

# Harmonics and its mitigation

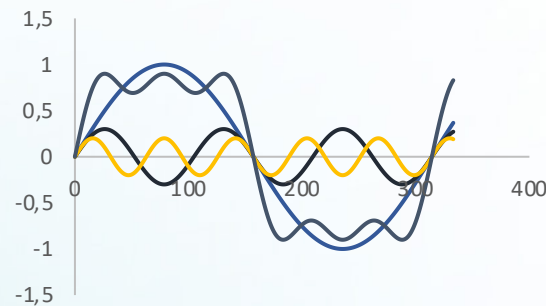


**Ms Rebecca Roy**  
Segment Manager HVAC  
ABB

# 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



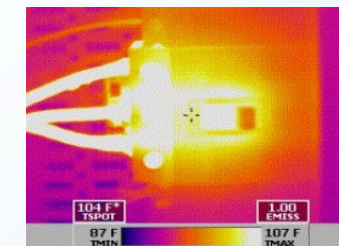
Overheated Neutral Bus



Humming Noise



Cable/Contact heating



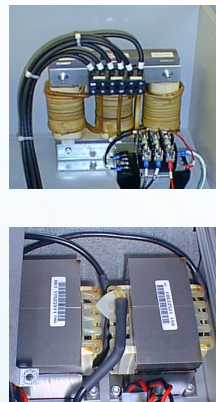
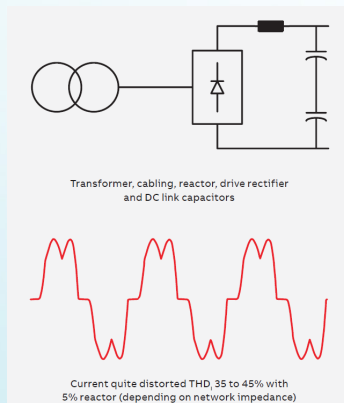
Capacitor Failure



# Methods of Harmonic Mitigation

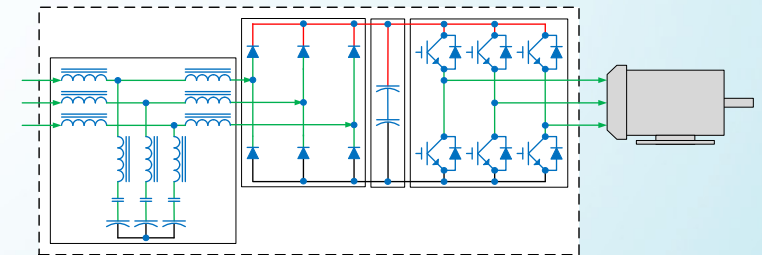
## DC and AC Input Reactors

- 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

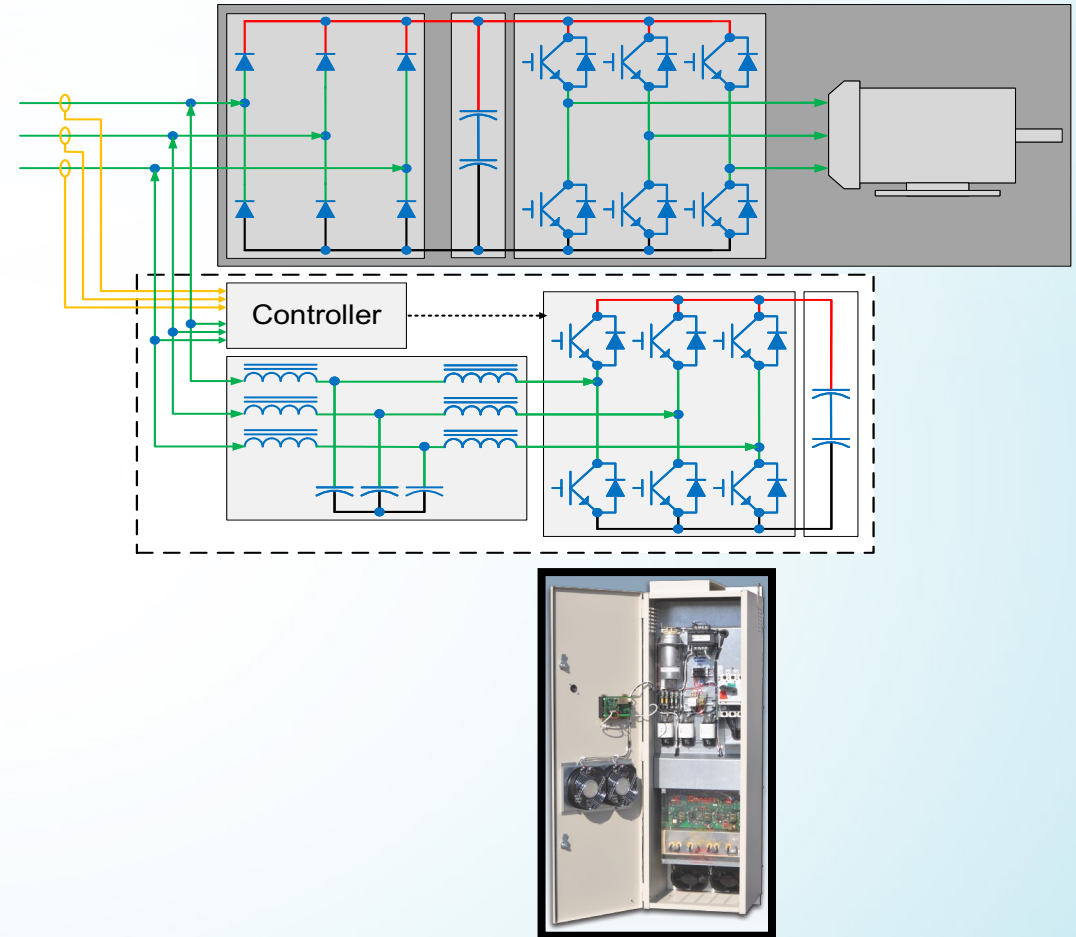
- Can significantly reduce harmonic distortion
- A current THD of 5% to 15% is possible, at nominal load point
- Sometimes can be retrofitted to an existing system
- Large size and requires often separate cabinet
- Causes a leading power factor at light loads
- Risk of resonances



# 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

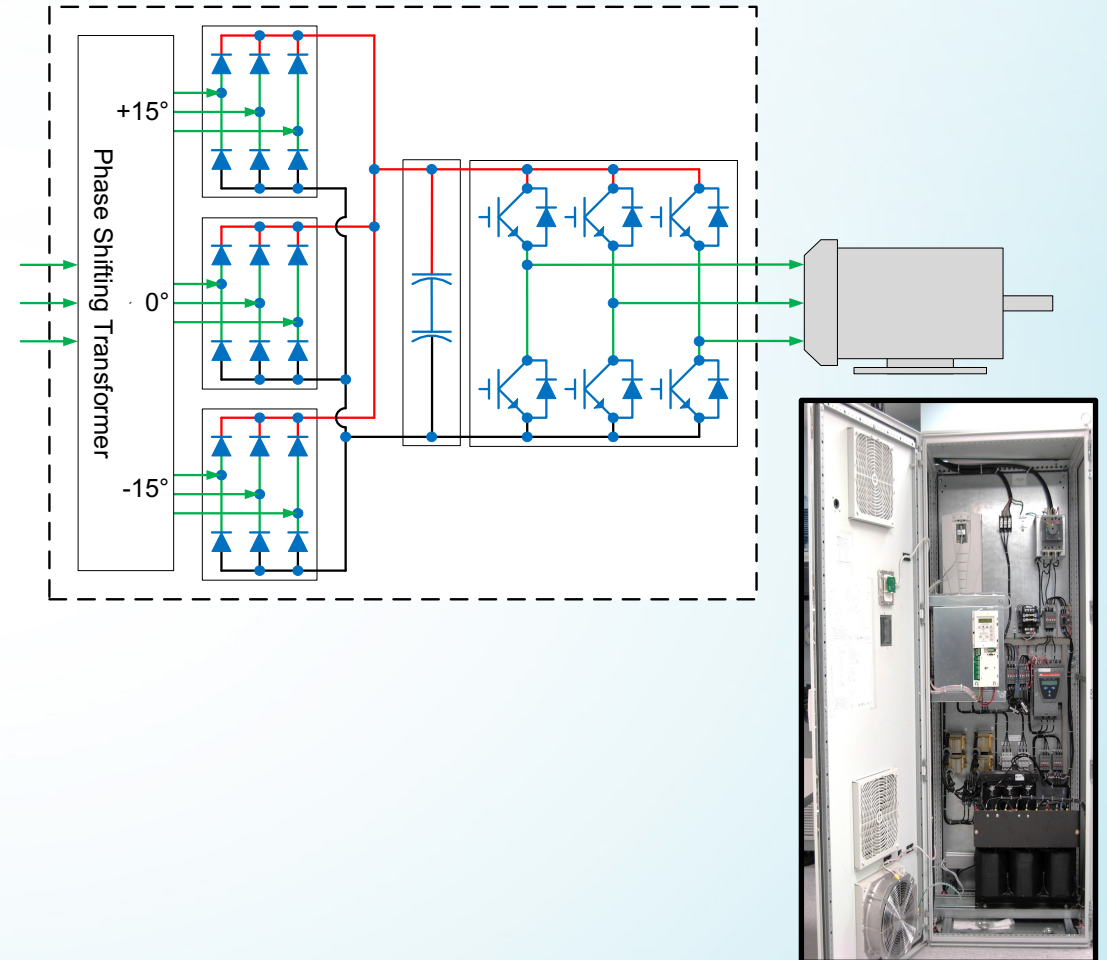




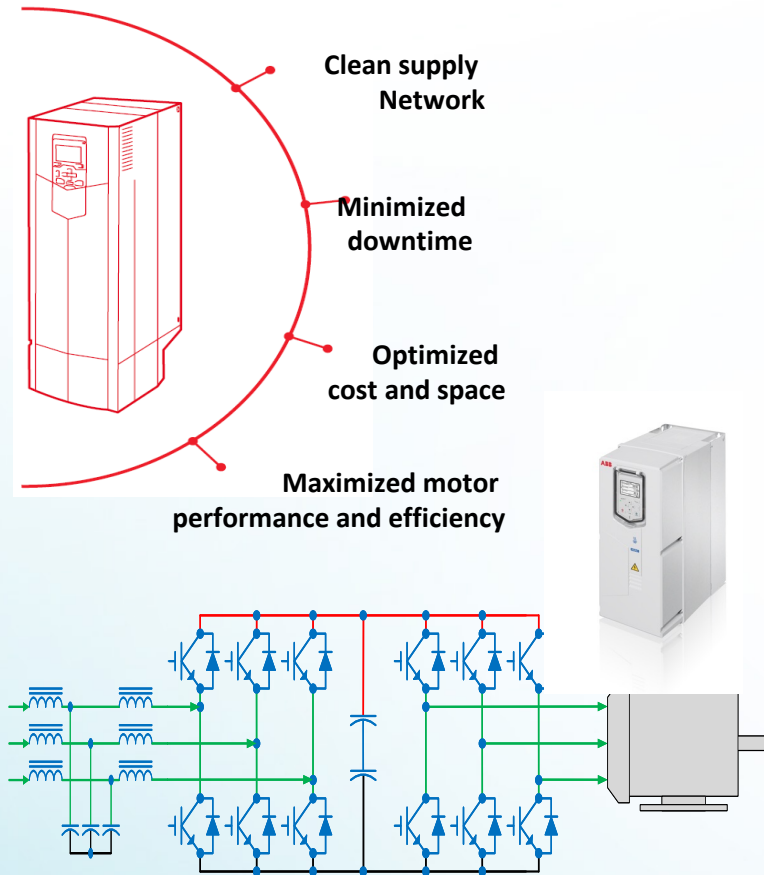
# Methods of Harmonic Mitigation

## 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



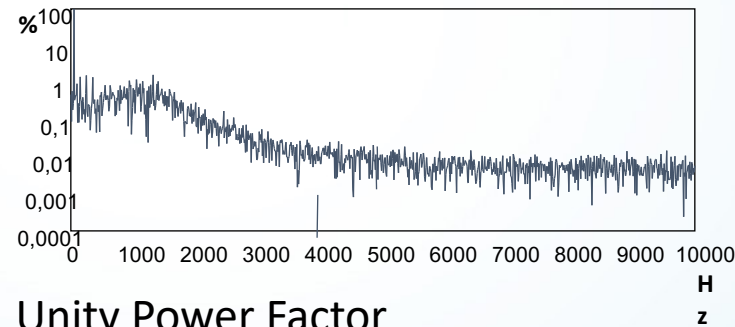
# Active Front End Technology



- 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

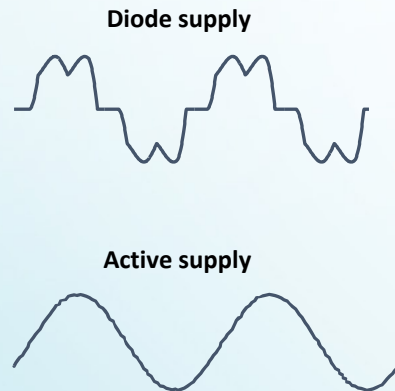


- Unity Power Factor
- Less OPEX Cost
- Possibility for Reactive Power Compensation

# Other Cost Saving Benefits of AFE Technology

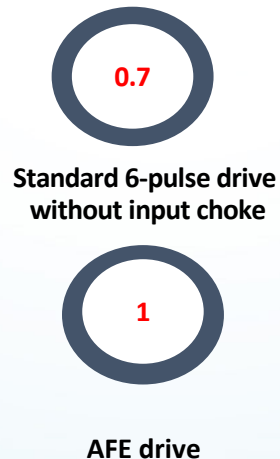
## Low Harmonic content, <3% THDi

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



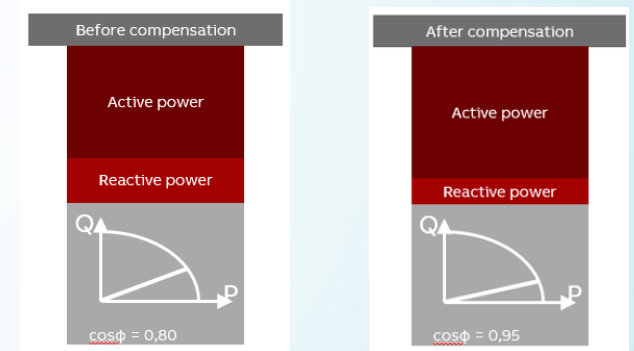
## Unity Power Factor, at all loads

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

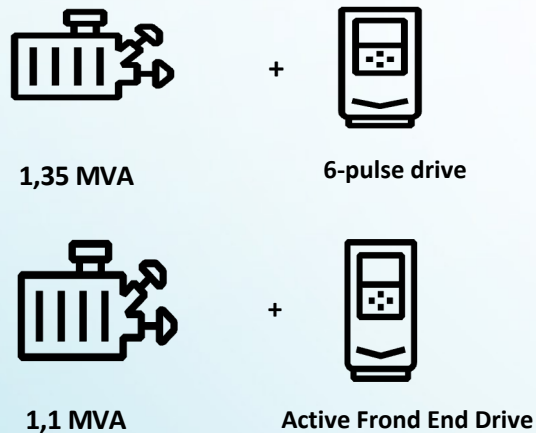
Active Front End drives have the built-in feature for reactive power compensation, without any additional components



# Other Cost Saving Benefits of AFE Technology

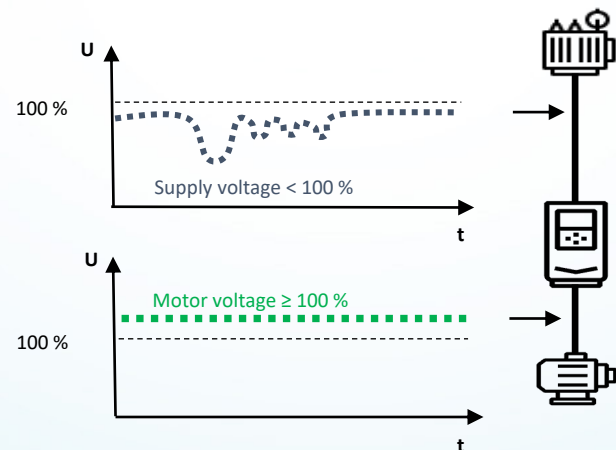
## Reduced Demand ~25%

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

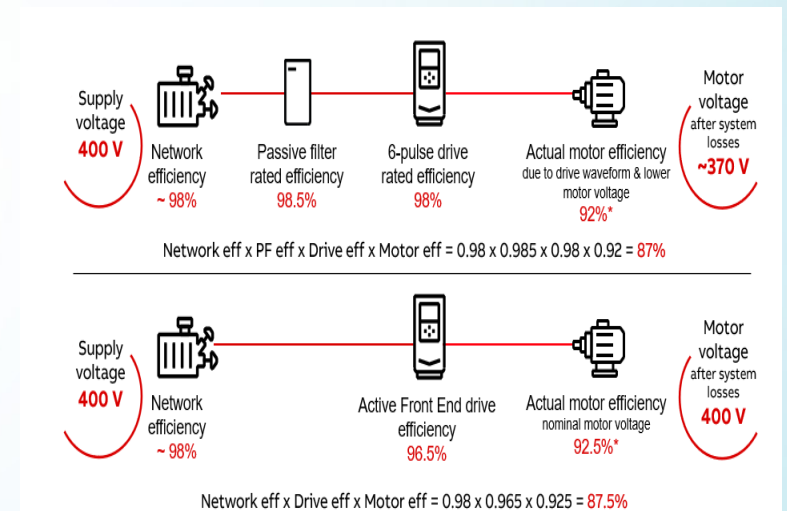


## Immunity to network variations

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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