International Conference on Computer and Communication Engineering (ICCCE 2010), 11-13 May 2010, Kuala Lumpur, Malaysia

Implementation of SCADA System for DC Motor Control

Afarulrazi Abu Bakar
Dept. of Electrical Power Eng.
Faculty of Electric & Electronic Eng.
Univ. Tun Hussein Onn Malaysia
Johor, Malaysia
afarul@uthm.edu.my

Hairulazwan Hashim
Dept. of Mechtronic & Robotic Eng.
Faculty of Electric & Electronic Eng.
Univ. Tun Hussein Onn Malaysia
Johor, Malaysia
azwan@uthm.edu.my

Md Zarafi Ahmad
Dept. of Electrical Power Eng.
Faculty of Electric & Electronic Eng.
Univ. Tun Hussein Onn Malaysia
Johor, Malaysia
zarafi@uthm.edu.my

***Abstract*— Supervisory Control and Data Acquisition (SCADA) systems are widely used in industrial control processes. SCADA focuses on the supervisory level, it is a purely software package that is positioned on top of hardware to which it is interfaced. The main purpose of this paper is to implement the hardware components for the controlling DC motor process and to interface between master station and control unit for controlling the data. It also concentrates on the design in terms of their architecture and their interface to the process hardware due to increasing usage of a different level of control system which has a different voltage. The Pulse Width Modulation (PWM) used as switching to control the speed of the DC motor.**

Keywords- SCADA; PLC; PWM

I. INTRODUCTION

SCADA is the technology that enables a user to collect data from one or more distant facilities and or send limited control instructions to those facilities [1]. It is mainly implemented by SCADA software to apply for controlling and monitoring of a system. SCADA system consists of one or more remote terminal units (RTUs) or programmable logic controllers (PLCs) connected to a several devices i.e sensors, actuators, switches, motors, lamps, etc. It applies interfacing sever protocol when needed between the SCADA software and the hardware process. Figure 1 shows the basic block diagram of a SCADA system.

This paper illustrates the implementation of SCADA system in DC motor control interfacing with PLC. The design system consists of IGSS SCADA software as a master station to control the device level i.e DC motor through a control unit. The control unit is formed by PLC, relay circuit and Altera UP1 board.

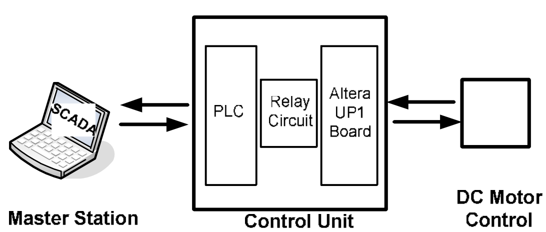

Figure 1. SCADA system for DC motor control.

The main objective of this paper is to design SCADA interface and implement the hardware component for controlling the DC motor with various speed. Through SCADA, user able to control and monitor the motor speeds in real-time. This system integrates the function of PLC and Altera UP1 board to control the speed of the DC motor.

II. SYSTEM ARCHITECTURE

Figure 2 shows the configuration of the overall SCADA system. This system is divided into three stages which are master station, control unit and motor control. The master station communicates with PLC through RS-232 cable. Omron CQM1H PLC is used as a control unit to communicate with SCADA. Besides that, it also received and sends a data to the Altera UP1 board.

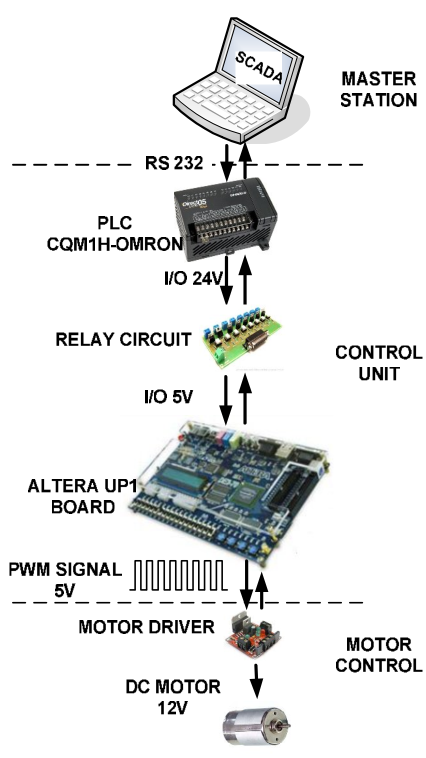

Figure 2. Configuration of overall SCADA system.

This system applies interfacing several protocols between the SCADA software and the hardware process. The Altera UP1 board has many features that facilitate rapid prototyping of digital logic. It used in several types of application such as digital system, switching application, signal processing and image processing. Through this board the programming can be easily programmed by using block diagram provide by Quartus II software. In addition, the complexity of hardware circuit is reduced as well as the power consumption.

This UP1 board is programmed to produce the PWM switching with various modulation indexes (ma) from PLC input. PWM is a modulation technique for generating variable width pulses to represent the amplitude of an input analog signal or wave. The data that is being transmitted is encoded on the width of these pulses to control the amount of power being sent to a load. The output PWM signal from Altera UP1 board directly connected to the motor driver. Motor driver hence amplify the low voltage level from 5VDC to 12VDC.

III. IMPLEMENTATION OF SCADA SYSTEM

A. *Software Development*

There are three software involves which is IGSS SCADA for SCADA design, CX-Programmer for PLC ladder diagram design and Quartus II for PWM signal generation. Units

1) *IGSS SCADA*

IGSS SCADA is software consists of a number of supporting programs, each with its own specific purpose. The programs are categorized into two main user types, which are system designers and operators. In this project, there are two main programs used in developing and designing GUI for IGSS system which is System Configuration and Definition.

The SCADA system consists of two windows which develop using Graphical User Interface (GUI). First window is the cover page and the second is Definition window. The Definition window will shows the interaction between the whole systems. Through this window, user can monitor and control the speed of the DC motor. Address of the PLC must be assign to the SCADA system. SCADA will continue update the window every cycle.

2) *Quartus II*

The PWM was design through this software by using combination of block diagram and VHDL programming. Figure 3 shows the block diagram of PWM generator which consists of clock_divider, lpm_counter and comparator. The input of the clock_divider is 25Mhz. The clock_divider is used to generate other clock as well. The lpm_counter is set to counting up from 0 to 39 in order to generate 25Hz switching frequency. The lpm_counter megafunction is a binary counter that can be set to count upwards, downwards, or up/down simultaneously.

Comparator generates PWM signal by comparing the output signal of lpm_counter and 6-bit output of relay circuit. The 6-bit output from the relay represents the six different speeds. The input and output of the comparator is then assigned to an expansion header of Altera UP1 board. The PWM generator is simulated by using Waveform Editor.

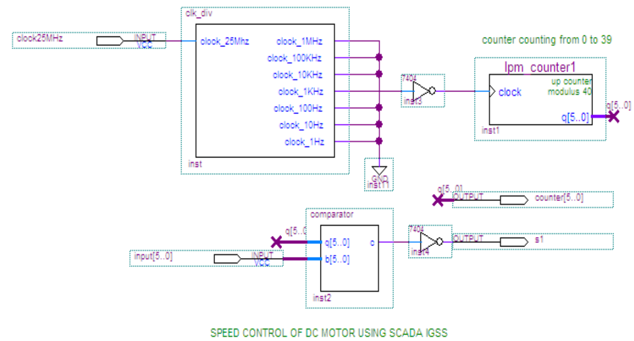

Figure 3. PWM generator using block diagram.

Table 1 show the percentage and duty cycle of PWM signal for 6 different speed of motor. Each bit represents the specific speeds of DC motor. For example, relay 1 is connected to LSB of an expansion header of Altera UP1 board to represent speed 1. The percentage of PWM signal can be calculated using (1) where, T is the number of cycle set by lpm_counter.

$$percentage \quad (\%) = \frac{bit\ (decimal)}{T} \times 100\ \% \tag{1}$$

Figure 4 shows the generated PWM signal using Waveform Editor. At this point, the on-off switching times of displayed PWM waveforms are compared with their calculated value and any deviation notes for correction. The shape of the PWM waveform at high switching speeds can be observed for a short interval by using the compress option to compress the waveform. The output of the PWM generator is then assigned to the expansion header of the Altera UP1 Board through Pin Planner.

TABLE I. VARIABLE SPEED MOTOR CONTROL

Speed	6 bit	Percentage (%)	Duty cycle
Speed 1	000001	2.5	0.025
Speed 2	000010	5.0	0.05
Speed 3	000100	10.0	0.1
Speed 4	001000	20.0	0.2
Speed 5	010000	40.0	0.4
Speed 6	100000	80.0	0.8

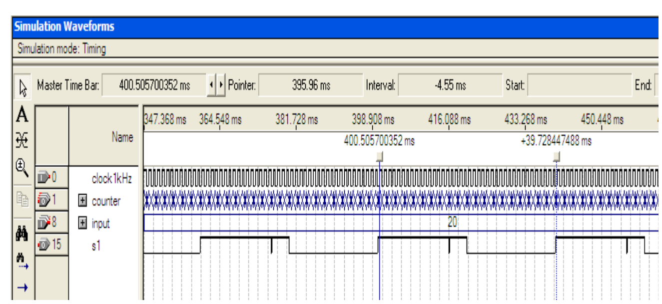

Figure 4. Simulation for PWM generator using Waveform Editor.

The Assembler which is the compiler module that completes project processing will generate a device programming image. For the FPGAs, this programming image is in the form of Programmer Object Files (.pof) and SRAM Object Files (.sof). The configuration data (.sof) for devices are downloaded to programme the hardware. The voltage levels of the input and output on the expansion header is 3.6VDC.

3) CX-Programmer

CX-Programmer version 8.0 by Omron used to program the PLCs. The program is written by using ladder diagram as shown in Figure 5. In the diagram, power flows from the left to the right and from top to the bottom. A ladder rung is a logical connection between the left and right bus bars.

B. Hardware Development

The hardware part is consisting of voltage relay circuit. It forms by electronics components such as relay, resistor and diode. The circuit acts as a switch which interfaces between PLC and Altera UP1 Board. This is due to different voltage levels between PLC and Altera UP1 Board. Altera UP1 Board operated at 5VDC and PLCs operated at 24VDC. The output of the PLC is connected to the input of the relay circuit. The relay circuit will step down the voltage to 3.6VDC and the output connected to the input of the Altera UP1 Board. The relay circuit designed in 6 parallel arrangements which represent 6-bit.

IV. RESULT AND ANALYSIS

This section discussed the result and analysis for this project. The analysis has been taken from hardware and software development.

A. IGSS SCADA

The SCADA system consists of two windows which develop using GUI. First window is the cover page and the second window is Definition. The Definition window will shows the interaction between the whole systems. Through this window, user can monitor and control the speed of the DC motor. Address of the PLC must be assign to the SCADA system. SCADA will continue update the window each cycle.

B. Altera UP1 Board

After simulation the Quartus II will automatically generate the .sop file. The file then downloaded the UP1 board through USB Byte Blaster cable. The PWM signals produce by the UP1 board. The frequency of the PWM signal is 25Hz. Figure 6 and 7 shows the PWM produce by the UP1 board for 80 and 40 percent duty cycle respectively.

C. Hardware Wiring

From the output PLC signal, it produces 24VDC at the output terminal. The sources output terminals connect to the relays to activate as the switch connecting to the input for Altera. SCADA has ability to control and monitor the speed of the DC motor. Figure 8 shows the prototype of the overall system.

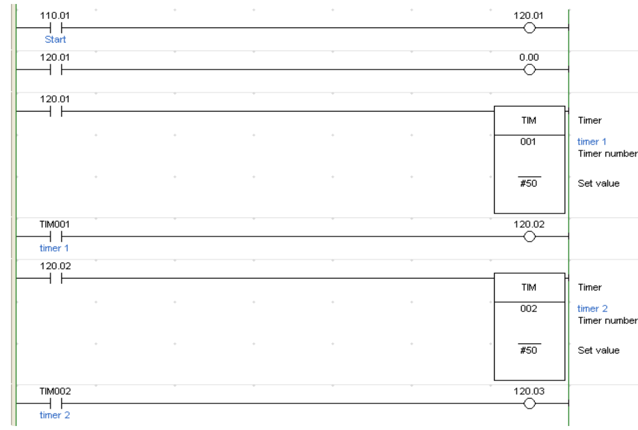

Figure 5. Ladder diagram of the system.

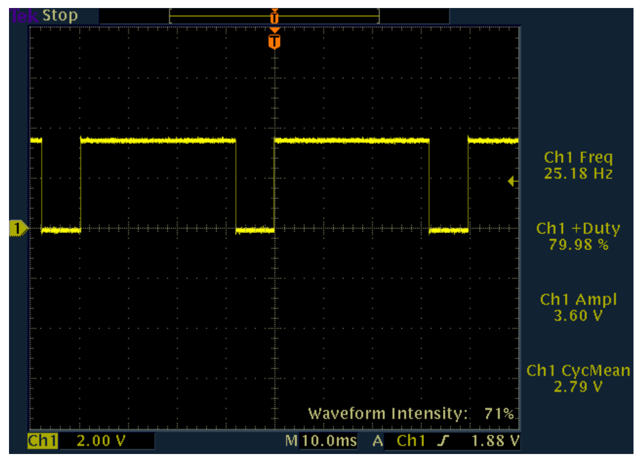

Figure 6. PWM signal for 80 percent duty cycle.

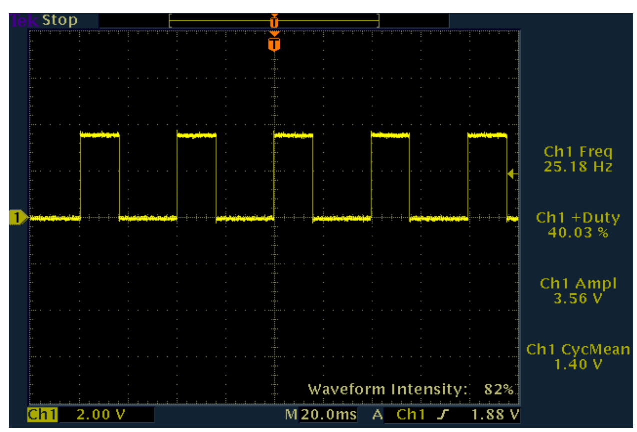

Figure 7. PWM signal for 40 percent duty cycle.

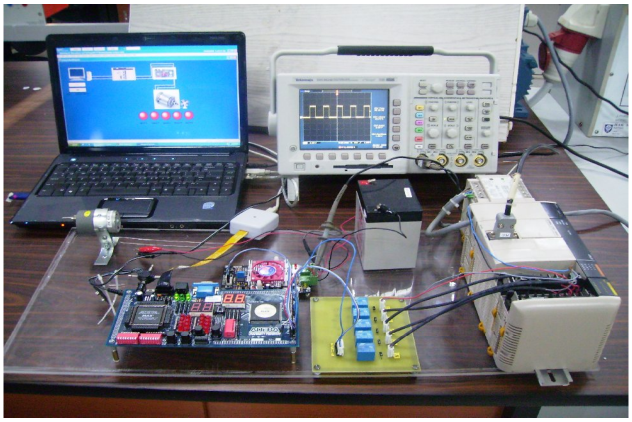

Figure 8. Prototype of the overall system.

V. CONCLUSION

This paper has illustrated a implementation of control unit using SCADA to control the speed of DC motor. Altera UP1 board used to produce the PWM switching signal to drive the DC motor. It provided flexibility which is ease to programmed and reduce the size of the hardware. This system is designed for the manufacturing system due to increasing usage of different voltage level.

ACKNOWLEDGMENT

The authors would like to thank University Tun Hussein Onn Malaysia (UTHM) for supporting this research.

REFERENCES

[1] Aung Naing Myint, Hla Soe, Theingi and Win Khaing Moe, "Implementation of Control Unit Using SCADA for Filling System", MTU, Mandalay, Myanmar, 2008

[2] Ronald L. Krutz, PhD. Securing SCADA systems. Ed Canada: Wiley, 2005.

[3] Thomas B. Sheriden "Humans and Automation (system design and research issues)": Wiley, 2002.

[4] Matteo Cantarelli "Control system design using Supervisory Control (from theory to implementation)", Universita degli Studi di Cagliari, 2006.

[5] Profesor Misbah Islam "Electrical Engineering project Course", Ottawa, 2005.

[6] Joseph La Fauci "PLC or DCS: selection and trends" Elsevier Science, 1997.

[7] BA Brandin, "The real-time supervisory control of an experimental manufacturing cell", *Robotics and Automation, IEEE Transactions on*, 12(1):1–14, 1996.