

REACTORS FOR FILTERING





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FILTER REACTORS



Many of the disturbance problems in LV systems may be solved by adequate filtering techniques. CIRCUTOR has developed a complete range of filtering reactors for the following typical applications:

- Avoid resonances and protect capacitors in power factor correction equipment
- Absorb (reduce) harmonics, improving THD (total harmonic distortion)
- Improve short circuit power
- Filtering the disturbed current caused by power converter equipment (variable speed drives,...) at D.C. or A.C. side.

Reactors for absorption filters

These filters are formed by as many L-C branches as harmonics to be filtered. The resonance frequencies of the different branches coincide with those of the harmonics to be filtered.

The constructive form of each branch is similar to that of the detuned filters, (see fig.2 in next page) but in this case the key data is the current to be filtered. This will define the size of the reactor and the capacitor. There are many possible values of current ratings and reactive energy for the filter. **CIRCUTOR** may offer the adequate reactors for all the cases.

Fig. 1.A and 1.B show the response in two typical branches provided for 5th and 7th harmonic filtering. Fig. 1.C shows the typical response of a filter bank including branches for the 5th, 7th, 11th and 13th, plus a high pass filter for $n > 15$.

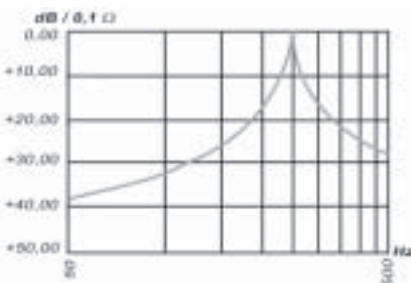


Fig. 1A - Frequency response for n = 5 branch

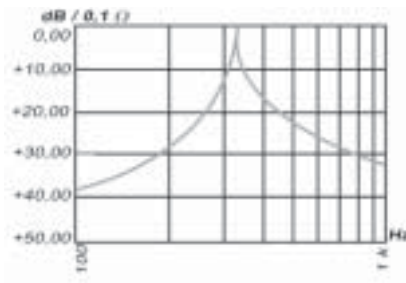


Fig. 1B - Frequency response for n = 7 branch

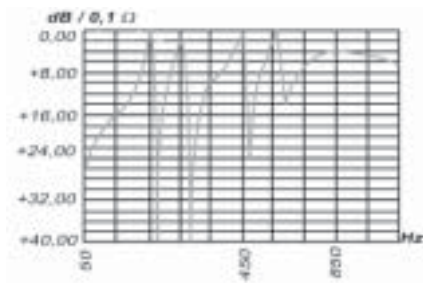
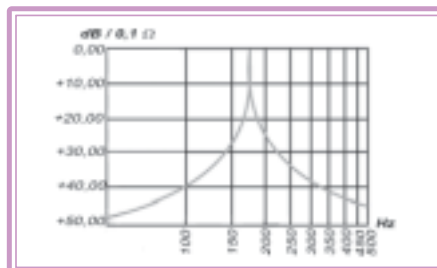


Fig. 1C - Frequency response of filter with n = 5, 7, 11, 13, >15

The impedance of filters is usually given in logarithmic graphs, where the impedances are represented in the Y axis, referred to a standard value (0,1 Ω in our case) as a function of frequency (X axis). The impedance unit is then the (dB/0,1Ω), defined as:

$$Z \text{ (dB / 0,1}\Omega) = 20 \cdot \log [Z \text{ (filter) / 0,1}\Omega]$$



Typical frequency response

dB / 0,1 Ω to Ω direct conversion			
Z	Z	Z	Z
(dB / 0,1 Ω)	Filter	(dB / 0,1 Ω)	Filter
0	0,100	20	1,00
2	0,125	22	1,25
4	0,158	24	1,58
6	0,199	26	1,99
8	0,251	28	2,51
10	0,316	30	3,16
12	0,398	32	3,98
14	0,501	34	5,01
16	0,630	36	6,30
18	0,794	38	7,94

Table 1



R / RE, FILTER REACTORS FOR POWER FACTOR CORRECTION



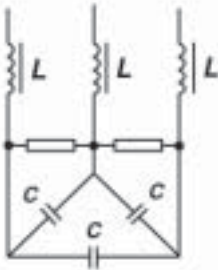
Reactors with detuned filters

The objective of a detuned filter is to avoid the resonance between the inductive impedance of the supply transformer plus the line cabling and the capacitors installed for the PF correction. Such resonance might cause large overloads in the distribution lines and in the capacitors themselves. The filter consists of several L-C branches, which configuration and response curves are like those shown in Fig. 2. The complete filter is formed by as many branches as necessary to obtain the compensation of the reactive energy.

The reactors for this type of filters are specified by the p% factor, which gives the relationship between the voltages across the reactor and the capacitor. The p% factor fixes also the series resonance frequency of the L-C branch.

$$p \% = 100 \cdot \frac{U_L}{U_C} = 100 \cdot \left(\frac{w_L}{w_r} \right)^2$$

Fig. 2



CIRCUTOR has a standard range of reactors, with $p = 7\%$, which means a resonance frequency of 189 Hz for 50 Hz networks or 227 Hz for 60 Hz networks.

This is the most commonly used value in balanced three-phase lines, to avoid resonances to 5th harmonic and above.

In certain installations other p % values must be used. CIRCUTOR may supply reactors adapted to any situation (p % 5.67%, 12.5%, 14% value) on request.

CONSTRUCTIVE CHARACTERISTICS OF FILTER REACTORS

Reactors for low power ratings, type R are built with oriented grain iron sheet and copper windings. The input / output connections use clamp terminals for cable connection.

For higher power ratings RB reactor types are used, which have a core made of oriented grain iron sheet with split air gaps. That gives excellent anti saturation characteristics and very low losses. The RB coils are made of aluminium foil (or copper foil on request).

The input / output connections are made through bars.

Both types, R and RB are vacuum impregnated with a varnish having high insulation properties.

REACTORS III SERIES R / RB / RX / RBX

400 V a.c., 50 Hz, P = 7 % (*)



Type	Code	kvar	For capacitor	I_n	L (mH)	Losses
R-5-400	P70110	5	CF 46 / 6	7,5 A	7,66	25 W
R-10-400	P70115	10	CF 46 / 12,5	15 A	3,83	50 W
R-15-400	P70117	15	CF 46 / 19	22 A	2,55	57 W
RB-20-400	P70125	20	CF 46 / 25	30 A	1,92	76 W
RB-25-400	P70130	25	CF 46 / 30	37 A	1,53	90 W
RB-30-400	P70135	30	CF 46 / 37	45 A	1,27	120 W
RB-40-400	P70140	40	CF 46 / 50	60 A	0,95	145 W
RB-50-400	P70145	50	CF 46 / 62	75 A	0,76	185 W
RB-60-400	P70150	60	CF 46 / 74	90 A	0,63	205 W
RB-80-400	P70155	80	CF 46 / 100	120 A	0,47	235 W
RB-100-400	P70160	100	CF 46 / 62 (x2)	145 A	0,38	250 W
RB-120-400	P70165	120	CF 46 / 74 (x2)	175 A	0,32	295 W

Type	Code	kvar	For capacitor	I_n	L (mH)	Losses
RX-6,25-400	P7101F	6,25	CF 46 / 7,5	9	6,12	36
RX-12,5-400	P70013	12,5	CF 46 / 15	18	3,06	53
RX-25-400	P70016	25	CF 46 / 30	37	1,53	92
RBX-50-400	P70019	50	CF 46 / 63	75	0,76	187

(*) Other upon request

REACTORS III SERIE R/ RBC

400 V a.c., 50 Hz, P = 14 % (Fr = 134 Hz)



Type	Code	kvar	I_n	L (mH)	Losses
R-5-400-14%	P70110 00 003	5	7,5 A	16,31	31 W
R-10-400-14%	P70115 00 003	10	15 A	8,152	61 W
R-12,5-400-14%	P70117 00 003	12,5	18 A	6,52	65 W
R-15-400-14%	P70120 00 003	15	22 A	5,43	71 W
R-20-400-14%	P70125 00 003	20	30 A	4,07	110 W
R-25-400-14%	P70130 00 003	25	37 A	3,26	112 W
RBC-30-400-14%	P70135 00 003	30	45 A	2,71	146 W
RBC-40-400-14%	P70140 00 003	40	60 A	2,03	181 W
RBC-50-400-14%	P70145 00 003	50	75 A	1,63	225 W
RBC-60-400-14%	P70150 00 003	60	90 A	1,35	254 W

Type R reactors: Cu wire conductor

Type RBC reactors: Cu band conductors

FEATURES

	R / RB	RX / RBX	R-14% / RBC
Insulation voltage	4 kV		
Tolerance of L	3 %		
Linearity (5 % of L) to	$1,8 I_n$		
Maximum ambient temperature	45 °C		
Internal insulation	Class F (155 °C)*		

	R / RB	RX / RBX	R-14% / RBC
Maximum overload	$\sqrt{\sum (n \cdot I_n)^2}$		
Permanent	1,17 I_n		
Transient (1 min)	2 I_n		
Protection thermostat	90 °C		
Standards	IEC-289, IEC-076		

* On request, H class (180 °C)

ACCESSORIES

Capacitors
see catalogue R1/2



REACTORS III FOR RE/ RBE SERIES (STATIC)

400 V a.c., 50 Hz, P = 7 % (Fr= 189 Hz)

For static banks with thyristor module based reconnection with reject filters, the RE / RBU reactors have been standardised at 400 V–p=7% especially for this application. These reactors are connected within a triangle forming the capacitor set for improved operation.



Type	Code	kvar	For capacitor	I_n	L (mH)	Losses
RE-5-400	P70210	5	CF 46 / 6-6B	5 A	23,67	25 W
RE-10-400	P70215	10	CF 46 / 12,5-6B	9 A	11,27	50 W
RE-15-400	P70220	15	CF 46 / 19-6B	13 A	7,50	57 W
RE-20-400	P70225	20	CF 46 / 25-6B	17 A	5,68	76 W
RE-25-400	P70230	25	CF 46 / 30-6B	21 A	4,68	90 W
RE-30-400	P70235	30	CF 46 / 37-6B	26 A	3,84	120 W
RE-40-400	P70240	40	CF 46 / 50-6B	35 A	2,84	145 W
RBE-50-400	P70245	50	CF 46 / 62-6B	42 A	2,29	185 W
RBE-60-400	P70250	60	CF 46 / 74-6B	51 A	1,89	205 W
RBE-80-400	P70255	80	CF 46 / 100-6B	68 A	1,42	235 W

FEATURES

	RE / RBE
Insulation voltage	4 kV
Tolerance of L	3 %
Linearity (5 % of L) to	1,8 I_n
Maximum ambient temperature	45 °C
Internal insulation	Class F (155 °C)*

* On request, H class (180 °C)

	RE / RBE
Maximum overload	$\sqrt{\sum (n \cdot I_n)^2}$
Permanent	1,17 I_n
Transient (1 min)	2 I_n
Protection thermostat	90 °C
Standards	IEC-289, IEC-076

ACCESSORIES

Capacitors
see catalogue R1/2

REACTORS FOR POWER CONVERTERS



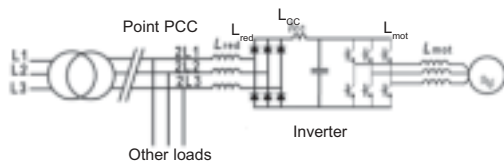
The variable speed drives, for D.C. or A.C. motors (frequency converters) the UPS, and in general all the converters based on thyristors or power transistors, produce a large harmonic distortion and commutation noise in the mains. Also sometimes an excess of ripple at the D.C. side (motor side in case of D.C. drives). All these perturbations may disturb the converter controller or disturb some electronic equipment supplied by the same supply network.

The basic problems caused by power converters are:

- Notches in the voltage wave and excessive di/dt at the mains side of the converters
- Current spikes at the mains side, due to connection of capacitors at the D.C. side of the frequency converters
- Excess of ripple in the armature current and commutation sparks at the collector of D.C. motors

All these problems may be palliated and corrected by the use of chokes or filters. See the next drawings:

Filtering of commutation notches at mains and motor side



PCC voltage without L_{red}



PCC voltage with L_{red}



Motor current without L_{mot}



Motor current with L_{mot}

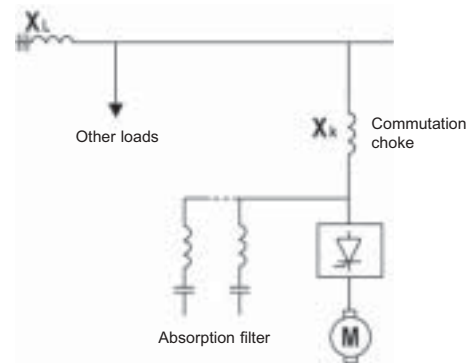


Mains current without L_{cc}

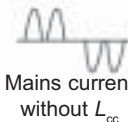


Mains current with L_{cc}

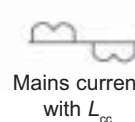
Notch suppression and harmonics filter



D.C. inductance for commutation improving



Mains current without L_{cc}



Mains current with L_{cc}



FILTERS FOR POWER CONVERTERS: MAINS SIDE, L_{MAINS} AND MOTOR SIDE L_{MOT}

May be used both at mains and at motor side. Allow the attenuation of notches and spikes due to initial connection and commutation and reduce the harmonics of current at the mains side. When placed at the motor side the harmonic frequencies due to commutation are damped.

LR, MAINS SIDE REACTORS

400 V a.c., 50 Hz, 4 %

Three-phase reactors (*)

MAINS / MOTOR at 380 V / 415 V

- Short circuit voltage U_k : 4 % for 400 V - 50 Hz
4,8 % for 400 V - 60 Hz



Motor Power		I_n A	L mH	Losses (W)	Type	Code
kW	CV					
0,75	1	2,5	14,8	6	LR 04-003	P70301
1,5	2	4	7,9	8	LR 04-004	P70302
2,2	3	5,5	5,9	10	LR 04-006	P70303
3	4	7,5	4,3	12	LR 04-008	P70304
4	5	10	3,2	15	LR 04-010	P70305
5,5	7	13	2,5	18	LR 04-013	P70306
7,5	10	17	1,85	25	LR 04-017	P70307
11	15	22	1,47	30	LR 04-022	P70308
15	20	32	0,98	45	LR 04-033	P70309
18,5	25	40	0,80	55	LR 04-041	P7030A
22	30	47	0,67	64	LR 04-050	P7030B
25	34	53	0,59	77	LR 04-058	P7030C
30	41	64	0,49	88	LR 04-066	P7030D
37	50	76	0,40	110	LRB 04-080	P7030E
45	61	90	0,34	120	LRB 04-095	P7030F
55	75	110	0,28	145	LRB 04-115	P7030G
75	102	148	0,20	190	LRB 04-150	P7030H
90	122	180	0,17	230	LRB 04-185	P7030J
110	150	200	0,15	245	LRB 04-200	P7030K
132	180	250	0,12	285	LRB 04-250	P7030L
160	220	300	0,10	355	LRB 04-300	P7030M
200	270	400	0,07	475	LRB 04-400	P7030N
250	340	500	0,06	550	LRB 04-500	P7030P
315	428	600	0,05	634	LRB 04-600	P7030Q

The same 400 V – 50 Hz – 4% reactors may be used with other voltages.
The voltage drops obtained at the same current (I_n) are as follows:

50 Hz	
Voltage (V a.c.)	Short circuit voltage
400	4 %
440	3,60 %
460	3,50 %
480	3,34 %

60 Hz	
Voltage (V a.c.)	Short circuit voltage
400	4,80 %
440	4,30 %
460	4,17 %
480	4 %

* Single-phase types for mains side and other values of voltage drop, under request

LR, MAINS SIDE REACTORS

230 V a.c., 50 Hz, 4 %



Motor power		I_n A	I_{calc} A	L mH	Losses (W)	Type	Code
kW	CV						
0,75	1	4	3,4	4,90	8	LR 02-004	P70311
1,5	2	7	6,5	2,60	10	LR 02-007	P70312
2,2	3	10	8,6	1,96	14	LR 02-010	P70313
3	4	13	11,7	1,43	17	LR 02-013	P70314
4	5,5	16	15,7	1,07	20	LR 02-016	P70315
5,5	7,5	22	20,2	0,84	26	LR 02-023	P70316
7,5	10	30	27,5	0,61	35	LR 02-030	P70317
10	13,5	38	34,8	0,49	44	LR 02-039	P70318
15	20	58	52,2	0,32	66	LRB 02-058	P70319
18,5	25	70	64,3	0,26	80	LRB 02-071	P7031A
22	30	82	76,5	0,22	94	LRB 02-083	P7031B
25	34	92	86,9	0,19	105	LRB 02-094	P7031C
30	40	112	104,3	0,16	115	LRB 02-100	P7031D
37	50	138	125,5	0,13	148	LRB 02-130	P7031E

FEATURES

Voltage drop (standard) *	4 %
Insulation voltage	2 kV
Linearity (5 % of L) to	$1,5 I_n$
Maximum ambient temperature	45 °C

Maximum overload	$\sqrt{\sum(n \cdot I_n)^2}$
- permanent - transient (30 s)	$1,17 I_n$ $2 I_n$
Protection thermostat	Under request
Standards	IEC 289, IEC 076

* Single-phase types for mains side and other values of voltage drop, under request

LM, THREE-PHASE REACTORS FOR RIPPLE REDUCTION (MOTOR SIDE)



Switching frequency > 10 kHz

The main role of this type of reactors is the filtering of ripple at commutation frequency and its main harmonics.

Motor power		I_n A	L μ H	Type	Code
from (kW)	to (kW)				
7,5	11	20	50	LM 22-050	P71111
11	22	40	50	LM 40-050	P71121
22	37	75	50	LM 75-050	P71131
37	55	110	50	LM 110-050	P71141
55	90	180	50	LM 180-050	P71151

FEATURES

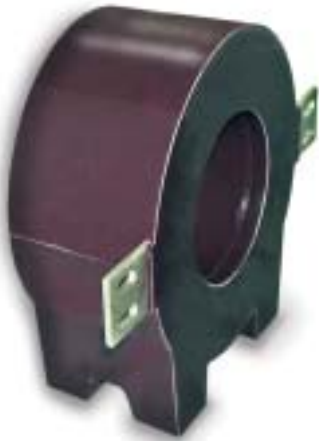
For switching frequencies	> 10 kHz
Losses according to frequency	máx. 25 kHz
Insulation voltage	2 kV
Linearity (5 % of L) to	$1,5 I_n$
Maximum ambient temperature	45 °C

Maximum overload	$\sqrt{\sum(n \cdot I_n)^2}$
- permanent - transient (30 s)	$1,17 I_n$ $2 I_n$
Protection thermostat	On request
Standards	IEC 289, IEC 076

* Other values, on request



CHOKES REACTORS, RMV



Connecting capacitor banks bring about voltage and current transients and very high currents.

The IEC 60871-1 standard defines the maximum value that a capacitor bank is capable of supporting as a connection spike. Specifically this is 100 times its nominal current.

If this value is exceeded, shock RMV reactancies need to be installed to limit the current transient to acceptable values for the capacitors.

The value of this reactance varies with the installation's conditions and basically depends on the following parameters:

- Short circuit power in the installation.
- Existence of more capacitor banks.
- Closure power of the automatic switches. Once the reactance is assembled, the residual connection value must also be less than the closure powers of the equipment in general.

RMV

I (A)	Type	L (μH)	Weight	Code
50	RMV - 260 - 50 - 350	350	13	R80628
60	RMV - 260 - 60 - 250	250	14	R80637
100	RMV - 260 - 100 - 100	100	16	R80664
125	RMV - 260 - 125 - 50	560	14	R80672
175	RMV - 260 - 175 - 30	30	14	R80691

RMV

I (A)	Type	L (μH)	Weight	Code
60	RMV - 330 - 60 - 450	450	20	R80739
75	RMV - 330 - 75 - 350	350	21	R80748
90	RMV - 330 - 90 - 250	250	26	R80757
125	RMV - 330 - 125 - 100	100	22	R80774
200	RMV - 330 - 200 - 50	50	22	R807A2
250	RMV - 330 - 250 - 30	30	23	R807B1

FEATURES

Electrical features

Assigned short duration current	$43 I_n / 1 \text{ s}$
Dynamic current	$2,5 I_t$
Insulation level	12 kV (28/75)

Environmental conditions

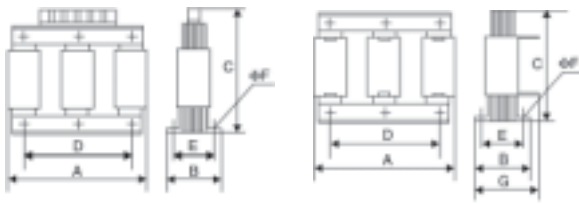
Operating temperature	Category B
Maximum temperature	135°

Assembly features

Type	Encapsulated in resin, air core
Mountings	M/12 / M/16 according to type
Dimensions (mm)	According to type
Weight	According to type (See table)
Color	RAL 8016
Standards	IEC 60289

DIMENSIONS

R / RB / RX / RBX-7%



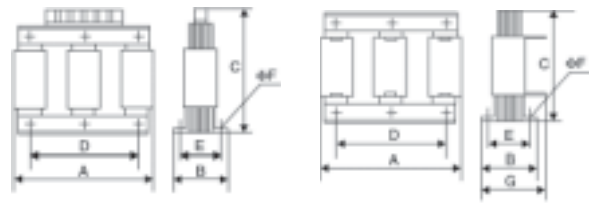
R / RX type

RB / RBX type

Type	A mm	B mm	C mm	D* mm	E* mm	F mm	G mm	kg
R-5-400	155	112	165	75	85	7	---	6
R-10-400	180	102	190	90	75	7	---	8
R-12,5-400	180	112	192	90	85	7	--	9,2
R-15-400	180	112	190	90	85	7	---	9,5
RB-20-400	260	124	174	150	90	7	150	14
RB-25-400	260	124	174	150	90	7	150	14
RB-30-400	290	124	231	160	90	9	150	19
RB-40-400	293	124	231	160	90	9	150	20
RB-50-400	310	144	233	160	110	9	175	27
RB-60-400	305	146	260	160	110	11	180	31
RB-80-400	335	155	280	180	120	11	185	38
RB-100-400	338	170	300	180	135	11	215	50
RB-120-400	355	170	350	200	135	13	220	58
RX-6,25-400	180	102	190	90	75	7	--	8
RX-12,5-400	180	112	192	90	85	7	--	9,2
RBX-25-400	180	137	196	90	110	7	--	15
RBX-50-400	292	144	232	160	110	9	175	26

* Distance between fixing screws

RE / RBE



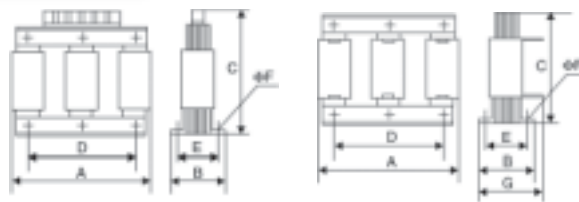
RE type

RBE type

Type	A mm	B mm	C mm	D* mm	E* mm	F mm	G mm	kg
RE-05-400	155	92	165	75	75	7	--	6
RE-10-400	180	102	190	90	75	7	--	8
RE-15-400	180	112	190	90	85	7	--	9,5
RE-20-400	180	122	190	90	95	7	--	11,5
RE-25-400	240	122	250	130	90	9	--	17
RE-30-400	240	132	250	130	100	9	--	20,5
RE-40-400	240	147	250	130	115	9	--	25,5
RBE-50-400	310	154	233	160	120	9	185	29
RBE-60-400	310	154	234	160	120	9	185	30
RBE-80-400	338	165	280	180	130	11	195	41

* Distance between fixing screws

R-14% / RBC-14%



Type R-14%

Type RB-14%

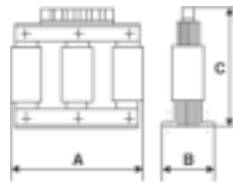
Type	A mm	B mm	C mm	D* mm	E* mm	F mm	G mm	kg
R-5-400-14%	180	102	197	90	75	7	-	9,5
R-10-400-14%	180	122	197	90	95	7	-	13
R-12,5-400-14%	180	137	197	90	110	7	-	16
R-15-400-14%	250	122	250	130	90	9	-	21,5
R-20-400-14%	250	132	250	130	100	9	-	25
R-25-400-14%	250	147	256	130	115	9	-	30,5
RBC-30-400-14%	285	154	233	160	120	9	181	35
RBC-40-400-14%	290	159	233	160	125	9	184	41
RBC-50-400-14%	307	164	233	160	130	9	194	48
RBC-60-400-14%	335	196	280	280	150	11	197	60

* Distance between fixing screws

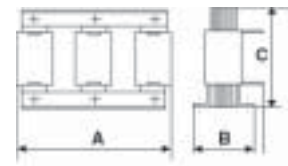


DIMENSIONS

LR / LRB



LR type



LRB type

Type	A mm	B mm	C mm	kg
LR 04-003	120	60	125	1,8
LR 04-004	120	60	125	1,8
LR 04-006	120	60	125	2
LR 04-008	120	60	125	2
LR 04-010	120	70	125	2,3
LR 04-013	120	70	125	2,3
LR 04-017	150	75	150	3,5
LR 04-022	150	90	152	4,6
LR 04-033	150	90	152	5
LR 04-041	180	100	193	7,5
LR 04-050	180	110	197	9
LR 04-058	180	110	197	9,5
LR 04-066	180	120	197	11

Type	A mm	B mm	C mm	kg
LRB 04-080	180	135	160	13
LRB 04-095	237	120	195	18
LRB 04-115	237	131	195	21
LRB 04-150	237	131	215	26
LRB 04-185	242	154	256	32
LRB 04-200	245	154	256	36
LRB 04-250	285	154	300	44
LRB 04-300	280	164	300	48
LRB 04-400	320	208	350	72
LRB 04-500	320	228	350	80
LRB 04-600	385	320	505	105

LM

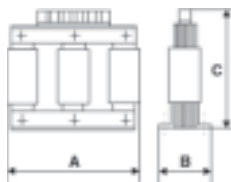


Figure A

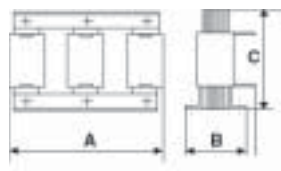
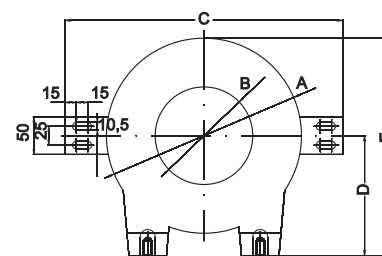
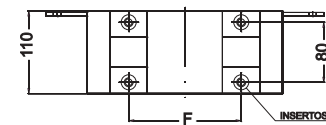


Figure B

Type	A mm	B mm	C mm	G mm	kg	Figure
LM 22-050	120	70	125	--	2,2	A
LM 40-050	150	90	152	--	5	A
LM 75-050	180	110	160	185	10	B
LM 110-050	180	120	160	175	12	B
LM 180-050	237	145	220	175	25	B

RMV



Type	A Ø mm	B Ø mm	C mm	D mm	E mm	F mm	Inserts
RMV-260	260	130	370	160	370	290	M12
RMV-330	330	150	470	190	355	210	M12/M16



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