

■ Analytics[™] GuardianAl[™]

expanding human possibility°



Training Outline

- FactoryTalk Analytics GuardianAl Overview
- Understanding Motor Current Signature Analysis (MCSA)
- Application Deployment
- Connecting to the Drive
- Configuration and Training Workflow
- Labeling Workflow
- Email Notifications



Reactive

Run to failure

Only performing maintenance when problems occur

X Unexpected equipment failures

× Expensive repairs

- **X** Costly unplanned downtime
- ★ Lost production during extended downtime events

Maintenance Planning **Challenges**



Regularly scheduled maintenance

Based on **predetermined** time intervals

X Unnecessary, frequent planned downtimes

✗ Increased need for maintenance resources

× Expensive asset maintenance or replacements

Predictive Maintenance

Condition-based monitoring with analytics applied

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Monitor the current condition of the asset



Use **analytics** or machine learning to predict upcoming asset failures

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Increased Production

Maintenance engineers can plan downtime for repairs, reducing the amount of time offline

Cost Savings

Maintenance tasks are performed only when required

Maintenance engineers can plan to have the right resources and parts required when they do maintenance



Fr Analytics" Guardian Al

Machine learning for predictive maintenance at the edge



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Leverage drive data for predictive maintenance

Detect upcoming equipment failures via **electrical signal analysis**

- Acquires buffered drive signals via trend object
- 3 phase current data
- Performs time and frequency domain analysis
- Data fidelity is enhanced algorithmically
- Useful in detecting bearing fault, stator fault, broken-bar, misalignment as well as application related faults

FT Analytics" Guardian Al"

Use existing devices as sensors



Understanding Motor Current Signature Analysis (MCSA)

- MCSA monitors the three-phase supply current of the induction motor.
- Can be sensed using a current sensor and recorded in time domain.
- Frequency of MCSA is typically between 0-5khz
- Typical faults detected
 - Static and/or dynamic air-gap irregularities
 - Broken rotor bar or cracked rotor end-rings.
 - Stator faults (opening or shorting of one coil or more of a stator phase winding)
 - Abnormal connection of the stator windings
 - Bent shaft (akin to dynamic eccentricity) which can result in a rub between the rotor and stator, causing serious damage to stator core and windings.
 - Bearing and gearbox failures
- Source: Miljković, Dubravko. (2015). Brief Review of Motor Current Signature Analysis. CrSNDT Journal. 5. 14–26.



Example of time domain motor signal



Frequency spectrum from motor with broken rotor bars



4 step workflow for no code machine learning

► Analytics GuardianAl No data science required



Complete initial setup



Establish a baseline of each asset's behavior 3

Monitor plant assets



Notify user when an anomaly is detected



Two methods for anomaly identification

FT Analytics" Guardian Al Anomaly detection to anomaly identification



Embedded Expertise

F Analytics[™] GuardianAl[™] Anomaly detection to anomaly identification



User Classification

Analytics[®] GuardianAl[®] Anomaly detection to anomaly identification



Analyze data where it originates

Analytics" GuardianAl" Analyze at the edge

Deploy and Set up FactoryTalk Analytics GuardianAl

- Configure in three primary steps
- Guided user experience for first time initiation

What is a container?

- Applications run in isolated packages of code
- Containers include all the dependencies needed to run.
- Includes libraries, binaries, configuration files, and frameworks, into a single lightweight executable.
- Podman is the container engine used for GuardianAl.
- Streamlined path for deployment of Open Container Initiative (OCI) compliant containers

How to deploy FactoryTalk Analytics GuardianAl

Several ways to install and run the edge AI application

FactoryTalk Edge Manager

Pre-requisite: Eve-OS based hardware certified for Edge Manager

Edge Manager account

Install Process:

- Configure edge node
- Load GuardianAl to edge node from Edge Manager
- Start containers on edge node

PCDC Download

Manual Container Deployment Pre-requisite: Linux Debian 11, 12 based PC

Install Process:

- Download zip from PCDC
- Extract zip
- Place content on Linux Based PC
 - guardianai-install.sh
 - guardianai-uninstall.sh
 - guardianai-reset-password.sh
 - guardianai.tar
 - redis.tar
- Run script:
 - guardianai-install.sh

lanual Containe Deployment

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FactoryTalk Edge Manager Deployment Process

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FT-Analytics-GuardianAl-Redis Analytics & Data Management

Manual Container Deployment Process

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Hardware Specifications

Hardware and OS Specifications

Minimum specifications tested with 10 drives used as sensors

FactoryTalk Edge Manager

- Edge Node Minimum Hardware Spec
 - Processor: Intel Atom 4 core
 - Ram: 8 GB
 - SSD: 120 GB
- Edge Node OS: EvE OS
- Edge Node certified for Deployment with FactoryTalk Edge Manager
- Client PC Accessing GuardianAl
 - OS Windows
 - Web Client: Chrome or Edge

Manual Install

- Host Minimum Hardware Specifications
 - Processor: Intel Atom 4 core
 - Ram: 8 GB
 - SSD: 120 GB
- Host Machine OS: Linux Debian 11, 12
- Client PC Accessing GuardianAl
 - OS Windows
 - Web Client: Chrome or Edge

FactoryTalk Analytics GuardianAl on a FactoryTalk Edge Manager Edge Device

FactoryTalk Analytics GuardianAl on an Industrial Computer

Configuring FactoryTalk Analytics GuardianAl

Workflow to Add and Configure an Asset

Connecting to the Drive

Configuration Workflow

- Drive Type: 755, 755TM, 755TR, 755TL, 755TS, 6000T
- Ethernet IP
 - Direct drive connection
 - Enter IP address \rightarrow Test Connection
- Support subnet via Ethernet Module
 - Controller \rightarrow Ethernet Module \rightarrow Drive IP
 - Format: {BridgeModuleIP}/Backplane/{BridgeModuleSlot}/Port/{DriveIP}
 - Example: 10.91.0.96/1/1/2/192.168.1.75

Add Asset

Configuration Workflow

- Pumps, Fans and Blowers
- Motor Analytics for other asset types
- Input fields
 - Bearing info (optional)
 - Inner Race Multiplier
 - Outer Race Multiplier
 - Rolling Element Multiplier
 - Cage Multiplier
 - Pump & Fans \rightarrow Number of Blades
- Motor bearing and pump/fan specs are used for First Principle failure mode recommendations

Outer ring

Balls

Cage

Inner ring

• An excel database of over 7000 bearings will be provided

sset overview	+ Add	Configuration			Back to Monitoring
Q Search nodes,drives			2	3	4
New Folder 1 1 asset	:	Drive	Asset	Training	Summary
New Drive 1 . New Asset 1	:	Name of asset* New Asset 1			
		Select type of asset* Pump	Ŧ		
		Manufacturer	Serial number		
		Model number	Part number		
		Bearing Monitoring			
		inner race multiplier 0.01	Rolling element multiplier 0.1		
		Outer race multiplier 0.2	Cage multiplier 0.1		
		Pump Specifications			
		Number of blades* 5			

Additional Bearing Details

- Inner Race Multiplier: [decimal number input] BPFI (Ball Pass Frequency Inner) or inner race failing frequency. Corresponds physically to the number of balls or rollers that pass through a given point of the inner track each time the shaft makes a complete turn.
- Outer Race Multiplier: [decimal number input] BPFO (Ball Pass Frequency Outer) or outer race failing frequency. Corresponds physically to the number of balls or rollers that pass through a given point of the outer race each time the shaft makes a complete turn.
- Rolling Element Multiplier: [decimal number input] BSF (Ball Spin Frequency) or rolling element failing frequency. Corresponds physically to the number of turns that a bearing ball or roller makes each time the shaft makes a complete turn.
- **Cage Multiplier**: [decimal number input] FTF (Fundamental Train Frequency) or Cage failing frequency. Corresponds physically to the number of turns that makes the bearing cage each time the shaft makes a complete turn.

Set Operating Frequencies

Configuration Workflow

- GuardianAl trains at every half hertz frequency of the operation
- Training time ~14-16 min per frequency bucket
- Specify Min and Max frequency (speed) of operation
- Note: Frequencies detected outside the specified range will not be trained
- Advanced Settings
 - Training iterations: data resolution to establish baseline
 - Trigger Value (Hz): optional Minimum threshold frequency configured in the VFD to send data to GuardianAl for training and monitoring.

Configuration Summary

Configuration Workflow

PUBLIC

Initiate Training

- Training Summary provided
- Baseline established at each half hertz increment
- Time for each training increment ~14-16 minutes of data
- Command Frequency of the drive is automatically picked up
- Training and Monitoring occur simultaneously
- Training will switch to monitoring automatically once sufficient data is acquired

Stop and Restart Training/Monitoring

- Training and Monitoring are connected to each other
- Stop Training will also stop Monitoring
- Any training in progress at a specific frequency will be reset when the user stops training
- Fully trained frequencies will resume monitoring once training is started again
- Re-Train will completely reset the training and erase all frequency baselines

Workflow to Add and Configure an Asset

Monitoring Assets

Monitoring Asset Performance

Demo Video

Workflow for labeling

Incoming anomaly shown as a deviation Select label from First Principle recommendation, Normal Behavior, Other or Add New

Select

Deviation shifts to Failure Risk

Mark a Failure Risk as resolved

⑦ Deviations			
000002	Peak above baseline:	Duration	Identified
	112%	32s	6 hours ago
000004	Peak above baseline:	Duration	Identified
	36%	1m 21s	3 days ago
000005	41%	43s	5 days ago
000006	Peak above baseline:	Duration	Identified
	161%	1h 2m	12 days ago

0	Cavitation		
0	Viscosity Changes		
0	Normal Behavior		
0	Other		
	Risk Name Select Risk Name	v	+ Add New

🗥 Fail	ure risks		Show History
000002	Extreme bearing wear	Severity: Medium	Identified 1 days ago
000001	Extreme bearing wear	Severity: High	Identified 32 days ago
00003	Unbalance	Severity: Medium	Identified 20 days ago

Failure risk 000002

4 Oct 2023, 8:22:42 | Recipe: Name-of-the-recipe

Confirm the failure risk:

Extreme bearing wear

Description: This problem can include insufficient lubrication, over-lubrication, using the wrong type of lubricant, or contamination of the lubricant.

Quick Filters Show Additional Insight

• At Risk

- Summary of assets with identified failure risks
- Additional details about identified risks are provided

Guardian AI
Assets overview
Line#1

12 assets Line#2

3 assets

3 assets

2 assets

1 assets

To Label: 5) (At Risk: 4)

To Label: 1) (At Risk: 2)

To Label: 2) (At Risk: 1)

0

Deviation Below Baseline

- To Label
 - Shows deviations that need to be labeled

d fail	lure risks	Guardian Al		¢° &
uran		Assets overview	Line#1	
d risł	ks are provided	Line#1 12 assets O To Label: 5 (At Risk	All Assets: 12 At Risk: 4 ⑦ To Label: 5 Ø H	lealthy: 7
		Line#2 3 assets Or Label: 1) (At Risk	2 Pump#1 PowerFlex755TR, 10(1), 19, 10	3 Identified Risks
		Line#3 3 assets	Misalignment	Identified: 2 d ago
elabe	eled	Line#4	hy Misalignment	Identified: 2 d ago
			C 🔅 reme bearing wear	Identified: 0 d ago
	Line#1		#3 rerFlex755TM, 10.88.19.14	2 Identified Risks
At Risk: 4	All Assets: 12 At Risk: 4 ⑦ To Label:	: 5 🖉 Healthy: 7	ating	Identified: 2 d ago
At Risk: 2	Pump#1 PowerFlex755TR, 10.88.19.10	3 Deviation	to Label > salignment	Identified: 2 d ago
At Risk: 1)	Oeviation Below Baseline	Peak above baseline: 70%	Identified: 2 d ago mp#5	
Healthy	Oeviation Below Baseline	Peak above baseline: 70%	Identified: verFlex755T, 10.18.88.144 2 d ago	1 Identified Risk
O Healthy	Oeviation Below Baseline	Peak above baseline: 70%	Identified: ating 2 d ago	0 d ago
	Motor#2 PowerFlex755T, 10.88.19.144	2 Deviation	to Label >	
	Deviation Below Baseline	Peak above baseline: 70%	Identified: 2 d ago	
	Oeviation Below Baseline	Peak above baseline: 70%	Identified: 2 d ago	
	Bo Fan#3 PowerFlex755TM, 10.88.19.14	1 Deviation	to Label >	
		Peak above baseline:	Identified:	

2 d ago

70%

Understanding Deviations

- All new anomalies detected by GuardianAl will be shown as Deviations
- Deviations have associated First Principle Recommendations
- User can label by selecting a First Principle, Normal Behavior, or Other
- The Other drop down is populated by First Principle options and user labels
- Add New can be used to created a new label
- A Deviation labeled by a user becomes a failure risk

Vestor SDFT No Failure risks Normal Behavior Normal Behavior	Analytics" Guardian Al				駿 (j)
A Falure risks No falure risks O beviations 00001 Pesk above baseline 4.65% Recurrence 2 01/25/2024 8:11 PM UT Deviation 000001 Calure of the deviation: Choose the root cause of the deviation: Choose the root cause of the deviation: Choose the root cause of the deviation: Cost of the deviation: Normal Behavior Normal Behavior	< Back to SDFT	Asset type: Pump			tit Trainin	g
UTC	 Failure risks No failure risks Deviations 000001 	Peak above baseline 4.65%	Recurrence 2	Last seen 01/25/2024 8:11 PM	Deviation 000001 25 Jan 2024, 8:11 PM UTC	
Risk Name Select Risk Name + Add New					Bit Description Observe the root cause of the deviation: Cavitation Viscosity Changes Normal Behavior Other Risk Name Select Risk Name	

Understanding Failure Risks

- Failure Risks are deviations which have been labeled and confirmed by a user.
- When the same labeled anomaly is encountered again, it will be shown as a Failure Risk.
- Failure Risk labels can be changed

n	Analytics" Guardian Al*			稼 〔
	< Back to SDFT	Asset type: Pump		tit Training
	Failure risks	Severity F Mediun 1	Last seen Recurrence 01/25/2024 9:45 PM 13 UTC	Failure risk 000001 25 Jan 2024, 9:45 PM UTC
	⑦ Deviations No deviations			Confirm the failure risk: Cavitation Risk Name Select Risk Name Cavitation Cavitati
				Mark as Resolved

Understanding First Principles

• MCSA first principle frequencies do overlap

- Bearing faults (Ball, Inner Race, Outer Race, Cage)
- Unbalance, Misalignment, Looseness Mounting/Component

• Cavitation, Shaft Alignment, Viscosity Changes

• Blade Misalignment, blade Imbalance, blade wear, Loose blade • ML Engine Overview

Workflow for labeling

Incoming anomaly shown as a deviation Select label from First Principle recommendation, Normal Behavior, Other or Add New

Select

Deviation shifts to Failure Risk

Mark a Failure Risk as resolved

⑦ Deviations			
000002	Peak above baseline:	Duration	Identified
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000004	Peak above baseline:	Duration	Identified
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0	Cavitation		
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0	Other		
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🗥 Fail	ure risks		Show History
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Failure risk 000002

4 Oct 2023, 8:22:42 | Recipe: Name-of-the-recipe

Confirm the failure risk:

Extreme bearing wear

Description: This problem can include insufficient lubrication, over-lubrication, using the wrong type of lubricant, or contamination of the lubricant.

Email Notifications

Email Notification Configuration

Configure SMTP Server

- SMTP server configuration available
- Notifications can be turned on and off
- Mailing lists available to notify users
- Users in list receive info about all managed assets
- Two types of notifications
 - Individual Notifications
 - Deviations and Failure Risks
 - Summary Notifications
 - Configurable Daily, Weekly, Monthly cadence

Analytics" Guardian Al"				段 (j)
\leftarrow Settings				
General Notifications				
Email Notifications				SMTP Server Information
Individual Notifications ()	Summary Notifications 1 Notification Frequency			Server Domain*
	Disabled 👻			Port*
Distribution List				Email Id*
First Name	Last Name	Email		
Add Email			0 of 0 < < > >	User Name
				Password
				Connection Type
				Send Test Email Restore Save

Email Notification - Deviations

Immediate Notifications Switched On

- Each deviation will provide an email when encountered.
- Subsequent recurrences of the same deviations will not generate an email.
- The deviation will be included in the summary report until labeled and resolved.
- Deviation Template:
 - **Asset Name**: Name of the asset given during the first-time configuration.
 - Asset Type: Pump, Fan, Blower, or Motor Analytics.
 - **Folder Name**: The folder name containing the drive and asset combination.
 - **Time Detected**: The time at which the event was detected based on the local time zone of the FactoryTalk Analytics GuardianAl instance.
 - **Percent above baseline**: The percentage deviation from baseline.
 - Duration: Amount of time the deviation has persisted. •
 - Probable Causes: First Principle Failure mode recommendations.
 - **Number of recurrences**: The amount of time the deviation has been detected

Subject:	GuardianAl Deviation Detected Pri						
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−ello <usern< td=""><td>ame>,</td><td></td><td></td></usern<>	ame>,						
A Deviation ł	nas been detected on	<assetname> connected to <drivename>.</drivename></assetname>					
Asset nam	ne	Example Asset Name					
Asset typ	be	Pump XYZ					
Folder na	ame	Folder Example Name					
Time det	ected	02/02/2024 5:15:49 AM (UTC) Coordinated Universal Time					
Deviation	n	Test Deviation					
Deviation							
Percent a	above baseline	42.00%					

Test Cause A, Test Cause B

Visit GuardianAI now to check on the health of your assets!

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Best Regards,

Your Friendly Asset Guardian

Probable Causes

Total Recurrences

Email Notification – Failure Risk

Immediate Notifications Switched On

- Each Failure Risk will provide an email when encountered.
- Subsequent recurrences of the same Failure Risk will not generate an email.
- The Failure Risk will be included in the summary report until labeled and resolved.
- Failure Risk Template:
 - **Asset Name**: Name of the asset given during the first-time configuration.
 - Asset Type: Pump, Fan, Blower, or Motor Analytics.
 - **Folder Name**: The folder name containing the drive and asset combination.
 - **Time Detected**: The time at which the event was detected based on the local time zone of the FactoryTalk Analytics GuardianAl instance.
 - **Failure Risk Name**: The name of the failure risk, this is given during the labeling process for a deviation.
 - **Failure Risk Description**: The description of the failure risk indicates additional details about the detected anomaly.
 - **Failure Risk Prescription** (if exists): Recommendation regarding the action to take to resolve the failure risk.
 - Severity: A ranking of the severity (low, medium, high).
 - Time to Resolve: Time expected to resolve the failure risk.

ubject: Guard	ianAl Failure Risk Detected Price				
Calibri 🗘 11	$\widehat{\bullet} \triangleq \bullet \mathbf{B} I \sqcup \ominus \forall \mathbf{x}^2 \mathbf{x}_2 \coloneqq \underbrace{\overset{1}{\exists} = = \bullet}{\overset{1}{\exists} = = \bullet} \oplus \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc \bigcirc$				
Hello < <u>user-name</u> >	<i>'</i> ,				
A failure risk has b	een detected on <asset-name></asset-name> connected to <drive-name></drive-name> .				
Asset name	Example Asset Name				
Asset type	Pump XYZ				
Folder name	Folder Example Name				
Time detected	02/05/2024 7:54:49 PM (UTC) Coordinated Universal Time				
Failure Risk	Lubrication Issue				
	This problem can include insufficient lubrication, over-lubrication, using the				
Failure Risk Descript	ion wrong type of lubricant, or contamination of the lubricant.				
Failure Risk Descript	 wrong type of lubricant, or contamination of the lubricant. Identify the source of the lubrication issue by examining the machinery or equipment and analyzing the lubrication process. Determine the appropriate type and amount of lubricant needed based on the manufacturer's recommendations 				
Failure Risk Descript Failure Risk Prescrip	 wrong type of lubricant, or contamination of the lubricant. Identify the source of the lubrication issue by examining the machinery or equipment and analyzing the lubrication process. Determine the appropriate type and amount of lubricant needed based on the manufacturer's recommendations and operating conditions. 				
Failure Risk Descript Failure Risk Prescrip Severity	 wrong type of lubricant, or contamination of the lubricant. Identify the source of the lubrication issue by examining the machinery or equipment and analyzing the lubrication process. Determine the appropriate type and amount of lubricant needed based on the manufacturer's recommendations and operating conditions. Medium 				

Visit GuardianAl now to check on the health of your assets!

Best Regards,

Your Friendly Asset Guardian

Email Notification – Summary Report

- Configurable on a cadence (Daily, Weekly, Monthly)
 - Daily: 8 AM each day
 - Weekly: 8 AM Monday
 - Monthly: 8 AM first Monday of the month
- Summary Table
 - Unresolved Failure Risk sorted by severity
 - Unlabeled Deviations
 - Last event time encountered
- Asset Deviation list
 - Additional insights listed below the summary table similar to the deviation and failure risk notifications.

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High Severity Medium Severity Low Severity Deviations Last Event Asset Name Failure Risks Deviations Last Event 1 Pump XYZ 1 2 1 15 12/11/23 20: 2 Blower ABC 2 1 2 2 12/11/23 4:3 Failure Risk Details: Pump XYZ Asset Type: Pump Location: Line #1, Mayfield Heights Plant Last Event: 12/11/2023 20:09 High Failure Risks (1) 1 Shaft Misalignment, Last detected: 12/11/2023 10:00 PM Medium Failure Risks (2) 1 Extreme Bearing Wear, Last detected: 12/22/2023 5:57 AM 2 Lubrication, Last detected: 12/15/2023 2:23 AM Elower ABC Asset Type: Blower Lost Conton: Line #1, Mayfield Heights Plant Last Event: 12/11/2023 4:33 High Failure Risks (2) 1 Lubrication, Last detected: 12/11/2023 10:00 PM 2 Shaft Misalignment, Last detected: 12/8/2023 7:33 AM Medium Failure Risks (1) 1 3 Misalignment, Last detected: 12/19/2023 2:12 PM Visit GuardianAl now to check on the health of your assets! Best Regards, Est Regards,	Calibri	;	€ 11 €	≜	I ∐ S	- ∀ • >	<² × ₂ :=
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Resources

- <u>GuardianAl Reference Architecture</u>
- <u>GuardianAl Installation Guide Publication 95055-in010</u>
- <u>GuardianAl User Guide Publication FTALK-sp022</u>

