Learning Report

Course : Electronics and Medical Devices

LTTS GLOBAL ENGINEERING ACADEMY

L&T Technology Services

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ABOUT THE COURSE

This course, Electronics and Medical Devices is very relevant in the present times. After the outbreak of Covid-19 in December 2019, health systems all over the globe were challenged. Reality of the health infrastructure was all in open, on the verge of collapsing. It has now become clear that the COVID 19 pandemic is going to put significant stress on our already limited healthcare resource.

What is the way forward, especially for India? Involving electronics and its surrounding modules into the process of transforming health sector post covid has its own importance. Reports say that there's huge scope for this, behind that huge scope lies small basics, this course deals with those basics.

LEARNING OUTCOMES

On completion of this course, one will be able to take away the following learnings:

- Overview of electronics in Medical Devices:
  - Types of Biomedical Equipment
  - Building blocks of Biomedical Equipment
  - Building blocks of commonly used Biomedical Equipment
    a. Electronic Stethoscope
    b. Digital BP Monitor
    c. Pulse Oximeter
    d. Digital Temperature Monitor

- LTSpice:
  - Installation and configuration
  - Understanding the interface
  - Schematics
  - Simulation of schematics
  - Challenges

- Communication Protocols:
  - What are communication protocols and its applications?
  - Commonly used communication protocols
  - Working

CONTENT

Activity 1 (Team): Overview of electronics in Medical Devices

Aim: To learn about the types of Biomedical equipment's and the building blocks of Biomedical equipment's in general and commonly used equipment's in specific.

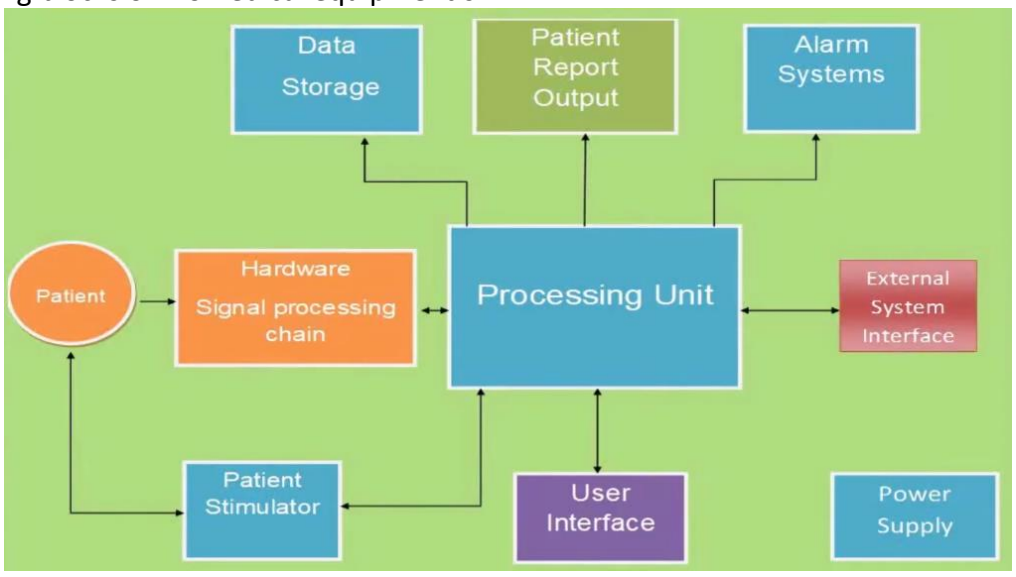
Types of Biomedical equipment's:

a) Diagnostic Equipment
b) Durable Medical Equipment (DME)
c) Treatment Equipment
d) Life Support Equipment
e) Medical Laboratory Equipment

Uses of Biomedical equipment's:

a) Biomedical Equipment are now used for quick diagnosis, flawless surgery, and therapeutics.
b) Use of a malfunctioning BME could result in faulty diagnosis and wrong treatment.
c) BMEs are used with machines to diagnose and treat diseases.

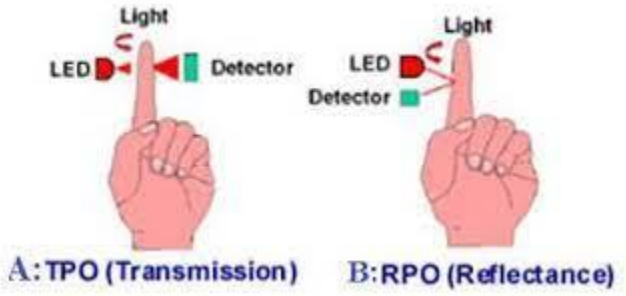
Basic building blocks of Biomedical equipment's:



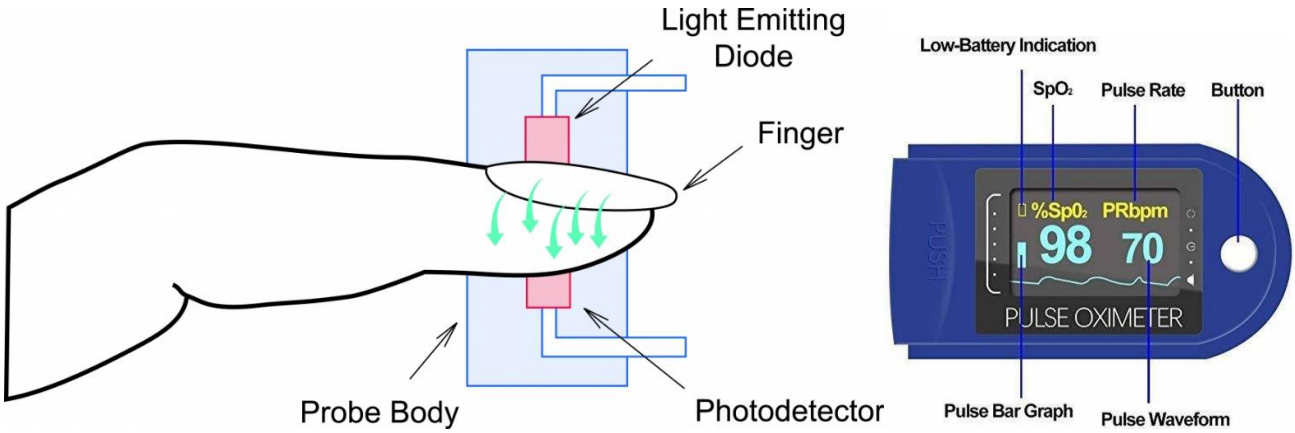
©E2ESolutions

Building blocks of the commonly used Biomedical equipment's:

Pulse Oximeter: A pulse oximeter is a tiny device that usually slides over your fingertip or clips on your earlobe and uses infrared light refraction to measure how well oxygen is binding to your red blood cells. Oximeters report blood oxygen levels via an oxygen saturation measurement called peripheral capillary oxygen saturation, or SpO2.



Types of pulse oximeter(©ResearchGate)



Working of pulse oximeter(©ResearchGate)

Observation	Oxygen saturation (SpO2) %	Pulse rate (bpm)	Temp (°C)
Normal readings	96% or more	40-100	36.5-37.5
Acceptable to continue home monitoring	95%	101-109	38
Seek advice from your GP	93-94%	110-130	38.1-39
Need urgent medical advice – call 999	92% or less	131 or more	39 or more

Levels of pulse oximeter(©RidgMountPractice)

High Level details:

a) Pulse oximeter measures oxygen saturation by illuminating the skin and measuring changes in light absorption of oxygenated (oxyhaemoglobin) and deoxygenated blood (reduced haemoglobin) using two light wavelengths: 660 nm (red) and 940 nm (infrared).
b) Display the details on oximeter screen

Low Level details:

a) Emit red and infrared light - It is fortuitous that O2Hb and HHb have significant differences in absorption at red and near-IR light because these two wavelengths penetrate tissues well whereas blue, green, yellow, and far-IR light are significantly absorbed by non-vascular tissues and water.
b) Collect them using photodetector - Photodetectors, also called photosensors, are sensors of light which detects the penetrated light. Oxygenated and deoxygenated haemoglobin have different light absorption rate.

Limitations:

a) Not reliable in patients with poor circulation (e.g. peripheral vascular disease, hypothermia, critically ill pts)
b) Does not work through nail polish, dyes, or pigments.
c) Not reliable in patients that have an irregular pulse rate.
d) Shivering and movement give false readings.
e) There have been reports of skin burns (earlier models).

Vendors throughout the world:

a) Dr Trust USA Fingertip Pulse Oximeter
b) BPL Smart Oxy Lite Pulse Oximeter
c) Vandelay Electronic Fingertip Pulse Oximeter
d) Microtek Pulse Oximeter Health Care Appliance Combo
e) Zebronics Fingertip Pulse Oximeter FP0500

Learning outcomes:

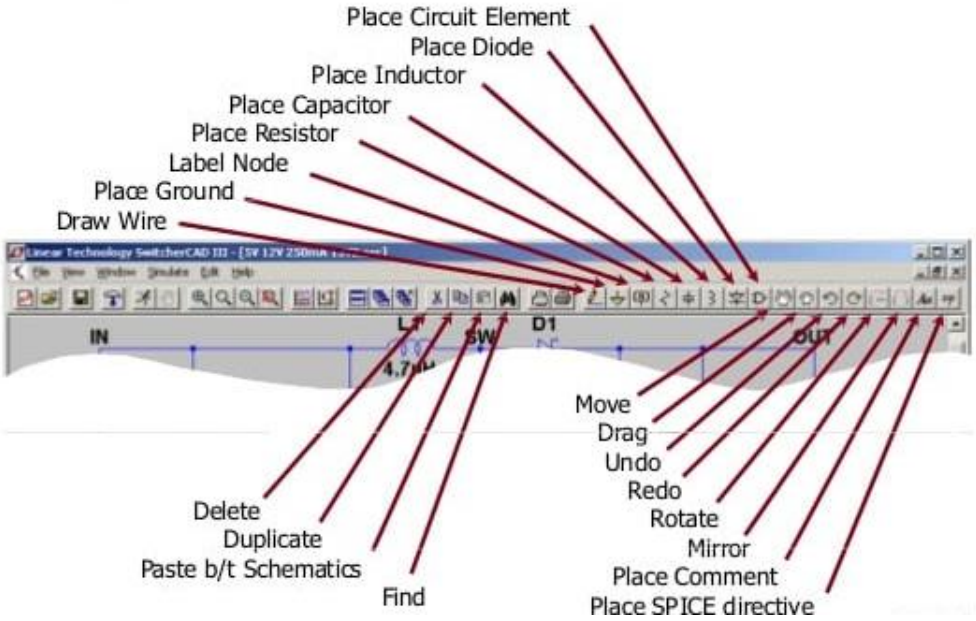
a) Insight about the biomedical devices and there building blocks
b) Deep dive about Pulse Oximeter

Challenges faced:

a) Understanding the building blocks of a biomedical device. Eventually got clarified.

Activity 2 (Team): LTSpice

Aim: To design a module (high level) of choice identified under common Biomedical equipment and do a circuit simulation of the same on LTSpice.



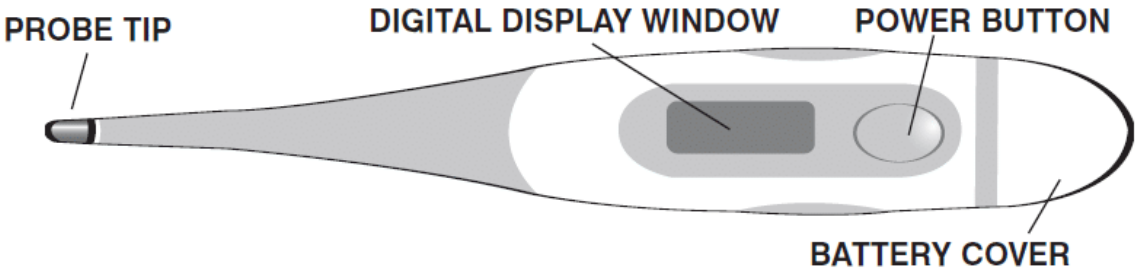
LTSpice Toolbar overview (©SlideShare)

Module: Electronic Thermometer

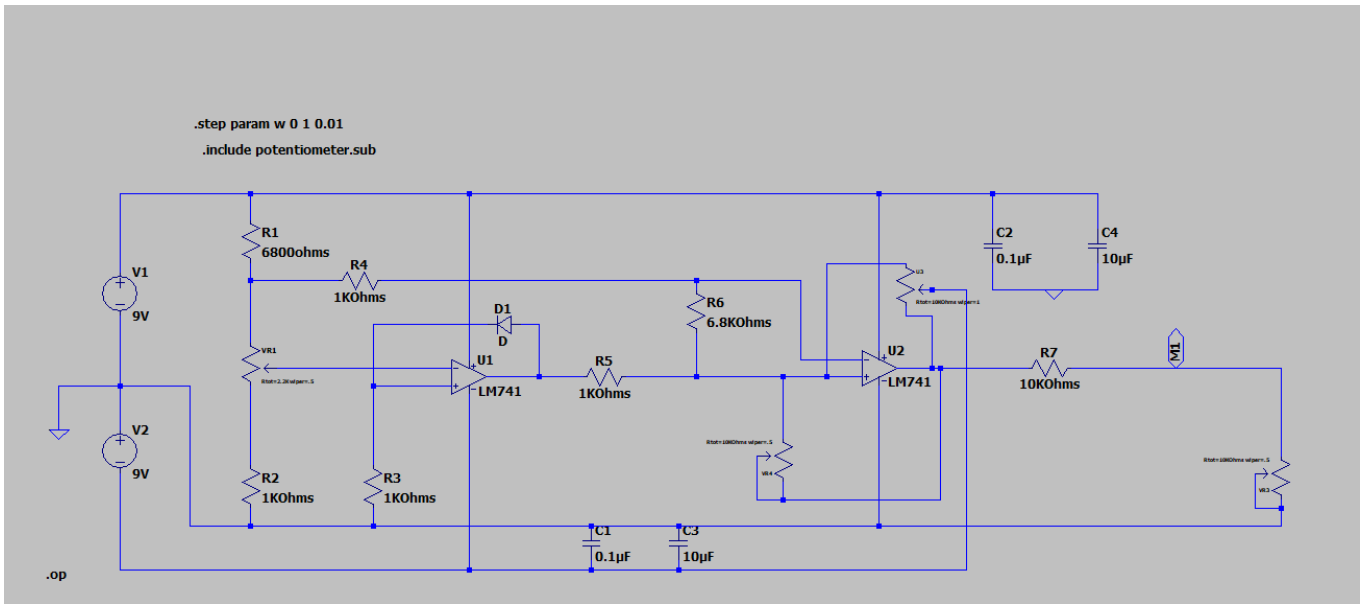
Electronic thermometers detect temperature changes. The voltage drops across the diode changes with a change in temperature. At room temperature, the voltage drop across the diode is 0.7V and reduces at the rate of 2mV/degree Celsius. This voltage change is sensed by the operational amplifier. The output of the operation depends upon the voltage drop across the diode.

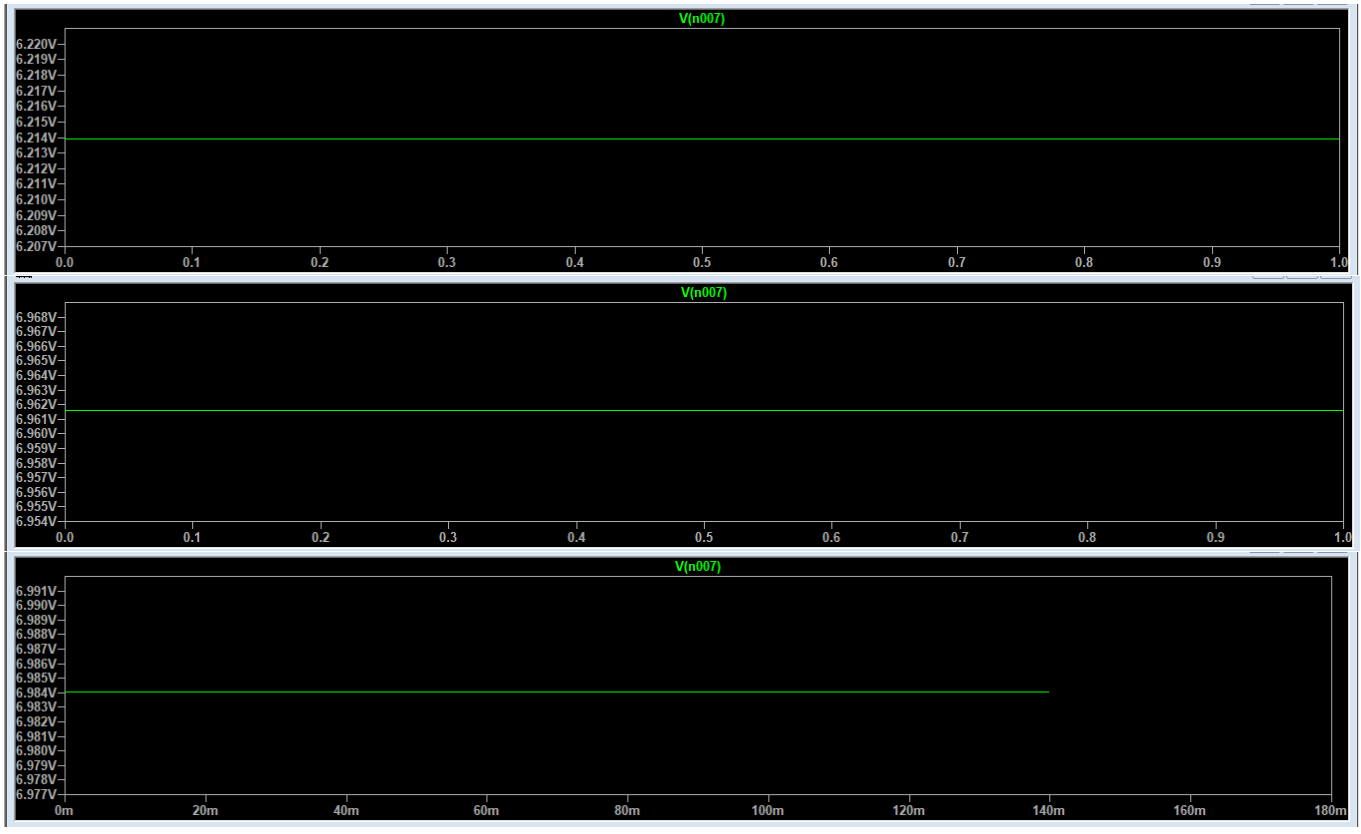
Components: Resistors, capacitors, variable resistors, ammeter, opamp and diode.

Circuit diagram and graphs at different potential of variable resistor (at 100%, 50% and 10% respectively):



Thermometer (©Manuals.plus)


.step param w 0 1 0.01
.include potentiometer.sub
R1
6800ohms
R4
1KOhms
V1
9V
D1
D
R6
6.8KOhms
C2
0.1µF
C4
10µF
U3
VR1
U1
LM741
R5
1KOhms
U2
LM741
R7
10KOhms
M1
V2
9V
R2
1KOhms
R3
1KOhms
C1
0.1µF
C3
10µF
.op


V(n007)
6.220V
6.219V
6.218V
6.217V
6.216V
6.215V
6.214V
6.213V
6.212V
6.211V
6.210V
6.209V
6.208V
6.207V
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
V(n007)
6.968V
6.967V
6.966V
6.965V
6.964V
6.963V
6.962V
6.961V
6.960V
6.959V
6.958V
6.957V
6.956V
6.955V
6.954V
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
V(n007)
6.991V
6.990V
6.989V
6.988V
6.987V
6.986V
6.985V
6.984V
6.983V
6.982V
6.981V
6.980V
6.979V
6.978V
6.977V
0m
20m
40m
60m
80m
100m
120m
140m
160m
180m

Leading vendors:

a) Omron
b) Vandelay
c) Yuwell
d) Dr Trust (USA)

Learning outcomes:

a) LTSpice installation
b) Thermometer and types of thermometer
c) Creating circuit(schematic) on LTSpice
d) Usage of features like label
e) Adding extra components according to requirement
f) Simulating the circuit according to requirement

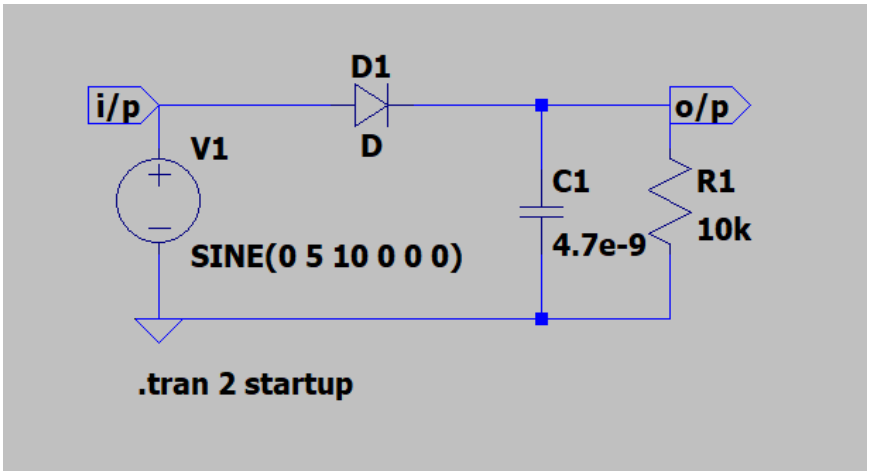
Challenges faced:

a) Adding components from external source. Got clarified after referring to a source (mentioned in the reference section.)

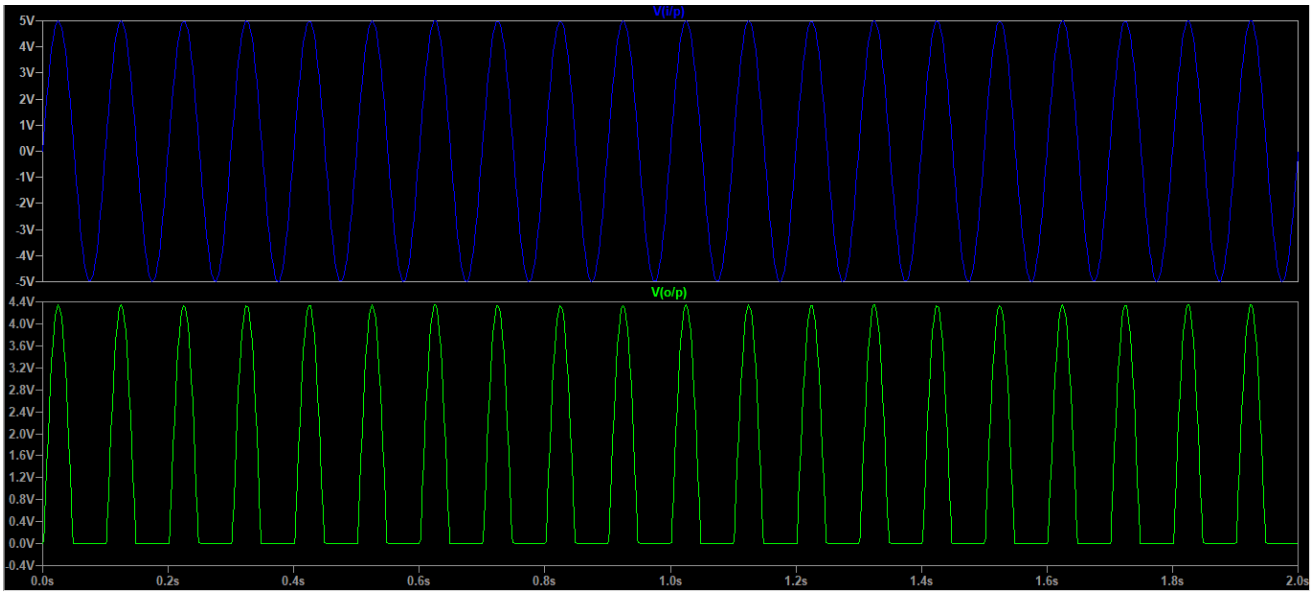
Activity 3 (Induvial): LTSpice

Aim: To design and simulate the circuits in LTSpice.

a) **Half wave bridge rectifier:** A rectifier is a device that converts alternating current (AC) to direct current (DC). It is done by using a diode or a group of diodes. A half wave rectifier is defined as a type of rectifier that only allows one half-cycle of an AC voltage waveform to pass, blocking the other half-cycle. Since diodes restrict the flow of current to one direction, they can be used to convert an AC power supply, which switches polarity from + to - many times a second, into a straight DC supply.

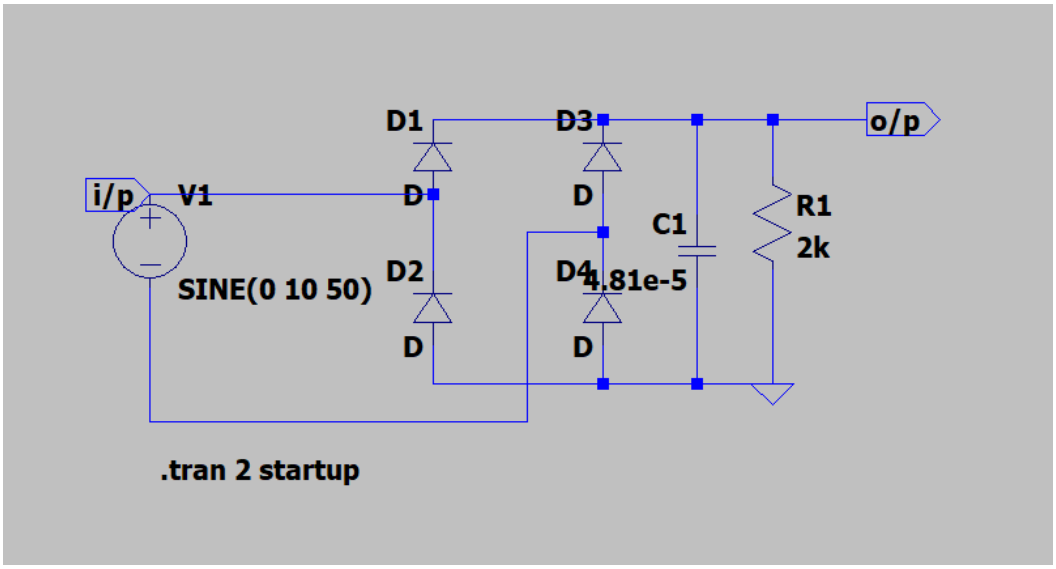


Half wave bridge rectifier circuit

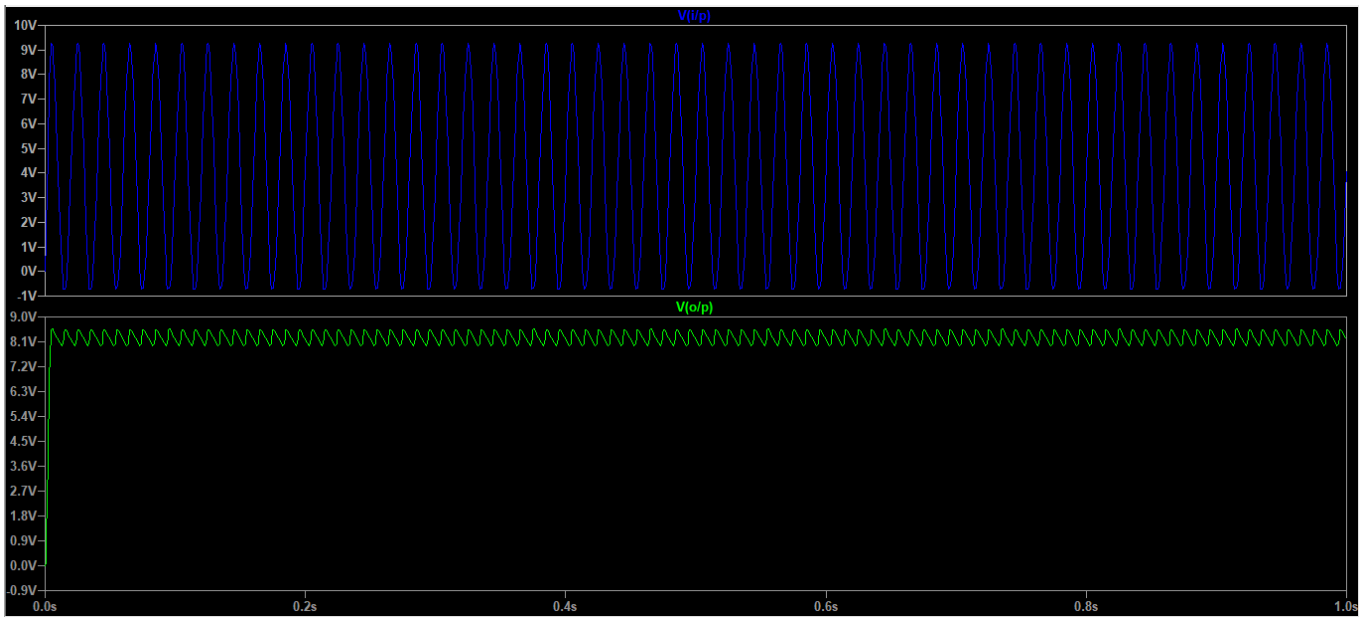


Half wave bridge rectifier graph

b) **Full wave bridge rectifier:** To rectify both half-cycles of a sine wave, the bridge rectifier uses four diodes, connected in a "bridge" configuration. The secondary winding of the transformer is connected on one side of the diode bridge network and the load on the other side.

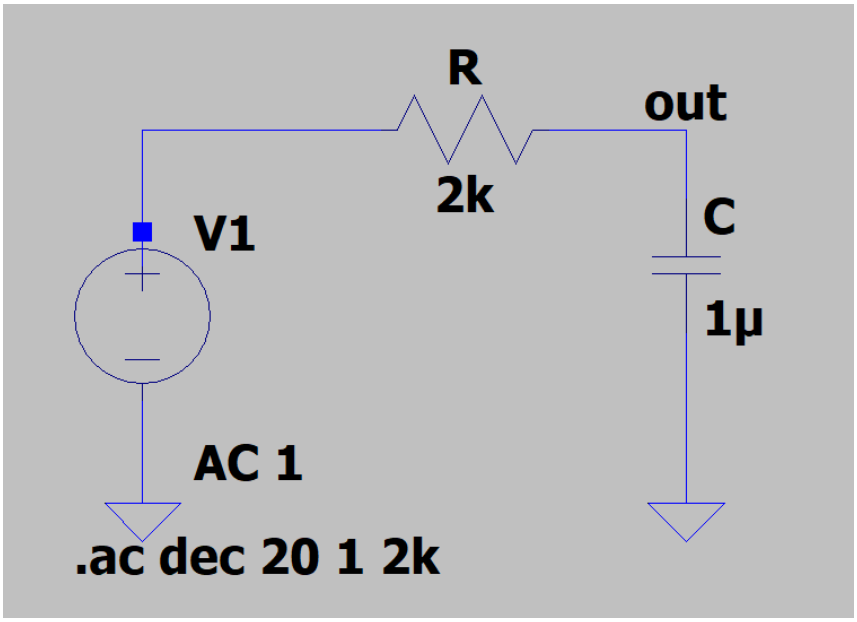


Full wave bridge rectifier circuit

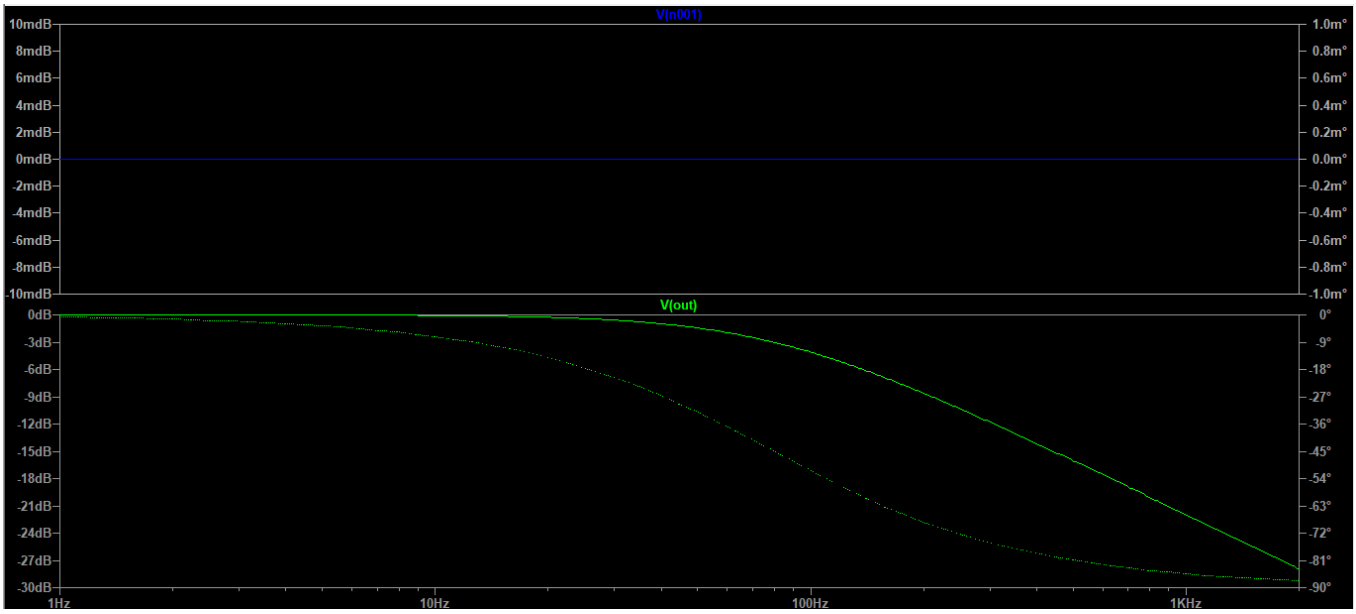


Full wave bridge rectifier graph

c) **Low pass filter:** A low-pass filter is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The exact frequency response of the filter depends on the filter design. fc=1/2pi*r*c

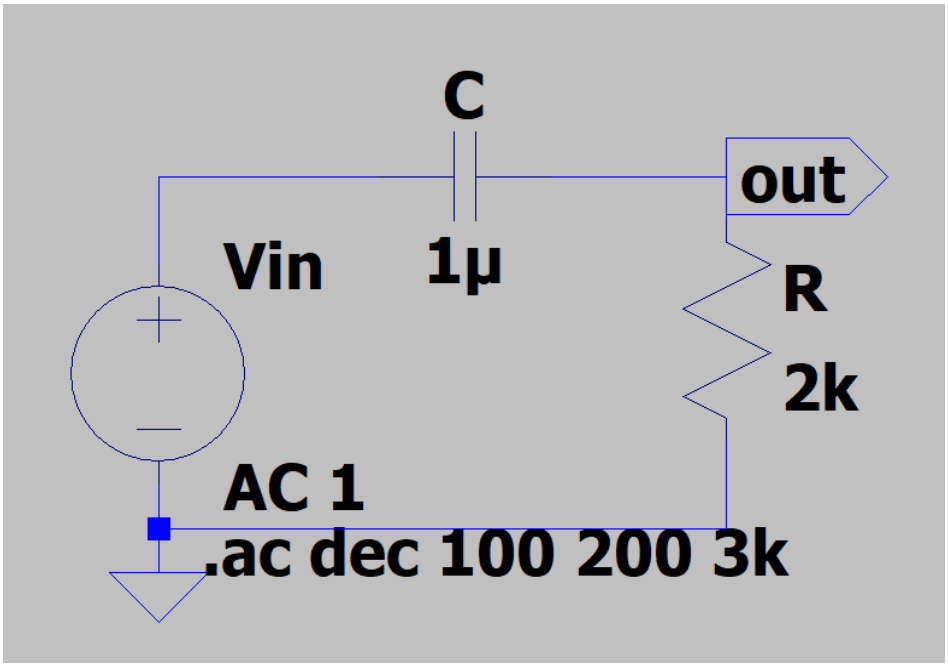


Low pass filter circuit

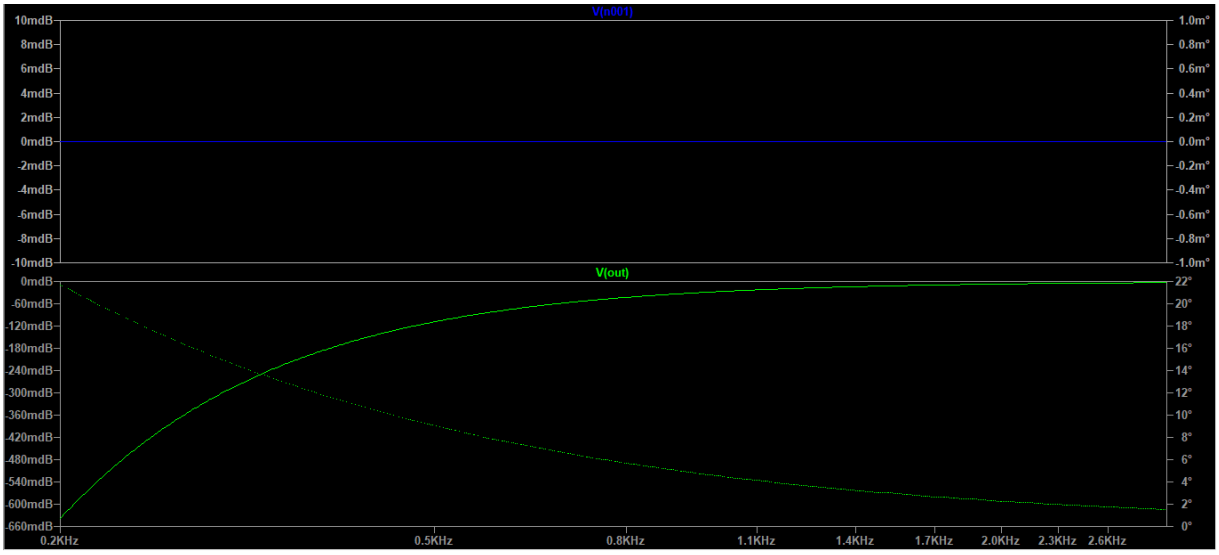


Low pass filter graph

d) **High pass filter:** A high-pass filter (HPF) is an electronic filter that passes signals with a frequency higher than a certain cutoff frequency and attenuates signals with frequencies lower than the cutoff frequency. High pass filter is used to remove unwanted sounds near to the lower end of the audible range.

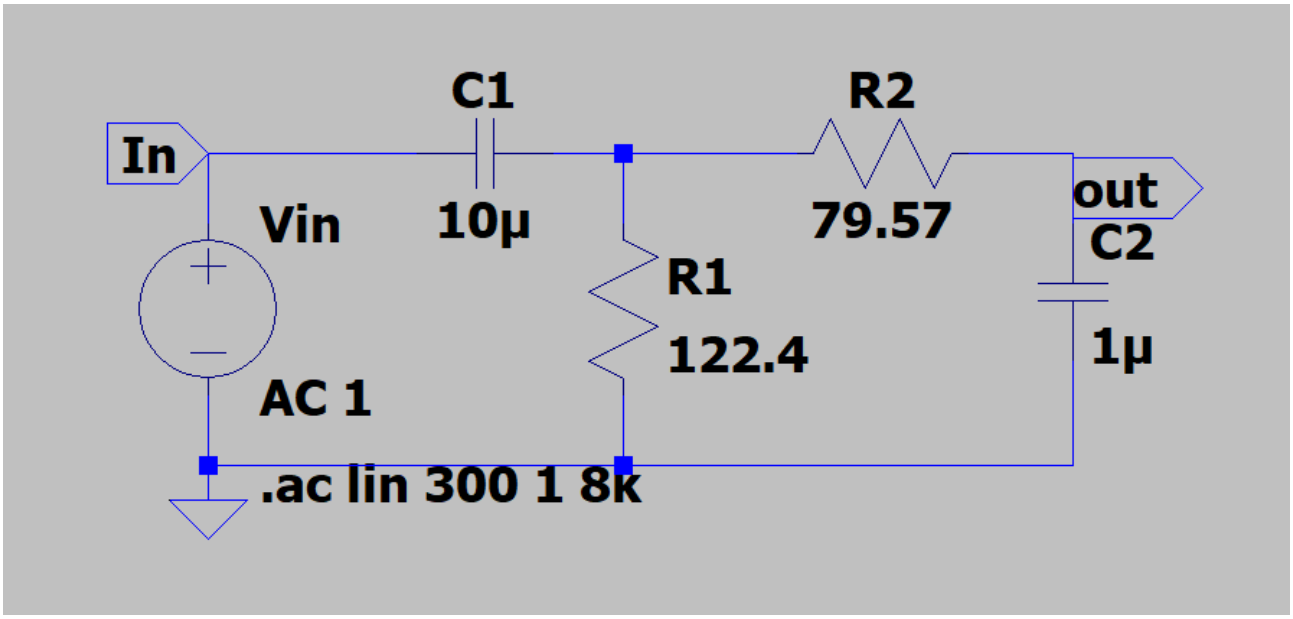


High pass filter circuit

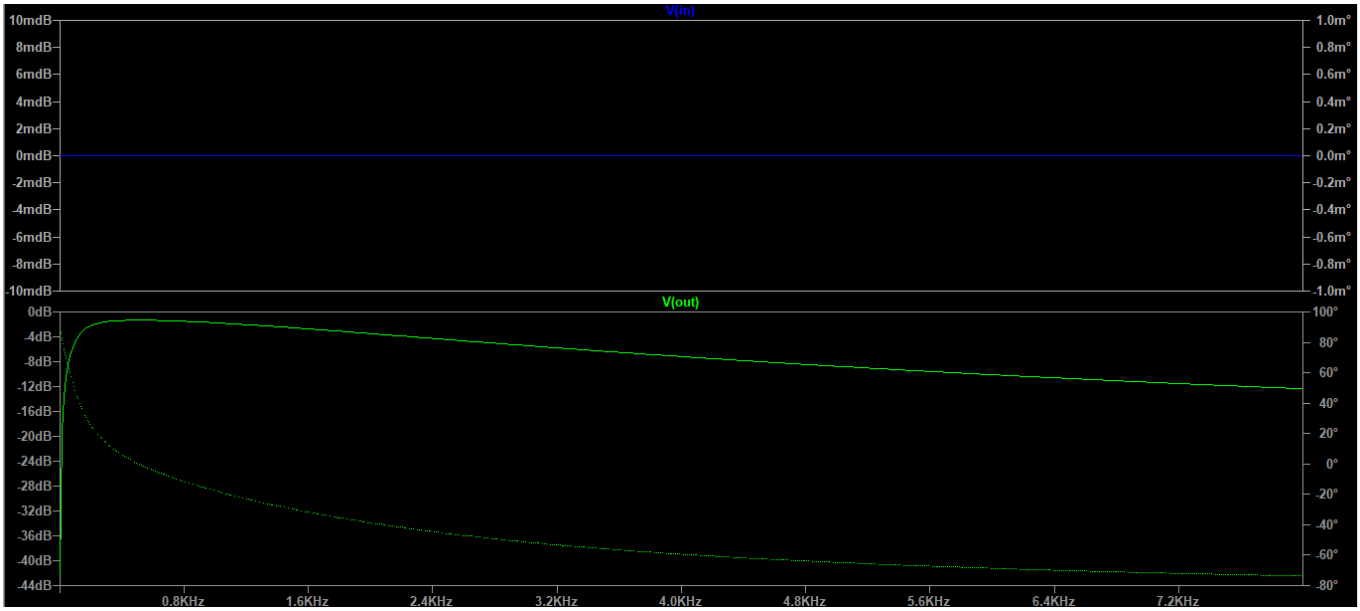


High pass filter graph

e) **Band pass filter:** Bandpass filters are widely used in wireless transmitters and receivers. The main function of such a filter in a transmitter is to limit the bandwidth of the output signal to the band allocated for the transmission. This prevents the transmitter from interfering with other stations.

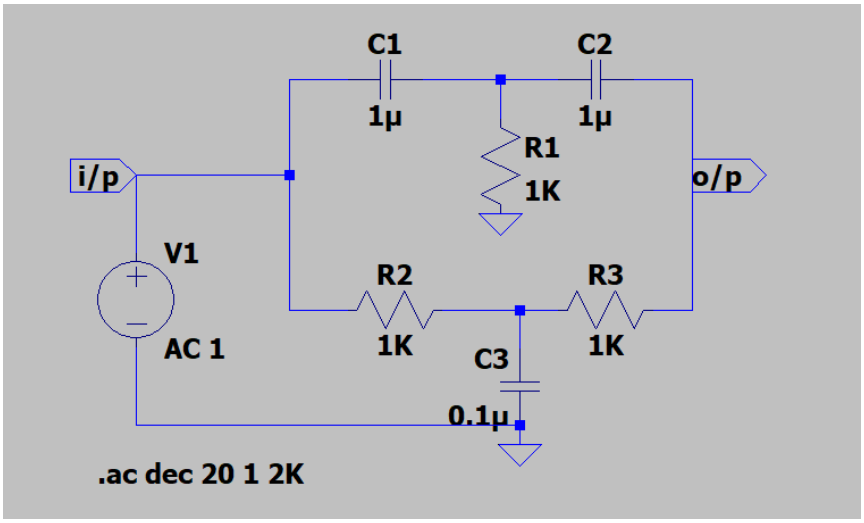


Band pass filter circuit

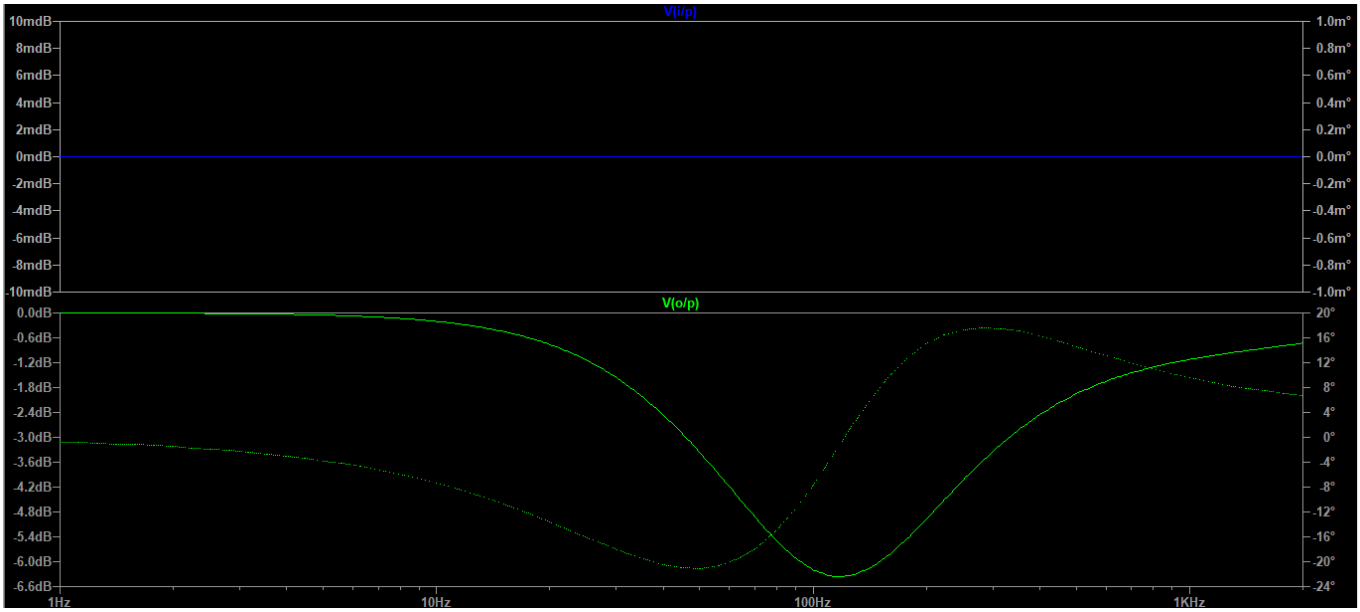


Band pass filter graph

f) **Band stop filter:** A Band Stop Filter, also sometimes called a notch or band reject filter allows a specific range of frequencies to not pass to the output, while allowing lower and higher frequencies to pass with little attenuation.



Band stop filter circuit

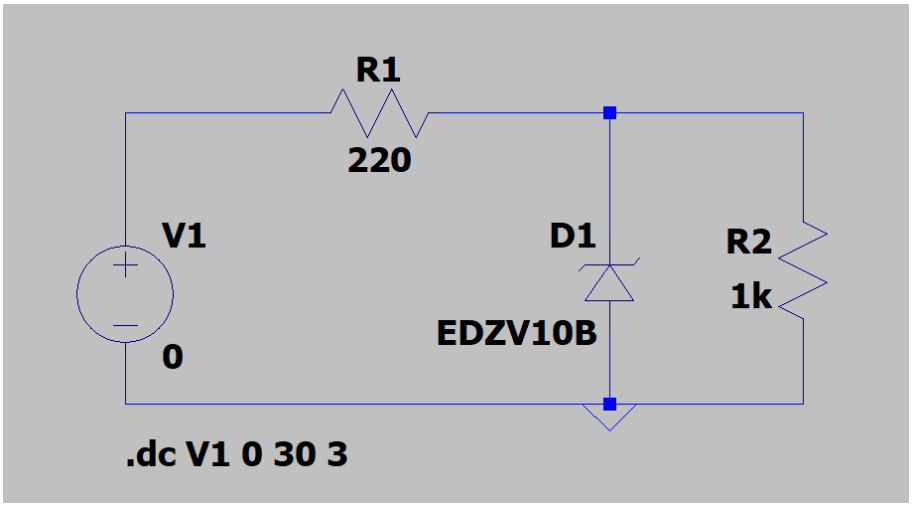


Band stop filter graph

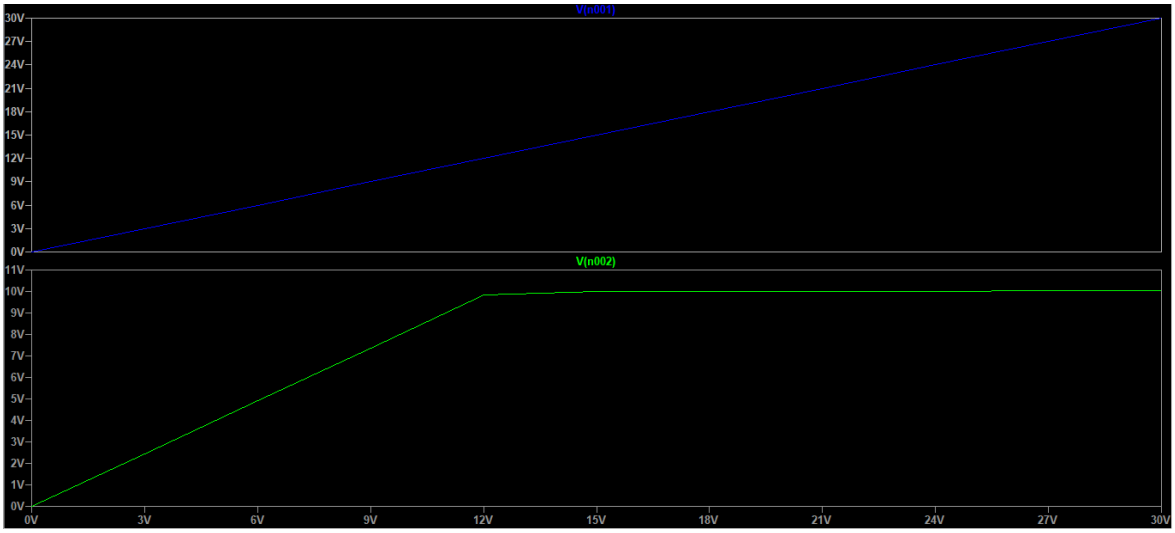
g) **Zener diode regulator:** A voltage regulator is a device that regulates the voltage level. It essentially steps down the input voltage to the desired level and keeps it at that same level during the supply. This ensures that even when a load is applied the voltage doesn't drop. The voltage regulator is used for two main reasons, and they are:

1. To vary or regulate the output voltage
2. To keep the output voltage constant at the desired value despite variations in the supply voltage.

Voltage regulators are used in computers, power generators, alternators to control the output of the plant.



Zener diode regulator circuit



Zener diode regulator graph

Learning outcomes: Understood the interface of the LTSpice, making schematics and producing graphs according to requirement. Learnt to use label feature in the LTSpice.

Challenges faced: Adding external components required from external sources. Understood by referring to a source mentioned in reference section

Activity 4 (Team): Communication protocol

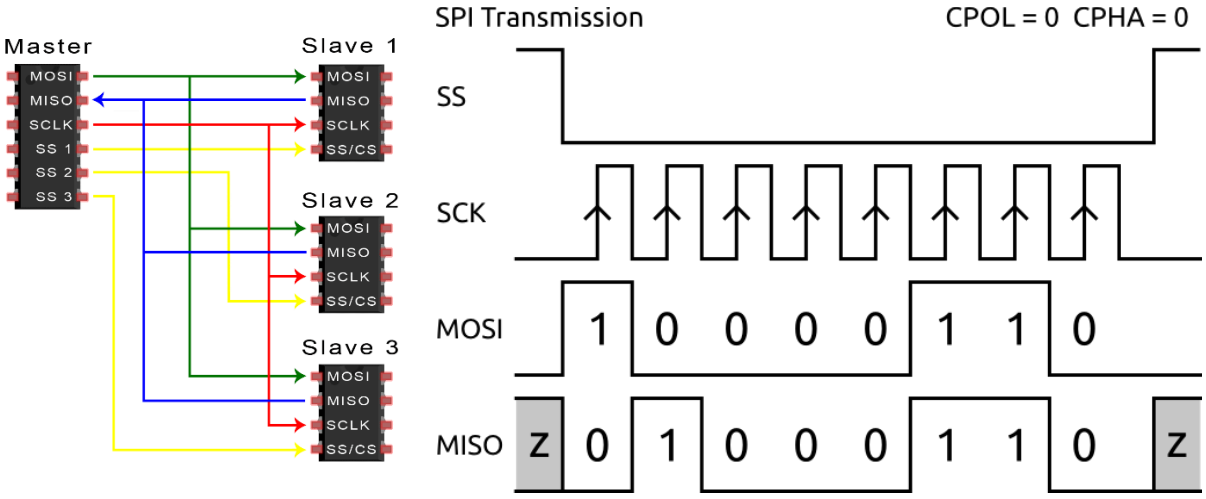
Aim: To understand the communication protocols and its functioning.

A communication protocol is a system of rules that allows two or more entities of a communications system to transmit information via any kind of variation of a physical quantity. The protocol defines the rules, syntax, semantics and synchronization of communication and possible error recovery methods. Protocols may be implemented by hardware, software, or a combination of both. Communicating systems use well-defined formats for exchanging various messages. Each message has an exact meaning intended to elicit a response from a range of possible responses pre-determined for that situation. In general, there are two types of communication protocols which are classified as inter system protocol and intra system protocol.

Communication protocols used commonly:

a) SPI
b) I2C
c) UART
d) USART
e) USB
f) Ethernet

SPI Communication Protocol: Developed by Motorola to provide synchronous serial communication between master and slave. **Serial Peripheral Interface**, or SPI, is a very common communication protocol used for two-way communication between two devices. A standard SPI bus consists of 4 signals, Master Out Slave In (MOSI), Master In Slave Out (MISO), the clock (SCK), and Slave Select (SS). Unlike an asynchronous serial interface, SPI is not symmetric. An SPI bus has one master and one or more slaves. The master can talk to any slave on the bus, but each slave can only talk to the master. Each slave on the bus must have its own unique slave select signal. The master uses the slave select signals to select which slave it will be talking to.



Data transmission in SPI Communication Protocol (©AllAboutElectronics)

Advantages and disadvantages of SPI protocol:

Advantages	**Disadvantages**
• It has very simple hardware interfacing.	• It supports only one master device. No inter-slave communications.
• Not limited to any maximum clock speed, enabling potentially high speed	• No error checking protocol.
• It's faster and requires low power than I2C. Ex: SPI 10-20Mbps, I2C 3.4Mbps	• SPI usually requires separate SS lines to each slave, which can be problematic if numerous slaves are needed.
• It supports multiple slaves	

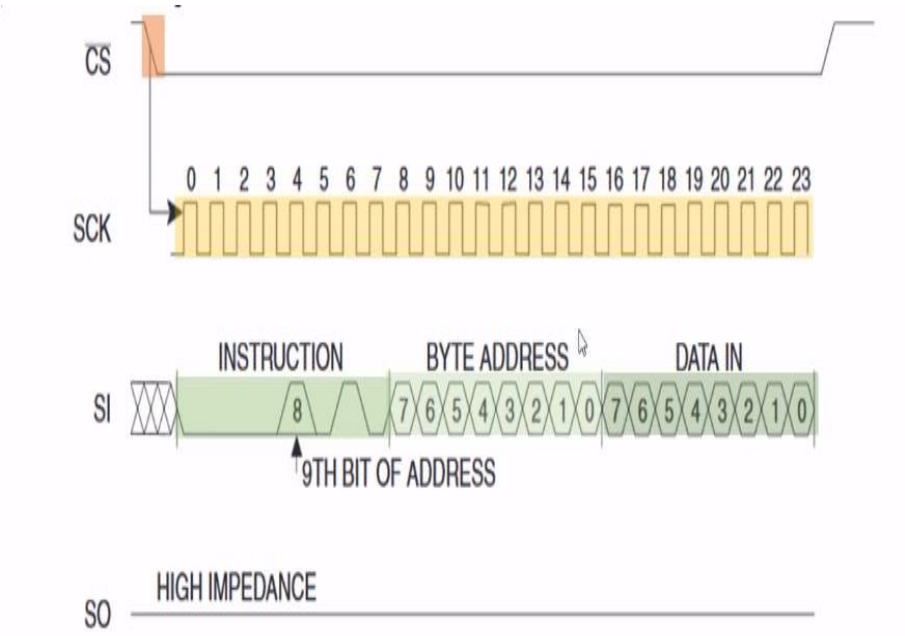
Data transmission:

Selecting slave (SS->0) ---->

Clock Signal ---->

SI ---->
Instruction 10 signifies **write**
Byte Address (MSB-Left)
Data to be sent (MSB-Left)

SO ---->
Not reading anything in this case.



Modes of SPI:

CPOL - Clock Polarity
CPOL - 0 (Active state = 1)
CPOL - 1 (Active state = 0)

CPHA - Clock Phase
CPHASE - 0 (Data sampling a leading edge)
CPHASE - 1 (Data sampling a trailing edge)

	Clock Starting Position	Data is received on the
SPI Mode 0	Low	Falling edge of the clock
SPI Mode 1	Low	Rising edge of the clock
SPI Mode 2	High	Falling edge of the clock
SPI Mode 3	High	Rising edge of the clock

SPI Modes (©AllAboutElectronics)

Applications of SPI:

a) It is used in MMC or SD card.
b) It is used to talk to a variety of peripherals such as sensors i.e. temperature and pressure, analog to digital converter (ADC), digital to analog converter (DAC).
c) It is used in real time clocks.
d) It is used in LCD and LED.
e) It is also used in video games.

Learning outcomes:

a) A brief understanding of communication protocols
b) Functioning of SPI protocol
c) Advantages and disadvantages of SPI Protocol

Challenges faced:

a) Understanding the data transmission working SPI protocol. Got clarified after referring to a source (mentioned in the reference section.)

LEARNING SUMMARY

In this module, the learnings were:

a) Understanding the Biomedical Equipment's and its types. High level and low-level details of biomedical equipment's. Also got idea about the working of pulse oximeter.
b) Installation of LTSpice, adding additional requirements from external sources, plotting the graphs. Understood the interface of LTSpice to get familiarize. Understood the bridges and filters, selection of components.
c) Got an idea about the communication protocols, common protocols used in present time. Got an understanding on SPI communication protocol, its functioning, applications of SPI and its advantages and disadvantages.

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-How pulse oximeter works?
https://www.youtube.com/watch?v=N3MCvREORVA

-Getting started with LTSpice
https://www.youtube.com/watch?v=JRcyHuyb1V0

-SPI Protocol
https://www.youtube.com/watch?v=qyHaiDMf7p4