ME 333 Homework 2

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January 18, 2022

Chapter 2 Exercises

3) **Describe the four functions that pin 12 of the PIC32MX795F512H can have. Is it 5 V tolerant?**

Pin 12 of the PIC32MX795F512H has the following functions:

a. AN4: Analog-to-digital input — allows for monitoring of analog voltage values (typically sensor inputs).

b. C1IN-: Comparator negative input – compares two analog input voltages and determines which is larger

c. CN6: Change notification — can generate an interrupt when input voltage changes from high to low, or vice versa.

d. RB4: Digital I/O — allows for reading or output of a digital voltage

It is not 5V tolerant.

4) **Referring to the Data Sheet section on I/O Ports, what is the name of the SFR you have to modify if you want to change pins on PORTC from output to input?**

SFR TRISC

5) **The SFR CM1CON controls comparator behavior. Referring to the Memory Organization section of the Data Sheet, what is the reset value of CM1CON in hexadecimal?**

0x00C3

6) **In one sentence each, without going into detail, explain the basic function of the following items shown in the PIC32 architecture block diagram Figure 2.2: SYSCLK, PBCLK, PORTA to PORTG (and indicate which of these can be used for analog input on the NU32's PIC32), Timer1 to Timer5, 10-bit ADC, PWM OC1-5, Data RAM, Program Flash Memory, and Prefetch Cache Module.**

a. SYSCLK: System clock; clocks CPU at maximum frequency of 80 MHz.

b. PBCLK: Peripheral bus clock; Frequency set to SYSCLK divided by 1, 2, 4, or 8. Setting lower than SYSCLK's saves power.

c. PORTA to PORTG: Registers that allow I/O pins to be accessed (bidirectional I/O ports) (PORTA is missing on PIC32MX795F512H); Only PORTB can be used for analog input on NU32's PIC32.

d. Timer1 to Timer5: Counts the number of pulses of a signal.

e. 10-bit ADC: Analog-to-digital converter that can monitor up to 16 analog voltage values via 16 different pins.

f. PWM OC1-5: Output compare pins generally used to generate PWM signals that can control motors or create analog voltage output.

g. Data RAM: Memory type that stores temporary data (128 KB).

h. Program Flash Memory: More plentiful source of memory but slower to read and write (512 KB).

i. Prefetch Cache Module: Stores recently executed program instructions, and can even run ahead of current instruction to prefetch future instructions.

7) **List the peripherals that are not clocked by PBCLK.**

- USB
- CAN1, CAN2
- Ethernet
- DMAC
- ICD

8) **If the ADC is measuring values between 0 and 3.3 V, what is the largest voltage difference that it may not be able to detect? (It's a 10-bit ADC.)**

$3.3V/2^{10} = 0.0032V$

9) **Refer to the Reference Manual chapter on the Prefetch Cache. What is the maximum size of a program loop, in bytes, that can be completely stored in the cache?**

256 bytes

10) **Explain why the path between flash memory and the prefetch cache module is 128 bits wide instead of 32, 64, or 256 bits.**

The prefetch cache module stores recently executed instructions to ultimately improve performance by allowing the CPU quicker access than with flash memory. Instructions are placed in a 16-byte wide prefetch cache buffer in preparation for execution. As such, each set of instructions occupies 128 bits of memory, which is why the path between flash memory and the prefetch cache module is 128 bits wide. This size of data path also provides the same bandwidth as a 32-bit path running at 4x frequency.

11) **Explain how a digital output could be confgured to swing between 0 and 4 V, even though the PIC32 is powered by 3.3 V.**

An output pin can be configured as **open drain**. This increases the range of voltages the pin can produce by allowing the pin's transistor to pull voltage down to 0V (sink current) or up to as high as 5.5V (turn off).

12) **PIC32's have increased their flash and RAM over the years. What is the maximum amount of flash memory a PIC32 can have before the current choice of base addresses in the physical memory map (for RAM, flash, peripherals, and boot flash) would have to be changed? What is the maximum amount of RAM? Give your answers in bytes in hexadecimal.**

- Flash Memory: 41.9 MB — 0x02800000
- RAM: 486.5 MB — 0x1D000000

13) **Examine the Special Features section of the Data Sheet.**

a. **If you want your PBCLK frequency to be half the frequency of SYSCLK, which bits of which Device Confguration Register do you have to modify? What values do you give those bits?**

- Bits 13-12 (FPBDIV<1:0>: Peripheral Bus Clock Divisor Default Value bits) of Register 28-2 (DEVCFG1)
- Set value to 01

b. **Which bit(s) of which SFR set the watchdog timer to be enabled? Which bit(s) set the postscale that determines the time interval during which the watchdog must be reset to prevent it from restarting the PIC32? What values would you give these bits to enable the watchdog and to set the time interval to be the maximum?**

- Watchdog timer: Bit 23 of the FWDTEN SFR (Register 28-2) sets the watchdog timer to be enabled
- Postscale: Bits 20-16 set the postscale that determines the time interval during which the watchdog must be reset to prevent it from restarting the PIC32
- Set Bit 23 to 1 to enable the watchdog and Bits 20-16 to 10100 or greater to set the time interval to be the maximum (since combinations not shown in the data sheet default to 10100).

c. **The SYSCLK for a PIC32 can be generated several ways, as discussed in the Oscillator chapter in the Reference Manual and the Oscillator Confguration section in the Data Sheet. The PIC32 on the NU32 uses the (external) primary oscillator in HS mode with the phase-locked loop (PLL) module. Which bits of which device confguration register enable the primary oscillator and turn on the PLL module?**

- Setting Bits 9-8 of Register 28-2 (DEVCFG1) to 10 will enable HS mode. Bits 2-0 of the same register set to 011 will enable the primary oscilaltor with the PLL module.

14) **Your NU32 board provides four power rails: GND, regulated 3.3 V, regulated 5 V, and the unregulated input voltage (e.g., 6 V). You plan to put a load from the 5 V output to ground. If the load is modeled as a resistor, what is the smallest resistance that would be safe? An approximate answer is fine. In a sentence, explain how you arrived at the answer**

16-17 Ω would be the smallest resistance I would deem safe. Anything lower could cause overheating, which would be best avoided. This range would allow for no more than about 300 mA draw from the NU32 — staying well below the 800 mA limit.

15) The NU32 could be powered by different voltages. Give a reasonable range of voltages that could be used, minimum to maximum, and explain the reason for the limits.

A reasonable voltage range to power the NU32 is 2.3 to 9 V. The NU32 requires at least 2.3 V, but also has a 5 V regulator to handle voltages above the ideal 2.3 to 3.6 V range. However, using a higher voltage than 9 V is not recommended, since the regulators will heat up.

16) Two buttons and two LEDs are interfaced to the PIC32 on the NU32. Which pins are they connected to? Give the actual pin numbers, 1-64, as well as the name of the pin function as it is used on the NU32. For example, pin 37 on the PIC32MX795F512H could have the function D+ (USB data line) or RG2 (Port G digital input/output), but only one of these functions could be active at a given time.

- LEDs: Pin 58 & 59 — RF0 (Digital I/O) and RF1 (Digital I/O), respectively
- Buttons: Pin 7 & 55 — $\overline{MCLR}$ (Master clear reset pin) and RD7 (Digital I/O), respectively