Diagnosing faulty fieldbuses – EMC problems often the cause

Ever increasing automation brings large economic advantages, but things are not all roses - it leads to a growing power density and, therefore, the risk of interference, which can cause a range of industrial networking problems to occur. The need for proper electromagnetic compatibility (EMC) is therefore becoming increasingly important. Nora Crocoll and Dietrich Homburg from Indu-Sol show how the issue is often galvanic in origin, and report on the various ways in which this significant issue can be tackled.

PLANT CONSTRUCTORS and maintenance technicians usually proceed on the assumption that most interference faults are field-bound and non-galvanic. The separation of motor and bus cables, crossings at 90 degree angles, additional shield connections when cables enter switchgear and control cabinets, plus large-surface connections are common counter measures used by experienced electrical installers. This is, therefore, a clear indication of the presumed non-galvanic nature of the troublemaker.

However, if the device and cable shielding works only in part, it provides almost no measurable benefit. So says René Heidl, Manager of Engineering & Development at Indu-Sol GmbH. After many years of trouble-shooting, his view is that most EMC faults are – after all - galvanic in origin.

Modern, properly designed field devices act as Faraday cages that can not be disturbed by external influences, and usually do not interfere with themselves or other devices. More critical are 'long lines' between devices that break through the end shield leading into and out of each device. This is the case with bus lines, for example.

Note that a 'long line' occurs when the line length exceeds the duration of a signal edge. The term is, therefore, used in a relative way and means in practical terms of busses that a 'long line' is one longer than one or two meters. Such lines can 'catch faults' and take them under the shield. An example is 24V supply voltage lines or analogue and digital transducer lines.

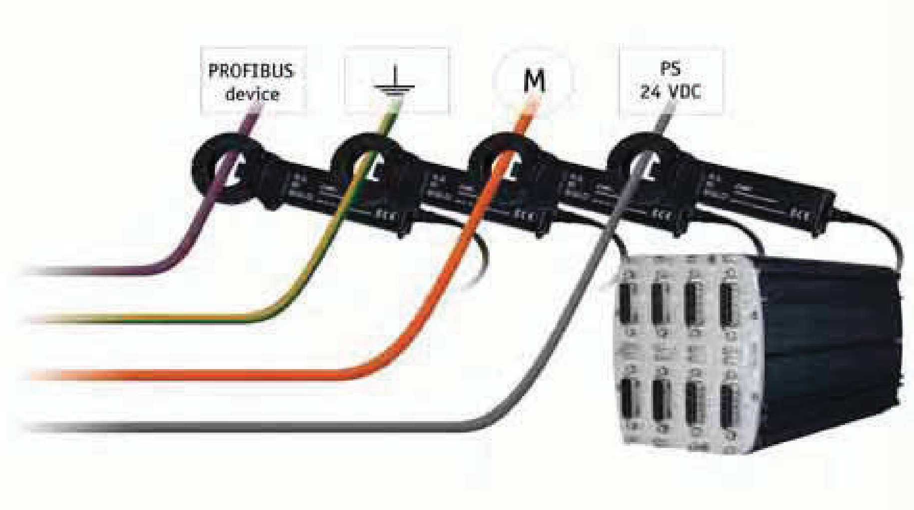

Fig. 1: Indu-Sol's EMC INspektor. Current clamps are used to measure uninterruptedly multiple potential interference sections. Using the error telegram information, it is then possible to determine partly automated relationships that help to detect interferers and coupling sections.

Compensating currents

Before an interference source can interfere with a device, the interference must be transmitted via a coupling section to the potentially susceptible device (i.e. the device interfered with). Such transmission can be either by a galvanic or non-galvanic coupling section, such as capacitive, inductive or radiation coupling. Galvanic coupling of interference currents occurs at joint impedances of the interference source's circuit and that of the potentially susceptible device. A typical example is provided by compensating currents that couple voltages via the joint line sections of both circuits.

The following is a real-life example: The negative line of bus modules' 24V DC power supply was earthed (grounded) not only at the power supply unit (PSU), but also at a system bus module. Such installation mistakes are common. A 230V AC isolating transformer for a motor fan had the same earthing. After five years of operation, a phase-to-frame short circuit occurred. This sporadic short circuit was not big enough to trigger the fuse, but via the system frame, it returned to the transformer in the switchgear cabinet because this was the location of the 23V AC-N earth.

Such types of earth fault current usually take all routes available back to the switchgear cabinet, and so also via the 24V DC negative pole with double earthing. In this way, the current 'crept' through several bus modules and caused major damage to the buses. As a result, Profibus failures occurred sporadically. In this example, the earthing of the 230V AC supply N-conductor and the earthing of the negative pole of the 24V DC power supply unit were the joint impedance.

Such galvanic interferences have one advantage from the installer's perspective - it is relatively easy to measure them. What can be more difficult is to find the right location for measuring. Where non-galvanic interferences are concerned, however, electrical and magnetic fields are encountered that cannot be measured so easily, which can be a significant difficulty.

Site EMC measurements

Bus maintenance experts should be consulted when problems occur in production lines or machinery. Because many system stoppages occur because of sporadic communication errors that are difficult to reproduce later, or cannot be reproduced at all, such network specialists rely on long-term monitoring. With the help of modern instruments developed over the past few years, networks can be monitored permanently and non-reactively for error telegrams.

It is also possible to detect permanent deteriorations in communication, and causes of failure can be more easily traced retroactively by storing error telegrams with exact time(s) of occurrence.

"Many EMC problems occur sporadically", says Heidl. "If you want to find out which interferer impairs the bus communication, you need permanent monitoring."

To this end, the company has developed a suitable measuring device - the EMC Inspektor (**Figs. 1** and **1a**). With relatively little instal-

-lation effort, bus maintenance experts can measure the EMC load uninterruptedly at four locations at the same time over a long period of time. Using the error telegram information, it is then possible to determine partly automated relationships that help to detect interferers and coupling sections.

Surprising insights

"Over the last few years, we carried out many measurements in different branches of the industry", says Heidl. "At first, we were looking at the wrong place. We mainly expected non-galvanic interferers and could not make a real strike then. But with the help of our measuring devices we were able to obtain reasonable measuring results, and so prove that - in many cases - galvanic EMC interference was the cause of the problems.

"After all the measurements that we've carried out in the past few years, I've come to the conclusion that this is true for over 80% of cases."

"Once you understood that most of the trouble is of galvanic nature, it seems natural. An interference current destroying one bit of a telegram need not be very high. To destroy an entire telegram, however, very high currents are needed. To couple interference currents of this magnitude non-galvanically is rather unrealistic from an engineering point of view.

One issue often encountered was the reverse current path between frequency converter and motor, for example (Fig. 2). The following should provide a clearer understanding of this: The inductive current, and part of the capacitive current, coupled in the protective conductor and the shield of the motor cable, take a route between the frequency converter and the motor via the equipotential bonding system. These high-frequency currents in the kilohertz range (which can be up to one tenth of the motor phase current under unfavourable conditions), have an adverse effect on the signal reference potential of electronic components, and lead to excessive currents on shielded lines.

Heidl gives an example from experience: "The upward trend in automation increases drive speed and control accuracy requirements. Operating sequences today are twenty times higher than they were 10 years ago. It means that the pulses become shorter and shorter, while frequencies increase."

Stray capacitances in the supply line from a phase to the protective conductor, for example, have therefore become much more important in terms of high-frequency leakage current occurrence. It is not uncommon that shield bonds of bus lines, or even measuring lines laid in parallel to the protective conductor or ground connector, are subject to such high-frequency compensating currents. This can cause faults in the connected periphery.

Such interferences can be easily reduced by

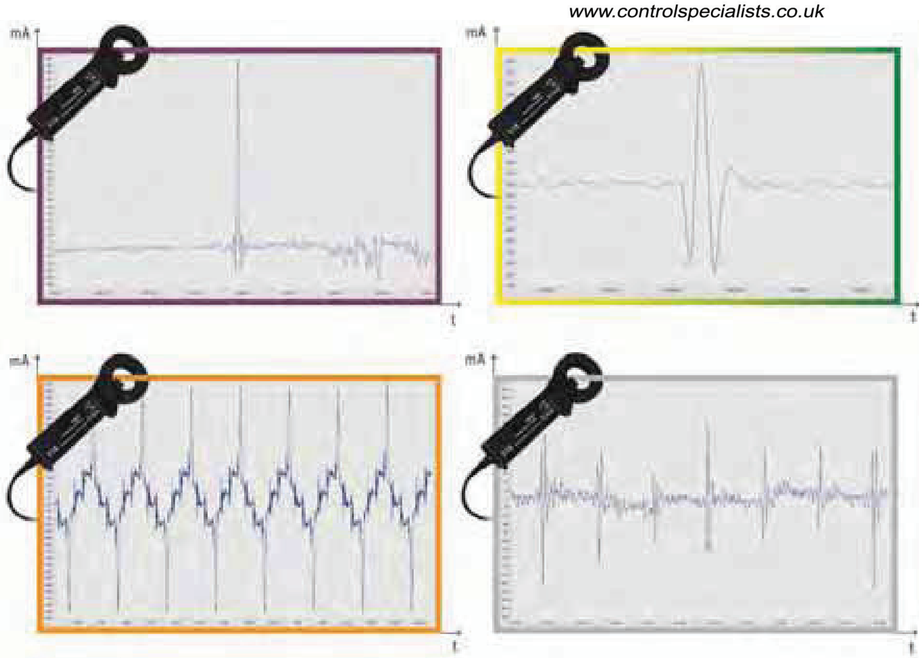

*Fig. 1a: **The EMC INspektor in action.** Showing measurement of Profibus shield current, in the PE/PA system, of shield current/PE current FC-controlled motors, and of EMC coupling to a 24 VDC supply.*

about 60% if existing unsymmetrical motor cables are replaced by symmetrical ones. Indeed, it definitely makes sense to consider this issue early when machines and systems are being designed and built.

Reproducible results

Making EMC measurements in a production line needed a great deal of expert knowledge in the past. Usually, it was not possible without an external expert's help. What exactly such a person did was difficult to understand for typical plant engineers, installers and operators.

Explains Heid: "There is no question that such experts have gained a wealth of experience and know-how over a great many years and they have, therefore, a very good idea of the causes of EMC problems, but how those same experts achieved the results they did was

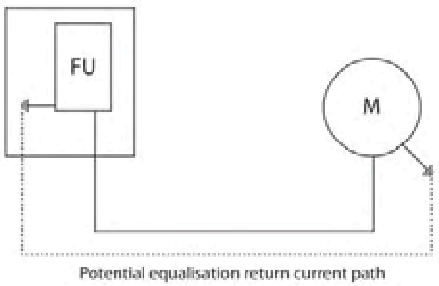

*Fig. 2: **A reverse current path.** The inductive current, and part of the capacitive current, are injected into the protective conductor and shield of the motor cable route.*

usually not understood by the involved electrical installers. That is why the search can easily become rather expensive", he said.

Modern measuring devices can now deliver problem detection in preliminary stages that helps in the long run. Long-term measurements provide lay people with the data they need so that an expert can make a rapid remote diagnosis.

Heidl provides an example: "An issue repeatedly emerging besides the reverse current path is the 24V DC power supply. A customer experienced a communication bus error every time a drive connected the brake. Permanent network monitoring and EMC measurement enabled us to find a connection - the bus modules and the drive's brake were connected to the same power supply. As soon as the brake was connected, an interference injection into the bus occurred. Again, it was a galvanic source of interference. The solution was simple - brake and bus modules received separate power supplies."

Monitoring is essential

EN 50310 is concerned with equipotential bonding and earthing in buildings containing IT equipment. It requires that equipotential bonding be of low impedance. In practice, however, equipotential bonding is mainly designed under ohmic aspects.

Communication problems will certainly occur from time to time. For example, the communication bus shield is a very good low-impedance conductor. If the equipotential bonding system is not low-impedance, compensating currents take their route via the bus shield. Another cause of trouble is the multiply-earthed 24VDC supply. Modern measuring devices monitor networks for ground faults, detect such problems and help avoid them from the outset.

Concludes Heidl: "Experts should pass their know-how on as services and training courses."

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