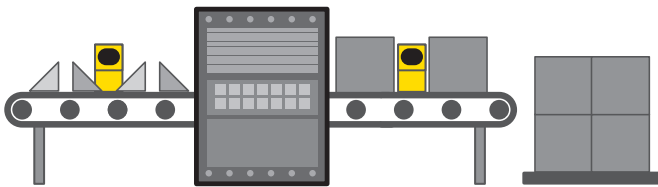
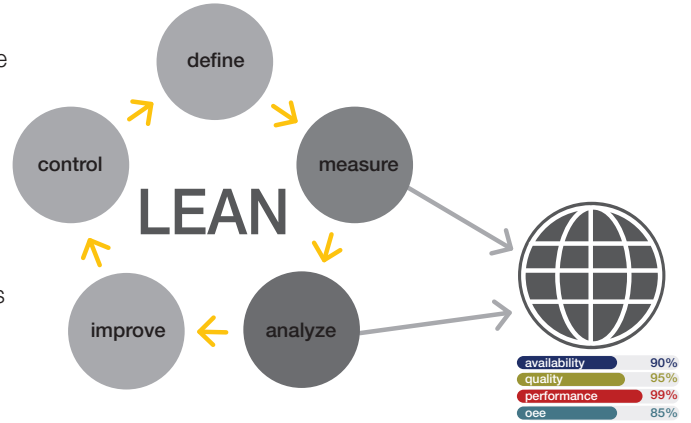


Background

Banner Engineering's Wireless part counting solution enables LEAN initiatives by providing the ability to measure and analyze OEE metrics of availability, performance, and quality to compare how your process/machine is performing against an ideal state.

Value

- **Increases uptime and capacity use**
- **Improves process awareness** – Immediate feedback on process states and error conditions
- **Reduces cost of quality** – Timely corrective actions = improved yields
- **Optimizes machine throughput** – Reducing cycle time lowers production cost
- **Standardizes the method for productivity** for benchmarking/continuous improvement
- **Uses IIOT** – Real-time monitoring, data collection, and alerts for better decision making

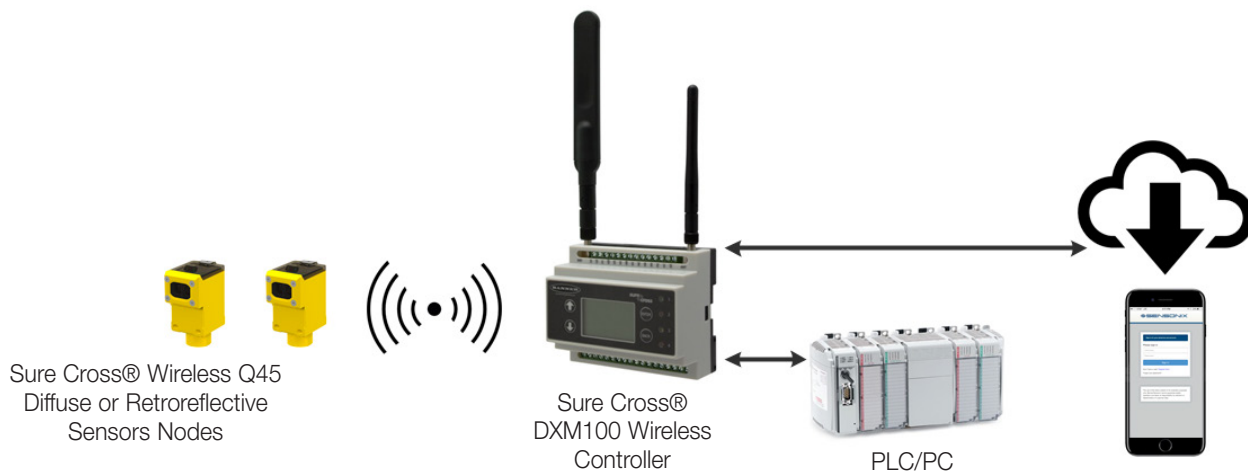


Banner OEE Solution – Wirelessly track parts flow

- **Availability** – Tracking of process/machine availability.
- **Performance** – Identify root causes for non-optimal productivity
- **Quality** – Identify continuous improvement opportunities

How Banner Solves

- Wireless sensors count the inputs and outputs and send the counts to the DXM Controller. The DXM Controller runs a script to calculate OEE based on known parameters. Data can be sent to a host system or directly to a website for IIOT.
- DXM Controller uses part count rates to determine process flow. Current production states, such as Running, Slow, Stopped, Jammed, and Starved, give feedback to troubleshoot performance issues.



A PDF version of this Solutions Guide is available at <https://goo.gl/YBLyBC>

Features and Benefits

| | |
|---|---|
| OVERALL EQUIPMENT EFFECTIVENESS (OEE) CALCULATIONS | Calculates OEE actual vs. user defined ideal state answering: "How close is system to ideal state". Instantaneous and averaged OEE parameters calculated including Availability (A) , Performance (P) , and Quality (Q) . OEE = A x P x Q |
| PART COUNTING | Utilize up to 8 pairs of battery powered wireless Q45 sensing nodes for part counting up to 960 |
| TRACK PARTS/MIN RATES | Calculates parts/min rates for each counting pair of sensor nodes |
| MONITORING MACHINE STATE | By counting in/out - Determines machine states: Running, Slowed, Stopped, Jammed, or Starved based on part rates and user configurable settings. Track times and counts of error states. |
| EXTENDED ERROR ALERTS | User configurable parameters to trigger alerts when error states are active for extended periods |
| SMS TEXT/EMAIL ALERTS | Generate SMS text and/or email alerts based on specific events |
| WIRELESS SENSORS | No additional control or power wires to install |
| IIOT - CLOUD MONITORING | Push data to Cloud Webserver or PLC for remote viewing, alerting, and logging |
| EXPANDABILITY | Ability to easily add additional wireless nodes to monitor other operations |

Solution Components

| Model | Description |
|---|---|
| Up to 8 Pairs of Wireless Q45 Sensor Nodes: DX80N9Q45D or DX80N9Q45LP (900 MHz) DX80N2Q45D or DX80N2Q45LP (2.4 GHz) | Sure Cross Wireless Q45 Sensor – Diffuse and/or Retroreflective |
| DXM100-B1C1R1 (900 MHz) or DXM100-B1C1R3 (2.4 GHz) | DXM100 Wireless Controller with Cellular module Select either 900 MHz or 2.4 GHz ISM radio to match the Q45 Sensor pairs; the C1 models are only necessary if a cellular module is desired |

Getting Started

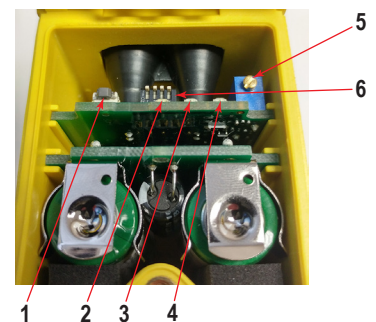
The following guide demonstrates how to bind the Wireless Q45 Sensor Nodes to the DXM Controller and load a preconfigured XML file and script. The application uses up to eight pairs of part counting Nodes to monitor incoming and outgoing part counts of a machine/process to determine status and OEE metrics.

The XML file requires only minor modifications to be customized for any site.

Step 1: Bind the System and Assign Addresses

Binding the Q45s to the DXM100 establishes a secure connection and assigns a specific network address to each Node in the wireless network. The Q45s work in pairs. On each machine or process, this example uses Node 1 for incoming part counts and Node 2 for outgoing part counts. Label the Q45s with their Node IDs after they are bound.

1. Apply power to the DXM Controller.
2. On the DXM Controller: Use the arrow buttons to select the **->ISM Radio** menu. Push **Enter**.
3. To bind Node 1:
 - a. Select **->Binding to >1** and push **Enter**.
 - b. On Node 1: Open the access door.
 - c. Set DIP switch 3 to the ON position.
 - d. **Triple-click** the button to begin the binding procedure. The green and red LEDs flash four times to indicate a successful binding. This Node binds to the DXM Controller as Node ID 1.
 - e. Label the device for future reference using the included label.



1. Button
2. Red LED (flashing) indicates a radio link error with the Gateway.
3. Green LED (flashing) indicates a good radio link with the Gateway.
4. Amber LED for Alignment or Test Mode. Indicates sensor function (optical sensor models) or when input 1 is active (dry contact models). The amber LED is not used during normal operation.
5. Excess gain potentiometer. Turn clockwise to increase the gain.
6. DIP switches

4. To bind Node 2:
 - a. On DXM Controller menu screen, click **Back**
 - b. Change the DXM Controller menu to **Bind to > 2** and press **Enter**.
 - c. Repeat steps 3b-e. The Node binds to the DXM Controller as Node ID 2.
5. After binding all devices: On the DXM Controller, press **Back** to return to the main menu. To bind more devices, repeat the previous steps as necessary.

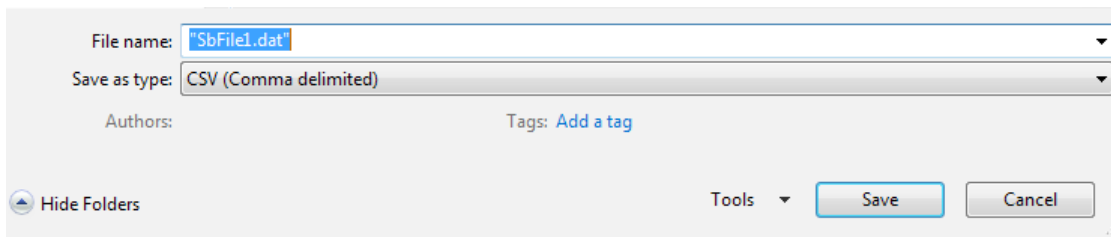
Step 2: Configure the System

To customize the system to an actual application, you may need to make some basic modification to the template files. There are three files uploaded to the DXM: the XML file sets the DXM's initial configuration, the Data file (.dat) is used to define custom OEE and part counting parameters, and the ScriptBasic file (.sb) uses all the incoming data for part counting and OEE calculations (creates a reset function via the DXM display for timer and count resets, and organizes the information in logical and easy to find registers in the DXM).

1. Download the [preconfigured files](https://goo.gl/wpttfr). (<https://goo.gl/wpttfr>)
2. Extract the ZIP files into a folder on your computer. Note the location where the files were saved.
3. Connect the DXM Controller, via the USB cable supplied, to a computer containing the downloaded DXM Configuration Tool .
4. Launch the software and load the "Part Counting OEE..." XML file by going to the **File > Open** menu and choosing the configuration files.
5. Connect the software to the DXM Controller:
 - a. Go to the **Device > Connection Settings** screen.
 - b. Select **Serial**, then select the COM port that the USB cable is plugged into.
 - c. Click **Connect**. (If you are unsure which COM port you need, and multiple appear, attempt to connect to each one of them until you are successful).
6. Upload the "Part Counting OEE..." script file:
 - a. Go to **Settings > Scripting** screen.
 - b. Click **Upload Script**.
 - c. Select the uploaded file in the window to the right of the **Upload Script** button.
 - d. Click **Add Selected to Startup** so the DXM runs this script every time it restarts.
7. **Save** the XML file using the **File > Save** menu. (Save the XML file any time the XML has been changed because the tool does not autosave.)

Set up the OEE Parameters

1. Open the provided SbFile1.csv file in Excel.
2. Set system information for each Node pair being used in the system, if the information is different than the defaults:
 - a. **Report Time** (recommended to stay at or above 60 seconds) – The time (seconds) that the Nodes report part counts back to the DXM
 - b. **Scale Factor** – Ratio of parts coming in to parts going out. For example, if 10 parts go into the process and get packaged into a single part going out, the Scale Factor is 10).
 - c. **Ideal IN Parts/Min** – User defined as the ideal parts per minute rate of parts entering the process for the Performance calculations.
 - d. **Ideal RUN Time/Min** – User defined as the ideal average running time in seconds of the process per minute for the Availability calculations. For example, if in an eight-hour period the ideal run time is 6 hours, this would be $6/8 \times 60$ seconds = 0.75×60 seconds = 45 seconds.
 - e. **RUN Parts/min** – Rate of parts/min for IN and OUT that would be considered “running” when at or above.
 - f. **STOPPED Parts/min** – Rate of parts/min for IN and OUT that would be considered “stopped” when below. Any value in between running and stopped is considered “slow”.
 - g. **Stop Reports** – Number of consecutive reports required before the system indicates a “stopped” condition.
 - h. **Extended Time** – Number of seconds before an error state (Stopped, Jammed, or Starved) is reported as an extended condition.
 - i. **Starved Threshold** – Rate of parts/min IN that when below is considered a “starved” condition after three consecutive reports.
 - j. **Jammed Threshold** – Percentage of Parts OUT vs Parts IN rates that would triggered a “jammed” condition after three consecutive reports. For example, setting the Jammed Threshold to 120 means a “jammed” condition occurs when the Parts OUT rate is 120% or more of the Parts IN rate.
3. Select **Save As...** on the CSV file with the name “SbFile1.dat” (including the quotation marks before and after the name) in the Save As file name box. This is necessary to generate the .dat type file.



4. Upload the “SbFile1.dat” data file by going to the **Settings > Scripting** screen.
 - a. Click **Upload Script**.
 - b. Change the file type just above the **Open/Cancel** buttons in the popup to “All Files (*.*)”.
 - c. Select the file.

This file can be modified at any time and can be scheduled to take effect at specific times. Refer to the *Additional Features* section for instructions on how to do this.

Optional Steps: Customize the XML file

1. On the DXM Configuration Tool: Go to the **Local Registers > Local Registers in Use** screen.
2. Enter a name for the Part Counting Sensor registers in the **Register Name** field.

| # | Register Name | Units | Signed | Constant or Timer | Cloud Reporting | LCD | Web |
|---|----------------------|-------|-------------------------------------|-------------------|-----------------|------|------|
| 1 | 1 Count IN | None | <input type="checkbox"/> | None | On | None | Read |
| 2 | 1 Count OUT | None | <input type="checkbox"/> | None | On | None | Read |
| 3 | 1 Count Differential | None | <input checked="" type="checkbox"/> | None | On | None | Read |
| 4 | 1 State IN | None | <input type="checkbox"/> | None | On | None | Read |
| 5 | 1 State OUT | None | <input type="checkbox"/> | None | On | None | Read |
| 6 | 1 Parts/Min IN | None | <input type="checkbox"/> | None | On | None | Read |
| 7 | 1 Parts/Min OUT | None | <input type="checkbox"/> | None | On | None | Read |
| 8 | 1 Running | None | <input type="checkbox"/> | None | On | None | Read |

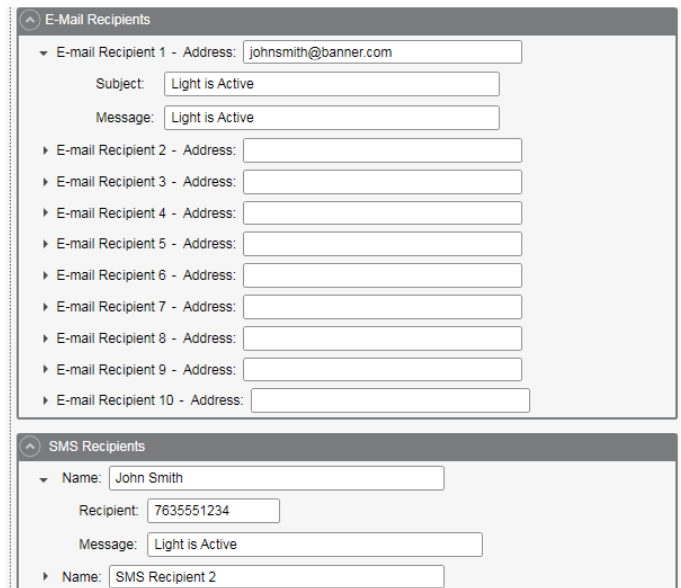
3. To display the station status, count, or timer on the website set the Web field to Read and set Cloud Reporting to ON for each stations' information piece (presence, timer, count, etc.) that you would like to appear on the website.
4. To display the registers for each part counting pair on the website, change the cloud permissions.
 - a. On the **Modify Multiple Registers** screen, select **Change** in the drop-down list next to **Cloud Permissions** and **Cloud Reporting**.
 - b. In the drop-down list to the right, select **ON** for **Cloud Reporting** and **Read** for **Cloud Permissions**.
 - c. Set the **Starting Register** to 1 and the **Ending Register** to the value equal to 40 x the number of stations in the system (Example: Set register to 320 for 8 part counting sensor pairs).
 - d. Click **Change Registers**.
5. Configure to receive email or text alerts based on an Action Rule.
 - a. Go to the **Action Rules** screen and expand any rule using the arrow next to the rule OR create a new action rule by clicking **Add Threshold Rule**.
 - 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. (Setting up the emails or SMS phone numbers to receive messages will be in the next section of the guide.)

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

Set up the Ethernet or Cellular Connection

By default, the XML file configures the DXM100 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 cellular module be installed in DXM Controller and a wireless plan set up for sending data.
2. The **Cloud Push Interval** determines how often the DXM pushes the current status data to the webserver. By default, this interval is set to zero and should not be changed. If data is being pushed to the cloud, set the Cloud Push Interval to 00:15:00 (15 minutes).
3. Set up the email and text messages. Expand the **Email Recipients** and **SMS Recipients** to enter up to 10 email addresses and 10 phone numbers, along with a custom message.
 - a. Go to the **Settings > Mail and Messaging** screen.
 - b. All SMTP fields should remain set to their default values, except the **Password** field (unless using customer's own desired SMTP server). Enter "9Hp7+anXhQ" into the password field.
 - c. Click **Send SMTP Password**.
 - d. Click **Yes** when asked to reboot the device.



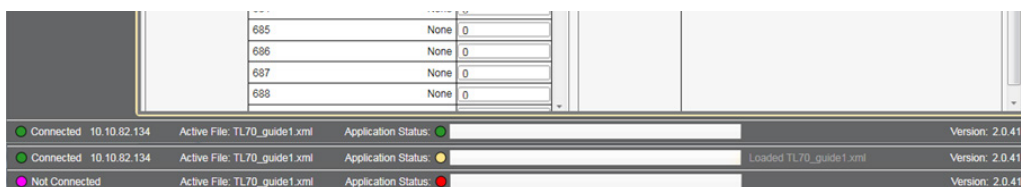
Step 3: Save and Load the XML File to DXM

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. Verifying 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 Tool, 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 4: Conduct a Site Survey

Conduct a Site Survey to verify the wireless connection between your Q45s and the DXM.

1. On the DXM: Use the arrow buttons to select the **ISM Radio** menu. Push **Enter**.
2. Select the **Site Survey** submenu, and press **Enter**.
3. Select each Node ID within the system to verify the wireless connection between the Node and the DXM.
4. When you are finished running the site survey, press **Back** twice to return to the main menu.

Forgetting to exit the site survey causes system issues and reduces the battery life of the Q45Us.

Step 5: Push Information to the Cloud

The DXM100 can connect to the web via Ethernet or an internal cell module to push data from the site to the cloud and displayed on a website. To enable this capability for remote monitoring and alarms settings, modify the XML file.

The website for storing and monitoring the system's data is <https://data.sensonix.net/>.

1. Connect the DXM to a computer with the DXM Configuration Tool software.
2. Launch the software and connect to the DXM.
3. **Load** the saved XML file.
4. Go to the **Settings > Cloud Services** screen.
5. Visit the Sensonix Web Services website (<https://data.sensonix.net/>) and log into an existing account or register a new account.
6. Go to **Settings > Sites**, and click **+ New Site**. Name your site.
7. On the **Settings > Sites** webpage, highlight and copy the Site ID.
8. On the DXM Configuration Tool: Return to the **Settings > Cloud Services** screen and paste the copied ID into the **Site ID** field.
9. **Save** the XML file (**File > Save**).
10. Upload the file to the DXM (**Device > Send XML Configuration to DXM**).
11. On the Sensonix Web Services website, click **Send XML to Web** and select the XML file that was just saved and uploaded to the DXM.

This 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. Refer to the Sensonix Web Services Instruction Manual to review all the features available for monitoring, comparing data, and establishing warnings/alarms on the website.

| Edit | Send XML | Get XML | Site Name | Site ID | Last Push | Method | Authentication | Poll Interval | Push Interval |
|------|----------|---------|--------------------|--------------------------------------|------------|----------|----------------|---------------|---------------|
| | | | Temp Humid | 5f72785f-5236-4d0b-8256-3b1ae15ec2fe | 5d 0h 48m | Ethernet | OFF | 00:00:00 | 00:05:00 |
| | | | Tank Monitoring | fc61818c-fe87-400a-810a-44b48f4cd9f | 101d 2h 8m | Cellular | OFF | 00:00:00 | 00:15:00 |
| | | | Machine Monitoring | 0ac243d1-b7c1-4622-9cc2-d27da1004f3a | 21d 4h 30m | Ethernet | OFF | 00:00:00 | 00:00:00 |

Additional Features

Resetting the Timer and Counts

Each pair of part counting sensors in the system has a reset register that is available on the face of the DXM's LCD and via the website. Setting this register to 1 resets all the counts and timers on that particular Station.

Resetting from the DXM

1. On the DXM: Use the arrows to select **Registers**.
The registers are labeled **Reset X** (where X is the sensor pair you want to reset). This resets all 40 registers associated with that counting pair. There is also a **Reset All** register available.
2. Select the appropriate register to reset.
3. Click **Enter**.
4. Change the value to 1 then click **Enter** three times.
The reset register automatically returns to zero after the register(s) reset.

Resetting from the Website

1. Go to the **Dashboard > Sites** screen.
2. Click **Update Device** for the site where the particular sensor pairs exists.
3. The **Update** pop-up window appears. From the **Type** drop-down list, select **Register**.
4. From the **Register Name** drop-down list, select the sensor pair ID you want to reset.
5. Enter 1 into the **Value** field and click **Queue**.
6. Repeat steps 4 and 5 for each station that needs to be reset or use the **Reset All** register following steps 4 and 5.
When the next data push occurs, the chosen units reset. The reset registers automatically return to zero after the register(s) reset.

Setting and Scheduling New User-Configurable Parameters

A new file (SbFile1.dat) can be created and added to the DXM at anytime after the device is initially setup. This allows a customer to make changes to the lines parameters to properly calculate the OEE statistics if the line is reconfigured or a different job is being run on that shift. Once the file is loaded, the system must be "Initialized" either immediately or by setting up a schedule in the XML. Follow the instructions on resetting an individual sensor pair or resetting all sensor pairs if desired to zero out previous data following the addition of the new parameters.

Adjust parameters and initialize

1. Create a new SbFile1.dat with new parameters and upload it to the DXM by following the second part of Step 2 of this guide.
2. To initialize the system based on these new parameters, use one of the following three methods:
On the DXM: Click **Registers** and select **Initialize**. Click **Enter** and change the value from 1 to 0 and hit **Enter** until you return to the **Registers** menu.
In the DXM Configuration Tool: While connected to the DXM, go to the **Register View** screen. On the right side of the screen enter 841 as the **Starting Register**, verify 0 is the value, and click **Write Registers**.
On the Sensorix Web Services website: click **Update Device** for the site where the particular sensor exists. Select **Register** from the **Type** drop-down list. In **Register Name** select Initialize. Enter a 0 into the **Value** field and click **Queue**.

Schedule parameters to take place

1. Create a new SbFile1.dat with new parameters and upload it to the DXM following the second part of Step 2 of this guide.
2. In the DXM Configuration Tool, go to the **Scheduler > One Time Events** screen.
3. Expand the **Schedule Initialize** event.
4. Adjust the parameters for the date and start time to initialize the device and put a 1 as the **Start Value**.
5. Check the box next to **End Value** and place a 0 for the End Value and set the date and time to 1 minute after the start time and date.
6. Save the XML by clicking **File > Save** and upload the XML file to the DXM. Note that sending the XML to the DXM causes a reboot. The data in the DXM is erased, so perform this step between work periods.

Configure Time-Stamped Logging

To set up time-stamped logging, follow these steps.

1. On the DXM Configuration Tool: Go to the **Local Registers > Modify Multiple Registers** screen.
2. Click **Reset Form**.
3. From the SD Card Logging drop-down list, select **Change**.
4. Select **Log 1** in the drop-down list that appears to the right.
5. Set the **Starting Register** to 1 and the **Ending Register** to a value equal to $40 \times$ Number of sensing pairs in the system. (For example, set the Ending Register to 320 for eight pairs of sensors).
6. Click **Change Registers**.

Retrieve a Log File

Follow these steps to save a log file to your computer.

1. On the DXM Configuration Tool: Go to the **Settings > Logging** screen.
2. Click **Refresh List**.
3. In the **Log File Management** window, select the file to save.
4. Click **Save Selected** to save the file to a folder on your computer.

Local Registers

| | Local Register # | Description |
|-------------------|--------------------------|--|
| Counter Node Info | $1 + 40 \times (N - 1)$ | Part Count IN |
| | $2 + 40 \times (N - 1)$ | Part Count OUT |
| | $3 + 40 \times (N - 1)$ | Part Count Differential between IN and OUT |
| | $4 + 40 \times (N - 1)$ | Counter State IN |
| | $5 + 40 \times (N - 1)$ | Counter State OUT |
| | $6 + 40 \times (N - 1)$ | Parts per minute IN |
| | $7 + 40 \times (N - 1)$ | Parts per minute OUT |
| Running | $8 + 40 \times (N - 1)$ | Running State |
| | $9 + 40 \times (N - 1)$ | Running Time Total |
| Slowed | $10 + 40 \times (N - 1)$ | Slowed State |
| | $11 + 40 \times (N - 1)$ | Slowed Time Total |
| Stopped | $12 + 40 \times (N - 1)$ | Stopped State |
| | $13 + 40 \times (N - 1)$ | Extended Stop State |
| | $14 + 40 \times (N - 1)$ | Stop Time Total |
| | $15 + 40 \times (N - 1)$ | Stop Count Total |
| | $16 + 40 \times (N - 1)$ | Average Stop Time |
| Jammed | $17 + 40 \times (N - 1)$ | Jammed State |
| | $18 + 40 \times (N - 1)$ | Extended Jam State |
| | $19 + 40 \times (N - 1)$ | Jammed Time Total |
| | $20 + 40 \times (N - 1)$ | Jammed Count Total |
| | $21 + 40 \times (N - 1)$ | Average Jam Time |
| Starved | $22 + 40 \times (N - 1)$ | Starved State |
| | $23 + 40 \times (N - 1)$ | Extended Starved State |
| | $24 + 40 \times (N - 1)$ | Starved Time Total |
| | $25 + 40 \times (N - 1)$ | Starved Count Total |
| | $26 + 40 \times (N - 1)$ | Average Starved Time |

| | | |
|-------------------------------------|--------------------------|--|
| OEE Instantaneous | $27 + 40 \times (N - 1)$ | OEE Calculation Instantaneous |
| | $28 + 40 \times (N - 1)$ | Availability Calc Instantaneous |
| | $29 + 40 \times (N - 1)$ | Performance Calc Instantaneous |
| | $30 + 40 \times (N - 1)$ | Quality Calc Instantaneous |
| OEE Averages | $31 + 40 \times (N - 1)$ | OEE 60 minute Moving Average |
| | $32 + 40 \times (N - 1)$ | Availability 60 minute Moving Average |
| | $33 + 40 \times (N - 1)$ | Performance 60 minute Moving Average |
| | $34 + 40 \times (N - 1)$ | Quality 60 minute Moving Average |
| Connection Error | $35 + 40 \times (N - 1)$ | Connection Error Report of either node in the sensing pair (0/1) |
| Background Registers Used by Script | 321–328 | Reset registers for each sensing pair |
| | 329–344 | Connection Status for each node |
| | 410–425 | Part Count Rate Timers |
| | 426–465 | Machine State Timers |
| | 467–474 | Report Timers |
| | 475–482 | Total Timers |
| | 500–515 | Sensor State (On/Off) |
| | 840 | Reset All |
| | 841 | Initialize |
| | 842 | Schedule Initialize |
| | 843 | Read Trigger |

Where N represents the Part Counting Pair ID.

Glossary of Terms Used

RUNNING—Process state when parts/min rate IN and OUT exceeds the Parts/min RUN threshold.

SLOW—Process state when parts/min rate IN or OUT is less than the Parts/min RUN and greater than the Parts/min STOPPED. Also considered slow if the parts rate is below the STOPPED threshold but for less than the user defined report cycles.

STOPPED—Process state when parts/min rate IN and OUT is less than the Parts/min STOPPED threshold for a length of time determine by Stop Reports \times Report Time.

JAMMED—Defined as more parts coming in than coming out of the process. Will not trigger until the condition is met for more than two report cycles. Jammed Threshold allows for some built-in variance allowance. Default: 120%.

STARVED—Defined as part rate IN being below user defined Starved Threshold for 2+ report cycles.

Overall Equipment Effectiveness (OEE)—Availability (A) \times Performance (P) \times Quality (Q) = OEE

AVAILABILITY (A)—(Running time + Slow time per min) \div (Ideal Run Time per min)

PERFORMANCE (P)—(Parts per minute IN) \div (Ideals parts per min IN)

QUALITY (Q)—(Parts per minute OUT) \div (Parts per minute IN)



more sensors, more solutions

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