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International Institute of Information Technology, Hyderabad

Communication and Controls in IoT

Mid Sem

Max. Time: 60 min **Max. Marks: 20**

NO CALCULATORS ALLOWED

1.5

Q1. Write a pseudo-code for setting up an LED toggle every 1 sec. If a human presses a button connected to INT0 (say falling edge), the blinking should stop. The blinking should resume if the button is pressed again. [3 marks]

```
// INT0 is the 2nd external pin connected to the Button
// LED is connected to pin 5.

void setup{ int State = LOW;
            int pin = 5;   // Say, for an example
    attachInterrupt( digitalPinToInterrupt(2), ISR, FALLING);
    }
void loop{   State = ! state;          // Invert State. (toggle)
             digitalWrite( pin, State);
         }   delay (1000);             // (1 sec delay)
void ISR{
         digitalWrite( pin, LOW);      // ISR routine to follow.
        }
```

3

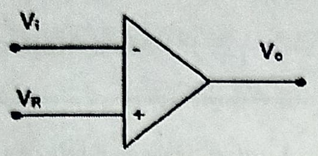
Q2. Name three parameters used for sensor selection. Explain them in 1-2 sentence. [3 marks]

The three parameters used for sensor selection is:

1. Range of the Sensor: The range of the sensor is the range of values that the sensor can detect accurately. Depending on the nature of the application, an appropriate sensor with the right range has to be chosen
2. Cost of the Sensor: A variety of sensors are available in the market, each with different qualities dependening on its cost. We have to rightly chose the sensor according to our budget constraints.
3. Availability of the Sensor: We have to make sure that we can acquire the desired sensor in a reasonable amount of time & that it is available readily without causing delays.

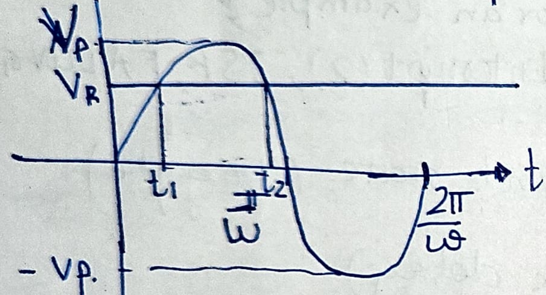
6

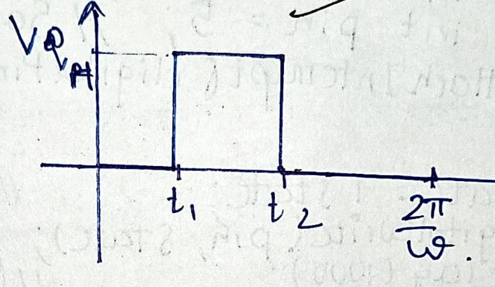
Q3. Suppose we use a comparator to create a PWM output, as shown in the figure. $V_i = V_p \sin wt$ is a sine wave. What is the duty cycle of the output PWM as a function of the voltage V_R? ($|V_R| < V_p$)



[6 marks]

· A comparator. outputs a HIGH (in this case say V_H) if the input voltage is higher than the reference voltage V_R, otherwise it outputs a LOW (0V) if it is lower. To find the duty cycle as a function of the voltage V_R, let us draw the one period of the input wave.





$\boxed{\forall\ V_R > 0}$

· The aim is to find the value of t_1 & t_2. Remember that, this method is ~~also valid for negative V_R values, so we shall use $|V_R|$ from now~~ for positive V_R only for now.

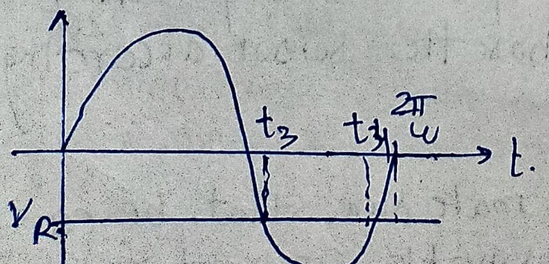
$|V_R| = V_p \sin(\omega t) \rightarrow \sin(\omega t) = \frac{|V_R|}{V_p} \Rightarrow \omega t = \sin^{-1}\left(\frac{|V_R|}{V_P}\right)$

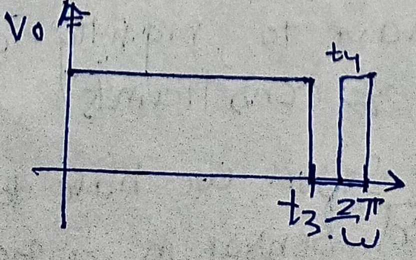
We thus have. $t_1 = \frac{1}{\omega}\sin^{-1}\left(\frac{|V_R|}{V_P}\right)$, $t_2 = \frac{1}{\omega}\left(\pi - \sin^{-1}\left(\frac{|V_R|}{V_P}\right)\right)$

∴ The Duty Cycle is given by $\rightarrow D.C = \frac{t_2 - t_1}{2\pi/\omega}$

$D.C = \frac{\frac{1}{\omega}\left(\pi - 2\sin^{-1}\left(\frac{V_R}{V_P}\right)\right)}{2\pi/\omega} = \boxed{\frac{1}{2\pi}\left(\pi - 2\sin^{-1}\left(\frac{V_R}{V_P}\right)\right) = D.C \quad (\text{if } V_R > 0)}$

If $V_R < 0$.





Again: $t_3 = \frac{1}{\omega}\left(\pi + \sin^{-1}\left(\frac{|V_R|}{V_R}\right)\right)$

~~& t_4 = 2π =~~

$t_4 = \frac{1}{\omega}\left(2\pi - \sin^{-1}\left(\frac{|V_R|}{V_R}\right)\right)$

$\rightarrow D.C = \frac{\frac{2\pi}{\omega} - (t_4 - t_3)}{\frac{2\pi}{\omega}}$.

P.T.O

$$D.C = \frac{\frac{2\pi}{\omega} - \frac{1}{\omega}\left(\pi - 2\sin^{-1}\left(\frac{|V_p|}{V_R}\right)\right)}{\frac{2\pi}{\omega}}$$

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$$= \frac{1}{2\pi}\left(\pi + 2\sin^{-1}\left(\frac{|V_p|}{V_R}\right)\right)$$

if $V_R < 0$

3

Q4. Explain the exponential backoff algorithm. What is the advantage of this algorithm compared to the backoff algorithm with a fixed maximum window size? What happens when a new user comes into a system with several users already in contention?

[3 marks]

Exponential backoff algorithm is a way to generate a random delay after which a node can send a message if collison occured previously. Say, for example. There are multiple users in contention. Say Node 'X' wants to send a message but has already seen 'N' collisons for the same. Then before sending the message again, the node will generate a random number M from the set $\{1, 2, \cdots, 2^N - 1\}$ and (in case of ethernet), wait for $t = M \times 512$ bit times before sending the next message. The advantage of this algorithm is that, compared to a fixed maximum window size for waiting, this algorithm is able to manage between High traffic & low traffic. If the node has seen less collisions, there's no point of it waiting for longer time to re-send. Similarly, if a node has seen a lot of collisions, it should not re-send in a fixed short window again as that will simply cause a collision again. Thus, a exponential backoff algorithm will ensure the communication with significantly less number of collisons (chance of collision).

Cont'd:- When a new user comes into a system, it doesn't see any delay & can immidiately send its data as it has not previously seen any collision so it need not wait. There is also a high chance of the new user's message going through without collision.

1

Q5. Explain the example of the Nest Learning Thermostat. What was the main takeaway from the example of the Nest Learning Thermostat, as discussed in the class?

[2 marks]

The nest learning thermostat is an IoT device developed by ex-Apple enginers and then acquired by Google; a company called as Nest. The company makes smart thermostat which has a lot of advance features compared to the tranditional thermostat that we generaly see. It hugely improves upon the quality of life of the user and also in other terms such as power or energy efficiency. The Nest Learning thermostat, as the name implies, learns of the patterns & behaviours of the user over time and then uses that data to train itself to automatically perform certain tasks in advance without the input of the user, that will improve their experience at home. For example the thermostat can learn when a user is likely to be outside, so that it can automatically adjust the temperature inside to save power. Similarly it can learn when the user returns to the home, and adjust the temperature in advance (P.T.O)

Q6. Consider Statistical Multiplexing used for packet switching. Assume that there are three users but only one transmission channel or slot. With the probability of a user being active being 0.1, what is the outage probability for this scenario? How many users can be accommodated in a circuit switch system for one slot, and what is the outage probability for the accommodated users?

[3 marks]

3

• Since the channel only has 1 slot it can ~~enter~~ entertaint only 1 user at a given time-frame. If more than one user is using the channel in this case, then it will cause an outage. The propability of outage is → (Pe). Let p = 0.1 be the probability of the user being active. The 1(1-p) is the probability of the user not being active. Then.

Ans = 1 − (Probability only 1 user is there + Probability no user is there)

$= 1 - (3p\cdot(1-p)^2 + (1-p)^3)$ (∵ There are three users)

$= 1 - ((1-p)^2(3p+1-p)) = 1 - (1-p)^2(2p+1)$

~~$= 1 - (1-p)^2 = (1-(1-p))(1+(1-p)) = p\cdot(2-p) = 0.1(2-0.1) = \boxed{0.19}$~~

~~Thus, the probability of outage is $\boxed{0.19}$~~

$= 1 - (0.9)^2(1.2) = 1 - 0.972 = \boxed{0.028}$ → Outage probability

• In a circuit-switch system designed for one slot, only 1 user can be accomodated as circuit switch system is reserved for one user & guarentees them the bandwidth, unlike packet-switched system. Thus, the outage probability for an accomodated user in packet-switch case is $\boxed{0}$ as the slot is reserved for them, and no one else can use it.

Q5) so that the user can have a pleasant experience. The main takeaway from this example discussed in the class is that connecting a traditional device to the internet & giving it access to data & computing power can greatly benefit the user experience & even the environment and other stake holders by running systems more efficiently.