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M ERATURE CONTROLLER

Resistance temperature detectors (RTDs), thermistors, solidstate devices and thermocouples are well known as temperature sensing elements. RTDs give linear output and offer temperature range of -220° to 550°C, whereas thermocouples are non-linear in character and they need cold junction compensation in measurement circuit. Their output is too low compared to RTDs which are excited externally to get proper output. Thermocouples are available in various ranges and are particularly useful for higher range of temperature, i.e. from -200°C to about 2500°C. Recently, ceramic style protection tube and ceramic fibre in place of asbestos insulation has improved thermocouples' temperature capability and resistance to corrosive environment.

In this article, use of temperature sensing elements, such as RTDs and TCs in temperature controller, has been discussed and design of temperature controller with defined band of temperature has been explained. These controllers have many diverse applications such as motorised valve, motor actuator, magnetic valve etc in the process control applications and in heating and airconditioning circuits. These controllers are found to give a control accuracy of 0.25% to 0.5% of FSD.

Principle of temperature controller

Popularly known as PT-100, a platinum resistance bulb is used as one arm of the wheatstone bridge as sensing element. Its calibration characteristics are shown in Fig. 1. This bridge when connected to 100-ohm resistance and excited by 5V DC source, would give an output proportional to the ambient temperature. This is amplified by an op-amp and fed to a voltmeter which has been calibrated for measurement purposes.

Theoretically obtained voltage V_{ab} from bridge can be

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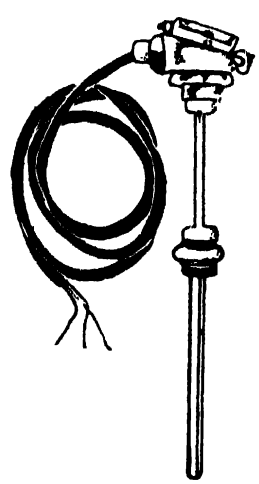
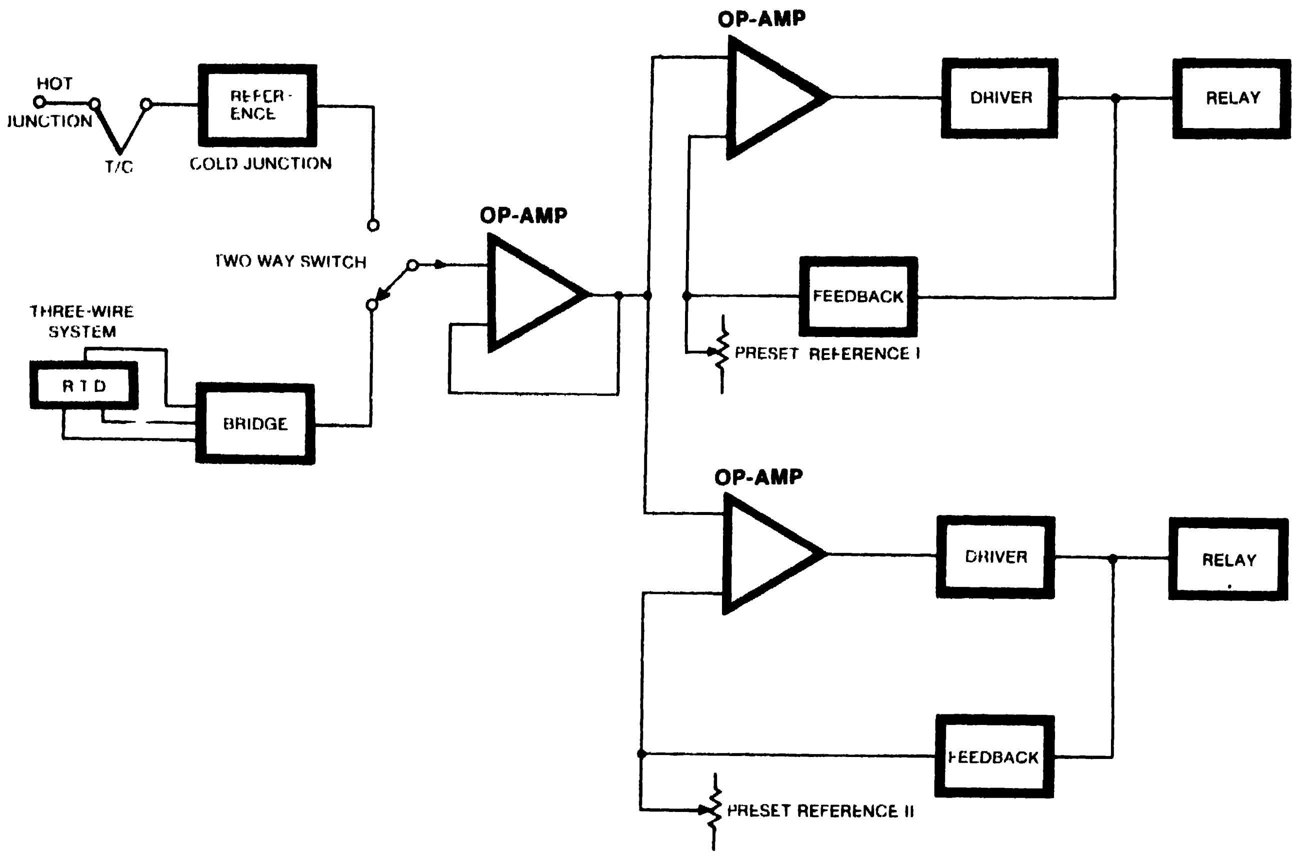


Characteristics for Platinum Resistance Bulbs (to DIN 43760)
(Tolerance from characteristics approx. ±0.3%)

°C	ohms	°C	ohms	°C	ohms	°C	ohms	°C	ohms
-220	10.40	-60	76.28	+90	134.70	+240	190.46	+380	240.16
-200	18.53	-50	80.25	100	138.50	250	194.08	390	243.61
-190	22.78	-40	84.21	110	142.28	260	197.70	400	247.06
-180	27.05	-30	88.17	120	146.06	270	201.30	410	250.50
-170	31.28	-20	92.13	130	149.82	280	204.88	420	253.93
-160	35.48	-10	96.07	140	153.57	290	208.46	430	257.34
-150	39.65	0	100.00	150	157.32	300	212.03	440	260.75
-140	43.80	+10	103.90	160	161.04	310	215.58	450	264.14
-130	47.93	20	107.79	170	164.76	320	219.13	460	267.52
-120	52.04	30	111.67	180	168.47	330	222.66	470	270.89
-110	56.13	40	115.54	190	172.16	340	226.18	480	274.25
-100	60.20	50	119.40	200	175.84	350	229.69	490	277.60
- 90	64.25	60	123.24	210	179.51	360	233.19	500	280.93
- 80	68.28	70	127.07	220	183.17	370	236.67	550	297.43
- 70	72.29	80	130.89	230	186.82				

Fig. 1: Calibration chart for PT-100.

Fig. 2: Block diagram for two set-point comparator.



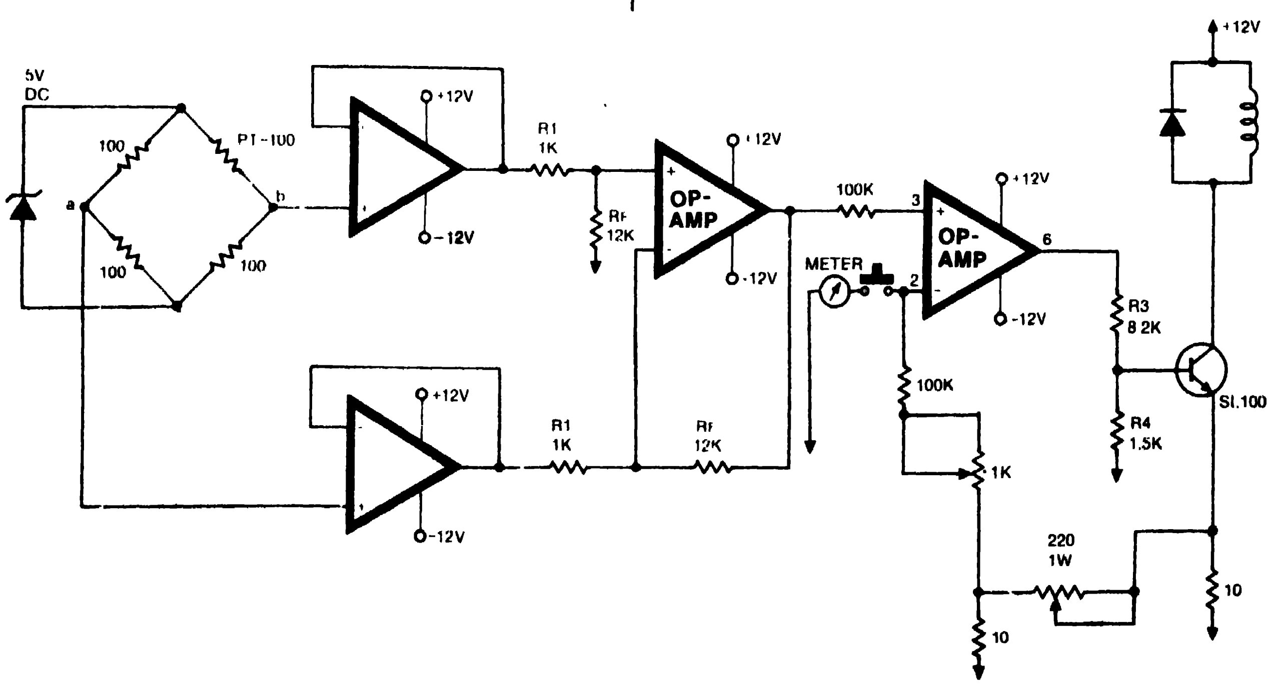


Fig. 3: Circuit diagram for temperature controller.

found out from the following equation:

$$V_{ab} = \frac{-\Delta R \; V_{de}}{2(2R + \Delta R)}$$

After amplification through op-amp having RF as feedback element, output voltage can be arrived at by the following equation:

$$V_o = V_{ab} \times \frac{RF}{R1}$$

It can be seen from the above equations that output voltage is a function of ΔR, i.e. the variation in the transducer resistance.

In order to reduce error due to load connection, transducer is connected in three wire system. Since, length of incoming/outgoing leads of the transducer depends upon the location where temperature is required to be sensed, the resistance effect introduced due to these lengths is nullified in this way.

The amplified voltage is fed to comparator where set point and measured output is compared and the difference of the two signals is amplified and used to bias the transistor to operate the relay. Thus, the circuit for controller consists of only a preset, a comparator and a switching stage to convert electronic thermometer into thermostat.

A set point is selected by pressing pushbutton and adjusting 10-turn potentiometer with screwdriver till the desired value is indicated by the meter. This value is indicated at pin 2 of IC shown in circuit. If the measured voltage at pin 3 is greater than reference temperature set at pin 2, voltage at pin 6 is high. A current will flow through biasing resistor R3 which is sufficient to cause drop of about 1.5V across R4. This is more than enough to make transistor conduct.

A number of comparators are used for achieving two or three set points, and process control for two or three defined points of temperature can be easily achieved with this circuit.

Thermocouple can also be used in the present circuit with a little modification in the measurement circuit. The output from thermocouple is directly obtained depending upon cold and hot junction temperatures. Since temperature of cold junction depends upon ambient temperature, the thermocouple has to be cascaded with wheatstone bridge output for adjustment of ambient. If this set-up is to be used with either RTD or TC, two-way switch can be used to connect either sensing elements desired for any particular range of temperature.

Operational requirement

If the period of duty cycle of the relay happens to be too much, the relay is found to chatter. A 220-ohm potentiometer is provided in feedback circuit of the comparator. This should be adjusted to reduce or increase the gain in the feedback to avoid this defect. The operation, otherwise, is very simple.

Electronic circuit for temperature control is better suited where accurate control is required. Thermostats are used for rough control. Being electromechanical devices, they wear out and therefore repeatability is lost. Hence electronic control is good for accuracy, repeatability and better resolution. □