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Danfoss Drives
Power Drive System Considerations

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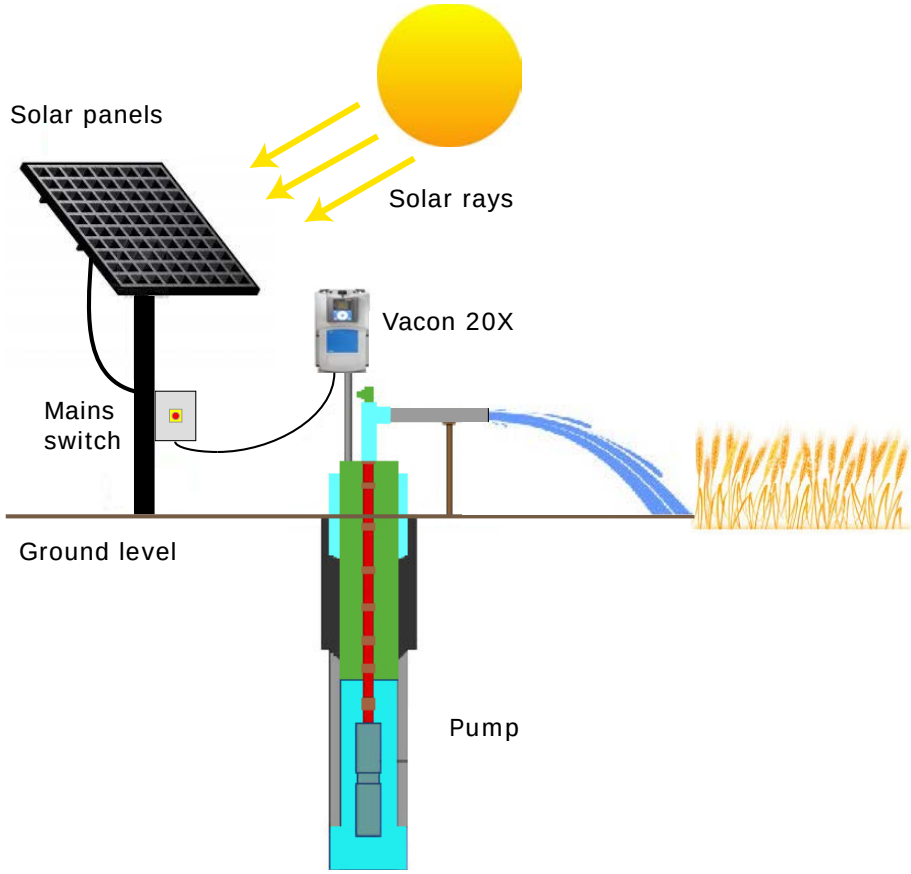
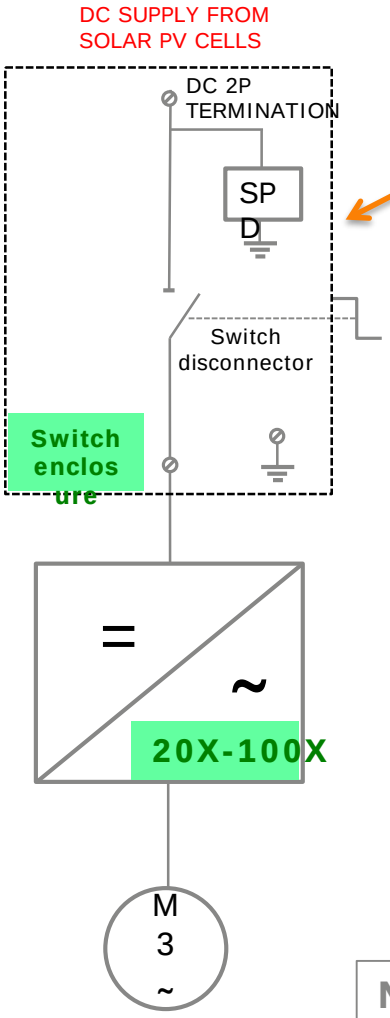
BDM SA / NT

Solar Pump Drives:

- The Vacon IP66 Solution is innovative from both the HW and the SW Control Strategy point of view.
- A small enclosure where to place the mains switch and the surge protection device replaces the usual big cabinet, as the Inverter is placed outside.
- The Vacon IP66 Drive can be installed outdoors without any reliability risk. It doesn't require maintenance, as there are no filters to clean/replace.
- Condensation inside the drive is prevented by a GORE® vent which blocks the moisture without the need of any heater.
- Correct operation of the drive is visible from outside thanks to 4 LEDs showing the operating conditions: Power-ON, Run, Ready, Fault. An IP66 display panel can also be connected to get detailed information when needed, or kept permanently installed on the drive to show several variables (running speed, MWh counter, etc.)



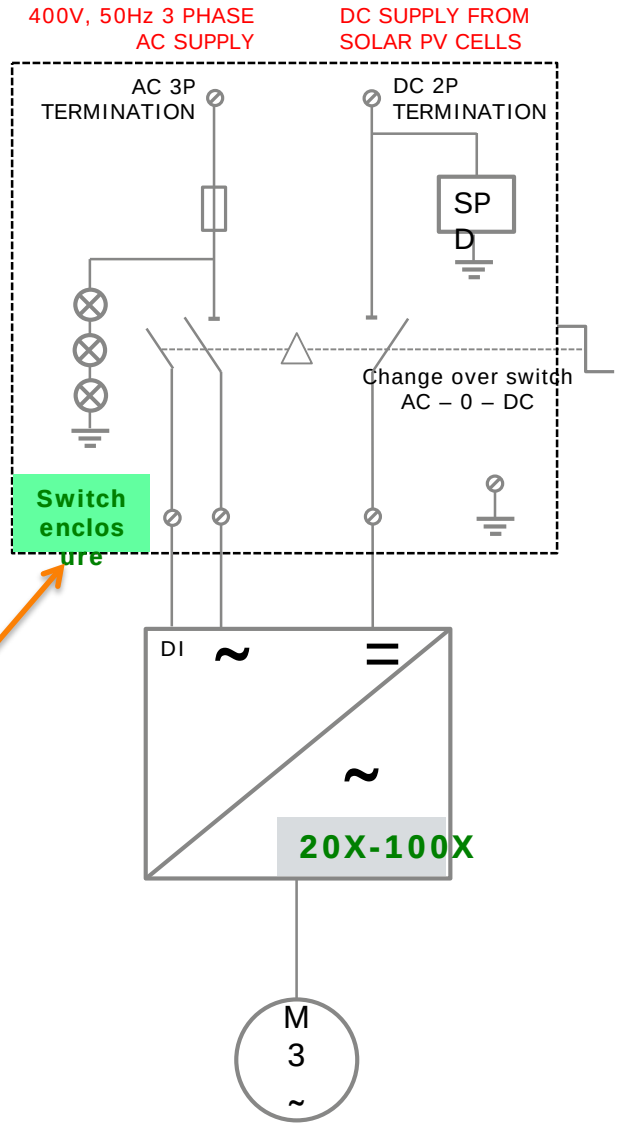
Solar Pump Drive: examples of supply modes



- **Solar panel connection mode:**
  - Stand-alone solution: inverter supplied by Solar Panels DC voltage.
  - Completely independent from the mains supply and self-sufficient installation.

- **Solar panel or Grid connection mode:**
  - With an external changeover switch, inverter can be supplied either by mains or solar panels.
  - Useful during night or panel maintenance operations.
  - The Vacon 20X-100X can have a “hot commutation” from grid to PV and vice-versa, as they recognize the supply source (solar panels or grid) by a digital input, selecting the appropriate control SW.

NOTE: submersible pumps may require a filter between the drive output and the motor. Refer to the pump supplier for more information.



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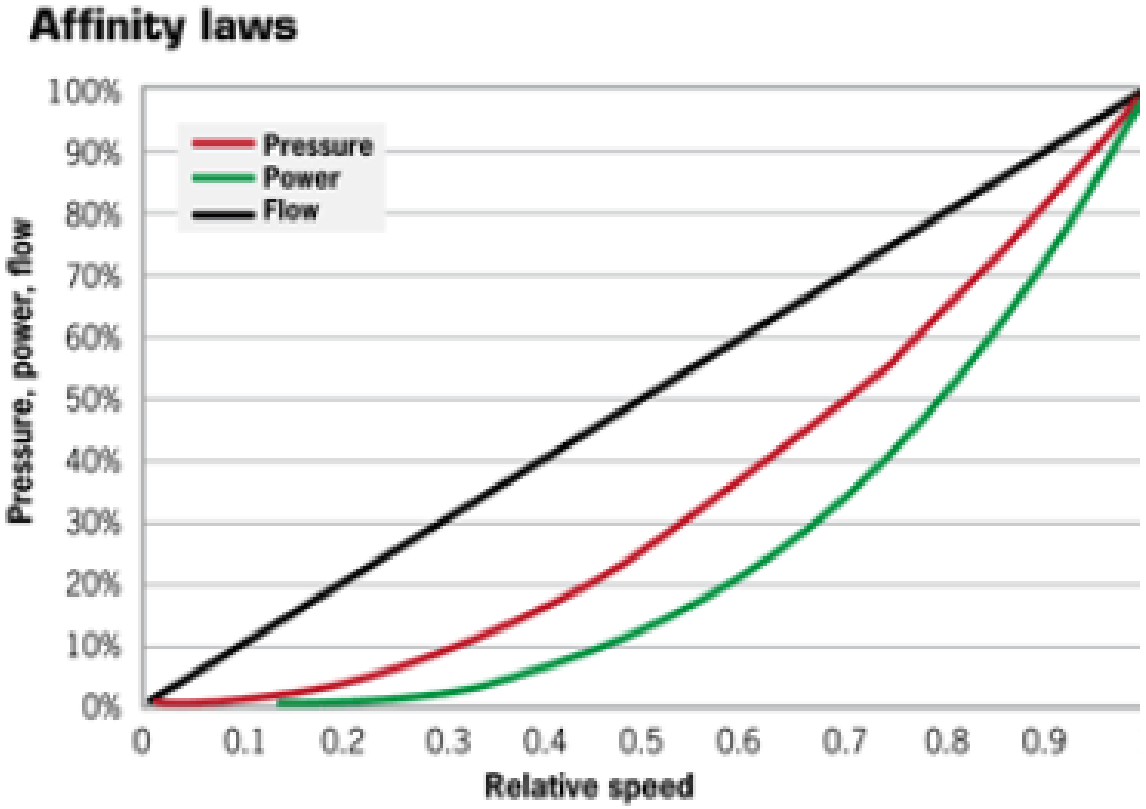
Considerations when utilising Variable Speed Drives

Relationship between Flow, Pressure & Power for Centrifugal Motors



Affinity laws are used in fluid control to express the mathematical relationship between several variables such as pressure, volumetric flow rate, speed, and the power involved in pumps and fans.

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Motor cable type & length impact
RFI conducted emissions on mains supply

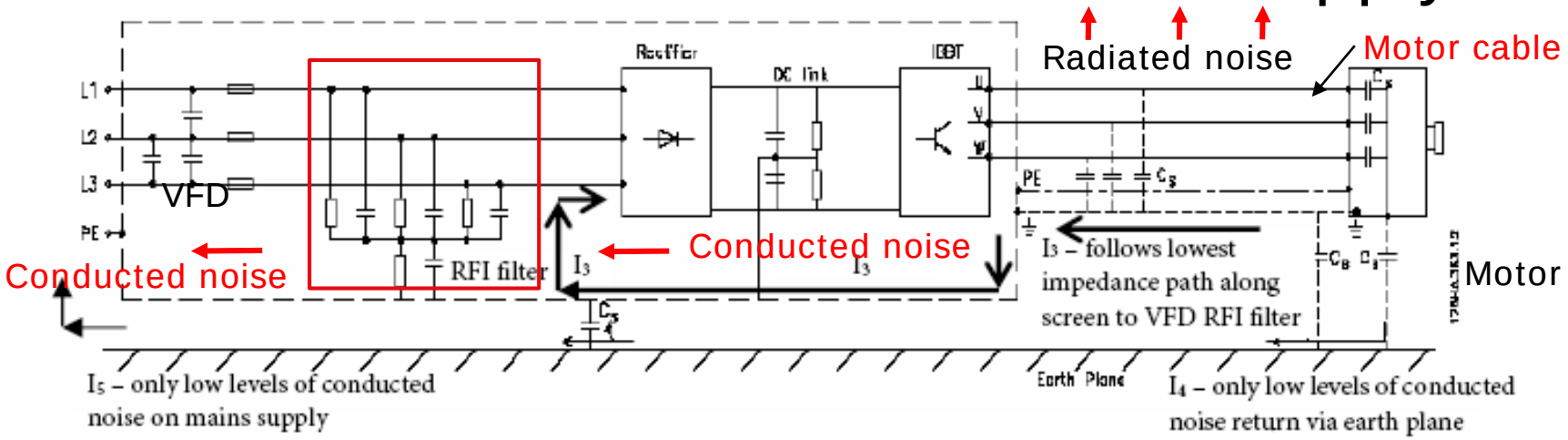
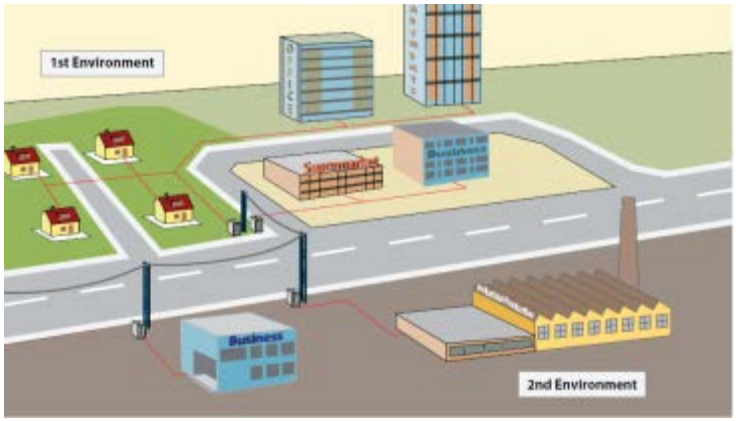


Figure 4: Correct VFD EMC installation with integrated RFI filter and screened motor cable earthed at both VFD and motor ends

- Harmonics: 50-2500Hz, Conducted: 9kHz-50MHz, Radiated: 50MHz-2GHz …..
- The length & type of motor cable effect the level of conducted RFI emissions on the mains supply
- Shielded cables have higher capacitance / leakage current compared to unshielded cables, but are required for EMC correct installation (Radiated noise)
- The RFI filter must be selected to match the “Environment” + motor cable type & length, which should be specified. Note: Potential extra CAPEX for suitable RFI Filter

RFI Environment & Product Standards (Note *)



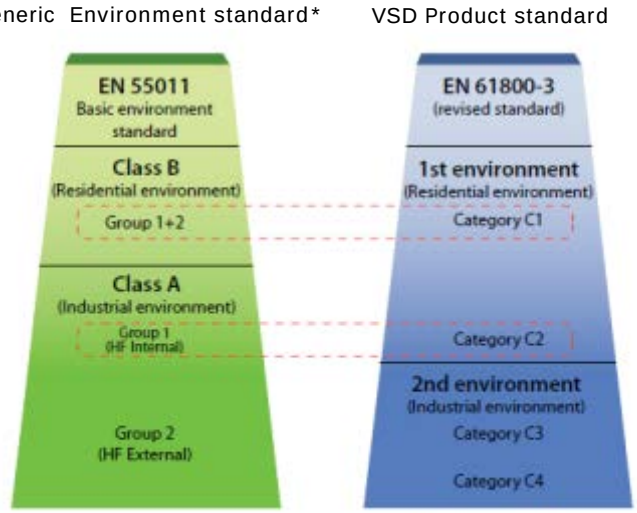
1st Environment / Class B Residential Environment: All sites directly connected to the public low voltage power grid, including light industrial areas, are classified as residential or business & commercial environments. (I.E.: do NOT have their own HV/MV distribution transformer)

2nd Environment / Class A Industrial Environment: Operating sites NOT directly connected to the public low voltage power grid, which do have their own HV/MV distribution transformer

- Facility operators must comply with EN 55011*

- VSD manufacturers must conform with EN 61800-3

(Note *: Or equivalent local standard)



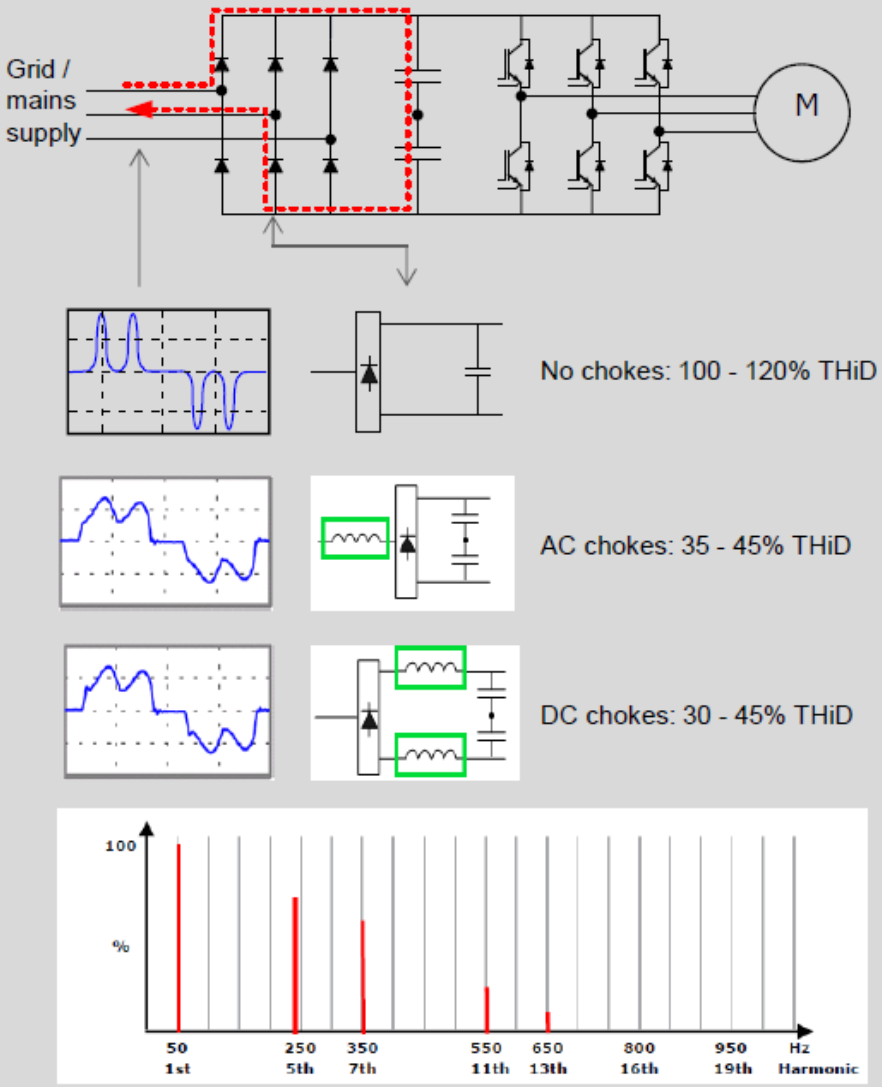
Comparison of the new categories C1 to C4 defined by the EN 61800-3 product standard and classes A and B of the EN 55011 environment standard.

EN 61800-3 product standard (2005-07) for electrical drive systems

Classification by category	C1	C2	C3	C4
Environment	1st Environment	1st or 2nd Environment (operator decision)	2nd Environment	2nd Environment
Voltage/current	< 1000 V			> 1000 V In > 400 A Connection to IT network
EMC expertise	No requirement	Installation and commissioning by an EMC expert		EMC plan required
Limits according to EN 55011	Class B	Class A1 (plus warning notice)	Class A2 (plus warning notice)	Values exceed Class A2

Classification of the new categories C1 to C4 of the EN 61800-3 product standard

Harmonics: causes



- Harmonics are primarily caused by loads that draw current in a non-sinusoidal manner. I.E: Non-linear loads, E.G.: UPS, Computer power supplies, VFD, Etc.
- Variable Speed Drives (VSD)
  - Most common design uses 6 pulse rectifier (6 diodes)
  - 5^{th} & 7^{th} harmonic currents are predominant (Pulse no. ± 1)
  - The level of harmonic current depends on:
    - DC bus capacitor size
    - Load
    - Whether or not AC / DC chokes, or other filters are used
    - DC chokes have lower losses & voltage drop vs AC chokes

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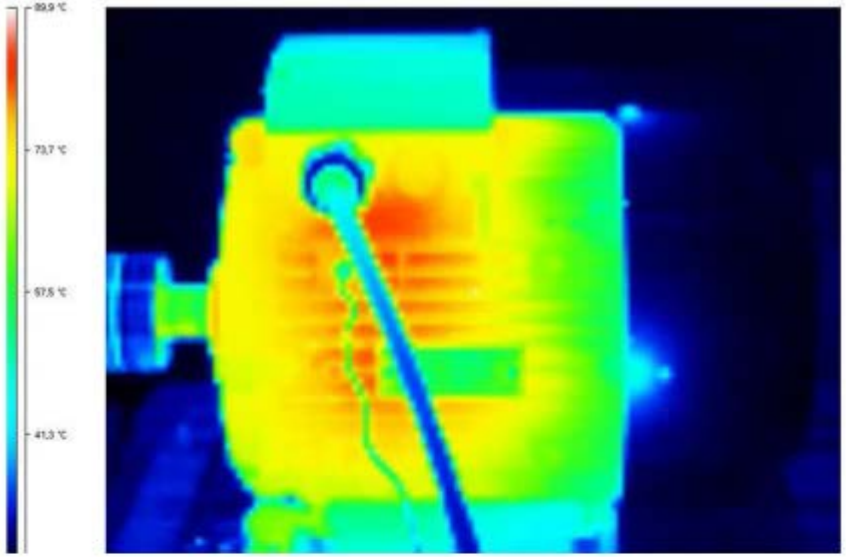
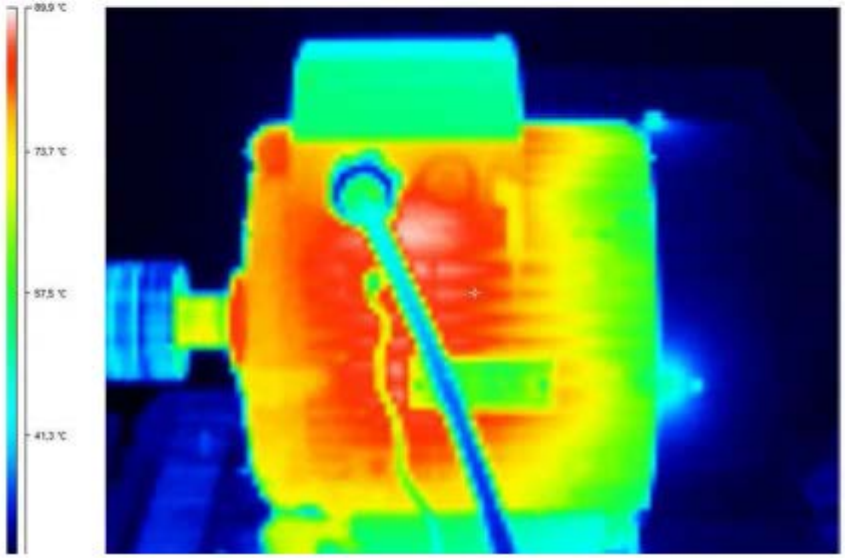


Example of equipment (motor) on mains supply with different levels of harmonic distortion showing effect on temperature, which impacts on service life



EMC: Harmonics Effects

Current Distortion

- Adds to system losses, E.G.:
  - Overloading / premature aging of transformers, cables & switchgear
- Stressing of PF correction caps.
- Nuisance tripping of protection relays & circuit breakers, etc

Voltage distortion

- Can disturb other equipment, E.G.:
  - Malfunction, erratic operation & breakdown of electronic equipment
  - Increased eddy current losses & torque ripple in DOL connected motors connected to same grid

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Harmonic Standards – South Australia

- SA Power Networks Service & Installation Rules - 2012

6.5.4 Harmonics

The customer must ensure that harmonic distortion caused by the electrical installation or by any appliances is not in excess of the limits prescribed in AS/NZS61000 part 3.2, 3.4 & 3.12 for low voltage and part 3.6 for high voltage.

Not withstanding the above, no customer shall make a contribution to harmonic voltage distortion of the Network greater than the values listed in Table 6.5 below:

Table 6.5

Maximum allowable harmonic distortion at the point of common coupling (PCC): -	
▫ total	1.67 %
▫ any individual odd harmonic	1.33 %
▫ any individual even harmonic	0.67 %

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Danfoss –harmonic product portfolio (Comsys)

NB! Standard VLT Drives has a built in DC link choke harmonics filter

Low harmonic Drives

- Include std. drive and an active filter in one package
- Best harmonic mitigation
- 99% energy utilization
- 132kw to 630kw (160%)
- 160kw to 710kw (110%)
- **Service Policy "repairable"** (based on D,E and F Frame sizes)
- FC102-103-202 & 302

COMSYS

ADF P100

ADF P100 active filters give you the compensation capabilities you need in a compact cabinet. It's small and cost-effective, but the ADF P100 features the cutting-edge performance you can expect with ADF Power Tuning.

Active Filters

- First Active Filter reusing 85% drive components
- Best performance at non perfect grids
- 190A, 250A, 310A and 400A
- **Service Policy "repairable"**
- Operating Instruction doc_MG90V302.pdf

Advanced harmonic filters:

- Lowest cost <300kw
- Most compact solution for drives <400A
- Individual matched for Danfoss drives to secure performance
- Capacitor Disconnect & IP21 kit
- **Service Policy The AHF is designed as a non-repair product** (**however it may be possible to get terminals, fans, capacitors, etc.**)

Output Waveforms (dV/dt vs Sinewave filters)

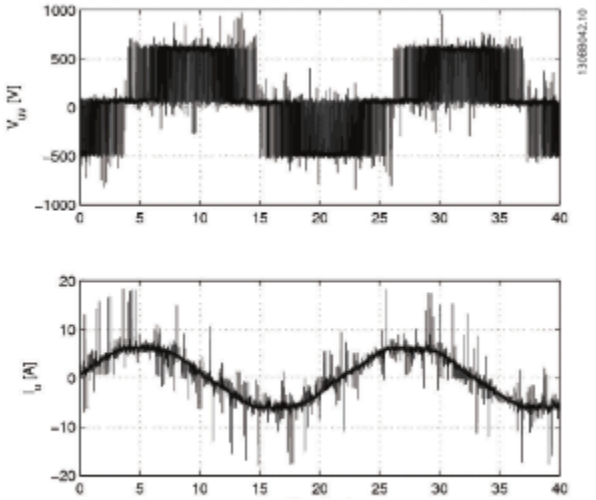

Illustration 3.9 Without Filter

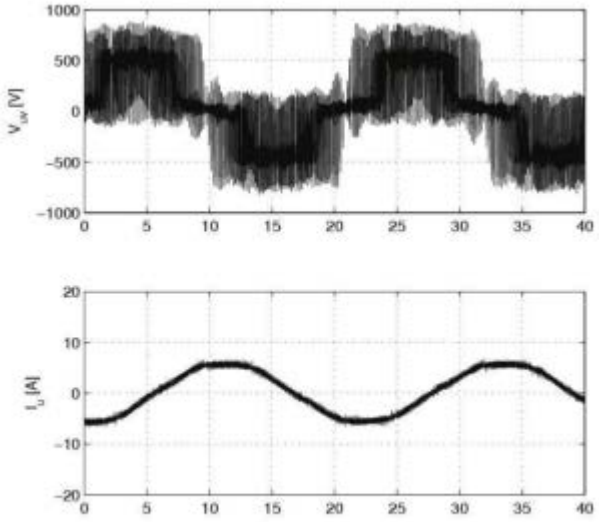

Illustration 3.10 With dU/dt Filter

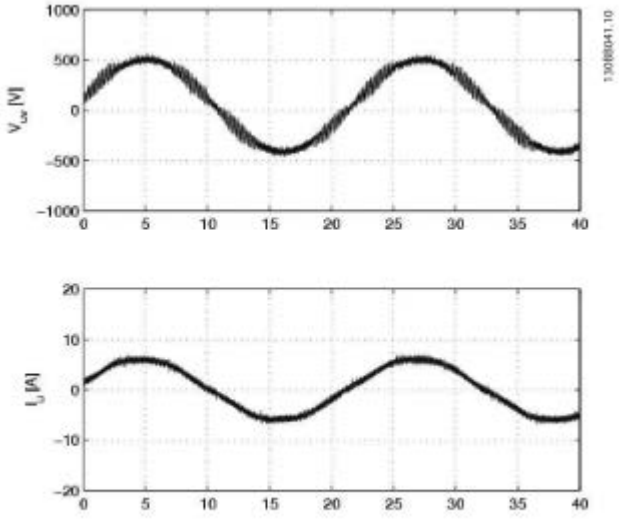

Illustration 3.15 With Sine-wave Filter

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Output Filter Portfolio

Our standard Product

- Danfoss VLT® Drives have peak voltage and rise time values compliant with **IEC60034-25.**
- Depending on motor cable type and length on 400V systems, Danfoss VLT® Drives have typical peak voltage and rise time values compliant with **IEC60034- 17 (curve C in figure 17)** Rotating electrical machines – General Requirements – Rating and Performance.

Simulation Tools

- Danfoss with assistance of SABER software estimates the dv/dt and Vpeak at the motor terminals.

Sine Wave Output Filters

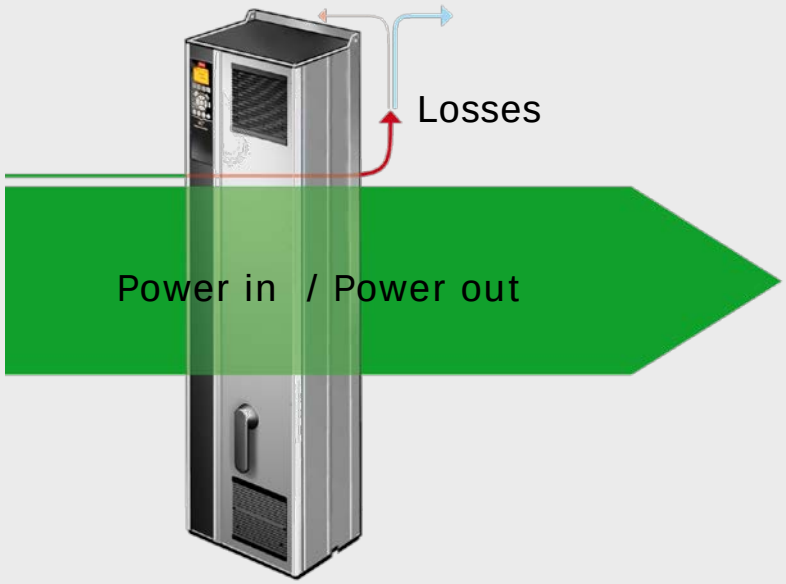
- Complies with IEC 60034-17 requirements for general purpose motors with cables up to **500M** <90Kw (**1kM for >110kw)**
- Guaranteed EMC performance up to 300 M of unshielded cable

Dv/dt Filters

- dv/dt<500V/microsec
- U_{peak} <900V
- max cable 150m

HF-CM Core

- The filter reduces the high-frequency noise radiated by motor cables shielded/unshielded
- The filter eliminates or reduces the electrical discharges in the motor bearings



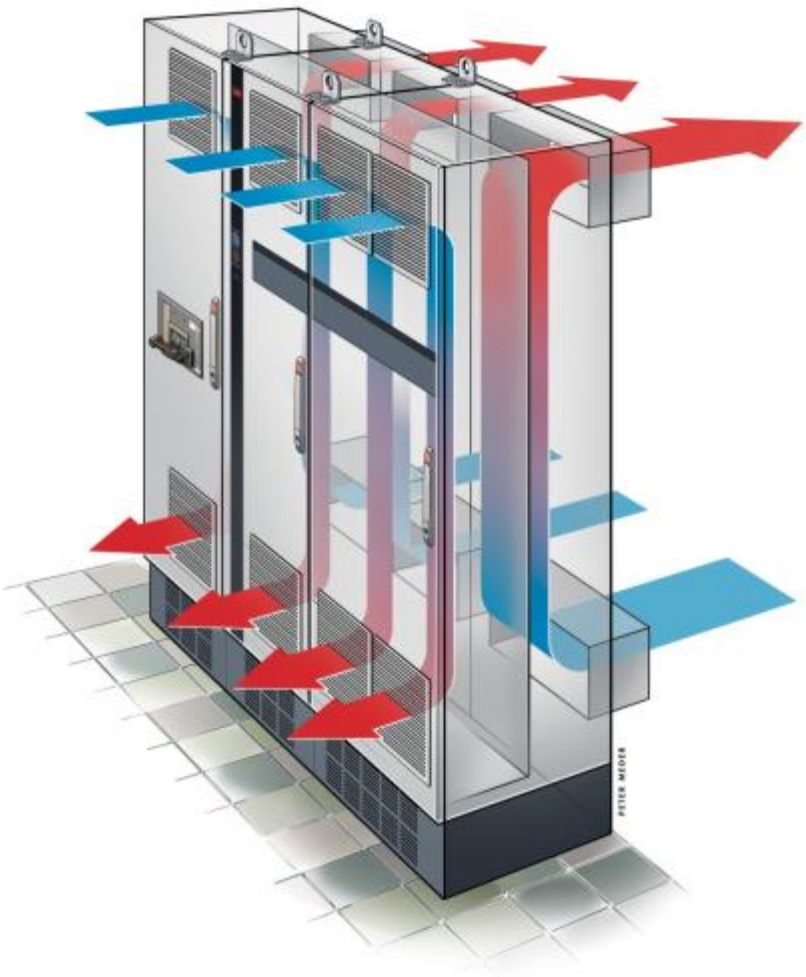
Energy efficiency / Watts losses

- Check & compare the facts
- VSD Watts losses can vary significantly depending on design, in particular in higher powers
- Allow 0.33kW energy for air conditioning for every 1.0kW extra heat dissipated
- Potential impact on switch room air conditioning initial capital cost (Note)
- + whole of life operating cost!

Note: Estimated ~$5K extra CAPEX per 5kW Air Conditioner

85% average lower switch room A/C heat load using thru wall back channel cooling

Average 15% heat dissipated into switch room = average 85% reduction in switch room A/C heat load. (>/= 110kW)



Average 85% heat dissipated via segregated back channel using outside cooling air (>/= 110kW)

D–Frame (110-315kW) = 90%
E-Frame (355-450kW) = 85%
F-Frame (>/500kW) = 80%
(400V, 6P drives)

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Ingress Protection Standards

IP54 typically suitable for switch room.
IP55 / 66 may be possible in plant area <90kW – check conditions

- IP rating according to IEC 60529

		Against penetration by solid foreign objects	Against access to hazardous parts by
First digit	0	(not protected)	(not protected)
	1	≥ 50 mm diameter	Back of hand
	2	12.5 mm diameter	Finger
	3	2.5 mm diameter	Tool
	4	≥ 1.0 mm diameter	Wire
	5	Dust protected	Wire
	6	Dust-tight	Wire

		Against water penetration with harmful effect	
Second digit	0	(not protected)	
	1	Drops falling vertically	
	2	Drops at 15° angle	
	3	Spraying water	
	4	Splashing water	
	5	Water jets	
	6	Powerful water jets	
	7	Temporary immersion	
	8	Long-term immersion	

		Additional information specifically for	
First digit	A		Back of hand
	B		Finger
	C		Tool
	D		Wire

		Additional information specifically for	
Additional letter	H	High-voltage device	
	M	Device moving during water test	
	S	Device stationary during water test	
	W	Weather conditions	

Missing digits are replaced by "x".

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Corrosion Protection

Note: Class 3C3 protection offers the high level of protection & potentially lower maintenance cost

- Levels of contaminants according to IEC 60721-3-3

Ambient parameters	Unit	Class				
		3C1	3C2		3C3	
			Average value	Max. value	Average value	Max. value
Sea salt	mg/m3	No	Salt mist		Salt mist	
Sulphur oxides	mg/ m3	0.1	0.3	1.0	5.0	10
Hydrogen sulphide	mg/ m3	0.01	0.1	0.5	3.0	10
Chlorine	mg/ m3	0.01	0.1	0.03	0.3	1.0
Hydrogen chloride	mg/ m3	0.01	0.1	0.5	1.0	5.0
Hydrogen fluoride	mg/ m3	0.003	0.01	0.03	0.1	3.0
Ammonia	mg/ m3	0.3	1.0	3.0	10	35
Ozone	mg/ m3	0.01	0.05	0.1	0.1	0.3
Nitrogen	mg/ m3	0.1	0.5	1.0	3.0	9.0

Classification according to IEC 60721-3-3; average values are anticipated long-term values.
Maximum values are transient peak values that do not occur longer than 30 minutes per day.

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