3 Tips for an easy Fieldbus Design

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Three Tips for an easier Fieldbus Design

1. How to count, and what
2. Mind your own business
3. Work smart, not hard
3a. Exploit it all
3b. Get smart
How to count, and what

Example from an enquiry:

<table>
<thead>
<tr>
<th>UNIT*</th>
<th>FF AI</th>
<th>FF AO</th>
<th>FF MUX I/O</th>
<th>FF SEGMENT</th>
<th>AI HART</th>
<th>AO HART</th>
<th>T/C</th>
<th>RTD</th>
<th>DI 24VDC</th>
<th>DI OTHER</th>
<th>DO 24VDC</th>
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<tbody>
<tr>
<td>CCR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>971</td>
<td>952</td>
<td>215</td>
<td>134</td>
<td>24</td>
<td>370</td>
<td>-</td>
<td>241</td>
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<tr>
<td>UTILITIES</td>
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<td>-</td>
<td>-</td>
<td>78</td>
<td>55</td>
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<tr>
<td>GPP</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>328</td>
<td>244</td>
<td>54</td>
<td>-</td>
<td>-</td>
<td>1,127</td>
<td>-</td>
<td>278</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>262</td>
<td>197</td>
<td>43</td>
<td>23</td>
<td>67</td>
<td>1,089</td>
<td>-</td>
<td>675</td>
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<tr>
<td>MCE</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>142</td>
<td>86</td>
<td>44</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>PIE</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>264</td>
<td>191</td>
<td>51</td>
<td>52</td>
<td>149</td>
<td>1,843</td>
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<td>1,497</td>
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<tr>
<td>SLE</td>
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<td>-</td>
<td>-</td>
<td>390</td>
<td>248</td>
<td>106</td>
<td>-</td>
<td>-</td>
<td>320</td>
<td>-</td>
<td>59</td>
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<tr>
<td>TPE</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>350</td>
<td>227</td>
<td>91</td>
<td>-</td>
<td>-</td>
<td>391</td>
<td>-</td>
<td>237</td>
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<tr>
<td>BKE</td>
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<td>-</td>
<td>-</td>
<td>557</td>
<td>392</td>
<td>112</td>
<td>59</td>
<td>59</td>
<td>1,032</td>
<td>-</td>
<td>591</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3,342</td>
<td>2,592</td>
<td>735</td>
<td>268</td>
<td>299</td>
<td>6,293</td>
<td>-</td>
<td>3,611</td>
</tr>
</tbody>
</table>

* Project units are anonymized, but data and structure is taken from actual project enquiry.
How to count, and what

Conditions of enquiry:
• Signals (AI, AO, DI, DO, MOV, RTD, T/C, …)
• 10% Intrinsically safe, 10% Ex d, 80% Zone 2
• Process areas: CCR, Utilities, GPP, …
• 20% Spares

¿ What is relevant?
How to count, and what

- Signals (AI, AO, DI, DO, MOV, RTD, T/C, …)

- Are these all Foundation Fieldbus devices?
  - AI? Probably, or most likely they could be.
  - AO? Probably, or most likely they could be.
  - DI?
    - Use converter DI to FF for the sake of technology?
    - Can this become a AI? (e.g. Trip Level)
    - Is this MOV position feedback? Can this use positioner?
How to count, and what

• Signals (AI, AO, DI, DO, MOV, RTD, T/C, …)

¿ DO?
• Use converter DO to FF for the sake of technology?
• Can this become a AO? (e.g. MOV, change to positioner)

¿ RTD, T/C?
• Use FF temperature transmitter or FF Multiplexer? (Quantity, location)
How to count, and what

• Signals (AI, AO, DI, DO, MOV, RTD, T/C, …)
  → Count Foundation Fieldbus devices, not field signals.
  → If a device is FF, it is irrelevant what type of device it is, or what signals it handles.
  → Calculate number of segments based on the typical design of “10+2”.

Connecting the World of Process Automation 7
Explosion protection

• 10% Intrinsically safe, 10% Ex d, 80% Zone 2

→ “Intrinsic safety” and “Ex d” are protection methods
→ “Zone 2” is a potentially explosive area

¿ What are Zones and protection methods?
¿ When do I use which?
¿ What should be used in Zone 2?
Explosion triangle

Ignition source

Fuel / Gas

Air / Oxygen
Zones and typical protection methods

Area, non-hazardous (safe area)
• Explosive atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Zone 1
• Explosive gas atmosphere is likely to occur periodically or occasionally in normal operation.

Zone 0
• Explosive gas atmosphere is present continuously or for long periods or frequently.

Zone 2
• Explosive gas atmosphere is not likely to occur in normal operation, but if it does occur it will exist for a short period only.
**Typical protection methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>Suitable up to</th>
<th>Principle of protection</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex n</td>
<td>Zone 2</td>
<td>Various options similar to Ex m, e, d, etc</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Ex m</td>
<td>Zone 1*</td>
<td>Encapsulation (filling with compound/resin)</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Ex e</td>
<td>Zone 1*</td>
<td>Increased safety</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Ex d</td>
<td>Zone 1*</td>
<td>Flameproof enclosure</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Ex ic</td>
<td>Zone 2</td>
<td>Intrinsic safety – safe under normal conditions</td>
<td>Electrical</td>
</tr>
<tr>
<td>Ex ib</td>
<td>Zone 1</td>
<td>Intrinsic safety – safe with one fault</td>
<td>Electrical</td>
</tr>
<tr>
<td>Ex ia</td>
<td>Zone 0</td>
<td>Intrinsic safety – safe with two faults</td>
<td>Electrical</td>
</tr>
</tbody>
</table>

* There are variations such as Ex ma and Ex da that are allowed to be mounted in Zone 0. Using a combination of two independent Zone 1 protection methods also allows mounting in Zone 0.
Energy limitation / Intrinsic safety

Connecting the World of Process Automation

Mounting in hazardous area will require additional protection methods.
High Energy Trunk with Fieldbus Barrier

Benefits
- Supports longest cable lengths and heavily loaded segments
- Suitable for any IEC Zone or Gas Group
- Compatible with FISCO and Entity certified IS field devices
- New generation products allow safer operation and maintenance
- Compatible with general-purpose, high density fieldbus power supplies
- Non-redundant and redundant fieldbus barriers available
Redundant FISCO (Fieldbus I.S. concept)

Benefits
- Internationally recognised and defined in national standards
- Single IS protection method used throughout, no mix of protection methods
- Safest possible technique in hazardous areas
- Unique power supply redundancy delivers high system availability
- Most reliable technique due to redundant supply and simple device coupler

Key:
- Non-Live Working
- Live Working

Zone 1 Division 1

Connecting the World of Process Automation
Explosion protection

What protection method should be used in Zone 2?

- Ex ic
  - Intrinsic safety for Zone 2
  - Allows live maintenance
  - Typically used with Ex ia devices
- Ex nA
  - Non-arcing
  - No live maintenance
  - Typically used with Ex nA and Ex d devices
Ex ic solution for Zone 2

Benefits

- Live maintenance where it is needed: field devices
- Spurs are intrinsically safe; can be combined with Ex ia
- Simple application, no complex barriers/isolators involved
- No conduits or armored cable required
Explosion protection

• 10% Intrinsically safe, 10% Ex d, 80% Zone 2

→ Specification should define project requirements for field devices in terms of live maintainability; or specify (preferred) field device protection method.
→ Specify availability (reliability); availability often expressed as percentage (e.g. “>99.999%”).
→ Notify vendors about the classification of your hazardous areas (important for mounting locations of field JBs), and device quantities in those areas.
Explosion protection

• 10% Intrinsically safe, 10% Ex d, 80% Zone 2

→ There are a variety of infrastructure implementations available that perform the same task. Don’t limit yourself – allow yourself the freedom to choose.
→ Specify your requirements in terms of distance, reliability, safety, maintainability
→ Remember: Redundancy is a only a means to increase reliability!
Mind your own business

Fieldbus design specifications are often amalgamations of:
- AG181
- Previous job(s)
- Peer company specification(s)

→ Irrelevant information in specification
→ Redundant information in specification
→ Conflicting information in specification
→ Outdated / Excludes better suited technology
Mind your own business

¿ What are the requirement for *this* plant?

- Explosion protection methods
- Availability (Reliability)
- Safety

→ Check relevance of what you copy
  - It helps if you understand what you do
→ Ask vendors for help
Mind your own business

¿ What segment design current to use?

Redundant FISCO Power Supply

Megablock (Device coupler)

Field instruments

\[ I_{TRUNK} = I_{MB} + I_{D1} + I_{D2} + I_{D3} \]
Mind your own business

¿ What segment design current to use?

• Most documentation/specifications **assume** 20mA per field device
• Most specifications call for 20% additional current margin
• Most specifications call for additional voltage margin in the magnitude of 1V to 5V (2V in AG-181 Rev 3.2.1)

→ Additional voltage margin causes additional current margin: \( I_{\text{margin,additional}} = \frac{U_{\text{margin,additional}}}{2} \)
Mind your own business

¿ What segment design current to use?

→ 2V additional margin using 600m of AWG16 cable (24 Ω/km) is equivalent to adding a current margin of:

\[ I_{\text{margin, additional}} = \frac{2V}{24 \times \frac{600}{1000}} = 0.139A = 139mA \ (\!) \]

→ At a total current of 240mA (20mA, 12 devices), this is an additional current margin of 58%.

→ Adding this to the specified 20% current margin, we are at almost 80% margin!

\[ I_{\text{margin, total}} = 1.2 \times I_{\text{assumed, total}} + \frac{U_{\text{margin}}}{R_{\text{trunk cable}}} - I_{\text{actual, total}} \]
Mind your own business

¿ And what is the actual current, and the actual margin?

→ **Calculated average current is 15.29mA**
  *Source: http://forums.fieldbus.org/showpost.php?p=5181*

- **Total actual current (statistically) = 10 x 15.29mA + ~20mA**
  ** = 173mA
  ** Current for handheld and device coupler

- **Total design current = 1.2 x 240mA + 139mA = 427mA**

→ \(I_{margin, total} = 427mA - 173mA = 254mA \quad (147\%)\)

→ **Resulting voltage margin @ 600m AWG16 =
  0.254 A * 24 Ω * 600/1000 = 3.66 V**

Or: 1.2 x 240 mA – 173 mA = 0.115 A, resulting in 1.66V;
Mind your own business

¿ What segment design current to use?

→ Several margins are no issue for most designs
  → You will have segments well within specification
→ Additional voltage margins are problematic for:
  ▪ very long segments
  ▪ segments with intrinsically safe field instruments

→ A single margin is sufficient to operate fieldbus
→ Margins should cover the unforeseen; if you consider all those (short circuits, handheld tester, voltage drops as coupler, terminals, surge protector, etc), you can safely reduce your margin if needed
Work smart, not hard

Segment Calculation tools
- Easy verification of segment power distribution
- Individual loop calculations (with individual voltage and current parameters) are not required
- Spur calculations negligible (spur voltage drop is < 0.1V)
- Exact lengths do not need to be known
Work smart, not hard

Segment design can be greatly reduced

Example: you have the following 3 segments:
• 6 devices, 500m trunk length
• 10 devices, 700m trunk length
• 12 devices, 900m trunk length

→ If the ‘worst case’ works, the others will also work
→ However, not all segments are comparable, or have similar combination → one typical may not be enough
Work smart, not hard

Segment design – ‘typicals’
Example ‘typicals’:
#1: 12 devices, 1000m trunk length, Ex d
#2: 12 devices, 1000m trunk length, Ex i HET
#3: 4 Temp Mux + 6 devices, 1000m trunk, Ex i HET
#4: 1 Radar level + 6 devices, 1200m trunk, Ex i HET

→ Different protection methods require different infrastructure with different criteria
→ Multiplexer, field displays (particularly with backlight) require higher currents
→ Some radar devices require significantly higher currents

→ Identify 2 to 4 ‘typicals’ that cover all your other segments
Exploit it all

- Changing a fieldbus device has no impact on the fieldbus design
  - Replace device types (e.g. MOV to positioner)
  - Change vendor (conventional: devices may have proprietary/different signals, 1-10V / 4-20)

- Digital communication opens possibilities
  - Make use of multi-variable devices
  - Use multiplexer
  - Integrate devices which previously required stand-alone operation, e.g. gas chromatograph
Bus technology reduces wiring for electric actuators

<table>
<thead>
<tr>
<th>Cores</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>DO Open/stop/close control</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>AO Desired valve position control</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>DO Emergency shut down</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>DI Valve position status (limit switches)</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>AI Percentage open</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Available for control</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Local/remote switch</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Motor running open direction</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Motor running closed direction</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Torque switch tripped</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>AI Percentage torque</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>DI Motor thermostat tripped</td>
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<tr>
<td>1</td>
<td>1</td>
<td>DI Battery condition low</td>
</tr>
<tr>
<td>22</td>
<td>16</td>
<td>ch TOTAL</td>
</tr>
</tbody>
</table>
Exploit it all

Multi-Channel Temperature Transmitter
• 8 channel, universal input

8 Point Remote Indicator

Digitally integrated On/Off Valve

Fully integrated Gas Chromatograph

Without fieldbus you cannot benefit from new innovations

Dual Temperature Transmitter
- 2 channels can be used for control
Get Smart

Digital communication opens possibilities

- Migrate to the IIoT
  - Level trip switch
  - Valve position switch
  - Pressure switch
  - Mechanical switch

  \[
  \text{Replace with FF transmitter}
  \]

- Asset Management for all devices
- New functions / Inventions
  - Make use of device informing you of needed maintenance
Three Tips for an easier Fieldbus Design

Summary

- Fieldbus is digital
  - Digital makes a lot of tasks unnecessary
  - Attempt to simplify your procedures and not just copy 4-20
  - Working procedures are normally more efficient than on 4-20
  - Make use of the possibilities that digital communication offers
- Use native FF devices where possible
  - Converters do not improve intelligence of field signals
- Use digital communication whenever reasonable
  - Try to avoid isolated island solutions
- Understand and specify your requirements clearly; It will speed up everything and brings down cost
Thank you for your attention

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