

POWER RESISTORS

- Neutral Grounding Resistors
- Generator Neutral Grounding & Leads Cubicles
- Inverter Braking Resistors
- Motor Starting & Control Resistors
- Cubicle Heaters
- Harmonic Filter Resistors
- Current Limiting Resistors
- RC Filters

REACTORS

- Current Limiting Reactors
- Neutral Grounding Reactors
- Shunt Reactors
- Harmonic Filtering Reactors
- Motor Starting Reactors
- Electric Arc Furnace Reactors
- Smoothing Reactors
- Line and Load Reactors
- Test Laboratory Reactors

TESTING SYSTEMS

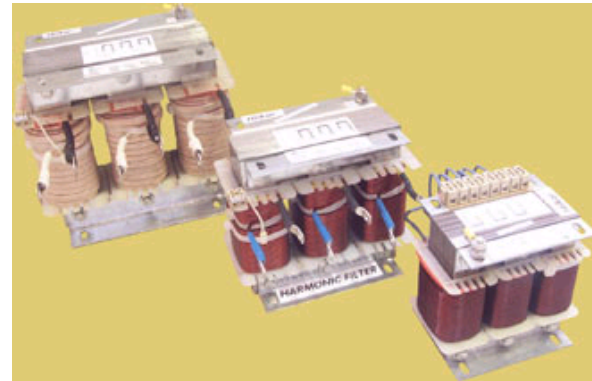
- Turn-key Short Circuit Laboratories
- High Current Injection Test Sets
- R - L - C Load Banks

HARMONIC FILTER REACTORS

Non-linear equipments generate harmonics as multiples of a fundamental frequency such as ac & dc motor speed controllers, arc furnaces, compact fluorescent lamps, uninterruptible power sources. As a result of this fact, besides the fundamental frequency, 3rd, 5th, 7th, 9th ... harmonics are generated.

COMMON REASONS FOR USING HARMONIC FILTERING REACTORS

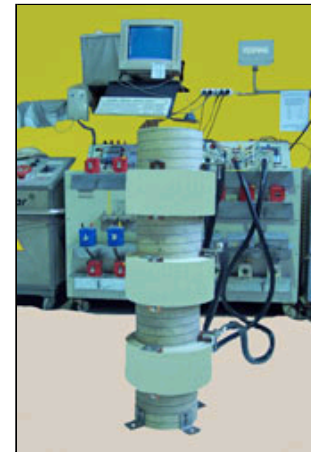
- Excessive heating effect on electrical distribution equipment and cables
- Increased electrical insulation stress
- Increased noise in electrical motors
- Electronic mis-timings: Computers, fax machines etc.
- Capacitor overloads - premature failure
- Increased maintenance requirements and downtime
- Fluorescent light flickering
- Tripping of thermal circuit breakers unexpectedly.



The distortion limits determined by IEEE 519 standard are as follows:

Hospitals and Airports	: % THD (V) = 3
Industrial Facilities	: % THD (V) = 5
Speed Control Equipments	: % THD (V) = 8

Most of the utilities impose high fees when certain level of harmonic distortion level is reached. Reactors with capacitors and sometimes with resistors creates a filter circuit tuned to a certain frequency in order to reduce, block or provide low impedance path for the harmonic currents in the audio frequency range.



Harmonic filtering reactors are connected in either parallel or a series configuration. Harmonic filters are normally installed in substations, in static var compensation and HVDC links.

Reactors are designed to meet specific design criteria such as Q factor, inductance tolerances etc.

Hilkar reactors can be equipped with off-load tapping to make a precise tuning at required frequency.

Power capacitors that are used in industrial plants in order to compensate reactive power can be used as filters besides being used for compensation. In order to prevent resonance in the systems, the value of inductance is selected approximately 20% different from the frequency of resonance which is $f_r = (2\pi \sqrt{L_n \cdot C_y})^{-1}$

The most commonly used filters are 189 Hz and 210 Hz filters. In these frequencies, X_L / X_C ratio which is called p factor is: %p = $X_L / X_C = 7\%$ and 5.67% respectively. The harmonic values of six stroke loads are : $I_5 = 0.251I_1$, $I_7 = 0.131I_1$, $I_{11} = 0.091I_1$. If an inductance is serial-connected to a capacitor (Q_{cn} (kVAR)) in p value (X_L / X_C) at U_{cn} voltage, Q_c which is effective reactive power flows to the network that has Un

voltage is :

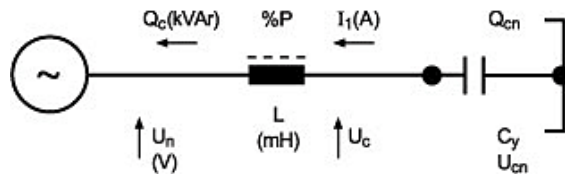
$$Q_c = \frac{Q_{cn} \cdot U_n^2 \cdot (50/f_n)}{U_{cn}^2 (1-p/100)}$$

The inductance which resonates the Q_{cn} capacitor at "fr" is: $L_n = f \cdot U_{cn}^2 / 2 \Pi f_r^2 \cdot Q_{cn}$

Example: In order to transfer $Q_c = 50$ kVar to a $U_n = 400$ V network for a serial-connected capacitor to a reactor ($\%p = 7$), a $U_{cn} = 440$ V capacitor must be $Q_{cn} = 56.3$ kVar (or 525 V, 80 kVar). Thus, the terminal voltage of the capacitor is $U_c = U_n / (1-\%P) = 400 / (1-0.07) = 430$ V.

Despite the fact that $U_{cn} = 400$ V power capacitors are manufactured to resist 10% overloading and it is safe to use a 400 V capacitor for this example, $U_{cn} = 440$ V capacitors should be used in order to ensure complete safety.

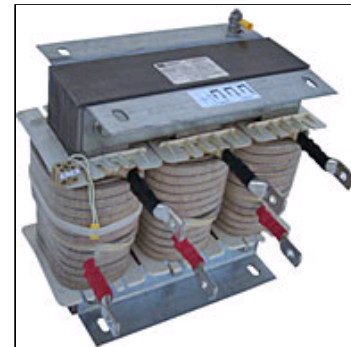
Using a bigger transformer than needed and using 12 stroke inverter instead of 6 stroke inverter reduces the harmonic distortion.



Network voltage in addition to the harmonic current :

$$I_{rms} = I_{th} = \sqrt{I_1^2 + I_5^2 + I_7^2 + \dots}$$

Power capacitors use 300-400 times more current than normal at the moment of switching. In order to reduce this to 100 times, a serial-connected reactor with a $p = 1\%$ value can be used.



SPECIFICATIONS OF 400 V HARMONIC FILTER REACTORS

- Network Frequency $f_n = 50$ Hz
- Maximum harmonic current $I_h = 0.3 I_1$
- Fundamental harmonic current $I_1 = \dots$ Ampere
- Heating limit current $I_{th} = 1.1 I_1$ ($p=7\%$) $1.2 I_1$ ($p=5.67\%$)
- Saturation current $I_{lin} = 1.8 I_1$ (for iron core)
- Maximum current $I_{max} = 2 I_1$ (60 seconds)
- Insulation class F ($155^\circ C$)
- Protection Degree IP00
- Insulation withstand voltage 3000 V ac 1 minute

ADVANTAGES

- Increases equipment and capacitor life
- Perfect mechanical strength to withstand high short-circuit forces.
- Limited temperature rise enables longer lifetime.
- Special surface protection against UV and pollution class IV areas.
- Maintenance-free design

STANDARD

EN 60289 or depending on customer requirements.

FEATURES :

- Air and iron core
- Dry type
- Side by side, delta or vertical arrangement depending on space availability
- Outdoor and indoor
- Single phase or three phase
- Enclosures are available on demand
- Aluminum or copper winding
- RAL 7032 or other colors
- Taps are available on request
- - 40 °C / + 55 °C ambient temperature range
- F class (155 °C) or customer specific design
- Fiberglass spacers are used in order to provide ease of cooling
- AN (air-natural) cooling method

INSULATION

- . F class (155 °C) film insulation or epoxy resin reinforced fiberglass.
- . Epoxy based paint & insulating varnish.

INSTALLATION

The height and the diameter of the reactor can be adjusted to customer specific needs in order to meet unusual space requirements

Complete installation guidelines are provided with the reactors in order to meet required magnetic clearances on close metallic structures. Each reactor is supplied with an INSTALLATION GUIDELINES that specifies minimum magnetic clearances for the reactor.

SUPPORT STANDS

Aluminum, hot dip galvanized steel or concrete support stands are designed for specific applications.

LOSSES

All Hilkar Electric reactors are computer designed in order to minimize investment and operating losses.

TESTS

All the routine tests are performed in accordance with EN 60289 or other standards depending on customer request. Type test reports are available on request. All the test reports are submitted to customer.

Basic testing program includes some or all of the following tests:

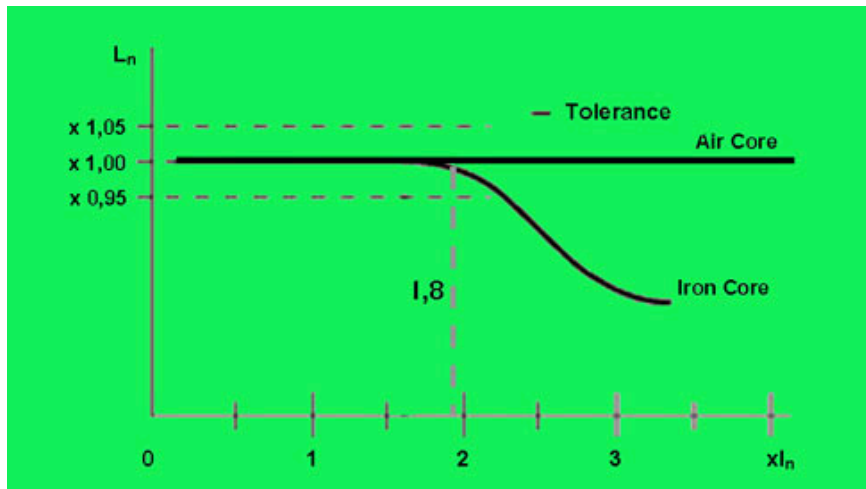
- Routine Tests (Inductance, Resistance, One Minute AC Insulation Voltage Withstand Test and Impulse Voltage Withstand Test)
- Short Circuit Withstand Test
- Temperature Rise Test
- Sound Level Test
- Seismic Test



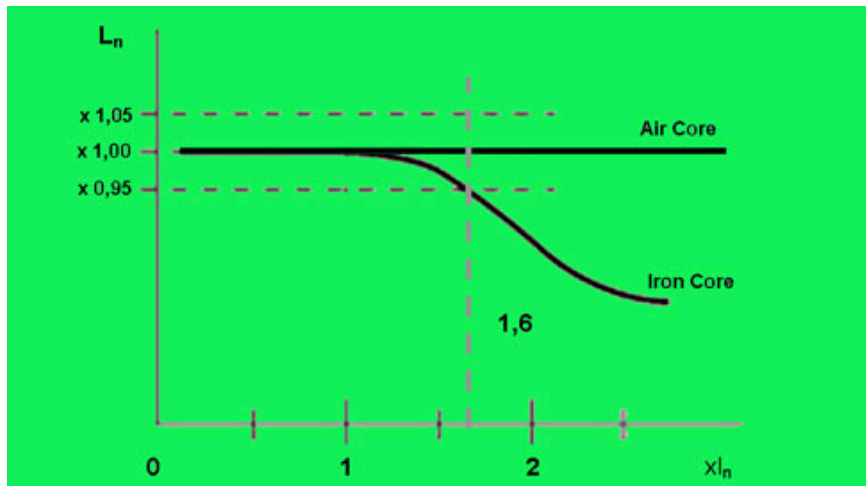


7,2 kV 92 mH 26 A Cast Resin Harmonic Filter Reactor

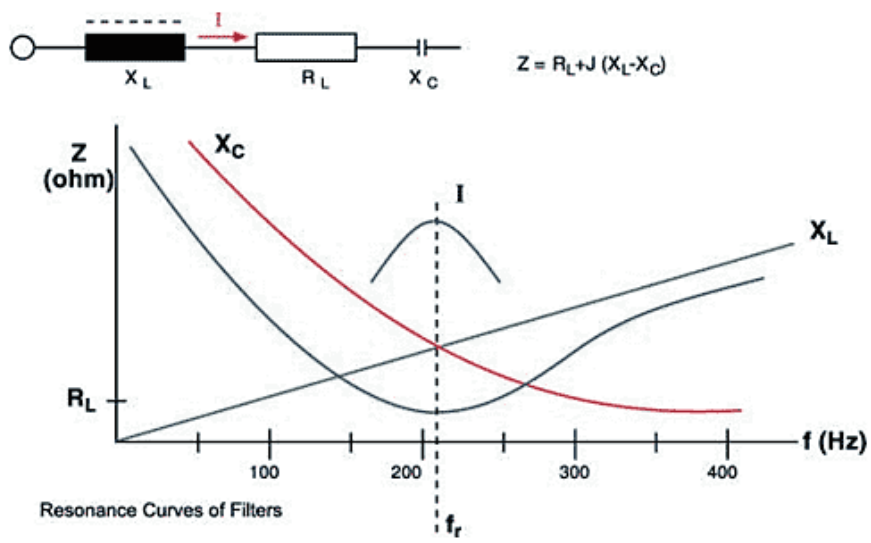
LINEARITY OF REACTOR



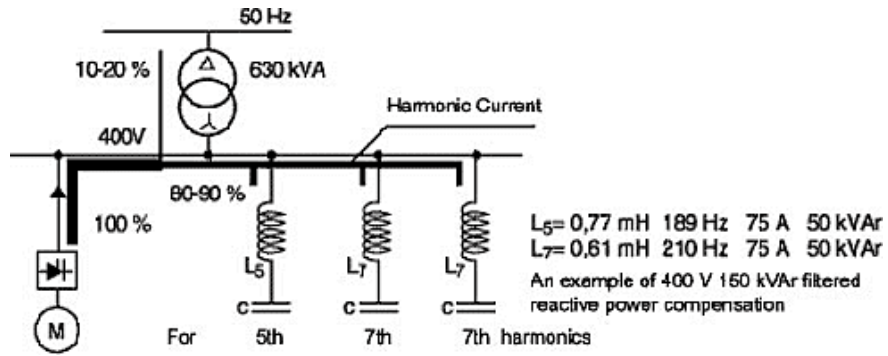
For harmonic and current limiting reactors.



For general purpose inductance.



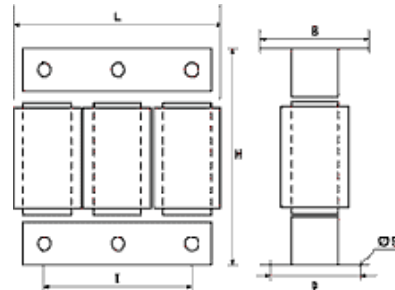
An example of 400 V 150 kVAr filtered reactive power compensation



Dimensions of 3 x 400 V Harmonic Filter Reactors

Q_{cn} : Capacitor power at nominal voltage (kVAr)

$C_y = 3$ (star equivalent capacity of delta connected capacitor)



Type		Q _{cn} (kVA) 50 Hz			C _v (μF)	L _n (mH)		I _n (A)	Loss (W)	Weight (kg)	(mm)				
		400 V	440 V	525 V		p= %5,67 (fr=210 Hz)	p= %7 (fr=189 Hz)				L	I	B	H	b
		HFR5/4/5	K6	4.7		5.7	8.1				3x32	6.12	-	7.65	50
HFR5/4/7	K6	4.7	5.6	8	3x31	-	7.66	15.3	65	11	180	120	95	160	85
HFR10/4/5	K6	9.4	11.4	16.2	3x63	3.06	-	23	76	12	180	120	95	160	85
HFR10/4/7	K6	9.3	11.2	16	3x62	-	3.84	30.6	100	12	180	120	95	160	85
HFR15/4/5	P8	14.1	17.1	24.3	3x93	2.04	-	38	130	23	240	160	160	210	112
HFR15/4/7	P8	13.9	16.8	23.9	3x93	-	2.56	46	140	24	240	160	160	210	112
HFR20/4/5	P8	18.8	22.8	32.4	3x125	1.53	-	61	150	25	240	160	160	210	112
HFR20/4/7	P8	18.5	22.4	31.8	3x125	-	1.92	76.5	160	25	240	160	160	210	112
HFR25/4/5	P8	23.6	28.5	40.6	3x156	1.22	-	61	150	25	240	160	160	210	112
HFR25/4/7	P8	23.2	28.1	40	3x154	-	1.53	61	150	26	240	160	160	210	112
HFR30/4/5	P8	28.2	34.1	46.6	3x188	1.02	-	76.5	160	25	240	160	160	210	112
HFR30/4/7	P8	27.8	33.6	47.8	3x185	-	1.28	76.5	160	26	240	160	160	210	112
HFR40/4/5	P10	37.9	45.8	65.2	3x252	0.76	-	76.5	160	33	300	200	170	260	120
HFR40/4/7	P10	37	44.8	63.8	3x247	-	0.96	76.5	160	36	300	200	170	260	120
HFR50/4/5	P10	47.2	57.1	81.3	3x314	0.61	-	76.5	160	36	300	200	170	260	120
HFR50/4/7	P10	46.2	55.8	79.5	3x308	-	0.77	76.5	160	36	300	200	170	260	120

Connection terminals:

K6 = 6 mm² connector

P8 = Metric 8 terminal

P10 = Metric 10 terminal

Hilkar reserves the right to make any changes in dimensions without prior notice.



QUALITY ASSURANCE

Hilkar maintains a complete quality assurance program including ISO 9001 and other major industry standards in its manufacturing plant.

TECHNICAL SUPPORT

Hilkar provides complete technical assistance to contractors and end customers for applications, design, calculations and field installation. All Hilkar reactors are custom designed for different applications by considering the voltage, current, inductance, size, loss characteristics that are required to provide the most efficient design at the most economical prices.