

Design and Implementation of PWM Generator Based on OMAP-L138

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Abstract. Aiming at the demand of PWM waveform in the fields of communication, measurement, control, electronic power, detection and so on, in this paper, the hardware circuit of PWM generator based on OMAP-L138 chip is designed, and the control program of PWM generator is designed with the idea of layered design. The correctness of the circuit design and control program of the PWM generator is tested and the performance indexes of the PWM generator circuit such as the CPU consumption rate and the precision of the CPU duty cycle are tested. The experimental results show that the PWM generator has the advantages of simple circuit structure, high control precision, high flexibility and good portability.

1. Introduction

With the rapid development of electronic technology and information technology, embedded technology has been widely used in mobile communications, smart home appliances, automobiles, medical equipment, aerospace, the Internet, robots and other fields [1]. At the same time, with the progress of technology, the requirements for performance, reliability and controllability of the systems application are higher and higher in various fields. Pulse width modulation (PWM) technique is a method of digital coding for analog signal level, which is equivalent to the required waveform by modulation of a series of pulses [2]. PWM is a very important part of electronic power technology. It is widely used in the field of automatic control, mobile communication and computer technology. It is used in communication, measurement, motor control and signal detection. PWM is the technical core of the whole system in practical application system such as power detection [3].

Currently, there are two methods for generating PWM in a system circuit requiring PWM, one is analog circuit and the other is digital circuit. The analog circuit is mainly composed of a PWM chip and some resistive capacitors, however, the disadvantage of using analog circuit is that once the circuit design is designed and manufactured, it is troublesome to change it, and it cannot realize the digital remote control and the dynamic adjustment function. Digital circuit is mainly composed of some embedded hardware circuit, such as using ARM, DSP, FPGA chip [4-5], then the program is designed to produce PWM waveform, the advantage of digital circuit to generate PWM waveform is that the control and modification are convenient and flexible. With the continuous improvement of the switching performance of electronic components. PWM technology has been developed rapidly. The generation of PWM waveform has been replaced by large-scale integrated circuit, which makes digital modulation technology become the mainstream technology of pulse width modulation technology [6]. Therefore, PWM generation system mostly adopts the special control chip integrated with digital pulse width modulator and microprocessor.



In this paper, a PWM multi-channel signal generator is designed with the OMAP-L138 chip of TI company, and the underlying PWM driver program is designed based on the Linux operating system, the upper application only needs to call the underlying driver to dynamically set PWM parameters to produce the desired PWM waveform. The correctness of the circuit design and control program of PWM generator is verified by the experimental test. The CPU consumption rate and duty cycle accuracy of PWM circuit are tested.

2. PWM Principle Analysis

The PWM waveforms are composed of a series of rectangular pulses with different proportions usually, and its duty ratio is proportional to the instantaneous sampling value of the signal. The principle block diagram and waveform diagram of the pulse width modulation system are shown in figure 1. The pulse width modulation system consists of a comparator and a sawtooth wave generator with a cycle of T_s , if the modulation signal is greater than the sawtooth signal, the comparator outputs a normal number of A, otherwise the output is 0[7]. Therefore it can be seen from figure 1; the comparator outputs a series of pulse width modulation waves by the descending edge modulation.

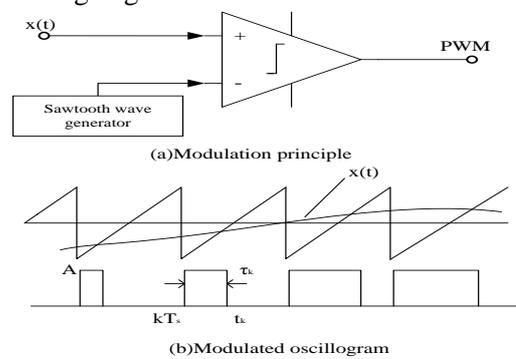


Figure 1. Pulse width modulation principle.

It can be seen from the modulated waveform of Figure 1(b), the width of the generated rectangular pulse depends on the amplitude of the modulated signal at the time of the pulse descent (t_k), and the time interval between the sample values is non-uniform, however, the difference between uniform sampling and non-uniform sampling is very small in practice when $t_k - kt_s \ll T_s$. Assuming that the sampling is uniformly sampled, the k TH rectangular pulse can be expressed as: $\tau_k = \tau_0 [1 + m x(kT_s)]$

In the formula, $x(t)$ is a discrete modulation signal; T_s is the sampling period; τ_0 is the unmodulated width; m is the modulation number.

3. Hardware Platform Design

In this article, the hardware circuit of PWM generator adopts OMAP - L138 chip of TI Company, the omap-l138 chip has dual core processor architecture with DSP+ARM, so it has rich system resources, powerful transaction control and digital processing power. So using the omap-l138 chip as the main CPU can meet the requirements of PWM generator and meet the resource requirements of other applications.

The OMAP-L138 chip provides two modules that can generate PWM waveforms, one is an enhanced capture module, and one is an enhanced high resolution pulse width modulator [8]. The OMAP - L138 chip including two groups of enhanced high resolution pulse width modulator, each group has two PWM outputs (EPWMx and EPWMxB), and each group has a dedicated 16-bit time-base counter for cycle and frequency control; There are three sets of enhanced capture modules, each of which is a 32-bit time-base counter. Taking into account the factors of duty cycle, period and design simplicity of PWM, in this paper, the hardware circuit is designed by adding the enhanced capture module is used as the interface output of the PWM generator.

An enhanced capture module represents a complete PWM channel, it can be output to the target device separately, and each enhanced capture module contains four 32-bit time base counters (cap1-cap4). The architecture diagram for multiple enhanced capture modules is shown in Figure.2.

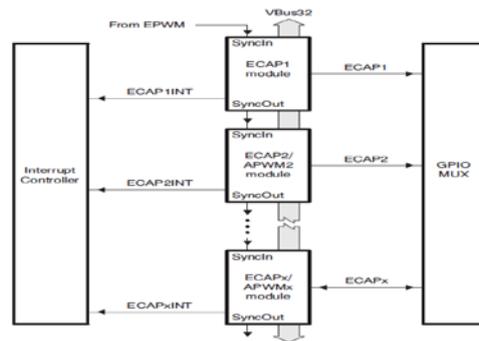


Figure 2. Architecture diagrams for multiple enhanced capture modules.

When the enhanced capture module is PWM generator, the time base counter works in counting mode and provides a time basis for the PWM waveform generation. The CAP1 and CAP2 registers represent the activity cycle and the comparison register respectively, and the CAP3 and CAP4 registers represent the cycle and capture image registers respectively. When the CAP1 and CAP2 registers are dynamically written, the values are mapped to CAP3 and CAP4 registers. The PWM operation mode of the enhanced capture module is shown in Figure 3.

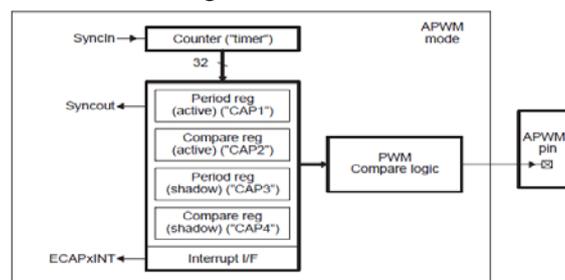


Figure 3. PWM operation mode of enhanced capture module.

Using the enhanced capture module as PWM generator, the schematic diagram of the hardware circuit is shown in Figure.4.

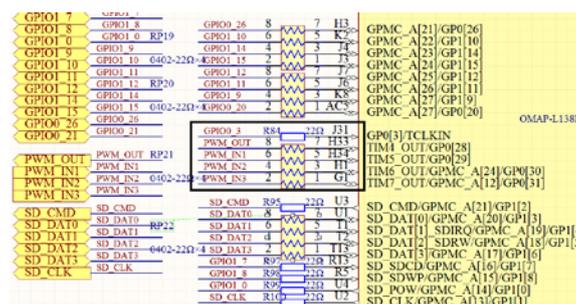


Figure 4. Hardware schematic diagram of PWM generator.

The design of the peripheral hardware circuit of PWM generator is very simple; no additional devices are required, only some resistance is added to the enhanced capture module interface as a filtering function.

4. Software Design

The advantage of PWM generator based on OMAP-L138 is to set PWM cycle and duty cycle flexibly and flexibly by software. Therefore the software design needs to focus on the flexibility and convenience of parameter setting and the portability of the whole software. In this paper, the software design adopts the hierarchical design idea, which is to divide it into the underlying hardware driver layer

program and the upper application, the underlying hardware driver provides the interface to the upper application, and the upper-layer application can invoke the provided interface, and the required PWM waveform can be generated as long as the corresponding parameters are passed.

Write the PWM underlying hardware driver, we need to know the register settings of the enhanced capture module. The PWM generator mode operation mainly needs to set the two registers of CAP1 and CAP2, the value of the CAP1 register represents the period, the value of the CAP2 register represents the comparison value, and the values of CAP3 and CAP4 registers correspond to CAP1 and CAP2 mapping values. Figure 5 shows the detailed output of PWM waveforms by PWM operate mode. In the figure, APRD is the value of CAP3 register, and ACMP is the value of CAP4 register.

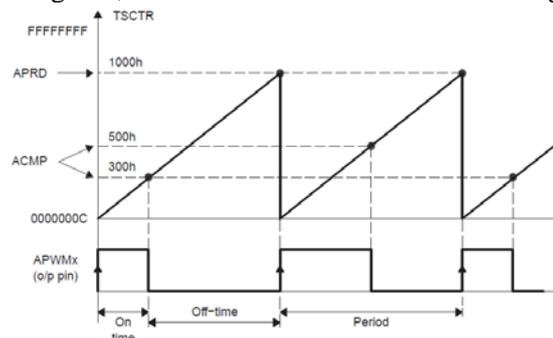


Figure 5. PWM waveform in PWM operation mode

In the program, the value of CAP1~CAP4 registers can be set to 0-FFFFFFFH, because CAP1~CAP4 registers are all 32 bits. The register base addresses of the three enhanced acquisition modules in omap-l138 are 0x01F08000, 0x01F07000, 0x01f06000, the address of the corresponding register is shown in Table.1.

Table.1. Register address of enhanced capture module.

Register name	Register address
Counter Phase Offset Value Register	Base address+0x04
Capture 1 Register	Base address+0x08
Capture 2 Register	Base address+0x0C
Capture 3 Register	Base address+0x10
Capture 4 Register	Base address+0x14
Capture Control Register 1	Base address+0x28
Capture Control Register 2	Base address+0x2A
Capture Interrupt Enable Register	Base address+0x2C
Capture Interrupt Flag Register	Base address+0x2E
Capture Interrupt Clear Register	Base address+0x30
Capture Interrupt Force Register	Base address+0x32
Revision ID	Base address+0x5C

The underlying hardware driver provides two interface functions, a write function that to set the PWM's duty ratio and cycle, and a read function that to read the corresponding parameters of PWM.

```
/* read function, pass the base address and offset address, and return the corresponding value. */
static inline u32 omapl138_pwm_read(unsigned int baseAddress,unsigned int offset);
```

```
/* write function, pass base address, offset address and write value, return 1 and 0 represents write success or unsuccessful. */
```

```
static inline u32 omapl138_pwm_write(unsigned value,unsigned int baseAddress,unsigned int offset);
```

For the flexibility and convenience of operation and testing, the upper application of generating PWM waveform is written as a thread, thus, if PWM is required only to call PWM's underlying driver interface in the thread, and set the corresponding parameters to output the corresponding PWM waveform.

5. Test Results Analysis

In order to verify the correctness of PWM generator circuit and program, it is necessary to design experiments to simulate and test its functions. The following is the function of PWM generator cycle and duty cycle and CPU usage rate were tested and verified.

First, test whether the PWM generator circuit and program can correctly generate PWM waveform, the PWM program is started and the parameters are set, the space ratio is set to 50%, and then the PWM generator output PWM waveform is tested by the spectrum analyzer. Figure 6 shows the PWM waveform from PWM generator output by spectrum analyzer tested.

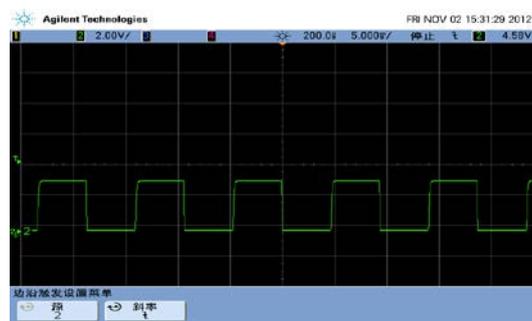


Figure.6. PWM waveform was tested by the spectrum analyzer.

As can be seen from the test results of the spectrum analyzer above that PWM generator can correctly generate PWM waveform and waveform duty ratio and cycle can be set. The experimental results show that PWM generator circuit and program are correct.

Next, the error rates of the PWM generator that theory and the actual test duty ratio is tested. The experimental set up the PWM waveform with eight different duty ratios by the upper application, and the duty ratio of the actual output PWM waveform was tested by using the spectrum analyzer. The upper application sets the duty ratio by setting the value of CAP2/CAP1. Table 2 shows the comparison table of PWM waveform duty ratio test value and theoretical value.

Table.2. Comparison table that the test value and theoretical value of PWM duty ratio.

Theoretical duty ratio	0.1	0.125	0.2	0.25	0.375	0.5	0.75	0.85
Actual duty ratio	0.1001	0.1249	0.2001	0.2501	0.375	0.5001	0.7498	0.8501

It can be seen from the experimental test data that the actual PWM output of PWM generator is very close to the theoretical value, which indicates the correctness and feasibility of the circuit and program of PWM generator.

Next, test the system CPU utilization rate when the PWM generator thread program is loaded. The PWM generator thread program is designed to generate three PWM waveforms at the same time, the CPU utilization was compared when the PWM generator thread was opened and the PWM generator thread was not opened. Figure 7 shows the CPU utilization of PWM generator PWM thread.

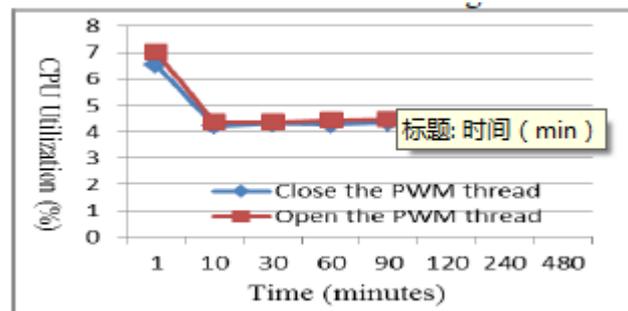


Figure.7. PWM threads CPU utilization of PWM generator.

From the experimental results, it can be seen that PWM generator thread can generate 3 PWM waveforms at the same time with very little CPU utilization, which is in line with the requirement of less resource.

6. Summary

As digital modulation technology has become the mainstream in the pulse width modulation technology, in this paper, the hardware circuit of PWM generator is designed based on OMAP-L138 chip, and considers its flexibility, control and portability, and its software design adopts the hierarchical design idea, which is divided into the underlying driver and the upper application. The correctness of the circuit and software program of PWM generator circuit and software is tested by the design experiment, and the performance indexes of PWM generator circuit and PWM were measured. The experimental results show that PWM generator has simple structure and high control precision. At the same time, the software program adopts the idea of layered design, therefore, for the situation of different PWM waveform requirements, it is necessary to modify the parameters of the PWM generator control program only slightly, and have the advantages of high flexibility and portability. This design has high application value in communication, power electronics, control, measurement, detection and so on.

7. Acknowledgement

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