Palestine Technical University - Kadoorie
جامعة فلسطين التقنية - خضوري

Electrical Engineering Department

Electronics Lab

Exp (4):
Zener Diodes (2)

Presentation By:
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Temperature Coefficient of Zener Diodes

- The temperature coefficient specifies the percent change in Zener voltage for each degree Celsius change in temperature.
- For example, a 12 V Zener diode with a positive temperature coefficient of 0.01%/°C will exhibit a 1.2 mV increase in *V*Z when the junction temperature increases one degree Celsius. The formula for calculating the change in Zener voltage for a given junction temperature change, for a specified temperature coefficient, is

$$\Delta V_Z = V_Z \times TC \times \Delta T$$

where *V*Z is the nominal Zener voltage at the reference temperature of *TC* is the temperature coefficient, and Δ*T* is the change in temperature from the reference temperature.

In some cases, the temperature coefficient is expressed in mV/°C rather than as %/°C. For these cases, is calculated as

$$\Delta V_Z = TC \times \Delta T$$

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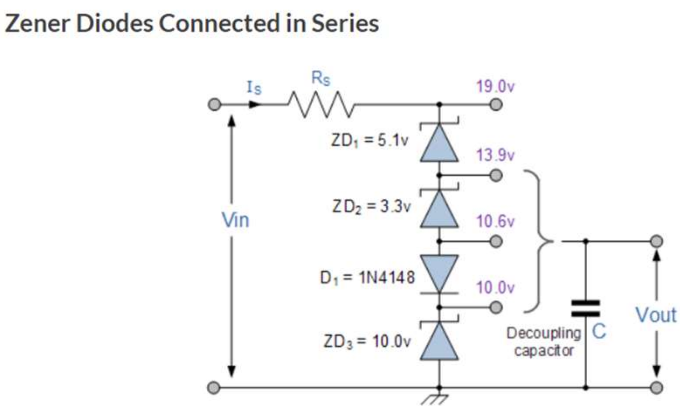
Zener as voltage limiters

- Zener diodes can be connected together in series to produce a variety of different reference voltage output values as shown below.



The values of the individual Zener diodes can be chosen to suit the application while the silicon diode will always drop about 0.6 – 0.7V in the forward bias condition. The supply voltage, Vin must of course be higher than the largest output reference voltage and in our example above this is 19v.

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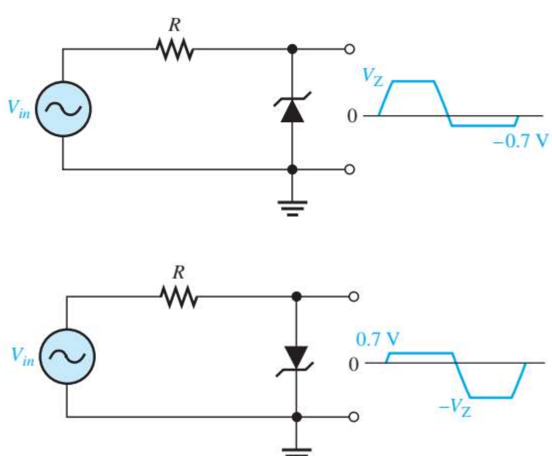
Zener as voltage limiters

- a Zener used to limit the positive peak of a signal voltage to the selected Zener voltage.



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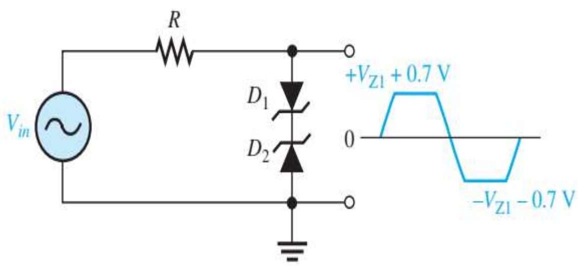
Zener as voltage limiters

- Two back-to-back Zeners limit both peaks to the Zener voltage ±0.7 V as shown below. During the positive alternation, *D*2 is functioning as the Zener limiter and *D*1 is functioning as a forward-biased diode. During the negative alternation, the roles are reversed. ;0.7



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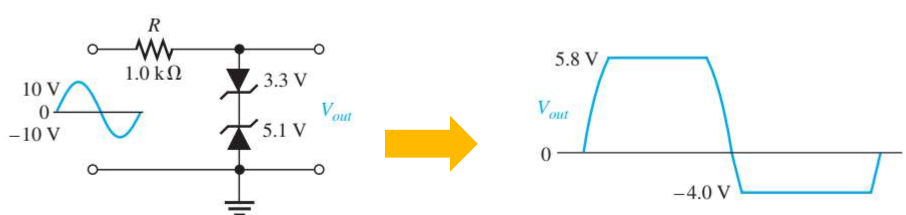
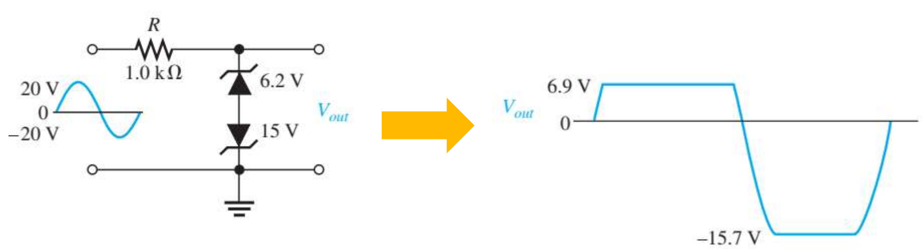
Zener as voltage limiters - Examples





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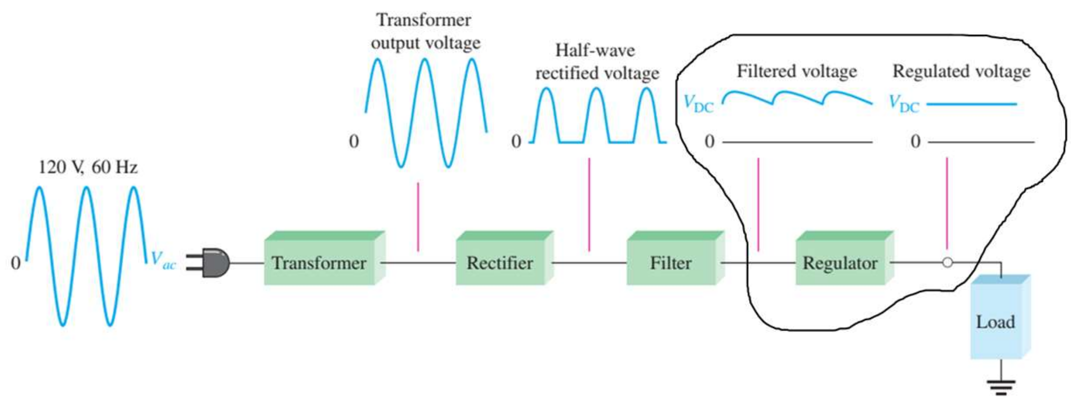
Zener Diodes as voltage regulator / stabilizer

The **regulator** is a circuit that maintains a constant dc voltage for variations in the input line voltage or in the load.



(a) Complete power supply with transformer, rectifier, filter, and regulator

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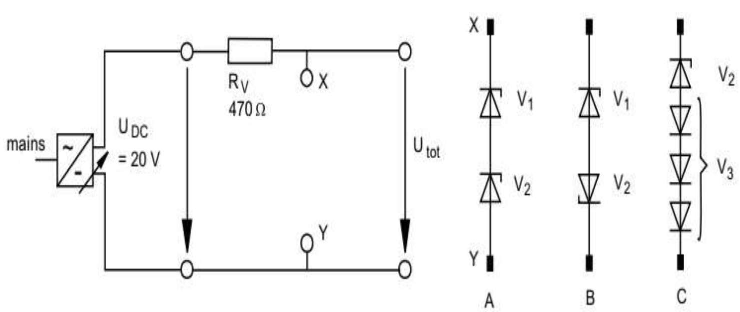
Practical Part:

Part 1: Connect different Zener and rectifier diodes in series and series-opposed, measure their total voltages and calculate their temperature coefficients.

1. Set up the circuit according to the Figure. connecting the series connections consisting of Zener and rectifier diodes.
2. Measure voltage Utot with the multimeter and enter the measured voltages into Table 2.3.2.1.
3. Calculate the temperature-dependent voltage changes of the different circuits and enter the values into Table 2.3.2.1 using the manufacturer specifications of Table 2.3.2.2 as a basis.



Circuit	U_{tot} [V]	$\Delta U / \Delta \vartheta$ [mV / K]
A		
B		
C		

Tab. 2.3.2.1

V_1 ≙ hps Type 9114.14
V_2 ≙ hps Type 9114.8
V_3 ≙ hps Type 9114.3

Practical Part:

Part 1: Connect different Zener and rectifier diodes in series and series-opposed, measure their total voltages and calculate their temperature coefficients.

To Calculate the temperature-dependent voltage changes

U = 3.3 V (hps Type 9114.14)	$-3 \cdot 10^{-4} \cdot K^{-1}$	-0.99 mV / K
U = 10 V (hps Type 9114.8)	$+8 \cdot 10^{-4} \cdot K^{-1}$	+8 mV / K
U = 0.7 V (hps Type 9114.3)	$-3 \cdot 10^{-4} \cdot K^{-1}$	-2.4 mV / K

Circuit	U_{tot} [V]	$\Delta U / \Delta \vartheta$ [mV / K]
A		
B		
C		

Tab. 2.3.2.1

This is Vz x TC

$$\Delta V_Z = V_Z \times TC \times \Delta T$$

$$\Delta V_Z = TC \times \Delta T$$

Series Circuit A:

$\Delta U / \Delta \vartheta = (\Delta U_1 / \Delta \vartheta) + (\Delta U_2 / \Delta \vartheta)$

Series Circuit B:

$\Delta U / \Delta \vartheta = (\Delta U_1 / \Delta \vartheta) + (\Delta U_2 / \Delta \vartheta)$

Series Circuit C:

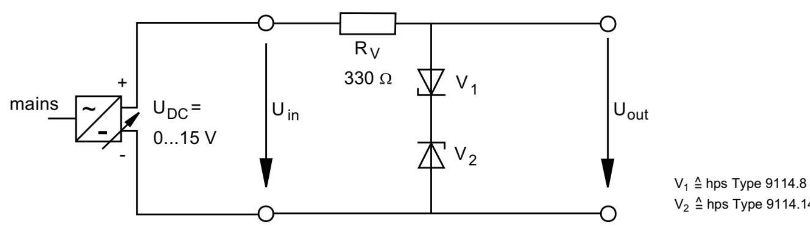
$\Delta U / \Delta \vartheta = (\Delta U_1 / \Delta \vartheta) + (\Delta U_2 / \Delta \vartheta) + (\Delta U_3 / \Delta \vartheta) + (\Delta U_4 / \Delta \vartheta)$

Practical Part:

Part 2: Record the characteristic U out = f (Uin) of two series opposed Zener diodes.

To prevent a rectifying effect caused by the low threshold voltage of the on-state range, two Zener diodes are connected series-opposed and thus a voltage-limiting effect which is independent of the polarity is obtained.

1. Set up the circuit according to the Figure and adjust the DC voltages Uin one after the other as shown in Table 2.4.2.1.
2. Measure the respective output voltages Uout with the multimeter and enter the voltage values in Table 2.4.2.1.



U_{in} [V]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
U_{out} [V]																

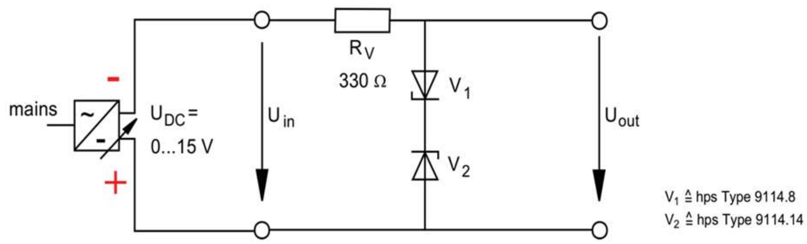
Tab. 2.4.2.1

Practical Part:

Part 2: Record the characteristic U out = f (Uin) of two series opposed Zener diodes.

To prevent a rectifying effect caused by the low threshold voltage of the on-state range, two Zener diodes are connected series-opposed and thus a voltage-limiting effect which is independent of the polarity is obtained.

3. Subsequently reverse the polarity of the input voltage Uin and repeat the measurements above. Enter the respective output voltages Uout in Table 2.4.2.2.



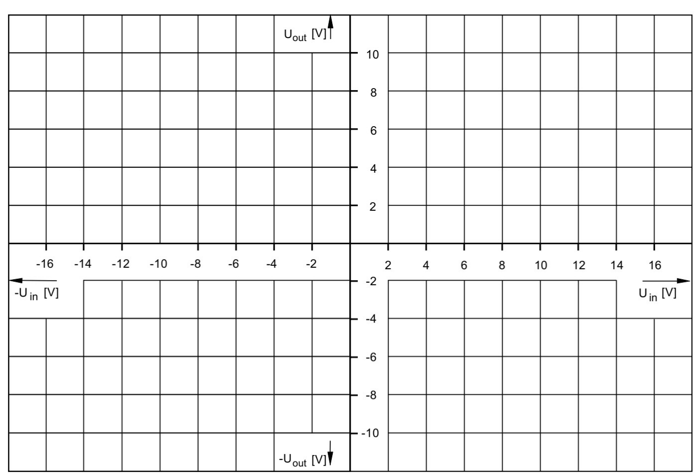
$-U_{in}$ [V]	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$-U_{out}$ [V]																

Tab. 2.4.2.2

Practical Part:

Part 2: Record the characteristic U out = f (Uin) of two series opposed Zener diodes.

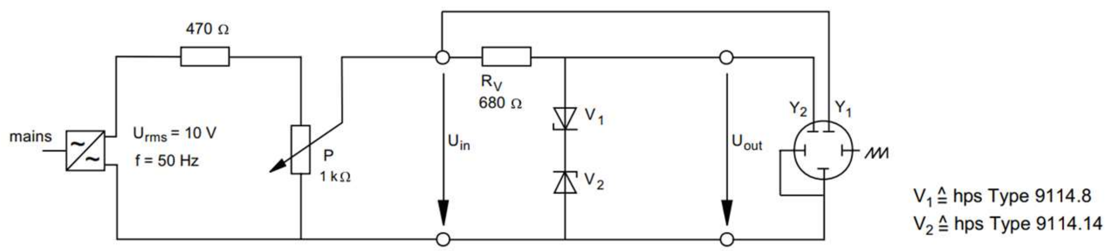
4. Show the dependence of the output voltage Uout on the input voltage Uin by plotting a graph in the grid of diagram 2.4.2.2.



Practical Part:

Part 3: Examine the voltage limiting effect of two series opposed Zener diodes with an oscilloscope.

1. Apply a sinusoid AC voltage U_{rms} = 10 V; f = 50 Hz to the circuit (Fig. 2.4.2.3) and set an input voltage of $U_{in\ rms}$ = 2 V with the potentiometer
2. Record the input voltage Uin and the output voltage Uout with the oscilloscope and plot a graph in diagram of Fig. 2.4.2.4.
3. Then increase the input voltage to Uin rms = 10 V.
4. Repeat the measurements above and enter the values in the diagram of Fig. 2.4.2.5.



Practical Part:

Part 3: Examine the voltage limiting effect of two series opposed Zener diodes with an oscilloscope.

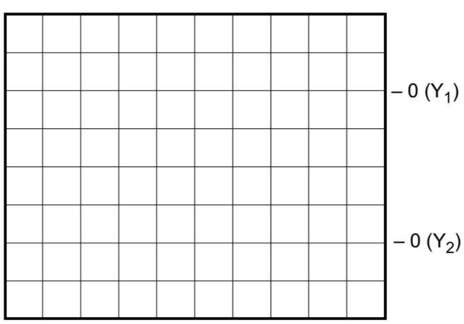


Fig. 2.4.2.4

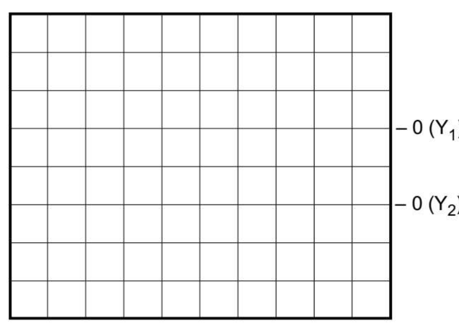


Fig. 2.4.2.5

Settings:
X = 5 ms / div.
Y_1 = 2 V / div.
Y_2 = 2 V / div.

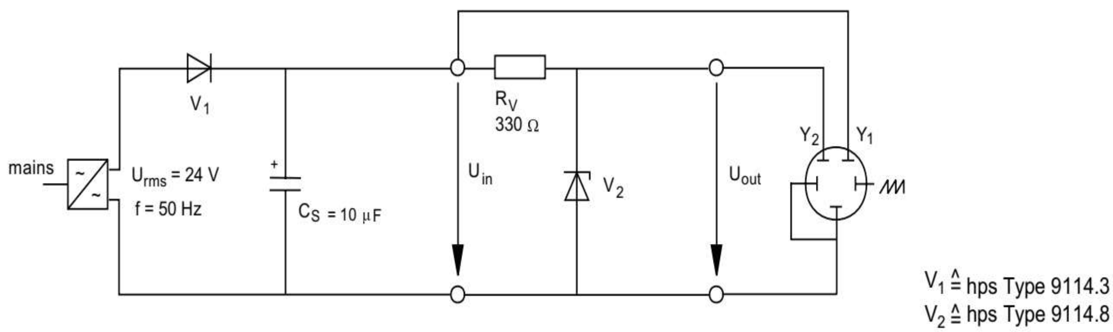
Remarks:
Y_1 = input voltage U_{in}
Y_2 = output voltage U_{out}

Settings:
X = 5 ms / div.
Y_1 = 20 V / div.
Y_2 = 5 V / div.

Remarks:
Y_1 = input voltage U_{in}
Y_2 = output voltage U_{out}

Practical Part:

Part 4: Examine the stabilizing effect of a Zener diode on a DC voltage with pronounced ripple.



Practical Part:

Part 4: Examine the stabilizing effect of a Zener diode on a DC voltage with pronounced ripple.

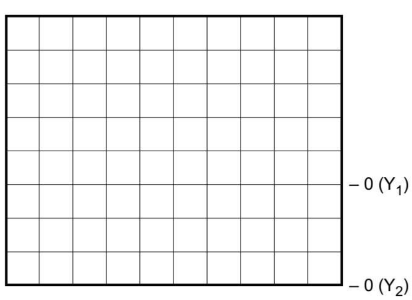


Fig. 2.5.2.2

Settings:
X = 5 ms / div.
Y_1 = 10 V / div.
Y_2 = 5 V / div.
(inputs on DC)

Remarks:
Y_1 = voltage U_{in}
Y_2 = voltage U_{out}

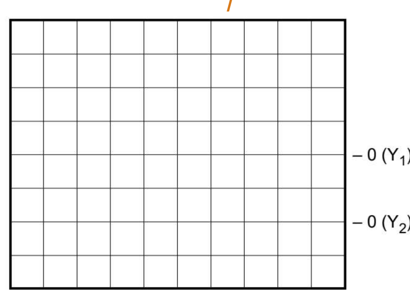


Fig. 2.5.2.3

Settings:
X = 5 ms / div
Y_1 = 5 V / div.
Y_2 = 0.1 V / div.
(inputs on AC)

Remarks:
Y_1 = voltage U_{in} without DC component
Y_2 = voltage U_{out} without DC component

Practical Part:

Part 4: Examine the stabilizing effect of a Zener diode on a DC voltage with pronounced ripple.

Question 1: How high is the ripple voltage ΔU_{in} on the smoothing capacitor C_S (measure in Fig. 2.5.2.2)?

Anwer:

ΔU_{in} =

ΔU_{in} = peak-to-peak value of the input voltage U_{in}

Question 2: How high is the ripple voltage ΔU_{out} on the Zener diode (measure in Fig. 2.5.2.3)?

Answer:

ΔU_{out} =

ΔU_{out} = peak-to-peak value of the output voltage U_{out}

Question 3: What is the value of the smoothing factor G (absolute stabilizing factor)?

Answer:

$$G = \frac{\Delta U_{in}}{\Delta U_{out}} =$$

G = smoothing factor

Question 4: What is the value of the relative stabilizing factor S?

Answer:

$$S = \frac{\Delta U_{in} \cdot U_{out}}{\Delta U_{out} \cdot U_{in}} = G \cdot \frac{U_{out}}{U_{in}} =$$

S = relative stabilizing factor

Measure the voltages U_{in} and U_{out} with the multimeter.

Practical Part:

Part 4: Examine the stabilizing effect of a Zener diode on a DC voltage with pronounced ripple.

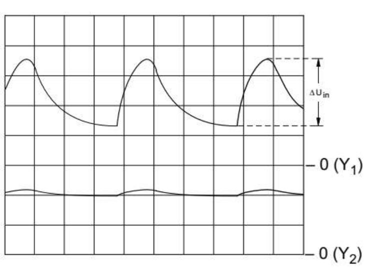


Fig. 2.5.2.2

Settings:
X = 5 ms / div.
Y_1 = 2 V / div.
Y_2 = 2 V / div.
Inputs on DC

Remarks:
Y_1 = voltage U_{in}
Y_2 = voltage U_{out}

The input voltage U_{in} contains ripple components which are still clearly visible; the output voltage U_{out} on the Zener diode has practically none.

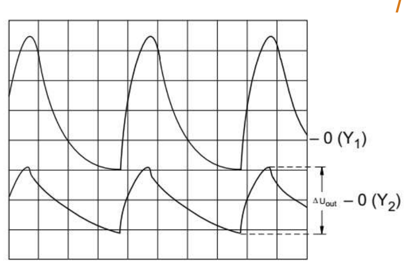


Fig. 2.5.2.3

Settings:
X = 5 ms / div.
Y_1 = 5 V / div.
Y_2 = 0.1 V / div.
Input on AC

Remarks:
Y_1 = voltage U_{in}
without DC
Y_2 = Spannung U_{out}
without DC

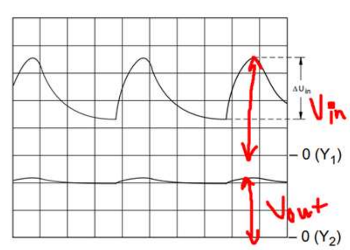


Fig. 2.5.2.2

Settings:
X = 5 ms / div.
Y_1 = 5 V / div.
Y_2 = 5 V / div.
Inputs on DC

Remarks:
Y_1 = voltage U_{in}
Y_2 = voltage U_{out}

$$S = \frac{\Delta U_{in} \cdot U_{out}}{\Delta U_{out} \cdot U_{in}} = G \cdot \frac{U_{out}}{U_{in}} =$$

Practical Part:

Part 4: Examine the stabilizing effect of a Zener diode on a DC voltage with pronounced ripple.