Code -

G. S. Mandal's

Maharashtra Institute of Technology, Aurangabad

(An Autonomous Institute)

END SEMESTER EXAMINATION

Second Year B.Tech (ECE) –Feb/March 2023

Course Code :ECE201 **Course Name : Electronic Design Technology**

Duration : 2 Hrs **Max. Marks : 50** **Date :**

Instructions :

i) All questions are compulsory
ii) Assume suitable data wherever necessary and clearly state it
iii)Figures to right indicate full marks

Q. 1	**Solve/Answer the following questions**	
	Answer/Solution	Step wise Marking Scheme
a)	The ULN2003 is known for its high-current, high-voltage capacity. The drivers can be paralleled for even higher current output. Even further, stacking one chip on top of another, both electrically and physically, has been done. Generally it can also be used for interfacing with a stepper motor, where the motor requires high ratings which cannot be provided by other interfacing devices. Main specifications: • 500 mA rated collector current (single output) • 50 V output (there is a version that supports 100 V output) • Includes output flyback diodes	02

- Inputs compatible with TTL and 5-V CMOS logic

b) 02

Electromechanical relays	Solid-state relays
In these relays, electromechanical force is generated by the relay coil on the application of voltage. This force pulls the armature and closes the relay contacts	SSRs do not have electromagnet or any moving contacts in it. Instead, it consists of semiconductors and optocouplers within. When a voltage is applied to the input section of the SSR, current flows through the optocoupler and triggers the TRIAC at the output section, and the TRIAC starts conducting.
An **electromechanical relay** consists of the following parts: 1. Electromagnetic coil 2. Armature 3. Contacts	A **Solid-state relay** consists of the following sections: 1. Input circuit 2. Optocoupler 3. Output driver circuits 4. Semiconductor switching devices.
An electromechanical relay uses physical contacts for switching.	An **SSR** uses semiconductor devices such as TRIAC, Thyristors, MOSFETs and transistors.
Relay contacts gets eroded during prolonged switching.	SSRs do not have mechanical contacts.
Heat generated by these relay are little and can be neglected.	Semiconductors inside the SSR generated large amount of heat. Therefore heat sinks are required for heat dissipation.
These relays produces noise while switching.	No switching noise.
Fluctuations in coil voltage causes chattering of contacts in an electromagnetic relays.	No chattering due to the absence of mechanical contacts.
On-load switching of relay contacts can result in arc formation.	No arch formation.
The inductance of electromagnetic coil may cause voltage surges while switching.	No risk of voltage surges in solid-state relays.
Electromechanical relays has a life time of few million mechanical switching.	SSR lasts longer than electromechanical relays.

c) Output voltage range adjustable from 1.25 V to 37 V • Output current greater than 1.5 A • Internal short-circuit current limiting • Thermal overload protection • Output safe-area compensation — 02

d) 02

- Used for Positive voltage regulations
- Variable power supply
- Current limiting circuits
- Reverse polarity circuits
- Commonly used in Desktop PC, DVD and other consumer products
- Used in motor control circuits

e) 02

f) The proper flow of zero signal collector current and the maintenance of proper collectoremitter voltage during the passage of signal is known as **Transistor Biasing**. — 02

Types of Biasing:

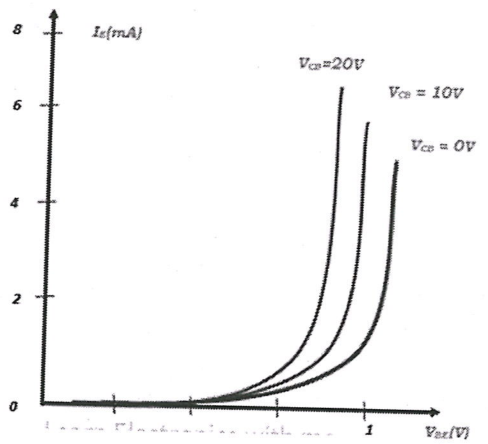
1) Fixed Bias
2) Base to collector Bias
3) Voltage divider bias

g) Capacitor sensors are easily available and are of very low cost. These sensors are highly used in mobile phones, iPods, automotive, small home appliances, etc... These are also used for measuring pressure, distance, etc... A drawback of these sensors is that they can give a false alarm. — 02

Resistive touch sensors only work when sufficient pressure is applied. Hence, these sensors are not useful for detecting small contact or pressure. These are used in applications such as musical instruments, keypads, touch-pads, etc.. where a large amount of pressure is applied

h) The alkaline method of wet PCB etching is used to etch the outer layers of a PCB. Here, the chemicals utilized are **chloride copper ($CuCl_2$, $2H_2O$) + hydrochloride (HCl) + hydrogen peroxide (H_2O_2) + water (H_2O)** composition. The alkaline method is a fast process and is a bit expensive as well — 02

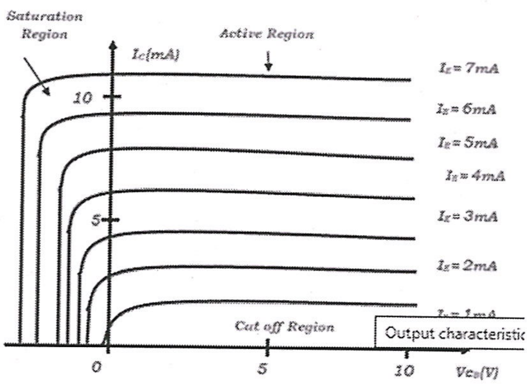
Q. 2 Input characteristics: — 08



Input characteristics are the relationship between the input current and input voltage with constant output voltage. In common base configuration input current is emitter current IE and the input voltage is base emitter voltage VBE. The curve is plotted between IE and VBE keeping VCB as constant.

The VBE is increased keeping VCB constant, initially at zero and the input current IE is noted, similarly the VCB value is increased and kept constant and VBE is increased and the input current IE is noted. Input side is forward biased so the input resistance is small so for a small increase in VBE there is rapid increase in the emitter current IE. As the output voltage VCB is increased the width of the depletion layer between emitter base decreases and the cut in voltage is reduced so the curve drifts to the left side.

Output characteristics:



Output characteristics are the relationship between output current IC and output voltage VCB keeping input current IE constant. When the input current IE is zero it is in cut off region. In saturation region both emitter base junction and collector base junction are forward biased.

In active region IE is gradually increased and kept constant and output voltage VCB is increased further and the output current IC almost remains constant. So in active region curve is almost flat. Output voltage causes only a very little change in output current.

OR

08

The Steps Required for Common-Emitter Transistor Amplifier Design

Let's examine the steps involved in designing a common-emitter transistor amplifier without emitter degeneration. In this transistor amplifier specification, some parameters such as bias voltage, collector current, input resistance, the input AC signal, load resistance, gain, and output voltage can be given according to how the amplifier is designed. Next, let's consider the given values: bias voltage V_{CC}, collector current I_C, input resistance R_{in}, and load resistance R_L.

Step 1: Determine R_C

To calculate the value of RC, we can use equation (1), below. The values of V_{CC} and I_C are known. For symmetrical output, the maximum possible value of voltage V_{CE} is $0.5V_{CC}$. So, by substituting these known values and rearranging the equation, we can obtain equation (2), allowing us to calculate R_C.

$$V_{CE} = V_{CC} - I_C R_C \quad (1)$$

$$R_C = \frac{V_{CC} - V_{CE}}{I_C} \quad (2)$$

Step 2: Determine the 'Q' Point

Once the values of V_{CE} and I_C are obtained, the Q point can be found from the output characteristics of the transistor. From the output characteristics of the transistor, find the base current curve on which the coordinate ($0.5V_{CC}$, I_C) lies. The base current required for this bias point is obtained.

Step 3: Determine R_E

The emitter resistor R_E is usually set as 10% of the resistor R_C:

$$R_E = 0.1 \times R_C \quad (3)$$

Step 4: Determine Emitter Voltage V_E

Using the I_B and I_C values, the emitter current I_E can be calculated with the following equation:

$$I_E = I_B + I_C \quad (4)$$

$$V_E = I_E \times R_E \quad (5)$$

Step 5: Determine Base Voltage V_B

$$V_B = V_E + V_{BE} \quad (6)$$

V_{BE} = 0.7 V for Si transistor
0.3 V for Ge transistor

Step 6: Determine R_{B1} and R_{B2}

The resistors RB1 and RB2 should be designed so that the base current IB flowing in the circuit corresponds to that of the Q-point base current. The Thevenin equivalent circuit of the voltage divider is formed by RB1 and RB2. VBB is the Thevenin equivalent voltage, RB is the Thevenin equivalent resistance, and Rib is the input resistance looking into the base of the transistor.

$$V_{BB} = \left(\frac{R_{B2}}{R_{B1} + R_{B2}}\right) V_{CC} \quad (7)$$

$$R_B = \frac{R_{B1} R_{B2}}{R_{B1} + R_{B2}} \quad (8)$$

Step 7: Calculate Thevenin Resistance R_B

The input resistance R_{in} can be written as equation (9). The resistance R_{ib} can be calculated using equation (10). From the known values of R_{in} and R_{ib}, the resistance R_B can be derived from equation (9).

$$R_{in} = \frac{R_B R_{ib}}{R_B + R_{ib}} \quad (9)$$

$$R_{ib} = (\beta + 1) R_E \quad (10)$$

The base voltage can be given as:

$$V_{BB} = I_B R_B + V_B \quad (11)$$

Step 8: Calculate R_{B1} and R_{B2}

From equations (7), (8), and (11), the resistors R_{B1} and R_{B2} can be calculated.

The bypass capacitor C_{E1} is selected so that it obeys equation (12), where X_{CE} is the reactance of the bypass capacitor C_{E1}:

$$X_{CE} \leq \frac{R_E}{10} \quad (12)$$

Step 9: Determine CC1 and CC2

The coupling capacitors can be calculated using the following equations:

$$CC_1 \leq \frac{R_{in}}{10} \quad (13)$$

$$CC_2 \leq \frac{R_L}{10} \quad (14)$$

The variants of common-emitter transistor amplifiers with or without degeneration can be employed to satisfy amplifier requirements in electronic applications. Basic common-emitter transistor amplifier design can be carried out by following steps 1 through 9, provided the values of V_{CC}, I_C, R_{in}, and R_L are known. Depending on the parameters given in amplifier specifications, various equations are derived from the amplifier circuit diagram, which supports the design of the amplifier components.

Q. 3

1) Selection of V_{cc} :

$V_p = \sqrt{2 P_o R_L}$

$= \sqrt{2 \times 4 \times 8}$

$= 8\,V$

$I_p = \sqrt{\frac{2P_o}{R_L}}$

$= \sqrt{\frac{8}{8}}$

$= 1\,A$

Select $V_{cc} \geq 2V_p$

$\geq 2 \times 8 \geq 16\,V$

$\therefore V_{cc} = 18\,V$

2) Selection of R_1 & C_1

$A_V = 1 + \frac{R_F}{R_1}$

Assume $R_F = 4\,k\Omega$

$100 = 1 + \frac{4 \times 10^3}{R_1}$

$\therefore R_1 = 43\,\Omega$

$F_L = \frac{1}{2\pi R_1 C_1}$

$\therefore C_1 = 200\,\mu f$.

3) Selection of R_b, C_b

Assume $R_b = 100\,\Omega$

$f_L = \frac{1}{2\pi R_b C_b}$

$\therefore C_b = 68\,\mu f$

4) Selection of C_{c1} & R_2

$R_2 = 100\,k\Omega$

$C_{c1} = \frac{1}{2\pi f_L \times 20} = 79.57\,nf$

$C_{c2} = \frac{1}{2\pi R_L f_L}$

$C_{c2} = 1000\,\mu f$.

5) $C_6 = 0.1\,\mu f$

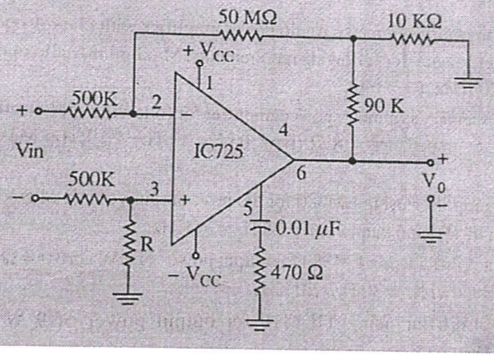
$C_7 = 1000\,\mu f$.

OR

The high gain associated with the op-amp is obtained only for a few cycles above dc before it begins to drop. The narrow bandwidth of the device makes it far from an ideal choice as an audio amplifier. However with the addition of feedback, gain is reduced and bandwidth is correspondingly increased. The feedback also reduces output impedance and signal distortion, improves its stability. The slew rate of op-omp also plays an important role in affecting the output waveshape to prevent distortion. The slew rate should be 1.5 to 2 times the highest rate of change of the output. Thus slew rate decides the highest frequency of the amplifier which can pass.

Another important characteristics or consideration for the selection of op-amp as audio power amplifier is its power output capability. The device must be able to supply at the rated voltage.

Figure (5.25) shows the connection diagram of IC725 as an audio power amplifier.



08

Q 4

current to the 8 Ω load.

Solution : Refer figure (3.15)

Using table (3.1), the quiescent current of 7805C regulator is 8 mA.

1. **Calculation of R_1 :**

Form figure, the maximum load current flowing through R_2 is,

$$I_2 = I_1 + I_Q$$

But $$I_1 = V_R / R_1$$

$$\therefore \quad R_1 = \frac{V_R}{(I_2 - I_Q)} = \frac{5V}{150\text{ mA} - 8\text{ mA}}$$

$$R_1 = 35.21\ \Omega \cong 36\ \Omega$$

2. **The output voltage :**

The maximum output voltage with respect to ground is,

$$V_0 = V_R + I_2 R_2$$

$$= 5 + 150\text{ mA} \times 8$$

$$V_0 = 6.2\text{ V}$$

3. **The minimum input voltage :**

$$V_{in} = V_0 + \text{Dropout voltage}$$

$$= 6.2\text{ V} + 2\text{V}$$

$$V_{in} = 8.2\text{ V}$$

(Use the input capacitor of 0.33 μF, if regulator is placed at longer distance from source)

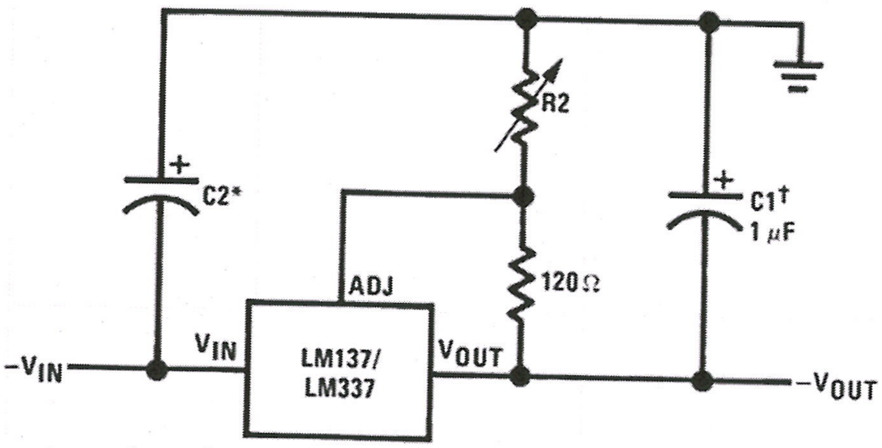
08

OR

LM337T (LM337) Variable Negative Voltage Regulator

LM337T (LM337) Variable Negative Voltage Regulator The LM137 and LM337-N are adjustable 3-terminal negative voltage regulators capable of supplying −1.5 A or more currents over an output voltage range of −1.25 V to −37 V. It requires only two external resistors to set the output voltage and one output capacitor for frequency compensation. The circuit design has been optimized for excellent regulation and low thermal transients. Further, the LM137 and LM337-N feature internal current limiting, thermal shutdown, and safe area compensation, making it virtually blowout-proof against overloads. The LM137 and LM337-N are ideal complements to the LM117 and LM317 adjustable positive regulators. The LM137 has a wider operating temperature range than the LM337-N and is also offered in military and space-qualified versions. The IC commonly used in Adjustable Lab Voltage generators in combination with the LM317 IC. It can also be used as Current Regulators and negative voltage protection circuits, refer to the datasheet linked below for application circuits. The IC has three pins, in which the input voltage is supplied to the VIN pin then using a pair of resistors (potential divider) we set a voltage at Adjust pin which will decide the output voltage of the IC that is given out at VOUT pin. Now to make it act as a variable voltage regulator we

have to set variable voltages which can be done by using a potentiometer in the potential divider (R2 shown below). The below circuit is shown for reference from the LM337 datasheet.



The output voltage thus obtained can be calculated using the below formulae

VOUT = – 1.25 × (1 + (R2/R1))

The actual formulae in the datasheet will also include Iadj (Current through the adjust pin), but for simplification purposes, we have assumed Iadj to be 50uA constant which will slightly differ in practical application. Also note that the output current of the IC will not be 1.5A always, if the difference voltage between the input and output voltage is high the output current will also decrease. Refer to the difference voltage vs Output Current graph from the datasheet for more information.

Features/Specs:

Output Voltage Range: −1.25V to −37V
Output Current: 1.5A
Line Regulation 0.01%/V (Typical)
Load Regulation 0.3% (Typical)
77-dB Ripple Rejection
50 ppm/°C Temperature Coefficient
Thermal Overload Protection
Internal Short-Circuit Current Limiting Protections
Package: To-220
Length: 15.1mm
Width: 10.16mm
Heigh: 4.45mm
Approx Weight: 4gm

Application:

Used for Positive voltage regulations
Variable power supply
Current limiting circuits
Reverse polarity circuits
Commonly used in Desktop PC, DVD and other consumer products
Used in motor control circuits
Industrial Power Supplies
Factory Automation Systems
Building Automation Systems
PLC Systems
Instrumentation
IGBT Drive Negative Gate Supplies
Networking
Set-Top Boxes

Q. 5 | 08

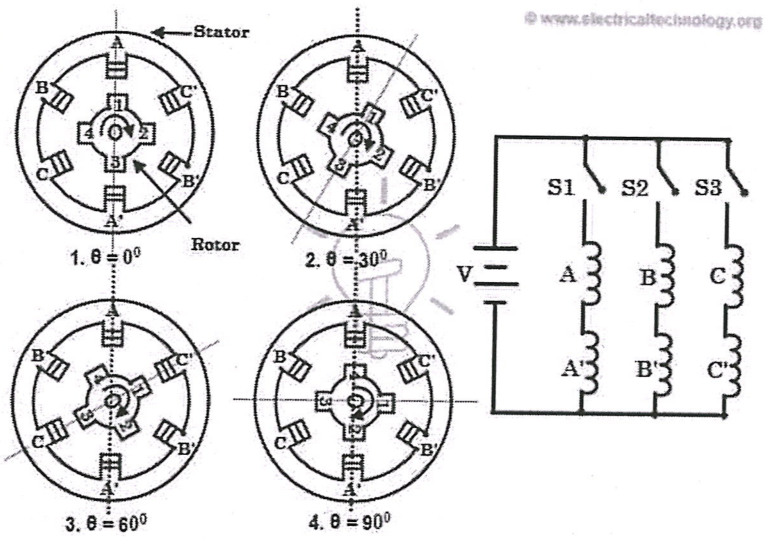
The *stepper motor works on the principle* that the rotor aligns in a particular position with the teeth of the excitation pole in a magnetic circuit wherein minimum reluctance path exist. Whenever power is applied to the motor and by exciting a particular winding, it produces its magnetic field and develops its own magnetic poles.

Due to the residual magnetism in the rotor magnet poles, it will cause the rotor to move in such a position so as to achieve minimum reluctance position and hence one set of poles of rotor aligns with the energized set of poles of the stator. At this position, the axis of the stator magnetic field matches with the axis passing through any two magnetic poles of the rotor.

When the rotor aligns with stator poles, it has enough magnetic force to hold the shaft from moving to the next position, either in clockwise or counter clockwise direction.

Consider the schematic diagram of a 3-phase, 6 stator poles and 4 rotor teeth is shown in figure below. When the phase A-A' is supplied with a DC supply by closing the switch -1, the winding become a magnet which results one tooth become North and other South. So the stator magnetic axis lies along these poles.

Due to the force of attraction, stator coil North Pole attracts nearest rotor tooth of opposite polarity, i.e., South and South Pole attract nearest rotor tooth of opposite polarity, i.e., North. The rotor then adjusts to its minimum reluctance position where the rotor magnetic axis exactly matches with stator magnetic axis.



Working of Variable Reluctance Stepper Motor

When the phase B-B' is energized by closing switch -2 keeping phase A-A' remain de-energized by opening switch-1, winding B-B' will produce the magnetic flux and hence the stator magnetic axis shifts along the poles thus formed by it. Hence the rotor shifts to the least reluctance with magnetized stator teeth and rotates through an angle of 30 degrees in the clockwise direction.

OR	A) Solid State Relay: Unlike electro-mechanical relays (EMR) which use coils, magnetic fields, springs and mechanical contacts to operate and switch a supply, the solid state relay, or SSR, has no moving parts but instead uses the electrical and optical properties of solid state semiconductors to perform its input to output isolation and switching functions. Just like a normal electro-mechanical relay, SSR's provide complete electrical isolation between their input and output contacts with its output acting like a conventional electrical switch in that it has very high, almost infinite resistance when nonconducting (open), and a very low resistance when conducting (closed). Solid state relays can be designed to switch both AC or DC currents by using an SCR, TRIAC, or switching transistor output instead of the usual mechanical normally-open (NO) contacts. While the solid state relay and electro-mechanical relay are fundamentally similar in that their low voltage input is electrically isolated from the output that switches and controls a load, electro-mechanical relays have a limited contact life cycle, can take up a lot of room and have slower switch speeds, especially large power relays and contactors. Solid state relays have no such limitations. b) BLDC Motor: A **brushless DC electric motor'**, ***also known as an*** *software/firmware programmed motor so elimatated the mechanical brush/commuter/switch* , is a synchronous motor using a switched power supply. It uses an programable chip controller to synthesis DC current waveforms and apply them to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows. The controller adjusts the phase and amplitude of the DC current pulses to control the speed and torque of the motor. This control system is an alternative to the mechanical commutator (brushes) used in many conventional electric motors. The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction (asynchronous) motor. They may also use neodymium magnets and be outrunners (the stator is surrounded by the rotor), inrunners (the rotor is surrounded by the stator), or axial (the rotor and stator are flat and parallel).[1] The advantages of a brushless motor over brushed motors are high power-to-weight ratio, high speed, nearly instantaneous control of speed (rpm) and torque, high efficiency, and low maintenance. Brushless motors find applications in such places as computer peripherals (disk drives, printers), hand-held power tools, and vehicles ranging from model aircraft to automobiles. In modern washing machines, brushless DC motors have allowed replacement of rubber belts and gearboxes by a direct-drive design	08
Q. 6	Types of Noise – 2 Marks Explanation – 6 Marks	08

OR	**The PCB Fabrication Process** PCB fabrication is the process or procedure that transforms a circuit board design into a physical structure based upon the specifications provided in the design package. This physical manifestation is achieved through the following actions or techniques: • Imaging desired layout on copper clad laminates • Etching or removing excess copper from inner layers to reveal traces and pads • Creating the PCB layer stackup by laminating (heating and pressing) board materials at high temperatures • Drilling holes for mounting holes, through hole pins and vias • Etching or removing excess copper from the surface layer(s) to reveal traces and pads • Plating pin holes and via holes • Adding protective coating to surface or solder masking • Silkscreen printing reference and polarity indicators, logos or other markings on the surface • Optionally, a finish may be added to copper areas of surface	

Course Coordinator