1. Introduction

In the vicinity of electronics and control systems, there is often high powered equipment and cabling. In these situations it is possible that electronic circuits can be affected by these mains carrying components in such a way that signals become corrupted. Corrupted signals, especially in industrial surroundings, can lead to faulty operations or the disruption of a production line.
These interferences are caused by mains failure, harmonic distortion and transient switching voltages. The important frequency range lies mostly between 10 kHz and 100 MHz with the majority of this between 100 kHz and 10 MHz.

Electromagnetic compatibilty dicusses this topic in great detail.

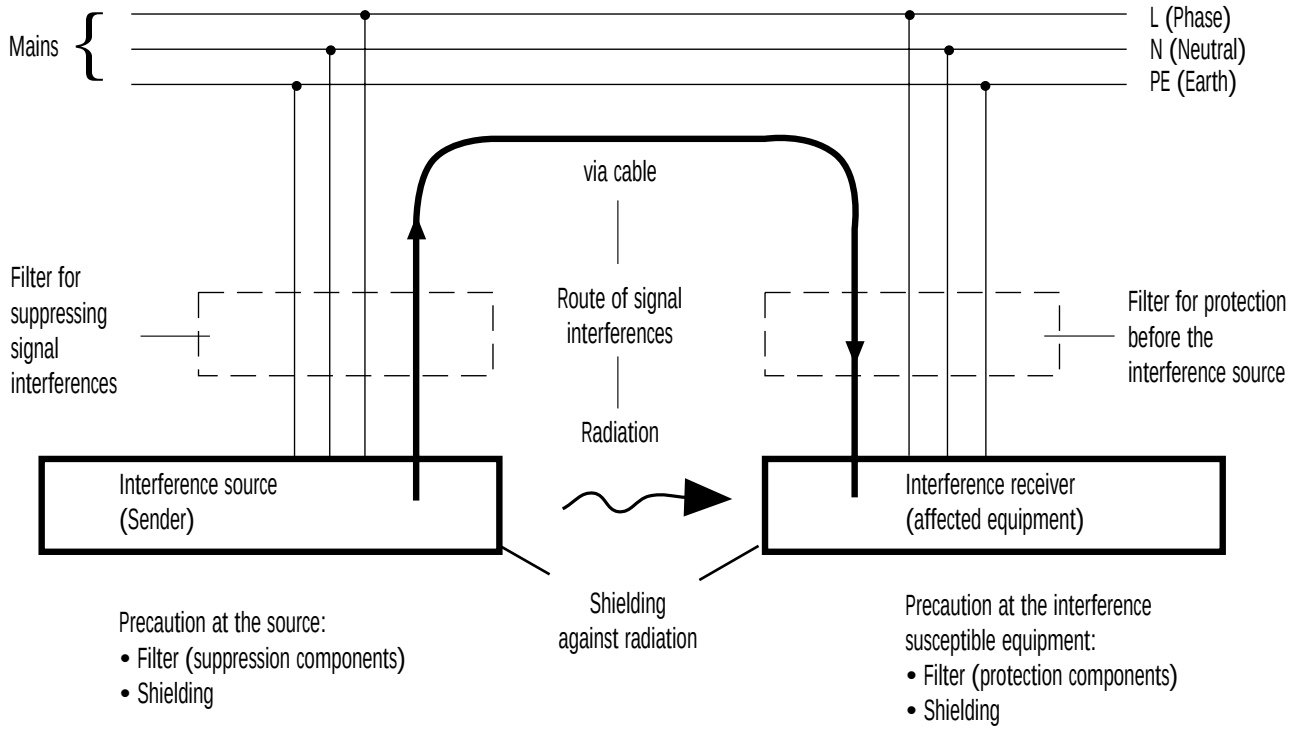
2. Definition of EMC

In DIN VDE 0870 part 1, the term electromagnetic compatibilty (EMC) is defined as the ability of electronic equipment in an electromagnetic enviroment to function satisfactorily, without affecting the surrounding equipment or enviroment in a negative manner.

3. The law on EMC

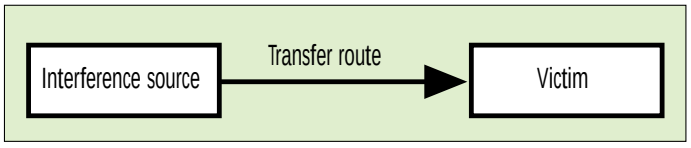
On the 03. May 1989, the E.E.C set up guidelines 89/336/EEC of the council of the European commission for harmonizing the laws on electromagnetic compatibilty in each of the member states. In this guideline, EMC was defined as a goal.
The EMC guidelines became mandatory law in Europe on the 01. January 1996. The law is upheld in that manufacturers and importers must provide EEC conformity declarations. An electrical product conforms, as soon as it fulfills all of the harmonized European laws.

The route of signal interferences



4. The Model

The electro-magnetic model is made up of three components i.e. the interference source, the transmission medium and the victim. The transmission medium can be described as the route taken by the interference. The transmission of interference can be by cable or by air.



To combat cable carried interferences, mains filters or transient absorbers should be used.

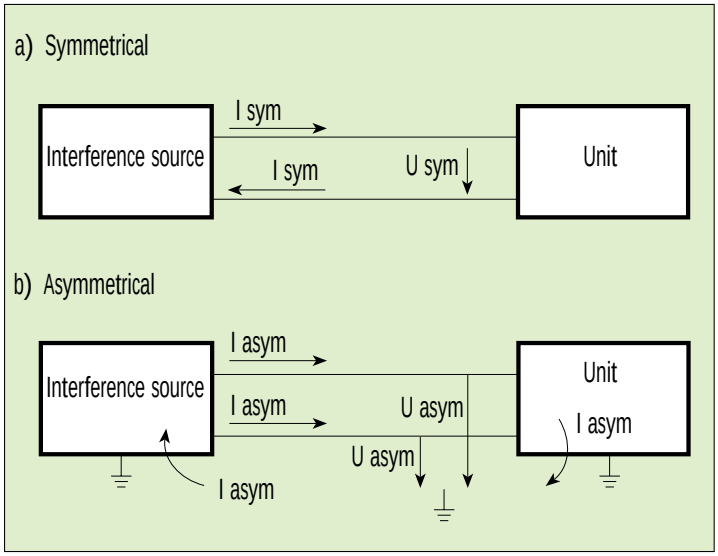
5. Interferences via cable

Cable carried interferences can be divided into two groups Asymmetrical and Symmetrical .

Symmetrical interference:- the interference appears on the phase wire with reference to the neutral wire. The passage of interference to and from the victim, gives rise to a potential difference, which can be reduced by the connection of an X capacitor.

Asymmetrical interference:- the interference is measured against earth. The interference appears on the phase wire and neutral wire together with reference to the earth wire. By placing a Y capacitor in front of the potential victim , the interference can be greatly reduced.

In reality a mix of both interference types will occur. By using mains filters and transient absorbers, both the susceptibilty of the equipment is reduced as well as the degree at which interference emissions are released. Suppression equipment therefore plays a vital role in fulfilling EMC regulations.



6. How to chose the correct filters

The choice of filter to solve EMC problems should be made on both technical and economic grounds. To make the optimum choice a few important questions must be asked:

- Nominal voltage and frequency
- Nominal current: For the best performance the nominal current of the filter should be the same as that of the equipment.
- How demanding is the application
  a) of the damping abilities as an interference protection unit?
  b) in respect to the interference rating which are to be met?
- Placement
- Max. value of the leakage current

7. Filter parameters

Nominal voltage: The nominal voltage of the filter should be equivalent to the max. supply voltage. This voltage should not be exceeded for more than 20% of the time.

Nominal current: The nominal current shown is normally valid for temperatures up to 45 °C . The filter can be kept continually operating at any temperature up to this. At higher temperatures, the recommended supply current decreases. The max. temperature is 85 °C.

Leakage current: When choosing a filter, the leakage current is often an important factor. The maximum leakage current for machine and elec. equipment is listed in various guidelines.

8. Murrelektronik Testing Center

Since 01.01.1996 electronic products have to meet either the EMC guideline (European Union) or the EMC law (Germany).

The Murrelektronik testing center helps you with all the required tests and documentations for your products or applications in the field in order to get “CE” approval.

Extensive testing equipment in the laboratory and our absorbtion room make it possible to reproduce the interference phenomena your products have to deal with.

The euipment at our testing center meets all the national and international approvals and guidelines. It also meets all the technical requirements and gets upgraded constantly in order to adapt to the newest norms.

EMC tests have to be performed in an early stage of the project. This minimizes the cost for re-design and construction. Your product then makes its way to the market faster. The later the EMC tests are made the higher the costs are for modifying the product.

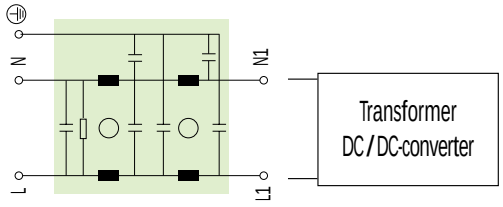
Please ask for more information.

EMC services

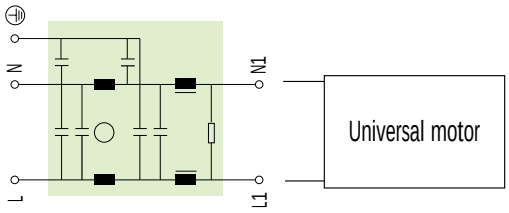
- **EMC conformity tests to international norms**
- **Suppression device and modification suggestions**
- **Tests of the machines out in the field**
- **Tests during development**
- **Tests and optimization of circuit boards**
- **Advice of EMC guidelines and norms**
- **Advice of designing machines to EMC guidelines**

Examples of applications for mains interference filters

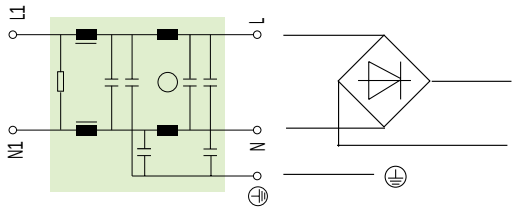
NEF 2 asymmetrical



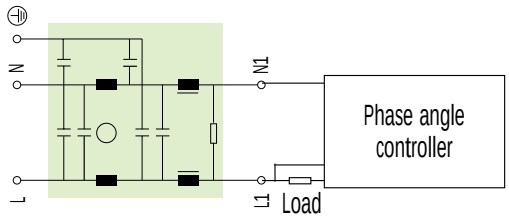
NEF 2 symmetrical



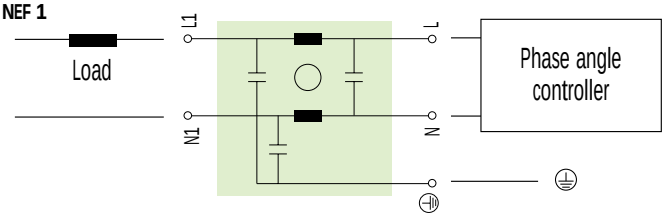
NEF 2 symmetrical



NEF 2 symmetrical

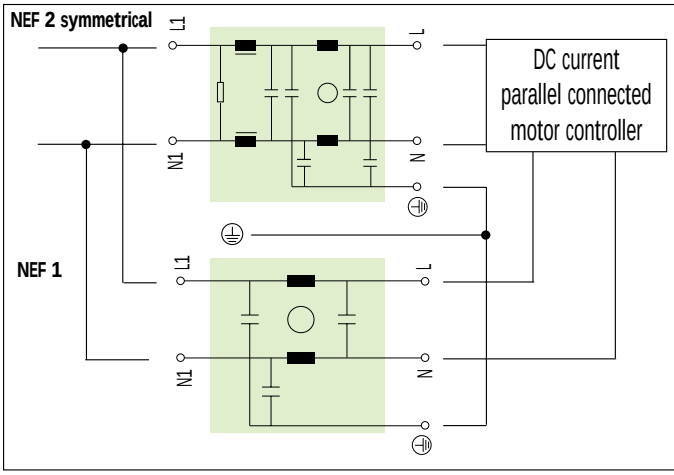


NEF 1

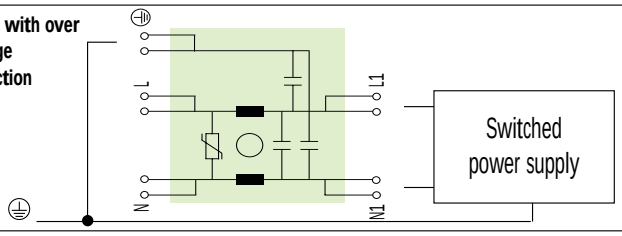


NEF 2 symmetrical

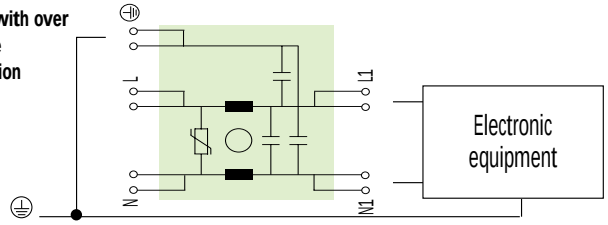
NEF 1



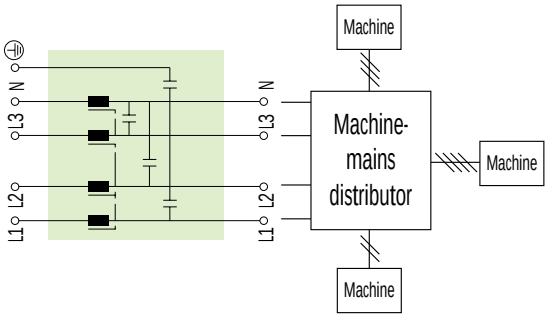
NEF 1 with over voltage protection



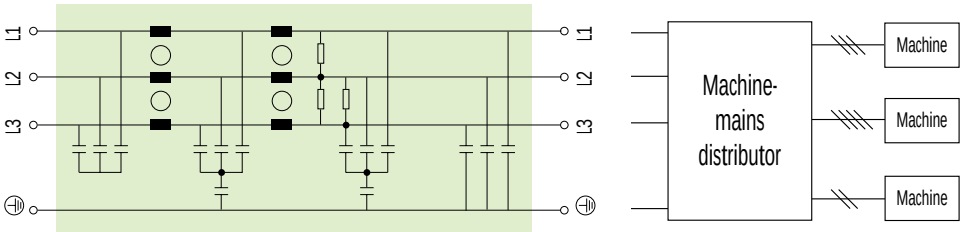
NEF 1 with over voltage protection



NEF 3

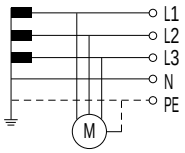


NEF 3/2

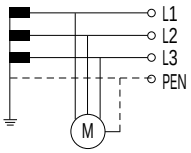


Circuit type

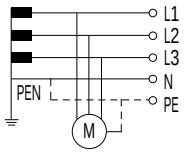
TN-S-circuit



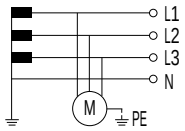
TN-C-circuit



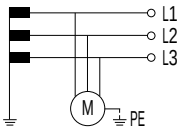
TN-C-S-circuit



TT-circuit

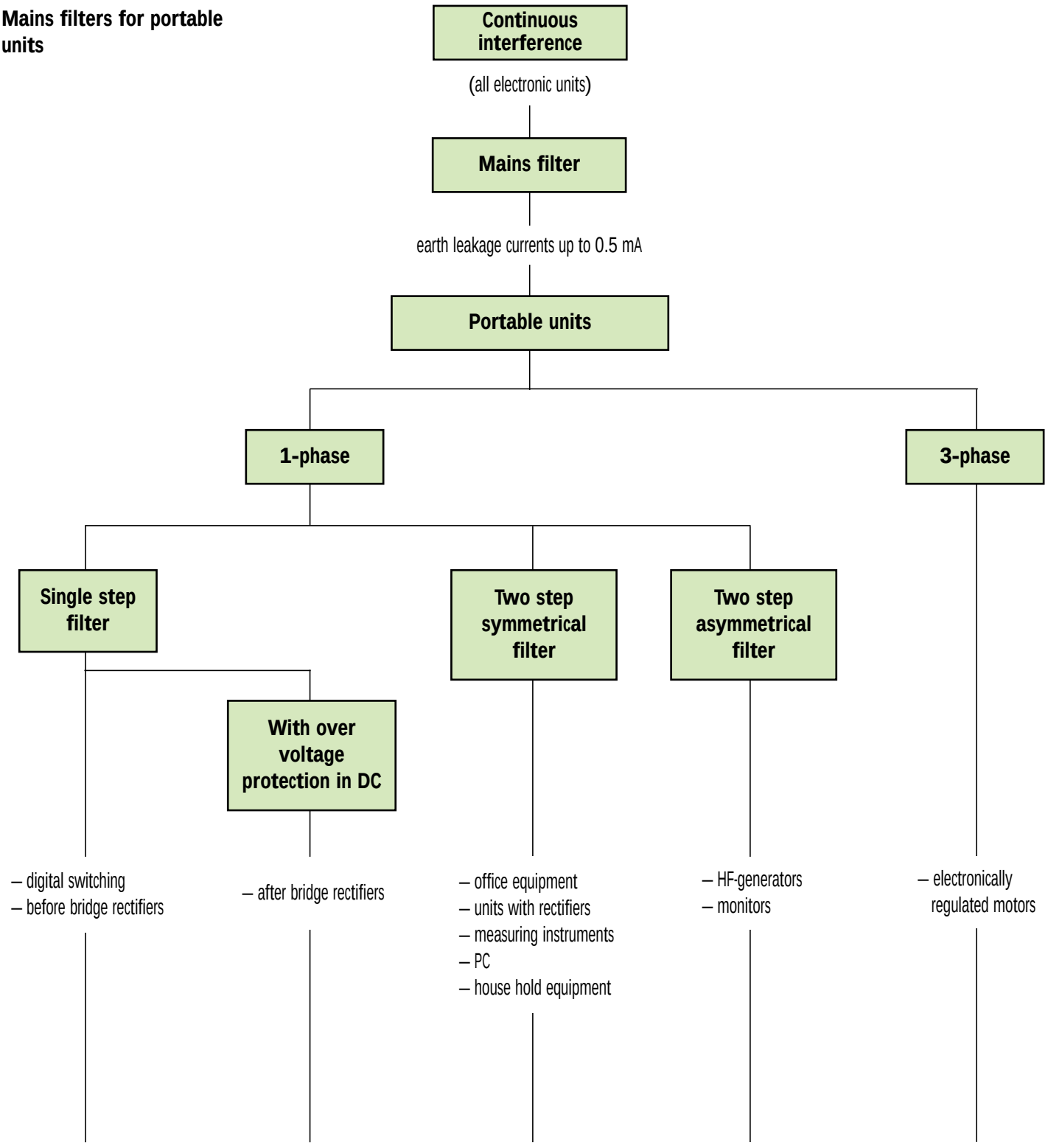


IT-circuit



Selection table for mains filters

Mains filters for portable units



NEF 1	
I_N	Art.-No.
1,0 A	10220
1,6 A	10221
2,5 A	10222
4,0 A	10223
6,5 A	10224

NEF 1	
I_N	Art.-No.
10,0 A	67350

NEF 2	
I_N	Art.-No.
1,0 A	10260
2,0 A	10261
3,0 A	10262

NEF 2	
I_N	Art.-No.
3,0 A	10270
6,0 A	10271
10,0 A	10272

NEF 3	
I_N	Art.-No.
3,0 A	10310
6,0 A	10311
10,0 A	10312

Selection table for mains filters

Mains filters for fixed units

Continuous interference

(all electronic units)

Mains filter

earth leakage currents up to 5 mA

Fixed units

1-phase

Single step filter

Without over voltage protection

With over voltage protection

– digital switching
– regulated P.S.U´s
– phase controllers (load side)
– bridge rectifiers

Two step symmetrical filter

– measuring instruments
– primary switch mode
– power supplies
– control panels
– universal motors
– phase angle controllers (mains side)

Two step asymmetrical filter

– DC mains
– DC/DC-converters
– before transformers

NEF 1

I_N	Art.-No.
10,0 A	10215
20,0 A	10216

NEF 1

I_N	Art.-No.
1,0 A	10220
1,6 A	10221
2,5 A	10222
4,0 A	10223
6,5 A	10224

NEF 2

I_N	Art.-No.
1,0 A	10260
2,0 A	10261
3,0 A	10262
4,0 A	10263
6,0 A	10264
16,0 A	10266

NEF 2

I_N	Art.-No.
3,0 A	10270
6,0 A	10271
10,0 A	10272

Selection table for mains filters

Mains filters for fixed units

Continuous interference

(all electronic units)

Mains filter

earth leakage currents up to 5 mA

Fixed units

3-phase

Single step

Two step

With neutral

– for TN-S-, TN-C-S- and TT circuits
– electrically controlled motors
– circuit breakers

NEF 3	
I_N	Art.-No.
3,0 A	10310
6,0 A	10311
10,0 A	10312
20,0 A	10313

– high damping

NEF 3	
I_N	Art.-No.
16,0 A	10372
25,0 A	10373
36,0 A	10374
50,0 A	10375
80,0 A	10377
110,0 A	10378

Without neutral

– for TN-C- and IT-circuits
– linear and smoothed power supply units

NEF 3	
I_N	Art.-No.
8,0 A	10331
16,0 A	10332
25,0 A	10333
36,0 A	10334
50,0 A	10335
80,0 A	10337
110,0 A	10338
180,0 A	10339

Without neutral

– for TN-C- and IT-circuits
– switch mode power supply units
– frequency inverters

NEF 3/2	
I_N	Art.-No.
8,0 A	10350
12,0 A	10351
16,0 A	10352
25,0 A	10353
36,0 A	10354
50,0 A	10355
80,0 A	10353

Mains filters

Mains filters are used to attenuate cable born interference without impairing the supply.

These filters effectively attenuate both incoming interference which may affect sensitive equipment and also outgoing interference from the equipment to which they are connected and which may otherwise enter the mains supply.
Typical sources of continuous interference are switch mode power supplies, motors and phase controllers.

Comprising of inductive and capacitive components, they are most effective when their impedance is matched to the source of the interference.
Good low impedance earthing is important.

Earth bonds should be kept as short as possible and mating surfaces should be free from paint and other impairments etc.

Ideally, the filter should be fitted as close as possible to the point at which the cable enters the cabinet. If this is not possible, shielded cable should be used between the filter and the point of entry with the shield firmly bonded to the cabinet

NEF 1
Single-phase, one-stage, for large currents, without over voltage protection.
For general applications.
Supply voltage max. 250 V AC/DC
Nominal current: 10…20 A

Page 3.1.8

NEF 1
Single-phase, one-stage, for smaller currents, with over voltage protection.
For general applications with minimal space available. Suitable for both fixed and portable units.
The filters are suitable for double sided performance, from the unit outwards as a frequency suppressor and in in the opposite direction as a mains transient filter.
Supply voltage max. 250 V AC/DC
Nominal current : 1…6,5 A

Page 3.1.8

NEF 1
DC-Filter, single-phase, one-stage, for larger currents, with over voltage protection.
Supply voltage max. 32 V DC
Nominal current : 10 A

Page 3.1.9

NEF 2
Single-phase, 2-stage, against symmetrical interference.
Especially suitable for applications with switch mode P.S.U´s, or for units in which rapid switch repetitions are carried out. The two step filter achieves high suppresion values for more demanding applications.
Supply voltage max. 250 V AC/DC
Nominal current : 1…6 A

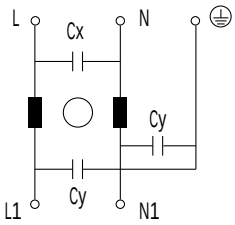
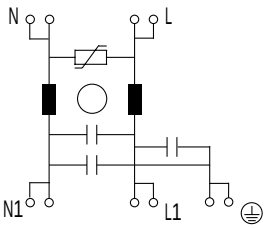
Page 3.1.10

NEF 2
Single-phase, 2-stage, against asymmetrical interference.
Especially suitable for applications with switch mode P.S.U´s, or for units in which rapid switch repetitions are carried out. The two step filter achieves high suppresion values for more demanding applications.
Supply voltage max. 250 V AC/DC
Nominal current : 3…10 A

Page 3.1.10

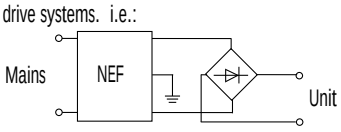
NEF 3 - NEF 3/2
Three-phase, one-stage, for general applications.
These filters reduce interference, that often appear through mains influences in electronically controlled motors (Transients).
Supply voltage max. 440 V AC/250 V DC
Nominal current : 3…180 A

Page 3.1.11/12

	NEF 1 Single-phase, one-stage	**NEF 1** Single-phase, one-stage with over voltage protection
		
Circuit diagram		
		
Ordering data	**Art.-No.**	**Art.-No.**
Nominal current I_N (at 45 °C)		
1,0 A		**10220**
1,6 A		**10221**
2,5 A		**10222**
4,0 A		**10223**
6,5 A		**10224**
10 A	**10215**	
20 A	**10216**	
Technical data		
Supply voltage	max. 250 V AC	max. 250 V AC
Supply frequency	0…60 Hz	0…60 Hz
Max. consumption (at 250 V AC to VDE 0875)	< 5 mA	< 0,5 mA
Test voltage (to VDE 0565/3)	L/N → PE 2 kV/ 50 Hz / 10 s	L/N → PE 2 kV/ 50 Hz / 10 s
Overload current	18 x I_N t < 0,5 ms; 1,5 x I_N t < 1 min. (1 x per hour)	18 x I_N t < 0,5 ms; 1,5 x I_N t < 1 min. (1 x per hour)
Attenuation	-6 dB at 2 x I_N	-6 DB at 2 x I_N
Over voltage protection		varistor suppression
		switch on time < 50 ns, continuous loading time 0,6 W
		energy absorbtion 8 J 100 times (8/20µ s)
General data		
Wiring method	rising-clamp screw terminals	rising-clamp screw terminals
Wire cross-section	AWG 22-10 ≤ 4 mm²	AWG 22-12 ≤ 2,5 mm²
Temperature range	-20…+60 °C	-20…+60 °C
Mounting method	DIN-rail mounting to EN 50022	DIN-rail mounting to EN 50022
Dimensions H x W x D	97 x 60 x 50 mm	86 x 45 x 65 mm

Description / Application

The mains filters operate in the frequency range 0,1…40 MHz and dampen interferences found in cables from the mains, supply units and control systems. The best results are obtained with short connection cables (example: earth connection < 10 cm) of the largest possible cross-section.
The mains filters are bi-directional. The single phase, one-stage mains filters dampen interference no matter what its origin (mains supply or equipment). The filters can be used for protection of the electronic circuit against mains born interference, or as protection of the mains supply against interference from other equipment. The single phase, two-stage filter is for more demanding applications. One stage is always used for asymmetrical interferences (magnetic compensating choke). The second stage is available for symmetrical as well as asymmetrical loads. These filters can be used with switch-mode power supplies and other equipment with high switching frequencies. The 3-phase, one-stage filters reduce the interference injected into the mains by electronic motor drive systems. i.e.:



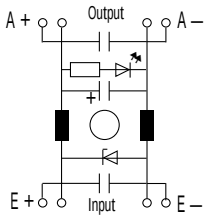
Notes

Damping curves on request.

NEF 1

Single-phase, one-stage
DC-Filter with over voltage protection

Circuit diagram



Ordering data	Art.-No.
Nominal current I_N (at 45 °C)	
10 A	**67350**

Technical data

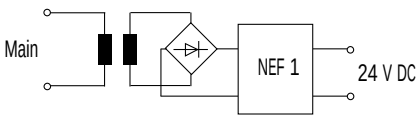
Supply voltage	max. 32 V DC
Supply frequency	0 Hz
Overload current	1,5 x I_N t < 1 min. (1 x per hour)
Attenuation	-6 dB at 2 x I_N
Over voltage protection	zener diode, 43 V
Switch on time	< 10 ns
Continuous loading	1 W

General data

Wiring method	rising-clamp screw terminals
Wire cross-section	AWG 22-12 ≤ 2,5 mm²
Temperature range	-20…+60 °C
Mounting method	DIN-rail mounting to EN 50022
Dimensions H x W x D	86 x 45 x 65 mm

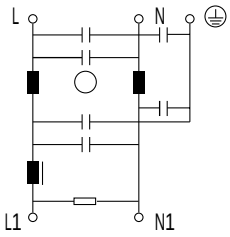
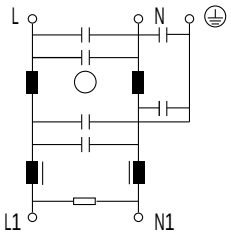
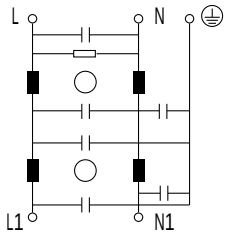
Description / Application

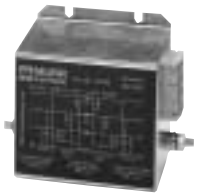
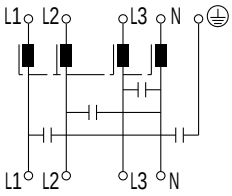
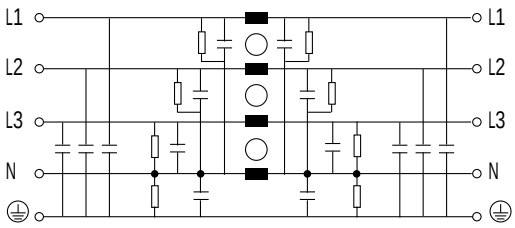
The single phase, single step mains filters NEF 1 are used in the range 0.1…40 MHz to suppress cable carried interference in power and control cabling. Voltage interferences irrespective of where they originate, either **voltage input** or **modules,** are suppressed
The filter with over voltage protection has an additional transient function.
Typical usage: –good filter performance is achieved when applied to the bridge rectifier i.e.:



Notes

Damping curves on request.

	NEF 2 Single-phase, 2-stage against symmetrical interference		**NEF 2** Single-phase, 2-stage against asymmetrical interference
			
Circuit diagram			
			
Ordering data	**Art.-No.**	**Art.-No.**	**Art.-No.**
Nominal current I_N (at 45 °C)			
1 A	**10260**		
2 A		**10261**	
3 A	**10262**		**10270**
4 A	**10263**		
6 A		**10264**	**10271**
10 A			**10272**
16 A		**10266**	
Technical data			
Supply voltage	max. 250 V AC		max. 250 V AC
Supply frequency	0…60 Hz		0…60 Hz
Max. consumption (at 250 V AC to VDE 0875)	< 0,5 mA (I_N = 4 A and more: < 3 mA)		< 0,5 mA
Test voltage to (VDE 0565/3)	L/N → PE 2 kV/50 Hz/10 s		L/N → PE 2 kV/50 Hz/10 s
Overload current	18 x I_N t < 0,5 ms; 1,5 x I_N t < 1 min (1 x per hour)		18 x I_N t < 0,5 ms; 1,5 x I_N t < 1 min (1 x per hour)
Attenuation	-12 dB at 2 x I_N		-12 dB at 2 x I_N
General data			
Wiring method	rising-clamp screw terminals		
Wire cross-section	AWG 22-10 ≤ 4 mm²		
Temperature range	-20…+60 °C		
Mounting method	DIN-rail mounting to EN 50022 (Art.-No. **10266** cannot be snapped onto DIN-rail)		
Dimensions H x W x D	97 x 60 x 50 mm (Art.-No. **10266** 173 x 127 x 85 mm)		
Description / Application			
	The single phase two step mains filters NEF 2 are used in the range 0.1…40 MHz to suppress cable carried interference on Mains-, and control cables. The best filter performance is achieved by using short connection wires (Suggestion: earth connection < 10 cm) and the largest possible diameter. The mains filters work bi-directionally (in both directions). The filters are for demanding applications. The Filters are designed for use with fixed or portable modules. One step of the filter is always for the suppression of asymmetrical interferences (magnetically compensated suppression). The second step is, dependant on application for symmetrical or asymmetrical interferences. Application: symmetrical interferences: – units with high repetitions of the switching process – switch mode P.S.U´s – phase controllers – static change over rectifiers – supply of universal motors – to transformers asymmetrical interferences: –units with high switching freq. and rapid repetitions – in DC-circuits – for transformers		
Notes			
	Damping curves on request.		

	NEF 3 3-phase, one-stage with neutral	**NEF 3** 3-phase, one-stage with neutral and increased damping
		
Circuit diagram		
Ordering data	**Art.-No.**	**Art.-No.**
Nominal current I_N (at 45 °C)		
3 A	**10310**	
6 A	**10311**	
10 A	**10312**	
16 A		**10372**
20 A	**10313**	
25 A		**10373**
36 A		**10374**
50 A		**10375**
80 A		**10377**
110 A		**10378**
Technical data		
Supply voltage	max. 3 x 440 V AC	max. 3 x 440 V AC
Supply frequency	0…60 Hz	0…60 Hz
Max. consumption (at 250 V AC to VDE 0875)	< 0,5 mA (at 20 A: < 3 mA)	< 5 mA
Test voltage (to VDE 0565/3)	L/N → PE 2 kV/50 Hz/10 s	L/N → PE 2,8 kV/50 Hz/2 s; L → L 1,7 kV/50 Hz/2 s
Overload current	18 x I_N t < 0,5 ms; 1,5 x I_N t < 1 min. (1 x per hour)	1,5 x I_N t < 1 min. (1 x per hour)
General data		
Wiring method	rising-clamp screw terminals	rising-clamp screw terminals
Wire cross-section	AWG 22-10 ≤ 4 mm²	16 A = ≤ 4 mm²; 25 A = ≤ 6 mm²; 36…50 A = ≤ 10 mm² 80 A = ≤ 25 mm²; 110 A = ≤ 50 mm²
Temperature range	-20…+60 °C	-20…+60 °C
Mounting method	DIN-rail mounting to EN 50022	screw fixing
Dimensions H x W x D	97 x 60 x 50 mm	dimensions see table

Description

Dimensions vertical mounting

Art.-No.	H x W x D	Weight
10372, 10373	151 x 241 x 66	2,8 kg
10374, 10375	151 x 251 x 66	3,5 kg
10377	151 x 378 x 81	7,6 kg
10378	387 x 150 x 81	7,8 kg

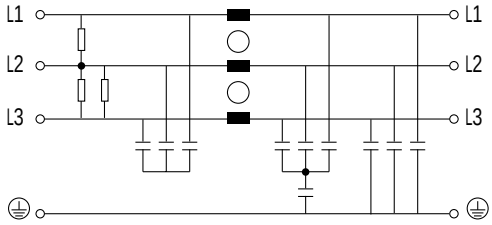
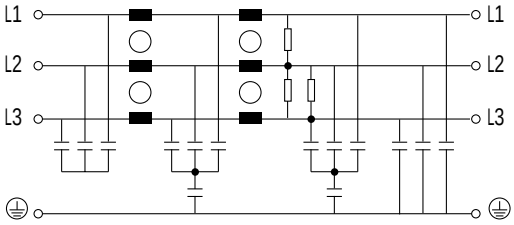
Application

The mains filters operate in the frequency range 0,1…40 MHz and dampen interferences found in cables from the mains, supply units and control systems. The best results are obtained with short connection cables (example: earth connection < 10 cm) of the largest possible cross-section. The mains filters are bi-directional.
Suitable for TN-S-, TN-C-S- and TT-circuits.
They reduce symmetrical and asymmetrical interferences, that regularly appear with electronically controlled three phase units through mains influences.

Notes

Damping curves on request.

Mains filters

	NEF 3 3-phase, one-stage without neutral	NEF 3/2 3-phase, 2-stage without neutral
		
Circuit diagram		
		
Ordering data	**Art.-No.**	**Art.-No.**
Nominal current I_N (at 40 °C)		
8 A	**10331**	**10350**
12 A		**10351**
16 A	**10332**	**10352**
25 A	**10333**	**10353**
36 A	**10334**	**10354**
50 A	**10335**	**10355**
80 A	**10337**	**10356**
110 A	**10338**	
180 A	**10339**	

Technical data		
Supply voltage		max. 3 x 440 V AC
Supply frequency		0…60 Hz
Max. consumption (at 250 V AC to VDE 0875)		up to < 3,5 mA (50 A and more: < 6 mA)
Test voltage (to VDE 0565/3)		L/N → L = 2,1 kV/50 Hz/2 s; L/N → PE = 2,7 kV/50 Hz/2 s
Overload current		1,5 x I_N, t < 3 min; 2,5 x I_N, t < 30 s (1 x per hour)
General data		
Wiring method		rising-clamp screw terminals
Wire cross-section	8…16 A	≤ 4 mm²
(AWG 22-10)	25…50 A	≤ 10 mm²
	80 A	≤ 25 mm²
	120…150 A	≤ 50 mm²
	180 A	≤ 95 mm²
Temperature range		-25…+60 °C
Mounting method		screw fixing

Description

Dimensions vertical mounting

Art.-No.	H x W x D	Weight
10331, 10332	113 x 163 x 81	2,2 kg
10333, 10334, 10335	156 x 216 x 91	3,7 kg
10337	171 x 300 x 141	9,5 kg
10338	171 x 348 x 141	10 kg
10339	171 x 404 x 141	13 kg
10350, 10351, 10352	156 x 193 x 81	3,8 kg
10353, 10354, 10355	156 x 281 x 91	5,7 kg
10356	171 x 409 x 141	16 kg

Application

The mains filters operate in the frequency range 0,1…40 MHz and dampen interferences found in cables from the mains, supply units and control systems. The best results are obtained with short connection cables (example: earth connection < 10 cm) of the largest possible cross-section. The mains filters are bi-directional.
Suitable for TN-C- and IT-circuits.
They reduce symmetrical and asymmetrical interferences, that regularly appear with electronically controlled three phase units through mains influences.

Notes

Damping curves on request.