T90 - Motor and Power Control Solutions For Oil & Gas Applications
Introduction

- Benefits of the integration of intelligent motor control and field devices – Industrial 4.0, China 2020, Connected Enterprise
- Automation / integration = reduced time and costs throughout project lifecycle
- Many long-term benefits realized by the end user
- Recent convergence of a number of technologies has led to the latest major trend in the electrical industry
  - Advancements in intelligent motor control and field devices
  - Cloud technology
  - Ethernet communications
- It is expected that industrial operations will see more radical change in the next 5 years than it has in the past 20
- The Industrial Internet of Things (IIoT)
Introduction

These developments are leading us to question and change our perspective in the workplace in many areas

- Safety
- Security
- Commissioning
- Failures
- Unplanned outages
- Maintenance strategies

- It is now feasible to do things which were not possible before – IT is uncomfortable

- This is not without growing pains with security being one of the first areas to address
Current Situation

- Global competition and current economic circumstances
  - Drive out inefficiencies in manufacturing and business processes
  - Agility / adaptability – smaller batches, quicker turnarounds, and so forth.
  - Industry 4.0
- Aging workforce that is retiring faster than new personnel are coming on board leaving a shortfall of skilled workers
  - Leverage SMEs
  - Capture their expertise before lost
- Companies are attempting to deal with
  - Legacy equipment
  - Networks, which have evolved over time
  - Proprietary network protocols
  - Ineffective data that is not being utilized effectively to optimize process
Current Situation

- Need to streamline shop floor communications – operational technology (OT)
- Huge gap between the production floor operational technology (OT) and the front-end information technology (IT)
- Massive amount of ongoing human intervention is required to bridge the gaps at most facilities
- Time is better utilized on improvements to overall process rather than patching and revisiting the same tedious tasks.
- A common protocol would lead to huge gains in efficiency and other process improvements for any business.
Data and Analytics

- Data was seen as the path to improvement – big data
- Too much raw data can be an impediment
- Actionable knowledge is required which comes from the data
- To become actionable, data must be analyzed, assessed, and put into a format that is readily understood
- This requires the application of intelligence and expertise
Intelligent Motor Control

- Information comes from intelligent field devices
- Most machines, processes, or systems are driven by motors
- The motor control device that is used is determined by the required and expected operation of the load, and the electrical requirements
Field Devices

- Simplified integration
  - Standard operator faceplates
  - Minimized programming required
- Reduced hardware costs
  - Eliminate additional interfaces
  - Single instrument can provide real-time data for multiple variables
EtherNet/IP

- Engineering workstation
- Operator workstations
- Asset management

IT connection
Number of topologies from Linear to Device Level Ring

Process Controller
1756 Hart I/O

VSD
MCC

EtherNet/IP

10
Topology Flexibility

Compared to a multi-network architecture, EtherNet/IP provides the ability to implement multi-topology and multi-layer on a single network with no device mix restrictions.

- **Linear Topology** helps to reduce wiring and provides the longest network options.
- **A hybrid topology** is cost-effective for a broad range of devices with varying connectivity.
- **Device Level Ring** is an ODVA standard and provides fault tolerant connectivity for high drive availability.
EtherNet/IP Industrial Network

Standard, unmodified Ethernet using standard TCP/IP
- Real-time industrial control
- High-performance motion and safety
- Time synchronization
- High availability
- Configuration and diagnostics

An automation network with the performance, capacity, and expandability we need to meet the future

Flexible topologies
- Star, Switch-Level Linear, Switch-Level Ring, Device Level Ring, Hybrid, and so on.

Connects to thousands of automation devices from both commercial and industrial suppliers

Is the same technology used for the Internet

Managed by Open Device Vendor’s Association (ODVA)
EtherNet/IP Industrial Network

EtherNet/IP networks have been tested to the most rigorous standards for electrical noise immunity. Used in subsea and space.

- **Lightning Strike**
  - +/- 2 KV, 40 A surge that is repeatedly applied to the network cable
  - IEC 61000-4-5

- **Industrial Noise**
  - +/- 1 KV high voltage burst applied to the network cable
  - IEC 61000-4-4

- **Radio Frequency Interference**
  - 150 kHz … 80 MHz interference that is applied to the network cable
  - IEC 61000-4-6

- **Static Discharge**
  - +/- 8 KV ESD event at 12 locations on the MCC and network cable
  - IEC 61000-4-2
EtherNet/IP Industrial Network

Modified Ethernet

Application Layer
TCP / UDP
IP
Standard Ethernet Controller
Switch

Modified Stack

Application Layer
TCP / UDP
IP
H/W Support w/ Switching Technology

= STANDARD

= NON-STANDARD
CIP – Common Industrial Protocol
# The CIP Advantage

## Standard Unmodified Ethernet with CIP Motion™, CIP Sync™, CIP Safety™

**Information**

EtherNet/IP for motion, safety, and I/O control on the same network as the front office for robust, real-time networking.

## Motion

- One network for servos and AC Drives
- Enterprise-wide information access
- One development and control environment

## Safety

- SIL3/PLe rated for high integrity safety
- Stratix® technology for network segmentation
- One development and control environment

## Process

- Scalable for high availability
- Dual topologies
- Field device integration
- One development and control environment

CIP seamlessly integrates EtherNet/IP, DeviceNet and ControlNet to meet the broadest range of networking needs in industry.
Software & Programming - Integrated Software

- **Single** software tool to configure entire network

- Reduces potential for user errors when configuring network I/O
- Training, software, etc. benefits
- Done in parallel with equipment fabrication

I/O & programming network with fully integrated software
Automatically build the I/O tree for intelligent motor control devices in an MCC

- Module Discovery
  - Easily add devices to the I/O tree
  - Without needing exact catalog number
  - Without needing Slot # or address
  - Without needing to know firmware revision

Auto-generate device tags using device profiles
Plug and Play Industrial Environment

- Automatic generation of network tag names with **proper data types** respective for each parameter
- Descriptive tag names eliminate need to manually add descriptions
- Accuracy, consistency and speed greatly reduce troubleshooting which inevitably occurs with manual entry
Plug and Play Industrial Environment

- Readily understandable format
- Example - ABB circuit breaker
- The equipment is recognized when connected on the system
- Plug and play
Plug and Play Industrial Environment

- Drive Configuration
  - System software utilizes the same tools found in ASD-specific software
Plug and Play Industrial Environment

Variable Speed Drive

- Wizard which is used to set the speed profile.

- Reduces the risk of making an erroneous entry due to a lack of understanding of the actual purpose of the parameter.

- Read manual???
Plug and Play Industrial Environment

Save time by creating sets of commonly used custom instructions

Promote consistency between projects – no need to constantly re-invent commonly used control algorithms

Example AOI to scale drive engineering units to units operators can understand
Plug and Play Industrial Environment

- Improve speed of application and implementation
  - Online browse of the backplanes and networks for devices
  - Supports virtually all devices supported by software
  - Simple cut and paste quickly duplicates system elements

- Module Discovery
  - Easily add devices to the I/O tree
  - Without needing exact catalog number
  - Without needing Slot # or address
  - Without needing to know firmware revision
Intelligent Motor Control

The E300 is fully integrated into the Integrated Architecture®

- Network connectivity – Native EtherNet/IP reduces hardware and engineering cost
- Integrated into Logix – Device profiles and faceplates reduce engineering time and project development
- Automatic Device Configuration – Reduces time to repair

Simultaneous real-time control, configuration, and data acquisition
The modular design allows users to have choices in each of the sensing, control, and communications modules with additional accessories to tailor the E300™ Electronic Overload Relay or exact needs of the application:

- Multiple Sensing Capabilities *(Current, Ground Fault Current, and Voltage and Power)*
- Simplified Control Wiring *(120V AC, 240V AC, and 24V DC)*
- Wide Current Range *(10:1 and Higher up to 200A)*
- Expansion I/O *(Digital and Analog I/O)*
- Operator Interfaces
- Stocked Modules for Fast Replacement
Motor Diagnostics

- The E300 provides a wide variety of diagnostic information to monitor motor performance and proactively alert users to possible motor issues.
- This information can trigger either manual or automatic intervention before the occurrence of an unplanned shutdown.
  - Voltage, Current, and Energy
  - CIP Energy Enabled
  - Trip / Warning Histories
  - % Thermal Capacity Utilization
  - Motor Winding Temperature
  - Trip Snap Shot
  - Time to Trip
  - Time to Reset
  - Operational Hours
  - Number of Starts
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Variable speed control

- Reducing the speed of a variable torque application by only 20% can save up to 50% in energy consumption
- Reduction of energy consumption through adoption of variable speed control
PowerFlex 750-Series Low Voltage AC Drives

PowerFlex 753 & PowerFlex 755
- The PowerFlex 750-Series was designed for flexibility, productivity and ease of use.
- PowerFlex 753: General-purpose control for applications ranging up to 350HP/250kW
- PowerFlex 755: Maximum flexibility and capability up to 2000HP/1500kW.

PowerFlex 755TR Regenerative Drive
- Regenerative drive applications from 250 to 3000Hp (160 to 2300kW)
- IEEE-519 Compliant
- 400/480/600/690V
- Type 1 (IP21) & Type 12 (IP54)

PowerFlex 755TL Low Harmonic Drive
- Low harmonic drive for non-regenerative applications from 250 to 1800Hp (160 to 1400kW)
- 75 to 250HP in 2018
- 400/480/600/690V
- Type 1 (IP21) & Type 12 (IP54)

PowerFlex 755TM Drive System
- Drive Systems 250 to 3000Hp (160 to 2300kW)
  - Regenerative bus supplies
  - Common bus inverters
- 400/480/600/690V
- Type 1 (IP21) & Type 12 (IP54) & IP00
Improve productivity with built-in predictive maintenance capabilities to monitor drive and associated motors before an unplanned event occurs

- Predict remaining life of:
  - Fan/Blower
  - Bus & LCL Capacitors
  - IGBTs
  - Relay Contacts

- Active drive feedback protection:
  - Blown Fuse & Surge Suppression
  - Thermal Manager
Predictive models have been developed to allow for assessment of remaining life and proactive replacement for fans/blowers in the drive.
Predictive maintenance monitors the following drive and system components with parameters in the drive:

- Predictive algorithms calculate remaining life of components based on several application factors including temperature, air quality, vibration, and drive size
- Drive keeps track of runtime or cycles
- Drive provides notification before or at calculated component life

### Drive Components
- Heat sink fan(s)
- Internal fan(s)
- Relay output contacts

### System Components
- Motor bearing
- Motor lubrication
- Machine bearing
- Machine lubrication
PowerFlex 755T Drive Products

Safety options help protect personnel and assets while enabling increased application uptime

- **Network Safety**
  - Safe Torque Off (20-750-S3) – removes rotational power to the motor without shutting down the drive. SIL 3/PLc CAT 3

- **Hardwired Safety**
  - Safe Torque Off (20-750-S) – removes rotational power to the motor without shutting down the drive. SIL 3/PLc CAT 3
  - Safe Speed Monitor (20-750-S1) – allows access to parts of the application while there is limited motion. SIL 3/Plc CAT 4
Medium Voltage Portfolio

PowerFlex 6000

Features
• Cost competitive
• SVC control
• Basic connectivity into Logix via faceplates and AOI's
• Solid-state automatic cell bypass

PowerFlex 7000

Features
• Premier integration
• Transformerless AFE
• High-performance application capability
• Regenerative
• Long motor cable lengths

ArcShield™ PowerFlex 7000

Features
• ArcShield™
• 50 kA rating

Performance / Intelligent Motor Control Capability
Standard applies to VSD applications – induction and synchronous AC machines

- > 375 kW (500 HP)

First release of the document
June 2006

Culmination of 6 years of work

Input provided and document written by IEEE members from all areas of industry

Revised in February 2015
Power Extension

PF6000 Power Extension in Horsepower

Motor Voltage

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Existing PF6000 (HP)</th>
<th>PF6000 Gen. 2 (HP)</th>
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<tbody>
<tr>
<td>2.4KV</td>
<td>950</td>
<td>3205</td>
</tr>
<tr>
<td>3.3KV</td>
<td>2430</td>
<td>4399</td>
</tr>
<tr>
<td>4.15KV</td>
<td>3150</td>
<td>5550</td>
</tr>
<tr>
<td>6.6KV</td>
<td>4940</td>
<td>8800</td>
</tr>
<tr>
<td>6.9KV</td>
<td>9200</td>
<td>7500</td>
</tr>
<tr>
<td>10KV</td>
<td></td>
<td>13340</td>
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<tr>
<td>11KV</td>
<td></td>
<td>14680</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECO Design Main Cooling Fans</strong></td>
</tr>
<tr>
<td>- ErP directive 2009/125/EG</td>
</tr>
<tr>
<td>- EC Regulation 327</td>
</tr>
<tr>
<td>- High-efficient</td>
</tr>
<tr>
<td>- 400V rated</td>
</tr>
</tbody>
</table>

| **Optional dv/dt Filter**                    |
| - For motor cable distances >400m.           |
| - RC circuit                                 |
| - Reduces reflected wave and dv/dt at the motor for long motor cable lengths. |

| **Optional pre-charge circuit**              |
| - Reduces in-rush current to VFD             |
| - Reduces stress on power components during startup |
| - In the circuit for 2 to 6 seconds during startup |

| **Optional IP42 Enclosure**                  |
| - Protected against solid objects over 1mm   |
| - Protected against falling drops of water, if the case is disposed up to 15 degrees from vertical. |

| **Optional Seismic-Rated Enclosure**         |
| - IBC 2013 for worst-case level excluding class F |
| - ASCE/SEI 7-10                              |
| - Equipment will not fall over during or after a seismic event |

| **Optional Redundant Fan**                   |
| - ECO Design rated                           |
| - Redundant fan for both transformer and power cell cabinet |
| - Automatic switchover                       |
PowerFlex 7000 Product Portfolio

- General-purpose standalone MV VFD
  - Controls speed, torque, direction, starting and stopping of induction or synchronous motors

- Global standards compliance
  - IEC / NEMA / UL / CSA
  - 2300 – 6900V
  - Air-cooled versions:
    - “A” Frame (up to 160A)
    - “B” Frame (heat sink to 430A / heat pipe to 720A)
  - Liquid-cooled version:
    - “C” Frame (up to 720A)
  - Units can be utilized in parallel to extend to higher rating and / or redundancy

- Focus on high reliability, ease of use, and lowest total lifecycle costs
The PowerFlex 7000 topology offers a simple, reliable, cost-effective power structure with a wide voltage and power range.

- Current Source Inverter with SHE (Selective Harmonic Elimination - PWM)
- 6500 volt rated power semiconductor devices reduce component count:
  - Only 6 inverter switching devices are required at 2400V
  - 12 at 3300-4160V
  - 18 at 6600V.

Fuses are not required for the power structure due to the current limiting DC link inductor.

Design is inherently current limiting – no pre-charge circuits or power fuses.

The PWM rectifier approach is the same as the PWM inverter:
- Same SGCT devices – commonality of spare parts.
Topology fundamentals: CSI & VSI

Current Source Topology

- Utility supply
- Load

- Always active front end rectifier
- Stiff current supply @ link

Voltage Source Topology

- Utility supply
- Load

- Passive or active front end rectifier (add’n cost)
- Must have phase controlled rectifier for braking
- Stiff voltage supply @ DC link
Energy Intelligence

Energy monitoring capabilities

- Monitor power consumption across the network
- Correlate energy consumption with operational data to track equipment performance
Real-time Analytics: Prediction of Potential Failures

Monitor > Analyze / Predict > Optimize

**Failure Modes Minimize Unscheduled Downtime**

- Unanchored
- Static Valve Leak
- Travel Valve Leak
- Gas Locked
- Tapping Up
- Tapping Down
- Worn Pump
- Hole in Barrel

**Pump Fillage Optimization** IMPROVES Well Production
Management can view entire fleet “at-a-glance”

Data is real-time, reliable, and secure
ConnectedProduction™
Production Intelligence: Example – Operations Engineer

- Operations Engineer can view traditional SCADA information on their mobile device via the ConnectedProduction portal.
- Same portal also shows analytics, dashboards, reports, and integrated third-party systems.

User can modify dashboard on-the-fly to investigate issues.
ConnectedProduction™
Production Intelligence: Example – Production Engineer

- Production Engineers can look at “out-of-the-box” intelligent asset dashboards
- They can also build and share their own dashboards

"At-a-glance" view of assets in tree or on dashboard

When new assets are added, they will automatically be available and have data, analytics, and dashboards

Extremely high performance trending

Simple and quick to link to third-party analytics and applications using common interface standards
• Maintenance Engineer can create a folder in his own tree to group similar assets and easily monitor for issues

Underlying objects are common, secure, and reliable

Custom grouping and layers of assets
Workflows: Initiated by event, user, or analytics
ConnectedProduction™

Production Intelligence: Example - Intelligent Power Consumption
Automated device configuration of equipment if replaced required

Powerful combination of resources
field device + controller + communication infrastructure
Remote Monitoring

Improve Asset Utilization

• Embedded diagnostics
• Remote monitoring
• Automatic Device Configuration
• Troubleshooting wizards

Reduce unplanned downtime
• Reduce time to repair
• Centralized maintenance staff

Secure tunneling technology preserves and extends security at customer locations

Virtual Support Engineer®

Blocked: Connection initiated by inbound attempts.

Plant personnel focus on production improvements while we:

- Monitor performance parameters continuously
- Alert customers immediately when performance moves out of tolerance
- Provide troubleshooting assistance through remote SME
Diagnostics - Reducing unplanned downtime

Diagnostic data from intelligent motor control devices can trigger either manual or automatic intervention before occurrence of unplanned shutdown.

- Electric motor current indicating loading conditions
- Vibration signature indicating mechanical unbalance
- Torque signature indicating process anomalies
Diagnostics – Reducing unplanned downtime

Available information from overload

- Current
- Trip / Warning Histories
- % Thermal Capacity Utilization
- Time to Trip
- Time to Reset
- Operational Hours
- Number of Starts
- Voltage & Energy
Integration & Electrical Safety
Electrical Safety

• Safety by Design
  – Arc Resistant Equipment

  • Remote monitoring & troubleshooting
    – Removes workers from inside arc flash boundary
  • Use of intelligent motor control devices helps workers avoid unnecessary tasks in front of equipment
  • Worker risk mitigation & higher productivity

  • Better visual awareness & dexterity
    – Help add clarity & ease when performing tasks
    – Allows safe interaction with MCC
    – Higher productivity without sacrificing safety
Arc Resistant Technology
ArcShield™ Option

IEEE C37.20.7 compliant

- Limit amount of available arc fault current

in Low Voltage and Medium Voltage applications

- Help shield personnel at front, rear & sides of enclosure
  - Type 2 accessibility low voltage MCC
  - Type 2B accessibility medium voltage MCC
PowerFlex® 7000 Drive System with ArcShield™

- Designed to redirect the fault energy, created from an arc flash event, away from personnel
- Certified type 2B protection
  - This level of protection is maintained when the low voltage control door is open for maintenance purposes
  - Helps protect personnel while in front, at the side, or in the rear of the enclosure
- Meets:
  - IEEE C37.20.7
  - CSA C22.2 No. 22-11
  - IEC 62271-200
  - EEMAC G14-1
  - IEC 62447-2
  - IEC 62271-200

50 kA rated Drive System with ArcShield™
IEEE Type Accessibility

Type 1
- All doors closed and latched
- Level 1 PPE
- Protected zone
- Unprotected from an arc blast

Type 2
- All doors closed and latched
- Level 1 PPE
- Protected zone

Type 2B
- All doors closed and latched
- LV panel door open
- Protected zone
- Level 1 PPE
Arc Resistant Testing

- Passing* an arc test means the following criteria must be met:
  - Doors and covers do not open (bowing allowed)
  - No parts are ejected from the equipment
  - Hot gases are not ejected in protection zones
    - Cotton test indicators must not ignite or be perforated (150 g/m² approximates typical industrial work clothes)
  - No burn through of the exterior of the structure
  - (in the applicable zones for the accessibility level)
  - Grounding connections remain effective

*Per IEEE C37.20.7 (varies by guide/standards)
Electrical Safety

- Reduce the need to “suit up” with the necessary PPE to be in front of the gear

- Safest place to be is not in front of any electrical equipment

- Lessen / avoid permitting and the time associated with it
Integration & Security
Information security is essential to productivity and safety.

Increasingly more equipment is being connected on networks – plant floor.

The plant floor has been insulated from the internet due to the gap which exists between the IT and OT technologies - cyber security.

OT systems are time critical and their main goal is to provide safe and reliable operation of plant process.

IT systems are mostly based on speed of information, confidentiality, and protection of the operation assets.

While we can restart IT computers if necessary with minimal disruption, it is not possible to restart OT systems that have to control process in real time.
Security

- Security is seen as a cost of doing business
- Reliability is a continuous process which would begin with an assessment of the criticality of currently installed asset(s) to determine risk.
- If security is made part of the overall approach to reliability, the effort is self-funding and a daily activity
- Asset management is the best security as it is consistent and part of everyday business
- Password example
- > 50% of security violations are from within the organization
  - Management of change
A secure application depends on multiple layers of protection. Industrial security must be implemented as a system.

- **Layered Security Model**
  Shield potential targets behind multiple levels of protection to reduce security risks
- **Defense in Depth**
  Use multiple security countermeasures to protect integrity of components or systems
- **Openness**
  Consideration for participation of a variety of vendors in our security solutions
- **Flexibility**
  Able to accommodate a customer’s needs, including policies & procedures
- **Consistency**
  Solutions that align with Government directives and Standards Bodies
No single product, technology or methodology can fully secure industrial automation and control system (IACS) applications.

Protecting IACS assets requires a defense-in-depth security approach, which addresses internal and external security threats.

This approach utilizes multiple layers of defense (physical, procedural and electronic) at separate IACS levels by applying policies and procedures that address different types of threats.
Overall Cost Efficiency

Reduce Time to Production

- Integrated, preconfigured network infrastructure
  - Factory-installed, configured, and validated
- Preconfigured user interface software for monitoring and configuration
  - Order-specific, customized support materials
- Lower installation cost if job site labor and materials are considered.
- Lower installation time

- Elimination of mismatch errors
- Reutilization of application code
- Configuration wizards

- Reduce development time
- Reduce commissioning time
- Common user experience
Considerations - Revisions
Considerations

- Requires different skill set
- New way of thinking
- New generation of electrical support
- Training
Different Tools

**EtherScope**
- Troubleshoot copper, fiber and wireless LANS
- Discover devices, networks, VLANs, access points and mobile network-wide
- Monitor traffic
- Measure end-to-end Ethernet performance
- Protocol statistics on all Industrial protocols

**Link Assistant Multimeter**
- Resolve device connectivity issues on 10M, 100M and 1G links
- Validate network configurations
- Check availability of key network resources
- Verify twisted-pair cabling integrity
- Locate and isolate twisted-pair cables
Technology - Benefits

- Faster Integration
  - Network is factory tested or at least preconfigured and programmed
    - Node number, IP address, communication rate, functionality verified
- Faster installation compared to hardwired I/O
  - Factory testing can be more comprehensive than field
  - Better environment / less stress / reduced errors
- Precise control with intelligent motor control devices
  - Wide array of device level components
- Improved security – management of assets and change
- Better information - actionable
- Improved uptime
  - Warnings in advance of failure – Predictive Maintenance
  - Troubleshooting tools and information at your fingertips
- More agile process – simplifies conversions
Rockwell Automation® – Scalable Partner

Oil & Gas Production or Operation Company

OEM, Driller, Ship Builder

MAC / EPC Company

Capital Project Teams in O&G Company

Product Supplier

System Supplier

Solution Supplier

MAC

Rockwell & 3rd Party(s)

Services
Conclusion

- The IoT has led to Industrial Internet of Things (IIoT)
- The IIoT greatly enhances connectivity in all areas
- Just as public domain IoT is part of our day to day lives, industry is adopting and utilizing new technology to drive productivity into their manufacturing systems.
- US is outpacing Chinese manufacturing – digitization, automation and electrification – core technologies in Industry 4.0
- 8 of top 10 IT companies are North American based
- > 50% of MCCs are Ethernet
Thank You!

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