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ENERDOOR SA

Singapur 17th april

Agenda

ENERDOOR Group
Harmonics
Power factor compensation
Radio frequency intreferences RFI
Motor protection
Voltage stabilizers

History
ENERDOOR / FINMOTOR

Our History

Mr. Sergio Medved, founder and CEO is a physicist who started Finmotor in Italy in 1991 and Enerdoor in 2007. Enerdoor is the sales and marketing company for all Finmotor products in Worldwide. Finmotor was the first Italian company to design and produce RFI filters. Both companies, coupled with others still exist today as a family owned an operated buiness. Looking to expand markets.

1991 Italian commercial brand with location, technical support and Emc laboratory in Italy. The manufacture company of Emc filter, high frequency inductance and harmonic filter for industry, military and medical.

1992 Emc laboratory with anechoic chamber located in Milan – Italy. Three mobile laboratory vans travel throughout Europe.

2007 Worldwide commercial brand with locations, technical support and Emc laboratories in United States, Germany and Switzerland.

2011 Acquisition based merger with over 40 years experience in safety transformers & electronic ignition systems

Sales Organization / Group

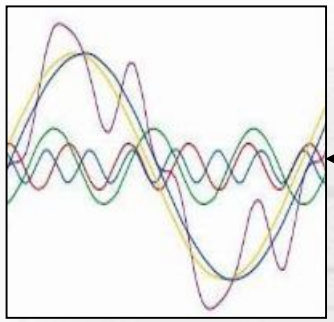


Subsidiary / Offices

EMC laboratory

Manufaturing plant

Power Target Areas



EMC filters
Harmonics
PFC
Voltage stabilizers





Motor Protection

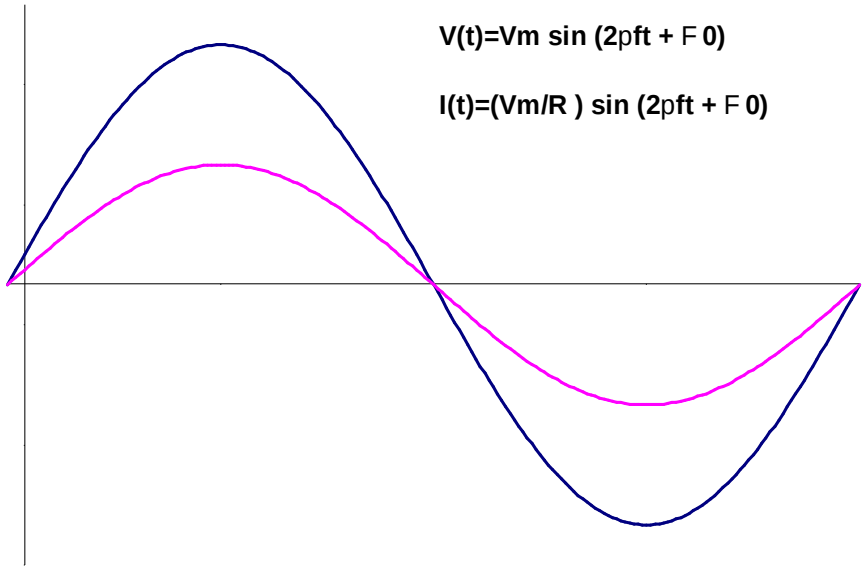


Radio Frequency interferences

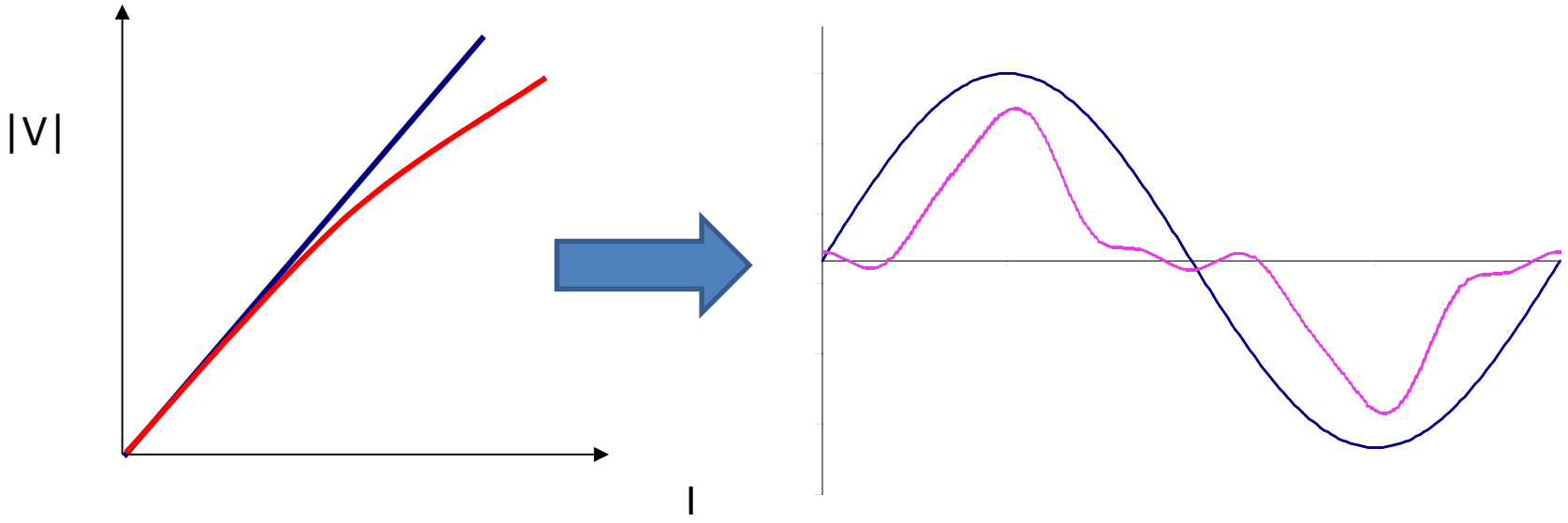
Harmonics

- **Voltage generators has sinusoidal shape**
  - **$V(t)=V_M \sin(2\pi ft+F0)$**

- **Linear loads give sinusoidal current:**
  - **$I(t)=(V_M/R) \sin(2\pi ft+F0)$**
    - **R is the load resistance**



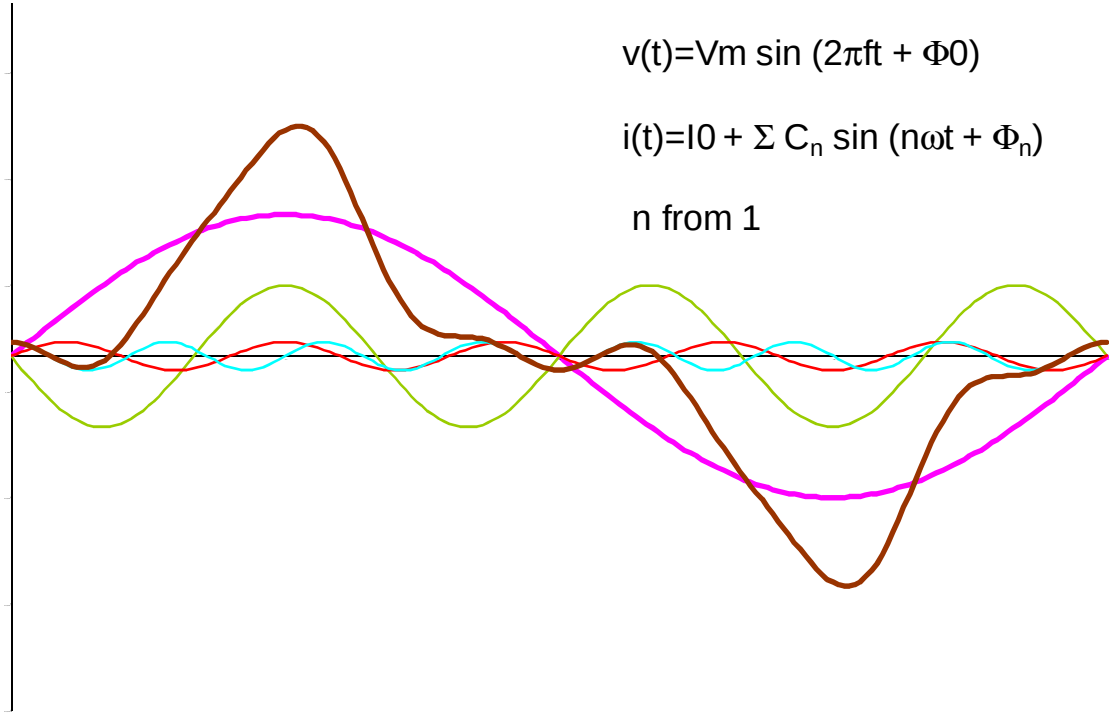
- **When the load is nonlinear load the current has distortion, this means current harmonics.**
- **The current is not sinusoidal**



A generic periodical wave shape can be represented by a sum of sinusoidal waves with frequency multiple of the fundamental

V, I

I1, I3, I5, I7

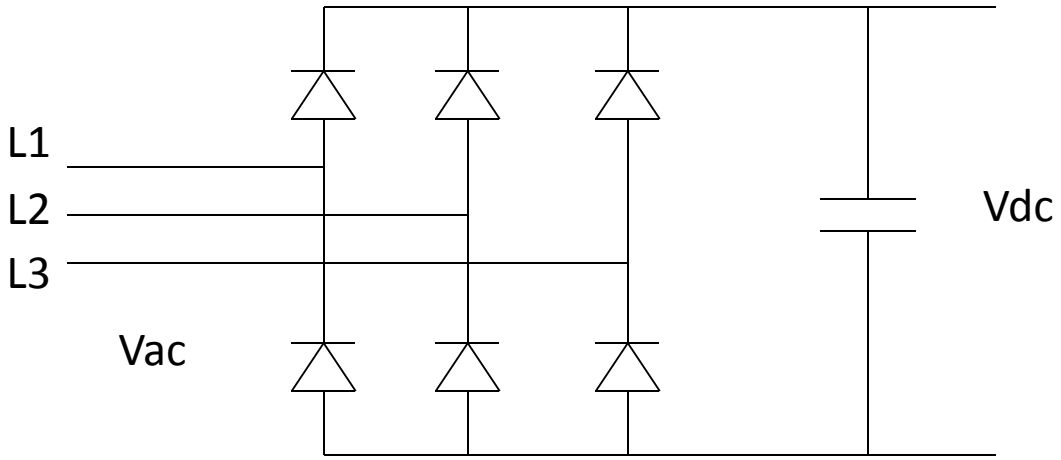


$v(t)=Vm \sin(2\pi ft + \Phi 0)$

$i(t)=I0 + \Sigma C_n \sin(n\omega t + \Phi_n)$

n from 1

- **Typical diagram 6 diodes drive input**
- **Normally the power supplies don’t have an input transformer so the loads is a high nonlinear load**
- **The most common non linear load present in the automation today**

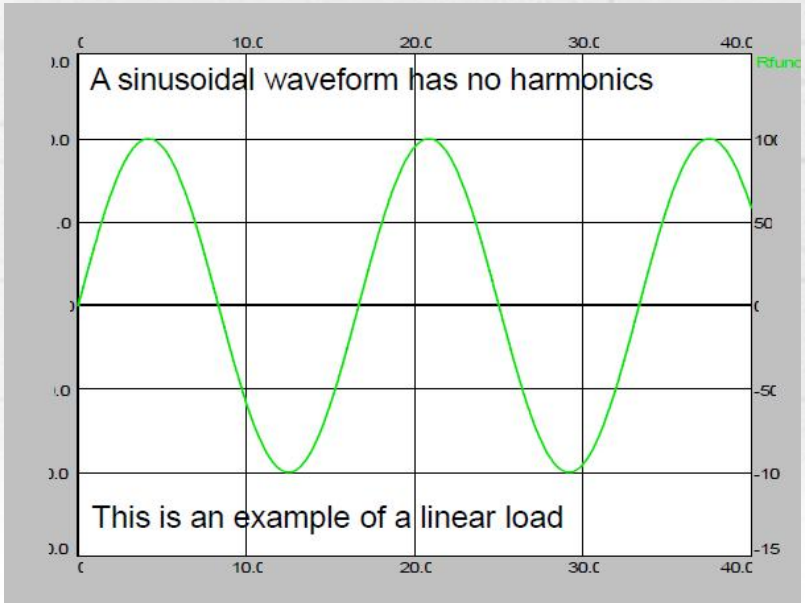


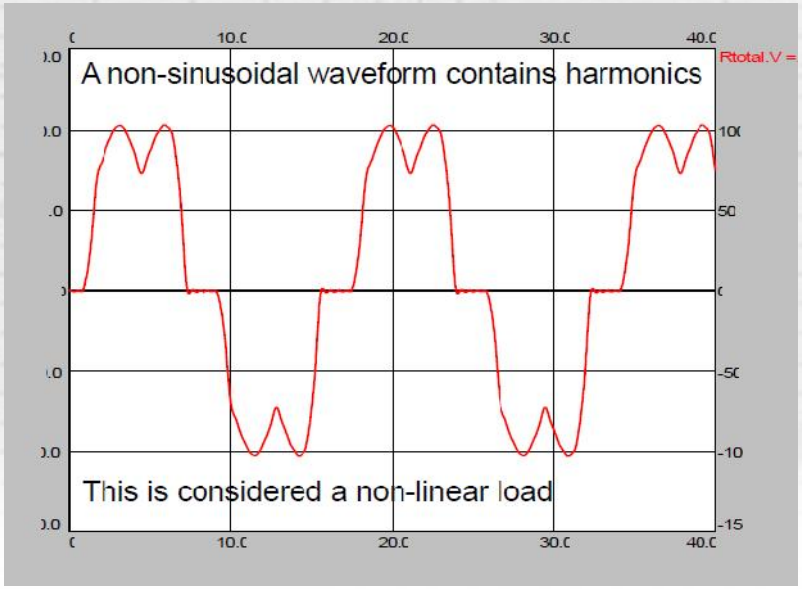
- **Number of harmonic generated by a 6 pulses diode brige are fixed following the rule:**
  - **h=N p +/- 1**
    - **h= number of harmonics**
    - **N= progressive number starting from 1**
    - **p= number of pulses per period equivalent to the number of diodes**

- **Example:**
  - **3 phase drives means 6 diodes bridge**
  - **p= 6**
  - **h= (1x6)-1=5 5x50 = 250 Hz**
  - **h= (1x6)+1=7**
  - **h= (2x6)-1=11**
  - **h= (2x6)+1=13**

Harmonics – The Problem

A non-linear electrical load creates distortion on the electrical current. This results in harmonics on the power line.





How to evaluate the harmonics

$$THD = \frac{\sqrt{(I_2^2 + I_3^2 + I_4^2 + I_5^2 \ldots + I_n^2)}}{I_1}$$

n= tipically up to 50

- **THD Total Harmonic Distortion**
  - **I_1: fundamental current (current at 50 Hz or 60 Hz)**
  - **I_2, I_3, … harmonics current**

$$TDD = \frac{\sqrt{(I_2^2 + I_3^2 + I_4^2 + I_5^2 \ldots + I_n^2)}}{I_r}$$

n= tipically up to 50

- **TDD Total Demand Distortion**
  - **I_r: full rated current**
  - **I_2, I_3, … harmonics current**

Difference between THD and TDD

• Full rated current	1000 A	1000 A
• fundamental current (50 Hz)	50 A	500 A
• Current distorted $\sqrt{(I_2^2 + I_3^2 + I_4^2 + I_5^2 \ldots + I_n^2)}$	25 A	250 A
• THD around	50%	50 %
• TDD around	2,5 %	25 %

THD has always the same value (50%) but the second condition is much worst thah the first.

The quantity of harmonic is bigger (250 A vs. 25°)

Knowing the full rated current the TDD immediately gives weight of the harmonics

Harmonics problems

- High current on neutral line
- Damage of Capacitor bank
- Voltage Distortion in the network
- Increasing losses in transformers
- Vibrations and increasing losses in motors
- Inopportune intervention of circuit breaker
- Cost of energy

Three phase plus neutral single phase loads

single phase drives means 4 diodes bridge

p= 4
h= (1x4)-1=3 3x50 = 150 Hz
h= (1x4)+1=5
h= (2x4)-1= 7
h= (2x4)+1=9

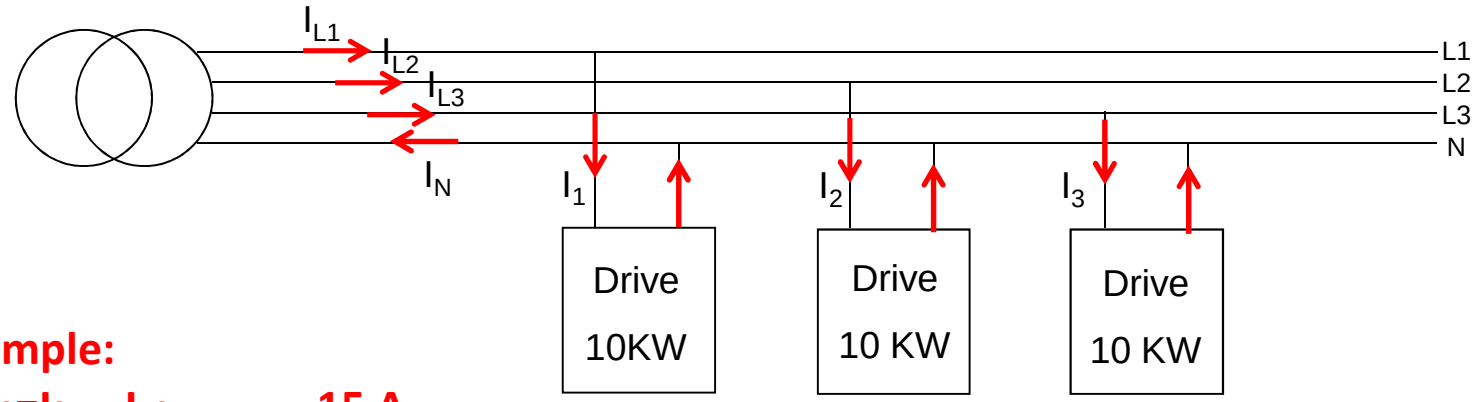
.

Three phase plus neutral single phase loads

In this configuration the 3rd harmonic and multiple 0f 3rd will sum in the neutral.

It means that I can have on the neutral 3 times the current harmonic that is present on the phase

This can generate overheating on the neutral line, can increase the voltage between neutral and phase



Example:

$I_1=I_2=I_3$ $I_{50\ Hz}$ = **15 A**

$I_{150\ Hz}$ = **10 A**

I_N $I_{N50\ Hz}$ = **0 A**

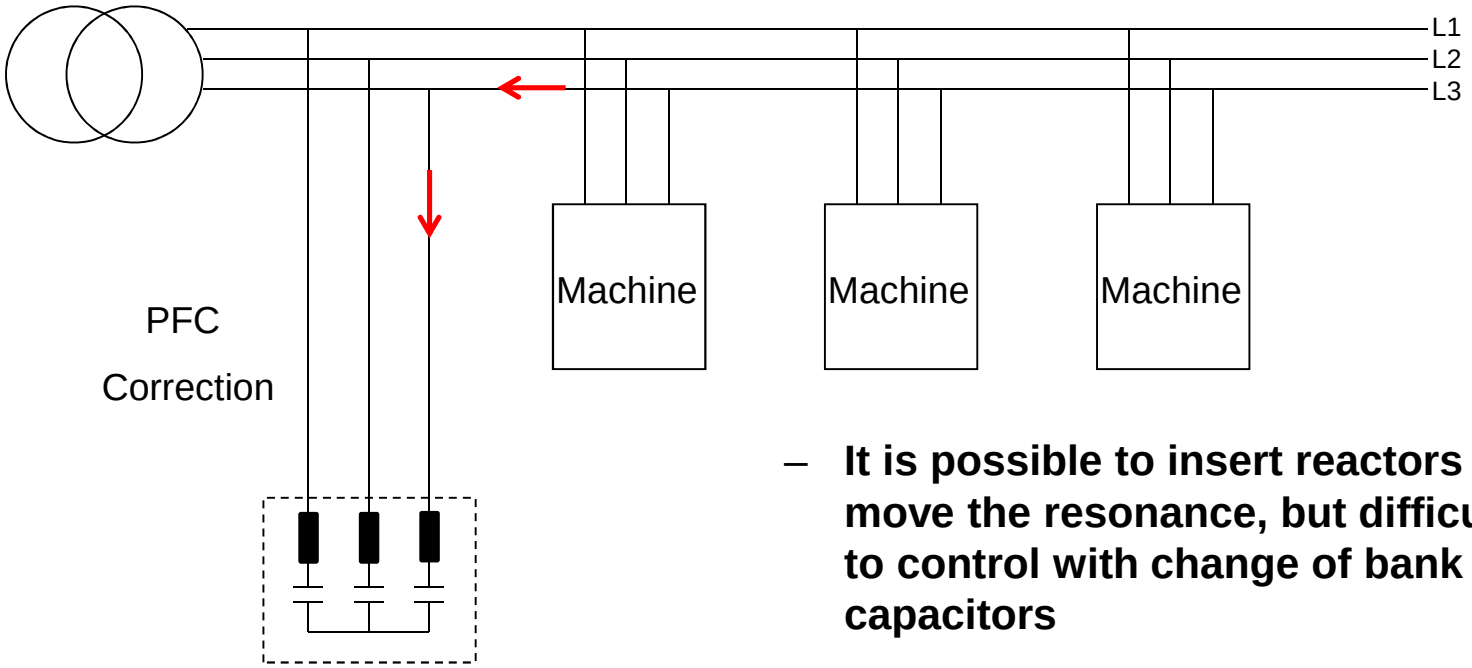
$I_{N150\ Hz}$ = **30 A**

$I_{L1}=I_{L2}=I_{L3}$ $I_{50\ Hz}$ = **45 A**

$I_{150\ Hz}$ = **10 A**

Damage of Capacitor bank

- **The bank capacitor for PFC correction can have resonance at the harmonic frequencies, in this case the current on these capacitor can be very high and can damage them**



  - **It is possible to insert reactors to move the resonance, but difficult to control with change of bank capacitors**

Damage of Capacitor bank

- **The problems on the bank capacitor for PFC correction can very high impact on the cost of maintenance**
- **In case of high penalty for low PF the damage of capacitor can increase the cost of the energy**

- **The transformer can easily saturate with harmonics:**
  - **Overloads due to peak current**
  - **Create distortion on the voltage**
  - **The current harmonic increase also du to this effect**

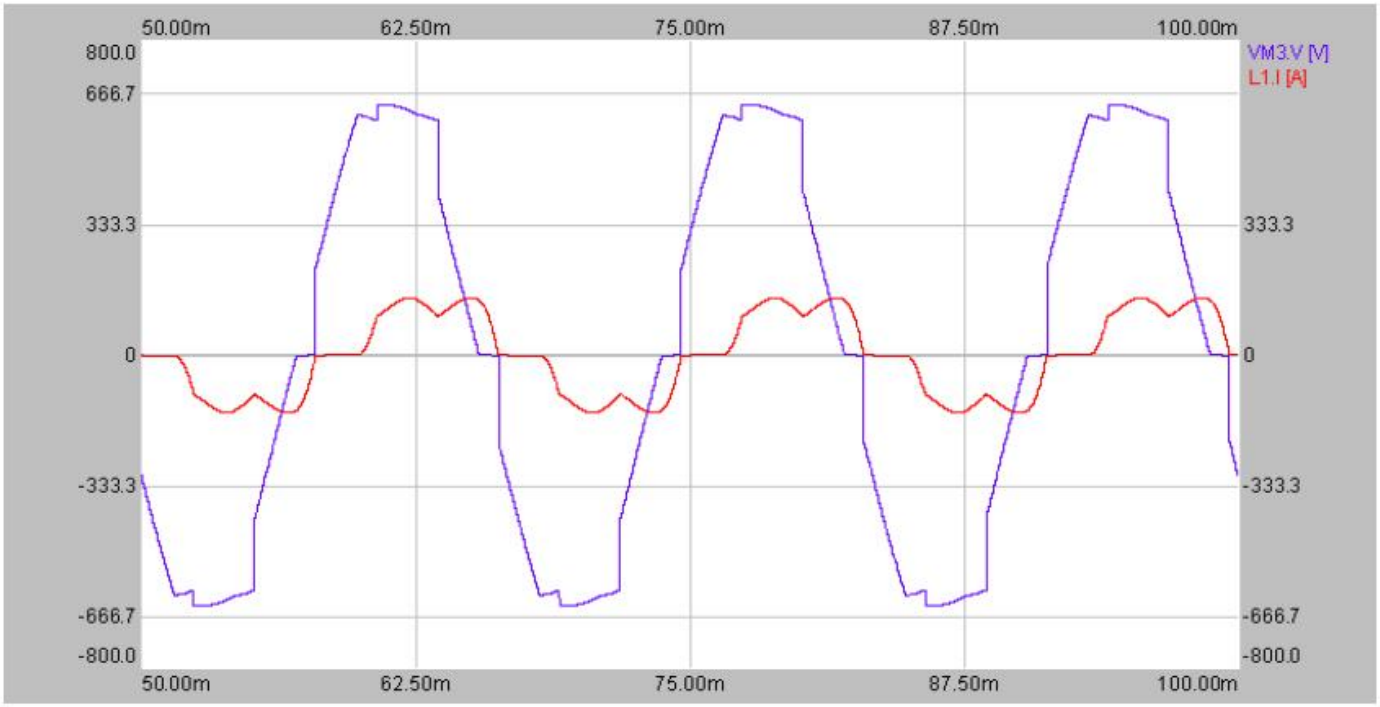
- **Case 1 Transformer power 1 MVA Load 50 KW**
  - **Almost no effect on the voltage distortion**



Ithd = 37% Vthd = 0.9%

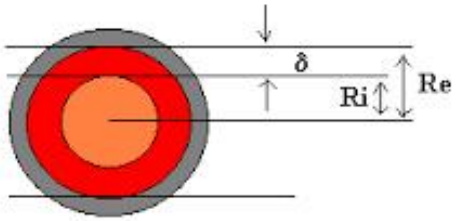
Voltage Distortion in the network

- **Case 1 Transformer power 1 MVA Load 500 KW**
  - **High distortion in the voltage**
  - **Dangerous for motors, electronic equipment**



Ithd = 29% Vthd = 9.3%

- **Transformers:**
  - **Distortion in current increases losses in the copper due to the skin effect**



- **The skin effect reduce the area of the condutcor so increase the resistance and the losses**
- **Increasing the frequency increase this effect so for the harmonic currents the resistance is higher increasing in this way the losses**

Increasing losses in transformers

- **Transformers:**
  - **Distortion in voltage increases losses in the iron**
  - **It means to increase the cost of energy**
  - **Increasing loss in iron and copper increase the temperature and decrease the life or it is necessary to oversize the transformer**

Vibrations and increasing losses in motors

- **Motors:**
  - **Voltage harmonics creates electric fields in the motor at different frequencies**
  - **Increasing vibrations**
  - **Increasing losses**
  - **Increasing temperature**
  - **Reducing life**

- **Circuit breaker:**
  - **Due to the harmonic the thermal protection can open also if apparently the RMS value is less then the level of intervention**
  - **The differential protection could not sum correctly the harmonics current and in this way read a wrong value of differential current, evaluated as a fault leakage current**
  - **Voltage distortion increases the leakage current in presence of filters**
  - **In case of inopportune intervention of a circuit breaker the cost of stopping the production could be dramatic.**

- **Efficiency:**
  - **The current harmonics and the voltage harmonics increase the losses. Cleaning the harmonics we reduce the cost of the energy due to the losses**
  - **The harmonic filter doesn’t reduce the power that is necessary to work**
  - **The reduction of voltage distortion as consequence of the reduction of current distortion can have an high impact on cost of maintenance**

- **Standards**
  - **EN61000-3-2 (up to 16 A)**
  - **EN61000-3-12 (up to 75 A)**
  - **IEEE 519 most popular in this moment**
  - **ER G5/4**

- **Standards**
  - **IEEE 519 limits at PCC (Point of Common Coupling)**

Table 10.3: Current Distortion Limits for General Distribution Systems (120V through 69,000V)						
Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{SC}/I_L	<11	11≤ h < 17	17 ≤ h <23	23 ≤ h <35	35 ≤ h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1,000	12.0	5.5	5.0	2.0	1.0	15.0
>1,000	15.0	7.0	6.0	2.5	1.4	20.0
Even harmonics are limited to 25% of the odd harmonic limits above.						
Current distortions that result in a DC offset (e.g., half-wave converters) are not allowed.						
* All power generation equipment is limited to these values of current distortion, regardless of actual I_{SC}/I_L.						
where, I_{SC} = maximum short-circuit current at PCC I_L = maximum demand load current (fundamental frequency component) at PCC.						

- **Solutions for drives considering to start from THD around 60%**

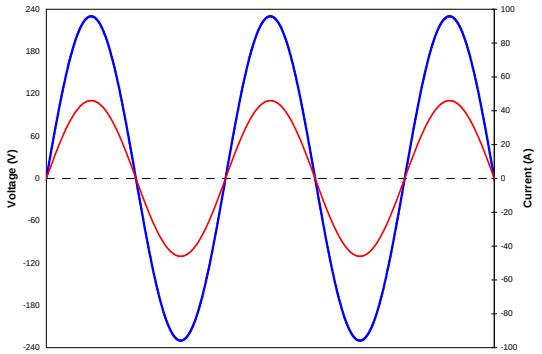
– DC Reactor	min THD	30%
– Line reactor	min THD	30%- 35%
– 12 pulse drives	min THD	10%
– Active front end	min THD	5%
– PASSIVE FILTERS	min THD	5%
– ACTIVE FILTERS	min THD	5%

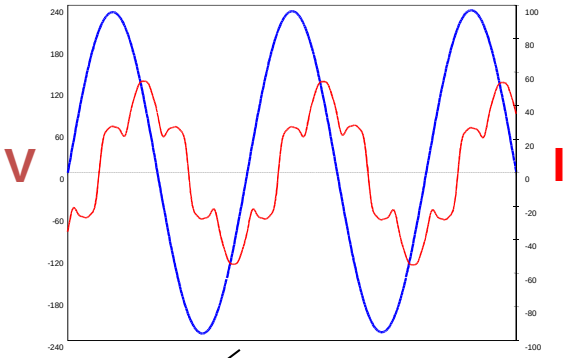
- **Passive Filters**
  - **Based on LCL circuit**
  - **Is in series to the load, so must be considered the total current for selecting the product**
  - **Can arrive up to 5% but can be big**
  - **Best attenuation at full load, the attenuation is fixed and normally can guarantee the TDD demand**
  - **Can introduce drop voltage**
  - **Cheaper solution**
  - **Easy to install**

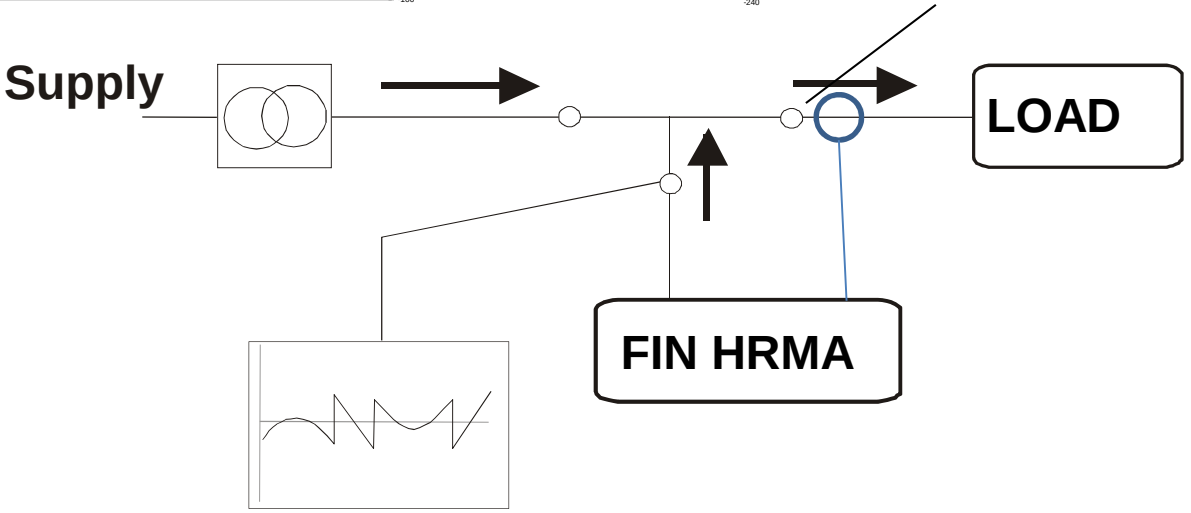
- **Active Filters**

  - **The active filter is in concrete an inverter, able to create the harmonic current in opposite to the existing, so the result is a compensation of the harmonic**
  - **Same attenuation at different currents**
  - **Can compensate reactive power**
  - **Need normally a simple commissioning**
  - **The size of the filter must be selected considering the current harmonic to compensate**

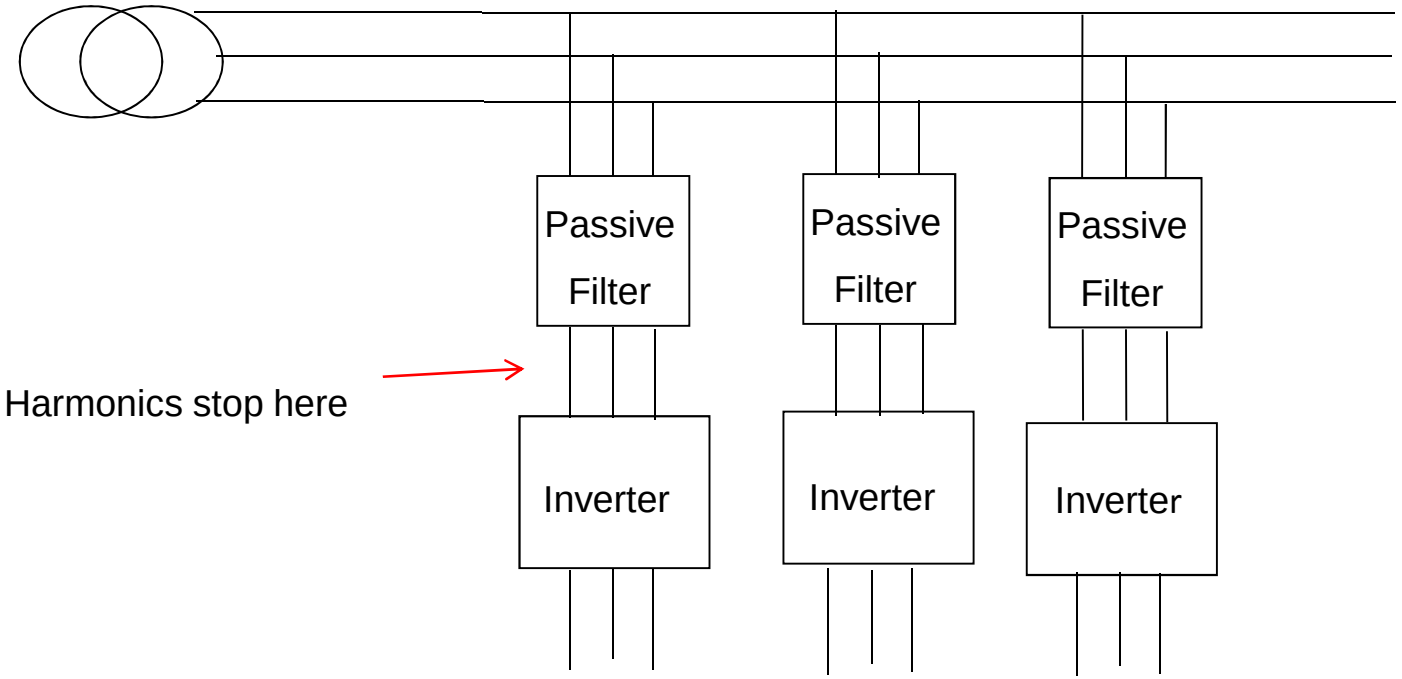
Active Filter: principle of operation



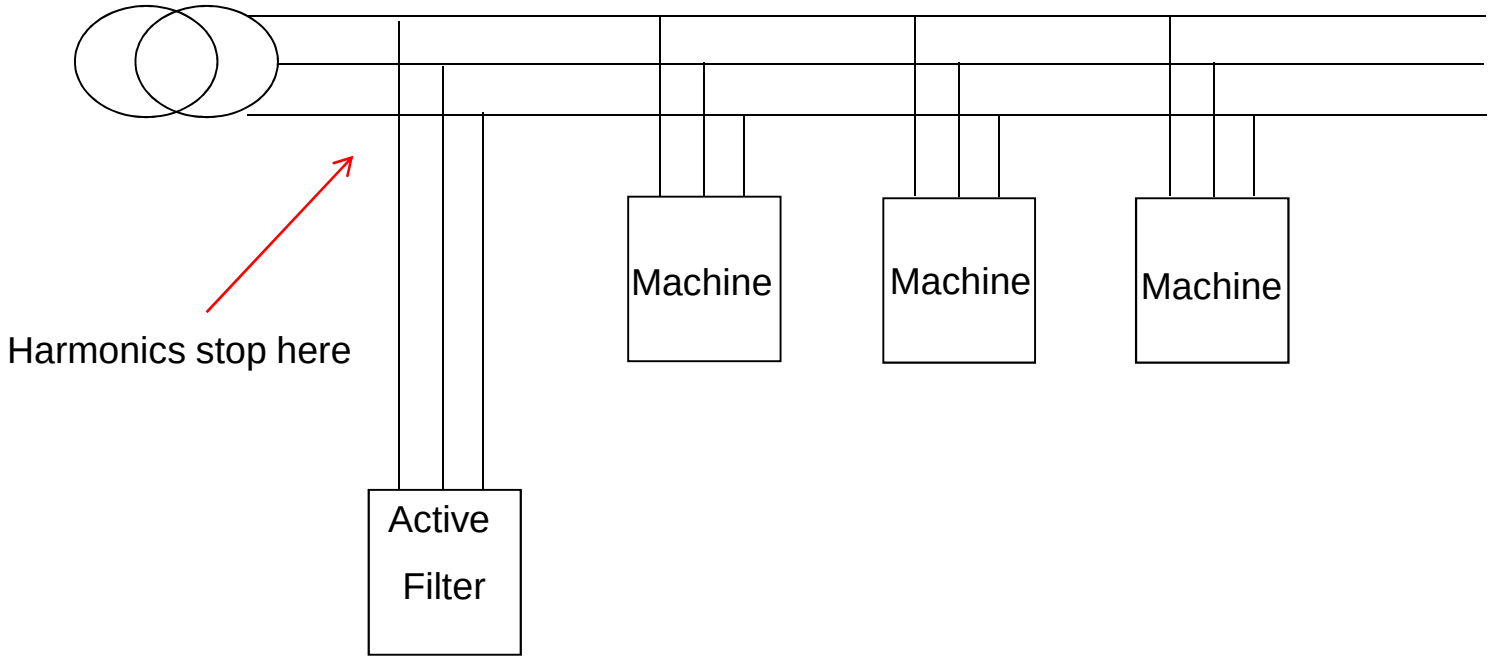




- **Passive Filters**
  - **normally used on the inverter, where the load is quite stable, in this situation the passive filter is convenient, is cheaper, doesn't need a commissioning.**



- **Active Filters**
  - **in this application the use of an active filter is more convenient, the load can change with the insertion of the machine. Normally in this application the current is big but the THD don't exceed 30%.**
  - **For example with a current of 1000 A could be enough a filter of 300 A.**



FINHRM

Passive Harmonic Filter



FINHRM.(016 - 200).M

FEATURES

- Rated current from 16 to 200A
- THDI reduction <15%
- <10% with DC reactor

BENEFITS

- 2 Year warranty
- Safety terminal block connectors
- Improves harmonics and flickers

MARKETS

- Variable frequency drives
- Woodworking machinery
- Packaging equipment
- Printing machinery

ORDERING CODE

FINHRM	.016	.M	010
Model	Current (A)	Connection	
		M = Terminal block	

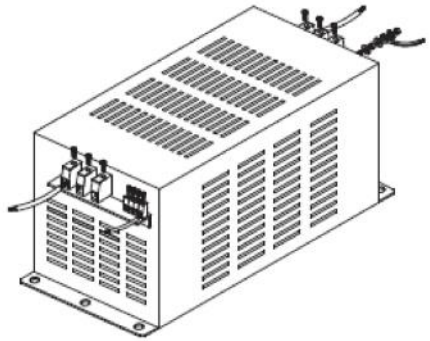
FINHRM

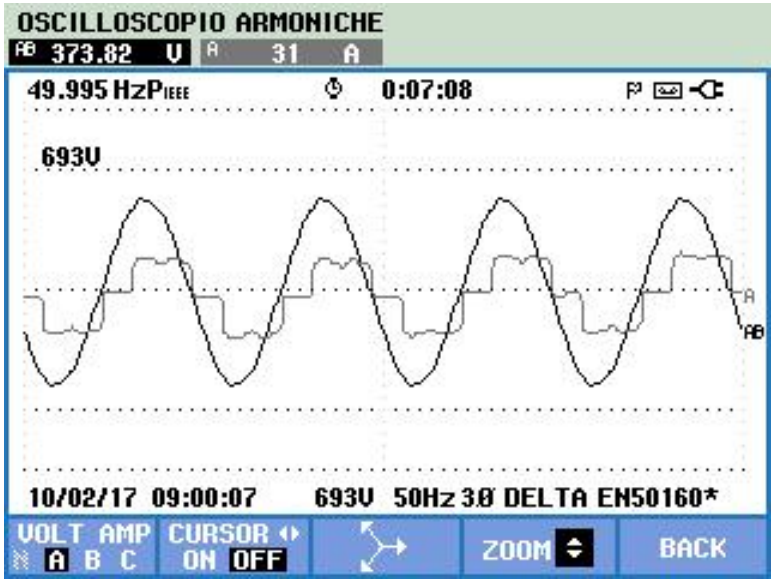
Passive Harmonic Filter

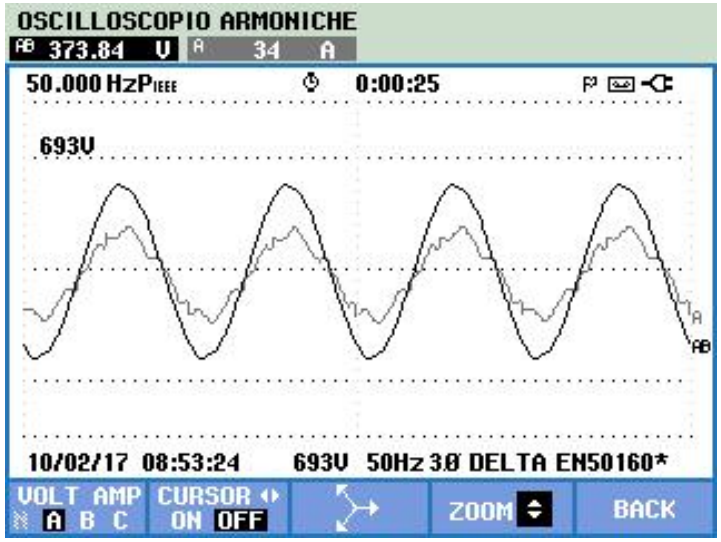
TECHNICAL SPECIFICATIONS

Nominal voltage	400 / 480 Vac (600Vac upon request)
Frequency	50 – 60 Hz
Rated current	16 to 200A
Potential test voltage phase to phase	2400 Vdc (2 sec.)
Potential test voltage phase to ground	3200 Vdc (2 sec.)
IP Protection	IP20
Overload capability	4 x Rated current (Switch ON) 2 x In 10 seconds 1.5 In for 10 minutes
Climatic class	-40 / +85° C
MTBF at 40°C	250.000 Hrs

ASSEMBLY CONNECTION "M"




OSCILLOSCOPIO ARMONICHE
AB 373.82 V
A 31 A
49.995 HzPIEEE
0:07:08
693V
10/02/17 09:00:07
693V 50Hz 3Ø DELTA EN50160*
VOLT AMP
A B C
CURSOR
ON OFF
ZOOM
BACK


OSCILLOSCOPIO ARMONICHE
AB 373.84 V
A 34 A
50.000 HzPIEEE
0:00:25
693V
10/02/17 08:53:24
693V 50Hz 3Ø DELTA EN50160*
VOLT AMP
A B C
CURSOR
ON OFF
ZOOM
BACK

FINHRM5

Passive Harmonic Filter



FINHRM5. (010 - 160).M



FINHRM5.(210 – 800).B

FEATURES

- Rated current from 10 to 800A
- Current THD <5%
- Improves flicker and power factor

BENEFITS

- Breaker available upon request
- Finger safe protection upon request
- Enclosure available upon request

MARKETS

- Variable frequency drives
- Pumps
- HVAC system
- Industrial equipment
- UPS

ORDERING CODE

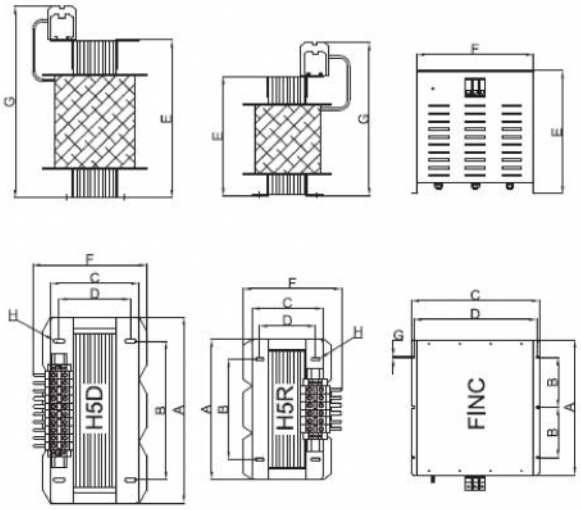
FINHRM5	.007	.M	-60	.HV
Model	Current (A)	Connection	Frequency	690 Vac
		M = Terminal block	Only for 60Hz application	
		V= Screw		
		BC= Bus bar		

FINHRM5

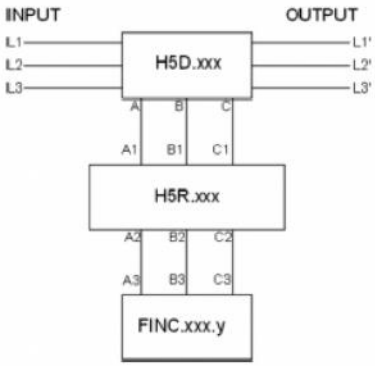
Passive Harmonic Filter

TECHNICAL SPECIFICATIONS

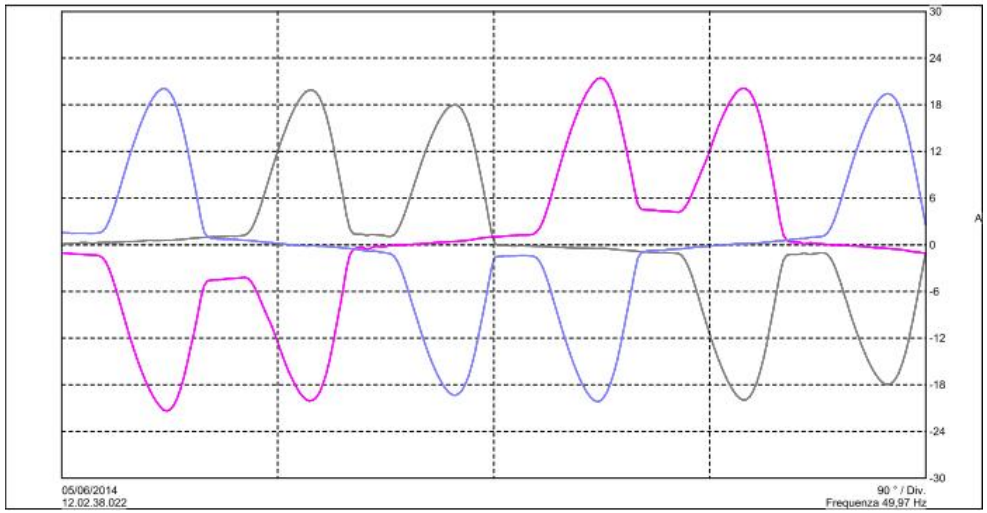
Nominal voltage	230 / 400 / 480 / 690 Vac
Frequency	50 – 60 Hz
Rated current	10 to 800A
Potential test voltage phase to phase	2400 Vdc (2 sec.)
Potential test voltage phase to ground	3200 Vdc (2 sec.)
IP Protection	IP20 up to 160 A, IP00 over
Overload capability	4 x Rated current (Switch ON) 2 x In 10 seconds 1.5 In for 10 minutes
Climatic class	-40 / +85° C
MTBF at 40°C	250.000 Hrs



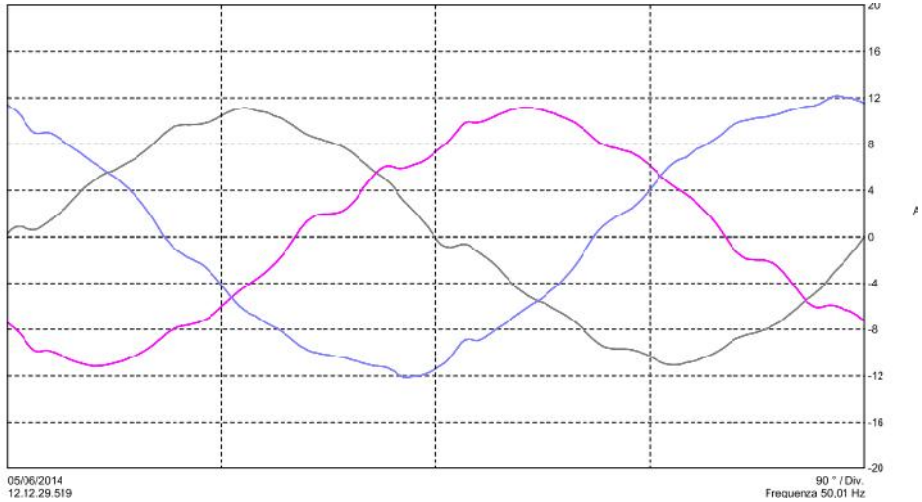
ELECTRIC DIAGRAM



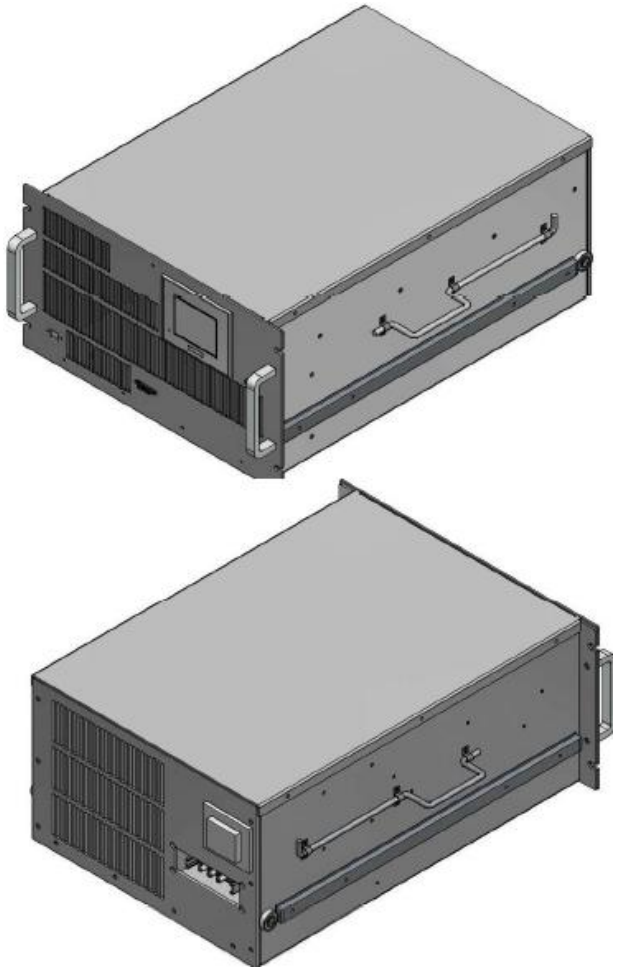
Typical 6 poles drive distortion



With FINHRM5

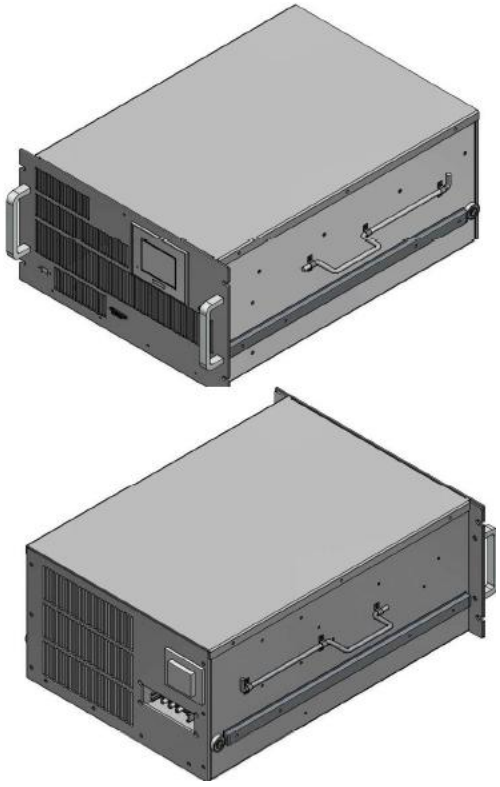


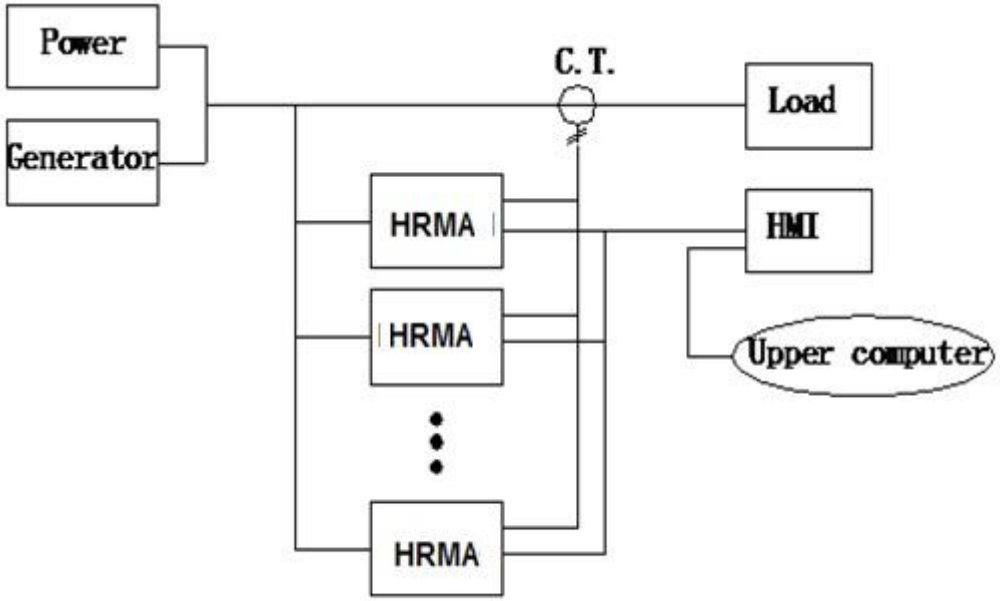
FINHRMAE: Active Filter (new)



- modular system
- module 50 A, 100 A, 150 A
- 2 mechanical dimensions
- Distortion correction ability: <5％ THD
- rack and wall mounting
- Operation voltage: 400 , 480 and 690 Vac
- Frequency: 50Hz and 60 Hz
- Harmonic order: 2^{nd}~50^{th}
- 3 level topology;
- Display/interface: LCD
- Extension: up to 10 units in parallel
- 3 phase plus neutral product with compensation on neutral 3 times than phase compensation

- **Communication**
  - **RS485, Ethernet, Modbus**



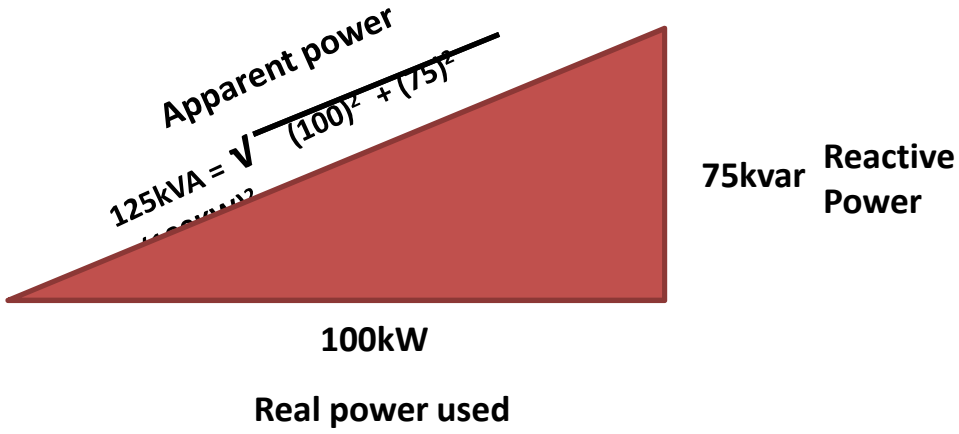


POWER FACTOR COMPENSATION

PF Power Factor – The Problem

Large inductive loads cause low power factor.

Others devices with non-linear load : rectifiers, fluorescent lamps, electric welding or arc furnaces create

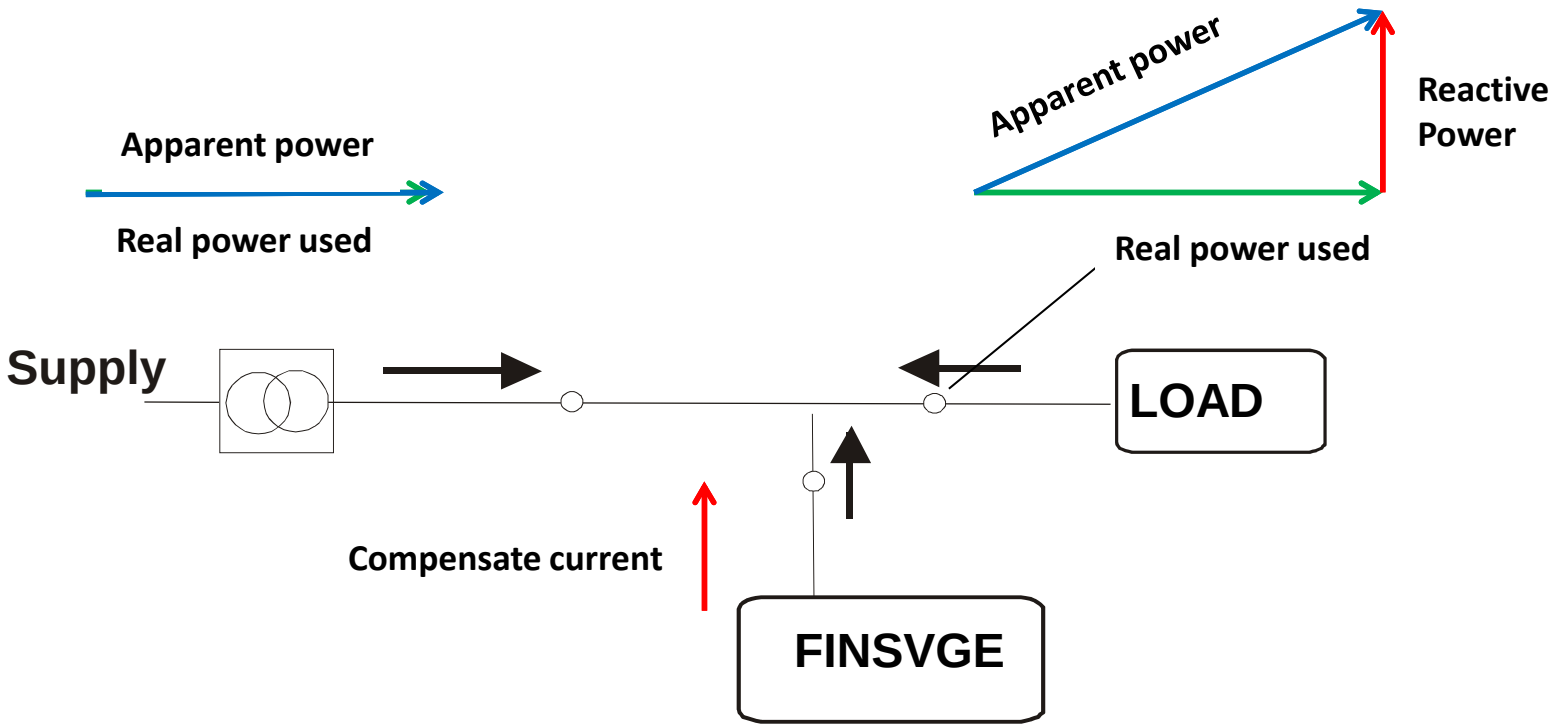


$$\text{Power Factor } \cos\theta = \frac{P, real\ power}{S, apparent\ power}$$

PF Power Factor – The Problem

- Very high cost of reactive power
- Penalty and fee from utility company
- PF in non linear loads create unbalanced power which damages equipment

Static Var Generator

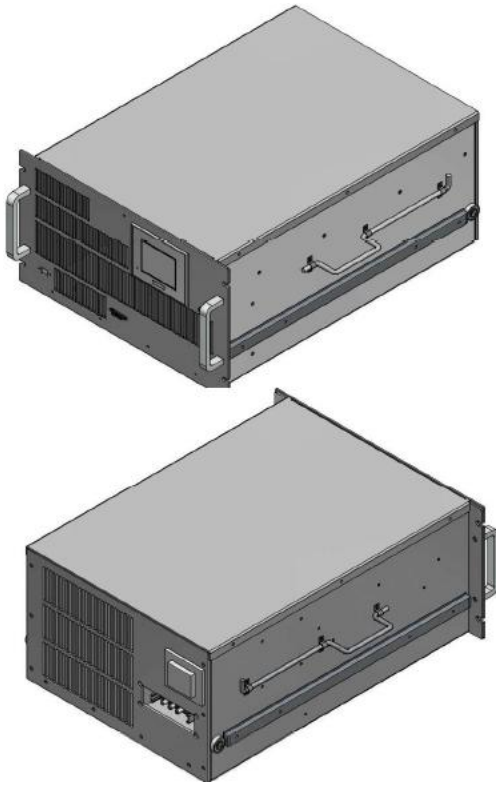


Why improve your Power factor?

- **Your utility bill will be smaller. Low power factor requires an increase in the electric utility's generation and transmission capacity to handle the reactive power component caused by inductive loads. Utilities usually charge a penalty fee.**

- **Your electrical system's branch capacity will increase. Uncorrected power factor will cause power losses in your distribution system. You may experience voltage drops as power losses increase. Excessive voltage drops can cause overheating and premature failure of motors and other inductive equipment.**

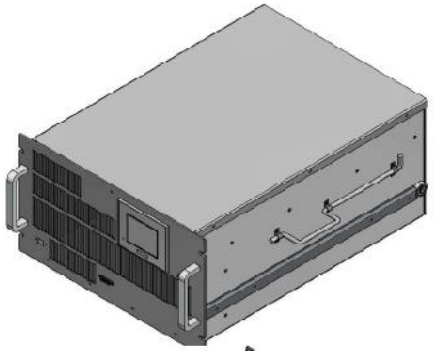
FINSVGE: Active Filter (new)



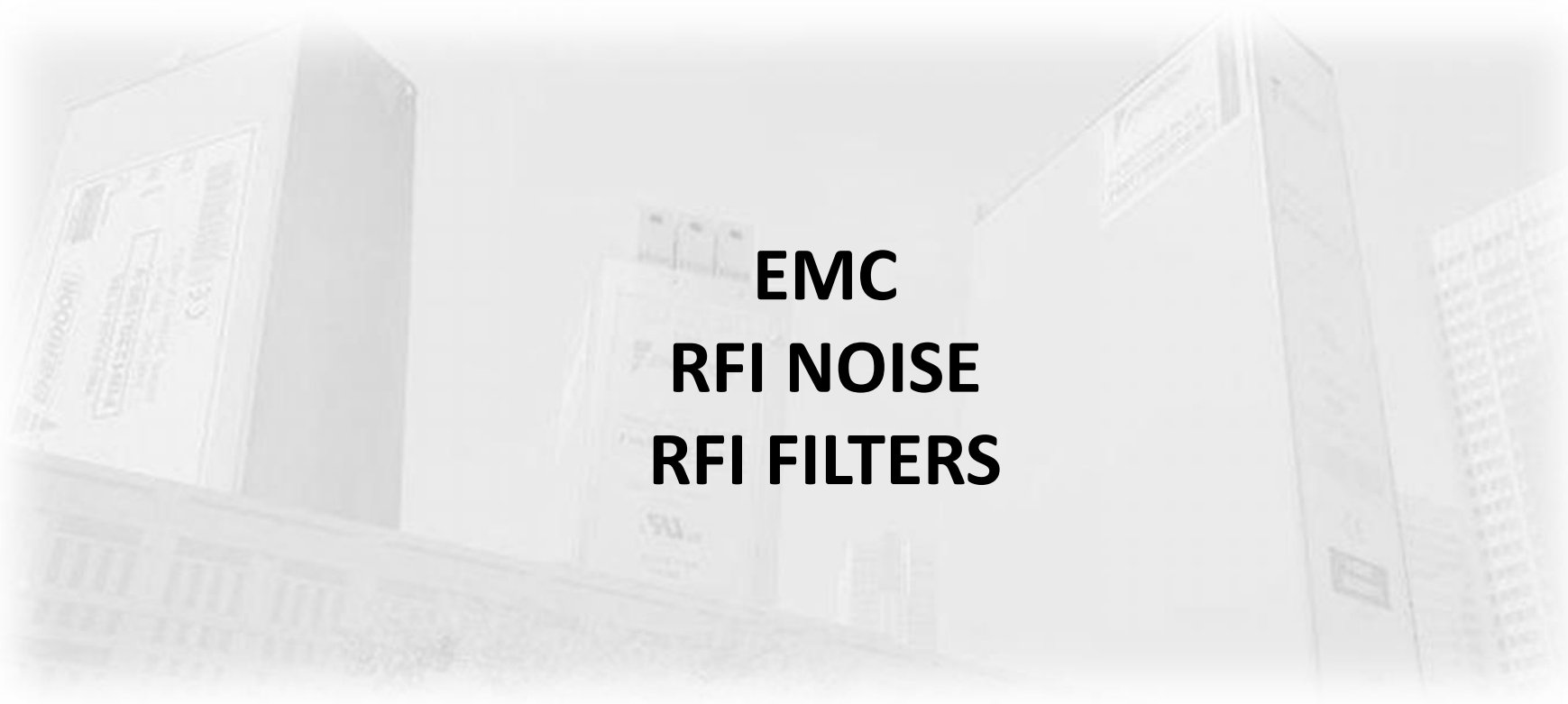
- modular system
- module 50 KVA, 100 KVA
- rack and wall mounting
- Operation voltage: 400 , 480 and 690 Vac
- Frequency: 50Hz and 60 Hz
- 3 level topology
- Full response time: 10ms
- Display/interface: LCD
- Extension: up to 10 units in parallel

Capacitor bank VS Active Var Generator



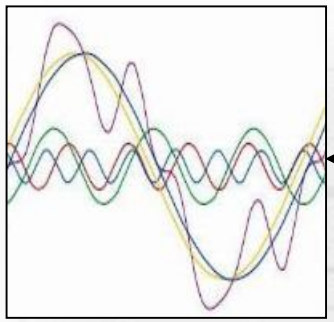


Capacitor banks are typically grouped by switch. Output current is step style, which often leads to over/under compensation.	Active VAR generator is controlled by a current transformer (CT) thus obtaining compensation effect with the level of PF 0.99
Conventional compensation is 20ms	Dynamic response time is less than 50uS – Total response time is less than 15ms.
Reactive power is compensated mainly by SCR and capacitors. This system may be affected by harmonic resonance which causes challenges and prematurely failure.	Filter does not require installation of a filter bank resulting in no concerns with resonant amplification
Only compensates inductive reactive power	Compensates both inductive reactive power and capacitive reactive power
Capacitors provide capacitive reactive power. The output of reactive power is subject to the voltage of the grid. Reactive compensation will be low if voltage is low; This causes inadequate compensation	System is active; Voltage from the grid has little influence on the compensation capacity
To have a better compensation, conventional capacitor banks require an installed capacity larger than required	The compensation capacity is the same as the installed capacity

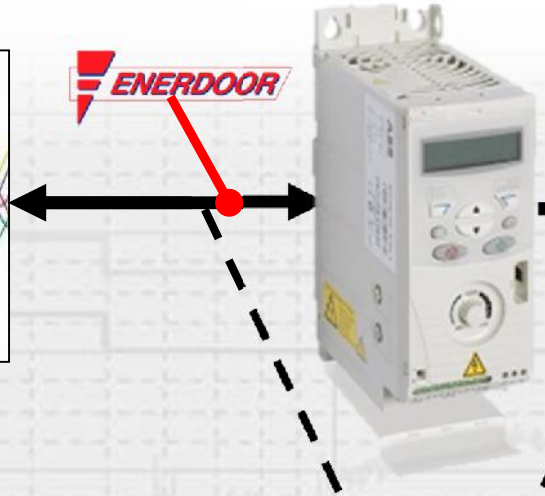


EMC
RFI NOISE
RFI FILTERS

Power Target Areas



EMC filters
Harmonics
PFC
Voltage stabilizers



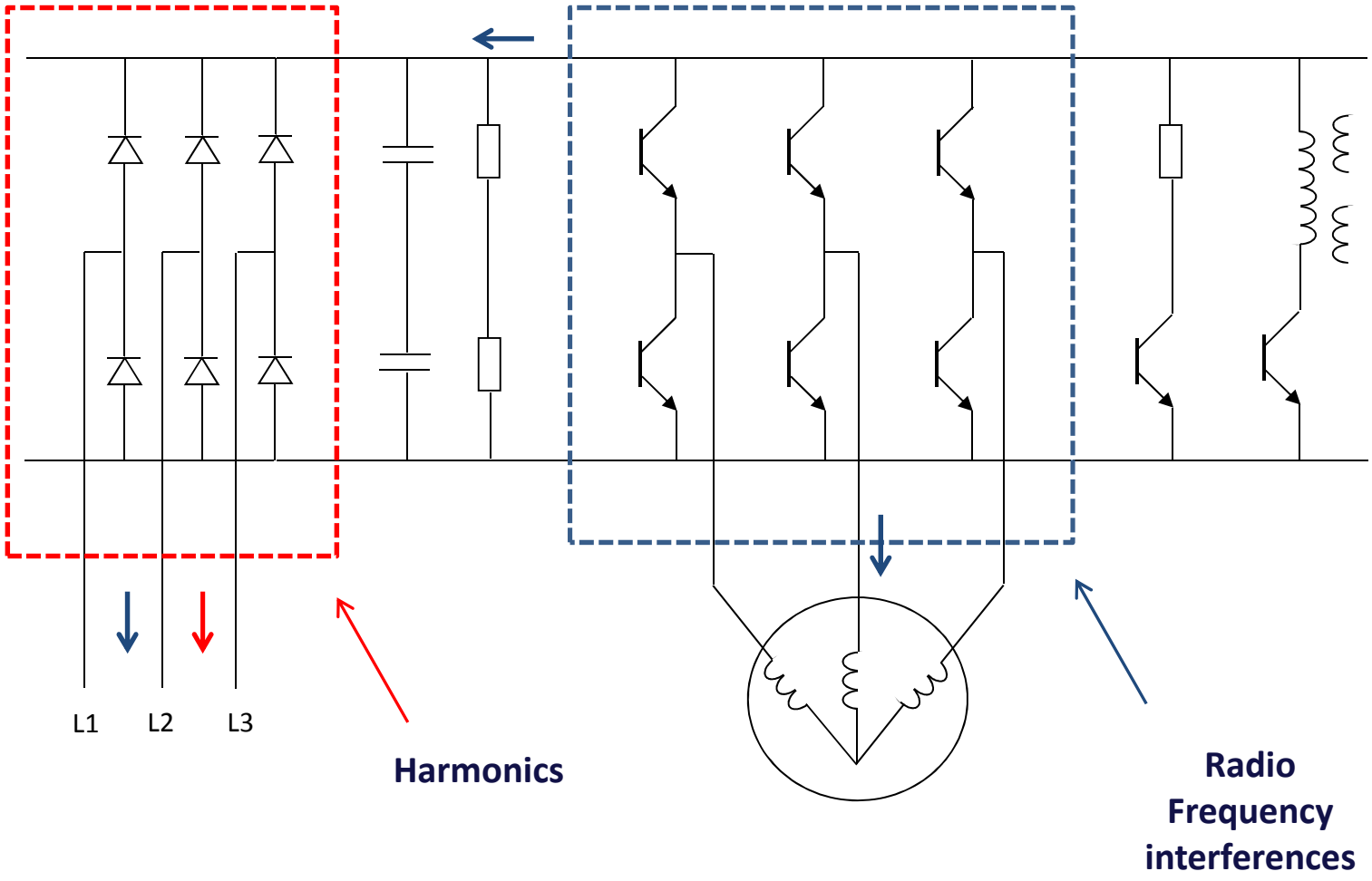


Motor Protection



Radio Frequency interferences

Power drive system full concept scheme



Noise vs Frequency

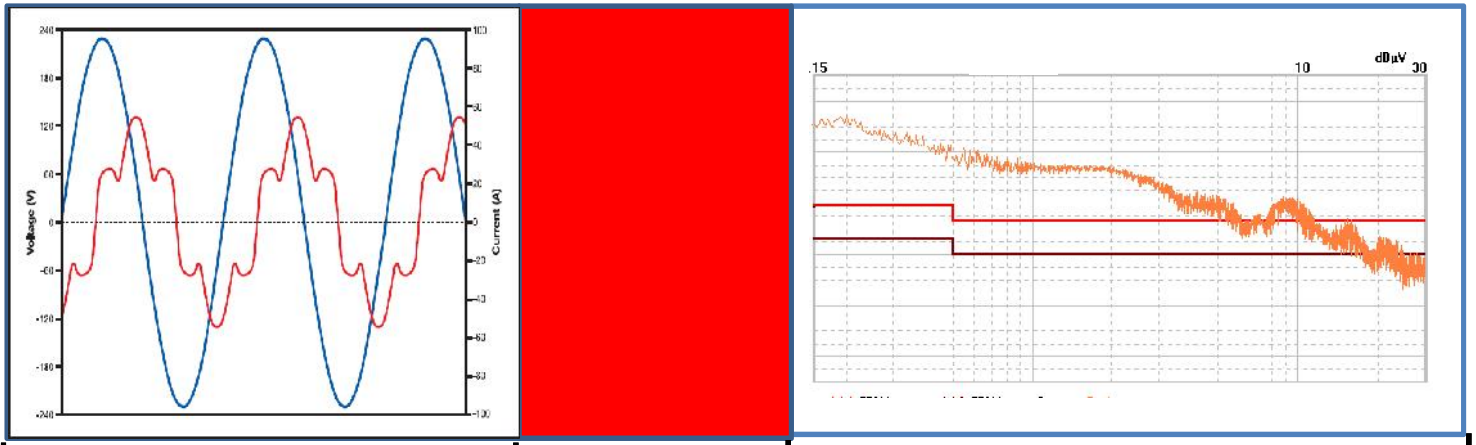
Harmonics

IEEE-519
EN 61000-3-11

Various noise disturbances

Electromagnetic Interference

CISPR-16
EN 61000-6-4
FCC-15

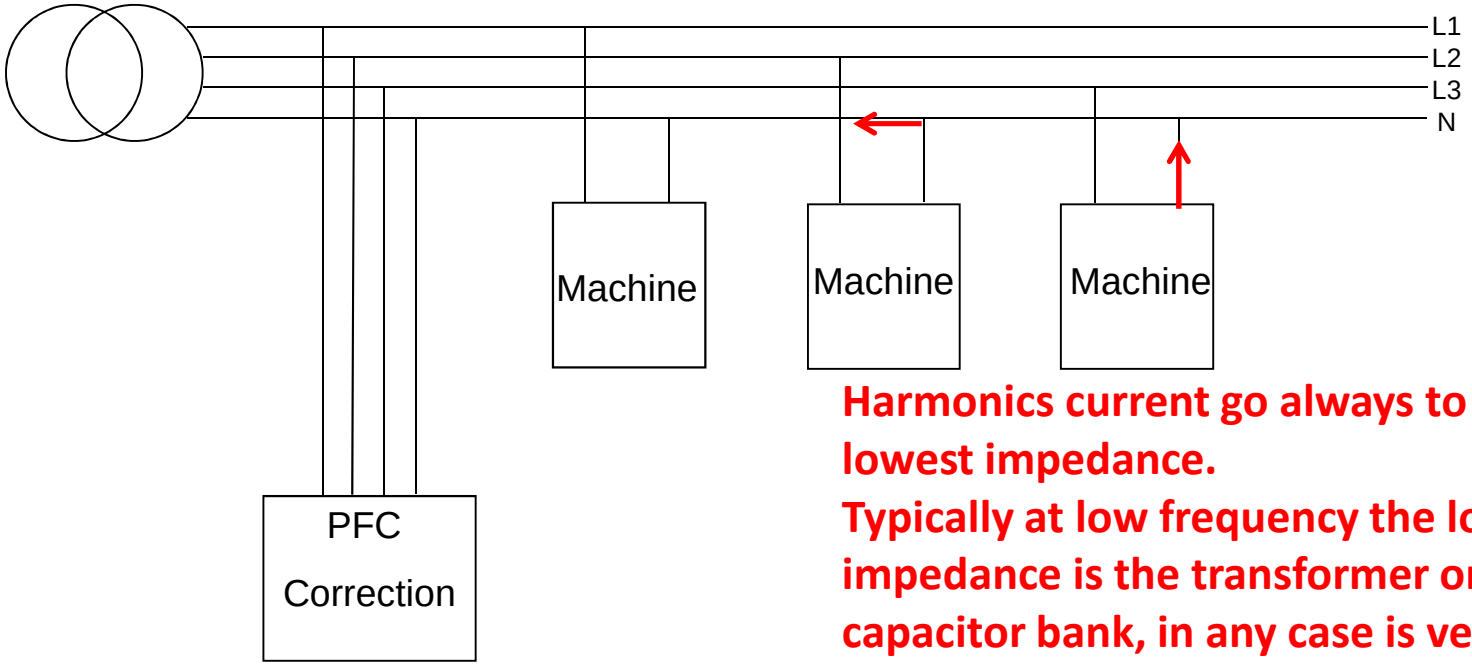


50-60Hz — **3KHz** — **150KHz** — **30MHz**

NETWORK

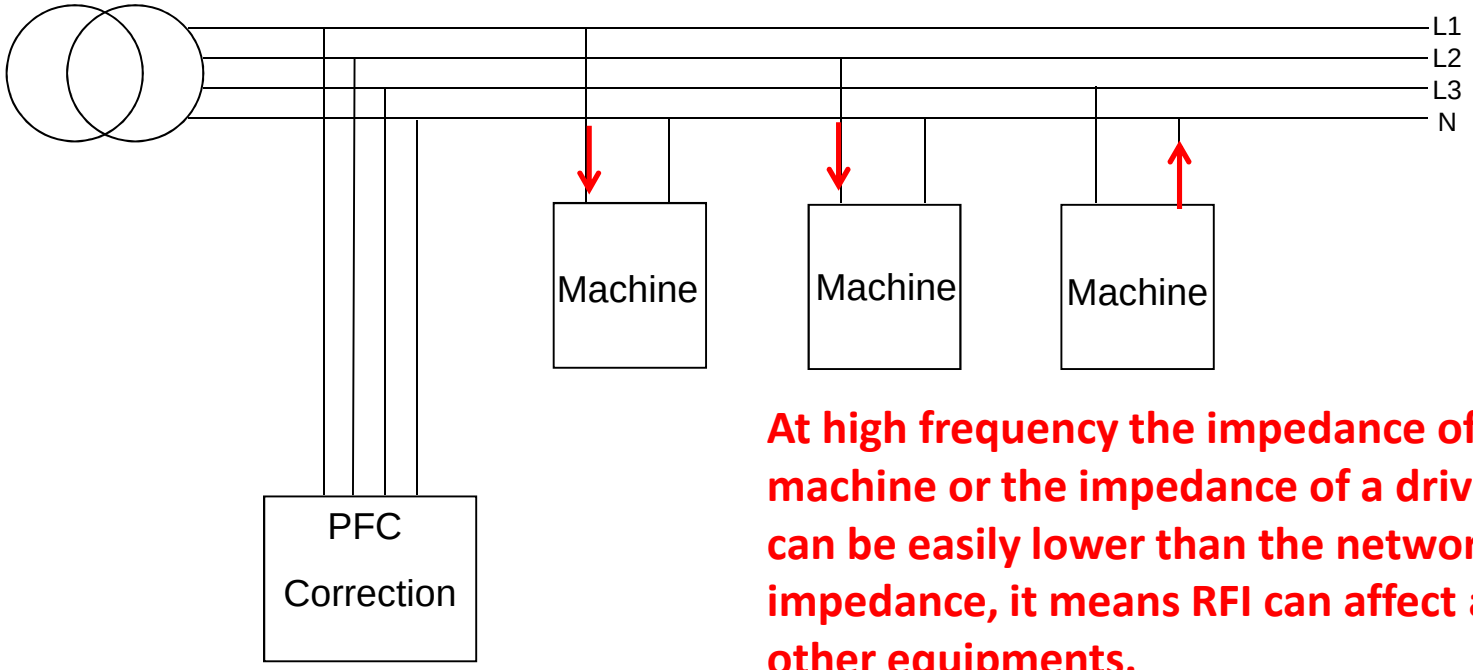
INTEFERENCES

- **Harmonics :**



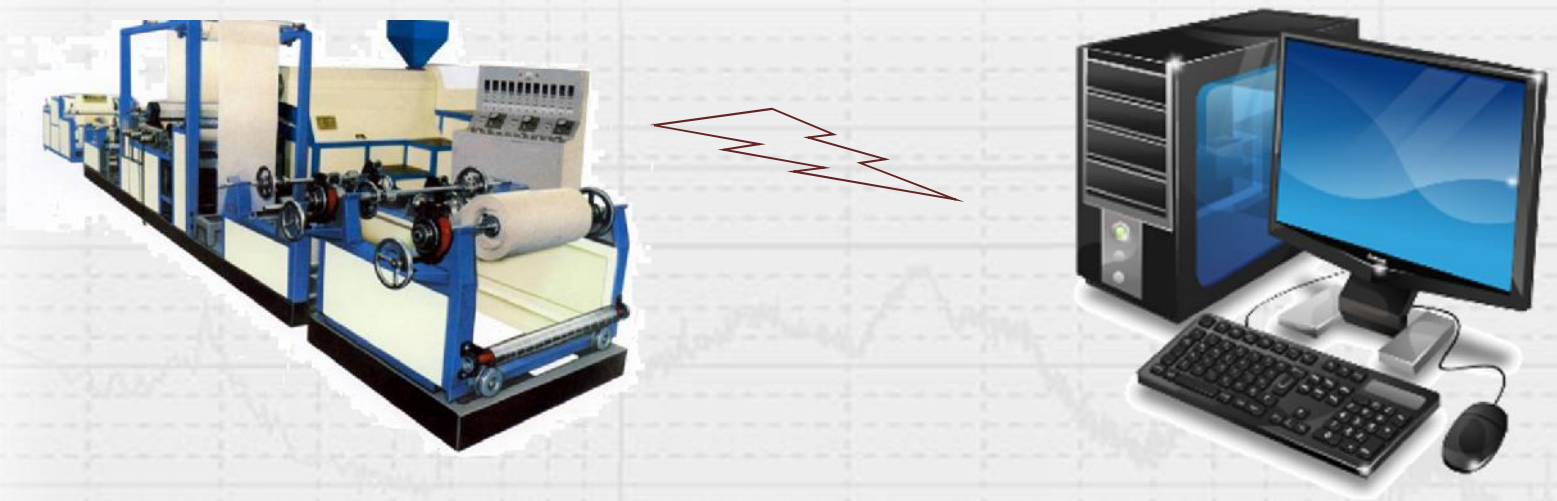
Harmonics current go always to the lowest impedance.
Typically at low frequency the lowest impedance is the transformer or the capacitor bank, in any case is very difficult that the impedance of one machine or drive can be lower than the network impedance. It means current harmonics affect the network

- **RFI:**



At high frequency the impedance of a machine or the impedance of a drive can be easily lower than the network impedance, it means RFI can affect also other equipments.

Example



Electrical components inside a machine create disturbances at high frequencies. These disturbances can affect other electrical devices such as other machines, PC, telephone lines, FAX, etc.

- How to reduce the effect of the interferences from drives
  - Use of correct filters
  - Realize the cabinet with a correct cabling
  - Use of shielded cables
  - Good connection of the shields
  - Following the standards; the standards were create to allow compatibility between the machines, following the standard is the best point of start.

In Europe, CE Compliance Is Not Optional

89/336/CEE Directive

Mandatory since January 1st 1996

2004/108/EC Directive

Mandatory since July 1st 2007

2014/30/EU Directive

Mandatory since July 20th 2016

DIRECTIVE 2014/30/EU
Minimum requirements

1) Does Not Effect Other Machines

EMISSIONS



2) Is Not Effected By Other Machines

IMMUNITY



Standards

Why do we have standards?

To prevent problems of interference and allow compatibility in the environment

What Standards do we use and where?

EUROPE: CE mark is mandatory, one of the directives regarding the CE mark covers the EMC aspects, so it is mandatory for all the manufacturers to comply with this directive, also for the US manufacturer that export in Europe.

AUSTRALIA & NEW ZEALAND : EMC Directive as Europe with CE Mark.

USA: The FCC standard part 15 has the same limits of European emission. (Not mandatory).

JAPAN : EMC Directive as Europe with CE Mark with some restrictions.

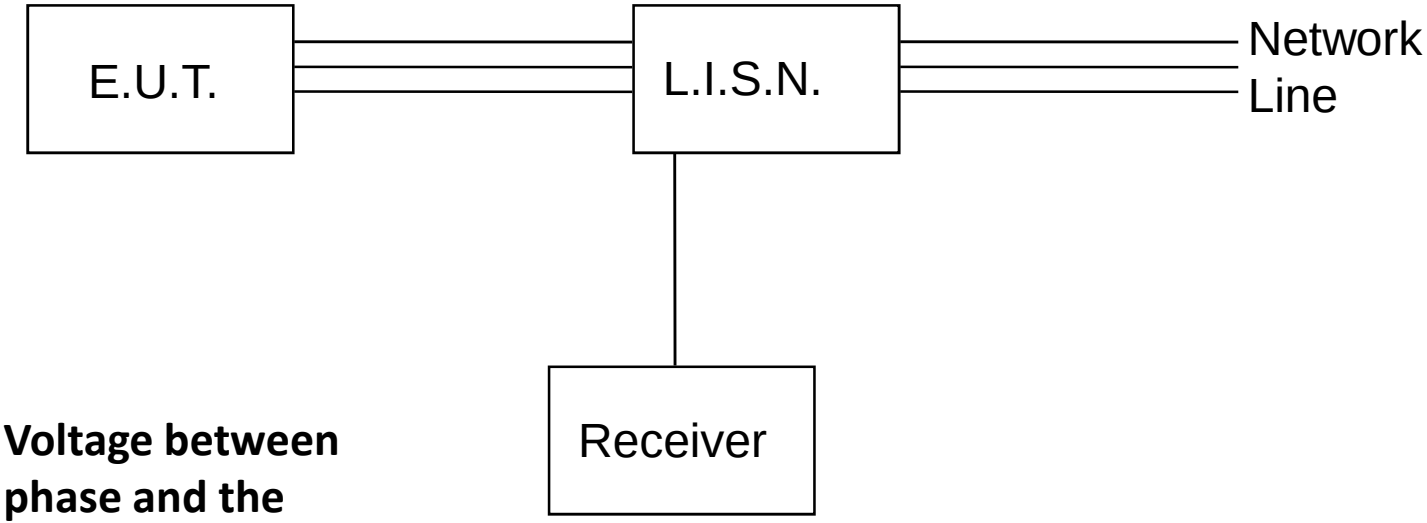
CHINA : CCC Mark report 90% of the International Standard IEC included the EMC Directive.

Conducted Emission

Required Instrumentation:

- Receiver
- Reference impedance: **L**ine **I**mpedance **S**tabilization **N**etwork (L.I.S.N.)
- Voltage probe (High current)

Conducted Emission – Less than 25 Amps

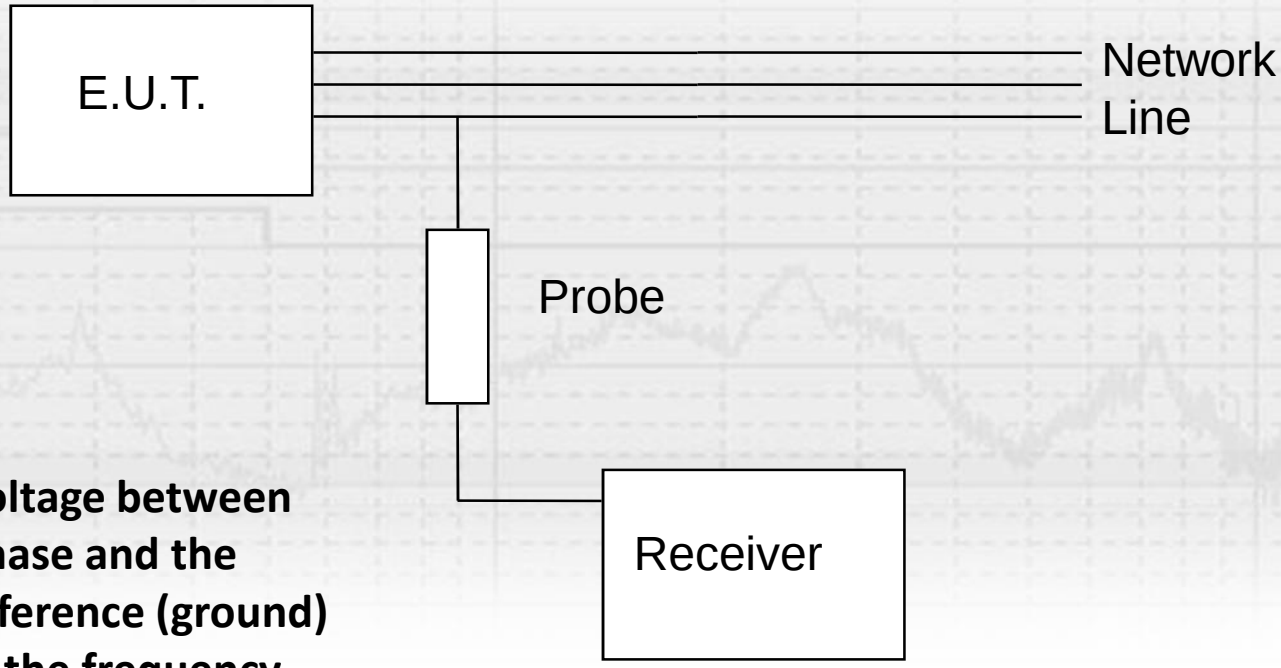


Voltage between phase and the reference (ground) in the frequency band from 150 KHz up to 30 MHz

Conducted Emission – Less than 25 Amps

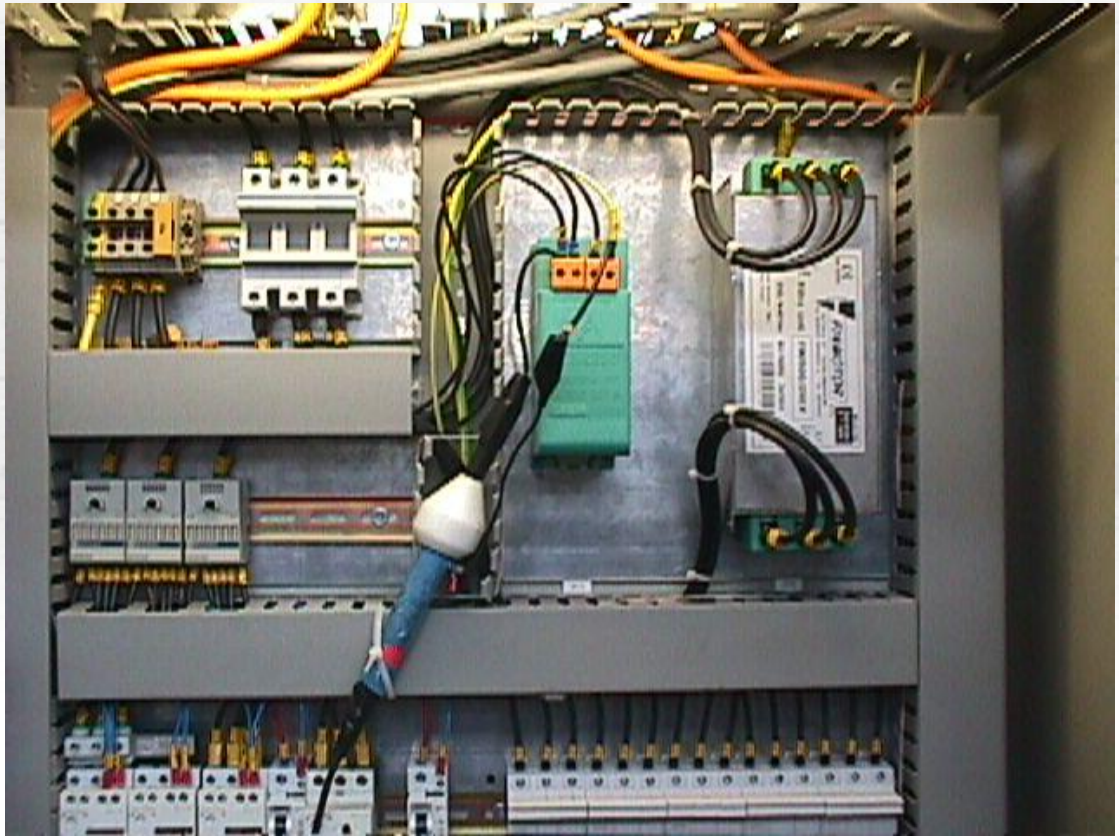


Conducted Emission – More than 25 Amps



Voltage between phase and the reference (ground) in the frequency band from 150 KHz up to 30 MHz

Conducted Emission – More than 25 Amps

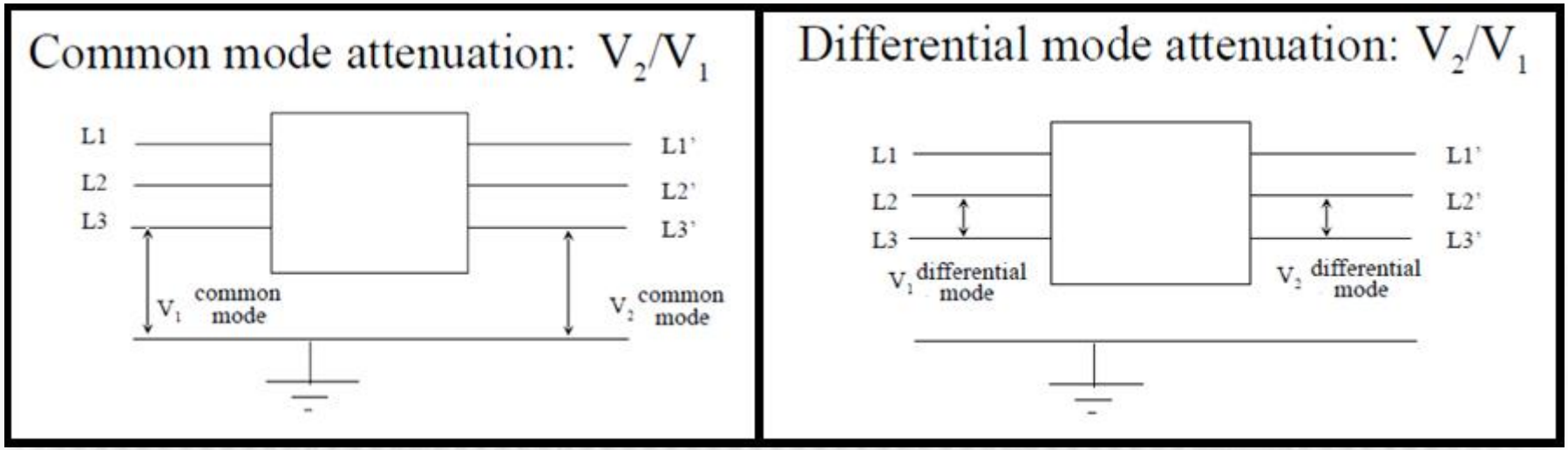


What does this disturbance look like?

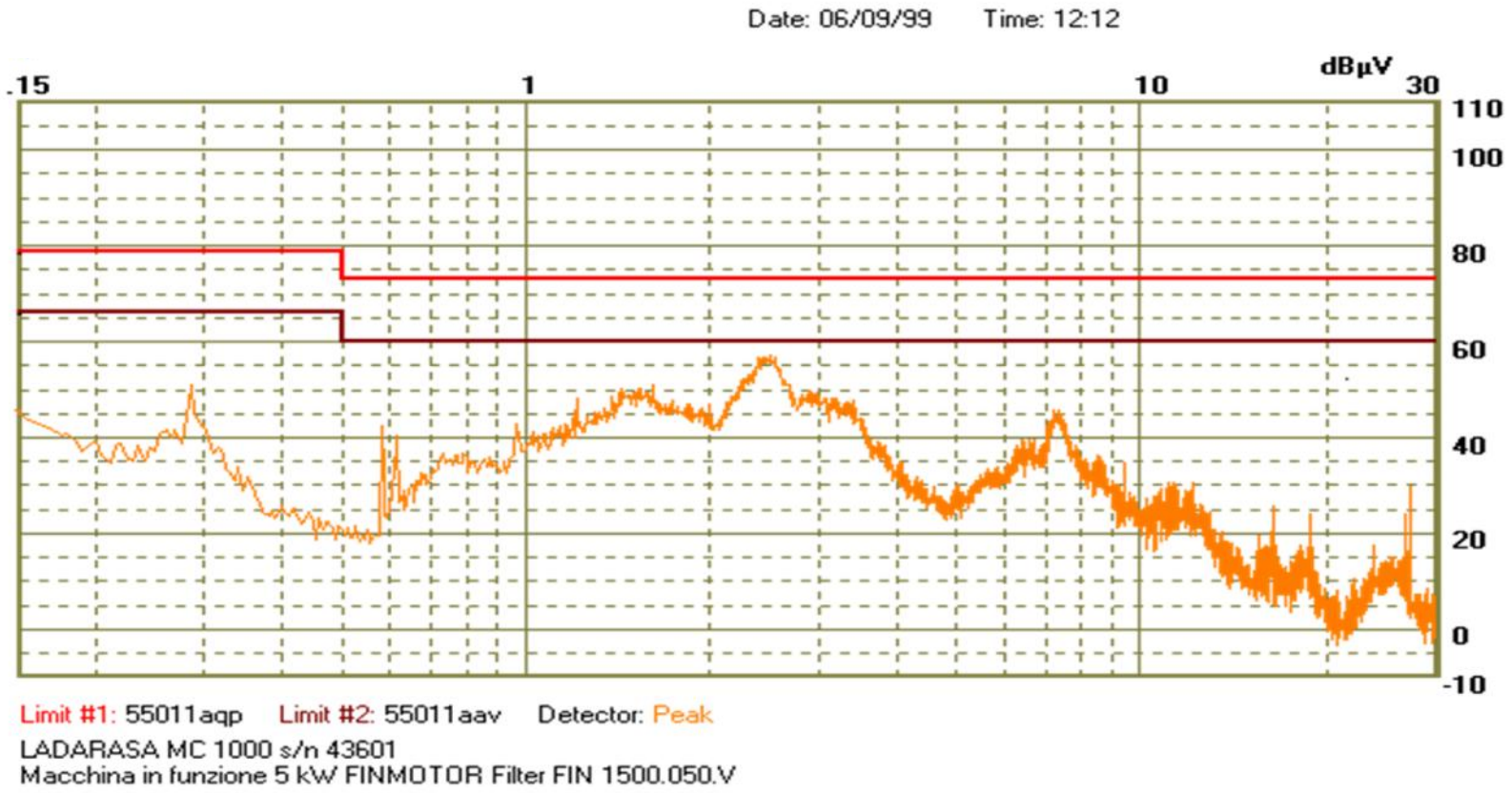
Noise from a Variable Frequency Drive
* Note red limit lines



Filters attenuation

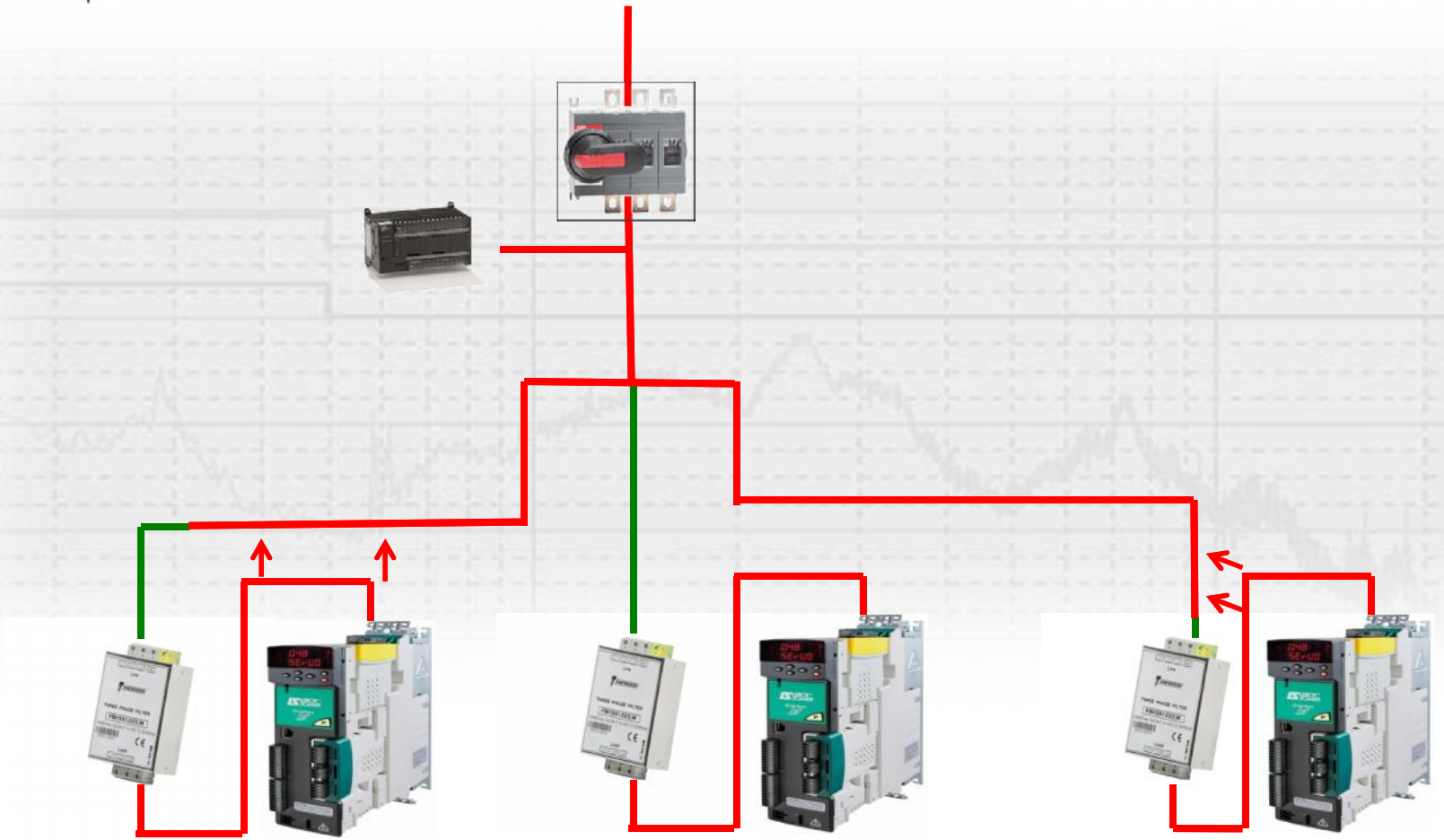


Disturbance coming from a drive after installation of filter



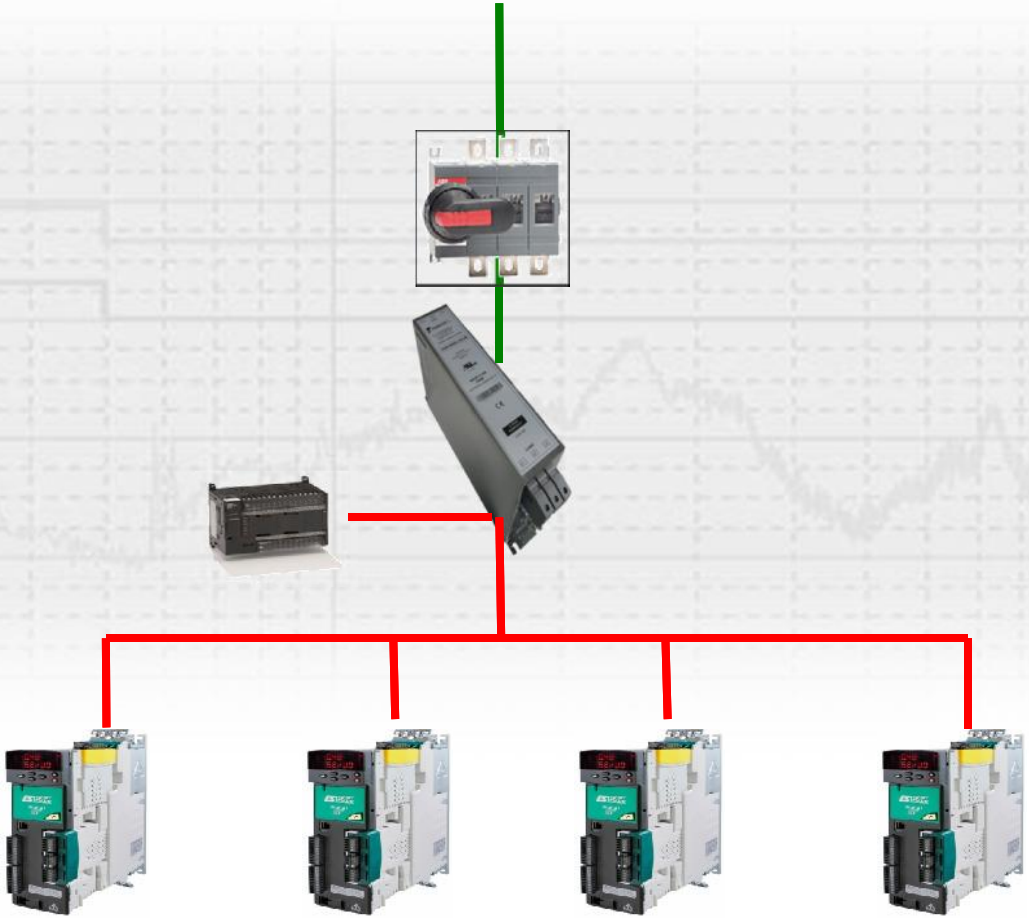
Where the filter is connected matters

- Solution 1: Filter for each source



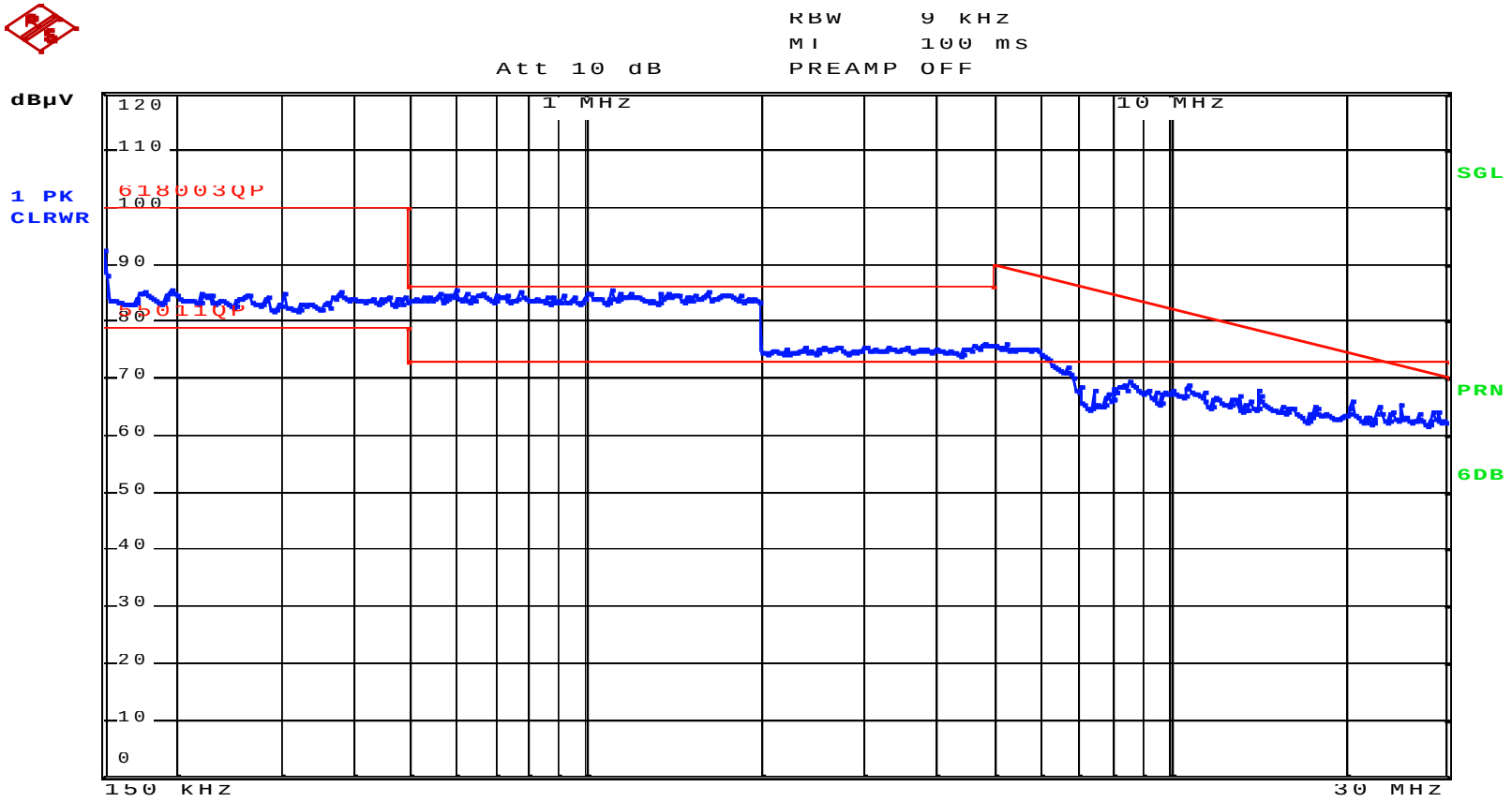
Where the filter is connected matters

- Solution 2: one single central filter (Enerdoor solution)



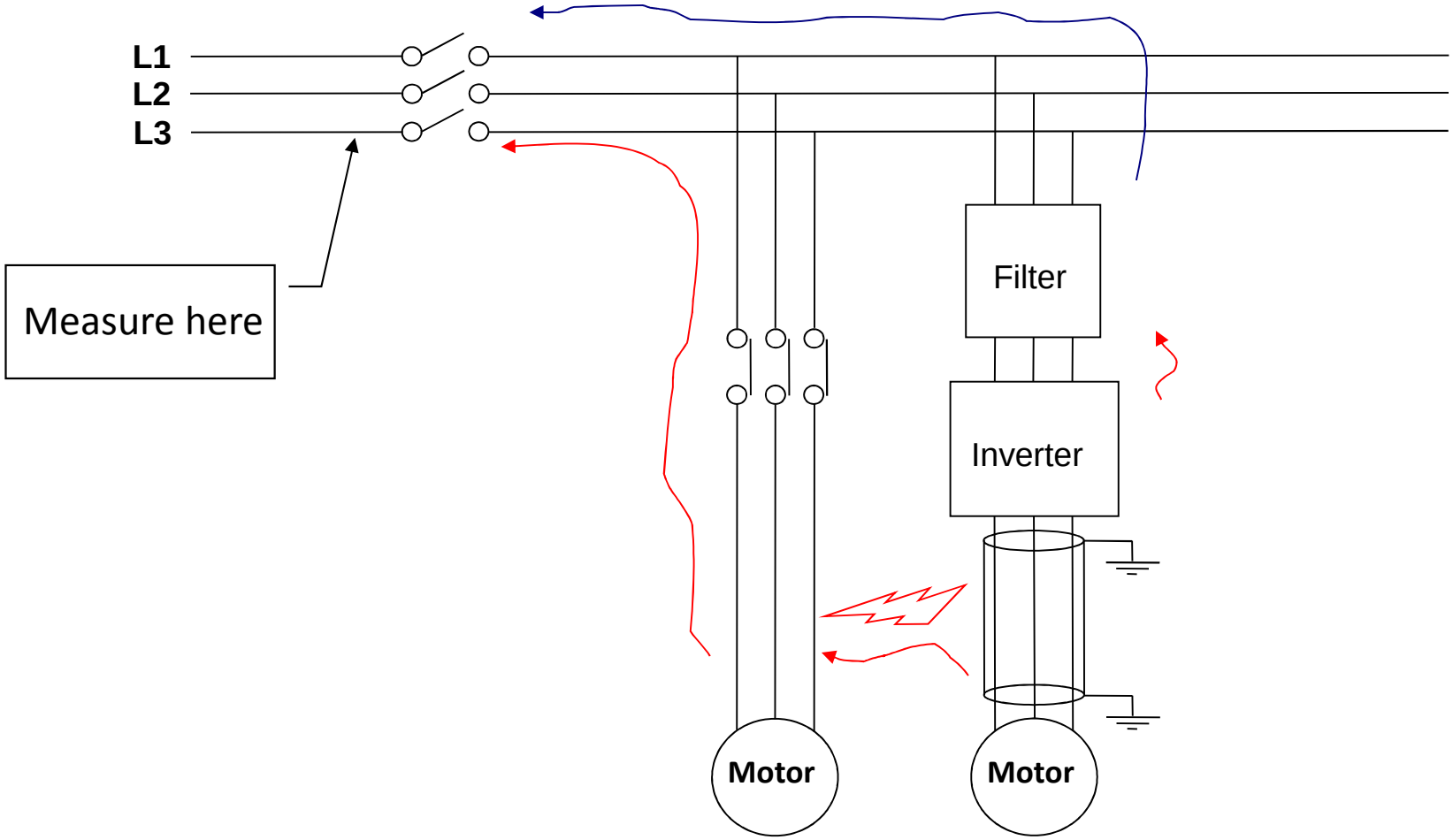
CE Has More Than One Limit

What works for VFDs may not work for the panel!



Comment: Sample Company Model ABC SN:1234
Comment: Machine Cycling, Difference Between 61800 & 55011
Date: 23.APR.2012 09:51:54

❑ Coupling on the measurement



Advantages of central filter

- Less leakage current, less current to ground
- Less cost: one filter of 100 Amps is less expensive than 10 filters of 10 Amps
- Better results of measurement due to the better position of the filters, means less problems due to coupling
- Requires less space in the panel.
- Reduced time for wiring multiple filters.
- Protect the entire panel (PLC, PC, other components inside in the cabinet), not only the drives

Advantages of Enerdoor

- 5 Year Warranty
- UL/CSA up to 600Vac for three-phase filter and three-phase plus neutral
- Only manufacturer with parallel filter for low frequency attenuation.
- Complies with UL508A.
- 25 years of experience dealing with EMC interference.
- Can provide EMC and FCC testing of customers machine on-site.

Filter Applications

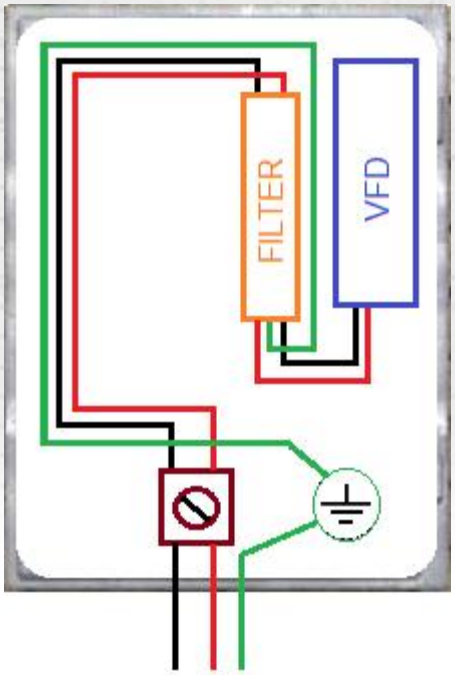
Filters are not a cure all!

- **Grounding Practice**
  - **Length of Cable**
  - **Diameter of Cable**
  - **Bare Metal Contact**
- **Cable Practices**
- **Length of Cable**
- **Shielded Cable**
  - **Grounding of Shielded Cable**

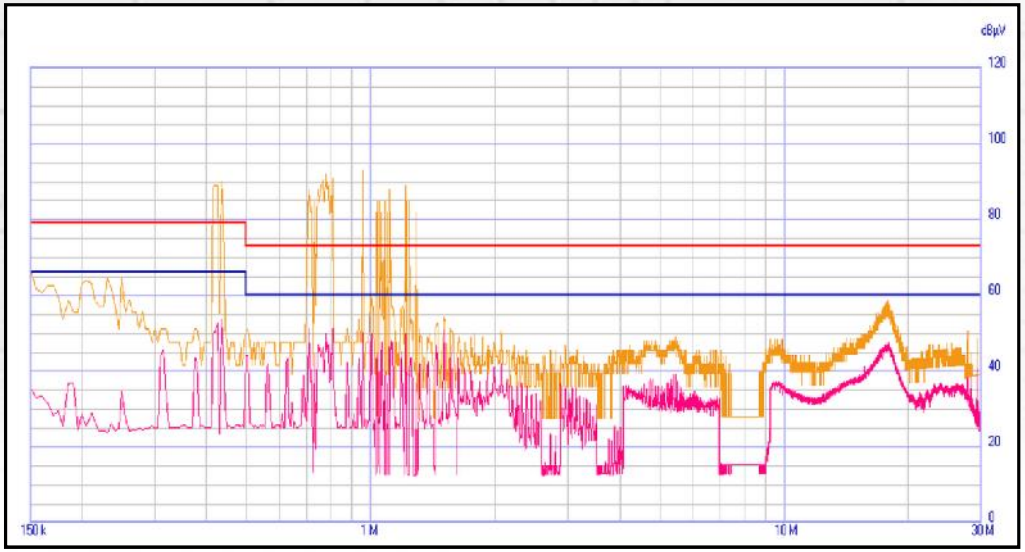
Grounding - Filter

Example: Original Configuration

Panel Layout



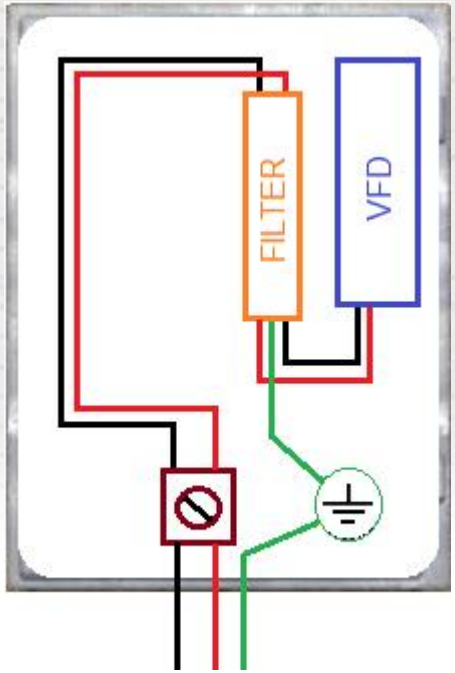
Test Results



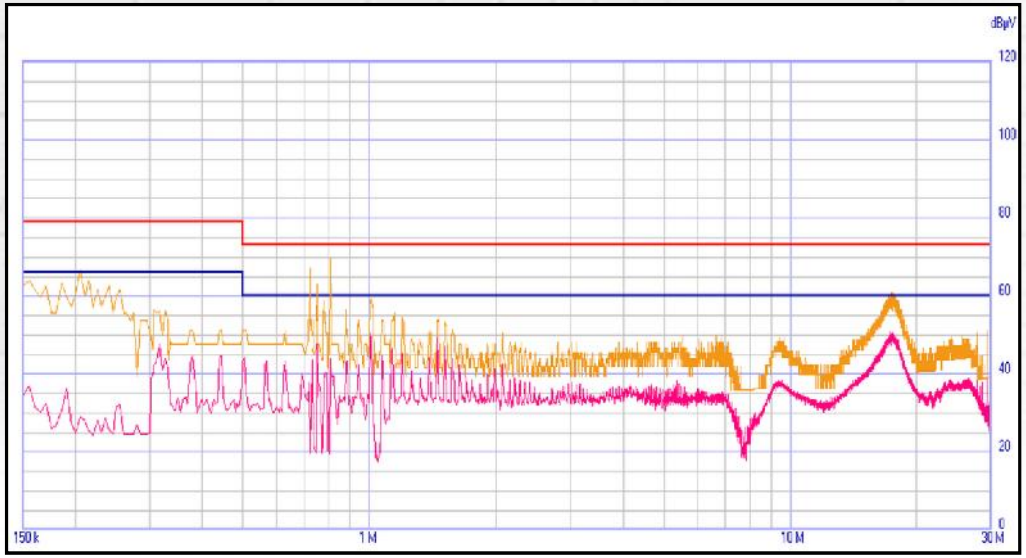
Grounding - Filter

Example: Shorter Ground Cable

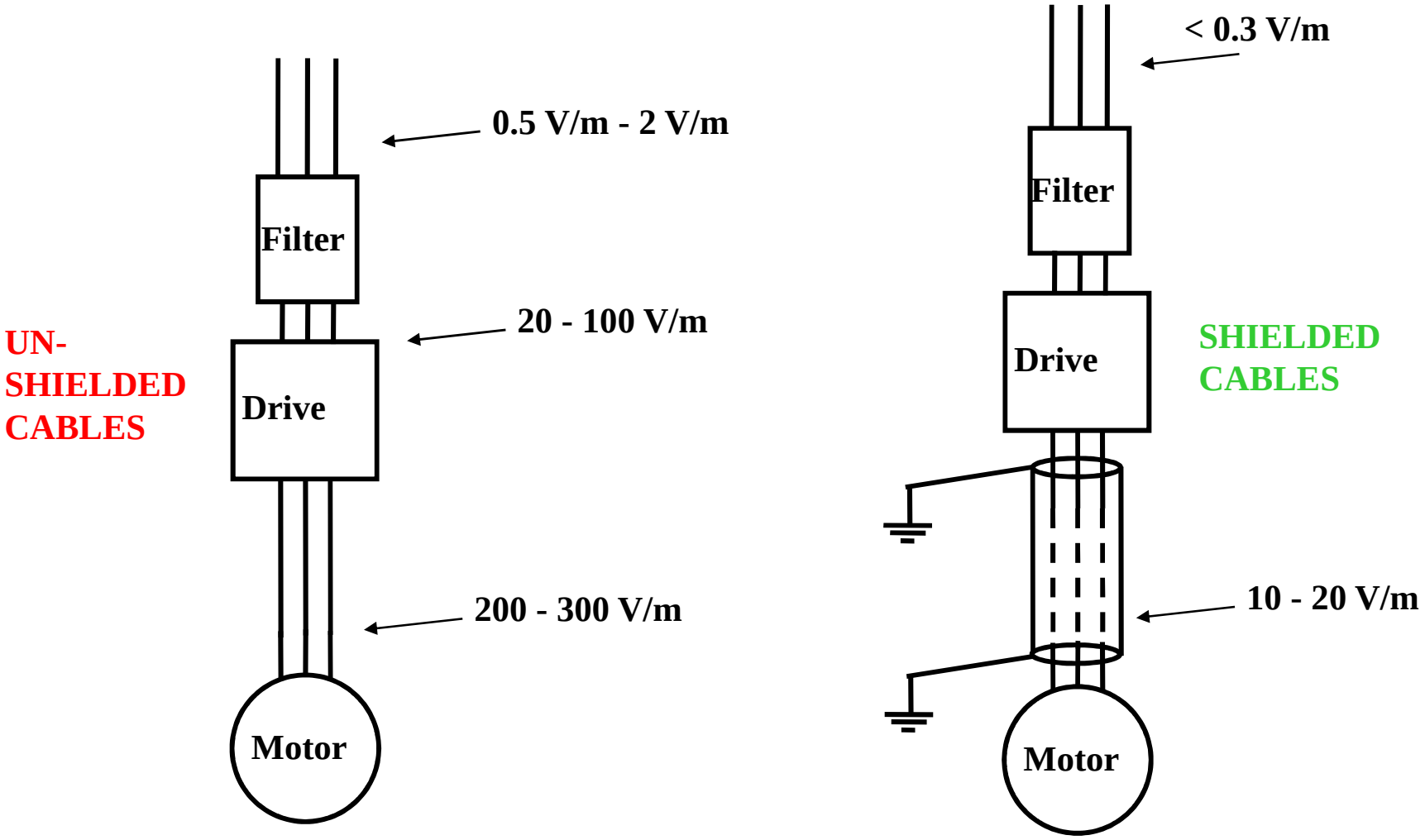
Panel Layout



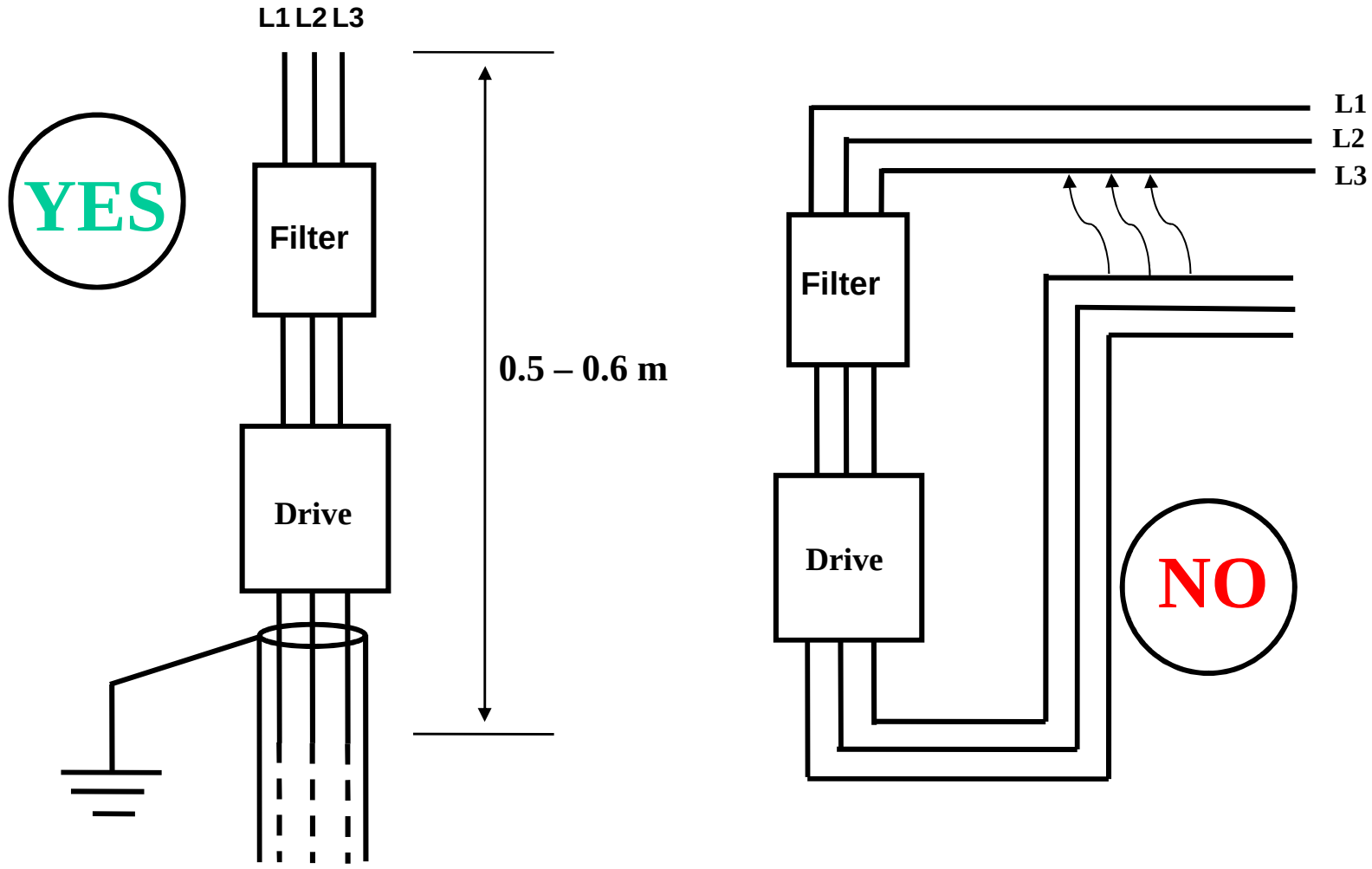
Test Results



Power cables radiate! Use shielded cable



Motor cables should be separated from line filtered cables



Motor cables shield





Very bad connection

Filter Installation



Initial condition
EMC filter on the drive

Filter Installation



Second condition
EMC filter on the drive, improved the shielding of the motor cable

Filter Installation



Final condition
EMC filter on the mains
improved the shielding of the motor cable

Filters application



Main switch



3 phase
series filter

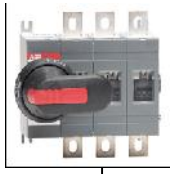


PLC



Servodrives / VDF

Filters application



Main switch

3-phase
parallel filter





3 phase
series filter



PLC

Servodrives





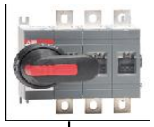


Servomotors



Servomotors

Filters application



Main switch



3-phase parallel filter



PLC

Servodrives 30Amps





3 phase series filter

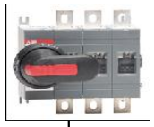


Motors pump 100Amps



Servomotors

Filters application



Main switch

3 phase series filter





PLC

Spindle and Servodrives

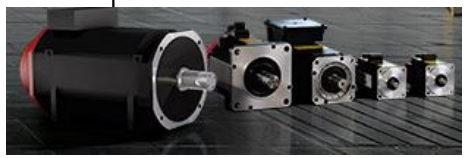


Energy line reactor



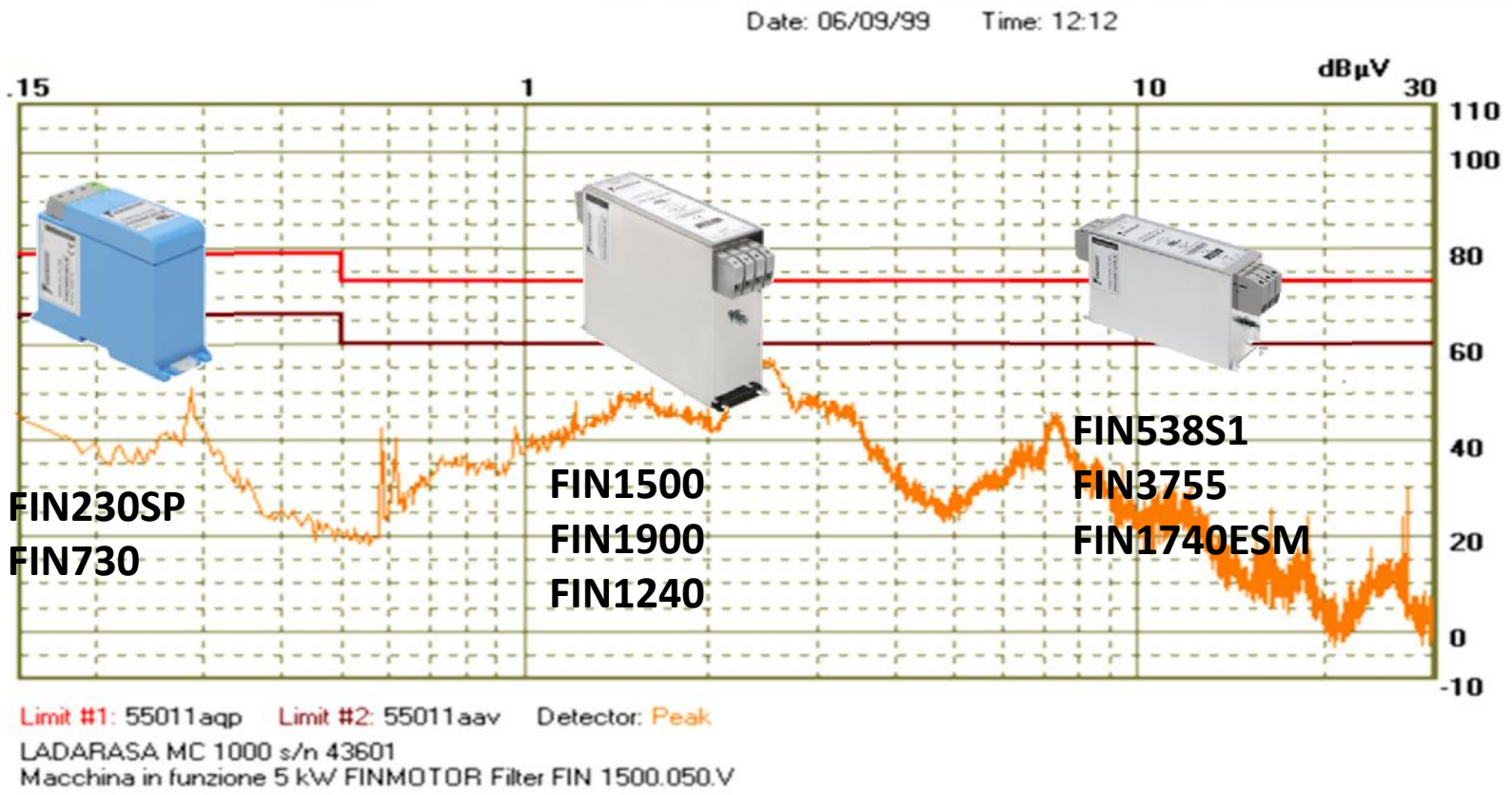


3-phase
parallel filter

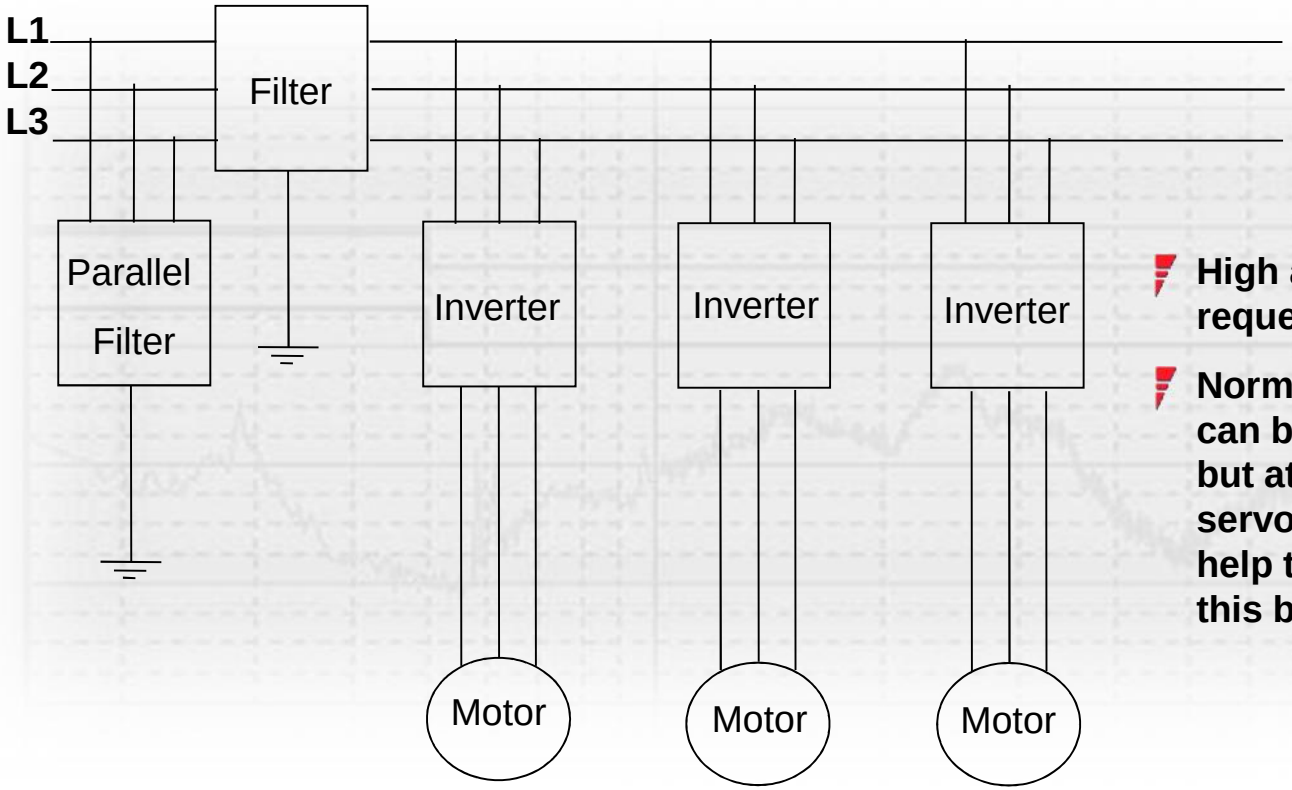


Servomotors

EMI Solution



Application



- **High attenuation in the low f requency band 30 kHz – 5 MHz,**
- **Normally this range of frequency can be reduced by the series filter but at high noises generated by the servodrive, the parallel filter can help to reduce the disturbances in this band.**

Three Phase Filter – Parallel Filter

FIN130SP/FIN230SP/FIN735 *Three Phase Parallel Filters*



FIN130SP.001.M



FIN230SP.001.M



FEATURES

- Independent from nominal current
- Low leakage current
- DIN rail or panel mounting
- Excellent attenuation in low frequency range

BENEFITS

- 5 Year warranty
- High differential and common mode attenuation
- Compact design
- Easy installation

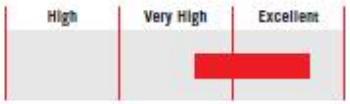
MARKETS

- CNC machines
- Recharging stations
- Multiple drive applications
- Renewable energy

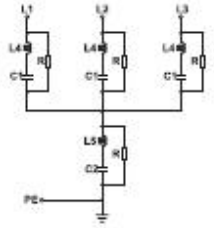
ORDERING CODE

FIN 230SP	.001	.M
Model		Connection
		M = Terminal Blocks

ATTENUATION INDICATOR



ELECTRIC DIAGRAM

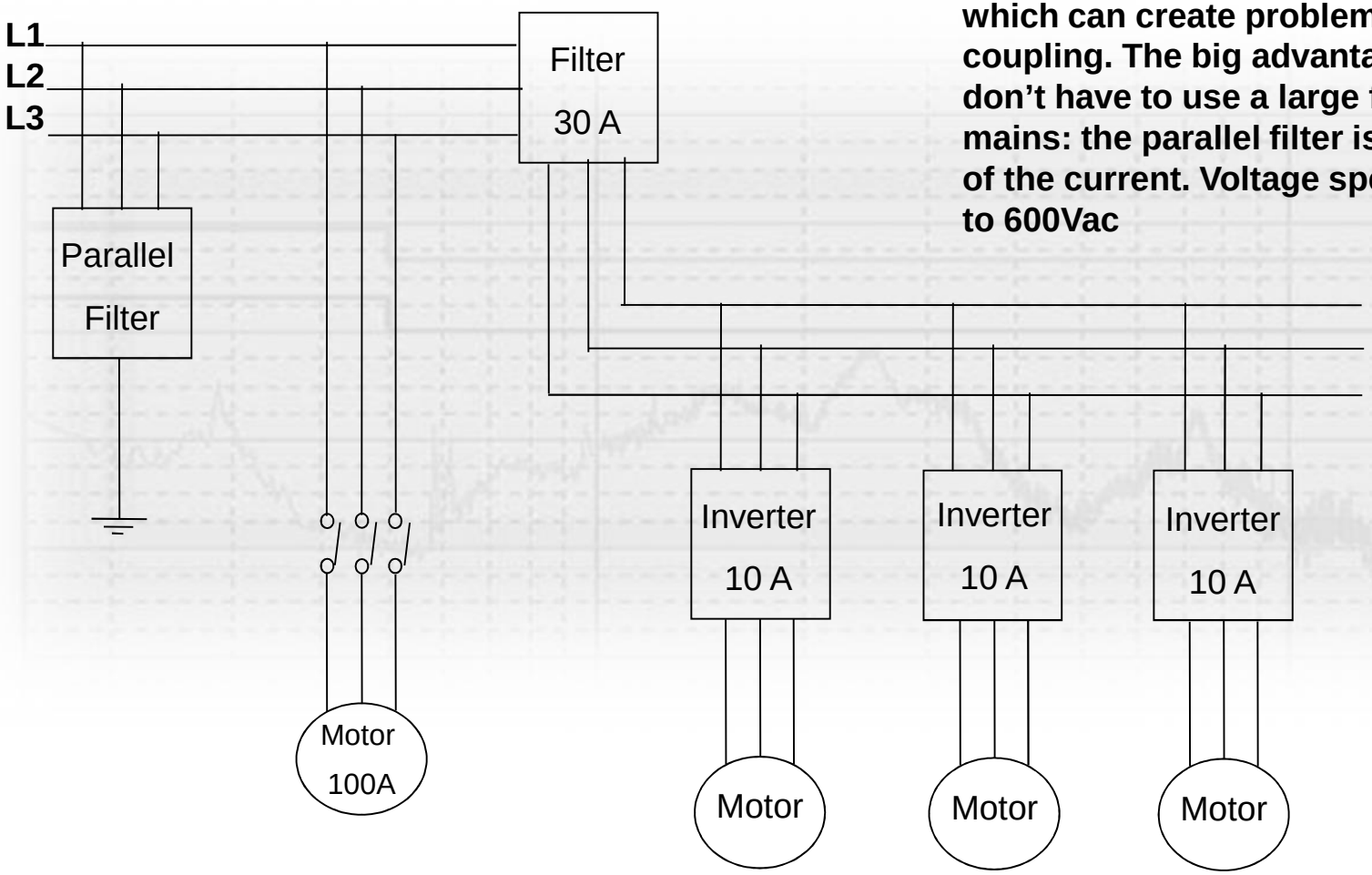


TECHNICAL SPECIFICATIONS

Nominal voltage	See Electrical Characteristics
Frequency	50 – 60 Hz
Rated current	Unlimited
Potential test voltage phase to phase	2400 Vdc (2 sec.)
Potential test voltage phase to ground	3200 Vdc (2 sec.)
Leakage current normal conditions	< 25 mA *
Leakage current worst conditions	< 70 mA
IP Protection	IP20
Climatic class	-40 / +85° C
MTBF at 40°C	250.000 Hrs

Three Phase Filter – Parallel Filter

Application



In this example the parallel filter helps to reduce the disturbance in the band which can create problems of coupling. The big advantage is that we don't have to use a large filter on the mains: the parallel filter is independent of the current. Voltage specific only up to 600Vac

FIN27 — Single Phase Filter



FIN27.(003 - 020).M

FEATURES

- Rated current from 3 to 20A
- Low leakage current
- DIN rail mounting
- Panel mounting available

BENEFITS

- 5 Year warranty
- Excellent differential and common mode attenuation
- Compact design
- Helps comply with industrial and residential Standards

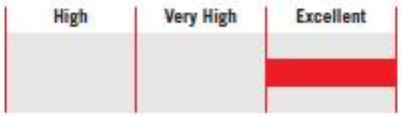
MARKETS

- Automated machines
- LED applications
- Variable frequency drives / servo drives
- Medical equipment

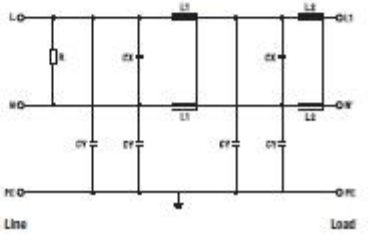
ORDERING CODE

FIN27	.016	.M
Model	Current (A)	Connection
		M = Terminal block

ATTENUATION INDICATOR



ELECTRIC DIAGRAM



Three Phase Filter (FIN538S1)

FIN538S1 — Three Phase Filter



FIN538S1.(007 – 180).M



FIN538S1.(250 – 280).V



FEATURES

- Rated current from 7 to 3000A
- Excellent differential and common mode attenuation
- Low leakage current
- Terminal blocks up to 180A

BENEFITS

- 5 Year warranty
- Various connections available
- Finger safe protection upon request
- Vertical bus bar available

MARKETS

- Electrical equipment
- Machine tools
- Industrial automation
- Frequency drives and servo drives
- Regenerative systems
- Renewable energy

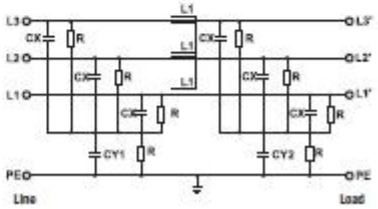
ORDERING CODE

FIN538S1	.007	.M
Model	Current (A)	Connection
		M = Terminal block
		V = Screw
		BC = Bus bar

ATTENUATION INDICATOR



ELECTRIC DIAGRAM



Three Phase Filter (FIN538S1)

FIN538S1 *Three Phase Filter*



FIN538S1.(280 – 1750).BC



FIN538S1.(1750 – 3000).BC

TECHNICAL SPECIFICATIONS	
Nominal voltage	0 / 600 Vac
Frequency	50 – 60 Hz
Rated current	7 to 3000A
Potential test voltage phase to phase	2400 Vdc (2 sec.)
Potential test voltage phase to ground	3200 Vdc (2 sec.)
Leakage current normal conditions	< 10 mA *
Leakage current worst conditions	< 80 mA
IP Protection	IP20 up to 180 A, IP00 over**
Overload capability	4 x Rated current (Switch ON) 2 x In 10 seconds 1.5 In for 10 minutes
Climatic class	-40 / +85° C
MTBF at 40°C	250.000 Hrs

Three Phase plus neutral Filter

FIN1740ESM — *Three Phase + Neutral Filter*



FIN1740ESM.(010 – 180).M

FEATURES
- Rated current from 10 to 180A
- Very high differential and common mode attenuation
- Low leakage current

BENEFITS
- 5 Year warranty
- Suitable for medical applications
- Compact design

MARKETS
- Conveyors
- Automated machinery
- 3D printers
- Medical equipment

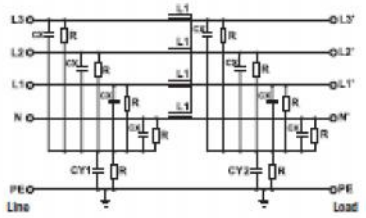
ORDERING CODE

FIN 1740ESM	.072	.M
Model	Current (A)	Connection
		M = Terminal block

ATTENUATION INDICATOR

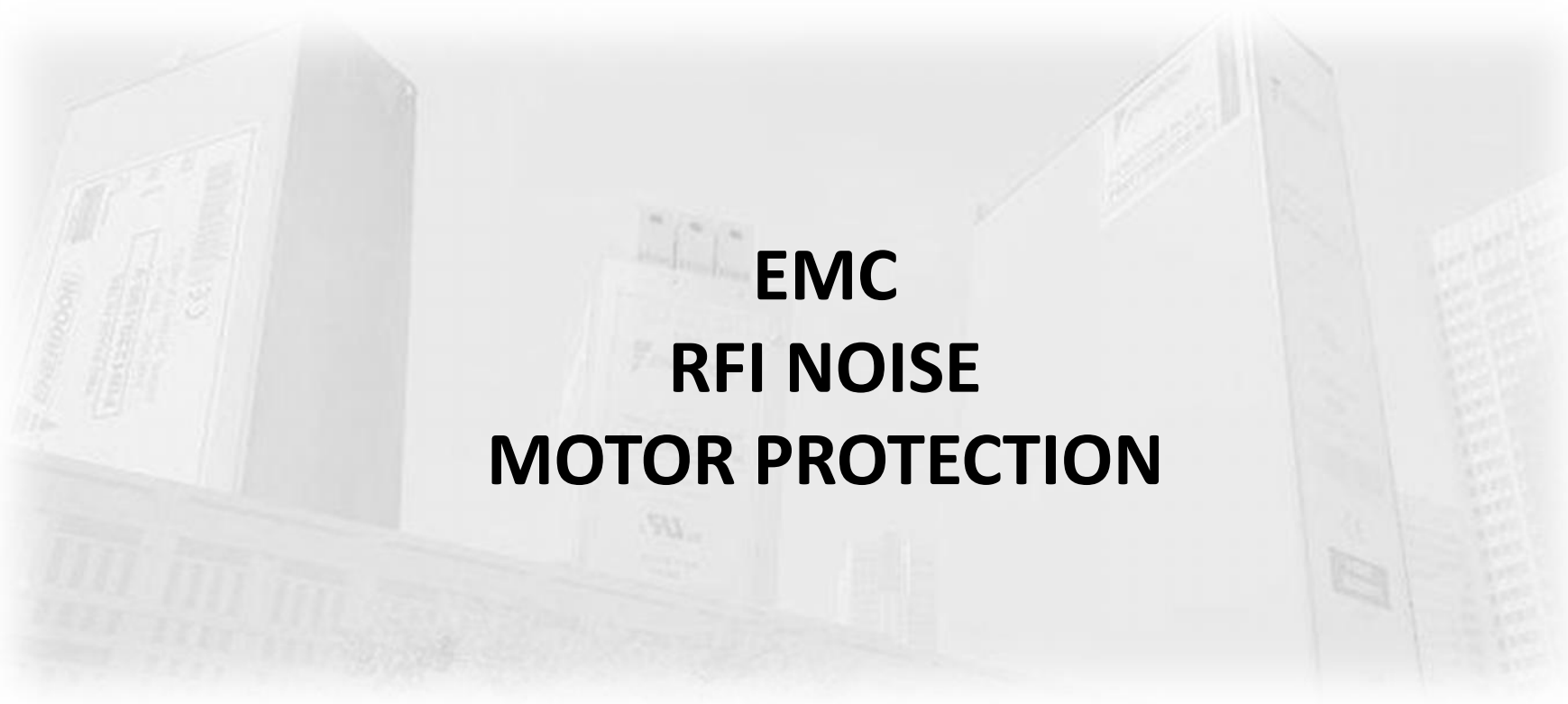


ELECTRIC DIAGRAM



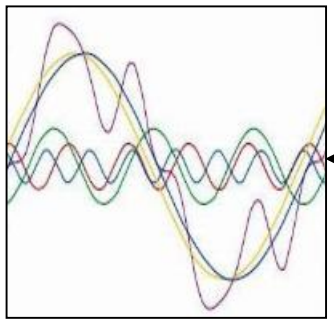
Filters vs. drives manufacturer

Drive manufacturer	Series suggested	Alternative
ABB	FIN538S1	FIN1700
SIEMENS (SIMODRIVE)	FIN538S1 (+ FIN230SP)	FIN1500 (+FIN730)
SIEMENS (MICROMASTER or MASTERDRIVE)	FIN1700 or FIN1700E	
CONTROL TECHINQUES / EMERSON	FIN1700	FIN538S1
YASKAWA (OMRON)	FIN1700 or FIN1700E	
PANASONIC	FIN1700 or FIN1700E	
LENZE	FIN3755	FIN1700E
HEIDENHAIN	FIN538S1 (+ FIN230SP)	FIN1500 (+FIN730)
GE FANUC	FIN538S1 (+ FIN230SP)	FIN1500 (+FIN730)
HITACHI	FIN1700	
ALLEN BRADLEY	FIN538S1 (+ FIN230SP)	FIN1500
BOSCH REXROTH	FIN538S1 (+ FIN230SP)	FIN1500
DELTA	FIN3755	FIN1700E



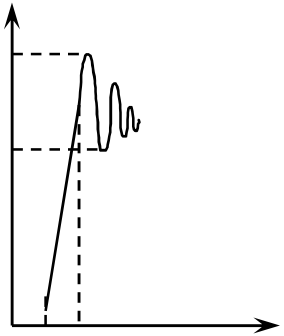
EMC
RFI NOISE
MOTOR PROTECTION

Power Target Areas



Harmonics
PFC
Voltage
stabilizeers





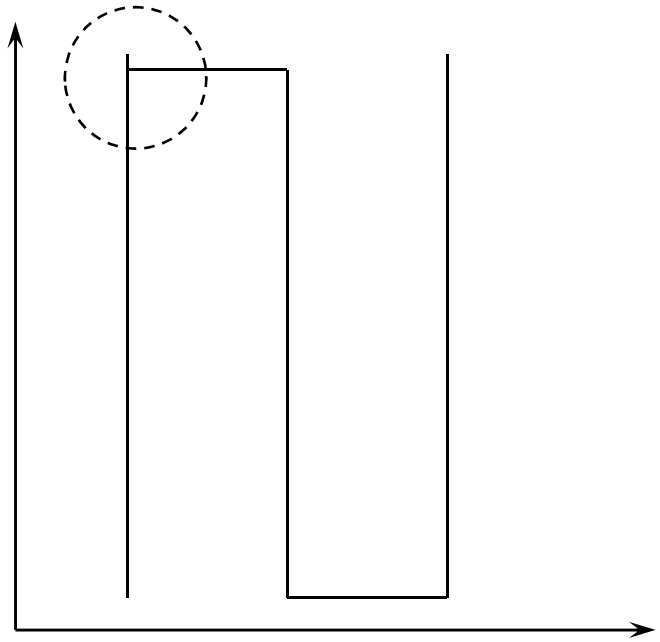


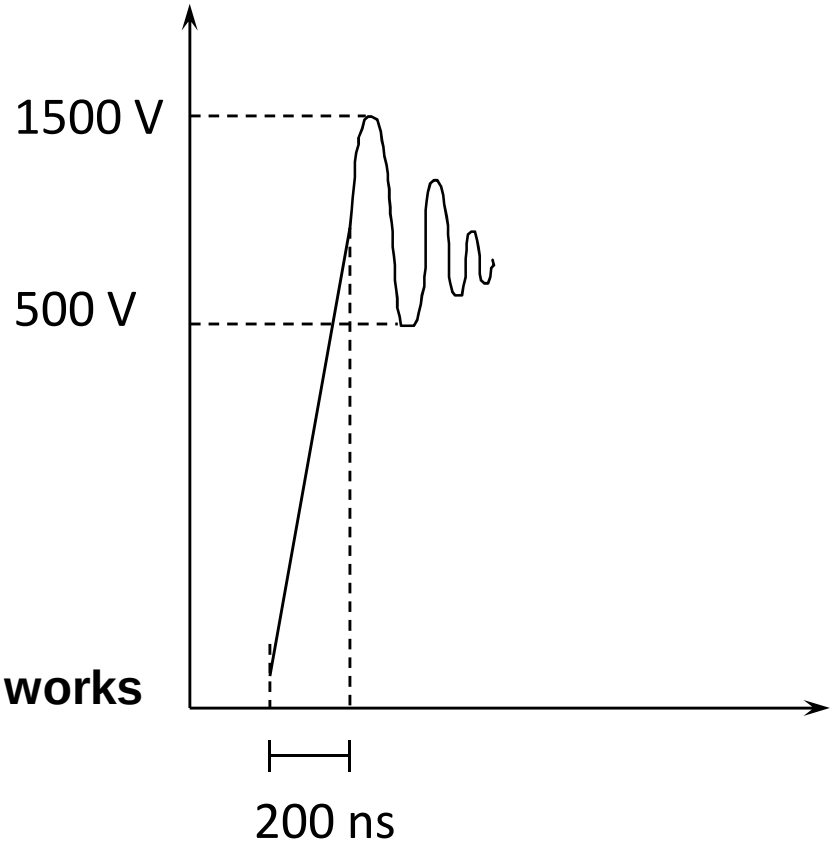
Motor Protection



Radio Frequency interferences

This happens with the frequency of the PWM, it means from 2 to 20 KHz today

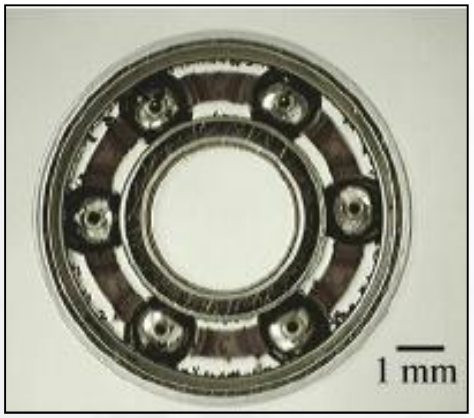




The insulatio system of the motor works in a very stressed condition

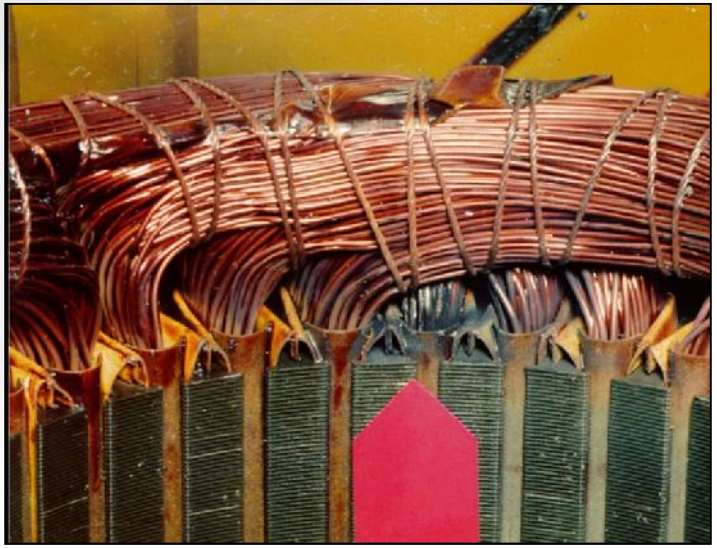
Motor Protection

How does motor protection help?



Motor Protection Reduces:

- Premature Bearing Failure
- Winding Insulation Failure
- Energy Loss (temperature)
- Downtime Production
- Loss of Precision



Solutions

- Output reactor
- Sine wave filter
- Snubber
- High frequency inductance

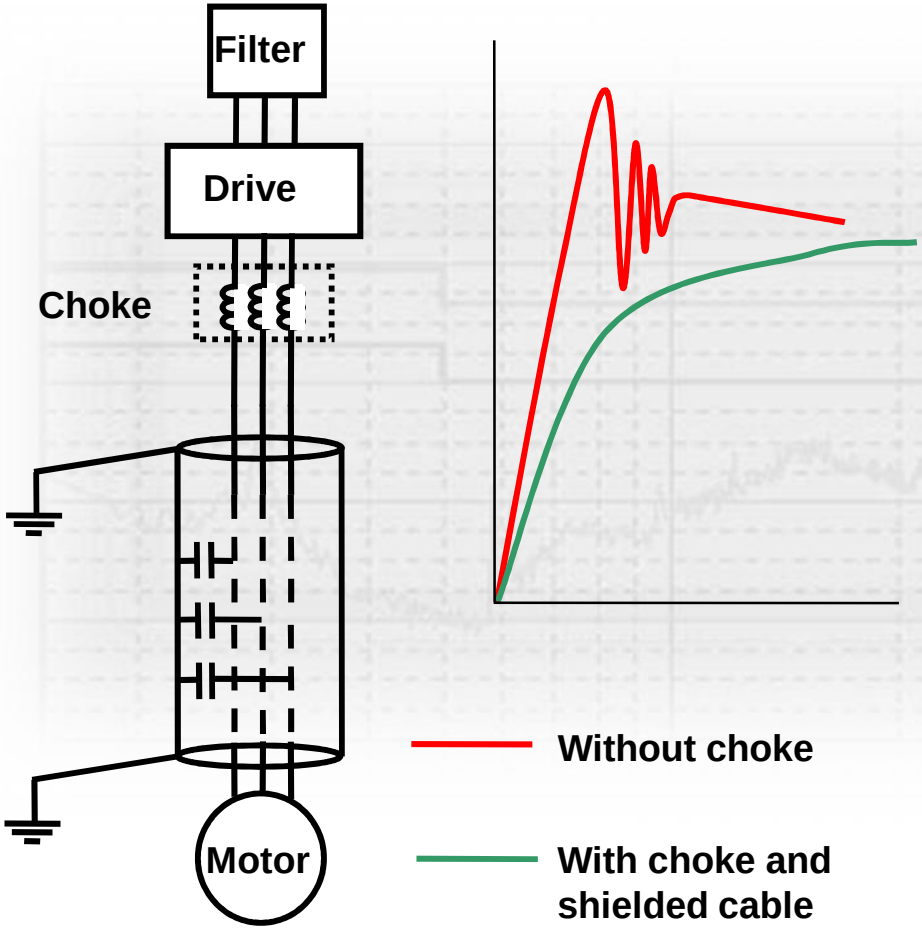






Output reactors

Application



Chokes can be used to reduce overvoltage at the output of the drive

- **Common mode:** often used in combination with shielded cables. Does not add voltage drop
- **Differential mode:** used to separate the drive from multiple motors or long cable runs.

Reducing overvoltage increases the life of the insulation in the motor

Output reactors

FIN950U — Motor Protection



FIN950U.(008 - 300).M

Models available with current ratings up to 3000A

FEATURES
- Rated current from 8 to 300A
- Increases motor life
- Protects against voltage spikes to the motor

BENEFITS
- Terminal blocks up to 200A
- Low power loss
- Available in open frame or enclosure

MARKETS
- Motors controlled by drives
- Pumps
- Conveyers

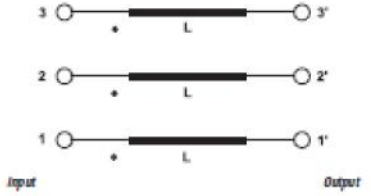
ORDERING CODE

FIN 950U	.008	.M
Model	Current (A)	Connection
		M = Terminal block

ATTENUATION INDICATOR



ELECTRIC DIAGRAM



Output reactors

FIN900 — Motor Protection



FIN900.(010 - 030).1C



FIN900.(010 - 030).C



FEATURES

- 5 Year warranty
- Protects against voltage spikes on the motor
- Compact design

BENEFITS

- Rated current from 10 to 280A
- Reduces voltage rise and high frequency
- Helps pass European emission Standards

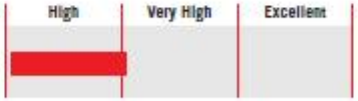
MARKETS

- Motors controlled by drives
- Pumps
- Conveyers
- Automated equipment

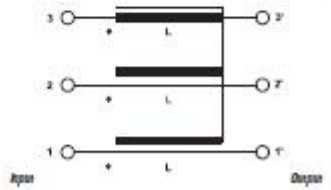
ORDERING CODE

FIN900	.016	.1C
Model	Current (A)	Connection
		1 C = cable 200mm
		2 C = cable 400mm
		C = cable
		V = screws

ATTENUATION INDICATOR

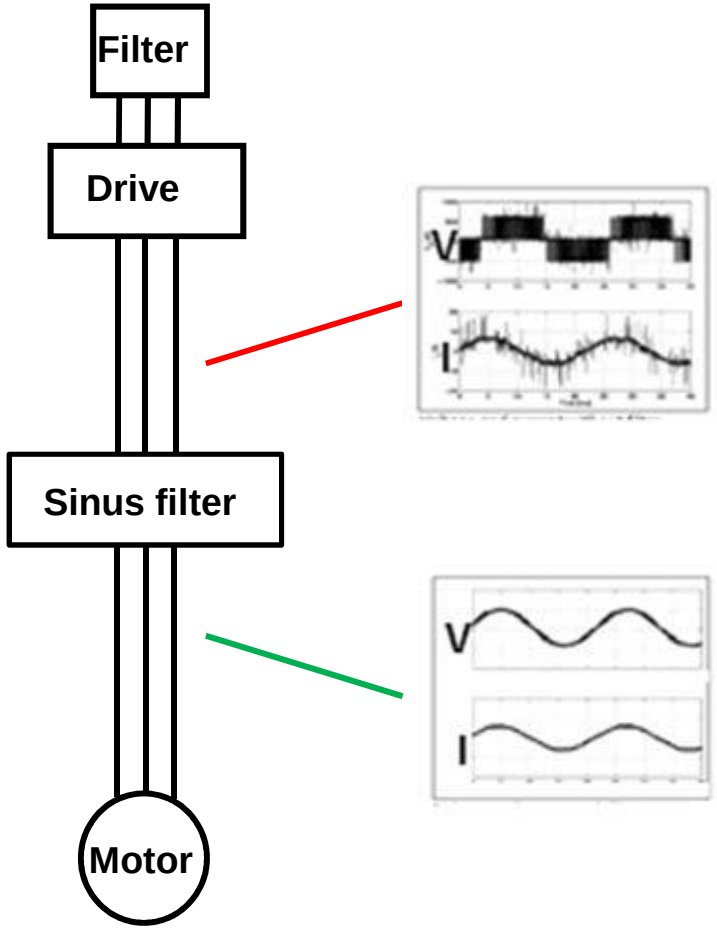


ELECTRIC DIAGRAM



TECHNICAL SPECIFICATIONS

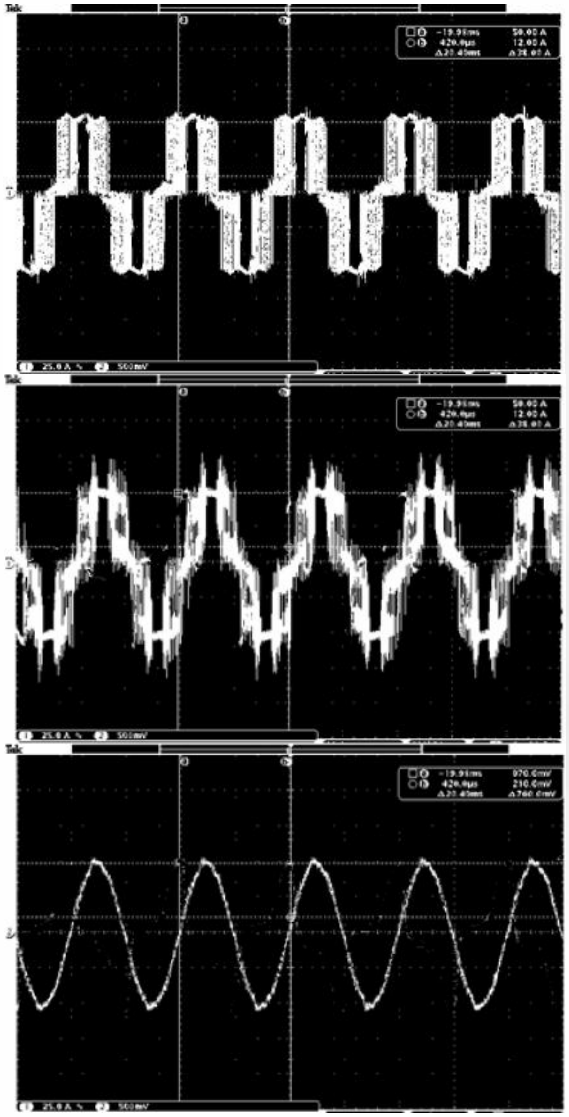
Application



Sinus filter converts the PWM output signal into a sinusoidal wave with residual < 5%

- No overvoltage transient occurring at the motor winding
- Low motor noise due to low presence of harmonics
- No need for motor shielding power cables
- EMC testing, conducted and radiated emission

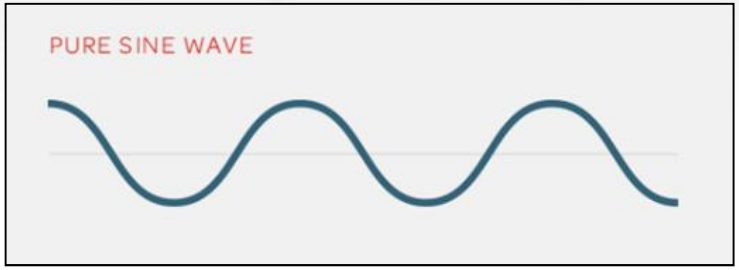
Sinus filter



Measurement between VFD and motor **without filtering**

Measurement between VFD and motor **with load reactor**

Measurement between VFD and motor **with sine wave filter**



*Grid Power Typical
Best for Motors

Sinus filter

ENERDOOR

FIN905SF — Motor Protection

FEATURES
- Rated current from 5 to 880A
- Very compact size
- Available in Nema 1 or Nema 3R enclosure

BENEFITS
- Low power loss
- No ventilation required
- Excellent performance versus frequency and current
- Available in open frame or enclosure

MARKETS
- Long cable applications - 2.500m
- Process plants
- Water treatment
- Agriculture
- Variable frequency drives

ORDERING CODE

FIN905SF	.100	.M	-N1
Model	Current (A)	Connection	Enclosure
		M = Terminal	N1 = Nema 1 (IP20)
		V = Screws	N3R = Nema 3R (IP54)
		B = Bus bar	



FIN905SF.(005 - 045).M

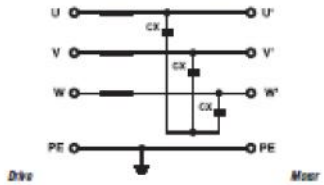


FIN905SF.(260 - 410).B

ATTENUATION INDICATOR

High	Very High	Excellent

ELECTRIC DIAGRAM





FIN905SF.(060 - 180).M



FIN905SF.(480 - 880).B

TECHNICAL SPECIFICATIONS

Nominal voltage	0 / 600 Vac
Output frequency	0 - 100 Hz
Rated current	5 to 880A
Carrier frequency (PWM)	>4 KHz, see table
Ambient temperature	70°C
Altitude	1000 m
Relative humidity	<95% no condensation
Overload capability	4 x Rated Current (Switch ON) 2 x In 10 seconds 1.5 x In 10 minutes
IP Protection	IP20 up to 180A IP00 over 260A
Optional	Enclosure, fan

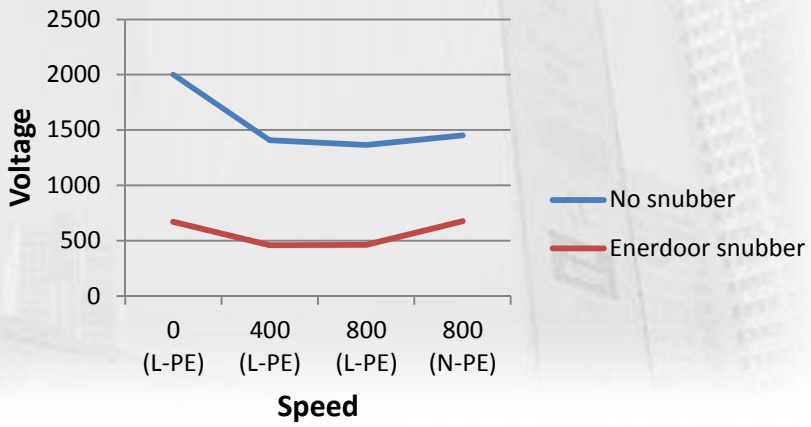
Motor protection Solution

Snubber reduces dV/dt spikes, improving motor life and reducing stress to the components.

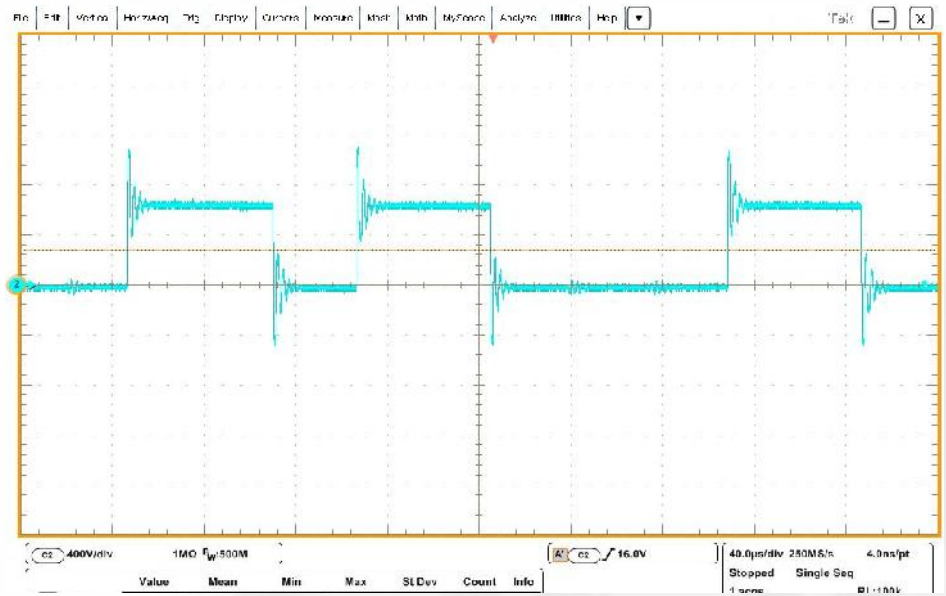
Application



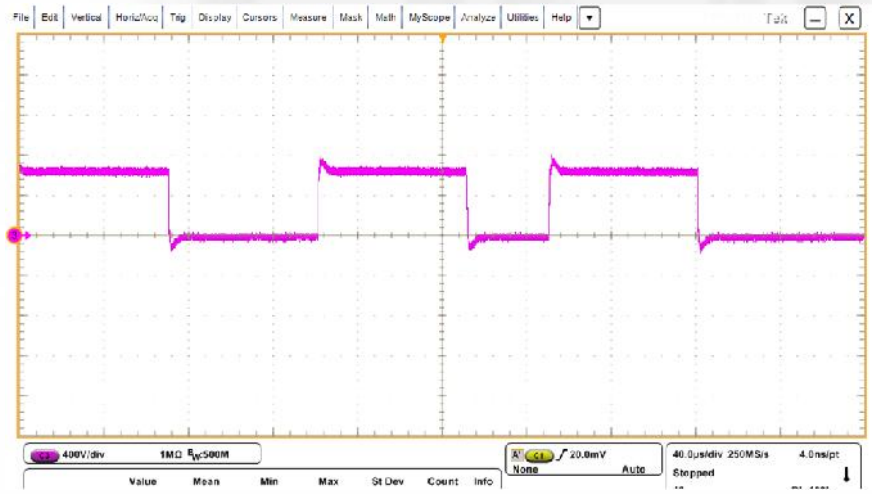
Example of spikes reduction



Solutions - Snubber

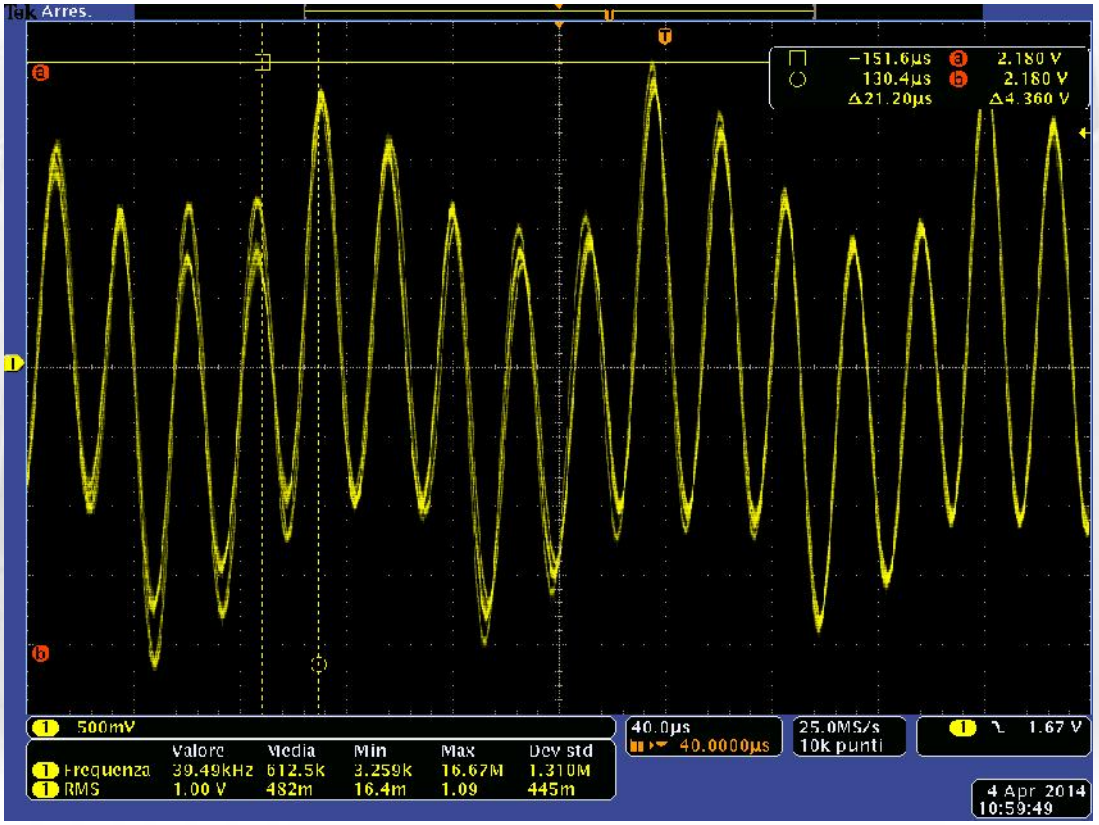


No snubber filter
Max: 1104 V
Min: -480 V
dv/dt: ~ 3.04 kV/us



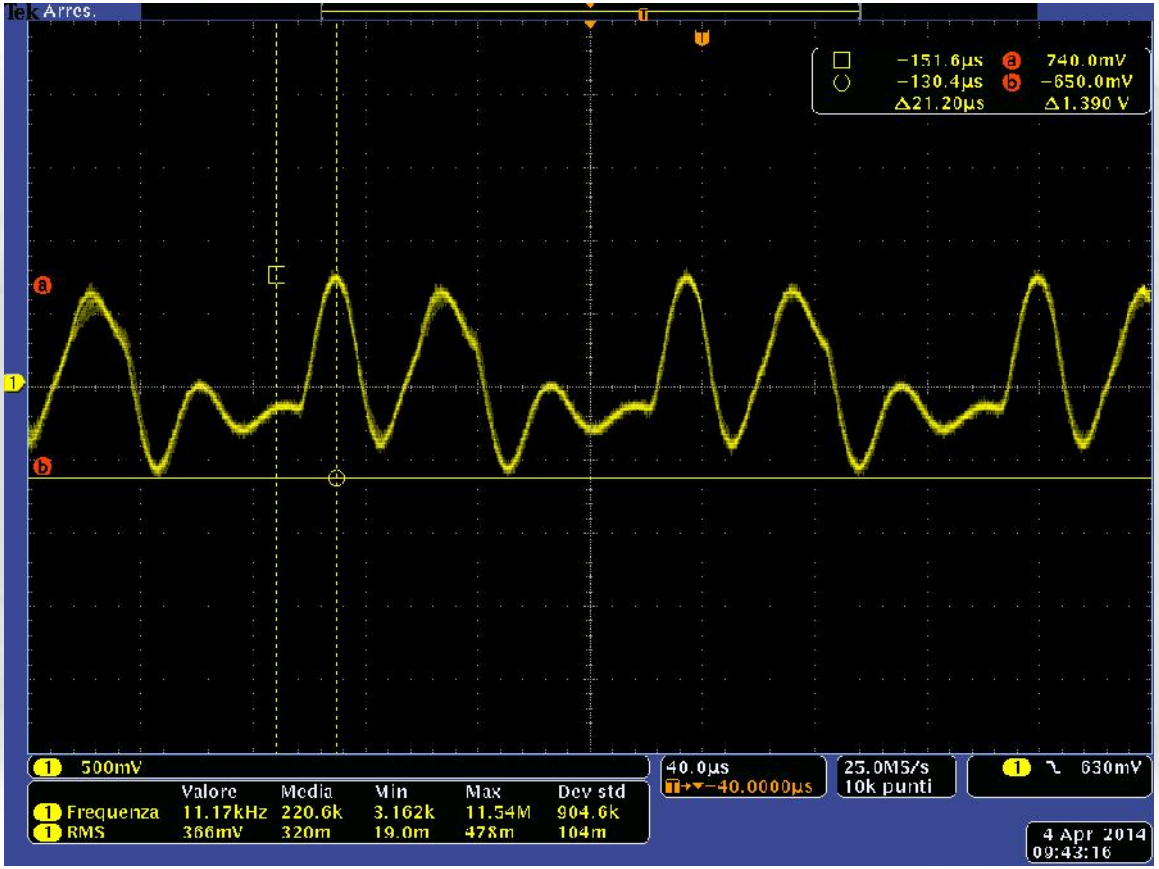
With snubber filter
Max: 800 V
Min: -176 V
dv/dt: ~ 1.93 kV/us

Choke from competitors with wrong material
NO snubber



Initial condition
life duration of the motorn 15 MINUTES

FIN960F with snubber



Final condition
Still working after 4 years

ENERDOOR

ENERDOOR **FINSTP** *Motor Protection*



FINSTP.(068 - 100).M100

FEATURES

- Reduces dV/dt star point -PE
- Protection of motor winding insulation and bearings
- Remote contact indicator
- Compact dimension due to the parallel installation

BENEFITS

- Very low power loss
- Over temperature protection
- Easy installation
- Only one model for unlimited HP motors

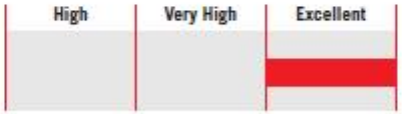
MARKETS

- Large motors
- Spindle motors
- Long cable applications with variable frequency drives or servo drives

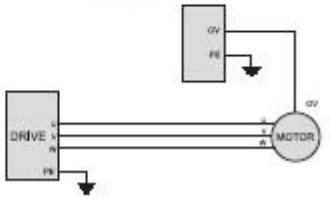
ORDERING CODE

FINSTP	.068	.M100	.A
Model	Impedance	-	Fan nominal voltage A = 24Vdc B = 24Vac C = 110Vac D = 220Vac

ATTENUATION INDICATOR



ELECTRIC DIAGRAM



ENERDOOR

ENERDOOR

FIN47SNB

Motor Protection



FIN47SNB.050.1M

FEATURES

- Reduces dV/dt
- Protection of motor winding insulation and bearings
- Remote contact indicator
- Compact dimension due to the parallel installation

BENEFITS

- Very low power loss
- Available with remote electronic control
- Easy installation
- Only one model for unlimited HP motors

MARKETS

- Large motors
- Spindle motors
- Long cable applications with variable frequency drives or servo drives

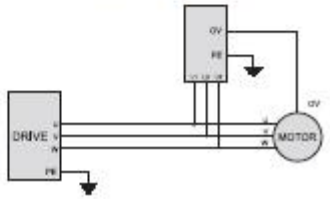
ORDERING CODE

FIN47SNB	.050	.1M	.A	MSD1
Model	Impedance	Connection	Fan nominal voltage	Electronic control
		1M = 1 motor	A = 24Vdc B = 24Vac	MSD1 at 24Vdc
		2M = 2 motors	C = 110Vac D = 220Vac	MSD2 at 230Vac

ATTENUATION INDICATOR



ELECTRIC DIAGRAM



High frequency reactors

ENERDOOR

FIN960F — Motor Protection



FIN960F.(010 - 1000).M

FEATURES
- Rated current from 10 to 1000A
- Increases motor life
- Protects against voltage spikes to the motor
- Customizable per motor specifics to optimize the system

BENEFITS
- Low power loss with frequency output up to 5 kHz
- No ventilation required
- Excellent performance versus frequency and current
- Available in open frame or enclosure

MARKETS
- High speed motors
- CNC Machines
- Woodworking machines

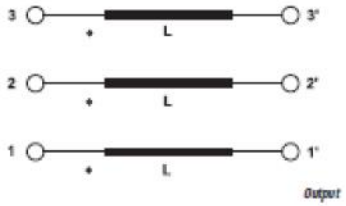
ORDERING CODE

FIN960F	.050	.M	010
Model	Current (A)	Connection	Inductance value (L)
		M = Terminal block	

ATTENUATION INDICATOR

High	Very High	Excellent

ELECTRIC DIAGRAM

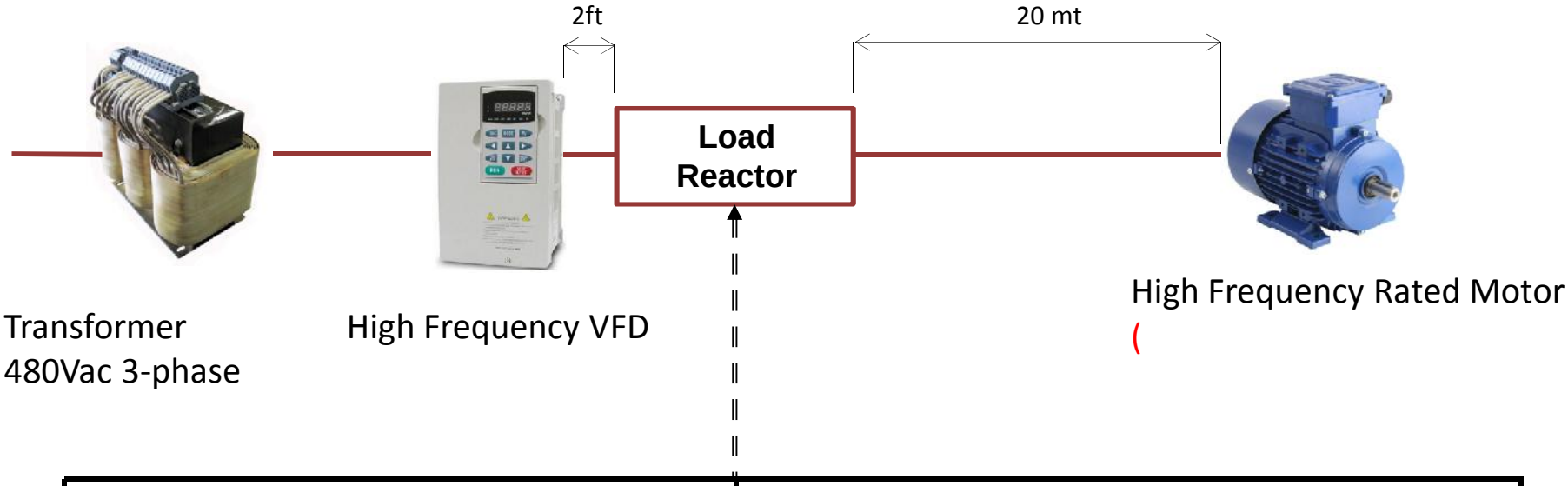


TECHNICAL SPECIFICATIONS

Nominal voltage	0 / 750 Vac
Output frequency	0 - 5000 Hz
Rated current	10 to 1000A
Carrier frequency (PWM)	0 - 20 kHz
Potential test voltage phase to phase	2400 Vdc (2 sec.)
Potential test voltage phase to ground	3200 Vdc (2 sec.)
IP Protection	IP20
Overload capability	4 x Rated current (Switch ON) 2 x In 10 seconds 1.5 In for 10 minutes
Climatic class	-40 / +85° C
MTBF at 40°C	250.000 Hrs

High frequency reactors

Setup

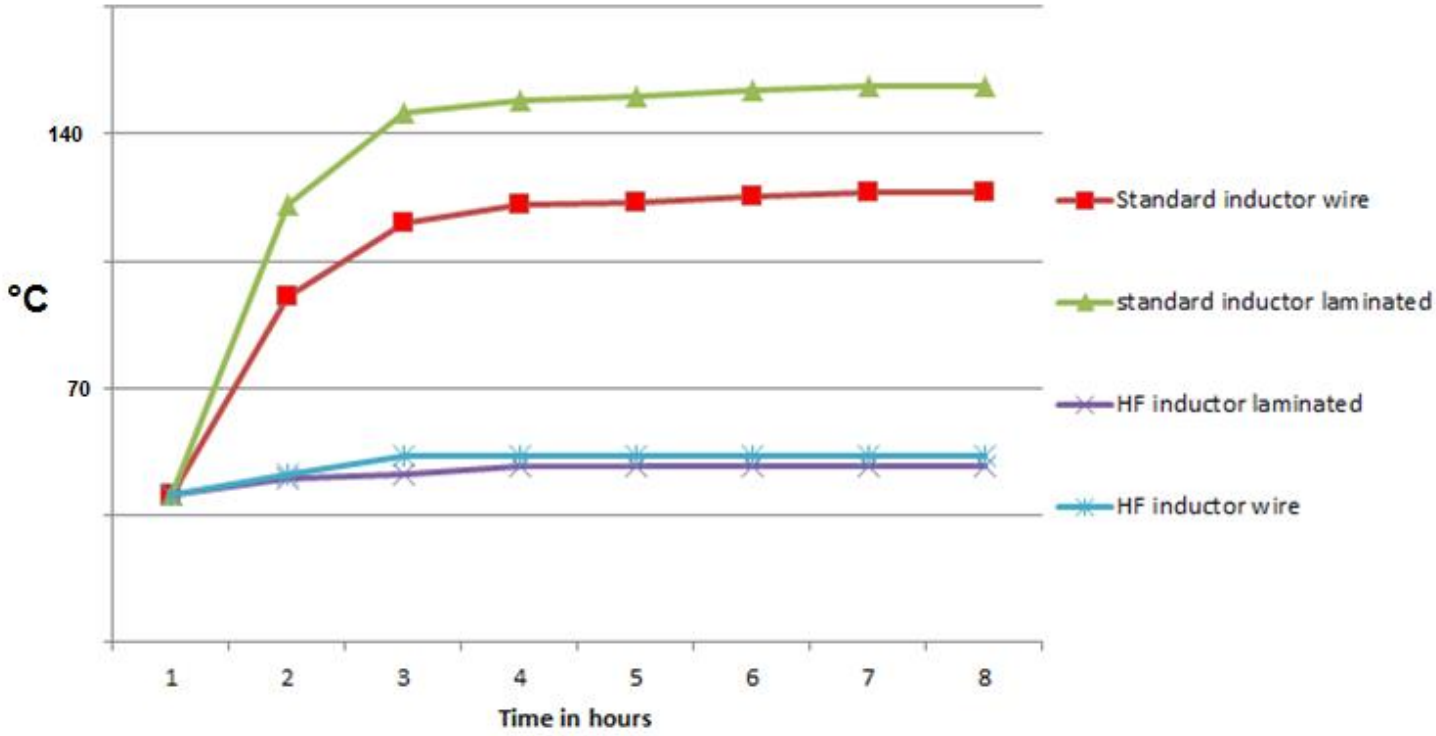


PRODUCT A	PRODUCT B
 3-phase load reactor V = 480Vac L = 2.4mH I = 25 A Core Material: Iron laminate	 3-phase high frequency load reactor V = 480Vac L = 2.4mH I = 25 A Core Material: high frequency material

Temperature Testing

- **Wire Temperature**
- **Laminate Temperature**

Laminated Inductor & High Frequency Inductor at 300Hz



Note: Ambient Temperature = 25 °C



POWER QUALITY
VOLTAGE STABILIZERS

Voltage Stabilizer– The Problem

- Under voltage shut-down the equipment
- Over-voltage – equipment in protection
- Voltage variation increase electrical and mechanical stress

Voltage Stabilizer

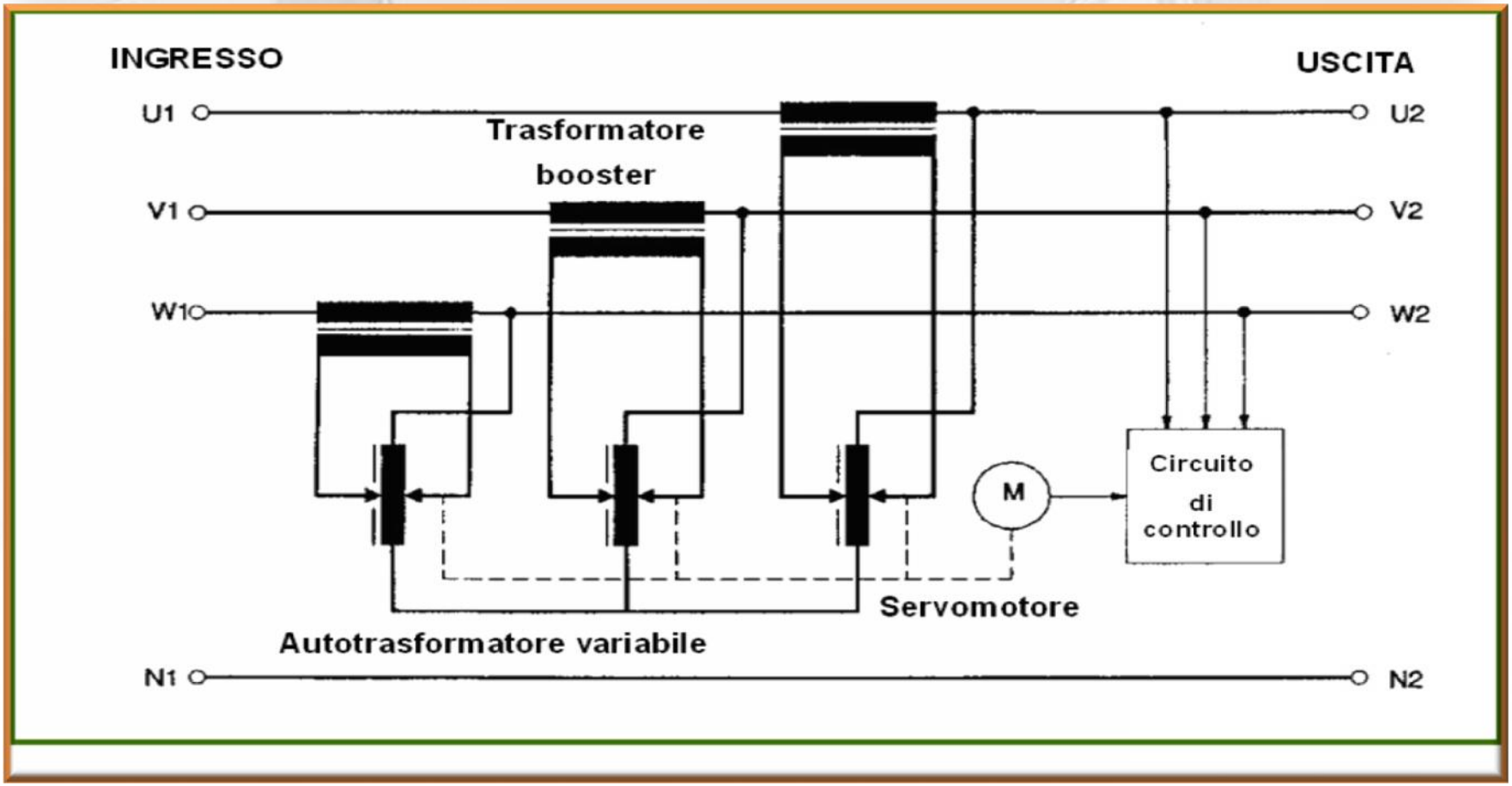
- What is a Voltage Stabilizer

  The scope of the voltage stabilizer is to maintain the output voltage in a certain tolerance range (for example 1%); independently by the input voltage in a certain tolerance (for example 30%).

- Wher are used?

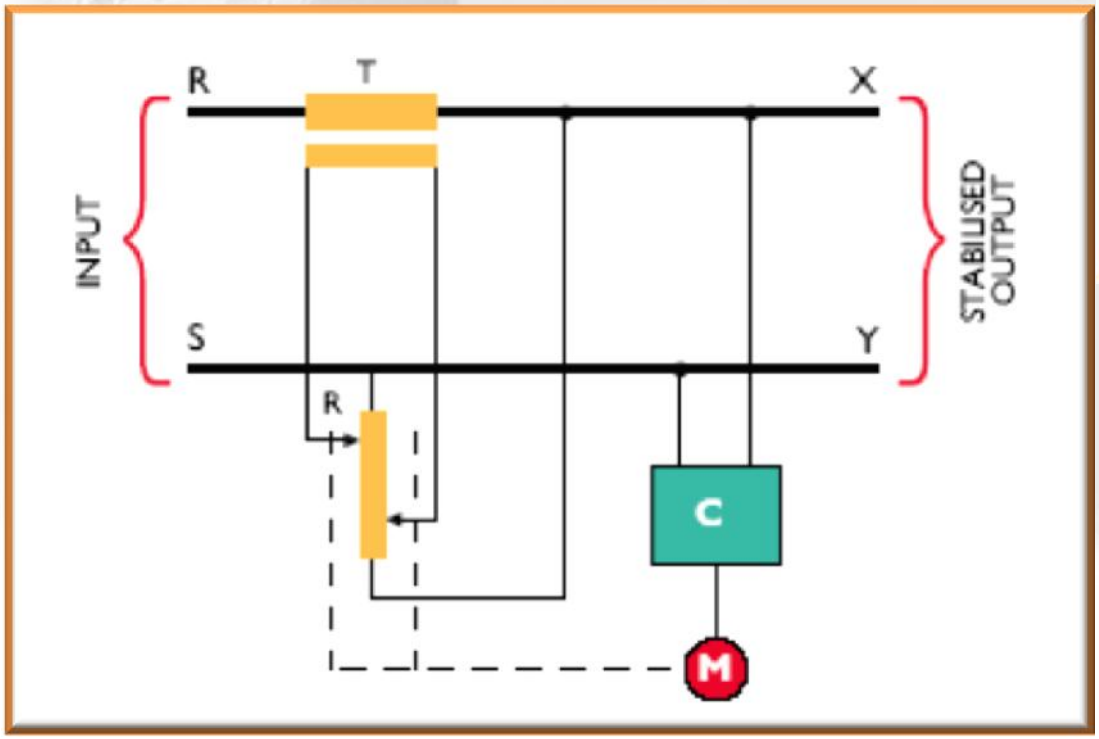
  When the electrical network is not stable the variation of the voltage can creat problems or damages on the machine or on the components; in this case is necessary to use a voltage stabilizers.

Principle of operation

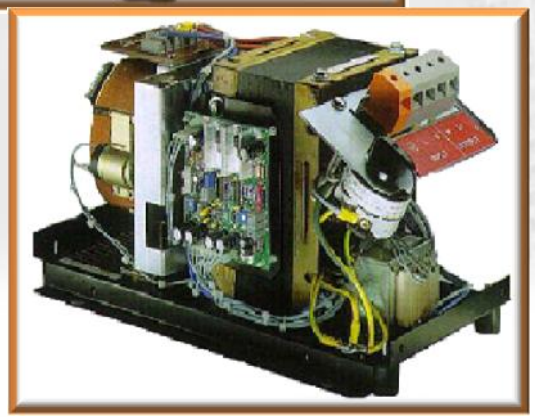


FINSMT - FINSMC

Single phase





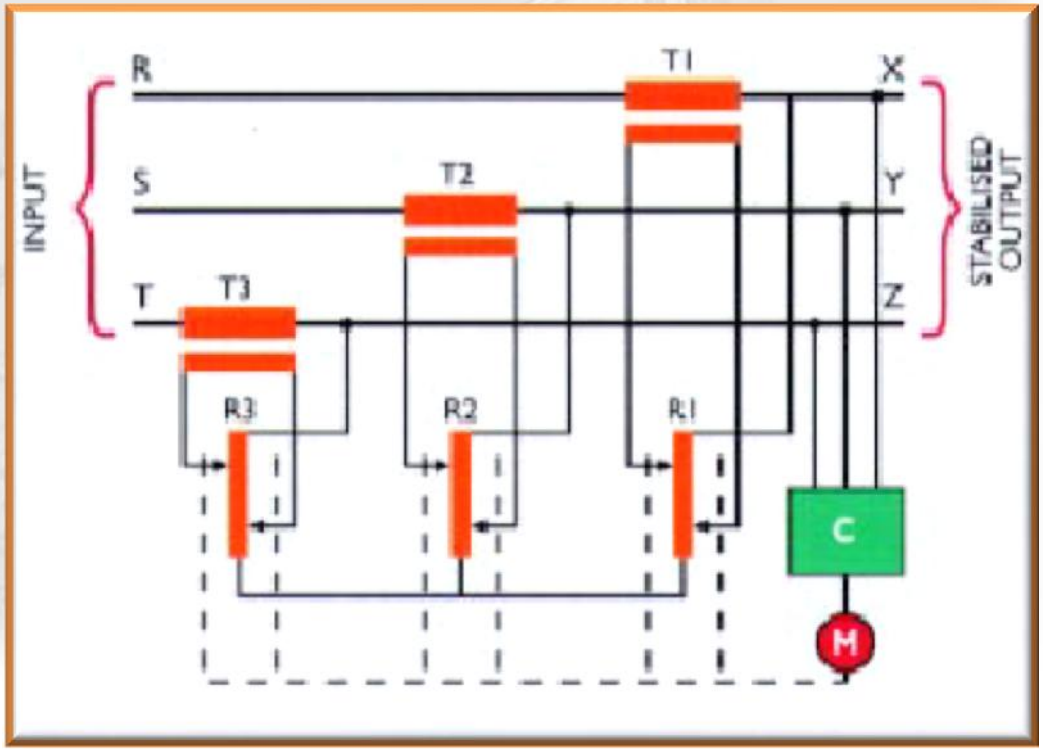


FINSTT - FINSTC

Average regulation: the control measures the 3 phase, evaluate the average and make the correction basing on this value.

There is one motor for the three phase, same correction on the three phase.

If the variation are always in the same direction (example 3 phase down or up in similar way) this product is perfect.

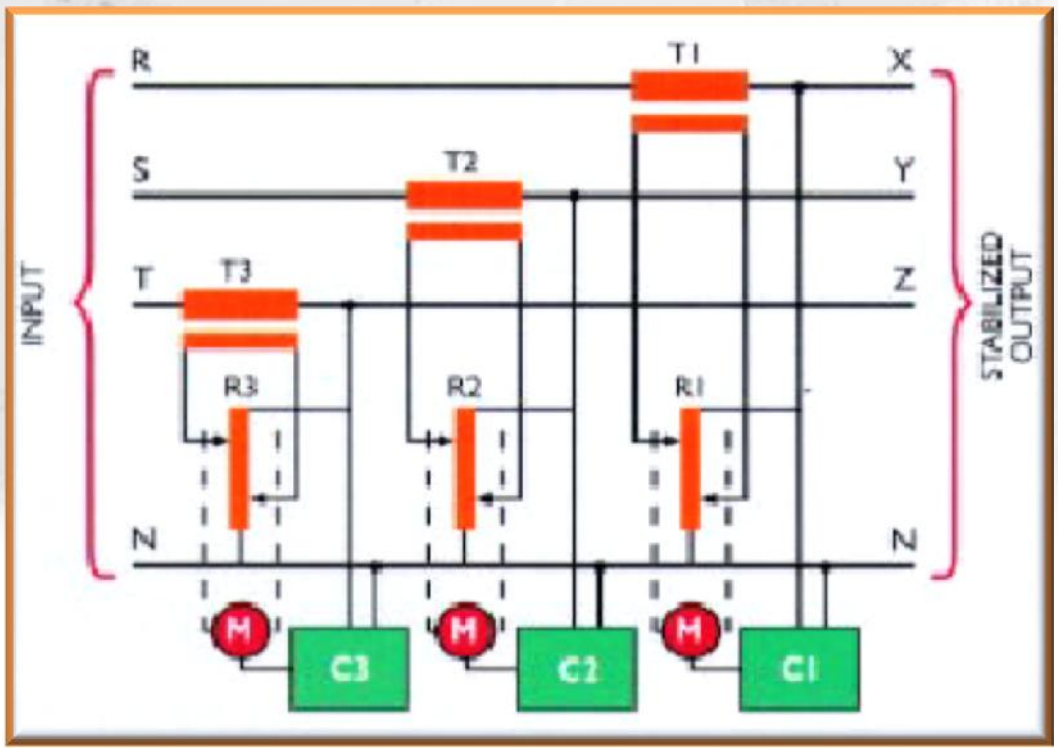


FINSTTY – FINSTCY – FINSTTA – FINSTCA

Indipendent regulation:
the control measures the 3 phase indipendently.

There are three motors for the three phase, every phase has indipendent correction

If the variation are different on the three phase (example 420 Vac, 400 Vac, 380 Vac) is necessary to use this product.



FINS Voltage Stabilizers



8 types

2 single phase

- ➢ **FINSMT**
- ➢ **FINSMC**

6 Three phase

- ✓ **FINSTT**
- ✓ **FINSTC**
- ✓ **FINSTTY**
- ✓ **FINSTCY**
- ✓ **FINSTTA**
- ✓ **FINSTCA**

FINS Voltage Stabilizers



Single phase Voltage:

From 100 to 300 V

Three phase Voltage:

From 200 to 690 V

Frequency:

50 and 60 Hz

FINS Voltage Stabilizers



2 types of regulation:

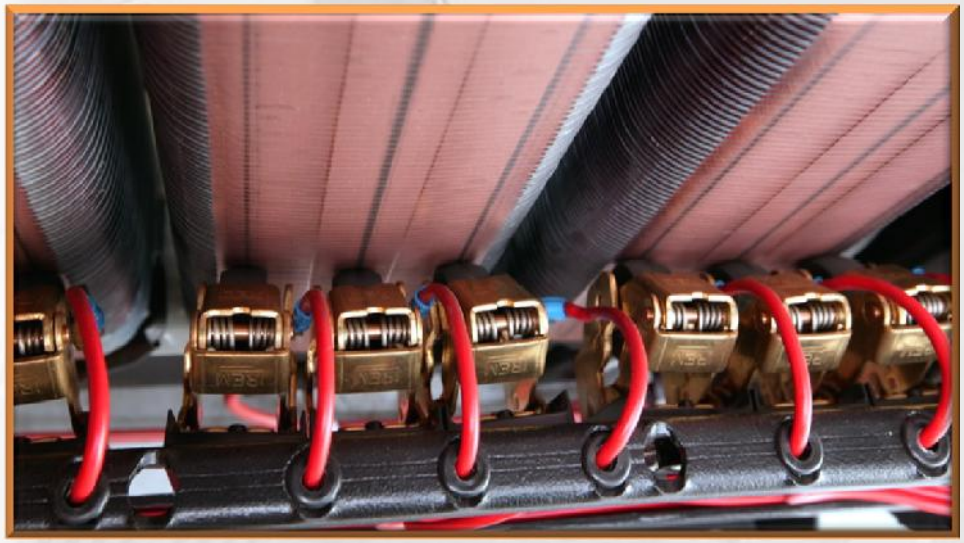
- Average
- Indipendent

2 different cores

- Toroidal
- Square section core

FINSTTY – FINSTCY – FINSTTA – FINSTCA

Square section core



Autotrasformatore variabile monofase



FINS Voltage Stabilizers



Different possibility in input

- ±30%
- ±25%
- ±20%
- ±15%
- ±10%

- +15 / -35%

FINS Voltage Stabilizers



Output tolerance

Single phase

- ±0,5%
- ±1,0%
- ±1,5%

Three phase

- ±1,0%

Tempi di risposta (ms/V)

- 11 fino 50 ms/Volt

FINS VOLTAGE STABILIZERS



Protection	Envinronment
IP20/21/31	INDOOR

FINS VOLTAGE STABILIZERS



Protection	Envinronment
IP54	INDOOR

FINS VOLTAGE STABILIZERS



Protection	Envinronment
IP54	OUTDOOR

FINS VOLTAGE STABILIZERS

Options:

- ✓By-Pass manual or automatic
- ✓Main swithc
- ✓Differential protection
- ✓Soft start
- ✓Insulation transformer
- ✓Overvoltage protection
- ✓Power analyzer
- ✓Voltage regulation
- ✓ Others….



THANK YOU

