

Timing Hardware

ECE 331

Functions of Timer

- A microcontroller is required with features to generate output signals with precise parameters, measure the characteristics of input signals, and count external events. All these requirements are provided by the microcontroller's timer module.

Functions of Timer

- Many designs require delay operators. A timer can be used to create an adjustable wait statement.
- The program delay loop can be used to create a time delay. However, it is inflexible.

General Time Technique

- Internal MCU counter
 - X-bit counter counts up to 2^x-1 . # counts= 2^x , then overflow. (TOF=time overflow)
 - Counter=timing register, holds current x-bit counter value.
 - Count increments each clock cycle.
 - Often “ prescale” counter clock
 - Count slower than main clock

General Time Technique

- EX: 8 bit timing register & 1MHz clock

- EX: above with prescale=16

Time Delay using Free-running Timer

- Timer (counter) is always running (counting).
- Options for measuring set delay time
 - Option 1: clear timing register & wait for delay time.
 - Option 2: read current (initial) timer register value
add "current value" to delay time & wait
 - Option 3: preset timer register to (max value - delay) & wait for timer to overflow (pass max value)

Time Delay using Free-running Timer

- EX: 16 bit counter starts at \$B025. What is count after 0.2 msec if $f_{clk}=2$ MHz?

Time Delay using Free-running Timer

- How do we check/test delay time using ASM code?
 - Option 1: test when timer register value=delay.
Ex: BEQ
LOOP CPX \$addr of counter ;2
BEQ LOOP ;3
But, counter is running as fast as ASM code.
-> could miss a specific value on timer
=> **Don't** use option 1.

Time Delay using Free-running Timer

- Option 2: test when timer value > delay
EX: BHI (branch if higher), BHS (higher or same)
Check if count value has passed.

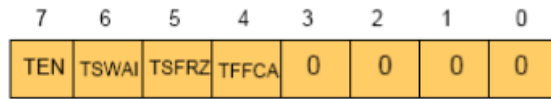
HCS12 Timer Systems

- Timer Count Register (TCNT)
 - 16 bit counter: read with 16-bit load (LDX,LDY,LDD).
 - **Don't** use 8-bit loads (LDAA, LDAB)
 - Timer counter register high (TCNTH) : addr \$0044
Timer counter register low (TCNTL) : addr \$0045
 - TCNT clock = main_clock/prescale (in TSCR2)
 - Main_clock=4 MHz
 - TCNR overflows every 65536 counts (2^{16})

HCS12 Timer Systems

- Timer system control register 1 (TSCR1)

- Address: \$0046



- Bit 7: Timer Enable (0 disable; 1 enable)

- Counter starts from \$0000 when TEN is **first** set to 1.
 - TCNT cannot otherwise be set

HCS12 Timer Systems

- Timer Interrupt Flag (TFLG2)

- Address \$004F



Timer Overflow Flag

- Bit 7: timer overflow flag (TOF)

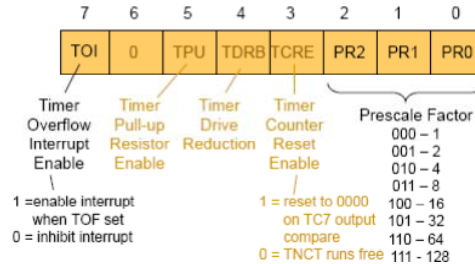
- Goes HI ('1') when TCNT overflows (from FFFF to 0000)
 - Can be polled by software to catch overflow
 - Can activate an interrupt if enabled
 - Bit set TOF to clear TOF flag

Cannot set TOF to 1

Can be done with in interrupt service routine

HCS12 Timer Systems

- Timer system control register 2 (TSCR2)
 - Address: \$004D



- Bit 2:0 prescale factor
- Bit 7: timer overflow interrupt (TOI)
 - Enables interrupt when TOF goes high
 - TOF interrupt service vector: \$FFDE:\$FFDF, where interrupt will look for addr to begin service subroutine

HCS12 Timer Systems

- Avoid using STORE instruction to set control bits.
 - Could modify other bits in that register
 - Use bit_set/clear instructions to set specific bits
- EX: Two input capture events occur at counts \$0037 and \$FB20, if $f_{clk}=2\text{MHz}$ and prescale bits PR=011, how much time between two events?

HCS12 Timer Systems

- EX: Assume $f_{\text{clk}}=2\text{MHz}$ and PR was set to 001, how many TOFs will occur in one minute?
- EX: Write code to use timer for 0.5 msec delay at $f_{\text{clk}}=8\text{ MHz}$.

HCS12 Timer Systems

- Other timer functions
 - Input capture
Capture/store free running timer value when (counter) rising/falling (configurable) edge occurs on assigned pin (PortT)
 - Output compare
Generate output signal (high, low, pulse, periodic wave) to desired specifications.
 - Pulse Accumulator
Count pulse (clock cycles) on a specific input pin.

Timer & Interrupts

- Design HC12 system where timer overflow (TOF) creates highest priority interrupt possible.

Software:

Hardware:

Timer & Interrupts

- Connect a microcontroller to 64 addressable sensors with 1-bit output (Y/N). Software poll sensors. Generate interrupt if sensor output =1 longer than 1msec. Assume hardware timer can be set to overflow (TOF) at 1msec & TOF is an output pin.