

A STUDY ON POWER QUALITY PHENOMENA BY QUANTIFYING INDEXES IN FTMSK, UiTM SHAH ALAM

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ABSTRACT

This study emphasizes on PQ disturbance in FTMSK, UiTM Shah Alam. Due to the today's rapid growth use of electronic devices especially at academic buildings, the non-compatibility with power environment is an increasing concern. Power Quality disturbance is considered as "nuisance" in a certain power system. There are various types of Power Quality (PQ) disturbance such as voltage sag (dip), voltage swell, outage, noises, harmonic, surges and flickers. These disturbances will limit on the integrity or damage a certain power system. The limits used in this study are IEEE 519-1992, IEC 61000-3, and RPM to check on the PQ phenomena

Keywords: *harmonics, IEEE519-1992 and IEC 61000-3 standards and Power Quality (PQ)*

1.0 INTRODUCTION

In order to analyze on PQ phenomena UiTM Shah Alam, which have PQ disturbance occasionally at Faculty of Electrical Engineering and Faculty of Mass Communication, the Harmonics and Total Harmonic Distortion of Voltage (THDV) in Faculty of Science Information Technology and Science Quantitative is compared in terms of raw data taken by using Reliable Power Meter (RPM).

The data taken will be analyzed throughout five days. This building is chosen as a starter, before analyzing other problematic power disturbance academic building in UiTM Shah Alam.

Most of the common sources of power quality disturbance within the FTMSK academic

building are too much capacity of personal computers, data networks, security systems, copy machines and central air conditioners. This paper presents the result and analysis of power quality monitoring at the FTMSK building.

2.0 OBJECTIVE

The objective of this study is to study the PQ phenomena in FTMSK, UiTM Shah Alam via data taken by using Reliable Power Meter (RPM). This is to acknowledge type or types of disturbances that occurs in FTMSK, UiTM Shah Alam, and what causes it.

As the IEEE and IEC standard is concerned, the data collected/ tabulated are compared with the IEEE and IEC standards. Reasonable recommendations are improvised in order to improve the Power Quality in UiTM Shah Alam, if needed.

These readings are compared to IEEE519-1992 [8] and IEC 61000 standards [2], [10]-[12], which guide us with certain limits. Examples are, the comparative is the THDV readings pertaining IEEE standards must not exceed 5%. It is shown as below; Table 1, Table 2 and Table 3; the exceeding above these standards will leads to equipment heating or damage.

Table 1: IEEE 519-1992 Voltage Harmonic Limits.

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

Table 2: IEC 61000-3 Voltage Harmonic Limits

Odd harmonics				Even harmonics	
Not multiple of 3		Multiple of 3			
Order h	Harmonic voltage (%)	Order h	Harmonic voltage (%)	Order h	Harmonic voltage (%)
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.5	15	0.3	6	0.5
13	3	21	0.2	8	0.5
17	2	>21	0.2	10	0.5
19	1.5			12	0.2
23	1.5			>12	0.2
25	1.5				
>25 $0.2 + 1.3 \times 25/h$					

*Limit for total harmonic distortion (THD) is 8 percent.

Table 3: IEC 61000-3 Current Harmonic Limits

Max. permissible harmonic current order (A)		Max. permissible harmonic order (A)	
Odd order h	Even order h	Odd order h	Even order h
3	2.3	2	1.08
5	1.14	4	0.43
7	0.77	6	0.3
9	0.4	8-40	$0.23 \times 8/h$
11	0.33		
13	0.21		
15-39	$0.15 \times 15/h$		

3.0 METHODOLOGY

The data was taken using a Reliable Power Meter (RPM) at location FTMSK. The data was recorded at the location from 06/08/08 10:27:13 through 11/08/08 10:27:13. Before taking any readings, any problem regarding power quality at location site is acknowledged. Table 4 is a summary check-up of the power conditions at the FTMSK, UiTM Shah Alam site;

Table 4: Check-up List on FTMSK building

Information	Answers
• Location of site	• FTMSK building, UiTM Shah Alam
• Is there any kind of power problems?	• Rarely voltage fluctuations
• Are there any copy machines on circuit?	• Yes
• Are there any large air conditioners on the same circuit?	• Yes
• What about damage to equipment?	• Nil
• Is there a UPS backing up critical component?	• Yes
• Any frequency problem?	• Unknown

3.1 Report Parameters

The report limits were programmed by Engineering Services of Reliable Power Meters. The following limits were used in analyzing the results.

Table 5: Limits by Engineering Services of Reliable Power Meter (RPM)

Information	Limits
• Maximum Phase Voltage.	254 V
• Minimum Phase Voltage.	208 V
• Maximum Neutral Voltage.	3 V
• Maximum Impulse Voltage.	500 V
• Maximum. Waveshape Voltage.	10 V
• Maximum Frequency Deviation	.02 Hz
• Minimum Power Factor.	.85
• Maximum Voltage T.H.D.	5 %
• Maximum Current T.H.D	20 %
• Maximum Voltage Imbalance	2 %
• Maximum Current Imbalance.	5 %

3.2 Audit site visit

The Area that affects the studies is FTMSK academic building. The site visit was done to acknowledge wiring and grounding problem before acquiring the data using the RPM.

3.2.1 Wiring and grounding

Table 6 shows the checking of wiring and measuring the grounding resistance are carried out. The observations are:

- Grounding resistance is averaged at 0.3 ohm
- No bad wiring connection
- No Grounding mistakes
- Air conditioner is on the same circuit.

Table 6: Ohms reading per phase

Fundamental Impedance	Readings
• Phase A	282.4m Ohms
• Phase B	318.0m Ohms
• Phase C	332.5m Ohms

3.2.2 Flowchart

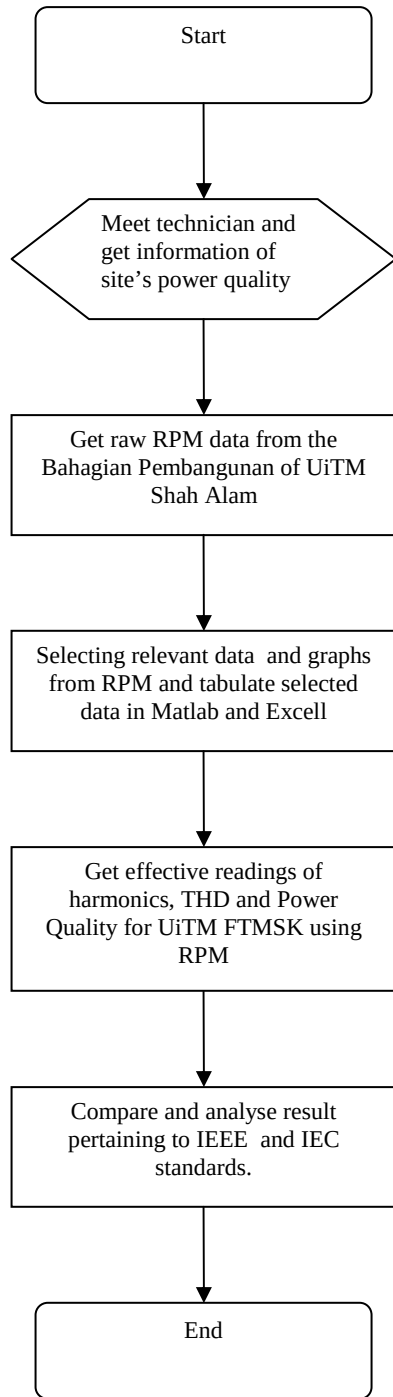


Figure 1: The study's flow chart

Figure 1 shows the Flowchart of how completing the FTMSK building's PQ study.

4.0 RESULTS AND DISCUSSIONS

4.1 Power Quality Characteristics

The IEEE 519-1992, IEEE 1159-1995 [4] contains widely-adopted recommendations for harmonic controls separated between voltage and current permissible harmonics, either equipment connected to the network, or as well as the limits of emissions from the equipment.

Most examples of types of recorded voltage problems are:

Power quality symptoms which are transients, sags, swells, outage, noises, harmonics, surges and flickers. [1], [10].

Table 7 shows disturbance in voltage, current and frequency data in FTMSK building.

Table 7: Disturbance of Voltage and Current and Frequency

Disturbance Location of measurement	Number of interruptions	Flicker Plt		Imbalance%		Frequency average
		Max	Average	Voltage	Current	
• Phase A	1	0.8	0.5	0.47%	9.16%	50Hz
• Phase B	2	0.79	0.6			50Hz
• Phase C	1	0.5	0.48			50Hz

4.2 Voltage imbalance

Excessive Voltage Imbalance is when one or two phases may be overloaded. The main sources of voltage imbalance are imbalanced single phase loads on a 3-phase circuit, capacitor bank problems and single-phasing conditions. The maximum measured voltage imbalance is 0.47 % that is within the standard limit 3 %.

4.3 Voltage Flicker

Voltage fluctuations are caused by changing load characteristics. [9] and [10] Even though FTMSK building air conditioner is on the same circuit as electronic sensitive equipment, however, there is no event of flicker during the recording data period. The maximum measured long term flicker Pl_{t*} is 0.5 which is within the standard limit (0.8).

* Pl_{t*} is the long term flicker of voltage.

4.4 Harmonics

Harmonic distortion results from the operation of nonlinear loads and devices on the power system. Harmonic voltage distortion results from the interaction of harmonic currents with the system impedance. The Total harmonics per phase will then be compared with the standard of IEC 61000-3, Table 2.

Table 8: RPM data of Phase A voltage harmonics

Harmonic Phase A	Amplitude	Percent
0	610.3mV	0.18%
1	330.9V	100%
2	505.1mV	0.15%
3	2.695V	0.81%
4	185.6mV	0.06%
5	3.193V	0.96%
6	152.5mV	0.05%
7	4.357V	1.32%
8	110.0mV	0.03%
9	2.320V	0.70%
10	43.16mV	0.01%
11	977.3mV	0.30%
12	152.6mV	0.05%
13	830.7mV	0.25%
14	110.1mV	0.03%
15	475.4mV	0.14%
16	43.16mV	0.01%
	Odd Harmonics	2.00%
	Even Harmonics	0.21%
	Total Harmonics	2.01%

Table 8 shows the raw data from RPM of harmonic voltage of phase A. the 100% indicates the phase voltage is totally at fundamental harmonic 1. The total voltage harmonics for phase A is 2.01%.

The figure 2 shows the bar chart of phase A's harmonics voltage percent of each harmonic number for the first 16 harmonics.

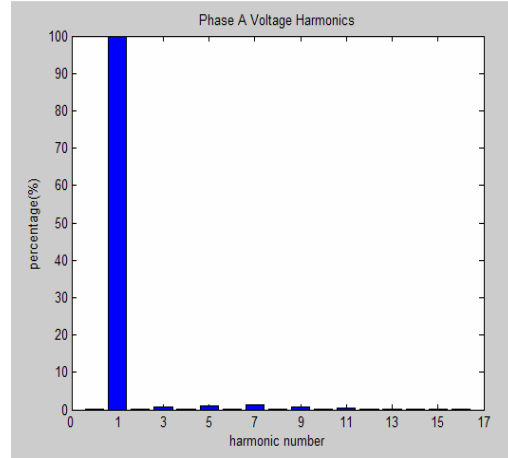


Figure 2: Bar chart of Phase A voltage harmonics

The data is then compared to the IEC 61000-3 limits standard (Table 2) which accurately states limits on voltage harmonics, not just THDV as for IEEE 519-1992. Figure 3 shows the comparison between readings data and the IEC 61000-3 standards limit.

FTMSK's phase A voltage harmonics is within the limits on voltage harmonics of IEC.

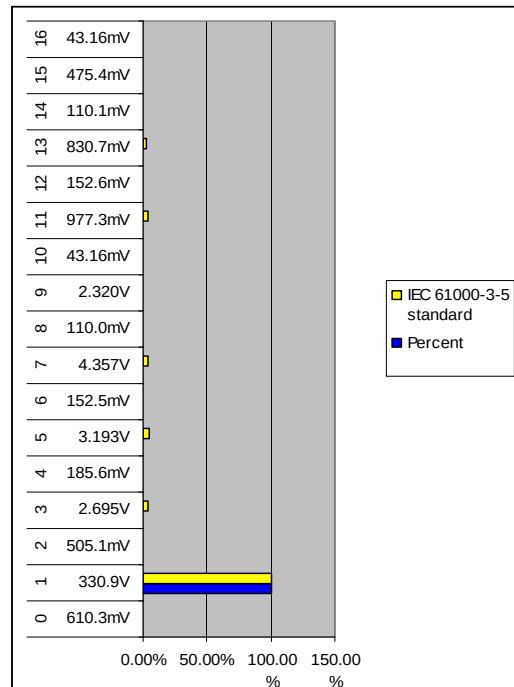


Figure 3: Comparison between Phase A voltage harmonics with IEC 61000-3 standards

The RPM readings of voltage harmonics on both phase B and phase C was also taken and tabulated as shown below. The same action was taken to verify whether its' harmonics up to the standards.

Figure 4 shows the bar chart of phase B's harmonics voltage percent of each harmonic number for the first 16 harmonics.

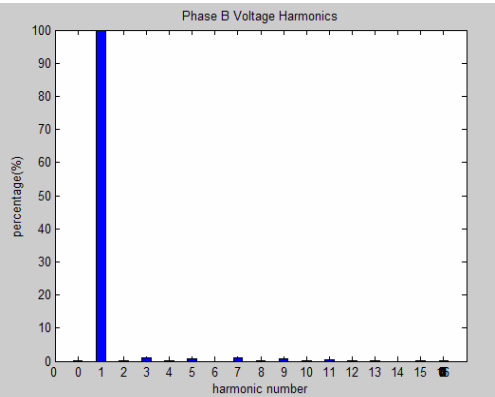


Figure 4: Bar chart of Phase B voltage harmonics.

Phase B voltage harmonics is compared with IEC 61000-3 limits. Figure 5 shows the comparison between readings data (phase B) and the IEC 61000-3standards limit. It shows the readings are within the IEC's voltage harmonics limits.

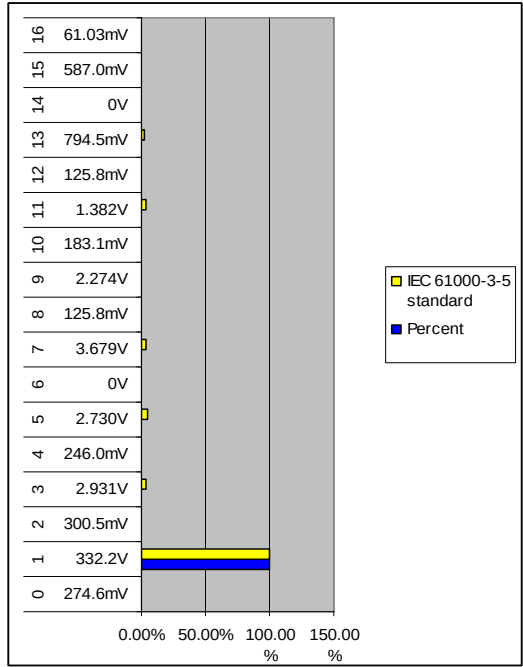


Figure 5: Comparison between Phase B voltage harmonics with IEC 61000-3 standards.

Figure 6 shows the bar chart of phase C's harmonics voltage percent of each harmonic number for the first 16 harmonics.

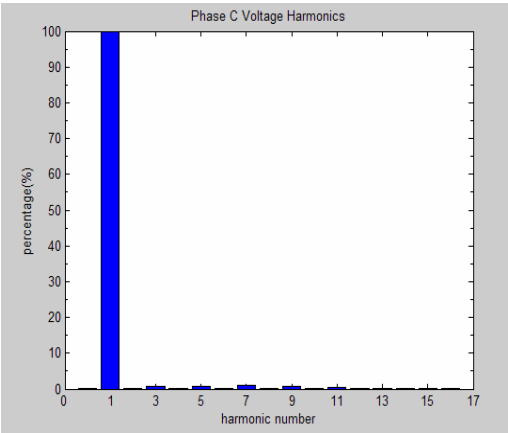


Figure 6: Bar chart of Phase C voltage harmonics.

Phase C voltage harmonics is compared with IEC 61000-3 limits. Figure 7 shows the comparison between readings data (phase C) and the IEC 61000-3standards limit. It shows the readings are within the IEC's voltage harmonics limits.

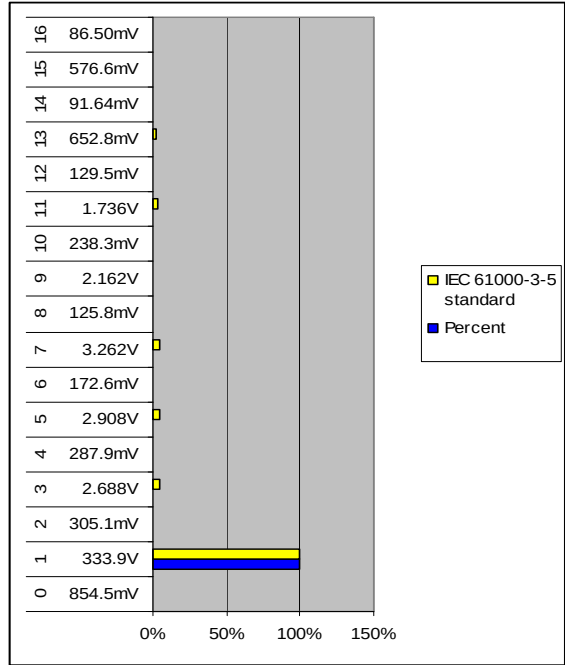


Figure 7: Comparison between Phase C voltage harmonics with IEC 61000-3 standards.

Table 9 shows the THDV and THDI percentage values from FTMSK building. The observations from table are;

- Maximum THDV% is 2.34% which is within the limit standards (5%)
- Maximum THDI% is 25.82% which exceeds the limit (20%). However, the average readings (95%) of THDI is under the limit (20%)

Table 9: Maximum and average readings of THDV and THDI

Phase	THDV%		THDI%	
	Max	Average	Max	Average
Phase A	2.34	1.709	23.04	11.43
Phase B	2.26	1.635	25.82	11.28
Phase C	2.02	1.441	20.04	9.866

Figure 8 shows the RPM generated waveforms of the event of the highest THDI%, which 25.82% is at phase B. Figure 9 shows the generated waveforms of the event of the highest THDV%, which is 2.34% at phase A.

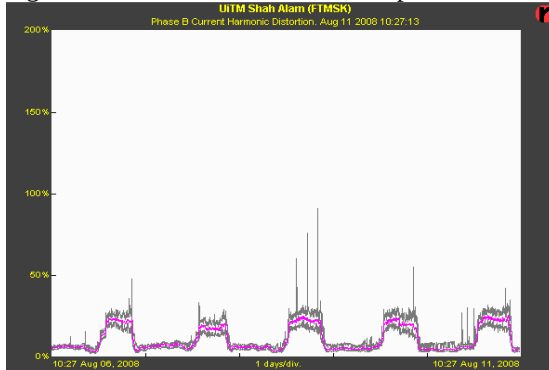


Figure 8: Waveform of phase B current distortions

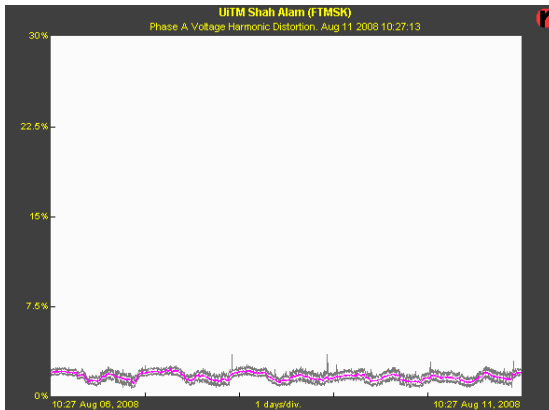


Figure 9: Waveform of phase A voltage distortions

4.5 Voltage dips (sags)

Common causes of voltage dips are faults on the electric power system, motor-starting, customer load additions and large load addition in the utility service area. Dips can cause sensitive equipment to malfunction or simply shut off, and cause lighting flicker.

The utility strives to keep RMS levels within a +5%, -10% range of the nominal voltage. Surges are those RMS levels which go above the +5% range. Sags are those RMS levels which go below the -10% range. The duration is generally from a few cycles to a few seconds. Figure 10 shows Event 20, a typical RMS event occurred at the phase A voltage. The event 20 is for 3.405 hours long.

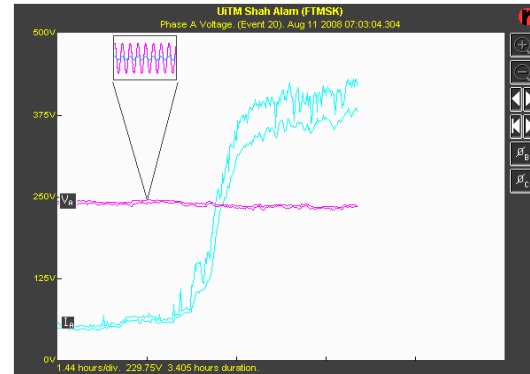


Figure 10: Waveform of voltage dip event 20

4.6 Current imbalance

Excessive Current Imbalance also indicates a poor distribution of loads. Although there may be no corresponding voltage imbalance, excessive current imbalance may result in tripped circuit breakers or transformer overheating.

UiTM Shah Alam (FTMSK) (CBEMA) Phase B Event Tolerance Summary - August 11, 2009: 6 events			
	Type I	Type II	Type III
Start Duration	1 us	8.333 ms	2 sec
End Duration	8.333 ms	2 sec	1 day
Total Events	0	2	2
Total Faults	0	0	0
	Event No.	Amplitude	Duration
Longest Type I Event	N/A		
Largest Type I Event	N/A		
Longest Type II Event	61	234.0V	280 ms
Largest Type II Event	21	225.3V	20 ms
Longest Type III Event	81	231.8V	19.815 hr
Largest Type III Event	1	230.9V	4.91 hr

Figure 11: Event tolerance Summary phase B

Figure 11 above shows the event tolerance summary for phase B. From the RPM data, the utility current imbalance is 9.16% which exceeds the limit of IEEE 519-1992 (5%).

There are only 2 type II events, which is event 61 and 21 (280ms and 20ms respectively), and 2 type III (Event 81 and 1) disturbance (19.815 and 4.91 hours respective

The current imbalance is the longest type III; event (81) which is a type III disturbance (> 2 s) for nearly 20 hours.

5.0 CONCLUSION

With the increased use of sensitive loads, power quality issues have become more important. Most of cases of power quality disturbances found inside buildings are the result of, or made worse by, grounding and wiring errors. However, the power quality phenomena in FTMSK building are:

- Wiring connection and groundings are at satisfying level.
- Both voltage and current harmonics data for all phase are within IEC 61000-3 limits
- Average readings of voltage flicker are within the limit.
- THDI% & TVDV% are within the IEEE limit.
- Current Imbalance rates exceeds the standards at event 81, a type III event for nearly 20 hours
- Voltage dip are at event 20 for 3.405 hours

The following are of the types of mitigation for pre-caution for the event experienced by FTMSK building. Even though FTMSK only experienced minor disturbance, it is advised to implement on the most economical and feasible electrical solutions;

- Type II is commonly due to system fault.
The solutions;
 - 1- Constant Voltage Transformers(CVT)
 - 2- Motor Generator
 - 3- Standby power supply
 - 4- Uninterruptible Power Supply (UPS)system
 - 5- Static Voltage Regulator
 - 6- Energy storage technologies
- Type III is commonly due to motor starting, load variations, and load dropping. The solutions;
 1. Constant Voltage Transformer
 2. Voltage Regulators
 3. Backup Generators
 4. Energy storage technologies

For the future development, it is advisable to implement this study to area which has more severe PQ problem. The more severe cases are at Science and Technology Tower, UiTM.

6.0 REFERENCE

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