



# PMU Status Monitoring at BPA



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# Content

- System architecture
- PMU status issues
- Monitoring systems
- Response systems

# BPA Synchrophasor System Architecture

- Redundant, CIP-compliant PMUs
- C37.118 Protocol
- PDC functionality
- Network architecture

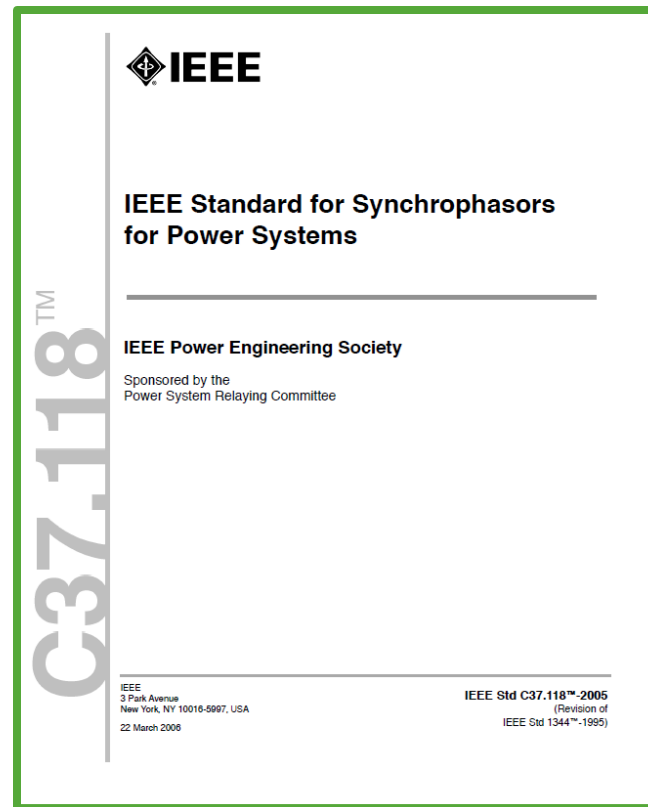
## Control PMU Installations

- Fully Redundant (PMU, GPS, Network)
- Encrypted stream, access control
- Reside inside of physical and electronic security perimeters
- 79 pairs at 55 sites (1-3 pairs per site)
- May be used to make operational decisions
- Referenced in dispatch operational directives (DSO)

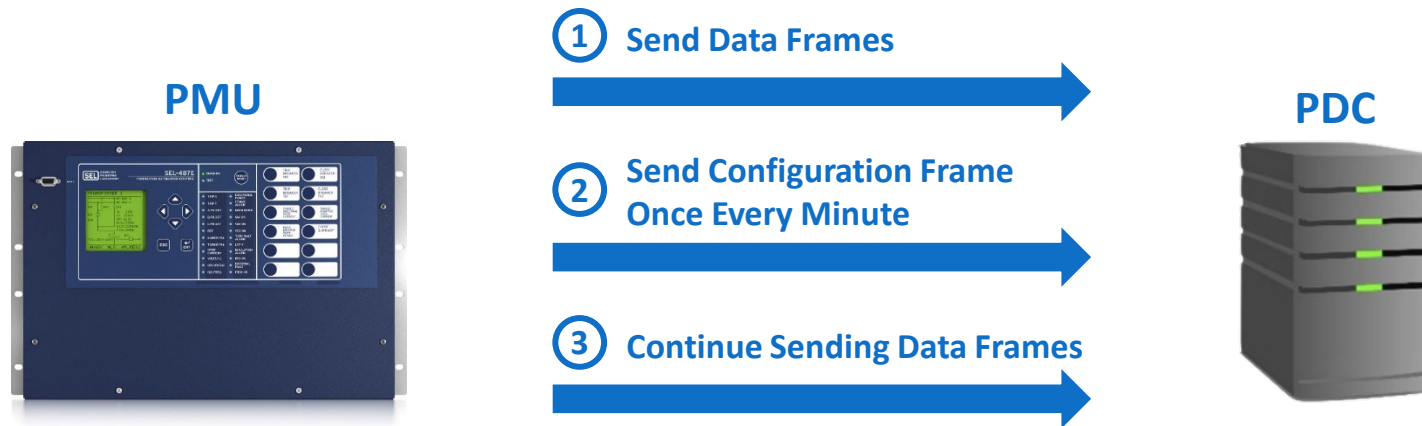


# IEEE C37.118

- Defines measurement performance standards **and** message formats
  - Configuration frame
  - Data frame
  - Includes **PMU Status** digital word
- May be bidirectional or **unidirectional**
- Covers both PMU and PDC streams



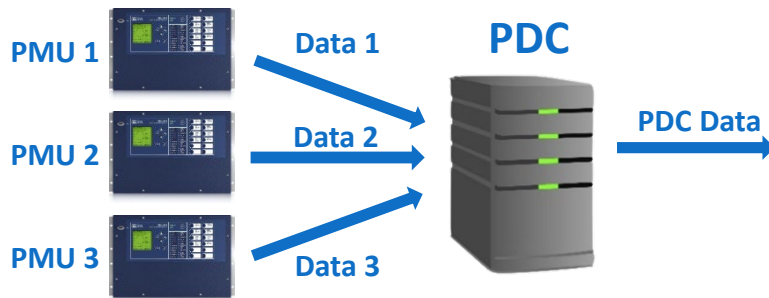
## IEEE C37.118 – Unidirectional



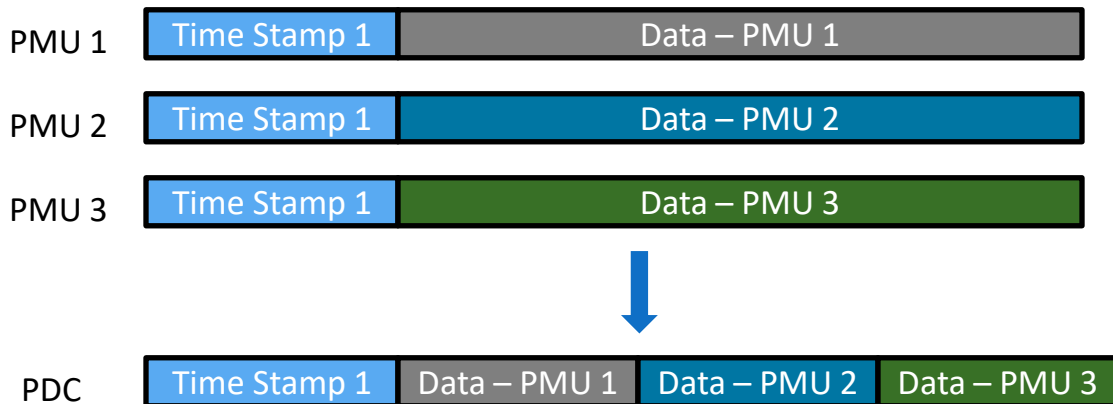
- In this mode, all C37.118 commands are ignored by the PMU
- Allows for multiple devices to receive streams from the same PMU
- ***This is the method used at BPA***

# Phasor Data Concentrator (PDC)

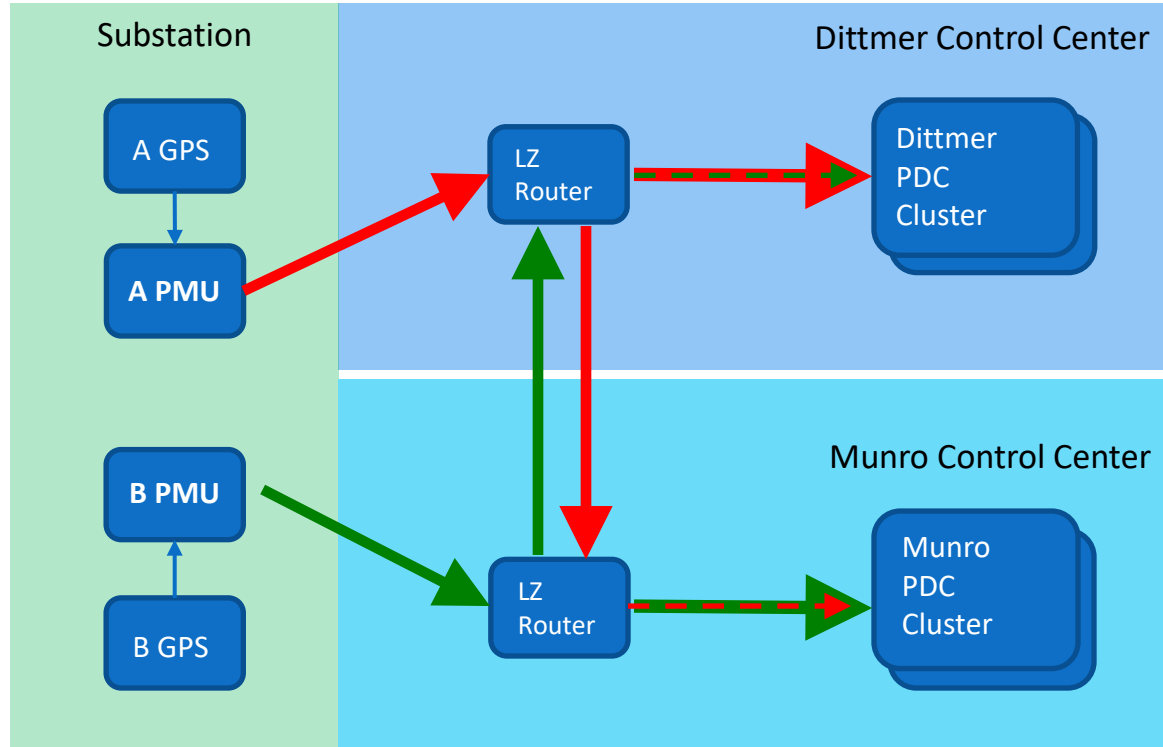
Concatenate and  
time align data  
from multiple  
PMUs



- Typically located in central environments (control centers)
- Usually software installed on PC/server
- Can receive data from PMUs and/or other PDCs
- Provides status information
- Can manage redundant data streams

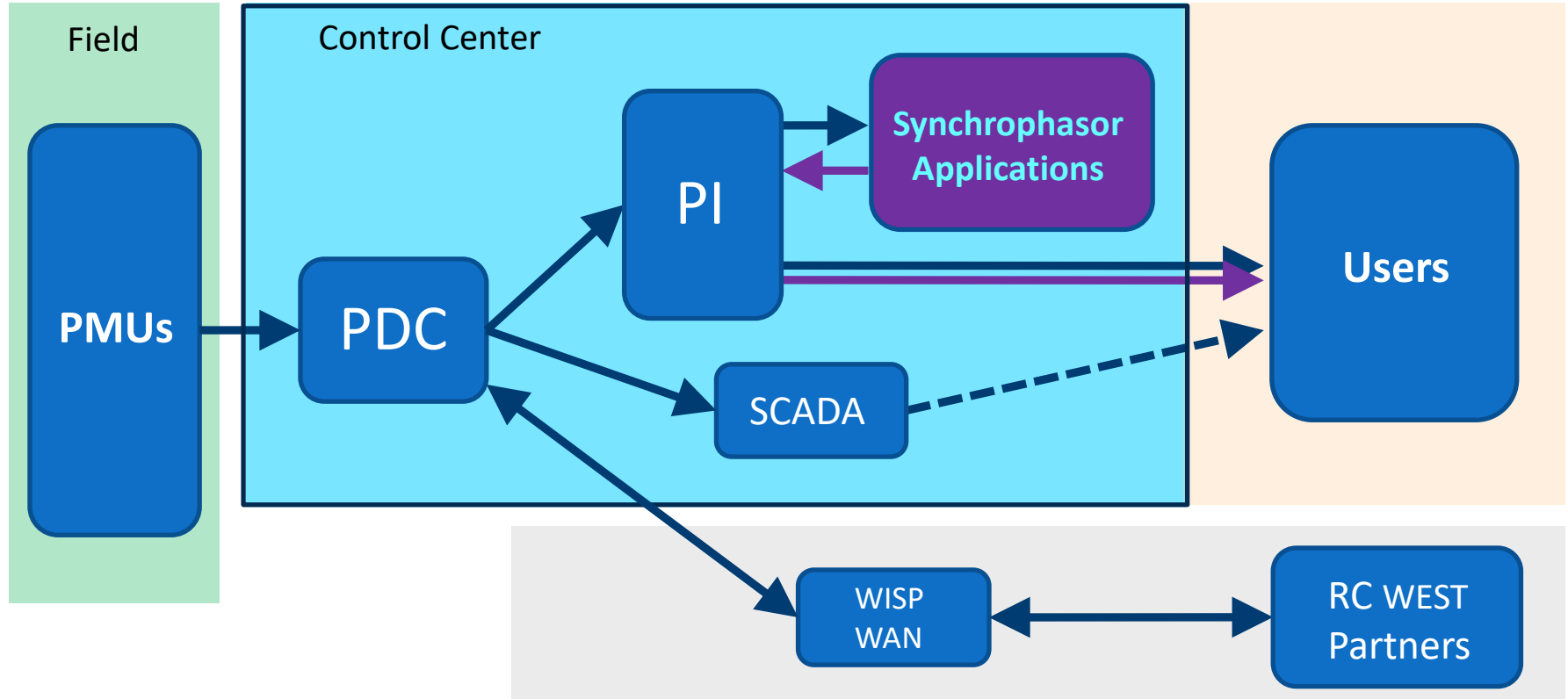


## Architecture: Field to Control Center





## Architecture: Control Center Systems



# PMU Status Problems

- Common problems
- Uncommon problems
- Other problems

# Common PMU Status Problems

Reported in the C37.118 Status Word

**Data Invalid**



**Sync Errors**



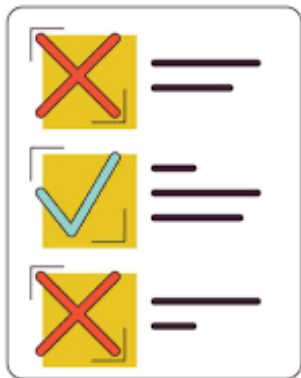
**PMU Errors**



# Common PMU Status Problems

Reported by the PDC

**Composite**



**Dropout**

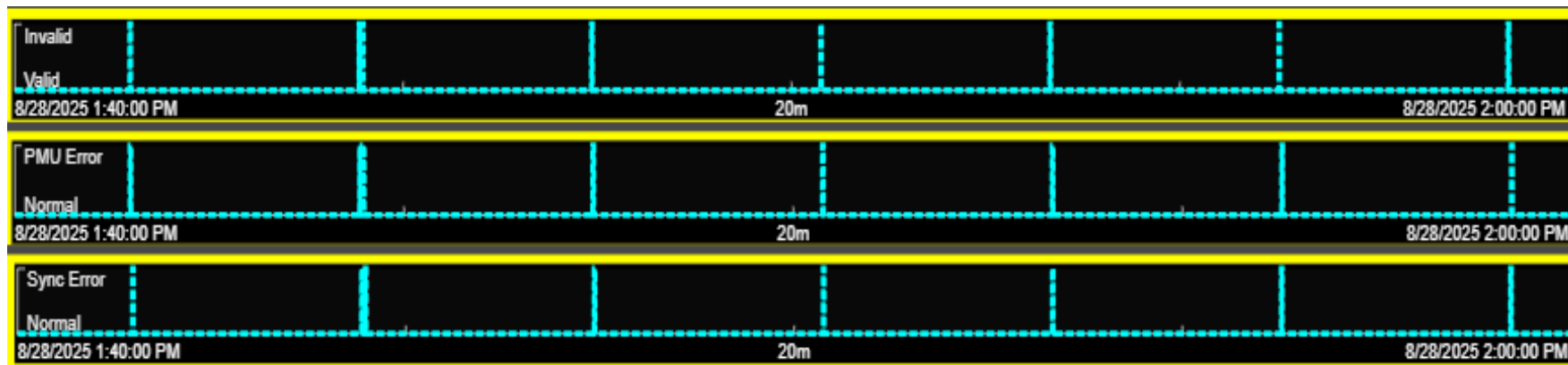


**Latency**



# Uncommon PMU Status Problems

## Momentary Periodic Dropouts



## Other PMU Status Problems

### PDC-to-Historian Integration Problems



**OSI**soft®

*open* **PDC**

# PMU Status Monitoring Systems

- SCADA
- Email Alerts
- Email Reports
- PMU Status Displays

# PMU Status SCADA Display

PMU Communications											↓	↓	↓	↓
EPDC and EPDC_STS RTUs														
Station		KV-Angle	PMU 3-PH KV-Mag.	PMU A-PH KV-Mag.	SCADA XDCR	Freq.	Drop Out A B		Out of Sync A B		PMU Error A B		Data Invalid A B	
PMU Name	500 North	-14.66	542.18	540.92	544.36	60.0118	Off	Off	Off	Off	Off	Off	Off	Off
	500 South	-14.68	543.09	541.30	545.34									



# PMU Status SCADA Alerts

The screenshot displays a SCADA alarm summary window. On the left, a sidebar shows the date and time as 22-Jan-2025 09:39:32, along with buttons for 'PERMIT SW', 'SILENCE', and 'CONTROL IS ON DCC'. The main window title is 'ALARM, UNACK, FIRST, LATEST, FIRST, BP, ALARM(SM)' and it shows 'Page 1 of 1 - Viewport C - DISDERAB'. The alarm summary table lists three alerts:

Time	State	Message
Jan22 09:39:02	ALARM	PMU PSC 500 AI DROPOUT NORMAL
Jan22 09:35:44	ALARM	BPANMI has found that automatic enabling of door alarms is disabled.
Jan22 09:36:49	ALARM	PMU PSC 500 AI DROPOUT ALARM



# Email Alerts



Scope: Single PMU (A or B in redundant pair)

**PMU Errors**



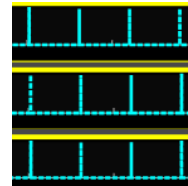
**Sync Errors**



**Latency**



**177s Drop**



**Test-Fail**



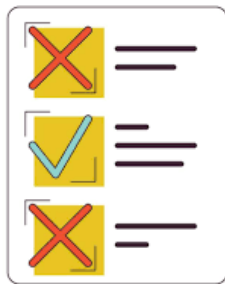


# Email Alerts



Scope: Source-selected PMU

**Composite**



**Bad Pair**



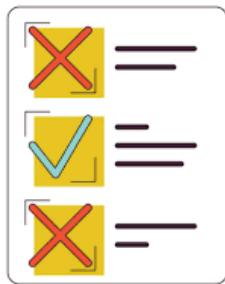


# Email Alerts



Scope: All PMUs

**Composite**



**ICC Link**



## Email Reports - Daily

SYNC ERR = Sync Error and NOT PMU Error and NOT Test-Fail and redundant PMU is Good

DROP OUT = Data Invalid and PMU Error and NOT Test-Fail and redundant PMU is Good

### A PMUs STATUS SUMMARY: 01/16/2025

PMU Status was all good today.

### B PMUs STATUS SUMMARY: 01/16/2025

PMU Status was all good today.

### A PMUs STATUS SUMMARY: 01/15/2025

PMU	STATUS	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	TOTAL
	DROP OUT	-	-	-	-	-	-	-	-	-	-	-	-	-	606	-	-	-	-	-	-	-	-	-	-	606
	SYNC ERR	-	-	-	-	-	-	-	-	-	-	-	31	126	132	-	-	-	-	-	-	-	-	-	-	288

### B PMUs STATUS SUMMARY: 01/15/2025

PMU	STATUS	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	TOTAL
	DROP OUT	-	-	-	-	-	-	-	-	-	-	761	-	-	-	-	-	-	-	-	-	-	-	-	-	761
	SYNC ERR	-	-	-	-	-	-	-	-	-	472	2032	-	-	-	-	-	-	-	-	-	-	-	-	-	2504

## Email Reports - Weekly

*Same logic as the Daily Report*

SYNC ERR = Sync Error and NOT PMU Error and NOT Test-Fail and redundant PMU is Good

DROP OUT = Data Invalid and PMU Error and NOT Test-Fail and redundant PMU is Good

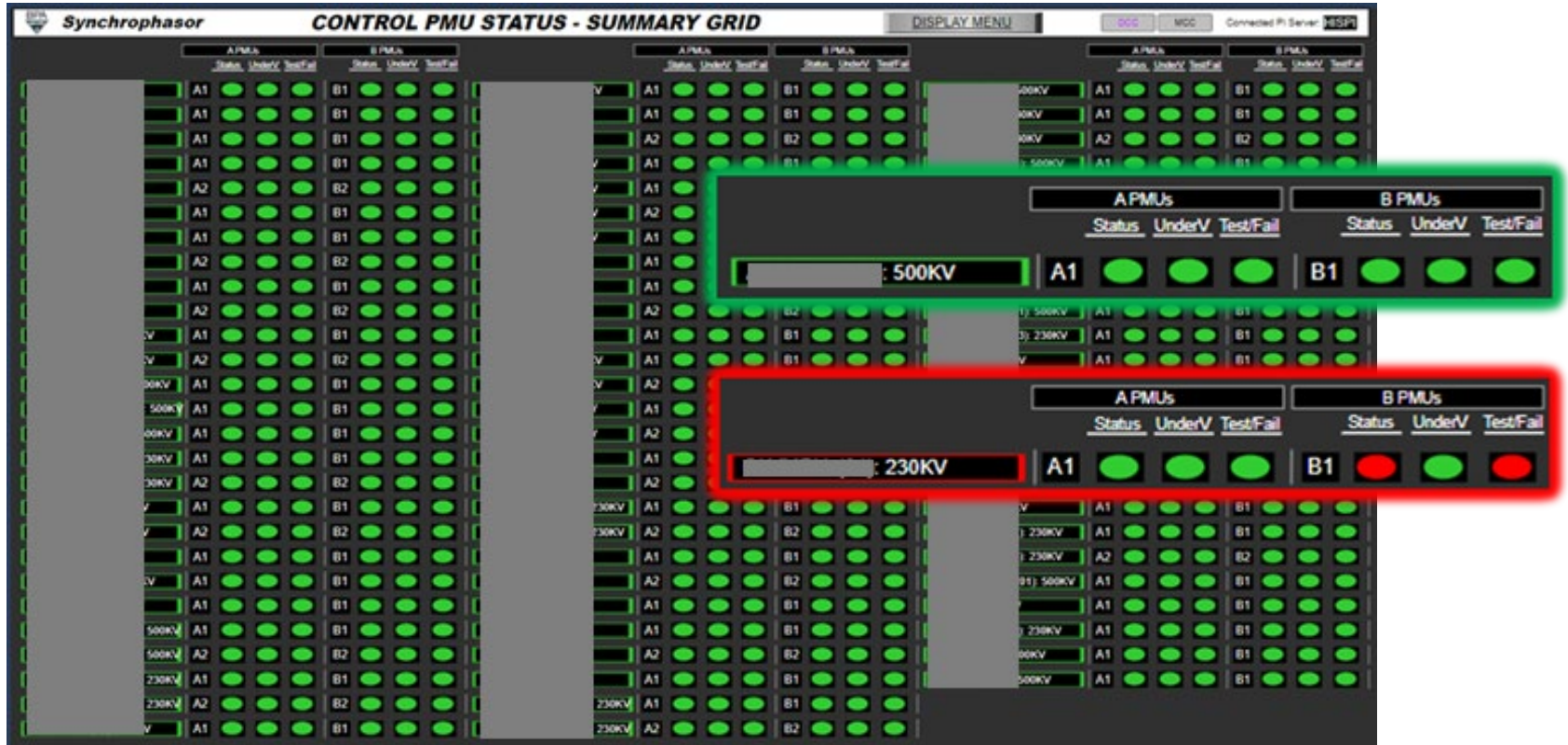
### A PMUs STATUS SUMMARY: 01/13/2025 - 01/19/2025

		01/13		01/14		01/15		01/16		01/17		01/18		01/19		TOTAL	
PMU	STATUS	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT
	DROP OUT	-	-	-	-	606	1	-	-	-	-	-	-	-	-	606	1
	SYNC ERR	-	-	-	-	288	3	-	-	-	-	-	-	-	-	288	3
	DROP OUT	-	-	-	-	-	-	-	-	-	-	-	-	0.07	1	0.07	1

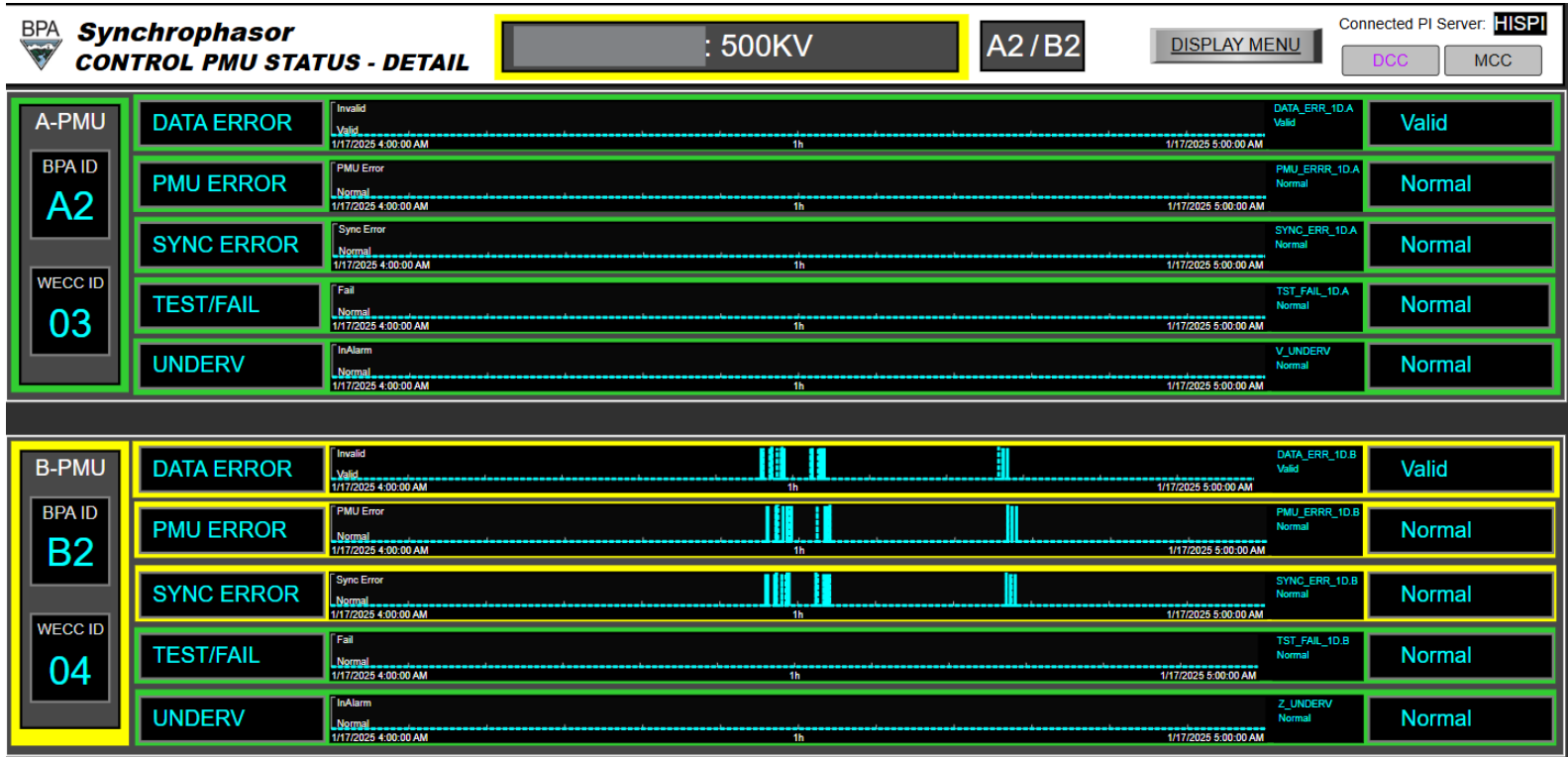
### B PMUs STATUS SUMMARY: 01/13/2025 - 01/19/2025

		01/13		01/14		01/15		01/16		01/17		01/18		01/19		TOTAL	
PMU	STATUS	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT	TIME	COUNT
	DROP OUT	-	-	-	-	761	1	-	-	-	-	-	-	-	-	761	1
	SYNC ERR	-	-	-	-	2504	5	-	-	-	-	-	-	-	-	2504	5
	DROP OUT	-	-	-	-	-	-	-	-	18	549	-	-	-	-	18	549
	DROP OUT	-	-	-	-	-	-	-	-	15	439	-	-	-	-	15	439

## PI Vision PMU Status Summary



# PMU Status PI Vision Display – PMU Details





# PMU Status PI Vision Display – PMU Details

**Synchrophasor**  
**CONTROL PMU STATUS - DETAIL**

:
500KV

A2 / B2

DISPLAY MENU

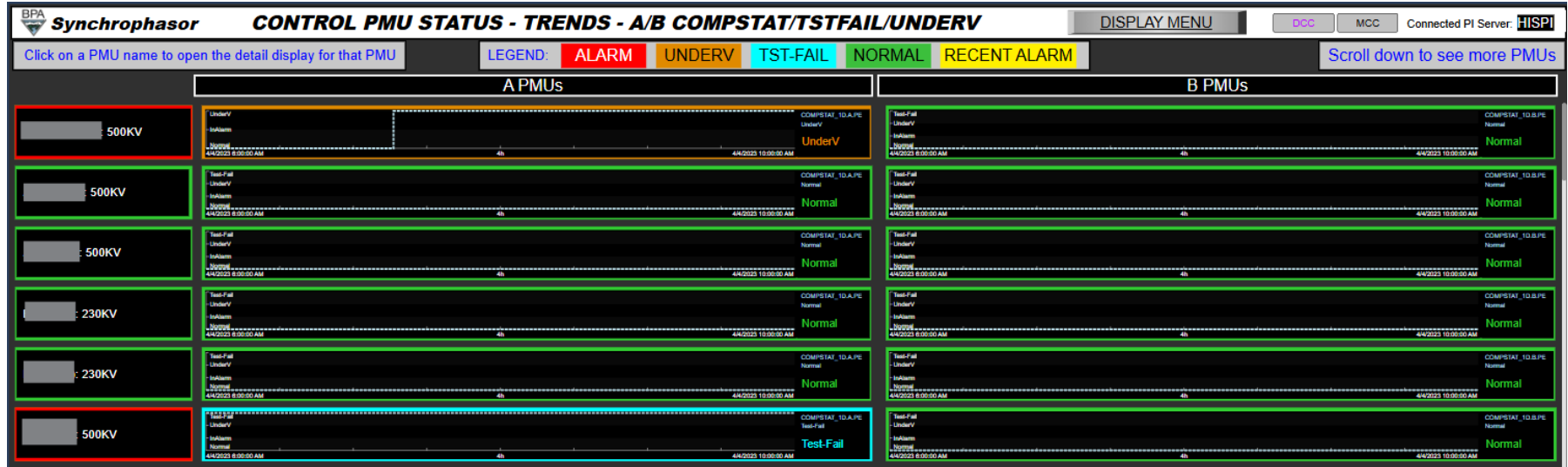
DCC

MCC

Connected PI Server: **HISPI**

	STATUS	DETAILS	RESULT
<b>A-PMU</b>  BPA ID <span style="font-size: 24px; color: cyan;">A2</span>  WECC ID <span style="font-size: 24px; color: white;">03</span>	DATA ERROR	Invalid Valid 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Valid
	PMU ERROR	PMU Error Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal
	SYNC ERROR	Sync Error Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal
	TEST/FAIL	Fail Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal
	UNDERV	InAlarm Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal
<b>B-PMU</b>  BPA ID <span style="font-size: 24px; color: cyan;">B2</span>  WECC ID <span style="font-size: 24px; color: white;">04</span>	DATA ERROR	Invalid Valid 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Invalid
	PMU ERROR	PMU Error Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	PMU Error
	SYNC ERROR	Sync Error Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Sync Error
	TEST/FAIL	Fail Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal
	UNDERV	InAlarm Normal 1/17/2025 3:43:41 AM 1h 1/17/2025 4:43:41 AM	Normal

# PI Vision PMU Status with COMPSTAT, TSTFAIL & UNDERV



# PMU Status Response Systems at BPA

# Synchrophasor Team

- We pay the most attention to PMU status – all the time.
- We receive PMU status notifications from both the Development and Production systems. And we receive notifications that are exclusively sent to us.
- We coordinate response activities between craftsmen in the field, system operations and control center network operations.
- We are continuously developing new monitoring tools and improving existing tools.

# District & Control Center Craftsmen

- There are 2 groups of craftsmen that support PMU systems:
  - Power system device support: This group conducts work on the actual PMU devices.
  - Network communications systems support: This group supports the GPS clocks and all network systems.
- As described previously, each PMU has a Test/Fail switch that the craftsman will set before performing any maintenance. The maintenance procedures include a call to the Synchrophasor Team before any work is performed.
- There is a daily morning meeting with representation from the control centers network operations teams to discuss any existing PMU problems or planned maintenance. The Synchrophasor Team also attends these meetings.

## Systems Operation Center (SOC)

- The SOC receives alerts from SCADA and contacts appropriate field staff or the Synchrophasor Team as needed.
- Operations will reach out to the SOC for support if needed.

## **BPA Labs and the Synchrophasor Coordination Team**

- This group isn't really a “response” entity. It is more focused on planning and development.
- If there is a recurring or persistent PMU status problem, this group will help to coordinate the response. All the other response teams have representation in this group.
- We meet monthly to keep everyone apprised of ongoing issues and development work.

# Summary



**In the end, the PMU data is primarily relevant in the context of the value it provides to operations.**

- The most important reason to identify and respond to PMU status issues is in support of the Synchrophasor Applications used by dispatch.
- It is imperative to address PMU status issues that cause data quality problems with the Synchrophasor Apps.

## **Effective PMU Status Monitoring requires a significant investment in methods and response systems.**

- Real time monitoring of multiple different types of possible status symptoms is required.
- Each PMU system will have different types of unique problems.
- Redundant alert methods are helpful.
- Constant vigilance is mandatory.
- Dedicated and qualified technical support is essential.

## Contact Information

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