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**Measuring relays and protection equipment –
Part 118-1: Synchrophasor for power systems – Measurements**

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CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	10
2 Normative references	10
3 Terms, definitions, and abbreviated terms	10
3.1 Terms and definitions.....	10
3.2 Abbreviated terms.....	11
4 Synchrophasor measurement	12
4.1 Input and output quantities.....	12
4.2 Power system signal	12
4.3 Measurand definitions	13
4.3.1 Synchrophasor phase angle.....	13
4.3.2 Synchrophasor measurand	13
4.4 Frequency measurand definition	13
4.5 Rate of change of frequency measurand definition	14
4.6 Measurement time synchronization	14
5 Measurement compliance evaluation	14
5.1 PMU measurement capability.....	14
5.2 Measurement evaluation	14
5.2.1 Synchrophasor measurement evaluation	14
5.2.2 Frequency and ROCOF measurement evaluation	15
5.2.3 Measurement response time and delay time	15
5.2.4 Overshoot and undershoot.....	16
5.2.5 Measurement reporting latency.....	18
5.2.6 Measurement and operational errors	18
5.3 Measurement reporting	19
5.3.1 General	19
5.3.2 Reporting rates.....	19
5.3.3 Reporting times	19
5.4 Measurement compliance	19
5.4.1 Performance classes	19
5.4.2 Compliance verification.....	20
6 Measurement compliance test and evaluation.....	20
6.1 Testing considerations	20
6.2 Reference and test conditions.....	21
6.3 Steady-state compliance	21
6.4 Dynamic compliance – Measurement bandwidth	24
6.5 Dynamic compliance – Performance during ramp of system frequency.....	27
6.6 Dynamic compliance – Performance under step changes in phase and magnitude.....	29
6.7 PMU reporting latency compliance	30
7 Documentation	31
Annex A (informative) Time tagging and dynamic response	32
A.1 Dynamic response	32
A.2 Time tags.....	32
A.3 Magnitude step test example	34

A.4	PMU time input	35
Annex B (informative) Parameter representation and definition application examples		37
B.1	General.....	37
B.2	Representing non-stationary sinusoids.....	37
B.3	Introduction of definition application examples	38
B.3.1	General	38
B.3.2	Example 1: steady-state at nominal frequency	38
B.3.3	Example 2: steady-state and constant off-nominal frequency	38
B.3.4	Example 3: oscillation of the phase and amplitude of the power signal	39
B.3.5	Example 4: constant, non-zero rate of change of frequency	40
B.4	Reconstruction of the power system sinusoidal signal from the synchrophasor	41
Annex C (informative) PMU evaluation and testing.....		42
C.1	General.....	42
C.2	TVE measurement evaluation	42
C.3	Phase-magnitude relation in TVE and timing.....	43
C.4	Evaluation of response to stepped input signals.....	45
C.5	Harmonic distortion test signal phasing	47
C.6	ROCOF limits.....	47
C.6.1	General	47
C.6.2	Derivation.....	48
C.7	PMU reporting latency.....	49
Annex D (informative) Reference signal processing models		50
D.1	General.....	50
D.2	Basic synchrophasor estimation model	50
D.3	Timestamp compensation for low-pass filter group delay.....	51
D.4	Positive sequence, frequency, and ROCOF	52
D.5	P Class reference model for phasor	53
D.6	P class filter details.....	53
D.7	M class reference model for phasor	55
D.8	Data rate reduction model.....	57
D.9	Trade-offs in the reference model	58
D.9.1	Immunity to off-nominal components, reporting latency and time alignment.....	58
D.9.2	Response time and the accuracy of synchrophasors, frequency and ROCOF measurements.....	59
Annex E (informative) Synchrophasor measurement using sampled value input to PMU		61
E.1	General.....	61
E.2	Creation of sampled values.....	61
E.3	Sources of synchrophasor error when using sampled values.....	62
E.4	Performance	62
E.4.1	General	62
E.4.2	Steady-state performance considerations	62
E.4.3	Dynamic performance considerations	63
E.4.4	Latency.....	63
E.5	Proposed changes to performance requirements	64
Annex F (informative) Suggested subset of tests for PMU evaluation under environmental influences		65

Annex G (normative) Extended accuracy specification for PMUs in steady-state	66
G.1 General.....	66
G.2 Applicable conditions	66
G.3 Accuracy specification	66
G.4 Usage examples	67
G.5 Preferred accuracy ranges	67
G.6 Testing issues.....	67
G.6.1 Testing for improved accuracy	67
G.6.2 Testing at currents exceeding continuous thermal rating.....	68
G.6.3 Environmental considerations	68
Annex H (informative) Generator voltage and power angle measurement.....	69
H.1 General.....	69
H.2 Measurement methods.....	69
H.3 Input signal	69
H.4 Measuring process.....	69
Annex I (normative) Extended PMU bandwidth classes	71
I.1 General.....	71
I.2 Bandwidth determination.....	71
I.3 Enhanced bandwidth classes	71
I.4 Testing issues.....	72
Bibliography.....	73
Figure 1 – Input and output quantities	12
Figure 2 – Step transition examples	17
Figure A.1 – Frequency step test phase response without group delay compensation.....	33
Figure A.2 – Frequency step test phase response after group delay compensation	33
Figure A.3 – Magnitude step test results for 3 different algorithms	34
Figure A.4 – Magnitude step test example	35
Figure B.1 – Sampling a power frequency sinusoid at off-nominal frequency.....	39
Figure C.1 – Total vector error (TVE)	43
Figure C.2 – The 1 % TVE criterion shown on the end of a phasor	43
Figure C.3 – TVE as a function of magnitude for various phase errors	44
Figure C.4 – TVE as a function of phase for various magnitude errors	45
Figure C.5 – Example of step change measurements using a magnitude step at $t = 0$	46
Figure C.6 – PMU reporting latency example (actual PMU measurement).....	49
Figure D.1 – Single phase section of the PMU phasor signal processing model	51
Figure D.2 – Complete PMU signal processing model	52
Figure D.3 – P class filter coefficient example ($N = 2 \times (16 - 1) = 30$)	54
Figure D.4 – P class filter response as a function of frequency	54
Figure D.5 – Reference algorithm filter frequency response mask specification for M Class	56
Figure D.6 – M class filter coefficient example	57
Figure D.7 – Data rate reduction signal processing model.....	58
Figure D.8 – Factors affecting estimation	58
Figure D.9 – Reference filter magnitude frequency response with $F_s = 60$ fps	59

Figure E.1 – Synchrophasors having sampled values as inputs.....	61
Figure H.1 – Phasor diagram under no-load conditions	70
Figure H.2 – Phasor diagram with load on generator.....	70
Table 1 – Standard PMU reporting rates	19
Table 2 – Steady-state synchrophasor measurement requirements.....	22
Table 3 – Steady-state frequency and ROCOF measurement requirements	24
Table 4 – Synchrophasor measurement bandwidth requirements using modulated test signals	26
Table 5 – Frequency and ROCOF performance requirements under modulation tests	26
Table 6 – Synchrophasor performance requirements under frequency ramp tests	29
Table 7 – Frequency and ROCOF performance requirements under frequency ramp tests	29
Table 8 – Phasor performance requirements for input step change	30
Table 9 – Frequency and ROCOF performance requirements for input step change.....	30
Table 10 – PMU reporting latency	30
Table C.1 – Harmonic phase sequence in a balanced three-phase system.....	47
Table D.1 – M class low pass filter parameters	57
Table E.1 – Summary of proposed performance requirement changes	64
Table G.1 – Conditions for extended accuracy tests.....	66
Table I.1 – Conditions for extended bandwidth testing	71

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International standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

A list of all parts in the 60255 International Standard, published under the general title *Measuring relays and protection equipment*, can be found on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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INTRODUCTION

This document provides continuation and further development of previous synchrophasor standards, notably the IEEE C37.118 series. It defines synchrophasor, frequency, and rate of change of frequency (ROCOF) measurements as used in this technology. These definitions are in agreement with most research on and analysis of dynamic electric power system measurements, but may differ from those given in other contexts. Function and performance requirements are given for synchrophasor measurements. Tests, evaluation criteria, and error limits are provided to determine compliance with the requirements.

Informative Annexes A, B, C, F, and H provide details about timing aspects, definition application and derivations, PMU measurements, generator power angle, and environmental tests. Informative Annex D details the M and P class reference models used to ensure the requirements can be met; these models are for limit qualification only, as it is expected that most real implementations will perform better than these models. Informative Annex E proposes revised performance requirements for synchrophasors produced from sampled values. These may be used as a basis for normative requirements in a future standard revision. Normative Annexes G and I provide optional qualification of extended steady-state accuracy and measurement bandwidth determination.

A phasor measurement unit (PMU) estimates the parameters magnitude, phase angle, frequency, and rate of change of frequency from the signals appearing at its input terminals or interface. Input signals may be corrupted by harmonics, noise, and changes in state caused by load changes and control and protective actions which complicate parameter estimation. Some examples are harmonics introduced by non-linear loads, step changes in phase introduced by switched reactive elements, and random noise from arc furnaces. These artefacts complicate the process of measuring the generation and load characteristics at or near the system fundamental frequency. The intent of this document is to describe and quantify the performance of a PMU so that it provides a reliable and accurate measurement under real power system conditions.

Synchrophasors are estimated from samples of the voltage and current AC waveforms. Since these signals are alternating current, the estimate uses an interval or "window" over which the samples are taken and used to make the estimate. There could be changes in the waveform parameters during the estimation interval, so the estimate will represent some kind of "average" value for the sinusoid over that window. The length and weighting of the window directly impacts the estimate. A longer window reduces interference but averages out more dynamic changes. In conditions of rapid dynamic changes, such as during a fault, the phasor values can be very inaccurate. The user needs to evaluate their applications and employ appropriate filtering if such conditions could cause a problem.

Frequency and ROCOF are defined as the first and second derivatives of phase angle. They are often computed using finite differencing of the measured angle. Any interference in the angle adversely affects these measurements. Consequently, these measurements are less precise and can produce misleading values. This document presents a set of PMU performance requirements to ensure that compliant instruments will perform similarly when presented with this suite of test signals. The user should be aware that, in the presence of real system interference, higher measurement errors could result. These errors may be substantial, particularly where higher order derivatives (such as ROCOF) are used. Signal processing alternatives may be employed to reduce or eliminate these errors, though they are difficult to implement in a real-time environment. Alternatives are neither described nor evaluated in this document.

Specific environmental requirements are out of scope for this document, which specifies functional requirements. Testing required by this document will be performed under standard laboratory conditions which do not include environmental conditions that may be specified for some deployments. Devices implementing the functions described in this document may also follow environmental standards such as IEEE Std 1613TM and IEC 60255-1. Vendors are encouraged to provide information regarding the effect of environmental influences on device performance, perhaps including the pass/fail criteria used when determining environmental compliance. Guidance regarding suggested test profiles is included in Annex F.

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 118-1: Synchrophasor for power systems – Measurements

1 Scope

This part of IEC 60255 is for synchronized phasor measurement systems in power systems. It defines a synchronized phasor (synchrophasor), frequency, and rate of change of frequency measurements. It describes time tag and synchronization requirements for measurement of all three of these quantities. It specifies methods for evaluating these measurements and requirements for compliance with the standard under both static and dynamic conditions. It defines a phasor measurement unit (PMU), which can be a stand-alone physical unit or a functional unit within another physical unit. This document does not specify hardware, software or a method for computing phasors, frequency, or rate of change of frequency.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60255-1, *Measuring relays and protection equipment – Part 1: Common requirements*

IEEE Std C37.90™, *IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus*