ILAHIA COLLEGE OF ENGINEERING & TECHNOLOGY

(Affiliated to APJ Abdul Kalam Techonological University & Approved by AICTE)

MULAVOOR P.O, MUVATTUPUZHA

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

V SEMESTER

POWER ELECTRONICS & INSTRUMENTATION LAB

(EC 307)
LABORATORY MANUAL - 2017

NAME : ____________________

ROLL NO. : __________

YEAR : __________

VISION

To nurture the talents of electronics and communication engineers, making them highly competent for growth of the society.

MISSION

- To deliver excellence in teaching - learning process.
- Promote safe, orderly, caring and supportive environment to learners.
- Development of skilled engineers to perform innovative Research for betterment of the society.
- To encourage industry - institute interaction, career advancement, innovation and entrepreneurship development.

PROGRAM EDUCATIONAL OUTCOME (PEO)

PEO1: To acquire a strong foundation in mathematics and scientific fundamentals, to develop an ability to analyze various functional elements of different disciplines of electronics and communication engineering.

PEO2: Develop technical competence to move in pace with rapid changes in technology.

PEO3: Equip learners to strengthen knowledge and soft skills for carrier advancement.

PEO4: Adhere to ethics to contribute for betterment of the society.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1. To understand principles and applications of various electronic components/devices and circuits.

PSO2. Enable learners to solve complex problems using modern hardware and software tools.

EC335: Power Electronics and Instrumentation Lab

COURSE OUTCOME

C335.1	The student will be able to Design and demonstrate basic power electronic circuits
C335.2	The student will be able to Use transducers for application
C335.3	The student will be able to Function effectively as an individual and in a team to accomplish the given task
C335.4	The student will be able to design and analyze the operation of converters and Power devices

CO - PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
EC335.1	1	1	2		1								1	
EC335.2			2											
EC335.3	1												1	
EC335.4			2		1									

COURSE CODE	COURSE NAME	L-T-P-C	YEAR OF INTRODUCTION
EC335	Power Electronics & Instrumentation Lab	0-0-3-1	2016

Prerequisite: NIL

Course objectives:

- To design and implement basic power electronic circuits
- To study the working of transducers
- To train the usage of Digital Instruments

List of Experiments (8 experiments mandatory):

Cycle I (Four mandatory)

1. Design and Set up DC-DC converter
2. Design and Set up Push pull DC- DC Converter
3. Design and Set up Buck DC-DC Converters
4. Design and Set up Simple SMPS
5. Design and Set up Half bridge and full bridge converters
6. Design and Set up basic Inverter Circuits

Cycle II (Four mandatory)

7. Transducer measurements using diode thermometer
8. Transducer measurements using LVDT
9. Transducer measurements using Strain gauge.
10. Transducer measurements using Pressure transducer.
11. Transducer measurements using Thermocouple & RTDS
12. Transducer measurements using Photocells

Desired Experiment

13. Study of Digital LCR meter, Frequency synthesizer, Spectrum analyzer and Logic State analyzer application.

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Expected outcome:

The students will be able to:

1. Design and demonstrate basic power electronic circuits.
2. Use transducers for application.
3. Function effectively as an individual and in a team to accomplish the given task.

LIST OF EXPERIEMENTS

CYCLE 1	
1	Design and Set up DC-DC converter
2	Design and Set up Buck DC-DC Converters
3	Design and Set up Simple SMPS
4	Design and Set up Half bridge and full bridge converters
5	Design and Set up basic Inverter Circuits
CYCLE 2	
1	Transducer measurements using LVDT
2	Transducer measurements using Strain gauge.
3	Transducer measurements using Pressure transducer
4	Transducer measurements using Thermocouple & RTDS

CONTENTS

Date:

Experiment No: 1

DC-DC CONVERTER

1. BOOST CONVERTER

Aim

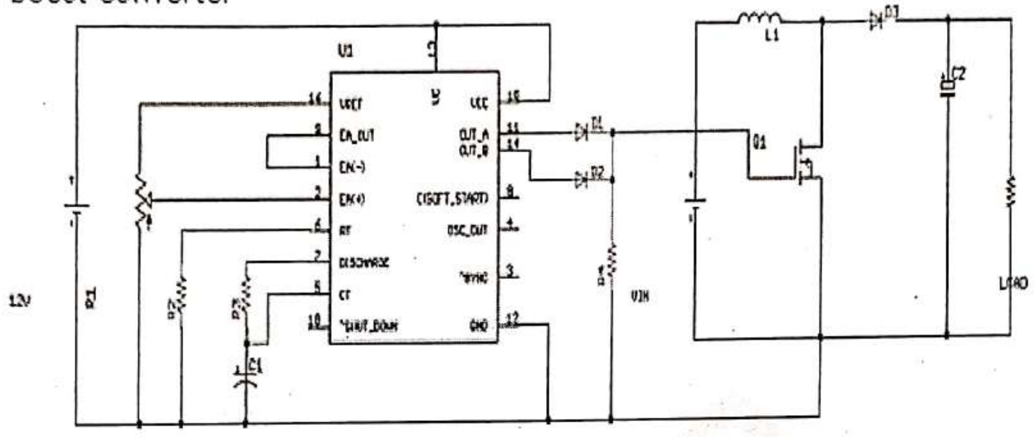
To design and set up a Boost Converter

Components & Equipments Required

Sl.no	Components	Specification	Quantity
1.	Resistors	10 k pot	1
		100 ohm	2
		10k	1
		14.4 ohm	1
2.	Diode	1N4148	2
		UF4007	1
3.	Capacitors	0.01 uf	1
		270 uf	1
4.	Transistor	IRF540	1
5.	Inductor	1 mH, 1A	1
6.	DC supply	12v	

Circuit Diagram

Boost Converter

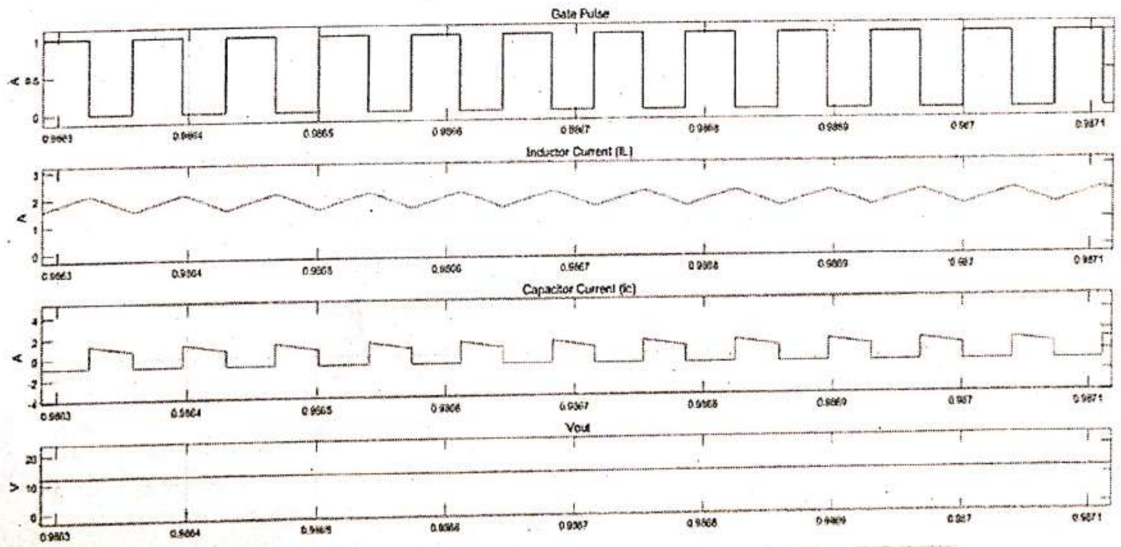


Theory

Power for the boost converter can come from any suitable DC sources, such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion.

A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. Since power must be conserved, the output current is lower than the source current. Two battery-powered applications that use boost converters are used in hybrid electric vehicles (HEV) and lighting systems.

Output Waveforms



Observations and measurements:

Input voltage, current and power

Output voltage, current and power

Efficiency(Pout/Pin)

Converter Gain(Vout/Vin)

Verify the equation: $Vout = Vin \times \frac{1}{1 - D}$, by varying duty cycle (D)

Result: Designed and set up the boost converter.

Date:

Experiment No:

PUSH PULL DC-DC CONVERTER

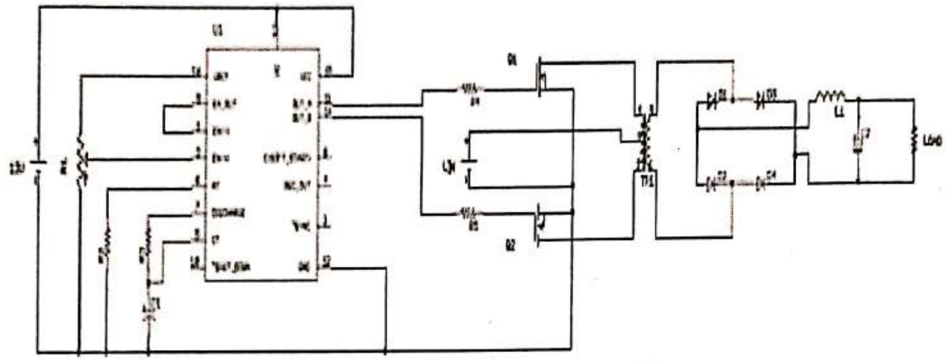
Aim

To design and setup Push Pull DC-DC converter.

Components & Equipments Required

Sl.no	Components	Specification	Quantity
1.	Resistors	10 k pot	1
		100 ohm	3
		4.7 k	1
		3.6 ohm	1
2.	Diode	UF4007	4
3.	Capacitors	100 uf,25v	1
		0.01 uf	1
4.	Transistor	IRF540	2
5.	Inductor	1 mH, 1.67 A	1
6.	DC supply	12v	

Circuit Diagram



Theory

A push–pull converter is a type of DC-to-DC converter, a switching converter that uses a transformer to change the voltage of a DC power supply. The distinguishing feature of a push-pull converter is that the transformer primary is supplied with current from the input line by pairs of transistors in a symmetrical push-pull circuit. The transistors are alternately switched on and off, periodically reversing the current in the transformer. Therefore, current is drawn from the line during both halves of the switching cycle. This contrasts with buck-boost converters, in which the input current is supplied by a single transistor which is switched on and off, so current is only drawn from the line during half the switching cycle. During the other half the output power is supplied by energy stored in inductors or capacitors in the power supply.

Push–pull converters have steadier input current, create less noise on the input line, and are more efficient in higher power applications.

Design

$$Transformer\ Turns\ ratio(N): > \frac{Vout}{Vin} = 3$$

$$Duty\ Cycle(D) = \frac{Vout}{2NVin} = 0.33$$

$$Output\ voltage\ ripple(\Delta Vout) = 0.1V$$

$$Output\ current(Iout) = \frac{Pout}{Vout} = 1.67A$$

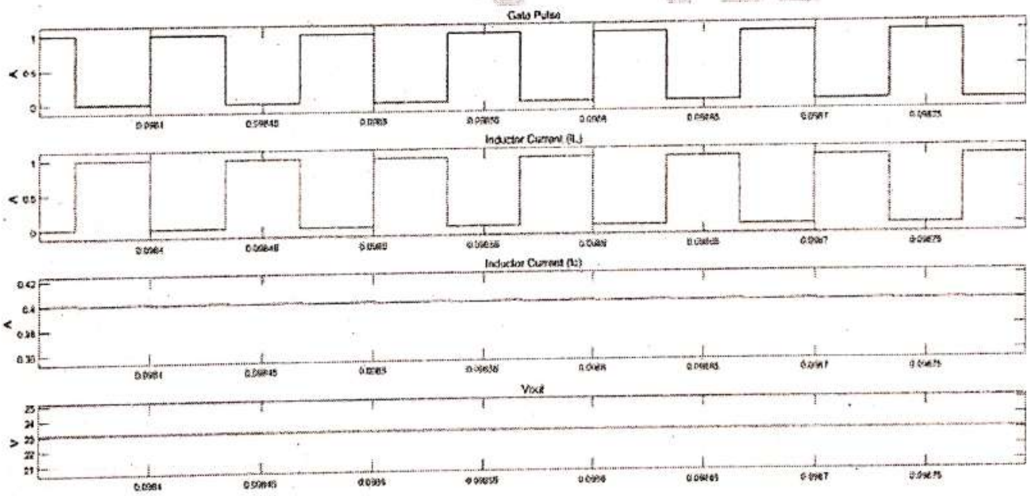
$$Load\ Resistor: \frac{Vout^2}{P} = 3.6\ ohm$$

$$Inductor\ ripple\ current(\Delta IL) = 0.33Iout = 0.55A$$

$$Inductor\ Lmin = \frac{(VinN - Vout)D}{\Delta IL \times Fs} = 0.3mH$$

$$Output\ Capacitance\ \min(Cout) = \frac{\Delta IL}{2Fs \times \Delta Vout} = 25\mu F.$$

Output waveforms:



Result: Designed and set up Push Pull DC-DC Converter.

DATE:

EXPERIMENT NO:

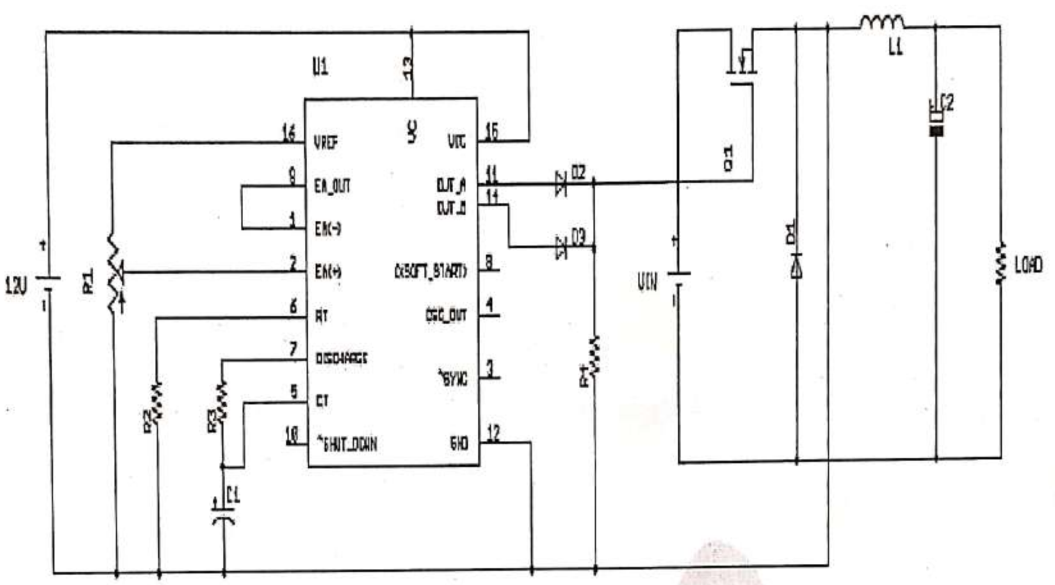
Buck DC-DC Converters

AIM: To design and setup a Buck DC-DC Converters

EQUIPMENTS AND COMPONENT SREQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	DC Power Supply	12V	01
2.	Resistors	10K pot	01
		10K	01
		100ohm	02
3.	Diode	1N4148	02
		UF4007	01
4.	Capacitors	0.01μf	01
		100μf	01
5.	Inductor	1mH,1A	01
6.	MOSFET	IRF540	01
7.	Rheostat	10 ohm,2A	01

CIRCUIT DIAGRAM:



Buck DC-DC Converter

THEORY:

A buck converter is a DC-to-DC power converter which steps down voltage from its input to its output. The buck Converter circuit consists of the switching transistor, together with the flywheel circuit. While the transistor is on, current is flowing through the load via the inductor. The action of any inductor opposes changes in current flow and also acts as a store of energy. In this case the switching transistor output is prevented from increasing immediately to its peak value as the inductor stores energy taken from the increasing output; this stored energy is later released back into the circuit as a back e.m.f. as current from the switching transistor is rapidly switched off. MOSFET can be turned ON by applying a voltage greater than Vgs threshold across gate and source. Similarly, MOSFET can be turned OFF by disconnecting the gate-source voltage. Gate pulse should be capable of turn on MOSFET within very smaller time as compared to total switching time.

DESIGN:

$Vout/Vin=D$

$Duty\ cycle(D)=Vout/Vin=0.5$

$Output\ Current(Iout)=Pout/Vout=1.66A$

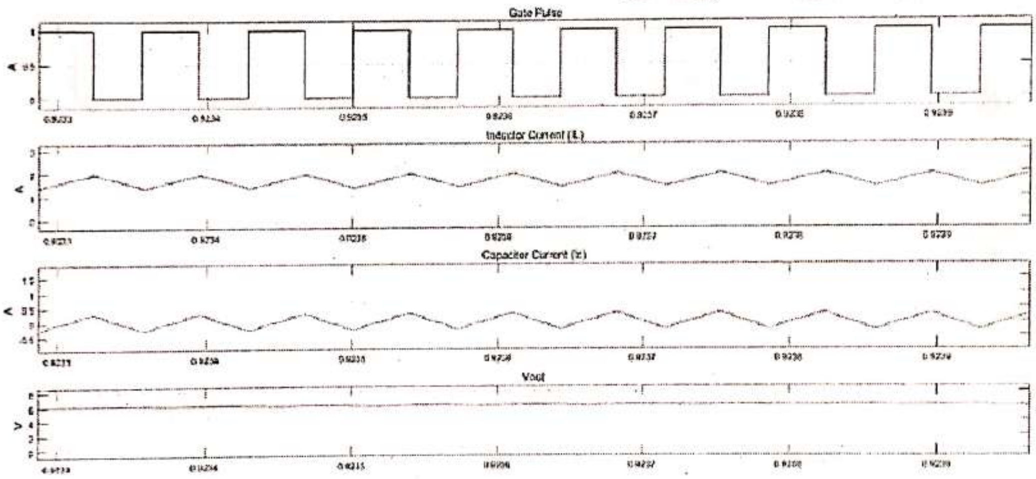
$LoadResistor: Vout^2/P=3.6\ ohm$

$Inductor\ ripple\ current(\Delta IL)=0.33Iout=0.5478A$

$Inductor\ Lmin=(Vin-Vout)D/(\Delta IL\times Fs)=365\mu H$

$Output\ Capacitance\ \min(Cout)=\Delta IL/(8\times Fs\times\Delta Vout)=45.5\mu F$

MODEL WAVE FORM:



RESULT:

Designed and setup Buck DC-DC Converter and obtained the output waveform.

DATE:

EXPERIMENT NO:

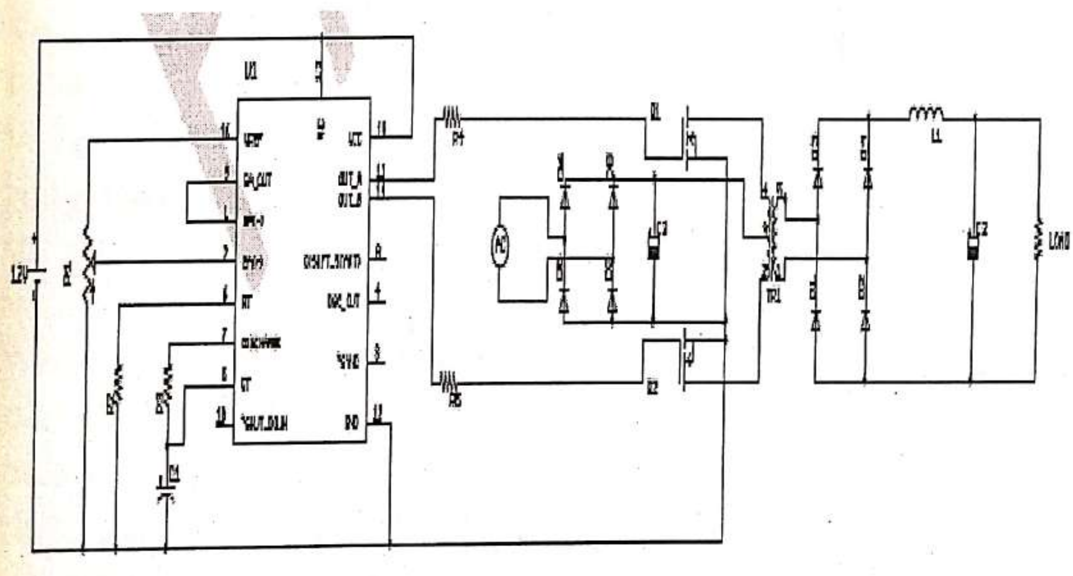
SMPS

AIM: To design and setup SMPS

EQUIPMENTS AND COMPONENTS REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	DC Power Supply	12V	01
2.	Resistors	10K pot	01
		4.7K	01
		100ohm	01
3.	Capacitors	0.01µf	01
4.	Inductor	725µH,1A	01

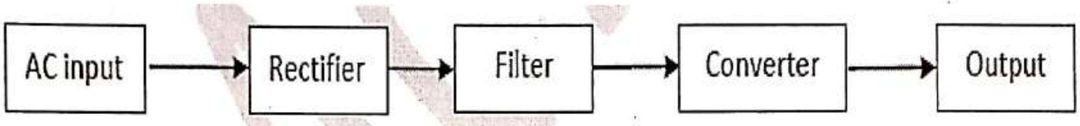
CIRCUIT DIAGRAM:



SMPS

THEORY:

A switched-mode power supply (**SMPS**) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state.



The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.

DESIGN:

<u>Rectifier:</u>

Diode: 24A 0.5A:- 1N4001

Filter capacitor (C3) $=P/(2\times F\times Vdc\times Vr)$ ~= 4700uF

Vdc: rectified DC voltage

F : line frequency (50Hz)

Vr: ripple voltage (1v)

<u>Push pull converter:</u>

Vin : 24V

Vout: 12v

$Transformer\ Turns\ ratio(N){:}{>}Vout/Vin=1$

$Duty\ Cycle(D)=Vout/2NVin=0.25$

$Output\ voltage\ ripple(\Delta Vout)=0.1V$

$Output\ current(Iout)=Pout/Vout=0.833A$

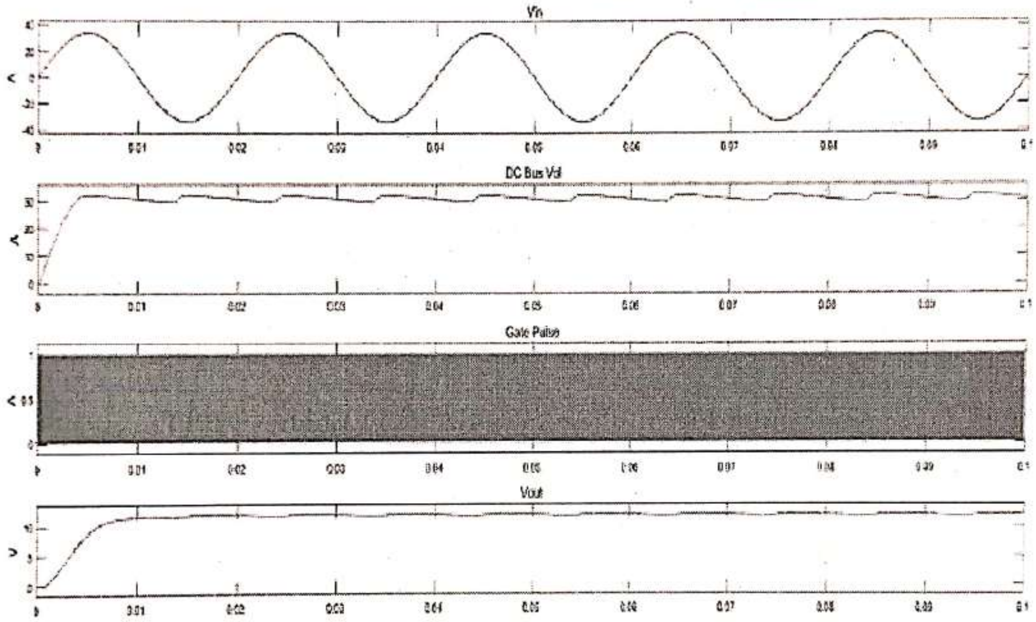
$Load\ Resistor{:}Vout^2/P=14.4$ ohm

Inductor ripple current(ΔIL)=$0.33Iout$=$0.274A$

Inductor Lmin=$(VinN-Vout)D/(\Delta IL\times Fs)$=$725uH$

Output Capacitance min$(Cout)$=$\Delta IL/(2Fs\times\Delta Vout)$~=$100\mu F$

MODEL WAVE FORM:



RESULT:

Designed SMPS and obtained the output waveform.

DATE:

EXPERIMENT NO:

HALF BRIDGE AND FULL BRIDGE CONVERTER

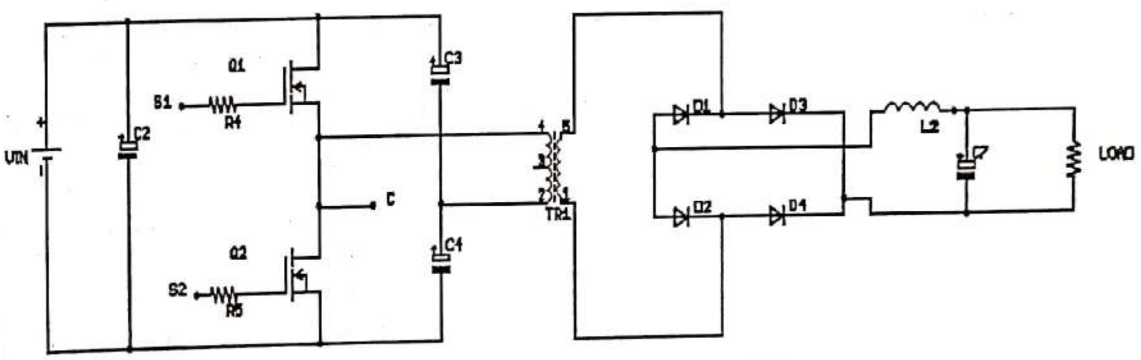
AIM: To design and setup half bridge and full bridge converter

HALF BRIDGE CONVERTER

EQUIPMENTS AND COMPONENTS REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	DC Power Supply	12V	01
2.	Resistors	100ohm	02
3.	Capacitors	100uF, 25 V	04
4.	Diode	UF4007	04
5	MOSFET	IRF 540	02
6	Inductor	1 mH	01
7	Rheostat	10 ohm	01
8	Transformer		01

CIRCUIT DIAGRAM



THEORY

The Half Bridge converter is similar to the Push-Pull converter, but a center tapped primary is not required. The reversal of the magnetic field is achieved by reversing the direction of the primary winding current flow. In this case, two capacitors, C1 and C2, are required to form the DC input mid-point. Transistors Q1 and Q2 are turned ON alternately to avoid a supply short circuit, in which case the duty cycle *d* must be less than 0.5.

For the Half-Bridge converter, the output voltage VOUT equals:

$$V_{out} = V_{in} \frac{N_2}{N_1} \times d$$

Where, *d* is the duty cycle of the transistors and $0 < d < 0.5$. N2/N1 is the secondary to primary turns ratio of the transformer.

DESIGN

$$Transformer\ Turns\ ratio(N): > 2 \times \frac{Vout}{Vin} = 2$$

$$Duty\ Cycle(D) = \frac{Vout}{NVin} = 0.125$$

$$Output\ voltage\ ripple(\Delta Vout) = 0.1V$$

$$Output\ current(Iout) = \frac{Pout}{Vout} = 1.67A$$

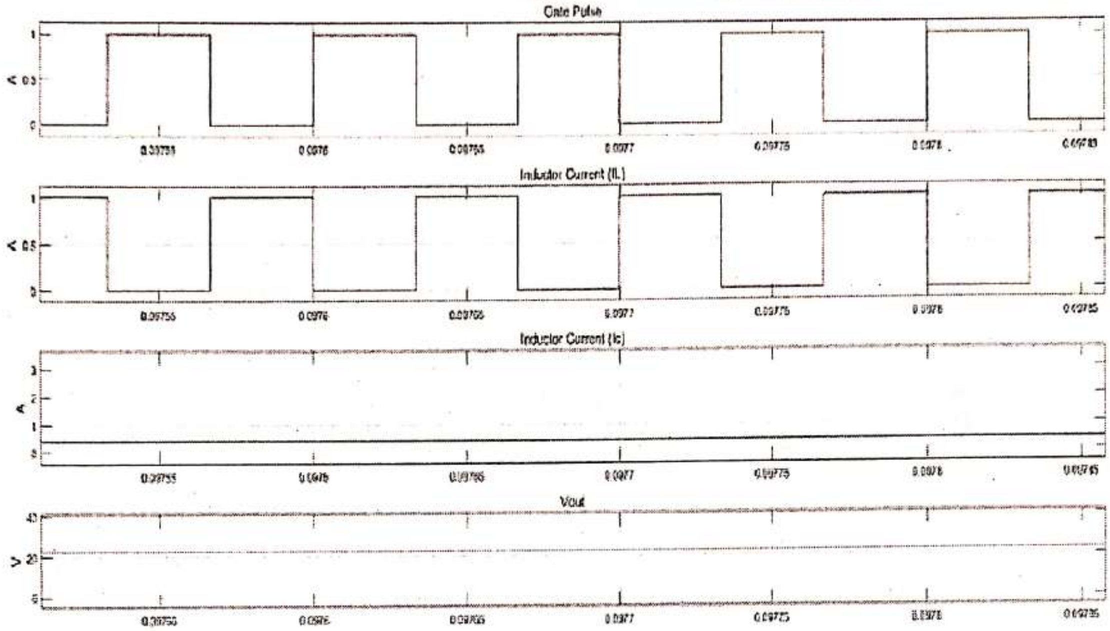
$$Load\ Resistor: \frac{Vout^2}{P} = 3.6\ ohm$$

$$Inductor\ ripple\ current(\Delta IL) = 0.33Iout = 0.55A$$

$$Inductor\ Lmin = \frac{(VinN - Vout)D}{\Delta IL \times Fs} = 0.54mH$$

$$Output\ Capacitance\ \min(Cout) = \frac{\Delta IL}{8Fs \times \Delta Vout} = 45.8\mu F$$

MODEL WAVEFORM

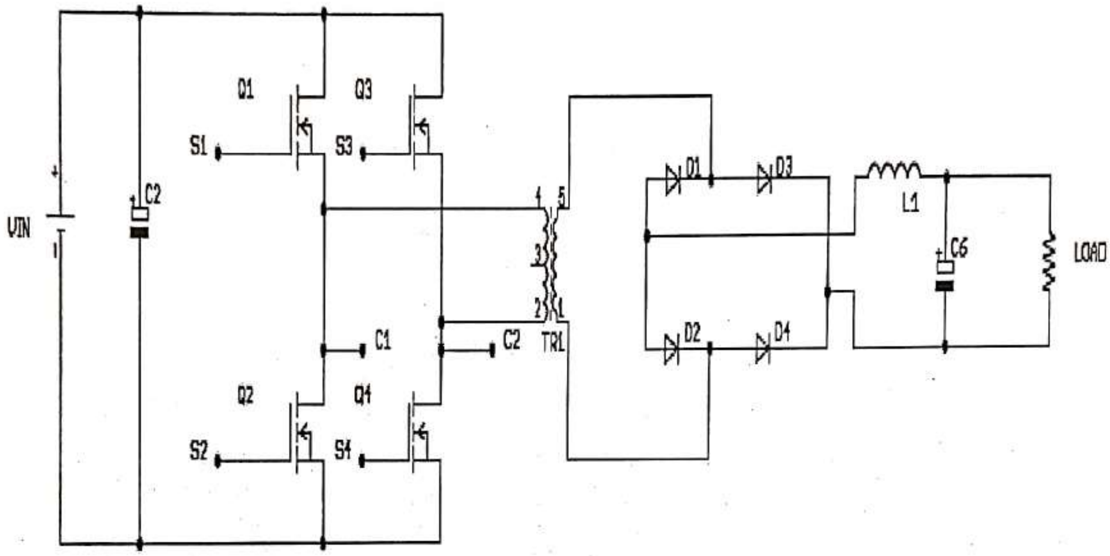


FULL BRIDGE INVERTER

EQUIPMENTS AND COMPONENTS REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	DC Power Supply	12V	01
2.	Resistors	100ohm	02
3.	Capacitors	100uF, 25 V	04
4.	Diode	UF4007	04
5	MOSFET	IRF 540	02
6	Inductor	1 mH	01
7	Rheostat	10 ohm	01
8	Transformer		01

CIRCUIT DIAGRAM



THEORY

The transformer topology for both the Half Bridge and Full Bridge converter is the same, except that for a given DC link voltage of the Half Bridge transformer sees half the applied voltage as compared with that of the Full Bridge transformer. The current flows in opposite directions during alternate half cycles. So flux in the core swings from negative to positive, utilizing even the negative portion of the hysteresis loop, thereby, reducing the chances of core saturation. Therefore, the core can be operated at greater Bm value here. The largest power is transferred when the duty cycle is less than 50%. Diagonal pairs of transistors (Q1-Q4 or Q2-Q3) conduct alternately, thus, achieving current reversal in the transformer primary.

Output voltage equals:

$$V_{out} = 2 \times V_{in} \frac{N_2}{N_1} \times d$$

Where, d is the duty cycle of the transistors and $0 < d < 0.5$.

N2/N1 is the secondary to primary turns ratio of the transformer.

DESIGN

$$Transformer\ Turns\ ratio(N): > 2\times\frac{Vout}{Vin} = 4$$

$$Duty\ Cycle(D) = \frac{Vout}{2NVin} = 0.2$$

$$Output\ voltage\ ripple(\Delta Vout) = 0.1V$$

$$Output\ current(Iout) = \frac{Pout}{Vout} = 0.5A$$

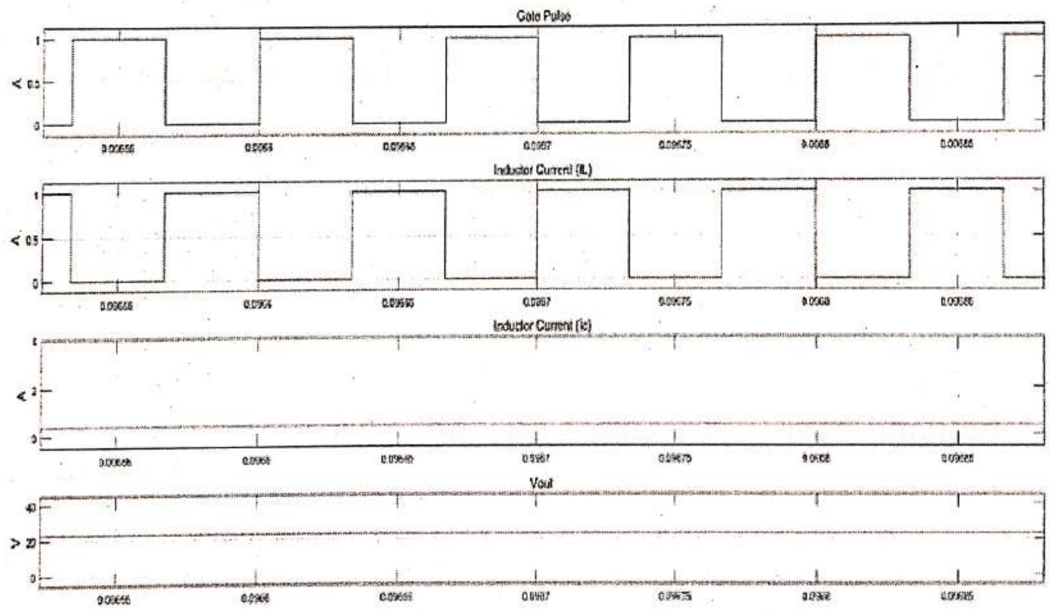
$$Load\ Resistor: \frac{Vout^2}{P} = 40\ ohm$$

$$Inductor\ ripple\ current(\Delta IL) = 0.33Iout = 0.165A$$

$$Inductor\ Lmin = \frac{(VinN - Vout)D}{\Delta IL\times Fs} = 2.3mH$$

$$Output\ Capacitance\ \min(Cout) = \frac{\Delta IL}{8Fs\times\Delta Vout} = 22\mu F$$

MODEL WAVEFORM



RESULT

Designed and set up half bridge and full bridge inverter and obtained the waveforms.

DATE:

EXPERIMENT NO:

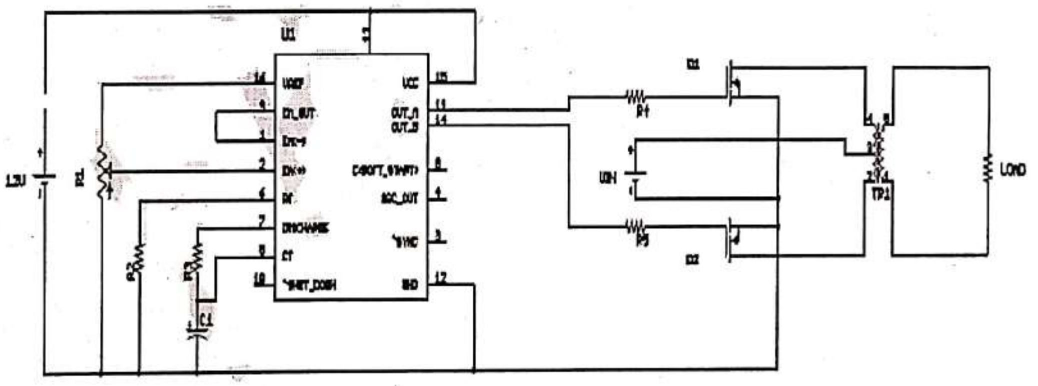
BASIC INVERTER

AIM: To design and setup basic inverter circuit.

EQUIPMENTS AND COMPONENTS REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	DC Power Supply	12V	01
2.	Resistors	100ohm	03
		10 K pot	01
		3.3 K	01
3.	Capacitors	4. 7µf	01
4	MOSFET	IRF 540	02
5	Transformer		01
6	Rheostat	10 ohm	01

CIRCUIT DIAGRAM



THEORY

A device that converts dc power into ac power at desired output voltage and frequency is called an inverter. The applications of inverters are aircraft power supply, ups etc. Te inverter gain is the ration of ac output voltage to dc input voltage. The output voltage of ideal inverters should be sinusoidal.

Push pull inverter requires a transformer with centre tapped primary.

When Q1 is on, Vo = -Vin/n and

when Q2 is on, Vo – Vin/n

DESIGN

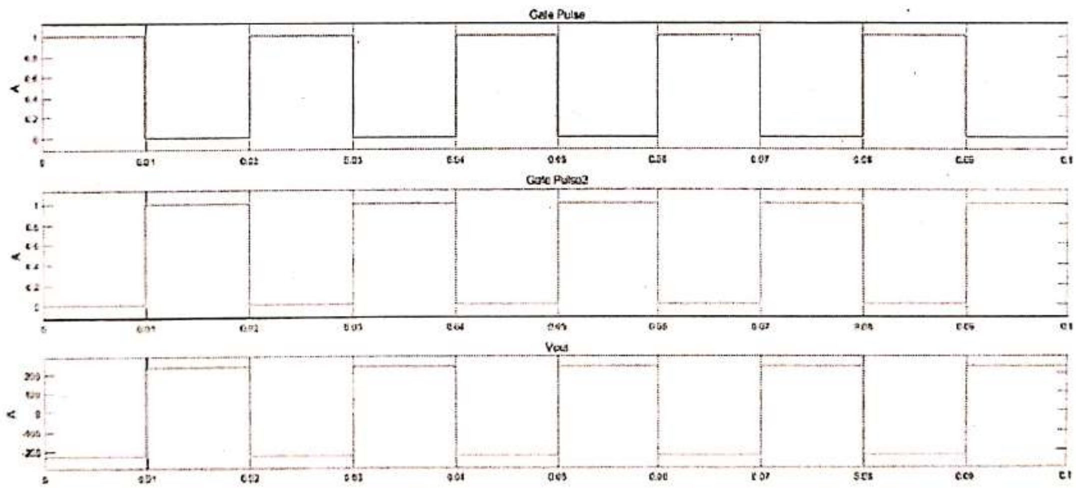
$$Transformer\ Turns\ ratio(N):> \frac{Vout}{Vin} = 20$$

$$Duty\ Cycle(D) = \frac{Vout}{2NVin} = 0.5$$

$$Load\ Resistor: \frac{Vout^2}{P} = 5.290K$$

230V/10W Lamp can be used as load

MODEL WAVEFORM



RESULT

Designed and set up basic inverter circuit.

Instrumenentation Laboratory Experiments

DATE:
EXPERIMENT NO:

Diode Thermometer

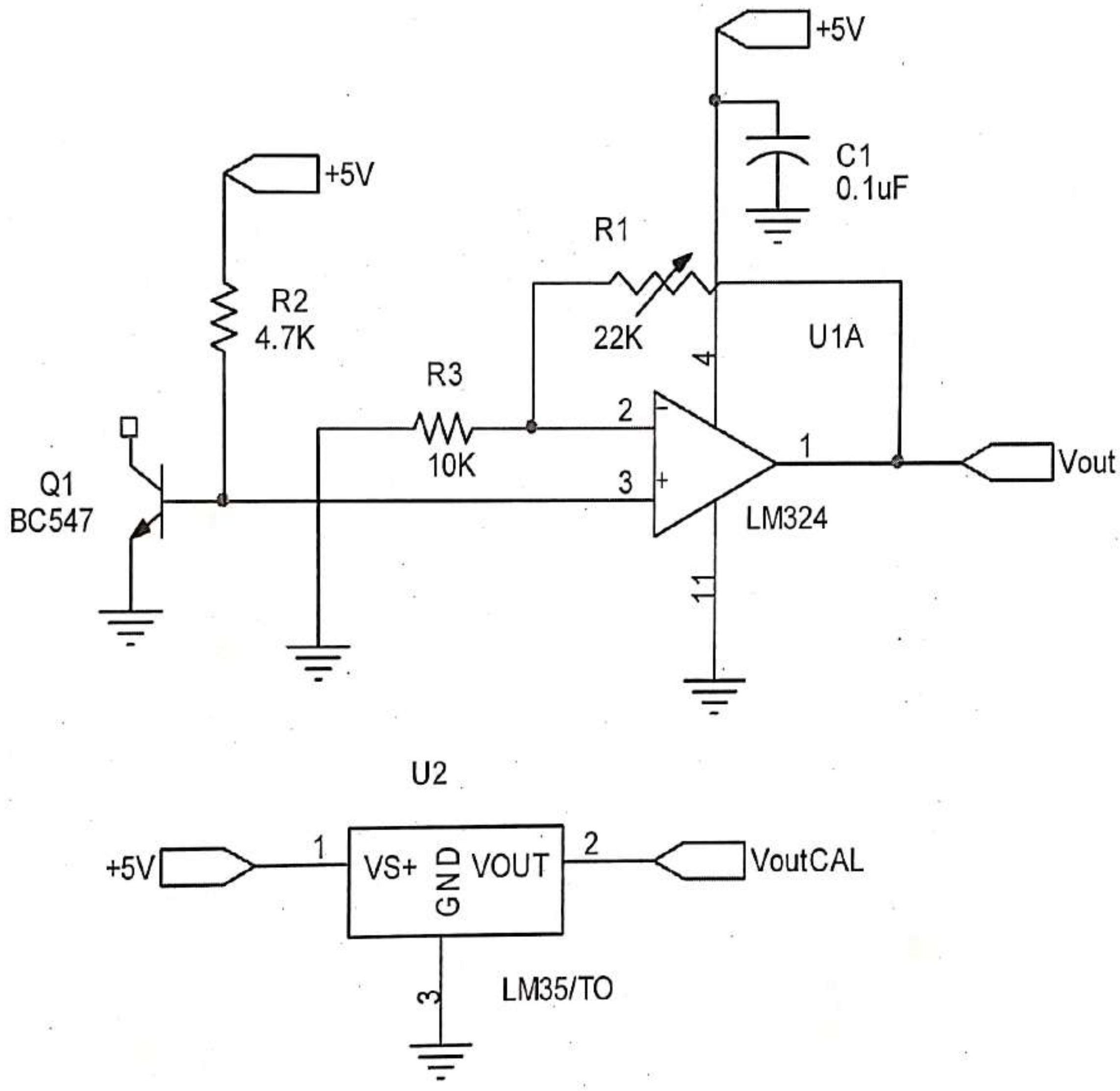
Aim:

Transducer measurement using diode thermometer.

Components & Equipments Required:

SLNO:	COMPONENTS	SPECIFICATION	QUANTITY
1.	Resistors	4.7k	1
		22k pot	1
		10k	1
2.	Transistors	BC547	1
3.	Op-amp	LM324	1
4.	capacitor	0.1uf	1
5.	sensor	LM35/TO	1

CIRCUIT DIAGRAM



Design

Forward bias a pn junction diode. Allow to flow 1mA current through the diode at room temperature.

Choose R2=4.7K

Use EB junction diode of an npn transistor(BC 547) which gives a change in diode voltage as 2mV/°C.

This is amplified using a non inverting amplifier.

For the calibration of the circuit use LM 35 temperature sensor which gives 10mV/°C.

Standard temperature=VoutCAL/10

Set the gain of amplifier using R1.

Vary the temperature and find out the standard temperature and plot the temperature vs Vout graph.

RESULT:

Conducted transducer measurements using Diode Thermometer.

DATE:

EXPERIMENT NO:

LVDT

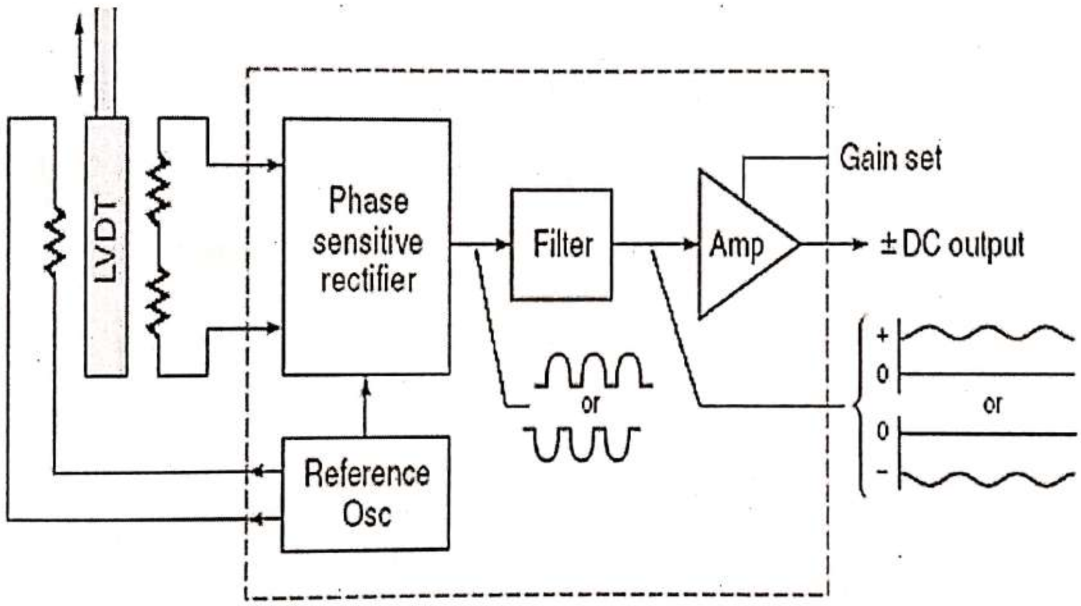
AIM

To make transducer measurements using LVDT

COMPONENTS REQUIRED

LVDT Trainer kit

CIRCUIT DIAGRAM:



THEORY:

LVDT stands for linear variable differential transformer. It works on the principle of mutual induction LVDT illustrated in figure consist of three symmetrically spaced coils bound out and illustrated bobbin. A magnetic core , which moves through the bobbin, provides a path for magnetic flux linkage between coils. The position of the magnetic core control the mutual inductance between the primary coils and two secondary coils.

When a carrier excitation is applied to the primary coil, voltage is induced in the two secondary coils that are wired in series opposing circuit. When the core is centered between the two secondary coils, the voltage induced in secondary coils are equal but cut of phase by 180° with series opposing circuit, the voltage in two secondary coils contact cancel each other and the O/P voltage is zero. When the core is moved from the centre position, an in-balance in the mutual inductance between the primary and secondary coils occurs and an o/p voltage develops. The o/p voltage is linear function of core position as long as the motion of the core is within the operating range of LVDT. The direction of motion can be determined from the phase of o/p voltage.

RESULT:

Conducted transducer measurements using LVDT.

DATE:

EXPERIMENT NO:

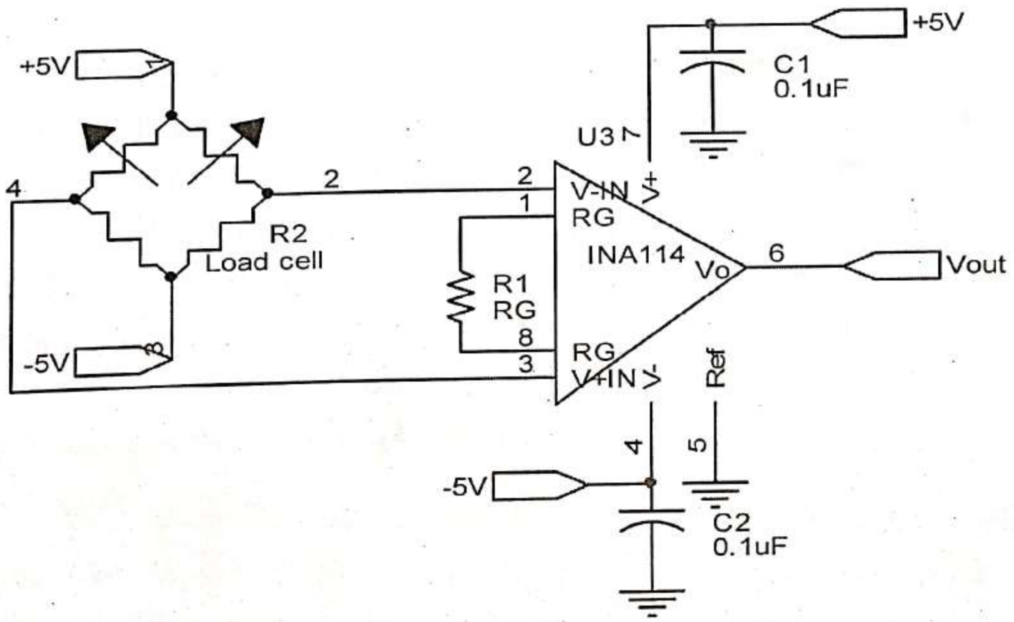
STRAIN GAUGE

AIM: To make transducer measurements using strain gauge

EQUIPMENTS AND COMPONENT REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	Dual Power Supply	5V	01
2.	Resistors	10K pot	01
3.	IC	INA114	01
4.	Capacitors	0.01μf	02

CIRCUIT DIAGRAM:



DESIGN

Use an instrumentation amplifier for amplifying very small signal.

$$G = 1 + \frac{50k\Omega}{R_G}$$

DESIRED GAIN	R_G (Ω)	NEAREST 1% R_G (Ω)
1	No Connection	No Connection
2	50.00k	49.9k
5	12.50k	12.4k
10	5.556k	5.62k
20	2.632k	2.61k
50	1.02k	1.02k
100	505.1	511
200	251.3	249
500	100.2	100
1000	50.05	49.9
2000	25.01	24.9
5000	10.00	10
10000	5.001	4.99

Here a resistive type of strain gauge in the form of load cell is used as the sensor. Use standard weight for calibration purpose.

THEORY

Four strain gauges are connected in the four arms of the Wheatstone bridge. +8 V DC is used to excite the bridge and output is taken from the remaining arm. When no weight is placed on the cantilever, strain developed is zero. Resistances of all four strain gauges are equal so bridge is balanced and output of bridge is zero. Whenever weight is placed, strain developed at fixed end causes resistance of strain gauge to vary which disturbs the balanced condition of bridge and output is produced which is amplified by instrumentation amplifier and is measured.

RESULT

Conducted transducer measurement using strain gauge.

DATE:

EXPERIMENT NO:

THERMOCOUPLE

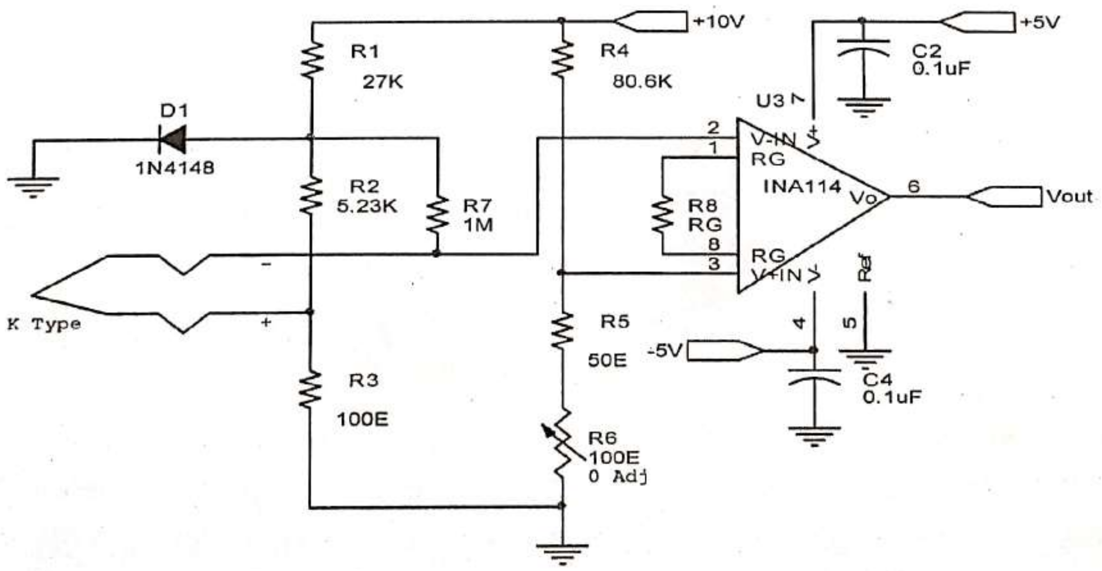
AIM

To make transducer measurements using Thermocouple.

EQUIPMENTS AND COMPONENTS REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	Dual Power Supply	5V	01
2.	Resistors	27K,5.2K,80.6K,100K pot	01 Each
3.	Diode	IN 4148	01
3.	IC	INA114	01
4.	Capacitors	0.1µf	02

CIRCUIT DIAGRAM:



DESIGN:

Choose K Type thermocouple which gives 39.4μV/°C.

Choose gain of amplifier as 1000.

So RG=50Ω

THEORY:

The thermocouple is a simple, widely used component for measuring temperature. A thermocouple consists of two wires of dissimilar metals joined together at one end, called the measurement ("hot") junction. The other end is called the reference ("cold") junction. The voltage produced at the reference junction depends on the temperatures at both the measurement junction and the reference junction. Since the thermocouple is a differential device rather than an absolute temperature measurement device, the reference junction temperature must be known to get an accurate absolute temperature reading. This process is known as reference junction compensation (cold junction compensation). Here the circuit is designed specifically to measure K-type thermocouples. This analog solution is optimized for minimum design time: It has a straightforward signal chain and requires no software coding.

RESULT:

Conducted transducer measurements using Thermocouple.

DATE:

EXPERIMENT NO:

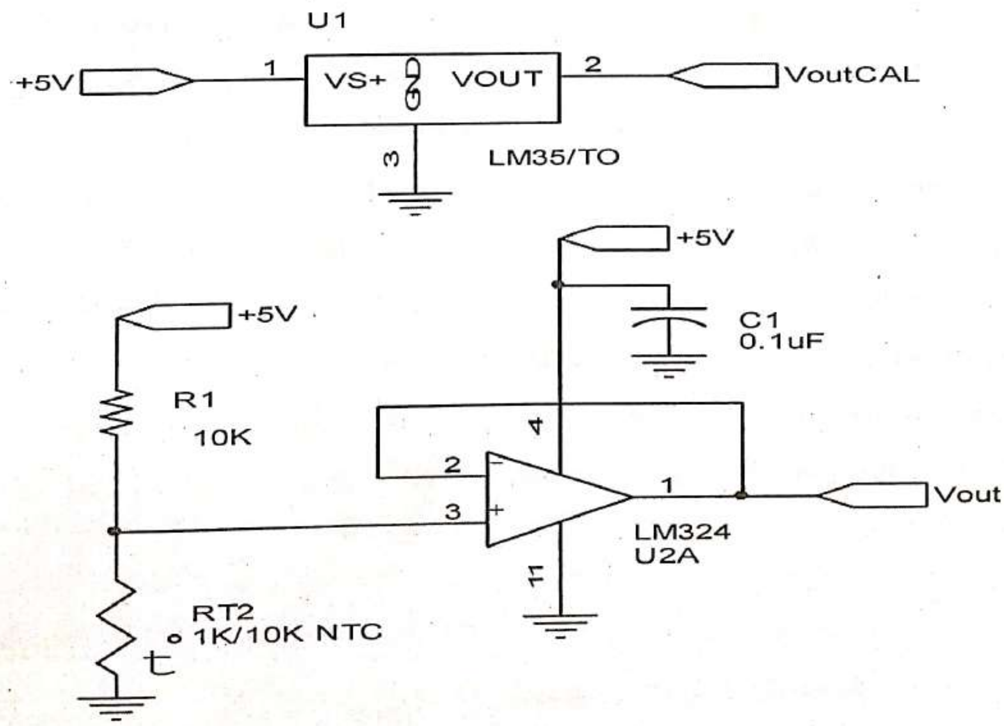
RTDS

AIM: To make transducer measurements using RTDS

EQUIPMENTS AND COMPONENT REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	Dual Power Supply	5V	02
2.	Resistors	10K	02
3.	IC	LM324	01
4.	Capacitors	0.1μf	01

CIRCUIT DIAGRAM:



DESIGN:

Use 1K or 10K NTC thermistor as the temperature sensor which gives an exponential decrease in resistance as the temperature increases.

$R_T=R_o \exp[\beta\{(1/T)-(1/T_o)\}]$

Use a resistive divider network.Choose R1=10K

Voltage across the thermistor is buffered using a voltage follower.

For the calibration of the circuit use LM 35 temperature sensor which gives 10mV/°C.

Standard temperature=VoutCAL/10.Vary the temperature and find out the standard temperature and plot the temperature vs Vout graph.

THEORY:

An RTD or Resistance Temperature Detector is a passive circuit element whose resistance increases with increasing temperature in a predictable manner. Resistance temperature detector (RTDs) operate on the principle of changes in electrical resistance of pure metals and are characterized by a linear positive change in resistance with temperature. Typical elements used for RTDs include nickel (Ni) and copper (Cu), but platinum (Pt) is by far the most common because of its wide temperature range, accuracy, and stability. Measuring the temperature of an RTD involves measuring this resistance accurately. To measure the resistance, it is necessary to convert it to a voltage and use the voltage to drive a differential input amplifier. The use of a differential input amplifier is important as it will reject the common mode noise on the leads of the RTD and provide the greatest voltage sensitivity. The RTD signal is generally measured one of two ways: either by connecting the RTD element in one leg of a Wheatstone bridge excited by a constant reference voltage, or by running it in series with a precision current reference and measuring the corresponding IR voltage drop. The latter method is generally preferred as it has less dependence on the reference resistance of the RTD element.

RESULT:

Conducted transducer measurement using RTDS.

DATE:

EXPERIMENT NO:

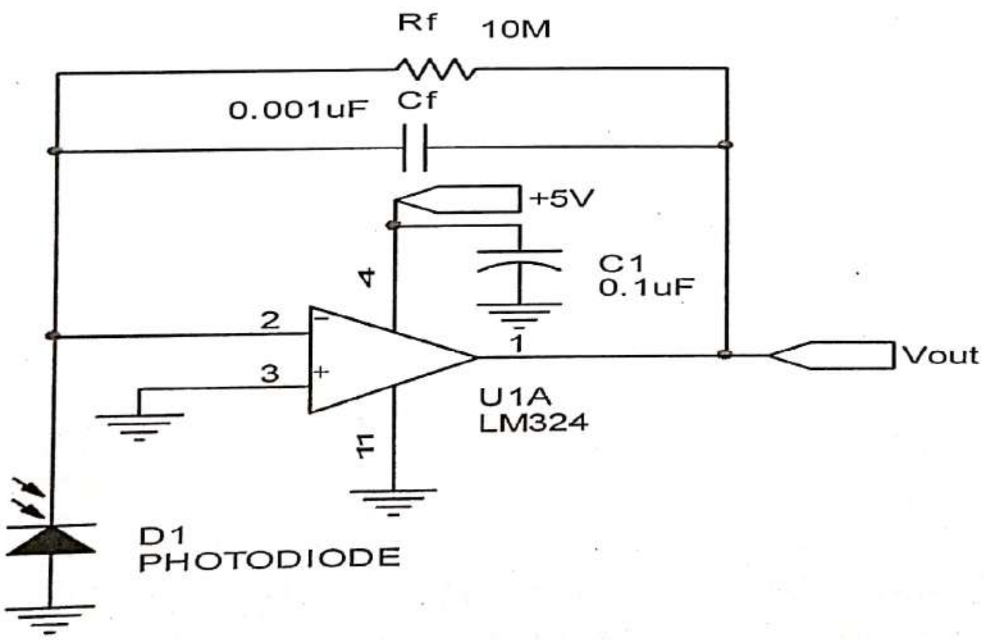
PHOTOCELLS

AIM: To make transducer measurements using Photocells.

EQUIPMENTS AND COMPONENT REQUIRED:

SL NO	NAME OF EQUIPMENTS/COMPONENTS	SPECIFICATIONS	QTY
1.	Dual Power Supply	5V	01
2.	Resistors	10M	01
3.	IC	LM 324	01
4.	Capacitors	0.001µf ,0.1µf ,	02
5.	Photocell		01

CIRCUIT DIAGRAM:



DESIGN:

Use a photodiode as the sensor in which the diode current varies with light intensity due to the generation carriers. This current is amplified by a trans- impedance amplifier.

Vout=Rf.Id

Find out the Vout for various light intensities.

THEORY:

Photocells act as light sensors.In this type of device the electrical resistance of material wires varies with the amount of the light energy. Starting it, when the photocell has appropriate light incident on it, its resistance is low and current is high. When the light is interrupted partially or completely then the current reduces due to increase in resistance.

RESULT:

Conducted transducer measurement using photocell.

DATE:

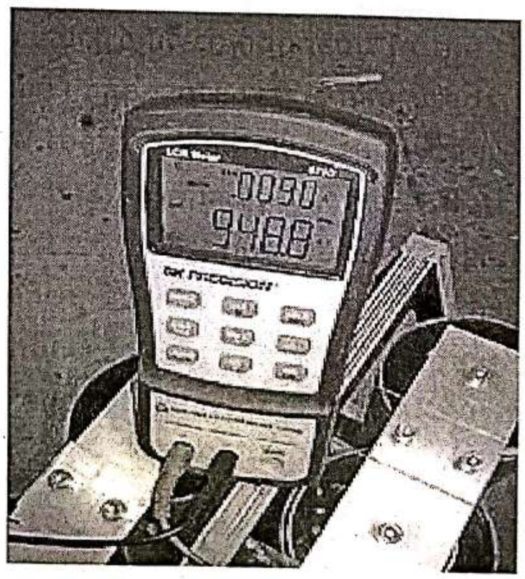
EXPERIMENT NO:

STUDY OF DIGITAL LCR METER

AIM: To Familiarize digital LCR meter

DESCRIPTION:

An LCR meter is a type of electronic test equipment used to measure the inductance (L), capacitance (C), and resistance (R) of an electronic component. In the simpler versions of this instrument the impedance was measured internally and converted for display to the corresponding capacitance or inductance value. Readings should be reasonably accurate if the capacitor or inductor device under test does not have a significant resistive component of impedance. More advanced designs measure true inductance or capacitance, as well as the equivalent series resistance of capacitors and the Q factor of inductive components.



Usually the device under test (DUT) is subjected to an AC voltage source. The meter measures the voltage across and the current through the DUT. From the ratio of these the meter can determine the magnitude of the impedance. The phase angle between the voltage and current is also measured in more advanced instruments; in combination with the impedance, the equivalent capacitance or inductance, and resistance, of the DUT can be calculated and displayed. The meter must assume either a parallel or a series model for these two elements. An ideal capacitor has no characteristics other than capacitance, but there are no physical ideal capacitors. All real capacitors have a little inductance, a little resistance, and some defects causing inefficiency. These can be seen as inductance or resistance in series with the ideal capacitor or in parallel with it. And so likewise with inductors. Even resistors can have inductance (especially if they are wire wound types) and capacitance as a consequence of the way they are constructed. The most useful assumption, and the one usually adopted, is that LR measurements have the elements in series (as is necessarily the case in an inductor's coil) and that CR measurements have the elements in parallel (as is necessarily the case between a capacitor's 'plates'). Leakage is a special case in capacitors, as the leakage is necessarily across the capacitor plates, that is, in series.

An LCR meter can also be used to measure the inductance variation with respect to the rotor position in permanent magnet machines. (However, care must be taken, as some LCR meters will be damaged by the generated EMF produced by turning the rotor of a permanent-magnet motor; in particular those intended for electronic component measurements.)

Handhold LCR meters typically have selectable test frequencies of 100 Hz, 120 Hz, 1 kHz, 10 kHz, and 100 kHz for top end meters. The display resolution and measurement range capability will typically change with the applied test frequency since the circuitry is more

sensitive or less for a given component (ie, an inductor or capacitor) as the test frequency changes.

Bench top LCR meters sometimes have selectable test frequencies of more than 100 kHz. They often include options to superimpose a DC voltage or current on the AC measuring signal. Lower end meters might offer the possibility to externally supply these DC voltages or currents while higher end devices can supply them internally. In addition bench top meters typically allow the usage of special fixtures (ie, Kelvin wiring, that is to say, 4-wire connections) to measure SMD components, air-core coils or transformers.

RESULT: Familiarized and Studied LCR Meter.

DATE:

EXPERIMENT NO:

FREQUENCY SYNTHESIZER

AIM:

To familiarize the operation of Frequency synthesizer.

DESCRIPTION:

A frequency synthesizer is an electronic circuit that generates a range of frequencies from a single reference frequency. Frequency synthesizers are used in many modern devices such as radio receivers, televisions, mobile telephones, radiotelephones, walkie-talkies, CB radios, cable television converter boxes satellite receivers, and GPS systems. A frequency synthesizer may use the techniques of frequency multiplication, frequency division, direct digital synthesis, frequency mixing, and phase-locked loops to generate its frequencies. The stability and accuracy of the frequency synthesizer's output are related to the stability and accuracy of its reference frequency input. Consequently, synthesizers use stable and accurate reference frequencies, such as those provided by crystal oscillators.

The frequency generators are of two types.

1. One is free running frequency generators in which the output can be tuned continuously either electronically or mechanically over a wide frequency range. The generators discussed up till now are of this type.

2. The second is frequency generator with frequency synthesis technique. The synthesis means to use a fixed frequency oscillator called reference oscillator or clock and to derive the wide frequency range in steps from the output of the reference oscillator.

The stability and accuracy of free running frequency generator is poor while frequency synthesizers provide output which is arbitrarily selectable, stable and accurate frequency. The reference oscillator used in frequency synthesizers is generally precision crystal oscillator with an output at some cardinal frequency such as 10 MHz. Various signal processing circuits then operate in synchronism to provide a large choice of the output frequencies. Frequency synthesizer technology is now an accepted part of RF development and RF equipment. Synthesizers enable the flexible operation of high performance oscillators used in a variety of equipment from radio receivers and transmitters of all sorts to highly stable and flexible signal generators. Frequency synthesizers were not widely used until the 1970s. The reason for this was that prior to the introduction of RF capable integrated circuit technology, frequency synthesizers required a considerable amount of circuitry, and this meant that costs were very high. This put them out of the range of most applications. With the introduction of RF capable ICs, frequency synthesizer technology using phase locked loops became feasible, and with their advantages, their use became widespread.

Frequency synthesizer types / categories

There are several different types of categories of synthesizer. Each of them obviously has its own advantages and disadvantages. There are often choices that can be made about which type to choose

Direct: The direct forms of frequency synthesizer, are as the name suggests implemented by creating a waveform directly without any form of frequency transforming element. Direct techniques including forms of oscillator and mixer are used.

Direct Analogue Frequency Synthesis: This form of frequency synthesizer was sometimes called a mix-filter-divide architecture. The direct analogue frequency synthesizer gained this name because it accurately defines one of the more popular architectures for this form of synthesis. The direct analogue frequency synthesizer had several drawbacks: it required a considerable amount of critical circuitry which today does not lend itself to integration; the successive mix processes introduced significant numbers of spurious signals; the spurious signals required considerable levels of filtering, again adding to the cost. As a result, this type of frequency synthesis was only used as a last resort before the widespread availability of RF ICs and the possibility of utilising other forms of frequency synthesis.

Direct Digital Frequency Synthesis: Direct digital synthesizers, DDS are widely used now. They create the signal by having a stored version of the waveform required, and then advancing the phase in fixed increments. The phase advance increments determine the signal frequency that is generated.

<u>**Indirect:**</u> Indirect frequency synthesis is based around phase locked loop technology. Here the output signal is generated indirectly. In other words the final signal is generated by an oscillator that is controlled by other signals. In this way the signals used in creating the output are indirectly replicated by the output oscillator, thereby giving the name to this technique.

Indirect Analogue Frequency Synthesis: Indirect analogue frequency synthesis uses phase locked loop technology with a mixer placed between the voltage controlled oscillator and phase detector. This enables and offset frequency to be introduced into the loop.

Indirect Digital Frequency Synthesis: The indirect digital frequency synthesis techniques introduce a digital divider into the phase locked loop between the voltage controlled oscillator and the phase detector. The VCO runs at a frequency equal to the phase comparison frequency times the division ratio. By altering he division ratio, it is possible to alter the frequency of the output signal. Typically the comparison frequency is equal to the channel spacing required. This could be 100 of 50 kHz for an FM tuner, 25 or 12.5 kHz for professional mobile communications systems, etc. It could be much smaller for general radio applications

RESULT:

Familiarized the operation of Frequency synthesizer.

DATE:

EXPERIMENT NO:

SPECTRUM ANALYZER

AIM:

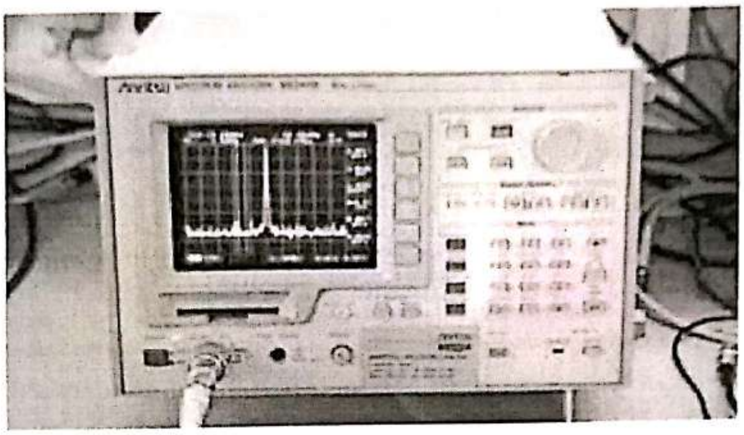
To familiarize the operation of Spectrum analyzer.

DESCRIPTION:

A spectrum analyzer measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. The primary use is to measure the power of the spectrum of known and unknown signals. The input signal that a spectrum analyzer measures is electrical; however, spectral compositions of other signals, such as acoustic pressure waves and optical light waves, can be considered through the use of an appropriate transducer. Optical spectrum analyzers also exist, which use direct optical techniques such as a monochromator to make measurements.By analyzing the spectra of electrical signals, dominant frequency, power, distortion, harmonics, bandwidth, and other spectral components of a signal can be observed that are not easily detectable in time domain waveforms. These parameters are useful in the characterization of electronic devices, such as wireless transmitters.The display of a spectrum analyzer has frequency on the horizontal axis and the amplitude displayed on the vertical axis. To the casual observer, a spectrum analyzer looks like an oscilloscope and, in fact, some lab instruments can function either as an oscilloscope or a spectrum analyzer.

Today there are several different types of spectrum analyzer technology that can be used. Selecting the required type of spectrum analyzer enables the best test instrument to be chosen for the given application, whilst also not incurring an unnecessary outlay.

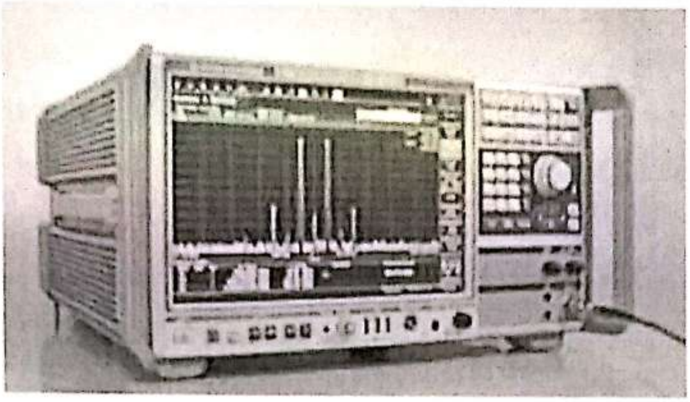
Swept or superheterodyne spectrum analyzer: A swept or superheterodyne spectrum analyzer is the traditional form of test instrument. This type of spectrum analyzer formed the mainstay of spectrum analysis testing for many years and relied on analogue techniques in the main until recent years. Although many modern types of spectrum analyzer include a down-conversion to place the signal into the required range for digitising the signal, they use digital techniques in the main. The older swept types of spectrum analyzer rely on analogue techniques.



Superheterodyne / swept type of spectrum analyzer

Using analogue techniques it converts the frequency down to a fixed intermediate frequency which has filters of the required bandwidths. These can be switched to the required value. The scan is generated by a saw tooth generator that drives the scan across the screen at the same time as varying the local oscillator linearly across the frequency band. The amplitude of the signal at any frequency is displayed in the vertical axis

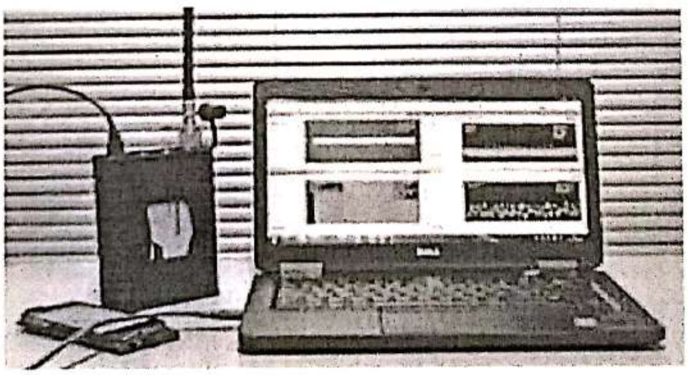
- **Digital FFT spectrum analyzer:** Digital technology is now widely used in spectrum analyzers. It is more cost effective and can provide better performance than ones using all analogue techniques. In a digital spectrum analyzer, the signals are converted into a digital format, and the signals analysed using Fast Fourier Transforms, FFTs. The signals are then converted into a format to be displayed or analysed further by a test system.
- **Real time spectrum analyzer:** A real time spectrum analyzer is one in which the manipulation of the FFTs is undertaken very fast, i.e. virtually in real time. This enables many signals to be captured and detected that may not otherwise be visible.



Real time spectrum analyzer

This form of analyzer continually captures a band of frequencies which it then analyses to display the spectrum - capturing a whole band at once enables transient effects to be seenPXI spectrum analyzer: Many test instruments are available in a PXI format. PXI is a standard in which test instruments are contained on a card that can be incorporated into a PXI rack. PXI, or PCI extensions for Instrumentation is a rack format that is widely used for test instrumentation, data acquisition and control.

- **USB spectrum analyzer:** Many lower cost instruments have been developed that are connected to a PC via a USB interface. This enables them to use the processing power of the computer to perform the processing and display the results, thereby saving a considerable degree of cost.



Typical USB spectrum analyzer

- **Handheld spectrum analyzer:** Spectrum analyzer are also made in small handheld formats. This type of spectrum analyzer obviously does not have the same performance as the larger bench top instruments. However this type of spectrum analyzer is very useful for field service applications where radio or wireless transmissions or other radio frequency signals need to be monitored and the spectrum needs to be checked.

Typical handheld type of spectrum analyzer

- **Audio analyzer:** This type of spectrum analyzer is focussed on analysing audio spectra. As such their upper frequency limits are much lower.

These are the most widely used forms of spectrum analyse that are available. Although the swept spectrum analyzer using only analogue techniques is largely out dated, some are still available on the second hand market and are still able to provide good service.

RESULT:

Familiarized the operation of Spectrum analyzer.

DATE:

EXPERIMENT NO:

LOGIC STATE ANALYSER

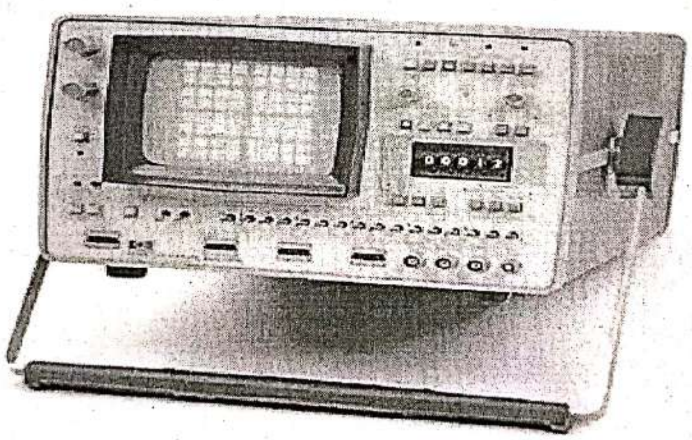
AIM

To familiarize the operation of logic state analyser

DESCRIPTION

Logic analyzers or logic analysers are widely used for testing complex digital or logic circuits. Although oscilloscopes can perform many of the functions of a logic analyser, the analyzer is more suited to operating in a digital environment because it is able to display relative timing of a large number of signals. Essentially a logic analyser enables traces of logic signals to be seen in such a way that the operation of several lines in a digital circuit can be monitored and investigated.

Logic analysers come in a variety of formats. One of the most popular is a typical test instrument case. However it is also possible to utilise the processing power of a computer and PC based logic analysers are available.



Logic analyser key characteristics

There are several key characteristics of a logic analyser that separate it from multi-channel oscilloscopes and other test instruments:

- Provide a time display of logic states: Logic analysers possess a horizontal time axis and a vertical axis to indicate a logic high or low states. In this way a picture of the digital lines can be easily displayed.
- Multiple channels: Logic analyzers are designed to monitor a large number of digital lines. As logic analyzers are optimised for monitoring a large number of digital circuits, typically they may have anywhere between about 32 and 200+ channels they can monitor, each channel monitoring one digital line. However some specialised logic analyzers are suitably scaled to be able to handle many more lines, and in this way enable tracking and fault finding on much more complex systems.
- Displays logic states: The vertical display on the analyser displays the logic state as a high of low state. The signals enter the various channels and are converted into a high or low state for further processing within the analyser. It provides a logic timing diagram of the various lines being monitored.
- Does NOT display analogue information : These test instruments do not present any analogue information, and in this way they differ from an oscilloscope. They are purely aimed at monitoring the logic operation of the system. If any analogue information is required, then an oscilloscope must be used in addition.

Logic analyser types

There are some main categories into which most logic analyzers can be split:

- Modular logic analyzers : This type of logic analyser is probably what may be thought of as the most typical form of test instrument, although it is the highest cost option providing the highest level of functionality. It comprises a chassis and the various modules - including channel modules. The number of modules being larger for the higher channel counts.
- Portable logic analyzers : In a number of instances there may be a need for a smaller analyser, possibly for restricted budgets or for field service. These test instruments incorporate all elements of the analyser into a single box for ease of transportation.
- PC based logic analyzers: There is a growing number of PC based logic analysers. These consist of an analyser unit that is connected to a PC. USB is an obvious option for this, but Ethernet is also widely used because of its high speed. This form of PC based instrument uses the processing power of the PC combined with its display to reduce the cost of the overall system.

RESULT

Familiariesd the operation of logic state analyser.