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JITTER GENERATION AND MEASUREMENT CIRCUITS FOR ON-CHIP DESIGN

Sheroz Khan, Othman O. Khalifah and Md. Rafiqul Islam

Department of Electrical and Computer Engineering, International Islamic University
Kuala Lumpur 53100, Malaysia; Fax: 603-2056 4853
E-mail: cnar32@yahoo.com; sheroz@iiu.edu.my

ABSTRACT

This paper focuses on how the basic circuit concepts are used at creating a noise voltage which is injected as a jitter with known duration into a clock. The jitter is measured in terms of clock pulses to show how this method can be applied for numerous applications in VLSI chip design. The measurement of jitter-time is in terms of clock pulses is based on the basic idea of charging a capacitor by a voltage of known time-duration which is being discharged by another pulse of unknown time duration. The charging process makes an associated counter disabled while the discharging process of the capacitor enables a counter to keep on recording the number of pulses equivalent to the time in which a capacitor is discharged. In the rest of the paper a comparison is made between the time the jitter was injected for by the test circuit, and the time measured by the experimental circuit. The proposed method looks certain to be of immense utility in the circuit design for both digital and analog integrated circuits.

1. INTRODUCTION

Signals applied to the input of integrated circuits go through a delay process while being routed on to the outputs by the clock. Maintaining a constant phase difference between the input and the output is critically important in designing circuit of complex densities. However, due a couple of reasons this constant phase difference is difficult to maintain and there is going to be some variations in the phase difference between the input and the output. One such source of jitter is the noise picked at some point form the circuit or the environment through which the cable is passing through. The noise and its transmission pattern on a transmission line can disturb the timing of clock signals and shift pulse edges out of phase before or after their intended positions. Such disposition occurrences of the clock are because of a phenomenon called jitter. Jitter is defined to be the variation or deviation of the output transition of the clock from its intended ideal average positions in the range of picoseconds durations.

PC boards are made from a number of ICs and various discrete components including resistors, capacitors, and inductors. In additions other building blocks such dc-dc converters are made from discrete components on-chip alongside a number of integrated circuits. The current through the inductors cause EMI problems due to the switching characteristics of the converters, leading to the increase in jitter of clock. Also, the jitter problem may become worse with the increase in clock frequency.

Sometime in high-speed digital transmission systems and high-speed digital I/O buses circuits are often needed to collect or regenerate data using a clock signal that is recovered or extracted from the data waveform. The variations occurrences of clock pattern lead to variations in the data which can complicate the clock recovery and data regeneration process as a result. To guarantee a high level of performance in the presence of jitter, components and systems are typically required to adhere to a rigorous set of jitter performance standards. Thus it is important to know the generation, analysis and measurement of jitter in integrated circuit designs.

This paper attempts at designing three circuits: one circuit is used to generate an artificial jitter in the form of a noise with known duration, the second circuit is used to inject the noise into a clock at intended locations, and the third circuit is used how to measure the jitter duration in terms of clock pulses. The time measured by the third circuit is finally compared with the actual times of the noise generated by circuit one. The measurements of such timing measurements make an important part of many applications such as radar, automatic metering, and modulators, etc.

2. BASICS OF RLC CIRCUITS

Hence a resistor R in an RLC circuit acts as a kind of electrical energy transfer agent, and gets its commission every time energy is transferred from L to C or vice versa. Thus before long, the agent has taken all without leaving a single Joule with either L or C. In the case of an effective zero R in series RLC (or an effective infinite R in the case of parallel RLC), we have a simple LC loop in which the transfer of energy between L and C takes place without any single Joule taken by R, so that a large natural un-damped oscillatory response is maintained forever without any supply of energy from a source external to the circuit. In other words the current response in the case of RLC series and the voltage response in the case of parallel RLC do not decay.

3. LEVEL-TO-LEVEL CONVERTERS

Level-to-Level converters are in fact switching power supplies, accepting DC input to produce a scaled down DC output. Test boards are made from various components requiring varying voltage levels, so level-to-level converters are commonly used on such boards. One such level-to-level converter is as shown in Fig. 1.

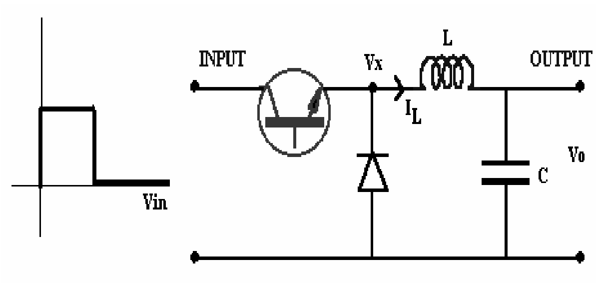

Fig.1 LC Circuit Showing Level-to-Level Converter

Transistor is turned ON and the pulse is applied as V_{in} applied to one end of inductor 'L'. This pulse voltage causes a linear rising current 'I_L' to flow through the inductor when the transistor is ON, which falls linearly when the transistor is OFF. In the case when the transistor is OFF, the current will continue flowing through the diode as that of Fig. 2.

The current through the coil on board produces EMI effect which creates a jitter in the clock being routed through circuits in the field of the EMI

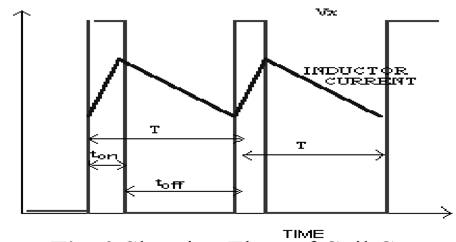

Fig. 2 Showing Flow of Coil Current

4. NOISE GENERATION

The circuit shown in Fig. 3 is used to generate and amplify noise.

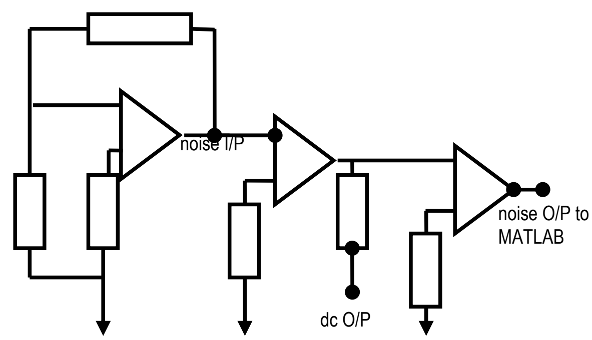

Fig. 3 Showing Generation of Noise

The noise voltage is then injected into the clock signal at a determined location using the concept of charging a capacitor (see Fig. 4). The clock is applied to an RC circuit, and the voltage across the capacitor of which is used to turn ON a transistor injecting the noise voltage at a determined location equal to time constant delay after the clock's transition. The capacitor is being discharged as long as the transistor is ON, which in turn goes OFF when the capacitor voltage drops below the threshold level.

5. JITTER-TIME MEASUREMENT

The principle of this method is based on the charging a capacitor to voltage V_T for time duration, T, between the start and the stop of a pulse under measurement. This voltage in terms of the charging current I_C is given by:

$$V_T = (I_C * T)/C$$

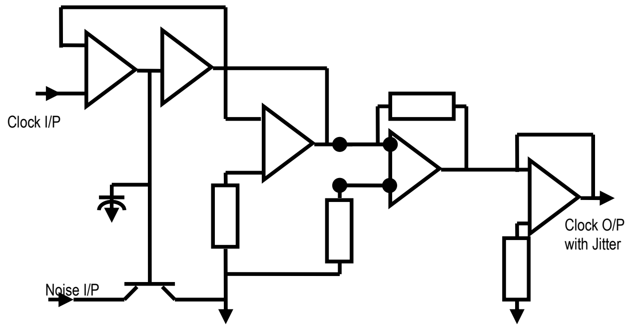

Fig. 4 Showing Injection of Noise into Clock

One method of measuring the time interval T consists of an RC circuit followed by a comparator. A known voltage V_{Ref} is applied to the negative input, while the voltage across the capacitor of the RC circuit is applied to the positive input of the comparator (see Fig. 5). The capacitor voltage is:

$$v_c(t) = V_{Ref} + [v_c(0) - V_{Ref}]e^{-t/RC}$$

Where $v_c(0)$ is the initial voltage across the capacitor and RC is the time constant of the circuit. The comparator's output switches form HIGH to LOW and vice versa depending upon which of the two inputs is higher than the other. The time T when the comparator's output switches from LOW to HIGH is the time when $v_c(T) = V_{Ref}$, which is:

$$T = RC \ln[(v_c(0) - V_{Ref})/(V_T - V_{Ref})]$$

As long as the output form a comparator is logic '1', a clock is sending pulses into a an associated counter, which is set to count. The time duration of the clock jitter introduced is given as a product of the count and the clock's time period, T, which is used to re-calculate the voltage V_T by

$$T = (C^*V_T)/I_C$$

The voltage obtained may be used as a digital count for many applications both in hardware design or programming the designed hardware.

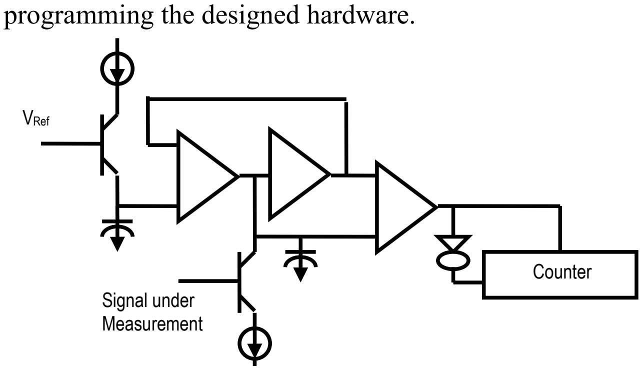

Fig. 5 Showing Measurement of Small Time Intervals

6. CONCLUSIONS

This paper has suggested how to generate a noise, which is measured and reduced to a desirable frequency range using MATLAB filter design. This is then injected into a clock signal at a pre-determined location for creating an artificial jitter. Using the concepts of circuit design a circuit is proposed how to measure the resulting jitter. It has shown that the jitter measured is different form the injected jitter by a measure. Work is still carrying on reporting the resulting waveforms and any errors between the actual noise generated and the measured jitter. This work will be of critical importance in the design of analogue and digital circuits.

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