SCHAFFNER

- Differential/symmetrical chokes
- Storage mode chokes

RS 512, RS 612
RS 514, RS 614
RS 522, RS 622
250 VAC, 0.5 to 4 A

This state of the art RS 500, RS 600 choke series has the following features:

- **5 different applications specified**
- **IEC 950 compatible for any:**
  - **basic/reinforced insulation equipment**
- **Quasi linear saturation for storage mode**
- **40 to 450 microjoules storage**
- **F_0 from 500 kHz to 60 MHz in symmetrical mode**
- **3 µH to 3600 µH**
- **0.5 A to 4 A**
- **6 different housings**

This product is ideally suited for the following applications:

- **Energy filtering**
- **Multistage discrete filtering**
- **General purpose differential/symmetrical mode filtering**
- **S.M.P.S., U.P.S.**
- **DC/DC converters**
- **Frequency converters**
-

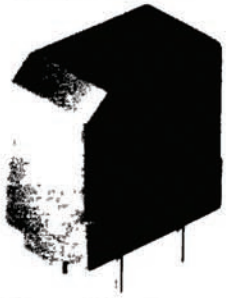
Environmental Ratings

• Maximum operating voltage	250 V @ 40° C
• High potential test voltage	
winding to winding at 25°C.	1500 V AC, 1 min, guaranteed
	2000V, 50/60 Hz, 1 s, factory test
winding to housing at 25°C	4000V, 50/60 Hz, 1 s,
• Power operating frequency:	DC to 1 KHz at 40°C in filtering
	up to 150 KHz at 40°C in storage mode
• Operating temperature range	– 40°C to +125°C (DIN 40040 = G, K)
• Derating above 40°C.	$I = I_N \sqrt[2]{(125 - \theta) / 85}$
• Storage temperature range:	– 40°C to +125°C
• Operating relative humidity:	(DIN 40040 = C) 100 % 30 days, 95 % average
• Climatic class per IEC 68:	40 / 125 / 56
• Vibrations:	5 g, 3 Axis, 10...150 Hz, 4 cycles per IEC 68-2-6
• Shocks:	10 g, 1000 times, per IEC 68-2-29
• Temperature rise at I_n:	40°C @ 40°C Amb
• MTBF at 40°C, per MIL-HB-217E.	12'000'000 h
• Surge current at 10 ms.	50 x I_n max. @ 25°C
• Solderability:	235°C 2 s dip, 265°C max per IEC 68-2-20
• Pin's pull strength:	20 N
• Resistance to solvent	
- ultrasonic	2 s, 25 kHz
- solvent :	T.C.E. 60°C
• Flammability	UL94VO

Housing Types

RS 512 (GH2 housing)
17.1 x 17 7 x 12 5 mm
RS 514 (GH3 housing)
21 5 x 22 5 x 13 2 mm
RS 522 (GH4 housing)
28 x 27 x 16 5 mm

RS 612 (GV2B housing)
18 x 12 5 x 20 mm



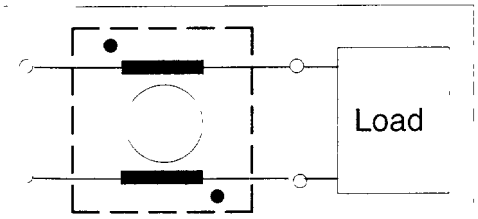
RS 614 (GV3A housing)
23 x 15 5 x 25 mm
RS 622 (GV 4 A housing)
31 x 18 x 29.3 mm

Certified ISO 9001 EN 29 001 supplier

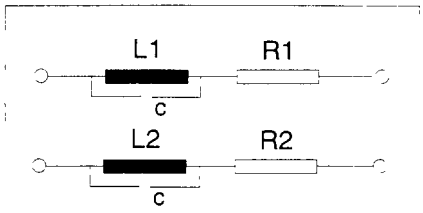
690 – 274 A

● EMI suppression/filtering mode

● Application type no. 1: Symmetrical/differential mode



Functional schematic



Equivalent electrical schematic

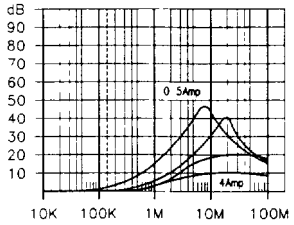
Electrical Characteristics at 25°C ± 2°C

Product Type	Nominal current at 40°C A	Nominal Inductance L1 = L2 = L µH ① min	typ.	max.	Resistance R1 = R2 = R Ω ② min	typ.	max.	Resonance Frequency F_0 - MHz ③ typical	Equivalent Self-Capacitance C at F_0 ④ pF typical	Attenuation dB at F_0 typical
RS 512-0 5/02, RS 612-0 5/02	0 5	150	200	250		0.65		8	2 0	46
RS 512-1/02, RS 612-1/02	1 0	42	55	69		0 13		20	1 1	40
RS 512-2/02, RS 612-2/02	2.0	10	13	16		0 03		25	3 2	20
RS 512-4/02, RS 612-4/02	4 0	2.3	3	3 8		0 01		33	7 8	10
RS 514-0 5/02, RS 614-0 5/02	0 5	360	480	600		0 8		7	1	56
RS 514-1/02, RS 614-1/02	1.0	90	120	150		0 2		11	1.8	25
RS 514-2/02, RS 614-2/02	2 0	23	30	38		0.05		16	3 3	17
RS 514-4/02, RS 614-4/02	4.0	6	8	10		0.02		22	6 5	10
RS 522-0.5/02, RS 622-0 5/02	0 5	675	900	1125		1 25		2	7	45
RS 522-1/02, RS 622-1/02	1 0	169	225	281		0.3		4	7	40
RS 522-2/02, RS 622-2/02	2.0	42	55	69		0 07		7	9 4	33
RS 522-4/02, RS 622-4/02	4 0	11	15	19		0 03		13	10	27

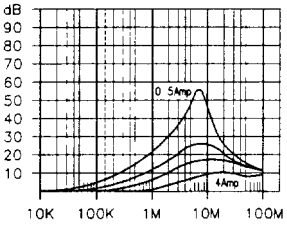
① At 1 kHz, 5 mA for L < 160 µH 1 kHz, 500 µA for L < 1600 µH or ≥ 160 µH
② At 0 1 A DC for R ≤ 200 mΩ 10 mA DC for R > 200 mΩ.
③ Per CISPR 17 section 4 2 (50 Ω / 50 Ω), no load.
④ Computed C: $C = 1/4\pi^2 f_0^2 L$

Typical functional characteristics (Attenuation/Resonance)

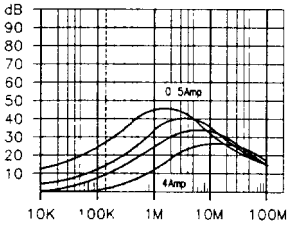
RS 512, RS 612



RS 514, RS 614

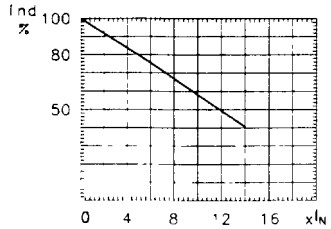


RS 522, RS 622

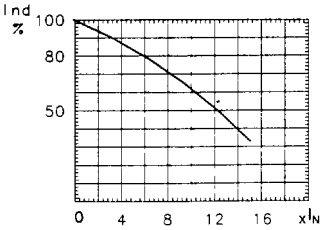


Typical saturation characteristics

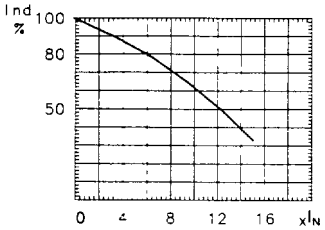
RS 512, RS 612



RS 514, RS 614

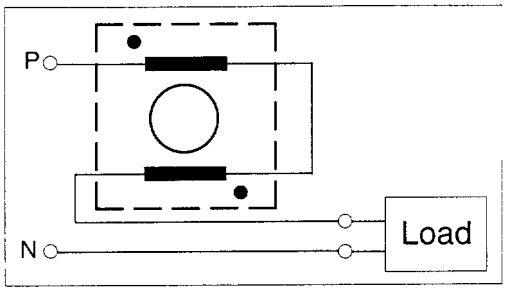


RS 522, RS 622

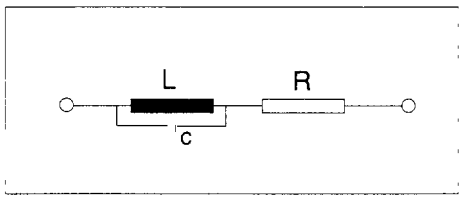


● EMI suppression/filtering mode

● Application type no. 2: Symmetrical/differential mode



Functional schematic



Equivalent electrical schematic

Electrical Characteristics at 25°C ± 2°C

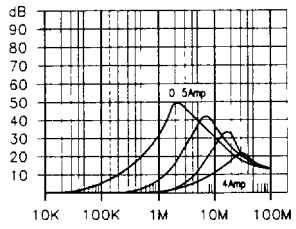
Product Type	Nominal current at 40°C A	Nominal Inductance L - µH ①			Resistance R - Ω ②			Resonance Frequency F_0 - MHz ③	Equivalent Self-Capacitance C at F_0 ④	Attenuation dB at F_0
		min	typ	max.	min	typ	max.	typical	pF typical	typical
RS 512-0.5/02, RS 612-0.5/02	0 5	600	800	1000		1.3		2	7 8	50
RS 512-1/02, RS 612-1/02	1 0	165	220	275		0.26		8	1 7	43
RS 512-2/02, RS 612-2/02	2.0	39	52	65		0.06		17	1.7	33
RS 512-4/02, RS 612-4/02	4 0	9	12	15		0 02		27	2 9	22
RS 514-0 5/02, RS 614-0.5/02	0.5	1425	1900	2375		1 6		2 5	2 1	56
RS 514-1/02, RS 614-1/02	1.0	360	480	600		0 4		5.5	1.8	50
RS 514-2/02, RS 614-2/02	2.0	90	120	150		0 1		10	2.2	37
RS 514-4/02, RS 614-4/02	4.0	24	32	40		0.04		18	2 4	26
RS 522-0.5/02, RS 622-0.5/02	0.5	2700	3600	4500		2.5		0 6	19 5	63
RS 522-1/02, RS 622-1/02	1 0	675	900	1125		0.6		1.5	12 5	52
RS 522-2/02, RS 622-2/02	2.0	165	220	275		0.14		3	12 8	40
RS 522-4/02, RS 622-4/02	4.0	45	60	75		0.06		5	16 8	31

① At 1 kHz, 5 mA for L < 160 µH. 1 kHz, 500 µA for L < 1600 µH or ≥ 160 µH
② At 0 1 A DC for R ≤ 200 mΩ. 10 mA DC for R > 200 mΩ.
③ Per CISPR 17 section 4 2 (50 Ω / 50 Ω), no load.
④ Computed C: $C = 1/4\pi^2 \ f_0^2 . L$

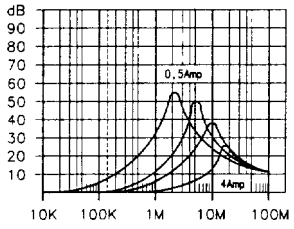
Typical functional characteristics

Attenuation/Resonance frequency characteristics

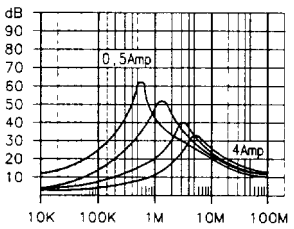
RS 512, RS 612



RS 514, RS 614

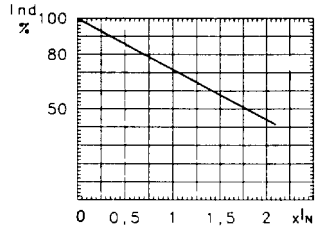


RS 522, RS 622

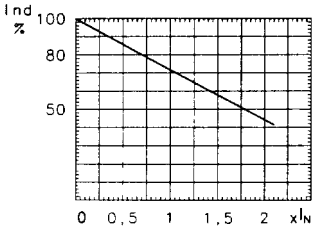


Typical saturation characteristics

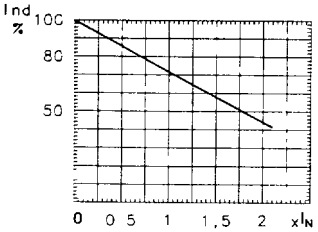
RS 512, RS 612



RS 514, RS 614

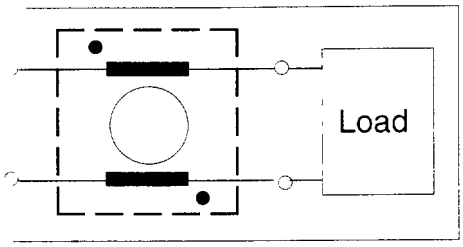


RS 522, RS 622

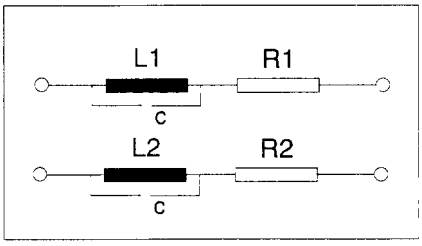


● EMI suppression/filtering mode

● Application type no. 3: Asymmetrical/common mode



Functional schematic



Equivalent electrical schematic

Electrical Characteristics at 25°C ± 2°C

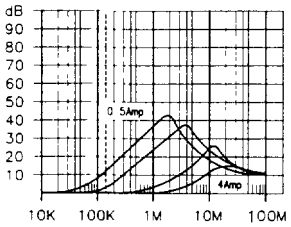
Product Type	Nominal current at 40°C A	① Nominal Inductance L1 = L2 = L µH			② Resistance R1 = R2 = R Ω			③ Resonance Frequency F_0 - MHz	④ Equivalent Self-Capacitance C at F_0	Attenuation dB at F_0
		min.	typ	max.	min	typ.	max	typical	pF typical	typical
RS 512-0 5/02, RS 612-0.5/02	0.5	150	200	250		0.65		3	14	41
RS 512-1/02, RS 612-1/02	1.0	42	55	69		0.13		10	4.6	36
RS 512-2/02, RS 612-2/02	2.0	10	13	16		0 03		35	1.6	30
RS 512-4/02, RS 612-4/02	4.0	2 3	3	3.8		0 01		52	3.1	20
RS 514-0 5/02, RS 614-0.5/02	0.5	360	480	600		0 8		1 5	23.5	44
RS 514-1/02, RS 614-1/02	1.0	90	120	150		0 2		8	3.4	39
RS 514-2/02, RS 614-2/02	2.0	23	30	38		0.05		20	2.2	30
RS 514-4/02, RS 614-4/02	4 0	6	8	10		0.02		40	2.0	22
RS 522-0.5/02, RS 622-0.5/02	0 5	675	900	1125		1 25		5	1 1	50
RS 522-1/02, RS 622-1/02	1.0	169	225	281		0 3		12	0.8	44
RS 522-2/02, RS 622-2/02	2 0	42	55	69		0.07		30	0 5	36
RS 522-4/02, RS 622-4/02	4 0	11	15	19		0 03		60	0 5	28

① At 1 kHz, 5 mA for L < 160 µH 1 kHz, 500 µA for L < 1600 µH or ≥ 160 µH
② At 0 1 A DC for R ≤ 200 mΩ. 10 mA DC for R > 200 mΩ
③ Per CISPR 17 section 4 2 (50 Ω / 50 Ω), no load.
④ Computed C: $C = 1/4\pi^2 . f_0^2 . L$

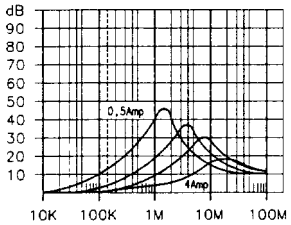
Typical functional characteristics

Attenuation/Resonance frequency characteristics

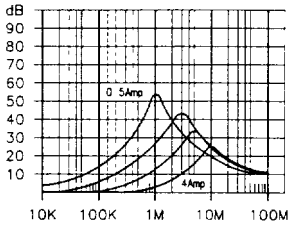
RS 512, RS 612



RS 514, RS 614

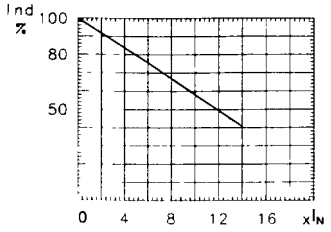


RS 522, RS 622

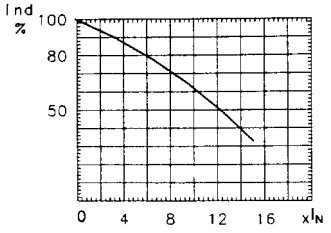


Typical saturation characteristics

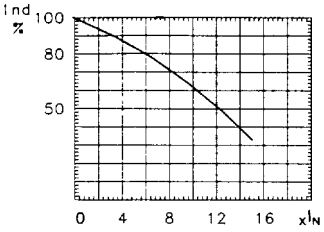
RS 512, RS 612



RS 514, RS 614

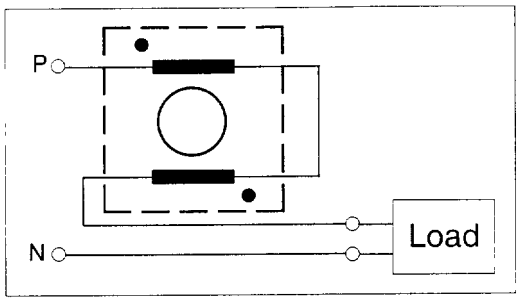


RS 522, RS 622

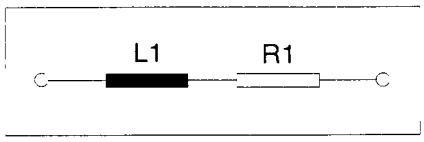


● Energy storage mode

● Application type no. 4: Energy storage



Functional schematic



Equivalent electrical schematic

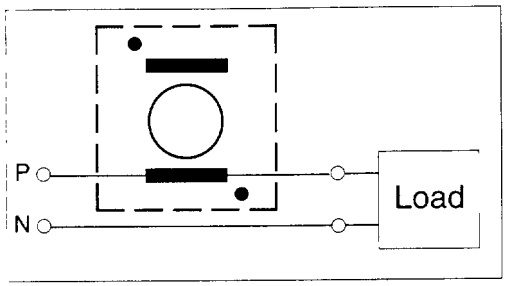
Electrical Characteristics at 25°C ± 2°C

Product Type	Nominal current at 40°C A	Nominal Inductance L - µH ①			Resistance ② R1 = R2 = R Ω			Energy ③ E - µJ
		min.	typ.	max.	min	typ.	max	typ
RS 512-0 5/02, RS 612-0.5/02	0 5	600	800	1000		1 3		100
RS 512-1/02, RS 612-1/02	1 0	165	220	275		0.26		100
RS 512-2/02, RS 612-2/02	2.0	39	52	65		0 06		100
RS 512-4/02, RS 612-4/02	4 0	9	12	15		0.02		100
RS 514-0 5/02, RS 614-0.5/02	0.5	1425	1900	2375		1 6		240
RS 514-1/02, RS 614-1/02	1 0	360	480	600		0 4		240
RS 514-2/02, RS 614-2/02	2 0	90	120	150		0.1		240
RS 514-4/02, RS 614-4/02	4.0	24	32	40		0.04		240
RS 522-0 5/02, RS 622-0.5/02	0 5	2700	3600	4500		2.5		450
RS 522-1/02, RS 622-1/02	1 0	675	900	1125		0 6		450
RS 522-2/02, RS 622-2/02	2.0	165	220	275		0 14		450
RS 522-4/02, RS 622-4/02	4 0	45	60	75		0 06		450

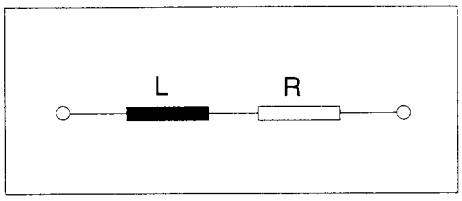
① At 1 kHz, 5 mA for L < 160 µH 1 kHz, 500 µA for L < 1600 µH or ≥ 160 µH
② At 0.1 A DC for R ≤ 200 mΩ 10 mA DC for R > 200 mΩ.
③ Computed E : $E = {}^{1}/_{2} . L\ I^2$

● Energy storage mode

● Application type no. 5: Energy storage



Functional schematic



Equivalent electrical schematic

Electrical Characteristics at 25°C ± 2°C

Product Type	Nominal current at 40°C A	④ Permitted current at 40°C A	① Nominal Inductance L - µH min	typ.	max.	② Resistance R - Ω min	typ.	max.	③ Energy E - µJ typ
RS 512-0 5/02, RS 612-0 5/02	0 5	0 63	150	200	250		0.65		40
RS 512-1/02, RS 612-1/02	1 0	1.25	42	55	69		0.13		40
RS 512-2/02, RS 612-2/02	2 0	2.5	10	13	16		0 03		40
RS 512-4/02, RS 612-4/02	4 0	5.0	2.3	3	3.8		0 01		40
RS 514-0.5/02, RS 614-0.5/02	0.5	0.63	360	480	600		0 8		95
RS 514-1/02, RS 614-1/02	1 0	1.25	90	120	150		0 2		95
RS 514-2/02, RS 614-2/02	2 0	2.5	23	30	38		0.05		95
RS 514-4/02, RS 614-4/02	4 0	5 0	6	8	10		0 02		95
RS 522-0.5/02, RS 622-0 5/02	0.5	0 63	675	900	1125		1.25		175
RS 522-1/02, RS 622-1/02	1 0	1 25	169	225	281		0.3		175
RS 522-2/02, RS 622-2/02	2.0	2.5	42	55	69		0.07		175
RS 522-4/02, RS 622-4/02	4.0	5.0	11	15	19		0.03		175

① At 1 kHz, 5 mA for L < 160 µH. 1 kHz, 500 µA for L < 1600 µH or ≥ 160 µH
② At 0.1 A DC for R ≤ 200 mΩ. 10 mA DC for R > 200 mΩ.
③ Computed E · E = $^1/_2$. L I^2 with permitted current.
④ Increased in current value when using only one winding side.

Application Example

The RS 500, RS 600 family attenuation process in a S.M.P.S.

Fig 1. shows the conducted emissions of a switched mode power supply which has no suppression components.
The conducted emissions exceed the standards from 35 kHz to over 10 MHz.
The effect of inserting an RS choke of the line can be seen in Fig. 2.
Below 100 kHz the narrowband differential mode peaks have been significantly reduced. Differential mode suppression is the strong point from choke series RS 500.
A significant reduction in emissions is also noted above 3 MHz.
At the choke self resonance frequency of 1.5 MHz an increase in emissions is noted To reduce this effect other suppression components would be used.
By using this choke with other components a complete suppression of this power supply can be achieved as shown in Fig 4.

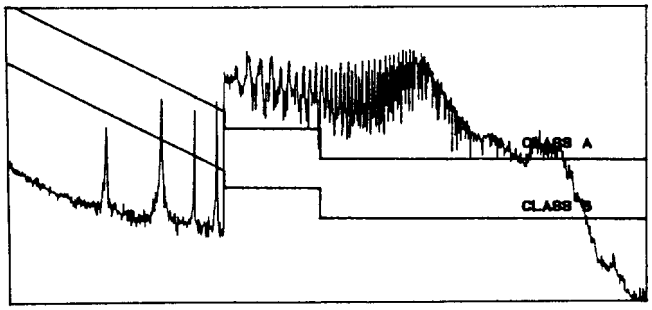


Fig. 1 Emissions level of a S.M.P S without suppression device

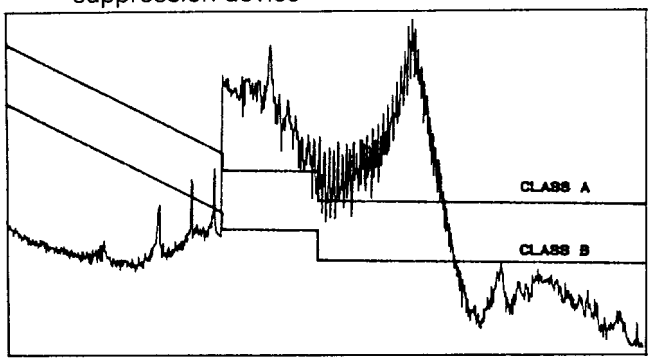


Fig. 2 Suppression effect of a RS 522-05

Multilevel attenuation Process in a S.M.P.S.

Usage of dedicated discrete suppression devices, like symmetrical mode attenuation chokes (RS 500, RS 600 series) and/or asymmetrical mode attenuation chokes, (RN 100, RN 200 series) and/ or capacitor suppression network (SN 9223, SN 223) allow the designer to build multistage filtering. Each stage works in a specific frequency area, or noise mode, see fig. 3.
This added flexibility has been made feasible with the proper design of the 3 above mentioned Schaffner product families. Build to work together and optimized for perfect interaction, this combined with the freedom to select capacitance and inductance values they allow fast and efficient design for high volume production equipment In our example the result is shown on fig. 4.

For further information, refer to the following Schaffner publications:

- RN 100, RN 200 family data sheet.
- SN 9223, SN 223 family data sheet.
- Application note 11006E:
  The S.M.P.S. EMC COMBO Set

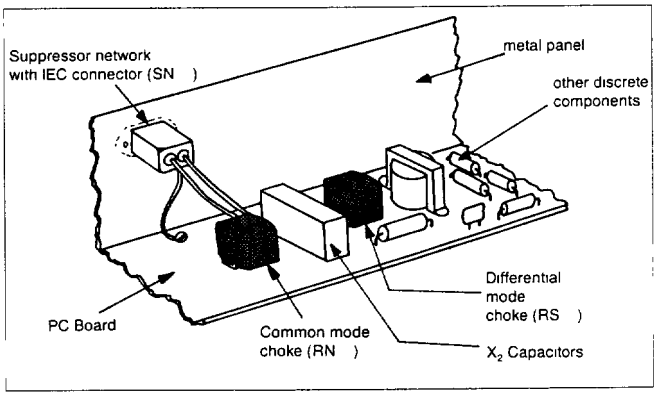


Fig. 3 A typical discrete filtering assembly

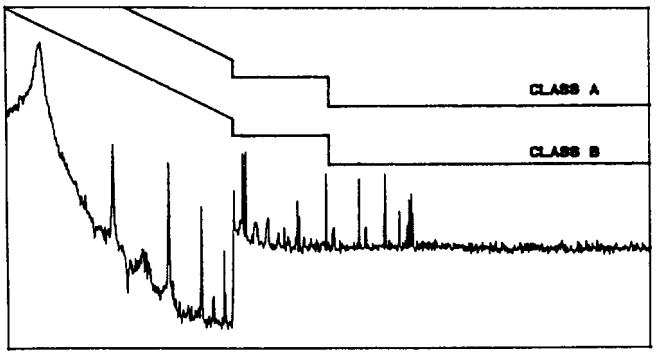
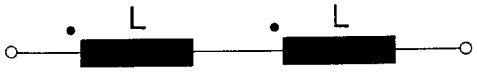


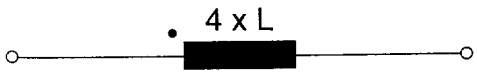
Fig. 4 Suppression effect of combined SN 223, RS 522, RN 114

Connection in Storage Mode

The RS range of chokes are suitable for storage applications for switching frequencies greater than 150 kHz!
The low dc resistance and use of low loss cores makes these chokes ideal for low current power supplies operating at high switching frequencies.
The recommended connection for the chokes in storage mode is a series connection as shown.



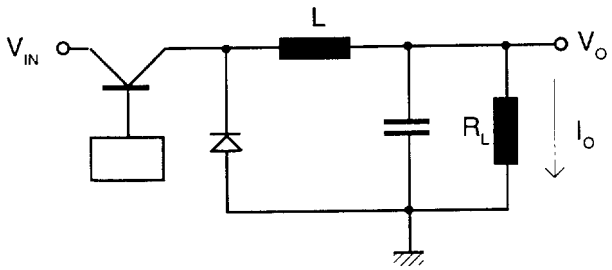
since they are on the same core, this is equivalent to



Care must of course be taken to ensure that the dot convention is observed.

Example of the selection of storage chokes:

Consider a simple Buck converter with the shown values:



Assume:

V_{IN} = 30V
V_{OUT} = 12V
I_O = 1A

$$L = \frac{2.5\, V_{IN}\, V_O}{f_{swi}(V_O + V_{IN})\, I_O}$$

for f switch = 25 kHz, L = 857 µH
required choke RS 522-1-02 (900 µH)

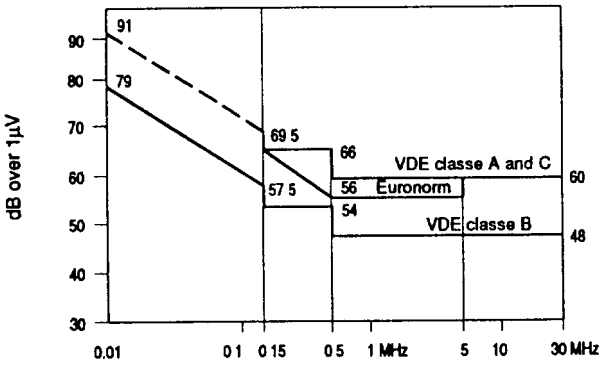
for f switch = 48 kHz, L = 446 µH
required choke RS 514-1-02 (460 µH)

for f switch = 100 kHz, L = 214 µH
required choke RS 512-1-02 (230 µH)

At higher switching frequencies the required choke becomes smaller, however there is an increased likelihood of higher interference levels

By using 48 kHz frequency a medium sized choke can be used and the 3rd harmonic is at 144 kHz which is just below the critical EMC frequency of 150 kHz If the 3rd harmonic is over 150 kHz. There may be a need for large suppression elements. The advantage of small storage elements can be lost due to an increase in filtering requirements.

Definition of the Euronorms and VDE levels A, B and C:
(all with quasi-peak measurement)



For Euronorms there exists also an AVERAGE level that is 10 dB's below the QUASI-PEAK level. Both the QUASI PEAK and the AVERAGE level must be met.

IEC 950

IEC 950 - What is it?

The IEC (International Electrotechnical Commission) is a non governmental organisation responsible for preparing standards and recommendations for the Electrotechnical Industry, like ISO (International Standards Organisation) is for most other area of activities.

IEC standards and recommendations are adopted as regulations by national and international bodies such as: UL, VDE, BSI for their respective countries and by CENELEC (Comité Européen de Normalisation Electrotechnique) to cover member states of the EC (European Community).

IEC 950 is a safety recommendation covering "Information Technologie" and "Electrical Business" machines Therefore IEC 950 covers: small and large computers, faxes, copiers, typewriters and the many other types of equipment available in a business environment

IEC 950 does not specifically mention power line filters but as filters are components in most of the above mentioned equipment, several aspects of IEC 950 have a direct effect on power line filters design, test, measurement and specifications.

IEC 950 Specifications - what are they?

Schaffner IEC 950 compatible filters fulfill IEC 950 requirements in the following way:

IEC 950 BASIC and SUPPLEMENTARY INSULATION for TN and TT power distribution systems.
High potential tests rated at 2,125 VDC (1500 VAC test is not recommended for capacitor reliability reasons) this phase to neutral, phase to housing, or, neutral to housing. Test duration is 60 secs at the system qualification level, as well as at the component qualification level. For production of equipment or of filter this test is only carried out for 1 sec or more at 80 % of the rated value.

IEC 950 leakage current
The Schaffner filters have been designed to produce less leakage current than the maximum permitted In most cases, allowance for additional leakage from the equipment is included. This to meet all the mobility equipment type of the IEC 950 class 1.

IEC 950 discharge time
All filters have a phase to neutral discharge of less than 1 second. This meets the requirements for all classes of equipment, pluggable as well as permanently installed.

IEC 950 - How to get your system tested and approved?

Approving equipment to IEC 950 with power line filters implies a system test at 2125 VDC (or 1500 VAC) test for 60 secs. During these tests the discharge resistors, when they exist, are many times overloaded IEC 950 allows this test to be carried out without these resistors.

For such tests, filter without the discharge resistor can be supplied. They are the FN xxxxT types. RS 500 and RS 600 do not require special "T" units for system tests

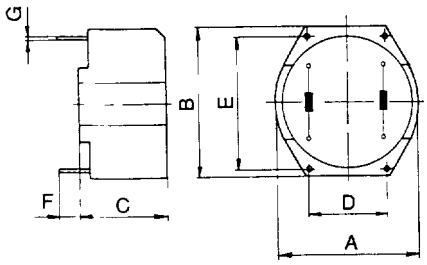
Filters for other IEC 950 requirements

For other IEC 950 requirements such as 3 kV test for reinforced insulation or the 4 kV test to earth for "IT" earthing applications, please contact your nearest Schaffner sales office to obtain a specially designed or specified filter based on the original standard type. Please note that changes in dimension may result due to the increased insulation requirements.

For further Information, please read the SCHAFFNER application note:
IEC 950, Compliance Requirements for Electronic Equipment - (Publication 2102E)

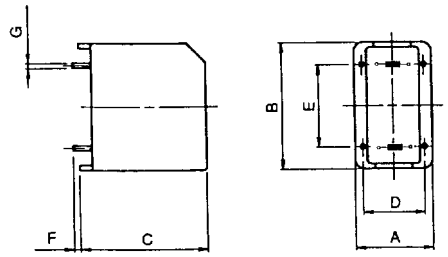
Mechanical specifications

RS 512, RS 514, RS 522



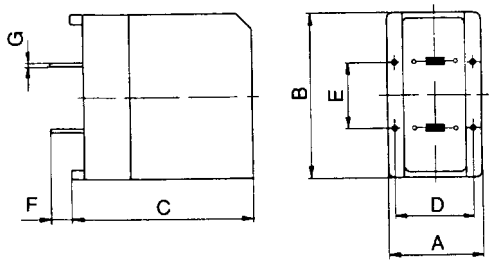
	RS 512 (GH2 housing)		RS 514 (GH3 housing)		RS 522 (GH4 housing)	
	mm	tol ±	mm	tol.±	mm	tol.±
A	17 1	0.3	21,5	0.3	27	0.3
B	17.7	0.3	22,5	0.3	28	0.3
C	12 5	0.3	13,2	0.3	16.5	0 3
D	10	0 2	12.5	0.2	15	0.2
E	15	0 2	20,1	0.2	25	0 2
F	4	0.6	4	0.6	4	0.6
G	0.8	0.1	0.8	0.1	0.8	0.1

RS 612



	RS 612 (GV2B housing)		RS 614 (GV3A housing)		RS 622 (GV4A housing)	
	mm	tol.±	mm	tol.±	mm	tol.±
A	12.5	0.3	15.5	0.3	18	0.3
B	18 0	0.3	23	0.3	31	0.3
C	20	0.3	25	0.3	29.3	0.3
D	10	0.2	12 5	0.2	15	0.2
E	15	0.2	10	0.2	12.5	0.2
F	4	0.5	4	0.5	4,7	0.5
G	0.8	0.1	0.8	0.1	0.8	0.1

RS 614, RS 622



Weight chart

Type	g
RS 512	6
RS 514	11
RS 522	22
RS 612	9
RS 614	15
RS 622	30

SCHAFFNER

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