

PDQ TRACKER

phasor data quality alarming & reporting

NASPI Technical Workshop

Synchrophasor Data Quality Management and Improvement

J. Ritchie Carroll

Russell Robertson

March 18, 2016

Phasor Data Quality Tracker

A Practical Tool

- An open source project jointly funded by Dominion and PeakRC
- Version 1.0 has been released and is now available which includes core functionality and two data quality reports

<http://github.com/GridProtectionAlliance/pdqtracker>

PDQ TRACKER

phasor data quality alarming & reporting

© 2016 Grid Protection Alliance.



High Level Features

- Focus is on the two major dimensions of quality
 - Data Completeness (Availability)
 - Data Correctness (Accuracy)
- Stand alone product for use within any synchrophasor data architecture
- Outputs to support:
 - Business processes for correcting / improving data quality
 - Integration with applications to flag incorrect data

Data Quality Tests

Completeness

- **Bad CRC**
- **Out-of-Order Frames**
- **Missing Frames**

Correctness

- **Time**
 - Reasonableness
 - Latency
- **Values**
 - Reasonableness
 - Latched Value
 - Comparison Tolerance
 - Bad Data Pattern

PDQ Tracker maintains statistics on data completeness

PDQ Tracker raises alarms to flag incorrect data

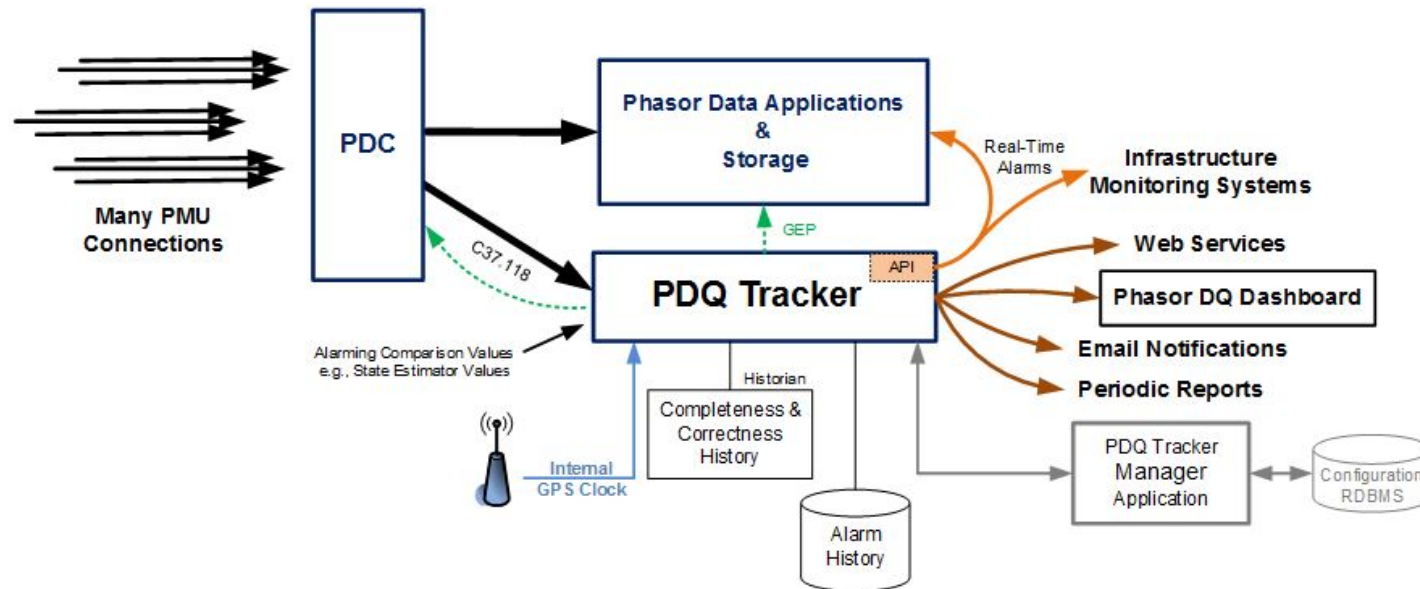
PDQ TRACKER

phasor data quality alarming & reporting

© 2016 Grid Protection Alliance.



Typical Installation



PDQ Tracker is installed in parallel to existing infrastructure, can be used with any vendor's PDC and by default is self-configuring.

PDQ TRACKER

phasor data quality alarming & reporting

© 2016 Grid Protection Alliance.

Add Device Streams

The screenshot displays the PDQTracker Manager interface. At the top, the title bar reads 'PDQTracker Manager - GPA\rcarroll'. The main header includes a power icon, the text 'PDQTracker Manager', and a 'Current Node: Default' dropdown. A navigation menu contains 'Home', 'Devices', 'Monitoring', 'Alarms', 'Reports', 'Diagnostics', and 'Advanced'. The central area is titled 'Input Device Configuration Wizard' and features a 'Launch Walkthrough' button. Below this, 'Step 1: Configure Connection Settings' is active. It includes a 'Select PMU Connection File (from PMU Connection Tester)' section with a 'Connection File' input field and a folder icon. An 'OR' separator is present. The 'Connection String' section has a 'Connection String Builder' dialog box open, which has tabs for 'TCP', 'UDP', 'Serial', and 'File'. The 'TCP' tab is selected, showing 'Host IP' (127.0.0.1), 'Port' (4712), 'Max Send Queue Size' (-1), and a 'Force IPv4' checkbox (checked). There is also an 'Establish TCP Server' checkbox (unchecked) and a 'Save' button. Below the dialog, the 'Alternate Command Channel' section has two empty input fields. At the bottom of the wizard, 'Device ID Code' is set to '0' and 'Device Protocol' is set to 'IEEE C37.118-2005'. 'Step 2: Select Device Configuration Settings' and 'Step 3: Select Devices to Configure' are listed below. 'Previous' and 'Next' buttons are at the bottom.

Enabling Reporting

The screenshot shows the PDQTracker Manager web interface. The top navigation bar includes Home, Devices, Monitoring, Alarms, Reports, Diagnostics, and Advanced. The current node is set to 'Default'. The main content area is titled 'Configure Correctness/Accuracy Report' and contains two main sections:

- Manual Report Generation:** Includes a 'Report Date' field set to 3/17/2016, a 'Generate Report...' button, and an 'Automatic daily reporting is disabled' status with an 'Enable' button circled in red. A callout box labeled 'Click Button' points to the 'Enable' button.
- Reporting Services Configuration:** Includes instructions on report location, a 'Report Location' field set to 'Reports', a 'Reports expire after' field set to 14 days, and an 'Apply' button.

At the bottom, there are two empty tables: 'Available Reports' with columns for 'Date' and 'Status', and 'Pending Reports' with a column for 'Date'.

Configure Automated Report E-mails

Configuration Editor

Configuration Editor Application Settings

C:\Program Files\PDQTracker\PDQTracker.exe.Config Load Settings

Configuration loaded from: C:\Program Files\PDQTracker\PDQTracker.exe.Config

- > activeDirectory
- > alarmServicesAlarmService
- ▼ completenessReporting
 - ArchiveFilePath Eval(statArchiveFile.FileName)
 - Company Eval(systemSettings.CompanyName)
 - EnableReportEmail False
 - FromAddress reports@gridprotectionalliance.org
 - IdleReportLifetime 14
 - Level3Alias Fair
 - Level3Threshold 90
 - Level4Alias Good
 - Level4Threshold 99
 - ReportLocation Reports
 - SntpServer localhost
 - Title Eval(securityProvider.ApplicationName) Co
 - ToAddresses wile.e.coyote@acme.com
- ▼ correctnessReporting
 - ArchiveFilePath Eval(statArchiveFile.FileName)
 - Company Eval(systemSettings.CompanyName)
 - EnableReportEmail False
 - FromAddress reports@gridprotectionalliance.org
 - IdleReportLifetime 14
 - ReportLocation Reports
 - SntpServer localhost
 - Title Eval(securityProvider.ApplicationName) Correctness Report
 - ToAddresses wile.e.coyote@acme.com
- > cryptographyServices
- > errorLog
- > errorLogger
- > exampleConnectionSettings
- > externaldatapublisher
- > healthExporter
- > internaldatapublisher

completenessReporting

Save Settings

E-mail Server

E-mail Addresses

Completeness Report

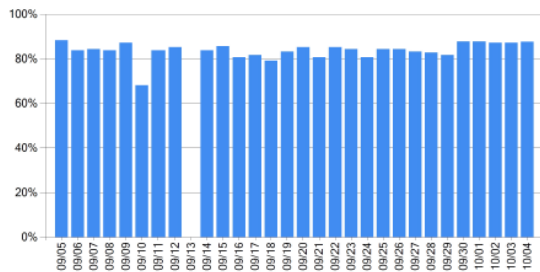
PDQTracker Completeness Report Grid Protection Alliance

Sunday, October 04, 2015

5-day Device Data Completeness

	09/30	10/01	10/02	10/03	10/04
L4: Good	156	141	160	163	163
L3: Fair	18	33	13	10	10
L2: Poor	17	12	12	10	9
L1: Offline	3	8	8	10	10
L0: Failed	4	4	5	5	5
Total	198	198	198	198	197

Percent of Devices with Acceptable Quality (30 days)



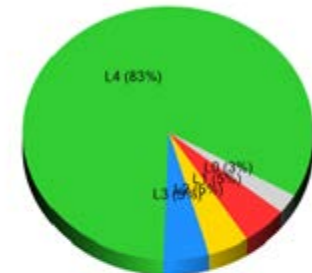
Definitions

Level 4: Good - Devices which are reporting as expected, with a completeness of at least 90% on the report date.
 Level 3: Fair - Devices with a completeness of at least 90% on the report date.
 Level 2: Poor - Devices which reported on the report date, but had an completeness below 90%.
 Level 1: Offline - Devices which did not report on the report date, but have reported at some time during the 30 days prior to the report date.
 Level 0: Failed - Devices which have not reported during the 30 days prior to the report date.
 Completeness: Percentage of measurements received over total measurements expected, per device.
 Acceptable Quality: Devices which are in Level 4 or Level 3.

Sunday, October 04, 2015

Data Completeness Breakdown

Level 4 163
Level 3 10
Level 2 9
Level 1 10
Level 0 5



Level 0

Name	Completeness	Data Errors	Time Errors
_____N_01	0%	0	0
_____02	0%	0	0
_____01	0%	2,591,678	2,591,678
_____PE_01	0%	2,591,678	2,591,678
_____tC_01	0%	2,591,678	2,591,678

Level 1

Name	Completeness	Data Errors	Time Errors
_____R_01	0%	2,591,672	2,591,672
_____HN_01	0%	2,591,672	2,591,672
_____01	0%	2,591,672	2,591,672
_____PI_01	0%	2,591,749	2,591,749
_____P_01	0%	2,591,678	2,591,678
_____02	0%	0	0
_____01	0%	0	0
_____01	0%	0	0
_____01	0%	0	0
_____01	0%	0	0

Level 2

Name	Completeness	Data Errors	Time Errors
_____01	4.85%	2,465,957	2,465,957
_____CM_04	84.24%	0	0
_____CM_05	84.24%	0	0

Report Areas

- 5-Day Summary
- 30-Day Trend
- Quality Level Graph
- Breakdown Details

5-Day Summary

- Summary data by PMU
- Each cell shows count of the number of PMUs that met the definition for each of the last 5 days
- Definitions are editable and managed on the PDQ server

5-day Device Data Completeness

	09/30	10/01	10/02	10/03	10/04
L4: Good	156	141	160	163	163
L3: Fair	18	33	13	10	10
L2: Poor	17	12	12	10	9
L1: Offline	3	8	8	10	10
L0: Failed	4	4	5	5	5
Total	198	198	198	198	197

Definitions

Level 4: Good - Devices which are reporting as expected, with a completeness of at least 99% on the report date.

Level 3: Fair - Devices with a completeness of at least 90% on the report date.

Level 2: Poor - Devices which reported on the report date, but had an completeness below 90%.

Level 1: Offline - Devices which did not report on the report date, but have reported at some time during the 30 days prior to the report date.

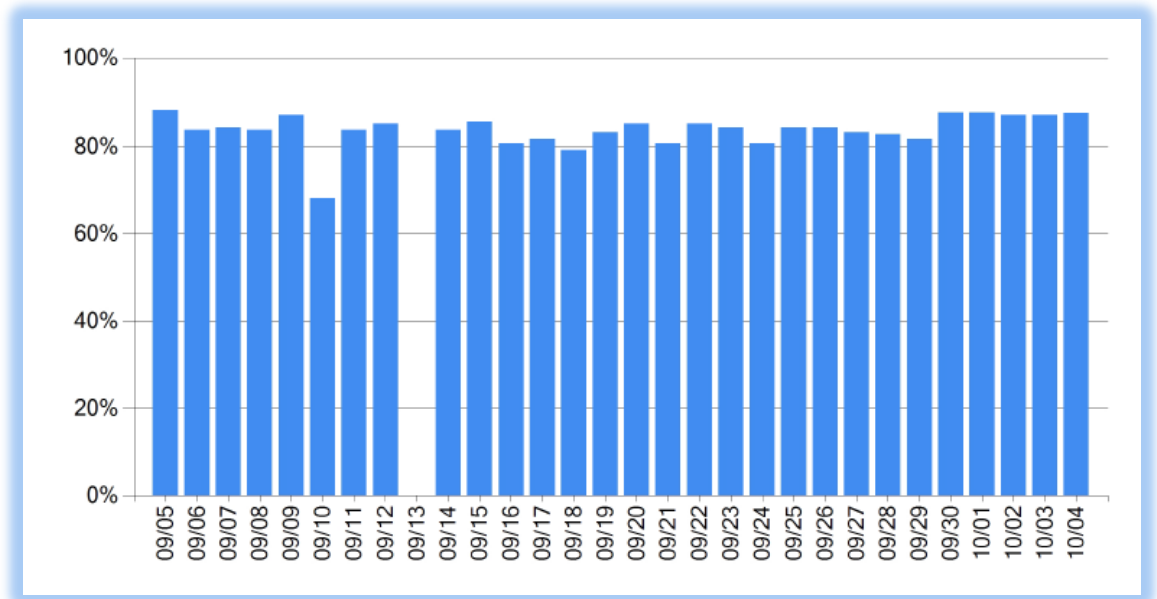
Level 0: Failed - Devices which have not reported during the 30 days prior to the report date.

Completeness: Percentage of measurements received over total measurements expected, per device.

Acceptable Quality: Devices which are in Level 4 or Level 3.

30-Day Trend

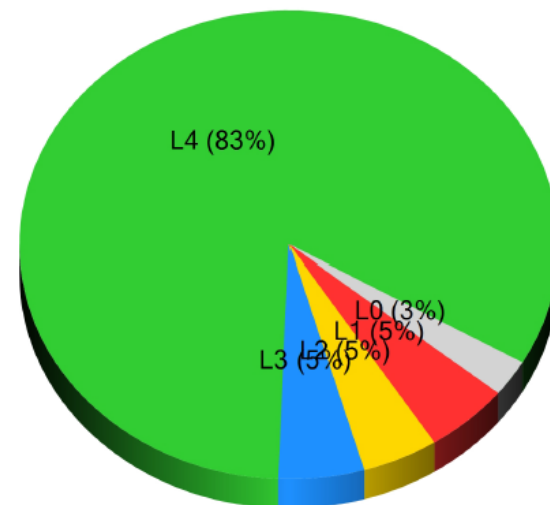
- Count of devices (PMUs) which are in Level 4 or Level 3
- One bar for each of the last 30 days



Quality Level Graph

- Simple graph summarizing the number of devices (PMU) that were at each level for the reporting day

Level 4	163
Level 3	10
Level 2	9
Level 1	10
Level 0	5



Breakdown Details

- One line per device (PMU) grouped by Level designation (0-worst to 4-best)
- **Completeness:** Percentage of measurements received over total measurements expected, per device. Uses calculated statistic of *Number of measurements received* divided by *Expected number of measurements* over reporting period (defaults to 10 seconds)
- **Data Errors:** Total number of data errors (IEEE C37.118 Bit-15) reported by the device. Uses device statistic for Number of data quality errors reported by device during last reporting interval
- **Time Errors:** Total number of time errors (IEEE C37.118 Bit-13) reported by the device. Uses device statistic for Number of time quality errors reported by device during last reporting interval

Level 3			
Name	Completeness	Data Errors	Time Errors
UNIT_2	98.24%	0	954,034
UNIT_3	98.24%	0	954,034
ER	93.85%	0	0
.R1	92.81%	0	0
.R2	92.98%	0	0

Correctness Report

PDQTracker Correctness Report

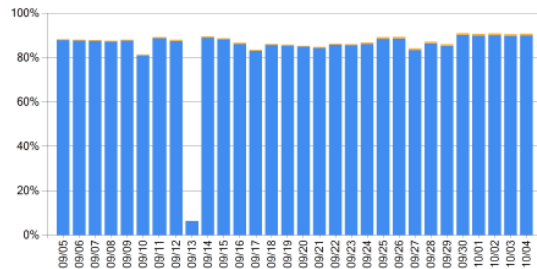
Grid Protection Alliance

Sunday, October 04, 2015

5-day Correctness Summary

	09/30	10/01	10/02	10/03	10/04
Good	90.10%	89.82%	90.03%	89.72%	89.93%
Latched	0.52%	0.53%	0.52%	0.60%	0.61%
Unreasonable	0.39%	0.39%	0.34%	0.22%	0.22%

30-day Correctness Overview



Definitions

Good: Measurements received which are neither latched nor unreasonable.
 Latched: Measurements received which have maintained the same value for an extended period of time.
 Unreasonable: Measurements received whose values have fallen outside of the range defined by reasonability constraints.
 Correctness: Percentage of good measurements over total measurements expected, per device.

Sunday, October 04, 2015

Data Correctness Breakdown

Name	Correctness	Latched	Unreasonable	Total
E_09	78.71%			
Name				
E_09-FQ		2,194,781	0	2,194,781
N_02	68.09%			
Name				
N_02-PM2		0	2,591,872	2,591,872
N_02-FQ		8	0	8
DX_03	68.44%			
Name				
DX_03-PM2		0	2,591,872	2,591,872
N_03	68.09%			
Name				
TN_03-PM2		0	2,591,872	2,591,872
N_03	68.43%			
Name				
N_03-PM2		0	2,591,872	2,591,872
DX_04	68.44%			
Name				
DX_04-PM2		0	2,591,871	2,591,871
IT_03	83.34%			
Name				
NT_03-PA1		2,589,574	0	2,589,574

Reporting Areas

- 5-Day Summary
- 30-Day Trend
- Breakdown Details

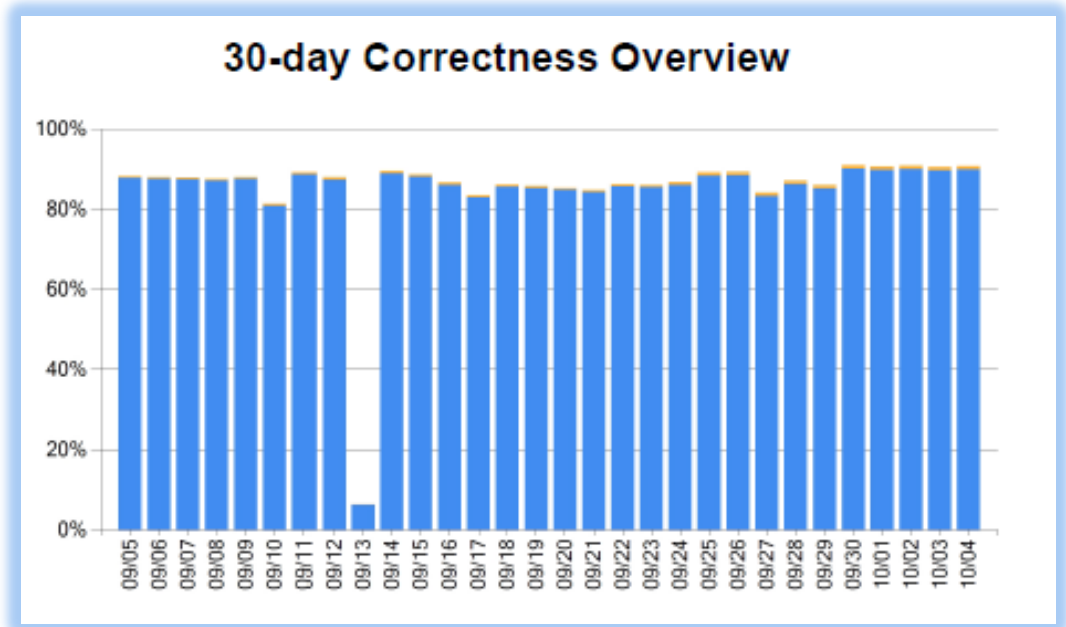
5-Day Summary

- Summary data by PMU
- Each cell shows count of the number of PMUs that met the definition for each of the last 5 days

	09/30	10/01	10/02	10/03	10/04
Good	90.10%	89.82%	90.03%	89.72%	89.93%
Latched	0.52%	0.53%	0.52%	0.60%	0.61%
Unreasonable	0.39%	0.39%	0.34%	0.22%	0.22%

30-Day Trend

- One bar for each of the last 30 days



Definitions

Good: Measurements received which are neither latched nor unreasonable.

Latched: Measurements received which have maintained the same value for an extended period of time.

Unreasonable: Measurements received whose values have fallen outside of the range defined by reasonability constraints.

Correctness: Percentage of good measurements over total measurements expected, per device.

Breakdown Details

Correctness is calculated as $(\text{Received} - \text{Latched} - \text{Unreasonable}) / \text{Expected}$

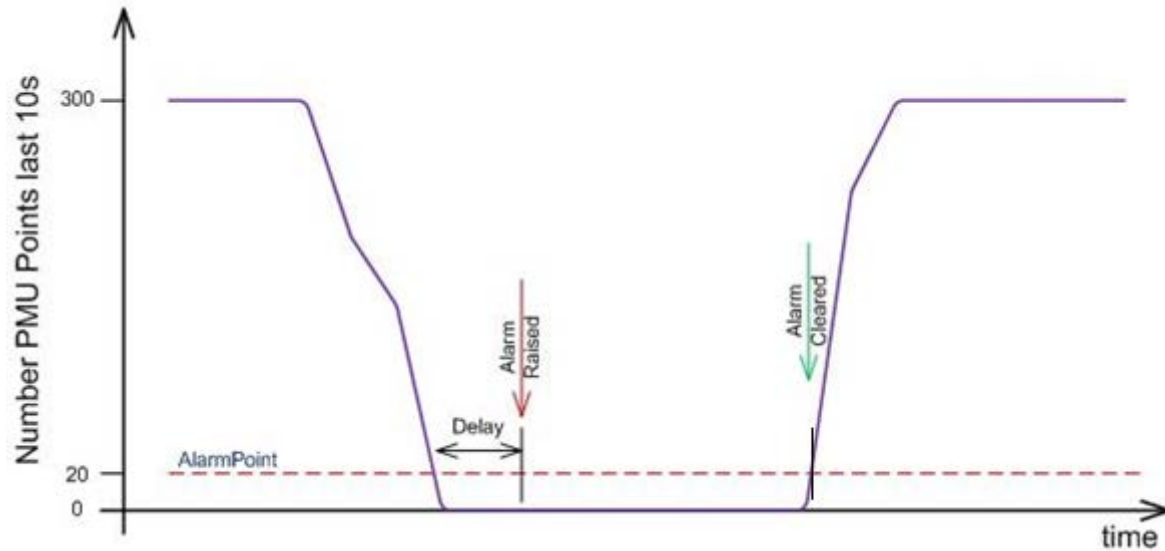
- **Good:** Not Latched and Not Unreasonable
- **Latched:** Alarm when value has changed over defined delay period (defaults to 10 seconds as defined in application, configurable)
- **Unreasonable:** Alarm when value is outside defined engineering reasonableness range (default depends on data type as defined in SQL below, configurable)

Likely that this data set will need to be refined as measurement quality continues to be evaluated.

Hierarchy of Alarms

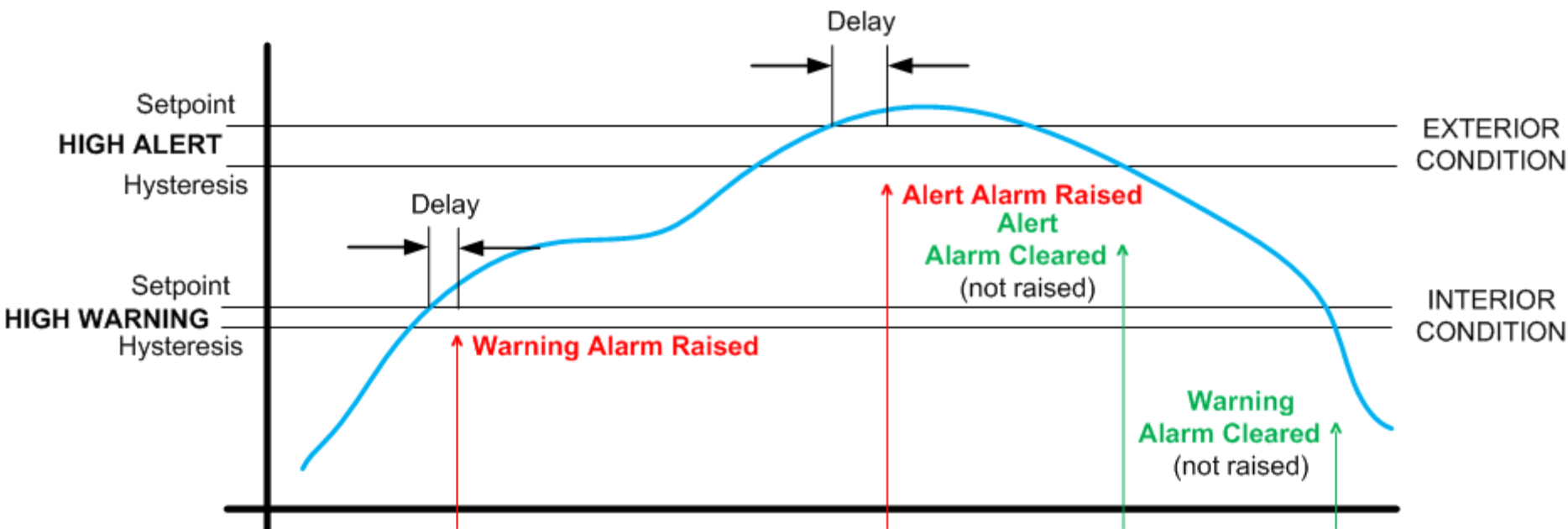
- A group of alarms is created for a “measurement point” provided to PDQ Tracker
- A measurement point can be:
 - A measured phasor magnitude or angle
 - A calculated value, such as
 - the difference between a measured value and a value from the state estimator
 - The rate of change of a measured value

Simple Alarming



Alarm Set Point and Delay

More Complex Alarming Example



Warning and Alert Alarms are raised at set points and are cleared only after falling below a specified hysteresis.

Configuring Alarming

PDQTracker Manager - GPA\rcarroll

PDQTracker Manager Current Node: Default

Home Devices Monitoring Alarms Reports Diagnostics Advanced

Manage Alarm Configuration

Tag Name* AL-HIGH:GPA_DEFAULT!SYSTEM:ST3

Signal* GPA_DEFAULT!SYSTEM:ST3 ...

Operation Greater than Alarm Point 85

Delay 10 seconds Tolerance

Description High CPU Alarm Severity High

Load Order* 0 Enabled Create Associated Measurement

Delete Add New Save

TagName	Operation	Severity	Description	Enabled
AL-HIGH:GPA_DEFAULT!SYSTEM:	GPA_DEFAULT!SYSTEM:ST3 > 85	High	High CPU Alarm	<input checked="" type="checkbox"/>

Page Size: 15 << < 1 of 1 > >>

Version 1.0 Available

<http://www.PDQTracker.com/>

The screenshot shows the PDQTracker Manager web interface. The top navigation bar includes Home, Inputs, Outputs, Actions, Metadata, Monitoring, Reporting, and System. The main content area is divided into several sections:

- Quick Links:** A vertical list of buttons for Graph Measurements, Stream Statistics, Input Device Wizard, Browse Input Devices, Concentrator Output Streams, Remote System Console, and Restart Service.
- Completeness:** A section titled "2-Day Completeness Report" showing data for 10/22 and 10/23. The data is as follows:

	10/22	10/23
L4: Good	21	24
L3: Fair	73	70
L2: Poor	5	5
L1: Offline	0	0
L0: Failed	0	0
Total	99	99
- Current Configuration:** A section with the following details:
 - Instance Type: 64-bit
 - Server Time: 2014-10-23 01:13:07.047
 - Local Time: 2014-10-23 01:13:07.046
 - Current User: swills-PC\swills
 - Version Information:
 - Server: 2.0.167.0
 - Manager: 2.0.167.0
 - Database Information:
 - Type: SQLServer
 - Name: PDQTracker
- Correctness:** A section titled "2-Day Correctness Report" showing data for 10/22 and 10/23. The data is as follows:

	10/22	10/23
Good	89.89%	89.90%
Latched	1.84%	1.83%
Unreasonable	1.57%	1.57%

PDQ TRACKER

phasor data quality alarming & reporting

© 2016 Grid Protection Alliance.



phasor data platform

New Tool for Analytic Development
Including Data Quality Analyses



DOE FOA 970
DE-OE-778

Architectural Elements

- Data Conditioning / Alarming (*Quality Check!*)
- Data Distribution Service
- Common Analytics Interface (CAI)
- Electric System Model
- Shared Platform Services
- Analytics

