DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE MATERIAL

FACULTY DETAILS:

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Designation	**ASSISTANT PROFESSOR**
Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**

COURSE DETAILS:

Name of the Course	**B.E(PART TIME)**
Branch	**EEE**
Year	**IV**
Subject Code	**EEE2018FT01**
Title of the subject	**POWER QUALITY**

SUBJECT : POWER QUALITY

AIM : The quality of electrical power may be described as a set of values of parameters, such as:

- Continuity of service (Whether the electrical power is subject to voltage drops or overages below or above a threshold level thereby causing blackouts or brownouts)
- Variation in voltage magnitude
- Transient voltages and currents
- Harmonic content in the waveforms for AC power

It is often useful to think of power quality as a compatibility problem: It is the equipment connected to the grid compatible with the events on the grid, and is the power delivered by the grid, including the events, compatible with the equipment that is connected.Compatibility problems always have at least two solutions: in this case, either clean up the power, or make the equipment tougher.The tolerance of data-processing equipment to voltage variations is often characterized by the CBEMA curve, which give the duration and magnitude of voltage variations that can be tolerated. This unit describes the definition os electric power quality,its causes and classification.It describes the impact of poor power quality on power system and guidelines of various IEEE and IEC standards.

OBJECTIVES :

Introduces the definition of electric power quality, its causes and classification: transients, short-duration voltage variations, interruptions, sags, swells, long-duration voltage variations, sustained interruption, under- and over-voltage, voltage imbalance, waveform distortion, DC offset, harmonics, inter-harmonics, non-integer harmonics, triplen harmonics, sub-harmonics, time and space harmonics, characteristic and uncharacteristic harmonics, positive-negative- and zero-sequence harmonics, notching, electric noise, voltage fluctuation and flicker, and power-frequency variations. The formulations and measures used for power quality; impacts of poor power quality on power system and end-use devices; most important IEEE and IEC guidelines/recommendations/standards referring to power quality are presented.

PRE TEST-MCQ TYPE:

1. Most of the power quality problems are related to ______

(a) Transmission Issue (b) **Grounding Issue** (c) Distribution Issue (d) all of the above

2. Which of the following is not considered as good power quality voltage

(a) **Power Supply is more compared to demand** (b) Constant sine wave (c) Constant Velocity (d) Constant RMS Value unchanged with time

3. Grounding is done (i) for safety (ii) to provide a low-impedance path for the flow of fault current in case of a ground fault (iii) to create a ground reference plane for sensitive electrical equipment

(A) Only (i)

(B) Only (ii)

(C) (i) & (ii)

(D) (i), (ii), (iii)

4. ________________ refers to the interaction between electric and magnetic fields and sensitive electronic circuits and devices.

(A) Radio frequency interference

(B) Power frequency disturbances

(C) Electromagnetic interference

(D) Power system harmonics

5. All electrical devices are prone to failure or malfunction when exposed to one or more power quality problems

(A) True

(B) False

THEORY BEHIND:

UNIT-I

INTRODUCTION

POWER QUALITY:

The concept of powering and grounding sensitive equipment in a manner that is suitable for that equipment's operation is known as power quality.

- **TERMS & DEFNITION:**

Voltage quality:

Voltage quality is a word that is frequently used, particularly in European literature. It might be understood as the utility's ability to supply a high-quality product to its customers.

Power quality:

The term "power quality" refers to the combination of voltage and current quality. As a result, power quality is concerned with voltage and/or current deviations from the ideal.

Quality of supply:

The technical portion of power supply quality (voltage quality above) is combined with a nontechnical component known as "quality of service." The latter refers to the customer's relationship with the utility, such as how quickly the utility responds to concerns or how transparent the tariff structure is.

Electromagnetic Compatibility (EMC):

Electromagnetic compatibility refers to how equipment interacts with one another as well as how equipment interacts with the power supply.

- **POWER QUALITY EVENTS:**

Many distinct properties can be used to describe a transient overvoltage; three of the most common are:

1. Magnitude: either the greatest voltage or the maximum voltage divergence from the regular sine wave is the magnitude.

2. Duration: the duration is more difficult to measure because the voltage frequently takes a long time to fully recover. The period when the voltage has recovered to within 10% of the magnitude of the transient overvoltage; the time-constant of the average voltage decay; and the ratio of the Vt-integral defined below to the magnitude of the transient overvoltage are all possible definitions.

An overview of various types of power quality events is given below:

I. Interruptions: A "voltage interruption" [IEEE Std.I 159], "supply interruption" [EN 50160], or simply "interruption" [IEEE Std. 1250] is when the voltage at the supply terminals is close to zero. The IEC defines close to zero as "less than I percent of the reported voltage," while the IEEE defines it as "less than 10%" [IEEE Std. II59].

Interruptions can also be classified into categories based on how long they last and how they are restored:

• manual or automatic switching;

• repair or replacement of the faulty component

2. Undervoltages: Undervoltages of varied durations are referred to by various names. "Voltage sags" or "voltage dips" are short-duration undervoltages. The lEe prefers to use the latter term. The term voltage sag is used by the IEEE and many journal and conference papers on power quality. Long-term undervoltage is commonly referred to simply as "undervoltage."

3. Overvoltages. Overvoltage events, like undervoltage events, are given multiple names depending on how long they last. "Transient overvoltages," "voltage spikes," or "voltage surges" are overvoltages with a short duration and a large magnitude. The latter word is a bit misleading because it's occasionally used to refer to overvoltages that last anywhere from one cycle to one minute. "Voltage swell" or "temporary power frequency overvoltage" are more accurate terms for the latter phenomenon.

- **Overview of Voltage Magnitude Events**

The bulk of current occurrences are linked to either a decrease or a rise in the magnitude of the voltage. These are known as "voltage magnitude occurrences." A voltage magnitude event is a short-term (substantial) divergence from the normal voltage magnitude. Taking the rms of the voltage over a multiple of one half-cycle of the power-system frequency yields the magnitude.

The magnitude of the voltage is divided into three parts:

• interruption: the voltage magnitude is zero;

• undervoltage: the voltage magnitude is less than the nominal value; and

• overvoltage: the voltage magnitude is more than the nominal value.

There are three types of durations: very short, which corresponds to transient and self-restoring events; short, which corresponds to automatic restoration of the pre-event situation; long, which corresponds to manual restoration of the pre-event situation; and very long, which corresponds to repair or replacement of faulty components.

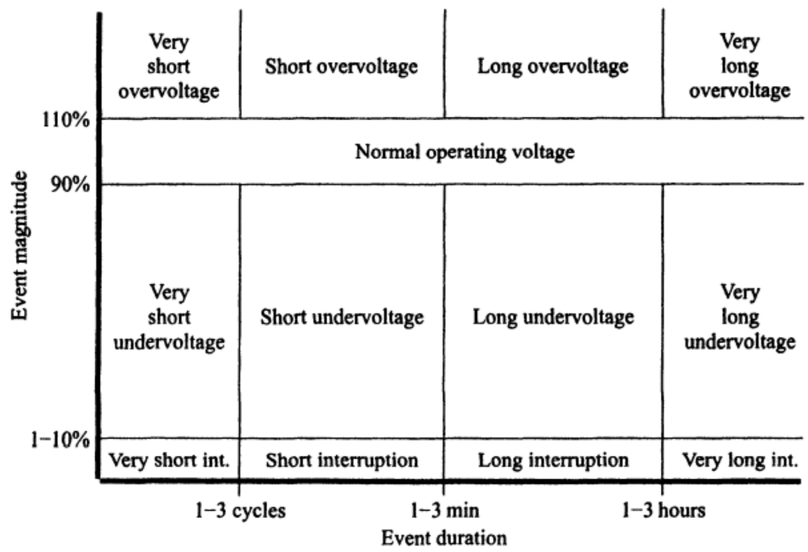

Fig 1. Suggested classification of voltage magnitude events

- **POWER QUALITY AND EMC STANDARDS**

➢ **The IEC Electromagnetic Compatibility Standards**

The ability of a device, equipment, or system to work satisfactorily in its electromagnetic environment without causing unbearable electromagnetic disturbances to anything else.

EMC has two components: (1) a piece of equipment must be able to operate properly in its surroundings, and (2) it must not damage the environment excessively.

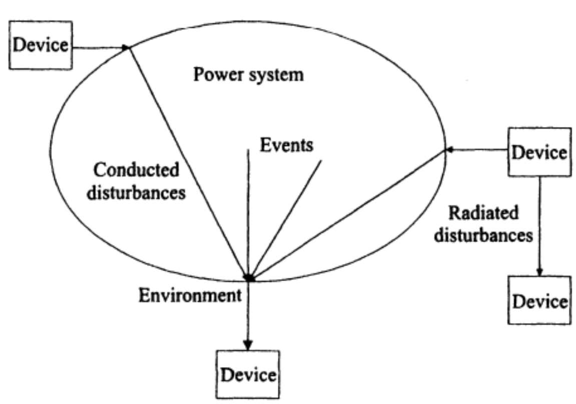

Fig 2. Overview of EMC terminology

- **The European Voltage Characteristics Standard**
  - Electricity is described as a product in European standard 50160 [80], which includes its flaws. Under typical operating conditions, I gives the major properties of the voltage at the customer's supply terminals in public low-voltage and medium-voltage networks. Some disturbances are simply noted, while others are given a wide range of usual values, and yet others are given real voltage characteristics.
  - Variations in voltage. Some changes are limited by the EN 50160 standard. For each of these changes, a value is assigned that must not be surpassed 95% of the time. A certain average window should be used for the measurement. For most variations, this window is 10 minutes long; therefore, very short time scales are not considered in the standard. The following are the low-voltage voltage limits:
  - Standard EN 50160 does not give any voltage characteristics for events. Most event-type phenomena are only mentioned, but for some an indicative value of the event frequency is given. For completeness a list of events mentioned in EN 50160 is reproduced below:

• Voltage magnitude steps: generally, these do not exceed 5°AJ of the nominal voltage, but fluctuations of up to 100 /o can happen several times every day.

• Voltage sags occur infrequently, ranging from a few tens to thousands of times each year. The duration is usually shorter than a second, and the voltage seldom falls below 40%. Sags caused by load switching are particularly common in some regions.

• There are a few tens to several hundreds of short outages per year. In almost 70% of cases, the duration is shorter than one second.

• Long supply voltage interruptions with a frequency of less than 10 or up to 50 per year.

• Under some conditions, voltage swells (brief overvoltages in Fig. 1.16) occur. Due to overvoltages.

❖ **Reference:**

1.”UNDERSTANDING POWER QUALITY PROBLEMS”,MATH.H.J BOLLEN

UNIT-II

SHORT AND LONG INTERRUPTIONS

- **Interruptions:**

A protracted interruption occurs when the voltage at a customer connection or at the equipment terminals drops to zero and does not automatically return. Long power outages are one of the most common and serious power quality issues. The official IEC definition mentions three minutes as the minimum duration of a long interruption. An interruption with a duration of less than three minutes should be called a "short interruption." Within the IEEE standards the term "sustained interruption" is used for interruptions lasting longer than 3 seconds [IEEE Std. 1159] or longer than 2 minutes [IEEE Std. 1250].

- **Terminology:**

→ Failure: A gadget or system that does not work as it should.

→ Outage: The removal of a key component from the system, such as a transformer or a generating station, is referred to as an outage.

→ Interruption: It is a circumstance in which a customer's electricity supply has been interrupted by one or more outages.

- **Causes of Long Interruptions:**

Component outages are always the cause of long interruptions. Component outages can be caused by one of three things:

When a malfunction arises in the power system, the power system protection system intervenes.

The failure is usually a short-circuit fault, but other factors such as transformer overloading or underfrequency can cause protracted outages.

A protective relay intervenes wrongly, resulting in a component outage, which could result in another extended outage. Operator activities produce a component loss, which can also lead to a long interruption. If erroneous tripping (or maltrip) occurs in a part of the system without redundancy, it will always result in an interruption.

- **Short Interruptions:**

→ **INTRODUCTION:**

Short interruptions have the same reasons as long interruptions: protection clearing faults, inappropriate protection intervention, and so on. The resulting event is known as a short interruption when the supply is restored automatically. When the supply is restored manually, it causes long and very long disruptions. Reclosing the circuit breaker that cleared the issue or switching to a healthy supply are both options for automatic restoration.

→ **ORIGIN OF SHORT INTERRUPTION:**

→ A lightning strike to an overhead line is a common cause of a transient failure. The lightning stroke injects a very high current into the line causing a very fast rising voltage.

→ The main breaker can also clear a persistent fault, although this would cause a long outage for all customers served by this feeder. An expulsion fuse, on the other hand, is used to clear a permanent problem. The recloser has two options for accomplishing this: an immediate trip and a delayed journey. For all potential fault currents, the protection coordination should be such that the instantaneous trip is faster than the expulsion fuse and the delayed trip is slower.

→ **VOLTAGE MAGNITUDE EVENTS DURING RECLOSING:**

As described above, the combination of reclosing and fuse saving results in various voltage magnitude events for different customers.

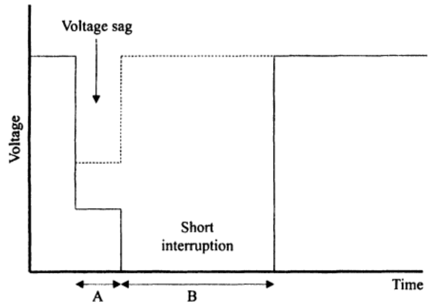

Fig 3. Origin of short interruptions

→ **INFLUENCE ON EQUIPEMENT:**

During a short interruption, the voltage is zero, and the equipment receives no power at all. All of this happens in a matter of seconds, but the repercussions can last much longer: disruption of production operations, loss of computer memory contents, evacuation of buildings owing to fire alarms going off, and in certain cases, damage when the power returns (uncontrolled starting).

Induction Motors (Induction Motors): A zero voltage on an induction motor has a straightforward effect: the motor slows down. An induction motor's mechanical time constant, including its load, is in the range of 1 to 10 seconds. The motor has not yet come to a halt with dead times of many seconds, but it has undoubtedly slowed dramatically.

Reference:

1.”UNDERSTANDING POWER QUALITY PROBLEMS”,MATH.H.J BOLLEN

UNIT-III

VOLTAGE SAG AND TRANSIENTS

- **INTRODUCTION:**

Short circuits, overloads, and the beginning of powerful motors create voltage sags, which are short-term drops in rms voltage. The difficulty that voltage sags generate on various types of equipment has sparked interest: adjustable-speed drives, process control equipment, and computers are infamous for their sensitivity. When the rms voltage falls below 900/0 for more than one or two cycles, some equipment trips.

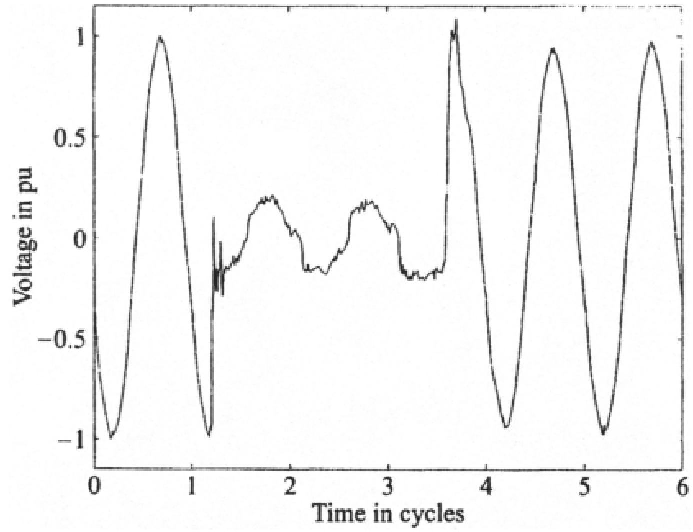

Fig 4. Voltage sag due to short circuit fault.

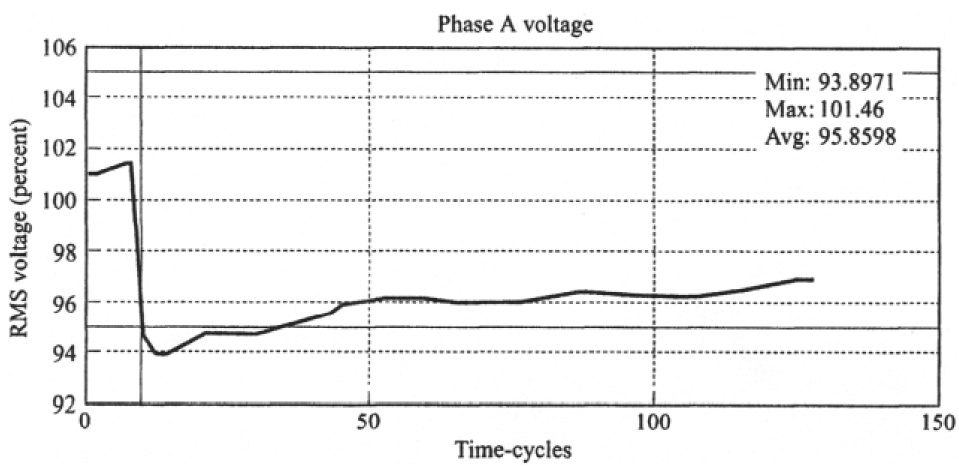

Fig 5. Voltage sag due to induction motor starting.

- **VOLTAGE SAG MAGNITUDE:**

  A voltage sag's magnitude can be determined in a variety of methods. The sag magnitude is calculated by most existing monitors using the rms voltages.

- **VOLTAGE SAG DURATION:**

  → Fault-Clearing Time:

An overview of the fault-clearing time of various protective devices are:

• current-limiting fuses: less than one cycle

• expulsion fuses: 10-1000 ms

• distance relay with fast breaker: 50-100 ms

• distance relay in zone 1: 100-200 ms

• distance relay in zone 2: 200-500 ms

• differential relay: 100-300 ms

• overcurrent relay: 200-2000 ms

- **THREE PHASE UNBALANCE:**

A three-phase fault shorts all three networks at the fault location. For the positive sequence, this results in the usual voltage divider model, whereas for the negative and zero sequences, it results in zero voltage and current.

→ Single-Phase Faults
→ Phase-to-Phase Faults
→ Two-Phase-to-Ground Faults
→ Phase-Angle Jumps

- MAGNITUDE AND PHASE-ANGLE JUMPS FOR THREE-PHASE UNBALANCED SAGS

→ Magnitude and Phase-Angle Jump are defined as the rms value of the lowest of the three voltages in a three-phase unbalanced sag.
→ Phase-to-phase failures have varying degrees of impact depending on the transformer winding connections between the fault and the equipment.
→ Single-Phase Faults: The issue becomes slightly more complicated with single-phase faults.

→ A type B sag would occur if star-connected equipment was operating at the same voltage level as the fault. These three-phase imbalanced sags' characteristic magnitude is no longer equal to the beginning magnitude. The phase-angle leap is the same way.

→ Two-Phase-to-Ground Faults: The treatment of two-phase-to-ground faults is identical to that of phase-to-phase faults. In the same way that type B contains a single-phase-to-ground fault, type E contains a multi-phase-to-ground fault.

- **LOAD INFLUENCE ON VOLTAGE SAGS:**

→ **Induction Motors and Three-Phase Faults:**

- The voltages at the motor terminals decrease dramatically during a three-phase malfunction. The magnetic flux in the air gap is no longer in harmony with the stator voltage, which has two effects. With a time constant of several cycles, the flux decays. During this decay, the induction motor contributes to the defect by maintaining voltage at the motor terminals to some extent.

- • As voltage decreases, electrical torque decreases as well: electrical torque is proportional to the square of the voltage's rms value. In the meantime, the mechanical torque is virtually unaltered. As a result, the motor begins to slow down. The engine will accept a larger current as it slows down.

→ **Power Electronics Load:**

  • A considerable portion of the electronics load will trip, especially for longer and deeper sags. During and after the sag, this will reduce the load current and hence increase the voltage.

  • The dc bus capacitors will absorb a big current pulse from the supply when the voltage recovers. This can cause the voltage recovery to be delayed by up to one cycle.

Reference:

1.”UNDERSTANDING POWER QUALITY PROBLEMS”,MATH.H.J BOLLEN

UNIT-IV

WAVEFORM DISTORTION

The following equations can be used to define a sinusoidal voltage or current function that is dependent on time t:

v(t) = V sin(t) is the voltage function. ———— (1)

i(t) = I sin(t) is the current function. ———(2)

where = 2 f is the periodic waveform's angular velocity and is the phase angle difference between the voltage and current waveforms, which is referred to as a common axis. If the current leads the voltage, the phase angle is positive; if the current lags the voltage, the phase angle is negative.

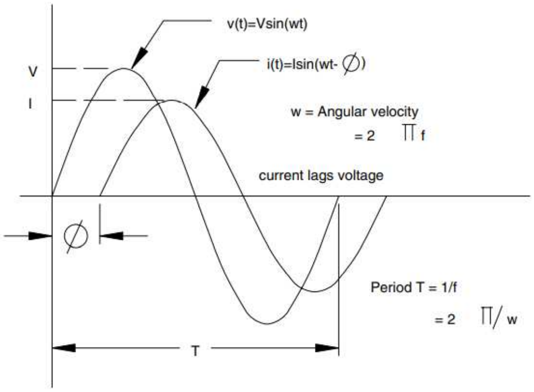

Fig 5. Sinusoidal voltage and current functions of time (t)

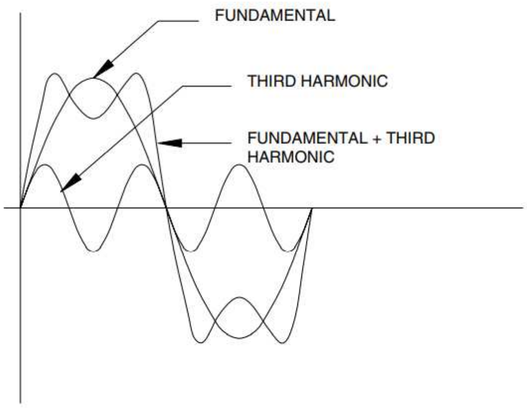

Fig 6. Non linear waveform with third harmonic frequency waveform

- **HARMONIC NUMBER (h)**

The individual frequency elements that make up a composite waveform are referred to as the harmonic number (h). For instance, h = 5 denotes the fifth harmonic component, which has a frequency five times that of the fundamental frequency. The fifth harmonic frequency is 5 60, or 300 Hz, if the fundamental frequency is 60 Hz. The component with the harmonic number 6 has a frequency of 360 Hz.

- **ODD AND EVEN ORDER HARMONICS**

Due to the phenomena of core saturation, the DC component of a waveform has unwanted effects, particularly on transformers. Operating the core at magnetic field values above the knee of the magnetization curve causes saturation of the core. Transformers are made to work in the area below the knee of the curve. Large DC magnetic fields form in the transformer core when DC voltages or currents are applied to the transformer winding. The sum of the AC and DC magnetic fields can cause the transformer to operate in areas beyond the saturation curve's knee. The power system must handle a lot of excitation power when operating in the saturation range. The transformer losses have increased significantly, resulting in an extreme temperature rise. Vibrations in the core

- **CAUSES OF VOLTAGE AND CURRENT HARMONICS**

→ A pure sinusoidal waveform with zero harmonic distortion is a theoretical, not a practical, characteristic. Because of nonuniformity in the excitation magnetic field and discontinuous spatial distribution of coils around the generator stator slots, the voltage waveform retains a tiny amount of distortion even at the point of generation.

→ The generated voltage is sent hundreds of miles, changed into many levels, and then delivered to the power user. In big commercial or industrial systems, user equipment generates currents with a lot of harmonic frequency components. Due to impedance voltages associated with various power distribution equipment, such as transmission and distribution lines, harmonic currents cause further voltage distortion as they travel to the power source.

- **EFFECT OF HARMONICS ON POWER SYSTEM DEVICES**

→ **TRANSFORMERS**

→ Transformers are largely affected by harmonics in two ways. Higher frequency harmonic voltages create hysteresis loops, which superimpose over the basic loop, causing extra losses in the transformer core. Each loop means larger core losses and higher magnetization power requirements. Harmonic frequency currents in the transformer windings are a second and more harmful effect of harmonics. Harmonic currents raise the net RMS current in the transformer windings, resulting in increased I2R losses. Losses from winding eddy currents have also increased.

→ **AC MOTORS**

The application of distorted voltage to a motor causes additional losses in the motor's magnetic core. As higher frequency harmonic voltages are imprinted on the motor windings, hysteresis and eddy current losses in the core grow. Hysteresis losses rise with frequency, while eddy current losses rise with frequency squared. Harmonic currents also result in additional I2R losses in the motor windings, which must be taken into account.

→ **CAPACITOR BANKS**

Capacitor banks are often used to adjust for low power factor circumstances in commercial and industrial power systems. Capacitor banks are rated to operate at 110 percent of their rated voltages and 135 percent of their rated kVARS. When there are a lot of voltage and current harmonics, the ratings are frequently exceeded, which leads to problems. Harmonic currents can enter a capacitor bank because the reactance of a capacitor bank is inversely proportional to frequency. The capacitor bank works as a sink, absorbing stray harmonic currents and overloading the bank, resulting in failure.

- **HARMONIC CURRENT MITIGATION:**

→ **EQUIPMENT DESIGN**

Electronic power devices are becoming increasingly popular. Nonlinear loads are expected to account for more than 70% of a facility's loading by 2010, hence demand for devices that produce less distortion is increasing. As seen by technological advancements in fluorescent lamp ballasts, adjustable speed drives, battery chargers, and uninterruptible power source (UPS) units, the importance of equipment design in decreasing harmonic current output has grown.

→ **HARMONIC FILTERS**

Harmonic currents are generated by nonlinear loads and can travel to other parts of the power system before returning to the source. Harmonic currents, as we've seen, can have a number of negative impacts on the power system. Harmonic currents are caused by the properties of specific loads. As long as we choose to use those loads, we must accept that harmonic currents will exist to some extent, depending on the loads.

Reference:

1.”POWER QUALITY”,C.SANKARAN

UNIT-V

POWER QUALITY SOLUTIONS

- **POWER QUALITY MEASUREMENT DEVICES**

→ HARMONIC ANALYZERS

Harmonic analyzers, also known as harmonic metres, are basic equipment used to measure and record harmonic distortion data. Harmonic analyzers typically include a metre with a waveform display screen, as well as voltage leads and current probes. Some of the analyzers are portable, while others are designed to be used on a tabletop. Some instruments provide a snapshot of the waveform and harmonic distortion at the time of measurement. Other instruments can take snapshots as well as keep a running log of harmonic distortion over time. Obviously, more information-rich units are more expensive.

→ TRANSIENT-DISTURBANCE ANALYZERS

Transient-disturbance analyzers are sophisticated data collecting systems that capture, store, and display short-duration, subcycle power system disturbances. These instruments have high sampling rates, as one might assume. Transient-disturbance recorders are commonly equipped with sampling rates of 2 to 4 million samples per second. Higher sampling rates allow for more precise characterization of transient events in terms of amplitude and frequency content. The waveform's amplitude indicates whether or not the afflicted equipment is at risk of harm. The frequency content reveals how the occurrences may interact with other circuits and how they might be prevented.

→ OSCILLOSCOPES

On power and control circuits, oscilloscopes are useful for measuring repetitive high-frequency waveforms or waveforms with superimposed high-frequency noise. The sampling rate of oscilloscopes is much higher than that of transient-disturbance analyzers. Oscilloscopes capable of sampling hundreds of millions of samples per second are prevalent. This enables the device to record recurrent noise and high-frequency waveforms with pinpoint accuracy. The proper usage of oscilloscopes necessitates the selection of voltage probes. Oscilloscope voltage probes are divided into two categories: passive and active. Passive probes rely on passive components (such as resistance and capacitance) to provide the required filtering and scale factors. Passive probes are commonly used in circuits with a voltage of up to 300 volts. Passive probes with higher voltages can be utilised in circuits with up to 1000 VAC. The majority of passive probes are made

→ DATA LOGGERS AND CHART RECORDERS

Voltage, current, demand, and temperature data are sometimes recorded in electrical power systems using data loggers and chart recorders. Charts and data loggers 9.4 FIGURE A lighting panel supplying fluorescent illumination has a current waveform and a current history graph. CRC Press LLC published it in 2002. Slow-response devices, such as recorders, are useful for capturing steady-state data over a lengthy period of time.

→ TRUE RMS METERS

In power quality applications, the phrase genuine RMS is frequently employed. True RMS metres are what they sound like. The RMS value of a current or voltage might fluctuate significantly from the basic component of the voltage or current, as we observed in previous chapters. If we need the RMS value of the waveform, we can't use a metre that measures the average or peak value of a quantity. Waveforms with a lot of harmonics have different average and peak values than waveforms that are entirely sinusoidal or near to sinusoidal. There would be mistakes if you measured a signal's average or peak value and then scaled the readings to get an RMS value.

→ POWER QUALITY MEASUREMENTS:

Examining the power quality to the problematic equipment at a position as close to the equipment as possible is the best technique to analysing power quality concerns. Move upstream with a process-of-elimination plan if power quality problems are discovered. Determine whether the issue is caused by load-side anomalies or line-side issues at each location. Despite the fact that this approach is time consuming and possibly useless, it might yield useful information. Understanding and resolving power quality issues is rarely simple and straightforward.

- **NUMBER OF TEST LOCATIONS**

Power quality checks should be carried out at many locations at the same time. Data gathered in this manner is useful in immediately determining the nature of the power quality problem and its likely source. If simultaneous monitoring is not possible owing to cost or other constraints, each location can be monitored separately, with care taken to create equivalent operating circumstances for testing at each location so that data can be compared directly. The number of test sites would be determined by the nature of the issue and the impacted equipment.

- **TEST DURATION**

Even a well-trained engineer has to battle with determining the length of time each test point should be watched for acceptable data collection at times. Ideally, you'd want to keep testing until the true cause emerges. This isn't always possible, and it can be rather expensive. In power quality tests, you're searching for not only the actual failure mode to repeat itself (which is ideal), but also any event that would indicate a failure propensity.

- **INSTRUMENT SETUP**

→ Setting up instruments to collect data on power quality is perhaps the most important component of testing, and it's also the one that determines the end results the most. Setting up is a period when extreme caution is required. The first step is to ensure that specific safety guidelines are followed. Power to electrical equipment cannot be switched off in most circumstances to allow for instrument setup. Users of the facility want as little disruptions as feasible, if not none at all. It takes perseverance and patience to open the covers of electrical switchboards and distribution panels. Power quality assessment necessitates the use of personal protective equipment (PPE). Electrical gloves, safety glasses, and flame-resistant apparel should all be included in the minimum PPE. It occurred when removing panel covers and installing instrument probes.

- **INSTRUMENT SETUP GUIDELINES**

The installation of power quality equipment and probes necessitates extra caution. It's best if voltage and current probe leads aren't too close to high-current cables or buses, especially if they're exposed to a lot of current inrush. This can cause inductive voltages to be induced in the probes' leads, resulting in erroneous data being shown. Parallel to a high-current bus or cable, a voltage and current lead runs. 9.13 FIGURE Personal protective equipment (PPE) is required for the setup and testing of power quality instruments. The photo depicts the wearing of flame-resistant gear, a safety cap, and shoes. When connecting instrument probes to the test point, safety glasses must be worn. Unauthorized persons will not be able to enter the test site because it is adequately walled.

MCQ POST TEST:

1. Lightening and Tree striking on a live conductor is an example________ Power Quality issue.

(a) Voltage Sag (b) **Voltage Swell** (c) Interruption (d) Surge

2. Interruption is

(a) complete loss of power (b) **complete loss of voltage** (c) complete loss of current (d) all the above

3. The Transients in the power system occurs for

a) less than two complete cycles b) exact two complete cycles c**) less than one complete cycles** d) exact one complete cycles

4. The most common cause of long interruption is ______ (a) Faults (b) Outages **(c) Both (a) & (b)**

(d) none of the above

5. Outage is the

(a) Removal of Primary Component (b) No Power Generation (c) Transmission Faults (d) None of the above

6.Single Phase Tripping is generally used in _________________.

(a) Transmission System (b) Distribution System (c) Low Voltage System (d) Generation System

7. The Short Interruptions occurs for

(a) Less than two complete cycles (b) exact two complete cycles **(c) less than one complete cycles** (d) exact one complete cycles

8. Most electrical equipment is designed to operate within a voltage of ± _____ of nominal with marginal decrease in performance.

(A) 5 %

(B) 1 %

(C) 10 %

(D) 0.5 %

9. Which of the following equipment has low immunity index?

(A) electronic medical equipment

(B) adjustable speed drives

(C) transformers

(D) electromechanical relays

10. As per the power quality indices, which of the following applications face low power quality problems?

(A) HVAC power panels

(B) lighting power distribution panel

(C) elevators

(D) large motors

CONCLUSION:

Power quality maintenance is an important aspect in the economic operation of a system. Various power quality problems may lead to another undesirable problem. Proper mitigation devices may be used to maintain the level of power quality as desired. Power-quality standards address limits to harmonics and power-quality events at the point of common coupling in power systems. Emphasis is given to causes and effects of current harmonics on different power system components.

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ASSIGNMENTS :

1. What do you understand about power quality issues? Discuss all the power quality issues in brief.

2. Explain the cause and effect with respect to power quality point of view? What is an immunity of the equipment? Discuss the treatment criteria for a machine.

3. Define and technically describe following terms: (1)Linear loads (2)Inrush current (3)Power factor(displacement) (4)Voltage swell (5)Transient

4. What are the power quality standards? Discuss responsibilities of supplier and user of electrical power with respect to power quality

5. Define the following terms 1. Displacement Power Factor 2. Flicker 3. Nonlinear load

6. Explain following terms related to power quality. (1) Grounding (2) Noise (3) Notch.

7. Explain all power quality concerns in brief.

8. What are CBEMA and ITIC graphs? Draw and discuss the ITIC graph in detail

9. Explain different power quality solution techniques in detail.

10. Define the term "Power Quality". Discuss the common power frequency disturbances with suitable examples.