

- 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
- $3 \mu\text{H}$ to $3600 \mu\text{H}$
- 0.5 A to 4 A
- 6 different housings

This product is ideally suited for the following applications:

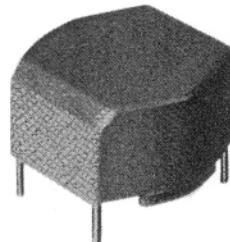
- Energy filtering
- Multistage discrete filtering
- General purpose differential/symmetrical mode filtering
- S.M.P.S., U.P.S.
- DC/DC converters
- Frequency converters
-

Environmental Ratings

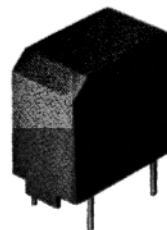
- Maximum operating voltage: 250 V @ 40° C
- High potential test voltage
 - winding to winding at 25°C: 1500 V AC, 1 min, guaranteed
 - winding to housing at 25°C: 2000V, 50/60 Hz, 1 s, factory test
- Power operating frequency:
 - DC to 1 KHz at 40°C in filtering
 - up to 150 KHz at 40°C in storage mode
- Operating temperature range: - 40°C to +125°C (DIN 40040 = G, K)
- Derating above 40°C:

$$I = I_N \sqrt{(125 - \theta) / 85}$$
- 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

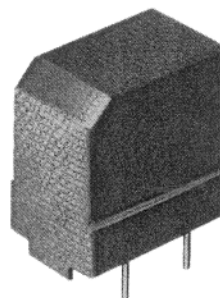
Housing Types



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 4A housing)
 31 x 18 x 29.3 mm

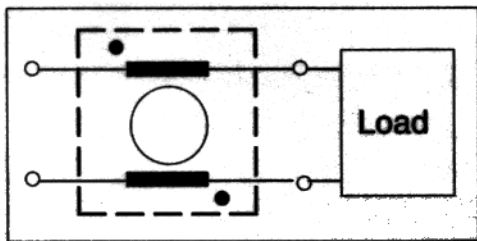


Certified
ISO 9001
EN 29 001
 supplier

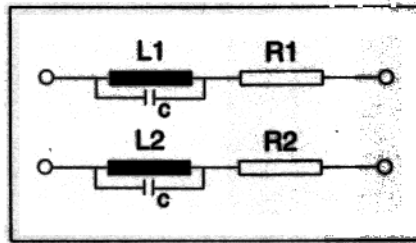
(Provisional data sheet 7/92)

● 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			Resistance R1 = R2 = R Ω ^②			Resonance Frequency F ₀ - MHz ^③	Equivalent Self-Capacitance C at F ₀ pF typical ^④	Attenuation dB at F ₀ typical
		min.	typ.	max.	min.	typ.	max.			
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.

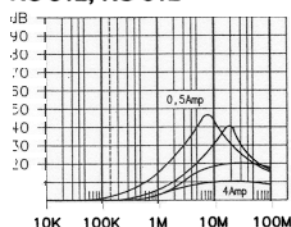
② At 0.1 A DC for R ≤ 200 mΩ. 10 mA DC for R > 200 mΩ.

③ Per CISPR 17 section 4.2 (50 Ω / 50 Ω), no load.

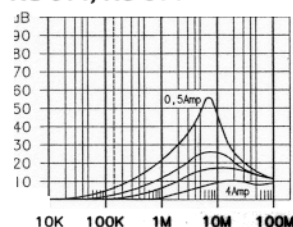
④ Computed C: $C = 1/4\pi^2 \cdot f_0^2 \cdot L$

Typical functional characteristics (Attenuation/Resonance)

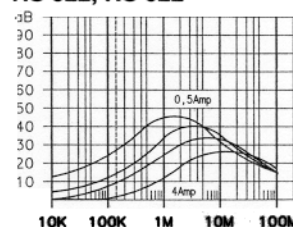
RS 512, RS 612



RS 514, RS 614

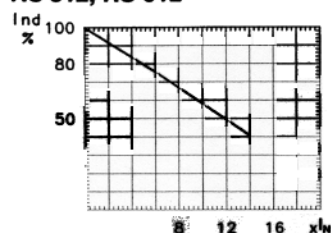


RS 522, RS 622

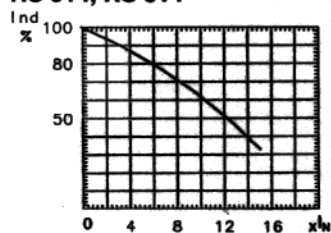


Typical saturation characteristics

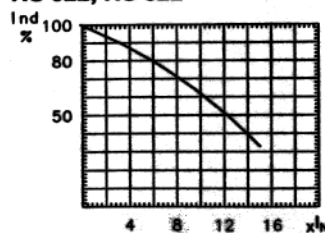
RS 512, RS 612



RS 514, RS 614

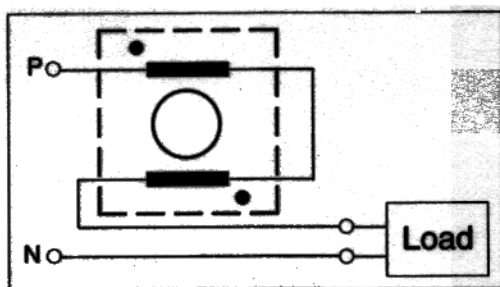


RS 522, RS 622

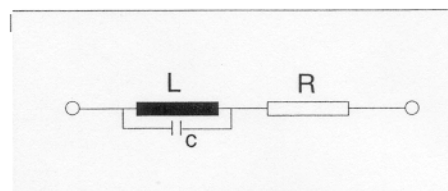


● EMI suppression/filtering mode

● 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 pF typical ^④	Attenuation dB at F ₀ typical
		min.	typ.	max.	min.	typ.	max.	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.

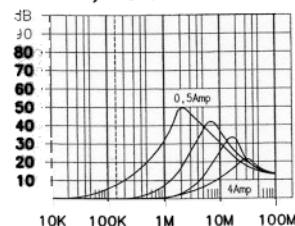
③ Per CISPR 17 section 4.2 (50 Ω / 50 Ω), no load.

④ Computed C: $C = 1/4 \pi^2 \cdot f_0^2 \cdot L$

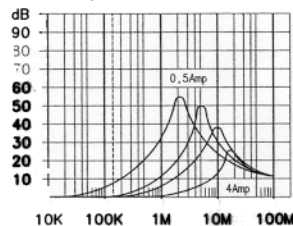
Typical functional characteristics

Attenuation/Resonance frequency characteristics

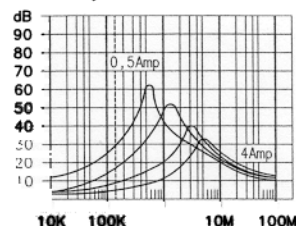
RS 512, RS 612



RS 514, RS 614

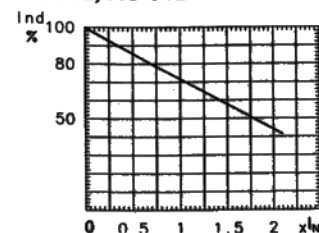


RS 522, RS 622

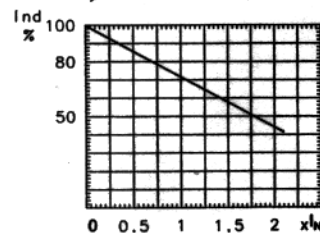


Typical saturation characteristics

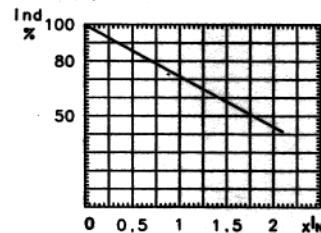
RS 512, RS 612



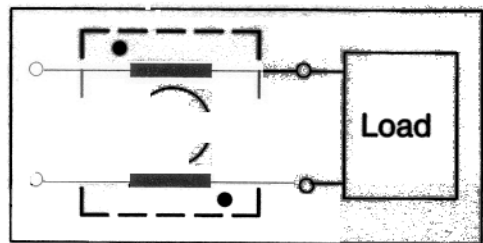
RS 514, RS 614



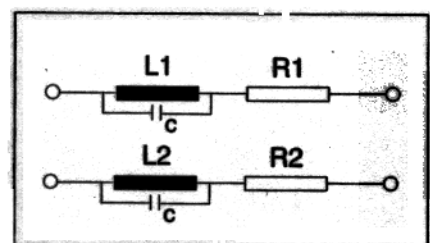
RS 522, RS 622



● EMI suppression/filtering mode



Functional schematic



Equivalent electrical schematic

Electrical Characteristics at 25°C ± 2°C

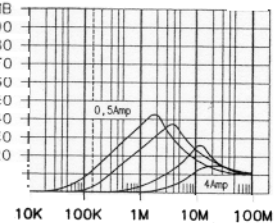
Product Type	Nominal current at 40°C A	Nominal Inductance ^① L1 = L2 = L μH			Resistance ^② R1 = R2 = R Ω			Resonance ^③ Frequency F ₀ - MHz	Equivalent ^④ Self-Capacitance C at F ₀ pF typical	Attenuation dB at F ₀ typical
		min.	typ.	max.	min.	typ.	max.	typical	pF typical	typical
RS 512-0.5/02, RS 612-0.5/02	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: $C = 1/4 \pi^2 \cdot f_0^2 \cdot L$

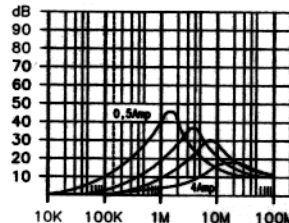
Typical functional characteristics

Attenuation/Resonance frequency characteristics

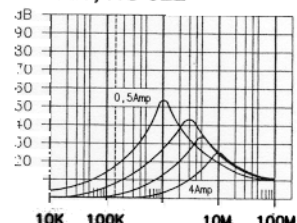
RS 512, RS 612



RS 514, RS 614

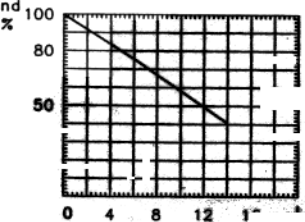


RS 522, RS 622

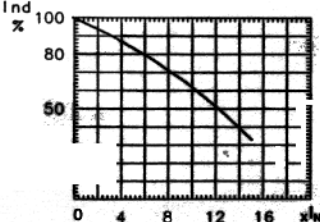


Typical saturation characteristics

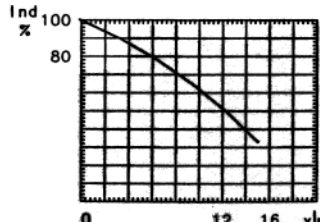
RS 512, RS 612



RS 514, RS 614

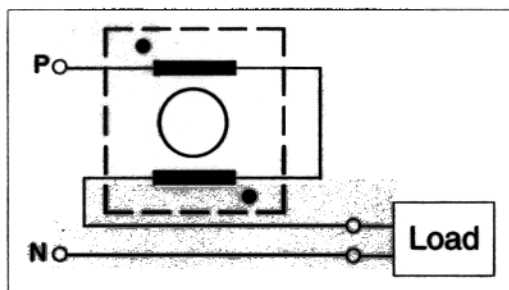


RS 522, RS 622

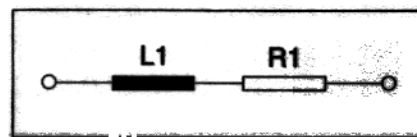


● Energy storage mode

● Application type no. 4: Energy storage



Functional schematic



Equivalent electrical schematic

Electrical Characteristics at 25°C ± 2°C

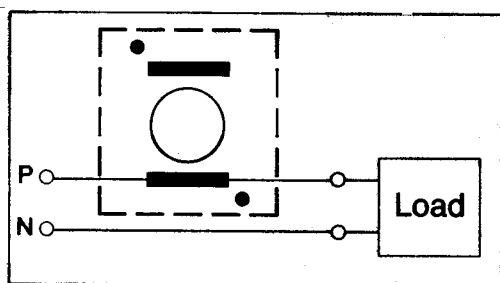
Product Type	Nominal current at 40°C A	Nominal Inductance ^① L - μH			Resistance ^② R1 = R2 = R Ω			Energy ^③ E - μJ
		min.	typ.	max.	min.	typ.	max.	
RS 512-0.5/02, RS 612-0.5/02	0.5	600	800	1000	1.3			100
RS 512-1/02, RS 612-1/02	1.0	165	220	275	0.26			100
RS 512-2/02, RS 612-2/02	2.0	39	52	65	0.06			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.

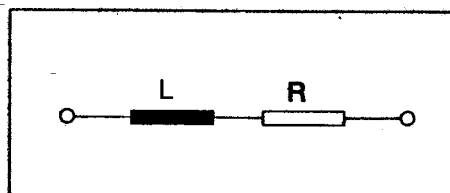
② At 0.1 A DC for R ≤ 200 mΩ. 10 mA DC for R > 200 mΩ.

③ Computed E : $E = \frac{1}{2} \cdot L \cdot I^2$

- 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	Permitted current at 40°C A	① Nominal Inductance L - μH			② Resistance R - Ω			③ Energy E - μJ typ.
			min.	typ.	max.	min.	typ.	max.	
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 : $E = \frac{1}{2} \cdot L \cdot I^2$ 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.

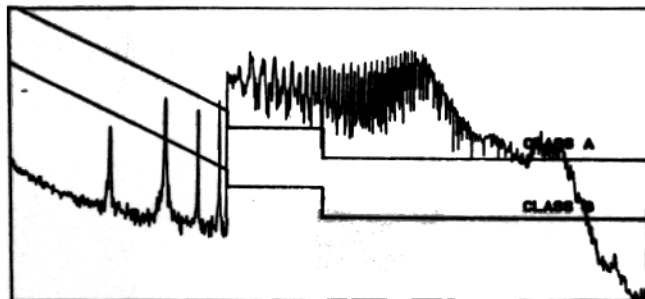


Fig. 1 Emissions level of a S.M.P.S. without suppression device

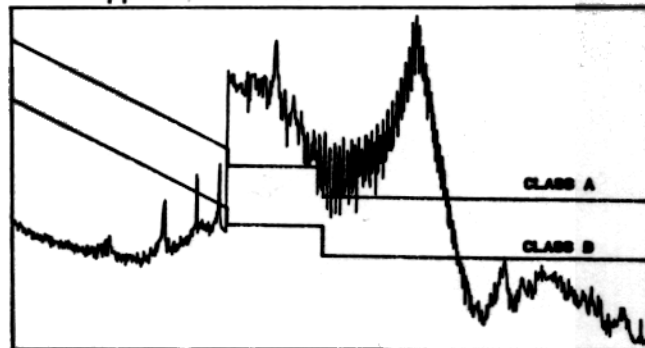


Fig. 2 Suppression effect of a RS 522-05

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.

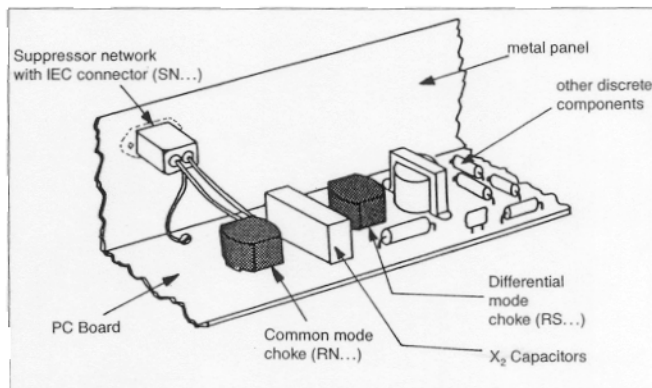


Fig. 3 A typical discrete filtering assembly

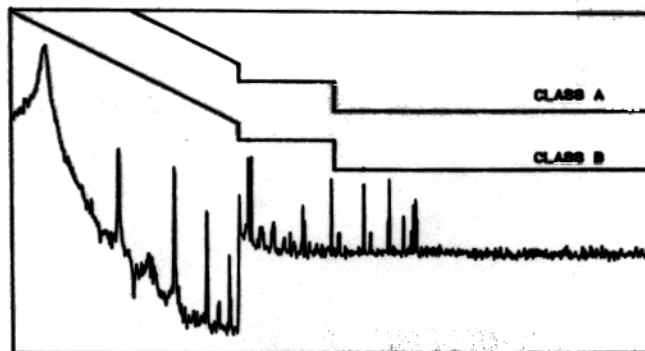
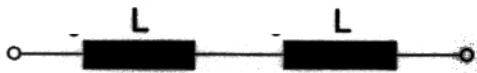


Fig. 4 Suppression effect of combined SN 223, RS 522, RN 114

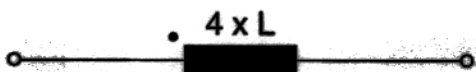
Connection in Storage Mode

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.



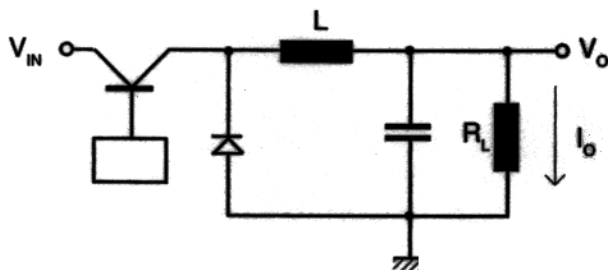
since they are on the same core, this is equivalent to:



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:

$$\begin{aligned} V_{IN} &= 30V \\ V_{OUT} &= 12V \\ I_O &= 1A \end{aligned}$$

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

$$\begin{aligned} \text{for } f_{\text{switch}} &= 25 \text{ kHz,} & L &= 857 \mu\text{H} \\ \text{required choke} & & & \text{RS 522-1-02 (900 } \mu\text{H)} \end{aligned}$$

$$\begin{aligned} \text{for } f_{\text{switch}} &= 48 \text{ kHz,} & L &= 446 \mu\text{H} \\ \text{required choke} & & & \text{RS 514-1-02 (460 } \mu\text{H)} \end{aligned}$$

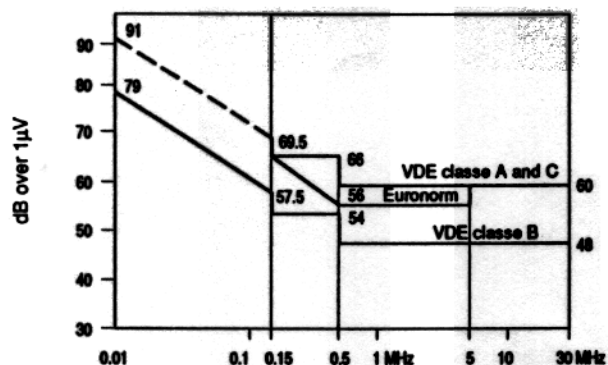
$$\begin{aligned} \text{for } f_{\text{switch}} &= 100 \text{ kHz,} & L &= 214 \mu\text{H} \\ \text{required choke} & & & \text{RS 512-1-02 (230 } \mu\text{H)} \end{aligned}$$

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:

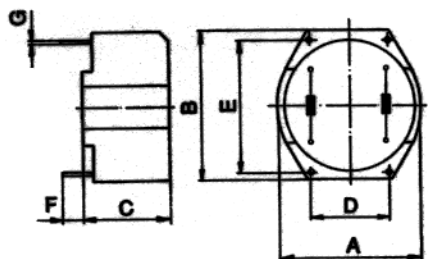
(all with quasi-peak measurement)



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.

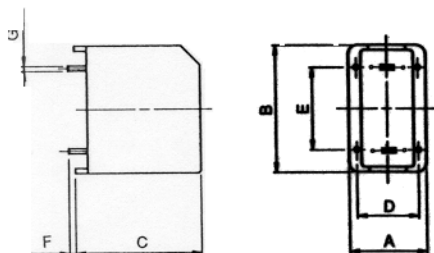
Mechanical specifications

RS 512, RS 514, RS 522



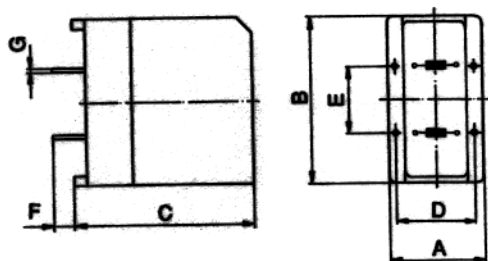
	RS 512 (GH2 housing)		RS 514 (GH3 housing)		RS 522 (GH4 housing)	
	mm	tol.±	mm	tol.±	mm	tol.±
A	17.1	0.3	21,5	0.3	27	0.3
B	17.7	0.3	22,5	0.3	28	0.3
C	12.5	0.3	13,2	0.3	16.5	0.3
D	10	0.2	12.5	0.2	15	0.2
E	15	0.2	20,1	0.2	25	0.2
F	4	0.6	4	0.6	4	0.6
G	0.8	0.1	0.8	0.1	0.8	0.1

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