

DISTRIBUTION PMU REPORT

INVESTIGATION INTO
REQUIREMENTS FOR A PMU
FOR DISTRIBUTION SYSTEMS

BY: IEEE PSRC WG C41

PRESENTED BY:

PANAGIOTIS MOUTIS

NASPI WORK GROUP HYBRID MEETING
AND VENDOR SHOW

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AGENDA

- Introduction
 - WG formation & assignment
- Report development
 - Investigation
 - Results
- Recommendations
- Ongoing activity





DISTRIBUTION PMU INVESTIGATION



INVESTIGATION OF NEED FOR A DISTRIBUTION PMU STANDARD

- IEEE PSRC Task Force TFC41 established in 2019 to investigate the need for a standard for PMU measurements in distribution systems
- Found concern with measurement problems but little information on the extent and persistence of the conditions that create the problems
- There was little information or experience with the anticipated applications, so the required accuracy and other characteristics were hard to specify
- WG C41 established in 2020 with the Assignment:
“WG C41 will prepare a technical report on the measurement performance needs and requirements for PMUs that are intended for use in distribution systems. This will include examination of the measurement environment, detailing the data requirements of phasor-based distribution applications, and supporting liaisons with other groups working with synchrophasors in the distribution environment including other IEEE TC’s, NASPI, NERC, and IEC.”

REPORT FROM C-41

- WG C-41 produced this report on the measurement requirements and validation tests needed for PMUs intended for distribution systems. The report includes recommendations for standardization,
- The report required two principal investigation paths:
 - Analyze and characterize the distribution signal environment
 - Analyze and describe the data requirements for applications applied to distribution systems
- The results of both are combined into recommended distribution PMU standard requirements and performance standard development



DISTRIBUTION PMU INVESTIGATION



SECTION 2 – CHARACTERISTICS OF DISTRIBUTION MEASUREMENTS

- The measurement environment was examined to determine the differences between distribution systems and transmission systems using point on wave recordings from five different distribution systems
- The examination included:
 - Interference including noise & harmonics
 - Extreme measurement values including maximum values and rate of change
- Findings were that there is not a great amount of difference
 - Higher harmonic content & higher rates of signal change need to be considered
- The requirement and test structure in present standard 60255-118-1 is adequate with changes in the performance requirements and limits

EXAMPLE – HARMONICS

- Voltage harmonic levels are small, typically < 1%, though some current harmonics were nearly 10%
- Standard 60255-118-1 tests at 1% (P-class) and 10% (M-class)
- New tests should be 10% with multiple harmonics
- White noise content was inconsequential (< -70 dB)

Data name	Nominal frequency (Hz)	Nominal signal amplitude	Harmonics	Amplitude (V)	Harmonic amplitude (%)
EPFL	50	17116.	3 rd	19.22	0.11
			5 th	120.36	0.70
			7 th	31.67	0.19
			9 th	17.63	0.10
Ireland	50	224.	3 rd	1.69	0.75
			7 th	5.14	2.30
			5 th	4.90	2.19
			11 th	0.70	0.31
			9 th	0.44	0.20
NPL	50	317.	5 th	3.08	0.97
			7 th	1.55	0.49
			11 th	0.52	0.16
California	60	101.3	3 rd	0.45	0.44
			5 th	2.29	2.26
			7 th	1.014	1.00
			13 th	0.27	0.26
IBA	50	331.3	3 rd	2.97	0.89
			5 th	7.13	2.15
			7 th	1.49	0.45
			9 th	2.62	0.79
			11 th	1.76	0.53



EXAMPLE – MAXIMUM VALUES AND RATE OF CHANGE

- PMU has to handle measurable values and dynamic signal changes
- Large spikes and high rate of change in V, I, f, & ROCOF were observed
- Standard will need increased rate-of-change & ROCOF test parameters

Data name	Maximum frequency deviation from nominal (Hz)	Average ROCOF (Hz/s)	Maximum ROCOF (Hz/s)
EPFL	0.235	0.015	3.187
Ireland	0.133	0.0	0.535
NPL	0.113	0.001	0.159
IBA	0.337	0.0	1.72

SECTION 3 – DATA REQUIREMENTS OF APPLICATIONS USED WITH DISTRIBUTION SYSTEMS

- Selected one from several reports outlining potential applications of PMU measurements*
- Report described 75 applications collected into 19 categories
 - Most applications have not been implemented – the measurement needs are estimated based on similar experience
- Analyzed measurement needs for successful application operation
- Determined several performance requirements that need to be increased for certain application categories, but not needed across the board
- Recommend establishing performance levels for meeting different application needs

* “Distribution Synchronized Measurements Roadmap, Final Report”, Quanta 961 Technology, Oak Ridge National Laboratory, prepared for US DOE and ORNL, 962 Sept 2021

19 CATEGORIES OF APPLICATIONS

- Roadmap report provided description for each application and further analysis on impact/adoption
- Report also provided estimated accuracy and maximum delay requirements

Group	Application type
1	Advanced Volt-Var Control
2	Distribution Grid Monitoring
3	Asset Management of Critical Infrastructure
4	Wide-Area Visualization
5	Advanced DER Integration and Control
6	Real-Time Distribution System Operation
7	Enhanced Reliability and Resilience Analysis
8	Advanced Distribution System Planning
9	Distribution Load, DER, and EV Forecasting
10	Improved Stability Management
11	High-Accuracy Fault Detection and Location
12	Advanced Distribution Protection and Control
13	Advanced Microgrid Applications and Operation
14	Improved Load Shedding Schemes
15	Advanced Distribution Automation
16	Technical and Commercial Loss Reduction
17	Monitoring and Control of Electric Transportation Infrastructure
18	Integrated Resource, Transmission, and Distribution System Planning and Operations
19	Power Quality Assessment and Analysis



SUMMARY OF PERFORMANCE REQUIREMENTS BASED ON APPS

- Table narrowed to requirements that differentiate application groups

Master Group	Application groups	Application Types	Accuracy (TVE %)	Reporting rate (Hz)	Voltage range (% of nominal)	Current range (% of nominal)
A	1	Advanced controls	0.5	$f_0 / 2$	10-190	10-200
B	16	Loss reduction	0.5	1	10-190	10-200
C	2, 4, 5, 6, 13, 17, 18	Monitoring, analysis & some control functions	1	$f_0 / 2$	10-190	10-200
D	3	Asset Management of Critical Infrastructure	1	1	10-190	10-400
E	7, 10, 14	Analysis, stability management & load shed	1	$f_0 / 2$	10-190	10-400
F	8, 11, 12, 15	Planning, fault location, protection, automation	1	$f_0 / 2$	10-190	10-6300 (10% - 63x)
G	9	Forecasting	1	1	10-190	10-200





REPORT SUMMARY & CONCLUSION



SECTION 4 -- RECOMMENDED DISTRIBUTION PMU PERFORMANCE REQUIREMENTS

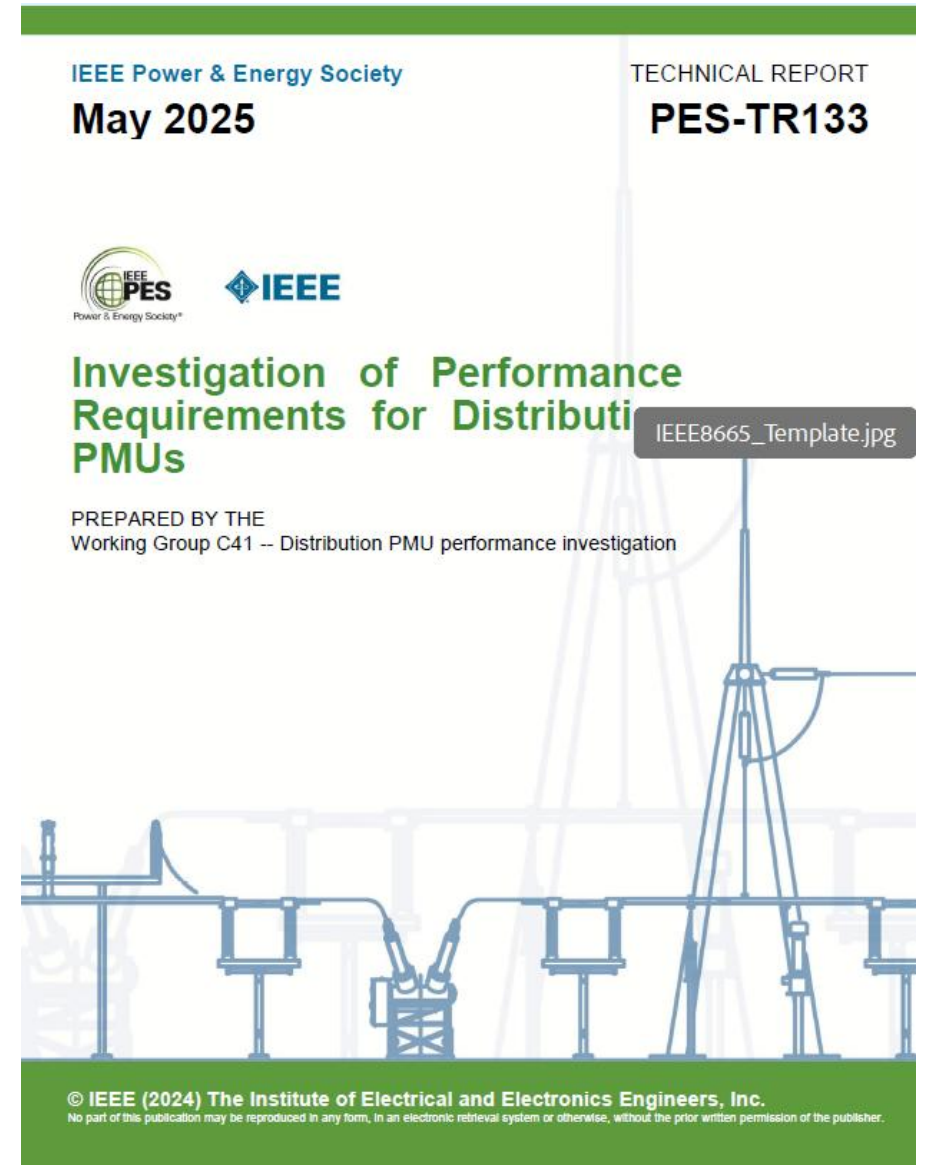
- Summary of the changes from the present standard needed to test PMUs intended for distribution systems and serve projected applications
- The performance categories and prescribed tests in the present standard are adequate for distribution PMUs. Most of the needed changes are small
- Recommend establishing another class of PMU (D Class?) targeted for distribution. The Class should include some optional performance levels targeting different applications

SECTION 5 – RECOMMENDATIONS FOR STANDARD DEVELOPMENT

- WG recommends revising the present standard, IEC/IEEE 60255-118-1, rather than creating an entirely new standard
- It recommends creating an additional class of PMU for distribution
- It also recommends establishing performance and accuracy levels to target different applications
- It recommends extending some changes to all PMU types, such as adding an optional figure of merit

THE FULL REPORT IS PUBLISHED

- The official IEEE report, PES-TR133, is available from IEEE at:
https://resourcecenter.ieee-pes.org/publications/technical-reports/pes_tr_133_psrc_052725
- PES members – free, IEEE member - \$45, non-member - \$70
- PSRC has its own version of the same report which can be found on the PSRC web site at:
<https://www.pes-psrc.org/reports>



FOLLOW –ON WORK

- The present standard IEC/IEEE 60255-118-1, is due for revision – expires in 2028 in both IEEE and IEC
- IEEE PSRC formed Task Force TFC59 to create a PAR to revise the standard. A PAR application has been submitted to IEEE-SA to revise the standard
- The report and other descriptive documents will be circulated by IEC TC95 to initiate standard revision activity within the IEC
- The official revision process should start in January 2026
- Contact kemartin8421@comcast.net to volunteer for the Revision process

THANK YOU

Comment & discussion

