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Real Time Energy Management and Load Forecasting in Smart Grid using CompactRIO

K.Thiyagarajan[a,*], Dr.R. SaravanaKumar.[b]

[a,b]*VIT University, Vellore, Tamilnadu, 632014, India*

Abstract

The energy management is the process of monitoring, controlling, and conserving energy in building or organization. In this paper a real time energy management and load forecasting in smart grid based on the NI CompactRIO platform is done. A console is created to monitor the electrical load connected with the smart grid. The CompactRIO used here is to get the real time data from different electrical loads and the data is transferred and stored through console via Ethernet. Load forecasting is done by past and present data of electrical load connected with the grid using artificial neural networks.

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Keywords: Load forecasting; Smart Grid; Monitoring; CompactRIO; Artificial neural networks.

1. Introduction

The National Instruments CompactRIO system consist of an embedded controller for communication and processing, a reconfigurable chassis, the user programmable FPGA, hot-swappable I/O modules and graphical LabVIEW software for real time monitoring and programming the FPGA. The monitoring system as developed in LabVIEW graphical environment. Monitoring system will displays voltage, current, power factor, frequency, and power of different connected loads of smart grid and these values continuously stored in TDMS format for analysis.

Load forecasting is a method which is used to predict the future load consumption. With the advancement in technology in soft computing, Neural Networks have been a Powerful tool in such prediction of load.

* Corresponding author. Tel.: +91-8428450733.
E-mail address:thiyagarajreddy@gmail.com

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This paper aims at forecasting the electrical load consumption in smart grid, using Artificial Neural networks in Matlab where the neural network train initially by using the real time training data stored in the console and it is fed to the neural network that makes it to get trained with the presence and repetition of a pattern present over a long run of data collection, so that prediction will be effective with less error and better accuracy. This prediction and monitoring system can help us get aware of the power needed to full fill the demand in the smart grid so whenever the load necessity is low, demand can be switch over to renewable power sources and the electricity get conserved.

2. Basic Structure and Specification of the System Design

The compactRIO and real time module which is used to measure the data through FPGA. With the help of LabVIEW program, programming and monitoring the compactRIO FPGA and storing the data into TDMS storage (Traditional Approaches to Measurement Data Storage). Using neural network in matlab for load forecasting. The System overview is shown in the flow chart given in Fig.1. (a).

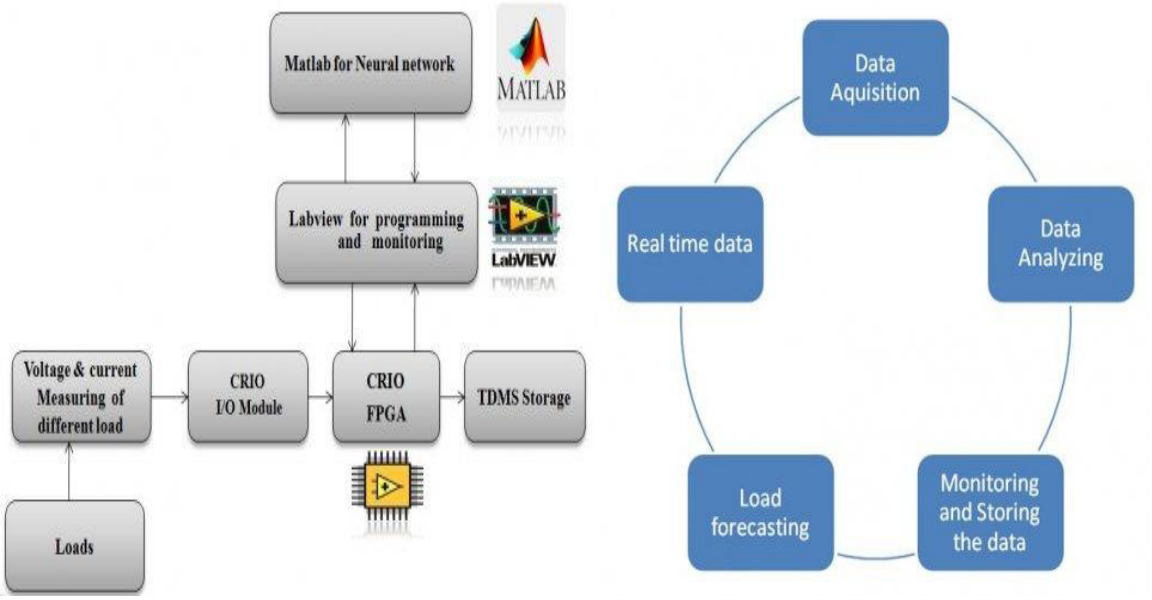

Fig. 1. (a) A block diagram for System overview flow chart; (b) Data flow chart

The data flow in this structure is shown in the Fig.1. (b).First step is acquiring real time data by CompactRIO. Second step is analyzing the acquired data using LabVIEW programming. Third step is analyzed data is displayed on front panel and stored. Forth step is forecasting the load by stored data.

3. Implementation

The following section discussed about the hardware and software implementation of the real time data monitoring and storing.

3.1 Hardware Implementation

The CompactRIO 9076 system consist of an embedded controller and reconfigurable chassis. The controller has execution of LabVIEW real-time applications. The chassis is at the centre of the system because it contains the I/O FPGA core.

Fig. 2. NI 9076, 9227and 9225

Package	Channels	Resolution	Max range	Sample rate
NI-9227	4	24	5A rms	50ks/s/ch
NI-9225	3	24	300V rms	50ks/s/ch

Table. 1. Package details

The package details are given in Table 1. NI 9227, 9225 is used to measure the current and voltage from the load. These I/O modules can measure up to 5A rms, 300V rms current and voltage ranges directly without any current transformer and potential transformer arrangement.

Fig. 3.Small smart grid setup

S.no	Type of Load	Rating
1	A.C single phase induction motor	0.18KW,0.25HP
2	Incandescent lamp	100W

Table .2. Load type and ratings

Small smart grid arrangement is made as shown in Fig .3 and CompactRIO is connected with loads to get real time data. Type and rating of load used in a small smart grid setup is shown in Table 2.

3.2 Software Implementation

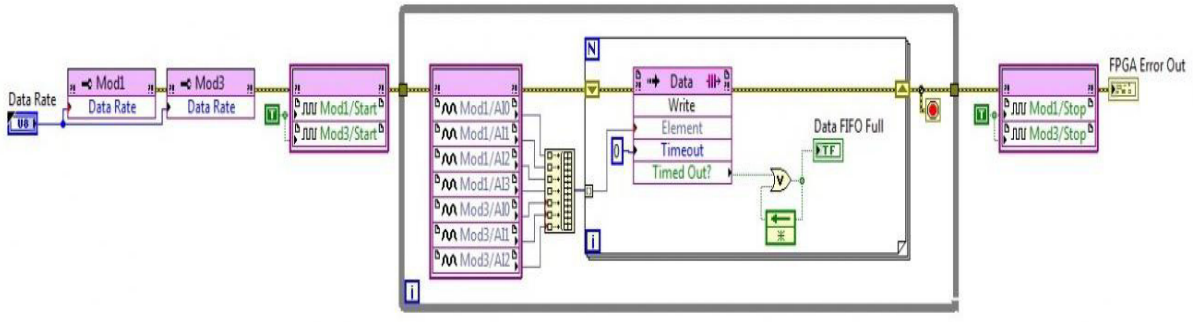

Fig .4. First part of the code

The diagram shown in Fig 4 specifies the configuration of FPGA to measure real time voltage and current values from loads connected with grid. In this programming using all the ports of IO module and storing the data into FIFO memory of FPGA.

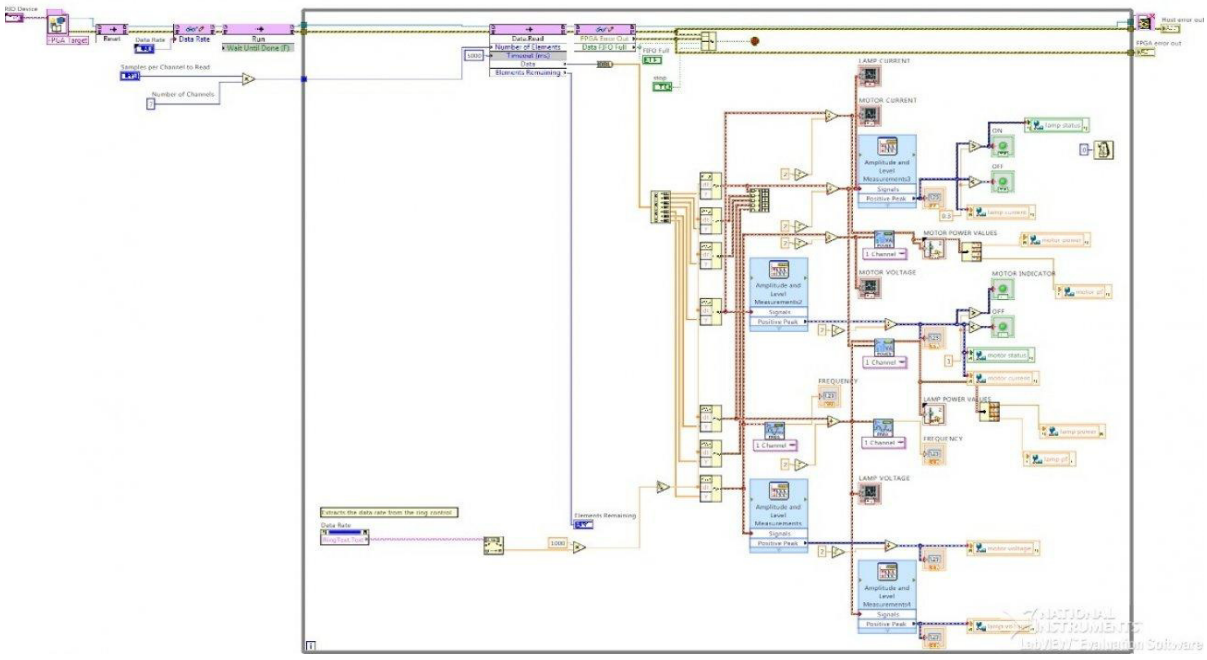

Fig 5. Second part of the code

Second part of the code was built to get a waveform from data stored with FIFO and Aanalysis the voltage and current waveform using electrical power suit. Utilizing of this electrical power suit we are get the voltage, current. Frequency, power factor and power.

3.3 Graphical Interface

Graphical panel was designed to monitor and analyze different type of load parameter. Induction motor and lamp load is used for analysis in this paper. Load rating is given in the Table 2. Created a front panel to monitor different load parameter as shown in Fig 6.

Fig 6.front panel for monitoring

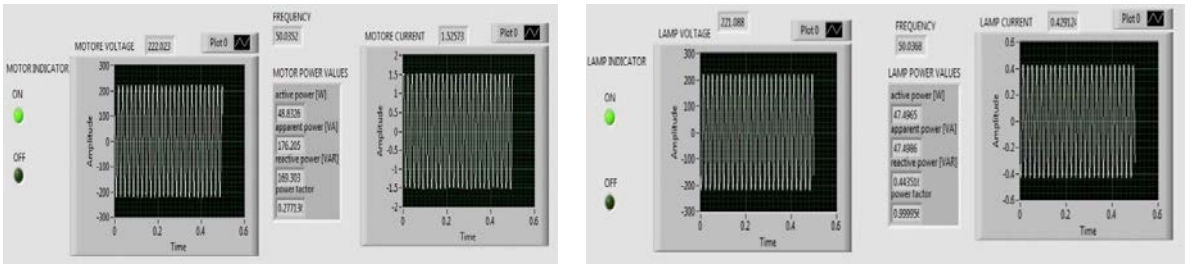

Fig. 7. (a).Simulated result of induction motor ; (b) Simulated result of Lamp

The front panel shown in the Fig 7. (a) is shows the all the parameters of the induction motor load and it displays the motor on/off status. Similarly simulated output of the lamp load shown in Fig 7. (b).

After the measurement, data is stored with TDMS format. TDMS (Technical Management Streaming), and the best thing for this format is, it contains description of the file, group and channel details. “Write to spreadsheet’’. VI can be used to create an array which can be read through Microsoft Excel.

4. Load Forecasting

Using of artificial neural network prediction of future load of the system done. For this training the neural network using of past data of loads. Real time data of induction motor is used to train the artificial neural network. From the voltage and current reading we found the power of motor in Kilowatts.

4.1 *Neural network Structure*

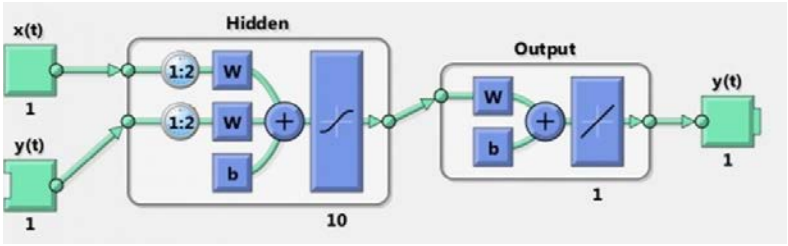

Fig 8. Neural network structure

To train the neural network using time in hours and power in KW. On training the network we see that it takes sufficient iterations.

4.2 Neural network performance

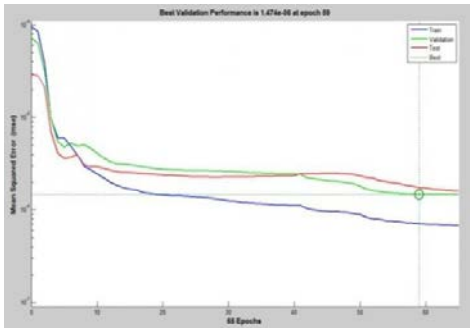

Fig. 9. Neural network performance

Actual Load	Predicted Load
0.1750	0.1710
0.1750	0.1790
0.1710	0.1730
0.1790	0.1721
0.1730	0.1801
0.1720	0.1711
0.1800	0.1708
0.1710	0.1722
0.1710	0.1732
0.1720	0.1744

Table 3. Outputs observed during prediction

It is seen that the convergence occurred at 65th epoch as shown in a Fig 9. The predicted outputs (power consumption in Kilowatts) are shown in the Tables 3. Similarly we can train the neural network with different load data's. The more the training data, the more accurate the results are.

5. Conclusion

Hardware and software has implemented on small smart grid setup with NI products. This energy management and load forecasting is done with different platform of LabVIEW and Matlab. In future both should be in single front panel, using the web server customized dashboard for an android mobile phone can be develop.

6. References

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