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Voltage drops studies for the operation of the microprocessor and microcircuits

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Annotation: The article explores the possibility of using flexible circuits in rectifier systems. An optimal topology of the power converter is proposed, fully using the functionality of the microcircuits. The proposed solution generates a relatively smooth DC output with less high frequency harmonic content, avoiding the high frequency harmonic problems found in rectifiers and will play a significant role in improving profitability and reliability in low to medium range power rectifier systems.

Keywords: Power supply, shutter lag transistors, power fluctuations, Vdd-drain plus (+) and Gnd (zero ground), Voltage drop, PDN-network power (mains power supply), IC-integrated circuit, CSN-simultaneous switching noise, CMOS- (MOSFET English) (metal-oxide-semiconductor), MOSFET, in nature nanofarad FMAX -Frequency, JTAG (Joint test action group-working group on the IEEE standard-Institute of Electrical and Electronics Engineers,).

The power supply (which is the source of voltage and current) is usually bulky and cannot be connected directly to the Vdd and Gnd terminals of the chip. Therefore, wires (interconnects) with resistance and inductance are used to establish this connection. The current flowing through these wires creates both a DC drop (not shown) and time-varying voltage fluctuations on the Vdd and Gnd terminals of the chip (shown in Figure 1-3) are harmful to the transistors in the chip. Therefore, a suitable PDN must be created between the power supply and the IC. so that the voltage is well regulated to supply the required current to the transistors for the required period of time. Voltage fluctuations at the Vdd and Gnd [1] transistor terminals can cause the following transistor problems:

Reducing the voltage at the terminals of the IC power supply, which slows down the transistor or prevents the transistor states from switching.

• Increased voltage at the IC supply terminals, which creates reliability problems.

• Leakage of voltage fluctuations (oscillations) into a silent transistor, as shown in Fig. 1-3 causing incorrect switching of silent transistor circuits at the far end of the communication path, as well as crosstalk from adjacent signal lines.

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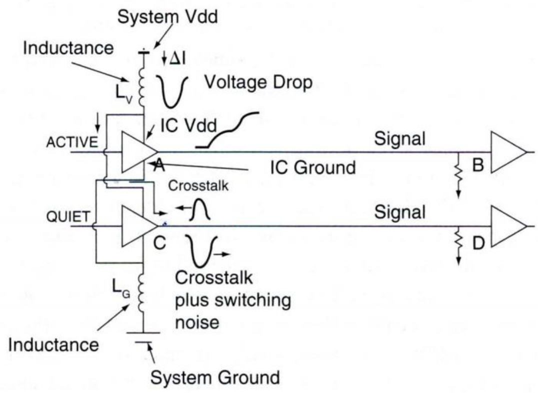

Figure 1-3 Voltage fluctuation [2].

• Time margin errors caused by degraded waveforms at the output of drivers.

A voltage fluctuation on an IC power supply is called power supply noise, delta I noise, or simultaneous switching (SSN) noise because it occurs only when transistors are switched.

Given the voltage fluctuations on the transistor's power supply, it is useful to understand how a microprocessor works (as an example at a holistic level) and the impact of voltage fluctuations on the microprocessor's performance.

The microprocessor consists of millions of CMOS transistors connected by wires in a very complex way. The speed of a microprocessor can be limited by shutter (or transistor) delays, interconnect (or wire) delays, or both. The reverse shutter delay (frequency) is proportional to the shutter voltage. For a gate-advantaged circuit, a 1% drop in gate voltage results in a frequency drop of almost 1%. However, interconnect delay is a very weak voltage function. There is an important relationship between the microprocessor's operating voltage and its speed. (measured as frequency) relative to the nominal voltage of the microprocessor.

This relationship is shown in Fig. 1-4 for a 64-bit Scalable Processor Architecture (SPARC) microprocessor [3]. At a nominal voltage of 1.6 V, the relationship between frequency and voltage is almost linear. As can be seen from the graph, a decrease in voltage reduces the operating frequency of the microprocessor, and an increase in voltage increases its frequency. This is an important ratio true for most microprocessors, and we use this example to explain the effect of fluctuations in supply voltage on the operating frequency of the microprocessor. In fact, the relationship between processor performance and voltage is more than complex and depends not only on the magnitude of the noise of the power supply, but also on the frequency of the noise.

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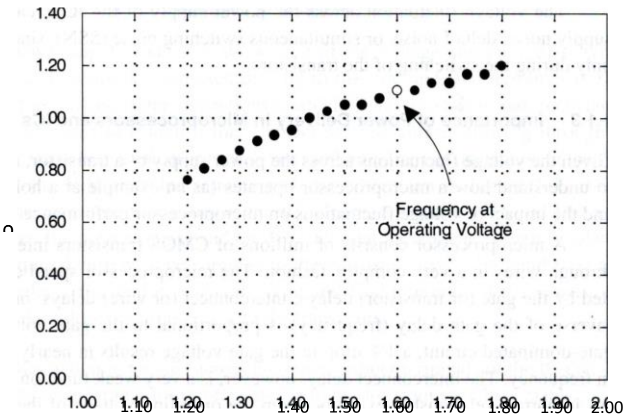

Figure 2. Frequency-voltage dependence for the 64-bit SPARC V9 microprocessor. The chip is built on 150-nm technology with seven layers of aluminum interconnects. It is designed to operate at a frequency of 1.0 GHz at a supply voltage of 1.6 V. The temperature is maintained at 600C.

Consider Figure 1-5, which assumes a linear relationship between the frequency of the microprocessor (along the y-axis) and the voltage (along the x-axis), as in Figure 1-4. In Figure 1-5, FMAX is the maximum operating frequency of the microprocessor. Any voltage above 1.65 V causes reliability problems and is displayed as the reliability boundary. Any voltage within the reliability limit causes the gate oxide dielectric to break through in the MOSFET due to excessive electric field. Therefore, for this example, the supply voltage cannot exceed 1.65 V. Suppose initially that the operating voltage of the microprocessor is 1.55 V. Judging by the Graphics, the nominal FMAX for the microprocessor is 720 MHz. However, changes in the voltage in the power supply cause the voltage to change by plus or minus 100 mV relative to the rated voltage. On the top side, the voltage of 1.65 V (1.55 V + 100 mV) is below the maximum allowable voltage of 1.65 V, which ensures that there are no reliability problems. On the underside, the supply voltage is reduced to 1.45 V (1.55 V – 100 mV). At 1.45 V, FMAX now becomes 670 MHz. Consequently, any drop or decrease in the supply voltage causes the microprocessor to operate at a lower frequency. In other words, PDN causing oscillations at the supply terminals of the IC causes the microprocessor to slow down. Similarly, an increase in the voltage on the POWER SUPPLY of the IC, if it exceeds the maximum allowable voltage, causes the IC to malfunction.[4]

When designing a PDN , the focus is always on minimizing the voltage drop at the transistor circuit power supply terminals inside the IC, as well as ensuring that the maximum voltage does not cause reliability problems [4].

The PDN power supply network consists of a power supply, DC converters (also called voltage regulator modules or VRM), a large number of decoupling capacitors, and interconnects that act as channels for supplying and removing charges from switch circuits.

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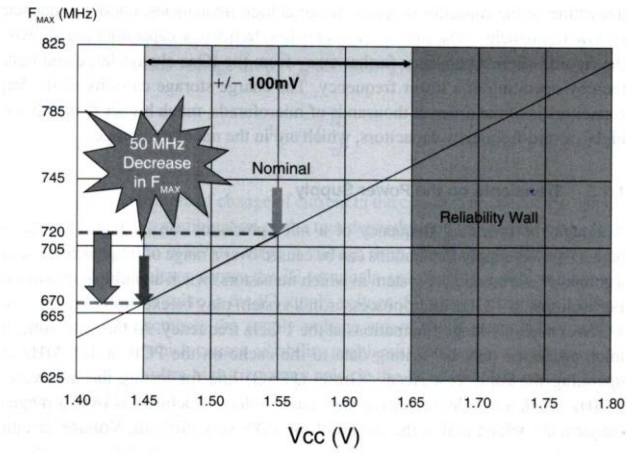

Figure 1-5 Relationship between voltage fluctuation and performance for a microprocessor [4].

Rice. 2 The relationship between voltage fluctuations and microprocessor performance [1].

In a typical computer system, the chip is packaged and placed on the motherboard (with or without an outlet) with a power supply on the motherboard. The power supply supplies the motherboard with high voltage and current. The voltage is lowered through the DC-TO-DC converter and fed to the IC through the interconnects in the motherboard and the chassis.

Untying capacitors are distributed across the motherboard, case and chip; they act as reservoirs in which a charge can be stored. Charge is applied as needed to the transistors from the decoupling capacitors. The proximity of the capacitors to the switching circuits determines the time it takes to apply charge. The time required is determined by the speed of light in the medium, which is the minimum time it takes to transfer charge from the capacitor to the transistors. For example, the minimum time it takes to deliver charge from a capacitor located on the motherboard at a distance of 6 inches from the transistor circuit is 1 ns, since the speed of light in typical printed circuit boards (PP) is 166 ps/inch.

A typical PDN for a semiconductor is shown in Figure 1-6 [5]. Because the delay time is inversely proportional to the frequency, the proximity of the capacitors to the transistors determines whether the capacitor is charging at high, medium, or low frequencies. The figure shows high-, medium- and low-frequency capacitors, and the capacitor farther from the chip is always larger and therefore operates at a lower frequency. The charge accumulation capacitance of large capacitors is on the order of thousands of microfarads, which is much higher. than high-frequency or mid-frequency capacitors, which are in the nanofarade range. Although the operating frequency of a microprocessor can be high (1 GHz or higher), power fluctuations can be caused in the frequency range because the computer is a broadband system in which transistors switch at multiple frequencies. For example, a 1 GHz microprocessor in the system can execute instructions at a frequency of 1 GHz, causing voltage fluctuations at a frequency of 1 GHz. At the same time, the microprocessor can write data to the cache on the PCB at a frequency of 400 MHz and control the JTAG line to test the equipment at a frequency of 1 MHz. Such switching activity can cause voltage fluctuations in the frequency range, making PDN design very difficult.

High Frequency Capacitors

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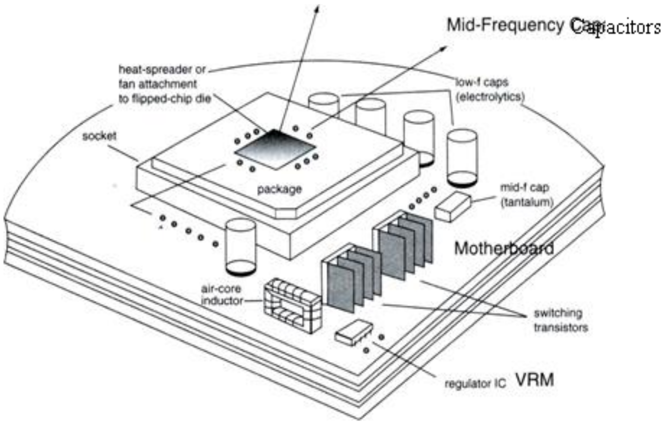

Rice. 1-6 Feed network. "Simulation of power distribution systems in PCs",. [2]

$$V_L = L\frac{dI}{dt} \quad (1.1)$$

Changing the voltage of electricity where dl/dt is the rate of change of current in the circuit. Inductor L can be equal to Lv or LG or a combination of both depending on the current path. A positive value of dl/dt through the inductor causes a voltage drop on it, which leads to a decrease in the supply voltage at the TERMINALS of the IC and causes performance problems due to a negative power surge of the IC. Similarly, a negative value of dl/dt through the inductor coils increases supply voltage at the IC terminals, which leads to a positive jump, which causes reliability problems.

Power supply noise consists of four components (1) ultra-high-frequency noise in the range from 10 to 100 GHz, (2) high-frequency noise in the range from 100 to 1000 MHz, (3) midrange noise in the range from 1 to 1000 MHz. 10 MHz and (4) low-frequency noise in the range from 1 to 100 kHz. On-chip inductance affects both ultra-high-frequency and high-frequency noise (> 1 GHz), while the casing has a large effect on high-frequency and mid-frequency noise. Localization of dips — dips observed on the crystal — can affect the local pathways of the circuit will affect all the paths of the circuit.

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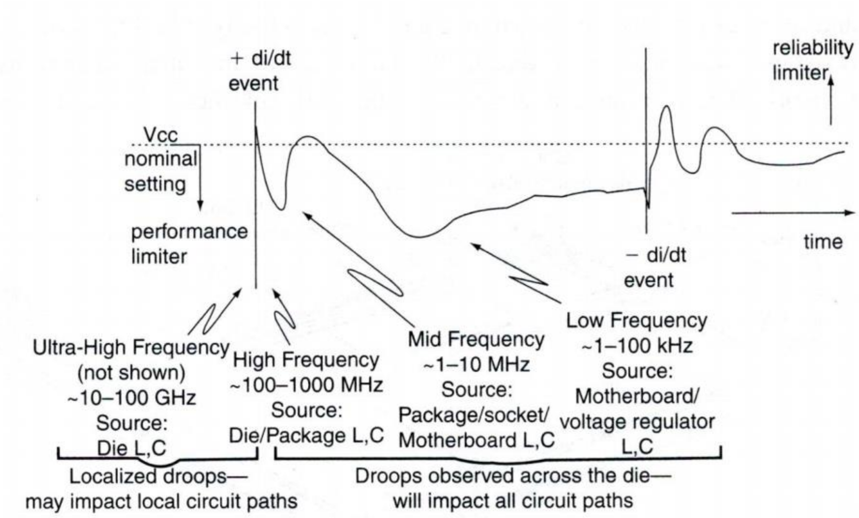

Figure 1-7 Noise response. Low Frequency. Ultra High Frequency. High Frequency. Mid frequency -1-100 kHz-10-100 (not shown) GHz -100-1000 MHz. [5]

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