Control Loop Performance Monitoring

Contents

Chapter 1

Control Loop Performance Monitoring Overview

Topics:

What is Process Control?

Process control is an engineering discipline for maintaining the output of a specific process within a desired range.

A control system is a device or set of devices used to manage the behavior of other devices or systems in an industrial process facility.

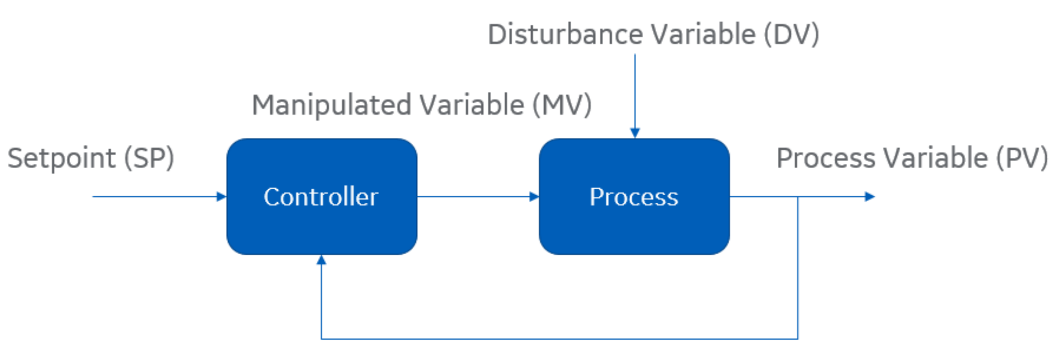
What is a Control Loop?

A control loop is the fundamental building block of industrial control systems. It consists of all the physical components and control functions necessary to automatically adjust the value of a measured Process Variable (PV) to equal the value of a desired Setpoint (SP).

A control loop includes the process sensor, the controller function, and the Final Control Element (FCE), all of which are required for automatic control.

The difference between the SP value and the current value of the PV is called the Error, and this is used by the control algorithm to calculate adjustments to the Manipulated Variable (MV). The MV is sent to the FCE (also referred to as the actuator) to bring the PV back to the SP value, using a closed loop feedback mechanism. This mechanism allows control systems to adapt to varying process operating circumstances and disturbances. Disturbances can sometimes be measured and compensated for by means of a Disturbance Variable (DV).

Industrial Process Control Loop



What is a PID Control Loop?

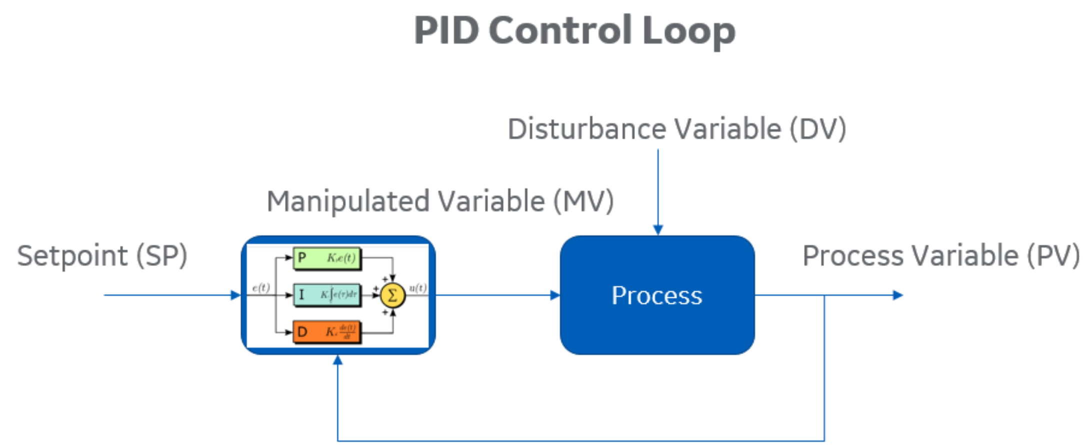
A PID control loop is a generic control loop feedback mechanism that uses a well-known PID(F) algorithm. It is very common in industrial control systems.

The PIDF (Proportional–Integral–Derivative-Filter) control algorithm involves four separate tuning constant parameters:

- Proportional value (P)
    - The variable control required in proportion to the current needs of the system.

- Integral value (I)
  - The integral control that applies ever-increasing control actions, until the error is reduced to zero.
- Derivative value (D)
  - The derivative value of the algorithm is determined by how quickly the error changes over time.
- Filter value (F)
  - Adding a filter (F) to the PID controller helps to remove noise signals from the system and enables better control under some conditions.

Many different implementations (variations) of the PID(F) algorithm are used in industry today.



What is PID Control Loop Tuning?

When a disturbance to the process occurs, the task of the controller is to reduce the error signal to zero and restore the PV back to the SP value, as effectively, efficiently, and quickly as possible. Choosing the right PIDF values for the parameters in the PIDF controller algorithm allows the controller to achieve this goal in the most effective way possible. This is referred to as loop tuning: selecting the best PIDF values to get the most accurate and effective control loop performance behavior. If the loop is tuned properly, the response time to disturbances is reduced. If the loop is tuned too aggressively, cycling and overshoot of the setpoint value may occur.

What is Control Loop Performance Monitoring?

Control Loop Performance Monitoring (CLPM) provides a solution to monitor the performance of an enterprise fleet of industrial process control loops, to detect and identify underperforming control loops, and to help to diagnose control loop problems.

Industrial process plants typically have hundreds or thousands of control loops configured inside PLC (Programmable Logic Controller), DCS (Distributed Control System), and SCADA (Supervisory Control and Data Acquisition) systems to automate and control plant operations.

Control Loops are located at the interface between equipment and process. They also operate industrial equipment to form an industrial process.

The stability, reliability, and optimal performance of an industrial process is dependent on the stability and performance of the fleet of control loops used to operate and control that process. Industrial process plants are also capital-intensive assets. Suboptimal control loops can directly impact equipment reliability, equipment lifetime, and operational performance.

It is therefore essential to manage the performance of control loops as valuable assets in an industrial enterprise facility that should be continuously monitored and optimized.

Evaluating Control Loop Performance

- Control loops are performing well when the monitored process variable (PV) varies within the defined upper and lower control limits from the desired SP value.
- Control loops are performing poorly where the monitored PV functions outside of the desired process control limits.

The Asset Model in CLPM

The asset model is central to CLPM in a number of ways:

- Loops are defined as assets, according to a predefined template/definition for a control loop.
- Deployment of data collections in Edge Analytics is driven by the asset model.
- CLPM configuration is driven from the asset.
- Loop thresholds and control limits are defined on the asset.
- Edge data is extracted from the asset.
- Actions on a control mode are defined on the asset.

Consult the Control Loop Asset Definition for details.

CLPM Components

CLPM is made up of the following components working together.

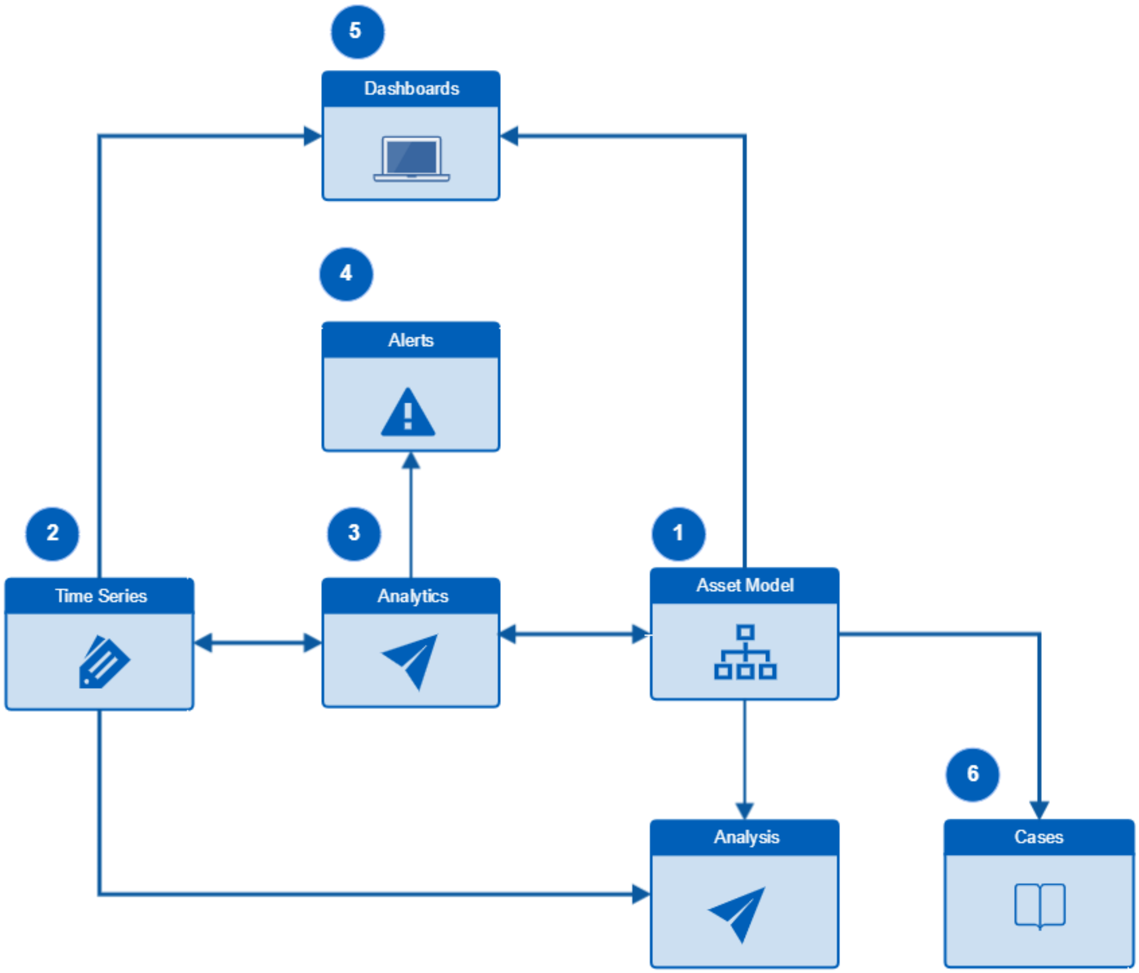


Figure 1: CLPM components

These components enable the following functionality.

1. Loops are defined as assets, according to a predefined template for a control loop.
2. Selected tags are collected into TimeSeries for each loop.
3. Loop analytics are deployed.
4. Alerts produced by these analytics are triggered under conditions defined in analytic configuration.
5. Data produced by these analytics is viewed via the Fleet Dashboard and Loop Dashboard.
6. Issues identified with loops (cases) are resolved.

User Workflow in CLPM

Following the CLPM workflow / process described below helps users monitor and optimize the performance of an enterprise fleet of control loops. Underperforming control loops can be identified, prioritized, and optimized.

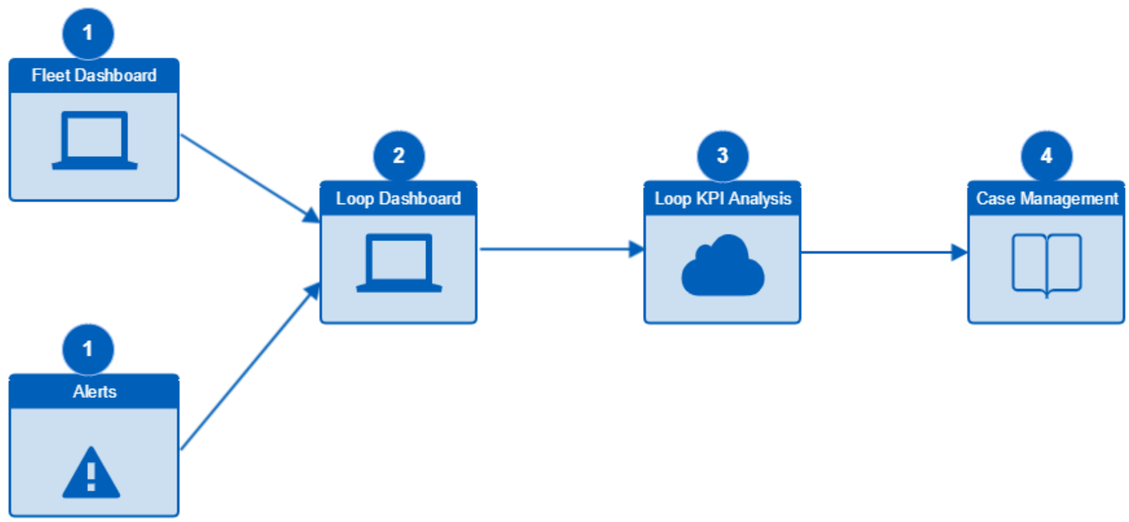


Figure 2: User workflow / process

1. The Fleet Dashboard

Use the Fleet Dashboard to rank the performance of all control loops contained in any level of an enterprise asset model (Enterprise, Segment, Site, etc.) over a specified time period. This helps in identifying underperforming control loops and prioritizing them for optimization. Consult the Fleet Dashboard section of this documentation for details.

OR

1. Alerts

Alerts notify you about potential problems with control loops. Consult the section of this documentation on deploying CLPM analytics for details on analytics that trigger alerts and how to configure them.

2. The Loop Dashboard

Use the Loop Dashboard to visualize the performance of any individual control loop in detail over a specified time period. This helps in assessing control loop performance and diagnosing potential causes of suboptimal performance. Consult the Loop Dashboard section of this documentation for details.

3. Loop KPI Analysis

Analyze the historical performance of loop KPIs over any historical time period to gain further insight. Loop KPIs can be assessed in relation to other loop KPIs or compared with the same loop KPIs calculated using other data and other tags available in Predix TimeSeries. Consult the KPI Reference for CLPM for more on loop KPIs.

4. Case Management

Action, collaborate on, and resolve any issues identified with control loops. Consult the Application Analytics documentation for details.

CLPM Terminology

The following terms are frequently used in control loop performance monitoring (CLPM).

Term	Description
CLPM	Control Loop Performance Monitoring
PV (Process Variable)	This is the measured process variable, reflecting the actual state of the process that is being controlled.
SP (Setpoint)	This is the desired value (target value) to which the PV is controlled.
Error	This is the difference between the PV and SP. It is calculated as Error = PV-SP. Note that this is not an absolute value.
Controller	The subsystem containing the control algorithm that manipulates the MV to control the PV to the SP.
MV (Manipulated Variable)	The variable manipulated (adjusted) by the controller to control the PV to the SP.
DV (Disturbance Variable)	A measured disturbance variable that can be used by the controller to compensate for the impact of the disturbance on the PV.
P (Proportional Value)	Normally the Proportional Gain value of the PID controller.
I (Integral Value)	Normally the Integral Gain value of the PID controller.
D (Derivative Value)	Normally the Derivative Gain value of the PID controller.
F (Filter Value)	Normally the Filter Time Constant value of the PID controller.
Final Control Element (FCE)/ Actuator	The device that is physically affected by a change in the MV so as to have an impact on the process.

Chapter 2

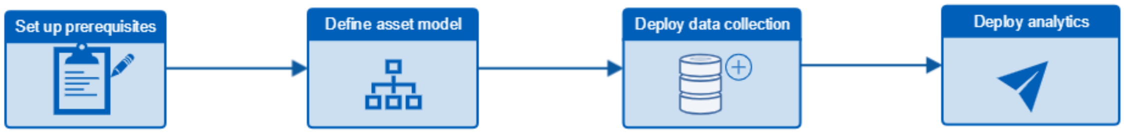
Get Started with CLPM

Topics:

Getting Started with CLPM

This section provides instructions for getting started with CLPM.

At the high level, this involves the following steps, to be performed by the CLPM solution administrator.



1. Set up the prerequisites for CLPM.
2. Define the asset model.
3. Deploy data collection. This includes the following:
    a. Set up control mode logic.
4. Deploy CLPM analytics.
5. Access loop and fleet dashboards.

Prerequisites for CLPM

To get started with CLPM, first ensure that you have met these prerequisites.

Tenancy Requirements

Ensure that your OPM application instance has the following apps and services set up:

- Application Analytics
- The Asset Model Service
- The Time Series Service
- The Dashboard Service
- Predix Event Hub
- Predix Insights
- KPI Management
- Analysis Service
- Alert Service

Analytics Requirements

Ensure that you have access to the CLPM analytics in the Analytics Catalog.

Browser Requirements

Only the Chrome 43 or higher browser is supported for accessing the Loop and Fleet Dashboards.

Define the Asset Model

Construct the asset ingestion file required by Application Analytics and perform asset ingestion.

The asset ingestion files (there can be several files or they can be combined into one) are JSON files that specify customer assets and their hierarchical structure or asset model. In the context of CLPM, the assets in this file are control loops that together define an industrial control system.

The basic structure of the files is as outlined in the APM Assets documentation for asset ingestion.

In addition to the required attributes that are standard for all such files, files describing control loop assets require custom attributes defined in the Control Loop Asset Definition for CLPM that you need to specify.

Note: It is important to ensure that your asset ingestion file conforms to the control loop asset definition for CLPM. If your file does not conform to this definition, CLPM will be unable to function correctly.

To define the asset model, carefully follow the instructions given with the Control Loop Asset Definition for CLPM.

Deploy Data Collection

Collect data into TimeSeries for all the analytic input tags as defined in your asset model. The recommended rate for data collection is every 5 seconds or slower.

Once you have set up data collection, you are ready to set up control mode logic.

Set Up Control Mode Logic

Set up control mode logic for CLPM by creating and deploying your Control Mode Analytic. Use the Python example provided here to create a Predix Insights-based analytic.

What Is the Control Mode Analytic?

CLPM analytics require an input tag that describes the current control mode for each loop. The control mode tag must contain values of type `double` and must be one of the following:

Tag Value	Description
1	A tag value of 1 indicates a control loop that is currently operating manually. The controller is not controlling the process.
2	A tag value of 2 indicates a control loop where the process is currently being controlled by the controller.
3	A tag value of 3 indicates a controller that is currently set to CASCADE.
4	A tag value of 4 indicates a process that is currently shut down. **Note:** Most KPIs will not be calculated for this control mode.

CLPM provides an example Predix Insights analytic to get you started towards developing your own control mode analytic. The resulting analytic will vary depending on your available data, but each control mode analytic must produce a result that matches one of the tag values in the table above.

Example Control Mode Analytic

The Python script that follows can be used as the basis for you Control Mode Analytic.

```
'''
Created on Aug 30, 2018

@author:
'''
from pyspark.sql import SparkSession
from pyspark.sql import *
from pyspark.sql import functions
from pyspark.sql.types import *
from pyspark.sql.dataframe import *
from pyspark.sql.functions import *
import sys
import time
from datetime import datetime

class ControlModeScript():
    # ################ DO NOT EDIT ########################
    MANUAL = "1.0"
    AUTO = "2.0"
    CASCADE = "3.0"
    SHUTDOWN = "4.0"
    QUALITY_GOOD = "3"
    QUALITY_BAD = "0"
    # ################ END ########################

    # ################ MODIFY THIS FUNCTION ########################
    # When modifying this function, TQVs for the custom tags (Tag_VV,
Tag_XX, Tag_YY, Tag_ZZ) can be obtained as follows:
    #     * timestamp is common amongst all tags
    #     * quality_XX is quality of Tag_XX, quality_YY is quality of
Tag_YY and so on
    #     * value_XX is value of Tag_XX, value_YY is value of Tag_YY
and so on
    #
    def control_mode_query(self):

        # The example SQL query below does the following:
        # select timestamp as the timestamp of the tag
        # always select quality as good
        # if quality is bad
        #    select value as shutdown
        # else if value of tag_XX is 1
        #    select value as MANUAL
        # else if value of tag_YY is 1
        #    select value as AUTO
        # else if value of tag_ZZ is 1
        #    select value as CASCADE
        # else
        #    select value as SHUTDOWN
        string = "timestamp as timestamp, CASE WHEN quality_XX != 3 OR
quality_YY != 3 OR quality_ZZ != 3 OR quality_VV != 3 THEN " +
self.SHUTDOWN
        string += " WHEN value_XX = 1 THEN "+self.MANUAL+" WHEN
value_YY = 1 THEN "+self.AUTO+" WHEN value_ZZ = 1 THEN "+self.CASCADE
+" WHEN value_VV = 1 THEN "+self.SHUTDOWN+" ELSE "+self.SHUTDOWN+" END
as value," + self.QUALITY_GOOD +" as quality"
        return string
```

```
    # ################ END ########################

    # ################ DO NOT EDIT ########################
    def run_job(self, spark_session, runtime_config, job_json,
context_dict, logger):
            try:
                spark = spark_session
                logger.info("Starting analytic...")
                configContext = context_dict["configDS"]
                tsContext = context_dict["timeseriesReadDS"]
                configDF = configContext.sql("select * from " +
context_dict["configDS"].table_name)
                configDF.createOrReplaceTempView("configDF")
                tsDF = tsContext.sql("select * from " +
context_dict["timeseriesReadDS"].table_name)
                tsDF.createOrReplaceTempView("timeseriesReadDF")

                Tag_XXDDF = tsContext.sql("SELECT c.AssetSourceKey as
asset, t.timestamp as timestamp, t.value as value_XX, t.quality as
quality_XX FROM `timeseriesReadDF`"
                    + " t JOIN `configDF` c on t.tag = c.MappingValue
WHERE c.MappingKey = 'Tag_XX' DISTRIBUTE BY asset")
                Tag_XXDDF.createOrReplaceTempView("tag_XXDDF")


                Tag_YYDDF = tsContext.sql("SELECT c.AssetSourceKey as
asset, t.timestamp as timestamp, t.value as value_YY, t.quality as
quality_YY FROM `timeseriesReadDF"
                                             + "` t JOIN `configDF` c
on t.tag = c.MappingValue WHERE c.MappingKey = 'Tag_YY' DISTRIBUTE BY
asset")
                Tag_YYDDF.createOrReplaceTempView("tag_YYDDF")

                Tag_ZZDDF = tsContext.sql("SELECT c.AssetSourceKey as
asset, t.timestamp as timestamp, t.value as value_ZZ, t.quality as
quality_ZZ FROM `timeseriesReadDF"
                                             + "` t join `configDF` c
on t.tag = c.MappingValue WHERE c.MappingKey = 'Tag_ZZ' DISTRIBUTE BY
asset")
                Tag_ZZDDF.createOrReplaceTempView("tag_ZZDDF")

                Tag_VVDDF = tsContext.sql("SELECT c.AssetSourceKey as
asset, t.timestamp as timestamp, t.value as value_VV, t.quality as
quality_VV FROM `timeseriesReadDF"
                                             + "` t JOIN `configDF` c
on t.tag = c.MappingValue WHERE c.MappingKey = 'Tag_VV' DISTRIBUTE BY
asset")
                Tag_VVDDF.createOrReplaceTempView("tag_VVDDF")

                Tag_XXYYDF =  tsContext.sql("SELECT
COALESCE(tag_XXDDF.asset, tag_YYDDF.asset) as
asset,COALESCE(tag_XXDDF.timestamp,tag_YYDDF.timestamp) as timestamp,
tag_XXDDF.value_XX, tag_XXDDF.quality_XX,
tag_YYDDF.quality_YY,tag_YYDDF.value_YY FROM tag_XXDDF FULL OUTER JOIN
tag_YYDDF ON tag_XXDDF.asset = tag_YYDDF.asset and tag_XXDDF.timestamp
= tag_YYDDF.timestamp DISTRIBUTE BY asset")
                Tag_ZZVVDF =  tsContext.sql("SELECT
COALESCE(tag_ZZDDF.asset, tag_VVDDF.asset) as
asset,COALESCE(tag_ZZDDF.timestamp,tag_VVDDF.timestamp) as
timestamp,tag_ZZDDF.quality_ZZ, tag_ZZDDF.value_ZZ,
tag_VVDDF.quality_VV,tag_VVDDF.value_VV FROM tag_ZZDDF FULL OUTER JOIN
```

```
tag_VVDDF ON tag_ZZDDF.asset = tag_VVDDF.asset and tag_ZZDDF.timestamp
= tag_VVDDF.timestamp DISTRIBUTE BY asset")
                Tag_XXYYDF.createOrReplaceTempView("tag_XXYYDF")
                Tag_ZZVVDF.createOrReplaceTempView("tag_ZZVVDF")
                timeseriesDF =  tsContext.sql("SELECT
COALESCE(tag_XXYYDF.asset,tag_ZZVVDF.asset) as asset,
COALESCE(tag_XXYYDF.timestamp,tag_ZZVVDF.timestamp) as timestamp,
tag_XXYYDF.quality_XX, tag_XXYYDF.value_XX,
tag_XXYYDF.quality_YY,tag_XXYYDF.value_YY,
tag_ZZVVDF.quality_ZZ,tag_ZZVVDF.value_ZZ,
tag_ZZVVDF.quality_VV,tag_ZZVVDF.value_VV FROM tag_XXYYDF FULL OUTER
JOIN tag_ZZVVDF ON tag_XXYYDF.asset = tag_ZZVVDF.asset and
tag_XXYYDF.timestamp = tag_ZZVVDF.timestamp")
                timeseriesDF.createOrReplaceTempView("collectedDS")

                queryString = "SELECT configDF.MappingValue as tag, "
                queryString +=  self.control_mode_query()
                queryString += " FROM `collectedDS` JOIN `configDF` on
collectedDS.asset = configDF.assetSourceKey WHERE configDF.mappingType
= 'OutputMappings'"
                resultDF = tsContext.sql(queryString)
                resultDF.createOrReplaceTempView("resultDF")
                timeseriesWriteDF = tsContext.sql("SELECT tag,
timestamp, CAST((value) as double) as value, quality FROM `resultDF`")
                logger.info("Returning result...")
                result = {"timeseriesWriteDS" : timeseriesWriteDF}
                return result

            except Exception as e:
                print("ERROR RETURNED")
                logger.info("Error: " + str(e))
                exc_tb = sys.exc_info()[2]
                logger.info("Line number: " + str(exc_tb.tb_lineno))
    # ################ END ########################
```

Control Mode Constants

The script includes the following constants to represent the various control modes:

- MANUAL
- AUTO
- CASCADE
- SHUTDOWN

Available Tags

The following configurable tags can be queried in the script. These tags will be mapped to tags in Predix TimeSeries.

- Tag_VV
- Tag_XX
- Tag_YY
- Tag_ZZ

For these tags, the timestamp, quality, and value (T,Q,V) are represented in a table with the following columns:

Timestamp	value_VV	quality_VV	value_XX	quality_XX	value_YY	quality_YY	value_ZZ	quality_ZZ

Note: The timestamp is common among all these tags.

Example Query

The script includes the following example query:

```
def control_mode_query(self):
        string = "timestamp as timestamp, CASE WHEN quality_XX != 3 OR
quality_YY != 3 OR quality_ZZ != 3 OR quality_VV != 3 THEN " +
self.SHUTDOWN
        string += " WHEN value_XX = 1 THEN "+self.MANUAL+" WHEN
value_YY = 1 THEN "+self.AUTO+" WHEN value_ZZ = 1 THEN "+self.CASCADE
+" WHEN value_VV = 1 THEN "+self.SHUTDOWN+" ELSE "+self.SHUTDOWN+" END
as value," + self.QUALITY_GOOD +" as quality"
        return string
```

The preceding query does the following:

1. Sets the control mode timestamp to the timestamp used by these tags.
2. Sets the control mode quality to good.
3. Sets the control mode value as follows:
    a. If the quality of any of the tags is bad, sets the control mode value to SHUTDOWN.
    b. Else if the value of tag_XX is 1, sets the control mode value to MANUAL.
    c. Else if the value of tag_YY is 1, sets the control mode value to AUTO.
    d. Else if the value of tag_ZZ is 1, sets the control mode value to CASCADE.
    e. Else, sets the control mode value to SHUTDOWN.

You should create your own query, based on your own business needs.

Modify the Control Mode Analytic

Modify the `control_mode_query()` function in the Python script, building up a SQL string to query one or more of the available tags and (based on the T,Q,V of these tags) to return a T,Q,V for the control mode.

Note: You should modify ONLY the `control_mode_query()` function in this template. Do not modify anything else in the template.

Note: You MUST use Tag_VV in your query. Using the other available tags in your query is optional.

Create Your Analytic Template

Once you have modified the Python script to include the control mode logic you require, do the following.

Procedure

1. For the Control Mode Template Analytic, create a Spark analytic called OPM-CLPM-Control_Mode, following the guidance given in the Spark and Application Analytics documentation.
2. Publish the analytic to the Analytics Catalog.
3. Set up the input and output definitions as follows:

Table 1: INPUT DEFINITION: TAGS

Name	Type	Required
Tag_VV	Double	Yes
Tag_XX	Double	No
Tag_YY	Double	No
Tag_ZZ	Double	No

Note: For each of the tags used in your Control Mode Analytic, ensure that you specify the corresponding tag as Required in the input definition.

Table 2: OUTPUT DEFINITION: TAGS

Name	Type	Required
Control Mode	Double	Yes

Next Steps

Now that you have set up the control mode logic, you are ready to deploy the CLPM analytics.

Deploy CLPM Analytics

Deploy each of the CLPM analytics as described in this section.

Overview of CLPM Analytics

The following specialized analytics are provided with CLPM, and these are used for data collection and transformation.

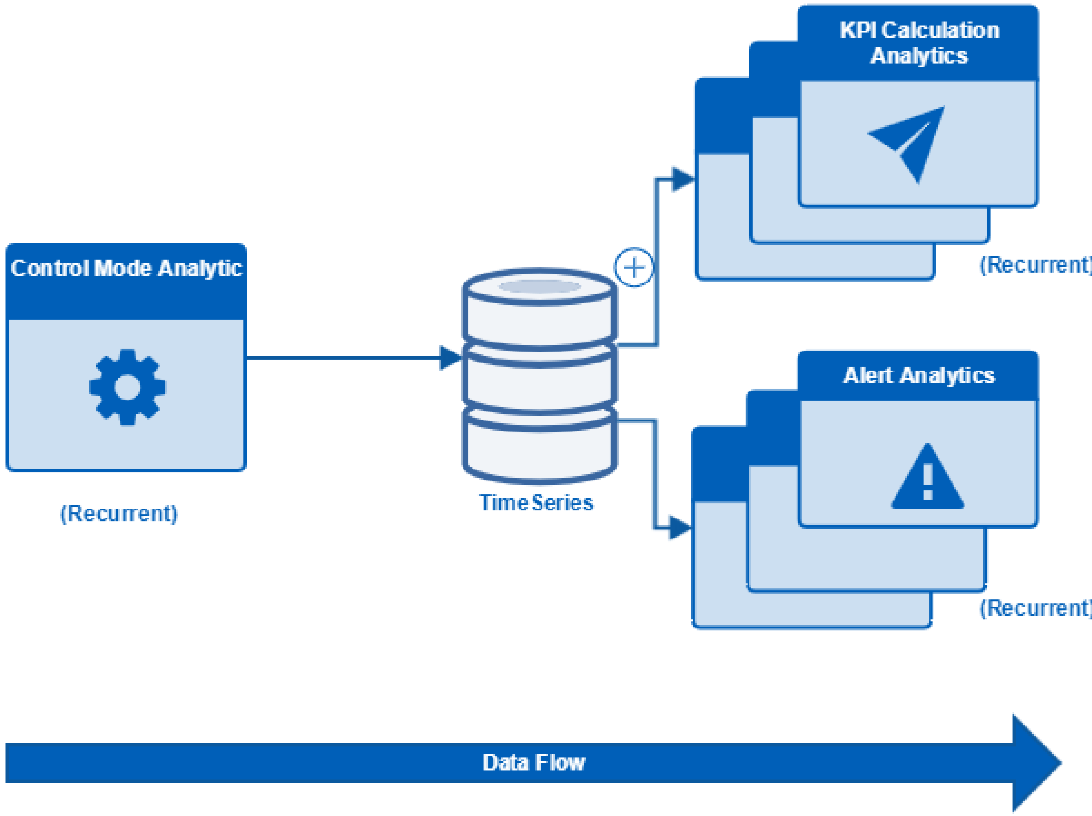
Table 3: CLPM Analytics

Analytic Name	Use	Location
OPM-CLPM-Control_Mode	Operates on scheduled data and contains the control mode logic.	Will be in your Analytics Catalog if you have correctly performed the step to Set Up Control Mode Logic.
OPM-CLPM-PV_Statistics	Scheduled and produces the following KPIs based on the incoming data: • PV Error • Lower SP Threshold • Upper SP Threshold Consult the KPI Reference for details on the KPIs produced by this analytic.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.
OPM-CLPM-Performance	Scheduled and produces a set of performance KPIs based on the incoming data. Consult the KPI Reference for details on the KPIs produced by this analytic.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.

Analytic Name	Use	Location
OPM-CLPM-Performance_Ext	Scheduled and produces a set of performance KPIs based on the incoming data. Consult the KPI Reference for details on the KPIs produced by this analytic.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.
OPM-CLPM-Config_Change	Scheduled and produces the Total PIDF Changes KPI based on the incoming data. Consult the KPI Reference for details on this KPI.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.
OPM-CLPM-Alert_Perf	Scheduled and produces an alert for poor overall performance. The Overall Performance KPI is compared to a threshold configured on the analytic. For the last 3 hourly calculated samples, if the Overall Performance KPI is greater than the threshold, an alert is triggered. Consult the KPI Reference for details on the Overall Performance KPI.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.
OPM-CLPM-Alert_Limits	Scheduled and produces an alert for limits being exceeded. The Percentage Limits Exceeded KPI is compared to a threshold configured on the analytic. For the last 3 hourly calculated samples, if the Percentage Control On KPI is 100% and the Percentage Limits Exceeded KPI is greater than the threshold, an alert is triggered. Consult the KPI Reference for details on the Percentage Limits Exceeded KPI and Percentage Control On KPI.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.

<table>
<tr><th>Analytic Name</th><th>Use</th><th>Location</th></tr>
<tr><td>OPM-CLPM-Alert_Manual</td><td> Scheduled and produces an alert for control mode changing to Manual Mode. Control mode changes are examined over a data window of one hour. If the last control mode change detected is a change from Auto, Cascade, or Shutdown Mode to Manual Mode, an alert is triggered. For example, the following control modes recorded over the window have the following corresponding results. (Auto = A, Cascade = C, Shutdown = S, Manual = M) |SMASAM|: A to M is last change. Alert! |AAAMMM|: A to M is last change. Alert! |MMCMCM|: C to M is last change. Alert! |AAAAMS|: M to S is last change. No alert. |MMMMMS|: M to S is last change. No alert. |SMMMMM|: S to M is last change. Alert!</td><td>Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.</td></tr>
<tr><td>OPM-CLPM-Alert_PV_Quality</td><td> Scheduled and produces an alert for poor PV sensor data, indicating that a possible PV sensor health problem has been detected. This alert is triggered when the control mode is not Shutdown and either of the following is true: Percentage of PV sensor data of good quality is lower than a threshold configured on the analytic.
The PV Variance KPI is zero (that is, the PV is flatlining). Consult the KPI Reference for details on the PV Variance KPI. Recommendation: If running this analytic triggers an alert, check the PV sensor data collection and sensor health. </td><td>Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.</td></tr>
</table>

Analytic Name	Use	Location
OPM-CLPM-Alert_Tuning	Scheduled and produces an alert indicating possible loop tuning or design problems. This alert is triggered when all of the following are true: • The Reversal Count KPI is greater than a threshold configured on the analytic. • The Reversal Amplitude KPI is greater than a threshold configured on the analytic. • The Percentage MV Saturation KPI is less than a threshold configured on the analytic. • The Percentage Control On KPI is 100%. • The Percentage Limits Exceeded KPI is greater than a threshold configured on the analytic. Consult the KPI Reference for details on each of the KPIs involved in triggering this alert. Recommendation: If running this analytic triggers an alert, review the loop tuning and design.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.
OPM-CLPM-Alert_MV_Quality	Scheduled and produces an alert for poor MV sensor data, indicating that a possible actuator health problem has been detected. This alert is triggered when the controller is on and any of the following is true: • Percentage of MV sensor data of good quality is lower than a threshold configured on the analytic. • The Movement Index KPI is zero (that is, the MV is flatlining). • The Percentage MV Saturation KPI is greater than a threshold configured on the analytic. Consult the KPI Reference for details on each of the KPIs involved in triggering this alert. Recommendation: If running this analytic triggers an alert, check the MV sensor data collection and actuator health.	Located in your Analytics Catalog. If you do not find it there, contact your tenant administrator.



Deploy analytics

Before You Begin

Make sure that you have set up control mode logic.

About This Task

```
This task describes how to deploy a single CLPM analytic.
```

Note: Using the steps described here, all CLPM analytics must be deployed, starting with the OPM-CLPM-Control_Mode analytic.

Note: Variations in configuration between the different kinds of CLPM analytics are explained in the tables that follow the procedure.

Procedure

1. Log into your tenant.
2. In the module navigation menu, select **Analytics** > **Deployments**.
3. Select the **Add** icon () next to **Deployments** to add a deployment.
4. In the **New Deployment** window, select Analytic Template.
5. Enter a value in the **Deployment Name** box.

   Make sure you enter a unique name. The system checks for duplicates.

The **Author** box will be pre-populated with your login name and cannot be modified.

6. Enter a value in the **Template Name** box for the particular CLPM Analytic. All CLPM analytics start with OPM-CLPM-...

   This field is pre-populated to autocomplete with all matching options for the template name you specify. You cannot modify any of these names; you must select one of them.
7. Step through the deployment wizard, in the same way you would for other kinds of analytics. Refer to the APM Analytics documentation for details on how to map analytic inputs and outputs to tags. For CLPM analytic configuration, it is important to adhere to the CLPM-specific guidance in the tables that follow.
8. Select **Deploy**.

CLPM Analytic Configuration

These tables give a configuration reference for the different types of CLPM analytics.

- OPM-CLPM-Control_Mode
- KPI analytics (share common configuration)
  - OPM-CLPM-Performance
  - OPM-CLPM-Performance_Ext
  - OPM-CLPM-PV_Statistics
- KPI analytic: OPM-CLPM-Config_Change
- Alert analytic: OPM-CLPM-Alert_Perf
- Alert analytic: OPM-CLPM-Alert_Limits
- Alert analytic: OPM-CLPM-Alert_Manual
- Alert analytic: OPM-CLPM-Alert_PV_Quality
- Alert analytic: OPM-CLPM-Alert_Tuning
- Alert analytic: OPM-CLPM-Alert_MV_Quality

OPM-CLPM-Control_Mode Analytic

Configure the OPM-CLPM-Control_Mode analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All analytics are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Control_Mode** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	It is mandatory to map the Tag_VV input. The Tag_XX, Tag_YY, and Tag_ZZ inputs are optional.	Map the analytic inputs to tags on the selected control loop asset. These tags are used to determine control mode logic.
	OUTPUT DEFINITION: TAGS & ATTRIBUTES	It is mandatory to map the Control Mode output. This tag specifies the control mode logic.	Map the analytic outputs to tags on the selected control loop asset. Ensure that the analytic output name matches the corresponding mapped tag name exactly.
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 10 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 10 minutes	
	DATA REQUEST > **Sample Duration**	Required value: 10 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 second	
4. Review			Review the deployment to ensure that all configuration is correct.

KPI Analytics

Configure the following KPI analytics as described in the table that follows.

- OPM-CLPM-Performance
- OPM-CLPM-Performance_Ext
- OPM-CLPM-PV_Statistics

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All analytics are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **<analytic_name>** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES		Map the analytic inputs to tags on the selected control loop asset. Ensure that each analytic input name matches the corresponding mapped tag name exactly.
	OUTPUT DEFINITION: TAGS & ATTRIBUTES		Map the analytic outputs to tags on the selected control loop asset. Ensure that the analytic output name matches the corresponding mapped tag name exactly.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Required value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 second	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Config_Change Analytic

Configure the OPM-CLPM-Config_Change analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All analytics are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Config_Change** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Not all the P, I, D, and F inputs need to be mapped, as these inputs are optional. However, some will have to be mapped.	Map the analytic inputs to tags on the selected control loop asset. Ensure that each analytic input name matches the corresponding mapped tag name exactly.
	OUTPUT DEFINITION: TAGS & ATTRIBUTES		Map the analytic outputs to tags on the selected control loop asset. Ensure that the analytic output name matches the corresponding mapped tag name exactly.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Required value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 second	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_Perf Analytic

Configure the OPM-CLPM-Alert_Perf analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_Perf** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: Overall Performance, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Overall Performance tag is a KPI tag produced by a previously run CLPM analytic.
	CONSTANTS:	Name: Threshold, Type: Double, Value: <a value between 0 and 100>, Data Format: Constant	Define a threshold constant for the analytic. The Overall Performance KPI is compared to this threshold maximum value. For the last 3 hourly calculated samples, if the Overall Performance KPI is greater than the threshold, an alert is triggered. Consult the KPI Reference for details on the Overall Performance KPI.
		[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Loop_Performance, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Loop_Performance, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Required value: 180 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 hour	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_Limits Analytic

Configure the OPM-CLPM-Alert_Limits analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.

Wizard Page	Option	Values	Comments
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_Limits** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: Percentage Limits Exceeded, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage Limits Exceeded tag is a KPI tag produced by a previously run CLPM analytic.
		Required input tag: Percentage Control On, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage Control On tag is a KPI tag produced by a previously run CLPM analytic.
	CONSTANTS:	Name: Threshold, Type: Double, Value: <a value between 0 and 100>, Data Format: Constant	Define a threshold constant for the analytic. The Percentage Limits Exceeded KPI is compared to this threshold maximum value. For the last 3 hourly calculated samples, if the Percentage Control On KPI is 100% and the Percentage Limits Exceeded KPI is greater than this threshold, an alert is triggered. Consult the KPI Reference for details on the Percentage Limits Exceeded KPI.
		[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Limits_Exceeded, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Limits_Exceeded, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Required value: 180 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 hour	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_Manual Analytic

Configure the OPM-CLPM-Alert_Manual analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_Manual** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: Control Mode, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly.
	CONSTANTS:	[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Manual_Control, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Manual_Control, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Any window size acceptable. Recommended value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Recommended value: 1 second or the rate at which control mode values are written to Predix Timeseries	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_PV_Quality Analytic

Configure the OPM-CLPM-Alert_PV_Quality analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_PV_Quality** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: PV, Type: Double	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. This tag is needed to calculate percentage good quality. For the calculated samples over the last data window, the percentage of PV values that are of good quality is compared to the PV_Quality_Threshold constant you will configure on this page.
		Required input tag: PV Variance, Type: Double	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The PV Variance tag is a KPI tag produced by a previously run CLPM analytic. If the PV Variance KPI is zero (i.e., the PV is flatlining) for the calculated samples over the last data window, and the control mode is not Shutdown, an alert is triggered.

Wizard Page	Option	Values	Comments
	CONSTANTS:	Required input tag: Control Mode, Type: Double	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly.
		Name: PV_Quality_Threshold, Type: Double, Value: <a value between 0 and 100>, Data Format: Constant	Define a threshold percentage constant for the analytic. For the calculated samples over the last data window, the percentage of PV values that are of good quality is compared to this threshold percentage. If that quality is lower than the threshold, and the control mode is not Shutdown, an alert is triggered.
		[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Sensor_Health, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Sensor_Health, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Minimum value: 60 minutes, Recommended value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Recommended value: 1 second or the rate at which control mode and PV values are written to Predix Timeseries	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_Tuning Analytic

Configure the OPM-CLPM-Alert_Tuning analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.

Wizard Page	Option	Values	Comments
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_Tuning** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: Reversal Count, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Reversal Count tag is a KPI tag produced by a previously run CLPM analytic. This KPI is compared to the Reversal_Count_Threshold constant you will configure on this page.
		Required input tag: Reversal Amplitude, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Reversal Amplitude tag is a KPI tag produced by a previously run CLPM analytic. This KPI is compared to the Reversal_Amplitude_Threshold constant you will configure on this page.
		Required input tag: Percentage MV Saturation, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage MV Saturation tag is a KPI tag produced by a previously run CLPM analytic. This KPI is compared to the Percentage_MV_Saturation_Threshold constant you will configure on this page.

Wizard Page	Option	Values	Comments
		Required input tag: Percentage Control On, Type: Double, Value: <a value between 0 and 100>	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage Control On tag is a KPI tag produced by a previously run CLPM analytic. If the Percentage Control On KPI is 100%, this satisfies one of the requirements for an alert to be triggered.
		Required input tag: Percentage Limits Exceeded, Type: Double.	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage Limits Exceeded tag is a KPI tag produced by a previously run CLPM analytic. This KPI is compared to the Percentage_Limits_Exceeded_Threshold constant you will configure on this page.

Wizard Page	Option	Values	Comments
	CONSTANTS:	Name: Reversal_Count_Threshold, Type: Double, Value: <any whole number>, Data Format: Constant	Define a reversal count threshold constant for the analytic. For the calculated samples over the last data window, the Reversal Count KPI is compared to this threshold. If the KPI is greater than the threshold, this satisfies one of the requirements for an alert to be triggered.
		Name: Reversal_Amplitude_Threshold, Type: Double, Value: <any whole number>, Data Format: Constant	Define a reversal amplitude threshold constant for the analytic. For the calculated samples over the last data window, the Reversal Amplitude KPI is compared to this threshold. If the KPI is greater than the threshold, this satisfies one of the requirements for an alert to be triggered.
		Name: Percentage_MV_Saturation_Threshold, Type: Double, Value: <any whole number>, Data Format: Constant	Define a percentage MV saturation threshold constant for the analytic. For the calculated samples over the last data window, the Percentage MV Saturation KPI is compared to this threshold. If the KPI is less than the threshold, this satisfies one of the requirements for an alert to be triggered.
		Name: Percentage_Limits_Exceeded_Threshold, Type: Double, Value: <any whole number>, Data Format: Constant	Define a percentage limits exceeded threshold constant for the analytic. For the calculated samples over the last data window, the Percentage Limits Exceeded KPI is compared to this threshold. If the KPI is greater than the threshold, this satisfies one of the requirements for an alert to be triggered.
		[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Loop_TuningOrDesign, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.

Wizard Page	Option	Values	Comments
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Loop_TuningOrDesign, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Minimum value: 60 minutes, Recommended value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Required value: 1 hour	
4. Review			Review the deployment to ensure that all configuration is correct.

OPM-CLPM-Alert_MV_Quality Analytic

Configure the OPM-CLPM-Alert_MV_Quality analytic as described in the table that follows.

Wizard Page	Option	Values	Comments
1. Asset Selection: Select the target control loop assets for the analytic deployment.	Asset Filters	All Assets	Filter on All Assets. Use the search to select the target control loop assets for the analytic deployment. **Note:** All assets are selected by default, so you will need to deselect all those you do not want and use the search to find the ones you do want.

Wizard Page	Option	Values	Comments
2. I/O Mapping: Map inputs and outputs in your analytic template definitions to tags on the control loop asset.	**SELECTED STEP**: **OPM-CLPM-Alert_MV_Quality** > **Tag Mapping**	Map for All Assets	
	INPUT DEFINITION: TAGS & ATTRIBUTES	Required input tag: MV, Type: Double	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. This tag is needed to calculate percentage good quality. For the calculated samples over the last data window, the percentage of MV values that are of good quality is compared to the MV_Quality_Threshold constant you will configure on this page.
		Required input tag: Movement Index, Type: Double	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Movement Index tag is a KPI tag produced by a previously run CLPM analytic. If the Movement Index KPI is zero (i.e., the MV is flatlining) for the calculated samples over the last data window, this satisfies one of the requirements for an alert to be triggered.
		Required input tag: Percentage MV Saturation, Type: Double, Value: <a value between 0 and 100>	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage MV Saturation is a KPI tag produced by a previously run CLPM analytic. For the calculated samples over the last data window, the Percentage MV Saturation KPI is compared to the Percentage_MV_Saturation_Threshold constant you will configure on this page.

Wizard Page	Option	Values	Comments
		Required input tag: Percentage Control On, Type: Double, Value: <a value between 0 and 100>	Map the analytic input to the tag on the selected control loop asset. Ensure that the analytic input name matches the corresponding mapped tag name exactly. The Percentage Control On tag is a KPI tag produced by a previously run CLPM analytic. If the Percentage Control On KPI is 100%, this satisfies one of the requirements for an alert to be triggered.
	CONSTANTS:	Name: MV_Quality_Threshold, Type: Double, Value: <a value between 0 and 100>, Data Format: Constant	Define a threshold percentage constant for the analytic. For the calculated samples over the last data window, the percentage of MV values that are of good quality is compared to this threshold percentage. If that quality is lower than the threshold, this satisfies one of the requirements for an alert to be triggered.
		Name: Percentage_MV_Saturation_Threshold, Type: Double, Value: <a value between 0 and 100>, Data Format: Constant	Define a percentage MV saturation threshold constant for the analytic. For the calculated samples over the last data window, the Percentage MV Saturation KPI is compared to this threshold. If the KPI is less than the threshold, this satisfies one of the requirements for an alert to be triggered.
		[Prepopulated Constant] Name: alertTemplateName, Value: CLPM-Actuator_Health, Type: String, Data Format: Constant	**Note:** This constant is already defined on the analytic. Do not modify this constant.
	OUTPUT DEFINITION: ALERTS	[Prepopulated Alert] Name: CLPM-Actuator_Health, Active: On	**Note:** This alert mapping is already defined on the analytic. Do not modify this alert mapping.

Wizard Page	Option	Values	Comments
3. Schedule	**SCHEDULE**	Required value: Recurrent	
	SCHEDULE > **Repeats Every**	Required value: 60 minutes	
	DATA REQUEST > **Offset Before Schedule**	Required value: 60 minutes	
	DATA REQUEST > **Sample Duration**	Minimum value: 60 minutes, Recommended value: 60 minutes	
	DATA REQUEST > **Sample Data**	Required value: Interpolated	
	DATA REQUEST > **Sampling Interval**	Recommended value: 1 second or the rate at which MV values are written to Predix Timeseries	
4. Review			Review the deployment to ensure that all configuration is correct.

Access Loop and Fleet Dashboards

About This Task

Loop and Fleet dashboards are deployed automatically when you deploy CLPM as part of tenant set up. No additional steps are required. You can access the Loop and Fleet dashboards.

Chapter 3

The Fleet Report

Topics:

The Fleet Report

The Fleet Report provides a summary of all loops in the selected asset context for the selected time period. The report contains the following information:

- Average Control Loop Performance chart
- The Diagnostic Alerts Filtering smart filter
- Control Loop Performance table

Note:

- CLPM analytics process raw tag data and produce results that are interpolated. These interpolated results are then used to produce the Fleet Report chart and table.
- The measures presented in the Fleet Report are derived from KPIs that are produced by CLPM analytics. Consult the KPI Reference for details on these KPIs.

Access the Fleet Report

Procedure

In the module navigation menu, select **Intelligence** and then go to **Control Loop Performance**.
The Fleet Report appears, displaying the Average Control Loop Performance graph, diagnostics alerts filtering, and the Control Loop Performance table on selecting the required asset context, in the **Select Context** window. By default, the data reported in the Fleet Report is for seven days prior to the current date.

Note: Control Loop Performance reports are also accessible from the **Dashboard** menu.

Tip: If needed, you can perform the following steps:

- Modify the asset context by selecting **SELECT ASSET CONTEXT**, navigating to the asset, and then selecting **OPEN**.
- Modify the date range for which the data is reported.

Modify the Date Range for a Fleet Report

Procedure

1. Access the Fleet Report.
2. In the **Fleet Report** workspace, specify the new date range by selecting the start date and end date. The report is updated with the new data.

   Note: The date and time range for the reported data also appears in the report.

   Important: The Fleet Report supports only a date range of up to 30 days.

   Note: When you navigate from a Fleet Report to a Loop Report, the Loop Report is plotted with the end date selected in the Fleet Report. For example, if the date range selected in the Fleet Report is 12th November, 2018 00:00:00 to 18th November, 2018 23:59:59 (the last data point is from 19th November, 2018 00:00:00 to include any last micro second data point), after you navigate to the Loop Report, the Loop Report is plotted with data reported for 18th November, 2018 (that is, 18th November, 2018 00:00:00 to 19th November, 2018 00:00:00).

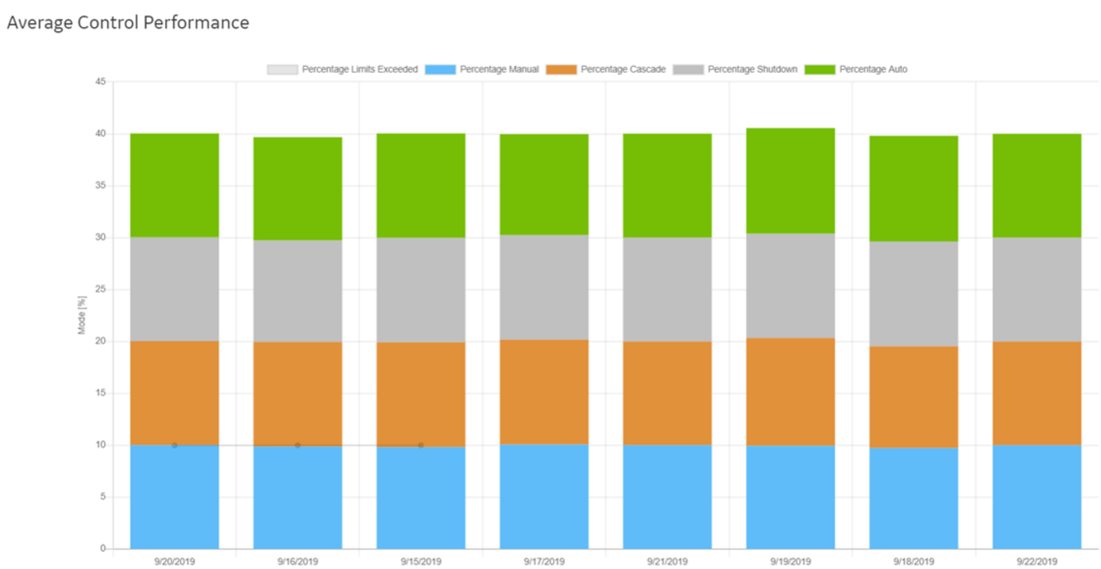
Average Control Loop Performance Chart

About the Average Control Loop Performance Chart

The Average Control Loop Performance chart contains a stacked-bar graph and a trend line. Each item in a stack represents the percentage of time the control element operated at each of the following control modes during the reporting period:

- Manual
- Auto
- Cascade
- Shutdown

The trend line represents the percentage of time the control element operated out of the specified limits during the reporting period.



The chart contains the following axes:

- x-axis: Represents the date for which the data is plotted.
- y-axis: Represents the percentage of time the control element operated at each control mode. It is calculated based on hourly samples for each date.

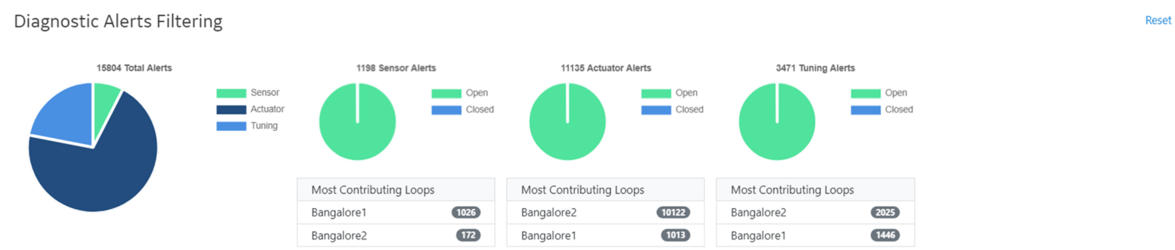
The Diagnostic Alerts Filtering Smart Filter

The Diagnostic Alerts Filtering smart filter is a visual tool to identify faulty control loops. Using this filter, you can perform the following tasks:

- Identify control loops based on diagnostic alerts.
- Classify the loops in three fault categories, namely Sensor, Actuator, and Tuning.
- Drill down into the status of the alerts to find the list of control loops where action is needed.
- Identify bad actors (poorly performing loops) among a large set of control loop assets.

Note: The filter is limited to the control loop diagnostic alert generated based on pre-defined probabilistic analytics.

The filter displays the number of alerts for each fault mode and the total number of alerts using interactive pie charts.



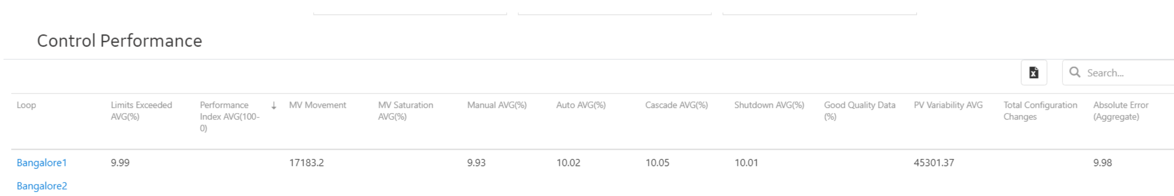
The pie charts illustrate the different fault modes of your control loops and the corresponding number of alerts. Each pie chart is further classified based on the alert status. The pie charts display the total the number of open and closed alerts. Each pie chart has a list displaying the top three control loops contributing the most number of alerts, in descending order.

On selecting the **Open** area of the pie chart, the details about the loops with the open alerts are updated in the list below the pie charts. Also, the **Control Loop Performance** table is updated to list only the control loops with open alerts.

Tip: Select **Reset** to reset the **Diagnostic Alerts Filtering** smart filter and the **Control Loop Performance** table.

The Control Loop Performance Table

Note: By default, the **Control Loop Performance** table is not populated with details about the control loops. Select **Show all** to access the list of all the control loops in the table.



In the Fleet Report, you can modify the reporting period by selecting a date prior to the current date in the **Date Selector** box. You can sort data based on any column in this table. By default, the table is sorted based on the value in the **Performance Index AVG (100-0)** column.

You can filter data in the table by:

- Applying a global filter on the table
- Using multiple-level filters
- Using text in the filter field
- Using conditional parameters

You can search for a specific control loop using different search options.

For each loop in the selected asset context, the table contains the following information.

Loop Statistic	Interpretation
Loop	The name of the control loop asset. If you select the link in this column, the Loop Report appears.
Limits Exceeded AVG (%)	The percentage of time for which the loop was in Auto, Cascade, or Manual mode, where the limits for these modes were exceeded. The time when the loop was in shutdown mode is not included in this statistic.
Performance Index AVG (100-0)	The average of the performance index during the specified reporting period. The value ranges from 100 to 0, where 100 indicates poor performance and 0 indicates good performance. By default, the table is sorted based on the value in this column. The performance index is an aggregate of the following values in the following proportions: • One-third of the performance index value is composed of the percentage of time for which the loop limits were exceeded. The time when the loop was in the shutdown mode is not included in this statistic. • One-third of the performance index value is composed of the percentage of time for which the loop was in the manual control mode. • One-third of the performance index value is composed of the percentage of time for which the controller output was saturated. The controller output is considered saturated when the MV has a value of 0 or 100, which are the lower and upper limits for controller output saturation, respectively. A higher average performance index indicates that the loop is not performing well.
MV Movement	The average number of oscillations of the manipulated variable. You can use this statistic to investigate the ability of the control element to maintain the PV operating within process limits.
MV Saturation AVG (%)	The percentage of time that the MV for each loop was saturated.
Manual AVG (%)	The percentage of time that the loop was in the manual control mode.
Auto AVG (%)	The percentage of time that the loop was in the auto control mode.
Cascade AVG (%)	The percentage of time that the loop was in the cascade control mode.
Shutdown AVG (%)	The percentage of time that the loop was in the shutdown control mode.
Good Quality Data (%)	The percentage of time that the data was of good quality.

Loop Statistic	Interpretation
PV Variability AVG	The average PV variability. This value is a measure of the data spread in the PV data set, expressed as a percentage. This is the average value of the PV Variability KPI. Refer to the KPI Reference for the definition of this KPI.
Total Configuration Changes	The number of times the controller configuration was changed during the reporting period.
Absolute Error (Aggregate) AVG	The average of the absolute values of all errors during the reporting period. Error is calculated as the difference between PV and SP. **Tip:** Sorting the table based on this field is useful only if all loops use the same unit of measure.

Chapter 4

The Loop Report

Topics:

About the Loop Report

The Loop Report provides a systematic approach to optimizing the performance of a control loop by monitoring the loop performance and providing diagnostic data about the loop. The report contains various charts and tables that help in assessing the performance of a control loop. The data used for assessing the performance of the loop is derived from the tags associated with the control loop assets.

Note: CLPM analytics process raw tag data and produce results that are interpolated. These interpolated results are then used to produce the Loop Report charts and tables.

Note: The measures presented in the Loop Report are derived from KPIs that are produced by CLPM analytics. Consult the KPI Reference for details on these KPIs.

Note: Unless otherwise stated, only data of good quality is considered when calculating the measures represented in these tables and charts. Bad quality data is ignored.

The Loop Report: Charts

The Loop Report contains the following charts:

- Process Variable Performance
- Manipulated Variable Distribution (%)
- Control Overview
- Error Distribution

The Loop Report: Tables

The Loop Report contains the following tables:

- Control Mode Summary
- Controller Performance
- PV Performance
- Error Statistics
- Controller Configuration

Access the Loop Report

About This Task

This topic describes how to access the Loop Report from the module navigation menu.

Procedure

1. In the **OPM** navigation menu, go to **Intelligence** > **Control Loop Performance**.
   The fleet dashboard appears, displaying the Average Control Loop Performance graph, diagnostic alerts filtering, and the Control Loop Performance Table on selecting the required asset in the **Select Context** window.
2. In the **Control Loop Performance Table** of an associated fleet report, select the link in the loop column.
   The Loop Report appears, displaying the preconfigured widgets for graphs and tables. The report contains data for the selected asset context from the Fleet Report.

Note: If there is no context selected, select the required asset by selecting the **Select Context** tab in the header.

Note: Control Loop Performance reports are also accessible from the **Dashboard** menu.

Modify the Date for a Loop Report

About This Task

This topic describes how to modify the date for a Loop Report.

Procedure

Note: By default, the Loop Report is plotted with data reported for the current date. For example, when you directly access the loop report on 12th November, 2018 20:00:00, the dashboard is plotted with data reported from 12th November, 2018 00:00:00 to 12th November, 2018 20:00:00 (till the latest available data point). The loop report can be displayed for a time period of one day only.

1. Access the Loop Report whose date you want to modify.
   The **Date Selector** box appears, displaying the default date. You can access data for a single day. Data is reported till the current time of the day. For example, if the current date and time is 20th November, 2018 20:00:00, and you select 20th November, 2018, then data is reported from 20th November, 2018 00:00:00 to 20th November, 2018 20:00:00. However, if the current date and time is 20th November, 2018 20:00:00, and you select 19th November, 2018, then data is reported from 19th November, 2018 00:00:00 to 20th November, 2018 00:00:00.
2. Select the **Date Selector** box.
   The date selector window appears.
3. Select the date you want to set, and then select **Apply**.
   The date is modified, and the report is updated. The date for which the data is reported appears in the upper-right corner of the report.

   Tip: You can reset the date to the default value by selecting **reset**.

The Process Variable Performance Chart

The process variable performance (PVP) chart helps in analyzing the trend of the process variable (PV) against the setpoint (SP).

The chart contains the following axes:

- x-axis: Represents the time period selected in the control loop report.
- y-axis: Represents the PV and SP values.

The trend of each value over the selected time period appears as a step chart, which helps you understand the magnitude of change at a specific timestamp. The following trend lines are plotted on the chart:

Trend Line	Description
PV	A step chart representing the trend of PV over the time period selected in the report. Consult the CLPM Terminology table for the definition of the PV.
SP	A step chart representing the trend of SP over the time period selected in the report. Consult the CLPM Terminology table for the definition of the SP.
Upper Limit	A step chart representing the trend of the acceptable upper limit for the PV value. The Upper Limit on this chart represents the Upper SP Threshold KPI. Consult the KPI Reference for the definition of the Upper SP Threshold.
Lower Limit	A step chart representing the trend of the acceptable lower limit for the PV value. The Lower Limit on this chart represents the Lower SP Threshold KPI. Consult the KPI Reference for the definition of the Lower SP Threshold.

Interpreting the PVP Chart

Based on the values plotted on the PVP chart, you can identify performance issues in the process control loop. The following table lists a few scenarios that may appear in the chart and what each scenario indicates about the loop performance:

Note: If data for a tag is missing, a message appears at the top of the page, specifying the tag for which the data is missing.

What You See	Interpretation	Suggested Action
The trend of the PV values is centered around the trend of the SP values.	Process is under control.	None. Maintain the parameter settings.
The trend of the PV values exceeds the trend of the upper or lower limit.	Process is not under control.	Tune the control loop to reduce process variation.
Gaps in the trend line.	The plotted data contains a mix of good and bad quality data.	Investigate why the quality of some data is bad.
A flat trend line appears.	• There has been no change in data for the time period selected. The last recorded value is maintained. -or- • The connection to a real-time server has been lost.	• Investigate why there is no change in data. • Fix the connection to the real-time server.
An empty chart.	The quality of all the data for the selected time period is bad.	Investigate why the quality of data is bad.

The Manipulated Variable Distribution Chart

The manipulated variable distribution (%) chart is a histogram that helps you analyze the efficiency of a control element and evaluate the suitability of the element for the process.

A control element receives the output signal from the controller and controls the operating conditions such as flow, pressure, temperature, and liquid level in response to the signal. The manipulated variable

(MV) is a percentage measure of the value at which the control element is functioning. For example, in the temperature control loop in an air conditioner, based on how much cooling is required (that is, setpoint), the thermostat (that is, the controller) sends a signal to manipulate the flow of cooling agent such that the room temperature (that is, the process variable) is adjusted to match the desired temperature. In this example, MV is the percentage of flow of cooling agent allowed through the valve.

The chart contains the following axes:

- x-axis: Represents the value of the MV measured in percentage
- y-axis: Represents the count of samples of the MV

The histogram represents the count of samples that the control element was set to at each percentage value, and not the length of time the element remained at each value. Therefore, you must always consider the distribution pattern of MV when interpreting the statistical significance of the samples displayed in this histogram.

Interpreting the Manipulated Variable Distribution Chart

Based on the values plotted on the chart, you can identify performance issues in the controller. The following table provides a few scenarios that may appear in the chart and what each scenario indicates regarding the controller performance.

Note: If data for a tag is missing, a message appears at the top of the page, specifying the tag for which the data is missing.

What you see	Interpretation	Required action
Red bars appear.	The samples can be interpreted as follows: • < 6%: Indicates that the control element is operating at a very low saturation level and that the element is oversized. • > 95%: Indicates that the control element is operating at a very high saturation level and that the element is undersized. A controller operating at the extreme high or low values of its capacity will result in asset fatigue over time.	Install a different type of controller, either a larger one that is more suitable for the purpose, or a smaller one that is more energy-efficient and cost-effective.
Yellow bars appear.	The samples can be interpreted as follows: • 6% - 30%: Indicates that the control element is operating close to its lower saturation level. • 71% - 95%: Indicates that the control element is operating close to its higher saturation level. A controller operating at high or low values of its capacity will result in asset fatigue over time.	Monitor the control element for signs of asset fatigue.

What you see	Interpretation	Required action
Blue bars appear.	The controller is operating at the desired capacity, that is, in the range of 31% through 70%. More samples in this range indicate that the controller is well-designed.	None. This is the ideal value.
Image displays a message stating that there is no data.	Data is not available for the selected time period.	Investigate if there is a loss of connection with the database.
An empty histogram appears.	The quality of all the data for the selected time period is bad.	Investigate why the quality of data is bad.
One trend interval (bin) appears with majority of data counts.	This indicates that there has been no data change, and that the last recorded value has been maintained. This can possibly occur as a result of loss of connection to a real-time server.	Verify and fix the connection to the real-time server.
Flat histogram, with no discernible peaks, appears.	The control element is operating over its whole range to control the PV. This typically indicates that the control element is too small for the system and will cause asset fatigue over time.	Optimize the size of the control element.

The Control Overview Chart

The control overview chart displays the trend of the manipulated variable (MV). The chart contains the following axes:

- x-axis: Represents the time period selected in the report.
- y-axes (two in number): Represent the MV value and the control mode in which the control loop was operating over the time period. The following table provides the number that represents each control mode:

Number	Control Mode
1	Manual
2	Auto
3	Cascade
4	Shutdown

Trend lines appear in the following colors in the chart:

- Blue: Indicates the control mode in which the system is operating. The control mode can change over the recording period.
- Red: Indicates the trend of the MV value over the total calibrated range.

Interpreting the Control Overview Chart

Based on the values plotted on the chart, you can identify performance issues in the controller. The following table provides a few scenarios that may appear in the chart and what each scenario indicates regarding the controller performance.

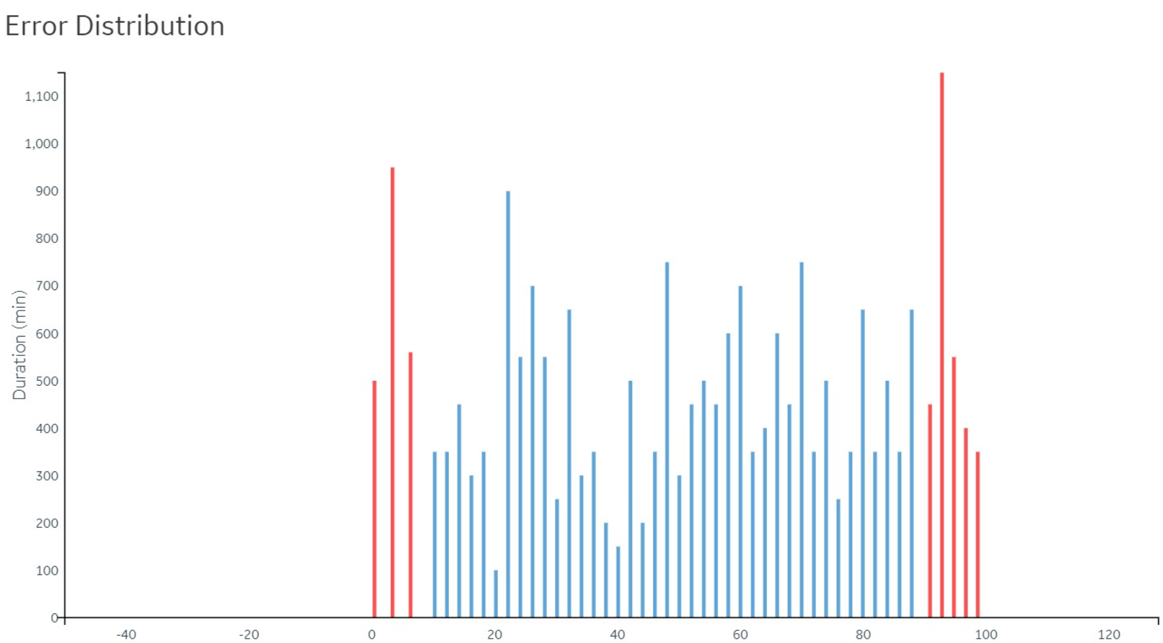
Note: If data for a tag is missing, a message appears at the top of the page, specifying the tag for which the data is missing.

What you see	Interpretation	Required action
The blue trend line is set to Shutdown.	Indicates that the control element is in the Shutdown mode.	Ensure that the system is operating in the required control mode. Investigate causes of a change to Shutdown mode.
The red trend line indicates the MV percentage functioning value over the total calibrated range.	• < 5%: Indicates that the control element is operating at a very low saturation level and that the element is oversized. • 5 - 30%: Indicates that the control element is operating close to its lower saturation level. • 30 - 70%: Indicates that the control element is operating at its optimal value. This is the ideal value for the variable. • 70 - 95%: Indicates that the control element is operating close to its higher saturation level. • > 95%: Indicates that the control element is operating at a very high saturation level and that the element is undersized.	Optimize the size of the controller.
The blue trend line is set to Bad.	The data was of bad quality and loop statistics could not be calculated.	Identify the reason for bad quality data. Check the connection to the server or database.
A report with no value for MV in the y-axis appears.	Either the MV has no data or the data is of bad quality.	Investigate which of these is true and why.
Gaps in the trend line appear.	Data was a mixture of good and bad quality.	Investigate why the quality of some data is bad.
A flat trend line appears.	• There has been no change in data for the time period selected. The last recorded value is maintained. -or- • The connection to a real-time server has been lost.	• Investigate why there is no change in data. • Fix the connection to the real-time server.
The Control Mode and MV values are responding quickly relative to the PV and SP values in the PV trend.	The control element has an appropriate reaction to changes in the PV.	None. The controller is well-tuned.
The Control Mode and MV values are responding very slowly relative to the PV and SP values in the PV trend.	The control element has a sluggish reaction to changes in the PV.	Tune the control loop PIDF parameters.

The Error Distribution Chart

The error distribution chart displays a histogram that represents the distribution of the amount of time the controller operated at each error value. Controller error is calculated as the difference between the values, PV and SP. The chart contains the following axes:

- x-axis: Represents the controller error.
- y-axis: Represents the time for which the controller was operating at the PV error value.



Interpreting the Error Distribution Chart

Based on the values plotted on the chart, you can identify performance issues in the controller. The following table provides a few scenarios that may appear in the chart and what each scenario indicates regarding the controller performance.

Note: If data for a tag is missing, a message appears at the top of the page, specifying the tag for which the data is missing.

What you see	Interpretation	Required action
The histogram bars appear in red.	The error is out of acceptable limits.	Control the PV so that it functions within the defined process limits.
The histogram bars appear in blue.	The error is in acceptable limits.	None.
Bimodal or oscillating distribution of histogram bars appears.	Possible friction exists in control element.	Check the functioning of the control element.
Histogram bars appear primarily in the higher error range.	Possible errors in loop tuning exist, or the control element is not working effectively.	Check the functioning of the control element. Tune the PIDF controller parameters.

What you see	Interpretation	Required action
One trend interval (bin) appears with majority of data counts.	There has been no change in PV error for the time period selected. The last recorded value is maintained. Or, the connection to a real-time server has been lost.	Investigate why there is no change in data. Fix the connection to the real-time server.
An empty histogram appears.	The quality of all the data for the selected time period is bad.	Investigate why the quality of data is bad.

The Control Mode Summary Table

The control mode summary table helps you assess the performance of the control loop based on the percentage of time the loop operated in each control mode. The table contains a row for each of the following control modes:

- **Manual**
- **Auto**
- **Cascade**
- **Shutdown**

The table contains the following information for each control mode:

Column name	Description
Duration (%)	Indicates the percentage of time the control loop operated in each controller mode. This is the average value of the Percentage <control mode> KPI.
Lower Limit Exceeded (%)	Indicates the percentage of time the loop operated below the lower limit. This is the average value of the Percentage <control mode> LL Exceeded KPI.
Upper Limit Exceeded (%)	Indicates the percentage of time the loop operated above the upper limit. This is the average value of the Percentage <control mode> UL Exceeded KPI.
Total Limits Exceeded (%)	Indicates the total percentage of time that the loop operated out of limit. This value is calculated as the sum of the Lower Limit Exceeded (%) and Upper Limit Exceeded (%) values.

Note: Consult the KPI Reference for the definition of each KPI referenced in the preceding table.

The last row in the table, **Total**, contains the sum of values in each column for all control modes, except the Shutdown mode.

In the **Total** row, if the value in the **Duration (%)** column is not **100%**, it indicates missing data for the selected time period, possibly due to bad quality data.

The Controller Performance Table

The controller performance table helps you analyze the performance of the control element using a range of KPIs. It contains the following information.

KPI	Interpretation	Required action
Manipulated Variable [%]	The average value of the control variable, expressed as a percentage. • < 5%: Indicates that the control element is operating at a very low saturation level and that the element is oversized. • 5 - 30%: Indicates that the control element is operating close to its lower saturation level. • 30 - 70%: Indicates that the control element is operating at its optimal value. This is the ideal value for the variable. • 70 - 95%: Indicates that the control element is operating close to its higher saturation level. • > 95%: Indicates that the control element is operating at a very high saturation level and that the element is undersized. This is the average value of the Percentage Controller Output KPI.	If the variable is not in the ideal range, install a different type of controller. Depending on the variable value, install either a larger controller that is more suitable for the process, or a smaller one that is more energy-efficient and cost-effective.
Total MV Movement	An indication of the absolute sum of all changes made in the MV. The closer the value for this variable is to zero, the closer the MV is to staying at a constant value. You can use this statistic to help you keep the PV operating within process limits. This is the average value of the Movement Index KPI.	Investigate and optimize the size of the control system.
Average MV Change [%]	The average percentage change in the MV between samples. The closer the value for this variable is to zero, the closer the MV is to staying at a constant value. This is the average value of the Control Amplitude KPI.	Investigate and optimize the size of the control system.
MV Oscillation Count [#]	The number of times that the MV changes direction. This indicates the level of noise in the system. The closer this value is to zero, the less noise there is in the system. All data is taken into account for this statistic, regardless of the quality. This is the average value of the MV Oscillation Count KPI.	Add a better filter to the control system.

KPI	Interpretation	Required action
Average oscillation amplitude [%]	The average percentage change in the MV before changing direction. • 0: The closer this value is to zero, the closer the MV is to staying at a constant value. • <5% Indicates a good control system. • > 5%: Indicates a possibility of damage or failure, but must be viewed in conjunction with the number of controller oscillations. This is the average value of the Reversal Amplitude KPI.	Investigate and optimize the control element.
MV Saturation [%]	The percentage of the reporting window for which the controller output is saturated. The controller output is considered saturated when the MV has a value of 0 (the lower limit for controller output saturation) or 100 (the upper limit for controller output saturation). The closer this is to zero, the more likely it is that the control element is appropriately sized and functioning correctly. This is the average value of the Percentage MV Saturation KPI.	Investigate for a possibility of an undersized or oversized control element, a malfunctioning control element, or other causes for MV saturation, and optimize the control element.
Duration Not Utilized [%]	The percentage of the reporting window for which the loop is not in use. The loop is considered to be not in use if it is in manual mode or if the controller output is saturated. The controller output is considered saturated when the MV has a value of 0 (the lower limit for controller output saturation) or 100 (the upper limit for controller output saturation). The closer this is to zero, the more likely it is that the loop is in a mode other than manual and the control element is appropriately sized and functioning correctly. This is the average value of the Percentage Not Utilized KPI.	If the percentage of time not utilized is too high this can be for either or both of the following reasons: • The loop spends a large proportion of time in manual mode. Investigate the reasons for that behavior. • Investigate for a possibility of an undersized or oversized control element, a malfunctioning control element, or other causes for MV saturation, and optimize the control element.

Note: Consult the KPI Reference for the definition of each KPI referenced in the Interpretation column of the preceding table.

The PV Performance Table

The process variable performance table helps you analyze the performance of the process variable based on values as specified in the following table.

Column name	Interpretation
Average PV Limits exceeded	This value is an average of the percentage of time the PV exceeded the upper or lower limits. This is the average value of the Percentage Limits Exceeded KPI.
PV Variance [%]	This value is a measure of the average deviation of the PV from the average PV, expressed as a percentage of the reporting window span. This is the average value of the PV Variance KPI.
PV Variability	This value is an averaged measure of how spread or closely clustered the PV data set is, expressed as a percentage This is the average value of the PV Variability KPI.

Note: Consult the KPI Reference for the definition of each KPI referenced in the preceding table.

The Error Statistics Table

The error statistics table contains the statistics that indicate the extent at which the process variable deviates from the set point. The table contains the following values:

Measured variable	Interpretation
Integrated Error	This value indicates the percentage time the process has spent out of limits. If there is a substantial integrated error, investigate the functioning of the PV, and tune the system to maintain the PV within the defined limits. This is the sum of the Integrated Sum KPI values for the window.
Average Error	This value indicates the average tag error. Tag error is the difference between process variable and set point, expressed as a percentage. This is the average value of the PV Error Average KPI.
Average Absolute Error	This value indicates the average absolute value of the tag error. This is the average value of the PV Error Absolute Average KPI.
PV Error Standard Deviation	This value indicates the standard deviation of the tag error, where the tag error is the difference between process variable and set point, expressed as a percentage. This is the average value of the PV Error Standard Deviation KPI.

Note: Consult the KPI Reference for the definition of each KPI referenced in the preceding table.

The Controller Configuration Table

The controller configuration table contains the Proportional (P), Integral (I), Derivative (D), or Filter (F) values at the beginning and end of the selected time period.

Chapter 5

The Loop Analysis Template

Topics:

About the Loop Analysis Template

The Loop Analysis Template allows you to visualize and analyze loop data with grouped KPIs in various pre-built charts. Using the template, you can investigate potential issues with a loop, perform analysis to manually troubleshoot issues, and optimize the performance of the loop.

Access the Loop Analysis Template

Procedure

1. Access the loop dashboard whose analysis template you want to access.
2. In the workspace, select .
   The loop analysis template appears, displaying the graphs, tags, tag expressions, and other information about the template.

   For more information, refer to the Analysis section of the documentation.

Modify the Date for a Loop Analysis

About This Task

This topic describes how to modify the date range for a loop analysis.

Procedure

1. Access the loop analysis whose date you want to modify.
   The **Date Selector** box appears, displaying the default date as current date. For example, if today's date is 21st November, 2018, then the default time range in the loop analysis is 20th November, 2018 00:00:00 to 21st November, 2018 00:00:00.
2. In the drop-down list box, select an option as specified in the following table.

   Note: For each day that is included in the date range, data is reported for the complete day (that is, 24 hours). Therefore, the time that appears in the drop-down list box is not considered in the report. For example, even if 1st November, 2018 3:00:00 to 2nd November, 2018 1:00:00 is the specified date range, data is reported for the following date range: 1st November, 2018 00:00:00 to 3rd November, 2018 00:00:00.

Option	Description
Date Selector	Select this option if you want to access data for a single day. If, however, you select the current date, data is reported for the previous day. For example, if you select 19th November, 2018, then data is reported from 19th November, 2018 00:00:00 to 20th November, 2018 00:00:00. If, however, the current date is 19th November, 2018, then data is reported from 18th November, 2018 00:00:00 to 19th November, 2018 00:00:00.
Time Span	Select this option if you want to access data for the past day, week, month, three months, six months, or year. For example, if you select **1W**, and if the current date is 21st November, 2018, then data is reported from 14th November, 2018 00:00:00 to 21st November, 2018 00:00:00.
Date & Time Span	Select this option if you want to access data for a day, week, month, three months, six months, or year up to a selected date. If, however, you select the current date, data is reported till the previous day. For example, if you select 13th November, 2018, and then select **1D**, then data is reported from 13th November, 2018 00:00:00 to

Option	Description
	14th November, 2018 00:00:00. If, however, the current date is 13th November, 2018, then data is reported from 12th November, 2018 00:00:00 to 13th November, 2018 00:00:00.
Custom Time Span	Select this option if you want to access data for a specific date range. If, however, you select current date, data is reported till the previous day. For example, if you select 10th November, 2018 to 15th November, 2018, data is reported from 10th November, 2018 00:00:00 to 16th November, 2018 00:00:00. If, however, the current date is 15th November, 2018, then data is reported from 10th November, 2018 00:00:00 to 15th November 2018 00:00:00.

The date range is modified, and the analysis is updated. The date and time range for which the data is reported appears in the upper-right corner of the analysis.

Tip: You can reset the date range to the default value by selecting **reset**.

Chapter 6

Manage Loops

Topics:

Add a Loop

To add a loop:

About This Task

Note: It is important to follow these instructions carefully and to ensure that your asset ingestion file conforms to the Control Loop Asset Definition for CLPM. If your file does not conform to this definition, CLPM will be unable to function correctly.

Procedure

1. Define the asset classification.
2. Create asset instances.

   (Follow the instructions in the APM Asset documentation for creating asset instances.)
3. Set up tag classifications for outputs.
4. Associate inputs and outputs for control loop assets.
5. Modify all existing analytic deployments to add the asset to the deployments. Consult the section of this documentation on deploying CLPM analytics for details.

   IMPORTANT: If this step is not performed, analytics will be unable to produce KPIs and alerts for the loop.

Modify a Loop

To modify a loop:

Procedure

1. Log in to your tenant.
2. In the module navigation menu, select **Assets**.
3. Use the Context Browser to select the control loop asset instance you want to modify.
4. In the control loop asset instance, hover over, then select the field on the asset you want to modify. It will only be possible to modify those properties that you should be able to modify.

   For **Custom Attributes** on the control loop asset and on the tags associated with the control loop asset, consult the Control Loop Asset Definition for CLPM to ensure that the changes you make comply with the definition/template. The following custom attributes are important for CLPM configuration:

Custom Attribute	Function
Attributes > Custom Attributes > Lower SP Offset	Used to calculate the Lower SP Threshold.
Attributes > Custom Attributes > Upper SP Offset	Used to calculate the Upper SP Threshold.
Tags > PV or MV > Custom Attributes > Minimum Operating Value	Used for data clipping.
Tags > PV or MV > Custom Attributes > Maximum Operating Value	Used for data clipping.

   Note: It is important to ensure that your modifications to custom attributes conform to the control loop asset definition for CLPM. If your change does not conform to this definition, CLPM will be unable to function correctly.

   For other properties common to both control loop assets and other kinds of assets, consult the APM Asset documentation for asset instances.

5. Make the change you want to make, then press Enter or select outside the field.

Results

The newly modified value for the field you have changed appears on the control loop asset instance page.

Delete a Loop

To delete a loop:

About This Task

Note: This action cannot be reversed.

Procedure

1. Log in to your tenant.
2. In the module navigation menu, select **Assets**.
3. Use the Context Browser to select the asset instance you want to delete.
4. Select the trash icon and confirm that you want to delete the loop.
5. Modify all existing CLPM analytic deployments to remove the asset from the deployments.

Chapter 7

Reference

Topics:

CLPM Terminology

The following terms are frequently used in control loop performance monitoring (CLPM).

Term	Description
CLPM	Control Loop Performance Monitoring
PV (Process Variable)	This is the measured process variable, reflecting the actual state of the process that is being controlled.
SP (Setpoint)	This is the desired value (target value) to which the PV is controlled.
Error	This is the difference between the PV and SP. It is calculated as Error = PV-SP. Note that this is not an absolute value.
Controller	The subsystem containing the control algorithm that manipulates the MV to control the PV to the SP.
MV (Manipulated Variable)	The variable manipulated (adjusted) by the controller to control the PV to the SP.
DV (Disturbance Variable)	A measured disturbance variable that can be used by the controller to compensate for the impact of the disturbance on the PV.
P (Proportional Value)	Normally the Proportional Gain value of the PID controller.
I (Integral Value)	Normally the Integral Gain value of the PID controller.
D (Derivative Value)	Normally the Derivative Gain value of the PID controller.
F (Filter Value)	Normally the Filter Time Constant value of the PID controller.
Final Control Element (FCE)/ Actuator	The device that is physically affected by a change in the MV so as to have an impact on the process.

Control Loop Asset Definition

The Control Loop Asset Definition specifies all the necessary attributes of a control loop asset. The various sections of the definition are detailed here. This is the definition to be used for the JSON asset ingestion file(s).

Define the Control Loop Asset

To define the control loop asset, perform the following steps:

1. Define the asset classification.
2. Create asset instances.
   - Follow the instructions in the APM Asset documentation for creating asset instances.
3. Set up tag classifications for outputs.
4. Associate inputs and outputs for control loop assets.

Note: It is important to follow these instructions carefully and to ensure that your asset ingestion file conforms to the control loop asset definition for CLPM. If your file does not conform to this definition, CLPM will be unable to function correctly.

Define the Asset Classification

Define the asset classification for the control loop asset.

Asset Classification: Reserved Attributes

The attributes in the following table are inherited as standard asset classification required attributes. No action is required on your part to modify them.

Property/Attribute	Data Type
Family Type	String
Equipment Type	String
Make	String
Model	String
Series	String
Serial Number	String
Maintenance Criticality Risk Score	Integer
Fault Mode	String

Asset Classification: Custom Attributes

The attributes in the table that follows are custom asset classification attributes specifically for control loop assets. You need to specify values for them.

Property/Attribute	Data Type	Range	Property Required?	Notes
Name	String	N/A	Required	Required as an analytic input in order to be able to log the loop name with any individual logging entries.
Description	String	N/A	Optional	
Loop Priority	Enumeration	Enumeration (High, Medium, Low)	Required	Used for filtering during visualization.
Type	String	N/A	Required. Must be set to PID Control Loop	
Lower SP Offset	Numeric	>0	Required	Used to calculate the lower SP threshold.
Upper SP Offset	Numeric	>0	Required	Used to calculate the upper SP threshold.

Set Up Tag Classifications for Outputs

Define each analytic output using the Control Loop KPI tag classification described in the table that follows.

Tag Classification

Required Property / Attribute	Data Type
Source Unit of Measure	String
Data Type	String
Category	String
Maximum Operating Value	Double
Minimum Operating Value	Double
Highest Threshold Value	Double
Lowest Threshold Value	Double
Resolution	String
Sensor Health Index Low Threshold	Double
Sensor Health Index High Threshold	Double
Sensor Health Index Flat Line Number	Integer
Sensor Health Index Flat Line Epsilon	Double
Bad Observation Persistent / Penalty Window	Integer
False Alarm Probability	Double
Missed Alarm Probability	Double
Sample Failure Magnitudes Mean	Integer
Sample Failure Magnitudes Variance	Integer
Null Hypothesis Variance	Double
NaN Test Weight	Double
Outlier Test Weight	Double
Flat Test Weight	Double

Associate Analytic Inputs for Control Loop Assets

Specify analytic inputs by mapping timeseries tags onto asset instances defined by the control loop asset classification.

Each analytic input is uniquely identified by the `Tag Alias`, and the data type must match the corresponding type specified in the table that follows.

However, no specific tag classification is required for analytic inputs. You may use whatever tag classification you want to use.

Note: As you can see in the table that follows, the `Maximum Operating Value` and `Minimum Operating Value` tag attributes for the PV are significant because they are used for data clipping.

Note: It is important to carefully follow this specification. If your file does not conform to this definition, CLPM will be unable to function correctly.

Tag Alias	Tag Description	Tag Attributes (Required)							Tag Value Ranges	User Input Required?	Required?
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value			
Setpoint	The setpoint for the process variable (PV) represents the desired value for PV.	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	Any	No	Yes
PV	Process variable	Specifies the appropriate unit of measure.	Numeric	Any	Used as a custom attribute to specify the upper limit of the PV tag. This is the upper Engineering (clipping) limit for PV. Data outside of this limit is not used for calculations.	Used as a custom attribute to specify the lower limit of the PV tag. This is the lower Engineering (clipping) limit for PV. Data outside of this limit is not used for calculations.	Any	Any	Any	No	Yes

Tag Alias	Tag Description	Tag Attributes (Required)							Tag Value Ranges	User Input Required?	Required?
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value			
MV	The controller output or "Manipulated Variable"	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	Percentage [0%-100%]	No	Yes
P	Proportional value	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	>0	Optional	No
I	Integral value	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	>0	Optional	No
D	Derivative value	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	>0	Optional	No

Tag Alias	Tag Description	Tag Attributes (Required)							Tag Value Ranges	User Input Required?	Required?
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value			
F	Filter value	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	>0	Optional	No
Control Mode	Control Mode	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	Enumeration (Auto, Manual, Cascade, Shutdown)	No	Yes

Associate Analytic Outputs for Control Loop Assets

Specify analytic outputs by mapping timeseries tags onto asset instances defined by the control loop asset definition.

Analytic Outputs

Each output is identified with the `Control Loop KPI` tag classification.

Consult the KPI Reference topic for descriptions of the KPIs corresponding to each output tag, along with formulas and notes on interpreting each KPI.

Note: The following applies to the Tag Source ID.

- The Tag Source ID must be of the form `<AssetID>.<Output Tag Name>` for all analytic outputs.
- The `<AssetID>` in the table that follows refers to the ID of the asset to which the tag belongs.
- For example, observe that the Tag Association in the Example Loop Asset for `Percentage Controller Output`, for the `Loop1` asset with ID `Loop1`, the Tag Source ID must be `Loop1.Percentage Controller Output`.
- When manually creating the tags on the asset, this property is referred to as the `Source ID`.
- When constructing `Asset Ingestion files`, this property is referenced using the `ID` in the **tags** section.

Note:

The Master Quality referenced in the table that follows is good if all the following tags are of good quality:

- Control Type
- MV
- PV
- SP

Otherwise, it is bad.

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Percentage Controller Output	The average MV value (expressed as a %).	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Controller Output	Percentage [0%-100%]	Master Quality
Percentage Not Utilized	Percentage Not Utilized	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Not Utilized	Percentage [0%-100%]	Master Quality
Percentage MV Saturation	Percentage MV Saturation	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage MV Saturation	Percentage [0%-100%]	Master Quality
Overall Performance	Overall Performance	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Overall Performance	Percentage [0%-100%]	Master Quality
Movement Index	Gives the sum of all changes of the MV, divided by 100	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Movement Index		Master Quality

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Control Amplitude	Calculates the sum of all MV rate of change values divided by the total number of samples	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Control Amplitude		Master Quality
Reversal Count	The number of times MV changes direction	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Reversal Count		MV Quality
Reversal Amplitude	Percentage Reversal Amplitude	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Reversal Amplitude	Percentage [0%-100%]	Master Quality
Integrated Sum	Integrated Sum	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Integrated Sum		Master Quality
PV Error Average	PV Error Average	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.PV Error Average		Master Quality

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
PV Error Absolute Average	PV Error Absolute Average	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.PV Error Absolute Average		Master Quality
PV Error Standard Deviation	PV Error Standard Deviation	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.PV Error Standard Deviation		Master Quality
PV Variance	PV Variance	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.PV Variance		Master Quality
PV Variability	PV Variability	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.PV Variability		Master Quality
Percentage Good Quality	Percentage Good Quality	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Good Quality	Percentage [0%-100%]	Master Quality
Total PIDF Changes	Total PIDF Changes	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Total PIDF Changes	>=0	Worst Quality of P, I, D, F

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Percentage Manual	Percentage Manual	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Manual	Percentage [0%-100%]	Master Quality
Percentage Manual LL Exceeded	Percentage Manual LL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Manual LL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Manual UL Exceeded	Percentage Manual UL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Manual UL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Auto	Percentage Auto	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Auto	Percentage [0%-100%]	Master Quality
Percentage Auto LL Exceeded	Percentage Auto LL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Auto LL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Auto UL Exceeded	Percentage Auto UL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Auto UL Exceeded	Percentage [0%-100%]	Master Quality

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Percentage Cascade	Percentage Cascade	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Cascade	Percentage [0%-100%]	Master Quality
Percentage Cascade LL Exceeded	Percentage Cascade LL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Cascade LL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Cascade UL Exceeded	Percentage Cascade UL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	AssetID>.Percentage Cascade UL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Shutdown	Percentage Shutdown	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Shutdown	Percentage [0%-100%]	Master Quality
Percentage Shutdown LL Exceeded	Percentage Shutdown LL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Shutdown LL Exceeded	Percentage [0%-100%]	Master Quality
Percentage Shutdown UL Exceeded	Percentage Shutdown UL Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Shutdown UL Exceeded	Percentage [0%-100%]	Master Quality

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Percentage Control On	Percentage Control On	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Control On	Percentage [0%-100%]	Master Quality
Statistics Period	The time period in seconds over which the KPIs have been calculated.	Specifies the appropriate unit of measure.	Numeric	Any	Any	0	Any	0	<AssetID>.Statistics Period	>=0	None
Percentage Limits Exceeded	Percentage Limits Exceeded	Specifies the appropriate unit of measure.	Numeric	Any	100	0	100	0	<AssetID>.Percentage Limits Exceeded	Percentage [0%-100%]	Master Quality
PV Error	PV Error	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.PV Error		Master Quality
Lower SP Threshold	Lower SP Threshold	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Lower SP Threshold		Setpoint Quality

Output Tag Name	Tag Description	Tag Attributes (Required)								Tag Value Ranges	Quality
		UOM	Data Type	Category	Maximum Operating Value	Minimum Operating Value	Highest Threshold Value	Lowest Threshold Value	Tag Source ID		
Upper SP Threshold	Upper SP Threshold	Specifies the appropriate unit of measure.	Numeric	Any	Any	Any	Any	Any	<AssetID>.Upper SP Threshold		Setpoint Quality
MV Oscillation Count	MV Oscillation Count	Specifies the appropriate unit of measure.	Numeric	Any	Any	0	Any	0	<AssetID>.MV Oscillation Count		

Example Loop Asset for APM Asset Ingestion

The following sample JSON gives an example of the definition of a control loop asset for ingestion into APM.

The sample JSON below is split up into asset classification, asset instances, tag classifications, and tag associations.

This example produces two loops (Loop1 and Loop2).

Asset Classification

```
{
    "classifications": [
        {
            "id": "CLPM-Enterprise",
            "name": "Control Loop Enterprise Classification",
            "description": "",
            "ccomClass": "ENTERPRISE_TYPE",
            "parent": null
        },
        {
            "id": "CLPM-Site",
            "name": "Control Loop Site Classification",
            "description": "",
            "ccomClass": "SITE_TYPE",
            "parent": null
        },
        {
            "id": "CLPM-Segment",
            "name": "Control Loop Segment Classification",
            "description": "",
```

```
            "ccomClass": "SEGMENT_TYPE",
            "parent": null
        },
        {
            "id": "ControlLoop",
            "name": "Control Loop",
            "description": "",
            "ccomClass": "ASSET_TYPE",
            "parent": null,
            "properties": [
                {
                    "id": "Name",
                    "value": [],
                    "type": "String"
                },
                {
                    "id": "Description",
                    "value": [],
                    "type": "String"
                },
                {
                    "id": "Loop Priority",
                    "value": [
                        "Medium"
                    ],
                    "type": "String"
                },
                {
                    "id": "Type",
                    "value": [],
                    "type": "String"
                },
                {
                    "id": "Lower SP Offset",
                    "value": [

                    ],
                    "type": "Double"
                 },
                {
                  "id": "Upper SP Offset",
                    "value": [
                    ],
                  "type": "Double"
                }
            ]
        }
    ]
}
```


Instances


```
{
    "instances": [
        {
            "id": "SavoryFoodsInc",
            "name": "Savory Foods Inc",
            "description": "This is a digital manufacturing
enterprise",
```

```
            "classification": "CLPM-Enterprise",
            "ccomClass": "ENTERPRISE"
        },
        {
            "id": "CapeTownSouthAfricaFactory",
            "name": "Cape Town, South Africa Factory",
            "description": "This is the Cape Town, South African
factory",
            "properties": [
                {
                    "id": "Address",
                    "value": [
                        "Cape Town"
                    ],
                    "type": "string"
                }
            ],
            "classification": "CLPM-Site",
            "ccomClass": "SITE"
        },
        {
            "id": "TortillaPlant",
            "name": "Tortilla Plant",
            "description": "This is the tortilla plant",
            "properties": [
                {
                    "id": "PlantNumber",
                    "value": [
                        "TortillaPlant001"
                    ],
                    "type": "string"
                }
            ],
            "classification": "CLPM-Segment",
            "ccomClass": "SEGMENT"
        },
        {
            "id": "Loop1",
            "name": "Loop1",
            "description": "The tortilla fryer",
            "properties": [
                {
                    "id": "Lower SP Offset",
                    "value": [
                        20
                        ],
                    "type": "Double"
                },
                {
                    "id": "Upper SP Offset",
                    "value": [
                            120
                        ],
                    "type": "Double"
                }
            ],
            "classification": "ControlLoop",
            "ccomClass": "ASSET"
        },
        {
            "id": "Loop2",
```

```
            "name": "Loop2",
            "description": "The tortilla fryer",
            "properties": [
                {
                    "id": "alias",
                    "value": [
                        "Fryer"
                    ],
                    "type": "string"
                },
                {
                    "id": "Lower SP Offset",
                    "value": [
                        30
                        ],
                    "type": "Double"
                },
                {
                    "id": "Upper SP Offset",
                    "value": [
                            150
                        ],
                    "type": "Double"
                }
            ],
            "classification": "ControlLoop",
            "ccomClass": "ASSET"
        }
    ],
    "connections": [
        {
            "from": {
                "id": "CapeTownSouthAfricaFactory",
                "ccomClass": "SITE"
            },
            "to": [
                {
                    "type": "parent",
                    "id": "SavoryFoodsInc",
                    "ccomClass": "ENTERPRISE"
                }
            ]
        },
        {
            "from": {
                "id": "TortillaPlant",
                "ccomClass": "SEGMENT"
            },
            "to": [
                {
                    "type": "parent",
                    "id": "CapeTownSouthAfricaFactory",
                    "ccomClass": "SITE"
                }
            ]
        },
        {
            "from": {
                "id": "Loop1",
                "ccomClass": "ASSET"
            },
```

```
            "to": [
                {
                    "type": "parent",
                    "id": "TortillaPlant",
                    "ccomClass": "SEGMENT"
                }
            ]
        },
        {
            "from": {
                "id": "Loop2",
                "ccomClass": "ASSET"
            },
            "to": [
                {
                    "type": "parent",
                    "id": "TortillaPlant",
                    "ccomClass": "SEGMENT"
                }
            ]
        }
    ]
}
```

Tag Classifications

```
{
    "tagClassifications": [
        {
            "id": "ControlLoopKPI",
            "name": "Control Loop KPI",
            "description": "",
            "unitGroup": "",
            "reservedProperties": {
                "uom": "",
                "dataType": "Double",
                "category": ""
            }
        },
        {
            "id": "AnalyticInputs",
            "name": "AnalyticInputs",
            "description": "Tag Classification for analytic input
tags",
            "unitGroup": ""
        }
    ]
}
```

Tag Associations

```
{
    "tagAssociations": [
        {
            "monitoredEntity": {
                "id": "Loop1",
                "ccomClass": "ASSET"
            },
```

```
            "tags": [
                {
                    "name": "Control Mode",
                    "id": "Loop1.ControlMode",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "timeseriesLink": "Loop1.ControlMode",
                        "dataType": "String"
                    },
                    "aliases": [
                        "Control Mode"
                    ]
                },
                {
                    "name": "D",
                    "id": "Loop1.D",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "D"
                    ]
                },
                {
                    "name": "F",
                    "id": "Loop1.F",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "F"
                    ]
                },
                {
                    "name": "I",
                    "id": "Loop1.I",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "I"
                    ]
                },
                {
                    "name": "MV",
                    "id": "Loop1.CV",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "MV"
                    ],
```

```
                    "properties": [
                        {
                            "id": "Maximum Operating Value",
                            "value": [
                                120
                            ],
                            "type": "Double"
                        },
                        {
                            "id": "Minimum Operating Value",
                            "value": [
                                0
                            ],
                            "type": "Double"
                        }
                    ]
                },
                {
                    "name": "P",
                    "id": "Loop1.P",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "P"
                    ]
                },
                {
                    "name": "PV",
                    "id": "Loop1.PV",
                    "classification": "AnalyticInputs",
                    "unit": "",
                    "reservedProperties": {
                        "dataType": "Double"
                    },
                    "aliases": [
                        "PV"
                    ],
                    "properties": [
                        {
                            "id": "Maximum Operating Value",
                            "value": [
                                120
                            ],
                            "type": "Double"
                        },
                        {
                            "id": "Minimum Operating Value",
                            "value": [
                                0
                            ],
                            "type": "Double"
                        }
                    ]
                },
                {
                    "name": "Setpoint",
                    "id": "Loop1.Setpoint",
                    "classification": "AnalyticInputs",
```



```
            "unit": "",
            "reservedProperties": {
                "dataType": "Double"
            },
            "aliases": [
                "Setpoint"
            ]
        },
        {
            "name": "Control Amplitude",
            "id": "Loop1.Control Amplitude",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double"
            }
        },
        {
            "name": "Integrated Sum",
            "id": "Loop1.Integrated Sum",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double"
            }
        },
        {
            "name": "Lower SP Threshold",
            "id": "Loop1.Lower SP Threshold",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double"
            }
        },
        {
            "name": "Movement Index",
            "id": "Loop1.Movement Index",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double"
            }
        },
        {
            "name": "MV Oscillation Count",
            "id": "Loop1.MV Oscillation Count",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double",
                "minOperatingValue": 0,
                "lowestThresholdValue": 0
            }
        },
        {
            "name": "Overall Performance",
            "id": "Loop1.Overall Performance",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
```

```
                "dataType": "Double"
            }
        },
        {
            "name": "Percentage Auto LL Exceeded",
            "id": "Loop1.Percentage Auto LL Exceeded",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double",
                "maxOperatingValue": 100,
                "minOperatingValue": 0,
                "highestThresholdValue": 100,
                "lowestThresholdValue": 0
            }
        },
        {
            "name": "Percentage Auto UL Exceeded",
            "id": "Loop1.Percentage Auto UL Exceeded",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double",
                "maxOperatingValue": 100,
                "minOperatingValue": 0,
                "highestThresholdValue": 100,
                "lowestThresholdValue": 0
            }
        },
        {
            "name": "Percentage Auto",
            "id": "Loop1.Percentage Auto",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double",
                "maxOperatingValue": 100,
                "minOperatingValue": 0,
                "highestThresholdValue": 100,
                "lowestThresholdValue": 0
            }
        },
        {
            "name": "Percentage Cascade LL Exceeded",
            "id": "Loop1.Percentage Cascade LL Exceeded",
            "classification": "ControlLoopKPI",
            "unit": "",
            "reservedProperties": {
                "dataType": "Double",
                "maxOperatingValue": 100,
                "minOperatingValue": 0,
                "highestThresholdValue": 100,
                "lowestThresholdValue": 0
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KPI Reference for CLPM

This reference details all the KPIs calculated over the data window.

These KPIs are produced by deployed CLPM analytics and are associated with assets in Predix TimeSeries.

The KPIs are also used to produce the tables and charts on the Loop Dashboard and Fleet Dashboard, which help you monitor and diagnose loop performance.

The KPIs are categorized in the tables that follow as:

- Aggregate KPIs
- Non-Aggregate KPIs

Note: The samples over which these KPIs are calculated are resampled to be at regular intervals. The resulting samples are therefore equally weighted in the calculations. All KPIs are calculated off interpolated data.

Aggregate KPIs

These aggregate KPIs are calculated over the data window.

KPI	Description	Formula	Interpretation	Source KPI Analytic
Control Amplitude	The Control Amplitude gives the sum of all changes of the MV, divided by the number of samples. Only data of good quality is considered for the calculation of this value. Bad quality data is ignored.	Control Amplitude = SUM(|MV_ROC|) / Number of Samples where: • MV_ROC = MV current - MV previous • MV_ROC Quality is the worst quality of MV current and MV previous.	The closer this KPI is to zero the better. An amplitude close to zero indicates that the manipulated variable does not need to be greatly adjusted in order to control the PV to the SP. If this KPI is large, it indicates a large adjustment to the MV. One of the following is likely the cause of this: • The sensor or FCE/Actuator is broken. • The FCE/Actuator is incorrectly sized. • An unsuitable MV with little or no leverage is currently selected to control the PV. • The loop settings (for tuning) are too aggressive.	OPM-CLPM-Performance_Ext
Integrated Sum	This gives the sum of the absolute values of all PV Error (PV - SP) samples within the data window that are of good quality.	Integrated Sum = SUM(|PV-SP|) for samples of good quality in window	This KPI gives an indication of the total size of the absolute PV Error over the whole reporting period. The closer this KPI is to zero the better. It is not normalized, so it cannot be directly compared across different loops, but is best analyzed over time for the same loop to see how well a specific loop is controlling over time.	OPM-CLPM-Performance_Ext

KPI	Description	Formula	Interpretation	Source KPI Analytic
Movement Index	The Movement Index gives the sum of all changes of the MV, divided by 100. Only data of good quality is considered for the calculation of this value. Bad quality data is ignored.	Movement Index = SUM(|MV_ROC|) / 100 where: • MV_ROC = MV current - MV previous • MV_ROC Quality is the worst quality of MV current and MV previous.	The closer this KPI is to zero the better. An index close to zero indicates that the manipulated variable does not need to be adjusted a lot in order to control the PV to the SP. If this KPI is large, it indicates a lot of adjustment to the MV. One of the following is likely the cause of this: • The sensor or the FCE/ Actuator is broken. • The FCE/Actuator is incorrectly sized. • An unsuitable MV with little or no leverage is currently selected to control the PV. • The loop settings (for tuning) are too aggressive.	OPM-CLPM-Performance_Ext
MV Oscillation Count	This calculates the number of times that the MV oscillates (changes direction twice) over the reporting period.	Reversal Count = Reversal Count / 2 = COUNT(MV direction change) / 2	The closer this KPI is to zero the better. A large value for this KPI indicates that MV changes tend to overshoot the mark and require MV changes in the opposite direction to compensate.	OPM-CLPM-Performance_Ext

KPI	Description	Formula	Interpretation	Source KPI Analytic
Overall Performance	This indicates the overall performance of the loop by combining the (equally weighted) Percentage Manual, Percentage MV Saturation, and Percentage Limits Exceeded KPIs into a single percentage value.	OverallPerformance = Percentage Manual / 3 + Percentage MV Saturation / 3 + Percentage Limits Exceeded / 3 where Percentage Manual, Percentage MV Saturation, and Percentage Limits Exceeded are KPIs described elsewhere in this table.	This gives a broad picture of the performance of the system. This should be low. If this KPI is large, one of the following is likely the cause of this: • The sensor, or FCE/ Actuator is broken. • The SP is set at an unrealistic/unreachable value. • The FCE/Actuator is incorrectly sized. • The loop is set to Manual mode for most of the time. • The loop control limits (specifying the target control range) are set to an unrealistically narrow range. • The current control loop design, settings, and algorithm are unable to effectively control the target process or equipment. Examine the individual KPIs that comprise this KPI for a more precise indicator of what is contributing to the behavior of the system.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Auto	This indicates the percentage of the samples of good quality within the data window for which the control mode used was Auto.	% Auto = Number of samples WHERE (Auto control mode AND samples of good quality)/ Number of samples of good quality	For Auto control mode, a controller within a control system implements automated changes to a variable when a sensor measures the process operating outside the defined process limits. The output is calculated by the controller using the error signal, which is the difference between the set point and the process variable. Ideally, the control loop would always be in either Auto or Cascade mode, implying that the loop is switched ON to actively, automatically, and continuously control the PV to SP.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Auto LL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Auto and the PV was below the Lower SP Offset..	% Auto LL Exceeded = Number of samples WHERE (Auto control mode AND PV < Lower SP Offset AND samples of good quality) / Number of samples of good quality	If PV violates the lower control limits while the loop is in Auto mode, it means one of the following: • The loop tuning is incorrect. • The control loop is not able to do its job or is not suitable for its job. Possible reasons can include: ◦ The loop is complex loop and you need an Advanced Controller like MPC to control this type of loop. ◦ The control loop is not designed correctly. ◦ The sensor or FCE/ actuator is unsuitable or is faulty. ◦ The equipment being controlled is malfunctioning. • The control loop and process/equipment are OK, but the control limits are too tight/strict and should be reviewed/ updated.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Auto UL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Auto and the PV was above the Upper SP Offset.	% Auto UL Exceeded = Number of samples WHERE (Auto control mode AND PV > Upper SP Offset AND samples of good quality) / Number of samples of good quality	If PV violates the upper control limits while the loop is in Auto mode, it means one of the following: • The loop tuning is incorrect. • The control loop is not able to do its job or is not suitable for its job. Possible reasons can include: ◦ The loop is complex loop and you need an Advanced Controller like MPC to control this type of loop. ◦ The control loop is not designed correctly. ◦ The sensor or FCE/ actuator is unsuitable or is faulty. ◦ The equipment being controlled is malfunctioning. • The control loop and process/equipment are OK, but the control limits are too tight/strict and should be reviewed/ updated.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Cascade	This indicates the percentage of the samples of good quality within the data window for which the control mode used was Cascade.	% Cascade = Number of samples WHERE (Cascade control mode AND samples of good quality)/ Number of samples of good quality	In Cascade control mode the loop output/MV is not directly driving an actuator, but rather it is linked to or setting or calculating the SP for another controller loop. For example, a flow control loop is trying to control the flow, measured by a flow meter, to a desired SP by changing a valve position. The flow control loop calculates a desired valve position, which in turn becomes the requested position SP for a valve positioning control loop that changes a pressure to move the valve to a desired position. The two loops are linked together in cascade. The flow control loop depends on the valve positioning control loop to do its job; if the latter does not work well, the former will also not work well.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Cascade LL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Cascade and the PV was below the Lower SP Offset.	% Cascade LL Exceeded = Number of samples WHERE (Cascade control mode AND PV < Lower SP Offset AND samples of good quality) / Number of samples of good quality	If PV violates the lower control limits while the loop is in Cascade mode, it means one of the following: • The loop tuning is incorrect. • The control loop is not able to do its job or is not suitable for its job. Possible reasons can include: ◦ The loop is complex loop and you need an Advanced Controller like MPC to control this type of loop. ◦ The control loop is not designed correctly. ◦ The sensor or FCE/ actuator is unsuitable or is faulty. ◦ The equipment being controlled is malfunctioning. ◦ The downstream, dependent cascaded loop has a problem. • The control loop and process/equipment are OK, but the control limits are too tight/strict and should be reviewed/ updated.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Cascade UL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Cascade and the PV was above the Upper SP Offset.	% Auto UL Exceeded = Number of samples WHERE (Auto control mode AND PV > Upper SP Offset AND samples of good quality) / Number of samples of good quality	If PV violates the upper control limits while the loop is in Cascade mode, it means one of the following: • The loop tuning is incorrect. • The control loop is not able to do its job or is not suitable for its job. Possible reasons can include: ◦ The loop is complex loop and you need an Advanced Controller like MPC to control this type of loop. ◦ The control loop is not designed correctly. ◦ The sensor or FCE/ actuator is unsuitable or is faulty. ◦ The equipment being controlled is malfunctioning. ◦ The downstream, dependent cascaded loop has a problem. • The control loop and process/equipment are OK, but the control limits are too tight/strict and should be reviewed/ updated.	OPM-CLPM-Performance
Percentage Control On	This indicates the percentage of the samples of good quality within the data window for which the control mode is enabled.	% Control On = Number of samples WHERE ((Auto or Cascade control mode) AND samples of good quality)/ Number of samples of good quality	This KPI corresponds to either Auto or Cascade control modes. The control loops are meant to be actively, automatically, continuously controlling.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Controller Output	This indicates the average MV value (expressed as a %) for data within the data window that is of good quality.	Percentage Controller Output = SUM(MV for samples of good quality in window) / Number of samples of good quality	The MV Average should be around 50% most of the time. If the MV is permanently stuck at a minimum of 0%, or a maximum of 100%, it shows that the MV cannot control the PV to the SP. One of the following is likely the cause of this: • The sensor, or FCE/ Actuator is broken. • The SP is set at an unrealistic/unreachable value. • The FCE/Actuator is incorrectly sized. • An unsuitable MV with little or no leverage is currently selected to control the PV. For example, if the valve/ pump acting as the FCE is too small, the MV Average will be closer to 80/90%. Conversely, if the valve/ pump is too big, then the MV Average will be closer to 10/20% most of time.	OPM-CLPM-Performance
Percentage Good Quality	This indicates the percentage of data within the data window that is of good quality.	% Good Quality = Number of samples of good quality / Number of samples	This KPI gives you an idea of how trustworthy the data within the data window is. The higher the percentage good quality, the more trustworthy the data is. Other KPIs should be understood with this measure in mind, bearing in mind that control loop KPI calculations exclude bad quality data samples.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Limits Exceeded	This indicates the total percentage of time that the system is in Auto, Cascade, or Manual modes where the upper or lower limits for those modes have been exceeded.	PercentageLimitsExceeded = (Total number of samples WHERE upper or lower limits exceeded in Auto, Cascade, or Manual modes / Total duration in Auto, Cascade, or Manual modes) * 100	This gives a broad picture of the performance of the system. This should be low. If this KPI is large, then the upper or lower control limits are being exceeded more than is healthy. Examine the individual KPIs for each mode indicating that limits have been exceeded for a more precise indicator of what is contributing to the behavior of the system.	OPM-CLPM-Performance
Percentage Manual	This indicates the percentage of the samples of good quality within the data window for which the control mode used was Manual.	% Manual = Number of samples WHERE(Manual control mode AND samples of good quality) / Number of samples of good quality	A loop is typically set to Manual control mode if the Operator wants the ability to manually set MV values. For example, the plant may be in abnormal operating conditions, but not completely shutdown. For Manual control mode, the MV is set manually by the operator to make control changes. When a measured variable operates out of the limits, an operator personally implements a control change to restore the system to within operating limits. Ideally, the control loop should be in Manual mode as little as possible.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Manual LL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Manual and the PV was below the Lower SP Offset.	% Manual LL Exceeded = Number of samples WHERE (Manual control mode AND PV < Lower SP Offset AND samples of good quality) / Number of samples of good quality	If the PV violates the lower control limits while the loop is in Manual mode, this is undesirable and it means that the operator is not successfully controlling the loop to remain within acceptable control limits. In such a case, the loop should rather be set to Auto control mode so it can be automatically controlled to remain within acceptable control limits around a chosen SP. If the loop is working correctly, Auto control will generally be better than Manual control, unless the loop has tuning, design, or equipment problems.	OPM-CLPM-Performance
Percentage Manual UL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Manual and the PV was above the Upper SP Offset.	% Manual UL Exceeded = Number of samples WHERE (Manual control mode AND PV > Upper SP Offset AND samples of good quality) / Number of samples of good quality	If the PV violates the upper control limits while the loop is in Manual mode, this is undesirable and it means that the operator is not successfully controlling the loop to remain within acceptable control limits. In such a case, the loop should rather be set to Auto control mode so it can be automatically controlled to remain within acceptable control limits around a chosen SP. If the loop is working correctly, Auto control will generally be better than Manual control, unless the loop has tuning, design, or equipment problems.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage MV Saturation	This indicates the percentage of samples of good quality where the MV is saturated. The MV is considered saturated when it is at 0% or at 100%.	Percentage MV Saturation = (Number of samples of good quality WHERE (MV is 0% or 100%) / Number of samples of good quality) * 100	This gives an indication of how much MV is at one extreme or the other. This should be low. If this KPI is large, one of the following is likely the cause of this: • The sensor, or FCE/ Actuator is broken. • The SP is set at an unrealistic/unreachable value. • The FCE/Actuator is incorrectly sized.	OPM-CLPM-Performance
Percentage Not Utilized	This indicates the percentage of samples of good quality where the loop is not being utilized. The loop is considered not utilized when the MV is at 0% or at 100% (saturated), or when the control mode is Manual.	Percentage Not Utilized = (Number of samples of good quality WHERE (MV is 0% or MV is 100% or control mode is Manual) / Number of samples of good quality) * 100	This gives an indication of how much MV is not being used effectively. This should be low. If this KPI is large, one of the following is likely the cause of this: • The sensor, or FCE/ Actuator is broken. • The SP is set at an unrealistic/unreachable value. • The FCE/Actuator is incorrectly sized. • The loop is in Manual mode for other reasons.	OPM-CLPM-Performance

KPI	Description	Formula	Interpretation	Source KPI Analytic
Percentage Shutdown	This indicates the percentage of the samples of good quality within the data window for which the control mode used was Shutdown.	% Shutdown = Number of samples WHERE (Shutdown control mode AND samples of good quality)/ Number of samples of good quality	In Shutdown control mode, the loop is switched off because the plant is in an abnormal operating mode. For example, the plant may be shut down for maintenance. Shutdown mode means that the loop is off, and the plant is off or not in a condition to be automatically controlled. The CLPM solution excludes all data from loop KPI calculations during this time. During CLPM deployment, an analytic is created that decides based on operational rules, when each control loop should be considered in Shutdown mode.	OPM-CLPM-Performance
Percentage Shutdown LL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Shutdown and the PV was below the Lower SP Offset.	% Shutdown LL Exceeded = Number of samples WHERE (Shutdown control mode AND PV < Lower SP Offset AND samples of good quality) / Number of samples of good quality	It is OK if a loop violates limits during Shutdown mode, since the loop is off and not meant to be controlling, and data is not used in KPI calculations.	OPM-CLPM-Performance
Percentage Shutdown UL Exceeded	This indicates the percentage of the samples of good quality within the data window for which the control mode was set to Shutdown and the PV was above the Upper SP Offset.	% Shutdown UL Exceeded = Number of samples WHERE (Shutdown control mode AND PV > Upper SP Offset AND samples of good quality) / Number of samples of good quality	It is OK if a loop violates limits during Shutdown mode, since the loop is off and not meant to be controlling, and data is not used in KPI calculations.	OPM-CLPM-Performance
PV Error Absolute Average	This gives the average of the absolute values of all PV Error (PV - SP) samples within the data window that are of good quality.	PV Error Absolute Average = SUM(|PV Error Samples of good quality in window|) / Number of PV Error samples of good quality	The closer this KPI is to zero the better. An absolute average of zero indicates that the loop is controlling exactly on the SP. The KPI gives an indication of how far away the PV is on average from the SP over the reporting period.	OPM-CLPM-Performance_Ext

KPI	Description	Formula	Interpretation	Source KPI Analytic
PV Error Average	This gives the average of all PV Error (PV - SP) samples within the data window that are of good quality.	PV Error Average = SUM (PV Error Samples of good quality in window) / Number of PV Error samples of good quality	The closer this KPI is to zero the better. An average of zero indicates that the loop is on average controlling centered around the SP.	OPM-CLPM-Performance_Ext
PV Error Standard Deviation	This gives the standard deviation of all PV Error (PV - SP) samples of good quality.	PV Error Standard Deviation = SQUARE ROOT (SUM(PV Error - PV Error Average) ^2 for each PV Error sample of good quality) / Number of PV Error samples of good quality)	This KPI gives an indication of the amount of variation in PV Error sample values of good quality over the reporting period.	OPM-CLPM-Performance_Ext
PV Variability	This gives a ratio which is a measure of the standard deviation relative to the PV sample average, for PV samples of good quality within the reporting period.	PV Variability = (PV Standard Deviation * 200) / |PV Average|	This KPI gives an indication of how spread out or closely clustered the PV data samples are, expressed as a percentage. It is a measure of relative PV variability. This is also sometimes referred to as the coefficient of variation.	OPM-CLPM-Performance_Ext
PV Variance	This gives the variance of all PV samples of good quality over the reporting period.	PV Variance = SUM((PV Sample - PV Average) ^2 for each PV sample of good quality) / Number of PV samples of good quality	This KPI gives an indication of the amount of variation in PV sample values of good quality over the reporting period.	OPM-CLPM-Performance_Ext
Reversal Amplitude	This calculates the sum of all the changes in the MV relative to the number of times the MV changes direction. Only data of good quality is considered for the calculation of this value. Bad quality data is ignored.	Reversal Amplitude = SUM(|MV_ROC|) / Reversal Count = SUM(|MV_ROC|) / COUNT(MV direction change)	The closer this KPI is to zero the better. A low value likely means that the system is responsive and smaller changes are made to keep the system on track. A large reversal amplitude likely indicates that the system is unresponsive and hence requires larger changes in the MV to keep it on track.	OPM-CLPM-Performance_Ext
Reversal Count	This calculates the number of times that the MV changes direction over the reporting period.	Reversal Count = COUNT(MV direction change)	The closer this KPI is to zero the better. A large value for this KPI indicates that MV changes tend to overshoot the mark and require MV changes in the opposite direction to compensate.	OPM-CLPM-Performance_Ext

KPI	Description	Formula	Interpretation	Source KPI Analytic
Statistics Period	This is the time period in seconds over which the KPIs have been calculated.	Statistics Period = End time - Start time, expressed in seconds	The time period in seconds over which the KPIs have been calculated.	OPM-CLPM-Performance_Ext
Total PIDF Changes	This indicates the total number of times that one of the P, I, D, or F (Proportional, Integral, Derivative, or Filter) values has changed inside the window of data.	Total PIDF Changes = COUNT (All samples where P, I, D, or F values have changed)	Different settings will change this KPI and can explain sudden changes in control loop performance. For example, there may have been some change in the loop tuning settings and that has affected loop performance.	OPM-CLPM-Config_Change

Non-Aggregate KPIs

These non-aggregate KPIs are given for the data window.

KPI	Description	Formula	Interpretation	Source KPI Analytic
Lower SP Threshold	This returns a dataset that is the set of all differences between the SP and the Lower SP Offset for each point in the data window where that difference has changed from the previous difference. The quality of each datapoint in the dataset is the quality of the SP at that point in time. This is used to produce a step graph indicating changes in the Lower SP Threshold.	For each sample in window, add a datapoint, IFF it differs from the previous datapoint: SP-LowerSPOffset where quality is WORST(SP,LowerSPOffset).	This returns a dataset that is the set of all differences between the SP and the Lower SP Offset for each point in the data window where that difference has changed from the previous difference. This represents the acceptable lower control limit within which the PV should be controlled.	OPM-CLPM-PV_Statistics
PV Error	This returns a dataset that is the set of all differences between the PV and SP for each point in the data window. The quality of each datapoint in the dataset is the worst quality of the PV and SP at that point in time. This is used to produce the error histogram.	For each sample in window, add a datapoint: PV-SP, where quality is WORST(PV,SP).	This returns a dataset that is the set of all differences between the PV and SP for each point in the data window. Ideally, the PV Error should be zero. A large positive or negative PV Error means that the control loop is not controlling the PV to the SP effectively.	OPM-CLPM-PV_Statistics
Upper SP Threshold	This returns a dataset that is the set of all sums of the SP and the Upper SP Offset for each point in the data window where that sum has changed from the previous sum. The quality of each datapoint in the dataset is the quality of the SP at that point in time. This is used to produce a step graph indicating changes in the Upper SP Threshold.	For each sample in window, add a datapoint, IFF it differs from the previous datapoint: SP+UpperSPOffset where quality is WORST(SP,UpperSPOffset).	This returns a dataset that is the set of all sums of the SP and the Upper SP Offset for each point in the data window where that difference has changed from the previous difference. This represents the acceptable upper control limit within which the PV should be controlled.	OPM-CLPM-PV_Statistics

Chapter 8

Release Notes

Topics:

Control Loop Performance Monitoring Release Notes Q2 2019

This topic provides a list of product changes released for this module on the dates listed below.

Release Date: June 3, 2019

Table 4: Enhancements and New Features

The following enhancements and new features have been added.

Description	Tracking ID
The Loop Dashboard now has the capability to display information till the latest available data point for the specified dates.	US340762
In the Fleet Dashboard, you can now access the historical data by specifying a date range of up to 30 days.	US325581

Control Loop Performance Monitoring Release Notes Q1 2019

This topic provides a list of product changes released for this module on the dates listed below.

Release Date: March 29, 2019

Table 5: Enhancements and New Features

The following enhancements and new features have been added.

Note	Tracking ID
Additional alerting analytics are now available for scheduling. Once configured, these alerts can notify you of the following situations: • Poor PV sensor data. • Potential problems with loop tuning or design. • Poor MV sensor data. Consult the Deploy CLPM Analytics section of this documentation for more information.	F41291
Enhancements have been made to the Control Loop Performance Table in the Fleet Dashboard. • Advanced filters are now available, including a global filter, multiple-level filters, text filters, and conditional parameters to filter data in the table. • Updates have also been made to improve responsiveness when loading the table.	F41287
The Diagnostic Alerts Filtering smart filter has been added to the Fleet Dashboard in this release. This smart filter is a visual tool to identify faulty control loops.	F36574

Table 6: Known Issues

The following issues are unresolved in this release.

Note	Tracking ID
Not all PIDF configuration changes are currently detected by the Configuration Change Detection analytic.	DE91981
For interpolated data, APM Timeseries returns bad quality data until the first sample of good quality in the data window is encountered.	DE95724

Table 7: Limitations

The following limitations apply to this release.

Note	Tracking ID
Only the Chrome 43 or higher browser is supported for accessing the Loop and Fleet dashboards.	NA
CLPM has been benchmarked for deployment over a maximum of 200 assets.	NA
All analytic inputs are read as interpolated data. Ensure that your raw data in Predix Timeseries is sampled at a lower frequency than the data interval of your deployed analytics. Results for data recorded at higher frequencies may not be statistically accurate representations of the performance of the control loop in question.	NA
All CLPM analytics must currently be configured to use recurrent scheduling and interpolated sample data. Streaming scheduling and raw sample data options are not currently available.	NA