# New Technique to Generate the PWM Signal

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**Abstract**: This paper presents a new technique to generate the 1-bit signal by decoding Pulse Width Modulation (PWM) signal to a binary file before programming onto the ROM. Since each PWM signal requires only 1-bit digital signal, PWM signal and other forms of digital signal related to multi-bit can be simply generated. The results demonstrate that using this new technique to generate the PWM signal can simplify the process and hardware complication. Moreover, the signal's data and frequency can be easily modified by programming the data onto the ROM and using the counter, respectively, which can reduce the size of the circuit and make the PCB easier.

**Keywords:** Pulse Width Modulation (PWM), Binary File, ROM, Duty Cycle, SPWM

## 1. INTRODUCTION

PWM signal has been widely used to control the static switch in various switching circuits [1]. It is basically generated by comparing the sawtooth signal with some specified reference signals in order to obtain pulse signal having different $t_{on}$ and $t_{off}$ . When a lot of PWM signals are simultaneously desired, the circuits become huge and complex [2]. This paper presents a new technique to generate the PWM signal by analyzing the data using the software before transferring to the binary file. The binary file is then programmed onto the ROM such that each bit represents the data of the PWM signal. The resolution of the data can be determined according to the size of the memory chosen. The results show that this new technique can simplify the circuit design and the signal modification as well as reduce the circuit's size.

## 2. PRINCIPLE AND THEORY

Static switch is controlled using PWM signal to regulate the on-off. PWM signal is basically generated as in Figure 1.

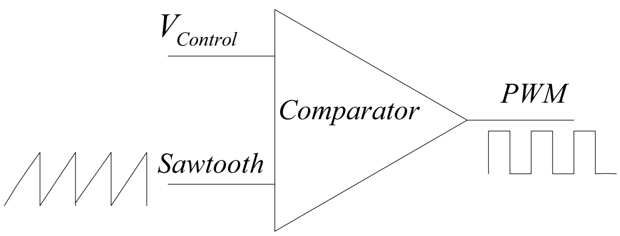


Figure 1 The original PWM signal

From Figure 1, the frequency of the PWM signal can be defined from the sawtooth signal. The sawtooth signal is then compared with the referenced signal $V_{Control}$ .The output obtained is the PWM signal with $t_{on}$ and $t_{off}$ different in accordance with the modulated DC signal as shown in Figure 2.

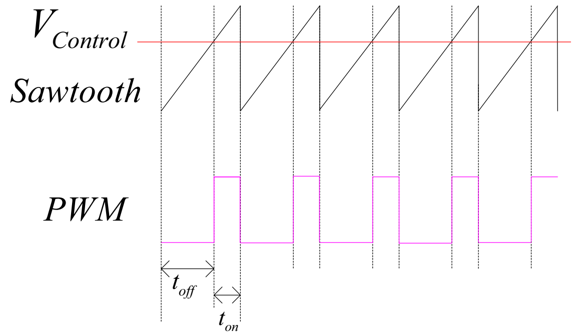


Figure 2 PWM signal obtained from modulating the DC signal

From Figure 2, $t_{off}$ is obtained when the amplitude of the sawtooth signal is lower than $V_{Control}$ while $t_{on}$ is obtained when the amplitude of the sawtooth signal is higher than $V_{Control}$ . The ratio between $t_{on}$ and T can be represented by $D$ as shown in Equation (1).

$$D = \frac{t_{on}}{T} \tag{1}$$

where

$D$ is the Duty Cycle
$t_{on}$ is the time of switch on
$T$ is the time of each period

Since the referenced signal used when generating SPWM signal is the sinusoidal signal instead of the DC signal $V_{Control}$ , the $t_{on}$ and $t_{off}$ of the output signal are different undoubtedly related to the amplitude of the sinusoidal signal as shown in Figure 3.

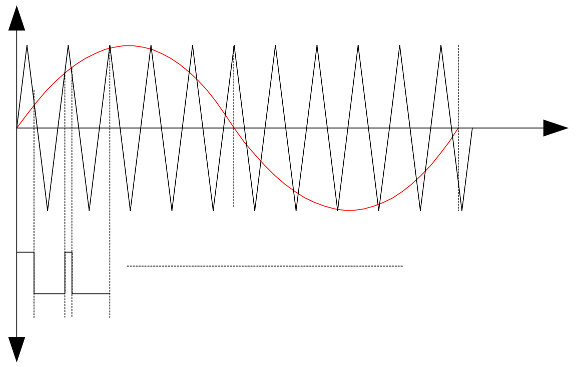

Figure 3 PWM signal obtained from modulating the sinusoidal signal

From Figure 3, the frequency of the PWM signal obtained is equal to that of the sawtooth signal and the Duty Cycles for each period are unequal depending on the amplitude of the sinusoidal signal.

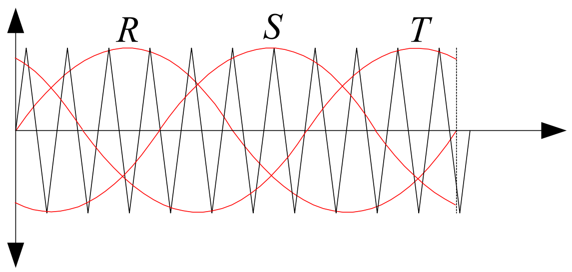


Figure 4 3-phase SPWM modulation

Figure 4 illustrates the modulation with the 3-phase Sinusoidal signal, Phase R, Phase S, and Phase T, in order to obtain 3 SPWM signals.

## 3. DESIGN OF THE SYSTEM

This paper presents a new technique to generate the PWM signal by analyzing the data using the software before transferring to a binary file. The binary file is then programmed onto the ROM such that each bit represents the data of the PWM signal.

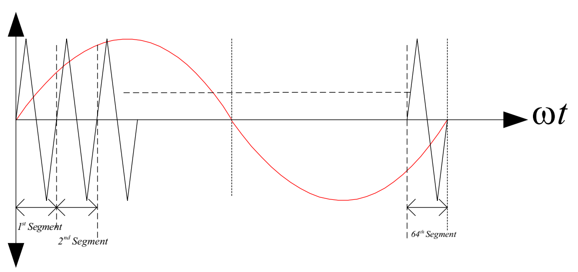


Figure 5 signal segmentation related to the period of the sawtooth signal

In this research, SPWM signal is generated by dividing the sine signal into several segments according to the period of the sawtooth signal. The resolution of the segmentation depends on the size of the ROM chosen. This research uses 4 Kbytes ROM.

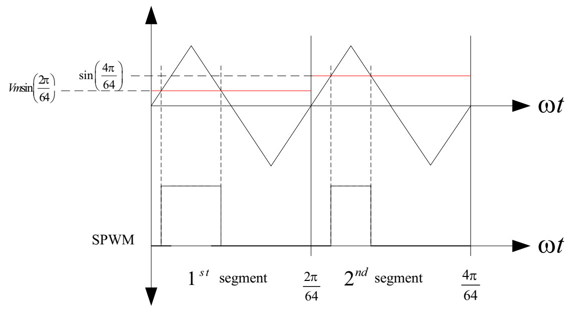


Figure 6 Details of the segmentation

From Figure 6, each segment represents one period of the SPWM signal. The first segment is obtained by comparing the amplitude of the sinusoidal signal whose angle is $\frac{2\pi}{64}$ $\left(\sin\frac{2\pi}{64}\right)$ with that of sawtooth signal. SPWM signal has $t_{on}$ obtained when the amplitude of the sinusoidal signal is lower than that of the sawtooth signal and $t_{off}$ obtained when the amplitude of the sinusoidal signal is higher that that of the sawtooth signal. SPWM signal as in Figure 6 is then transferred to the binary file with the resolution of $2^6$ ; $t_{on}$ is 1 and $t_{off}$ is 0. This research also develops the program to analyze the data of the SPWM signal and pulse signal having the corresponding phase as follows.

1. 3-phase SPWM signal

Where

$Data\_R$ is the PWM of R phase

$Data\_S$ is the PWM of S phase

$Data\_T$ is the PWM of T phase

2. 1-phase SPWM signal

Where

$Data\_\sin$ is the SPWM of sine signal

$Data\_\cos$ is the SPWM of cosine signal

3. Pulse signal

Where

$Data\_Pulse1$ is the Pulse signal1

$Data\_Pulse2$ is the Pulse signal2

$Data\_Toggle$ is the Pulse signal3

$Data\_Pulse1$'s phase and $Data\_Pulse2$'s phase are 180 degree different. $Data\_Toggle$ is a toggle puylse. All signals are analyzed and arranged in the binary file as follows.

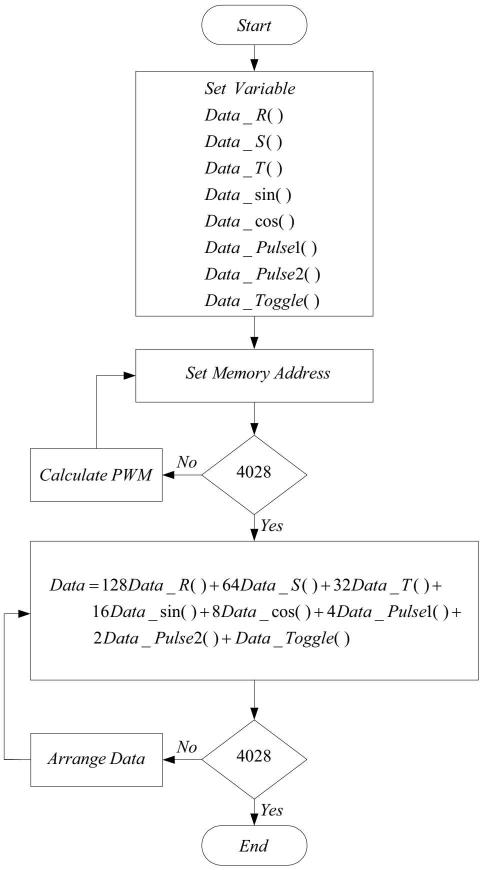


Figure 7 Flowchart for analyzing the data

After analyzing, the data is transferred to binary, which can be shown in the table 1.

| Memory Address | Data |
|---|---|
| 00000H | BC BD BC BD BC BD BC BD<br>BC BD BC BD BC FD FC FD |
| 00010H | FC FD BC BD BC BD BC BD<br>BC BD BC BD BC BD BC 2D |
| 00020H | 2C 2D 2C 2D 2C 2D 2C 2D<br>2C 2D 2C 2D 2C 0D 0C 0D |
| 00030H | 0C 0D 2C 2D 2C 2D 2C 2D<br>2C 2D 2C 2D 2C 2D 2C 2D |
| 00040H | 2C BD BC BD BC BD BC BD<br>BC BD BC BD BC FD FC FD |
| 00050H | FC FD BC BD BC BD BC BD<br>BC BD BC BD BC BD 2C 2D |
| 00060H | 2C 2D 2C 2D 2C 2D 2C 2D<br>2C 2D 2C 2D 2C 2D 0C 0D |
| 00070H | 0C 2D 2C 2D 2C 2D 2C 2D<br>2C 2D 2C 2D 2C 2D 2C 2D |
| 00080H | 2C 2D 2C BD BC BD BC BD<br>BC BD BC BD FC FD FC FD |

Table 1. The example data which analyzing by software

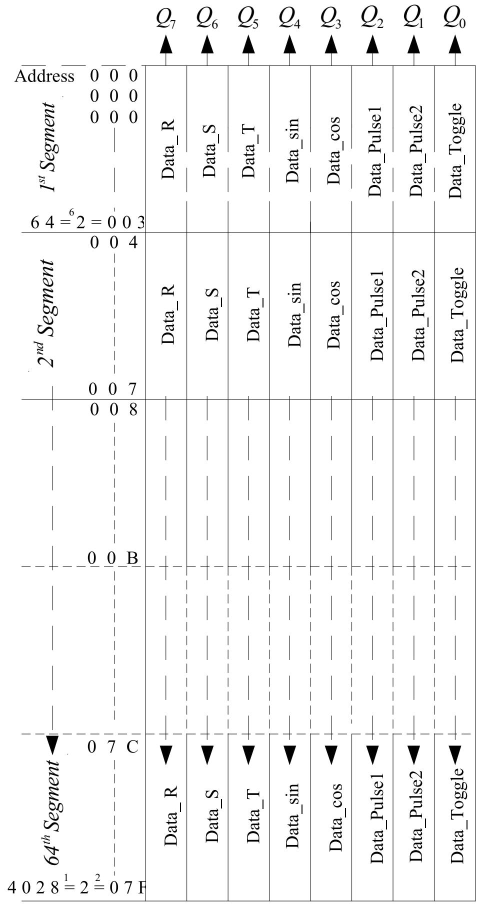


Figure 8 Data arrangement inside the ROM

The binary data will be arranged to 1 bit as shown in Figure 8. Each bit represents the following signals.

$Q_7$ Represents $Data\_R$

$Q_6$ Represents $Data\_S$

$Q_5$ Represents $Data\_T$

$Q_4$ Represents $Data\_\sin$

$Q_3$ Represents $Data\_\cos$

$Q_2$ Represents $Data\_Pulse1$

$Q_1$ Represents $Data\_Pulse2$

$Q_0$ Represents $Data\_Toggle$

## 4. EXPERIMENTAL RESULT

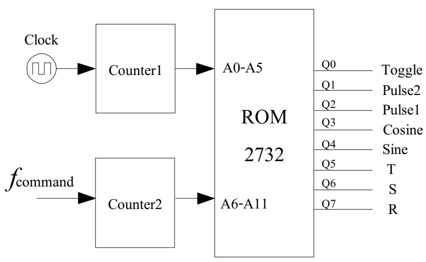


Figure 9 Circuit's block diagram

The experiment is conducted using Counter1 and Counter2 connected together with the ROM 2732. The purpose of Counter1 is to decode the data in each segment of the signal while the purpose of counter2 is to determine the frequency of the obtained signal.

The results when experimenting with different output signals are shown in Figure 10.

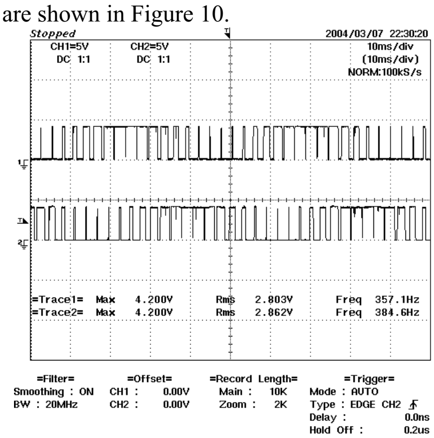


Figure 10 Output Signal of $Q_7$ and $Q_6$

Figure 10 illustrates the 3-phase SPWM signal, which has phase R and phase S 120 degree different.

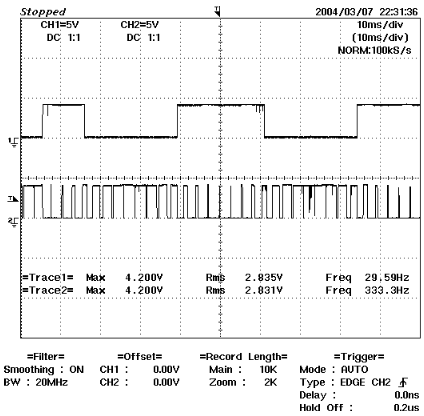


Figure 11 Output Signal of $Q_2$ and $Q_4$

The upper line in Figure 11 is the output signal $Q_2$, which is the pulse signal, and $Q_4$, which is the SPWM signal.

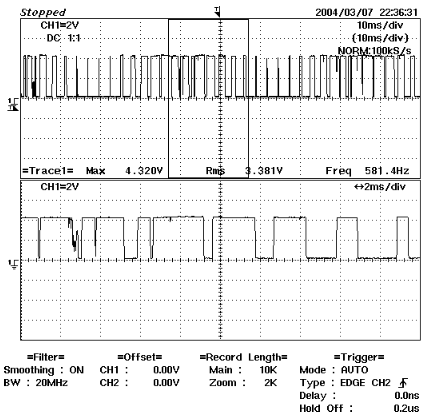


Figure 12 Output Signal of $Q_3$

Figure 12 illustrates the SPWM signal after being modulated with the Cosine signal and the enlarged signal.

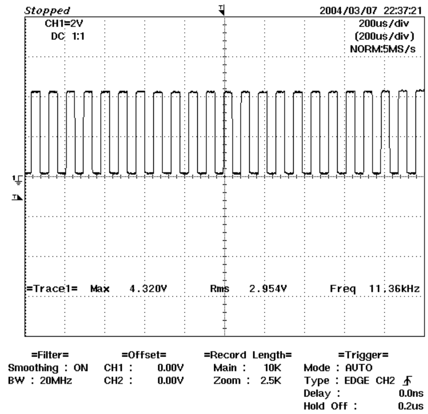


Figure 13 Output Signal of $Q_0$

Figure 13 illustrates the output toggle signal, which is the pulse signal with the frequency of $f_{command}$

## 5. CONCLUTION

The new technique to generate the PWM signal divides the signal into several segments. The resolution of the segmentation depends on the ROM used. Since each PWM signal requires only 1-bit digital signal, a lot of PWM signals can be simultaneously acquired. Analyzing data to a binary file is advantageous since the data is digital and the noise is decreased. Moreover, the signal's value and frequency can be easily modified. The results show that the analyzed PWM signals and pulse signals kept in the ROM are correspondent and can response at high frequency without the error.

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