Design and delivery of a Control System for an Aluminum Smelter.

Skúli Björn Jónsson

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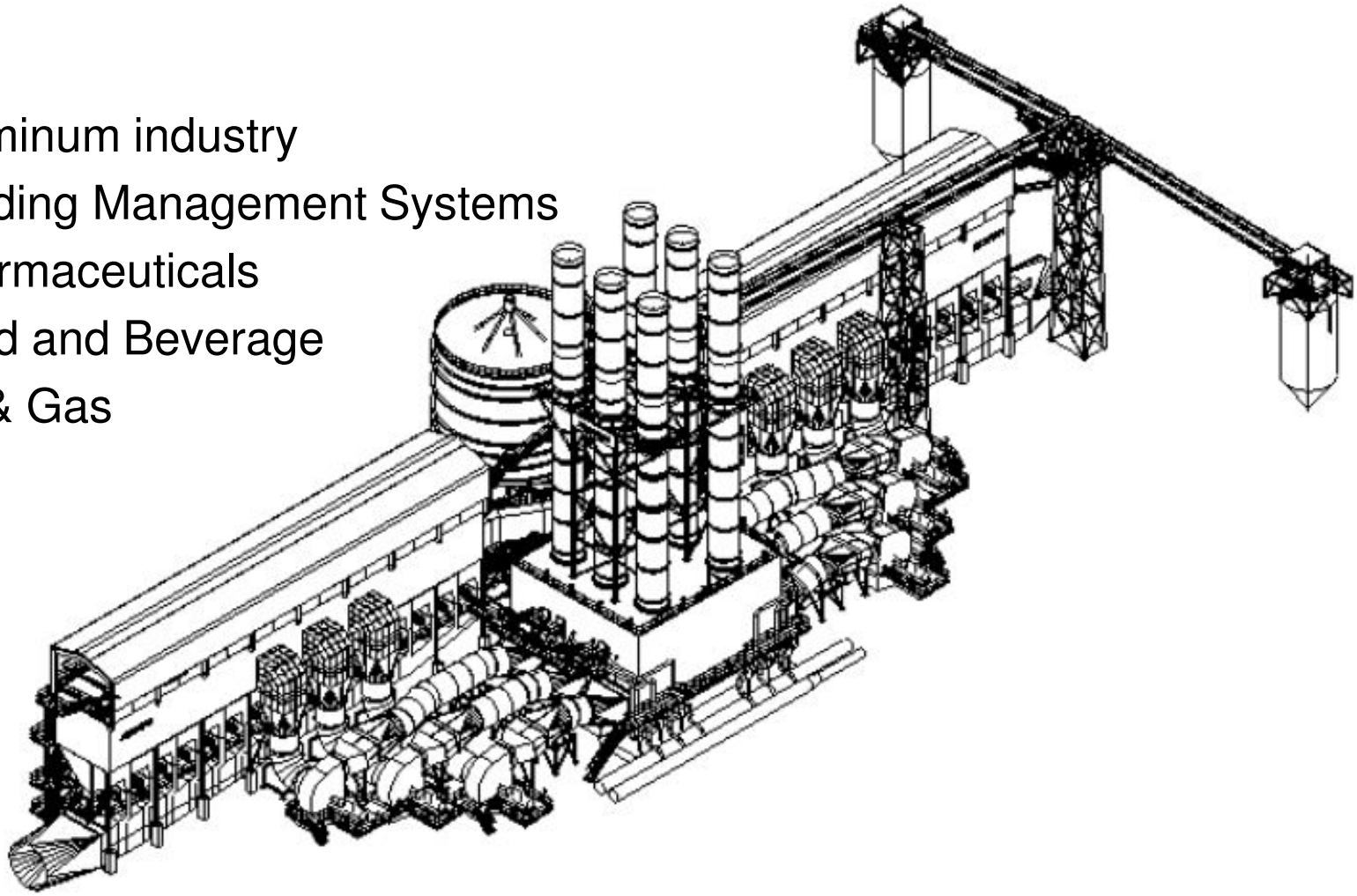
Our experience

- Aluminum industry
- Building Management Systems
- Pharmaceuticals
- Food and Beverage
- Oil & Gas



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Today's Topics

- Design and Design Conditions.
- Redundancy.
- Programming
- Communication to 3 party devices.
- Ambient Conditions.
- Interlocks.
- Startup and Commissioning.
- Advantage of using AOI and Faceplates.

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First Steps when designing a Control System.

- Data From Client
  - I/O List
  - P&ID
  - Equipment list
  - Specifications

- Documents we deliver
  - FDS (Functional Design Specifications)
  - DDS (Detailed design Specifications)
  - ASS (Automation System Sequences)
  - SCD (System Control Diagrams)
  - CSA (Control System Architecture)
  - FAT / SAT Documents
  - User Manuals
  - Heat Calculations

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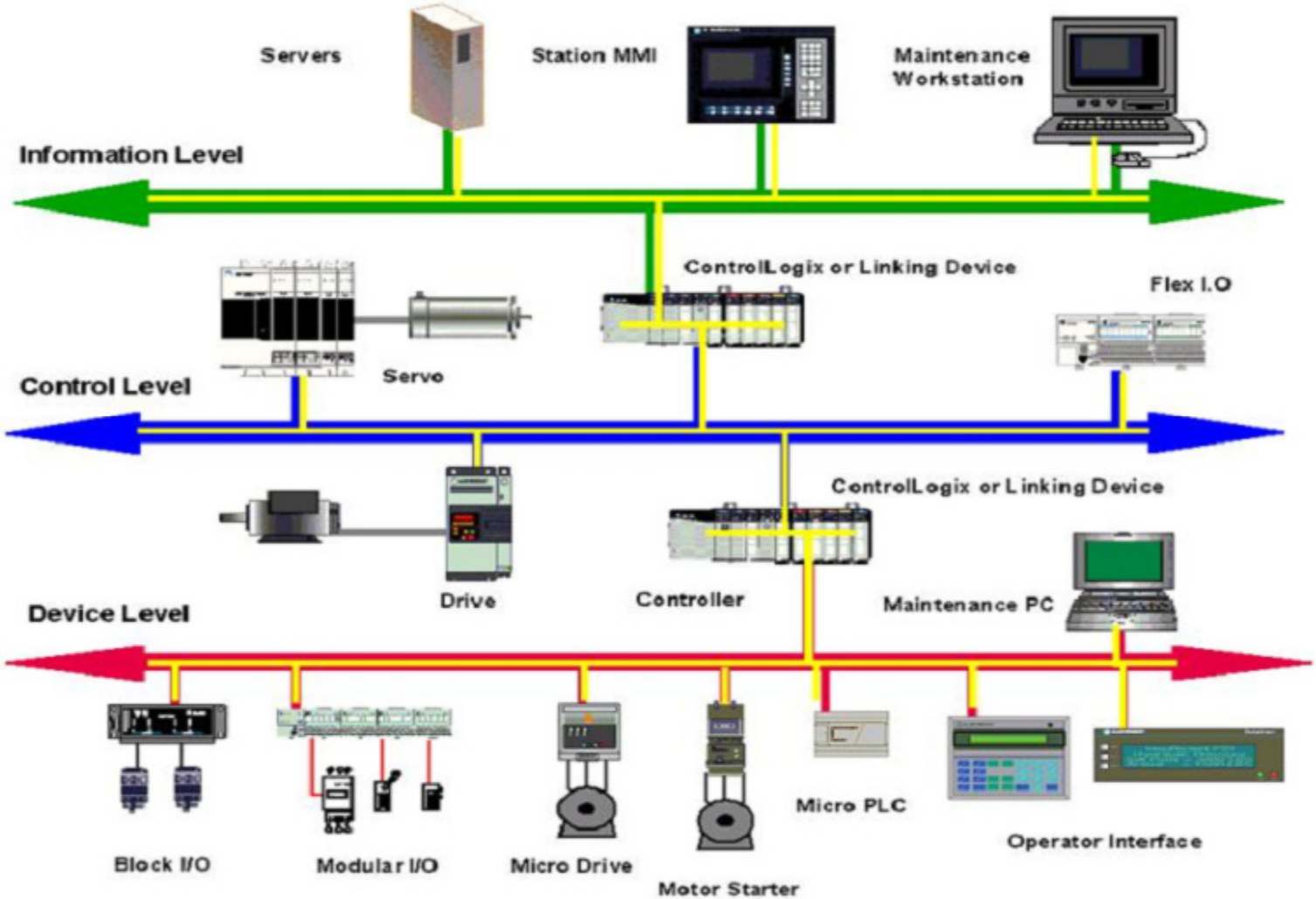
Data From Client



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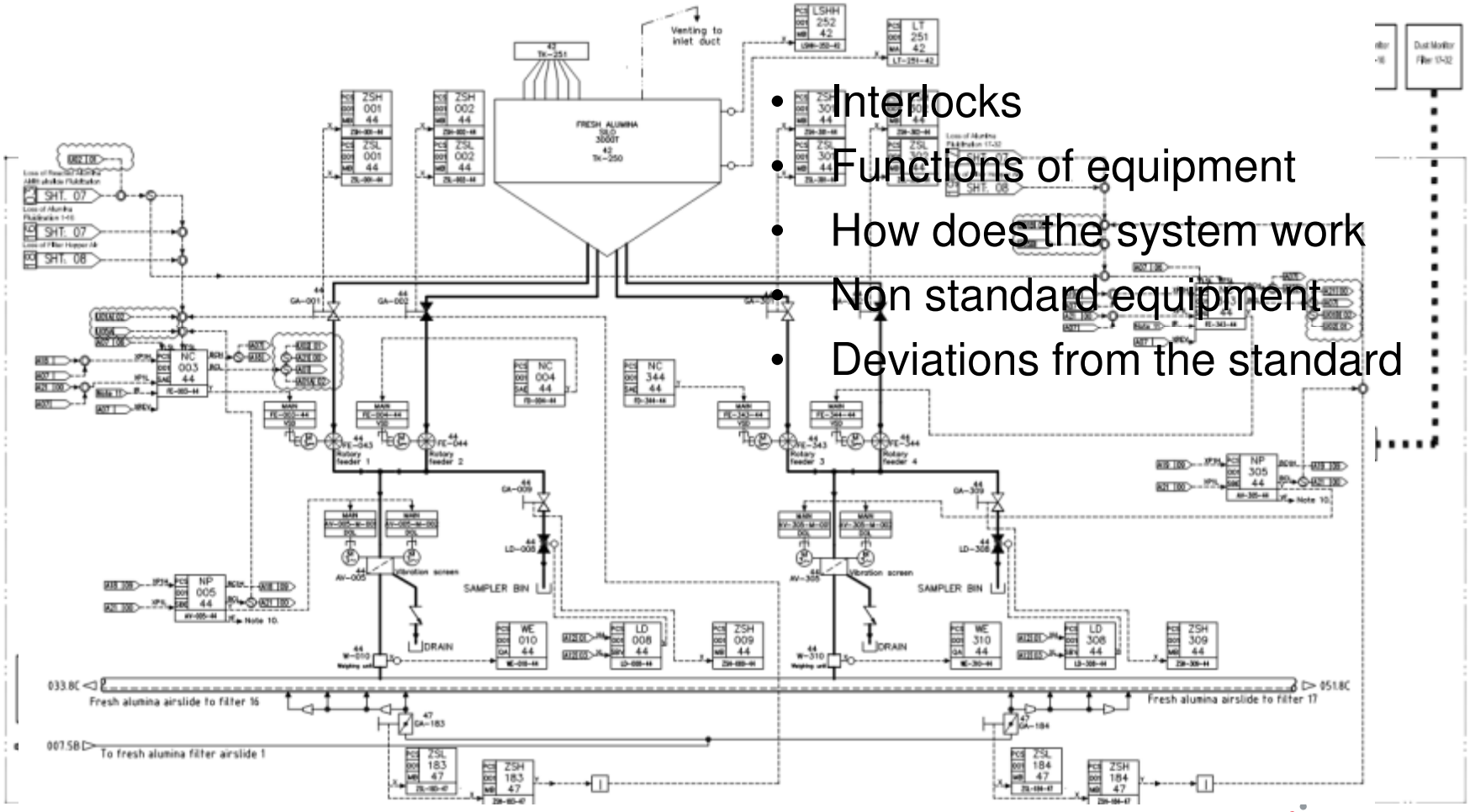
First Steps when designing a Control System.



- Interlocks
- Functions of equipment
- How does the system work
- Non standard equipment
- Deviations from the standard

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Design and design conditions

- Physical I/O
  - Digital / Analog
- Intelligent I/O
  - Network connected I/O
- Location of equipment
  - Size of the plant
  - Ambient conditions
  - Logistics
- Communications
  - How much data transferred
  - Time critical equipment
  - Types of networks
  - Number of networks
  - Redundancy

ControlNet	Connections	Number Of Modules	Number Of Modules
Analog Modules	1	30	30
Digital Diagnostic Modules	1	56	56
DeviceNet Modules	2	18	36
Total Connections			122
Number of I/O modules required		45	11	30
Minimum No. of Flex I/O a			

DeviceNet	DeviceNet Nodes
Variable Frequency Drive	39
Auxiliary I/O modules	39
Motor Managers	50
Valve Island	32
Weighing Unit	2
Main Exhaust Fan	6
Condition Monitoring	6
Guide Vane Damper	10
Total Nodes	184

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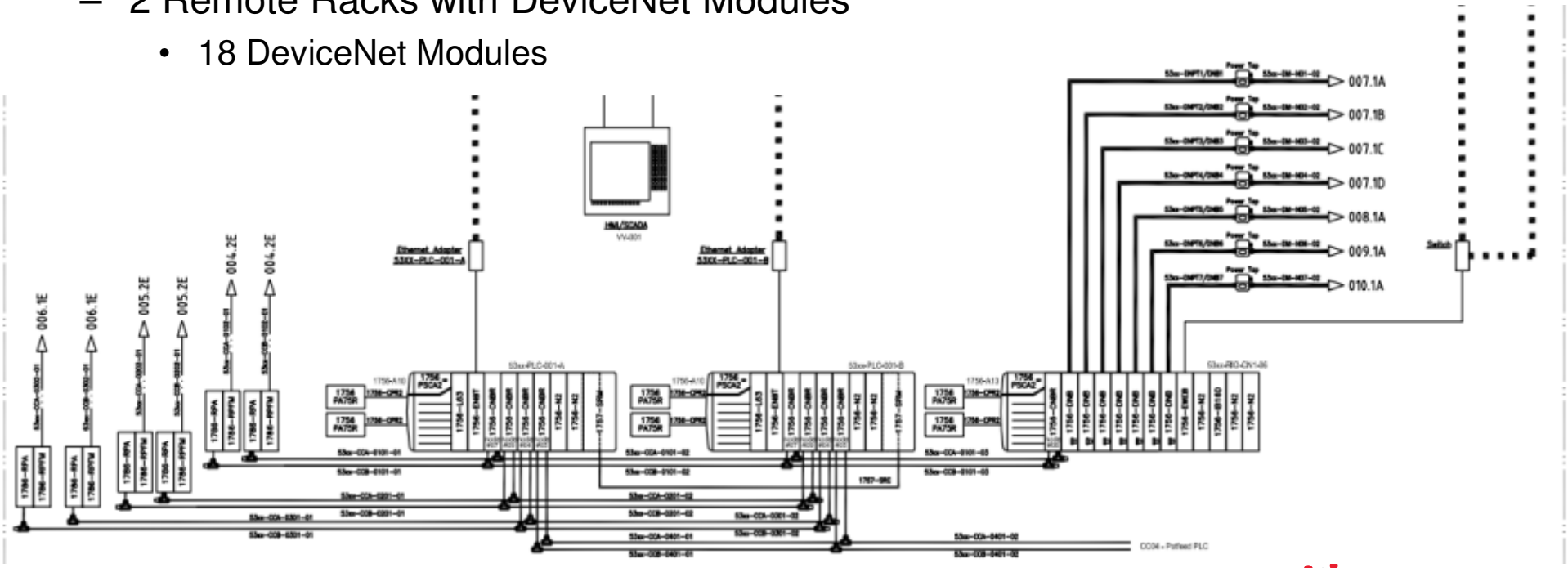
Setup of the control system

- Local Control Panel
  - Redundant PLC
  - Redundant ControlNet Networks
  - Remote Rack only for DeviecNet Modules
- 4 Redundant ControlNet Segments
- 2 Remote Racks with DeviceNet Modules
  - 18 DeviceNet Modules



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Setup of the control system

- 7 Remote I/O Panels
  - Redundant ControlNet Connection
  - Remote Rack only for DeviecNet Modules

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Controller Selection

- 1756-L6x controllers
  - Memory
  - Redundancy
  - Connections

Estimate Memory Use

These equations provide an estimate of the memory needed for a controller.

Controller tasks	_____	* 4000	=	_____	bytes (minimum 1 needed)
Digital I/O points	_____	* 400	=	_____	bytes
Analog I/O points	_____	* 2600	=	_____	bytes
DeviceNet modules[1]	_____	* 7400	=	_____	bytes
Other communication modules[2]	_____	* 2000	=	_____	bytes
Motion axis	_____	* 8000	=	_____	bytes
FactoryTalk alarm instruction	_____	* 1000	=	_____	bytes (per alarm)
FactoryTalk subscriber	_____	* 10000	=	_____	bytes (per subscriber)
		Total	=	_____	bytes

[1]The first DeviceNet module is 7400 bytes. Additional DeviceNet modules are 5800 bytes each.

[2]Count all the communication modules in the system, not just those in the local chassis. This includes device connection modules, adapter modules, and ports on PanelView terminals.

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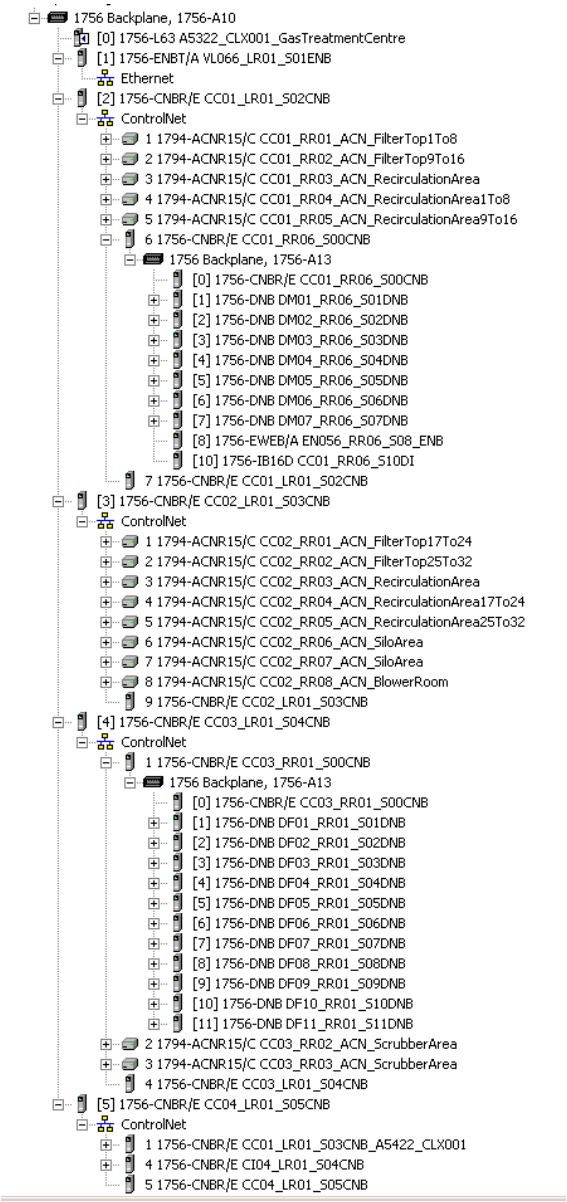
Considerations

- ControlNet Network
  - Connections
  - NUT (Network Update Time)
  - RPI (Requested Packet Interval)
  - Bandwidth



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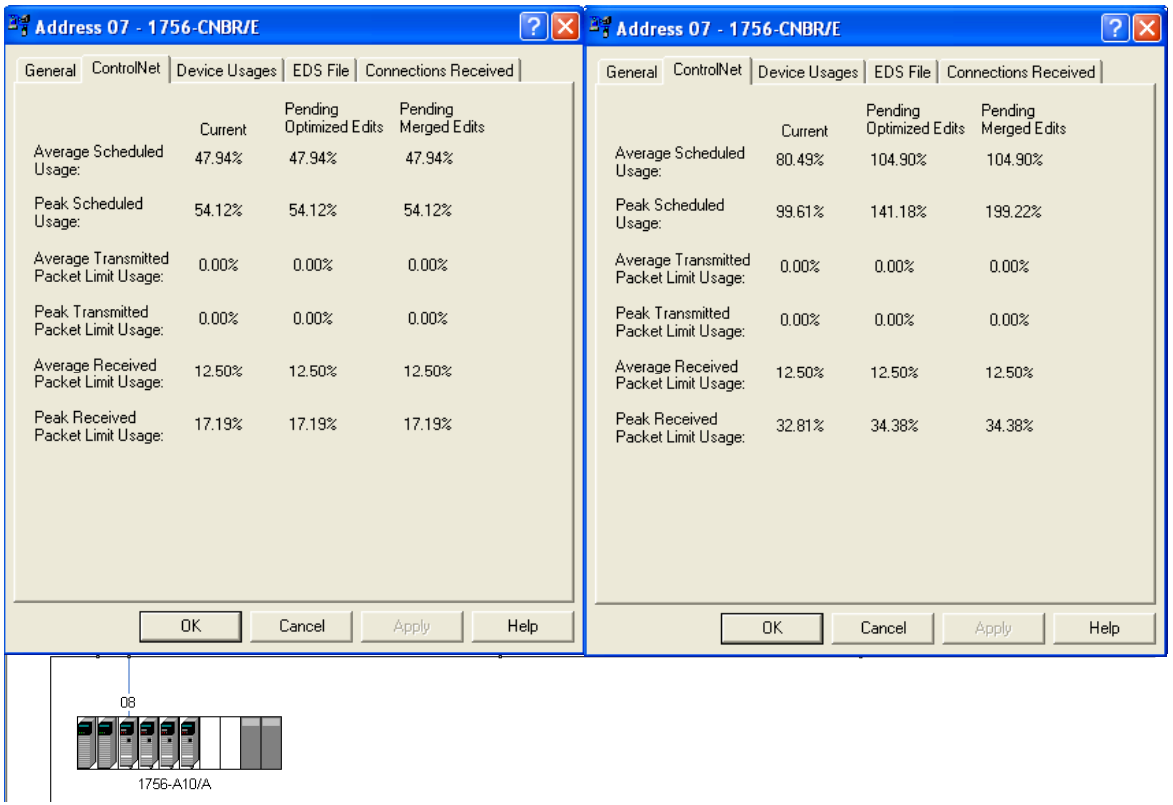
ControlNet



- Schedule a Network
- Network RPI
- NUT
- Bandwidth
- Connections

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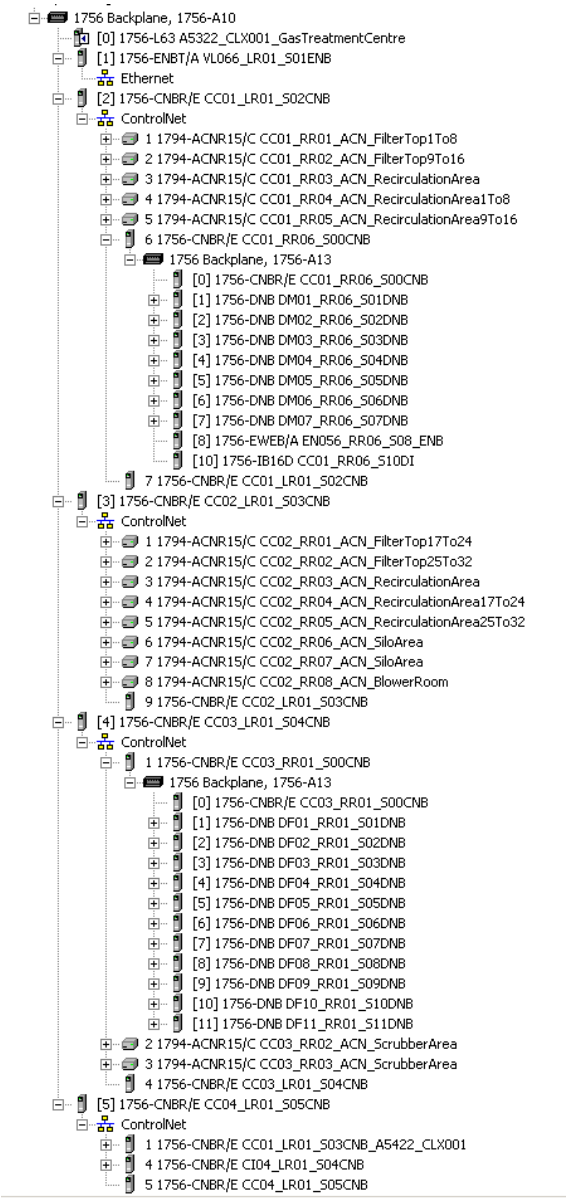
Considerations

- Amount of data on the DeviceNet Network
  - Input Size
  - Output Size
  - RPI (Requested Packet Interval)
  - NUT (Network Update Time)
  - Number of Nodes



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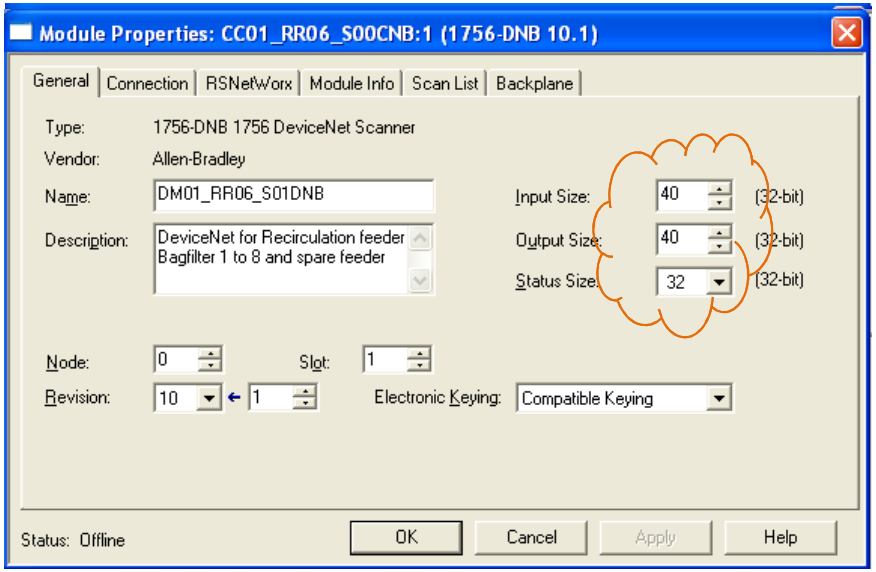
DeviceNet Load

- 6 1756-CNBR/E CC01_RR06_S00CNB
  - 1756 Backplane, 1756-A13
    - [0] 1756-CNBR/E CC01_RR06_S00CNB
    - [1] 1756-DNB DM01_RR06_S01DNB
    - [2] 1756-DNB DM02_RR06_S02DNB
    - [3] 1756-DNB DM03_RR06_S03DNB
    - [4] 1756-DNB DM04_RR06_S04DNB
    - [5] 1756-DNB DM05_RR06_S05DNB
    - [6] 1756-DNB DM06_RR06_S06DNB
    - [7] 1756-DNB DM07_RR06_S07DNB
    - [8] 1756-EWEB/A EN056_RR06_S08_ENB
    - [10] 1756-IB16D CC01_RR06_S10DI
- 1 1756-CNBR/E CC03_RR01_S00CNB
  - 1756 Backplane, 1756-A13
    - [0] 1756-CNBR/E CC03_RR01_S00CNB
    - [1] 1756-DNB DF01_RR01_S01DNB
    - [2] 1756-DNB DF02_RR01_S02DNB
    - [3] 1756-DNB DF03_RR01_S03DNB
    - [4] 1756-DNB DF04_RR01_S04DNB
    - [5] 1756-DNB DF05_RR01_S05DNB
    - [6] 1756-DNB DF06_RR01_S06DNB
    - [7] 1756-DNB DF07_RR01_S07DNB
    - [8] 1756-DNB DF08_RR01_S08DNB
    - [9] 1756-DNB DF09_RR01_S09DNB
    - [10] 1756-DNB DF10_RR01_S10DNB
    - [11] 1756-DNB DF11_RR01_S11DNB

- 18 DeviceNet Cards
  - Variable amount of data per card
  - Compact the data
  - Cut off the extra



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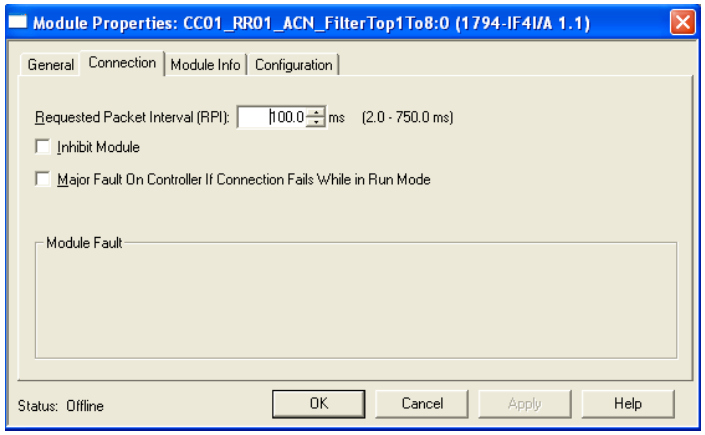
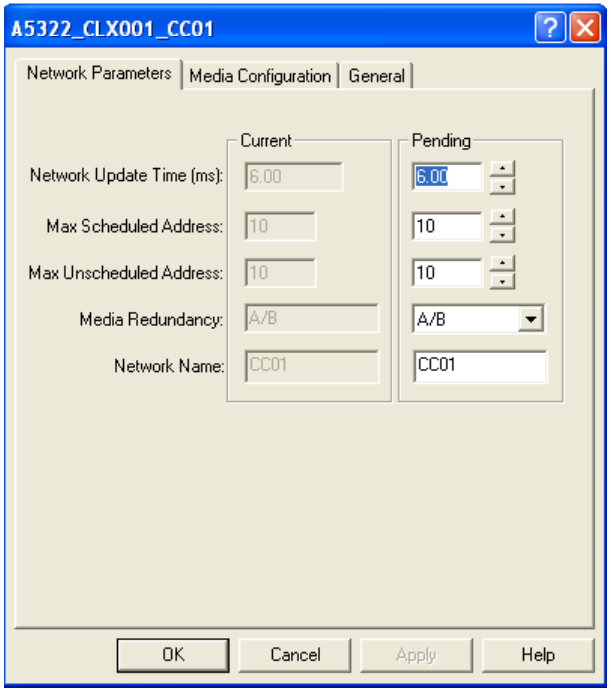
Network Load





- Increase the requested packet interval (RPI)
- Specify the maximum unscheduled address on the network to be less than or equal to the maximum scheduled address.
- Review and delete any unneeded connections or change the media configuration

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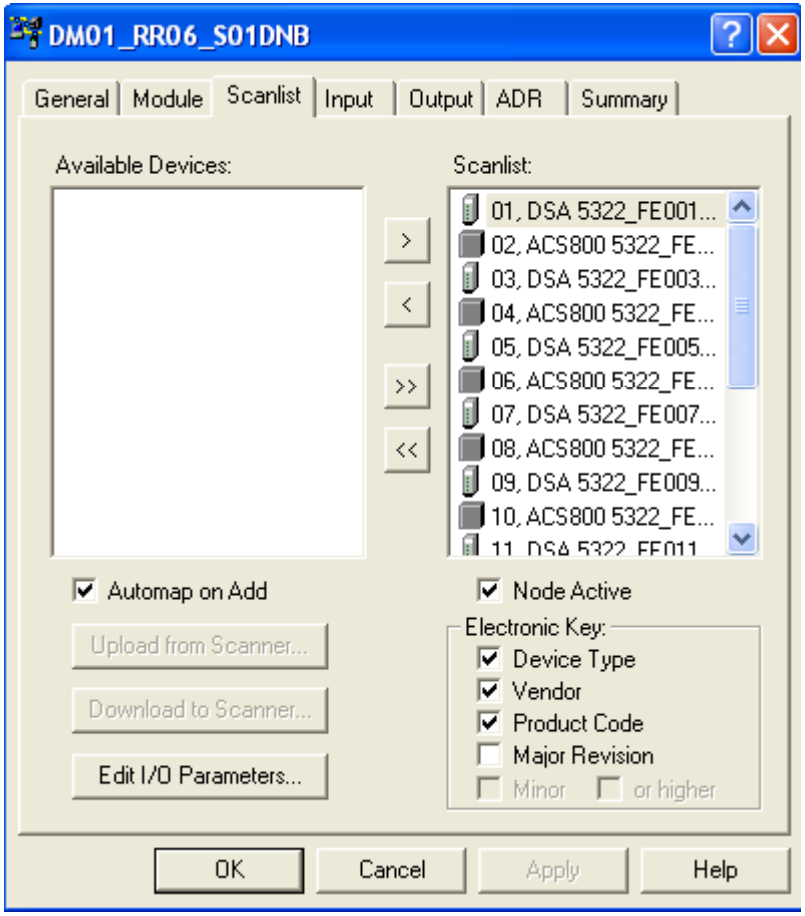
Compact Network

- Add Modules
- Edit I/O
  - Select data assembly that fits
  - Edit the data assembly so it fits
  - Group equipment together
  - Equipment with high speed data requirements together



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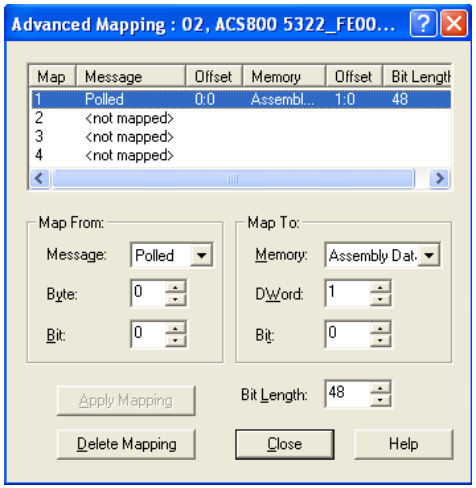
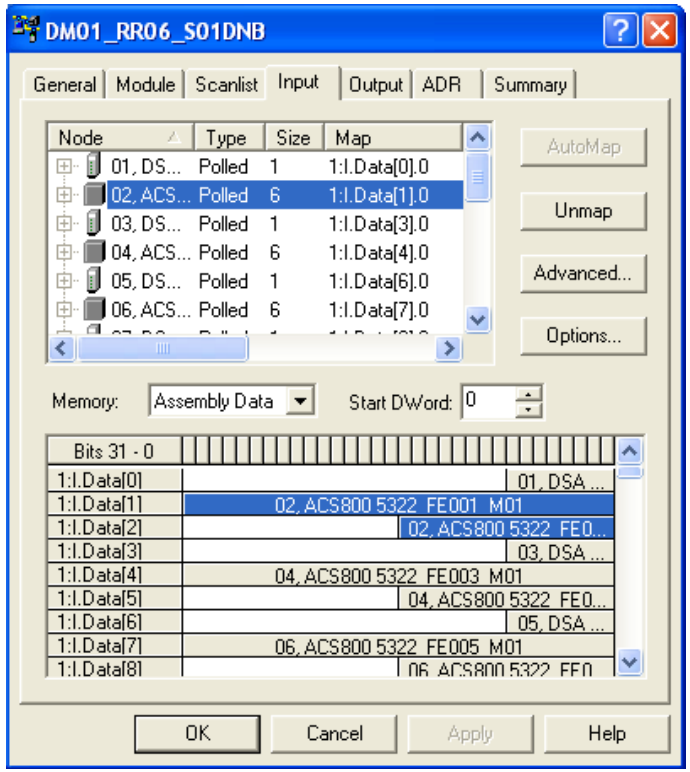
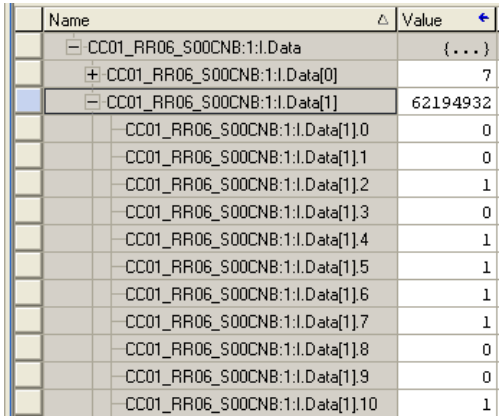
Mapping

- Mapping
- Giving each equipment its own data area
- Do not add equipment directly one after the other.







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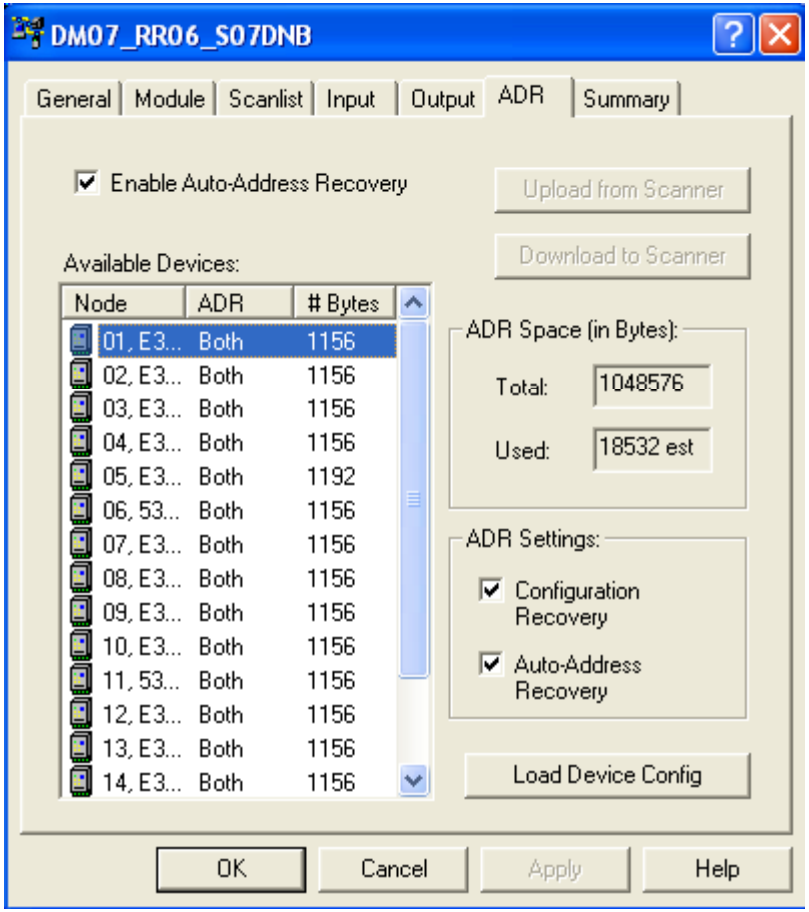
ADR Automatic Device Recovery

- Fast Replacement
  - Scanner Stores Data
  - Download settings automatically
  - Configuration Recovery
  - Auto-Address Recovery
  - “Plug and Play”



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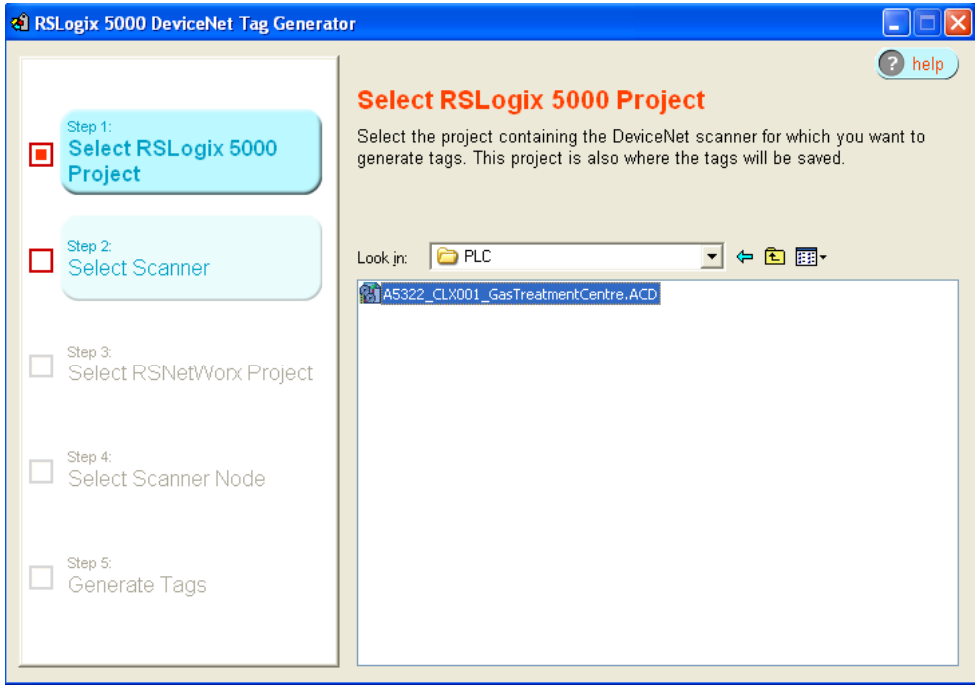
DeviceNet Tag Generator

- Imports tags from DeviceNet to the controller
- Easy changes
- Creates routines
  - Input
  - Output
  - User Defined Data types



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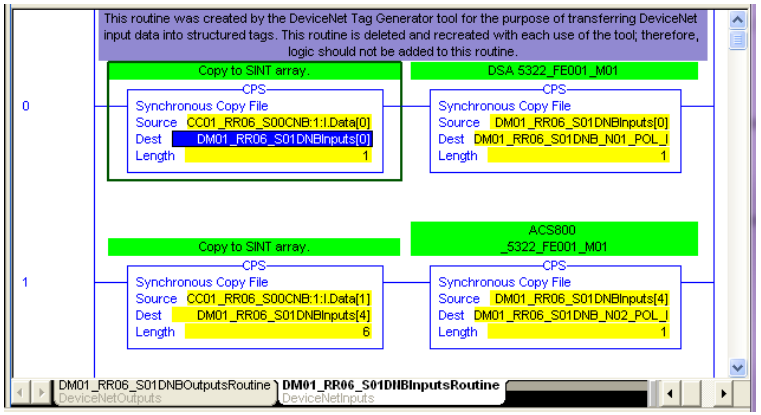
DeviceNet Tag Generator



Name	Value
CC01_RR06_S00CNB:1:I.Data	{...}
CC01_RR06_S00CNB:1:I.Data[0]	7
CC01_RR06_S00CNB:1:I.Data[1]	62194932
CC01_RR06_S00CNB:1:I.Data[1].0	0
CC01_RR06_S00CNB:1:I.Data[1].1	0
CC01_RR06_S00CNB:1:I.Data[1].2	1
CC01_RR06_S00CNB:1:I.Data[1].3	0
CC01_RR06_S00CNB:1:I.Data[1].4	1
CC01_RR06_S00CNB:1:I.Data[1].5	1
CC01_RR06_S00CNB:1:I.Data[1].6	1
CC01_RR06_S00CNB:1:I.Data[1].7	1
CC01_RR06_S00CNB:1:I.Data[1].8	0
CC01_RR06_S00CNB:1:I.Data[1].9	0
CC01_RR06_S00CNB:1:I.Data[1].10	1

Name	Value	Data Type
DM01_RR06_S01DNB_DIAG	{...}	DNB_Diag
DM01_RR06_S01DNB_FAULT	0	DINT
DM01_RR06_S01DNB_N01_POL_I	{...}	AB_100_DNY42R_I_49718537
DM01_RR06_S01DNB_N01_POL_I.Input0	1	BOOL
DM01_RR06_S01DNB_N01_POL_I.Input1	1	BOOL
DM01_RR06_S01DNB_N01_POL_I.Input2	1	BOOL
DM01_RR06_S01DNB_N01_POL_I.Input3	0	BOOL
DM01_RR06_S01DNB_N01_POL_I.OutputAFault	0	BOOL
DM01_RR06_S01DNB_N01_POL_I.OutputBFault	0	BOOL
DM01_RR06_S01DNB_N01_POL_I.UndefinedData	0	BOOL
DM01_RR06_S01DNB_N01_POL_I.InputFault	0	BOOL
DM01_RR06_S01DNB_N01_POL_O	{...}	AB_100_DNY42R_O_B9097A9E
DM01_RR06_S01DNB_N02_POL_I	{...}	_002E_ACS800_I_643472D0
DM01_RR06_S01DNB_N02_POL_I.Data	0	SINT
DM01_RR06_S01DNB_N02_POL_I.Data1	0	SINT
DM01_RR06_S01DNB_N02_POL_I.Data2	0	SINT
DM01_RR06_S01DNB_N02_POL_I.Data3	0	SINT
DM01_RR06_S01DNB_N02_POL_I.ExtendedData	0	SINT
DM01_RR06_S01DNB_N02_POL_I.ExtendedData1	0	SINT

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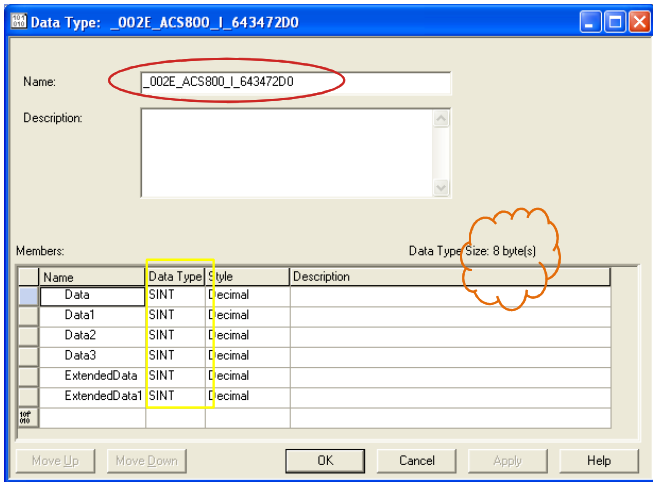
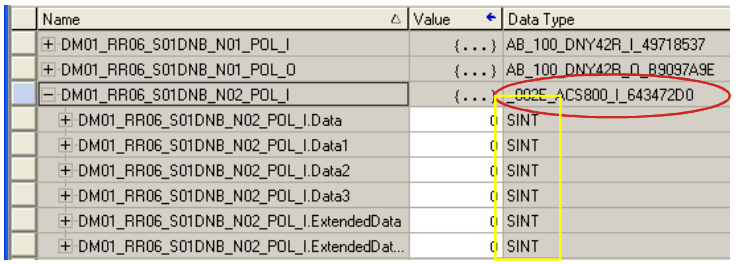
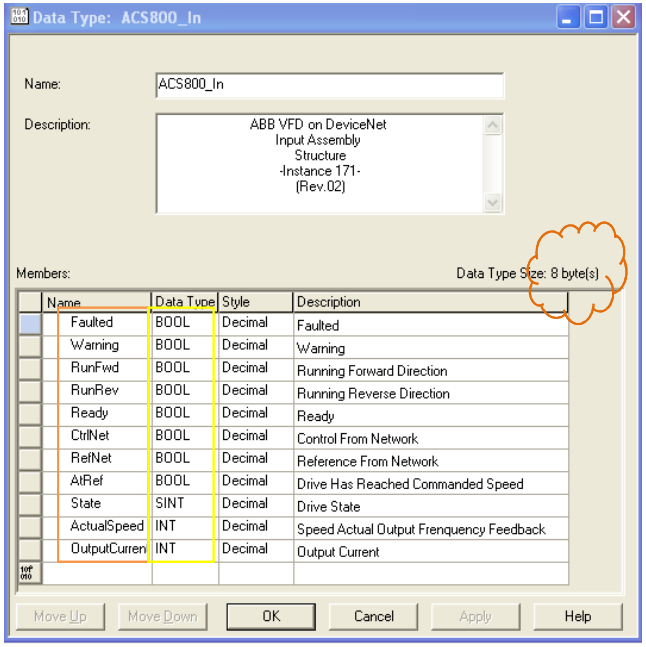
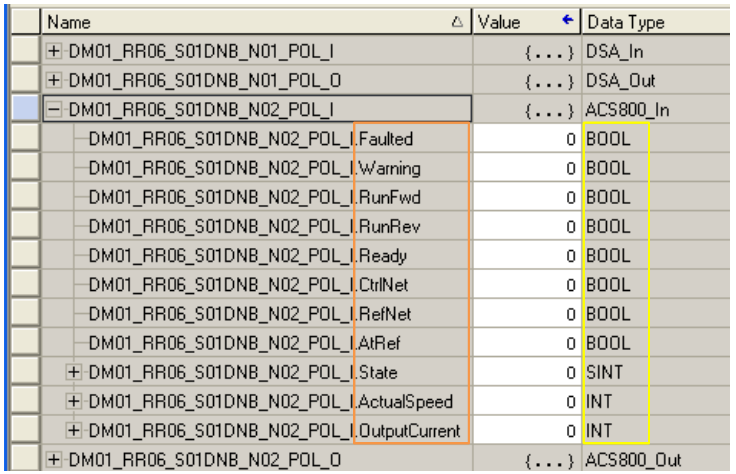
User Defined Data Types









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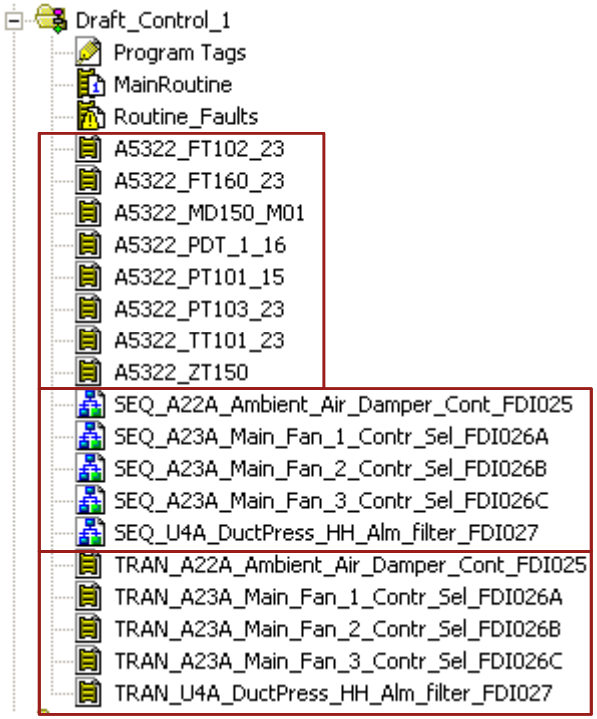
Programming

Program structure

Periodic or Continuous Tasks

- Programs
  - Routines
    - Equipment Routines
    - Sequential Function Charts
      - Sequence
      - Transitions

A well organized program will be easier to troubleshoot and maintain.



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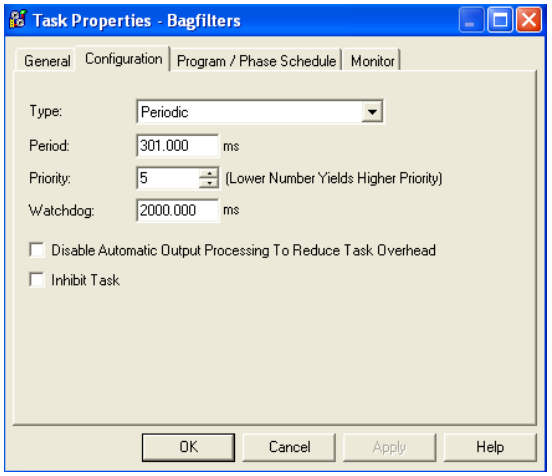
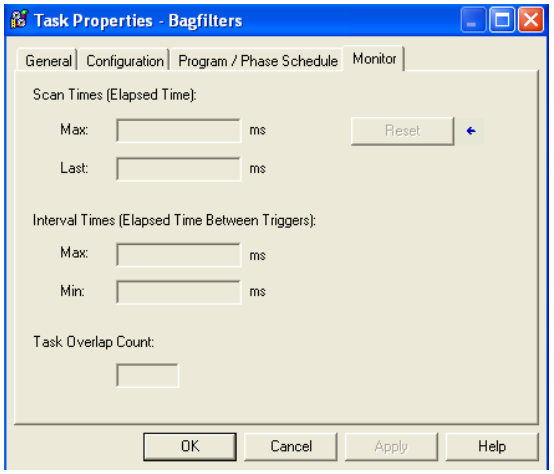
Programming

Scan Time can be a major factor in large applications.

- Periodic tasks to control the scan time.
- Priority setting
- Take care when setting the priority and time
- Task overlap
- Adjust network RPI to adjust scan time
- Redundant Controllers add ~50% scantime





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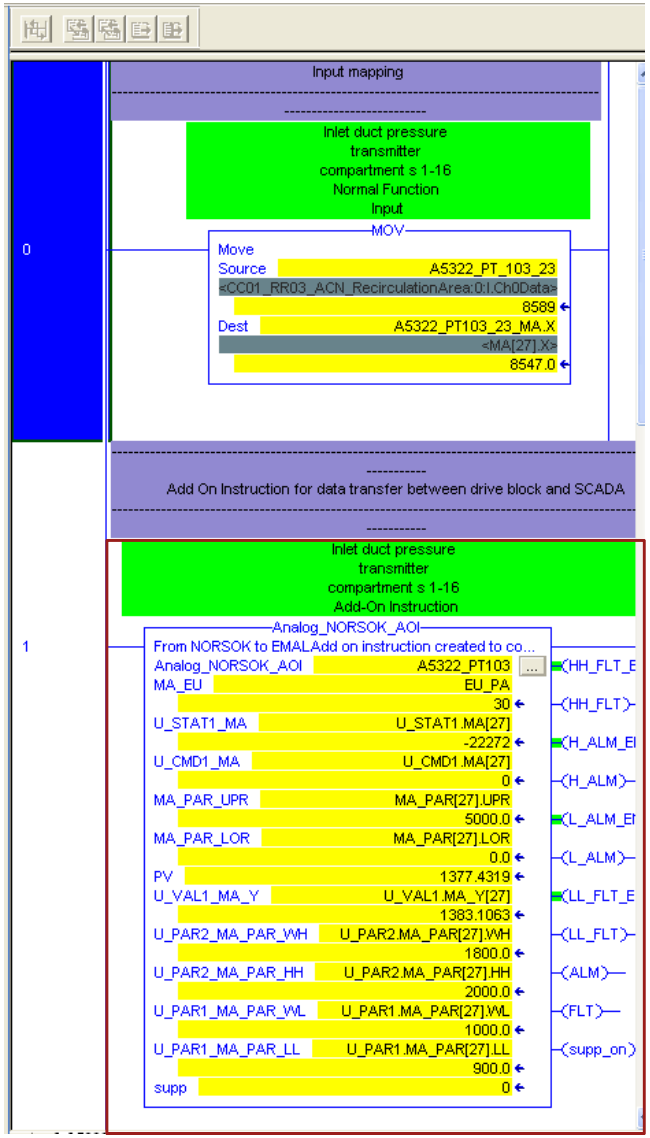
Programming

- Equipment routines
  - Each equipment is identical
  - Export / Import changes
  - Import constants
  - Easy to debug the code

- Add on Instructions
  - Standard control every time
    - Test once use multiple times
  - Minimum debugging
  - Easy SCADA / HMI setup



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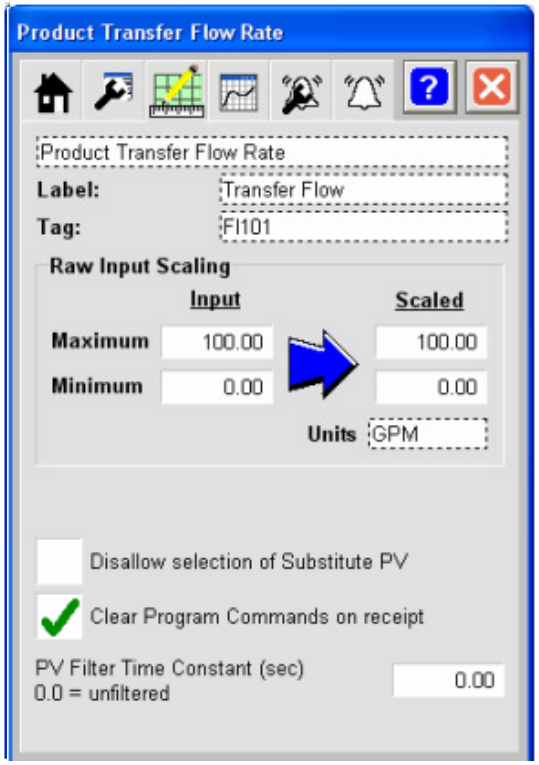
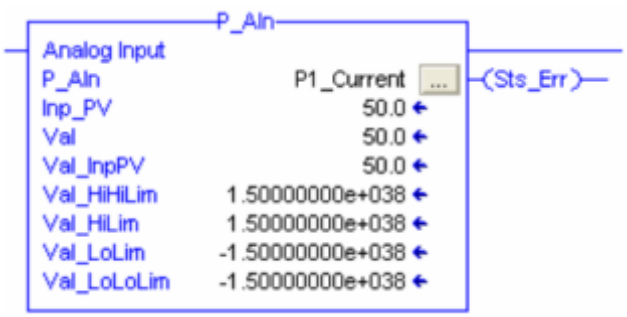
Add on Instruction

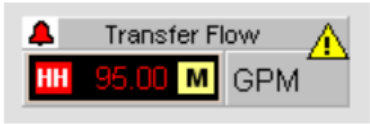
- Normal Programming
- We usually program one equipment in ladder and test it then create the AOI
- Quick connection to Faceplates
- Standard Communication
- No need to troubleshoot the Faceplates every time



Standard



Standard



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Validation

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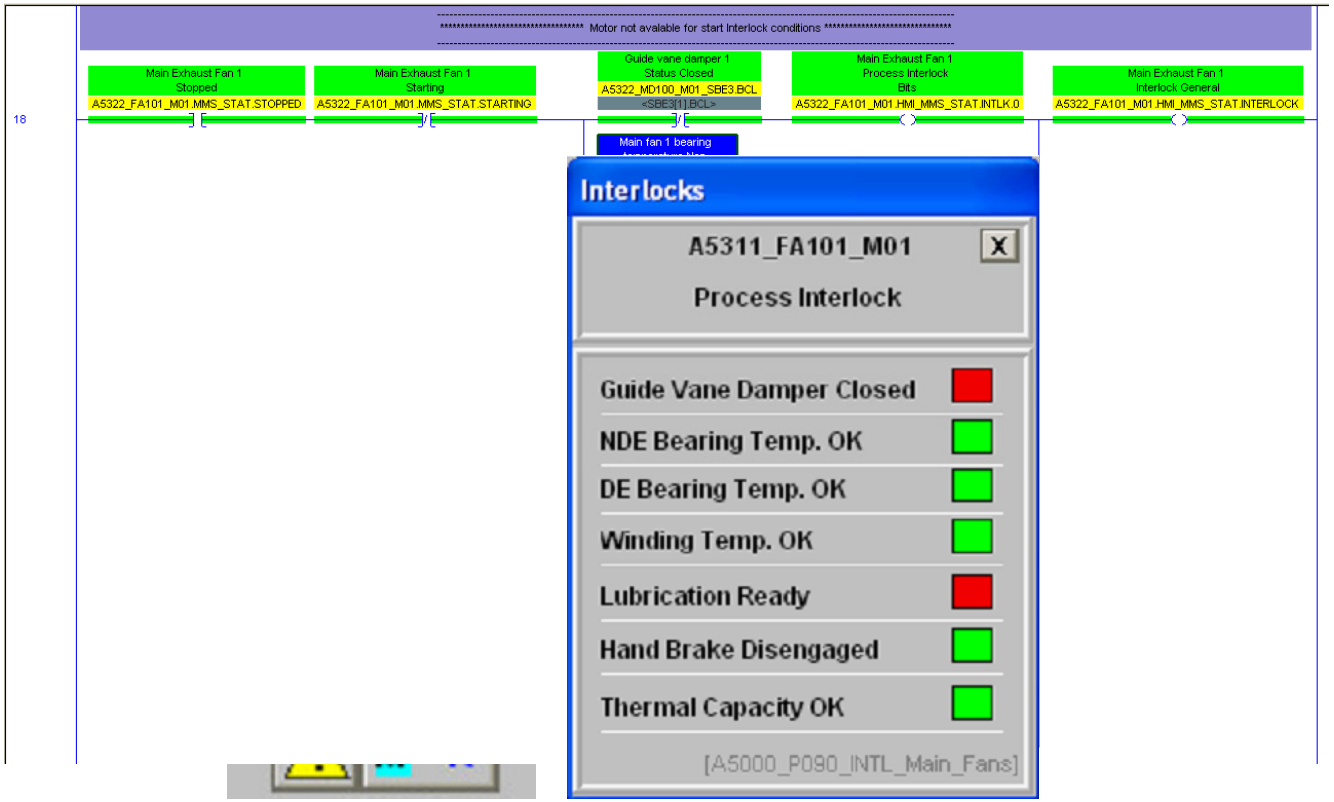
Interlocks

- Information is valuable
- Keep text simple
- Make sure text can not be misinterpreted
- Homogeneous
- Keep the same structure in PLC and SCADA



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Communicating to 3 Party Devices.

Why choose a network to 3 Party Devices?

- Reduce cost
  - Less Cabling and I/O
  - Fewer points of failure
  - Improved Troubleshooting
- Additional data
  - Data analyzing within the equipment
  - Multiple data signals
  - Real time health
- No other way!
  - High level communication
  - Socket communication

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Finding the Platform

- Ethernet/IP
- DeviceNet
- ControlNet
- Profibus
- Modbus
- DH+
- Can Bus
- BACnet
- Hart
- RS232

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DeviceNet to 3 party

- Norgren Valve Islands
- Siemens Weight Cell
- ABB VSD
- GE Multilin
- Auma GVD

RSI_EDS_NORGREN VSxx 32 Rev 2.255 - Notepad

File Edit Format View Help

```
$ Electronic Data Sheet IMI Norgren Ltd
$ Produced By A HUGHES
$ IMI Norgren Limited, Lichfield, England
$
$ This EDS file works with VSxx DeviceNet Node with 32 Outputs (16 VALVES)

[File]
DescText = "NORGREN VSxx 32";
CreateDate = 12-05-2001;
CreateTime = 10:00:00;
ModDate = 02-02-2004;
ModTime = 10:00:00;
Revision = 2.2;                                                 $ EDS revision.

[Device]
VendCode = 42;
VendName = "IMI Norgren Limited";
ProdType = 27;
ProdTypeStr = "Pneumatic Valve";
ProdCode = 332;
MajRev = 2;
MinRev = 0;
ProdName = "NORGREN VSxx 32";
Catalog = "N/A";

[IO_Info]
Default = 0x0001;                                               $ The default I/O type is polled I/O.
PollInfo =
0x0001,                                                                 $ Polled
0,                                                                      $ Input1 entry is 0 (No Inputs)
1;                                                              $ Output1 entry is the default output connection.

Output1 =
4,                                                                      $ The size in bytes that this connection consum
0,                                                              $ all bits of this connection are significant.
0x0001,                                                                 $ Polled I/O is compatible.
"Norgren Slave consumed data",                                  $ Name of Connection.
6,                                                              $ Path length.
"20 04 24 25 30 03",                                            $ Path to I/O Consumption Assembly.
"32 Solenoid Output Points";                                    $ Help String

[ParamClass]
MaxInst = 0x08;                                                 $ Maximum Parameter Number
Descriptor      = 0x09;                                                 $ Stub param instances in eeprom.
CfgAssembly = 0x64;                                             $ The config assembly is instance #100 of assy obj.

[Params]
Param1=
0,                                                              $ reserved
6,                                                                      $ path
"20 03 24 01 30 01",                                            $ link path size
0x0020,                                                                 $ descriptor
8,1,                                                                    $ unsigned int, 1 byte
"MAC ID",                                                               $ Name
"",                                                             $ units
"MAC ID of this Node",                                  $ help
0,63,63,                                                                $ min,max,default
1,1,1,0,                                                                $ mult,div,base,offset scaling
0,0,0,0,0;                                                              $ scaling links & precision

Param2=
0,                                                                      $ reserved
6,                                                                      $ path
"20 03 24 01 30 02",                                            $ link path size
0x0022,                                                         $ descriptor
0xC6,1,                                                         $ unsigned int, 1 byte
```

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Ethernet Communication

- Laser Dust Monitor
  - ASCII, C-format Text, TCP/IP
  - To gain valuable emission values
- Pot Controllers
  - Communication from PLC to C-format application
- Vehicles
  - Translation from CodeSys PLC to the factory standard
  - Opening a gateway to Databases

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Why did we choose network for a Laser Dust Monitor

- The LDM could do high speed sampling
- LDM could to automatic calculations
- Trigger calculations
- Multiple readings
- Detailed health monitoring of the optics and electronics
- Broken bags could be found faster, therefore less emission!
- Faster troubleshooting
- Less cabling

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Ambient Conditions.

-20 ℃
Wind factor
Heating

+50 ℃
Sun Factor
Cooling

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Ambient Conditions.

- Rain / Snow
- Heat /Cold
- Wind
- Magnetic field
- Vibration
- Dust
- Alumina
- Sulfur dioxide
- Hydrogen Fluoride
- Seawater

	ControlLogix I/O Modules
Operating Temperature	0...60 °C (32...140 °F)
Storage temperature	-40...85 °C (-40...185 °F)
Relative Humidity	5...95% noncondensing
Vibration	2 g at 10...500 Hz
Operating Shock	30 g
Nonoperating Shock	50 g

Enclosure Type Rating	None (open-style)
Mounting Type	DIN-rail, Panel
Operating Temperature	0...55 °C (32...131 °F) -20...70 °C (-4...158 °F)‡
Nonoperating Temperature	-40...85 °C (-40...185 °F)
Relative Humidity	5...95% noncondensing
Operating Shock*	30 g
Nonoperating Shock*	50 g
Vibration*	5 g at 10...500 Hz

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Ambient Conditions.

- Over Pressured rooms
- Panels IP 66 or higher.
  - Indoors
  - Outdoors
  - Heating / Cooling
- Cable installations
  - Proximity to liquid metal
  - Fire hazards
  - Corrosion
  - Distance

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FAT

- PLC
- SCADA
- HMI
- Panels
- Network
- Redundancy

- All In One.

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Thank You
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