

***TMS320C24x***  
***General Purpose Timer 1***  
***Symmetric Mode***

Application Report  
SPRA368



## **IMPORTANT NOTICE**

Texas Instruments (TI) reserves the right to make changes to its products or to discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information being relied on is current.

TI warrants performance of its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Certain application using semiconductor products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications").

TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.

Inclusion of TI products in such applications is understood to be fully at the risk of the customer. Use of TI products in such applications requires the written approval of an appropriate TI officer. Questions concerning potential risk applications should be directed to TI through a local SC sales office.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein. Nor does TI warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used.

# Overview

There are three General Purpose (GP) Timers in the Event Manager of the 'C240. These timers can be used as independent time bases in applications such as:

- generation of sampling period in a control system,
- providing time base for quadrature encoder sensor signal processing in a motor control system,
- providing time base for the operation of Full and Simple Compare Units and associated PWM circuits to generate PWM outputs in a motor control system.

This application report presents one application of the GP Timer: Time base and PWM generation using GP Timer One in asymmetric mode.

## Index

<b>1. Possibilities of GP Timer 1 in Symmetric Mode</b>	<b>4</b>
<b>2. Description : Event Manager Programming</b>	<b>6</b>
<i>2.1 Timer Composition</i>	<i>6</i>
<i>2.2 Preparation Phase for Timer Configuration</i>	<i>6</i>
<i>2.3 Calculation for the Time Slots in the Symmetric Case</i>	<i>7</i>
<i>2.4 Example</i>	<i>7</i>
<i>2.5 Modification of the Active Width during Running</i>	<i>10</i>

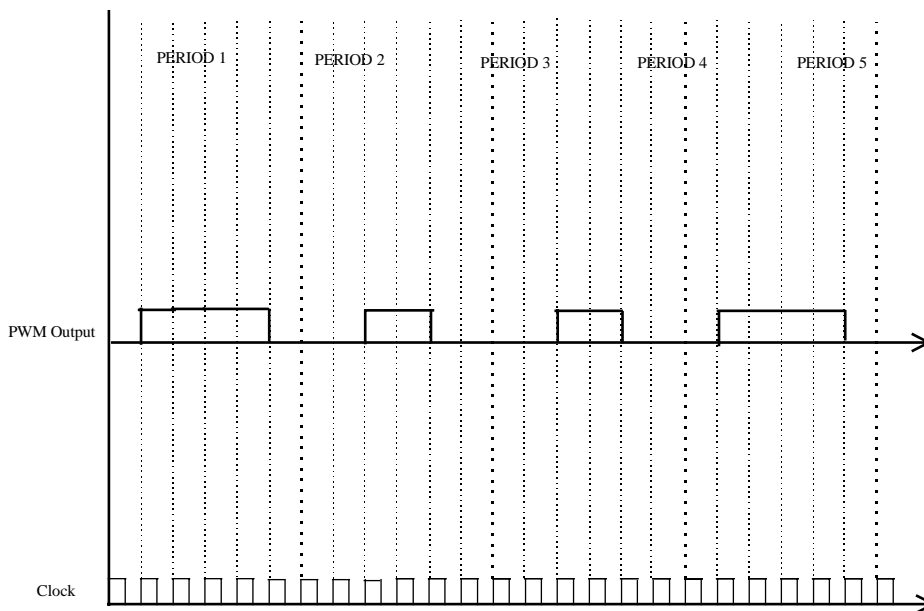
Note:

General Purpose Timer 2 and General Purpose Timer 3 have same functionalities than Timer 1 except for Time Base generation for Full or Simple Compare.

## 1. Possibilities of GP Timer 1 in Symmetric Mode

General Purpose Timer 1 in symmetric mode can be used:

- To generate one **symmetrical PWM** on the GP Timer 1 output with following features :
  - this PWM connected to Time Base One is Time Base dependent (Counter and Period) with the three pairs PWM (Full Compare) connected exclusively to Time Base One.
  - this PWM could be totally independent with the three PWM (Simple Compare) if these three PWM are based on Time Base Two.

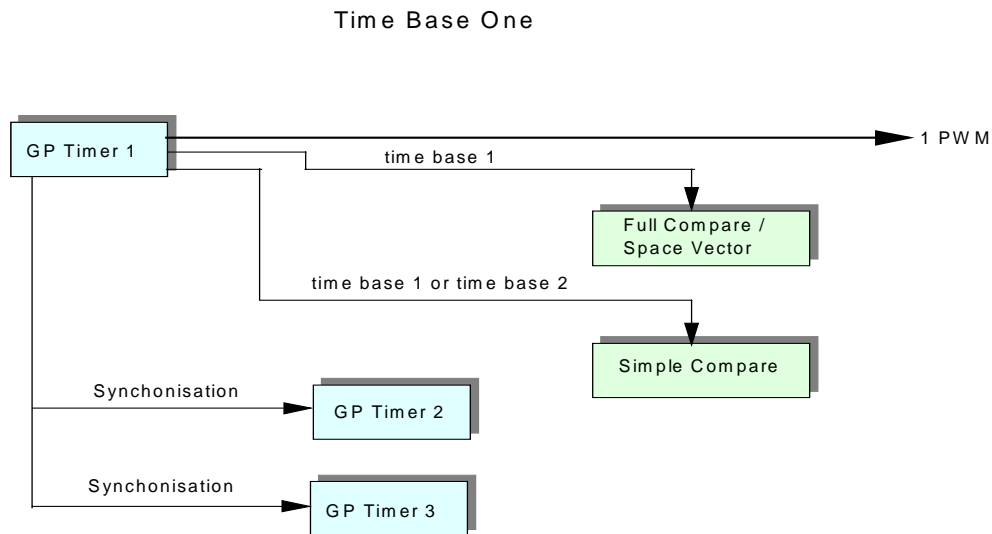


- To generate a time base for the Compare and/or the Simple compare module.

Three pairs PWM (Full Compare) are exclusively based on the Time Base One.

Three PWM (Simple Compare) can be connected to the Time Base One or Time Base Two.

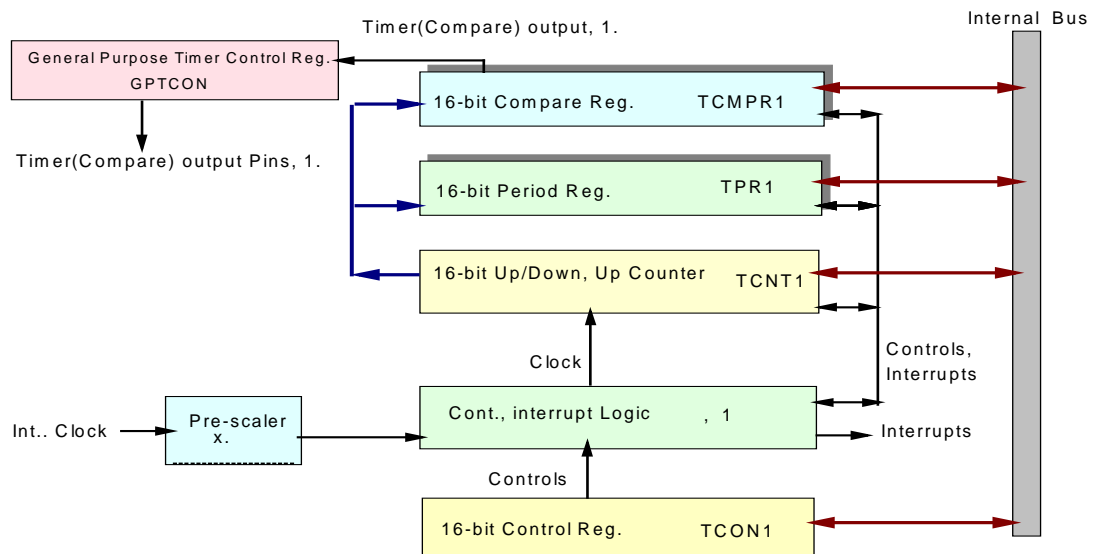
- To generate a Time Base for the Space Vector modulation module.
  - To generate a Time Base for GP Timer 2 and GP Timer 3.
- Time Base Two or Three can be independently or both synchronous to Time Base One.



- To generate a Time Base with Period modification on the fly.
- To generate a Time Base for QEP, Capture, ...

## 2. Description : Event Manager Programming

### 2.1 Timer Composition:



### 2.2 Preparation Phase to Configure this Timer

The preparation phase for timer configuration is to:

- write GPTCON to determine action on GP Timer 1 compare output pin (active low, active high, forced low, forced high)
- write TPR1 : Timer Period register.
- write TCMPR1 : Compare Period register.
- write TCNT1 : Counter Period register.
- write TCON1 with bit 6=0b (timer disable)  
: Control register to program Count Mode Selection, Clock Pre-scaler, Clock Source, compare reload condition, enable compare operation .
- write TCON1 with bit 6=1b to start the timer.  
: Control register to enable the Timer 1

### **2.3 Calculation for the Time Slots in the Symmetric Case**

- PWM cycle time:  $T_{\text{PWM}} = 2 * \text{TPER}$  timer counts. TPER is the value programmed into the period register for the PWM time base counter.
- ACTIVE pulse width:  $T_{\text{on}} = (\text{TPER} - \text{CMPRup} + \text{TPER} - \text{CMPRdn})$  timer counts. CMPRup is the value programmed into the compare register during the UP count half of the PWM cycle. Likewise, CMPRdn is the value programmed into the compare register during the DOWN count half of the PWM cycle. If these are one and the same (CMPR), the equation will reduce to  $T_{\text{ON}} = 2 * (\text{TPER} - \text{CMPR})$ . This equation is only true for CMPR values in the range 0 to TPER-1. If CMPR is TPER, the output will remain in its INACTIVE state.
- INACTIVE time:  $T_{\text{OFF}} = \text{CMPRup} + \text{CMPRdn}$  timer counts. If these two compare triggers are the same, the equation reduces to  $T_{\text{OFF}} = 2 * \text{CMPR}$ . The off times will be at the start and the end of the PWM cycle.

### **2.4 Example:**

Timer 1B is programmed to generate an up/down count with a symmetrical PWM.

- Free run, no emulation mode.
  - Timer count mode Continuous Up/Down-Count Mode.
  - No timer input prescaler and internal clock.
  - Reload the shadow compare register when counter=0.
  - PWM output Active Low.
- 
- Period:  $5 * 2 * 50\text{ns}$ .
  - Compare transition after  $3 * 50\text{ns}$ .

## Register programming

GPTCON	= 042h		
	Bit 1&2	: 10b	, State of GP Timer 1 compare output active High.
	Bit 6	: 1b	, All 3 GP Timer outputs are enabled (no High Impedance State).
TPR1	= 5h		
TCMPR1	= 3h		
TCNT1	= 0h		
TCON1 (1st)	= a802h		
	Bit 1	: 1b	, Enable timer compare operation.
	Bit 3&2	: 00b	, Compare Register reload when counter is zero.
	Bit 5&4	: 00b	, Internal Clock source selected.
	Bit 6	: 0b	, Timer 1 Disabled and prescaler reset.
	Bit 13,12&11	: 101b	, Continuous-Up/Down Count Mode.
	Bit 15&14	: 10b	, GP timer not affected by emulation suspend.
TCON1 (2nd)	= a842h		
	Bit 6	: 1b	, Timer 1 is enabled.

## Initialization Assembly code:

;Note : GP timer registers are memory mapped.

```

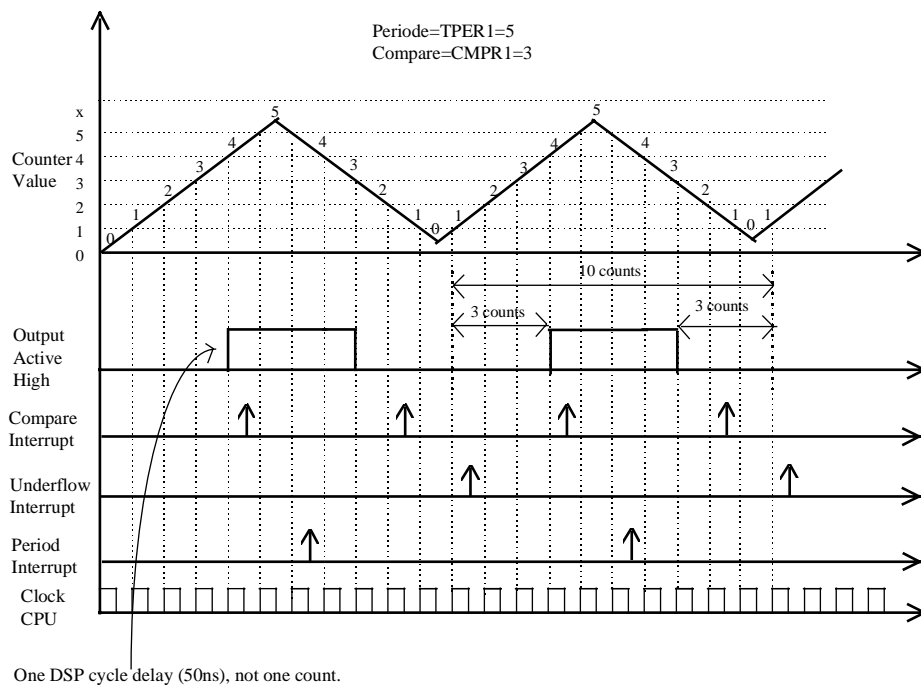
GPTCON .set 7400h      ;General Timer Controls
TCNT1  .set 7401h      ;T1 Counter Register
TCMPR1 .set 7402h      ;T1 Compare Register
TPR1   .set 7403h      ;T1 Period Register
TCON1  .set 7404h      ;T1 Control Register

LDP    #232
SPLK   #42h,GPTCON
SPLK   #5h,TPR1
SPLK   #3h,TCMPR1
SPLK   #0h,TCNT1
SPLK   #0a802h,TCON1

```



Result of this example:



Note:

The first period of a continuous up/down count is 1 DSP cycle longer and is not totally symmetrical (see diagram above).

## 2.5 Modification of the Active Width during Running

When a new compare value in the CMPR1 register is written, the new value is loaded in the timer register and is active at the end of the period, when TCNT1=0 (for this base configuration).

Example:

CMPR1 switches from 3 to 4 during the second period, the result will be:

