SATEC
Powerful Solutions

APPLICATION NOTE:

LOW BUDGET POWER QUALITY

Voltage sags, swells and interruptions are among the most common power quality events that affect the operation of electrical systems. A detailed analysis of these events requires the use of a power quality analyzer. However, with the advanced performance of the SATEC power meters, such functionality can be achieved to some extent on a lower budget.

SATEC 130 series of power meters, which includes the EM132, EM133, PM130 and PM135, offers basic power quality analysis. For power quality analysis, the EM133 or the EH model of the PM130/PM135 should be used. This allows harmonic monitoring (including individual harmonic, THD, TDD and K Factor), waveform monitoring, unbalance measurement, frequency deviations as well as voltage sags, swells and interruption detection. This application note describes how to detect sags, swells and interruption using the EM133/PM130EH PLUS/PM135 models.

The detection of events is performed with the comprehensive set-points mechanism that is incorporated in all SATEC devices. This is a very powerful tool, allowing each power meter to perform various operations that are often performed by additional equipment, thus saving costs, space and installation.

For sag/swell interruption detection, several set-points should be defined (see Figure 1):

1. **Set-point #2**. Start of the swell: since most standards recommend a 10% threshold, a value of 253v is used (10% more than the nominal 230v L-N)
2. **Set-point #3**. End of swell: since the event drives operation only when it is activated, this set-point is required to detect the end of the swell. It should use the same threshold
3. **Set-point #1**. The operation in the set-point is activated once. Therefore, if the voltage level will change more slowly, it will not be possible to distinguish between 110% and 120% swells, a distinction which is required for many event classifications. Set-point #1 is used to make additional logging if the voltage is over 120%
4. **Set-point #6**. Start of interruption: recommended threshold of 5% from nominal
5. **Set-points #7 to 11**. Start of sag, with various levels
6. **Set-point #5**. End of sag/Interruption

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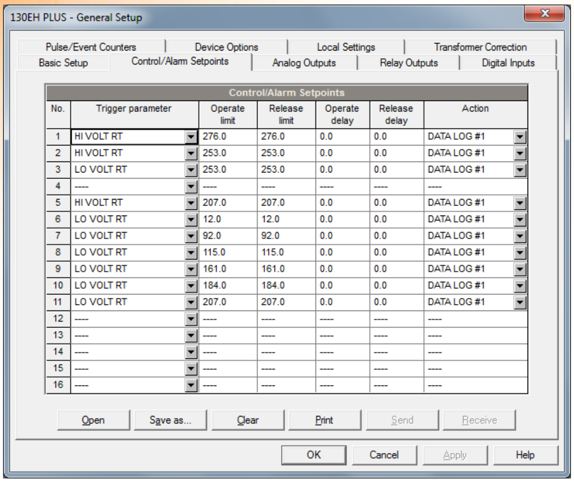
130EH PLUS - General Setup

Pulse/Event Counters | Device Options | Local Settings | Transformer Correction
Basic Setup | Control/Alarm Setpoints | Analog Outputs | Relay Outputs | Digital Inputs

Control/Alarm Setpoints

No.	Trigger parameter	Operate limit	Release limit	Operate delay	Release delay	Action
1	HI VOLT RT	276.0	276.0	0.0	0.0	DATA LOG #1
2	HI VOLT RT	253.0	253.0	0.0	0.0	DATA LOG #1
3	LO VOLT RT	253.0	253.0	0.0	0.0	DATA LOG #1
4	----	----	----	----	----	----
5	HI VOLT RT	207.0	207.0	0.0	0.0	DATA LOG #1
6	LO VOLT RT	12.0	12.0	0.0	0.0	DATA LOG #1
7	LO VOLT RT	92.0	92.0	0.0	0.0	DATA LOG #1
8	LO VOLT RT	115.0	115.0	0.0	0.0	DATA LOG #1
9	LO VOLT RT	161.0	161.0	0.0	0.0	DATA LOG #1
10	LO VOLT RT	184.0	184.0	0.0	0.0	DATA LOG #1
11	LO VOLT RT	207.0	207.0	0.0	0.0	DATA LOG #1
12	----	----	----	----	----	----
13	----	----	----	----	----	----
14	----	----	----	----	----	----
15	----	----	----	----	----	----
16	----	----	----	----	----	----

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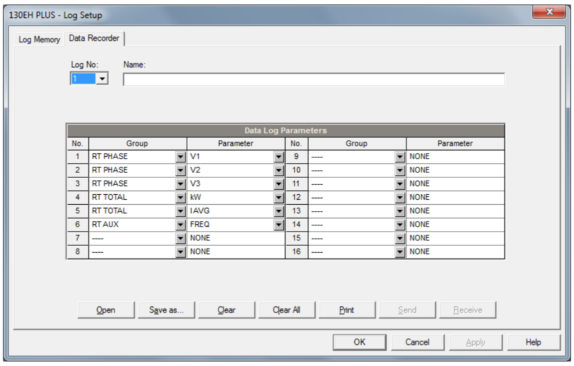
Figure 1: Setpoints Configuration
(PAS Software Screenshot)


130EH PLUS - Log Setup

Log Memory | Data Recorder

Log No: 1 Name:

Data Log Parameters

No.	Group	Parameter	No.	Group	Parameter
1	RT PHASE	V1	9	----	NONE
2	RT PHASE	V2	10	----	NONE
3	RT PHASE	V3	11	----	NONE
4	RT TOTAL	kW	12	----	NONE
5	RT TOTAL	I AVG	13	----	NONE
6	RT AUX	FREQ	14	----	NONE
7	----	NONE	15	----	NONE
8	----	NONE	16	----	NONE

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Figure 2: Data Log Configuration
(PAS Software Screenshot)

The operation of each set-point is data logging, which is programmed to log the three voltages (it is recommended to add currents for good analysis as well as other parameters, depending on the requirements, while considering the amount of parameters vs. memory size constraints). The result is a list of events and values of voltages with time stamps. Thanks to the 1 cycle measurement capability of the device, the time stamp resolution is 20ms. Since the events are logged during the beginning of the sag/swell/ interruption, the voltage values do not represent the most extreme value. However, the multiple set-points ensure that the sag/swell can be correctly classified. This is the major limitation of using these devices and care should be taken, especially when comparing to international sag/swell schemes such as CBEMA/ITI Curve.

The following test was performed in order to demonstrate this capability:

1. SATEC PM130EH PLUS was connected to OMICRON CMC 256 – a programmable power source generator
2. Data log #1 was set as shown in Figure 2
3. Set-points were programmed as described above and shown in Figure 1
4. Voltage disturbances were delivered from the OMICRON CMC 256
5. EM720 was connected in parallel to compare the results
6. PAS software was used to download the information. The PAS built-in scheduler can be used to automatically download the information. PAS creates standard MDB files that are easily read by many applications
7. The MDB file was opened by Microsoft Excel (one can create an automatic link to MDB files to make the process automatic). See Figure 3
8. Using Excel standard functions, the time periods between events were measured (column P), the peak voltage in % was calculated (column Q) and the event type was identified based on the set-point ID (column R).
9. The results were classified according to EN50160 cells (Figure 4) and plotted using Excel standard XY scatter chart, together with the various sag/swell standards – CBEMA/ITIC, SEMI F47, IEC 61000-4-11, IEC 61000-4-34 and Samsung Power Vaccine (Figure 5).

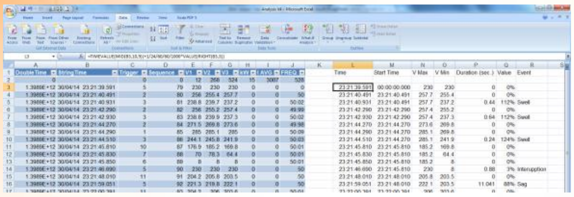

Figure 3: Sag/Swell/Interruption Analysis

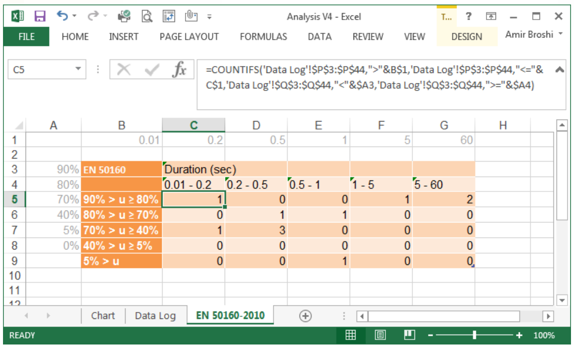

Figure 4: Sag/Interruption EN50160 Classification

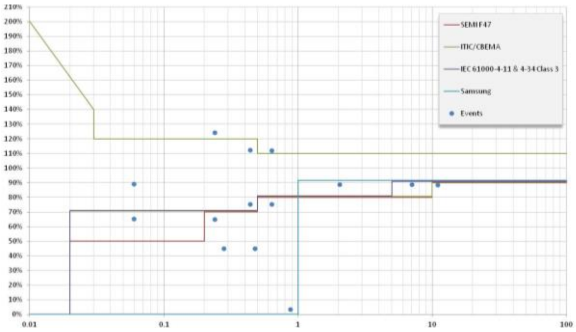

Figure 5: Sag/Swell/Interruption Chart

Table 1 compares the injected events to the detected ones. The voltage level was changed during 40ms before and after the event and the "event net duration" column represents the duration in which it was flat at that level. Due to this, an addition 1 or 2 cycles (0.02-0.04s) is added before and after each event (total 0.04-0.08s).

Table 1: Comparing Expected and Detected Events

Event Net Duration	Measured Duration	Event Level	Measured Level
0.40	0.44	115%	112%
0.60	0.64	115%	112%
0.20	0.24	124%	124%
0.80	0.88	3%	3%
11.00	11.04	85%	88%
7.00	7.04	85%	89%
2.00	2.04	85%	89%
0.60	0.64	75%	75%
0.40	0.44	75%	75%
0.20	0.24	65%	65%
0.40	0.48	45%	45%
0.20	0.28	45%	45%
0.02	0.06	65%	65%
0.02	0.06	85%	89%

The results are that the PM130EH PLUS (as well as the EM133 and PM135EH) can detect sags, swells and interruptions in one cycle resolution and sufficient voltage accuracy, as well as compare the information with international compliance charts. It cannot replace the dedicated power quality analyzer, which has ½ cycle resolution (according to standards) and accurate voltage levels (plus additional functionality such as waveform logging and voltage flickering), but it does provide reliable and cost effective detection of 1 cycle or higher events.

Table 2 compares the Power Quality options of SATEC devices.

Table 2: Comparing Power Quality Capabilities

	Data Logs	Measurement	Waveform Log	RMS Plot	Power Quality
PM130P **PM135P** **EM132**	✗	1 cycle	✗	✗	No
PM130/5 E/EH **PM135E/EH** **EM133**	✓	1 cycle	✗	✗	Basic
BFM136	✓	1 cycle	✗	✗	Limited
PM172P	✗	1 cycle	✗	✗	No
PM172E/EH	✓	1 cycle	✓	✓	Advanced
PM175 **PM180** **EM720** **EM920** **ezPAC**	✓	½ cycle	✓	✓	Complete

In similar way, it is also possible to monitor voltage imbalance and frequency events, which together cover most of EN50160 type of events. Table 3 lists the various power quality events, the order of magnitude of its measurement (the period itself depends on the standard) and the possibility of detecting it with this technique.

Table 3: Additional Power Quality Events

Supply Voltage Phenomenon	Measurement Duration Order of Magnitude	Detectable using suggested technique (limitations apply)
Frequency	Seconds	✓
Slow voltage changes	Minutes	✓
Sag/Dip	10 milliseconds	✓
Interruption (Short/Long)	10 milliseconds	✓
Temporary over-voltage (swell)	10 milliseconds	✓
Transient over-voltage	Tens of microseconds	✗
Voltage unbalance	Minutes	✓
Harmonic voltage	Seconds/minutes	Partial
Harmonic current	Seconds/minutes	Partial

Summary

- It is possible to detect power quality issues using power meters only, providing they have <u>fast</u> and <u>large</u> set-point capabilities.
- The method allows wide implementation for single loads and secondary MCCs.
- In primary MCCs, important secondary MCCs and sensitive sites, a Power Quality Analyzer is required.