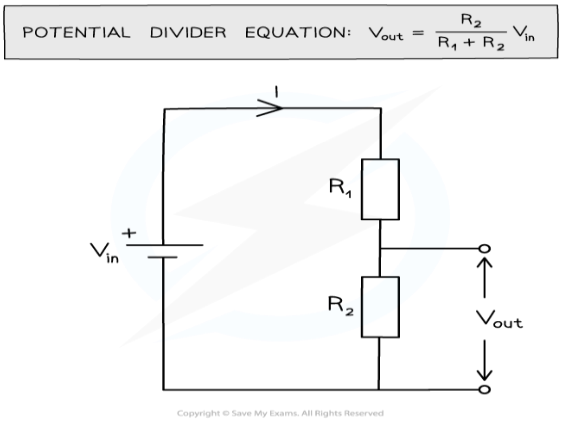
# TASK-1

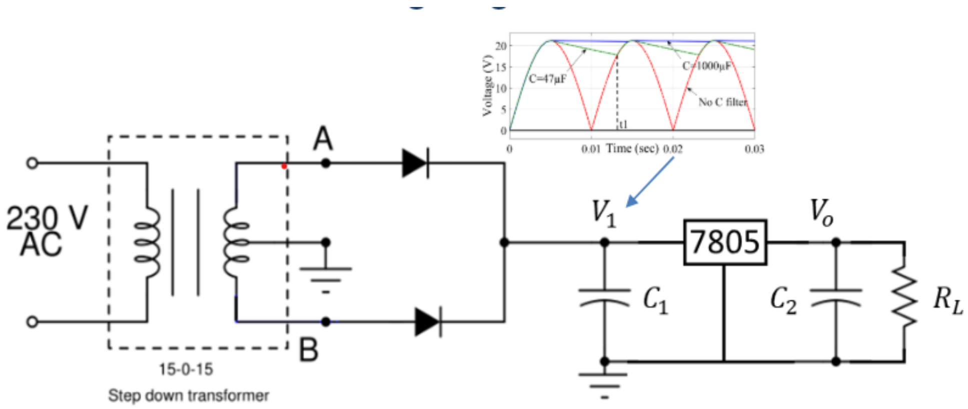
# Buck-Boost-Converter

There are various possible ways through which we can do DC-DC conversion in a circuit :

1)potential divider

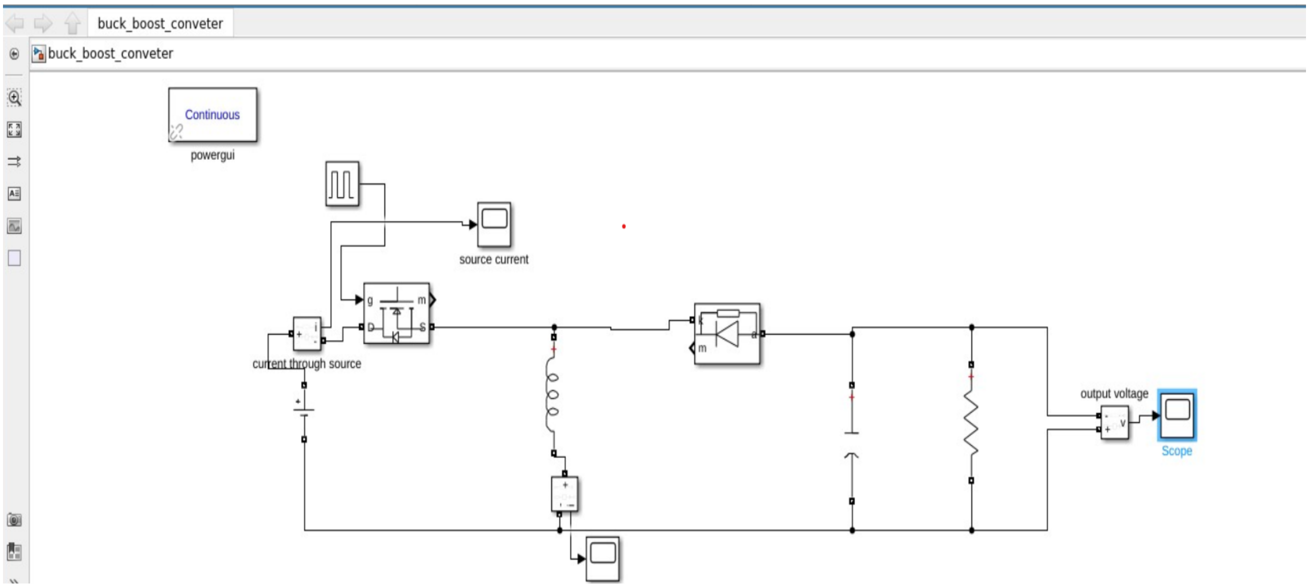



2)Using linear voltage regulator ‘7805’.




$V_1$ can range from 7 to 35 V

But there is unnecessary power loss in resistors and ICs in these circuits hence we use buck-boost-converter where we use passive elements like capacitor, inductor(average power is 0) combined by a high frequency switch hence producing A.C. voltage for these passive elements.




- **Voltage Source**: Represents the input voltage.
- **Inductor**: For energy storage and transfer.
- **Capacitor**: To smooth the output voltage.
- **Diode**: Ensures unidirectional current flow.
- **Switch (MOSFET)**: Controls the connection and disconnection of the inductor to the source.
- **Resistor**: Represents the load.
- **Pulse Generator**: For controlling the switch (duty cycle).

Duty cycle is ratio of time when switch is on to total time period.

Output voltage is given as Vo

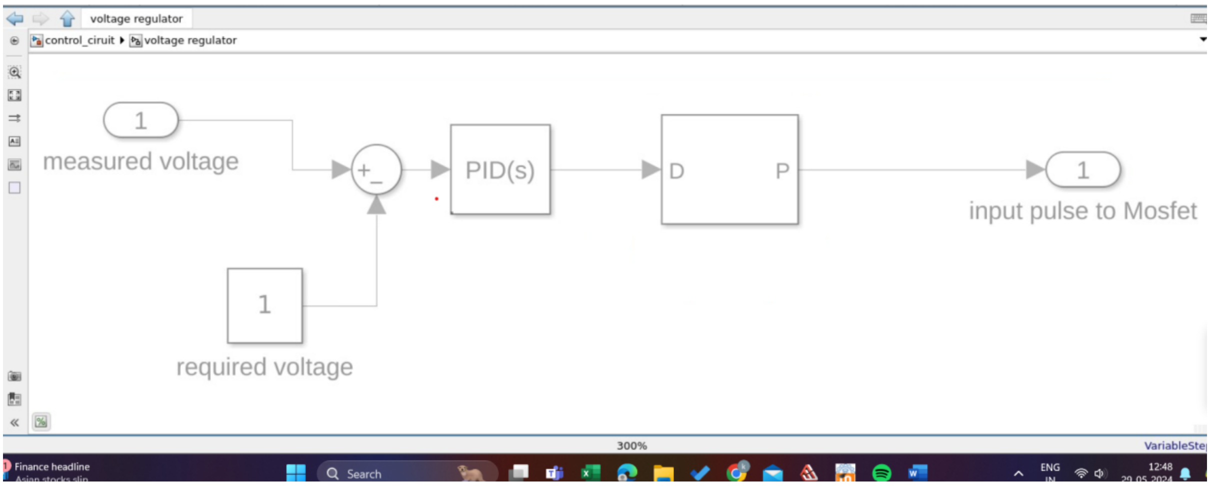
Therefore, $V_o=(D\times V_{in})\div(1-D)$

# Task-2

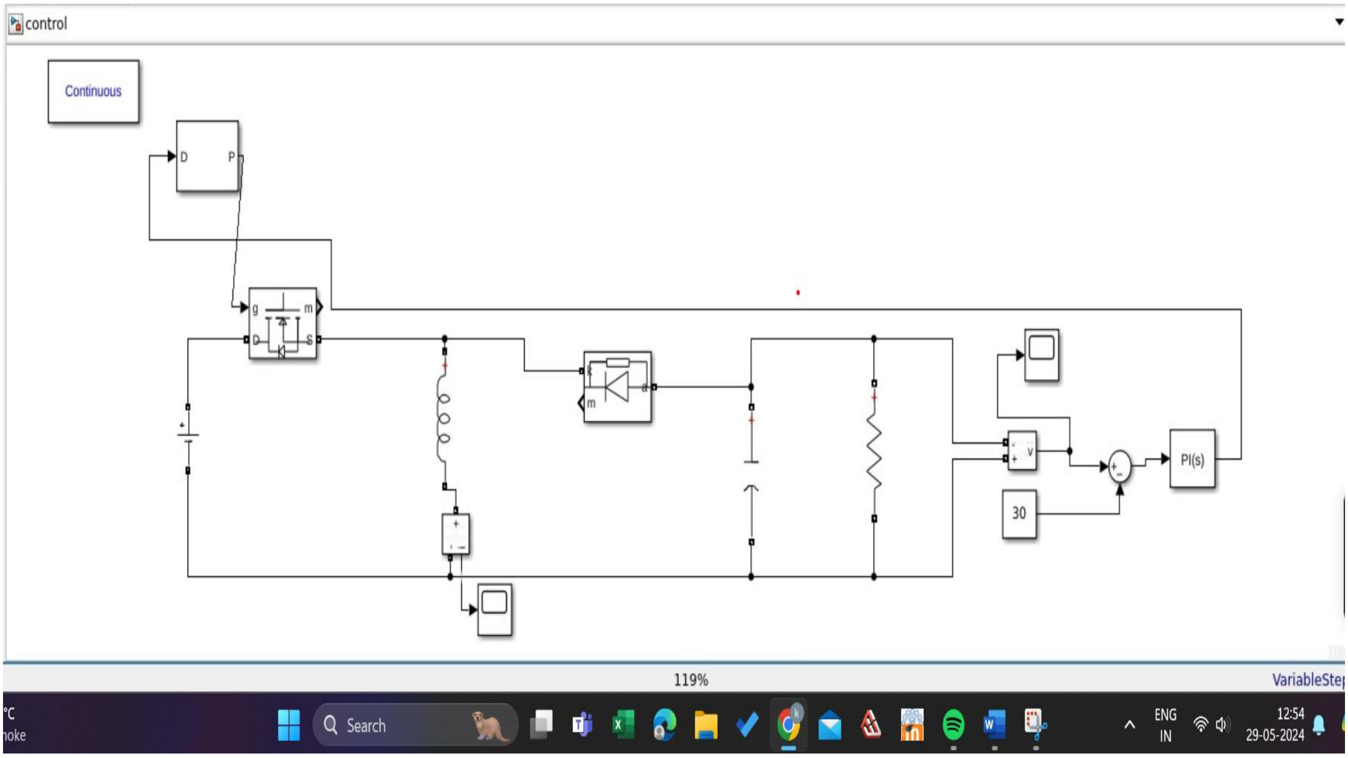
# Design of control circuit

Obtained output voltage in buck-boost converter might not be same as desired voltage due to some heat loss in resistance and diode drop hence there maybe some error in obtained voltage with respect to desired vltage.

Hence, we use a PID controller ,so that it changes the duty cycle and obtain our desired output voltage .We do this by tuning the controller and finding appropriate PID constants.




Error is calculated by Sum block and PID then tries to make it zero ,it does this by sending control signal to PWM generator and thus changing the value of Duty cycle.




Here given input voltage is 20v and desired voltage is 30v .Thus we need to tune PID cotroller i.e. it generates an appropriate duty voltage.

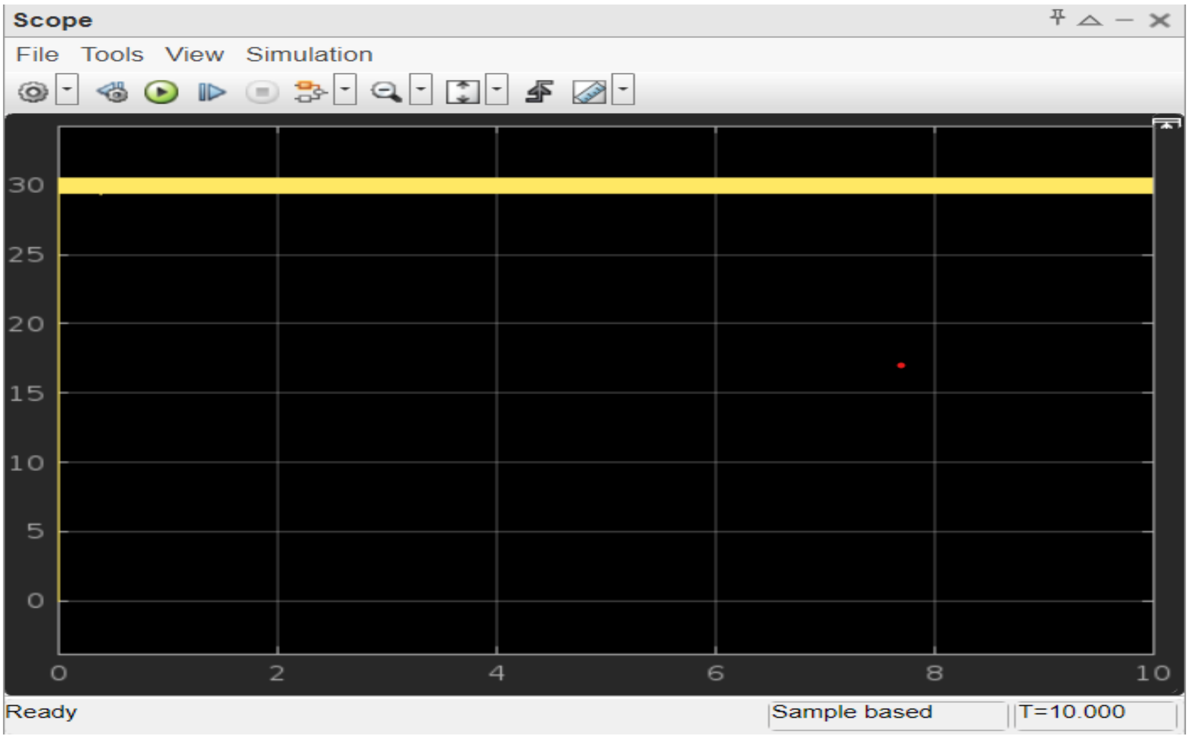
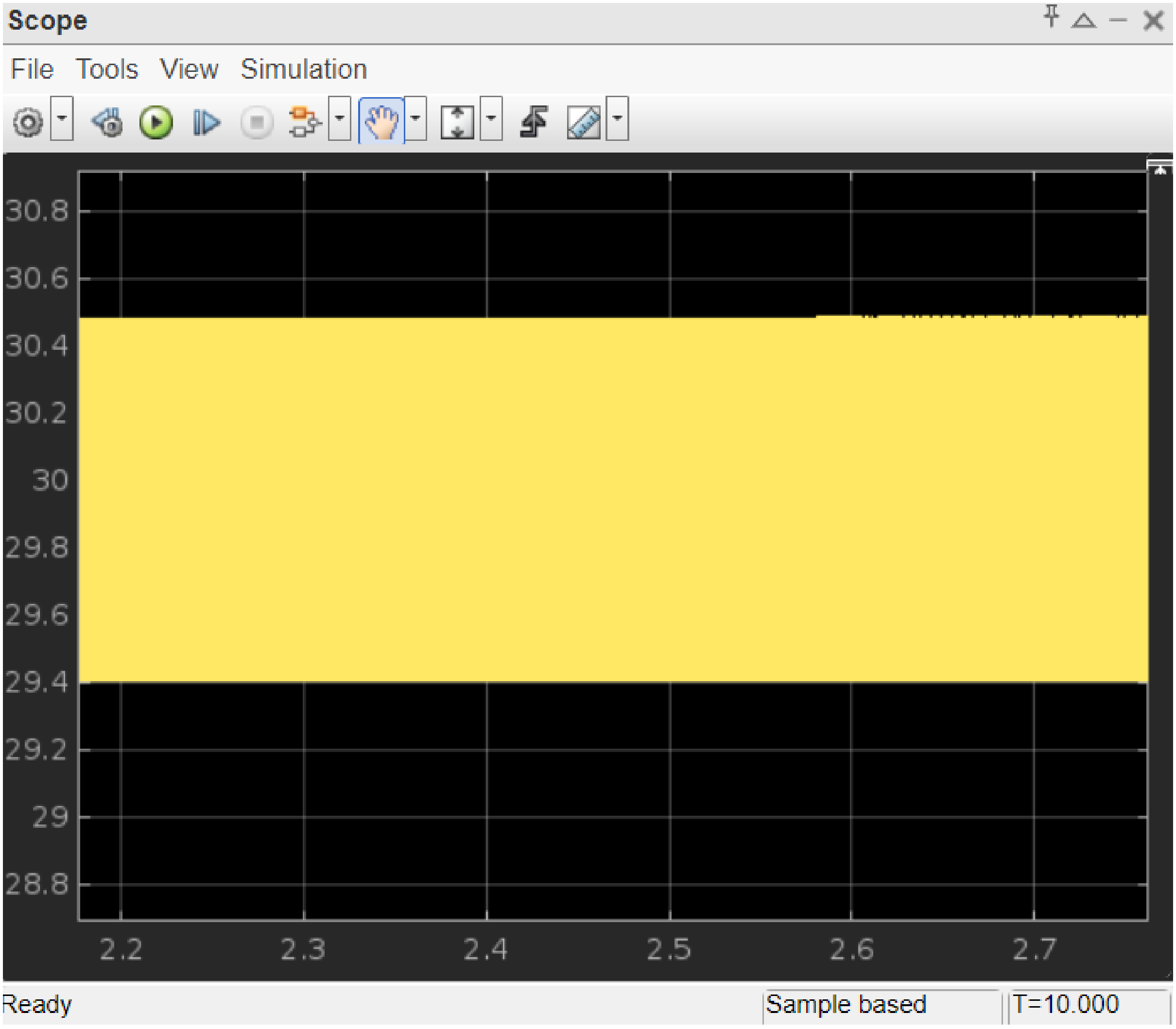
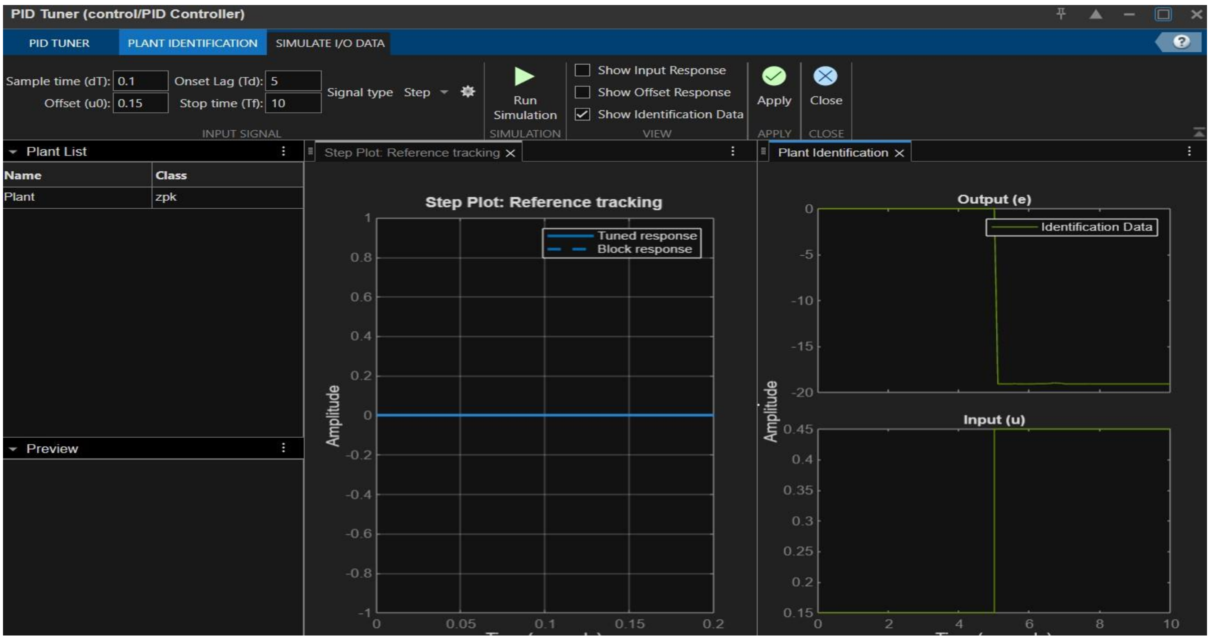



Fig. output voltage

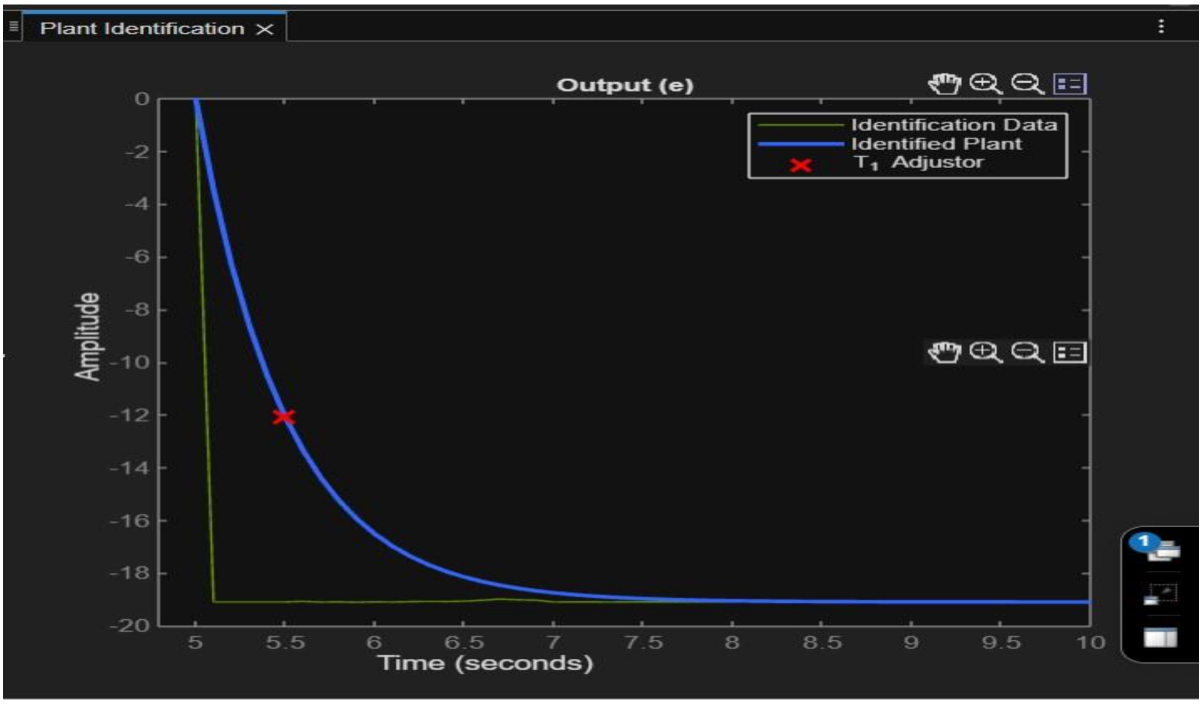



Here calculated average is 30.

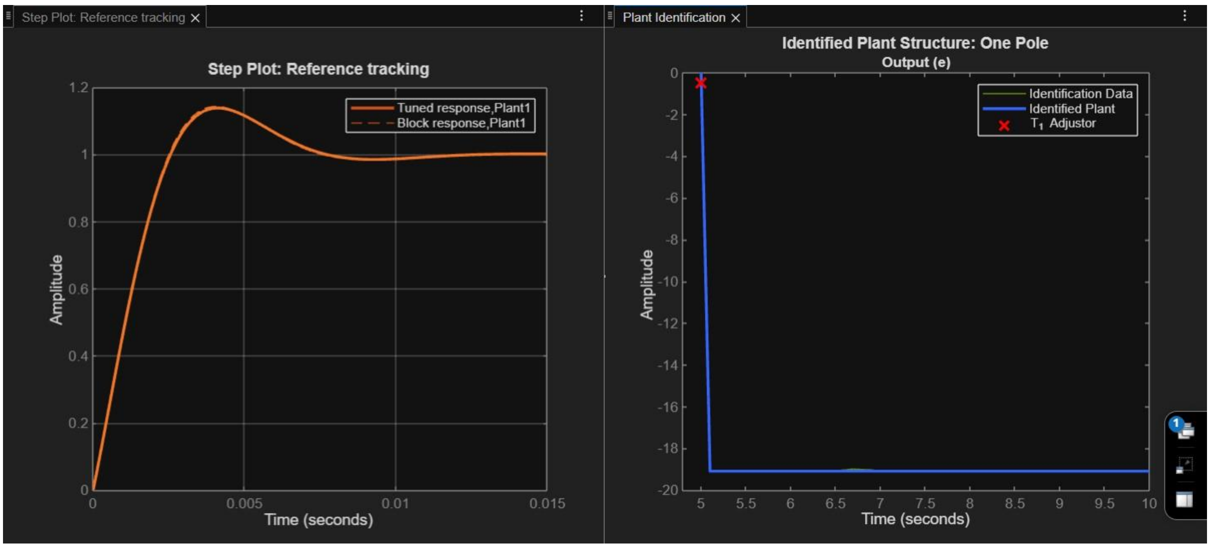


In previous figure it can be seen that when we tune the controller, we run the cycle for Duty cycle (D1)=0.15 from t=0 to t=5sec and then for Duty cycle(D2)=0.45 from t=5sec to t=10sec.

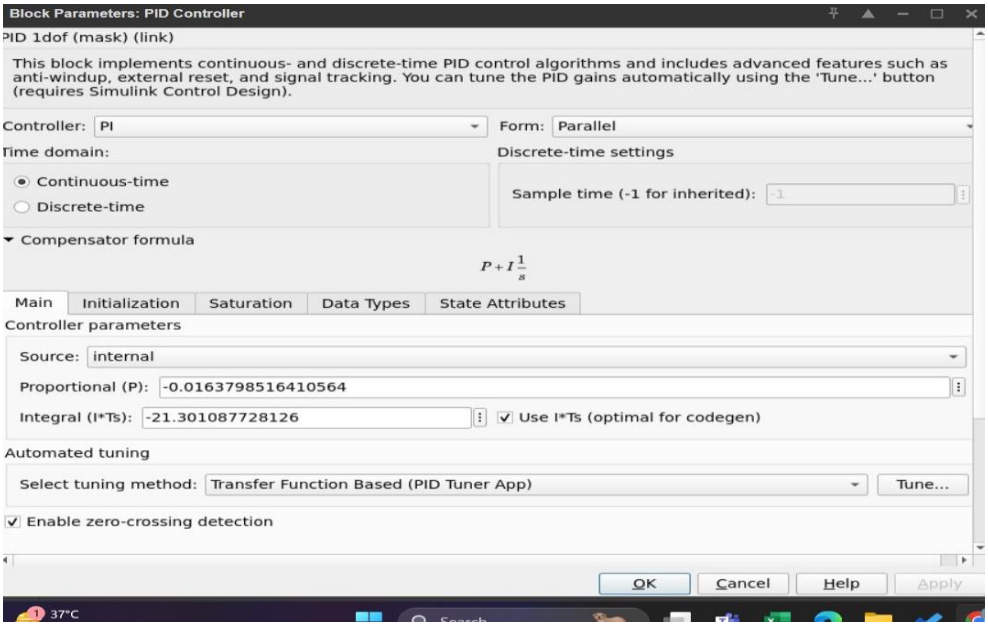
Observed output can also be noticed.




Untuned




tuned




Calculated value of PID constants.

# Task-3

# Load Testing

We perform load testing with various types of loads:

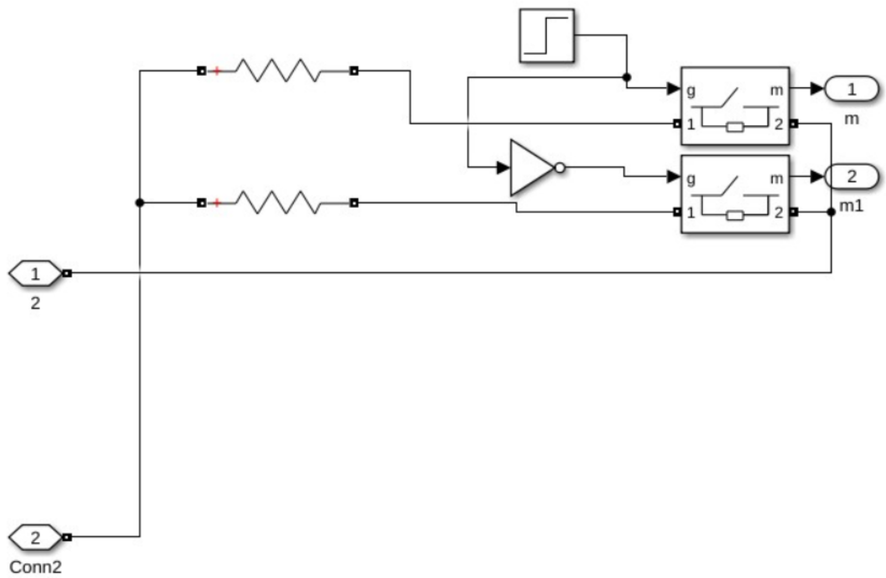
1)Step-Up load

2)pulsating load

3)inductive load

We don't test with a capacitive or resistive load because it doesn't make any sense as capacitive or resistive load will be in parallel connection with capacitor and resistor in converter hence output will almost remain same.

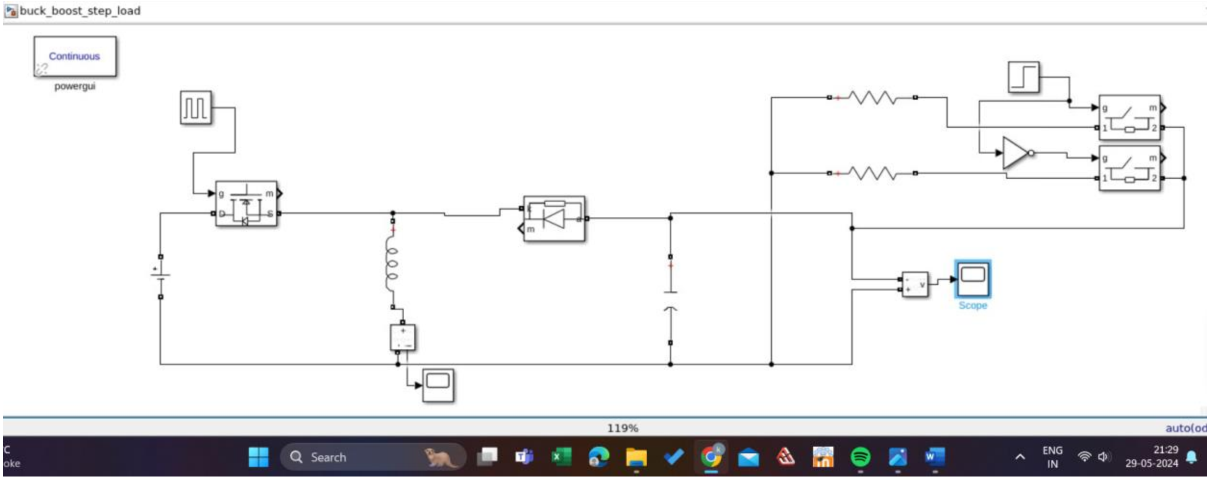
## **1)step-up load**:



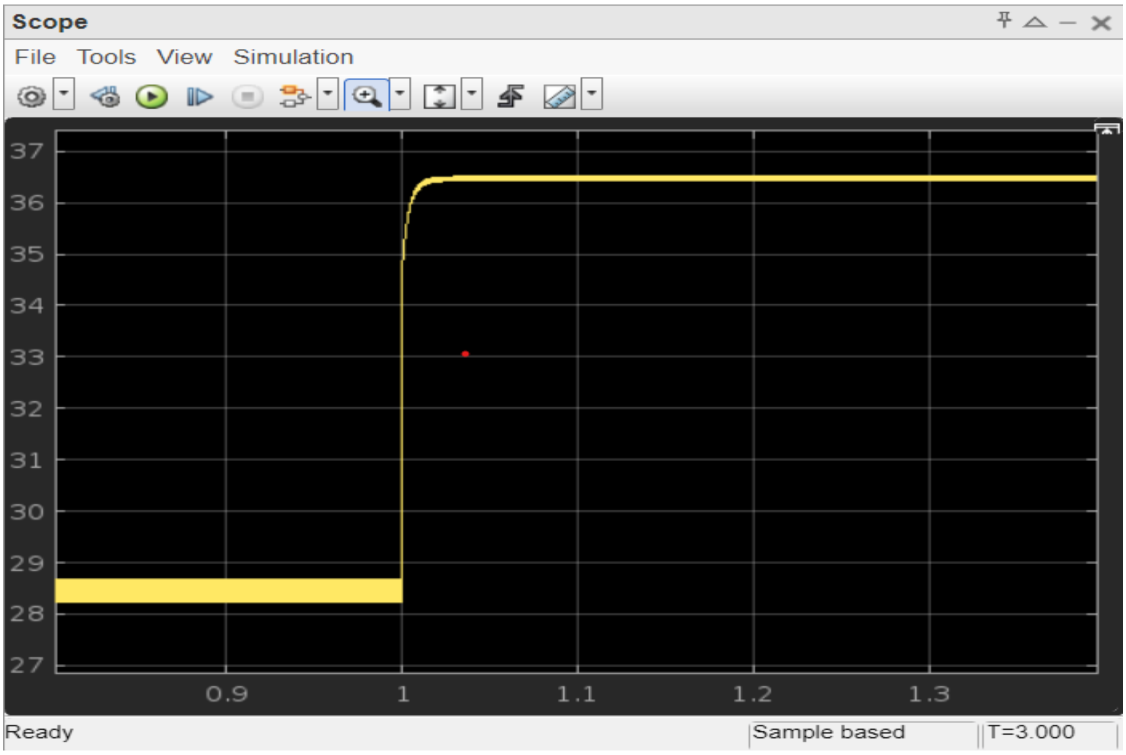

This circuit involves:

- Two resistors
- Not gate
- Step block
- Two ideal switches

When step has 0/1 amplitude ,due to presence of NOT gate one switch will be ON while other will be OFF.




From t=0sec to t=1sec resistance=10ohms and from t=1sec to t=3sec resistance=80ohms ,so there is a step-up in resistance value.

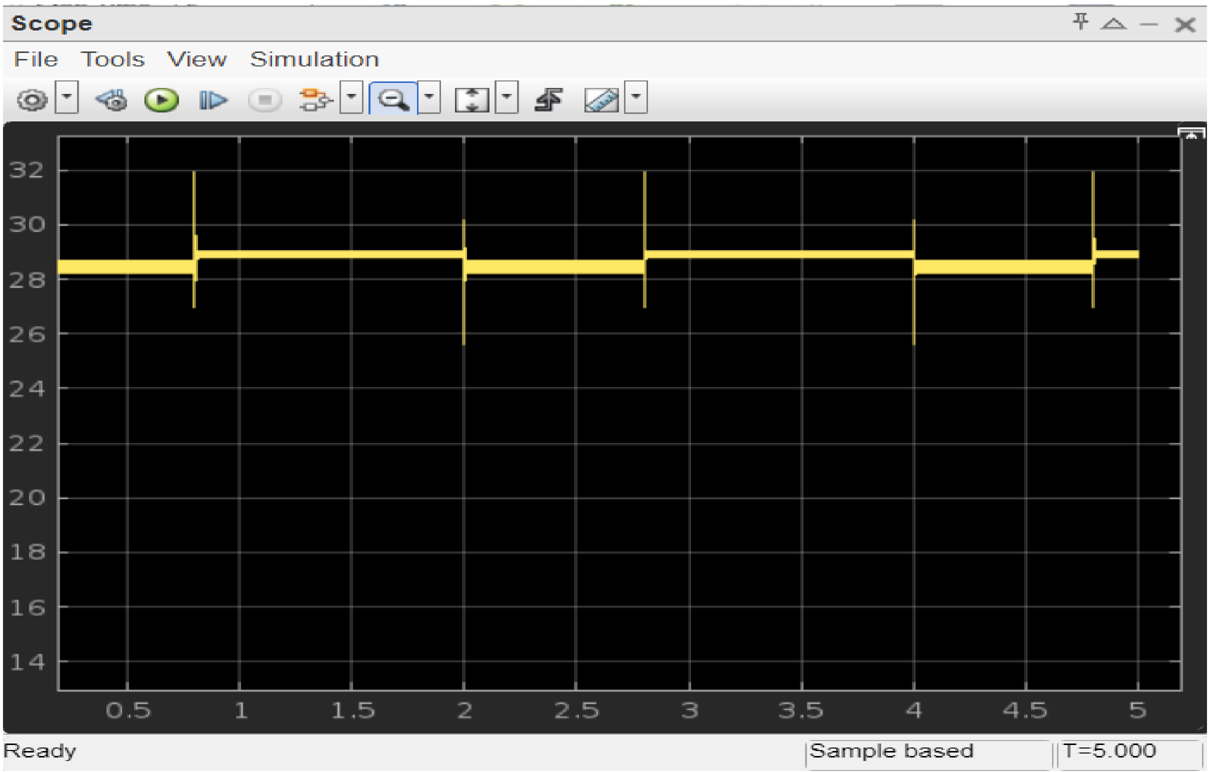



We can see how output voltage changes from 28.5v to 36.4v.

## 2)pulsating load

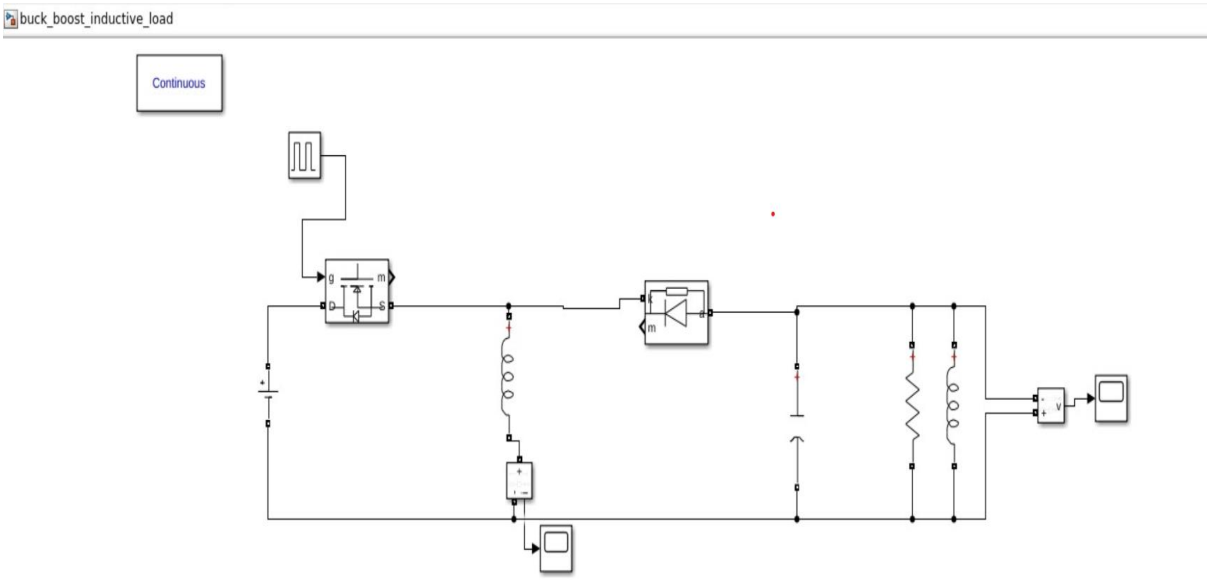
Circuit of pulsating load is same as step-up load circuit, only difference is that instead of step block we use a pulse generator.

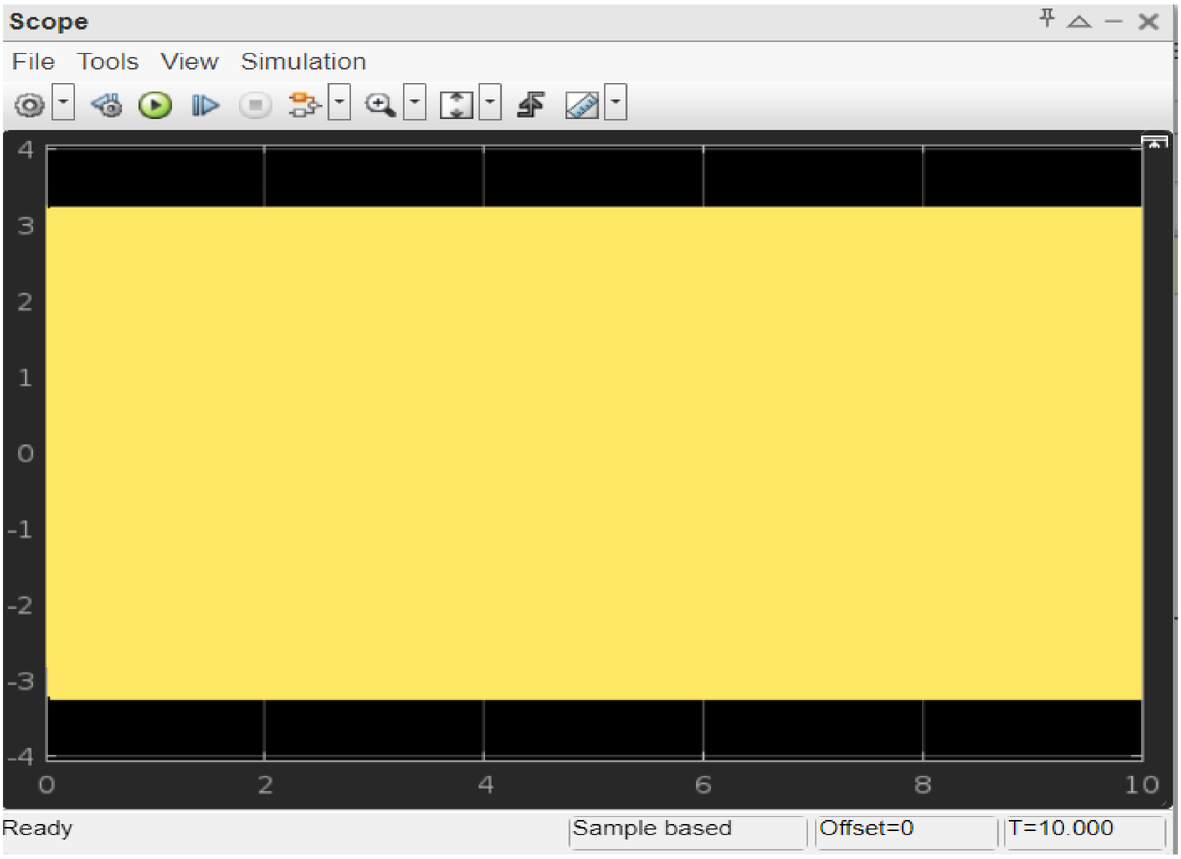
The value of load resistance pulsates between 10ohms and 80ohms in provided duty cycle.




Here we can see how output voltage pulsates between 28.42v to 28.9v.Given duty cycle in pulse generator of pulsating load is 0.4. Also we can notice overshoot in voltage waveforms as value of load resistance pulsates.

## 3)inductive load.






NOTE:Average output voltage is 0 due to presence of inductor.

# TASK-4

## Analysing the efficiency and stability of various circuits

1. Buck-Boost converter:

   In general, the efficiency of a practical buck boost converter is expected to be above 90%.

   While calculating the efficiency we need to follow the formula,
   Efficiency= $P_{out}/P_{in}*100$
   As in an ideal converter, losses are near zero, efficiency= 100%.
   I.e., $V_{out}/V_{in}= I_{in}/I_{out}= 0.67$ (as duty cycle is 0.4)
   Assuming the current ratios to remain constant even during non-ideal scenario.
   For the provided circuit, efficiency is;
   $100*11.33/ (18*0.67) = 94.42\%$
   This matches with our initial prediction that efficiency goes above 90%.

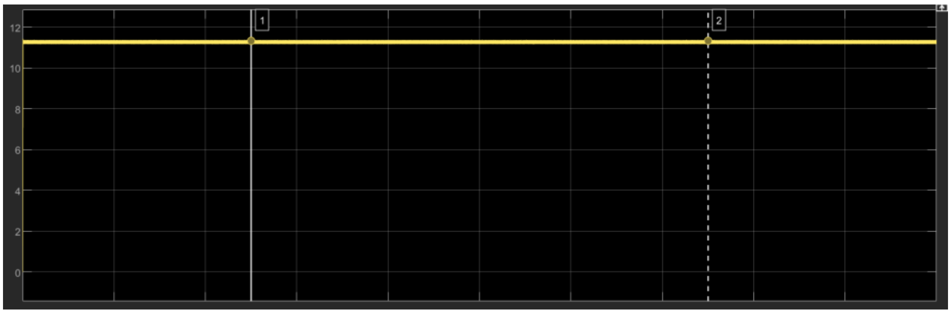
   
   

   Fig: Output voltage characteristics

2. Buck-Boost with Step Load:

   As in the circuit only the load resistance value is being changed at a fixed frequency, the efficiency change happens only due to the change of resistance in the parallel branch and hence the efficiency of the circuit will reduce when the load resistance value is increased. This is because of higher losses in the load resistance as compared to when it had a lower value of resistance.

3. Buck-Boost with Pulsating Load:

   As in the circuit only the load resistance value is being changed at a fixed frequency, the efficiency change happens only due to the change of resistance in the parallel branch and hence the efficiency of the circuit will reduce when the load resistance value is increased. This is because of higher losses in the load resistance as compared to when it had a lower value of resistance.

But as compared to case (2) where the value remains constant after the change, in this case the value of efficiency keeps pulsating as the load resistance value pulsates. We will have to assume an average value of efficiency here.

4. Buck-Boost with inductive load:

   Using the same logic as above, the load value will keep reducing as the inductor starts conducting more and more current. Initially all current passes through the resistor and none through the inductor. Later on the inductor starts conducting and hence efficiency should go up due to reduced losses in the load with current decrease.

# STABILITY of converter

Stability analysis ensures that the converter maintains a stable output voltage without excessive oscillations or slow response times.

## Steps for Stability Analysis:

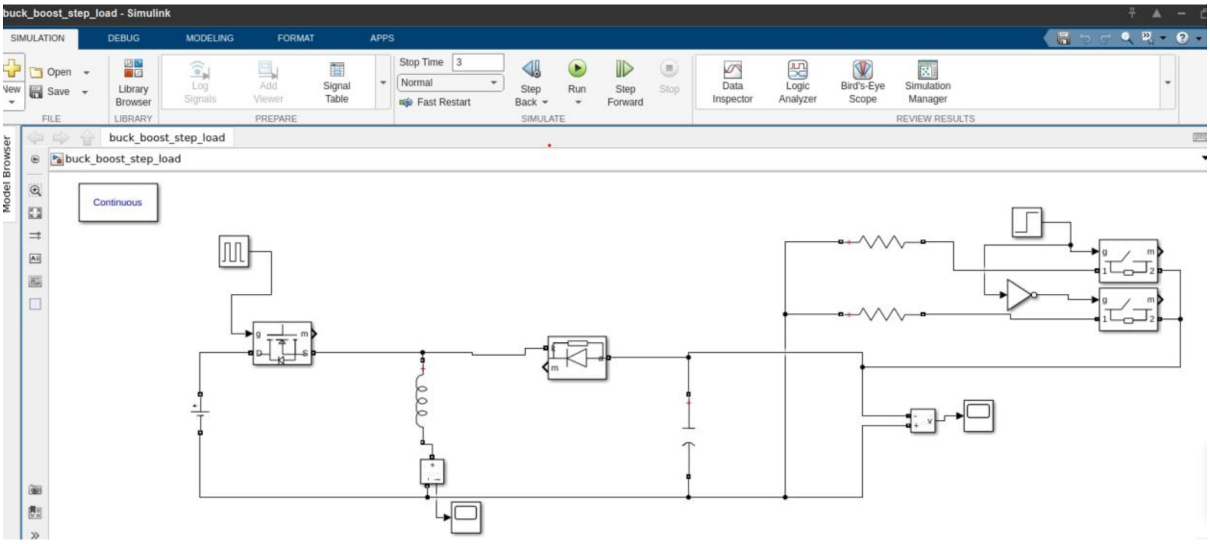
**Step Response Analysis**: Observe how the converter responds to a step change in input voltage or load.

**1**.step response analysis:

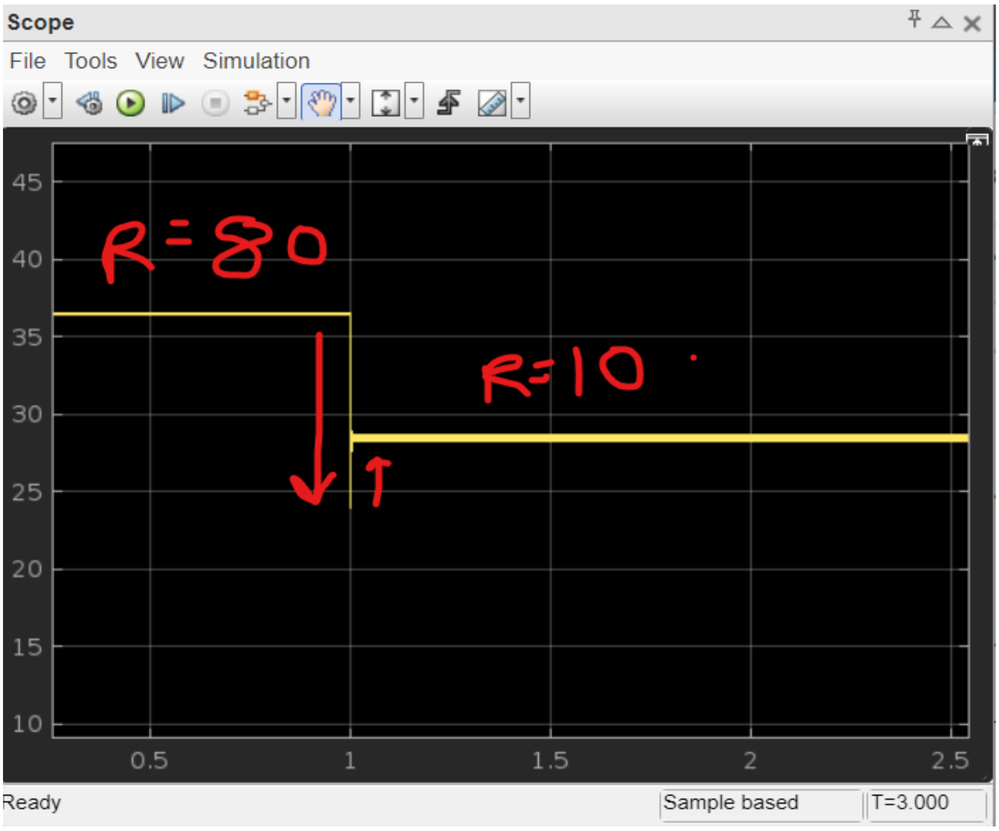
### Using Simulink scope measurements:

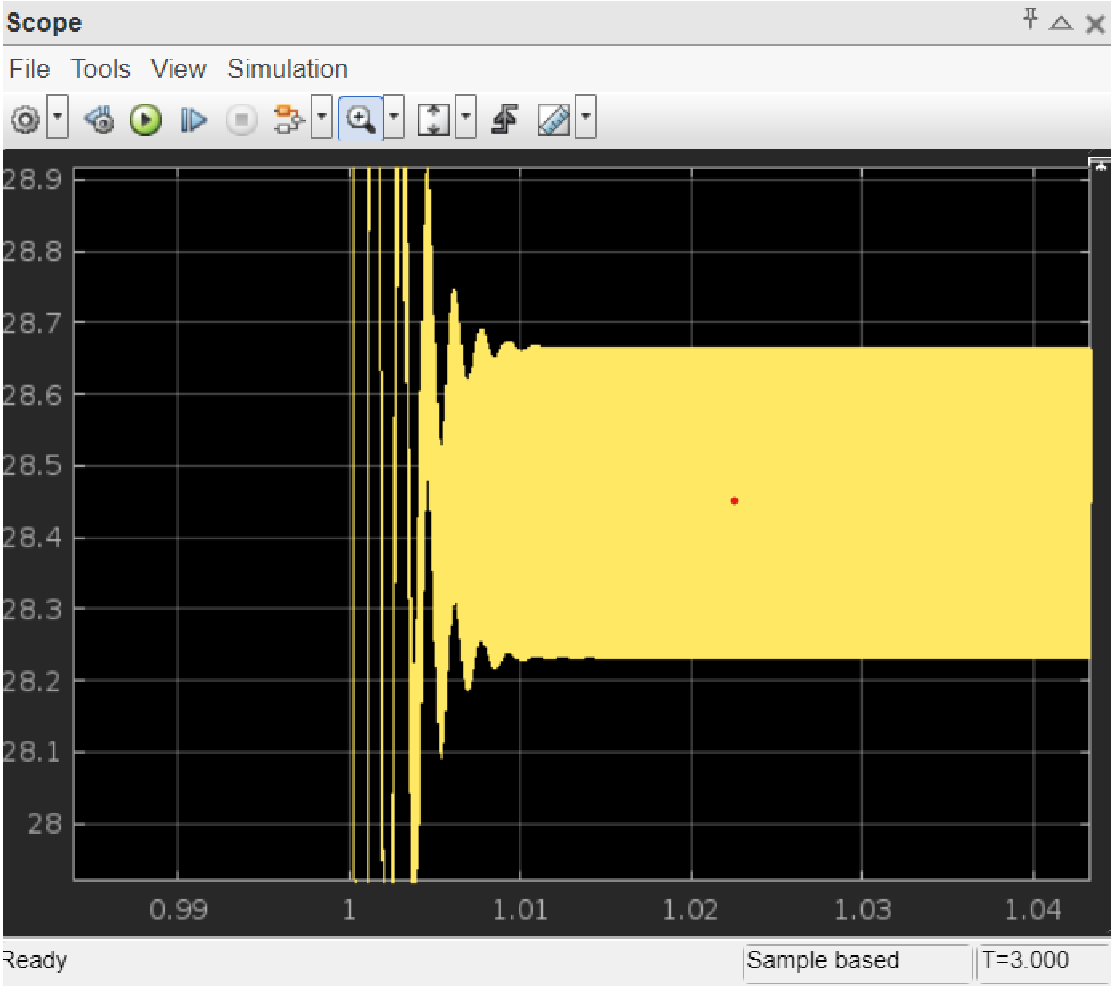
- **Overshoot**: Look at the maximum peak value in the `Scope` after the step change and compare it to the desired steady-state value. Overshoot is the amount by which the output exceeds the desired value.
- **Settling Time**: Observe the time it takes for the output to stay within a certain percentage (commonly 2% or 5%) of the steady-state value after the step change.
- **Steady-State Error**: Compare the final value of the output to the desired steady-state value. The difference is the steady-state error.

1. **Step load analysis**: we change value of resistance from 80 ohms to 10 ohms after t=1sec.




Overshoot of voltage can be noticed from graph,after t=1sec value of load resistance changes and output voltage changes from 36.5 to 28.5 with overshoot(over-drop) of 36.5 to 23.9 .



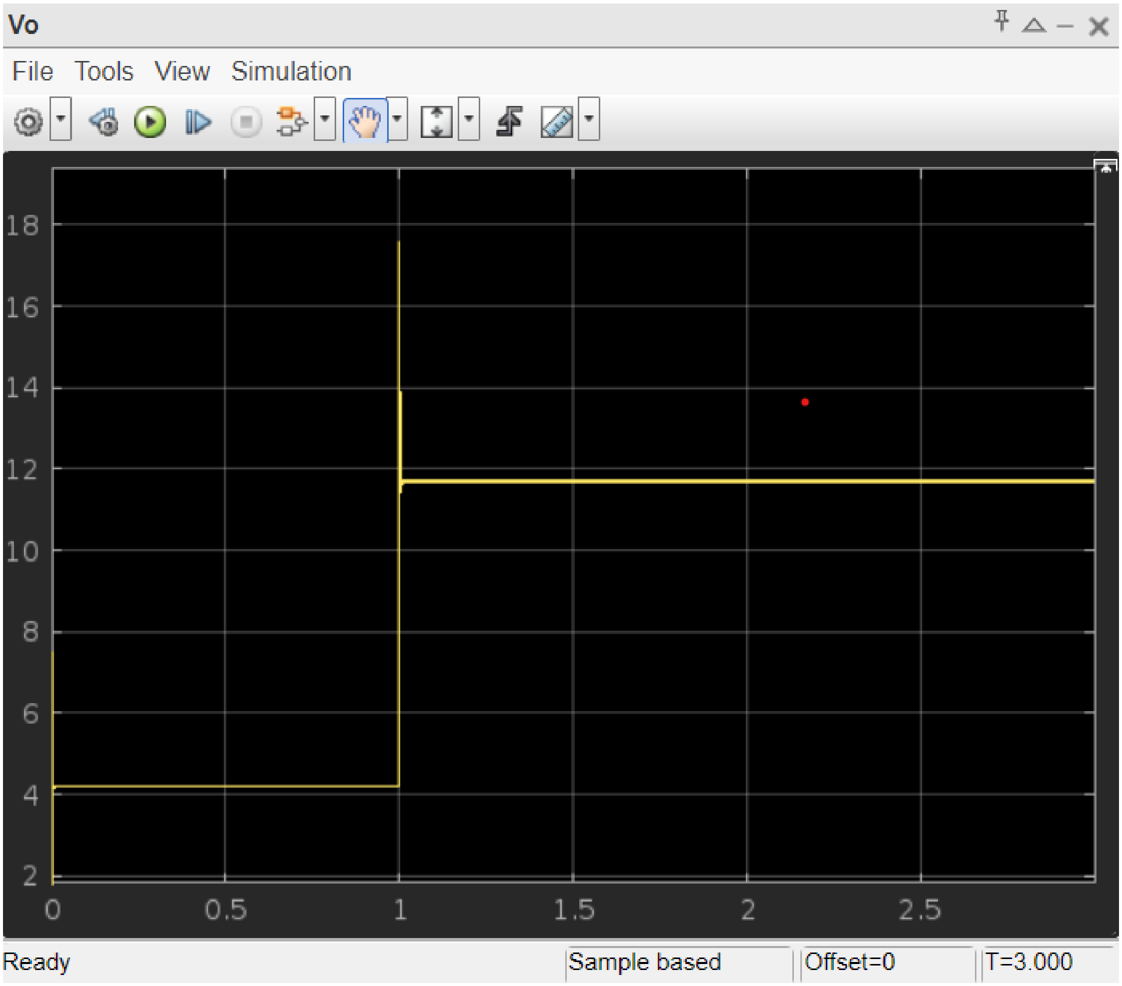



Here ,settling time=1.01-1=0.01 sec after which steady state is obtained.

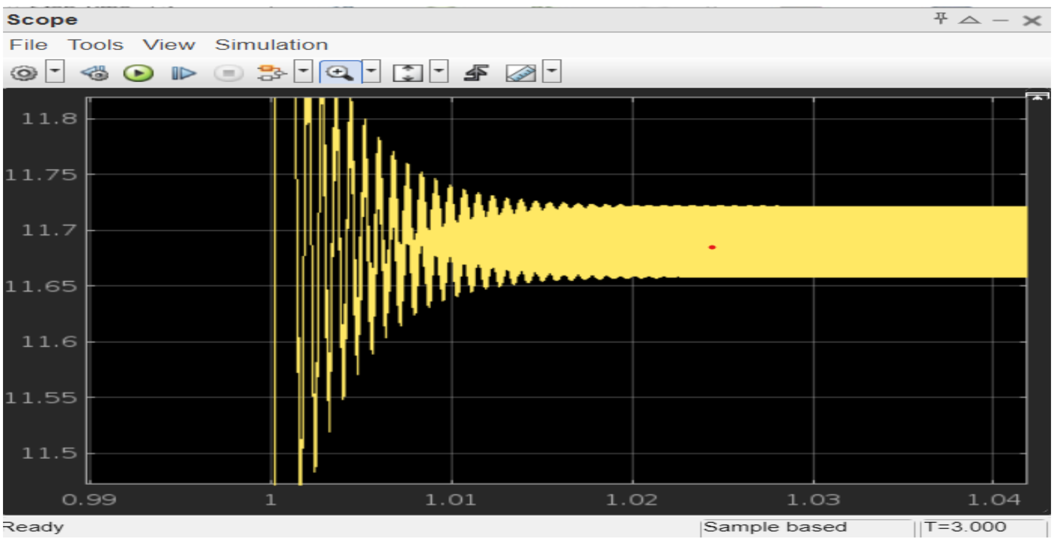
It can be seen that final value of  expected output is 30v (as D=0.6 and Vin=20) but output is 28.5 hence steady state error is (30-28.5)÷30=0.05 or 5%.

2. Step input voltage analysis:

Now we will change input voltage after certain time from 20v to 50v.




Overshoot of voltage can be noticed from graph,after t=1sec value of input voltage changes and output voltage changes from 4.2 to 11.7 with overshoot of 36.5 to 17.55 .




Settling time =1.02-1=0.02

Here expected output voltage at steady state is 12.5(as Vin=5-0 and D=0.2) but observed steady state output voltage is 11.7 hence steady state error =(12.5-11.7)÷12.5=0.064 or 6.4%.