

## Cmos inverter characteristics pdf

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Full PDF PackageDownload Full PDF PackageThis PaperA short summary of this paper34 Full PDFs related to this paperDownloadPDF Pack TE = thermal equilibrium MOS = metal-on-silicon MOSFET = metal-oxide-semiconductor field-effect transistor BJT = bipolar junction transistor CMOS = complementary metal-oxide-semiconductor CS = common source OCTC = open circuit time constant LEC # TOPICS SLIDES ADDITIONAL NOTES 1 Introduction to semiconductors, doping, generation/recombination, TE carrier concentrations. Carrier dynamics and transport: drift. (PDF) 2 Excess populations and minimum carrier lifetime, photoconductivity. Non-uniform concentrations and diffusion. Fick's first and second laws. (PDF) 3 The five basic equations. Device structures in TE: carriers and electrostatic potential: the 60 mV rule. Poisson's equation (PE). 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(PDF - 1.1MB) 23 Frequency response of CS amplifiers, the Miller effect. Intrinsic frequency limitations of MOSFETs. Biasing to maximize speed, power trade-off. (PDF) 24 OCTC method for estimating frequency response. Subthreshold amplifiers for ultra-lower power electronics, frequency performances. (PDF - 1.1MB) 25 MOS imagers. Semester wrap-up; life after 6.012. (PDF) Loading PreviewSorry, preview is currently unavailable. You can download the paper by clicking the button above. Ring oscillator test structures fabricated on silicon using p-type MOSFETs of different sizes. A schematic of a simple 3-inverter ring oscillator whose output frequency is  $1/(6 \times \text{inverter delay})$ . A ring oscillator is a device composed of an odd number of NOT gates in a ring, whose output oscillates between two voltage levels, representing true and false. The NOT gates, or inverters, are attached in a chain and the output of the last inverter is fed back into the first. Details Because a single inverter computes the logical NOT of its input, it can be shown that the last output of a chain of an odd number of inverters is the logical NOT of the first input. The final output is asserted a finite amount of time after the first input is asserted and the feedback of the last output to the input causes oscillation. A circular chain composed of an even number of inverters cannot be used as a ring oscillator. The last output in this case is the same as the input. However, this configuration of inverter feedback can be used as a storage element and it is the basic building block of static random access memory or SRAM. The stages of the ring oscillator are often differential stages, that are more immune to external disturbances. This renders available also non-inverting stages. A ring oscillator can be made with a mix of inverting and non-inverting stages, provided the total number of inverting stages is odd. The oscillator period is in all cases equal to twice the sum of the individual delays of all stages. A ring oscillator only requires power to operate. Above a certain voltage, typical well below the threshold voltage of the MOSFETs used, oscillations begin spontaneously. To increase the frequency of oscillation, two methods are commonly used. First, making the ring from a smaller number of inverters results in a higher frequency of oscillation, with about the same power consumption. Second, the supply voltage may be increased. In circuits where this method can be applied, it reduces the propagation delay through the chain of stages, increasing both the frequency of the oscillation and the current consumed. Operation A transistor level schematic of a three-stage ring oscillator with delay in a .25u CMOS process. This particular circuit has high power consumption for its speed, since the inverters run a large current from power to ground when their inputs are at an intermediate voltage. A circuit with current-limiting devices in series with the inverter switches is more energy efficient. To understand the operation of a ring oscillator, one must first understand gate delay. In a physical device, no gate can switch instantaneously. In a device fabricated with MOSFETs, for example, the gate capacitance must be charged before current can flow between the source and the drain. Thus, the output of every inverter in a ring oscillator changes within a finite amount of time after the input has changed. From here, it can be easily seen that adding more inverters to the chain increases the total gate delay, reducing the frequency of oscillation. The ring oscillator is a member of the class of time-delay oscillators. A time-delay oscillator consists of an inverting amplifier with a delay element between the amplifier output and its input. The amplifier must have a gain greater than 1 at the intended oscillation frequency. Consider the initial case where the amplifier input and output voltages are momentarily balanced at a stable point. A small amount of noise can cause the amplifier output to rise slightly. After passing through the time-delay element, this small output voltage change will be presented to the amplifier input. The amplifier has a negative gain of greater than 1, so the output will change in the direction opposite to this input voltage. It will change by an amount larger than the input value, for a gain greater than 1. This amplified and reversed signal propagates from the output through the time-delay and back to the input where it is amplified and inverted again. The result of this sequential loop is a square-wave signal at the amplifier output with the period of each half of the square wave equal to the time delay. The square wave will grow until the amplifier output voltage reaches its limits, where it will stabilize. A more exact analysis will show that the wave that grows from the initial noise may not be square as it grows, but it will become square as the amplifier reaches its output limits. The ring oscillator is a distributed version of the time-delay oscillator. The ring oscillator uses an odd number of inverters to give the effect of a single inverting amplifier with a gain of greater than one. Rather than having a single delay element, each inverter contributes to the delay of the signal around the ring of inverters, hence the name ring oscillator. Adding pairs of inverters to the ring increases the total delay and thereby decreases the oscillator frequency. Changing the supply voltage changes the delay through each inverter, with higher voltages typically decreasing the delay and increasing the oscillator frequency. Vojtěch Šimáček describes some methods of frequency-stability and power consumption improving of the CMOS ring-oscillator.[1] If  $T$  represents the time delay for a single inverter and  $n$  represents the number of inverters in the inverter chain, then the frequency of oscillation is given by:  $f = 1/2 \pi n \left( \frac{1}{T} \right)^2$  [2] jitter The period of a ring oscillator varies in a random manner as  $T = T_0 + \Delta T$  where  $T_0$  is a random value. In high-quality circuits, the range of  $T$  is relatively small compared to the period of oscillation. The period of oscillation is averaged over time [4]. When the local silicon is hot, the propagation delay is slightly shorter, causing the ring oscillator to oscillate slightly higher frequency, which eventually raises the local temperature. When the local silicon is hot, the propagation delay is slightly longer, causing the ring oscillator to run at a slightly lower frequency, which eventually lowers the local temperature. So, the frequency of a silicon ring oscillator will generally be stable, when the ambient temperature is constant and factors of heat transfer from the device to the ambient environment do not vary. Applications The voltage-controlled oscillator in most phase-locked loops is built from a ring oscillator.[5] Jitter of ring oscillators is commonly used in hardware random number generators.[3][4][6] A ring oscillator is sometimes used to demonstrate a new hardware technology, analogous to the way a hello world program is often used to demonstrate a new software technology.[7][8] Many wafers include a ring oscillator as part of the scribe line test structures. They are used during wafer testing to measure the effects of manufacturing process variations.[9] Ring oscillators can also be used to measure the effects of voltage and temperature on a chip.[10] See also Bode plot Phase margin Ring counter Notes Wikipedia Commons has media related to Ring oscillators. ^ Vratislav MICHÁL. "On the Low-power Design, Stability Improvement and Frequency Estimation of the CMOS Ring Oscillator". 2012. ^ Mandal, M.K. & Sarkar, B.C. "Ring oscillators: Characteristics and applications" ^ a b A Provably Secure True Random Number Generator with Built-in Tolerance to Active Attacks ^ a b Andy Green, Whirlygig GPL Hardware RNG, 2010 ^ Takahiro MIYAZAKI Masanori HASHIMOTO Hidetoshi ONODERA. "A Performance Prediction of Clock Generation PLLs: A Ring Oscillator Based PLL and an LC Oscillator-Based PLL" (dubious – discuss)[1] ^ THE INTEL RANDOM NUMBER GENERATOR, CRYPTOGRAPHY RESEARCH, INC ^ Slashdot Science: "IBM Creates Ring Oscillator on a Single Nanotube" ^ Slashdot Hardware: "World's First Completely Transparent IC" ^ "Ring oscillators for CMOS process tuning and variability control" by BHUSHAN Manju; GATTIKER Anne; KETCHEN Mark B.; DAS Koushik K. ^ "Analysis of a ring oscillator based on chip thermal sensor" Archived 2014-03-28 at the Wayback Machine Retrieved from "

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