Measuring Temperature

with

Resistance Temperature Detectors (RTDs)

TEMPERATURE SENSORS

THERMOCOUPLE	RTD	THERMISTOR	SEMICONDUCTOR
Widest Range: –184°C to +2300°C	Range: –200°C to +850°C	Range: 0°C to +100°C	Range: –55°C to +150°C
High Accuracy and Repeatability	Fair Linearity	Poor Linearity	Linearity: 1°C Accuracy: 1°C
Needs Cold Junction Compensation	Requires Excitation	Requires Excitation	Requires Excitation
Low-Voltage Output	Low Cost	High Sensitivity	10mV/K, 20mV/K, or 1µA/K Typical Output

Applications Of Temp: Sensors

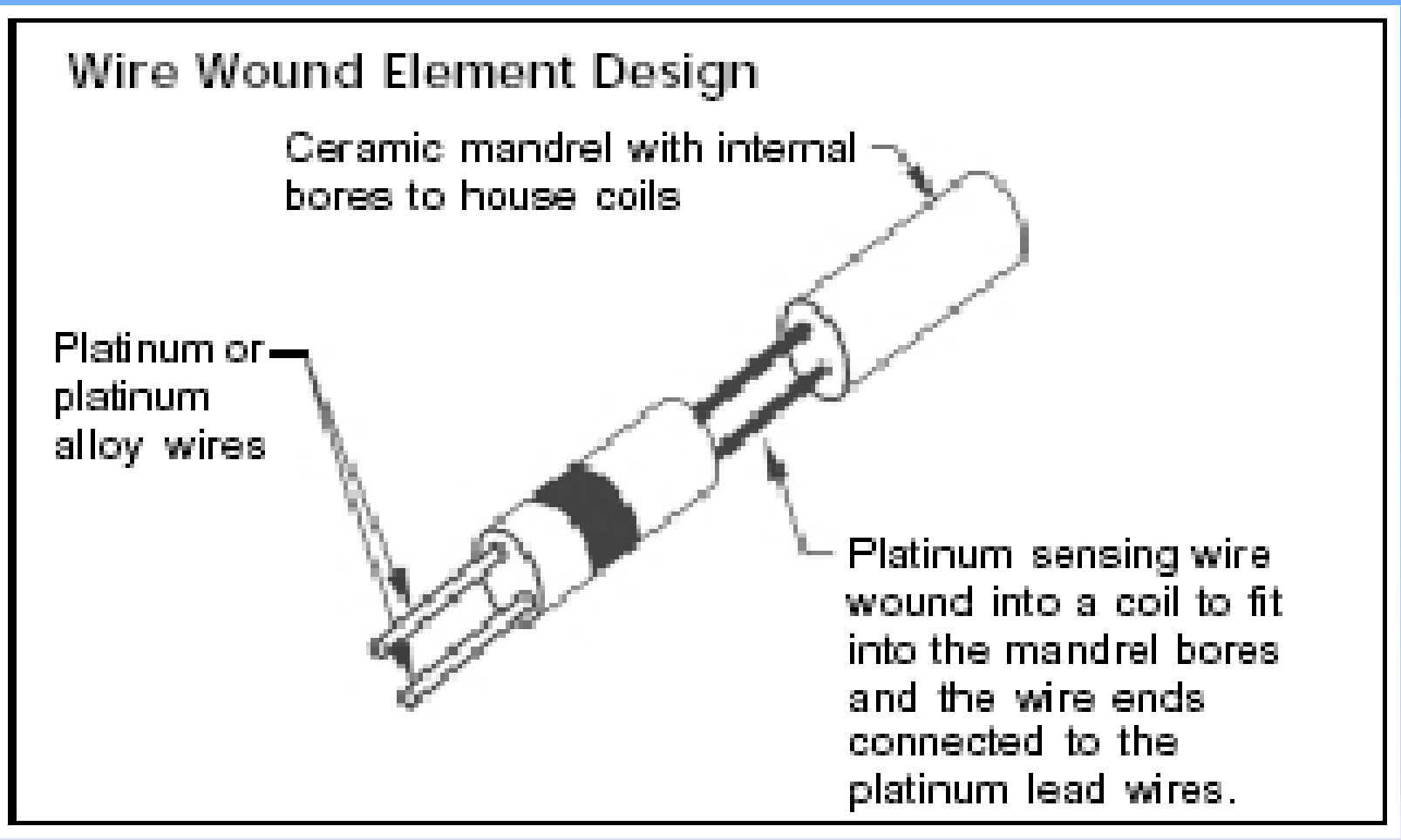
Control

- Process Control
- Battery Charging

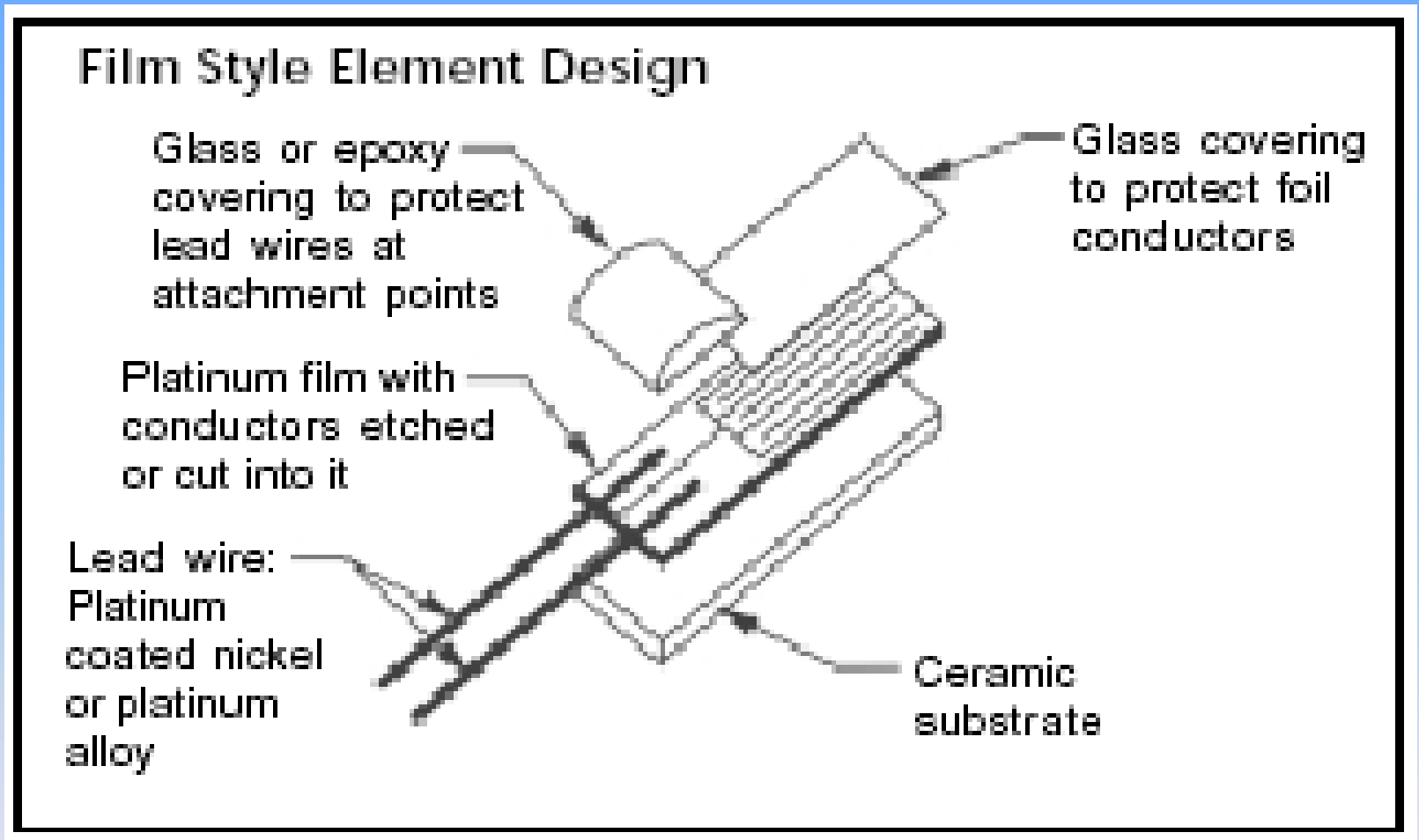
Monitoring

- Portable Equipment
- CPU Temperature
- Battery Temperature
- Ambient Temperature

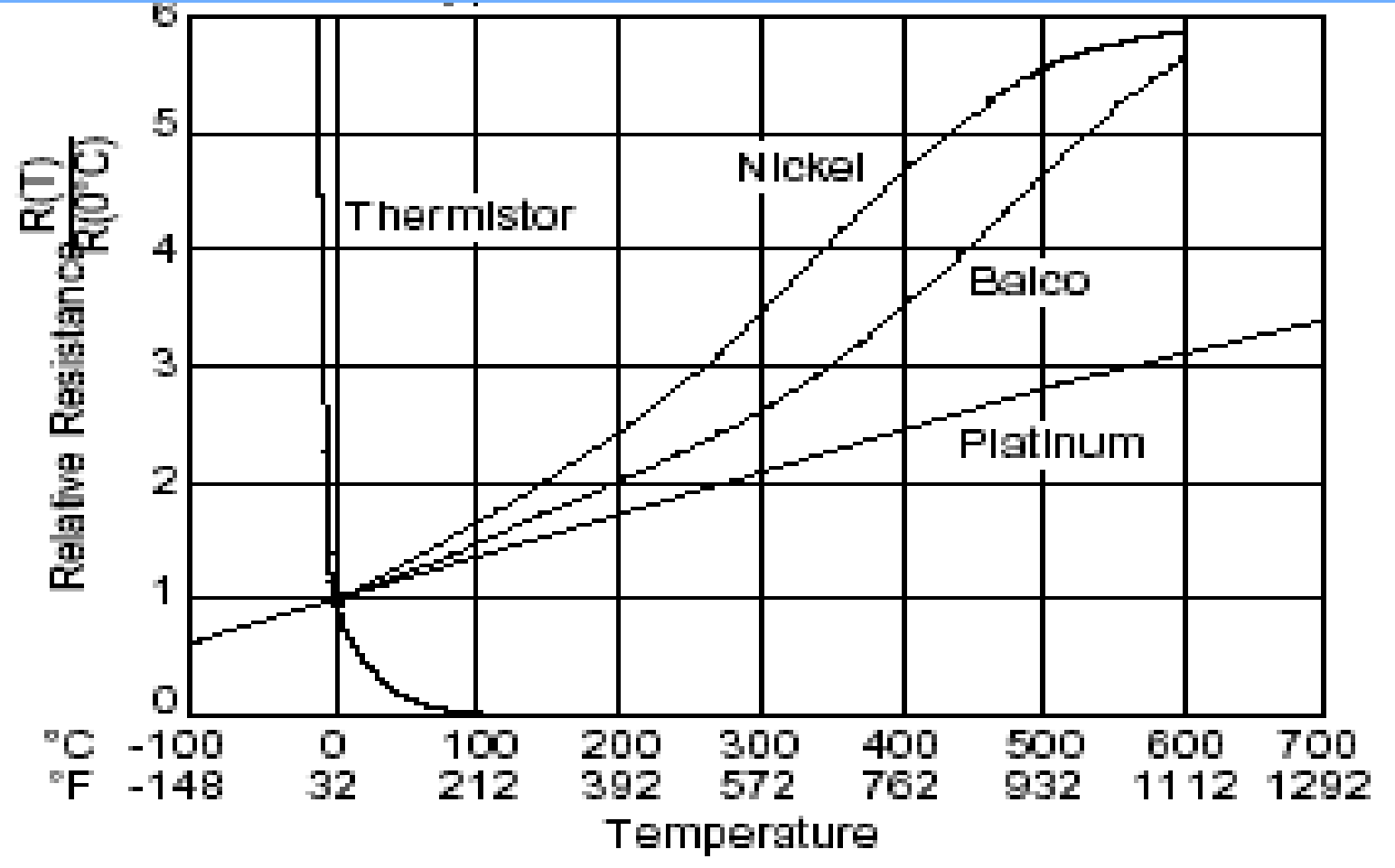
Wire Wound RTD



Thin Film RTD

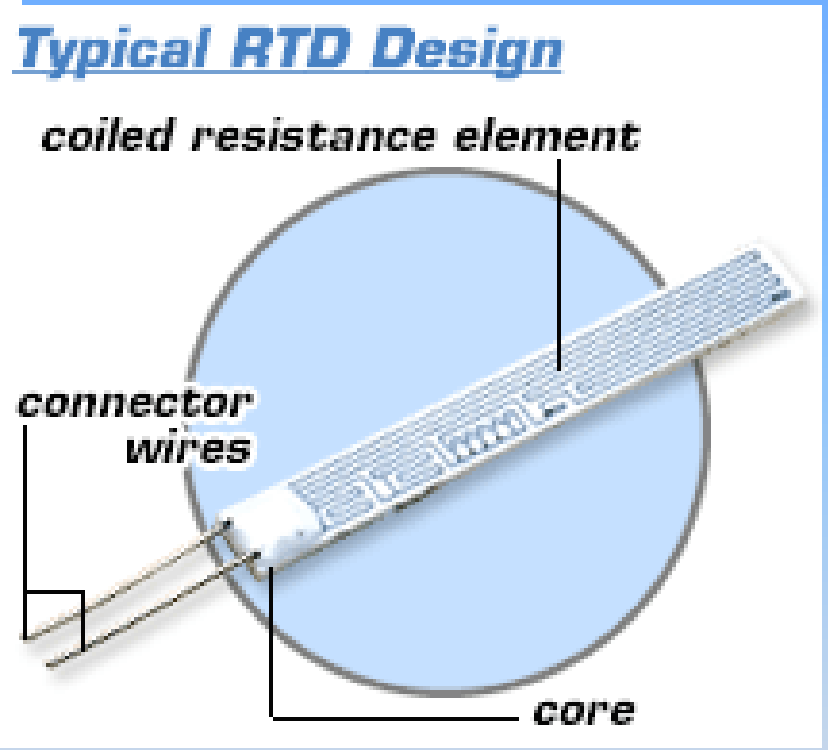


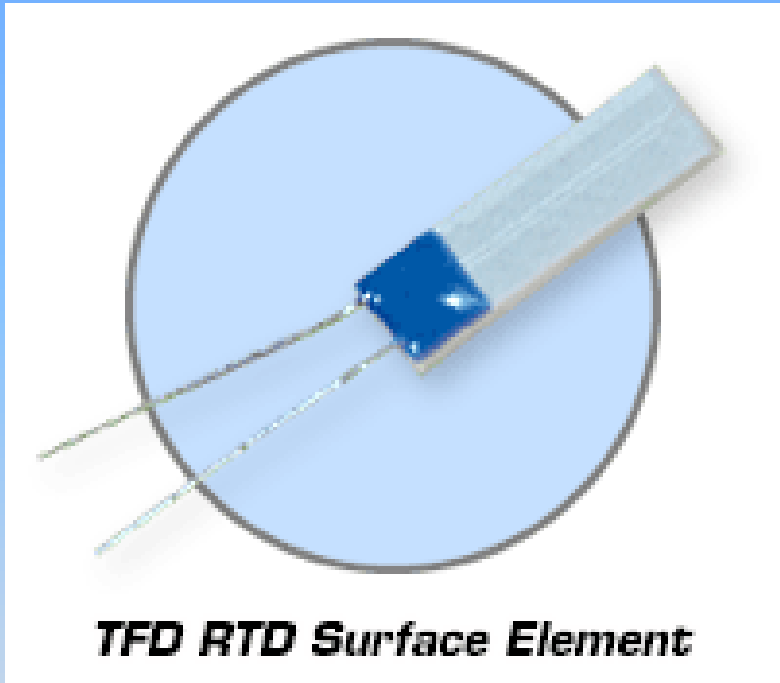
Relative Res. Vs Temp. of RTDs & Thermistors



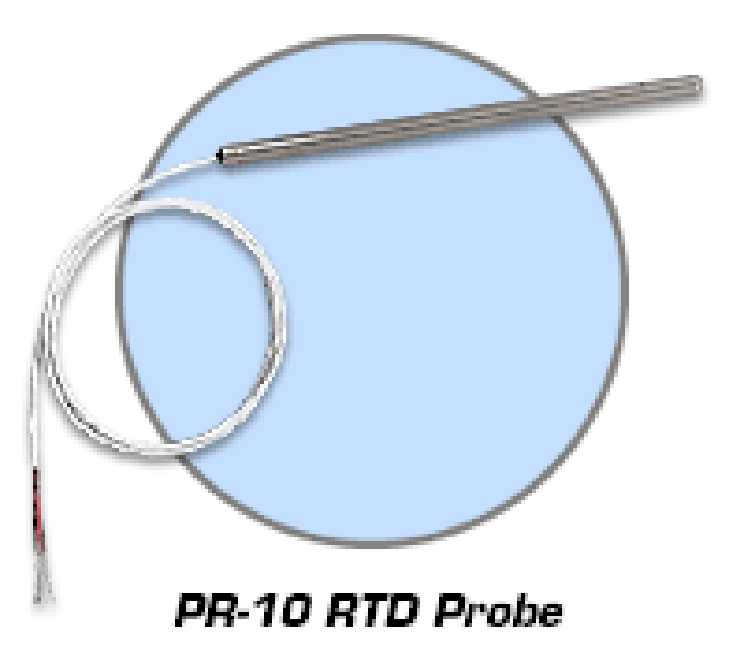
RTD Elements

1PT100G RTD Elements





TFD RTD Surface Element

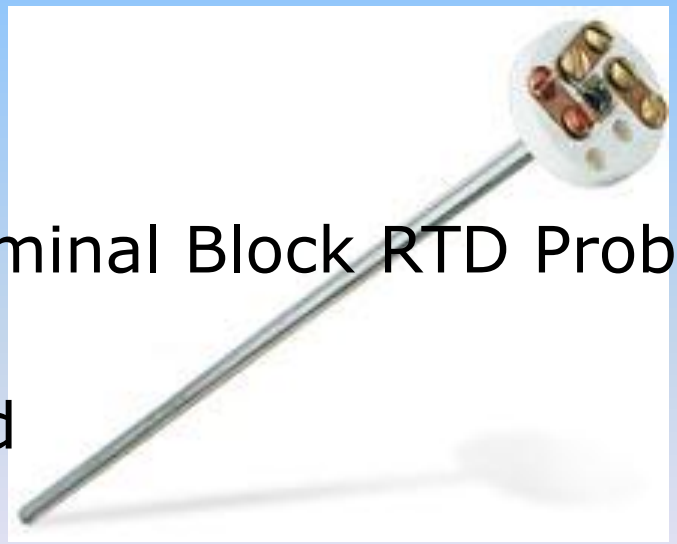


PR-10 RTD Probe

Industrial RTDs

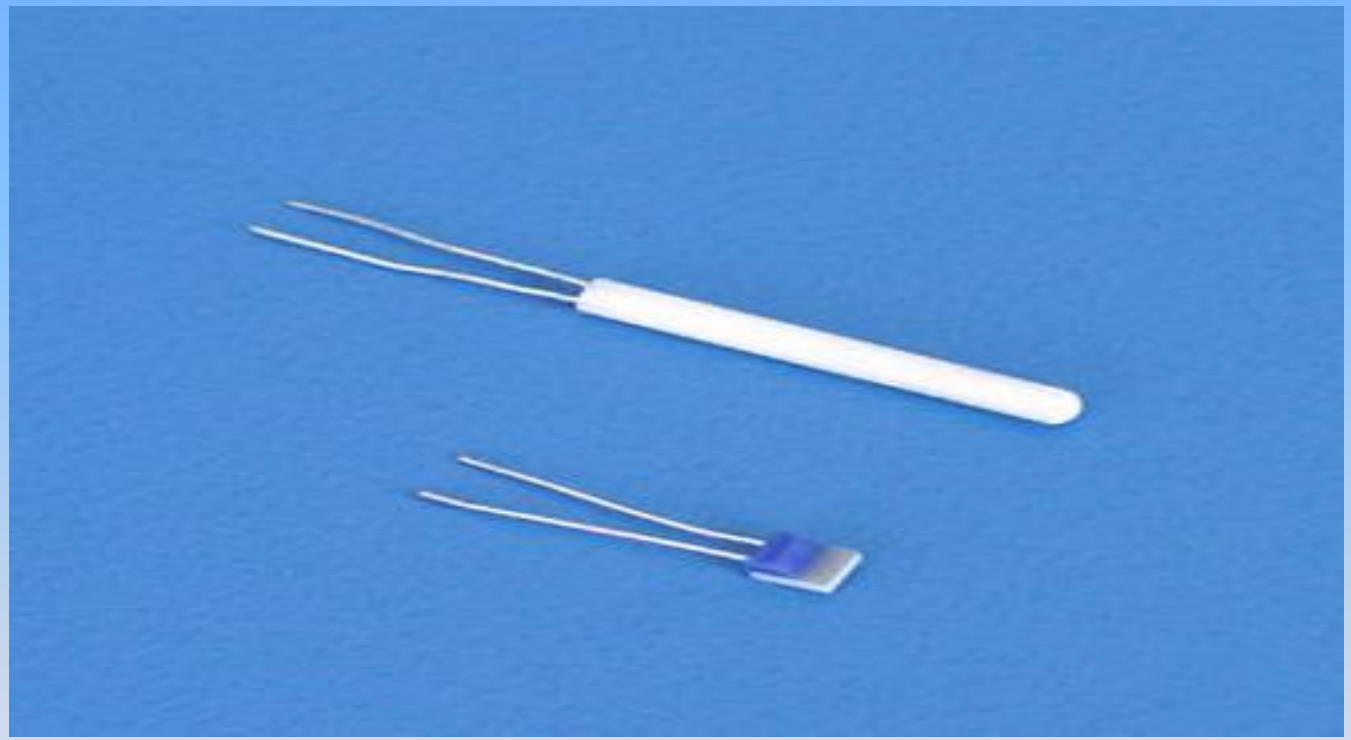
With Aluminum Protection Head

With Cast Iron Protection Head

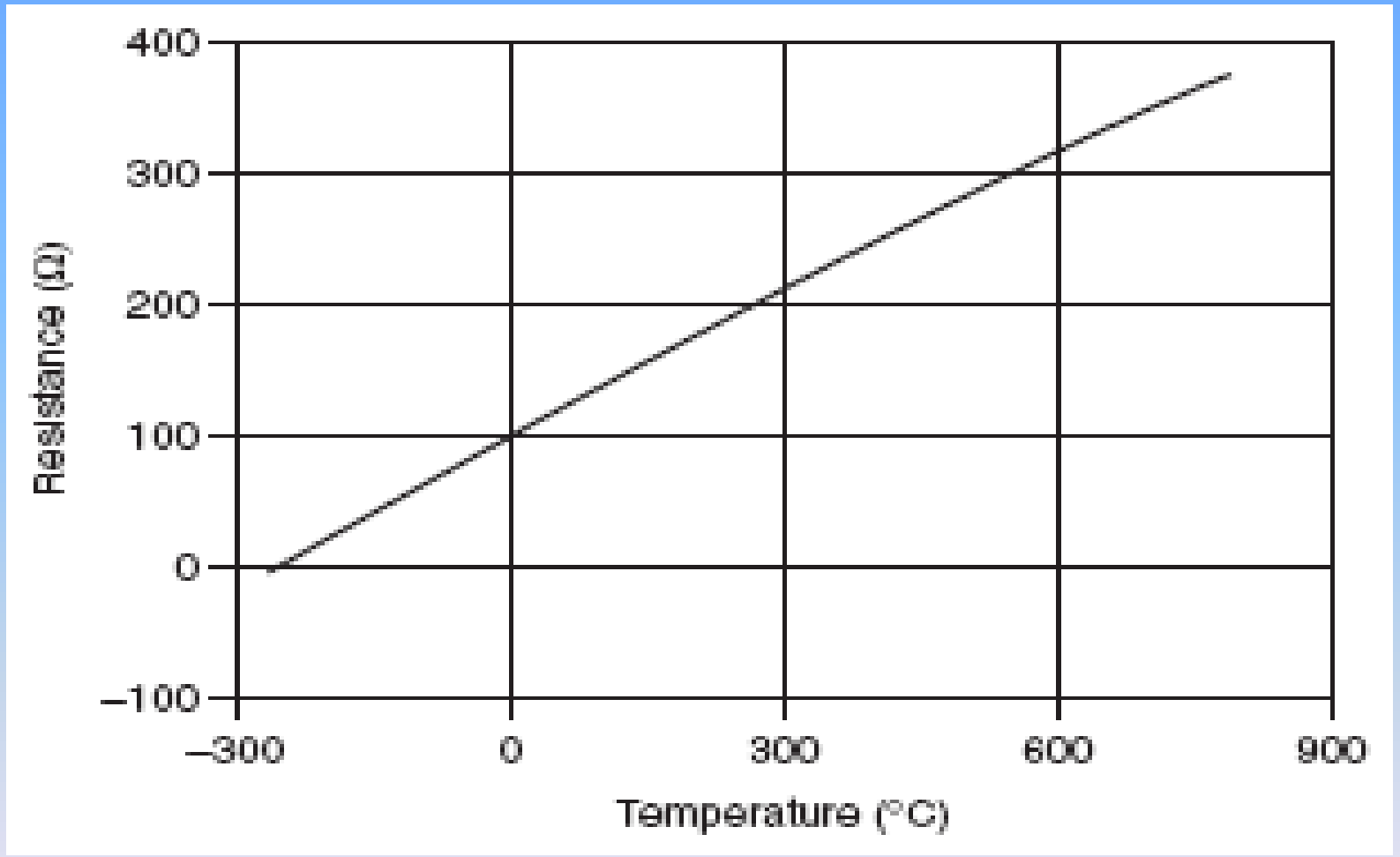


Terminal Block RTD Probe

Industrial RTD Elements



Res. Vs Temp. of 100 Ω, Pt RTD (α = 0.00385)



Platinum (Pt) **RTD**

- The Most Common
- 100 Ω &1000 Ω Standard Values
- Typical TC = 0.385% / °C,
- Good Linearity - Better than Thermocouple,Easily Compensated
- Superior repeatability & long term stability

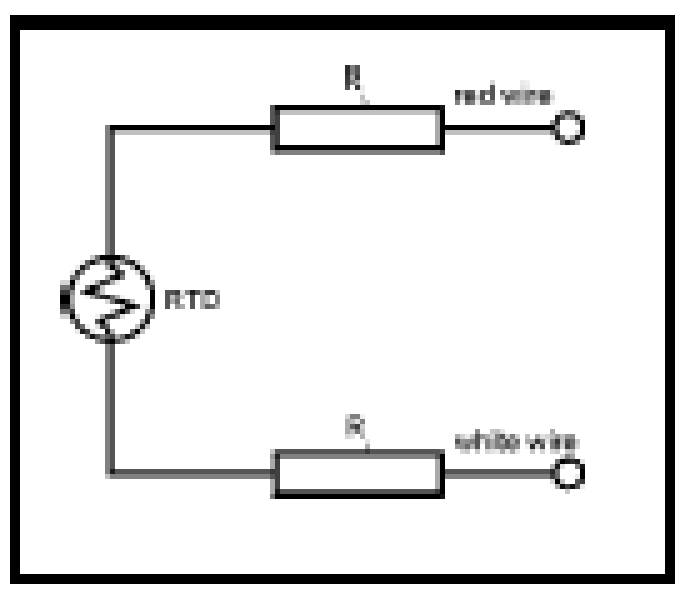
Pt RTD Comparison Chart

Characteristic	Pt RTD, Film	Pt RTD, WW
Active Material	Platinum thin film	Platinum, wire wound
Relative Sensor Cost	Moderate to Low	Moderate
Relative System Cost	Moderate	Moderate
Temp Range	-200°C to 750°C (560°C max. typ.)	-200°C to 850°C (600°C max. typ.)
Changing Parameter	Resistance	Resistance
Base Value	100 Ω TO 2000 Ω	100 Ω
Interchangeability	±0.1% , ±0.3°C	±0.06% , ±0.2°C
Stability	Excellent	Excellent

Pt RTD Comparison Chart

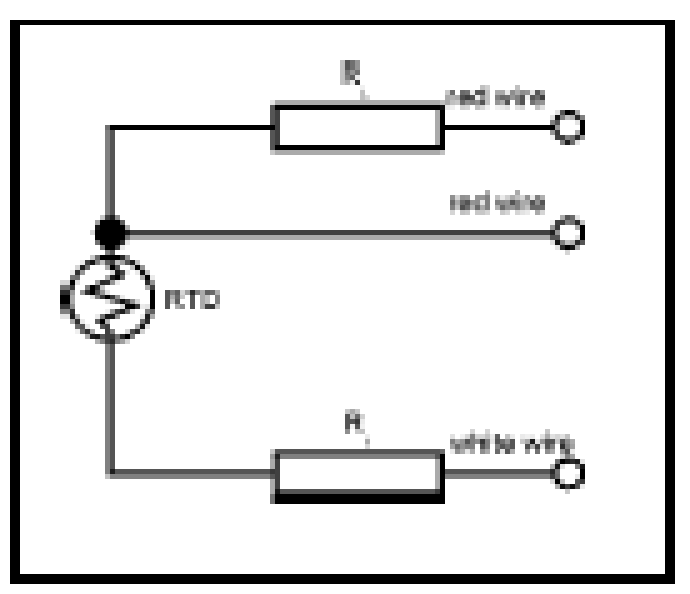
Sensitivity	0.39% /°C	0.39% /°C
Relative Sensitivity	Moderate	Moderate
Linearity	Excellent	Excellent
Slope	Positive	Positive
Noise Susceptibility	Low	Low
Lead Resistance Errors	Low	Low
Minimum Size (in.)	.050 x .065	0.5 x .060 ϕ
Minimum Probe Diameter	.080	.080
Special Requirements		Lead compensation

RTD Configurations



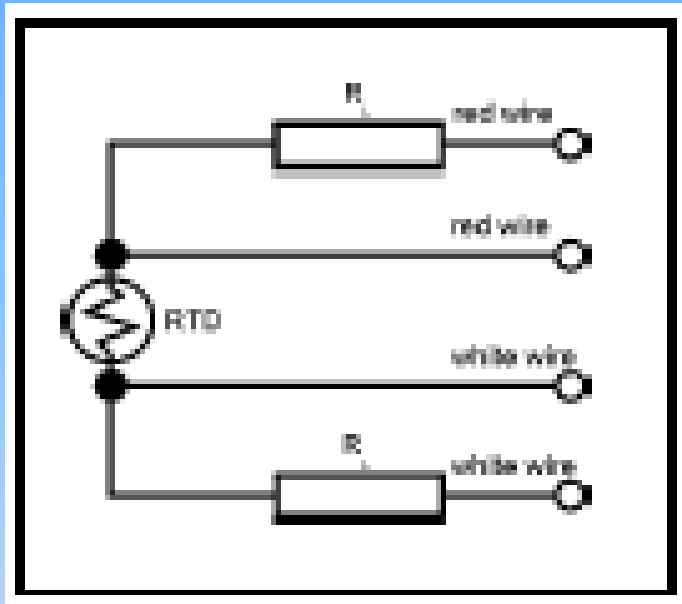
< Two Wire RTD

Three Wire RTD >



RTD Configurations

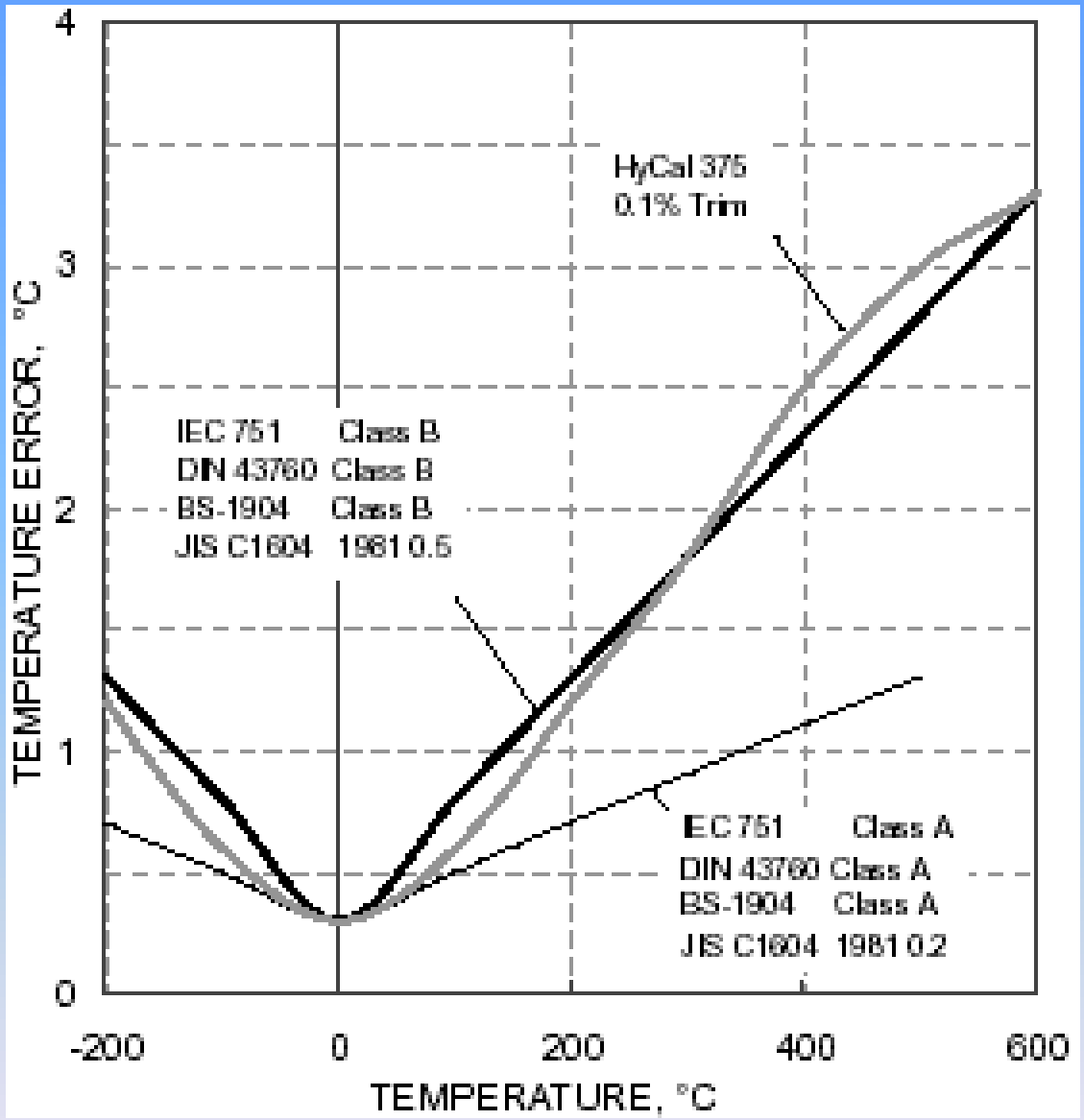
Four Wire RTD >



INTERNATIONAL STANDARDS	
Standard	Comment
IEC 751	Defines Class A and B performance for 100 Ω 0.00385 alpha Pt RTDs.
DIN 43760	Matches IEC 751.
BS-1904	Matches IEC 751.
JIS C1604	Matches IEC 751. Adds 0.003916 alpha.
ITS-90	Defines temperature scale and transfer standard.

Parameter	IEC 751 Class A	IEC 751 Class B
R_0	100Ω ± 0.06%	100Ω ± 0.12%
Alpha, α	.00385 ± .000063	.00385 ± .000063
Range	-200°C to 650°C	-200°C to 850°C

Pt RTD TEMPERATURE ACCURACY



Pt RTD Characteristics (IEC 751)

Stability:

- Drift in the temperature reading per unit time
- 0.005 to 0.25°C/year for Platinum

Repeatability:

- Drift at 0°C experienced after 10 cycles over its full operating temperature range
- Less than 0.05 % of FS at 0°C, for Platinum

Pt RTD Characteristics (IEC 751)….

Linearity:

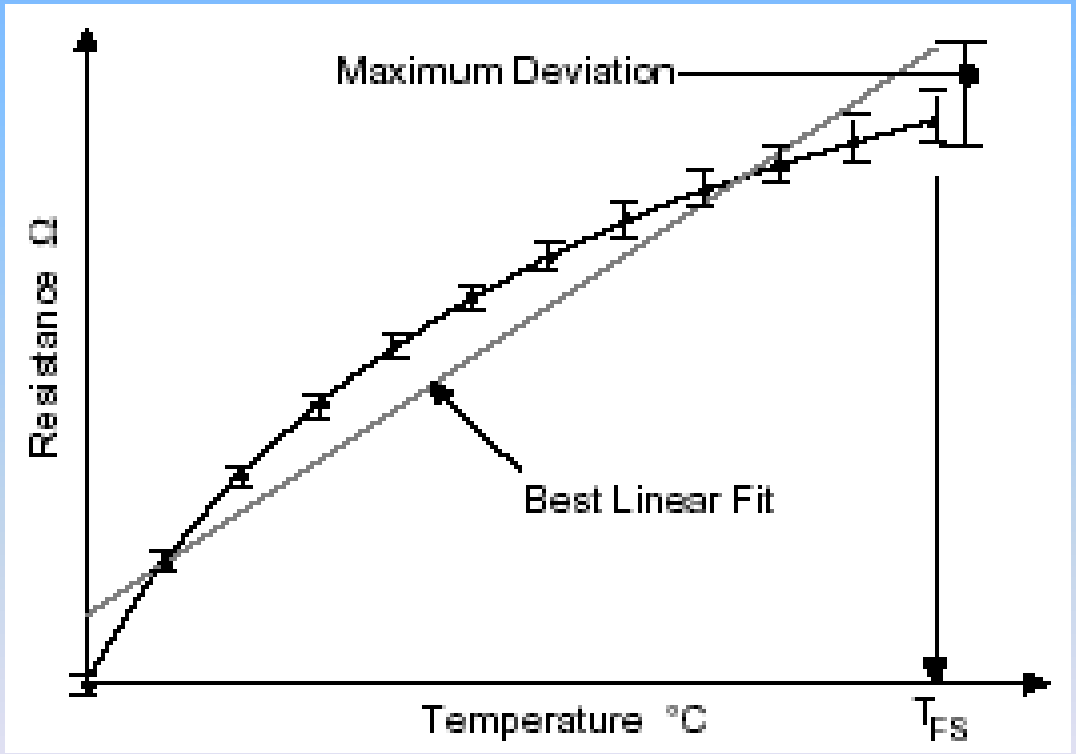
- Reference Line: Best linear fit

•Expressed as

Maximum deviation

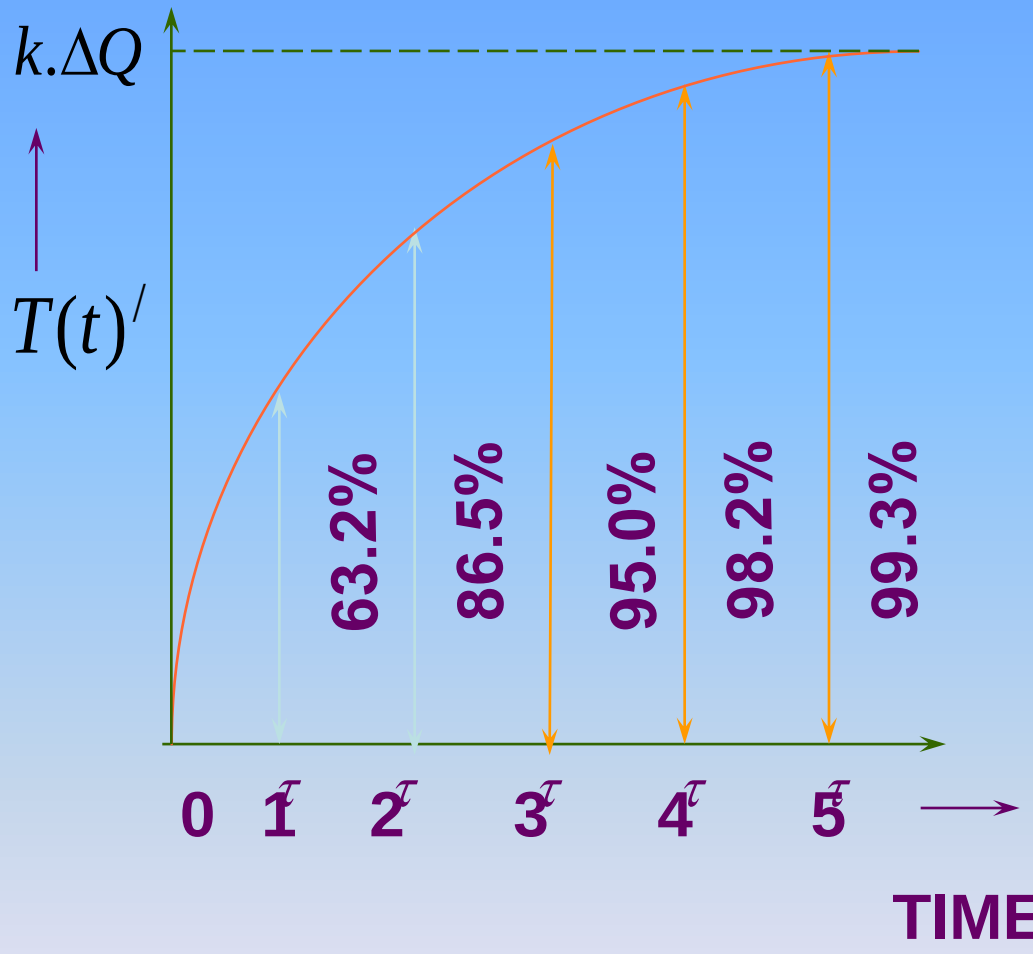
or

% of FS



Pt RTD Characteristics (IEC 751)….

Response Time:



Outlet Temperature Variation to the Step Change in Heat Input

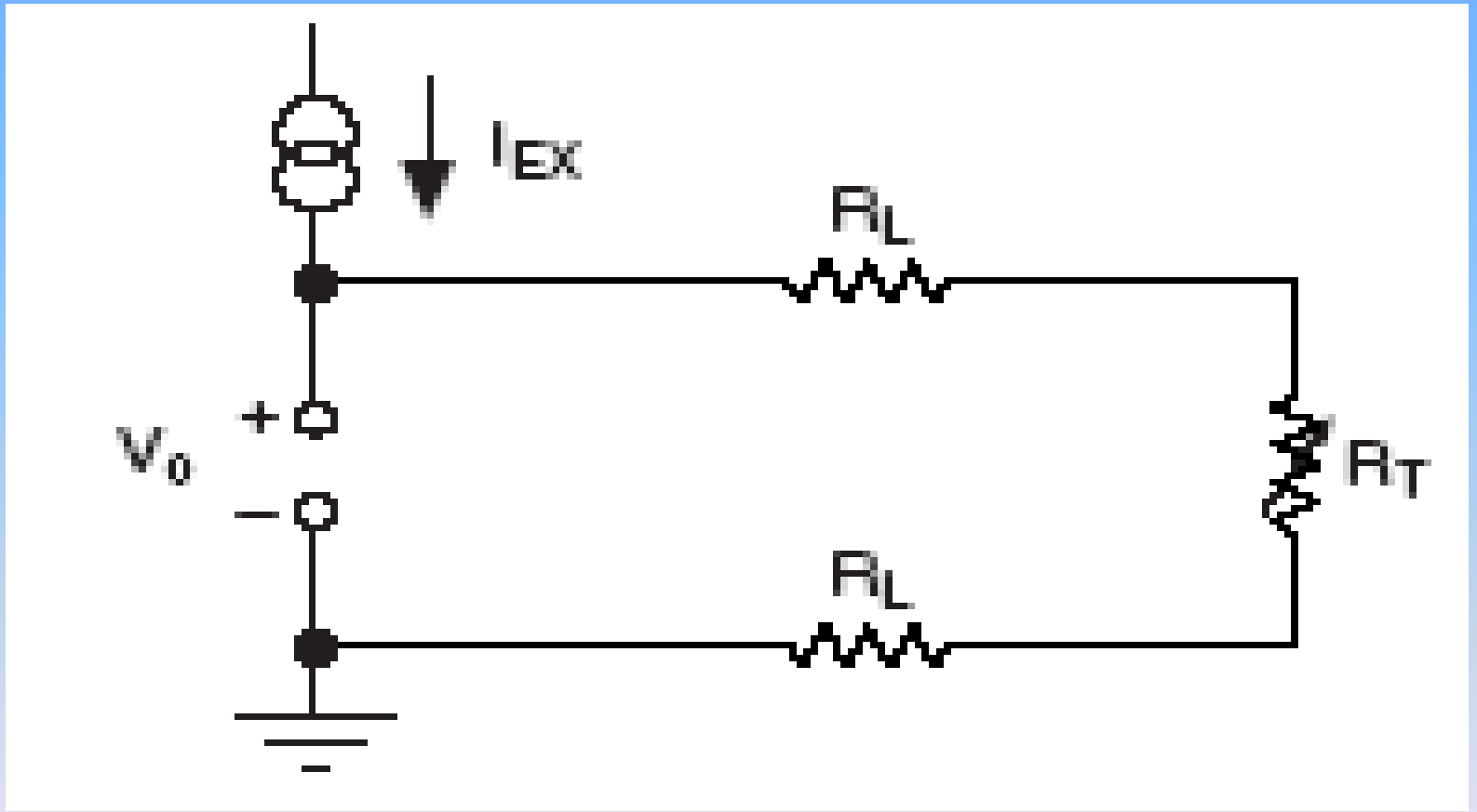
Pt RTD Characteristics (IEC 751)….

Response Time:

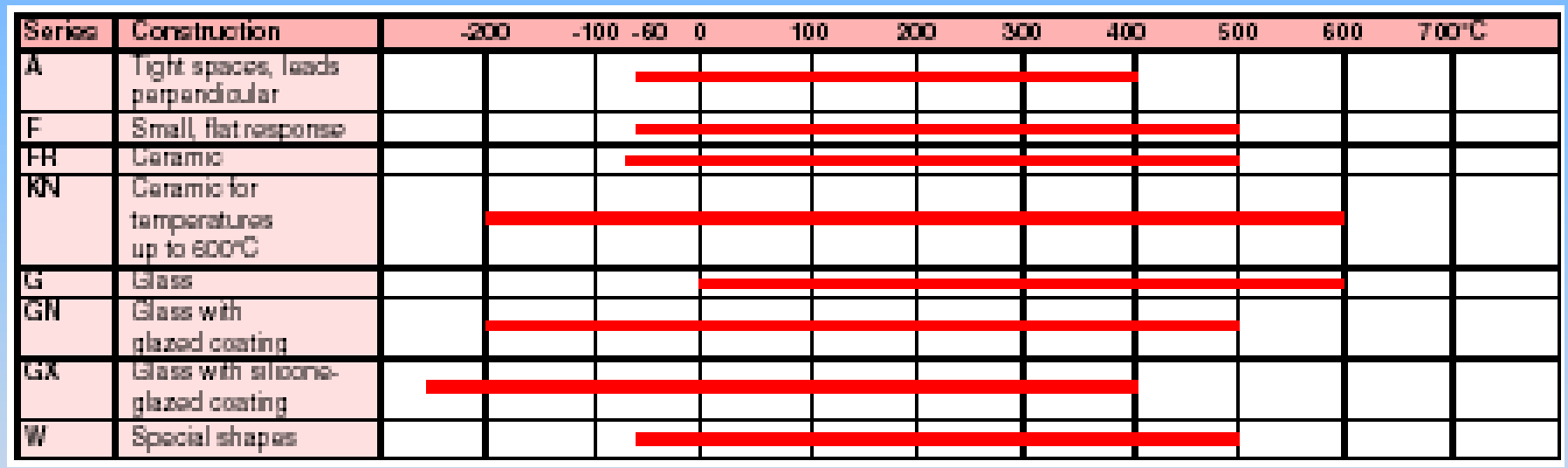
Sheath Diameter	Response Time
1/8"	2 Seconds
3/16"	3 Seconds
1/4"	5 Seconds

Self Heating:

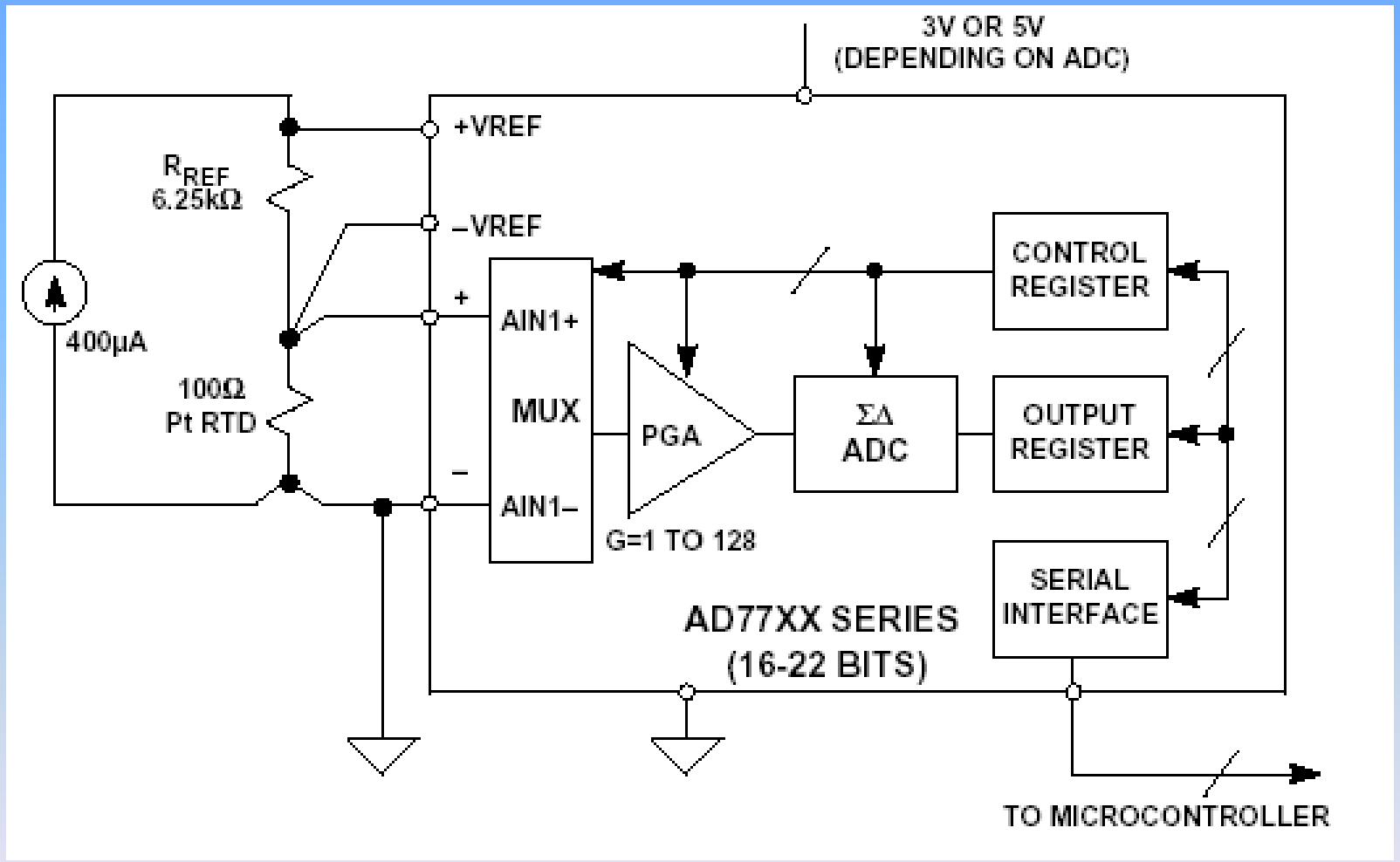
2-Wire RTD Measurement



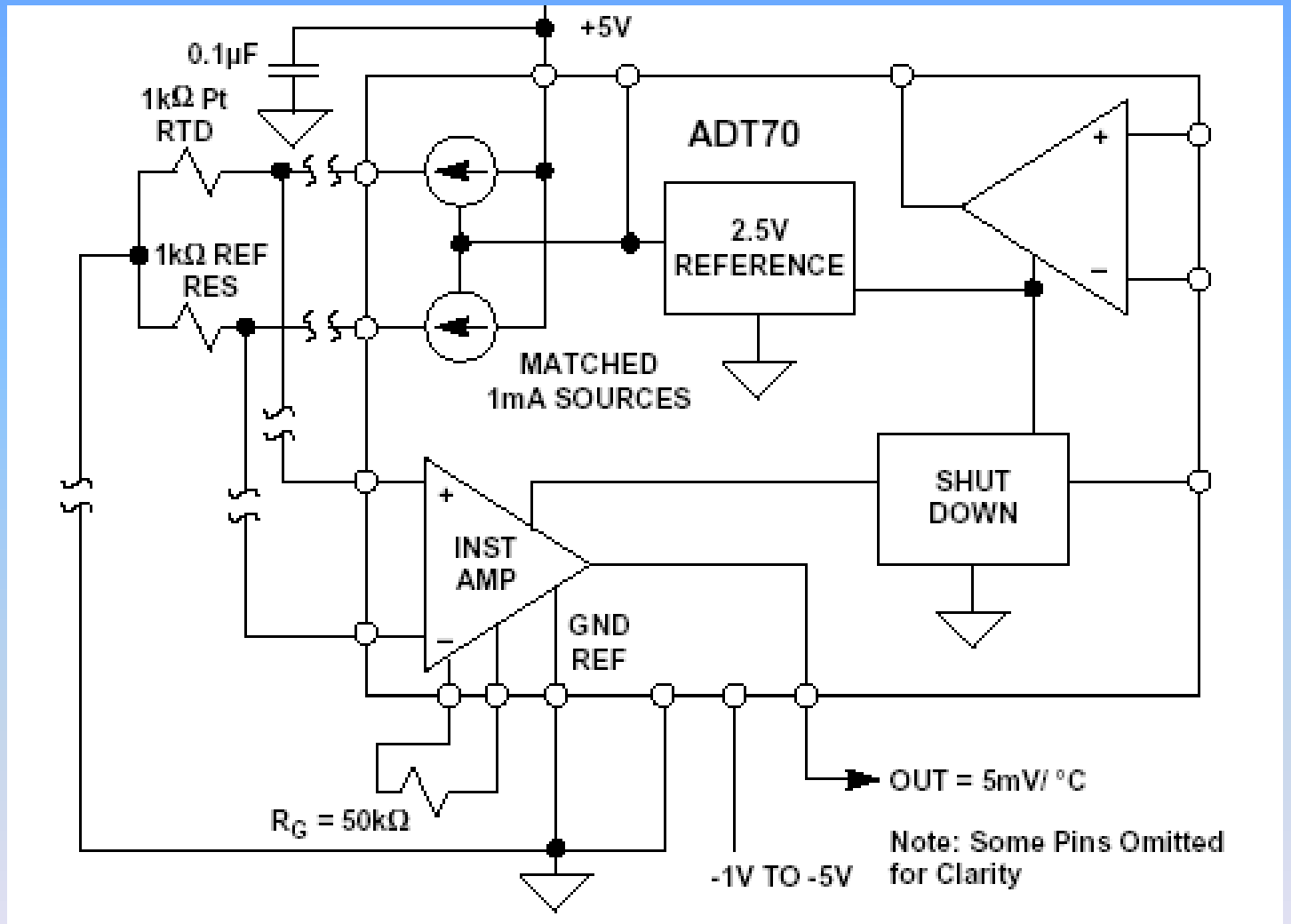
Recommended Temp. Ranges-PtRTD Elements



Interfacing Pt RTD to ADC



Interfacing &Conditioning Pt RTD Signal



Callendar-Van Dusen equation

$$R_t = R_0 [1 + At + Bt^2 + C(t - 100)^3]$$

For T>0, C =0

$$R_t = R_0 [1 + At + Bt^2]$$

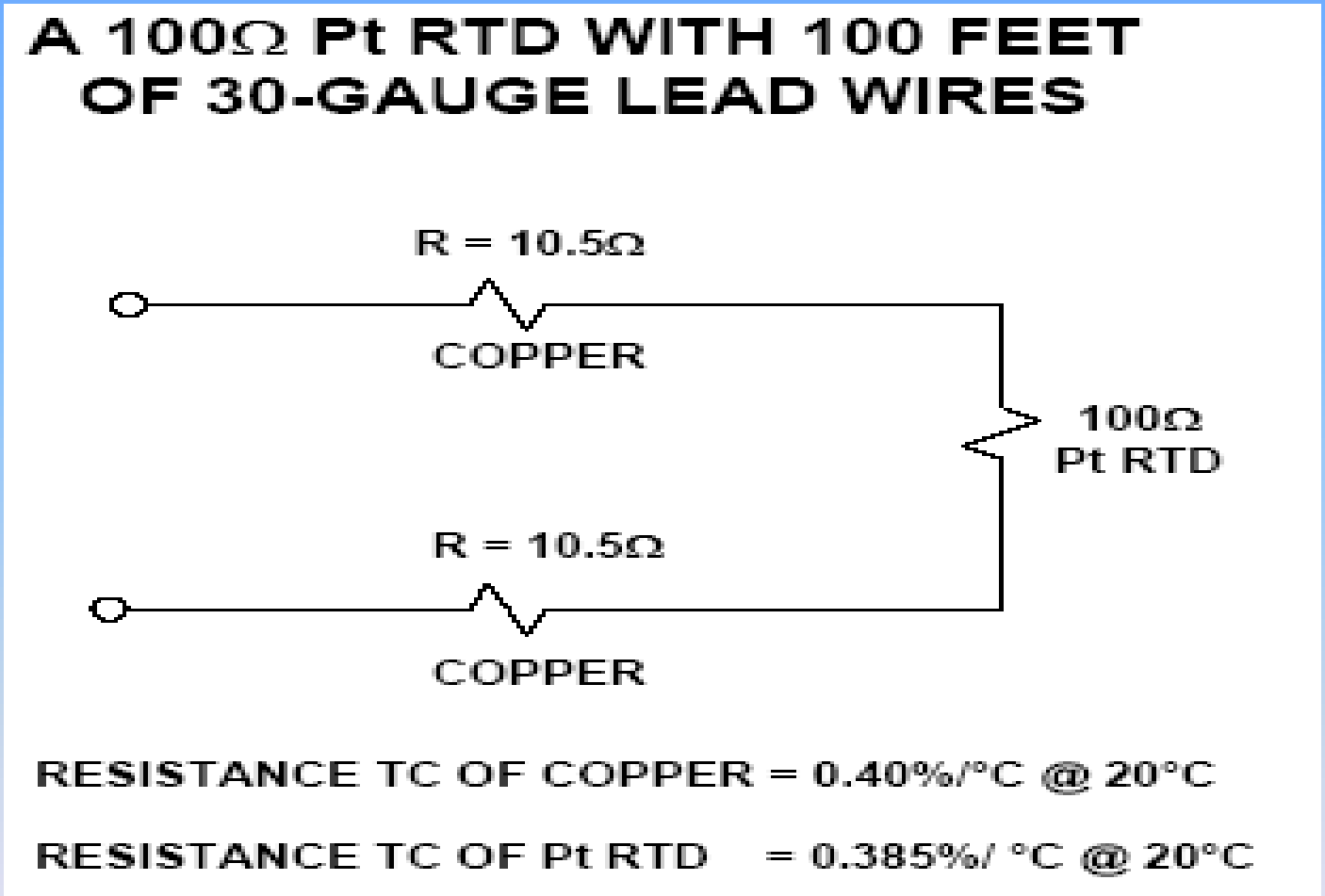
$$R_t = V_0 / I_{EX}$$

$$V_0 / I_{EX} = R_0 [1 + At + Bt^2]$$

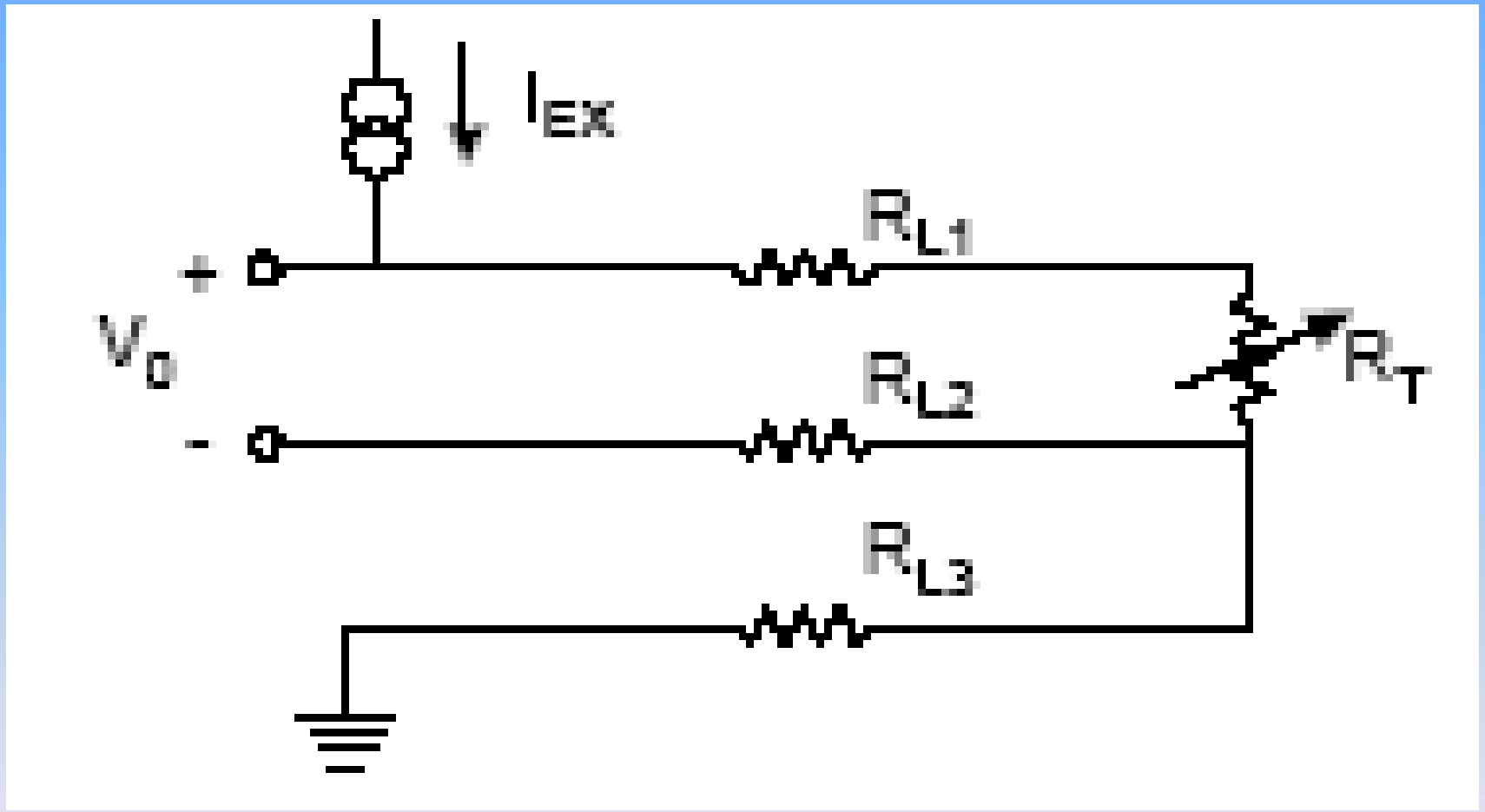
Callendar-Van Dusen Coefficients: Platinum RTDs

Standard	α	$A/10^{-3}$	$B/10^{-7}$	$C/10^{-12}$
IEC 751/ DIN 43760	0.003850	3.9080	-5.8019	-4.2735
American	0.003911	3.9692	-5.8495	-4.2325
ITS-90	0.003926	3.9848	-5.870	-4.0000

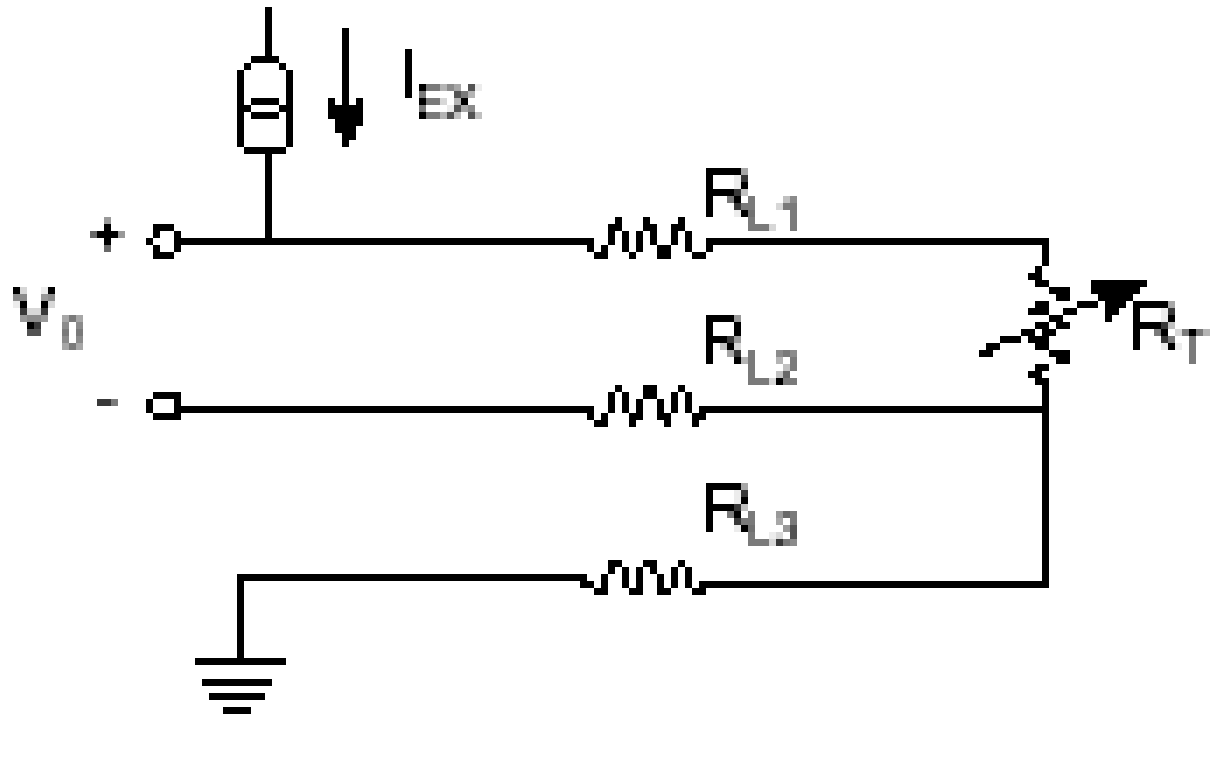
2-Wire RTD Measurement…..



3-Wire RTD Measurement (con: I)



3-Wire RTD Measurement (con:I).....

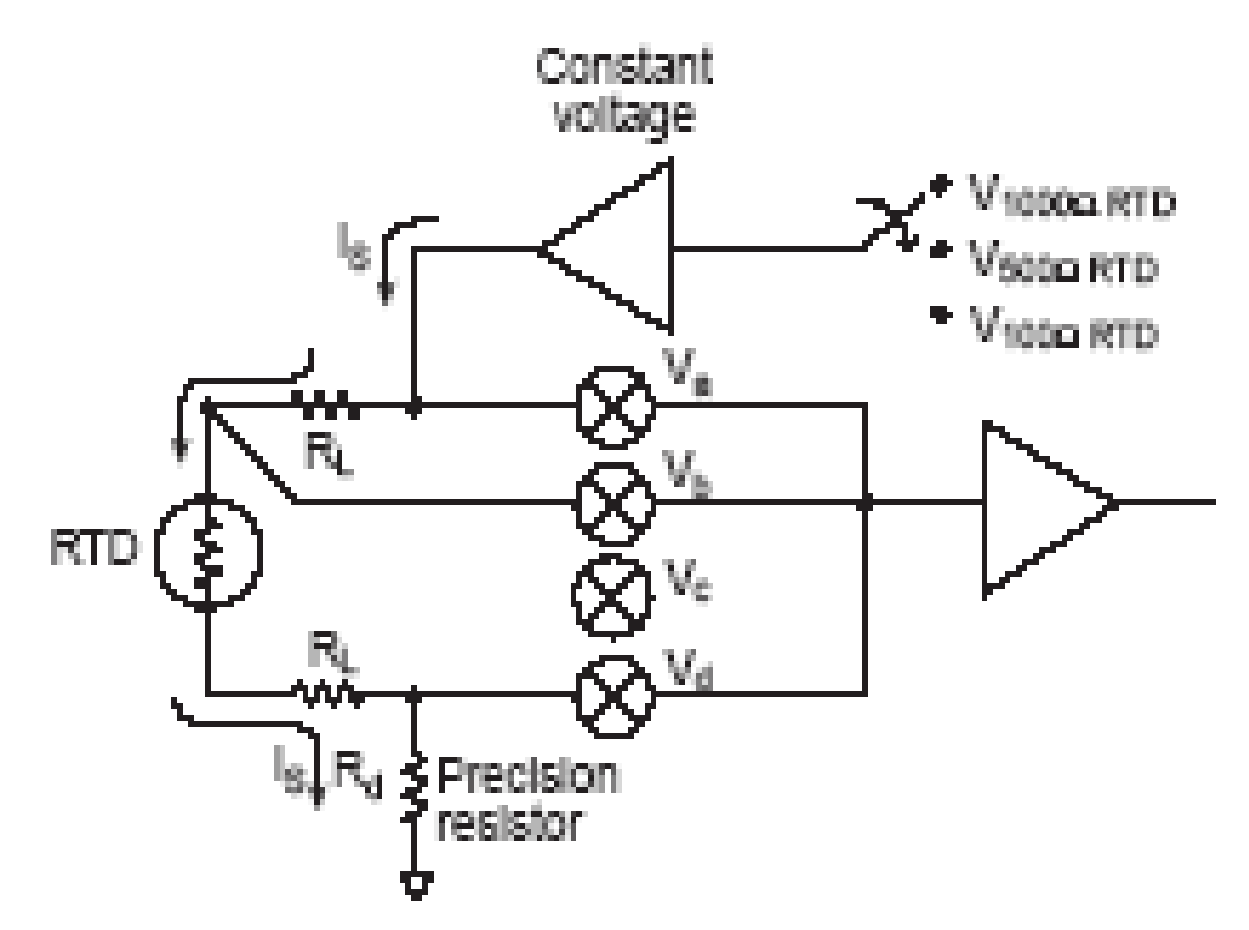


3-Wire RTD Measurement (con:I)..

$$V_{RTD} = V_0 - V_{wiredrop}$$

$$R_{RTD} = V_{RTD} / I_s$$

3-Wire RTD Measurement (Ratiometric)



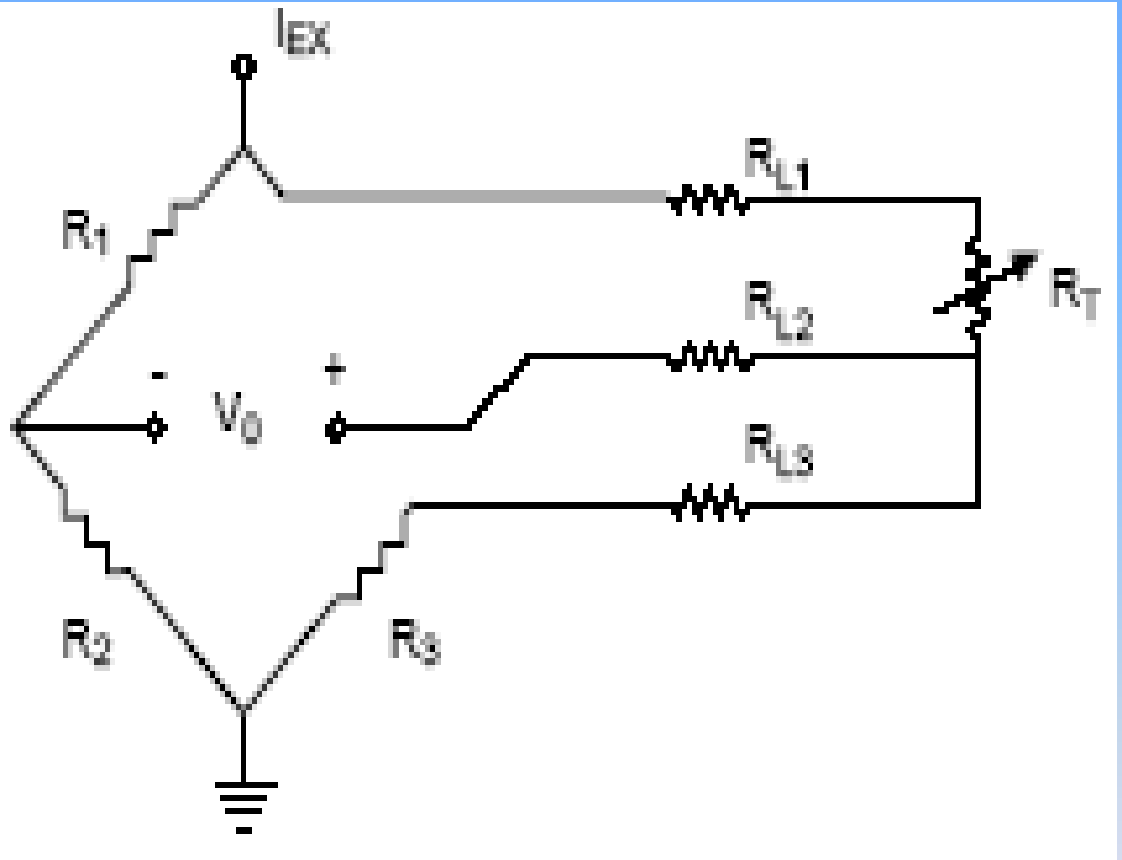
3-Wire RTD Measurement (Ratiometric)

$I_s = V_d/R_d$

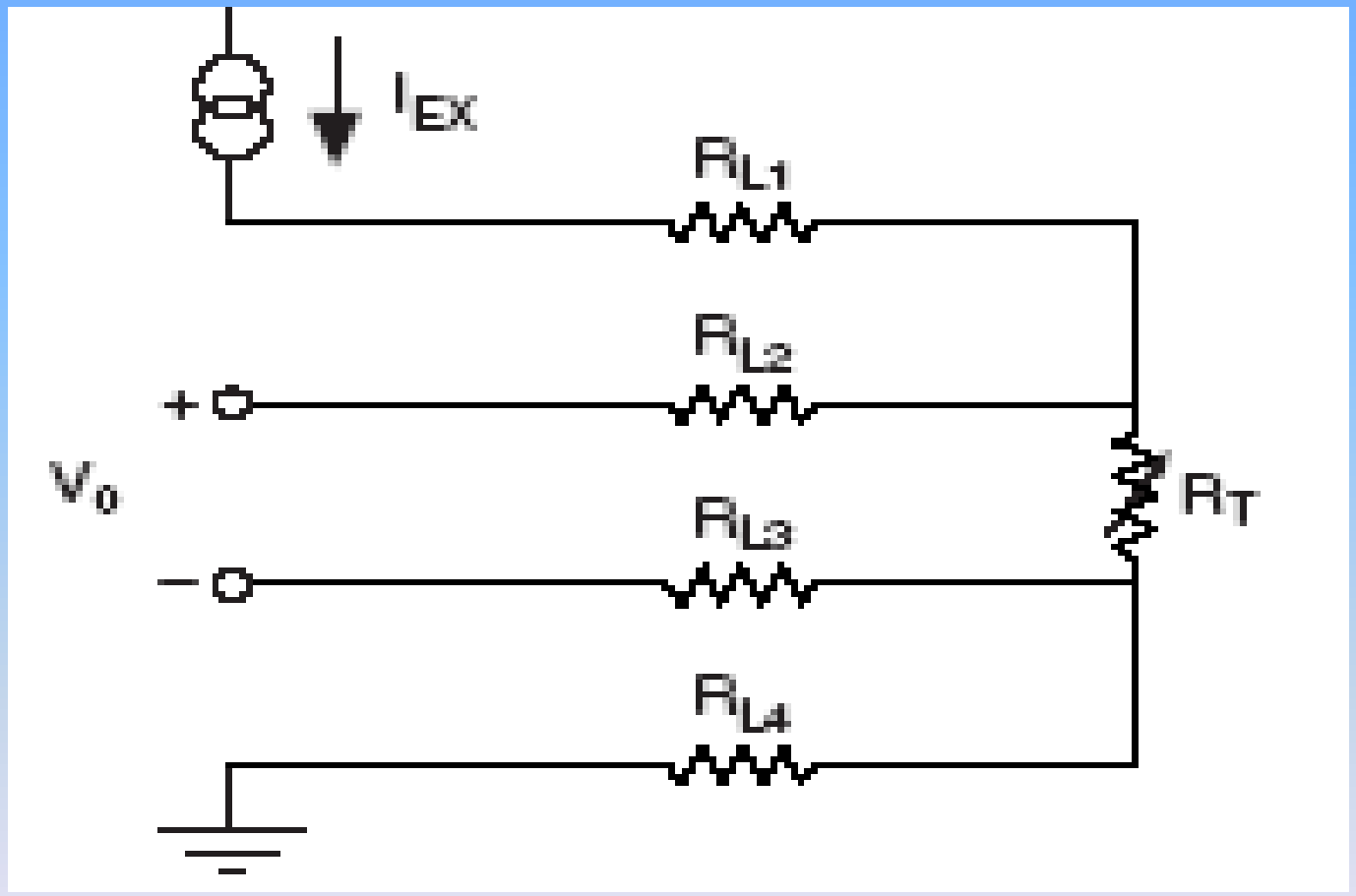
$V_{RTD} = Va\text{-}2\ (V_a\text{-}V_b)\text{-}V_d$

$R_{RTD} = V_{RTD} / I_s$

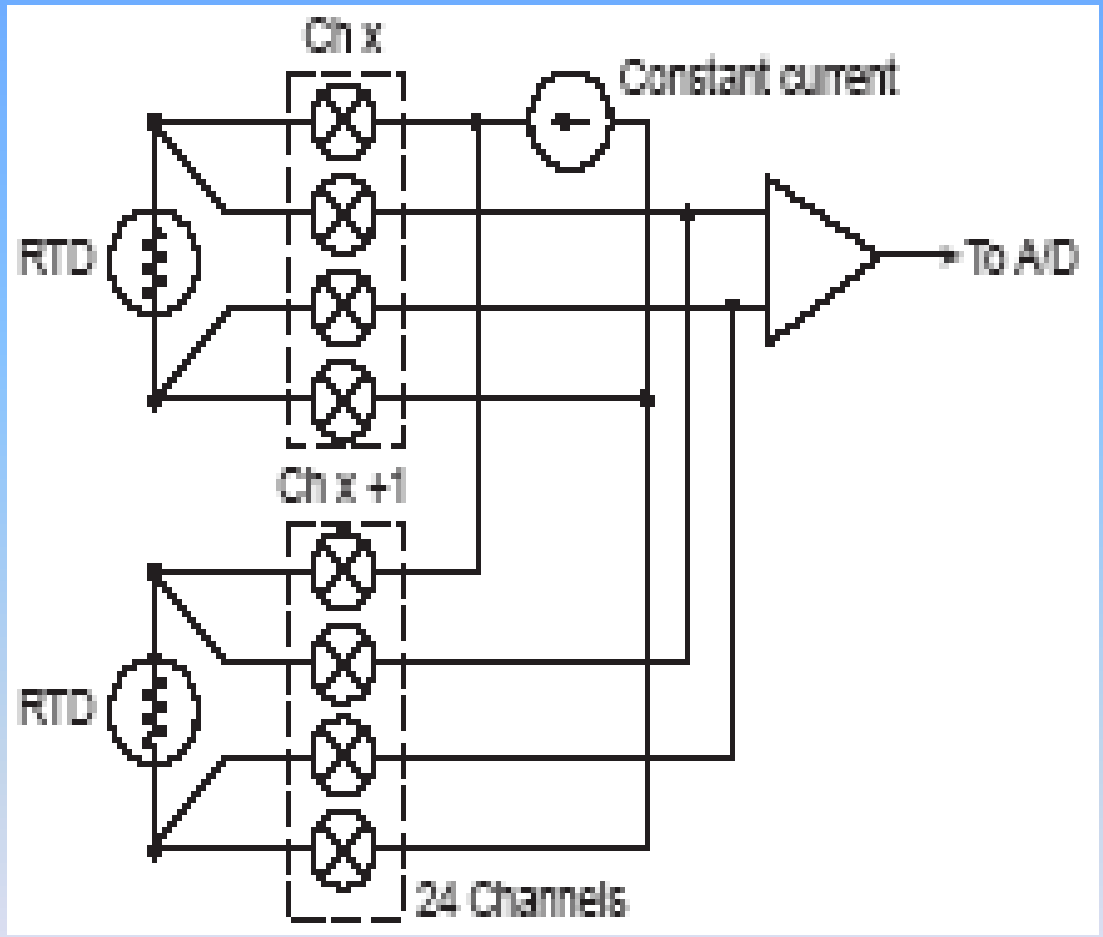
3-Wire RTD Measurement (Bridge Config:)



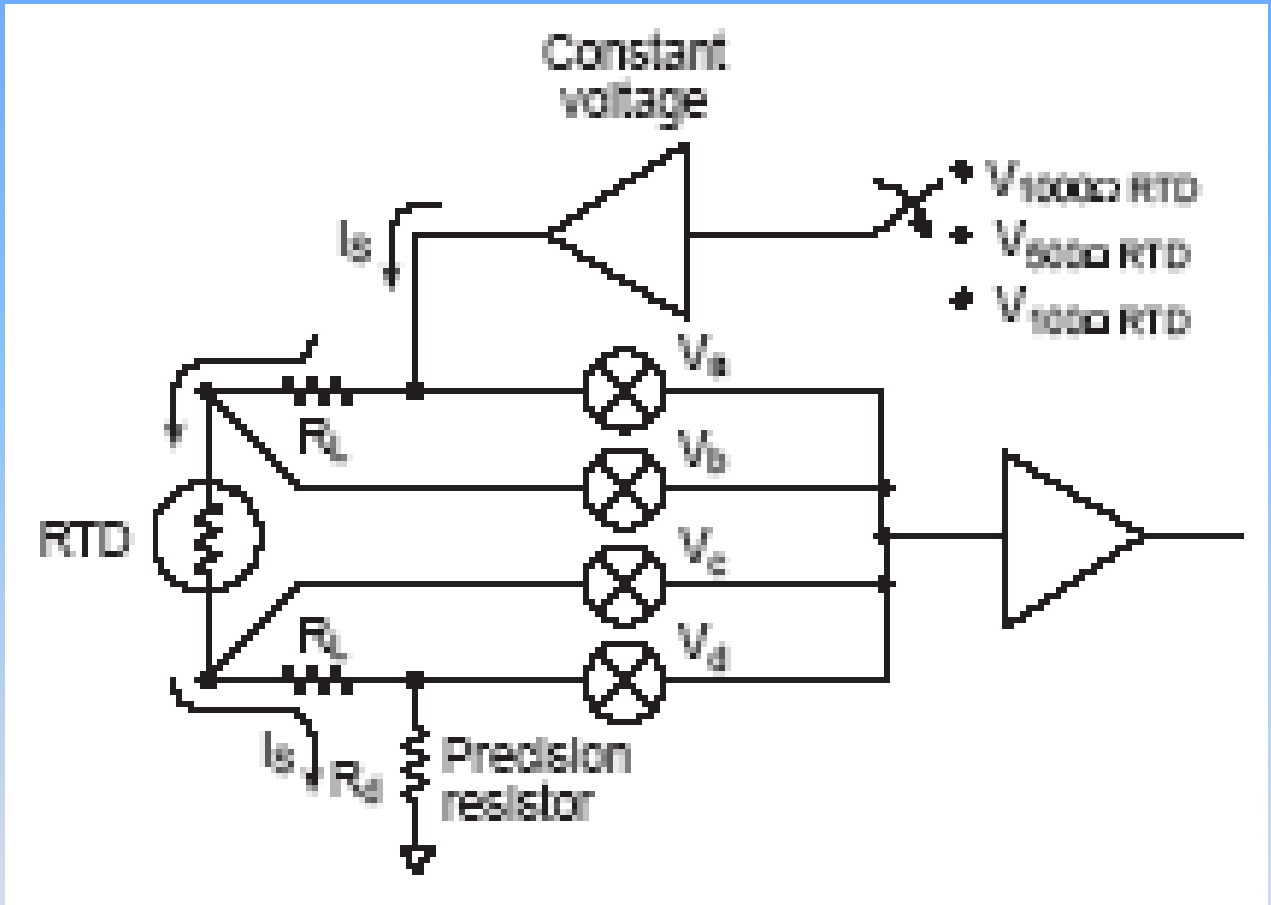
4-Wire RTD Measurement



4-Wire RTD Measurement(con: I)



4-Wire RTD Measurement(Ratiometric)



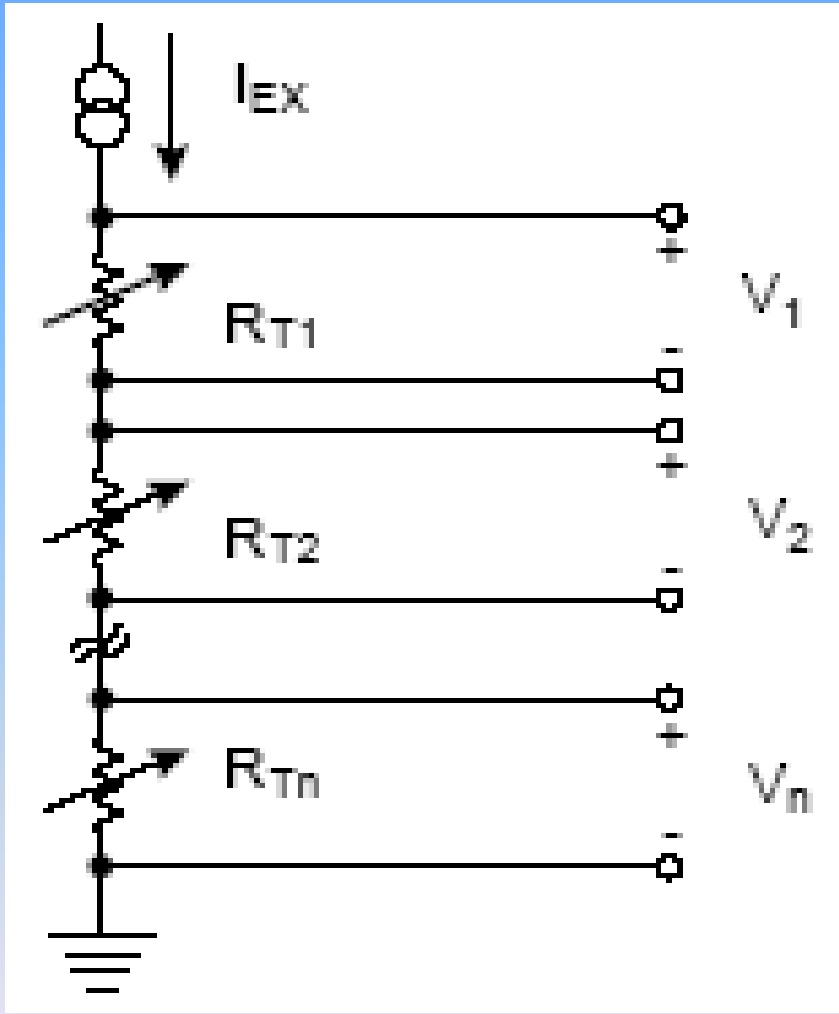
4-Wire RTD Measurement (Ratiometric)

$$I_s = V_d / R_d$$

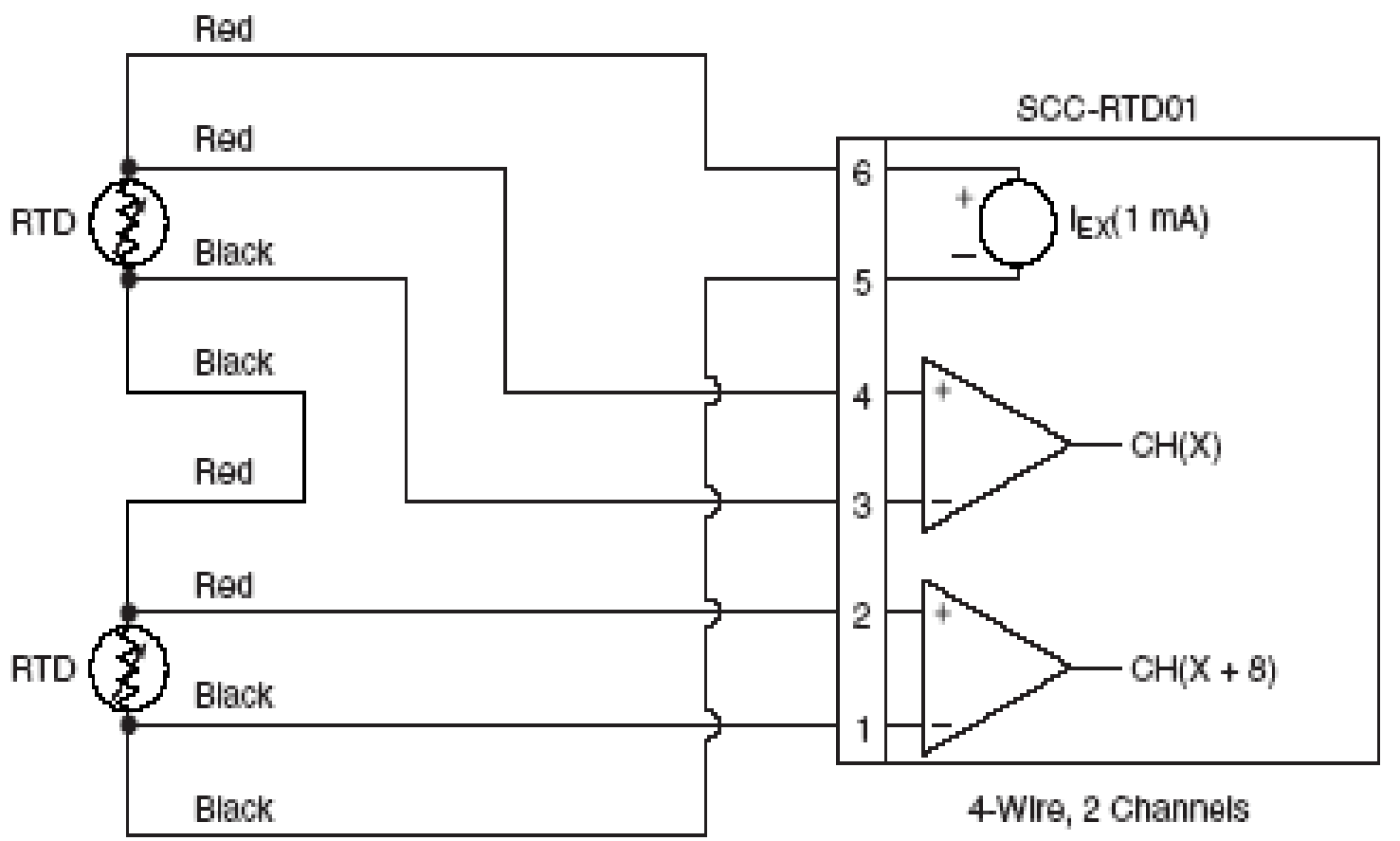
$$V_{RTD} = V_b - V_c$$

$$R_{RTD} = V_{RTD} / I_s$$

Low-Cost RTD Measurements



Low-Cost RTD Measurements



RTD Measurement Issues

Small Resistance vs. Large Resistance RTDs		
	Small RTD	Large RTD
Response Time	Fast	Slow
Thermal Shunting	Low	Poor
Self-heating Error	High	Low

Selection of Thermocouple Vs Pt RTD

Criteria	Comparison
Range	TC:-184°C to 2300°C RTD: -200°C to 850°C (600°C max. typ.)
Response	Grounded TC, 3 time faster than RTD
Sensor Cost	TC costs 3 time less than RTD
System Cost	More than RTD
Sensor Accuracy	RTD accuracy ≥ TC accuracy

Selection of Thermocouple Vs RTD.....

Criteria	Comparison
Linearity	Better for RTD
Stability	Better for RTD
Repeatability	Better for RTD
Ruggedness	TC essentially single piece construction
Long term accuracy	RTD has Long term Stability, Linearity, Superior Repeatability .....
Vibration & Mechanical Shock	TC is better than RTD