DISTURBANCE DIRECTION DETECTION

Network Disturbances and Resulting Damage

Detecting network disturbances, such as voltage dips and swells, is an important aspect of power quality monitoring. However, it is often difficult to determine and locate the cause responsible for the disturbance detected. This of course presents a further challenge in preventing such future events.

A power quality analyzer is normally situated in a network operator's substation or at a client/facility's grid connection. The functionality is identical but harbors different interests. Since faulty power quality can damage equipment, the client wants to record and document such cases and claim damages from the operator. Accordingly, the operator must conduct its own independent monitoring, to confirm or dispute such claims.

Likewise, the monitoring is needed for providing internal alerts for power quality issues, before any damage is incurred.

Figure 1: Electric motor as possible cause

Causes and Detection

Voltage dips or swells occur as the result of sudden events within the network, such as short circuits, the energizing of a transformer or the introduction of big loads. For example, a big industrial client turning on an induction motor could cause a notable voltage sag experienced by neighboring facilities as well. Determining this is extremely important for a network operator for preventing such events and for deflecting charges from clients.

When a power quality analyzer records a disturbance, the questions above are phrased asking whether the event has taken place *upstream* or *downstream*. Upstream indicates occurrence on the generation side / provider side of the analyzer; downstream indicates the consumer / load side of the analyzer.
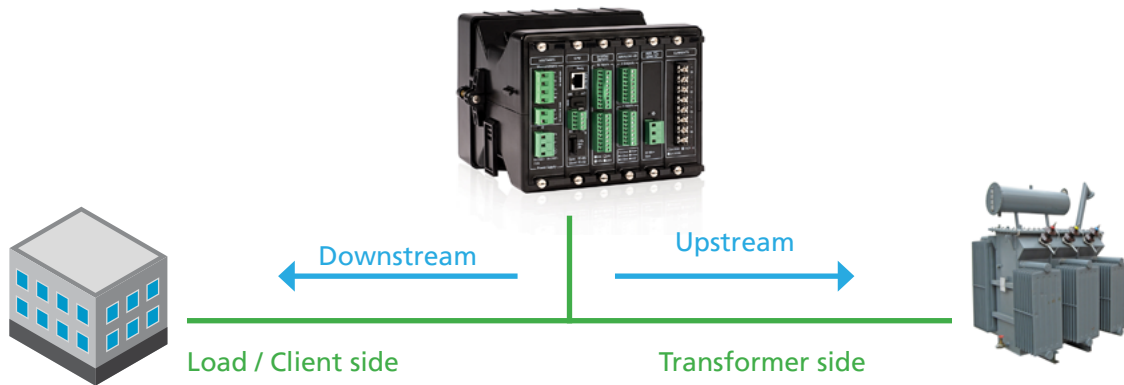
SATEC

Figure 2: Disturbance Direction

Disturbance Direction Detection with the PM180 Power Analyzer

Providing 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 location 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.

PM180

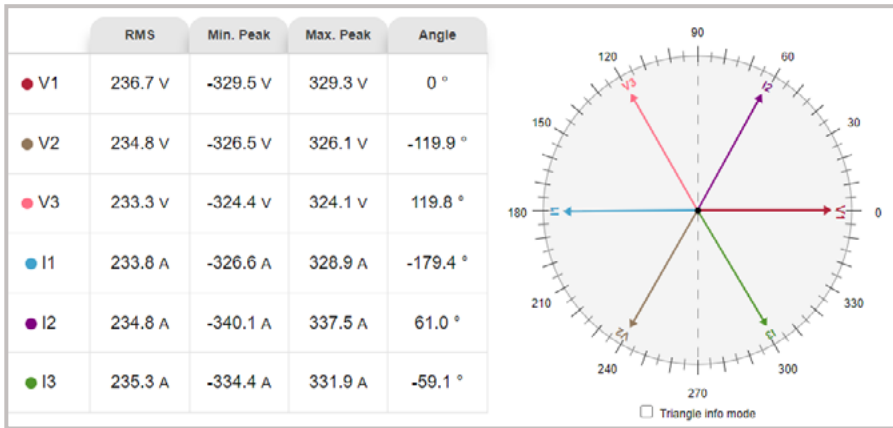Figure 3: Voltage Dip, viewed on SATEC's Expertpower software

	RMS	Min. Peak	Max. Peak	Angle
● V1	236.7 V	-329.5 V	329.3 V	0 °
● V2	234.8 V	-326.5 V	326.1 V	-119.9 °
● V3	233.3 V	-324.4 V	324.1 V	119.8 °
● I1	233.8 A	-326.6 A	328.9 A	-179.4 °
● I2	234.8 A	-340.1 A	337.5 A	61.0 °
● I3	235.3 A	-334.4 A	331.9 A	-59.1 °

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 4: 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 5: 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 6: Downstream Indication

The PM180 Analyzer

The PM180 is a Class A, Edition 3, multifucntion power quality analyzer.

Functionality includes: Digital Fault Recorder, PMU (per IEEE C37.1118), PLC controller and more. for further information, please visit the PM180 web-page.