# Harmonics and its mitigation techniques


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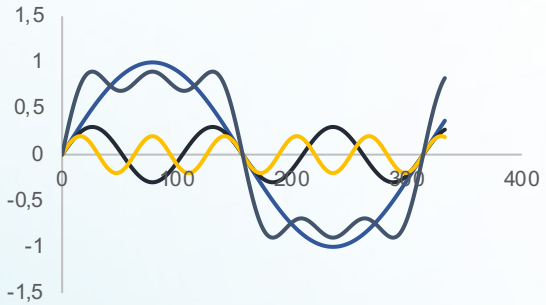
# Causes and Effects

## How we define harmonics

Fundamental signal = sin(x)

Periodic signal (x)
= sin(x) + 0,3 sin(3x) + 0,2 sin(5x)




$$THDI = \frac{\sqrt{\sum_{n=2}^{50} I_n^{\,2}}}{I_1}$$

A harmonic frequency is a multiple of the network frequency. On a 50 Hz network a 150 Hz (3 x 50 Hz) waveform is the 3rd harmonic, a 250 Hz (5 x 50 Hz) waveform is the 5th harmonic.

## Potential problems: Harmonics

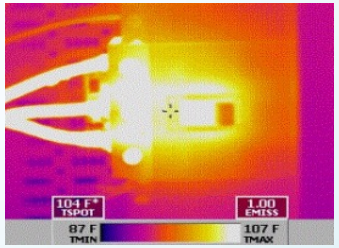
**Overheated Other Motor**


**Uneven Heating in Trafo**

**Overheated Neutral Bus**

**Humming Noise**

**Cable/Contact heating**

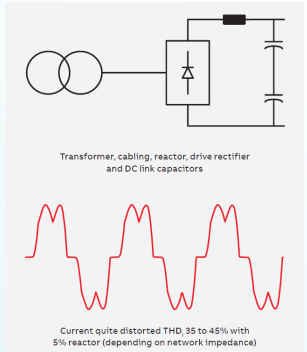


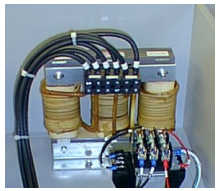

**Capacitor Failure**

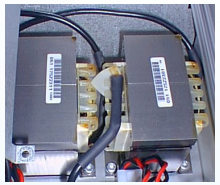
# Methods of Harmonic Mitigation

## DC and AC Input Reactors

- Easy solution for applications where there is no need for huge mitigation Harmonics are reduced to 25 to 35%.
- Reactor also protects the VFD parts from power line transients.
- Integrated choke in drive enclosure reserves always less space compared to a loose choke outside the drive
- May not provide sufficient harmonic filtering in all cases. Adds some cost to the VFD

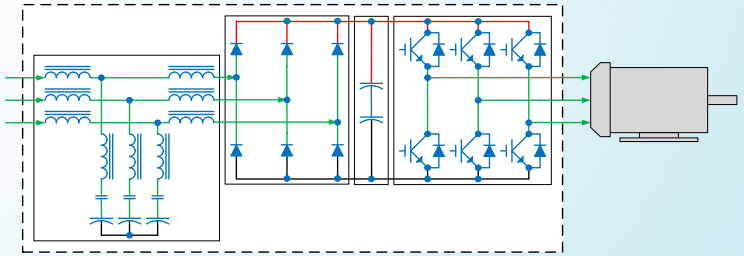




## Passive Filters

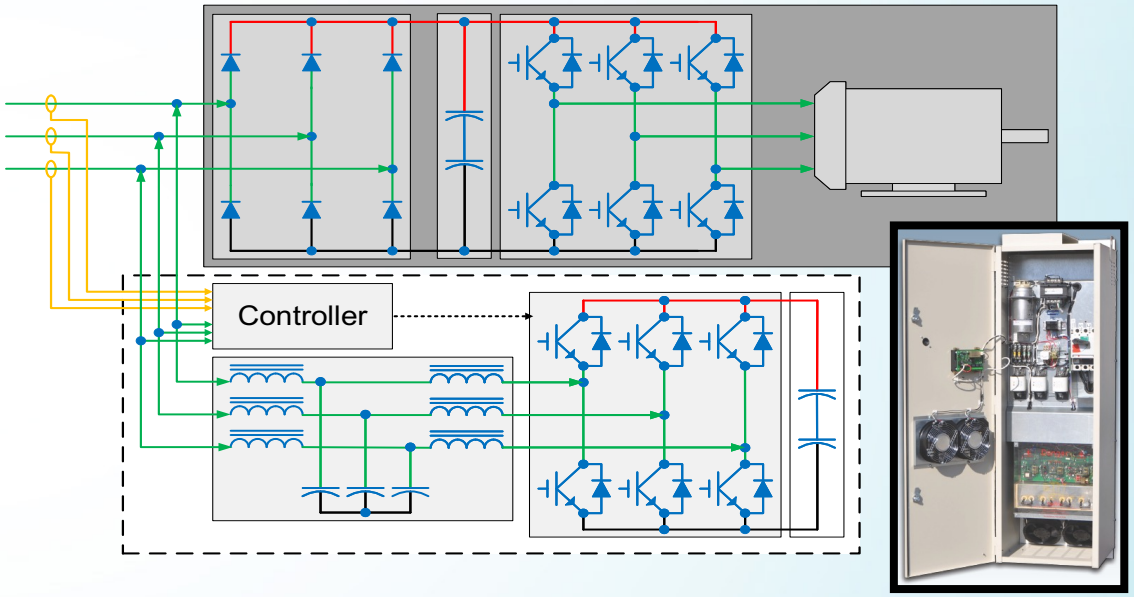
- Can significantly reduce harmonic distortion
- A current THD of 5% to 15% is possible, at nominal load point
- Sometimes can be retrofitted to an existing system
- Large size and requires often separate cabinet
- Causes a leading power factor at light loads
- Risk of resonances



# Methods of Harmonic Mitigation

**Active Filters**

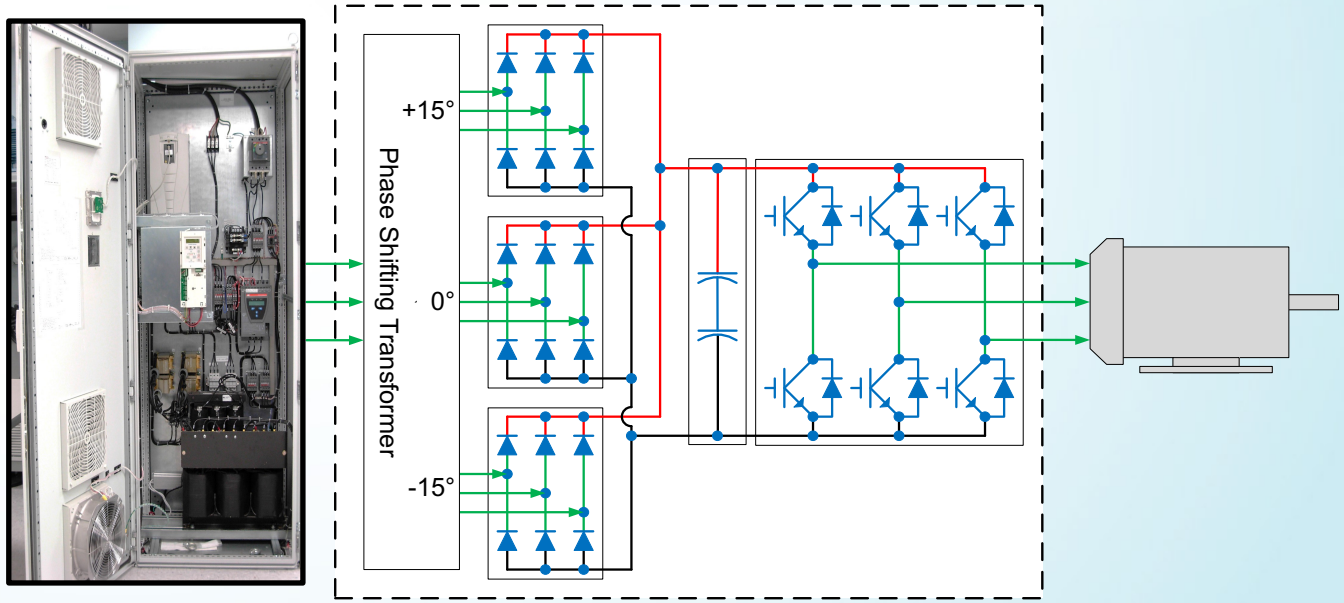
- Can reduce harmonic current distortion down to 5%
- In partial loads the performance gets
- Maintains a high input power factor of the system
- Can be retrofitted into an existing system
- Can be used to correct multiple non-linear loads
- Large size & high cost
- Power Quality study needed to dimension and determine location
- If only one active filter is used in the system, a failure may cause high distortion



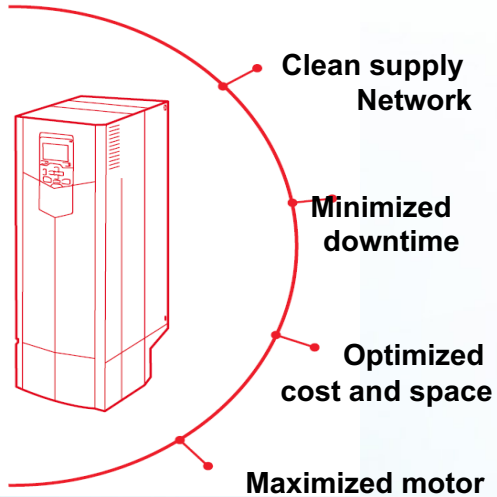
# Methods of Harmonic Mitigation

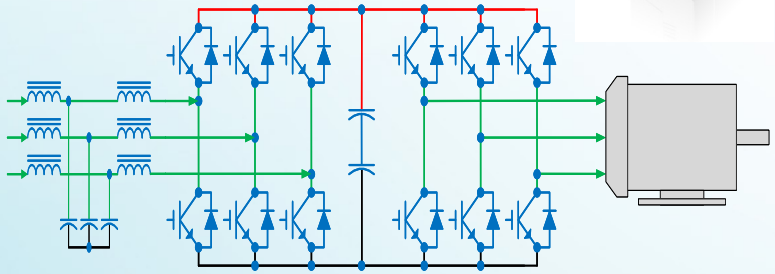
## Multipulse Rectifier

- THDI typically 12%
- Requires a special transformer
- Lower power losses in the drive and lower power factor
- Effectiveness depends on line imbalance and transformer windings balance
- Higher cabling and installation cost
- Space and weight demand
- Heat generation



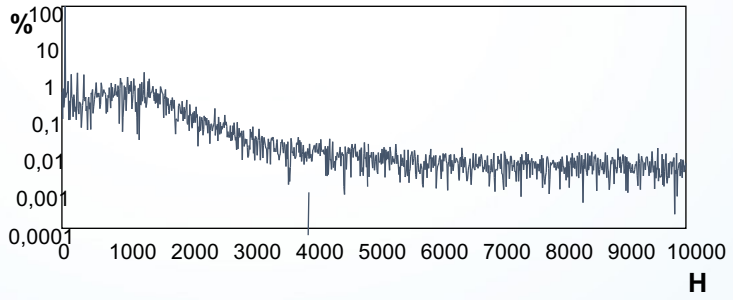
# Active Front End Technology



- Active supply unit controls the current cleaning the waveform below IGBTs' switching frequency


- Line filter removes high order components cleaning the waveform above IGBTs' switching frequency




- Unity Power Factor
- Less OPEX Cost
- Possibility for Reactive Power Compensation