KANDULA SRINIVASA REDDY MEMORIAL COLLEGE OF ENGINEERING (AUTONOMOUS)

KADAPA-516005. AP

(Approved by AICTE, Affiliated to JNTUA, Ananthapuramu, Accredited by NAAC)

(An ISO 9001-2008 Certified Institution)

DEPARTMENT OF EEE

VALUE ADDED COURSE

ON

"POWER QUALITY ISSUES AND MITIGATION TECHNIQUES"

Coordinator: Dr. Kumar Reddy. C, Associate Professor, EEE, KSRMCE

Resource Person: Dr. M.S. Priyadarshini, Associate Professor, EEE, KSRMCE

Duration: **14/11/2022 to 30/11/2022**

Lr./KSRMCE/EEE/2021-22/ Date: 09-11-2022

To
The Principal,
KSRMCE,
Kadapa.

Respected Sir,

Sub: Permission to Conduct Value Added Course on "Power Quality Issues and Mitigation Techniques" from 14-11-22 to 30-11-22 – Req. – Reg.

The Department of EEE is planning to Conduct Value Added Course on "Power Quality Issues and Mitigation Techniques" for B. Tech final year students from 14-11-22 to 30-11-22. In this regard, I kindly request you to grant permission to conduct Certification Course.

Thanking you sir,

Forwarded to Principal sir,
D. S. [signature]

Yours faithfully

C. [signature]

(Dr. Kumar Reddy.C)

Permitted
V. S. S. Murty

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 005

Approved by AICTE, New Delhi & Affiliated to JNTUA, Ananthapuramu.

An ISO 14001:2004 & 9001: 2015 Certified Institution

Cr./KSRMCE/EEE/2021-22/

Date: 11/11/2022

Circular

The Department of EEE is offering a Value Added Course on "Power Quality Issues and Mitigation Techniques" from **14/11/2022 to 30/11/2022** to B. Tech final year students. In this regard, interested students are requested to register for the Value Added Course.

For further information contact Course Coordinators.

Course Coordinator: Dr. Kumar Reddy. C, Associate Professor, Dept. of EEE - KSRMCE.
Contact No: 7095880565

Dr. S. Prasad Babu

HOD

Dept. of EEE

HEAD
Department of Electrical & Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

Cc to:

IQAC-KSRMCE

Date:11-11-22

DEPARTMENT OF EEE

REGISTRATION FORM

Value Added Course
On
"Power Quality Issues and Mitigation Techniques" From 14/11/2022 to 30/11/2022

S. No	Full Name	Roll Number	Branch	Semester	Signature
1	B. Chandra Sekhar Naik	199y1a0203	EEE	VII	B. Chandra Sekhar Naik
2	C. Pramod Joshi	199y1a0206	EEE	VII	C. Pramod Joshi.
3	C.Hari Prasad	199y1a0207	EEE	VII	C. HariPrasad
4	D. Naveen Sai	199y1a0209	EEE	VII	D.naveen Sai
5	D.Bhoje Gowd	199y1a0210	EEE	VII	D. BhoJe Goud
6	G. Ashok	199y1a0215	EEE	VII	G. Ashok
7	G.Anand	199y1a0216	EEE	VII	G. Anand.
8	G.Sai Puneeth	199y1a0217	EEE	VII	G.Sai Puneeth
9	K.Samara Simha Reddy	199y1a0222	EEE	VII	K.Samara Simha Reddy
10	K.Sakesh Reddy	199y1a0226	EEE	VII	[illegible]
11	M. Rammohan	199y1a0227	EEE	VII	M. Rammohan
12	M. Kiran Babu	199y1a0228	EEE	VII	M. kiran babu
13	M.Sreenath Reddy	199y1a0230	EEE	VII	M. Sreenath Reddy
14	M.Guruteja	199y1a0231	EEE	VII	M. Guruteja
15	M. Ruthesh Kumar	199y1a0232	EEE	VII	M. Ruthesh kumar
16	P. Chinna Peddi Reddy	199y1a0238	EEE	VII	P. chinna peddi Reddy
17	P. Nagendra	199y1a0239	EEE	VII	P.Nagendra
18	P.Taraka Ramudu	199y1a0241	EEE	VII	P. TarakaRamudu.
19	P. Giridhar	199y1a0242	EEE	VII	P.Giridhar
20	S. Lokendra Reddy	199y1a0245	EEE	VII	S.lokendraReddy
21	S.Harikrishna Reddy	199y1a0246	EEE	VII	S.HarikrishnaReddy

S. No	Full Name	Roll Number	Branch	Semester	Signature
22	S.Yaswanth Reddy	199y1a0247	EEE	VII	S. Yaswanth Reddy
23	V. Kranthi Kumar Reddy	199y1a0254	EEE	VII	V. Kranthikumar R..
24	K. Mohammed Ali	209y5a0203	EEE	VII	K. Mohammed Ali
25	S. Mahesh	209y5a0205	EEE	VII	S. Mahesh
26	T. Shahansha Khan	209y5a0207	EEE	VII	T. Shahansha Khan
27	U. S. Ashwak	209y5a0208	EEE	VII	U.S. Ashwak

Coordinators:

HOD

HEAD
Department of Electrical &
Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

Syllabus of Value Added Course

Course Name: Power Quality Issues and Mitigation Techniques

Course Objective:

To learn various power quality issues, standards, harmonic analysis, and end effects of harmonics, harmonic mitigation techniques, and design of harmonic filters.

UNIT-I **(10 Hours)**

Power quality issues, IEEE standards and recommended practices, Power system quantities under non sinusoidal conditions, Harmonic Analysis, Effects of Power System harmonics on Power System equipment and loads, Harmonic mitigation techniques.

UNIT – II **(20 Hours)**

MATLAB simulation of power quality issues, Modeling of Nonlinear loads, Design of passive harmonic filters, Active harmonic Filters, Hybrid Active Filters

Text books:

1. Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.WayneBeaty, Electrical Power Systems Quality, McGraw Hill,2003
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality Problems and Mitigation Techniques Wiley, 2015.

Reference Books:

1. G.T. Heydt, Electric Power Quality, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994.
2. M.H.J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, (New York: IEEE Press), 2000.

KSNR lives on..

SCHEDULE

Department of EEE

Value Added Course
On
"Power Quality Issues and Mitigation Techniques" From 14/11/2022 to 30/11/2022

Date	Timing	Resource Person	Topic to be covered
14/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Power quality issues
15/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	IEEE standards and recommended practices
16/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Power system quantities under non sinusoidal conditions,
17/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Harmonic Analysis,
18/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Effects of Power System harmonics on Power System equipment and loads.
19/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Harmonic mitigation techniques.
21/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	MATLAB simulation of power quality issues
22/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Modeling of Nonlinear loads
23/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Modeling of Nonlinear loads
24/11/22	4 PM to 6 PM	Dr.MS Priyadarshini	Modeling of Nonlinear loads
25/11/22	3 PM to 6 PM	Dr.MS Priyadarshini	Design of passive harmonic filters
26/11/22	3 PM to 6 PM	Dr.MS Priyadarshini	Design of Active harmonic Filters
28/11/22	3 PM to 6 PM	Dr.MS Priyadarshini	Design of Active harmonic Filters
29/11/22	3 PM to 6 PM	Dr.MS Priyadarshini	Design of Hybrid Active harmonic Filters
30/11/22	3 PM to 6 PM	Dr.MS Priyadarshini	Design of Hybrid Active harmonic Filters

Resource Person(s) Coordinator(s) HOD

HEAD
Department of Electrical &
Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

K.S.R.M. COLLEGE OF ENGINEERING

(UGC-AUTONOMOUS)

Kadapa, Andhra Pradesh, India– 516 005

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DEPARTMENT OF EEE

Attendance sheet of Value Added Course on "Power Quality Issues and Mitigation Techniques" From 14/11/2022 to 30/11/2022

Sl. No.	Roll No	Name of the Student	14/11	15/11	16/11	17/11	18/11	19/11	21/11	22/11	23/11	24/11	25/11	26/11	28/11	29/11	30/11
1	199y1a0203	B. Chandra Sekhar Naik	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra	Chandra
2	199y1a0206	C. Pramod Joshi	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod	Pramod
3	199y1a0207	C.Hari Prasad	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari	Hari
4	199y1a0209	D. Naveen Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai
5	199y1a0210	D.Bhoje Gowd	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje	Bhoje
6	199y1a0215	G. Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok	Ashok
7	199y1a0216	G.Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand	Anand
8	199y1a0217	G.Sai Puneeth	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai	Sai
9	199y1a0222	K.Samara Simha Reddy	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara	Samara
10	199y1a0226	K.Sakesh Reddy	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh	Sakesh
11	199y1a0227	M. Rammohan	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram	Ram
12	199y1a0228	M. Kiran Babu	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran	Kiran
13	199y1a0230	M.Sreenath Reddy	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath	Sreenath
14	199y1a0231	M.Guruteja	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru	Guru

15	199y1a0232	M. Ruthesh Kumar
16	199y1a0238	P. Chinna Peddi Reddy
17	199y1a0239	P. Nagendra
18	199y1a0241	P.Taraka Ramudu
19	199y1a0242	P. Giridhar
20	199y1a0245	S. Lokendra Reddy
21	199y1a0246	S.Harikrishna Reddy
22	199y1a0247	S.Yaswanth Reddy
23	199y1a0254	V. Kranthi Kumar Reddy
24	209y5a0203	K. Mohammed Ali
25	209y5a0205	S. Mahesh
26	209y5a0207	T. Shahansha Khan
27	209y5a0208	U. S. Ashwak

Coordinator(s)

HoD

HEAD
Department of Electrical &
Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

KSRM
COLLEGE OF ENGINEERING
(UGC - Autonomous)
Kadapa, Andhra Pradesh, India– 516 005
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LIGHTED TO LIGHTEN

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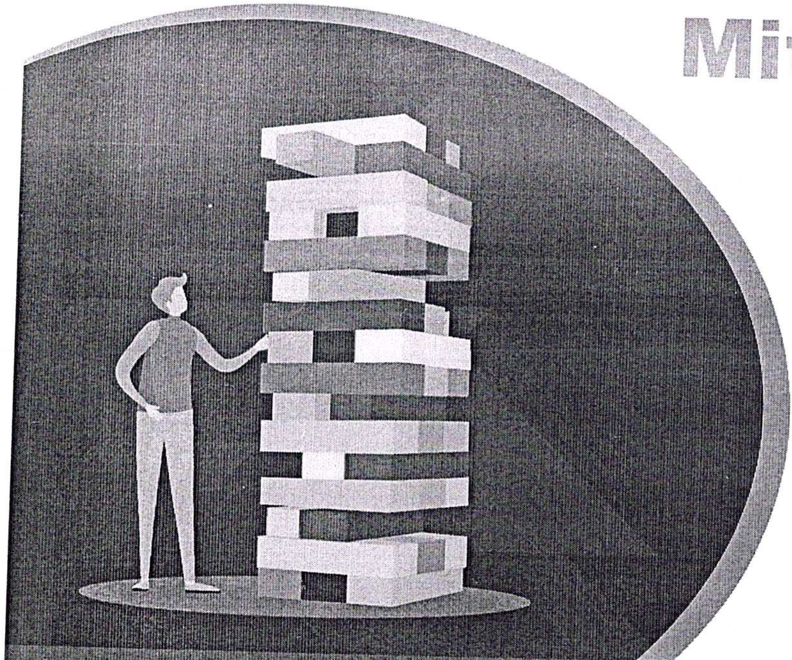
Power Quality Issues and Mitigation Techniques



Department of EEE, KSRMCE

SJ 112

14-11-22 to 30-11-22

Resource Person — **Dr. M.S. Priyadarshini**
Associate Professor, EEE

Coordinator — **Dr. Kumar Reddy Cheepati**
Associate Professor, EEE

Dr. K. Amaresh (Professor & HOD)
Dr. V.S.S. Murthy (Principal)
Dr. Kandula Chandra Obul Reddy (MD, KGI)
Smt. K.Rajeswari (Correspondent,Secretary,Treasurer)
Sri K. Madan Mohan Reddy (Vice - Chairman)
Sri K. Raja Mohan Reddy (Chairman)

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8143731980, 8575697569

Department of EEE

Activity Report

Name of the Activity	:	Value Added Course
Title of the Course	:	Power Quality Issues and Mitigation Techniques
Date (s) covered	:	14-11-2022 to 30-11-2022
No of Hours	:	40
Target Audience	:	VII semester EEE students
No. of Participants	:	27
Resource Person	:	Dr. M.S Priyadarshini Associate Professor, EEE, KSRMCE
Coordinator		Dr. Kumar Reddy Cheepati Associate Professor, EEE, KSRMCE
Venue of the Event	:	SJ-112

Certificate Course Description:

Department of EEE, KSRMCE has organized a certification course on "Power Quality Issues and Mitigation Techniques from 14-11-2022 to 30-11-2022. This course covers 40 hours duration. Totally 27 students has registered for this course. The resource persons are explained about various power quality issues like voltage sags, swells, interruptions, transients, harmonics, unbalance, flickers and notches and their effects with respect to power system equipment. All these power quality issues are created using MATLAB Simulink by the students. Various active and passive power quality compensators have been designed and implemented in MATLAB Simulink. The prescribed syllabus of this certification course is enclosed here with this report.

K.S.R.M. COLLEGE OF ENGINEERING

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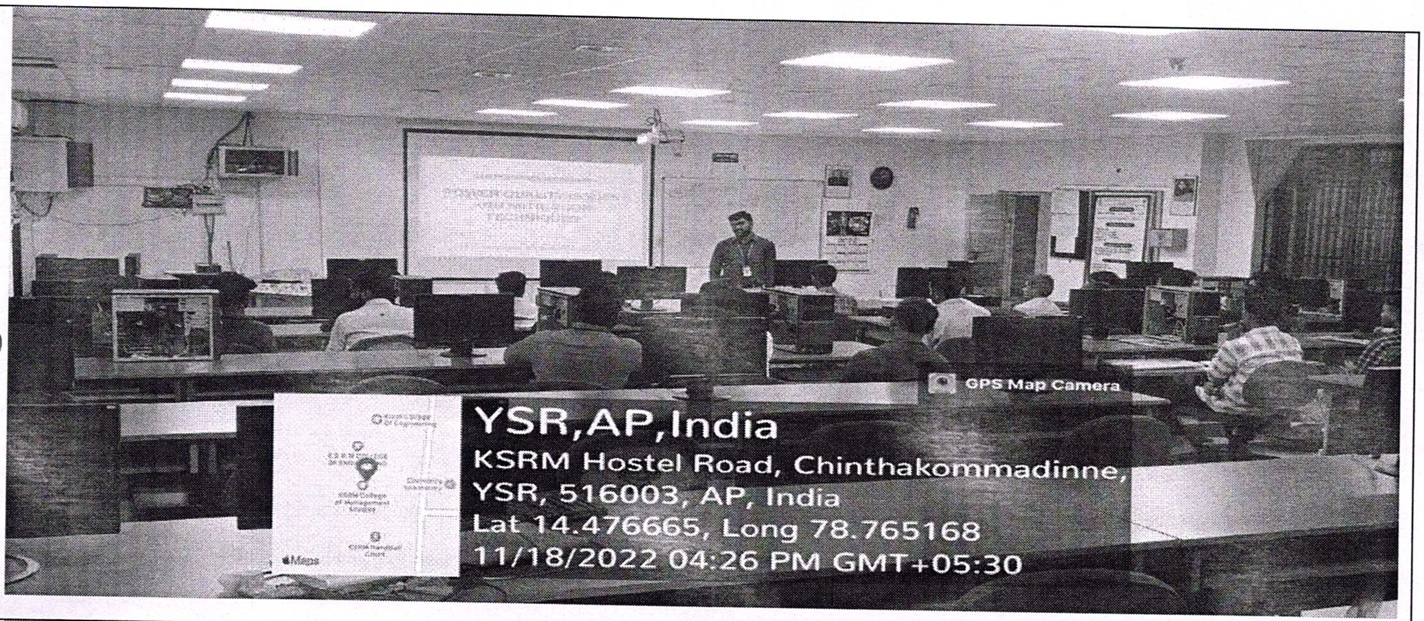
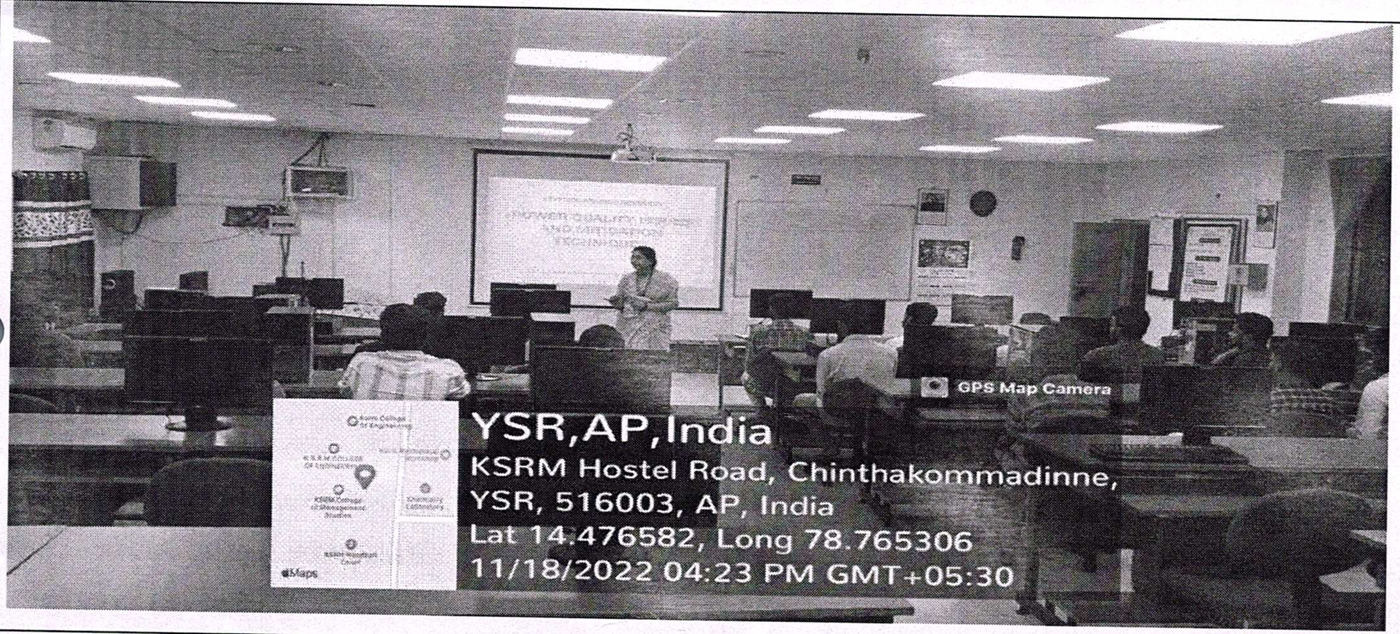
The pictures taken during the course are given below:





Coordinator(S)

Head of the Department

HEAD
Department of Electrical &
Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

Principal

K.S.R.M. COLLEGE OF ENGINEERING

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Kadapa, Andhra Pradesh, India– 516 005

Certificate

This is to certify that **G. Ashok** bearing roll no: **199Y1A0215** has attended a Value Added Course on **Power Quality Issues and Mitigation Techniques** organized by the Department of EEE, KSRM College of Engineering (Autonomous) from 14-11-22 to 30-11-22

Co-ordinators | HoD, EEE | Principal

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Kadapa, Andhra Pradesh, India– 516 005

Certificate

This is to certify that **D. Naveen Sai** bearing roll no: **199Y1A0209** has attended a Value Added Course on **Power Quality Issues and Mitigation Techniques** organized by the Department of EEE, KSRM College of Engineering (Autonomous) from 14-11-22 to 30-11-22

Co-ordinators HoD, EEE Principal

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Kadapa, Andhra Pradesh, India– 516 005

Certificate

This is to certify that **B. Chandra Sekhar Naik** bearing roll no: **199Y1A0203** has attended a Value Added Course on **Power Quality Issues and Mitigation Techniques** organized by the Department of EEE, KSRM College of Engineering (Autonomous) from 14-11-22 to 30-11-22

C. Kumar Reddy	Amaresh	V. S. S. Murthy
Co-ordinators	HoD, EEE	Principal

Feedback form on Value Added Course " Power Quality Issues and Mitigation Techniques" from 14-11-22 to 30-11-22

* Indicates required question

1. Roll Number *

____

2. Name of the Student *

____

3. The objectives of the Value Added Course were met (Objective) *

Mark only one oval.

- ( ) Excellent
- ( ) Good
- ( ) Satisfactory
- ( ) Poor

4. The content of the course was organized and easy to follow (Delivery) *

Mark only one oval.

- ( ) Excellent
- ( ) Good
- ( ) Satisfactory
- ( ) Poor

5. The Resource Persons were well prepared and able to answer any question (Interaction) *

Mark only one oval.

- Excellent
- Good
- Satisfactory
- Poor

6. The exercises/role play were helpful and relevant (Syllabus Coverage) *

Mark only one oval.

- Excellent
- Good
- Satisfactory
- Poor

7. The Value Added Course satisfy my expectation as a value added Programme (Course Satisfaction) *

Mark only one oval.

- Excellent
- Satisfactory
- Good
- Poor

8. Any Issues

____

Value Added Course on "Power Quality Issues and Mitigation Techniques"
14/11/2022 to 30/11/2022
Feedback responses

S.No.	Roll number	Name of the Student	The objectives of the Value Added Course were met (Objective)	The content of the course was organized and easy to follow (Delivery)	The Resource Persons were well prepared and able to answer any question (Interaction)	The exercises/role play were helpful and relevant (Syllabus Coverage)	The Value Added Course satisfy my expectation as a value added Programme (Course Satisfaction)	Any Issues
1	199y1a0203	B. Chandra Sekhar Naik	Excellent	Excellent	Excellent	Excellent	Excellent	Nothing
2	199y1a0206	C. Pramod Joshi	Excellent	Excellent	Excellent	Excellent	Excellent	very good
3	199y1a0207	C.Hari Prasad	Good	Good	Good	Good	Good	very good
4	199y1a0209	D. Naveen Sai	Excellent	Excellent	Excellent	Excellent	Excellent	very good
5	199y1a0210	D.Bhoje Gowd	Excellent	Excellent	Excellent	Excellent	Excellent	nothing
6	199y1a0215	G. Ashok	Excellent	Excellent	Excellent	Excellent	Excellent	Good
7	199y1a0216	G.Anand	Excellent	Excellent	Excellent	Excellent	Excellent	Good
8	199y1a0217	G.Sai Puneeth	Excellent	Excellent	Excellent	Excellent	Excellent	nothing
9	199y1a0222	K.Samara Simha Reddy	Excellent	Excellent	Excellent	Excellent	Excellent	nothing
10	199y1a0226	K.Sakesh Reddy	Good	Good	Good	Good	Good	nothing
11	199y1a0227	M. Rammohan	Excellent	Excellent	Excellent	Excellent	Excellent	Good
12	199y1a0228	M. Kiran Babu	Excellent	Excellent	Excellent	Excellent	Excellent	Good

13	199y1a0230	M.Sreenath Reddy	Good	Good	Good	Good	Good	very good
14	199y1a0231	M.Guruteja	Excellent	Excellent	Excellent	Excellent	Excellent	very good
15	199y1a0232	M. Ruthesh Kumar	Excellent	Excellent	Excellent	Excellent	Excellent	nothing
16	199y1a0238	P. Chinna Peddi Reddy	Good	Good	Good	Good	Good	very good
17	199y1a0239	P. Nagendra	Excellent	Excellent	Excellent	Excellent	Excellent	no
18	199y1a0241	P.Taraka Ramudu	Good	Good	Good	Good	Good	nithing
19	199y1a0242	P. Giridhar	Excellent	Excellent	Excellent	Excellent	Excellent	Good
20	199y1a0245	S. Lokendra Reddy	Excellent	Excellent	Excellent	Excellent	Excellent	Good
21	199y1a0246	S.Harikrishna Reddy	Excellent	Excellent	Excellent	Excellent	Excellent	Good
22	199y1a0247	S.Yaswanth Reddy	Excellent	Excellent	Excellent	Excellent	Excellent	Good
23	199y1a0254	V. Kranthi Kumar Reddy	Excellent	Excellent	Excellent	Excellent	Excellent	Good
24	209y5a0203	K. Mohammed Ali	Good	Good	Good	Good	Good	Good
25	209y5a0205	S. Mahesh	Excellent	Excellent	Excellent	Excellent	Excellent	Good
26	209y5a0207	T. Shahansha Khan	Excellent	Excellent	Excellent	Excellent	Excellent	Nothing
27	209y5a0208	U. S. Ashwak	Excellent	Excellent	Excellent	Excellent	Excellent	no

Coordinator

HoD/EEE

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516005
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VALUE ADDED COURSE ON
POWER QUALITY ISSUES AND MITIGATION TECHNIQUES FROM 14/11/2022 TO 30/11/2022

AWARD LIST

S.No	Roll Number	Name of the Student	Marks Obtained
1	199y1a0203	B. Chandra Sekhar Naik	12
2	199y1a0206	C. Pramod Joshi	16
3	199y1a0207	C.Hari Prasad	17
4	199y1a0209	D. Naveen Sai	19
5	199y1a0210	D.Bhoje Gowd	15
6	199y1a0215	G. Ashok	18
7	199y1a0216	G.Anand	16
8	199y1a0217	G.Sai Puneeth	14
9	199y1a0222	K.Samara Simha Reddy	14
10	199y1a0226	K.Sakesh Reddy	17
11	199y1a0227	M. Rammohan	16
12	199y1a0228	M. Kiran Babu	16
13	199y1a0230	M.Sreenath Reddy	19
14	199y1a0231	M.Guruteja	20
15	199y1a0232	M. Ruthesh Kumar	15
16	199y1a0238	P. Chinna Peddi Reddy	16
17	199y1a0239	P. Nagendra	16
18	199y1a0241	P.Taraka Ramudu	18
19	199y1a0242	P. Giridhar	18
20	199y1a0245	S. Lokendra Reddy	19
21	199y1a0246	S.Harikrishna Reddy	17
22	199y1a0247	S.Yaswanth Reddy	15
23	199y1a0254	V. Kranthi Kumar Reddy	16
24	209y5a0203	K. Mohammed Ali	15
25	209y5a0205	S. Mahesh	17
26	209y5a0207	T. Shahansha Khan	16
27	209y5a0208	U. S. Ashwak	16

Coordinator

HoD EEE

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Department of Electrical &
Electronics Engineering
K.S.R.M. College of Engineering
Kadapa -516003.

(17)

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516005
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VALUE ADDED COURSE ON
POWER QUALITY ISSUES AND MITIGATION TECHNIQUES FROM 14/11/2022 TO 30/11/2023
ASSESSMENT TEST **Date:** 30/11/23.
Roll Number: 20945A0207 **Name of the Student:** S. mahesh.

Time: 20 Min **(Objective Questions)** **Max.Marks:20**

Note: Answer the following Questions and each question carries one mark.

1 Which of the following are the objectives of the power quality monitoring? [d]

(a) to characterize system performance (b) to characterize specific problems (c) enhanced power quality service **(d) all of these**

2 Which of the following is the most general objective of the power quality monitoring? [a]

(a) characterize system performance

(b) characterize specific problems

(c) enhanced power quality service

(d) Predictive or just-in-time maintenance.

3 characterize specific problems in power quality monitoring is also called as ____ [a]

(a) reactive mode of power quality monitoring

(b) active mode of power quality monitoring

(c) both a & b

(d) either a or b

4 The Site surveys are performed to evaluate concerns for power quality and equipment performance throughout a facility includes________ [ ]

(a) inspection of wiring and grounding concerns

(b) equipment connections

(c) voltage and current characteristics throughout the facility

(d) **All of these**

5 The initial site survey should be designed to obtain the information such as [d]

(a) Nature of the problems

(b) Characteristics of the sensitive equipment experiencing problems

(c) The times at which problems occur

(d) all of these

6 The lightning can cause [a]

(a) very high frequency impulses	(b) high frequency impulses	(c) medium frequency impulses	(d) low frequency impulses

7 Outages can be defined simply [a]

(a) time duration	(b) frequency	(c) voltage magnitude	(d) none of these

8 The function of digital fault recorder is [c]

(a) to record voltage wave form during the fault event	(b) to record current wave form during the fault event	(c) **to record voltage and current wave form during the fault event**	(d) none of these

9 The advantage of digital fault recorder is [c]

(a) measuring voltage sag	(b) measuring THD	(c) **measuring sag and THD**	(d) none of these

10 Smart relays and other IEDs can be located at [c]

(a) sub stations	(b) feeder circuits	(c) **both a and b**	(d) none of these

11 The resolution of voltage recorder is [a]

(a) more than 2 sec	(b) less than 2 sec	(c) 2 sec	(d) none of these

12 In-plant power monitors can be located at [a]

(a) service entrance (b) sub stations

(c) feeder circuits (d) all of these

13 The purpose of setting monitoring threshold is [d]

(a) to identify the normal condition	(b) to identify the fault condition	(c) to identify power quality disturbances	**(d) All of these**

14. The damping of very high frequencies quick in [a]

(a) low voltage circuits	(b) medium voltage circuits	(c) high voltage circuits	(d) all of the above

15 The best location for the power quality monitoring equipment is [a]

(a) near to the power quality disturbances	(b) far to the power quality disturbances	(c) both a and b	(d)either a or b

16 The following are linear loads [b]

(a) Computers	(b) Switched mode power supplies	(c) Microwave ovens	(d) None

18 Poor power factor is due to ___ loads [ ]

(a) Nonlinear (b) Linear (c) Both (d) None of the above

19 The following problems are due to nonlinear loads [ ]

(a) Increased losses (b) Poor power factor (c) heating of components (d) All of the above

20 The following converters are improved AC to DC converters [c]

A) Boost B) Buck C) Buck Boost D) All of the above

18

K.S.R.M. COLLEGE OF ENGINEERING (AUTONOMOUS), KADAPA-516005
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VALUE ADDED COURSE ON
POWER QUALITY ISSUES AND MITIGATION TECHNIQUES FROM 14/11/2022 TO 30/11/2023
ASSESSMENT TEST

Date: 30-11-2023
Roll Number: 199Y1A0241 **Name of the Student:** P. Taraka Ramudu.

Time: 20 Min **(Objective Questions)** **Max.Marks:20**

Note: Answer the following Questions and each question carries one mark.

1 Which of the following are the objectives of the power quality monitoring? [d]

(a) to characterize system performance (b) to characterize specific problems (c) enhanced power quality service **(d) all of these**

2 Which of the following is the most general objective of the power quality monitoring? [a]

(a) characterize system performance

(b) characterize specific problems

(c) enhanced power quality service

(d) Predictive or just-in-time maintenance.

3 characterize specific problems in power quality monitoring is also called as ____ [b]

(a) reactive mode of power quality monitoring

(b) active mode of power quality monitoring

(c) both a & b

(d) either a or b

4 The Site surveys are performed to evaluate concerns for power quality and equipment performance throughout a facility includes________ [d]

(a) inspection of wiring and grounding concerns

(b) equipment connections

(c) voltage and current characteristics throughout the facility

(d) **All of these**

5 The initial site survey should be designed to obtain the information such as [d]

(a) Nature of the problems

(b) Characteristics of the sensitive equipment experiencing problems

(c) The times at which problems occur

(d) all of these

6 The lightning can cause [a]

(a) **very high frequency impulses** (b) high frequency impulses (c) medium frequency impulses (d) low frequency impulses

7 Outages can be defined simply [a]

(a) **time duration** (b) frequency (c) voltage magnitude (d) none of these

8 The function of digital fault recorder is [C]

(a) to record voltage wave form during the fault event (b) to record current wave form during the fault event (c) **to record voltage and current wave form during the fault event** (d) none of these

9 The advantage of digital fault recorder is [c]

(a) measuring voltage sag (b) measuring THD (c) **measuring sag and THD** (d) none of these

10 Smart relays and other IEDs can be located at [b]

(a) sub stations (b) feeder circuits (c) **both a and b** (d) none of these

11 The resolution of voltage recorder is [a]

(a) **more than 2 sec** (b) less than 2 sec (c) 2 sec (d) none of these

12 In-plant power monitors can be located at [a]

(a) **service entrance** (b) sub stations

(c) feeder circuits (d) all of these

13 The purpose of setting monitoring threshold is [d]

(a) to identify the normal condition (b) to identify the fault condition (c) to identify power quality disturbances (d) **All of these**

14. The damping of very high frequencies quick in [A]

(a) **low voltage circuits** (b) medium voltage circuits (c) high voltage circuits (d) all of the above

15 The best location for the power quality monitoring equipment is [A]

(a) **near to the power quality disturbances** (b) far to the power quality disturbances (c) both a and b (d)either a or b

16 The following are linear loads [B]

(a) Computers (b) Switched mode power supplies (c) Microwave ovens (d) None

18	Poor power factor is due to ___ loads				[C]
	(a) Nonlinear	(b) Linear	(c) Both	(d) None of the above	
19	The following problems are due to nonlinear loads				[D]
	(a) Increased losses	(b) Poor power factor	(c) heating of components	(d) All of the above	
20	The following converters are improved AC to DC converters				[C]
	A) Boost	B) Buck	C) Buck Boost	D) All of the above	

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ASSESSMENT TEST

Roll Number: 199Y1A0206 **Name of the Student:** C. Pramod Joshi **Date:** 30/11/23

Time: 20 Min **(Objective Questions)** **Max.Marks:20**

Note: Answer the following Questions and each question carries one mark.

1 Which of the following are the objectives of the power quality monitoring? [d]

(a) to characterize system performance (b) to characterize specific problems (c) enhanced power quality service **(d) all of these**

2 Which of the following is the most general objective of the power quality monitoring? [a]

(a) characterize system performance

(b) characterize specific problems

(c) enhanced power quality service

(d) Predictive or just-in-time maintenance.

3 characterize specific problems in power quality monitoring is also called as ____ [c]

(a) reactive mode of power quality monitoring

(b) active mode of power quality monitoring

(c) both a & b

(d) either a or b

4 The Site surveys are performed to evaluate concerns for power quality and equipment performance throughout a facility includes________ [A]

(a) inspection of wiring and grounding concerns

(b) equipment connections

(c) voltage and current characteristics throughout the facility

(d) **All of these**

5 The initial site survey should be designed to obtain the information such as [d]

(a) Nature of the problems

(b) Characteristics of the sensitive equipment experiencing problems

(c) The times at which problems occur

(d) all of these

6 The lightning can cause [a]

(a) very high frequency impulses (b) high frequency impulses (c) medium frequency impulses (d) low frequency impulses

7 Outages can be defined simply [a]

(a) time duration (b) frequency (c) voltage magnitude (d) none of these

8 The function of digital fault recorder is [c]

(a) to record voltage wave form during the fault event (b) to record current wave form during the fault event (c) **to record voltage and current wave form during the fault event** (d) none of these

9 The advantage of digital fault recorder is [b]

(a) measuring voltage sag (b) measuring THD **(c) measuring sag and THD** (d) none of these

10 Smart relays and other IEDs can be located at [c]

(a) sub stations (b) feeder circuits **(c) both a and b** (d) none of these

11 The resolution of voltage recorder is [a]

(a) more than 2 sec (b) less than 2 sec (c) 2 sec (d) none of these

12 In-plant power monitors can be located at [a]

(a) service entrance (b) sub stations

(c) feeder circuits (d) all of these

13 The purpose of setting monitoring threshold is [d]

(a) to identify the normal condition (b) to identify the fault condition (c) to identify power quality disturbances **(d) All of these**

14. The damping of very high frequencies quick in [a]

(a) low voltage circuits (b) medium voltage circuits (c) high voltage circuits (d) all of the above

15 The best location for the power quality monitoring equipment is [a]

(a) near to the power quality disturbances (b) far to the power quality disturbances (c) both a and b (d)either a or b

16 The following are linear loads [d]

(a) Computers (b) Switched mode power supplies (c) Microwave ovens (d) None

18 Poor power factor is due to ___ loads [b]

(a) Nonlinear (b) Linear (c) Both (d) None of the above

19 The following problems are due to nonlinear loads [d]

(a) Increased losses (b) Poor power factor (c) heating of components (d) All of the above

20 The following converters are improved AC to DC converters [C]

A) Boost B) Buck C) Buck Boost D) All of the above

16

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ASSESSMENT TEST

Date: 30/11/2023

Roll Number: 209Y5A0207 **Name of the Student:** T. Shahansha khan

Time: 20 Min **(Objective Questions)** **Max.Marks:20**

Note: Answer the following Questions and each question carries one mark.

1 Which of the following are the objectives of the power quality monitoring? [d]

(a) to characterize system performance (b) to characterize specific problems (c) enhanced power quality service **(d) all of these**

2 Which of the following is the most general objective of the power quality monitoring? [b]

(a) characterize system performance

(b) characterize specific problems

(c) enhanced power quality service

(d) Predictive or just-in-time maintenance.

3 characterize specific problems in power quality monitoring is also called as ____ [c]

(a) reactive mode of power quality monitoring

(b) active mode of power quality monitoring

(c) both a & b

(d) either a or b

4 The Site surveys are performed to evaluate concerns for power quality and equipment performance throughout a facility includes________ [d]

(a) inspection of wiring and grounding concerns

(b) equipment connections

(c) voltage and current characteristics throughout the facility

(d) **All of these**

5 The initial site survey should be designed to obtain the information such as [d]

(a) Nature of the problems

(b) Characteristics of the sensitive equipment experiencing problems

(c) The times at which problems occur

(d) all of these

6 The lightning can cause [a]

(a) very high frequency impulses (b) high frequency impulses (c) medium frequency impulses (d) low frequency impulses

7 Outages can be defined simply [a]

(a) time duration (b) frequency (c) voltage magnitude (d) none of these

8 The function of digital fault recorder is [C]

(a) to record voltage wave form during the fault event (b) to record current wave form during the fault event (c) **to record voltage and current wave form during the fault event** (d) none of these

9 The advantage of digital fault recorder is [c]

(a) measuring voltage sag (b) measuring THD **(c) measuring sag and THD** (d) none of these

10 Smart relays and other IEDs can be located at [b]

(a) sub stations (b) feeder circuits **(c) both a and b** (d) none of these

11 The resolution of voltage recorder is [a]

(a) more than 2 sec (b) less than 2 sec (c) 2 sec (d) none of these

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(a) service entrance (b) sub stations

(c) feeder circuits (d) all of these

13 The purpose of setting monitoring threshold is [d]

(a) to identify the normal condition (b) to identify the fault condition (c) to identify power quality disturbances **(d) All of these**

14. The damping of very high frequencies quick in [a]

(a) low voltage circuits (b) medium voltage circuits (c) high voltage circuits (d) all of the above

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(a) Computers (b) Switched mode power supplies (c) Microwave ovens (d) None

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(a) Nonlinear (b) Linear (c) Both (d) None of the above

19 The following problems are due to nonlinear loads [d]

(a) Increased losses (b) Poor power factor (c) heating of components (d) All of the above

20 The following converters are improved AC to DC converters [c]

A) Boost B) Buck C) Buck Boost D) All of the above

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ASSESSMENT TEST **Date:** 30/11/2023
Roll Number: 199Y1A0215 **Name of the Student:** G. ASHOK

Time: 20 Min **(Objective Questions)** **Max.Marks:20**

Note: Answer the following Questions and each question carries one mark.

1 Which of the following are the objectives of the power quality monitoring? [d]

(a) to characterize system performance (b) to characterize specific problems (c) enhanced power quality service **(d) all of these**

2 Which of the following is the most general objective of the power quality monitoring? [a]

(a) characterize system performance

(b) characterize specific problems

(c) enhanced power quality service

(d) Predictive or just-in-time maintenance.

3 characterize specific problems in power quality monitoring is also called as ____ [b]

(a) reactive mode of power quality monitoring

(b) active mode of power quality monitoring

(c) both a & b

(d) either a or b

4 The Site surveys are performed to evaluate concerns for power quality and equipment performance throughout a facility includes________ [d]

(a) inspection of wiring and grounding concerns

(b) equipment connections

(c) voltage and current characteristics throughout the facility

(d) **All of these**

5 The initial site survey should be designed to obtain the information such as [c]

(a) Nature of the problems

(b) Characteristics of the sensitive equipment experiencing problems

(c) The times at which problems occur

(d) all of these

6 The lightning can cause [a]

(a) very high frequency impulses (b) high frequency impulses (c) medium frequency impulses (d) low frequency impulses

7 Outages can be defined simply [a]

(a) time duration (b) frequency (c) voltage magnitude (d) none of these

8 The function of digital fault recorder is [c]

(a) to record voltage wave form during the fault event (b) to record current wave form during the fault event (c) **to record voltage and current wave form during the fault event** (d) none of these

9 The advantage of digital fault recorder is [c]

(a) measuring voltage sag (b) measuring THD **(c) measuring sag and THD** (d) none of these

10 Smart relays and other IEDs can be located at [c]

(a) sub stations (b) feeder circuits **(c) both a and b** (d) none of these

11 The resolution of voltage recorder is [a]

(a) more than 2 sec (b) less than 2 sec (c) 2 sec (d) none of these

12 In-plant power monitors can be located at [a]

(a) service entrance (b) sub stations

(c) feeder circuits (d) all of these

13 The purpose of setting monitoring threshold is [d]

(a) to identify the normal condition (b) to identify the fault condition (c) to identify power quality disturbances **(d) All of these**

14. The damping of very high frequencies quick in [a]

(a) low voltage circuits (b) medium voltage circuits (c) high voltage circuits (d) all of the above

15 The best location for the power quality monitoring equipment is [a]

(a) near to the power quality disturbances (b) far to the power quality disturbances (c) both a and b (d)either a or b

16 The following are linear loads [d]

(a) Computers (b) Switched mode power supplies (c) Microwave ovens (d) None

18 Poor power factor is due to ___ loads [C]

(a) Nonlinear (b) Linear (c) Both (d) None of the above

19 The following problems are due to nonlinear loads [d]

(a) Increased losses (b) Poor power factor (c) heating of components (d) All of the above

20 The following converters are improved AC to DC converters [C]

A) Boost B) Buck C) Buck Boost D) All of the above

UNIT-1

FUNDAMENTALS OF POWER QUALITY

Definitions of Power Quality

- Any power problem manifested in voltage, current, or frequency deviations that results in failure or mis-operation of customer equipment.
- power supply that enable the equipment to work properly.
- Power quality is the concept of powering and grounding sensitive equipment in a matter that is suitable to the operation of that equipment.
- Ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.
- Deviations of voltage and current from its ideal.
- Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy.

General classes of power quality problems

- The IEC classifies electromagnetic phenomena into the groups shown in Table 2.1.

TABLE 2.1 Principal Phenomena Causing Electromagnetic Disturbances as Classified by the IEC

Conducted low-frequency phenomena
- Harmonics, interharmonics
- Signal systems (power line carrier)
- Voltage fluctuations (flicker)
- Voltage dips and interruptions
- Voltage imbalance (unbalance)
- Power frequency variations
- Induced low-frequency voltages
- DC in ac networks

Radiated low-frequency phenomena
- Magnetic fields
- Electric fields

Conducted high-frequency phenomena
- Induced continuous-wave (CW) voltages or currents
- Unidirectional transients
- Oscillatory transients

Radiated high-frequency phenomena
- Magnetic fields
- Electric fields
- Electromagnetic fields
- Continuous waves
- Transients

Electrostatic discharge phenomena (ESD)

Nuclear electromagnetic pulse (NEMP)

- *Sag* is used as a synonym to the IEC term *dip.*
- The category *short-duration variations* is used to refer to *voltage dips* and *short interruptions.*
- The term *swell* is introduced as an inverse to sag (dip).
- The category *long-duration variation* has been added to deal with American National Standards Institute (ANSI) C84.1 limits.
- The category *waveform distortion* is used as a container category for the IEC *harmonics, inter harmonics,* and *dc in ac networks* phenomena as well as an additional phenomenon from IEEE Standard 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems,* called *notching.*

For steady-state phenomena, the following attributes can be used:
- Amplitude
- Frequency
- Spectrum
- Modulation
- Source impedance
- Notch depth
- Notch area

For non-steady-state phenomena, other attributes may be required:
- Rate of rise
- Amplitude
- Duration
- Spectrum
- Frequency
- Rate of occurrence
- Energy potential
- Source impedance

- Table 2.2 provides information regarding typical spectral content, duration, and magnitude where appropriate for each category of electromagnetic phenomena.
- The categories of the table, when used with the attributes previously mentioned, provide a means to clearly describe an electromagnetic disturbance.
- The categories and their descriptions are important in order to be able to classify measurement results and to describe electromagnetic phenomena which can cause power quality problems.

TABLE 2.2 Categories and Characteristics of Power System Electromagnetic Phenomena

Categories	Typical spectral content	Typical duration	Typical voltage magnitude
1.0 Transients			
1.1 Impulsive			
1.1.1 Nanosecond	5-ns rise	<50 ns	
1.1.2 Microsecond	1-µs rise	50 ns–1 ms	
1.1.3 Millisecond	0.1-ms rise	>1 ms	
1.2 Oscillatory			
1.2.1 Low frequency	<5 kHz	0.3–50 ms	0–4 pu
1.2.2 Medium frequency	5–500 kHz	20 µs	0–8 pu
1.2.3 High frequency	0.5–5 MHz	5 µs	0–4 pu
2.0 Short-duration variations			
2.1 Instantaneous			
2.1.1 Interruption		0.5–30 cycles	<0.1 pu
2.1.2 Sag (dip)		0.5–30 cycles	0.1–0.9 pu
2.1.3 Swell		0.5–30 cycles	1.1–1.8 pu
2.2 Momentary			
2.2.1 Interruption		30 cycles–3 s	<0.1 pu
2.2.2 Sag (dip)		30 cycles–3 s	0.1–0.9 pu
2.2.3 Swell		30 cycles–3 s	1.1–1.4 pu
2.3 Temporary			
2.3.1 Interruption		3 s–1 min	<0.1 pu
2.3.2 Sag (dip)		3 s–1 min	0.1–0.9 pu
2.3.3 Swell		3 s–1 min	1.1–1.2 pu
3.0 Long-duration variations			
3.1 Interruption, sustained		>1 min	0.0 pu
3.2 Undervoltages		>1 min	0.8–0.9 pu
3.3 Overvoltages		>1 min	1.1–1.2 pu
4.0 Voltage unbalance		Steady state	0.5–2%
5.0 Waveform distortion			
5.1 DC offset		Steady state	0–0.1%
5.2 Harmonics	0–100th harmonic	Steady state	0–20%
5.3 Interharmonics	0–6 kHz	Steady state	0–2%
5.4 Notching		Steady state	
5.5 Noise	Broadband	Steady state	0–1%
6.0 Voltage fluctuations	<25 Hz	Intermittent	0.1–7% 0.2–2 Pst
7.0 Power frequency variations		<10 s	

NOTE: s = second, ns = nanosecond, µs = microsecond, ms = millisecond, kHz = kilohertz, MHz = megahertz, min = minute, pu = per unit.

Transients

Two types:

1) Impulsive transient
2) Oscillatory transient

- The term *transients* has long been used in the analysis of power system variations to denote an event that is undesirable and momentary in nature. The notion of a damped oscillatory transient due to an *RLC* network is probably what most power engineers think of when they hear the word transient.
- part of the change in a variable that disappears during transition from one steady state operating condition to another.
- It is also named as surge

Impulsive transient

- An *impulsive transient* is a sudden, non–power frequency change in the steady-state condition of voltage, current, or both that is unidirectional in polarity (primarily either positive or negative).
- Impulsive transients are normally characterized by their rise and decay times, which can also be revealed by their spectral content. For example, a 1.2 / 50-s 2000-volt (V) impulsive transient nominally rises from zero to its peak value of 2000 V in 1.2 s and then decays to half its peak value in 50 s. The most common cause of impulsive transients is lightning.
- Because of the high frequencies involved, the shape of impulsive transients can be changed quickly by circuit components and may have Significantly different characteristics when viewed from different parts of the power system. Impulsive transients can excite the natural frequency of power system circuits and produce oscillatory transients.

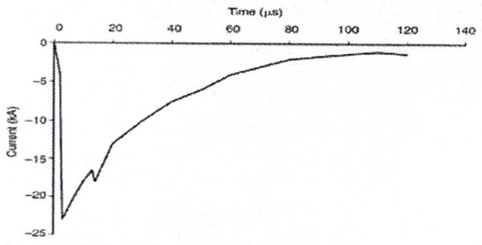

Figure 2.1 Lightning stroke current impulsive transient.

Oscillatory transient

- An oscillatory transient is a sudden, non–power frequency change in the steady-state condition of voltage, current, or both, that includes both positive and negative polarity values.
- An oscillatory transient consists of a voltage or current whose instantaneous value changes polarity rapidly.
- It is described by its spectral content (predominate frequency), duration, and magnitude. The spectral content subclasses defined in Table 2.2 are high, medium, and low frequency.

- Oscillatory transients with a primary frequency component greater than 500 kHz and a typical duration measured in microseconds (or several cycles of the principal frequency) are considered *high-frequency transients*. These transients are often the result of a local system response to an impulsive transient.
- A transient with a primary frequency component between 5 and 500 kHz with duration measured in the tens of microseconds (or several cycles of the principal frequency) is termed a *medium-frequency transient.*
- Back-to-back capacitor energization results in oscillatory transient currents in the tens of kilohertz as illustrated in Fig. 2.2. Cable switching results in oscillatory voltage transients in the same frequency range. Medium-frequency transients can also be the result of a system response to an impulsive transient.

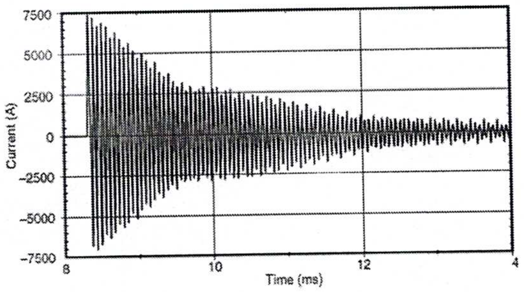

Figure 2.2 Oscillatory transient current caused by back-to-back capacitor switching.

- A transient with a primary frequency component less than 5 kHz, and a duration from 0.3 to 50 ms, is considered a *low-frequency transient*. This category of phenomena is frequently encountered on utility sub transmission and distribution systems and is caused by many types of events. The most frequent is capacitor bank energization, which typically results in an oscillatory voltage transient with a primary frequency between 300 and 900 Hz. The peak magnitude can approach 2.0pu, but is typically 1.3 to 1.5 pu with a duration of between 0.5 and 3 cycles depending on the system damping (Fig. 2.3).

- Oscillatory transients with principal frequencies less than 300 Hz can also be found on the distribution system. These are generally associated with ferro resonance and transformer energization (Fig. 2.4). Transients involving series capacitors could also fall into this category. They occur when the system responds by resonating with low-frequency components in the transformer inrush current (second and third harmonic) or when unusual conditions result in ferro resonance.

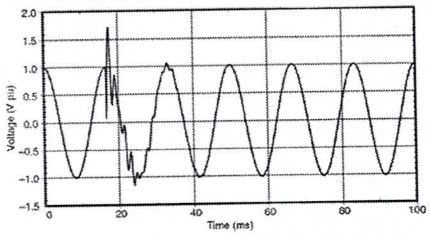

Figure 2.3 Low-frequency oscillatory transient caused by capacitor bank energization. 34.5-kV bus voltage.

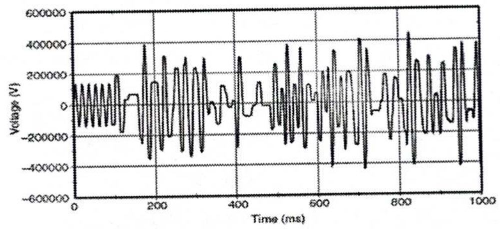

Figure 2.4 Low-frequency oscillatory transient caused by ferroresonance of an unloaded transformer.

Long duration voltage variations - over voltage, under voltage, sustained interruption.

- Long-duration variations encompass root-mean-square (rms) deviations at power frequencies for longer than 1 min. Long-duration variations can be either *overvoltages* or *undervoltages.*

- Overvoltages and undervoltages generally are not the result of system faults, but are caused by load variations on the system and system switching operations. Such variations are typically displayed as plots of rms voltage versus time.

Over Voltage

- 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.
- Over voltages are usually the result of load switching (e.g., switching off a large load or energizing a capacitor bank).
- The over voltages 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 over voltages.

Under Voltage

- An *under voltage* is a decrease in the rms ac voltage to less than 90 percent at the power frequency for a duration longer than 1 min.
- Under voltages are the result of switching events that are the opposite of the events that cause over voltages.
- A load switching on or a capacitor bank switching off can cause an under voltage until voltage regulation equipment on the system can bring the voltage back to within tolerances. Overloaded circuits can result in under voltages also.

Sustained interruption

- When the supply voltage has been zero for a period of time in excess of 1 min, the long-duration voltage variation is considered a *sustained interruption.*
- Voltage interruptions longer than 1 min are often permanent and require human intervention to repair the system for restoration.
- Outage is different from interruption. *Outage,* as defined in IEEE Standard 100 does not refer to a specific phenomenon, but rather to the state of a component in a system that has failed to function as expected.

Short duration voltage variations - interruption, sag, swell and outage

- *instantaneous, momentary,* or *temporary,* depending on its duration as defined in Table 2.2.
- 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.

Interruption

- An *interruption* occurs when the supply voltage or load current decreases to less than 0.1 pu for a period of time not exceeding 1 min.
- Interruptions can be the result of power system faults, equipment failures, and control malfunctions. The interruptions are measured by their duration since the voltage magnitude is always less than 10 percent of nominal. The duration of an interruption due to a fault on the utility system is determined by the operating time of utility protective devices.

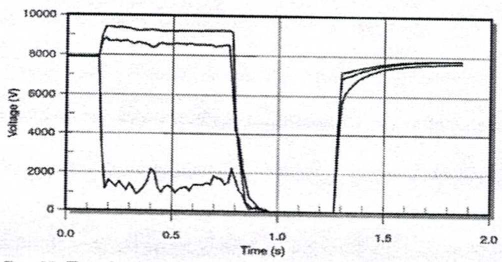

Figure 2.5 Three-phase rms voltages for a momentary interruption due to a fault and subsequent recloser operation.

Sag(dip)

A *sag* is a decrease to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for durations from 0.5 cycle to 1 min.

The IEC definition for this phenomenon is *dip*

Voltage sags are usually associated with system faults but can also be caused by energization of heavy loads or starting of large motors.

Figure 2.6 shows a typical voltage sag that can be associated with a single- line-to-ground (SLG) fault on another feeder from the same substation. An 80 percent sag exists for about 3 cycles until the substation breaker is able to interrupt the fault current. Typical fault clearing times range from 3 to 30 cycles, depending on the fault current magnitude and the type of overcurrent protection.

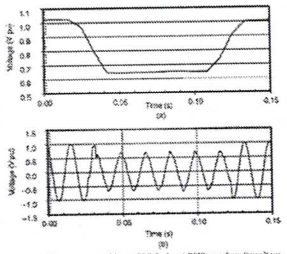

Figure 2.6 Voltage sag caused by an SLG fault. (a) RMS waveform for voltage sag event. (b) Voltage sag waveform.

- Figure 2.7 illustrates the effect of a large motor starting. An induction motor will draw 6 to 10 times its full load current during start-up. If the current magnitude is large relative to the available fault current in the system at that point, the resulting voltage sag can be significant.
- In this case, the voltage sags immediately to 80 percent and then gradually returns to normal in about 3 s.

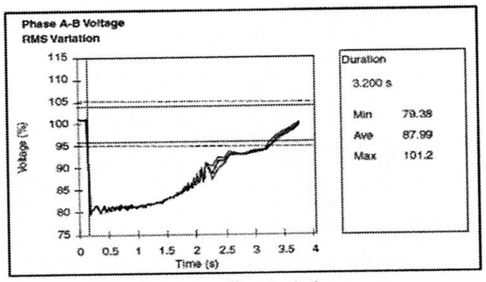

Figure 2.7 Temporary voltage sag caused by motor starting.

Sag durations are subdivided here into three categories—instantaneous, momentary, and temporary which coincide with the three categories of interruptions and swells. These durations are intended to correspond to typical utility protective device operation times as well as duration divisions recommended by international technical organizations.

Swells

- A *swell* is defined as an increase to between 1.1 and 1.8 pu in rms voltage or current at the power frequency for durations from 0.5 cycle to 1 min.
- swells are usually associated with system fault conditions,but they are not as common as voltage sags. One way that a swell can occur is from the temporary voltage rise on the un faulted phases during an SLG fault. Figure 2.8 illustrates a voltage swell caused by an SLG fault. Swells can also be caused by switching off a large load or energizing a large capacitor bank.

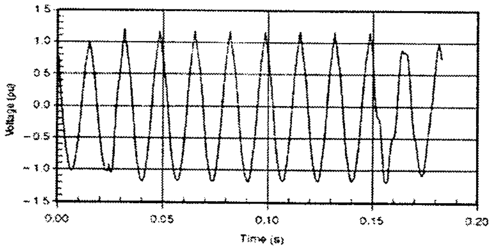

Figure 2.8 Instantaneous voltage swell caused by an SLG fault.

- Swells are characterized by their magnitude (rms value) and duration. The severity of a voltage swell during a fault condition is a function of the fault location, system impedance, and grounding. On an ungrounded system, with an infinite zero-sequence impedance, the line-to-ground voltages on the ungrounded phases will be 1.73 pu during an SLG fault condition. Close to the substation on a grounded system, there will be little or no voltage rise on the un faulted phases because the substation transformer is usually connected delta-wye, providing a low-impedance zero-sequence path for the fault current. Faults at different points along four-wire, multi grounded feeders will have varying degrees of voltage swells on the un faulted phases. A 15 percent swell, like that shown in Fig. 2.8, is common on U.S. utility feeders.
- The term *momentary overvoltage* is used by many writers as a synonym for the term *swell.*

- *Sag* is used as a synonym to the IEC term *dip.*
- The category *short-duration variations* is used to refer to *voltage dips* and *short interruptions.*
- The term *swell* is introduced as an inverse to sag (dip).
- The category *long-duration variation* has been added to deal with American National Standards Institute (ANSI) C84.1 limits.
- The category *waveform distortion* is used as a container category for the IEC *harmonics, inter harmonics,* and *dc in ac networks* phenomena as well as an additional phenomenon from IEEE Standard 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems,* called *notching.*