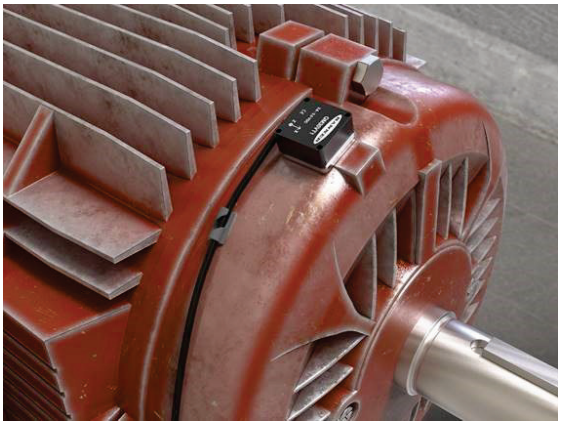
Vibration Monitoring Application Guide v2.0

Background

Industrial facilities have hundreds of critical rotating assets, such as motors, pumps, gearboxes, and compressors. Unexpected failures result in costly down-time. An equipment health monitoring (EHM) preventative maintenance solution uses machine learning to identify when assets exceed pre-defined parameters.



Value

- Increased Uptime – Eliminate unplanned shut-downs by continuously monitoring up to 40 assets with a single system
- Reduced Maintenance Cost – Repair prior to failure or extensive collateral damage
- Effective Maintenance/Parts Scheduling – Spare parts and labor planning
- Ease of Use – Reduce installation costs and eliminate complexity of traditional data analysis
- Improved Asset Selection – Use data to assist in root cause and reliability analysis
- IIoT – Real-time alerts for better decision making and remote asset management

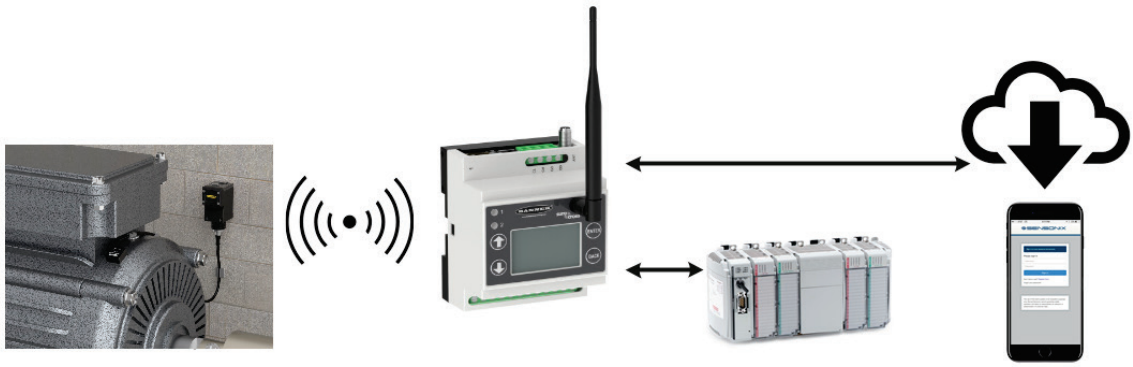
Banner Solution

Monitors for changes in vibration of rotating assets that are the result of:

- Imbalanced/misaligned components
- Loose or worn components
- Improperly driven or mounted components
- Over-temperature condition
- Early bearing failure

How Banner Solves

- Banner's Wireless vibration/temperature sensor continually monitors RMS velocity (10-1000 Hz), RMS high frequency acceleration (1000-4000 Hz), and temperature on rotating equipment, but uses vibration data only when the asset is operational.
- DXM Controller uses machine learning algorithm to baseline values and set control limits for alerts with limited end-user interaction. Creates a "check engine light" for each motor!
- DXM Controller collects data for trending and analysis. Script defines acute verses chronic issues.
- Data and alerts can be sent to the host control or to the cloud for IIoT connectivity.



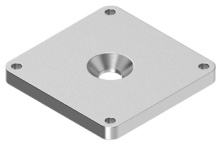
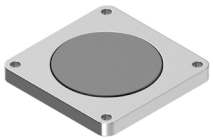
Guide Features and Benefits

CONTINUOUS VIBRATION MONITORING	Monitor vibration data on up to 40 assets sensing X and Z axis RMS velocity and high frequency RMS acceleration. RMS velocity is indicative of general rotating machine health (unbalance, misalignment, looseness) and high frequency RMS acceleration is indicative of early bearing wear.
SELF-LEARNING BASELINE & THRESHOLDS	Prevent users from having to generate baselines or alarms by using machine learning algorithms to create an initial baseline reading and warning/alarm thresholds for each motor individually.
ACUTE & CHRONIC ALARMS	“Check engine light” alarms and warnings are generated for both acute and chronic conditions for each motor. Acute thresholds indicate a short-term condition, such as a motor jam or stall that crosses the threshold rapidly. Chronic thresholds use a multi-hour moving average of the vibration signals to indicate a long-term condition, such as a wearing/failing bearing or motor.
TEMPERATURE ALARMS	Each vibration sensor will also monitor temperature and indicate an alarm when the threshold is exceeded.
SMS TEXT/EMAIL ALERTS	Generate SMS text and/or email alerts based on individual warnings and/or alarms.
CLOUD MONITORING	Push data to Cloud Webserver or PLC (via LAN or Cellular connection) for remote viewing, alerting, logging.

Solution Components

Model	Description
QM30VT1 or DX80N9Q45VA or DX80N2Q45VA	Sure Cross® Vibration and Temperature Sensor or All-in-one Vibration Sensor with Radio Node
DX80N9Q45U or Q45VTP DX80N2Q45U or Q45VTP P6 or P6L Performance Radios	Sure Cross® Wireless Q45 Sensor Node Universal 1-Wire Serial or Q45VTP or P6 or P6L Nodes; select either 900 MHz or 2.4 GHz ISM radio to match the DXM100
DXM700-B1R1 or DXM700-B1R3	DXM700 or newer Wireless Controller; select either 900 MHz or 2.4 GHz ISM radio to match the Q45s

The following mounting options are listed from least effective to most effective. In all mounting options, care must be taken to ensure there is no sensor movement as this could lead to inaccurate information or changes in from the time-trended data.

Mounting Options	Bracket	Application Description
BWA-BK-022 Center Mount Bracket and Thermal Conductive Adhesive Tape (included with QM30VT1 sensor)		Center mount bracket for direct screw or epoxy mounting to allow for sensor removal. Thermal tape for single use flexible mounting option but can introduce flex that reduces accuracy. Recommend epoxy designed for accelerometer mounting: Loctite Depend 330 and 7388 activator.
BWA-BK-013 Flat magnet sensor bracket		Highly flexible and re-usable, flat magnetic mount for larger diameter surfaces or flat surface
BWA-BK-019 Center mounting bracket with curved surface magnet attached to sensor bracket		Curved surface magnet mounts are best suited to smaller curved surfaces. Attention should be made to orient in the correct direction for the strongest mount. Offers flexibility for future sensor placement.

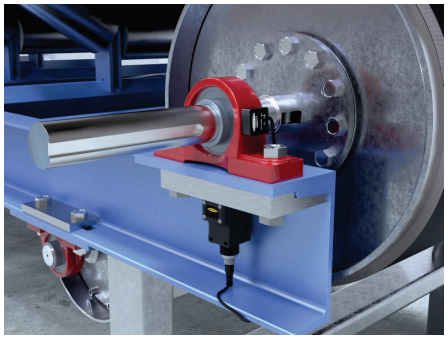
The following guide demonstrates how to load a preconfigured XML file and script to the DXM700 or newer models for up to 40 Vibration Sensor Nodes. The XML file only requires some minor modifications to be customized for any site. Follow binding and site survey instructions on the datasheet of your specific Node.

Step 1: Install the Sensor

Mounting and installing the vibration sensors on a motor are important for getting the most accurate readings. Sensors can be mounted using magnetic brackets, thermal transfer dual-sided tape, standard brackets epoxied directly to the motor, or standard brackets bolted directly to the motor.

The vibration sensors have an X and Z axis indication on the face of the sensor. The Z axis goes in a plane through the sensor while the X goes horizontally.

1. Install the sensor so that the X axis line in aligned with the motor shaft of the motor, or axially.
2. Install the sensor's Z axis into/through the motor. These can be swapped where the X axis is going into/through the motor and the Z axis is in line with the shaft of the motor if you are placing the sensing vertically for easier installation.
3. Install the sensor as close to the bearing of the motor as possible. Using a cover shroud or location far from the bearing may result in reduced accuracy or a reduced ability to detect certain vibration characteristics.



Step 2: Configure the System

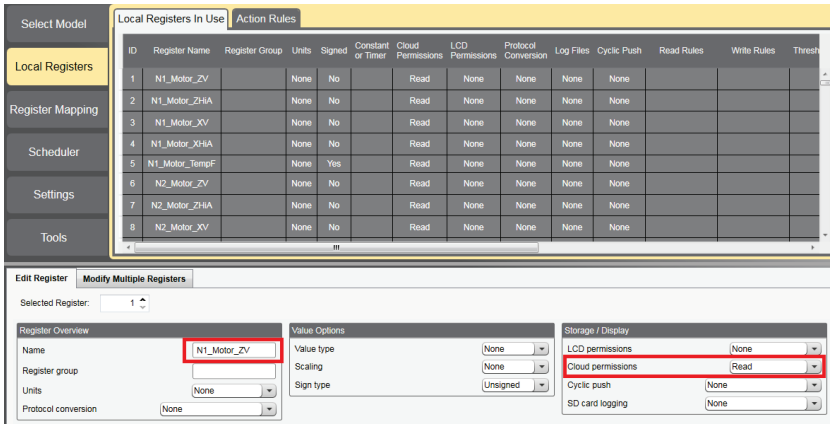
To customize the system to an actual application, make some basic modifications to the template files. There are two files uploaded to the DXM700 or newer models: the XML file sets the DXM's initial configuration and the ScriptBasic file reads vibration data, performs the machine learning, sets the thresholds for warnings and alarms, and organizes the information in logical and easy to find registers in the DXM.

Loading these files and making adjustments requires using Banner's DXM Configuration Software and the Vibration Monitoring files available from in the links below.

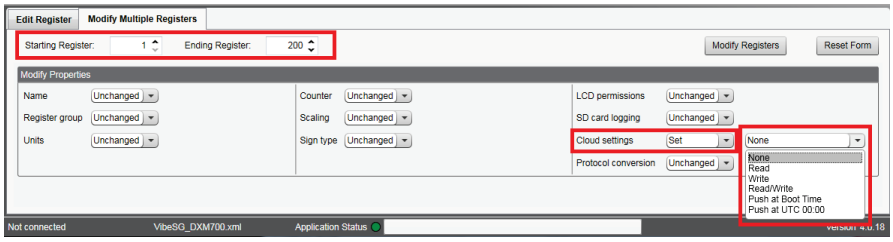
1. Install the Sensor Node pairs after the Nodes are bound to the master radio and a site survey performed. The files automatically begin baselining after they are loaded to the DXM. Avoid any unrelated vibrations from sensor installation.
2. Download the preconfigured files.
3. Extract the ZIP files into a folder on your computer. Note the location where the files were saved.
4. Connect the DXM, via the USB cable supplied with the DXM, to a computer containing the DXM Configuration Software v4 or download the software and install it on a computer.
5. Launch the software and select the DXM700 or newer model.
6. Open the Vibration Monitoring XML file by going to the **File** > **Open** menu and choosing the configuration files.
7. Connect the software to the DXM by going to the **Device** > **Connection Settings** menu. Select **Serial** and then select the COM port that the USB cable is plugged into. Click Connect. If unsure which COM port and multiple appear, attempt to connect to each one of them until successful.
8. Upload the Vibration Monitoring script file (.sb) by going to the **Settings** > **Scripting** tab. Click **Upload file** and select the script file.
9. Save the XML file any time the XML has been changed because the tool DOES NOT autosave.

Optional Steps: Customize the XML file

1. Within the DXM Software, go to the **Local Registers > Local Registers in Use** screen.
2. **Rename the Motors** by clicking on the register and using the text boxes within the **Register Overview Box** on the lower half of the screen. Because there are 5 registers per motor being monitored, copy and paste names for efficiency. To display the motor vibration data, warnings and alarms on the website, change the **Cloud Settings** to **Read** for each motor' information piece (velocity, acceleration, alert mask, etc.) that you would like to appear on the Banner Cloud Data Service (CDS) website. All recommended registers to send to the cloud are preselected to **Read.**



3. To change multiple Node's motor vibration data on the website, change the **Cloud Settings**.
   a. On the **Modify Multiple Registers** screen (lower half), select **Set** in the drop-down list next to **Cloud Settings**.
   b. Set the **Starting Register** to 1 and the **Ending Register** to the value equal to 5 × Number of motors in the system (for example, set the ending register 80 for only using 16 motors).
   c. In the drop-down list to the right, select **Read** for **Cloud Permissions**. This will push those registers every 5 minutes. (RECOMMENDED for Raw Data registers and alarm masks registers 1-240)
   d. Set to **Write** or **Read/Write** to be able to update the register value from the Banner CDS website. (RECOMMENDED for Re-baselining registers 321-360)
   e. Set to **Push UTC 00:00** to only have those registers push once a day (RECOMMENDED for Baseline, Warning and Alarm Registers 5181-5660)
   f. Click **Modify Registers** on the bottom right of the section.



NOTE: If you are using fewer than 40 Nodes, change the Cloud Settings to NONE for registers that aren't being used in the ranges listed in the previous steps to avoid sending unnecessary data.

4. Warnings and alarms within the system are contained within a register for each Nodes in local registers 201-240. The registers are labeled "NXX VibMask" where XX is the Node number. The number displayed is a decimal form of a 18-bit binary number with a value of 0 or 1 to accommodate up to 18 warnings or alarms for each Node.

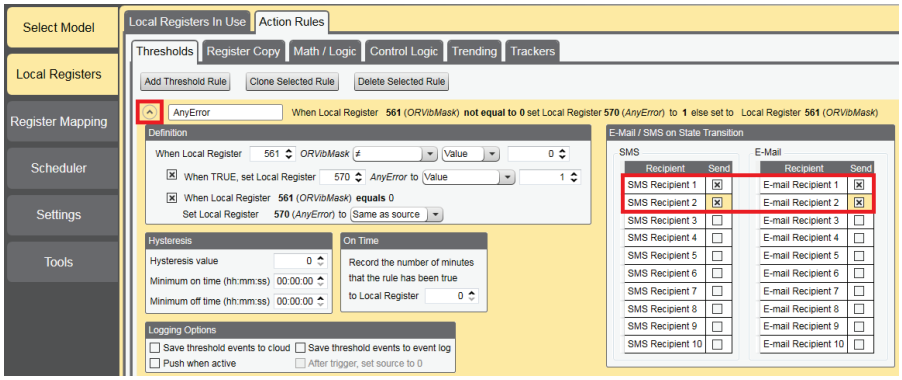
The 18-bit binary masks are broken out as follows:

Bit0 – Warning – X-Axis – Acute Velocity	= (0/1) * 2^0
Bit1 – Warning – X-Axis – Acute Acceleration (Hi Freq)	= (0/1) * 2^1
Bit2 – Warning – Z-Axis – Acute Velocity	= (0/1) * 2^2
Bit3 – Warning – Z-Axis – Acute Acceleration (Hi Freq)	= (0/1) * 2^3
Bit4 – Alarm – X-Axis – Acute Velocity	= (0/1) * 2^4
Bit5 – Alarm – X-Axis – Acute Acceleration (Hi Freq)	= (0/1) * 2^5
Bit6 – Alarm – Z-Axis – Acute Velocity	= (0/1) * 2^6
Bit7 – Alarm – Z-Axis – Acute Acceleration (Hi Freq)	= (0/1) * 2^7
Bit8 – Warning – X-Axis – Chronic Velocity	= (0/1) * 2^8
Bit9 – Warning – X-Axis – Chronic Acceleration (Hi Freq)	= (0/1) * 2^9
Bit10 – Warning – Z-Axis – Chronic Velocity	= (0/1) * 2^10
Bit11 – Warning – Z-Axis – Chronic Acceleration (Hi Freq)	= (0/1) * 2^11
Bit12 – Alarm – X-Axis – Chronic Velocity	= (0/1) * 2^12
Bit13 – Alarm – X-Axis – Chronic Acceleration (Hi Freq)	= (0/1) * 2^13
Bit14 – Alarm – Z-Axis – Chronic Velocity	= (0/1) * 2^14

Bit15 – Alarm – Z-Axis – Chronic Acceleration (Hi Freq)	= (0/1) * 2^15
Bit16 – Warning Temperature (> 158°F or 70°C)	= (0/1) * 2^16
Bit17 – Alarm Temperature (> 176°F or 80°C)	= (0/1) * 2^17

The decimal version is the sum of the calculations shown in the right column for each Node's mask register. Note that any value greater than zero in registers 201-240 indicates a warning or alarms for that particular Node. To know the exact warning or alarm, the decimal value will need to be backed out to a binary value, which is done on the Banner CDS cloud site using the automated dashboard icons or can be done with a PLC or HMI. Multiple warnings and alarms may trigger on an event depending on severity.

5. Configure to Receive Email or Text Alerts based on an Action Rule. An example action rule is when the warning/alarm masks in registers 201-240 are greater than zero, trigger an email or text message. There are six threshold rules that are already configured that trigger on Any Error, Any Acute Warning or Alarm, Any Chronic Warning or Alarm, or Any Radio Connection Error. The steps below can be used for any action rule.

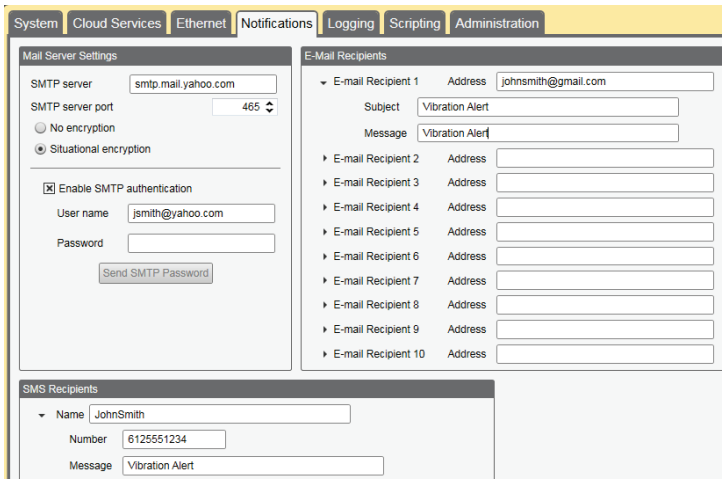


   a. Click on the **Action Rules** tab and expand any rule using the arrow next to the rule OR create a new action rule using the **Add Threshold Rule** button on the top.
   b. Click on the arrow next to **Email/SMS on State Transition**.
   c. Select the recipient of the SMS and/or email upon the action rule becoming true.

In the example shown, both SMS Recipient 1 and 2 and Email Recipient 1 and 2 receive a message when the action rule meets its criteria.

Set up the Ethernet or Cellular Connection

By default, the XML file configures the DXM700 with an Ethernet Push interface with the ability to send emails and push the data registers to a webserver. The device can also be configured to use a cellular push if the DXM Controller contains a cellular module and data plan. This section is only necessary if the user wants to receive or display information beyond just the DXM Controller's LCD.



1. If the DXM will text, email, or push to the cloud webserver, set up the push interface.
   a) On the DXM Configuration Tool, go to the **Settings > Cloud Services** screen.
   b) Select the appropriate **Push Interface** (Ethernet or Cell) from the drop-down list. Selecting Cell requires a cellular module be installed in the DXM Controller and a wireless plan be set up for sending data.

2. The **Cloud Push Interval** is set to None for XML because the script associated with this file establishes the five minute push interval internally, so it occurs immediately after the sample of the Nodes. To enable the Script to push, register 844 must be have the Value Type set to Constant and the value of 1 on the **Local Register in Use** screen.
3. To send emails or text messages, go to the **Settings > Notifications** screen and enter in the addresses and/or phone numbers in the recipient boxes.
   a) To send emails, fill out all SMTP fields for the mail server delivering the email messages.
   b) Passwords are not stored in the XML and must be send via the Send SMTP Password button when the DXM software is connected to the DXM.

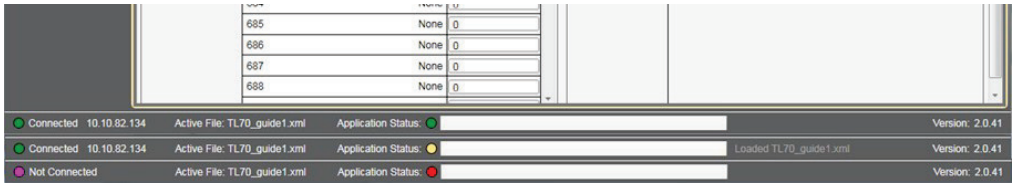
Step 5: Save and Load the XML File to DXM

When changes are made to the XML file, save the changes. To apply the changes, load the XML file to the DXM.

1. **Save** the file by going to the **File > Save** menu.
2. **Load** the file onto the DXM by going to the **Device > Send XML Configuration to DXM** menu.

Because of the size of the XML file, the file may take up to three minutes to load. Verify the file is loading by looking at the Application Status indicator in the status bar.

If the Application Status indicator is **RED**, close and restart the DXM Configuration Software, unplug and re-plug in the USB cable and reconnect the DXM to the software. If the Application Status indicator is **GREEN**, the file upload is complete. If the Application Status indicator is **YELLOW**, the file transfer is in progress.

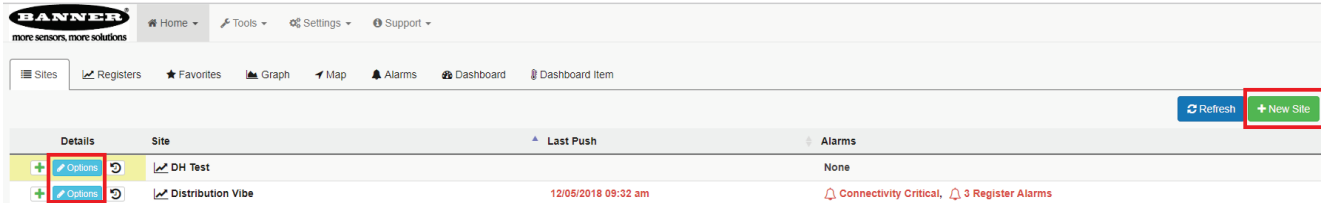


Step 6: Push Information to the Cloud

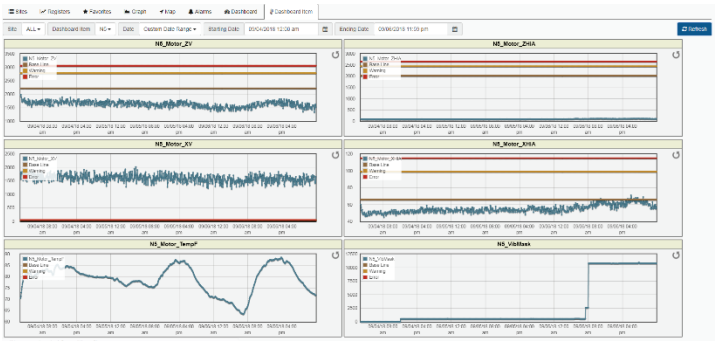
The DXM700 can connect to the web via Ethernet or an internal cell module to push data from the site to the cloud and display the data on a website. To enable this capability for remote monitoring and alarms settings, modify the XML file.

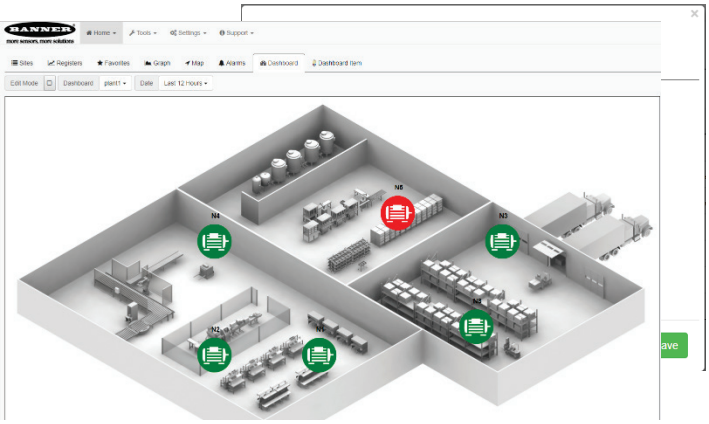
The Banner Cloud Data Services (Banner CDS) website can be used for storing, monitoring, and visualizing the system's data at https://bannercds.com/.

1. Connect the DXM to a computer with the DXM Configuration Software.
2. Launch the software and connect to the DXM.
3. Open the saved XML file (**File>Open**).
4. Go to the **Settings > Cloud Services** screen.
5. Visit the Banner CDS website (https://bannercds.com/) and log into an existing account or register a new account.
6. Click **+ New Site**, select the company where the site will reside and name your site.
7. Highlight and copy the Site ID and click **Save**.
8. On the DXM Configuration Software: Return to the **Settings > Cloud Services** screen and verify the server name is push.bannercds.com.
9. Paste the copied ID into the **Site ID** field.
10. Save the XML file (**File > Save**).
11. Upload the file to the DXM (**Device > Send XML Configuration to DXM**).



12. On the Banner CDS website, click **Options** next to the newly created site.
13. In the pop-up window, click the highlighted **Update XML** box and select the XML file that was just saved and uploaded to the DXM.
14. To have Banner CDS automatically configure dashboard visualization “check engine” widgets based on the vibration mask and dashboard item graphs based on the raw data (shown below), change the **Site Type** to Vibration and in **Objects** enter the number of sensor Nodes in the network.





Completing these steps creates continuity between the site created on the website with the DXM used in the field. The DXM pushes data to the website, which can be viewed at any time. Use the **Support** tab on the website for more information about monitoring, comparing data, and establishing warnings/alarms on the website.

Register Glossary and Options for User Interaction

Acute Samples – Non-Volatile Register 853 – Set to a default value of 5 consecutive samples before triggering an acute alert. User adjustable to any value 1 or greater for the number of consecutive samples above a warning or alarm threshold before triggering an acute alert.

Baseline Samples – Non-Volatile Register 852 – Set to a default value of 300 samples for a baseline. User adjustable to any number of five minute samples used to generate a baseline, warning, and alarm thresholds.

Baseline, Warning and Alarm Levels – Local Registers 5181-5660 – Each Node has a baseline, warning, and alarm level for each of the four vibration characteristics stored in these registers. Set to push once per day. Use for graphing with raw vibration data for comparison.

Cloud Push – Local Register 844 – Set to a value of 1 to enable cloud pushing from script.

Load Baseline – Local Register 842 – Users can manually adjust warning and alarm thresholds by entering values into non-volatile registers 7001-7320 for vibration and 7681-7760 for temperature. After the data is entered in those registers, change register 842 to 1 for 10 seconds, then set it back to 0 to load the data and override the automatically generated values

Motor Run Flag On/Off (0/1) – Local Registers 241-280 – The script determines whether or not a motor is running and only uses data from a running motor for trending, alerts, and baselining. These registers could be used to track run time or ON/OFF count with action rules.

Node Connection Status – Local Registers 281-320 – A value of 1 in the 8th bit (decimal 128) indicates a Node is in sync with its master radio. Any other value indicates a Node is no longer in sync with its master radio. This could be due to radio interference or low battery.

OR'd Warnings and Alarms – Local Registers 570-578 – All registers here provide a value of 0 or 1 to indicate if the value is false or true. These indicate a warning or error on any of the 40 Nodes based on the description of the register. Some are for vibration acute or chronic warnings or alarm, some for temperature, and some for the radio connection.

Sensor Vibration and Temperature Data – Local Registers 1-200 – Each Node has five registers, two for RMS velocity, two for RMS High Frequency Acceleration, and one for Temperature. The data is unscaled for easier viewing. In English units (in/s), the velocity = Register value ÷ 10000. For metric (mm/s), the velocity = Register value ÷ 1000. For either units, acceleration (g) = Register value ÷ 1000. For example, a velocity register value of 500 = 0.05 in/s and an acceleration register value of 15 = 0.015 g.

Setup Nodes – Local Register 833 – When the DXM boots up, it attempts to automatically set up Nodes in sync to have the proper vibration characteristics in the correct inputs. When a new Node is bound to the system after initial boot up, the new Node(s) need to be configured. This requires either sending a value of 1 to register 833 or rebooting the DXM.

User Adjustable Temperature Warning and Alarm Levels – Non-Volatile Registers 7681-7760 – Set to a default of 158F(70 deg C) for warning and 176 F(80 C) for alarm. Enter in the required level for each Node. Trigger Load Baseline register to a 1 for 10 seconds after setting user adjusted levels.

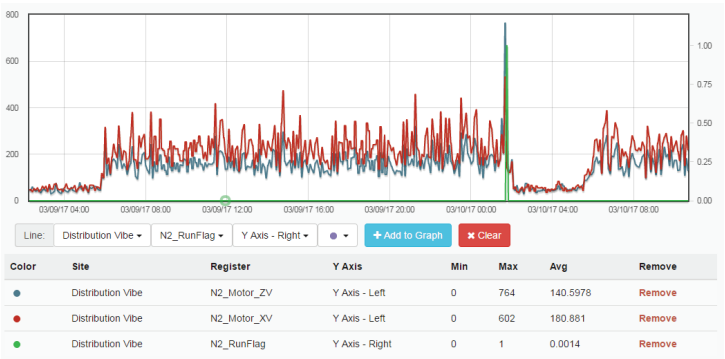
User Adjustable Vibration Warning and Alarm Levels – Non-Volatile Registers 7001-7320 – Default level is 0 to use automatically generated values. Users can adjust the level manually by entering a value for any warning or alarm level on any vibration characteristic. In English units (in/s), the velocity = Register value ÷ 10000. For metric (mm/s), the velocity = Register value ÷ 1000. For either units, acceleration (g) = Register value ÷ 1000. For example, 0.05 in/sec = register value of 500. Trigger Load Baseline register to a 1 for 10 seconds after setting user adjusted levels.

Vibration Alerts Mask – Local Registers 201-240 – Each Node has one register in this grouping where all the vibration and temperature alerts are bitpacked into a single register. Any value greater than zero indicates a warning or alarm condition and can be used as a "check engine light" for setting up notifications via email or SMS.

Additional Features

Adjusting the Velocity thresholds for Run Flag

The script in this Vibration Application Guide uses a function to automatically generate baselines and standard deviations by recognizing when a motor is running and collecting data. If a motor has a very low RMS velocity and acceleration when running, it can be very difficult to distinguish between the baseline and deviations. To ensure the system is working properly, view the Run Flag and X/Z RMS velocity over time. Visually it can be seen when a motor is running. If the Run Flag doesn't turn ON (1) when the motor turns on, decrease the Running Motor RMS Velocity threshold. To assess this, view the data over time as shown below:



Color	Site	Register	Y Axis	Min	Max	Avg	Remove
	Distribution Vibe	N2_Motor_ZV	Y Axis - Left	0	764	140.5978	Remove
	Distribution Vibe	N2_Motor_XV	Y Axis - Left	0	602	180.881	Remove
	Distribution Vibe	N2_RunFlag	Y Axis - Right	0	1	0.0014	Remove

Color	Site	Register	Y Axis	Min	Max	Avg	Remove
	VibQ45_ScriptTest	N2_Motor_ZV	Y Axis - Left	26	382	116.9374	Remove
	VibQ45_ScriptTest	N2_Motor_XV	Y Axis - Left	28	424	148.1592	Remove
	VibQ45_ScriptTest	N2_RunFlag	Y Axis - Right	0	1	0.361	Remove

On the left, we can see that the motor Node 2 is between 150 and 425 for RMS velocity when running and below 100 when it is not running. Looking at the Run Flag (green line) it only indicates the motor is running when the velocity spikes. In comparison, if we look at the RMS velocities for Node 2 on the right, we can see the Run Flag (green line) clearly indicates when the motor is running and not running even if the velocities are fairly low. This means the acceleration is high enough to distinguish a Running state.

To adjust for this, move the Running RMS Velocity Thresholds for the X and Z axis down to a level that is above the OFF state and below the lowest data collected in the Running state. In this case, 100 would be the appropriate value, but it will vary depending on the motor and should be assessed for each individual situation. To change the Run Velocity thresholds:

1. Using the DXM Configuration tool, go to **Local Registers** -> **Local Registers in Use**.
2. The X Velocity Run thresholds are in registers 661-700 and are labeled **NX_RunThres_XV** (where X is the motor ID number).
3. Change the value in the **Constant or Timer** column to an appropriate threshold for that motor as described above.
4. The Z Velocity Run thresholds are in registers 701-741 and are labeled **NX_RunThres_ZV** (where X is the motor ID number).
5. Change the value in the **Constant or Timer** column to an appropriate threshold for that motor as described above.
6. After you have completed this for each motor, **Save and Load XML File to DXM**.

After adjusting this velocity threshold, re-baseline the motor.

Re-Baseline a Motor

The script included with this guide uses the first few days' worth of data points of a motor running after loading the script to the DXM to generate a baseline and statistics for determining warning and alarm threshold levels. If changes are made to the motor or vibration sensor, generate a new baseline to ensure the system is running as accurately as possible. Re-baselining a motor can be done either from the DXM or from the website.

Baselining from the DXM

1. On the DXM: Use the arrows to select Registers. The registers are labeled NX_Baseline (where X is the motor node ID you want to baseline).
2. Select the appropriate register to reset.
3. Click the Enter button.
4. Change the value to 1 then push Enter three times. The reset register automatically returns to zero after baselining.

Baselining from the Website

1. Go to the **Dashboard > Sites** screen.
2. Click **Update Device** for the site where the particular device location exists. The **Update** pop-up window appears.

3. From the **Type** drop-down list, select **Register**.
4. From the **Register Name** drop-down list, select the motor Node ID you want to baseline.
5. Enter 1 into the **Value** field and click **Queue**.
6. Repeat steps 4 and 5 for each motor Node that needs to be reset.

Adjusting Vibration Warning and Alarm Thresholds

After baselining is complete, warning and alarm thresholds are set for each vibration characteristic on each axis automatically. To view those values, check registers 5181-5660 (12 registers per Node). To adjust those thresholds, use registers 7001-7320 (8 registers per Node). These values are stored in non-volatile registers so they will remain through a power loss. Triggering a new baseline zeroes out the user-defined registers.

Adjusting Vibration Thresholds from the DXM tool.

1. Using the DXM Configuration Software, connect to the DXM that is running the Vibration Solutions Kit.
2. Go to **Tools -> Register View**.
3. The vibration warning and alarm thresholds are in registers 7001 through 7320 and are labeled User_NX_XVel_Warning or User_NX_XVel_Alarm, etc. (where X is the motor ID number).
4. Use the right column and enter in the starting register to change and the value to set it to.
5. Click **Write Registers**.
6. To change another threshold, follow steps 3 through 5.
7. To modify up to 40 thresholds at a time, adjust the number of registers underneath the starting register and fill in each value next to the register. Click **Write Registers** when complete.
8. To return to using an original baseline value for a particular Node's vibration characteristic, set the user-defined register (7001 through 7320) back to 0 for that particular vibration characteristic.

Adjusting Vibration Thresholds from a host (PLC or HMI)

1. Write the appropriate value in to registers (X is the Node number 1 through 40):

7000+X for X Velocity Warning	7004+X for X Acceleration Warning
7001+X for X Velocity Alarm	7005+X for X Acceleration Alarm
7002+X for Z Velocity Warning	7006+X for Z Acceleration Warning
7003+X for Z Velocity Alarm	7007+X for Z Acceleration Alarm

2. To return to using an original baseline value for a node's vibration characteristic, set the user-defined register (7001 through 7320) back to 0 for that particular vibration characteristic.

Adjusting Temperature Thresholds

1. Set temperature warning values in registers 7681 through 7720 for sensors 1 through 40.
2. Set temperature alarm values in registers 7721 through 7760 for sensors 1 through 40.

Local Registers

Name	Register	Range	Description	Cloud Push Default
Vibration Data	1 + (N - 1) × 5	1-200	Z Axis Velocity (Scaled ÷ 10000)	✔
	2 + (N - 1) × 5		Z Axis Hi Freq Acceleration (Scaled ÷ 1000)	✔
	3 + (N - 1) × 5		X Axis Velocity (Scaled ÷ 10000)	✔
	4 + (N - 1) × 5		X Axis Hi Freq Acceleration (Scaled ÷ 1000)	✔
	5 + (N - 1) × 5		Temperature (Scaled ÷ 20) (Signed Reg)	✔
Vibe Mask	201 + (N - 1)	201-240	Bit Packed Alarm Message	✔
Run Flag	241 + (N - 1)	241-280	Motor Running Flag (0/1)	
Node Status	281 + (N - 1)	281-320	Connection Status of Radio (128 = Connected)	✔
Baseline	321 + (N - 1)	321-360	Indication of Baseline & Trigger to Re-baseline a Sensor Node (0/1)	Read/Write
Raw Register Data	1 + (N - 1) × 5	361-560	Placeholder Registers for Script	
	2 + (N - 1) × 5			
	3 + (N - 1) × 5			
	4 + (N - 1) × 5			
	5 + (N - 1) × 5			
Warn/Alarm masks		561-574	OR'd Alarm Registers	
Temp ORs		575-576		
Status Radio ORs		577-578		
Temp Warn	581 + (N - 1)	581-620	Individual Temperature Warning Regs (0/1)	
Temp Alarm	621 + (N - 1)	621-660	Individual Temperature Alarm Regs (0/1)	
Run Thresholds Constants	661 + (N - 1)	661-700	Threshold Constant for Motor Run determination	
	701 + (N - 1)	701-740		
	741 + (N - 1)	741-780		
	781 + (N - 1)	781-820		
Site Survey		821-823	Solutions Kit Functionality	
Binding		824		
Alert Warning Lights		825-830	Trigger for lights on DXM related to Alerts/Alarms	
Sample Count		831	1-Second Timer Count up to 300 between Samples	
Read Rule Enable		832	System Function to trigger read rules when sample count hits 300	
Setup Nodes		833	Register to trigger Node Config Setup(0/1) (Controlled by Script)	
Sample Time		834	Placeholder Registers for Script	
Push Count		835		
Nodes 1-10 Status		836	Solutions Kit Functionality	
Nodes 11-20 Status		837		
Nodes 21-30 Status		838		
Nodes 31-40 Status		839		
Fast Sample Trigger		843		
Cloud Push Enable		844	Enable or Disable cloud pushing (0/1)	
First Run		851	Solutions Kit Functionality (0/1, set to 0 to reinitialize settings)	
Baseline samples		852	Set number of samples for a baseline (default 300)	
Acute Sample		853	Number of samples in a row for Acute fault (default 5)	
CT Enable		854	Set to 1 to enable CT Measurements (0/1)	

Name	Register	Range	Description	Cloud Push Default
Chronic Fault Trends 100 Point Moving Average	5021 + (N - 1) × 4	5021-5180	Z Velocity Trend	
	5022 + (N - 1) × 4		Z Acceleration Trend	
	5023 + (N - 1) × 4		X Velocity Trend	
	5024 + (N - 1) × 4		X Acceleration Trend	
Visible Baseline and Alarms	5181 + (N - 1) × 12	5181-5660	Baseline & Thresholds being used for alarms (Selected from Learned or User Defined)(X Velocity(3), Z Velocity(3), X Acceleration(3), Z Acceleration (3). (Scaling = Velocity ÷ 10000, Acceleration ÷ 1000)	Push once a day at UTC 00:00
Learned Thresholds	5661 + (N - 1) × 8	5661-5980	Calculated Baseline & Thresholds from algorithm (used in 5181-5660 if equivalent user thresholds in 7001-7320 are set to 0)(X Velocity(3), Z Velocity(3), X Acceleration(3), Z Acceleration (3) (Scaling = Velocity ÷ 10000, Acceleration ÷ 1000)	
Scaled Temp Reading	5981 + (N - 1)	5981-6020	Placeholder Registers for Script	
User Selected Nodes	6021 + (N - 1)	6021-6060	Solutions Kit Functionality	
Current (A) Reading	6061 + (N - 1)	6061-6100	Current reading in amps from CM node if used (Scaled ÷ 100)	✔
Current Alerts Mask	6101 + (N - 1)	6101-6140	Current Alerts Mask (Bit 1 Warning, Bit 2 Alarm)	✔
User Defined Thresholds	7001 + (N - 1) × 8	7001-7320	User Defined Vibration Thresholds (will override Learned Thresholds) (X Velocity(2), Z Velocity(2), X Acceleration(2), Z Acceleration (2) (Scaling = Velocity ÷ 10000, Acceleration ÷ 1000)	
Saved Count/Mean/StdDev	7321 + (N - 1) × 9	7321-7680	Solutions Kit Functionality	
Temp Warn Thresholds	7681 + (N - 1)	7681-7720	User Defined Temperature Thresholds (Unscaled)	Push once a day at UTC 00:00 / Write
Temp Alarm Thresholds	7721 + (N - 1)	7721-7760		
Current Warn Thresholds	7761 + (N - 1)	7761-7800	User Defined Current Thresholds (Scaled ÷ 100)	Push once a day at UTC 00:00 / Write
Current Alarm Thresholds	7801 + (N - 1)	7801-7840		
Current Scale	7841 + (N - 1)	7841-7880	Current Scale (read from dip switches but user adjustable for non-standard CTs) (Unscaled)	

Where N represents the Motor Node ID number.

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