Designing Industrial Networks using TIA 1005a

Gregg Schaefer

ANIXTER

Bicsi
Introduction

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ISA Member since 2013
Overview of ANSI TIA-1005A 5/2012 revision of ANSI TIA 1005
- physical aspects of the network (cabling and topology)
- Telecom grounding, TCL and solutions for EMI.
- TSB-185 MICE Tutorial

MICE classification referenced in ANSI TIA-1005A.
- Gaps between the MICE tables and workable solutions

Logical aspects of and impact upon the physical design.
- Rational of using Ring topologies,
- Industrial Ethernet Switch characteristics

Organizations involved in developing standards for industrial networks
TIA 1005 PURPOSE

• Specify telecom cabling to support industrial premises applications
  – Voice, video, data
  – Industrial applications and building controls
  – Security, fire alarm
• Allows for exposures to wider ranges of temperature humidity, electrical noise, shock, vibration, corrosive gases, dust, liquids, etc.
• Based upon ANSI/TIA/EIA-568-C and includes allowances and exceptions to these standards for industrial premises
## Standards Review

### Common Standards
- ANSI/TIA 568-C.0 *(Generic)*
- TIA-569 (Pathways and spaces)
- ANSI/TIA-607 *(Bonding and grounding [earthing]*)
- ANSI/TIA-758 *(Outside plant)*
- ANSI/TIA-862 *(Building automation systems)*

### Premesis Standards
- ANSI/TIA-568-C.1 *(Commercial)*
- ANSI/TIA-570 *(Residential)*
- ANSI/TIA-942 *(Data Centers)*
- ANSI/TIA-1005 *(Industrial)*
- ANSI/TIA-1179 *(Healthcare)*

### Component Standards
- ANSI/TIA-568-C.2 *(Balanced twisted-pair)*
- ANSI/TIA-568-C.3 *(Optical fiber)*
- ANSI/TIA-568-C.4 *(Coaxial)*
Trends

- Companies are reducing industrial plant power consumption
  - VFD installations reduce power but create unexpected and harmful by-product for communications networks: Harmonics
- Cost reduction in “hardwire” cabling
  - Move towards ethernet cabling- HMI, VFD, PLCs, Optical Relays
- IHS report, “Industrial Internet of Things – 2014 Edition.” By 2025,
Enterprise vs. Industrial Telecom Spaces

Industrial Spaces for Concern
- Telecom equipment near switch gear and MCC (EMI)
- Telecom cabling/equipment on machine (vibration)
- Class 1 Div 2 (explosion potential)
- Robot pit- oil, corrosive (chemical)
- Outdoor connectivity-temperature
8.2.1 Star Topology

8.2.2 Cabling directly between TRs and TEs

TIA 1005-1 Section 4.2.2

- Space constraints, especially in existing installations, may require the use of a telecommunications enclosure (TE) instead of a telecommunications room (TR).

ANSI/TIA-568-C.1
Premises Standard

ANSI/TIA-569-C
Pathway considerations

ANSI/TIA-1005A
Premises Standard

*Switch Gear

*Switch Gear/Control Gear: See IEC60715-for mounting electrical devices
Commercial vs Industrial

factors that drive topology decisions

- Client-server architecture: Critical devices centrally located or bound by TR or data center cabinet locations
- Design is *hierarchical*
- Network is *non-deterministic*
- *End devices do not require a redundant path, user can wait*

- Peer to peer: critical devices are not restricted to TR locations
- Mesh not required
  - MRP, PRP, RSTP common
- Design is *not hierarchical*
- Network is *deterministic*

*Events occur on a schedule, timing is mission critical*
Ring/Mesh Topology
Today’s Recovery Mechanisms

**RSTP Rapid Spanning Tree Protocol**
802.1D-2004
- Invented by Radia Perlman
- Works in a mesh or ring topology
- Used for loop detection and Failed link recovery
- Undermined recovery time--seconds

**MRP Media Redundancy Protocol**
IEC-62439-2-2010
- 200ms recovery 50 switches
- 30ms 50 switches (fast MRP)
- Rings only

**PRP Parallel Redundancy Protocol**
IEC 62439-3-3012-07
- 0ms recovery time
- Specialized hardware
Benefit of Sub Rings

• RSTP causes total network failure until recovery
• With sub rings, only the faulty ring reconfigures
• Can mix MRP and RSTP
  – Why is this important?
True or False

RSTP is the preferred method of ring recovery in industrial networks.
Industrial Network Performance Requirements

- Determinism (repeatable message delivery)
  - Jitter from <microsecond to 10 milliseconds

- Industry solutions- Switches generally need to support these:
  - Ethernet IP (multicast, IGMP snooping), managed switches
  - Profinet RT, Profinet IRT, IEEE 1588 (precision time protocol)
  - EtherCAT (has ethernet PHY but no switches)
Ethernet Performance

Node A

100m

Switched 100Mbps Ethernet

100m

Node B

64-byte packet

Node time 330

Network

Propagation 0.5
Transmission 5.12
Switch latency 10
Transmission 5.12
Propagation 0.5

All times in μs

University of Michigan Industrial Ethernet Book “Performance Metrics for Industrial Ethernet”
Vendor performance mechanism

University of Michigan Industrial Ethernet Book  “Performance Metrics for Industrial Ethernet
Industrial Spaces/concepts- Industrial Areas

Work Area:
- Warm
- Dusty

Automation Island:
- Machines reside here:
  - High Vibration
  - High Humidity/dust
  - High Heat
  - Corrosive materials
  - High EMI

Control Equipment
Telecommunications Room

Temperature controlled
Low or no dust—clean
“MICE” Definitions and purpose

The MICE concept is based upon the assumption that cabling, even under the worst conditions, is still protected and guarantees reliable network operation.

Understand the environment class as best you can then:
1. Design cable to guarantee reliable network performance in worst case.
2. Design enclosures and channels to guarantee reliable performance.

The MICE matrix defines environmental classes in three levels and four parameters.
### Mechanical MICE TABLE GUIDELINES

<table>
<thead>
<tr>
<th>MECHANICAL</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock/bump (see a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak acceleration</td>
<td>40 m/s-2</td>
<td>100 m/s-2</td>
<td>250 m/s-2</td>
</tr>
<tr>
<td>IEC60721-3-3 class 3M2</td>
<td>IEC60721-3-3 class 3M6</td>
<td>IEC60721-3-3 class 3M8</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement amplitude (2 Hz to 9 Hz)</td>
<td>1.5 mm</td>
<td>7.0 mm</td>
<td>15.0 mm</td>
</tr>
<tr>
<td>Acceleration amplitude (9 Hz to 500 Hz)</td>
<td>5 m/s-2</td>
<td>20 m/s-2</td>
<td>50 m/s-2</td>
</tr>
<tr>
<td>IEC60721-3-3 class 3M2</td>
<td>IEC60721-3-3 class 3M6</td>
<td>IEC60721-3-3 class 3M8</td>
<td></td>
</tr>
<tr>
<td>Tensile force</td>
<td>Installation Specific</td>
<td>Installation Specific</td>
<td>Installation Specific</td>
</tr>
<tr>
<td>See IEC 61918</td>
<td>See IEC 61918</td>
<td>See IEC 61918</td>
<td></td>
</tr>
<tr>
<td>Crush</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 N over 25 mm (linear) min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 100 N over 150 mm (linear) min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 200 N over 150 mm (linear) min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact</td>
<td>1 J</td>
<td>10 J</td>
<td>30 J</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.7 ft·lbs/11.8 N·m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation Specific</td>
<td>Installation Specific</td>
<td>Installation Specific</td>
<td>Installation Specific</td>
</tr>
<tr>
<td>See IEC 61918</td>
<td>See IEC 61918</td>
<td>See IEC 61918</td>
<td></td>
</tr>
</tbody>
</table>

**Typical Crush Resistance:**
- 1370 lb/in 2400 N/cm,
- 8.7 ft·lbs/11.8 N·m

**Impact Resistance over standard loose tube cables:**
- Thermo Plastic Elastomer-TPE
- Fluorinated ethylene propylene-FEP

**Abrasion Resistance:**
- Polyurethane jacket- PUR
## MICE TABLE GUIDELINES

### Ingress

<table>
<thead>
<tr>
<th>INGRESS</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate ingress (dia. max)</td>
<td>12.5 mm</td>
<td>50 μm</td>
<td>50 μm</td>
</tr>
<tr>
<td>Immersion</td>
<td>None</td>
<td>Intermittent liquid jet ≤ 12.5 l/min ≥ 6.3 mm jet &gt; 2.5 m distance and immersion (≤1 m for &lt;=30 minutes)</td>
<td></td>
</tr>
</tbody>
</table>

### NEMA enclosures types:
- NEMA 1 IP10
- NEMA 3R IP14
- NEMA 4X IP56
- NEMA 6 IP67
## MICE TABLE GUIDELINES
### Chemical/Climatic

<table>
<thead>
<tr>
<th>Climatic/Chemical</th>
<th>I1</th>
<th>I2</th>
<th>I3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature</td>
<td>-10 °C to +60 °C</td>
<td>-25 °C to +70 °C</td>
<td>-40 °C to +70 °C</td>
</tr>
<tr>
<td>Rate of change of temperature</td>
<td>0.1 °C per minute</td>
<td>1.0 °C per minute</td>
<td>3.0 °C per minute</td>
</tr>
<tr>
<td>Humidity</td>
<td>5 % to 85 % (non-condensing)</td>
<td>5 % to 95 % (non-condensing)</td>
<td>5 % to 95 % (non-condensing)</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>700 Wm-2</td>
<td>1120 Wm-2</td>
<td>1120 Wm-2</td>
</tr>
<tr>
<td>Liquid pollution (see c))</td>
<td>Concentration x 10-6</td>
<td>Concentration x 10-6</td>
<td>Concentration x 10-6</td>
</tr>
<tr>
<td>Sodium chloride (salt/sea water)</td>
<td>0 &lt;0,3 &lt;0,3</td>
<td>&lt;0,3</td>
<td>&lt;0,3</td>
</tr>
<tr>
<td>Oil (dry-air concentration) (for oil types see b)</td>
<td>0 &lt;0,005 &lt;0,5</td>
<td>&lt;0,5</td>
<td></td>
</tr>
<tr>
<td>Sodium stearate (soap) None</td>
<td>&gt;5 x 104 aqueous nongelling</td>
<td>None</td>
<td>Temporary</td>
</tr>
<tr>
<td>Conductive materials</td>
<td>None</td>
<td>Temporary</td>
<td>Present</td>
</tr>
</tbody>
</table>

### INDUSTRY SOLUTIONS
**Chemical Resistance Jackets**
- Fluorinated ethylene propylene- FEP

**Low-temperature bending**
- Fluorinated ethylene propylene- FEP

**Conformal Coating- pc board chemical resistance**
- Ethernet Switches
## The Guideline Gap

### MICE Table Guidelines

#### EMI

<table>
<thead>
<tr>
<th>Electromagnetic</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic discharge – Contact (0.667 μC)</td>
<td>4 kV</td>
<td>4 kV</td>
<td>4 kV</td>
</tr>
<tr>
<td>Electrostatic discharge – Air (0.132 μC)</td>
<td>8 kV</td>
<td>8 kV</td>
<td>8 kV</td>
</tr>
<tr>
<td>Radiated RF - AM</td>
<td>3 V/m at (80 to 1 000 MHz)</td>
<td>3 V/m at (1 400 to 2 000 MHz)</td>
<td>10 V/m at (80 to 1 000 MHz)</td>
</tr>
<tr>
<td>Conducted RF</td>
<td>3 V at 150kHz</td>
<td>3 V at 150kHz</td>
<td>10 V at 150kHz</td>
</tr>
<tr>
<td>EFT/B (comms)</td>
<td>500 V</td>
<td>1 kV</td>
<td>1 kV</td>
</tr>
<tr>
<td>Surge (transient ground potential difference) - signal, line to earth</td>
<td>500 V</td>
<td>1 kV</td>
<td>1 kV</td>
</tr>
<tr>
<td>Magnetic Field (50/60 Hz)</td>
<td>1 Am-1</td>
<td>3 Am-1</td>
<td>30 Am-1</td>
</tr>
<tr>
<td>Magnetic Field (60 Hz to 20 000 Hz)</td>
<td>ffs</td>
<td>ffs</td>
<td>ffs</td>
</tr>
</tbody>
</table>

### Industry Solutions

- Shielded Twisted Pair Copper
- Category 6, UTP - High TCL
- Separation
- Conduit or metal pathway
- Use Fiber
EMI Mitigation in the cabling channel

Fig. 7: EMC consideration EN 50174-2

Fig. 8: Metallic cable trays EN 50174-2

Source: TSB-185

Bicsi
Modular Switch Gear

- Arc Flash - what not to steal
- Arc Flash Accident Arc Flash Categories 0-4
Switch Gear

- M1 I1 C1 E3
- E3 condition
  - EFT probability high
- Shielded pathway
- Fiber Optics
Possible Fiber Solutions-Switch Gear

- Remove inner duct, use all dielectric fiber with PUR jacket for damage resistance during pull. Gain .8”+ per fiber run inside gear.
- Use damage resistant Tactical fiber
  - This flexible cable uses 900 μm TBII® buffered fibers surrounded by dielectric strength members and is protected by a rugged polyurethane outer jacket that provides superior environmental and mechanical protection.
    - OM1 002K8U-31130-24
- No Tie wraps Cabinet to door. Use spiral wrap.
- Patch cables to switch to avoid re pulling fiber run.
- Separate metal duct for fiber and copper.
FOR TRAY APPLICATIONS- all dielectric, crush resistant

- Tray Rated: UL 1277, UL13, UL444
- Available in Riser or Plenum
- 6-24 fibers
- Available in 12 different colors
- 17% lighter than Interlocking Armor
- Exceeds ICEA S-83-596 crush test by 200%
- No grounding required
Quiz

Regarding valid metal connector grounding practices for shielded twisted pair, which answer is not correct?

A. Bond the shield to the connector only on one end of the cable.
B. Bond the shield on both ends of the cable.
C. Single point grounds are preferred.
D. Hybrid bonding in the switches are recommended.
**Copper in high EMI Environment**

**Hybrid Bonding- STP application**

- Single point grounds preferred
- Hybrid bonding used when multiple grounds exist for safety.
- Most switches use RC network to block low frequency (60Hz) and pass high frequency noise to ground.

Reference: TIA-1005A Section 11, ANSI/TIA-607-B requirements.”
Recognized Horizontal Cables

- Twisted-pair copper
  - 4-pair, 100 ohm balanced twisted-pair cabling (ANSI/TIA-568-C.2) (unshielded or shielded)
  - 2-pair, 100-ohm balanced (unshielded or shielded)
    - NOTE – 2-pair cables may be limited in scope and may not support a full set of applications.

- Optical fiber
  - multimode optical fiber cabling (ANSI/TIA-568-C.2)
  - single-mode optical fiber cabling (ANSI/TIA-568-C.2)
Connecting Hardware- Copper

- Automation outlet/connector
  - A 2-pair sealed connector. Where a full set of applications is not required (100BASE-T max), the M12 4-pin D micro connector is allowed to achieve IP67 performance.
  - It should be a minimum of Category 5e for four connections or less and Category 6 for more than four connections.

<table>
<thead>
<tr>
<th>Pin Number with Wiring Color Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIN #</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

“D” Coding Keyways

M12-4 ‘D’ Plug

M12-4 ‘D’ Jack
## M12 D connector to RJ45 pinout

<table>
<thead>
<tr>
<th>Color Code</th>
<th>Face View Pinout</th>
<th>Face View RJ45 Pinout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-Pin</td>
<td>8-Pin</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 White-Orange</td>
<td>TxData +</td>
</tr>
<tr>
<td>2</td>
<td>2 Orange</td>
<td>TxData -</td>
</tr>
<tr>
<td>3</td>
<td>3 White/Green</td>
<td>Recv Data +</td>
</tr>
<tr>
<td>4</td>
<td>4 Blue</td>
<td>Unused</td>
</tr>
<tr>
<td>A</td>
<td>1 White-Green</td>
<td>5 White/Blue</td>
</tr>
<tr>
<td>A</td>
<td>4 Green</td>
<td>6 Green</td>
</tr>
<tr>
<td>A</td>
<td>4 Green</td>
<td>7 White/Brown</td>
</tr>
<tr>
<td>A</td>
<td>8 Brown</td>
<td>8 Brown</td>
</tr>
</tbody>
</table>
Outside of Control Panel Connectivity
X coded M12 connectors, IP67
Control Panel Bulkhead Connectors
Inside the Panel DIN Rail Connectivity
True or False

More than 4 connections are not recommended in an industrial channel?
Informative- more Then 4 conn. in the channel (not part of TIA 1005)

- 5 or 6 connections Allowed* Check RL and NEXT- ANNEX B
- 2 or 4 pair Recognized- Category 5e, 6

Source: TIA-1005A
* The elevated RL and NEXT performance levels shown may require the use of category 6A connections as specified in ANSI/TIA-568-C.2.
What is the maximum combined length for work area cords, patch cords and equipment cords for 22-24 ga patch cables?

A. 90 meters (295 ft)
B. 85 meters (279 ft)
C. 80 meters (262 ft)
D. 10 meters (33 ft)
Combined Work Area Patch Cord Length

<table>
<thead>
<tr>
<th>Horizontal Cable Length (ft)</th>
<th>Maximum length of work area cord m</th>
<th>Maximum combined length of work area cords, patch cords, and equipment cord m (ft)</th>
<th>Maximum length of work area cord m (ft)</th>
<th>Maximum combined length of work area cords, patch cords, and equipment cord m (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 (295)</td>
<td>5 (16)</td>
<td>10 (33)</td>
<td>4 (13)</td>
<td>8 (26)</td>
</tr>
<tr>
<td>85 (279)</td>
<td>9 (30)</td>
<td>14 (46)</td>
<td>7 (24)</td>
<td>11 (37)</td>
</tr>
<tr>
<td>80 (262)</td>
<td>13 (44)</td>
<td>18 (60)</td>
<td>11 (35)</td>
<td>15 (48)</td>
</tr>
<tr>
<td>75 (246)</td>
<td>18 (57)</td>
<td>23 (74)</td>
<td>14 (46)</td>
<td>18 (59)</td>
</tr>
<tr>
<td>70 (229)</td>
<td>22 (71)</td>
<td>27 (87)</td>
<td>17 (57)</td>
<td>21 (70)</td>
</tr>
<tr>
<td>67 (220)</td>
<td>24 (79)</td>
<td>29 (96)</td>
<td>19 (63)</td>
<td>23 (77)</td>
</tr>
<tr>
<td>58 (190)</td>
<td>32 (104)</td>
<td>37 (120)</td>
<td>25 (83)</td>
<td>29 (96)</td>
</tr>
<tr>
<td>50 (164)</td>
<td>38 (126)</td>
<td>43 (142)</td>
<td>31 (101)</td>
<td>35 (114)</td>
</tr>
<tr>
<td>43 (141)</td>
<td>44 (145)</td>
<td>49 (161)</td>
<td>35 (116)</td>
<td>39 (129)</td>
</tr>
<tr>
<td>37 (121)</td>
<td>49 (161)</td>
<td>54 (178)</td>
<td>39 (129)</td>
<td>43 (142)</td>
</tr>
<tr>
<td>32 (105)</td>
<td>53 (175)</td>
<td>58 (191)</td>
<td>43 (140)</td>
<td>47 (153)</td>
</tr>
<tr>
<td>25 (82)</td>
<td>59 (194)</td>
<td>64 (211)</td>
<td>47 (155)</td>
<td>51 (168)</td>
</tr>
<tr>
<td>20 (66)</td>
<td>63 (208)</td>
<td>68 (224)</td>
<td>51 (166)</td>
<td>55 (179)</td>
</tr>
<tr>
<td>15 (49)</td>
<td>68 (221)</td>
<td>73 (238)</td>
<td>54 (177)</td>
<td>58 (190)</td>
</tr>
<tr>
<td>10 (33)</td>
<td>72 (235)</td>
<td>77 (252)</td>
<td>57 (188)</td>
<td>61 (201)</td>
</tr>
<tr>
<td>5 (16)</td>
<td>76 (249)</td>
<td>81 (265)</td>
<td>61 (199)</td>
<td>65 (212)</td>
</tr>
<tr>
<td>0</td>
<td>80 (262)</td>
<td>85 (279)</td>
<td>64 (211)</td>
<td>68 (223)</td>
</tr>
</tbody>
</table>

Source: TIA-1005A
Quiz

What are correct statements concerning the use of two pair cable?

A. All un-used conductors of a four-pair cabling shall be differentially terminated in accordance with the balanced cable characteristic impedance (100 ohms).

B. Network switching equipment with two-pair physical interfaces should not be connected to four-pair cabling.

C. Mixing two-pair cabling in the same channel with four-pair cabling is not recommended.

D. All of the above.
Two Pair/Four Pair Quiz Answers

• See ANNEX A.2- Requirements for mixing four-pair cabling and two-pair cabling
• This is considered normative and part of the standard
• Mixing two-pair cabling in the same channel with four-pair cabling is not recommended.
  – a) All un-used conductors of a four-pair cabling shall be differentially terminated in accordance with the balanced cable characteristic impedance (100 ohms). Where appropriate, the unused pairs should also be common mode terminated.
  – b) When connecting a complete two-pair cabling system into equipment interfaces designed for four-pair but communicating over only two pairs (e.g. 100BASE-T), ensure that the correct pair assignment is used.
  – c) Network switching equipment with two-pair physical interfaces should not be connected to four-pair cabling. Application specific to two-pair cabling systems should be used with such equipment. When adapting four-pair cabling for use with two-pair network interface, the unused pairs of the four-pair cabling shall be terminated in accordance with “a” above. Unused pairs shall not be left exposed outside the connector housing.
  – d) When mixing four-pair and two-pair cabling systems, additional care should be taken to ensure that the resulting cabling channel meets the requirements of the application
Fiber for Industry: Tray Ratings

- Fiber optic cables are designed for tough, rigorous industrial environments
  - Tray Rated—3rd party verified per UL1277, UL13, UL444, and CSA22.2 No. 230.
  - 70% Increased Tensile Load capability over standard loose tube cables – 1000 lbf/4500N
  - 170% Increased Impact Resistance over standard loose tube cables – 8.7 ft·lbs/11.8 N·m
  - 1000% Increased Crush Resistance over standard loose tube cables – 1370 lb/in/2400 N/cm
Jacket Identification

- Provides fiber type identification (Indoor Cables)
- Provides UV protection (Outdoor Cables)

Orange = OM1 and OM2

Yellow = OS2 (SM)

Aqua = OM3 and OM4

Black = Outdoor Cables
Copper Category 5e, 6
Industrial Cable Identification

PROFINET: Lime green
ROCKWELL: Teal rated for 600v
BLUE: Server Connection, also typical Voice or Data jack
GRAY: Standard voice or data connection
WHITE: Secondary Server Connection, sometimes voice or data
YELLOW: Wireless Access Point Connection
GREEN: Analog Phones
RED-: Security, Fire Alarm
RED-: TPE high flex, oil and sunlight resistant
ORANGE-: Visitor
ORANGE-: Industrial, high flex
Resources

- Anixter
- 3 Tips for Selecting Industrial Ethernet Cable & Connectors Posted by: Heather MacKenzie on May 22, 2013
  - http://www.belden.com/blog/industrialethernet/3-Tips-for-Selecting-Industrial-Ethernet-Cable-Connectors.cfm
- Noise mitigation layout
  - IEEE 1100 Chapter 10
  - Rockwell Automation GMC-RM001_-en-p.pdf
- Panel Design tools
- “Performance Metrics for Industrial Ethernet”
  - Panduit Industrial Design Guide:
Thank You!

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