Zener Diodes and Applications

Dr. José Ernesto Rayas Sánchez

Some figures of this presentation were taken from the instructional resources of the following textbooks:

A. S. Sedra and K. C. Smith, *Microelectronic Circuits*. New York, NY: Oxford University Press, 2003.

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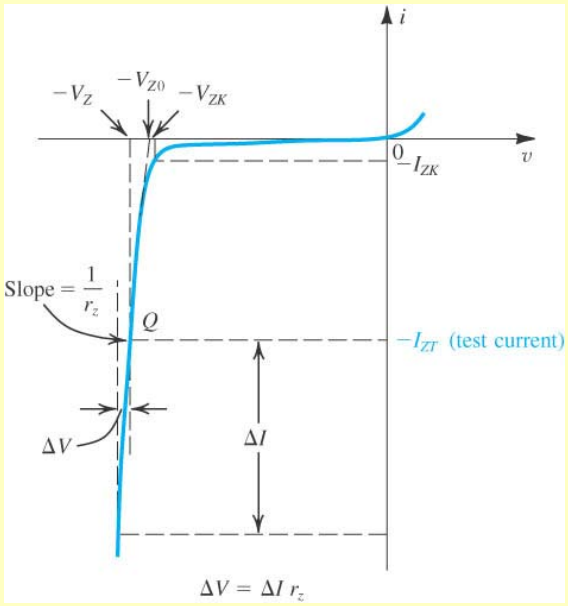
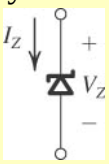
Outline

- I-V characteristics of a Zener diode
- Models for a Zener diode
- Manufacturer's data sheets
- Obtaining model parameters from data sheets
- Voltage regulators
- Other applications of Zener diodes

I-V Characteristics of a Zener Diode



Symbol:



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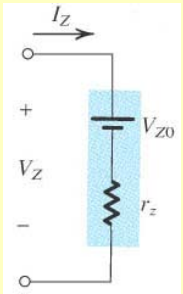
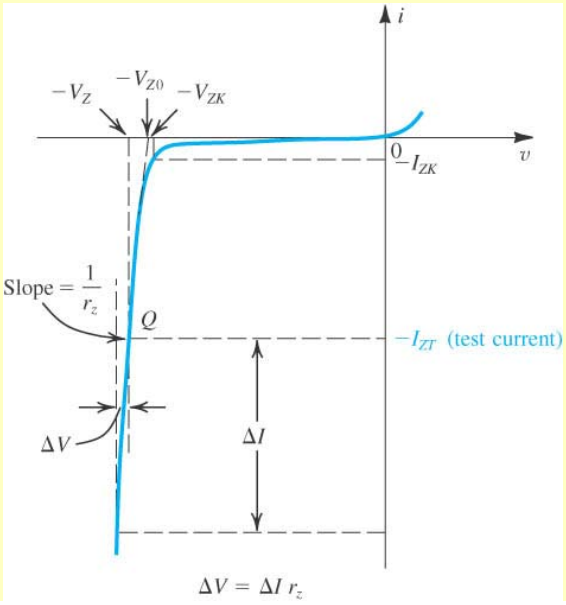
Modeling a Zener Diode in Regulation





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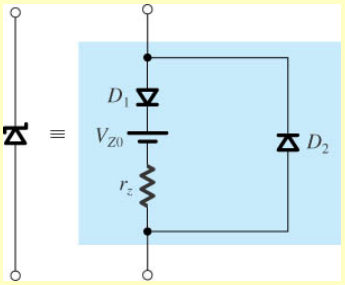
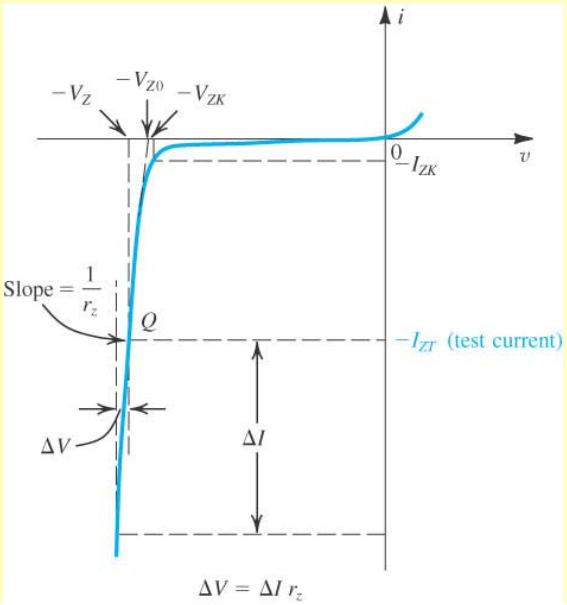
A Zener Diode Model for all Regions



(D_1 is an ideal diode)



$\Delta V = \Delta I \, r_z$

Manufacturers Data Sheets for Zener Diodes

ON Semiconductor™
http://onsemi.com

1N957B Series

500 mW DO-35 Hermetically Sealed Glass Zener Voltage Regulators

MAXIMUM RATINGS (Note 1.)

Rating	Symbol	Value	Unit
Max. Steady State Power Dissipation @ $T_L \le 75°C$, Lead Length = 3/8″ Derate above 75°C	P_D	500 4.0	mW mW/°C
Operating and Storage Temperature Range	T_J, T_{stg}	–65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, V_F = 1.5 V Max @ I_F = 200 mA for all types)

Device (Note 2.)	Device Marking	Zener Voltage (Note 3.) V_Z (Volts) Min	Nom	Max	@ I_{ZT} mA	Zener Impedance (Note 4.) Z_{ZT} @ I_{ZT} Ω	Z_{ZK} @ I_{ZK} Ω	mA	Leakage Current I_R @ V_R µA	Volts	I_{ZM} (Note 5.) mA
1N957B	1N957B	6.46	6.8	7.14	18.5	4.5	700	1.0	150	5.2	47
1N958B	1N958B	7.125	7.5	7.875	16.5	5.5	700	0.5	75	5.7	42
1N959B	1N959B	7.79	8.2	8.61	15	6.5	700	0.5	50	6.2	38
1N960B	1N960B	8.645	9.1	9.555	14	7.5	700	0.5	25	6.9	35
1N961B	1N961B	9.5	10	10.5	12.5	8.5	700	0.25	10	7.6	32
1N962B	1N962B	10.45	11	11.55	11.5	9.5	700	0.25	5	8.4	28

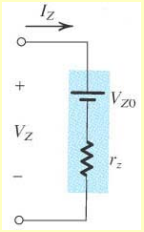
Getting Zener Model Parameters

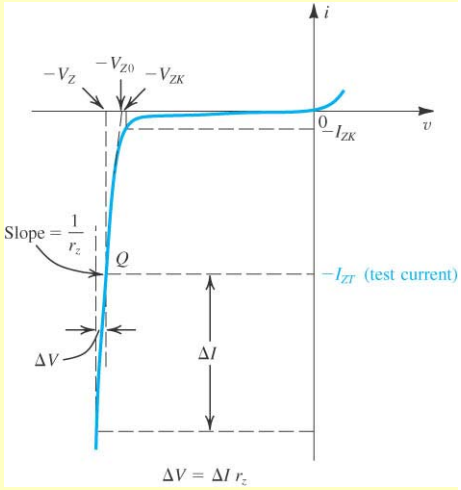
From the manufacturer's data sheet we get:

- V_{ZT} and Z_{ZT} @ I_{ZT}
- I_{ZM}

then

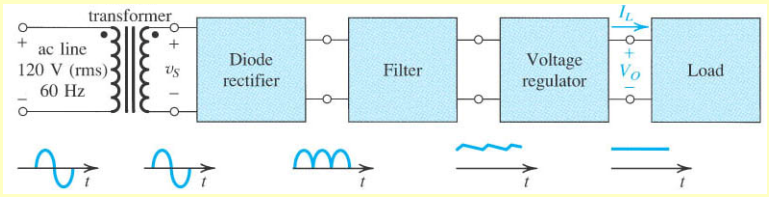
$$r_z = Z_{ZT}$$
$$V_{Z0} = V_{ZT} - I_{ZT} r_z$$

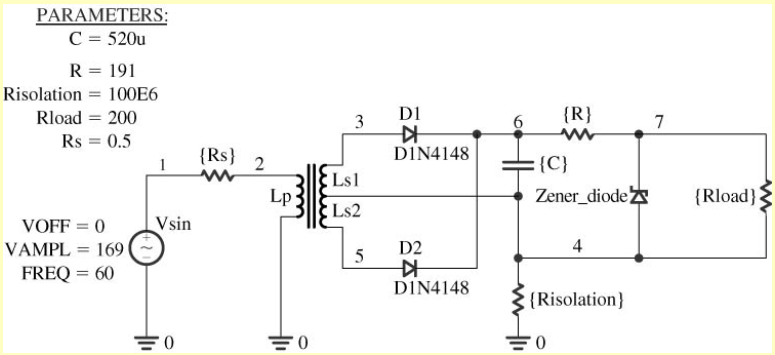




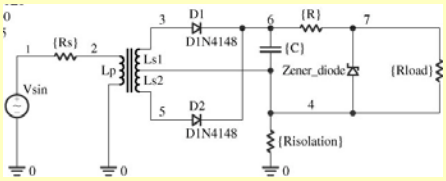
A practical current range for voltage regulation is $0.3I_{ZT} \le I_Z \le I_{ZM}$

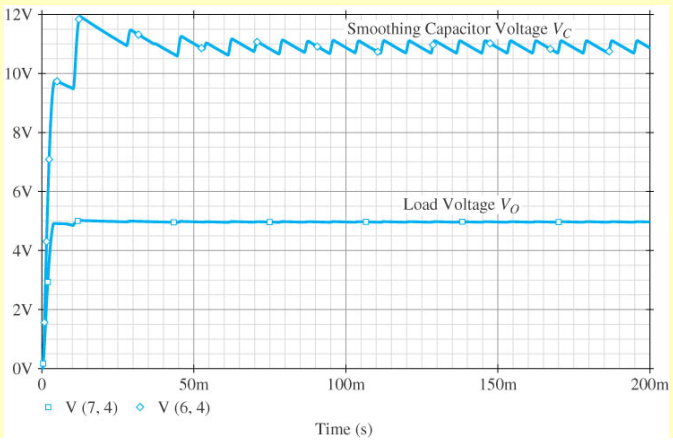
Typical Linear DC Voltage Source



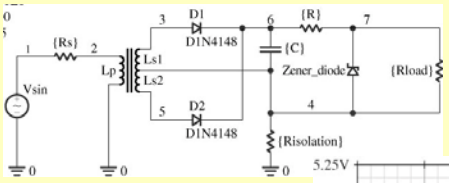


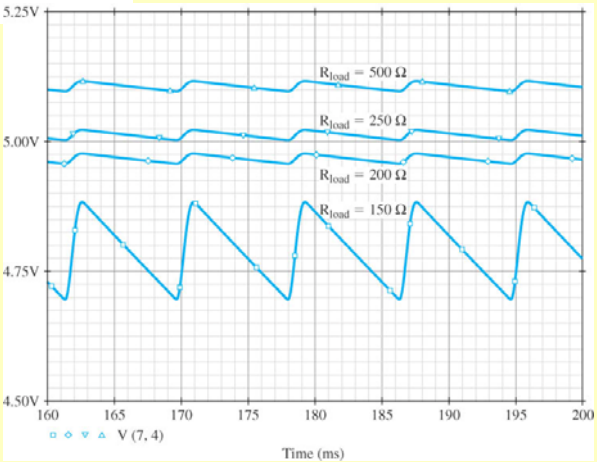
Typical Linear DC Voltage Source (cont)



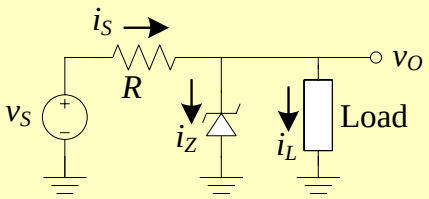


Typical Linear DC Voltage Source (cont)





Designing a Zener-Based Voltage Regulator



If $V_{S\min} \le v_S \le V_{S\max}$

$I_{L\min} \le i_L \le I_{L\max}$

Find a feasible range of R such that

$0.3I_{ZT} \le i_Z \le I_{ZM}$

$$v_O = \frac{R}{R+r_z}V_{Z0} + \frac{r_z}{R+r_z}v_S - (R \| r_z)i_L$$

$$\frac{\partial v_O}{\partial v_S} = \frac{r_z}{R+r_z} \qquad \frac{\partial v_O}{\partial i_L} = -(R \| r_z)$$

Other Applications of Zener Diodes (Clippers)