

EE-463 STATIC POWER CONVERSION-I

Harmonics and Filters

Ozan Keysan

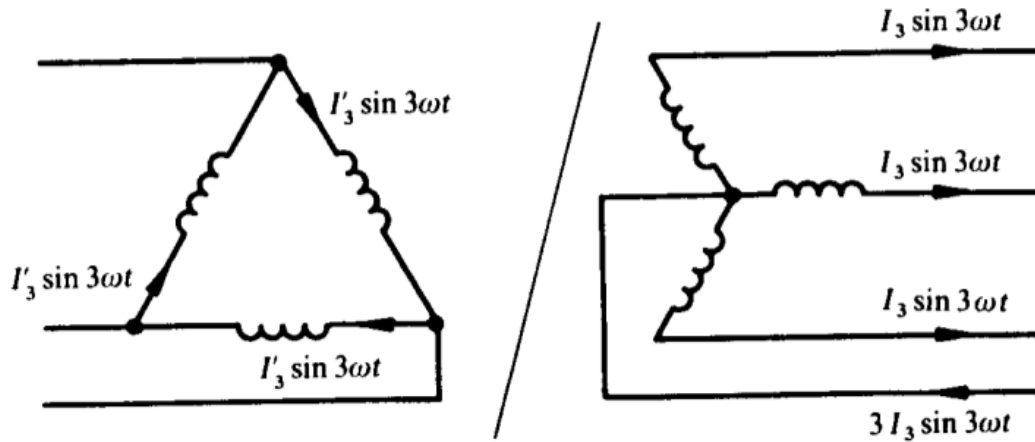
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Harmonics

Ref: Lander CH7, Ericsson CH10,CH14

Delta or Wye Connections



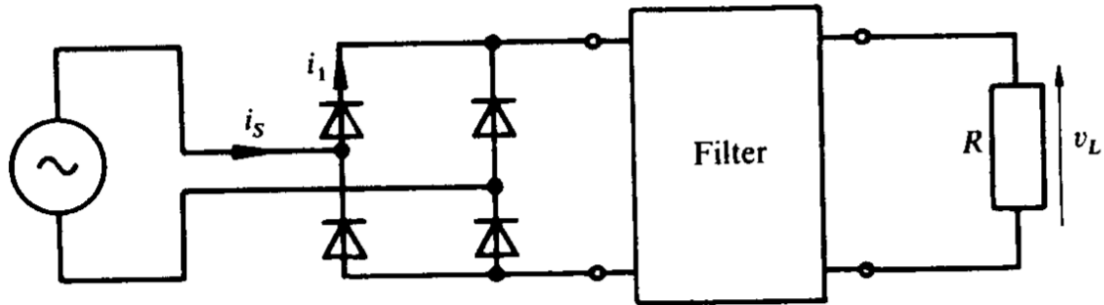
Filters

Filters

Consider a single phase rectifier

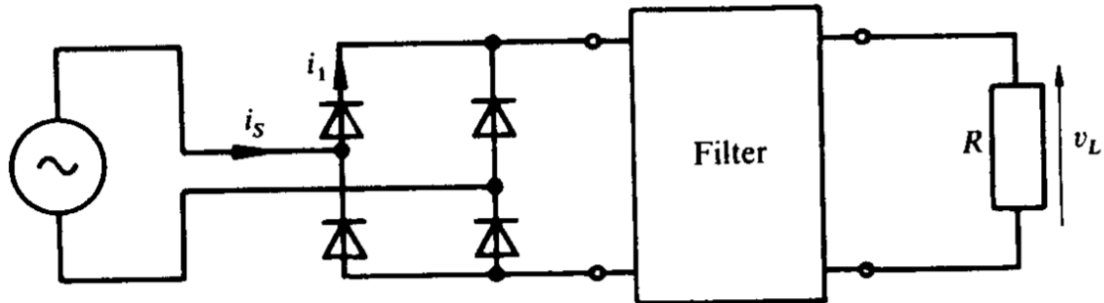
Filters

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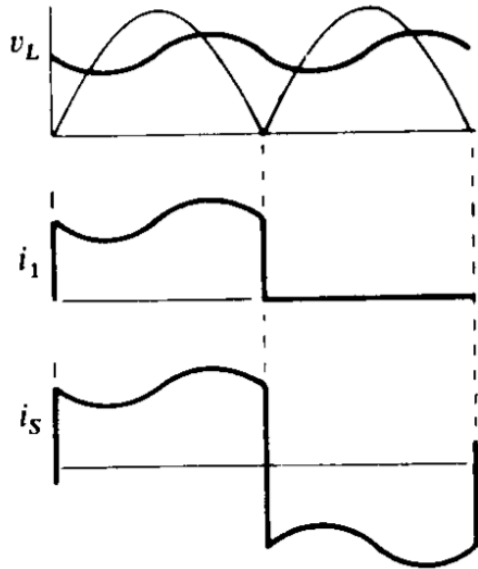
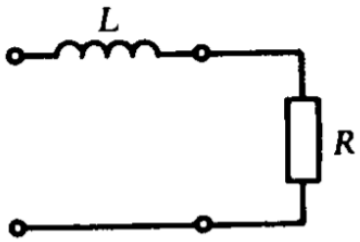


Can you draw voltage, current waveforms without filter?

Filters

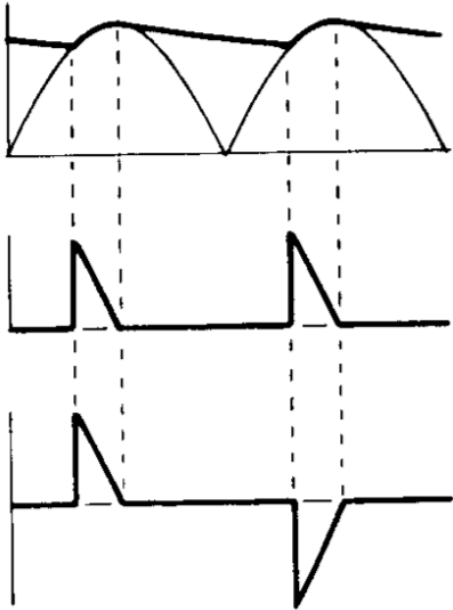
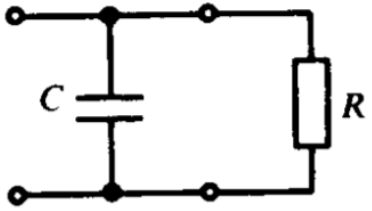
Filters

What about with Inductor?



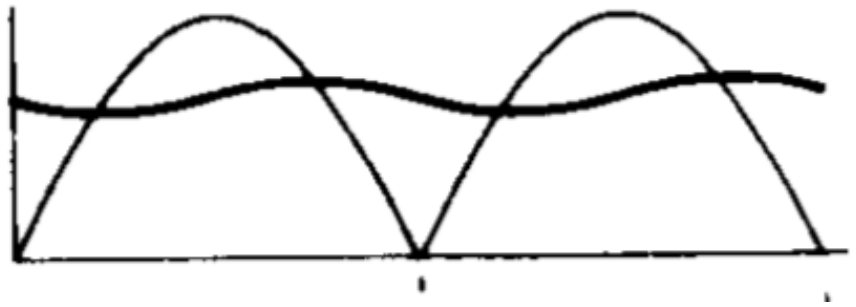
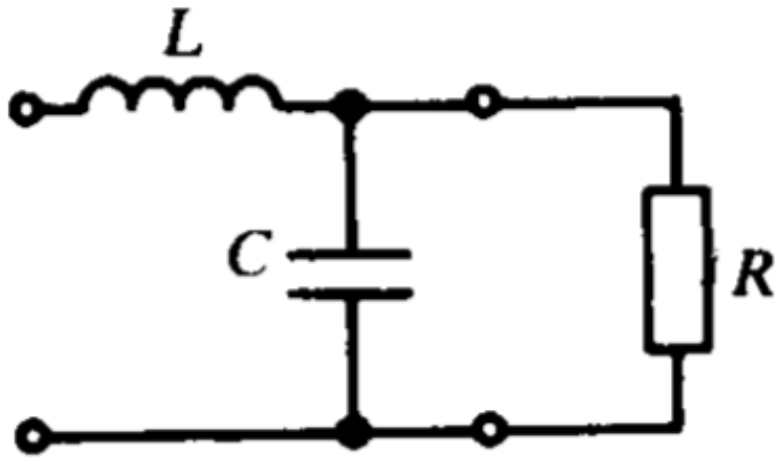
Filters

What about with Capacitor?



Filters

Capacitor and Inductor Combined?



LC Filter

LC Filter(Undamped)

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$$f_o =$$

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

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Transfer Function

LC Filter(Undamped)

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Transfer Function

$$H(s) = \frac{1}{1 + LCs^2}$$

LC Filter

LC Filter

With Damping

LC Filter

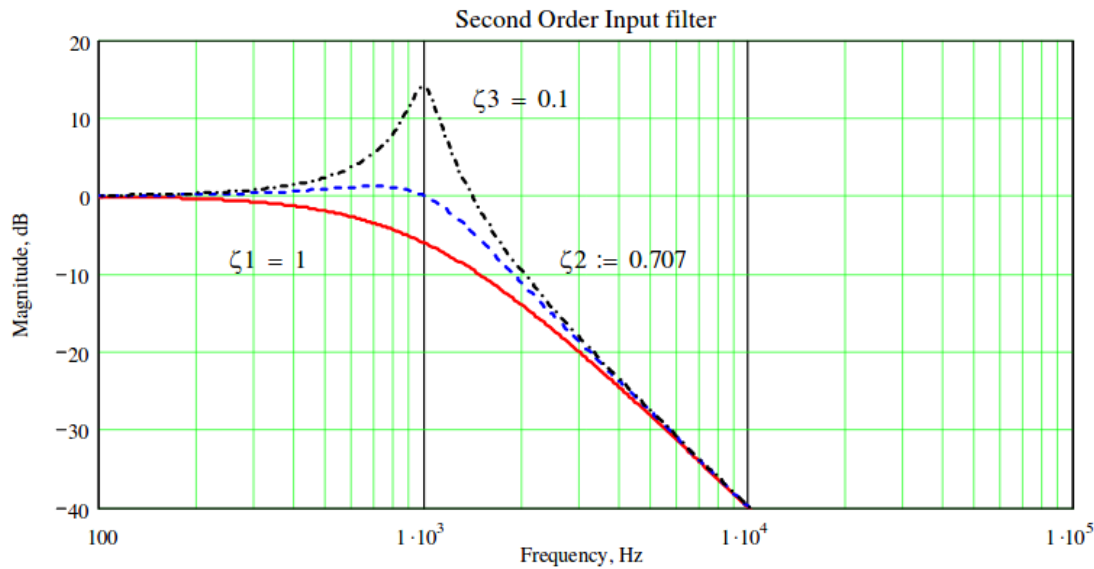
With Damping

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

Damping Factor

$$\zeta = \frac{L}{2R\sqrt{LC}}$$

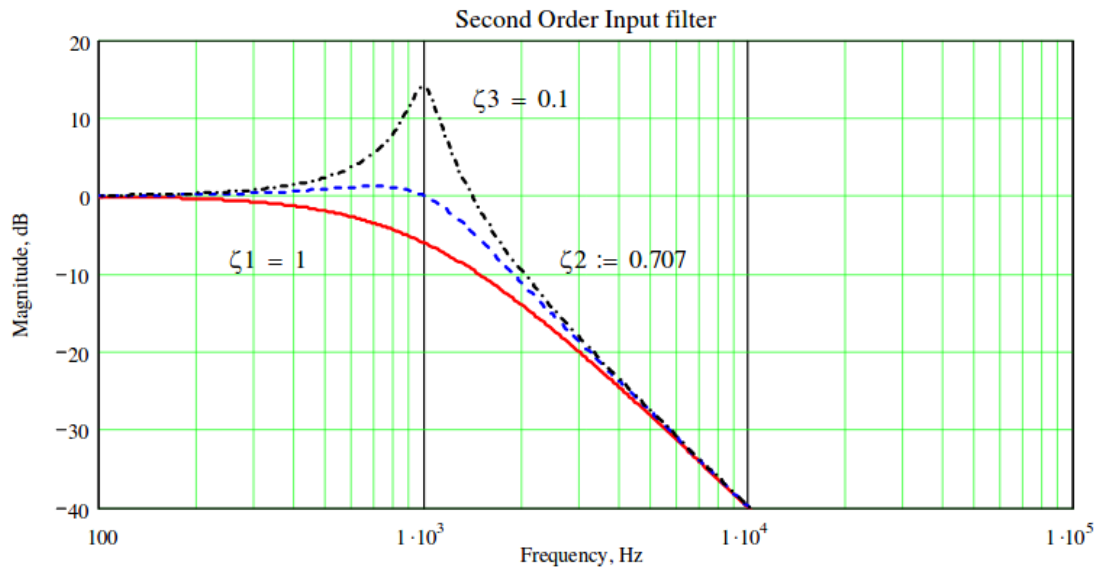
Damping Factor



Damping factor controls the gain at the corner frequency

Rule of thumb: $\zeta > \frac{1}{\sqrt{2}}$ (gives 3dB attenuation at f_0)

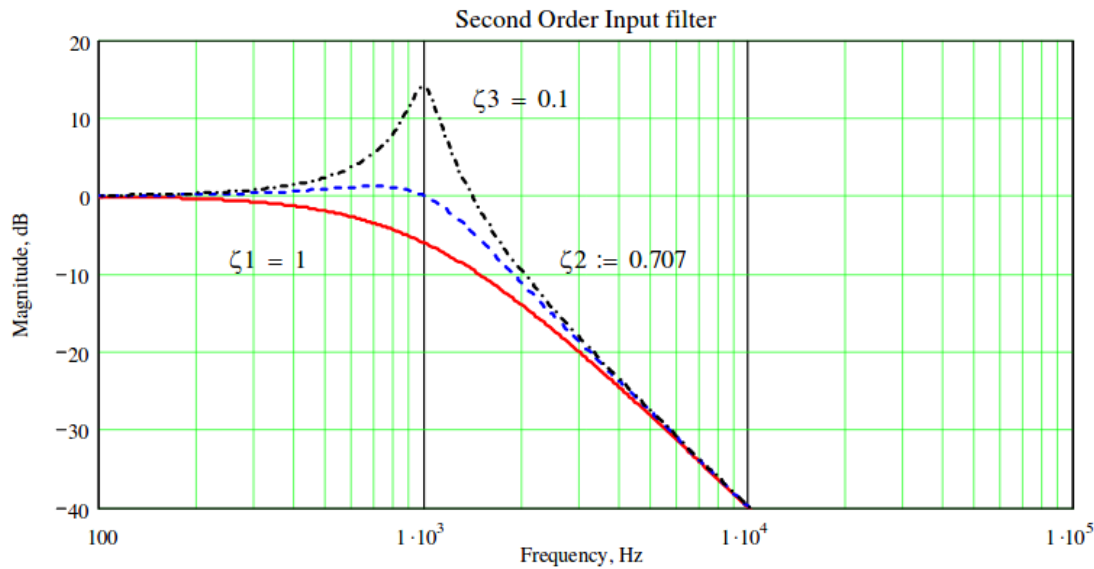
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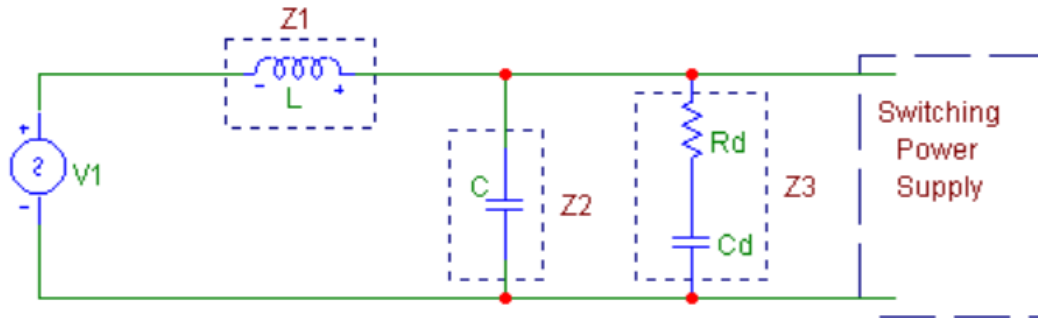


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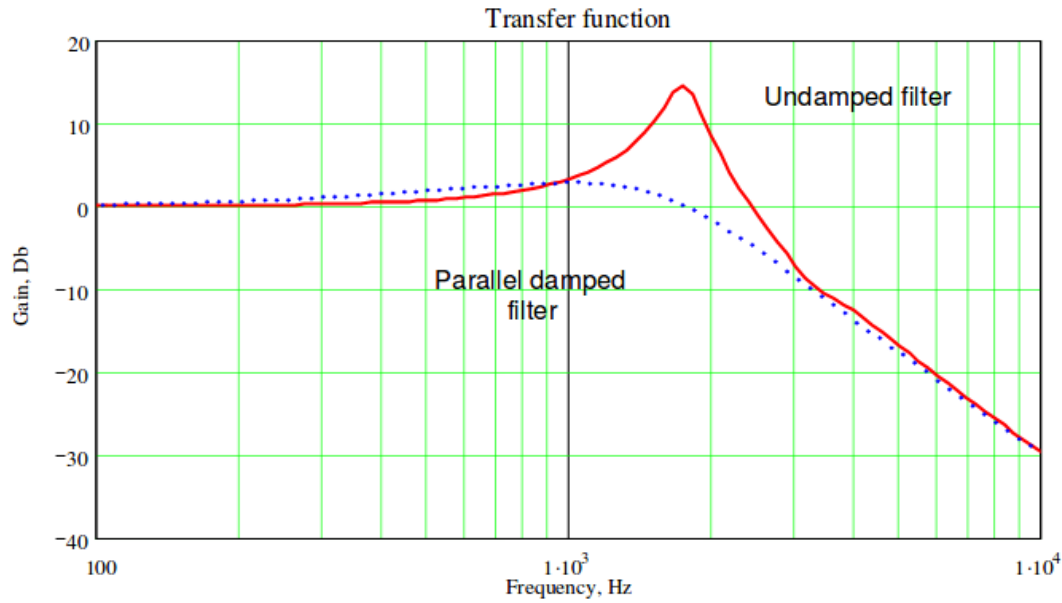
Parallel Damped LC Filter

Parallel Damped LC Filter

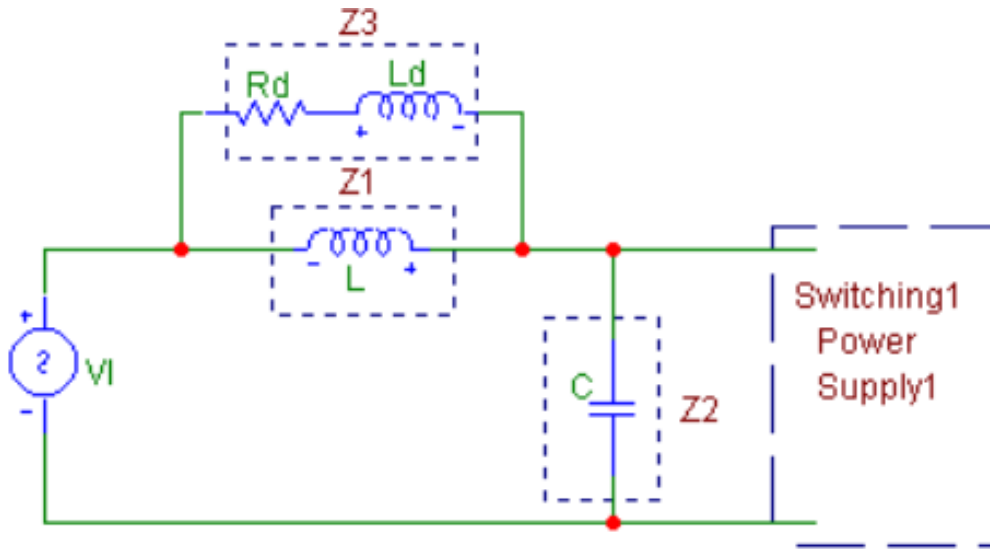


Detailed calculations given in the [handouts](#)

Parallel Damped LC Filter



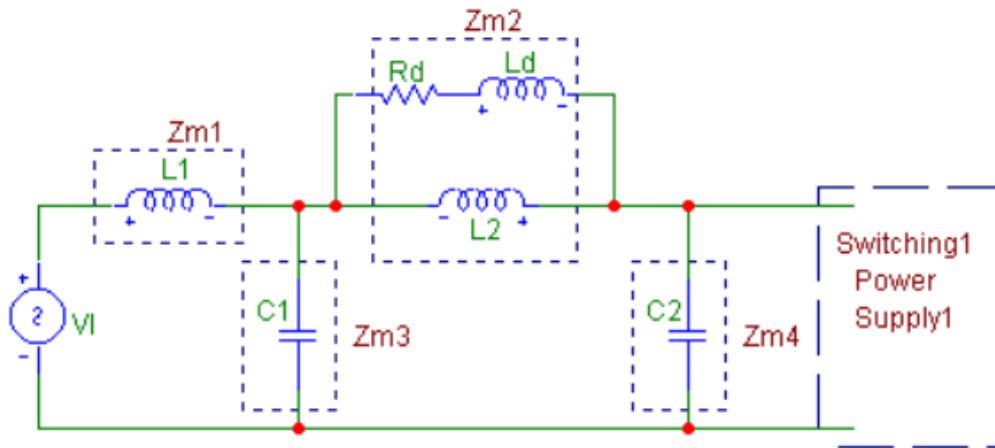
Series Damped LC Filter



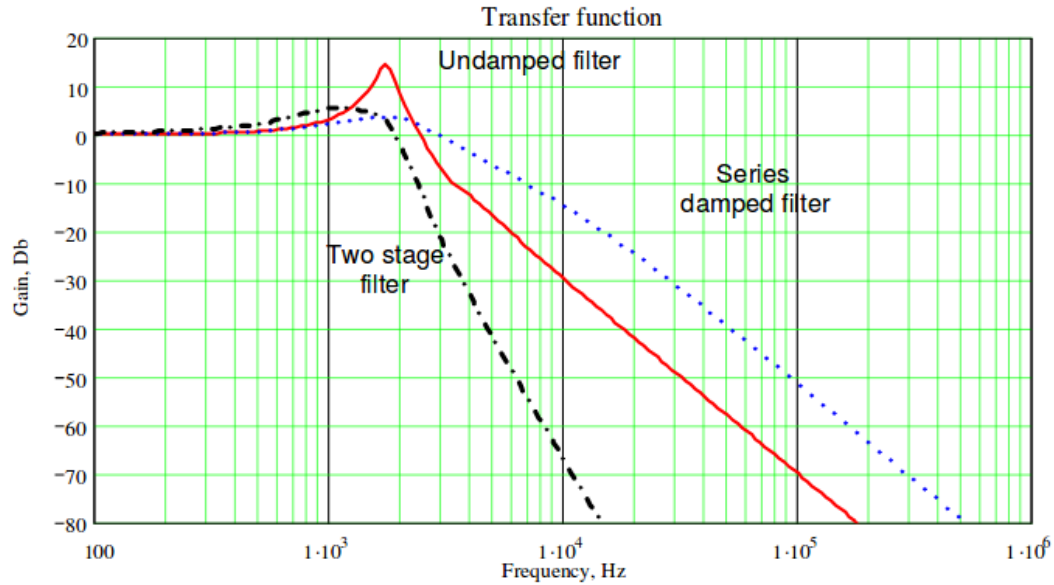
Detailed calculations given in the [handouts](#)

Multiple Stage Filters

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Multiple Stage Filters



Capacitor, Inductor Selection

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- Capacitors should be low ESL and ESR should be selected

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- The most common type is aluminum electrolytic type
- Parallel connection of capacitors can help to reduce ESR and ESL
- Filter inductances should have small parasitic capacitance

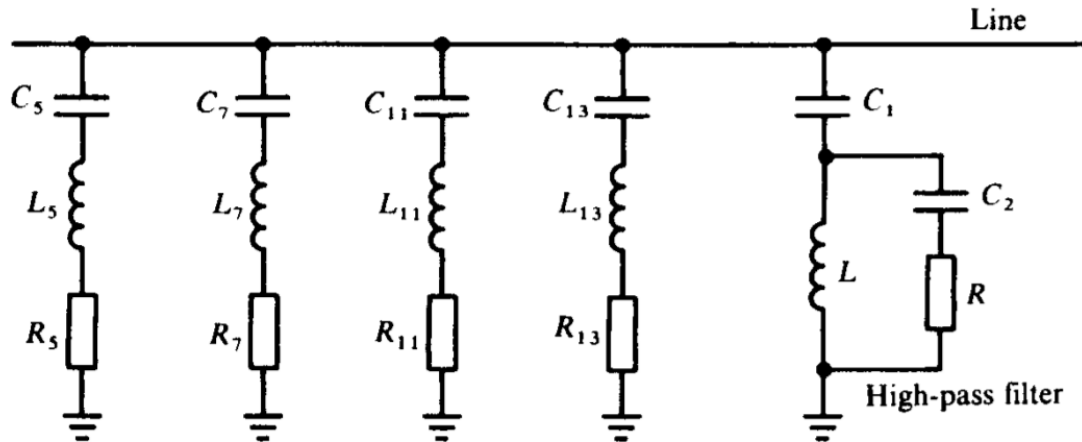
AC Line Filters

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Many filters can be cascaded to filter specific harmonics

AC Line Filters

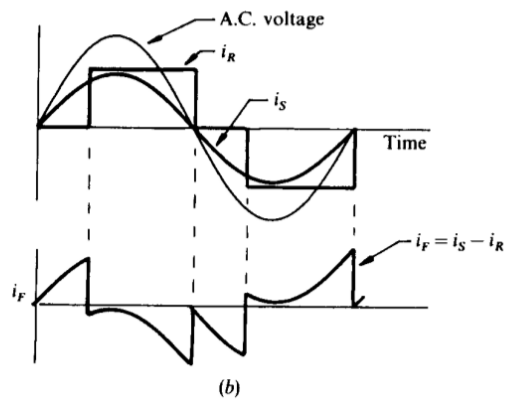
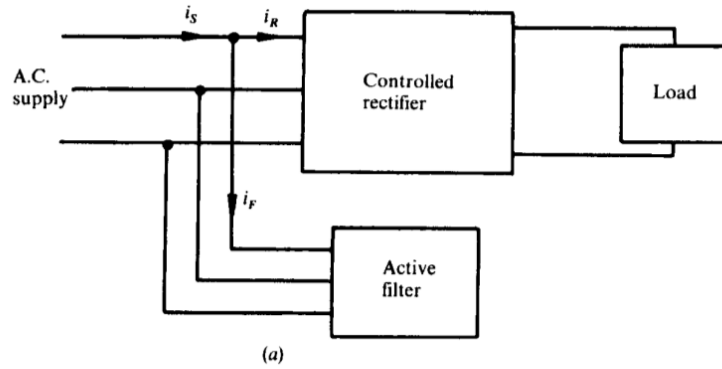
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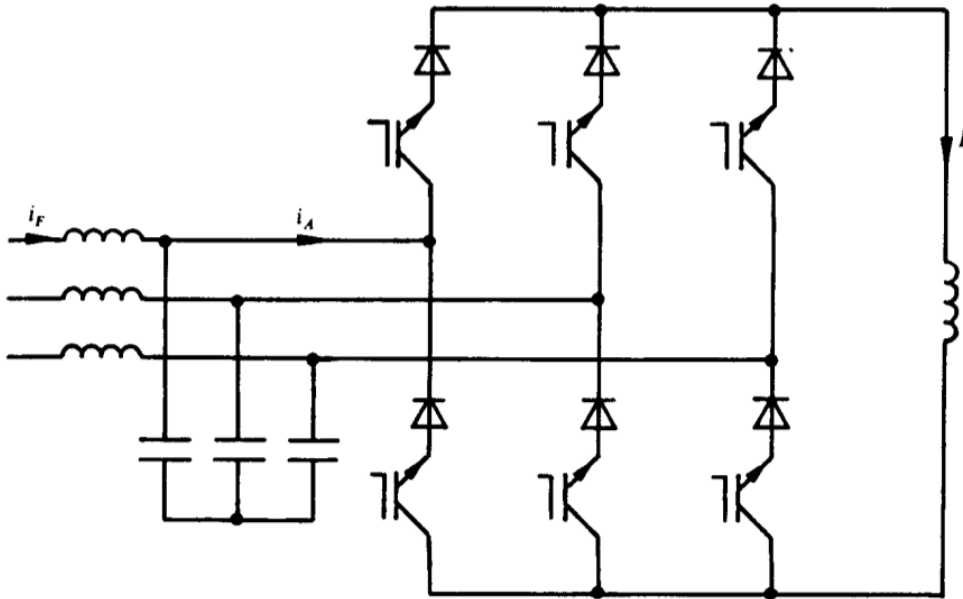
Harmonic line traps

Active Filters

Active Filters

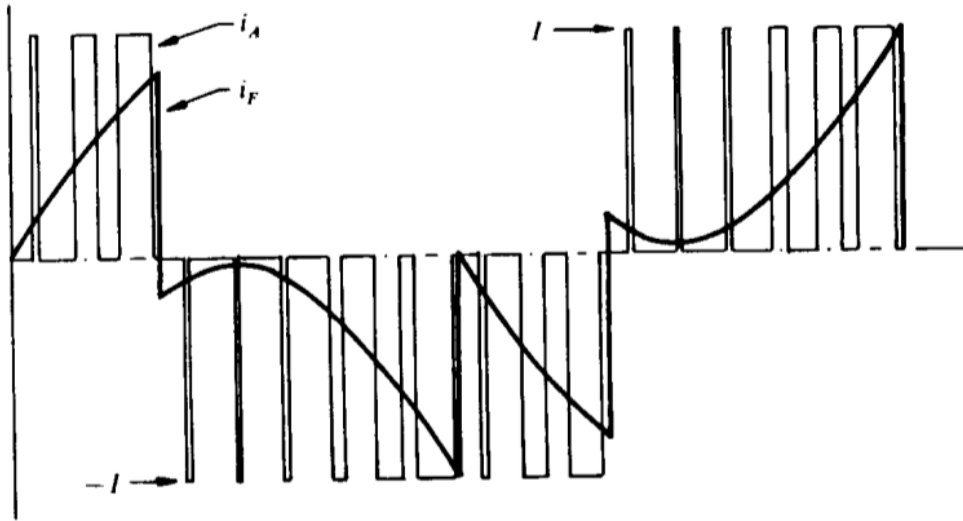


Active Filters



3-Phase Current Sourced Active Filter

Active Filters



3-Phase Current Sourced Active Filter

Useful Documents

- [Input and Output Capacitor Selection](#)
- [Selection of Capacitors for Pulse Applications](#)
- [Aluminum Electrolytic Capacitors](#)
- [Capacitor Input Filter Calculation](#)
- [Power Smoothing](#)

You can download this presentation from:
keysan.me/ee463.