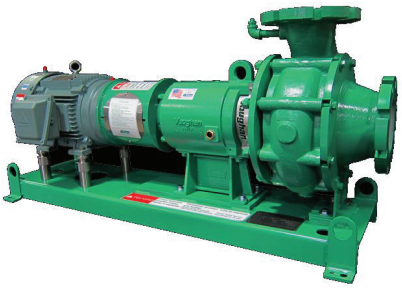
Introduction
Why Monitor Machine Condition?

Rockwell Automation

- In any plant we have assets (big or small) that we want to:
  - Protect from damage
  - Prevent problems that would result in a loss of production
  - Assure or improve Quality
  - Reduce maintenance costs






Protect from Damage
Monitor the Overall (total) Vibration

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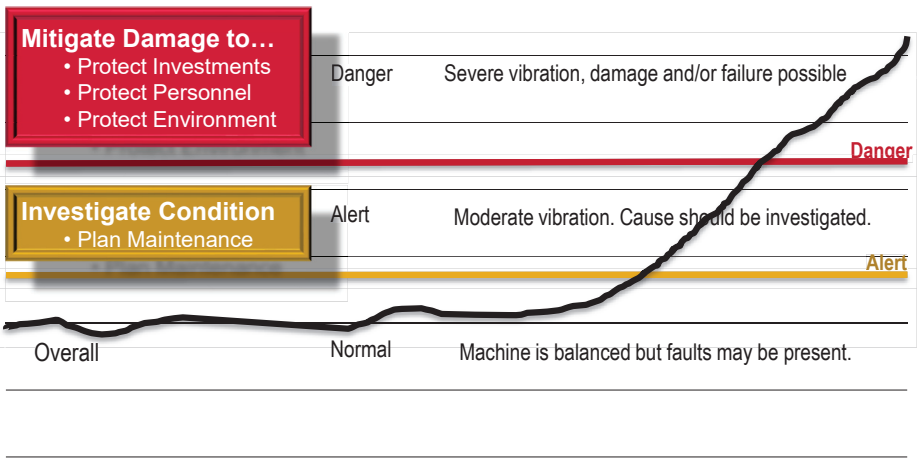

Operation at a level above "Danger" may result in significant damage, and possibly catastrophic failure. Maintenance performed before this point will be less expensive and require less time to perform.

Monitoring Machine Condition…

Requires detecting and identifying faults

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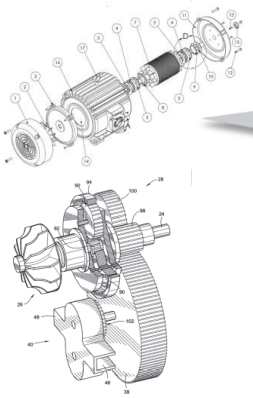
- Overall vibration does not provide insight into what is ***causing*** the vibration
- To understand **what is causing** the vibration, monitor the **Indicators of fault**...

Mechanical attributes

Speed
Type of bearings
Number of impeller vanes
Number of fan blades
Number of gear teeth
etc.



Electrical attributes

Speed
Type of motor
Line frequency
Number of rotor bars
Number of stator slots
etc.

Identifying fault indicators requires knowing basic characteristics of the machine.

Monitoring Machine Condition…

Faults are identified by the ***frequency*** of the vibration it causes

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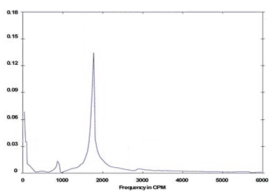
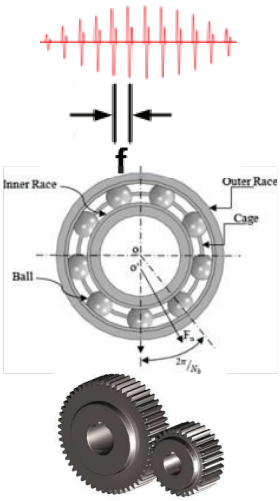
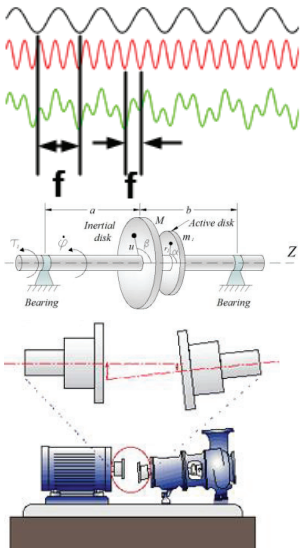
- Faults induce **repetitive** impact or cyclic forces at <u>specific</u>, <u>predictable</u> frequencies (**f**).

Except for structural resonances which simply "ring" at the resonant frequency when excited.





Pits or scratches on balls, broken or damaged gear teeth...



Imbalanced rotors, misaligned shafts...

Monitoring Machine Condition…

The FFT separates the individual ***frequencies*** from the raw signal

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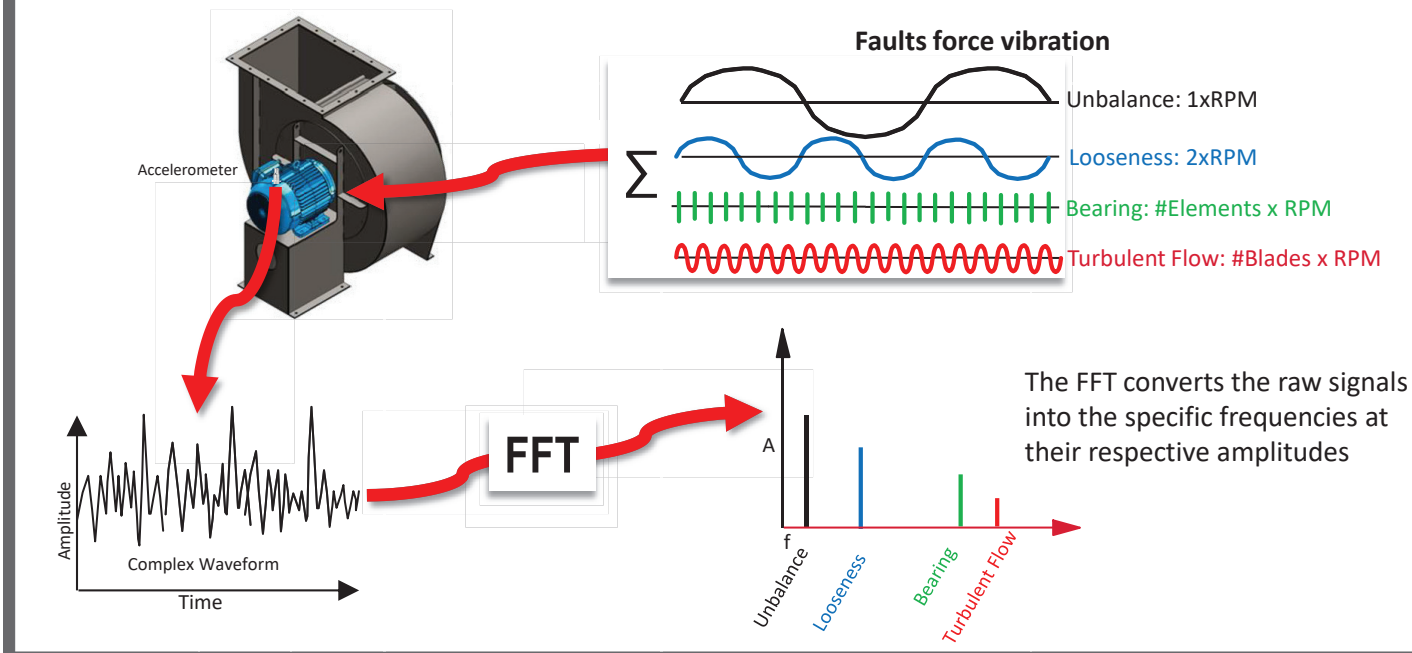

The FFT converts the raw signals into the specific frequencies at their respective amplitudes

Monitoring Machine Condition…

A simple example

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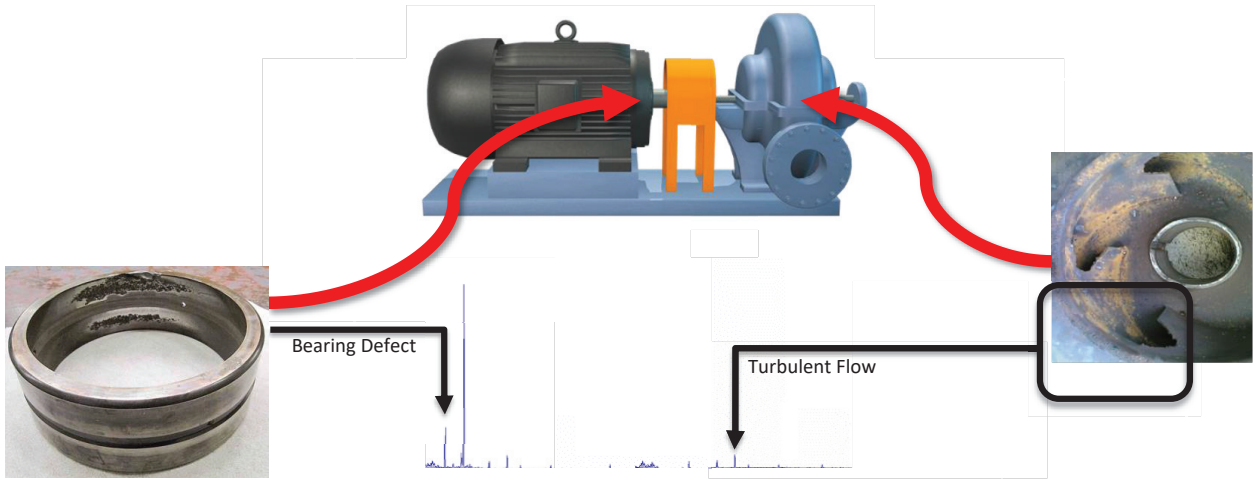
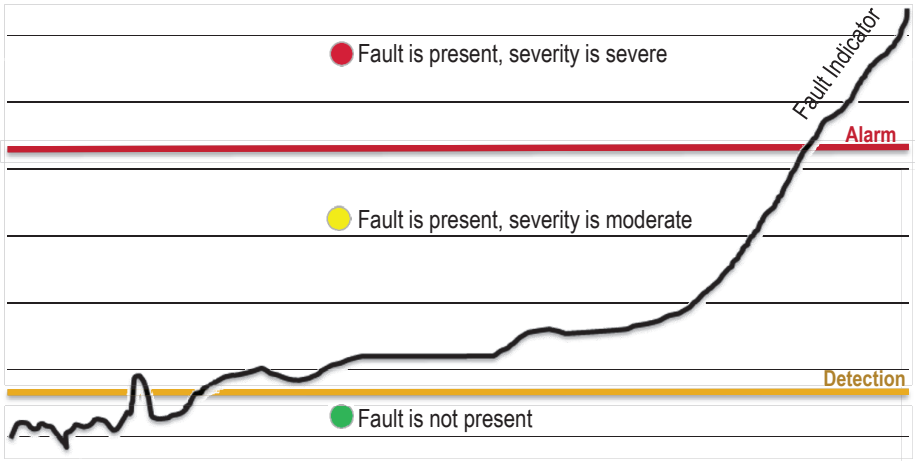


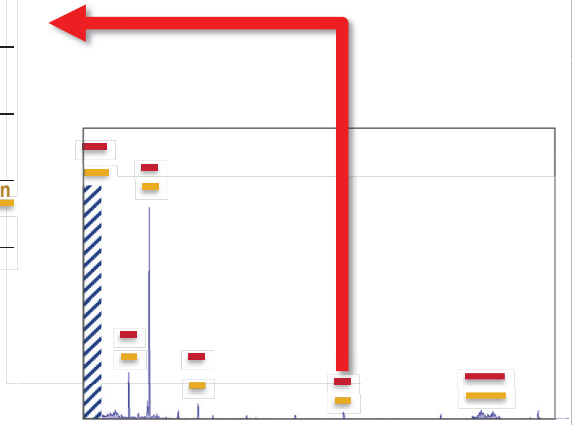
- Vibrations at these frequencies indicate the presence of a specific condition or fault*
- The magnitude of the vibration is an indication of the severity of the condition or fault

*or, sometimes, one of several faults that could cause vibration at the same frequency.

Monitoring Machine Condition…

By trending fault indicators





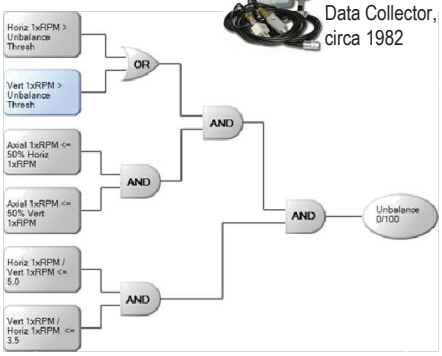
Continued operation above "Alarm" may result in damage to components other than the wearable component, which will cause longer and more expensive repairs.

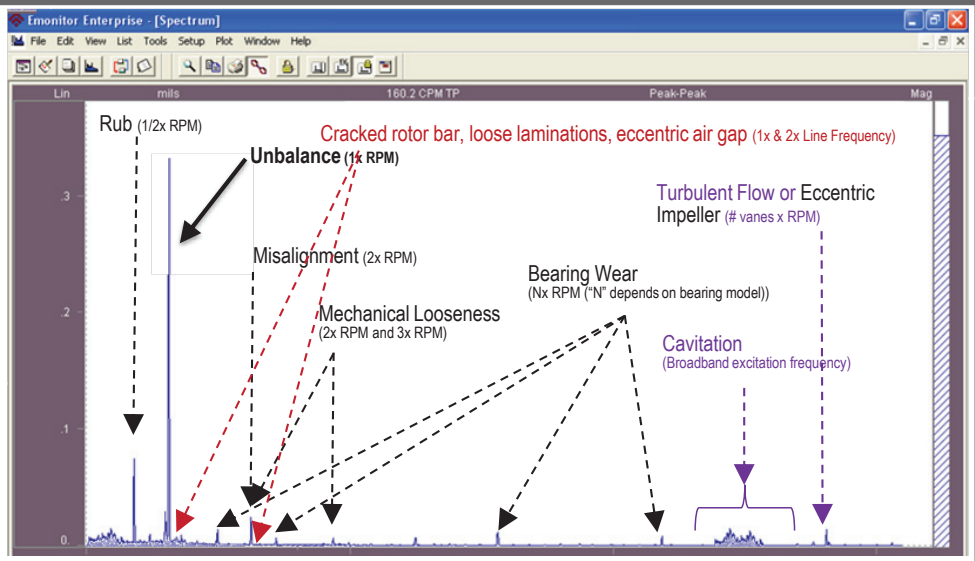
Monitoring Machine Condition…

Proven Technology

- We have been analyzing machine vibration for over 30 years. We *know* what it means!

Data Collector, circa 1982





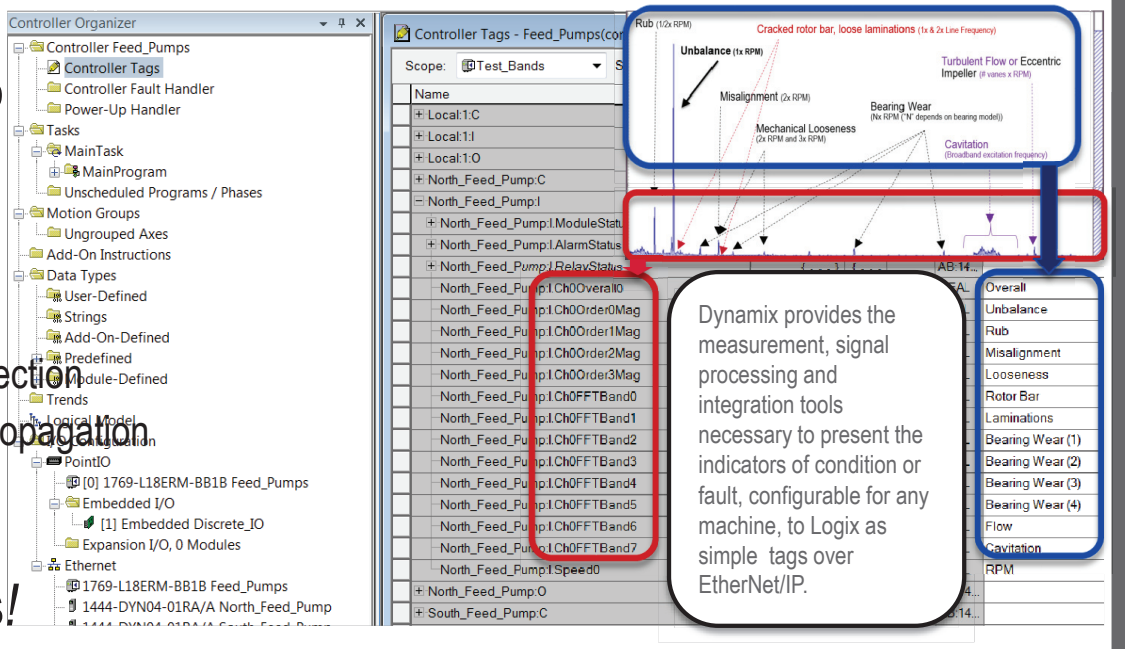
Mechanical & electrical faults and many process conditions force vibration at specific, predictable, frequencies

Fault Indicators in Logix

Integrated Fault Detection and Identification

Rockwell Automation

- Tags represent the tools used to measure the considered fault indicators
  - Alarms signal detection
  - Trends monitor propagation
- This is what Dynamix does!

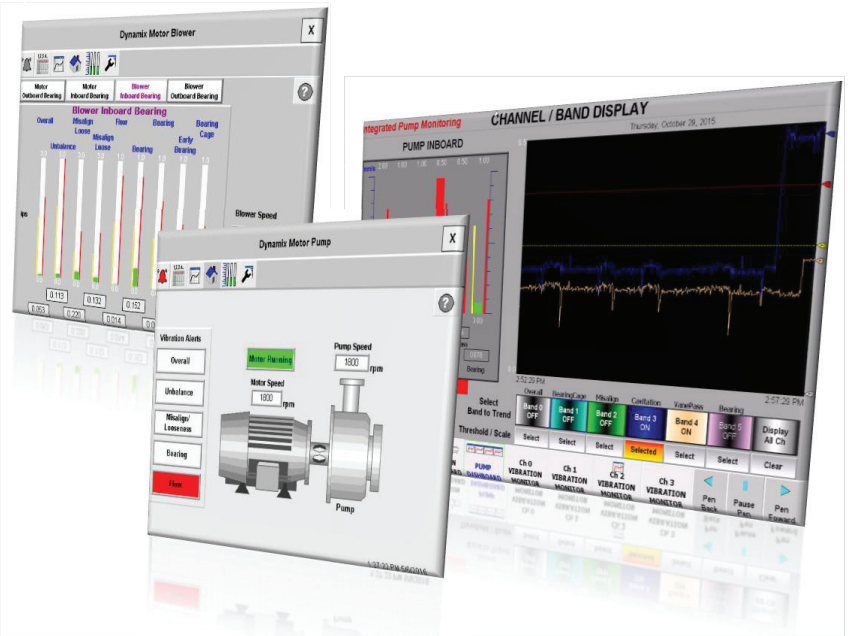


Fault Indicators in the IA

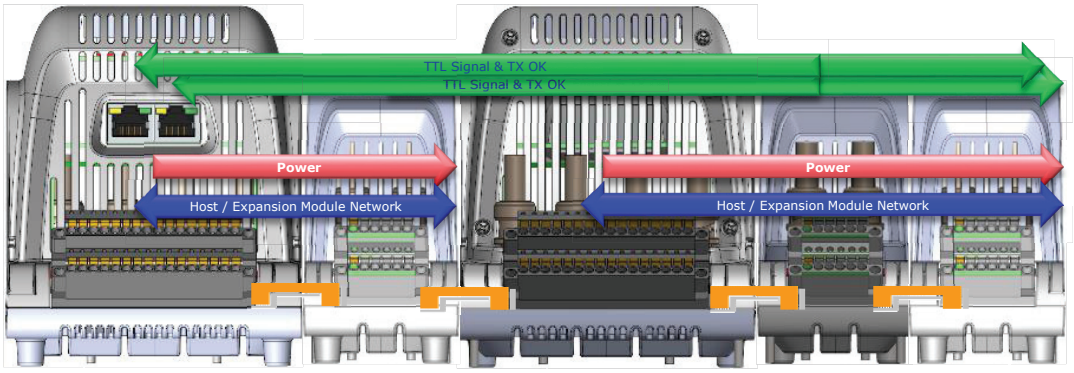
Integrated Visualization

Rockwell Automation

- True machine condition made "part of what you do".
  - Fault Indicators can be acted on, the same as any other tags.
  - Fault Indicators can be presented on faceplates and other HMI's the same as any other tags.
  - Fault Indicators can be written to an historian and trended the same as any other tags.



Dynamix 1444 Series
Architecture & Local Bus



Architecture

Network Connections on Main Module
Insert / Remove Under Power
Interconnect via included ribbon cable between terminal bases

Local Bus

Host / Expansion Module Communications
Speed Signal Distribution
Power Distribution

Functional Summary
Capabilities

- The capabilities necessary to serve any application
  - Machinery Protection
    - General machine protection
    - API-670 compliant protection
  - Machine Condition Monitoring
    - Production assurance (uptime)
    - Condition based maintenance
    - Quality

- Vibration
  - Acceleration
  - Velocity
  - Displacement
  - Absolute Shaft Vibration
  - Spike Energy (gSE)
- Speed
- Pressure
- Thrust
- Case Expansion
- Differential Expansion
- Rod Drop

- Relays
- 4-20mA Outputs
- Event Capture
  - Event Log
  - Trend / Alarm
  - Startup / Coastdown

Real Time, Continuous, Surveillance

Real Time Processing of Critical Parameters, Continuous Processing of Diagnostic Data, Demand Processing of Infrequent Measures

EtherNet/IP

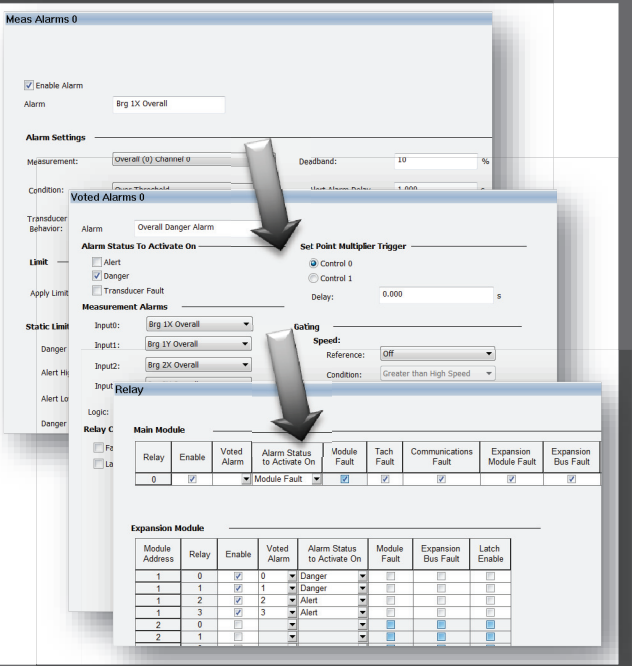
Functional Summary
Measurements

- The measurements necessary to monitor any kind of machine
  - Dynamic (AC) Measurements
    - Discrete Measurements
      - Per Channel Pair
        - SMAX Magnitude
        - Shaft Absolute Vibration
      - Per Channel
        - Overall (2)
        - Order Magnitude & Phase (4)
        - FFT Band (8)
        - Not 1x (1)
        - Bias / Gap (1)
        - gSE Overall (1)
    - Complex Measurements
      - TWF and FFT (to 1800 lines)
      - Asynchronous and Synchronous
  - Static (DC) Measurements
    - Single DC Channels
      - Axial Position
        - Thrust
        - Valve Position
      - Eccentricity
      - Rod Drop
      - Proportional Voltage
    - Paired DC Channels
      - Differential Expansion
  - Demand Measurements
    - Synchronous, Asynchronous TWF and FFT (to 14,400 lines)
    - Simultaneous Cross Module Measurements
  - Speed Measurements
    - Speed
      Retains maximum speed measured
    - Rate of change of speed

Functional Summary
Alarms and Relays

- Alarm and relay solutions necessary to meet any requirement
  - Measurement Alarms
    - Apply limits to measured parameter
    - 24 measurement alarms may be defined
  - Voted Alarms
    - Apply voting logic to Measurement Alarms
    - 13 voted alarms may be defined
  - Relays

    Main modules include a single onboard physical relay. With expansion modules this can be expanded to 5, 9 or 13 relays
    - Associate with any voted alarm, or…
    - Leave unassigned to actuate only on fault.



Dynamix in the Integrated Architecture

Part of the Connected Enterprise

Rockwell Automation

Dynamix™
Enables analytics within the control architecture!

Dynamix™
Information from data, at the machine!

Internet of Things

Analytics

Scalable Computing
(Control, Edge, Cloud)

Model-predictive Control, Optimization

Information Management & Analytics

Multi-discipline Control & Information

Augmented Reality, Virtual Reality, Wearables

Mobility & Visualization

Smart Assets

Secure Network Infrastructure

End-end Security

Dynamix in the Integrated Architecture

Controller I/O

Rockwell Automation

- Supported by Logix

  I/O is provided and managed the same way as for any device.
  - Requires Logix version
    - V24+
    - V24.51+ Redundancy
  - Configuration
    - Provided by an Add On Profile
  - Assemblies
    - Configuration
    - Input

      User selectable tags for input
    - Output

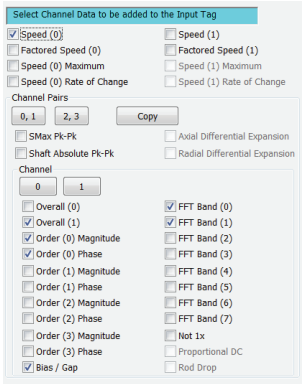
      User selectable tags for output

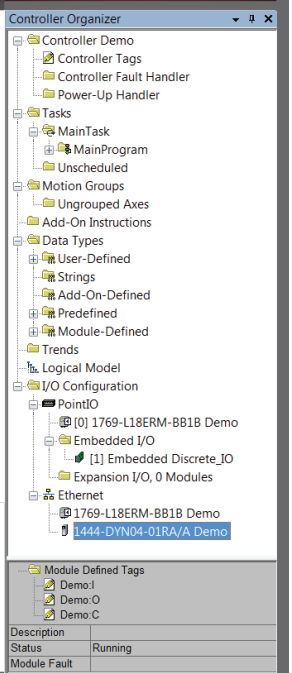
Controller Output

Control Bits	Data
Trip Inhibit	Speeds (2)
Set Point Multiply (2)	Alarm Limits (16)
Gate Controls (2)	
Alarm Reset	
Alarm Buffer Trigger	
Alarm Buffer Reset	
Transient Buffer Resets (4)	

Controller Input

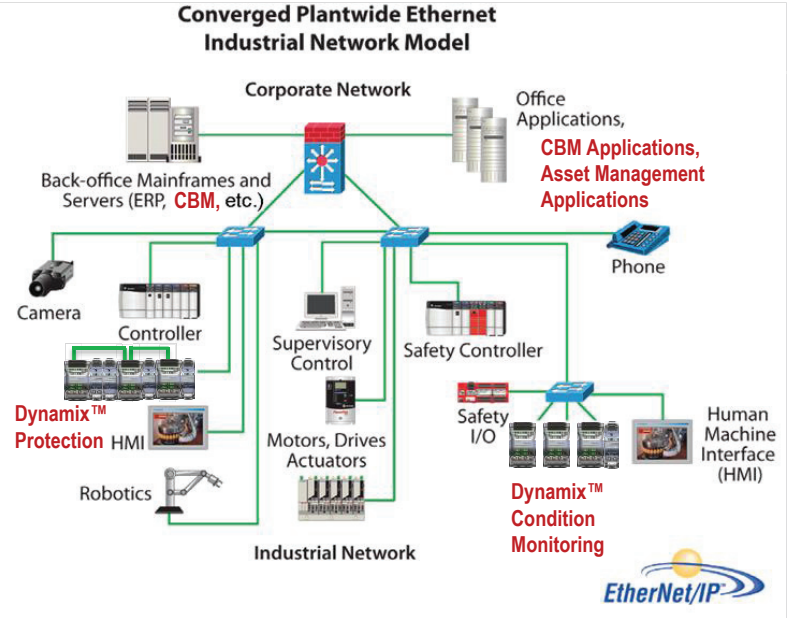
Input Assembly parameters selected in Module Definition.





Our EtherNet/IP Network Strategy

With Dynamix



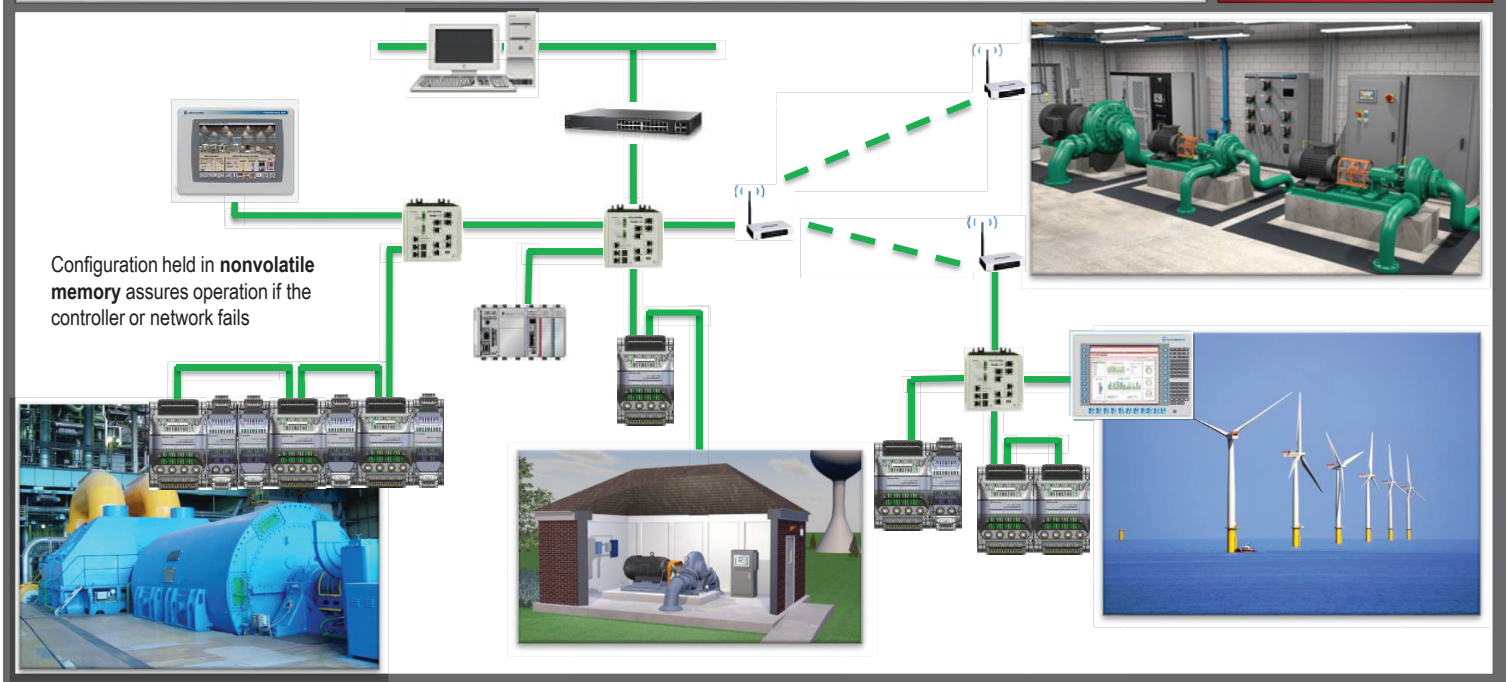
From the beginning the **Dynamix 1444 Series** was **designed** and **developed to execute this** core Rockwell Automation **strategy**.

Native dual port **Ethernet**, the **EtherNet/IP** protocol, **Device Level Ring**, an integrated **Logix** solution, and all of the products and capabilities of Rockwell Automation's **Integrated Architecture**...

These are what makes the **Dynamix 1444 Series** the industries most **open yet secure, integrated** and **capable solution** for **machinery monitoring and protection available** today.

Dynamix System Architectures

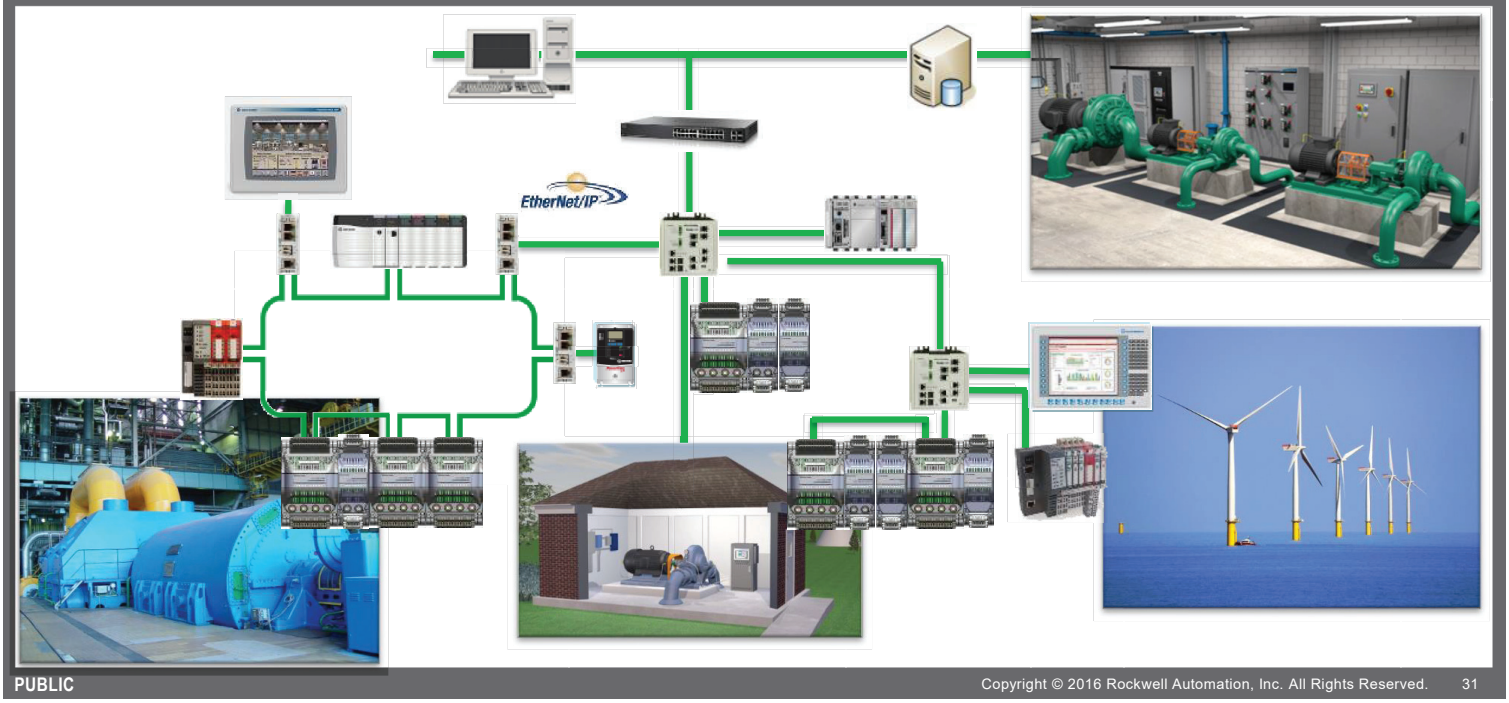
Dedicated Condition Monitoring System



Dynamix System Architectures

Condition Monitoring within an Integrated Architecture

Rockwell Automation



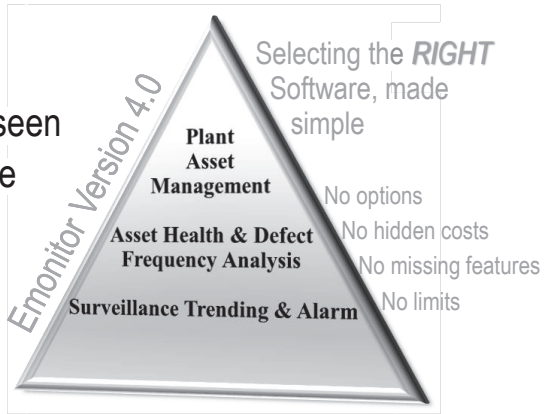
Emonitor CMS

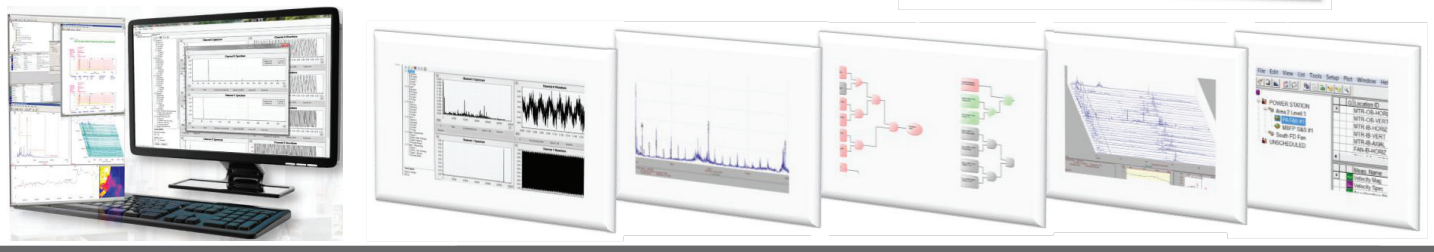
Condition Monitoring Software for Dynamix

Rockwell Automation

- Because sometimes…
  - The problem is "Other"
  - The actual time waveforms and spectrum must be seen
  - Dynamix 1444 monitor is a part of a larger predictive maintenance program

When "Other" happens, when the solution requires *data* and the *tools* required by **Condition Monitoring Professionals**, there's Emonitor CMS.

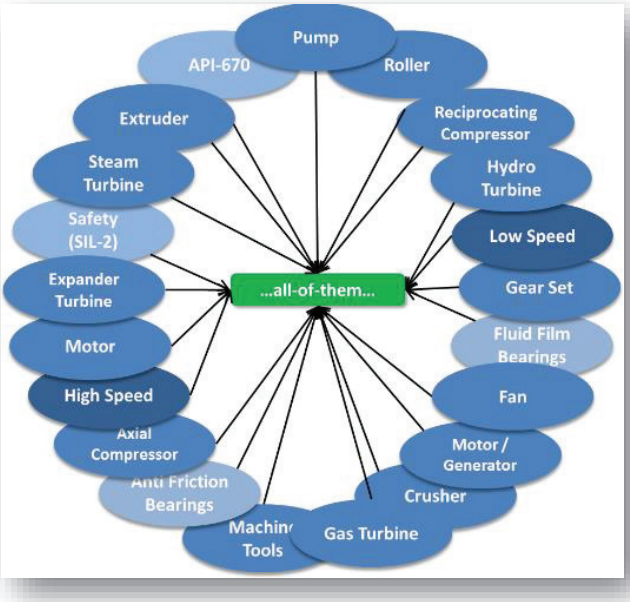




The Dynamix 1444 Series

And the Integrated Architecture

- An architecture with a single core module that:
  - Can be applied to any Machinery Protection application
  - Can serve any Condition Monitoring Application
  - Applies a native EtherNet/IP backplane
  - Is a component of Rockwell Automation's Integrated Architecture



Integrated Condition Monitoring

from Rockwell Automation

Dynamix™ 1444 Monitors:

- Integrated condition monitoring
- API-670 capable machinery protection
- Smart machine monitoring…
  - Automated fault detection and identification within the Integrated Architecture
- Secure configuration in Logix Designer

Dynamix™ 2500 Portables:

- Data collector for predictive maintenance and machinery vibration diagnostics.
  - Part of a comprehensive CbM program
  - Download your measurements to Emonitor CMS
- A real-time, multi-channel signal analyzer
  - A stand alone instrument for use in balancing, run up / coastdown analysis, bump testing and more.

Emonitor CMS Software:

- Proven, comprehensive tools for executing any size condition based monitoring program
- Online and offline analysis and data collection
- Automated diagnostics
  - Fault frequency identification
  - Built-in and user editable rule sets

Sensors:

- 1442 Series Eddy Current Probes
  - API-670 compliant sensors, extension cables and drivers for all common size and range requirements
- 1443 Series Sensors
  - Industrial accelerometers, cables and mounting solutions