Electromagnetic Interference (EMI) Prevention

From: White, Don. *Electromagnetic Compatibility: What is it? Why is it needed?* Instrumentation & Control Systems EMI/EMC Course.

Principal coupling paths:

1. *Transmitter-to-transmitter EMI* via antenna coupling of both source and victim equipment in which the source transmitter falls in the passband, adjacent channel, harmonics of the transmitter and/or spurious responses in the receiver.

2. *Common-impedance coupling*, in which two or more units or systems are connected to the same safety wire, ground grid or plane at more than one place (multipoint grounding.)

3. *Common-mode and ground-loop coupling*, in which radiated fields couple into ground loops that convert interference to undesired common-mode currents, and to differential-mode currents (the failure mechanism.)

4. *Differential-mode coupling*, in which radiated fields penetrate signal and control cables to develop interfering voltages at the victim.

5. *Power-line coupling*, in which either radiated EMI picked up by power lines or transients directly generated on the power lines couple to the victim's power cable and from there to victim circuits.

Most frequent EMI violations in industrial control systems:

1. **Ground loops and other ground problems:**

No matter what you might think, you do have many ground loops – some of which may include cable shields. Here are a few examples:

- Both commercial power and UPS safety grounds entering the cabinet
- Cabinet grounded to building ground grid and/or steel and indirectly grounded to other ground points
- Internal dedicated analog reference (returns) grounded via long external runs to building ground
- Analog and logic returns connected together (often indirectly) and grounded to the cabinet
- Uncovered cable trays multipoint grounded to building steel

The solution is to open all or most ground loops. If ground loops persist or cannot be opened, place hefty snap-on ferrites on all ground leads/cables at cabinet entry points. In addition, avoid long ground cable runs; their high inductance at RF makes them worthless as EMI grounds, and they act as carriers of interference currents.

2. **Incorrectly terminated cable shields**

Sensor, control device, and digital cable shields (i.e., shielded twisted pairs) are rarely terminated at the cabinet entry. Instead, they are terminated inside on a terminal strip via pigtails and jumpered to the cabinet frame. This allows radiation from cable shields to take place inside the cabinet, which compromises its shielding effectiveness.

Electromagnetic compatibility (EMC) solutions include terminated cable shields via connectors at the cabinet wall, a shielded terminal strip plate a the entry, or installing snap-on ferrites on every cable shield or group of shields at the cabinet entry.

3. **Unfiltered power mains**

Often, raw, polluted AC power entering the cabinet meanders to the location of the DC power supply before filtering – if filtering is, indeed, even done. This allows radiation to take place inside the cabinet from the outside power and safety leads, and this significantly reduces the cabinet's shielding effectiveness.

Because there are multiple DC power supplies inside the DCS cabinet, all raw AC power should be surge suppressed and EMI filtered, and/or a shielded isolation transformer should be used upon entry to the cabinet. Once contaminated power enters the cabinet, it is too late for subsequent AC regulators to remove the potential damage. Even ferroresonant and other regulators can be parasitically bypassed by crosstalk at high frequencies, especially if the AC input and DC output are on the same terminal strip.

If filtering can't be done upon entry, at least install snap-on ferrites at all power and safety leads entering the cabinet.

4. **Cable tray crosstalk**

If analog sensor and control device cables must share the same cable tray, at least position the sensor cables on one side of the tray and the controlled device cables on the other side. Use tray separators. Since most cable trays, unfortunately, are open at the top, ferrites can be added every 10 or 20 feet. Check their effectiveness with clamp-on RF current probes and a spectrum analyzer or wide-band oscilloscope.