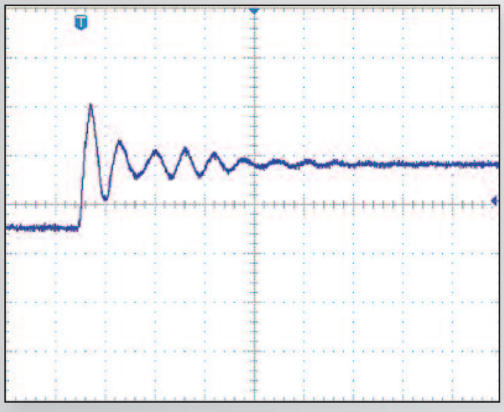
Introduction

Motors controlled by VFDs or servo drives require additional attention to avoid overvoltage spikes, known as dV/dt. Voltage wave reflection is a function of the voltage rise time (dV/dt) and the length of the motor cables. This phenomenon creates additional overvoltage spikes which cause premature degradation and failure to the motor insulation.

The challenge for OEMs, system integrators and distributors is to ensure that the installed motors are well protected from overvoltage. Markets using VFDs have adopted a special motor, better known as, a motor rated VFD or inverter duty motor.

The motor rated VFD construction can change significantly based on the manufacturer. However following the National Electrical Manufacturer's Association (NEMA), the greatest difference between a standard motor and an inverter duty motor is the winding insulation.

For example, a nominal 480 Vac AC drive using a standard grade motor should maintain performance and function with peak voltage up to 1000V. For inverter duty rated motors the acceptable peak voltage is typically 1500V.



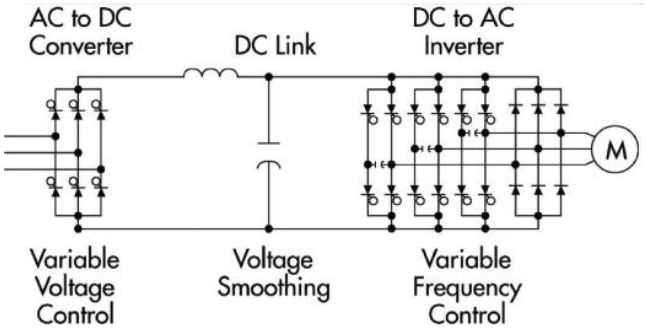
Typical example of dV/dt measured on the motor with cable length of 50m (150 ft)

Theory

To better understand what causes motor failure and unforeseen challenges, it is best to first understand how a VFD is assembled. VFDs are made up of three major parts:

- The rectifier - takes incoming AC power and converts it to DC power
- The DC link - several capacitors used for energy storage from the output of the rectifier
- The inverter - produces 2-20 kHz signal used to generate the output waveform to the motor using pulse width modulation (PWM)

PWM is a technique which generates the width of a pulse based on modulation signal information. Due to this technique, the dV/dt presents a significant concern.



Typical example of VFD layout

The Solution

Enerdoor has developed the motor protection series to protect motors from harmful overvoltage and dV/dt spikes generated by the drive's output.

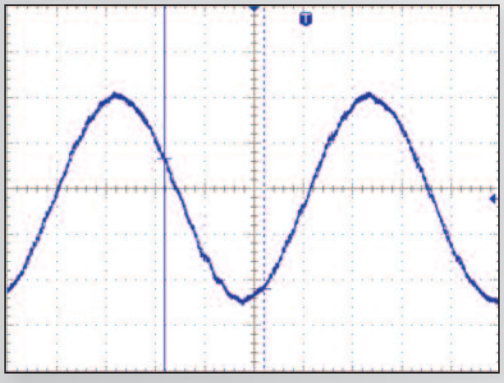
This is particularly useful for applications with variable frequency drives and servo drives. Enerdoor solutions include: common mode and differential mode chokes, sine wave filters and snubbers; all of which are designed to work with various carrier frequencies, output frequencies and applications.

Specific Solutions

Sine Wave Filters: This series reduces the effect of the PWM by converting the drive's output to a true sine waveform,eliminating dV/dt.

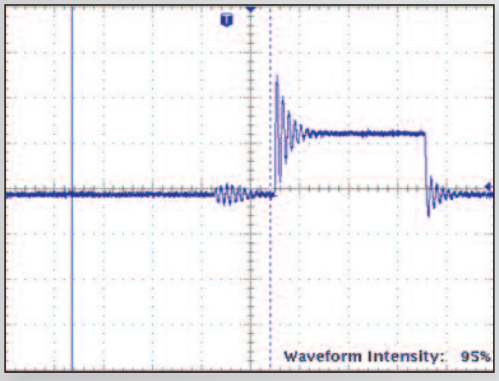
The **FIN915SF** model is used with fundamental frequencies up to 25kHz.

The high frequency inductance **FIN960F** is a unique solution used for synchronous motor spindle applications with output frequencies ranging from 1 Hz to 10 kHz.

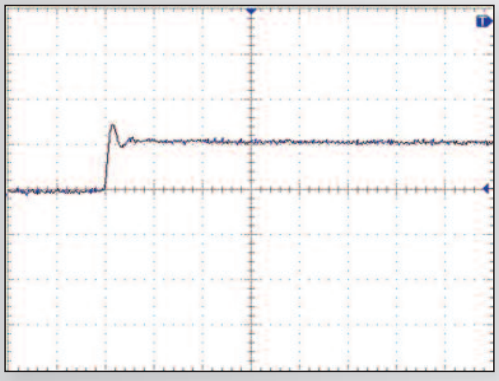


Typical example of a waveform between the VFD and motor using an Enerdoor sine wave filter FIN915SFH

Snubber: Enerdoor snubber **FIN47SNB** is a unique solution to reduce common mode and differential mode noise. The snubber is used in parallel to the system and is an ideal solution for clients in need of improving the reliability of winding insulation and bearings.



Typical measurement of dV/dt on the motor side of VFD with cable length of 100m (300ft)



Typical measurement of dV/dt on the motor side of VFD with cable length of 100m (300ft) with Enerdoor snubber FIN47SNB installed

ENERDOOR

Filter Selection Guide				CONNECTORS				FEATURES					APPLICATIONS					
Motor Protection	Description	Current Range (A)	Voltage	Cables	Terminal Blocks	Screws	Bus Bar	Common Mode Attenuation	Differential Mode Attenuation	Very Long Cable Applications	Output Frequency >75Hz	Compact Case	Long Cable Application >300m	CNC Machine	High Frequency Spindle Motor	Motor Controlled by VFD <100m	Closed Loop Motor Application	Approval
FIN900	3-phase	10-280	0-600	✘	✘	✘		✘				✘		✘		✘		
FIN930	3-phase	6-200	0-600		✘			✘									✘	
FIN950U	3-phase	8-300	0-600		✘		✘		✘							✘		
FIN5955	3-phase	3-20	0-600		✘				✘			✘		✘		✘		c UL us
FIN5958	3-phase	12-110	0-600		✘				✘		✘	✘	✘	✘	✘		✘	
FIN5980P	3-phase	9-22	0-480	✘	✘									✘				c UL us
FIN5983	3-phase	12-60	0-600		✘								✘	✘			✘	c UL us
FIN960F	3-phase	10-1000	0-750		✘				✘		✘			✘	✘			
FIN905SF	3-phase	5-880	0-600		✘		✘		✘	✘			✘					
FIN915SFH	3-phase	5-1100	0-600		✘				✘	✘	✘				✘			
FIN47SNB	3-phase plus neutral	-	0-600		✘					✘		✘	✘			✘	✘	
FINSTP	star point to groud	-	0-600		✘					✘	✘	✘	✘			✘	✘	c UL us

Motor Protection

Enerdoor motor protection reduces harmful dV/dt generated by variable frequency drives imposed onto the motor. Motor protection devices are designed to work in various applications of switching frequencies and frequency outputs.

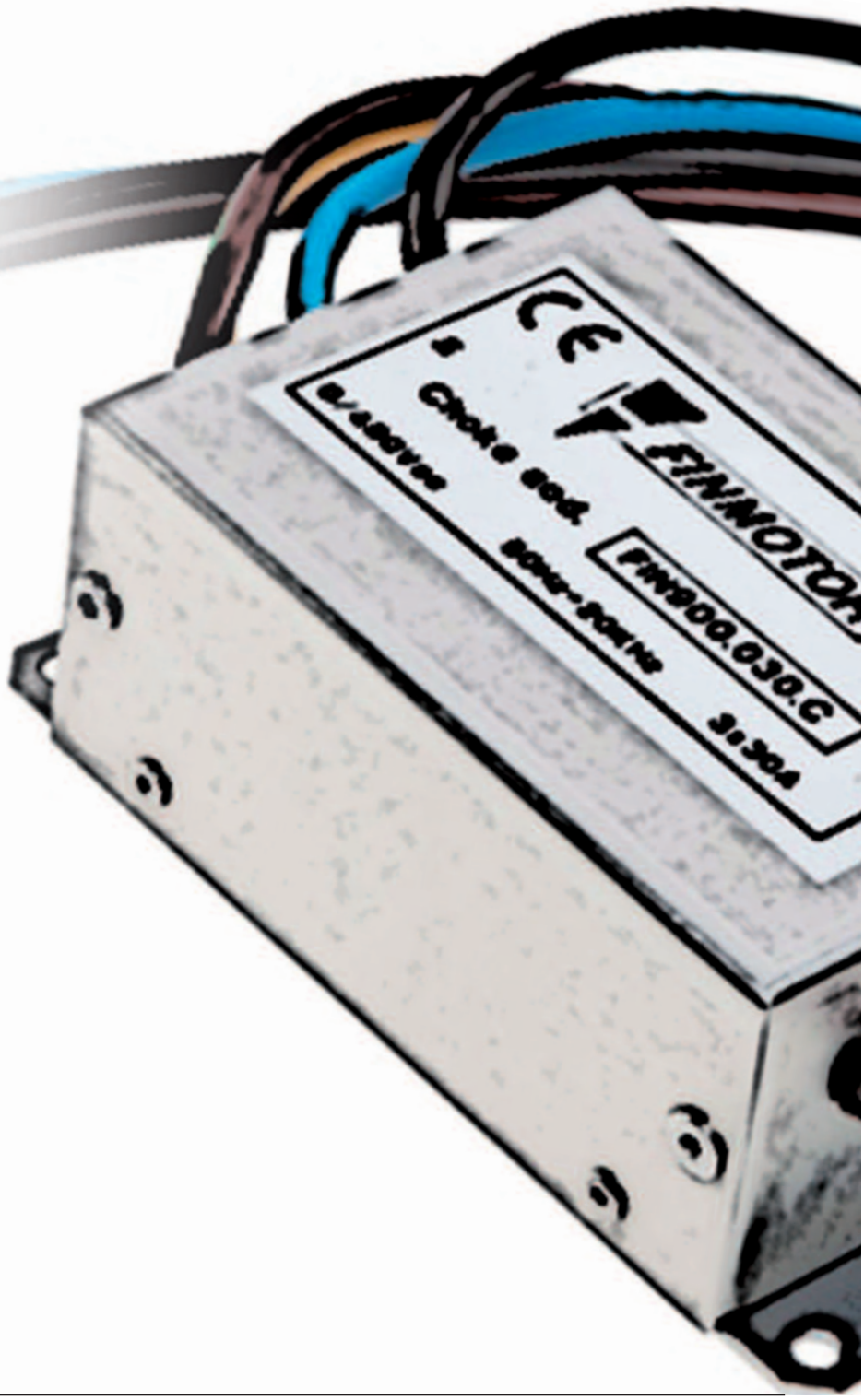
This series carries CE and UL approvals and offers a current range from 3 to 1100A. Enerdoor motor protection includes common mode and differential mode inductance, sine wave filters and snubbers.

Unique features include: high linearity vs frequency and current, very low operating temperatures, and compact dimensions.

The FIN960F high frequency inductance is a unique solution used for synchronous spindle motor applications. This line works with frequency output up to 2 kHz while allowing the motor to operate at a low temperature.

The FIN905SF and FIN915SFH sine wave filters reduce the PWM effect, convert the PWM to a sine wave and eliminate dV/dt. These lines work with applications in open or closed loop feedback.

The FIN905SF works with frequency output up to 70 Hz. The FIN915SFH line is used with fundamental frequencies up to 2 kHz while maintaining a very low application temperature.



Motor protection applications include:

- Motors controlled by drives
- Pumps and conveyors
- Automated machinery
- Closed loop motor applications
- High speed motors
- CNC machinery
- Long cable applications 2,500m (8,200 ft)
- Process plants
- Water treatment plants
- Packaging machinery

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Sine wave filter with excellent attenuation for variable frequency drive applications

APPROVALS:

RoHS CE

FIN905SF.(005 - 045).M

FEATURES

- Rated current from 5 to 880A
- Very compact design
- Available in Nema 1 or Nema 3R enclosures

BENEFITS

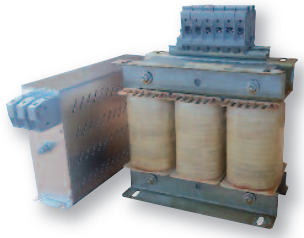
- Low power loss
- No ventilation required
- Excellent performance versus frequency and current
- Available in open frame or enclosure

MARKETS

- Long cable applications - 2.500m
- Process plants
- Water treatment plants
- Variable frequency drives
- Agriculture

ORDERING CODE

FIN905SF	.100	.M	-N1
Model	Current (A)	Connection	Enclosure
		M = Terminal	N1 = Nema 1 (IP20)
		V = Screws	N3R = Nema 3R (IP54)
		B = Bus bar	

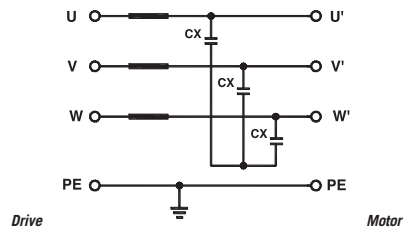


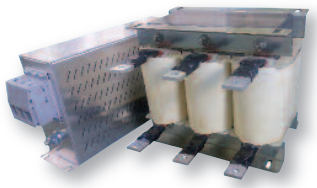
FIN905SF.(060 - 180).M

ATTENUATION INDICATOR

High	Very High	Excellent

ELECTRIC DIAGRAM

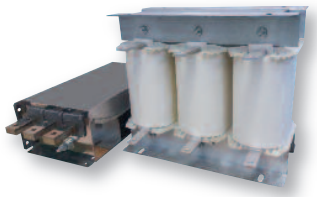




FIN905SF.(260 - 410).B

TECHNICAL SPECIFICATIONS

Nominal voltage	0 / 600 Vac
Output frequency	0 - 100 Hz
Rated current	5 to 880A
Carrier frequency (PWM)	>4 kHz, see table
Ambient temperature	70°C
Altitude	1000 m
Relative humidity	<95% no condensation
Saturation current	4 x Rated Current (Switch ON) 2 x In 10 seconds 1.5 x In 10 minutes 1.5 x Nominal current
IP Protection	IP20 up to 180A IP00 over 260A
Optional	Enclosure, fan



FIN905SF.(480 - 880).B

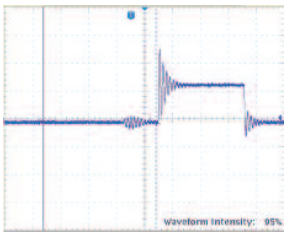
ELECTRICAL CHARACTERISTICS

CONNECTIONS

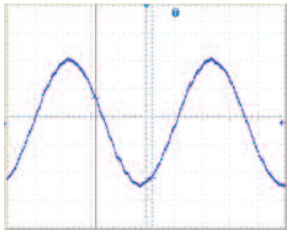
TYPICAL MEASUREMENT

FIN905SF	Rated Current 40°C	Rated Current 50°C	Min. Switch Freq. (kHz)	Power Loss (W)	LINE			PE
					Solid Cable (mm²)	Stranded Cable (mm²)	Terminal Block Torque (Nm)	Torque (Nm)
.005.M	5	4	4	67	0.2-10	0.2-6	1.2	1.2
.008.M	8	7	4	79	0.2-10	0.2-6	1.2	1.2
.010.M	10	8	4	88	0.2-10	0.2-6	1.2	1.2
.016.M	16	14	4	116	0.2-10	0.2-6	1.2	1.2
.025.M	25	21	4	151	0.2-10	0.2-6	1.2	1.2
.036.M	36	30	4	175	0.2-10	0.2-6	1.8	1.8
.048.M	48	39	4	250	0.2-10	0.2-6	1.8	1.8
.060.M	60	50	4	282	6-35	4-25	4.5	4.5
.075.M	75	60	4	340	6-35	4-25	4.5	4.5
.115.M	115	95	4	575	10-50	10-50	4	4

FIN905SF	Rated Current 40°C	Rated Current 50°C	Min. Switch Freq. (kHz)	Power Loss (W)	LINE			PE
					Solid Cable (mm²)	Stranded Cable (mm²)	Terminal Block Torque (Nm)	Torque (Nm)
.180.B	180	145	4	695	39-95	35-95	20.0	20.0
.320.B	320	290	4	950	M8	14	M10	18
.410.B	410	350	6	1170	M8	14	M10	18
.480.B	480	420	6	1390	M12	20	M10	18
.660.B	660	580	6	2050	M12	20	M10	18
.750.B	750	650	6	2900	M12	20	M10	18
.880.B	880	750	6	3450	M12	20	M10	18



Standard waveform measured when the motor is controlled by VFD drive.

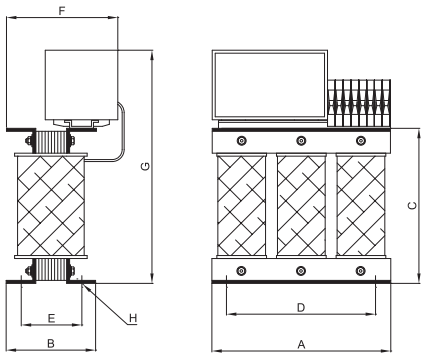


Standard waveform measured when Enerdoor sine wave filter is installed on motor controlled by VFD drive.

MECHANICAL DIMENSIONS mm

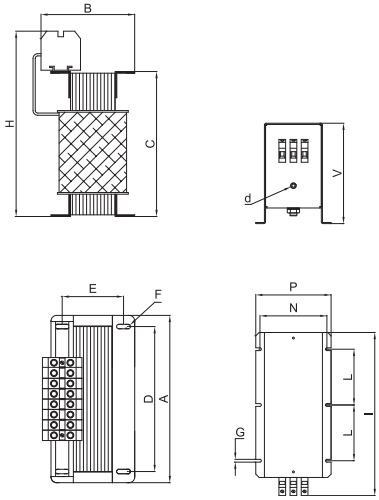
FIN905SF	A	B	C	D	E	F	G	H Ø	Weight Kg.	Case
005.M	180	90	156	150	60	116	235	8	8	1
008.M	180	90	156	150	60	116	235	8	10	1
010.M	180	90	156	150	60	116	235	8	11	1
016.M	240	130	210	210	95	165	290	8	16	1
025.M	240	130	210	210	95	165	290	8	20	1
036.M	240	130	210	210	95	165	290	8	22	2
.048.M	240	130	210	210	95	165	290	8	28	2

CASE 1, 2



FIN905SF	A	B	C	D	E	F	G	H	I	L	N	P	V	d	Weight Kg.	Case
.060.M	300	165	260	260	110	8	5	332	260	100	120	135	180	M5	34	3
.075.M	360	174	305	260	120	8	5	377	293	100	120	135	180	M5	47	3
.115.M	360	203	310	260	145	8	5	400	389	130	205	220	260	M5	72	4

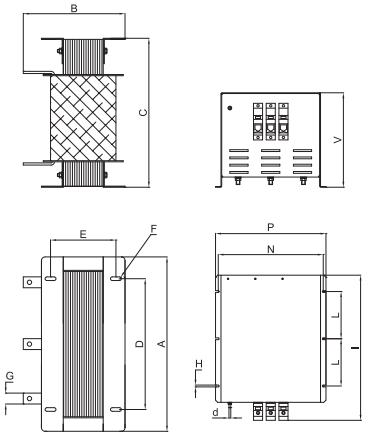
CASE 3, 4



MECHANICAL DIMENSIONS mm

FIN905SF	A	B	C	D	E	F	G	H	I	L	N	P	V	d	S	Weight Kg.	Case
.180.B	350	230	310	260	165	8	5	400	389	130	205	220	260	M5	-	86	5
.260.B	480	280	410	360	230	8	30	5	400	130	290	305	260	M5	-	132	5
.320.B	48	300	410	360	230	8	40	5	400	130	290	305	260	M5	-	163	5
.410.B	480	340	410	360	230	10	60	5	400	130	290	305	260	M5	-	188	5
.480.B	480	360	410	360	230	10	60	5	660	620	245	292	260	M5	25x10	208	6
.660.B	600	370	510	380	240	10	60	5	660	620	245	292	260	M5	25x10	309	6
.750.B	600	390	510	380	240	10	80	5	830	750	245	292	260	M5	25x10	356	6
.880.B	600	370	570	380	240	10	80	5	830	750	245	292	260	M5	25x10	351	6

CASE 5



CASE 6