Voltage multiplier

- A ***voltage multiplier*** is a specialized rectifier circuit which can potentially produce an output voltage many times greater than of the applied input voltage
- Usually an integer times the AC peak input, for example, 2, 3, or 4 times the AC peak input.
- Thus, for a 100 V_{peak} AC source it is possible to get 200 V_{DC} from a using a **doubler**, 400 V_{DC} from a **quadrupler.**
- Voltage multipliers are AC-to-DC power conversion devices, comprised of **diodes and capacitors,** that produce a high potential DC voltage from a lower voltage AC source.
- Multipliers are made up of multiple stages. Each stage is comprised of one diode and one capacitor.

Types of voltage multiplier

- Depending on the output voltage, multipliers can be of different types
  - Voltage doublers
  - Voltage tripplers
  - Voltage quadrupler

Voltage doublers

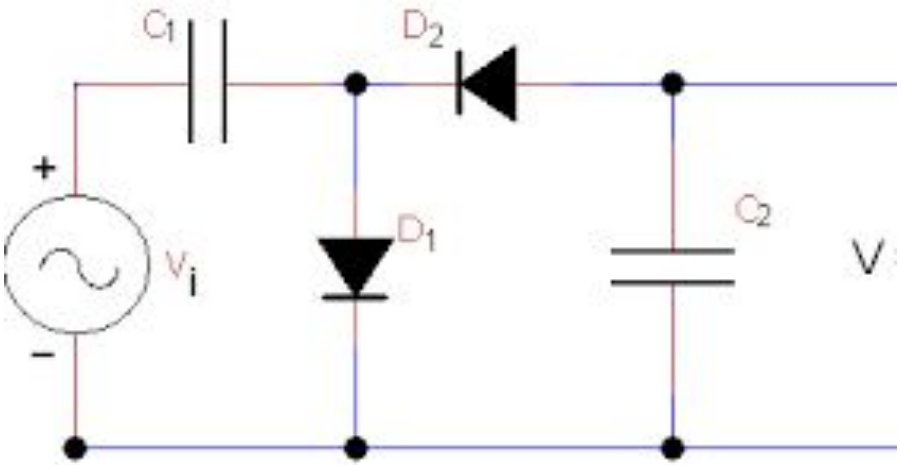
- A Voltage doubler produces a DC voltage almost twice the rms value of the input AC voltage.
- Voltage doubler can be of two types;
  - Half wave voltage doubler
  - Full wave voltage doubler

Half wave voltage doubler

The half-wave voltage doubler

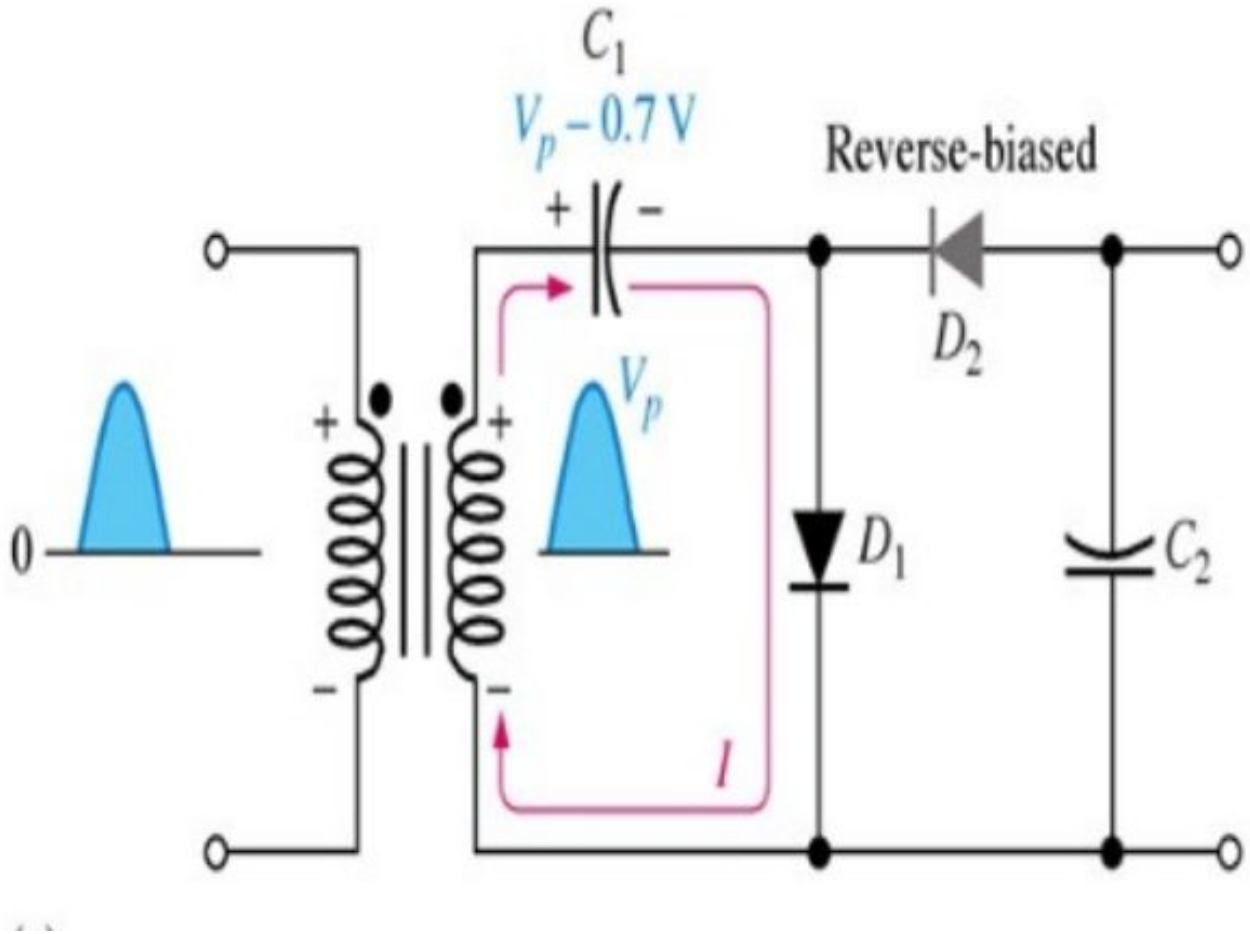
(a) clamper at

(b) peak detector (half-wave rectifier)

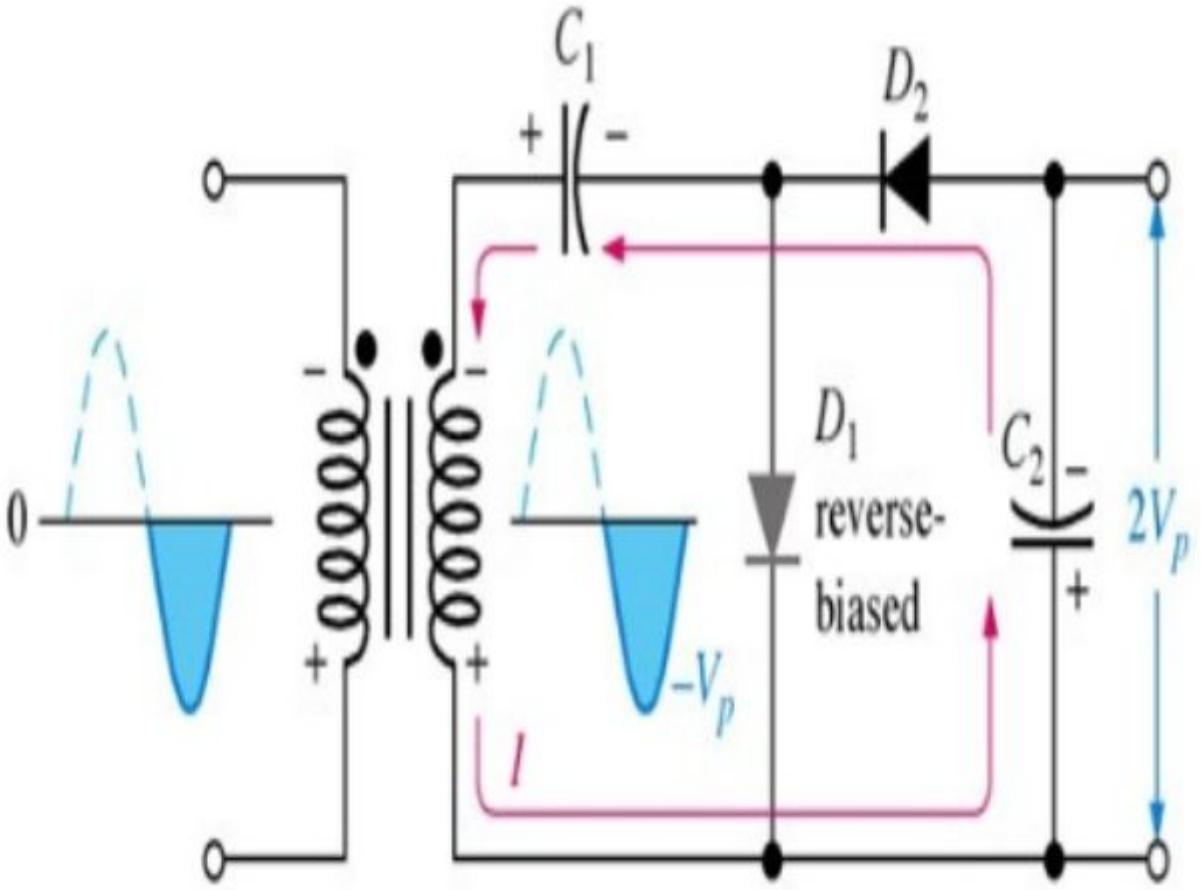


$$V_{out} = V_{C2} = 2V_m$$

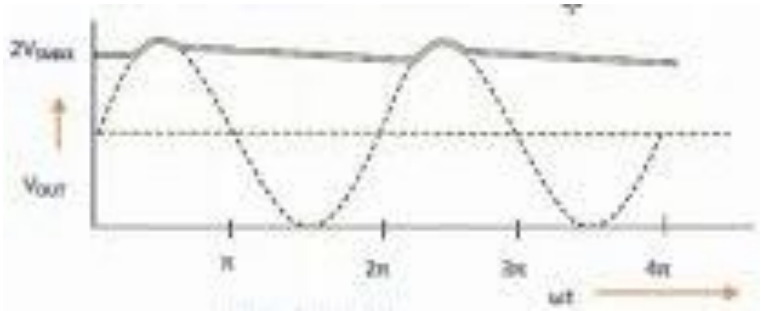
- During the positive half cycle of the secondary voltage diode D_1 conducts and D_2 is cut off.
- Now capacitor C_1 charges to the peak rectified voltage V_p



- During the negative half cycle, the secondary voltage comes in series with voltage across the capacitor C_1.
- Thus C_2 will try to charge towards $2V_p$ (V_p of the input and V_p of the capacitor C_1.

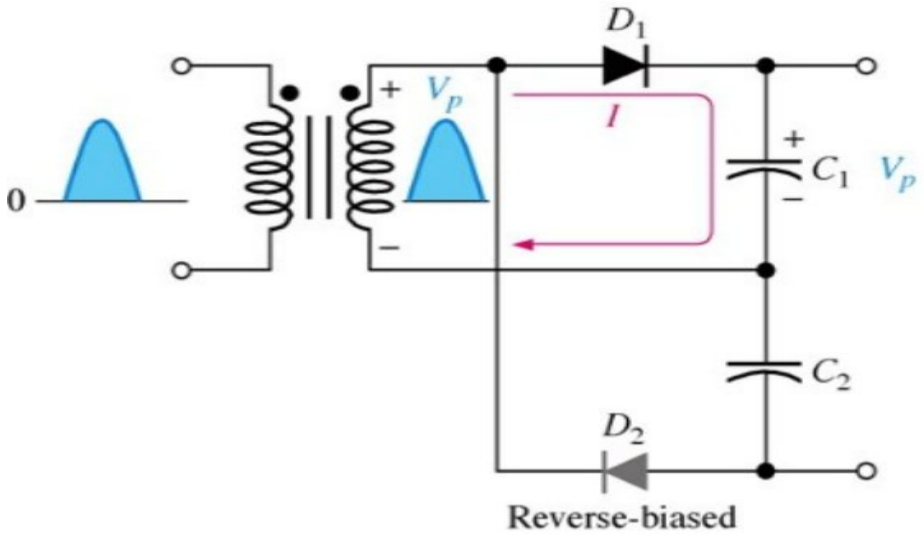


- After few cycles the voltage across the capacitor C_2 will be equal to $2V_m$
- Since diode D_2 acts as a short during the negative half-cycle (and diode D1 is open), we can sum the voltages around the outside loop.
- In the circuit capacitor C_1 will discharge in the negative half cycle.
- Again in the positive half cycle, it starts charging.
- Thus the half wave voltage doubler supplies the voltage to the load in one half cycles.
- Therefore regulation of the half wave voltage doubler is poor.



Full wave voltage doubler

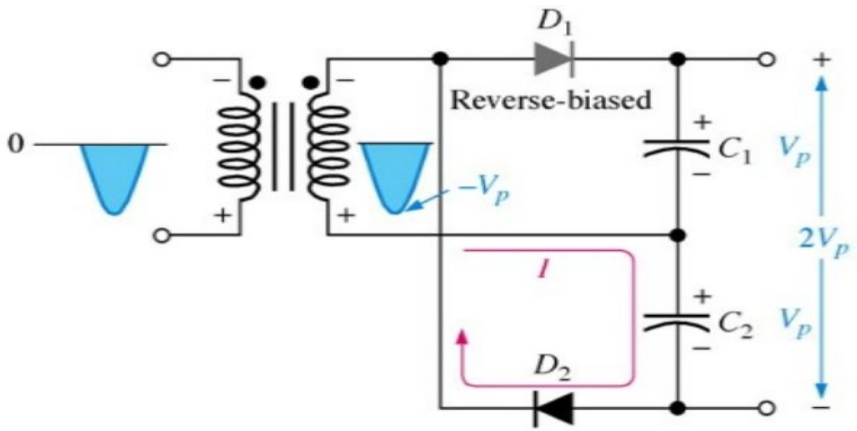
- The full-wave voltage doubler is composed of a pair of series stacked half-wave rectifiers.
- Positive Half-Cycle
  - D_1 conducts
  - D_2 is switched off
  - Capacitor C_1 charges to V_m

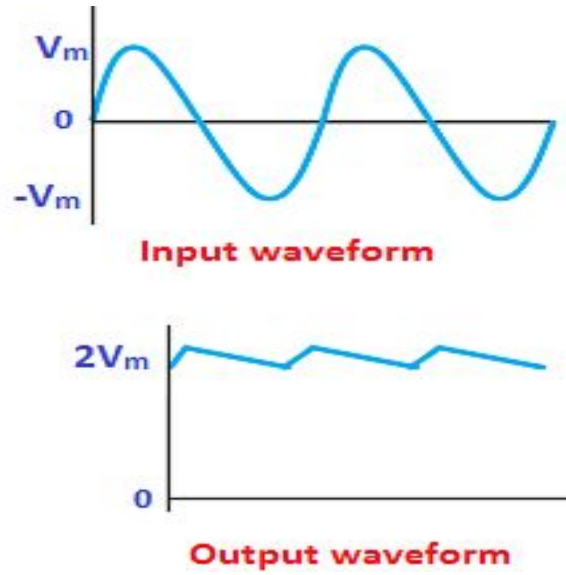


- **Negative Half-Cycle**
  - D_1 is switched off
  - D_2 conducts
  - Capacitor C_2 charges to V_p

  Since both capacitors $C_1$and $C_2$are in series, the final output voltage is approximately $2V_p$ Full Wave Voltage Multiplier

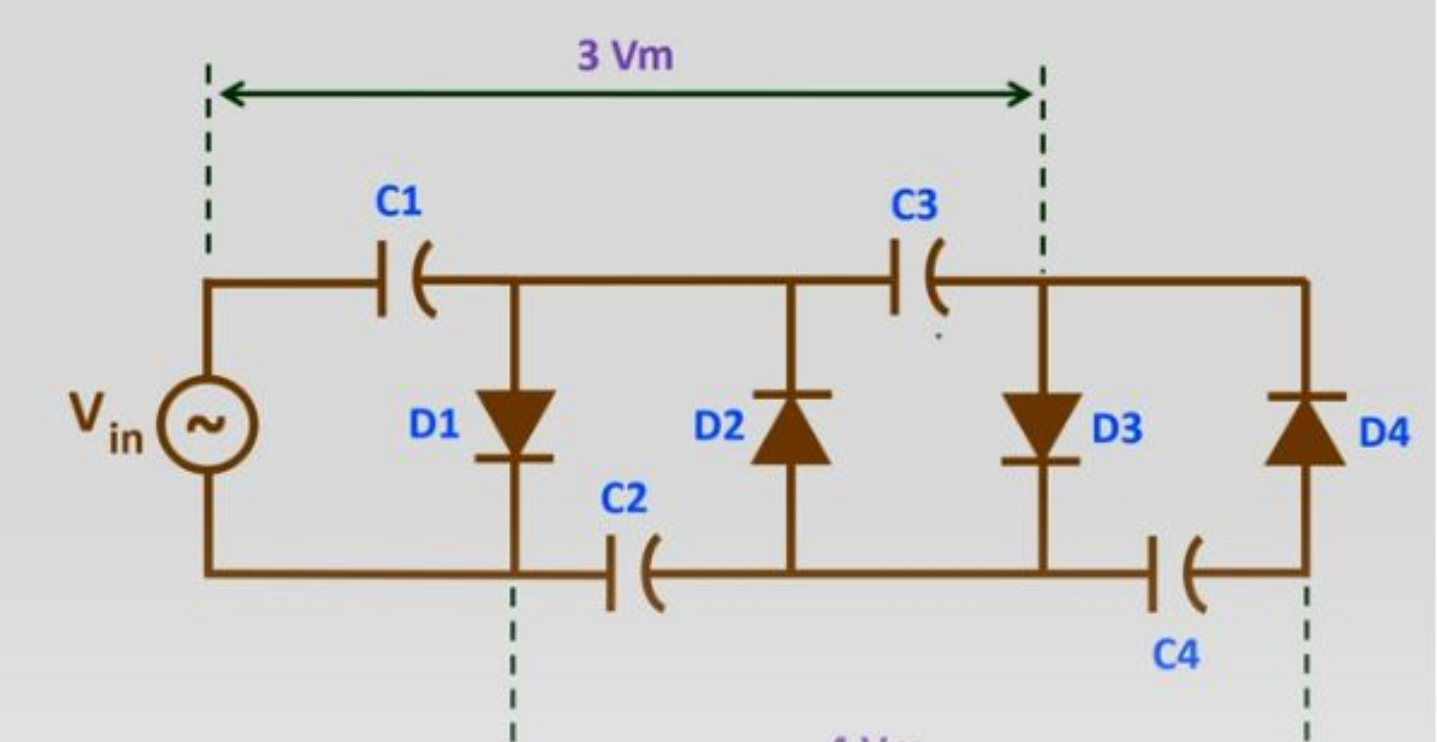
$$V_{out} = V_{C1} + V_{C2} = 2V_p$$



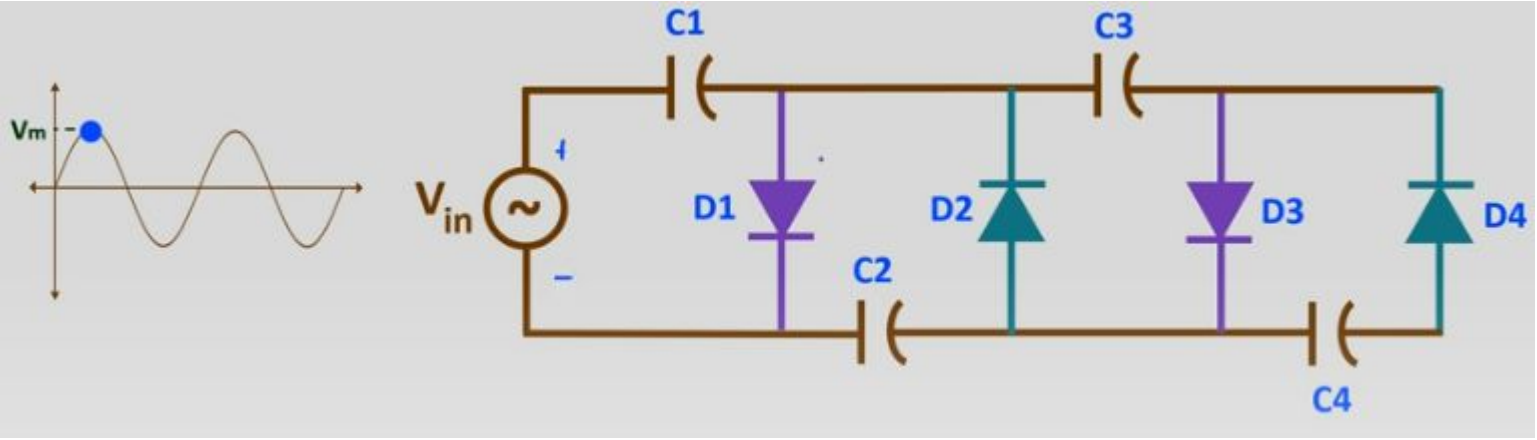


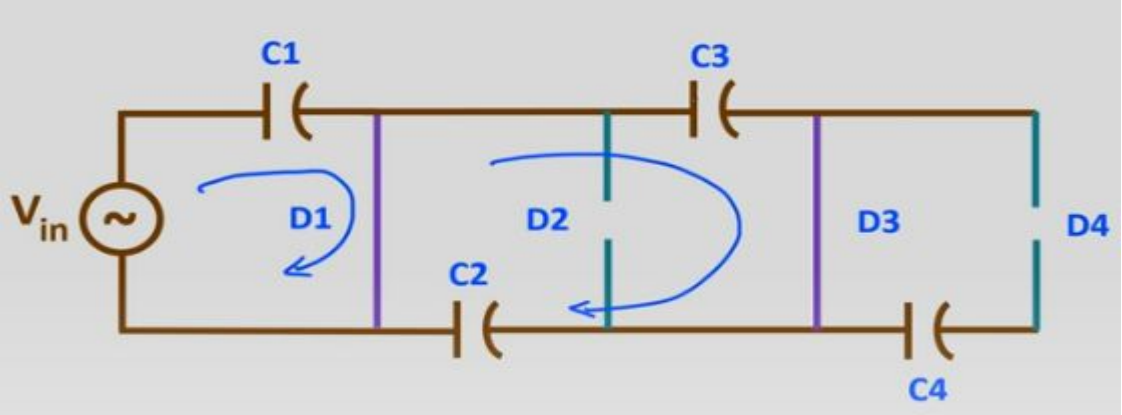
Voltage tripler and Quadrapler

- To build the voltage **Tripler** circuit, we just need to add 1 more Diode and capacitor to the above Half wave Voltage Doubler
- Again we just need to add one more diode and capacitor to Voltage Tripler circuit, to build the **Voltage Quadruple circuit** (4 times the input voltage).



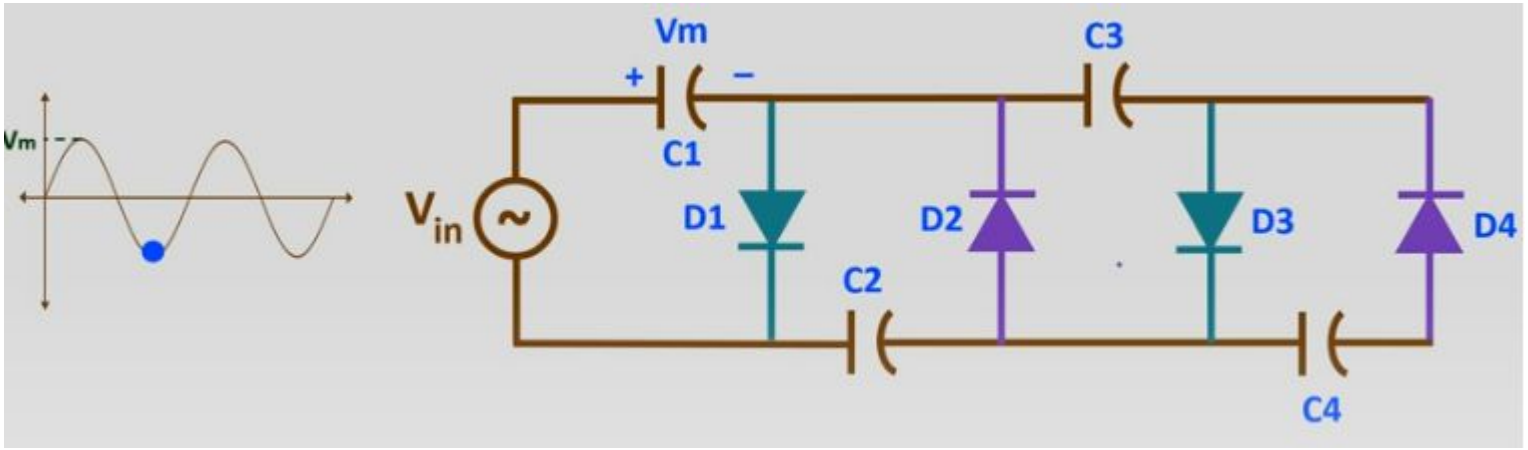
- Positive half-cycle: D1 and D3 conducts

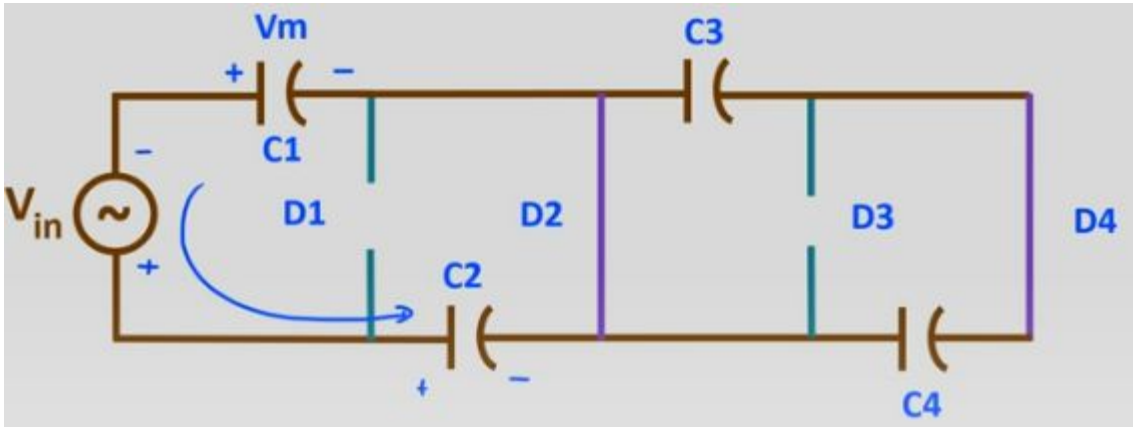




- C_1 charges to V_p through D_1

- Negative half-cycle: D2 and D4 conducts

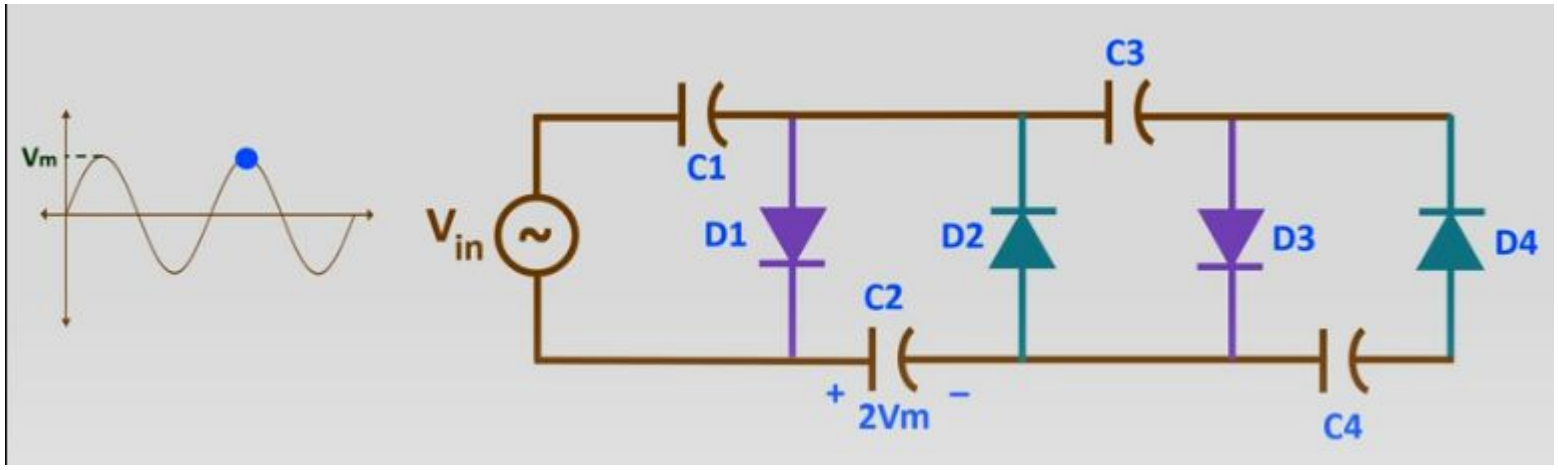




$V_{in} - V_{c2} - V_m = 0$

$V_{c2} = V_{in} + V_m$

$= 2\,V_m$


Vm
C3
C1
Vin
D1
D2
D3
D4
C2
+
2Vm
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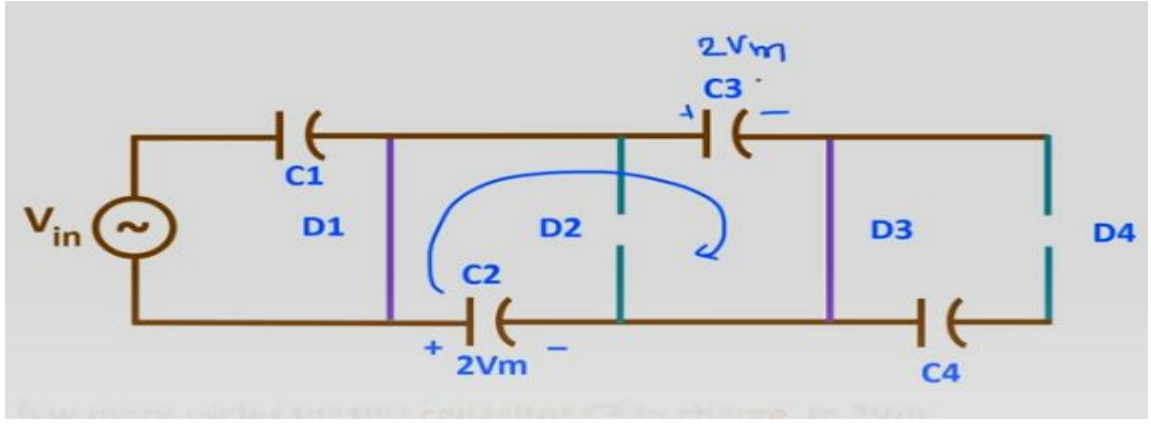
C4


2Vm
C3
+
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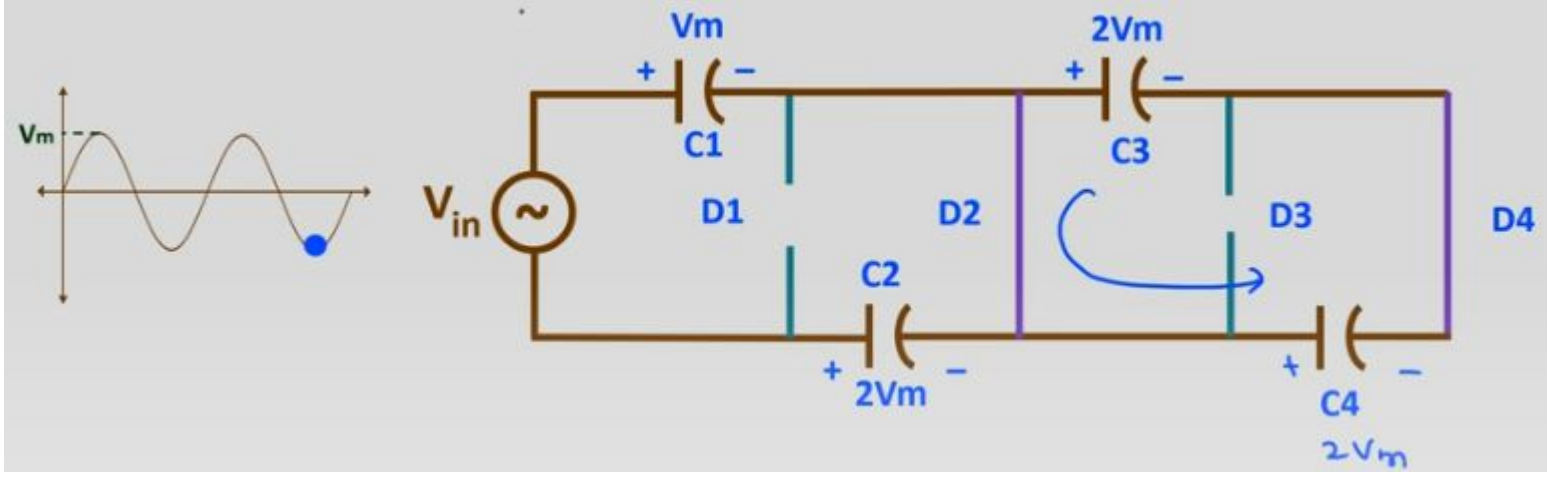
C1
Vin
D1
D2
D3
D4
C2
+
2Vm
–
C4

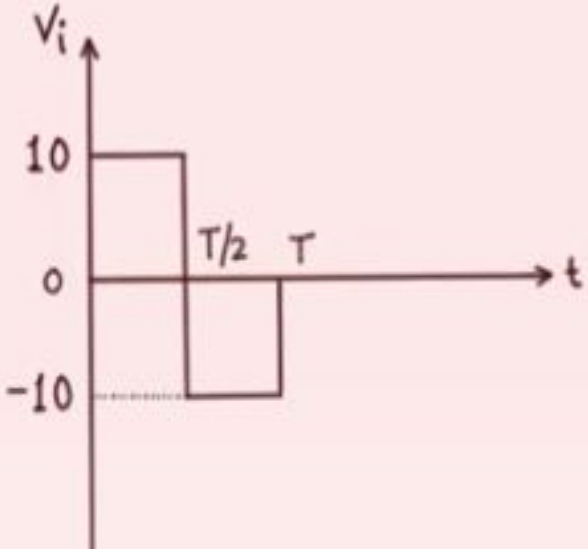

Vm
Vm
+
–
2Vm
+
–
C1
C3
Vin
D1
D2
D3
D4
C2
+
2Vm
–
+
–
C4
2Vm

Voltage Quadruplers

- **+ half-cycle:**
- C_1 charges to V_p through D_1,
- **- half-cycle:** C_2 charges to $2V_p$ through C_2
- **Next + half-cycle:**
- C_3 charges to $2V_p$ through C_3.
- **Next - half-cycle**: C_4 charges to $2V_p$ through C4 • Quadruple Output is across C_2 & C_4.

Multiplier Applications

- Originally used for television CRT’s,
- voltage multipliers are now used for
  - lasers,
  - x-ray systems,
  - traveling wave tubes (TWT's),
  - photomultiplier tubes,


Vi
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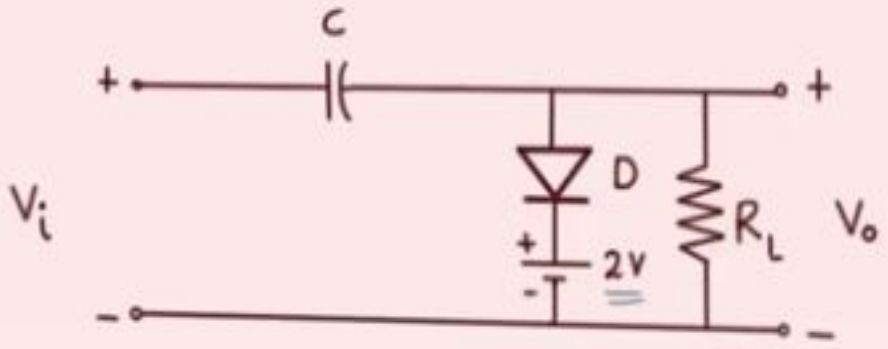
0
-10
T/2
T
t


C
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+
D
Vi
RL
Vo
2V
-
-