

Steady-state disturbances

Steady state disturbances can be classified into two categories namely, long duration variations and short duration variations.

1.4 Long duration variations

A variation is considered to be long duration when the limits are exceeded for more than one minute. Long duration variations can be classified into overvoltage, undervoltage and sustained interruptions.

1.4.1 Overvoltage

An *overvoltage* is an increase in the rms ac voltage greater than 110 percent at the power frequency for a duration longer than 1 min. Overvoltages are usually the result of load switching (e.g., switching off a large load or energizing a capacitor bank). The overvoltages result because either the system is too weak for the desired voltage regulation or voltage controls are inadequate. Incorrect tap settings on transformers can also result in system overvoltages.

1.4.2 Undervoltage

An *undervoltage* is a decrease in the rms ac voltage to less than 90 percent at the power frequency for duration longer than 1 min. Undervoltages are the result of switching events that are the opposite of the events that cause overvoltages. A load switching on or a capacitor bank switching off can cause an undervoltage until voltage regulation equipment on the system can bring the voltage back to within tolerances. Overloaded circuits can result in undervoltages also. The term *brownout* is often used to describe sustained periods of undervoltage initiated as a specific utility dispatch strategy to reduce power demand. Because there is no formal definition for brownout and it is not as clear as the term undervoltage when trying to characterize a disturbance, the term brownout should be avoided.

Magnitude of event	Very Short Over voltage	Short Over voltage	Long Over voltage	Very Long Over voltage
	Nomal Operating Voltage			
90%	Very Short Under voltage	Short Under voltage	Long Under voltage	Very Long Under voltage
	1-3 Cycles	1-3 Min	1-3 hours	
	Duration of events			

Figure 1.1 Magnitude duration plot for classification of power quality events

1.5 Short duration variations

This category encompasses the IEC category of voltage dips and short interruptions. Each type of variation can be designated as instantaneous, momentary, or temporary, depending on its duration. Short-duration voltage variations are caused by fault conditions, the energization of large loads which require high starting currents, or intermittent loose connections in power wiring. Depending on the fault location and the system conditions, the fault can cause either temporary voltage drops (*sags*), voltage rises (*swells*), or a complete loss of voltage (*interruptions*). The fault condition can be close to or remote from the point of interest. In either case, the impact on the voltage during the actual fault condition is of the short-duration variation until protective devices operate to clear the fault.

1.5.1 Voltage sag

A voltage sag (also called a “**dip**”) is defined as a decrease in voltage magnitude below 90% of nominal, but not a complete interruption. The typical duration is from 3 to 10 cycles, 50 to 167 milliseconds. Typical end-use equipment sensitive to voltage sags are: computers, programmable logic controllers, controller power supplies, motor starter contactors, control relays and adjustable speed drives.

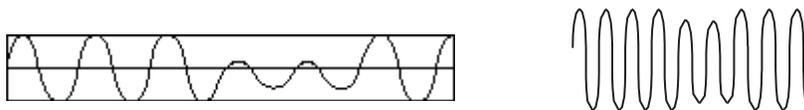


Figure 1.2 Voltage Sag Waveform

A voltage sag is a short duration decrease in voltage values. Voltage sags longer than two minutes are classified as undervoltages. Common causes of voltage sags and undervoltages are short circuits (faults) on the electric power system, motor starting, customer load additions, and large load additions in the utility service area.

Sags can cause computers and other sensitive equipment to malfunction or simply shut off. Undervoltage conditions can damage certain types of electrical equipment.

1.5.2 Voltage swells

A voltage swell is the converse to the sag. A swell is a short duration increase in rms line voltage values of 110 to 180 percent of the nominal line-voltage for a duration of 0.5 cycle to 1minute. Voltage swells lasting longer than two minutes are classified as overvoltages. Voltage swells and overvoltages are commonly caused by large load changes and power line switching.

If swells reach too high a peak, they can damage electrical equipment. The utility's voltage regulating equipment may not react quickly enough to prevent all swells or sags. Sources of voltage swells are line faults and incorrect tap settings in tap changers in substations.

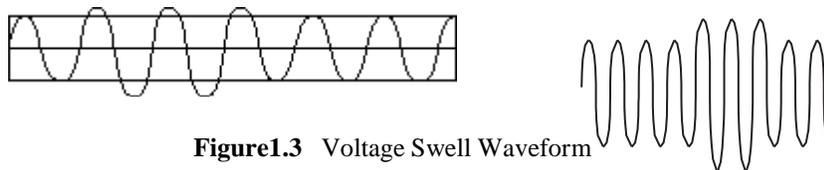


Figure1.3 Voltage Swell Waveform

1.5.3 Interruption

Interruptions occur when voltage levels drop to zero. Interruptions are classified as momentary, temporary, or long-term. Momentary interruptions occur when service is interrupted, but then is automatically restored in less than two seconds.

Temporary interruptions occur when service is interrupted for more than two seconds, but is automatically restored in less than 2 minutes. Long-term interruptions last longer than two minutes and may require field work to restore service.

In some cases, momentary outages may go unnoticed or cause no apparent problems. However, even momentary outages can last long enough to shut down computers and disrupt the operation of sensitive electrical equipment.

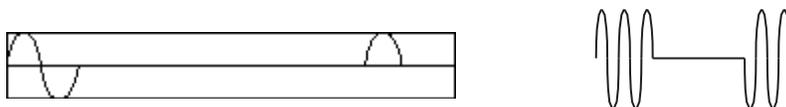


Figure1.4 Interruptions Waveform

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