3-2 **ZENER DIODE APPLICATIONS**:

1. Voltage references **2**. Regulators **3.** Limiters or clippers.

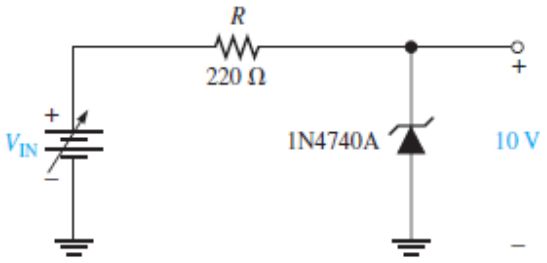
(1) Zener Regulation with a Variable Input Voltage:

- A zener diode can be used to regulate a dc voltage. As the input voltage varies (within limits), the zener diode maintains a nearly constant output voltage across its terminals.

- **Example**: Determine the minimum and maximum input voltages that can be regulated by the 1N4740A zener. Use the **ideal model** of the 1N4740A zener diode (ignoring the zener resistance)

- **Solution:**
  - From the datasheet: the minimum zener current is I_{ZK} = 0.25 mA
  - The maximum current can be calculated from the power specification:

$$I_{ZM} = \frac{P_{D(max)}}{V_Z} = \frac{1\text{ W}}{10\text{ V}} = 100\text{ mA}$$



For minimum zener current I_{ZK}

$$V_R = I_{ZK}R = (0.25\text{ mA})(220\ \Omega) = 55\text{ mV}$$

Since $V_R = V_{IN} - V_Z$,

$$V_{IN(min)} = V_R + V_Z = 55\text{ mV} + 10\text{ V} = 10.055\text{ V}$$

For max zener current I_{ZM}

$$V_R = I_{ZM}R = (100\text{ mA})(220\ \Omega) = 22\text{ V}$$

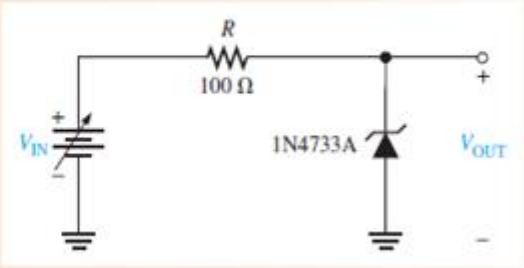
$$V_{IN(max)} = 22\text{ V} + 10\text{ V} = 32\text{ V}$$

This shows that this zener diode can ideally regulate an input voltage from 10.055 V to 32 V and maintain an approximate 10 V output.

EXAMPLE 3–5

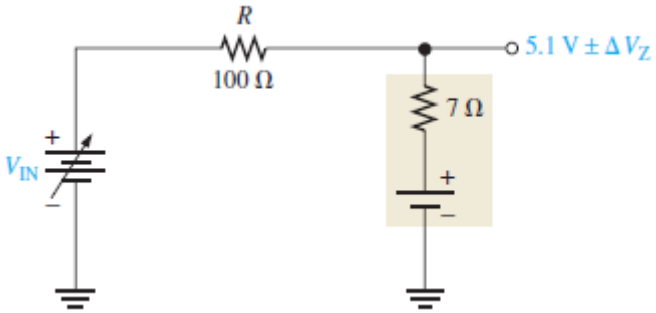
Determine the minimum and the maximum input voltages that can be regulated by the zener diode in Figure 3–11.

FIGURE 3–11



Solution:

Form the Datasheet of 1N4733A: Vz = 5.1 V at Iz = 49 mA, I_{ZK} = 1 mA, and Zz = 7 Ω.
The equivalent circuit is shown below:



At I_{ZK} = 1 mA, the output voltage is

$$V_{OUT} \cong 5.1\text{ V} - \Delta V_Z = 5.1\text{ V} - (I_Z - I_{ZK})Z_Z = 5.1\text{ V} - (49\text{ mA} - 1\text{ mA})(7\ \Omega)$$
$$= 5.1\text{ V} - (48\text{ mA})(7\ \Omega) = 5.1\text{ V} - 0.336\text{ V} = 4.76\text{ V}$$

Therefore,

$$V_{IN(min)} = I_{ZK}R + V_{OUT} = (1\text{ mA})(100\ \Omega) + 4.76\text{ V} = \mathbf{4.86\text{ V}}$$

To find the maximum input voltage, first calculate the maximum zener current. Assume the temperature is 50°C or below; so from Figure 3–7, the power dissipation is 1 W.

$$I_{ZM} = \frac{P_{D(max)}}{V_Z} = \frac{1\text{ W}}{5.1\text{ V}} = 196\text{ mA}$$

At I_{ZM}, the output voltage is

$$V_{OUT} \cong 5.1\text{ V} + \Delta V_Z = 5.1\text{ V} + (I_{ZM} - I_Z)Z_Z$$
$$= 5.1\text{ V} + (147\text{ mA})(7\ \Omega) = 5.1\text{ V} + 1.03\text{ V} = 6.13\text{ V}$$

Therefore,

$$V_{IN(max)} = I_{ZM}R + V_{OUT} = (196\text{ mA})(100\ \Omega) + 6.13\text{ V} = \mathbf{25.7\text{ V}}$$