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PLC Based Smart Grid Application to Curtail And Connect Renewable Energy Sources To The Grid

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Abstract - *This project is an attempt to develop a smart grid that would curtail and connect the renewable energy sources with the grid. The Matlab based simulation of the solar and wind sources connected to the grid is developed and interfaced with the hardware which is connected through the power line communication hardware. The decision making of the curtailing and connecting the renewable energy is made using the load margin, which defines the amount of load the power system would withstand. The voltage amplitude of the power system would get reduced when the load is increased to a level which is called the load margin. Matlab based implementation is carried out and the output is connected to the serial port which passes the decision making from the Matlab Simulink to the Power line Communication (PLC). The 8051 receiver of the decision making algorithm would curtail or connect the renewable energy to the grid.*

Keywords – *Smart Grid, Power Line Communication, Renewable Energy Sources, Microcontroller 8051, Matlab/Simulink.*

1.INTRODUCTION

Today's electrical infrastructure have remained electrical grid has been ageing infrastructure; the demand for electricity has gradually increased. The demand and utilization of electricity increased by 2.5% annually over the last 20 years. Today the electric power distribution network is very complex. Among the deficiencies are a lack of some ideas and switching mechanically causes slow response system, due to lack of system response blackouts were occurred over past few years.

The various factors are the growing population, the demand for the energy, the global climate condition, equipment failures problem, the capability limitations of electricity generation, energy storage problems, one-way communication and decrease in fossil fuels. Consequently, a new grid infrastructure is straight away needed to address these challenges. Smart grid is a new trend in electric power grid infrastructure to improve the overall efficiency and reliability of the system. Smart grid is the best technique for smooth integration of renewable energy sources through automated control and modern two way communications technologies [4].

The power factor plays a significant role inorder to design an energy saving scheme in load side. The power losses in the electrical network is increased due to lagging power factor in the output power[2].The non -linear load will be the major cause for lagging power factor. The designed scheme is concerning about maintaining the power factor of load side. Power factor be the cosine of the angle between the voltage and current. The current and voltage is sensed with current and voltage transformer.

The phase angle between the voltage and the current is calculated and the result will be compared in the microcontroller. These processes are continuously carried out by microcontroller and maintain the power factor automatically [1].

2.BLOCK DIAGRAM

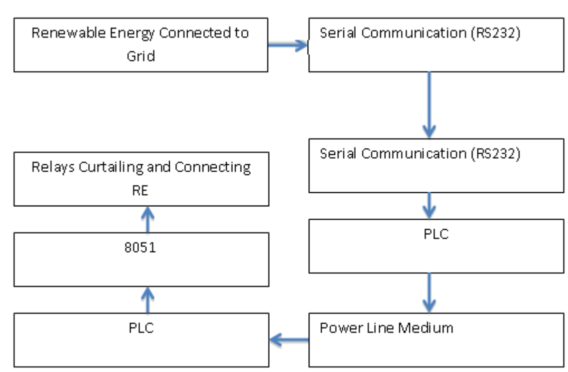

Fig 2(a): Block Diagram

Matlab based implementation is carried out and the output are connected to the serial port which passes the decision making from the Matlab Simulink to the Powerline Communication (PLC).

The 8051 receiver of the decision making algorithm would curtail or connect the renewable energy to the grid. The serial communication from the Matlab is connected to the PLC and the PLC would connect the data from one end to the other end of the power line. The other end of the power line is connected to the serial communication and the microcontroller receives the data and curtails the renewable source when voltage amplitude is disturbed and connected when the voltage amplitude is settled.

3.SIMULATION DESCRIPTION

3.1 Solar Description:

A 100KW solar model is connected to 25KV grid using boost converter and three phase three level voltage source converter.

MPPT(maximum power point tracking) is implemented in boost converter by means of simulink model using the incremental conductance and the integral regulator techniques.

Model contains the following components:

- PV array delivering a maximum of 100 kW at 1000W/m^2 sun's irradiance.
- 5-kHz DC-DC boost converter increasing voltage from PV natural voltage (273 V DC at maximum power) to 500 V DC. Switching duty cycle is optimized by a MPPT controller that uses the 'Incremental Conductance + Integral Regulator' technique. This MPPT system automatically varies the duty cycle in order to generate the required voltage to extract maximum power.
- 1980-Hz 3-level 3-phase VSC: The VSC converts the 500 V DC link voltages to 260 V AC and keeps unity power factor. The VSC control system uses two control loops: an external control loop which regulates DC link voltage to +/- 250 V and an internal control loop which regulates Id and Iq grid currents (active and reactive current components). Id current reference is the output of the DC voltage external controller. Iq current reference is set to zero in order to maintain unity power factor. Vd and Vq voltage outputs of the current controller are converted to three modulating signals Uabc_ref used by the PWM Generator.
- The control system uses a sample time of 100 microseconds for voltage and current controllers as well as for the PLL synchronization unit. Pulse generators of Boost and VSC converters use a fast sample time of 1 microsecond in order to get an appropriate resolution of PWM waveforms.
- 10-kvar capacitor bank filtering harmonics produced by VSC.
- 100-kVA 260V/25kV three-phase coupling transformer.
- Utility grid (25-kV distribution feeder + 120 kV equivalent transmission systems).

The PV array block menu allows you to plot the I-V and P-V characteristics for one module and for the whole array.

The PV array block has two inputs that allow you varying sun irradiance (input 1 in W/m^2) and temperature (input 2 in deg. C). The irradiance and temperature profiles are defined by a Signal Builder block which is connected to the PV array inputs.

The 100-kW PV array uses 330 Sun Power modules (SPR-305E-WHT-D). The array consists of 66 strings of 5 series-connected modules connected in parallel (66*5*305.2 W= 100.7 kW).

The 'Module' parameter of the PV Array block allows you to choose among various array types of the NREL System Advisor Model.

The manufacturer specifications for one module are:

- Number of series-connected cells : 96
- Open-circuit voltage: Voc= 64.2 V
- Short-circuit current: Isc = 5.96 A
- Voltage and current at maximum power : Vmp =54.7 V, Imp= 5.58 A

3.2 Wind Description:

Wind speed is working at 10 m/s at maximum velocity. Larger the tip speed ratio faster the rotation of wind turbine rotor at a given wind speed. High speed turbines are preferred for efficient electricity generation .75Kvar P.F correction capacitor has been used for reducing reactive power of wind generation.100KVA, 260V/25KV transformer also has been used for transferring the power to the grid.

Asynchronous generator is generating the 260 V AC voltages. The generator is taking 1.0sec for generating the AC power. 75 KVar P.F correction capacitor is used for stabilizing reactive power and continuous supply of real power to the load.

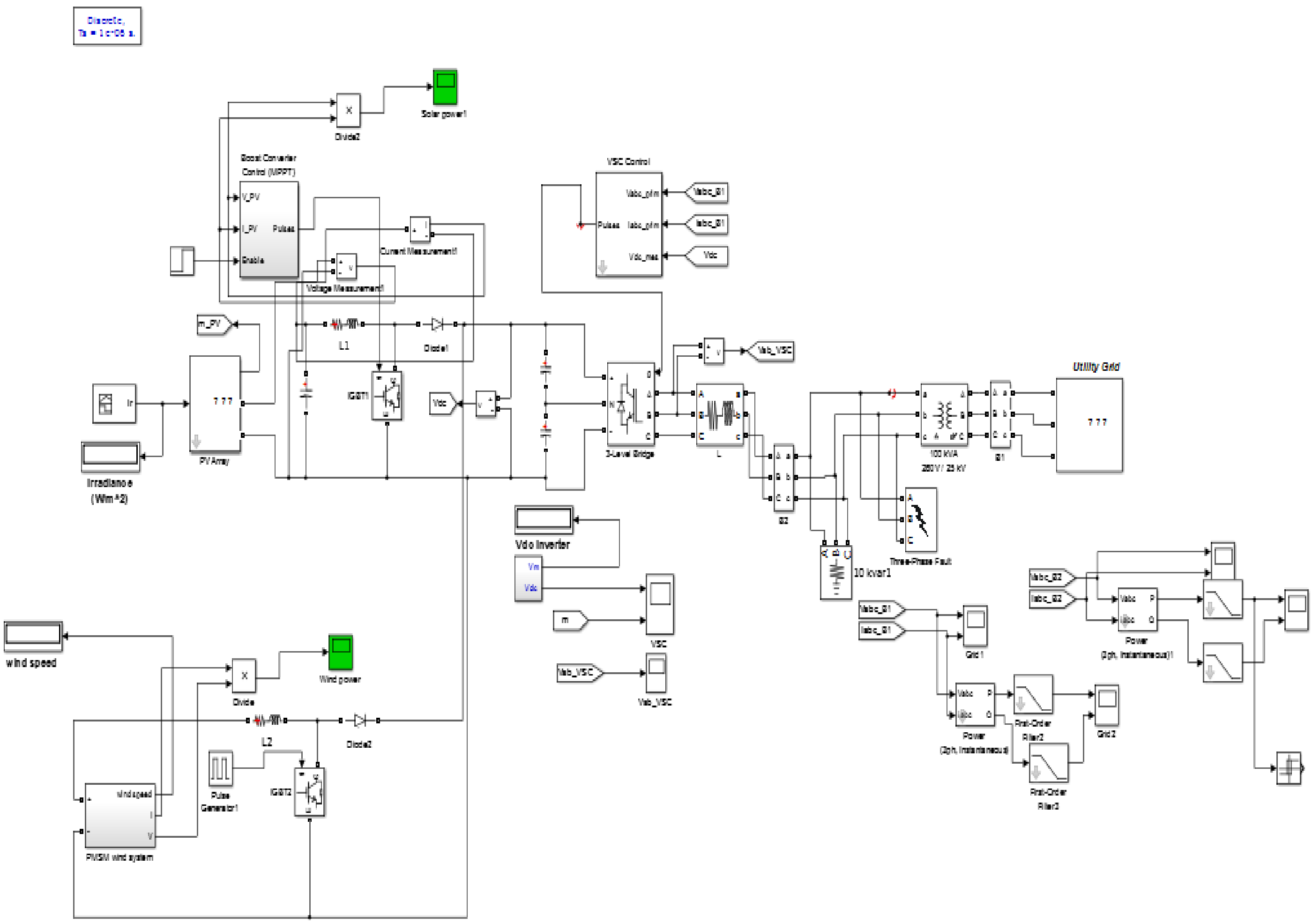

Fig 3(a): Simulation Circuit

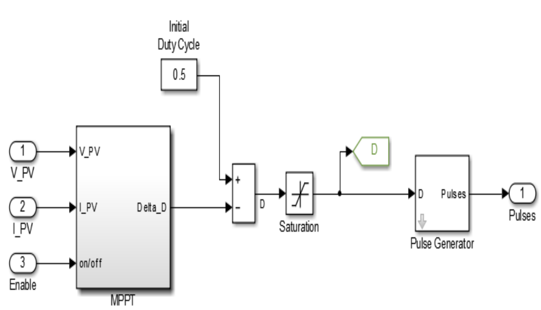

Fig 3(b): Subsystem Of Boost Converter Control (MPPT)

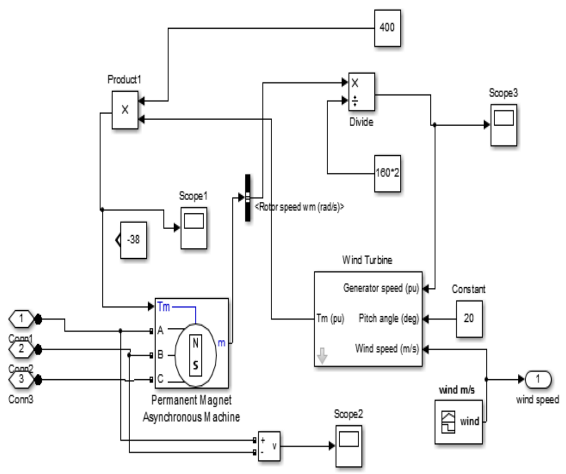

Fig 3(c): Sub Circiut Of Wind System

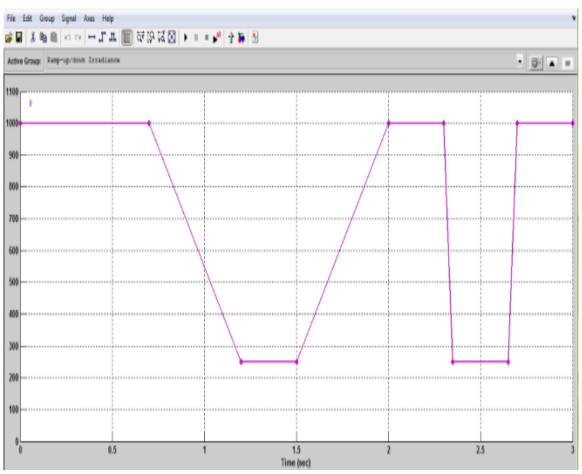

Fig 3(d): Graph Of Irradiance

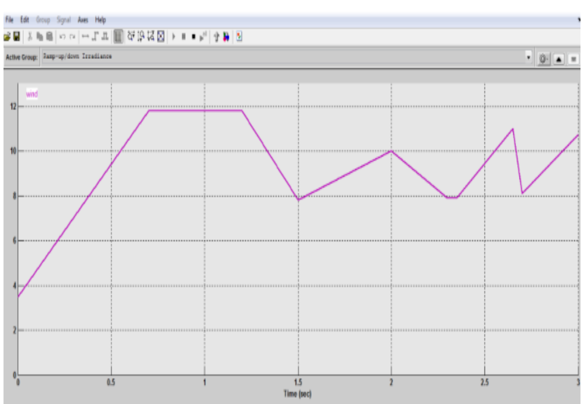

Fig 3(e): Graph of Wind Speed

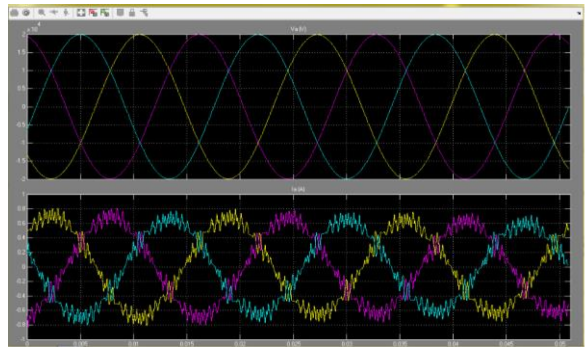

Fig 3(f): Output Waveform

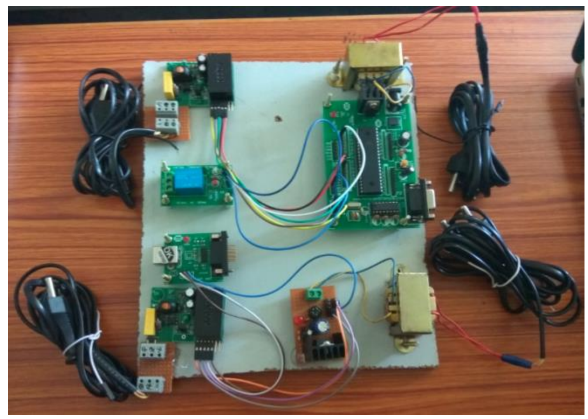

Fig 3(g): Hardware

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