Experiment 4: Hardware Timers

REVISION HISTORY			
NUMBER	DATE	DESCRIPTION	NAME
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Contents

1 Objectives

- Using hardware timers
- Using the LPC1769 manual to figure out how to use a given register
- Identifying how to access a given register by referring to the `LPC17xx.h` file

2 Parts List

- LPC1769 LPCXpresso board
- USB A-Type to Mini-B cable
- Breadboard
- LEDs
- 330-Ohm Resistors
- Jumper wires

3 Background

There are four hardware timers in LPC1769. They are identical and can work independently with different settings.

3.1 Peripheral Clock (PCLK)

Timers, among other devices, rely on *peripheral clocks* (`PCLK`), which in turn are derived from the *core clock* (`CCLK`).

There are four possible frequency configurations for the peripheral clock (`PCLK`), which are set using a pair of bits.

Table 1: Peripheral Clock (`PCLK`) Frequency Configurations

Bit Values	Frequency Configuration
`01`	`PCLK` = `CCLK`
`10`	`PCLK` = `CCLK` / 2
`00`	`PCLK` = `CCLK` / 4
`11`	`PCLK` = `CCLK` / 8

These pairs of bits belong to the `PCLKSEL0` and `PCLKSEL1` registers, which control the `PCLK` frequency for all peripherals.

The PCLKSEL0 and PCLKSEL1 Register Fields figure illustrates some of the fields of the `PCLKSEL0` and `PCLKSEL1` registers. Every two bits control the `PCLK` frequency for a specific peripheral.

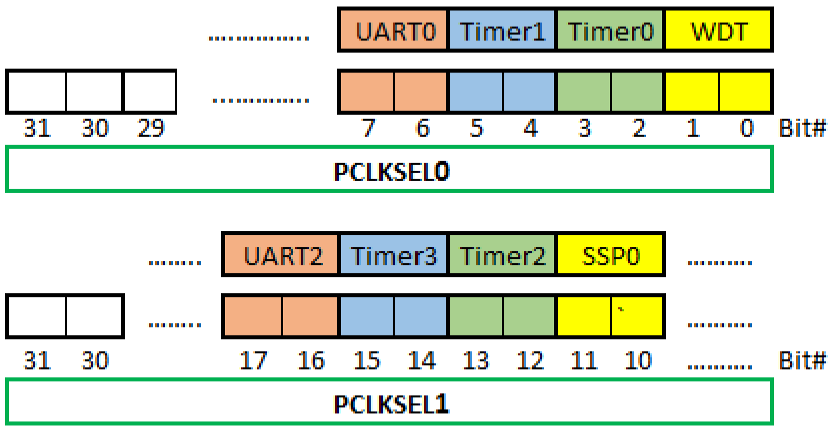


Figure 1: `PCLKSEL0` and `PCLKSEL1` Register Fields

Question
Can you ignore this step? What would happen if we skip it?

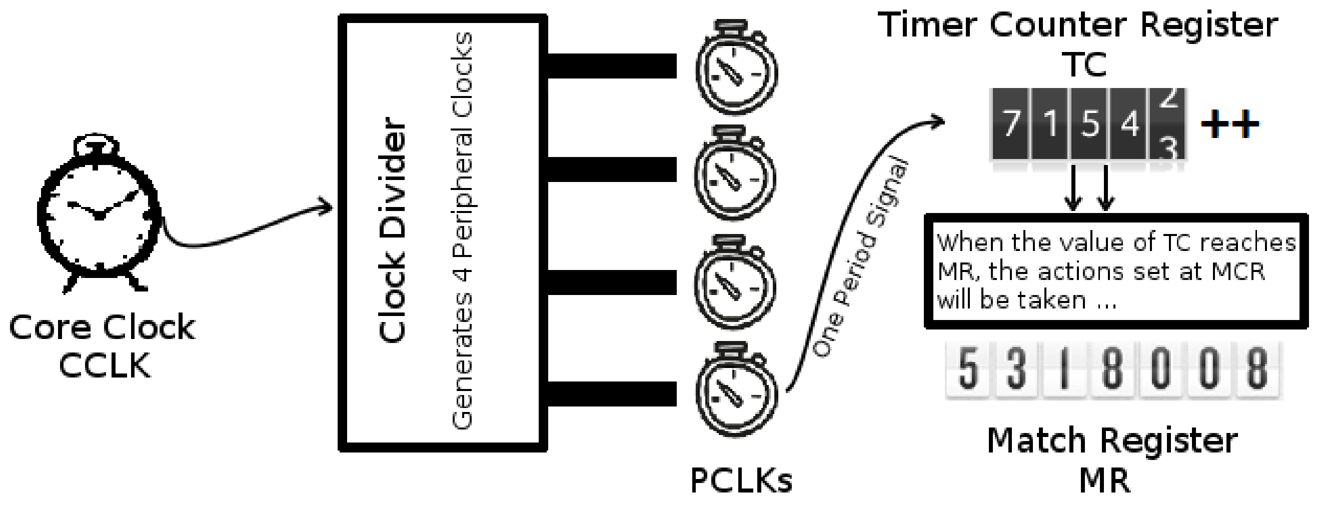
Note
For the full list of peripherals and their corresponding two bits in `PCLKSEL0` or `PCLKSEL1`, you can refer to Chapter 4 (section 4.7.3) in the LPC1769 manual.

Note
This section is not specific to timers. It is about configuring the frequency of `PCLK`, which is required for timers.

Note
You may want to refer back to this section whenever you want to use a peripheral that requires `PCLK`.

3.2 How Timers Work

By default, the *Timer Counter* (`TC`) register is incremented every `PCLK` cycle. When the value of `TC` reaches the value in *Match Register 0* (`MR0`), an action can be taken. Therefore, setting `MR0` specifies the timer's period.


Core Clock
CCLK
Clock Divider
Generates 4 Peripheral Clocks
PCLKs
One Period Signal
Timer Counter Register
TC
++
When the value of TC reaches MR, the actions set at MCR will be taken ...
Match Register
MR

The action to be taken every time `TC` reaches `MR0` can be set using the *Match Control Register* (`MCR`) to one (or more) of the following:

1. Generate an interrupt
2. Reset `TC`
3. Stop `TC`

You can enable or disable the above actions by setting or clearing the three least significant bits of the `MCR` register.

Table 2: Setting Timer Actions Using the `MCR` Register

`MCR` bit	**Bit value = 1**	**Bit value = 0**
0	Enable timer interrupt	Disable timer interrupt
1	Reset `TC`	Disable this feature
2	Stop `TC`	Disable this feature

3.3 Important Notes

- For `TC` registers to start counting, the least significant bit of the *Timer Control Register* (`TCR`) must be set. This bit is known as *Counter Enable*.
- If you choose to enable the timer interrupt, remember to enable the the NVIC and to clear the interrupt bit in the ISR. To clear the `MR0` interrupt flag, set the least significant bit in the *Interrupt Register* (`IR`).
- A common misconception is to assume that register `MR0` can be used with timer 0 only, register `MR1` with timer 1 only, and so on. Any of the `MRx` registers can be used with any of the four timers. Moreover, multiple `MRx` registers can be used with the same timer.
- As usual, all the registers in this experiment are fields of some structures. Refer to the `LPC17xx.h` header file to find the required name and field to access the required register.

Exercise

In this exercise, we will use a hardware timer and timer interrupts to blink an LED.

```
// "x" is a placeholder. Replace x with an appropriate value.

int main(void) {

    // Try to find out the IRQ number. Why is this step important?
    NVIC_EnableIRQ(x);
    // Answer:

    // What does register TCR do?
    LPC_TIMx->TCR |= x;
    // Answer:

    // What does register MRx do?
    LPC_TIMx->MRx = x;
    // Answer:

    // What does register MCR do?
    LPC_TIMx->MCR = x;
    // Answer:

    LPC_GPIOx->FIODIR = 1 << x ;

    // Can we remove this while loop? Why?
    while(1);
    // Answer:

    return 0 ;
}


// When will the following function be executed? Who is going to call it?
// Answer:

void TIMERx_IRQHandler() {

    LPC_GPIOx->FIOPIN ?? (1 << x);
    // Replace "??" with the appropriate operator

    // What does register IR do?
    LPC_TIMx->IR |= (1 << x);
    // Answer:
}
```

4 Tasks

Hello Mr. Engineer! We heard that you are a problem solver! We are a company that provides solutions to clients, and we need your help!

A client asked for a binary counter that counts from 0 to 15. He has requirements that we will need to meet! Here is his email:

Hi,

I want a binary counter that displays its value using LEDs. The counter should be incremented once every second. My counter should start when I push the start button, and should pause when I press it again.

I also want it to resume counting when the start button is pushed again.

Thanks,
Client

Help us satisfy this client's request. We know you can help!

Tip
You will only need 4 LEDs, and one button.

5 Resources

[lpc1769-manual]
NXP Semiconductors. *UM10360 LPC176x/5x User manual*. Rev. 3.1. 2 April 2014.
http://www.nxp.com/documents/user_manual/UM10360.pdf

6 Grading Sheet

Task	**Points**
Use hardware timers and timer interrupts	5
Identifying required register settings for alternative configurations	3
Discussion	2