BY THOMAS R. FOX

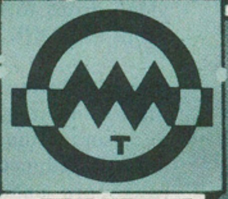
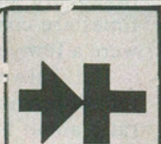
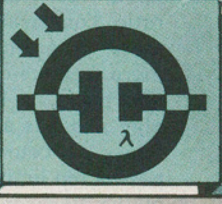
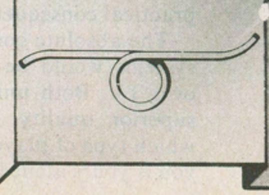
SOME LIKE IT HOT...

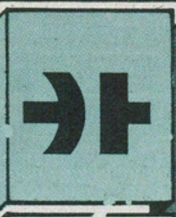
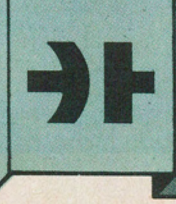
But which ones? Test your knowledge of how circuit components respond to temperature.

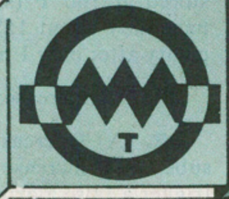
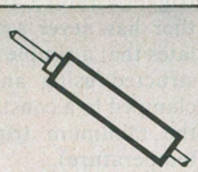
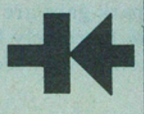
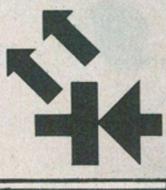
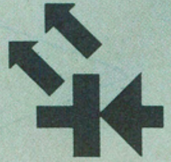
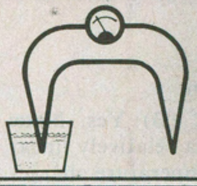
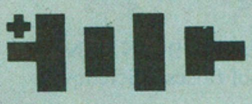
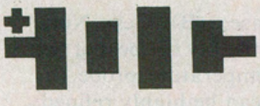
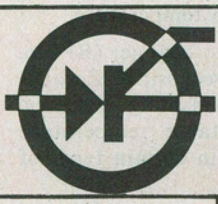
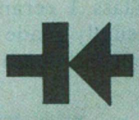
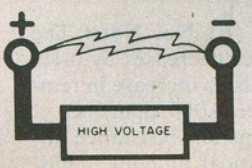
SOME electronic components, especially semiconductors, are extremely sensitive to temperature changes. Even passive components (resistors and capacitors, for example), which are normally insensitive to temperature variations, can undergo parameter changes that are sometimes sufficient to influence circuit behavior.

Here is a quiz that will check your knowledge of how the parameters of some common electrical components (as well as a few rare ones) change with temperature. The quiz gives you the common name and electrical symbol or pictorial representation of the components and the parameters of interest under temperature change (resistance, voltage, etc.).

Your task is to answer the following questions about each component: (A) Does the parameter of interest increase or decrease as the component's temperature increases from 68°F (20°C) to 95°F (35°C)? (B) Is the component frequently used in temperature measuring, control, or compensation circuits? As an example, for component No. 1, the thermistor, the answers are: (A) Decrease; (B) Yes. Answers for the rest are on the third page of the quiz. If you get 35 correct answers out of the total 50, you have done very well indeed.

Component	Symbol	Parameter of interest
1 Thermistor		Resistance
2 Silicon diode		Forward voltage drop
3 Silicon photovoltaic cell (Solar cell)		Power output
4 Copper wire		Resistance

Component	Symbol	Parameter of interest
5 Platinum wire		Resistance
6 Electrolytic capacitor (A1)		Capacitance
7 Polystyrene capacitor		Capacitance
8 NPO-type capacitor		Capacitance

Component	Symbol	Parameter of interest
9 Class I ceramic capacitor		Capacitance
10 Carbon composition resistor		Resistance
11 Positive temp. coef. silicon resistor		Resistance
12 Insulated test lead		Insulation resistance
13 Thermistor (TC= −1000 ppm/°C) Sensistor TC= +1000 ppm/°C) (Pos. temp. coef.)		Resistance between points A and B (Assume perfect linearity)
14 NPN silicon transistor		DC Beta (current gain)
15 Germanium diode		Reverse leakage current
16 Red LED		Radiant power (light output)
17 Red LED		Wavelength of light (Red = long wave Violet = short wave)
18 Copper-iron thermocouple		Current when temp. of test junction rises
19 Lead-acid storage battery		Capacity
20 Typical primary battery (Zn/C, for example)		Storage life
21 Inductor		Inductance
22 Silicon controlled rectifier		Minimum trigger voltage
23 Passivated alloy silicon diode		Reference voltage
24 7400 TTL gate		Threshold voltage
25 CMOS gate		Transfer voltage
26 Spark gap		Minimum spark voltage

QUIZ ANSWERS

1. See introduction.

2. (A) Decrease; (B) Yes. **Note:** The silicon diode has a relatively linear forward voltage vs. temperature characteristic. It is also low-cost and readily available. However, it is comparatively insensitive.

3. (A) Decrease; (B) No. **Note:** Keeping the cell cool raises efficiency.

4. (A) Increase; (B) No. **Note:** Except possibly at high temperatures, copper's variation of resistance is seldom taken into account in designs.

5. (A) Increase; (B) Yes. **Note:** Platinum makes probably the best of the metallic type of temperature probe. Its advantages are: it can be highly refined; it resists contamination; it is electrically and chemically stable; its resistance characteristic is quite linear; and its drift and error with age are negligible.

6. (A) Increase; (B) No. **Note:** Seldom used in critical circuits.

7. (A) Slight decrease; (B) No. **Note:** The capacitance of polystyrene units varies little with temperature.

8. (A) Almost no change; (B) No. **Note:** NPO (Negative-Positive-Zero) is a temperature compensating dielectric that has an ultrastable temperature characteristic. Used in certain types of ceramic capacitors.

9. (A) Most decrease (B) Yes. **Note:** Some types of Class I ceramic capacitors, which are usually made of titanium dioxide, are frequently used in compensation circuits.

10. (A) Increase; (B) No. **Note:** This workhorse of the resistor world has quite a high temperature coefficient and thus isn't used frequently in critical circuits that must be temperature stable. Carbon-film, metal-film, or wire-wound resistors are better choices for application in critical circuits.

11. (A) Increase; (B) Yes. **Note:** Because of its fairly linear resistance/temperature characteristic (especially with a properly chosen fixed resistor in parallel) this component has possible use in simple digital thermometers.

12. (A) Decrease; (B) No. **Note:** Keep this in mind when testing high-voltage circuits.

13. (A) None; (B) No. **Note:** The thermistor resistance decreases by 0.1% for every degree Celsius increase in temperature (remember, 1000 ppm/°C = 0.1%) and the Sensitor resistance increases by an identical amount. Thus, the overall effect is zero.

14. (A) Increase; (B) Yes. **Note:** This effect has been used in inexpensive electronic thermometers. Also, it must be compensated for when designing a transistor circuit so that the transistor's operating point doesn't change significantly with temperature.

15. (A) Increase; (B) Yes. **Note:** A simple electronic thermometer can be constructed from a reverse-connected germanium diode, a battery, and a microammeter. The relatively high, temperature-dependent reverse leakage currents of germanium diodes make the silicon diode, whose leakage is far smaller, preferable in some applications.

16. (A) Decrease; (B) No. **Note:** Keep LEDs cool for increased brightness.

17. (A) Increase; (B) No.

18. (A) Decrease; (B) Yes. **Note:** Does this surprise you? Well, this is sort of a trick question. One normally thinks of a thermocouple's output as increasing with an increase in temperature. The fact is, a thermocouple's output increases with an increase in the *difference* in temperature between its standard junction and the test junction. Since the standard junction shown is at a constant 120°F, the thermocouple's output *decreases* until the test junction reaches 120°F, at which point the output is zero. For test junction temperatures above 120°F, the output increases with further increase in temperature. Since we are limited to a maximum temperature of 95°F, the output is said to *decrease* with increasing temperature.

19. (A) Increase; (B) No. **Note:** This answer is obvious to anyone who had no trouble starting his car on a relatively mild winter afternoon, but early the following morning, when it was bitter cold, had to jumper the battery to start the car. (Of course, thickening oil exacerbates the problem.)

20. (A) Decrease; (B) No. **Note:** This effect is more important than most people realize. One answer is to store batteries in as cool an area as possible. A standard battery will retain nearly all its original capacity for as long as two years if stored at 32°F. This same battery, if stored at 160°F (say in an attic), will have only about 15% of its original capacity after only 1 month of storage!

21. (A) Increase; (B) No.

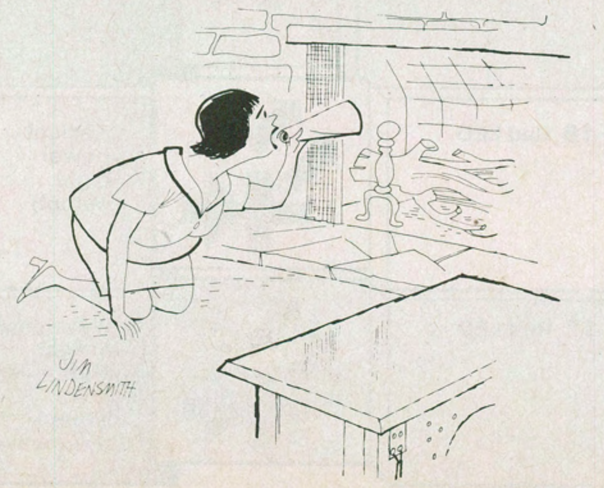
22. (A) Decrease; (B) No. **Note:** A substantial increase in temperature can trigger a false alarm. (Although the author has never seen it done, he speculates that a simple fire alarm can be constructed using an SCR with its gate clamped to a constant voltage just below the minimum trigger point (at room temperature).

23. (A) Almost none; (B) No. **Note:** This diode provides a reference voltage whose stability compares with that of standard cells.

24. (A) Decrease; (B) No. **Note:** Here is one reason why commercial-quality TTLs should be used only between 0°C and 70°C.

25. (A) Slight decrease; (B) No. **Note:** CMOS devices are less sensitive to temperature than TTLs. Plastic-cased CMOS are guaranteed to operate satisfactorily from −40°F to 185°F (−40°C to 85°C).

26. (A) Decrease; (B) No. **Note:** Spark gaps are frequently used to measure extremely high voltages. While this method may seem crude, it is accurate.◇



"I said, I think maybe the ghosts seem sharper now!"