

Harmonics and its mitigation

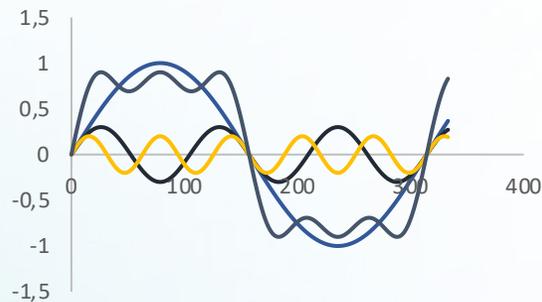


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Causes and Effects

- **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



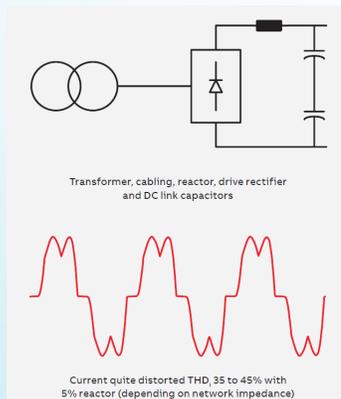
Capacitor Failure



Methods of Harmonic Mitigation

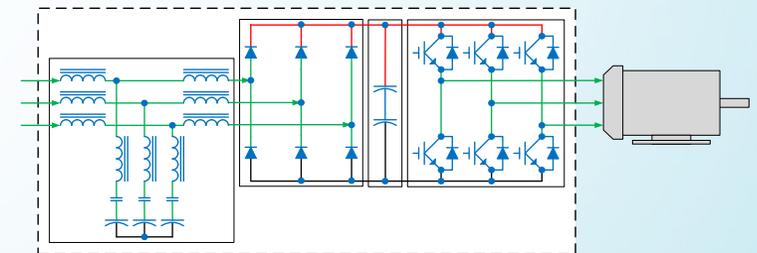
DC and AC Input Reactors

- 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

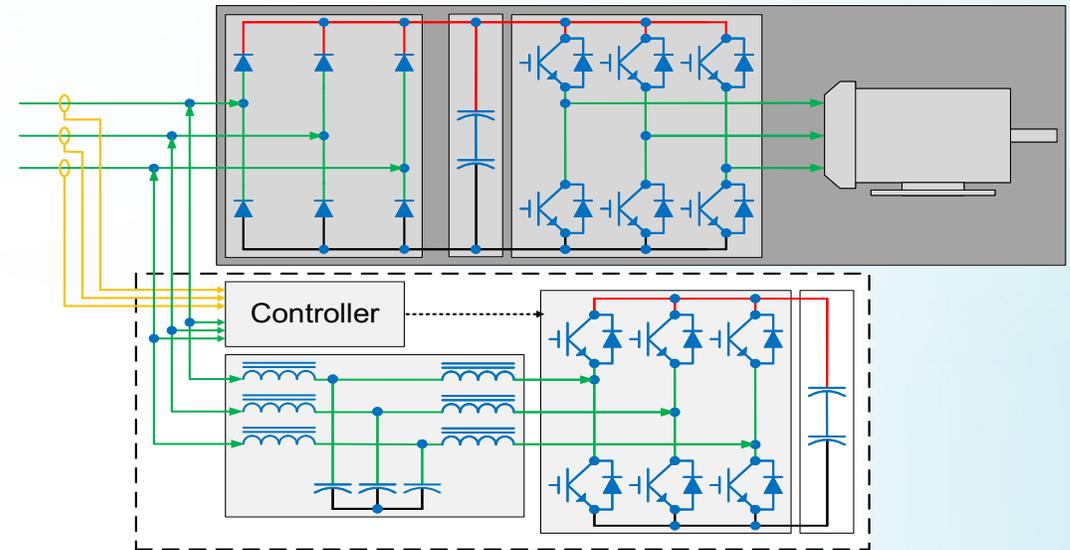
- Can significantly reduce harmonic distortion
- A current THD of 5% to 15% is possible, at nominal load point
- Sometimes can be retrofitted to an existing system
- Large size and requires often separate cabinet
- Causes a leading power factor at light loads
- Risk of resonances



Methods of Harmonic Mitigation

Active Filters

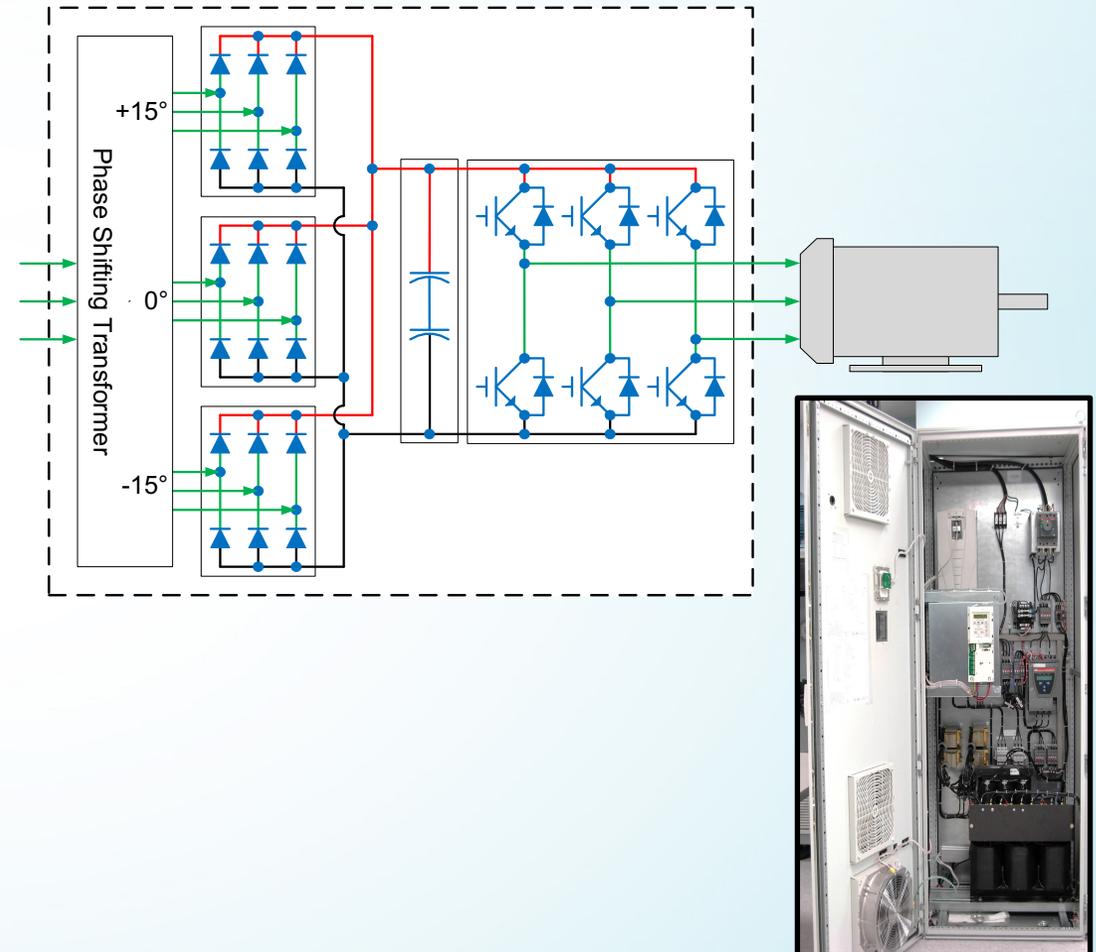
- Can reduce harmonic current distortion down to 5%
- In partial loads the performance gets
- Maintains a high input power factor of the system
- Can be retrofitted into an existing system
- Can be used to correct multiple non-linear loads
- Large size & high cost
- Power Quality study needed to dimension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



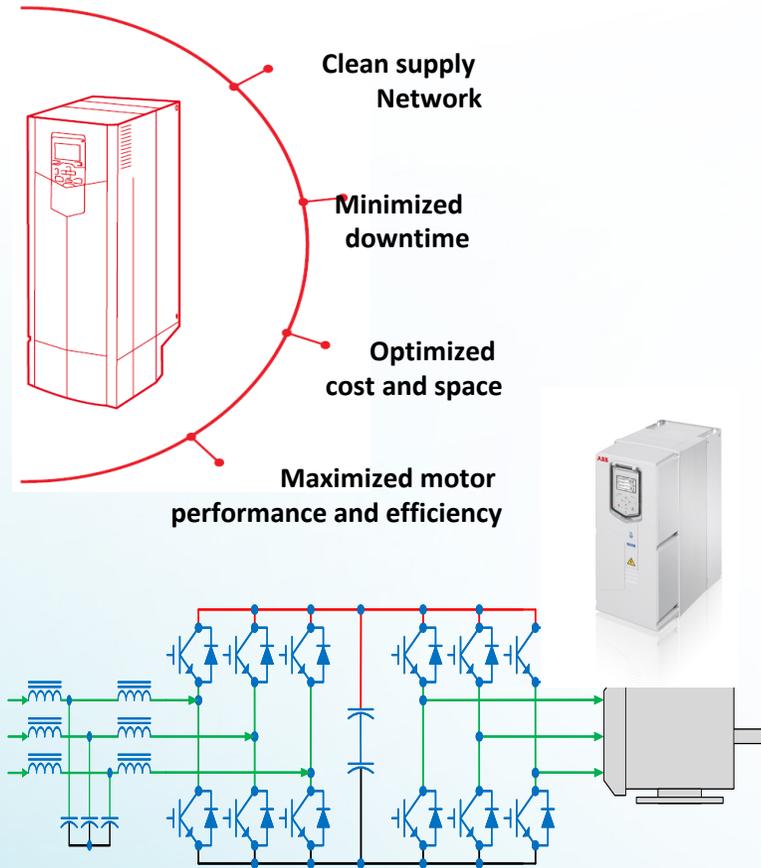
Methods of Harmonic Mitigation

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



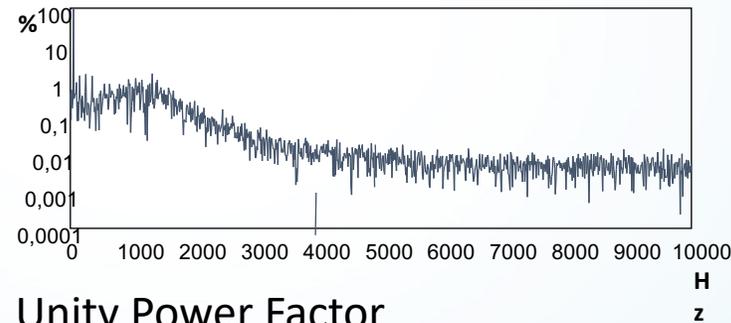
Active Front End Technology



- 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

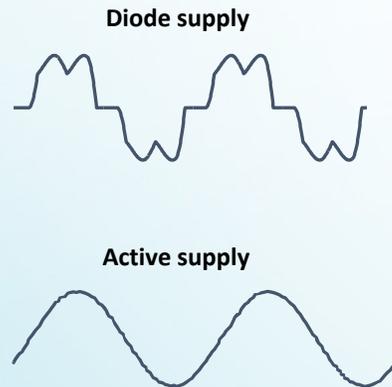


- Unity Power Factor
- Less OPEX Cost
- Possibility for Reactive Power Compensation

Other Cost Saving Benefits of AFE Technology

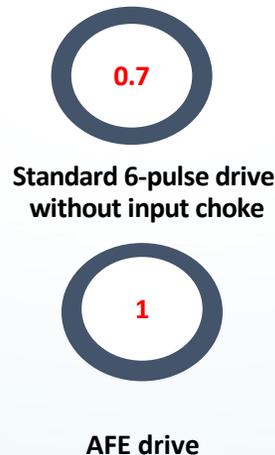
Low Harmonic content, <3% THDi

The drive produces exceptionally low harmonic content and exceeds the requirements of harmonic recommendations, such as IEEE 519 and G5/4. The total harmonic current distortion is typically <3% in nominal situation and undistorted network



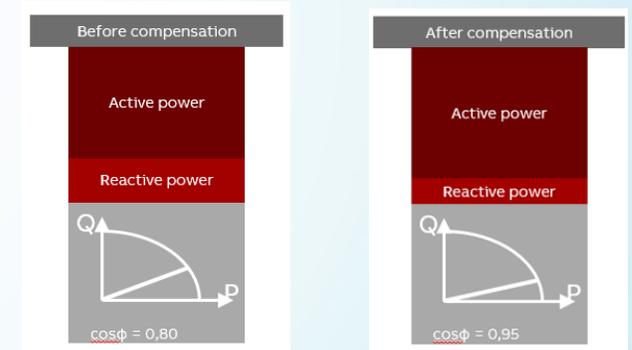
Unity Power Factor, at all loads

Active Front End drives have been designed to be neutral from the network point of view. Drive reaches unity power factor. This high power-factor indicates that electrical energy is used efficiently.



Reactive Power Control

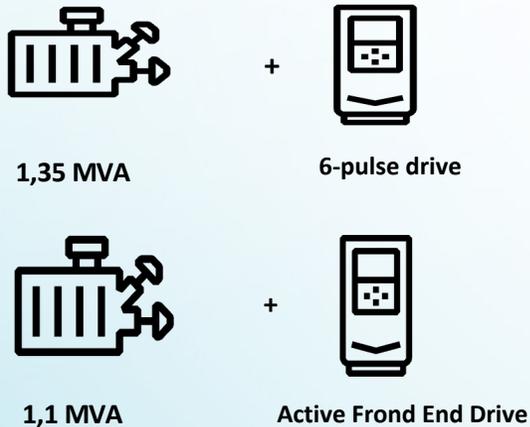
Active Front End drives have the built-in feature for reactive power compensation, without any additional components



Other Cost Saving Benefits of AFE Technology

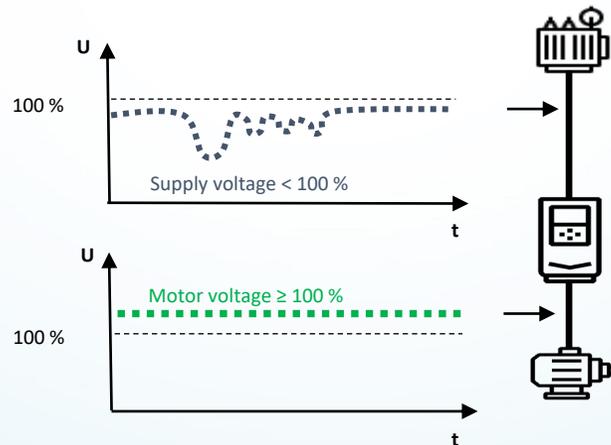
Reduced Demand ~25%

Active Front End drives kills the cause for the harmonics at the source and hence the demand for the network also reduces by 25%

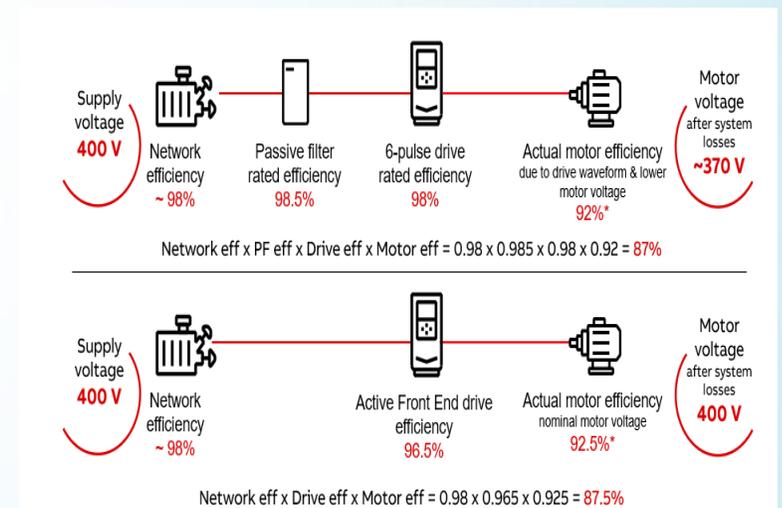


Immunity to network variations

The voltage stabilization feature in the ultra-low harmonic drives can boost the output voltage more than the source voltage. And ensures 100% voltage at motor terminals consistently despite of input fluctuations.



Improve System Efficiency



THANK YOU

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