BOOST CONVERTER

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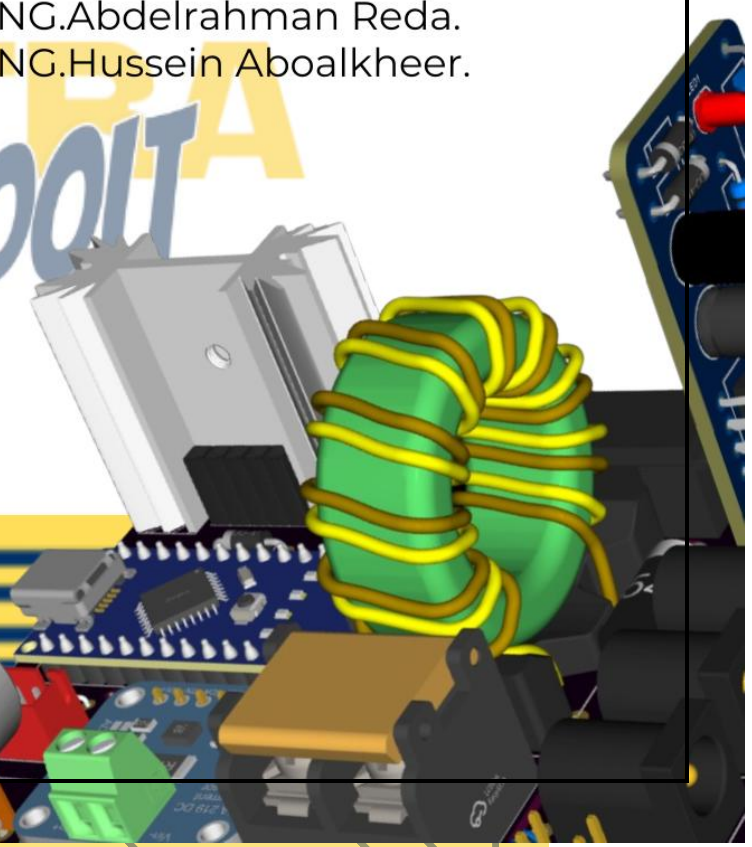


Table of Contents

1- Project Objective

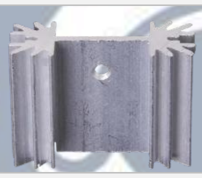
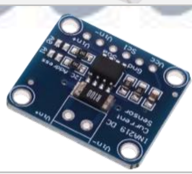
The aim of this project is to design and implement an **Irreversible Boost Converter** as an educational model for understanding the core principles of **asynchronous (non-isolated) DC–DC boost conversion**.
This project focuses on simplifying the concept for learners by providing a practical demonstration of voltage step-up operation using basic switching components, without the added complexity of synchronous rectification.
The converter increases the input DC voltage to a higher, regulated output level using an inductor-based energy transfer mechanism combined with a diode for unidirectional current flow—making it an *irreversible* topology.
As part of this design, we incorporated an **OBT isolated gate driver (TLP250)** to ensure proper MOSFET switching, electrical noise immunity, and safe isolation between the control circuitry and the power stage. This allows for stable gate signal delivery and enhances the reliability of the converter under varying load conditions.
Through this project, students gain hands-on experience with key topics such as:

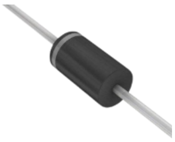
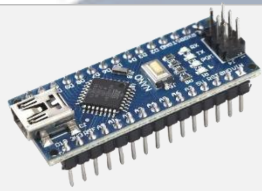
- Inductor charging and discharging cycles
- Duty cycle control and its impact on output voltage
- Component selection and real-world losses
- Efficiency considerations in asynchronous converters
- Switching behavior and waveform analysis
- Using isolated gate drivers for safe and reliable operation

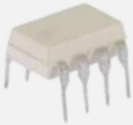
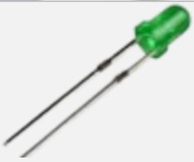
Overall, this project serves as a foundational step for understanding power electronics and prepares learners for more advanced topologies such as synchronous boost converters and isolated converters.

2- List of Components

1.1 Boost components

NO	NAME	Photo	Price	Quantity
1	inductor 40 mH		100.00 EGP	1
2	IRFP260 200V 50A 40mΩ@28A,10V 300W MOSFET N-Channel TO-247AC		60.00 EGP	1
3	Aluminium Heatsink For TO-247 White 34mmx25mmx12mm		10.00 EGP	1
4	Capacitor 22uF 350V		4.50 EGP	1
5	DC Power Jack Female Socket Connector 5.5mmx2.1mm		3.00 EGP	3
6	HB9500SS Barrier Terminal Block with Cover 300V/30A 2 Pin 9.5mm Pitch		7.50 EGP	1
7	BLX-A Fuse Holder 5mm x 20mm PCB Mount		4.00 EGP	1
8	Ceramic Fuse 3A - 250V T5x20mm		3.00 EGP	1
9	INA219 DC Current Measurement Sensor Module		110.00 EGP	1
10	Character LCD 16×2 Display Module		70.00 EGP	1

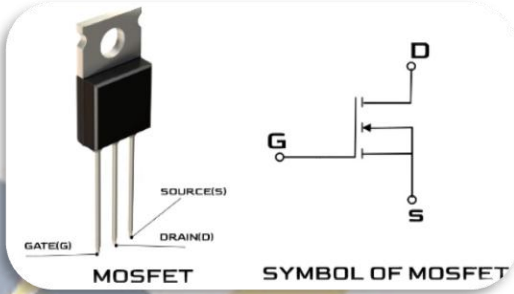
11	BY399 Fast Recovery Diode 3A 800V		3.50 EGP	1
12	1N4007 General Purpose Diode 1A 1.1V@1A 1kV DO-41		0.50 EGP	1
13	Metal Potentiometer 10K Ohm 3-Pin		5.50 EGP	1
14	Arduino Nano ATmega328PB-U CH340C Driver 5V 16MHz Mini USB		230.00 EGP	1
15	B4B-PH-S JST PH Data Terminal Male 4 Pin Connector Header 2mm		1.00 EGP	1
16	JST XH Female To Female Data Cable 4 Pin 2.54mm 30cm		8.00 EGP	1
17	Pin Headers Female 2.54mm : 40-Pin, Straight, Black, 11mm		5.00 EGP	2
18	Carbon Resistor 100 kΩ 0.5W Through Hole		0.25 EGP	1
19	Carbon Resistor 10 kΩ 0.5W Through Hole		0.25 EGP	1
20	AA Battery Holder 3-slot		13.00 EGP	1
21	Rechargeable 18650 Li-ion Battery 3.7V 1500mAh		60.00 EGP	3

22	AYD-0510 Adapter 5V 1A with Dual Jack		45.00 EGP	1
		1.2 TLP Gate driver		
1	TLP250 Mosfet Driver Dip-8		45.00 EGP	1
2	IC Socket (4+4)- Base 8 Pin		0.75 EGP	01
3	Round LED 3mm 2Pin - Green		0.50 EGP	1
4	Diodes Fast Recovery Rectifier UF4007		1.00 EGP	2
5	Capacitor 100uF 50V		1.50 EGP	1
6	Capacitor 10uf 100V		1.00 EGP	1
7	Ceramic Capacitor 100nF 50V		0.50 EGP	1
8	Carbon Resistor 47Ω 2W Through Hole		1.25 EGP	1
9	Carbon Resistor 10kΩ 0.5W Through Hole		0.25 EGP	1
10	Carbon Resistor1KΩ 1W Through Hole		0.50 EGP	2

3- Basic Concepts

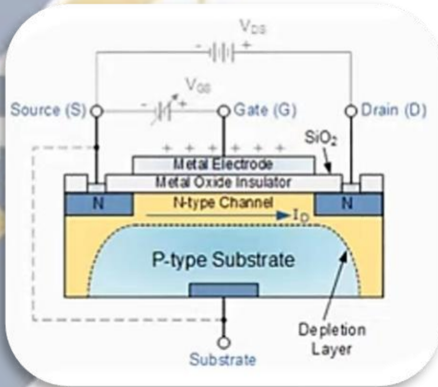
2.1 MOSFET (N-Type Enhancement)

An **N-type enhancement MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor)** is one of the most commonly used transistors in modern electronics. It is widely applied in switching and amplification because it operates efficiently as a **voltage-controlled device**.



2.1.1 Operating Principle

- The MOSFET consists of three main terminals: **Drain (D)**, **Source (S)**, and **Gate (G)**.
- The MOSFET remains **OFF** (no current flows between drain and source) until a **positive voltage** greater than the threshold voltage (**Vth**) is applied to the **gate terminal**.
- When the gate-to-source voltage (**Vgs**) exceeds **Vth**, an electron-rich channel forms between the drain and source, allowing current to flow. This condition is called **enhancement mode** because the conductivity of the channel is “enhanced” by the applied gate voltage.



2.1.2 Advantages

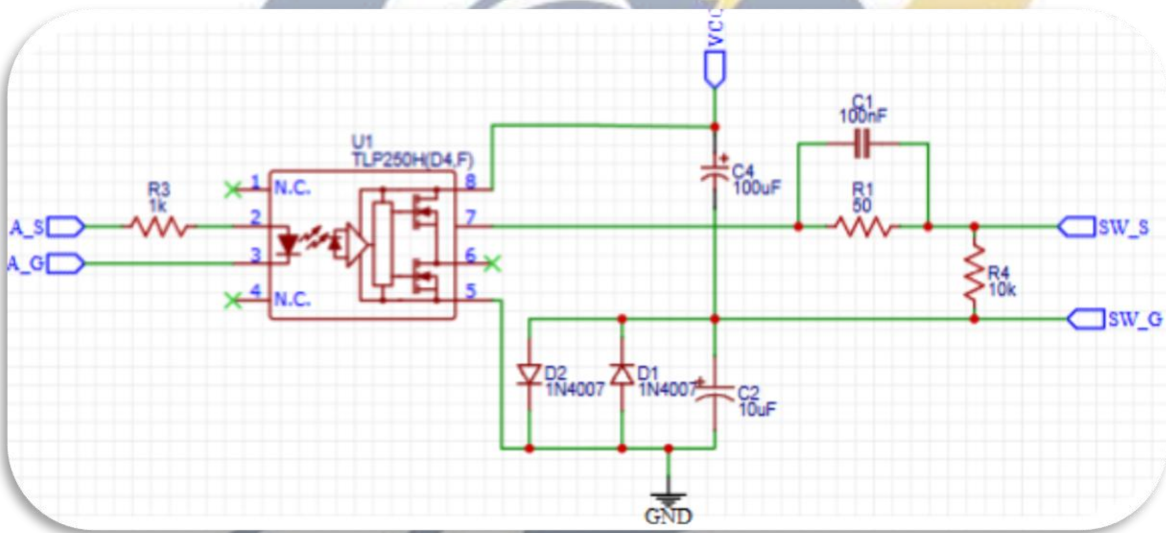
- **High input impedance** (almost no steady gate current).
- **Fast switching speed**, suitable for high-frequency circuits.
- **Low power losses**, making it ideal for power electronic applications.

2.2. TLP250 Gate Driver

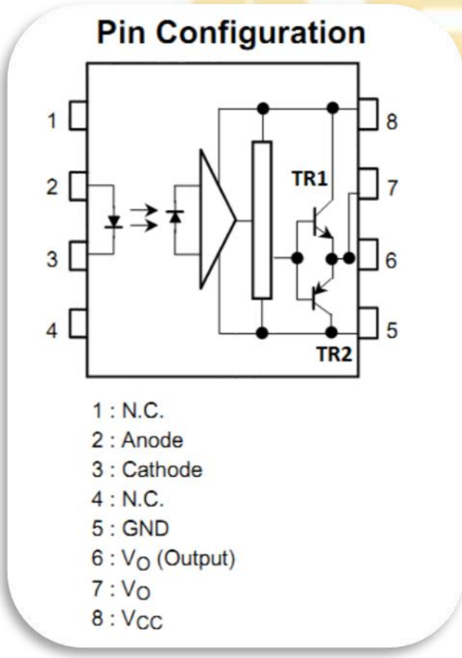
The TLP250 is an opto-isolated gate driver designed to drive MOSFET in high-frequency power circuits. It provides:

- Isolation between low-voltage control (e.g., Arduino) and high-power switching circuits.
- High-speed gate drive with peak source/sink current up to 1.2 A.
- Reliable PWM signal amplification for safe and efficient transistor switching.

In this project, it is used to drive the MOSFET of a 50 kHz boost converter.



2.2.1 TLP250 Important Pins



Pin	Function
2 (A_S)	PWM input to internal LED
3 (A_G)	Input ground
5	GND
7 (SW_S)	Gate output to MOSFET
8	VCC

2.2.2 Circuit Explanation

2.2.2.1 Input Section

- **R3 (1 kΩ)** limits the current flowing into the internal LED of the TLP250.
- The **PWM signal from the Arduino** passes through R3 to the **A_S input pin**, enabling the TLP250 to switch ON.
- **A_G** is connected to the Arduino ground to ensure a common reference for proper signal operation.

2.2.2.2 Power Supply Decoupling

Two capacitors are used across the TLP250 supply (VCC–GND) to ensure a stable 18 V input:

- **C2 = 10 µF (high-frequency capacitor):**
  - Filters high-frequency noise.
  - Suppresses fast voltage spikes.
  - Ensures clean and stable PWM operation inside the TLP250.
- **C4 = 100 µF (bulk capacitor):**
  - Stabilizes VCC during large current pulses.
  - Prevents voltage sag (*dips*) during switching events.

Using both capacitors provides complete decoupling:
C2 handles fast transients, while **C4 handles slow, low-frequency variations**.

2.2.2.3 MOSFET Gate Control

- **R1 = 50 Ω (Gate Resistor):**
  - Controls the MOSFET gate charging speed to prevent ringing.
  - Protects the TLP250 output from high inrush current.
  - Reduces electromagnetic interference (EMI).
- **R4 = 10 kΩ (Gate Pull-Down Resistor):**
  - Forces the MOSFET gate to **0 V** when the driver is OFF.
  - Prevents gate floating and unwanted MOSFET turn-on.
  - Enhances safety in bridge or high-side/low-side switching circuits.

2.2.2.4 Protection Diodes

D1 and D2 (1N4007) are connected in an anti-parallel configuration to the driver output. Their roles include:

- Clamping reverse voltage spikes.
- Providing a safe discharge path for the MOSFET gate.
- Reducing ringing and minimizing EMI.

2.2.2.5 Gate Behavior Explanation

The MOSFET gate behaves like a capacitor and can **retain charge** if not controlled. A floating gate may cause:

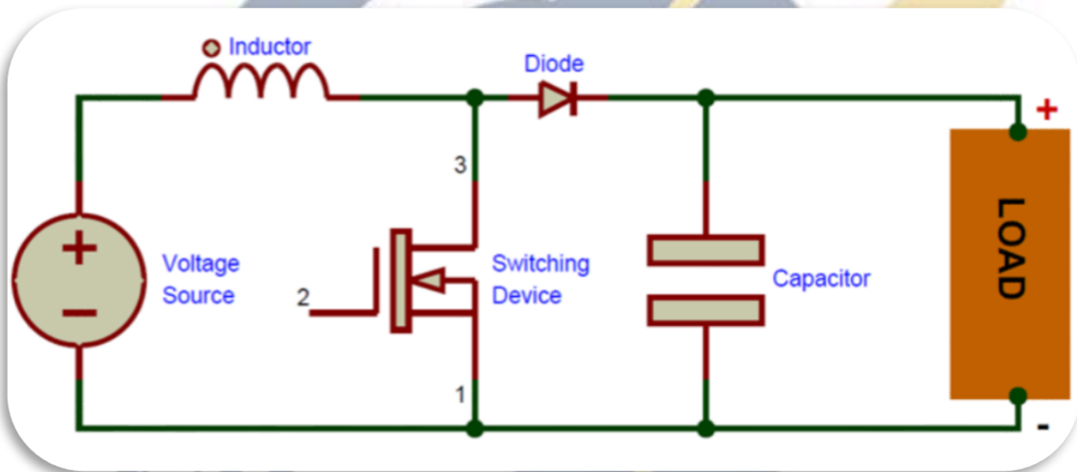
- Unintended or partial MOSFET turn-on.
- Excessive heating and power loss.
- Possible circuit malfunction or load activation.

The **pull-down resistor (R4)** ensures that the gate is quickly and safely discharged to **0 V** whenever the TLP250 output is not actively driving it.

4- Boost Converter

A boost converter is a DC–DC power electronic circuit specifically designed to **step up (increase)** a lower input voltage to a higher output voltage. It is widely used in power electronics applications such as battery-powered systems, renewable energy interfaces, and automotive electronics where efficient voltage elevation is required.

Its operation is based on the switching action of MOSFETs, energy storage elements (inductor and capacitor), and a diode to direct energy flow. By turning the switching device ON and OFF at high frequency, the boost converter transfers-controlled amounts of energy to the output and maintains a stable, regulated voltage greater than the input.



4.1 Basic Operation Components

4.1.1 Switching Device (MOSFET):

The MOSFET acts as the main high-speed switch. It alternates between ON and OFF states, controlling how much energy is stored in and released from the inductor.

4.1.2 Inductor (L):

The inductor stores energy during the ON state of the MOSFET. When the MOSFET turns OFF, the inductor releases this stored energy, which adds to the input voltage and raises the output voltage above the input.

4.1.3 Diode (D):

The diode ensures unidirectional current flow. It blocks current during the MOSFET ON phase and becomes forward biased during the OFF phase, allowing the inductor to transfer energy to the capacitor and load.

4.1.4 Output Capacitor (C):

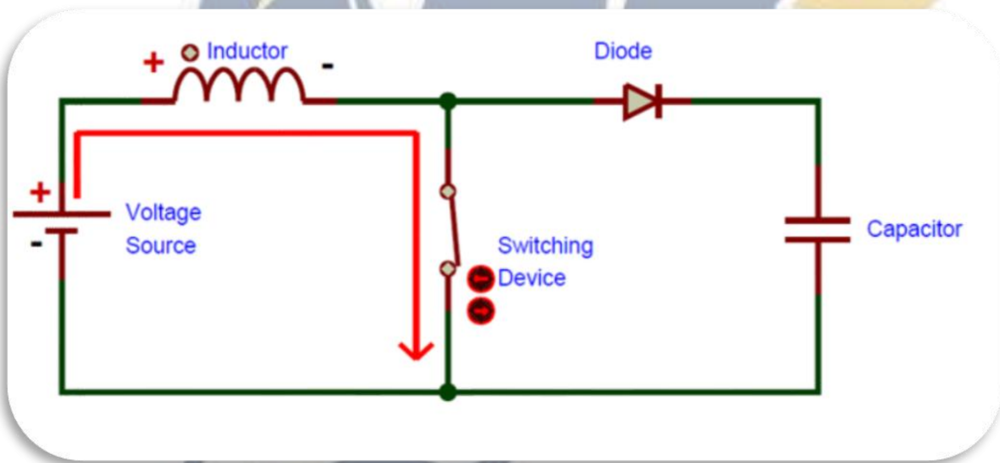
The capacitor smooths the pulsating voltage coming from the inductor during switching, reducing ripple and maintaining a continuous DC output voltage.

4.1.5 Control Circuit:

Provides gate-drive signals to the MOSFET and regulates the duty cycle, which directly controls the output voltage level.

4.2 Operation Cycle

4.2.1 Switch ON, Diode OFF (Energy Storage



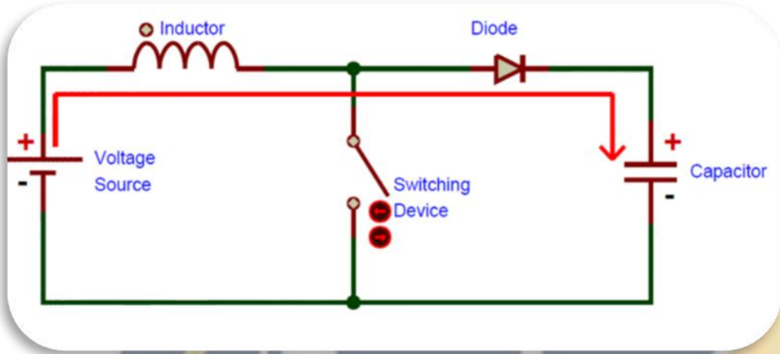
Mode)

In this mode, the MOSFET is turned ON, creating a low-resistance path from the input source through the inductor to ground.
As a result:

- The inductor current increases linearly, and energy is stored in its magnetic field.
- The diode becomes reverse-biased, isolating the output stage from the input.
- The output capacitor provides the required energy to the load, ensuring a stable and continuous output voltage.
- Since the diode is OFF, the capacitor voltage remains nearly constant and does not discharge back into the inductor.

This stage is fundamental for boost operation because it allows the converter to accumulate energy that will be released to the load during the OFF state. The switch duty cycle directly controls how much energy the inductor stores, making this mode essential for voltage regulation when input conditions vary.

4.2.2 Switch OFF, Diode ON (Energy Transfer Mode)



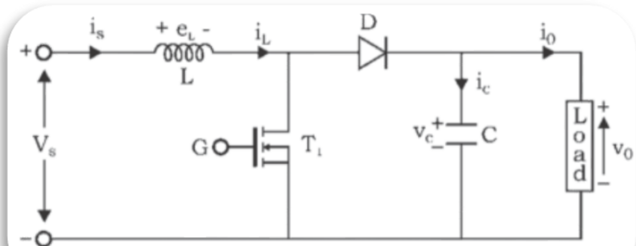
When the MOSFET turns OFF, the current path from the input is suddenly interrupted. The inductor reacts to the drop in current by reversing its polarity and generating a higher voltage than the input.
This forward-biases the diode and creates a path for energy to flow to the output.
In this phase:

- The inductor releases its stored energy to both the load and the output capacitor.
- The capacitor is recharged, helping to maintain a smooth, ripple-reduced output voltage.
- The load continues receiving uninterrupted power even though the input path is disconnected.
- The combined voltage of the input and inductor boosts the output above the source voltage.

This phase is critical for proper boost converter function, ensuring efficient energy transfer, voltage boosting, and stable operation under dynamic load conditions.

4.3Calculation of a Boost Converter's

4.3.1 Basic Configuration of a Boost Converter



(a)

4.3.2 General Design Equations for a Boost Converter

4.3.2.1 Duty Cycle (D)

Determines how much the converter boosts the voltage.

$$D = 1 - \frac{V_{in}}{V_{out}}$$

To account for real-world losses :

$$D_{real} = 1 - \eta \cdot \frac{V_{in}}{V_{out}}$$

4.3.2.2 Inductor Value (L)

Chosen to keep the converter in Continuous Conduction Mode (CCM).

$$L = \frac{V_{in} \cdot D}{\Delta I_L \cdot f_s}$$

Where:

- ΔI_L = inductor ripple current (typically 20–40% of average inductor current)
- fs = switching frequency

4.3.2.3 Inductor Ripple Current (ΔIL)

$$\Delta I_L = \frac{V_{in} \cdot D}{\mathrm{L} \cdot f_s}$$

The inductor ripple current cannot be calculated because the inductor is not known. A good estimation for the inductor ripple current is

$$\Delta I_L = (0.2 to 0.4)\mathrm{Iout(max)}\frac{V_{out}}{V_{in}}$$

20% to 40% of the output current.

ΔI_L = estimated inductor ripple current

$I_{OUT(max)}$ = maximum output current necessary in the application

4.3.2.4 Inductor Current (IL)

Average inductor current:

$$I_L = \frac{I_{out}}{1 - D}$$

4.3.2.5 Peak Inductor Current (IL_peak)

the maximum switch current in the system is calculated

$$I_{L,peak} = I_L + \frac{\Delta I_L}{2}$$

4.3.2.6 Output Capacitor (C)

Controls output voltage ripple.

$$C = \frac{I_{out} \cdot D}{\Delta V_{out} \cdot f_s}$$

ΔV_{OUT} = desired output voltage ripple(Recommended ΔV_{out} = 1–3% of V_{out}).

<u>Practical selection :</u>

- Use Low-ESR capacitors
- Prefer ceramic X5R / X7R
- Combine electrolytic + ceramic

4.3.2.7 Output voltage ripple due to capacitors (ΔVOUT(ESR))

$$\Delta V_{OUT(ESR)} = ESR\left(\frac{\Delta I_L}{2} + \frac{I_{out(max)}}{1 - D}\right)$$

$\Delta V_{OUT(ESR)}$ = additional output voltage ripple due to capacitors ESR

ESR = equivalent series resistance of the used output capacitor

$I_{OUT(max)}$ = maximum output current of the application

4.3.2.8 Diode Selection

To reduce losses, Schottky diodes(Fast recovery) should be used.

The forward current rating needed is equal to the maximum output current:

Forward current ≥ IL_peak

The other parameter that has to be checked is the power dissipation of the diode. It has to handle: $P_D = I_F \times V_F$

I_F = average forward current of the rectifier diode

V_F = forward voltage of the rectifier diode

4.3.2.9 MOSFET Selection

MOSFET must handle:

Voltage:

$$V_{DS} \geq V_{out}$$

Current:

$$I_{DS} \geq I_{L,peak}$$

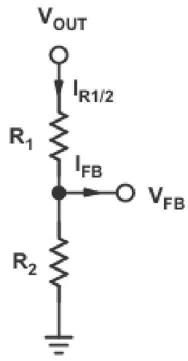
Other recommendations:

- Low Rds(on)
- Fast switching
- Good thermal performance

4.3.2.10 Output Voltage Setting (feedback):

Almost all converters set the output voltage with a resistive divider network (which is integrated if they are fixed output voltage converters). With the given feedback voltage, VFB, and feedback bias current, IFB, the voltage divider can be calculated :

The current through the resistive divider shall be at least 100 times as big as the feedback bias current: $I_{R1/2} = 100 \times I_{FB}$



IR1/2 = current through the resistive divider to GND

IFB = feedback bias current from data sheet

With the above assumption, the resistors are calculated as follows:

$$R_2 \geq \frac{V_{FB}}{I_{R1/2}}$$

$$R_1 = R_2 \times (\frac{V_{OUT}}{V_{FB}} - 1)$$

R_1,R_2 = resistive divider,

V_{FB} = feedback voltage from the data sheet

$I_{R1/2}$ = current through the resistive divider to GND

V_{OUT} = desired output voltage

4.3.3.11 Boost Converter Design Summary (Vin=12V → Vout=34V @ 50kHz)

Parameter	Equation Used	Calculated Value	Practical Selected Value
Duty Cycle (Ideal)	D = 1 - Vin/Vout	0.647	—
Duty Cycle (Real)	D = 1 - η·Vin/Vout	0.682	Use 0.68
Inductor Ripple (ΔIL)	0.3·Iout·(Vout/Vin)	0.85 A	30% recommended
Inductor (L)	L = Vin·D / (ΔIL·fs)	192 µH	40 mH
Inductor Current (Avg)	I_L = Iout/(1-D)	3.12 A	MOSFET >3A
Inductor Current (Peak)	IL_peak = IL + ΔIL/2	3.55 A	Design ≥4A
Output Capacitor	C = Iout·D / (ΔVout·fs)	20 µF	22 µF
Ripple ESR	ΔV_ESR = ESR(...)	0.14 V	OK
Diode Current	≥ IL_peak	—	BY399 Fast Recovery Diode 3A 800V
MOSFET Voltage	≥ Vout	—	60V MOSFET
MOSFET Current	≥ IL_peak	≥3.55A	IRFP260
R2	VFB / I	12.5kΩ	10kΩ
R1	R2(Vout/VFB - 1)	315kΩ	100kΩ

5- Explanation of Boost converter Arduino code

5.1 Libraries and hardware used

```
#include <Wire.h>                // I2C library
#include <Adafruit_INA219.h>     // INA219 current sensor library
#include <TimerOne.h>            // Timer1 library for PWM at custom frequency
#include <LiquidCrystal_I2C.h>  // LCD I2C library
```

5.2 Pin / object mapping

```
// ----------------- Pins -----------------
#define loadVoltagePin  A1   // Analog pin connected to voltage divider (Vout measurement)
#define potPin          A0   // Analog pin connected to potentiometer (reference for duty cycle)

// ----------------- Objects -----------------
Adafruit_INA219 ina219;            // INA219 current sensor object
LiquidCrystal_I2C lcd(0x27,16,2); // LCD I2C object (0x27 is common I2C address)
```

5.3Important constants and variables

```
// ----------------- Variables -----------------
int duty = 0;                  // PWM duty value (0-1023)
float current_mA = 0;          // Measured current in mA from INA219
float V_actual = 0;            // Measured voltage on load via voltage divider
int adc;                        // Raw ADC reading for load voltage
float Vadc;                     // Converted voltage from ADC

// ----------------- Constants -----------------
float Vin = 12.0;              // Input voltage to the boost converter
float R1 = 110000.0;           // Voltage divider resistor R1 in Ohms
float R2 = 10000.0;            // Voltage divider resistor R2 in Ohms
```

5.4Void setup ()

```
setup() {
Serial.begin(115200);           // Start serial communication for debugging
while (!Serial) { delay(1); }   // Wait for serial to be ready (needed on some boards)

// ---------- INA219 Setup ----------
if (!ina219.begin()) {           // Initialize INA219 sensor
  Serial.println("Failed to find INA219 chip");
  while(1){ delay(10); }        // Stop execution if INA219 is not detected
}

// ---------- LCD Setup ----------
lcd.init();                      // Initialize LCD
lcd.backlight();                 // Turn on backlight
lcd.clear();                     // Clear LCD
lcd.setCursor(0,0);
lcd.print("Astra Volt");         // Initial message
delay(800);

// ---------- PWM Setup ----------
Timer1.initialize(20);           // Set Timer1 period: 20us → 50kHz PWM
Timer1.pwm(9, 0);                // Start PWM on pin 9 with 0 duty

pinMode(loadVoltagePin, INPUT); // Configure load voltage pin as input
pinMode(potPin, INPUT);          // Configure potentiometer pin as input
lcd.clear();                     // Clear LCD for main loop
```

5.5void loop

5.5.1 Read potentiometer and Compute theoretical Vout from current duty

```
void loop() {
  // -------- Read potentiometer to control Duty --------
  int potRaw = analogRead(potPin);       // Read potentiometer (0-1023)
  float D =  potRaw / 1023.0;              // Convert current PWM duty to fraction (0-1)
  float V_theoretical = Vin / (1.0 - D);  // Calculate theoretical Vout from current duty (Boost formula)
```

- The potRow ADC value is divided by 1023 to map it to a **fraction between 0 and 1**.
- This fraction represents the **duty cycle D** of the boost converter, where:

$$D = \frac{\text{on} - \text{time}}{\text{total switching period}}$$

- Compute theoretical Vout from current duty

$$V_{out} = \frac{V_{in}}{1 - D}$$

5.5.2 Read measured output voltage

```
// -------- Read actual load voltage --------
adc = analogRead(loadVoltagePin);       // Read ADC value from voltage divider
Vadc = adc * (5.0 / 1023.0);            // Convert ADC to voltage (0-5V)
V_actual = Vadc * (R1 + R2) / R2;       // Convert to actual load voltage using voltage divider formula
```

_ADC reading converted to 0–5V (Vadc), then scaled by voltage divider to get the actual output voltage:

$$V_{actual} = V_{adc} \times \frac{R1 + R2}{R2}$$

With R1 = 110k and R2 = 10k the divider ratio is 12, So measured ADC 5 V corresponds to 60 V

5.5.3 Read current from INA219

```
// -------- Read current from INA219 --------
current_mA = ina219.getCurrent_mA();  // Read current in mA
```

5.5.4 Feedback control

```
// -------- Simple feedback control --------
if(V_theoretical > V_actual) {            // If theoretical voltage higher than measured
  duty++;                                 // Increase PWM duty
} else if(V_theoretical < V_actual) {     // If theoretical voltage lower than measured
  duty--;                                 // Decrease PWM duty
}
duty = constrain(duty,0,1023);            // Ensure duty stays within 0-1023
Timer1.setPwmDuty(9,duty);                // Apply PWM duty to pin 9
```

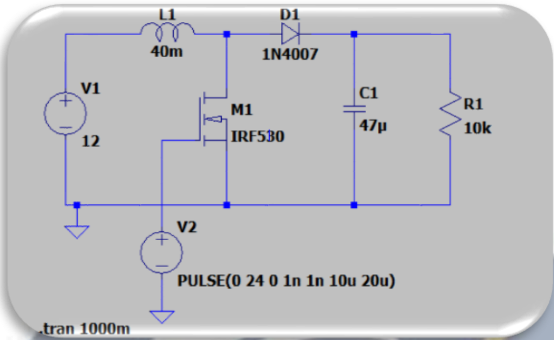
5.5.6 LCD and Serial output

```
// -------- LCD Display --------
lcd.setCursor(0,0);
lcd.print("Vout:");
lcd.print(V_actual,1);                  // Show measured voltage
lcd.print("V   ");                      // Clear extra characters

lcd.setCursor(0,1);
lcd.print("I:");
lcd.print(current_mA,0);                // Show measured current
lcd.print("mA   ");                     // Clear extra characters

// -------- Serial Monitor --------
Serial.print("Vout="); Serial.print(V_actual);
Serial.print(" | I="); Serial.print(current_mA);
Serial.print("mA | PWM="); Serial.println(duty);

delay(150);                             // Small delay for stability
```

6- Simulation

6.1 LTspice

6.1.1 Circuit Desing

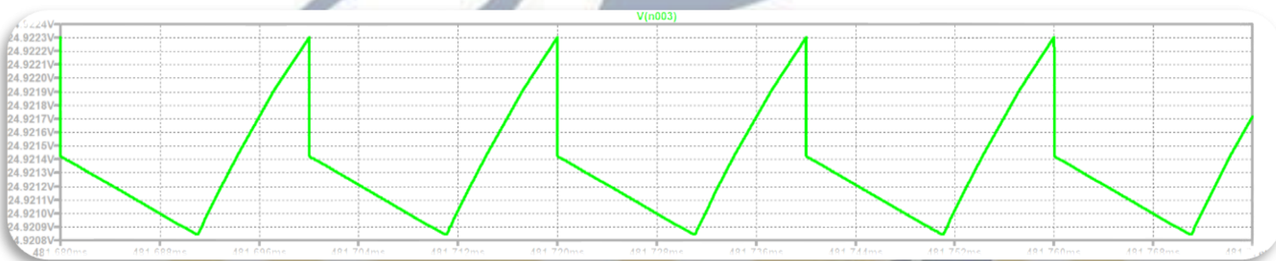


6.1.2 Wave form of circuit

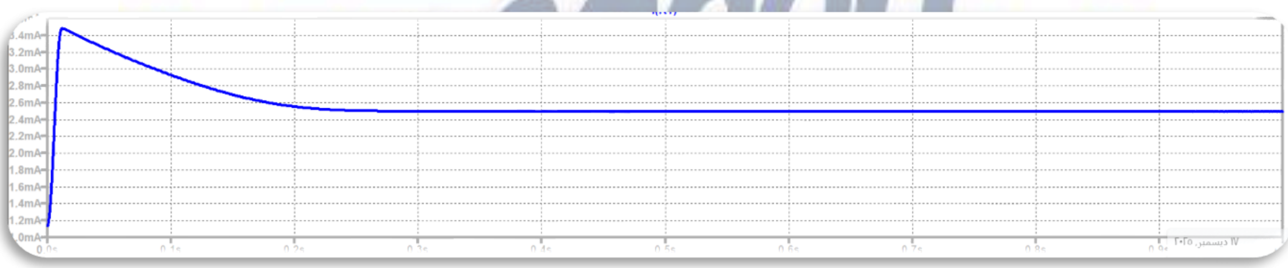
(Duty Cycle = 50%)

Output Voltage

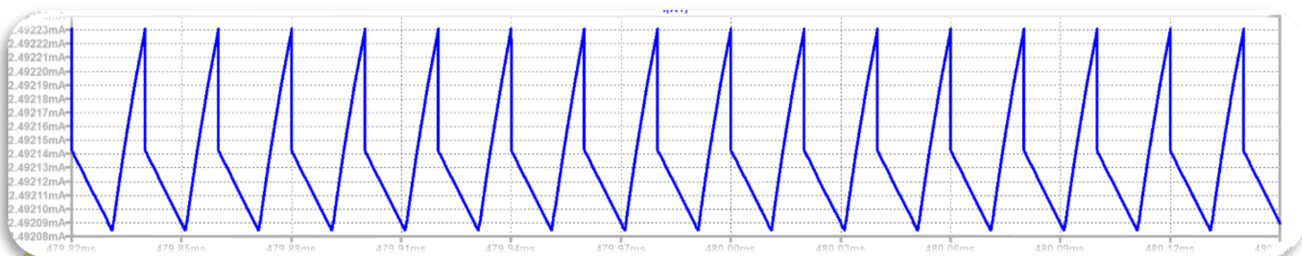
Output Voltage ripple



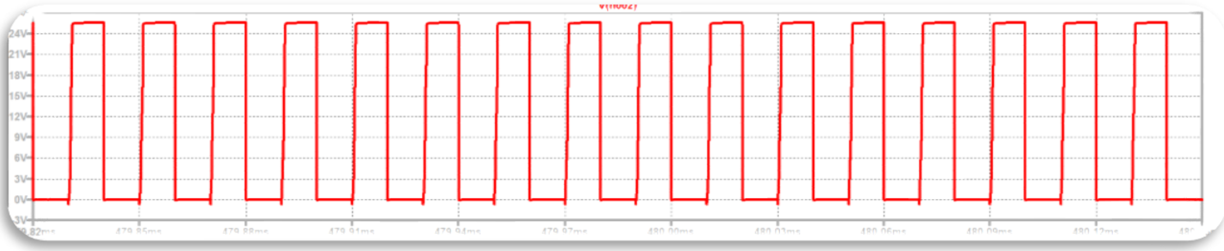
Output Current



Output current ripple



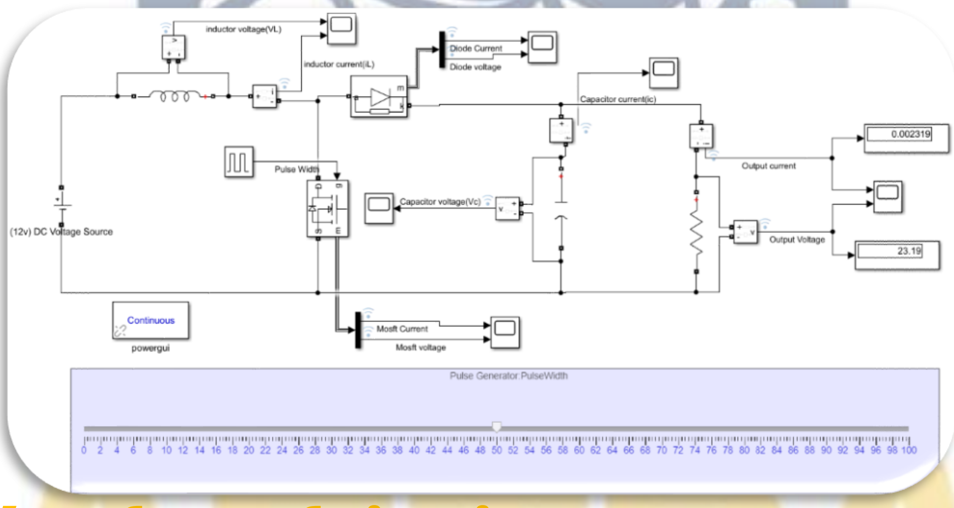
Inductor / MOSFT / Diode Voltage



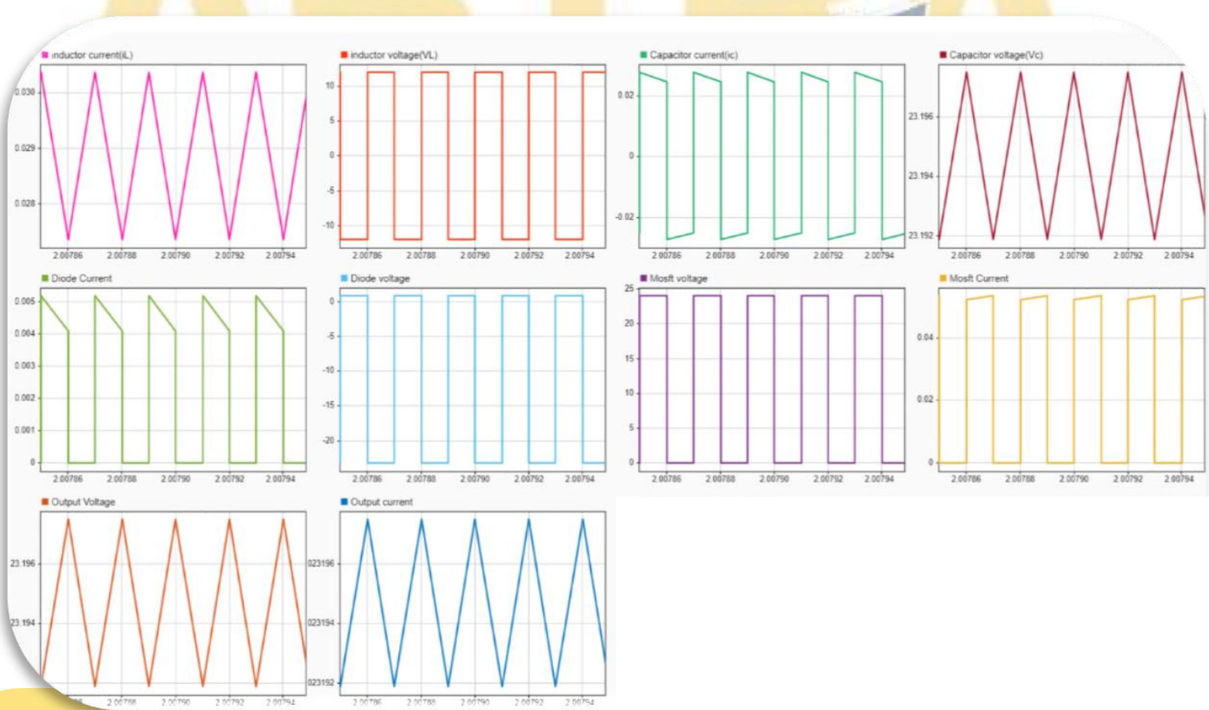
Inductor current

6.2 MATLAB (Simulink):

6.2.1 Circuit Desing



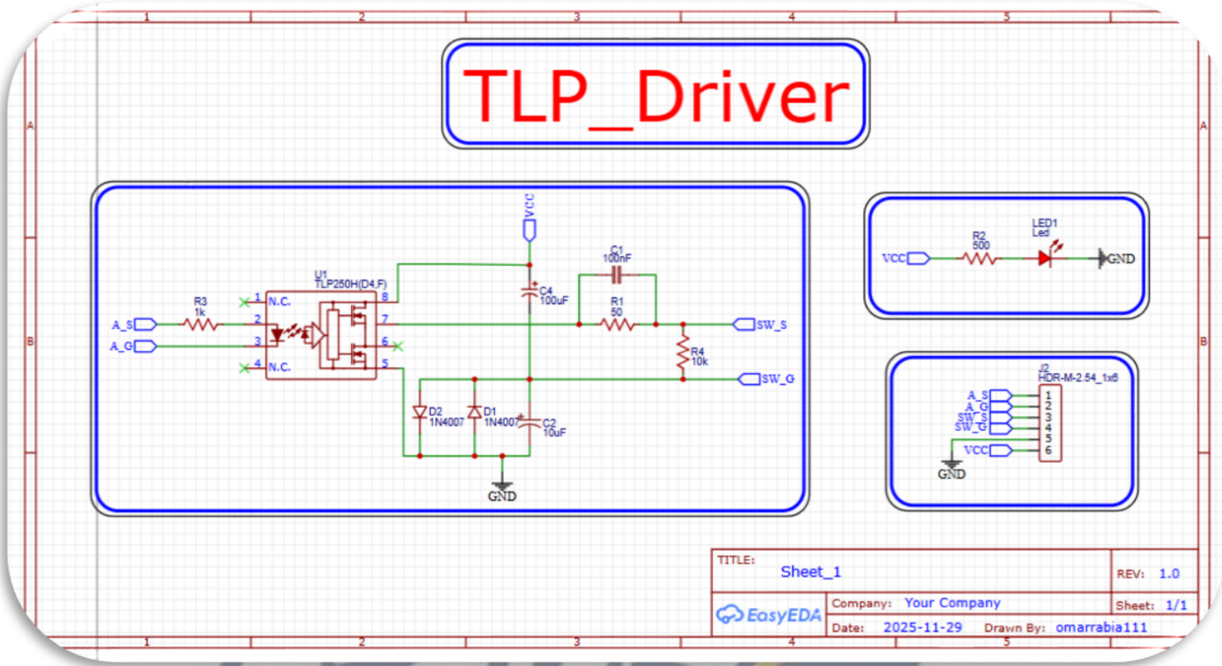
6.1.3 Wave form of circuit



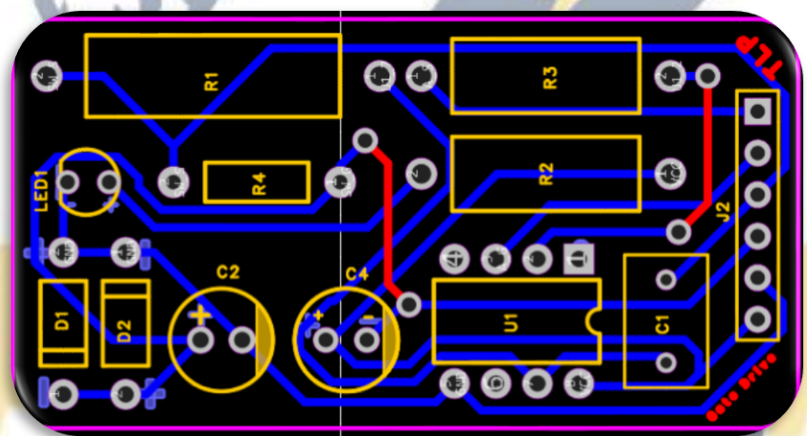
7- Easy EDA DESIGN

6.1 Gate Drive (TLP250):

7.1.1 Schematic



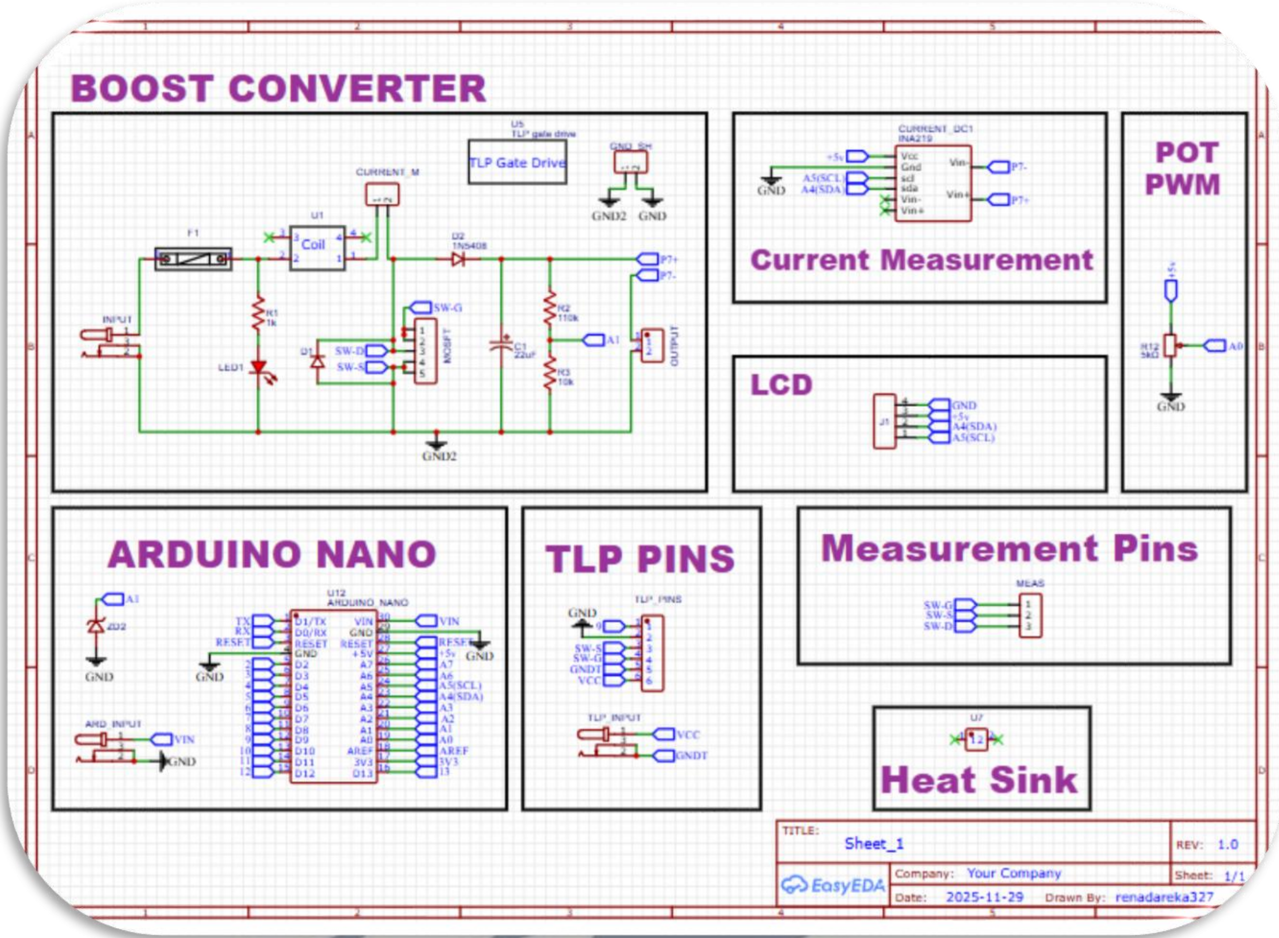
7.1.2 PCB



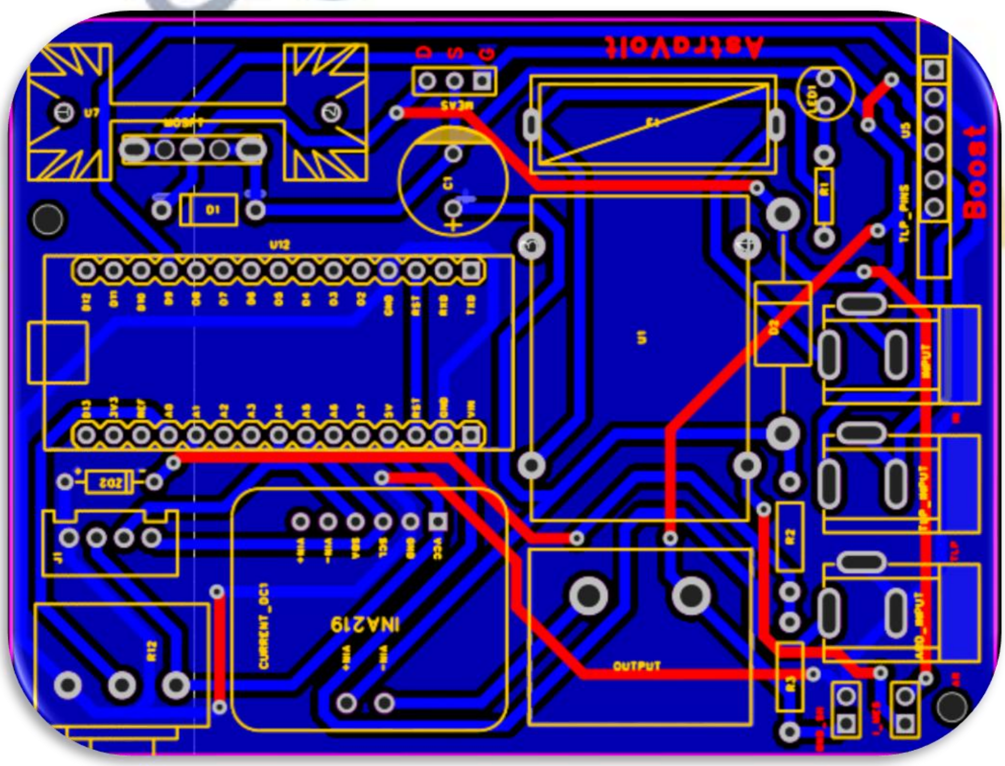
7.1.3 3D

6.2 Boost Converter:

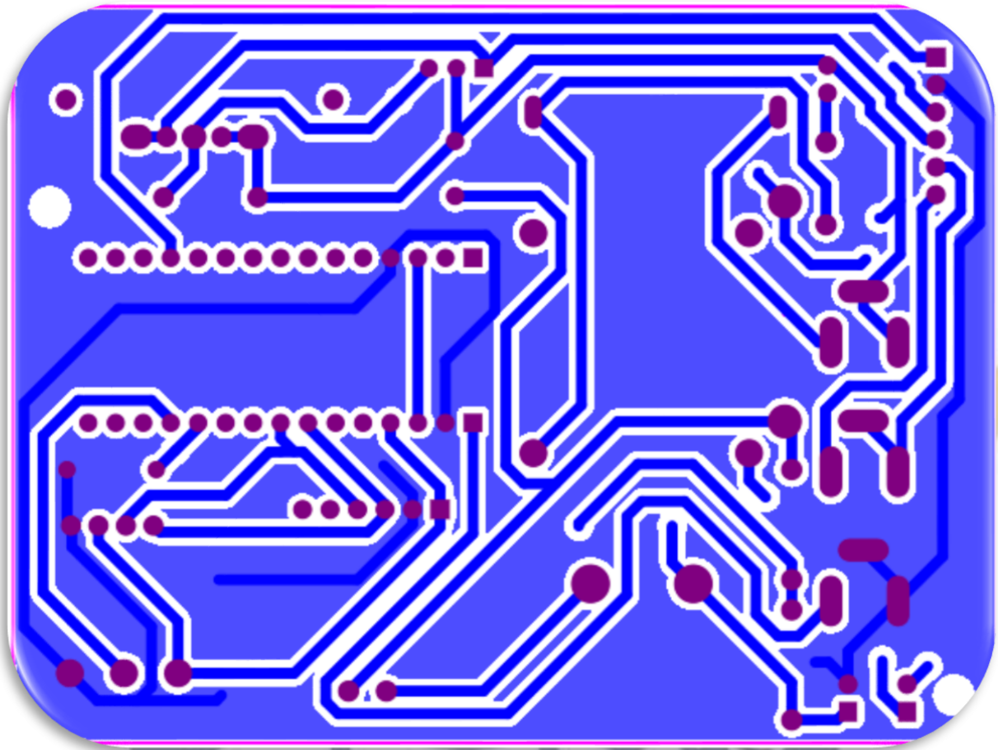
7.2.4 Schematic



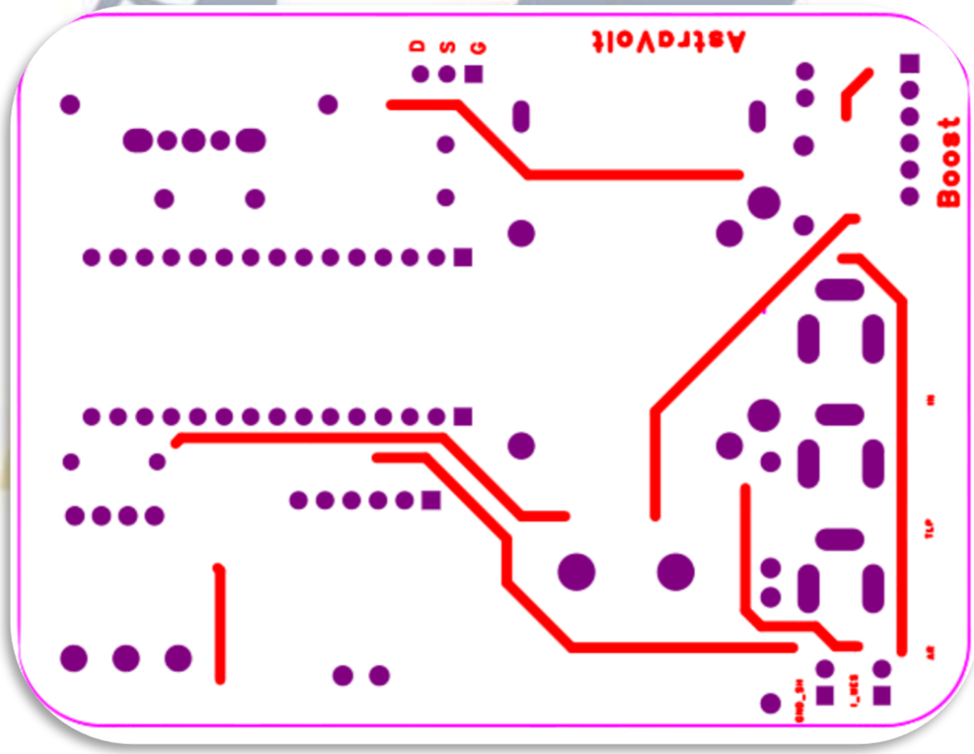
7.2.5 PCB



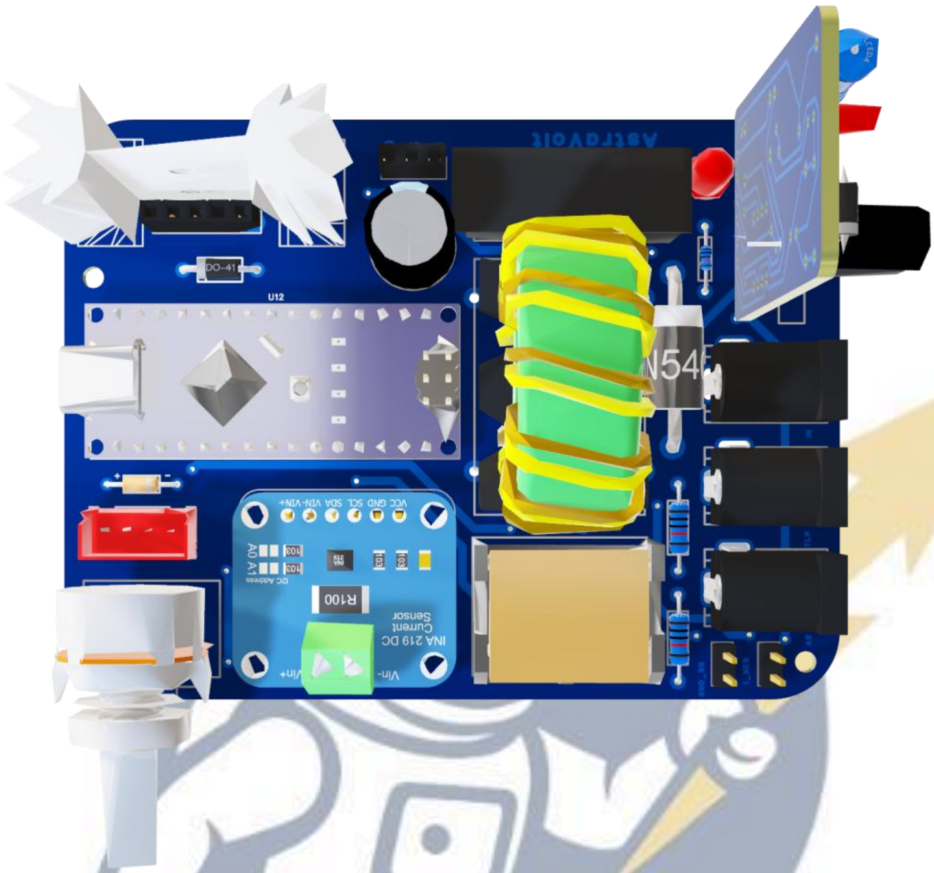
7.2.6 Bottom Layer

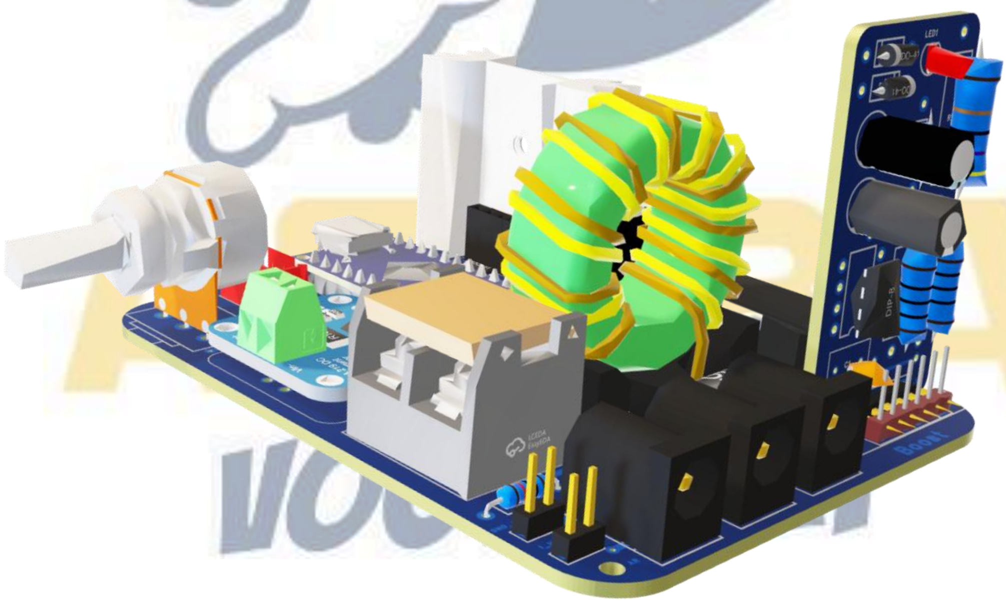


7.2.7 Top Layer



7.2.8 3D

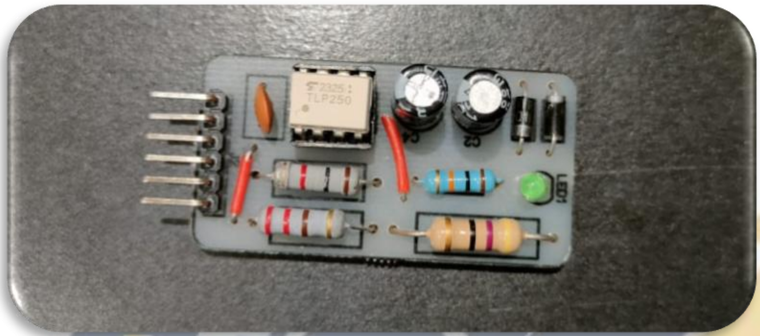




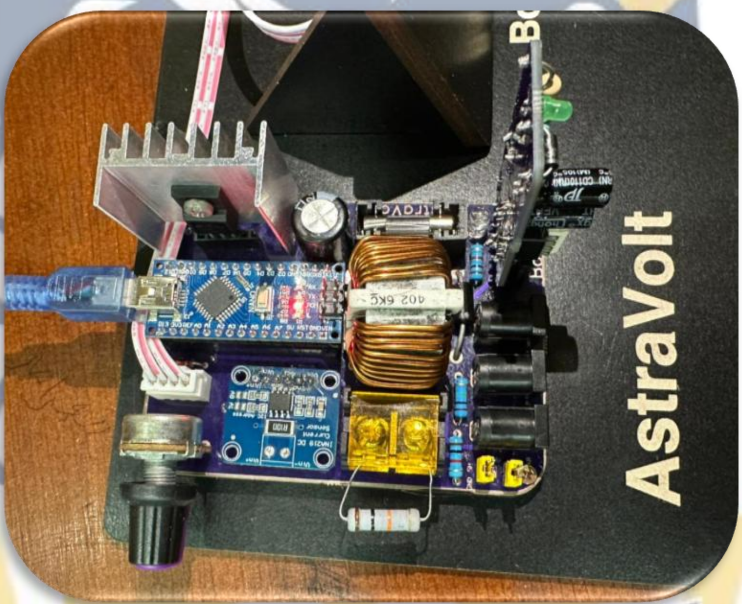
8- Testing & Results

8.1 PCB Testing:

8.1.1 Gate Drive :



8.1.2 Boost Converter :



8.2 Complete project :

8.3 Testing with different duty cycle :

Testing using Vin = 12.5 V & R load = 10KΩ

8.3.1 duty cycle = 70%

8.3.2 duty cycle = 60%

8.3.3 duty cycle = 50%

8.3.4 duty cycle = 30%

8.3.5 duty cycle = 20%

8.3.6 More Testing for circuit

9- Challenges & Solutions

9.1 Unavailability of the Required MOSFET in the Local Market

One of the initial challenges faced in the project was the **unavailability of the required MOSFET specifications in the Egyptian market**. The intended MOSFET needed to meet certain performance criteria including:

- High voltage rating
- Low $R_{DS(on)}$
- Fast switching capability
- Adequate thermal performance
- Reliability under repetitive switching stress

Most available components either had **limited voltage capability**, **high conduction losses**, or were unsuitable for high-frequency boost converter applications due to manufacturing variations, temperature derating, or mismatched gate charge parameters.

As an attempt to resolve this issue, several MOSFETs were tested, including the **IRFP260**, but it did not achieve the required performance level in terms of efficiency and thermal stability.

Therefore, we switched to a more suitable device:
FQPF20N60 (isolated package)

Key Parameters of the FQPF20N60 Used

V_{DS}	700V@150℃
I_D (at V_{GS}=10V)	20A
$R_{DS(ON)}$ (at V_{GS}=10V)	< 0.37Ω

- **Isolated TO-220F package**, improving thermal and safety performance

These parameters matched the design requirements better and allowed the converter to operate reliably with the TLP250 isolated gate driver.

IRFP260

FQPF20N6

9.2 Inductor Charging and Discharging Issue

During the initial testing phase, a major challenge appeared in the **charging and discharging behavior of the inductor**.

The inductor did not have sufficient time to fully store and release energy within each switching cycle, which caused:

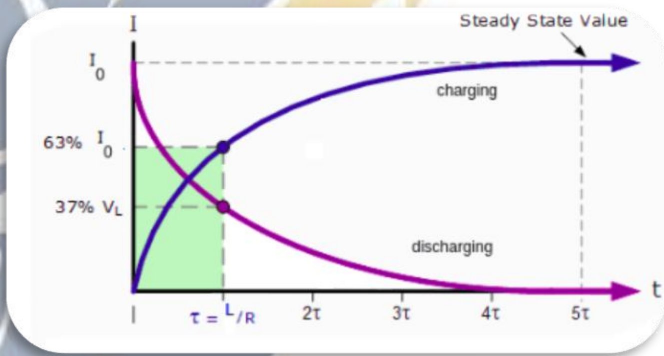
- High ripple current
- Increased switching losses
- Poor energy transfer
- Noticeable efficiency drop

The behavior of the inductor in a boost converter follows the time constant:

$$\tau = \frac{L}{R}$$

Where:

- **τ** is the time constant of the inductor
- **L** is the inductance
- **R** is the equivalent resistance seen by the inductor during charging



The inductor requires approximately:

$$5\tau$$

to complete a full charging cycle (reach steady-state current).

If the switching frequency is too high or the inductor value is too small, the inductor will not complete its **5τ charging interval**, resulting in poor performance and unstable converter behavior.

Solution

To fix this, we aligned the inductor’s natural charging/discharging time with the switching period:

- **Inductor value**: 40 mH
- **Switching frequency**: 50 kHz
- **Load fixed at**: 10 kΩ

This ensured:

- Proper completion of the **5τ** interval
- Stable inductor current
- Reduced ripple
- Improved efficiency
- Smooth operation in Continuous Conduction Mode

9.3 Load Stabilization Issue

Due to the previous inductor problem, the converter output behavior became heavily dependent on the load value, which forced the load to be fixed at **10 kΩ** to maintain acceptable operation.
This is not ideal for a practical boost converter that should operate across varying load conditions.

Solution – Implementing Feedback Control

To overcome this limitation, a **feedback loop** was added.

The feedback system monitors the output voltage and adjusts the **duty cycle** dynamically to maintain a stable output regardless of load variations. This allows:

- Automatic correction of voltage deviations
- Improved regulation
- Better efficiency
- Safe operation under varying conditions

The addition of feedback ensured that the boost converter could operate reliably even when the load was

not fixed, restoring proper performance and output stability.

10- Acknowledge

We would like to extend our appreciation to Dr. Mohamed El-Gohary for supervising the course and providing a supportive learning environment. We also thank Eng. Mohand Samir for his guidance during the laboratory sessions and for facilitating the project requirements.

Their roles in the course contributed to the completion of this report.

11- Reference

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