The Other 5 Wires in the SPE In-Cabinet Solution

Changing the way Industrial Control Panels are designed, built and commissioned

Yutao (Tony) Wang  Rockwell Automation, Inc.
Kelly Passineau  Rockwell Automation, Inc.
Chirag Malkan  Rockwell Automation, Inc.
Conventional Industrial Panel “Before”

- Manual wiring takes longer
- High potential for mis-wire or lose connections
- Manual wire connection test takes longer
- Densely packed panel reduces thermal dissipation reducing panel life or requires bigger panel
Industrial SPE In-Cabinet Panel

- **10% or more** reduction in panel space
- **80%** reduction in wiring and time required to wire
- **50%** reduction in testing time
- **30%** reduction in project eng. time
- Optimized for thermal disposition for long panel life
- Helps reduce time & effort to diagnose a problem
- Due to reduced downtime by increasing visibility of panel diagnostics & overall health
- With highly secure smart infrastructure
Total Cost of Ownership – Lowered with ODVA SPE Industrial In-Cabinet Media

- Control Wire Elimination
- Panel Simplification
- Reduced Engineering Costs
System Overview

- NP Power 4Amp continuous for 40 nodes
- SP Power 4Amp continuous, 8Amp up to 100ms for driving large load, contactor coil, etc.
- 25-meter total cable length
- Multi-drop 10Base-T1S based on IEEE 802.3cg standard
10BASE-T1S from IEEE 802.3cg

- Half-duplex multidrop (8 nodes, 25m)
- Half-duplex or full-duplex point-to-point
- 10 Mb/s, 1Vpp
- Multidrop allows larger PHY count provided the mixing segment specifications in 147.8 are met

IEEE 802.3cg-2019
IEEE Standard for Ethernet - Amendment 5:
SPE In-Cabinet Cable

- 7 Conductors
- 20AWG wires (19 strands) for NP-, NP+, SP+, SP-
- 24AWG wires (7 strands) for SPE+, SPE-, Select line
- 4A current for NP-, NP+, SP+, SP- lines
- SPE conductors will be used as keying feature to prevent wrong connector orientation.
SPE Industrial In-Cabinet Connector

- Inline inductors to compensate for node capacitance.
- Ease of use for field termination with a standard plier.
- SPE and Select line were severed.
NP Power for Communication Electronics

**Key Benefits**

- 100mA is allowed for end node device, one power tap has enough current for all 40 nodes.
- Allows all end node devices to tap on the same power bus.
- End node devices circuit simplified and require no further protection for shock or fire hazards.
SP Power for Coil Control

- No additional control power wires for coil control
- Current boost capabilities allow more loads to be turned on at the same time.
- Additional switch power can be made available by supplemental power tap.
- Same 24V DC supply can be used for multiple power taps
- Bank of loads can be powered by the same power tap, allows zone control.
- Planning and installation tool can help users identify how much switch power is needed based on the number of loads.

### Key Benefits

<table>
<thead>
<tr>
<th>Switched Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP Output Voltage</td>
</tr>
<tr>
<td>SP Output Current</td>
</tr>
<tr>
<td>SP Output Power</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The CIP Networks Library Volume 2: EtherNet/IP Adaptation of CIP
- SPE in-cabinet solution with 40 nodes
- Switch power from first power tap/gateway 0 for Zone 1
- Switch power from supplemental power tap node 14 for Zone 2
- Switch power from supplemental power tap node 3 for Zone 3
Select Line

- A single conductor that runs through In-Cabinet media to facilitate sequential command delivery.
- “Select” line is severed by media connector resulting in “Select A” and “Select B” lines
- On initial power up, the “Select A” and “Select B” pins on all nodes are configured to be input pins
- After a first message is detected on one of the Select pins, the other Select pin is configured to be an output pin
- System wide sequential commands delivered for actual topology discovery, system commissioning and device replacement operations.
Select Line Enables Discovery of Actual Topology

- A “Nodal Topology” is a complete ordered set for all devices on a network.

- In-Cabinet Actual Topology Object works together with the Select Line Link Object and the LLDP Data Table Object to capture the nodal topology for an SPE In-Cabinet network segment.

- Node implements the In-Cabinet Actual Topology Object must be the first (leftmost or rightmost) node on the network segment.
Select Line Enables Agnostic Cable Routing Direction

- Select line is bi-directional, cable can be routed from left to right or right to the left.

- Panel builder can minimize cable length, make cable routing neat and clean.

- It makes it easy to track down devices by following the flat cable.

- Panel builders can change panel component layout, re-route the cable and don’t have to update ladder logic program.
Select Line Enables SPE In-Cabinet Commissioning

- In-Cabinet Commissioning Object works with the Select Line Link Object and the In-Cabinet Actual Topology Object to facilitate node commissioning (configuration of T1S PHY settings, and TCP/IP Interface Object) for SPE In-Cabinet network.

- Node containing the In-Cabinet Commissioning Object must be the first (leftmost or rightmost) node on the SPE network.

Various addressing scheme (last octet of IP address) can be implemented:
- Sequential full: addresses are sequential based on topology location of the devices on the cable.
- Sequential light: addresses are sequential based on "next available node address" for each newly added device.
- Traditional node commissioning: pump is always set at 20.
Select Line Enables Auto Device Replacement

- Turn off the 24V DC control power to the system. Remove the cable connection from the SPE end nodes.
- Install the replacement devices from new out-of-the-box. Re-apply 24Vdc control power.
- Gateway (CIP Router) will detect the new end node devices and will initiate Discover Topology Service to determine the actual topology.
- When the reference topology and new actual topology match, the Gateway configures the end node with the same IP address.
- Controller sends the configuration parameters to the new devices.
- All IO connections will get re-established.
Cable Conformance

Table 8-10.5 Cable C1 Specifications and Requirements

<table>
<thead>
<tr>
<th>Minimum Specifications and Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical</strong></td>
</tr>
<tr>
<td>Conductors: SPE+, SPE-, SEL, 24 AWG, 7/32 stranded tin-coated copper (0.23 mm² (strand 0.203 mm DIA / bundle 0.61 mm DIA)).</td>
</tr>
<tr>
<td>Lay length of outer layer is from 12 min. to 16 max. times outer diameter.</td>
</tr>
<tr>
<td>NP-, NP-, SP-, SP+: 20 AWG, 19/32 stranded tin-coated copper (0.61 mm² (strand 0.203 mm DIA / bundle 0.25 mm DIA)).</td>
</tr>
<tr>
<td>Lay length of all layers is from 12 min. to 16 max. times outer diameter.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impedance (Ω)</th>
<th>Reference impedance of 100 Ω for SPE pair</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Insertion Loss (IL) (dB)</th>
<th>Measured per section 8-10.4.4, for SPE pair, at 25 m length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 * (2.75 * sqrt(f)) = 0.026 * f = 0.375 / sqrt(f)</td>
<td>0.3 ≤ f ≤ 40 where f is the frequency in MHz.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return Loss (RL) (dB)</th>
<th>Measured per section 8-10.4.4, for SPE pair, at 25 m length</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 = 5 * log₁₀(f)10, 24 max.</td>
<td>0.3 ≤ f ≤ 40 where f is the frequency in MHz.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode Conversion, MC (dB)</th>
<th>Measured per section 8-10.4.4, for SPE pair, at 25 m length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCL and TCRL: 46 = 10 * log₁₀(f), 40 max.</td>
<td>0.3 ≤ f ≤ 100 where f is the frequency in MHz.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current</th>
<th>NP+, NP-, SP+, SP+: 4A minimum at ±75 °C ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPE+, SPE+: 12 mA minimum at ±75 °C ambient</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DCR</th>
<th>Measured for each conductor, at 25 m length, at ±20 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP and SP: 0.935 Ω max.</td>
<td></td>
</tr>
<tr>
<td>SPE and SEL: 2.355 Ω max.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DCR Unbalance</th>
<th>Measured per ASTM D4566</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP and SP: 3%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dielectric Strength</th>
<th>2000 V AC</th>
</tr>
</thead>
</table>

(Data from Actual Cable Sample Measurement)

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(Ref. UL 1581)

(UL 258, Table 29.1, 600 V AC)
EMC-Conducted Immunity

Setup

- SPE in-cabinet proto cable and connectors.
- SPE Node 0 is the master node.
- SPE Node 1 is the DUT.
- Conducted immunity test per IEC/EN 61000-4-6
- 10V is the Test level required by products.

Acceptance criteria

- Criteria A, Equipment should operate normally during and after EMC testing.

Configurations:

1. 10V with AM on;
   Master node 0: transmitting node
   DUT Node 1: receiving node  Passed BER no loss of packet.

2. 10V with AM on;
   Master node 0: receiving node
   DUT Node 1: transmitting node  Passed BER no loss of packet.

Conclusion: SPE in-cabinet solution showed good performance during conducted immunity testing.
EMC-Fast Transient

Setup
- 25meter SPE-In Cabinet cable and connector protos.
- SPE in-cabinet Node 0 is the transmitting node.
- SPE in-cabinet Node 1 is the DUT and the receiving node.
- Conducted test per IEC/EN 61000-4-4

Acceptance criteria
- Criteria B, temporary degradation or loss of performance which is self-recoverable. **PASS**

<table>
<thead>
<tr>
<th>EFT Test Levels</th>
<th>Frames sent by Node 0</th>
<th>Frames received by Node 1</th>
<th>Frames Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>+500V</td>
<td>65000</td>
<td>64987</td>
<td>13</td>
</tr>
<tr>
<td>-500V</td>
<td>65000</td>
<td>64988</td>
<td>12</td>
</tr>
<tr>
<td>+100V</td>
<td>65000</td>
<td>64989</td>
<td>11</td>
</tr>
<tr>
<td>-100V</td>
<td>65000</td>
<td>64985</td>
<td>15</td>
</tr>
<tr>
<td>+200V</td>
<td>65000</td>
<td>64994</td>
<td>6</td>
</tr>
<tr>
<td>-200V</td>
<td>65000</td>
<td>64988</td>
<td>12</td>
</tr>
<tr>
<td>+300V</td>
<td>65000</td>
<td>64998</td>
<td>2</td>
</tr>
<tr>
<td>-300V</td>
<td>65000</td>
<td>64991</td>
<td>9</td>
</tr>
<tr>
<td>+400V</td>
<td>65000</td>
<td>Node 1 LED flashes, unit self recovered back</td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: SPE in-cabinet solution showed good performance during preliminary EFT testing.
SPE In-Cabinet Solution Demo