# DC to AC Converter: Inverter

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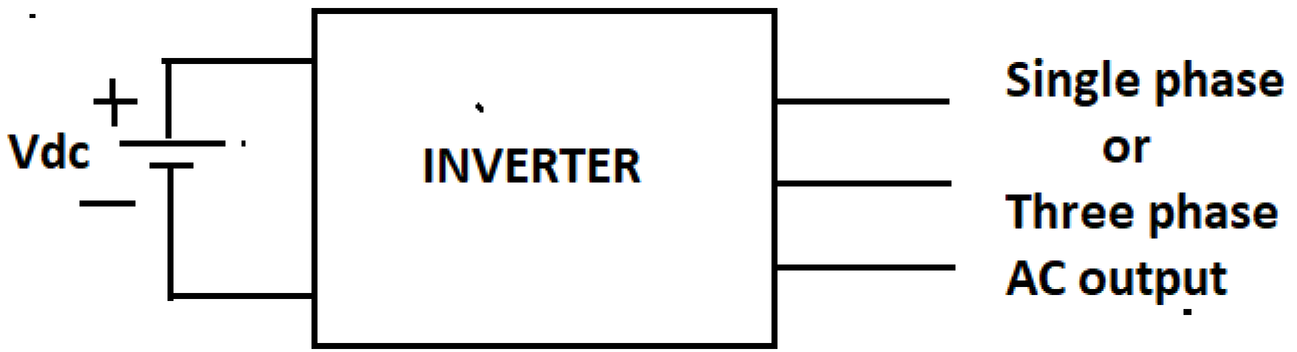
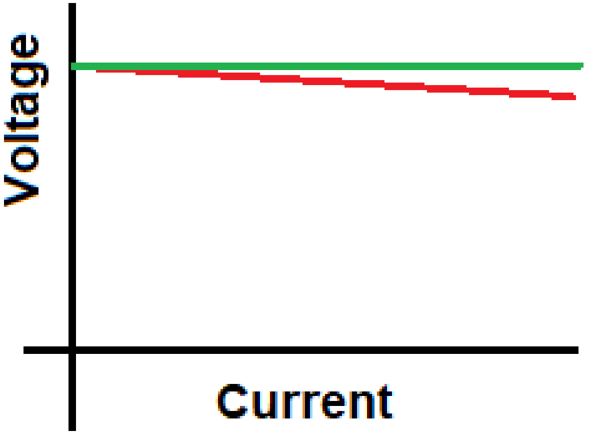
# Introduction

- DC to AC conversion




- Variable voltage variable frequency output
- Devices used are MOSFET or IGBT
- Applications : UPS, AC Drives & VSC used in power systems

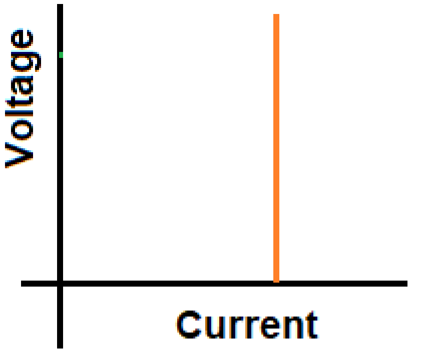
# Types of DC Sources

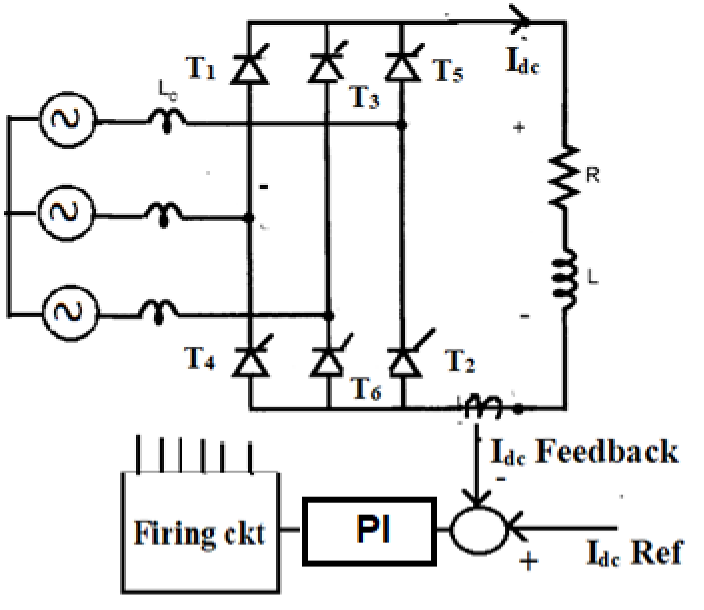



- DC Voltage source
- V-I Characteristics
- Examples
- Battery
- Uncontrolled AC to DC converter
- Controlled AC to DC converter
- O/P voltage of DC shunt generators

# DC Current Source

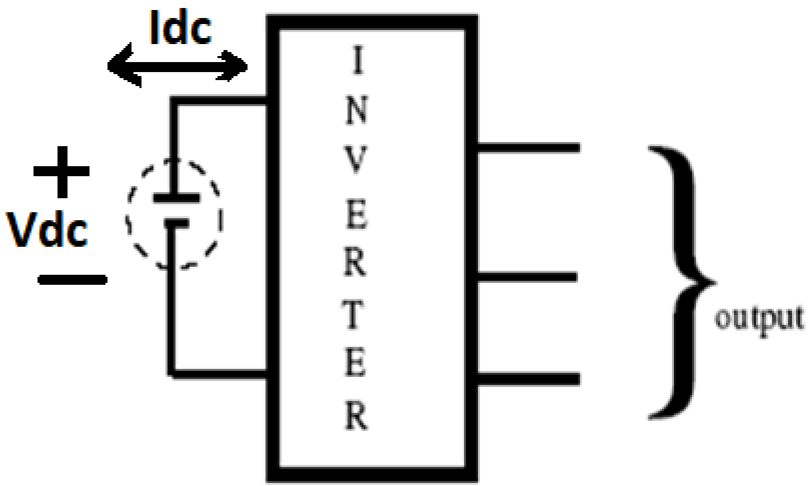
- DC current source is obtained from AC to DC converter with closed loop current control
- $I_{dc}$ is always maintained to a set value by adjusting $\alpha$ of the 6 pulse converter
- Voltage of the converter changes as per change in load to maintain $I_{dc}$ constant



# Types of Inverter based on DC Source

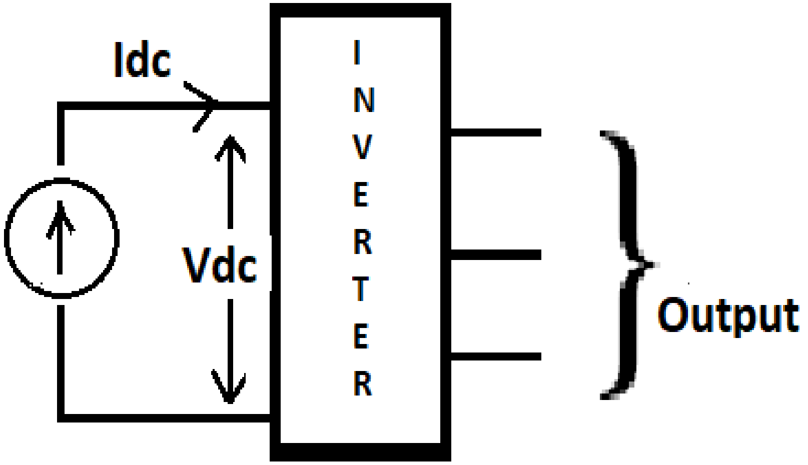
- Voltage source Inverter (VSI)
- Input  to inverter is DC voltage source.
- Battery or Large  C at input dc side.
- Input DC current can rev
- DC voltage polarity cant
  be  reversed.
- Power  flow can be
  bi –directional.



# Types of Inverter based on DC Source

- Current source Inverter (CSI)
- Input to inverter is DC current source.
- Input DC current cant be reversed.
- DC voltage polarity can be reversed.
- Power flow can be bi –directional.

How to obtain dc current source?

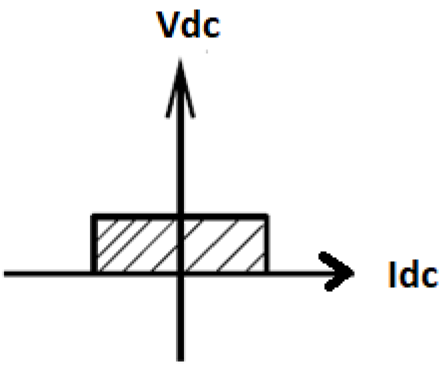


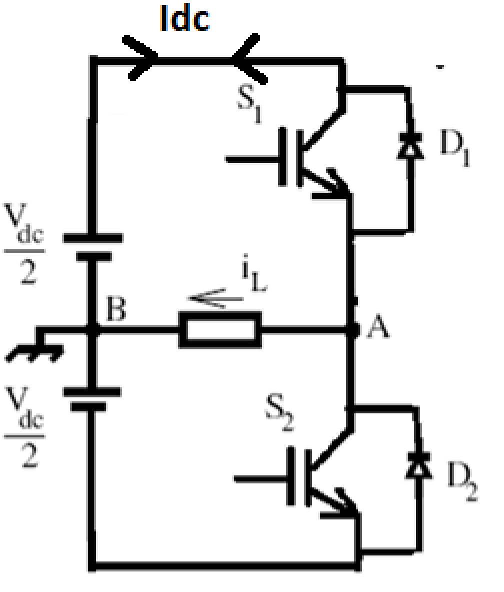
# Types of Inverter based on topology

- Voltage source Inverter (VSI)
- Single phase
  - i) Half Bridge
  - ii) Full bridge
- Three phase Bridge Inverter
- $120^0$ mode
- $180^0$ mode
- PWM switching

# 1ϕ half bridge Inverter

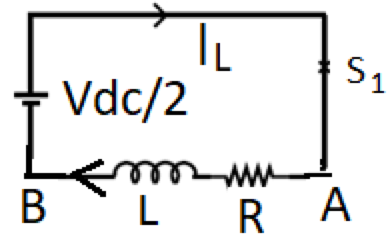
- Circuit configuration
- Basic configuration : half bridge
- Switches can carry bidirectional current
- Diode antiparallel with switch
- Two quadrant operation

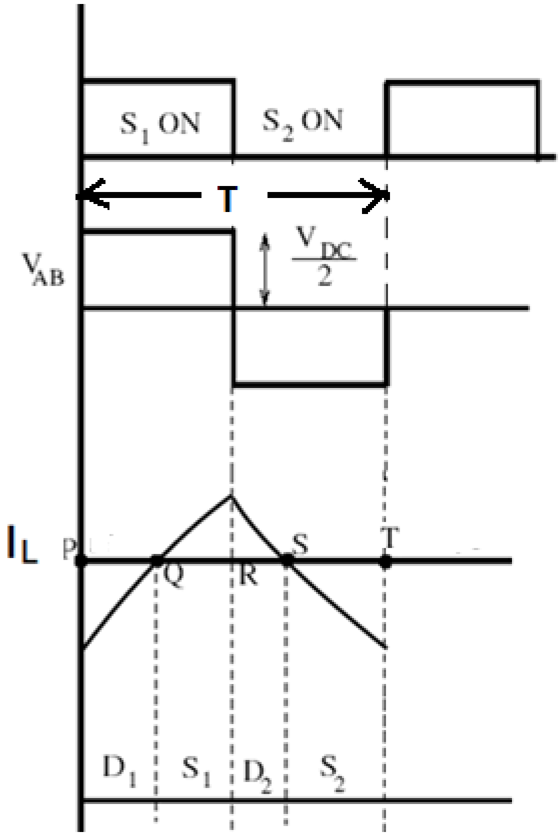


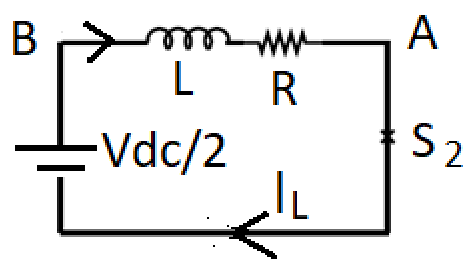
# 1ϕ half bridge Inverter

- Output voltage waveform
- Switching signals S1 and S2
- Are complementary
- When S1 is ON
- $V_{AB} = +V_{DC}/2$




- When S2 is ON
- $V_{AB} = - V_{DC}/2$



# 1ϕ half bridge Inverter

- Observations
- Time for $S_1$/ $S_2$ on will determine the output frequency
- If T/2= 10 msec then F = 50 Hz
- Similarly T/2 = 100 msec then F= 5 Hz
- Steady state operation
- PQ Period => applied voltage to load = +ve

  $I_L$ is negative (flowing from B to A

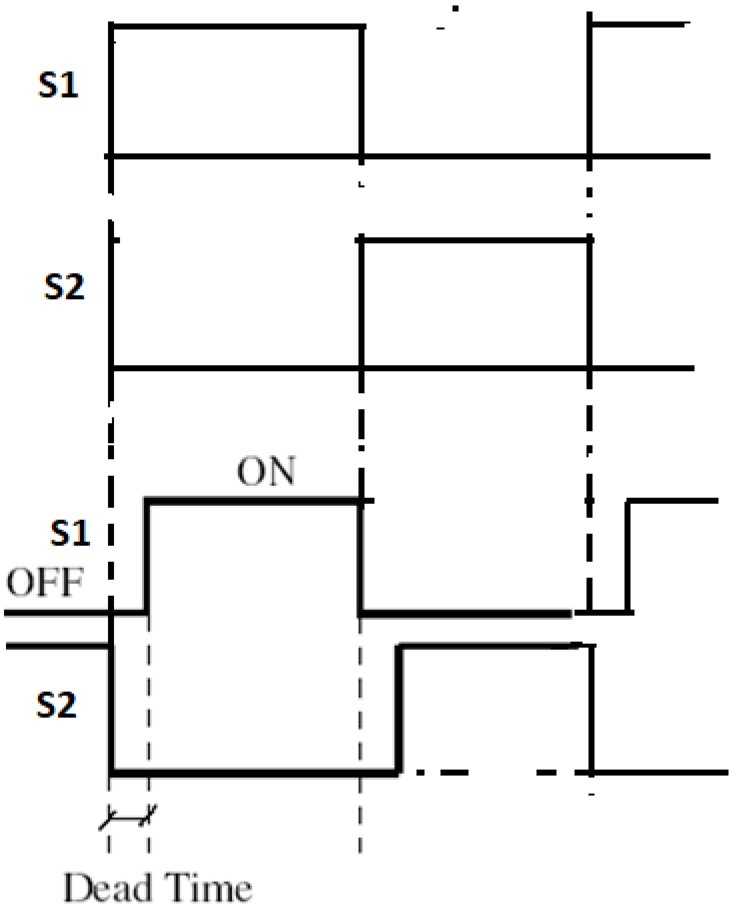
  $D_1$ carrying current

# 1ϕ half bridge Inverter

- Period Q R => V and I are +ve
  S1 is conducting
- Period R S => V is – ve and I is +ve
  D2 is conducting
- Period S T => V and I are -ve
  S2 is conducting
- If load is RL then switch should have anti-parallel diode

# 1ϕ half bridge Inverter

- Dead Time
- S1 and S2 should not on simultaneously
- DC source short Circuited
- Avoid short circuit by using dead time
- Switch on instant is delayed by few μsec



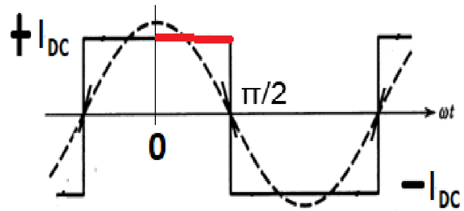
# Harmonics

- The relationship between rms current, fundamental current and harmonic current
- $I^2_{rms} = I^2_{1rms} + I^2_{2rms} + I^2_{3rms} + I^2_{4rms} + I^2_{5rms} + \text{-----}$
- $I^2_{rms} = I^2_{1rms} + I^2_{hrms}$
- Where,
- Total harmonic current can be
- $I^2_{hrms} = I^2_{2rms} + I^2_{3rms} + I^2_{4rms} + I^2_{5rms} + \text{-----}$
- For the given waveform $I^2_{rms}$ and $I^2_{1rms}$ is computed
- $\%THD = (I_{hrms} / I_{1rms}) \times 100$

# Harmonic spectrum of a waveform

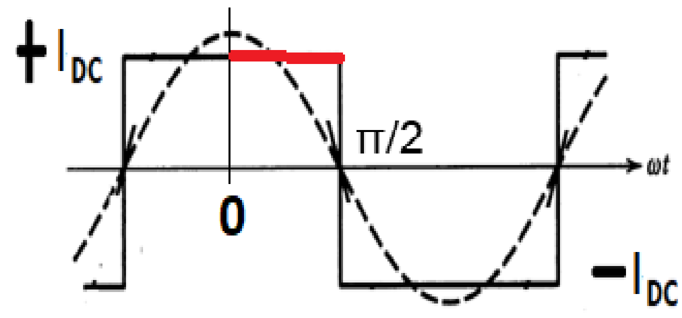
- Procedure

- Determine the RMS value of the waveform.= I
- Determine the peak amplitude of nth harmonic
- Considering quarter wave symmetry
- An=$\frac{8}{2\pi}\int_0^{\pi/2} F(\theta)\cos(n\theta)\,d\theta$
- Where An= peak amplitude of nth Harmonic.
- Determine peak amplitude of fundamental and the RMS value of fundamental = $I_1$
- $I^2 = I_1^{\,2} + I_h^{\,2}$
- %THD $= (I_h/I_1) \times 100$



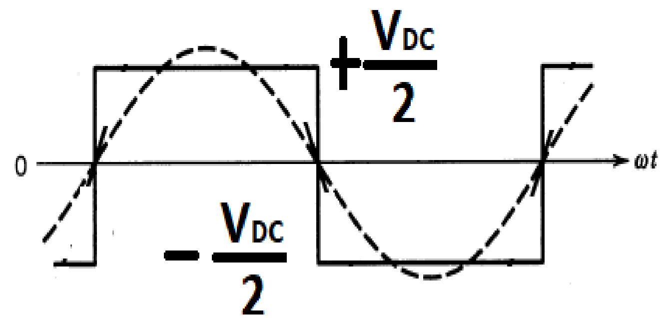
# Harmonic spectrum of square wave

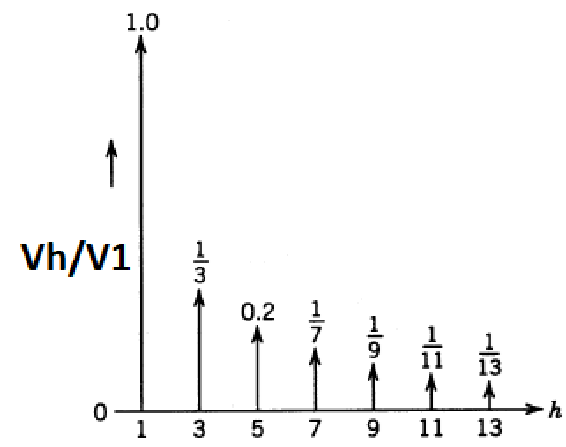
- Harmonic spectrum
- RMS value $I = I_{dc}$
- $A_n = \frac{8}{2\pi} \int_0^{\pi/2} I_{dc} \cos(n\theta)\, d\theta$
- $A_n = (4/n\pi)\, I_{dc} \sin(n\pi/2)$
- $A_1 = 4I_{dc}/\pi$ (*Peak amplitude of fundamental*)
- $I_1 = \frac{2\sqrt{2}}{\pi} I_{dc}$ *and* $I_h = I_{dc}\sqrt{\left(1 - \frac{8}{\Pi^2}\right)}$
- $I_h/I_1 = 0.482$



# 1ϕ half bridge Inverter

- Output voltage and harmonic spectrum
- Output voltage is square wave ($V_{DC}/2$ amplitude)
- It contains all
- odd harmonics
- $V_1$ peak =2Vdc/π
- THD is 48 %
- Vrms = $V_{DC}/2$



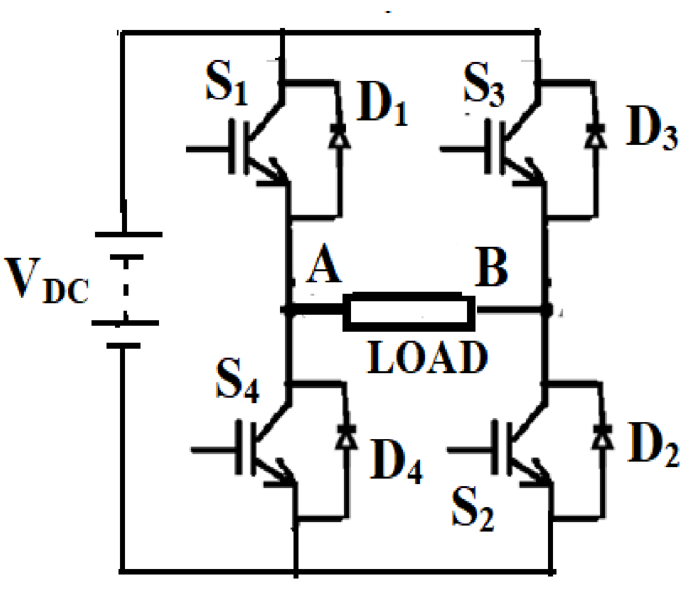



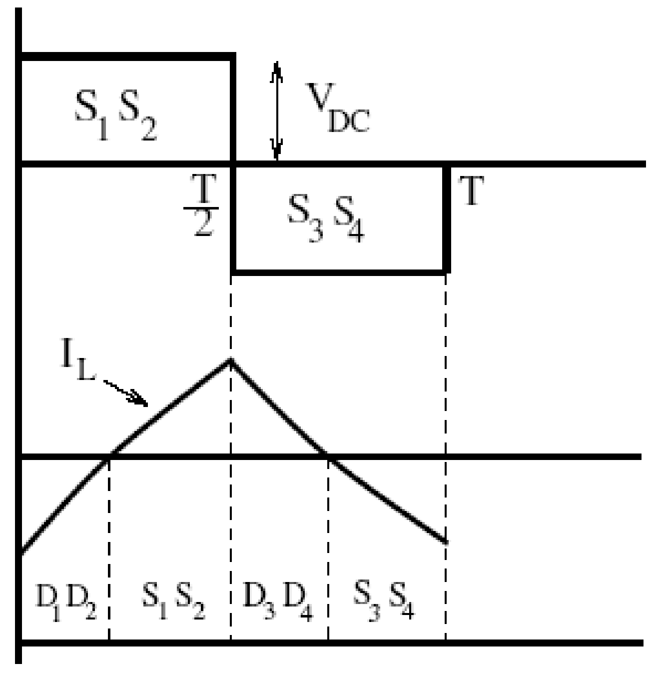
# 1ϕ half bridge Inverter

- Disadvantages
- Input voltage = Vdc
- Output voltage V(rms) = Vdc/2
- One switch is conducting at a time
- Use full bridge inverter

# 1ϕ full bridge Inverter

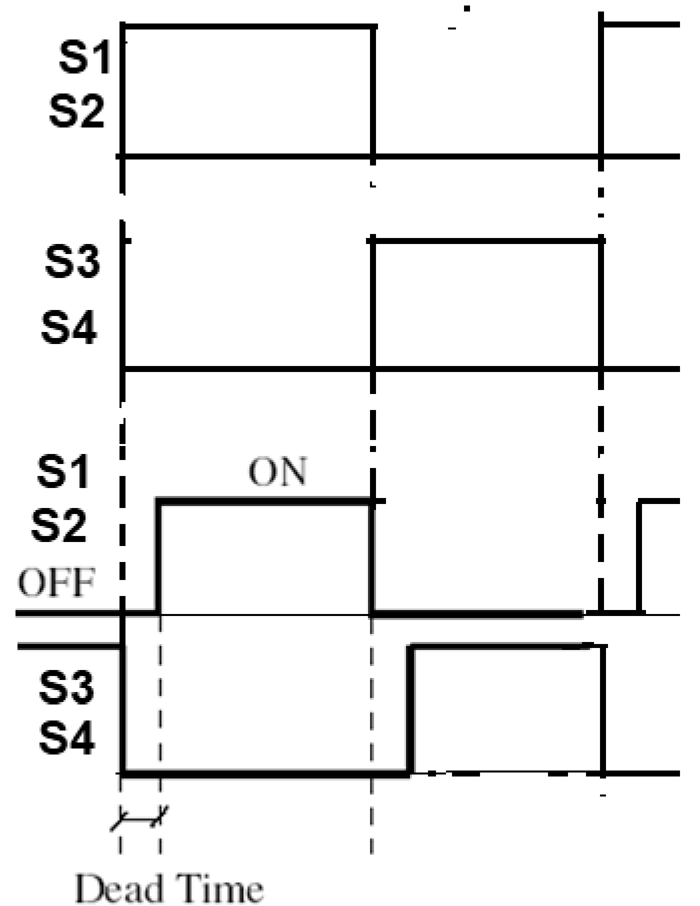
- Square wave Mode
- Two devices are conducting simultaneously
- Center point of DC link is not required



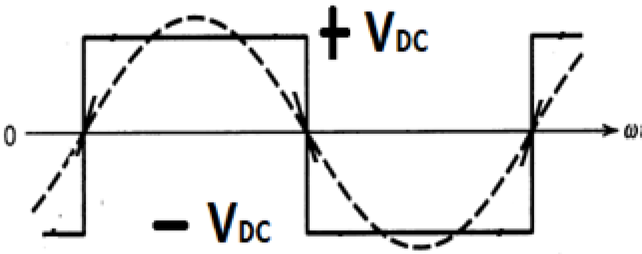
# 1ϕ full bridge Inverter

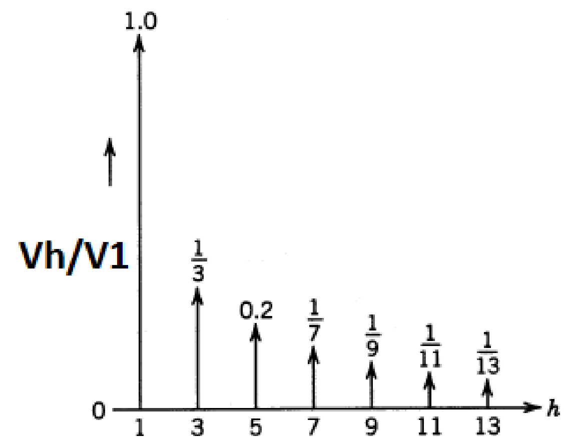
- Dead Time
- (S1 and S4) OR
- (S2 &S3) should not on simultaneously
- DC source short Circuited
- Avoid short circuit by using dead time
- Switch on instant is delayed by few μsec



# 1ϕ full bridge Inverter

- Output voltage and harmonic spectrum
- Output voltage is square wave ($V_{DC}$ Amplitude)
- It contains all
- odd harmonics
- $V_1$ peak = 4Vdc/π
- THD is 48 %
- AC o/p voltage(rms) = $V_{DC}$



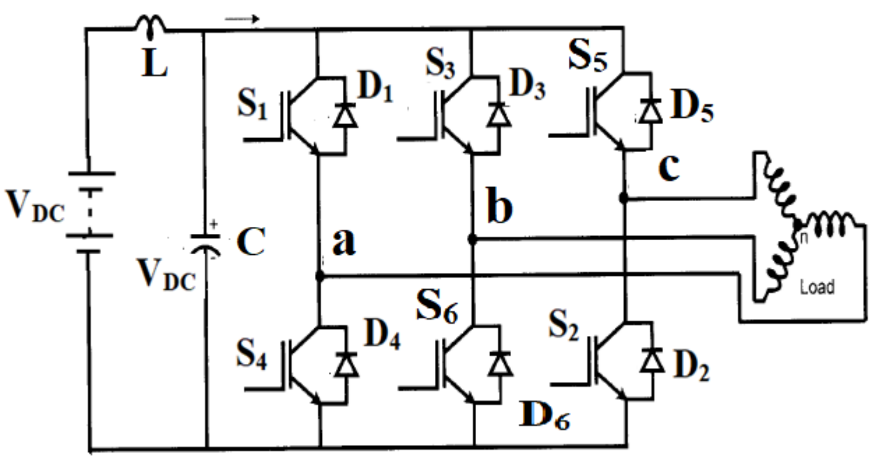
# Three Phase VSI Bridge Inverter

- It consists of 3 legs
- Devices are named as per conducting sequence
- Controlled quantities

  Voltage, frequency

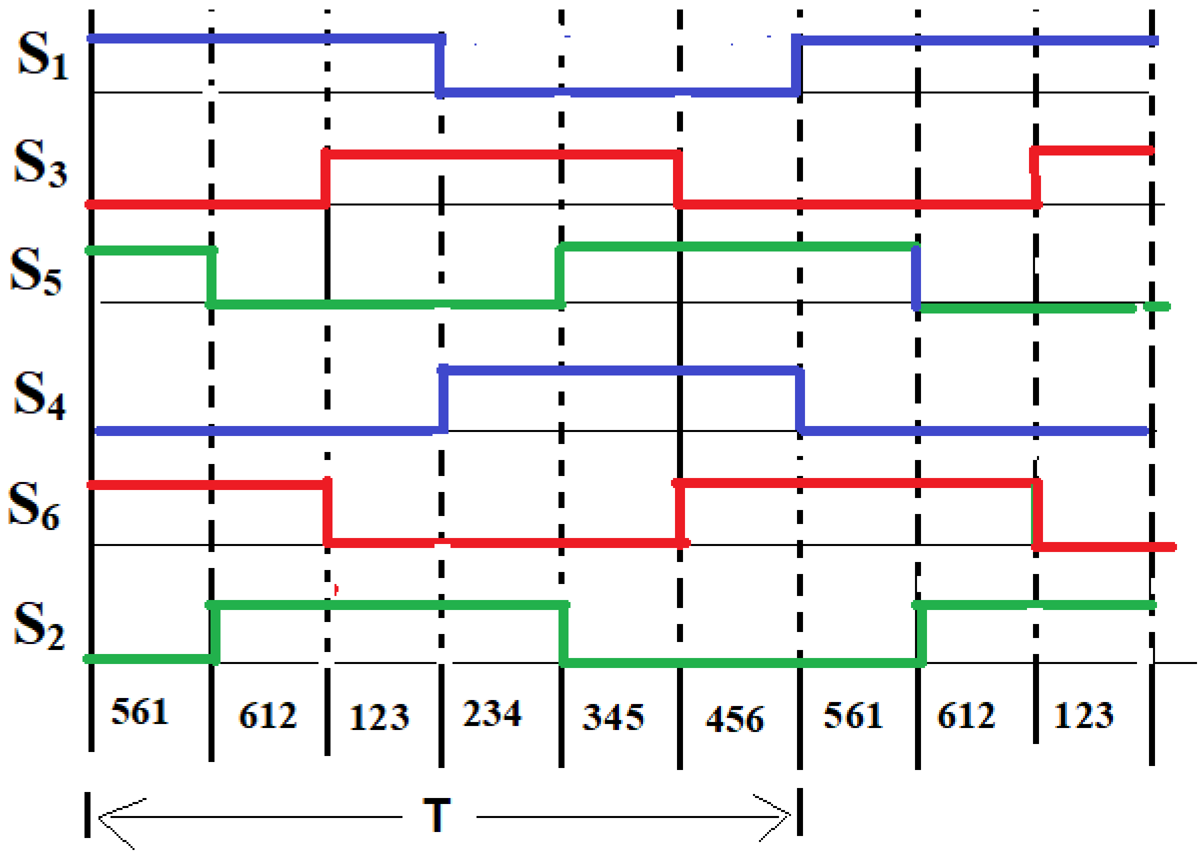
  and phase sequence
- Operating modes

$180^0$ ,$120^0$ and PWM



# $180^0$ mode of conduction

- Switching signal



# $180^0$ mode of conduction

- Each device conducts for $180^0$
- One device from each leg is ON
- Three deices are on simultaneously
- Devices are named as per conducting sequence
- Dead time is required to avoid the short circuit of DC link
- Phase shift between the legs is $120^0$.