Reference: Microelectronics circuit analysis and design by Donald Neamen

2.2.2 Zener Resistance and Percent Regulation

In the ideal Zener diode, the Zener resistance is zero. In actual Zener diodes, however, this is not the case. The result is that the output voltage will fluctuate slightly with a fluctuation in the input voltage, and will fluctuate with changes in the output load resistance.

Figure 2.19 shows the equivalent circuit of the voltage regulator including the Zener resistance. Because of the Zener resistance, the output voltage will change with a change in the Zener diode current.

Two figures of merit can be defined for a voltage regulator. The first is the **source regulation** and is a measure of the change in output voltage with a change in source

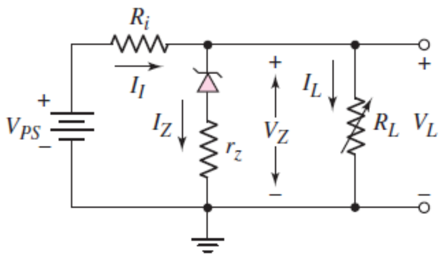

Figure 2.19 A Zener diode voltage regulator circuit with a nonzero Zener resistance

voltage. The second is the **load regulation** and is a measure of the change in output voltage with a change in load current.

The source regulation is defined as

$$\text{Source regulation} = \frac{\Delta v_L}{\Delta v_{PS}} \times 100\% \quad \textbf{(2.34)}$$

where Δv_L is the change in output voltage with a change of Δv_{PS} in the input voltage.

The load regulation is defined as

$$\text{Load regulation} = \frac{v_{L,\text{no load}} - v_{L,\text{full load}}}{v_{L,\text{full load}}} \times 100\% \quad \textbf{(2.35)}$$

where $v_{L,\text{no load}}$ is the output voltage for zero load current and $v_{L,\text{full load}}$ is the output voltage for the maximum rated output current.

The circuit approaches that of an ideal voltage regulator as the source and load regulation factors approach zero.

Below design example 2.6 is given for Reference study only: It helps in understanding voltage Regulation better

EXAMPLE 2.6

Objective: Determine the source regulation and load regulation of a voltage regulator circuit.

Consider the circuit described in Example 2.5 and assume a Zener resistance of $r_z = 2\ \Omega$.

Solution: Consider the effect of a change in input voltage for a no-load condition ($R_L = \infty$). For $v_{PS} = 13.6$ V, we find

$$I_Z = \frac{13.6 - 9}{15.3 + 2} = 0.2659 \text{ A}$$

Then

$$v_{L,\max} = 9 + (2)(0.2659) = 9.532 \text{ V}$$

For $v_{PS} = 11$ V, we find

$$I_Z = \frac{11 - 9}{15.3 + 2} = 0.1156 \text{ A}$$

Then

$$v_{L,\min} = 9 + (2)(0.1156) = 9.231 \text{ V}$$

We obtain

$$\text{Source regulation} = \frac{\Delta v_L}{\Delta v_{PS}} \times 100\% = \frac{9.532 - 9.231}{13.6 - 11} \times 100\% = 11.6\%$$

Now consider the effect of a change in load current for $v_{PS} = 13.6$ V. For $I_L = 0$, we find

$$I_Z = \frac{13.6 - 9}{15.3 + 2} = 0.2659 \text{ A}$$

and

$$v_{L,\text{no load}} = 9 + (2)(0.2659) = 9.532 \text{ V}$$

For a load current of $I_L = 100$ mA, we find

$$I_Z = \frac{13.6 - [9 + I_Z(2)]}{15.3} - 0.10$$

which yields

$$I_Z = 0.1775 \text{ A}$$

Then

$$v_{L,\text{full load}} = 9 + (2)(0.1775) = 9.355 \text{ V}$$

We now obtain

$$\text{Load regulation} = \frac{v_{L,\text{no load}} - v_{L,\text{full load}}}{v_{L,\text{full load}}} \times 100\%$$

$$= \frac{9.532 - 9.355}{9.355} \times 100\% = 1.89\%$$

Comment: The ripple voltage on the input of 2.6 V is reduced by approximately a factor of 10. The change in output load results in a small percentage change in the output voltage.