Voltage Multiplier

BASIC ELECTRONICS

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Voltage multiplier definition

The voltage multiplier is an electronic circuit that delivers the output voltage whose amplitude (peak value) is two, three, or more times greater than the amplitude (peak value) of the input voltage.

or

The voltage multiplier is an electronic circuit that converts the low AC voltage into high DC voltage.

or

The voltage multiplier is an AC-to-DC converter, made up of diodes and capacitors that produce a high voltage DC output from a low voltage AC input.

What is voltage multiplier?

- The voltage multiplier is made up of capacitors and diodes that are connected in different configurations.

- Voltage multiplier has different stages. Each stage is made up of one diode and one capacitor.

- These arrangements of diodes and capacitors make it possible to produce rectified and filtered output voltage whose amplitude (peak value) is larger than the input AC voltage.

Types of voltage multipliers

Voltage multipliers are classified into four types:

- ❑ Half-wave voltage doubler
- ❑ Full-wave voltage doubler
- ❑ Voltage tripler
- ❑ Voltage quadrupler

Working Principle of Half-wave voltage doubler

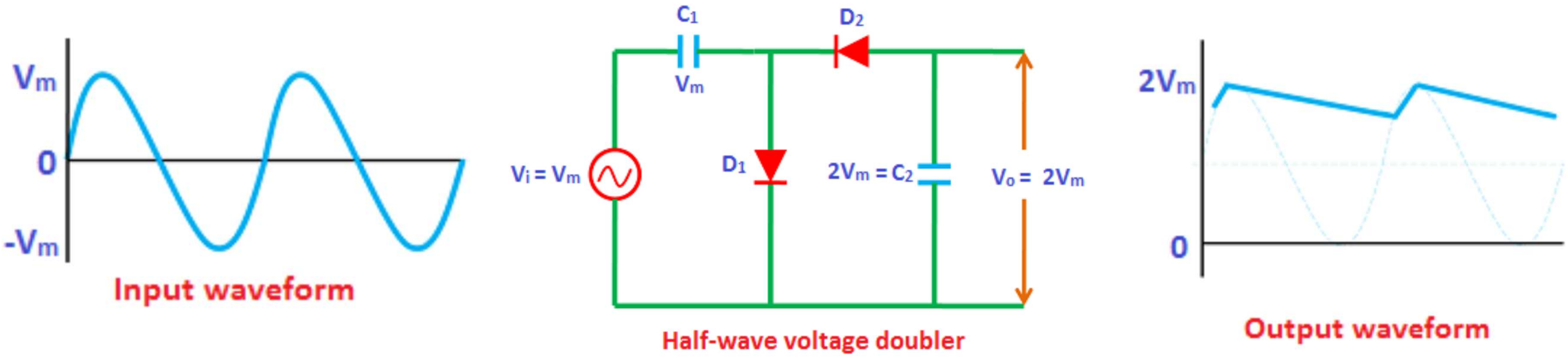


Figure 1

During positive half cycle:

- The circuit diagram of the half-wave voltage doubler is shown Figure 1.
- During the positive half cycle, diode D_1 is forward biased.
- So it allows electric current through it. This current will flows to the capacitor C_1 and charges it to the peak value of input voltage I.e. V_m.

During negative half cycle:

- During the negative half cycle, diode D_1 is reverse biased. So the diode D_1 will not allow electric current through it. Therefore, during the negative half cycle, the capacitor C_1 will not be charged. However, the charge (V_m) stored in the capacitor C_1 is discharged (released).
- On the other hand, the diode D_2 is forward biased during the negative half cycle. So the diode D_2 allows electric current through it. This current will flows to the capacitor C_2 and charges it. The capacitor C_2 charges to a value $2V_m$ because the input voltage V_m and capacitor C_1 voltage V_m is added to the capacitor C_2. Hence, during the negative half cycle, the capacitor C_2 is charged by both input supply voltage V_m and capacitor C_1 voltage V_m. Therefore, the capacitor C_2 is charged to $2V_m$.
- If a load is connected to the circuit at the output side, the charge ($2V_m$) stored in the capacitor C_2 is discharged and flows to the output.
- During the next positive half cycle, diode D_1 is forward biased and diode D_2 is reverse biased. So the capacitor C_1 charges to V_m whereas capacitor C_2 will not be charged. However, the charge ($2V_m$) stored in the capacitor C_2 will be discharged and flows to the output load. Thus, the half-wave voltage doubler drives a voltage of $2V_m$ to the output load.

During negative half cycle Cont.

- The capacitor C_2 gets charged again in the next half cycle.
- The voltage ($2V_m$) obtained at the output side is twice that of the input voltage (V_m).
- The capacitors C_1 and C_2 in half wave-voltage doubler charges in alternate half cycles.
- The output waveform of the half-wave voltage doubler is almost similar to the half wave rectifier with filter. The only difference is the output voltage amplitude of the half-wave voltage doubler is twice that of the input voltage amplitude but in half wave rectifier with filter, the output voltage amplitude is same as the input voltage amplitude.
- The half-wave voltage doubler supplies the voltage to the output load in one cycle (either positive or negative half cycle). In our case, the half-wave voltage doubler supplies the voltage to the output load during positive half cycles. Therefore, the output signal regulation of the half-wave voltage doubler is poor.

Advantages of half-wave voltage doubler

High voltages are produced from the low input voltage source without using the expensive high voltage transformers.

Disadvantages of half-wave voltage doubler

Large ripples (unwanted fluctuations) are present in the output signal.

Working Principle of Full-wave voltage doubler

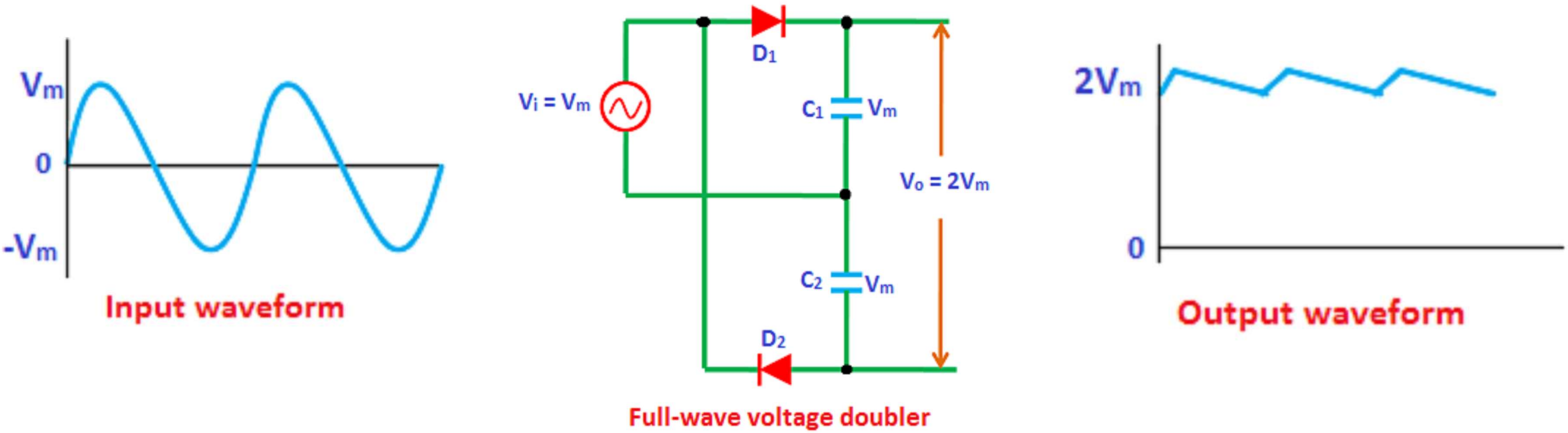


Figure 2

HTTPS://WWW.PHYSICS-AND-RADIO-ELECTRONICS.COM/ELECTRONIC-DEVICES-AND-CIRCUITS/RECTIFIER/VOLTAGEMULTIPLIERS-VOLTAGEDOUBLER-TRIPLER-QUADRUPLER.HTML

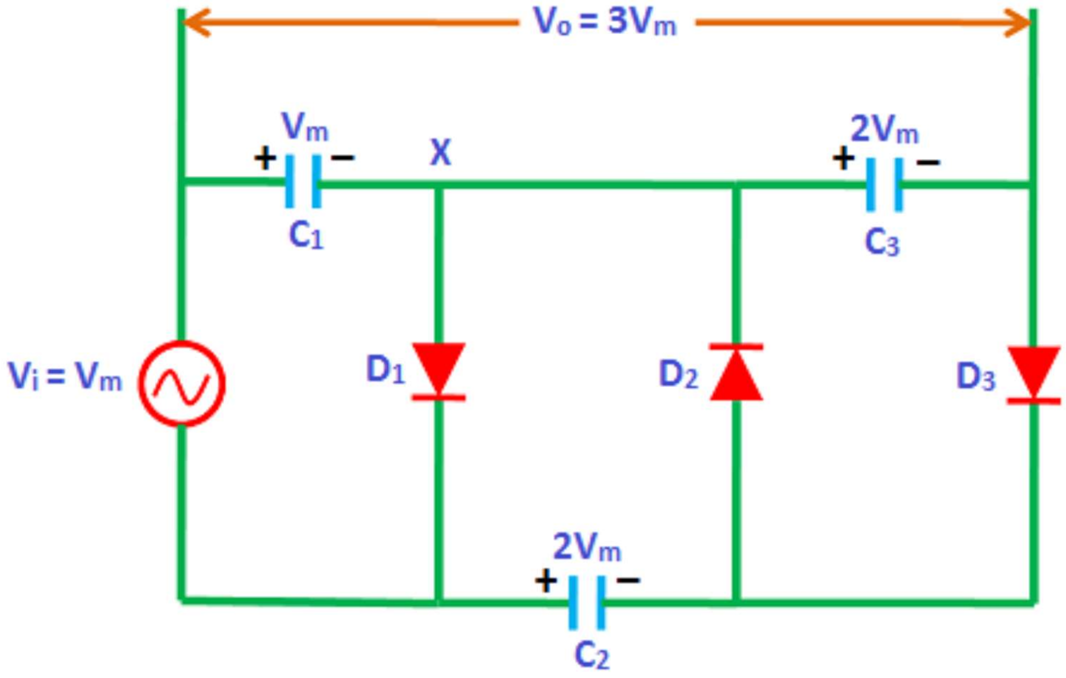
During positive half cycle:

- During the positive half cycle of the input AC signal, diode D_1 is forward biased.
- So the diode D_1 allows electric current through it. This current will flows to the capacitor C_1 and charges it to the peak value of input voltage I.e V_m.
- On the other hand, diode D_2 is reverse biased during the positive half cycle. So the diode D_2 does not allow electric current through it. Therefore, the capacitor C_2 is uncharged.

During negative half cycle:

- During the negative half cycle of the input AC signal, the diode D_2 is forward biased. So the diode D_2 allows electric current through it. This current will flows to the capacitor C_2 and charges it to the peak value of the input voltage I.e. V_m.
- On the other hand, diode D_1 is reverse biased during the negative half cycle. So the diode D_1 does not allow electric current through it.
- Thus, the capacitor C_1 and capacitor C_2 are charged during alternate half cycles.
- The output voltage is taken across the two series connected capacitors C_1 and C_2.
- If no load is connected, the output voltage is equal to the sum of capacitor C_1 voltage and capacitor C_2 voltage I.e. $C_1 + C_2 = V_m + V_m = 2V_m$. When a load is connected to the output terminals, the output voltage V_o will be somewhat less than $2V_m$.
- The circuit is called full-wave voltage doubler because one of the output capacitors is being charged during each half cycle of the input voltage.

Working Principle of Voltage Tripler



Voltage Tripler

During first positive half cycle:

- During the first positive half cycle of the input AC signal, the diode D1 is forward biased whereas diodes D2 and D3 are reverse biased.
- Hence, the diode D1 allows electric current through it. This current will flows to the capacitor C1 and charges it to the peak value of the input voltage I.e. Vm.

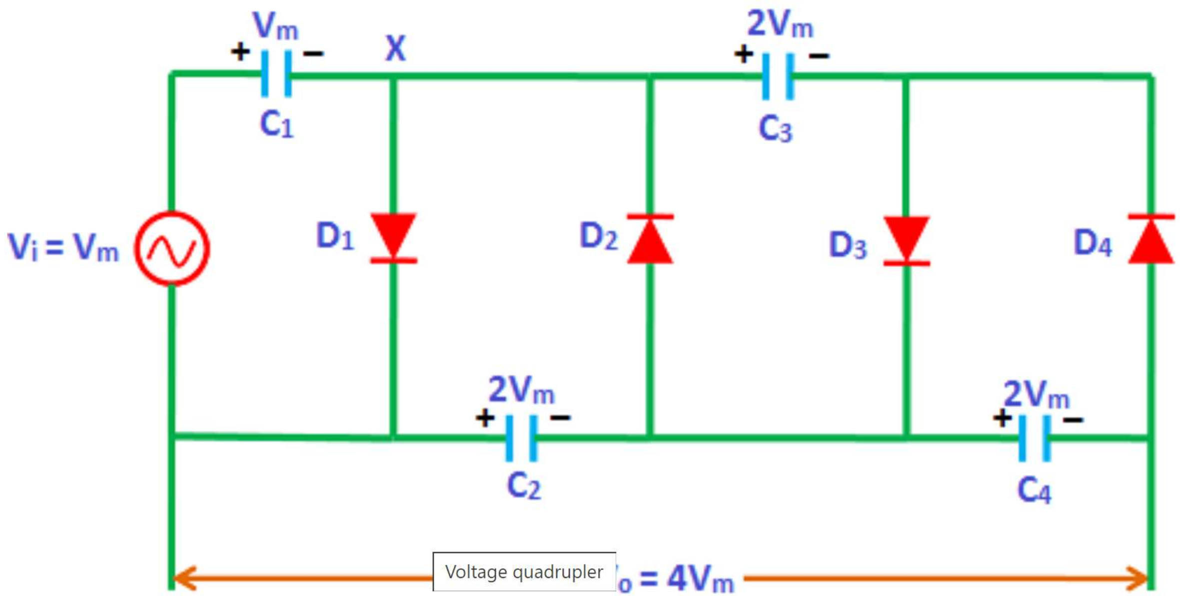
During negative half cycle:

- During the negative half cycle, diode D2 is forward biased whereas diodes D1 and D3 are reverse biased.
- Hence, the diode D2 allows electric current through it. This current will flows to the capacitor C2 and charges it.
- The capacitor C2 is charged to twice the peak voltage of the input signal (2Vm). This is because the charge (Vm) stored in the capacitor C1 is discharged during the negative half cycle.
- Therefore, the capacitor C1 voltage (Vm) and the input voltage (Vm) is added to the capacitor C2 I.e Capacitor voltage + input voltage = Vm + Vm = 2Vm. As a result, the capacitor C2 charges to 2Vm.

During second positive half cycle:

- During the second positive half cycle, the diode D3 is forward biased whereas diodes D1 and D2 are reverse biased.
- Diode D1 is reverse biased because the voltage at X is negative due to charged voltage Vm, across C1 and diode D2 is reverse biased because of its orientation. As a result, the voltage (2Vm) across capacitor C2 is discharged. This charge will flow to the capacitor C3 and charges it to the same voltage 2Vm.
- The capacitors C1 and C3 are in series and the output voltage is taken across the two series connected capacitors C1 and C3. The voltage across capacitor C1 is Vm and capacitor C3 is 2Vm. So the total output voltage is equal to the sum of capacitor C1 voltage and capacitor C3 voltage I.e. C1 + C3 = Vm + 2Vm = 3Vm.
- Therefore, the total output voltage obtained in voltage tripler is 3Vm which is three times more than the applied input voltage.

Working Principle of Voltage quadrupler



Voltage Quadrupler

During first positive half cycle:

- During the first positive half cycle of the input AC signal, the diode D_1 is forward biased whereas diodes D_2, D_3 and D4 are reverse biased.
- Hence, the diode D_1 allows electric current through it. This current will flows to the capacitor C_1 and charges it to the peak value of the input voltage I.e. V_m.

During first negative half cycle:

- During the first negative half cycle, diode D_2 is forward biased and diodes D_1, D_3 and D_4 are reverse biased. Hence, the diode D_2 allows electric current through it. This current will flows to the capacitor C_2 and charges it.

- The capacitor C_2 is charged to twice the peak voltage of the input signal ($2V_m$). This is because the charge (V_m) stored in the capacitor C_1 is discharged during the negative half cycle.

- Therefore, the capacitor C_1 voltage (V_m) and the input voltage (V_m) is added to the capacitor C_2 I.e Capacitor voltage + input voltage = V_m + V_m = $2V_m$. As a result, the capacitor C_2 charges to $2V_m$.

During second positive half cycle:

- During the second positive half cycle, the diode D_3 is forward biased and diodes D_1, D_2 and D_4 are reverse biased.

- Diode D_1 is reverse biased because the voltage at X is negative due to charged voltage V_m, across C_1 and, diode D_2 and D_4 are reverse biased because of their orientation.

- As a result, the voltage ($2V_m$) across capacitor C_2 is discharged. This charge will flow to the capacitor C_3 and charges it to the same voltage $2V_m$.

During second negative half cycle:

- During the second negative half cycle, diodes D_2 and D_4 are forward biased whereas diodes D_1 and D_3 are reverse biased.
- As a result, the charge ($2V_m$) stored in the capacitor C_3 is discharged. This charge will flow to the capacitor C_4 and charges it to the same voltage ($2V_m$).
- The capacitors C_2 and C_4 are in series and the output voltage is taken across the two series connected capacitors C_2 and C_4.
- The voltage across capacitor C_2 is $2V_m$ and capacitor C_4 is $2V_m$. So the total output voltage is equal to the sum of capacitor C_2 voltage and capacitor C_4 voltage I.e. $C_2 + C_4 = 2V_m + 2V_m = 4V_m$.
- Therefore, the total output voltage obtained in voltage quadrupler is $4V_m$ which is four times more than the applied input voltage.

Applications of voltage multipliers

Voltage multipliers are used in:

Cathode Ray Tubes (CRTs), Traveling wave tubes, Laser systems, X-ray systems, LCD backlighting, hv power supplies, Power supplies, Oscilloscopes, Particle accelerators, Ion pumps, Copy machines.

THANK YOU

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