

Circuit Simulation Project

<https://esim.fossee.in/circuit-simulation-project>

Name of the participant: Sufiyan Shaikh

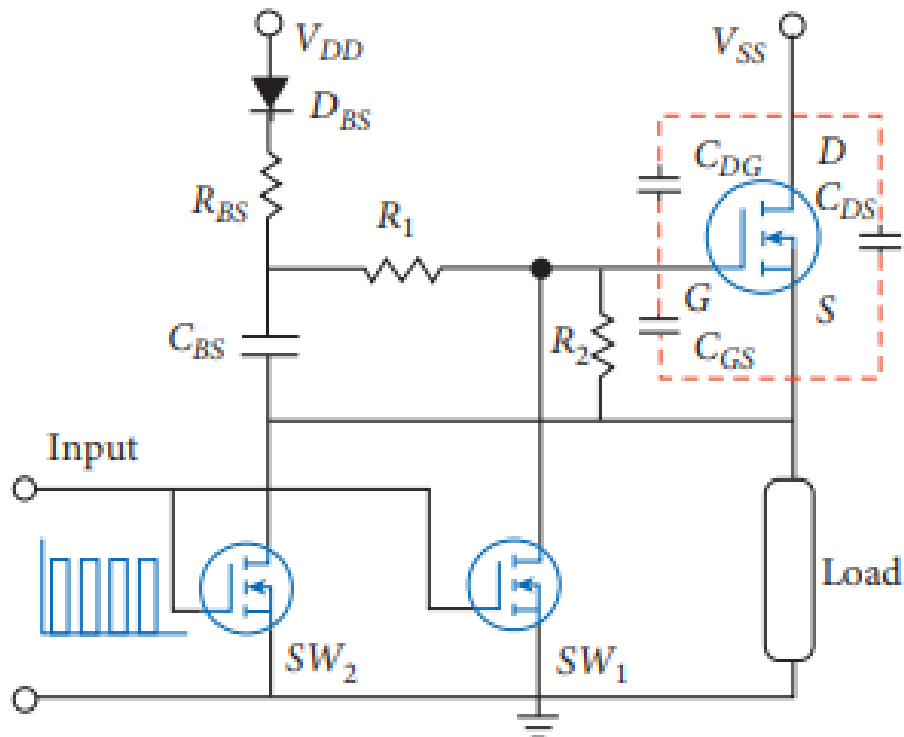
Title of the circuit: Design and Optimization of a High-Side MOSFET Bootstrap Driver Circuit

Theory/Description: A bootstrap driver is an essential circuit used to efficiently control high-side MOSFETs in various switching applications, such as DC–DC converters, motor drivers, and power management circuits. High-side MOSFETs are challenging to drive directly because their source terminal is not at a fixed voltage, but rather rises and falls with the load. To fully turn on a MOSFET, the gate-to-source voltage (V_{GS}) must exceed a certain threshold. When the source voltage is moving, supplying a gate voltage higher than the source becomes non-trivial.

The bootstrap circuit provides an elegant solution. It primarily consists of a bootstrap capacitor and a diode. During the period when the low-side MOSFET or switch is ON, the capacitor charges up from the supply voltage through the diode. When the high-side MOSFET turns ON, the charged capacitor acts as a temporary voltage source, boosting the gate voltage above the source voltage. This ensures the MOSFET is fully enhanced, resulting in reduced conduction losses, improved switching efficiency, and reliable operation under dynamic load conditions.

Bootstrap drivers are widely adopted in high-frequency power electronics because they simplify gate drive requirements without needing an additional isolated supply, making them highly efficient, compact, and cost-effective. The performance of the circuit depends on proper selection of the bootstrap capacitor, diode, and associated gate resistances, which together determine the voltage stability, switching speed, and reliability of the high-side driver.

Circuit Diagram(s):



Results: The output of the bootstrap driver circuit is a boosted gate voltage that exceeds the supply voltage, allowing the high-side MOSFET to fully turn on and switch efficiently. During operation, the bootstrap capacitor charges and discharges correctly, ensuring stable and reliable MOSFET switching without voltage spikes or partial conduction. In simulation, the gate voltage waveform rises above the supply when the high-side MOSFET is on, while the source voltage follows the load switching, demonstrating the proper functioning of the bootstrap mechanism.

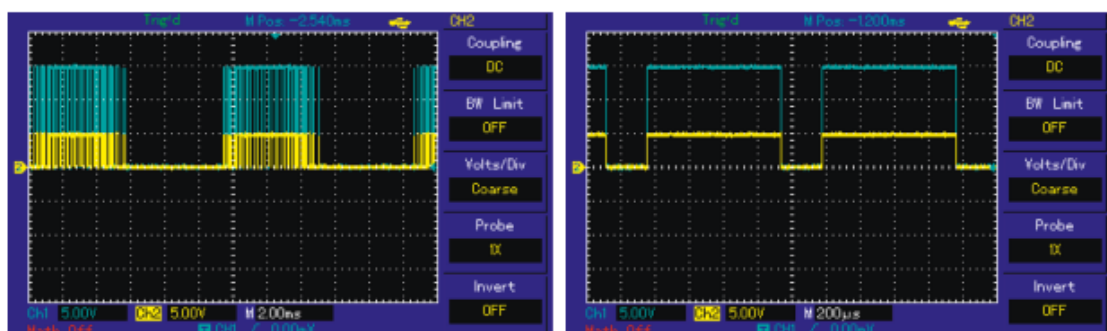


FIGURE 13: The generated waves and GS wave signals at different frequencies.

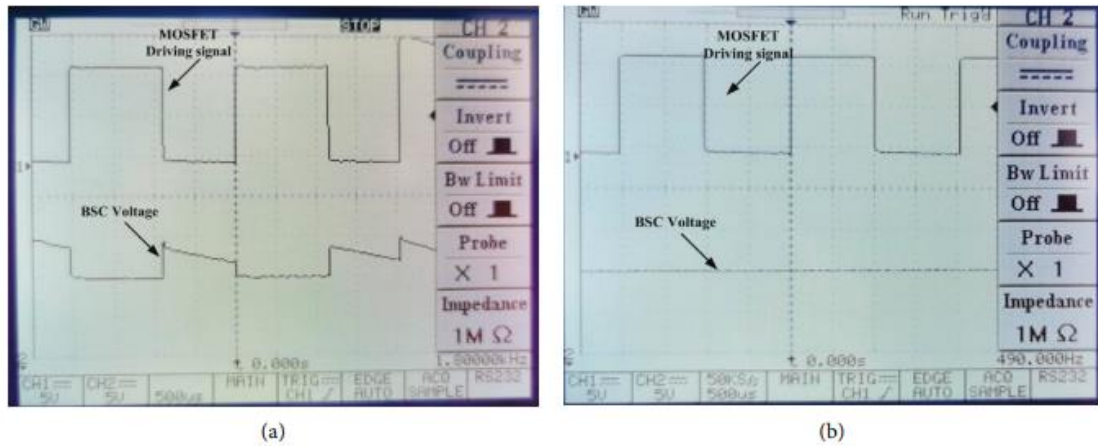


FIGURE 16: Charging and discharging of the BSC (500 Hz, $D = 0.5$).

Source/Reference(s): Abd El-Halim, H., Soliman, E.S. and Refky, A., 2022. Performance of MOSFET driven via a bootstrap capacitor for dynamic load continuity enhancement. *Journal of Engineering*, 2022(1), p.2273819.