# Installation of Fieldbus

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# Agenda

- Foundation Physical Layer
- Choosing Components and Layout
- System Design
- Field Checkout and Commissioning
- Trouble Shooting a Fieldbus System

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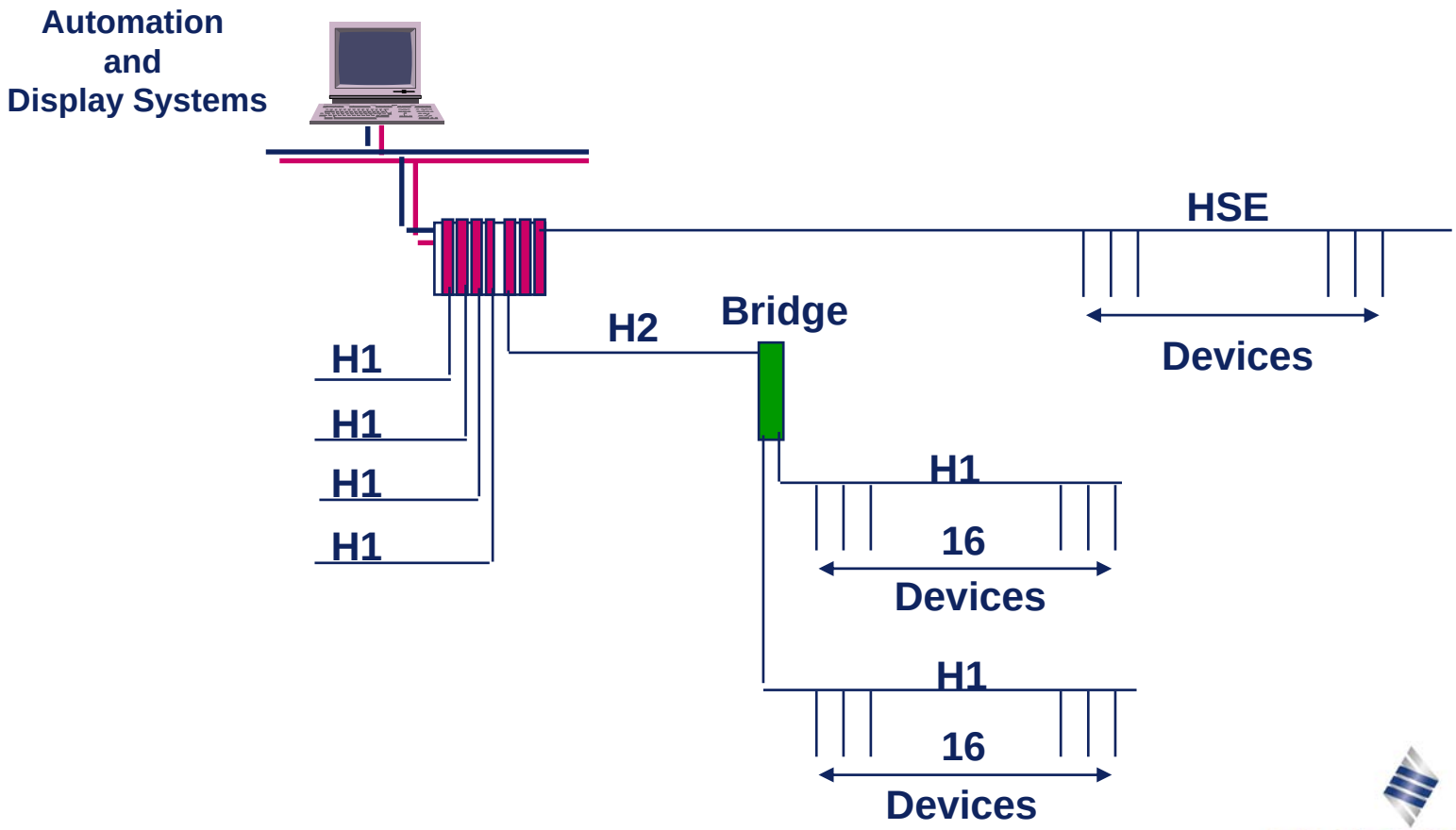
# Fieldbus Technology

## General Fieldbus Topology

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*Foundation Fieldbus was designed by the Process Industry for the Process Industry*

# Agressive environment

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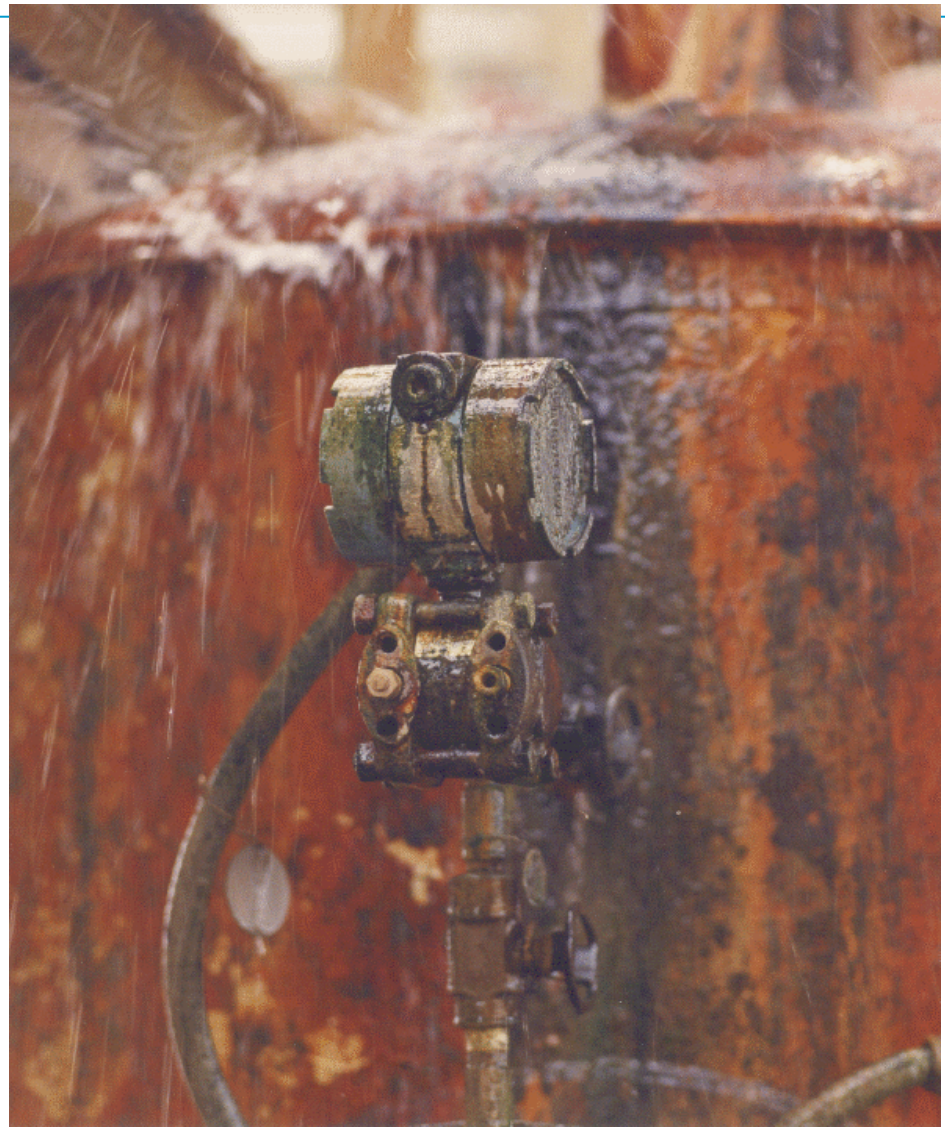
# Typical installation



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# Instruments are spread over large areas

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# Hazardous Areas

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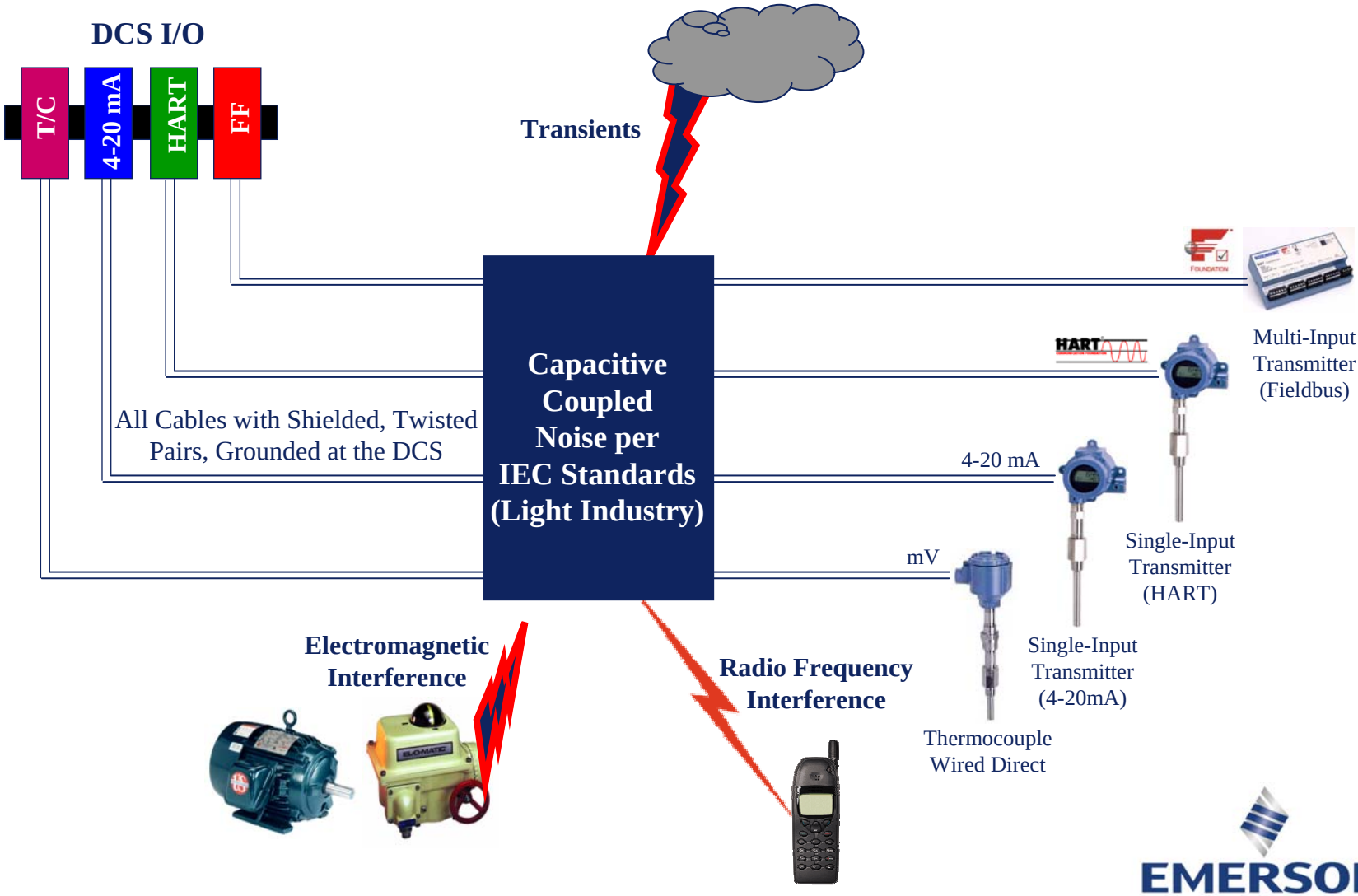
# Electromagnetic Interference

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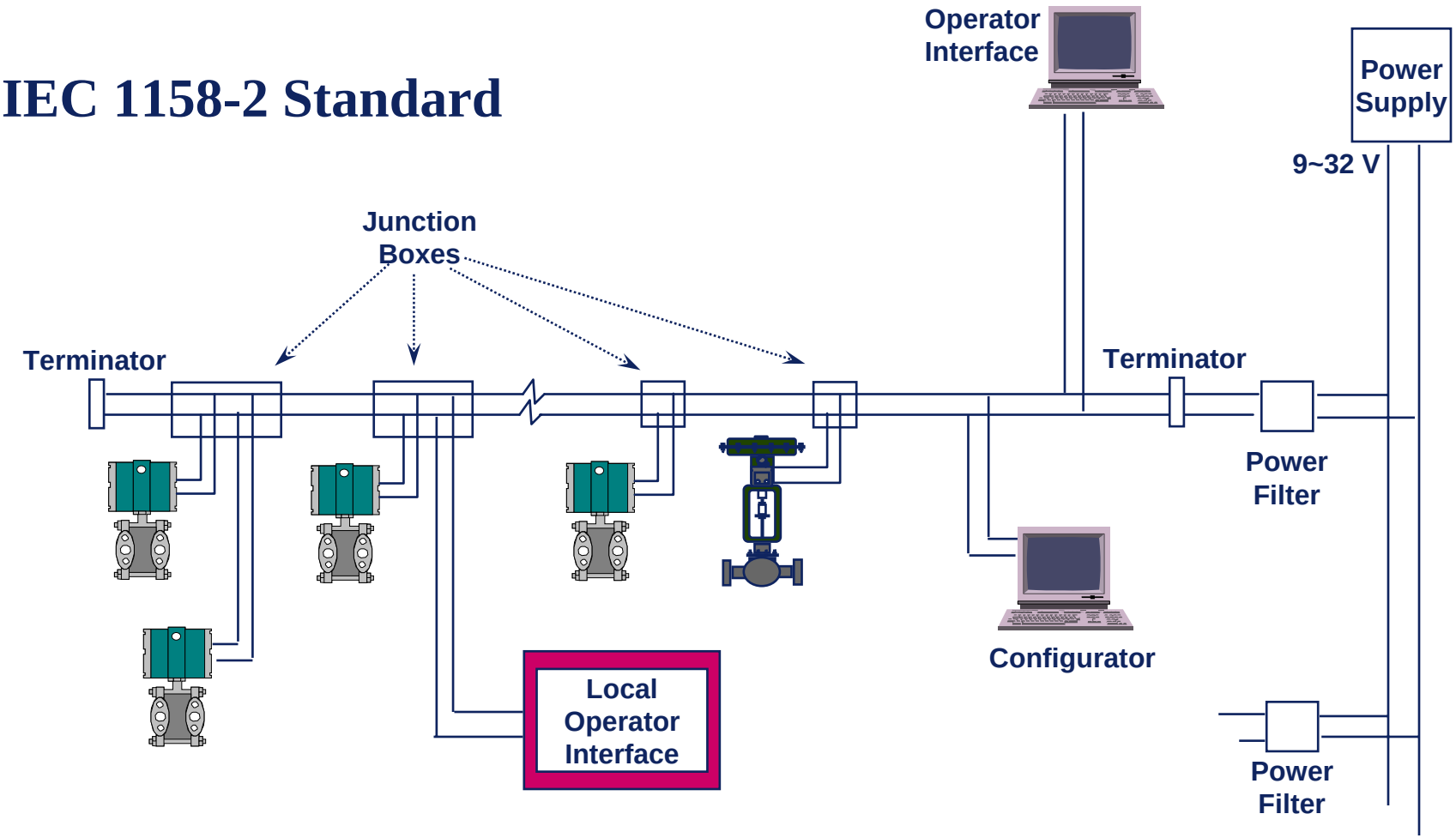
# Electromagnetic Interference

# Fieldbus Foundation Fieldbus

## IEC 1158-2 Standard



# *Number of devices per segment*

- Based on present device power consumption, Power conditioner current limitation and resistance of wires, experience demonstrates that up to

**16 Devices per segment**

**can be used.**

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# Fieldbus Cable Types

| Cable Type and Description | Size | Length |
|---|---|---|
| – Type A (New) Shielded, twisted-pair | | |
| – H1: 31.25 Kbps | #18 AWG | 1900* m |
| – Type B (Existing) Multi-twisted-pair, w/shield | | |
| – H1: 31.25 Kbps | #22 AWG | 1200* m |
| – Type C Multi-twisted-pair, w/o shield | | |
| – H1: 31.25 Kbps | #26 AWG | 400* m |
| – Type D Multi-core, w/o shield | | |
| – H1: 31.25 Kbps | #16 AWG | 200* m |

* Spurs count in overall length

# Cable Length

- Total cable length should be less than 1900 m (shielded, 18 AWG, Type B)
- Connecting up to 12 devices in a powered bus, the Spur length limit should be:

  * 120 m with one device
  * 90 m with two devices
  * 60 m with three devices
  * 30 m with four devices

- Length reduces with more devices in the network

**Standard is Conservative!**

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# Installation Procedures

- Fieldbus requires standard wiring practices

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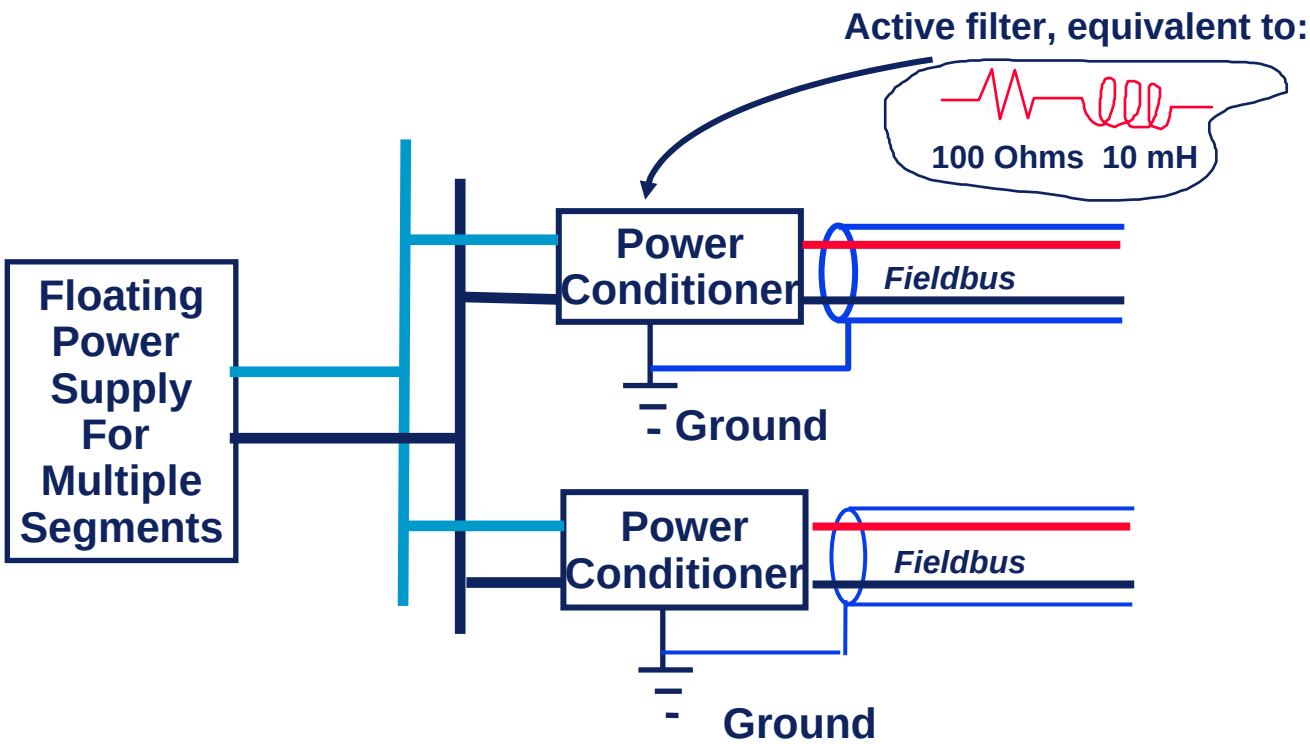
# Fieldbus Segment Power

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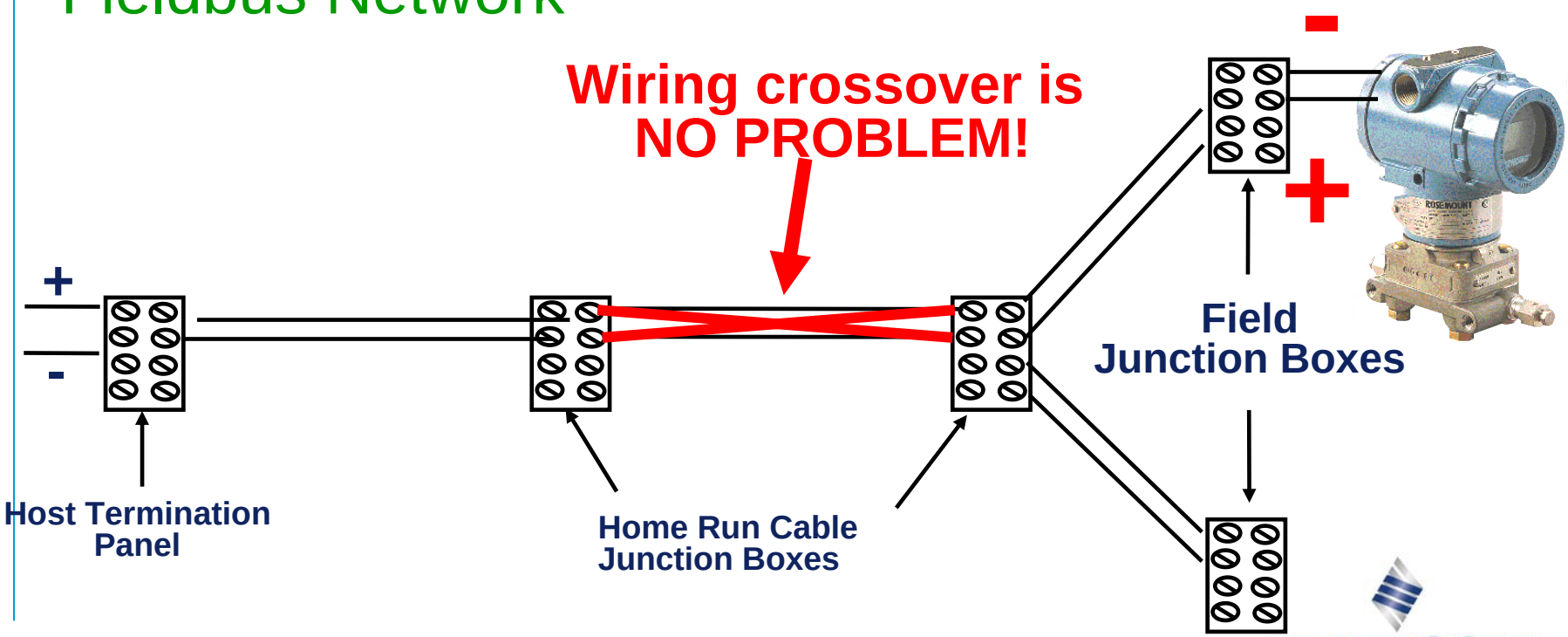
# Polarity Insensitive Devices

- Some suppliers provide Polarity Insensitive Fieldbus Devices
- This enables fast and safe commissioning of the Fieldbus Network

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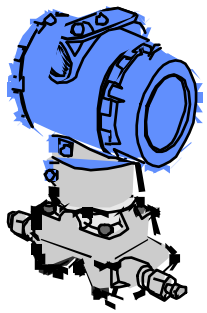
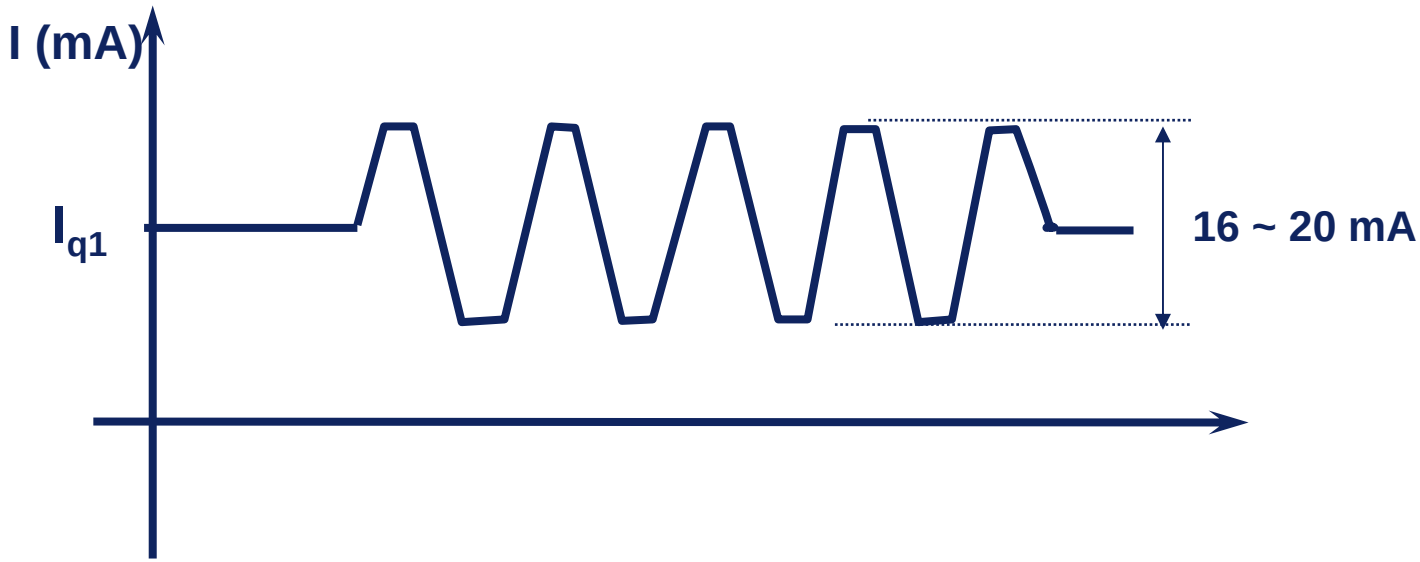
# Current Consumption And Signal Shape



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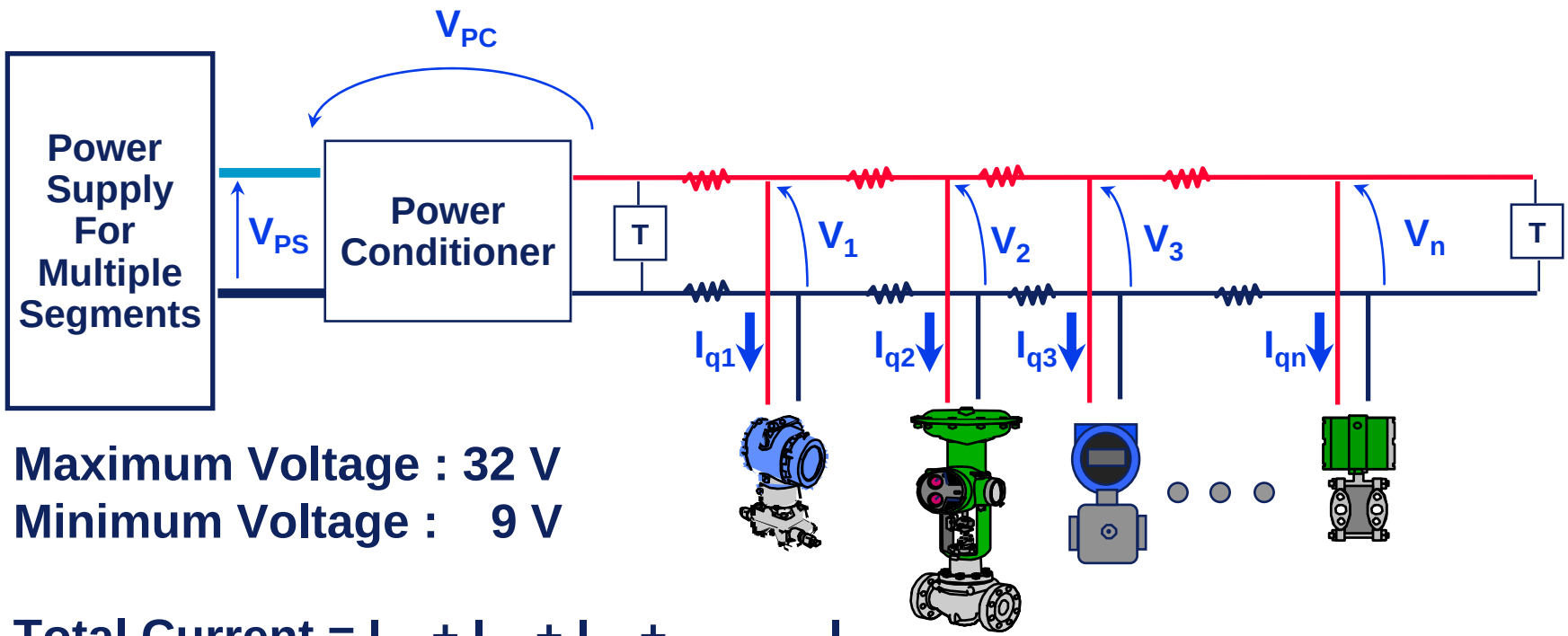
# Voltage and Current




**Maximum Voltage : 32 V**
**Minimum Voltage : 9 V**

**Total Current = $I_{q1} + I_{q2} + I_{q3} + \ldots\ldots\ldots I_{qn}$**

**Maximum current limited by the power conditioner.**
**Example: 400 mA**

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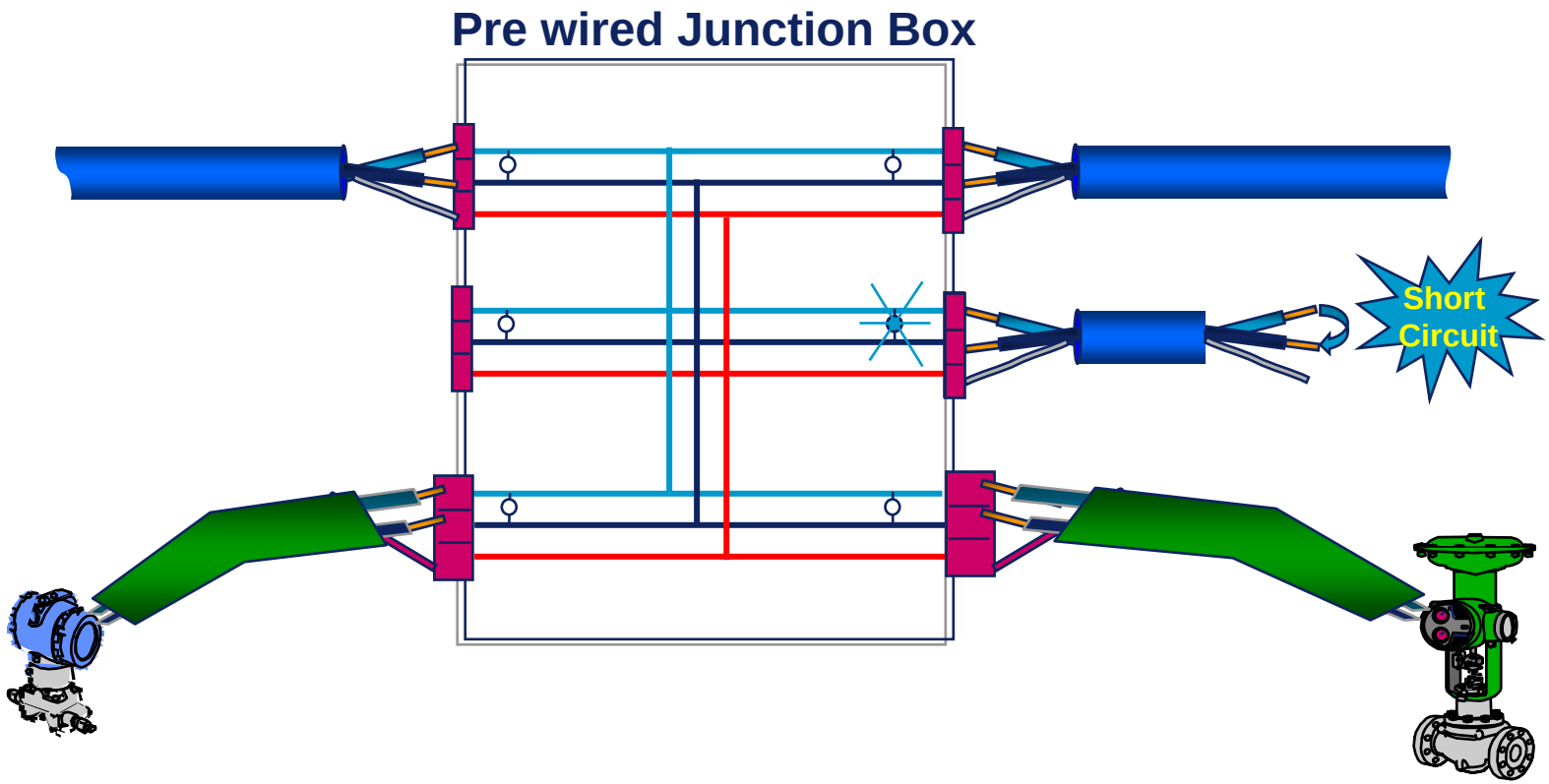
# Short Circuit Protection

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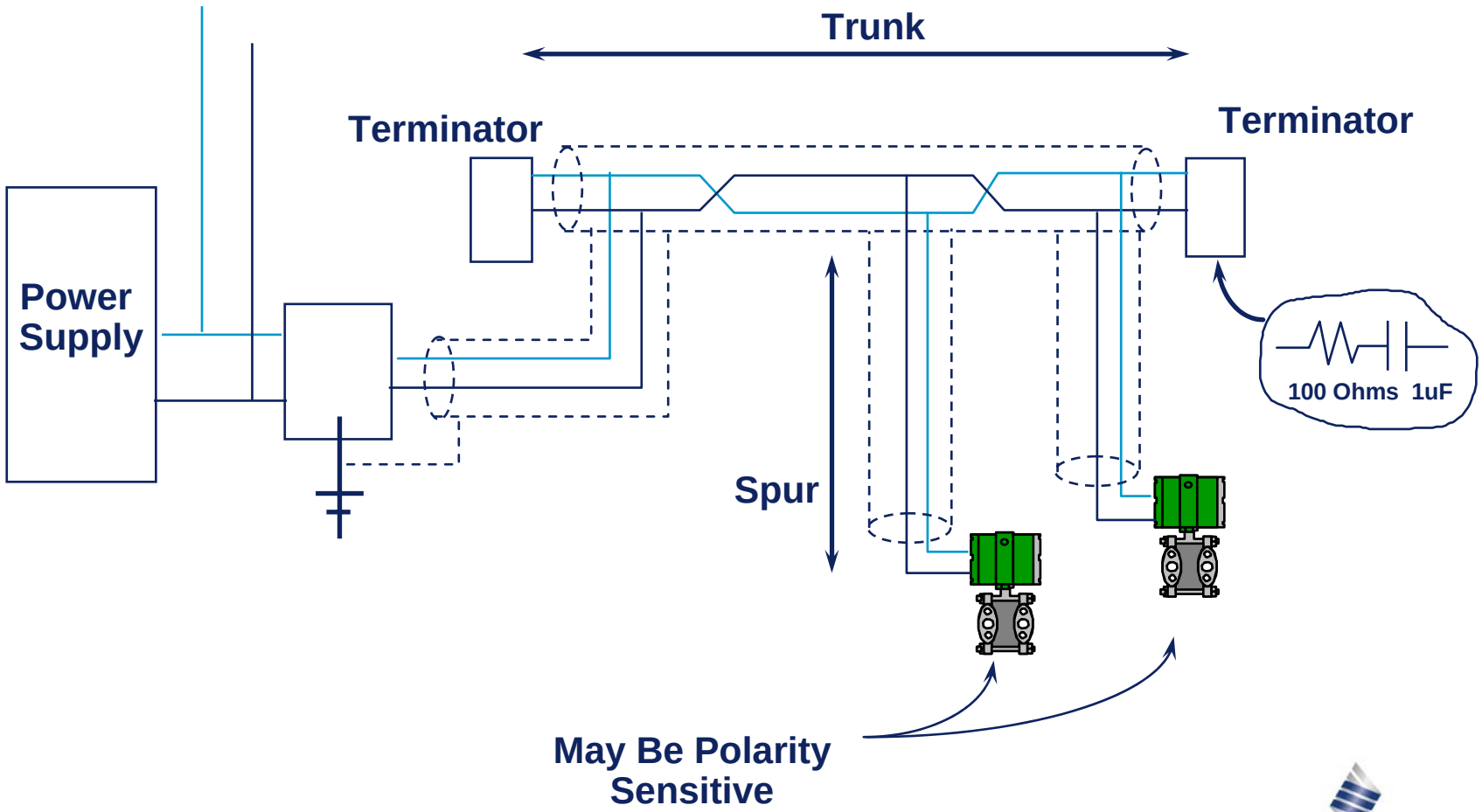
# Termination and Twisted Pair Shielding

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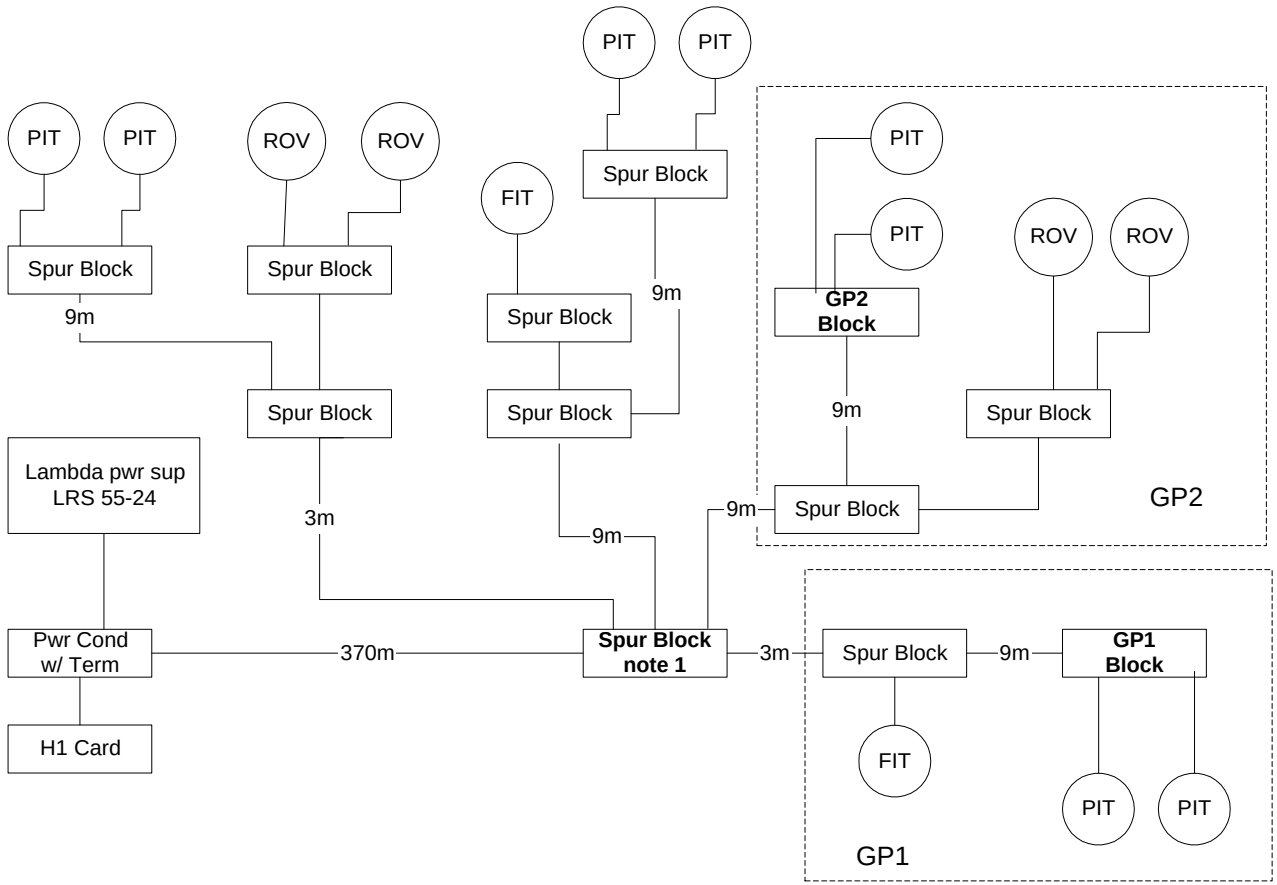
# Terminator Located at Far Ends of Main Segment Trunk

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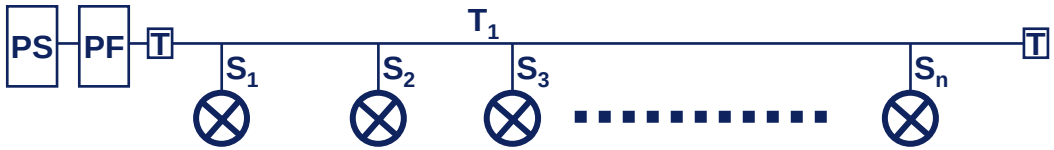
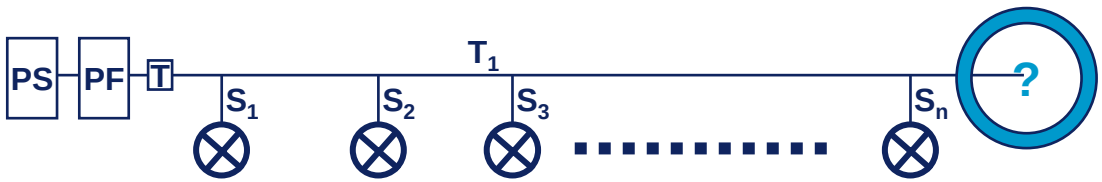
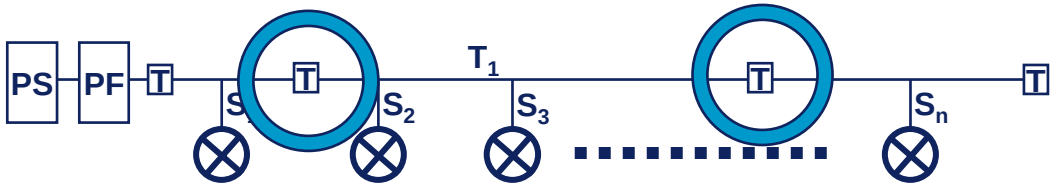
# Communications under abnormal conditions



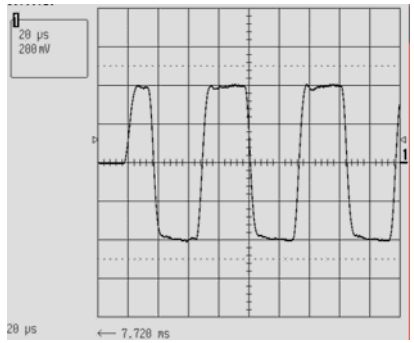

Normal

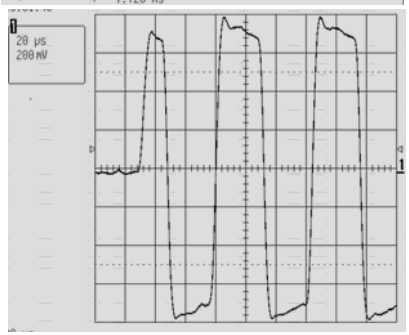


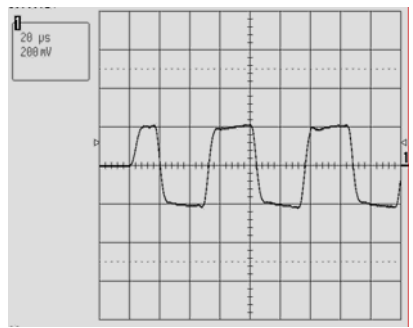

One terminator missing



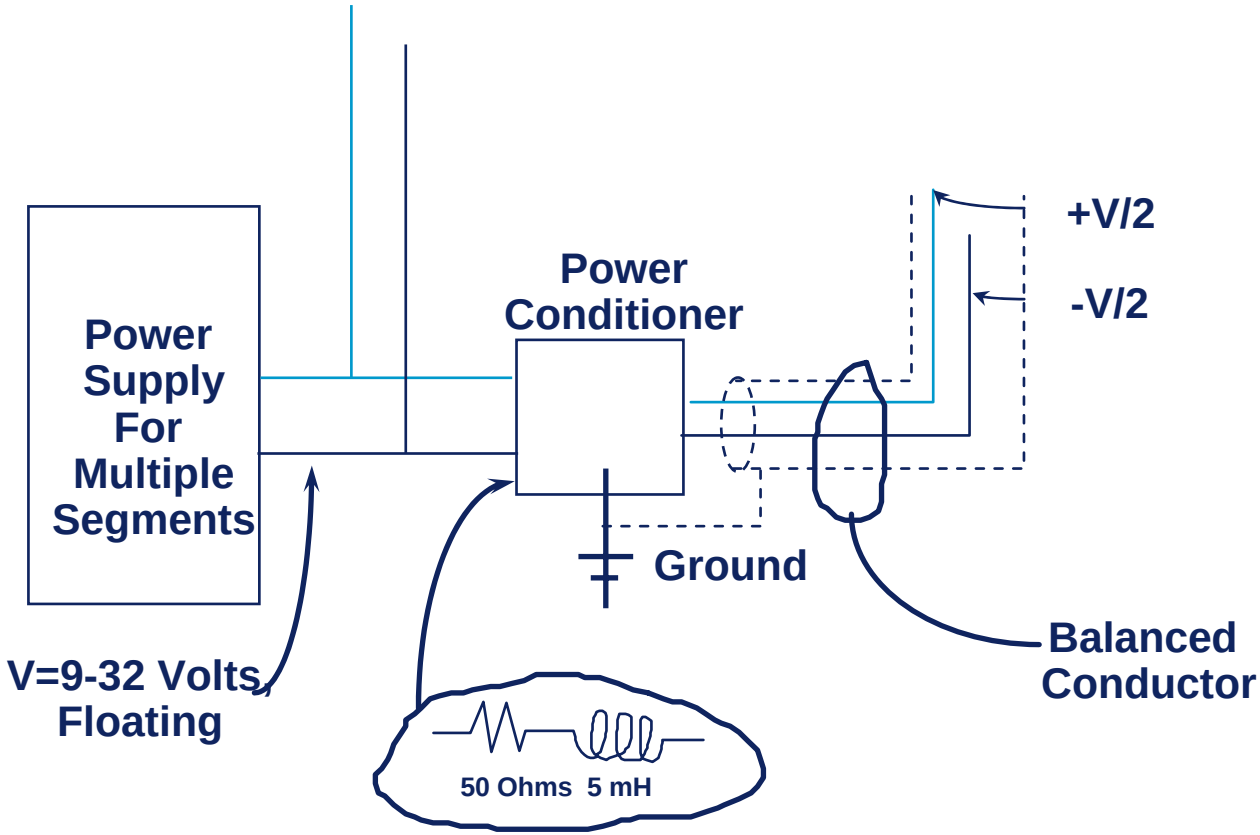

Too many terminators



# Power Conditioning For Fieldbus Segments

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# *Important rules*

- Shield should be grounded at a single point!
- Do not ground signal wires
- Observe terminator location

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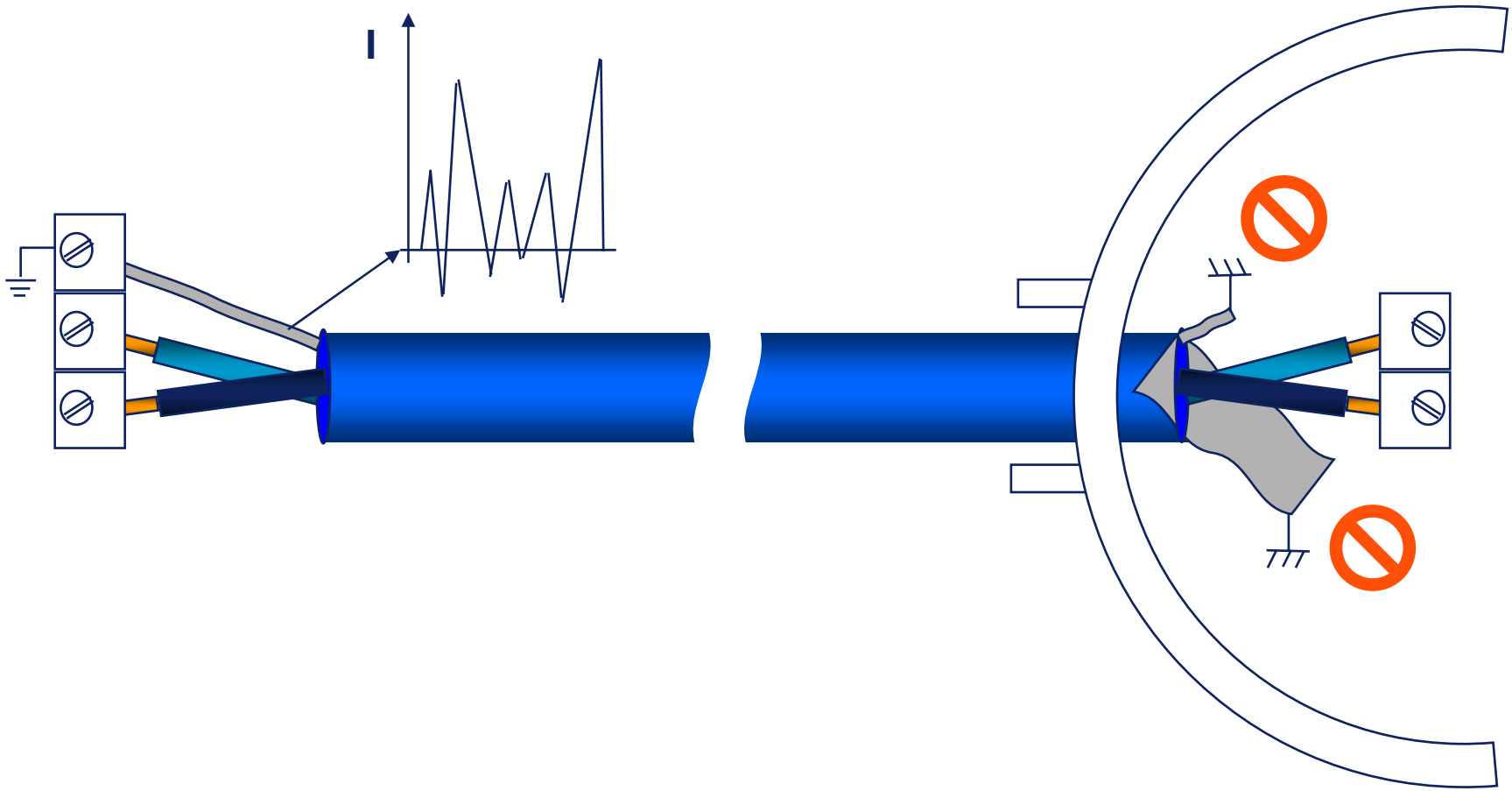
# Shield should be grounded at a single point

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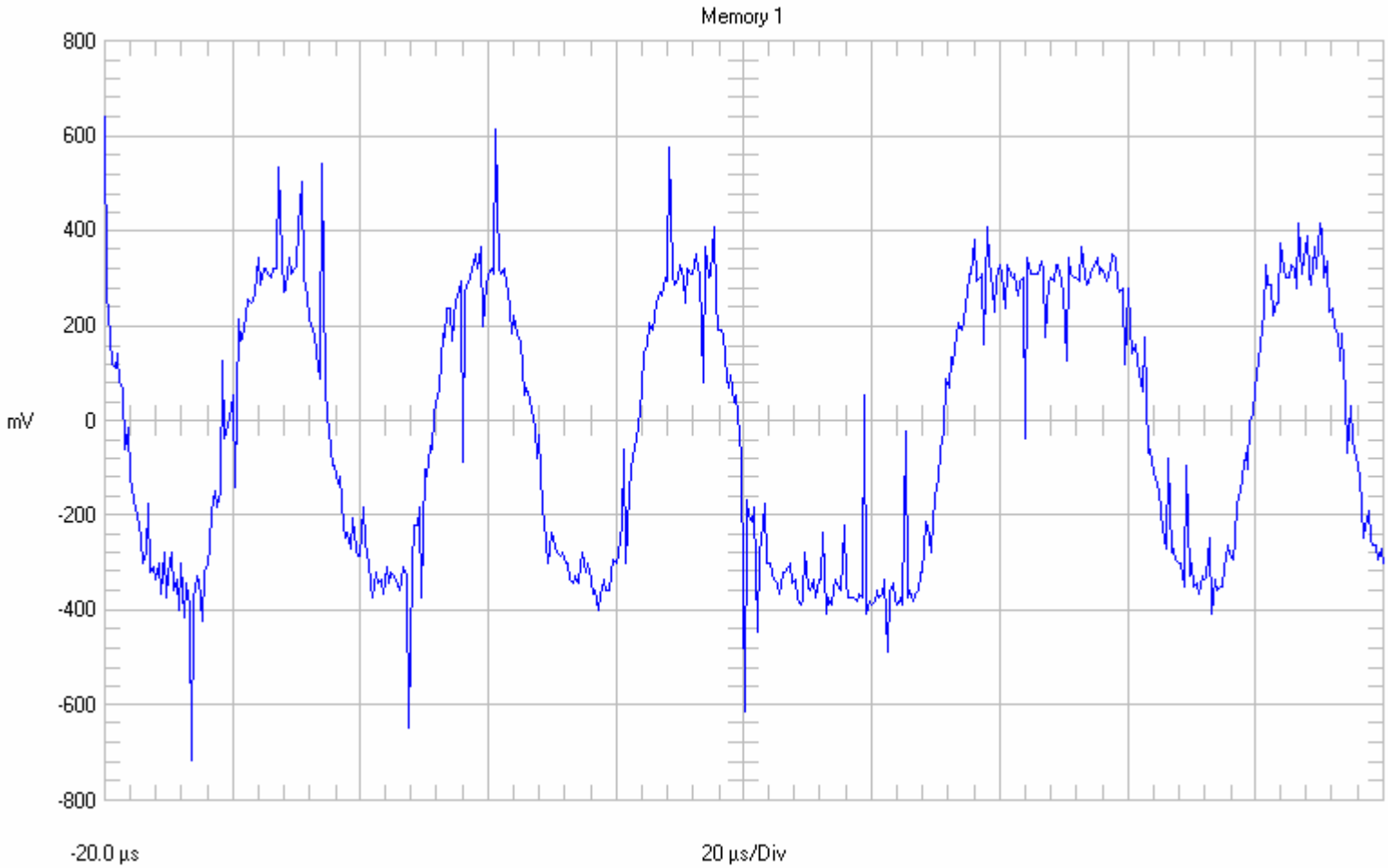
# Signal form in a bad installation

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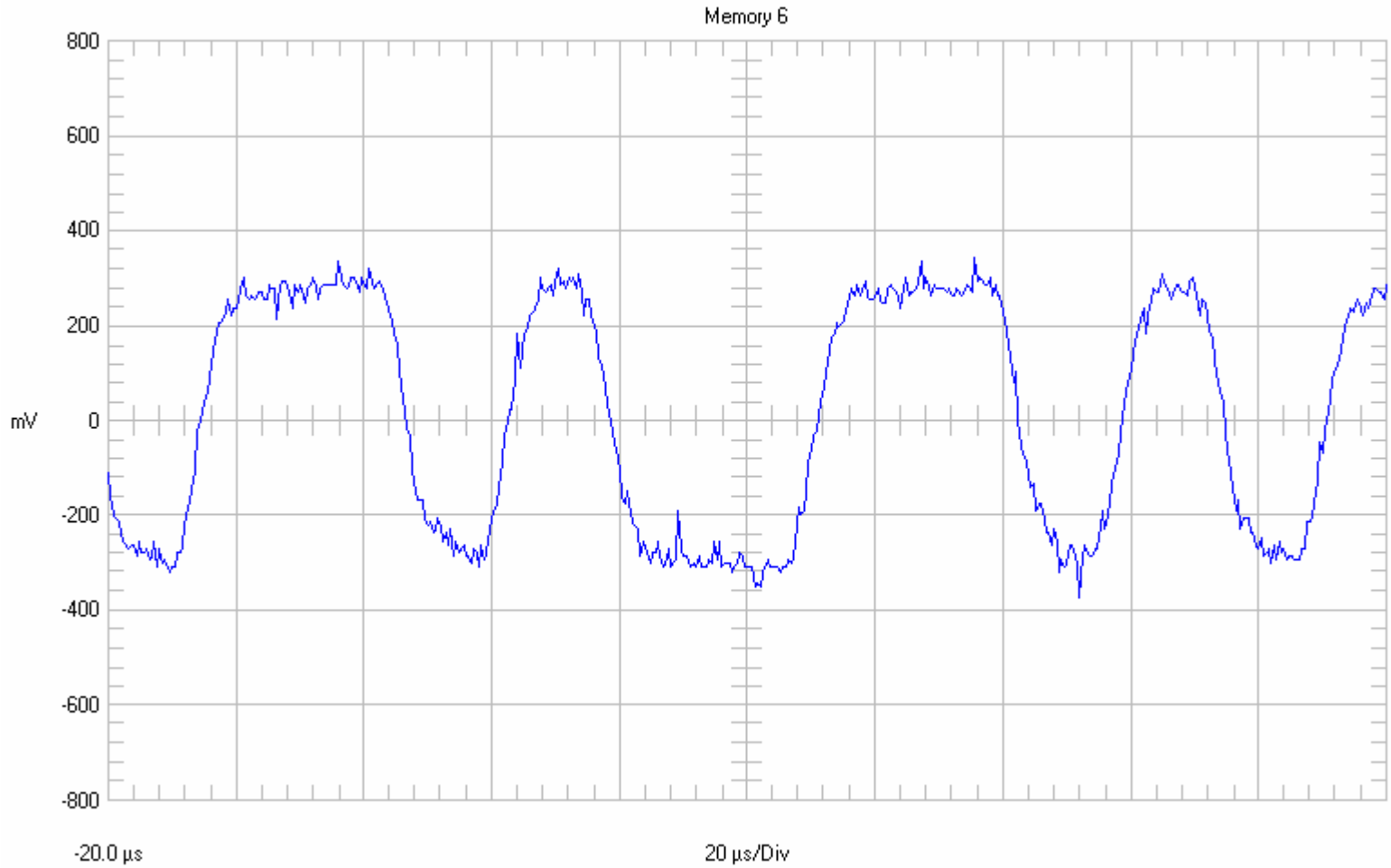
# Same location after fixing the installation

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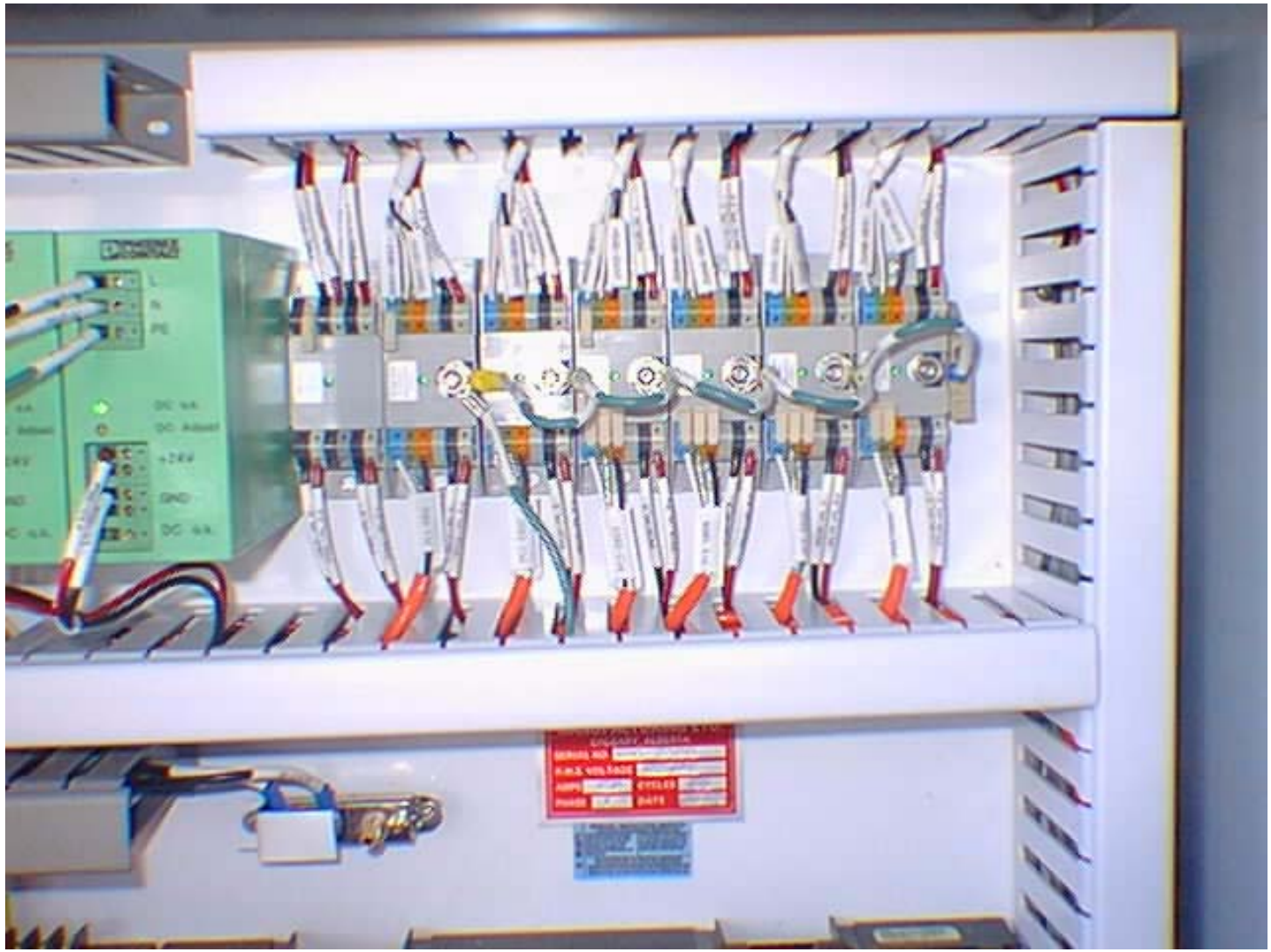
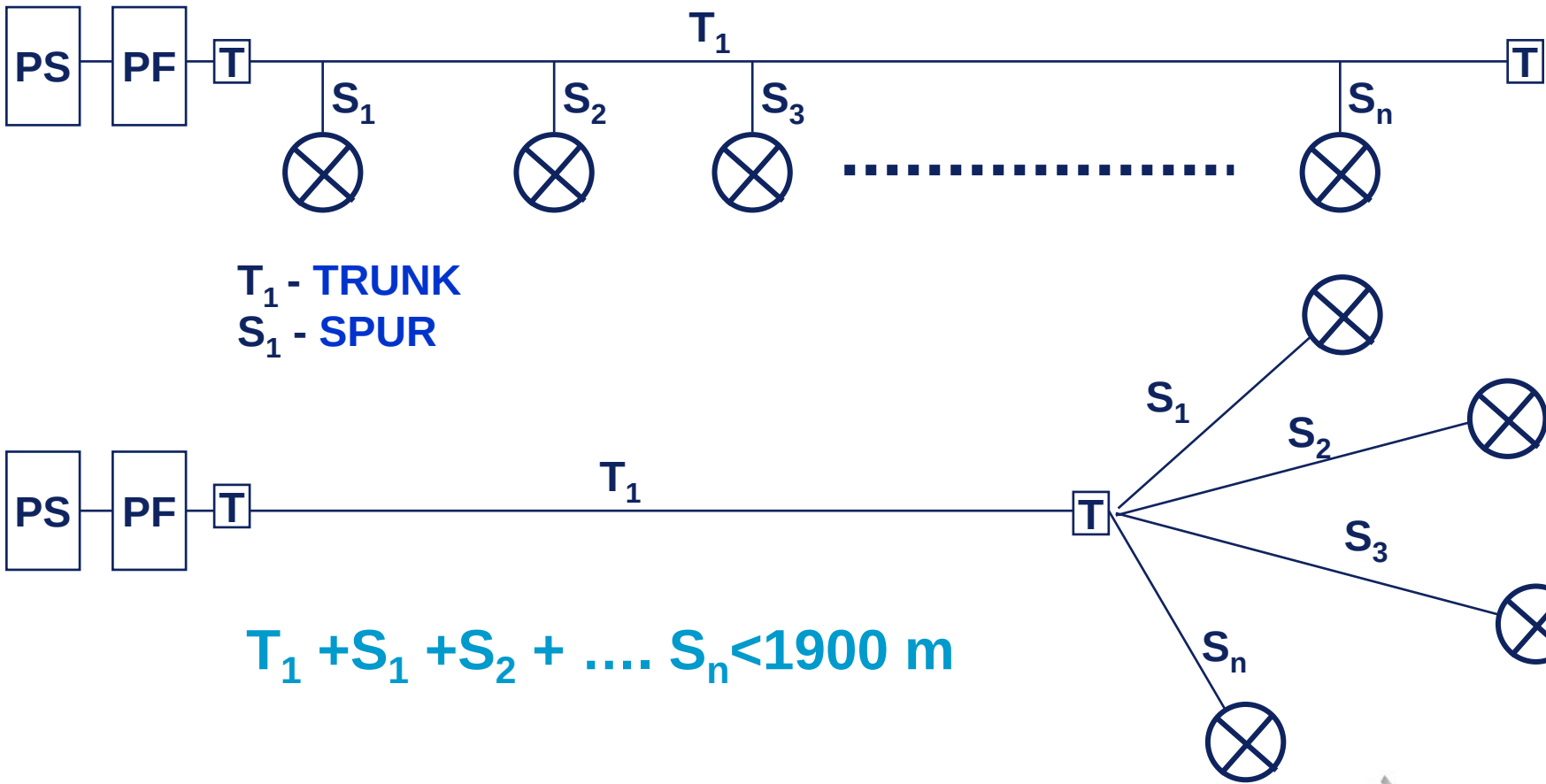
# Example Power Supply – One per Segment



# Fieldbus Supports Multiple Topologies

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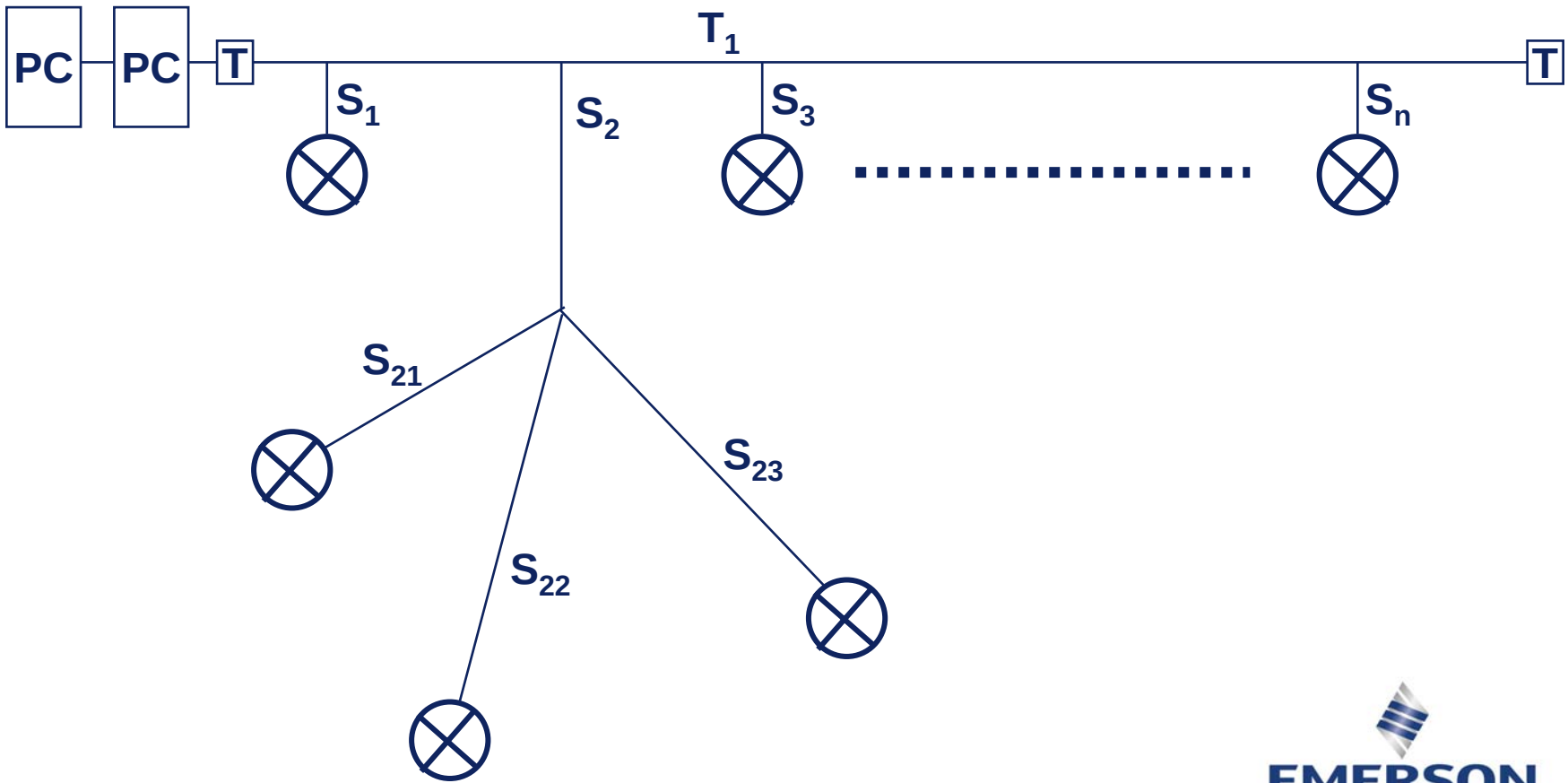
# Fieldbus Supports Multiple Topologies

$T_1 + S_1 + S_2 + S_{21} + S_{22} + S_{23} \ldots + S_n < 1900\ m$

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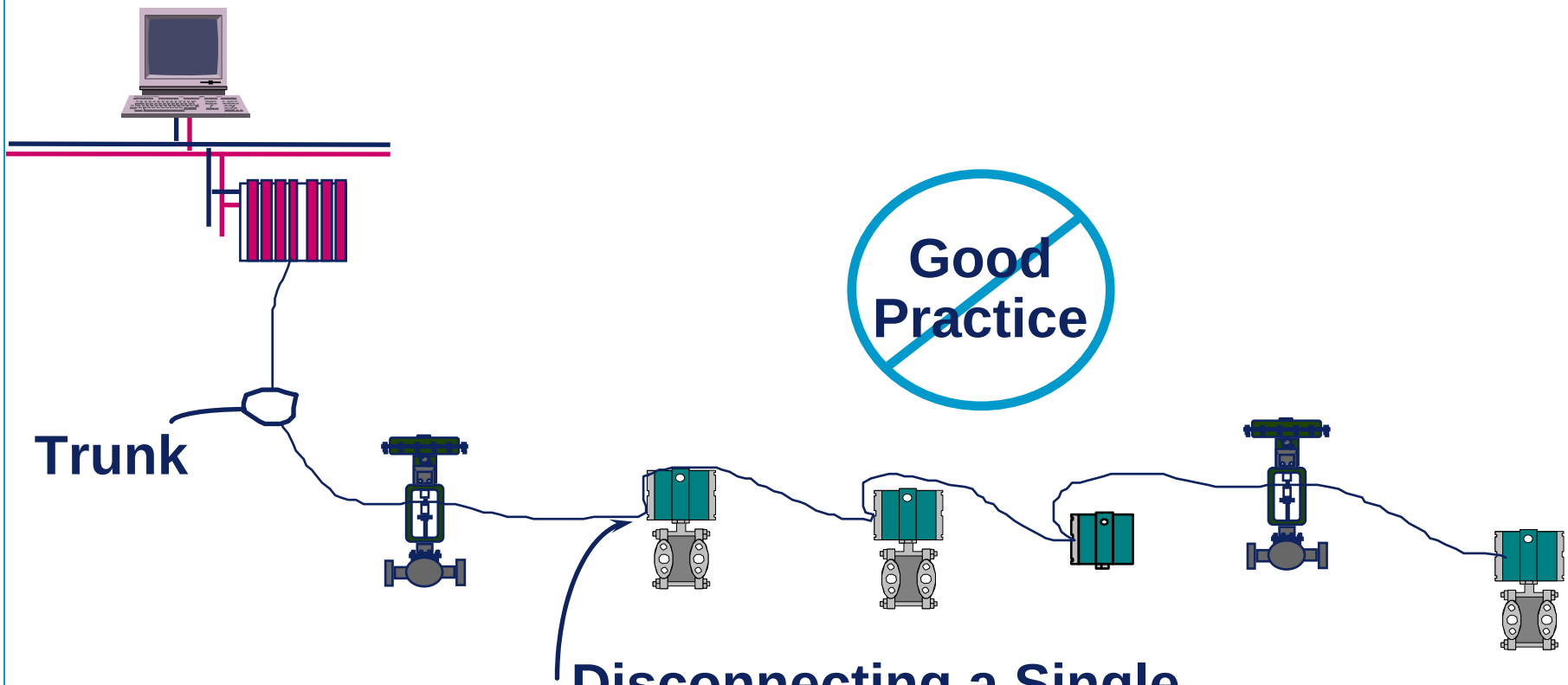
# Daisy-Chain Topology

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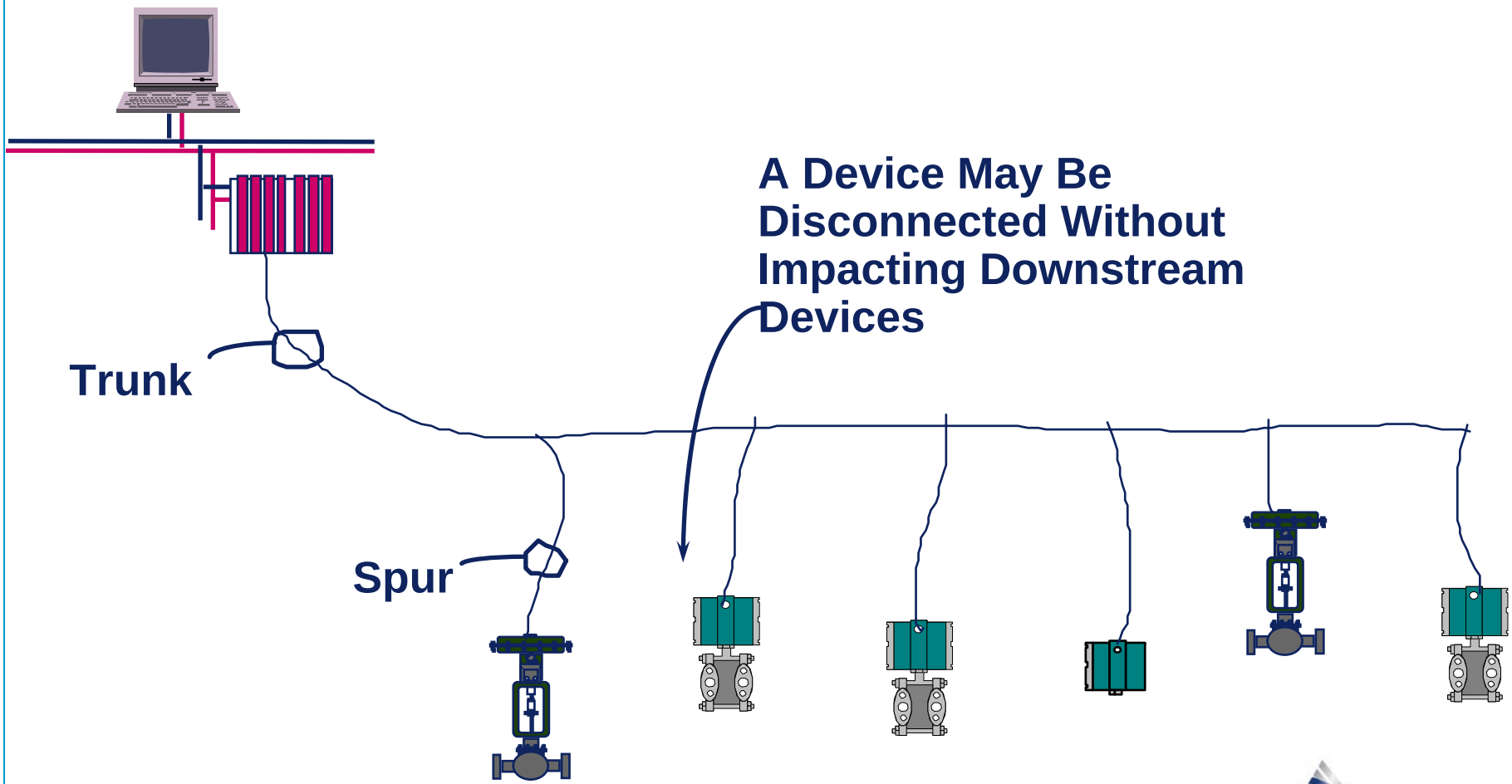
# Branch Topology

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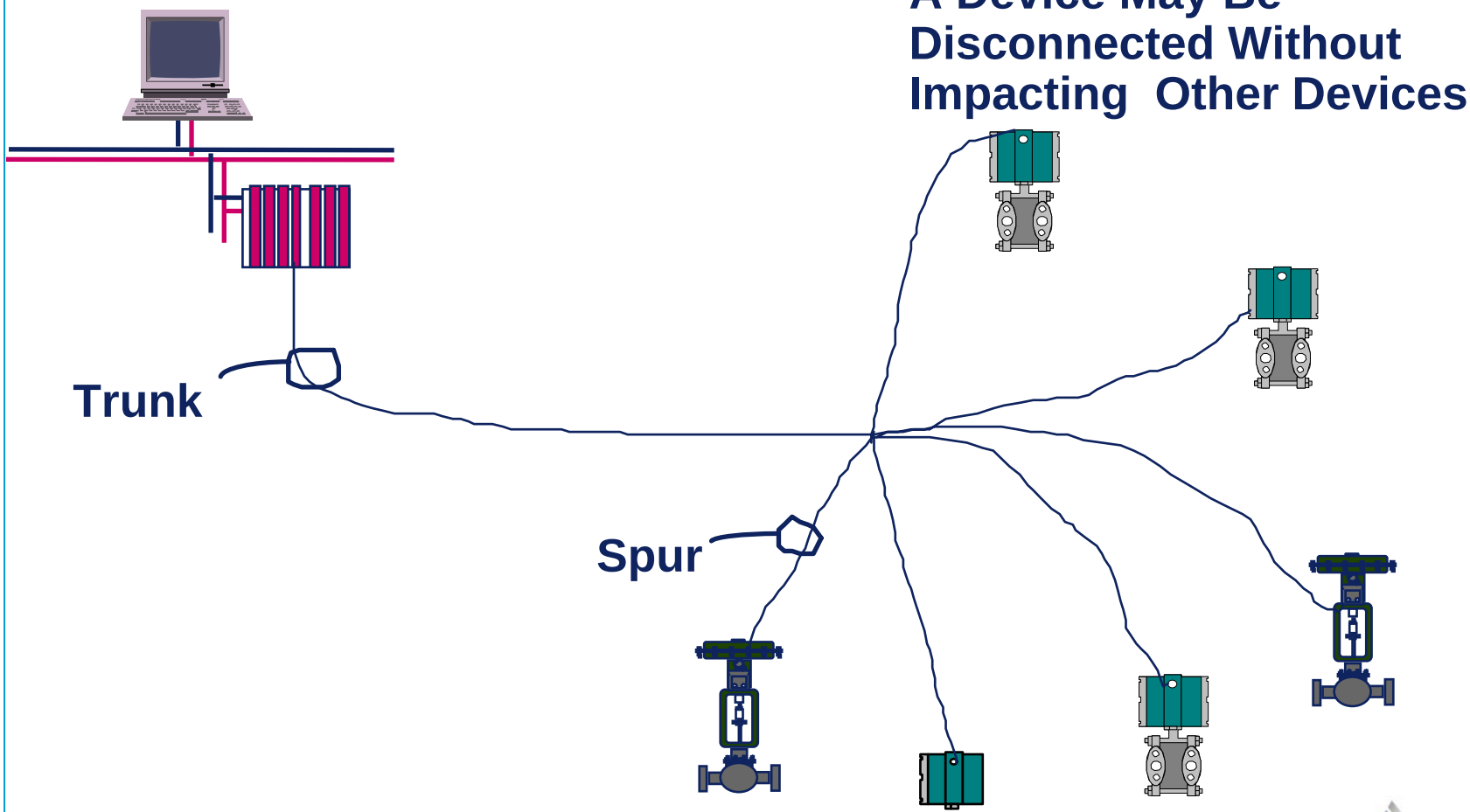
# Tree Topology

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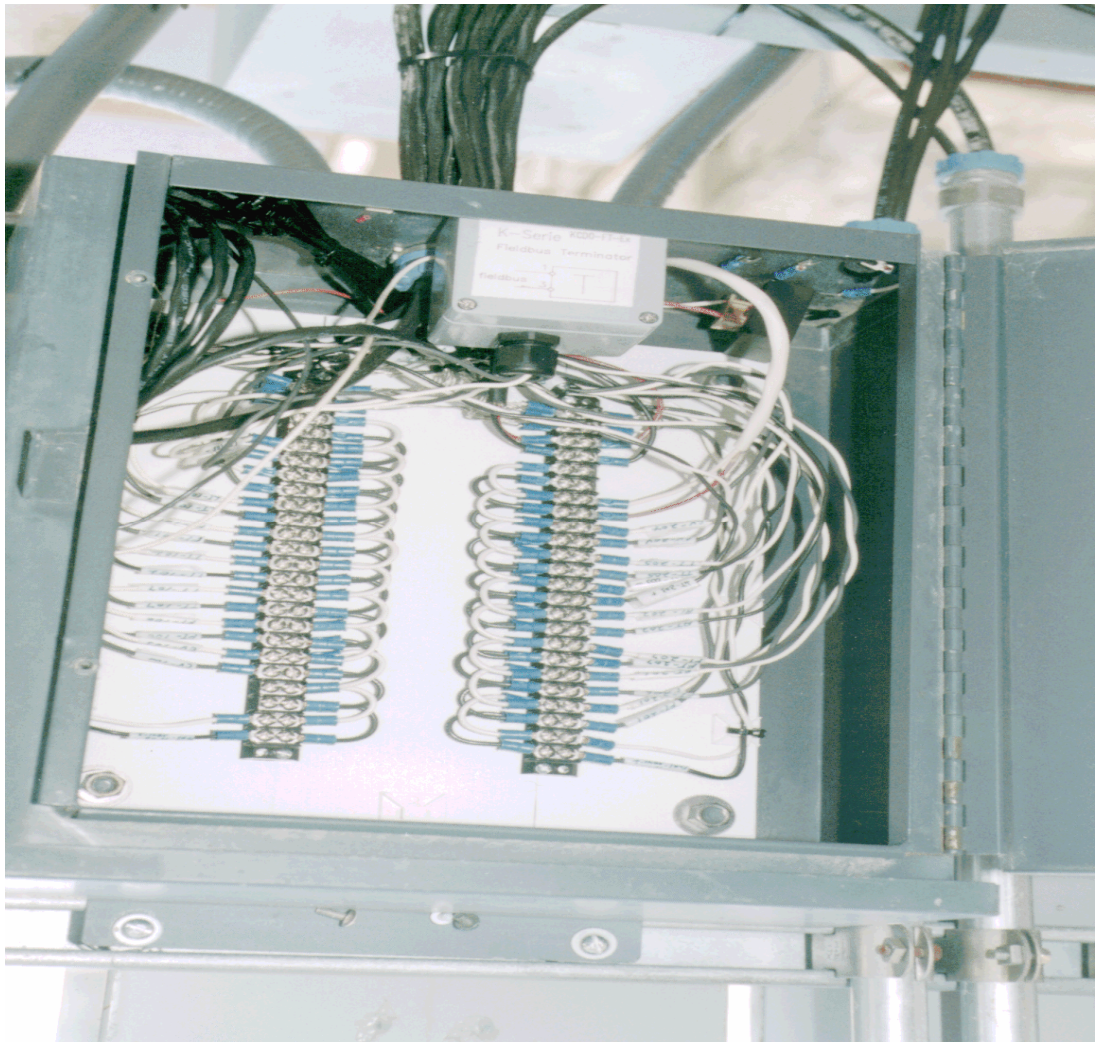
# Example - Field Junction Box



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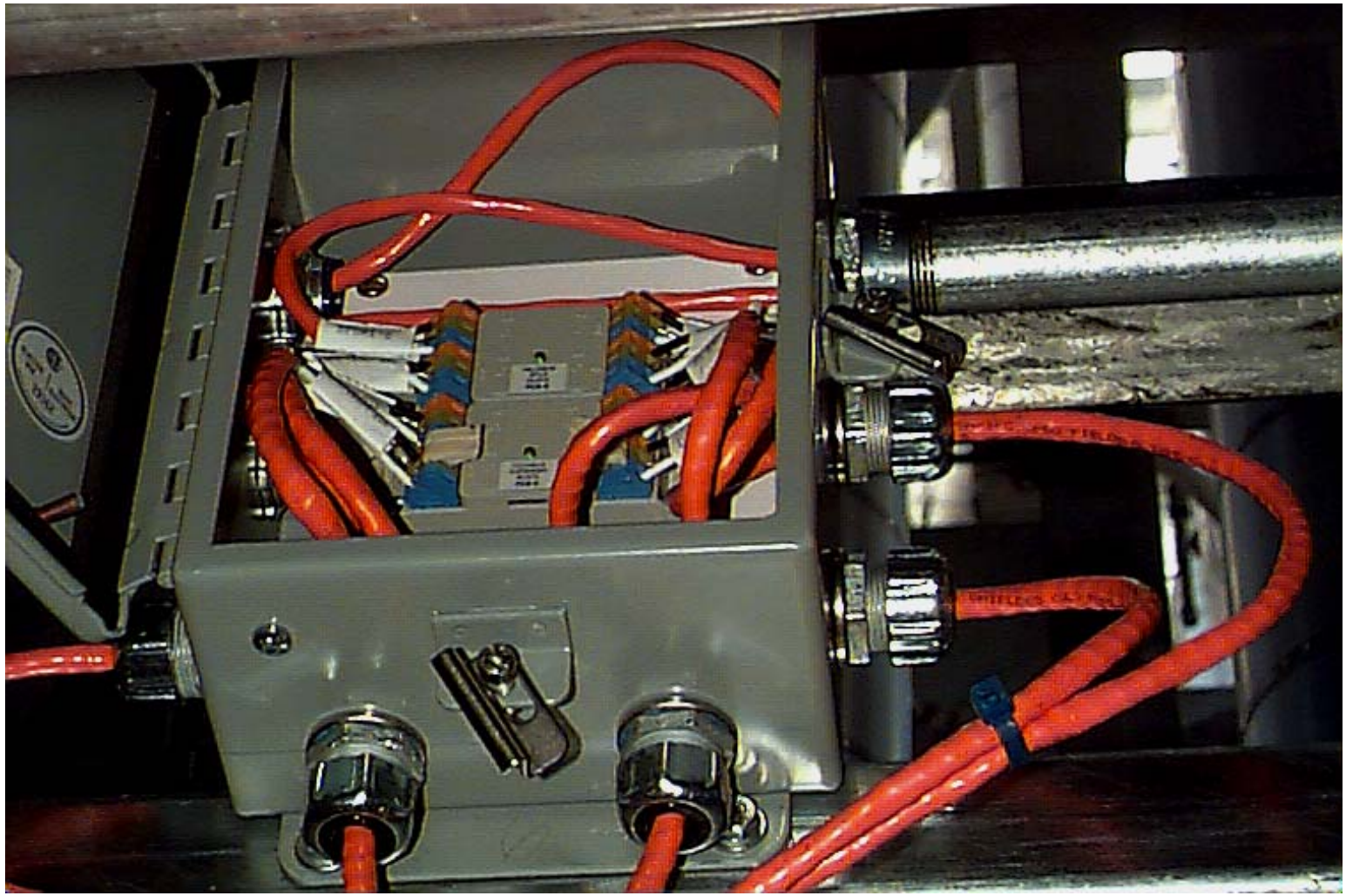
# Example - Field Junction Box



# Standard is conservative

- Total length of cable should be less than 1900 m (shielded, 18 AWG, Type B)
- When connecting up to 12 devices in a powered bus, the Spur length limit should be:
  * 120 m with one device
  * 90 m with two devices
  * 60 m with three devices
  * 30 m with four devices.
- More devices in the network reduce the lengths given above

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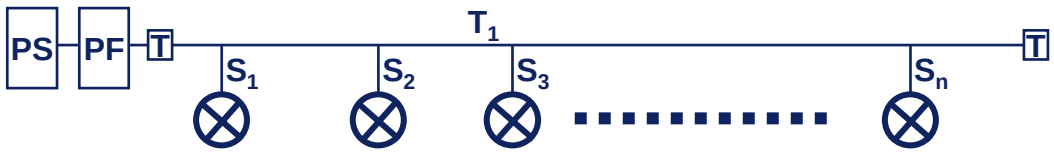
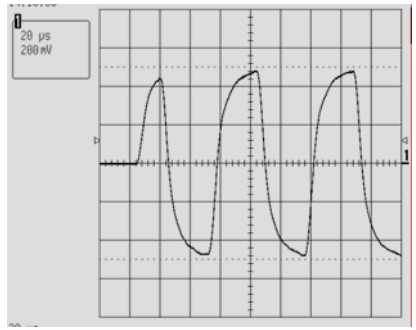
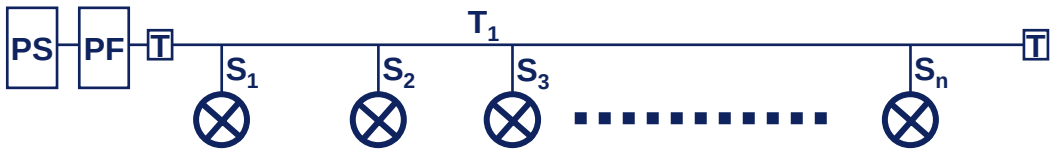
# Communications under abnormal conditions

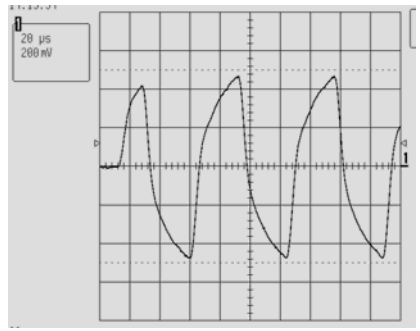



Long spurs (240 m)




Long Trunk (4000 m)

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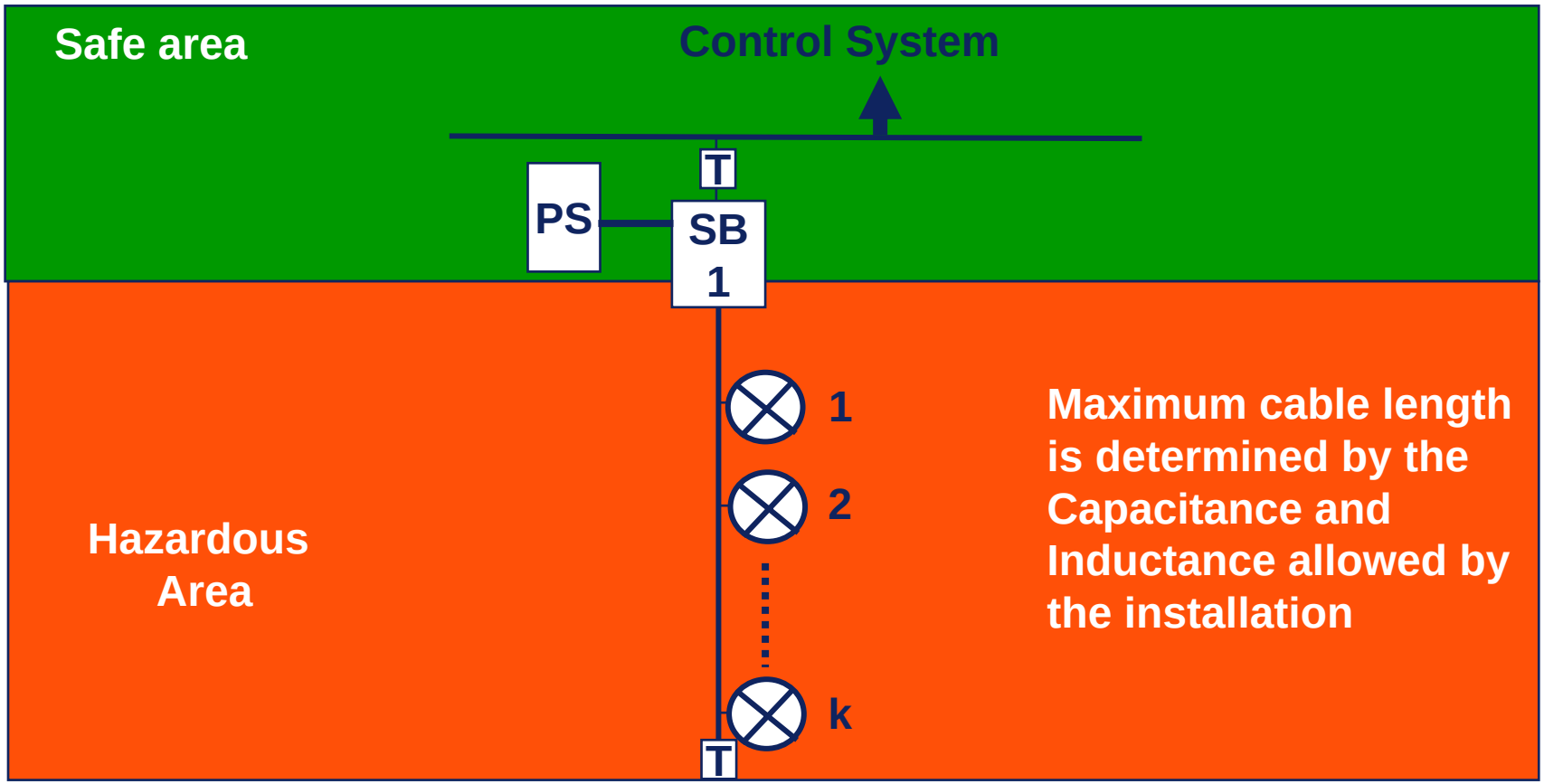
# Intrinsic Safety Installations




k - depends on the power consumption of the devices, Entity parameters and barrier

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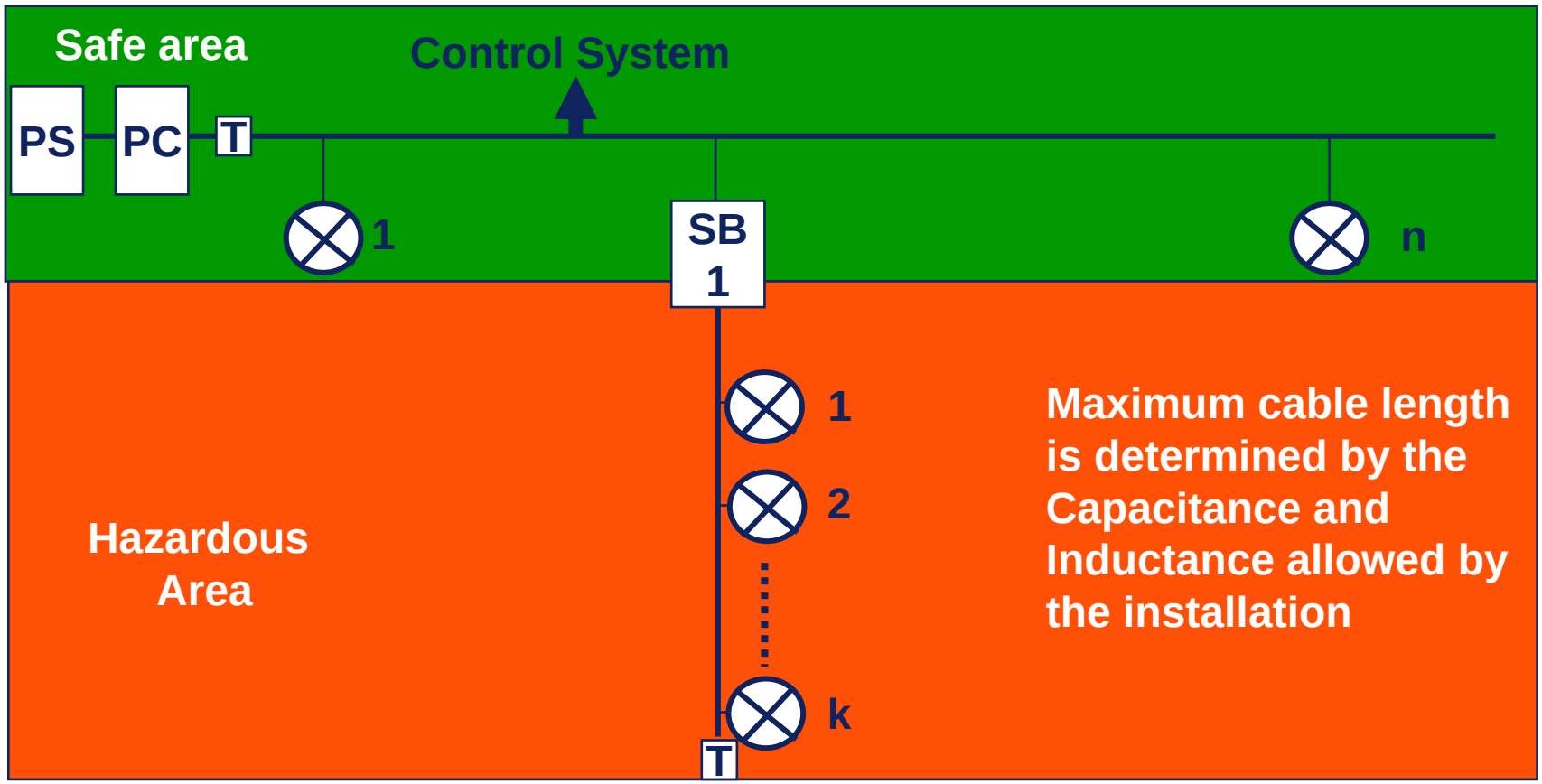
# Intrinsic Safety Installations




k - depends on the power consumption of the devices, Entity parameters and barrier

k+n < 16

Total cable length < 1900 m

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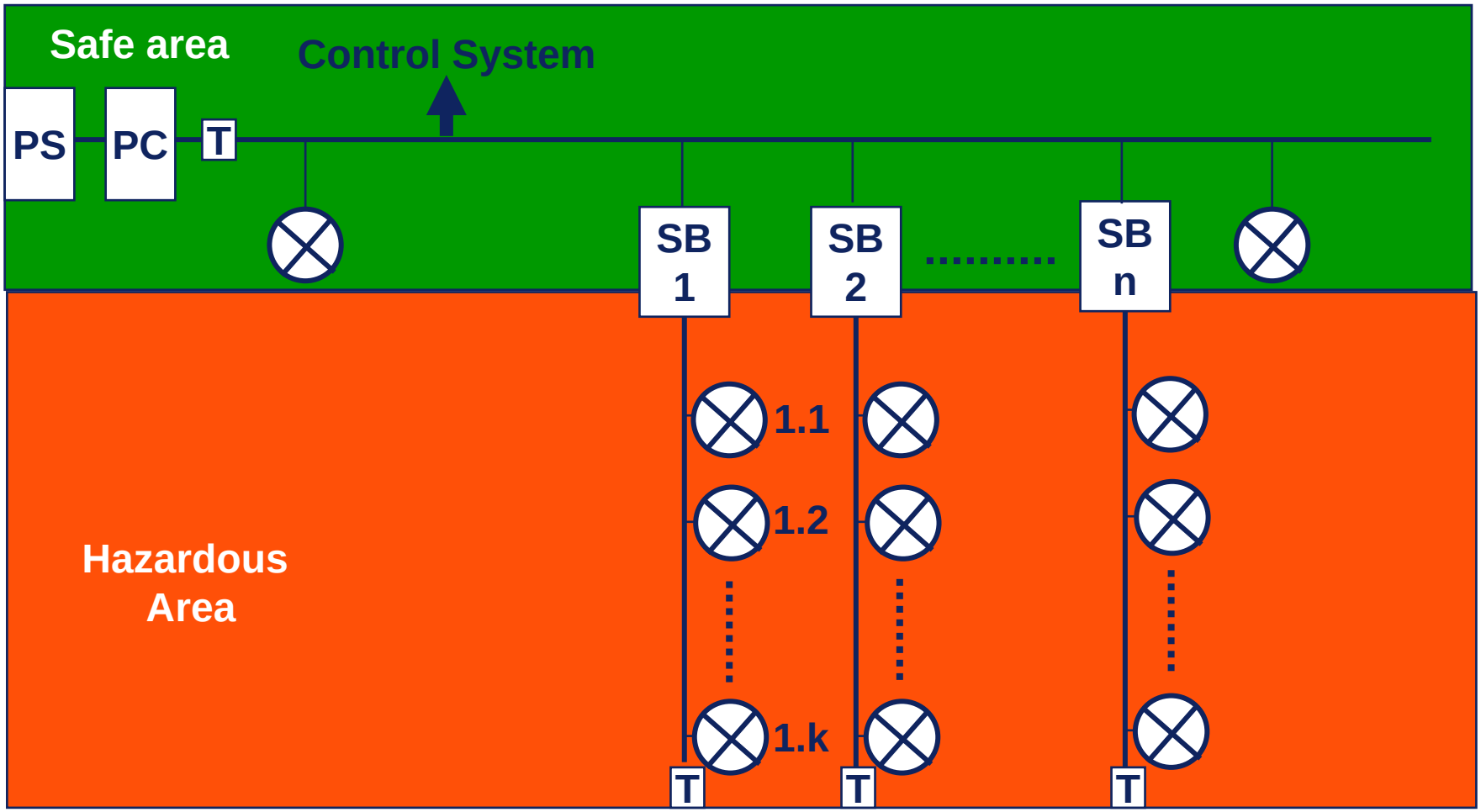
# *Intrinsic Safety Installations*




k - depends on the power consumption of the devices and cable length

n - depends on the barrier type and cable length

# Traditional Intrinsic Safety Installation (4-20 mA Analog / HART)

## 1 Measurement per I.S. Barrier

**Hazardous Area**

**Safe Area**

**Cable**
C/ft
L/ft

**I.S. Barrier**

**CONTROL ROOM EQUIPMENT**

**I.S. Transmitter**
Vmax
Imax
Pmax
Ci/Ceq
Li/Leq

Voc
Isc
Ca
La
Po = .25 x Voc x Isc

**Safety Assessment:**
**Vmax >= Voc**
**Imax >= Isc**
**Pmax >= Po**
**Ci + Ccable <= Ca**
**Li + Lcable <= La**

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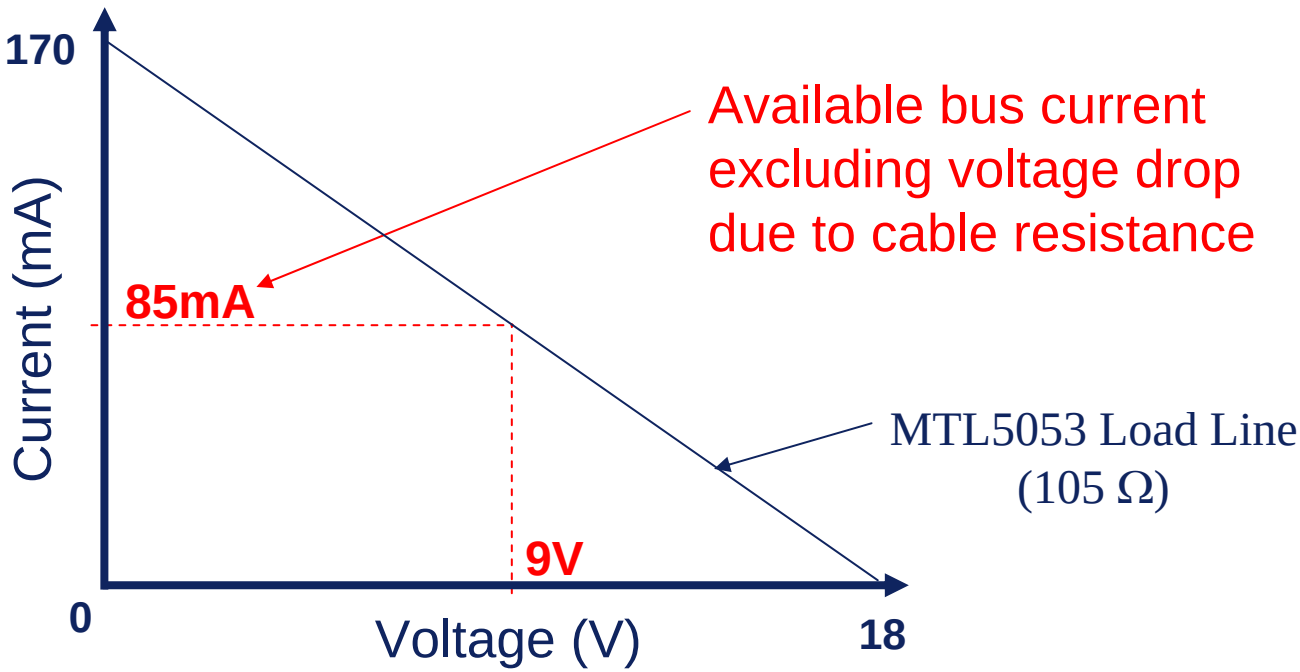
# Intrinsic Safety - Conventional Approach (Entity Model)

- What does it Mean ?
  - Using an MTL Barrier as an Example
  - More current = Less Volts

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# Intrinsic Safety - Conventional Approach (Entity Model)

- So How Much Current do the devices need ?
  - 3051
    - 17mA

X 2 = 34mA

  - 3244
    - 17mA

X 2 = 34mA

  - Communication Current Required
    - 10mA

= 10mA

78mA

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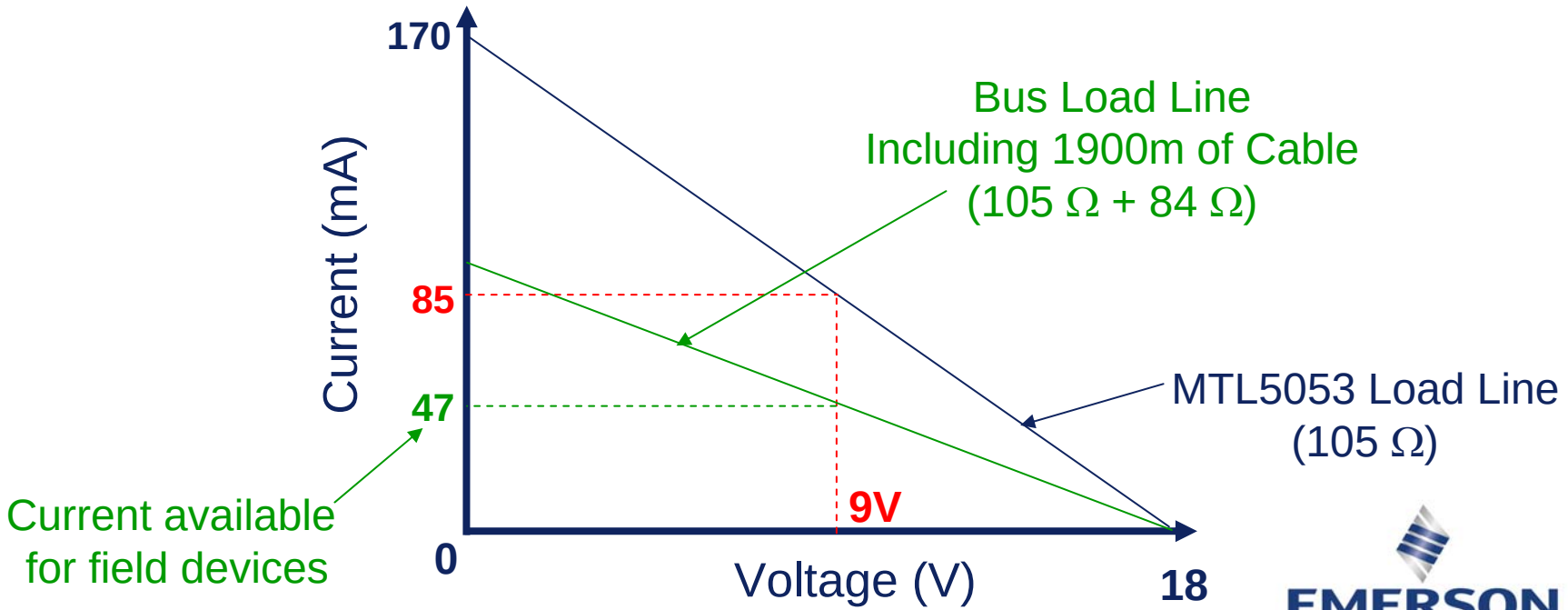
# Intrinsic Safety - Conventional Approach (Entity Model)

- What does it Mean ?
  - Using an MTL I.S. Fieldbus Power Supply as an Example
  - More current = Less Volts

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# The Entity Model - Cable Length and Quality

- The Calculation.
  - Current available =

MTL5053 = 18V

Tx Minimum Lift off voltage

$$\frac{\text{(Open Circuit Output Voltage of the Power Supply) - 9Volts}}{\text{(Source Resistance of the Barrier) + (Fieldbus Cable Loop Resistance)}}$$

MTL5053 = 105 Ohms

1900m = 84 Ω

The Main Issue

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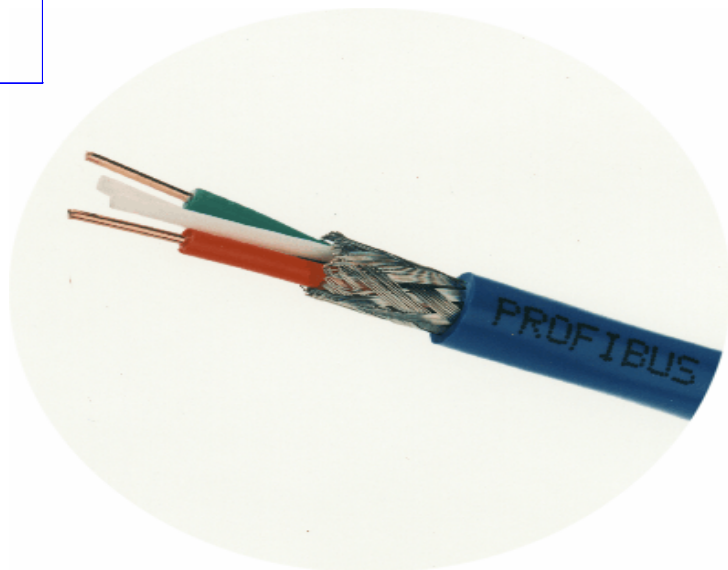
# What types of Wire

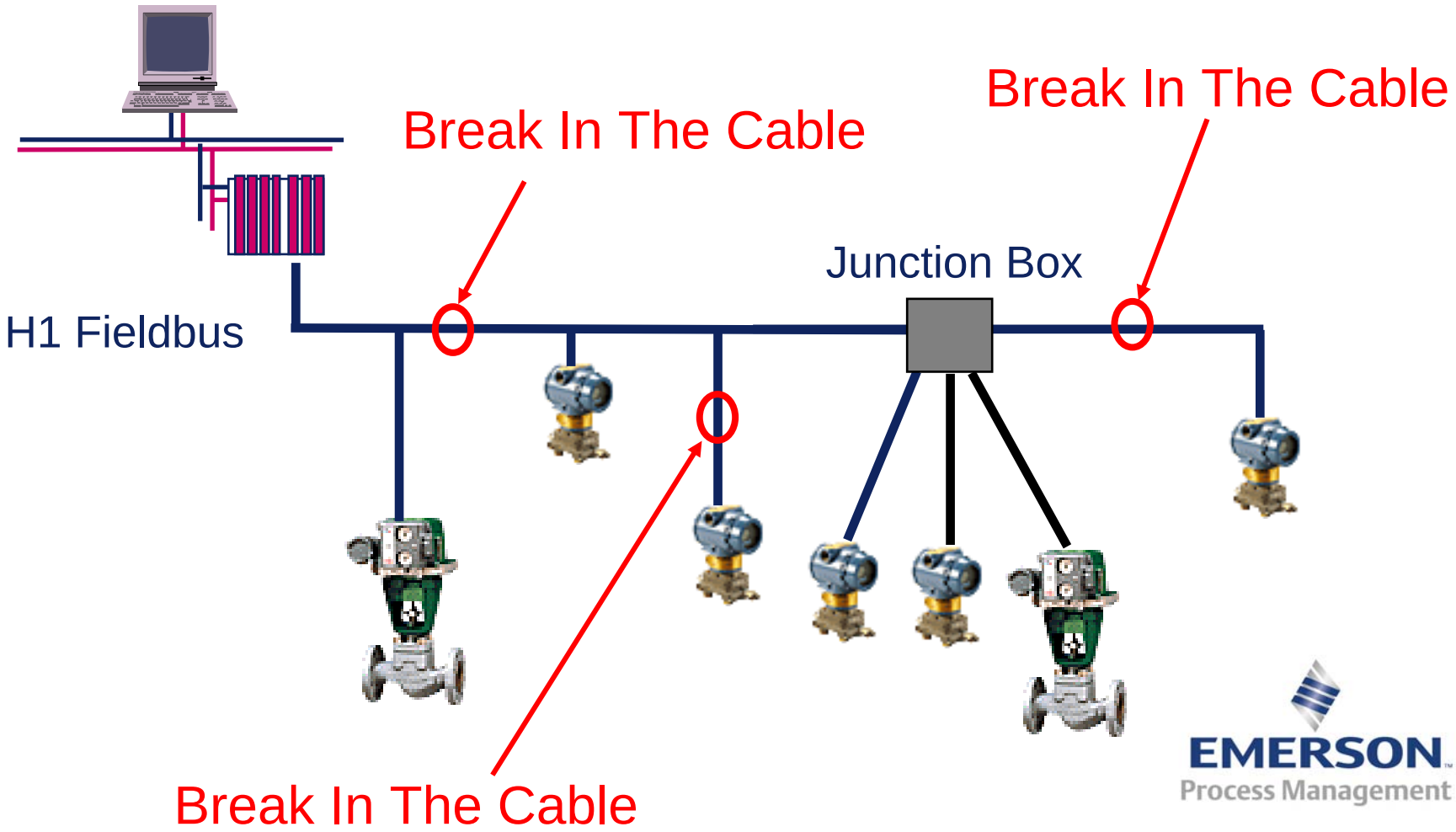
## "Typical" Length Restrictions With Existing Wire

| Type | Description | Size | Max Length |
|---|---|---|---|
| A | Shielded, Twisted Pair | #18 AWG (.8 $mm^2$) | 1900 m (6232 ft.) |
| B | Multiple-Twisted-Pair with Shield | #22 AWG (.32 $mm^2$) | 1200 m (3963 ft.) |
| C | Multi-Twisted-Pair Without Shield | #26 AWG (.13 $mm^2$) | 400 m (1312 ft.) |
| D | Multi-core, w/o Twisted Pairs and Having Overall Shield | #16 AWG (1.25 $mm^2$) | 200 m (656 ft.) |



# Entity Model Point Failure

Assumes that **ALL** the Electrical Characteristics Manifest themselves at the Cable Break

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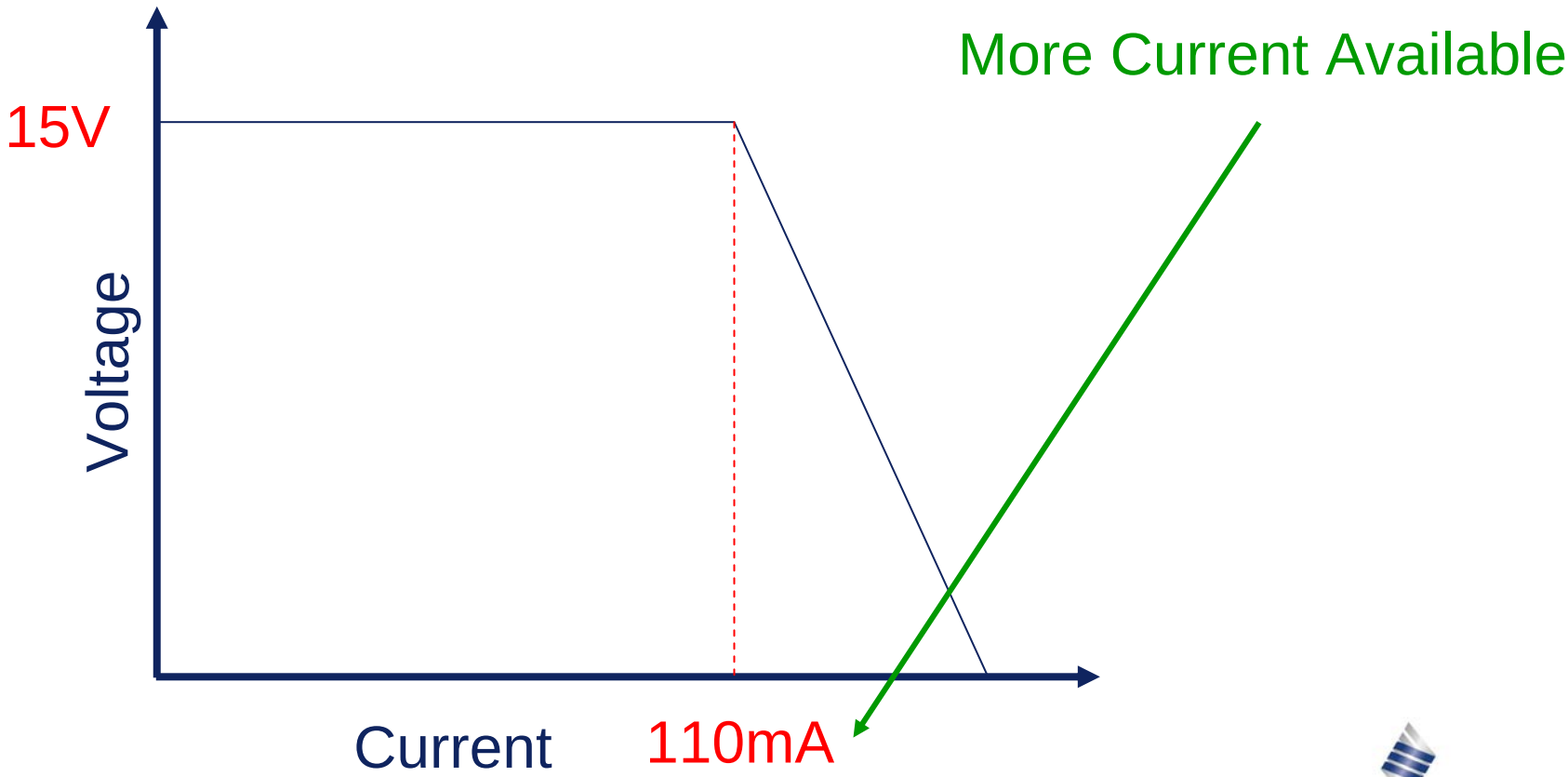
# Intrinsic Safety - FISCO Approach

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# Intrinsic Safety - FISCO Approach

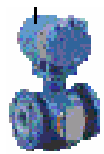
- So How Much Current do the devices need ?
  - 3051
    - 17mA

X 3 = 51mA

  - 3244
    - 17m

X 2 = 34mA

  - 8742C
    - 12mA



X 1 = 12mA

  - Communication Current Required
    - 10mA

= 10mA

107mA

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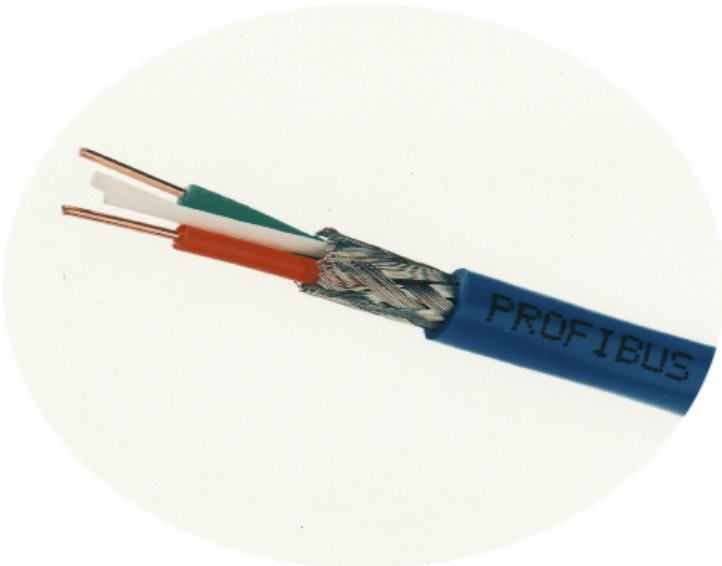
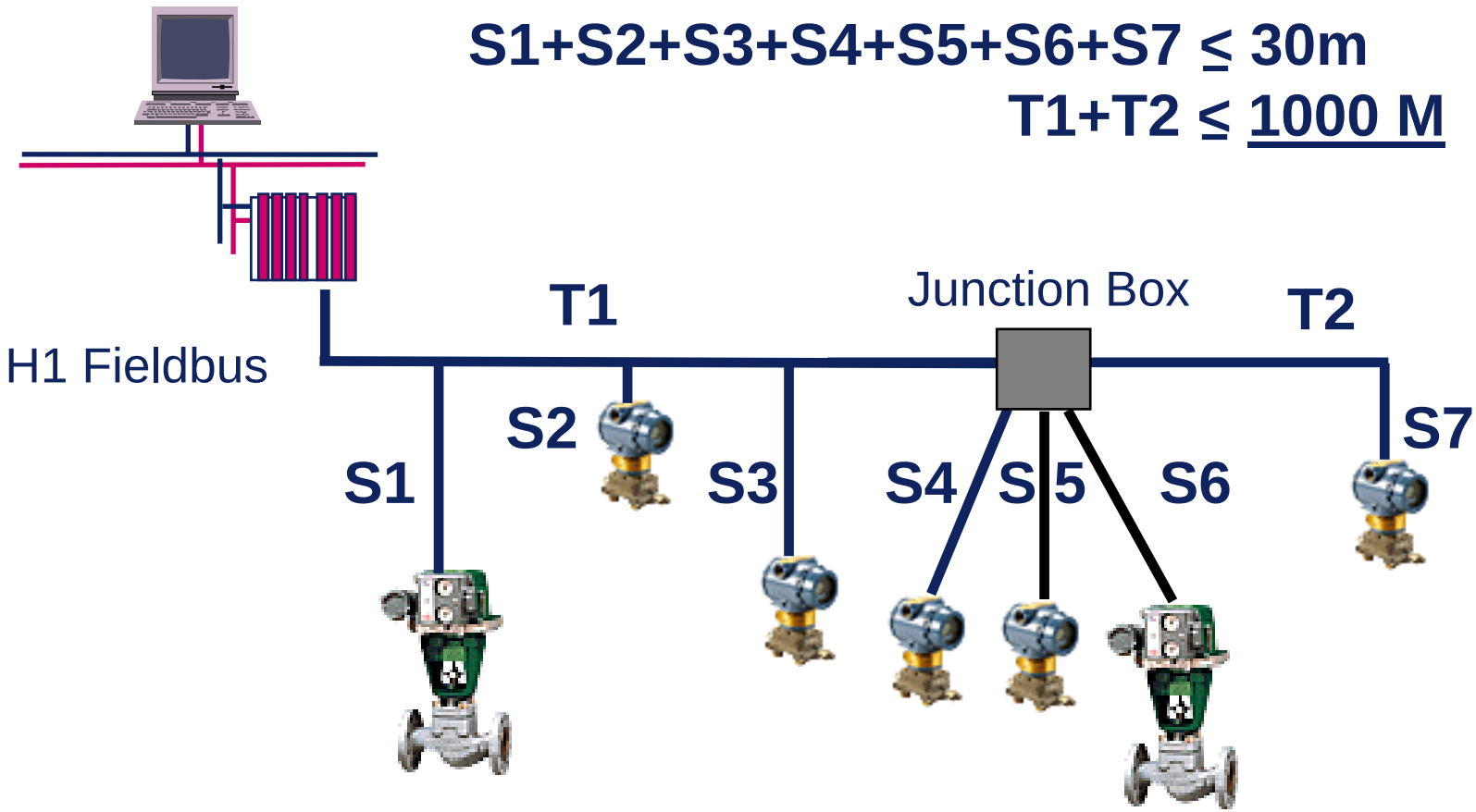
# FISCO - What types of Wire

- Cable parameters
  - Loop resistance 15 to 150 ohms / km
  - Inductance per unit length 0.4 to 1mH / km
  - Capacitance per unit length 80 to 200nF
- Length of cable
  - Trunk up to 1000 m
  - Spur up to 30m
  - Splice up to 1m



# FISCO - Rules and Capacities

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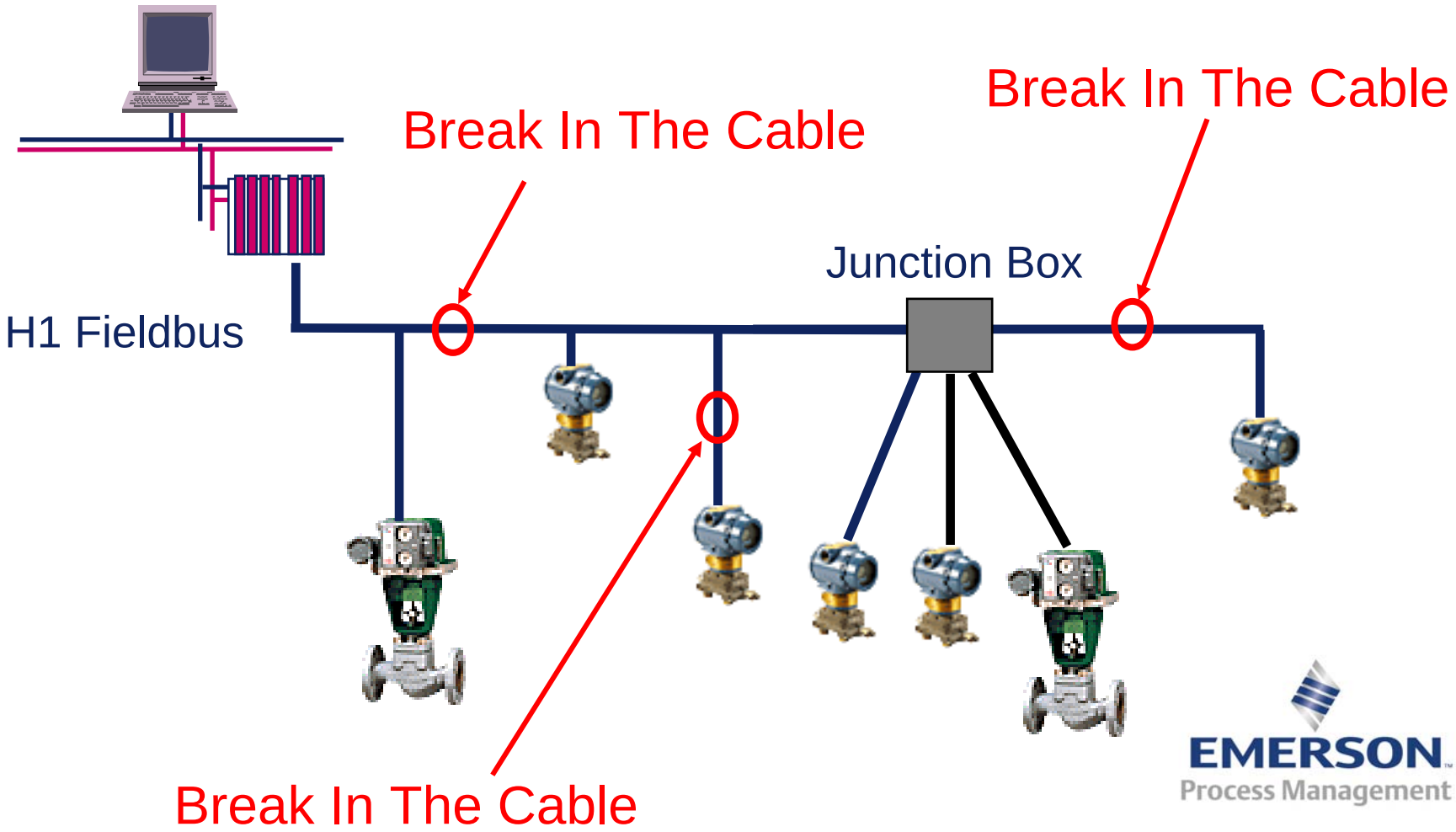
# FISCO - Point Failure

Assumes that the Electrical Characteristics are Distributed around the Segment

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# *Summary - What do they have in Common ?*

- Only one source of power applied to the fieldbus segment
- Field devices designed to contribute no energy to the bus (whether transmitting or receiving)
- Each device has small permitted effective internal inductance and capacitance (similar maximum values defined in both approaches)
- Bus segment terminated at both ends (terminator is resistor-capacitor series combination)

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# Summary - What are the Differences ?

- **Entity Model**
  - Linear (resistively limited) power supply characteristic
  - Power supply approval defines max. system C and L values, and therefore bus cable limitations
  - Bus power defined as 1.2W max. at 60ºC, to simplify device approval
  - Current available for devices: 60mA on 1900m bus, 90mA on short bus (using Type 'A' cable) on IIC or IIB systems
  - Typically 4 (20mA) devices on IS bus segment - in any gas group

- **FISCO**
  - Square or trapezoidal power supply characteristic
  - Power supply approved without max. C and L values, allowing bus length up to 1km with a variety of cable types
  - Higher power supplied to bus: up to 1.9W in IIC (Groups A & B) and 4.9W in IIB (Group C) systems. Each device must be approved compatible with this power.
  - Current available for devices: 110mA for IIC, greater for IIB systems
  - Typically 6 (20mA) devices on IS bus in IIC, 10 devices in IIB gas group

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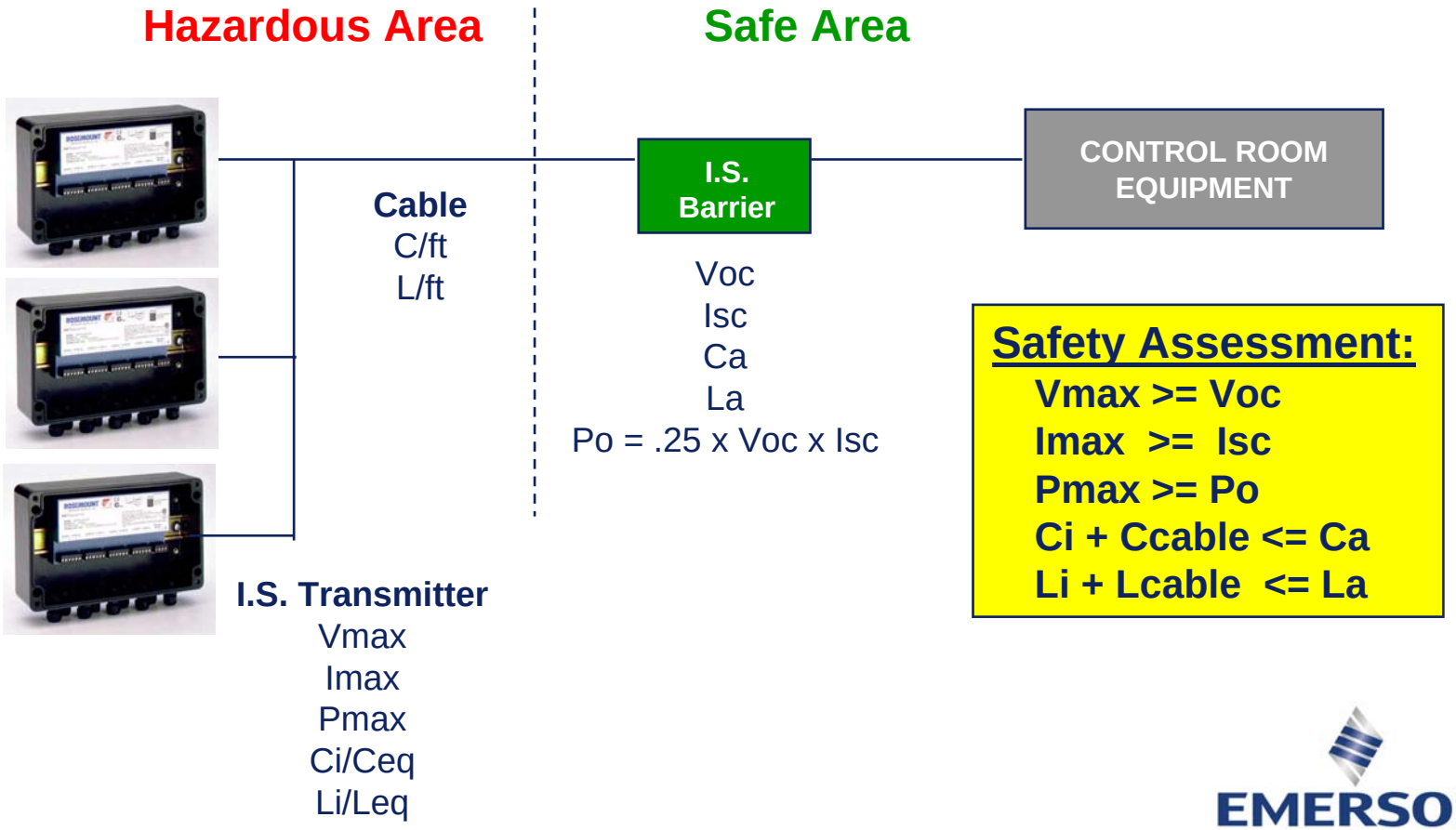
# Intrinsic Safety
# - Conventional Approach (Entity Model)

## 24 Measurements per I.S. Barrier

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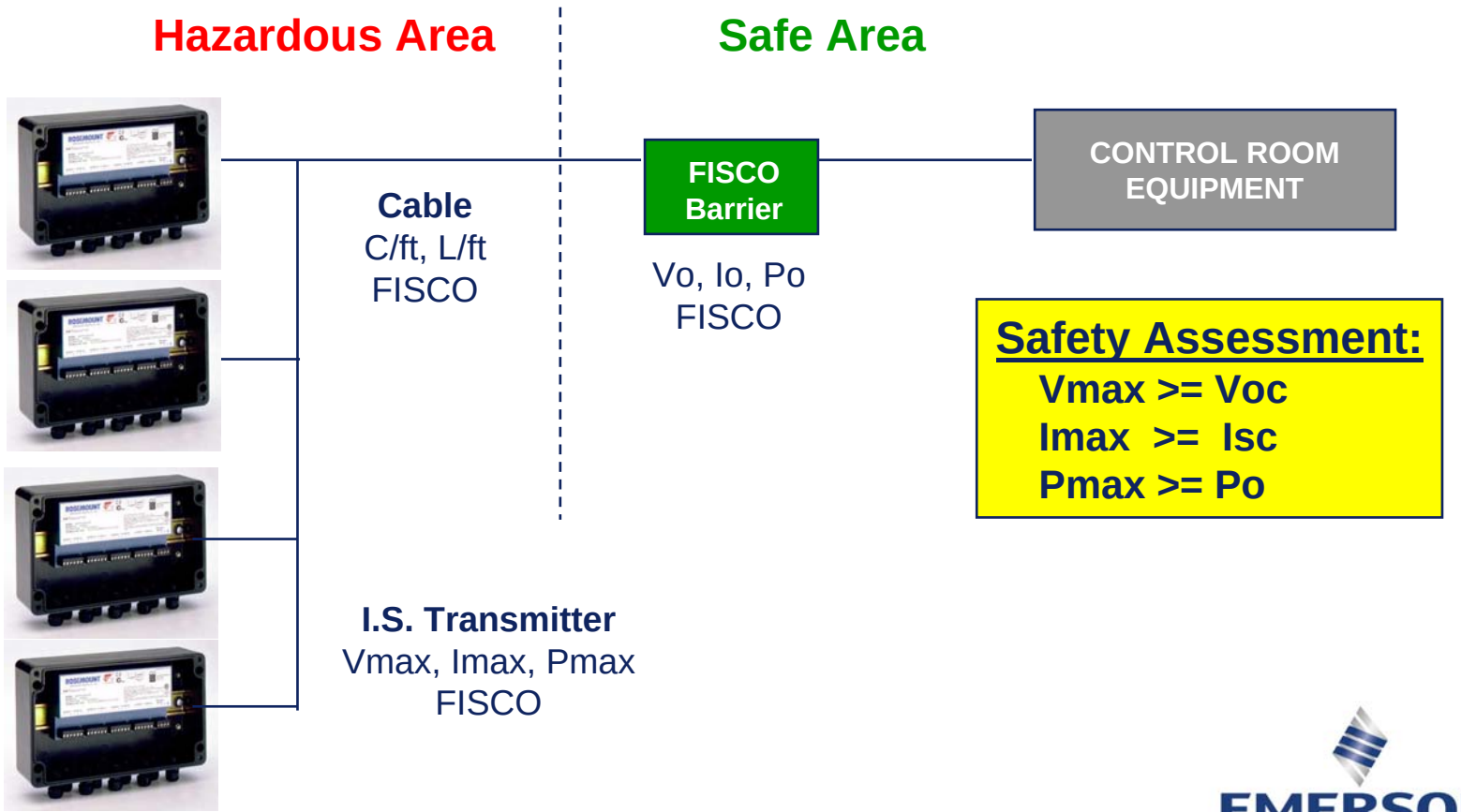
# Intrinsic Safety - FISCO Approach

## 32 Measurements per FISCO Barrier

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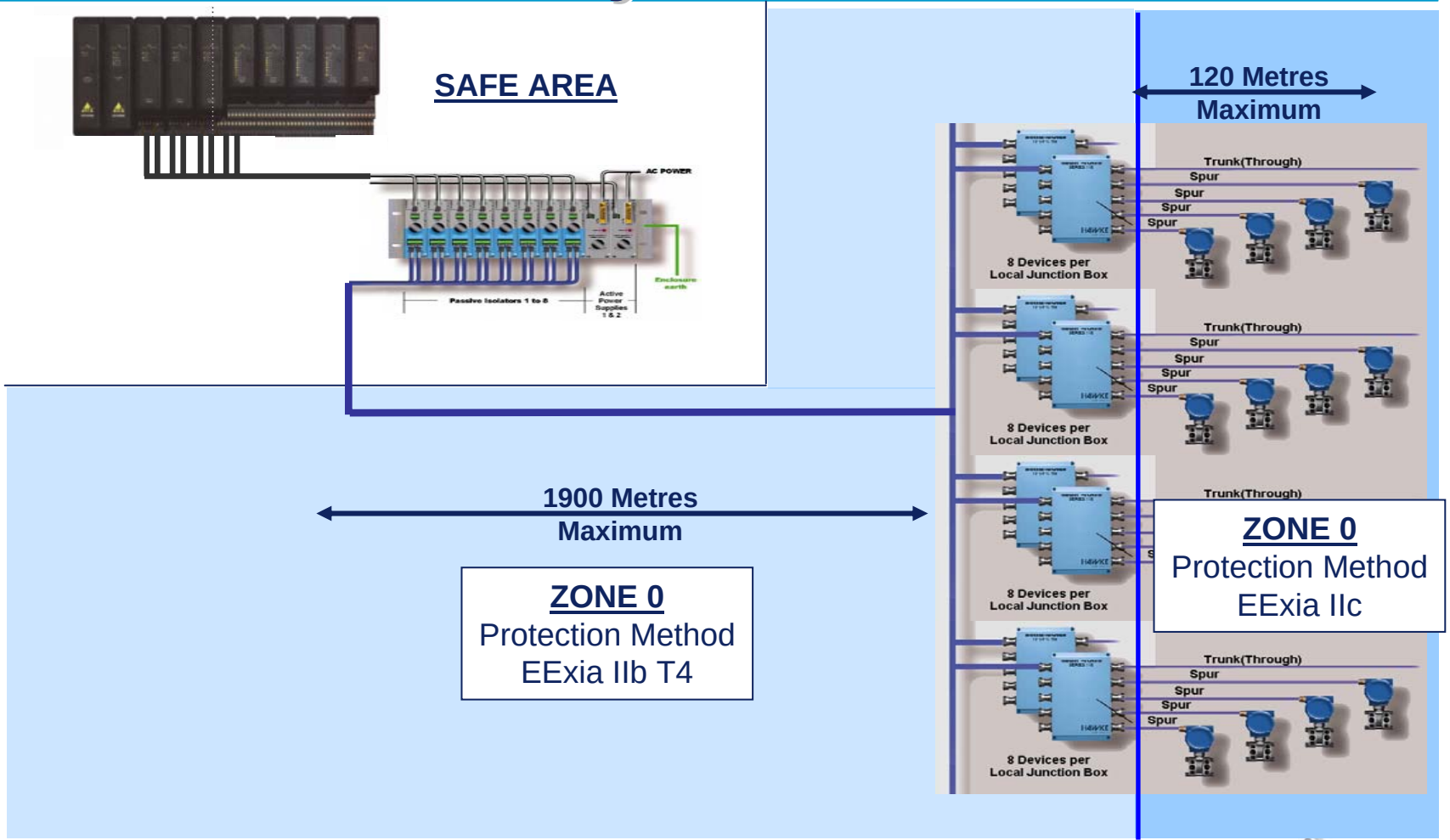
# Hawke Intrinsically Safe Installation

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# Choose Components For Reliability

- Physical Installation – Wiring, connectors, grounding, shielding
  - Short Circuit Protection
- Power for Fieldbus
  - Redundant Power Conditioners
  - Isolated Power
- Control System Interface
  - Redundant H1 Cards
  - Diagnostics, communication statistics
- Devices Design and Functionality
  - Watchdog timer, Anti-jabber
  - Diagnostics and Mode Shedding
  - Failsafe mode
  - Backup Link Active Scheduling Capability

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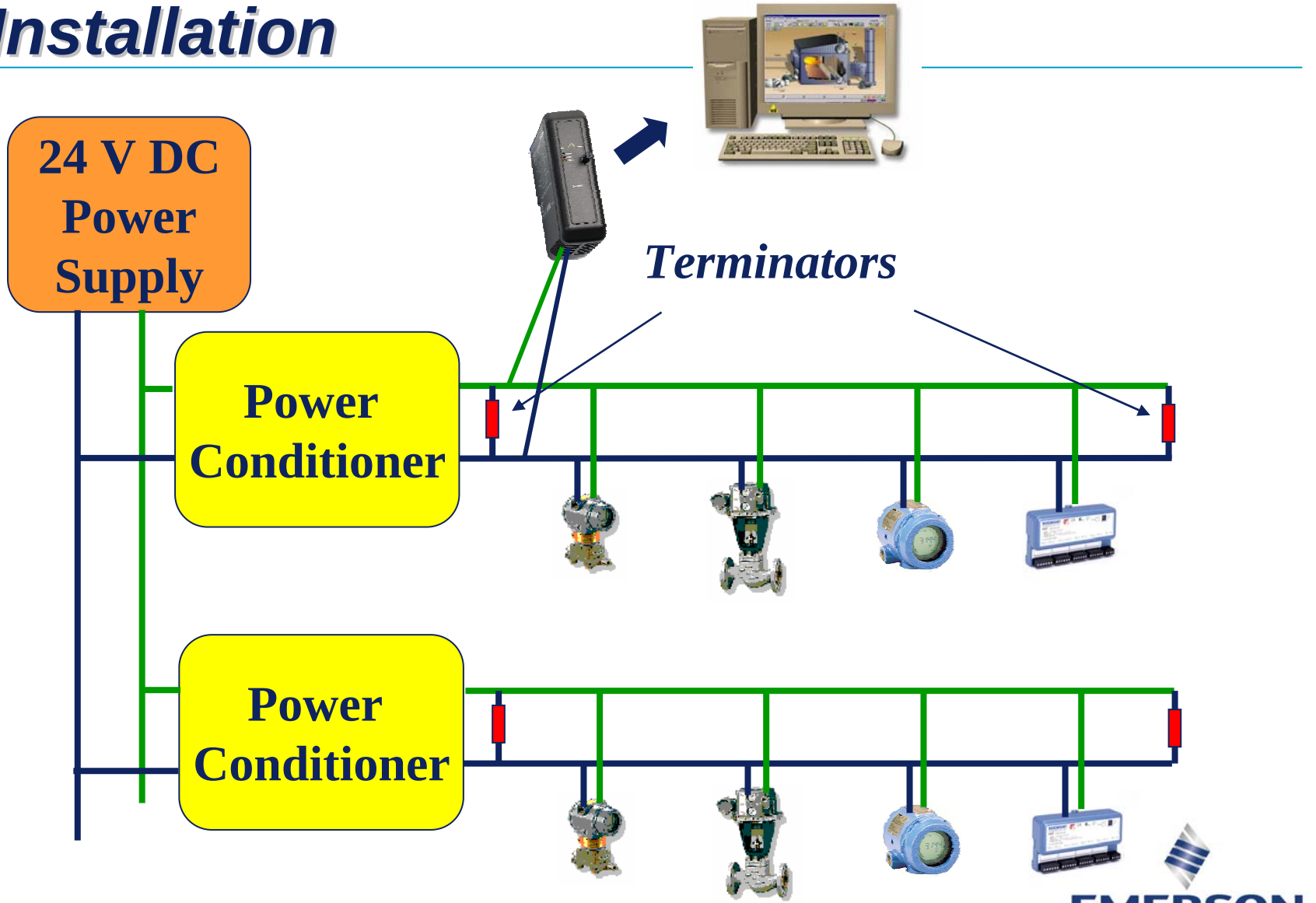
# Installation

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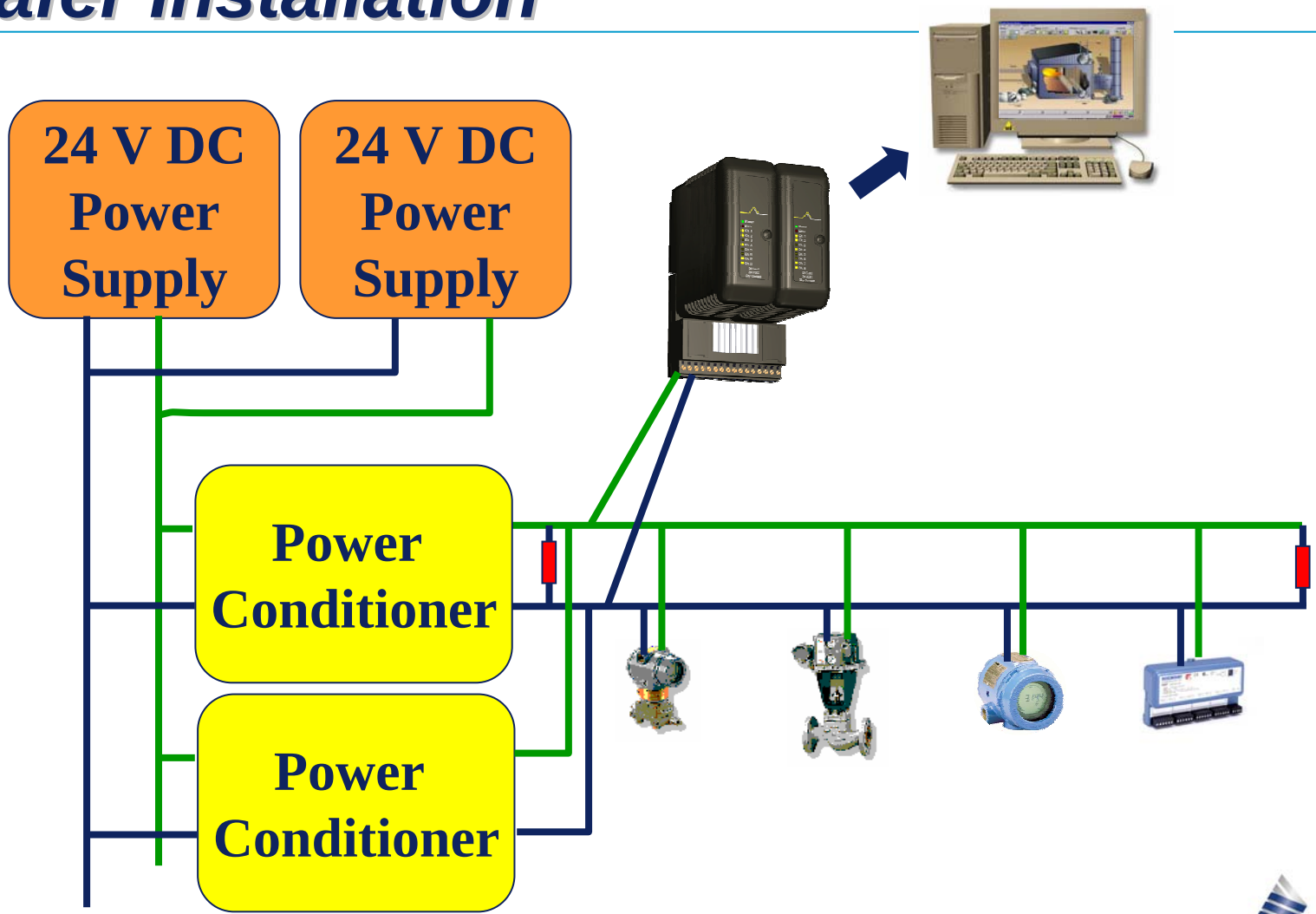
# Safer Installation

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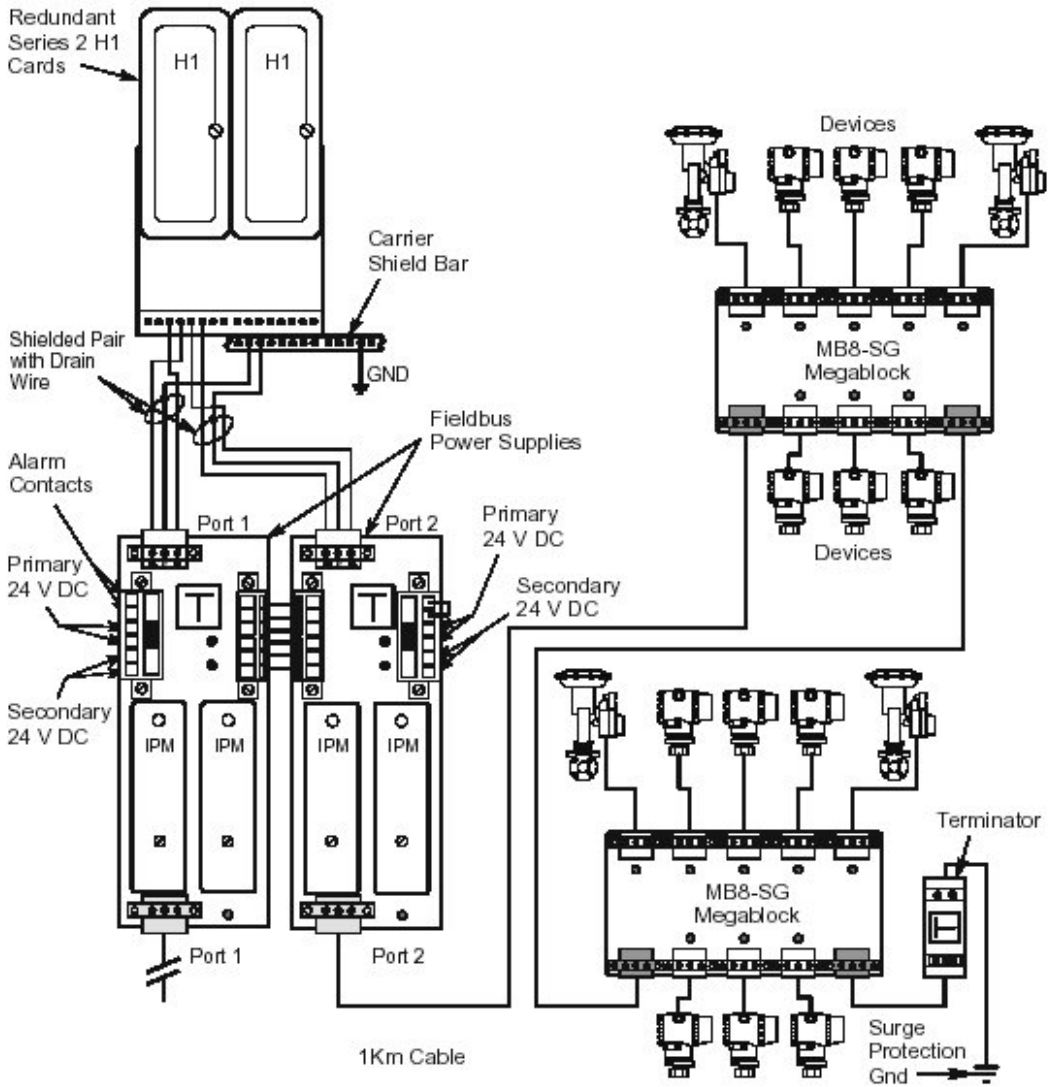
# High Availability System Design

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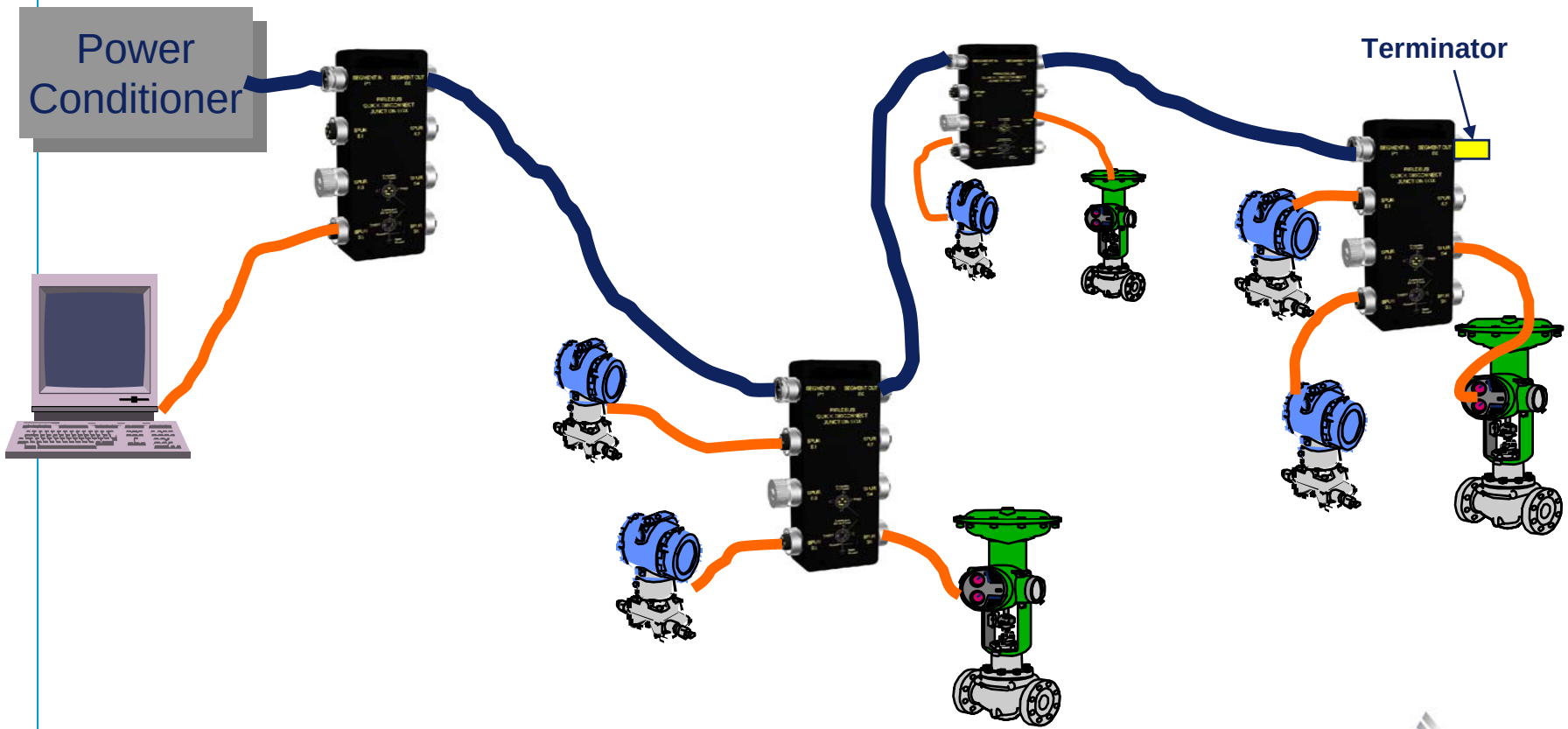
# Installation Cost Reduced By Brick and T's

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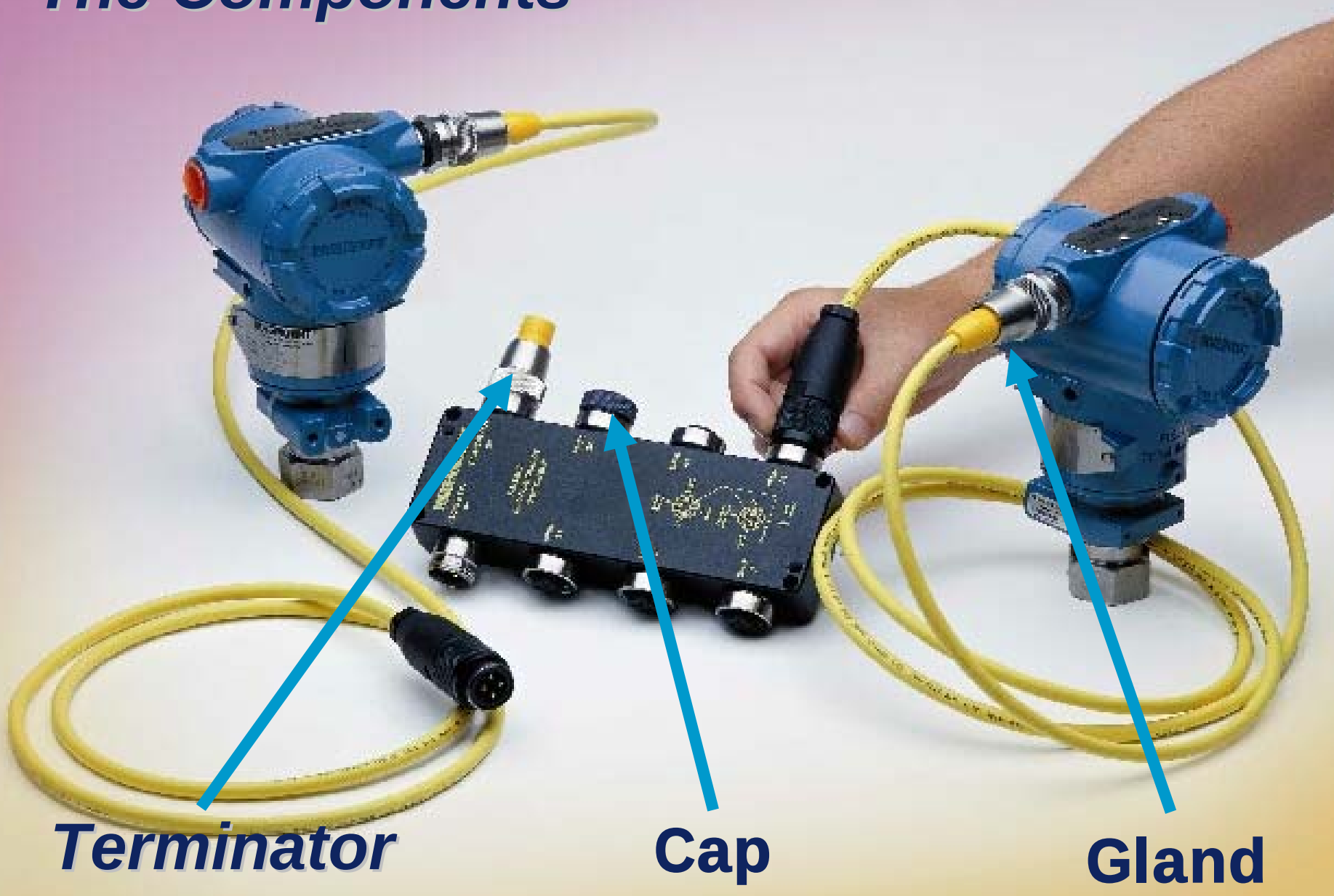
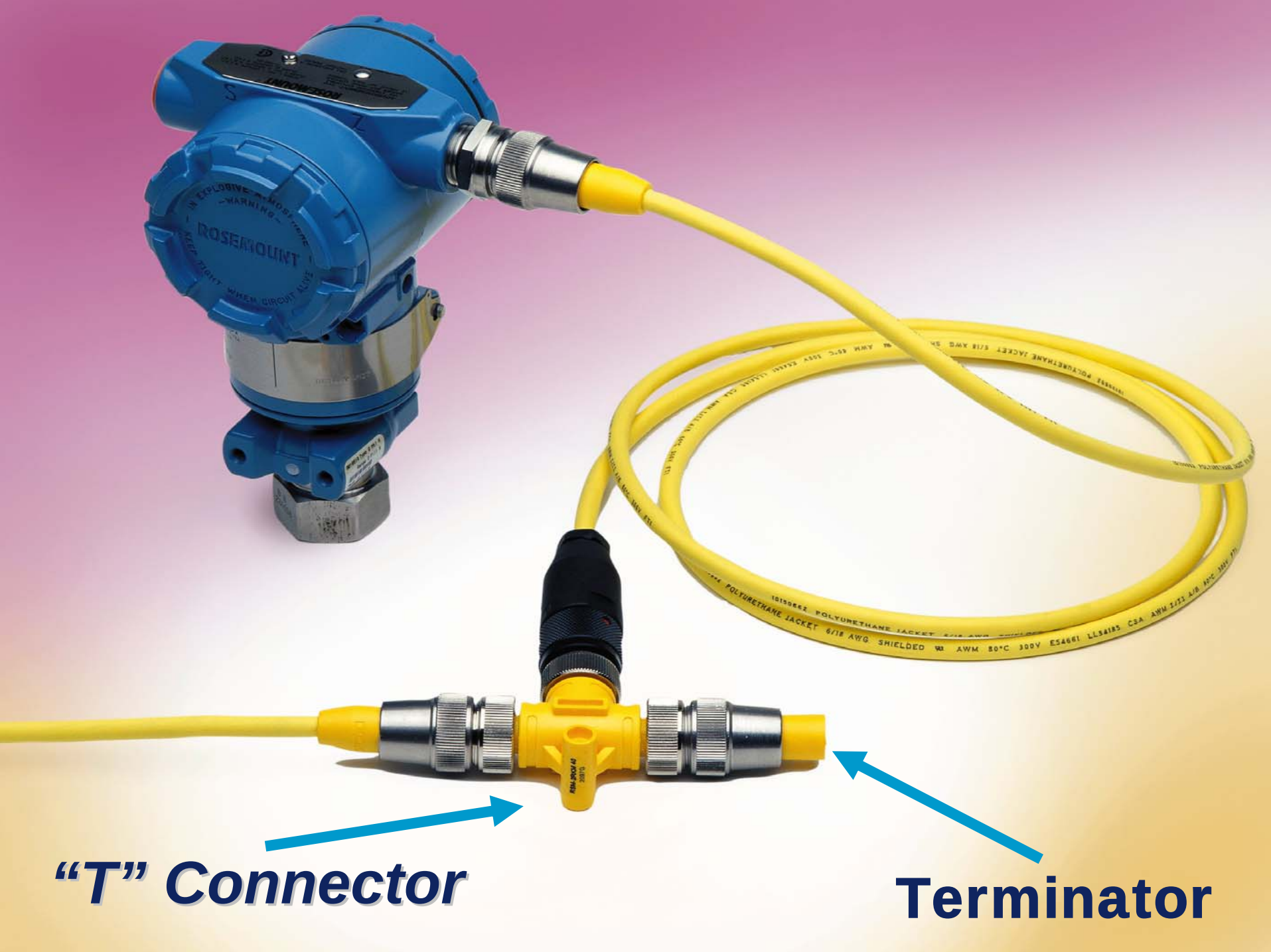
# Quick connection Junction Boxes

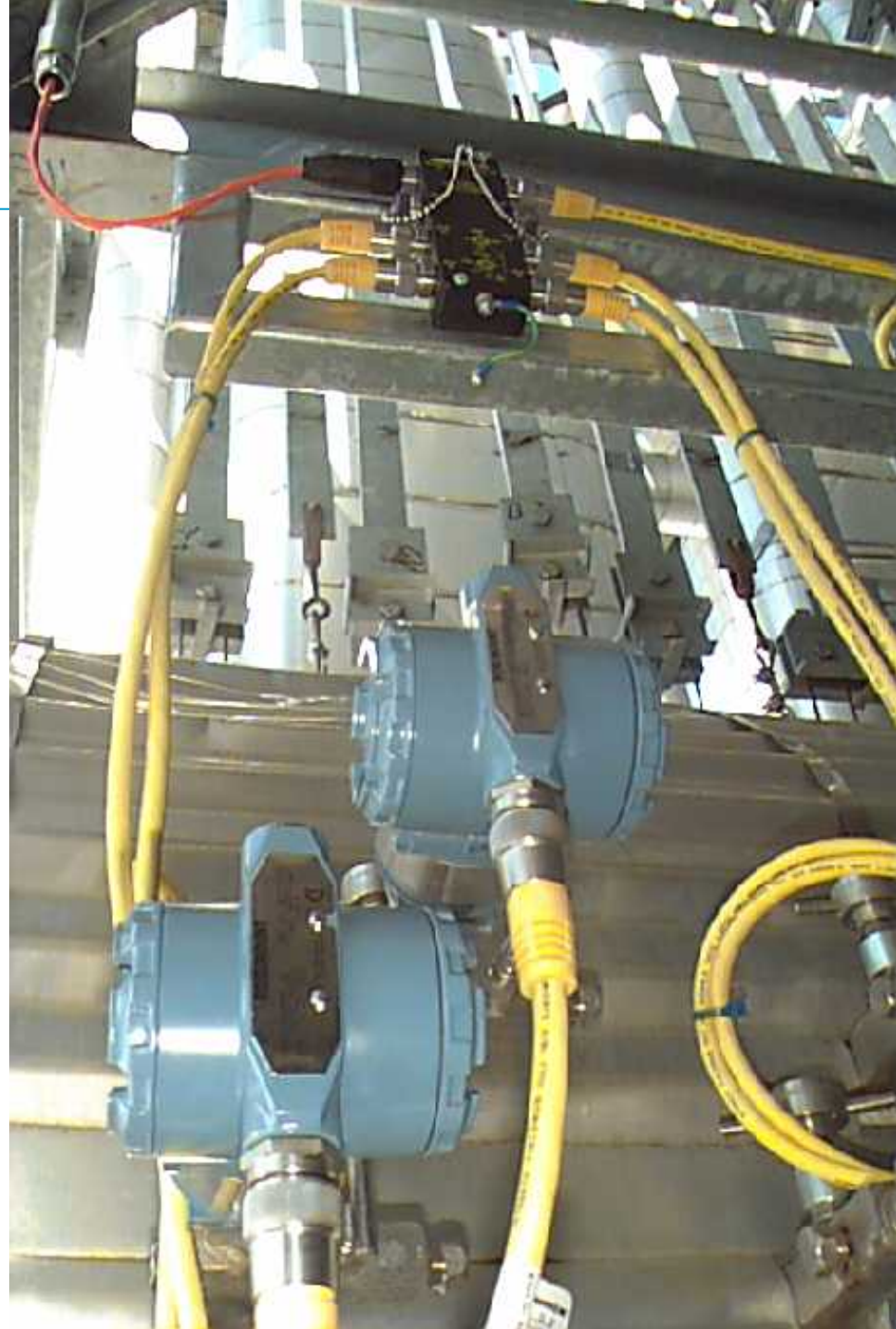
# The Components



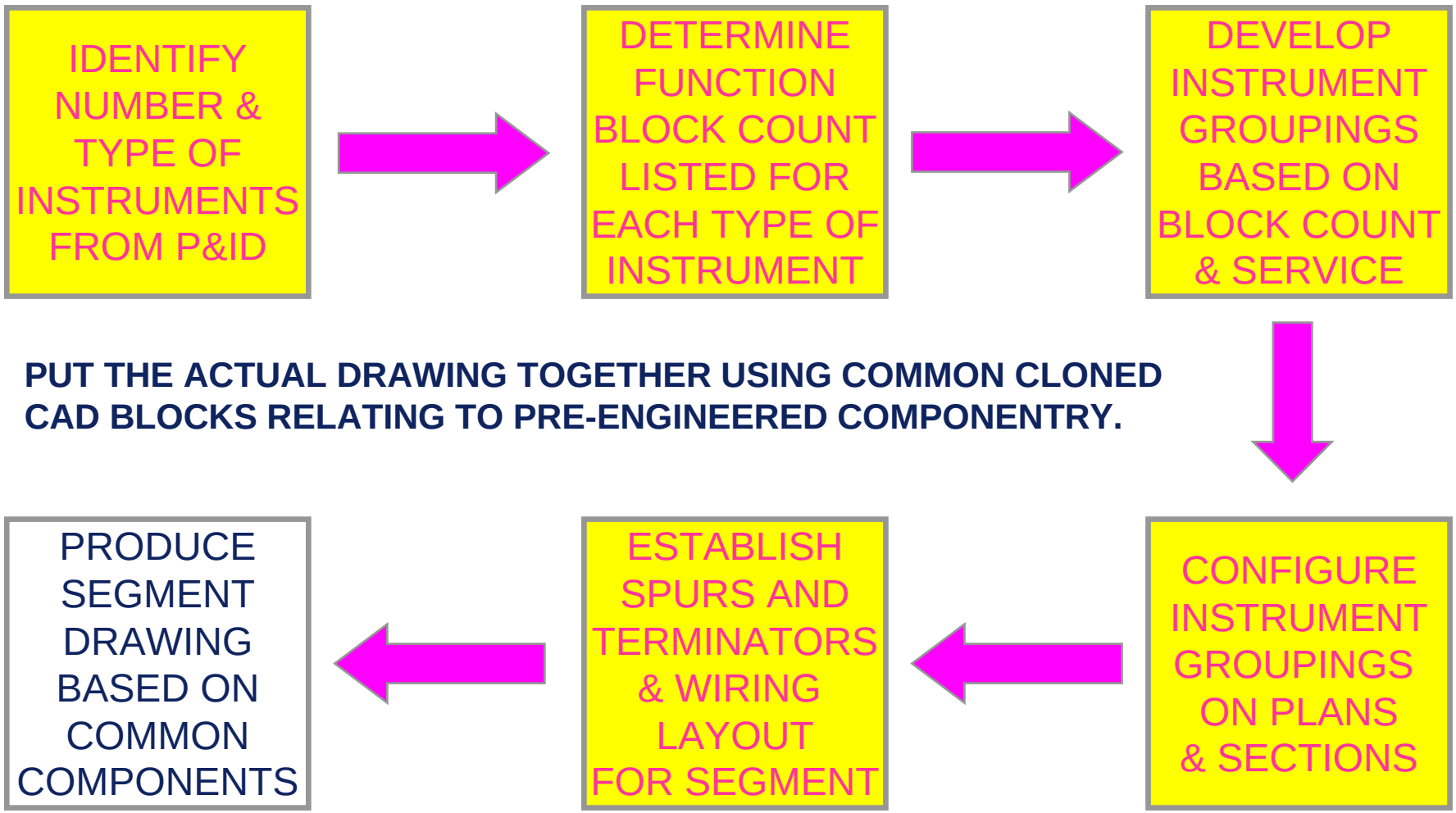

ROSEMOUNT
POLYURETHANE JACKET 6/18 AWG SHIELDED AWM 80°C 300V E54661 LL54185 CSA
"T" Connector
Terminator

# Typical Installation

# Typical Installation



# SIX STEPS TO A SUCCESSFUL DESIGN



# A SEGMENT DRAWING CAN DOCUMENT AN ENTIRE SECTION OF PLANT

Cloned CAD Blocks

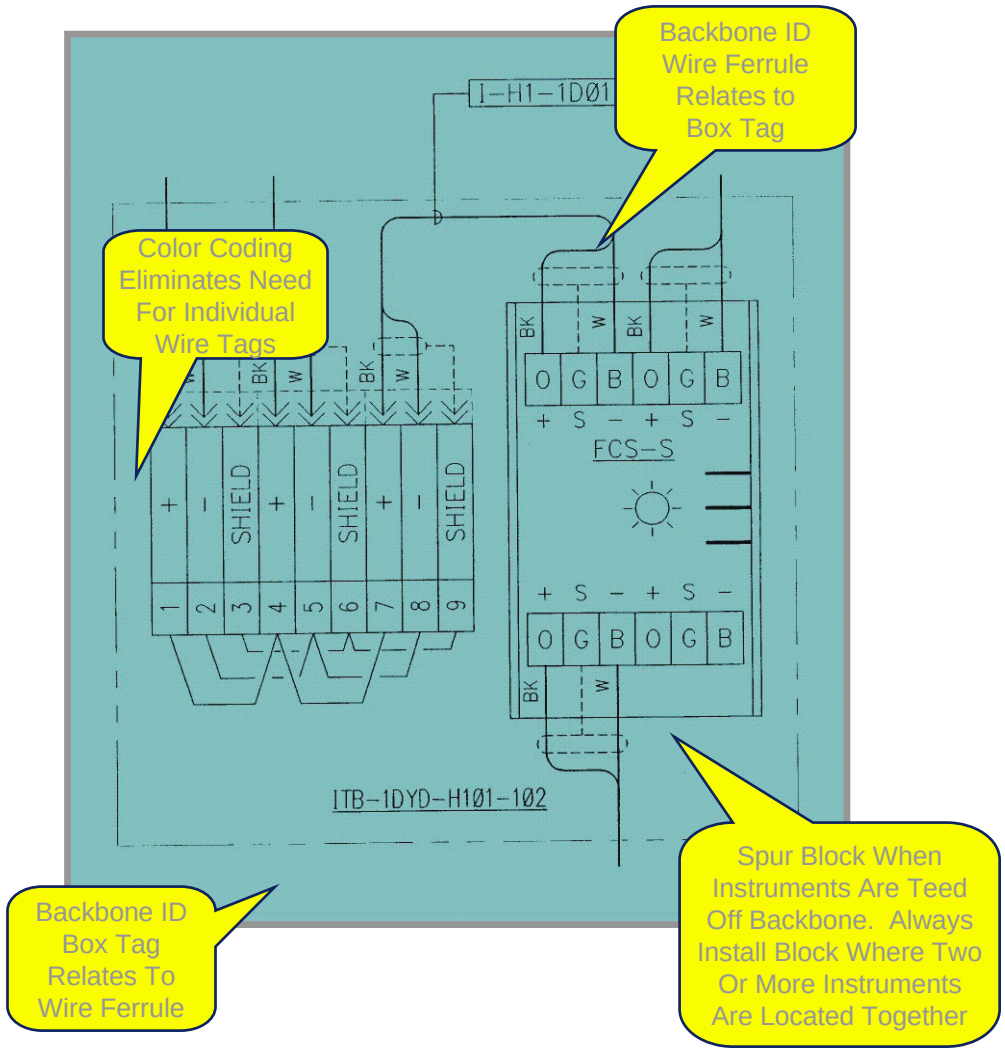
Cobbled Together

Allow Segment

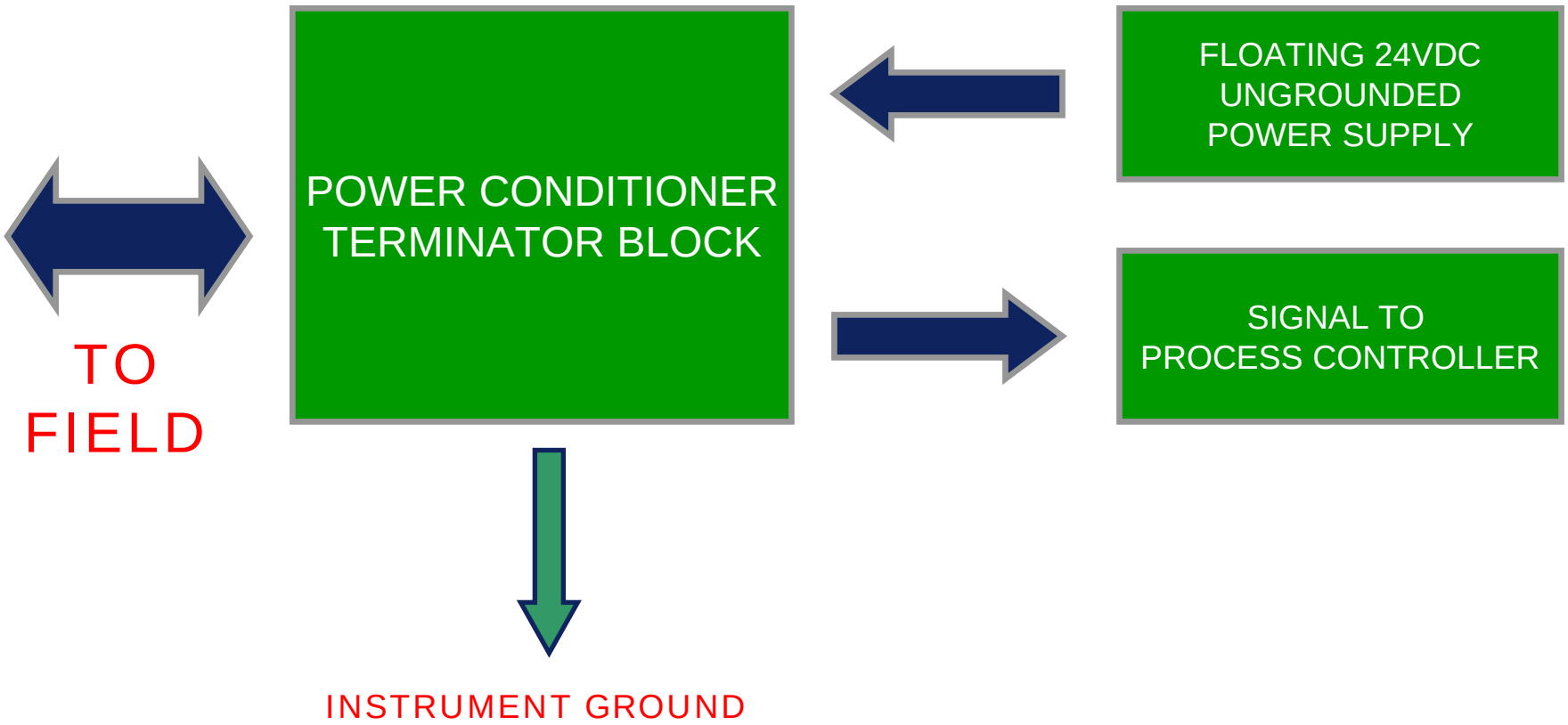
Drawings To Be

Assembled Quickly and Easily

(BOTH LOOPS AND CONNECTION DRAWINGS REPLACED BY ONE SEGMENT DRAWING)



# INSTRUMENT PANEL "FRONT END"

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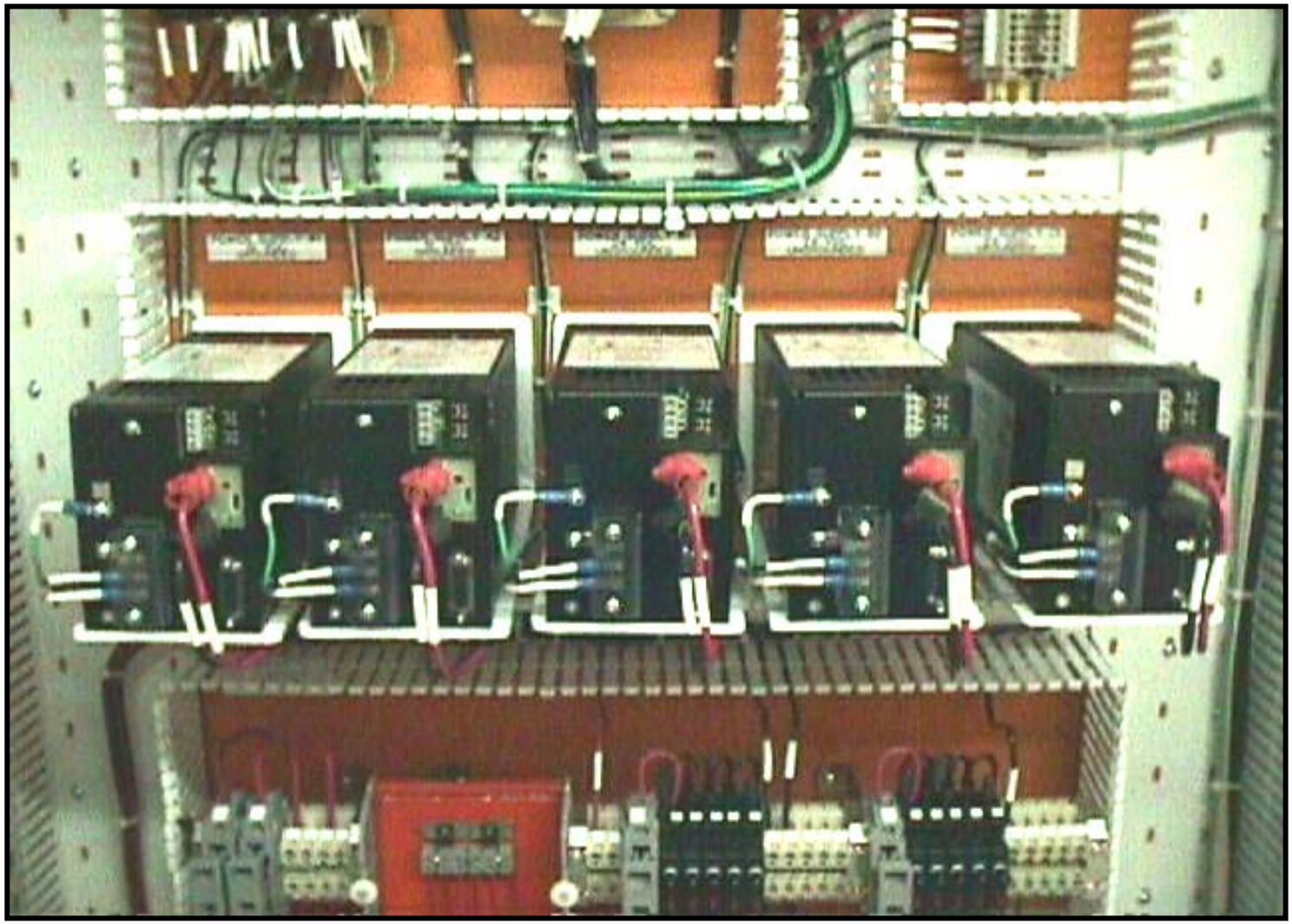
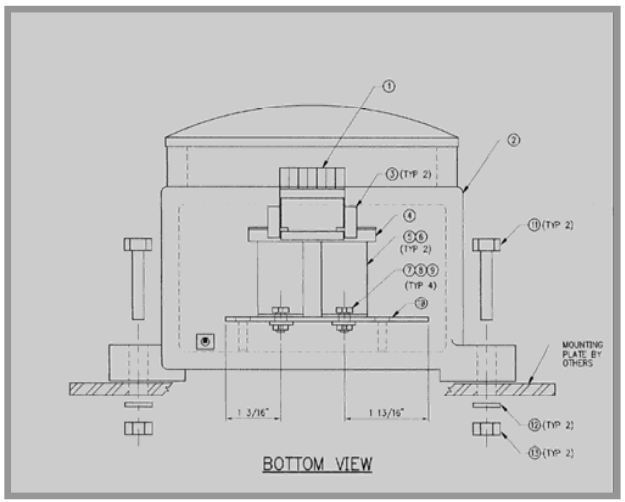
# “FRONT END” POWER CONDITIONERS

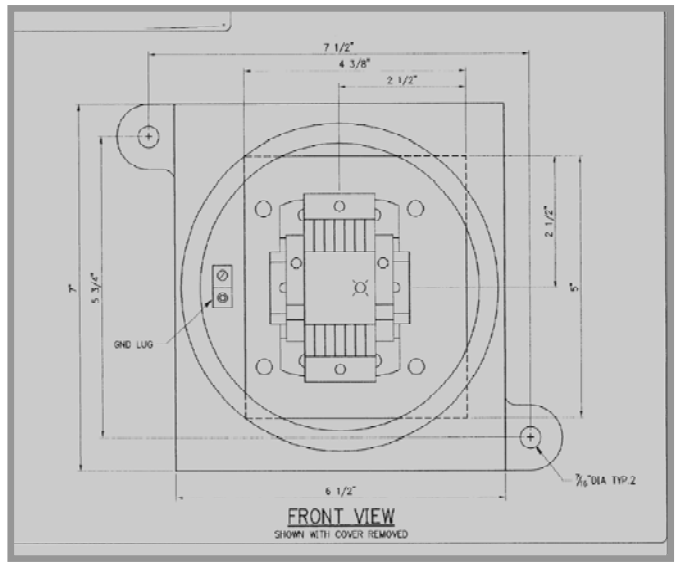
# “FRONT END” FLOATING SEGMENT POWER SUPPLY



# *SUPPORTING DRAWINGS*

## A FEW PRE-ENGINEERED ELEMENTS THAT RELATE TO THE PHYSICAL INSTALLATION SUPPORT THE SEGMENT DRAWING




TYPICAL SPUR ITB

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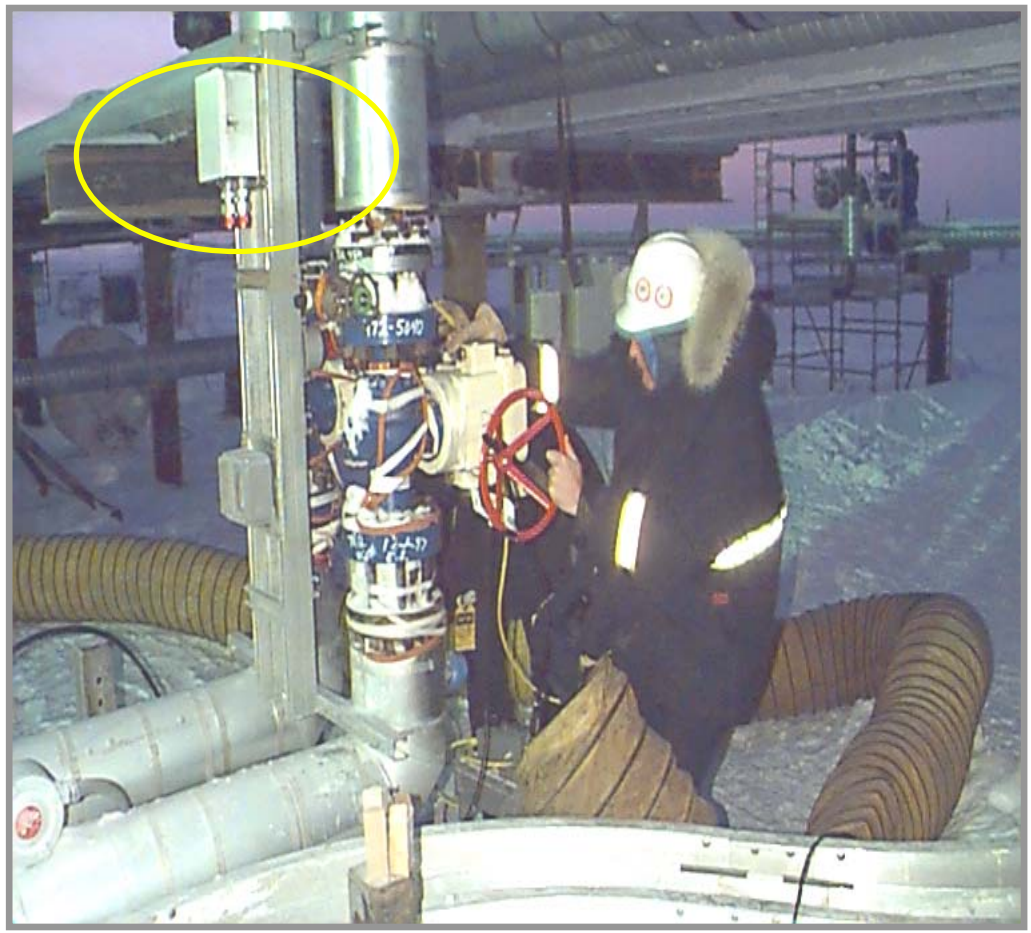
# FIELD INSTALLATION MADE UP OF PRE-ASSSEMBLED ELEMENTS

Prefabricated Components Allow For Minimal Documentation



WE USED “MC-HL” FIELDBUS CABLE

# *FASTER ENGINEERING, FASTER DESIGN* AND -- *MUCH FASTER INSTALLATION*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# Automatic Address Assignment

- Devices may be connected to the bus with the same permanent default address.
- A configuration utility in the host assigns an unused valid address to each device.

- This feature allows fast and safe commissioning of the Fieldbus Network!
- No dip switches, no pre-configuration.

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# Checkout of Fieldbus Wiring

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# Required Equipment

- Battery Powered Digital Volt-Ohm Meter
- Battery Powered Scope
- Signal Generator

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# Systematic Approach

- Don’t Rush

- Follow Procedures
  - Grounding Checks
  - Proper Voltages
  - Terminators Functioning

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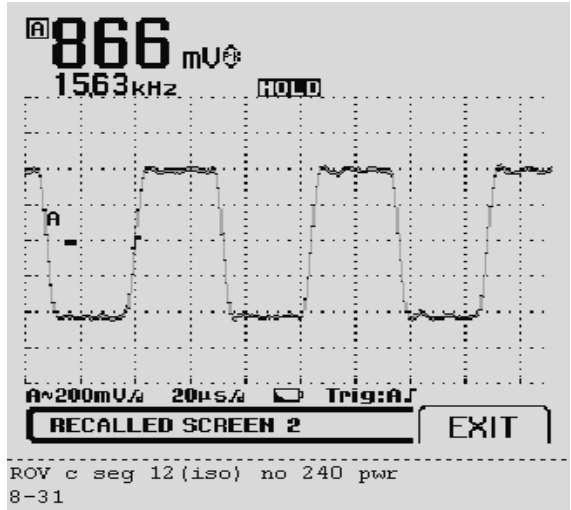
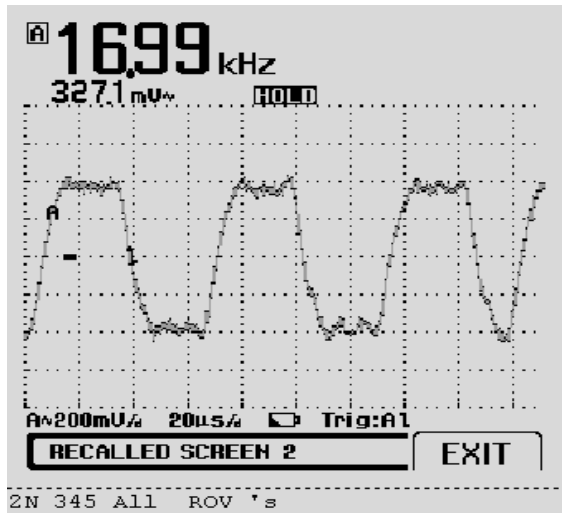
# Verify Results

- Don’t Rush!
- Be Consistent
  - Terminology
  - Procedures
  - Troubleshooting
  - Initial Checkout
  - Training

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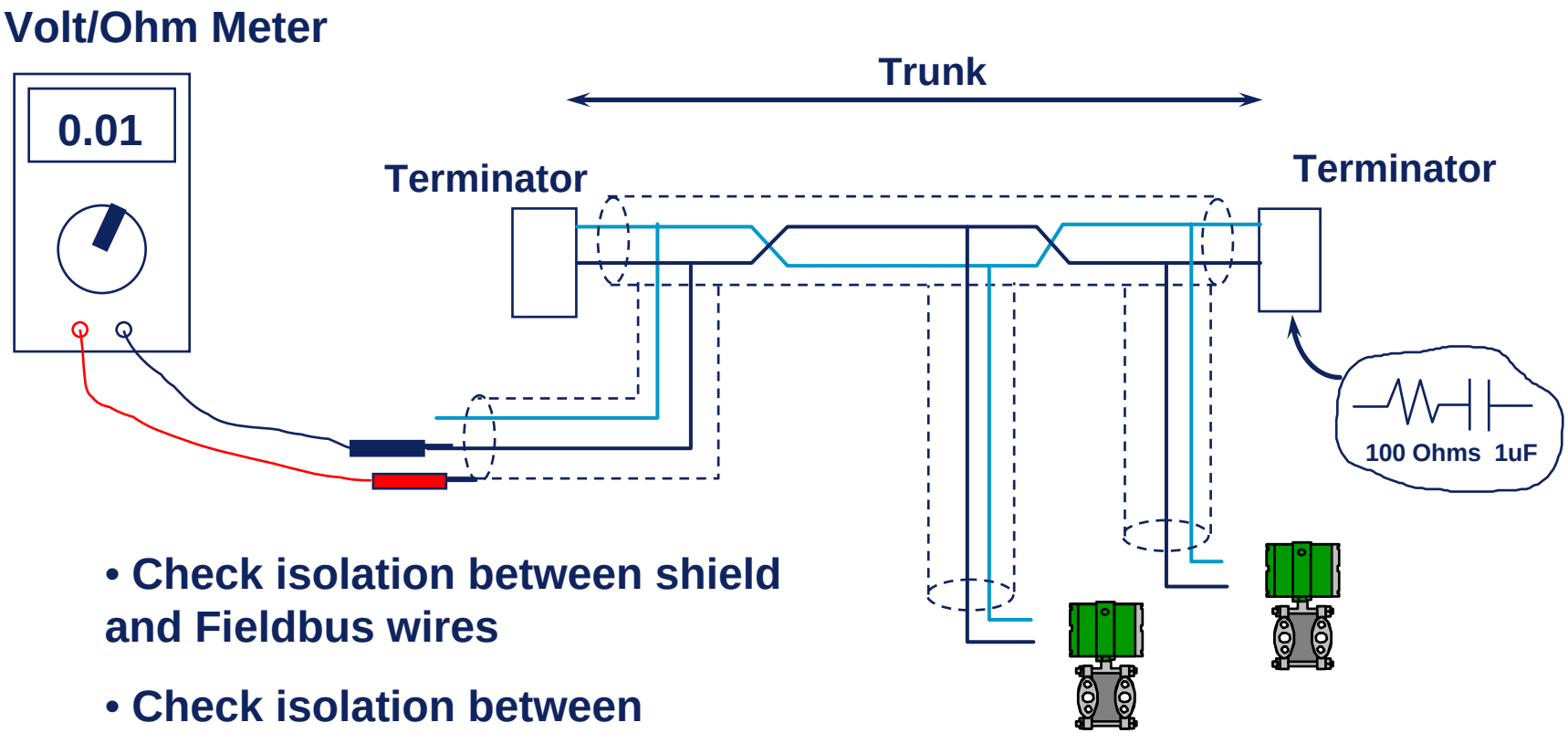
# FIELDBUS WIRING CHECKOUT BEFORE CONNECTING POWER TO THE SEGMENT




- Check isolation between shield and Fieldbus wires
- Check isolation between Fieldbus wires
- Lift shield from Ground and Check isolation between shield and Ground

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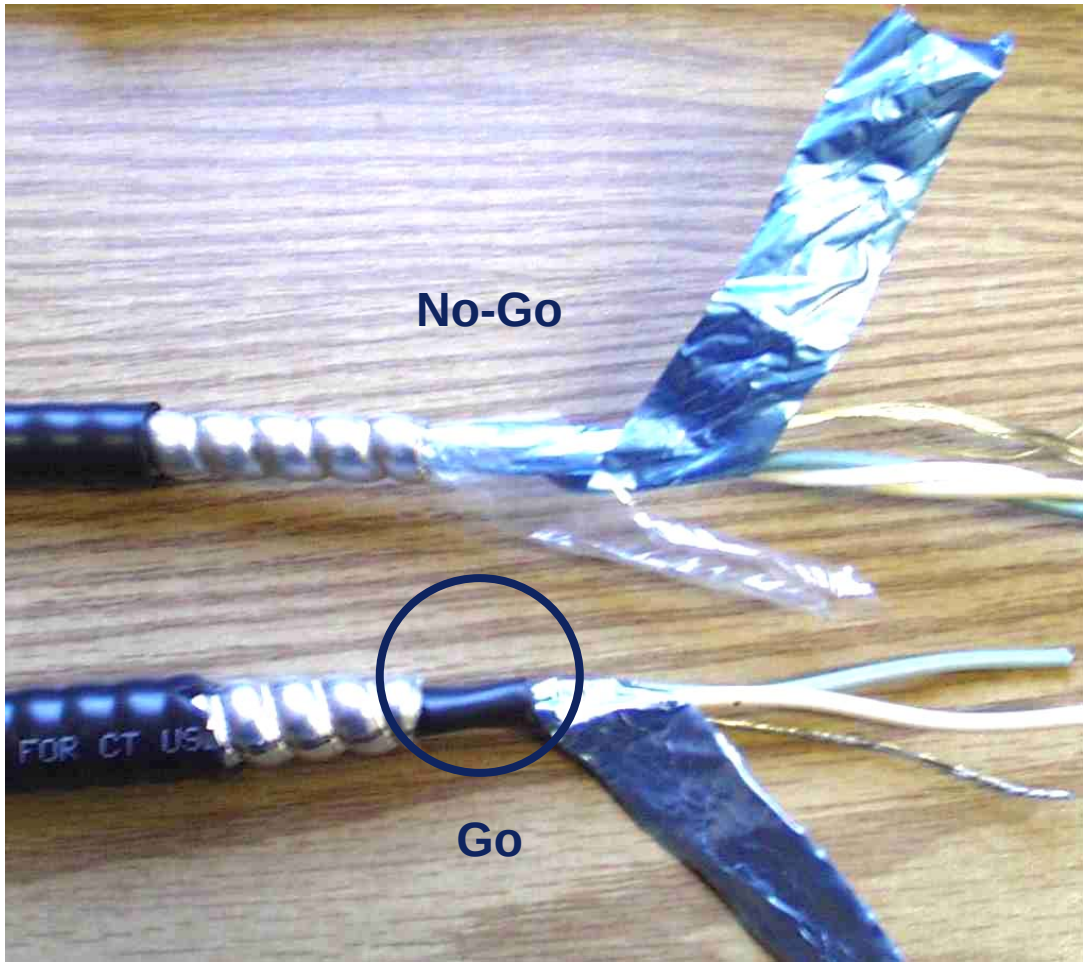
# Cable Example

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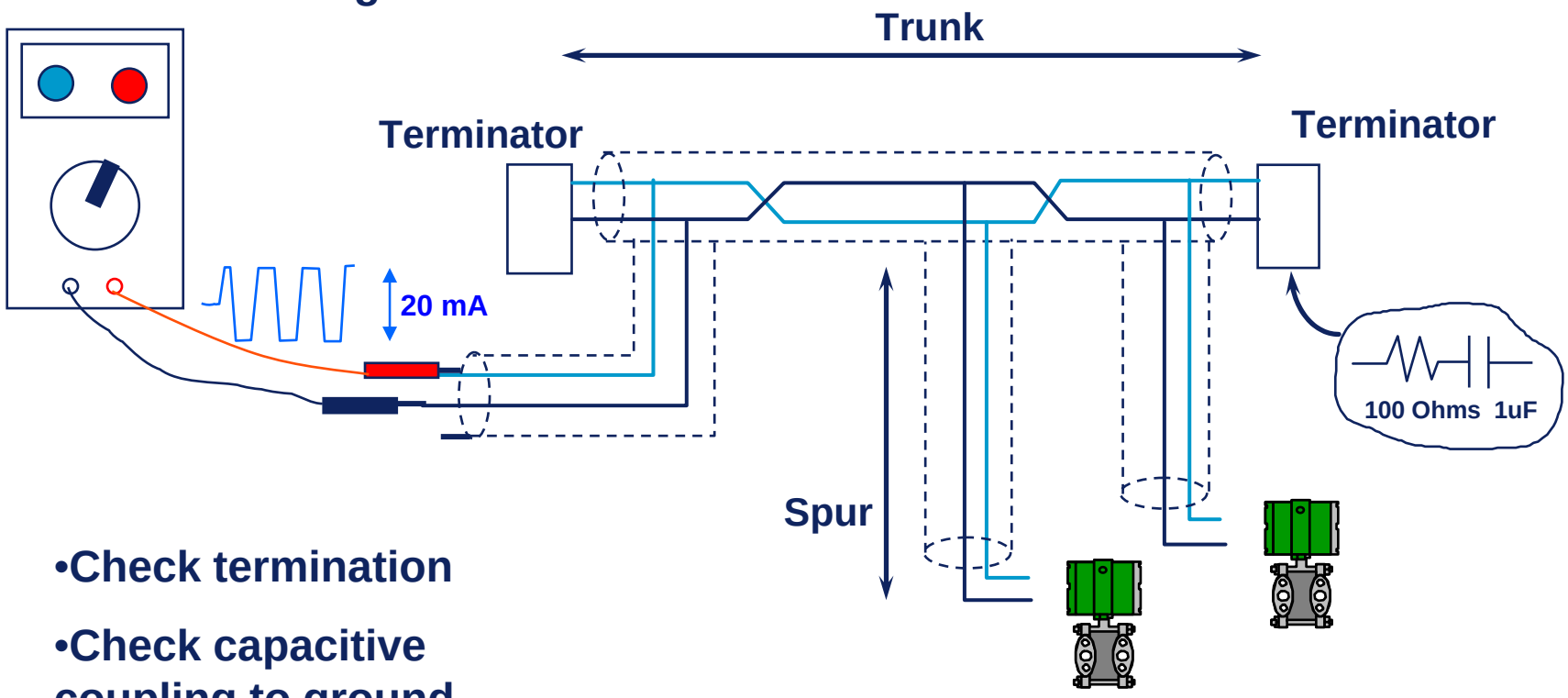
# FIELDBUS WIRING CHECKOUT BEFORE CONNECTING POWER TO THE SEGMENT

**Fieldbus checking tool**




- Check termination
- Check capacitive coupling to ground

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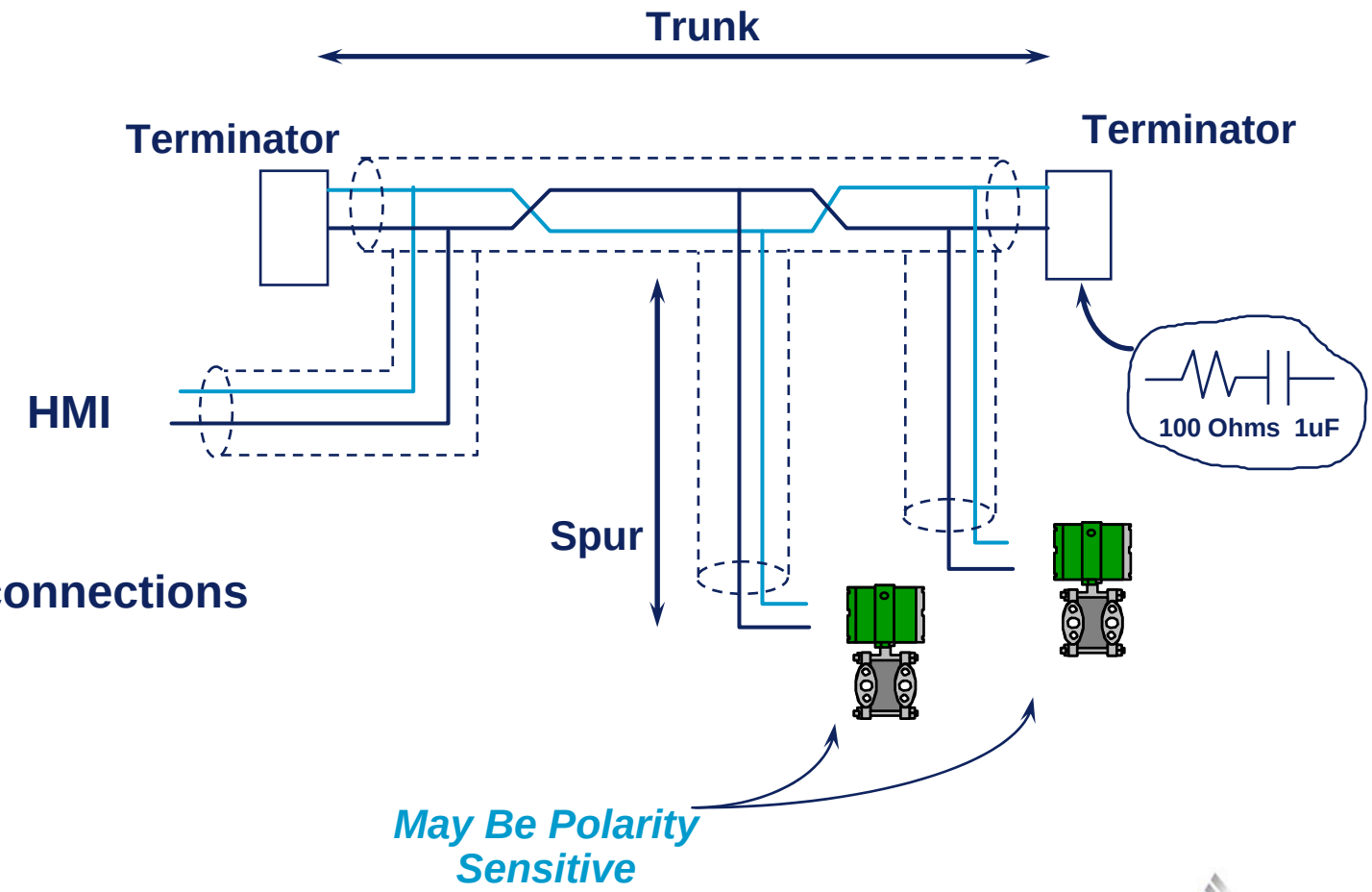
# FIELDBUS WIRING CHECKOUT BEFORE CONNECTING POWER TO THE SEGMENT




1. Verify connections

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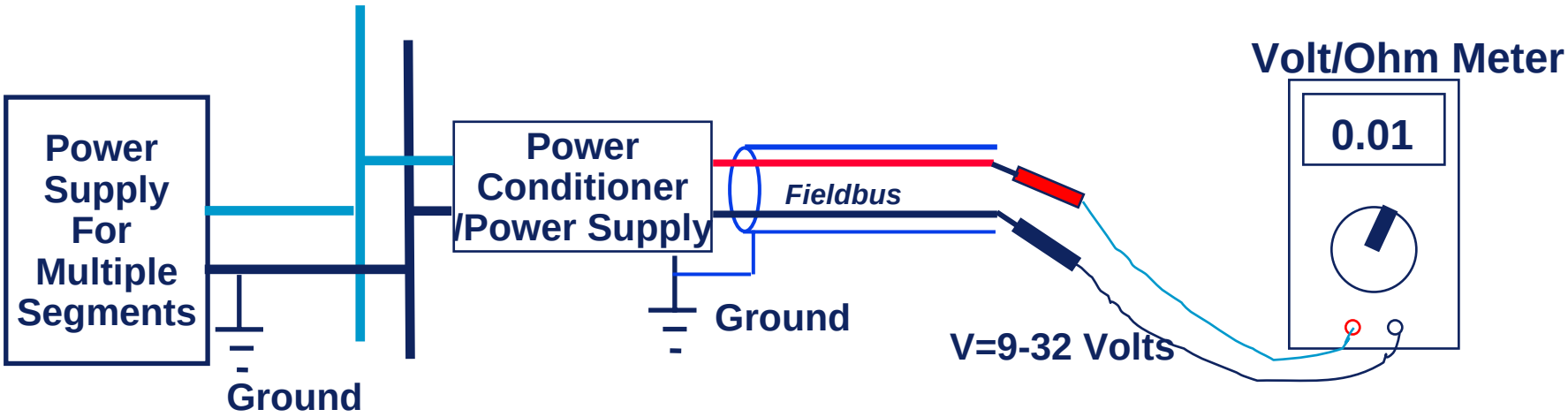
# *Fieldbus Segment Power*

**Fieldbus power, grounding installation and checkout may vary with the components selected.**

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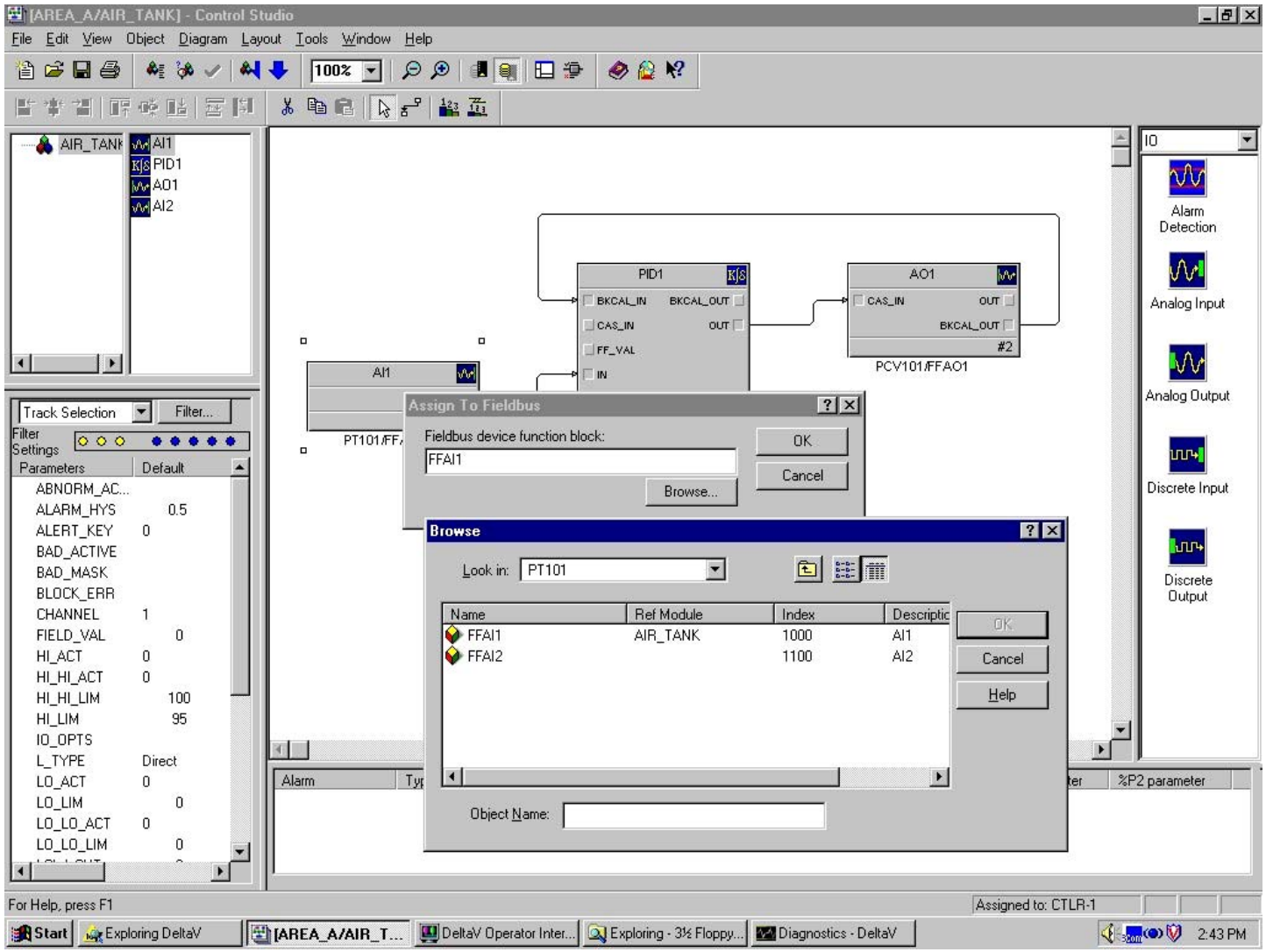
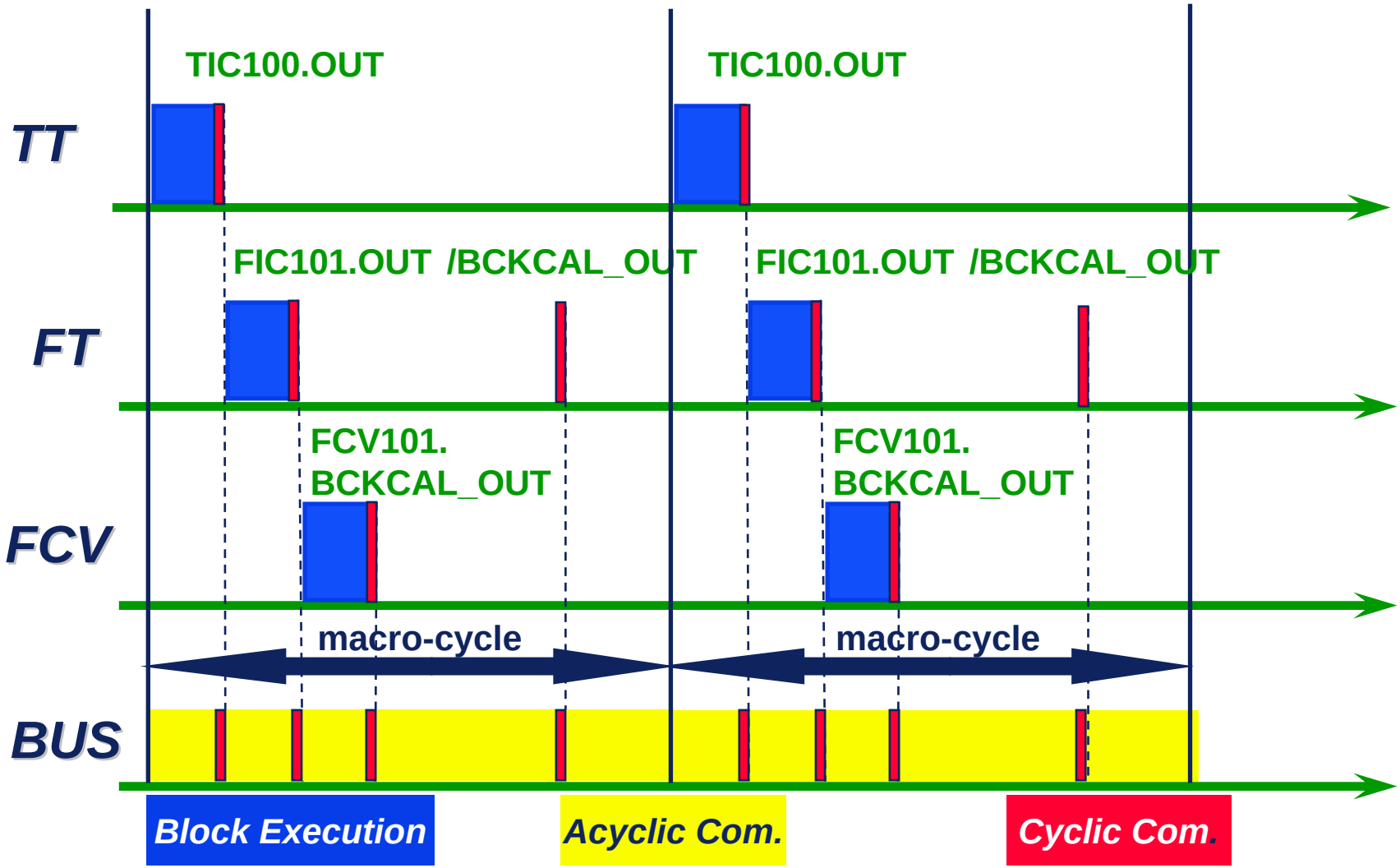
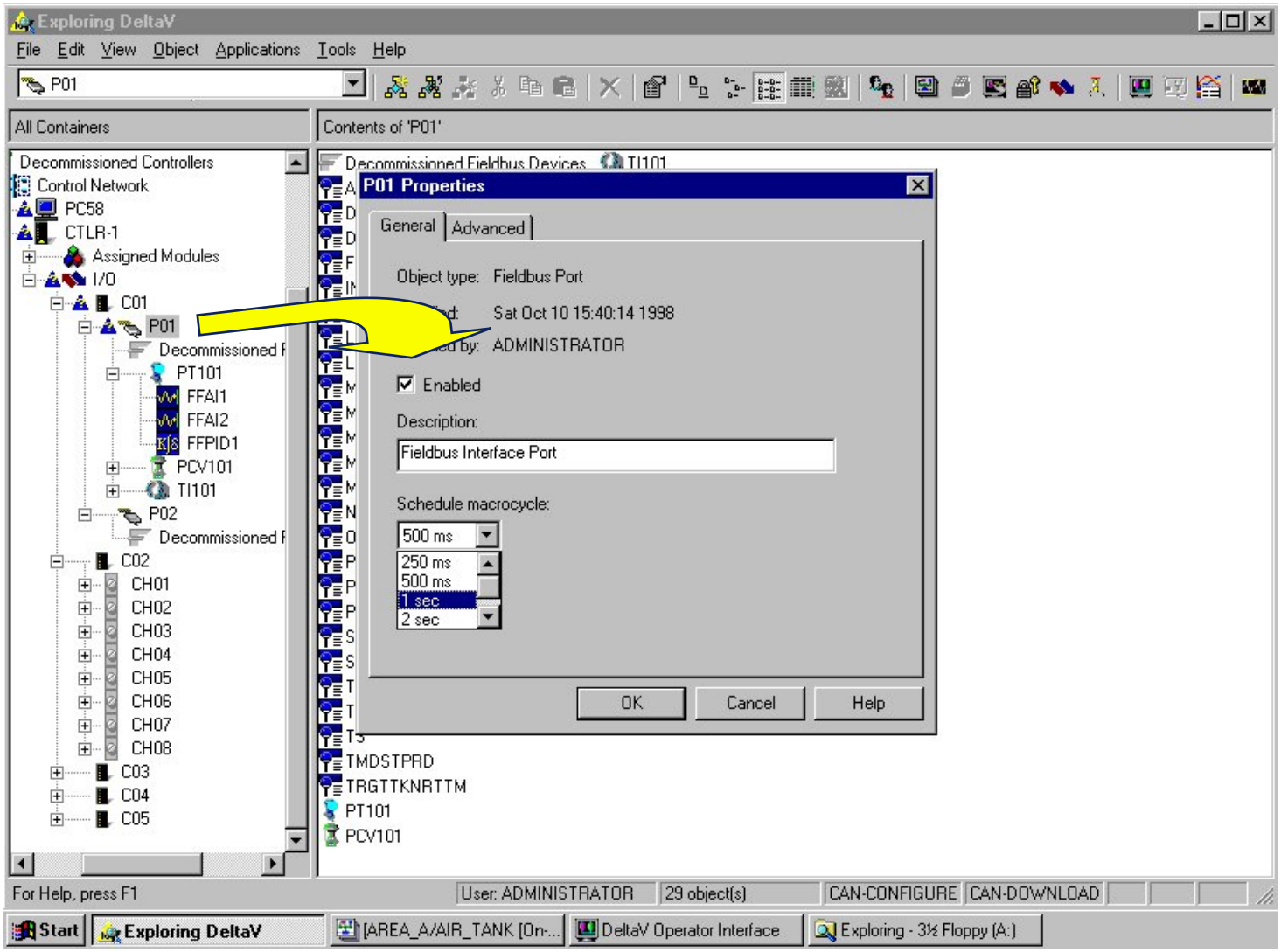
# Device Parameter Values, Links and Order of Execution Must be Loaded



# Foundation Fieldbus Devices Support Deterministic Scheduling of Control and Communications



# MACROCYCLE MAY BE SET BASED ON CONTROL EXECUTION REQUIRMENT



# Commissioning Fieldbus Devices - Automatic Address Assignment

- Devices may be connected to the bus with the same default address.
- A configuration utility in the host assigns an unused valid address to each device.

This feature allows fast and safe commissioning of the Fieldbus Network!

No dip switches, no pre-configuration.

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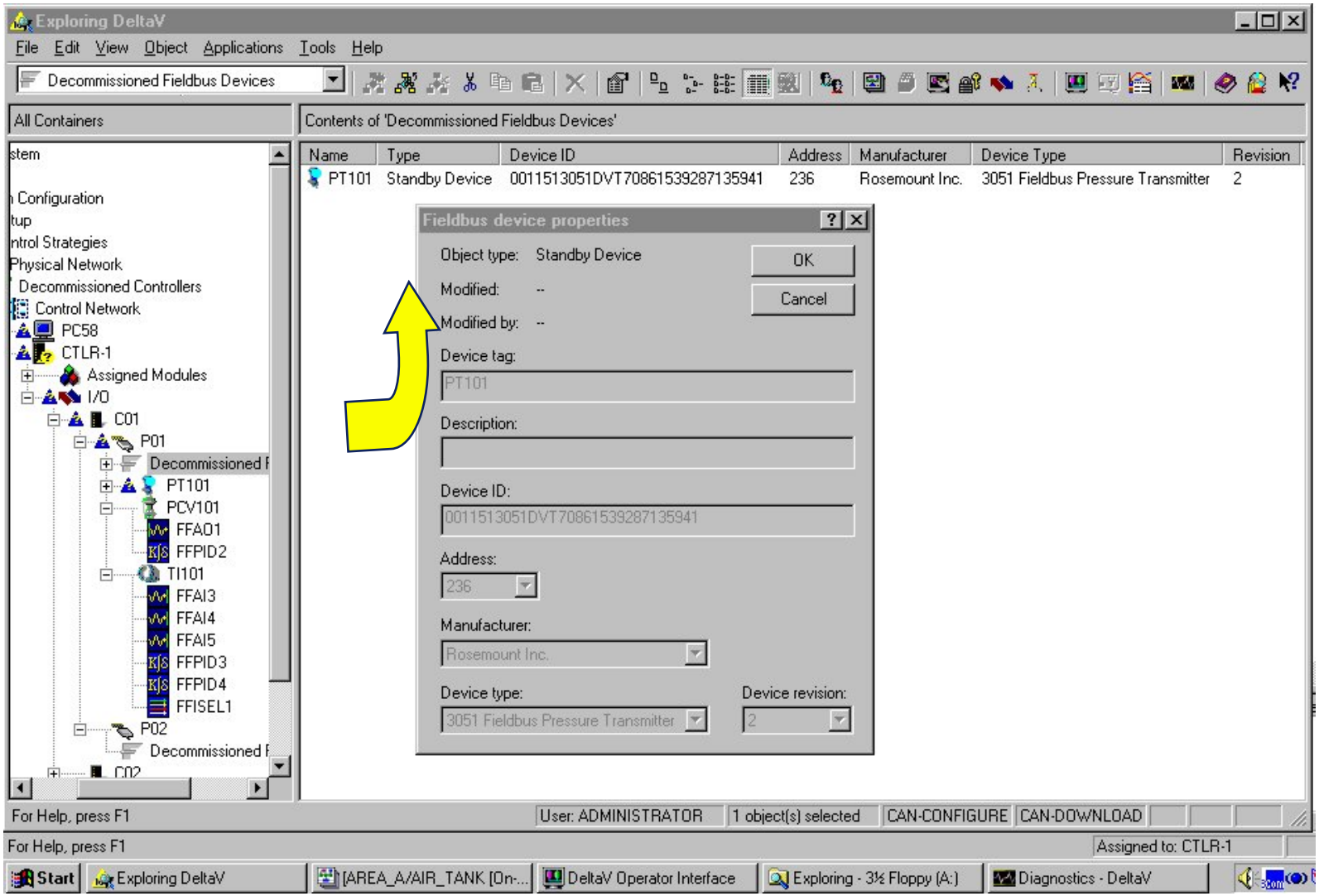
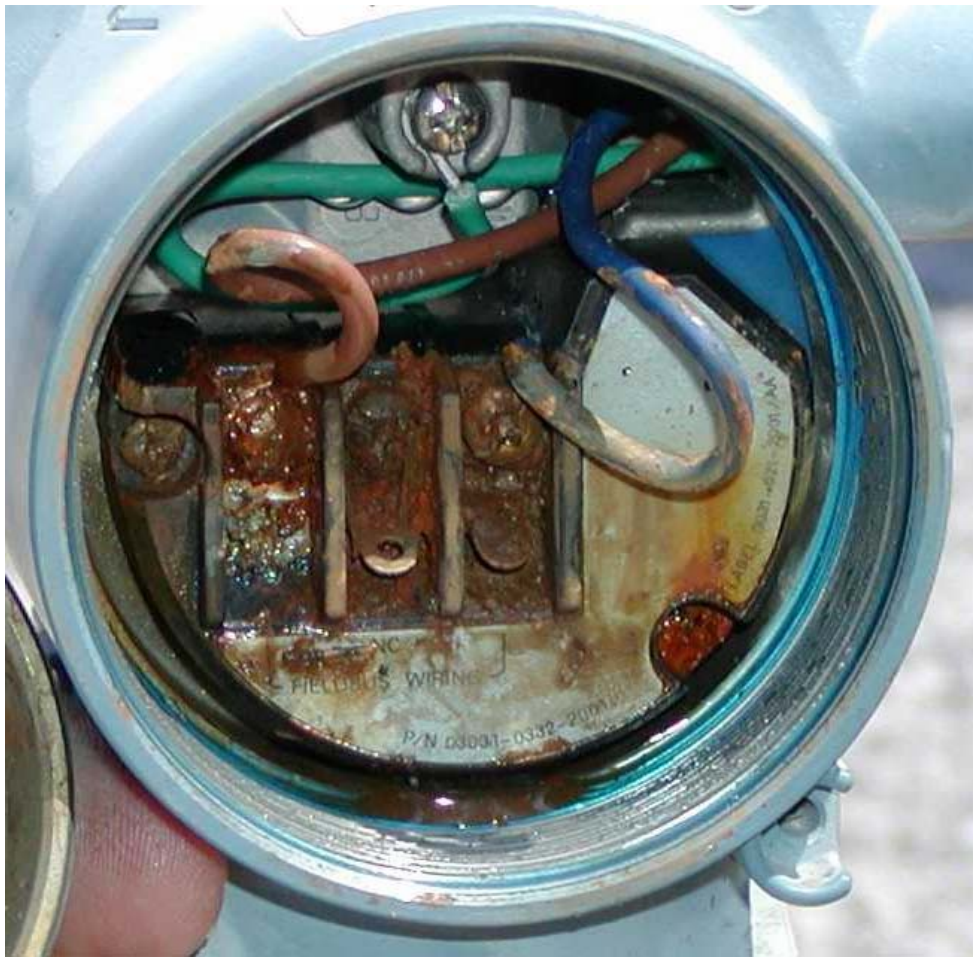
# As New Devices Are Attached, They may be Identified and Moved to Permanent Addresses



# What Happens When Things Don't Go Right?



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# *COMMON REASON FOUND FOR COMMUNICATION ERRORS ON A NEW FIELDBUS INSTALLATION*

1. **Missing or defective terminator at far end of the main segment**
2. **Shield or conductor has ground reference in the field - causing ground loop.**
3. **Faulty or overloaded power conditioner and/or power supply**
4. **Loose wiring connections**
5. **Defective cable from manufacturer**
6. **Use of uncertified component or devices.**

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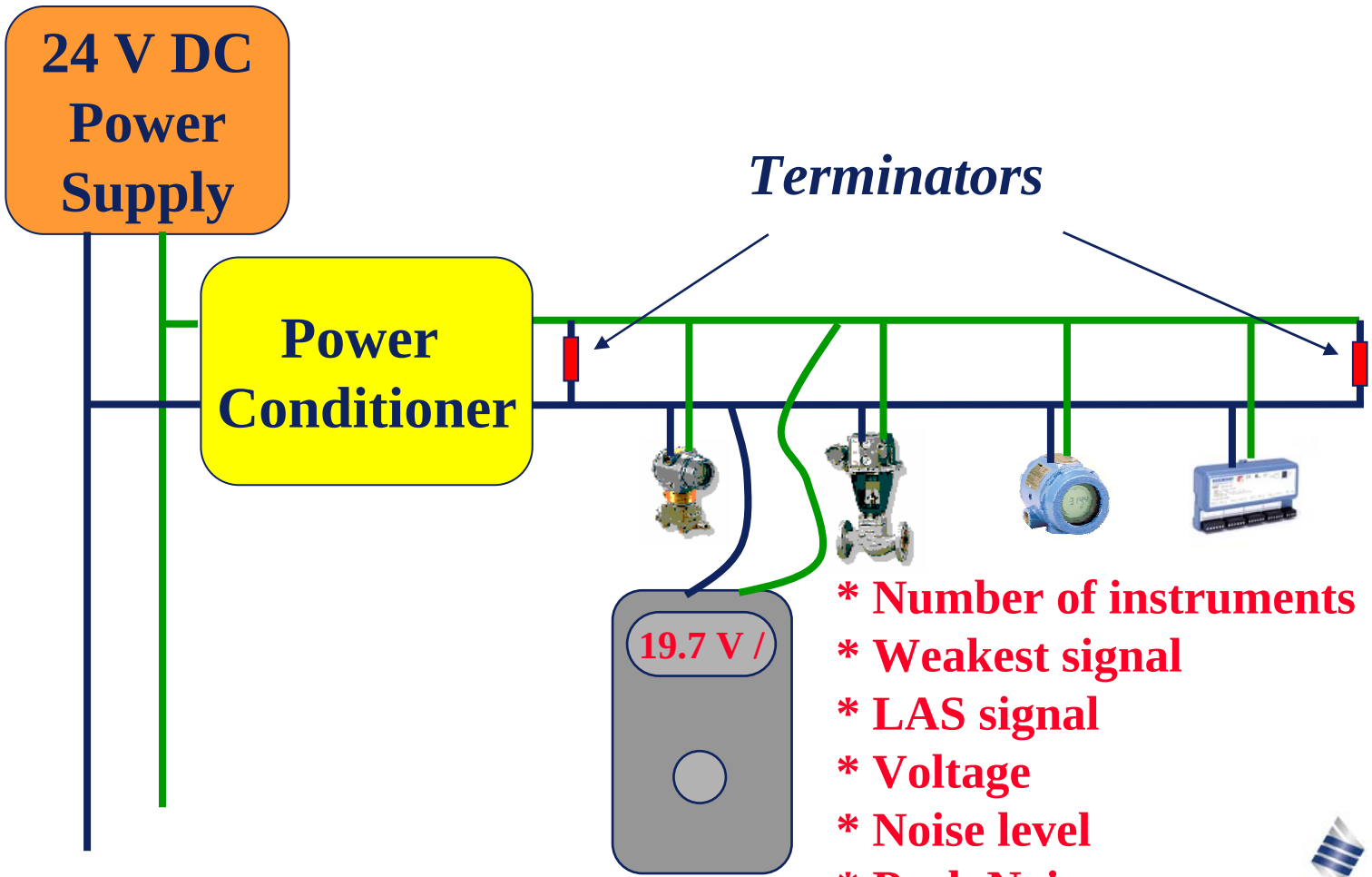
# Troubleshooting made easy




* Number of instruments
* Weakest signal
* LAS signal
* Voltage
* Noise level
* Peak Noise

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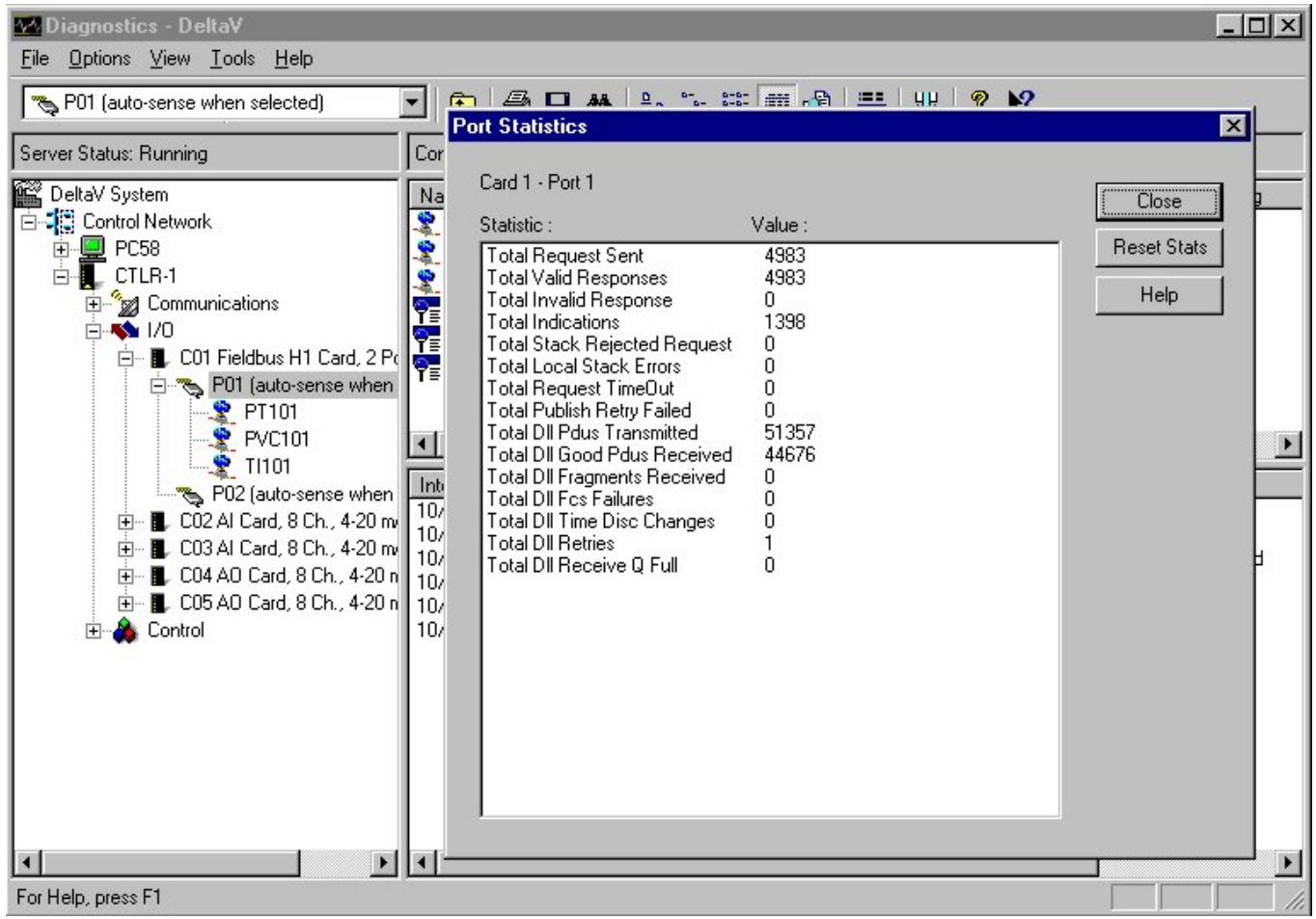
# Fieldbus Diagnostic can easily indicate a faulty installation!

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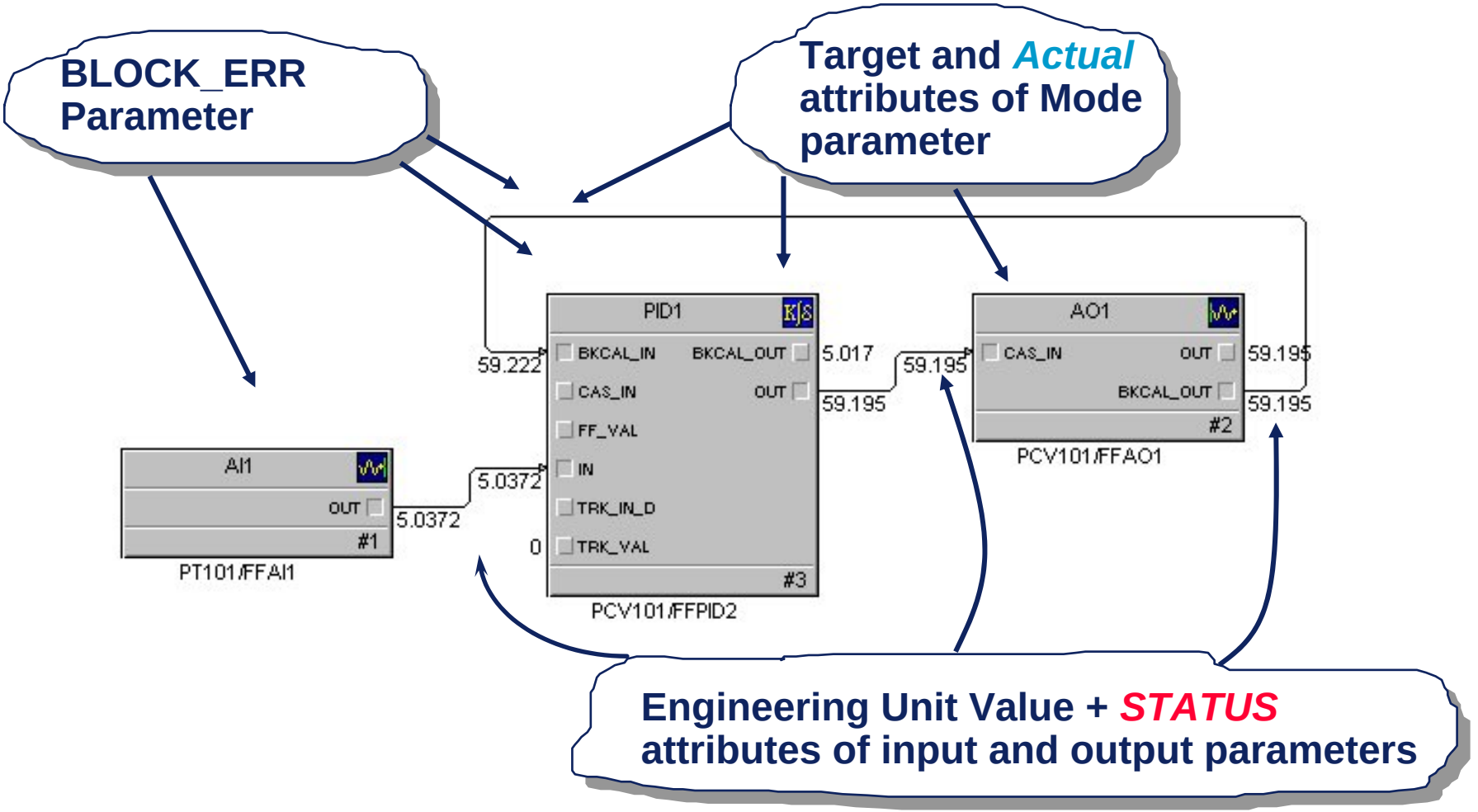
# DIAGNOSTIC SUPPORT AVAILABLE FOR FOUNDATION FIELDBUS BLOCKS

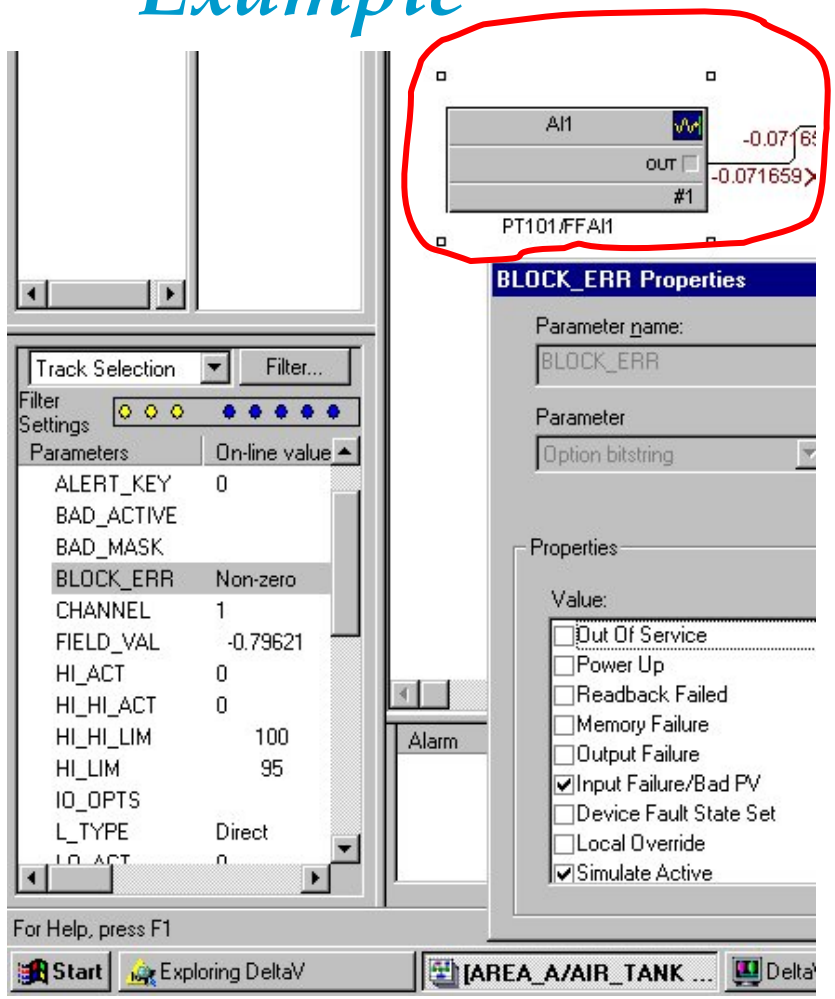


# BLOCK_ERR - PROVIDES INSIGHT INTO DEVICE HEALTH AND STATE of DEVICE CONFIGURATION

## BLOCK_ERR ATTRIBUTES

- Other
- Block Configuration Error
- Link Configuration Error
- Simulation Active
- Local Override
- Device Fault State Set
- Device Needs Maintenance Soon
- Input Failure/PV Bad Status
- Output Failure
- Memory Failure
- Lost Static Data
- Lost NV Data
- Readback Check Failed
- Device Needs Maintenance Now
- Power-up
- Out-of-Service

*Example*



# STATUS ATTRIBUTE OF INPUT AND OUTPUT PARAMETERS - INDICATES QUALITY OF VALUE

## STATUS ATTRIBUTE

***GOOD***

***UNCERTAIN***

- Non-specific
- Substitute/Manual entry
- Initial Value
- Sensor Conversion not Accurate
- Engineering Units Range Violation
- Sub-normal

***BAD***

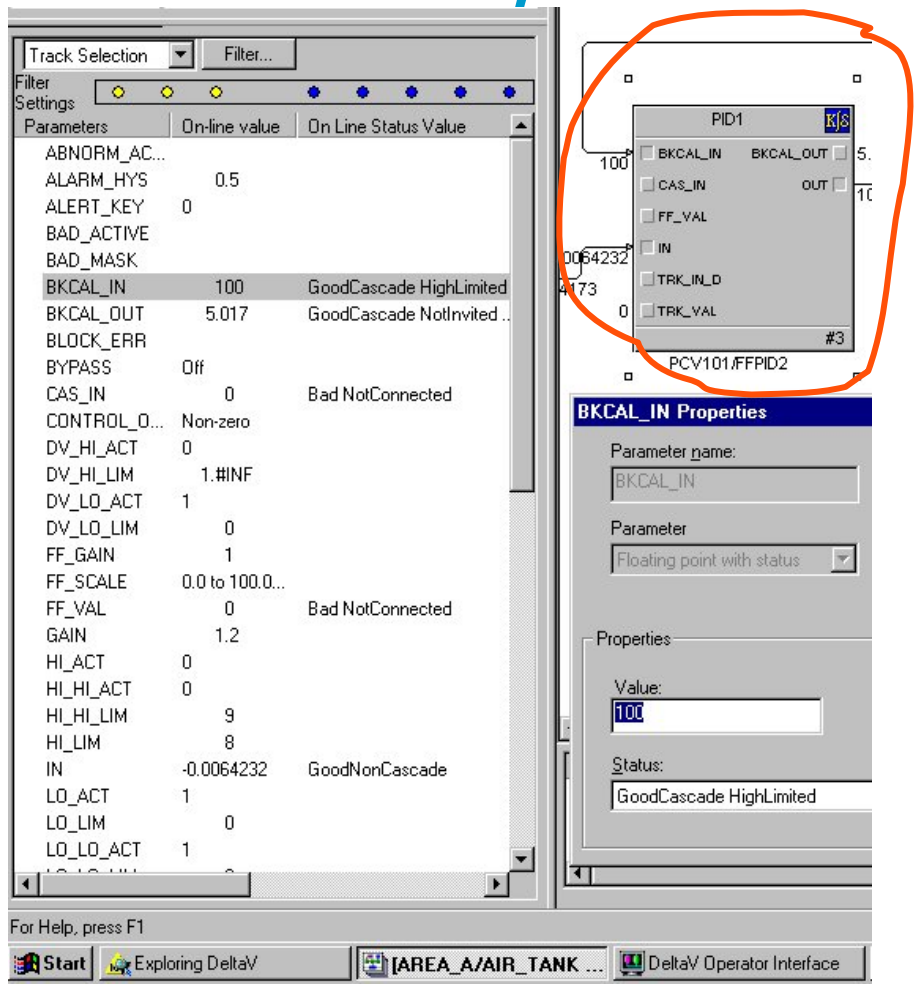
- Non-specific
- Configuration Error
- Not connected
- Device Failure
- Sensor Failure
- No Communication
- Out of Service

***LIMIT***

\+

- Not Limited
- Low Limited
- High Limited
- Constant

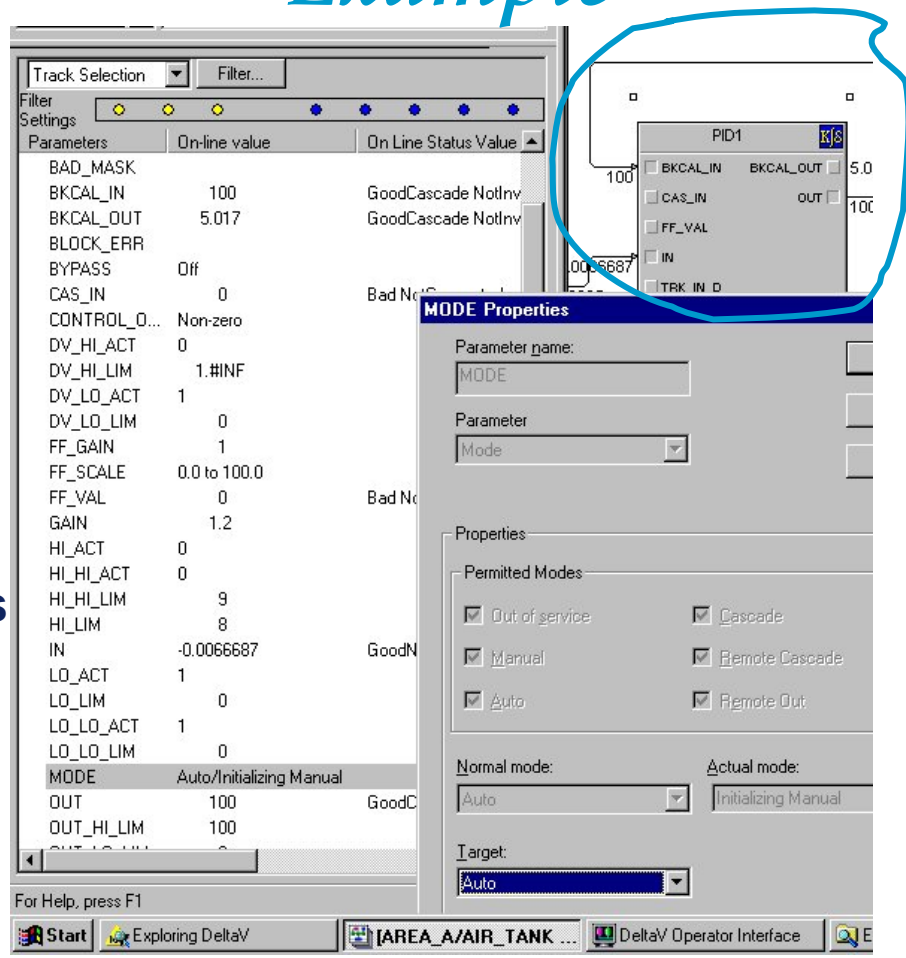
*Example*



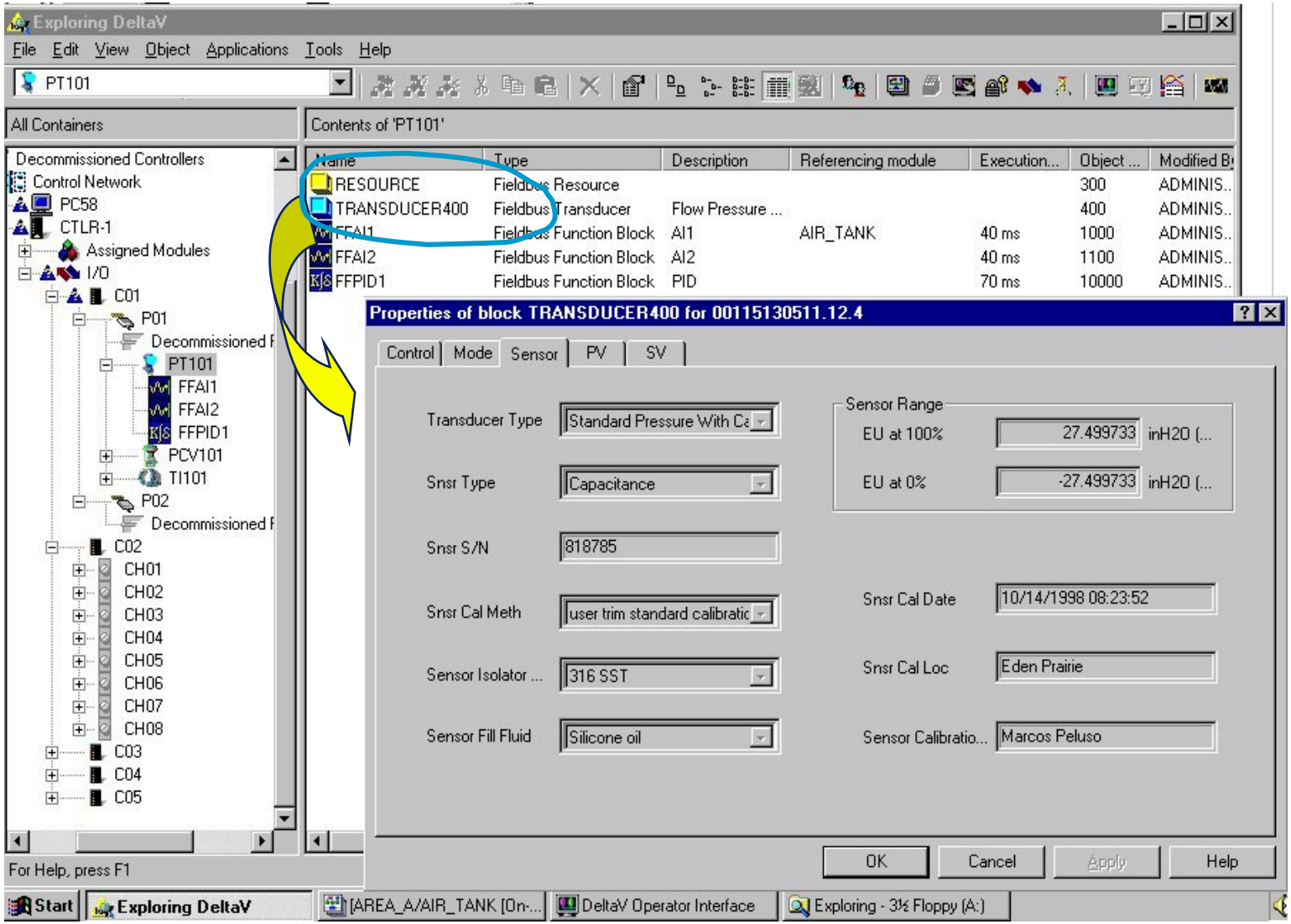
# "ACTUAL" ATTRIBUTE OF MODE - REFLECTS DOWNSTREAM CONDITION AND INPUT STATUS

| TARGET/ACTUAL | CONDITION |
|---|---|
| (Target/Actual Match) | NORMAL |
| ( ) / OS | Device is OS |
| Auto, Cas / Man | PV BAD |
| Rcas / Cas, Auto<br>Rout / Cas, Auto | Host is Not Communicating |
| ( ) / Iman | No Path to Process (Downstream) |
| ( ) / LO | Fault State Active (Output Block)<br>Input Track Active (Control Block) |

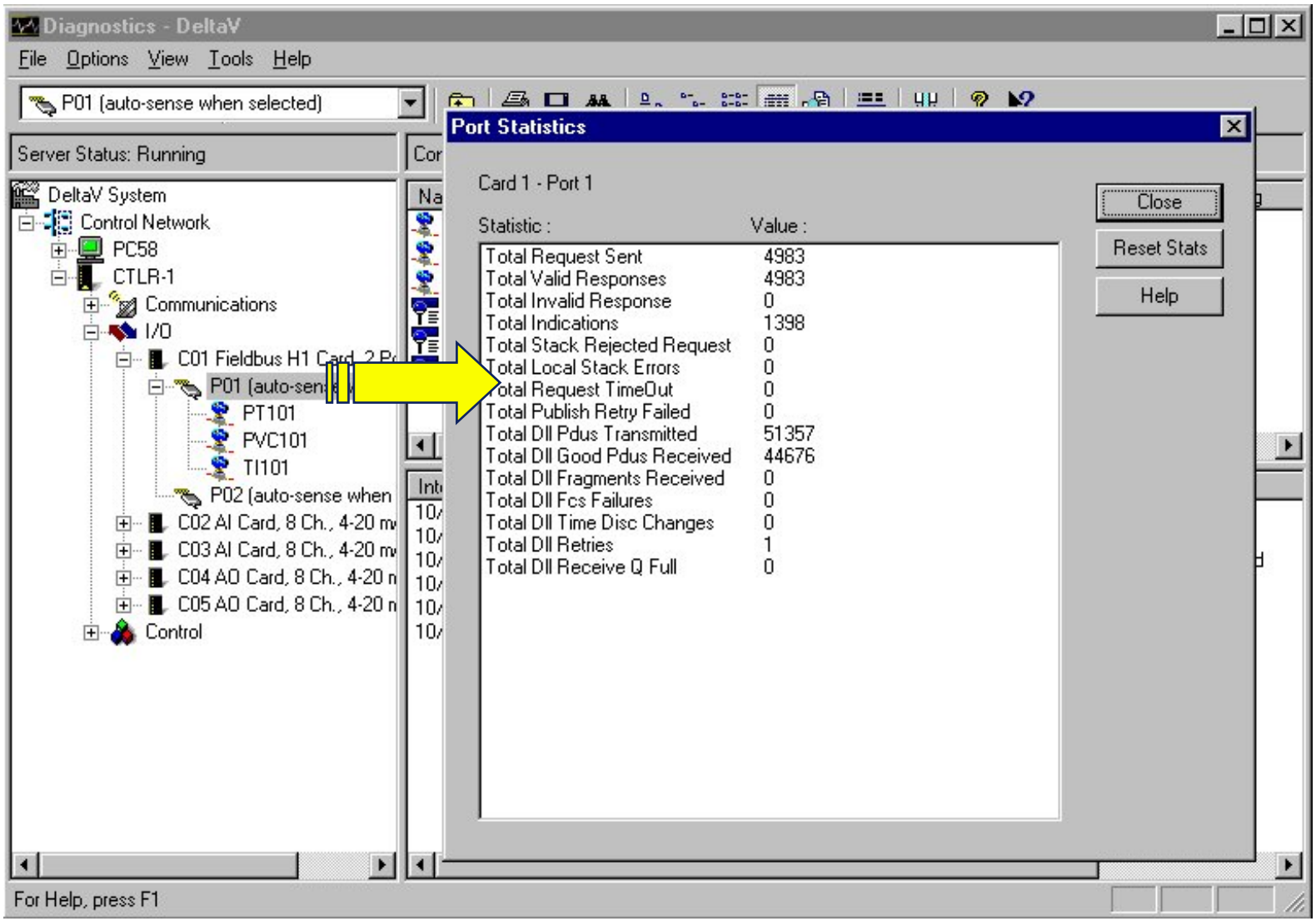
*Example*



# TRANSDUCER BLOCKS PROVIDE DEVICE SPECIFIC INFORMATION WHICH MAY BE HELPFUL



# COMMUNICATION STATISTICS PROVIDE INSIGHT INTO THE INTEGRITY OF THE FIELDBUS SEGMENT



# Summary

- Observe trunk and spur lengths.
- Locate the two terminators in the opposite far ends of the trunk.
- Check installation according to standard wiring practices.
- Limit the number of the devices on the segment according to power consumption and wire length.
- Set Network Parameters based on the “slowest” device in both Primary and Backup Link Masters.
- Calibrate in the Transducer Block and compensate off sets in the Analog Input Block.
- For Macro cycles shorter than 250 ms, restrict the number of devices based on desired Operator Interface update.

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