

Basic installation rules for electromagnetic compatibility (EMC) in automation systems

Introduction

The importance of electromagnetic compatibility is greater than ever. Technical advances mean a concentration of electrical and electronic components in steadily decreasing spaces. At the same time, switching frequencies of controllers (PLC, communication interfaces) and power devices (frequency inverters) are increasing. The risk of mutual interference and associated functional problems is, therefore, also increasing.

Many of these problems are directly related to the installation and cabling technique of the installed components. In times when only few PLCs and almost no bus systems were used, the mostly electromechanical components were usually not affected by electromagnetic noise that was produced by switching components (contacts). In the meantime, high complex PLC and communication systems (field buses) have become more familiar due to their chances of overall cost reduction. To ensure proper functionality of all modern equipment it was necessary to define limits of noise emission for components that produce noise while their normal operation and as well, levels of noise immunity for components that could be affected by noise. Nevertheless, it is still possible that problems occur, if some basic installation rules are not taken in consideration.

The following rules are based on experiences in the field of modern automation systems and are kept as simple as possible to make an easy and cost effective use possible. If they are taken into consideration as early as possible in the design and projection phase of a new automation system they usually do NOT result in higher costs.

The aims of that rules are:

- More cost effective equipment construction by avoiding costly EMC countermeasures at a later stage
- Short commission times by avoiding the time consuming search for interference sources
- Safer operation by avoiding machine and plant malfunctioning
- Longer lifetime of electrical equipment by protection against damaging EMC effects

As more than 90 % of all EMC problems are related to the combination of control devices and motor drives the following examples mainly refer to that combination.

Basic rule 1 (Grounding)

Proper grounding is necessary for human protection and noise reduction as well. Therefore, all metal machine parts (housings, cable trays, motors etc.) should be connected to the same reference ground potential (usually in the main cabinet). Important is a low impedance path for both low frequencies (LF) and high frequencies (HF) as well. The following figures show how low impedance (LF and HF) of the grounding connections can be achieved:

EMC RULES FOR INSTALLATION

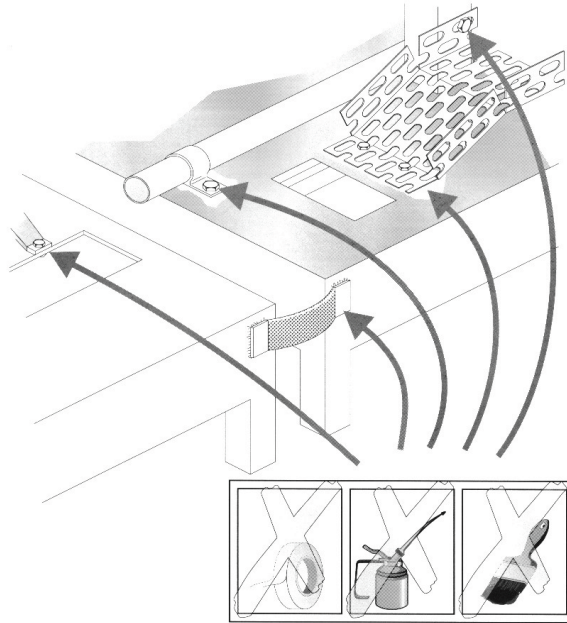


Fig. 1: Bonding of ground conductors

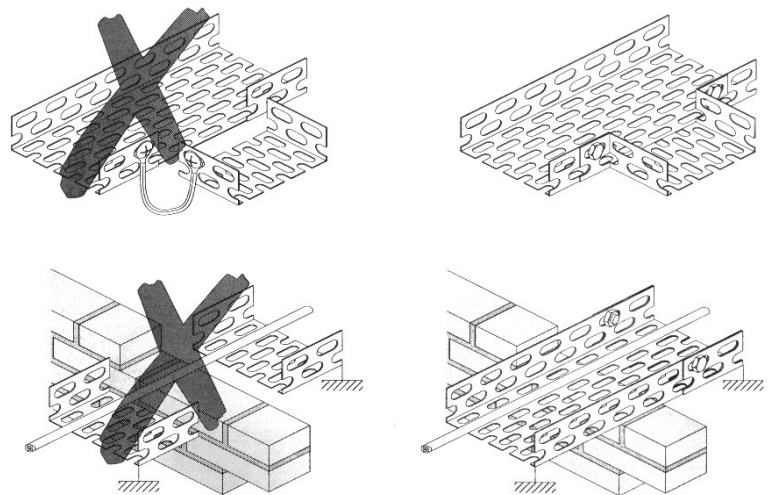


Fig. 2: Joints in metal cable trays

Basic rule 2 (Cabinet design)

The easiest way to avoid coupling of noise into another system is to keep as much physical distance as possible. This countermeasure starts in the cabinet and ends in the field where electrical and electronic components are mounted (refer to basic rule 3 also).

The best way to separate control and power equipment is to have different cabinets for low voltage control components and high voltage power circuits (contactors, inverters, etc.) or at least have one cabinet with a metal partition (see figure 3) between these components.

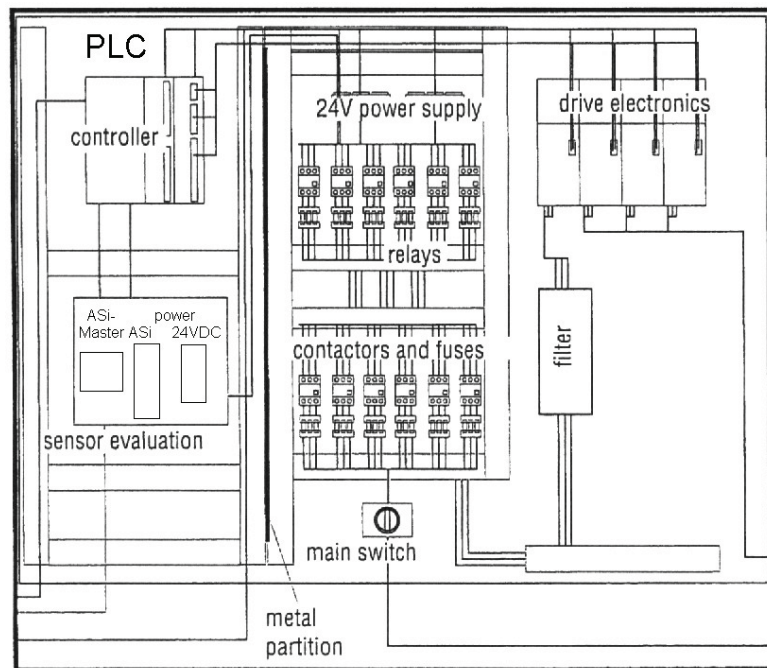


Fig. 3: Switch cabinet with separated control and power components

For systems using ASi that means:

ASi master, ASi power supply (yellow flat cable) and 24VDC power supply (black flat cable) must be mounted on the “control” side (left in the above figure). Crossing of ASi lines and power lines must be avoided or at least be achieved at an angle of 90° (right angle, refer to basic rule 3 also).

Basic rule 3 (Cabling)

In the following considerations cables are classified in four groups I, II, III and IV:

- Group I: very sensitive to noise (analog signals, measurement cables)
- Group II: sensitive (digital signals, sensor lines, 24VDC switch signals, communication signals like field buses or ASi)
- Group III: noise source (control cables for inductive loads, unswitched power lines, motor brakes, contacts)
- Group IV: strong noise sources (output cables from inverters, supply cables to welding equipment, switched power circuits)

The most effective ways to avoid coupling of noise between a.m. cable groups are:

- Spacing between groups I, II and III, IV (see figure 4). Following distances have proven to be suitable:

For $L_1 < 3$ meters: $d_1 \geq 0.1$ meter;
 For $L_2 > 3$ meters: $d_2 \geq 0.2$ meter.

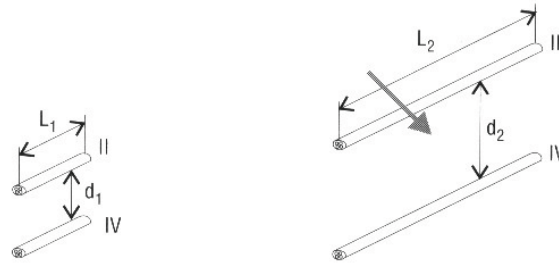


Fig. 4: Spacing between different cable groups

- If possible groups I, II and III, IV should be installed in different cable trays or at least a cable tray with a metal partition (see figure 5)

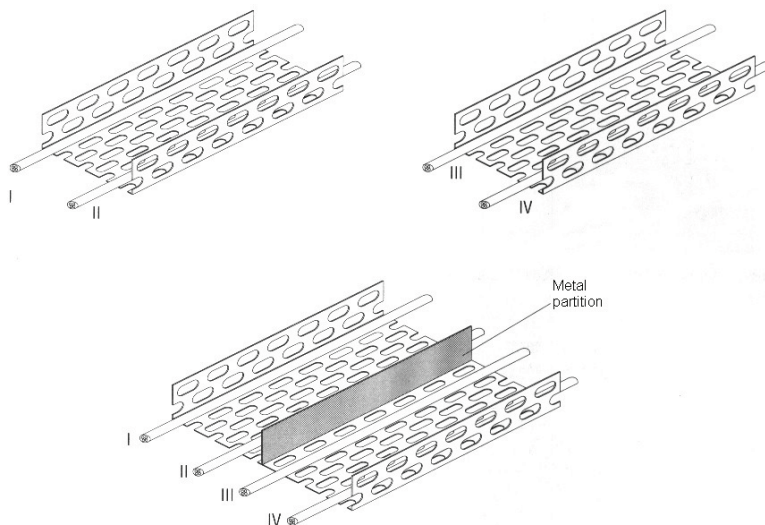


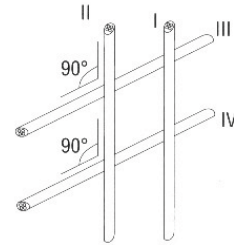
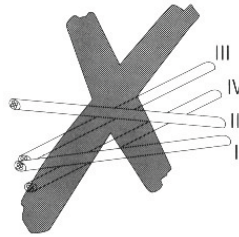
Fig. 5: Various solutions for laying cables in cable trays



EMC RULES FOR INSTALLATION

- Group IV cables (output cables of frequency inverters) must be shielded due to requirements of the manufacturer (refer to basic rule 4) if the above mentioned distances between groups I, II and III, IV is not possible.
- Cables of groups I, II and III, IV must always intersect at right angles (see figure 6)

Fig. 6: Intersection of cables of different groups



For systems using ASi that means:

The ASi system has to be treated as a “control” system. Therefore ASi cables (yellow and black) belong to a.m. cable group II.

Basic rule 4 (Shielding)

Where the separate installation of control (group I, II) and power (group III, IV) cables is not possible at least the lines that are connected to strong noise sources (III, IV) must be shielded.

Shielding is only effective if the shield is properly connected to ground on both ends of the cable (see figure 7). “Pigtailing” of shields is strongly prohibited as it reduces the shielding effect to nearly zero.

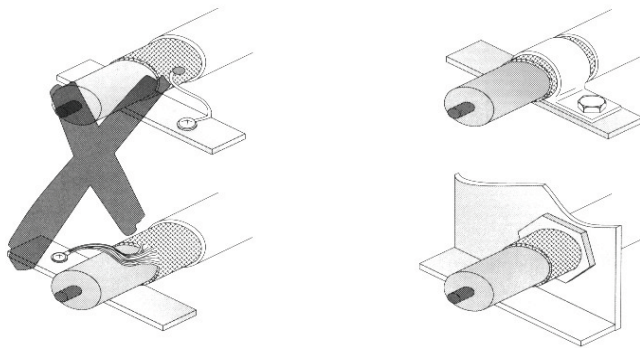


Fig. 7: Examples of shield connection

For systems using ASi that means:

If it is necessary to install ASi lines in parallel to switched power lines (e.g. motor cables) in the same cable tray at low distances (< 0,1 meter) the switched power lines must be shielded.

Basic rule 5 (Filtering)

Where shielding or proper separation of control and power lines are not possible or applicable the use of filters is an alternative.

High frequency noise of switching power circuits can be reduced dramatically by the use of simple ferrite coils that are installed near to the noise source (inverter output, motor side of contacts etc.). (see figure 8)

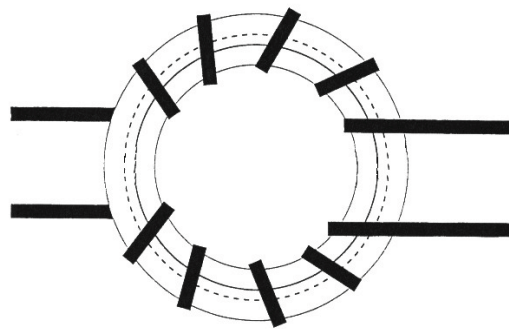


Fig. 8: Ring ferrite coil

With very high noise from unshielded output cables of frequency inverters output filters (sine filter, surge filter) have to be used. Their effect is to change rectangular output voltage of frequency inverters to an approximated sine form (see figure 9).

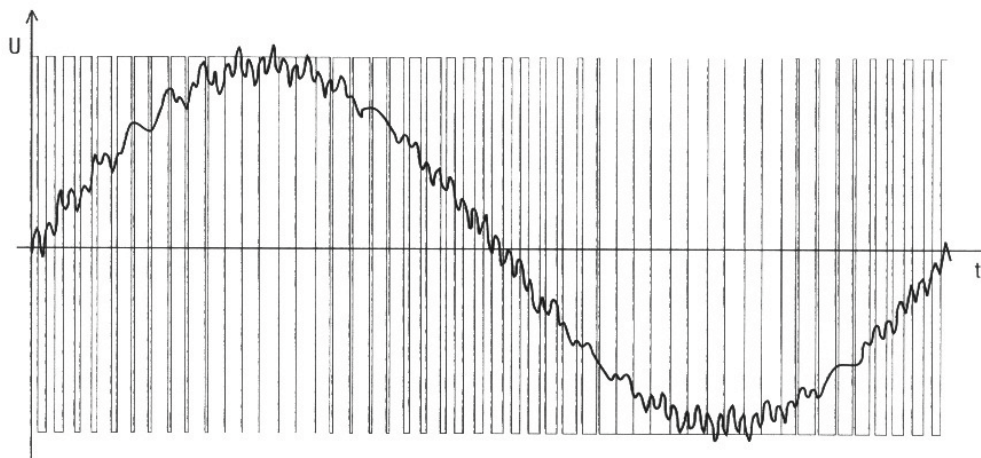


Fig. 9: Output voltage with and without sine filter

Conclusions

The easiest way to avoid noise problems is the proper planning of the installation by taking electromagnetic conformity into consideration at an early state of designing. Especially the separate cabling of control and power circuits reduces the risk of getting EMC problems dramatically without additional costs. Where separate cabling is not possible, shielding and/or filtering the noisy lines are alternatives that are still cost effective compared to the costs and efforts that have to be taken if EMC problems occur after complete installation at the customer side.

For systems using ASi that means:

As the above mentioned rules are general rules to ensure EMC (electromagnetic compatibility) there has to be no special treatment of ASi systems as long as these general rules are considered.

Countermeasures at already installed machines and plants

In case of EMC trouble after the installation time often is a critical factor to solve these problems. Therefore filtering (output chokes, surge filters) or noise reduction with additional electronic components (diodes, varistors) at switching devices (contactors) are the only countermeasures due to the fact that cabling is usually already fixed.

Additional information can be found in the following documents:

1. European Standards: EN 50081-2; EN 50082-2; EN 55011
2. IEC Standards: IEC 801-2/-3/-4/-5/-6
3. SEW Eurodrive: Drive Engineering-Practical Implementation Volume 9: Electromagnetic Compatibility (EMC) in Drive Engineering
4. Mitsubishi Electric: FREQROL FR-A Inverter Operation Manual #506674
5. Mitsubishi Electric: EMC Installation Guidelines (manual # BCN-A21041-202)

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