كلية التقنية الالكترونية - طرابلس
College of Electronic Technology - Tripoli

القســـم : الإتصالات
لطلبة الفصل : الرابع

أسئلة الامتحان النهائي لمادة : أنظمة حاسب دقيقة
رمز المادة : CE223 التاريخ : 24 / 9 / 2019

الفصل الدراسي : ربيع 2019
إسم الطالب : ....
إسم الأستاذ: عبدالباسط عاشور
رقم القيد : ....
الزمن: ساعتان
المجموعة: ....

Important Notes:

- This paper contains **FIVE** questions in **THREE** pages.
- Attempt **ALL** questions.
- Enhance your answers with proper sketches whenever applicable.

Total Marks: **100**

Q.1 [20 Marks] Multiple Choice Questions (**MCQ**): **2 Marks each**

1. Moore's law states that the number of transistors in a chip will approximately double every

a. 1 month.
b. 24 weeks.
c. 2 years.
d. None of the above.

2. The default Vref of ATmega328 ADC used in Arduino Uno is

a. 1.1 V.
b. 3.3 V.
c. 5 V.
d. None of the above.

3. The bandwidth of ATmega328 is

a. 8-bit.
b. 32K Byte.
c. 1023 quantization levels.
d. 5 V.

4. STS instruction is used with ……………… addressing mode.

a. Direct.
b. Indirect.
c. Immediate.
d. None of the above.

5. …………… registers are used to control/configure of MCU or peripherals.

a. GPR.
b. SFR.
c. Data pointer registers.
d. None of the above.

6. The first packet in I2C transmitted data is called

a. Address packet.
b. Error check packet.
c. Idle packet.
d. LSB packet.

تمنياتي للجميع بالتوفيق
أستاذ المادة : عبدالباسط عاشور

Choose True or False and Provide a valid reason if false. **4 Marks each**

7. For ADC of a microcontroller, the terms resolution and accuracy have the same meaning.

a. True. ( ) **b. False. ( )**

Reason: The two statements are not the same although they are related.
Resolution is the number of ADC digital output bits (n) that determines the total **number of quantization levels** which is equal to 2^n. Whereas Accuracy is the maximum **value of conversion error** and is equal to $\pm 0.5*Vref/2^n$, where Vref is ADC reference voltage.

8. Both I2C and SPI can be configured in full-duplex transmission mode.

a. True. ( ) **b. False. ( )**

Reason: I2C has **one bi-directional data line**, so it can only be configured as half duplex.

Q.2 [**20 Marks**] Explain the purpose of the following: **5 Marks each**

a) Arduino function **pinMode(6, INPUT_PULLUP)**.

It configures pin 6 as a **Digital Input** and enables the internal **Pull-up Resistor**.

b) Signal Conditioning Circuit.

It is usually used to interface **input devices** with MCU for:

- Voltage level voltage: Examples include logic level, ADC voltage level, etc..
- Filtering: In some cases input signals must be filtered, for example to remove **noisy signal components**, to **select specific frequency** range, etc…
- MCU protection: To protect MCU input ports from **higher current and/or high voltage** signals, to **electrically isolate** MCU from the rest of the system, etc…

c) The SS/CS line of SPI transmission.
SS: Slave Select or sometimes known as CS: Chip Select is **used by master to select one particular slave** to communicate with.

d) H-Bridge.
It is a common motor **drive circuit** in discrete or integrated form. It is implemented using transistors configured as switches to control direction of current flow so it can be used to:

- Control **direction** of rotation of a DC motor.
- Control **speed** of rotation using PWM signals.
- Drive **high current** motors.

Q.3 [12 Marks] Write ATmega328 assembly instruction(s) for the following tasks:

a) **[5 Marks]** Read state of a push button connected to PB0.

```
; Initialize port B as INPUT
CLR R16        ;OR LDI R16,0
OUT DDRB, R16
; Enable Pull-up resistors for port B
SER R16        ;OR LDI R16,0xFF
OUT DDRB, R16
; Read input data
IN R17, PINB
```

b) **[2 Marks]** Enabling global interrupt.

```
; Enabling global interrupt
SIE
```

c) **[5 Marks]** Add the content of the first two register of SRAM.

```
; Using direct addressing mode
; Clear R16 & R17 to receive new data
CLR R16
CLR R16
; Load data from first RAM register
LDS R16, [0x0100]
; Load data from second RAM register
LDS R17, [0x0101]
; Add loaded data
ADD R16, R17
```

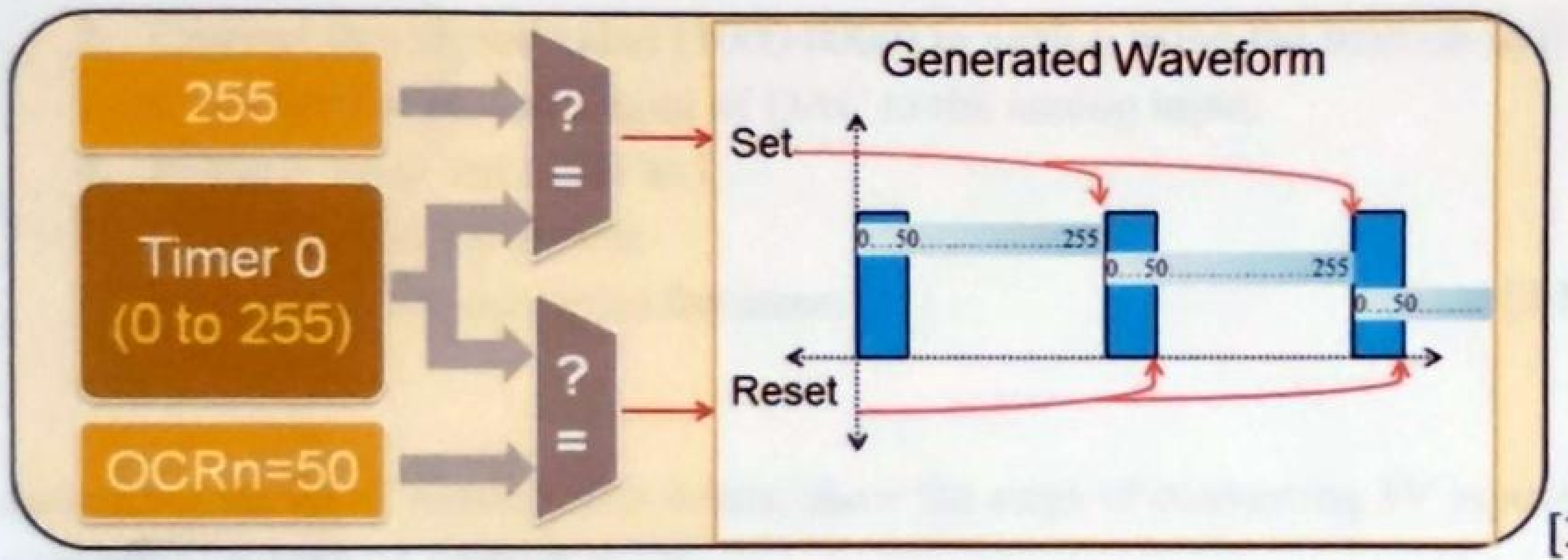
Q.4 [24 Marks] For ATmega328 explain the following in detail: **6 Marks each**

a) Explain in detail the process of generating PWM signals using timers.

ATmega328 has 3 timers that can be used to generate PWM signals. Each timer has two SFR registers known as Output Compare Registers (OCR) used for this purpose. These are **OCR0A, OCR0B, OCR1A, OCR1B, OCR2A and OCR2B**. **[2 Marks]**

To generate PWM using Timer2 for example, the corresponding OCR register is loaded with a value to determine the required duty cycle of PWM signal using the following relation: $\boldsymbol{Duty\ cycle} = \frac{\boldsymbol{OCR2A+1}}{\boldsymbol{256}} \times \mathbf{100}$

In this case, Timer2 (8-bit timer) will count from 0 to 255 and restart counting causing the output signal to be set (HIGH), while OCR will cause the signal to reset (LOW) every time the count reaches the value loaded in OCR. The figure below shows this process. **[2 Marks]**



[2 Marks]

b) Write assembly instructions to generate 40% duty PWM signal with Timer2.

Register name: OCR2A or **OCR2B** [**1 Mark**]

$\boldsymbol{Duty\ cycle} = \frac{\boldsymbol{OCR2A+1}}{\boldsymbol{256}} \times \mathbf{100}$ [**1 Mark**]

$\mathbf{40} = \frac{\boldsymbol{OCR2A=1}}{\mathbf{256}} \times \mathbf{100}$

$\frac{\mathbf{40 \times 256}}{\mathbf{100}} = \boldsymbol{OCR2A} = \mathbf{1}$

$\mathbf{102.4} = \boldsymbol{OCR2A} + \mathbf{1}$

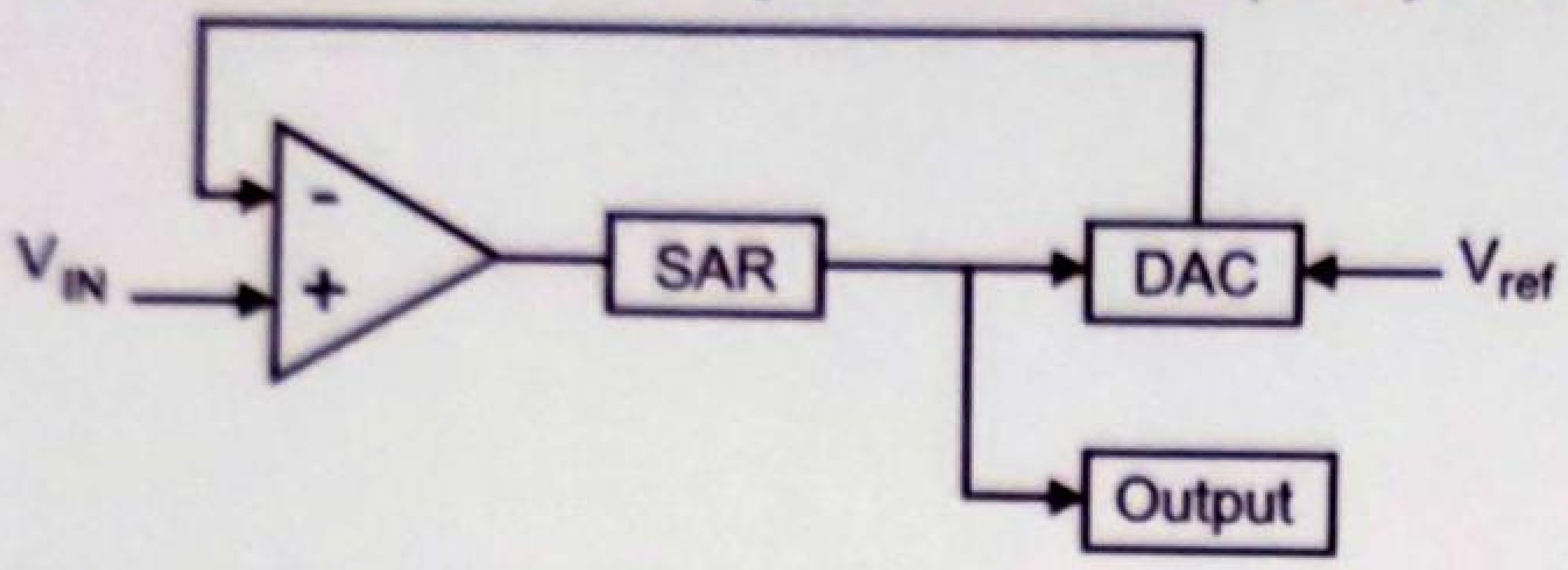
$\boldsymbol{OCR2A} = \mathbf{102.4 - 1 \cong 101}$ **[2 Marks]**

Assembly code: **[2 Marks]**

```
LDI R16, 101
OUT OCR2A, R16
```

c) How successive approximation ADC works?

Successive approximation ADC (SAR) uses DAC and comparator to convert analog signals to digital values with specified resolution (n-bits) as shown in the figure below.



[3 Marks]

SAR algorithm for 8-bit ADC:

1. Initialize MSB as 1 and keep remaining bits as zeros.
2. Convert this digital value (1000 0000) to analog using the built-in DAC.
3. Compare the analog output of DAC to the analog input.
4. If $V_{IN} > V_{DAC}$, set MSB to 1.
5. Otherwise set MSB to 0.
6. Go to next bit and repeat the steps. **[3 Marks]**

d) Assuming the ADC resolution is 4-bits, show the steps of converting 3V input into digital number, if reference voltage is 5V.

SAR steps to convert 3V analog input to 4-bit digital value if Vref=5V:

1. Initialize MSB as 1 and keep remaining bits as zeros (SAR=1000b). **[2 Marks]**
2. Convert this digital value (1000b) to analog using the built-in DAC.
   1000b = 8, since the max value for 4-bit is 16 the DAC output will be $V_{DAC} = 8/16 \times 5V = 2.5V$ **[2 Marks]**
3. Compare the analog output of DAC to the analog input.
4. If $V_{IN} > V_{DAC}$ (3V>2.5V) so MSB is set. The new digital value =1000b.
5. Next bit is set (1100).
   1100b = 12 then $V_{DAC} = 12/16 \times 5V = 3.75V$
6. $V_{IN} < V_{DAC}$ (3V<3.75V) so this bit is cleared. The new digital value = 1000b.
7. Next bit is set (1010).
   1010b = 10 then $V_{DAC} = 10/16 \times 5V = 3.125V$
8. $V_{IN} < V_{DAC}$ (3V<3.125V) so this bit is cleared. The new digital value = 1000b.
9. Next bit is set (1001).
   1001b = 9 then $V_{DAC} = 9/16 \times 5V = 2.8125V$
10. $V_{IN} > V_{DAC}$ (3V>2.8125V) so this bit is set. Since this is the last bit, then the digital value corresponding to 3V is 1001b. **[2 Marks]**