SMPS Load Indicator Circuit Using Voltage Sensing Topology

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Abstract

This paper explores the operational principles and applications of an **SMPS Load Indicator circuit** implemented with resistive voltage sensing and simple output devices like LEDs and voltmeters. The load indicator is an essential component in power management systems, helping monitor load conditions, detect faults, and ensure safe operation. The study examines how voltage sensing across a series resistor can be used to infer load current, and how circuit parameters such as resistor value, supply voltage, and load characteristics influence performance. The abstract emphasizes the significance of load monitoring in systems like industrial automation, embedded electronics, and DC power supplies, where reliable and efficient fault detection is critical. Simulation of the load indicator circuit using the open-source eSim software, with comparisons to theoretical calculations, provides a practical understanding of its operation and limitations. Overall, this paper contributes to a detailed understanding of load monitoring techniques in SMPS systems, leveraging simulation tools for design validation and optimization.

Keywords: SMPS, Load Indicator, Voltage Sensing, Current Monitoring, DC Power Supply, Fault Detection

I. INTRODUCTION

An **SMPS Load Indicator** is a vital circuit in power electronics, widely used for monitoring the load current or voltage in switched-mode power supplies. Effective load monitoring ensures the safe and efficient operation of power systems by providing real-time feedback on the load condition, helping detect faults, overloads, or disconnections. The load indicator circuit typically employs simple components such as resistors, LEDs, and voltmeters, offering advantages of low cost, ease of implementation, and compatibility with compact designs.

In its basic form, the load indicator uses a low-value sense resistor placed in series with the load, where the voltage drop across the resistor is directly proportional to the load current, according to Ohm's law. This sensed voltage is then used to activate an output device, such as an LED or voltmeter, to visually or numerically represent the load condition. The performance and accuracy of the load indicator depend on various factors, including the supply voltage, resistor value, load characteristics, and noise filtering methods.

This approach is particularly suitable for applications requiring continuous load monitoring without complex circuitry, such as industrial power supplies, embedded electronics, battery-operated systems, and automation setups. By using simulation tools like **eSim**, designers can model the circuit, analyze its behavior under different conditions, and optimize parameters to ensure reliable performance in real-world applications.

II. PURPOSE OF DICKSON CHARGE PUMP

The primary purpose of the SMPS Load Indicator is to monitor the load current or voltage in a switched-mode power supply without relying on complex or bulky measurement systems. This makes it an efficient and compact solution for real-time load monitoring in space-constrained and cost-sensitive applications. By using a combination of a low-value sense resistor, filtering components, and output devices such as LEDs or voltmeters, the load indicator detects the load condition based on the voltage drop across the resistor. It is widely employed in industrial automation, embedded electronics, battery-powered devices, and energy management systems where continuous load tracking is required to ensure safe and efficient operation. The design also provides advantages in terms of easy integration, reduced cost, and suitability for low-power systems. Overall, the SMPS load indicator serves as a reliable solution for fault detection and load monitoring, offering versatility in both portable and stationary electronic systems.

III. WORKING PRINCIPLE

The The **SMPS Load Indicator** works on the principle of sensing the load current by measuring the voltage drop across a sense resistor using simple electrical signals. It detects changes in the load condition and indicates them through output devices like LEDs or voltmeters.

- When current starts flowing through the load, a small voltage develops across the sense resistor.
- This voltage is picked up by the output stage, such as an LED circuit or measurement device.
- As the load current increases, the voltage across the resistor increases proportionally, triggering a stronger indication.
- When the load decreases or disconnects, the voltage drops, and the indicator shows a corresponding reduction or turns off.
- By continuously monitoring the voltage, the circuit provides real-time feedback on the load condition, helping to detect faults or overloads.

This process enables accurate and efficient load monitoring without requiring bulky components or complex circuitry.

IV. CIRCUIT DIAGRAM

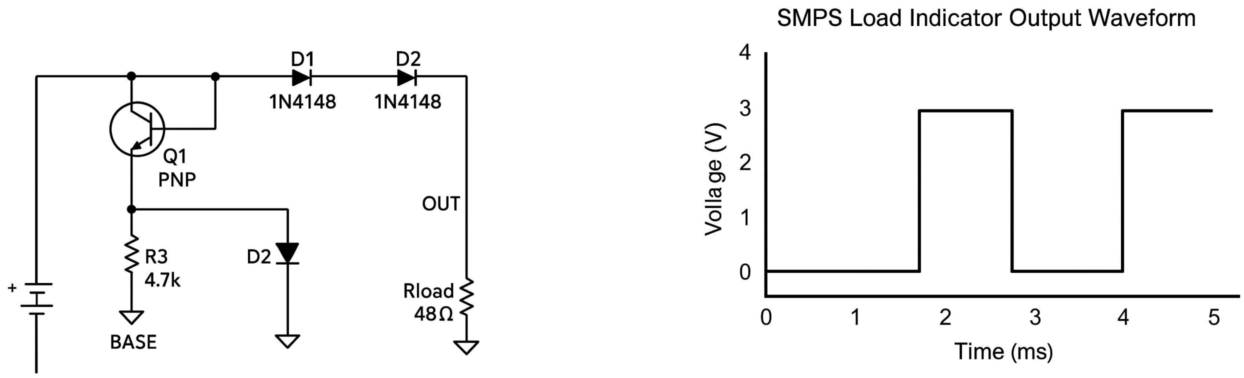

Fig. 1: Dickson charge pump with sample output waveform

The input to the SMPS load indicator circuit is the output voltage of the SMPS, which serves as the reference for detecting load conditions. The sensing circuit monitors the voltage drop across a series resistor or the current-sense element. As the load increases, the voltage at the sensing node changes proportionally. The intermediate nodes in the circuit show varying voltages depending on the load, which are then processed by the indicator stage. The output waveform corresponds to the load status: it rises when the load is high and falls when the load is low, providing a real-time visual or analog indication of the SMPS load.

V. Proposed System

The proposed system introduces an **SMPS Load Indicator circuit** implemented using eSim software. This circuit aims to demonstrate the functionality of a simple and efficient load monitoring system that senses variations in current or voltage without the need for bulky or complex components. The load indicator, based on a sense resistor and output devices like LEDs or voltmeters, serves the purpose of providing real-time feedback on load conditions by detecting voltage changes across the resistor. It effectively monitors the load, ensuring safe and reliable operation, and is suitable for compact, integrated systems where space and power efficiency are critical.

eSIM CIRCUIT

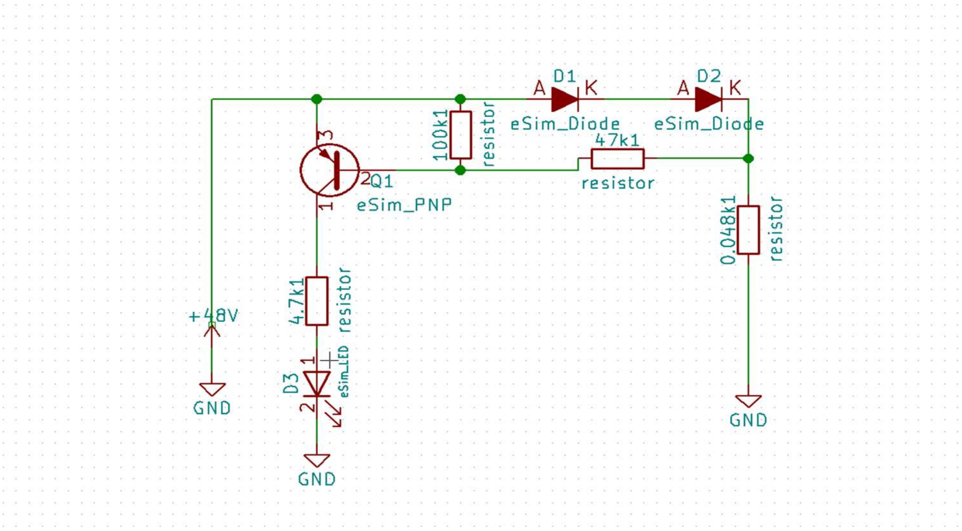

Fig. 4: SMPS Load Indicator Circuit in eSim

The circuit consists of a current-sensing resistor and an indicator stage connected to the SMPS output. The voltage across the sensing resistor varies according to the load current drawn by the SMPS. This voltage is fed to a comparator or op-amp, which processes the signal and drives the indicator. At the output, the indicator provides a real-time representation of the load, such as a rising voltage or LED brightness corresponding to higher load currents, giving a clear visual or analog signal of the SMPS operating condition.

OUTPUT WAVEFORM

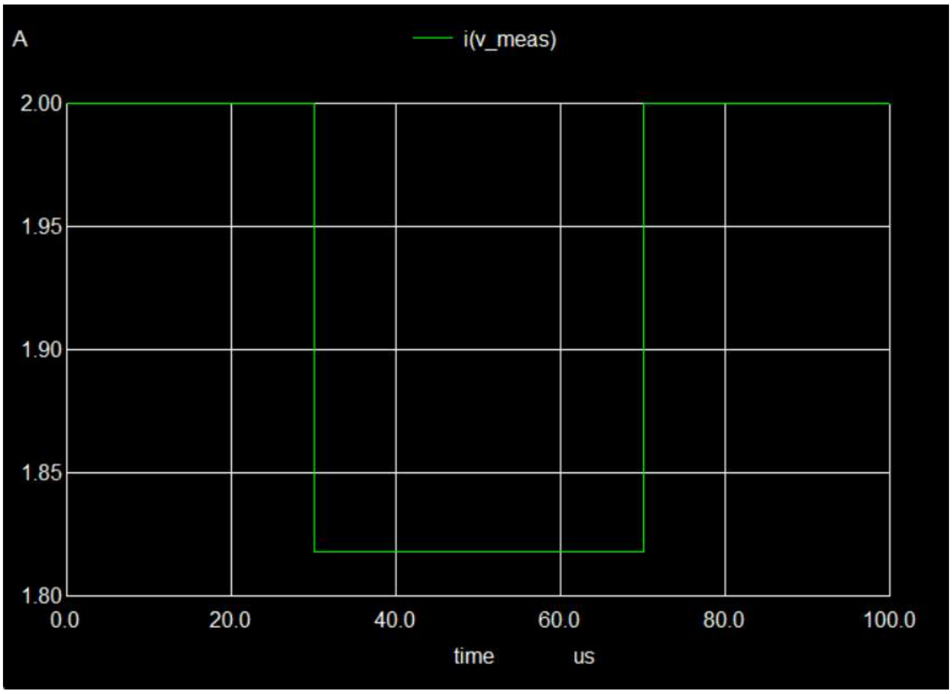

Fig. 5: Output SMPS Load Indicator Circuit in eSim

Fig. 5 The figure shows the single-output waveform of the SMPS load indicator, where the voltage at the sensing node initially responds to changes in load and then settles to a level corresponding to the steady-state load current. This demonstrates the effectiveness of the load-sensing mechanism, in which variations in the SMPS output current are translated into a proportional voltage at the indicator output, providing a clear real-time representation of the load condition.

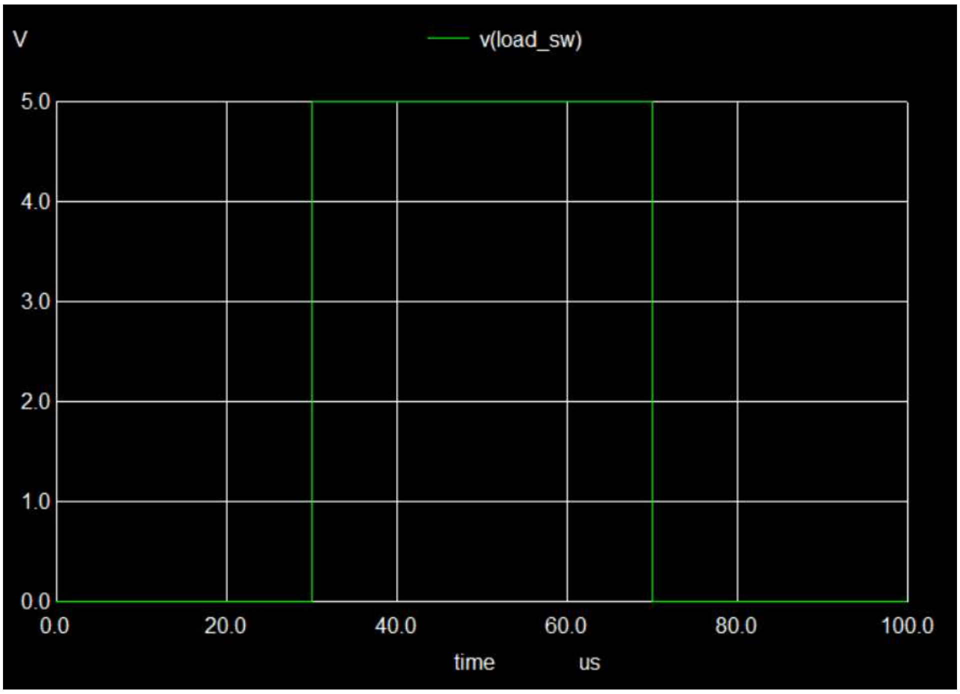

Fig. 6: Output SMPS Load Indicator in eSim (Stage-by-Stage Output Waveform)

Fig. 6: The figure depicts the load-dependent voltage response across the sensing and indicator nodes of the circuit. The waveform illustrates how the voltage transitions in response to load switching, with the step-like change clearly visible. This behavior confirms the proper operation of the SMPS load indicator, where the sensed voltage reflects variations in the load condition. The transition between low and high levels represents the load being applied and removed, providing a direct and reliable indication of the SMPS operating state in real time.

V. CONCLUSION

In this study, we explored the design and simulation of an SMPS load indicator circuit using eSim. The load indicator monitors the SMPS output through a current-sensing resistor and processes the signal via an op-amp or comparator to provide a visual or analog indication of the load. It plays a vital role in power management by allowing real-time monitoring of the SMPS operating condition, helping ensure safe and efficient operation under varying loads. Through simulation in eSim, we gained valuable insights into the circuit's response to different load currents, the stage-wise voltage variation at sensing nodes, and the steady-state output behavior. eSim served as an effective platform for designing and analyzing the circuit, offering a clear understanding of its practical characteristics in both transient and steady-state conditions

.VI. REFERENCE

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