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DESIGN AND IMPLEMENTATION OF A METER FOR MONITORING VOLTAGE QUALITY BY MEASURING WAVE-SHAPE DATA OF SUPPLY VOLTAGE

by

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INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

SEPTEMBER 2021

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A project
submitted as partial fulfilment of the requirement for the degree of

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

SEPTEMBER 2021

CERTIFICATE OF APPROVAL

The project entitled "**Design and Implementation of a Meter for Monitoring Voltage Quality by Measuring Wave-Shape data of supply voltage**" was submitted by **Muhammad Moshiur Rahman Khan**, bearing Matric ID. **ET-163010** and **Tanzim Hasnat,** bearing Matric ID. **ET-163030** of session **Autumn 2020**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **30 March 2021**.

____

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DECLARATION

This project was prepared by us, and no part of it has been submitted elsewhere for the awarding of a degree or other diploma, and we swear by signing below that this is true...

____

Muhammad Moshiur Rahman Khan

____

Tanzim Hasnat

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Our Chairman of the Department, as well as our faculty associates, are also thanked for their unwavering support. Lastly, we would want to express our gratitude to all of our classmates for their constant assistance and support.

Authors.

ABSTRACT

The purpose of this study is to determine the voltage's quality. We know there are many reasons where supply voltage can be distorted and fluctuated. If the voltage fluctuates, the line's power may be damaged, resulting in power loss. Many complications will arise if we do not receive the requested power that is truly required for proper operation. Our work is to find out not only the voltage fluctuation but also the specific time period of the fluctuated or deviated voltage. So making it possible we need to sample the voltage after 1 millisecond and got 20 different data from a single wave-form. This waveshape can tell us about the amount of voltage at 20 different points in a total 20 ms time period. We took a reference waveform to see the difference of the waveform of the phase voltage if it is fluctuated/deviated or not. So we've done the sampling process of the standard (Phase voltage) voltage into 20 milliseconds at 1 millisecond after. We call it standard or Context structure because we will compare the upcoming wave-form based on this waveform (standard). The upcoming voltage will also be sampled in 20 milliseconds at 1 millisecond after. From this process, we will identify the place of the deviation or fluctuation of the upcoming voltage cycle. Both of the voltage waveshapes will be plotted on one another for identifying the actual distortion of the voltage. After all, the RMS (Root Mean Square) values of those waveforms can tell the entire difference between the deviated waveform of the voltage and the phase voltage's context waveform. If any area is found with this fluctuating or deviated condition, as well as on the number of observers and their locations, the disturbances that are going to be recorded, and indices that will be calculated.

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CHAPTER 1
INTRODUCTION

1.1 Introduction to Voltage Quality Monitoring System Design

The extensive usage of electricity, even without the complexity of new load types, has resulted in an increase in the requirement for supply voltage regulation and monitoring. The majority of end-users do not monitor any Voltage Quality (VQ) abnormalities in their installation's provided electricity. Voltage fluctuations, on the other hand, seem to be to blame for any electrical and electronic damage and malfunctions experienced by end-users equipment. With the right methods of measurement, voltage fluctuations may be recorded and evaluated.

Transmission System Operators (TSOs) and large-scale power production units both monitor and record such events in order to address fault situations in the generation and transmission systems. However, there is a dearth of VQ event monitoring, which primarily occurs at low and medium voltages...

The monitoring is very important to capture VQ events and correlate them with fault situations in electrical installations. Moreover, the recording of such events is very useful for energy management and energy-saving techniques. Statistical data that can be extracted from VQ monitoring will answer many questions about electrical equipment ageing and how VQ events act throughout the time. VQ should be monitored not only for identifying VQ issues but also for ranking the measuring point from a VQ point of view. This procedure will help for the future protection of the users and the network.

The aim of this project is to present, analyze and classify the results of several VQ field measurements at different points of the electric grid. The analysis will be used for further voltage quality improvement and where the condition of the voltage is changing.

During previous years several VQ measurements have been performed. In this analysis, seven different locations are presented. The locations were chosen after users' claims for VQ issues in the past. The measurement campaign was initiated during the year 2013 and is still ongoing.

The measurements mainly took place in the central distribution board of each installation. To capture VQ events and their severity in electrical equipment at different locations in the network, the major goal was to collect data. During that period the duration of each VQ disturbance and the frequency of these events has been recorded and analyzed. Users' opinions have been of great importance to correlateVQ events with fault situations in their installation.

It is obvious from the examples of VQM (Voltage Quality Monitoring) applications described above that creating a national VQM program has multiple benefits for various stakeholders.

However, there are costs involved, thus finance structures must be explored in order to ensure that it is implemented effectively. Two essential steps should be included in the VQM finance framework: the financial plan and the cost analysis VQM program costs should be assessed as part of a comprehensive inventory of all costs connected with program deployment (capital expenses) and maintenance (operational expenditure).

Funding such a programme through grid indictments, with a majority of linked customer base contributing, is the most acceptable method of funds to support it.

1.2 Method

All VQ properties as stated in international standards can be captured and monitored using measuring equipment. According to EN 50160, the minimum timeframe necessary to extract safe results is one week for continuous disturbances and a year for discontinuous disturbances [1].

The minimal time period measured in this study was 15 days, and the majority of the measurements were done for one week. Users' recordings were used for discrete events like interruptions and voltage fluctuations.

1.3 Aims and Objectives

a. **Voltage Quality:**
   When we focus on the improvement of the **Voltage Quality**, **Power Quality** will be improved for that. While many Power Improvement Projects can be designed with capacitors and batteries to counter undesired electrical features such as power factor lag, utilities will no longer be required to generate additional power at that time. Rechargeable cells can also be used as part of a demand-response strategy.
b. **Holding the Wave-forms:**

As we’ve mentioned earlier, for monitoring the quality of the voltage means, monitoring every single possible sampling portion of the wave-form of a voltage. We can not get any readings from a running wave-form until we can hold them.

c. Sampling the Wave-form:

We hold a waveform for the eligibility for the sampling process. We will sample the wave-form to get the sampling voltage from each sampling portion. The more sampling we will be able to achieve the more quality can possible be ensured

CHAPTER 2

METHODOLOGY

2.1 System Equipment

The system is made up of eight key embedded electronics components.

1. Precision Resistor
2. Function Generator
3. Microcontroller
4. LCD Display.
5. Op-Amp.
6. LED
7. Switch.
8. Board

2.2 Voltage Quality Management Methodology

When it came to **Voltage Quality** management, there was no internationally recognised methodology, which slowed down the adoption of best energy management practices until 2011, when ISO 50001 was introduced as a framework for managing and improving energy performance.

With a few tweaks, ISO50001's principles for energy management might be applied to voltage quality control as well. As a result, the ISO 50001 model will be discussed in the next section.

2.3 Voltage Quality Management Model

The International Organization for Standardization (ISO) published "ISO 50001 Energy Quality Management Systems Requirements with Guidance for Use" in 2011. (ISO). It establishes a framework for establishing, maintaining, and developing a Voltage Quality Management System in order to achieve continuous energy performance improvement. It is appropriate for any organisation, regardless of its size, industry, or geographic location.

The framework of a Voltage Quality Management System is based on the "Plan – Do – Check – Act" Methodology and may be described in **Figure 2.1**.

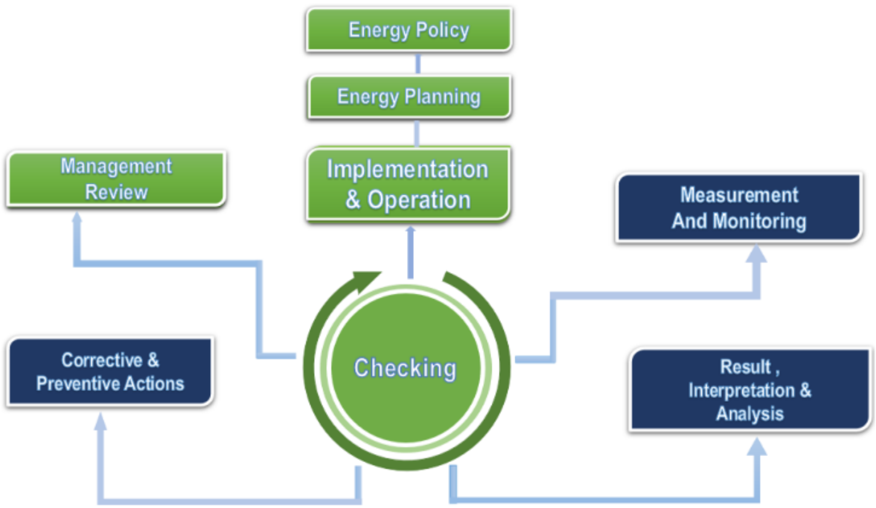


Fig. 2.1: Energy Quality Management Model.

And, in order to obtain long-term solutions and return on investment evaluations on power quality tracking systems, it is very necessary to Measure, Analyze, and Improve Power and Voltage Quality in a continual flow.

CHAPTER 3

HARDWARE DESCRIPTION

3.1 Microcontroller

A microcontroller (abbreviated C or MCU) is a single-chip computer that comprises a CPU core, memory, and reconfigurable input/output chipsets. Microcontrollers, as opposed to general-purpose integrated circuits, are designed for embedded applications. Any real-time control or communication system would be incomplete without it. It has the required processing power as well as improved I/O operating capabilities [2].

3.1.1 Reason for Using Microcontroller

Microcontrollers have become widely used and popular in a variety of fields and may be derived from a variety of products such as home appliances, computer equipment, automobiles, and so on. A microcontroller can be found in anything from a microwave oven to refrigeration to high-tech robots. Microcontrollers are utilized in traffic light control, automotive engines, anti-lock brakes, cruise control, industrial automation, and other applications. Microcontrollers have grown ubiquitous in everything from basic electronics like digital cameras, cell phones, and printing machines to very sophisticated satellites, robotics, and nuclear missile defence systems [3].

3.1.2 PIC Microcontroller

PIC is a microchip-based series of modified Harvard architecture microcontrollers evolved from the PIC1650 created by General Instrument's microelectronics division. Due to its low cost, wide availability, huge user base, a substantial collection of application notes, availability of low cost or free development tools, and serial programming (and reprogramming with flash memory) capabilities, PICs are popular with both industrial developers and amateurs alike. Figure 3.1 shows an example of a PIC microcontroller, with its pin layout given in Figure 3.1 [4].

3.1.3 Pin Diagram of PIC16F73 Microcontroller

An example of the PIC 16F73 Microcontroller is showed in figure 3.1 and the pin Diagram of the PIC16F73 Microcontroller is given in **Figure 3.2**.

Fig. 3.1: Photography of PIC16F73 Microcontroller [5].

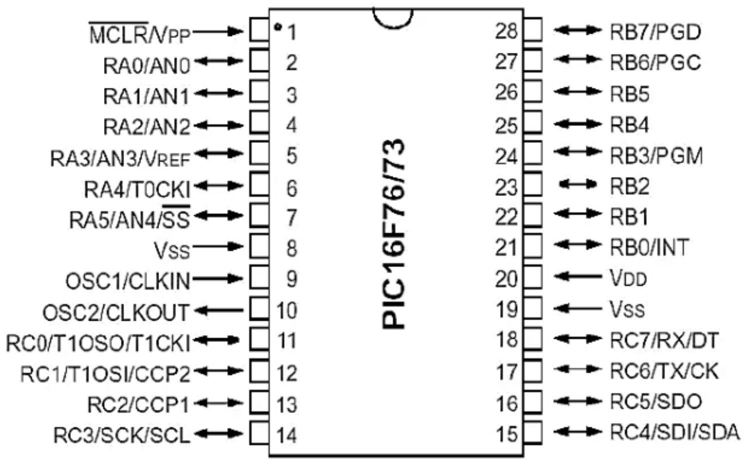


Fig. 3.2: Pin Diagram of PIC16F73 Microcontroller [6].

3.1.4 Memory Unit of Microcontroller

Memory is a component of the microcontroller that stores information. We obtain the contents of a certain targeted memory region for specific input. All memory locations make up memory, and attempting to address is simply selecting one. The meaning of this is, on the one hand, we must choose the appropriate memory location, and on the other, it is quite obvious for us to wait for the contents of the location.

Memory must allow for both readings from and writing to a memory place. This is accomplished by providing a control line in addition to the data line. This line will be labelled R/W (read/write). The control line is used as follows: If r/w=1, reading is done, and if the opposite is true, reading is not done then writing is done on the memory location [7].

3.1.5 Type of Memory

In a microcontroller chip, there have been three types of memory.

(i) Program memory

(ii) Data memory

(iii) EEPROM memory.

(i) Program Memory (ROM)

Program Memory is a somewhat of memory that stores a running programme continuously. Program memory can be incorporated within the microcontroller or added as a separate chip from the outside, depending on the microcontroller type; if added from the outside, the microcontroller is less expensive and the programme can last much longer. At the same time, because the microcontroller links to the memory through its own input/output ports, the number of accessible pins is decreased. The maximum memory size for a programme is 14k bytes.

(ii) Data Memory (RAM)

Data Memory is a form of storage that is used to temporarily store and maintain various data and constants during the operation. The contents of this memory are erased when the power is switched off. The maximum data memory capacity is 368 bytes.

(iii) EEPROM Memory

The EEPROM Memory is a unique sort of memory that is not compatible with all microcontrollers. Its content can be modified while the programme is running (similar to RAM), but it is kept permanently even if the power is turned off (similar to ROM). It is used to save distinct values that must be saved when the device is turned off during the operational process. Up to 256 bytes of EEPROM memory, The programming speed of this memory is measured in milliseconds, which is a drawback.

3.1.6 Microcontroller Core Features

- High-performance RISC CPU
- Only 35 single word instructions to learn
- Operating speed: DC - 20 MHz clock input DC - 200 ns instruction cycle
- Up to 14k bytes of FLASH Program Memory, Up to 368 bytes of Data Memory (RAM) Up to 256 bytes of EEPROM Data Memory.

- Eight levels deep hardware stack.
- Direct, indirect, and relative addressing modes.
- Power-on reset (POR).
- Power-up timer (PWRT) and Oscillator start-up timer (OST).
- The design is completely static.
- With a single 5V supply in-circuit, serial programming is possible.
- Read/write access to programme memory by the processor.
- A wide operating voltage range of 2.0V to 5.5V is available.
- Increased source/sink current: 25mA.
- Temperature ranges for commercial, industrial, and extended use.

3.1.7 Peripheral Features

- Timer0: 8-bit timer/counter with 8-bit pre-scalar.
- Timer1: 16-bit timer/counter with pre-scalar, can be incremented during sleep via external.
- crystal/ clock.
- Timer2: 8-bit timer/counter with 8-bit period register, pre-scalar and post scalar.
- Two Capture, Compare, PWM modules.
- Capture is 16-bit with a maximum resolution of 12.5 nanoseconds, and compare is 16-bit with a maximum resolution of 200 nanoseconds.
- PWM maximum resolution is 10-bit.
- 8-bit multi-channel analogue-to-digital converter.
- Synchronous serial port (SSP) with enhanced.
- Universal synchronous asynchronous receiver.

3.1.8 Features of PIC16F73 microcontroller

Table 3.1: Features of PIC16F73 Microcontroller.

Key Features	PIC16F73
Operating Frequency	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)
Flash Program Memory	8K
Data Memory (bytes)	368
EEPROM Data Memory (bytes)	256

Interrupts	15
I/O Ports	Ports A, B, C
Timers	3
Capture/Compare/PWM modules	2
Serial Communications	MSSP, USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
Analog Comparators	2
Packages	40-pin PDIP 28-pin PLCC 28-pin TQFP 28-pin QFN

3.1.9 Block Diagram

The Diagram for PIC16F73 Microcontroller is shown in **Figure 3.3**.

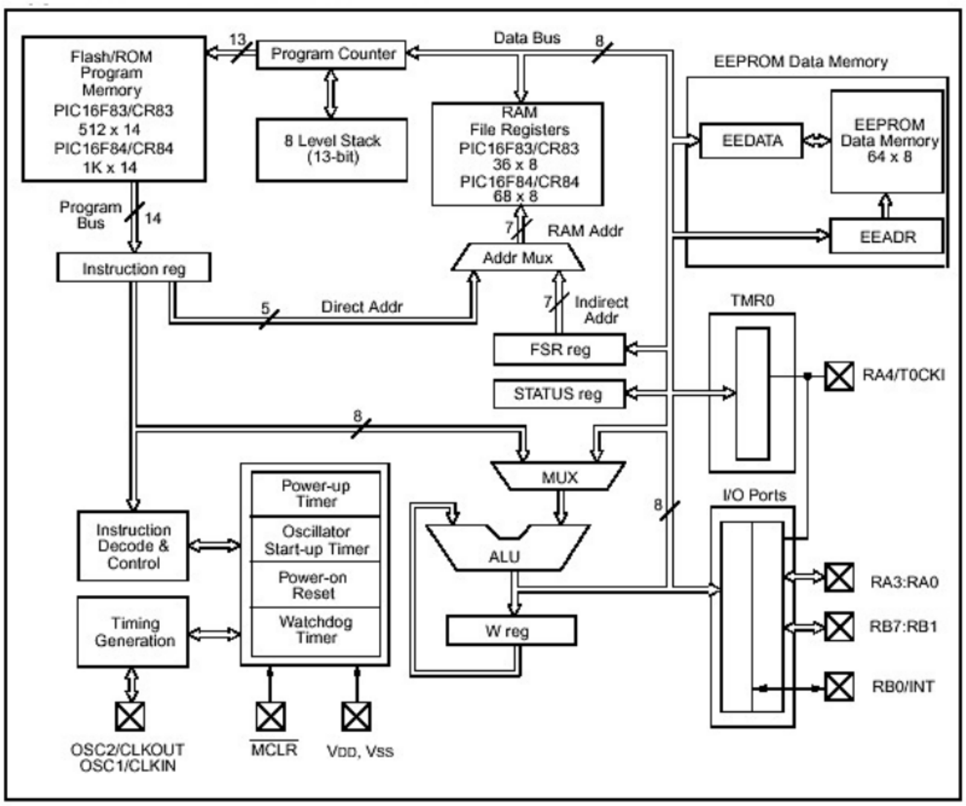


Fig. 3.3: Block Diagram of PIC16F73 microcontroller [8].

3.1.10 Pin Description

The description of PIC16F73 is given in Table 3.2:

Table 3.2: Pin Description of PIC16F73 [9].

(a)

Name	Number (DIP 40)	Function	Description
RE3/MCLR/Vpp	1	RE3	General purpose input Port E
		MCLR	Reset pin. Low logic level on this pin resets microcontroller.
		Vpp	Programming voltage
RA0/AN0/ULPWU/C12IN0-	2	RA0	General purpose I/O port A
		AN0	A/D Channel 0 input
		ULPWU	Stand-by mode deactivation input
		C12IN0-	Comparator C1 or C2 negative input
RA1/AN1/C12IN1-	3	RA1	General purpose I/O port A
		AN1	A/D Channel 1
		C12IN1-	Comparator C1 or C2 negative input
RA2/AN2/Vref-/CVref/C2IN+	4	RA2	General purpose I/O port A
		AN2	A/D Channel 2
		Vref-	A/D Negative Voltage Reference input
		CVref	Comparator Voltage Reference Output
		C2IN+	Comparator C2 Positive Input
RA3/AN3/Vref+/C1IN+	5	RA3	General purpose I/O port A
		AN3	A/D Channel 3
		Vref+	A/D Positive Voltage Reference Input
		C1IN+	Comparator C1 Positive Input
RA4/T0CKI/C1OUT	6	RA4	General purpose I/O port A
		T0CKI	Timer T0 Clock Input
		C1OUT	Comparator C1 Output
RA5/AN4/SS/C2OUT	7	RA5	General purpose I/O port A
		AN4	A/D Channel 4
		SS	SPI module Input (*Slave Select*)
		C2OUT	Comparator C2 Output
RE0/AN5	8	RE0	General purpose I/O port E
		AN5	A/D Channel 5
RE1/AN6	9	RE1	General purpose I/O port E
		AN6	A/D Channel 6
RE2/AN7	10	RE2	General purpose I/O port E
		AN7	A/D Channel 7
Vdd	11	+	Positive supply
Vss	12	-	Ground (GND)

(b)

Name	Number (DIP 40)	Function	Description
RA7/OSC1/CLKIN	13	RA7	General purpose I/O port A
		OSC1	Crystal Oscillator Input
		CLKIN	External Clock Input
RA6/OSC2/CLKOUT	14	OSC2	Crystal Oscillator Output
		CLKO	Fosc/4 Output
		RA6	General purpose I/O port A
RC0/T1OSO/T1CKI	15	RC0	General purpose I/O port C
		T1OSO	Timer T1 Oscillator Output
		T1CKI	Timer T1 Clock Input
RC1/T1OSO/T1CKI	16	RC1	General purpose I/O port C
		T1OSI	Timer T1 Oscillator Input
		CCP2	CCP1 and PWM1 module I/O
RC2/P1A/CCP1	17	RC2	General purpose I/O port C
		P1A	PWM Module Output
		CCP1	CCP1 and PWM1 module I/O
RC3/SCK/SCL	18	RC3	General purpose I/O port C
		SCK	MSSP module Clock I/O in SPI mode
		SCL	MSSP module Clock I/O in I^2C mode
RD0	19	RD0	General purpose I/O port D
RD1	20	RD1	General purpose I/O port D
RD2	21	RD2	General purpose I/O port D
RD3	22	RD3	General purpose I/O port D
RC4/SDI/SDA	23	RC4	General purpose I/O port A
		SDI	MSSP module *Data* input in SPI mode
		SDA	MSSP module *Data* I/O in I^2C mode
RC5/SDO	24	RC5	General purpose I/O port C
		SDO	MSSP module *Data* output in SPI mode
RC6/TX/CK	25	RC6	General purpose I/O port C
		TX	USART Asynchronous Output
		CK	USART Synchronous Clock
RC7/RX/DT	26	RC7	General purpose I/O port C
		RX	USART Asynchronous Input
		DT	USART Synchronous Data

(c)

Name	Number (DIP 40)	Function	Description
RD4	27	RD4	General purpose I/O port D
RD5/P1B	28	RD5	General purpose I/O port D
		P1B	PWM Output
RD6/P1C	29	RD6	General purpose I/O port D
		P1C	PWM Output
RD7/P1D	30	RD7	General purpose I/O port D
		P1D	PWM Output
Vss	31	-	Ground (GND)
Vdd	32	+	Positive Supply
RB0/AN12/INT	33	RB0	General purpose I/O port B
		AN12	A/D Channel 12
		INT	External Interrupt
RB1/AN10/C12INT3-	34	RB1	General purpose I/O port B
		AN10	A/D Channel 10
		C12INT3-	Comparator C1 or C2 Negative Input
RB2/AN8	35	RB2	General purpose I/O port B
		AN8	A/D Channel 8
RB3/AN9/PGM/C12IN2-	36	RB3	General purpose I/O port B
		AN9	A/D Channel 9
		PGM	Programming enable pin
		C12IN2-	Comparator C1 or C2 Negative Input
RB4/AN11	37	RB4	General purpose I/O port B
		AN11	A/D Channel 11
RB5/AN13/T1G	38	RB5	General purpose I/O port B
		AN13	A/D Channel 13
		T1G	Timer T1 External Input
RB6/ICSPCLK	39	RB6	General purpose I/O port B
		ICSPCLK	Serial programming Clock
RB7/ICSPDAT	40	RB7	General purpose I/O port B
		ICSPDAT	Programming enable pin

3.2 Precision Resistor

A precision resistor is a normal resistor with very close to accurate ohmic values.

They would have an incredibly low tolerance value when compared to ordinary resistors.

The lower the resistor tolerance value, the less deviation from the resistor value; the higher the resistor tolerance value, the more divergence from the actual standard value.

A film resistor or foil resistor is another name for a precision resistor.

The tolerance level is expressed as a percentage (%). Precision resistors have tolerances in the range of 0.005%, 0.025, 0.1, 0.01 percentage, and so on. A precision resistor is shown in **Figure 3.4**

Fig. 3.4: Precision Resistor.

3.2.1 Important factors of precision resistors

The Technology Involved: Wire wound, Metal Film, Metal Foil, Bare Metal, Thin Film were the technologies used. Resistor performance varies depending on the technology used.

Temperature Coefficient (ppm/°C): This is the amount that the Resistor value varies when the temperature changes by 1°C. 110 ppm/°C means that for every 1M Ohm resistance increase in temperature, the resistance increases by 110 Ohms. For other values, say 11 ohms for every 100k or 1.1 ohms for every 10k.

Operating Temperature: This is the temperature range in which the resistor is stable and can function without being harmed.

Power Rating: The power rating of a resistor specifies how much power it can handle without being destroyed.

3.2.2 Application of Precision resistor

Precision resistors offer that accuracy in the weighing machine's circuit. Electronic weighing machine/scales: An electronic weighing machine is a two-way device, and its focus must be completed with accuracy; precision resistors provide that accuracy in the weighing machine's circuit.

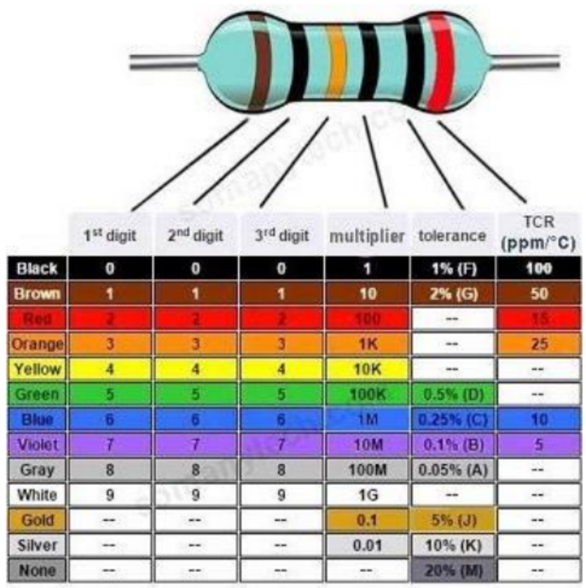
Audio application/low noise amplifier: One of the most often used devices that require precise very low noise resistors and other components is the audio device. A precision resistor has a very consistent and linear response. It's perfect for audio applications.

Industry of commercial aviation: The aeroplane's onboard equipment must be extremely accurate in order to operate and handle the essential conditions of such a massive machine.

Precision resistors are installed in measuring instruments and metres such as digital multimeters, LC metres, audio metres, altimeters, as well as other types of measuring equipment that has to give the measured value of a specific physical or electrical condition.

3.2.3 Precision Resistor Color Code

5 band and 6 band resistor colour code is generally used to indicate the colour code of Precision resistors, the following table showing 5/ 6 band resistor colour code. These colour codes have individual values for the easy calculation of the resistivity of the resistors shown in **Figure 3.5**.



	1st digit	2nd digit	3rd digit	multiplier	tolerance	TCR (ppm/°C)
Black	0	0	0	1	1% (F)	100
Brown	1	1	1	10	2% (G)	50
Red	2	2	2	100	--	15
Orange	3	3	3	1K	--	25
Yellow	4	4	4	10K	--	--
Green	5	5	5	100K	0.5% (D)	--
Blue	6	6	6	1M	0.25% (C)	10
Violet	7	7	7	10M	0.1% (B)	5
Gray	8	8	8	100M	0.05% (A)	--
White	9	9	9	1G	--	--
Gold	--	--	--	0.1	5% (J)	--
Silver	--	--	--	0.01	10% (K)	--
None	--	--	--	--	20% (M)	--

Fig 3.5: Precision Resistor colour code [10].

3.3 Function Generator

A function generator is a piece of electronic test equipment or software that develops many sorts of electrical waveforms over a wide range of frequencies. The sine wave, square wave, triangle wave, and sinusoidal signal waveforms are some of the most frequent waveforms generated by the function generator.

3.4 ICL8038

The 8038 waveform generator in **Figure 3.6** is a modular 8-bit microcontroller that can produce high-precision sine, square, triangular, sawtooth, and pulse waveforms with few external components. External resistors or capacitors can be used to adjust the frequency (or repetition rate) from 0.001Hz to more than 300kHz, and an external voltage can be used to modulate and sweep the frequency. The 8038 is made with superior monolithic technology and Schottky barrier diodes and thin-film resistors, and its output is stable across a wide temperature and supply range. To reduce temperature drift, these devices can be connected to phase-locked loop circuitry to less than 250ppm/oC.

Fig. 3.6: ICL8038 [11]

3.4.1 Features

- Low Frequency Drift with Temperature. 250ppm/oC
- Low Distortion. . . . . 1% (Sine Wave Output)
- High Linearity . . . . 0.1% (Triangle Wave Output)
- Wide Frequency Range . . . . 0.001Hz to 300kHz
- Variable Duty Cycle . . . . 2% to 98%
- High Level Outputs . . . . TTL to 28V
- Simultaneous Sine, Square, and Triangle Wave Outputs
- Easy to Use - Just a Handful of External Components Required

3.4.2 Block Diagram Of ICL8038

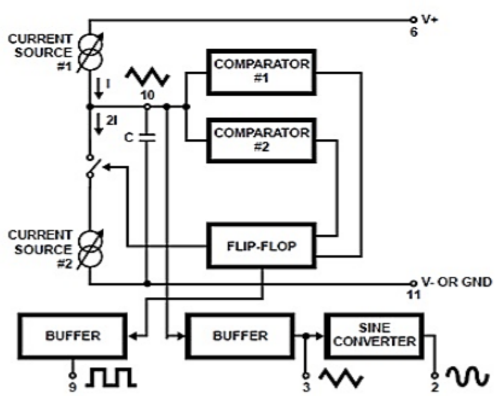


Fig. 3.7: Block Diagram Of ICL8038 [12]

3.5 Quartz Crystal Oscillators

Frequency stability, or the capacity to provide a steady frequency output under shifting load conditions, is one of the most critical characteristics of an oscillator. Temperature, variations in the load, and changes in the DC power source are all factors that affect an oscillator's frequency stability. The frequency stability of the output signal can be enhanced by carefully selecting the components for the resonant feedback circuit, including the amplifier, although standard LC and RC tank circuits have a limit to their stability. A quartz crystal is generally applied as the frequency source to achieve an extremely high oscillator stability device that determines whether or not to make another form of oscillator circuit known as a Quartz Crystal Oscillator (XO). A 4 MHz crystal oscillator is used in this project which is shown in **Figure 3.8**

Fig. 3.8: Construction of Quartz Crystal Oscillator [13].

3.6 Op-Amp LM324

These devices in Figure 3.9 are divided into four main independent high-gain frequency-compensated operational amplifiers that are designed to operate over a wide selection of voltages from a single supply or split source.

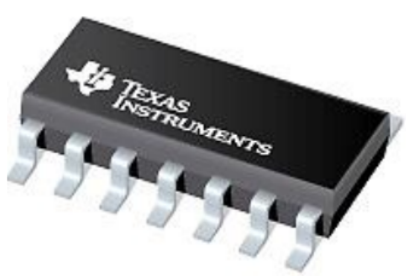


Fig. 3.9: Op-Amp [14]

3.6.1 Features

2-kV ESD Protection for:

- LM224K, LM224KA
- LM324K, LM324KA
- LM2902K, LM2902KV, LM2902KAV

Wide Supply Ranges

- Single supply:3V to 32V
  (26 V for LM2902)
- Dual Supplies: ±1.5 V to ±16 V
  (±13 V for LM2902)
- Low supply current drain independent of supply voltage: 0.8 mA typical
- Common-Mode input voltage range includes ground, allowing direct sensing near the ground
- Low Input bias and offset parameters
- Input Offset Voltage: 3 mV typical
  A Versions: 2 mV Typical
- Input Offset Current: 2 nA Typical
- Input Bias Current: 20 nA Typical
  A Versions: 15 nA Typical
- Differential input voltage range equal to maximum-rated supply voltage: 32 V (26 V for LM2902)
- Open-Loop differential voltage amplification: 100 V/mV Typical
- Internal frequency compensation
- On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. on all other products, production processing does not necessarily include testing of all parameters.3.6.2

3.6.2 Block Diagram of Op-Amp LM324

The Block Diagram of Op-Amp LM324 is projected in **Figure 3.10**.

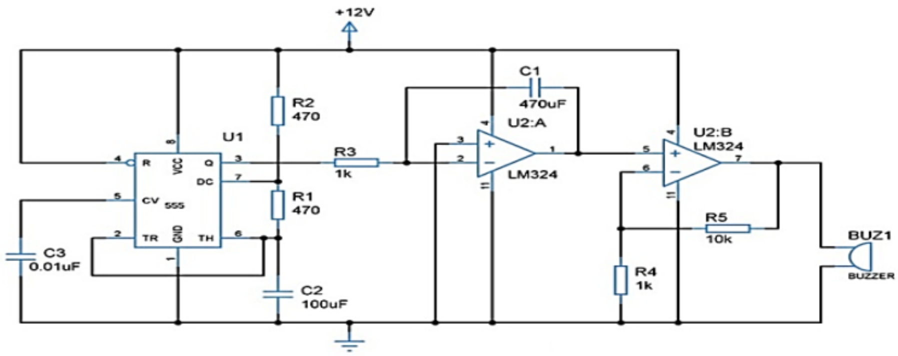


Fig. 3. 10: Block Diagram of Op-Amp LM324

3.7 LCD Display

Standard HD44780 LCDs in **Figure 3.11** are useful for creating standalone projects.

- 16 characters wide, 2 rows shown in **Figure 4.5**
- White text on blue background.
- The connection port is 0.1" pitch, single row for easy breadboarding and wiring.
- Pins are documented on the back of the LCD to assist in wiring it up.
- Single LED backlight included can be dimmed easily with a resistor or PWM and uses much less power than LCD with EL (electroluminescent) backlights.
- Can be fully controlled with only 6 digital lines (Any analogue/digital pins can be used).

Fig. 3.11: LCD

3.7.1 Pin Configuration of LCD

Table 3.3: Pin Configuration of LCD [15]

Pin	Name	Function	Connection
1	VSS	Ground	GND
2	VCC	Positive supply for LCD	5V
3	VEE	Brightness adjust	Connected to a trimmer to adjust LCD brightness
4	RS	Select register, select instruction or data register	RC0
5	R/W	Select read or write	GND
6	E	Start data read or write	RC1
7	DB0	Data bus pin	
8	DB1	Data bus pin	
9	DB2	Data bus pin	
10	DB3	Data bus pin	
11	DB4	Data bus pin	RC4
12	DB5	Data bus pin	RC5
13	DB6	Data bus pin	RC6
14	DB7	Data bus pin	RC7
15	LED+	Backlight positive input	
16	LED-	Backlight negative input	

3.8 Voltage regulator

A voltage regulator that outputs +5 volts is an LM7805 shown in **Figure 3.12** Voltage Regulator. A voltage regulator that outputs +5 volts is an LM7805 Voltage Regulator. The last two digits of the number are a simple way to identify the voltage output of an LM78XX series of voltage regulators. An LM7805 has a "05" at the end of its name, denoting that it produces 5 volts. The "78" part is mainly a chip maker's standard for referring to a series of positive voltage regulators [16].

Fig. 3.12: Voltage Regulator 7805 [17].

3.8.1 Features

- 3-Terminal Regulators.
- Regulated up to 40 V.
- **Pin1** (Input Pin): The Input pin is the pin that accepts the incoming DC voltage, which the voltage regulator will eventually regulate down to 5 volts.
- **Pin 2** (Ground): The ground pin establishes the ground for the regulator.
- **Pin 3** (Output Pin): The Output pin is the regulated 5 volts DC.

3.9 Transistor

Since the 8050 which is shown in Figure 3.13 is an NPN transistor when the base pin is held at the ground, the collector and emitter are left open (reverse biassed), and when a signal is applied to the base pin, they are closed (forward biassed). It has a maximum gain of 400, which specifies the transistor's amplification capacity, which is generally S8050. It is usually utilised for amplification because it is so high. The typical value of gain at a normal operating collector current, on the other hand, is 110. Because the Collector pin can only carry 700 milliamperes of current, we can't use this transistor to power loads that use more than 700 milliamperes. We must supply current to the base pin of a transistor to bias it, and this current (IB) should be limited to 5mA. When fully biassed, this transistor can enable a maximum of 700mA to flow between the collector and emitter. The normal voltage allowed across the Collector-Emitter (VCE) or Collector-Base (VCB) could be 20V or 30V, respectively, in the Saturation Region. The transistor gets entirely off when the base current is reduced; this stage is known as the Cut-off Region.

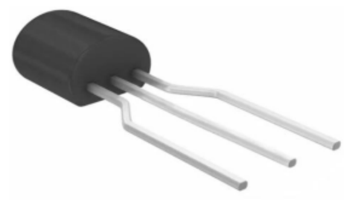


Fig. 3.13: Transistor [18]

3.9.1 Features

- Low Voltage, High Current NPN Transistor.
- Small Signal Transistor.
- Maximum Power: 2 Watts.
- Maximum DC Current Gain (hFE) is 400.
- Continuous Collector current (IC) is 700mA.
- Base- Emitter Voltage (VBE) is 5V.
- Collector-Emitter Voltage (VCE) is 20V.
- Collector-Base Voltage (VCB) is 30V.
- High Used in push-pull configuration doe Class B amplifiers
- Available in To-92 Package.

3.9.2 Block diagram of Transistor

The Block diagram of the Transistor is shown in **Figure 3.14**.

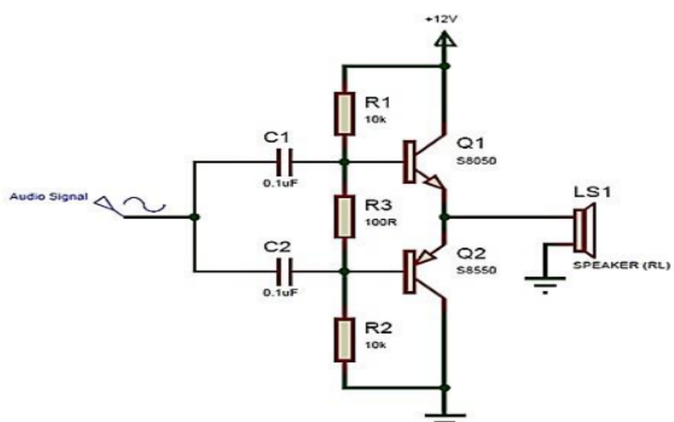


Fig. 3.14: Block diagram of Transistor [19]

3.10 LED

A two-lead semiconductor light source is the light-emitting diode shown in **Figure 3.15**. When activated, it is a P-N junction diode that emits light. Electrons can recombine with electron holes within the device when a sufficient current is provided to the leads, releasing energy in the form of photons. Low power consumption, great efficiency, and long life are all advantages of LEDs.

Fig. 3.15: LED [20]

3.11 Push Button

A push-button switch in **Figure 3.16** is a type of switch that is used to control a process. Plastic or metal buttons are the most common types of buttons. When someone pushes it, it can connect two places in a circuit. Because there is no connection between the two legs of the push button when it is not pressed, it is open and the reading will be high. When the button is pressed, it closes the circuit, resulting in a low reading as it joins two legs and connects the pin to the ground. One point of the resistor is connected to 12v, while the other connects the 10k resistor to the ground.

Fig. 3.16: Push Button [21]

CHAPTER 4

DESIGN AND IMPLEMENTATION

4.1 Block Diagram of Voltage Quality Control System

To run the system first we need to connect Microcontroller with the power supply as Microcontroller is the main control unit. On the input side, we have humidity, temperature, smoke sensor and some manual buttons. On the other hand, the output is shown on the LCD. The operational process of the MCU in Block is shown in **Figure 4.1**

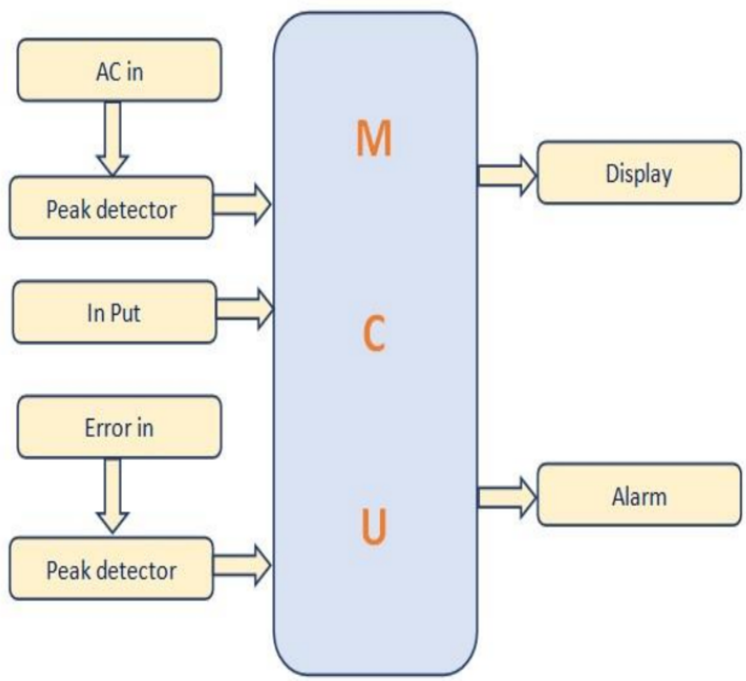


Fig. 4.1: Block Diagram

4.2 Circuit Diagram For Voltage Quality Control System

The Connection diagram between the pins of the MCU chip is shown in Figure 4.2. This device has two independent sections. The first section is shown in **Figure 4.2(b)** which is consisted of a function generator and AC reference which will be used to create the artificial deviated waveform later. The second section is shown in **Figure 4.2(c)** of the device consists of the main MCU chip and other materials that will be used to hold the waveform and sample them at our desirable state.

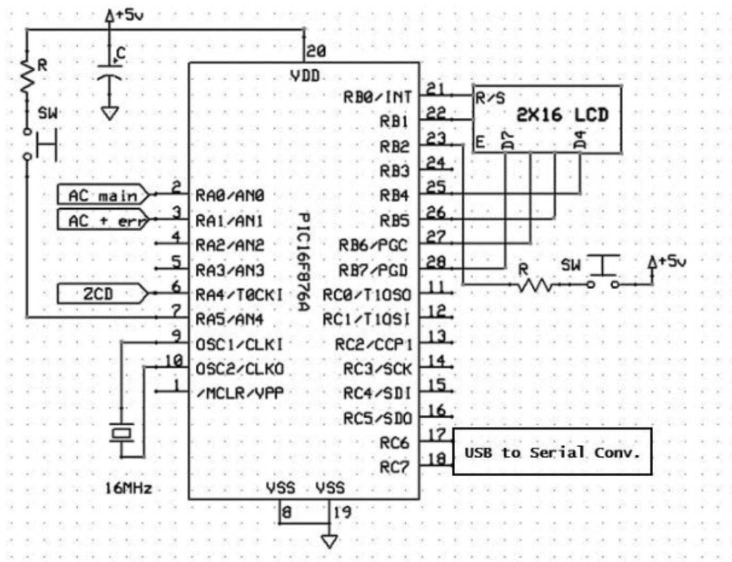


Fig. 4.2 (a): MCU pin Connection

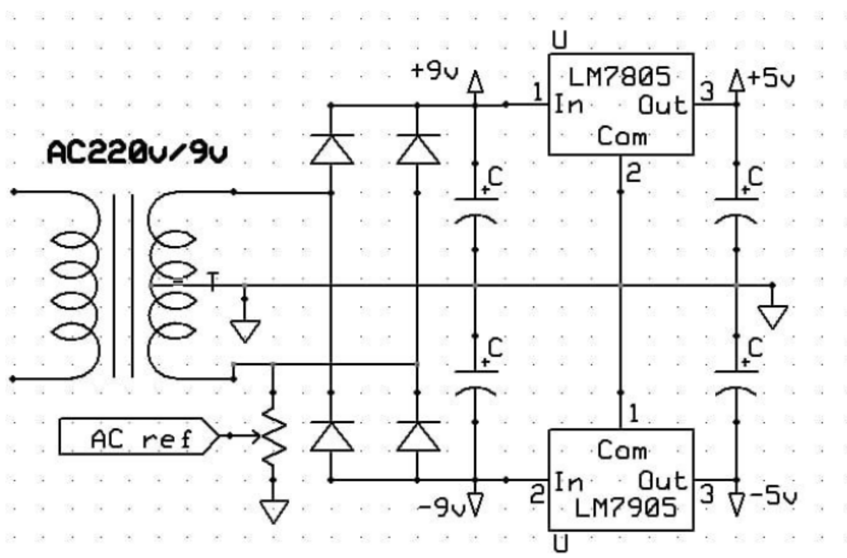


Fig. 4.2 (b): Diagram of the power supply portion of the circuit

4.3 Methodology

As we've mentioned earlier in this project we will try to sample the waveform from a phase voltage. Sampling a wave-form is not an easy task. It's quietly common to question why we need to sample the wave-form? We need to sample the wave-form because the data coming from every single possible portion of a wave-form. We want to take 20 data from 20 sampling rates to check the voltage of those portions. So that we can easily identify the distortion or deviation.

4.3.1 Working Principle

As input, we used 220 V phase voltage as the reference voltage. We used a step-down transformer to down the voltage at our desirable state which is 9V×2 600mA. We work with this voltage. Because we worked with a microcontroller that can not possess voltage more than 5 V.

The stepped-down voltage then will go into two Ics (LM7805) shown in Figure 4.2(b) to be identified individually for (+)ve 5v and (-)ve 5v. Because for operating the MCU we need only (+)ve. These two voltages will go to the 2nd portion of the circuit shown in **Figure 4.2(c).**

In the second portion shown in **Figure 4.2(c),** we sample the waveform and transferred this data to our computer. So that we can plot these data and analyse the voltage if it is in well-condition or not. We made a deviated waveform making circuit which is actually an operational amplifier. This operational amplifier took an AC input from the ICL-8038 and another from the output of the adder. By using these two inputs this opAmp generates a deviated waveform. We designed this circuit as an extension and optional purpose. The purpose was, our system worked on the AC phase 220V. So, deviation in a phase voltage is not a common affair. In case, if there happens no deviation in the phase voltage, we designed an artificial deviation for the detection to see if our system can detect it or not.

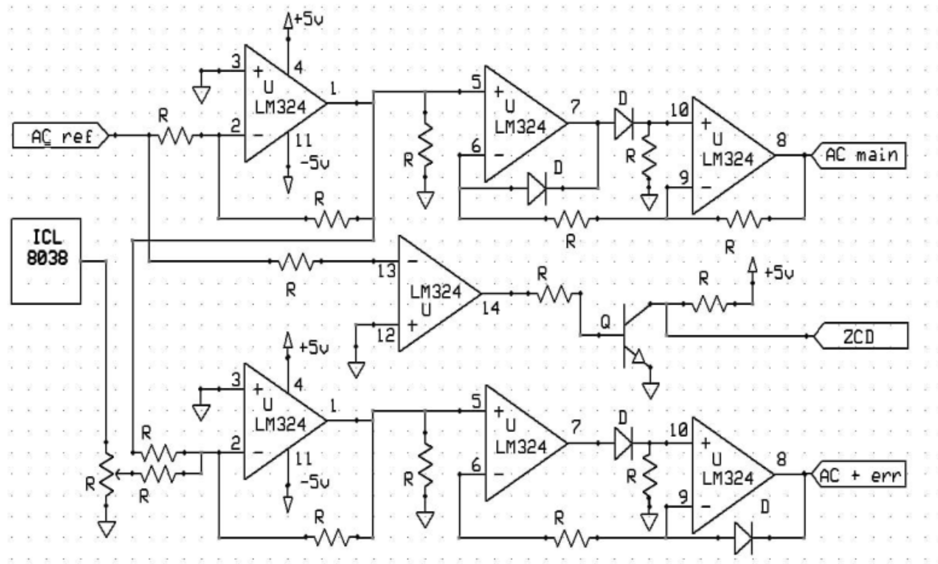


Fig. 4.2 (c): Diagram of the 2nd Circuit (Sampling and output section)

4.3.2 Circuit Operation

In the circuit shown in **Figure 4.2(d)** we have an adder noted with 5 and a phase shifter. The reason for using the adder is to make a deviated waveform as we have mentioned earlier. This adder has two input come from the ICL-8038 function generator and another one come from the output of the phase shifter. Using these two signals the adder will deliver a deviated waveform. This wave-form will be used in case we find no deviation from the phase voltage. We need the phase shifter as shown in **Figure 4.2(d)** noted with 1 just because to keep it in phase with the adder. After changing the phase from 1 of **Figure 4.2(d)** we send it to the peak detector circuit which is noted with 2 and 3 combined in **Figure 4.2(d)**. The Peak detector circuit will send this data into the MCU Chip. Same for the noted 5 which is also sent into the MCU Chip through peak detector circuit. We use a zero-crossing detector because the operational amplifier is working on ± 5V.

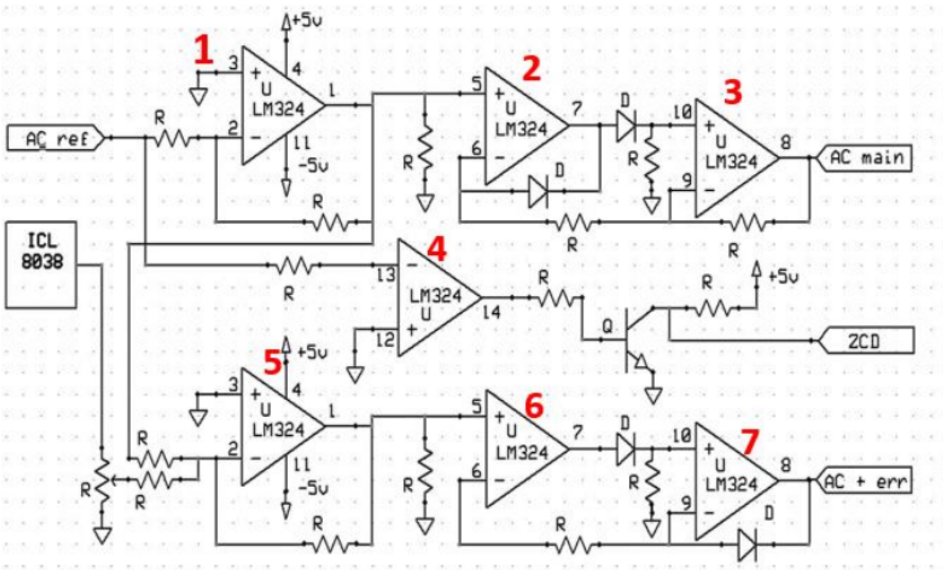


Fig. 4.2(d) Notation of Diagram of the 2nd Circuit (Sampling and output section)

4.4 Outlook of Voltage Quality Control System

The outlook view of this project is given in **Figure 4.3.**

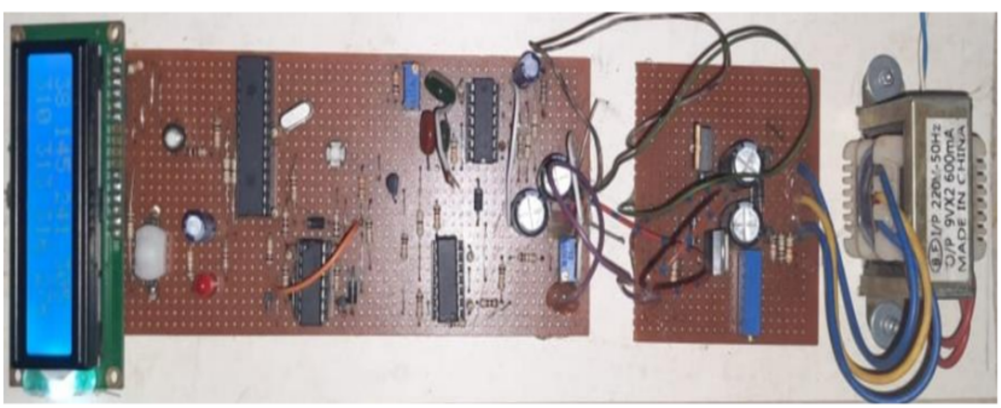


Fig. 4. 2: Voltage Quality Control System

4.5 Internal figure of Voltage Quality Control System

Internal detailed view of this project is given in **Figure 4.3**:

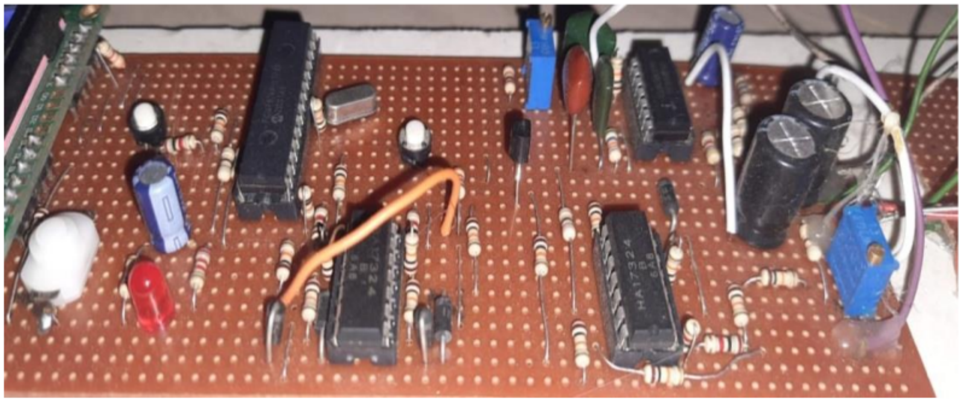


Fig. 4.4: Internal figure of **Voltage Quality Control System**

4.6 List of Components & Cost Analysis

Table 4.1: List of components & cost analysis

S.N.	Component Name	Price (Taka)
1	Microcontroller (PIC16F73)	250
2	Op-Amp	200
3	LCD Display (16*2)	250
4	Battery	50
5	Crystal Oscillator (4MHz)	30
6	Touch Switch	110
7	Registor (1k,10k)	15
8	Voltage Regulator	20
9	On/Off Switch	20

10	LED	4
11	Box	60
12	Wire	50
1	Board(PVC)	100
14	Vero board	30
15	Lead	40
16	Precision Resistor	100
17	Function Generator	300
Total Cost		**1559**

4.7 Results Interpretation & Analysis

The analysis entails deciphering recorded data and assessing the influence of voltage quality on electrical installations and equipment. The analysis might be done on a regular basis (for example, once a month) or on an as-needed basis (when there is a problem potentially caused by Voltage Quality Disturbance)

Voltage Quality problems should be correlated with equipment damage, malfunction, or electric installation downtime by a competent, qualified, and experienced individual with skills in Voltage Quality, Electric Installation, and Equipment. A Voltage Quality monitoring system can also help with measurement analysis and interpretation. For warning and system behaviour prediction, automated processing of power quality data based on a known baseline of voltage and current parameters, trend limitations, and custom models can be employed. VQM professionals can benefit from automated model-based analysis of long-term PQ parameter trends.

The Voltage Quality Monitoring System may also estimate losses owing to poor power quality, which is a cost component of power quality [21]. The cost-benefit analysis of power quality solutions and the return on investment evaluations of Voltage Quality Monitoring Systems are made easier by "putting a price tag" on power quality concerns.

4.8 Corrective and Preventive Actions

Various alternatives can be suggested based on the analysis results and conclusions. They could include equipment for reducing voltage quality disturbances, changes to settings, changes to design and architecture, or even the selection of equipment that is less sensitive to power quality disturbances.

Harmonic monitoring is used to highlight corrective and preventive activities as well as their implementation sector.

CHAPTER 5

RESULT AND OUTCOMES

5.1 Introduction

When we talk about monitoring of the voltage there is a question arise that when? When we want to monitor the voltage is the main matter because, at different times in a day, the condition of the voltages varies from one another. It happens because of the workload and voltage demand in the different portions of time in a single day.

We've already mentioned the period of total time when we should take the value of the voltage which was "A whole Week Data". So, we'd decided to take the value of voltage 3 times a day (Late Morning, Mid-Day and Late Night). The Graphs are shown from Figure 5.1 to Figure 5.21

5.2 Graphs and Analysis

Day 1.

Late Morning:

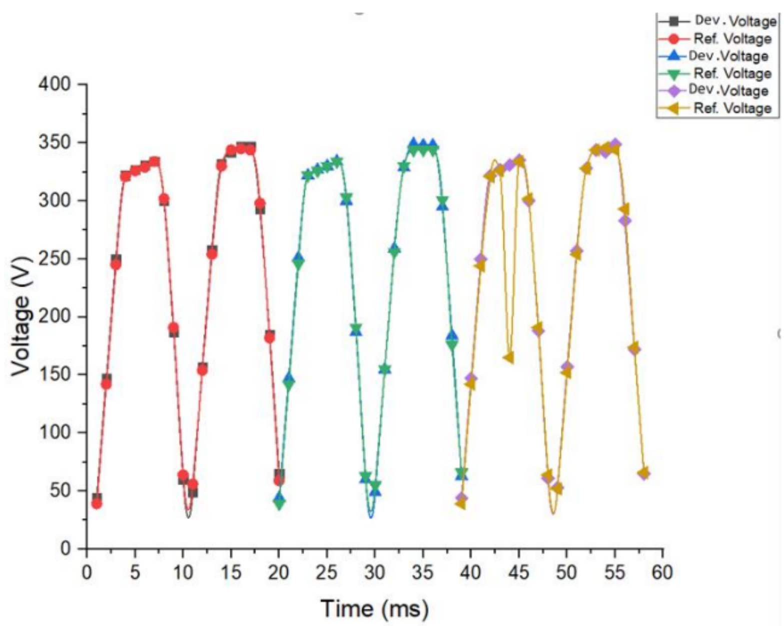


Fig. 5.1: Time Voltage Curve for the late morning of Day 1

RMS Value of 1st **Reference** waveform **=** 233.08 V

RMS Value of 1st **Deviated** waveform = 232. 86 V

RMS Value of 2nd **Reference** waveform = 234.15 V

RMS Value of 2nd **Deviated** waveform = 233.39 V

RMS Value of 3rd **Reference** waveform = 233.53 V

RMS Value of 3rd **Deviated** waveform = 221.92 V

Deviated wave-form of Voltage in Figure 5.1 is seen from 43 ms to 46 ms

Mid-Day:

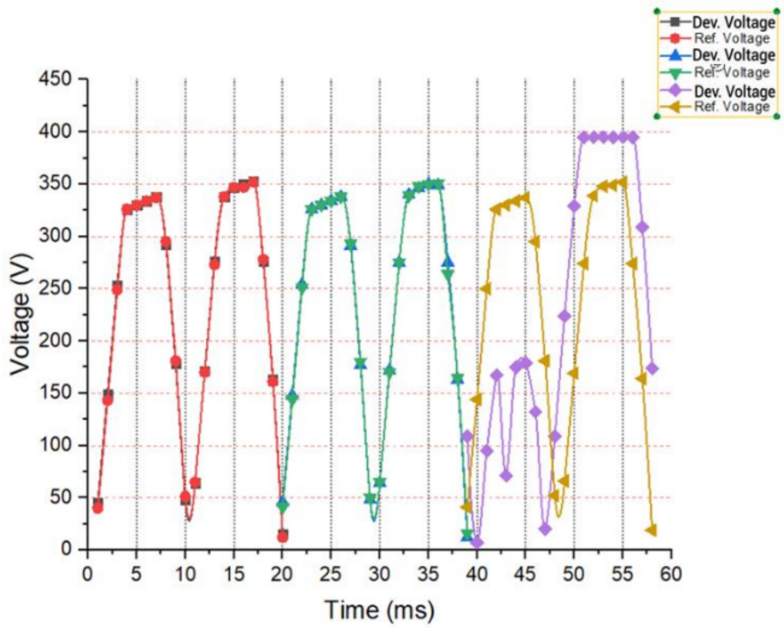


Fig. 5.2: Time Voltage Curve for the Mid-Day of Day 1

RMS Value of 1st **Reference** waveform **=** 257.83 V

RMS Value of 1st **Deviated** waveform = 257.72 V

RMS Value of 2nd **Reference** waveform = 257.72 V

RMS Value of 2nd **Deviated** waveform = 257.50 V

RMS Value of 3rd **Reference** waveform = 256.93 V

RMS Value of 3rd **Deviated** waveform = 244.51 V

Deviated wave-form of Voltage in Figure 5.2 is seen from 41 ms to 43 ms

Late Night:

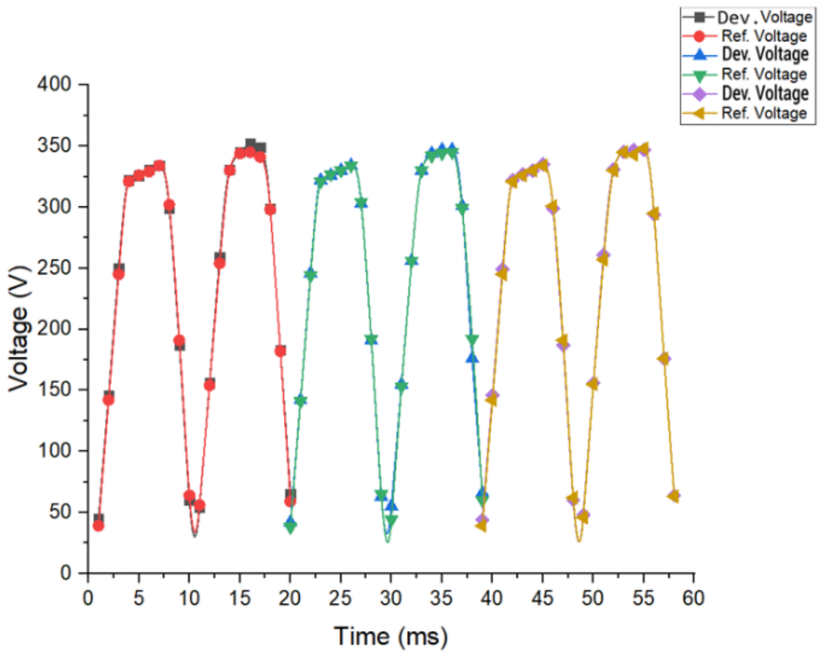


Fig. 5.3 Time Voltage Curve for the Late-Night of Day 1

RMS Value of 1st **Reference** waveform = 257.09 V

RMS Value of 1st **Deviated** waveform = 259.90 V

RMS Value of 2nd **Reference** waveform = 257.75 V

RMS Value of 2nd **Deviated** waveform 258. 66 V

RMS Value of 3rd **Reference** waveform = 257.79 V

RMS Value of 3rd **Deviated** waveform = 258.81 V

Deviated wave-form of Voltage in Figure 5.3 is seen no deviation

Day 2:

Late Morning:

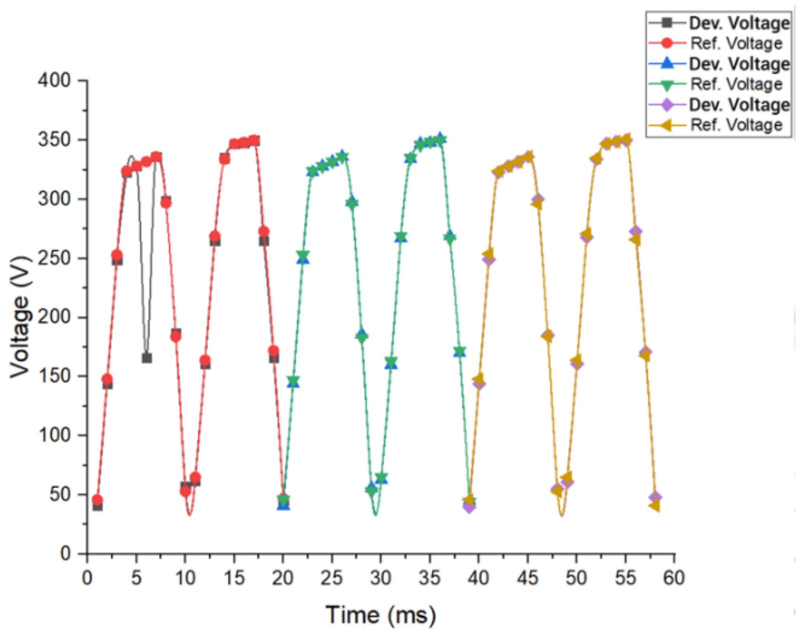


Fig. 5.4 Time Voltage Curve for the late morning of Day 2

RMS Value of 1st **Reference** waveform **=** 224.45 V

RMS Value of 1st **Deviated** waveform = 208.64 V

RMS Value of 2nd **Reference** waveform = 223.79 V

RMS Value of 2nd **Deviated** waveform = 224.19 V

RMS Value of 3rd **Reference** waveform = 223.32 V

RMS Value of 3rd **Deviated** waveform = 221.97 V

Deviated wave-form of Voltage in Figure 5.4 is seen from 5 ms to 9 ms

Mid-Day:

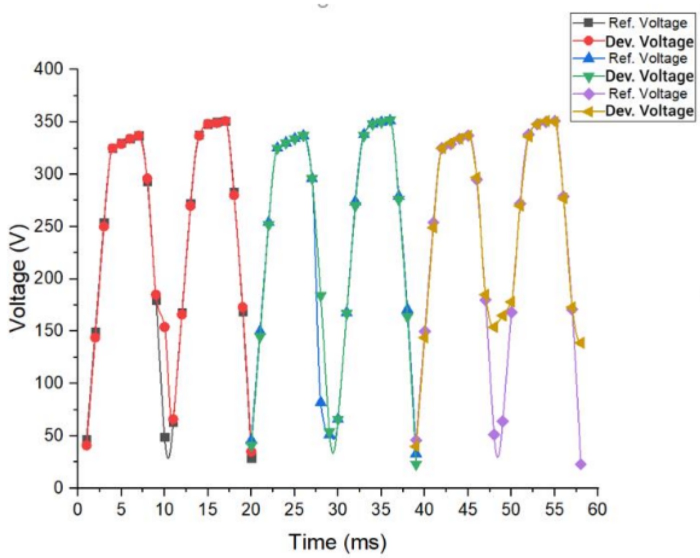


Fig. 5.5 Time Voltage Curve for the Mid-Day of Day 2

RMS Value of **1st Reference** waveform **=** 259.45 V

RMS Value of **1st Deviated** waveform = 261.10 V

RMS Value of **2nd Reference** waveform = 257.15 V

RMS Value of **2nd Deviated** waveform 258.85 V

RMS Value of **3rd Reference** waveform = 259.43 V

RMS Value of **3rd Deviated** waveform = 265.29 V

Deviated wave-form of Voltage in Figure 5.5 is seen from 11ms to 12ms, 28ms to 30ms and 47ms to 50ms

Late Night:

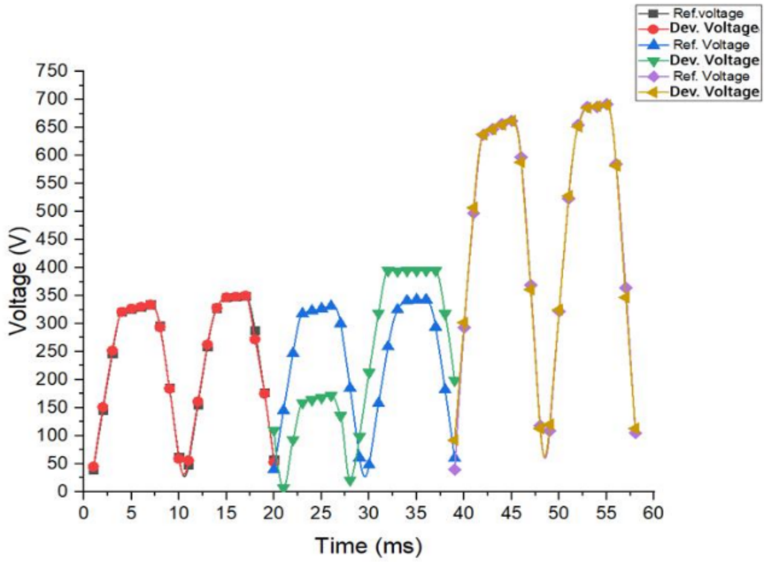


Fig 5.6. Time Voltage Curve for the Late Night of Day 2

RMS Value of 1st **Reference** waveform **=** 257.08 V

RMS Value of 1st **Deviated** waveform = 256.88 V

RMS Value of 2nd **Reference** waveform = 255.75 V

RMS Value of 2nd **Deviated** waveform = 262.93 V

RMS Value of 3rd **Reference** waveform = 512.56 V

RMS Value of 3rd **Deviated** waveform = 512.49 V

Deviated wave-form of Voltage in Figure 5.6 is seen from 21 ms to 40 ms

Day 3:

Late Morning:

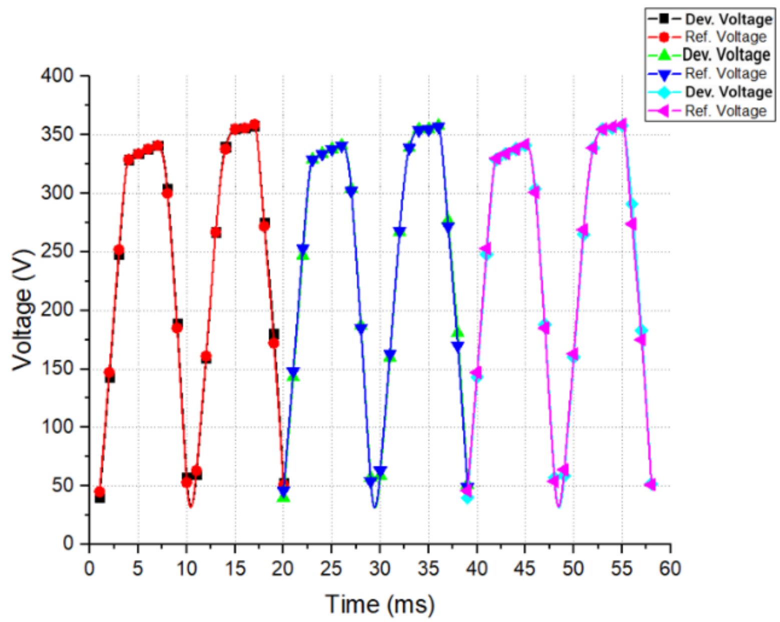


Fig. 5.7 Time Voltage Curve for the late morning of Day 3

RMS Values:

RMS Value of 1st **Reference** waveform **=** 261.50 V

RMS Value of 1st **Deviated** waveform = 261.99 V

RMS Value of 2nd **Reference** waveform = 261.53 V

RMS Value of 2nd **Deviated** waveform = 261.87 V

RMS Value of 3rd **Reference** waveform = 256.74 V

RMS Value of 3rd **Deviated** waveform = 257.19 V

Deviated wave-form of Voltage in Figure 5.7 is seen no deviation

Mid-Day:

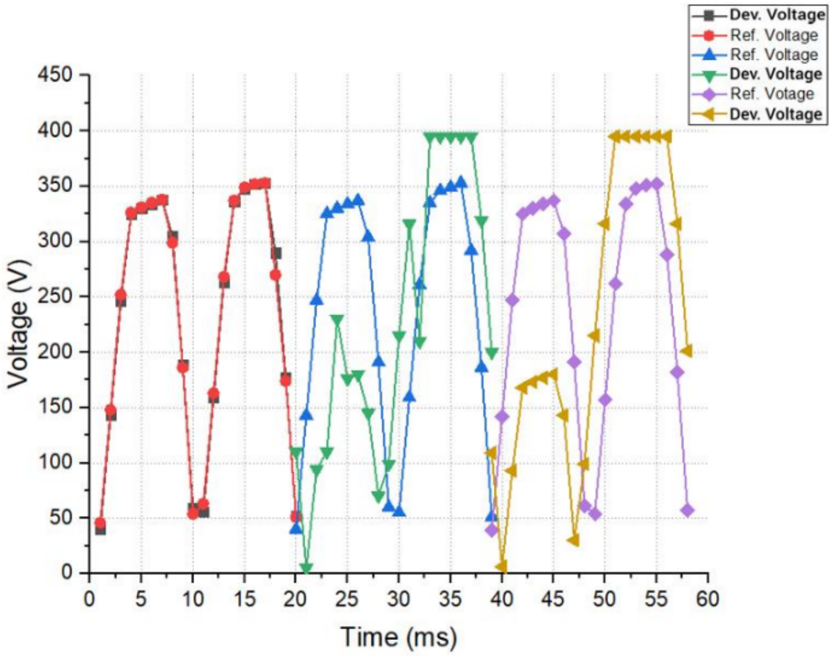


Fig. 5.8 Time Voltage Curve for the Mid-Day of Day 3

RMS Value of 1st **Reference** waveform **=** 259.68 V

RMS Value of 1st **Deviated** waveform = 260.41 V

RMS Value of 2nd **Reference** waveform = 260.11 V

RMS Value of 2nd **Deviated** waveform = 254.20 V

RMS Value of 3rd **Reference** waveform = 261.43 V

RMS Value of 3rd **Deviated** waveform = 264.20 V

Deviated wave-form of Voltage in Figure 5.8 is seen from 20 ms to 60 ms

Late Night:

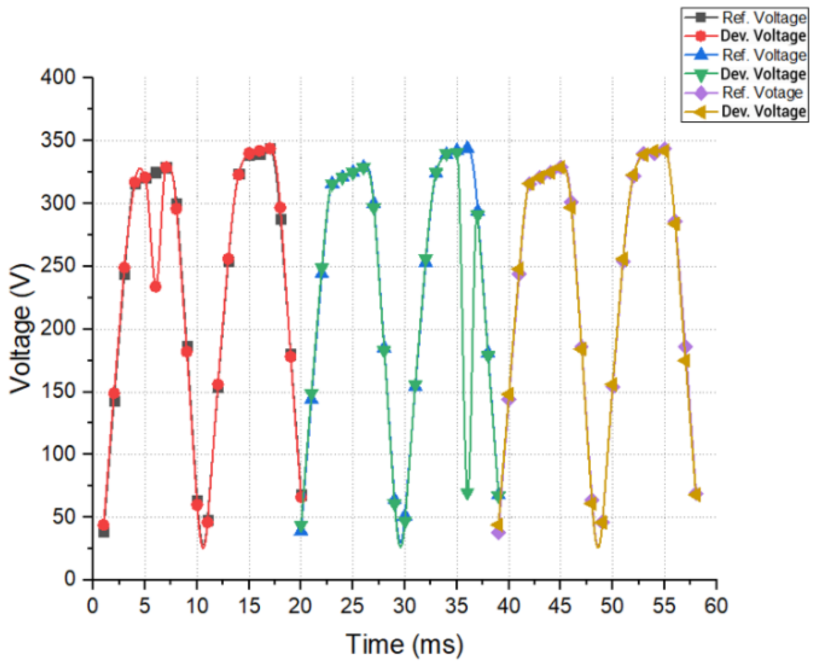


Fig. 5.9 Time Voltage Curve for the Late Night of Day 3

RMS Value of **1st Reference** waveform **=** 254.13 V

RMS Value of **1st Deviated** waveform = 249.84 V

RMS Value of **2nd Reference** waveform = 255.09 V

RMS Value of **2nd Deviated** waveform = 243.31 V

RMS Value of **3rd Reference** waveform = 254.98 V

RMS Value of **3rd Deviated** waveform = 254.21

Deviated wave-form of Voltage in Figure 5.9 is seen from 4ms to 6ms and 36ms to 38ms

Day: 4

Late Morning:

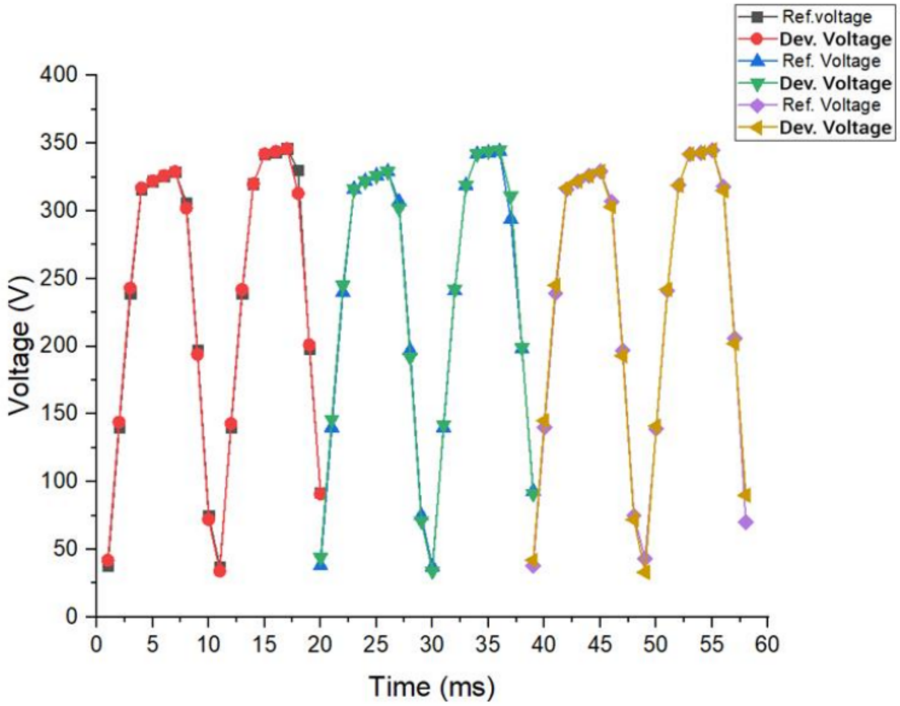


Fig. 5.10 Time Voltage Curve for the late morning of Day 4

RMS Value of **1st Reference** waveform **=** 257.45 V

RMS Value of **1st Deviated** waveform = 256.75 V

RMS Value of **2nd Reference** waveform = 257.49 V

RMS Value of **2nd Deviated** waveform 256.81 V

RMS Value of **3rd Reference** waveform = 257.21 V

RMS Value of **3rd Deviated** waveform = 256.79 V

Deviated wave-form of Voltage in Figure 5.10 is seen no deviation

Mid-Day:

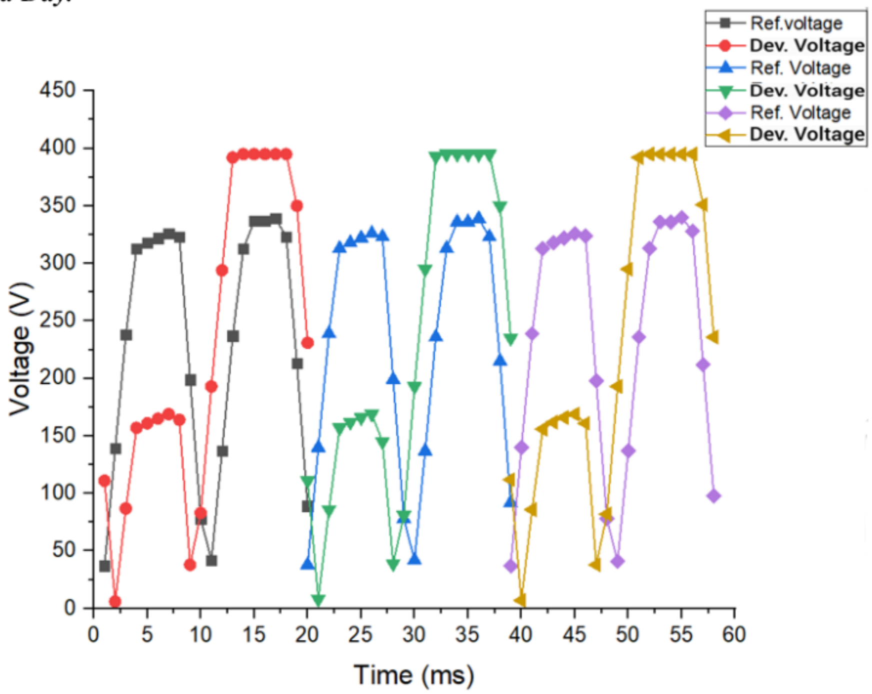


Fig. 5.11 Time Voltage Curve for the Mid-Day of Day 4

RMS Value of 1st **Reference** waveform **=** 256.002 V

RMS Value of 1st **Deviated** waveform = 264.08 V

RMS Value of 2nd **Reference** waveform = 256.13 V

RMS Value of 2nd **Deviated** waveform = 266.21 V

RMS Value of 3rd **Reference** waveform = 256.43 V

RMS Value of 3rd **Deviated** waveform = 267.74 V

Deviated wave-form of Voltage in Figure 5.11 is seen from 1 ms to 60 ms

Late Night:

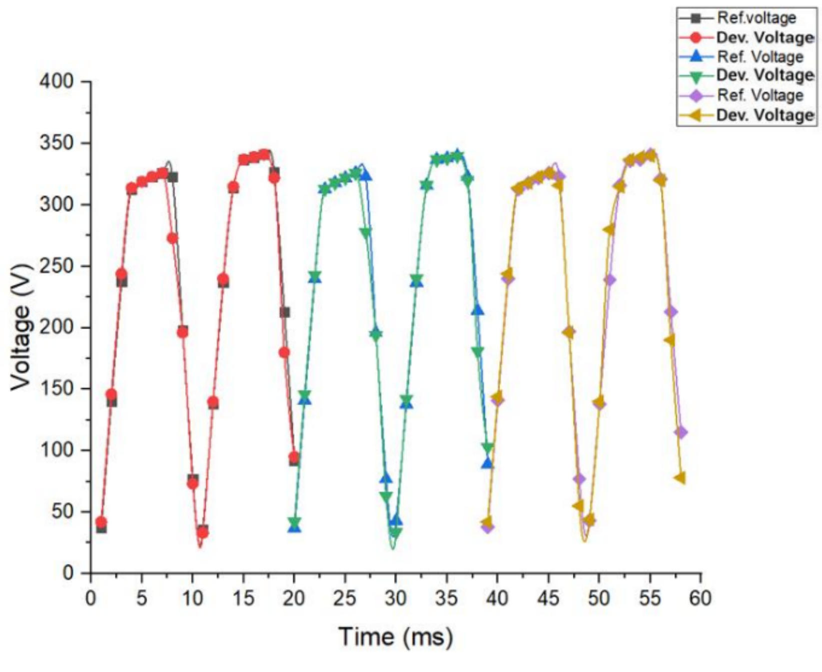


Fig. 5.12 Time Voltage Curve for the Late-Night of Day 4

RMS Value of **1st Reference** waveform = 256.71 V

RMS Value of **1st Deviated** waveform = 252.90 V

RMS Value of **2nd Reference** waveform = 256.75 V

RMS Value of **2nd Deviated** waveform = 252.93 V

RMS Value of **3rd Reference** waveform = 256.78 V

RMS Value of **3rd Deviated** waveform = 252.91 V

Deviated wave-form of Voltage in Figure 5.12 is seen from 5ms to 6ms and 29ms to 30ms

Day 5:

Late Morning:

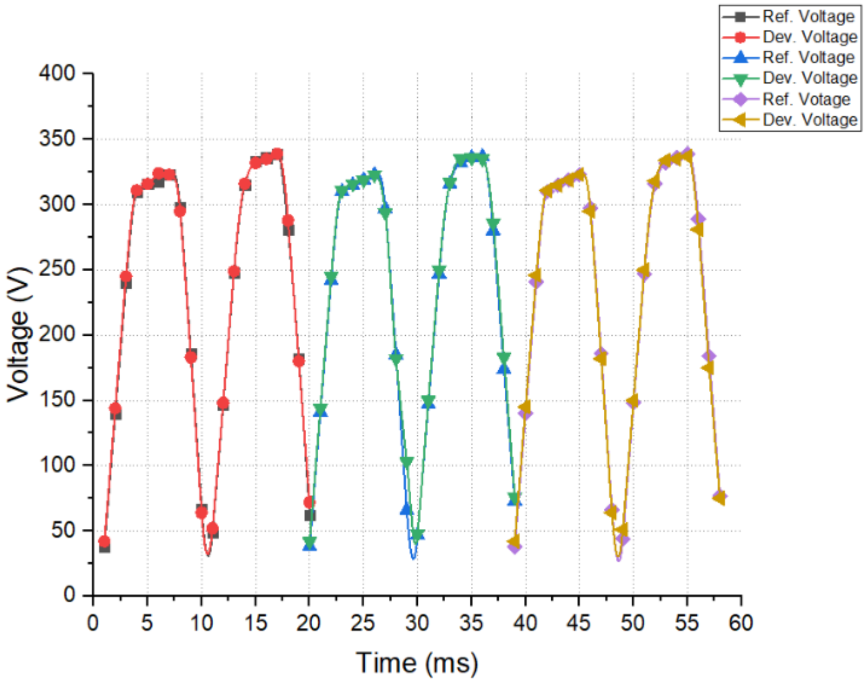


Fig. 5.13 Time Voltage Curve for the late morning of Day 5

RMS Value of 1st **Reference** waveform **=** 249.73 V

RMS Value of 1st **Deviated** waveform = 239.16 V

RMS Value of 2nd **Reference** waveform = 249.34 V

RMS Value of 2nd **Deviated** waveform = 251.15 V

RMS Value of 3rd **Reference** waveform = 250.37 V

RMS Value of 3rd **Deviated** waveform = 250.08 V

Deviated wave-form of Voltage in Figure 5.13 is seen no deviation

Mid Day:

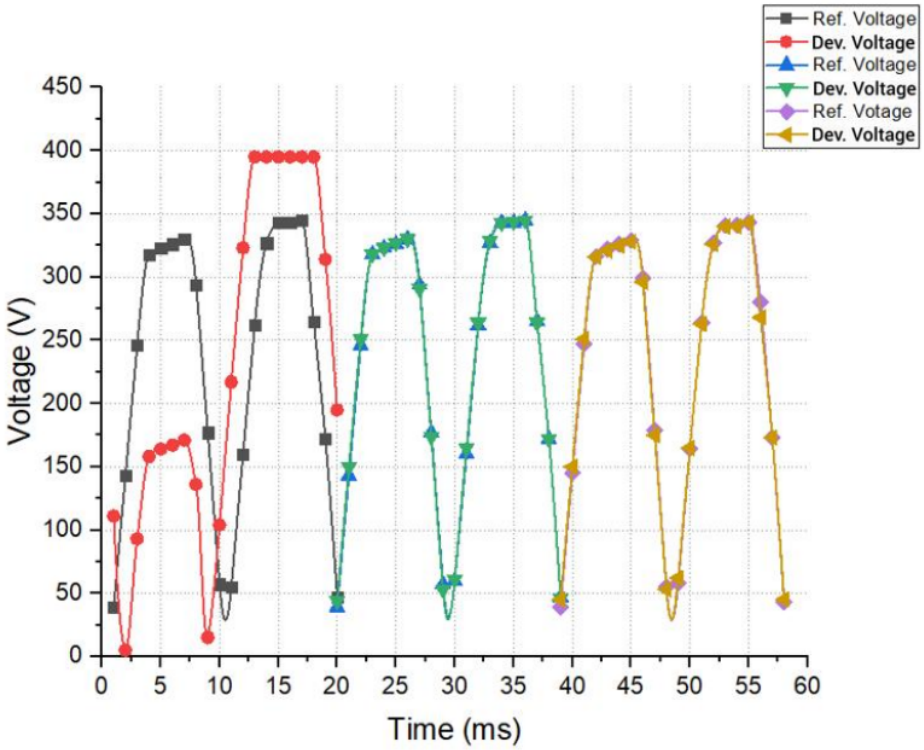


Fig. 5.14 Time Voltage Curve for the Mid-Day of Day 5

RMS Value of 1st **Reference** waveform = 240.26 V

RMS Value of 1st **Deviated** waveform = 226.49 V

RMS Value of 2nd **Reference** waveform = 238.38 V

RMS Value of 2nd **Deviated** waveform = 238.49 V

RMS Value of 3rd **Reference** waveform = 240.73 V

RMS Value of 3rd **Deviated** waveform = 239.98 V

Deviated wave-form of Voltage in Figure 5.14 is seen from 1ms to 20ms

Late Night:

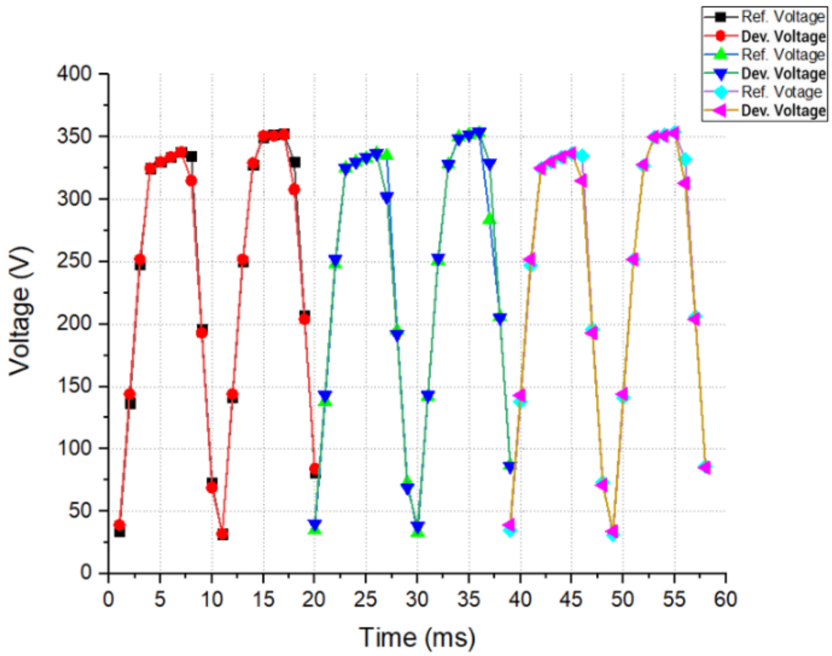


Fig. 5.15 Time Voltage Curve for the Late-Night of Day 5

RMS Value of 1st **Reference** waveform **=** 243.79 V

RMS Value of 1st **Deviated** waveform = 241.46 V

RMS Value of 2nd **Reference** waveform = 242.52 V

RMS Value of 2nd **Deviated** waveform = 238.59 V

RMS Value of 3rd **Reference** waveform = 241.49 V

RMS Value of 3rd **Deviated** waveform = 240.63 V

Deviated wave-form of Voltage in Figure 5.15 is seen in 9ms and 19ms and 29ms and 38ms and 45ms and 60ms

Day 6:

Late-Morning:

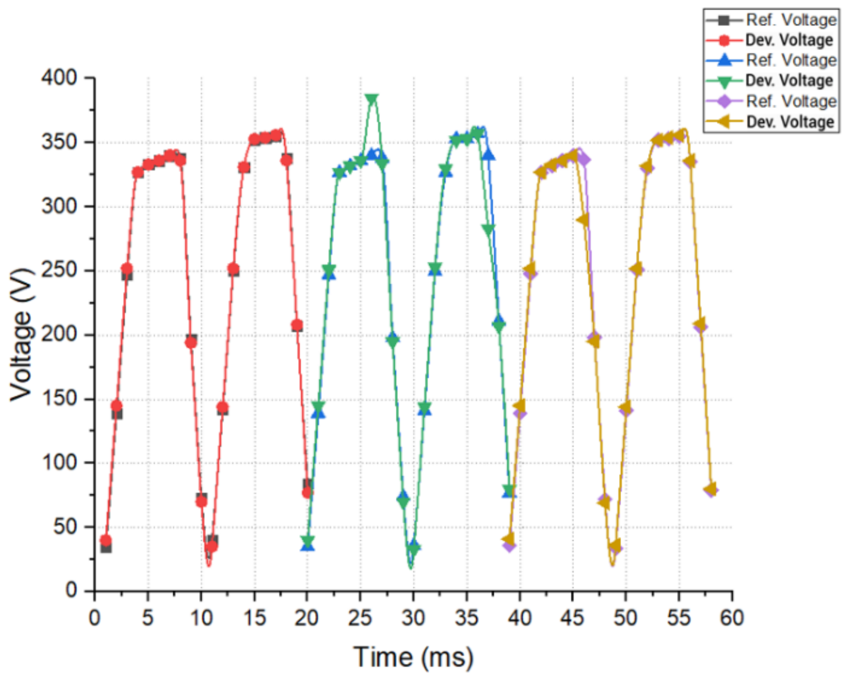


Fig. 5.16 Time Voltage Curve for the late morning of Day 6

RMS Value of **1st Reference** waveform **=** 255.73 V

RMS Value of **1st Deviated** waveform = 257.77 V

RMS Value of **2nd Reference** waveform = 255.19 V

RMS Value of **2nd Deviated** waveform = 260.21 V

RMS Value of **3rd Reference** waveform = 254.89 V

RMS Value of **3rd Deviated** waveform = 256.29 V

Deviated wave-form of Voltage in Figure 5.16 is seen from 25ms to 26 ms and 39ms to 40ms and 49ms to 50ms

Mid-Day:

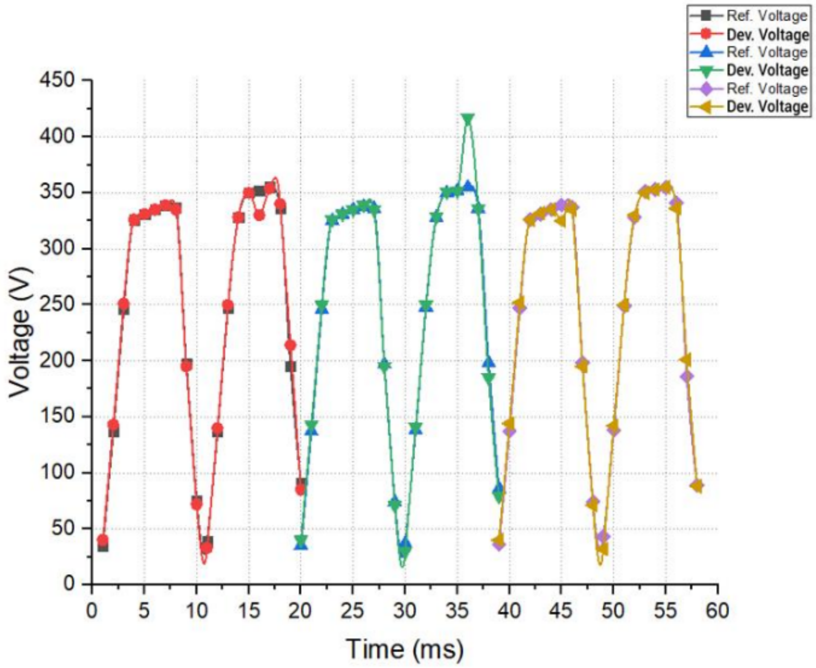


Fig. 5.17 Time Voltage Curve for the Mid-Day of Day 6

RMS Value of **1st Reference** waveform **= 255.56 V**

RMS Value of **1st Deviated** waveform = 253.91 V

RMS Value of **2nd Reference** waveform = 255.19 V

RMS Value of **2nd Deviated** waveform = 258.37 V

RMS Value of **3rd Reference** waveform = 256.21 V

RMS Value of **3rd Deviated** waveform = 255.81 V

Deviated wave-form of Voltage in Figure 5.17 is seen from 15ms to 16 ms and 35ms to 36ms

Late Night:

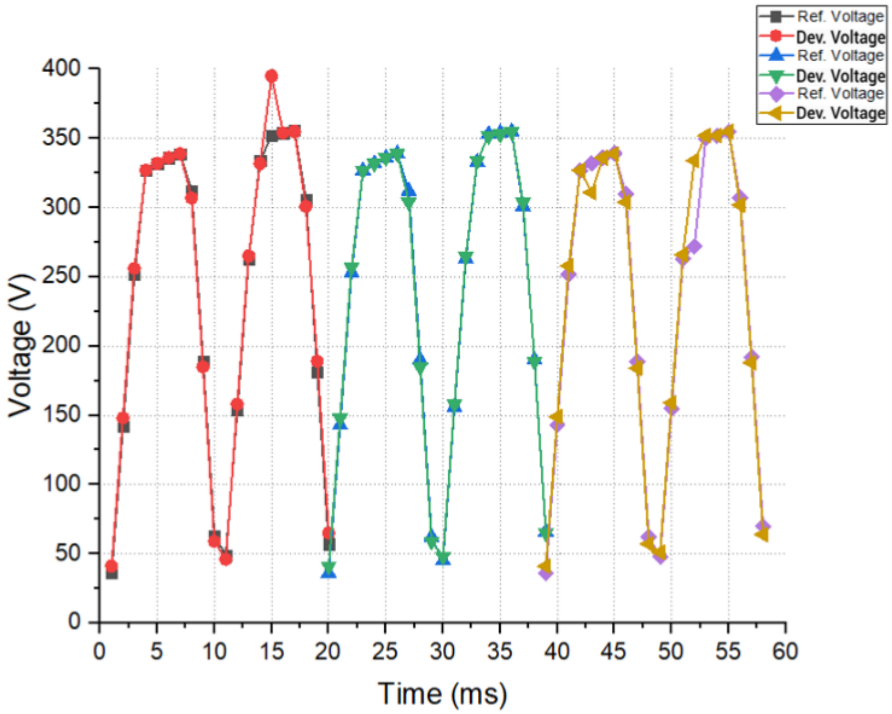


Fig. 5.18 Time Voltage Curve for the Late-Night of Day 6

RMS Value of 1st **Reference** waveform **= 251.36 V**

RMS Value of 1st **Deviated** waveform = 255.73 V

RMS Value of 2nd **Reference** waveform = 250.33 V

RMS Value of 2nd **Deviated** waveform 251.73 V

RMS Value of 3rd **Reference** waveform = 250.52 V

RMS Value of 3rd **Deviated** waveform = 247.54 V

Deviated wave-form of Voltage in Figure 5.18 is seen from 14 ms to 15 ms and 43ms to 44ms and 52ms to 53ms

Day 7:

Late-Morning:

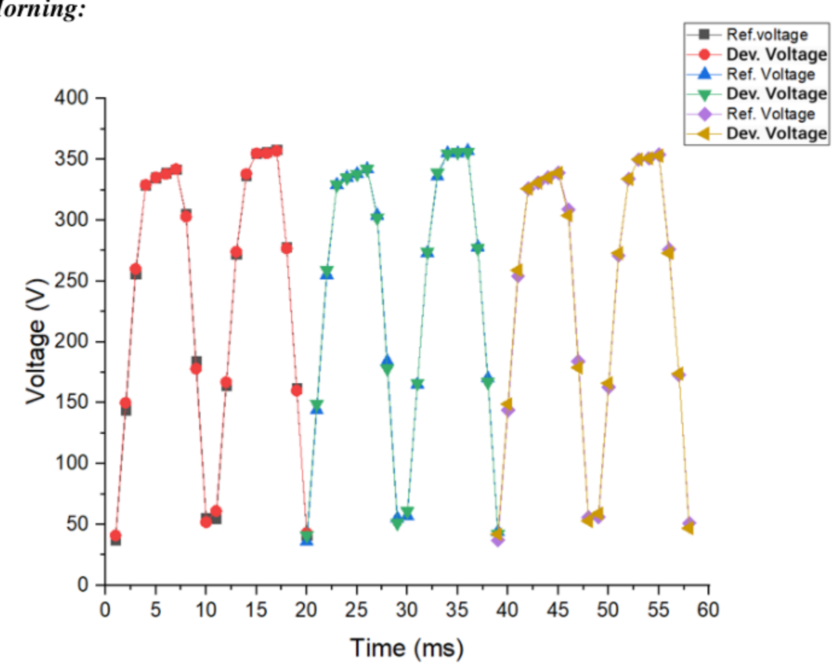


Fig. 5.19 Time Voltage Curve for the late morning of Day 7

RMS Value of 1st **Reference** waveform **=** 261.77 V

RMS Value of 1st **Deviated** waveform = 262.13 V

RMS Value of 2nd **Reference** waveform = 261.44 V

RMS Value of 2nd **Deviated** waveform 162.27 V

RMS Value of 3rd **Reference** waveform = 261.68 V

RMS Value of 3rd **Deviated** waveform = 262.18 V

Deviated wave-form of Voltage in Figure 5.19 is seen no deviation

Mid-Day:

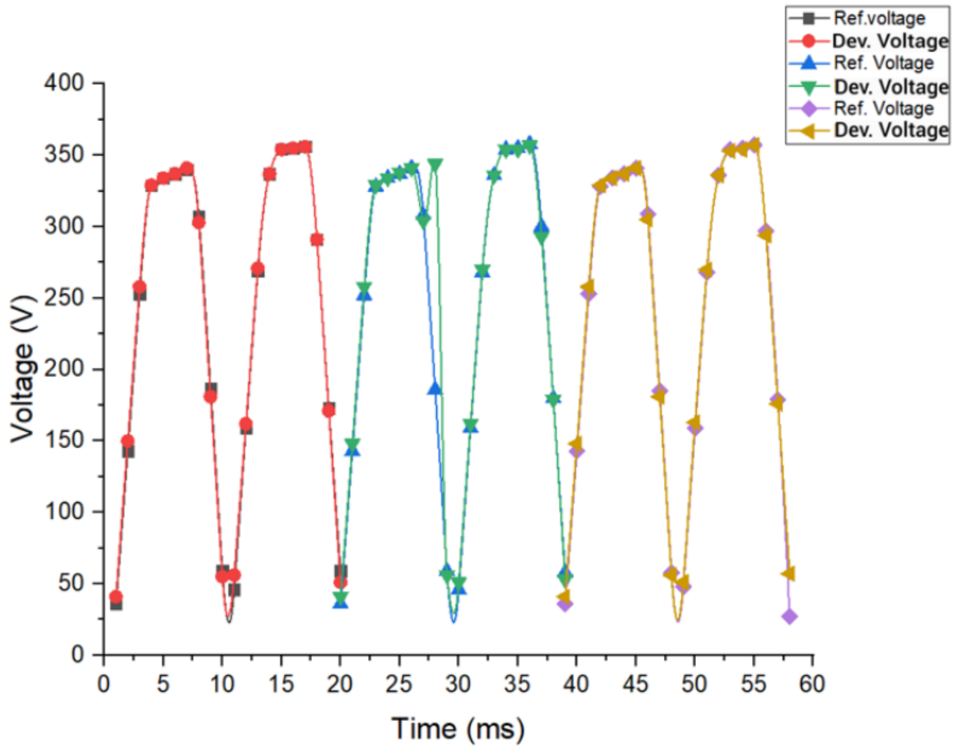


Fig. 5.20 Time Voltage Curve for the Mid-Day of Day 7

RMS Value of **1st Reference** waveform **=** 261.39 V

RMS Value of **1st Deviated** waveform = 262.19 V

RMS Value of **2nd Reference** waveform = 261.53 V

RMS Value of **2nd Deviated** waveform = 267.43 V

RMS Value of **3rd Reference** waveform = 260.89 V

RMS Value of **3rd Deviated** waveform = 262.17 V

Deviated wave-form of Voltage in Figure 5.20 is seen from 23 ms to 24 ms

Late Night:

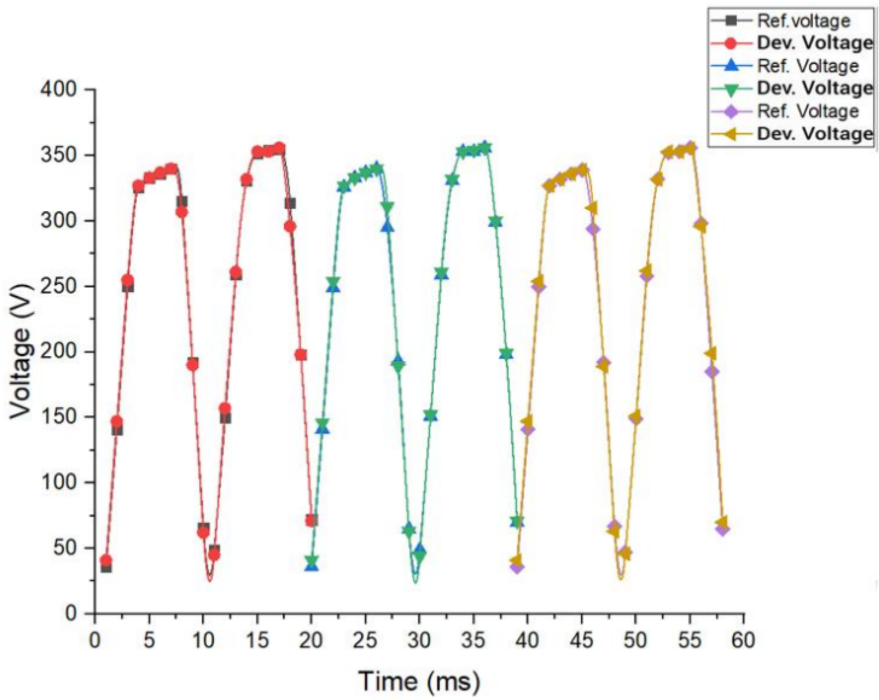


Fig. 5.21 Time Voltage Curve for the Late-Night of Day 7

RMS Value of 1^{st} **Reference** waveform **=** 262.71 V

RMS Value of 1^{st} **Deviated** waveform = 263.11 V

RMS Value of 2^{nd} **Reference** waveform = 262.62 V

RMS Value of 2^{nd} **Deviated** waveform = 263.14 V

RMS Value of 3^{rd} **Reference** waveform = 262.66 V

RMS Value of 3^{rd} **Deviated** waveform = 263.38 V

Deviated wave-form of Voltage in Figure 5.21 is seen no deviation

From these figures, we can easily relate the voltage fluctuation w.r.to the reference voltage. The voltage can be easily understood by the root mean and square system. Here is a question that arises, why there is no negative portion of these wave-forms. As we use the microcontroller to sample these waveforms, and the microcontroller can not process the negative values. So, that's why there are no negative values. But we can consider the 1st half-cycle as a positive half cycle and the 2nd half-cycle as a negative half cycle.

CHAPTER 6

IMPORTANCE & DRAWBACKS

6.1 Advantages

Voltage quality analysis, which uses continuously recorded waveform to detect abnormalities such as power outages, sags and swells, and transient harmonics, can compare current operational characteristics of electrical equipment to the manufacturer's baseline, cycle by cycle in milliseconds.

6.2 Recommendations on Future Research

Since this paper presents a voltage quality management technique, it makes sense to build the entire cycle of Voltage Quality continuous improvement, in addition to the individual processes.

The term "set and forget" was widely used to describe voltage quality improvement technologies. A specific follow-up to verify and quantify the solution's efficacy was not conducted after installation. As power and voltage improve, next-generation devices will incorporate self-learning warning systems that adapt to and alert in real-time if performance decreases suddenly or deviates slowly over time. It will also be useful for calculating and proving the genuine efficiency increase after the solution has been installed. As a result of the improved return on investment estimates, the rate of advanced education will grow as well as device adoption. Flexibility in the design and adaptability over time will be the two most important features in an evolving electrical distribution network where capital expenditure will become tighter.

CHAPTER 7

CONCLUSION

7.1 Conclusion

For the regulation of voltage quality, voltage quality monitoring programs are quite useful. VQM data can be used in a variety of ways, resulting in benefits for the network user.
On the proposed lines, the expenditures of such a program represent a minor proportion of the total costs of operating power networks.
Alternatively, the network operator can build and maintain such monitoring software, with the NRA gaining access to the collected data. Determining which approach is best relies on the country's conditions.[22]
Measurements will be used for calculating a unique Fuzzy Total Power Quality Index (FTPQI) [23] for every measured point of the electric network according to Archimedes research proposal. FTPQI could be used by the system administrator giving a reliable way to check the total PQ of electric networks.

This measuring campaign contributed significantly to understand that the limits of EN50160 are quite lenient and consequently not appropriate for this research proposal. In order to answer the question "How good Power Quality of a point is" stricter PQ limits for designing membership functions must be adopted [24].

Useful conclusions can be obtained, if two similar Power Quality Analyzers are placed at the same site, set –however- to different limits for PQ events. In this case, the researchers will be able to compare the results on Power Quality when applying standard EN50160 limits or stricter limits of power quality, indicated by the operational needs of the consumers' equipment. Such measurements will assist the target of structuring a common, stricter PQ standard all over EU countries.

Finally, it is important to introduce a new type of smart meter, which can measure most of PQ characteristics, in order to extract significant conclusions about PQ events and their consequences to end-users. The extended installation of smart meters will help each network administrator to identify the reasons for equipment failures and to introduce successful policies for efficient network and customer protection.

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APPENDIX

```
'PIC16F876A
TRISA = 255
TRISB = 12
TRISC = %10100000
Define CLOCK_FREQUENCY = 16
Define LCD_BITS = 4
Define LCD_DREG = PORTB
Define LCD_DBIT = 4
Define LCD_RSREG = PORTB
Define LCD_RSBIT = 0
Define LCD_EREG = PORTB
Define LCD_EBIT = 1
Lcdinit 0

Dim v1(20) As Word
Dim v2(20) As Word
Dim x As Long
Dim y As Word
Dim a As Byte
Dim b As Byte
Dim t As Byte
Dim tm As Word
Dim mt As Byte
Dim wt As Byte
        Lcdcmdout LcdClear  'clear lcd
        Lcdout " Welcome to IIUC"  'text for the line 1
        Lcdcmdout LcdLine2Home  'set cursor at the beginning of line 2
        Lcdout "  Dept. of EEE"  'text for the line 2
        WaitMs 2500
        Lcdcmdout LcdClear  'clear lcd
        Lcdout " Digital power"  'text for the line 1
        Lcdcmdout LcdLine2Home  'set cursor at the beginning of line 2
        Lcdout " quality meter"  'text for the line 2
        WaitMs 1500
        Dim er As Bit
        Dim n As Bit
main:
                er = 0
                n = 0
                While RA4 = 1
                Wend

                While RA4 = 0
                Wend  '. . . . . First wave
                WaitUs 300
```

```
		For a = 0 To 19
			If er = 0 Then
				If RA5 Then er = 1
			Endif
			Adcin 0, v1(a)
			WaitUs 940  '0  '0
		Next a

		While RA4 = 1
		Wend
		While RA4 = 0
		Wend  '. . . . . 2nd wave

		WaitUs 350
		If er Then
			For a = 0 To 19
				Adcin 1, v2(a)
				WaitUs 940  '890
			Next a
		Else
			For a = 0 To 19
				Adcin 0, v2(a)
				WaitUs 940  '890
			Next a
		Endif
	Gosub comp
	If n Then Goto dt
	If er Then Goto dt
	If RB2 Then Goto dsp
	b = b + 1
	If b > 50 Then Gosub volt
Goto main
End

comp:
	n = 0
	For a = 0 To 19
		If v1(a) > v2(a) Then
			t = v1(a) - v2(a)
		Else
			t = v2(a) - v1(a)
		Endif
		If er Then
			If t > 40 Then n = 1
		Else
			If t > 30 Then n = 1
		Endif
	Next a
Return

err:
```

```
            Lcdcmdout LcdClear
            Lcdout " New data "
            Lcdcmdout LcdLine2Home
            For a = 0 To 15
                        Lcdout ".",
                        WaitMs 80
            Next a
            b = 40
            Goto main
Return

volt:
            v1(5) = v1(5) / 2
            x = v1(5) * 1000
            x = x / 1414
            Lcdcmdout LcdClear
            Lcdout "  Vrms = ", #x
            Lcdcmdout LcdLine2Home
            Lcdout "  Vmax = ", #v1(5)
            WaitMs 250
            b = 0
            Goto main
Return

dt:
            If n = 0 Then Goto dsp
            Lcdcmdout LcdClear
            Lcdout " Error Detected "
            Lcdcmdout LcdLine2Home
            For a = 0 To 15
                        Lcdout ".",
                        WaitMs 80
            Next a

dsp:
            For a = 0 To 19
                        v1(a) = v1(a) / 2
                        v2(a) = v2(a) / 2
            Next a
            Lcdcmdout LcdClear
            Lcdout "   1st wave "
            Lcdcmdout LcdLine2Home
            If n Then
                        Lcdout " Forced data"
            Else
                        Lcdout " Normal data"
            Endif
            WaitMs 1500

            Lcdcmdout LcdClear
            For a = 0 To 3
```

```
        Lcdout "", #v1(a), " "
    Next a
    Lcdcmdout LcdLine2Home
    For a = 4 To 7
        Lcdout "", #v1(a), " "
    Next a
    While RB2 = 0
        If RA5 Then Goto err
    Wend
    While RB2 = 1
    Wend
    WaitMs 300

    Lcdcmdout LcdClear
    For a = 8 To 11
        Lcdout "", #v1(a), " "
    Next a
    Lcdcmdout LcdLine2Home
    For a = 12 To 15
        Lcdout "", #v1(a), " "
    Next a
    While RB2 = 0
        If RA5 Then Goto err
    Wend
    While RB2 = 1
    Wend
    WaitMs 300

    Lcdcmdout LcdClear
    For a = 16 To 19
        Lcdout "", #v1(a), " "
    Next a
    Lcdcmdout LcdLine2Home
    Lcdout " End of 1st wave"
    While RB2 = 0
        If RA5 Then Goto err
    Wend
    While RB2 = 1
    Wend
    WaitMs 300
'///////////////// . . Second wave
    Lcdcmdout LcdClear
    Lcdout "   2nd wave "
    WaitMs 1000

    Lcdcmdout LcdClear
    For a = 0 To 3
        Lcdout "", #v2(a), " "
    Next a
    Lcdcmdout LcdLine2Home
    For a = 4 To 7
```

```
            Lcdout "", #v2(a), " "
        Next a
        While RB2 = 0
            If RA5 Then Goto err
        Wend
        While RB2 = 1
        Wend
        WaitMs 300

        Lcdcmdout LcdClear
        For a = 8 To 11
            Lcdout "", #v2(a), " "
        Next a
        Lcdcmdout LcdLine2Home
        For a = 12 To 15
            Lcdout "", #v2(a), " "
        Next a
        While RB2 = 0
            If RA5 Then Goto err
        Wend
        While RB2 = 1
        Wend
        WaitMs 300

        Lcdcmdout LcdClear
        For a = 16 To 19
            Lcdout "", #v2(a), " "
        Next a
        Lcdcmdout LcdLine2Home
        Lcdout " End of 2nd wave"
        While RB2 = 0
            If RA5 Then Goto err
        Wend
        While RB2 = 1
        Wend
        WaitMs 300
        Lcdcmdout LcdClear
        Lcdout "Prev. data contn"
        WaitMs 1000
    Goto dsp
```

ACRONYMS

BUET	Bangladesh University of Engineering and Technology
BMTF	Bangladesh Machine Tools Factory
DC	Direct current
EC	Election commission
EL	Electroluminescent
EVM	Electronic voting machine
FEMA	Fair Election Monitoring Alliance
GND	Ground
IC	Integrated circuit
I	Input
I/O	Input/ Output
IR	Instruction register
IICT	Institute of Information and Communication Technology
LCD	Light crystal display
O	Output
P	Power
OST	Oscillator start-up timer
POR	Power-on reset
PWRT	Power-up timer
RAM	Random-access memory
ROM	Read-only memory
UNDP	United Nations Development Program
VQM	Voltage Quality Monitoring
VQ	Voltage Quality
VQC	Voltage Quality Control
VVPAT	Voter Verified Paper Audit Trail

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