

POWER QUALITY SYSTEMS FOR TRANSMISSION SYSTEM OPERATORS



Power quality, or PQ for short, relates to the reliability and consistency of the electric energy delivered by the grid. Since the grid is a closed ecosystem, overall power quality is as well

influenced by the character of electric loads feeding off the power grid.

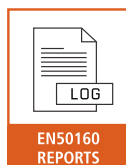
Ramifications of compromised power quality include damage to equipment, eye fatigue and in extreme cases – fire hazards.

Accordingly, the vast majority of national grid TSOs have either already installed PQ monitoring systems, or in the various stages of planning such a system. Such systems can be installed in HV or MV substations, in accordance with the extent of deployment and coverage needed.

PQ Platform Mandatory Components



Certified PQ analysers



PQ reports generated in accordance with local standards



Communication platform for relaying data



Software Platform for viewing data and configuring reports



PM180

Figure 1: SATEC's PM180 Power Quality Analyzer

The above points will be elaborated below, demonstrating how SATEC ensures fulfillment of these requirements. The SATEC solution is based on the [PM180 power quality analyzer](#) and the [Expertpower software suite](#) for energy management.

PQ Analyzer Certification

The international recognized standards for PQ analyzers are IEC 61000-4-30, Ed. 3 (2015: Testing and measurement techniques – Power quality measurement methods) and IEC 62586-2, Ed. 2 (2017: Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirement).

SATEC has had the PM180 analyzer (figure 1) certified for both these standards (figure 2) by the independent and prestigious NMI institute (NL).



Figure 2: NMI Class A, Ed. 3 certification

Power Quality Reports

Nearly each country goes by one standard or another, which stipulates the allowed deviations from consistency of the electrical power parameters of a system. PQ statistical reports, generated by analyzers recording the statistical data, are designed according to these standards. These reports indicate a Pass or Fail for each parameter over a certain amount of time.

EN50160

A great number of countries follow this European standard for power quality or different versions of it. Countries will normally implement this standard "as is" or with minimal adaptations. For example, The UK has implemented the BS EN50160; Romania has implemented the RS EN 50160, and so forth.

IEEE 1159

This is the North American equivalent, normally observed by countries following ANSI standards, such as the Philippines and many countries in Latin America.

GOST 32144

This standard is the equivalent in the CIS countries.

Communication Platforms

A crucial aspect of statistical metering is transmitting the data for viewing and processing. SATEC's PM180 analyzer features multiple communication ports and protocols for compatibility with every possible communication platform in a substation. An extra challenge of this aspect might be collecting data from remote locations or such that lack adequate physical communications.

To this end SATEC developed an embedded cellular modem, supplied as a hot-swap module for the analyzer. This is on top of basic serial, ETH and TX FX Fiber Optic communication.

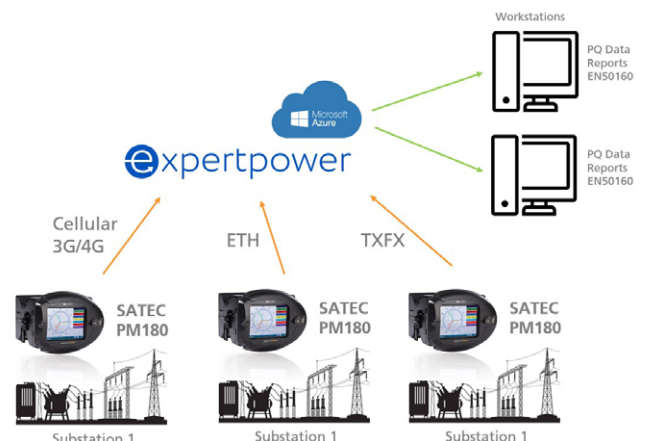


Figure 3: System architecture proposal

Software

There are two aspects to discuss regarding the collected data. The one is to provide a platform for viewing and circulate the PQ reports generated according to the different standards. This answers the fundamental regulatory need of statistical PQ reports. The other is a more advanced use, intended for getting out of the system more than a regulatory need, analyzing PQ events and determining their cause.

Expertpower software suite is a multifunction cloud-based platform (SaaS). In the field of power

quality, it serves as a robust system for gathering data and reports from thousands of devices. It is fully configurable, allowing admins to set up users and to determine levels of clearance.

The gathered data includes PQ events and corresponding waveform recordings which can be viewed graphically, at high resolution, enabling further analysis (figure 1).

Likewise, customizable reports are available for non-standard events or statistics of interest.

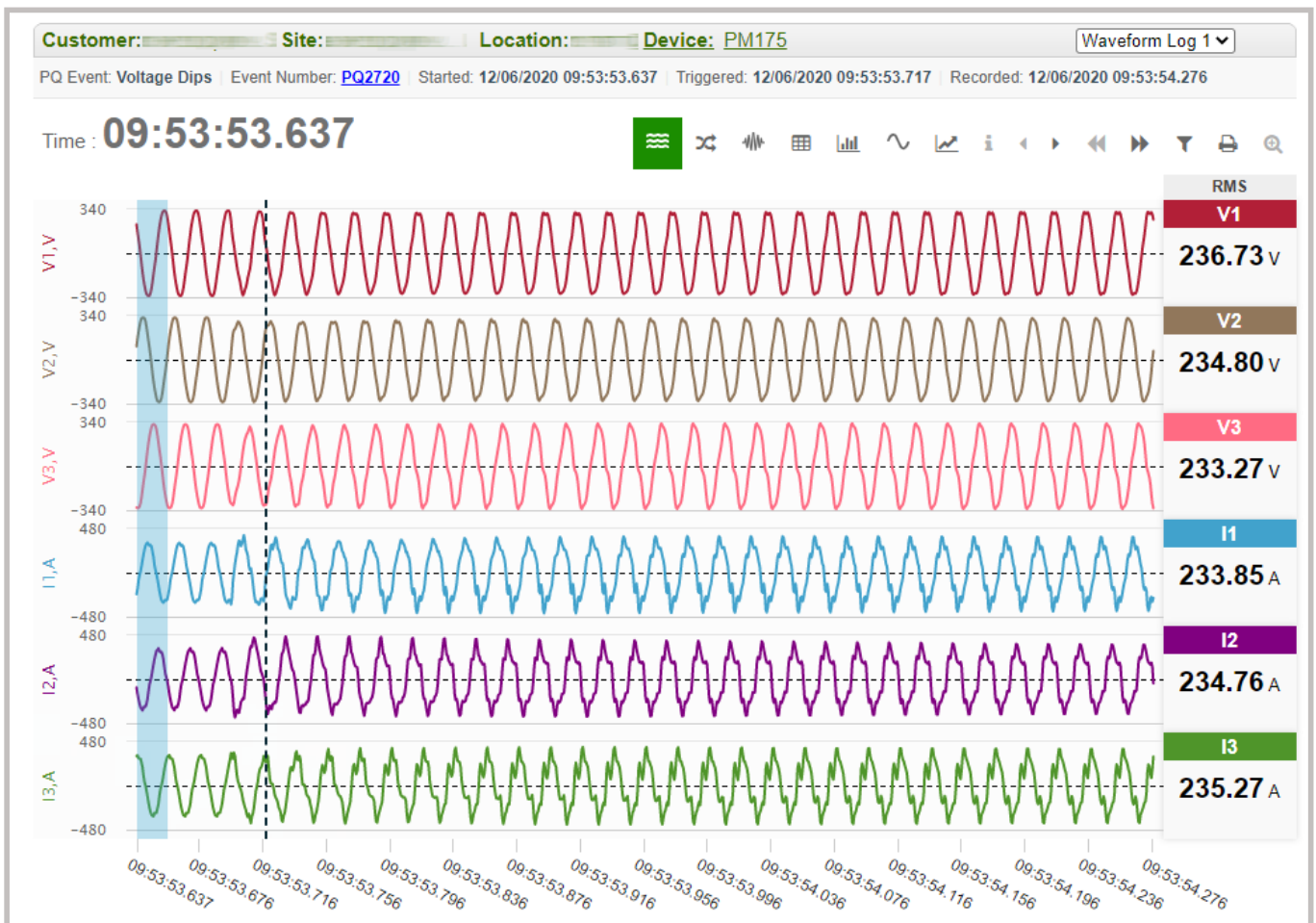


Figure 4: Voltage Dip, viewed on SATEC's Expertpower software

Disturbance Direction Detection

SATEC's PM180 also features an advanced capability of disturbance direction detection, i.e. determining whether the source of the disturbance lies between the recorder and the generator (upstream) or between the recorder and the load (downstream).

This detection is not trivial and is not featured by most power analyzers on the market. The PM180 uses synchronous voltage and current waveforms recorded before and during an event to determine the locations of the disturbance source. Depending on the characteristics of the fault, the device can

apply different methods of analyzing the collected data to give the most reliable indication of the direction of the fault.

Symmetrical (three-phase) dips and swells are analyzed using the relative level of the fault or inrush current and the fundamental power angle. Asymmetric (single-phase and two-phase) dips and swells can be analyzed using the negative sequence power angle or, in the case of insufficient information, using the fundamental power angle.

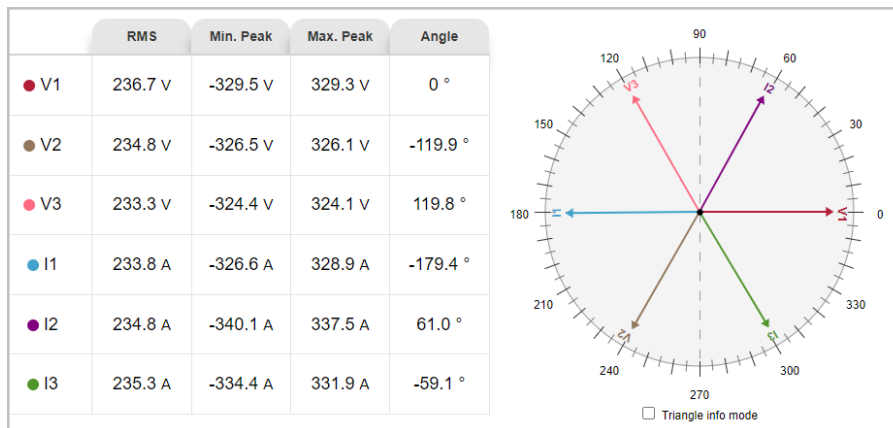


Figure 5: Voltage dip data and phasor as viewed on Expertpower

	V	I
Positive Sequence	234.892 V	234.209 A
Negative Sequence	0.726 V	0.739 A
Zero Sequence	1.319 V	0.341 A
Negative Sequence Unbalance	0.309 %	0.315 %
Zero Sequence Unbalance	0.562 %	0.146 %

Figure 6: Sequence data as viewed on Expertpower

No.	Date/Time	Event	Fault Category	Phase	Fault Magnitude	PU	Duration
1	05/06/21 10:46:39.337	PQE6:5024	Voltage interruption	V1,V2,V3	0	0.00	0:00:06.000008
2	05/06/21 10:46:50.337	PQE5:5025	Voltage dip (downstream, high confidence)	V12	694	0.03	0:00:00.520208
3	05/06/21 10:46:50.337	PQE5:5025	Voltage dip (downstream, high confidence)	V23	690	0.03	0:00:00.520208
4	05/06/21 10:46:50.337	PQE5:5025	Voltage dip (downstream, high confidence)	V31	695	0.03	0:00:00.520208
5	05/06/21 10:46:55.837	PQE5:5026	Voltage dip (downstream, high confidence)	V12	694	0.03	0:00:00.520193
6	05/06/21 10:46:55.837	PQE5:5026	Voltage dip (downstream, high confidence)	V23	690	0.03	0:00:00.520193
7	05/06/21 10:46:55.837	PQE5:5026	Voltage dip (downstream, high confidence)	V31	695	0.03	0:00:00.520193

Figure 7: Downstream Indication

SATEC as Global PQ Solution Provider

Power quality monitoring has been SATEC's core expertise since it was founded back in 1987. Over the years we have accumulated a great amount of experience in delivering to national grid operators full end-to-end solutions for power quality monitoring. Below are several examples of such project from over the past several years.

We've been doing this for over 30 years. Please feel free and confident to consult with us over your own power quality monitoring project.

COUNTRY	END USER	COMPONENTS	DELIVERED
India	DNO	PM180: 51 units	
Peru	Distriluz (DNO)	PM180: 350 units	
Russia	Russian National Dispatch Center	PM180: 98 units	
Romania	Distributie Energie Oltenia SA	PM180: 140 units Expertpower SW	<ul style="list-style-type: none"> + Real-time PQ event data collection + Automated PQ reports generated (standard & customizable) + V & I waveform recordings
Singapore	SPPG, Singapore DNO (66 kV)	PM180: 120 units	
Thailand	PEA National Grid	PM180: 195 units Expertpower SW	
Israel	IEC, National Grid	EM720: 400 units Expertpower SW	
Tanzania	TANESCO National Grid	PM180: 200 units Expertpower SW	<ul style="list-style-type: none"> + Automated PQ reports generated (standard & customizable) + V & I waveform recordings
USA	San Diego Gas & Electric	PM180: 50 units (Planned: 2,000+)	<ul style="list-style-type: none"> + Real-time PQ event data collection + Automated PQ reports generated (standard & customizable) + V & I waveform recordings + PMU + Capacitor control / PLC IEC61131
Czech Republic	CEZ substations	ENA075: 7,000+ units	Local requirement PQ monitoring
Ukraine	Ukrenergo	400 units (PM175 / PM180)	National PQ on 110/220 kV