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Power Quality Products



APF SVG SPC

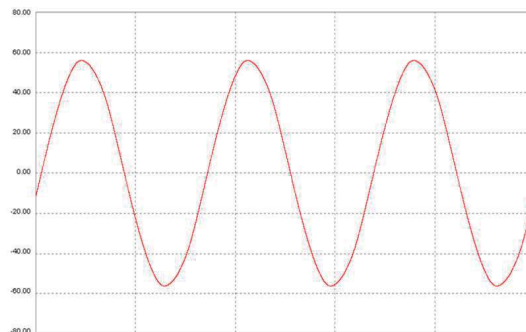
380-690V
50-600A



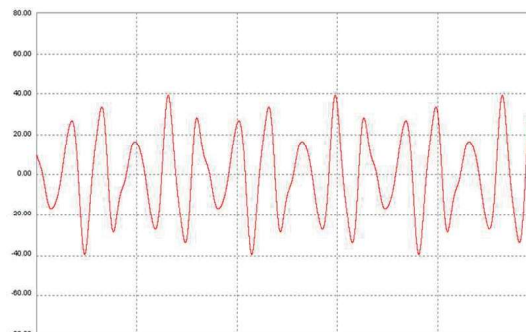
Harmonic



three-phase rectifier current



fundamental current

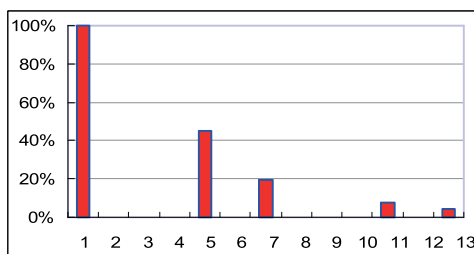


Harmonic current

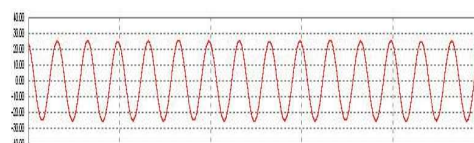
Harmonic



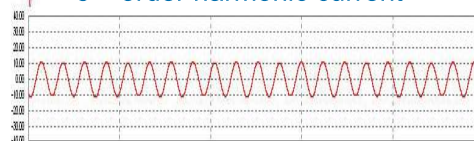
Harmonic current waveform



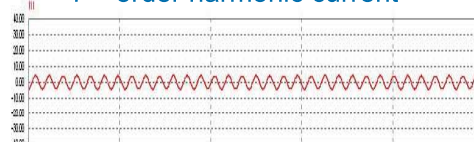
spectrum



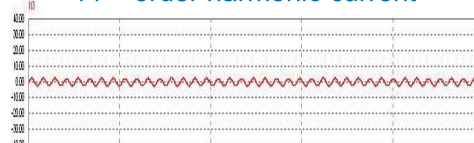
5th order harmonic current



7th order harmonic current



11th order harmonic current



13th order harmonic current

Harmonic Index

Total Harmonic Distortion (THD)

- Based on fundamental

$$\text{THD}_F \% = \frac{I_H}{I_1} \times 100\% = \frac{\sqrt{\sum_{n=2} I_n^2}}{I_1} \times 100\%$$

- Based on total RMS

$$\text{THD}_R \% = \frac{I_H}{I_{\text{rms}}} \times 100\% = \frac{\sqrt{\sum_{n=2} I_n^2}}{I_{\text{rms}}} \times 100\%$$

$$I_{\text{rms}} = \sqrt{\sum_{h=1,2,3,\dots} I_h^2} = \sqrt{I_1^2 + I_2^2 + I_3^2 + I_4^2 + I_5^2 + \dots}$$

- Note : I1 is fundamental RMS; Irms is total RMS

I_H is total harmonic current RMS

I_n is harmonic current RMS for each order (n is 2, 3, 4....)

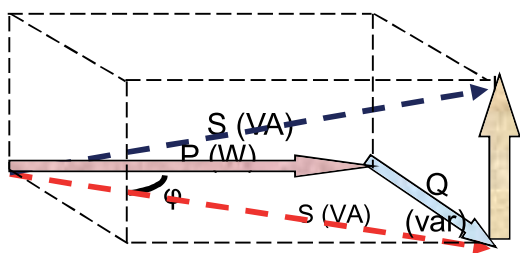
Harmonic Basic

- current harmonic distortion is due to nonlinear load
- Voltage harmonic distortion is due to voltage drop on source impedance by harmonic current
- Lower source impedance will be beneficial for harmonic current to flow to source, meantime voltage distortion is lower
- Higher voltage impedance prevent harmonic current flowing to source, but voltage distortion is also high
- The relation between source impedance and total harmonic distortion (u, i) is non-linear

Harmonic Basic

linear load without harmonic:

- Power factor = $\cos\phi$



Nonlinear load:

- Power factor = P/S (active power/apparent power)



$$S = \sqrt{P^2 + Q^2}$$

- > S = apparent power
- > P = active power
- > Q = reactive power
- > D = distortion power

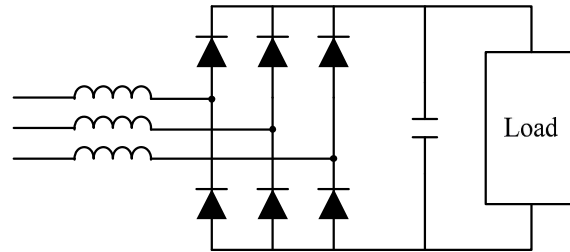
$$S = \sqrt{P^2 + Q^2 + D^2}$$



Typical Three Phase Nonlinear Load

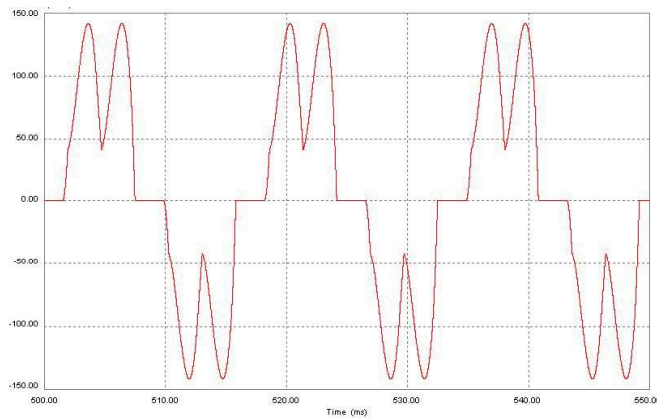
6 Pulse Rectifier

- UPS, VFD
- Current harmonics order: $6n \pm 1$

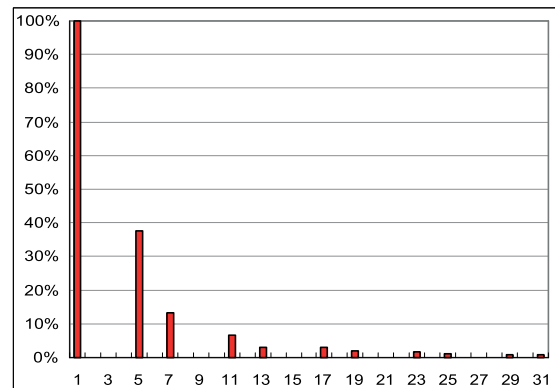


Typical Three Phase Nonlinear Load

6 Pulse Rectifier



$I_{rms}=84.5 \text{ A}$
 $THDF\%=40.7\%$

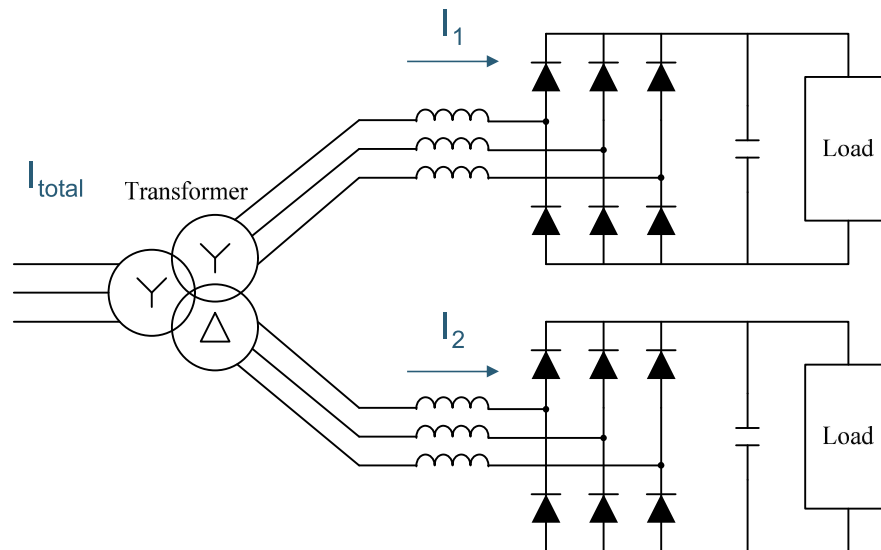


Spectrum

Typical Three Phase Nonlinear Load

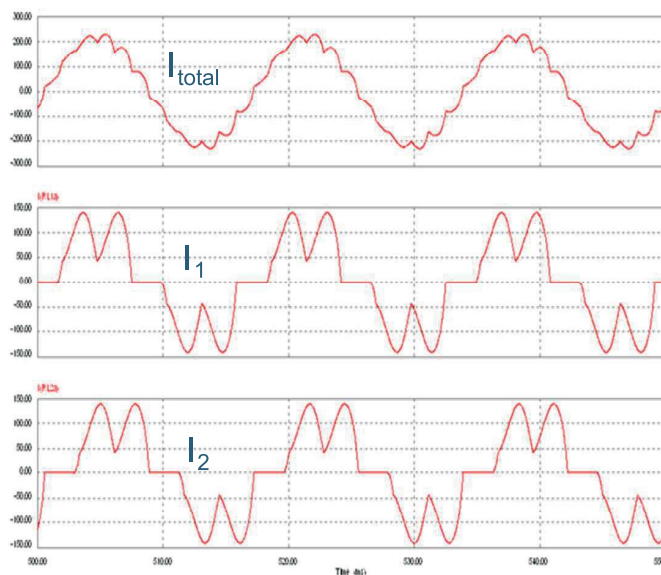
12 Pulse Rectifier

- Current harmonics order: $12n \pm 1$



Typical Three Phase Nonlinear Load

12 Pulse Rectifier



$$I_{rms} = 156.7 \text{ A}$$

$$THD_F \% = 7.9\%$$

$$I_{rms} = 84.5 \text{ A}$$

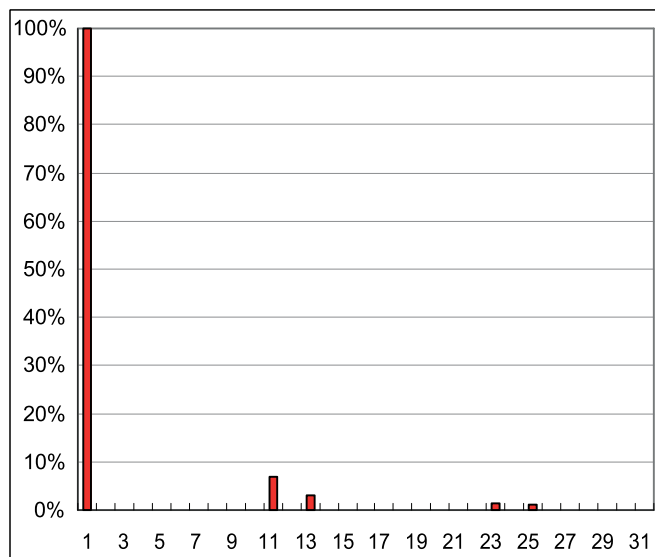
$$THD_F \% = 40.7\%$$

$$I_{rms} = 84.5 \text{ A}$$

$$THD_F \% = 40.7\%$$

Typical Three Phase Nonlinear Load

12 Pulse Rectifier



Spectrum

Harmonic Order

$$n = k \times p \pm 1$$

n: harmonic order

k: constant 1,2,3,...

p: pulse number

Example:

$$n = 1 \times 6 \pm 1 \quad \left\{ \begin{array}{l} 5 \\ 7 \end{array} \right.$$

$$n = 2 \times 6 \pm 1 \quad \left\{ \begin{array}{l} 11 \\ 13 \end{array} \right.$$

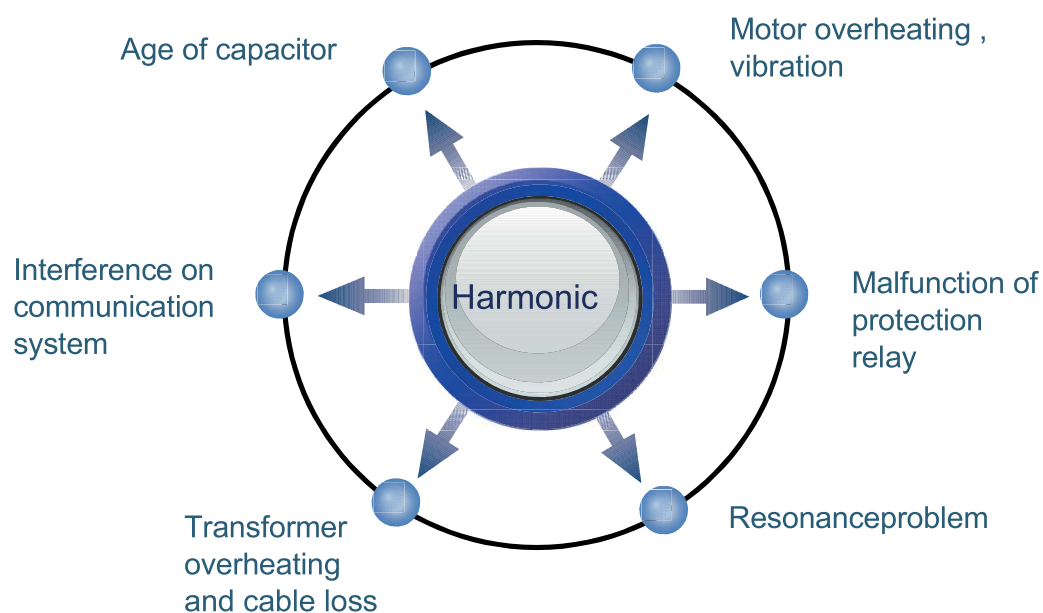
⋮

Harmonic Source-Nonlinear Load

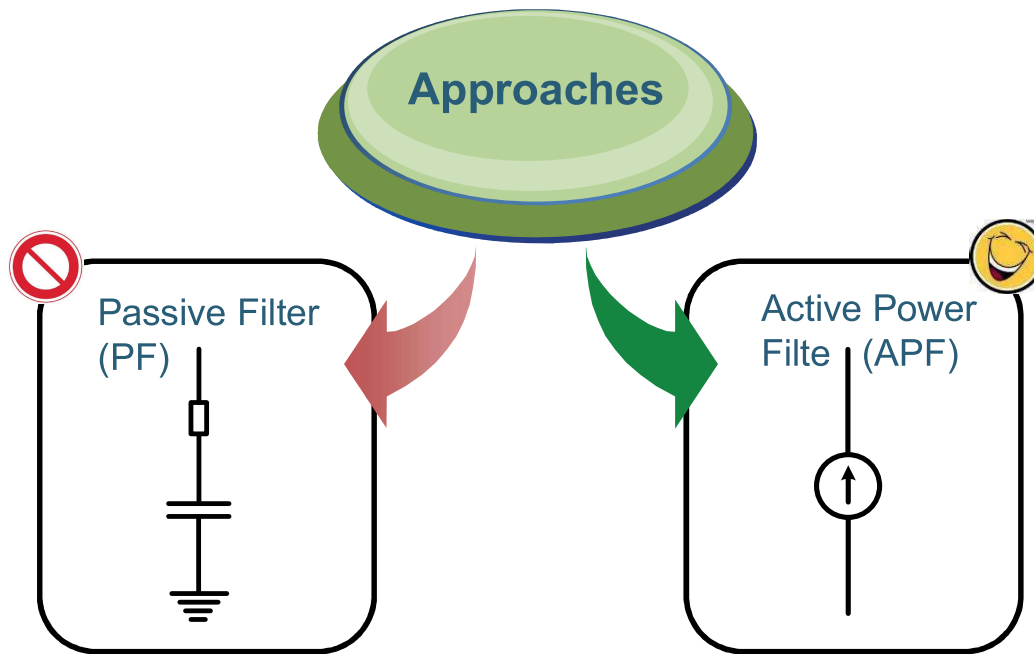
- Uninterruptable Power Supply (UPS)
- DC Power, Rectifier, DC Charger
- Variable Frequency Drive, DC Drive
- Lighting, Gas discharge lamp, Fluorescent lamp
- Welding equipment, Inductive heating, Arc furnace
- Computer and peripheral equipment
- Transformer, Reactor



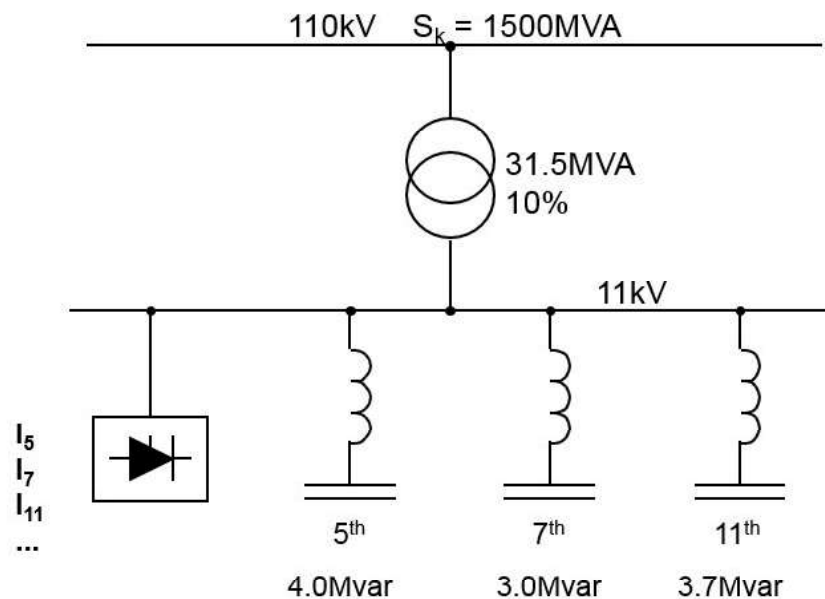
Harm of Harmonics



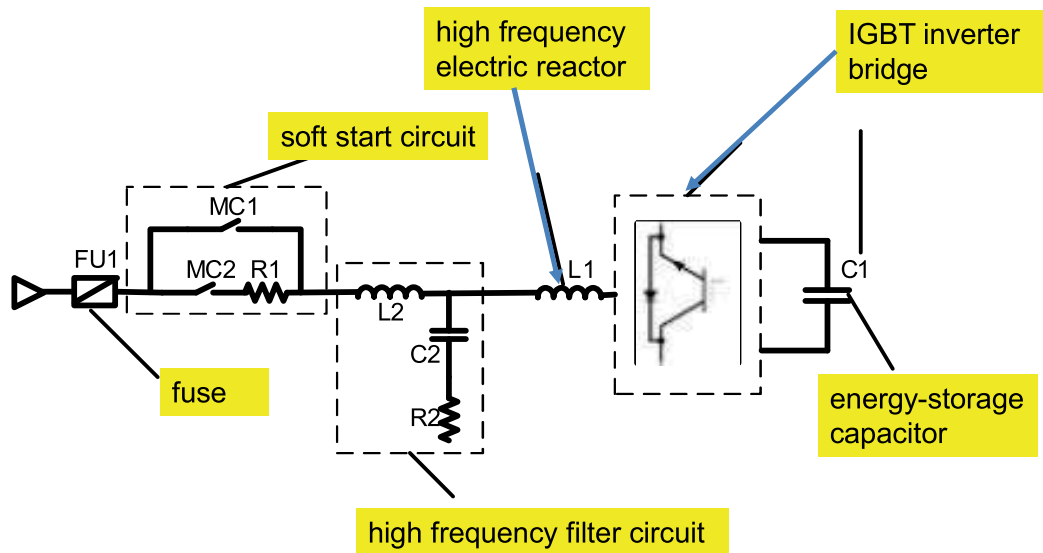
Solution of Harmonic



Passive filter



Structure

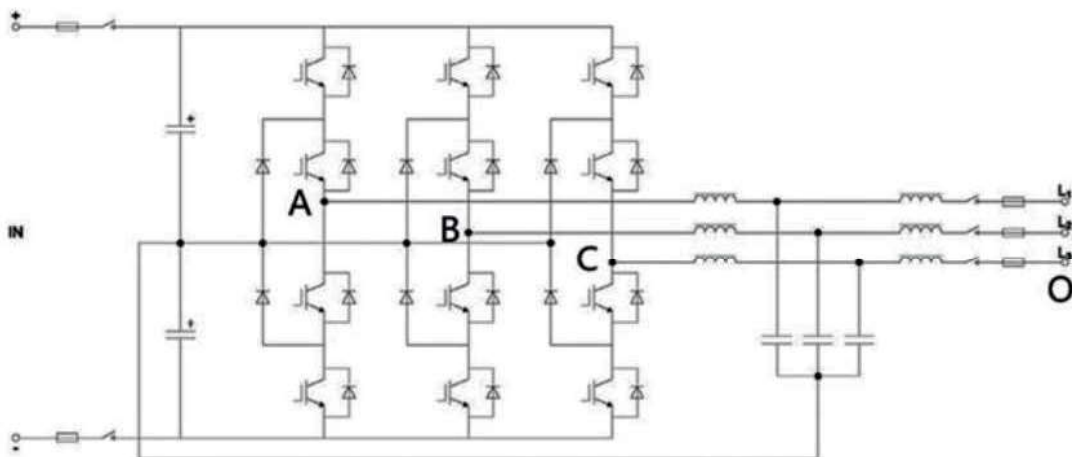


NPC PWM, 20kHz switching frequency, Compact design,
High efficiency, High reliability

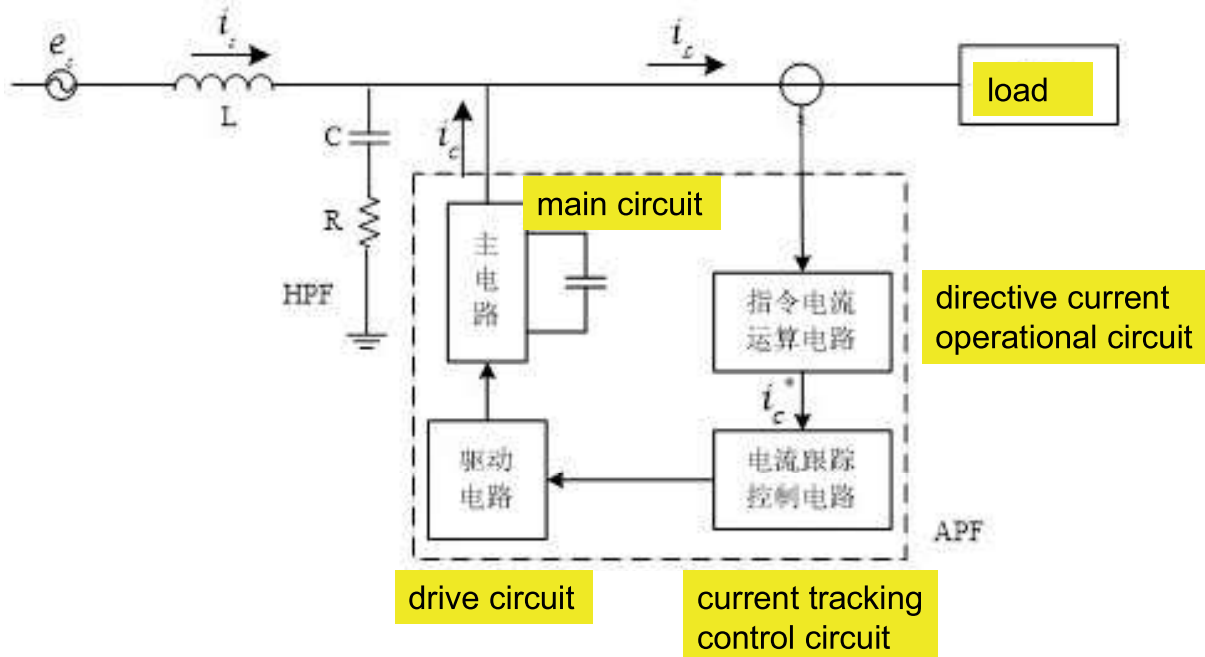
Topology

Three-level inverter

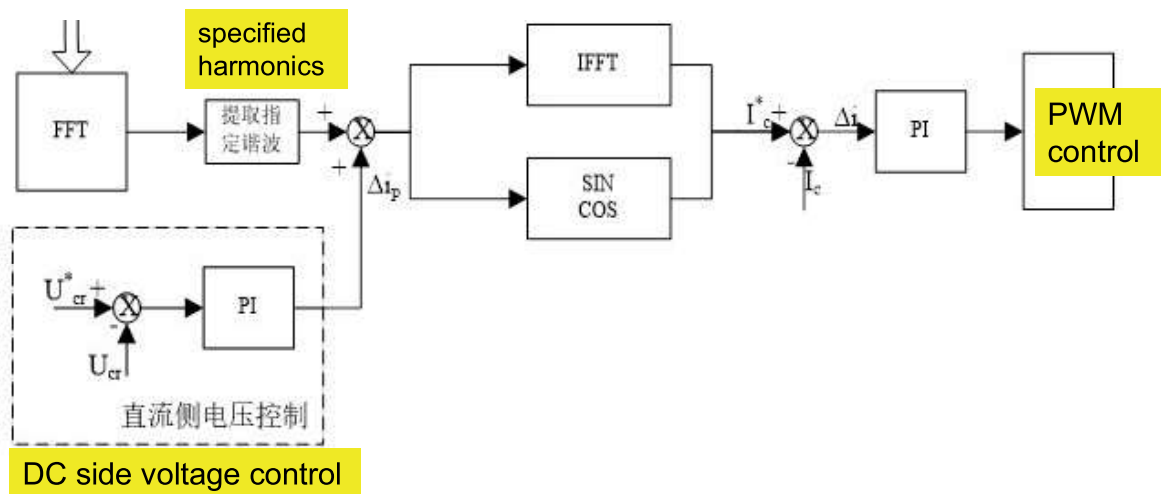
NPC mode three-level PWM inverter, high power density, high efficiency,
better waveform and high reliability.



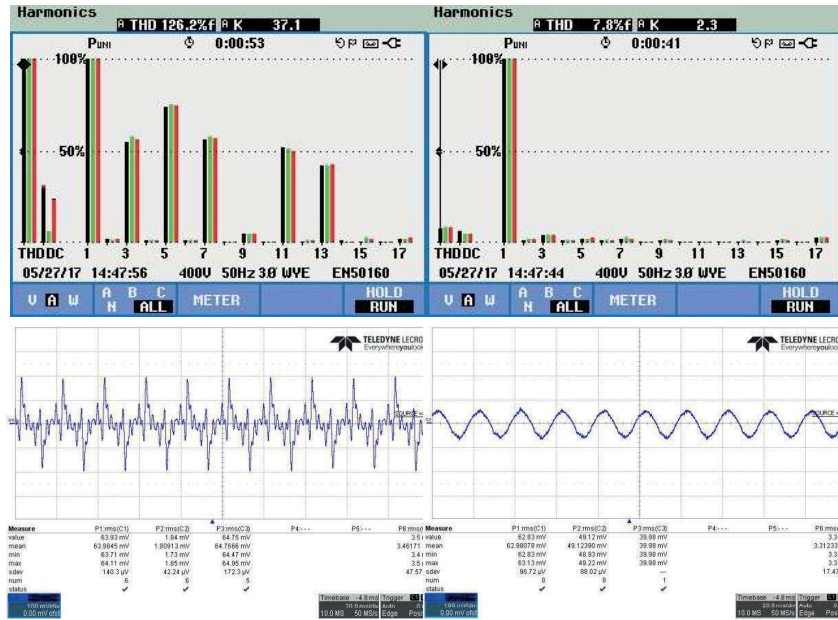
APF Control Principle



APF Control Principle

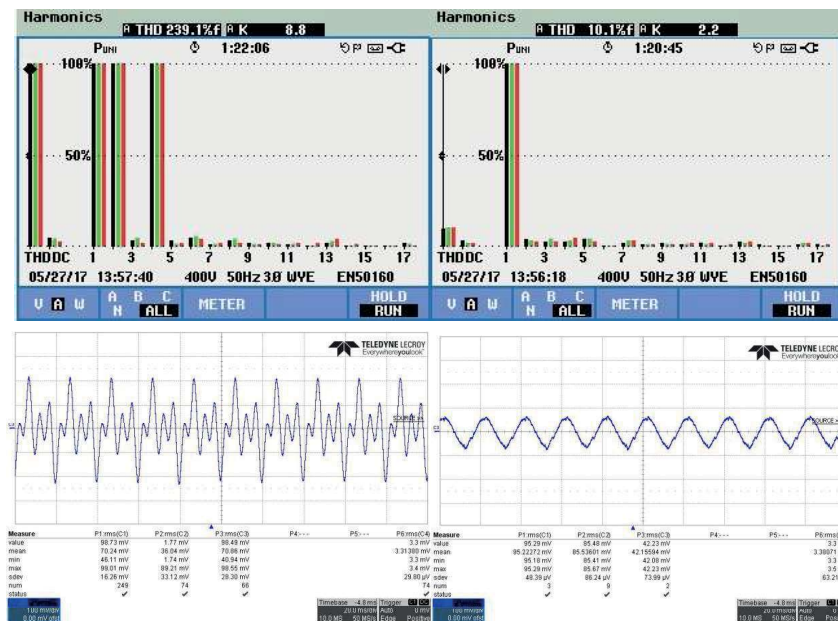


Harmonic Compensation Effects



Odd harmonics

Harmonic Compensation Effects



Even harmonics

Product Features

- **Modular design (Module 30A/50A/60A/100A/150A)**

wall-mounted/cabinet
convenient installation
plug type optional, maintenance friendly

- **Remarkable performance**

harmonic elimination rate $>97\%$
2~61 order compensation (selectable or whole)
reactive compensation range: -1~1 (adjustable)
three-phase unbalance compensation $<3\%$
3 wire / 4 wire compatible



- **Reliable and stable**

automatic resonance avoiding, automatic limiter, overvoltage, overcurrent,
Germany brand IGBT chip

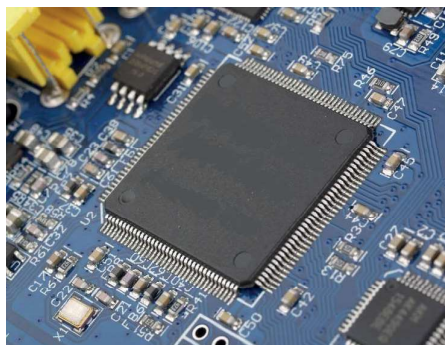
- **Energy saving**

speed adjustable cooling fans and isolated air duct design, hibernation/ awakening
efficiency $\geq 97\%$

Product Features

Texas Instrument

DSP28377 chip



- **Control hardware**

Dual core 32-bit CPU + 2CLA
Main frequency 200MHz
Each CPU equips three 32-bit timers
12 channel 16-bit high-accuracy AD sampling

- **Calculation**

2nd generation complex calculator VCU II
Trigonometric functions calculator TMU0
Floating point arithmetic

- **APF Response time**

Instantaneous response time $<25\mu s$
Total response time $<5ms$

Product Features

Global leader
power semiconductor



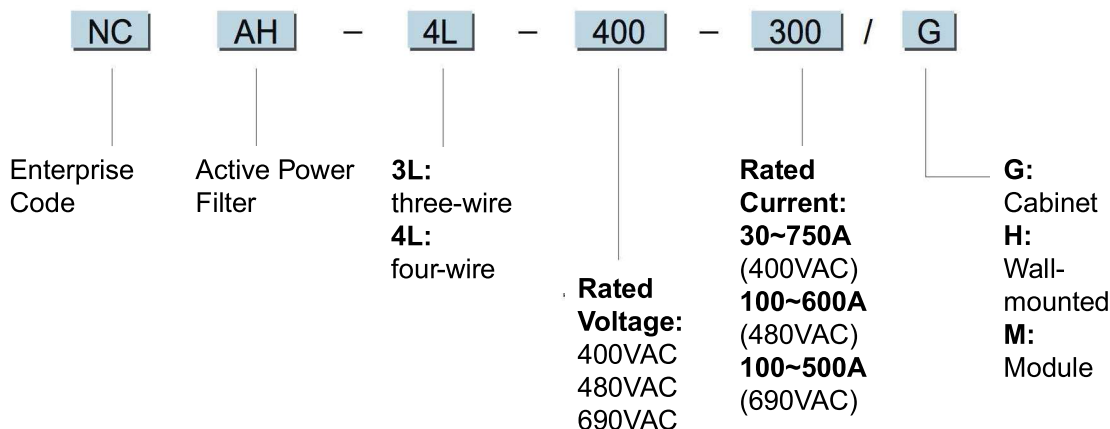
- **3-level topology structure**
 - lower voltage stress per each IGBT
 - optimize output waveform
 - high performance, low power consumption
- **High-performance drive circuit**
 - self-designed, stable and reliable
 - special design, high-efficiency
 - safety design, comprehensive protection
- **High quality**
 - Germany brand IGBT
 - domestic leading brand inductor and capacitor
 - long service life

Product Features

- **Modular design, flexible configuration**
 - can be expanded later per requirement, up to 16 modules, low initial investment
 - easy maintenance, high reliability
- **Cabinet or wall-mounted installation**
 - cabinet type, or modules can be placed in customer's switchgear
 - wall-mounted installation to save space and cost
 - APF can be paralleled for capacity expansion up to 10 units



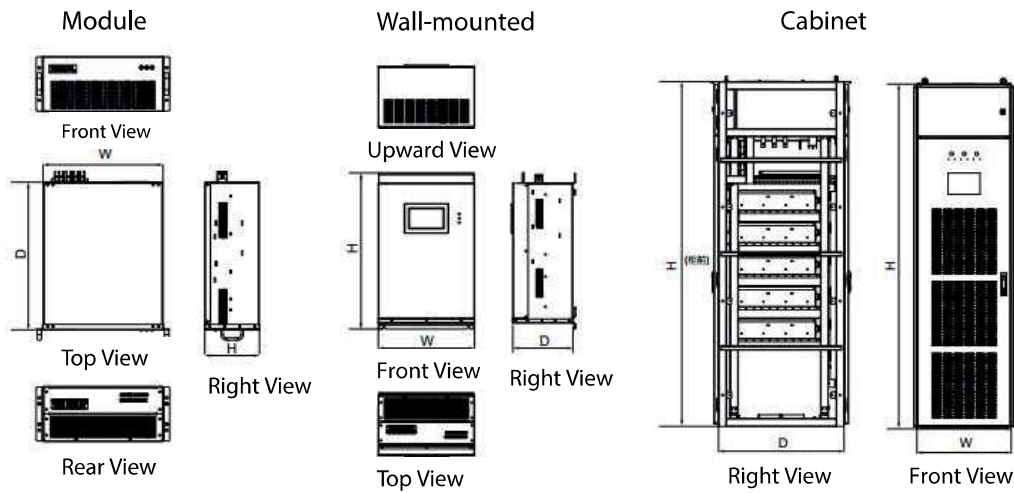
APF Product Model



APF Specifications

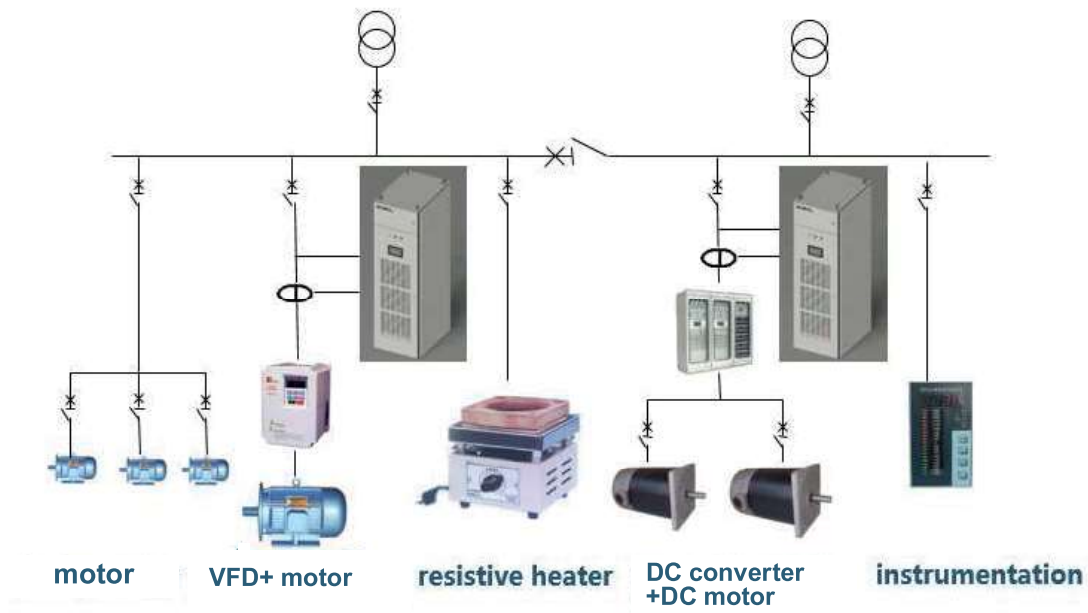
rated current	30/50/60A	100A	150A	100-750A	100-600A	100-500A
rated voltage	380V (-40% ~ +20%)			480V (-40% ~ +20%)		690V (-40% ~ +20%)
controller	DSP based full-digital control					
compensation current of neutral line	triple phase current					
filter capacity	2~61 order (selectable or whole compensation)					
harmonic elimination rate	>97%					
Line frequency	50Hz/60Hz ± 5%					
line structure	three-phase three-wire /three-phase four-wire					
topology	three-level NPC					
three-phase unbalance compensation capacity	<3%					
reactive compensation	-1~1 (adjustable)					
response time	<5ms complete response ; <25us transient response					
automatic current limiting	yes					
switching frequency	20 kHz (adjustable)					
cooling method	air cooling, speed adjustable					
noise level	<60dBA					
efficiency	≥97%					
protection function	overvoltage, undervoltage, overcurrent, over-temperature etc.					
HMI	standard 7 inch colored touch screen or customized					
communication interface	RS485/CAN/internet access					
installation	wall-mounted/cabinet			cabinet		
color	RAL7032(optional)					
storage temperature	-40~70 °C					
operation temperature	-10~50 °C					
humidity	<95% non-condensing					
altitude	<1500m (derating when exceed 1500m)					
enclosure	IP21 or customized					

APF Size Outline



Module & Wall-mounted	Module size (W*D*H mm)	Wall-mounted size (W*D*H mm)	Weight (kg)
30A/50A/60A (400V)	450*545*205	450*265*545	35
100A (400V)	450*645*230	450*290*645	45
150A (400V)	550*645*290	550*350*645	60
Cabinet	Size (W*D*H mm)	Weight (kg)	
100-750A (400V)	600*800*2200	200-600	
100-600A (480V)	800*1000*2200	200-600	
100-500A (690V)	800*1000*2200	200-600	

Distributed Compensation



Centralized Compensation

