HT8 MCU Timer Module Application Note (2) – Generating Infrared Remote Control Carrier Waves in the PWM Mode

Introduction

The Holtek HT8 MCU series provide various types of timer modules, such as the Compact type TM, the Standard type TM and the Periodic type TM, which all have their own unique characteristics. In practical applications, PWM signals generated by the TM modules can be used in areas such as motor power control, heating control or illumination control. This application note will introduce another way of using PWM signals which is for infrared signal transmission applications. The application will show how to generate the desired 38kHz carrier wave signal used by infrared remote controls using the CTM PWM mode. The inclusion of a practical application will help users to understand and skillfully use the CTM function.

Functional Description

Infrared Transmission Introduction

Infrared forms one of the invisible parts of sunlight, which was discovered in 1800 by German-British scientist William Herschel, who split sunlight using a prism. By placing thermometers under the different colours, in an attempt to measure the different colour heating effects, he discovered that just beyond the red end of the visible spectrum, a higher temperature was measured. Although invisible to the human eye but due to this effect being near the red end of the visible spectrum it was named infrared.

The Infrared radiation wavelength is longer than that of visible light, therefore it is invisible and often used as a transmission media. The infrared wavelength extends from 0.75 to 1000 micrometers, which can be separated into three parts, namely near-infrared with a wavelength which extends from 0.75 to 1.50µm, mid-wavelength infrared with a wavelength which extends from 1.50 to 6.0µm and far-infrared whose wavelength extends from 6.0 to 1000µm.

In actual circuit applications, an IR LED will be required if the data is transmitted by means of infrared. This component, which when supplied with a suitable forward bias
voltage, will generate a current and stimulate infrared light radiation. The common infrared emission diode wavelengths are 850nm, 870nm, 880nm, 940nm 980nm, etc.

**Infrared Remote Control Signal Composition**

**Carrier Wave Signals**

Carrier waves are waves which can be modulated in order to transmit information signals. Common infrared transmission carrier signal frequencies are normally within a range of 38kHz~56kHz. Data is transmitted after being modulated onto the transmitter. The receiver should use a frequency selective amplifier circuit which operates at the same frequency as the transmitter for optimal anti-interference performance.

**Infrared Remote Control Signal Encoding Format**

Presently, the most widely used infrared remote control encoding methods are NEC Protocol Pulse Width Modulation and the Philips RC-5 Protocol Pulse Position Modulation. In this application note the NEC protocol will be taken as an example to show how to generate a group of infrared remote control signals.

The NEC infrared remote control signal encoding format characteristics are listed as follows:

1. Uses a 38kHz carrier wave frequency
2. The preamble code interval is 9ms + 4.5ms
3. Uses a 16-bit user code
4. Uses an 8-bit data code and an 8-bit data inverse code
5. 1-bit stop bit

The remote control signal encoding format is composed of a preamble code, the user code, the data code as well as the data inverse code for data verification.

![Fig 1. Signal Encoding Format](image1)

![Fig 2. Encoding Time](image2)
Carrier Wave Signal Format - H/L Ratio

![38kHz Carrier Wave Signal](image)

**Fig 3. 38kHz Carrier Wave Signal**

**DATA "0" and DATA "1" Formats**

Each bit in the user code or the data code can be either '0' or '1', which can be distinguished using the pulse time. Such an encoding method is called Pulse Position Modulation which is abbreviated to PPM.

![DATA "0" and DATA "1" Formats](image)

**Fig 4. DATA "0" and DATA "1" Formats**

**Operational Principles**

**Compact Type TM Basic Structure Description**

As the simplest form of the TM types, the Compact type TM can implement three operating modes, which are Compare Match Output, Timer/Event Counter and PWM Output modes, using an external input signal TCKn and an output signal TPn.

The CTM core is composed of a count-up counter and two internal comparators with the names, Comparator A and Comparator P. The count-up counter can be driven by an internal clock or an external TCKn pin. The output signal TPn status is determined by comparing the count values in the Comparator A and Comparator P with the CCRA and CCRP register values. As the following figure shows, the counting values are compared with the 16-bit CCRA register value and the CCRP high byte register value. When the counter overflows, the TnON bit changes from low to high or a comparator match event occurs, which is determined by the operating mode, the counter will be automatically cleared.
PWM Output Mode

The most common PWM functions are for motor control, heating control and illumination control applications. The CTM can be setup to operate in the PWM mode by configuring the TnM[1:0] bit field to “10”, which will then allow a PWM signal to be generated on the TPn pin.

In the PWM mode, the period and duty is adjustable. Taking the HT66F0185 as an example, it can be configured using the TnDPX bit. This bit allows the period to be determined by the 16-bit CCRA while the duty is determined by the CCRP high byte or vice versa.

The TnOC bit in the TMnC1 register determines the PWM waveform polarity. The TnIO[1:0] bit field is used to enable the PWM output on the TPn pin or to setup the TPn to be either a fixed output logic high or low. The PWM output polarity will be inverted or non-inverted by configuring the TnPOL bit.
Application Circuits

Taking the HT66F0185 as an example, the above figure shows a circuit that generates a 38kHz infrared carrier wave signal using the CTM PWM mode. Pin TP2 is the PWM signal output pin, which can be used to control the transistor Q1 through the transistor base current-limiting resistor, R1. Resistor R2 is the IR LED current-limiting resistor. The general IR LED forward voltage, $V_f$, is about 1.3V and the C8050 transistor collector-emitter saturation voltage drop is about 0.3V. As a result the R2 voltage drop is $(5V - 1.3V - 0.3V)$, namely 3.4V, resulting in a diode operating current of about $3.4V/39\Omega = 87mA$.

Note that the infrared emission diode wavelength $\lambda$ is 940nm, while the operating current is 100mA.

Software Design

This application note takes the HT66F0185 as an example to implement a CTM timer module function which will transmit a group of infrared codes each time the key is pressed. Details are as follows.

Infrared carrier wave signal frequencies generally range from 30kHz to 60kHz, where a 35kHz square wave is commonly used, determined by the transmitter 455kHz crystal. The transmitter crystal requires an integer frequency division, in this case a division factor of 12 is required. The frequency is $455kHz/12 = 37.9kHz = 38kHz$.

The HT66F0185 CTM is used to generate the 38kHz infrared carrier wave signal. The system frequency is defined as 16MHz which is also used as the CTM clock source. The CCRA register is selected to be used as the PWM period compared register with a register value of 416, thus the PWM period $= 16MHz/416 = 38kHz$, namely about 26µs. The CCRP register is used to define the duty. As the CCRP available value comes from the highest 8 bits, when the CCRP register value is “01”, the PWM duty $= 01 \times 255 \times (1/16MHz) = 15.9\mu s
The control register configurations for the HT66F0185 Compact type timer module which generates the PWM carrier wave signal are shown below:

<table>
<thead>
<tr>
<th>Register</th>
<th>Operating Bit Function</th>
<th>Setup Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM2C0</td>
<td>Bit 7: T2PAU: Counter pause control bit</td>
<td>When set to “0”, the counter is in the running state</td>
</tr>
<tr>
<td></td>
<td>Bit 6<del>4: T2CK2</del>T2CK0: Select TM1 counter clock bit</td>
<td>Set this field to “001” to select the fSYS as the TM1 counter clock</td>
</tr>
<tr>
<td></td>
<td>Bit 3: T2ON: TM2 counter On/Off control bit</td>
<td>When set to “1”, the counter is on</td>
</tr>
<tr>
<td></td>
<td>Bit 2~0: Unimplemented, read as “0”</td>
<td></td>
</tr>
<tr>
<td>TM2C1</td>
<td>Bit 7<del>6: T2M1</del>T2M0: Select TM2 operating mode</td>
<td>Set to “10” to select the PWM output mode</td>
</tr>
<tr>
<td></td>
<td>Bit 5<del>4: T2O1D1</del>T2O1D0: Select TP2 output function</td>
<td>Set to “10” to select PWM output</td>
</tr>
<tr>
<td></td>
<td>Bit 3: T2OC: TM2 TP2 output control bit</td>
<td>When set to “1”, the PWM signal is active high</td>
</tr>
<tr>
<td></td>
<td>Bit 2: T2POL: TM2 TP2 output polarity control bit</td>
<td>Set to “0”</td>
</tr>
<tr>
<td></td>
<td>Bit 1: T2DPX: TM2 PWM period/duty control bit</td>
<td>Set to “0”</td>
</tr>
<tr>
<td></td>
<td>Bit 0: T2CCLR: Select TM1 counter clear condition</td>
<td>Set to “1” for Comparator A match</td>
</tr>
</tbody>
</table>

Software Design Flowchart

Start

Initialisation (I/O port, PTM, CTM, variables)

No

Check if key is pressed?

Yes

Transmit a group of infrared data

Fig 8. System Flowchart
CTM Initialisation

Set the bit 2 in the TMPC to 1, select the PB3 as TP2 output

Setup 38kHz Duty by configuring the TM2RP register value

Setup 38kHz period by configuring the TM2RAL/TM2RAH register value

Setup the TM2C0 and TM2C1 control registers

Turn on the TM, the 38kHz PWM will be output on the TP2(PB3) pin

END

Fig 9. CTM PWM Generation Software Flowchart

Transmit a group of infrared data

Transmit preamble code (Carrier signal 9ms, low level signal 4.5ms)

Transmit user code 16 bits (The actual value is 0x5555)

Transmit data code 8 bits (The actual value is 0xaa)

Transmit data inverse code 8 bits (The actual value is 0x55)

Transmit stop bit (1 bit stop bit)

End

Fig 10. Transmitting a group of NEC Codes - Software Flowchart
Generating Infrared Remote Control Carrier Waves in the PWM Mode

Fig 11. Key Scanning Flowchart

Fig 12. Infrared Transmission Waveform
Program Examples

Test-38KHz with KEY-asm.rar  Test-38KHz with KEY-c.rar

Conclusion

This application note has shown how to configure the counter, output pin, PWM period and duty in the PWM operating mode of the CTM to help users understand and utilise the specific TM functions.

Reference Files

Reference file: HT66F0175/185 Datasheet

Version and Modification Information

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<th>Date</th>
<th>Author</th>
<th>Issue</th>
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<tr>
<td>2017.01.20</td>
<td>王贊臣 (Jasenwang)</td>
<td>First Version</td>
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