Frequency inverters, set everything in motion

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Installation - Supply

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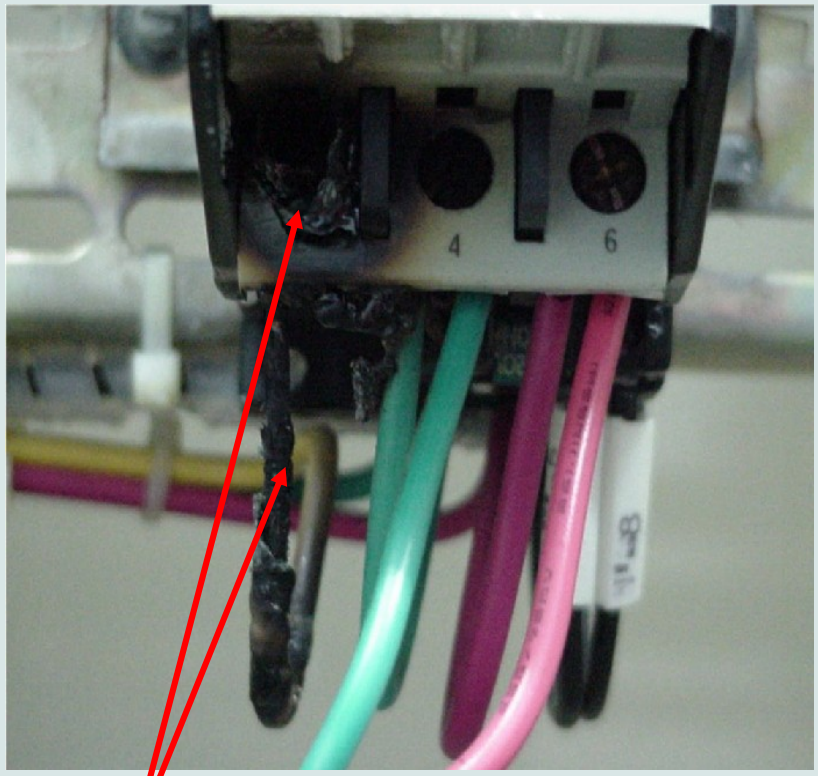
- **VSD เหมาะสำหรับมืออาชีพ ทางวิศวกรรม ไม่เหมาะสำหรับการใช้งานโดยทั่วไป โดยผู้ที่ไม่มีความรู้ หรือเคยผ่านการอบรมมาก่อน**
- **ต้องมั่นใจว่า ระบบไฟฟ้า ที่จ่ายให้ VSD ตรงตามที่กำหนด โดยมีค่าไฟฟ้าเปลี่ยนแปลงไม่เกิน**
  200 - 240 +/- 10%
  380 - 480 +/- 10%
- **ขนาดของฟิวส์ เหมาะสม และตรงกับขนาดของกระแสตามที่ระบุในคู่มือ.**
- **ขนาดของสายไฟ และหางปลา ถูกต้อง ได้ตามมาตรฐานทางวิศวกรรม หรือมีขนาดไม่เล็กกว่า ตามคู่มือระบุไว้**
- **แนะนำให้ใช้ gland fittings ในกรณีที่ใช้ VSD โดยไม่มีตู้ติดตั้ง**



ตัวอย่างการต่อสาย ไม่ดีพอ
และใช้สายไม่ได้ตามมาตรฐาน เกิดการร้อนไหม้ละลาย

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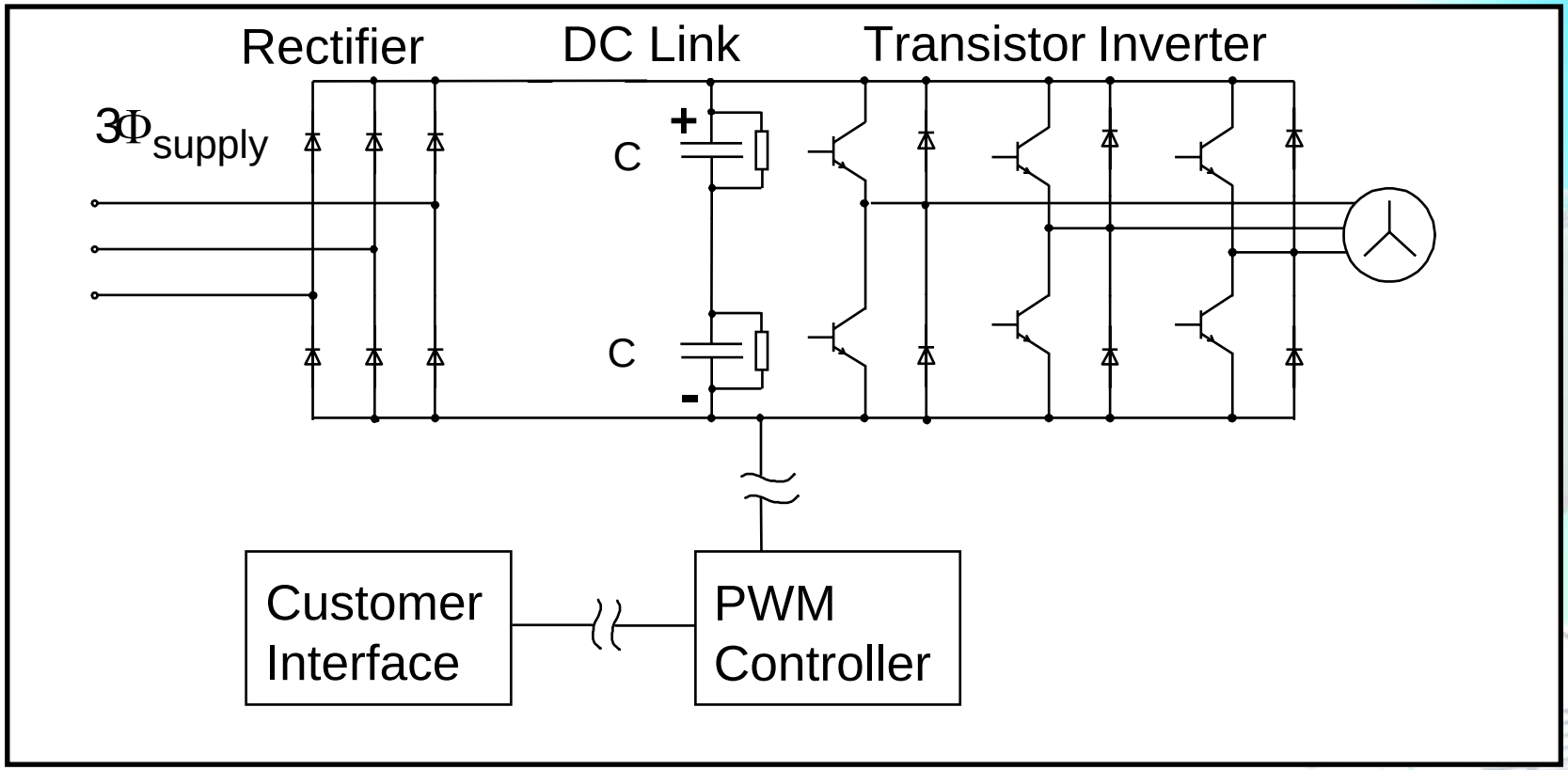
The Inverter



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EMC: Theory

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When an electric current flows, an electromagnetic field is generated. This field may interact with other conductors and cause currents to flow in them.

There is a greater tendency to transmit and receive signals when conductor lengths are similar in length to the frequency concerned.

Cables inside a cubicle are usually a few metres in length, and therefore transmission and reception is usually limited to high frequencies (> 30MHz) .

Conducted Interference can pass between equipment via the power or control connections.

Low frequency EMI is usually a result of conducted interference.

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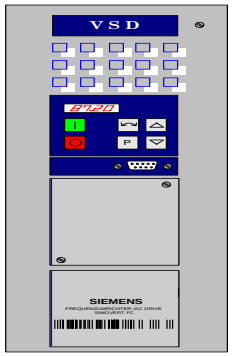
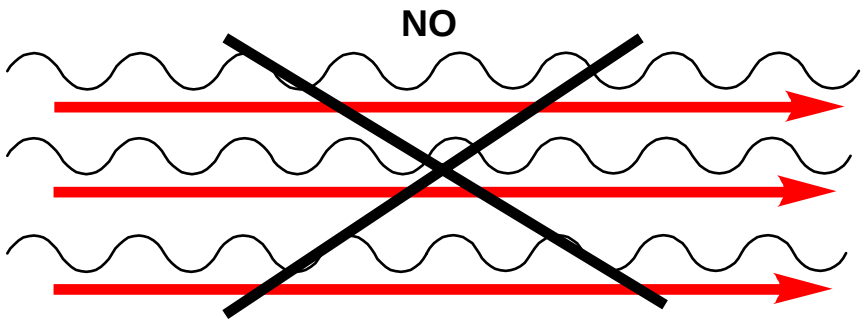
Electromagnetic Compatibility - Emissions

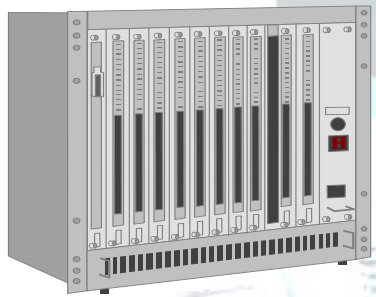
The essential protection requirements of EMC regulations demand that electrical equipment must be constructed in such a way as to:-

Not emit electromagnetic interference which disturbs the intended operation of other apparatus

CONDUCTED OR RADIATED NOISE!







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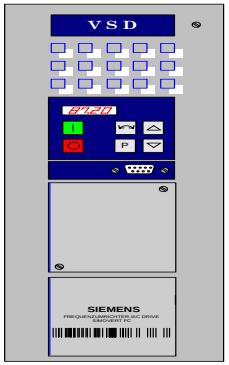
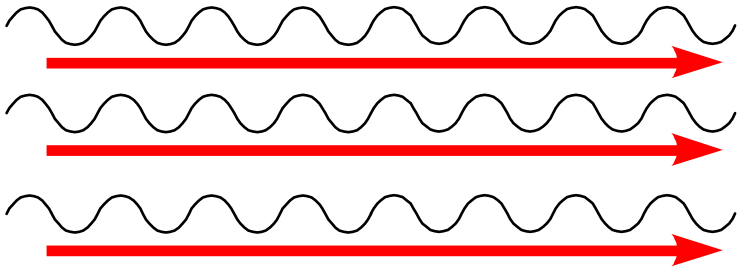
Electromagnetic Compatibility - Immunity

The essential protection requirements of EMC regulations demand that electrical equipment must be constructed in such a way as to:-

Have sufficient inherent immunity to externally generated electromagnetic disturbances to enable it to operate as intended





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EMC: Some Terms Explained

- EMC. Electromagnetic Compatibility.

Compatible means ‘can work together’, so EMC is about equipment working with other equipment

- EMI Electromagnetic Interference. This is the interference generated by equipment which may or may not cause problems.
- RFI. Radio Frequency Interference. An older and inaccurate name for EMI.
- Harmonics. Frequencies that are an exact multiple of the fundamental (base) frequency.
- Fourier Theory. A theory which shows that any repetitive signal consists of the sum of a series of sinusoidal signals of higher harmonics and different magnitudes.

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EMI - Practical Effects

- A variable speed drive contains Power Electronics switching high power at high frequencies.
- It also contains sensitive electronics operating at high switching frequencies.
- Many users connect the electronics to other control systems.
- The drive operates in an uncontrolled electromagnetic environment.

Surprising it works at all really!

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EMC: Theory; Transmission and Reception

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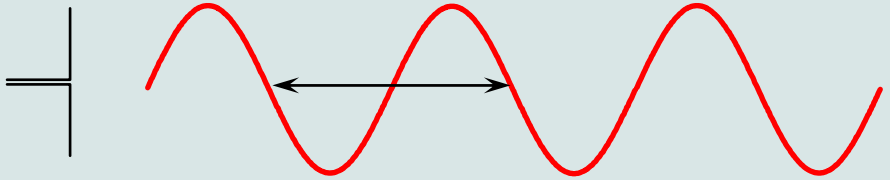
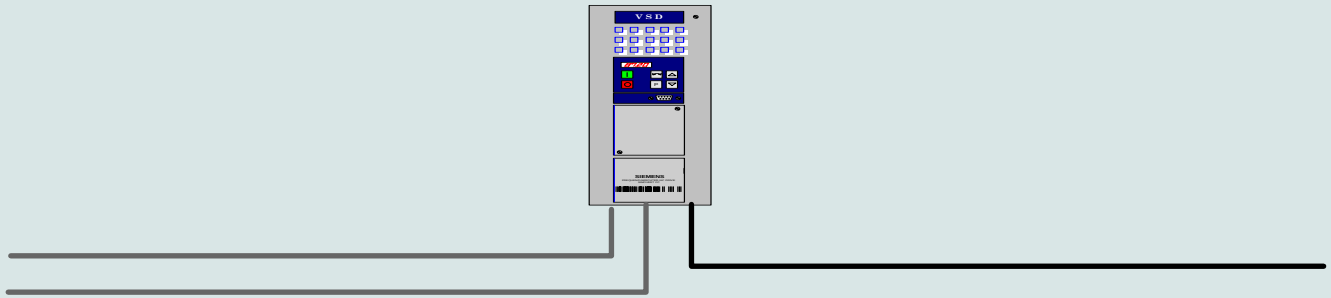
Typical Dipole transmitter
ideal length λ/2



Wave length λ

Any cable is a potential transmitter and receiver of Electromagnetic radiation.



EMI can also enter or leave equipment via the control and power and output (motor) cables.

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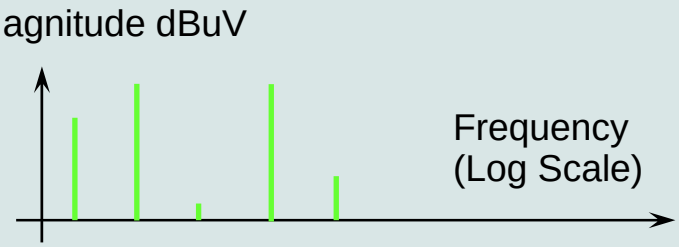
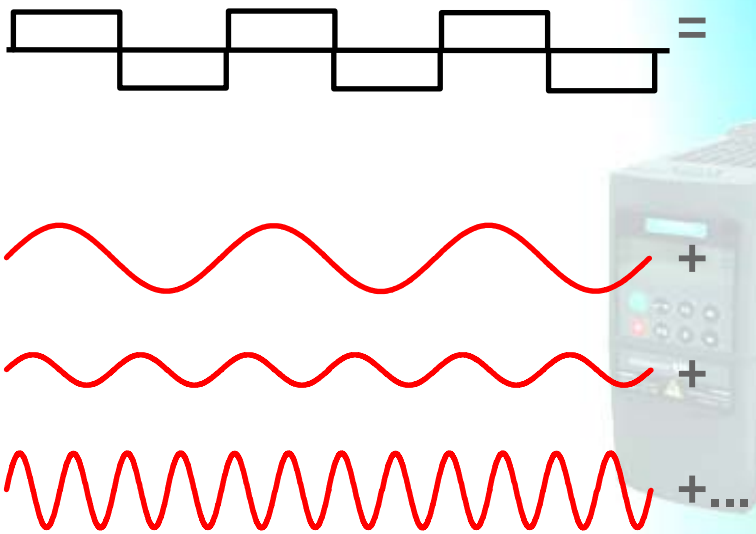
EMC Theory: Fourier Analysis

Fourier Analysis:

A repetitive waveform consists of a sum of higher harmonics. This can be calculated using complex mathematics.

Spectrum Analysers will carry out Fourier analysis and show the resulting Spectrum:





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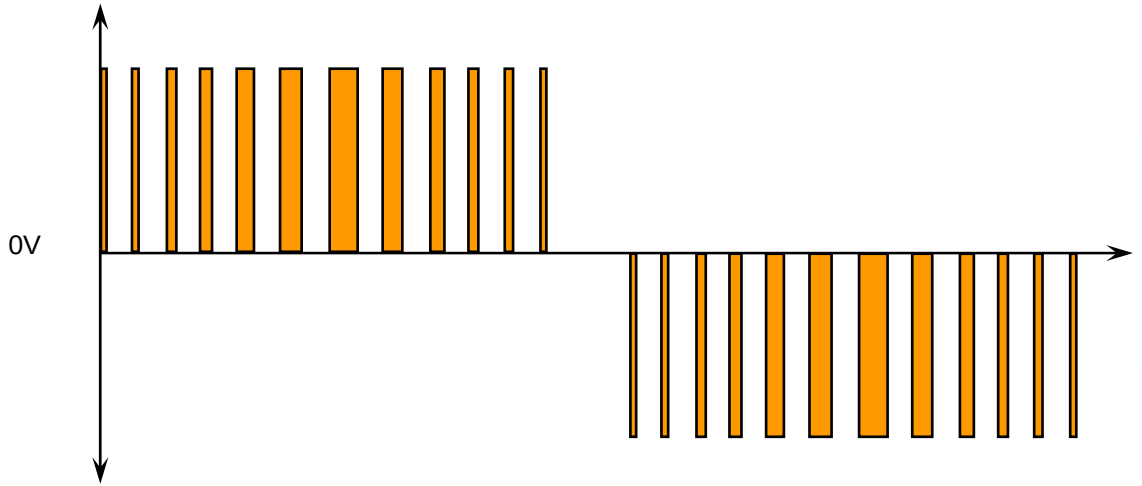
EMC: Theory; Transmission and Reception

This means that complex waveforms such as the Pulse Width Modulated output voltage of an inverter contain high frequency harmonics:



In a Variable Speed Drive these waveforms operate at high powers and are present in the output cable and motor.

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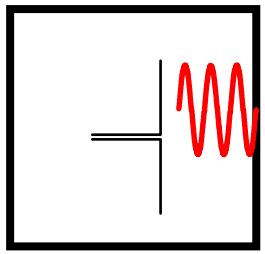
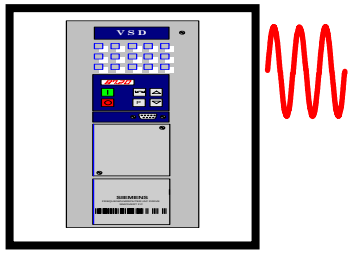
EMC Theory: Screening





If a conducting screen is placed around a transmitter, the EM field is contained within the screen.

A conducting screen will prevent an EM field from entering.

A conducting screen is sometimes known as a Faraday cage.

A screen will be effective if the holes and slots in it are less than 1/10 of the wavelength of the EM Radiation.

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EMC Theory: Screening and Cables

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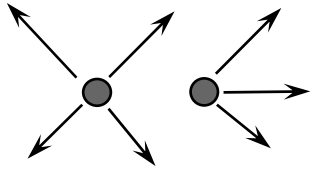
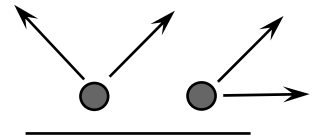
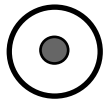


Separate Cable pairs will radiate and receive.

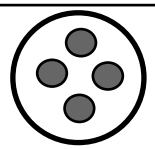


Radiation will be reduced close to a ground plane

Cables close together or twisted will largely cancel their radiation.



Screened, co-axial and armoured cables give excellent cancellation.



Multicore cables with grounded screen cancel and are protected by a Faraday cage.

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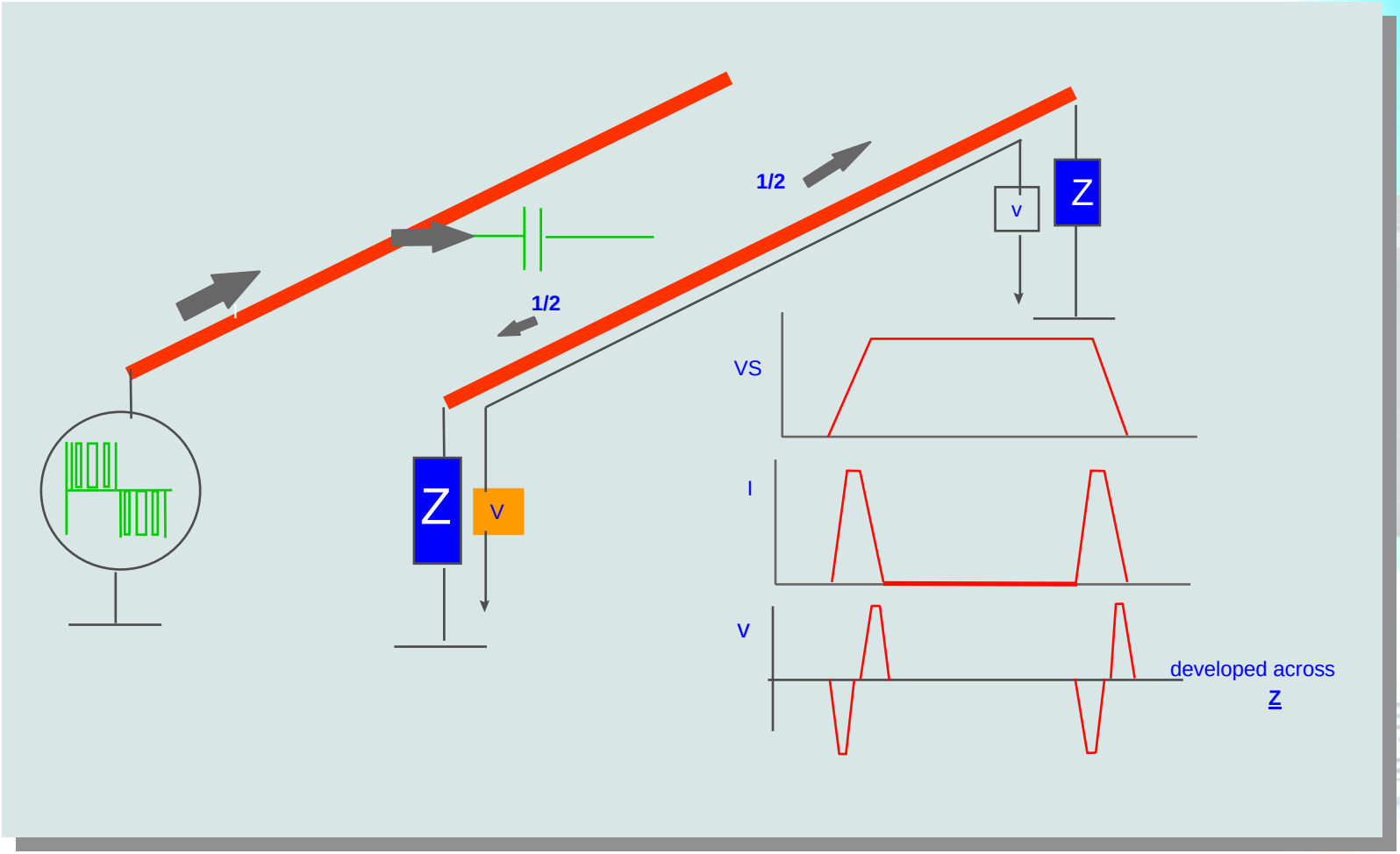
Capacitive Coupling



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EMC: Poor Grounding

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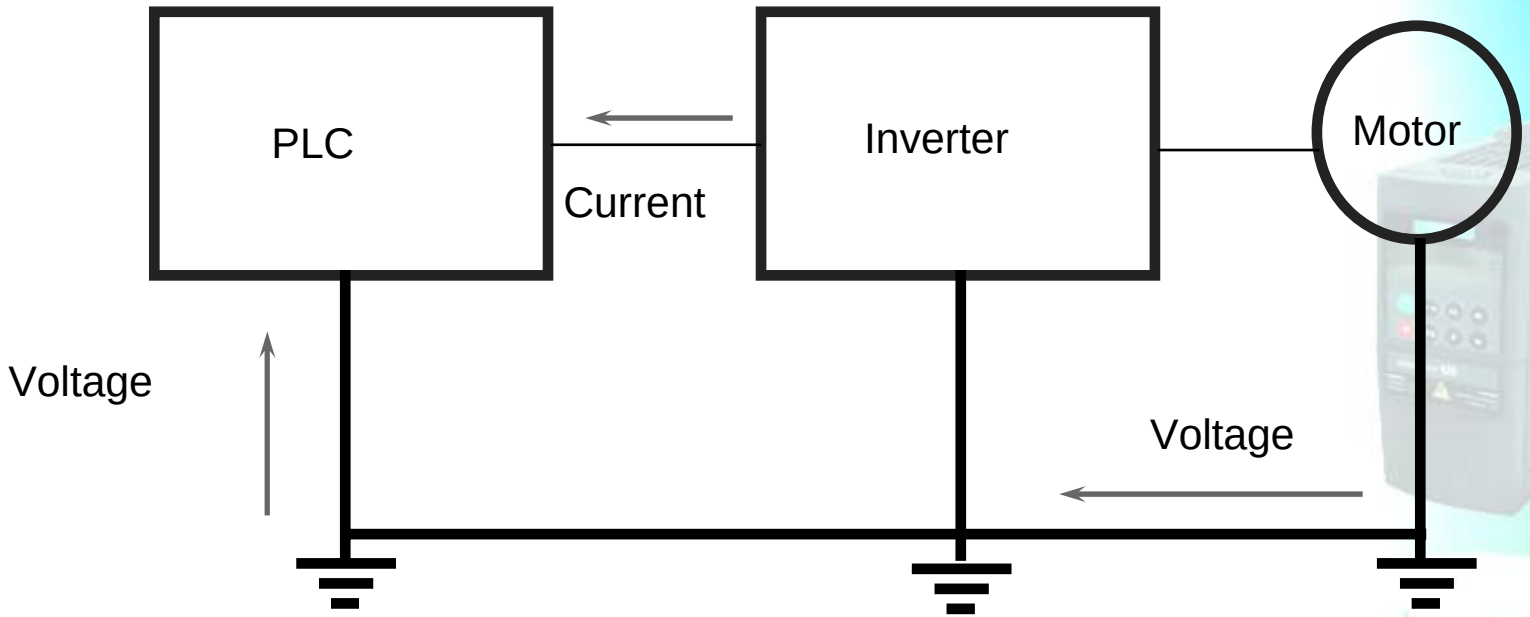

Interfering Voltage will build up in the long thin ground connections and cause interfering current to flow

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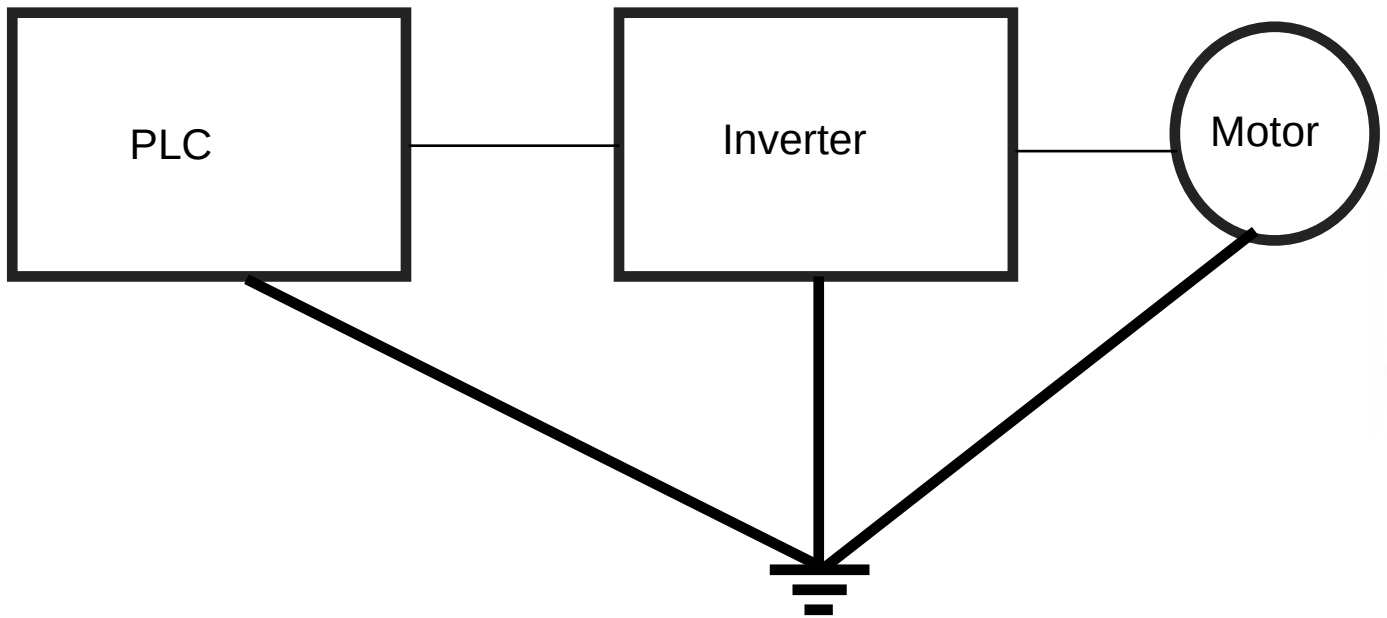
EMC: Good Grounding



There is much less interfering voltage because the ground is thick, short and Star connected.

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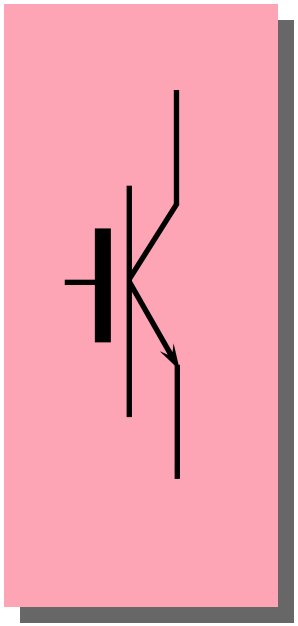
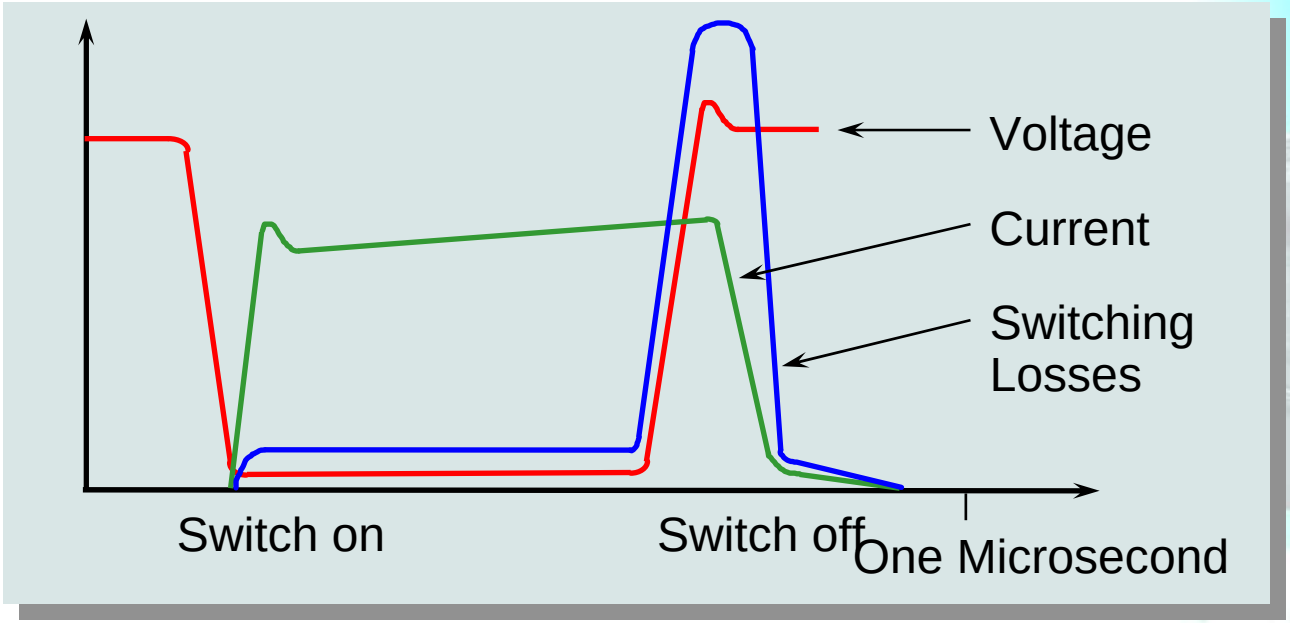
Insulated Gate Bipolar Transistors





IGBTs are rugged, efficient, fast (but not too fast) electronic switches.

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EMC and Variable Speed Drives.

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The VSD will send out and receive EMI in different ways:

1. The mains supply
2. The motor connection.
3. The earth connection.
4. The control connections.
5. By coupling and radiation.

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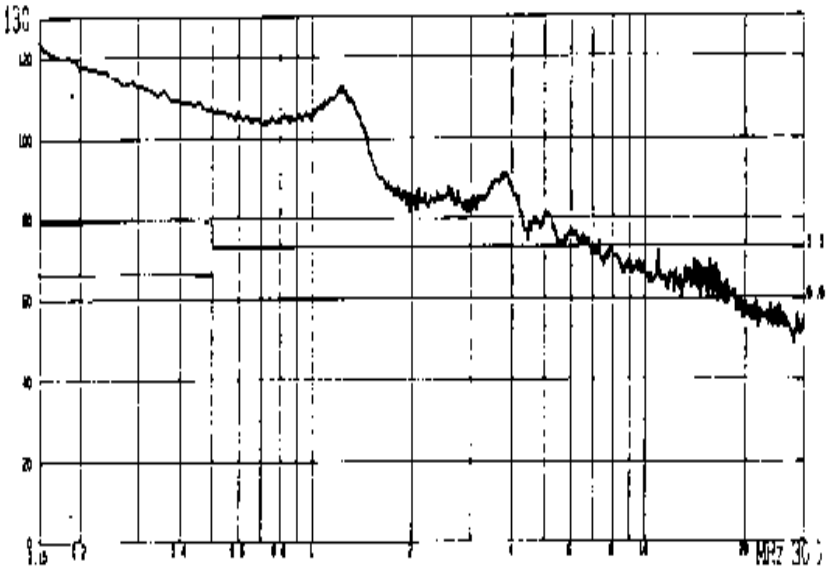
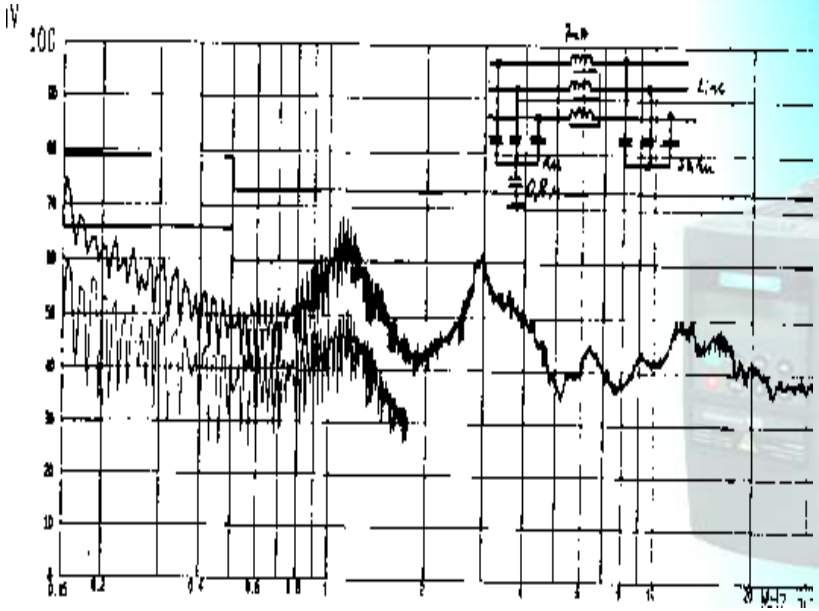
Supply Connection - Emissions





Without Filter

With Filter

Variable speed Drives generate a lot of interference over a wide frequency range that can be reduced, but not eliminated, by a filter.

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Supply Connection - Immunity

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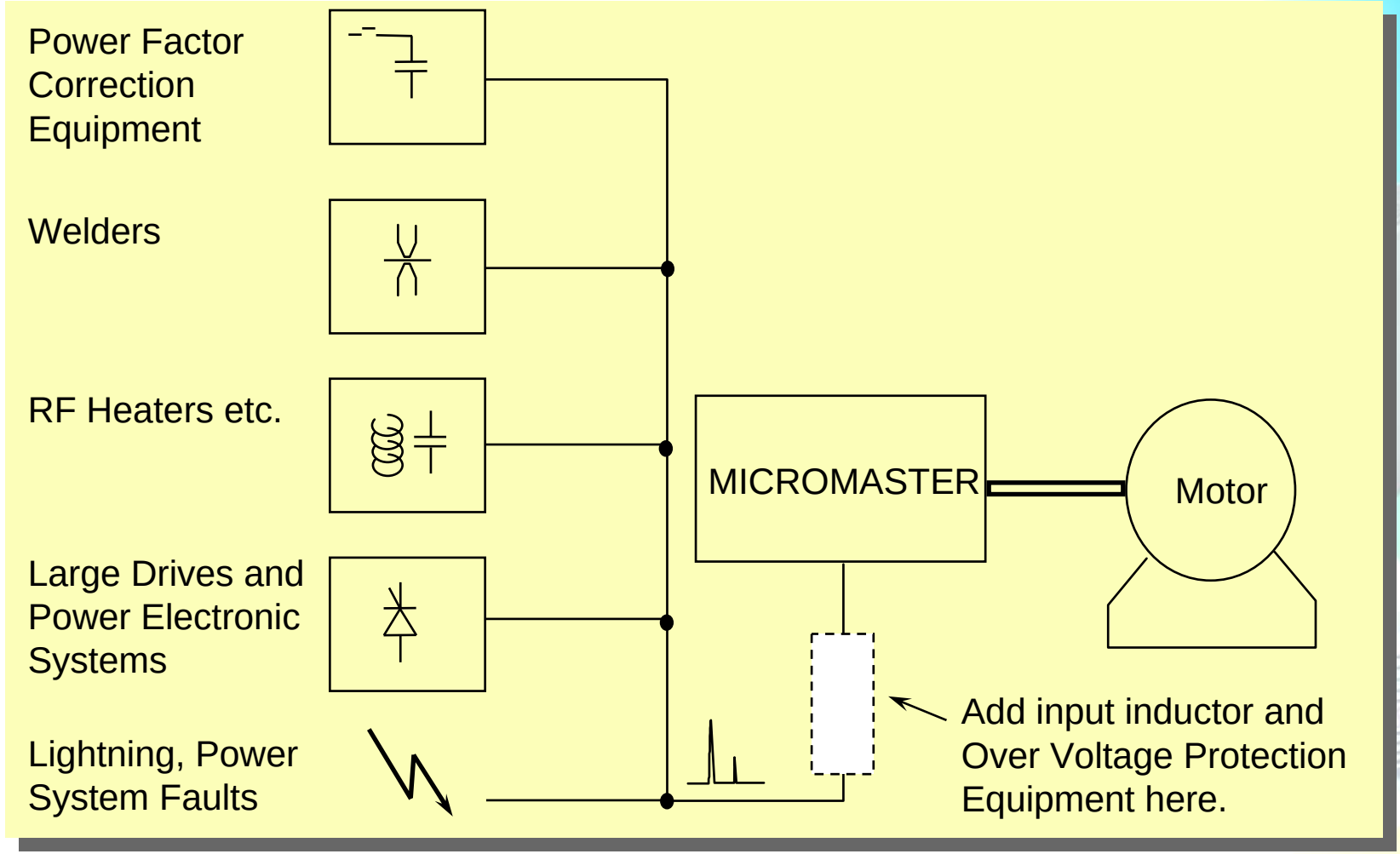

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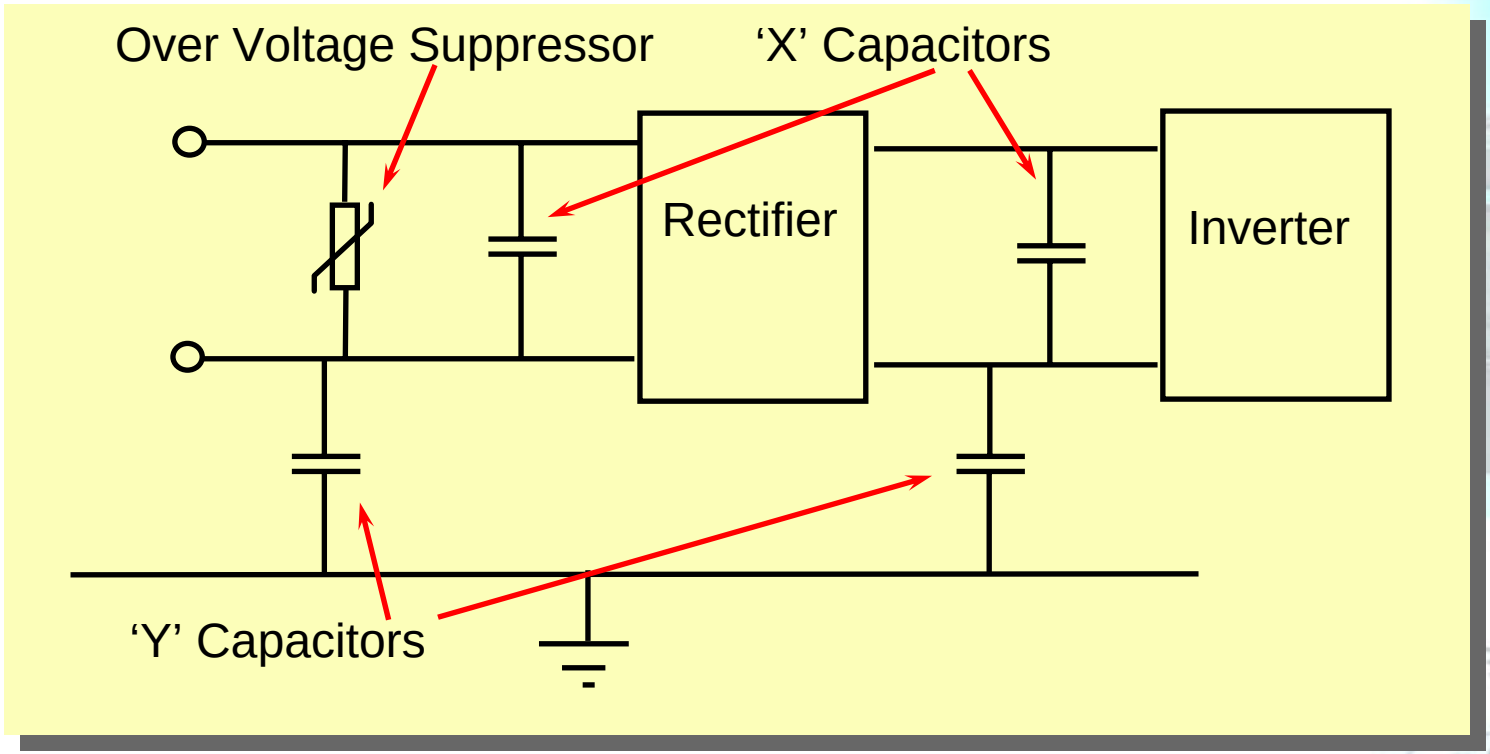
Supply Connection - Input Circuitry



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Typical Filter for Inverter operation, single phase.

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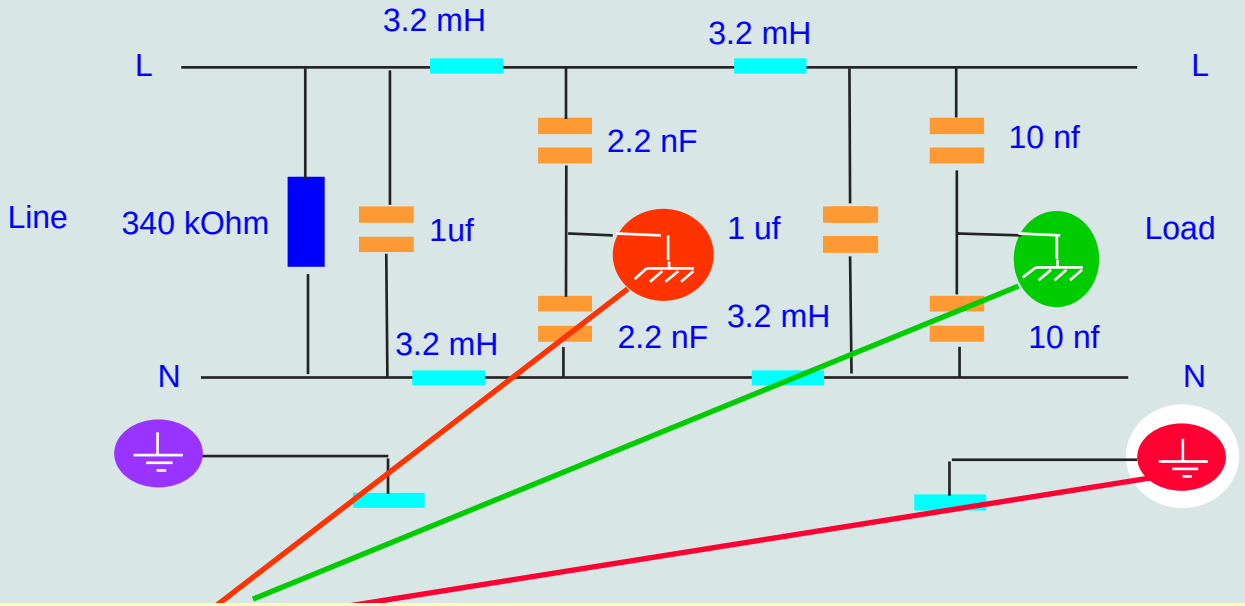

Correct operation is dependent upon good equipotential bonding

250 Volt , 6Amp, 50/60 Hz, T. Ambient 60 Deg. Centigrade.

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Output Connection - Emissions

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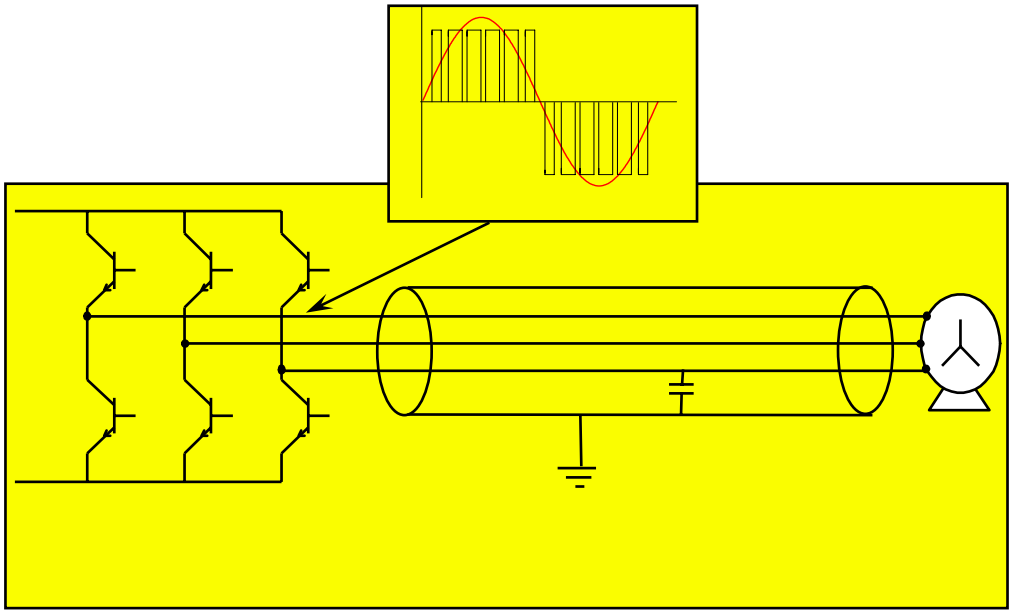

High frequency, high voltage switching causes currents to flow in stray capacitance to ground, or coupling into adjacent cables.

Screened cables give good protection, but cause high currents to flow to ground through stray capacitance

These voltages and currents are also present in the motor.

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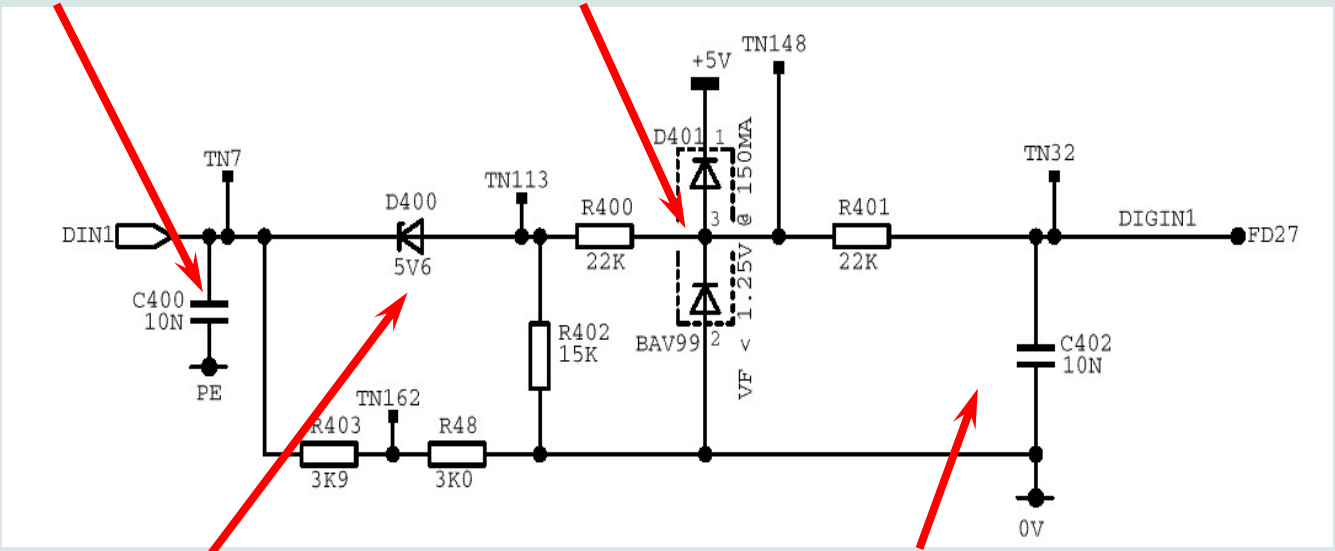
Control Circuit - Input protection

‘Y’ Capacitor to Ground

Diode ‘clamps’ to supply



Zener diode for high voltage threshold

‘X’ Capacitor to Ground

Digital input Circuitry showing Protection Components

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Control Circuit - Immunity

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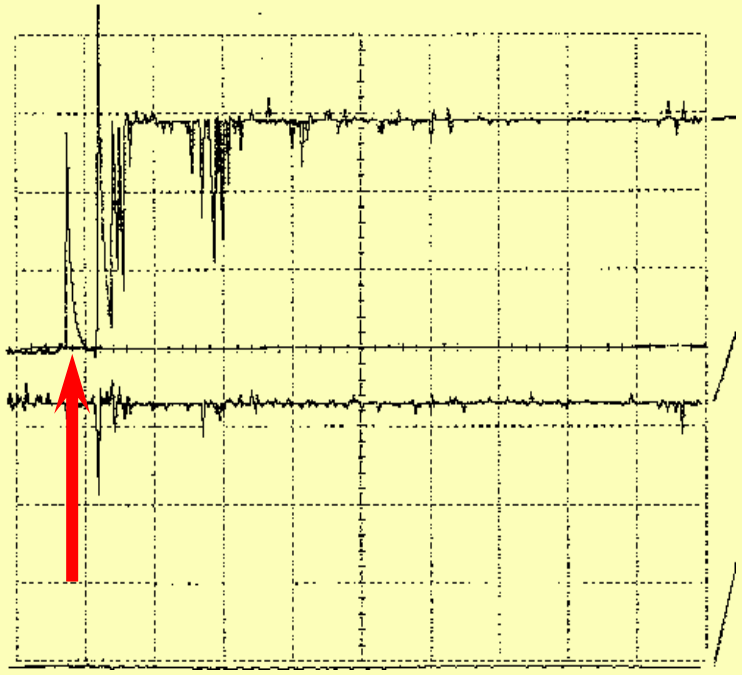
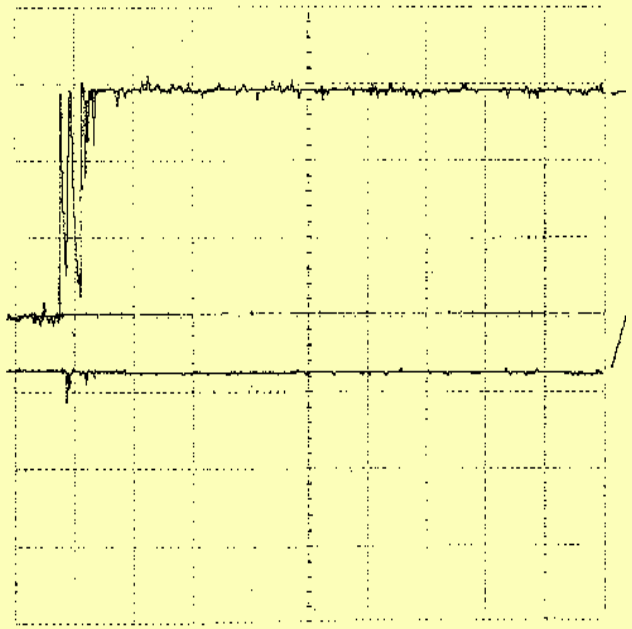


Cables routed inside Cabinet



Cables routed outside Cabinet

Poor cubicle layout has caused high levels of interference in the control signals.

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EMC: The Installation Rules

1. Ground all metalwork together using thick solid straps.

2. Separate signal and power cables.

3. Suppress all coils, contactors, relays, solenoids etc. using RC suppressors.

4. Use shielded cable or twisted pairs where possible.

5. Avoid long cable runs or loops. Keep cables close to grounded metalwork.

6. Ground unused cables at both ends.

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EMC: To Summarise

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- Plan the installation with EMC in Mind
- Segregate the different components
  screen into different Zones
  Consider using cabinets etc with built in screening.
- Segregate Motor cables from signal cables.
  Screen analogue and digital cables at each end.
  De-couple if necessary.
- Equipotential bonding for high frequency currents.
  Thick flat braided bonding cables.
- Remember - Prevention is better - and cheaper - than cure.

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Operation with incorrect Ground

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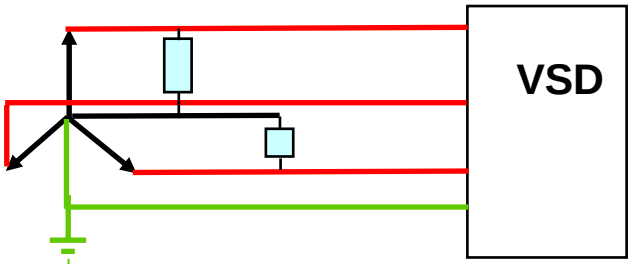
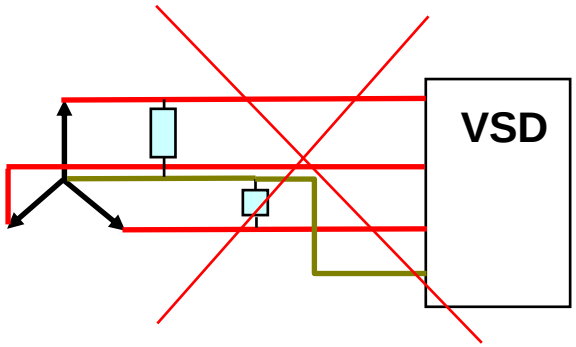
The Earth must be an independent ground connection carrying no current

Neutral grounding systems are not acceptable



Single Phase loads generate neutral currents - OK



Single Phase loads generate Earth currents - NO!

All Standard Drives MUST BE EARTHED!

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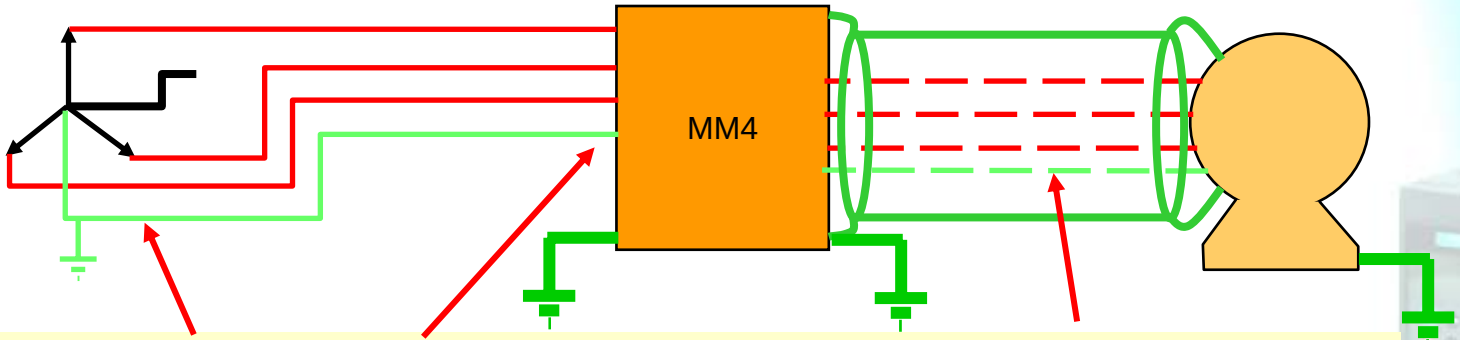
Operation with incorrect Ground

Grounding is very important!



The ground must be connected to the neutral at the supply

The MICROMASTER must be grounded

The Motor must be grounded to the MICROMASTER

Additional grounding is useful to reduce EMI:
Ground the metal work to the cubicle.
Ground the motor
Ground the motor screen or armour at both ends

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Operation with inadequate Earth

Gounding is about Safety, EMC, and Protection of equipment.

Correct grounding is Essential for safe,correct and reliable operation.

Incorrect grounding may result in failure or injury. In many countries this is illegal and may result in prosecution

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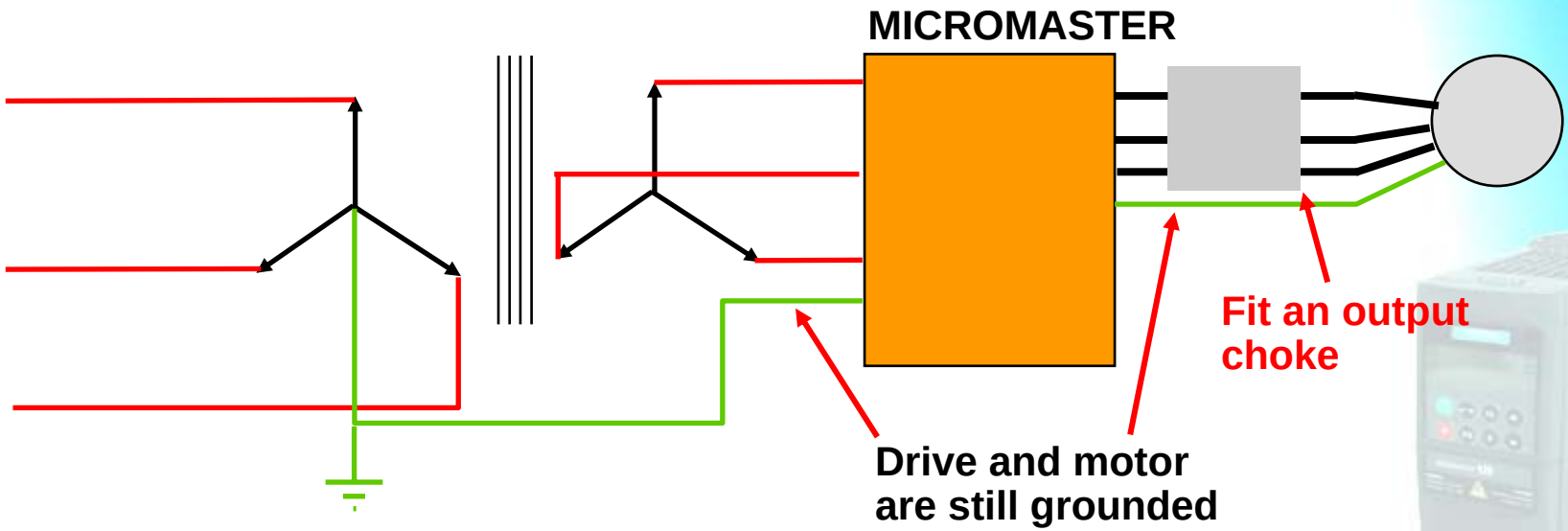
Operation with unearthed Supplies (IT Supplies)



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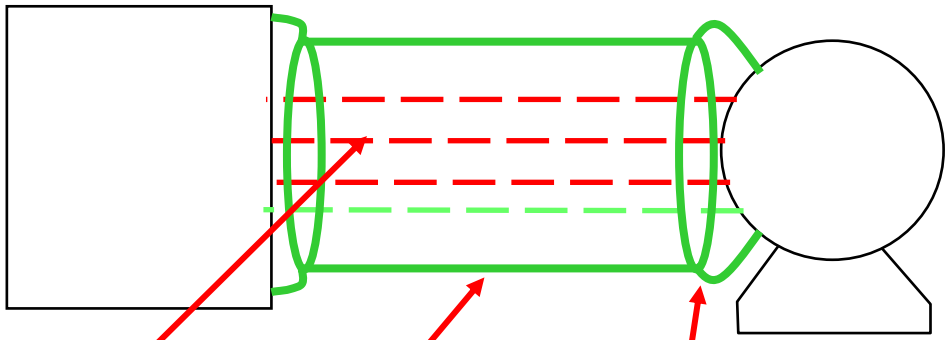
Correct Motor Grounding



Four Core cable with armour or screen correctly terminated at both ends

NO OTHER ARRANGEMENT IS ACCEPTABLE!

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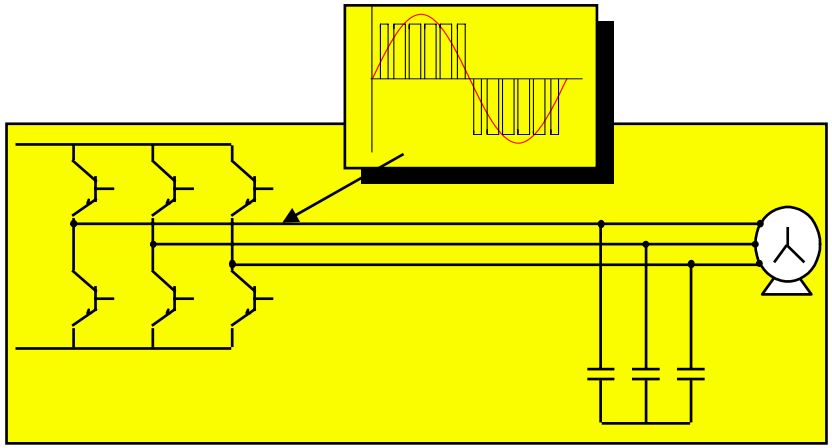
Operation with Long Cables



High frequency, high voltage switching causes currents to flow in stray capacitance to ground.

Problem is worse with long cables and with screened cables.

MM4 drives are fully specified to 50m screened cable

Solution:
De-rate inverter to account for higher currents, or fit inductor close to inverter output to reduce these currents.

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Correct Motor Grounding - How not to do it.

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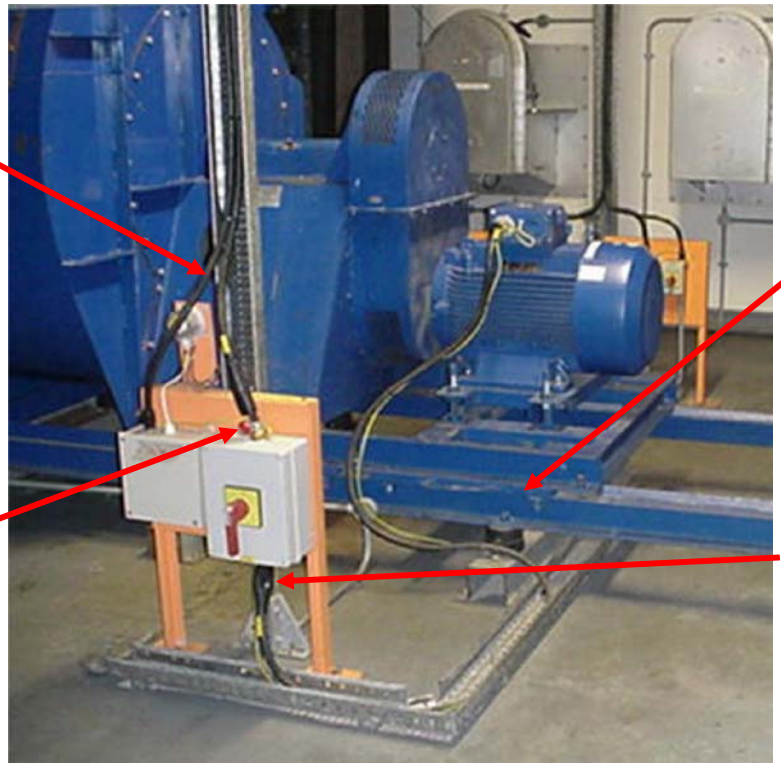

Ground between motor and Inverter is steel armour only

Motor/Fan Assembly fully isolated

Plastic Box breaks screen and ground continuity

10mm 3 core cable 35mm 4 core required

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Ground all Metalwork...

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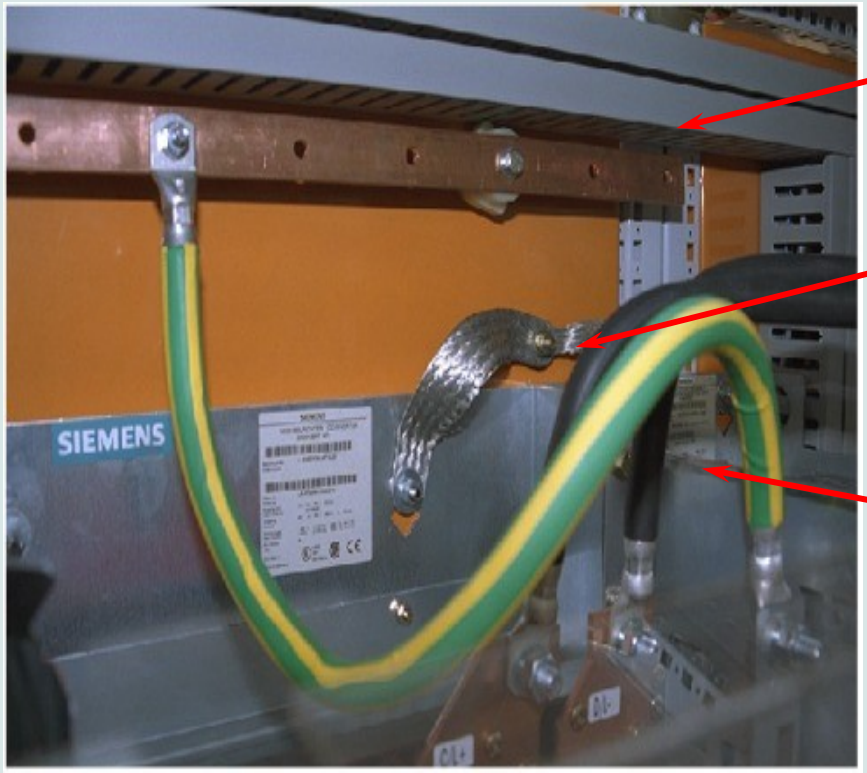

Solid Bussbar for main Ground connection.

Short flat conductor where possible

Thick Braided ground wire.

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Ground all Metalwork...

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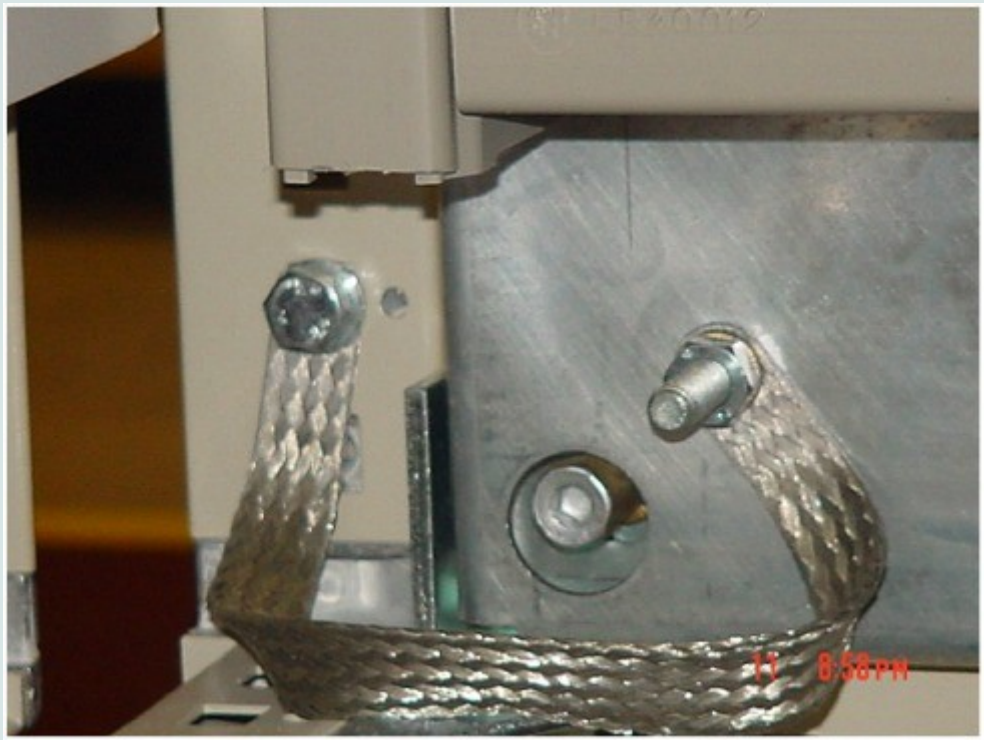

Thick Braided ground wire ties together different metalwork parts

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Ground all Metalwork...

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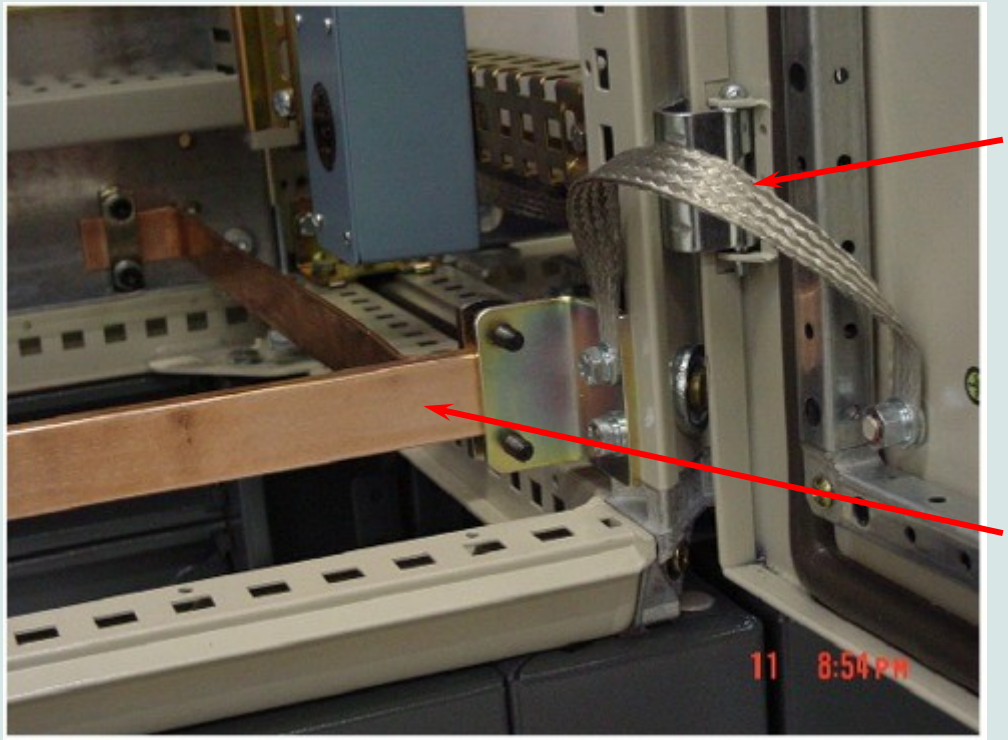

Thick Braided ground wire for grounding of door.

Solid Bussbar for main Ground connection - connects between cubicles.

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Separate Signal and Power Cables...

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- Separate the power, control, incoming power etc. into different Zones.
- Ensure cables from different zones are routed in separate cable ducts.
- Use shielding between different Zones.
- Ensure cables cross at right angles to minimise coupling.

Poor EMC Installation: all wiring mixed.

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Separate Signal and Power Cables...

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Signal cables are screened and separated from other wiring

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Suppress all Coils

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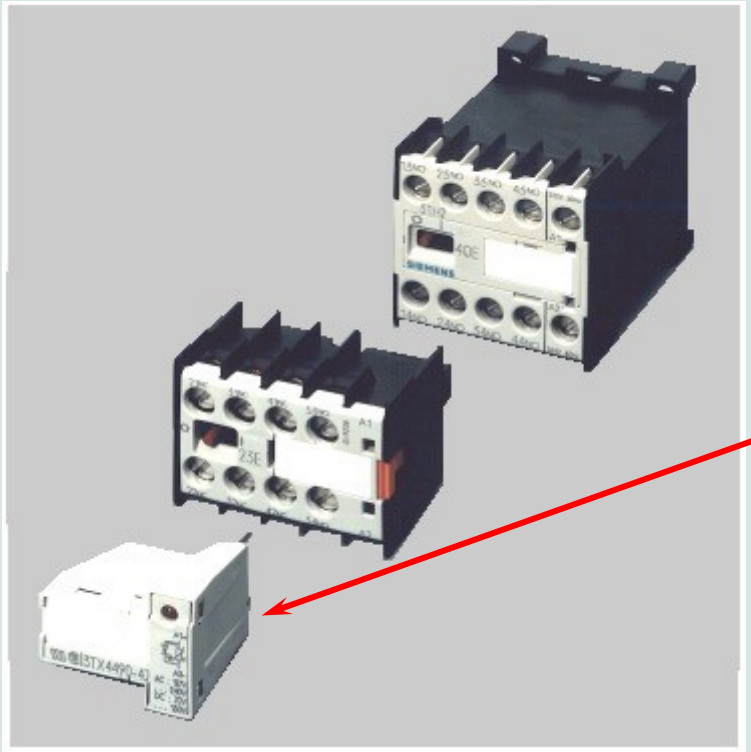

Suppress all contactors /relays etc using Varistors, Diodes or (best) RC networks

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Suppress all Coils

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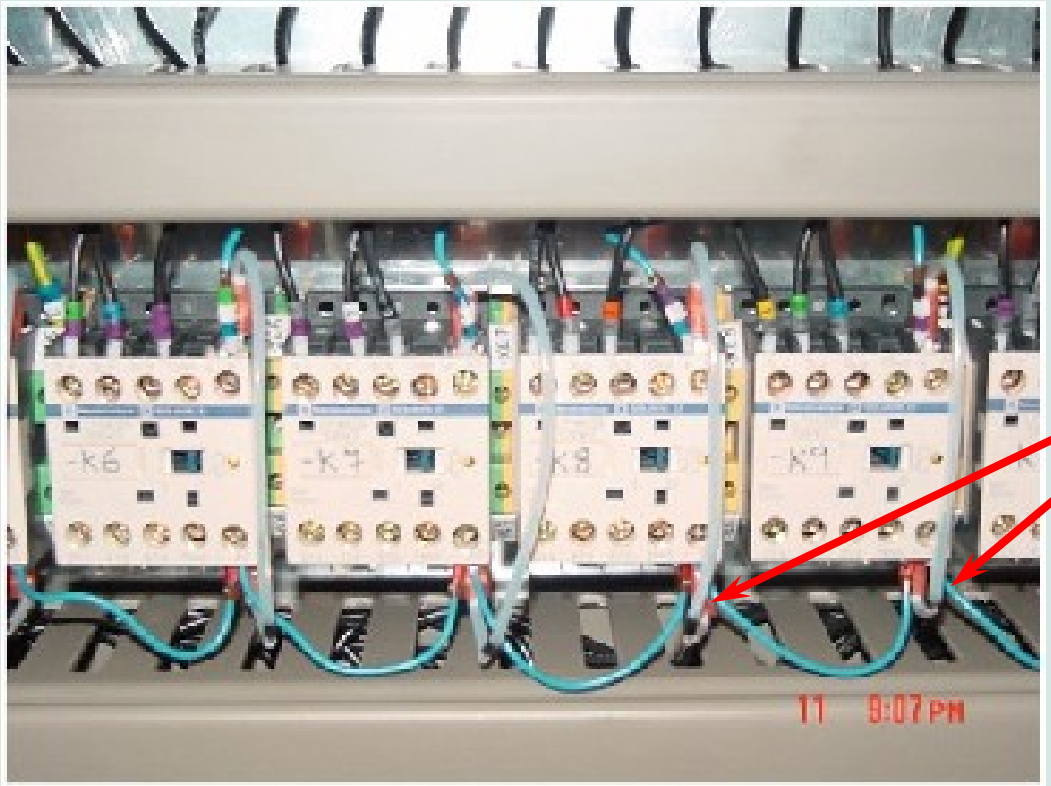

Suppress all contactors /relays etc using Varistors, Diodes or (best) RC networks

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Use Shielded Cables or Twisted Pairs...

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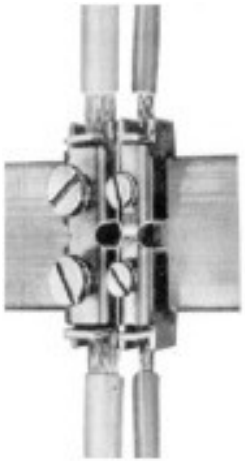
Ground cable shields at both ends



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How to do it

บริษัท ไทนามิก จำกัด
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+ Good Groundplane

+ Screened control cables.

+ Input Choke

- No separation of input, output, or signal cables.

- No filter.

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How to do it

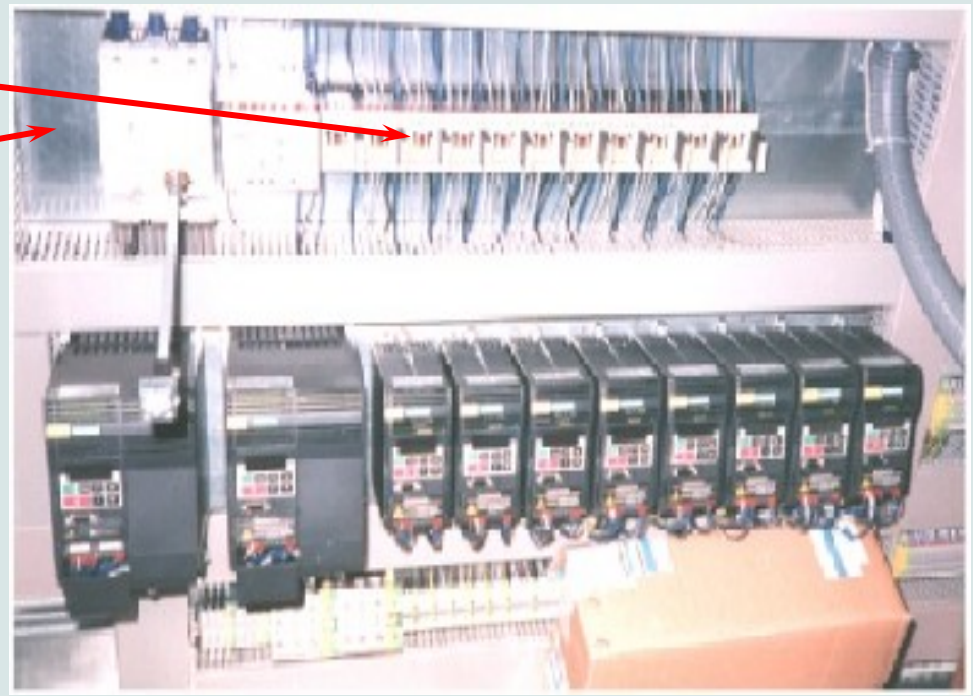
บริษัท ไทนามิก จำกัด
Tinamics Co., Ltd.

+ Suppressed contactors

+ Good Groundplane

+ Screened control cables.

- No separation of input, output, or signal cables.



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How to do it

บริษัท ไทนามิก จำกัด
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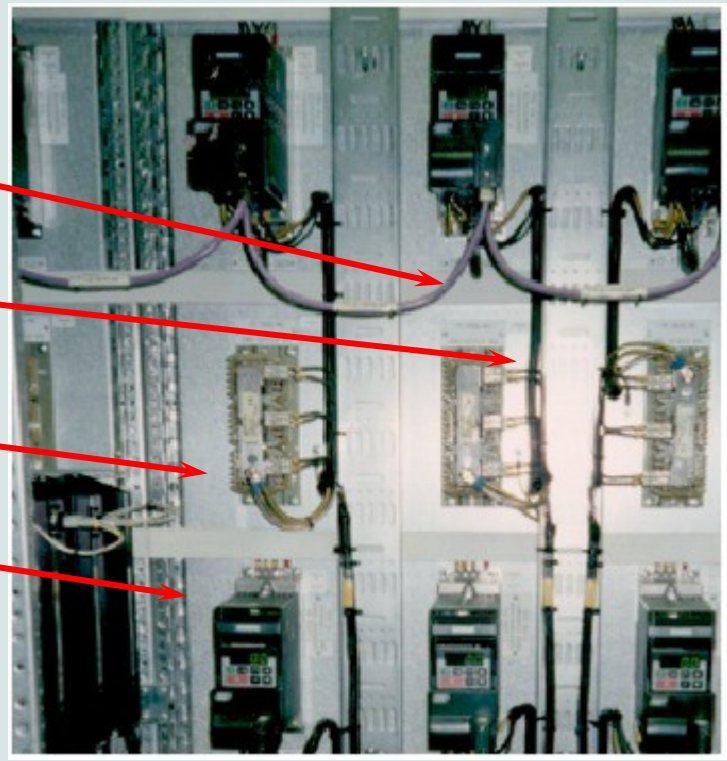
+ Screened PROFIBUS cable crossing at right angles

+ Screened input and output power cables.

+ Output Chokes (Long Cables)

+ EMC Filter well grounded to metal backplane.

- Supply and motor cables together.



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How to do it

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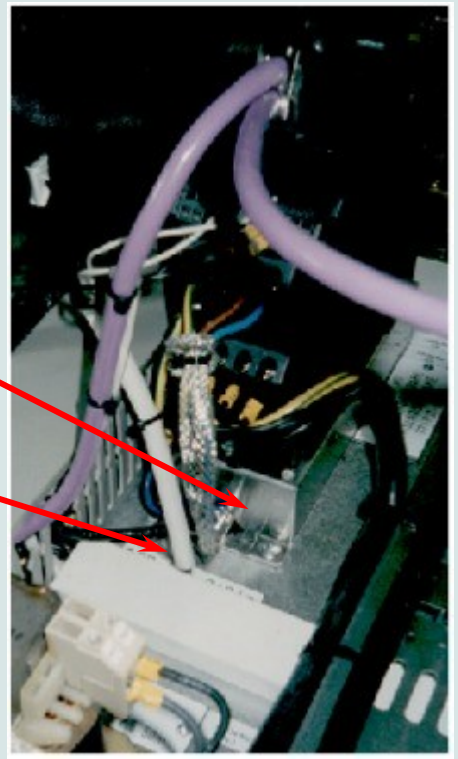
+ Correctly installed filter unit

+ Screened Cables throughout.



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How to do it

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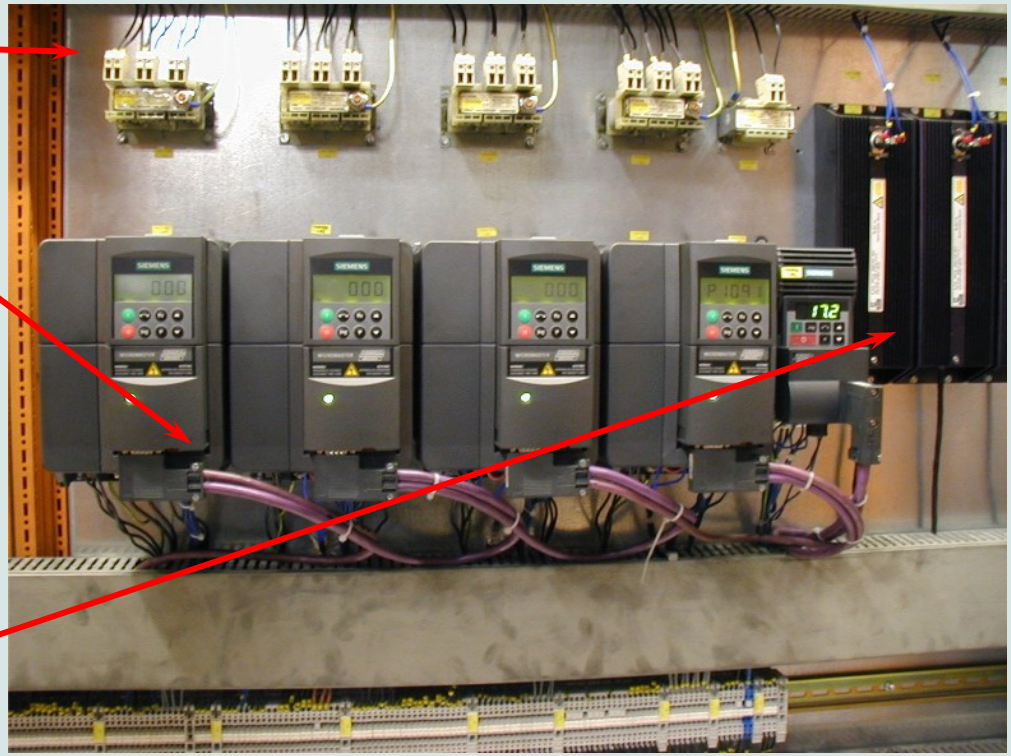
+ Input Chokes

+ Separate PROFI wiring



Braking Resistors

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Poor installation / Not to do it

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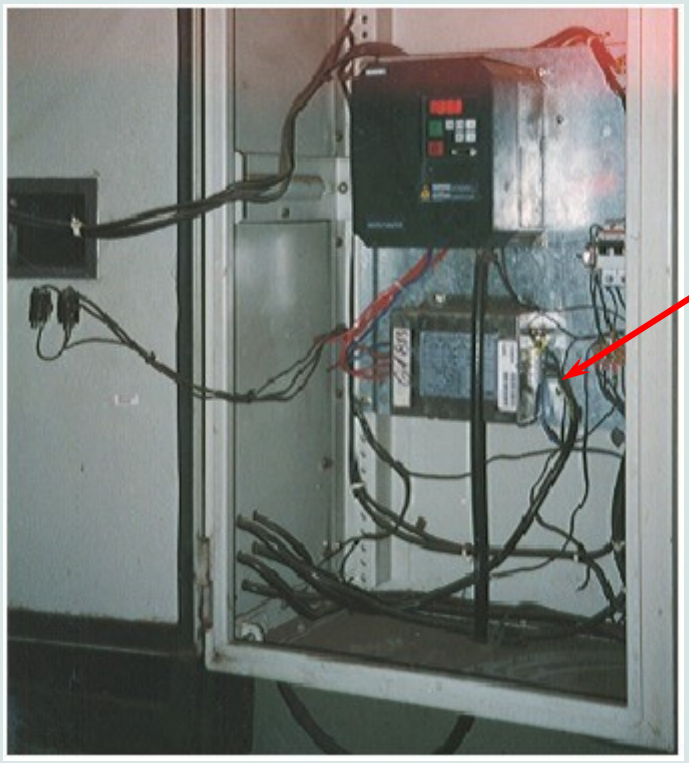

The filter is achieving very little because of poor grounding and because cables can cross couple around it.

Zoning is non existent.

Wires are crossing, clear of the metalwork and tied together to encourage radiated EMI

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Poor installation / Not to do it

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- Mixed power and signal wiring.

- All cables unscreened.

- Unsuppressed contactor and relay coils.

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Poor installation / Not to do it

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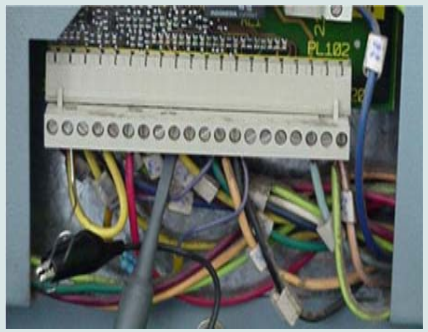
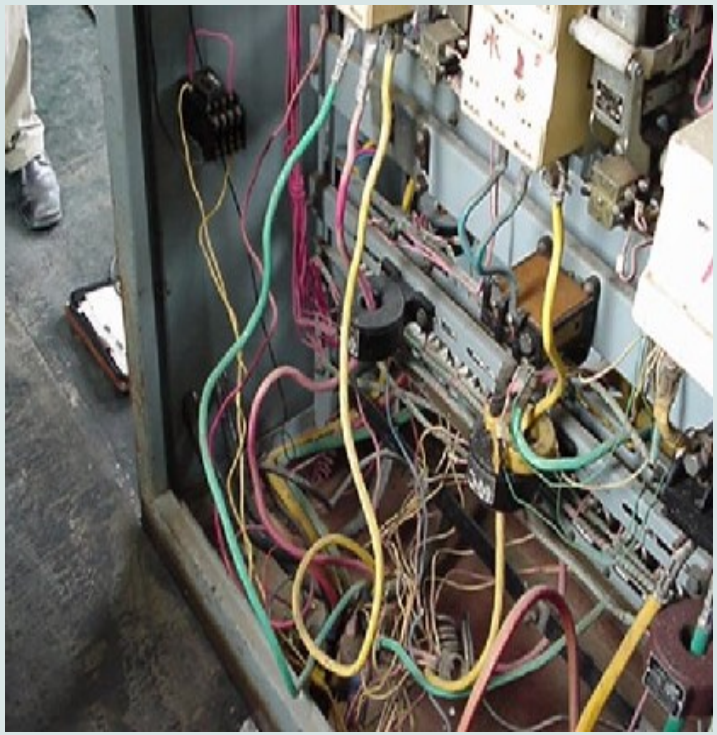
A poor installation is:

untidy….

So everything else can't be checked.

How safe is this equipment?





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Not to do it

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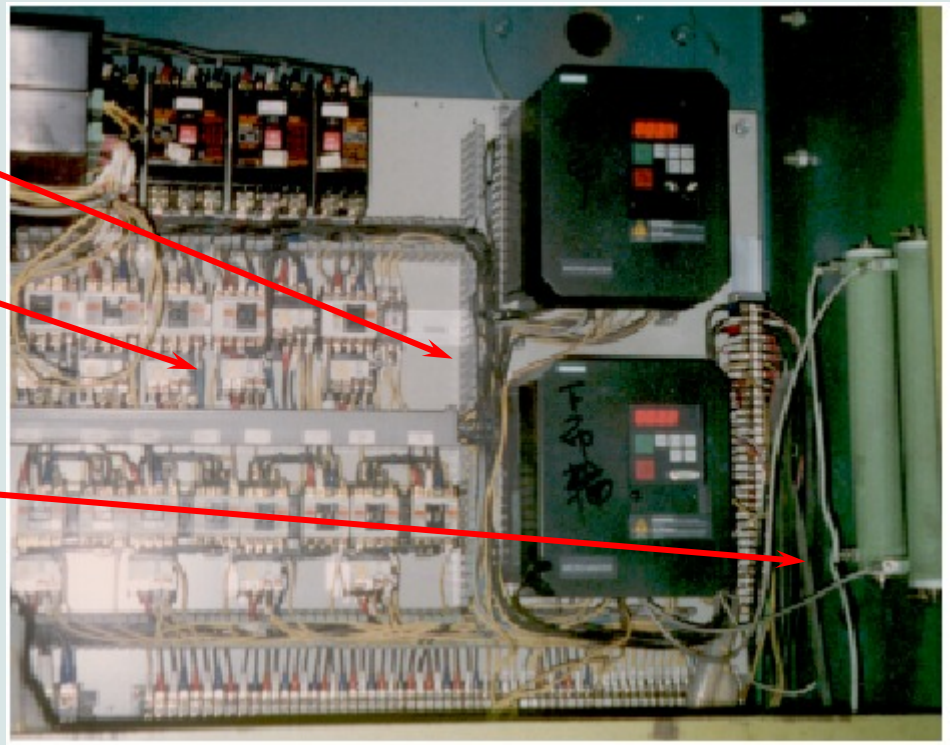
- Mixed power and signal wiring.

- All cables unscreened.

- Unsuppressed contactor and relay coils.

- Braking resistor wiring!



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