



BLMS

Bolt Load Monitoring System

Technical White Paper

Clamp Force Control During Tightening
Continuous Joint Integrity Monitoring After Installation

Document No. ZWP-BLMS-001
Version 1.0 · September 2026

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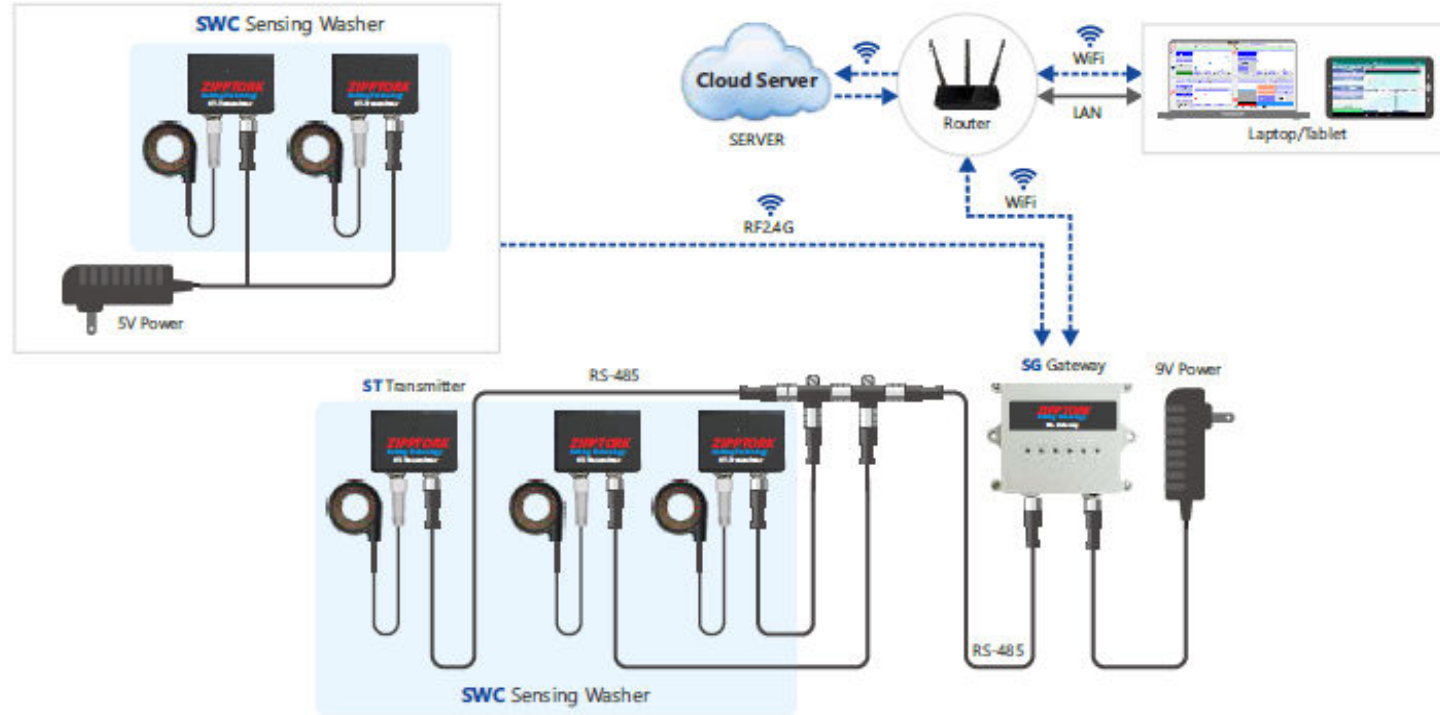
Executive Overview

Turning Critical Bolt Preload into a Measurable Lifecycle Parameter

Bolted joints are commonly tightened and accepted based on applied torque.

However, clamp force—the axial load that holds the joint together—is the actual fastening result. Friction, surface conditions, embedment, gasket relaxation, vibration, and thermal cycling can cause achieved and retained preload to differ significantly from expectations.

ZIPPTORK BLMS uses a patented anti-loosening sensing washer to measure clamp force during tightening and monitor its change after installation.



DURING TIGHTENING
Measure actual clamp force and support tightening control based on the required bolt load.

AFTER INSTALLATION
Establish the initial preload baseline for subsequent monitoring.

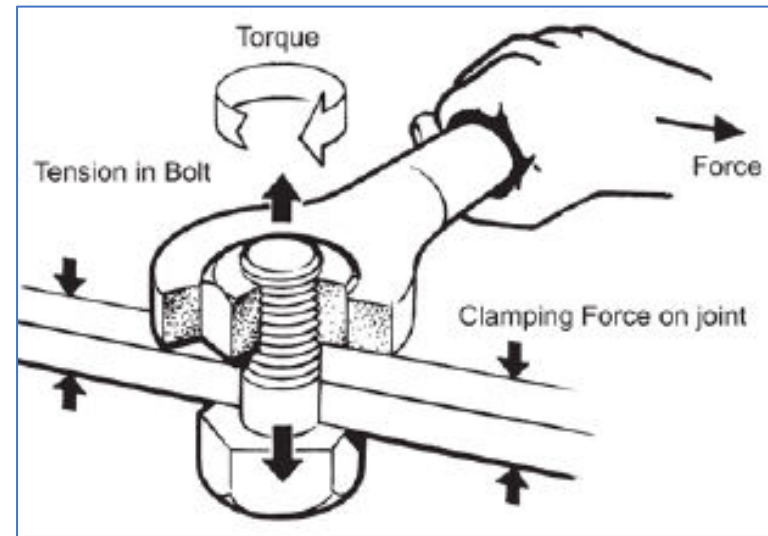
DURING OPERATION
Detect preload drift, abnormal variation or threshold excursions before they develop into joint-integrity risks.

Not every bolt requires continuous monitoring.

BLMS is designed for selected joints where safety, uptime, quality, or inspection accessibility makes preload visibility essential.

Bolted Joints Can Lose Integrity Without Visible Warning

Preload can degrade during operation—even when the bolt remains in place.



INITIAL PRELOAD

Tightening stretches the bolt and creates the clamp force that holds the joint together.

The retained preload determines the joint's resistance to separation, slip, and vibration-induced movement.

OPERATING CONDITIONS

- Embedment and surface settling
- Gasket creep and relaxation
- Vibration and transverse loading
- Thermal expansion and contraction
- Repeated or fluctuating external loads
- Joint movement, wear or deformation

POTENTIAL CONSEQUENCES

Preload Loss



Joint Separation or Microslip



Leakage · Misalignment · Fatigue



Unplanned Downtime or Safety Risk

A bolt can remain visually intact while its retained clamp force is already changing.

Periodic inspection may not reveal what happens between inspection intervals.

Torque Is an Input—Not the Final Fastening Result

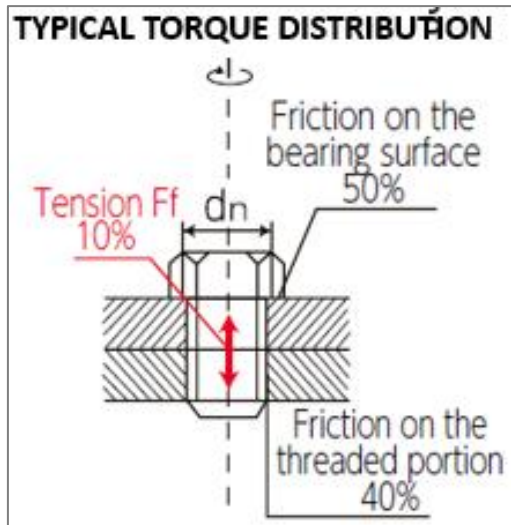
The same applied torque can produce different clamp forces under different fastening conditions.

APPLIED TORQUE

Applied torque must overcome:

- Thread friction
- Friction beneath the bolt head or nut
- Resistance created as the bolt stretches

Only part of the applied torque is converted into useful bolt tension and joint clamp force.



SAME TORQUE $\neq$ SAME CLAMP FORCE

APPLIED TORQUE



FRICITION & JOINT CONDITIONS



ACTUAL CLAMP FORCE

- Same Torque → Higher Friction → Lower Clamp Force
- Same Torque → Lower Friction → Higher Clamp Force

WHAT **BLMS** CHANGES

BLMS measures the actual clamp force directly at the joint.

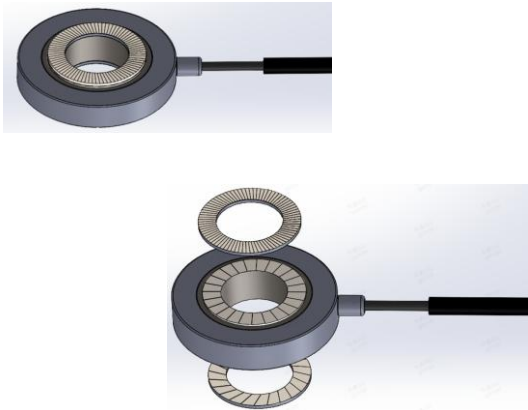
Instead of relying only on applied torque, the **BLMS Sensing Washer** provides direct visibility of the bolt load achieved during tightening.

Torque controls the tightening input. BLMS measures the fastening result.

How BLMS Measures Clamp Force

The BLMS Sensing Washer converts bolt preload into a measurable electrical signal at the joint.

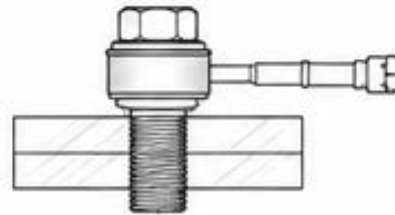
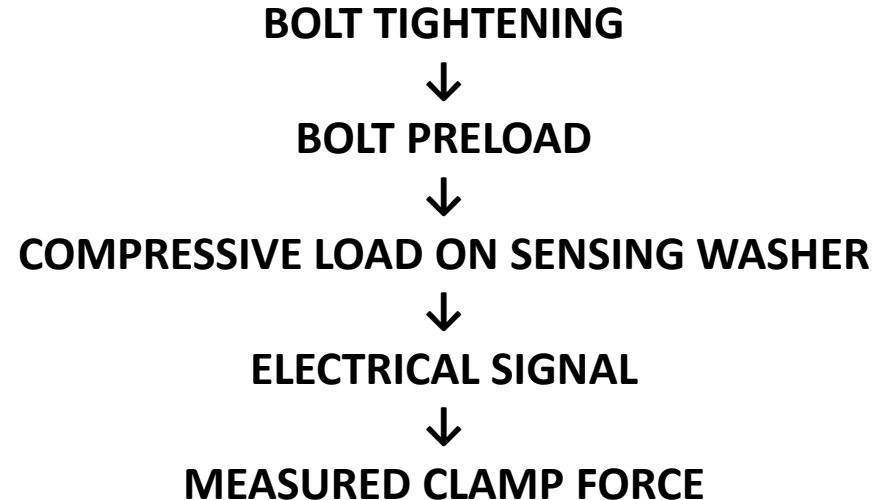
BLMS SENSING WASHER



Installed as part of the bolted joint

- Senses the compressive load generated by bolt preload
- Measures clamp force directly at the joint

FROM PRELOAD TO MEASUREMENT



As bolt preload changes, the load acting on the sensing washer changes accordingly.

WHAT BLMS MEASURES

DURING TIGHTENING

Measure the actual clamp force as the preload is established.

AFTER INSTALLATION

Establish the initial preload baseline.

DURING OPERATION

Monitor retained clamp force and detect preload changes over time.

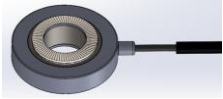
BLMS measures what the joint actually retains—not simply what the tightening tool applies.

From Sensing Washer to Connected Bolt Load Monitoring

BLMS converts clamp-force measurement at the joint into transmitted, monitored, and recorded bolt-load data.

SWC—SENSING WASHER

Measures Clamp Force



ST—Signal Transmitter

Signal Processing & Transmission



SG—System Gateway

Data Collection & Communication



APPLICATION SOFTWARE

Monitoring • Alarm • Data Recording

1 | SENSING WASHER — SWC



- Installed at the monitored joint
- Measures bolt clamp force
- Supports preload measurement throughout the joint lifecycle

2 | SIGNAL TRANSMITTER — ST



- Receives the sensing washer signal
- Processes the sensor signal
- Transmits measurement data to the system

3 | SYSTEM GATEWAY — SG



- Collects data from multiple ST units
- Provides communication to the monitoring system
- Supports multi-point bolt-load monitoring

4 | APPLICATION SOFTWARE



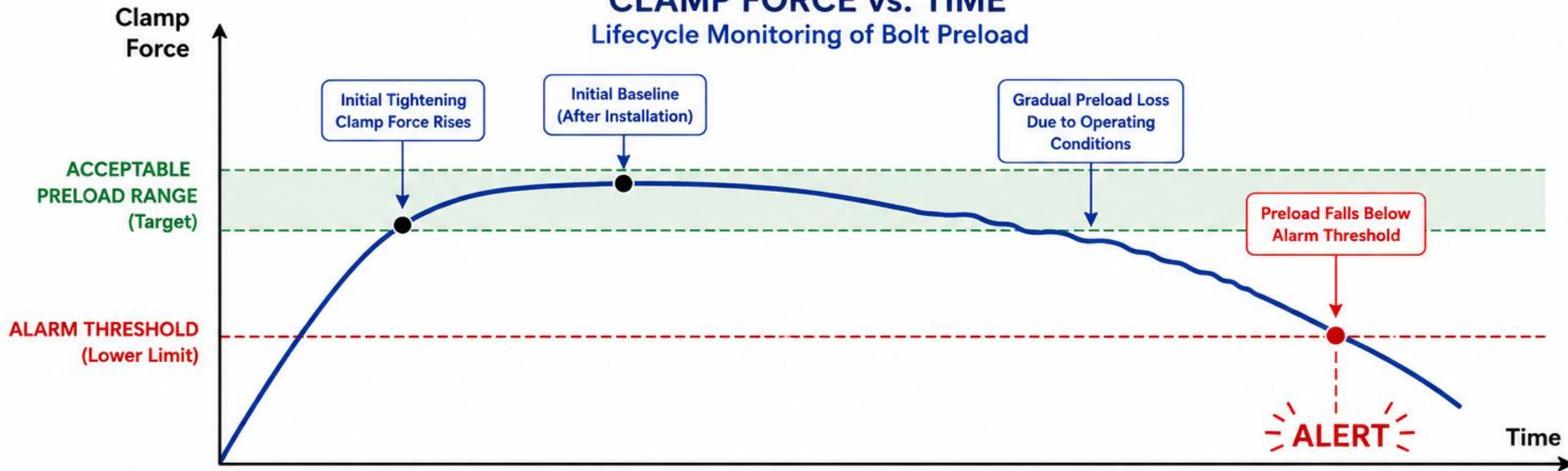
- Displays clamp-force data
- Monitors preload status and threshold conditions
- Records measurement history for traceability

From a Single Monitored Joint to a Multi-Point Bolt Load Monitoring Network

Monitoring Clamp Force Throughout the Joint Lifecycle

BLMS extends bolt-load visibility from initial tightening to long-term joint integrity monitoring.

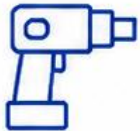
CLAMP FORCE vs. TIME Lifecycle Monitoring of Bolt Preload



During Tightening

1 TIGHTENING

Establish Required Preload



- Measure actual clamp force during tightening
- Support tightening based on the required bolt load
- Confirm the achieved preload

After Installation

2 INSTALLATION

Establish Initial Baseline



- Record the achieved clamp force
- Establish the reference preload condition
- Create the baseline for future comparison

During Operation

3 OPERATION

Monitor Retained Preload



- Monitor clamp-force changes over time
- Detect preload loss or abnormal variation
- Identify threshold excursions

Maintenance Action

4 MAINTENANCE

Condition Response



- Alarm when defined limits are exceeded
- Identify joints requiring inspection
- Support condition-based maintenance decisions

BLMS turns bolt preload from a one-time installation value into a measurable condition throughout the joint lifecycle.

Scalable Multi-Point Monitoring Architecture

BLMS scales from a single monitored joint to a comprehensive multi-point monitoring network.

SCALABLE MONITORING NETWORK



1 to 64 Monitoring Points per System

Monitor from a single critical joint up to 64 joints in one network.



Flexible Communication Options

RS-485 (wired), Bluetooth®, or RF 2.4 GHz (wireless). Designed for industrial environments.



Reliable & Industrial-Grade

Stable communication, strong noise immunity, and high data reliability.



Centralized Monitoring & Management

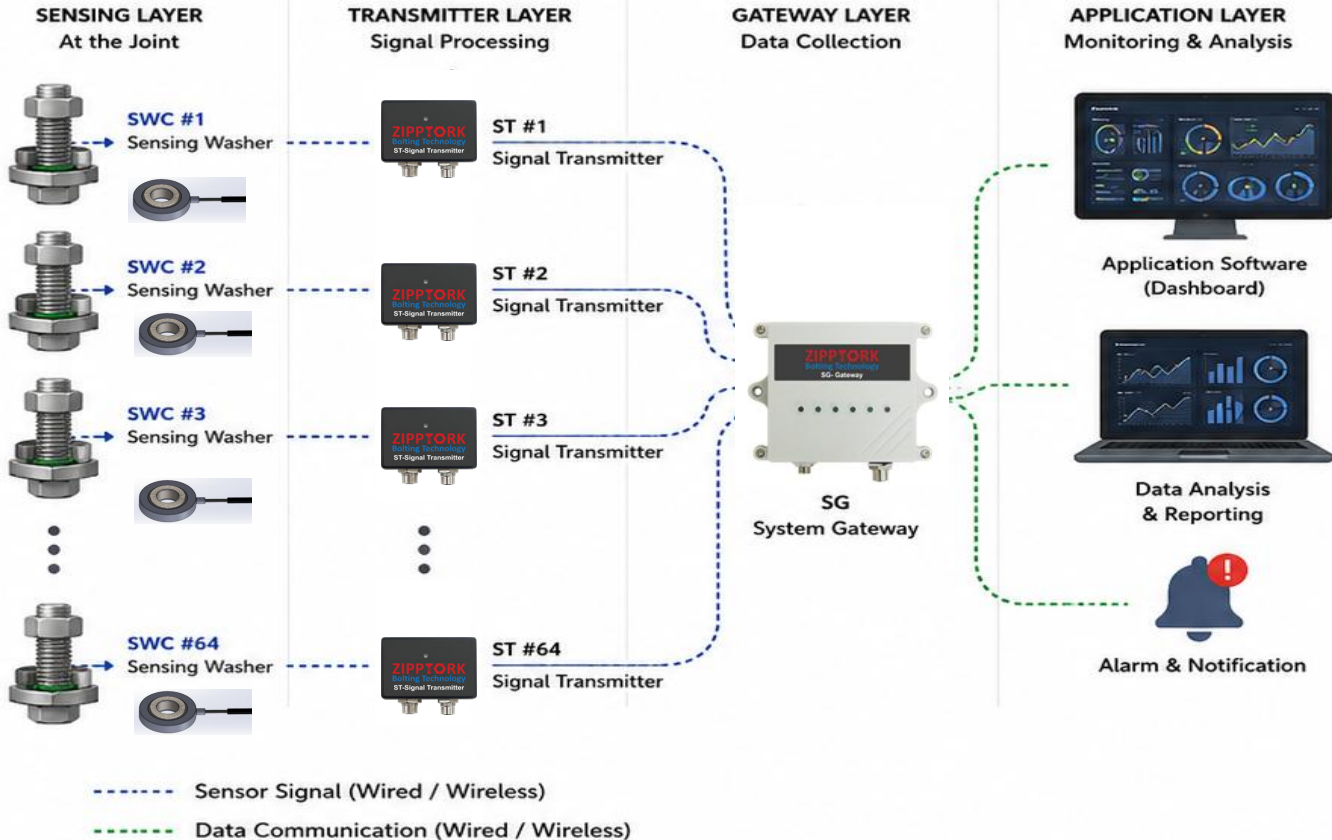
Collect, visualize, and analyze data from all monitored joints in real time.



Data Logging & Traceability

Store measurement history for trend analysis, reporting, and maintenance planning.

BLMS SYSTEM ARCHITECTURE



COMMUNICATION OPTIONS



RS-485 (Wired)

Stable, long-distance communication for industrial environments.



Bluetooth® (Wireless)

Easy setup and flexible configuration for short-to-medium range.



RF 2.4 GHz (Wireless)

Robust wireless communication for challenging environments.

SCALABILITY

1 → 64

Monitoring Points per System



BLMS enables scalable, reliable, and continuous bolt load monitoring—delivering the right data to the right people.

Note: The maximum number of monitoring points may vary depending on the communication method.

Monitoring Only the Joints That Matter

BLMS is designed for selected critical joints where preload visibility provides the greatest operational value.

Monitor the bolts that matter most.

BLMS provides continuous or periodic preload visibility where conventional inspection cannot provide sufficient assurance.

1 SAFETY CRITICAL

Joint failure may create a safety risk.



3 QUALITY CRITICAL

Joint integrity directly affects product or process performance.



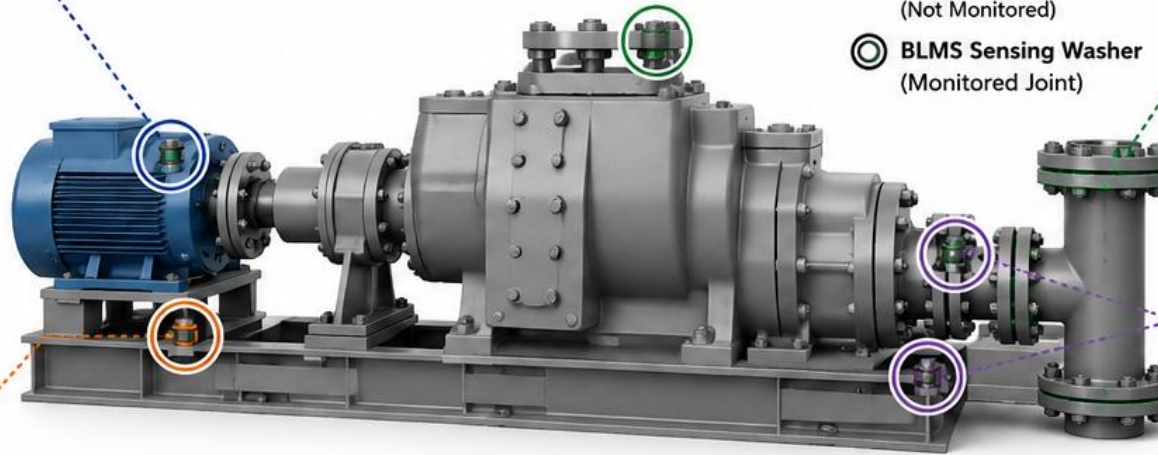
2 DOWNTIME CRITICAL

Preload loss may cause costly unplanned shutdown.



4 DIFFICULT TO INSPECT

Manual inspection is difficult, hazardous, or costly.



- Standard Bolts (Not Monitored)
- ◎ BLMS Sensing Washer (Monitored Joint)

From Critical Joints to Actionable Insight



- Real-time / Periodic Monitoring
- Trend Analysis & History
- Alarm & Notification
- Reporting & Traceability



Targeted monitoring makes continuous bolt-load visibility practical for critical joints without instrumenting every bolt.

Typical Applications for BLMS

BLMS delivers bolt-load visibility in high-value applications across industries.

1 PUMPS & COMPRESSORS



- Monitor critical flange connections
- Detect preload loss due to vibration
- Reduce unplanned downtime
- Improve reliability and safety

2 TURBINES & GENERATORS



- Monitor high-stress bolted joints
- Maintain preload under thermal cycling
- Support long-term operational stability
- Prevent costly outages

3 PRESSURE VESSELS



- Monitor vessel and nozzle connections
- Detect preload degradation over time
- Support fitness-for-service programs
- Enhance plant safety

4 PIPE FLANGES



- Monitor critical pipeline flanges
- Detect effects of pressure, vibration and thermal cycling
- Minimize leak and failure risk

5 STRUCTURAL CONNECTIONS



- Monitor structural bolted connections
- Detect preload loss from dynamic loads
- Improve structural integrity assurance
- Extend inspection intervals

6 GEARBOXES & DRIVETRAINS



- Monitor gearbox cover and housing
- Detect preload loss from vibration
- Prevent misalignment and failures
- Improve uptime and durability

7 WIND TURBINES



- Monitor critical bolted joints
- Withstand harsh environmental conditions
- Reduce maintenance costs

8 OTHER APPLICATIONS



Valves & Actuators



Chemical & Process Plants



Marine & Offshore



Railway & Transportation

Why BLMS for These Applications?



Enhance Safety
Detect preload loss before it leads to joint failure.



Reduce Downtime
Prevent unplanned shutdowns and production losses.



Improve Reliability
Maintain optimal preload for long-term joint performance.



Optimize Maintenance
Enable condition-based inspection and reduce maintenance costs.



Data-Driven Decisions
Leverage measurement history for better engineering decisions.



BLMS helps you focus on the joints that matter—improving safety, reliability, and operational performance.

Note: Application examples are representative and not limited to the above.

Transforming Bolt-Load Monitoring

BLMS transforms bolt-load inspection from periodic snapshots into measurable condition information over time.

BEFORE: Manual & Periodic Inspection



Periodic Inspection

Performed at fixed intervals based on schedule.



Manual Effort

Time-consuming and labor-intensive on-site inspections.



Uncertain Condition

Actual preload condition between inspections is unknown.



Limited Data

Paper-based records, difficult to track and analyze.



Reactive Maintenance

Issues are discovered after degradation or failure occurs.

BLMS

Bolt Load Monitoring System



AFTER: Continuous Monitoring with BLMS



Continuous Monitoring

Real-time or periodic visibility of clamp force condition.



Automated Data Collection

BLMS captures and transmits data automatically.



Early Detection

Preload loss or abnormal change is detected at an early stage.



Centralized Data Management

All measurement data is stored, trended, and easily accessible.



Proactive Maintenance

Make informed decisions and act before problems occur.

KEY CAPABILITIES OF BLMS



MONITOR

Real-Time / Periodic Monitoring

- Monitor clamp force in real time or at configurable intervals.
- Adapt to operational needs and criticality.



ANALYZE

Trend Analysis & Visualization

- Visualize clamp-force trends over time.
- Identify abnormal changes and degradation patterns.



ALERT

Alarm & Notification

- Set thresholds and receive instant alerts.
- Escalate issues before they impact operations.



RECORD

Reporting & Traceability

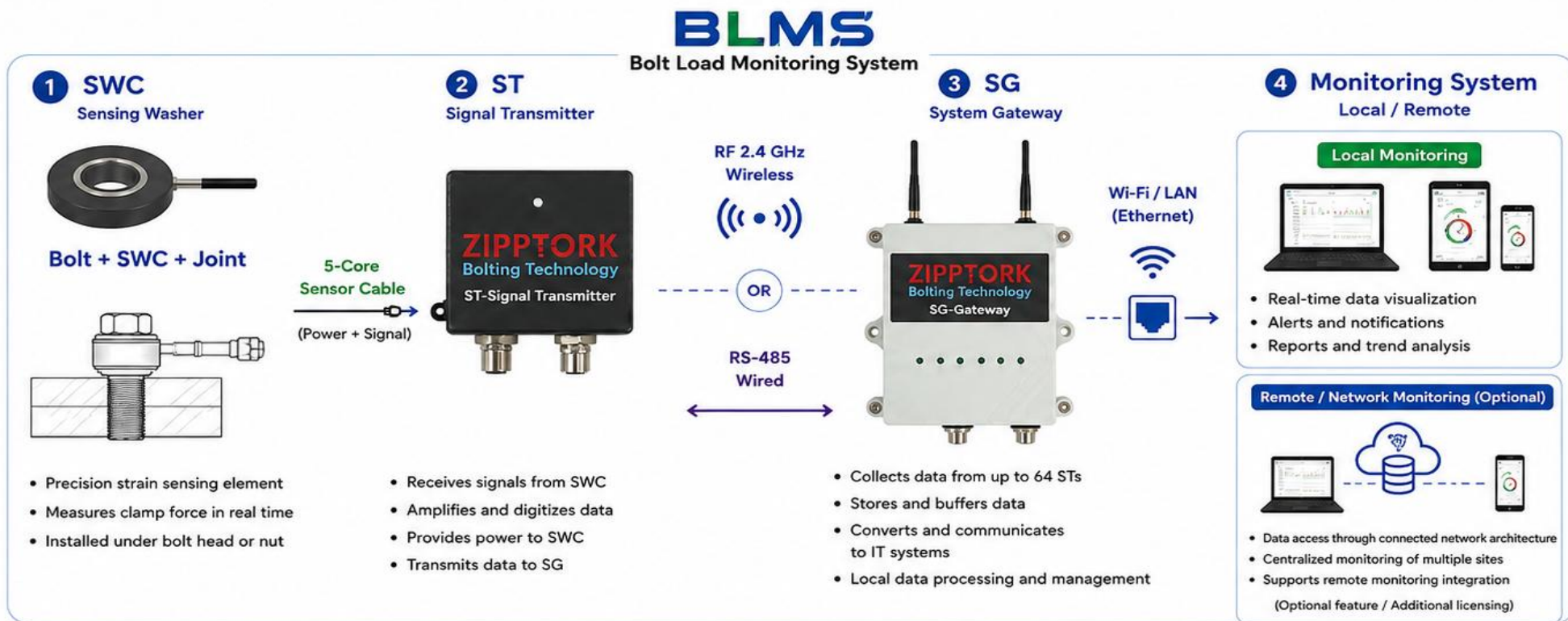
- Generate reports for compliance and audit.
- Maintain full traceability of bolt-load history.



BLMS delivers the right information to the right people—at the right time.

BLMS Application System Architecture

A scalable, reliable architecture—enabling continuous bolt-load monitoring and data-driven asset integrity.



COMMUNICATION OPTIONS



RS-485 (Wired)

Stable and reliable communication for long distances. Typical distance up to 1,000 m (3,280 ft).



RF 2.4 GHz (Wireless)

Flexible wireless communication for easy installation. Typical distance up to 100 m (330 ft) line of sight.



LoRa® (Optional)

Long-range, low-power communication for extended coverage. Typical distance up to 10 km (6.2 miles) line of sight.

Choose the communication method that best suits your application and environment.

KEY SYSTEM CAPABILITIES



Multi-Point Monitoring

Supports up to 64 signal transmitters per system for scalable coverage of critical joints.



Data Collection

Reliable acquisition and storage of clamp-force data with time synchronization.



Alarm & Trend Analysis

Early detection of preload loss or abnormal changes with alerts and trends.



Data Recording & Traceability

Complete measurement history, reporting, and data export for compliance and audits.



BLMS delivers continuous bolt-load visibility—connecting sensors to insights, anywhere, anytime.
Modular hardware. Flexible communication. Scalable software.

* Optional features available based on customer requirements.

SWC – Patented Sensing Washer

The SWC (Sensing Washer) is a patented strain sensing washer that sits directly in the load path of the bolted joint. It measures clamp force directly in the joint load path while supporting anti-loosening functionality through adaptable interface designs.

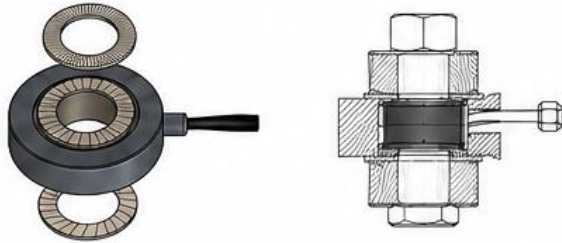
1 Patent Anti-Loosening Design – Adaptable Interfaces

The patented SWC architecture allows different anti-loosening surface geometries to be incorporated into its two load-transfer interfaces according to application requirements.

Representative Configuration A

Wedge-Lock Interface

(Representative wedge-cam configuration)

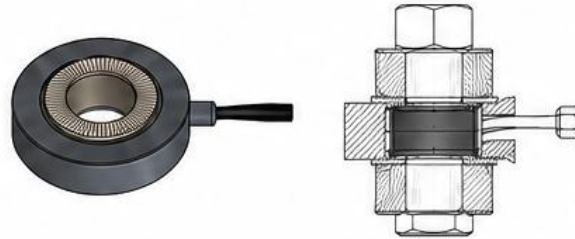


- Wedge-cam surfaces generate high resistance to loosening under vibration and dynamic load
- Requires a mating wedge-lock washer pair

Representative Configuration B

Integrated Radial-Rib Interface

(Representative radial-rib configuration)



- Radial-rib surfaces provide strong resistance to self-loosening without additional washers
- Integrated design for simplified assembly and reduced stack height



The configurations shown above are representative examples.

The patented SWC design is **NOT limited** to any specific anti-loosening geometry or commercial washer system.

2 Key Features & Benefits



High Accuracy

Measures true clamp force with high accuracy and excellent repeatability.



Dual Function

Combines precise load sensing with anti-loosening protection.



Direct in Load Path

Installed under bolt head or nut – measures actual load at the joint interface.



Wide Operating Range

Performs reliably in extreme temperatures and harsh environments.



Designed for Long-Term Monitoring

Rugged construction for long-term monitoring and structural health management.

4 Customizable Options



Other bolt sizes (M16, M24, M27, M30, M36, etc.) and load capacities are available upon request.

3 SWC-M20 – Standard Specifications

SWC-M20 (Standard Reference Configuration)

Nominal Bolt Size	M20
Rated Capacity (F_{nom})	200 kN
Measurement Range	2 ~ 200 kN
Accuracy (Non-linearity)	$\pm 1.0 \% F_{nom}$
Repeatability	$\leq \pm 0.5 \% F_{nom}$
Safe Overload	120 % F_{nom}
Ultimate Overload	> 150 % F_{nom}
Operating Temperature	-20 ~ +90 °C
Temperature Effect on Zero	$\leq \pm 0.02 \% F_{nom} / ^\circ\text{C}$
Temperature Effect on Span	$\leq \pm 0.02 \% F_{nom} / ^\circ\text{C}$
Ingress Protection	IP66
Sensing Element	Strain Gauge Full Bridge
Cable / Interface	5-Core Shielded Cable (Power + Signal)
Max. Cable Length	100 m / 328 ft
Weight (Approx.)	~ 130 g (without cable)



SWC delivers accurate clamp force measurement with adaptable anti-loosening interfaces for lifecycle monitoring of critical bolted joints.

ST – Signal Transmitter

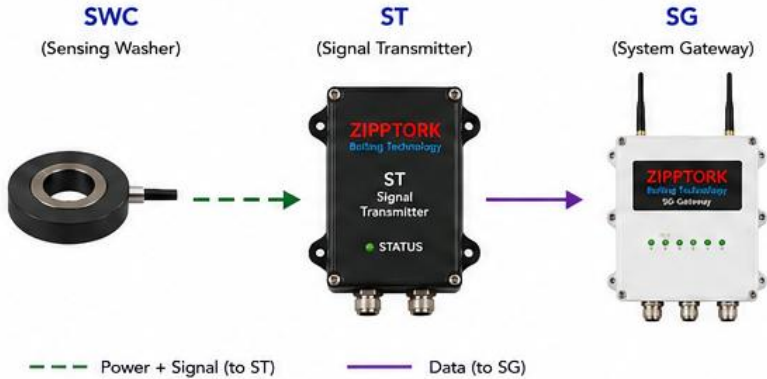
The ST (Signal Transmitter) receives signals from the Sensing Washer (SWC), amplifies and digitizes the data, powers the SWC, and transmits the measurement data to the System Gateway (SG).



1 Key Functions

- Receives signals from SWC
- Amplifies and digitizes data
- Provides stable excitation power to SWC
- Transmits data to SG
- Status indication
Front LED provides visual indication of power, communication and fault status.

System Connection



2 Communication Options



RS-485 (Wired)

- Standard wired connection
- Stable and reliable
- Typical distance up to 1,000 m
- Modbus RTU protocol



RF 2.4 GHz (Wireless)

- Flexible wireless communication
- Easy installation
- Typical distance up to 100 m
- Line of sight



LoRa LoRa* (Optional)

- Long-range communication
- Low power consumption
- Typical distance up to 100 m
- Ideal for extended coverage



Signal Processing

Amplifies and digitizes sensor signals.



Sensor Power

Provides stable and regulated power to SWC.



Data Transmission

Sends measurement data securely to SG.



Status Indication

Front LED provides visual indication of power, communication and fault status.

3 ST – Key Specifications

Item	Specification
Power Input	9 ~ 30 VDC
Power Consumption	≤ 1.0 W @ 24 VDC
SWC Power Output	5 VDC (Regulated)
Input Channel	1 Channel (from SWC)
Cable / Interface (to SWC)	5-Core Shielded Cable (Power + Signal)
Communication to SG	RS-485 (Wired) or RF 2.4G (Wireless) or LoRa (Optional)
Transmission Distance	Up to 1,000 m (RS-485) or up to 100 m (RF 2.4G) or up to 10 km (LoRa)
Support per SG	Up to 64 STs
Sampling Rate	Up to 100 Hz
Resolution	24-bit ADC
Operating Temperature	-20 ~ +90 °C (Special environments customizable)
Enclosure	IP67 (Industrial Grade)
Dimensions (L x W x H)	IP6 × 70 × 28 mm (3.78 × 2.76 × 1.10 in)
Weight (Approx.)	~ 250 g (with connectors)



Installation & Design

- Enclosed design for industrial installation
- Easy mounting with 4 holes
- Wide operating temperature range
- Secure connectors for reliable field performance



Accurate Measurement

High-fidelity signal acquisition for precise clamp force data.



Reliable Communication

Stable wired or wireless data transmission to SG.



Stable Sensor Power

Consistent and regulated power for SWC.



Easy Integration

Multiple communication options for flexible deployment.



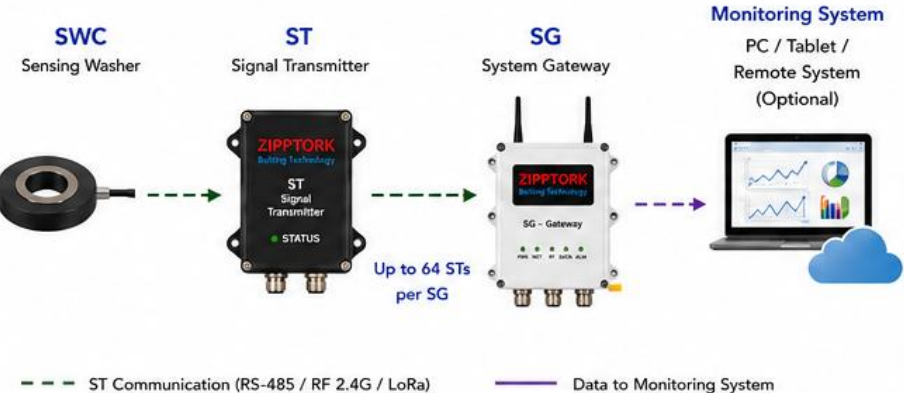
ST provides signal processing, sensor power, and data transmission — the communication link between SWC and SG.

SG – SYSTEM GATEWAY

The SG (System Gateway) collects measurement data from multiple STs, manages and stores the data, and communicates with monitoring software or external systems for analysis and traceability.



1 SYSTEM ROLE



3 SG – KEY SPECIFICATIONS

Item	Specification
Power Input	9 ~ 30 VDC
Power Consumption	≤ 5 W @ 24 VDC
ST Communication	RS-485 (Wired) RF 2.4 GHz (Wireless) LoRa (Optional)
Max. STs Supported	Up to 64 STs per SG
Monitoring Interfaces	LAN / Ethernet (Optional) Wi-Fi (Optional) Bluetooth (Local Access) Remote Connectivity (Optional)
Data Storage	Built-in memory for data storage and buffering
Time Synchronization	NTP / Manual
Operating Temperature	-20 ~ +90 °C (Special environments customizable)
Enclosure	IP66 (Industrial Grade)
Dimensions (L × W × H)	160 × 120 × 60 mm (6.30 × 4.72 × 2.36 in)
Weight (Approx.)	~ 700 g (with connectors)

2 KEY FEATURES

- Multi-Point Data Collection**
Collects measurement data from multiple STs. Supports up to 64 STs for large-scale monitoring.
- Data Storage & Buffering**
Built-in memory supports data storage and buffering to prevent data loss.
- System Communication**
Supports various wired and wireless communication interfaces.
- Monitoring Data Communication**
Transmits measurement data to software or external systems for analysis and traceability.
- Industrial Installation**
Enclosed design for industrial installation.

4 COMMUNICATION OPTIONS

ST → SG (Data Collection)	
	RS-485 (Wired) - Stable and reliable wired communication - Long distance up to 1,000 m (typ.) - Modbus RTU protocol
	RF 2.4 GHz (Wireless) - Flexible wireless communication - Easy installation - Typical range up to 100 m (line-of-sight)
	LoRa® (Optional) - Long-range wireless communication - Low power consumption - Typical range up to 10 km, depending on environment
SG → Monitoring System	
	LAN / Ethernet (Optional) High-speed data connection to local network and systems
	Wi-Fi (Optional) Wireless connection to monitoring software
	Bluetooth (Local Access) Easy local configuration and maintenance
	Remote Connectivity (Optional) Remote access and integration according to system needs

5 SYSTEM FUNCTIONS

- Data Management**
Collects, stores, and manages measurement data from multiple STs.
- Data Integrity**
Buffering and time synchronization help maintain data consistency and reliability.
- System Connectivity**
Connects to monitoring software or external systems for analysis and traceability.
- Status Indication**
Front LEDs provide visual indication of power, communication, data activity, and system status.

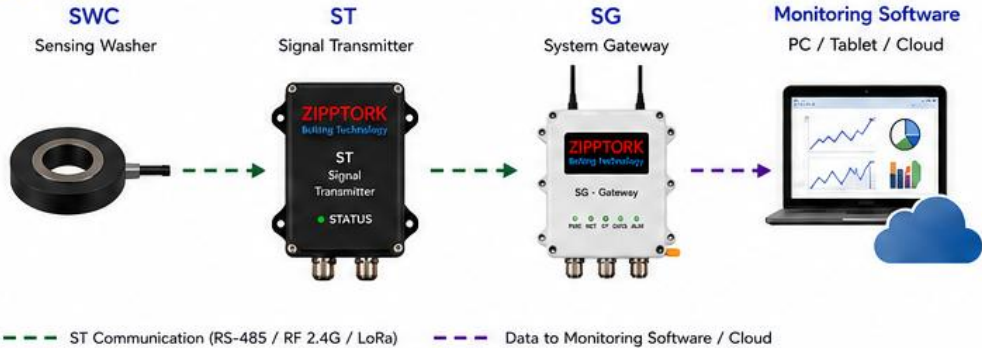


SG provides centralized data collection, communication, and system connectivity for multi-point bolt-load monitoring.

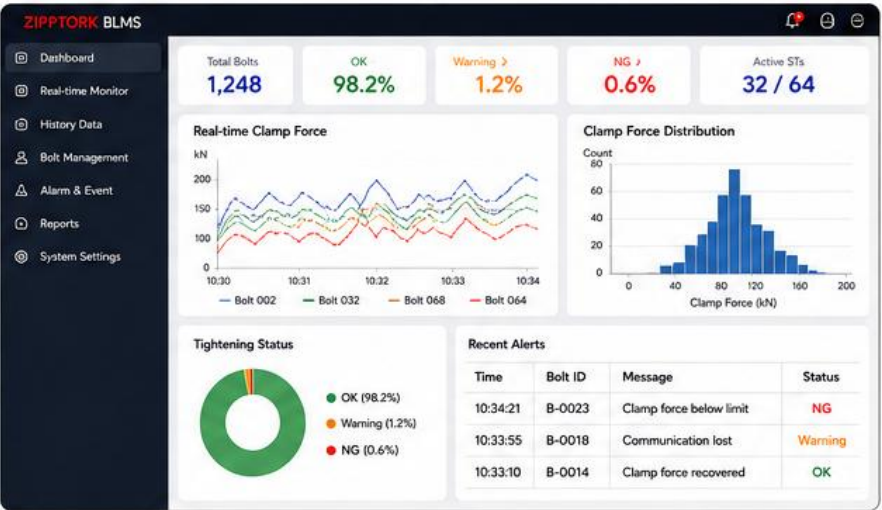
Monitoring Software & Data Management

The BLMS monitoring software provides real-time visibility, comprehensive data logging, and powerful analysis tools to ensure bolt load integrity and operational efficiency.

System Data Flow



Dashboard Overview



Software Capabilities

- Real-time Monitoring**
Live clamp force and tightening status from multiple bolts and STs.
- Data Logging & Storage**
Stores all measurement data securely with time stamp and bolt ID.
- Trend Analysis**
Powerful charts and graphs for clamp force trends and distribution.
- Alarm & Notification**
Configurable alarm limits with visual and audible notifications.
- Report Generation**
Custom reports for traceability and quality documentation.
- User & Access Management**
Role-based access control for data security.

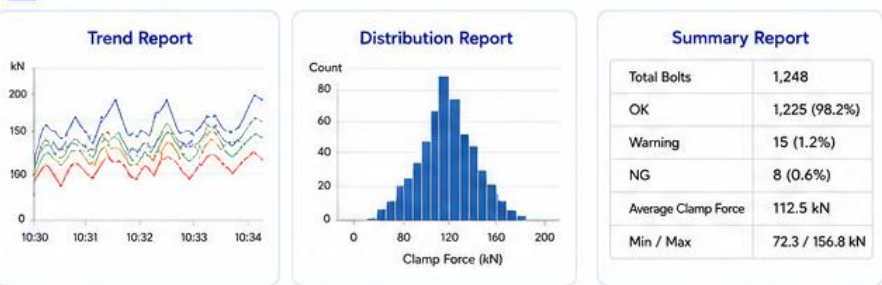
Key Data Recorded

- ✓ Bolt ID / Location
- ✓ ST / SG ID
- ✓ Operator ID
- ✓ Timestamp
- ✓ Clamp Force (Real-time)
- ✓ Tightening Status (OK / Warning / NG)
- ✓ Alarm & Event Log
- ✓ Environmental Data (Optional)

Supported Platforms

- Windows PC**
Full-featured desktop application
- Tablet**
Web-based interface for mobile monitoring
- Cloud**
Secure cloud storage and remote access

Data Analysis & Reports



Benefits

Ensure Bolt Integrity
Continuous monitoring ensures reliable bolt load performance.

Improve Productivity
Real-time visibility reduces rework and downtime.

Full Traceability
Complete data records for quality and compliance.

Prevent Failures
Early detection of issues prevents costly failures.

Data-Driven Decisions
Insightful analysis supports continuous improvement.

Scalable & Flexible
Supports small to large-scale industrial applications.



Powerful software. Reliable data. Smarter decisions. — BLMS empowers you to monitor, analyze, and optimize every critical joint.

BLMS Moves Beyond Anti-Loosening

BLMS transforms bolted joints from passive mechanical solutions to intelligent, data-driven assets with real-time visibility of actual clamp force throughout the entire lifecycle.

1 Conventional Anti-Loosening



✗ Prevents rotation but cannot verify remaining clamp load

2 Bolt Load Measurement



Measures actual clamp force accurately

3 Real-Time Monitoring



Continuously tracks clamp force, temperature, vibration, and alarms

4 Predictive Maintenance



Early warning & trend analysis to prevent potential failures

5 Smarter Decisions Higher Reliability



Ensure joint integrity with real-time data



Extend equipment life & reduce downtime



Data-driven maintenance & decision making



Supports IIoT / Industry 4.0 & digital transformation

From Traditional Methods to BLMS — What Changes?

Traditional Approach		With BLMS	
Periodic inspection Takes time, labor & downtime	✗ →	Continuous monitoring 24/7 real-time visibility	
Manual measurement Point-in-time, limited data	✗ →	Automatic data acquisition Accurate, consistent, traceable	
Reactive maintenance Problems found after failure	✗ →	Predictive maintenance Issues detected before failure	
Isolated information Hard to analyze & share	✗ →	Centralized data management Easy analysis, reporting & integration	



Typical Applications



Wind Turbines



Bridges & Structures



Heavy Equipment



Power Generation



Railway & Transit



Industrial Machinery



Reliable
Ensure joint integrity



Accurate
Measures actual clamp force



Connected
Supports IIoT & remote access



Efficient
Reduces downtime & maintenance cost



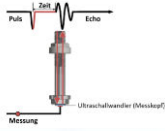
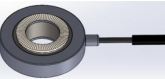
Sustainable
Extends asset life & improves safety



BLMS turns every bolted joint into a monitored, data-driven asset — ensuring safety, reliability, and operational excellence.

BLMS vs. Conventional Technologies

BLMS combines direct clamp-force measurement, adaptable anti-loosening functionality, and lifecycle monitoring in an integrated sensing-washer architecture.

Technology Category	Mechanical Anti-Loosening (e.g., Nord-Lock®)	Visual Preload Indicators (e.g., SmartBolts®)	Load-Indicating / Sensing Bolts (e.g., MaxBolt®)	Ultrasonic Measurement (Bolt Elongation)	Load / Sensing Washers (e.g., JPB / SCT / BoltSafe-type)	BLMS Sensing Washer System (BLMS)
						
 Primary Function	Resist self-loosening	Visual indication of preload status	Measure bolt preload via instrumented bolt	Estimate preload from bolt elongation	Measure clamp force at joint	Measure clamp force + monitor + anti-loosening in one system
 Direct Clamp-Force Measurement	✗ (No)	△ (Visual Only)	✓ (Yes)	△ (Indirect)	✓ (Yes)	✓ (Yes, Direct)
 Post-Installation Monitoring	✗ (No)	△ (Visual Check Required)	△ (Limited)*	△ (Periodic Measurement)	△ (Depends on Monitoring System)	✓ (Continuous Monitoring)
 Lifecycle Data / Trend Analysis	✗ (No)	✗ (No)	△ (Limited)*	△ (Limited)	△ (Depends on Monitoring System)	✓ (Full Data History)
 Anti-Loosening Function	✓ (Yes)	✗ (No)	✗ (No)	✗ (No)	✗ (No)	✓ (Integrated / Adaptable Anti-Loosening Interface)
 Installation / Measurement Method	Washer installation (addition or replacement)	Special bolt with visual indicator	Special instrumented bolt (replace bolt)	Access to bolt end / reference required	Washer installed in load path	Sensing washer installed in load path
 Key Limitation	Does not provide clamp-force data	No quantitative data, operator dependent	Requires special bolt, higher cost	Requires access & skill, affected by conditions	No inherent anti-loosening function, monitoring varies	Requires power & monitoring system

✓ = Yes / Available

△ = Limited / Depends

✗ = No / Not Available

* = Depends on monitoring system & configuration

What Differentiates BLMS



Direct Measurement
Measures actual clamp force directly in the load path.



Anti-Loosening Integration
Adaptable interface design provides anti-loosening functionality.



Lifecycle Monitoring
Continuous monitoring and full data history throughout the asset lifecycle.



Connected Architecture
Connected system enables data-driven maintenance and remote access.



BLMS integrates direct clamp-force sensing, adaptable anti-loosening interfaces, and connected lifecycle monitoring in a single system architecture — turning every bolted joint into a smarter, safer, and more reliable asset.

Where BLMS Creates Value — Why Clamp Force Changes Over Time

Even when a bolt remains in place, retained clamp force can change due to operating, environmental, and joint conditions. BLMS detects these changes early, so you can take action before they become problems.



Bolts Do Not Always Loosen

Clamp force can drop without any visible movement or loosening.



Many Conditions Cause Clamp-Force Loss

Multiple factors act over time and reduce joint reliability.



You Cannot See Clamp-Force Loss

Traditional methods cannot measure real clamp force during service.



Early Detection Supports Timely Action

Monitoring preload change can provide earlier indication of developing conditions.

5 Major Mechanisms That Reduce Clamp Force Over Time

1

Vibration & Dynamic Loading



Cyclic or dynamic loads can cause micro-slip, transverse movement, and gradual preload loss.

Typical Applications

- Wind turbine joints
- Rotating equipment
- Pumps / compressors
- Railway equipment

2

Thermal Cycling / Temperature Change



Differential thermal expansion and contraction can change bolt elongation and reduce retained preload.

Typical Applications

- Power generation equipment
- Heat exchangers
- Piping systems
- Bridges & structures

3

Embedment / Joint Settlement



Surface embedment and joint settlement reduce bolt elongation and clamp force.

Typical Applications

- Steel structures
- Base plates
- Concrete anchoring
- Machine foundations

4

Creep / Relaxation / Material Aging



Time-dependent deformation of materials can gradually reduce retained preload under sustained load.

Typical Applications

- High-temperature joints
- Pressure vessels
- Pipelines
- Long-term loaded structures

5

Corrosion / Joint Degradation



Corrosion or surface degradation changes contact conditions and can reduce retained preload.

Typical Applications

- Offshore structures
- Marine equipment
- Chemical plants
- Outdoor installations



WHY MONITORING MATTERS



Hidden / Inaccessible Joints

Many critical joints are located in areas that are difficult, hazardous, or costly to access.



Changes Between Inspections

Preload can change between scheduled inspections when no one is looking.



No Obvious Visual Indication

Clamp-force loss typically occurs without visible signs until it may be too late.



BLMS makes retained clamp force measurable as joint conditions change over time.

BLMS in Action — Priority Industrial Applications

BLMS is ideal for critical bolted joints where clamp-force integrity is essential for safety, uptime, and asset performance. Across industries, BLMS provides continuous or periodic preload visibility to support earlier detection and condition-based maintenance.

PRIORITY INDUSTRIES

1 Oil & Gas / Petrochemical	2 Wind Energy	3 Railway & Transportation	4 Bridges & Infrastructure	5 Mining & Heavy Equipment	6 Power Generation
					
 Critical Joints • Pipe & vessel flanges • Heat exchangers / reactors • Valve and process-equipment joints	 Critical Joints • Tower flange joints • Nacelle / drivetrain joints • Blade-root connections	 Critical Joints • Bogie and underframe bolted joints • Coupler / drivetrain connections • Critical structural fasteners	 Critical Joints • Bearing / support bolts • Expansion-joint assemblies • Cable anchorages • Structural connections	 Critical Joints • Frame / chassis connections • Boom and attachment joints • Gearbox / drivetrain joints	 Critical Joints • Turbine / generator bolting • Boiler / pressure-system flanges • Piping and valve connections
 Why Monitor • Leakage-sensitive joints • Thermal cycling and process vibration • Inspection access and uptime requirements	 Why Monitor • Cyclic and dynamic loading • Difficult / costly inspection access • Long-term preload retention	 Why Monitor • Dynamic loads and vibration • Safety-critical components • Service continuity and reliability	 Why Monitor • Dynamic loading and vibration • Settlement / structural movement • Difficult inspection access	 Why Monitor • Shock and high vibration • High cyclic loading • Severe operating environment	 Why Monitor • Thermal cycling • High consequence of unplanned outage • Long-term preload retention

HOW TO SELECT MONITORING POINTS

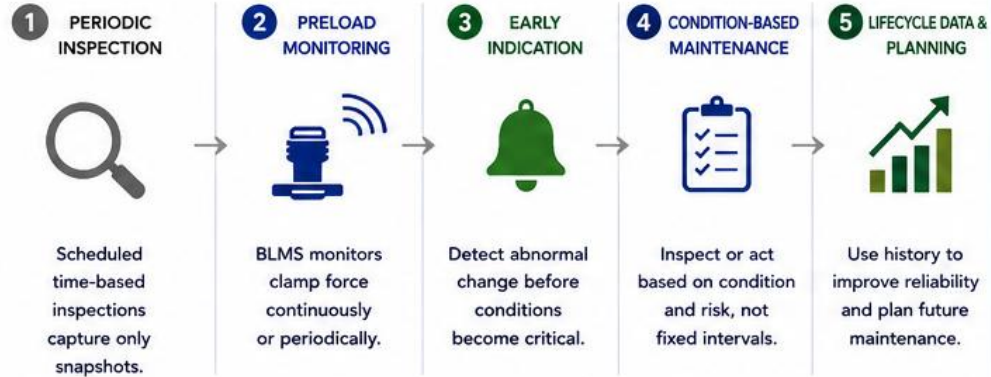
1 Identify Critical Joints  Focus on joints where failure consequences are high. • Safety • Uptime • Asset impact	2 Assess Operating Conditions  Consider vibration, temperature, cyclic loading, corrosion, and other factors that can reduce clamp force.	3 Evaluate Accessibility  Prioritize joints that are difficult, hazardous, or costly to inspect manually.	4 Implement BLMS Install SWC + ST and connect monitored points through the SG according to system configuration. 	5 Monitor & Act Use preload trends and alerts to support inspection, maintenance, and condition-based decisions. 	 Target the Right Joints. Monitor What Matters. Detect Change Early. Support Better Decisions.
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BLMS in Action — From Periodic Inspection to Condition-Based Maintenance

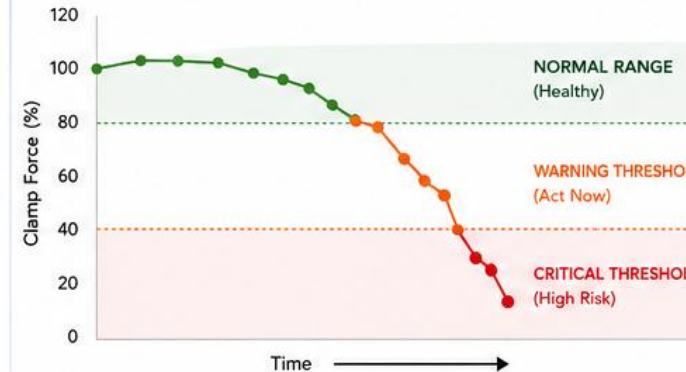
BLMS adds retained-preload visibility between inspections, supporting earlier detection and condition-based maintenance decisions throughout the asset lifecycle.

THE EVOLUTION OF BOLT JOINT ASSURANCE



From time-based to data-informed — enabling smarter maintenance and better outcomes.

ILLUSTRATIVE PRELOAD TREND



* Conceptual illustration. Thresholds are application-defined.



Detect trends, not just instant values.



Alert before clamp force reaches a critical level.



Support investigation before conditions become more severe.



Provide condition data for maintenance and engineering decisions.

WHAT BLMS DETECTS BEFORE IT BECOMES A PROBLEM



BLMS provides visibility into these changes between inspections — when they matter most.

DATA FOR DIFFERENT DECISIONS



Flexible integration with customer systems and tools.

Data access, frequency, and analysis are configurable based on project requirements.



BLMS turns preload history into actionable information for condition-based maintenance.
Monitor what matters. Detect change early. Support better decisions.

Bolt-Joint Risk Scenarios — Where Preload Visibility Matters

Loss of retained preload can contribute to leakage, joint movement, fatigue, misalignment, or other joint-integrity concerns.

BLMS provides clamp-force visibility to support earlier detection of changing joint conditions.



JOINT INTEGRITY

Preload loss can affect joint stability and sealing.



INSPECTION VISIBILITY

Changes may develop between scheduled inspections.



CONSEQUENCE AWARENESS

Critical joints may warrant closer condition monitoring.



BLMS adds clamp-force visibility to help you understand joint conditions earlier.

TYPICAL RISK SCENARIOS IN CRITICAL BOLTED JOINTS

1

PROCESS FLANGES

Oil & Gas / Petrochemical



RISK SCENARIO

Loss of flange preload may increase the potential for joint movement or sealing degradation.

CONTRIBUTING CONDITIONS

- Thermal cycling
- Vibration
- Creep / relaxation

BLMS VISIBILITY

- Monitor retained clamp force
- Identify abnormal change over time

2

POWER GENERATION

Turbine / Piping / Pressure-System Bolting



RISK SCENARIO

Preload reduction may affect sealing and joint stability, increasing outage risk.

CONTRIBUTING CONDITIONS

- Thermal cycling
- High temperature
- Creep / relaxation

BLMS VISIBILITY

- Track clamp-force trends
- Detect change before it impacts operation

3

RAILWAY

Bogie / Underframe / Drivetrain Connections



RISK SCENARIO

Preload loss in critical bolted connections may contribute to looseness or misalignment.

CONTRIBUTING CONDITIONS

- Vibration and shock
- Cyclic loading
- Joint settlement

BLMS VISIBILITY

- Monitor critical joints
- Provide trend data to support inspection planning

4

WIND ENERGY

Tower / Nacelle / Drivetrain Joints



RISK SCENARIO

Loss of preload at tower or drivetrain joints may affect structural and operational reliability.

CONTRIBUTING CONDITIONS

- Cyclic and dynamic loading
- Environmental effects
- Difficult access

BLMS VISIBILITY

- Continuous preload monitoring
- Early indication of change between inspections

5

BRIDGES & STRUCTURES

Bearing / Anchor / Structural Connections



RISK SCENARIO

Preload loss may influence structural performance and connection stability.

CONTRIBUTING CONDITIONS

- Vibration and wind loading
- Settlement / movement
- Corrosion

BLMS VISIBILITY

- Long-term trend visibility
- Support inspection and maintenance decisions

6

HEAVY EQUIPMENT

Frame / Boom / Drivetrain Connections



RISK SCENARIO

Preload reduction in structural or drivetrain joints may affect equipment availability.

CONTRIBUTING CONDITIONS

- Shock and high vibration
- Heavy cyclic loads
- Misalignment

BLMS VISIBILITY

- Detect clamp-force reduction
- Help prevent unplanned downtime

WHY PRELOAD VISIBILITY ADDS VALUE



VISUAL / PERIODIC INSPECTION

- Important for overall condition
- Provides snapshots in time
- May not reveal preload changes between inspections



BLMS PRELOAD VISIBILITY

- Measures actual clamp force
- Detects change between inspections
- Provides history, trends, and alerts

Together, they provide a more complete understanding of joint condition.

BLMS CAN PROVIDE



Direct clamp-force measurement



Continuous or periodic preload monitoring



Preload history and trend visibility



Application-defined threshold alerts



Data for inspection, maintenance, and engineering decisions



BLMS makes retained clamp force visible—providing measurable data as critical joint conditions change over time.

Visibility. Insight. Actionable Information.

BLMS: Where It Fits — Replacing, Complementing, and Integrating with Existing Technologies

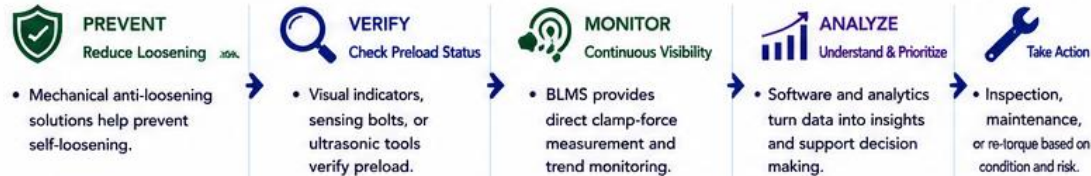
Multiple technologies address bolted-joint integrity from different perspectives.

BLMS (Sensing Washer System) adds direct clamp-force measurement and lifecycle monitoring to support earlier detection of changing joint conditions.

TECHNOLOGY LANDSCAPE FOR BOLT-JOINT INTEGRITY ASSURANCE

1 BLMS Sensing Washer System (REPLACE / COMPLEMENT)  Primary Function Direct clamp-force measurement in real time. Monitoring Mode Continuous or periodic, real-time data and trends. Typical Relationship to BLMS Core technology for direct clamp-force visibility and lifecycle monitoring. Best for: Continuous visibility and early detection of preload change.	2 Load / Sensing Washer Systems BoltSafe / JPB / SCT (ALTERNATIVE / COMPLEMENT)   Primary Function Measure or indicate bolt preload at a specific or discrete time. Monitoring Mode Snapshot or limited monitoring; varies by product. Typical Relationship to BLMS Alternative to BLMS for point-in-time verification; can complement BLMS for additional checkpoints. Best for: Periodic verification, high-value assets, or retrofit with limited monitoring needs.	3 Load-Indicating / Sensing Bolts MaxBolt / Strainert / RotaBolt (ALTERNATIVE / COMPLEMENT)   Primary Function Indicate or measure bolt load through the bolt body. Monitoring Mode Snapshot or limited monitoring; requires specialized fastener. Typical Relationship to BLMS Alternative for verification; can complement BLMS in critical joints where replacement is acceptable. Best for: Periodic verification in critical joints where replacement is acceptable.	4 Visual Preload Indicators DTI / SmartBolts (INSPECT / VERIFY)  Primary Function Provide visual indication of preload status. Monitoring Mode Visual check; detects gross changes only. Typical Relationship to BLMS Useful for quick field checks; complements BLMS by providing simple verification. Best for: Quick verification routine visual inspection.	5 Mechanical Anti-Loosening Nord-Lock / GaLock / RIPP LOCK (PREVENT / COMPLEMENT)   Primary Function Resist self-loosening due to vibration or dynamic loads. Monitoring Mode No preload measurement. Passive prevention. Typical Relationship to BLMS Prevention technology; can be used together with BLMS for monitoring retained preload. Best for: Preventing loosening; used in combination with BLMS.	6 Ultrasonic Bolt Measurement IHF / Ultrasonic Systems (VERIFY / INSPECT)   Primary Function Measure bolt elongation to estimate preload. Monitoring Mode Snapshot or on-demand measurement. Typical Relationship to BLMS Verification and troubleshooting tool; complements BLMS. Best for: Inspection, verification, and troubleshooting.
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HOW THESE TECHNOLOGIES CAN WORK TOGETHER



These technologies may be used independently or together according to joint design, operating conditions, inspection strategy, and monitoring requirements.

INTEGRATION LAYER (OPTIONAL)



Monitoring & Data Platforms
Customer Systems / IIoT / MES / SCADA

- BLMS data can be integrated with plant or enterprise systems.
- Data access, frequency, and analytics are configurable.
- Integration supports dashboards, alerts, reporting, and analytics.



BLMS complements existing bolted-joint technologies by adding direct clamp-force visibility and lifecycle monitoring.
The appropriate combination depends on application needs, joint criticality, and maintenance strategy.

BLMS: Real-World Impact Across Critical Industries

Loss of bolt preload is a leading cause of equipment failure, leakage, and unplanned downtime.

BLMS provides continuous visibility of clamp force — helping prevent incidents and protecting people, assets, and the environment.

WHERE BOLT LOAD LOSS CREATES REAL RISKS

 Petrochemical & Oil / Gas	 Power Generation (Nuclear / Thermal)	 Railway	 Wind Energy	 Bridges & Infrastructure	 Mining & Heavy Equipment
 - High temperature & vibration - Process cycling - Flange leakage & fugitive emissions - Strict safety & environmental regulations Real Case (Example) Flange joint failure in a natural gas pipeline facility caused ~20,000 m³ of gas leakage and temporary shutdown. (CSB Case No. 2017-031-I, Canada)	 - Thermal expansion & vibration - Fatigue & stress relaxation - Bolting degradation / failures are common Real Case (Example) NRC reports numerous bolting degradation / failure events in U.S. nuclear plants over the past decades. (NRC Generic Issue 29, 2020)	 - Severe vibration & dynamic loads - Track components rely on critical bolted joints - Safety-critical, zero tolerance Real Case (Example) Loose bolts in track fastenings can cause gauge widening, component damage, and derailment risk. (ERA RINF Safety Guidance)	 - Cyclic loads & vibration - Blade root bolts critical for rotor integrity - Failure can lead to catastrophic blade separation Real Case (Example) Investigations show blade root bolts fatigue and preload loss can lead to blade failure and major damage. (DNV GL Failure Investigation)	 - Traffic loads, vibration, temperature - High consequence of bolt loss - Long life-cycle, difficult inspection Real Case (Example) Loosening or corrosion of structural bolts has contributed to section loss and safety hazards in bridge structures. (NTSB / FHWA Reports)	 - Heavy vibration & shock loads - Joint looseness leads to failure and high maintenance cost - Downtime is extremely costly Real Case (Example) Undetected bolt loosening caused by vibration led to equipment failure and structural failures in mining equipment. (Industry Field Reports)

Why Continuous Clamp Force Visibility Matters

- ✓ Detect preload loss early
- ✓ Prevent leakage and failures
- ✓ Reduce unplanned downtime
- ✓ Extend asset life
- ✓ Improve safety & compliance
- ✓ Lower total cost of ownership
- ✓ Enable predictive maintenance

 BLMS turns every critical bolted joint into a monitored asset — from assembly to daily operation.

BLMS DELIVERS VALUE THROUGHOUT THE ASSET LIFECYCLE



TYPICAL APPLICATIONS OF BLMS



PARTNERSHIP & MARKET DEVELOPMENT OPPORTUNITIES

Sensing Technology Partners Integrate BLMS washer technology into your monitoring solutions to offer continuous clamp force visibility. JPB SYSTEMS  SCT  BOLTSAFE Joint solutions for industrial monitoring, digital bolting, and IIoT.	Anti-Vibration Washer Partners Combine anti-loosening performance with real-time preload monitoring. NORD-LOCK GROUP  Böllhoff RIPP LOCK  GaLLock Gallerrated Locking Value-added solutions that prevent and detect loosening.	Ultrasonic & Bolting Service Partners Transition customers from periodic inspection to continuous monitoring.  IHF  THF FASTENER SYSTEMS Measuring Technology Fastener Systems Offer BLMS as the next generation of bolting assurance.
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BUSINESS BENEFITS WITH BLMS

-  **Maximize Safety**
Prevent failures, leaks, and accidents
-  **Increase Reliability**
Ensure joint integrity under all conditions
-  **Reduce Costs**
Lower maintenance, inspection and downtime
-  **Regulatory Compliance**
Meet safety and environmental requirements
-  **Sustainability**
Reduce emissions, waste and energy loss

BLMS: BUILT FOR THE FUTURE



BLMS is the smart choice for industries that cannot afford uncertainty in bolt integrity.

BLMS: Partnership & Market Development Strategy

Partner with established bolting technologies and channels to accelerate adoption in critical applications.

1 SENSING TECHNOLOGY PARTNERS

Leverage proven sensing solutions and channels with BLMS monitoring.



Load / Sensing Washer Systems



Potential Collaboration

Combine established sensing washer solutions and market channels with BLMS lifecycle-monitoring capabilities.

Load-Indicating / Sensing Bolts



Potential Collaboration

Extend preload-verification solutions with continuous or periodic monitoring for selected critical joints.

2 COMPLEMENTARY BOLTING TECHNOLOGY PARTNERS

Combine strengths to deliver more complete bolted-joint solutions.

Visual Preload Indicators



Potential Collaboration

Add electronic preload monitoring where visual or periodic verification alone does not meet application requirements.

Mechanical Anti-Loosening



Potential Collaboration

Combine anti-loosening expertise with direct clamp-force visibility and monitoring.

3 ULTRASONIC & BOLTING SERVICE PARTNERS

Complement periodic verification with installed monitoring for critical joints.



Potential Collaboration

- Complement periodic or on-demand ultrasonic verification with installed preload monitoring.
- Combine bolting service expertise with electronic monitoring for higher reliability.
- Transition from periodic inspection to continuous visibility where appropriate.

4 SYSTEM INTEGRATION & DATA PARTNERS

Integrate BLMS data into customer systems for actionable intelligence.



Plant Systems
MES / MOM / SCADA / DCS



Maintenance Systems
CMMS / EAM



Monitoring & Analytics Platforms
Dashboards / Trend Analysis / Reporting



System Integrators
Project-specific connectivity and integration

Potential Collaboration

BLMS data interfaces and integration functions can be configured according to project requirements.

WHY THESE PARTNERSHIPS MATTER



Leverage Established Markets
Access proven channels, technologies, and applications to accelerate market entry.



Expand Solution Capability
Combine complementary technologies to address more application needs.



Create New Application Opportunities
Provide preload visibility in applications where current solutions are limited.



Support Customer-Specific Integration
Configure hardware, communication, and software according to project needs.



BLMS adds measurable clamp-force visibility and connected monitoring to selected critical bolted joints.

HOW WE CREATE VALUE TOGETHER



IDENTIFY APPLICATIONS

Identify critical joint opportunities and target industries.



JOINT CUSTOMER ENGAGEMENT

Share application needs, requirements, and success goals.



SOLUTION CONFIGURATION

Configure BLMS and partner technologies for the application.



PILOT & VALIDATION

Verify performance in-field and prove value together.



DEPLOYMENT & SUPPORT

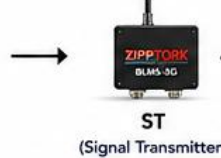
Implementation, training, and ongoing technical support.

BLMS INTEGRATION ARCHITECTURE

BLMS HARDWARE CHAIN



SWC
(Sensing Washer)



ST
(Signal Transmitter)
(S-core cable)

SG (Smart Gateway)



RS-485
RF 2.4 GHz
LAN
(Other Interfaces
Optional)

CUSTOMER MONITORING & DATA SYSTEMS



MES / SCADA / CMMS / Cloud Platforms
Dashboards & Analytics

DATA & INSIGHTS

- ✓ Real-time clamp-force monitoring
- ✓ Trend analysis & early warning
- ✓ Alarm notification & event log
- ✓ Historical data & traceability
- ✓ Data for condition-based / predictive maintenance
- ✓ Improved safety & reliability



Leverage Existing Markets. Combine Complementary Technologies. Build Bolt-Load Visibility Together.

Contact ZIPPTORK to explore partnership opportunities and application-specific BLMS solutions.

ZIPPTORK
SMART BOLTING SOLUTIONS

BLMS — From Tightening to Lifecycle Joint Visibility

Make bolt preload visible. Keep it visible. Use the data to protect what matters.



MEASURE

Directly measure actual clamp force at the joint.



MONITOR

Track retained preload continuously or periodically.



DETECT

Identify abnormal preload changes and application-defined threshold conditions.



CONNECT

Record, analyze, and integrate bolt-load data according to application requirements.



SWC
Sensing Washer



ST
Signal Transmitter



SG
Smart Gateway



MONITORING SOFTWARE
Visualization • Analytics • Alerts • Integration

- Real-time Monitoring
- Trend Analysis
- Alarm & Notification
- Data Logging
- System Integration

DESIGNED FOR SELECTED CRITICAL JOINTS



SAFETY-CRITICAL
Protect people and the environment



UPTIME-CRITICAL
Prevent unplanned downtime



QUALITY-CRITICAL
Maintain process and product integrity



DIFFICULT-TO-INSPECT
Remote, hidden, or hard-to-reach joints



**BLMS makes bolt preload measurable throughout the joint lifecycle—
from installation to long-term condition monitoring.**



Data you can trust



Designed to integrate



Built for reliability

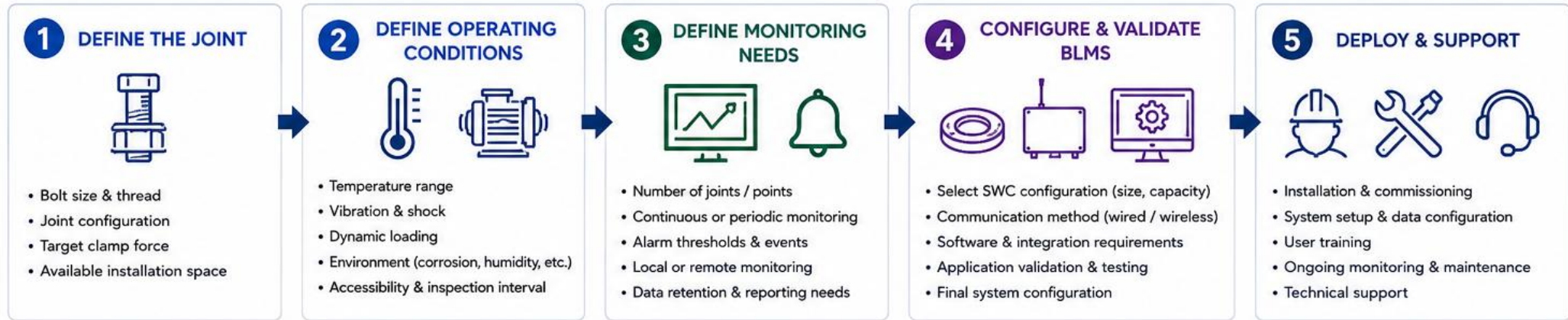


Insight you can act on

Measurable. Connected.
Built for real-world reliability.

Starting a BLMS Application — From Joint Requirements to Deployment

A practical process to configure and deploy BLMS for your critical bolted joints.



WHAT TO PROVIDE ZIPPTORK

BOLT SIZE	TARGET CLAMP FORCE	JOINT DRAWING / PHOTO	OPERATING ENVIRONMENT	NUMBER OF POINTS	MONITORING / COMMUNICATION REQUIREMENTS
					
Thread size, material & grade (e.g., M20, M24, etc.)	Target clamp force or preload requirement	Joint configuration, critical location, or photos	Temperature, vibration, corrosion, chemicals, outdoor/indoor, etc.	Number of joints or monitoring points required	Monitoring method, alarm, reporting, local/remote, integration needs



CONFIGURABLE & FLEXIBLE

- ✓ SWC standard reference: M20. Other sizes & capacities available on request.
- ✓ Communication options: wired (RS-485), Bluetooth, RF 2.4GHz.
- ✓ Remote monitoring and long-range solutions available.
- ✓ Software integration via Modbus RTU / TCP, OPC UA, MQTT and other interfaces.
- ✓ Local or cloud-based data management.
- ✓ Scalable from a few joints to hundreds of monitoring points.



BLMS is configured around the application—not the other way around.
We work with you to deliver the right solution for your critical joints and operational goals.

READY TO GET STARTED?

✉ Contact ZIPPTORK today to discuss your application.

Let's Make Critical Bolt Preload Visible

ZIPPTORK works with customers and partners to configure BLMS around the joint, operating environment, monitoring objective, and system requirements.



DISCUSS YOUR APPLICATION

Tell us about:



Bolt size & joint configuration



Target clamp force



Operating conditions



Number of monitoring points



Monitoring & communication requirements



CONFIGURE THE SOLUTION

ZIPPTORK can support:



SWC configuration



ST / SG communication architecture



Local or remote monitoring



Application-specific software & integration



Pilot and validation support



WORK WITH ZIPPTORK

Let's build success together:



Customer Projects

Industrial facilities, infrastructure, energy, and more.



OEM / ODM Cooperation

Customized solutions and co-development.



Technology Partnerships

Innovate and integrate for greater value.



Distribution & System Integration

Global network, local support, shared growth.



SWC

Sensing Washer



ST

Signal Transmitter



SG

Smart Gateway



Monitoring Software

Analytics • Alerts • Integration



From tightening to long-term monitoring,
BLMS makes retained bolt preload measurable throughout the joint lifecycle.

Application-specific. Configurable. Connected.

ZIPPTORK
SMART BOLTING SOLUTIONS



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Learn more about BLMS
and our smart bolting
solutions.

Scan the QR code
or visit our website.

We're ready to help.



Contact ZIPPTORK today
to discuss your application.