The Journal of CPRI,
Vol. 12, No. 3, September 2016 pp. 511-516

Micro controller programming for PWM control of MOSFET based converters

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Pulse Width Modulation (PWM) control of MOSFET based converters is used in almost all electrical application for accurate and efficient operation, like in motor drives, power supply units, power conditioners etc. The algorithm of PWM control in such system is the most important factor determining the operational features which can be implemented using microprocessors, micro controller, digital signal processors or higher end technologies. Here a detailed study of micro controller programming is done for PWM control of MOSFET based converters. The method of configuring the controller for PWM generation and programming steps are explained in detail with an example of PIC16F877A micro controller. Hardware implementation is done and program variation for different operating characteristics are observed. Micro controller programming is easiest, accurate and cost effective method for PWM control of converter. The program is flexible and higher end micro controllers can be used for complex control technique.

***Key** words : Programming, micro controller, PWM control*

1.0. INTRODUCTION

Power electronic converters are widely used in almost all areas of electrical power generation, conversion, transmission and utilization. Micro controller is the simplest method of controlling power electronic converters based on the desired operation. Micro controller programming is used for variety of applications from simple LED displays to complex control of machines, power generations units etc, out of which most of them are based on Pulse Width Modulation (PWM) techniques. Efficient operation of micro controller and hence the converters largely depend upon the effective programing of the micro controller.

Different control techniques using PWM and their applications are under studies for past few decades [1-2]. Micro controller architecture is more or less standardized, but their operational features and capabilities vary according to the model and technology used. [3-4]. Different types of converter applications using PWM control are attempted by researchers, industrial developers and micro controller manufacturers all over the world [5-6]. The complete operational features can be analyzed from data sheet of the chip so that suitable micro controllers can be selected as per the converter requirement [7-9].

Here the micro controller programming and hardware implementation of PWM based converter model is explained in detail. Use of micro controller for converter control is easy and flexible compared to other techniques. General features of PWM based converters and hardware requirements for their operation are explained in section 2. Details of micro controller programming method and hardware studies are explained in section 3 and 4. The results obtained by micro controller programming are explained in section 5 followed by conclusions obtained.

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2.0. PWM BASED CONVERTERS

Pulse Width modulation based on different algorithm are used in almost all power electronic converter applications. Figure 1 shows the circuit diagram of a typical BLDC motor drive controlled by micro controller program. Majority of converters like inverters, DC to DC converters, variable frequency drives, motor speed controllers, battery chargers, renewable energy systems etc are designed based on PWM control using micro controllers. Micro controllers take user inputs and feedback sensor inputs to calculate the PWM signals [1-6].

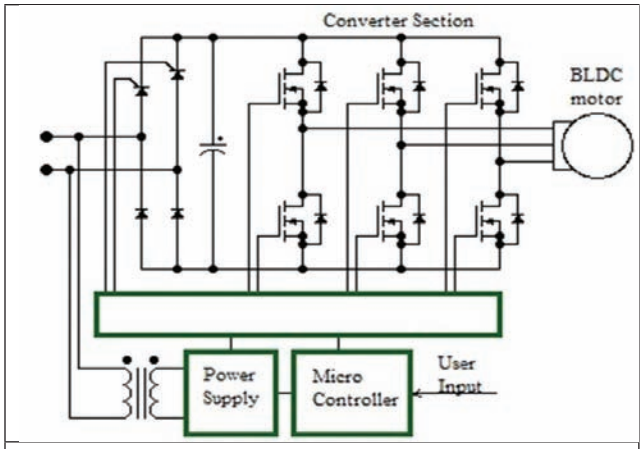

FIG. 1. MOSFET BASED SPWM INVERTER

2.1. Hardware Requirement

For micro controller based PWM control, the interface between the controller and converter switches is the most important factor to be taken in to consideration. Power supply and grounding based on the controller rating are to be given.

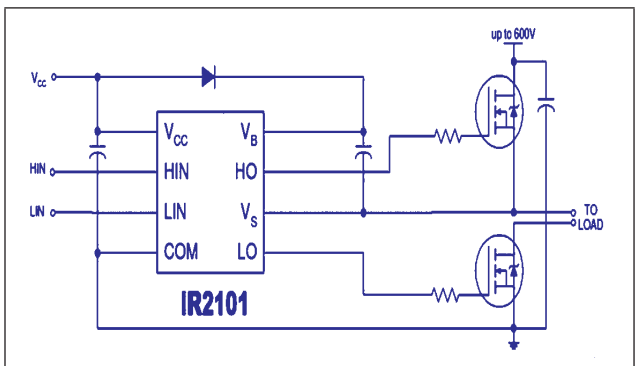

FIG. 2. GATE DRIVER FOR MOSFET

The output PWM signals of micro controller are at low voltage levels which are not enough to drive the MOSFET gates. Hence gate driver is required to drive the MOSFET which requires higher voltage supply. The connection of High and low side gate driver to 2 MOSFETs of inverter leg is also shown in Figure 2 [7-9].

3.0. MICRO CONTROLLER PROGRAMMING

3.1. Programming Setup

Figure 3 shows the connection diagram of programmer to the micro controller pins to load the program in to the chip. PGD and PGC pins are connected to the data pins of programmer. The programmer/debugger is connected to the PC where program in high level language is compiled [10].

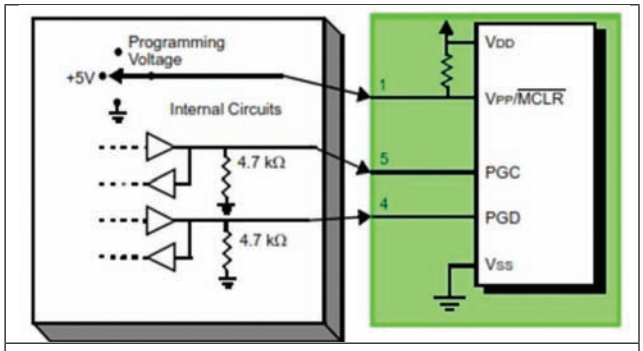

FIG. 3. PROGRAMMING OF MICRO CONTROLLER

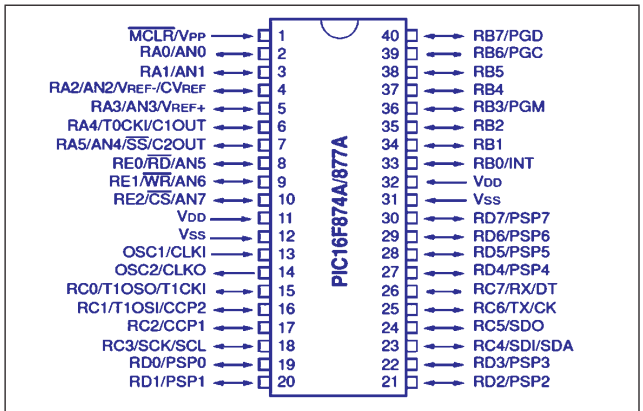

FIG. 4. PIN CONFIGURATION OF PIC 16F877A

For example the programming for PIC 16F877A is explained. Pin configuration of 16F877A is shown in Figure 4. Pin 39 and 40 are used for programming. Pins 32 and 11 are to be connected to 5 V DC supply with ground at pins 31 and 12. If internal oscillator is not available, crystal oscillator should be provided at pins 13 and 14.

3.2. PWM Generation Routine

The width of the switching pulse is generated based on the type of control required. Methods like sinusoidal PWM, vector control, sliding mode control, Fuzzy logic control, hysteresis control etc are used for obtaining the duty cycle value of PWM signals. The result of any PWM calculation algorithm is the pulse width at a particular switching frequency. Based on these values, PWM generation routine is to be implemented in the program for continuous generation of PWM. Figure 5 shows the steps for configuring PWM generation in micro controller. PWM time period, duty cycle, PWM pin, and PWM control registers are configured using relevant bits of corresponding registers as shown in Figure 5 [11-12].

All timer values are calculated based on the clock frequency of the controller. So initially the clock frequency is to be defined in the program. The basic program code for generating PWM is shown below

```
void main( )

{
PWM1_init(5000); // Switching frequency
PWM2_init(5000);
PWM1_Duty(0); // Initialise duty cycle with 0
PWM1_Duty(0);
PWM1_start( );  //Start PWM
PWM2_start( );
}
```

These functions are implemented by turning on corresponding bits in the control registers. For example PWM is started by using 2nd and 3rd bits of CCP1M register as shown below.

```
PWM_Start()
{
CCP1M3=1;
CCP1M2=1;
{
#if TMR2PRESCALAR==1
        T2CKPS0=0;
   T2CKPS0=0;
#elif TMR2PRESCALAR==4
        T2CKPS0=1;
   T2CKPS0=0;
#elif TMR2PRESCALAR==16
        T2CKPS0=1;
   T2CKPS0=1;
#Endif }}
```

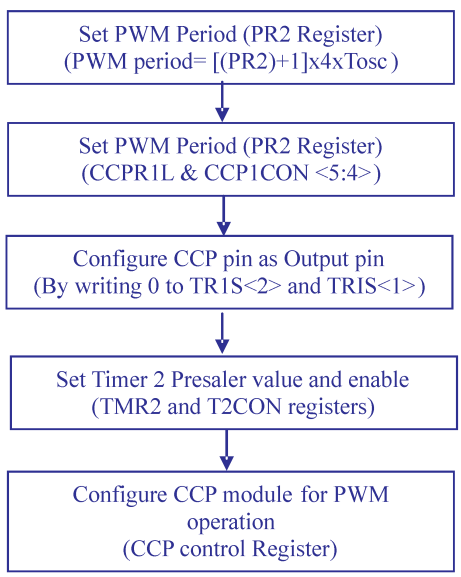

FIG. 5. FLOW CHART FOR CONFIGURING PWM GENERATION PROGRAM

4.0. HARDWARE STUDIES

The setup for programming micro controller is shown in Figure 6. microchip® ICD3 programmer/ debugger is used for loading the program in to the IC. A programming pod compatible for all types of micro controllers is used to interface the programmer with PGC and PGD pins of micro controller along with power supply and grounding. The program is compiled in MPLab X IDE environment as seen in Figure 6 [13].

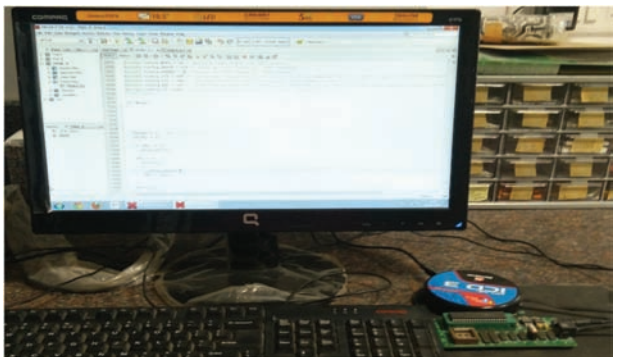

FIG. 6. PROGRAMMING SETUP FOR MICRO CONTROLLER

In order to check the operation of PWM generation code, the micro controller V_{DD}, V_{SS}, crystal oscillator and MCLR pins are to be connected as shown in Figure 7 for PIC 16F877A. This basic configuration is applicable for almost all micro controller models.

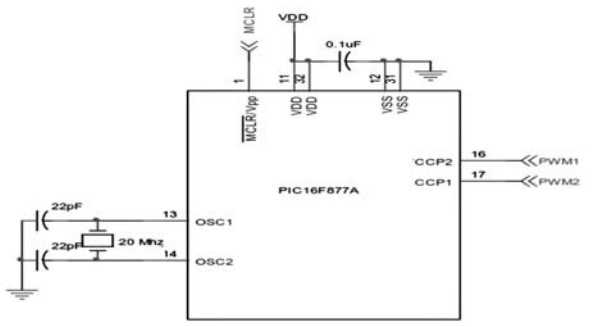

FIG. 7. CONNECTION OF PIC FOR OBTAINING PWM OUTPUT

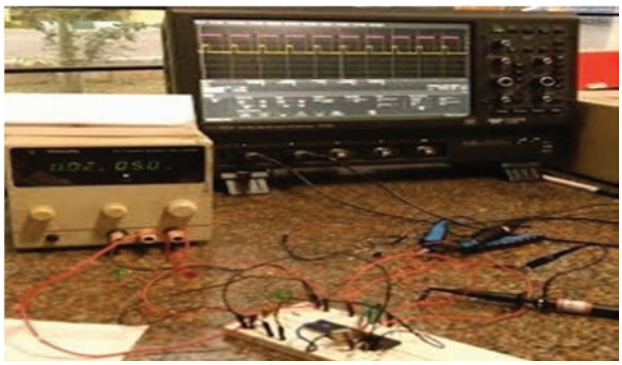

FIG. 8. CONNECTION OF PIC FOR OBTAINING PWM OUTPUT

Figure 8 shows the hardware setup for verifying the micro controller programming. The circuit as shown in figure 7 is hardwired on bread board and the PWM outputs at CCP1 and CCP2 pins are viewed in the oscilloscope as shown in Figure.

5.0. RESULTS AND ANALYSIS

The micro controller is programmed to generate 2 PWM signals of controllable pulse width at 50 kHz switching frequency. The oscillograms at pins 16 and 17 of PIC 16F877A is shown in figure 9. The switching frequency and duty cycle as per requirement are obtained. From the specification of micro controller, output voltage level is 5 V for the PWM signals.

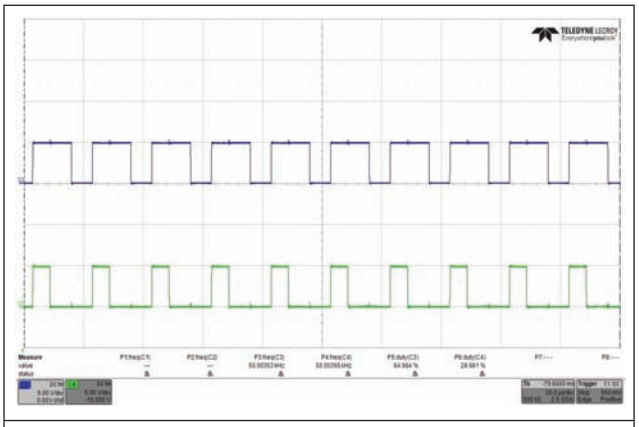

FIG. 9. PWM GENERATION OUTPUT

The pulse width control operation is verified using and AC to AC converter as explained in previous section. IR 2101 is used as gate driver. The current value is found to vary proportionately as per the variation in pulse width. Figure 10 shows the voltage and current waveform obtained by applying AC current control on the resistive load at the output of a solar PV inverter. Input DC voltage and current of the inverter are shown in channel 1.

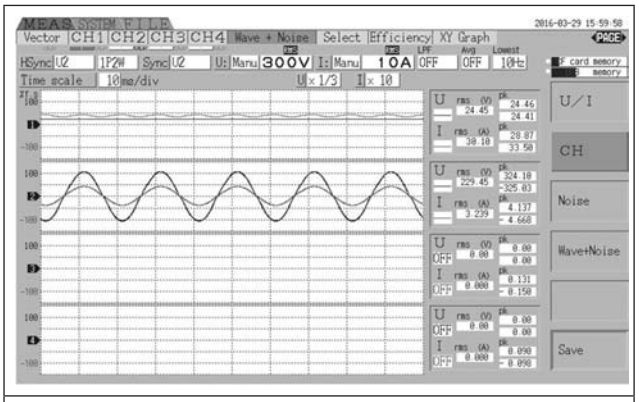

FIG. 10. VOLTAGE AND CURRENT WAVEFORMS OBTAINED BY PWM CONTROL OF AC CURRENT CONTROL CONVERTER

6.0. CONCLUSIONS

This paper presents the programming of micro controller for PWM control of MOSFET based converter. PWM control is used in almost all power electronic converters for fine voltage and current control. The hardware requirements and programming method for PWM generation and control are explained. The following observations are made from the experimental studies conducted.

- Micro controllers are simplest and easiest way to implement PWM generation as per different algorithms.
- The logic implementation is simple and effective using C program coding with suitable compilers.
- The memory can be erased and reprogrammed easily
- PWM control of inverters, DC - DC converters and rectifiers which are commonly used in real life application can be effectively implemented using micro controller.
- For more complicated control higher processors like DSP and FPGA will be required since micro controller has limitation of internal memory and speed.

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