Using the STM PWM Function in the HT66F40

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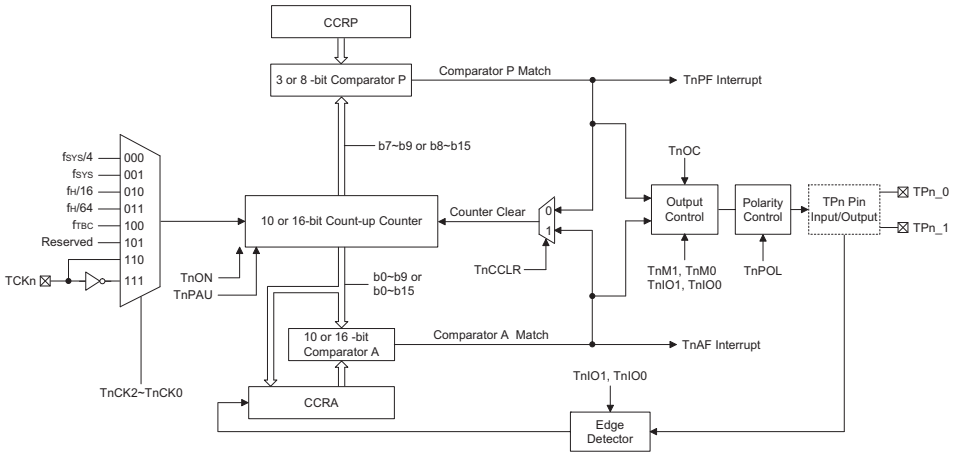
Introduction

The HT66Fx0 series devices include what are known as Timer Modules, which have multiple functions and combine features such as Timer and PWM output generation into a single module. These multiple functions include general timer, external counter, programmable duty/period PWM output, single pulse output and input capture etc. The Timer Modules come in three types, namely Compact Type TM (CTM), Standard Type TM (STM) and Enhanced Type TM (ETM.)

The following application content uses the HT66F40 to describe the PWM function in the STM.

Operation Principles

At the core of the STM is a 16-bit counter-up counter and two comparators as illustrated in the following diagram:



Standard Type TM Block Diagram

Note: n = 2 in this example

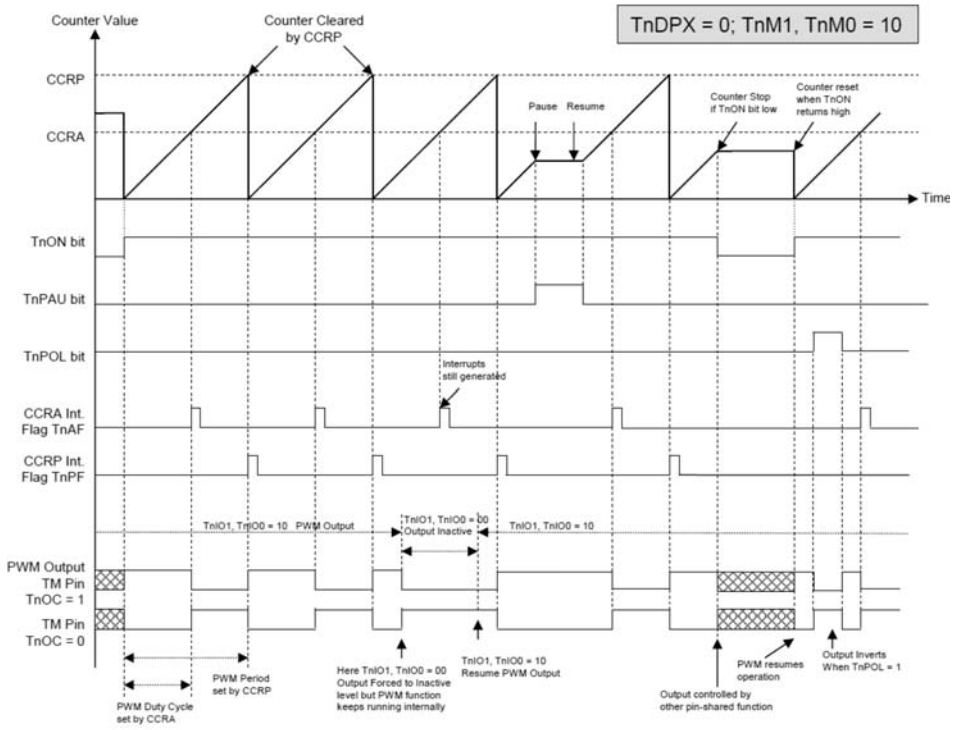
The counter clock source can be selected as $f_{SYS}/4$, f_{SYS}, $f_H/16$, $f_H/64$, f_{TBC} or the TCK input by setting up the T2CK0~T2CK2 bits. Two internal comparators, CCRP and CCRA, are used to setup the compare values. CCRP, having an 8-bit width, is only compared with the high eight bits of the counter. CCRA is the same width as the counter and is therefore compared with all counter bits. When the related registers are setup and the TM is enabled, the counter starts to count up and the TM will compare the present CCRA value with the counter value. When the counter overflows or equals the preset CCRA value, it will be cleared to zero automatically and generate an interrupt signal. It may also generate changes in the TM output pins. The counter registers, TM2DH/TM2DL, are read only and cannot be modified by the application program. The only way to manually clear the counter to zero is by setting the T2ON bit from 0→1. The T2POL bit is used to control the TP2 outputs, and when set high, the TP2AO outputs will be inverted.

HT66F40 Output Pin Description:

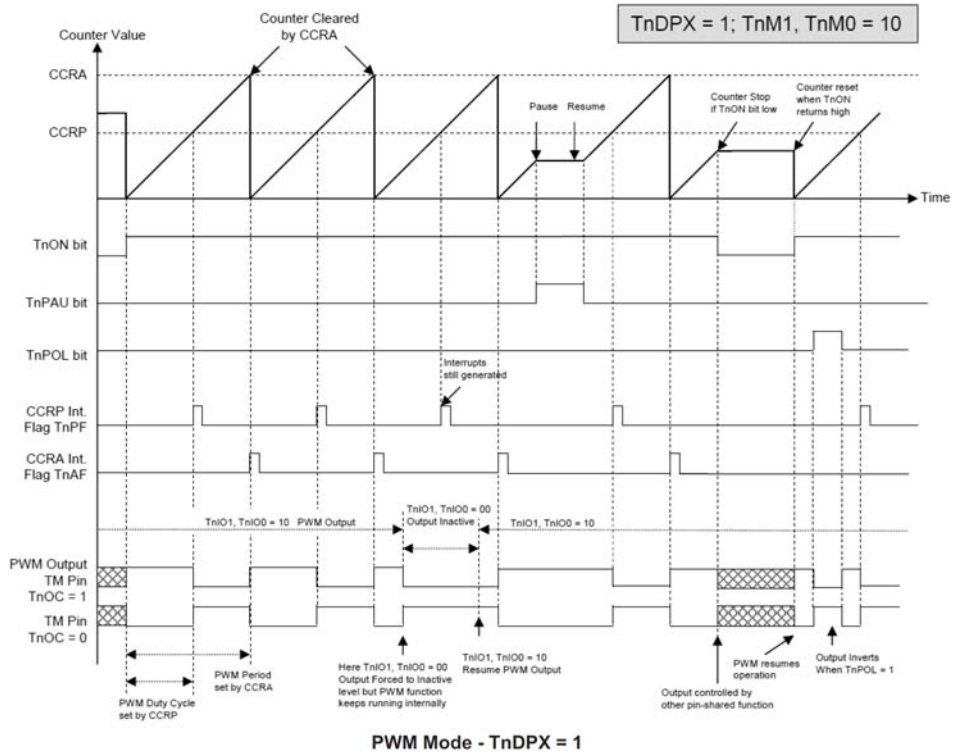
Pin	Function	TMPC0	PRM2
TP2_0	CCRA/CCRP Compare Match Output Pin	T2CP0 1 : enable TP2 0 : I/O or other functions	TP20PS 0 : Enable TP2_0 on PC3 1 : Enable TP2_0 on PD1
TP2_1	CCRA/CCRP Compare Match Output Pin	T2CP1 1 : enable TP2 0 : I/O or other functions	TP21PS 0 : Enable TP2_1 on PC4 1 : Enable TP2_1 on PD4

In the PWM mode, the counter can select the PWM Period and PWM Duty configuration by setting the T2DPX bit. When T2DPX is set to zero, the PWM period is controlled by CCRP and the PWM duty is controlled by CCRA. When T2DPX is set to 1, CCRA controls the PWM period while CCRP controls the PWM duty. After the STM operation mode is set to PWM, set T2ON to 1 to enable the counter. Once the counter value matches with either CCRA or CCRP, the corresponding interrupt flag, T2AF or T2PF, will be set to 1. If the stack is not full and the corresponding interrupt is enabled, the program will enter its related interrupt service program. Note that the interrupt vector for a CCRP and CCRA compare match interrupt is the same. To determine the actual interrupt source, it is necessary to distinguish the interrupts after entering the interrupt service program. As the T2AF and T2PF flags will not be cleared to zero automatically, they must be cleared manually by the application program, otherwise subsequent interrupts will not be generated.

PWM Mode Timing:



PWM Mode - TnDPX = 0



PWM Mode - TnDPX = 1

Note: n = 2 in this example.

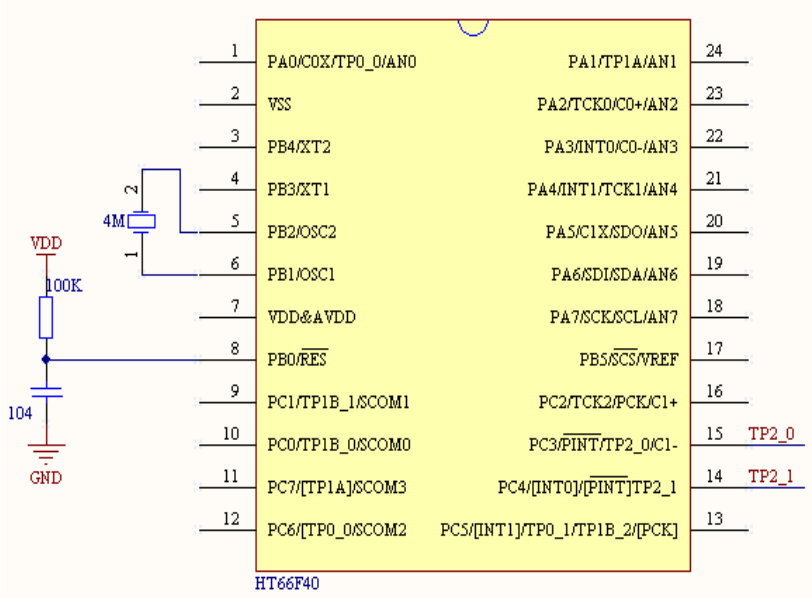
In the PWM mode, T2CCLR is invalid.

Before setting the PWM mode, setup the corresponding bits in the PRM2 register and set the TP2 to a different I/O pin. Then configure the TMPC1 register to enable theTP2 output function on its related I/O pin.

Setup steps for the PWM mode operation in the CTM:

Step	Operation	Register	Setup Bit	Functional Description
1	Clock source setup	TM2C0	T2CK0~T2CK2	Select STM clock source
2	PWM control	TM2C1	T2DPX : 1 : CCRA controls Period CCRP controls Duty 0 : CCRA controls Duty CCRP controls Period	Choose CCRA or CCRP to control the PWM Period and PWM Duty
3	Set the CCRA, CCRP register value	TM2AH/TM2AL	All bits	Setup compare register
		TM2RP	All bits	
4	Setup STM operation mode	TM2C1	T2M1, T2M0=10	″00″= STM operates in the PWM mode
5	Select STM output pin	PRM2	TP20PS : 0 : Enable TP2_0 on PC3 1 : Enable TP2_0 on PD1 TP21PS : 0 : Enable TP2_1 on PC4 1 : Enable TP2_1 on PD4	Choose the I/O to output the STM TP2_0 and TP2_1
6	Enable STM output pin	TMPC1	T2CP1, T2CP0	Enable the STM corresponding pin function
7	Setup the initial level of the TP2 output	TM2C1	T2OC : 0 : output low level 1 : output high level	Setup the TP2 output level before the first compare match
8	Setup the TP2 output function	TM2C1	T2IO1/T2IO0 : 00 : TP2 outputs invalid level 01 : TP2 outputs valid level	Choose 10 for PWM output
9	Setup the TP10 output polarity	TM2C1	T2POL : 1 : output invert 0 : output non-invert	TP2 output invert control
10	Setup interrupt enable bit	INTC2	MF0E	Enable STM and multi-function interrupts
		MFI0	T2AE, T2PE	
11	Enable STM	TM2C0	T2ON 0 → 1	Reset counter and enable STM
12	Disable STM	TM2C0	T2PAU 0 → 1	Disable STM, keep the counter value
			T2ON 1 → 0	Disable STM, keep the counter value

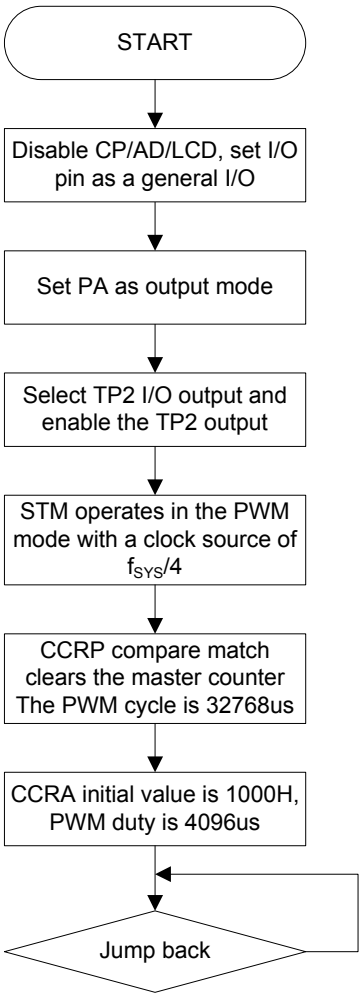
Application Circuit



Description:

The STM in the PWM mode can provide two pins for the TP2_0/TP2_1 PWM output. The PWM outputs can be selected to be a TP2_0 (Pin 15) output, a TP2_1 (Pin 14) output, or the TP2_0 and TP2_1 outputs at the same time.

S/W Flowchart (Example 1)



Note: The above is the flow when T2DPX=0 which is where CCRP controls the PWM Period and CCRA controls the PWM Duty.

Program Description - Example 1

The example uses the PWM program in the STM to observe the PWM output through TP2_0 or TP2_1.

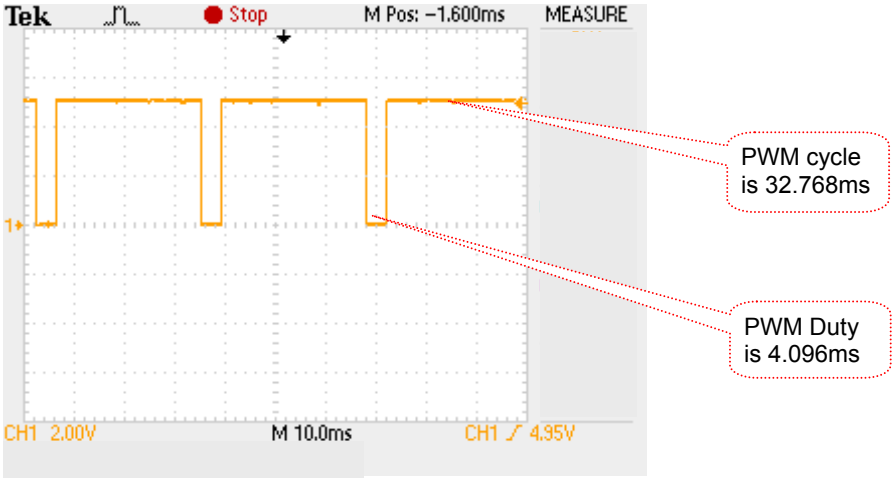
Main Flow: The program starts with an initialization of all the data registers. Set CP0C, CP1C to 08H and disable the comparator function. Clear ACERL and SCOMEN to zero and disable the analog inputs as well as the LCD function. Set the PC port to the output mode and to a low logic value, otherwise the TP2 output will invert. PRM2 [5:4] =00 means that the TP2 outputs are located on PC4 and PC3. TM2C0 [6:4] =000 will select the STM clock source as $f_{SYS}/4$. TM2C1[7:6] =10 means the STM is in the PWM mode. T2DPX=0 will allow CCRP to control the PWM period with a value of 32768us while CCRA controls the PWM duty with a value of 4096us. When the counter matches CCRP and CCRA, TP2 will invert and output the PWM signal.

Program Example - Example 1

The program in the example is in the attached file, pwm1.zip.

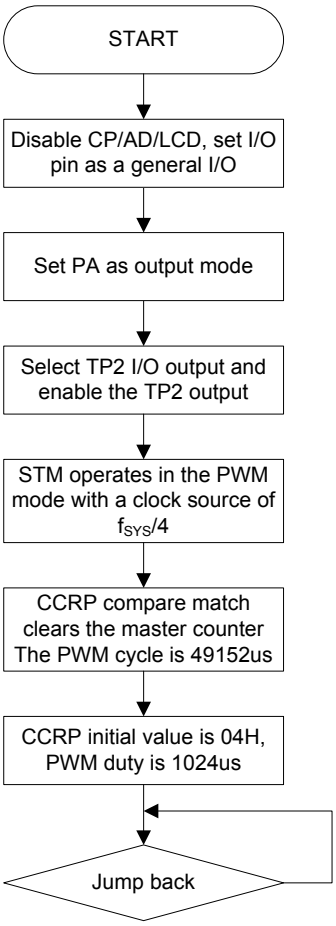
Note: The above program is for T2DPX=0, where CCRP controls the PWM period and CCRA controls the PWM duty.

The actual output waveform is shown below.



Note: The above is the waveform when T2DPX=0, where CCRP controls the PWM period and CCRA controls the PWM duty where the PWM output is Active Low.

S/W Flowchart - Example 2



Note: The above program flow is when T2DPX=1, where CCRA controls the PWM period and CCRP controls the PWM duty.

Program Description - Example 2

The example uses the PWM program in the STM to observe the PWM outputs through TP2_0 or TP2_1.

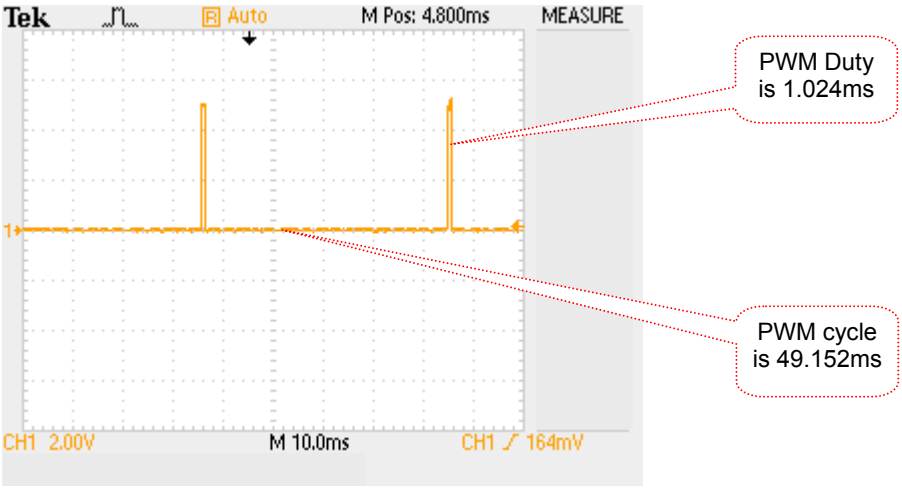
Main Flow: The program starts with an initialization of all the data registers. Set CP0C, CP1C to 08H and disable the comparator function. Clear ACERL and SCOMEN to zero and disable the analog inputs as well as the LCD function. Set the PC port to the output mode and to a low logic value, otherwise the TP2 output will invert. PRM2 [5:4]=00 means that the TP2 outputs are located on PC4 and PC3. TM2C0[6:4]=000 will select the TM clock source as $f_{SYS}/4$. TM2C1[7:6] =10 means that the TM is in the PWM mode. When T0DPX=1, CCRA controls the PWM period with a value of 49152us and CCRP controls the PWM duty with a value of 1024us. When the master counter matches CCRP and CCRA, TP2 will invert and output the PWM signals.

Program Example

The program in the example is in the attached file, pwm2.zip.

Note: The above program is for T2DPX=1, where CCRA controls the PWM Period and CCRP controls the PWM Duty.

The actual output waveform is shown below.



Note: The above waveform is T2DPX=1, where CCRA controls the PWM Period and CCRP controls the PWM Duty where the PWM outputs is Active High.

Conclusion

The application content has described the STM PWM function in which the user can configure the required waveform according to their actual needs.