Specifying Adjustable Speed Drives for Improved Control and Integration

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Agenda

Bio

VFD Fundamental Design

Traditional Integration Requirements

EtherNet Integration Requirement

EtherNet Benefits

Harmonic Considerations

Specification Considerations
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• 30 years experience in controls and automation
  – Water/Wastewater
  – Pulp and Paper
  – Systems Integration

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Traditional Approach to Control/SCADA

*Digital communication limited to control and visualization devices*

*Individual I/O connections for motor control devices*

- *Basically limited to interlocking, no additional functionality*
- *High costs: Design, Hardware, Installation*

**Design**
- Engineering and documentation costs

**Hardware**
- Digital I/O card for every 16 points
- Analog I/O card for every 6/8 variables

**Installation**
- Wiring and accessories
- Installation labor
- Commissioning time to verify all connections
Integration Considerations – I/O

Minimum Requirements
- DI – Start command
- DI – Stop command
- DI - Enable/Permissive
- DI - Local/Remote select (or keypad)
- DI – Local Start/Stop buttons (or keypad)
- DO – Drive Fault
- DO – Drive Running
- DO - Local/Remote
- AI – Speed Ref 0-10vdc, 4-20ma
- AI – Local Speed Reference (Door or Keypad)
- AO – Load Fdbk

Lots of I/O Needed

Options based on parameter setting
i.e. Ramp time, slow speed etc.
Integration Considerations  
2wire vs. 3wire control

- **2 Wire Control**
  - Manual Operation
  - Safety Considerations - will auto-start on power restore
  - Less Control Required
  - Beneficial in controlled unmanned environments
  - May cause process issues with on power up. (Aeration Blowers)
  - Requires constant run signal from PLC

- **3 Wire Control**
  - Safer Operation on Power Failure
  - Requires manual start on power loss
  - If PLC fails drive keeps running
Reference/Set Point Control

- Centrifugal Pumps don’t pump efficiently below 50% Speed
- Scaling
  - Setpoint 4-20ma = 30-60hz
  - Feedback 4-20ma = 0-60hz
- Improves signal span and granularity
- Improves accuracy
Emergency Stop Circuits

• According to NFPA79, an E-Stop requires that the drive be disconnected from the load.

• The following configurations are acceptable:
  – “E-Stop” with input contactor (Air Break)
  – " Drive Disable “ Turns off the drive (Electronic)
  – " E-Stop " with output contactor (Air Break)
  – " E-Stop " without contactor if customer provides written notice that E-Stop is required but NFPA79 is not required.
  – If operator does not have access to moving parts, Sometimes a simple lockable disconnect switch is technically acceptable (but review carefully).
E-Stop with Input Contactor

- **Isolates Drive and Motor from power (Air Break)**
- **Contactor 1K supplies power to the inverter part of the VFD**
- **Enable** – (Shown as TB3-30 on the figure) enables/disables the inverter
- **Coordination of Input Contactor 1K and Enable is required**
  - E-Stop Opens Enable and Opens 1K

Ensures the drive is enabled along with the 1K contactor
E-Stop Circuit with Output Contactor

- Isolates only the Motor from power (Air Break)
- Contactor 2K isolates the motor
- Need to ensure 0 VAC on motor (Drive Disabled and Motor Flux is decayed) when 2k contactor is opened
- Bulletin 100 has 6-20ms coil drop out time
- Size output contactor at drive amp rating not motor 600% FLA
- E-Stop opens enable and output contactor in controlled manner
Influent Pumping / Raw Wastewater / Headworks – Wet Well

- **Pumps On**
  - Lead - 1st pump on at the lowest level
  - Lag - 2nd pump on
  - Lag Lag – 3rd pump on

- **Pumps Off as the level drops**

- **VFD’s are used for improved process control and energy efficiency**

- **Floats are used as emergency feedback/control on Ultrasonic failure**
Ethernet Connected Enterprise

Simultaneous real-time control, configuration and data acquisition ... EtherNet Connected Integrated Architecture
Ethernet Connected Enterprise
Ethernet Benefits

- Reduces System Integrator Design Time/Cost
- Real time control
- Improves Safety
  - Access to Alarm, Configuration, Feedback Parameters Remotely
- Enables Smart Applications
  - Pump Efficiency
  - Aeration Control
  - Advance Process Control
  - Maintenance Management Systems
  - Pump Optimization
  - Energy Management Systems
- Flexibility with future system scaling and modifications
Improved SCADA Systems

- Provides for more robust actionable data, less variability, less cost
- Device parameters automatically “mapped” into controller memory
- Devices configured from any location in the system
- No tables and / or logic to move data
Improved SCADA Systems

Automatic Variable Mapping

- Variables in motor control devices automatically “mapped” into the control system
- Logical variables can be associated with physical I/O at any time during the project
  - Very simple process to associate variables
  - More efficient use of engineering time
  - Ability to reuse code

Remote Access to Diagnostic Information in Motor Control Devices

- Identifying issues before a fault results in a shut-down
- Diagnose issues without having to shut-down, lock-out, or remove the device
- Access information from any remote location on your enterprise network
Ethernet Enabled Advanced Capability

Automatic Device Configuration of equipment eventually replaced during commissioning

Powerful combination of resources in the field device, controller and communication infra structure

Significant contribution to lower commissioning time and MTTR along the life cycle of the plant
Ethernet Design Criteria – EtherNet Cable Systems

• Issues with traditional approach in industrial environments
  – Noise Immunity
  – Physical Isolation
  – Physical Environment – Heat, Grease, Corrosives, etc.
  – Voltage – Standard Ethernet Jacks – rated 300V
  – Does not meet standard industrial codes – NFPA79 or IEC 60204-1

• Industrial Approach
  – Use industrial rated EtherNet cable
  – Provides 600V AWM rating
  – Can be run in same cable tray as other power wiring without barriers
  – Specially designed for noise immunity, and isolation
  – Meets NFPA79, IEC 60204-1 and ODVA EtherNet/IP standards
Harmonic Considerations

- All Drives (Switched Power Supplies) produce Harmonics
- Multiple Mitigation Techniques

Pure AC Voltage

Affect of Harmonics

Mitigated AC Voltage

Passive Filter

Active Filter

18 Pulse Transformer

Active Front End
Harmonic Considerations

Legend
A. 6-pulse, no link choke
B. 6-pulse, with link choke
C. Input line reactor
D. Tuned and non-tuned filters
E. 12-pulse with auto transformer
F. 12-pulse with isolation transformer
G. 18-pulse with auto transformer
H. 18-pulse with isolation transformer
I. Regenerative active front end
J. Active power filter
Areas of Focus in Specifications

1. Proper I/O requirements
2. E-Stop design considerations
3. Reference/Feedback signal span and scaling
4. Data, Power Management and Reporting requirements
5. Industrial Cable Standards
6. Network Validation Testing
7. Discuss power source impact on drive installation.
8. Harmonics
9. Have Systems integrator provide all devices connected to the network - PLC’s, Instrumentation, HMI, SCADA, Drives, MCC’s in CSI Section 17000