

# **Efficient High-Side N-Channel MOSFET Driver Circuit**

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## **ABSTRACT**

The high-side N-channel MOSFET driver circuit utilizes a bootstrap technique to provide the necessary gate voltage, which is higher than the supply voltage, for proper switching of the MOSFET in high-side configurations. This circuit employs a bootstrap capacitor and diode to charge during the low-side MOSFET conduction and supply the elevated gate drive voltage during the high-side MOSFET turn-on. It offers an efficient, cost-effective, and compact solution for high-frequency power switching applications such as motor drives, DC-DC converters, and half-bridge circuits. The bootstrap approach eliminates the need for isolated power supplies and simplifies high-side MOSFET gate driving..

**Keywords :** Gate Drive Voltage, N-Channel MOSFET, Bootstrap capacitor, High-Side Driver, eSim

## **INTRODUCTION:**

High-side N-channel MOSFETs require a gate voltage that exceeds the supply voltage for full enhancement, which poses a challenge when driving from low-voltage references. The bootstrap gate driver circuit solves this by using a capacitor and diode to boost the gate voltage referenced to the MOSFET source, a floating node. This technique is widely used for its simplicity and efficiency in half-bridge and full-bridge topologies.

## **PURPOSE:**

This circuit aims to drive a high-side N-channel MOSFET by generating a gate voltage higher than the source voltage through bootstrapping. It charges a bootstrap capacitor during low-side conduction, which then provides the required gate voltage during the high-side MOSFET conduction period, enabling reliable switching with minimal external components and cost.

## **WORKING PRINCIPLE:**

During the low-side MOSFET ON state, the switching node is pulled to ground, allowing the bootstrap capacitor to charge from the 12V supply through the diode. When the high-side MOSFET is turned on, this charged capacitor raises the gate voltage above the source node, enabling full MOSFET enhancement. The diode prevents discharge back into the supply and ensures energy is stored in the capacitor to maintain gate drive voltage during the ON state. This cycle repeats with complementary PWM signals controlling the low and high-side devices.

## CIRCUIT DIAGRAM:

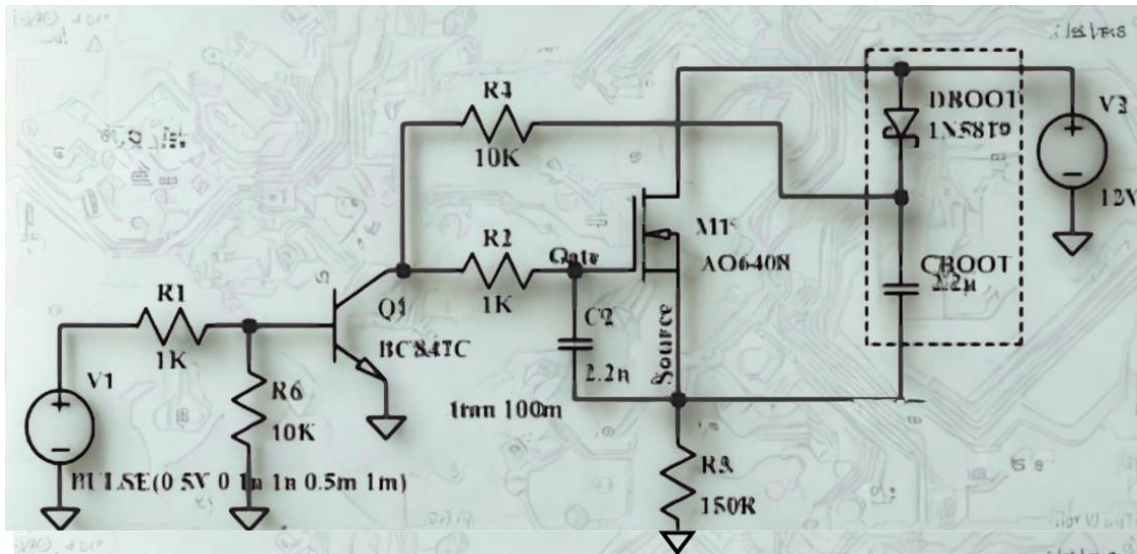


Fig 1: Circuit Diagram

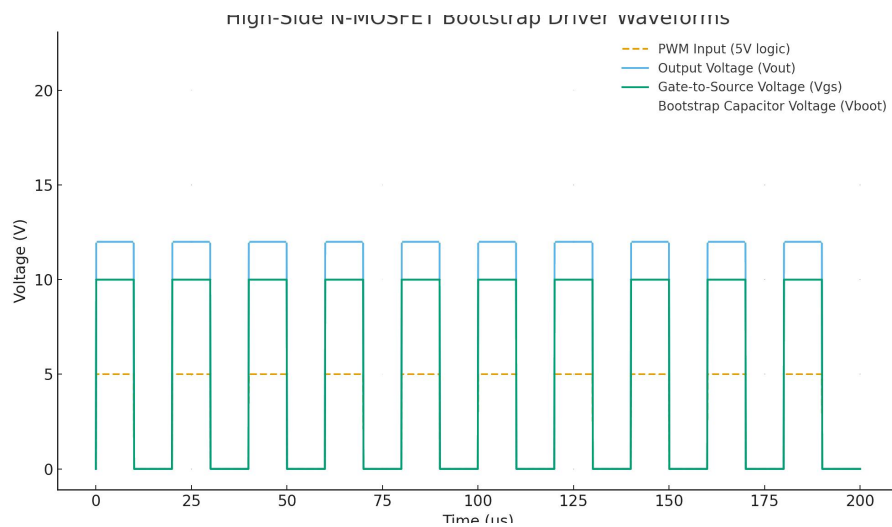


Fig 2: Expected Output

The circuit consists of an input pulse source, transistor Q1 as a level shifter, a gate resistor, the N-channel MOSFET, a bootstrap diode, and a bootstrap capacitor. The source of the MOSFET connects to the load resistor and ground, while the bootstrap components raise the gate voltage relative to the MOSFET source during operation.

## PROPOSED SYSTEM:

The proposed bootstrap-based high-side N-channel MOSFET gate driver provides a simple, reliable, and cost-effective means to drive the MOSFET in power converters or switching applications. It supports high-frequency operation with low component count and avoids the complexity of isolated power supplies, making it suitable for efficient power switching applications.

## eSim Circuit:

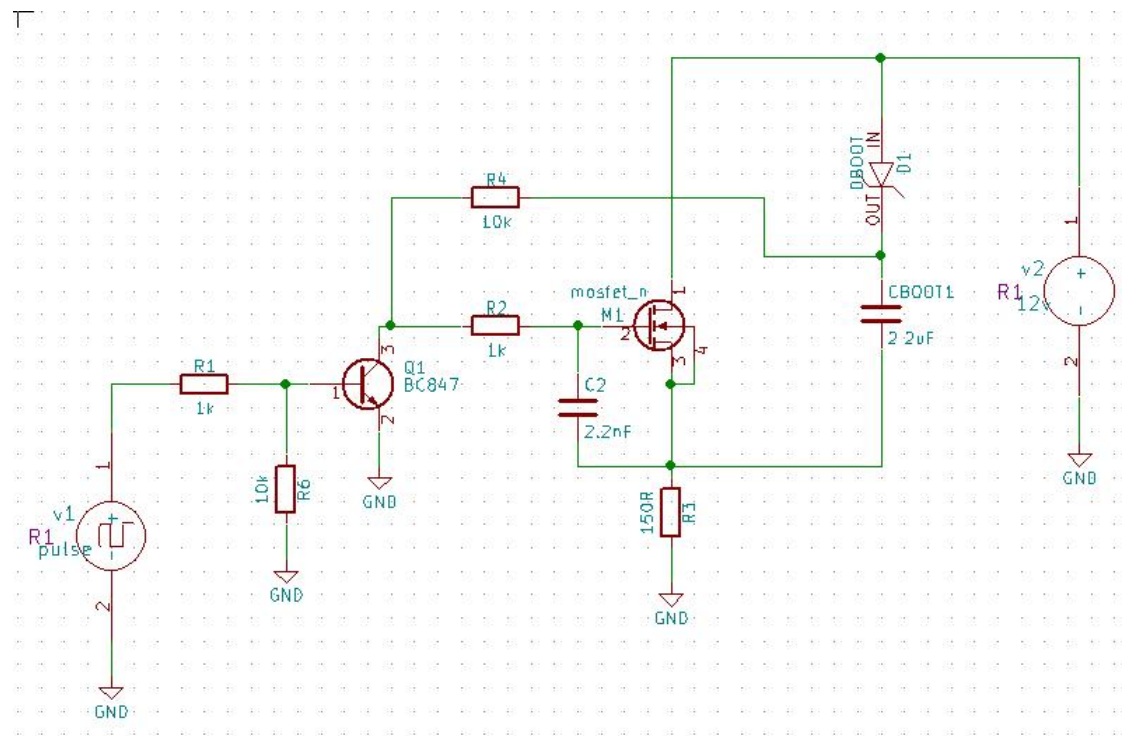


Fig 3: Bootstrap Driver in eSim Software

## OUTPUT WAVEFORM:

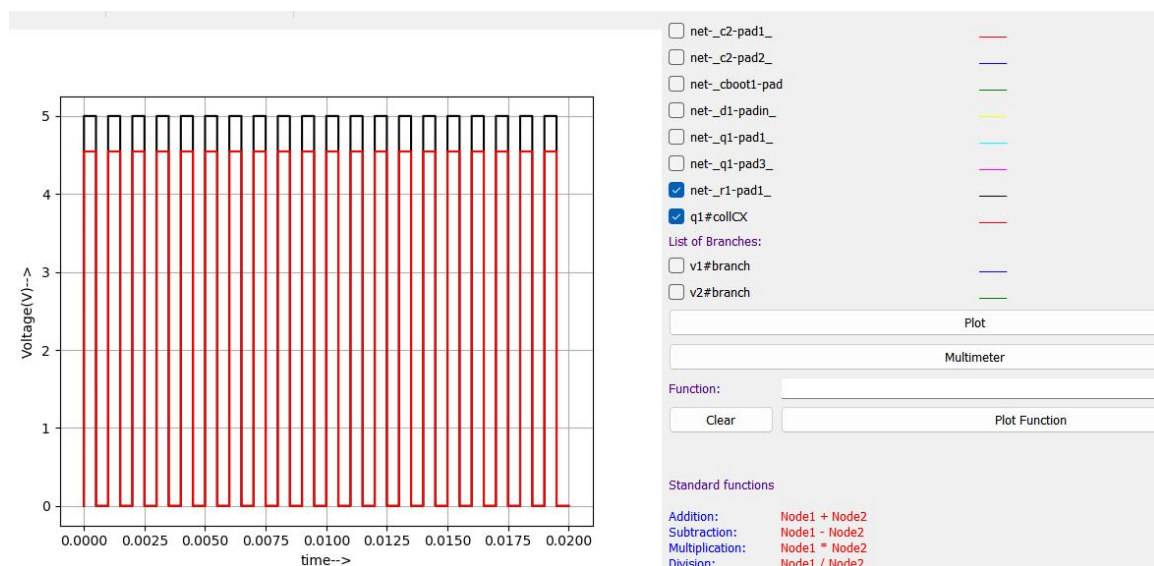


Fig 4 : Output waveform (Python plot)

The output waveform of the high-side N-channel MOSFET bootstrap driver circuit is a square wave voltage toggling between 0 V and the supply voltage (e.g., 5 V or 12 V) at the switching frequency. This waveform indicates the MOSFET is switching ON and OFF in response to the input pulse signal. The sharp transitions and stable amplitude of the output confirm that the bootstrap capacitor and diode are effectively providing the elevated gate voltage required for proper MOSFET operation. Such a waveform is characteristic of efficient high-side switching in power electronics applications using bootstrap drive circuits.

## **CONCLUSION :**

The high-side N-channel MOSFET bootstrap driver circuit provides an efficient and economical solution to gate driving challenges. By leveraging bootstrap capacitors and diodes, it ensures the gate voltage is adequately boosted relative to the MOSFET source node for proper switching. This design facilitates high-frequency operation and reliable high-side switching in various power electronic applications.

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