

The Big Event

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By now, the "big event" will have come and gone, and in my humble opinion, it probably have been without anything really eventful, no global disturbances, not the end of the world as we know it. (Of course, if the world did end, I wouldn't have to worry about anybody reading this and saying "That's what you said!") As far as I can tell, electrons don't know what time it is, no less what day of the year, nor what year. For the most part, they just keep flowing happily along. When they don't, we usually call it "an event", "a disturbance", or, in geek-speak, "a power quality phenomena." However, what is an event to one person may be a non-event to another. And what makes up an event to one person may be a series of events to another.

The key issues here are system operation and system susceptibility. The electric utility system is designed to respond in a certain manner to certain "events" on the electrical distribution and transmission systems. Knowledge of how these systems operate, especially the fault protection portions of them, can be very valuable in determining the source of a disruption to a process in an industrial facility, or the computer systems in a data processing center.

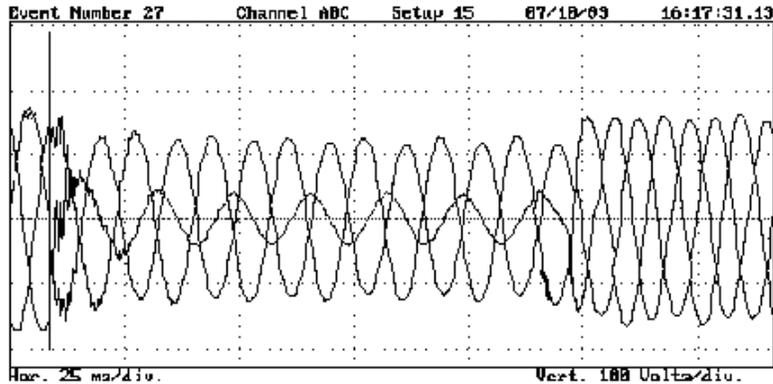
The electrical generators produce power at a comparatively low voltage. This voltage is stepped up through transformers to hundreds of thousands of volts. This is so that it flows more efficiently, with less losses in the wiring along the way. Transmission systems at 500KV are not uncommon anymore. These transmission lines feed many distribution feeders, so a transmission level fault can have vast effects, covering hundreds of miles. Fortunately, such events are generally rare, since drunk drivers, tree branches, and critters are less likely to affect these tall towers than the distribution system poles.

The most common sources of problems on the electric utility system occur on the distribution system, typically less than 69KV. A typical distribution substation may have 3-7 feeders at 13KV, being supplied off a common voltage buss fed from a transmission line through a step-down transformer. The most common sources of sags found in a 1976 study in Northern Virginia [1] are shown below, where there were an average of 40 thunderstorms/year.

CAUSE OF SAGS ON DISTRIBUTION SYSTEM

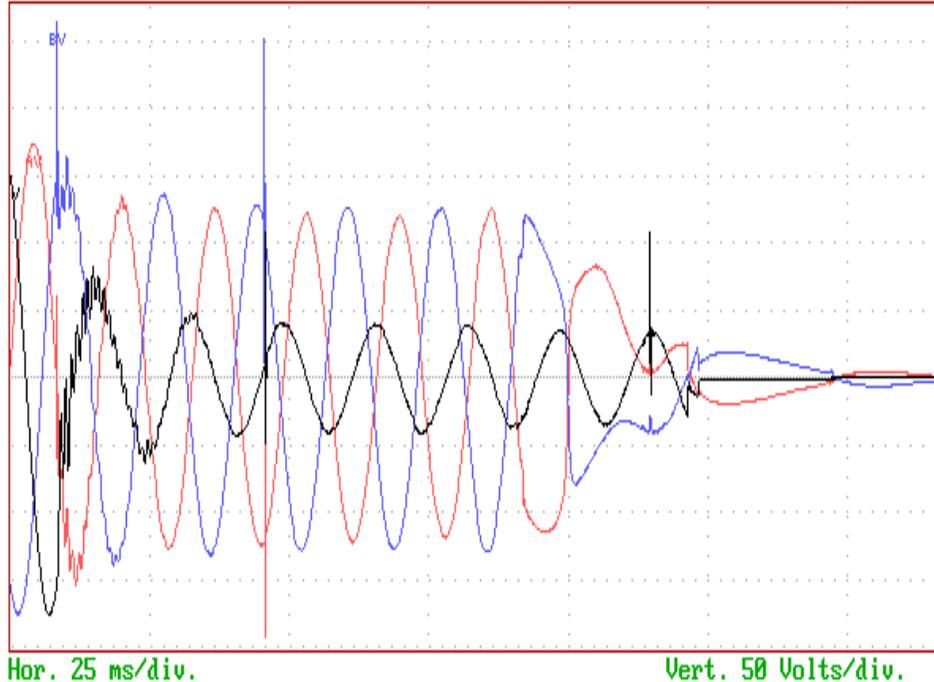
CAUSE	# of OCCURRENCES	PERCENTAGE
Wind and lightning	37	46%
Utility equipment failure	8	10%
Construction or traffic accident	8	10%
Animals	5	6%
Tree limbs	1	1%
Unknown	21	26%
TOTAL	80	

When phase-to-ground or phase-to-phase faults occur, the system protection schemes begin to operate. The typical distribution breaker will wait 6-10 cycles before opening, to give the fault a chance to clear itself. It will then stay open for a period of time, and try to reclose to see if the cause of the fault is no longer present. This recloser sequence may repeat itself for 3-6 times, after which the breaker will be "locked out", requiring human intervention before the circuit can be re-energized. This lock-out prevents the wire laying on the drunk driver's car after he/she just hit the utility pole from arcing on and off continually. However, if the fault was caused by a lightning-induced flashover, the opening of the breaker should extinguish the arc, and the recloser will be successful.

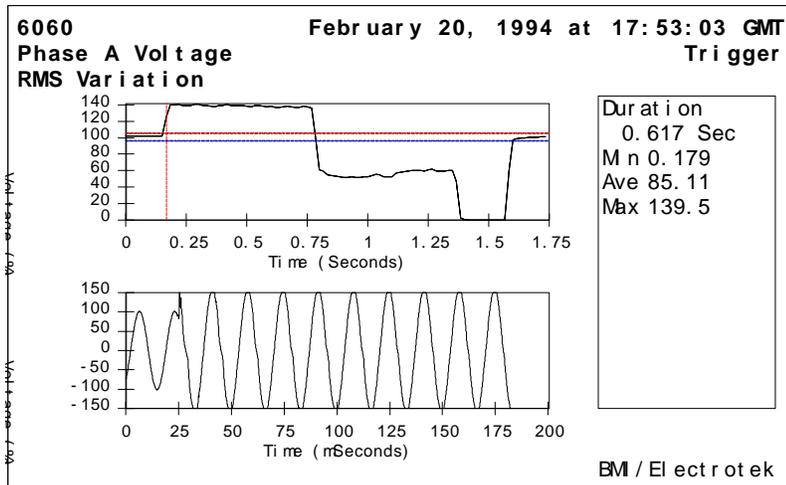


A good example of the effect on the three phase voltage can be seen in the above waveforms. When the breaker operated, the voltage returned to normal, indicating the voltage was being monitored at a site that was on a different feeder than the one where the fault occurred. Otherwise, the voltage would have gone to zero volts when the breaker operated, as shown in the next waveforms.

658 GRAPHICAL & HARMONIC ANALYSIS (c)1988-1994 Dranetz Technologies, Inc.
EAST ORANGE 12KV BUS 2
Event Number 24 Channel ABC Setup 15 07/10/93 16:17:41.02



If the breaker operated several times before the fault was cleared, those using the electricity may experience a series of voltage sags, which may have a different effect on their process than just one sag. For example, if the process successfully road through the first sag, but it depleted some the stored energy in the power supply, it may be the second sag that trips the process of line. Or each sag may have caused a quality problem on the product being extruded. To the electric utility company, this sequence is often called just one event, since there was one problem that the system properly reacted to try to eliminate. However, the consumer of the electricity may have a quite different perspective. When the such "aggregation" rules were applied to the benchmark study conducted of 100 distribution feeders as part of the EPRI DPQ project, it obviously reduced the number of events per feeder.



Even more confusing can be events that have multiple power quality phenomena characteristics in them. As shown in the below waveforms, Phase A experiences first a swell, then a sag, and finally an interruption from a fault on another phase of a high impedance grounded system-- one event or three?

The moral of the story is to be sure that you are speaking the same language with another power quality person when trying to determine what the event was, and what caused it. It is often a matter of perspective.

1- Berutti, Al, and R.M.Waggoner, Practical Guide to Quality Power for Sensitive Electronic Equipment, EC&M, Based on Materials originally written by John A. DeDad and editors of EC&M, Intertec Publishing Corp, 1993