Filtering **solutions** for improving **energy efficiency**

CIRCUTOR

Technology for energy efficiency

ORIGIN	FAULTS
Interference caused by converters Motor drives, UPS, etc. (Individual protection is recommended)	Sypply side: Current harmonics (Low frequency) · Excessive losses in lines and transformers · Wave form distortion · Earth-leakage tripping EMI (High frequency) · Earth-leakage tripping · Interference to electronic equipment Load side: Excessive ripple at the switching frequency · Interference to electronic equipment Excessive du/dt · Damage to insulation in motors
Non linear loads distributed in the system Converters, induction ovens, UPS, discharge lamps, etc. (Overall protection of the system is recommended)	Harmonic resonance: · Overload of PF correction equipment · Overload and vibration in the transformer · Distortion of the voltage wave Current harmonics: · Excessive losses · Distortion of the voltage wave · Earth-leakage relays tripping
Single-phase, non linear loads between phase and neutral Electronic equipment, discharge lighting, etc. (Zonal protection is recommended)	High third harmonic: · Waveform distortion · Earth-leakage relays tripping Overload of neutral in systems of 4 wire (3 phases + neutral)

SOLUTIONS

· LR reactors

· LCL and LCL-th filters

LR Reactors

LCL and
LCL-th Filters

· EMI filters

· Inmunized earth-leakage protection

EMI Filters

Sinus filter
FS type

· Sinus filters

· du / dt filters

FR, FRE rejection filters:

· 7% if 5th, 7th harmonics are dominant

· 14% if third harmonic is dominant

Absorption regulated filters:

· FAR-Q, FARE-Q (5th and 7th harmonic)

· FAR-H (5th, 7th, 11th, 13,...)

ACTIVE filters with or without phase balance

ACTIVE Filters

FR, FAR-Q, FARE-Q and FAR-H Filters

· FB3 and FB3T filters

· TSA insolation transformer with harmonics filtering

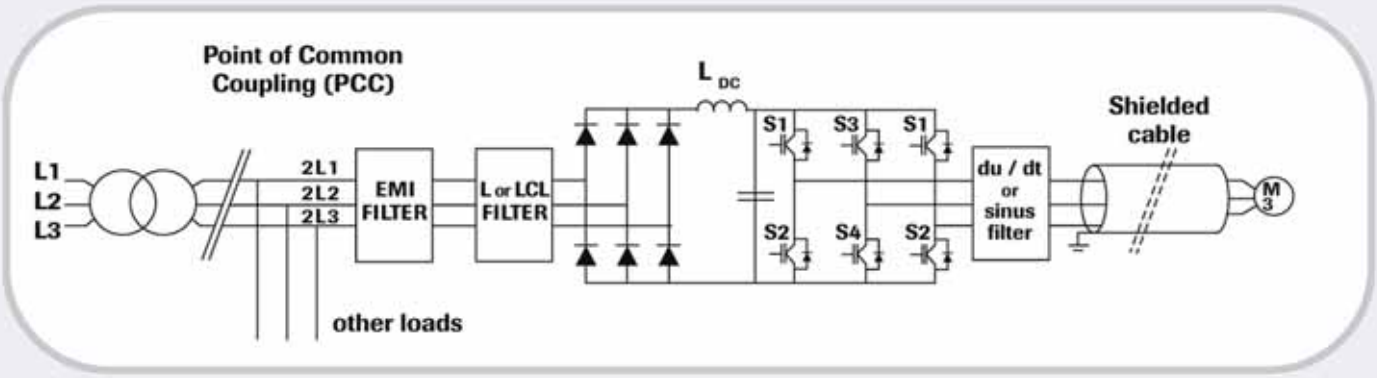
FB3 Filter

FB3T Filter

TSA Insulation transformer
with harmonic filtering

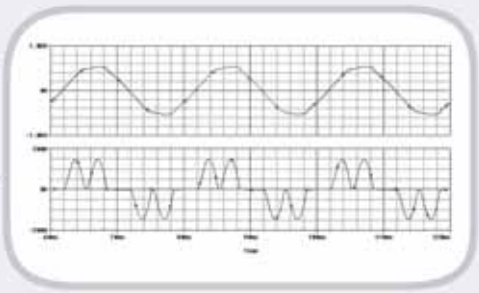
Filters for power converters (individual filtering)

Static converters generate different type of disturbances, both on the system side and on the load side. CIRCUTOR has filters to avoid problems caused by these converters and allow installations where they are installed to comply with the EN-60000-4-3, IEEE-519 standards and the 89/336/EEC, 92/31/EEC and 93/68/EEC Compatibility Directives.

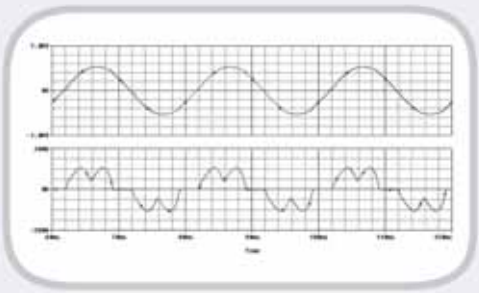


LR filters: Reactors

LR filter reactors allow current harmonics to be reduced in any converter from levels of 40% or 50% to values around 20%. They reduce the short circuit current and increase the safety of the converter's semi-conductors.



Without reactor: THD = 45%

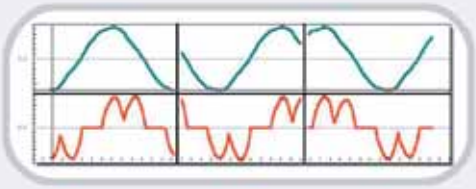


With reactor: THD = 20%

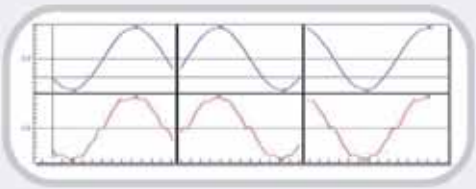
LCL and LCL-th filters

LCL Filters are individual filters for converters reducing the level of harmonics produced by converters in the system. Inserting LCL Filters allows an installation with converters to comply with the EN-61000-4-3 and IEEE-519 standards.

LCL-th's add a disconnection capacity to the filter's parallel branch in the event that the filter operates with no load. Ideal for lifts.



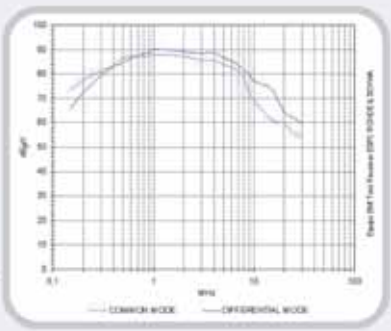
Without filter: THD (I) = 35% ÷ 50%



With filter: THD (I) < 5 %

EMI filters

EMI filters are used to remove high frequency disturbances (150kHz- 30MHz) and to comply with the 89/336/EEC, 92/31/EEC and 93/68/EEC European Directives on Electromagnetic compatibility.



Insertion loss curve

SINUS and du/dt filters

"Sinus" and du/dt filters are used between the converter and motor in inverters with PWM output to improve the waveform and to avoid overvoltages.

Without filter

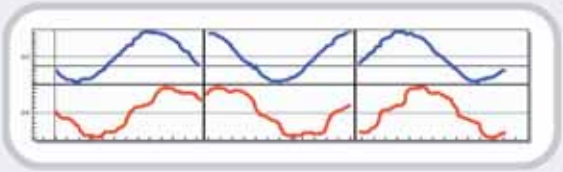
With filter

Power Factor correction in installations with harmonic disturbances

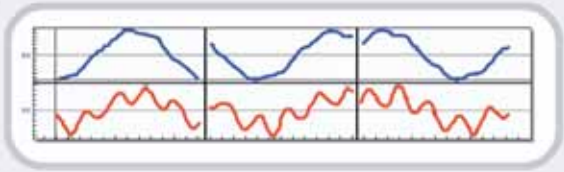
Industrial systems usually require power factor correction. In the event that the system supplies non linear loads which generate harmonics, the design of PF equipment has to take this into account and will have to combine a correction of cos φ with harmonic filtering. CIRCUTOR has equipment to prevent harmonics overload and to reduce harmonics effects on the system, in particular preventing the phenomenon of resonance, which may give rise to serious faults in the installation.

FR and FRE filters

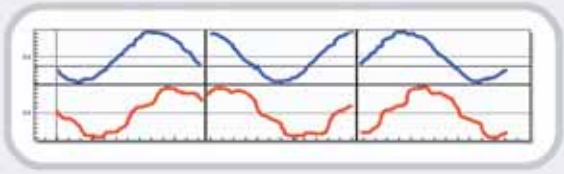
FR and FRE filters are power factor correction equipment with built in filters to prevent resonance and overloads in capacitors and transformers due to harmonics. This equipment reduces THD (V) in the system between 1 and 3 percentage points, depending on impedance of the system. In particular, the FRE series uses a “real time” static correction system and is specially designed for installations where there are fast load fluctuations.



Without power factor correction THD(V)=5%



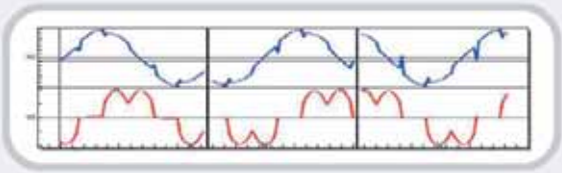
PF correction without filter: resonance THD (V)=12%



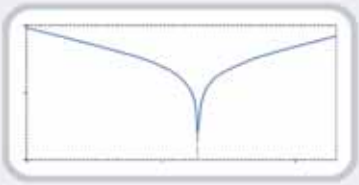
PF correction with filter THD (V)=3.5%

FAR-Q, FARE-Q hybrid filters

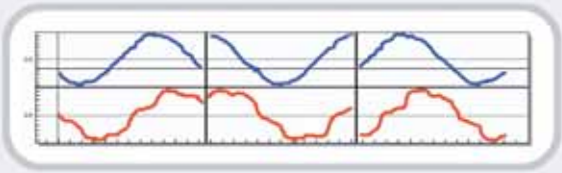
FAR-Q and FARE-Q filters are power factor correction equipment with built in filters absorbing the 5th and 7th harmonic. This considerably decreases THD(I) in the system. The FAR-Q and FARE-Q’s absorb 5.3 A of the 5th harmonic + 2.65 A of 7th for each 10 kvar. This decreases THD (V) in the system between 3 and 6 percentage points, depending on the system’s impedance. In particular, the FARE-Q uses a “real time” static correction system and is specially designed for installations where there are fast load fluctuations.



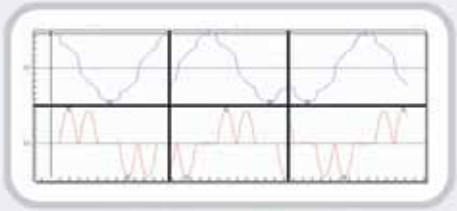
Without PF correction THD (V)=12%



Filter impedance



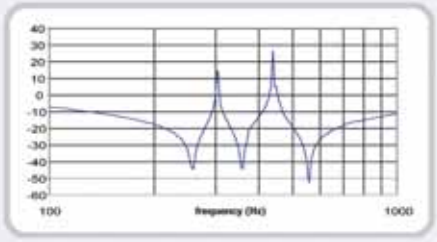
PF correction with filter THD (V)=3.5%



PF correction without filter:
Without resonance THD (V)=15%

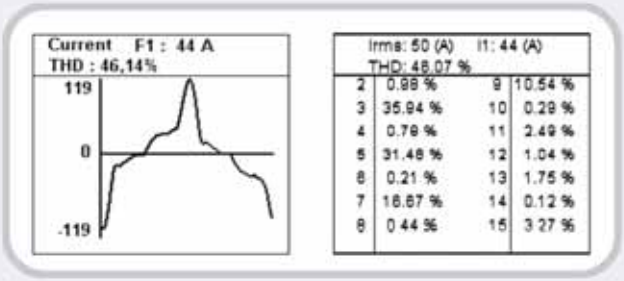
FAR-H filters

FAR-H filters are harmonic filtering equipment, based on individual filtering. They may be set with branches for the 5th, 7th, 11th, 13th and HF. They are regulated depending on load current THD (I).



Frequency response of a 5, 7 and 11 harmonic filter

Blocking filters filtering the 3rd harmonic

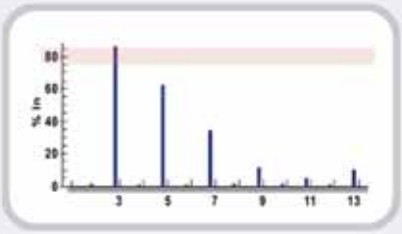


Typical wave form in non linear single-phase loads

Single-phase loads such as computers, battery chargers, single phase UPS, discharge lamps, etc., generate a large of amount of third harmonics. When these loads are connected between phase and neutral, they generate strong currents in the neutral conductor at the frequency of: 3rd harmonic and its multiples. CIRCUTOR has several solutions for this problem.

FB3 and FB3T filters

FB3 filters are harmonic blocking filters, where receivers can be directely plugged. Their main function is to reduce the 3rd harmonic, but they also significantly reduce the 5th and 7th harmonic and others present in domestic and business installations. FB3T filters are harmonic blocking filters for 3rd harmonic and multiples. The filter must be placed in series with neutral and also provides a significant reduction of the 5th, 7th harmonics and others present in industrial installations.



Harmonic spectrum without filter

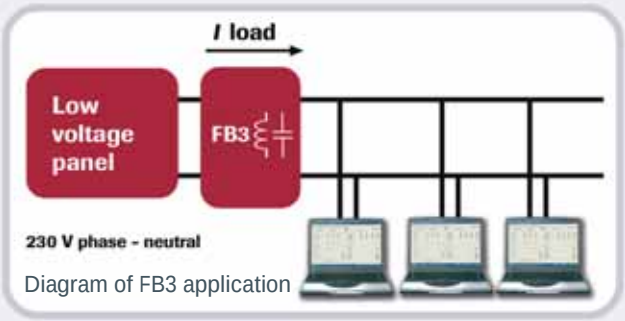
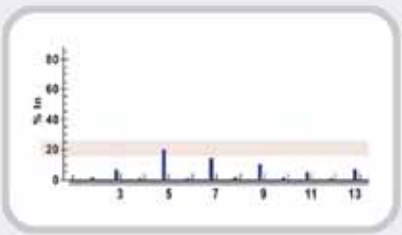


Diagram of FB3 application



Harmonic spectrum with filter

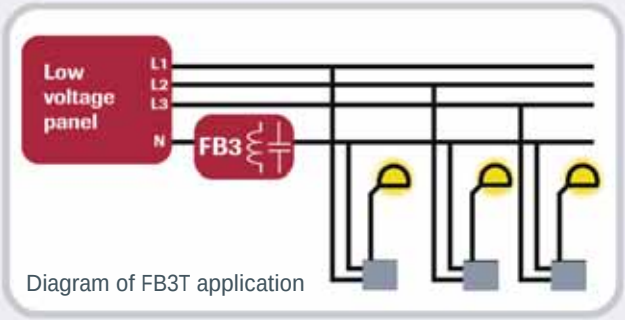
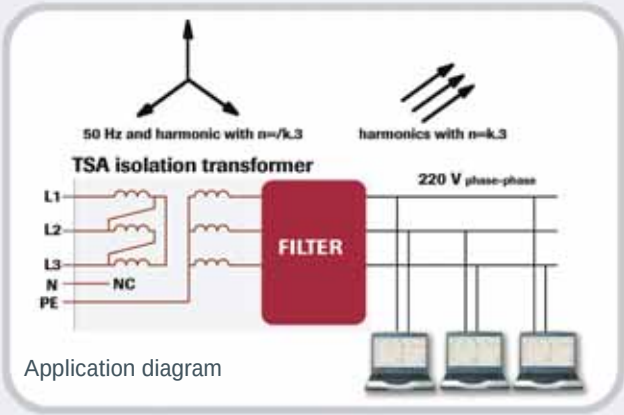


Diagram of FB3T application

Isolation transformer with filter: TSA

The TSA is an isolation transformer combined with a high frequency absorption filter.

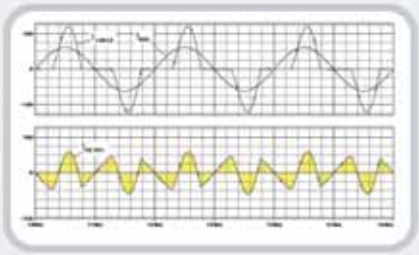
Features:
- Elimination of the third harmonic
- Galvanic insulation of single-phase loads (earth separation)
- Balancing loads



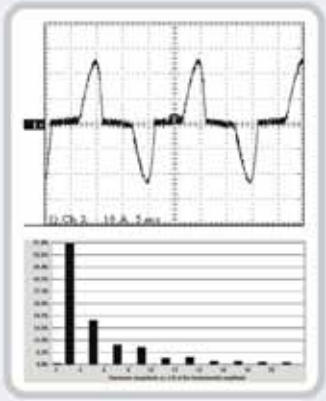
Application diagram

Single-phase Active filter: AF-2W

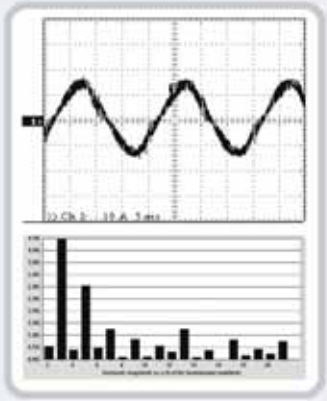
The AF-2W is a filter based on injecting current by a static IGBT converter. The filter is designed for harmonics filtering up to 20 in single-phase lines.



Operating principle



Current without the filter



Filtered current

Active filters
(Full correction of Power Factor, Harmonics and Unbalance)

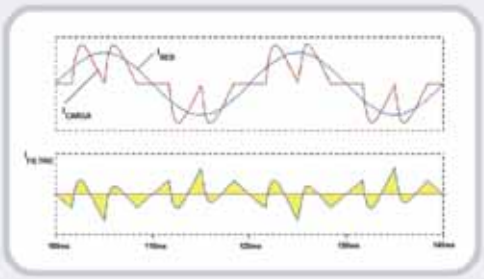
Active filters provide an overall solution to the problem of harmonics filtering, balancing loads and power factor correction. They are generally used to filter and balance and are combined with FR filters to correct displacement PF. Their operating principle is based on injecting a current in phase opposition to the harmonic currents.

CIRCUTOR has three types of active filters:

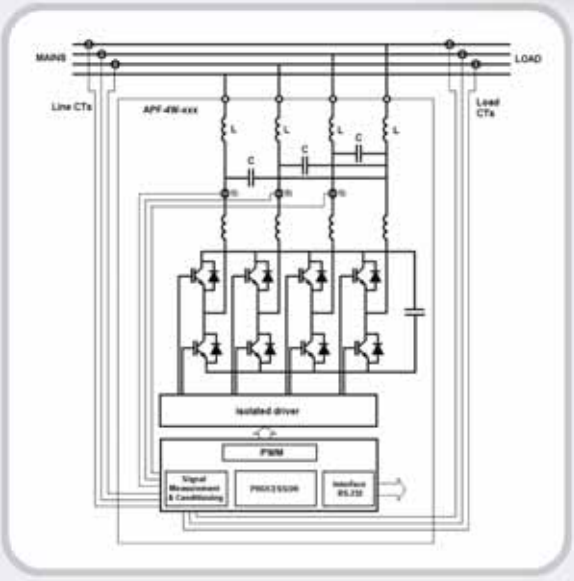
· AF-3W and AF-4W for 3 wire and 4 wire systems respectively with a filtering capacity of up to harmonic 20 without phase balance.

· APF-4W for 4 wire systems with a filtering capacity of up to harmonic 20, phase balance capacity and power factor correction.

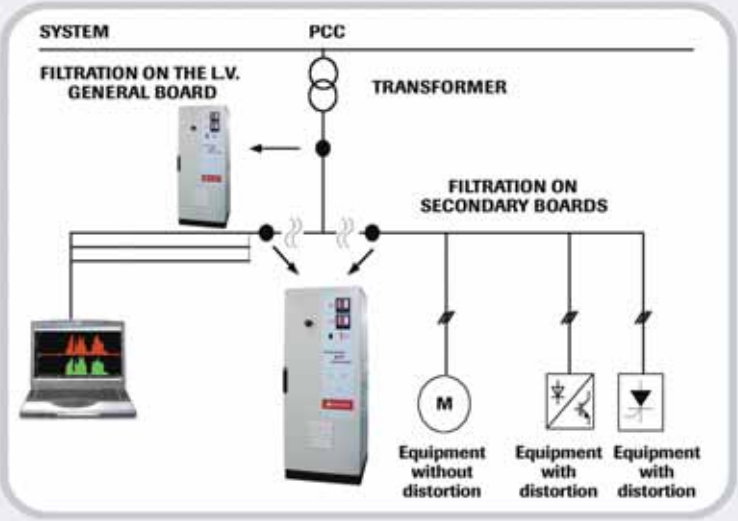
· AF-2W for filtering single-phase lines, with or without PF correction.



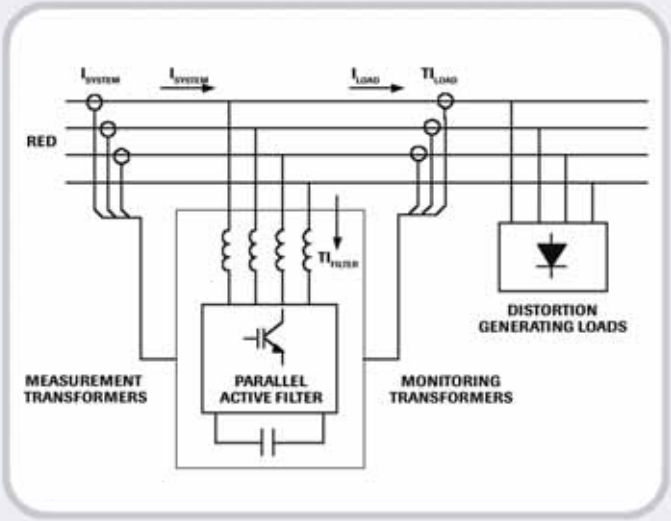
Operating principle



Equipment and block diagram

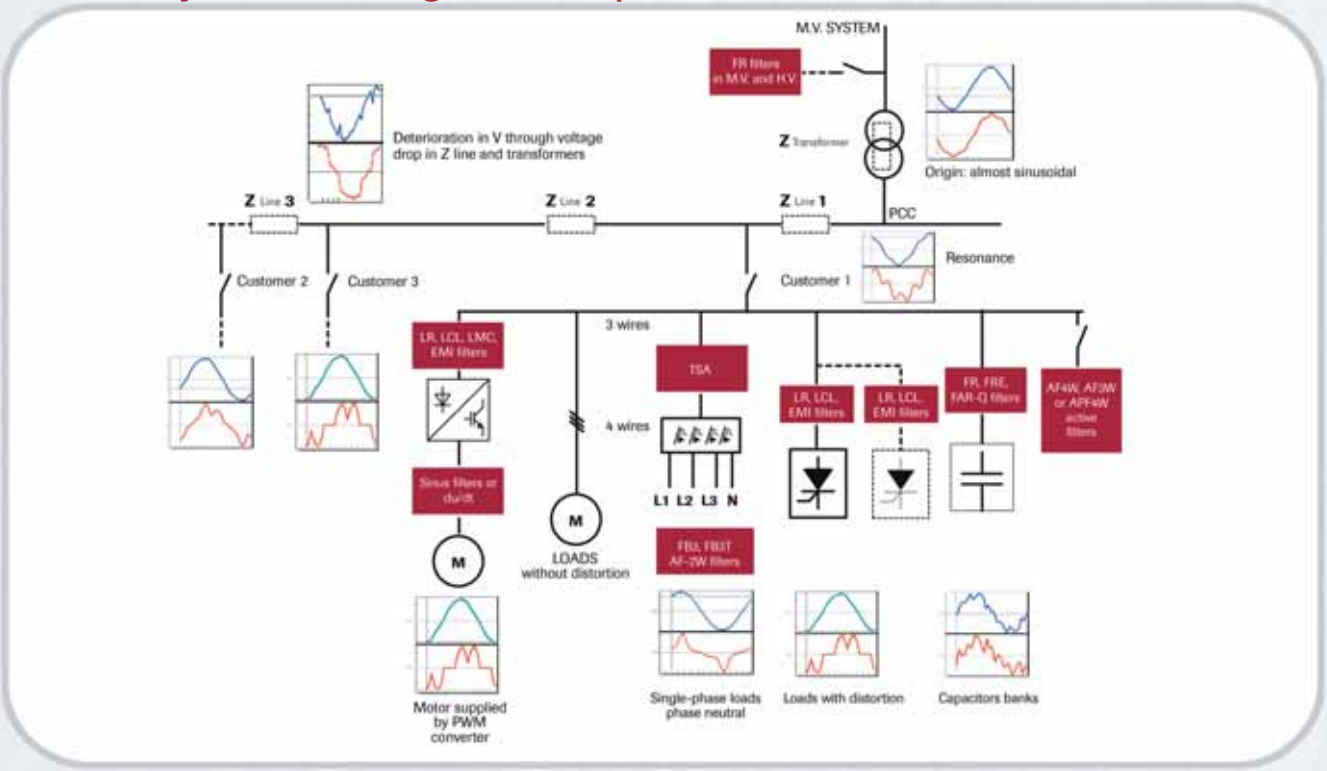


Application diagrams



Application diagrams

Summary of filtering techniques



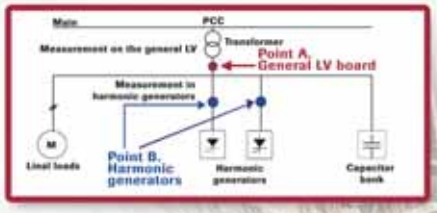
Information required for studying harmonics

• Installation information

1 DIAGRAM

The diagram has to show:

- Points where measurements have been taken using the portable AR5 power analyzer
- Load distribution



2 GENERAL INFORMATION

- Single wire diagram of installation
- Indication of measuring points
- Type of industrial process

Number of power transformers	
S_n (Transformer power)	kV·A
Transformer ratio	V
U_{cc} (Short-circuit volatge)	%

• Measurings

3 MAIN BOARD

- Active and reactive power measurement
- Harmonic measurement

Nbr. of harmonics	1	3	5	7	11	13	ΣTHD
THD (*U*)							
THD (*I*)							
I_n (A)							

- If there is a capacitor bank

With bank connected		Without bank connected	
THD (*U*)	%	THD (*U*)	%
THD (*I*)	%	THD (*I*)	%
Q (capacitor)			kvar
P (installation)			kW

4 LOADS

- Measurements at power converter loads terminals

Nbr. of harmonics	1	3	5	7	11	13	ΣTHD
THD (*U*)							
THD (*I*)							
I_n (A)							

- Measurements at other load generating terminals

Description of type of load:

- Discharge lighting
- Welding machinery
- Computers
- Others

Nbr. of harmonics	1	3	5	7	11	13	ΣTHD
THD (*U*)							
THD (*I*)							
I_n (A)							

Cod. C2R513 -01

Design by : Communication dpt. - CIRCUTOR SA

CIRCUTOR, SA - Vial Sant Jordi s/n, 08232 Viladecavalls (Barcelona) Spain. Tel (+34) 93 745 29 00 - Fax (+34) 93 745 29 14
e-mail: central@circutor.es - web: www.circutor.com