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MATLAB-SIMULINK CONTROLLER DESIGN FOR ADRUINO TARGET ON AC MOTOR CONTROL APPLICATION

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***Abstract*—This paper explains, the implementation of MATLAB-simulink block diagram with the Adruino DSP target in order to control the output current of the 3-phase inverter for ac motor application. There is no programming code has been involved but only uses the target preferences blocks that are available in the MATLAB-Adruino library. The current controller has been developed by using the PID-Hyterisis control in order to determine the efficiency of the controller to control the motor current. The system was been tested on the 1kW inverter output and was connected to the 3 phase induction motor with rating of 375W.**

***Index Terms*—MATLAB, Simulink, Adruino, PID, Hyterisis.**

I. INTRODUCTION

As known, ac motor is the widely used education motors for non electrical engineering student in order to understand the concepts of moving object from one direction to another direction. In doing so, the controller device needs to be developed. It can be developed by combining the microcontroller or Digital Signal Processing (DSP) device with the ac motor. The controller must have high switching frequency or slow switching frequency. As stated, the DSP is a device that able to generate miliseconds response that is needed for the 50Hz AC signal. The Adruino, Rasberry PI, ezdsp TI board or d-space are the examples of the DSP platform. Generally, the TI ezdsp and d-space are applied for high level application such as in power system application or in high precision application while the Adruino, Rasberry PI, PIC are for low level application.

The advancement and with the new simple structure of DSPs have attracted more and more non technical expert to use and applied the Adruino or Rasberry PI as a microcontroller. Due to this advantage, it makes the target such as the Adruino is easy to install and to troubleshoot when it been applied to the exsisting power converters that available today.

Today, the Adruino is capable to communicate with the MATLAB [1] by using the C programming that is based on the MATLAB software. Until this paper has been written, the MATLAB-Simulink for Adruino target never been tested with the power converters devices such as the inverter. Due to this finding, this paper is focused to test a simple controller that will be developed using the MATLAB-Simulink library and then downloaded to the Adruino microcontroller without changing to C programming in order to see the performance of the Adruino with the inverter in MATLAB-Simulink based library.

Due to this reason, a simple control method for ac motor controller is applied to the modern power electronics devices. As the results, many of researchers have come out with various controllers in order to control the parameters of electric motor such as the speed, voltage and current. The three phase ac motor also known as a non linear characteristics and for that reason the nonlinear controller is needed [2]. From the control parameters of the ac motor, the current input is important in order to determine the smoothness rotation of the ac motor. This current regulation is controlled by controlling the pulse-width-modulated (PWM) that will be developed in the DSP devices [6][7].

The controller that can be applied to ac motor can be categorized into two, which are the active and passive controller [3][4][5]. The active controller is a controller that responded to the reference target such as Field Oriented Control (FOC), Direct Torque Control (DTC), Proportional Integral Derivatives (PID), fuzzy control, nueral network, Sliding Mode Control (SMC), and Hysteresis control. For the passive control, it is based on the time control system response.

At the end of this paper, the dual loop controls that is combined the hyterisis current control with the PID controller model has been developed in the MATLAB-Simulink and will be tested in the experimental by using the Adruino DSP, the 3-phase inverter and the ac motor in order to see the current response. As a result the performance characteristics will be observed in terms of output motor line current, the switching algorithm for the Adruino and the inverter output voltage.

THE PROPOSED TOPOLOGY

Figure 1 shows the block diagram of the project. It consists of 6 main parts which are the DC source input, the gate driver circuit, the three phase inverter, the 375W three phase ac motor as a load, the current sensors and the Adruino target board. The Adruino is used to test the controller that has been developed in the MATLAB-Simulink

The 3-phase inverter was designed to produce 1kW output that can support about 450V input at the DC source. The inverter is known as voltage source inverter where it is the standard used inverter nowadays and it is easy to control [acul]. The gate driver is needed in order to supply a suitable voltage for the MOSFET for the inverter. It will produce six PWM signals that are needed by the inverter.

The ac motor that been used in this project, is a three phase induction motor rating of 0.37kW, 400V, and 1A input with maximum rotation speed of 1000rpm. As the input to the Adruino, the current sensor has been used in order to give current feedback signal from the ac motor back to the Adruino.

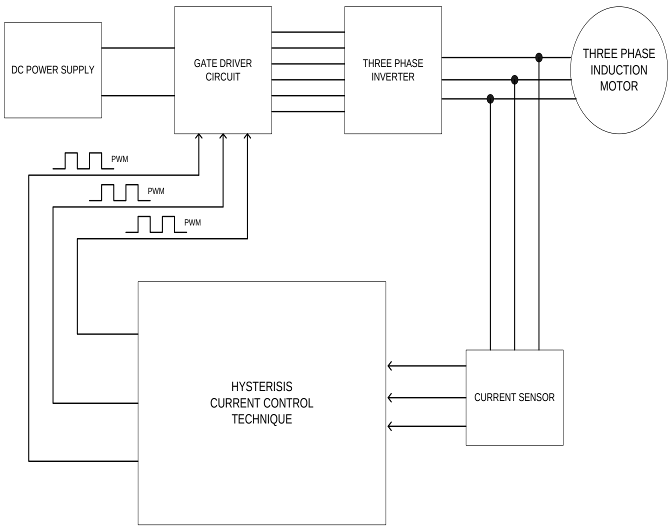

Figure 1: The proposed topology

A. *Development of the controller sturcture*

The hysteresis control is a nonlinear control that able to control the nonlinear element such as the ac motor with simple arrangement or lagging behind condition [13] in order to have past information for future prediction [14]. There is several methods that can be used for ac motor control such as Direct torque control (DTC), two hyteresis comparators [15] and uses the triangle signal in the error block to minimizes the flux and torque ripple of the ac motor [16].

In this project the hysteresis current controller is used in order to generate the PWM signal based on Figure 2. This method has been chosen because the robustness of the controller to adopt with the changing of the input control.The hyteris controller has been designed in MATLAB-Simulink environment as shown in Figure 3. This project also implements outher loop control by using the PID controller in order to improve the performance of the overall controller. The general equation of PID control is given in Equation 1.

$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{d}{dt} e(t) \qquad \text{(Eq.1)}$$

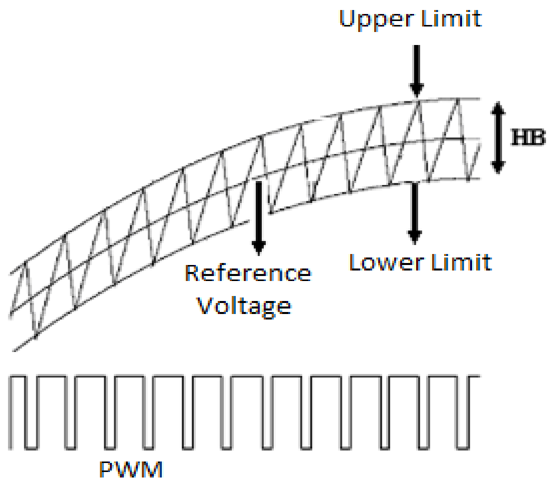

Figure 2: Hyterisis band

The function of Analog to Digital (ADC) and Digital to Analog (DAC) that are shown in Figure 3 are used to change the input signal from the hardware output to the pc digital input or vice versa. These bloks are available in the Matlab-Simulink where the models are embedded in the microcontroller by using the Arduino target installer.

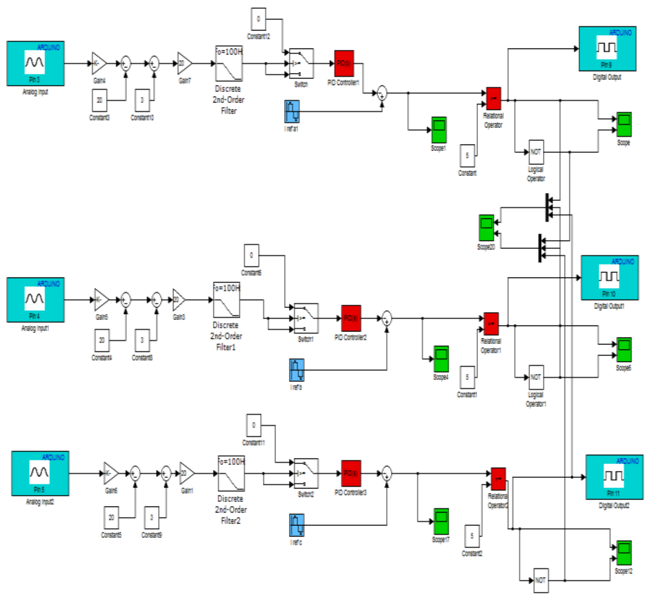

Figure 3 : Controller design

B. *The experimental setup*

The hardware or experimental setup was developed as shown in Fig. 4. From Fig.4, the three phase induction motor has been selected as the test load. The main parts of this experimental setup are the Adruino, the gate driver and the 3 phase inverter that have been modelled using Proteus and changes to 2 layer printed circuit board in order to have complete experimental setup. Since the PWM output from the Adruino is 5 V, the gate driver is needed to increase this voltage before been connected to the 3 phase inverter.

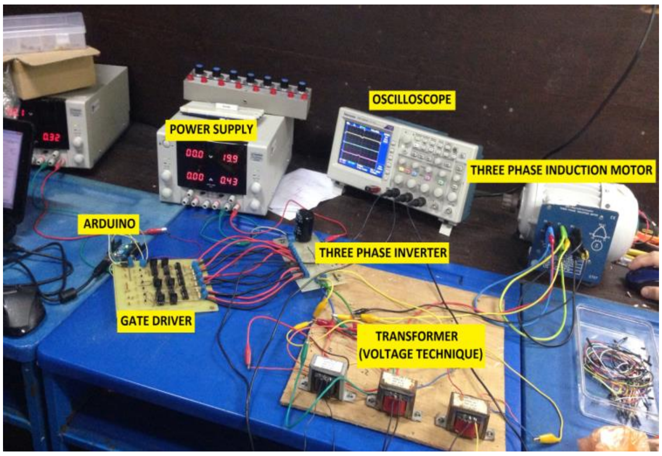

Figure 4: The experimental setup

Power Transistor (MOSFET SPP11N60C3) and a capacitor are act as voltage source inverter or full bridge inverter. It is where the power transistor is capable to handle the maximum voltage up to 600V or 1kW output.

II. SIMULATION VERIFICATION

From the simulation analysis, the Power System Blockset and Simulink models were used in order to study the characteristics of the inverter output with a dummy load. Figure 5 shows the complete simulation diagram in MATLAB. It consists of the inverter with six IGBTs which are connected to the PWM signals at each of the gate pins. The PWM signal receives from the PID-hysteresis current controller. For the simulation purpose, the three phase ac motor is replaced with the 1Ω resistor and 5mH inductor.

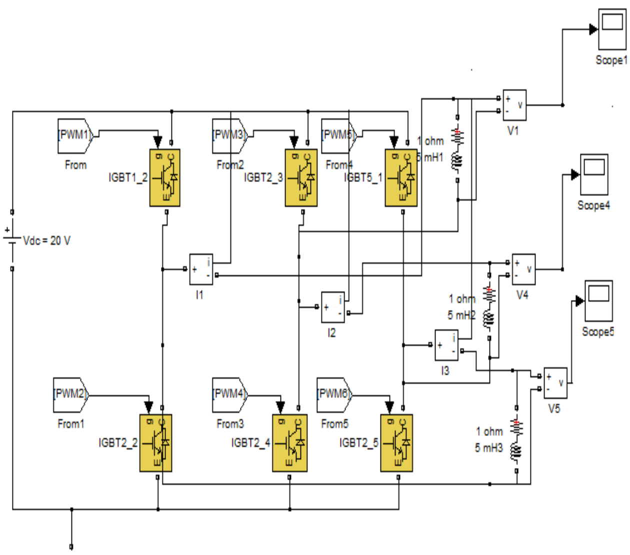

Figure 5: The Simulink simulation

The detail of the controller is shown in Figure 3 where for the simulation analysis the ADC and DAC blocks have been removed.

Figure 6 shows the response of the feedback current from the load with the current target reference. From this figure, it shows that the feedback current (green) is followed with the reference current (red). It indicates that the controller that has been designed capable to track the reference current.

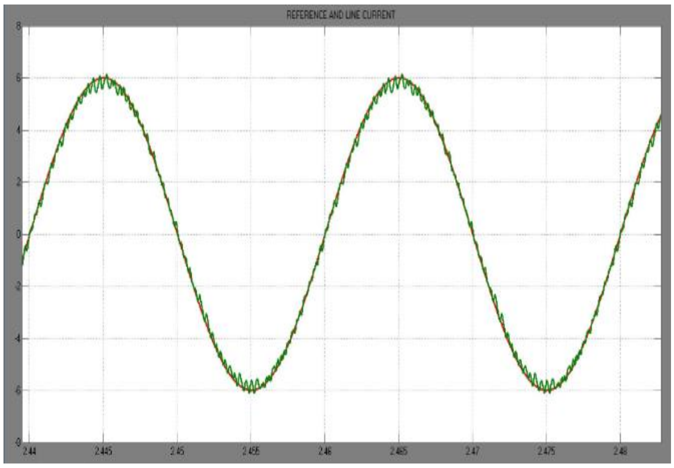

Figure 6: Reference and feedback current

Figure 7 shows the three phase output line current at the inverter. It shows that the lines current are balanced where the three phases are shifted equally. These line currents are in sinusoidal waveform due to the low pass filter that has been used at the inverter output.

Figure 7: The output current at the inverter

III. HARDWARE VERIFICATION

As seen from Figure 6, the input signal to the Adruino is in sinusoidal waveform. Due to this, the output that needs to be generated from the Adruino is in Sinusoidal Pulse Wave Modulation (SPWM) signal. Figure 8 shows the SPWM output after the gate driver circuit. These signals will be used to switch on and off the power MOSFET inside the inverter circuit.

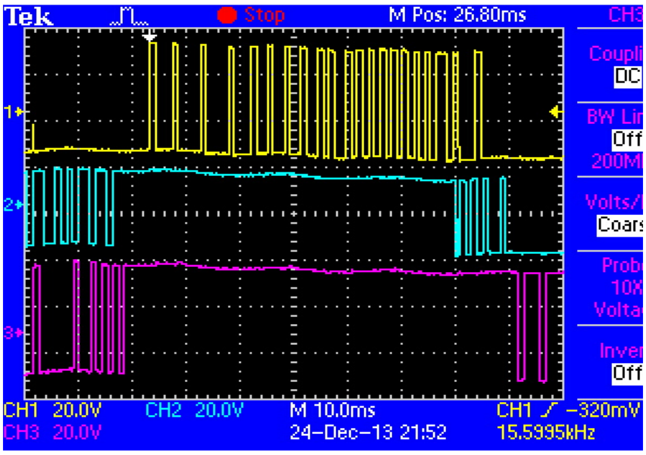

Figure 8: SPWM switching using Adruino

Figure 9 shows the inverter output phase voltage. This output is measured at the inverter circuit before the load. It shows the phase voltage is in the square-wave signal mode. To get the smooth sine wave filtering process must be done at the output signal.

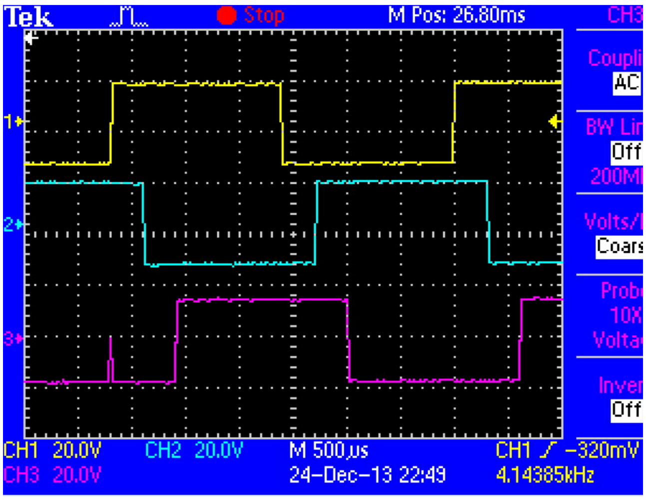

Figure 9 : Inverter output voltage

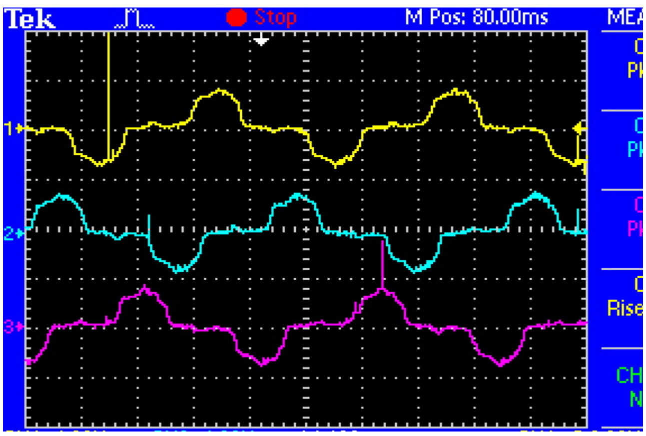

Figure 10: Inverter current output

Figure 10 shows the inverter output current. It indicates that the current waveform is not in sinusoidal waveform but the motor is still running smoothly. This problem has been recognized where it is the wrong selection of the low pass filter sizing. For the next paper the better design of low pass filter will be used.

IV. Conclusion

As a conclusion, the closed loop system for simulation and hardware results show the function of the Adruino as a target DSP is able to read the controller design block that has been developed in the MATLAB-Simulink environment. This explains that, with the mathematical equations of any controllers and without to change to programming code, the Adruino can still works as DSP platform. This will help the new players of DSP with less experience in programming to applied the Adruino microcontroller with the power converters applications as in teaching non electrical engineering student.

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