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DEPARTMENT OF EEE

EE2254- LINEAR INTEGRATED CIRCUITS AND APPLICATIONS

YEAR: II

SEM: IV

SUBJECTCODE: EE2254

SUBJECT NAME: LINEAR INTEGRATED CIRCUITS AND APPLICATIONS

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SYLLABUS

EE2254 LINEAR INTEGRATED CIRCUITS AND APPLICATIONS 3 0 0 3

1. IC FABRICATION 9

IC classification, fundamental of monolithic IC technology, epitaxial growth, masking and etching, diffusion of impurities. Realisation of monolithic ICs and packaging. Fabrication of diodes, capacitance, resistance and FETs.

2. CHARACTERISTICS OF OPAMP 9

Ideal OP-AMP characteristics, DC characteristics, AC characteristics, offset voltage and current:
voltage series feedback and shunt feedback amplifiers, differential amplifier; frequency response
of OP-AMP; Basic applications of op-amp – summer, differentiator and integrator.

3. APPLICATIONS OF OPAMP 9

Instrumentation amplifier, first and second order active filters, V/I & I/V converters, comparators, multivibrators, waveform generators, clippers, clampers, peak detector, S/H circuit,
D/A converter (R-2R ladder and weighted resistor types), A/D converter - Dual slope, successive
approximation and flash types.

4. SPECIAL ICs 9

555 Timer circuit – Functional block, characteristics & applications; 566-voltage controlled oscillator circuit; 565-phase lock loop circuit functioning and applications, Analog multiplier ICs.

5. APPLICATION ICs 9

IC voltage regulators - LM317, 723 regulators, switching regulator, MA 7840, LM 380 power amplifier, ICL 8038 function generator IC, isolation amplifiers, opto coupler, opto electronic ICs.

L = 45 Total = 45

TEXT BOOKS

1. Ramakant A.Gayakward, ‘Op-amps and Linear Integrated Circuits’, IV edition, Pearson Education, 2003 / PHI. (2000)
2. D.Roy Choudhary, Sheil B.Jani, ‘Linear Integrated Circuits’, II edition, New Age, 2003.

REFERENCE BOOKS

1. Jacob Millman, Christos C.Halkias, ‘Integrated Electronics - Analog and Digital circuits system’, Tata McGraw Hill, 2003.
2. Robert F.Coughlin, Fredrick F.Driscoll, ‘Op-amp and Linear ICs’, Pearson Education, 4th edition, 2002 / PHI.
3. David A.Bell, ‘Op-amp & Linear ICs’, Prentice Hall of India, 2nd edition, 1997

UNIT I

1. Define an Integrated circuit.

An integrated circuit(IC) is a miniature ,low cost electronic circuit consisting of active and passive components fabricated together on a single crystal of silicon.The active components are
transistors and diodes and passive components are resistors and capacitors.

2. What are the basic processes involved in fabricating ICs using planar technology?

1.Silicon wafer (substrate) preparation
2.Epitaxial growth
3.Oxidation
4.Photolithography
5.Diffusion
6.Ion implantation
7.Isolation technique
8.Metallization
9.Assembly processing & packaging

3. List out the steps used in the preparation of Si – wafers.

1.Crystal growth &doping
2.Ingot trimming & grinding
3.Ingot slicing
4.Wafer policing & etching
5.Wafer cleaning

4. Write the basic chemical reaction in the epitaxial growth process of pure silicon.

The basic chemical reaction in the epitaxial growth process of pure silicon is the hydrogen reduction of silicon tetrachloride.

$SiCl_4 + 2H_2 \rightarrow Si + 4\ HCl$

5. What are the two important properties of SiO2?

1. SiO2 is an extremely hard protective coating & is unaffected by almost all reagents except by hydrochloric acid. Thus it stands against any contamination.
2. By selective etching of SiO2, diffusion of impurities through carefully defined windows in the SiO2 can be accomplished to fabricate various components.

6. Explain the process of oxidation.

The silicon wafers are stacked up in a quartz boat & then inserted into quartz furnace tube. The
Si wafers are raised to a high temperature in the range of 950 to 1150^oC & at the same time, exposed to a gas containing O_2 or H_2O or both.The chemical action is

$Si + 2H_2O \rightarrow SiO_2 + 2H_2$

7. What is meant by molecular beam epitaxy(MBE)?

In the molecular beam epitaxy, ilicon along with dopants is evaporated.The evaporated species
are transported at a relatively high velocity in a vacuum to the substrate.The relatively low vapour pressure of silicon & the dopants ensures condensation on a low temperature substrate.Usually, silicon MBE is performed under ultra high vacuum (UHV) condition of 10-8
to 10-10 Torr.

8. What are the advantages of Molecular Beam Epitaxy(MBE)?

(i) It is a low temperature process, useful for VLSI. This minimizes out diffusion & auto doping.
(ii) It allows precise control of doping& permits complucated profiles to be generated.
(iii)Linear doping profile desirable for varactor diode in FM can be obtained with MBE.
(iv)Wider choice of dopants can be used.

9. What are oxidation induced defects in semi conductor?

1.Stacking faults
2.Oxide isolation defects

Stacking faults:

Structural defects in the silicon lattice is called oxidation induced stacking faults.The growth of stacking faults is a strong function of substrate orientation , conductivity type & defect nuclei present.The stacking faults formation can be suppressed by the addition of HCl.

Oxide isolation defects :

The stress along the edges of an oxidised area produce severe damage in the silicon. Such defects results in increased leakage in nearby devices.High temperatures (around 950^oC) will prevent stress induced defect formation.

10. What is bird's beak?

In local oxidation process, the oxidation of silicon proceeds slightly under the nitride as well. Also, a large mismatch in the thermal expansion co-efficients of Si_3N_4 & Silicon results in
damage to the semi conductor during local oxidation.This damage can be graetly reduced by
growing a thin layer of SiO_2 prior to placement of the Si_3N_4 mask.
Typically 100 to 200A^o is used for this puspose. Unfortunately, this greatly enhances the penetration of oxide under the nitride masked regions , resulting in oxide configurations called
bird's beak.

11. What is lithography?

Lithography is a process bywhich the pattern appearing on the mask is transfered to the wafer.It involves two steps: the first step requires applying a few drops of photoresist to the surface of the wafer & the second step is spinning the surface to get an even coating of the photoresist across the surface of the wafer.

12. What are the different types of lithography? What is optical lithography?

The different types of lithography are :
1. Photolithography 2.Electron beam lithography

3. X ray beam lithography 4.Ion beam lithography

Optical lithography:

Optical lithography comprises the formation images with visible or UV radiation in a photoresist using contact, proximity or projection printing.

13. What are the two processes involved in photolithography?

a) Making a photographic mask

b) Photo etching

The development of photographic mask involves the preparation of initial artwork and its reduction, decomposition of initial artwork or layout into several mask layers.

Photo etching is used for the removal of SiO_2 from desired regions so that the desired impurities

can be diffused.

14. What is meant by reactive plasma etching?

The term reactive plasma is meant to describe a discharge in which ionization & fragmentation of gases takes place& produce chemically active plasma species, frequently oxidizers and reducing agents. Such plasmas are reactive both in the gas phase & with solid surfaces exposed to them. When these interactions are used to form volatile products so that

material is removed or etching of material form surfaces that are not masked to form lithographic

patterns, the technique is known as reactive plasma etching.

15. What is isotropic & anisotropic etching processes?

Isotropic etching is a wet etching process which involves undercutting. Aisotropic etching is a dry etching process which provides straight walled patterns.

PART-B

1. With neat diagram explain the steps involved in the fabrication of the circuit shown in figure using IC technology. (16)
2. Explain in detail about monolithic IC technology. (16)
3. Write notes on (i) Epitaxial growth (ii) Masking & Etching Process (16)
4. Explain how a monolithic capacitor can be fabricated. (16)
5. Explain how a monolithic diode can be fabricated (16)

UNIT II

1. What are the advantages of ICs over discrete circuits?

1. Minimization & hence increased equipment density.
2. Cost reduction due to batch processing.
3. Increased system reliability
4. Improved functional performance.
5. Matched devices.
6. Increased operating speeds
7. Reduction in power consumption

2. What is OPAMP?

An operational amplifier is a direct coupled high gain amplifier consisting of one or more differential amplifiers, followed by a level translator and an output stage. It is a versatile device
that can be used to amplify ac as well as dc input signals & designed for computing mathematical functions such as addition, subtraction , multiplication, integration & differentiation.

3. List out the ideal characteristics of OPAMP?

(i)Open loop gain infinite (ii)Input impedance infinite
(iii)Output impedance low (iv)Bandwidth infinite
(v)Zero offset,ie,Vo=0 when $V_1=V_2=0$

4. What are the different kinds of packages of IC741?

a)Metal can (TO) package b)Dual-in-line package c)Flat package or flat pack

5. What are the assumptions made from ideal opamp characteristics?

i) The current drawn by either of the input terminals(non- inverting/inverting) is negligible.
ii) The potential difference between the inverting & non-inverting input terminals is zero.

6. Mention some of the linear applications of op – amps :

Adder, subtractor, voltage to current converter, current to voltage converters, instrumentation amplifier, analog computation, power amplifier, etc are some of the linear opamp
circuits.

7. Mention some of the non – linear applications of op-amps:-

Rectifier, peak detector, clipper, clamper, sample and hold circuit, log amplifier, anti-log amplifier, multiplier are some of the non-linear op-amp circuits.

8. What are the areas of application of non-linear op- amp circuits?

1. Industrial instrumentation 2. Communication 3.Signal processing

9. What happens when the common terminal of V+ and V- sources is not grounded?

If the common point of the two supplies is not grounded, twice the supply voltage will get applied and it may damage the op-amp.

10. Define input offset voltage.

A small voltage applied to the input terminals to make the output voltage as zero when the two input terminals are grounded is called input offset voltage.

11. Define input offset current. State the reasons for the offset currents at the input of the
op-amp.

The difference between the bias currents at the input terminals of the op-amp is called as input offset current. The input terminals conduct a small value of dc current to bias the input transistors. Since the input transistors cannot be made identical, there exists a difference in bias
currents.

12. Define CMRR of an op-amp.

The relative sensitivity of an op-amp to a difference signal as compared to a common – mode signal is called the common –mode rejection ratio. It is expressed in decibels.
CMRR= A_d/A_c

13. In practical op-amps, what is the effect of high frequency on its performance?

The open-loop gain of op-amp decreases at higher frequencies due to the presence of parasitic capacitance. The closed-loop gain increases at higher frequencies and leads to instability.

14. What is the need for frequency compensation in practical op-amps?

Frequency compensation is needed when large bandwidth and lower closed loop gain is desired. Compensating networks are used to control the phase shift and hence to improve the
stability.

15. Mention the frequency compensation methods.

*Dominant-pole compensation *Pole-zero compensation.

PART-B

1. Explain in detail of a basic differential amplifier. (16)
2. Draw the circuit diagram of op-amp differentiator, integrator and derive an expression for the output in terms of the input. (16)
3. Explain in detail about voltage series feedback amplifier. (16)
4. Derive the gain of inverting and non-inverting. (16)
5. Explain and derive the condition for DC-characteristics of an operational amplifier. (16)

UNIT III

1. What is the need for an instrumentation amplifier?

In a number of industrial and consumer applications, the measurement of physical quantities is
usually done with the help of transducers. The output of transducer has to be amplified So that
it can drive the indicator or display system. This function is performed by an instrumentation amplifier.

2. List the features of instrumentation amplifier:

- high gain accuracy
- high CMRR
- high gain stability with low temperature co-efficient
- low dc offset
- low output impedance

3. What is a comparator?

A comparator is a circuit which compares a signal voltage applied at one input of an opamp with a known reference voltage at the other input. It is an open loop op - amp with output
± Vsat .

4. What are the applications of comparator?

- Zero crossing detectors
- Window detector
- Time marker generator
- Phase detector

5. What is a Schmitt trigger?

Schmitt trigger is a regenerative comparator. It converts sinusoidal input into a square wave output. The output of Schmitt trigger swings between upper and lower threshold voltages,
which are the reference voltages of the input waveform.

6. What is a multivibrator?

Multivibrators are a group of regenerative circuits that are used extensively in timing applications. It is a wave shaping circuit which gives symmetric or asymmetric square output. It
has two states either stable or quasi- stable depending on the type of multivibrator.

7. What do you mean by monostable multivibrator?

Monostable multivibrator is one which generates a single pulse of specified duration in response to each external trigger signal. It has only one stable state. Application of a trigger causes a change to the quasi-stable state. An external trigger signal generated due to charging
and discharging of the capacitor produces the transition to the original stable state.

8. What is an astable multivibrator?

Astable multivibrator is a free running oscillator having two quasi-stable states. Thus, there are oscillations between these two states and no external signal is required to produce the
change in state.

9. What is a bistable multivibrator?

Bistable multivibrator is one that maintains a given output voltage level unless an external trigger is applied . Application of an external trigger signal causes a change of state, and this output level is maintained indefinitely until an second trigger is applied. Thus, it requires two external triggers before it returns to its initial state

10. What are the requirements for producing sustained oscillations in feedback circuits?

For sustained oscillations, The total phase shift around the loop must be zero at the desired frequency of oscillation,
f_o. ie, $\angle AB = 0$ (or) 360^o
 At f_o, the magnitude of the loop gain $|A\beta|$ should be equal to unity.

11. What are the different types of filters?

Based on functions: Low pass filter, High pass filter, Band pass filter, Band reject filter
Based on order of transfer function : first, second, third higher order filters.
Based on configuration: Bessel, Chebychev, Butterworth filters.

12. List the broad classification of ADCs.

1. Direct type ADC.
2. Integrating type ADC.

13. List out the direct type ADCs.

1. Flash (comparator) type converter
2. Counter type converter
3. Tracking or servo converter
4. Successive approximation type converter

14. List out some integrating type converters.

1. Charge balancing ADC
2. Dual slope ADC

15. What is integrating type converter?

An ADC converter that perform conversion in an indirect manner by first changing the analog I/P signal to a linear function of time or frequency and then to a digital code is known as
integrating type A/D converter.

PART-B

1. Explain the working of an instrumentation amplifier with a circuit. Give its characteristics and applications (16)
2. Explain the working of any one of sinusoidal oscillators. (16)
3. Explain the working of schmit trigger. (16)
4. Explain the R-2R ladder type DAC. (16)
5. Explain how a comparator can be used as a zero crossing detector. (16)
6. Draw the circuit of a first order and second order butter worth active low pass filter and derive its transfer functions. (16)

UNIT IV

1. What are the applications of 555 Timer?

- astable multivibrator
- monostable multivibrator
- Missing pulse detector
- Linear ramp generator
- Frequency divider
- Pulse width modulation
- FSK generator
- Pulse position modulator
- Schmitt trigger

2. List the applications of 555 timer in monostable mode of operation:.

- Missing pulse detector
- Linear ramp generator
- Frequency divider
- Pulse width modulation.

3. List the applications of 555 timer in Astable mode of operation:

*FSK generator
*Pulse-position modulator

4. Define 555 IC?

The 555 timer is an integrated circuit specifically designed to perform signal generation and timing functions.

5. List the basic blocks of IC 555 timer?

- A relaxation oscillator
- RS flip flop
- Two comparator
- Discharge transistor.

6. List the features of 555 Timer?

- It has two basic operating modes: monostable and astble

 It is available in three packages. 8 pin metal can , 8 pin dip, 14 pin dip.
 It has very high temperature stability.

7. Define duty cycle?

The ratio of high output and low output period is given by a mathematical parameter called duty cycle. It is defined as the ratio of ON Time to total time.

8. Define VCO.

A voltage controlled oscillator is an oscillator circuit in which the frequency of oscillations can be controlled by an externally applied voltage.

9. List the features of 566 VCO.

 Wide supply voltage range(10-24V)
 Very linear modulation characteristics
 High temperature stability

10. What does u mean by PLL?

A PLL is a basically a closed loop system designed to lock output frequency and phase to the frequency and phase of an input signal.

11. Define lock range.

When PLL is in lock, it can trap freq changes in the incoming signal. The range of frequencies over which the PLL can maintain lock with the incoming signal is called as lock range.

12. Define capture range.

The range of frequencies over which the PLL can acquire lock with the input signal is called as capture range.

13. Define pull-in time.

The total time taken by the PLL to establish lock is called pull-in time.

14. List the applications of 565 PLL.

 Frequency multiplier
 Frequency synthesizer
 FM detector

15. What are the two types of analog multiplier Ics?

a) IC AD 533
b) IC AD 534

PART-B

1. Explain the functional block diagram of 555timer. (16)
2. Explain working of PLL using suppropriate block diagram and explain any one application of the same. (16)
3. Draw the block diagram of an Astable multivibrator using 555timer and derive an expression for its frequency of oscillation. (16)
4. Draw the block diagram of monostable multivibrator using 555timer and derive an expression for its frequency of oscillation. (16)
5. write short notes on i) capture range ii) Lock in range iii) Pull in time (16)

UNIT V

1. What is a voltage regulator?

A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature, and ac line voltage variations.

2. Give the classification of voltage regulators:

*Series / Linear regulators
*Switching regulators.

3. What is a linear voltage regulator?

Series or linear regulator uses a power transistor connected in series between the unregulated dc input and the load and it conducts in the linear region .The output voltage is controlled by the continous voltage drop taking place across the series pass transistor.

4. What is a switching regulator?

Switching regulators are those which operate the power transistor as a high frequency on/off switch, so that the power transistor does not conduct current continously.This give improved efficiency over series regulators.

5. What are the advantages of IC voltage regulators?

- low cost,
- high reliability,
- reduction in size and excellent performance

6. Give some examples of monolithic IC voltage regulators:

- 78XX series fixed output, positive voltage regulators
- 79XX series fixed output, negative voltage regulators
- 723 general purpose regulator.

7. What is the purpose of having input and output capacitors in three terminal IC regulators?

A capacitor connected between the input terminal and ground cancels the inductive effects due to long distribution leads. The output capacitor improves the transient response.

8. Define line regulation.

Line regulation is defined as the percentage change in the output voltage for a change in the input voltage.It is expressed in millivolts or as a percentage of the output voltage.

9. Define load regulation.

Load regulation is defined as the change in output voltage for a change in load current. It is expressed in mill volts or as a percentage of the output voltage.

10. What is meant by current limiting?

Current limiting refers to the ability of a regulator to prevent the load current from increasing above a preset value.

11. Give the drawbacks of linear regulators:

The input step down transformer is bulky and expensive because of low line frequency. Because of low line frequency, large values of filter capacitors are required to decrease the ripple. Efficiency is reduced due to the continuous power dissipation by the transistor as it operates in the linear region.

12. What is the advantage of switching regulators?

Greater efficiency is achieved as the power transistor is made to operate as low impedance switch. Power transmitted across the transistor is in discrete pulses rather than as a
steady current flow. By using suitable switching loss reduction technique, the switching frequency can be increased so as to reduce the size and weight of the inductors and capacitors.

13. What is an opto-coupler IC?

Opto-coupler IC is a combined package of a photo-emitting device and a photo-sensing device.

14. What are the types of opto couplers?

- LED and a photo diode,
- LED and photo transistor,
- LED and Darlington.

15. Give two examples of IC optocouplers?

Examples for opto-coupler IC

- MCT 2F
- MCT 2E .

PART-B

1. Explain i) Oscillation amplifier. ii) Voltage regulator (16)
2. Draw and explain the functional block diagram of a 723 regulator. (16)
3. Draw the block diagram of the function generator in IC 8038 (or) any other equivalent and explain its operation. (16)
4. Write an explanatory note on opto-couplers. (16)
5. Explain in detail about the 380 power amplifier. (16)