Project Report

I, Chirdeep Singh Reen, currently pursuing my B.Tech. from NSIT, New Delhi in Instrumentation and Control engineering interned at LASTEC Lab (DRDO) from 13th June 2018 to 31st July 2018 under the able guidance of Scientist (E) Chandra Prakash.

During this time period I worked on some electronic circuits which helped me strengthen my foundation and concepts and learn new and interesting topics which further developed my interest in the field.

I am highly grateful to all the scientists and staff that helped me in my training. It was a great learning experience that was provided by DRDO and I look forward to interning again at DRDO.

The work done by me has been summarised below.

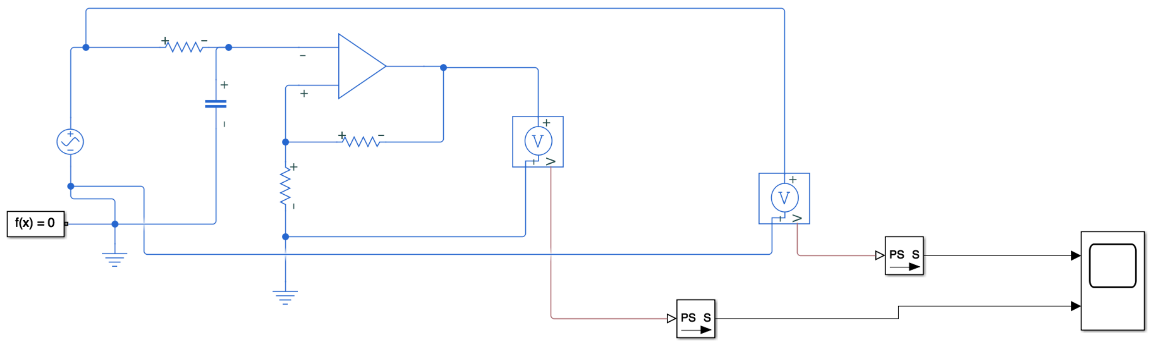
Thanking you
Chirdeep Singh Reen
9599435660

Contents

LOW PASS FILTER

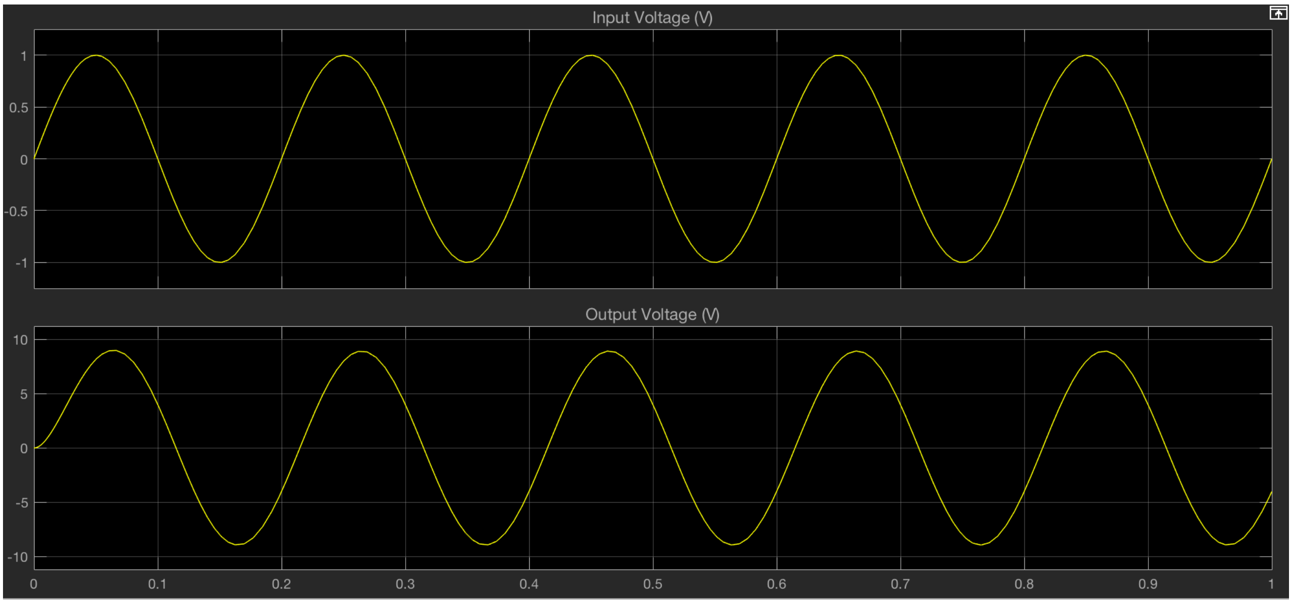
Design of a Low Pass Filter which has Cutoff Frequency = 10Hz and Gain = 10.

Circuit Diagram :

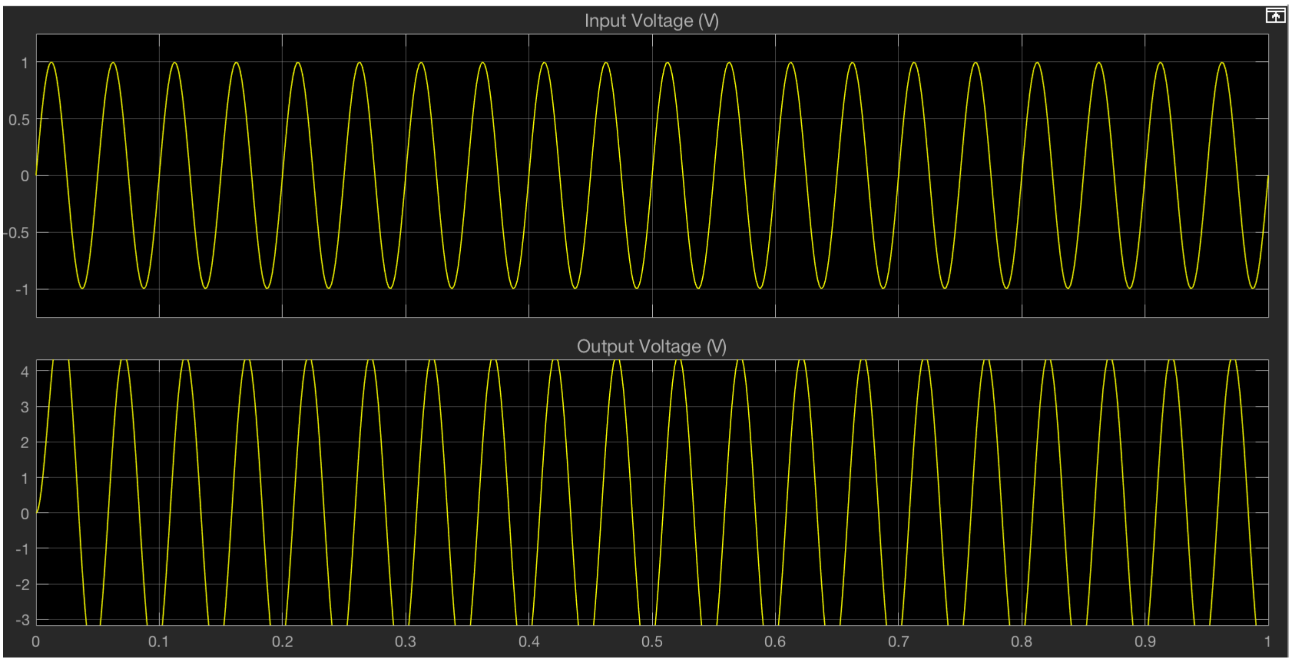


Output Waveforms :

i) Input Frequency = 5Hz



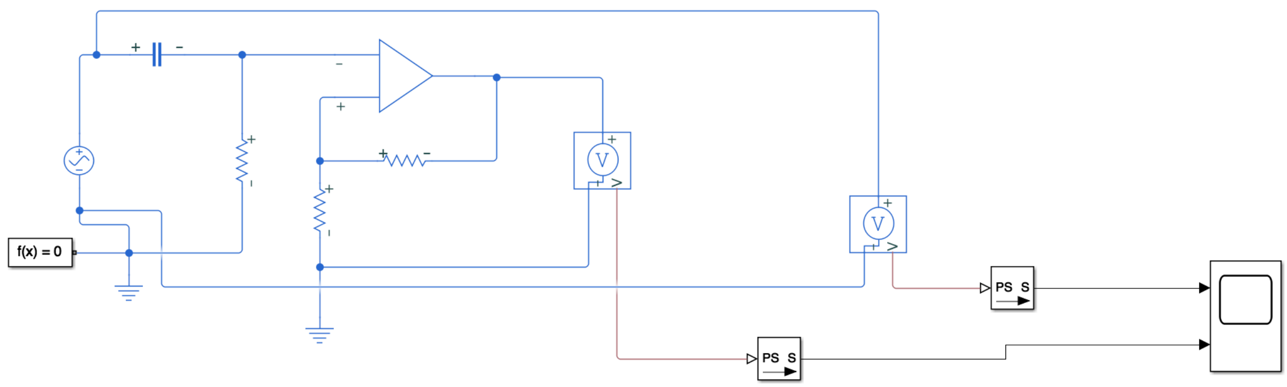
ii) Input Frequency = 20Hz



HIGH PASS FILTER

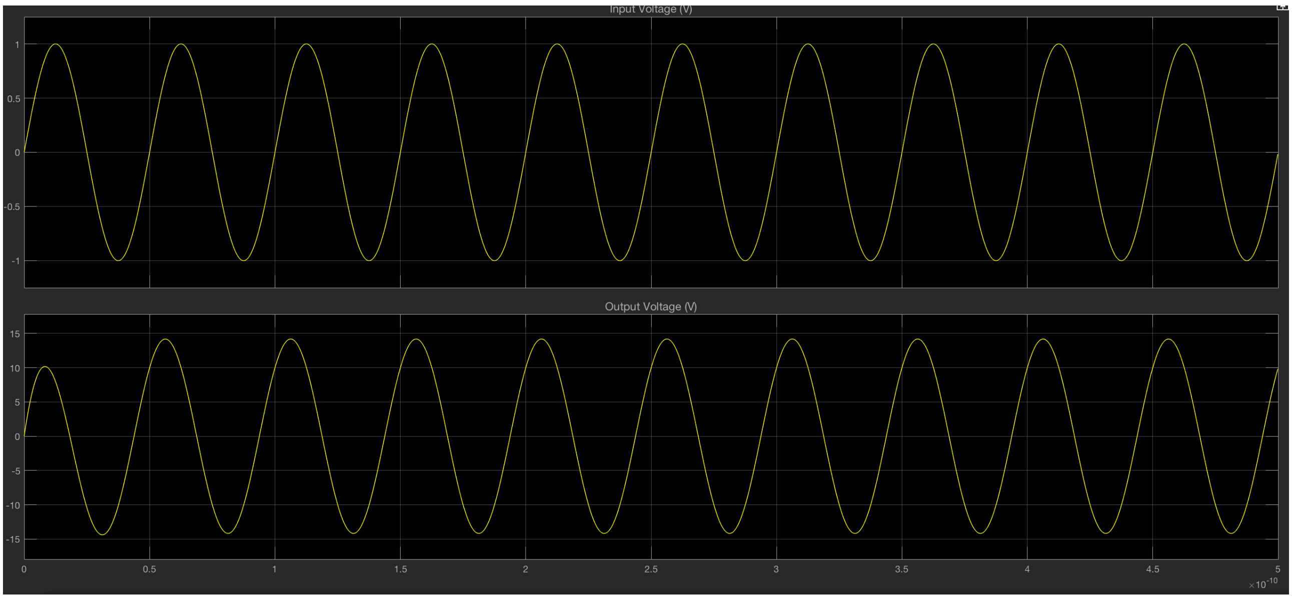
Design of a High Pass Filter which has Cutoff Frequency = 20Ghz and Gain=20

Circuit Diagram :

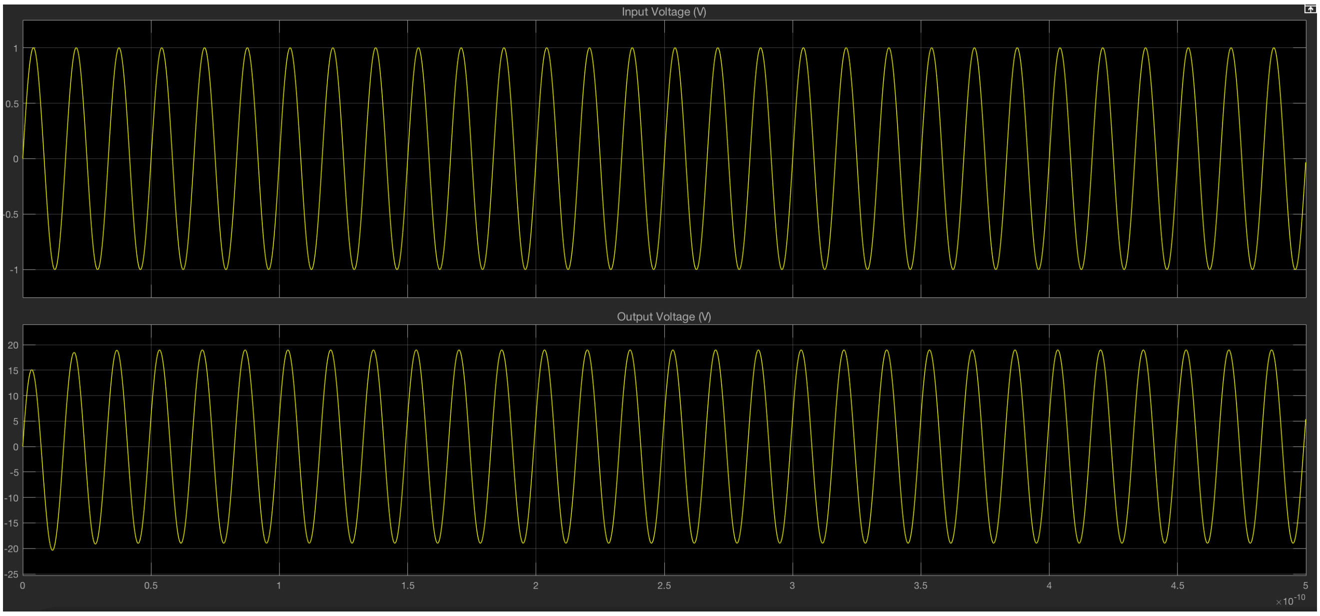


Output Waveforms :

i) Input Frequency = 20GHz



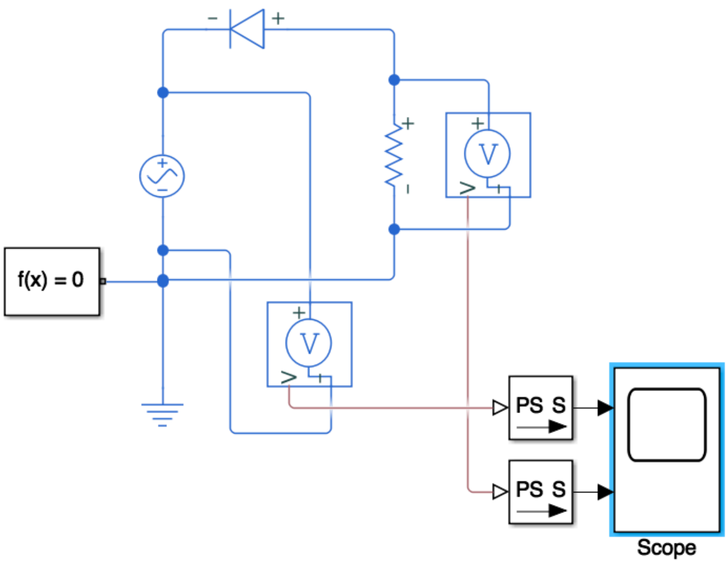
ii) Input Frequency = 60GHz



CLIPPER

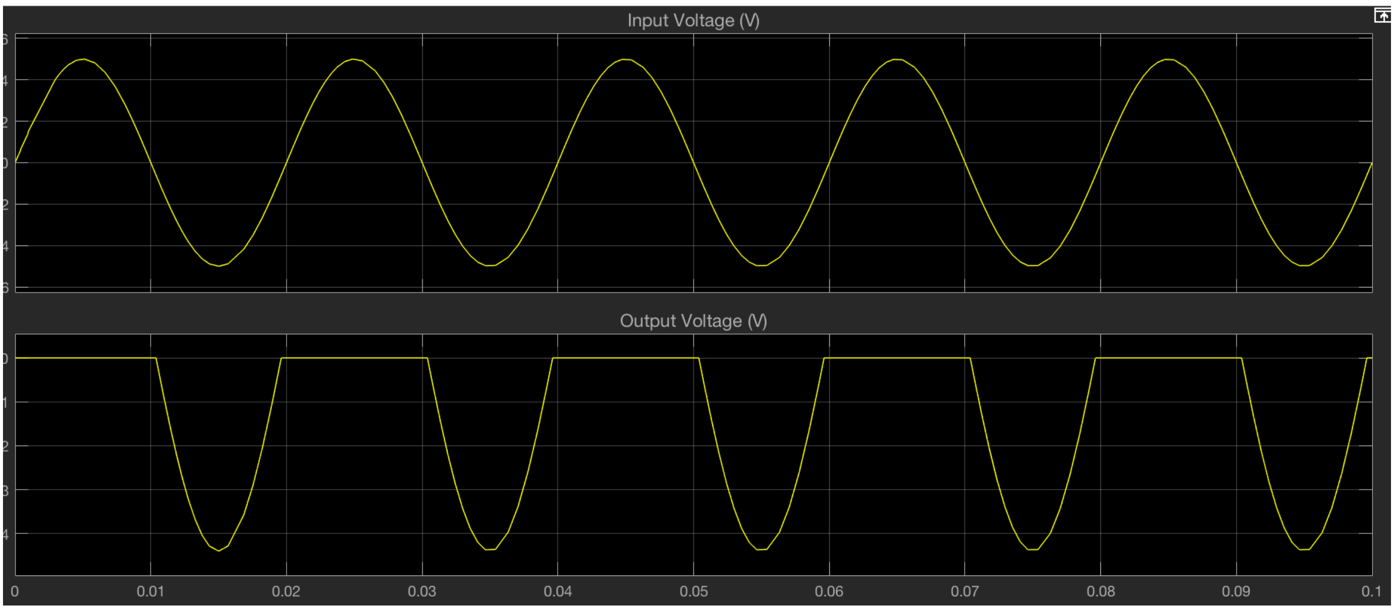
Positive Clipper :

Circuit Diagram :



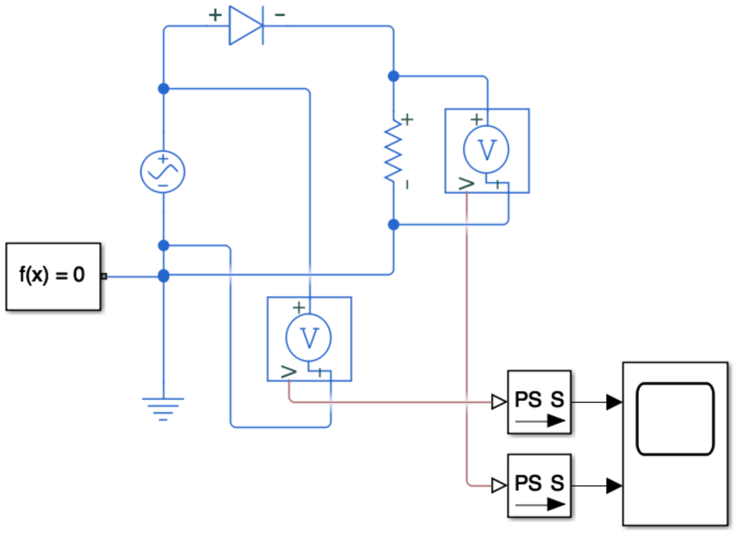
Positive Clipper Circuit

Output Waveform :



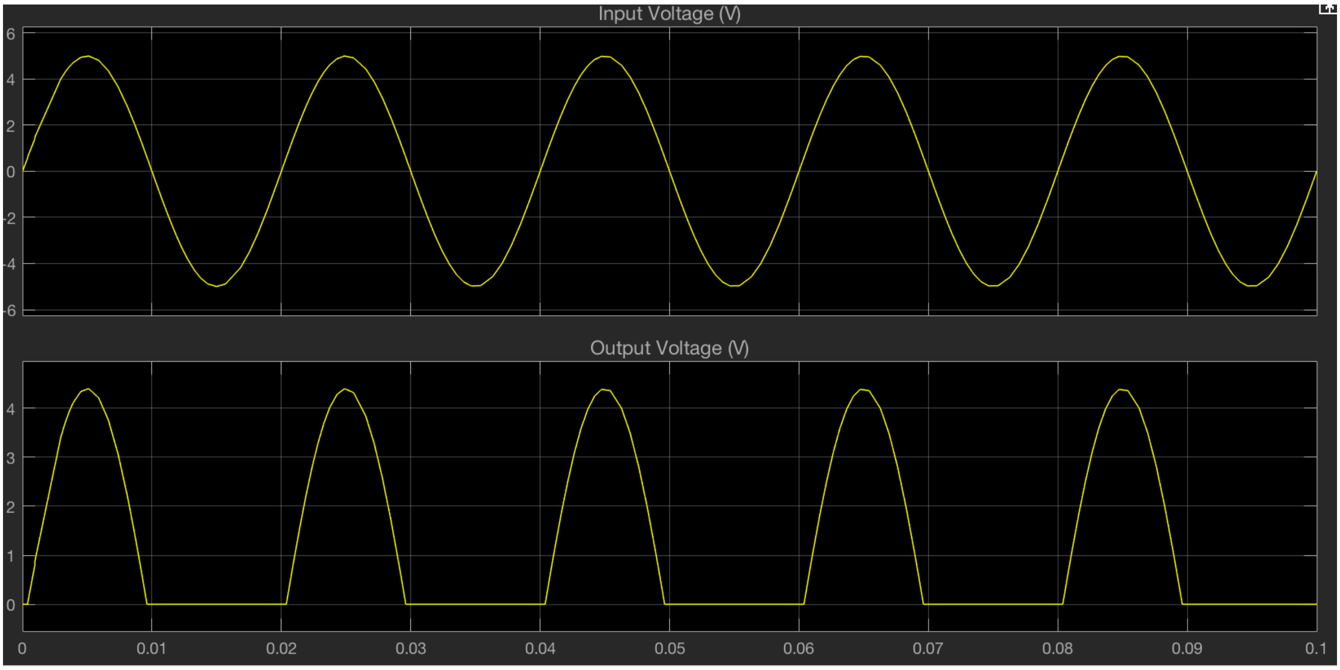
Negative Clipper :

<u>Circuit Diagram :</u>



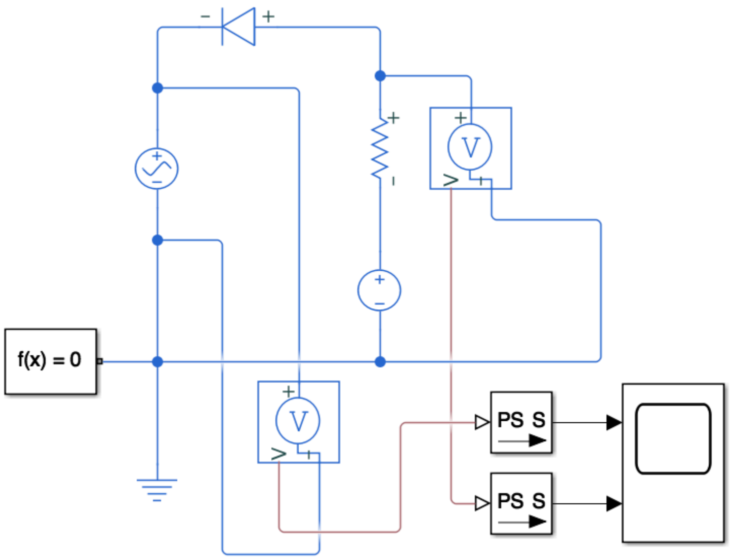
Negative Clipper Circuit

<u>Output Waveform :</u>



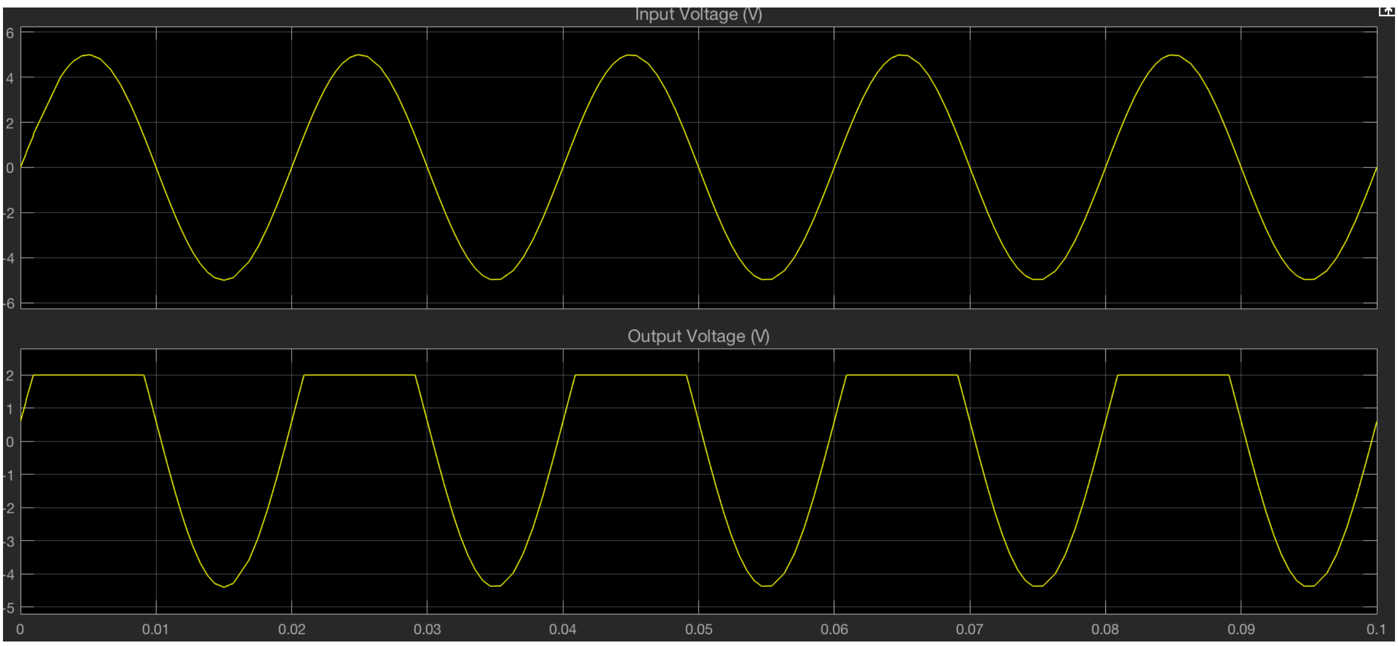
Positive Clipper with Positive external bias :

Circuit Diagram :



Positive Clipper Circuit iwth Positive Bias

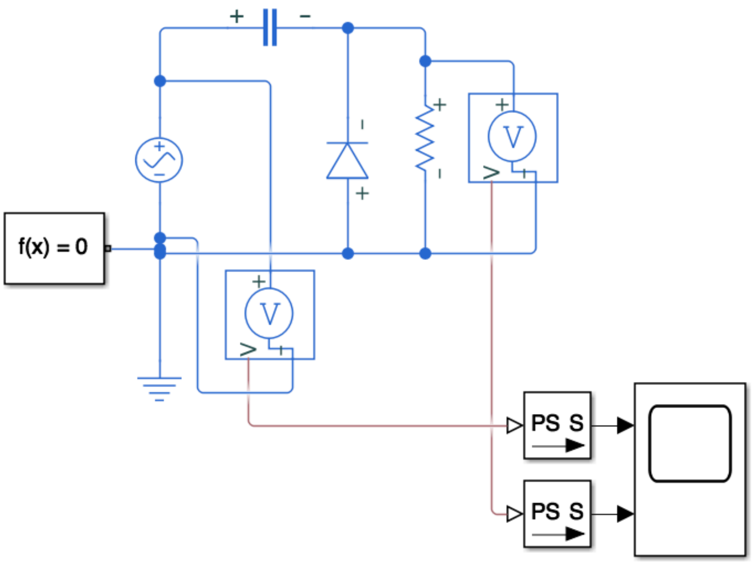
Output Waveform :



CLAMPER

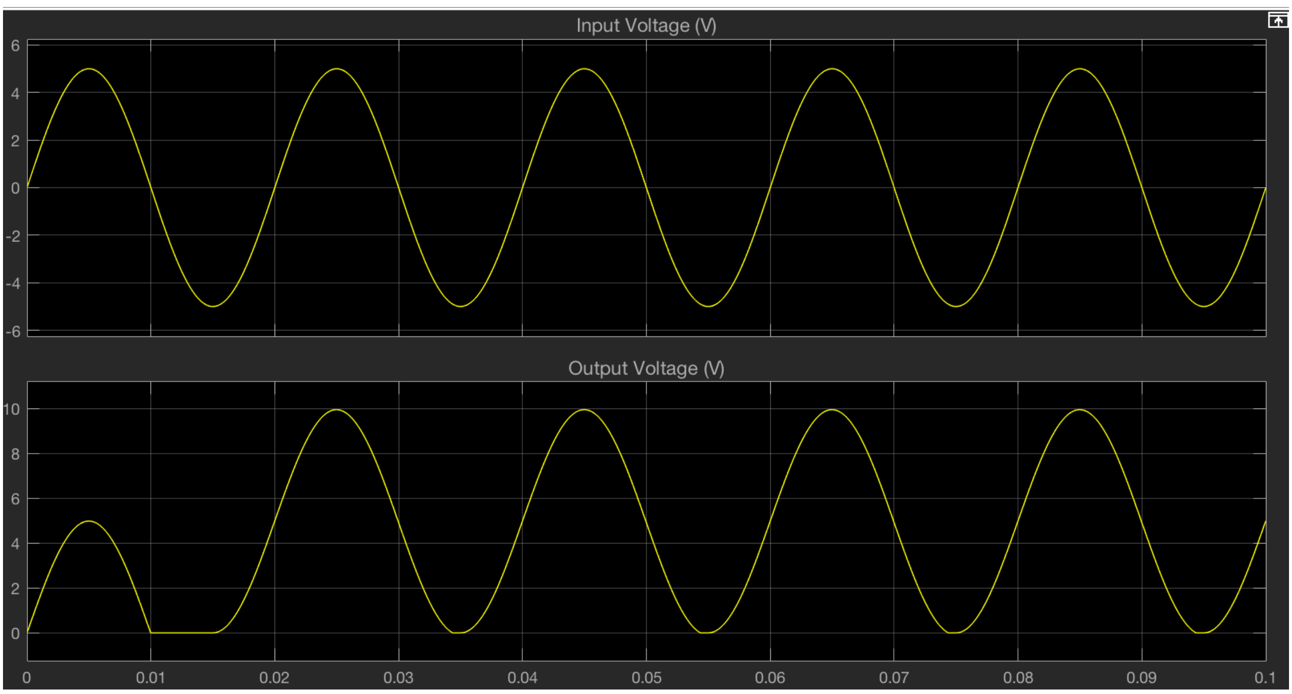
Positive Clamper :

Circuit Diagram :



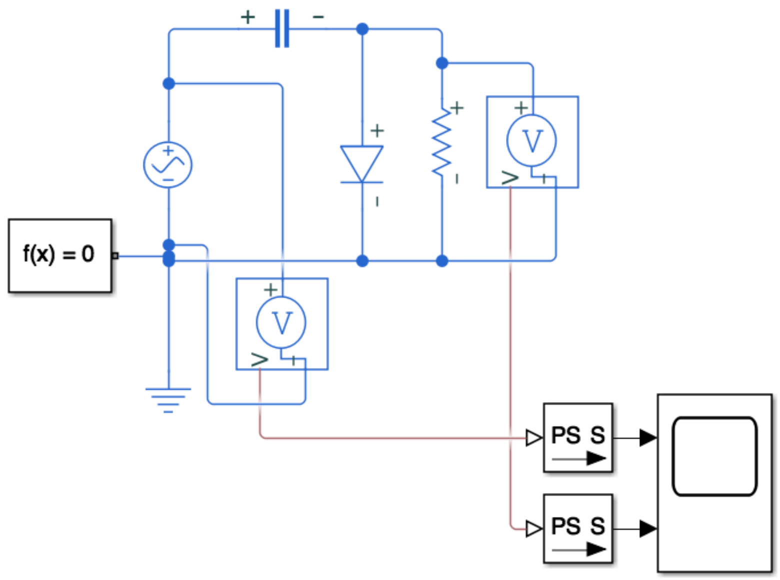
Positive Clamper Circuit

Output Waveform :



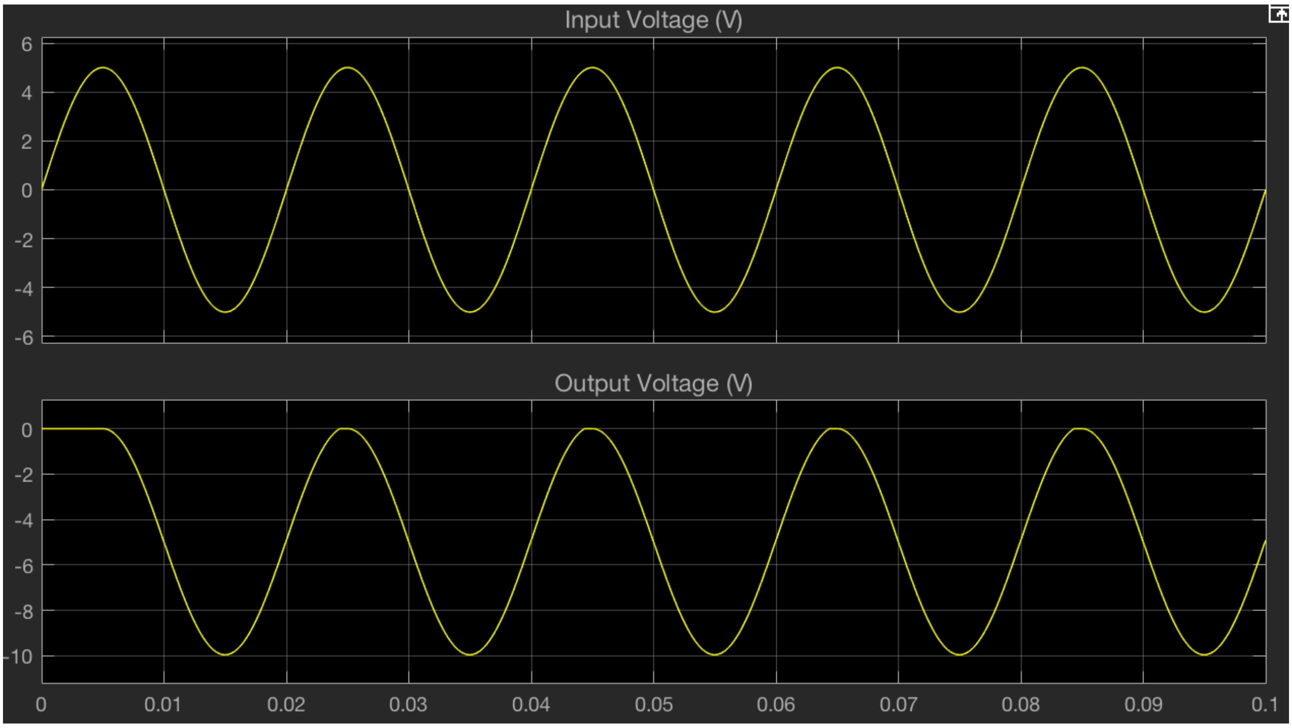
Negative Clamper :

Circuit Diagram :



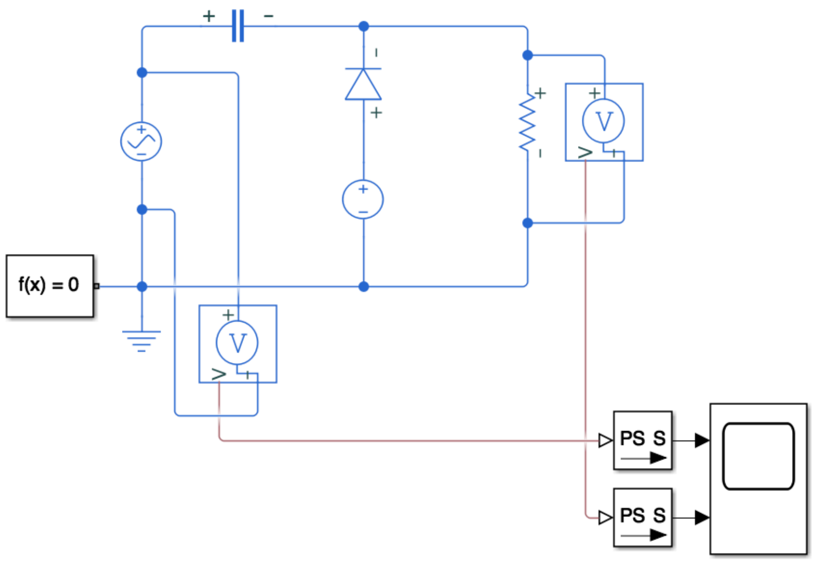
Negative Clamper Circuit

Output Waveform :



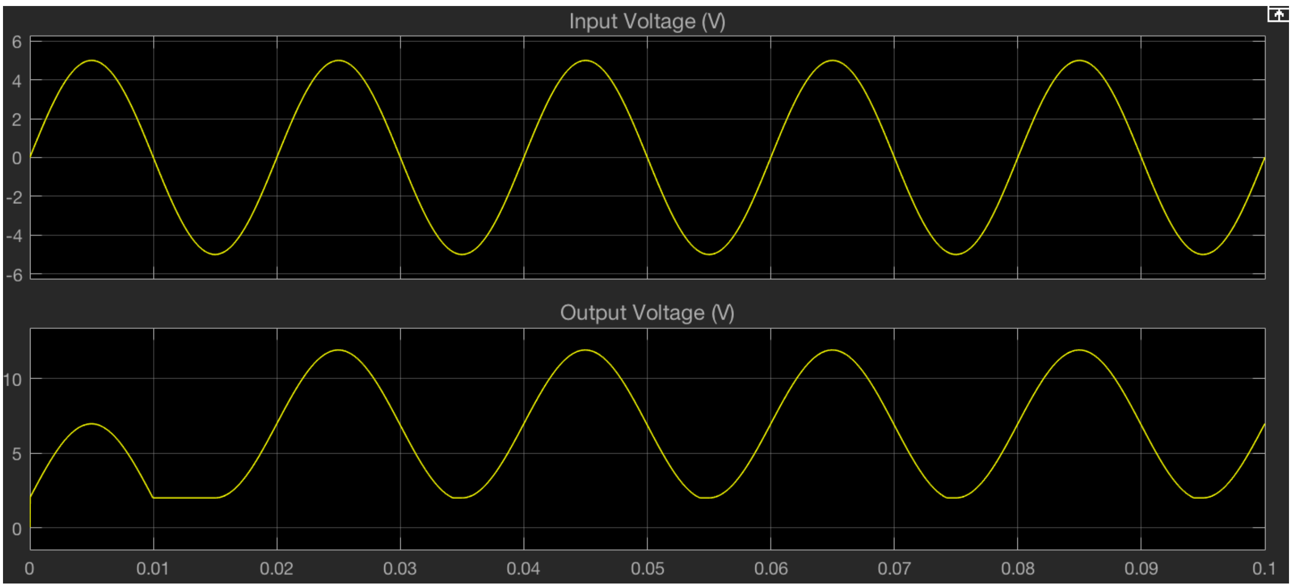
Positive Clamper with Positive external bias :

Circuit Diagram :



**Positive Clamper Circuit
iwth Positive Bias**

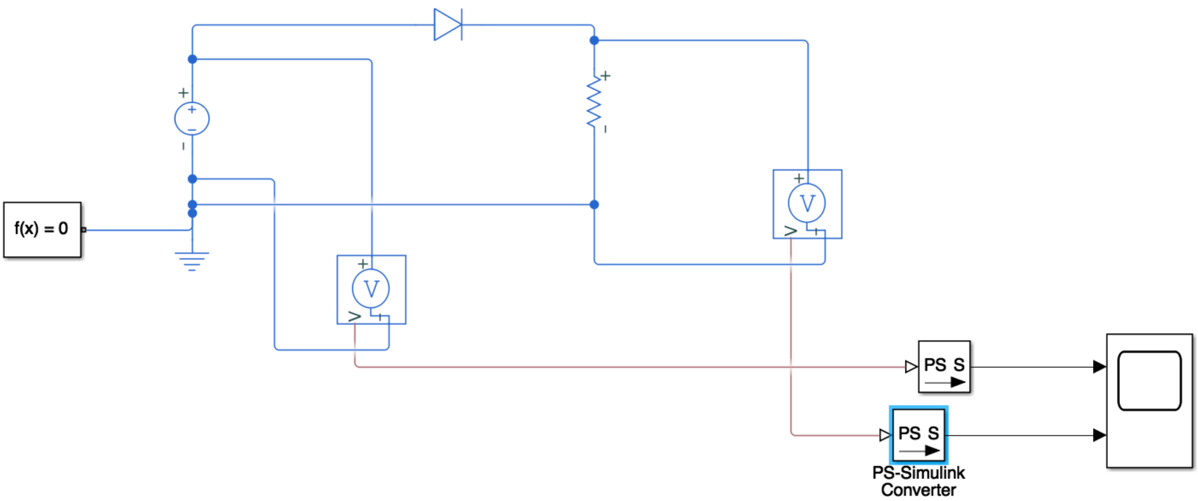
Output Waveform :



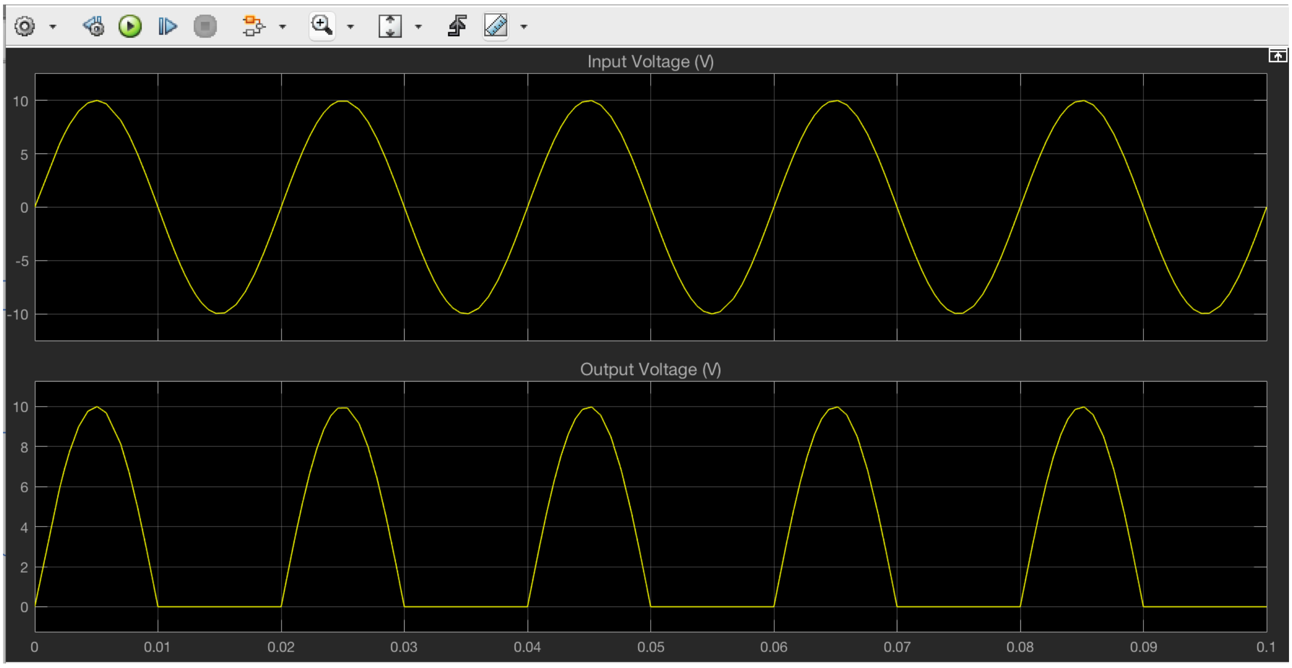
RECTIFIER

Half Wave Rectifier :

Circuit Diagram :

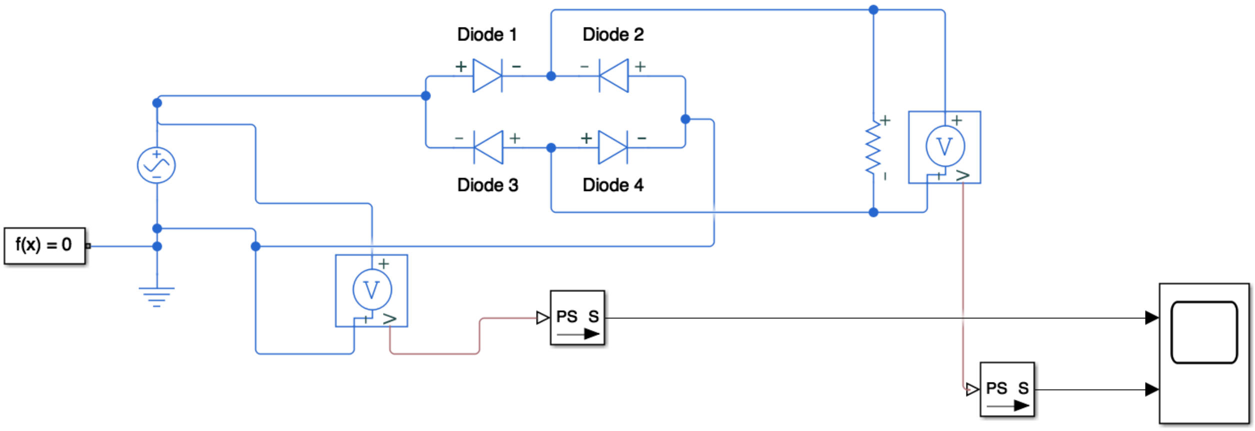


Output Waveform :

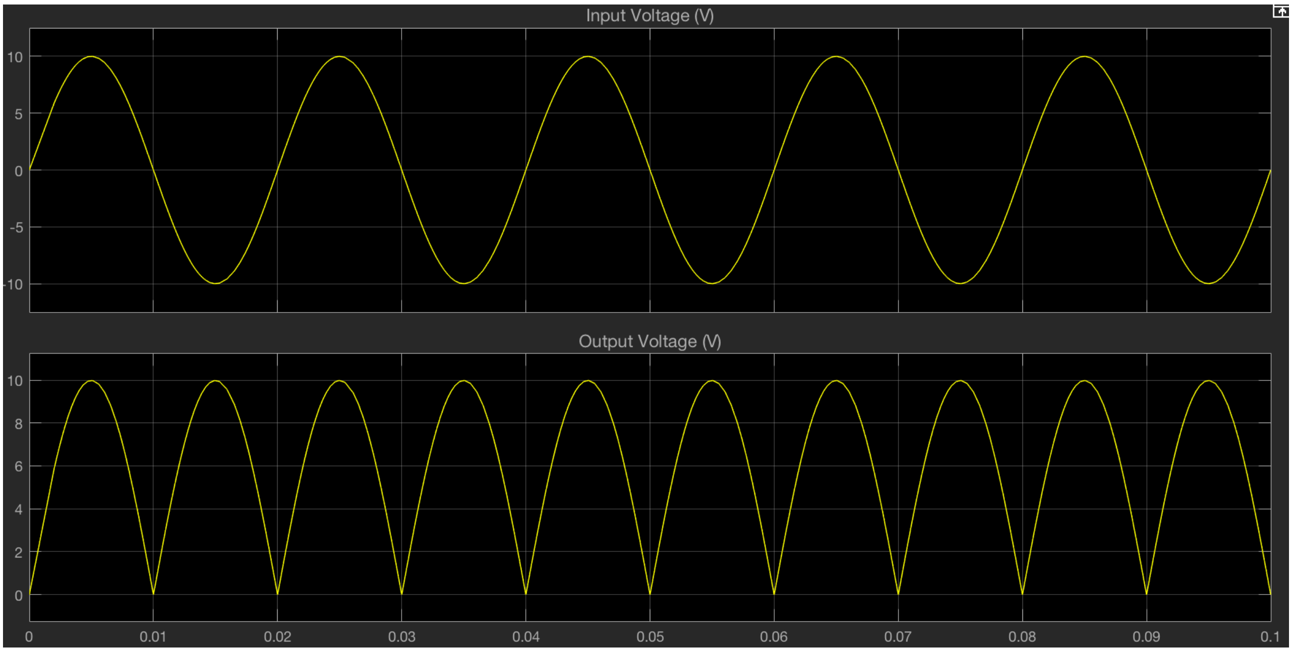


Full Wave Rectifier :

Circuit Diagram :



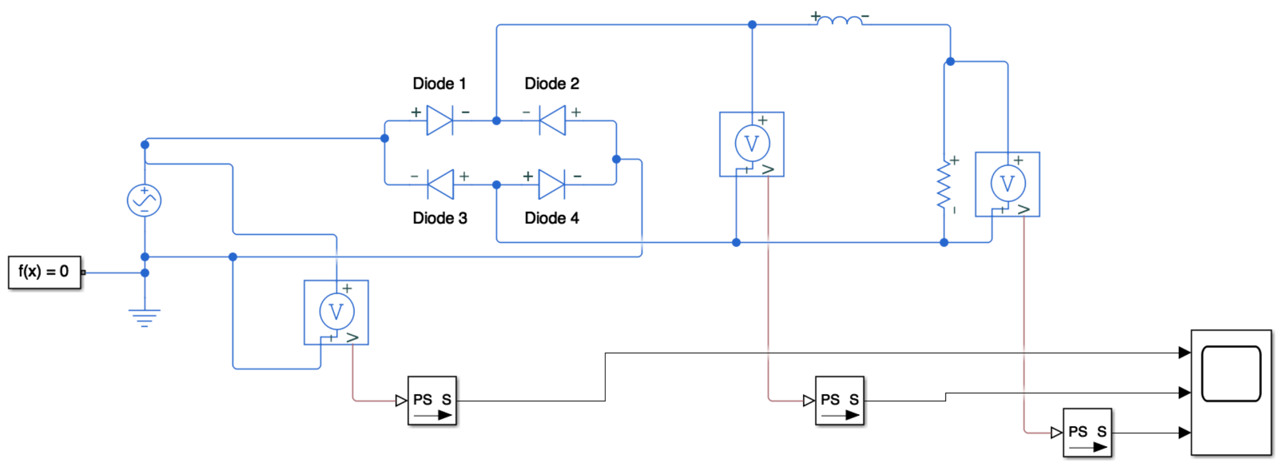
Output Waveform :



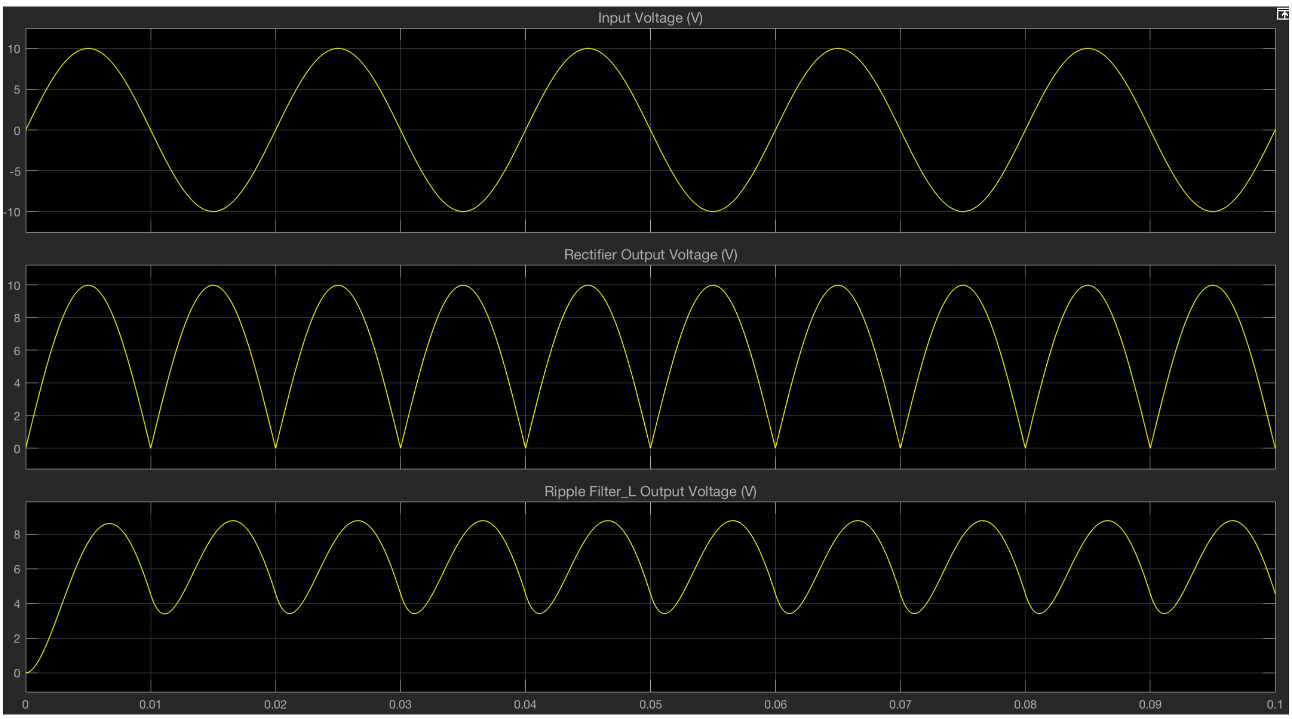
RIPPLE FILTER

i) Ripple Filter with Inductance

Circuit Diagram :

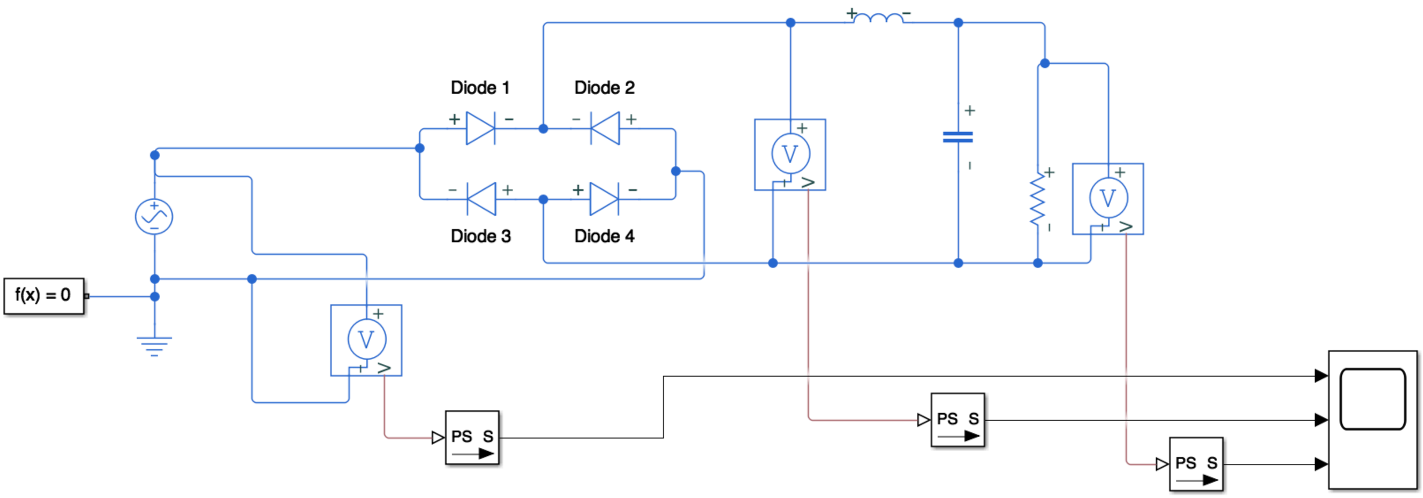


Output Waveforms :

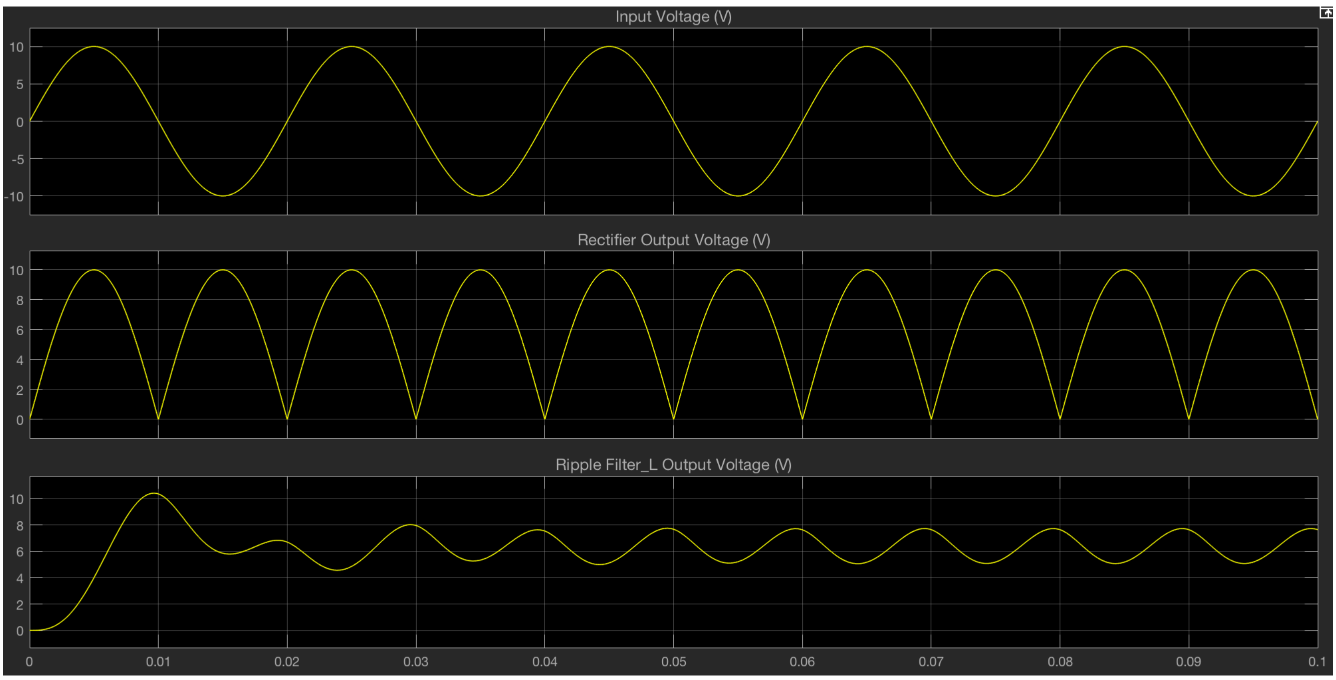


ii) Ripple Filter with Inductance and Capacitance

Circuit Diagram :



Output Waveforms :



LINEAR POWER SUPPLY

To convert 230V AC to 5V DC

In general, we use an AC supply of 230V 50Hz, but this power has to be changed into the required form with required values or voltage range for providing power supply to different types of devices. There are various types of power electronic converters such as step-down converter, step-up converter, voltage stabiliser, AC to DC converter, DC to DC converter, DC to AC converter.

4 Steps to Convert 230V AC to 5V DC :

11. *Step Down the Voltage Level :*

The step-down converters are used for converting the high voltage into low voltage. The converter with output voltage less than the input voltage is called as a step-down converter, and the converter with output voltage greater than the input voltage is called as step-up converter. There are step-up and step-down transformers which are used to step up or step down the voltage levels. 230V AC is converted into 12V AC using a step-down transformer. 12V output of stepdown transformer is an RMS value and its peak value is given by the product of square root of two with RMS value, which is approximately 17V.

Step-down transformer consists of two windings, namely primary and secondary windings where primary can be designed using a less-gauge wire with more number of turns as it is used for carrying low-current high-voltage power, and the secondary winding using a high-gauge wire with less number of turns as it is used for carrying high-current low-voltage power. Transformers works on the principle of Faraday's laws of electromagnetic induction.

2. *Convert AC to DC :*

230V AC power is converted into 12V AC (12V RMS value wherein the peak value is around 17V), but the required power is 5V DC; for this purpose, 17V AC power must be primarily converted into DC power then it can be stepped down to the 5V DC.

AC power can be converted into DC using one of the power electronic converters called as Rectifier. There are different types of rectifiers, such as half-wave rectifier, full-wave rectifier and bridge rectifier. Due to the advantages of the bridge rectifier over the half and full wave rectifier, the bridge rectifier is frequently used for converting AC to DC. Thus, AC is converted into DC; here the obtained is not a pure DC as it consists of pulses. Hence, it is called as pulsating DC power. But voltage drop across the diodes is (2*0.7V) 1.4V; therefore, the peak voltage at the output of this rectifier circuit is 15V (17-1.4) approx.

3. Smoothing the Ripples using Filter :

15V DC can be regulated into 5V DC using a step-down converter, but before this, it is required to obtain pure DC power. The output of the diode bridge is a DC consisting of ripples also called as pulsating DC. This pulsating DC can be filtered using an inductor filter or a capacitor filter or a resistor-capacitor-coupled filter for removing the ripples. Consider a capacitor filter which is frequently used in most cases for smoothing.

Capacitor is an energy storing element. In the circuit, capacitor stores energy while the input increases from zero to a peak value and, while the supply voltage decreases from peak value to zero, capacitor starts discharging. This charging and discharging of the capacitor will make the pulsating DC into pure DC.

4. Regulating 12V DC into 5V DC using Voltage Regulator :

15V DC voltage can be stepped down to 5V DC voltage using a DC step-down converter called as voltage regulator IC7805. The first two digits ‘78’ of IC7805 voltage regulator represent positive series voltage regulators and the last two digits ‘05’ represents the output voltage of the voltage regulator.

Thus, a 5V DC is obtained from 230V AC power.

BASIC BUILDING BLOCKS OF SMPS

Basic Theory :

SMPS- Switched Mode Power Supply

SMPS is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. The pass transistor pf SMPS continually switches between low dissipation, full-on and full-off states and spends least time in high dissipation transistors. This minimises wasted energy. An ideal SMPS dissipates no power.

A switching regulator is used in an SMPS. A switching regulator is a device that maintains steady voltage in a circuit. A switching regulator uses active devices like capacitors and inductors that switch on and off to maintain an average value of output. Capacitors and inductors are devices that are lossless storage elements in different electrical configuration for switching.

Advantages and Disadvantages :

Advantages :

The main advantage of the switching power supply is greater efficiency than linear regulators because the switching transistor dissipates little power when acting as a switch.

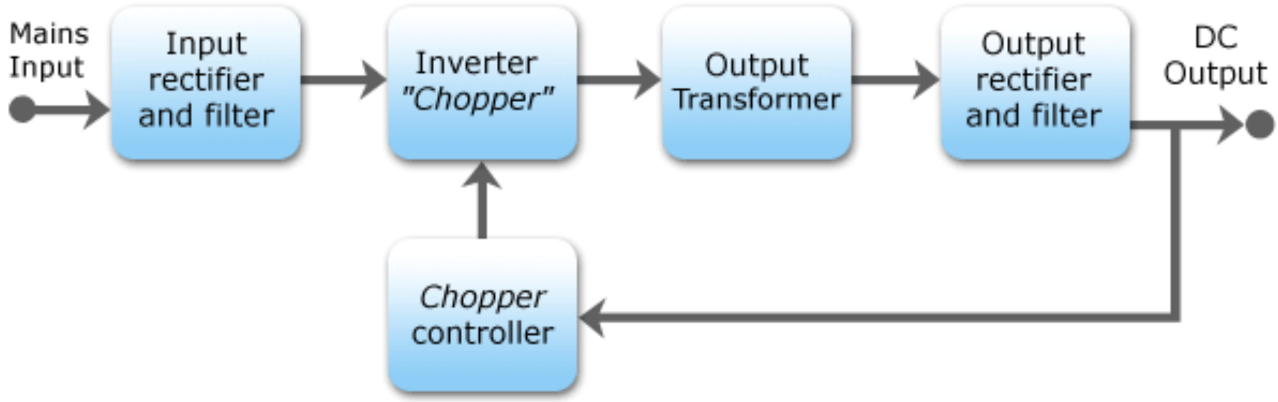
Other advantages include smaller size and lighter weight from the elimination of heavy line-frequency transformers, and comparable heat generation. Standby power loss is often much less than transformers.

Disadvantages :

Disadvantages include greater complexity, the generation of high-amplitude, high-frequency energy that the low-pass filter must block to avoid electromagnetic interference (EMI), a ripple voltage at the switching frequency and the harmonic frequencies thereof.

Very low cost SMPSs may couple electrical switching noise back onto the mains power line, causing interference with A/V equipment connected to the same phase. Non-power-factor-corrected SMPSs also cause harmonic distortion.

Theory Of Operation :



Input Rectifier Stage :

If the SMPS has an AC input, then the first stage is to convert the input to DC. This is called rectification. A SMPS with a DC input does not require this stage. In some power supplies, the rectifier circuit can be configured as a voltage doubler by the addition of a switch operated either manually or automatically. This feature permits operation from power sources that are normally at 115 V or at 230 V. The rectifier produces an unregulated DC voltage which is then sent to a large filter capacitor. The current drawn from the mains supply by this rectifier circuit occurs in short pulses around the AC voltage peaks. These pulses have significant high frequency energy which reduces the power factor. An SMPS designed for AC input can usually be run from a DC supply, because the DC would pass through the rectifier unchanged.

Inverter Stage :

This section refers to the block marked chopper in the diagram.
The inverter stage converts DC, whether directly from the input or from the rectifier stage described above, to AC by running it through a power oscillator, whose output transformer is very small with few windings at a frequency of tens or hundreds of kilohertz. The frequency is usually chosen to be above 20 kHz, to make it inaudible to humans. The switching is implemented as a multistage (to achieve high gain) MOSFET amplifier. MOSFETs are a type of transistor with a low on-resistance and a high current-handling capacity.

Voltage Converter &V Output Rectifier :

If the output is required to be isolated from the input, as is usually the case in mains power supplies, the inverted AC is used to drive the primary winding of a high-frequency transformer. This converts the voltage up or down to the required output level on its secondary winding. The output transformer in the block diagram serves this purpose.

If a **DC** output is required, the **AC** output from the transformer is rectified. For output voltages above ten volts or so, ordinary silicon diodes are commonly used. For lower voltages, Schottky diodes are commonly used as the rectifier elements; they have the advantages of faster recovery times than silicon diodes (allowing low-loss operation at higher frequencies) and a lower voltage drop when conducting. For even lower output voltages, MOSFETs may be used as synchronous rectifiers; compared to Schottky diodes, these have even lower conducting state voltage drops.

The rectified output is then smoothed by a filter consisting of inductors and capacitors. For higher switching frequencies, components with lower capacitance and inductance are needed.

Regulation :

A feedback circuit monitors the output voltage and compares it with a reference voltage, as shown in the block diagram above. Depending on design and safety requirements, the controller may contain an isolation mechanism (such as an opto-coupler) to isolate it from the DC output.

Open-loop regulators do not have a feedback circuit. Instead, they rely on feeding a constant voltage to the input of the transformer or inductor, and assume that the output will be correct. Regulated designs compensate for the impedance of the transformer or coil. Monopolar designs also compensate for the magnetic hysteresis of the core.

The feedback circuit needs power to run before it can generate power, so an additional non-switching power-supply for stand-by is added.

Types :

There are 4 types of SMPS :

1. DC to DC Converter
2. Forward Converter
3. Flyback Converter
4. Self Oscillating Flyback Converter

Applications :

Switched-mode power supply units (PSUs) in domestic products such as personal computers often have universal inputs, meaning that they can accept power from mains supplies throughout the world, although a manual voltage range switch may be required. Switch-mode power supplies can tolerate a wide range of power frequencies and voltages.

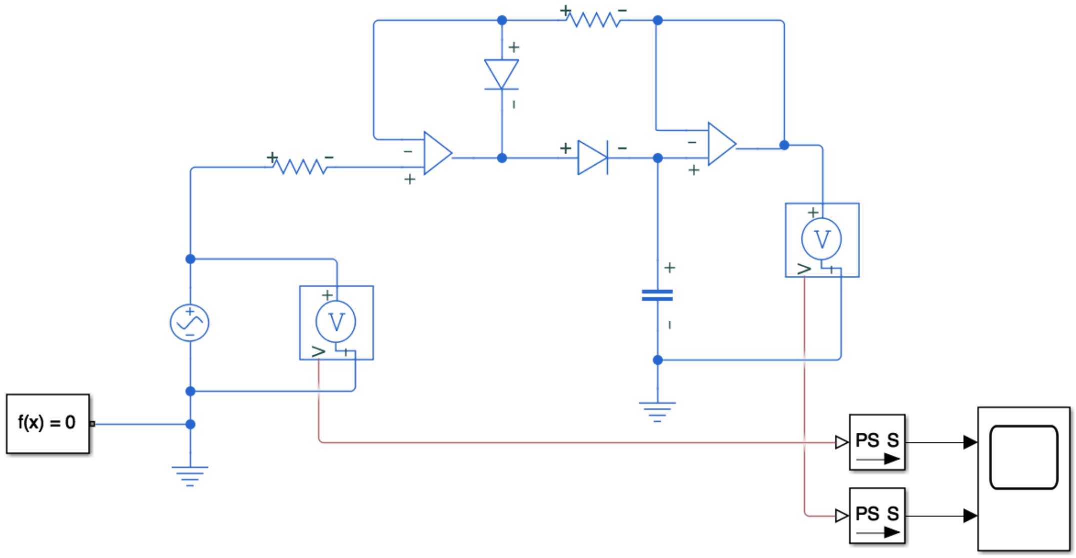
Due to their high volumes mobile phone chargers have always been particularly cost sensitive. The first chargers were linear power supplies, but they quickly moved to the cost effective ringing choke converter (RCC) SMPS topology, when new levels of efficiency were required. Recently, the demand for even lower no-load power requirements in the application has meant that flyback topology is being used more widely; primary side sensing flyback controllers are also helping to cut the bill of materials (BOM) by removing secondary-side sensing components such as optocouplers.

Switched-mode power supplies are used for DC to DC conversion as well. In automobiles where heavy vehicles use a nominal 24 V_{DC} cranking supply, 12V for accessories may be furnished through a DC/DC switch-mode supply. This has the advantage over tapping the battery at the 12V position (using half the cells) that all the 12V load is evenly divided over all cells of the 24V battery. In industrial settings such as telecommunications racks, bulk power may be distributed at a low DC voltage (from a battery back up system, for example) and individual equipment items will have DC/DC switched-mode converters to supply whatever voltages are needed.

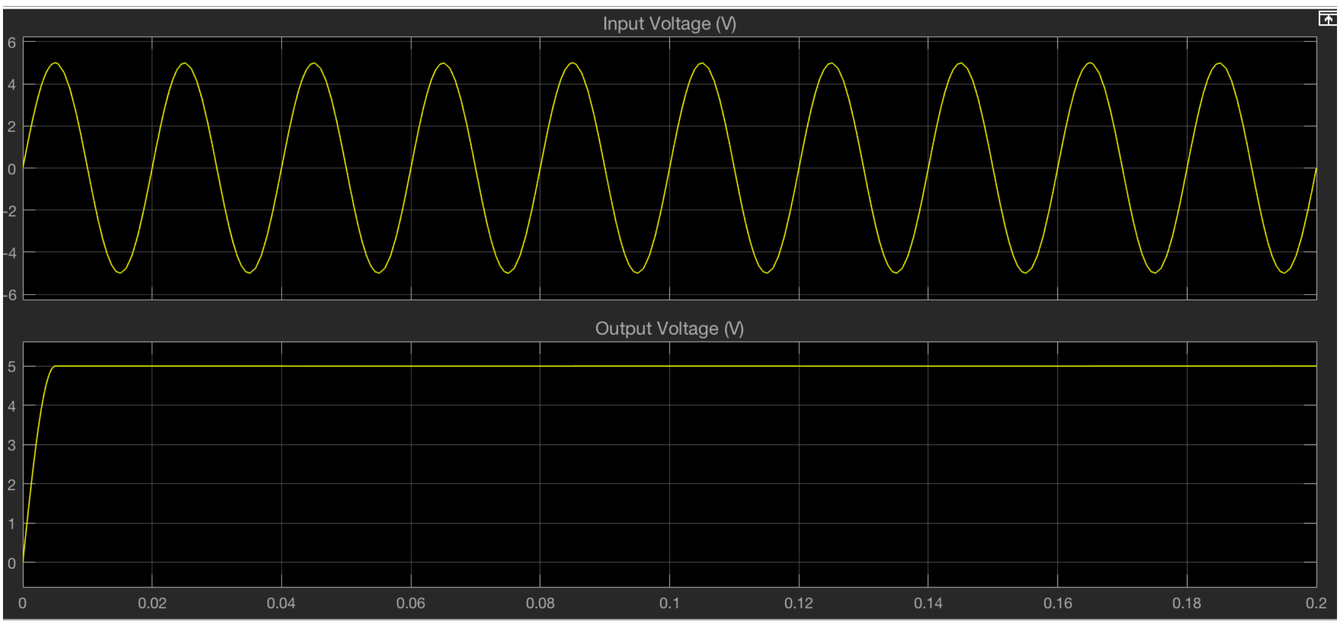
A common use for switched-mode power supplies is as extra-low-voltage sources for lighting, and for this application they are often called "electronic transformers”.

PEAK DETECTOR CIRCUIT

Circuit Diagram :



Output Waveform :



MOD-6 COUNTER