Monitoring and Wireless Controlling of Power Generation by LabView

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Abstract

In this paper we will try to improve and enhance the nation's energy infrastructure, by achieve controlling and monitoring of power generations remotely all over the world to evaluate performance of plants and investigate the voltage ,amperage, temperature and etc for each plant and also to decrease the workers number, cost saving in management and maintenance, predict failure before accrue and etc since the wireless networks made an advantages of low cost nature over traditional communication technologies used in today's electric power systems. This paper include design and implementation of internet based remote monitoring and controlling of power generation where the platform based on the design of an interface circuit with Arduino board, implemented by LabView software ALCS (Arduino-LabView Control System).The complete system can be controlled remotely where the remote control implemented by using a VSAT (Very Small Aperture Terminal) system. In this paper will focus on monitoring of coolant temperature and calculate the Mean Absolute Percentage Error (MAPE) of temperature between the Programming Logic Controller (PLC) reading that already install on power generation unit and the ALCS reading.

Keywords: Remote Monitoring and Control

1. Introduction

Wireless communication continues to play a significant role in the modernization of the electric power system [1] and Wireless communications provide both flexibility and cost savings in deployment and maintenance compared to wire line deployments. Wireless can be deployed anywhere and anytime; no trenches or conduits are required. Examples of modernization efforts related to increased communications in the electric power system to improve reliability and efficiency of power generation by controlling and monitoring networks throughout the electric power system and share the load between many power generations.

2. Related Work

Nowadays, internet and mobile phones are playing an important role in different domains. It had gained a lot of researches and investments. Hundreds of billions of dollars had been spent on the infrastructure and the backbone of the internet; as a result, internet now is covering almost the entire planet. This made the internet an excellent choice to transfer any kind of data between any two or more points [2]. Some studies concerning to the controlling through internet or mobile phones in reference [3] implemented two case studies to build web-based SCADA systems based on the client/server architecture. The first case study was concerned with controlling the water level of a network of dams. The second case study was issued for monitoring the network traffic on a set of VSAT modems and reference [4] proposes to apply the intranet technology to SCADA for power system and presents the result of development of the intranet-based SCADA trial system. The intranet-based SCADA is concerned with real-time performance and reliability of supervisory control. While reference [5] worked to develop data acquisition for remote monitoring and control of renewable energy sources based on the architecture of the server and client. The data distribution system is based on the client / server architecture, while the data transmission is carried out through the internet. Reference [6] discussed mobile application for remote monitoring of power generators condition. Application was run on symbian based cell phones and was developed using Python-interpreted ,scripting language. In the article, comparison between native applications coded in C++ and programs written in Python is shown. Some reference control or monitor of devices based by different type of hardware or software, these are able to be freely adapted to all network changes and expansions [7]. Following is an overview of some theses that deal with Microcontroller programmed with LabView such as reference [8] presents a remote experiment for controlling a DC motor. The experiment is controlled using a Proportional Integral Derivative controller (PID controller) algorithm programmed in a LabView environment.

The remote user can test PID digital algorithms and parameters, change reference velocity values and register the motor output velocity profile. Also reference [9] discussed the design, development and testing of Virtual Instrument (VI) modules using LabView front panel and real time engines and reference [10] studied a remote control system based on the LabView and ZLG PCI-5110 CAN interface card, in which students could perform experiments by remote control laboratory via the internet. In this paper will focus on controlling and monitoring using LabView, Arduino board and VSAT communication network with satellite the VSAT system include indoor (I direct modem model 3100) and outdoor unit(Android dish with LNB and BUC). LabView is a graphical programming language. Its main advantages are its fast learning curve .as well as its excellent connectivity to a lot of different types of industrial hardware [11].The general idea of this work is to use Laboratory Program (LabView) for monitoring and controlling of power generation, to engage power generation with the LabView we have to built an interface circuit between the power generation and LabView program that will be at P.C Server.

3. Hardware Architecture

There are two basic layers in this system; the first layer is a Client layer which provides for the Human Machine Interface (HMI) and the data server layer that handles most of the process data control activities [12]. The data servers communicate with devices in the field through process controllers. Process controllers, e.g. Microcontroller such as Arduino board that used microcontroller type ATmega328, are connected to the data servers either directly or via networks or field buses. Data servers are connected to each other and to client stations via a Local Area Network (LAN).

The power generation consist with input and output configuration the input represented by actuator that control to on and off the power generation and the sensors that represented as an output of power generation, and to implement this work we have to study the characteristics of an input and output configuration and built the appropriate software that will be control and monitor the power station and the figure 1 shows the all system.
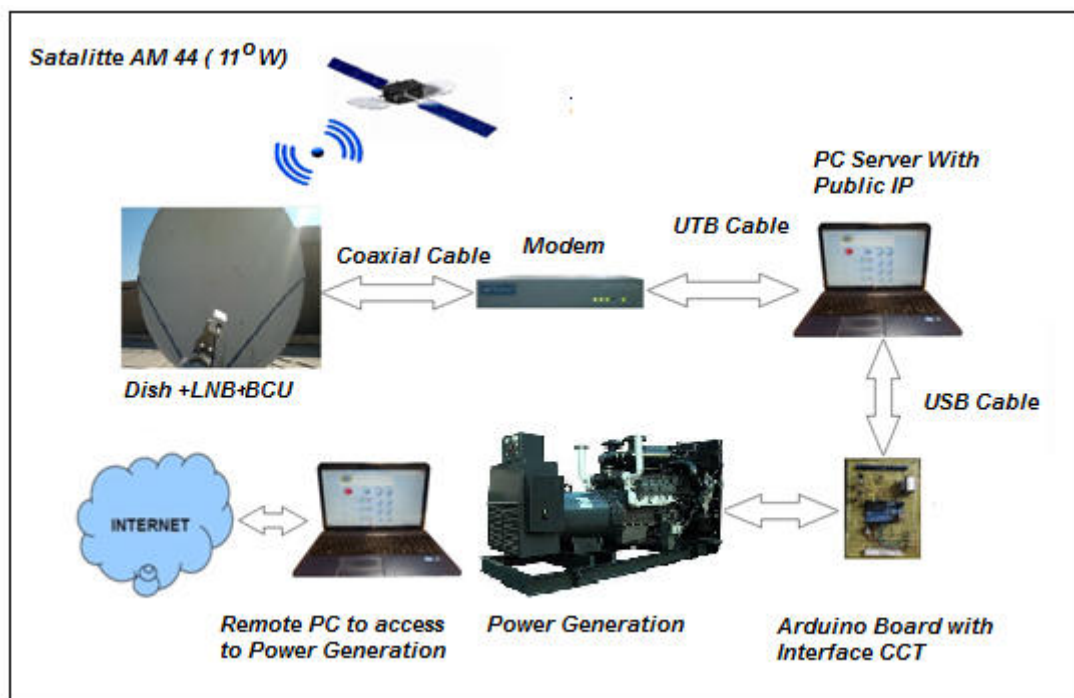

Figure 1. ALCS System Design

Where the modem worked as a gate way to the PC server to publish the labView server to the World Wide Web and the interface circuit that include Arduino board hook up to the PC server by USB cable. The PC client should have internet service with LabView software to access to the PC server for wireless monitoring and controlling.

4. Input and Output Parameter with Power Generation

Focus will be on some of the power generation parameters including coolant temperature, oil pressure, AC voltage, amperage, charger voltage and frequency. These parameters are an output of power generation to the

control system. And the input to the power generation is a on /off signal depending on the status of power generation.

In many systems, temperature control is fundamental and in this paper will focus on the temperature monitoring to calculate the characteristic equation that will used in LabView software for monitoring and control of power generation. There are a number of passive and active temperature sensors that can be used to measure system temperature, including thermocouple, resistive temperature detector, and thermostat and silicon temperature sensors. These sensors provide temperature feedback to the system controller to make decisions regarding temperature shutdown, turning the cooling fan on or off, temperature compensation or general purpose temperature monitoring. In the experimental work aVDO temperature sensor type 120°C resistive temperature detector, with type negative temperature coefficient (which means the sensor's resistance decreases as the temperature rises) is used as shown in figure 2.

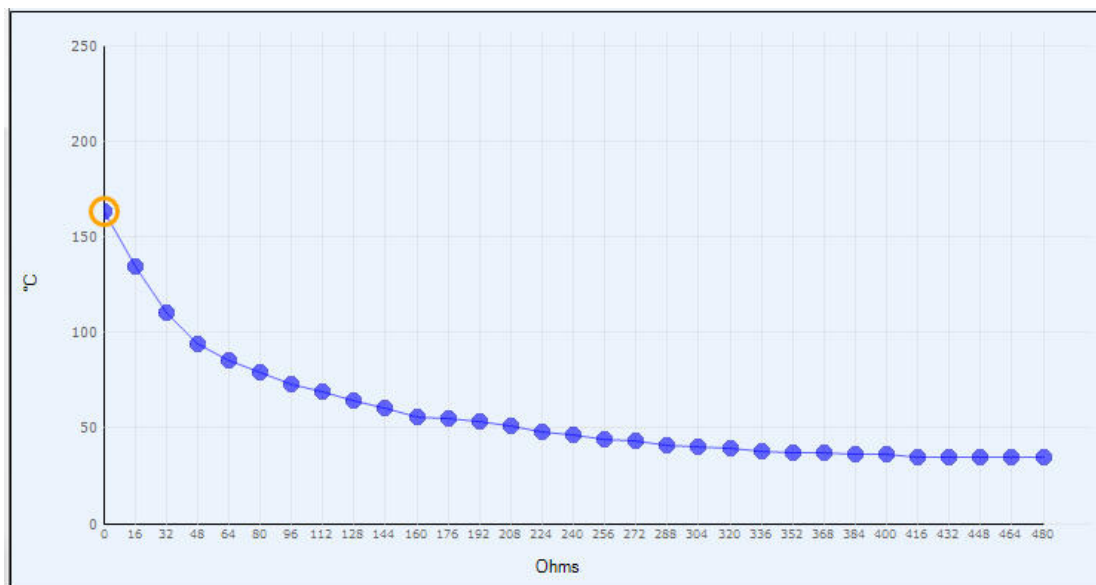Figure 2. Temperature sensor for power generation type VDO

Figure 3. Temperature sensor curve for VDO sensor

This sensor measures temperature by calculating the resistance of the sensor. The resistance is calculated by measuring voltage across the sensor with a fixed applied current. The measured current is (10 mA); hence full scale resistance is (480 Ohms). The relationship between the temperature and resistance is shown in figure 3.

To read the coolant temperature of power generation the sensor should be defined to the Arduino board. There is a relationship between the resistant and temperature so the coolant temperature sensor is a variable resistance depending on the coolant temperature, where the Arduino board has 6 analogue input pins that can read a

maximum voltage of (5V). Also, the Arduino board can supply an output voltage of (5 DCV). If (5 DCV) supplied to the sensor across fixed resistance (R=1KΩ), then the supplied voltage will be divided on the sensors and fixed resistance according to the voltage divider rule

$$\frac{V_O}{V_S} = \frac{R_{ts}}{R+R_{ts}}$$
(1)

It can read the voltage across the coolant sensor by the Arduino board with the analogue input pin (A0 pin), shown in figure 4.
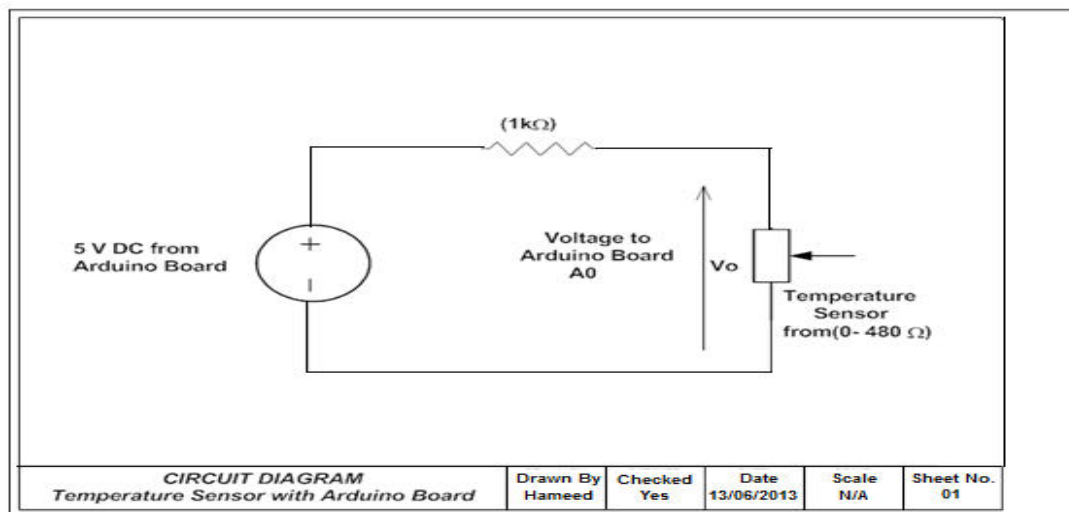

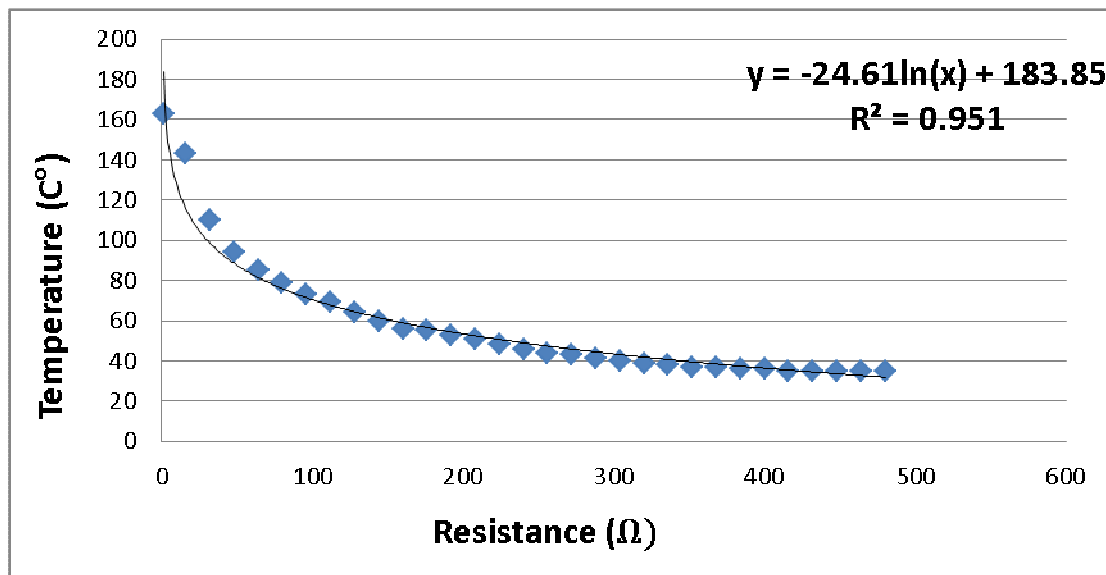Figure 4. Temperature sensor with Arduino board circuit

Figure 5. Relationship between resistance and temperature using regression analysis

The analogue input pin (A0) of the Arduino board is connected to the sensor. The voltage across the sensor can be read using LabView software. Since the voltage was read using LabView, then the resistance of the sensor (Rts) will be calculated according to the equation.

$$R_S = \left(\frac{V_O * R}{V_S - V_O} \right)$$
(2)

The resistance value of the coolant sensor is known then the coolant temperature can be calculated by the relationship between the resistance and temperature. Figure 3 shows the relationship between the resistance and

temperature. To express that graph as an equation a numerical analysis such as regression law can be used to choose a closer regression curve depending on value or by R-Square value. logarithmic regression is chosen since the R-Square is a maximum value (0.951) as compared with the linear, polynomial, power and exponential, where the R-square values are (0.6876, 0.9085, 0.8837 and 0.8611) respectively(By using Microsoft excel). Figure 5 shows the best curve matched with the original curve.

By using regression the relationship between resistance and temperature sensor can be found as shown in equation (3) which will be used by LabView software for temperature calculation where (T´) is the predicated temperature.

$$T' = -24.61 * \ln(Rts) + 183.8 \tag{3}$$

5. Software Architecture

Monitoring and control application is evolving according to the software architecture, having two main components: server application and client application. The servers are responsible for data acquisition and data storing in the database. The server application reads data from USB port and microcontroller. The client application uses the database actualized by the server in order to realize HMI. It consists of events lists, warning lists, alarm lists, graphical parameters' trending and measured parameters' lists for equipment or any device that needs monitoring and supervisory control.

6. Design of front panel and block diagram of LabView

Figure 6 shows the block diagram of LabView software, where the input from Pin A0 of Arduino board will converted to the resistance value according to the voltage divider rule equation (see equation 2) then will converted to temperature value according to equation 3, this value will compare relative to critical values (where will send High Temperature Alarm when have critical value up to 95 C and will send Off signal when exceed the critical value up to 100. LabView software consists of a control panel and block diagram components, as shown in figures (6) and (7). The design of the LabView software by VI where there are six analogue inputs from power generation to Arduino board and six digital outputs from Arduino board to Led for alarm and one digital output to the (5 DCV) relay for On/Off power generation.
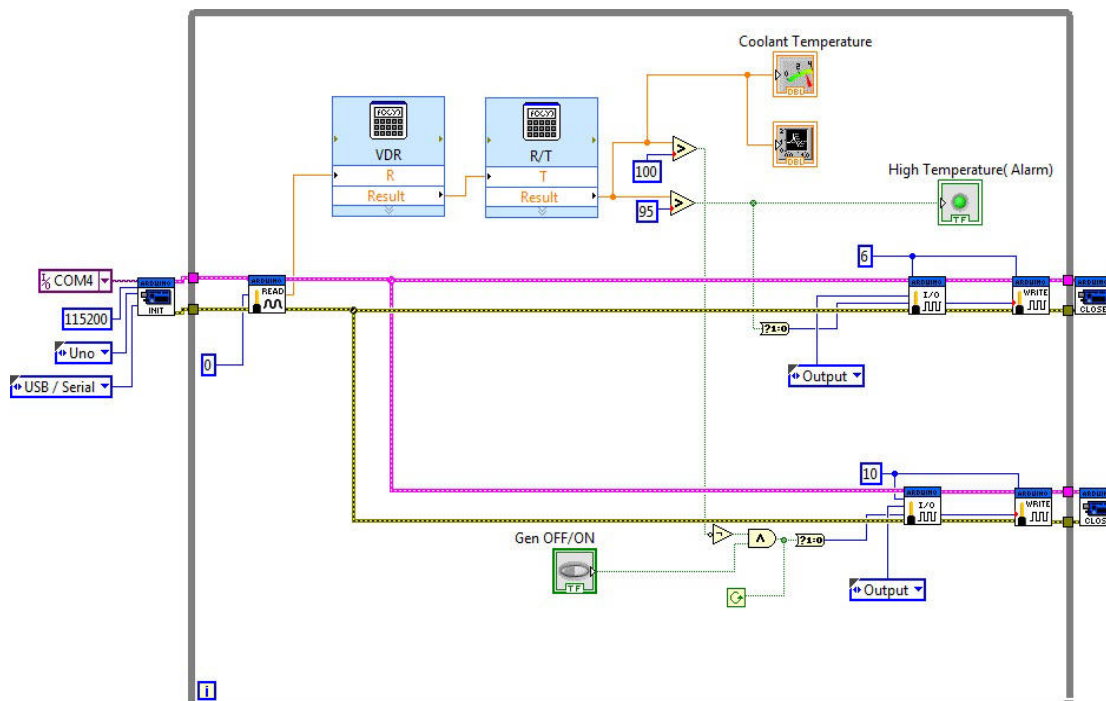

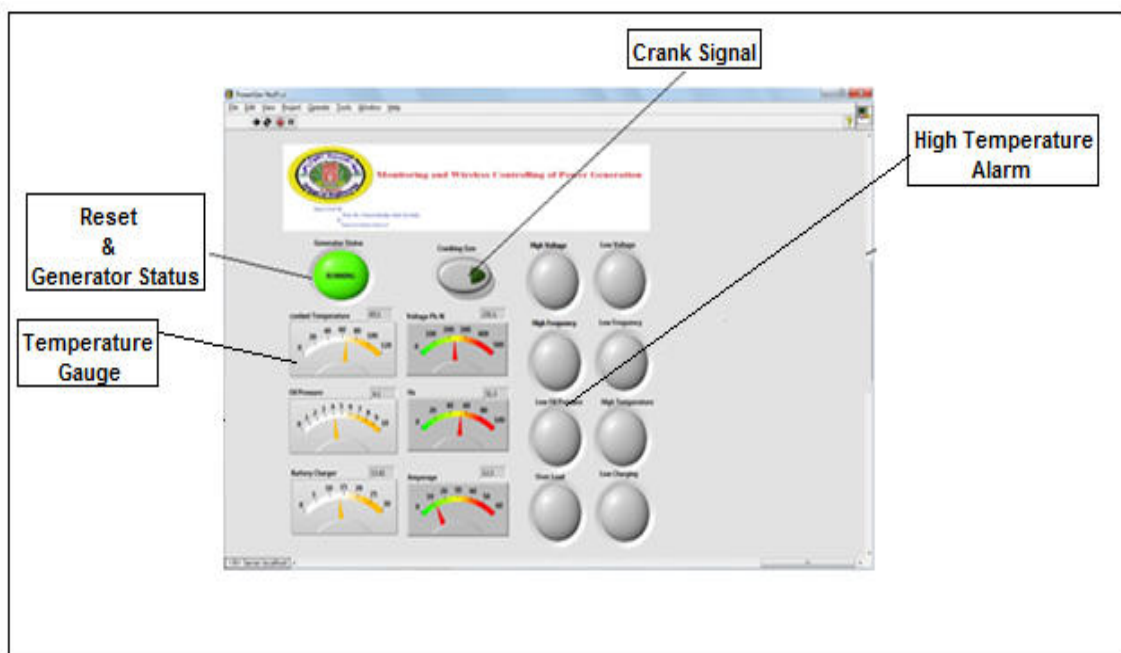Figure 6.Block Diagram of LabView Software for Temperature Monitoring and Control

Figure 7. Front panel of LabView Software

7. Implementation of Wireless Controlling and Monitoring

7.1 LabView –PC as Server

After designing the LabView software and hooking up the interface circuit that includes the Arduino board and electrical circuits to the PC by USB cable, the PC works as a server that is connected to the modem and will be defined by the public IP.
 Now the LabView software should be prepared at the site to be as a server, by defining the machine access (Public IP address) where the machine access address is the same Public IP address as the PC server

After hooking up the entire network the connection of the network should be checked by using the DOS window with the Ping instruction .Ping is a computer network administration utility used to test the reach ability of a host on an IP network. The last step after completing the setup of a LabView as a server is to connect the LabView to the internet service.

7.2 LabView –PC as Client

For remote access to the power generation by the PC Client with LabView, the LabView front panel should be opened for a new VI, select the operation from the task bar and select connect to remote panel. A new window will appear, the public IP address is keyed in, port number, and file name that was made using the LabView server, as shown in figure 8. Then, the remote panel will appear as shown in figure 9.
LabView software is ideal for any measurement or control system, and the heart of the NI design platform. Integrating all the tools that engineers and scientists need to build a wide range of applications in dramatically less time, LabView is a development environment for problem solving, accelerated productivity, and continual innovation.
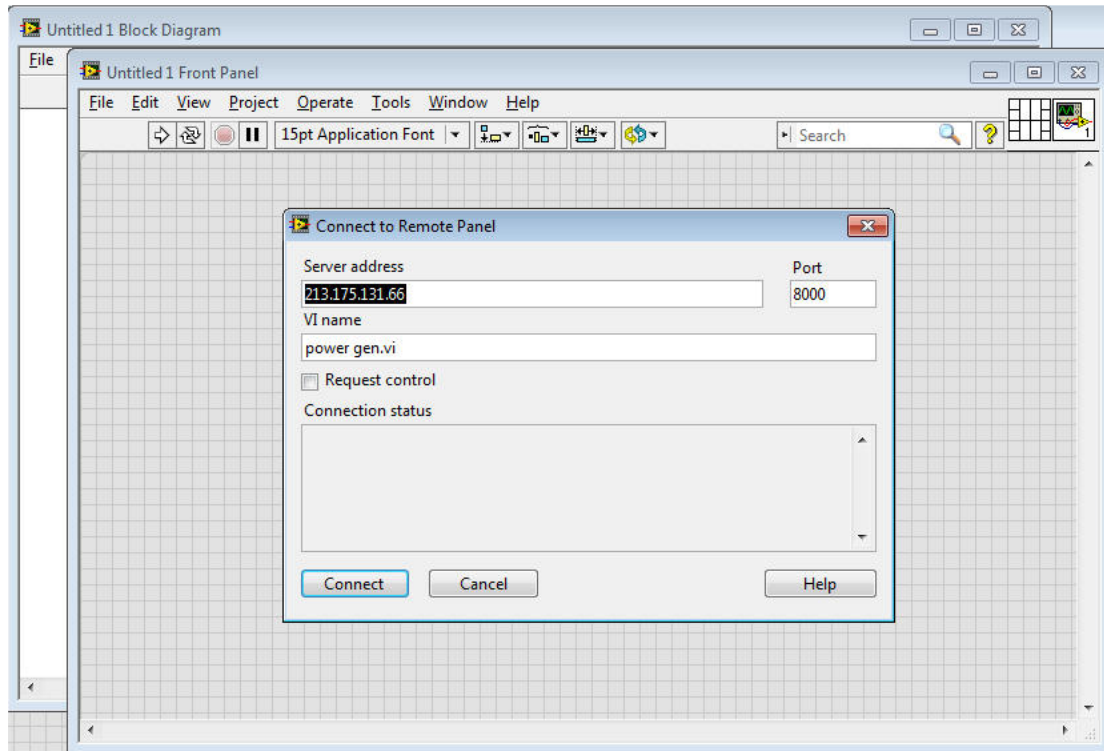
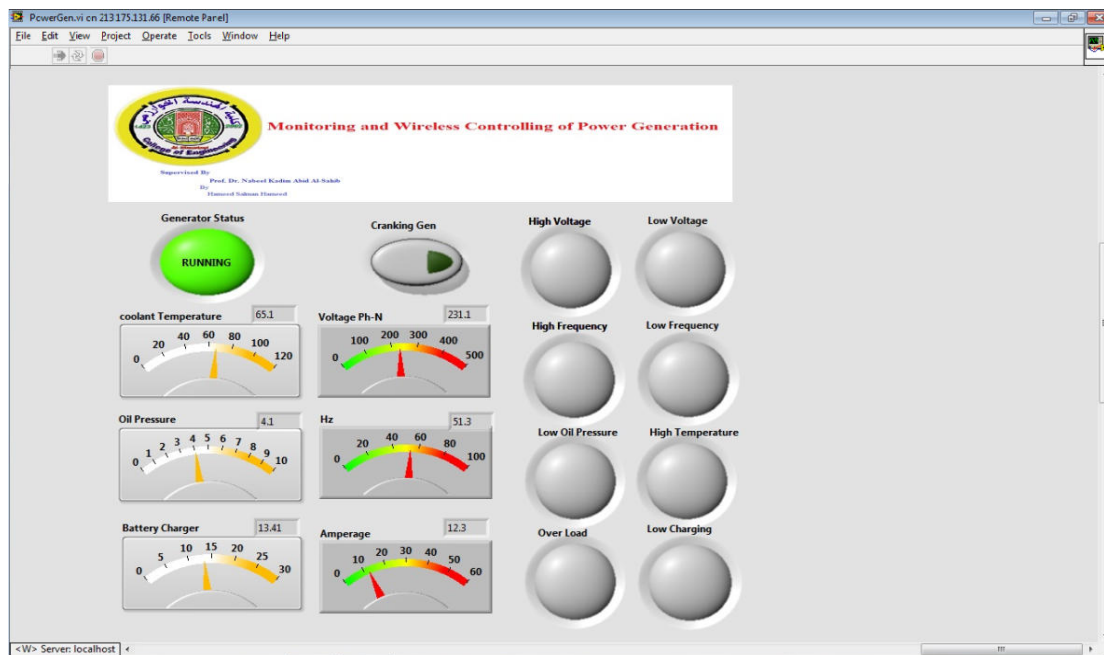Figure 8. Remote accesses to the server through IP and Port No.

Figure 9. Live monitoring and control by client.

8. Temperature Experimental results

To allow proper lubrication of engine parts and engine oil flows more readily at operation, especially in cold weather, the power generation unit should be kept warm by installing a block heater on the engine. To save time and electricity and prevent damage to cold engine parts, most power generators have this technique. The controller of the power generation is designed according to the minimum temperature 35 C°. Figure 10 and 11 show the temperature monitoring of PLC system and ALCS respectively.
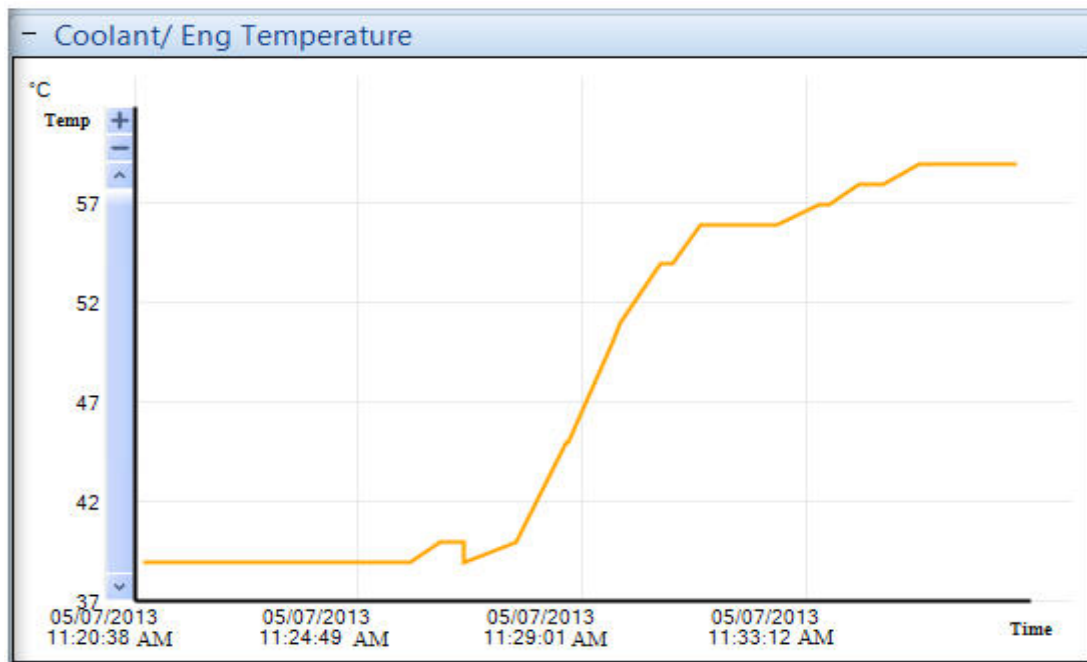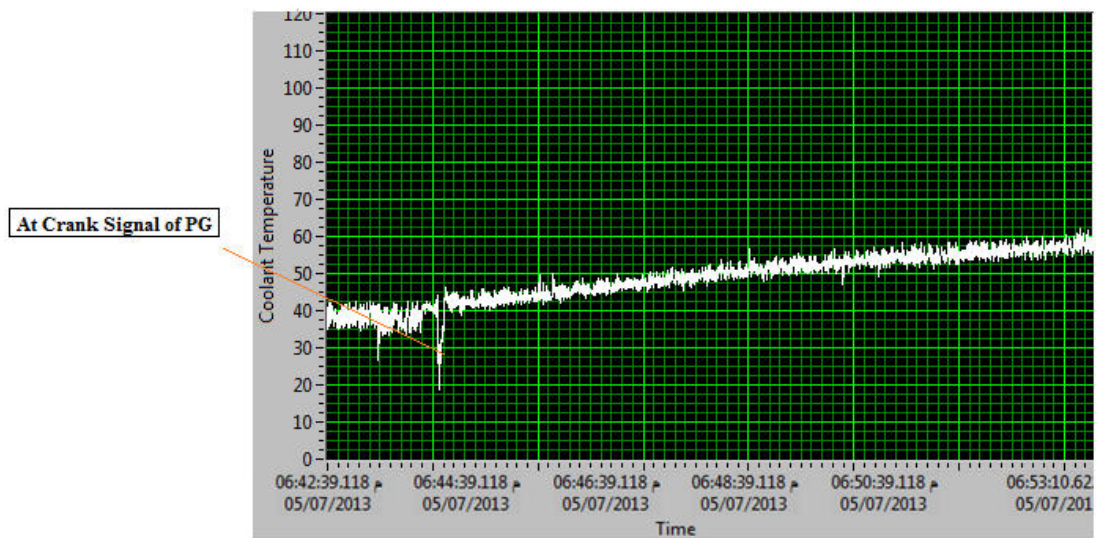
Figure 10. Temperature Monitoring by PLC System

Figure

11. Temperature Monitoring by ALCS

Readings of both systems will be taken at the same time for temperature by running both systems at the same PC server as shown in figure 12.
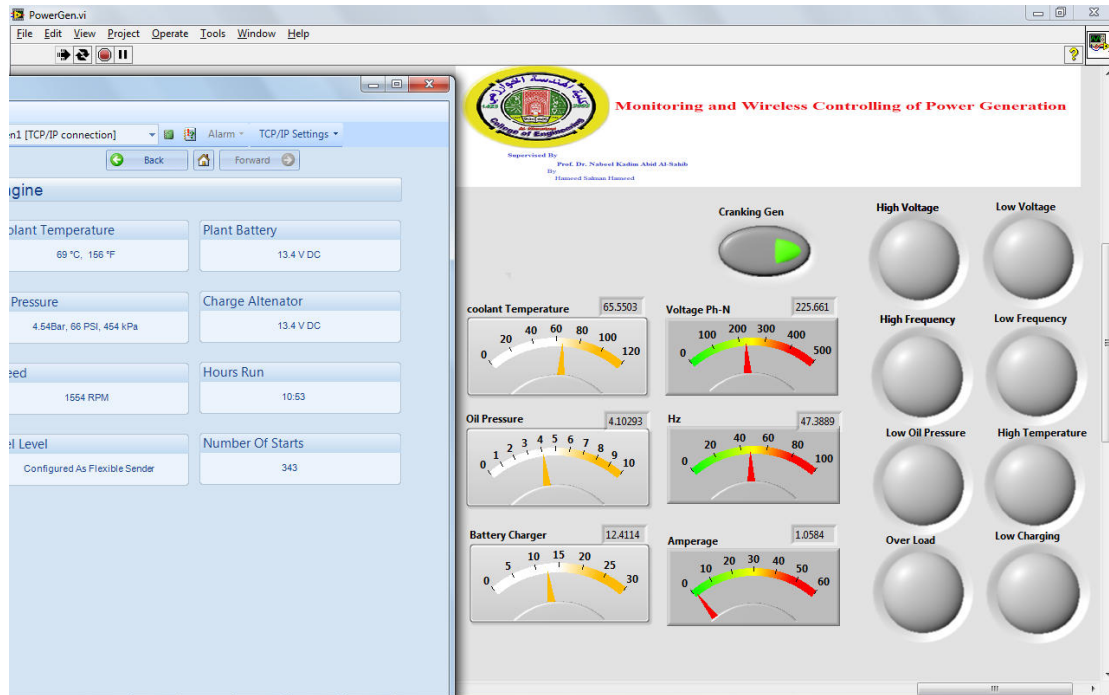
Figure 12. Reading of coolant temperature for PLC system and ALCS at the same time

The left side displays the value of mechanical parameter of PLC system, such as coolant temperature, oil pressure, voltage of charger system and etc; and the right side displays the mechanical and electrical parameters of ALCS at the same window. By monitoring temperature of power generation for a period of time and take the reading every ten seconds and documenting these readings of both systems at the same time in table (A) by taking screenshot of LabView front panel for ALCS and DSE Configuration suite program that monitoring at the same PC. Table (A) shows the readings of PLC system and ALCS, to calculate the percentage error between ALCS and PLC system using equation (4), and to calculate the MAPE of ALCS relative to PLC system by using equation (5) where the MAPE is (4.243678%).

$$\varepsilon_i T = \frac{T_2 - T_1}{T_2} * 100\% \qquad (4)$$

$$MAPE = \frac{1}{N} \sum_1^N |\varepsilon_i T| \qquad (5)$$

Where:
  T1 : PLC system Temperature
  T2 : ALCS Temperature
  $\varepsilon_i T$: Percentage temperature error of ALCS relative to PLC system
  N : Number of Reading

By taking an instantaneous reading of temperature for both systems and drawing these readings relative to the time; the fluctuation can clearly be seen in figure 13.

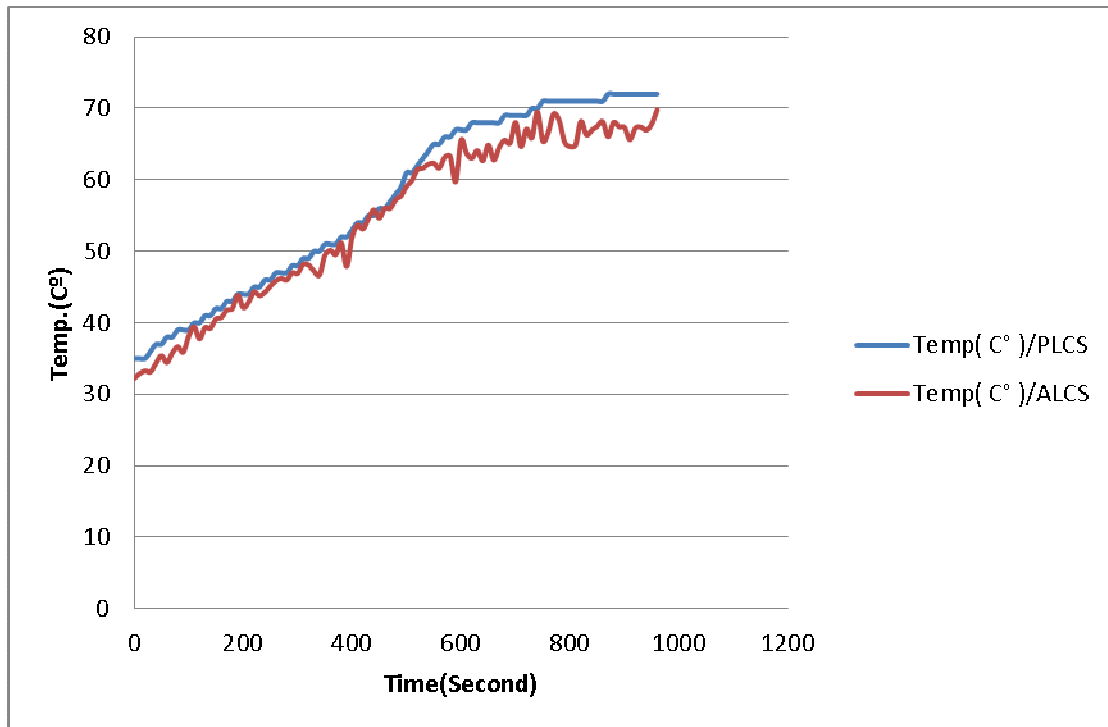Figure 13. Coolant temperatures monitoring for PLC system and ALCS

This error comes from different sources. For example, sensors are connected with long wires that act as antennas and pick up noise that causes the error. Also, errors come from the calibration between temperature and resistance of sensor (see equation (3). Sensor error is neglected since it is the same sensor used for both PLC system and ALCS system.

Table A. Temperature Error of ALCS relative to PLC System

Time / Second	Temp(C°) / PLC System	Temp (C°) / ACLS	εT%
0	35	32.21	7.971428571
10	35	32.89	6.028571429
20	35	33.29	4.885714286
30	36	33.12	8
40	37	34.33	7.216216216
50	37	35.4	4.324324324
60	38	34.43	9.394736842
70	38	35.78	5.842105263
80	39	36.67	5.974358974
90	39	35.89	7.974358974
100	39	38.11	2.282051282
110	40	39.45	1.375
120	40	37.75	5.625
130	41	39.34	4.048780488
140	41	39.23	4.317073171
150	42	40.54	3.476190476
160	42	40.76	2.952380952
170	43	41.78	2.837209302
180	43	41.98	2.372093023
190	44	43.86	0.318181818
200	44	42.12	4.272727273
210	44	42.9	2.5
220	45	44.31	1.533333333
230	45	43.79	2.688888889
240	46	44.28	3.739130435
250	46	45.12	1.913043478
260	47	45.89	2.361702128
270	47	46.21	1.680851064
280	47	45.98	2.170212766
290	48	47.02	2.041666667
300	48	46.9	2.291666667
310	49	48.17	1.693877551
320	49	48.09	1.857142857
330	50	47.23	5.54
340	50	46.67	6.66
350	51	49.45	3.039215686
360	51	50.14	1.68627451
370	51	49.53	2.882352941
380	52	51.18	1.576923077
390	52	47.89	7.903846154
400	53	52.02	1.849056604
410	54	53.67	0.611111111
420	54	53.12	1.62962963
430	55	54.56	0.8
440	55	55.8	-1.454545455
450	56	54.64	2.428571429
460	56	56.04	-0.071428571
470	57	56.01	1.736842105

Time / Second	Temp (C°) / PLC System	Temp (C°) / ACLS	εT%
480	58	57.22	1.344827586
490	59	57.79	2.050847458
500	61	59.11	3.098360656
510	61	59.94	1.737704918
520	62	61.45	0.887096774
530	63	61.65	2.142857143
540	64	62.19	2.828125
550	65	62.32	4.123076923
560	65	61.65	5.153846154
570	66	63.17	4.287878788
580	66	63.3	4.090909091
590	67	59.73	10.85074627
600	67	65.55	2.164179104
610	67	63.74	4.865671642
620	68	63.02	7.323529412
630	68	64.1	5.735294118
640	68	62.67	7.838235294
650	68	64.89	4.573529412
660	68	62.77	7.691176471
670	68	64.54	5.088235294
680	69	65.55	5
690	69	65.13	5.608695652
700	69	68.04	1.391304348
710	69	64.64	6.31884058
720	69	67.11	2.739130435
730	70	65.87	5.9
740	70	69.52	0.685714286
750	71	65.437	7.835211268
760	71	66.64	6.14084507
770	71	69.257	2.454929577
780	71	68.3066	3.793521127
790	71	65.2879	8.045211268
800	71	64.634	8.966197183
810	71	64.85	8.661971831
820	71	68.18	3.971830986
830	71	66.284	6.642253521
840	71	66.9537	5.699014085
850	71	67.4952	4.936338028
860	71	68.14	4.028169014
870	72	66.035	8.284722222
880	72	68.0443	5.494027778
890	72	67.4072	6.378888889
900	72	67.3437	6.467083333
910	72	65.63	8.847222222
920	72	67.22	6.638888889
930	72	67.39	6.402777778
940	72	66.95	7.013888889
950	72	67.8	5.833333333
960	72	69.8	3.055555556

9. Conclusion

Monitoring and wireless control of power generation was designed and implemented by two control systems, ALCS with VSAT system. The results of ALCS were compared relative to PLC system and the MAPE error calculated, where the MAPE error for monitoring of temperature was (4.2658%).Monitoring and wireless control of power generation can improve interoperability, cost effectiveness (by reducing the cost of installing when wire line communications to the remote site is prohibitively expensive,) reliability, efficiency and safety (by enabling the right the worker to be at the right place at the right time). In spite of the low cost of Monitoring and wireless control of power generation it is still less secure than a traditional wire system. Software packages and hardware are available today to support the SCADA systems to the internet and hardware technology allows an internet - SCADA to provide means to increase the security of the system.

References

1- Akyol, B., et al., *A survey of wireless communications for the electric power system.* Prepared for the US Department of Energy, 2010.

2- ABBAS, Hosny A.; MOHAMED, Ahmed M. Review on the Design of Web Based SCADA Systems Based on OPC DA Protocol. *International Journal Of Computer Networks (IJCN)*, 2.6.

3- KHATHAIR, A.Y. and AL-OBAIDY, *DESIGN AND IMPEMENTATION OF WEB BASED SCADA SYSTEM.* 2006.

4- EBATA, Yoshio, et al. Development of the Intranet-based SCADA (supervisory control and data acquisition system) for power system. In: *Power Engineering Society Winter Meeting, 2000. IEEE*. IEEE, 2000. p. 1656-1661.

5- Kalaitzakis, K., E. Koutroulis, Vlachos, *Development of a data acquisition system for remote monitoring of renewable energy systems.* Measurement, 2003. 34(2): p. 75-83.

6- PODSIADLY, P.; SWIERCZ, B.; WROBLEWSKI, S. Mobile remote control application for power generators vibration monitoring. In: *Mixed Design of Integrated Circuits & Systems, 2009. MIXDES'09. MIXDES-16th International Conference*. IEEE, 2009. p. 163-166.

7- Eng-Kiat Chan and Horst Ebenhoh, "*The Implementation and Evolutionof a SCADA System for a Large Distribution Network*", IEEE Transactions on Power Systems, Vol. 7, No. 1, February 1992.

8- Silva, V., et al., *Remote PID control of a DC motor.* 2007.

9- Swain, N.K., et al. *Remote data acquisition, control and analysis using LabVIEW front panel and real time engine*. in *SoutheastCon, 2003. Proceedings. IEEE*. 2003. IEEE.

10- Pengfei, L. and N. Luhua. Remote Control Laboratory Based On LabVIEW. in Intelligent Computation Technology and Automation, 2009. ICICTA'09. Second International Conference on. 2009. IEEE.

11- J Jeffrey Travis, Intemet Applications in LabVIEW, Prentice Hall, NJ 07458, 2000.

12- BARNES, Ken; JOHNSON, Briam; NICKELSON, Reva. Review of (SCADA) Systems. *Idaho National.*