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ET 260 Solid State I

Chapter 5: Special-purpose Diode

Problem 1-15 odd, 25-27 odd

#1. An unloaded zener regulator has a source voltage of 24V, a series resistance of 470Ω, and a zener voltage of 15V. What is the zener current?

 IR = IZ = $\frac{V1-V\_{z}}{R1}$ = $\frac{24V-15V}{470Ω}$ = 19.1 mA

 note, the zener 1N4744A has a 15.0 V rating.

#3. If the series resistor of Prob. 5-1 has a tolerance of $\pm $5 percent, what is the maximum zener current?

If the tolerance is $\pm $5 percent, the resistance can vary between 446.5Ω to 493.5 Ω.

R = 470Ω $\pm $ 470Ω (0.05) = 446.5 - 493.5 Ω

IR = IZ = $\frac{V1-V\_{z}}{R1}$ = $\frac{24V-15V}{446.5Ω}$ = 20.2 mA

#5. VL = Vz = 15V
 IL = VL / RL = 15V / 1.5 KΩ = 10mA

 IR = (24V - 15V) / 470Ω = 19.1mA
 IZ = IR - IL = 19.1 mA - 10 mA = 9.1mA



The zener diode keeps the load voltage and current in a steady condition even when the source voltage vary.
#7. Suppose the supply voltage of FIg. 5-40 can vary from 24 to 40V. What is the maximum zener current?
 VL = Vz = 15V
 IL = VL / RL = 15V / 1.5 KΩ = 10mA

 IR = (40V - 15V) / 470Ω = 53.19mA
 IZ = IR - IL = 53.19 mA - 10 mA = 43.19mA

#9.

 VL = Vz = 12V
 IL = VL / RL = 12V / 1 KΩ = 12mA

 IR = (20V - 12V) / 330Ω = 24.2mA
 IZ = IR - IL = 24.2 mA - 12 mA = 12.2mA

#13. A low source voltage can cause the zener circuit to fail to regulate. In addition, a zener circuit will fail to regulate if the load resistance is too low. In order for zener to regulate, there must be zener current for all source voltages and load currents.
If the voltage drop to 20V, IL = 10mA remain the same but IR = (20V - 15V) / 470Ω = 10.6mA
Hence, IZ = 10.6mA - 10mA = 0.6mA

If the load resistance drop to 500Ω, IL = 15V / 500Ω = 30 mA. IR = 19.1mA
Hence, IZ = 19.1mA - 30mA = -10.9mA (fail to regulate)

Rs (max) = $\left(\frac{V\_{s(min)}}{V\_{z}}- 1\right) R\_{L(min)}$
 = $\left(\frac{20}{15}- 1\right) 500$
 = 167 Ω (this is the maximum value the series resistance can have)

#15. What is the minimum load resistance that may be used in Fig. 5-40 without losing zener regulation?

Rs (max) = $\left(\frac{V\_{s(min)}}{V\_{z}}- 1\right) R\_{L(min)}$
$R\_{L(min)} $ = Rs (max)  / $\left(\frac{V\_{s(min)}}{V\_{z}}- 1\right)$
 = 470 / ( 24/15 -1 )
 = 784 Ω

#25. The voltage across the LED is approximately 2V.
 VR = 15V - 2V = 13V
 Iled = IR = VR / R = 13V / 2.2kΩ = 5.91 mA



#27. If the resistor is decreased to 1kΩ,
 VR = 15V - 2V = 13V
 Iled = IR = VR / R = 13V / 1kΩ = 13 mA