voltage $= E_m = 2 \times E$

Where: $E =$ Voltage across thermistor

$R =$ Resistance of thermistor at mid-point of temperature range

$P =$ D.C. of thermistor which will give desired accuracy (i.e. — if D.C. of thermistor is lmw/°C and 0.1°C off-set is allowable — use $P = .1mw$)

Selection of Meter Circuit ($R_m + R_s$)

If voltmeter is desired, the resistance of the voltmeter should be at least 10 times the resistance of the thermistor at the lowest temperature. The range of the meter should be selected so that it is compatible with the voltage output available with the circuit parameters selected.

If an ammeter readout is desired, the resistance of the meter circuit (Rm + Rs) should be approximately ten times the resistance of the thermistor at the maximum temperature. The selection of the meter circuit values with the proper current range (Im) can be determined by first solving for the maximum current flow through the thermistor that occurs at the highest temperature.

$$I_t = \sqrt{\frac{P_t}{R_t}}$$

Then: $$I_m = \frac{I_t R_2}{R_2 + R_m + R_s}$$

Where: $P_t =$ Allowable D.C. of the thermistor for desired accuracy

$R_t =$ Resistance of thermistor at maximum use temperature

$I_t =$ Maximum current through thermistor at maximum use temperature

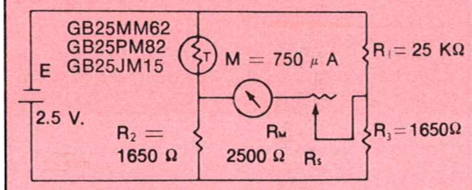
$I_m =$ Maximum current through meter circuit

$R_2 =$ Bridge resistor in series with thermistor

$R_m + R_s = 10\ (R_t)$

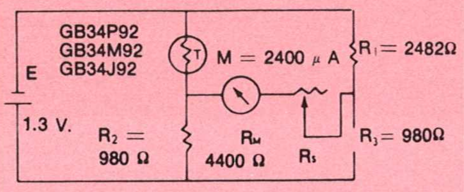
The range of the ammeter selected should have a full scale deflection at a value of current slightly less than the maximum current (I_m) calculated. The variable resistor (R_s) can then be adjusted by increasing its resistance to limit the current flow through the meter (R_m) not to exceed the full scale deflection value.

Typical Circuits



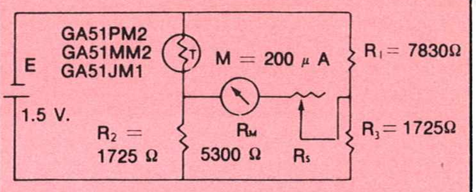
MINUS 100 TO PLUS 100°F ±1°F

Low Temperature Range



PLUS 100 TO PLUS 200°F ±1°F

Medium Temperature Range



PLUS 200 TO PLUS 400°F ±1°F

High Temperature Range

BEAD THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
STANDARD SMALL BEAD THERMISTORS (.013" TO .016") .014" NOMINAL															
1,000	20	GC31J1	Glass Coated Bead	1	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
1,000	20	GC31L7	Glass Coated Bead	2	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	20	GC32L8	Glass Coated Bead	2	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	25	GC32L1	Glass Coated Bead	2	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	25	GC32J1**	Glass Coated Bead	1	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	25	GC32J2	Glass Coated Bead	1	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,500	10	GC32L10	Glass Coated Bead	2	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,500	25	GC32L7	Glass Coated Bead	2	5.5	9	.1	1	.001	PT-IR	⅜	.014	—	—	—
8,000	20	GB38J1	Glass Coated Bead	1	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
8,000	20	GB38L1	Glass Coated Bead	2	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
10,000	20	GB41L2	Glass Coated Bead	2	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
30,000	1	GB43L2	Glass Coated Bead	2	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
30,000	5	GB43J3	Glass Coated Bead	1	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
30,000	25	GB43J1	Glass Coated Bead	1	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
30,000	25	GB43L1	Glass Coated Bead	2	7.04	11	.1	1	.001	PT-IR	⅜	.014	—	—	—
100,000	15	GA51L2	Glass Coated Bead	2	9.1	13	.1	1	.001	PT-IR	⅜	.014	—	—	—
LARGE BEAD THERMISTORS (.033" TO .048") .043" NOMINAL															
50	20	GD15L1	Glass Coated Bead	2	4.8	8	.4	4	.004	PT-IR	⅜	.043	—	—	—
70	1	GD17J1	Glass Coated Bead	1	4.8	8	.4	4	.004	PT-IR	⅜	.043	—	—	—
100	20	GD21J2	Glass Coated Bead	1	4.8	8	.4	4	.004	PT-IR	⅜	.043	—	—	—
200	20	GD22J1	Glass Coated Bead	1	4.8	8	.4	4	.004	PT-IR	⅜	.043	—	—	—
300	20	GD23J1	Glass Coated Bead	1	4.8	8	.4	4	.004	PT-IR	⅜	.043	—	—	—
1,000	20	GB31J1	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
1,000	20	GB31L1	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
1,500	5	GB31J3	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
2,000	10	GB32J54	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
2,000	5	GB32L2	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
2,000	20	GB32J2	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
2,000	20	GB32L1	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
3,000	20	GB33L3	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
4,000	20	GB34J14	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
5,000	1	GB35L2	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
5,000	20	GB35J1	Glass Coated Bead	1	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
5,000	20	GB35L1	Glass Coated Bead	2	7.04	11	.4	4	.004	PT-IR	⅜	.043	—	—	—
10,000	2	GB41J3	Glass Coated Bead	1	7.59	12	.4	4	.004	PT-IR	⅜	.043	—	—	—
10,000	20	GB41J1	Glass Coated Bead	1	7.59	12	.4	4	.004	PT-IR	⅜	.043	—	—	—
10,000	20	GB41L1	Glass Coated Bead	2	7.59	12	.4	4	.004	PT-IR	⅜	.043	—	—	—
15,000	15	GB42J1	Glass Coated Bead	1	7.59	12	.4	4	.004	PT-IR	⅜	.043	—	—	—
15,000	15	GA42J1	Glass Coated Bead	1	9.1	13	.4	4	.004	PT-IR	⅜	.043	—	—	—
15,000	20	GA42J16	Glass Coated Bead	1	9.1	13	.4	4	.004	PT-IR	⅜	.043	—	—	—
15,000	20	GA42L1	Glass Coated Bead	2	9.1	13	.4	4	.004	PT-IR	⅜	.043	—	—	—
20,000	15	GA42J2	Glass Coated Bead	1	9.1	13	.4	4	.004	PT-IR	⅜	.043	—	—	—
20,000	10	GA42J12	Glass Coated Bead	1	9.1	13	.4	4	.004	PT-IR	⅜	.043	—	—	—
40,000	15	GA44L2	Glass Coated Bead	2	9.53	14	.4	4	.004	PT-IR	⅜	.043	—	—	—
50,000	20	GA45J1	Glass Coated Bead	1	9.53	14	.4	4	.004	PT-IR	⅜	.043	—	—	—
50,000	15	GA45J2	Glass Coated Bead	1	9.53	14	.4	4	.004	PT-IR	⅜	.043	—	—	—
50,000	15	GA45L2	Glass Coated Bead	2	9.53	14	.4	4	.004	PT-IR	⅜	.043	—	—	—
75,000	15	GA47J1	Glass Coated Bead	1	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
75,000	15	GA47L1	Glass Coated Bead	2	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	1	GA51L3	Glass Coated Bead	2	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	2	GA51L6	Glass Coated Bead	2	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	5	GA51L9	Glass Coated Bead	2	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	5	GA51J11	Glass Coated Bead	1	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	15	GA51J2	Glass Coated Bead	1	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	15	GA51J1	Glass Coated Bead	1	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	15	GA51L1	Glass Coated Bead	2	10.45	15	.4	4	.004	PT-IR	⅜	.043	—	—	—
150,000	20	GA52J16	Glass Coated Bead	1	10.9	3	.4	4	.004	PT-IR	⅜	.043	—	—	—
200,000	20	GA52L1	Glass Coated Bead	2	10.9	3	.4	4	.004	PT-IR	⅜	.043	—	—	—
300,000	20	GA53J2	Glass Coated Bead	1	11.8	4	.4	4	.004	PT-IR	⅜	.043	—	—	—
400,000	20	GA54J4	Glass Coated Bead	1	11.8	4	.4	4	.004	PT-IR	⅜	.043	—	—	—
500,000	20	GA55J1	Glass Coated Bead	1	11.8	4	.4	4	.004	PT-IR	⅜	.043	—	—	—

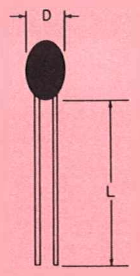


FIG. 1
ADJACENT LEADS

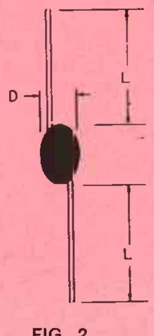


FIG. 2
AXIAL LEADS

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*E-I MATCHED FOR UHF POWER MEASUREMENT.
**STUB WIRE ENDS COATED.

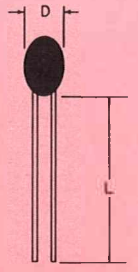


FIG. 1
ADJACENT LEADS

BEAD THERMISTORS

LARGE BEAD THERMISTORS (.033″ & Up) *Continued*

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
1 meg.	20	GA61J1	Glass Coated Bead	1	13.12	5	.4	4	.004	PT-IR	⅜	.043	—	—	—
1 meg.	20	GA61L1	Glass Coated Bead	2	13.12	5	.4	4	.004	PT-IR	⅜	.043	—	—	—
1.5 meg.	20	GA62J2	Glass Coated Bead	1	13.12	5	.4	4	.004	PT-IR	⅜	.043	—	—	—
2 meg.	20	GA62J1	Glass Coated Bead	1	13.12	5	.4	4	.004	PT-IR	⅜	.043	—	—	—
3 meg.	20	GA63J1	Glass Coated Bead	1	15.65	6	.4	4	.004	PT-IR	⅜	.043	—	—	—
5 meg.	20	GA65L1	Glass Coated Bead	2	15.65	6	.4	4	.004	PT-IR	⅜	.043	—	—	—
10 meg.	20	GA71L1	Glass Coated Bead	2	15.65	6	.4	4	.004	PT-IR	⅜	.043	—	—	—
15 meg.	20	GA72J1	Glass Coated Bead	1	23.71	7	.4	4	.004	PT-IR	⅜	.043	—	—	—
20 meg.	20	GA72J2	Glass Coated Bead	1	23.71	7	.4	4	.004	PT-IR	⅜	.043	—	—	—
30 meg.	20	GA73J1	Glass Coated Bead	1	23.7	7	.4	4	.004	PT-IR	⅜	.043	—	—	—

MATCHED PAIR BEAD THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
2,000	25	G170	2-GC32J1 Pair matched to 1% of each other at 25°C	1	5.5	—	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	25	G326	2-GC32L3 Pair matched to 2% of each other at 25°C	2	5.5	—	.1	1	.001	PT-IR	⅜	.014	—	—	—
2,000	20	G148	2-GB32J2 Pair matched to 1% of each other at 25°C	1	7.04	—	.4	4	.004	PT-IR	⅜	.043	—	—	—
2,000	20	G230	2-GB32J2 Pair matched to 5% of each other at 25°C	1	7.04	—	.4	4	.004	PT-IR	⅜	.043	—	—	—
8,000	20	G203	2-GB38L1 Pair matched to 5% of each other at 25°C	2	7.04	—	.1	1	.001	PT-IR	⅜	.014	—	—	—
50,000	15	G150	2-GA45J1 Pair matched to 1% of each other at 25°C	1	9.53	—	.4	4	.004	PT-IR	⅜	.043	—	—	—
100,000	15	G204	2-GA51L2 Pair mached to 5% of each other at 25°C	2	9.1	—	.1	1	.001	PT-IR	⅜	.014	—	—	—

GLASS PROBE THERMISTORS

MICRO-MINI PROBES (.020″ Dia.)

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
1,000	20	GD31MC1	Micro-Mini Probe	5	4.8	8	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
2,000	20	GC32MC1	Micro-Mini Probe	5	5.5	9	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
3,000	20	GC33MC1	Micro-Mini Probe	5	5.5	9	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
5,000	20	GC35MC1	Micro-Mini Probe	5	5.5	9	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
10,000	20	GB41MC1	Micro-Mini Probe	5	7.04	11	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
15,000	20	GB42MC1	Micro-Mini Probe	5	7.04	11	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
20,000	20	GB42MC11	Micro-Mini Probe	5	7.04	11	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
25,000	20	GB43MC1	Micro-Mini Probe	5	7.04	11	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
30,000	20	GB43MC11	Micro-Mini Probe	5	7.04	11	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
40,000	20	GB44MC1	Micro-Mini Probe	5	7.59	12	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
50,000	20	GB45MC1	Micro-Mini Probe	5	7.59	12	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
100,000	20	GA51MC1	Micro-Mini Probe	5	9.1	13	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
200,000	20	GA52MC1	Micro-Mini Probe	5	9.1	13	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
300,000	20	GA53MC1	Micro-Mini Probe	5	9.5	14	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
500,000	20	GA55MC1	Micro-Mini Probe	5	10.45	15	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
1 meg.	20	GA61MC1	Micro-Mini Probe	5	10.9	3	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—
5 meg.	20	GA65MC1	Micro-Mini Probe	5	11.78	4	0.15	1.6	.001	PT-IR	⅜	.020	¼	—	—

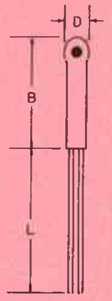


FIG. 5
GLASS PROBE

SUB-MINI PROBES (.030″ Dia.)

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
500	20	GD25SM2	Sub-Mini Probe	5	4.80	8	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
1,000	20	GD31SM2	Sub-Mini Probe	5	4.80	8	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
2,000	25	GC32SM2	Sub-Mini Probe	5	5.5	9	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
8,000	20	GB38SM2	Sub-Mini Probe	5	7.04	11	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
25,000	20	GB43SM2	Sub-Mini Probe	5	7.59	12	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
50,000	15	GA45SM2	Sub-Mini Probe	5	9.1	13	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
100,000	15	GA51SM2	Sub-Mini Probe	5	9.1	13	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
150,000	15	GA52SM2	Sub-Mini Probe	5	10.45	14	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—
300,000	15	GA53SM2	Sub-Mini Probe	5	9.5	14	0.3	2.6	.003	PT-IR	¼	.030	5/32	—	—

GLASS PROBE THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
MINI-PROBES (.060″ Dia.)															
100	20	GD21M2	Mini-Probe	5	4.8	8	0.7	10	.008	Dumet	1¼	.060	½	—	X
1,000	20	GB31M2	Mini-Probe	5	7.04	11	0.7	10	.008	Dumet	1¼	.060	½	—	X
2,000	20	GB32M2	Mini-Probe	5	7.04	11	0.7	10	.008	Dumet	1¼	.060	½	—	X
10,000	20	GB41M2	Mini-Probe	5	7.59	12	0.7	10	.008	Dumet	1¼	.060	½	—	X
50,000	20	GA45M2	Mini-Probe	5	9.53	14	0.7	10	.008	Dumet	1¼	.060	½	—	X
100,000	20	GA51M2	Mini-Probe	5	10.45	15	0.7	10	.008	Dumet	1¼	.060	½	—	X
FAST RESPONSE GLASS PROBES (.070″ Dia.)															
2,000	20	GC32P22	Glass Probe	7	5.50	9	.4	5	.012	Dumet	2	.070	½	—	X
8,000	20	GB38P11	Glass Probe	7	7.04	11	.4	5	.012	Dumet	2	.070	¼	—	X
8,000	20	GB38P12	Glass Probe	7	7.04	11	.4	5	.012	Dumet	2	.070	½	—	X
100,000	20	GA51P192	Glass Probe	7	9.1	13	.4	5	.012	Dumet	2	.070	½	—	X
1 meg.	20	GA61P22	Glass Probe	7	10.45	15	.4	5	.012	Dumet	2	.070	½	—	X
5 meg.	20	GA65P2	Glass Probe	7	13.12	5	.4	5	.012	Dumet	2	.070	½	—	X
STANDARD PROBES (.100″ Dia.)															
1,000	1	GB31P22	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
1,000	20	GB31P1	Glass Probe	5	7.04	11	1.0	14	.012	Dumet	2	.100	¼	—	X
1,000	20	GB31P2	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
1,000	20	GB31P8	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	2	—	X
2,000	2	GB32P62	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
2,000	5	GB32P22	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
2,000	10	GB32P108	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	2	—	X
2,000	15	GB32P72	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
2,000	20	GB32P1	Glass Probe	5	7.04	11	1.0	14	.012	Dumet	2	.100	¼	—	X
2,000	20	GB32P2	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
2,000	20	GB32P3	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	¾	—	X
2,000	20	GB32P4	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	1	—	X
2,000	20	GB32P5	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	1¼	—	X
2,000	20	GB32P6	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	1½	—	X
2,000	20	GB32P7	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	1¾	—	X
2,000	20	GB32P8	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	2	—	X
3,000	20	GB33P32	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
4,000	20	GB34P2	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
5,000	20	GB35P2	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	½	—	X
5,000	20	GB35P8	Glass Probe	5	7.04	11	1.7	22	.012	Dumet	2	.100	2	—	X
10,000	5	GB41P12	Glass Probe	5	7.59	12	1.7	22	.012	Dumet	2	.100	½	—	X
10,000	20	GB41P2	Glass Probe	5	7.59	12	1.7	22	.012	Dumet	2	.100	½	—	X
15,000	10	GA42P2	Glass Probe	5	9.1	13	1.7	22	.012	Dumet	2	.100	½	—	X
20,000	15	GA42P22	Glass Probe	5	9.1	13	1.7	22	.012	Dumet	2	.100	½	—	X
30,000	5	GA43P28	Glass Probe	5	9.1	13	1.7	22	.012	Dumet	2	.100	2	—	X
30,000	20	GA43P2	Glass Probe	5	9.1	13	1.7	22	.012	Dumet	2	.100	½	—	X
40,000	15	GA44P2	Glass Probe	5	9.53	14	1.7	22	.012	Dumet	2	.100	½	—	X
50,000	5	GA45P21	Glass Probe	5	9.53	14	1.0	14	.012	Dumet	2	.100	¼	—	X
50,000	15	GA45P1	Glass Probe	5	9.53	14	1.0	14	.012	Dumet	2	.100	¼	—	X
50,000	15	GA45P8	Glass Probe	5	9.53	14	1.7	22	.012	Dumet	2	.100	2	—	X
50,000	20	GA45P2	Glass Probe	5	9.53	14	1.7	22	.012	Dumet	2	.100	½	—	X
70,000	20	GA47P48	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	2	—	X
100,000	5	GA51P68	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	2	—	X
100,000	6	GA51P12	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	½	—	X
100,000	10	GA51P51	Glass Probe	5	10.45	15	1.0	22	.012	Dumet	2	.100	¼	—	X
100,000	15	GA51P1	Glass Probe	5	10.45	15	1.0	22	.012	Dumet	2	.100	¼	—	X
100,000	15	GA51P2	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	½	—	X
100,000	15	GA51P4	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	1	—	X
100,000	15	GA51P5	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	1¼	—	X
100,000	15	GA51P6	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	1½	—	X
100,000	15	GA51P7	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	1¾	—	X
100,000	15	GA51P8	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	2	—	X
200,000	20	GA52P2	Glass Probe	5	10.45	15	1.7	22	.012	Dumet	2	.100	½	—	X
350,000	15	GA54P2	Glass Probe	5	10.99	3	1.7	22	.012	Dumet	2	.100	½	—	X
400,000	20	GA54P52	Glass Probe	5	10.99	3	1.7	22	.012	Dumet	2	.100	½	—	X
500,000	20	GA55P2	Glass Probe	5	11.78	4	1.7	22	.012	Dumet	2	.100	½	—	X
1 meg.	20	GA61P2	Glass Probe	5	13.12	5	1.7	22	.012	Dumet	2	.100	½	—	X
1.5 meg.	20	GA62P2	Glass Probe	5	13.12	5	1.7	22	.012	Dumet	2	.100	½	—	X
2 meg.	20	GA62P22	Glass Probe	5	13.12	5	1.7	22	.012	Dumet	2	.100	½	—	X
10 meg.	20	GA71P2	Glass Probe	5	15.65	6	1.7	22	.012	Dumet	2	.100	½	—	X

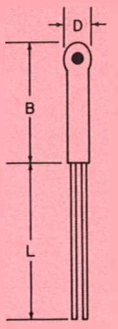


FIG. 5
STANDARD
GLASS PROBE

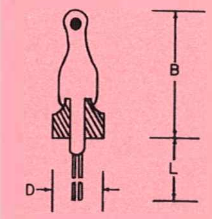


FIG. 6
NOTE: MAY BE
MOUNTED BY
SOLDERING TO
GIVE HIGH
PRESSURE SEAL

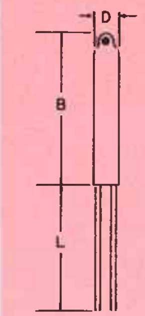


FIG. 7
FAST RESPONSE
PROBE

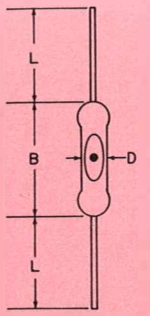


FIG. 8
BEAD IN GLASS
ENVELOPE

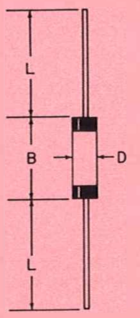


FIG. 9
EVACUATED OR GAS
FILLED UNIT

GLASS PROBE THERMISTORS

HIGH PRESSURE GLASS PROBE — GLASS TO METAL SEAL (.155″ Max. Dia.)

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
100	20	GD21P2-S	High Pressure Glass Probe	6	4.8	8	1.7	22	.012	Dumet	2	.155	0.50	—	X
1,000	20	GB31P2-S	High Pressure Glass Probe	6	7.04	11	1.7	22	.012	Dumet	2	.155	0.50	—	X
2,000	20	GB32P2-S	High Pressure Glass Probe	6	7.04	11	1.7	22	.012	Dumet	2	.155	0.50	—	X
10,000	20	GB41P2-S	High Pressure Glass Probe	6	7.59	12	1.7	22	.012	Dumet	2	.155	0.50	—	X
50,000	20	GA45P2-S	High Pressure Glass Probe	6	9.53	14	1.7	22	.012	Dumet	2	.155	0.50	—	X
100,000	15	GA51P2-S	High Pressure Glass Probe	6	10.45	15	1.7	22	.012	Dumet	2	.155	0.50	—	X

MATCHED PAIR PROBES

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
2,000	20	G106	2-GB32P8 Pair matched to 10% of each other at 25°C	5	7.04	11	1.7	22	.012	Dumet	2	—	2	—	X
10,000	20	G207	2-GB41P2 Pair matched to 5% of each other at 25°C	5	7.59	12	1.7	22	.012	Dumet	2	—	½	—	X
100,000	15	G107	2-GA51P8 Pair matched to 10% of each other at 25°C	5	10.45	15	1.7	22	.012	Dumet	2	—	2	—	X
100,000	15	G156	2-GA51P2 Pair matched to 2% of each other at 25°C	5	10.45	15	1.7	22	.012	Dumet	2	—	½	—	X

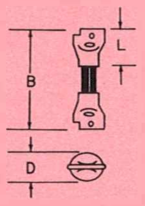


FIG. 10
EVACUATED OR GAS
FILLED UNIT

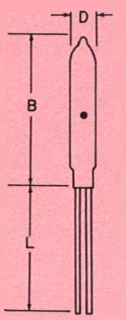


FIG. 11
EVACUATED OR GAS
FILLED BULB

BEAD THERMISTOR ASSEMBLIES

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
100	20	GD21R1	Ruggedized	8	4.8	8	1	6	.012	Dumet	2	.100	7/16	—	X
1,000	20	GB31R1	Ruggedized	8	7.04	11	1	6	.012	Dumet	2	.100	7/16	—	X
2,000	10	GB32R1	Ruggedized	8	7.04	11	1	6	.012	Dumet	2	.100	7/16	—	X
10,000	20	GB41R1	Ruggedized	8	7.53	12	1	6	.012	Dumet	2	.100	7/16	—	X
50,000	20	GA45R1	Ruggedized	8	9.53	14	1	6	.012	Dumet	2	.100	7/16	—	X
100,000	20	GA51R1	Ruggedized	8	10.45	15	1	6	.012	Dumet	2	.100	7/16	—	X
8,000	20	GB38A2	GB38J1 in glass envelope	8	7.04	11	N/A	N/A	.016	Dumet	1 ¾	.156	¾	—	X
8,000	20	GB38T1	GB38L1 on glass hermetic seal	12	7.04	11	0.1	1	.030	Ni-Fe	1 ¼	.380	½	—	X
30,000	25	GB43V1	GB43L1 in evacuated glass bulb	11	7.04	11	N/A	N/A	.016	Dumet	1 ¼	.135	¾	—	X
100,000	20	BA51V4	Large Bead in small evacuated bulb	11	10.45	15	N/A	N/A	.016	Dumet	1 ¼	.135	¼	—	X
2,000	25	GC32A1	GC32L1 in UHF glass envelope. Voltage is .825 to 1.175 at 25 milli-ampere.	8	5.5	9	N/A	N/A	.031	Nickel	1 ¾	.156	7/16	—	X
50,000	40	BA45N3	Standard large bead in N2 filled glass bulb in nylon cartridge voltage control.	9	9.53	14	N/A	N/A	.016	Dumet	1 ½	.250	1 ¼	—	X
50,000	40	BA45N1	Bare bead in N2 filled glass bulb in fibre cartridge. Time delay .13 to .23 sec. 140 Ω series R 62.5V source. To pass .0143 amp.	10	9.53	14	N/A	N/A	.016	N1-Ag	7/16	.250	1 5/16	—	X
50,000	40	BA45N2	(same as above)	9	9.53	14	N/A	N/A	016	Dumet	1 ½	.250	1 ¼	—	X
60,000	25	BL46V1	Standard large bead in evacuated glass bulb in fibre cartridge Time delay .5 to 1.2 sec 4400 Ω source. To pass .005 amps.	10	4.7	—	N/A	N/A	016	N1-Ag	7/16	.250	1 5/16	—	X
60,000	25	BL46V2	(same as above)	9	4.7	—	N/A	N/A	.016	Dumet	1 ½	.250	1 ¼	—	X
100,000	50	BA51V1	Lo vacuum std. bead in evacuated glass bulb in fibre cartridge. Time delay: after 0.5 to 1.01 sec. with 3200 Ω resistor in series with 70V will pass .0083A.	10	10.45	15	N/A	N/A	.016	N1-Ag	7/16	.250	1 5/16	—	X

BEAD THERMISTOR ASSEMBLIES

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
40,000	20	BA44V1	High vac., small bead evacuated glass bulb.	11	9.1	13	N/A	N/A	.016	Dumet	1¼	.260	1⅝	—	X
50,000	20	BA45V1	(same as above)	11	9.1	13	N/A	N/A	.016	Dumet	1¼	.260	1⅝	—	X
100,000	20	BA51V2	High vac, large bead evacuated glass bulb	11	10.45	15	N/A	N/A	.016	Dumet	1¼	.260	1⅝	—	X
100,000	20	BA51V3R	Ruggedized	11A	10.45	15	N/A	N/A	.016	Dumet	1¼	.260	1⅝	—	X
100,000	20	GA51T2	GA51L2 on glass hermetic seal	12	9.1	13	0.1	1	.030	Ni-Fe	1¼	.380	½	—	X
5.4 meg.	30	BK65V1	BK65L1	11	10	—	N/A	N/A	.016	Dumet	1⅝	.260	1⅝	—	X
2,000	20	GB32T1	GB32L1 mounted on glass hermetic seal.	12	7.04	11	N/A	N/A	.030	Ni-Fe	1¼	.380	½	—	X
MATCHED PAIR BEADS															
2,000	25	G126	2-GC32L3 mtd. on 2 glass hermetic seals and matched in air to within 15 millivolts of each other at 5.10 and 15 milliamperes. Matched to 5% Ro at 25°C	12	5.50	9	0.1	1	.030	Ni-Fe	1¼	.380	½	—	X
8,000	20	G112	2-GB38TI Thermistors matched in helium to within 30. 25. 20. 20 millivolts of each other at 2. 5. 10 & 15 milliamperes. Matched to 2% Ro at 25°C.	12	7.04	11	0.1	1	.030	Ni-Fe	1¼	.380	½	—	X
100,000	15	G128	2-GA5IT2 Thermistors matched in helium to within 100 millivolts of each other at .8, 1.5, 2.5 and 4 milliamperes. Matched to 5% Ro at 25°C.	12	9.1	13	0.1	1	.030	Ni-Fe	1¼	.380	½	—	X
INDIRECTLY HEATED THERMISTORS															
2,000	5	G332	Bead & Htr. sealed in glass rod. Htr. 325 Ω ± 20%. Low. temp.	13	7.04	11	N/A	N/A	Bead .016 Htr. .012	Dumet	1	.156	⅜	—	X
2,000	20	G110	Bead & Htr. sealed in glass rod. Htr. 650 Ω ± 10% voltage regulator bead less than 25 Ω with 28v applied to Htr.	13	7.04	11	N/A	N/A	Bead .016 Htr. .012	Dumet	1	.188	1	—	X
60,000	25	K365	Bead & Htr. sealed in glass rod. Htr. 20 Ω ± 25%.	13A	9.1	13	N/A	N/A	.016	Dumet	1½	.400	2	—	X

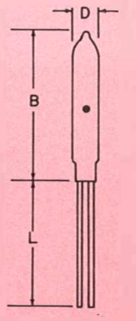


FIG. 11
EVACUATED OR GAS FILLED BULB

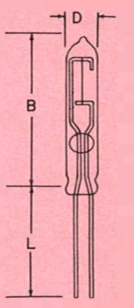


FIG. 11A
RUGGED BEAD THERMISTOR ASSEMBLY

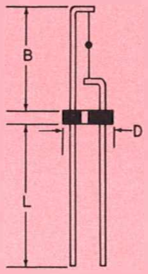


FIG. 12
MOUNTED BEAD

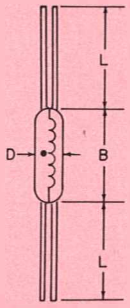


FIG. 13
INDIRECTLY-HEATED

MINI-WAFER THERMISTORS

Ro @ 25°C Ohms	% Tol.	Uncoated Code Number Fig. 15A	Epoxy Coated Code Number Fig. 15B	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l **	L	Uncoated Fig. 15A			Epoxy Coated Fig. 15B			Tinned
											D	B	T	D	B	T	
100	10	FD21J1-W	FD21J1-WC	5.8	17	1.0	10	.008	Copper	1½	060	.060	024	.095	—	—	X
300	10	FD23J1-W	FD23J1-WC	5.8	17	1.0	10	.008	Copper	1½	050	.050	036	.095	—	—	X
500	10	FB25J1-W	FB25J1-WC	6.35	10A	1.0	10	.008	Copper	1½	055	.055	030	.095	—	—	X
1,000	10	FB31J1-W	FB31J1-WC	6.35	10A	1.0	10	.008	Copper	1½	045	.045	030	.095	—	—	X
2,000	10	FA32J1-W	FA32J1-WC	9.1	16	1.0	10	.008	Copper	1½	075	.075	012	.120	—	—	X
3,000	10	FA33J1-W	FA33J1-WC	9.1	16	1.0	10	.008	Copper	1½	070	.070	014	.120	—	—	X
5,000	10	FA35J1-W	FA35J1-WC	9.1	16	1.0	10	.008	Copper	1½	060	.060	016	.095	—	—	X
10,000	10	FA41J1-W	FA41J1-WC	9.1	16	1.0	10	.008	Copper	1½	060	.060	027	.095	—	—	X
20,000	10	FA42J1-W	FA42J1-WC	9.1	16	1.0	10	.008	Copper	1½	045	.045	030	.095	—	—	X
30,000	10	FR43J1-W	FR43J1-WC	8.65	18	1.0	10	.008	Copper	1½	050	.050	026	.095	—	—	X
50,000	10	FT45J1-W	FT45J1-WC	10.45	1	1.0	10	.008	Copper	1½	065	.065	030	.095	—	—	X
100,000	10	FT51J1-W	FT51J1-WC	10.45	1	1.0	10	.008	Copper	1½	045	.045	034	.095	—	—	X
200,000	10	FT52J1-W	FT52J1-WC	10.45	1	1.0	10	.008	Copper	1½	045	.045	037	.095	—	—	X

*Time Constant (T.C.) and Dissipation Constant (D.C.) is totally dependent upon the desired method of mounting.

Note 1: Discs can be made to any resistance value from 1 Ω to 1 meg. ohm, dependent upon size.

Note 2: All disc types are rated to 150°C maximum temperature, except lacquer or varnish coated discs which are limited to 100°C.

All Fenwall Electronic glass-covered beads and probes may be used satisfactorily up to 550°C. However, for maximum stability, operating temperatures of 300°C should not be exceeded. All dimensions are in inches.

**Copper Alloy

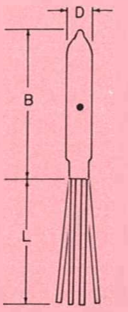


FIG. 13A
INDIRECTLY-HEATED

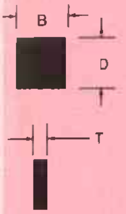


FIG. 14A
UNCOATED
INI-WAFER

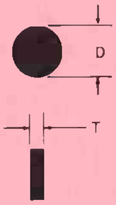


FIG. 14
PLAIN DISC

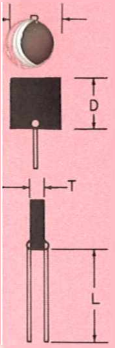


FIG. 15A
ADJACENT
LEADS

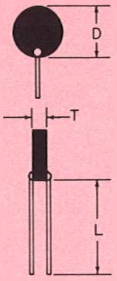


FIG. 15
ADJACENT
LEADS

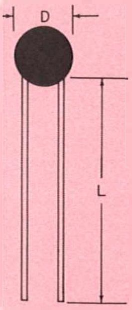


FIG. 15B
POXY COATED
MINI-WAFER

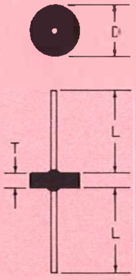


FIG. 16
AXIAL LEADS

DISC THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
.1″ Diameter															
400	10	JB24J1	Disc	16	6.95	10	4	15	.013	Copper	1½	.1	—	.028	X
500	10	JB25J1	Disc	15	6.95	10	3	10	.013	Copper	1½	.1	—	.035	X
500	10	JB25L1	Disc	16	6.95	10	3	10	.013	Copper	1½	.1	—	.035	X
500	10	JB25W1	Disc	14	6.95	10	*	*				.1	—	.035	
1,000	2	JB31J5	Disc	15	6.95	10	4	10	.013	Copper	1½	.1	—	.069	X
1,000	10	JB31J1	Disc	15	6.95	10	4	10	.013	Copper	1½	.1	—	.069	X
1,000	10	JB31W1	Disc	14	6.95	10	*	*				.1	—	.069	
3,000	10	JA33J1	Disc	15	9.1	16	3	10	.013	Copper	1½	.1	—	.029	X
3,000	10	JA33L1	Disc	16	9.1	16	3	10	.013	Copper	1½	.1	—	.029	X
3,000	10	JA33W1	Disc	14	9.1	16	*	*				.1	—	.029	
4,000	10	JA34L1	Disc	16	9.1	16	3	10	.013	Copper	1½	.1		.038	X
4,000	10	JA34W1	Disc	14	9.1	16	*	*				.1	—	.038	
5,000	10	JA35J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.048	X
5,000	10	JA35L1	Disc	16	9.1	16	4	10	.013	Copper	1½	.1	—	.048	X
5,000	10	JA35W1	Disc	14	9.1	16	*	*				.1	—	.048	
6,000	10	JA36J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.058	X
6,000	10	JA36L1	Disc	16	9.1	16	4	10	.013	Copper	1½	.1	—	.058	X
6,000	10	JA36W1	Disc	14	9.1	16	*	*				.1	—	.058	
7,000	10	JA37J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.067	X
8,000	10	JA38J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.076	X
8,000	10	JA38L1	Disc	16	9.1	16	4	10	.013	Copper	1½	.1	—	.076	X
8,000	10	JA38W1	Disc	14	9.1	16	*	*				.1	—	.076	
9,000	10	JA39J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.086	X
10,000	10	JA41J1	Disc	15	9.1	16	4	10	.013	Copper	1½	.1	—	.095	X
10,000	10	JA41L2	Disc	16	9.1	16	4	10	.013	Copper	1½	.1	—	.095	X
10,000	10	JA41W1	Disc	14	9.1	16	*	*				.1	—	.095	
20,000	10	JT42J5	Disc	15	10.45	1	3	10	.013	Copper	1½	.1	—	.019	X
30,000	10	JT43J2	Disc	15	10.45	1	3	10	.013	Copper	1½	.1	—	.030	X
50,000	10	JT45J5	Disc	15	10.45	1	3	10	.013	Copper	1½	.1	—	.047	X
100,000	10	JT51J5	Disc	15	10.45	1	4	15	.013	Copper	1½	.1	—	.095	X
100,000	10	JT51L1	Disc	16	10.45	1	4	15	.013	Copper	1½	.1	—	.095	X
.2″ Diameter															
10	10	KD11J1	Disc	15	4.80	8	4	20	.020	Copper	1½	.2	—	.053	X
20	10	KD12J1	Disc	15	4.80	8	4	20	.020	Copper	1½	.2	—	.107	X
30	10	KD13J3	Disc	15	4.80	8	4	20	.020	Copper	1½	.2	—	.160	X
40	10	KD14J1	Disc	15	4.80	8	6	50	.020	Copper	1½	.2	—	.213	X
40	10	KD14L1	Disc	16	4.80	8	6	50	.020	Copper	1½	.2	—	.213	X
100	10	KB21J1	Disc	15	6.95	10	4	16	.020	Copper	1½	.2	—	.028	X
100	10	KB21W1	Disc	14	6.95	10	*	*				.2	—	.028	
200	10	KB22J1	Disc	15	6.95	10	5	18	.020	Copper	1½	.2	—	.055	X
200	10	KB22L4	Disc	16	6.95	10	5	18	.020	Copper	1½	.2	—	.055	X
200	10	KB22W1	Disc	14	6.95	10	*	*				.2	—	.055	
300	10	KB23J1	Disc	15	6.95	10	6	20	.020	Copper	1½	.2	—	.083	X
300	10	KB23L3	Disc	16	6.95	10	6	20	.020	Copper	1½	.2	—	.083	X
300	10	KB23W2	Disc	14	6.95	10	*	*				.2	—	.083	
400	10	KB24J1	Disc	15	6.95	10	6	25	.020	Copper	1½	.2	—	.110	X
400	10	KB24L1	Disc	16	6.95	10	6	25	.020	Copper	1½	.2	—	.110	X
400	10	KB24W1	Disc	14	6.95	10	*	*				.2	—	.110	
500	10	KB25J1	Disc	15	6.95	10	6	25	.020	Copper	1½	.2	—	.138	X
500	10	KB25W1	Disc	14	6.95	10	*	*				.2	—	.138	
1,000	1	KA31L4	Disc	16	9.1	16	6	20	.020	Copper	1½	.2	—	.038	X
1,000	10	KA31J1	Disc	15	9.1	16	6	20	.020	Copper	1½	.2	—	.038	X
1,000	10	KA31L1	Disc	16	9.1	16	6	20	.020	Copper	1½	.2	—	.038	X
1,000	10	KA31W1	Disc	14	9.1	16	*	*				.2	—	.038	

*Time Constant (T.C.) and Dissipation Constant (D.C.) is totally dependent upon the desired method of mounting.

Note 1: Discs can be made to any resistance value from 1 Ω to 1 meg. ohm, dependent upon size.

Note 2: All disc types are rated to 150°C maximum temperature, except lacquer or varnish coated discs which are limited to 100°C.

Note 3: Discs can be supplied with epoxy coating upon request.

All Fenwall Electronics glass-covered beads and probes may be used satisfactorily up to 550°C. However, for maximum stability, operating temperatures of 300°C should not be exceeded. All dimensions are in inches.

DISC THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
.2″ Diameter															
2,000	10	KA32J2	Disc	16	9.1	16	6	22	.020	Copper	1½	.2	—	.076	X
2,000	10	KA32L3	Disc	16	9.1	16	6	22	.020	Copper	1½	.2	—	.076	X
2,000	10	KA32W1	Disc	14	9.1	16	*	*				.2	—	.076	
2,000	20	KA32L1	Disc	16	9.1	16	6	22	.020	Copper	1½	.2	—	.076	X
3,000	10	KA33J1	Disc	15	9.1	16	6	22	.020	Copper	1½	.2	—	.114	X
3,000	10	KA33L1	Disc	16	9.1	16	6	22	.020	Copper	1½	.2	—	.114	X
3,000	10	KA33W1	Disc	14	9.1	16	*	*				.2	—	.114	
4,000	10	KA34J1	Disc	15	9.1	16	6	22	.020	Copper	1½	.2	—	.152	X
4,000	10	KA34L1	Disc	16	9.1	16	6	22	.020	Copper	1½	.2	—	.152	X
4,000	10	KA34W1	Disc	14	9.1	16	*	*				.2	—	.152	
5,000	5	KA35J1	Disc	15	9.1	16	7	35	.020	Copper	1½	.2	—	.190	X
5,000	10	KA35J3	Disc	15	9.1	16	7	35	.020	Copper	1½	.2	—	.190	X
5,000	10	KA35L1	Disc	16	9.1	16	7	35	.020	Copper	1½	.2	—	.190	X
5,000	10	KA35L2	Disc	16	9.1	16	7	35	.020	Copper	1½	.2	—	.190	X
5,000	10	KA35W1	Disc	14	9.1	16	*	*				.2	—	.190	
10,000	10	KT41J3	Disc	15	10.45	1	4	20	.020	Copper	1½	.2	—	.038	X
10,000	10	KT41L1	Disc	16	10.45	1	4	20	.020	Copper	1½	.2	—	.038	X
20,000	10	KT42J5	Disc	15	10.45	1	4	20	.020	Copper	1½	.2	—	.077	X
30,000	10	KT43J2	Disc	15	10.45	1	4	20	.020	Copper	1½	.2	—	.114	X
50,000	10	KT45J3	Disc	15	10.45	1	6	50	.020	Copper	1½	.2	—	.191	X
50,000	10	KT45L1	Disc	16	10.45	1	6	50	.020	Copper	1½	.2	—	.191	X
.3″ Diameter															
100	10	CB21J1	Disc	15	6.95	10	8	42	.020	Copper	1½	.3	—	.062	X
100	10	CB21L1	Disc	16	6.95	10	8	42	.020	Copper	1½	.3	—	.062	X
300	10	CB23J1	Disc	15	6.95	10	9	70	.020	Copper	1½	.3	—	.186	X
300	10	CB23L1	Disc	16	6.95	10	9	70	.020	Copper	1½	.3	—	.186	X
300	10	CB23W1	Disc	14	6.95	10	*	*				.3	—	.186	
500	10	CA25J1	Disc	15	9.1	16	8	37	.020	Copper	1½	.3	—	.043	X
500	10	CA25L1	Disc	16	9.1	16	8	37	.020	Copper	1½	.3	—	.043	X
500	10	CA25W1	Disc	14	9.1	16	*	*				.3	—	.043	
1,000	10	CA31J1	Disc	15	9.1	16	8	48	.020	Copper	1½	.3	—	.086	X
1,000	10	CA31L1	Disc	16	9.1	16	8	48	.020	Copper	1½	.3	—	.086	X
1,000	10	CA31W1	Disc	14	9.1	16	*	*				.3	—	.086	
2,000	10	CA32J1	Disc	15	9.1	16	9	70	.020	Copper	1½	.3	—	.171	X
2,000	10	CA32L1	Disc	16	9.1	16	9	70	.020	Copper	1½	.3	—	.171	X
2,000	10	CA32W1	Disc	14	9.1	16	*	*				.3	—	.171	
.4″ Diameter															
10	10	LD11J1	Disc	15	4.80	8	8	40	.025	Copper	2	.4	—	.213	X
10	10	LD11L1	Disc	16	4.80	8	8	40	.025	Copper	2	.4	—	.213	X
50	10	LB15J1-M	Disc	15	6.35	10A	7	40	.025	Copper	2	.4	—	.049	X
50	10	LB15W1-M	Disc	14	6.35	10A	*	*				.4	—	.049	
100	5	LB21J3-M	Disc	15	6.35	10A	8	65	.025	Copper	2	.4	—	.100	X
100	10	LB21J1-M	Disc	15	6.35	10A	8	65	.025	Copper	2	.4	—	.100	X
100	10	LB21W1-M	Disc	14	6.35	10A	*	*				.4	—	.100	
100	20	LB21L2-M	Disc	16	6.35	10A	8	65	.025	Copper	2	.4	—	.100	X
200	10	LB22J5-M	Disc	15	6.35	10A	11	110	.025	Copper	2	.4	—	.220	X
200	10	LB22L1-M	Disc	16	6.35	10A	11	110	.025	Copper	2	.4	—	.220	X
200	10	LB22W1-M	Disc	14	6.35	10A	*	*				.4	—	.220	
300	5	LA23J3	Disc	15	9.1	16	8	45	.025	Copper	2	.4	—	.046	X

*Time Constant (T.C.) and Dissipation Constant (D.C.) is totally dependent upon the desired method of mounting.

Note 1: Discs can be made to any resistance value from 1 Ω to 1 meg. ohm, dependent upon size.

Note 2: All disc types are rated to 150°C maximum temperature, except lacquer or varnish coated discs which are limited to 100°C.

Note 3: Discs can be supplied with epoxy coating upon request.

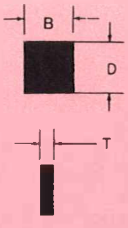


FIG. 14A
UNCOATED
MINI-WAFER

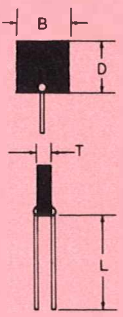


FIG. 15A
ADJACENT LEADS

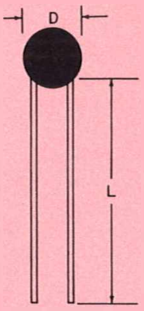


FIG. 15B
EPOXY COATED
MINI-WAFER

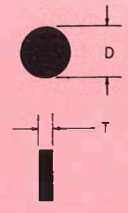


FIG. 14
PLAIN DISC

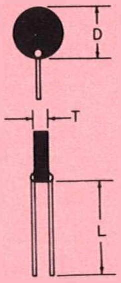


FIG. 15
ADJACENT LEADS

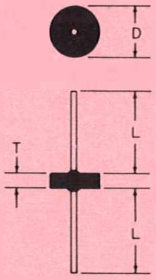


FIG. 16
AXIAL LEADS

DISC THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
.4″ Diameter															
300	10	LA23J15	Disc	15	9.1	16	8	45	.025	Copper	2	.4	—	.046	X
300	10	LA23L6	Disc	16	9.1	16	8	45	.025	Copper	2	.4	—	.046	X
500	10	LA25L2	Disc	16	9.1	16	8	60	.025	Copper	2	.4	—	.076	X
500	10	LA25W2	Disc	14	9.1	16	*	*				.4	—	.076	
700	5	LA27J1	Disc	15	9.1	16	9	65	.025	Copper	2	.4	—	.107	X
700	5	LA27L1	Disc	16	9.1	16	9	65	.025	Copper	2	.4	—	.107	X
700	5	LA27W1	Disc	14	9.1	16	*	*				.4	—	.107	
1,000	10	LA31J1	Disc	15	9.1	16	10	70	.025	Copper	2	.4	—	.152	X
1,000	10	LA31L1	Disc	16	9.1	16	10	70	.025	Copper	2	.4	—	.152	X
1,000	10	LA31W1	Disc	14	9.1	16	*	*				.4	—	.152	
2,000	10	LT32J1	Disc	15	10.45	1	8	40	.025	Copper	2	.4	—	.031	X
2,500	10	LT33J1	Disc	15	10.45	1	8	40	.025	Copper	2	.4	—	.038	X
15,000	10	LT42J1	Disc	15	10.45	1	10	150	.025	Copper	2	.4	—	.229	X
15,000	10	LT42L1	Disc	16	10.45	1	10	150	.025	Copper	2	.4	—	.229	X
.5″ Diameter															
50	10	DB15J1-M	Disc	15	6.35	10A	8	60	.025	Copper	2	.5	—	.078	X
100	10	DB21J1-M	Disc	15	6.35	10A	10	75	.025	Copper	2	.5	—	.168	X
500	10	DA25J3	Disc	15	9.1	16	8	60	.025	Copper	2	.5	—	.119	X
3,000	10	DT33J1	Disc	15	10.45	1	8	60	.025	Copper	2	.5	—	.071	X
5,000	10	DT35J1	Disc	15	10.45	1	8	60	.025	Copper	2	.5	—	.119	X
.6″ Diameter															
25	10	MB13J1-M	Disc	15	6.35	10A	25	85	.025	Copper	2	.6	—	.052	X
25	10	MB13L1-M	Disc	16	6.35	10A	25	85	.025	Copper	2	.6	—	.052	X
25	10	MB13W1-M	Disc	14	6.35	10A	*	*				.6	—	.052	
50	10	MB15J1-M	Disc	15	6.35	10A	35	100	.025	Copper	2	.6	—	.120	X
50	10	MB15L1-M	Disc	16	6.35	10A	35	100	.025	Copper	2	.6	—	.120	X
100	10	MA21J1	Disc	15	9.1	16	16	80	.025	Copper	2	.6	—	.034	X
100	10	MA21L1	Disc	16	9.1	16	16	80	.025	Copper	2	.6	—	.034	X
200	10	MA22L1	Disc	16	9.1	16	30	90	.025	Copper	2	.6	—	.069	X
300	10	MA23J1	Disc	15	9.1	16	50	115	.025	Copper	2	.6	—	.103	X
300	10	MA23L1	Disc	16	9.1	16	50	115	.025	Copper	2	.6	—	.103	X
.77″ Diameter															
25	10	NB13J1-M	Disc	15	6.35	10A	35	115	.032	Copper	2	.77	—	.096	X
50	10	NB15J1-M	Disc	15	6.35	10A	60	175	.032	Copper	2	.77	—	.196	X
100	10	NA21J1	Disc	15	9.1	16	20	100	.032	Copper	2	.77	—	.056	X
100	10	NA21W1	Disc	14	9.1	16	*	*				.77	—	.056	X
250	10	NA22J1	Disc	15	9.1	16	30	140	.032	Copper	2	.77	—	.141	X
250	10	NA22W1	Disc	14	9.1	16	*	*				.77	—	.141	
1,000	10	NT31J1	Disc	15	10.45	1	15	180	.032	Copper	2	.77	—	.057	X
1,000	10	NT31L1	Disc	16	10.45	1	15	180	.032	Copper	2	.77	—	.057	X
4,000	10	NT34J1	Disc	15	10.45	1	20	300	.032	Copper	2	.77	—	.227	X
4,000	10	NT34L1	Disc	16	10.45	1	20	300	.032	Copper	2	.77	—	.227	X
1.0″ Diameter															
10	10	ZB11J1-M	Disc	15	6.35	10A	30	140	.040	Copper	2	1.0	—	.065	X
100	10	ZA21J1	Disc	15	9.1	16	35	165	.040	Copper	2	1.0	—	.095	X
200	10	ZA22J1	Disc	15	9.1	16	40	230	.040	Copper	2	1.0	—	.190	X

*Time Constant (T.C.) and Dissipation Constant (D.C.) is totally dependent upon the desired method of mounting.
Note 1: Discs can be made to any resistance value from 1 Ω to 1 meg. ohm, dependent upon size.
Note 2: All disc types are rated to 150°C maximum temperature, except lacquer or varnish coated discs which are limited to 100°C.
Note 3: Discs can be supplied with epoxy coating upon request.

THERMISTOR IN GLASS DIODE TYPE ENCLOSURE

THERMISTOR IN GLASS DIODE TYPE ENCLOSURE ***

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
500	10	PD25D1	Diode Type Enclosure	18	5.8	17	2	8	**.020	Dumet	1⅛	.080	.180	—	X
1,000	10	PB31D1	Diode Type Enclosure	18	6.35	10A	2	8	**.020	Dumet	1⅛	.080	.180	—	X
2,000	10	PB32D1	Diode Type Enclosure	18	6.95	10	2	8	**.020	Dumet	1⅛	.080	.180	—	X
3,000	10	PB33D1	Diode Type Enclosure	18	6.95	10	2	8	**.020	Dumet	1⅛	.080	.180	—	X
5,000	10	PB35D1	Diode Type Enclosure	18	6.95	10	2	8	**.020	Dumet	1⅛	.080	.180	—	X
10,000	10	PB41D1	Diode Type Enclosure	18	6.95	10	2	8	**.020	Dumet	1⅛	.080	.180	—	X
20,000	10	PA42D1	Diode Type Enclosure	18	9.1	16	2	8	**.020	Dumet	1⅛	.080	.180	—	X
30,000	10	PA43D1	Diode Type Enclosure	18	9.1	16	2	8	**.020	Dumet	1⅛	.080	.180	—	X
50,000	10	PA45D1	Diode Type Enclosure	18	9.1	16	2	8	**.020	Dumet	1⅛	.080	.180	—	X
100,000	10	PA51D1	Diode Type Enclosure	18	9.1	16	2	8	**.020	Dumet	1⅛	.080	.180	—	X
200,000	10	PT52D2	Diode Type Enclosure	18	10.45	1	2	8	**.020	Dumet	1⅛	.080	.180	—	X
500,000	10	PT55D1	Diode Type Enclosure	18	10.45	1	2	8	**.020	Dumet	1⅛	.080	.180	—	X
1 meg.	10	PT61D1	Diode Type Enclosure	18	10.45	1	2	8	**.020	Dumet	1⅛	.080	.180	—	X

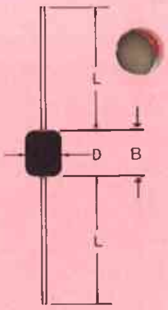


FIG. 18
DIODE PELLETS

ROD THERMISTORS

ROD THERMISTORS — SMALL

Ro @ 25°C Ohms	% Total	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
8,000	10	QB38J1	Rod	19	6.95	10	2.5	20	.016	Copper	1⅜	.053	½	—	X
10,000	10	QB41J1	Rod	19	6.95	10	2.5	20	.016	Copper	1⅜	.053	½	—	X
20,000	10	QB42L1	Rod	20	6.95	10	2.5	20	.016	Copper	1⅜	.053	½	—	X
100,000	1	QA51J3	Rod	19	9.1	16	2.5	20	.016	Copper	1⅜	.053	½	—	X
100,000	3	QA51J2	Rod	19	9.1	16	2.5	20	.016	Copper	1⅜	.053	½	—	X
100,000	10	QA51J1	Rod	19	9.1	16	2.5	20	.016	Copper	1⅜	.053	½	—	X
100,000	10	QA51L3	Rod	20	9.1	16	2.5	20	.016	Copper	1⅜	.053	½	—	X
150,000	10	QA52J1	Rod	19	9.1	16	2.5	20	.016	Copper	1⅜	.053	⅝	—	X

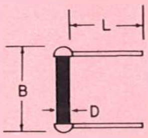


FIG. 19
ROD ADJACENT LEADS

ROD THERMISTORS — MEDIUM

Ro @ 25°C Ohms	% Total	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
2,000	10	RB32L1	Rod	20	6.95	10	4	70	.020	Copper	1⅜	.11	⅞	—	X
5,000	10	RB35L4	Rod	20	6.95	10	4	70	.020	Copper	1⅜	.11	⅞	—	X
8,000	10	RB38L1	Rod	20	6.95	10	4	70	.020	Copper	1⅜	.11	⅞	—	X
10,000	5	RB41J1	Rod	19	6.95	10	6	90	.020	Copper	1⅜	.11	1⅝	—	X
10,000	10	RB41L1	Rod	20	9.1	10	6	90	.020	Copper	1⅜	.11	1⅝	—	X
15,000	5	RB41J2	Rod	19	6.95	10	6	90	.020	Copper	1⅜	.11	1⅝	—	X
15,000	10	RA41L3	Rod	20	9.1	16	4	50	.020	Copper	1⅜	.11	⅞	—	X
15,000	10	RB41L2	Rod	20	6.95	10	6	90	.020	Copper	1⅜	.11	1⅝	—	X
20,000	10	RB42L1	Rod	20	6.95	10	6	90	.020	Copper	1⅜	.11	2	—	X
20,000	10	RA42J1	Rod	19	9.1	16	4	70	.020	Copper	1⅜	.11	⅞	—	X
31,500	10	RA43J1	Rod	19	9.1	16	4	70	.020	Copper	1⅜	.11	⅞	—	X
31,500	10	RA43L1	Rod	20	9.1	16	4	70	.020	Copper	1⅜	.11	⅞	—	X
38,000	10	RA44L2	Rod	20	9.1	16	4	70	.020	Copper	1⅜	.11	⅞	—	X
50,000	10	RA45J1	Rod	19	9.1	16	4	70	.020	Copper	1⅜	.11	⅞	—	X
100,000	10	RA51L1	Rod	20	9.1	16	6	90	.020	Copper	1⅜	.11	1⅝	—	X
100,000	10	RA51J1	Rod	19	9.1	16	6	90	.020	Copper	1⅜	.11	1⅝	—	X

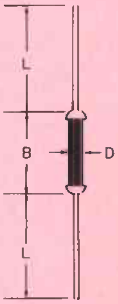


FIG. 20
ROD AXIAL LEADS

ROD THERMISTORS — LARGE

Ro @ 25°C Ohms	% Total	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
1,000	10	TB31L1	Rod	20	6.95	10	15	110	.032	Copper	2	.173	1¼	—	X
2,500	10	TB33L1	Rod	20	6.95	10	15	110	.032	Copper	2	.173	1¼	—	X
5,000	10	TB35J1	Rod	19	6.95	10	15	110	.032	Copper	2	.173	1½	—	X
20,000	10	TA42J1	Rod	19	9.1	16	15	100	.032	Copper	2	.173	1¼	—	X
50,000	10	TA45L1	Rod	20	9.1	16	24	125	.032	Copper	2	.173	1¾	—	X

WASHER THERMISTORS

Ro @ 25°C Ohms	% Tol.	Code Number	Assembly Description	Fig.	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	H	T	Tinned
10	10	WB11W1	Washer	21	6.9	10	—	—	—	—	—	.77	.281	.038	—
20	5	WB12W2	Washer	21	6.9	10	—	—	—	—	—	.77	.281	.076	—
21	10	WB12W1	Washer	21	6.9	10	—	—	—	—	—	.77	.281	.080	—
31.5	10	WB13W1	Washer	21	6.9	10	—	—	—	—	—	.77	.281	.112	—
50	10	WB15W1	Washer	21	6.9	10	—	—	—	—	—	.77	.281	.178	—
70	10	WA17W1	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.034	—
100	3	WA21W3	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.048	—
100	5	WA21W4	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.048	—
100	10	WA21W1	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.048	—
114	5	WA21W2	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.056	—
150	10	WA22W2	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.072	—
180	3	WA22W1	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.087	—
200	10	WA22W3	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.096	—
315	10	WA23W1	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.151	—
415	10	WA24W1	Washer	21	9.1	16	—	—	—	—	—	.77	.281	.195	—

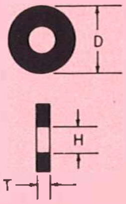


FIG. 21
WASHER

*Time Constant (T.C.) and Dissipation Constant (D.C.) is totally dependent upon the desired method of mounting.

Note 1: Rods can be supplied with epoxy coating upon request.

**.016" Leads available on special order. .016" or .020" Leads are available Gold plated on special order.

***Thermistors in Glass Diode Type Enclosure are recommended for usage to 300°C, however, they have been used successfully to 400°C under certain conditions.

ISO-CURVE®
INTERCHANGEABLE THERMISTORS

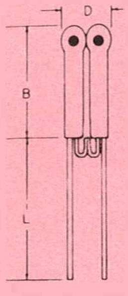


FIG. 22
ISO-CURVE
GLASS PROBES
SERIES

Standard Glass Probes

Ro @ 25°C Ohms	Temp. Tol. Over Temp Range (± °C)	Code Number	Fig.	Temp Range °C	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
500	0.25	GB25PM112	22A	-50°C to +50°C	7.04	500	3.0	22	.012	Dumet	2	.180	½	—	X
500	0.5	GB25PM82	22A	-50°C to +50°C	7.04	500	3.0	22	.012	Dumet	2	.180	½	—	X
500	1.0	GB25PM102	22A	-50°C to +50°C	7.04	500	3.0	22	.012	Dumet	2	.180	½	—	X
1,000	0.25	GB31PM42	22A	-50°C to +90°C	7.04	1K	3.0	22	.012	Dumet	2	.180	½	—	X
1,000	0.5	GB31PM22	22A	-50°C to +90°C	7.04	1K	3.0	22	.012	Dumet	2	.180	½	—	X
1,000	1.0	GB31PM32	22A	-50°C to +90°C	7.04	1K	3.0	22	.012	Dumet	2	.180	½	—	X
2,001	0.25	GB32PM162	22	0°C to +125°C	7.04	2K	3.0	22	.012	Dumet	2	.180	½	—	X
2,001	0.5	GB32PM122	22	0°C to +125°C	7.04	2K	3.0	22	.012	Dumet	2	.180	½	—	X
2,001	1.0	GB32PM132	22	0°C to +125°C	7.04	2K	3.0	22	.012	Dumet	2	.180	½	—	X
4,001	0.25	GB34PM322	22	0°C to +150°C	7.04	4K	3.0	22	.012	Dumet	2	.180	½	—	X
4,001	0.5	GB34PM282	22	0°C to +150°C	7.04	4K	3.0	22	.012	Dumet	2	.180	½	—	X
4,001	1.0	GB34PM292	22	0°C to +150°C	7.04	4K	3.0	22	.012	Dumet	2	.180	½	—	X
15,000	0.25	GB42PM142	22	0°C to +200°C	7.59	15K	3.0	22	.012	Dumet	2	.180	½	—	X
15,000	0.5	GB42PM122	22	0°C to +200°C	7.59	15K	3.0	22	.012	Dumet	2	.180	½	—	X
15,000	1.0	GB42PM132	22	0°C to +200°C	7.59	15K	3.0	22	.012	Dumet	2	.180	½	—	X
25,000	0.25	GA43PM22	22A	+50°C to +250°C	9.53	25K	3.0	22	.012	Dumet	2	.180	½	—	X
25,000	0.5	GA43PM2	22A	+50°C to +250°C	9.53	25K	3.0	22	.012	Dumet	2	.180	½	—	X
25,000	1.0	GA43PM12	22A	+50°C to +250°C	9.53	25K	3.0	22	.012	Dumet	2	.180	½	—	X
100,000	0.25	GA51PM162	22	+100°C to +300°C	9.53	100K	3.0	22	.012	Dumet	2	.180	½	—	X
100,000	0.5	GA51PM132	22	+100°C to +300°C	9.53	100K	3.0	22	.012	Dumet	2	.180	½	—	X
100,000	1.0	GA51PM142	22	+100°C to +300°C	9.53	100K	3.0	22	.012	Dumet	2	.180	½	—	X

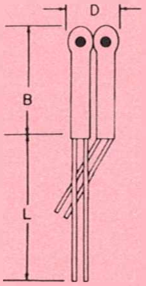


FIG. 22A
ISO-CURVE
GLASS PROBES
PARALLEL

Mini-Probe Thermistors

Ro @ 25°C Ohms	Temp. Tol. Over Temp. Range (± °C)	Code Number	Fig.	Temp. Range °C	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
500	0.25	GB25MM82	22A	-50°C to +50°C	7.04	500	1.4	10	.008	Dumet	1⅜	.120	½	—	X
500	0.5	GB25MM62	22A	-50°C to +50°C	7.04	500	1.4	10	.008	Dumet	1⅜	.120	½	—	X
500	1.0	GB25MM72	22A	-50°C to +50°C	7.04	500	1.4	10	.008	Dumet	1⅜	.120	½	—	X
1,000	0.25	GB31MM62	22A	-50°C to +90°C	7.04	1K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
1,000	0.5	GB31MM42	22A	-50°C to +90°C	7.04	1K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
1,000	1.0	GB31MM52	22A	-50°C to +90°C	7.04	1K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
2,001	0.25	GB32MM272	22	0°C to +125°C	7.04	2K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
2,001	0.5	GB32MM232	22	0°C to +125°C	7.04	2K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
2,001	1.0	GB32MM242	22	0°C to +125°C	7.04	2K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
4,001	0.25	GB34MM362	22	0°C to +150°C	7.04	4K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
4,001	0.5	GB34MM312	22	0°C to +150°C	7.04	4K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
4,001	1.0	GB34MM322	22	0°C to +150°C	7.04	4K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
15,000	0.25	GB42MM232	22	0°C to +200°C	7.59	15K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
15,000	0.5	GB42MM192	22	0°C to +200°C	7.59	15K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
15,000	1.0	GB42MM202	22	0°C to +200°C	7.59	15K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
25,000	0.25	GA43MM22	22A	+50°C to +250°C	9.53	25K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
25,000	0.5	GA43MM2	22A	+50°C to +250°C	9.53	25K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
25,000	1.0	GA43MM12	22A	+50°C to +250°C	9.53	25K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
100,000	0.25	GA51MM372	22	+100°C to +300°C	9.53	100K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
100,000	0.5	GA51MM322	22	+100°C to +300°C	9.53	100K	1.4	10	.008	Dumet	1⅜	.120	½	—	X
100,000	1.0	GA51MM332	22	+100°C to +300°C	9.53	100K	1.4	10	.008	Dumet	1⅜	.120	½	—	X

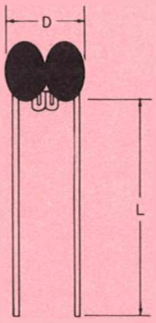


FIG. 23
ISO-CURVE
GLASS BEADS
SERIES

Standard Bead Thermistors

Ro @ 25°C Ohms	Temp. Tol. Over Temp Range (± °C)	Code Number	Fig.	Temp. Range °C	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
500	0.25	GB25JM18	23A	-50°C to +50°C	7.04	500	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
500	0.5	GB25JM15	23A	-50°C to +50°C	7.04	500	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
500	1.0	GB25JM16	23A	-50°C to +50°C	7.04	500	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
1,000	0.25	GB31JM22	23A	-50°C to +90°C	7.04	1K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
1,000	0.5	GB31JM20	23A	-50°C to +90°C	7.04	1K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
1,000	1.0	GB31JM21	23A	-50°C to +90°C	7.04	1K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
2,001	0.25	GB32JM51	23	0°C to +125°C	7.04	2K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
2,001	0.5	GB32JM48	23	0°C to +125°C	7.04	2K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
2,001	1.0	GB32JM49	23	0°C to +125°C	7.04	2K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
4,001	0.25	GB34JM86	23	0°C to +150°C	7.04	4K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
4,001	0.5	GB34JM79	23	0°C to +150°C	7.04	4K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
4,001	1.0	GB34JM80	23	0°C to +150°C	7.04	4K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
15,000	0.25	GB42JM63	23	0°C to +200°C	7.59	15K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
15,000	0.5	GB42JM55	23	0°C to +200°C	7.59	15K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
15,000	1.0	GB42JM56	23	0°C to +200°C	7.59	15K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
25,000	0.25	GA43JM4	23A	+50°C to +250°C	9.53	25K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
25,000	0.5	GA43JM1	23A	+50°C to +250°C	9.53	25K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
25,000	1.0	GA43JM2	23A	+50°C to +250°C	9.53	25K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
100,000	0.25	GA51JM91	23	+100°C to +300°C	9.53	100K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
100,000	0.5	GA51JM71	23	+100°C to +300°C	9.53	100K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—
100,000	1.0	GA51JM72	23	+100°C to +300°C	9.53	100K	0.8	4	.004	PT-IR	⅜	.100	.100	—	—

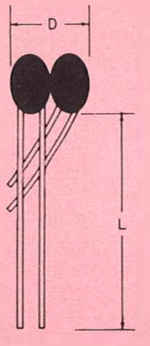


FIG. 23A
ISO-CURVE
GLASS BEADS
PARALLEL

Small Bead Thermistors

Ro @ 25°C Ohms	Temp. Tol. Over Temp Range (± °C)	Code Number	Fig.	Temp. Range °C	Ratio	R-T Curve	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
4,001	0.25	GB34JM89	23A	0°C to +150°C	7.04	4K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
4,001	0.5	GB34JM87	23A	0°C to +150°C	7.04	4K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
4,001	1.0	GB34JM88	23A	0°C to +150°C	7.04	4K	0.2	1.0	.001	PT-IR	½	.040	—	—	—
16,000	0.25	GB42JM66	23	0°C to +150°C	7.04	16K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
16,000	0.5	GB42JM64	23	0°C to +150°C	7.04	16K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
16,000	1.0	GB42JM65	23	0°C to +150°C	7.04	16K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
100,000	0.25	GA51JM90	23A	+100°C to +300°C	9.53	100K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
100,000	0.5	GA51JM88	23A	+100°C to +300°C	9.53	100K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
100,000	1.0	GA51JM89	23A	+100°C to +300°C	9.53	100K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
400,000	0.25	GA54JM3	23	+100°C to +300°C	9.53	400K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
400,000	0.5	GA54JM1	23	+100°C to +300°C	9.53	400K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—
400,000	1.0	GA54JM2	23	+100°C to +300°C	9.53	400K	0.2	1.0	.001	PT-IR	¼	.040	—	—	—

Note 1: All ISO-CURVE units can withstand maximum temperature to 300°C.

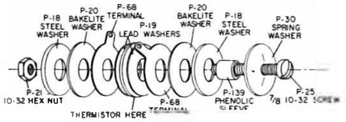
OCEANOGRAPHIC ISO-CURVE® INTERCHANGEABLE THERMISTORS

Ro @ 25°C Ohms	Temp. Tol. Over Temp. Range (±°C)	Code Number	Fig.	Temp. Range °C	Ratio	R-T Curve Ref. Page 30	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
OCEANOGRAPHIC ISO-CURVE® INTERCHANGEABLE R-T CURVED MATCHED THERMISTORS															
Sub-Mini-Probe										**SEE ISO-CURVE CATALOG L-2B**					
15,000	.1	GB42SMM1	22	−5 to +35	—	15K	.6	2.6	.003	PT-IR	¼	.060	.280	—	—
Mini-Probe															
2,001	.1	GB32MM172	22	−5 to +35	—	2K	1.4	16	.008	Tinned Dumet	1⅜	.120	½	—	—
4,002	.1	GB34MM132	22	−5 to +35	—	4K	1.4	16	.008	Tinned Dumet	1⅜	.120	½	—	—
Standard Probe															
2,001	.1	GB32PM82	22	−5 to +35	—	2K	1.9	25	.012	Tinned Dumet	2	.180	½	—	—
4,002	.1	GB34PM62	22	−5 to +35	—	4K	1.9	25	.012	Tinned Dumet	2	.180	½	—	—
Small Bead															
4,002	.1	GB34JM14	23A	−5 to +35	—	4K	.2	1	.001	PT-IR	¼	.040	.030	—	—
Standard Bead															
2,001	.1	GB32JM19	23	−5 to +35	—	2K	.8	2	.004	PT-IR	⅜	.100	.060	—	—
4,002	.1	GB34JM13	23	−5 to +35	—	4K	.8	2	.004	PT-IR	⅜	.100	.060	—	—

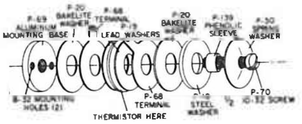
UNI-CURVE® INTERCHANGEABLE THERMISTORS

Ro @ 25°C Ohms	Temp. Tol. Over Temp. Range (±°C)	Code Number	Fig.	Temp. Range °C	Ratio	R-T Curve Ref. Pagea 30 and 31	D.C.	T.C.	Lead Dia.	Lead Mat'l	L	D	B	T	Tinned
UNI-CURVE® R-T CURVE MATCHED THERMISTORS										**SEE UNI-CURVE CATLOG L-6B**					
100	±0.2	UUD21J1	24	-20°C to 50°C	—	100	1	10	.008	Tinned Copper Alloy	1½	.095	—	—	—
300	±0.2	UUD23J1	24	-20°C to 50°C	—	300	1	10	.008		1½	.095	—	—	—
500	±0.2	UUB25J1	24	0°C to 70°C	—	500	1	10	.008		1½	.095	—	—	—
1,000	±0.2	UUB31J1	24	0°C to 70°C	—	1,000	1	10	.008		1½	.095	—	—	—
2,252	±0.2	UUA32J3	24	0°C to 70°C	—	2,252	1	10	.008		1½	.095	—	—	—
3,000	±0.2	UUA33J1	24	0°C to 70°C	—	3,000	1	10	.008		1½	.095	—	—	—
5,000	±0.2	UUA35J1	24	0°C to 70°C	—	5,000	1	10	.008		1½	.095	—	—	—
10,000	±0.2	UUA41J1	24	0°C to 70°C	—	10,000	1	10	.008		1½	.095	—	—	—
10,000	±0.2	UUF41J2	24	0°C to 70°C	—	10,000	1	10	.008		1½	.095	—	—	—
30,000	±0.2	*UUR43J1	24	0°C to 70°C	—	30,000	1	10	.008		1½	.095	—	—	—
30,000	±0.2	UUT43J1	24	0°C to 70°C	—	30,000	1	10	.008		1½	.095	—	—	—
50,000	±0.2	UUT45J1	24	0°C to 70°C	—	50,000	1	10	.008		1½	.095	—	—	—
100,000	±0.2	UUT51J1	24	0°C to 70°C	—	100,000	1	10	.008		1½	.095	—	—	—
2,252	±0.2	UUA32J4	24	0°C to 100°C	—	2,205	1	10	.008		1½	.095	—	—	—
3,000	±0.2	UUA33J4	24	0°C to 100°C	—	3,000	1	10	.008		1½	.095	—	—	—
5,000	±0.2	UUA35J3	24	0°C to 100°C	—	5,000	1	10	.008		1½	.095	—	—	—
10,000	±0.2	UUA41J8	24	0°C to 100°C	—	10,000	1	10	.008		1½	.095	—	—	—

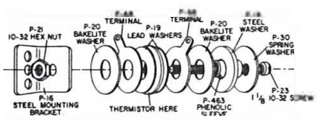
EXPERIMENTERS MOUNTING HARDWARE KITS — H100



ASSEMBLY H101



ASSEMBLY H102



ASSEMBLY H103

KIT H-100
CONTAINS H101, H102, & H103

*Available also as UUR43J1; reference curve No. 18, page 29.

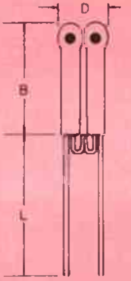


FIG. 22
ISO-CURVE
GLASS PROBES
SERIES

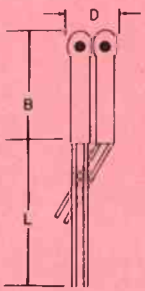


FIG. 22A
ISO-CURVE
GLASS PROBES
PARALLEL

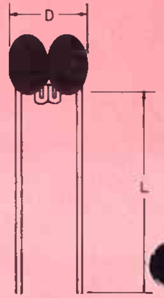


FIG. 23
ISO-CURVE
GLASS BEADS
SERIES

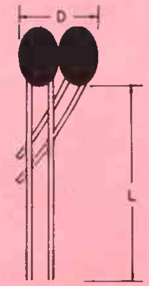


FIG. 23A
ISO-CURVE
GLASS BEADS
PARALLEL

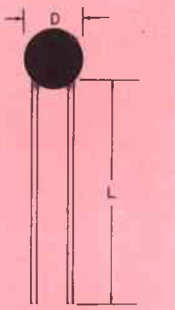


FIG. 24
UNI-CURVE DISCS

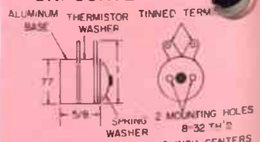


FIG. 25
WASHER ASSEMBLY

®REGISTERED TRADEMARK

RESISTANCE DEVIATION DUE TO BETA TOLERANCE TABLE

TEMP.	MAXIMUM % DEVIATION																	
°C	CURVE 1	CURVE 3	CURVE 4	CURVE 5	CURVE 6	CURVE 7	CURVE 8	CURVE 9	CURVE 10	CURVE 10A	CURVE 11	CURVE 12	CURVE 13	CURVE 14	CURVE 15	CURVE 16	CURVE 17	CURVE 18
– 60	—	10.8	10.4	10.2	10.3	10.5	—	—	9.7	9.7	10.9	10.8	11.1	10.9	10.8	6.6	9.7	—
– 50	—	9.2	8.9	8.8	8.8	8.1	19.1	18.5	8.2	8.2	9.3	9.1	9.4	9.2	9.2	5.6	8.2	—
– 40	7.6	7.6	7.5	7.6	7.4	6.9	15.8	15.4	6.8	6.8	7.7	7.6	7.8	7.7	7.6	4.7	6.8	—
– 30	6.2	6.2	6.2	6.1	6.1	5.9	12.8	12.5	5.6	5.5	6.3	6.2	6.4	6.2	6.2	3.8	5.5	4.3
– 20	5.0	4.9	4.9	4.9	4.8	4.7	10.0	9.9	4.4	4.4	5.0	4.9	5.0	4.9	4.7	3.0	4.4	3.4
– 10	3.7	3.7	3.8	3.6	3.6	3.7	7.3	7.4	3.3	3.3	3.7	3.7	3.7	3.6	3.6	2.2	3.3	2.6
0	2.5	2.5	2.5	2.5	2.5	2.5	5.0	5.0	2.3	2.3	2.5	2.5	2.5	2.5	2.5	1.5	2.3	1.8
10	1.4	1.3	1.5	1.3	1.4	1.5	2.7	2.7	1.2	1.3	1.4	1.5	1.4	1.4	1.4	0.8	1.3	1.0
20	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.6	0.7	0.7	0.7	0.7	0.6	1.4	1.4	0.6	0.6	0.5	0.7	0.7	0.7	0.7	0.4	0.6	0.4
40	1.6	1.6	1.7	1.8	1.5	1.7	3.3	3.2	1.4	1.4	1.6	1.8	1.6	1.6	1.6	1.0	1.4	1.1
50	2.5	2.5	2.5	2.5	2.5	2.5	5.0	5.0	2.2	2.4	2.5	2.5	2.5	2.5	2.5	1.5	2.4	1.7
60	3.4	3.3	3.3	3.3	3.3	3.3	6.7	6.7	3.0	3.1	3.3	3.3	3.3	3.3	3.4	2.0	3.1	2.3
70	4.2	4.2	4.1	4.2	4.1	4.1	8.2	8.2	3.6	3.7	4.1	4.1	4.1	4.1	4.2	2.5	3.7	2.8
80	4.9	4.9	4.9	4.9	4.9	4.9	9.6	9.8	4.3	4.4	4.9	4.8	4.9	4.7	4.9	3.0	4.4	3.3
90	5.6	5.6	5.6	5.6	5.6	5.6	11.0	11.2	4.9	5.1	5.6	5.5	5.6	5.5	5.6	3.4	5.1	3.8
100	6.3	6.3	6.3	6.3	6.3	6.3	12.3	12.6	5.5	5.7	6.3	6.2	6.3	6.2	6.3	3.8	5.7	4.2
110	7.0	7.0	6.9	7.0	6.9	7.0	13.4	13.9	6.1	6.3	6.9	6.4	6.9	6.8	7.0	4.2	—	4.7
120	7.6	7.6	7.6	7.6	7.5	7.6	14.6	14.9	6.7	6.9	7.5	7.5	7.5	7.4	7.6	4.6	—	5.1
125	7.9	8.0	7.9	7.9	7.8	7.9	15.2	15.6	6.9	7.3	7.8	7.8	7.8	7.7	7.9	4.7	—	5.3
130	8.2	8.3	8.2	8.3	8.2	8.1	15.8	16.3	7.1	7.5	8.1	8.0	8.2	8.0	8.2	4.9	—	5.5
140	8.6	8.7	8.8	8.7	8.5	8.8	16.8	17.6	7.6	8.0	8.4	8.6	8.5	8.6	8.8	5.3	—	5.9
150	9.3	9.4	9.3	9.3	9.3	9.3	17.8	18.4	8.0	8.5	9.2	9.1	9.2	9.2	9.3	5.5	—	6.2
160	9.8	10.0	9.9	9.9	9.8	9.9	—	—	8.5	—	9.7	9.6	9.7	9.6	9.8	5.8	—	—
180	10.8	11.0	10.7	10.9	10.9	10.9	—	—	9.3	—	10.6	10.6	10.7	10.6	10.8	6.5	—	—
200	11.8	12.0	11.9	11.8	11.7	11.8	—	—	10.0	—	11.4	11.5	11.5	11.5	11.8	7.0	—	—
220	12.6	12.9	12.8	12.7	12.8	12.7	—	—	10.7	—	12.2	12.3	12.3	12.3	12.6	7.4	—	—
240	13.4	13.6	13.7	13.5	13.5	13.5	—	—	11.3	—	12.9	13.1	13.0	13.0	13.4	7.8	—	—
260	14.1	14.4	14.3	14.3	14.1	14.1	—	—	11.9	—	13.4	13.7	13.7	13.7	14.1	8.3	—	—
280	14.8	15.0	14.9	14.9	14.8	14.7	—	—	12.4	—	14.0	14.4	14.2	14.4	14.8	8.6	—	—
300	15.4	15.7	15.6	15.6	15.4	15.1	—	—	12.9	—	14.5	14.8	14.8	15.0	15.4	8.9	—	—

The Ro deviation due to Beta tolerance between 0°/50°C must be added to the resistance tolerance at the reference temperature to give the complete percentage of resistance deviation. This reference point for standard catalog thermistors is 25°C.
As an example: at 25°C, a thermistor is selected having ± 10% resistance tolerance with R-T characteristics per curve 1. The total resistance deviation from a normal R-T curve will therefore be ± 10% at 25°C plus 2.5 at 0°/50°C and will have a total deviation of 12.5%.

TEMPERATURE COEFFICIENT TABLE

TEMP.					PERCENT RESISTANCE CHANGE PER °C													
°C	CURVE 1	CURVE 3	CURVE 4	CURVE 5	CURVE 6	CURVE 7	CURVE 8	CURVE 9	CURVE 10	CURVE 10A	CURVE 11	CURVE 12	CURVE 13	CURVE 14	CURVE 15	CURVE 16	CURVE 17	CURVE 18
– 60	—	—	—	—	—	—	—	—	—	6.3	—	—	—	—	—	—	6.0	—
– 50	—	7.4	7.4	7.2	8.2	7.9	5.4	5.5	6.1	5.9	6.2	6.4	7.2	7.1	7.3	7.2	5.6	—
– 40	—	6.9	7.0	7.0	7.7	7.6	5.0	5.1	5.8	5.5	5.8	6.0	6.7	6.8	6.9	6.7	5.2	—
– 30	6.5	6.5	6.6	6.7	7.3	7.4	4.6	4.8	5.4	5.1	5.5	5.6	6.3	6.5	6.5	6.2	4.9	5.9
– 20	6.1	6.2	6.3	6.5	6.9	7.2	4.3	4.5	5.1	4.8	5.1	5.3	5.9	5.8	6.1	5.8	4.5	5.6
– 10	5.7	5.8	5.9	6.3	6.5	7.0	4.0	4.2	4.8	4.5	4.8	5.0	5.5	5.6	5.8	5.5	4.3	5.2
0	5.4	5.5	5.6	5.9	6.2	6.9	3.7	4.0	4.5	4.3	4.5	4.7	5.1	5.2	5.4	5.1	4.0	4.9
10	5.1	5.2	5.3	5.6	5.9	6.7	3.5	3.7	4.2	4.0	4.3	4.4	4.8	4.9	5.1	4.8	3.8	4.7
20	4.8	4.9	5.1	5.3	5.6	6.5	3.3	3.5	4.0	3.8	4.0	4.2	4.5	4.6	4.8	4.5	3.6	4.4
25	4.7	4.8	4.9	5.1	5.5	6.3	3.1	3.4	3.9	3.7	3.9	4.0	4.4	4.5	4.7	4.4	3.5	4.3
30	4.6	4.7	4.8	5.0	5.4	6.2	3.0	3.3	3.8	3.6	3.8	3.9	4.3	4.4	4.6	4.3	3.4	4.2
40	4.3	4.4	4.5	4.8	5.1	6.0	2.8	3.1	3.6	3.4	3.6	3.7	4.0	4.1	4.3	4.0	3.2	4.0
50	4.1	4.2	4.3	4.5	4.8	5.7	2.7	3.0	3.4	3.2	3.4	3.5	3.8	3.9	4.1	3.8	3.1	3.7
60	3.9	4.0	4.1	4.3	4.6	5.3	2.5	2.8	3.2	3.0	3.2	3.3	3.6	3.7	3.9	3.6	2.9	3.6
70	3.7	3.8	3.9	4.1	4.4	5.1	2.4	2.6	3.0	2.9	3.0	3.2	3.4	3.5	3.7	3.4	2.8	3.4
80	3.5	3.6	3.7	3.9	4.2	4.8	2.2	2.5	2.8	2.7	2.9	3.0	3.3	3.3	3.5	3.3	2.7	3.2
90	3.3	3.4	3.5	3.7	4.0	4.6	2.1	2.4	2.7	2.6	2.7	2.9	3.1	3.2	3.3	3.1	2.6	3.1
100	3.2	3.3	3.4	3.6	3.8	4.4	2.0	2.2	2.5	2.5	2.6	2.7	2.9	3.0	3.2	2.9	2.5	2.9
110	3.0	3.1	3.3	3.4	3.6	4.2	1.9	2.1	2.4	2.3	2.5	2.6	2.8	2.9	3.0	2.8	—	2.8
120	2.9	3.0	3.1	3.2	3.5	4.0	1.8	2.1	2.3	2.3	2.3	2.5	2.7	2.7	2.9	2.7	—	2.7
125	2.9	2.9	3.0	3.2	3.4	3.9	1.8	2.0	2.2	2.2	2.3	2.4	2.6	2.7	2.8	2.6	—	2.6
130	2.8	2.9	3.0	3.0	3.3	3.8	1.7	1.9	2.1	2.2	2.2	2.4	2.5	2.6	2.8	2.5	—	2.6
140	2.7	2.8	2.9	3.0	3.2	3.7	1.6	1.9	2.0	2.0	2.1	2.3	2.4	2.5	2.7	2.4	—	2.5
150	2.5	2.6	2.7	2.9	3.1	3.5	—	—	1.9	2.0	2.0	2.2	2.3	2.4	2.5	2.3	—	2.4
160	2.4	2.5	2.6	2.8	2.9	3.3	—	—	1.8	—	1.8	2.1	2.2	2.3	2.4	2.2	—	—
180	2.3	2.3	2.4	2.5	2.7	3.1	—	—	1.7	—	1.6	1.9	2.0	2.1	2.3	2.0	—	—
200	2.1	2.2	2.2	2.3	2.5	2.8	—	—	1.5	—	1.5	1.7	1.8	1.9	2.1	1.8	—	—
220	1.9	2.0	2.0	2.2	2.3	2.5	—	—	1.3	—	1.4	1.6	1.6	1.8	1.9	1.6	—	—
240	1.8	1.9	1.9	2.0	2.1	2.4	—	—	1.2	—	1.2	1.5	1.5	1.7	1.8	1.5	—	—
260	1.7	1.7	1.8	1.9	2.0	2.2	—	—	1.1	—	1.1	1.4	1.3	1.5	1.7	1.3	—	—
280	1.6	1.6	1.7	1.8	1.8	2.0	—	—	1.0	—	1.0	1.3	1.1	1.4	1.6	1.1	—	—
300	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

The temperature coefficient table denotes the percent in resistance change per °C at a specific temperature, which is directly readable from the table.

RESISTANCE-TEMPERATURE CONVERSION TABLE

R-T CURVE NO.		1	3	4	5	6	7	8	9
MATERIAL		TYPE T	TYPE H	TYPE H	TYPE H	TYPE H	TYPE H	TYPE D	TYPE C
TYPE UNITS		DISCS & DIODES WAFERS	STD. LG. BEADS MINI-PROBES STD. PROBES	STD. LG. BEADS MINI-PROBES STD. PROBES	STD. LG. BEADS MINI-PROBES STD. PROBES	STD. LG. BEADS MINI-PROBES STD. PROBES	STD. LG. BEADS MINI-PROBES STD. PROBES	GLASS COATED BEADS & PROBES DISCS	GLASS COATED BEADS & PROBES
*Ro RANGES (OHMS) NOTE — FOR DISCS: Size DIA. (IN.) J .1 K .2 C .3 L .4 D .5 M .6 N .77 Z 1.0 NOTE — FOR RODS: Size DIA. (IN.) Q .053 R .110 T .173 NOTE: FOR WAFERS: Size F		DISCS Size Ro J 30K-100K K 10K-50K C 3.5K-24K L 2K-14K D 1300-9K M 1100-6K N 725-3700 P 200K-1 MEG. Z 550-2200 WAFERS Size Ro F 45K-200K	Ro NOM. 300K RANGE 100K-500K BEADS .043 DIA. MINI .060 DIA. STD. .100 DIA.	Ro NOM. 500K RANGE 300K-1 MEG. BEADS .043 DIA. MINI .060 DIA. STD. .100 DIA.	Ro NOM. 1 MEG. RANGE 600K-3 MEG. BEADS .043 DIA. MINI .060 DIA. STD. .100 DIA.	Ro NOM. 5 MEG. RANGE 2 MEG.-10 MEG. BEADS .043 DIA. MINI .060 DIA. STD. .100 DIA.	Ro NOM. 50 MEG. RANGE 20 MEG.-80 MEG. BEADS .043 DIA. MINI .060 DIA. STD. .100 DIA.	STD. SMALL BEADS (.014 DIA.) 250 — 1K STD. LG. BEADS & PROBES (.043 DIA.) 50-250 DISCS SIZE Ro J 15-75 K 4-35 C 2.5-18 L 1.5-10 D .9-6.5 M .7-4.5 PROBES MICRO-MINI (.020 DIA.) 250 — 1K SUB-MINI (.030 DIA.) 500 — 1K MINI (.060 DIA.) 50-250 STD. PROBES (.100 DIA.) 50-250	STD. SMALL BEADS (.014 DIA.) 1K-5K STD. LG. BEADS & PROBES (.043 DIA.) 250-2K PROBES MICRO—MINI (.020 DIA) 1K-5K SUB-MINI (.030 DIA) 1K-2K MINI PROBES (.060 DIA.) 250 — 2K STD. PROBES (.100 DIA.) 250 — 2K
PART NUMBERS PREFIXED BY		FT, JT, KT, CT, LT, DT, MT, NT, PT, ZT	GH	GH	GH	GH	GH	GD BEADS & PROBES DISCS JD, KD, CD, LD DD, MD	GC
BETA IN °K		4138 ± 86	4227 ± 86	4349 ± 87	4540 ± 86	4850 ± 86	5584 ± 86	2758 ± 175	3000 ± 175
RATIO Ro @ 0/50°C		10.45 ± 5%	10.99 ± 5%	11.78 ± 5%	13.12 ± 5%	15.65 ± 5%	23.71 ± 5%	4.80 ± 10%	5.50 ± 10%
RATIO TEST LIMITS 0/50°C		9.93-10.97	10.44-11.54	11.19-12.37	12.46-13.78	14.87-16.43	22.52-24.90	4.32-5.28	4.95-6.05
RATIO Ro @ 25/125°C		38.07	42.20	46.57	56.60	75.50	147.5	10.30	13.51
TEMPERATURE CO-EFFICIENT (α_T) @ 25°C		-4.7%/°C	-4.8%/°C	-4.9%/°C	-5.1%/°C	-5.5%/°C	-6.3%/°C	-3.1%/°C	-3.4%/°C
°F	°C								
-76	-60	—	190.1	224.0	269.4	384.4	898.5	39.32	47.04
-58	-50	—	88.02	101.1	119.2	162.0	337.2	22.21	26.34
-40	-40	40.70	42.78	48.03	55.43	71.92	133.3	13.15	15.37
-22	-30	20.78	21.74	23.88	26.97	33.47	55.86	8.113	9.306
- 4	-20	11.03	11.47	12.39	13.68	16.27	24.53	5.193	5.829
14	-10	6.119	6.314	6.681	7.215	8.232	11.25	3.435	3.760
32	0	3.510	3.591	3.733	3.942	4.323	5.376	2.340	2.500
50	10	2.078	2.107	2.157	2.227	2.354	2.669	1.637	1.700
68	20	1.267	1.272	1.284	1.297	1.322	1.373	1.172	1.187
77	25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
86	30	.7942	.7859	.7860	.7764	.7622	.7307	.8570	.8460
104	40	.5105	.5021	.4934	.4772	.4538	.4011	.6400	.6140
122	50	.3359	.3267	.3170	.3004	.2762	.2267	.4860	.4540
140	60	.2259	.2173	.2085	.1936	.1725	.1315	.3752	.3410
158	70	.1550	.1475	.1400	.1275	.1102	.07831	.2939	.2605
176	80	.1084	.1020	.09587	.08562	.07191	.04793	.2334	.2017
194	90	.07708	.07178	.06683	.05858	.04786	.02994	.1877	.1582
212	100	.05569	.05132	.04738	.04077	.03244	.01910	.1527	.1256
230	110	.04090	.03725	.03413	.02882	.02238	.01243	.1255	.1009
248	120	.03045	.02743	.02495	.02070	.01569	.008239	.1042	.08184
257	125	.02640	.02366	.02144	.01764	.01322	.006764	.09528	.07400
266	130	.02297	.02047	.01849	.01508	.01118	.005578	.08731	.06707
284	140	.01754	.01546	.01388	.01114	.008077	.003826	.07377	.05547
302	150	.01355	.01184	.01055	.008335	.005916	.002669	.06282	.04626
320	160	.01059	.009160	.008113	.006312	.004390	.001890		
356	180	.006659	.005653	.004951	.003741	.002502	.0009883		
392	200	.004344	.003621	.003140	.002309	.001490	.0005435		
428	220	.002927	.002399	.002061	.001477	.0009225	.0003128		
464	240	.002030	.001637	.001395	.0009767	.0005914	.0001874		
500	260	.001445	.001148	.0009706	.0006643	.0003913	.0001165		
536	280	.001053	.0008244	.0006923	.0004640	.0002663	.00007491		
572	300	.0007840	.0006053	.0005051	.0003320	.0001859	.00004961		

*Ro = RESISTANCE @ 25°C, Zero Power Applied.

Table shows curves of thermistors made of different types of materials. To determine resistance of thermistor at specified temperature, first determine RT curve number, material, type unit, and then select appropriate vertical column. Multiply resistance of thermistor at 25°C by appropriate horizontal value in line with the specified temperature to obtain resistance.

10	10A	11	12	13	14	15	16	17	18		
TYPE B	TYPE B SUB.	TYPE B	TYPE B	TYPE A	TYPE A	TYPE A	TYPE A	TYPE D	TYPE R		
DISCS & DIODES WASHERS RODS	DISCS, DIODES, WASHERS, RODS, WAFERS	GLASS COATED BEADS & PROBES	GLASS COATED BEADS & PROBES	GLASS COATED BEADS & PROBES	GLASS COATED BEADS & PROBES	GLASS COATED BEADS & PROBES	DISCS & DIODES WASHERS RODS WAFERS	DISCS, DIODES, WAFERS	DISCS, DIODES, WAFERS		
DISCS Size Ro J 400-1400 K 100-700 C 50-350 L 30-180 D 20-125 M 15-85 N 10-50 Z 7.5-30 P 2K-10K WASHERS 10-60 RODS Size Ro Q 4K-20K R 1K-15K T 350-7.5K	DISCS Size Ro L 50-200 D 20-125 M 15-85 N 25-50 UB 500-1000 Z 7.5-30 WASHERS 10-50 DIODES 1000-2000 RODS Size Ro Q 4K-20K R 1K-15K T 350-7.5K MINI-WAFERS Size Ro F 500 1500	STD. SMALL BEADS (.014 DIA.) 7K-30K STD. LG. BEADS (.043 DIA.) 1K-5K PROBES MICRO-MINI (.020 DIA.) 7K-30K SUB-MINI (.030 DIA.) 4K-18K MINI (.060 DIA.) 1K-5K STD. PROBES (.100 DIA.) 1K-5K	STD. SMALL BEADS (.014 DIA.) 40K-50K STD. LG. BEADS (.043 DIA.) 5K-10K PROBES MICRO-MINI (.020 DIA.) 40K-50K SUB-MINI (.030 DIA.) 23K-30K MINI (.060 DIA.) 5K-10K STD. PROBES (.100 DIA.) 5K-10K	STD. SMALL BEADS (.014 DIA.) 50K-200K STD. LG. BEADS (.043 DIA.) 10K-30K PROBES MICRO-MINI (.020 DIA.) 50K-200K SUB-MINI (.030 DIA.) 30K-120K MINI (.060 DIA.) 10K-30K STD. PROBES (.100 DIA.) 10K-30K	STD. SMALL BEADS (.014 DIA.) 200K-400K STD. LG. BEADS (.043 DIA.) 30K-60K PROBES MICRO-MINI (.020 DIA.) 200K-400K SUB-MINI (.030 DIA.) 110K-230K MINI (.060 DIA.) 30K-60K STD. PROBES (.100 DIA.) 30K-60K	STD. SMALL BEADS (.014 DIA.) 500K-1 MEG. STD. LG. BEADS (.043 DIA.) 75K-200K PROBES MICRO-MINI (.020 DIA.) 500K-1 MEG. SUB-MINI (.030 DIA.) 280K-600K MINI (.060 DIA.) 75K-200K STD. PROBES (.100 DIA.) 75K-200K	DISCS Size Ro J 3000-10K K 1000-5K C 375-2500 L 200-1400 D 130-900 M 110-600 N 72-375 Z 55-220 P 20K-100K WASHERS 70-425 RODS Size Ro Q 25K-125K R 6K-120K T 2.5K-42.5K WAFERS Size Ro F 2K-20K	DISCS Size Ro UUD 100-300 DIODES P 500-1000 WAFERS F 100-300	DISCS Size Ro UUR 30K DIODES P 30K-100K WAFERS F 10K-40K		
DISCS JB, KB, CB, LB, DB, MB, NB, PB, UB, ZB WASHERS WB RODS QB, RB, TB	DISCS JB, KB, CB, LB, DB, MB, NB, UB, ZB WASHERS WB RODS QB, RB, TB WAFERS FB	GB	GB	GA	GA	GA	DISCS JA, KA, CA, LA, DA, MA, NA, PA, ZA WASHERS WA RODS QA, RA, TA	DISCS UD DIODES PD WAFERS FD	DISCS UR DIODES PR WAFERS FR		
3420 ± 80	3260 ± 90	3442 ± 90	3574 ± 93	3894 ± 90	3980 ± 95	4118 ± 95	3887 ± 51	3100 ± 175	3800 ± 75		
6.95 ± 4.5%	6.35 ± 4.5%	7.04 ± 5%	7.59 ± 5%	9.1 ± 5%	9.52 ± 5%	10.45 ± 5%	9.1 ± 3%	5.8 ± 4.5%	8.73 ± 3.5%		
6.63-7.26	6.06-6.64	6.69-7.39	7.21-7.97	8.65-9.56	9.05-10.01	9.93-10.97	8.83-9.37	5.54 ± 6.06	8.35-8.95		
19.05	17.33	19.85	22.73	29.42	31.72	38.05	29.27	14.25	29.15		
-3.9%/°C	-3.7%/°C	-3.9%/°C	-4.0%/°C	-4.4%/°C	-4.5%/°C	-4.7%/°C	-4.4%/°C	-3.4%/°C	-4.2%/°C		
										°F	°C
81.67	59.77	80.78	91.10	143.2	160.1	174.0	140.5	49.10	—	-76	-60
42.12	32.64	41.75	46.54	68.02	74.50	81.60	67.01	27.54	—	-58	-50
22.66	18.55	22.61	24.88	34.03	36.63	40.20	33.65	16.06	29.48	-40	-40
12.73	10.92	12.77	13.83	17.84	18.93	20.60	17.70	9.703	16.08	-22	-30
7.4399	6.649	7.489	8.009	9.792	10.22	11.00	9.707	6.053	9.075	- 4	-20
4.5097	4.172	4.548	4.796	5.560	5.749	6.120	5.533	3.890	5.291	14	-10
2.8250	2.691	2.850	2.961	3.274	3.353	3.510	3.265	2.568	3.178	32	0
1.8361	1.779	1.839	1.882	1.992	2.021	2.080	1.990	1.731	1.968	50	10
1.2161	1.204	1.219	1.227	1.250	1.256	1.270	1.249	1.194	1.244	68	20
1.0000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	77	25
.8276	.8337	.8265	.8197	.8053	.8022	.7940	.8057	.8413	.8082	86	30
.5736	.5890	.5730	.5598	.5316	.5255	.5100	.5327	.6040	.5367	104	40
.4067	.4239	.4048	.3903	.3595	.3523	.3360	.3603	.4412	.3639	122	50
.2949	.3105	.2915	.2773	.2482	.2413	.2260	.2488	.3275	.2517	140	60
.2177	.2310	.2138	.2006	.1747	.1685	.1550	.1752	.2468	.1772	158	70
.1634	.1745	.1594	.1475	.1252	.1199	.1080	.1258	.1886	.1270	176	80
.1245	.1336	.1207	.1101	.09126	.08672	.07676	.09177	.1460	.09245	194	90
.09614	.1036	.09260	.08335	.06769	.06373	.05544	.06800	.1140	.06832	212	100
.07523	.0813	.07195	.06396	.05087	.04781	.04065	.05112		.05121	230	110
.05958	.0645	.05655	.04969	.03876	.03634	.03023	.03893		.03889	248	120
.05325	.0577	.05038	.04399	.03399	.03182	.02620	.03417		.03405	257	125
.04772	.0517	.04500	.03906	.02988	.02796	.02280	.03009		.02991	266	130
.03862	.04183	.03614	.03104	.02335	.02175	.01739	.02348		.02327	284	140
.03155	.03414	.02932	.02491	.01843	.01711	.01343	.01853		.01830	302	150
.02602		.02401	.02016	.01470	.01359	.01048	.01479			320	160
.01814		.01650	.01357	.009622	.008813	.006587	.009681			356	180
.01302		.01169	.009432	.006518	.005909	.004295	.006559			392	200
.009602		.008509	.006741	.004552	.004081	.002894	.004581			428	220
.007246		.006342	.004940	.003265	.002893	.002008	.003286			464	240
.005583		.004828	.003702	.002399	.002101	.001430	.002415			500	260
.004383		.003747	.002830	.001803	.001558	.001043	.001814			536	280
.003499		.002958	.002203	.001381	.001178	.0007773	.001390			572	300

ISO-CURVE TYPICAL RESISTANCE-TEMPERATURE TABLES

• 500 OHMS AT 25°C • —50°C TO +50°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—50	20,050	—30	6,296	—10	2,265	10	919.4	25	500.3	40	286.5
—40	11,030	—20	3,714	0	1,425	20	609.1	30	413.3	50	202.4

• 1,000 OHMS AT 25°C • —50°C TO +90°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—50	40,100	—20	7,428	10	1,839	30	826.5	60	291.5	90	120.5
—40	22,070	—10	4,530	20	1,218	40	573.0	70	213.8	—	—
—30	12,590	0	2,850	25	1,001	50	404.8	80	159.3	—	—

• 2,000 OHMS AT 25°C • 0°C TO +125°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
0	5,700	30	1,653	70	427.6	110	143.7	—	—	—	—
10	3,678	40	1,146	80	318.7	120	113.1	—	—	—	—
20	2,437	50	809.5	90	241.0	125	100.8	—	—	—	—
25	2,001	60	583.0	100	184.7	—	—	—	—	—	—

• 4,000 OHMS AT 25°C • 0°C TO +150°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
0	11,400	30	3,306	70	855.2	110	287.3	150	117.6	—	—
10	7,355	40	2,292	80	637.3	120	226.2	—	—	—	—
20	4,873	50	1,619	90	482.0	130	180.0	—	—	—	—
25	4,002	60	1,166	100	369.4	140	144.8	—	—	—	—

• 15,000 OHMS AT 25°C • 0°C TO +200°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
0	44,420	30	12,290	70	3,008	110	959.4	150	373.7	190	169.9
10	28,220	40	8,397	80	2,212	120	745.5	160	302.9	200	142.4
20	18,410	50	5,854	90	1,651	130	585.9	170	247.7	—	—
25	15,000	60	4,159	100	1,250	140	465.5	180	204.3	—	—

• 16,000 OHMS AT 25°C • 0°C TO +150°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
0	45,600	25	16,000	50	6,476	80	2,549	110	1,149	140	579.2
10	29,420	30	13,220	60	4,664	90	1,928	120	904.8	150	470.4
20	19,490	40	9,168	70	3,421	100	1,478	130	720.0	—	—

• 25,000 OHMS AT 25°C • +50°C TO +250°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
50	8,820	90	2,174	130	691.2	170	266.7	210	119.3	250	60.25
60	6,043	100	1,599	140	536.0	180	215.4	220	99.53	—	—
70	4,225	110	1,192	150	420.5	190	175.5	230	83.63	—	—
80	3,007	120	902.0	160	333.0	200	144.2	240	70.77	—	—

• 100,000 OHMS AT 25°C • +100°C TO +300°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
100	6,395	140	2,144	180	861.5	220	398.1	260	206.5	300	117.3
110	4,769	150	1,682	190	702.1	230	334.5	270	177.9	—	—
120	3,608	160	1,332	200	576.9	240	283.1	280	154.1	—	—
130	2,765	170	1,067	210	477.4	250	241.0	290	134.1	—	—

• 400,000 OHMS AT 25°C • +100°C TO +300°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
100	25,580	150	6,728	200	2,308	250	964.0	300	469.2	—	—
110	19,080	160	5,328	210	1,910	260	826.0	—	—	—	—
120	14,430	170	4,268	220	1,592	270	711.6	—	—	—	—
130	11,060	180	3,446	230	1,338	280	616.4	—	—	—	—
140	8,576	190	2,808	240	1,132	290	536.4	—	—	—	—

For Additional Information, Reference Pages 25 and 26 of this Manual and ISO-CURVE THERMISTOR CATALOG L-2A.

UNI-CURVE TYPICAL RESISTANCE-TEMPERATURE TABLES

• 100 OHMS AT 25°C • ±0.2°C • —20°C TO +50°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	17,833	—40	1,606	0	256.8	30	84.13	70	24.77	—	—
—70	9,140	—30	970.3	10	173.1	40	60.40	80	18.93	—	—
—60	4,910	—20	605.3	20	119.4	50	44.17	90	14.70	—	—
—50	2,754	—10	389.0	25	100.0	60	32.83	100	11.53	—	—

UNI-CURVE

TYPICAL RESISTANCE-TEMPERATURE TABLES

• 300 OHMS AT 25°C • ±0.2°C • —20°C TO +50°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	53,500	—40	4,818	0	770.5	30	252.4	70	74.3	—	—
—70	27,420	—30	2,911	10	519.4	40	181.2	80	56.8	—	—
—60	14,730	—20	1,816	20	358.2	50	132.5	90	44.1	—	—
—50	8,262	—10	1,167	25	300.0	60	98.5	100	34.6	—	—

• 500 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	114,500	—40	9,275	0	1,346	30	416.9	70	115.5	110	40.65
—70	57,150	—30	5,460	10	889.5	40	294.5	80	87.25	120	32.25
—60	29,885	—20	3,325	20	602.0	50	212.0	90	66.80	130	25.85
—50	16,320	—10	2,086	25	500.0	60	155.3	100	51.80	140	20.95
										150	17.10

• 1000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	229,000	—40	18,550	0	2,691	30	833.7	70	231.0	110	81.3
—70	114,300	—30	10,920	10	1,779	40	589.0	80	174.5	120	64.5
—60	59,770	—20	6,649	20	1,204	50	423.9	90	133.6	130	51.7
—50	32,640	—10	4,172	25	1,000	60	310.5	100	103.6	140	41.9
										150	34.2

• 2252 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C AND ± 0°C TO +100°C

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	1,659,300	—40	75,780	0	7,352.8	30	1,814.4	70	394.55	110	114.92
—70	702,060	—30	39,860	10	4,481.5	40	1,199.6	80	282.63	120	87.671
—60	316,380	—20	21,860	20	2,812.8	50	811.40	90	206.13	130	67.770
—50	150,910	—10	12,460	25	2,252.0	60	560.30	100	152.75	140	52.983
										150	41.881

• 3000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C AND ± 0°C TO +100°C

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	2,210,400	—40	100,950	0	9,795.0	30	2,417.1	70	525.60	110	153.09
—70	935,250	—30	53,100	10	5,970.0	40	1,598.1	80	376.50	120	116.79
—60	421,470	—20	29,121	20	3,747.0	50	1,080.9	90	274.59	130	90.279
—50	201,030	—10	16,599	25	3,000.0	60	746.40	100	203.49	140	70.581
										150	55.791

• 5,000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C AND ± 0°C TO +100°C

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	3,684,000	—40	168,250	0	16,325	30	4,028.5	70	876.00	110	255.15
—70	1,558,800	—30	88,500	10	9,950.0	40	2,663.3	80	627.50	120	194.65
—60	702,450	—20	48,535	20	6,245.0	50	1,801.5	90	457.65	130	150.47
—50	335,050	—10	27,665	25	5,000.0	60	1,244.0	100	339.15	140	117.64
										150	92.985

• 10,000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C AND ± 0°C TO +100°C

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—80	7,368,000	—40	336,500	0	32,650	30	8,057.0	70	1,752.0	110	510.30
—70	3,117,500	—30	177,000	10	19,900	40	5,327.0	80	1,255.0	120	389.30
—60	1,404,900	—20	97,070	20	12,490	50	3,603.0	90	915.30	130	300.93
—50	670,100	—10	55,330	25	10,000	60	2,488.0	100	678.30	140	235.27
										150	185.97

• 30,000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—40	1,204,600	0	105,310	30	23,827	70	4,650.5	110	1,224.9	150	399.56
—30	619,200	10	62,354	40	15,314	80	3,251.2	120	909.99	—	—
—20	331,030	20	38,022	50	10,077	90	2,312.3	130	684.31	—	—
—10	183,560	25	30,000	60	6,777.1	100	1,670.8	140	520.30	—	—

• 50,000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—40	2,007,700	0	175,510	30	39,711	70	7,750.9	110	2,041.5	150	665.94
—30	1,032,000	10	103,920	40	25,524	80	5,418.7	120	1,516.7	—	—
—20	551,720	20	63,370	50	16,795	90	3,853.9	130	1,140.5	—	—
—10	305,940	25	50,000	60	11,295	100	2,784.6	140	867.16	—	—

• 100,000 OHMS AT 25°C • ±0.2°C • 0°C TO +70°C •

TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω	TEMP. °C	RESIS. Ω
—40	4,015,500	0	351,020	30	79,422	70	15,502	110	4,082.9	150	1,331.9
—30	2,064,000	10	207,850	40	51,048	80	10,837	120	3,033.3	—	—
—20	1,103,400	20	126,740	50	33,591	90	7,707.7	130	2,281.0	—	—
—10	611,870	25	100,000	60	22,590	100	5,569.3	140	1,734.3	—	—

For Additional Information, Reference Page 26 of this Manual and UNI-CURVE THERMISTOR CATALOG L-6A.

ORDERING & SPECIFYING GUIDE & CHECK LIST

The following is a summary of the data which should be specified when you order or request quotations on standard or special thermistor sensor assemblies.

THERMISTOR ELEMENT

Specify

1. Resistance at 25°C or special temperature points
2. Temperature tolerance desired
3. Temperature span desired
4. Calibration if desired. Specify temperature point or points

STANDARD THERMISTOR SENSOR ASSEMBLY

Specify

1. Housing desired by "H" number (e.g. H39) from Thermistor Housing Manual L-5A

MODIFICATIONS TO STANDARD HOUSINGS

Specify

1. Modification desired (e.g. non-standard housing material, thread length, probe tips length, etc.)
2. Standard or maximum operating temperature
3. Shock, vibration, acceleration and pressure requirements, if not listed in housing

SPECIAL THERMISTOR SENSOR ASSEMBLIES

Specify

1. Housing configuration desired, by means of sketch or drawing indicating all critical dimensions and tolerances
2. Housing material
3. Working environment, medium and corrosiveness of media.
4. Maximum operating temperature
5. Operating temperature range
6. Acceleration, shock, vibration, pressure and humidity requirements
7. Time Constant and dissipation constant desired in specified medium

ORDERING THE COMPLETE ASSEMBLY

As an example:

If you wish a thermistor element of 2000 ohms to a tolerance of ±20% over a temperature range of 0°C to 175°C mounted in an H33 housing modified to have a thread length of ¼" . . .

Order as follows:

H33-2000 (GB32P2) ohms ±20% temperature range 0°C to 175°C. Modification: Thread length to be ¼".

THERMISTOR GLOSSARY OF TERMS

Thermistor (thur.mis ter) — thermally sensitive resistor whose primary function is to exhibit a change in electrical resistance with a change in body temperature.

THERMISTOR SYMBOL

Zero-Power Resistance (R_O)— the resistance value of a thermistor at a specified temperature with zero electrical power dissipation.

Standard Reference Temperature—the thermistor body temperature at which nominal zero-power resistance is specified.

Zero-Power Temperature Coefficient of Resistance (α_T) — the ratio at a specified temperature, T, of the rate of change of zero-power resistance with temperature to the zero-power resistance.

$$\alpha_T = \frac{1}{R_T}\frac{(dR_T)}{(dT)}$$

Maximum Operating Temperature — the maximum body temperature at which a thermistor will operate for an extended period of time with acceptable stability of its characteristics.
NOTE: This temperature is the result of external and internal heating.

Dissipation Constant (δ) — the ratio, at a specified ambient temperature, of a change in power dissipation in a thermistor to the resultant body temperature change.

Thermal Time Constant (τ) — the time required for a thermistor to change 63.2% of the difference between its initial and final body temperature, when subjected to a step function change in temperature under zero-power conditions.

Zero-Power Resistance Temperature Characteristic — the relationship between the zero-power resistance of a thermistor and its body temperature.

Temperature — Wattage Characteristic — the relationship, at a specified ambient temperature, between the thermistor temperature and the applied steady-state wattage.

Current — Time Characteristic — the relationship, at a specified ambient temperature, between the current through a thermistor and time upon application of a step function of voltage to it.

Resistance Ratio — the ratio of the zero-power resistances of a thermistor measured at two specified reference temperatures.

$$\frac{Ro\ (T_1)}{Ro\ (T_2)} = e^{\beta\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$$

Where:

$Ro\ (T_1)$ is the resistance at absolute temperature T_1.
$Ro\ (T_2)$ is the resistance at absolute temperature T_2.
e is 2.718.
β is a constant which depends on the material used to make the thermistor.

Stability — the ability of a thermistor to retain specified characteristics after being subjected to designated environmental and/or electrical test conditions.

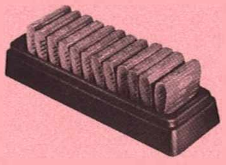
THERMISTOR DESIGN AND APPLICATION AIDS

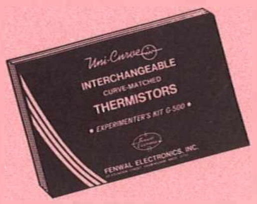
GENERAL THERMISTOR DATA	
Thermistor Short Form Catalog	L-1B
Capsule Thermistor Course	L-3A
TECHNICAL DATA AIDS	
Stability and Reliability Characteristics	TD-1A
Considerations in the Testing of Thermistors	TD-2A
APPLICATION AIDS	
Methods for Designing Linear Temperature Readout Circuits	AN-1A
Using Thermistors to Compensate for Transistor Temperature Sensitivity	AN-2A
Thermistor Slide Rule Calculator $1.50	G300B
INTERCHANGEABLE THERMISTORS	
*ISO-CURVE, R-T Curve-Matched, Precision Interchangeable Glass Bead and Probe Thermistors	L-2B
*UNI-CURVE, R-T Curve-Matched, Precision Interchangeable High Volume Disc Thermistors	L-6B
THERMISTOR OPERATION IN THE SELF-HEAT MODE	
E-I Curve Manual	L-7
THERMISTOR HOUSINGS	
Thermistor Housing Manual	L-5A
LINEAR THERMISTOR NETWORKS (LTN TM) BULLETIN	L-9A
MID-TEMP. 200°C TO 600°C THERMISTOR BULLETIN	L-10

EXPERIMENTER'S THERMISTOR KITS

Designed specifically for beginning or advanced usage by students, instructors or engineers in college and university biology, chemistry and physics labs or for R&D labs, circuit design or familiarization in a wide variety of electrical and electronic applications.

MODEL G200 Standard Kit — Contains 12 different thermistors (2 glass probes, 3 beads, 2 discs, 3 rods, 2 washers). Each thermistor is packaged with specification sheets showing characteristics. Bulletin EM-19.

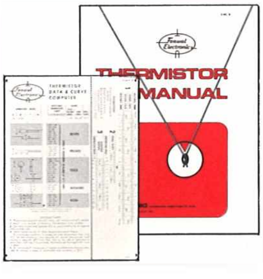




MODEL G500 UNI-CURVE Kit — Contains 6 standard R-T curve-matched interchangeable thermistors (3K, 5K, 10K, 30K, 50K, 100K). Includes complete data sheets with full specifications and DC, TC listings. Bulletin EM-58.

MODEL G700 Low-Cost Kit —Includes four glass beads and probes, manual and computer for a variety of applications. Bulletin EM-37.

MODEL G701 Economy Kit — Includes 10 glass beads and probes, manual and computer for a wider range of applications than G-700 kit above. Bulletin EM-37.



Free With the purchase of each G200 kit.

THERMISTOR
MANUAL
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and
THERMISTOR
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CALCULATOR
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