Power quality: ION meters and EN50160:2010

EN50160 is a European standard that defines, describes and specifies the main characteristic of the voltage at a network user's supply terminals in public low voltage, medium and high voltage AC electricity networks under normal operating conditions. This technical note summarizes the EN50160 data and statistics measured by the PowerLogic™ ION™ meters that monitor compliance to the EN51060:2010 standard, and includes references to the applicable parts of IEC 61000-4-30.

This documentation assumes that you have an advanced understanding of ION architecture, EN50160:2010, IEC 61000-4-30 standard, and the power system that your meter is connected to.

In this document

Related documents

- *4-30 compliance and ION meters* technical note

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Safety information

Important information

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death

⚠ DANGER

DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a hazardous situation which, if not avoided, **can result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a hazardous situation which, if not avoided, **can result in** minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

Please note

Electrical equipment should be installed, operated, serviced and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, installation, and operation of electrical equipment and has received safety training to recognize and avoid the hazards involved.

Introduction

Devices that support the EN50160:2010 standard are configured by default to measure a low voltage supply where the standard nominal value U_n = 230 V (either between phase and neutral, or between phases) for systems with a synchronous connection to an interconnected system. If your measured system is different, you must manually configure the meter to reflect the characteristics of the system being monitored.

Your meter presents power system characteristics according to a set of guidelines as defined by EN50160:2010.

NOTICE
DATA LOSS Use an uninterruptible power supply (UPS) to help ensure proper EN50160 operation during a power outage situation. **Failure to follow these instructions may result in lost data.**

Default EN50160:2010 measurements

The EN50160:2010 standard divides voltage characteristics into distinct components. Each component has operating conditions and requirements for samples to be considered valid.

The meter uses a counter-based scheme (for example, N, N_1, N_2...) to evaluate the compliance of each component within a defined observation period. Counter statistics are provided for current and previous observation periods; a brief description of each counter is also provided. The data logging section for each component provides a number of data log viewers for counter and parameter data. The following sections describe the data and statistics provided for each EN50160:2010 measurement.

You must configure your meter's nominal values for EN50160 measurements:

- Nom Volts
- Nom Freq

These nominal values can also be entered using your meter's display or through the meter's webpages (if available).

See "EN50160 external controls" on page 11 for details on enabling EN50160:2010 on your meter.

Power frequency

The frequency measurement is a mean value over fixed 10-second intervals.

- Observation period of one year with fixed steps of 10 seconds.
- N = the number of valid 10-second intervals monitored by your meter.
- N_1= the number of 10-second intervals in which the frequency exceeds ± 1% of nominal.
- N_2 = the number of 10-second intervals in which the frequency exceeds +4% or -6% of nominal.
- $N_{invalid}$ = the number of observed intervals or partial intervals that are not included in EN50160:2010 compliance calculations.

Power frequency complies with the standard if $N_1/N \leq 0.5\%$ and $N_2 = 0$.

EN50160 data (current observation period): the meter generates the N, N_1 and N_2 counts described. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the N, N_1 and N_2 counter values at the end of each observation period before these counters are reset. These registers are also stored in a data recorder for each observation period.

Power frequency default measurements

Power frequency default measurements are stored in the EN50160 Frq/Mg data recorder:

Register label	Source module type	Description
Freq N	Signal limit evaluation	Number of valid intervals
Freq N1		Number of intervals where the frequency is within ± 1% of nominal
Freq N2		Number of intervals where the frequency is within +4% and -6% of nominal.
Freq N invld		Number of invalid intervals

Parameter data is recorded every 10 minutes in the EN50160 Prm-f/V data recorder:

Register label	Description
PQ Freq mean	10-minute mean
PQ Freq low	minimum one-cycle value over 10 minutes
PQ Freq high	maximum one-cycle value over 10 minutes

Supply voltage variations

Each measurement is the 10-minute RMS (root mean square) voltage for each phase.

- Observation period of one week with fixed steps of 10 minutes.
- N = the number of valid 10-minute intervals monitored by your meter.
- N_1 = number of intervals in which the supply voltage exceeds ± 10% of nominal.
- N_2 = number of intervals in which the supply voltage exceeds +10%, -15% of nominal.
- $N_{invalid}$ = the number of observed intervals or partial intervals that are not included in EN50160:2010 compliance calculations.

Supply voltage complies with the standard if $N_1/N \leq 5\%$ during the observation period and $N_2 = 0$.

EN50160 data (current observation period): the meter generates the N, N_1 and N_2 counts described. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the N, N_1 and N_2 counter values at the end of each observation period before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time the N_1 and N_2 counters increases.

Supply voltage default measurements are stored in the EN50160 Frq/Mg data recorder:

Register label	Description
V1-Mag N	Number of valid intervals on phase 1
V1-Mag N1	Number of intervals where the supply voltage exceeds ± 10% of nominal on phase 1
V1-Mag N2	Number of intervals where the supply voltage exceeds +10%, -15% of nominal on phase 1
V1-Mag N invld	Number of invalid intervals on phase 1
V2-Mag N	Number of valid intervals on phase 2
V2-Mag N1	Number of intervals where the supply voltage exceeds ± 10% of nominal on phase 2
V2-Mag N2	Number of intervals where the supply voltage exceeds +10%, -15% of nominal on phase 2
V2-Mag N invld	Number of invalid intervals on phase 2
V3-Mag N	Number of valid intervals on phase 3
V3-Mag N1	Number of intervals where the supply voltage exceeds ± 10% of nominal on phase 3
V3-Mag N2	Number of intervals where the supply voltage exceeds +10%, -15% of nominal on phase 3
V3-Mag N invld	Number of invalid intervals on phase 3

V1, V2 and V3 are fed from the Power Quality Aggregation module outputs. See the *ION Reference* for more information

Parameter data is recorded every 10 minutes by the EN50160 Prm-f/V data recorder:

Register label	Description
PQ V1 mean	Phase 1 voltage 10 minute RMS
PQ V1 low	Phase 1 voltage minimum 1 cycle RMS over 10 minutes
PQ V1 high	Phase 1 voltage maximum 1 cycle RMS over 10 minutes
PQ V2 mean	Phase 2 voltage 10 minute RMS
PQ V2 low	Phase 2 voltage minimum 1 cycle RMS over 10 minutes
PQ V2 high	Phase 2 voltage maximum 1 cycle RMS over 10 minutes
PQ V3 mean	Phase 3 voltage 10 minute RMS
PQ V3 low	Phase 3 voltage minimum 1 cycle RMS over 10 minutes
PQ V3 high	Phase 3 voltage maximum 1 cycle RMS over 10 minutes

Supply voltage unbalance

Each basic measurement is the ratio of the 10-minute values of the negative and positive sequence voltages.

- Observation period of one week with fixed steps of 10 minutes.
- N = the number of valid 10-minute intervals monitored by your meter.
- N_1 = number of 10-minute periods in which the supply voltage unbalance exceeds 2%.
- $N_{invalid}$ = the number of observed intervals or partial intervals that are not included in EN50160:2010 compliance calculations.

Supply voltage unbalance complies with the standard if $N_1/N <= 5\%$ during the observation period (1 week by default). Voltage unbalance is calculated as follows, using the 10-minute sequence magnitude components from the Symmetrical Components module:

$$V_{UNBAL\%} = \frac{\text{negative sequence voltage (10 minute value)}}{\text{positive sequence voltage (10 minute value)}} \text{x} 100\%$$

NOTE: The voltage unbalance value provided by the Power Meter module is not used for EN50160:2010 calculations.

EN50160 data (current observation period): the meter generates the N and N_1 counts described. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the N and N_1 counter values at the end of each observation period before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time the N_1 counter increases.

Supply voltage unbalance default measurements are stored in the EN50160 Vunbal data recorder:

Label	Source module type	Description
Vunbal N	Signal limit evaluation	Number of valid intervals
Vunbal N invld		Number of invalid intervals
Vunbal N1		Number of intervals the supply voltage unbalance exceeds 2%.

Parameter data is recorded every 10 minutes by the 4-30 10m Log data recorder:

Register label	Description
NegSeqRatio 10m or VlnUnbal u2 10m	Ratio of the 10-minute negative sequence voltage value to the 10-minute positive sequence voltage value (voltage unbalance)

Harmonic voltage

All harmonic measurements are performed as defined by IEC 61000-4-30.

- Observation period of one week with fixed steps of 10 minutes.
- N = the number of valid 10-minute intervals monitored by your meter.
- N_1 = number of intervals in which one or more of the individual harmonic levels defined in the table below are exceeded.
- N_2 = number of intervals in which the THD (total harmonic distortion) value for each voltage phase exceeds 8%. The THD calculation includes all harmonics up to the highest value the modules goes up to (40th, 50th or 63rd).
- $N_{invalid}$ = the number of observed intervals or partial intervals that are not included in EN50160:2010 compliance calculations.

Harmonic voltage complies with the standard if $N_1/N \leq 5\%$ and $N_2/N \leq 5\%$ during the observation period.

Harmonic voltage criteria for low voltage systems

Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	Relative amplitude u_h	Order h	Relative amplitude u_h	Order h	Relative amplitude u_h
5	6.0%	3	5.0%	2	2.0%
7	5.0%	9	1.5%	4	1.0%
11	3.5%	15	0.5%	6....24	0.5%
13	3.0%	21	0.5%		
17	2. %				
19	1.5%				
23	1.5				
25	1.5%				

NOTE: No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable due to resonance effects.

NOTE: To configure your meter for medium or high voltage systems, configure the Harmonics Evaluation modules' limits for medium or high harmonic voltage criteria.

EN50160 data (current observation period): the meter generates the N, N_1 and N_2 counts described. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the N, N_1 and N_2 counter values at the end of each observation period before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time the N_1 and N_2 counters increases. The N_1 event includes the associated harmonic.

Harmonic voltage default measurements are stored in the EN50160 Hrm Vlt data recorder:

Label	Source module type	Description
V1-Hrm N	Harmonics evaluation	Number of valid intervals on phase 1
V1-Hrm N invld		Number of invalid intervals on phase 1
V1-Hrm N1		Number of intervals in which one or more of the individual harmonic levels exceed the harmonic voltage criteria on phase 1
V1-Hrm N2		Number of intervals in which the THD value for phase 1 exceeds 8%
V2-Hrm N		Number of valid intervals on phase 2
V2-Hrm N invld		Number of invalid intervals on phase 2
V2-Hrm N1		Number of intervals in which one or more of the individual harmonic levels exceed the harmonic voltage criteria on phase 2
V2-Hrm N2		Number of intervals in which the THD value for phase 2 exceeds 8%
V3-Hrm N		Number of valid intervals on phase 3
V3-Hrm N invld		Number of invalid intervals on phase 3
V3-Hrm N1		Number of intervals in which one or more of the individual harmonic levels exceed the harmonic voltage criteria on phase 3
V3-Hrm N2		Number of intervals in which the THD value for phase 3 exceeds 8%

Parameter data is stored every 10 minutes in the EN50160 PrmHrm1-2 data recorders:

Register label	Description
PQ V1 THD 10m	Phase 1 voltage total harmonic distribution (THD) 10 minute mean
PQ V1 THD mn	Phase 1 voltage minimum 3-second THD value over 10 minutes
PQ V1 THD mx	Phase 1 voltage maximum 3-second THD value over 10 minutes
PQ V1 TOHD 10m	Phase 1 voltage total odd harmonics distribution (TOHD) 10 minute mean
PQ V1 TOHD mn	Phase 1 voltage minimum 3-second TOHD value over 10 minutes
PQ V1 TOHD mx	Phase 1 voltage maximum 3-second TOHD value over 10 minutes
PQ V1 TEHD 10m	Phase 1 voltage total even harmonics distribution (TEHD) 10 minute mean
PQ V1 TEHD mn	Phase 1 voltage minimum 3-second TEHD value over 10 minutes
PQ V1 TEHD mx	Phase 1 voltage maximum 3-second TEHD value over 10 minutes
PQ V2 THD 10m	Phase 2 voltage total harmonic distribution (THD) 10 minute mean
PQ V2 THD mn	Phase 2 voltage minimum 3-second THD value over 10 minutes
PQ V2 THD mx	Phase 2 voltage maximum 3-second THD value over 10 minutes
PQ V2 TOHD 10m	Phase 2 voltage total odd harmonics distribution (TOHD) 10 minute mean
PQ V2 TOHD mn	Phase 2 voltage minimum 3-second TOHD value over 10 minutes
PQ V2 TOHD mx	Phase 2 voltage maximum 3-second TOHD value over 10 minutes
PQ V2 TEHD 10m	Phase 2 voltage total even harmonics distribution (TEHD) 10 minute mean
PQ V2 TEHD mn	Phase 2 voltage minimum 3-second TEHD value over 10 minutes
PQ V2 TEHD mx	Phase 2 voltage maximum 3-second TEHD value over 10 minutes
PQ V3 THD 10m	Phase 3 voltage total harmonic distribution (THD) 10 minute mean
PQ V3 THD mn	Phase 3 voltage minimum 3-second THD value over 10 minutes
PQ V3 THD mx	Phase 3 voltage maximum 3-second THD value over 10 minutes
PQ V3 TOHD 10m	Phase 3 voltage total odd harmonics distribution (TOHD) 10 minute mean
PQ V3 TOHD mn	Phase 3 voltage minimum 3-second TOHD value over 10 minutes
PQ V3 TOHD mx	Phase 3 voltage maximum 3-second TOHD value over 10 minutes
PQ V3 TEHD 10m	Phase 3 voltage total even harmonics distribution (TEHD) 10 minute mean
PQ V3 TEHD mn	Phase 3 voltage minimum 3-second TEHD value over 10 minutes
PQ V3 TEHD mx	Phase 3 voltage maximum 3-second TEHD value over 10 minutes

Supply voltage dips

All voltage supply dip measurements are performed as defined by IEC 61000-4-30. Conventionally, for low voltage networks, the dip start threshold is equal to 90% of the nominal voltage and hysteresis is typically 2%. The observation period is one week.

Multiple phase events are combined into single, equivalent events using polyphase aggregation. These equivalent events are used to classify dips.

Voltage dips classification

Residual voltage u (%)	Duration t (s)				
	0.01 ≤ t ≤ 0.2	0.2 < t ≤ 0.5	0.5 < t ≤1	1 < t ≤ 5	5 < t ≤ 60
90 > u ≥ 80	A1	A2	A3	A4	A5
80 > u ≥ 70	B1	B2	B3	B4	B5
70 > u ≥ 40	C1	C2	C3	C4	C5
40 > u ≥ 5	D1	D2	D3	D4	D5
5 > u	X1	X2	X3	X4	X5

NOTE: The figures to be put in the cells refer to the number of equivalent events.

EN50160 data (current observation period): the meter maintains the counters listed in the previous tables for each phase. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the counters listed in the previous tables for each phase on a weekly basis before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time one of the counters listed in the previous tables increases.

Voltage dip default measurements are stored in the EN50160 Vlt Dp1-2 data recorders:

Register labels				
V-Dip A1	V-Dip A2	V-Dip A3	V-Dip A4	V-Dip A5
V-Dip B1	V-Dip B2	V-Dip B3	V-Dip B4	V-Dip B5
V-Dip C1	V-Dip C2	V-Dip C3	V-Dip C4	V-Dip C5
V-Dip D1	V-Dip D2	V-Dip D3	V-Dip D4	V-Dip D5
V-Dip X1	V-Dip X2	V-Dip X3	V-Dip X4	V-Dip X5

Counters from the previous observation (PO) period are located in Store modules with the prefix PO:

Register labels				
PO V-Dip A1	PO V-Dip A2	PO V-Dip A3	PO V-Dip A4	PO V-Dip A5
PO V-Dip B1	PO V-Dip B2	PO V-Dip B3	PO V-Dip B4	PO V-Dip B5
PO V-Dip C1	PO V-Dip C2	PO V-Dip C3	PO V-Dip C4	PO V-Dip C5
PO V-Dip D1	PO V-Dip D2	PO V-Dip D3	PO V-Dip D4	PO V-Dip D5
PO V-Dip X1	PO V-Dip X2	PO V-Dip X3	PO V-Dip X4	PO V-Dip X5

The minimum RMS voltage for each phase during the sag, the duration of the sag, and the timestamp for when the sag occurred are recorded in the Sag/Swell log data recorder.

Supply voltage swells

All voltage supply swell measurements are performed as defined by IEC 61000-4-30. Conventionally, for low voltage networks, the duration of the swell corresponds to the period during which the RMS value remains more than 110% of the nominal voltage. The magnitude of the swell is defined as the ratio (expressed as a percentage) between the maximum RMS voltage during the swell and the nominal voltage. The observation period is 1 week.

Multiple phase events are combined into single, equivalent events using polyphase aggregation. These equivalent events are used to classify swells.

The table below defines the classification scheme for swell counters:

Residual voltage u (%)	**Duration t (s)**			
	0.01 ≤ t ≤ 0.5	**0.5 < t ≤ 5**	**5 < t ≤ 60**	**t > 60**
u ≥ 120	S1	S2	S3	S4
120 > u > 110	T1	T2	T3	T4

NOTE: The figures to be put in the cells refer to the number of equivalent events.

EN50160 data (current observation period): the meter maintains the counters listed in the previous table for each phase. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the counters listed in the previous table for each phase on a weekly basis before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time one of the counters listed in the previous table increases.

Counters for the current observation period are located in Bin modules, and are also recorded weekly by the EN50160 Swell data recorders:

Register labels			
V-Swell S1	V-Swell S2	V-Swell S3	V-Swell S4
V-Swell T1	V-Swell T2	V-Swell T3	V-Swell T4

The following counters are from the previous observation period (PO). These values are all located in Store modules containing the prefix PO:

Register labels			
PO V-Swell S1	PO V-Swell S2	PO V-Swell S3	PO V-Swell S4
PO V-Swell T1	PO V-Swell T2	PO V-Swell T3	PO V-Swell T4

The minimum RMS voltage for each phase during the swell, the duration of the swell, and the timestamp for when the swell occurred are recorded in the Sag/Swell log data recorder.

Short and long interruptions

All interruption detection measurements are performed as defined by IEC 61000-4-30.

Interruption detection is based on per phase 1-cycle RMS measurements. The duration of the interruption corresponds to the period during which the RMS value remains less than 5% of the nominal voltage on all phases. The observation period is 1 week.

Interruption counters classification

Duration of interruption	Duration < 1s	1s ≤ duration < 3min	duration ≥ 3min
Number of interruptions	N_1	N_2	N_3

EN50160 data (current observation period): the meter maintains the counters listed in the previous table for each phase. These counters are reset at the beginning of the next observation period.

EN50160 data (previous observation period): the meter stores the counters listed in the previous table for each phase on a weekly basis before these counters are reset. These registers are also stored in a data recorder for each observation period.

Events: the meter creates an entry in its onboard event log every time one of the counters listed in the previous table increases.

Counters for the current observation period are located in Bin modules and recorded weekly by the EN50160 Intrp data recorder.Counters from the previous observation (PO) period are located in Store modules labeled with the prefix PO:

Register label (current observation period)
V-Intrpt N1
V-Intrpt N2
V-Intrpt N3

Register label (previous observation period)
PO V-Intrpt N1
PO V-Intrpt N2
PO V-Intrpt N3

Parameter data is also recorded at every interruption event by the 4-30 Intrp Log:

Register label	Description
V Irtp DrtnAll	Interruption duration

EN50160 external controls

Enabling the EN50160 calculations

EN50160 statistics (counters N, N_1, etc.) monitoring and logging are enabled when:

- External Boolean module "EN50160 Enable" is ON (=1). You can set this value in the EN50160 Power Quality diagram in the Vista component of Power Monitoring Expert.
- The Sag/Swell module's *Nominal Voltage* setup register has a value greater than 0 or the input nominal is linked. You can set this value from the meter's front panel as well as in ION Setup or the Designer or Vista components of Power Monitoring Expert.

In addition to the above, **EN50160 parameter logging** (logging of the EN50160 voltage measurements themselves) is enabled when:

- External Boolean module "PQ Prm Rc Enbl" is also ON (=1). Parameter data logging can also be disabled (OFF). You can set this value in the EN50160 Power Quality diagram in the Vista component of Power Monitoring Expert.

EN50160 reset

EN50160 statistics (counters) and parameter data are cleared from the meter when the External Pulse module "EN50160 Reset" is triggered. The logged EN50160 quantities (data logs) are not affected by this external pulse.

EN50160 synchronization mode & synchronization timing

EN50160 data evaluation intervals are synchronized daily, weekly and yearly, depending on the parameter.

Use the EN50160 Power Quality diagram in the Vista component of Power Monitoring Expert/ION Enterprise to alter these settings through links to two External Boolean modules:

- Synchronization Mode: PQ Sync Mode (External Boolean 23)
- Synchronization Timing: PQ Sync Tdy/Sat (External Boolean 24).

Daily

For daily mode, you can configure **Free** or **Scheduled** synchronization.

If you select Scheduled, Synchronization Timing will start at midnight of the present day. If you select Free, then EN50160 statistics and data start accumulating after the first EN50160 reset (see above).

The default setting is Scheduled, synchronizing at midnight of the present day.

Weekly

For weekly mode, you can configure **Free** or **Scheduled** synchronization.

If you select Scheduled, then you can opt for Synchronization Timing to start at midnight of the present day, or at midnight of the coming Saturday (00:00h Sunday). If you select Free, then EN50160 statistics and data start accumulating after the first EN50160 reset (see above).

The default setting is Scheduled, synchronizing at midnight of the coming Saturday (00:00h Sunday).

Yearly

For yearly mode, you can opt for scheduled Synchronization Timing to start at the beginning of the month, or at the beginning of the year (January 1).

The default setting is synchronizing at the beginning of the year.