COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

AC Power Converter

EET 307

Lecture 12

- Series Inverter -

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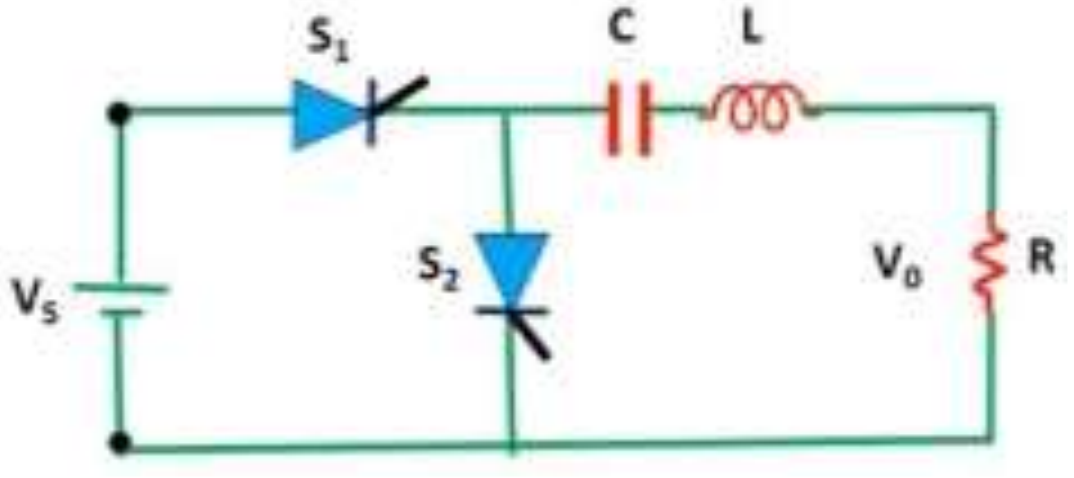
Circuit Description



- ➢ The circuit consists of:
- ▪ DC input source Vs.
- ▪ Two thyristors: $S1$ and S2.
- ▪ Series RLC circuit (R, L, C).
- ▪ Output voltage across R (load).
- ▪ This is called a series inverter because R, L, and C are connected in series and the circuit operates using resonance.

Principle of Operation

- The inverter works by turning ON thyristors alternately:
- First $S1$ ON → current flows in one direction.
- Then $S2$ ON → current flows in opposite direction.
- The RLC circuit causes the current to be sinusoidal (resonant current).
- So the inverter converts DC → AC.

Series Resonant Inverter

In this inverter, the inductor, capacitor, and load are connected in series.

SCR Based Series Resonant Circuit (conceptual):

+Vdc → SCR1 → L → C → Load → Return.
+Vdc → SCR2 → L → C → Load → Return.

```
+Vdc
  |
SCR1
  |------L------C------Load------|
  |                               |
SCR2                           -Vdc
```

Mode of Operation

1. SCR1 is triggered.
2. Current flows through L → C → Load.
3. The LC circuit resonates.
4. Current becomes sinusoidal.
5. When current reaches zero, SCR turns OFF naturally.
6. SCR2 is triggered for the next half cycle.

This process produces AC output from DC input.

Output Waveforms

Waveforms

- Load current → sinusoidal.
- Output voltage → sinusoidal.
- Thyristor current → half sine wave pulses.
- Capacitor voltage → oscillating.

Series Resonant Inverter Equations

Resonant frequency:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Angular frequency:

$$\omega_r = \frac{1}{\sqrt{LC}}$$

Peak current:

$$I_m = \frac{V_{dc}}{\omega_r L}$$

Series Resonant Inverter Equations

Inductor Formula

$$L = \frac{R_L \pi}{2\omega_d}$$

Where:

- L = Inductance (H).
- R_l = Load resistance (Ω).
- π = 3.1416.
- ωd = Damped resonant angular frequency (rad/s).

Meaning

This equation calculates the inductance required for the resonant circuit based on:

- Load resistance.
- Resonant frequency.

It is used when designing SCR series resonant inverters.

Capacitor Formula

$$C = \frac{4L}{4L^2\omega_d^2 + R_L^2}$$

Where:

- C = Capacitance (F).
- L = Inductance (H).
- ωd = Damped angular frequency.
- RL = Load resistance (Ω).

Meaning

This equation determines the capacitor value required to obtain the correct resonant condition.

Series Resonant Inverter

Advantages

- High efficiency.
- Natural commutation of SCR.
- Simple circuit.

Disadvantages

- Load must remain near resonant condition.
- Frequency control is limited.

Example 1

Suppose:

- $R_L = 10\,\Omega$
- $\omega_d = 2000\,rad/s$

Step 1 — Calculate L

$$L = \frac{10 \times \pi}{2 \times 2000}$$

$$L = 0.00785\,H$$

$$L = 7.85\,mH$$

Step 2 — Calculate C

$$C = \frac{4(0.00785)}{4(0.00785)^2(2000)^2 + 10^2}$$

$$C \approx 0.0000025F$$

$$C = 2.5\mu F$$

Example 2

Find resonant frequency, when

L = 10 mH = 0.01 H

C = 10 μF = 10×10^{-6}

Sol:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$LC = 0.01 \times 10 \times 10^{-6} = 10^{-7}$$

$$\sqrt{LC} = \sqrt{10^{-7}} = 3.162 \times 10^{-4}$$

$$f_r = \frac{1}{2\pi \times 3.162 \times 10^{-4}} = 503 \text{ Hz}$$

Example 3

Find angular frequency, when

L = 5 mH = 0.005 H

C = 20 μF = 20×10^{-6}

Sol:

$$\omega = \frac{1}{\sqrt{LC}}$$

$$LC = 0.005 \times 20 \times 10^{-6} = 10^{-7}$$

$$\omega = \frac{1}{3.162 \times 10^{-4}} = 3162 \text{ rad/s}$$

Example 4

The operating frequency (1 kHz), and the inductance (5 mH), Find the value of capacitance

Sol:

$$C = \frac{1}{(2\pi f)^2 L}$$

$$C = \frac{1}{(2\pi \times 1000)^2 \times 0.005}$$

$$C = \frac{1}{(6283)^2 \times 0.005}$$

$$C = \frac{1}{39.5 \times 10^6 \times 0.005}$$

$$C \approx 5\mu F$$