TACKLING RADIO FREQUENCY INTERFERENCE ASSOCIATED WITH FREQUENCY CONVERTERS

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Variable speed drives have been used in industrial applications for years because of their ability to provide precise process control. They have also become the standard method of control for heating ventilation and air-conditioning (HVAC) systems due to their precise control and significant energy savings.

The operational concerns for HVAC systems are quite different from those for industrial applications. In most HVAC installations there is a large installed base of sensitive electronic equipment such as computers, outstations and radios. Airports, hospitals and research facilities for example, make much heavier demands on variable speed drives than industrial plants.

This article deals with one aspect of electrical noise generation in variable speed drives: radio frequency interference (RFI) on the ac power line. We describe the causes and effects of such noise as well as the considerations to be made in connection with the selection and installation of a variable speed drive.

Causes of RFI from drives

Most variable speed drives operate by using a bridge rectifier to convert incoming ac voltage into dc bus voltage. The inverter bridge of the drive then converts the dc bus voltage into the controlled voltage and frequency that the motor requires. This is shown schematically in Figure 1.

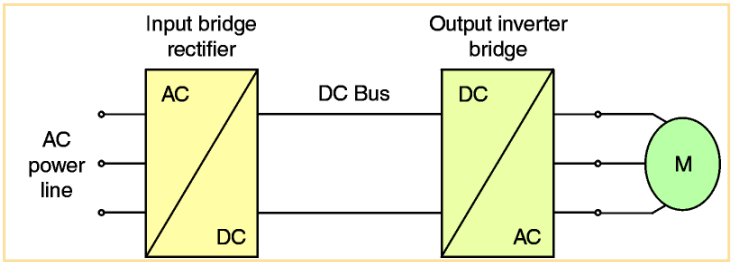

Figure 1. Schematic of basic drive design

For the most common types of drives, insulated gate bipolar transistors (IGBTs) are used to convert dc voltage into ac voltage with controlled amplitude and frequency. To perform this control most drives incorporate sophisticated control circuitry with microprocessors of high clock frequencies.

Both the inverter and the control circuitry generate electrical noise at frequencies higher than 150 kHz.

If the drive is not carefully designed, this noise will be conducted to the surroundings. It will cause malfunction of other electronic equipment when not designed with a high level of immunity to such high frequency noise.

Measuring RFI

The levels of RFI from a drive depends on different factors. The design of the drive is most important, since this determines how low the distortion can get.

The measuring results for different drives may vary, so to get a real picture it is important to know how the measuring was made. Some of the most important factors are:

- impedance between drive chassis and ground
- type of motor cable used or transfer impedance of cable
- screen
- length of motor cable

Radiated emission is almost impossible to reproduce. The reason is that even a slight change in the measuring set-up will influence the results. Measuring made on site is always unreliable as it is impossible to create a clean environment.

RFI limits

A number of standards governing RFI limits exist - one of the most important international standards being EN55011/CISPR11.

EN55011 sets three different limits as shown in Figure 2. Of these limits only 1A and 1B are applied as legal requirements. Each level contains limits to quasi peak and average conducted emission as well as quasi peak radiated emission.

Figure 2 shows the limit for average conducted emission. Conducted emission is a cause for concern. With EN55011 demands for quasi peak and average are combined in one standard. This is done to get more equal demands and remove the need to determine which of the two requirements should apply to the equipment. The level is about 10dB mV lower than the quasi peak levels.

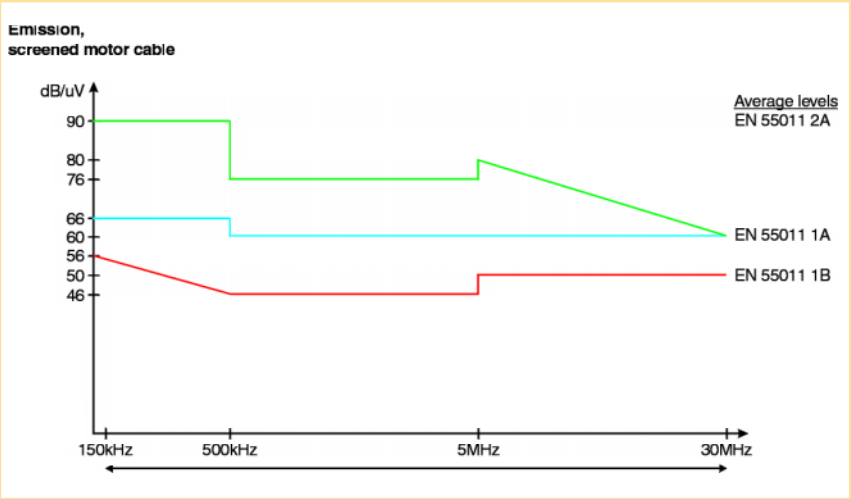

Figure 2. Average conducted emission levels

The quasi peak limits do not cause problems in the design of the RFI filter. The average limits however, have caused problems for many manufacturers.

RFI filters

RFI filters are available in different designs. The most economical and best functioning filter will match the drive very carefully.

An RFI filter mainly consists of common mode reactors and capacitors.

Whether a filter is good at filtering the frequencies exceeding the limit of the norm depends on the design. If the filter is not designed for the drive, the filter components need to be oversized which increases costs.

Installation considerations

The most important aspect is to follow the manufacturers' installation guidelines. However, a number of general rules will now be discussed.

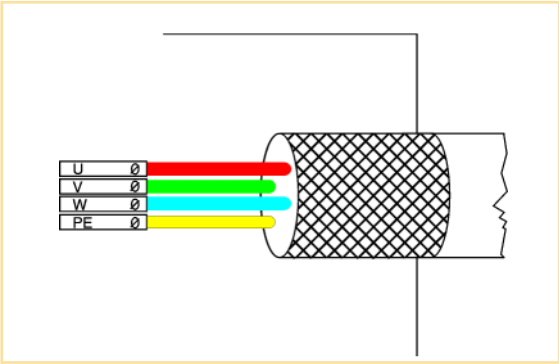

Figure 3. Motor cable with pigtail

Avoid pigtails

A pigtail is as shown in Figure 3, where the screen is twisted up and bonded to the power earth terminal by a screw. Effectively the pigtail ground connection increases the impedance to ground and therefore increases the noise level that can be measured on the mains cable. For example, a pigtail of only 20cm length has the same effect as adding an additional 150 m of cable to the link (at 10MHz).

Figure 4 shows the impact on compliance when a good installation (curve 1) is changed to an installation with a pigtail of 5 cm at the drive end, while the motor end is left untouched (curve 2). Where the good installation complies with EN 55011 1B, the installation with 5 cm of pigtail barely complies with EN 55011 1A.

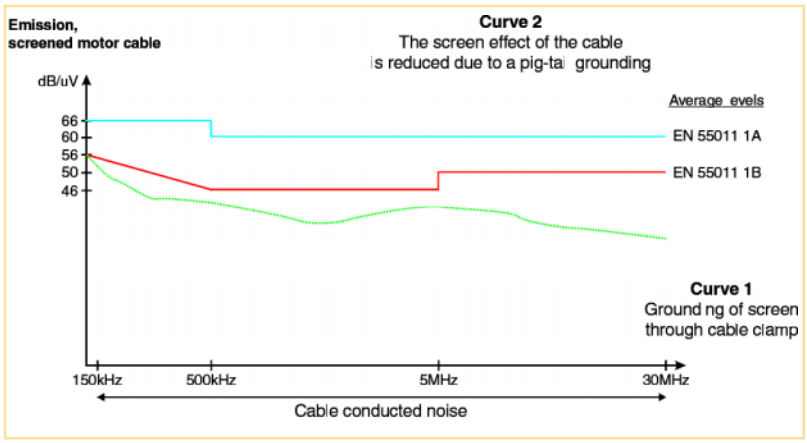

Figure 4. Comparison between good installation and pigtail installation.

Use of screened motor cables

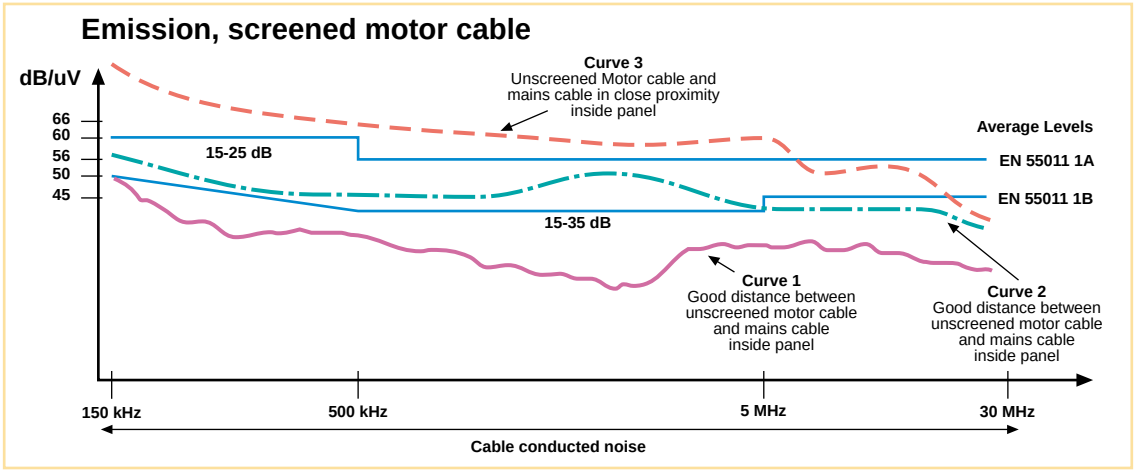

Figure 5. Using unscreened cables inside the panel.

The cable between the panel and the motor is usually screened. Unfortunately, output contactors inside panels are often connected with unscreened cables. This will give problems with noise being radiated between the cables.

Figure 5 shows a comparison between a good installation (curve 1) and a bad one, using unscreened motor cables inside the panel (curve 2). In this example great care was taken to separate the mains cable from the motor cable. It is sometimes not possible to avoid the use of unscreened motor cable inside the panels, but as curve 2 shows, compliance with EN 55011 1A is achievable.

The mains and motor cables are often placed too close. This causes transmission of noise directly between mains and motor cables, thus by-passing the RFI filter and losing compliance with EN 55011, as shown in curve 3.

Earth the screen at both ends

To get effective screening of the electric and magnetic field from the motor cable it is necessary to connect the screen at the motor and at the drive end. Connecting the screen at only one end will screen the electric field but will have no effect on the magnetic field. As the noise from the motor cable is mainly magnetic the screen will be very ineffective when connected only at one end.

Equalising currents rarely cause problems to the installation. As a rule of thumb the screen should therefore always be connected at both ends. If it is not possible to bond the screen at both ends, then rather than simply disconnecting it, it should be bonded via a 1 µF capacitor at the drive end.

Conclusion

To ensure optimum performance it is important to select the tight drive and filter and to install it correctly. A good drive with the appropriate RFI filter cannot ensure compliance if the installation work is not done properly.

Many buildings incorporate equipment that is sensitive to radio frequency interference. This is not only the case for airports, telecommunication facilities and hospitals. Ordinary apartment buildings and office complexes also have a lot of sensitive equipment installed. It is therefore especially important to limit radio frequency interference in HVAC installations.

Take Note

- *The drive must be carefully designed with immunity to high frequency noise.*
- *A good drive with the appropriate RFI filter cannot ensure compliance if the installation work is not done properly.*