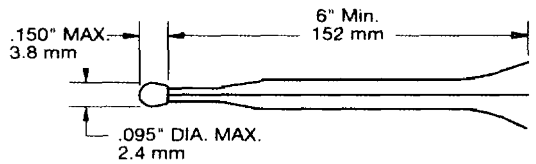
YSI Thermilinear Components

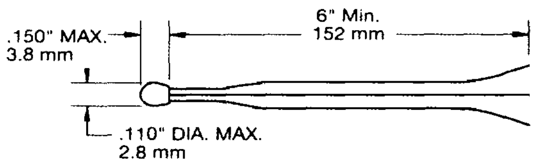
Temperature measurement, control and compensation applications requiring linear electrical response to temperature changes are easily handled by YSI Thermilinear Components. Each Thermilinear Network consists of two sub-components – a thermistor component and a resistor set.

The active element is the thermistor component, made from two YSI precision thermistors with three leads, epoxy encapsulated, to form the YSI 44018 and 44019A sensors; and three thermistors with four leads to form the YSI 44020 sensor.

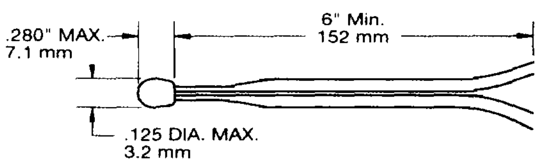
The resistor set consists of two precision metal film resistors for use with the YSI 44018 and 44019A thermistor composites, and three resistors for use with the YSI 44020 thermistor composite.



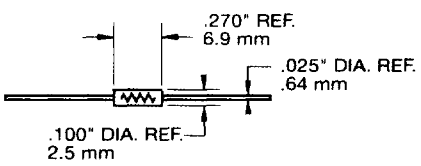
YSI 44018 Thermilinear Component



YSI 44019A Thermilinear Component



YSI 44020 Thermilinear Component



YSI 44300 Series Resistor

The combination of thermistor component and resistor set is called a Thermilinear Network. For example, a YSI 44018 thermistor component plus a YSI 44301 resistor set become a YSI 44201 Thermilinear Network. The Thermilinear Network may be used as a device for linear voltage versus temperature or linear resistance versus temperature.

Sensitivity is 400 times greater than a thermocouple, with outputs as high as 30 mV/°C. Output voltage applied to a recorder or digital voltmeter will produce a precise, sensitive, direct-reading thermometer.

How to Use YSI Thermilinear Networks

To understand how a Thermilinear Network functions, first consider what happens when a single thermistor is shunted with a fixed resistor.

As shown in the R versus T charts, the thermistor has an approximately logarithmic, negative temperature characteristic. To make the R/T characteristic more nearly linear, the rate of resistance change must decrease as the temperature decreases. A single shunt resistor will do this.

If this shunt combination is supplied with a constant current, the voltage change across the combination will be linear with resistance change and temperature.

These two components can be reconnected with the resistor in series with the thermistor to form a voltage divider (half bridge) which, when connected across a constant voltage source, will yield a linear output voltage versus temperature across either the resistor or thermistor.

These circuits, although useful because of their simplicity, are restricted to very narrow temperature ranges, usually 25°C or less. As the range is extended, the fixed resistor will be too large at the high temperature end and too small at the low temperature end.

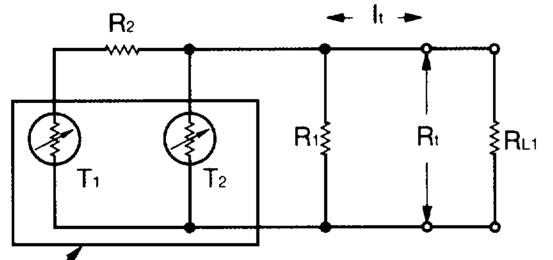
The solution is to add one or more thermistors to the circuit to compensate the first linearizing resistor already in the network.

Call us to discuss your application at 800 765-4974. Fax 513 767-9353

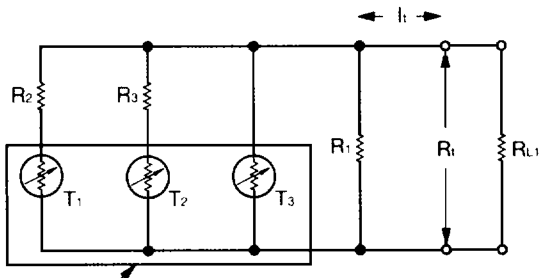
General Theory

Resistance Mode

Resistance mode operation is achieved by configuring the components as shown in the figures below.



YSI 44018 or 44019A Thermistor Network
R_1 & R_2 = Resistor Set



YSI 44020 Thermistor Network
R_1, R_2 & R_3 = Resistor Set

Different networks may be created by changing resistor values. Each Thermilinear network has a unique resistance versus temperature relationship. This relationship is defined by the formula:

$R_t = mX + b$

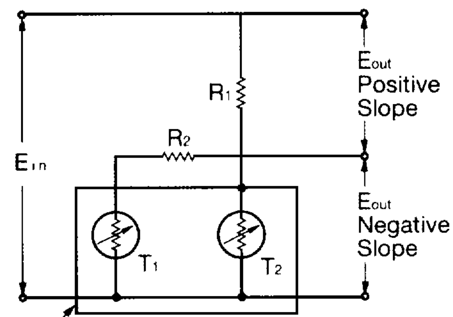
Where: R_t = total circuit resistance
m = change in resistance per degree (slope)
X = temperature in degrees
b = resistance at 0° (0°offset or intercept)

The slope and intercept values for standard networks are on the following pages. Non-standard range values are in the Technical Information Section.

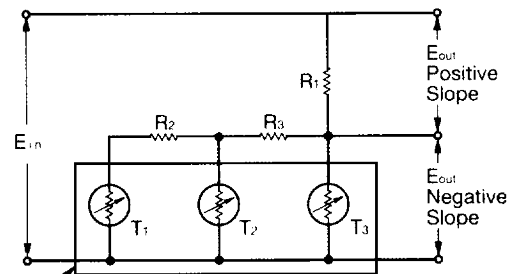
Variation from this calculated value by actual thermistor network values is defined as the linearity deviation. The lower the linearity deviation, the more closely the actual network values track the calculated values.

Voltage Mode

Voltage mode operation is achieved by configuring the components as shown in the figures below.



YSI 44018 or YSI 44019 Thermistor Network
R_1 & R_2 = Resistor Set



YSI 44020 Thermistor Network
R_1, R_2 & R_3 = Resistor Set

Since each network has a unique resistance versus temperature relationship, it follows that each will have a different sensitivity in the voltage mode. This relationship may be defined as

$E_{out} = (mE_{in})\,X + (bE_{in})$

Where: E_{out} = voltage output
m = voltage change per degree (slope)
E_{in} = input voltage
X = temperature in degrees
b = voltage at 0° and 1 volt E_{in} (0° offset or intercept)

The values for these slope and intercept values are on the same pages as the resistance mode values. How to use these equations in circuit development is in the Technical Information Section.

YSI Thermilinear Component Specifications

Component	Maximum Operating Temperature	Accuracy & Interchangeability
YSI 44018	105°C (220°F)	±0.15°C

YSI Thermilinear Network Specifications

YSI Networks Using 44018

44201	**Linear Range**		**Linearity Deviation**
	0 to +100°C		±0.216°C
44018	**Resistance Mode**		
T_1 = 6,000 Ω @ 25°C	R_t = (-17.115) T + 2768.23		
T_2 = 30,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
	E_{out} = (+0.0053483 E_{in}) T + 0.13493 E_{in}		E_{out} = (-0.0053483 E_{in}) T + 0.86507 E_{in}
44301	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 3200 Ω	2.0 V	625 μA	10 MΩ
R_2 = 6250 Ω	**Resistor Error**		
	±0.14°C @ 0°C, ±0.03°C @ +100°C		

44202	**Linear Range**		**Linearity Deviation**
	-5 to +45°C		±0.065°C
44018	**Resistance Mode**		
T_1 = 6,000 Ω @ 25°C	R_t = (-32.402) T + 4593.39		
T_2 = 30,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
	E_{out} = (+0.0056846 E_{in}) T + 0.194142 E_{in}		E_{out} = (-0.0056846 E_{in}) T + 0.805858 E_{in}
44302	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 5700 Ω	3.5 V	615 μA	10 MΩ
R_2 = 12,000 Ω	**Resistor Error**		
	±0.12°C @ -5°C, ±0.07°C @ +45°C		

44203	**Linear Range**		**Linearity Deviation**
	-30 to +50°C		±0.16°C
44018	**Resistance Mode**		
T_1 = 6,000 Ω @ 25°C	R_t = (-127.096) T + 12175		
T_2 = 30,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
	E_{out} = (+0.0067966 E_{in}) T + 0.34893 E_{in}		E_{out} = (-0.0067966 E_{in}) T + 0.65107 E_{in}
44303	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 18,700 Ω	3.0 V	475 μA	10 MΩ
R_2 = 35,250 Ω	**Resistor Error**		
	±0.12°C @ -30°C, ±0.02°C @ +50°C		

44204	**Linear Range**		**Linearity Deviation**
	-2 to +38°C		±0.03°C
44018	**Resistance Mode**		
T_1 = 6,000 Ω @ 25°C	R_t = (-32.1012) T + 4603.11		
T_2 = 30,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
	E_{out} = (+0.00563179 E_{in}) T + 0.192437 E_{in}		E_{out} = (-0.00563179 E_{in}) T + 0.807563 E_{in}
44301	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 3200 Ω	4.0 V	685 μA	10 MΩ
R_2 = 6250 Ω	**Resistor Error**		
	±0.13°C @ -2°C, ±0.08°C @ +38°C		

YSI Thermilinear Component Specifications

Component	Maximum Operating Temperature	Accuracy & Interchangeability
YSI 44019A	85°C (185°F)	±0.4°C (0 to 85°C), ±0.8°C (0 to -55°C)
YSI 44020	55°C (131°F)	±0.1°C

YSI Thermilinear Network Specifications

YSI Network Using 44019A

44211A	**Linear Range**		**Linearity Deviation**
	-55 to +85°C		±1.1°C
44019A	**Resistance Mode**		
T_1 = 1,000 Ω @ 25°C	R_t = (-17.99) T + 2339		
T_2 = 10,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
	E_{out} = (+0.005068 E_{in}) T + 0.3411 E_{in}		E_{out} = (-0.005068 E_{in}) T + 0.6589 E_{in}
44311A	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 3550 Ω	2.0 V	833 μA	10 MΩ
R_2 = 6025 Ω	**Resistor Error**		
	±0.18°C @ -55°C, ±0.02°C @ +85°C		

YSI Network Using 44020

44212	**Linear Range**		**Linearity Deviation**
	-50 to +50°C		±0.09°C
44020	**Resistance Mode**		
T_1 = 2,000 Ω @ 25°C	R_t = (-129.163) T + 13698.23		
T_2 = 15,000 Ω @ 25°C	**E_o Positive Mode**		**E_o Negative Mode**
T_3 = 45,000 Ω @ 25°C	E_{out} = (+0.00559149 E_{in}) T + 0.40700 E_{in}		E_{out} = (-0.00559149 E_{in}) T + 0.59300 E_{in}
44312	**E_{in} Max**	**I_t Max**	**Min RL**
R_1 = 23,100 Ω	3.5 V	700 μA	10 MΩ
R_2 = 88,200 Ω	**Resistor Error**		
R_3 = 38,000 Ω	±0.15°C @ -50°C, ±0.03°C @ +50°C		

Thermilinear Definitions

Thermilinear Component YSI 44018, 44019A or 44020 thermistor.

Resistor Set YSI 44301, 44302, 44303, 44304, 44311A or 44312 resistor sets consist of 2 resistors (3 for 44312) used with a Thermilinear component to create a Thermilinear network.

Thermilinear Network A Thermilinear component and corresponding resistor set.

Linear Range Temperature range over which linearity deviation applies.

Linearity Deviation Deviation, in degrees, between actual network values and calculated straight line. This is stated as worst case; actual deviation is roughly sinosoidal about the calculated nominal.

Resistance Mode Formula for calculating R vs T.

E_o Negative Mode Formula for calculating the voltage across thermistor/resistor parallel network (bottom of bridge).

E_o Positive Mode Formula for calculating the voltage across R_1 (top of bridge).

E_{in} Max & I_t Max Values below which thermistors exhibit minimal self heating; determined using 8mW/°C dissipation. E_{in} max and I_t max values may be exceeded 5 times without damaging probe.

Load Resistance Minimum, RL The minimum recommended resistive impedance. Lower values may adversely affect linearity and other performance characteristics of the network.

Resistor Error Possible circuit error in degrees, induced by ±1% fixed resistors.