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Lab1 Question Answers

Link to video: http://youtu.be/NctobYGFz8c

1. What are the arguments for ALU instructions? How big (in bits) is the memory address space? What is the minimum size of memory that can be addressed? Would you describe the MSP430g2553 CPU a 8 bit or 16 bit?

1) Arguments for ALU are **word instructions**; they are **16 bits, or 1 word, or 2 bytes**.

2) The addressable memory space is 128 KB, and one memory address is one byte (8 bits). So the total memory space is 128 * 1024 * 8 = **1048576 bits**.
Note: I assume KB represents 1024B.

3) **1 byte**.

4) MSP430g2553 has a **16 bit RISC** architecture, so I would describe MSP430g2553 CPU as **16 bit**. (*From first page of datasheet*)

2. What is the difference between the “indexed” and “indirect register” addressing mode?

1) In the “indexed mode” (syntax X(Rn)), (Rn + X) points to the operant, and X is stored in the next word. Valid for source and destination. (*From section 3.3.2 of user guide*)
2) On the other hand, in “indirect register mode” (syntax @Rn), Rn is used as a pointer to the operant. Valid only for source operand. (*From section 3.3.5 of user guide*)

3. What is the largest (most memory bytes used) possible operation?

The largest possible operations take 3 lengths of instruction. The operations are shown below (from page 64 in datasheet)

source addressing mode	destination addressing mode	operation
#N	x(Rm)	MOV
#N	EDE	ADD
#N	&EDE	ADD
x(Rn)	TONI	MOV
x(Rn)	x(Rm)	ADD
x(Rn)	&TONI	MOV
EDE	TONI	CMP
EDE	x(Rm)	MOV
EDE	&TONI	MOV
&EDE	TONI	MOV
&EDE	x(Rm)	MOV
&EDE	&TONI	MOV

4. What is the longest (most clock cycles) possible operation?

The largest possible operations take 6 cycles. The operations are shown below (from page 64 in datasheet)

source addressing mode	destination addressing mode	operation
x(Rn)	TONI	MOV
x(Rn)	x(Rm)	ADD
x(Rn)	&TONI	MOV
EDE	TONI	CMP
EDE	x(Rm)	MOV
EDE	&TONI	MOV
&EDE	TONI	MOV
&EDE	x(Rm)	MOV
&EDE	&TONI	MOV

5. What is the maximum operating voltage for the MSP430g2553? What is the maximum operating frequency? What is the minimum operating voltage to run at 16MHz?

1) The recommended maximum operating voltage is 3.6V with absolute maximum voltage of 4.1V.
2) The maximum operating frequency depends partially on the supply voltage and duty cycle. When Vcc = 3.3V and duty cycle = 50% +/- 10%, the processor can reach its maximum operating frequency of 16MHz.
3) The minimum operating voltage to run at 16 MHz is 3.3V.

6. In the skeleton file, what is the frequency and period of the LED?

The clock is set to 1MHz, and the argument ins __**delay_cycle** is set to 500000, which is 0.5MHz. So the LED turns on for 0.5 second, and turns off for 0.5 second. The period is therefore **1 second**, and the frequency is **1Hz**.

MORE ACCURATE ANSWER: I have checked that while loop takes 2 clock cycles, and XOR operation takes 4 clock cycles. Additionally, I have checked that the argument to __**delay_cycle** is exactly the number of clock cycles delayed. Therefore, besides __**delay_cycle**, there are additional 6 clock cycles during one exception of while loop. Since we need loop that while loop another time to turn off the LED, there are total 12 additional clock cycles in blinking the LED. As a result, the accurate frequency is (1,000,000 + 12) / 1,000,000 = **1.000012 second**, and 1 / 1.000012 = **0.99998800014 Hz**.

7. If you want to slow down the flashing of the LED in the skeleton code, how could you do it?

You could increase the number in the __**delay_cycle** function to slow down the flashing of the LED. Another way to slow down LED would be to set clock source (DCO) to a slower frequency; in this case less than 1MHz would do.

1) If you want to keep the duration when the LED is turned on, and make the duration when the LED is turned off, you can increase the number in the second __**delay_cycle** function, after the LED is turned on (P1OUT ^= BIT0).
2) If you want to increase the duration when the LED is turned on as well as the duration when the LED is turned off, and keep the above two durations the same, you can increase the number in both __**delay_cycle** functions.

8. What is the forward voltage on the LED? What is the maximum forward current?

Note: the answer below comes from data sheet provided by adafruit.

Since I used red LED…

Forward voltage: 1.85 - 2.5 V
Maximum forward current: 30 mA
(Note: on the data sheet there are several currents: DC forward current is 30mA, and peak forward current is 155mA. I think DC forward current is the operating current, so I take this value as answer.)

9. What is the supply voltage coming out of the MSP430? On the MSP430G2553, what is the maximum current any other pin can output?

Outputs, Ports Px

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER		TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
V_{OH}	High-level output voltage	$I_{(OHmax)}$ = –6 mA (1)	3 V		V_{CC} – 0.3		V
V_{OL}	Low-level output voltage	$I_{(OLmax)}$ = 6 mA (1)	3 V		V_{SS} + 0.3		V

(1) The maximum total current, $I_{(OHmax)}$ and $I_{(OLmax)}$, for all outputs combined should not exceed ±48 mA to hold the maximum voltage drop specified.

The above figure is captured from the data sheet for MSP430g2553. Since we are using port 1, the voltage to drive the LED should be, from the formula above, Vcc - 0.3, which in this case is **3 - 0.3 = 2.7V**. (assume here Vcc is 3 V, which is the Vcc shown on the table above. I am aware that the maximum operating voltage is 3.6V, but I am not using 3.6V in the calculation. Should I use 3.6V as Vcc, the answer would have been 3.3V.)

Since for all outputs combined the current should not exceed 48mA, so the maximum current output on any other pin is **48mA**.

10. Using all this, what is the resistor value you should use to supply exactly this maximum current? To be safe when using the MSP430, should you use a larger or smaller resistor?

To be absolutely safe, take 3.6 as the operating voltage. The pin voltage output is then 3.6-0.3 = 3.3V. The maximum voltage for the LED is 2.5V, which means that to reduce the voltage to the safe voltage for the LED, a resistor should be connected in series to the LED, and it should bear 3.3-2.5 = 0.8V of voltage. The maximum current for the LED is 30mA. Therefore, the resistance is R = V/I = 0.8V/30mA = **26.67 ohm**. To be even safer, you should use a larger resistor. In the above calculation, I am taking the maximum operating voltage for the LED; if we are to use a smaller operating voltage, we would need a bigger resistor. For the same reason, if we are to use a smaller operating current for the LED, we would need a bigger resistor.