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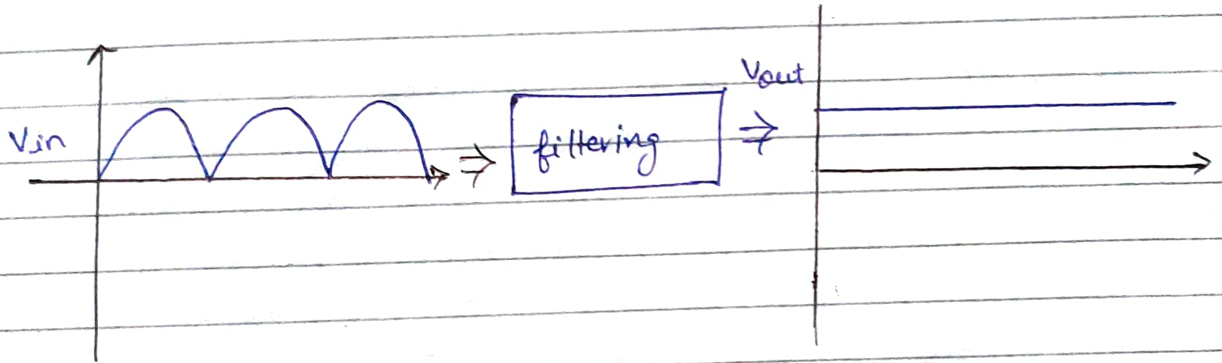
EC160: Experiment 6
Capacitive Rectification

Objectives :- i) to learn and understand filtering of rectified signal.
(ii) to study ripple voltage and ripple factor.
(iii) to understand capacitive filtering.

Theory: Filtering in rectifiers :-

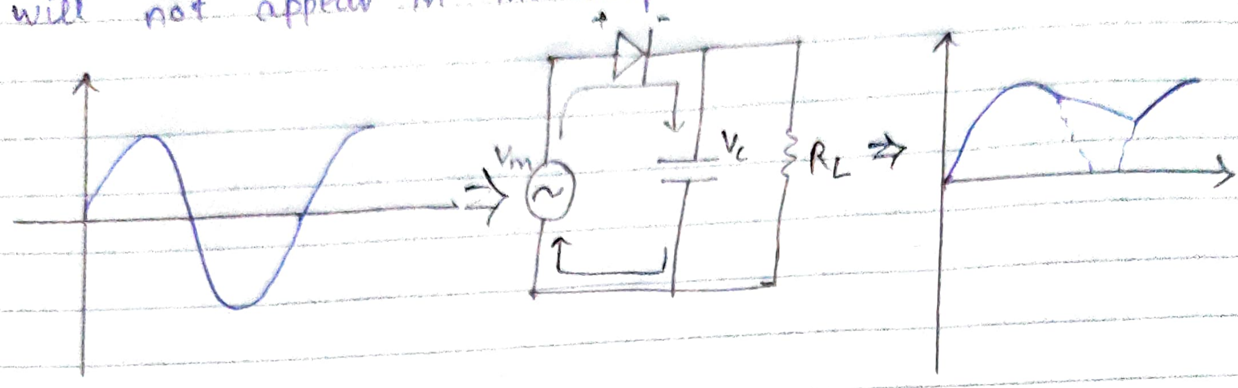


~~Hence~~ After filtering the pulsating input is ~~to~~ converted to a constant DC power supply. Thus, we would like to "filter" the pulsating input signal.

We can do this by splitting the input waveform into AC (high frequency) and the DC components (very low frequency) and by then 'rejecting' the high frequency components.

Capacitor filter circuit and its working:

When a capacitor is connected across the output of a rectifier, the AC components will face a low impedance path to ground and, therefore, will not appear in the output:



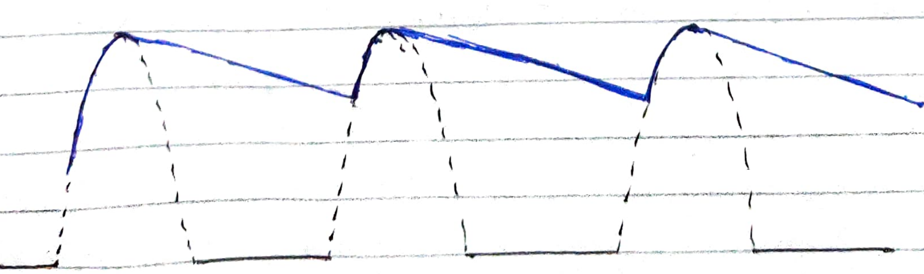
Working-:

In forward bias-

a) When the input begins to decrease below its peak, the capacitor retains its charge and the diode becomes reverse biased during the remaining part, the capacitor can discharge only through load resistance at a rate determined by RC time constant. Larger the time constant, the less the capacitor will discharge.

b) The diode will again become forward biased when the input voltage exceeds the capacitor voltage by approximately 0.7 V.

Half-Wave vs Full-Wave Capacitive Rectification



Half wave rectification + filtering

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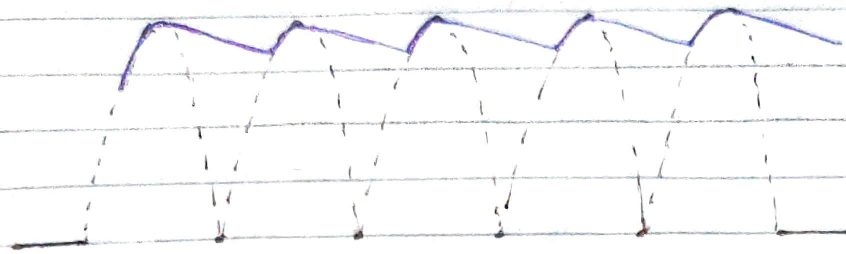

Full-Wave Rectification + Filtering

The advantage of a full-wave rectifier over a half-wave is quite clear. The capacitor can more effectively reduce the ripple factor when the time between the peaks is shorter.

Mathematical Expressions :-

For half-wave rectification

$$V_{av} = \frac{V_m}{\pi} \quad \text{and} \quad I_{av} = \frac{I_m}{\pi}$$

$$\text{Form factor (FF)} = \frac{V_{rms}}{V_{av}} = \frac{\pi}{2} = 1.57$$

$$\text{Ripple factor } (\gamma) = \sqrt{(FF)^2 - 1} = 1.21$$

$$\text{RMS load voltage} = \frac{V_m}{2}$$

$$\text{RMS load current} = \frac{I_m}{2}$$

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} \times 100\,\% = 40.56\%$$

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For full-wave rectification

$$V_{av} = \frac{2V_m}{\pi} \quad \text{and} \quad V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$I_{av} = I_{dc} = \frac{2I_m}{\pi} \quad \text{and} \quad I_{rms} = \frac{I_m}{\sqrt{2}}$$

form factor (FF) = 1.11

Ripple Factor $(\gamma) = \sqrt{(FF)^2 - 1} = 0.482$

$$\text{Efficiency } (\eta) = \frac{P_{out}}{P_{in}} \times 100\%$$

$$= 81.13\%.$$

Procedure for the Experiment :-

For half-wave rectification :-

Step 1: Take a diode, a load resistor of $1 K\Omega$ and a capacitor of 102 uF.

Step 2: Connect to AC voltage source of 50 Hz, 2V.

Step 3: Click on 'ON' button to make the circuit on.

Step 4: Click on 'Sine wave' button to observe the input waveform.

Step 5: Click on 'Run Simulation' button to observe the filtered waveform.

Step 6: Observe the corresponding waveform. Channel 1 shows input waveform, channel 2 shows output waveform and 'Dual' shows both of them simultaneously.

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For full-wave rectifier →

Step 1: Take 4 diodes, load resistance of 1 kΩ and
~~Step 2~~: capacitor of 102 µF.
Step 2: Connect to AC voltage source of 50 Hz, 2V.
Step 3: Click on 'ON' button to make circuit on.
Step 4: Click on 'sine wave' to get input waveform.
Step 5: Click on 'Run Simulation' to observed filtered waveform.
Step 6: Observe the waveforms.

Simulation Results

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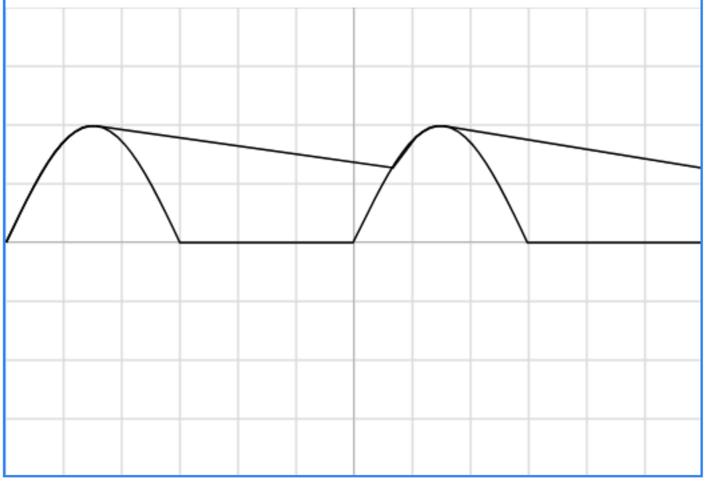
Capacitative Rectification for Half Wave Rectifier

INSTRUCTION

GRAPH PLOT



Channel 1 | Channel 2 | Ground | Dual

CALCULATION

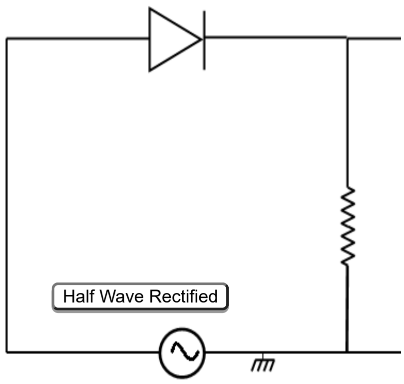
Measure the V_m

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_{dc} = \frac{V_m}{\pi}$

Ripple Factor$=\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \frac{\sqrt{(V_{rms}^2 - V_{dc}^2)}}{V_{dc}}$

CIRCUIT



Off

CONTROLS

V_{Pch1}: 1

Position Y-Axis: 0

Phase: 0

Frequency: 1000

V_{Pch2}: 1

Position Y-Axis: 0

Phase: 0

Frequency: 1000

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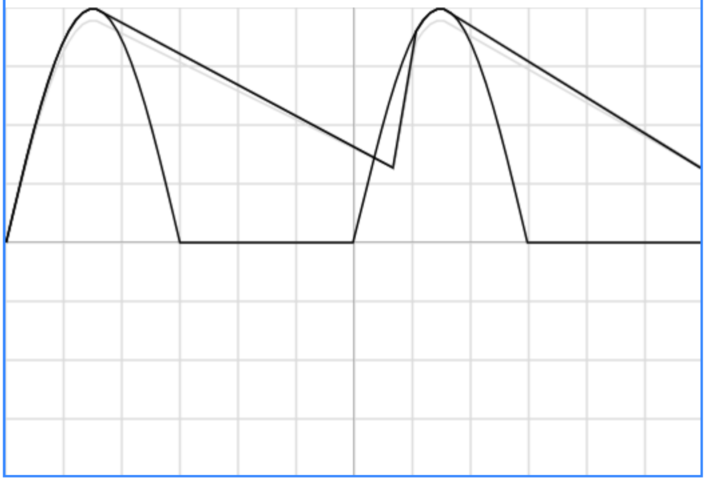
Capacitative Rectification for Half Wave Rectifier

INSTRUCTION

GRAPH PLOT



Channel 1 | Channel 2 | Ground | Dual

CALCULATION

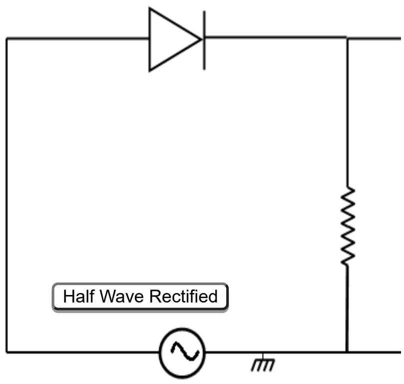
Measure the V_m

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_{dc} = \frac{V_m}{\pi}$

Ripple Factor$=\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \frac{\sqrt{(V_{rms}^2 - V_{dc}^2)}}{V_{dc}}$

CIRCUIT



Off

CONTROLS

V_{Pch1}: 2

Position Y-Axis: 0

Phase: 0

Frequency: 1000

V_{Pch2}: 2

Position Y-Axis: 0

Phase: 0

Frequency: 1000

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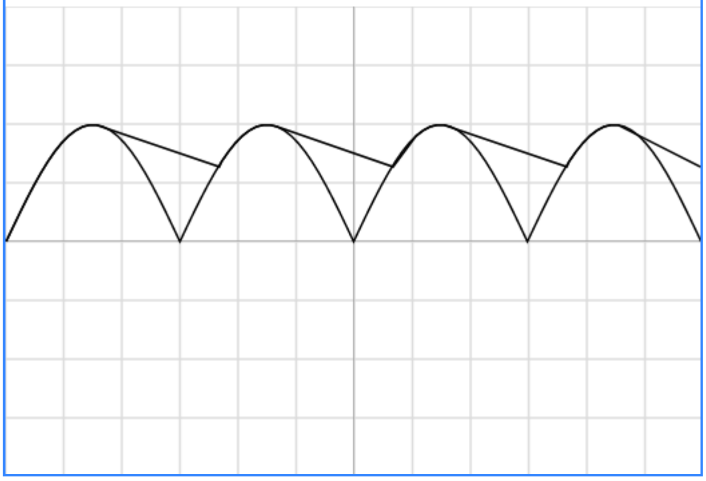
Capacitative Rectification for Full Wave Rectifier

INSTRUCTION

GRAPH PLOT



Channel 1 Channel 2 Ground Dual

CALCULATION

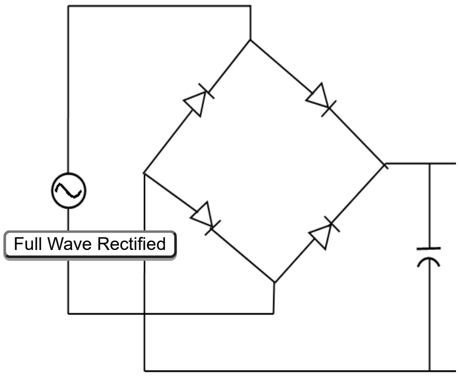
Measure the V_m

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_{dc} = \frac{V_m}{\pi}$

Ripple Factor$=\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \frac{\sqrt{(V_{rms}^2 - V_{dc}^2)}}{V_{dc}}$

CIRCUIT



Off

CONTROLS

V_{Pch1}: 1

Position Y-Axis: 0

Phase: 0

Frequency: 1000

V_{Pch2}: 1

Position Y-Axis: 0

Phase: 0

Frequency: 1000

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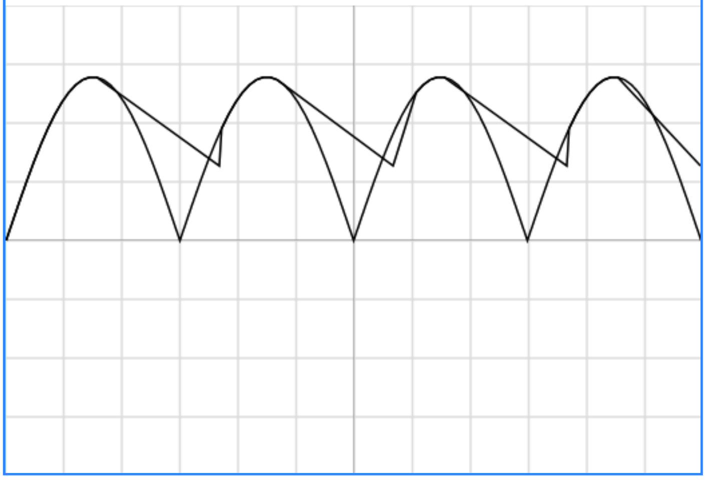
Capacitative Rectification for Full Wave Rectifier

INSTRUCTION

GRAPH PLOT



Channel 1 | Channel 2 | Ground | Dual

CALCULATION

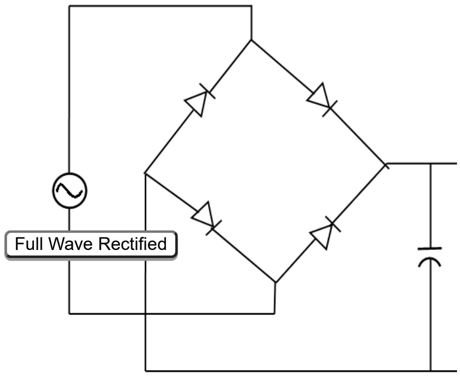
Measure the V_m

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$V_{dc} = \frac{V_m}{\pi}$

Ripple Factor$=\frac{V_{ac}}{V_{dc}}$ Since, $V_{ac} = \frac{\sqrt{(V_{rms}^2 - V_{dc}^2)}}{V_{dc}}$

CIRCUIT



Off

CONTROLS

V_{Pch1}: 1.4

Position Y-Axis: 0

Phase: 0

Frequency: 1000

V_{Pch2}: 1.4

Position Y-Axis: 0

Phase: 0

Frequency: 1000

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Conclusion-: Performing the experiment, following conclusions can be drawn-:

(i) Filtering implies ~~converting~~ pulses to a constant dc supply.
(ii) Filtering can be done using a capacitor.
(iii) The efficiency of rectifiers increases on using capacitive filters.
(iv) In full-wave bridge rectifiers, when capacitor filter is used, the current ripple is reduced more than then in a half-wave rectifier.
(v) The capacitor can reduce the ripple factor more efficiently when the time between peaks is lesser.

Quiz Performance

Capacitative Rectification

THEORY (#) PROCEDURE (#) SIMULATION (#) QUIZ (#) REFERENCES (#)

Quiz

Test Your Knowledge!!

✓ 1. A half wave rectifier circuit produces a peak rectified voltage output V_{RM} = 9V. The AC signal frequency f = 50Hz. The load Resistance = 12 k?. If the ripple voltage V_r is to be limited to 0.2V, then the filter capacitor C is

- ○ 25µF
- ○ 50µF
- ● 75µF
- ○ 100µF

✓ 2. A full wave rectifier circuit produces a peak rectified voltage output V_{RP} = 10V. The AC signal frequency is 50Hz. The load resistance is 10 k?. If the ripple voltage is to be limited to V_r = 0.1V then the filter capacitor C is

- ○ 10µF
- ○ 20µF
- ○ 50 µF
- ● 100µF

Submit