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COLLEGE OF ENGINEERING AND TECHNOLOGY

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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MESSAGE FROM THE HEAD OF DEPARTMENT

The Department of Electrical and Electronics Engineering (EEE) at Akshaya College of Engineering and Technology offers an undergraduate programme in B.E (Electrical and Electronics Engineering), with an annual intake of 30 students. The department is dedicated to provide a comprehensive understanding of electrical and electronics engineering built upon the principles of physical science, mathematics, computing, and technology. Approved by AICTE, New Delhi, and affiliated with Anna University Chennai, the department focuses on practical training in electrical engineering, emphasizing experimental design and communication skills throughout the academic years.

The program's strength lies in its innovative curriculum, which meets international quality standards. The department focuses on continuous improvement to address stakeholders' needs and is supported by a team of exceptional faculty members from various professional and academic backgrounds. The Department of Electrical and Electronics Engineering has modern, advanced equipment and features specialized labs, including PLC and SCADA Laboratory, Virtual Instrumentation Laboratory and Electronic System Design Laboratory.

Mrs. Balambigai G

HoD (i/c)

Department of EEE

VISION AND MISSION OF THE DEPARTMENT

VISION OF THE DEPARTMENT

To develop into a centre of learning in Electrical and Electronics Engineering by imparting quality and value based education among the students and mould them as professional engineers to meet the challenges in industry and society.

MISSION OF THE DEPARTMENT

DM 1: To impart the students in fundamental concepts of Electrical and Electronics Engineering by technology enabled learning.

DM 2: To update and upgrade the laboratory infrastructure periodically and collaborate with core electrical industries and universities to equip the students with professional skills to cater to the industrial needs.

DM 3: To impart human values and social responsibilities to the students and promote entrepreneurial activities with a willingness to serve the society, thereby making them responsible citizens.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: The graduates will be able to apply domain knowledge in electrical and electronics engineering for providing solutions to complex problems in power system, renewable energy systems, power electronics and drives.

PEO 2: The graduates will be able to fulfill the role and responsibility of the professional electrical engineers in their chosen career with a mind to serve the industry and society.

PEO 3: The graduates will be able to work as an electrical engineering professional or perform as a researcher pursuing higher education in reputed institutions, thereby encouraging life-long learning, keeping pace with technological developments in Electrical Engineering.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: The students will be able to analyze, design and implement solutions to problems in electrical and electronics engineering with a specific focus on energy engineering and power electronics.

PSO 2: The students will be able to use relevant software, apply modern techniques and practice professional ethics for electrical engineering related activities, understanding the need for sustainable development.

PSO 3: The students will be able to develop leadership qualities, perform as a team member, possess entrepreneurship skills and follow ethical values so as to become a successful electrical engineering professional.

PROGRAM OUTCOMES (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

MESSAGE FROM THE EDITORIAL TEAM

Dear Readers,

We are pleased to present the first issue of our publication, dedicated to the fascinating field of renewable energy and sustainable development. As we continue our journey, our aim remains to provide insightful articles that highlight the latest trends, technologies, and practices shaping resources. In this issue, we explore various aspects of renewable energy selection, tillage techniques and the essential role of precision in sustainable development.

Our editorial team has worked diligently to curate engaging content that is both informative and relevant to our readers. We believe this issue will not only deepen your understanding of various renewable energy sources but also inspire innovative thinking in how these technologies can be applied to improve sustainable development. We encourage you to reflect on the challenges and opportunities presented in our articles and consider how they may influence your own practices.

Thank you for your continued support and interest in our publication. We look forward to your feedback and suggestions, as we strive to make each issue better than the last. Together, let us embrace the future of renewable energy and the exciting possibilities it holds.

Warm regards,
The Editorial Team

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POWER DISSIPATION OF A CMOS INVERTER

This Article Explains Dynamic and Static Power Consumption in A CMOS Inverter Circuit. The development of the CMOS inverter, which provides essential functionality for integrated circuits, was a turning point in the history of technology. This logic circuit highlights the electrical properties that make CMOS so uniquely suitable for high-density, high-performance digital systems.

One advantage of CMOS is its efficiency. CMOS logic requires current flow only when changing states—a CMOS circuit that's simply maintaining a logic-high or logic-low voltage dissipates very little power. Low power dissipation is a desirable feature in general, and it's particularly beneficial when you're trying to pack as much transistor functionality as possible into a small space.

As computer CPU fans remind us, adequately removing heat from an integrated circuit can be difficult. It would be far more difficult without the CMOS inverter and other, similar CMOS circuits. In this article, the first in a three-part series, we'll review key characteristics of the CMOS inverter and discuss its two primary types of power dissipation: dynamic and static. We'll delve more deeply into dynamic power dissipation in the next two articles.

STRUCTURE AND OPERATION OF A CMOS INVERTER:

A CMOS inverter is composed of an NMOS transistor and a PMOS transistor connected together. Figure 1 shows the schematic for a basic CMOS inverter.

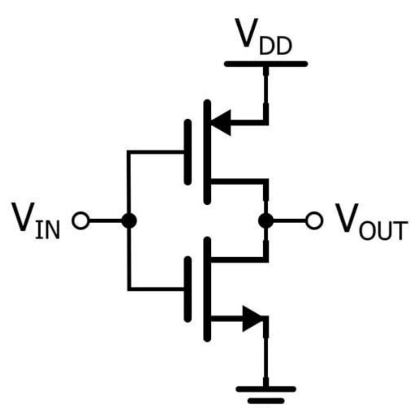

Figure 1. A CMOS digital inverter uses one NMOS and one PMOS transistor.

THE BASIC OPERATION OF A CMOS INVERTER IS QUITE STRAIGHTFORWARD:

• When the input terminal is driven to the logic-high voltage, the upper PMOS transistor blocks current and the lower NMOS transistor conducts current. The output terminal is thus connected to 0 V through a low-resistance path.

• When the input terminal is driven to the logic-low voltage, the PMOS conducts and the NMOS blocks. The output is connected through a low-resistance path to VDD.

In this way, a logic-high input creates a logic-low output, and a logic-low input creates a logic-high output.

DYNAMIC POWER CONSUMPTION:

Power is consumed whenever current is flowing through a conductive element. We see this relationship in the basic formula for electric power:

$$\mathbf{P = I \times VP = I \times V}$$

Though a CMOS inverter doesn't require current flow in its steady state, power is consumed during its logic transitions. This dynamic power loss comes in two types:

• Switching power dissipation.

• Short-circuit power dissipation.

SWITCHING POWER DISSIPATION:

When an input logic transition occurs, transient current must flow in order to charge or discharge capacitance in the circuit. During a low-to-high output transition, current flows to charge up the load capacitance as the output voltage increases to VDD. Figure 2 shows the path taken by this current.

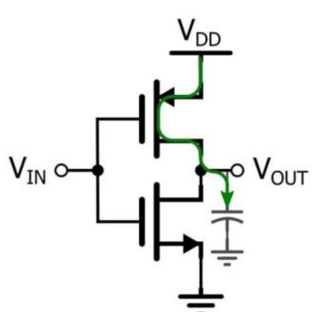

Figure 2. The flow of charging current during a low-to-high output transition.

Current also flows during a high-to-low output transition (Figure 3), discharging capacitance as the output voltage decreases to ground potential.

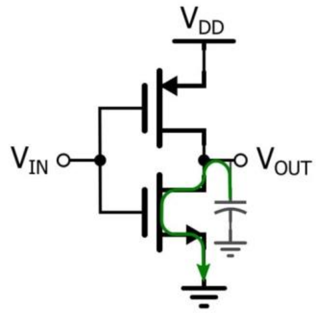

Figure 3. The flow of discharge current during a high-to-low output transition.

SHORT-CIRCUIT POWER DISSIPATION:

Another type of dynamic power dissipation is caused by short-circuit current. Also known as shoot-through current, this is a transient condition that occurs during an inverter's logic level transitions.

When a CMOS inverter is settled in a logic state, one of its two transistors is in a non-conductive mode. Consequently, current can't easily flow from VDD to ground. When the inverter changes states, however, there's a brief crossover period during which both the NMOS and the PMOS have some degree of conductivity. Energy is lost as current flows through the resulting short circuit (Figure 4).

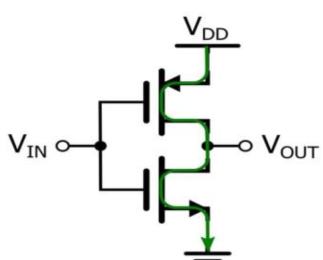

Figure 4. The NMOS and PMOS transistors briefly create a short circuit during logic-level transitions, allowing current to flow from VDD to ground.

STATIC POWER CONSUMPTION:

Throughout this article, avoided saying anything along the lines of "absolutely no steady-state power dissipation occurs in a CMOS inverter." The fact is that field-effect transistors aren't ideal switches. Even in the OFF state, leakage currents can flow from the drain to the source and from the drain or source to the substrate.

If the magnitude of these leakage currents is known, the resulting power dissipation can be calculated using the formula:

$$P_{static} = I_{leakage} \times VDDP_{static} = I_{leakage} \times VDD$$

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CHAPTER 2
BUCK-BOOST REGULATOR

The circuit shown in Figure 1 illustrates one of the most basic versions of the buck-boost voltage regulator. An electrical switch is connected in series with the line input to regulate the circuit. This could refer to any electrical power switch, such as a bipolar transistor, a power MOSFET, or similar controllable device capable of switching between ON and OFF states. The resistor RL in the schematic diagram symbolizes the load connected to the output, which may actually refer to any subsequent circuit that consumes current.

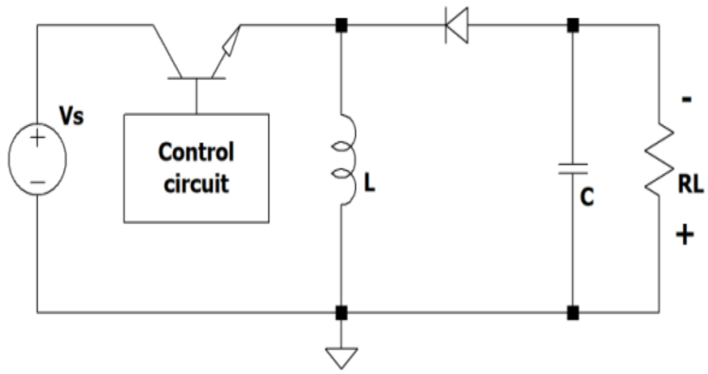

Figure 1: The General Schematic of the Buck-Boost Converter

The unique characteristic of the buck-boost regulator is its ability to produce an output voltage that is either greater or lower than the input voltage. It functions in a non-linear regime. Put simply, the device takes in a DC voltage at the input and adjusts it up or down as required by the application at the output. The output voltage is negative relative to ground, which is an important factor to consider. In the circuit schematic, the load experiences a reverse potential difference compared to a typical converter.

This polarity must be taken into account when designing any application. Its circuit is similar to those of buck and boost converters, but the whole system is contained within a single circuit, with the addition of a control device. They are used in consumer electronics devices, self-regulating power supplies and power amplifiers. It is therefore possible to use both buck and boost functions in a single configuration, acting on the input pulses. Let us now examine, in broad terms, the operation of this type of converter.

The circuit, as we saw earlier in the circuit diagram, contains an electronic switching component (transistor, MOSFET or other. It can be switched on and off (at high speed) by means of a pulsating signal from an oscillator circuit. The circuit also contains an inductor, a diode and a capacitor as well as, of course, the load. The electronic switch, therefore, operates under two different conditions, in the ON state and in the OFF state. During the ON state, current flows through the transistor and also flows instantaneously through the inductor, as the diode is inversely polarised. The inductor limits this sudden current and stores a certain amount of current.

When the transistor switches to the OFF state, blocking the normal passage of input current, the inductor sends its current (stored in it) back to the diode and thus to the output of the circuit on the load. The current is also stored in the capacitor. During the next ON state, the cycle repeats, but this time without current in the inductor. It is the capacitor that supplies the stored energy to the output.

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CHAPTER 3
SINGLE-PHASE FULL-BRIDGE INVERTER

PRINCIPLE OF OPERATION:

As previously stated, single-phase full-bridge inverters are utilized to convert direct current into alternating current. The circuit utilizes electrical switches that function in pairs. During one half-wave, only S1 and S2 are closed, while during the other half-wave, S3 and S4 are closed. The inverter produces an oscillating voltage with a frequency that can vary, depending on the frequency of the waveforms used to operate the devices. Figure 1 depicts the overall operational schematic of this inverter.

Practically, the electronic switches in part "a" of the circuit are operated in a complementary manner to the electronic switches in part "b". The switches in this scenario are considered to be optimal devices. Both signals are modulated using reference voltages that are identical in magnitude but opposite in direction. Usually, the identical electrical carrier is employed for both driving signals.

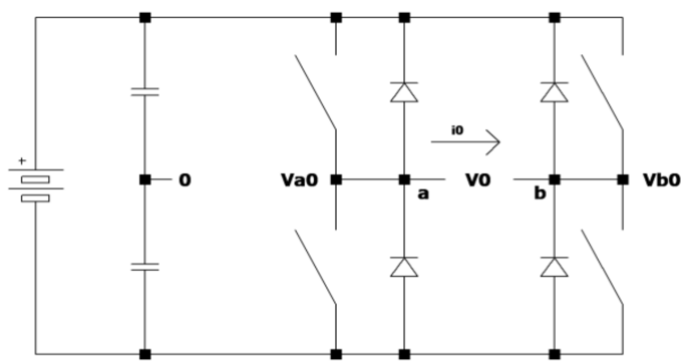

Figure 1: Principle diagram of a single-phase full-bridge inverter

The single-phase full-bridge voltage generator inverter consists of four chopper circuits. In it are four transistors, or MOSFETs, (Q1, Q2, Q3 and Q4). They can be driven individually and independently, so the final operation is different depending on the sequencing and how the electronic switches are turned on and off. This device is also called an "H-bridge" because of the peculiar graphic shape that its electronic components form. The end result is the combination of two single-phase, two-level inverters using the same supply voltage.

We will examine, below, the different activation sequences:

• if switching elements Q1 and Q2 are both closed, the load (present between nodes “a” and “b”) is subjected to a voltage equal to Vs, and precisely at node “a” there is a voltage value of about Vs and at node “b” there is a voltage value of about GND.

• If switching elements Q3 and Q4 are both closed, the load (present between nodes “a” and “b”) is subjected to a voltage equal to Vs, but this time reversed in polarity, and precisely at node “a” there is a voltage value of about GND while at node “b” there is a voltage value of about Vs.

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CHAPTER 4
AN OVERVIEW OF SEMICONDUCTORS

Semiconductors are crucial in building a future marked by environmental sustainability and more automation in the constantly changing field of technological innovation. In light of the pressing need to decrease carbon footprints and improve efficiency, semiconductors are becoming essential components for the advancement of environmentally friendly and highly automated technology. This article examines the potential of these powerful materials to transform businesses, creating a new era where environmental awareness effortlessly intersects with advanced automation.

Regarding electrical conductivity, solids can be roughly categorized into three groups:

INSULATORS:

Insulators are substances that possess poor electrical conductivity, making them suitable for creating a barrier between two surfaces where the passage of electric current is undesirable. Some examples of these materials are plastics, paper, and quartz, which is composed of silicon dioxide (SiO2).

METALS:

Metals are substances that possess the ability to easily transmit electricity, making them suitable for the purpose of transferring electrical current and establishing connections between two conducting materials. Some examples of these materials are copper and aluminum.

SEMICONDUCTORS:

Semiconductors possess the distinctive characteristic of being able to transition from a non-conductive state to a conductive one when subjected to an external influence, such as the application of voltage. When discussing semiconductors used in electronics, we typically refer to those that have a well-defined and repetitive crystal orientation, meaning the atomic orientation is organized in a specific manner. They may comprise of individual components, such as silicon (Si), or compound materials comprising many distinct elements, such as silicon carbide (SiC) and gallium nitride (GaN).

Figure 1 shows a visual depiction of these three categories. This illustrates the energy bands present in the substance. The valence band corresponds to the outermost shell of the atomic structure and contains the electrons that are readily available for bonding. The conduction band corresponds to unoccupied electron states with the lowest possible energy. The conduction of electric current in a semiconductor occurs by stimulating the movement of electrons from the valence band to the conduction band, which is separated by an energy gap.

In a metal, this gap is non-existent due to overlaps of these bands, and hence, they have high electrical conductivity. In an insulator, this gap is large (e.g., ~10 eV in SiO2, where eV is the amount of work done on an electron to make it go through a 1-V potential difference). In a semiconductor, the energy gap is typically in the 1-eV (Si) to 3-eV range (SiC and GaN). This gap makes it suitable for use in an application in which an externally applied voltage (typically a few volts) can change the behavior from insulating type to conducting type. The Fermi level EF in Figure 1 is a measure of the energy of the least tightly held electron in a solid. In an intrinsic semiconductor, it would typically lie between the valence and conduction band.

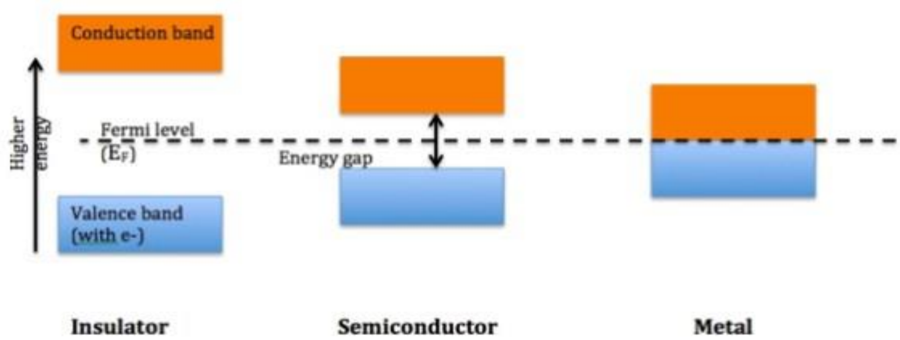

Figure 1: Energy-band diagram representations of an insulator, semiconductor and metal

DIFFERENT TYPES OF SEMICONDUCTORS AND THEIR USES:

The vast majority of all semiconductors used in electronics applications are based on silicon. Decades of technology development on this material have resulted in astounding levels of progress in the devices that are built from this, largely following Moore's Law of a doubling in device density every two years. Some of its unique advantages include:

The ability to easily dope its crystalline structure with atoms that can move the EF level up or down. In silicon, this can typically be done through ion implantation of ions like P, as (donors to create n-type Si) to B (to create p-type Si). In an n-type Si, the excess of electrons occupy vacant sites and so conduct electrons toward a positive voltage. In a p-type Si, electrons are pulled away from valence sites, creating a positive charge called a hole, which effectively flows in a direction opposite to an electron.

The ability to readily form a high-quality, insulating SiO2 oxide layer on its surface. This allows for control of the device state with high reliability in a device called a metal-oxide–semiconductor field-effect transistor (MOSFET). An applied positive voltage on the gate of the NMOS creates an electron channel under the oxide, effectively connecting the source and drain nodes.

The ease of forming both n- and p-type devices, along with a high-quality gate oxide that basically prevents static current draw on the gate supply VG, led to the rapid advancement of complementary MOS or CMOS technology. The main advantage of CMOS is that because the PMOS and NMOS are in series on a basic logic gate, one of these devices is always off, therefore making static current draw ID on VDD very low. The NMOS and PMOS ID versus VG curves indicate the turn-on voltage VT, at which the voltage applied on the gate turns on the channel between the source and drain.

Silicon is very cost-effective. Semiconductors are typically processed using flat, circular discs, which in turn are produced for a cylindrical bole that is sliced. High-quality, large-diameter (12-inch) silicon can be created at relatively low temperatures, making the starting wafer price typically a small fraction of the overall processed wafer cost.

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CHAPTER 5

A SHORT TUTORIAL ON DC POWER SUPPLIES

In accordance with the form of output voltage they produce, power supplies can be categorized as either DC power supplies or AC power supplies. These categories vary in accordance with the project's specifications and the ultimate requirements of the system in terms of complexity. Occasionally, conventional converters fail to meet the required level of safety, particularly in industrial and medical contexts where strict adherence to safety protocols is essential. DC power supplies are thus required to adhere to extremely stringent operational criteria and satisfy precise operational parameters.

DC POWER SUPPLIES:

Power supplies utilized in medical and industrial environments must satisfy a number of rigorous criteria. Single-stage converters fail to satisfy the majority of these criteria. Indeed, they fail to adequately isolate the input and output of the device galvanically, which can result in significant safety hazards for both operators and the devices. As a result, designers favor the use of multistage conversion techniques (AC/DC and DC/PAC), despite their increased complexity, due to the fact that they provide optimal safety factors.

Electrical isolation, another important element required, is ensured by the presence of a transformer between stages. The different types of conversion allow DC power supplies to be divided into various categories. Therefore, when designing DC power supplies, designers must comply with high power density, very high efficiency and low harmonic distortion of the various waveforms; the size and weight of the power supply must be as small as possible; galvanic isolation between the source and the load must be optimal; and there must be the possibility of flow direction and power factor control.

Therefore, to eliminate the problem of harmonics in the output signal while being isolated from the input, two-stage power supplies are used. One of the most important is the fly back converter, the principle diagram of which is shown in Figure 1. It is galvanically isolated from the load.

The operation of the fly back converter occurs in two stages:

- In the first phase, with the electronic switch Q1 closed, energy is stored in the Np inductor.
- In the second phase, with the electronic switch Q1 open, energy passes to the load via Ns, thus avoiding a direct connection between input and output.

If Ns is completely discharged during secondary conduction, the power supply operates in discontinuous-conduction mode; otherwise, it operates in continuous-conduction mode.

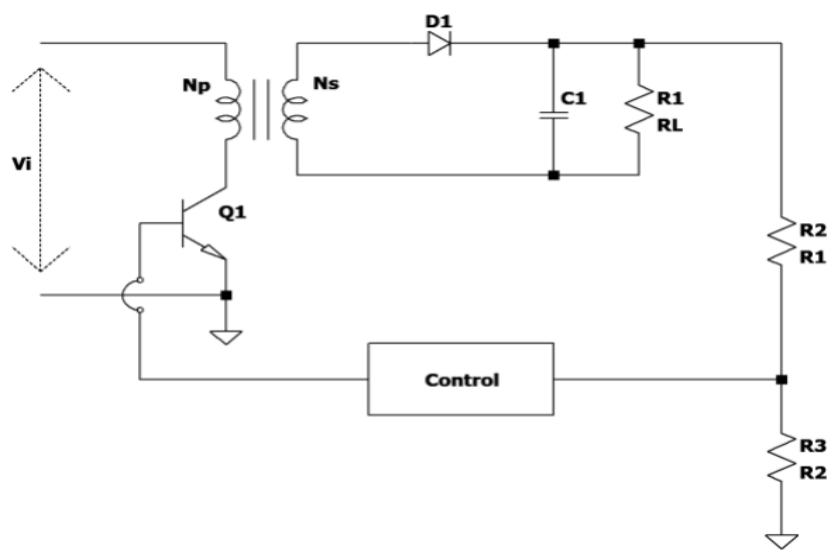

Figure 1: Principle diagram of a fly back converter

Even within an electronic simulation, it is always advisable to consider the adoption of non-ideal electronic components. Although ideal components speed up the simulation process and simplify mathematical calculations, the use of real components offers greater accuracy and more closely matches the behavior of the actual circuit. Indeed, real electronic components are characterized by a few inherent imperfections, including internal resistance, parasitic capacitances, saturation and temperature effects, noise and other non-linearities.

Predicting these effects within the simulation can help prevent design problems and evaluate circuit reliability and performance more accurately. However, it is important to always remember that electronic simulation is a design and analysis tool, but it cannot completely replace experimental testing. Therefore, the adoption of real electronic components can help ensure that the simulation is as close to reality as possible, making design development easier and faster and making it possible to fix any problems. In the example, some electronic components have been characterized with additional non-ideal elements.

They are as follows:

- The battery has an internal resistance of 0.3 Ω.
- The switching signal is not perfectly rectangular but contains rising and falling slopes lasting about 2 ms.
- The electronic switch was sized to have an on-resistance of 0.2 Ω and an off-resistance of 1 MΩ.
- The two inductors, the primary and secondary, have a series resistance of 0.1 Ω and a parallel capacitance of a few pico-farads.
- The inductive coupling of the two inductors is not ideal but has been fixed at 90%.

All of these non-ideal characteristics make it possible to obtain a fairly reliable simulation. During the first phase of operation of the circuit, Np charges linearly, while in the second phase, Np tends to keep the current constant, with an inversion of its voltage. Now, the voltage on the secondary inductor allows current to flow.

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