AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH (AIUB)
Faculty of Engineering
Department of Electrical and Electronic Engineering

Course/Lab Name: EEE4103 Microprocessor and Embedded Systems

Semester: Spring 2024-25 **Term**: Final **Quiz**: 01F **Total Marks**: 10 **Time**: 20 Minutes

Question Mapping with Course Outcomes:

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1-3	CO4	P.a.4.C.3	K4	P1, P3, P7		3×10	
					Total:	30	

Student Information:

Student Name:	Solve Sheet			**Section:**	**P**
Student ID #:	Solve Sheet	**Date:**	**21.05.2025**	**Department:**	

1. **Compute** the baud rate for the asynchronous double-speed operating mode when the oscillator frequency, f_{OSC} = 16 MHz, and register data is *UBRRn* = 010110101110. **Compute** the baud error and comment on whether there will be any communication errors. Standard Baud rates are 300, 600, 1200, 2400, 4800, 9600, 14400,19200, 38400, 57600, 115200, 230400, ... bps. **[10]**

   Answer:

   UBRRn = 010110101110 = $0\times2^{11}+1\times2^{10}+0\times2^{9}+1\times2^{8}+1\times2^{7}+0\times2^{6}+1\times2^{5}+0\times2^{4}+1\times2^{3}+1\times2^{2}+1\times2^{1}+0\times2^{0}$ = 1024+256+128+32+8+4+2 = 1454

   For the asynchronous double-speed operating mode, $Baud\ Rate = \frac{f_{osc}}{8(UBRRn+1)} = \frac{16\times10^6}{8(1454+1)} = 1375$ bps

   Baud Error Rate, $\varepsilon = \frac{Standard\ baud\ rate - calculated\ baud\ rate}{Standard\ baud\ rate} \times 100\% = \frac{1200-1375}{1200} \times 100\% = 14.6\%$

   This value is >> 2%, therefore, there will be communication errors.

2. For the following program, **show** the output on the serial monitor if the shutter remains open for 20 ms. **Determine** the baud rate and the pin number to which the camera shutter is connected. **[10]**

```
volatile boolean started;
volatile unsigned long startTime;
volatile unsigned long endTime;

void shutter() {      // interrupt service routine named shutter started
  if (started)
       endTime = micros();
  else
       startTime = micros();
started = !started; } // end of the ISR named shutter
void setup() {
  Serial.begin(230400);
  Serial.println("Shutter test ...");
  attachInterrupt(digitalPinToInterrupt(5), shutter, CHANGE);
}  // end of the setup

void loop() {
  if (endTime) {
    Serial.print("Shutter open for ");
    Serial.print(endTime - startTime);
    Serial.println(" microseconds.");
    endTime = 0;    }  // end of if statement
} // end of the loop
```

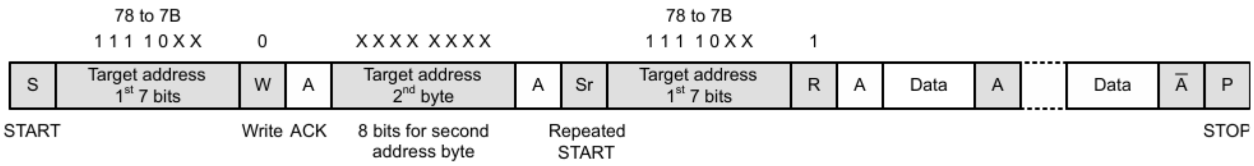
Answer:

Shutter test ...
Shutter open for 20000 microseconds.

From this command in the code, Serial.begin(230400);
We find the baud rate is 230400 bps

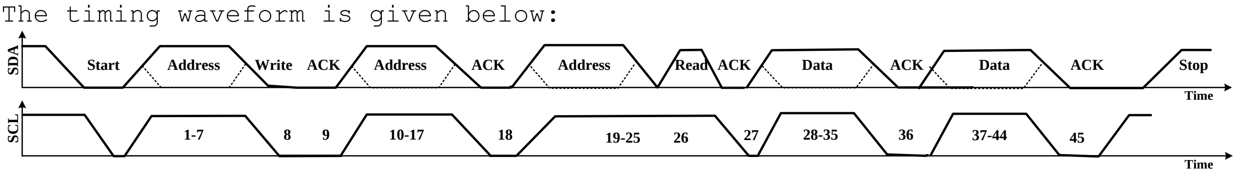
From the command in the code, attachInterrupt(digitalPinToInterrupt(5), shutter, CHANGE);
We find that the pin number is the digital pin 5.

3.	**Draw** the timing waveforms for the following data transfer structure using a 10-bit addressing I2C protocol. **Compute** the amount of data being transferred, data transfer rate, and frame rate. The operating frequency is 5 MHz.	[**10**]



Answer:

The timing waveform is given below:



The total amount of bits transferred = Target address bits + Read/Write bit + Acknowledgment bit + Target address bits + Acknowledgment bit + Target address bits + Read/Write bit + Acknowledgment bit + Data bit + Acknowledgment bit + Data bit + Acknowledgment bit = 7 + 1 + 1 + 8 + 1 + 7 + 1 + 1 + 8 + 1 + 8 + 1 = 45 bits

The operating frequency, f = 5 MHz. So, the clock period, $T = 1/f = 1/5\text{MHz} = 0.2\ \mu s$.

The total time for data transfer of 45 bits = 45×0.2 = 9 μs.

9 μs time is required to transfer 45 bits of data

∴ 1 μs time is required to transfer $\frac{45}{9}$ bits of data

∴ 1 s = 10^6 μs time is required to transfer $\frac{45\times10^6}{9}$ bits of data

That is, 5×10^6 bits of data are transferred per second, or 5 Mbps.

The total amount of bits transferred in one frame = Target address bits + Read/Write bit + Acknowledgment bit + Target address bits + Acknowledgment bit + Data bit + Acknowledgment bit = 7 + 1 + 1 + 8 + 1 + 8 + 1 = 27 bits

The total time for data transfer of 1 frame, i.e., 27 bits = 27×0.2 = 5.4 μs.

5.4 μs time is required to transfer 1 frame of data

∴ 1 μs time is required to transfer $\frac{1}{5.4}$ frame

∴ 1 s = 10^6 μs time is required to transfer $\frac{1\times10^6}{5.4}$ frame

That is, $\frac{10^6}{5.4} = 185185$ frames are transferred each second. Therefore, the frame rate is 185.185 kfps.