

# Introduction To Embedded System Design

## Assignment Solutions- Week 4

1. Which of the following is true about the MSP430 Microcontroller?
  - A. MSP430 MCU has a 20 bit Data Bus
  - B. MSP430 CPU has 8 16-bit registers.
  - C. MSP430 supports 2 Low Power Modes
  - D. Words are stored in memory in Little endian ordering**

Explanation: MSP430 MCU has a 16 bit data bus and its CPU has a set of 16 16-bit registers. Also, MSP430 supports 5 Low power Modes. So, A,B,C are false. And the memory ordering is Little Endian Ordering.

2. Which of the following is used to store the return addresses of the function calls?
  - A. Program Counter
  - B. Status Register
  - C. Stack Pointer**
  - D. Status Pointer

Explanation: The **program counter** contains the address of the next instruction to be executed. Status register is used to flag significant calculation results such as overflows and to control the operation of the processor. Whereas, The **stack pointer (R1)** points to the last value pushed (placed) on the **stack**.

3. Which of the following is not true about Flash information memory in MSP430G2553?
  - A. The information memory has 512-byte sized segments.**
  - B. The difference between the information memory and flash main memory is in the size of segments and the physical addresses.
  - C. The information memory stores calibration data of the Digitally Controlled Oscillator in one of its segments.
  - D. The information memory in MSP430G2553 occupies Address space from 0x1000 to 0x10FF of the Memory Map.

Explanation: The Information memory has four segments (A to D) and each segment has 64 bytes each. Rest all are true.

4. Which of the following bits of the status register allows the MSP430 to operate in the power saving modes, i.e. Low power modes?
  - A. CPUOFF, V, Z, N
  - B. CPUOFF, OSCOFF, SCG0, SCG1**
  - C. CPUOFF, SCG0, SCG1, GIE
  - D. CPUOFF, SCG0, SCG1, V

Explanation: Four bits SCG1, SCG0, OSCOFF, CPUOFF are used to switch MSP430 from active to LPM, The values of bits according to the mode are shown in the table below:

SCG1	SCG0	OSCOFF	CPUOFF	Mode	CPU and Clocks Status
0	0	0	0	Active	CPU is active, all enabled clocks are active
0	0	0	1	LPM0	CPU, MCLK are disabled, SMCLK, ACLK are active
0	1	0	1	LPM1	CPU, MCLK are disabled. DCO and DC generator are disabled if the DCO is not used for SMCLK. ACLK is active.
1	0	0	1	LPM2	CPU, MCLK, SMCLK, DCO are disabled. DC generator remains enabled. ACLK is active.
1	1	0	1	LPM3	CPU, MCLK, SMCLK, DCO are disabled. DC generator disabled. ACLK is active.
1	1	1	1	LPM4	CPU and all clocks disabled

5. `_BIC_SR_IRQ()` is used to
- Set the particular bits of the SR
  - Reset the particular bits of the SR**
  - Any of the above mentioned depending on the conditions
  - None of the above

Explanation: The function `__bic_sr_register_on_exit()` can be used to clear selected bits in SR if finer control is required. `_BIC_SR_IRQ()` is also the function which can be used to Clear the Bits of the Status Register. Whereas, `_BIS_SR_IRQ()` is used to set the particular bits of the SR.

6. Which of the following best explain why MSP430 is called an ultra low power MCU?
- The MSP430 CPU can be clocked with the help of an external crystal.
  - It can be powered by a lemon battery.
  - It is a 16 bit microcontroller which has a brownout detector.
  - It has been designed to easily operate in low power modes for most of the time and wake up very fast.**

Explanation: MSP430 is an ultra low power MCU because it has 5 Low Power Modes and ultra fast wake-up from Standby Mode (about 1 microsecond).

7. What is the output current range of any Digital I/O pin in MSP430G2553?:
- 15mA to +15mA
  - 10mA to +10mA
  - 6mA to +6mA**
  - 4mA to +4mA

Explanation: Refer to the data Sheet.

Outputs – Ports Px						
over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)						
PARAMETER	TEST CONDITIONS		V <sub>CC</sub>	MIN	TYP	MAX
V <sub>OH</sub> High-level output voltage	I <sub>OH(max)</sub> = -6 mA <sup>(1)</sup>		3 V	V <sub>CC</sub> - 0.3		V
V <sub>OL</sub> Low-level output voltage	I <sub>OL(max)</sub> = 6 mA <sup>(1)</sup>		3 V	V <sub>SS</sub> + 0.3		V

(1) The maximum total current, I<sub>OH(max)</sub> and I<sub>OL(max)</sub>, for all outputs combined should not exceed ±48 mA to hold the maximum voltage drop specified.

As per the table, it says 6mA current source or sink per pin or 48mA per port.

8. Typical operating voltage range of MSP430 is:

- A. 0-5V
- B. 5-7V
- C. 1.8-3.6V**
- D. 5-12V

Explanation: Refer to the data sheet.

**Recommended Operating Conditions**

Typical values are specified at  $V_{CC} = 3.3\text{ V}$  and  $T_A = 25^\circ\text{C}$  (unless otherwise noted)

		MIN	NOM	MAX	UNIT	
V <sub>CC</sub>	Supply voltage	During program execution		1.8	3.6	V
		During flash programming or erase		2.2	3.6	
V <sub>SS</sub>	Supply voltage	0			V	

9. MSP430G2553 is referred as a 16-bit microcontroller because:

- A. It has 16-bit address bus
- B. It has 16-bit data bus**
- C. It has maximum clock frequency of 16MHz
- D. All of the above

Explanation: When we say a microcontroller is N-bits microcontroller, it means that it can handle (access and operate on) an N-bit data at a time. It follows that the internal data bus, the ALU (arithmetic logic unit), internal registers and memory are all N-bit wide.

10. When the microcontroller MSP430G2553 receives RESET, then the CPU goes to which of the following memory locations?

- A. FFFE**
- B. C000
- C. FFC0
- D. 0000

Explanation: The Reset Vector for the MSP430 is located at 0xFFFFE and the CPU goes to 0xFFFFE whenever there is a Reset Condition.