Unit-3: Voltage Multipliers

- A electronic circuit consisting of diodes and capacitors and converts an AC electric signal from a lower voltage to a higher DC voltage value is referred as a Voltage Multiplier.

⇒ These circuits increases the input voltage of level 'V_m' to an output of 'n' times of 'V_m'.

⇒ $\boxed{V_o = n V_m}$

if $n=2$ ⇒ it's referred as voltage Doubler.
if $n=3$ ⇒ it's called as voltage Tripler.
if $n=4$ ⇒ its called as voltage quadrapler.

⇒ Here in the voltage multipliers, it performs both rectification and multiplication of voltage.

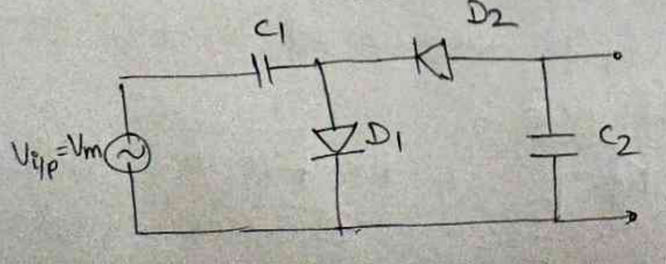
⇒ Rectification is done by rectifier = Diode
multiplication is done by capacitors.

Voltage Doubler-

The electronic circuit which multiplies the input voltage by '2' times (or) doubles the input voltage is called a Voltage Doubler.

They are two types - Halfwave Voltage Doubler
- Fullwave voltage Doubler

Half-wave Voltage Doubler -



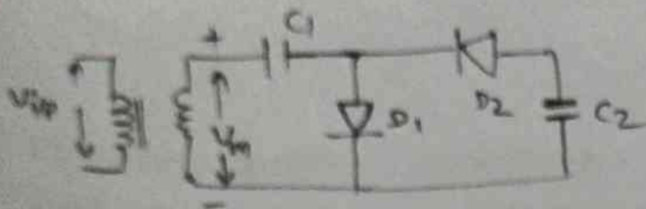
Voutput = $2V_m$.

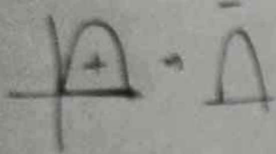
- As the name indicates, a voltage doubler is a voltage [multiplier]
which doubles the input voltage.

- It consists of two capacitors and two diodes.
- Thus it's a two-stage voltage multiplier.

The working of above circuit is as follows

→ for +ve half cycle of the input

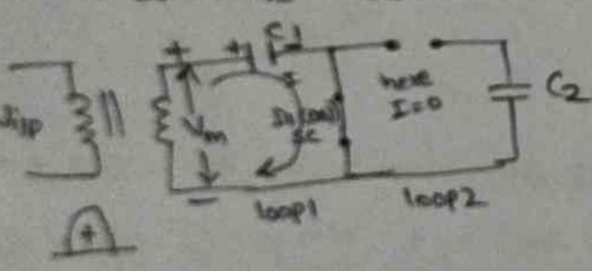




the D_1 diode is forward biased
D_2 diode is reverse biased

⇒ D_1 → ON ⇒ SC (Short circuited)
D_2 → OFF ⇒ OC (open circuited)

we redraw the circuit



then applying the KVL '1'

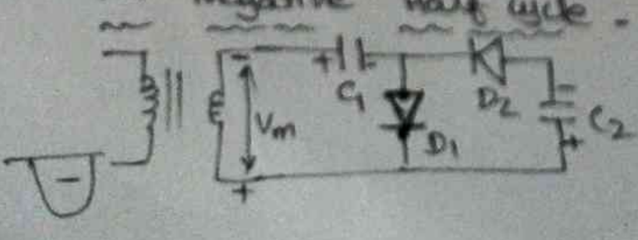
$$\rightarrow +V_m - V_{C_1} = 0$$

$\therefore \boxed{V_{C_1} = +V_m}$

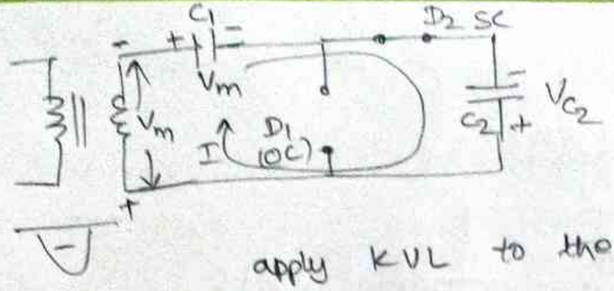
V_m ⇒ peak or maximum i/p voltage value

⇒ the capacitor C_1 is fully charged to $+V_m$ volts

* for Negative Half cycle.



for -ve Half cycle
D_1 → OFF (RB) → OC
D_2 – ON (FB) → SC

=> 

apply KVL to the above loop

we get $-V_m - V_m + V_{C_2} = 0$

$\Rightarrow -2V_m + V_{C_2} = 0$

$\therefore \boxed{V_{C_2} = 2V_m}$

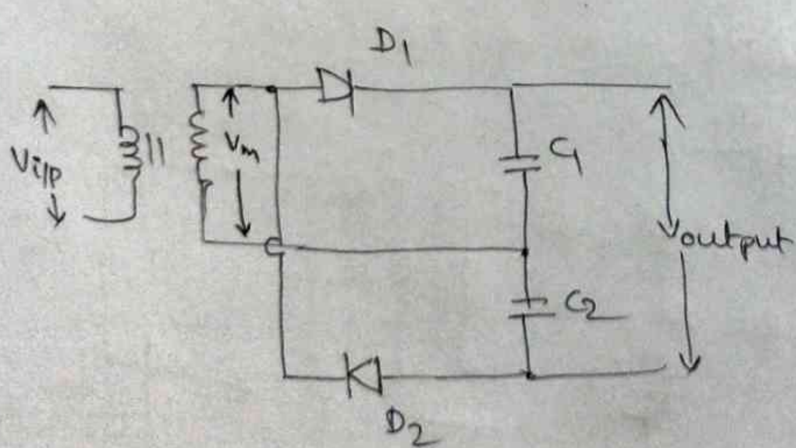
$\therefore$ the o/p voltage $\Rightarrow$ capacitor(2) voltage $= 2V_m$

→ thus the output voltage is double or 2 times that of the input voltage (V_m).

=> Full-wave Voltage Doubler

A full wave voltage doubler simply resembles a full wave rectifier (center-tapped).

It uses a center tapped transformer for the input.

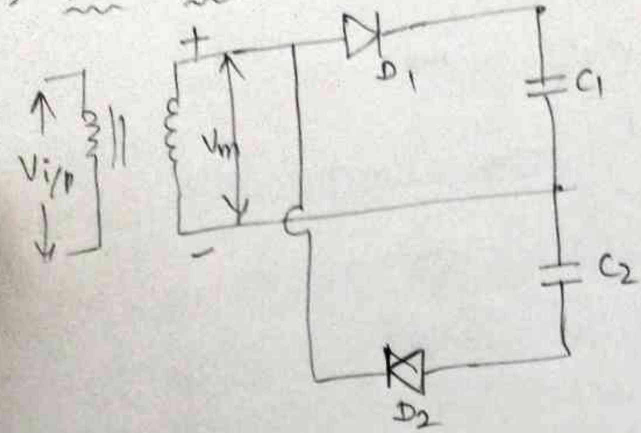


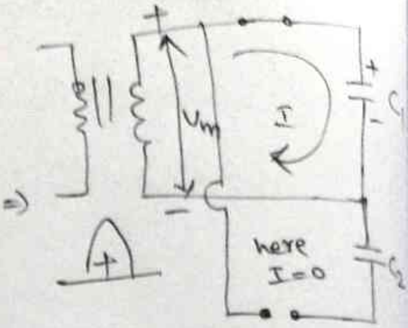
the above circuit is a fullwave voltage doubler

it consists of 2 capacitors, 2 diodes

working

→ For +ve half cycle.





the $D_1 \rightarrow$ F.B $\rightarrow$ ON $\rightarrow$ SC

$D_2 \Rightarrow$ R.B $\rightarrow$ OFF $\rightarrow$ OC

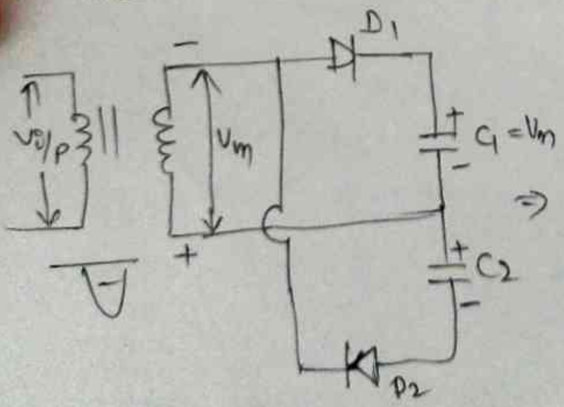
∴ the KVL for the above loop is

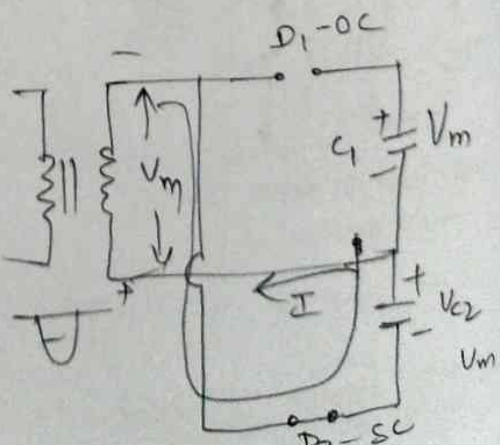
$$+V_m - V_{C_1} = 0$$

$$\therefore \boxed{V_{C_1} = V_m}$$

⇒ the capacitor → C_1 will be charged to V_m.

→ for negative half cycle of the input -





then $D_1 \rightarrow$ RB $\rightarrow$ OFF $\rightarrow$ OC

$D_2 \rightarrow$ FB $\rightarrow$ ON $\rightarrow$ SC

→ applying KVL to the above loop

$$\therefore \quad -V_m + V_{C_2} = 0$$

$\therefore \boxed{V_{C_2} = +V_m}$

$\Rightarrow$ during negative half cycle

capacitor C_2 charges to $+V_m$ volts.

$\therefore$ the output voltage is considered as $V_{C_1} + V_{C_2}$

$\Rightarrow V_{C_1} + V_{C_2} = V_m + V_m = 2V_m$

hence the output is double that of the i/p voltage.

hence its a full wave voltage doubler circuit.

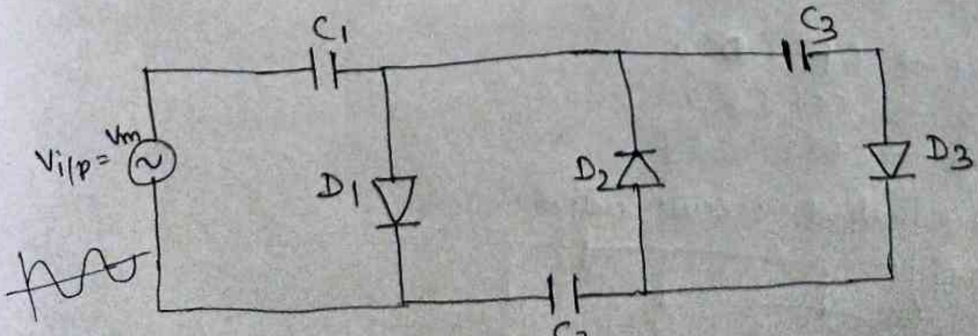
$\Rightarrow$ Voltage tripler

- A voltage multiplier which produces three times of input voltage at the output then it's called a Voltage-tripler.

- The voltage tripler circuit should have
  - $\rightarrow$ 3 capacitors
  - $\rightarrow$ 3 diodes

in order to produce three times the input voltage as the output voltage

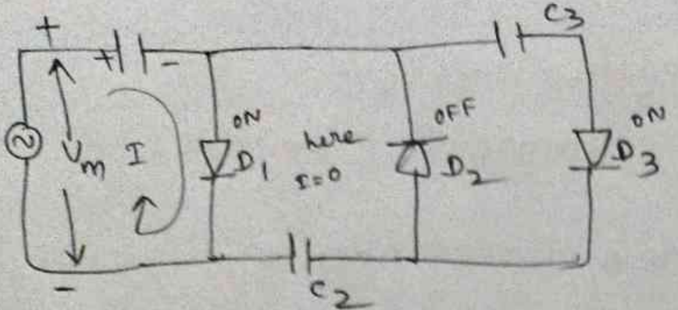
$\Rightarrow$ the circuit diagram is as follows



the output is considered between C_1 and C_3 capacitors

$\Rightarrow V_{out} = V_{C_1} + V_{C_3}$

working of the voltage-tripler circuit



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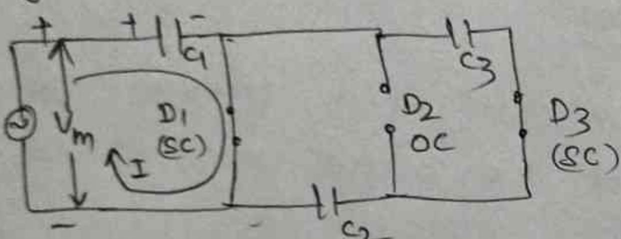
⇒ for positive half cycle of the input

then $D_1 \rightarrow$ F·B (ON) $\rightarrow$ SC

$D_2 \rightarrow$ R·B (OFF) $\rightarrow$ OC

$D_3 \rightarrow$ F·B (ON) $\rightarrow$ SC

applying the KVL for the above loop.



$\therefore \quad +V_m - V_{C1} = 0$

$\therefore \boxed{V_{C1} = +V_m}$

capacitor $C_1 \rightarrow$ charges to $+V_m$ volts. during the first +ve half cycle of i/p

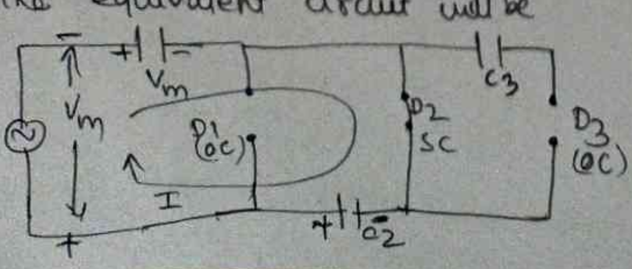
⇒ for negative half cycle -

the $D_1 \rightarrow$ OFF (OC)

$D_2 \rightarrow$ ON (SC)

$D_3 \rightarrow$ OFF (OC)

the equivalent circuit will be



applying KVL for the above loop

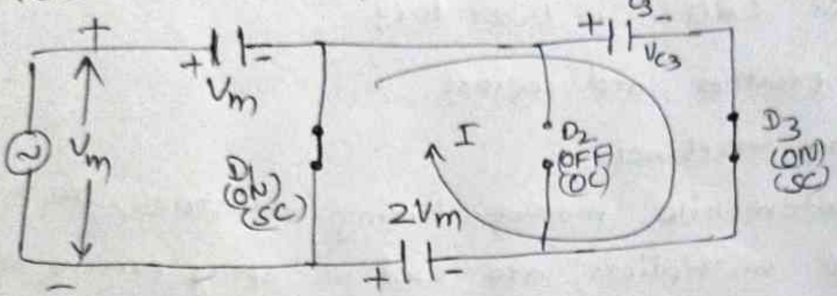
$\Rightarrow \quad -V_m - V_m + V_{C_2} = 0$

$\therefore \quad -2V_m + V_{C_2} = 0$

$\Rightarrow \quad \boxed{V_{C_2} = +2V_m}$

$\therefore$ the capacitor C_2 charges to $2V_m$ volts

$\Rightarrow$ for the next positive half cycle



D_1 – ON – SC
D_2 – OFF – OC
D_3 – ON – SC

Now apply KVL for the following loop where we need to determine V_{C_3}.

$\therefore \quad -V_{C_3} + 2V_m = 0$

$\therefore \quad \boxed{V_{C_3} = +2V_m}$

$\Rightarrow$ i.e the capacitor C_3 is charged to $2V_m$ volts.

As we mentioned the output voltage is considered as voltage between C_3 and C_1 capacitors.

$\therefore V_{output} = V_{C_1} + V_{C_3}$

$= +V_m + 2V_m$

$\therefore \boxed{V_o = 3V_m}$

$\therefore$ the output voltage is three times (or) triple of the input voltage.

Hence this circuit is refered as Voltage-tripler.

Applications of voltage multipliers -

- voltage multipliers are used to produce a DC voltage of few volts to large voltage meant for high energy applications (like physics, electronics experiments).

- some of the applications of voltage multipliers are-

- used in CRO's in laboratory
- laser printers and copiers
- x-ray machines
- in automobile manufacturing industries, the high voltage multipliers are used in spray paining machine
- SMPS (switch mode power supplies)

etc.