What is the voltage?

A stimulating educational quiz on the voltage regulating characteristics of common electronic components.

BY THOMAS R. FOX

AS NEARLY every electronics hobbyist knows, the zener diode is an extremely useful component. Nearly all regulated power supplies, including those using IC voltage regulators, are built around one or more zener diodes. (Most IC regulators have internal zener diodes.) The voltage-versus-current curve for an ideal 6.7-volt zener diode is shown in Fig. 1. The rather unusual appearance of this graph is due to the fact that a zener diode is usually reverse biased. By convention, both the voltage across and the current through the diode are negative.

This graph tells us that the ideal zener acts like a voltage source with zero ohms of internal impedance whenever the voltage applied across it equals or exceeds its zener voltage, which for this diode is 6.7 volts. The diode does not allow the voltage applied across it by an external source to exceed its zener voltage. Real-life zeners do exhibit a very slight increase in voltage as more current flows through them. This is the result of a small amount of internal "bulk" resistance.

Although zener diodes are probably the best known components endowed with this voltage regulating ability, many others exhibit this same characteristic. Most other components, however, are only fair-to-poor voltage regulators and are infrequently used in this application. For physical reasons, diodes cannot be manufactured with zener voltages less than two volts. Accordingly, to obtain low regulated voltages, other components must be used even though they are far from ideal regulators.

The following quiz tests your knowledge of the voltage regulating characteristics of some common electronic components. A few rare species have been thrown in to make the quiz a bit more stimulating. The basic test circuit is shown in Fig. 2.

To simplify matters, several assumptions will be made. . .

- The battery symbolizes a 100-volt regulated power supply.
- The resistance of power resistor *R* varies from one circuit to the next so that the magnitude of the current flowing through a component is "typical" for the particular device. Also, the resistance of *R* is great enough so that the maximum ratings of the component are not exceeded.
- The voltmeter has an input impedance of 1000 megohms and can be neglected in most cases.
- Unless otherwise noted, all components are at room temperature (68-77 °F, 20-25 °C).

TABLE OF VOLTAGES

100 V	97.85 V
2 V	0.2 V
14 V	6.7 V
0 V	0.7 V
0.13 V	50 V
24.6 V	0.35 V
12 V	3.3 V
1.0 V	1.4 V

60 V

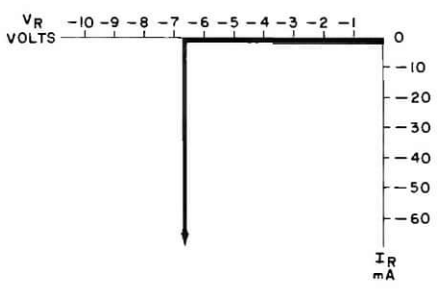


Fig. 1. V-I curve of an ideal 6.7-volt zener diode.

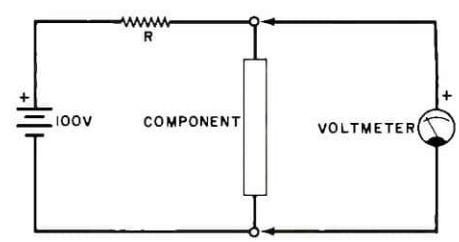
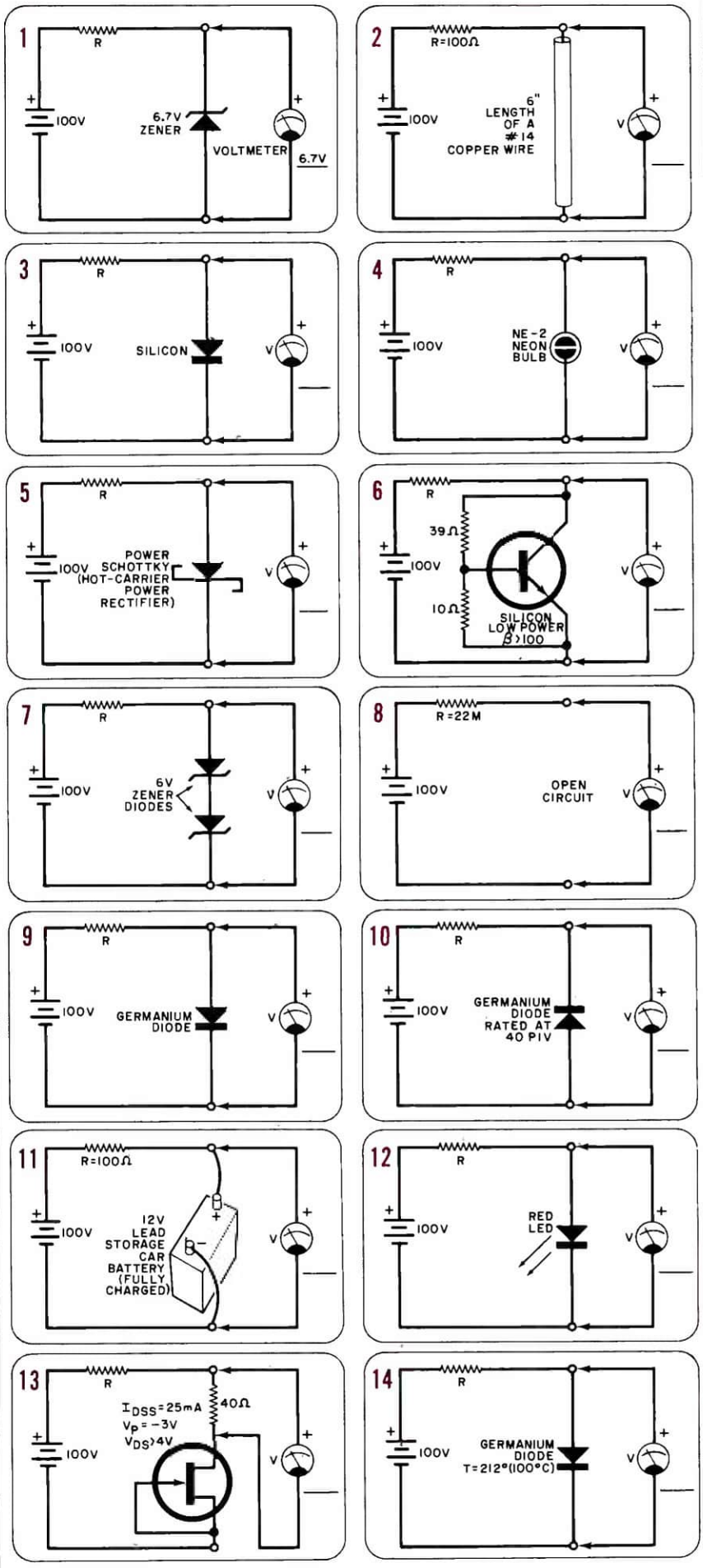


Fig. 2. Basic quiz circuit.



ANSWERS TO ZENER VOLTAGE QUIZ

Circuit 1—6.7 V
Circuit 2—0 V
Circuit 3—0.7 V
Circuit 4—60 V
Circuit 5—0.13 V
Circuit 6—3.3 V
Circuit 7—1.4 V
Circuit 8—97.85 V
Circuit 9—0.35 V
Circuit 10—50 V
Circuit 11—14 V
Circuit 12—2 V
Circuit 13—1.0 V
Circuit 14—0.2 V

• All diodes are conducting relatively low forward currents (approximately 1 mA) unless specified otherwise. The LED in Circuit 12 is operated at "normal" current levels to achieve "normal" brightness.

• The specific voltages listed in the Table are approximate.

To take the quiz, examine each of the 14 circuits and estimate the voltage indicated by the voltmeter. Next, refer to the 17 voltages listed in the Table and select the value closest to the voltage you think the voltmeter will indicate. Finally, write this voltage on the line next to the voltmeter. As an extra challenge, three of the voltages in the Table will not correspond to any of the circuits.

Example: Refer to Circuit 1. Assuming that the resistance of *R* is chosen so that approximately one-half of the maximum recommended current flows through the zener diode, it is obvious that the voltmeter will read 6.7 volts (the diode's zener voltage). Remember—the maximum current rating of the device and the exact resistance of *R* is not important; that the value of *R* is chosen so that the device exhibits its typical operating characteristics is important. The voltage in the table that is closest to 6.7 volts is 6.7 volts. Thus, we have written 6.7 volts on the line next to the meter. What the author has chosen as the best answers are given after the circuits. ◇