SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF

ELECTRONICS AND INSTRUMENTATION ENGINEERING

QUESTION BANK

I SEMESTER

1913101-TRANSDUCERS AND SMART INSTRUMENTS

Regulation – 2019

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DEPARTMENT OF EIE

QUESTION BANK

SUBJECT : IN 5151-TRANSDUCERS AND SMART INSTRUMENTS

SEM / YEAR: I / I

UNIT I - OVERVIEW OF CONVENTIONAL TRANSDUCER AND THEIR CHARACTERISITICS			
Overview of conventional sensors - Resistive, Capacitive, Inductive, Piezoelectric, Magnetostrictive and Hall effect sensors - Static and Dynamic Characteristics and specifications.			
PART –A			
Q.No	**Questions**	**BT Level**	**Competence**
1.	List the applications of a capacitive transducer.	1	Remembering
2.	State the principle of Magnetostrictive transducer.	1	Remembering
3.	Classify various proximity sensors.	2	Understanding
4.	Define the dynamic characteristics of the instruments.	1	Remembering
5.	Classify the mechanical structures used for measurement of displacement, force, pressure, fluid level and velocity.	4	Analyzing
6.	Write the expression of the gauge factor of strain gauge.	6	Creating
7.	Explain Static Characteristics of an Instrument.	2	Remembering
8.	Differentiate Analog transducer and digital transducer.	3	Applying
9.	Define gauge factor of a strain gauge.	1	Remembering
10.	A transducer is subjected to a sudden change in input. It takes 10 seconds for the transducer to reach equilibrium condition. Find the time constant of the transducer.	5	Evaluating
11.	Explain with an example, the term Hysteresis.	6	Creating
12.	The dead zone in an instrument is 0.125% of the span. The instrument is calibrated from $800^{o}C$ to $1800^{o}C$. What temperature change must occur before it is detected?	2	Understanding
13.	Point out the factors of static characteristics in Resistive type Transducers.	4	Analyzing
14.	Define Hall Effect.	1	Remembering
15.	What is meant by strain –gauge?	1	Remembering
16.	Describe the Factors of Dynamic Characteristics in an Instrument.	2	Understanding
17.	Summarize the basic concept of Magneto-strictive effects.	5	Evaluating

18.	Point out the applications of Inductive Proximity Sensor.	**4**	**Analyzing**
19.	Sketch the circuit of LVDT.	**3**	**Applying**
20.	Define Poisson's ratio.	**1**	**Remebering**
	PART – B		
1.	**(i)** Explain with a neat diagram the structure and operating principle of Strain-guage. **(7)** **(ii)** Explain with a neat diagram the structure of proximity and magnetostrictive elements. **(6)**	**2**	**Understanding**
2.	**(i)** Explain with a neat diagram the principle of working of capacitive transducers for pressure measurement. **(7)** **(ii)** Describe the temperature instabilities of resistive, inductive and capacitive elements. **(6)**	**2**	**Understanding**
3.	With a neat sketch, explain the different types of strain gauges. Also derive an expression for gauge factor.	**6**	**Creating**
4.	Explain working principle of any three different types of capacitive transducers.	**4**	**Analyzing**
5.	**(i)** Describe in detail about the method used for measurement of liquid level by variation of dielectric constant. **(7)** **(ii)** Discuss in detail the methods used for rotational displacement in capacitive Transducer. **(6)**	**1**	**Remembering**
6.	**(i)** Explain any one differential displacement element with a typical application. **(7)** **(ii)** Discuss with the signal conditioning circuit for temperature compensation of strain gauge. **(6)**	**2**	**Understanding**
7.	Develop the structure of capacitive elements and explain its operation with its equivalent circuits and characteristics.	**2**	**Understanding**
8.	Describe in detail about the single, differential and angle displacement elements of capacitive transducers.	**1**	**Remembering**
9.	Construct the potentiometric element with relevant circuit diagrams and explain its operation.	**3**	**Applying**
10.	Mention the advantages and disadvantages of potentiometric element. Also explain its characteristics.	**4**	**Analyzing**
11.	Explain with neat diagram the operation of Hall Effect sensors.	**4**	**Analyzing**
12.	Describe the working principle and operation of Piezoelectric Sensors.	**1**	**Remebering**

13.	Write Short notes on **(i)** Mean, Standard Deviation, Linearity and tolerance of an Instrument **(7)** **(ii)** Static Error, Static Sensitivity and Repeatability **(6)**	**5**	**Evaluating**
14.	Describe in detail about the capacitive Sensor which is used as a displacement Sensor.	**1**	**Remembering**
	PART C		
1.	Design the various types of inductive elements with structural diagram	**4**	**Analyzing**
2.	**(i)** A strain gauge is bonded to a beam of 0.1m long and has a cross sectional area of 4 cm^2. Young's modulus for steel is 20.7 GN/m^2. The Strain gauge has a unstamped resistance of 240 ohms and a gauge factor of 2.2. When a load is applied the resistance of gauge changes by 0.013 ohms. Calculate the change in length of the steel beam and amount of force applied to the beam. **(7)** **(ii)** Analyze the working of displacement to phase Converters **(8)**	**6**	**Creating**
3.	Analyze the dynamic Characteristics of an Instrument and derive the expressions for different signal inputs.	**4**	**Analyze**
4.	A variable resistance potentiometer having a resistance of 12 Kilo Ohm is connected to a DC voltage source of 60 V .The voltage output of the transducer is measured by means of a voltmeter of internal impedance of 120 kilo Ohm Determine the impedance loading error at 25% position on the transducer and the actual voltage reading observed at this position.	**6**	**Creating**

UNIT II-MEASUREMENT ERROR AND UNCERTAINITY ANALYSIS

Importance of error analysis - Uncertainties, precision and accuracy in measurement – limiting error and probable error - Random errors - Distributions, mean, width and standard error - Uncertainty as probability - Gaussian and Poisson probability distribution functions, confidence limits, error bars, and central limit theorem - Error propagation - single and multi-variable functions, propagating error in functions

PART –A

Q.No	Questions	BT Level	Competence
1.	State the importance of error analysis.	**1**	**Remembering**

2.	Define Rydberg Constant.	**1**	**Remembering**
3.	How do we Interpret an uncertainty in an instrument.	**1**	**Remembering**
4.	Mention the impact of random errors in an instrument.	**4**	**Analyzing**
5.	Define systematic errors.	**4**	**Analyzing**
6.	Write an expression for Gaussian Probability Distribution Function.	**1**	**Remembering**
7.	Discuss about Normal Distribution.	**6**	**Creating**
8.	What is meant by Precision?	**1**	**Remembering**
9.	Point out the importance of accuracy in an instrument.	**2**	**Understanding**
10.	Write the expression for standard deviation.	**1**	**Remembering**
11.	Explain about standard error?	**2**	**Understanding**
12.	Discuss about bias of an instrument.	**6**	**Creating**
13.	What is meant by Error Bars?	**2**	**Understanding**
14.	Write the expression for Central Limit theorem.	**1**	**Remembering**
15.	List the merits of Good Precision and Good Accuracy Instruments	**1**	**Remembering**
16.	Illustrate some of the examples of Central Limit Theorem.	**4**	**Analyzing**
17.	Write the expression for Poisson Probability Distribution Functions.	**4**	**Analyzing**
18.	Define Confidence Limits.	**1**	**Remembering**
19.	Explain about Standard distribution.	**2**	**Understanding**
20.	How to propagate errors in functions.	**1**	**Remembering**
	PART – B		
1.	Write short notes on the following **(i)** Random Errors **(7)** **(ii)** Systematic Errors **(6)**	**1**	**Remembering**
2.	Discuss in detail about Gaussian Probability Distribution Functions	**6**	**Creating**
3.	A box contains 100 ohm resistors which are known to have a standard deviation of 2ohm. What is the probability of finding a resistor in the range of 99-101 ohm?	**6**	**Creating**
4.	Discuss in detail about Poisson Probability Distribution Functions.	**6**	**Creating**
5.	State Central Limit theorem and explain with an example.	**1**	**Remembering**
6.	How to propagate the error in a single variable function. Explain?	**1**	**Remembering**

7.	Explain about multi variable function and also explain how to propagate the errors through them.	**2**	**Understanding**
8.	Discuss about the types of error based on the discussion of precision and accuracy.	**6**	**Creating**
9.	Explain about precision of Instruments in analog and digital instruments.	**2**	**Understanding**
10.	Explain in detail about Normal Distributions and Continuous Distributions.	**2**	**Creating**
11.	How to analyze distributions (i) The Mean **(3)** (ii) The Width of the Distribution **(5)** (iii) Standard Error **(5)**	**1**	**Remembering**
12.	**(i)** A 0-150 V voltmeter bas a guaranteed accuracy. of 1 percent of full scale reading. The voltage measured by this instrument is 75 V. Calculate the limiting error in percent. Comment upon the result. **(7)** **(ii)** A resistance is determined by voltmeter ammeter method. The voltmeter reads 100 V with a probable error of ±12 V and ammeter reads 10 A with a probable error of ±2 A. Determine the probable error in the computed value of resistance. **(6)**	**5**	**Evaluating**
13.	**(i)**Explain in detail about the importance of error Analysis. **(7)** **(ii)** Explain in detail about the types of errors. **(6)**	**4**	**Analyzing**
14.	Discuss about functional approach for multi variable functions.	**3**	**Applying**
	PART C		
1.	In a test temperature is measured 100 times with variations in apparatus and procedures After applying the corrections, the results are: Temperature: 397, 398, 399, 400, 401, 402, 403, 404, 405 Frequencyof occcurence: 1, 3, 12, 23, 37, 16, 4, 2, 2 Calculate arithmetic mean, mean deviation, standard deviation and the probable error of the mean.	**4**	**Analyzing**

2.	12 measurements of the sensitivity of a photodiode circuit (in amps/watt) are: 5.33, 4.95, 4.93, 5.08, 4.95, 4.96, 5.02, 4.99, 5.24, 5.25, 5.23 and 5.01. Calculate (i) the mean, (ii) the standard deviation (iii) the standard error.	**6**	**Creating**
3.	An experiment was conducted to determine the concentration of a sodium hydroxide solution. The eight repeat measurements of the volume of hydrochloric acid titrated (all in ml) are: 25.8, 26.2, 26.0, 26.5, 25.8, 26.1, 25.8 and 26.3. Calculate (i) the mean, (ii) the Average deviation (iii)the Standard deviation (iv) The standard error of the volume.	**5**	**Evaluating**
4.	Discuss some of the examples of central limit theorem.	**6**	**Creating**

UNIT III - SMART SENSORS

Definition – Integrated smart sensors –sensing elements –design of Interface electronics - parasitic effects – sensor linearization - Dynamic range - Universal Sensor Interface - front end circuits - DAQ – Design – Digital conversion - Microcontrollers and digital signal processors for smart sensors – selection criteria - Timer, Analog comparator, ADC and DAC modules - Standards for smart sensor interface.

PART – A

Q.No	Questions	BT Level	Competence
1.	Distinguish between temperature and sensitivity drifts.	**2**	**Understanding**
2.	What is an Integrated Smart Sensor Systems?	**1**	**Remembering**
3.	Discuss about two port Measurement.	**3**	**Applying**
4.	How to eliminate the cross effect and parasitic effects in sensing element?	**6**	**Creating**
5.	Discuss about Timer Modules.	**5**	**Evaluating**
6.	Define Cross Effect.	**1**	**Remembering**
7.	Illustrate the applications of Integrated Smart Sensor Systems.	**6**	**Creating**
8.	Explain about UTI.	**3**	**Applying**
9.	Examine Multipath Errors.	**4**	**Analyzing**
10.	Give some of the advanced chopping techniques in smart sensors.	**2**	**Understanding**

11.	Draw the block diagram of UTI	**6**	**Creating**
12.	Describe about Front End Circuits.	**1**	**Remembering**
13.	Write the main specific requirements of MCU's and DSP's.	**1**	**Remembering**
14.	Discuss about the architecture of MCU's and DSP's.	**5**	**Evaluating**
15.	Write the principle of piezoelectric resonator.	**1**	**Remembering**
16.	How to choose a Low Power DSP or MCU's	**2**	**Understanding**
17.	Sketch the schematic diagram of vibration measuring instrument.	**3**	**Applying**
18.	Discuss about the generation of pulse width modulated signals.	**2**	**Understanding**
19.	Explain some of the principles that can be applied to the measurement of time intervals.	**4**	**Analyzing**
20.	Explain the standards for smart sensor interface.	**4**	**Analyzing**
	PART – B		
1.	Explain about smart sensors, and also discuss about the functions of Integrated smart sensors.	**2**	**Understanding**
2.	Describe the sensing elements in Integrated smart sensor.	**1**	**Remembering**
3.	With a neat diagram demonstrate the object oriented design of sensor systems.	**3**	**Applying**
4.	Write Short notes on the following **(i)** Sensing elements and their parasitic effects. **(7)** **(ii)** Compatibility of packaging. **(6)**	**2**	**Understanding**
5.	**(i)** Discuss the effect of cable and wire impedances. **(7)** **(ii)**Discuss about parasitic and cross effect in sensing elements **(6)**	**5**	**Evaluating**
6.	**i)** Explain in detail about front end circuits for thermistor modes. **(7)** **(ii)** Explain in detail about front end circuits for bridge modes. **(6)**	**4**	**Analyzing**
7.	Analyze the methods for frequency to dgital conversion.	**4**	**Analyzing**
8.	What are the important parameters of present day MCU's and DSP's and aslo discuss some of them.	**2**	**Understanding**
9.	Develop the timer modules in present day DSP.	**6**	**Creating**
10.	Discuss the generation of pulse width modulated signals in DSP.	**3**	**Applying**

11.	Discuss about the excitation signals for sensing elements.	**3**	**Applying**
12.	Explain the UTI Systems and also discuss about the applied measurement techniques in UTI Systems.	**4**	**Analyzing**
13.	Describe about the modulator and the front end circuits for capacitive modes	**1**	**Remembering**
14.	Write a detailed technical note on the functions of interface circuits for measuring a platinum resistor.	**1**	**Remembering**
PART C			
1.	Analyze the standards for smart sensor interface.	**4**	**Analyzing**
2.	Discuss about the analog comparator in DSP's and MCU's	**6**	**Creating**
3.	Explain about the ADC modules in DSP's	**2**	**Understanding**
4.	Explain about the DAC modules in DSP's	**2**	**Understanding**

UNIT IV - MICRO SENSORS AND ACTUATORS

Micro system design and fabrication – Micro pressure sensors (Piezo resistive and Capacitive) – Resonant sensors – Acoustic wave sensors – Bio micro sensors – Micro actuators – Micro mechanical motors and pumps- Introduction to Nano sensors.

PART – A

Q.No	Questions	BT Level	Competence
1.	Distinguish MEMS and Microsystems.	**2**	**Applying**
2.	What are the most obivious ditinctions between microsystems and microelectronic technologies?	**1**	**Analyzing**
3.	Mention any three examples of the objects to be the size of an approximately 1 millimeter.	**3**	**Applying**
4.	Give two examples of miniaturization of consumer products.	**3**	**Analyzing**
5.	Explain any four distinct advantages of miniaturization of machines and devices?	**6**	**Analyzing**
6.	Define Aspect Ratio.	**4**	**Applying**
7.	Discuss the most challenging issue facing microsystems technology.	**3**	**Applying**
8.	Define Micromachinig.	**2**	**Understanding**
9.	Point out the applications of MEMS in Consumer Products.	**1**	**Analyzing**
10.	Discuss the applications of MEMS in Telecommunication Industry.	**4**	**Understanding**
11.	Point out the future automotive applications of MEMS.	**1**	**Remembering**
12.	Define Microsystems.	**1**	**Understanding**

13.	Point out the principal applications of microsensors,actuators and fluidics.	**2**	**Applying**
14.	Write short notes on microaccelerometers.	**1**	**Understanding**
15.	Explain MEMS as a microactuator.	**2**	**Remembering**
16.	Give the advantages and disadvantages of piezoresistor	**6**	**Remembering**
17.	Discuss the applications of Microfluids.	**5**	**Remembering**
18.	Explain Acoustic Sensors.	**3**	**Evaluating**
19.	Draw the circuit diagram of MEM as a microsensor.	**6**	**Evaluating**
20.	Define Biosensors.	**4**	**Creating**
	PART – B		
1.	Discuss the applications of microsystems in the automotive industry.	**1**	**Remembering**
2.	Explain the applications of microsystems in the health care industry and in the aerospace industry.	**3**	**Applying**
3.	Explain the working of microprocessor control components for future vehicles.	**2**	**Understanding**
4.	Explain with a neat diagram the operating principle and working of Biosensors.	**3**	**Applying**
5.	Explain with a neat diagram the operating principle and working of Piezoresistive pressure sensors.	**5**	**Evaluating**
6.	Describe with neat diagram and proper explanation for piezo capacitive pressure sensors.	**2**	**Understanding**
7.	Describe with neat diagram the principle and operation of Thermal Sensors and their following given types **(i)** Thermocouple **(6)** **(ii)** Thermopile **(7)**	**1**	**Remembering**
8.	Discuss in detail about **(i)** Actuation using Thermal Forces **(7)** **(ii)** Actuation using Piezoelectric crystals **(6)**	**2**	**Understanding**
9.	Explain in detail about Micro grippers.	**4**	**Analyzing**
10.	Explain the following (i) Bio Sensors **(7)** (ii) Applications of Smart Sensors in Telecommunication Industry **(6)**	**6**	**Creating**
11.	Explain with a neat diagram the working of Micro motors.	**4**	**Analyzing**
12.	Explain with a neat diagram the working of Micro valves	**4**	**Analyzing**

13.	Describe the working of Micropumps with necessary diagrams.	1	Remembering
14.	**(i)** Explain the working of Actuation using shape memory Alloys **(7)** **(ii)** Explain the working of Actuation using Electrostatic Forces **(6)**	2	Understanding
	PART C		
1.	Explain about the Fabrication Process **(i)** Oxidation Process **(8)** **(ii)** Chemical and Physical Vapor Deposition **(7)**	4	Analyzing
2.	Discuss about Photolithography in microsystem fabrication Process.	6	Creating
3.	Discuss about a micro device that function on the principle of micro actuation.	6	Creating
4.	Explain about the Fabrication Process **(i)** Process of etching **(4)** **(ii)** Ion Implantation **(5)** **(iii)** Diffusion **(6)**	4	Analyzing

UNIT V - RECENT TRENDS IN SENSOR TECHNOLOGIES

Thick film and thin film sensors- Electro chemical sensors – RFIDs - Sensor arrays - Sensor network - Multisensor data fusion - Soft sensor..

PART – A

Q. No	Questions	BT Level	Competence
1.	Define thick film technology	1	Remembering
2.	Point out the applications of thick film sensors.	4	Analyzing
3.	Discuss the characteristics of Electrochemical Sensors	6	Creating
4.	Discuss the principle of RFID's .	1	Remembering
5.	What is meant by lithography?	1	Remembering
6.	Explain photo resist development in fabricating micro sensors.	5	Evaluating
7.	What is meant by screen printing?	1	Remembering
8.	Write the advantages and disadvantages of electrochemical sensors.	6	Creating
9.	Give any two examples for silicon based sensors.	2	Understanding
10.	What is the working principle of metal oxide sensors?	1	Remembering
11.	Write the significance of MEMS sensors and actuators.	5	Evaluating

12.	Define Sensor Array.	**1**	**Remembering**
13.	Give the applications of Sensor Fusion.	**2**	**Understanding**
14.	Explain the principle of Multi data sensor fusion.	**4**	**Analyzing**
15.	Give any two algorithms that covers a number of methods in sensor fusion.	**2**	**Understanding**
16.	Write a note on Sensor Network.	**1**	**Remembering**
17.	Define Soft Sensor.	**1**	**Remembering**
18.	Discuss the technology involved in developing the soft sensor.	**6**	**Creating**
19.	Classify solid state chemical sensors.	**3**	**Applying**
20.	Differentiate chemical sensor and silicon based chemical sensor.	**2**	**Understanding**
	PART – B		
1.	Explain the preparation of PZT thin films on metallic substrates.	**4**	**Analyzing**
2.	Explain the applications of thick and thin film sensors with suitable example.	**4**	**Analyzing**
3.	**(i)** Compare and contrast thick and thin film sensors.**(6)** **(ii)** Show the impact of thick film technology on new inexpensive robust miniaturized sensors. **(7)**		**Applying**
4.	Explain in detail construction, principle of operation of electrochemical sensors.	**1**	**Remembering**
5.	Discuss the types of electrochemical sensors and explain any one of them.	**1**	**Remembering**
6.	Describe the silicon based chemical sensor and compare it with each other types of chemical sensor**.**	**1**	**Remembering**
7.	Write a detailed technical note on the MEMS sensors and illustrate their application in automobile industry.	**3**	**Applying**
8.	Explain about ampeiometric sensors in detail with neat diagram.	**2**	**Understanding**
9.	Explain the RFID sensor technology with basic principle involving using transducers and reflectors.	**2**	**Understanding**
10.	Enumerate the design and fabrication Application Specific Integrated Circuits.	**5**	**Evaluating**
11.	Discuss the principle of sensor array and the types of sensor array.	**4**	**Analyzing**
12.	Anticipate how membranes are used as sensing elements in solid state sensors.	**6**	**Creating**
13.	How parameter estimation is done using array design (or) Array signal processing? Explain	**2**	**Understanding**
14.	Explain the 2-level design approach of smart transducer technology in detail.	**1**	**Remembering**

PART C			
1.	Design the miniature sensor along with its basic factors**.**	**4**	**Analyzing**
2.	Explain the control theory involved in soft sensors.	**4**	**Analyzing**
3.	Explain the fuzzy logic reasoning and neural network adaptive in multisensory data fusion technology.	**6**	**Creating**
4.	Describe the techniques associated with soft sensors with image analysis in detail.	**6**	**Creating**