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Research paper

Power quality management using statcom for grid interfaced wind turbine controlled by microcontroller

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Abstract

Input source for wind power generation in wind turbine is wind. Variation of wind is uncontrolled. Quality of power gener- ated in a windmill is very poor due to uncontrolled and fluctuated nature wind. As per International Electro-technical Commission standard, IEC-61400 norms the power quality and measurements of wind turbine is to be calculate. Electrical energy generated from wind power is based on minimum pollution of environment as comparative to conventional sources of generation. In a grid connected wind power system there are some power quality issues. In grid integrated wind power systems, quality of power is measured by active power, reactive power & variation of voltages measured under guidelines of national & international standards. In this proposed system, the energy generated by wind turbine is converted to DC & DC bus is charged. A microcontroller regulated PWM inverter convert this DC voltage to AC to feed it to grid. The pro- posed DC Bus is augmented by PV (photovoltaic) charged Battery Based PWM controlled STATCOM.

Keywords: *Wind Energy; PWM Inverter; Power Quality Improvement; STATCOM.*

1. Introduction

Demand of electrical energy increased the requirement of fuel to generation; in this respect non-conventional sources are in trend and environment friendly. It is necessary for Rajasthan to use vast potential of wind and solar power in huge quantity, which helps in development of state. Rajasthan and centre government have launches many scheme for motivation and growth of wind and solar power. The problem arises with wind sources is its fluctuation in wind speed and hence variation in generated power. To overcome this issue, control structure is to me integrated with the plant. Power quality of this is observed with the parameters of voltage regulation, active and reactive power.

Total power generated from wind in this world is 12 % (approx. 486.8 GW) where as in India its 9.1% (approx. 28,700 MW) of total power generation [1]. The data showing the present situation of installed units in India up to 2016. It shows that the maximum units is installed in Tamil Nadu (7694.3 MW) and achieved target of 32287.27 MW up to April 2017[2].

2. Causes of deficiency in the power quality

Power quality depends on some parameters, to maintain power quality these parameters is controlled, and effect of these parameters are impact on voltage, current and frequency. Causes and effects due to these parameters are

a) Interruption

Interruption in the system means there is variation in voltage and current and it will be varying more than 90% of actual and it will be in system for more than 1 min. Similarly, there is another cause of fault that is notching which is from the rectifiers used in converters due to their finite inductive values [1].

b) Voltage Sag

Voltage sag is another example of occurrence of disturbance in system. In this, the voltage amplitude is decreased in similar percentage as in interruption. This occurs mainly due to operation of heavy machines in industry as of their heavy starting torque [1].

c) Voltage Swell

There are tap changing equipment's in the substation and that is changes as per requirement during running line. This causes a swell in the line voltage and the RMS line voltage increase up to double value of the nominal voltage and this fault remains in the system to the same time as sag and interruption in the system i.e. 0.5 to 1 minute [2].

d) Transients

Another impact on power quality is due to transients. In distribution system when lightning strikes and switching of heavy equipment happens then transients are injected in the power system. This can damage or force to shut down the system equipment and a bidirectional change in voltage or current can be observed in the system. By using FACTS
devices this effect of transients are compensated in power system [2].

e) Harmonics

Voltage fluctuations in the power line are occurs due to cycloconverters, arc furnaces, and other systems that draw current, which is not synchronized with the line frequency. Very short changes are occurring due to harmonics [3].

3. Statcom static synchronous compensator

FACTS devices are used to compensate reactive power, STATCOM is one of them to generate or absorb reactive power in transmission line. It is used to control given pa- rameters to gain stability of the power system network. This device works on its

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switching conditions, through control- ling of these conditions at input terminal and active-reactive power at its output terminals [3].
In the proposed work, STATCOM controls the DC power of DC bus. It generates active power and absorbs reactive power in the condition of unbalance at DC bus system. It maintains the voltage regulation and controls the load variation at same terminal of a wind power.
STATCOM regulates the transmission line variations and damping of system.

4. Microcontroller (pic16f73)

The microcontroller used in the proposed work is 28-pin package Microchip's PIC architecture by construction. It's different pin works for various functions as 1-5 of 8-bit Analog-to-Digital converter, captures and compare PWM functions in the system, 3-wire serial Peripheral Interface or

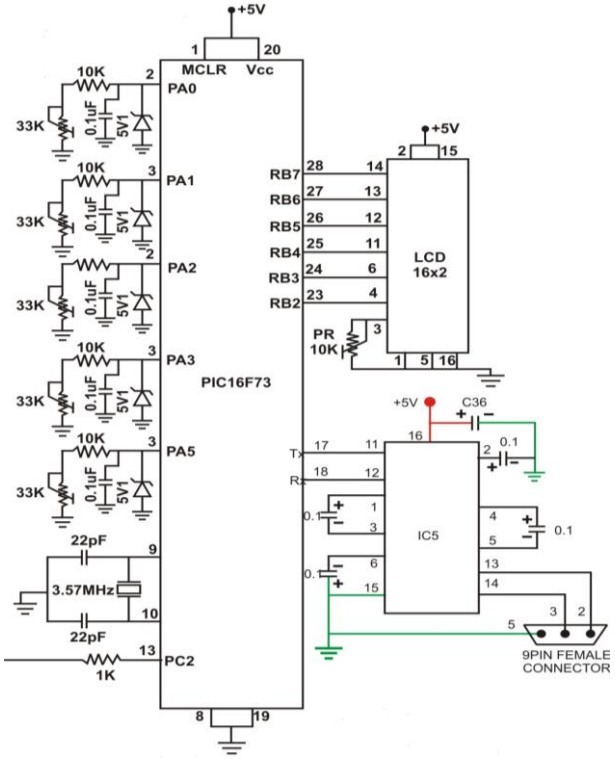


Fig. 1: Pin diagram of Microcontroller.

Integrated circuit bus and a Universal Asynchronous Re- ceiver and Transmitter.
This microcontroller controls the PWM of STATCOM and gives command to it for controlling bus parameters.

5. Block diagram of proposed system

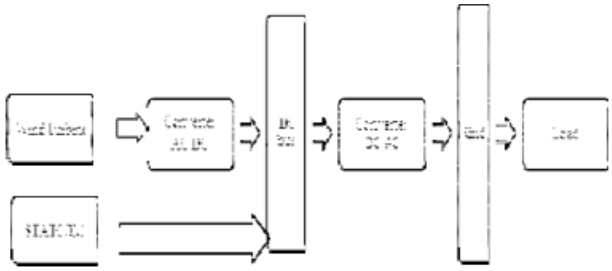


Fig. 2: Proposed Block Diagram of Power System.

The block diagram in fig.2 shows that the system is consist of Wind turbine, STATCOM, Converters, DC bus, Grid and load.

6. Proposed work

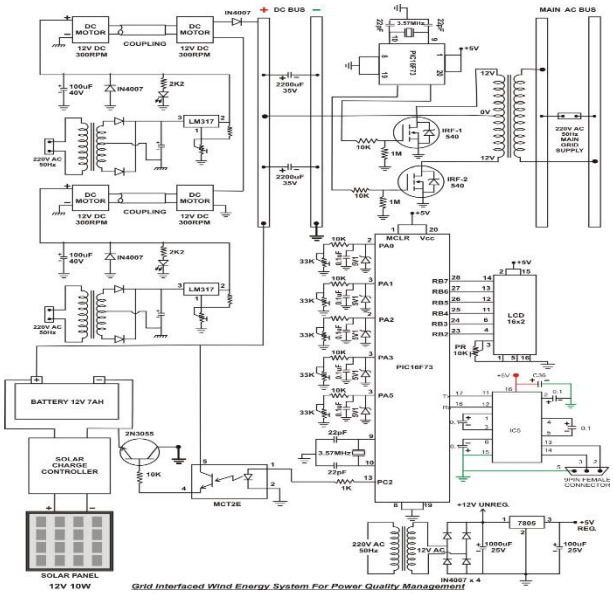


Fig. 3: Grid Interfaced Wind Energy System for Power Quality Management Circuit.

The proposed system comprises of a wind turbine based dynamo for electricity generation. The power generated is rectified & fed to a DC bus, which is point of common coupling of system & provides filter capacitor for ripple rejection.
The AC voltage so generated is electronically generated thus having fixed frequency & low harmonies, thus improving power quality. In addition, the produced AC voltage is fed to a PI (Potential Transformer) used for sensing AC voltage Produced & in turn to control STATCOM compensation using PWM. The STATCOM Battery is charged using Solar Power via Solar charge controller. The DC voltage on DC bus is fed to an Micro controller controlled PWM Inverter to produce 50 Hz using Dual MOSFET architecture, the voltage is stepped up using step up transformer & fed to Utility Grid.



Fig. 4: Hardware Model of Proposed Work.

A specially switched algorithm generates the proposed system, show by the Flowchart above. Initially the system initializes its components, & the STATCOM PWM is initialized at 400 Hz, 0% Duty cycle, thus initially no STATCOM compensation is present. Then AC voltage, DC voltage, wind voltage, solar voltage & Battery voltage are read from ADC (Analog to Digital converter) & displayed on USART & sent to serial terminal for logging. If AC output voltage is above 160 VAC, then STATCOM PWM is Zero, thus no STATCOM compensation is required. If AC voltage is below 160 AC, the STATCOM compensation is governed as

Duty = (160 – AC Voltage) * 3

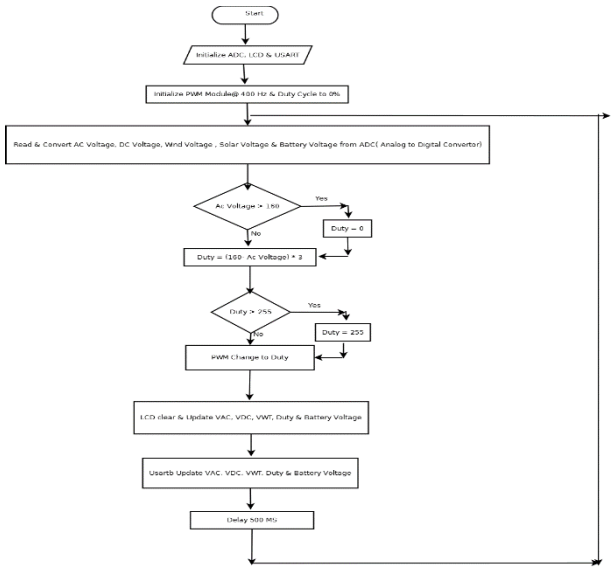


Fig. 5: Flowchart.

7. Results

Table 1: Simulated Wind on Load 1

Sr.No.	V_{wind} (wind turbine)	V_{dc} (DC Bus)	V_{ac} (Grid Bus)
	(Volt)	(Volt)	(Volt)
0	0	0	0
1	2	2	4
2	3	3	10
3	4	4	17
4	5	5	23
5	6	6	40
6	7	7	50
7	8	8	60
8	9	9	65
9	10	10	68
10	11	11	71
11	12	12	78

Table 2: Simulated Wind Supported by STATCOM on Load 1

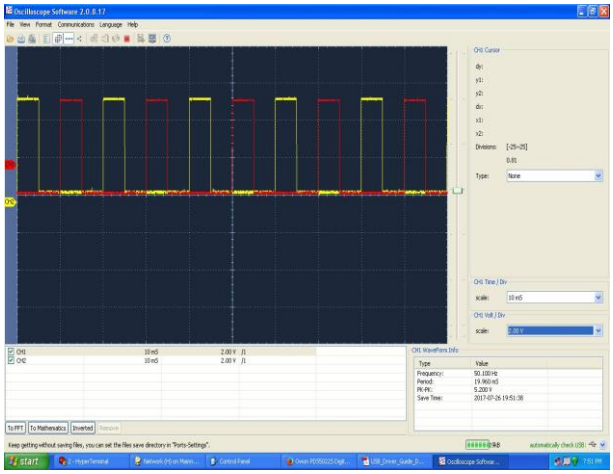
Sr.No.	V_{wind} (wind turbine)	V_{dc} (DC Bus)	V_{ac} (Grid Bus)	Remark
	(Volt)	(Volt)	(Volt)	
0	0	10.2	64	
1	2	10.2	64	
2	3	10.2	64	
3	4	10.2	64	
4	5	10.2	64	
5	6	10.2	64	
6	7	10.2	64	
7	8	10.2	64	
8	9	10.2	64	Constant output
9	10	10.2	64	
10	11	10.2	64	
11	12	10.2	64	

Table 3: Simulated Winds on Load 3

Sr. No.	V_{wind} (wind turbine)	V_{dc} (DC Bus)	V_{ac} (Grid Bus)
	(Volt)	(Volt)	(Volt)
0	0	0	0
1	2	2	10
2	3	3	10
3	4	4	10
4	5	5	10
5	6	6	15
6	7	7	23
7	8	8	25

Table 4: Simulated Wind Supported by STATCOM on Load 3

Sr.No.	V_{wind} (wind turbine)	V_{dc} (DC Bus)	V_{ac} (Grid Bus)	Remark
	(Volt)	(Volt)	(Volt)	
0	0	10.2	38	
1	2	10.2	38	
2	3	10.2	38	
3	4	10.2	38	
4	5	10.2	38	
5	6	10.2	38	
6	7	10.2	38	
7	8	10.2	38	
8	9	10.2	38	Constant output
9	10	10.2	38	
10	11	10.2	38	



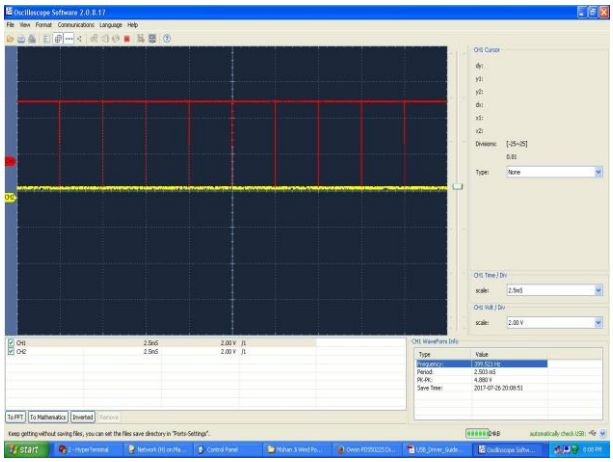


Fig. 6: Complimentary PWM on 50 HZ.

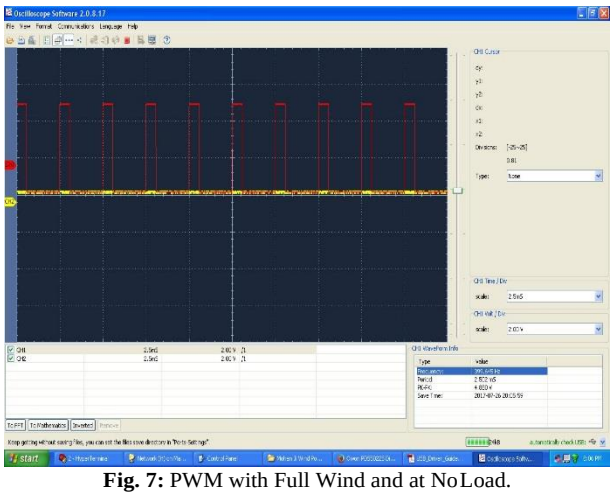


Fig. 7: PWM with Full Wind and at No Load.

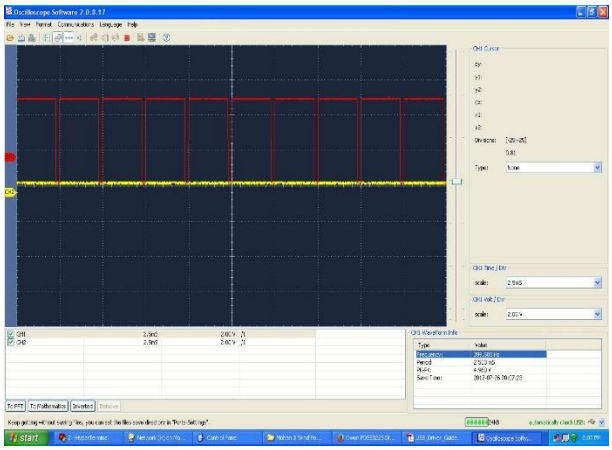


Fig. 8: PWM with Full Wind and at Load 1.

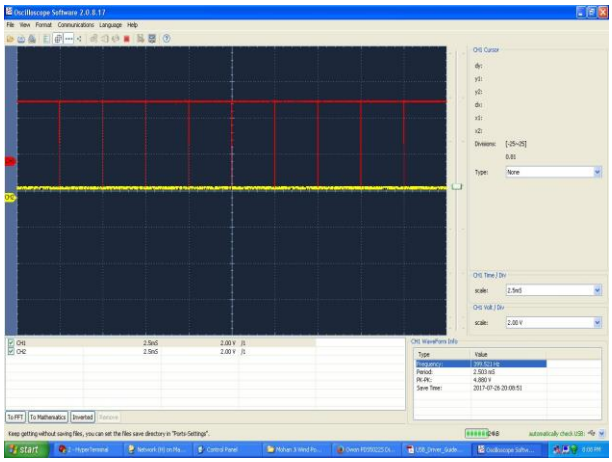


Fig. 9: PWM with Full Wind on Load 2 and 3.

8. conclusions

In this paper, we present a unique method of wind Generated power Quality Management. Use of advanced microcontroller technology allows for power quality improvement in grid connected wind generation system & with nonlinear load. The power quality issues & its consequences on the consumer & electricity grid are observed & rectified by having an advance DC Bus based Electronic PWM Inverter for grid power injection augmented battery charged of STATCOM batteries. The proposed system has proved by a warning prototype as discussed in results, & thus we are able to provide for a highly efficient power Quality Management System for Grid Interfaced wind Energy Generation System.

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