Zener Diode Problems

Lecture 10

Course No: CSE 251

Course Title: Electronic Devices and Circuits

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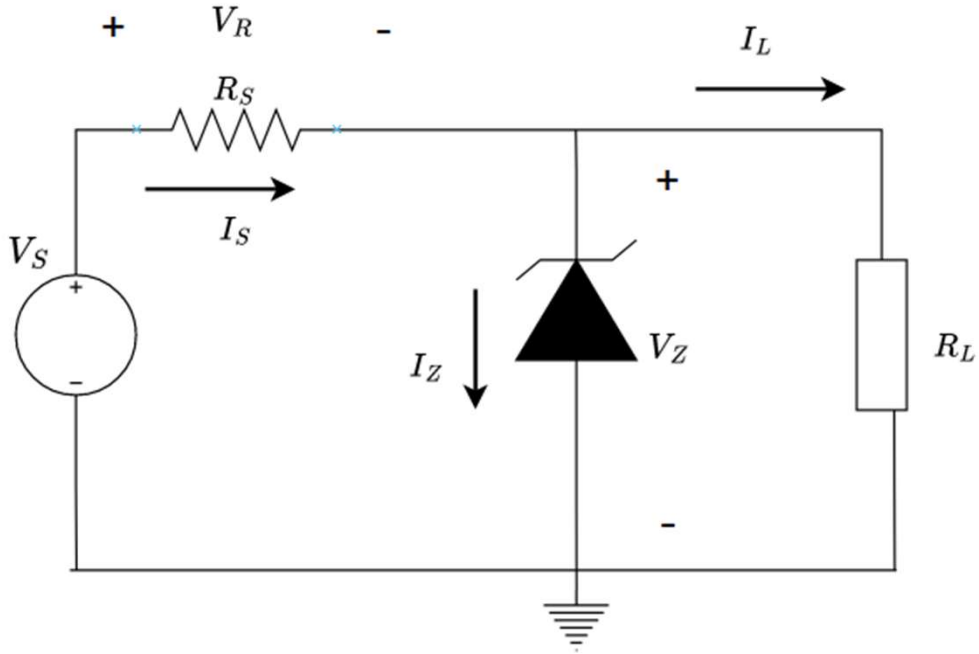
Example 1

The Zener diode is specified as V_{Z0}=3V, r_Z =0Ω, I_{ZK} = 1mA. The load current can vary from 0mA to 50mA. The source has a nominal value of 5V and can vary ±10%.

a)Find Vs(min), Vs(max), I_L(min), I_L(max)



So: 10% of 5V = 0.5V
Vs (min)= 5-0.5= 4.5V
Vs (max) = 5+0.5=5.5V
I_L(min) = 0 mA
I_L(max)=50mA

Example 1

b) What is the worst case I_L, I_Z and Vs?

Sol: In worst case, I_{ZK} will flow through the zener diode. [If the current falls below this, the regulation will not be maintained)

KCL $=> I_Z = I_S - I_L$

and $I_S = (Vs - V_L)/Rs$

So, I_Z is minimum when I_L is maximum. and Vs is minimum.

Worst case $=>$ $I_L = I_L(max) = 50mA$

$I_Z = I_Z(min) = I_{ZK} = 1\ mA$

$Vs = Vs(min) = 4.5V$

c) For worst case, what is the value of Is?

Sol: $Is = I_Z + I_L = 1 + 50 = 51mA$

Example 1

d)For worst case, what is the value of V_R?

Sol: In worst case scenario, the zener diode will barely maintain its voltage.

So, $V_L = V_Z = V_{Z0} + I_Z r_Z = 3V$

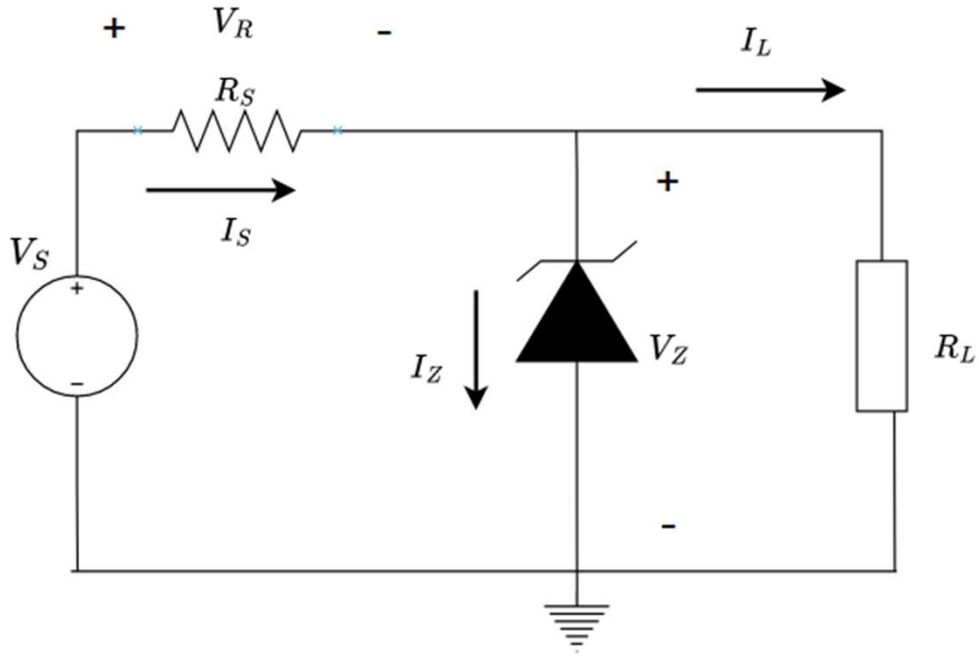
$V_R = Vs - V_L = 4.5\text{-}3 = 1{\cdot}5V$

e)Find the value of Rs, for which the Zener diode maintains regulation in worst case scenario.

Sol: $Rs = V_R / I_S = 1.5V/51mA = 30\Omega$

Example 2

The Zener diode is specified as $V_{Z0}=3V$, $r_Z=0\Omega$, $I_{ZK}=1mA$.
$Rs=100\Omega=0.1k\Omega$, $R_L=10k\Omega$.



Find the minimum value of Vs for which the Zener diode maintains regulation.

In worst case, $I_Z=I_{ZK}=1mA$

$I_L=V_L/R_L=3V/10k\Omega=0.3mA$

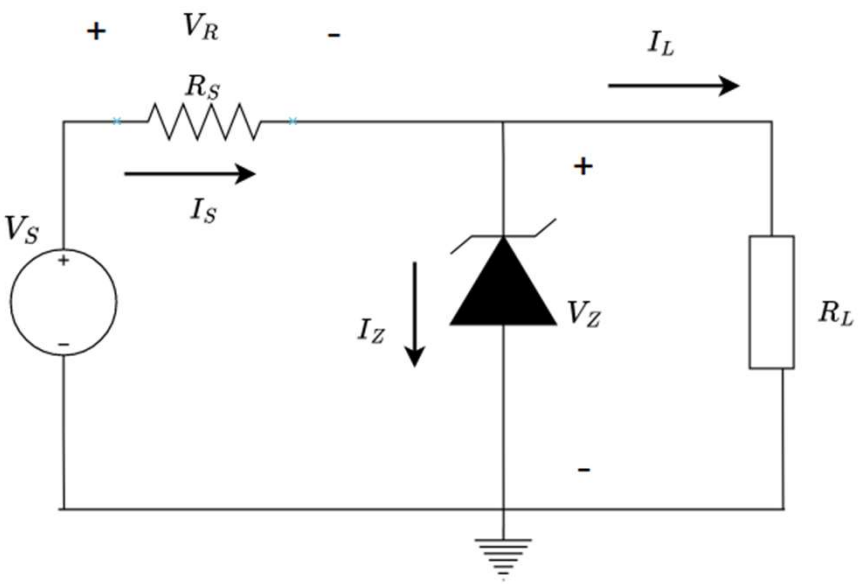
KCL→ $Is=I_Z+I_L=1+0.3=1.3mA$
$I_S=(Vs-V_L)/Rs$
$=>1.3mA=(Vs-3)/0.1k\Omega$
So, $Vs=3.13V$

As in worst case scenario, I_Z is minimum which happens when I_L is maximum. and Vs is minimum,
$Vs(min)=3.13V$

Example 3

The Zener diode is specified as $V_{Z0}=3V$, $r_Z=0\Omega$, $I_{ZK}=1mA$.
$Rs=100\Omega=0.1k\Omega$. The source has a nominal value of 5V and can vary $\pm 10\%$.

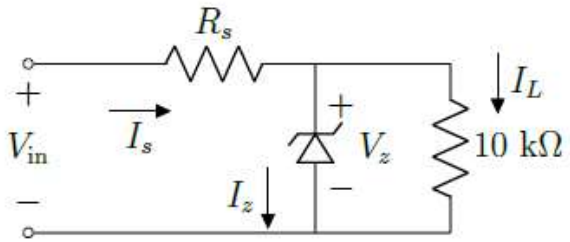
Find the minimum value of R_L for which the Zener diode maintains regulation.



In worst case, $I_Z=I_{ZK}=1mA$
$V_L=V_Z=V_{Z0}+I_Z r_Z=3V$

10% of 5V = 0.5V
In worst case, Vs=Vs (min)= 5-0.5= 4.5V
$I_S=(Vs-V_L)/Rs=(4.5-3)/0.1k\Omega=15$ mA
$I_L=I_S-I_Z=15-01=14mA$
$R_L=V_L/I_L=3V/14mA=214\Omega$
$R_L(max)=214\Omega$

Example 4



In the circuit, the input voltage V_{in} has a nominal voltage of 10 V with a fluctuation of ±10%. The Zener diode in the circuit is specified with parameter $V_z = 5.75$ V at $I_z = 5$ mA, $r_z = 0.05$ kΩ, and $I_{zk} = 0.3$ mA.

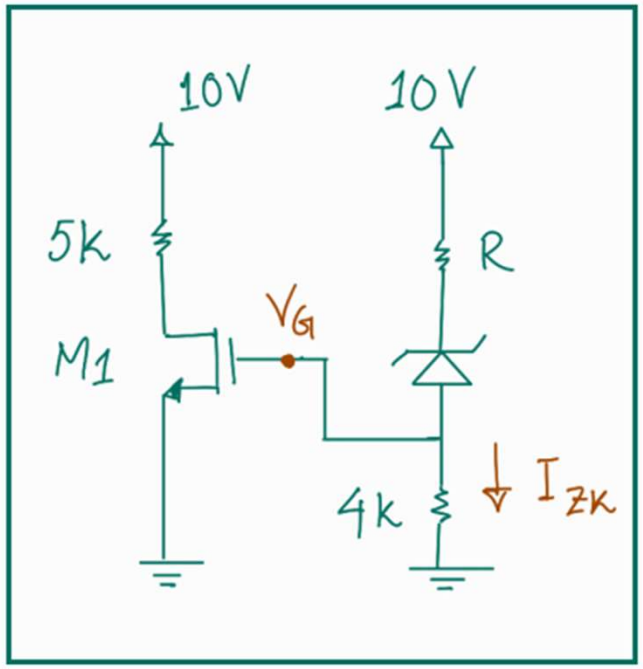
(a) **Compute** the Zener diode parameter V_{z_0}. [2]

(b) **Identify** the worst-case conditions and **calculate** the Zener current (I_z), Zener voltage (V_z), and the input voltage in this worst-case scenario. [1+1+1+1]

(c) **Calculate** the load current I_L and the source current I_s in the worst-case conditions. [2]

(d) **Design** the circuit, i.e., find the value of R_s, such that even in the worst-case scenario voltage regulation is maintained. [2]

Example 5



Given, $r_z = 100\Omega$, $I_{ZK} = 1.2\,mA$

$V_{Z0} = 3.3\,V$

(Q1) : Find the maximum value of R so that the zener diode stays in knee-voltage condition

(Q2) : Find the operating region of the Mosfet M1 using the value of R in (Q1).

$K_n = 1\,mA/V^2$

$V_T = 0.2V$

Thank You