DESIGN AND SIMULATION OF GATE DRIVE TRANSFORMER

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF TECHNOLOGY

In

ELECTRICAL ENGINEERING

By

VIVEK KUMAR GUPTA (11701619009)
SUMAN DAS (11701619007)
SOURAV SEN (11701619005)

UNDER THE SUPERVISION OF

Mr. SUBHASIS BANDHOPADHYAY

Assistant Professor

Department. of Electrical Engineering, RCCIIT

AT

RCC INSTITUTE OF INFORMATION TECHNOLOGY

[Affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), WestBengal, India]

CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700 015

ACKNOWLEDGEMENT

It is my great fortune that I have got opportunity to carry out this project work under the supervision of **Mr. Subhasis Bandhopadhyay** in the Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata- 700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India. I express my sincere thanks and deepest sense of gratitude to my guide for his constant support, unparalleled guidance and limitless encouragement**.**

I wish to convey my gratitude to Mr. Subhasis Bandhopadhyay, HOD, Department of Electrical Engineering, RCCIIT and to the authority of RCCIT for providing all kinds of infrastructural facility towards the research work.

I would also like to convey my gratitude to all the faculty members and staffs of the Department of Electrical Engineering, RCCIIT for their sincere cooperation to make this work turn into reality.

I would also like to thanks RCCIIT for financial support to perform this project work.

Name and Signature of the Students

Place:

Date:

Department of Electrical Engineering
RCC INSTITUE OF INFORMATION TECHNOLOGY
GROUND FLOOR, NEW BUILDING,
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015, WEST BENGAL
PHONE: 033-2323-2463-154, FAX: 033-2323-4668
Email: hodeercciit@gmail.com, Website: http://www.rcciit.org/academic/ee.aspx

CERTIFICATE

To whom it may concern

This is to certify that the project work entitled **Design And Simulation of Gate Drive Transformer** is the bona fide work carried out by **Vivek Kumar Gupta (11701619009), Suman Das (11701619007) & Sourav Sen (11701619005)**, students of Bachelor of technology in the Department of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year 2016-17, in partial fulfilment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

Signature of External Examiner

Name:

Signature of Mentor

Name:

Signature of HOD-(EE)

Name:

ABSTRACT

Gate drive transformers are essential components in power electronic systems that provide galvanic isolation and voltage level shifting between high-power semiconductor devices and their control circuitry. This abstract discusses the design considerations and methodologies for gate drive transformers. The key parameters, such as turns ratio, core material selection, winding arrangement, and insulation techniques, are explored in detail. The design process involves calculating the required turns ratio to achieve the desired voltage transformation, determining the core size and material based on power requirements and frequency range, optimizing winding arrangements to minimize leakage inductance and parasitic capacitance, and implementing appropriate insulation techniques to ensure safe operation. Simulation model design and development in MATLAB platform and LT-Spice platform. In addition, we obtain the output waveform of the voltage difference between the gate and source terminal of a MOSFET, as well as the voltage difference between the drain and source terminals of a MOSFET.

Gate drive circuits for modern power electronic switches, such as MOSFET, often require electrical isolation. This paper describes the modelling and experimental results of some coreless printed circuit board (PCB)-based transformers that can be used for MOSFET devices at high-frequency (500 kHz to 2 MHz) operation. PCB-based transformers do not require the manual winding procedure and thus simplify the manufacturing process of transformer-isolated gate drive circuits.

Table of Content

INTRODUCTION

GATE DRIVE circuits for power inverters and converters often require electrical isolation. Among various isolation techniques, isolation transformer is probably the most widely used method. Because of the relatively high manufacturing cost of manually wound transformers and inductors, recent research has focused on making transformer and/or inductor windings on printed circuit boards (PCB’s). Besides the cost factor, such a PCB based transformer and inductor winding concept is highly attractive to the automation process. In a recent industrial research, a PCB-based transformer has been proposed for isolated gate drive circuits for the power MOSFET. The transformer windings are printed on a double-sided PCB. A ferrite core is, however, needed in the transformer. While such a proposal avoids the use of a manually wound transformer, commonly used ferrite rings cannot be used because it is impossible to put ferrite rings through the PCB without breaking the rings. Instead of using ferrite rings, a U-I core set or a U-U core set can be glued together to form a closed magnetic path. In this paper, the performance of PCB-based transformers used for isolated gate drive circuits without using any magnetic core is presented. An analysis and an accurate circuit model of the coreless PCB transformer are included. PSpice simulation and measurements obtained from several PCB transformers of different dimensions have confirmed the validity of the model. It will be shown that coreless PCB transformers have several advantages for high-frequency operations for MOSFET and insulated gate bipolar transistor gate drive circuits.

LITRETURE SURVEY

1) **A New MOSFET Gate Drive Insulated By A Piezoelectric Transformer:** A new gate drive for MOSFET'S is presented based on the use of a piezoelectric transformer. The characterisation of the transformer and the analysis of the energy transferred to the grid of the transistor are achieved in order to determine the optimal physical structure of the transformer. Satisfactory results have been obtained in driving a 6A/100V/10kHz chopper.[2][3]

2) **Coreless PCB-based transformers for Power MOSFET Gate Drive Circuits:** Gate drive circuits for modern power electronic switches such as MOSFET and IGBT often require electrical isolation. This paper describes initial results of some coreless PCB-based transformers that can be used for MOSFET devices at high frequency (500kHz to 2MHz) operation. Such transformer substantially reduces the labour cost in winding core based transformer and simplifies the automation process of gate drive circuits[1]

3) **Self-Driven Synchronous Rectification Scheme Without Undesired Gate-Voltage Discharge for DC-DC Converters With Symmetrically Driven Transformers:** A new self-driven synchronous rectification scheme for dc–dc converters with symmetrically driven transformers and wide input voltage range. The driving signals are obtained from the output inductor. Two auxiliary switches are utilized to turn off the main switches properly. Two extra auxiliary switches, which are controlled by a delayed signal from the inductor, are added to avoid the undesired gate discharge. This approach can achieve high efficiency and is suitable for practical applications. Experimental results based on a 36–75 V input, 2.5 V/30 A output prototype are shown to verify the proposed scheme[9]

4) **Transformer-Isolated Gate Drive Design for SiC JFET Phase-Leg Module:** In order to take full advantage of the SiC devices' high-temperature and high-frequency capabilities, a transformer isolated gate driver is designed for the SiC JFET phase leg module to achieve a fast switching speed of 26V/ns and a small cross-talking voltage of 4.2V in a 650V and 5A inductive load test. Transformer isolated gate drive circuits suitable for high-temperature applications are compared with respect to different criteria. Based on the comparison, an improved edge triggered gate drive topology is proposed. Then, using the proposed gate drive topology, special issues in the phase-leg gate drive design are discussed. Several strategies are implemented to improve the phase-leg gate drive performance and alleviate the cross-talking issue. Simulation and experimental results are given for verification purposes.[4][7]

DIODE

A diode is a two-terminal electronic device that allows current to flow in only one direction. It is primarily composed of a semiconductor material, typically doped with impurities to create a P-N junction. The P-N junction forms the basic structure of the diode and determines its electrical properties.

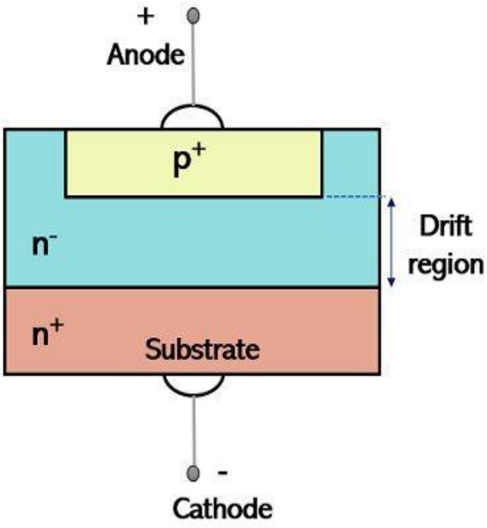


Fig-1: Construction of Diode

When a diode is forward-biased, meaning the positive voltage is applied to the P-region and the negative voltage to the N-region, it allows current to flow freely. The diode exhibits a low resistance or voltage drop (typically around 0.7 volts for a silicon diode) in the forward direction, enabling current to pass through easily.

On the other hand, when a diode is reverse-biased, meaning the positive voltage is applied to the N-region and the negative voltage to the P-region, it acts as an insulator, blocking the flow of current. The diode exhibits a high resistance in the reverse direction, preventing current from passing through.

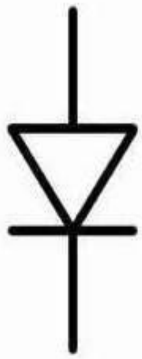
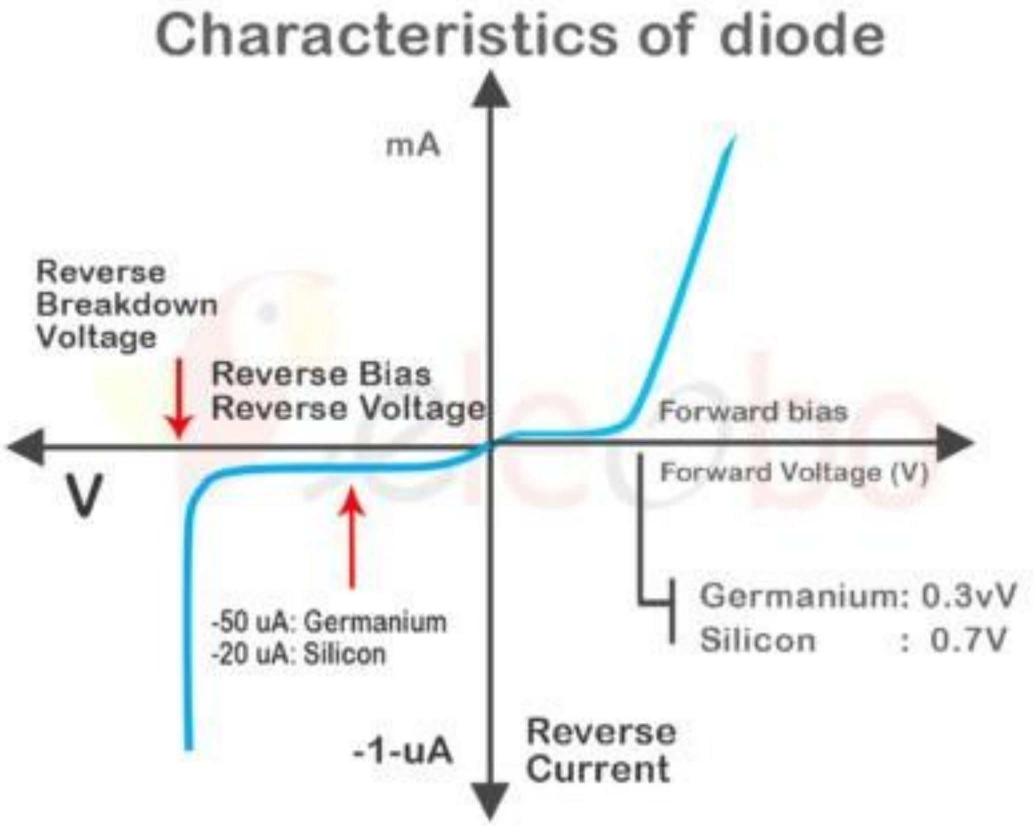


Fig-2: Symbol of Diode

In summary, a diode is an electronic component that allows current to flow in one direction while blocking it in the reverse direction. It plays a crucial role in controlling the flow of current and enabling various functions in electronic circuits.

The output characteristics of a diode represent the relationship between the voltage across the diode and the current flowing through it. There are two key output characteristics of a diode: the forward characteristic and the reverse characteristic.



Graph-1: Output Characteristics of Diode

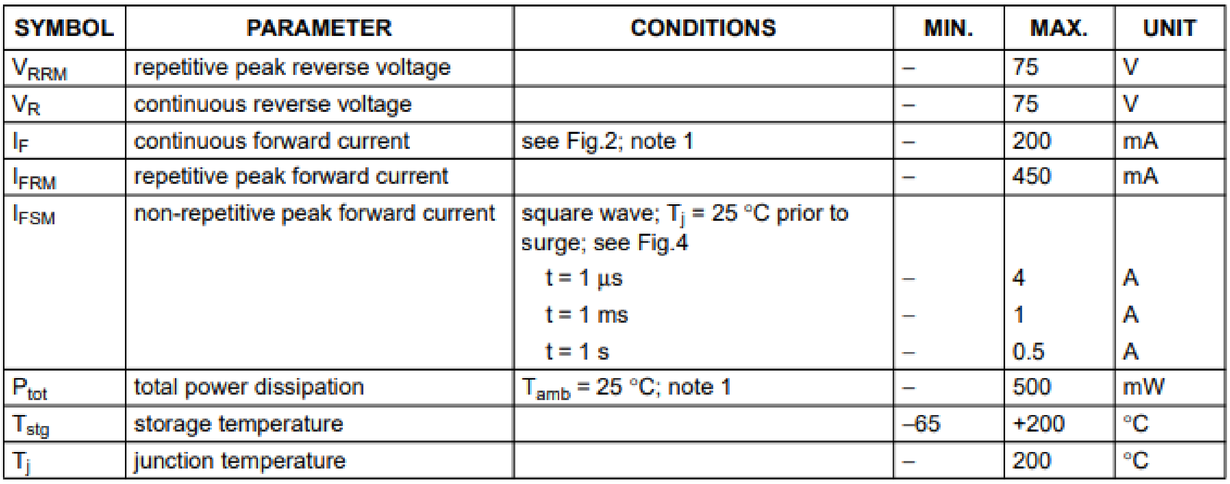
1. Forward Characteristic: The forward characteristic of a diode describes its behaviour when it is forward-biased, meaning a positive voltage is applied to the anode (P-region) and a negative voltage to the cathode (N-region). In the forward bias mode, the diode allows current to flow through it. The forward characteristic can be divided into two regions:

a. Forward Voltage (Vf) Region **b. Saturation Region**

2. Reverse Characteristic: The reverse characteristic of a diode describes its behaviour when it is reverse-biased, meaning a positive voltage is applied to the cathode (N-region) and a negative voltage to the anode (P-region). In the reverse bias mode, the diode blocks the flow of current and exhibits a very high resistance. However, a small amount of reverse leakage current (typically in the nanoampere or microampere range) can still flow due to minority carriers and other leakage mechanisms.

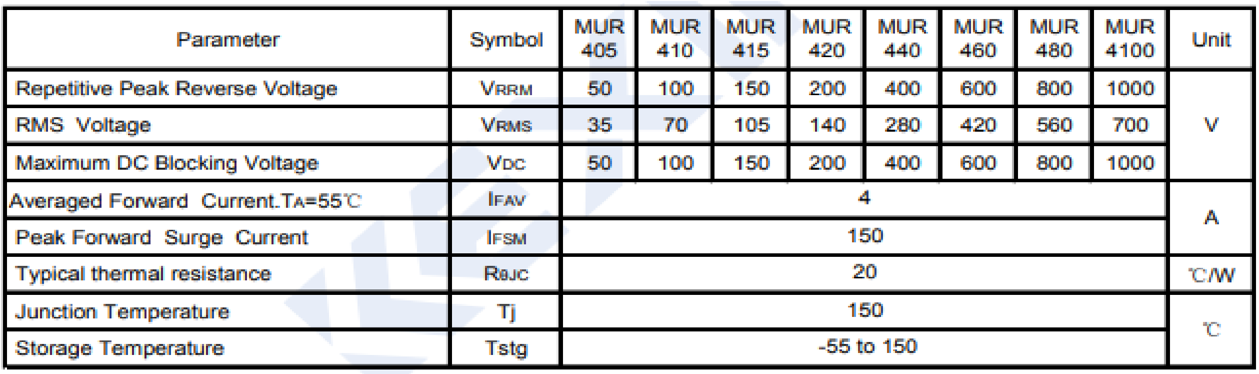
It's important to note that the output characteristics of a diode can vary depending on factors such as the diode's type, material, temperature, and manufacturing variations.

Manufacturers often provide datasheets that include detailed graphs illustrating the specific output characteristics of their diode products, allowing engineers to analyse and understand their behaviour in different operating conditions.



SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{RRM}	repetitive peak reverse voltage		–	75	V
V_R	continuous reverse voltage		–	75	V
I_F	continuous forward current	see Fig.2; note 1	–	200	mA
I_{FRM}	repetitive peak forward current		–	450	mA
I_{FSM}	non-repetitive peak forward current	square wave; T_j = 25 °C prior to surge; see Fig.4			
		t = 1 µs	–	4	A
		t = 1 ms	–	1	A
		t = 1 s	–	0.5	A
P_{tot}	total power dissipation	T_{amb} = 25 °C; note 1	–	500	mW
T_{stg}	storage temperature		–65	+200	°C
T_j	junction temperature		–	200	°C

Table-1: Limiting value of diode (1N4148)



Parameter	Symbol	MUR 405	MUR 410	MUR 415	MUR 420	MUR 440	MUR 460	MUR 480	MUR 4100	Unit
Repetitive Peak Reverse Voltage	V_{RRM}	50	100	150	200	400	600	800	1000	V
RMS Voltage	V_{RMS}	35	70	105	140	280	420	560	700	
Maximum DC Blocking Voltage	V_{DC}	50	100	150	200	400	600	800	1000	
Averaged Forward Current.T_A=55℃	I_{FAV}	4								A
Peak Forward Surge Current	I_{FSM}	150								
Typical thermal resistance	$R_{θJC}$	20								℃/W
Junction Temperature	Tj	150								℃
Storage Temperature	Tstg	-55 to 150								

Table-2: Limiting value of diode (MUR405)

BIPOLAR JUNCTION TRANSISTOR (BJT)

A Bipolar Junction Transistor (BJT) is a three-terminal electronic device widely used in both analog and digital circuits. It is composed of three semiconductor regions: the emitter (E), the base (B), and the collector (C). The BJT operates based on the principle of minority carrier injection and control of current flow.

The BJT has two types: NPN (negative-positive-negative) and PNP (positive-negative-positive). The construction and operation of the NPN and PNP BJTs are similar, but the doping types and polarities of the regions differ.

The construction of a BJT involves sandwiching two regions of one type of semiconductor material (either N or P type) with a region of the opposite type. This creates two back-to-back PN junctions. The emitter region has higher doping concentration, followed by the base region with moderate doping concentration, and the collector region with lower doping concentration. The physical structure can be represented as Emitter-Base-Collector (EBC) for an NPN transistor and Emitter-Base-Collector (EBC) for a PNP transistor.

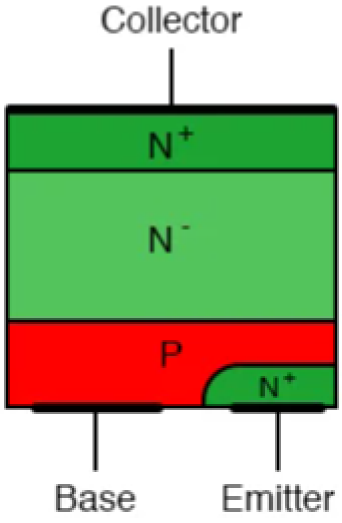


Fig-3: Construction of BJT

The BJT operates based on two types of conduction: NPN operates based on the flow of electrons (negative charges), and PNP operates based on the flow of holes (positive charges). The working principle of an NPN transistor is explained here:

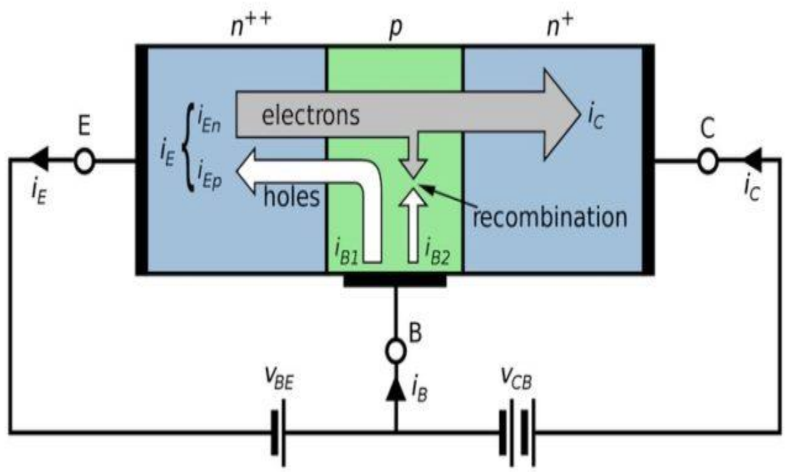


Fig-4: Working of BJT

Forward Bias: When a positive voltage is applied to the base-emitter junction (VBE), it forward biases the junction, allowing current to flow from the emitter to the base. Electrons are injected into the base region, which is thinner and lightly doped, and a small fraction of them recombine with the holes present. The remaining majority of electrons diffuse towards the collector region.

Reverse Bias: The base-collector junction (VBC) is reverse biased by applying a positive voltage to the collector terminal. This creates a depletion region with a potential barrier that prevents majority carriers from crossing the junction. However, a small fraction of electrons that cross the base region enter the collector region due to diffusion.

Transistor Action: The majority of electrons injected into the base region combine with the majority carriers (holes) present, resulting in a small base current (IB). The base current controls the larger collector current (IC), as it determines the number of electrons injected into the base region. The collector current is proportional to the base current, with the proportionality factor known as the transistor's current gain (β or hfe).

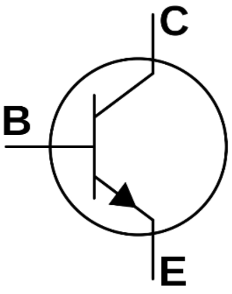
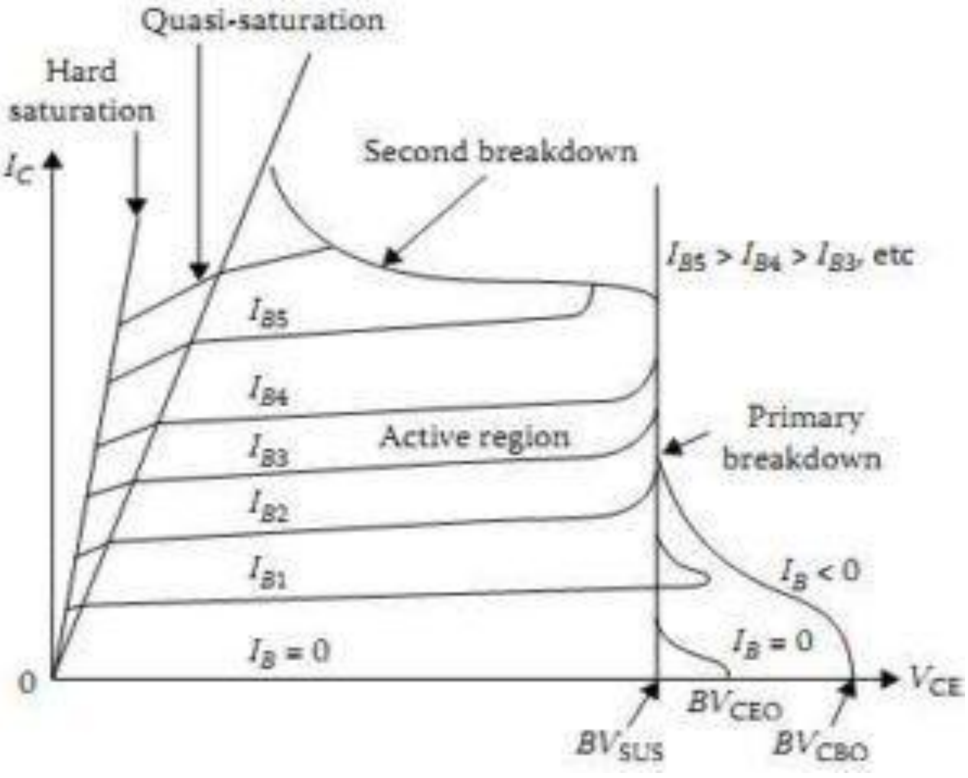


Fig-5: Symbol of BJT



Graph-2: Output Characteristics of BJT

The output characteristics of a Bipolar Junction Transistor (BJT) represent the relationship between the output current and output voltage of the transistor under different operating conditions. There are two key output characteristics of a BJT: the output characteristics in the active region and the output characteristics in the saturation and cut-off regions.

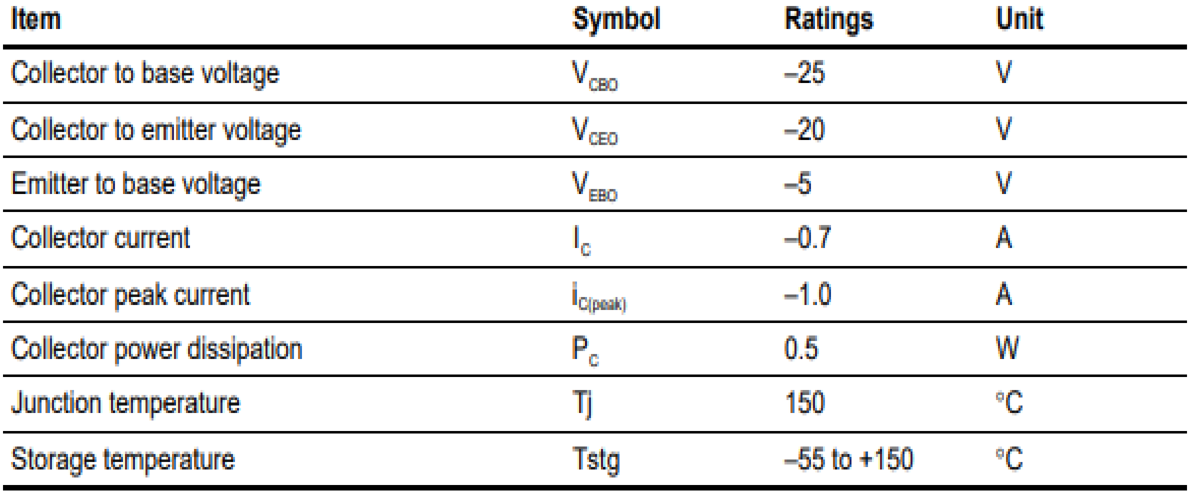
1. Output Characteristics in the Active Region: The active region of a BJT is the region of operation where the transistor is biased such that both the base-emitter junction and base-collector junction are forward biased. In this region, the BJT operates as an amplifier, and its output characteristics are typically represented by a graph of the collector current (IC) versus the collector-emitter voltage (VCE), with the base current (IB) as the parameter.

a. Collector Characteristic (IC vs. VCE): In the active region, with a fixed base current (IB), the collector current (IC) increases almost linearly with an increase in collector-emitter voltage (VCE). This linear relationship between IC and VCE is known as the collector characteristic or the output characteristic.

b. Saturation Current (IC sat): At a certain point, when VCE decreases to a low value, the collector current reaches a maximum value known as the saturation current (IC sat). In saturation, the BJT operates as a closed switch with a very low voltage drop across the collector-emitter junction.

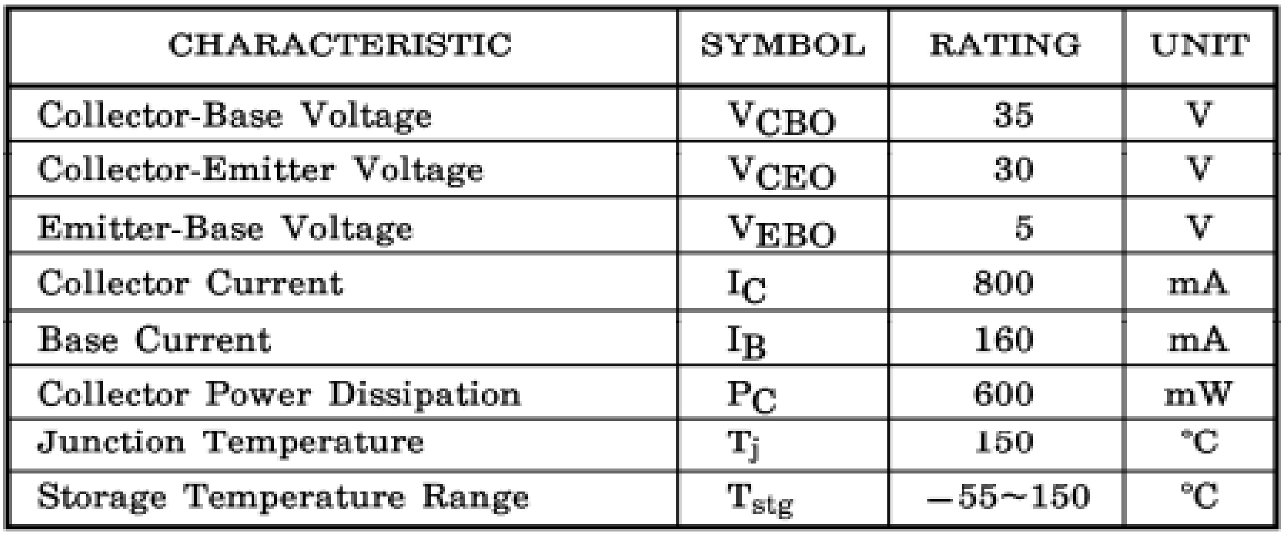
2. Saturation Region: In the saturation region, the base-emitter junction is forward biased, and the base-collector junction is also forward biased. The output characteristic in this region shows a relatively constant collector current (IC) with respect to collector-emitter voltage (VCE), indicating that the BJT is fully turned on.

b. Cut-off Region: In the cut-off region, both the base-emitter junction and the base-collector junction are reverse biased. The output characteristic in this region shows zero or negligible collector current (IC) for any collector-emitter voltage (VCE), indicating that the BJT is fully turned off.



Item	Symbol	Ratings	Unit
Collector to base voltage	V_{CBO}	–25	V
Collector to emitter voltage	V_{CEO}	–20	V
Emitter to base voltage	V_{EBO}	–5	V
Collector current	I_C	–0.7	A
Collector peak current	$i_{C(peak)}$	–1.0	A
Collector power dissipation	P_C	0.5	W
Junction temperature	Tj	150	°C
Storage temperature	Tstg	–55 to +150	°C

Table-3: Limiting value of BJT PNP (2SB561)



CHARACTERISTIC	SYMBOL	RATING	UNIT
Collector-Base Voltage	V_{CBO}	35	V
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector Current	I_C	800	mA
Base Current	I_B	160	mA
Collector Power Dissipation	P_C	600	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_{stg}	−55~150	°C

Table-4: Limiting value of BJT NPN (2SC2120)

METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTOR (MOSFET)

A Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) is a three-terminal electronic device that operates based on the principles of a field-effect transistor. It is a popular type of transistor used in a wide range of applications, including power electronics, digital circuits, amplifiers, and switching applications.

A MOSFET consists of a semiconductor substrate, typically made of silicon, on which different layers and structures are formed. The key components of a MOSFET are:

1. Substrate: The semiconductor substrate, often referred to as the body or bulk, provides the foundation for the MOSFET's operation. It is usually doped with impurities to control the conductivity of the substrate material.

2. Gate: The gate is made of a conductive material, such as metal or heavily doped polysilicon, and is separated from the substrate by a thin insulating layer known as the gate oxide (usually silicon dioxide). The gate controls the flow of current through the MOSFET.

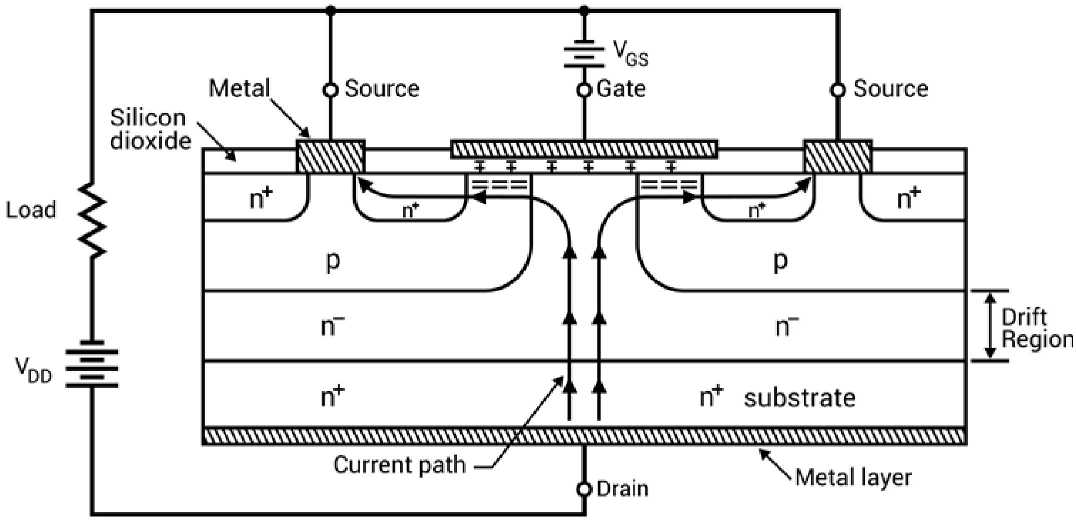


Fig-6: Consturction and Working of N-MOS

3. Source and Drain: The source and drain terminals are heavily doped regions located on either side of the channel in the semiconductor substrate. These regions are typically made up of N-type or P-type material, depending on whether the MOSFET is an N-channel or P-channel type.

Working Principle: The operation of a MOSFET is based on the modulation of the conductive channel between the source and drain regions by the electric field produced by the gate voltage. There are two main types of MOSFETs:

1. N-Channel MOSFET (NMOS): In an NMOS transistor, the substrate is P-type, and the source and drain regions are N-type. Applying a positive voltage to the gate (with respect to the source) creates an electric field that attracts electrons from the source region, forming an N-type channel between the source and drain. This allows current to flow from the source to the drain when a voltage is applied across them.

2. P-Channel MOSFET (PMOS): In a PMOS transistor, the substrate is N-type, and the source and drain regions are P-type. Applying a negative voltage to the gate (with respect to the source) creates an electric field that attracts holes from the source region, forming a P-type channel between the source and drain. This allows current to flow from the drain to the source when a voltage is applied across them.

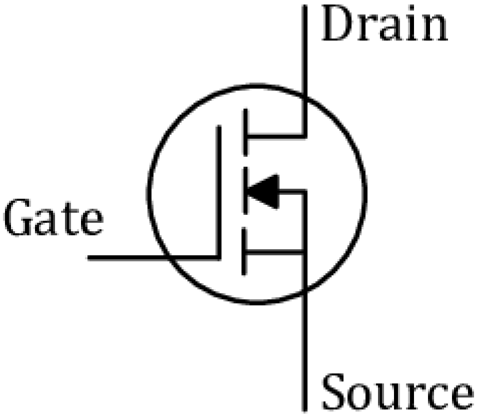


Fig-7: Symbol of N-MOS

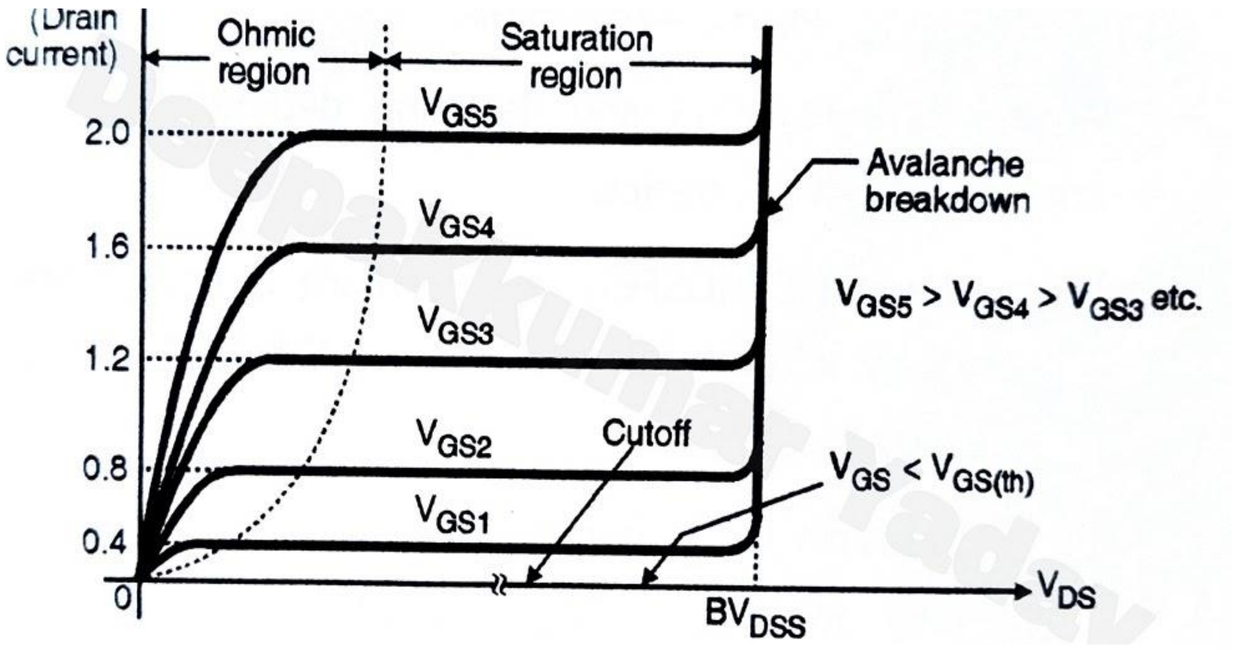
Modes of Operation: MOSFETs can operate in three different modes:

1. Cut-Off: In the cut-off mode, the transistor is off, and no current flows between the source and drain regions. The gate-source voltage is below the threshold voltage, and the channel is not formed.

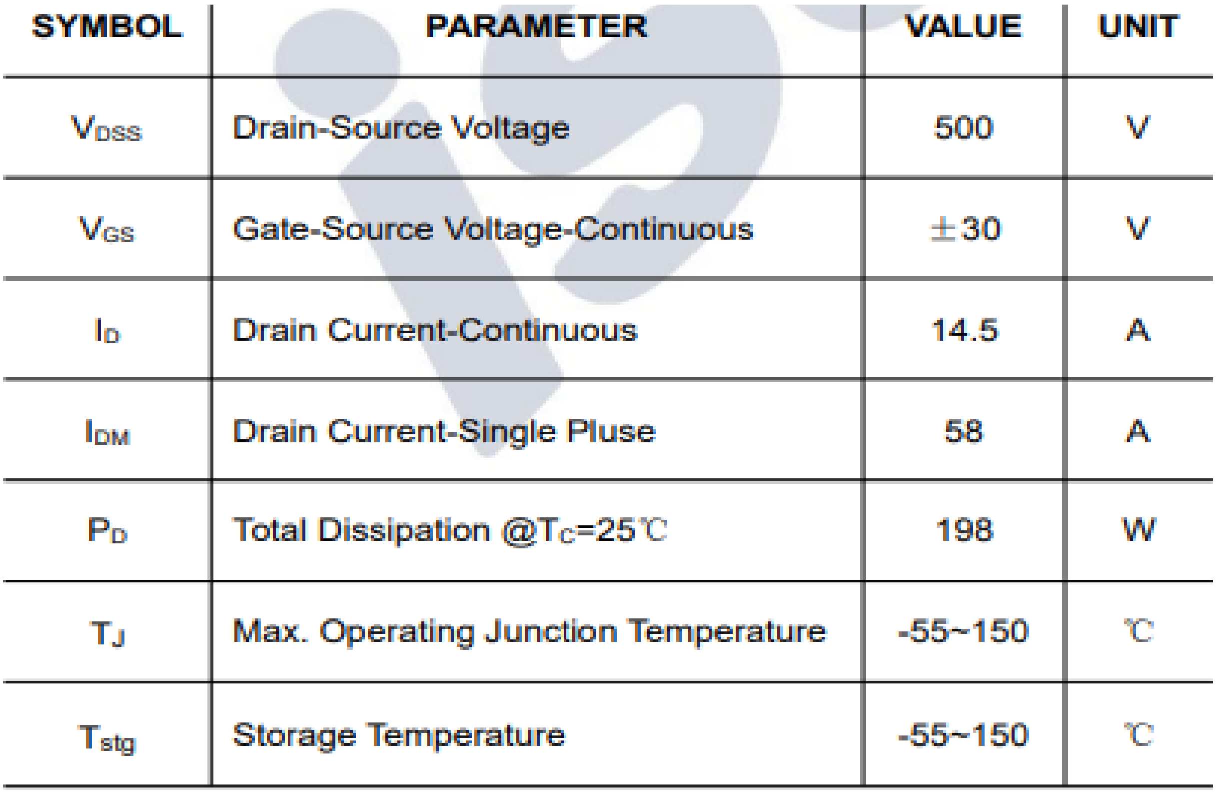
2. Triode/Linear Region: In the triode or linear region, the MOSFET operates as an amplifier. The gate-source voltage is above the threshold voltage, allowing the channel to form. The drain current increases linearly with the drain-source voltage when the transistor is in this region.

3. Saturation: In the saturation region, the MOSFET operates as a switch. The gate-source voltage is sufficiently high, and the channel is fully formed. The drain current remains relatively constant with further increases in the drain-source voltage.

MOSFETs offer advantages such as high input impedance, low power consumption, and high switching speeds, making them ideal for various applications. They come in different sizes and power ratings to accommodate different voltage and current requirements.



Graph-3: Output Characteristics of N-MOS



SYMBOL	PARAMETER	VALUE	UNIT
V_{DSS}	Drain-Source Voltage	500	V
V_{GS}	Gate-Source Voltage-Continuous	±30	V
I_D	Drain Current-Continuous	14.5	A
I_{DM}	Drain Current-Single Pluse	58	A
P_D	Total Dissipation @T_C=25℃	198	W
T_J	Max. Operating Junction Temperature	-55~150	℃
T_{stg}	Storage Temperature	-55~150	℃

Table-5: Limiting value of Mosfet (APT5040)

CORE LESS PULSE TRANSFORMER

A core less pulse transformer is a type of transformer specifically designed to transmit electrical pulses or short-duration signals with minimal distortion. It is commonly used in applications such as data transmission, telecommunications, power electronics, and pulse power systems. The primary purpose of a core less pulse transformer is to provide galvanic isolation and impedance matching between the source and load.

A core less pulse transformer consists of a primary winding and a secondary winding, both wound around a shared magnetic core. The core material is typically ferrite or iron-based, chosen for its high magnetic permeability and ability to efficiently transfer magnetic flux. The windings are made of insulated wire, and the number of turns on each winding depends on the required voltage transformation ratio and desired impedance matching.

The operation of a core less pulse transformer is similar to that of a conventional transformer, but it is designed to handle high-frequency or short-duration pulses. When an input pulse voltage is applied to the primary winding, it generates a magnetic field in the core. This magnetic field induces a voltage in the secondary winding, which is proportional to the turns ratio between the windings. The core less pulse transformer transfers the pulse energy from the primary side to the secondary side without significant distortion, providing galvanic isolation between the input and output circuits.

Applications:

1. Data Transmission: Core less pulse transformers are commonly used in communication systems, such as Ethernet networks and high-speed digital interfaces, to couple signals between devices while maintaining electrical isolation.

2. Telecommunications: Core less pulse transformers are used in telecommunication circuits to interface between different voltage levels and provide impedance matching. They are found in line drivers, modems, and other telecommunications equipment.

3. Power Electronics: Core less pulse transformers are utilized in power converters and inverters to provide isolation and voltage transformation between control circuits and power stages. They can also be employed in high-frequency switch-mode power supplies.

4. Pulse Power Systems: Core less pulse transformers find applications in pulse power systems, including pulsed lasers, particle accelerators, and radar systems. They enable the transmission of high-energy pulses with precise timing and minimal distortion.

Benefits:

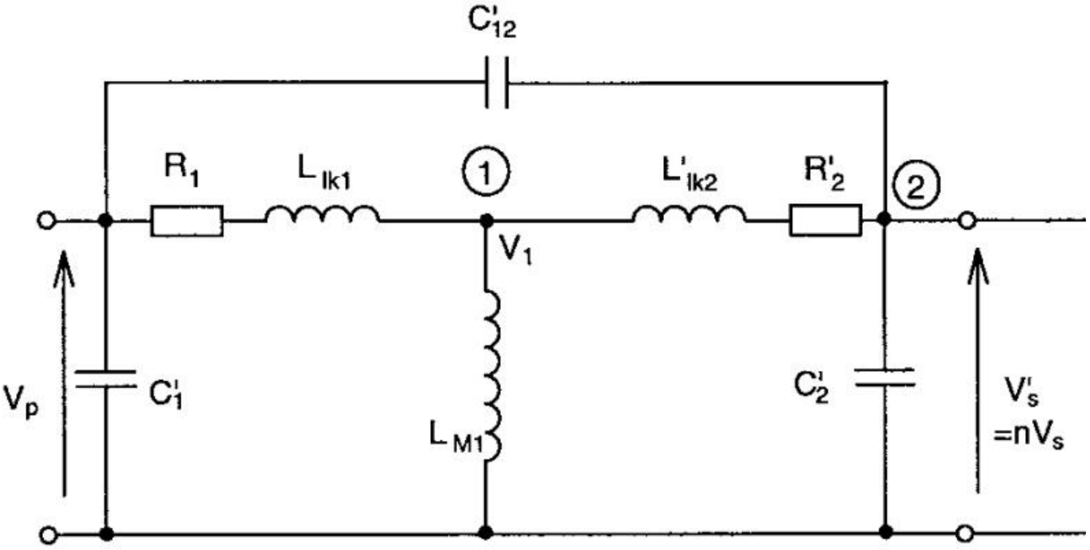
- Galvanic Isolation: Core less pulse transformers provide electrical isolation between the primary and secondary windings, protecting sensitive components from high voltages or voltage transients.

- Impedance Matching: They enable impedance matching between the source and load, ensuring efficient transfer of pulse energy without reflections.

- High-Frequency Operation: Core less pulse transformers are designed to handle high-frequency signals and pulses, allowing for accurate transmission of fast-switching signals.

Overall, core less pulse transformers play a crucial role in various applications where the accurate and reliable transmission of electrical pulses is required.

Equivalent Model of transformer:



R_1	primary winding resistance;
R_2	secondary winding resistance referred to the primary;
R_L	resistive load;
L_{lk1}	primary leakage inductance;
L_{lk2}	secondary leakage inductance referred to the primary;
L_{M1}	primary mutual inductance;
C_1	primary interwinding capacitance;
C_2	secondary interwinding capacitance referred to the primary;
C_{12}	capacitance between primary and secondary windings, and n is the turn ratio.

n is the turn ratio.

Transfer Function of Core less Pulse Transformer:

At node 1, $$-\frac{1}{R_1 + sL_{lk1}}V_p + \left(\frac{1}{R_1 + sL_{lk1}} + \frac{1}{sL_{M1}} + \frac{1}{R'_2 + sL'_{lk2}}\right)V_1 - \frac{1}{R'_2 + sL'_{lk2}}nV_s = 0 \tag{1}$$

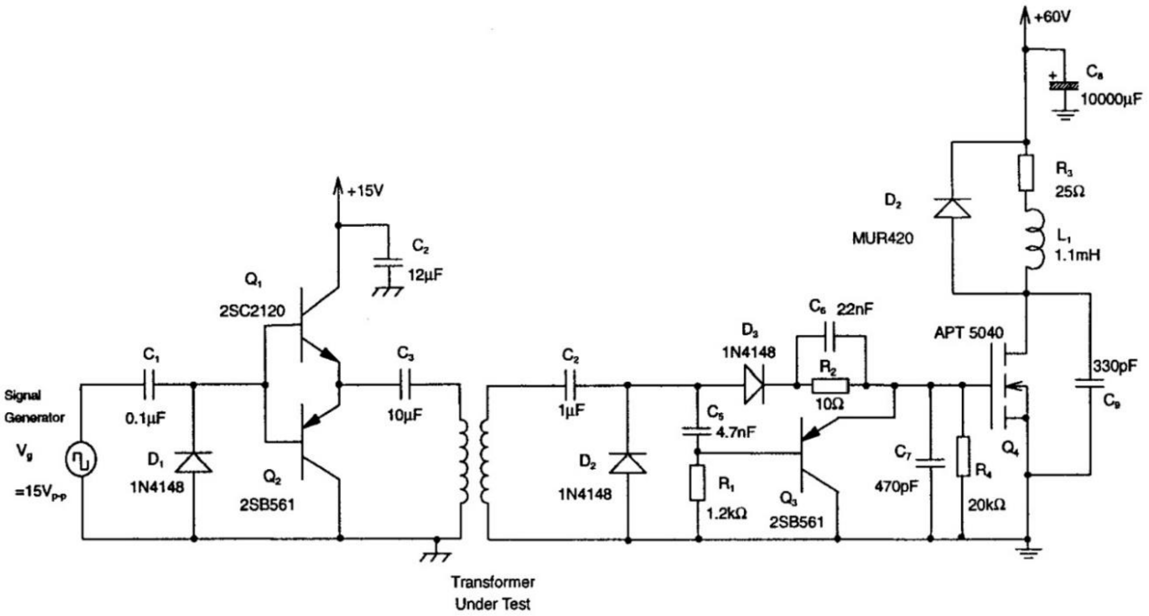
At node 2, $$-sC'_{12}V_p - \frac{1}{R'_2 + sL'_{lk2}}V_1 + \left(\frac{1}{R'_2 + sL'_{lk2}} + sC'_{12} + sC'_2 + \frac{1}{n^2 R_L}\right)nV_s = 0 \tag{2}$$

From (2), $$V_1 = \left(R'_2 + sL'_{lk2}\right)\left[-sC'_{12}V_p + \left(\frac{1}{R'_2 + sL'_{lk2}} + sC'_{12} + sC'_2 + \frac{1}{n^2 R_L}\right)nV_s\right] \tag{3}$$

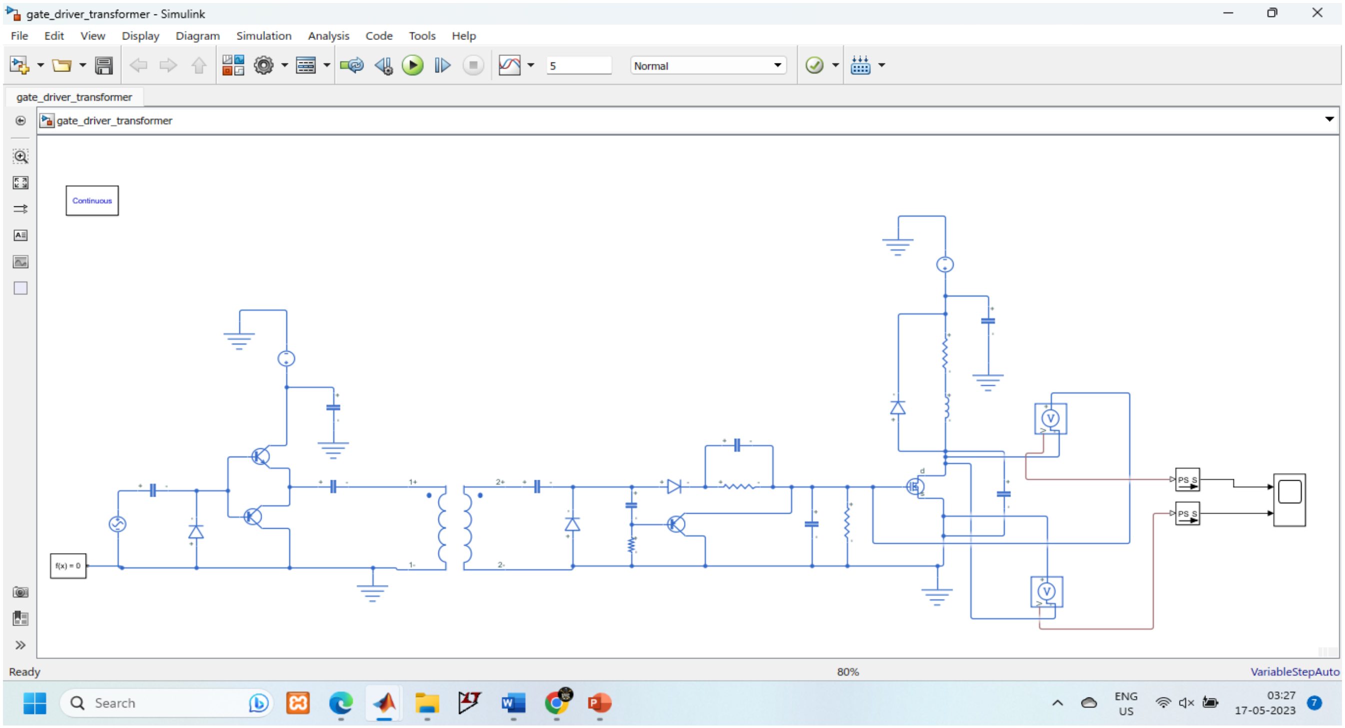
From (1) and (3)

$$\frac{V_s}{V_p} = \frac{1}{n}\frac{\frac{1}{R_1 + sL_{lk1}} + sC'_{12}\left[\left(R'_2 + sL'_{lk2}\right)\left(\frac{1}{R_1 + sL_{lk1}} + \frac{1}{sL_{M1}}\right) + 1\right]}{-\frac{1}{R'_2 + sL'_{lk2}} + \left(\frac{1}{R'_2 + sL'_{lk2}} + sC'_{12} + sC'_2 + \frac{1}{n^2 R_L}\right)\left[\left(R'_2 + sL'_{lk2}\right)\left(\frac{1}{R_1 + sL_{lk1}} + \frac{1}{sL_{M1}}\right) + 1\right]} \tag{4}$$

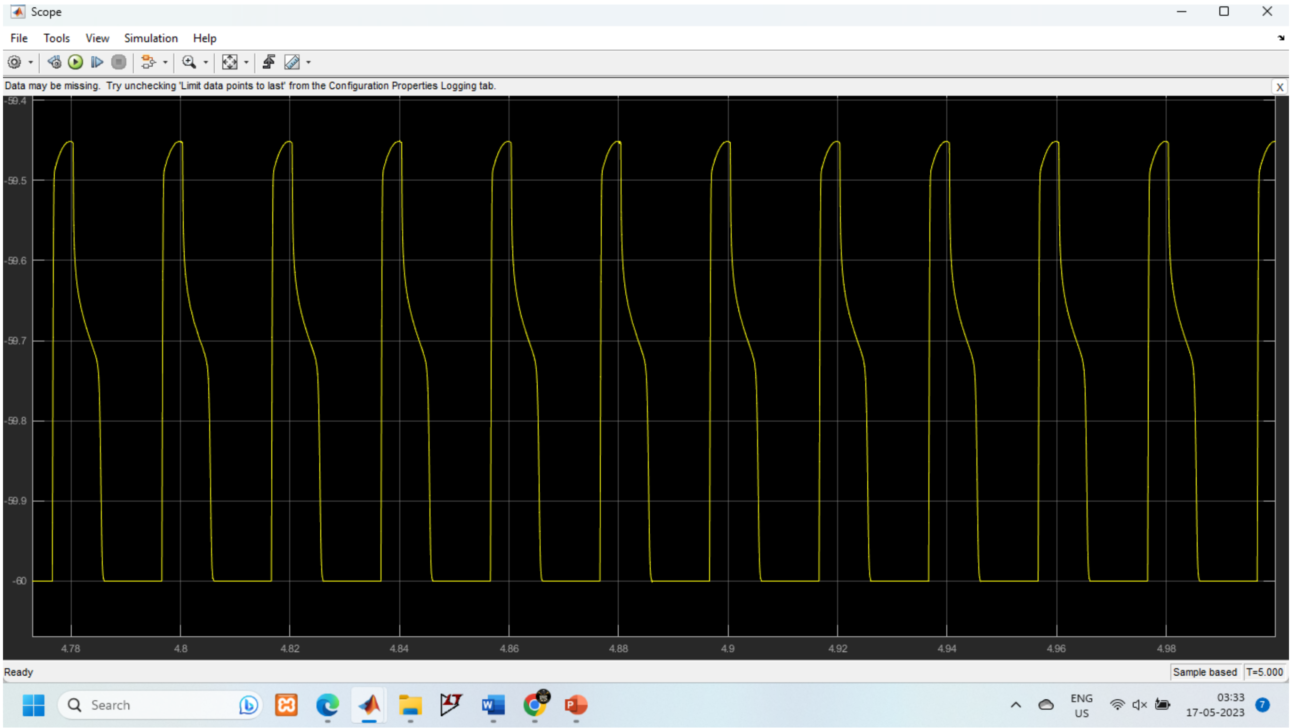
CURCUIT DIAGRAM



SIMULATION ON MATLAB

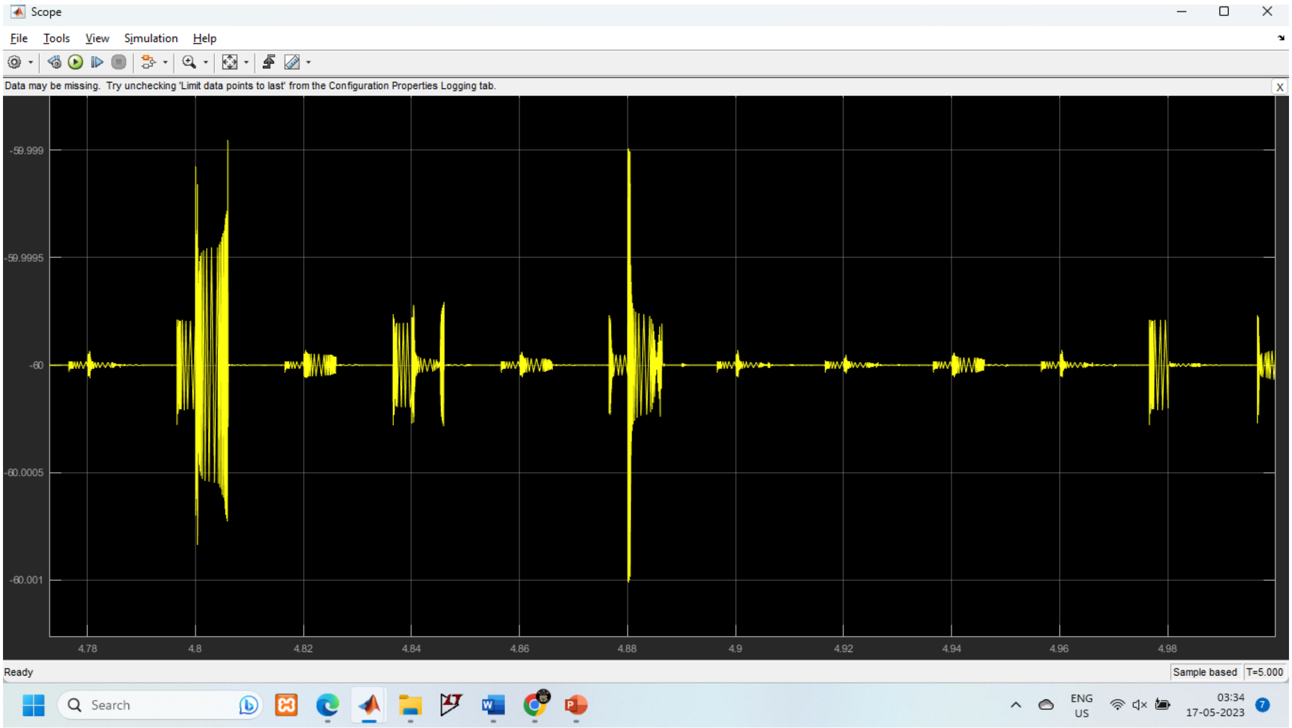


Simulation-1: MATLAB



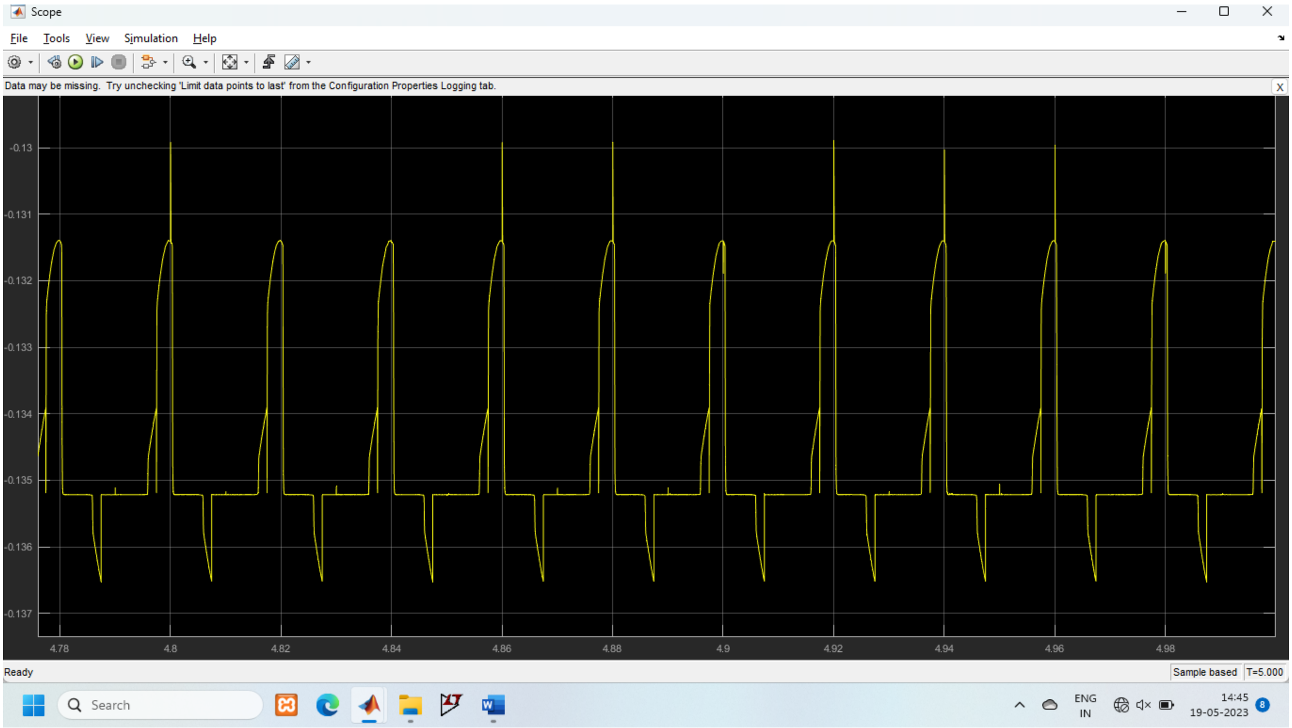
Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.

Output-1: Gate-Source Voltage vs time



Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.

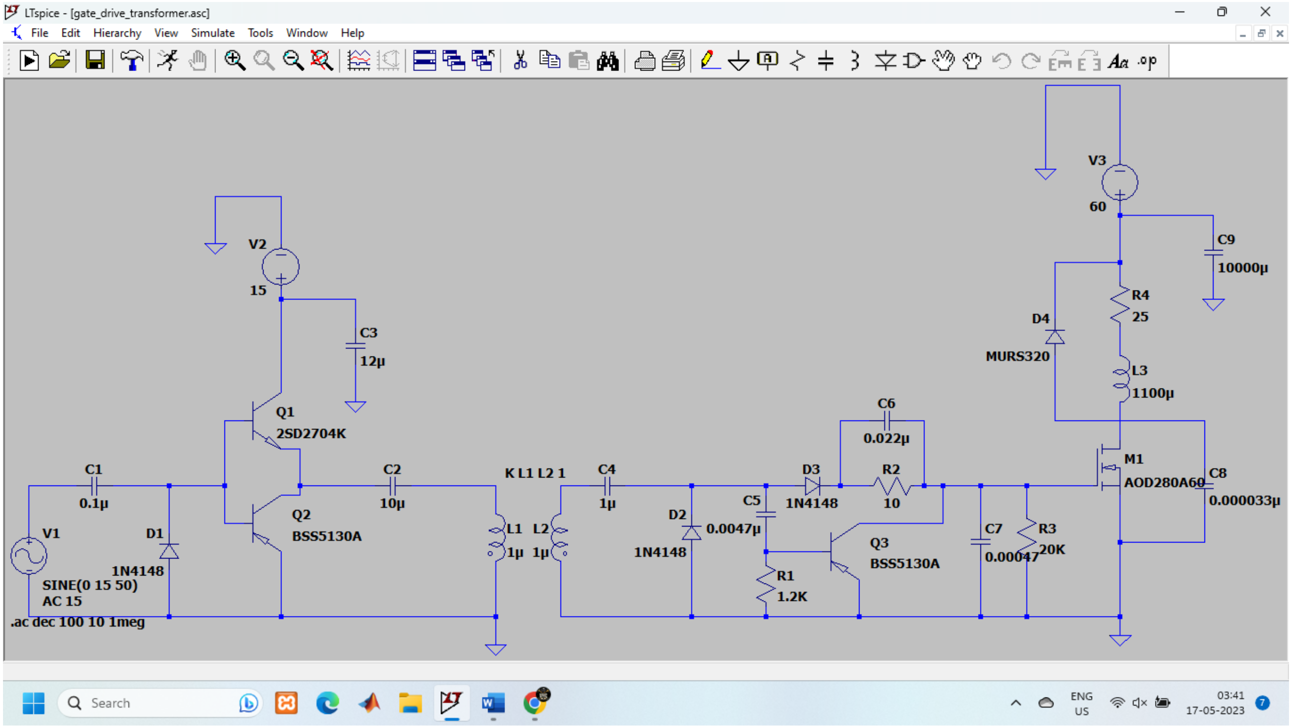
Output-2: Drain-Source Voltage vs time



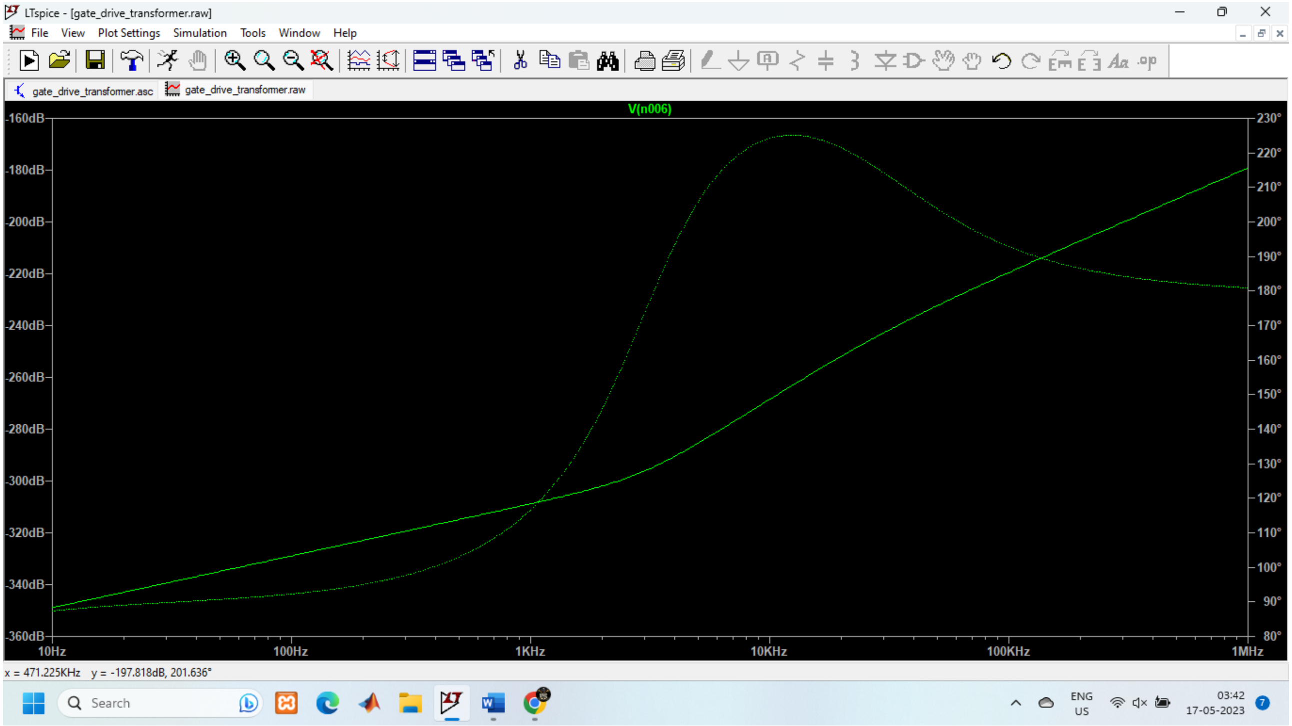
Data may be missing. Try unchecking 'Limit data points to last' from the Configuration Properties Logging tab.

Output-3: Drain-Source Current vs time

SIMULATION ON LT-Spice

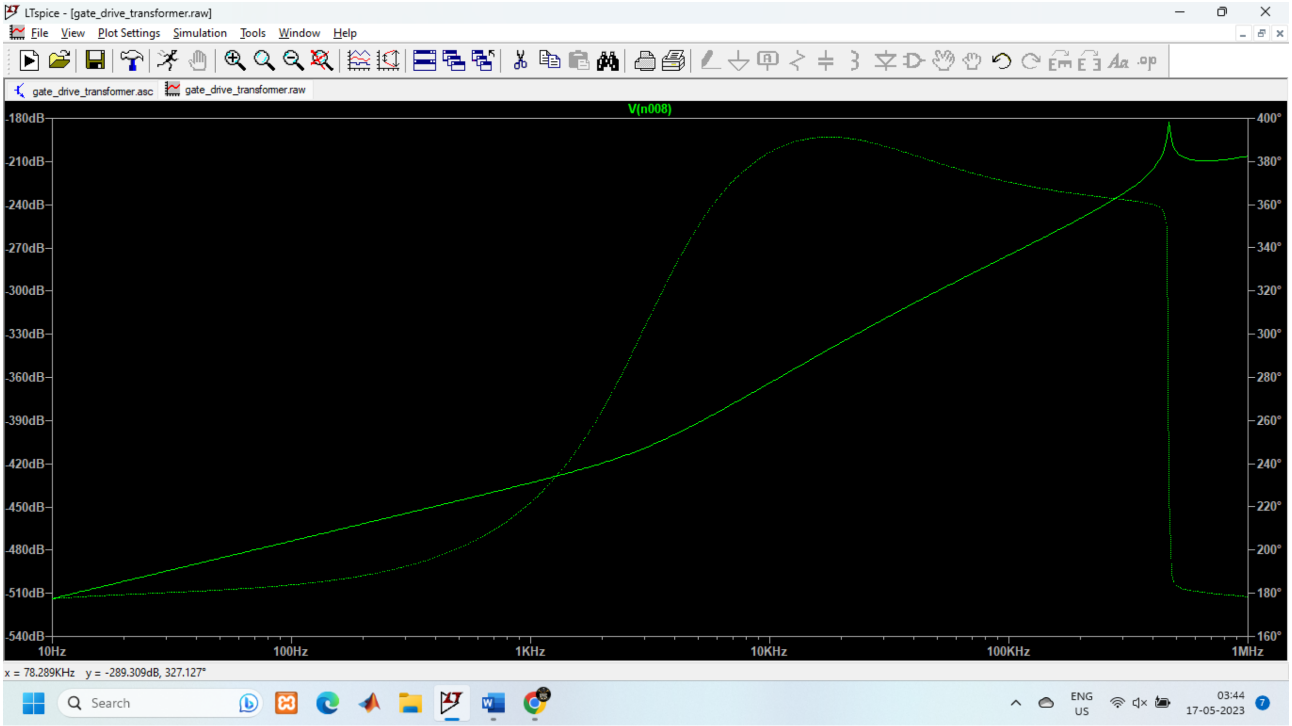


Simulation-2: LT-Spice



```
x = 471.225KHz   y = -197.818dB, 201.636°
```

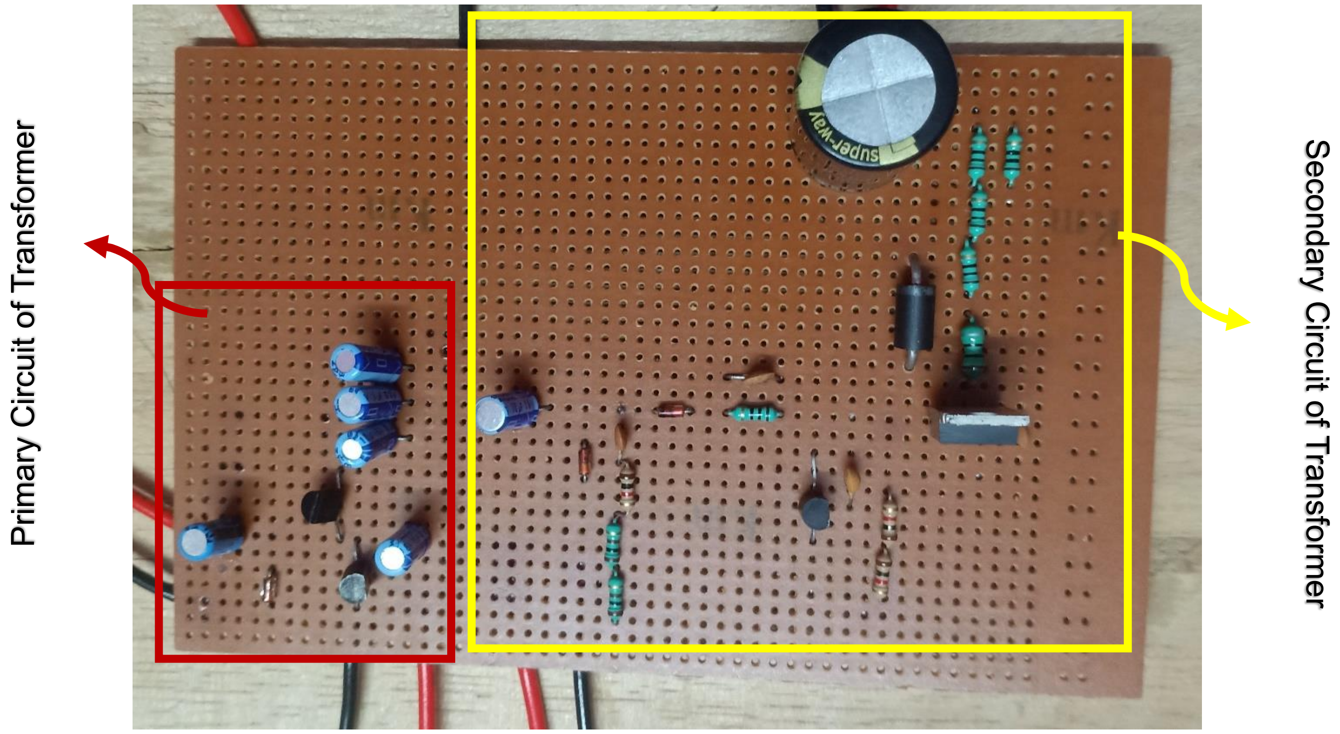
Output-1: Gate-Source Voltage vs frequency

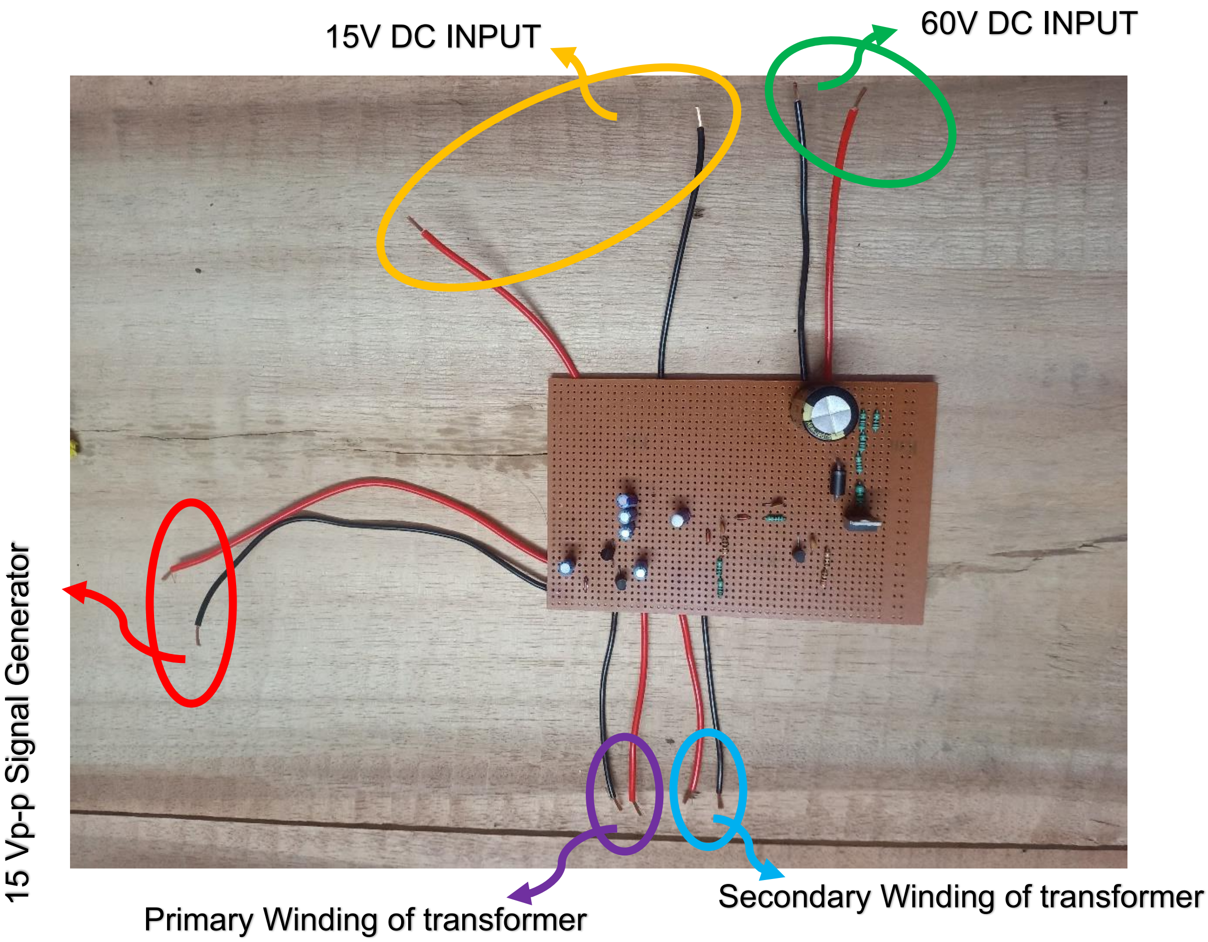


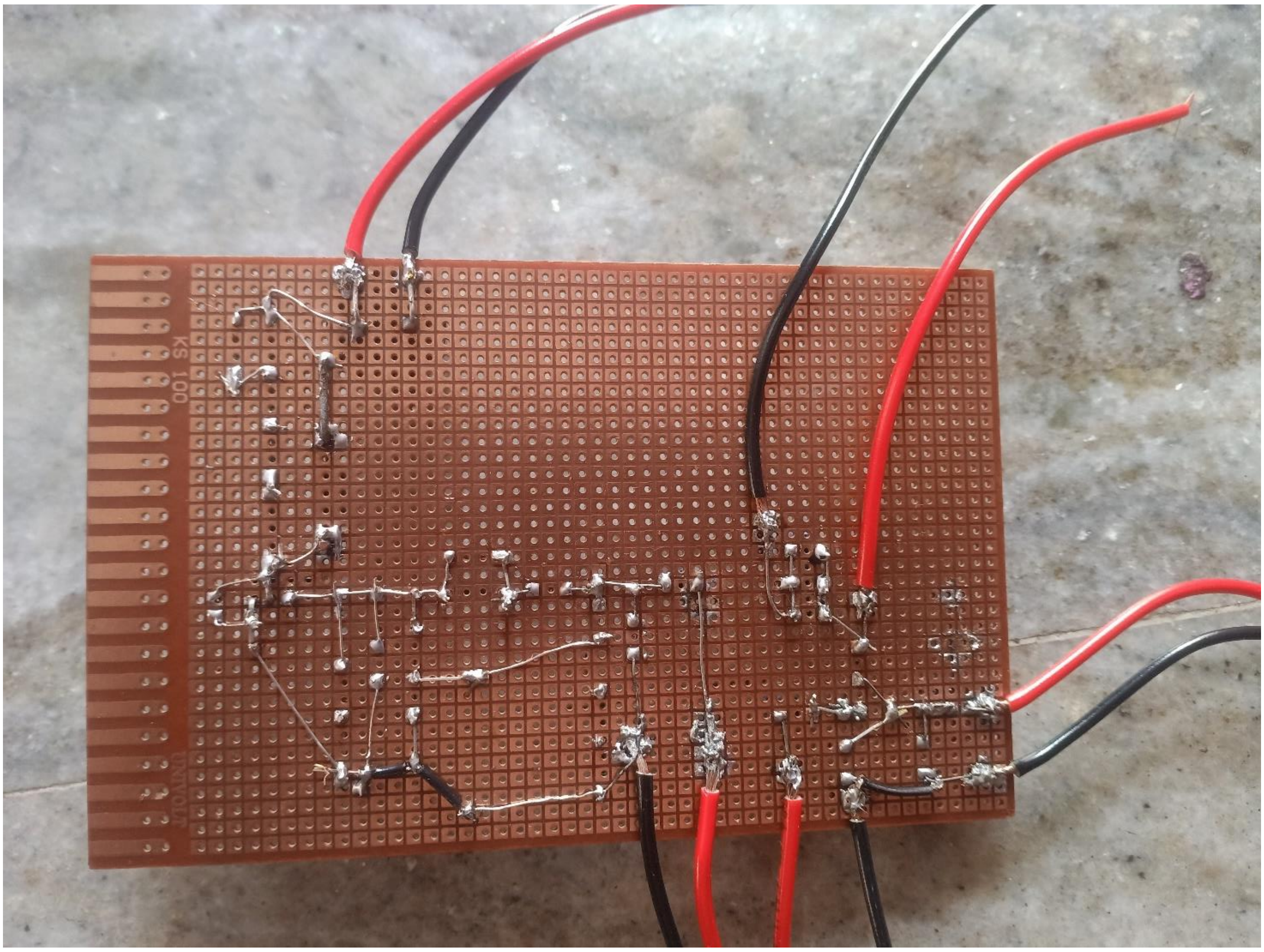
```
x = 78.289KHz   y = -289.309dB, 327.127°
```

Output-2: Drain-Source Voltage vs frequency

HARDWARE IMPLEMENTATION







Backside of Gate Driver Circuit

CONCLUSION

The principle of using coreless PCB-based transformer in isolated gate drive circuit for power MOSFET has been successfully demonstrated. Coreless transformers can be used for both signal and energy transfer. They eliminate the requirements of magnetic core and manually wound transformers in gate drive circuits. Consequently, automation in the manufacturing process of gate drive circuits becomes feasible and the manufacturing cost can be reduced. In addition, PCB offers electrical isolation of typically 15–40 kV , which is much higher than the typical electrical isolation of 2.5 kV offered by many optocouplers. In this paper, an accurate high frequency model and analysis have been presented. The simple model can be implemented in simulation package. Analytical, PSpice, and practical measurements of several coreless transformers with operating frequencies ranging from 500 kHz to 2 MHz have confirmed the operating principle of coreless PCB-based transformers. Together with switched capacitor converters, they can also be used to develop low-profile power converters (or power cards) without using magnetic cores..

Reference

[1] J. M. Bourgeois, “PCB based transformer for power MOSFET drive,” in IEEE APEC’94, pp. 238–244

[2] B.J. Swart, J.A. Ferreira, and J.D. Van Wyk, “Distributed magnetic components for PCB assembly,” in IEEE PESC’94, pp. 1315–1322.

[3] N. Dai, A. W. Lofti, G. Skutt, W. Tabisz, and F. C. Lee, “A comparative study of high-frequency, low-profile planar transformer technologies,” in IEEE APEC’94, pp. 226–232.

[4] K. Onda, A. Kanouda, T. Takahashi, S. Hagiwara, and H. Horie, “Thin type dc/dc converter using a coreless wire transformer,” in IEEE PESC’94, pp. 1330–1334.

[5] K. Yamaguchi, S. Ohnuma, T. Imagawa, J. Toriu, H. Matsuki, and K. Murakami, “Characteristics of a thin film micro transformer with circular spiral coils,” IEEE Trans. Magn., vol. 29, pp. 2232–2237, Sept. 1993.

[6] X. Huang, K. Ngo, and G. Bloom, “Design techniques for planar windings with low resistance,” in Proc. APEC’95, pp. 533–539.

[7] R. Goyal, High-Frequency Analog Integrated Circuit Design. New York: Wiley, 1995, pp. 110–125.

[8] S. Y. R. Hui and S. C. Tang, “Coreless printed circuit board transformers,” U.S. patent pending

[9] C. F. Coombs, Jr., Printed Circuits Handbooks, 3rd ed. New York; McGraw-Hill, 1988