Application of Data Acquisition and Telemetry System into a Solar Vehicle

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Abstract— **The Center for Product Design and Manufacturing (CPDM) of University Malaya going to take part in the World Solar Challenge (WSC) 2009. It is a biannual solar powered car race over 3021 km from Darwin to Adelaide. The aim of this project is to build a system for monitoring performance of the solar vehicle during testing and race, a data acquisition and telemetry (DaqT) system is needed. In this project, a DaqT system will be developed using National Instruments' (NI) LabVIEW, compactRIO (cRIO) and MaxStream Xstream Radio Frequency modules. The DaqT is able to measure signals from sensors which are thermocouples, current transducers, battery storage and tachometer. Experiment is conducted to investigate the capability of the DaqT system to process signals from essential sensors, transmit data with wireless communication and data logging. The results of this project from the experiment, the DaqT manage to transmit data in open space up to 700 meters and the percentages of the error is below 5%.**

Keywords-Solar Vehicle; DaqT; LabView; cRIO

I. Introduction

Since the introduction of the World Solar Challenge (WSC) in 1987, many universities and companies have taken part and are involved in research activities to develop solar vehicle including Center for Product Design and Manufacturing (CPDM) of University Malaya [1]. The competition requires the participating teams to design and built a solar vehicle that is capable of racing over 3000 km through central of Australia from Darwin to Adelaide.

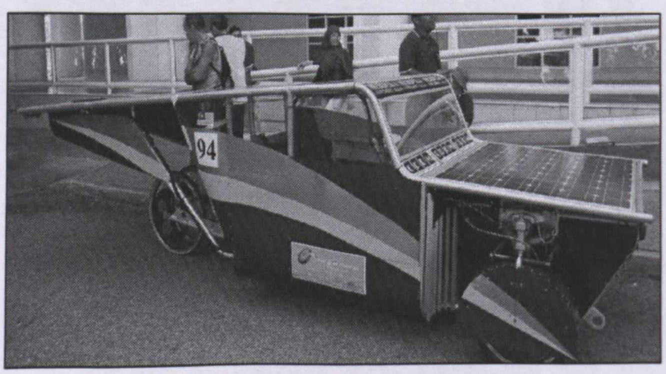

Figure 1. CPDM's solar vehicle.

For this race almost all vehicles used telemetry system for monitoring and collecting data, in 1993 Honda with a vehicle named Honda dream was used a telemetry system called supervision support system using ECU transmitted which has a function to enable the required calculations for remaining battery capacity and cruising distance during the race [2]. In this project the used of cRIO from National Instrument was installed and programmed using LabView to monitor a performance of the solar vehicle during testing and race.

A solar powered vehicle (Fig. 1) is built by CPDM [3]. It is expected to have sensors that measures temperature, speed, current and batteries' voltage. There is a strong need of monitoring system to allow the research team observes the condition of the solar vehicle. In order to ensure the safety of the driver and the performance of the solar vehicle, proper adjustments will be made based on the data obtained.

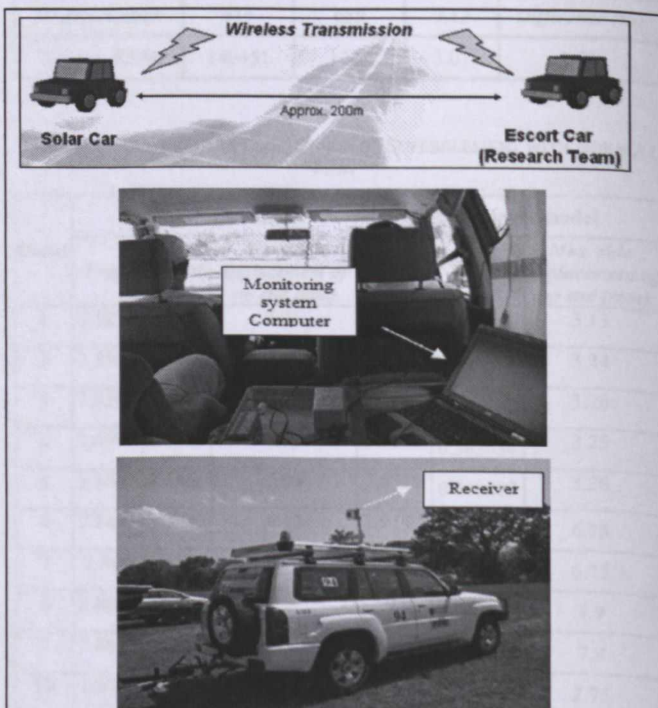

Figure 2. Data acquisition and telemetry system of CPDM's solar vehicle.

978-0-7695-3982-9/10 $26.00 © 2010 IEEE
DOI 10.1109/ICCEA.2010.26

In WSC, the solar vehicle will be followed by CPDM's research team (Fig. 2). The monitoring system has to acquire data from the sensors and send out the data through wireless connection. At the same time the system will saved the data into controller and laptop for analysis purpose [4].

A data acquisition and telemetry system (DaqT) is developed to fulfill the needs of the CPDM's research team. In this research, LabVIEW will be used as a programming language for this data acquisition and telemetry system.

II. APPARATUS AND RESEARCH DESIGN

Development of DaqT required 3 important components which are the programming software, National Instruments' (NI) LabVIEW, the controller, National Instruments' (NI) CompactRIO (cRIO) and Xstream OEM Radio Frequency Modules.

LabVIEW stands for Laboratory Virtual Instrumentation Engineering Workbench [5]. It is a graphical programming language for instrument control and data acquisition, analysis, and presentation [6]. In DaqT, LabVIEW is used to program the controller, CompactRIO as shows in Fig 3.

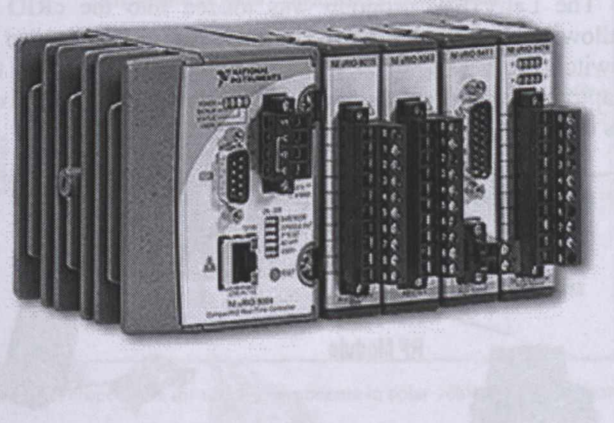

Figure 3. cRIO Hardware

National Instruments' CompactRIO (cRIO) is a programmable automation controller. CompactRIO is an advanced embedded control and data acquisition system designed for applications that require high performance and reliability [7]. It is small, light weight, rugged, low power consumption and flexible. It needs to program with software named LabVIEW to deliver a powerful real time (RT) signal acquisition, analysis, control and data logging. This controller is very suitable to be applied in solar vehicle of CPDM as a data acquisition and telemetry system (DaqT) during WSC 2009 as it can withstand and perform in the harsh competition environment at the same time consuming low power.

cRIO consists of three major components[7]:

1. Embedded real-time processor
2. High-performance Field Programmable Gate Array (FPGA) chassis
3. Hot-swappable input/output (I/O) modules.

TABLE. 1 Components in the cRIO

Hardware	Model	Description
Embedded real-time processor	NI cRIO-9014	• 400 MHz processor, 2 GB nonvolatile storage, 128 MB DRAM memory • Consist of Ethernet port, Serial port for connection to peripherals • Consist of USB port for connection to memory device.
High-performance FPGA chassis	NI cRIO-9104	• 3M gate reconfigurable I/O (RIO) FPGA core for ultimate processing power • 8-slot reconfigurable embedded chassis accepts any Compact RIO I/O module • Automatically synthesize custom control and signal processing circuitry using Lab VIEW
Hot Swappable I/O Module	NI 9211 (2 units)	• 4-channel thermocouple input module • ±80mV voltage measurement range
	NI 9221	• 8-channel current and voltage input module • ±60V voltage measurement range
	NI 9215	• 4-channel tachometer input module • ±10V voltage measurement range

Maxstream's Xtream is a radio frequency (RF) module with outdoor out of sight range of 11km. It provides communication link between the solar vehicle and the escort team. It is commonly applied for remote application.

Data need to be collected from

- 6 units of thermocouples
- 2 unit of current transducers
- 1 groups of battery
- 1 unit of tachometer

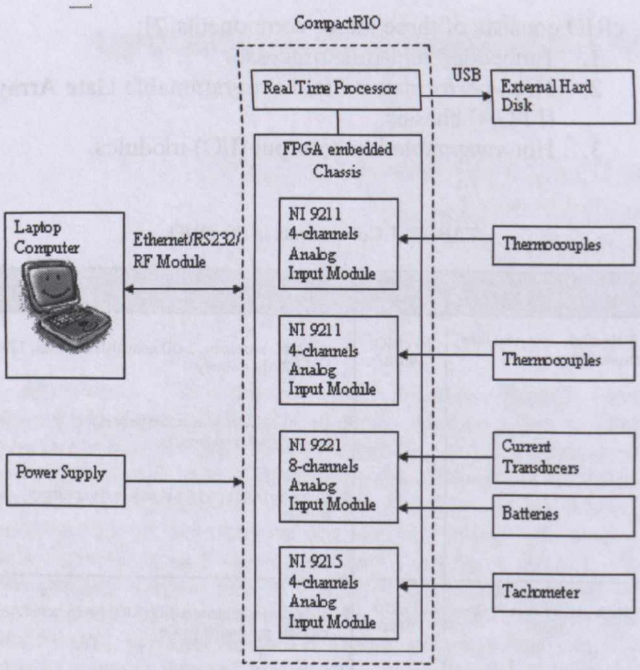

Figure 4. System architecture of cRIO

As shown in Table 1 and Fig 4, therefore a total of 4 input modules are selected for this purpose. Each of the NI9211 input modules consist of 4 channels. Total of 2 unit of NI 9211 are used to accommodate 6 unit of thermocouple. 2 unit of thermocouple will be placed on the photovoltaic cells, 2 units of thermocouple measure the temperature of motors and the other two on the batteries. An NI 9221 8-channels ±60 V input module is needed to measure the voltage level of a group of battery pack and obtain signal 2 units of current transducers which are measuring the current of the motors. An NI9215 8-channels input module is used to measure the signals from the tachometer.

Each of the sensors is connected to the respective I/O module which is fixed on the FPGA chassis of the cRIO. The real time controller will process and send the data to computer through the transmitter of Xstream RF module for monitoring. The data measured will be saved into cRIO and the laptop.

III. Experiments

An experiment is conducted to prove whether the DaqT is able to perform during the WSC 2009. Fig. 5 shows the controller was fixed into the solar vehicle rig test.

The sensors connected to the respective I/O modules. The real time controller is responsible to process and send the data to the Xstream OEM RF 900MHZ modules through the RS232 serial port. The data measured was saved into cRIO as back up. The receiver of Xstream RF module was connected to the computer with USB-RS232 cab. On the other hand, the transmitter of RF module was connected to the cRIO with a female-female serial cable.

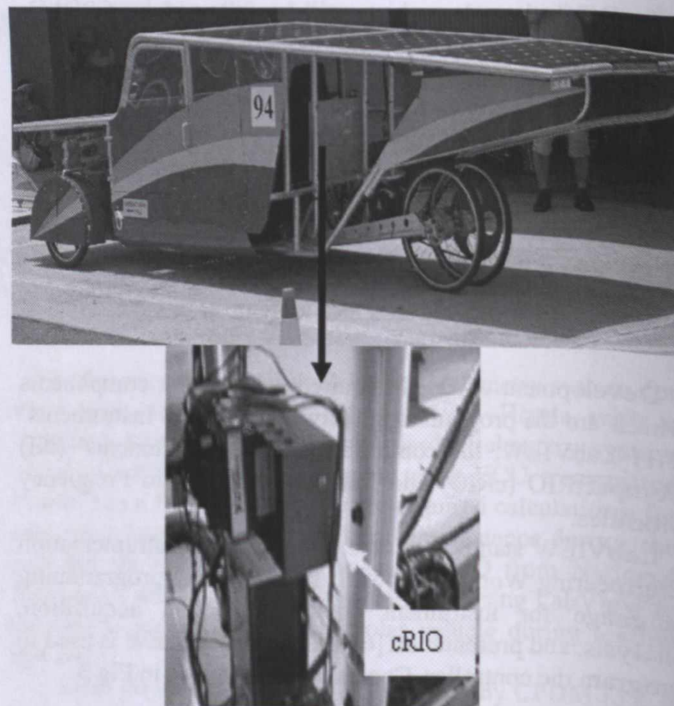

Figure 5. cRIO is fixed into the solar vehicle rig test.

The LabVIEW program was loaded into the cRIO to allow the program runs every time the cRIO's power is switched on. The program is written in such a way that the laptop computer only save the data when the data received is complete. (Fig. 6)

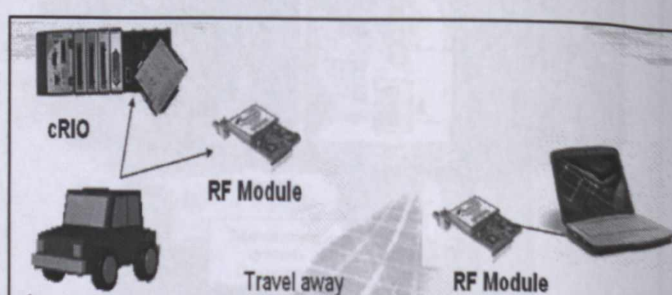

Figure 6. Illustration hardware setup

The experiment was conducted on a straight and flat road in Klang. The test drive environment is an open space without any buildings. Total distance traveled by the solar vehicle is about 700 meters.

The laptop computer was placed at the starting point while the solar vehicle of CPDM is traveled away from it. The data saved in cRIO and laptop is compared.

Fig 7 shows the visual display of the program using Lab View.

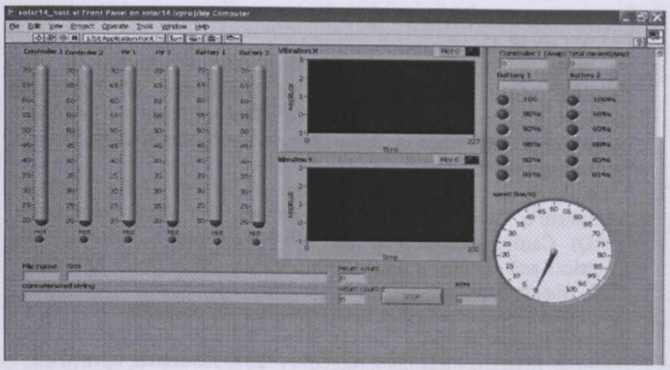

Figure 7. Visual Display of the Program using Lab View

IV. RESULTS AND DISCUSSIONS

Fig. 8 shows the result of temperatures in solar vehicle, measured by cRIO, Photovoltaic (PV) 1 located in front, and PV 2 at the top of vehicle, operating system for solar vehicle is 48 volt, and the battery system was split to be two banks, each bank has 24 volt system, in this result battery 2 was charge using PV, its mean the vehicle accelerate under charging and discharging

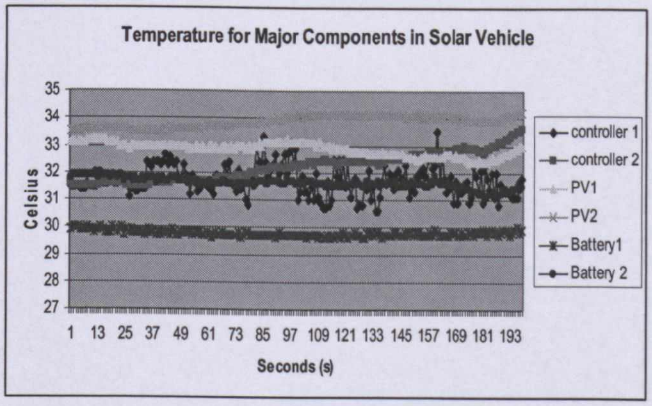

Figure 8. Temperature for major components in solar vehicle obtained from cRIO

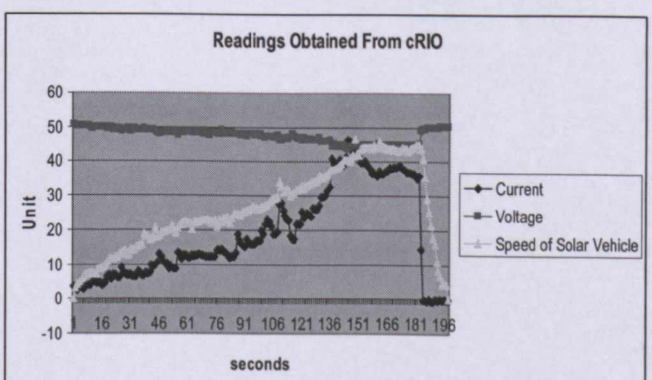

Figure 9. Readings obtained from cRIO

Fig. 9 presents road test result from cRIO consist of current, voltage and speed of the vehicle. However the data saved by the cRIO and the data collected by the laptop computer (transmitted data) are different.

The cRIO produced data in term of milliseconds while the saving rate is in term of seconds. The processor of the controller and the laptop computers are two different entities. Each of the processor runs at different speed or rate. Although both of them have the same sampling rate but the saving time and the samples saved by each of processor are not the same. Thus, the samples saved into each of the storage are different. Percentage of error is calculated by comparing the data saved by the cRIO and the laptop during the experiment. The values obtained are plot into graphs below.

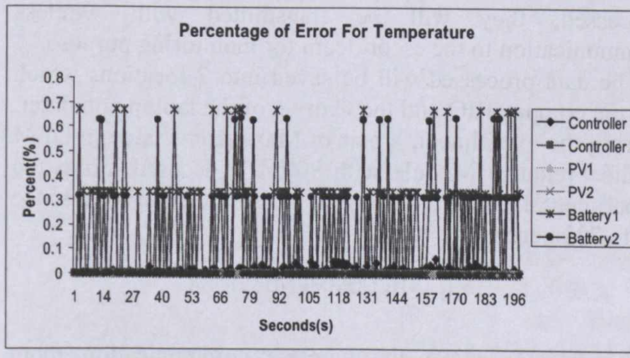

Figure 10. Percentage of error for temperature

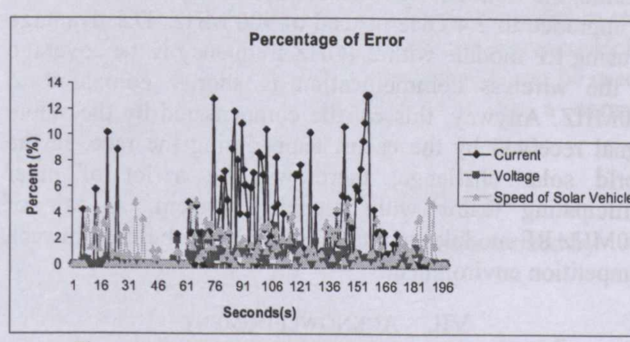

Figure 11. Percentage of error for current, voltage and speed

From the plotting percentage of error in figure 11, the most of the percentages of the error is below 5%, except for the values of the "Current of Controller 1" and "Total Current". The percentages of error for these 2 data are fall in between 0-14%. This is because the values of current are very small. Thus, a little difference between the data saved by cRIO and laptop will become very significant compared to the others.

Each time the data saved into the cRIO or laptop will occupied 101 bytes. The estimated file size for 9 hours of race is:

101bytes X (60 X 60 X 9) seconds = 3.2724 MB

~ 3.3 MB per day

One week race requires:

3.3 MB X 7 days = 23.2MB

The file size is small. Operator can choose to save the data into the USB storage device or into the controller which is consist of 2GB storage. As long as the storage is sufficient, the lost of data will not happen.

V. CONCLUSION

At the end of this study, a data acquisition and telemetry (DaqT) system for solar vehicle is developed. This system able to read the signals obtained from the sensors and processes them into desire form. Once the signals are processed, they will be transmitted with wireless communication to the escort team for monitoring purpose.

The data processed will be saved into 2 locations which are the compactRIO and the C drive of the laptop computer. During the experiment, a pair of Maxstream Xstream OEM Radio Frequncy Module with 900MHZ is used. From the experiment, the DaqT manage to transmit data in open space up to 700meters.

VI. RECOMMENDATIONS

In order to make the wireless communication more reliable, the Xstream OEM Radio Frequency module should be upgraded to 2.4 GHz instead of 900 MHZ. Disadvantage of using RF module with 2.4GHZ frequency is the coverage of the wireless communication is shorter compared to 900MHZ. Anyway, this can be compensated by the stable signal received by the escort team during the race. In the world solar challenge, there will be a lot of other participating teams with telemetry system. A pair of 900MHz RF module may not be suitable to be used in such competition environment.

VII. ACKNOWLEDGMENT

This project is supported by IPPP (PS091/2008C) and also by National Instruments Malaysia. The authors would like to acknowledge their advice and support

REFERENCES

[1]. Zahari Taha, Rossi Passarella, Jamali Md Sah & Nasrudin Bin Abd Rahim (2008) "A Review on Energy Management System of a Solar Car", The 9th Asia Pacific Industrial Engineering & Management Systems Conference,3-5 December 2008, Nusa Dua, Bali, paper 93, pp. 2527-2530.

[2]. Shimizu Y., Komatsu Y., Torii M., Takamuro M. (1998), Solar Car Cruising Strategy and Its Supporting System, JSAE Review 19, 143-149.

[3]. Z. Taha, J.M. Sah, R. Passarella, R.A.R. Ghazilla, N. Ahmad, Y.H. Jen, T.T. Khai, Z. Kassim, I. Hasanuddin, and M. Yunus, " A Solar Vehicle Based on Suistable Design Concept", Proceeding of the IASTED international Conference on Solar Energy, 16-18 March 2009, phuket, 647-034.pp 38-43.

[4]. Z. Taha, R. Passarella, J.M. Sah, H.X. Hui, N. Ahmad, R.A.R. Ghazilla, Y.H. Jen, and T.T. Khai,"Developing of Telemetry Monitoring system for a Solar Vehicle", Proceeding of the IASTED international Conference on Solar Energy, 16-18 March 2009, phuket, 647-035.pp 44-50.

[5]. R.N. Roy , " PC Based Automated System Using National Instrument's LabVIEW Software Package and Data Acquisition (DAQ) Card", presented at the 2nd International Conference on Electrical and Computer Engineering ICECE 2002, 26-28 December 2002, Dhaka, Bangladesh.

[6]. http://guide.apple.com/action.lasso?-database=macosguide&-layout=cgi_detail&-response=/ussearch/detail.html&prodkey=26493&-search, opened on December 2008.

[7]. http://www.ni.com/compactrio/whatis.htm opened on December 2008