EMC effects underestimated as fault causes

In many machinery and equipment, CAN is the backbone of communication technology. Despite this, bus systems are often not given the attention they deserve in preventive maintenance.

At the same time topics as Industry 4.0 and the Internet of Things (IoT) are bringing to the fore topics which result in an increasing degree of cross-linking. To avoid the risk of failure, you need to act now. If we take Industry 4.0 to the next logical step, the whole production will be order-related for the customer. Problems will disrupt not just the impacted machine, but the entire chain. Important intermediate storage facilities, which can supply products in the period of interruption are no longer foreseen. The increasing degree of cross-linking is also increasing power density and therefore susceptibility – for example by electromagnetic influences. This emphasizes the importance of a stable field bus communication.

The umbrella term used is Electromagnetic Compatibility (EMC). EMC considers whether electrical devices and networks themselves disturb other components (interference source) or are disturbed by other components (interference sink). The goal is therefore to construct all electrical equipment so that it doesn’t disturb others and cannot itself be disturbed.

Types of disturbance

The electromagnetic influence between the interference source and interference sink is known as coupling. A distinction is made between:

- Direct coupling - Conductive connection between two circuits, usually by means of shared supply or ground line
- Capacitive (electrostatic) coupling - Mutual influence by the electrical field, for example, by conductors located close to each other with a high potential difference
- Inductive (magnetic) coupling - The alternating field generated by a conductor’s current flow induces a disturbance voltage in other circuits
- External disturbance source - For example, lightning strike, should be noted in particular if the cables in extensive installations are routed outdoors

Disturbed serial bus systems

While initially a telegram bit fails occasionally, as the situation worsens, regular destruction of complete telegrams may occur. The bus communication failure is often caused by damage on the bus installation along with electromagnetic effects. These have a major influence on the data traffic and during operation result in gradual curtailments, culminating in a plant standstill. “When we are called to equipment stoppages, in over half of all cases, we find EMC problems,” tells Hans-Ludwig Göhringer from IVG Göhringer. For many years, the company has maintained serial bus systems, such as CAN, and is now a recognized expert in this field. IVG Göhringer is often called in to troubleshoot equipment stoppages and shares the experiences it has gained in various training courses.

Finding causes

When trying to find the reason what has caused faults, it should be distinguished between design shortcomings and bus installation ageing. However, compared with the situation ten years ago, we are currently seeing much more emphasis being placed on equipment design which takes EMC into consideration.

Design deficiencies include:

- Inferior quality plug connectors rather than industrial quality
- Shielding only being fitted on one side
- Pigtails shielding rather than connections covering the entire surface
- No potential compensation or potential compensation of an inadequate size
- Power and data cables not kept separate
- Neutral earthing rather than meshing

Figure 1: Errors in CAN communication are indicated by the integrated status LEDs and a potential-free alarm contact (Photo: IVG Göhringer)
"When looking for the components responsible for faults, we first consider switching contactors and inverters with high outputs and correspondingly high currents," said Hans-Ludwig Göhringer, adding: "But there are many other components which are needed for functional processes and may also be the cause of the problem." These include:

- frequency converters
- motors and brakes
- photovoltaic systems
- coils
- fluorescent lamps
- heaters
- switching power supplies, converters
- switches, contactors
- wireless sections
- magnetic alternating fields
- static discharges, arcs

The requirements of electric automation are also on the rise. Faster speeds in the equipment require shorter switching times and greater control accuracy when positioning. "We are seeing more and more switching sequences and steeper flanks, meaning that high-frequency faults are increasing too," explains Hans-Ludwig Göhringer.

**Shielding is important**

The most important way of protecting machinery and equipment from electromagnetic faults is proper shielded cables and connections. This includes a shield connection covering the entire surface and earthing at both ends. Every now and then we see shielding and shielded cables that are only soldered on at one point. So the shielding is ineffective, especially at high frequencies. The shielding is only fit for purpose if it is continuous, closed from one end to the other and is also connected to the functional earth with good conductivity. The use of metallic cable bushings prevents high-frequency faults from penetrating controllers and switch cabinets. "Sometimes the shielding is only used on one side as it is argued that no current can flow on the shielding," reports Hans-Ludwig Göhringer, adding: "But that is nonsense. A high shield current implies there is no potential equalization – that is where you have to start." Which brings us to the next issue.

EN 50310 sets out the minimum requirements for earthing and potential equalization for buildings with IT facilities, including electric control technology, bus systems and networks. We would always recommend changing from neutral earthing to a meshed earthing system.
This standard may have been produced in the context of Ethernet cabling, but it is useful for all other bus systems too. “The main idea behind the meshed structure is that the current finds the right route,” explains Hans-Ludwig Göhringer, adding: “In principle, this route is the right one. But there is no single solution that is suitable for all equipment. Even with textbook meshed earthing, instances may arise where the current gets somewhere you didn’t want it.” Furthermore, the corresponding cable cross-sections aren’t defined in EN 50310. A structured approach, incorporating experience from the field, is therefore proposed. Starting with neutral earthing, only specific earth cables should be used until the weak spots are localized and rectified. It is useful to produce a lay-out diagram for the equipment showing earth, power, and data cables. At the same time, the measurement procedures should be defined and documented to ensure comparable quality for equipment modifications and extensions.

Ageing and wear

“Moisture, temperature fluctuations, coolant, solvent vapours, vibrations and alternating flexural loads continually affect the field bus installation over its entire life,” explains Hans-Ludwig Göhringer. From the time of commissioning at the latest, these various influences leave their mark in the shape of wear on the bus installation. Without maintenance measures, sooner or later the signal-to-noise ratio is used up and the equipment stops.

Examples of ageing:
- Oxidation of contact surfaces
- Contacts being contaminated by dust, oil, adhesive and metal dust
- Cable failure in the cable track
- Cold soldering points caused by mechanical loading and strains associated with alternating temperatures
- Drying out of electrolytic capacitors
- Short circuit caused by mechanical friction
- Loading of bus cable by chemicals and solvents
- Formation of whiskers on printed circuit boards
- Embrittlement of plastics due to UV radiation

The wear cannot be measured or predicted. Continual condition monitoring has proved a suitable strategy. Fieldbus systems like CAN are reliable systems with error tolerance thanks to their functional principle. Special mechanisms, such as automatically repeating telegrams, compensate for errors to a certain extent without the user even noticing. The CAN quick tester C-QT 15 from IVG Göhringer makes use of this system. The diagnosis module is attached at any point on the CAN network, where it works completely reactionless. It does not measure physical parameters such as voltage level or signal times; instead it records errors at protocol level. More specifically, the modules detect a deterioration in bus communication by detecting missing telegrams, repeat telegrams and missing communication partners. These errors are indicated by LED and using a potential-free alarm contact. The potential-free alarm contact of the C-QT 15 can trigger a warning light or siren to indicate an error. The alarm contact can also be analyzed by the superordinate controller or main computer.

Conclusion

Although maintenance staff have increasingly focused on EMC in recent years, maintenance is often only deployed in the event of unexpected stoppages. However, the aim of efficient maintenance must be to maintain the performance of the bus systems and avoid unforeseeable faults. The CAN quick tester C-QT 15 of IVG Göhringer offers a simple solution. The compact diagnosis modules provide the user with continual monitoring. When the first telegram fails to appear, the maintenance staff can respond and scan the equipment for the error patterns described here.

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