GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: SUBSTATION ENGINEERING AND POWER QUALITY
(COURSE CODE: 3360904)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	Sixth

1. RATIONALE

This course provides an insight into the construction of Gas Insulated Substation (GIS), earthing in substation and Power Quality parameters of the power system. With the proliferation of power electronics and non linear loads invariably in all sectors, Power Quality is gaining more and more attention in recent years. It has become more important because power quality can have economic impacts on utilities, their customers, and suppliers of load equipment. The quality of power can have a direct economic impact on many industrial consumers as there is a great emphasis on automation and more modern electronically controlled, energy-efficient equipment. This course will enable the diploma pass out students to maintain GIS, earthing system in substation and analyze power frequency disturbance, electrical transients and harmonics in the power supply and apply appropriate mitigation techniques. Thus this course is very important for students who want to work in power companies.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and maintain electric substation equipment to improve Power Quality.**

3. COURSE OUTCOMES (COs):

i. Operate and maintain Gas insulated Substation.
ii. Maintain Substation earthing.
iii. Analyze various Power Quality problems.
iv. Apply techniques to mitigate Power Quality disturbance and transients
v. Apply techniques to mitigate harmonics

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Gas Insulated Substation	1a. Describe the construction of Gas Insulated Substation (GIS). 1b. Describe the Advantages and Disadvantages of SF_6 insulated switchgear. 1c. Explain loss measurement and temperature rise test of transformer. 1d. Explain the Installation and maintenance aspects of GIS.	1.1 GIS 1.2 Single line diagram of substation 1.3 SF_6 insulated switchgear 1.4 Partial discharge monitoring 1.5 Loss measurement and temperature rise test 1.6 Installation and maintenance of GIS
Unit– II Substation Earthing	2a. Describe the components of substation earthing. 2b. Describe the connection of substation equipment to earthing system. 2c. Explain earth resistance measurement techniques.	2.1 Substation earthing system 2.2 Connection of electrical equipment to station earthing system 2.3 Step potential, touch potential(tolerable and actual) 2.4 Earthing grid 2.5 Earth resistance of earthing system 2.6 Integrated earthing
Unit– III Fundamentals of Power Quality .	3a. Explain the significance of Power Quality. 3b. Describe the causes of Various Power Quality problems. 3c. Explain the need of PQ standards. 3d. Describe the use of Power Quality measurement	3.1 Significance of Power Quality(PQ) 3.2 Causes of Electric PQ problems – Transients- Impulsive, Oscillatory, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, 3.3 Power Quality measurement equipment- power line disturbance analyzer, harmonic / spectrum analyzer, flicker meters, disturbance analyzer.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit–IV Power Frequency Disturbance and Electrical Transients	4a. State the source and effects of voltage sag. 4b. Explain briefly the devices used to mitigate voltage sag. 4c. State the source and effects of transients. 4d. Explain briefly the devices being used to mitigate transients.	4.1 Voltage sag and their sources 4.2 Voltage sag, due to induction motor starting. Estimation of the sag severity 4.3 Mitigation of voltage sags- 4.4 Transients types and their sources- 4.5 Lightning protection – shielding – line arresters - protection of transformers and cables.
Unit-V Harmonics	5a. Explain the sources of harmonics. 5b. Explain the significance of Harmonic indices. 5c. State the detrimental effects of PQ problems on various equipment. 5d. Explain various harmonic mitigation techniques being used.	5.1 Harmonics – Odd and even, Voltage and current harmonics, inter harmonics 5.2 Effect of harmonics on: Motors Transformer, conductors, capacitors, power electronic equipment, meters, Relays, digital equipment, telephone/communication equipment, cable and lamps

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Gas Insulated Substation	08	04	04	04	12
II	Substation Earthing	08	02	04	04	10
III	Fundamentals of Power Quality	12	06	05	05	16
IV	Power Frequency Disturbance and Electrical Transients	14	04	06	06	16
V	Harmonics	14	06	05	05	16
	Total	**56**	**22**	**24**	**24**	**70**

Legends: R = Remember; **U**= Understand; **A**= Apply and above levels (Bloom's revised taxonomy)
Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED EXERCISES/PRACTICALS

The practical should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical. However, if these practical are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in*

a common list at the beginning of curriculum document for this programme) would be assured.
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Interpret the single line layout of GIS substation and its components	2
2	I	Measure of Partial Discharge in the GIS substation	2
3	II	Measure resistance of earthing system	2
4	II	Grounding sensitive electronic equipment as per IEEE /IEC standard	2
5	III	Monitor electrical power quality as per IEEE /IEC standard	2
6	III	Analyze the harmonic spectrum of a single phase system with sinusoidal voltage source supplying a non-linear (rectifier) load	2
7	III	Analyze the performance of a three phase(star and delta) balanced and unbalanced system supplying R-L loadsby plotting phase currents, real, reactive and apparent power and power factor	2
8	III	Use ideal compensator to compensate unbalanced and non-linear loads in three phase systems	2
9	III	Interpret IEEE /IEC standard for power quality delimitations	2
10	III	Interpret IEEE /IEC standard for power quality measurement methods	2
11	IV	Interpret IEEE /IEC standard for voltage fluctuations and other low frequency disturbances	2
12	V	Interpret IEEE /IEC standard for recommended practices and requirements for Harmonic control in electrical power systems	2
13	V	Interpret IEEE STD 519-1992 Harmonics Limits	2
14	V	Measurement of harmonics using power Analyzer	2
15	V	Solve tutorials for harmonic problem	2
Total			**30**
Note: Perform any of the practical exercises for a minimum of 28 hours from above list depending upon the availability of resources so that skills matching with the most of the outcomes in all the units are developed.			

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Visit websites of power supplying companies and study measures taken by them to improve the quality of power.
iii. Assignments on solving numerical
iv. Use Power Analyzer to assess the Power Quality of your Institute
v. Suggest appropriate remedies /mitigation techniques

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Arrange expert lectures by the engineers of power supply and Distribution Company.
ii. Show video/animation film to demonstrate various PQ problems
iii. Arrange a visit to nearby substation and study measures taken/equipment in use for improving power quality
iv. Use Flash/Animations to demonstrate PQ problems and its mitigation.
v. Give Mini projects to students

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1.	Substation Design and equipments	Partapsinghsatnam and P V Gupta	Dhanpat Rai & Sons
2.	Power Quality	C Sankaran	CRC Press
3.	Harmonics and Power system	Francisco C. De La Rosa	CRC (Taylor and Francis)
4.	Electric Power Quality	Heydt.G.T	Stars in a circle publications, Indiana,
5.	Power System Quality Assessment	J. Arrillaga, N.R. Watson, S. Chen,	New York:Wiley,Latest edition
6.	Electrical Power Systems Quality	R.C. Duggan	MG Graw Hill, Latest edition
7.	PSCAD User manual		
8.	Relevant IS Code for Power quality		Latest code

B) Major Equipment/ Instrument with Broad Specifications

1.	Digital Multimeter	4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A,
2.	Digital Tachometer	Hand held, battery operated, 5 digit display contact Type, 60 to 50000 r.p.m.,
3.	Four channel Digital Oscilloscope	Bandwidth :200MHz, Power supply:230V ± 10% tolerance,50 Hz AC supply
4.	Power Analyzer	3Phase/1Phase measurement, 8 Parameters in One Meter, Measures V, A, W, VA, PF, Hz, kWh & Time, State of The Art Microprocessor Design, LCD Display, TRMS Reading, High Performance, Portable Type, Bench Top Case with Tilt Stand, Bench Top Mounting Type,
5.	Harmonic Analyzer	
6.	Spectrum Analyzer	
7.	Any one simulation software	Open source software preferred Scilab, MATLAB/SIMULINK, PSCAD,

C. Software/Learning Websites

i. http://nptel.iitm.ac.in
ii. http://iitm.vlab.co.in/?sub=46&brch=144&sim=1056&cnt=4
iii. http://www.edumedia-sciences.com
iv. http://www.engineeringtv.com/video/Texas-Instruments
v. SEQUEL (open source)
vi. PSIM
vii. PSCAD

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. R D Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad
- **Prof. C T Patel**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. (Mrs.)C.S. Rajeshwari**, Professor and Head, Electrical& Electronics Engineering
- **Prof. A. S. Walkey**, Associate Professor, Electrical & Electronics Engineering