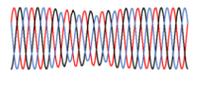
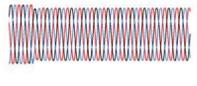
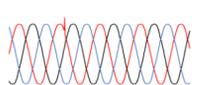
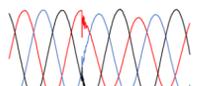
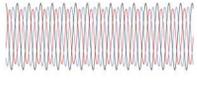
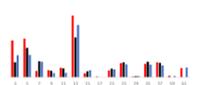
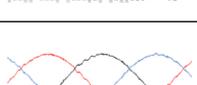


Summary table of the power quality indices (IEEE 1159-2019) with possible causes and consequences.

Voltage Sag/Undervoltage A voltage sag occurs when the RMS voltage decreases between 10% to 90% of the nominal voltage for a time greater than 0.5 cycles (8ms), and less or equal to 1 minute. An undervoltage is a decrease in rms voltage less than 90% for a duration longer than 1 min. Typical values are between 80% and 90%.			
Description	Waveform	Consequences	Possible causes
Sag		Unplanned production stoppages. Malfunction of PLC's, VFD's failures. Nuisance tripping. Increase maintenance cost. Electronic card failures. Data loss. Compressor failure. Failure of refrigeration systems.	Faults in the network caused by weather, animals across terminals, traffic accidents. Load switching upstream. Startup of large loads or transformer energization.
Under voltage		Production stoppages, equipment stoppages. Reduce life of equipment. Electronic board damage.	Utility reduced voltage. Load switching on or overloaded circuits can also result in a undervoltage.
Voltage Swell/Oversvoltage An overvoltage is a rms increase in ac voltage greater than 110% of the nominal voltage for a duration longer than 1 min. Typical values are 110% to 120%. A swell is an increase in rms voltage above 110% for durations from 0.5 cycle to 1 min. Typical values are 110% to 120%.			
Description	Waveform	Consequences	Possible causes
Swell		Nuisance tripping. Reduce life of equipment. System stoppages.	Faults in the network but less common than sags. Single line ground faults, resulting in a temporary voltage rise on the upfaulted phases. Switching of large loads, load shedding or switching on a capacitor bank.
Oversvoltage		Reduced life of equipment. System stoppages. Breakdown of insulation over time. Increase maintenance cost.	Utility capacitors left online during lower load conditions. Switching off large loads. Switching on a capacitor bank. Poor system voltage regulation. Incorrect tap settings on a transformer can results in oversvoltage.
Transient Impulse - a sudden, change from the nominal condition of voltage, current or both, that is primarily either positive or negative. Sometimes called notching. Oscillatory - a sudden, nonpower frequency change in the steady state condition of the voltage, current or both, that included both positive and negative polarity values.			
Description	Waveform	Consequences	Possible causes
Impulse Transient		Loss of data. Electronic component damage like computers, instruments, and control devices. System stoppages.	Utility fault clearing. Lightning strikes. Can excite resonance in the system and produce oscillatory transients. Line switching of heavy loads, operation of vacuum circuit breakers, welding equipment, poor grounding, SCR rectifier.
Oscillatory Transient		VFD, DC link overvoltage tripping. Reduce equipment life, Shorten the life of input diodes on drives. Timing errors on electronic circuits. Could produce multiple zero crossings.	Capacitive switching upstream to adjust the line voltage for differences in day and night load (shunt capacitors). Transformer energization.
Voltage Interruption Momentary Interruption - A type of RMS voltage variation where the complete loss of voltage on one or more phase conductors for a time between 0.5 cycles and 3 seconds. Sustained Interruption - The complete loss of voltage on one or more phase conductors for a time greater than 1 minute.			
Description	Waveform	Consequences	Possible causes
Interruptions		Loss of production, system stoppages, loss of data, damage shutdown, VFD stoppages. Compressor failure. Failure of refrigeration systems.	Recloser operation, Switching, utility faults, breaker tripping, equipment, or electronic failures.
Voltage Unbalance Voltage unbalance in a three-phase system is defined as the ratio of the magnitude of the negative sequence component to the magnitude of the positive sequence component, expressed as a percentage.			
Description	Waveform	Consequences	Possible causes
Voltage Unbalance		Reduce life on induction motors. VFD drive failure. Derating of a motor. Stator and rotor copper losses. Increase maintenance cost. Bearing degradation. Compressor failure. Failure of refrigeration systems.	Uneven distribution of loads in buildings between phases, Faulty rectifiers.
Waveform Distortion Waveform distortion is defined as a steady-state deviation from an ideal power frequency sinusoid principally characterized by the spectral content of the deviation.			
Description	Waveform	Consequences	Possible causes
Harmonics		Transformers overheated, system stoppages. Capacitor failures. Nuisance tripping. Increase heat in conductors and motor windings. Heat and fire risk in the neutral conductor. Faster bearing degradation.	Non-linear loads like rectifiers, switching power supplies, computers, CFL, VFD's injects current harmonics into the system.
Interharmonics		Affect power line carrier signaling, induce visual flicker in display devices. Induce background noise in sensors, RF, scanning equipment. Communication interference. Heating. Common mode Noise.	The main sources are pulse-width modulated inverters, static frequency converters, cycloconverters, induction furnaces, and arcing devices. Power line carrier signals can also be considered as Interharmonics.
Notching		Can cause frequency or timing errors on electronic circuits. Produce additional zero crossings. Case gating errors on SCR-based systems.	Three-phase converters that produce continuous dc. Interaction by large VFD drives. System resonance cause ringing. Windfarm resonance cause by significant capacitance in the system.
Noise		Noise disturbs electronic devices such as microcomputers and programmable controllers. Data loss.	Caused by power electronic devices, control circuits, arcing equipment, loads with solid-state rectifiers, and switching power supplies. Noise problems are often exacerbated by improper grounding.
Flicker		Human discomfort, health issues. Productivity loss. Injuries.	Arc furnaces are the most common cause. Ball mills in cement and mining. Car Shredders and Rock Crushers