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Power Quality Monitoring & Analysis using Smart Multi-Function Meter

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Abstract - Power quality problem become one of the main technical challenges in distribution network. In order to provide very efficient power quality of energy supply, needs to analyze and quantify the power quality level in distribution network, for such task Smart multi-function meter become an essential device in the development of current electrical distribution network. The function of meter go further beyond the basic automated meter reading for billing purpose, more ever it also used for real time power quality and energy monitoring and analysis, remote communication capability with other device, programmability, reset function, etc. These important feature make widely used equipment in distribution network. This paper carryout power quality impact at PV solar plant main grid generation and at various load condition. Frequency and voltage variation are analyzed in on grid mode of operation. Similarly real time measured value of unbalance voltage and current level, neutral current level, voltage and current THD at different power level was measured using smart multifunction meter.

Key words: Power Quality, smart multi-function meter, distribution network, automated meter reading.

1. Introduction

The development of new energy power generation technology, the use of a large number of power electronic components and non-linear loads in micro-grid seriously affect the power quality of systems. Monitoring of power quality parameter is a key function of realizing of smart distribution. This goal is achieved by means of adopting advanced technologies for real time power quality monitoring, wave form correction devices, condition monitor, and use of SCADA system for remotely monitor and check the status of power quality parameter.

The major causes of the above power quality disturbance in micro-grid is mainly due to use of excessive non -linear load and intermittent, nature of renewable energy resource, fault on the grid system etc. [1]. In order to achieve reliable quality of energy in micro grid power system, it is very important to monitor and analysis power quality of a micro grid at different condition.

Now a days, Power quality monitoring in micro-grid become the emerging issue in distribution network and the problem is more complicated than conventional distribution systems because of the intermittent nature of renewable energy sources, as well as the increased penetration of nonlinear loads and power electronic interfaced distributed generation system. Therefore, it is necessary to monitor the power quality parameters as well as improve energy management of the system. Smart multi-function meter become an essential device in the development of recent electrical distribution network. The function of the meters go further beyond the conventional meter reading for billing purpose and more ever it also used for real time power quality monitoring and energy management, remote communication capability with other device, programmability, reset function, These important feature make widely used device in micro-grid distribution network Real time Power quality monitor and analysis during operation maximize effective use of energy resources, and avoided.

Several research and analysis works are carried out in low voltage distribution network of micro-grid power system on power quality issues and their effect.

A. Vinayagam et al. [2] works on power quality issues like frequancy and voltgae variation and neutral curent level and current and voltgae THD level in low voltgae network of microgrid power system at various conditioned through expermental approach in real microgrid.the reaserch finding shows that the variation is higher at off-grid than on-grid mode this is due to This is due to the lack of power inertia availability in islanded MG network and also influence of PI based on controller performance during transient condition in micro grid network. However planting data acquisition device at each plant to collect data is very costly.

Zhanhe Liu1, and et al. [3] PV model and nonlinear model are simulated in Matlab Simulink environment. Power quality indices are used to estimate the current distortion from different scenario, and a composite model is modeled using crossed frequency admittance matrices theory. The result of this study shows PV inverter, different type of non-linear loads are the sources for harmonic distortion and unbalance in micro-grid. However its method of analysis is somewhat complex and difficult to understand easily.

Arangarajan Vinayagam and et al. [4] Total harmonic distortion of hybrid system with PV and wind renewable energy source in both mode of operation were analyzed through Matlab/Simulink software. The simulation study of this paper shows that the THD level was reduced when both PV and wind energy source connected to the grid and increased when isolated. However the analysis was limited for THD level.

Hossain and Ecklas [5] overall power quality issues in distribution system based on renewable energy sources were investigate. This paper studied power quality monitoring technique and possible solution using custom power device such as D-STATCOM, UPQC, UPS, TVSS, and DVR etc. The result of this paper shows that transient is the main power quality issues followed by voltage spike and fluctuation and the study suggest for renewable energy system STATCOM can be a potential choice due to its several advantage. However it mainly concern on transient phenomena.

A.Manjunath, and E. Prathibha [6] presents a brief review of the power quality disturbance, issues and its effect on efficiency and grid reliability of power grid supply, through analyzing major power quality disturbance in smart grid environment. The paper suggest there is need to adopt recent advanced communication technology to address and monitor the power quality problem to get quality and reliable power supply in smart grid environment. The research only explain various power quality issues not the solution.

N.Kulkarine, and Sonali [1] deals with the power quality parameters, challenges in renewable grid integration and the possible solution to maintain the power quality particularly wind energy. The paper result shows that most of the complexities occurs due to the interconnection of different type of power generators, transmission line, transformer and varying nature of the load. The study from this paper suggest: Modification in power curve, Aggregation of wind turbine, the distribution of wind turbine over a wider geographical area were a possible solution to improve power quality. However the study only focus on the arrangement of the turbine for power quality improvement

Arangarajan Vinayagam1 and et al. [7] power quality disturbance parameter like power variation, voltage variation, current and voltage level THD and unbalance voltage through simulation method using PSS-sincal software environment .from the simulation result power variation from solar PV output due to solar disturbance causes effect on power flow variation in both mode of operation and current THD level is exceed the limit standard this is due to the occurrence of non-linear load. The impact of PV sources on a micro-grid by considering composites linear/or nonlinear loads, in addition to this analysis of harmonic distortion were carried out by applying three power quality indices to give clear view of about power distortion, wave form distortion, and system unbalance. However finding every source power quality issue trough software is not effective.

2. Power quality problem and their effect

The term PQ in electrical network refers to maintaining wave form of voltage and current close to pure sinusoidal at rated magnitude and frequency [8]. In this study main power quality issues like voltage and frequency variation, voltage and current harmonic distortion unbalance voltage and neutral current level in neutral line of micro-grid network were analyzed.

2.1 frequency and voltage variation

In electrical power distribution system network it is necessary to maintain energy balance (Generation= consumption) continuously. However power variation due to intermittent nature of renewable energy resource, and changing of active and reactive power demand in distribution network, voltage and frequency variation is very common. Keeping voltage and frequency variation within the limit in on-grid mode of micro-grid operation easier than off-grid mode of operation, this is because in off grid mode, there is a challenges in coordination operation and control of different type and characteristics of DG sources. [8] Excessive variation affects the performance of sensitive electrical equipment and quality of energy supply.

Nominal operating frequency of power network is considered around 50Hz with allowable range of frequency and nominal operating voltage in low voltage network is considered 240V for single phase and 415V for three phase.

2.2. Unbalance voltage and neutral current

Unbalance voltage and current mean any deviation of phase voltage and current from its set value. It is one of the power quality issues in power system network. The major causes of unbalance in distribution network are: uneven distribution of single phase load, uneven power generation from single phase type power source, unbalanced three phase load, unequal impedance of three phase distribution network, etc. [9].excessive reactive power, abnormal function of protective relay, loss of performance of metering device, creating excessive heat and loss in motor, etc. excessive neutral current level leads overloading of the distribution feeder and transformer.

Voltage unbalance and neutral current in distribution network can be calculated in two methods, the international electro technical commission (IEC) which used symmetrical component for unbalance factor calculation and the national electrical and manufacture association (NEMA) method which used magnitude of system voltage.

2.2.1. IEC method

Under IEC method Unbalance voltage factor (VUF) equals the ratio of negative sequence voltage to positive sequence voltage. Similarly unbalance current factor (IUF) is the ratio between negative sequence current to positive sequence current. [10]

$$VUF= [V_n/V_p]\ \% \quad (1)$$

$$IUF = [In/Ip]\ \% \quad (2)$$

Vn and Vp is negative and positive sequence voltage respectively.

VUF can also calculated using three phase line voltage: [11]

$$\beta = \frac{vab^{4+}Vbc^4+Vca^4}{Vab^{2+}Vbc^{2+}Vca^2} \quad (3)$$

$$VUF= \sqrt{1-\sqrt{3-6\beta}}/\sqrt{1+\sqrt{3-6\beta}} \quad (4)$$

Where V_{ab}, Vbc, Vca are line voltage.

2.2.2. NEMA method calculation

According to NEMA voltage unbalance can be calculated as the ratio of maximum deviation of voltage from average value to the average value of three voltages

$$VUF= \frac{Vmean-Max(Vab,Vbc,Vca)}{Vmean} \quad (5)$$

Where V_{ab}, V_{bc}, V_{ca} are the line voltage.

3.2.3 Value of neutral current

The neutral current can be calculated as: [12]

$$In=\sqrt{Ia2+Ib2+Ic2-IaIb-IbIc-IcIa} \quad 6)$$

Where $I_{a,}$ $I_{b,}$ I_c are the phase RMS current value.

2.3 Total harmonic distortion

Current or voltage having frequency other than the fundamental frequency are called harmonics. Harmonics distortion can occur due to Non-linear characteristics of device existing in power system. Non -linear loads and power electronic convertor are the major source of harmonics. The effect of excessive harmonics in power system network Includes: over load in neutral current, transformer and cable heating, Increase system power losses, increase the system power losses, affect the performance level of measuring instrument, mal operation of protective relay, increase copper loss and heat loss in electrical equipment, etc.

3. System hardware

Experimental analysis has been carried out by taking Sharda university micro-grid using smart multifunction meter. The experimental analysis were been carried out at various hardware and software device.

3.1 Smart energy meter

Four smart energy meter is placed at various feeders as shown in the figure to measure different basic electrical parameter at various feeder line and power quality parameter. The feeders are: solar power feeder, mains feeder, UPS and AC feeder. Figure-1 shows layout of smart meter location at various feeder line.

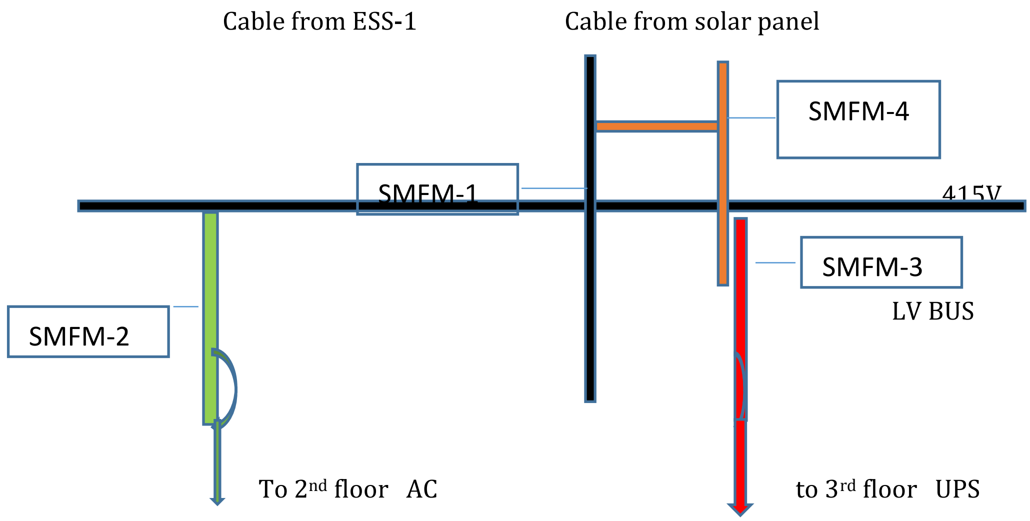


Figure-1 feeder line and smart meter location

Two types of smart energy meter has been used, Schneider EM 6400 and Procom ACE-Series, which are digital power meter that used for three phase electrical parameter measurement and load management facility in industry.

3.2 Gateway

It is used for converting the Modbus signals into Ethernet signals. This is because the Modbus signal are slow speed signal. M Gate MB3180 gateway used in this project. This gateway used to convert Modbus RS 485/ASCII/RTU to TCP IP so that the meter can easily communicate with the computer. It support 16 simultaneous TCP master with up to 32 simultaneous request per master with easy hardware setup and configuration.

3.3 Programing logic controller (PLC)

PLC is a solid state device stands for programmable logic control. It is a device which is designed to perform the logic function. In the past time relays and timers are used for doing this task. But such device are bulky and chance of error are more and difficult find fault on the system and time consuming to address the problem.

PLC ladder programming has been developed in RS Logix 500 software as shown in the Fig.3, the programming is mainly deals for acquiring data based on the selected parameter with the given address in the manual. More than 20 parameter is selected for ladder programing and each parameter is stored in holding register of PLC. Here two different ladder programing is used one is converz energy which is mounted on the control panel of block 3A and connected to the load and the other is for Procom EM6400 serious energy meter which is mounted in the office and isolated from the load.

PLC are located in the field, distributed throughout the process and interfaced with the process through field device. It has two main role: to acquire data from controlled process through sensors, process it and store the process data in memory and to receive control instruction in the form of control signal and transmit to actuator and for automatic control.

3.3 software system

The software required for doing this project includes: Rs logic 500 software which used for ladder programming for ladder programing to acquire real time data from various field device, to do these function the required parameter should be selected and the ladder programming should design based on that and temporary data is copied to PLC float register for a storage. The table below shows the required parameter with their address.

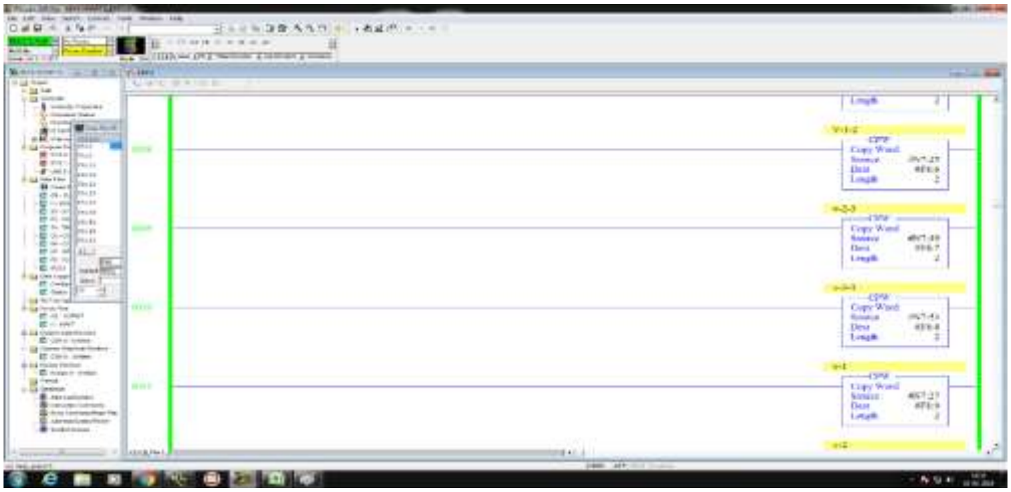
3.3 Parameter used with their address for ladder programming .

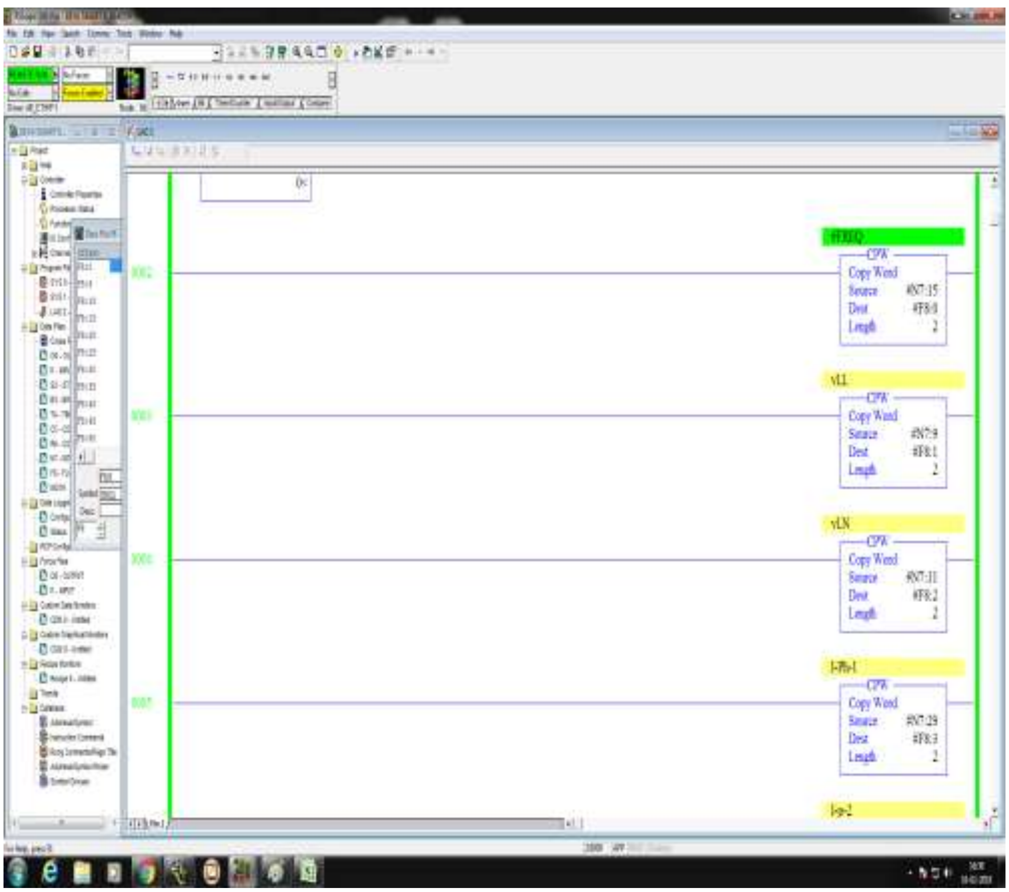
- ✓ The EM6400 power meter supports the transfer of whole block and also of individual data values (two register are used for storing single data values).
- ✓ The device address, block start address, number of register must be configured to suit the power meter. [16]

Table-1 Individual parameter address

Number	parameter	Address	Type
1	F	3915	Float
2	VLL	3909	Float
3	V12	3925	Float
4	V23	3939	Float
5	V31	3953	Float
6	W	3903	Float
7	A1	3929	Float
8	A2	3943	Float
9	A3	3957	Float
10	VTHD-1	3861	Float
11	VTHD-2	3863	Float
12	VTHD-3	3865	Float
13	ITHD-1	3867	Float
14	ITHD-2	3869	Float
15	ITHD-3	3871	Float
16	IUF	3889	Float
17	VUF	3891	Float
18	In	Calculated	Float

According to the above parameter and their adress the PLC programming for acquiering data from the variuos smart multifunction meter location is collected. Figure -2 shows adreess of each parameter.





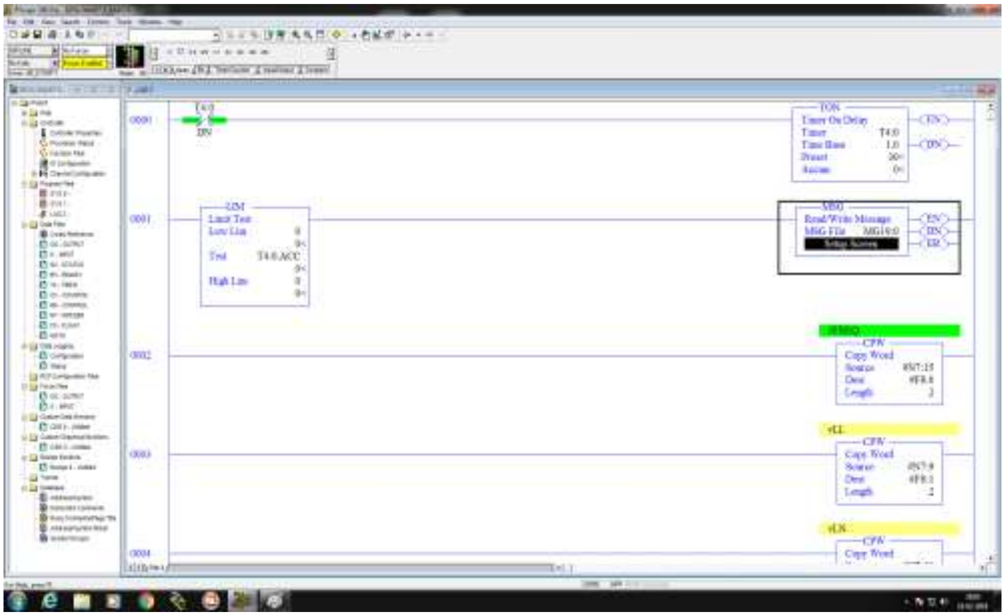


Figure 2: ladder program of individual address in RS logic software.

To communicate the meter with the PLC ladder programming configuration set up must require as shown in figure-3 on set up screen of message format, the communication set up, size of the address, meter selection as we required, address selection as required has been done.

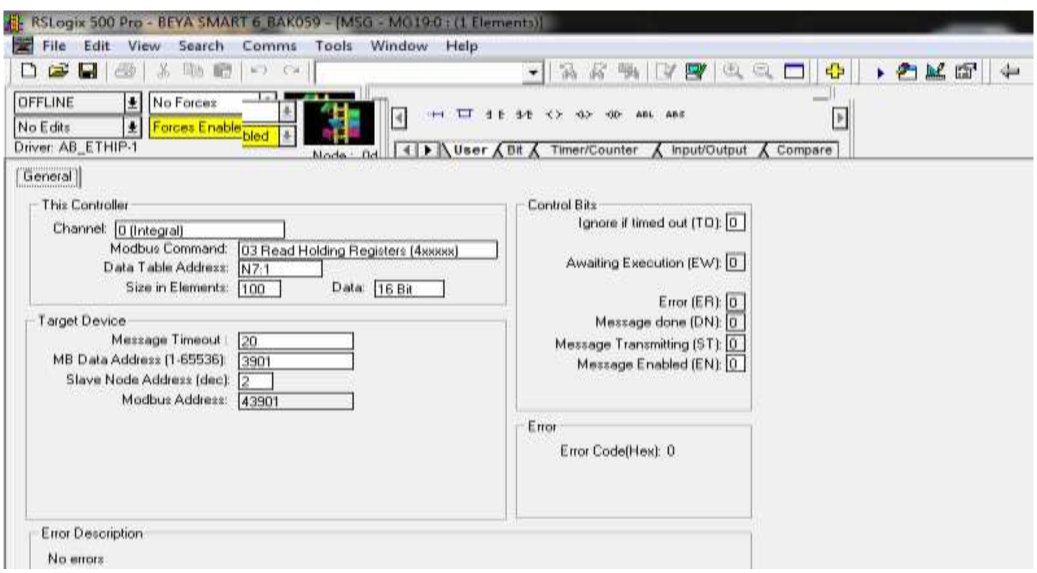


Figure-3 message frame format for adjustment the required parameter

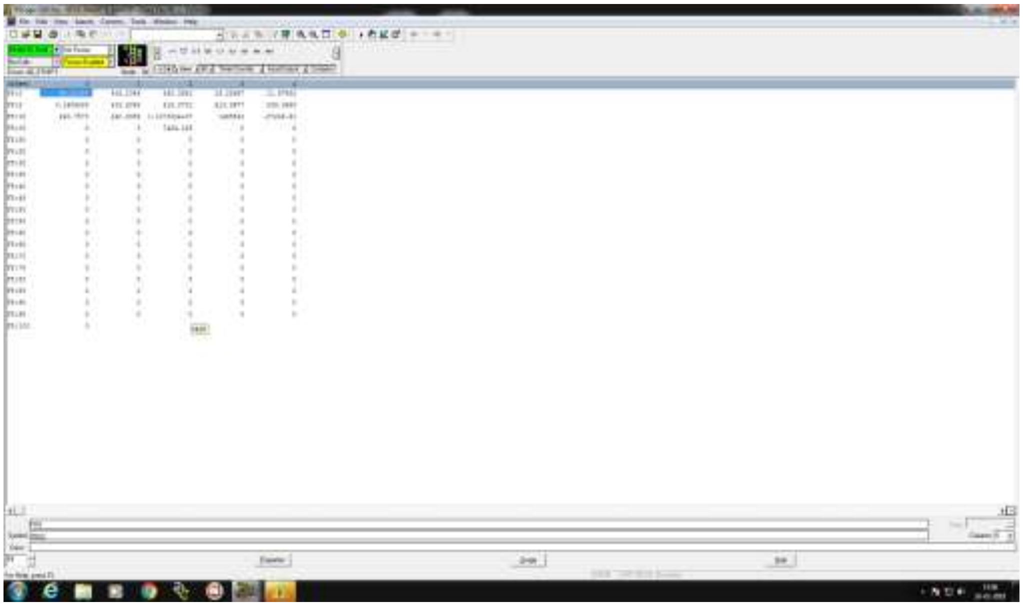


Figure 4: Real time data displayed on PLC holding register

4. Steps taken for the analysis

Steps taken in this project to monitor and analyze power quality using smart multifunction meter

I. Studying the manual for hardware installation and software configuration
II. Interfacing of smart meter with RTU and computer using communication protocol
III. Configuring the smart meter for acquiring data
IV. Identifying major power quality issue in micro-grid: power variation, voltage and frequency variation, unbalance voltage and current, neutral current are investigated for this project
V. Checking the capability of smart multifunction meter with the identified issue
VI. Selecting the parameter required with their address
VII. Design PLC programming for data Accusation from smart meter
VIII. Online monitor on excel and plot the real time data to show its variation
IX. Based on the acquired data analyze the power quality

In this project power quality issues such as voltage and frequency variation, current and voltage THD, unbalance voltage and neutral current level was analyzed through experimental analysis. Power variation, voltage and frequency variation level were analyzed in both mode of operation, THD, unbalance voltage and neutral current level were analyzed in On-Grid mode of micro-grid operation.

4.1 voltage and frequency level variation

Level of voltage and frequency was estimated in on grid mode by considering the following condition: PV power variation due to solar disturbance at various load condition and other factor. Generation= consumption but how ever due to intermittent nature of RE sources and varying active and reactive power demand in distribution network there is a chance of voltage and frequency variation in power network. Excess in off grid mode. This is due to the lack of power inertia availability, coordination operation and control of different type. [8]

- ✓ Normal operating frequency 50 Hz
- ✓ Allowable range of frequency during normal operation 49.85Hz to 50.15Hz.
- ✓ Normal operating voltage around 230v for single phase 415v for three phase
- ✓ Allowable operating voltage 216v to 253v and 376 v to 440v for three phase.

4.2 Unbalance voltage and neutral current

Unbalance voltage was analyzed by considering PV and main grid generation and load condition. Uneven distribution of single phase PV generation and single phase load is considered. Moreover neutral current level was calculated and compared with Australian standard. unbalance voltage and neutral current value is calculated using two approach: international electro technical commission (IEC),which assume symmetrical component and the Australian national electrical and manufactures association (NEMA) method which assume magnitudes of system voltage or current and the result is compared with the measured value using smart multifunction meter and compare with Australian standard. According to Australian standard the maximum allowable range for LV network should be 3% with a given specific period.

4.3. Voltage and current THD

Current and voltage THD value was quantified in each phase line at various PV- power level and from total in coming power (PV solar power plus power coming from substation one) and measured with 30 sec interval over a period of 6 minute using smart multifunction meter and the result was compared with Australian standard. And according to the standard the voltage THD level should not exceed more than 8% and the current THD level should not exceed more than 5%.

4.4 Analysis result and discussion

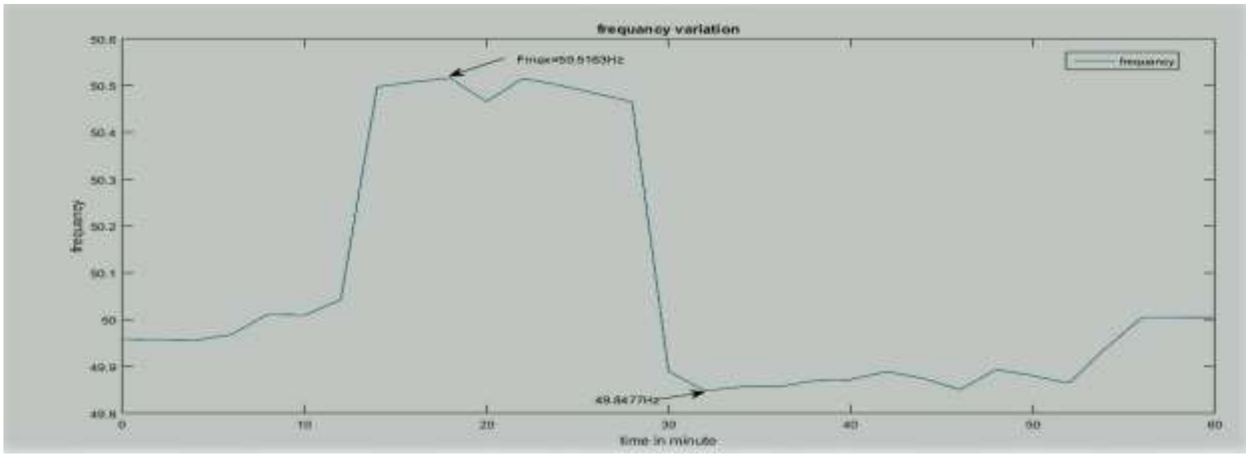
Experimental analysis has been carried out for doing this dissertation work by considering Sharda university micro-grid to quantify the impact of various power quality issues like: voltage and frequency variation, current and voltage THD, Unbalance voltage and neutral current level in MG network, Power variation among supply and load side were analyzed in on grid mode of operation. The method of analysis was based on by measuring actual electrical data during operation using Smart meter. Four smart energy meter is placed at various feeders to measure different electrical parameter. The feeders are: solar power feeder, mains feeder, UPS and AC feeder. The figure below shows layout of smart meter location

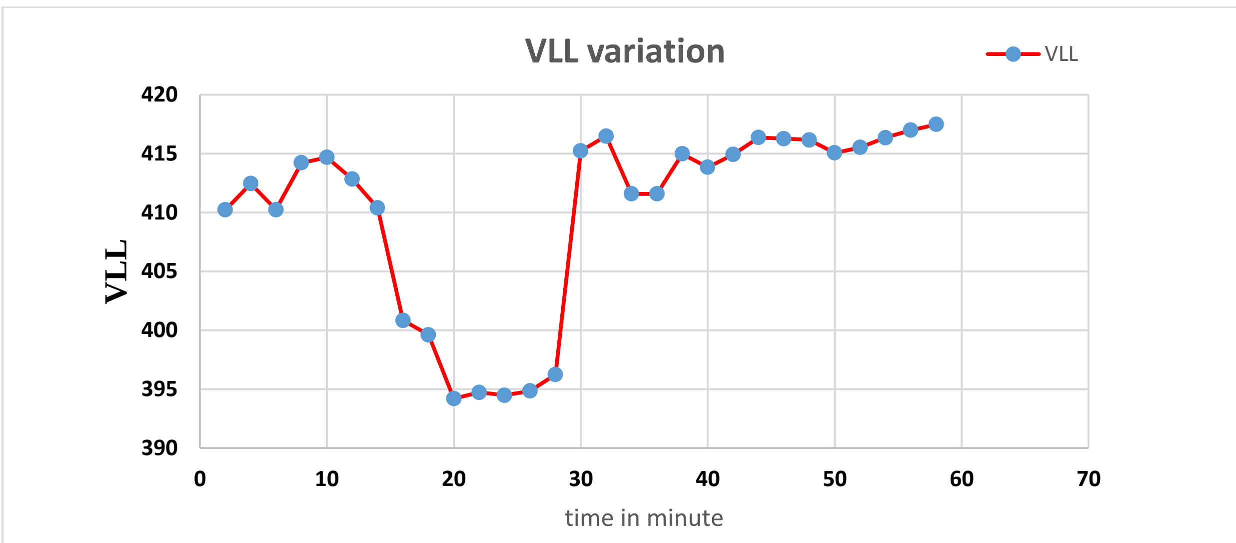
4.4.1. Frequency and voltage variation on total incoming feeder

Low voltage network of MG at Sharda University was considered with installed capacity of PV plant feeder with 100 kW power rating for block 3A building. Figure 10 shows the variation of total incoming power (PV solar plant and from mains grid supply). The output of total incoming power feeder was around 125.637KW which various and reach the minimum value of around 34.415kw.Total duration of analysis was considered over a period of 1 hour in every 2 minute interval. The minimum value observed either due to solar disturbance or when supply from the substation is disconnected.

Variation of frequency is shown in figure-10, indicate that the maximum value of frequency was occurred around 50.5165 Hz at total incoming feeder 115.1710KW and when the load was minimum. The minimum value of frequency was around 49.8477 Hz while total incoming feeder at around 34.415KW and maximum load demand. With reference to the nominal frequency (50HZ) that the maximum deviation in frequency level was around +0.5161 and exceed the limit. Similarly the minimum frequency deviation was a -0.1023Hz.

Variation in voltage level is shown in the figure 10, indicate that the maximum level of average line voltage is around 417.4747v at total incoming feeder 118. 8190kw. Similarly minimum level of voltage was around 394.1795V at total incoming feeder 115.1710kw.The voltage level at 118.8190KW total incoming feeder was around 0.59% more and voltage level at total power generation was around 5.28% less while compared to with the nominal voltage level at 415 in micro. Figure 8 clearly indicate that the variation of voltage was affected by the generation 0f PV power plant





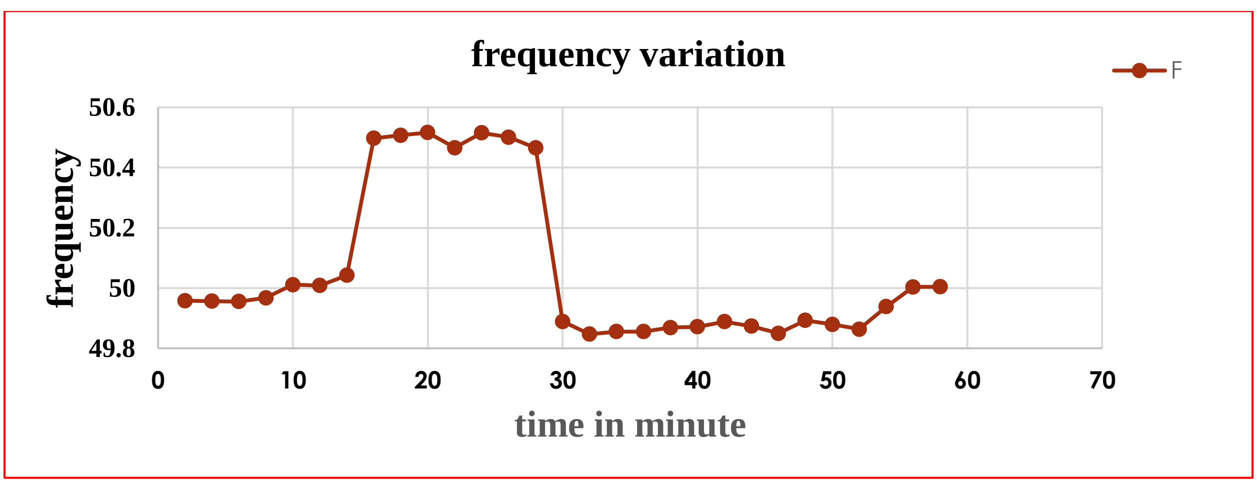


Figure 5. Power, frequency and voltage variation of total incoming feeder

Over all result of frequency variation with reference to nominal value of frequency (50Hz) and the maximum value of frequency exceed the limit but the minimum value was within the limit. But overall result of the voltage with nominal (415V) value was within the acceptable limit.

Table 1 of frequency and voltage over all result variation of total incoming feeder

Total incoming feeder							
Frequency (Hz)				voltage (V)			
Variation (Hz)		deviation (Hz)		Variation (Hz)		deviation (Hz)	
Max	Min	Max	Min	Max	Min	Max	Min
50.5163	49.8977	+0.516	- 0.1023	417.475	394.1795	0.59	-5.28

4.4.2. Unbalance voltage and neutral current analysis

Unbalance voltage and neutral current analysis has been carried out in two ways. The first method actual measuring of each value of line voltage and line current using smart multifunction meter and calculated its value NEMA methods. The second approach was direct measurement of the value of unbalance voltage and neutral current using smart multifunction meter.Table-3 shows value of unbalance voltage and neutral current level using MEMA Method and its measured value using Procom Smart multifunction meter the value of In during no load condition was zero. High neutral current in a building usually occur from two situation: the first cause was due to unbalanced loads or due to loads on and off the second situation was due to current harmonics distortion.

Table 2 calculated and measured value of VU and In total incoming feeder

v12	v21	v31	VU(NEMA) In %	VU(SM) In %	IPH1	IPH2	IPH3	In(NEMA)
415.9885	413.7342	408.8091	0.76	0.17	241.6592	149.4743	131.0273	102.6591
415.3291	413.3137	408.8053	0.69	0.24	225.8236	136.186	132.98	91.28283
415.0558	413.0441	407.724	0.76	0.28	240.4452	131.3202	145.889	102.6192
415.1727	413.6816	408.1173	0.69	0.29	243.7831	131.5171	129.7437	113.1631
416.3258	414.6901	409.174	0.71	0.352	240.4776	131.8163	143	103.5376
416.6008	415.2993	410.0595	0.63	0.306	236.8484	132.6537	129.4988	105.8074
415.5985	414.2636	409.7308	0.57	0.332	227.2601	130.7704	126.8439	98.51166
415.0441	413.2925	408.2953	0.69	0.423	249.4078	134.5609	143.5978	110.6057
416.2213	413.2511	408.406	0.87	0.285	249.1986	134.8837	132.3271	115.6144
415.1161	413.5402	408.6689	0.65	0.254	248.8032	139.8734	146.17	105.922
415.7157	413.8723	409.3529	0.66	0.469	236.3206	145.9468	144.9517	90.87544
415.7157	413.8723	409.3529	0.66	0.118	236.3206	145.9465	144.9517	90.87558
415.7157	413.8723	409.3559	0.65	0.269	236.3206	145.9468	144.9517	90.87544
415.4521	412.9952	408.2307	0.85	0.307	258.7966	141.8519	148.4541	113.7873
415.0669	412.1009	408.0483	0.81	0.401	235.0505	139.3945	148.2088	91.56758
416.8685	414.2055	410.4563	0.87	0.521	231.3087	143.2285	145.9817	86.73638
416.0561	412.8241	408.4683	0.87	0.673	246.4863	132.2135	159.9539	103.2368
414.5301	412.1335	407.445	0.77	0.543	243.2499	133.3962	147.3965	103.5657
414.9101	411.9947	407.6624	0.82	0.578	263.4078	147.6314	173.8852	105.1374
414.9101	411.9947	407.6624	0.82	0.897	263.4078	147.6314	173.8852	105.1374
415.9466	412.8349	408.2332	0.88	0.546	236.2563	145.3788	146.207	90.46624

417.465	414.3605	410.7958	0.79	0.784	226.0299	134.9578	144.2326	86.80711
416.4381	413.1374	409.3354	0.84	0.679	235.0649	144.1749	143.4084	91.27566
416.3522	413.6808	409.4776	0.77	0.420	236.1003	135.8637	143.023	96.8556
415.5071	412.6009	408.1103	0.83	0.765	239.4169	134.4323	143.1297	100.9174
417.1115	413.6619	410.2573	0.82	0.473	221.1022	145.8351	156.6105	70.49973
415.1376	412.8551	408.4355	0.72	0.983	232.7903	131.8025	147.2515	94.21808
414.1631	412.1689	407.6964	0.69	0.768	234.5495	132.997	134.6484	100.737
415.84	412.6766	409.0417	0.79	0.698	219.0854	133.215	144.3491	80.88018
414.5262	411.8045	407.5437	0.79	0.432	224.4901	134.014	143.5233	86.11613

4.4.3. Total harmonic distortion

The current and voltage THD level was measured in each phase of the network according to incoming feeder output over a period of 1 hour in two minute time interval Using Schneider as well as well Procom multifunction meter. The measured value of each phase THD using Schneider was invalid this was due to violation of THD measurement range so that it gives invalid measurement. Table-4 gives actual THD measurement for total incoming feeder, the THD value measured using Schneider gives very maximum THD value and it was invalid and when it measured in Procom it gives a valid value approximately zero for each phase, the reason to give zero value is that the feeder is not connected to the load.

Table 3 measured value of THD for total incoming feeder

Schneider	type	Meter	Procom	Type	meter
VTHD1	VTHD2	VTHD3	V1-THD	V2 THD	V3 THD
2.80E+08	1.02E+08	3375363	$2.8*10^{-18}$	$1*10^{-18}$	$3.7*10^{-18}$
2.86E+08	1.21E+08	3375363	$2*10^{-18}$	$1.5*10^{-18}$	$3.2*10^{-18}$
2.80E+08	1.22E+08	3375363	$4.1*10^{-18}$	$1.3*10^{-17}$	$2.8*10^{-18}$
2.80E+08	1.04E+08	3375363	$8.4*10^{-18}$	$1.1*10^{-18}$	$2.3*10^{-18}$
2.82E+08	1.07E+08	3375363	$1*10^{-18}$	$1.2*10^{-18}$	$7*10^{-18}$
2.83E+08	1.03E+08	3375363	$1.1*10\text{^}^{-17}$	$5.4*10^{-18}$	$4.3*10^{-18}$
2.80E+08	1.24E+08	3375363	$7.2*10^{-17}$	$3.4*10^{-18}$	$6.9*10^{-18}$
2.87E+08	1.07E+08	3375363	$3.8*10^{-17}$	$5.2*10^{-18}$	$5.4*10^{-18}$
2.71E+08	1.05E+08	3375363	$2.7\text{^}10^{-17}$	$1.2*10^{-18}$	$4.8*10^{-18}$
2.92E+08	1.09E+08	3375363	$8.4\text{^}10^{-17}$	$4*10^{-18}$	$2.2*10^{-18}$
2.93E+08	1.06E+08	3375363	$1.2\text{^}10^{-17}$	$1.1*10^{-17}$	$4.6*10^{-18}$
2.87E+08	1.08E+08	3375363	$5.4*10^{-17}$	$2.5*10^{-18}$	$1.6*10^{-18}$
2.94E+08	1.03E+08	3375363	$4.9*10^{-17}$	$5.8*10^{-18}$	$2.3*10^{-18}$
2.68E+08	1.06E+08	3375363	$1.2*10^{-17}$	$5.6*10^{-18}$	$1.4*10^{-18}$

Similarly voltage and current unbalance, neutral current value, THD, for PV plant feeder, AC load feeder, and 3rd floor has been analyzed.

5. Conclusion and future work

In this dissection work power quality issues like frequency, unbalance voltage and neutral current level and THD level on both supply and load side were analyzed in low voltage microgrid through experimental method.

Variation of frequency and voltage were analyzed in on-grid mode of microgrid operation at various supply and load conditions. From the result the variation and deviation level of frequency and voltage were found to be high on the supply side (PV power plant and total incoming feeder). However the variation level on the load side (AC load, 2ND floor and UPS 3RD floor feeder) was within the acceptable limit as per Australia standard.

The value of neutral current was found to be minimum on PV power plant feeder and UPS load feeder and high on total incoming and AC load feeder. However the value of unbalanced voltage was very minimum in all cases and well within the acceptable limit as per standards

Measurement result from THD level in all cases shows invalid values of THD in each phase when it was measured using Schneider smart meter. This was due to inappropriate THD measurement range. However when it was measured using Procom the result for each phase were valid THD values, this was due to the fact that Procom reads the value of THD in each phase properly. The measured value of THD in all cases was very minimum due the reason that feeder was not connected to the load.

5.1 Future work

Nevertheless this dissertation work can be used as a guidelines to develop a real microgrid distribution system with high of power quality suitable for sensitive electrical loads, further work also required.

I. Automatic control of load feeder circuit on both supply and demand side for peak demand reduction.
II. Replacing of Schneider smart meter with Procom in order to read voltage unbalance current unbalance, and THD directly without considering specific range on both supply and demand sides.
III.
IV. Develop MTU program (software) to acquire readings of smart meter using the principle of polling and using RTUs using Sharda University Ethernet LAN. So that the operator can remotely monitor the status from the control room and make decisions accordingly.
V. Develop a meter data management system for storing of meter data and displaying the same on demand.
VI. Develop MTU program for human machine interface so that the operator can remotely control the field devices.
VII. Develop MTU program for control and operation of main distribution panel as well as generation side.
VIII. Develop a communication interface to allow a communication between SCADA system and MATLAB software.

Reference

[1] Arangarajan Vinayagam1 and et al. "power quality analaysis in microgrid,experminetal approach," Journal of Power and Energy Engineering, 2016, 4, 17-34, p. 19, 2016.

[2] Muhammad Fahad Ziaa, "Microgrids energy management systems: A critical review on methods,," applied energy, vol. 222, pp. 1033-1055, 2018.

[3] S.Kulkarine, and et al. "A review on power quality challenges in renewable Energy grid intgeraion," International Journal of Current Engineering and Technology, vol. 6, no. 5, p. 6, 2016.

[4] G. w. chang,'' Monitoring issues and analaysis techniques of smart grid aspect of power quality, 2012.

[5] Chattopadhyay, S., Mitra, M. and Sengupta, S. (2011) Electric Power Quality. Springer, Dordrecht. http://dx.doi.org/10.1007/978-94-007-0635-4

[6] Gosbell, V.J., Herath, H.M.S.C., Perera, S. and Robinson, D.A. (2002) Sources of Error in Unbalance Measurements

[7] Baggini, A.B. (2008) Handbook of Power Quality. Wiley Online Library. http://dx.doi.org/10.1002/9780470754245

[8] Keljik, J. (2013) Electricity 3: Power Generation and Delivery. Nelson Education, Scarborough.
Verma H.K, "Energy Managemnt" Greator Noida, " www.profhkverma ,2017
[9] Jinshuangshen and et.al, ''A Microgrid Energy Management System with Demand Response for Providing Grid Peak
[10] Shaving' 'Journal of electrical power component system, vol. 44,no.8,2016

[11] Arangarajan Vinayagam1 and et al. "power quality analaysis in microgrid,experminetal approach," Journal of Power and Energy Engineering, 2016, 4, 17-34, p. 19, 2016.

[12] Zanhe liu and et.al. ''Power sytem harmonic study for unbalanced microgrid system ''Jornal of power and energy Engineering, P 43-55, no. 3, 2015

[13] Arangarajan Vinayagam1,Asma Aziz, "Power Quality Analysis of Hybrid AC/DC," International Journal of Engineering and Advanced Technology, vol. 7, no. 4, p. 7, 2018.

[14] E. Hossain, "Analaysis and mitigation of power quality issues using custom power device," IEEE access , p. 19, 2017.

[15] E. P. A.Manjunath, "An overview of power quality Isuues in smart grid," International Journal of Innovative Research in Advanced Engineering , vol. 1, no. 10, p. 5, 2014.

[16] Arangarajan Vinayagam1,and et.al "power quality impact in typical microgrid," International Conference on Sustainable Energy and Environmental Engineering, p. 7, 2015

[17] E. J. Palacios-Garcia, and et.al "Using Smart Meters Data for Energy Management and power qualty monitoring in microgrid," IEEE, p. 7, 2017.

[18] Guanlu Yang, and et.al "power quality monitoring and enery effecency management based on wind PV-ES hybrid system," 2018 2nd International Conference on Power and Energy Engineering, p. 8, 2018.
srefan gehorghe, "result of power power quality monitoring in romanian transmision and distribution system," 2016
[19] kuldiph singh , "A Review on Power Management and Power Quality in pv microrid," indian journal of scince and technolgy vol. 10, no. 17, p. 4, 2017.

[20] Miroslav bigovich, and et.al "harmonic distortion in microgrid and distribution system in photovolatic cell," IEEE xplorer , pp. 5-8, 2015

[21] Keljik, J. (2013) Electricity 3: Power Generation and Delivery. Nelson Education, Scarborough.

[22] V. Gummadilli, "SCADA based cenetralized Building energy managemnt system and automation system," internatinal journal of recent trends in engineering , vol. 4, no. 101, pp. 2455-1457, 2019.
Kamal deep kaur and et al Kemal deep , "energy managemnt using PLC and SCADA," internationla journal of
[23] enegineering research and technology , vol. 3, no. 11, pp. 2278-0181, Omkar naik and shereya pomaje "Implementation of Building Management System using Renewable energy source,SCADA and PLC," International
[24] Research Journal of Engineering and Technology, vol. 06, no. 03, pp. 2395-0072, 2019.

[25] R.periera and et al ," consumer energy managemnt system with integration of smart meters journal of enery report , vol. 1,, pp.22-29 2015

[26] M.fahad, "microgrid energy managemnt system," applied energy , Vols. 1033-1055, p. 222, 2018.

[27] Schneider Electric, Conzerv EM6400 Serious power meters user manual, 2015

[28] Verma H.K, " Advanced metering infurastructure" www.profhkverma Greator nida,2017

[39] http://www.elec.uow.edu.au/pqaustralia/main/images/stories/pqrctechnotes/technote6.pdf