1332105 Dasar Elektronika

Electronic Basic
Rectifiers

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4-1 Half-Wave Rectifiers

Diode – ability to conduct current in one direction and block current in other direction

→ used in circuit called **RECTIFIER (ac →dc)**

Objective:

- Discuss the operation of half-wave rectifiers
- Describe a basic dc power supply & half-wave rectifications
- Determine the average value, V_{AVG} of half-waves rectified voltage
- Discuss the effect of barrier potential, V_P on a half-wave rectifier output
- Define *Peak Inverse Voltage* (PIV)
- Describe Transformer-couple half-wave rectifier

4-2 Half-Wave Rectifiers (cont.)
(The Half-Wave Rectifier)

- A half wave rectifier(ideal) allows conduction for only 180° or half of a complete cycle.
- During first one cycle:

-*Vin* goes positive – diode *FB* – conduct current

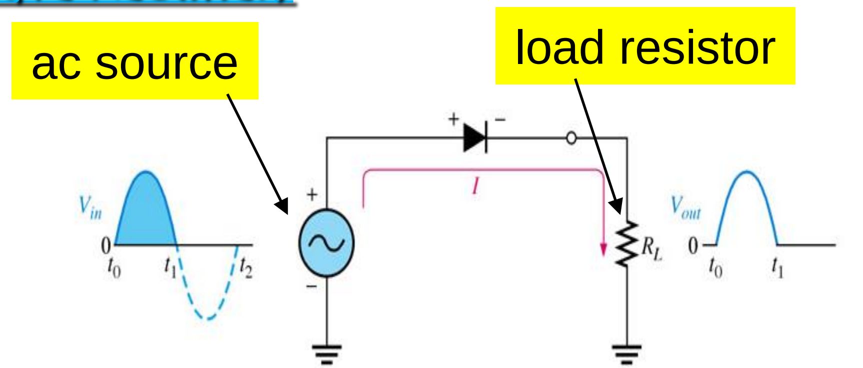
-*Vin* goes negative – diode *RB* – no current- 0V

- The output frequency is the same as the input (same shape).

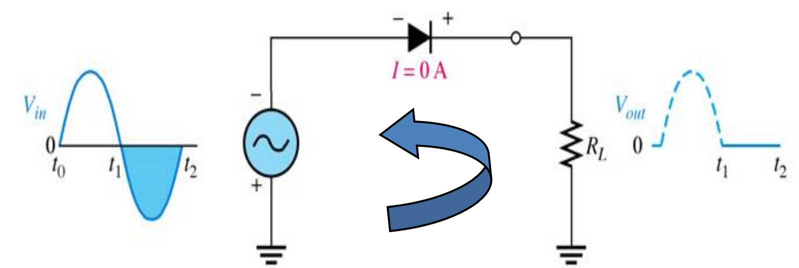
The average value V_{DC} or V_{AVG} :

$$\boxed{V_{AVG} = \frac{V_p}{\pi}}$$

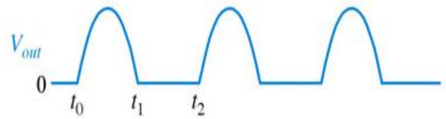
-Measure on dc voltmeter



(a) During the positive alternation of the 60 Hz input voltage, the output voltage looks like the positive half of the input voltage. The current path is through ground back to the source.



(b) During the negative alternation of the input voltage, the current is 0, so the output voltage is also 0.



(c) 60 Hz half-wave output voltage for three input cycles

Ideal diode model

4-3 Half-Wave Rectifiers (cont.)
(Effect of the Barrier Potential on the Half-Wave Rectifier Output)

- Practical Diode – barrier potential of 0.7V (Si) taken into account.
- During +ve half-cycle – V_{in} must overcome $V_{potential}$ for forward bias.

$$\boxed{V_{p(out)} = V_{p(in)} - 0.7V}$$

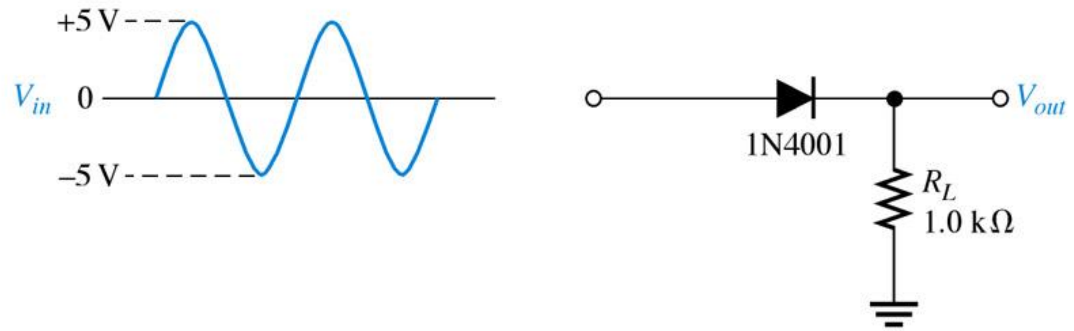
- Example 1: Calculate the peak o/p voltage, $V_{p(out)}$?

The peak o/p voltage:

$$V_{p(out)} = V_{p(in)} - 0.7V$$

$$= 5V - 0.7V$$

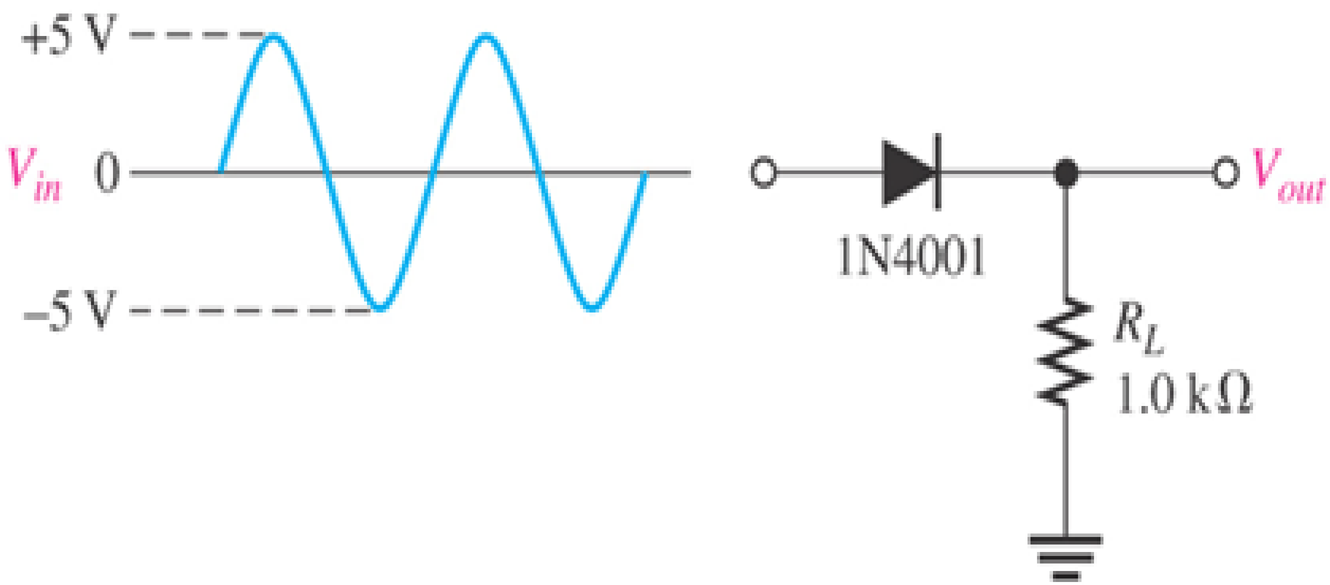
$$= 4.30V$$



(a)

4-4 Half-Wave Rectifiers (cont.)
(Effect of the Barrier Potential on the Half-Wave Rectifier Output)

Example 2:



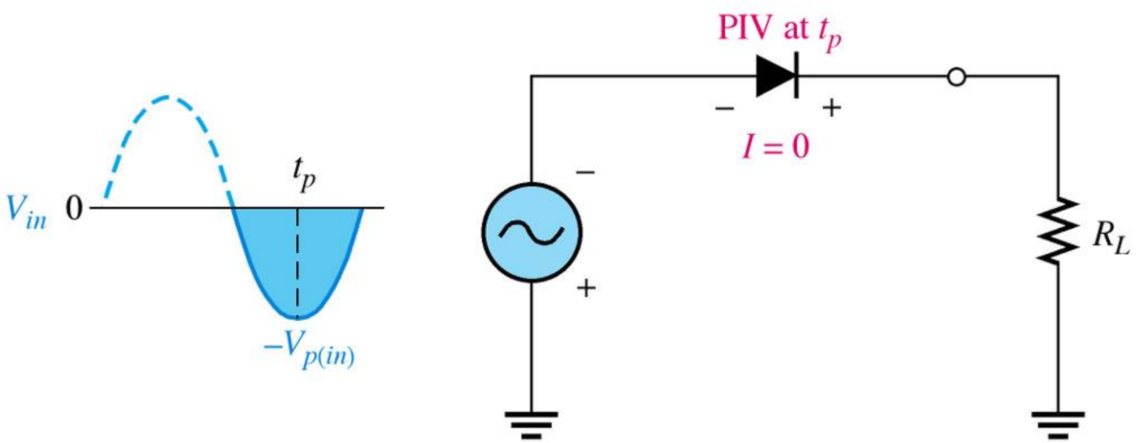
Sketch the output V_o and determine the output level voltage for the network in above figure.

4-5 Half-Wave Rectifiers (cont.)

[Peak Inverse Voltage (PIV)]

- Peak inverse voltage (PIV) is **the *maximum voltage* across the diode when it is in *reverse bias*.**

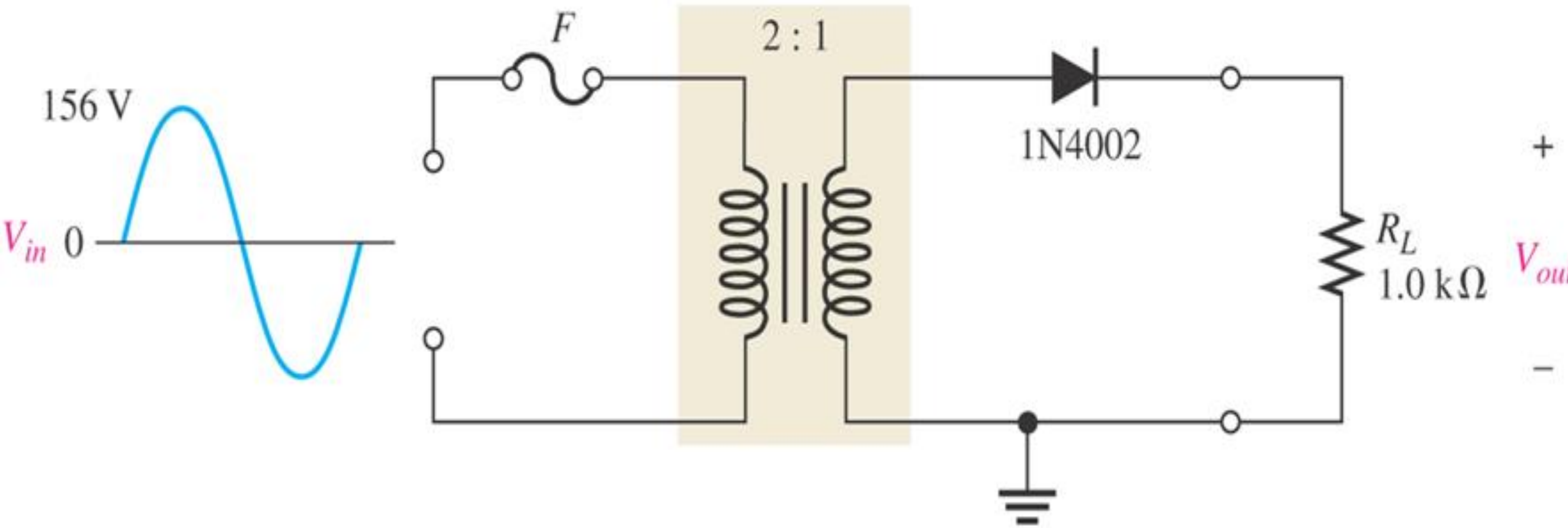
The diode must be capable of withstanding this amount of voltage.

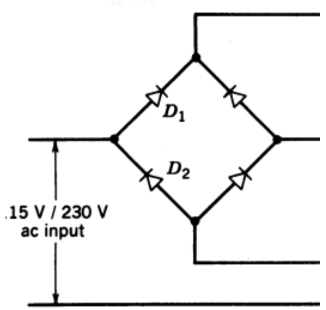


$$PIV = V_{p(in)}$$

Example 1:

Determine the peak value of output voltage as shown in below Figure.





4-6 Half-Wave Rectifiers (cont.)

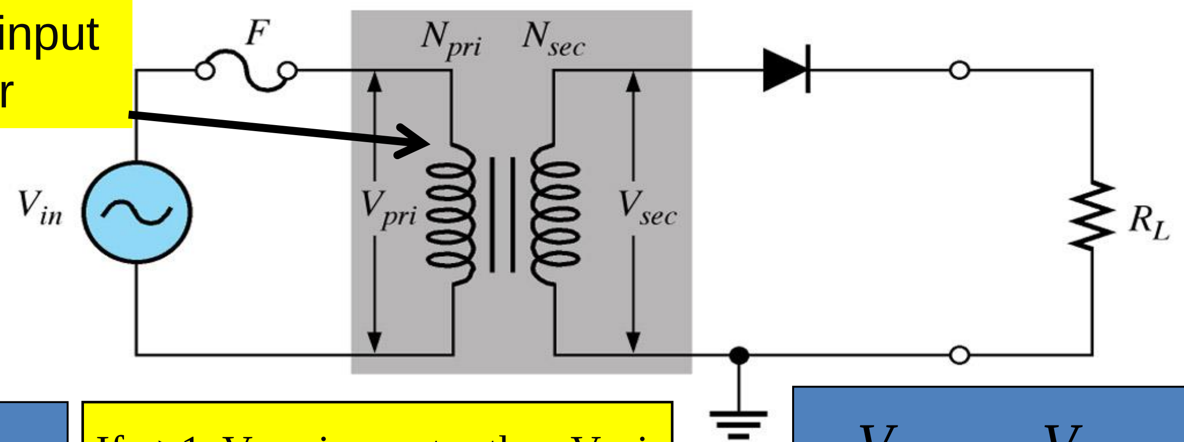
(Half-Wave Rectifier with Transformer-Coupled Input Voltage)

- Transformers are often used for voltage change and isolation.
- The *turns ratio, n* of the primary to secondary determines the *output versus the input.*

$$V_{\sec} = nV_{pri}$$

- The advantages of transformer coupling:
  1) allows the source voltage to be stepped up or down
  2) the ac source is electrically isolated from the rectifier, thus prevents shock hazards in the secondary circuit.

to couple ac input to the rectifier



$$n = \frac{N_{\sec}}{N_{pri}}$$

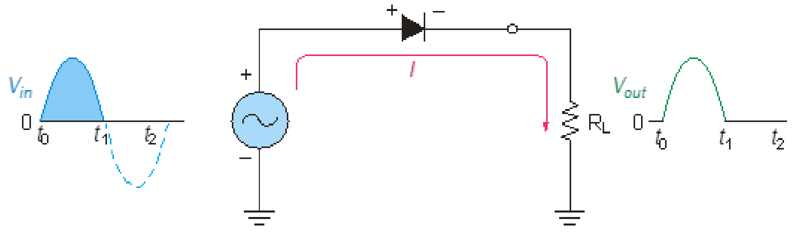
If n>1, Vsec is greater than Vpri.
If n<1, Vsec is less than Vpri.
If n=1, Vsec= Vpri.

$$V_{p(out)} = V_{p(\sec)} - 0.7V$$

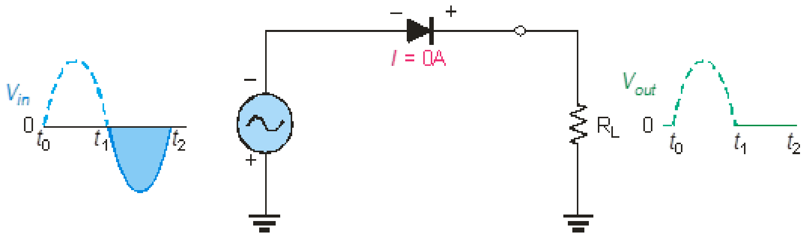
$$PIV = V_{p(\sec)}$$

The Half wave Rectifiers

- As diodes conduct current in one direction and block in other.
- When connected with ac voltage, diode only allows half cycle passing through it and hence convert ac into dc.
- As the half of the wave get rectified, the process called half wave rectification.



- A diode is connected to an ac source and a load resistor forming a half wave rectifier.
- Positive half cycle causes current through diode, that causes voltage drop across resistor.

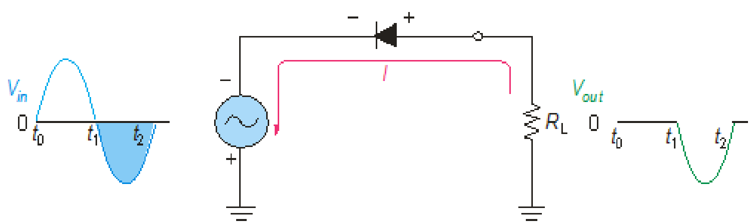


Diode as Rectifiers

❖ Reversing diode.

Ideal Half Wave

$$V_p(out) = V_p(in)$$



$$V_{rms} = 1.57.V_{avg}$$

$$V_{rms} = \mathrm{V_p} / \sqrt{2}$$

❖ DC Value of Half Wave Signal

❖ Half Wave (V_{dc}), Average value of Half wave output voltage:

$$V_{dc} = V_{AVG} = V_P / \pi \qquad 1/3{,}14 = 0{,}318$$

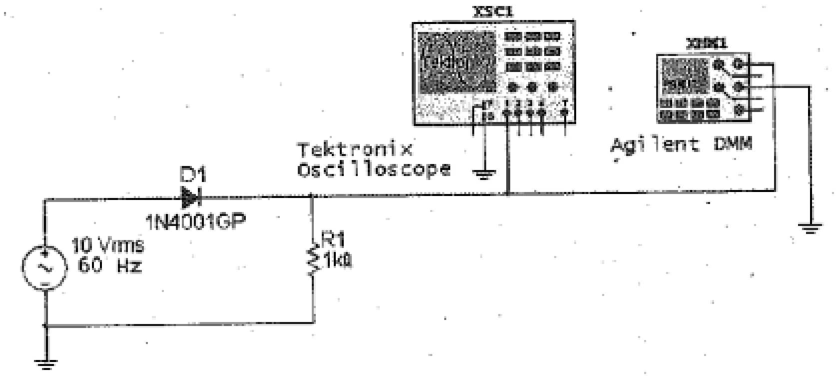
$$V_{dc} = 0{,}318\, V_p$$

❖ V_{AVG} is approx 31.8% of V_p

❖ PIV: Peak Inverse Voltage = V_p

$$f_p(out) = f_p(in)$$

2d Half Wave $$V_p(out) = V_p(in) - 0.7v$$



Example 4-1

MultiSim

Figure 4-3 shows a half-wave rectifier that you can build on the lab bench or on a computer screen with MultiSim. An oscilloscope is across the 1 kΩ. This will show us the half-wave load voltage. Also, a multimeter is across the 1 kΩ to read the dc load voltage. Calculate the theoretical values of peak load voltage and the dc load voltage. Then, compare these values to the readings on the oscilloscope and the multimeter.

SOLUTION Figure 4-3 shows an ac source of 10 V and 60 Hz. Schematic diagrams usually show ac source voltages as effective or rms values. Recall that the *effective value* is the value of a dc voltage that produces the same heating effect as the ac voltage.

Since the source voltage is 10 V rms, the first thing to do is calculate the peak value of the ac source. You know from earlier courses that the rms value of a sine wave equals:

$$V_{rms} = 0.707V_p$$

Therefore, the peak source voltage in Fig. 4-3 is:

$$V_p = \frac{V_{rms}}{0.707} = \frac{10\text{ V}}{0.707} = 14.1\text{ V}$$

With an ideal diode, the peak load voltage is:

$$V_{p(out)} = V_{p(in)} = 14.1\text{ V}$$

The dc load voltage is:

$$V_{dc} = \frac{V_p}{\pi} = \frac{14.1\text{ V}}{\pi} = 4.49\text{ V}$$

With the second approximation, we get a peak load voltage of:

$$V_{p(out)} = V_{p(in)} - 0.7\text{ V} = 14.1\text{ V} - 0.7\text{ V} = 13.4\text{ V}$$

and a dc load voltage of:

$$V_{dc} = \frac{V_p}{\pi} = \frac{13.4\text{ V}}{\pi} = 4.27\text{ V}$$

Figure 4-3 shows you the values that an oscilloscope and a multimeter will read. Channel 1 of the oscilloscope is set at 5 V per major division (5 V/Div). The half-wave signal has a peak value between 13 and 14 V, which agrees with the result from our second approximation. The multimeter also gives good agreement with theoretical values, because it reads approximately 4.22 V.

PRACTICE PROBLEM 4-1 Using Fig. 4-3, change the ac source voltage to 15 V. Calculate the second approximation dc load voltage V_{dc}.

4-1 The Basic DC Power Supply

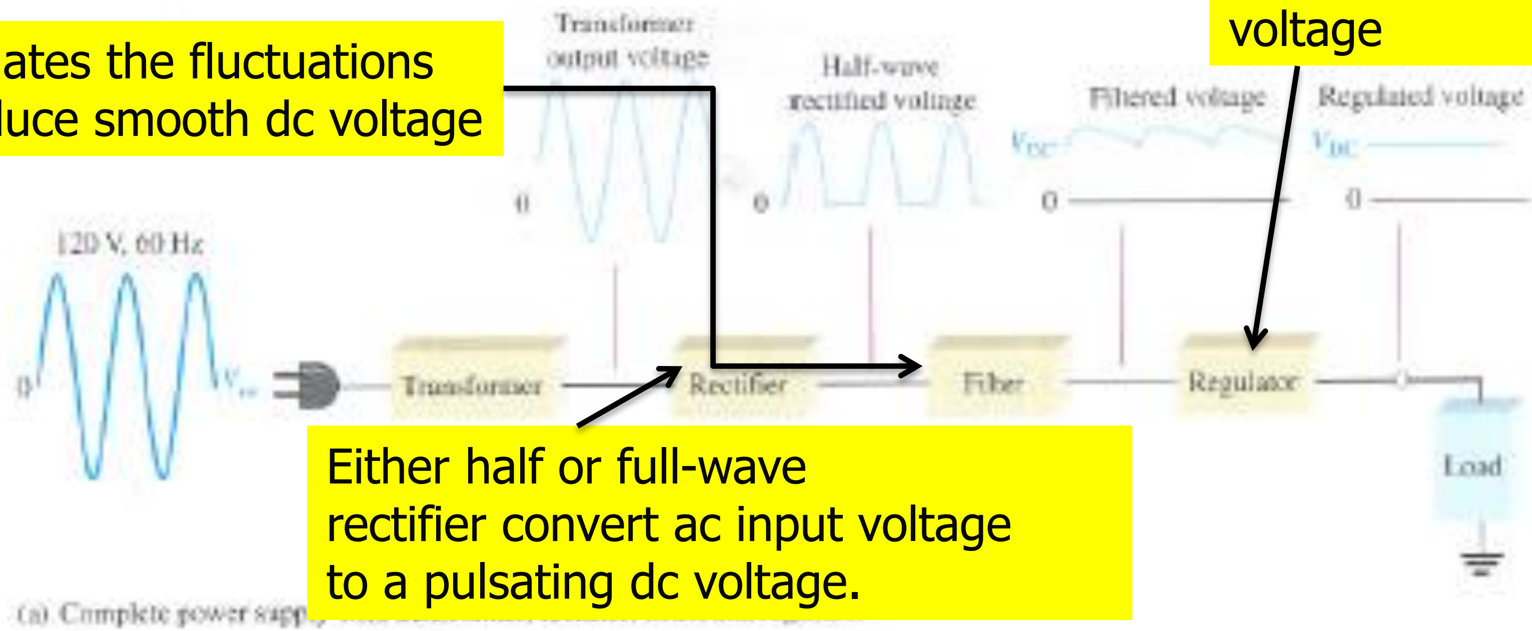
- Power supply is a group of circuits that convert the ***standard ac voltage*** (120 V, 60 Hz) provided by the wall outlet to ***constant dc voltage***.
- The voltage produced is used to power all types of electronic circuits including:
  - Consumer electronics (ex: radio, television, DVD, etc.)
  - Computers
  - Industrial controllers
  - Most laboratory instrumentation systems and equipment
- The dc voltage level required depends on the application, but most applications require relatively low voltage.
- There are two basic types of power supplies: a linear power supply and a switching power supply. These components are described as follows:
  1. A ***linear power supply*** is one that provides a ***constant current path*** between its input and its load.
  2. A ***switching power supply*** provides an ***intermittent current path*** between its input and its output.

4-2 The Basic DC Power Supply(cont.)

The basic function of a DC power supply is to convert an AC voltage to a constant DC voltage (AC → DC)

Maintains a constant dc voltage

Eliminates the fluctuations - produce smooth dc voltage



Either half or full-wave rectifier convert ac input voltage to a pulsating dc voltage.

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

(b) Half-wave rectifier

Fig. 4-1: Block diagram of a dc power supply with a load and rectifier.

The Basic DC Power Supply(cont.)

Transformer

- A transformer is a device that changes ac electric power at one voltage level to ac electric power at another voltage level through the action of a magnetic field.
- Simple transformer consist of:
  1. Primary winding (input winding)
  2. Secondary winding (output winding)
  3. Magnetic core
- If the secondary has more turns than the primary, the output voltage across the secondary will be higher and the current will be smaller. If the secondary has fewer turns than the primary, the output voltage across the secondary will be lower and the current will be higher.
- The core has a function to concentrate the magnetic flux.

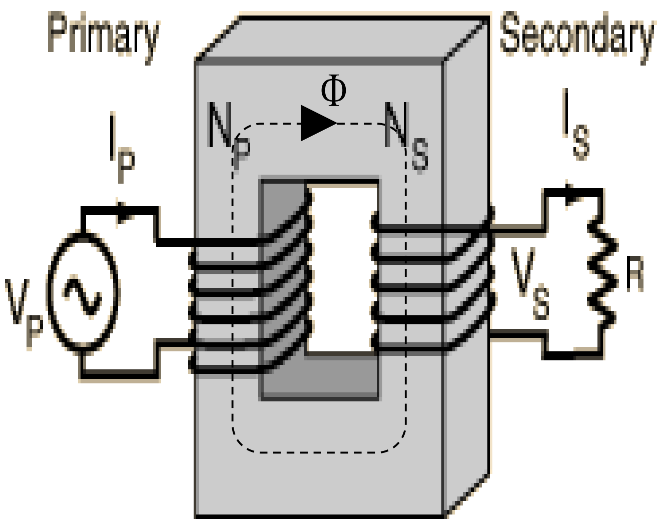
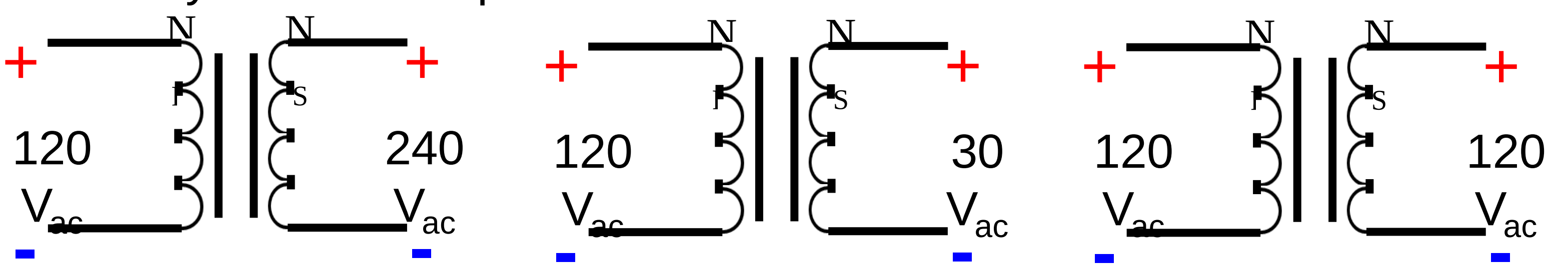


Fig.2-2: The general arrangement of a transformer

The Basic DC Power Supply(cont.)

There are three types of transformers: ***step-up, step-down,*** and ***isolation***. These components are described as follows:

1. The step-up transformer provides a secondary voltage that is ***greater*** than the primary voltage. Ex: a step-up transformer may provides a 240 V_{ac} output with a 120 V_{ac} input.
2. The step-down transformer provides a secondary voltage that is ***less*** than the primary voltage. Ex: a step-down transformer may provides a 30 V_{ac} output with a 120 V_{ac} input.
3. An isolation transformer provides an output voltage that is equal to the input voltage. This type of transformer is used to isolate the power supply electrically from the ac power line.



Step-up (a)

Step-down (b)

Isolation (c)

Fig.2-3

The Basic DC Power Supply(cont.)

The turns ratio of a transformer is equal to the voltage ratio of the component and since, the voltage ratio is the inverse of the current ratio. By formula:

$$\frac{N_{\sec}}{N_{pri}} = \frac{V_{\sec}}{V_{pri}} = \frac{I_{pri}}{I_{\sec}} \qquad (2\text{-}1)$$

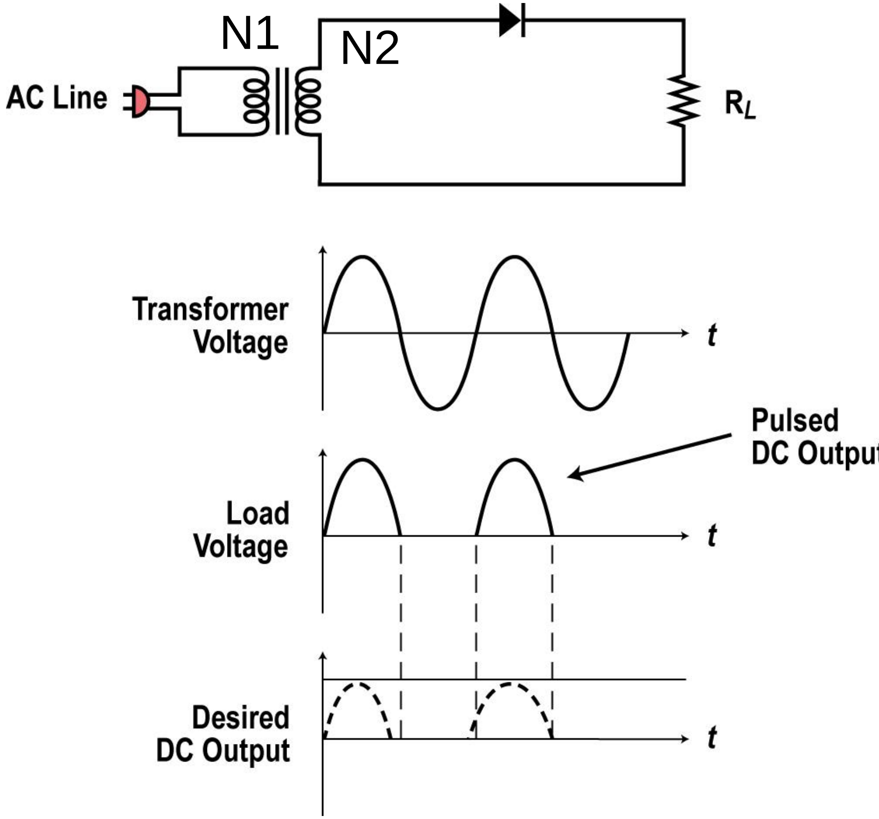
where
N_{Sec} = the number of turns in the secondary
N_{Pri} = the number of turns in the primary
V_{Sec} = the secondary voltage
V_{Pri} = the primary voltage
I_{Sec} = the secondary current
I_{Pri} = the primary current

By the equation (2-1) can be stated that:

- Step-down transformer secondary current is ***greater*** than its primary current ($I_{Sec} > I_{Pri}$).
- Step-up transformer secondary current is ***less*** than its primary current ($I_{Pri} > I_{Sec}$).

The Transformer

- The simplest form of rectifier is the half wave rectifier shown.
- Only the transformer, rectifier diode, and load (R_L) are shown without the filter and other components.
- The half wave rectifier produces one sine pulse for each cycle of the input sine wave.
- When the sine wave goes positive, the anode of the diode goes positive causing the diode to be forward biased. The diode conducts and acts like a closed switch letting the positive pulse of the sine wave to appear across the load resistor.



- Turn Rasio

$$V_2 = \frac{V_1}{(N_1 + N_2)}$$

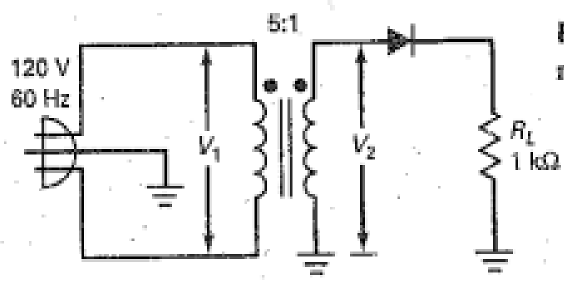
Step Down Trafo :

$$V_2 = \frac{N_2}{N_1} V_1$$

Example 4-2

What are the peak load voltage and dc load voltage in Fig. 4-5

Figure 4-5



SOLUTION The transformer has a turns ratio of 5:1. This means that the rms secondary voltage is one-fifth of the primary voltage:

$$V_2 = \frac{120\text{ V}}{5} = 24\text{ V}$$

and the peak secondary voltage is:

$$V_p = \frac{24\text{ V}}{0.707} = 34\text{ V}$$

With an ideal diode, the peak load voltage is:

$$V_{p(out)} = 34\text{ V}$$

The dc load voltage is:

$$V_{dc} = \frac{V_p}{\pi} = \frac{34\text{ V}}{\pi} = 10.8\text{ V}$$

With the second approximation, the peak load voltage is:

$$V_{p(out)} = 34\text{ V} - 0.7\text{ V} = 33.3\text{ V}$$

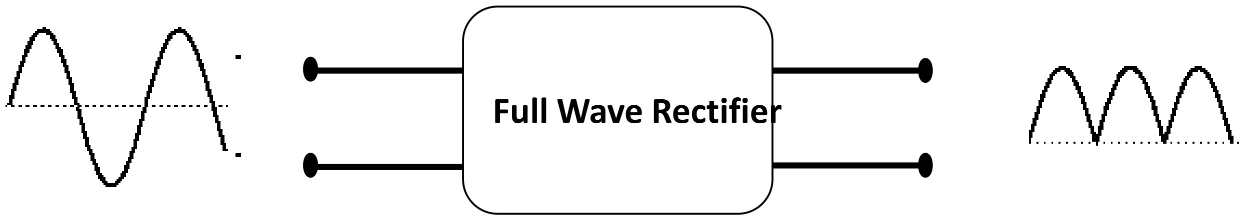
and the dc load voltage is:

$$V_{dc} = \frac{V_p}{\pi} = \frac{33.3\text{ V}}{\pi} = 10.6\text{ V}$$

PRACTICE PROBLEM 4-2 Using Fig. 4-5, change the transformer's turns ratio to 2:1 and solve for the ideal dc load voltage.

The Full wave rectifiers

- A full wave rectifier allows unidirectional current through the load during the entire 360 degree of input cycle.



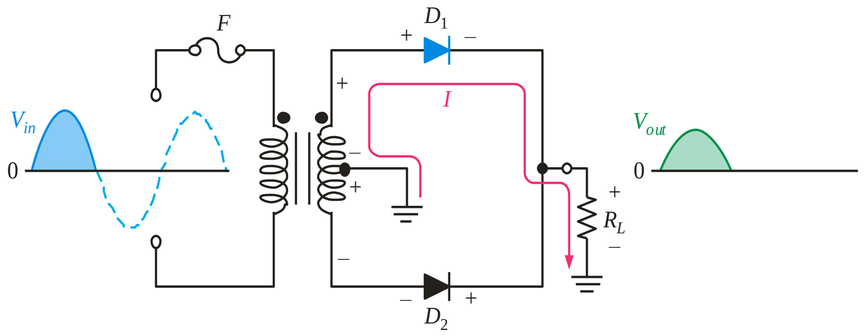
- The output voltage have twice the input frequency.

$$V_{AVG} = 2V_P / \pi \qquad V_p(out) = V_p(in)$$

- V_{AVG} is 63.7% of Vp

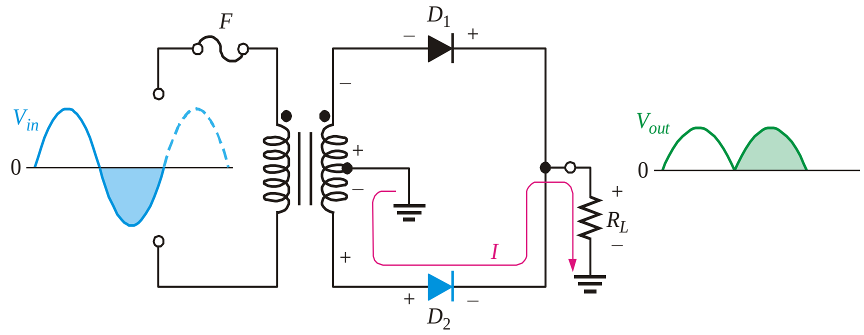
The Center-Tapped Full wave rectifiers

- A center-tapped transformer is used with two diodes that conduct on alternating half-cycles.



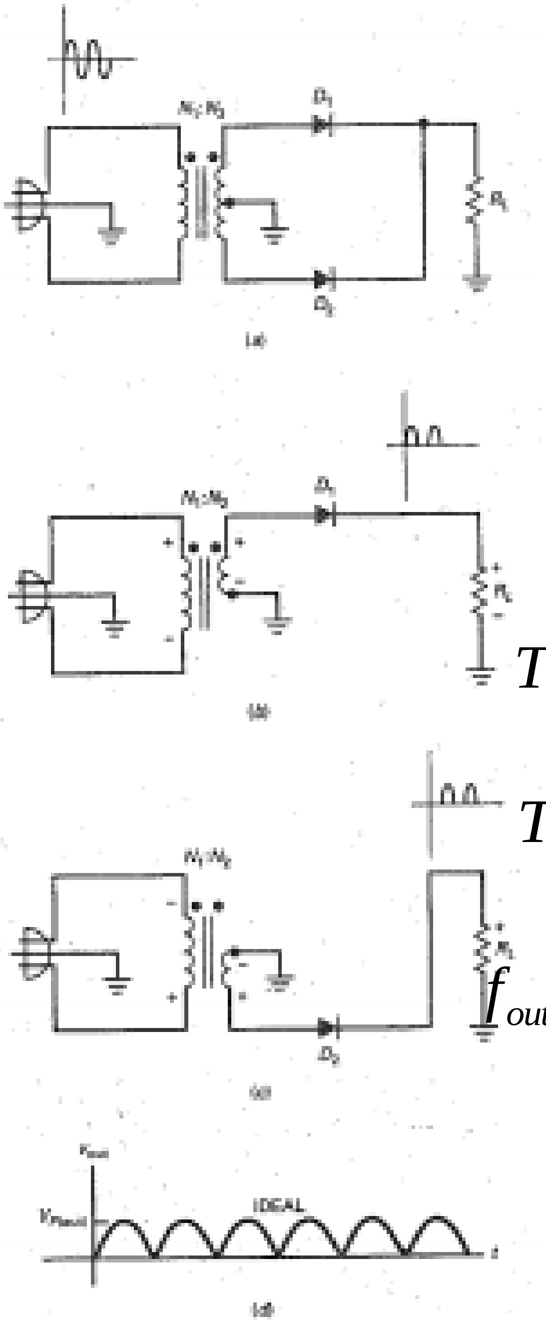
During the positive half-cycle, the upper diode is forward-biased and the lower diode is reverse-biased.

During the negative half-cycle, the lower diode is forward-biased and the upper diode is reverse-biased.



$$V_p(1) = \frac{V_{rms}}{0.707} \frac{129v}{0.707} = 170v$$

Figure 4-6 (a) Full-wave rectifier; (b) equivalent circuit for positive half cycle; (c) equivalent circuit for negative half cycle; (d) full-wave output.



Full Wave :

$$V_{dc} = 2.V_p / \pi$$

$$2 / pi = 0.636$$ equal $$V_{dc} = 0.636.V_p$$

$$V_{dc} = 0.636.V_p$$

If Full Wave signal : 100 V

Vdc = V avg = 63.6 V

Out Frequency

$$T_{in} = \frac{1}{f} = \frac{1}{60Hz} = 16.7ms$$

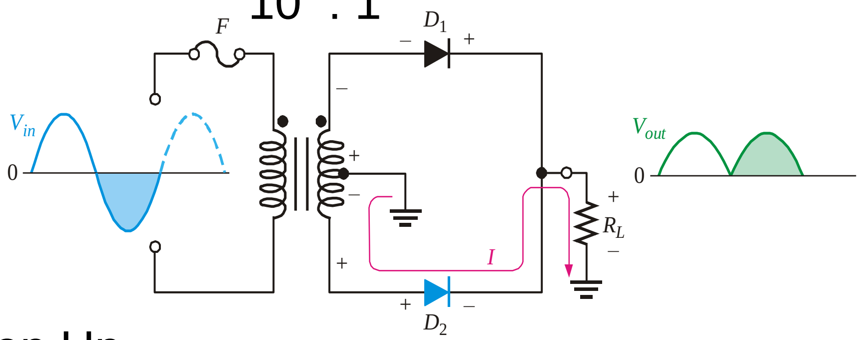
$$T_{out} = 0.5(16.7ms) = 8.33ms$$

$$f_{out} = \frac{1}{T_{out}} = \frac{1}{8.33ms} = 120Hz$$

Full Wave : $$f_{out} = 2 f_{in}$$

The Bridge Full-Wave Rectifier

10 : 1



Solution:

Step Up

$$V_p(1) = \frac{V_{rms}}{0.707} = \frac{129v}{0.707} = 170v$$

Step Down

$$V_p(2) = \frac{V_p(1)}{N_1/N_2} = \frac{170v}{10} = 17v$$

Only half the secondary

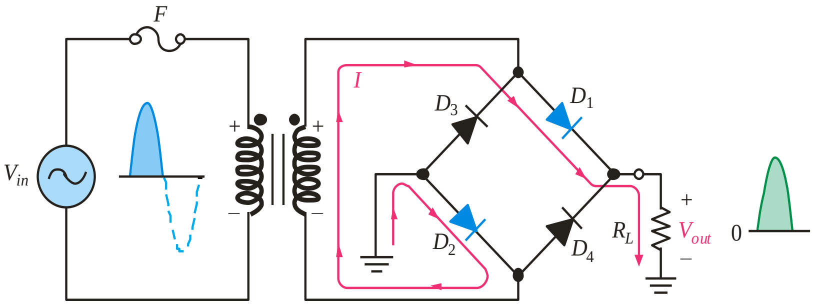
$$V_p(in) = 0.5(17V) = 8.5v$$

$$V_p(out) = 8.5 - 0.7V) = 7.8v$$

Now, let's compare the theoretical values with the measured values. The sensitivity of channel 1 is 100 V/Div. Since the sine-wave input reads approximately 1.7 divisions, its peak value is approximately 170 V. Channel 2 has a

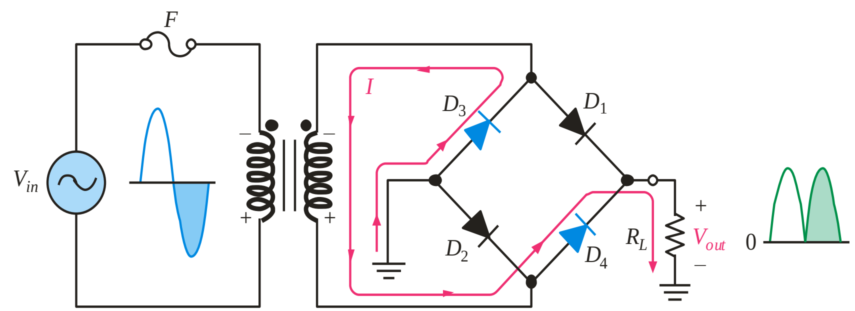
The Bridge Full-wave rectifiers

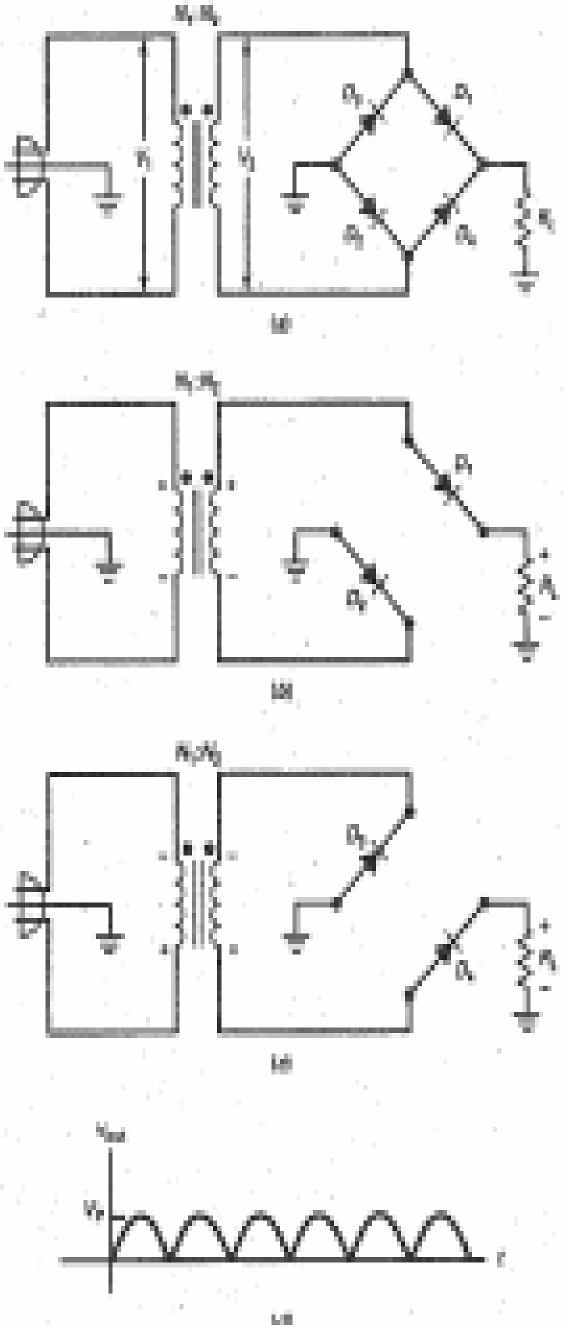
❖ The Bridge Full-Wave rectifier uses four diodes connected across the entire secondary as shown.



Conduction path for the positive half-cycle.

Conduction path for the negative half-cycle.





V average

$$V_{dc} = 2.V_p / \sqrt{2}$$

Out Frequency

$$f_{out} = 2 f_{in}$$

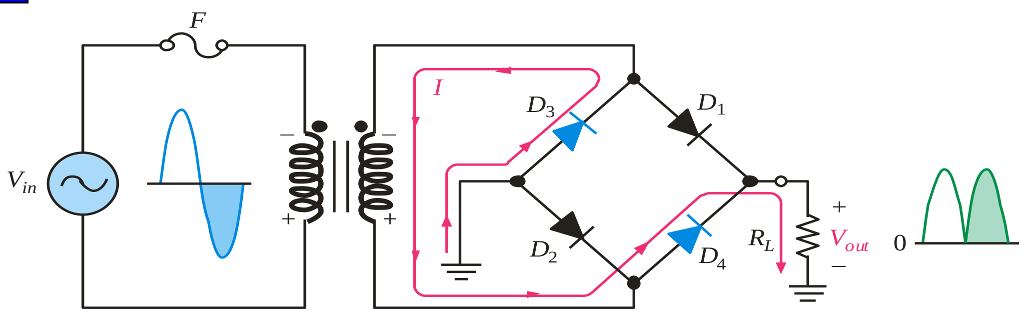
2 nd Bridge

$$V_p(out) = V_p(in).1.4v$$

Summary Table 4-1	Unfiltered Rectifiers*		
	Half-wave	Full-wave	Bridge
Number of diodes	1	2	4
Rectifier input	$V_{p(2)}$	$0.5V_{p(2)}$	$V_{p(2)}$
Peak output (ideal)	$V_{p(2)}$	$0.5V_{p(2)}$	$V_{p(2)}$
Peak output (2d)	$V_{p(2)} - 0.7\text{ V}$	$0.5V_{p(2)} - 0.7\text{ V}$	$V_{p(2)} - 1.4\text{ V}$
DC output	$V_{p(out)}/\pi$	$2V_{p(out)}/\pi$	$2V_{p(out)}/\pi$
Ripple frequency	f_{in}	$2f_{in}$	$2f_{in}$

*$V_{p(2)}$ = peak secondary voltage; $V_{p(out)}$ = peak output voltage.

The Bridge Full-Wave Rectifier



Solution:

$$V_p(1) = \frac{V_{rms}}{0.707} \; \frac{129v}{0.707} = 170v$$

$$V_p(2) = \frac{V_p(1)}{N_1 / N_2} = \frac{170v}{10} = 17v$$

$$V_p(out) = 1(17V) = 17v$$

$$V_p(out) = 17 - 1.4v = 15.6v$$

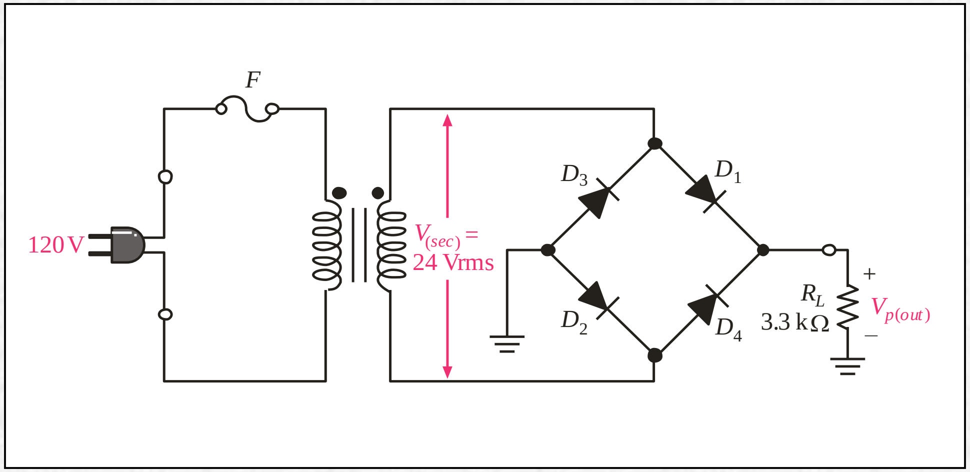
The Bridge Full-Wave Rectifier

Example:

Determine the peak output voltage and current in the 3.3 kΩ load resistor if V_{sec} = 24 V_{rms}. Use the practical diode model.

Solution:

The peak output voltage is:



$$V_{p(sec)} = 1.41 V_{rms} = 33.9 \text{ V}$$

$$V_{p(out)} = V_{p(sec)} - 1.4 \text{ V}$$

$$= 32.5 \text{ V}$$

Applying Ohm's law,

$I_{p(out)}$ = 9.8 mA

4-5 The Choke Input Filter

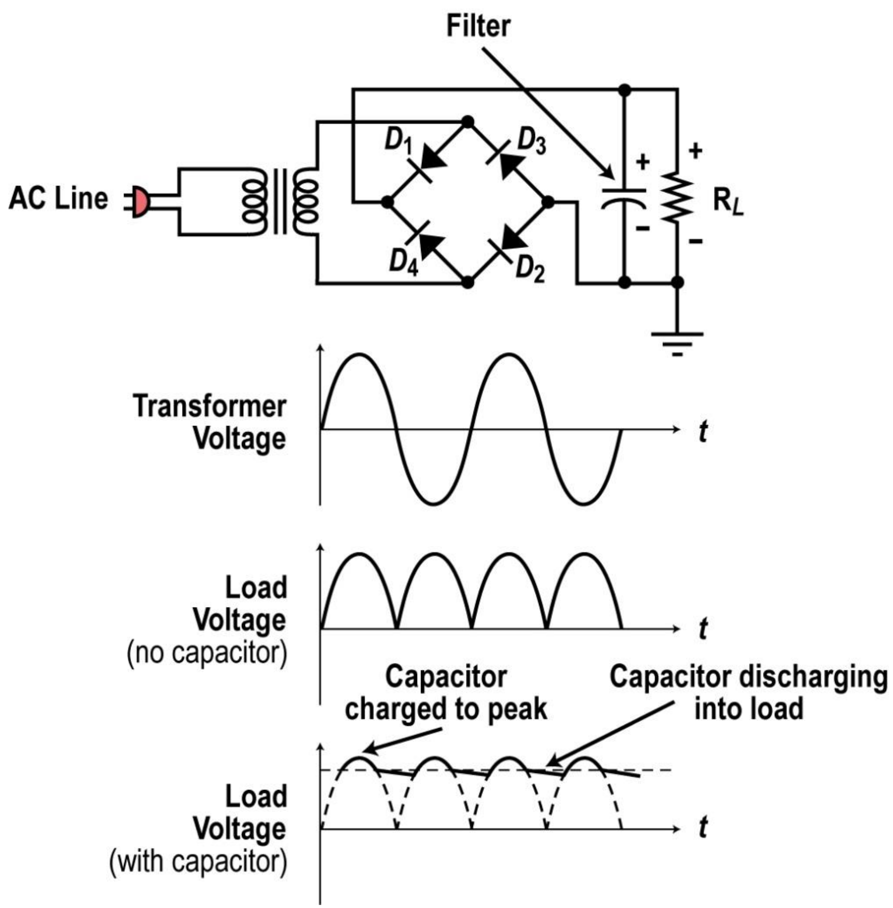
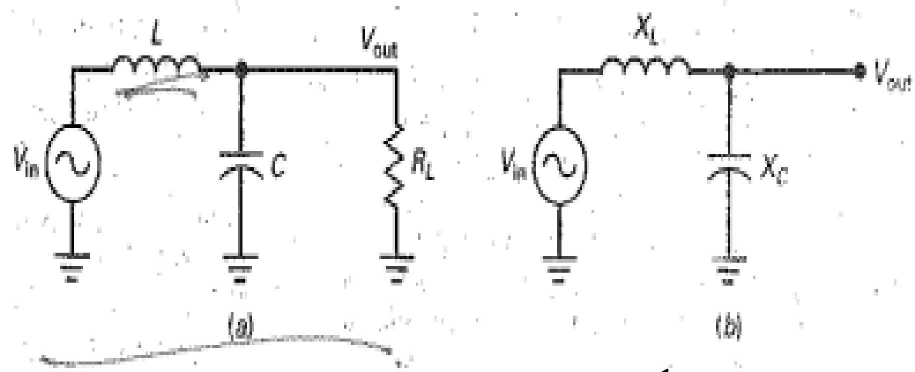


Figure 4-10 (a) Choke-input filter; (b) ac equivalent circuit.



$$X_C = 2\pi f l \qquad X_C = \frac{1}{(2\pi f c)}$$

$$V_{out} = \frac{X_C}{X_L} V_{in}$$

LC voltage Divider

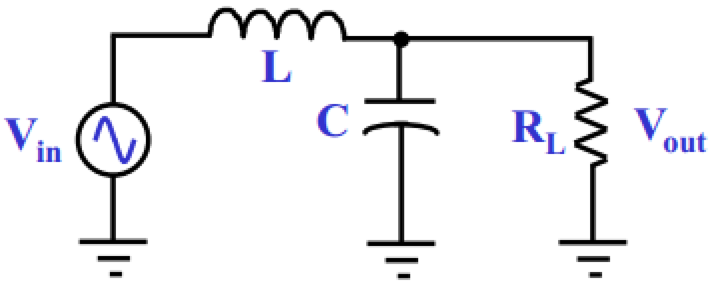
$X_L >> X_c$

The average value of a rectified signal passes to the load resistor

If XL = 10 kohm, Xc=100 ohm, Vin=15 V

$$V_{out} = \frac{100}{10kohm} 15V = 0.15v$$

The choke-input filter

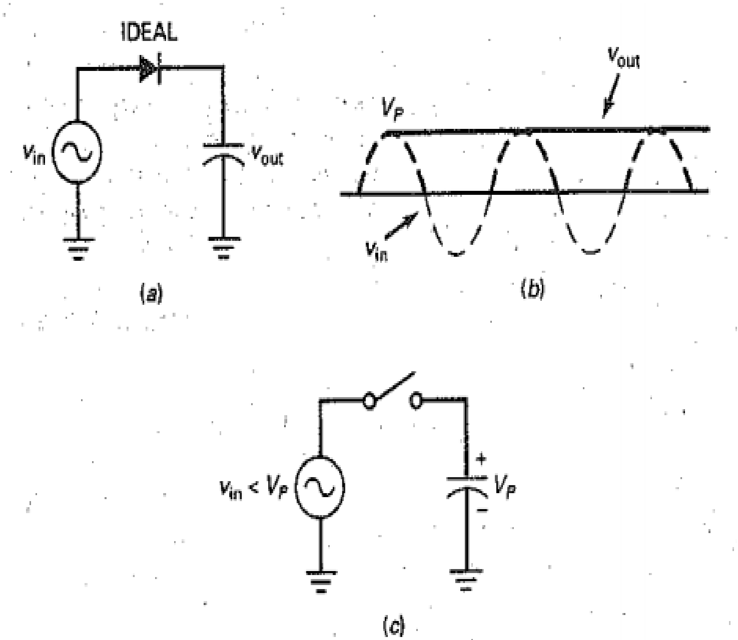


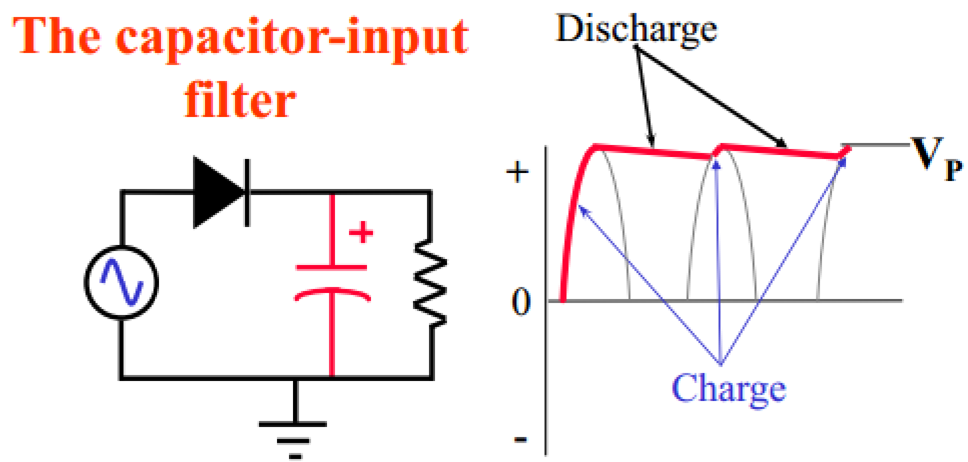
When $X_L >> X_C$:

$$V_{out} \cong \frac{X_C}{X_L} V_{in}$$

4.6 The Capacitor-input filter

- **Most widely used**
- **The peak value of the rectified signal passes to the load resistor**
- **With a large capacitor, ripple is small**



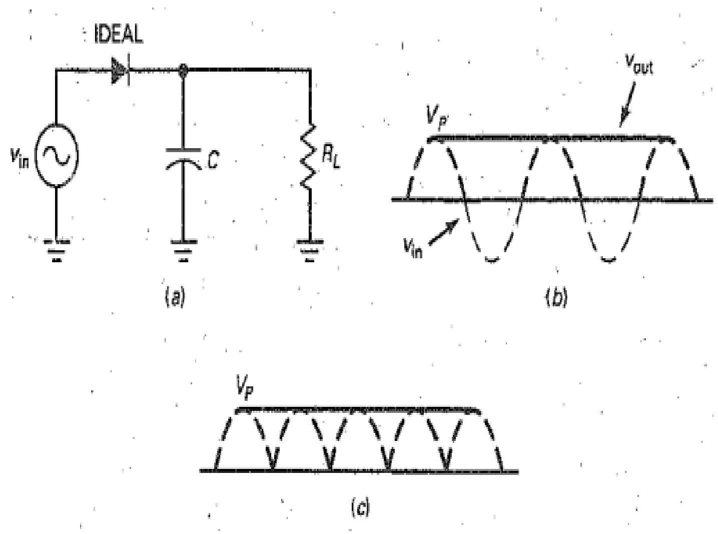


$$V_R = \frac{1}{fC}$$

Where V_R is the peak-to-peak ripple voltage

Full Wave Filtering

The peak-to-peak ripple voltage is half wave rectifier



The Ripple Formula

$$V_R = \frac{1}{fC}$$

where V_R = peak-to-peak ripple voltage
I = dc load current
f = ripple frequency
C = capacitance

Ripple voltage

$$V_R = V_{p(out)}(1 - \varepsilon^{-t/R_L C})$$

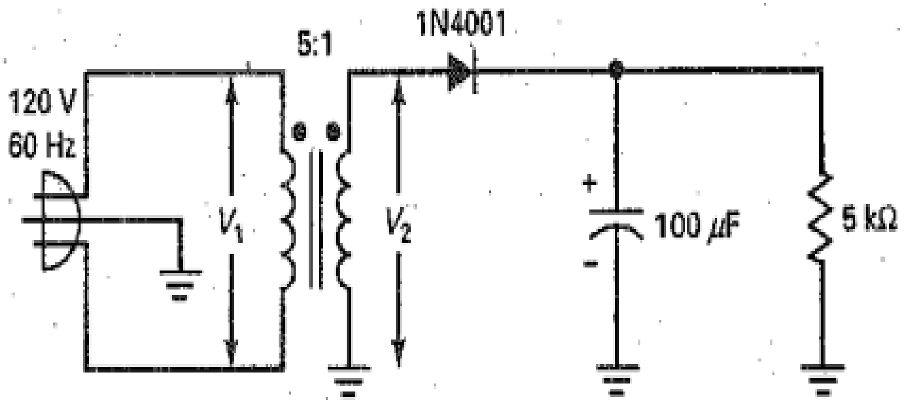
t = 16,67
If FullWave Rectifier : 8,33 ms

If load current 10 mA, C 200 uF
Calculate a ripple voltage ...

$$V_R = \frac{100mA}{(120Hz)(200\mu F)} = 0.417V_{pp}$$

$$V_{rms} = \frac{V_{pp}}{2\sqrt{2})}$$

Figure 4-14 Half-wave rectifier and capacitor-input filter.



SOLUTION The rms secondary voltage is:

$$V_2 = \frac{120\text{ V}}{5} = 24\text{ V}$$

The peak secondary voltage is:

$$V_p = \frac{24\text{ V}}{0.707} = 34\text{ V}$$

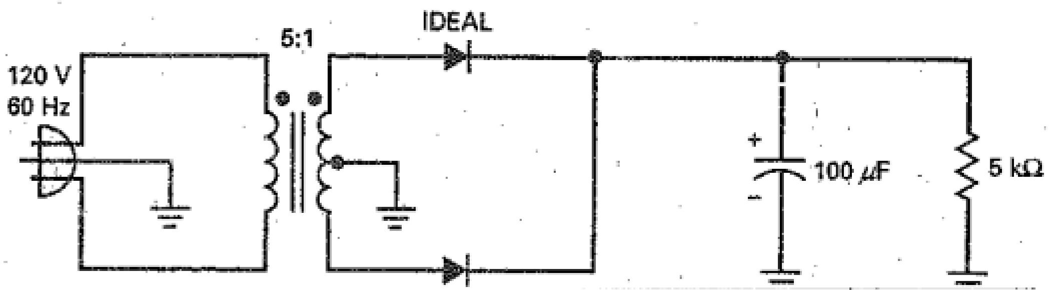
Assuming an ideal diode and small ripple, the dc load voltage is:

$$V_L = 34\text{ V}$$

To calculate the ripple, we first need to get the dc load current:

$$I_L = \frac{V_L}{R_L} = \frac{34\text{ V}}{5\text{ k}\Omega} = 6.8\text{ mA}$$

Figure 4-15 Full-wave rectifier and capacitor-input filter.



Example 4-7

IIII MultiSim

What is the dc load voltage and ripple in Fig. 4-15?

SOLUTION Since the transformer is 5:1 step-down like the preceding example, the peak secondary voltage is still 34 V. Half this voltage is the input to each half-wave section. Assuming an ideal diode and small ripple, the dc load voltage is:

$$V_L = 17\text{ V}$$

The dc load current is:

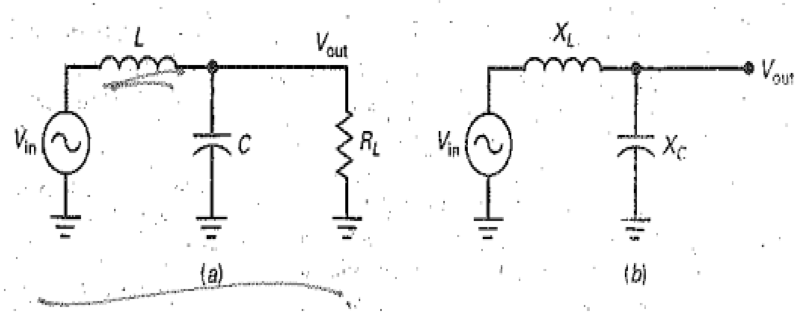
$$I_L = \frac{17\text{ V}}{5\text{ k}\Omega} = 3.4\text{ mA}$$

Now, Eq. (4-10) gives:

$$V_R = \frac{3.4\text{ mA}}{(120\text{ Hz})(100\ \mu\text{F})} = 0.283\text{ V pp} \approx 0.28\text{ V pp}$$

$$V_R = \frac{6.8\text{ mA}}{(60\text{ Hz})(100\ \mu\text{F})} = 1.13\text{ V pp} \approx 1.1\text{ V pp}$$

Figure 4-10 (*a*) Choke-input filter; (*b*) ac equivalent circuit.

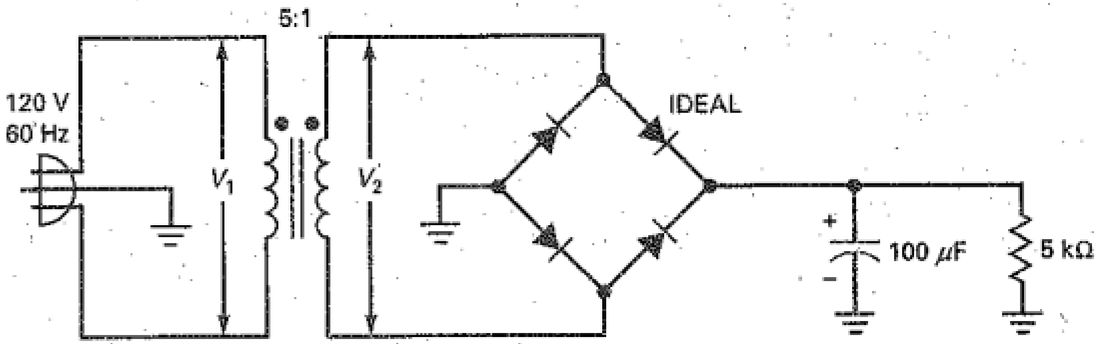


$$V_{out} \approx \frac{X_C}{X_L} V_{in} \tag{4-9}$$

For instance, if $X_L = 10\text{ k}\Omega$, $X_C = 100\ \Omega$, and $V_{in} = 15\text{ V}$, the ac output voltage is:

$$V_{out} \approx \frac{100\ \Omega}{10\text{ k}\Omega} 15\text{ V} = 0.15\text{ V}$$

Figure 4-16 Bridge rectifier and capacitor-input filter.



SOLUTION Since the transformer is 5:1 step-down as in the preceding example, the peak secondary voltage is still 34 V. Assuming an ideal diode and small ripple, the dc load voltage is:

$$V_L = 34 \text{ V}$$

The dc load current is:

$$I_L = \frac{34 \text{ V}}{5 \text{ k}\Omega} = 6.8 \text{ mA}$$

Now, Eq. (4-10) gives:

$$V_R = \frac{6.8 \text{ mA}}{(120 \text{ Hz})(100\ \mu\text{F})} = 0.566 \text{ V pp} \approx 0.57 \text{ V pp}$$

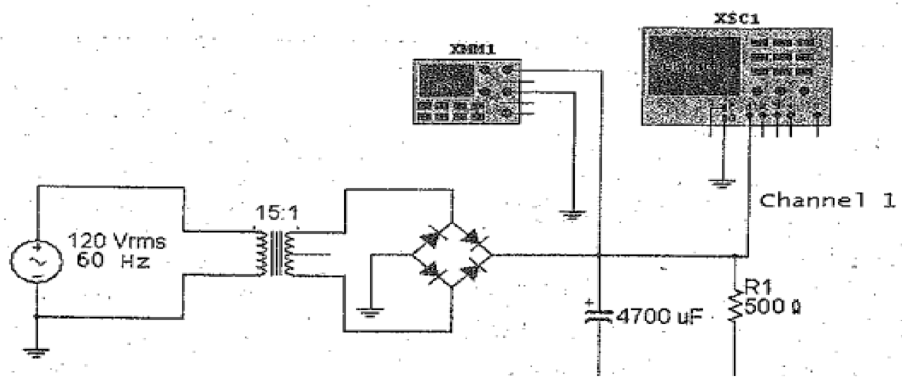
Because of the 1.4 V across two conducting diodes and the ripple, the actual dc load voltage will be closer to 32 V than to 34 V.

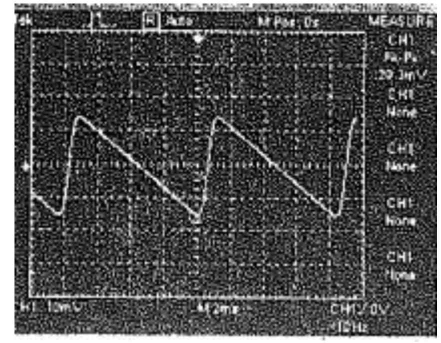
We have calculated the dc load voltage and ripple for the three different rectifiers. Here are the results:

Half wave: 34 V and 1.13 V

Full wave: 17 V and 0.288 V

Bridge: 34 V and 0.566 V





SOLUTION The transformer is a 15:1 step-down, so the rms secondary voltage is

$$V_2 = \frac{120\ \text{V}}{15} = 8\ \text{V}$$

and the peak secondary voltage is:

$$V_p = \frac{8\ \text{V}}{0.707} = 11.3\ \text{V}$$

Let's use the second approximation of the diodes to get the dc load voltage:

$$V_L = 11.3\ \text{V} - 1.4\ \text{V} = 9.9\ \text{V}$$

To calculate the ripple, we first need to get the dc load current:

$$I_L = \frac{9.9\ \text{V}}{500\ \Omega} = 19.8\ \text{mA}$$

Now, we can use Eq. (4-10) to get:

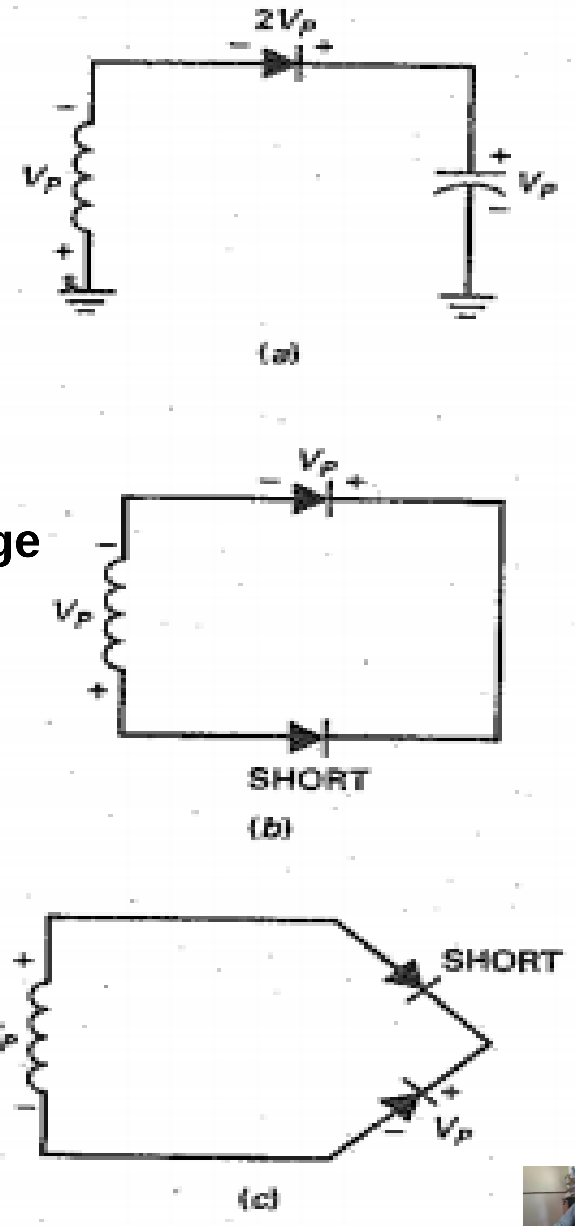
$$V_R = \frac{19.8\ \text{mA}}{(120\ \text{Hz})(4700\ \mu\text{F})} = 35\ \text{mV pp}$$

In Fig. 4-17, a multimeter reads a dc load voltage of 9.9 V.

Channel 1 of the oscilloscope is set to 10 mV/Div. The peak-to-peak ripple is approximately 2.9 Div and the measured ripple is 29.3 mV. This is less than the theoretical value of 35 mV, which emphasizes the point made earlier. Equation (4-10) is to be used for *estimating* ripple. If you need more accuracy, use computer simulation software.

4.7 Peak inverse voltage And Surge Current

Figure 4–18 (a) Peak inverse voltage in half-wave rectifier; (b) peak inverse voltage in full-wave rectifier; (c) peak inverse voltage in bridge-wave rectifier.



Non Conducting diode :

$$PIV = 2\ V_p$$

If the peak secondary voltage 15 V, see fig 4-18 a

So PIV are 30 V

- Maximum voltage across the nonconducting diode of a rectifier circuit
- Voltage must be less than diode breakdown voltage

Diode ratings

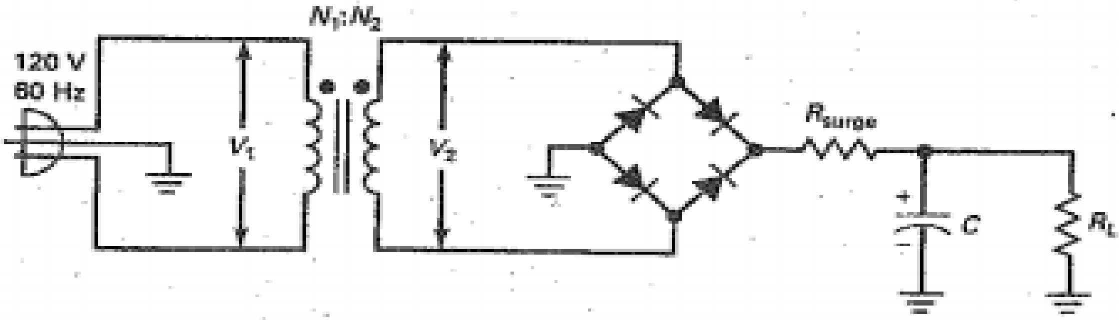
- Half-wave rectifier with capacitor-input filter:

  $PIV = 2V_P \quad I_{diode} = I_{dc}$
- Full-wave rectifier with capacitor-input filter:

  $PIV = V_P \quad I_{diode} = 0.5I_{dc}$
- Bridge rectifier with capacitor-input filter:

  $PIV = V_P \quad I_{diode} = 0.5I_{dc}$

Figure 4–19 Surge resistor limits surge current.



Example 4–10

What is the peak inverse voltage in Fig. 4-19 if the turns ratio is 8:1? A 1N4001 has a breakdown voltage of 50 V. Is it safe to use a 1N4001 in this circuit?

SOLUTION The rms secondary voltage is:

$$V_2 = \frac{120\ \text{V}}{8} = 15\ \text{V}$$

The peak secondary voltage is:

$$V_p = \frac{15\ \text{V}}{0.707} = 21.2\ \text{V}$$

The peak inverse voltage is:

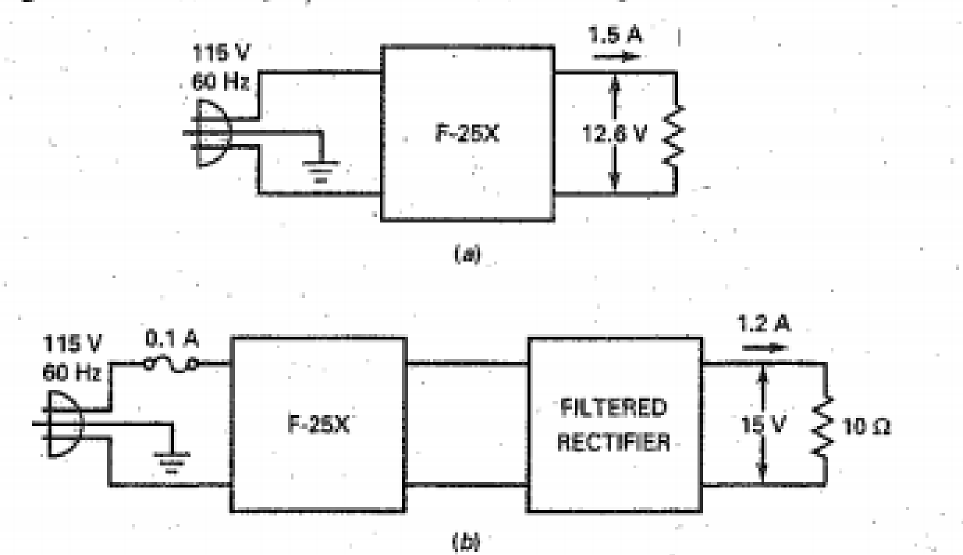
$$\text{PIV} = 21.2\ \text{V}$$

The 1N4001 is more than adequate, since the peak inverse voltage is much less than the breakdown voltage of 50 V.

Power supply topics

- **Real transformers usually specify secondary voltage at a rated load current**
- **Slow-blow fuses are often used to protect against surge current**
- **Average diode current in a half-wave rectifier equals the dc load current**
- **In a full-wave or bridge, the average current in any diode is half the dc load current**

Figure 4-20 (*a*) Rating on real transformer; (*b*) calculating fuse current.



$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

For instance, the F25X has $V_1 = 115$ V and $V_2 = 12.6$ V. The turns ratio at the rated load current of 1.5 A is:

$$\frac{N_1}{N_2} = \frac{115}{12.6} = 9.13$$

Calculating Fuse Current

When troubleshooting, you may need to calculate the primary current to determine whether a fuse is adequate or not. The easiest way to do this with a real transformer is to assume that the input power equals the output power: $P_{in} = P_{out}$. For instance, Fig. 4-20*b* shows a fused transformer driving a filtered rectifier. Is the 0.1-A fuse adequate?

Here is how to estimate the primary current when troubleshooting. The output power equals the dc load power:

$$P_{out} = VI = (15\text{ V})(1.2\text{ A}) = 18\text{ W}$$

Ignore the power losses in the rectifier and the transformer. Since the input power must equal the output power:

$$P_{in} = 18\text{ W}$$

Since $P_{in} = V_1 I_1$, we can solve for the primary current:

$$I_1 = \frac{18\text{ W}}{115\text{ V}} = 0.156\text{ A}$$

This is only an estimate because we ignored the power losses in the transformer and rectifier. The actual primary current will be higher by about 5 to 20 percent because of these additional losses. In any case, the fuse is inadequate. It should be at least 0.25 A.

Calculating Diode Current

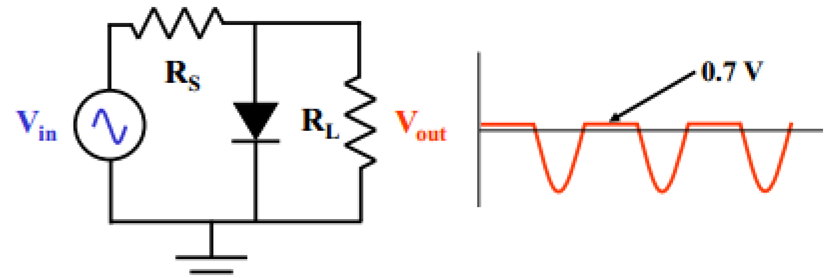
- **Half-wave rectifier with capacitor-input filter:** PIV = $2V_P$ $I_{diode} = I_{dc}$
- **Full-wave rectifier with capacitor-input filter:** PIV = V_P $I_{diode} = 0.5I_{dc}$
- **Bridge rectifier with capacitor-input filter:** PIV = V_P $I_{diode} = 0.5I_{dc}$

Calculate for Fiuse 2 A

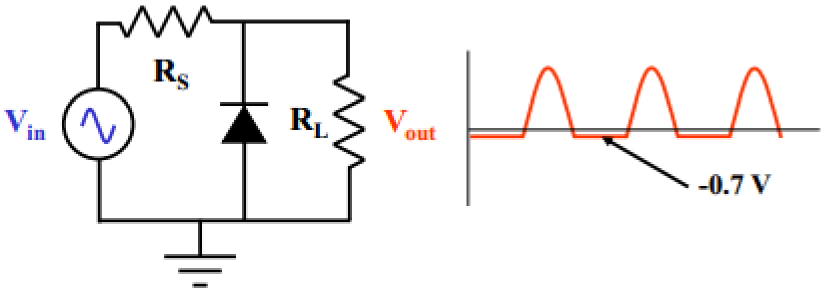
Summary Table 4–2	Capacitor–Input Filtered Rectifiers*		
	Half–wave	Full–wave	Bridge
Number of diodes	1	2	4
Rectifier input	$V_{p(2)}$	$0.5V_{p(2)}$	$V_{p(2)}$
DC output (ideal)	$V_{p(2)}$	$0.5V_{p(2)}$	$V_{p(2)}$
DC output (2d)	$V_{p(2)} - 0.7$ V	$0.5V_{p(2)} - 0.7$ V	$V_{p(2)} - 1.4$ V
Ripple frequency	f_{in}	$2f_{in}$	$2f_{in}$
PIV	$2V_{p(2)}$	$V_{p(2)}$	$V_{p(2)}$
Diode current	I_{dc}	$0.5I_{dc}$	$0.5I_{dc}$

*$V_{p(2)}$ = peak secondary voltage; $V_{p(out)}$ = peak output voltage; I_{dc} = dc load current.

Positive clipper



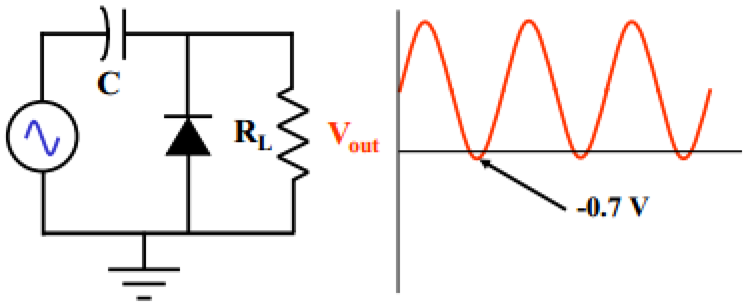
Negative clipper



$$R_B = \frac{1V - 0.7}{10mA} = 20$$

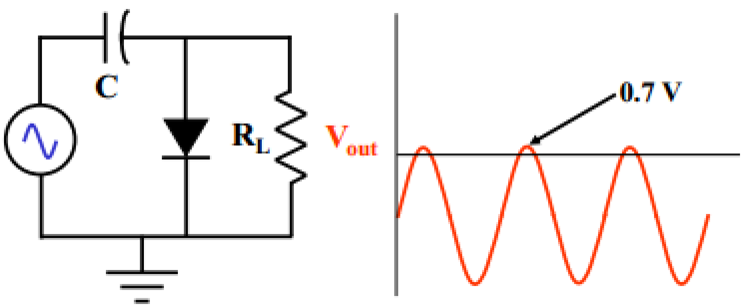
Stiff Clipper : 100 R_B < R_S < 0.01 R_L

Positive clamper

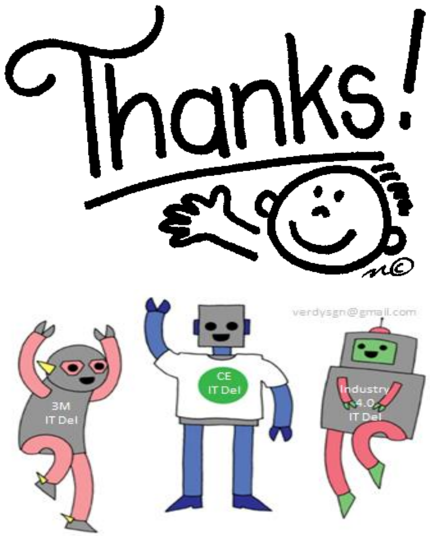


Stiff clamper: R_LC > 100T

Negative clamper



QA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PDS

4-7 Peak Inverse Voltage and Surge Current

4-8 Other Power-Supply Topics

4-9 Troubleshooting

4-10 Clippers and Limiters

4-11 Clampers

4-12 Voltage Multipliers

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