The Other 5 Wires in the SPE In-Cabinet Solution

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

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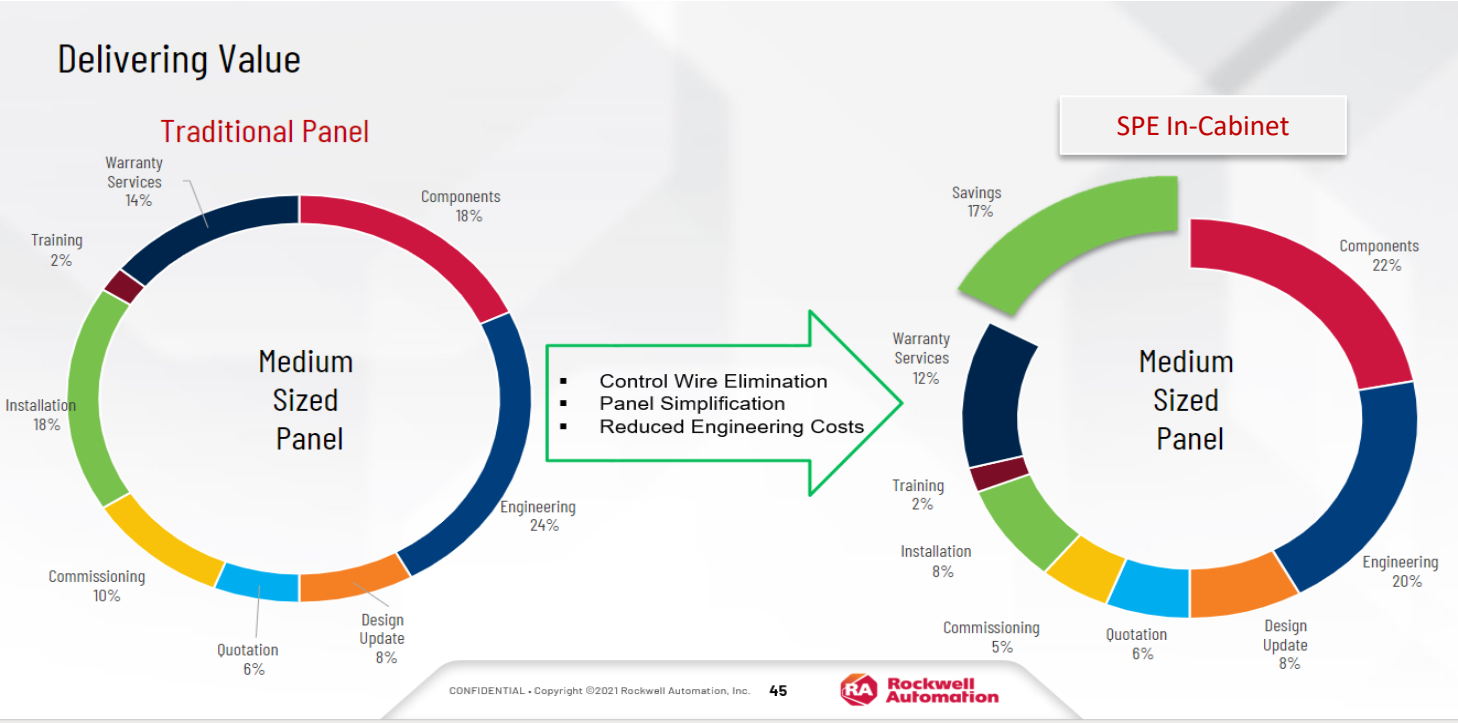
Conventional Industrial Panel “Before”

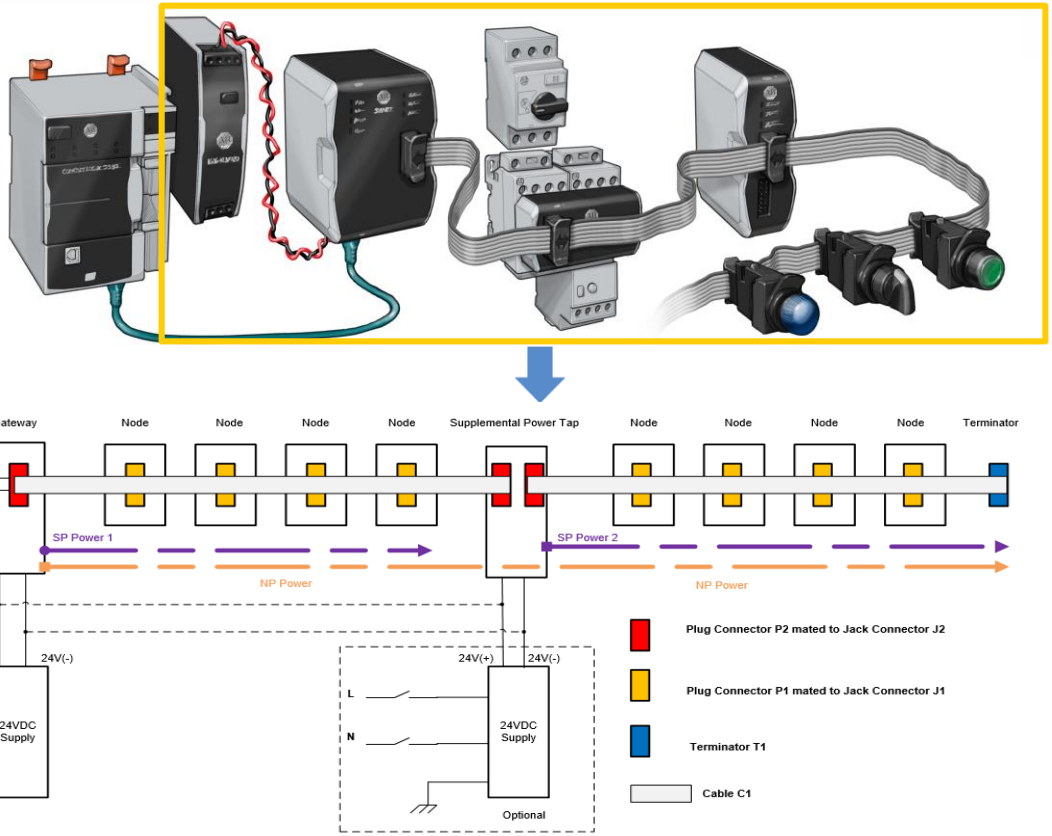
- Manual wiring takes longer
- High potential for mis-wire or lose connections
- Manual wire connection test takes longer
- Densely packed panel reduces thermal dissipation reducing panel life or requires bigger panel

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 infrastruture

Total Cost of Ownership – Lowered with ODVA SPE Industrial In-Cabinet Media





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

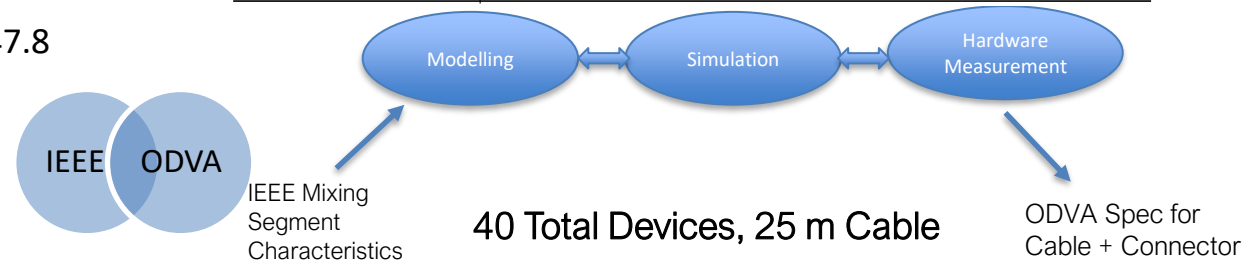
ODVA Spec

Table 8-10.4 IEEE PHY Options and Settings

IEEE PHY Option and Setting	Description	IEEE Reference	ODVA Support
*MULT	Multidrop mode	Clause 147.8	Required
*INS-MIX	Installation / Mixing segment	Clause 147.8	Required
aPLCATransmitOpportunityTimer	This value is assigned to define the time between PLCA transmit opportunities for the node.	Clause 30.16	Required Value = 32

Table 8-10.5 Cable C1 Specifications and Requirements

Minimum Specifications and Requirements	
Electrical	
Insertion Loss, IL (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length 0.25 * (2.73 * sqrt(f) + 0.026 * f + 0.375 / sqrt(f)) $0.3 \le f \le 40$ where f is the frequency in MHz
Return Loss, RL (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length 24 + 5 * $\log_{10}$(f/10), 24 max. $0.3 \le f \le 40$ where f is the frequency in MHz
Mode Conversion, MC (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length TCL and TCTL: 46 – 10 * $\log_{10}$(f), 40 max. $0.3 \le f \le 100$ where f is the frequency in MHz

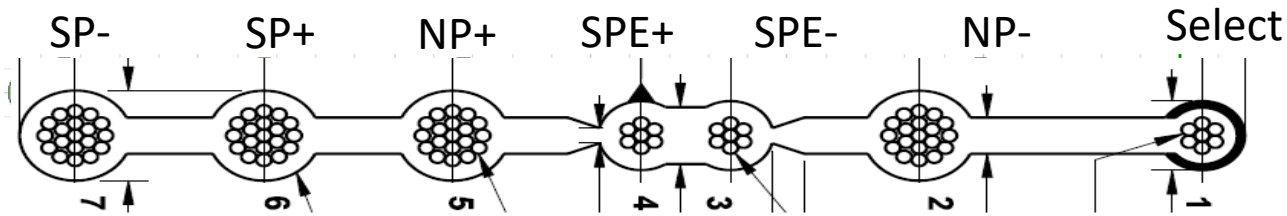


IEEE 802.3cg-2019
IEEE Standard for Ethernet - Amendment 5:

The CIP Networks Library Volume 2: EtherNet/IP Adaptation of CIP

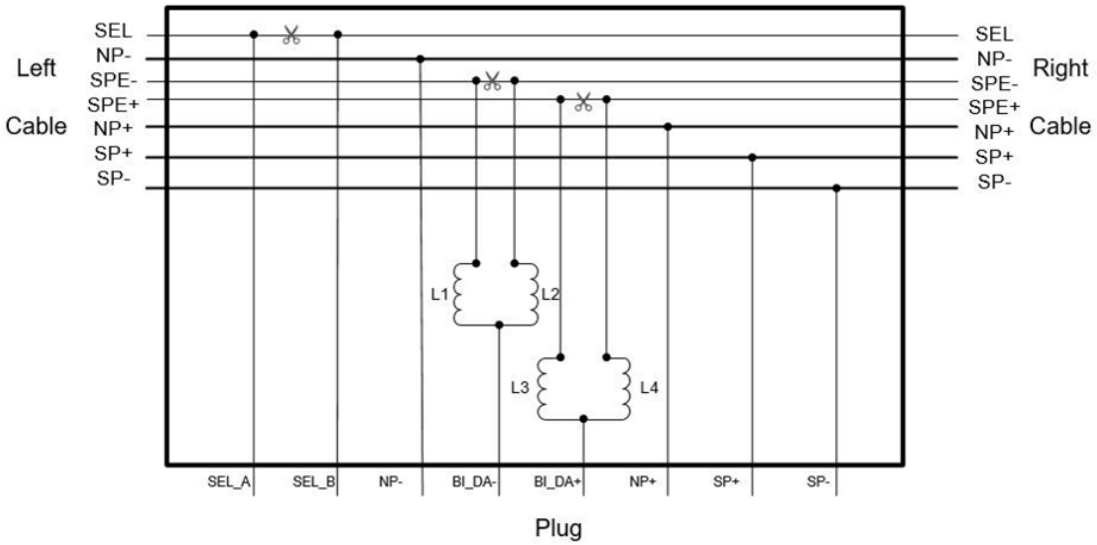
SPE In-Cabinet Cable

- 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

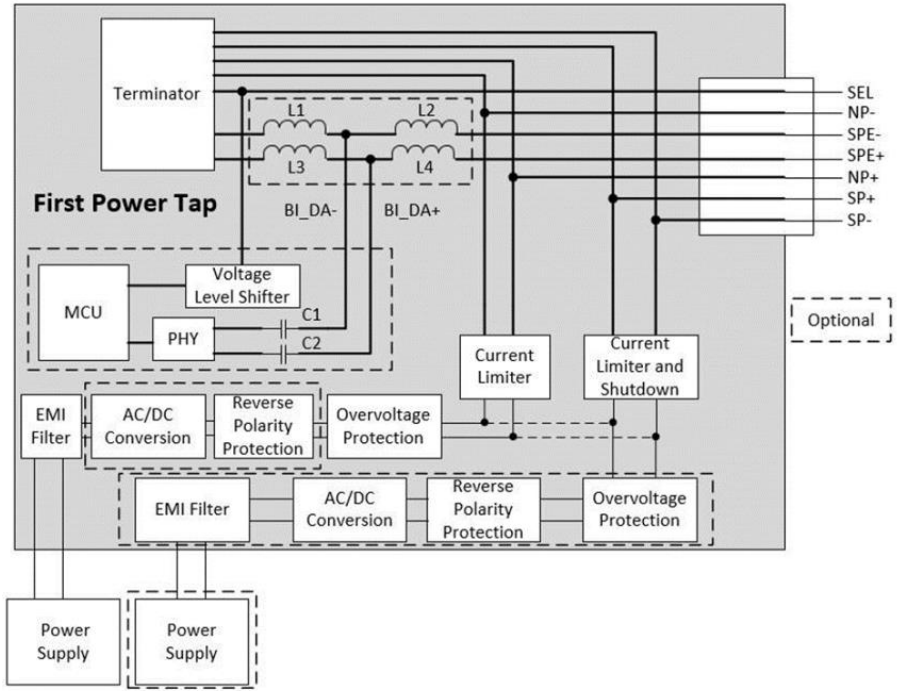
Figure 8-10.3 Plug Connector P1 Circuit



- 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

Figure 8-10_22 First Power Tap Block Diagram



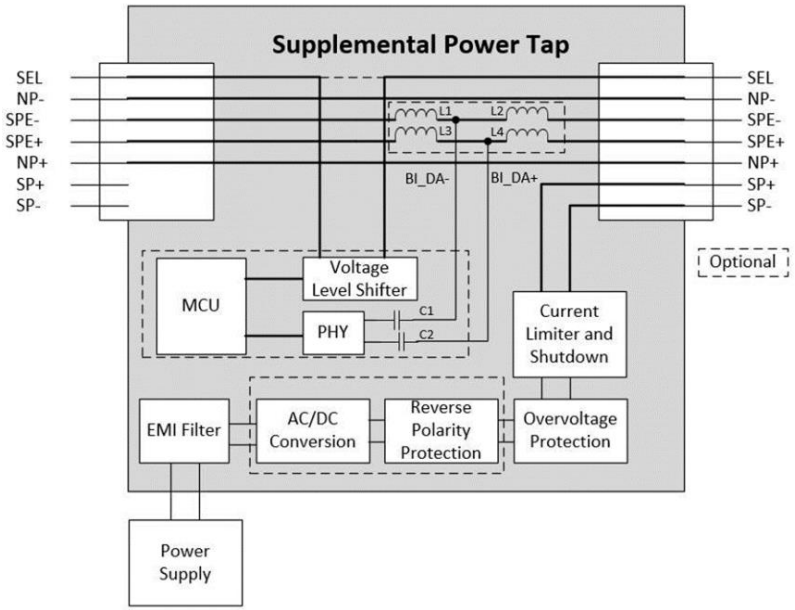
Network Power	
NP Output Voltage	21.1 Vdc min., 26.4 Vdc max.
NP Output Current	4 A max.
NP Output Power	100 VA_{max}, NEC Class 2

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

Figure 8-10.24 Supplemental Power Tap Block Diagram



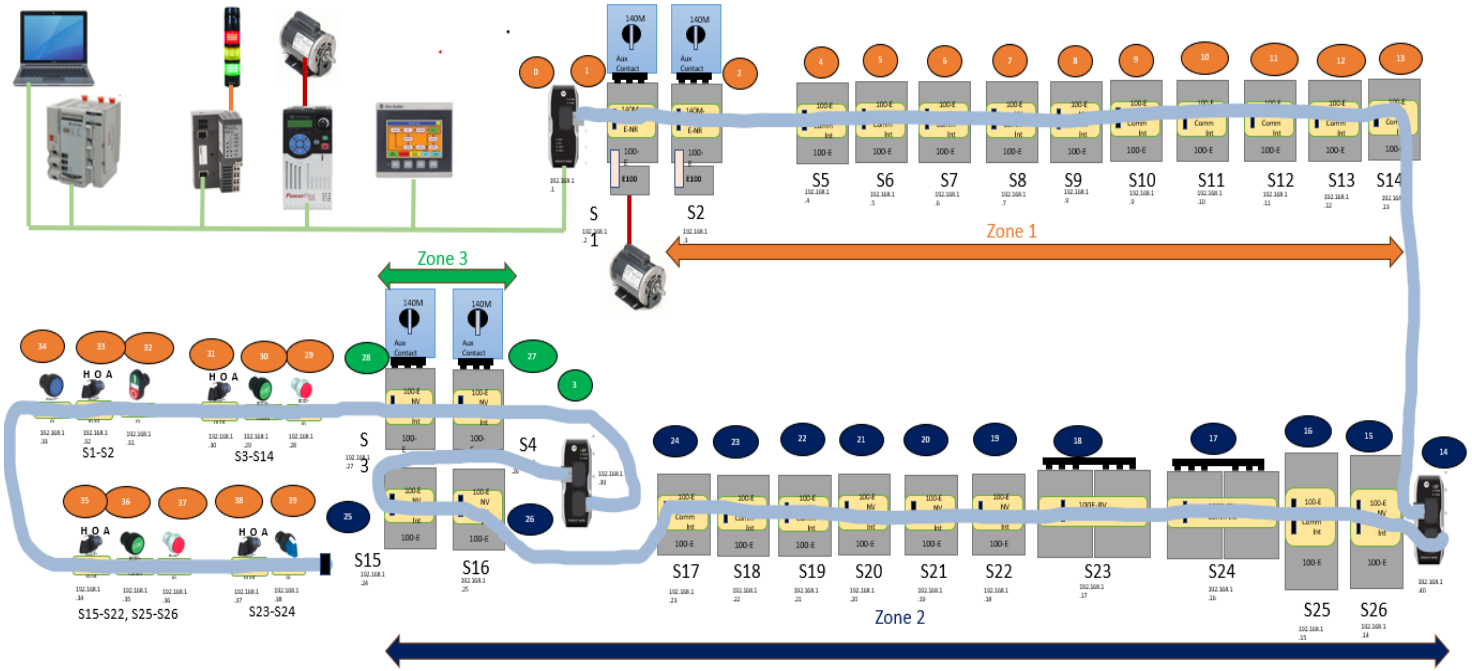
The CIP Networks Library Volume 2: EtherNet/IP Adaptation of CIP

Switched Power	
SP Output Voltage	21.1 Vdc min., 26.4 Vdc max.
SP Output Current	4 A max. continuous 8 A max. for up to 100 ms
SP Output Power	100 VA, NEC Class 2 Compliance

Key Benefits

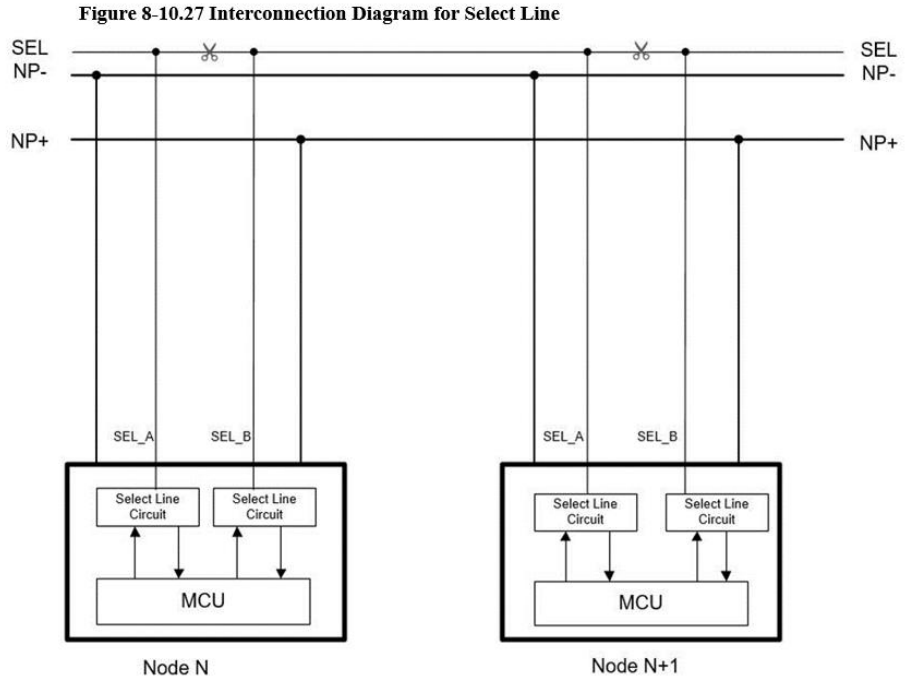
- No additional control power wires for coil control
- Current boost capabilities allow more loads to be turned on at the same time.
- Additional switch power can be made available by supplemental power tap.
- Same 24V DC supply can be used for multiple power taps
- Bank of loads can be powered by the 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.

SP Power for Zone Control



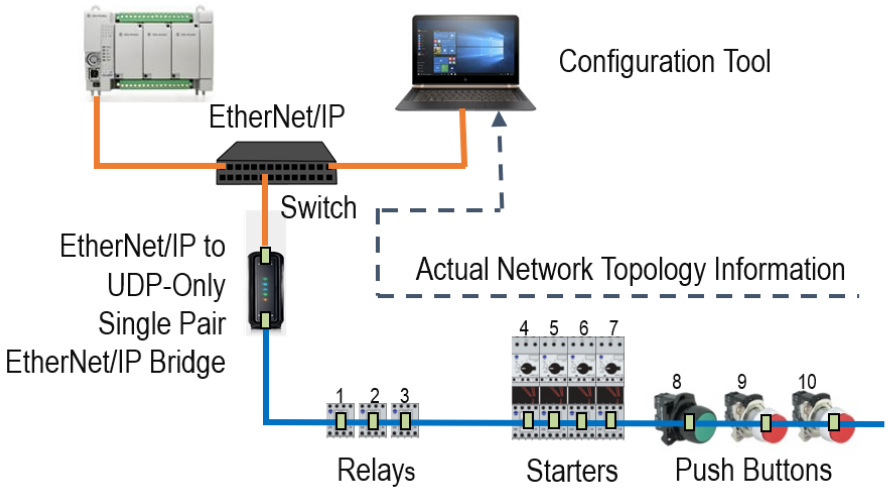
- SPE in-cabinet solution with 40 nodes
- Switch power from first power tap/gateway 0 for Zone 1
- Switch power from supplemental power tap node 14 for Zone 2
- Switch power from supplemental power tap node 3 for Zone 3

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.

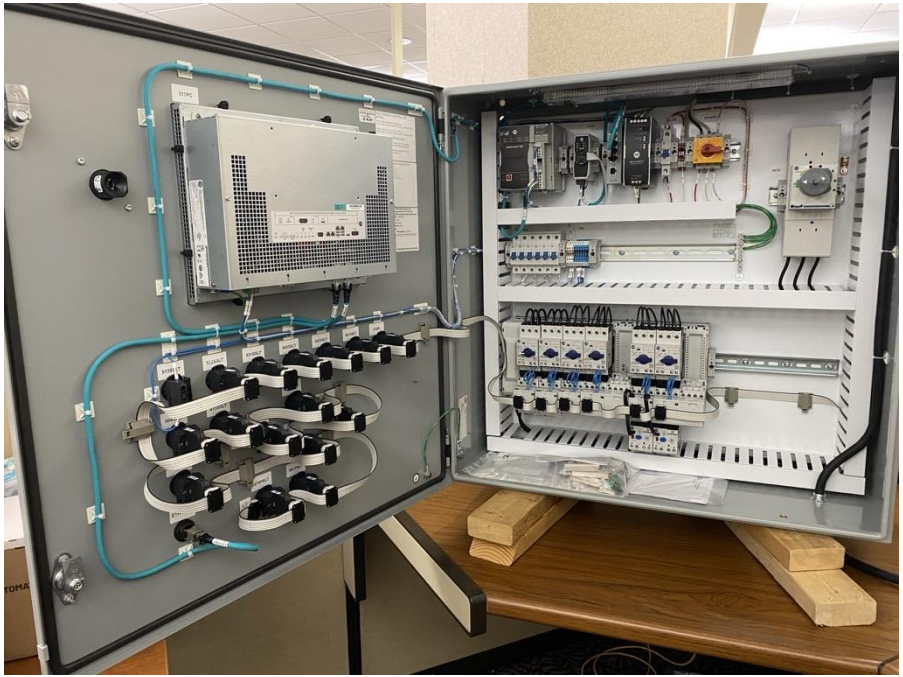
Select Line Enables Discovery of Actual Topology



UDP-Only Single Pair EtherNet/IP Network Segment

- 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

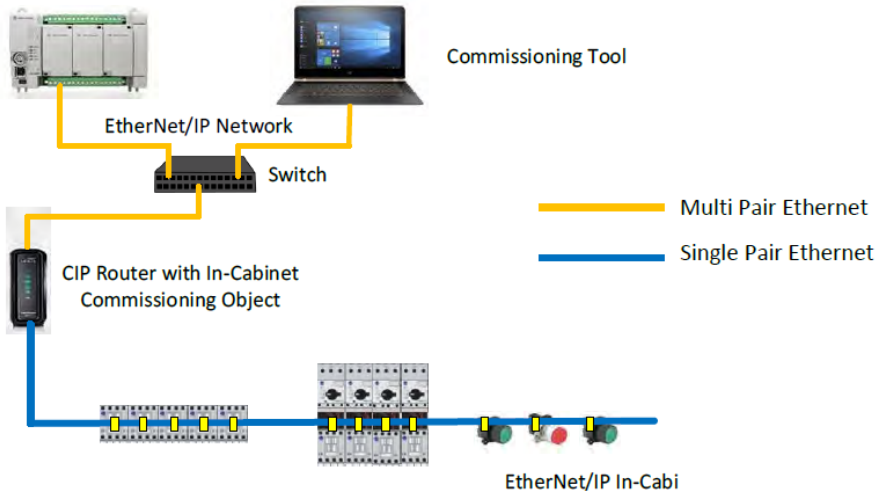
Select Line Enables Agnostic Cable Routing Direction



- 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

Figure 5-19.1 In-Cabinet Commissioning Object in CIP Router



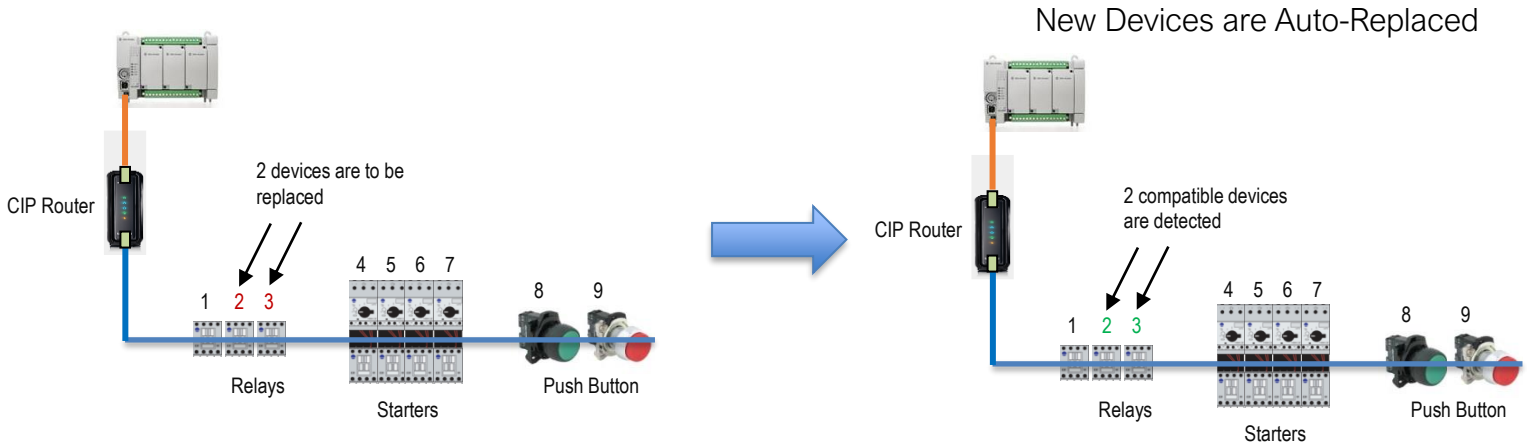
- In-Cabinet Commissioning Object works with the Select Line Link Object and the In-Cabinet Actual Topology Object to facilitate node commissioning (configuration of T1S PHY settings, and TCP/IP Interface Object) for SPE In-Cabinet network.
- Node containing the In-Cabinet Commissioning Object must be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

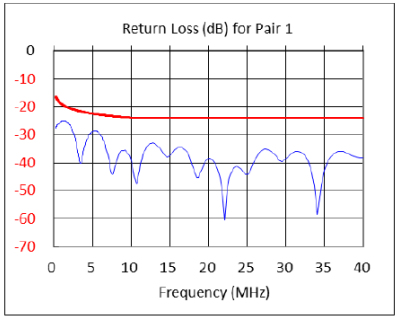


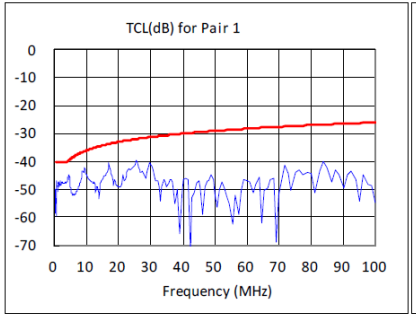
- Turn off the 24V DC control power to the system. Remove the cable connection from the SPE end nodes.
- Install the replacement devices from new out-of-the box. Re-apply 24Vdc control power.
- Gateway (CIP Router) will detect the new end node devices and will initiate Discover Topology Service to determine 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.

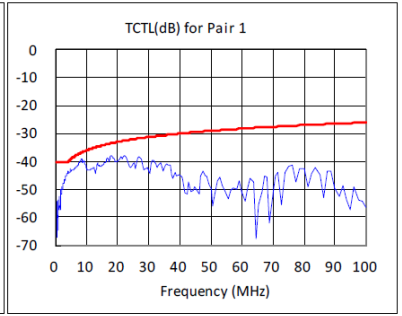
Cable Conformance

Table 8-10.5 Cable C1 Specifications and Requirements

Minimum Specifications and Requirements	
Electrical	
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.)) Lay length of outer layer is from 12 min. to 16 max. times outer diameter NP+, NP-, SP+, SP-: 20 AWG, 19/32 stranded tin-coated copper (0.61 mm² (strand 0.203 mm DIA. / bundle 0.95 mm DIA.)) Lay length of all layers is from 12 min. to 16 max. times outer diameter
Impedance (Ω)	Reference impedance of 100 Ω for SPE pair
Insertion Loss, IL (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length $0.25 * (2.73 * \sqrt{f} + 0.026 * f + 0.375 / \sqrt{f})$ $0.3 \le f \le 40$ where f is the frequency in MHz
Return Loss, RL (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length $24 + 5 * \log_{10}(f/10)$, 24 max. $0.3 \le f \le 40$ where f is the frequency in MHz
Mode Conversion, MC (dB)	Measured per section 8-10.4.4, for SPE pair, at 25 m length TCL and TCTL: $46 - 10 * \log_{10}(f)$, 40 max. $0.3 \le f \le 100$ where f is the frequency in MHz
Current	NP+, NP-, SP+, SP-: 4A minimum at +75 °C ambient SPE+, SPE-: 12 mA minimum at +75 °C ambient
DCR	Measured for each conductor, at 25 m length, at +20 °C NP and SP: 0.935 Ω max. SPE and SEL: 2.355 Ω max. (Ref: UL 1581)
DCR Unbalance	Measured per ASTM D4566 NP and SP: 3%
Dielectric Strength	2000 V AC (UL 758, Table 29.1, 600 V AC)

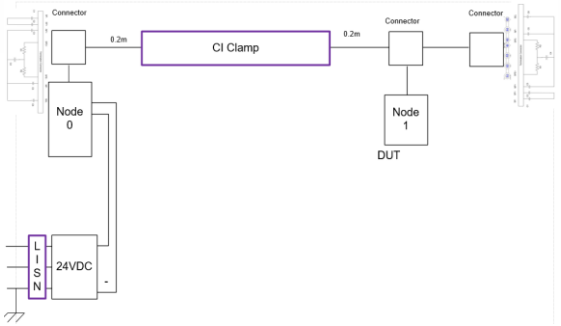






Data from Actual Cable Sample Measurement

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.

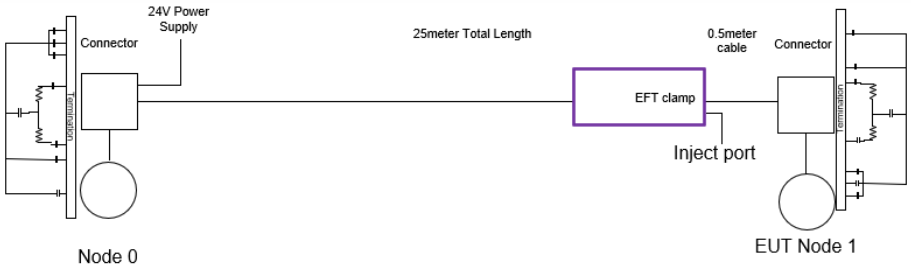
(2) 10V with AM on;
Master node 0: receiving node
DUT Node 1 : transmitting node Passed BER no loss of packet.

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

EMC-Fast Transient

Setup

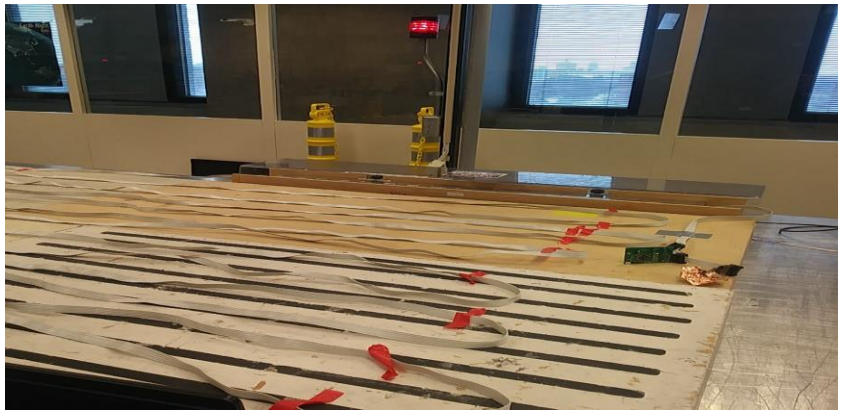
- 25meter SPE-In Cabinet cable and connector protos.
- SPE in-cabinet Node 0 is the transmitting node.
- SPE in-cabinet Node 1 is the DUT and the receiving node.
- Conducted test per IEC/EN 61000-4-4



Acceptance criteria

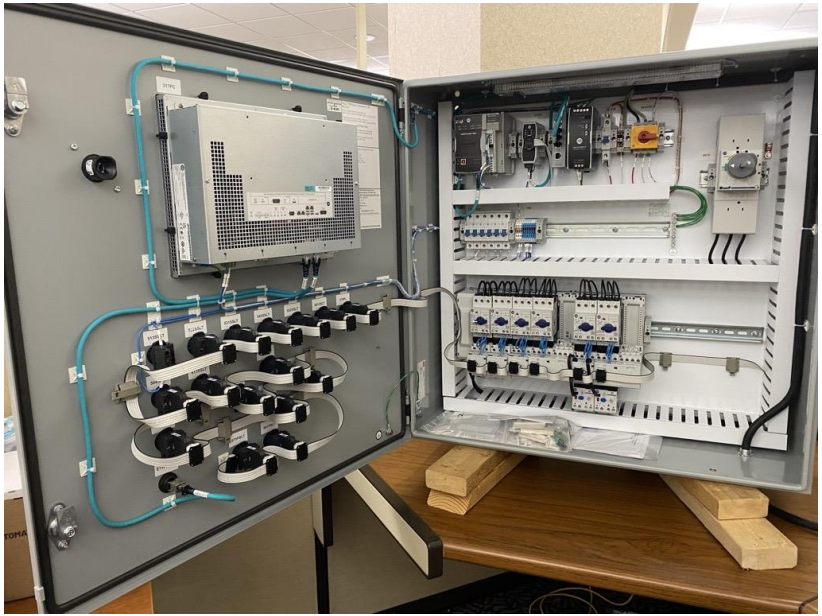
- Criteria B, temporary degradation or loss of performance which is self-recoverable. PASS

EFT Test Levels	Frames sent by Node 0	Frames received by Node 1	Frames Lost
+500V	65000	64987	13
-500V	65000	64988	12
+1KV	65000	64989	11
-1KV	65000	64985	15
+2KV	65000	64994	6
-2KV	65000	64988	12
+3KV	65000	64998	2
-3KV	65000	64991	9
+4KV	65000	Node 1 LED flashes, unit self recovered back	



Conclusion: SPE in-cabinet solution showed good performance during preliminary EFT testing.

SPE In-Cabinet Solution Demo

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Industry Conference and 22nd Annual Meeting