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EEE3090F Electronic Devices and Circuits

Noise in Electronic Circuits: Introduction

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Noise is mainly any voltage and current that accompany the desired signal and tend to contaminate it. The source of noise can be either internal or external to the system. When designing an electronic circuit, it is very important to determine its noise performance as, whenever the noise exceeds the input signal, the information transmitted by the circuit can be corrupted or distorted. Noise also impacts other aspects of the electronic system, like the component selection and signal conditioning of the system. Therefore, noise in electronic circuits is divided into two main categories, namely; in the first category the noise source is external to the elements of the circuit and in the second category the noise is generated within the circuit elements (components).

Contents

- Types of Noise
- Effect of Noise
- Sources of Noise
- Types of Intrinsic Noise
- Types of Extrinsic Noise

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In this lecture, the following are discussed:
-Types of noise.
-Effect of noise.
-Sources of noise.
-Types of intrinsic noise.
-Types of extrinsic noise.

Types of Noise

Noise in an electronic circuit can be divided into two main categories, namely;

- Intrinsic noise
- Extrinsic noise

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Intrinsic noise is internally generated noise caused by the random movement of charge within conductors. The level of intrinsic noise present in an electronic circuit is determined by the values of the circuit components – for example, resistor values and the current flowing through them – therefore it is governed by circuit design rather than circuit layout. While the extrinsic noise is generated in some external source coupled the circuit. For example, the electromagnetic radiation from transmitters, mechanical vibration coupled into the circuit using cable movement, and noise signals capacitively coupled to nearby conductors. Noise in this category is strongly influenced by the layout and construction of the circuit.

Effect of Noise

- Error in measurement of the signal level

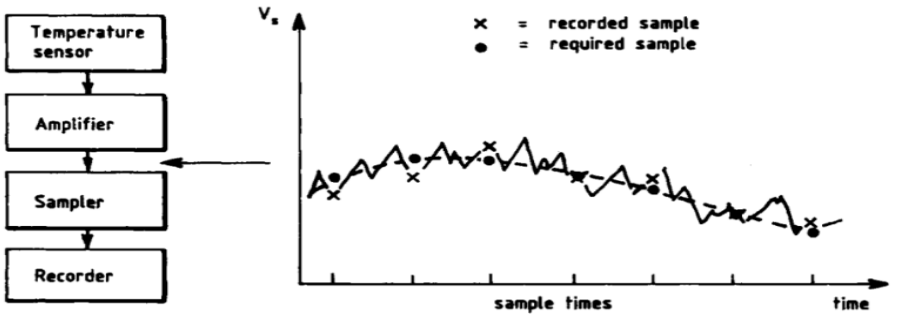

Figure 1: Noisy signal recorded by a temperature monitoring device

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In Figure 1, a noise-contaminated signal from the temperature sensor monitoring changes in the sensed quantity (which is the temperature in this case). From Figure 1, the erroneously recorded sample of the signal as a result of the noisy signal is illustrated.

Effect of Noise

- Error in measurement of signal timing

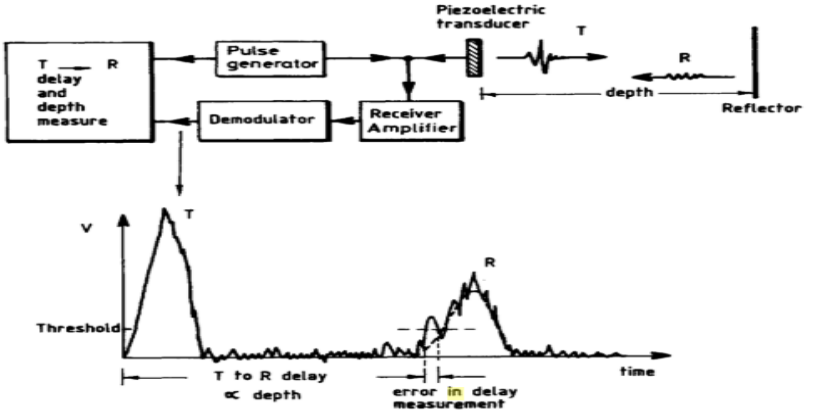

Figure 2: Ultrasonic depth measurement signal.

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Effect of noise resulting in an error in measurement of signal timing will affect the measurement of distance using the pulse-echo technique (as shown in Figure 2), which is used in radar, ultrasonic flaw detection, and medical ultrasound. In Figure 2, T represents the transmitter pulse, R represents receiver pulse and the dashed lines represent the noise-free received pulse. From the figure above, the distance of the reflector from the transducer may be measured from the time of arrival of the received pulse when it exceeds a defined threshold. Therefore, the presence of noise in the measured signal will cause either a premature or delayed threshold crossing resulting in erroneous measurement of the reflector depth.

Sources of Noise

The sources of noise that must be considered include the following:

1) Thermal noise from the source resistance
2) Noise produced at the input of the amplifier
3) Noise generated in the environment, such as; power frequency interference, auto ignition, lightning and structural vibration.

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The source resistance has thermal noise and converts current noise into voltage noise, increasing the amplifier total output-voltage noise. Current noise is most problematic when the source resistance is high. However, bipolar amplifiers have significant current noise but often have lower voltage noise than CMOS amplifiers for a given quiescent current. Therefore, a CMOS amplifier is a suitable choice whenever a high source resistance is used, and noise is the main concern.

Types of Intrinsic Noise

The main types of intrinsic noise are stated as follows;

- Thermal noise
- Shot noise
- Flicker noise

Intrinsic noise is caused by the random movement of charge carriers within electrical conductors. Thermal noise is caused by the random movement of electrons in a resistor. While shot noise is a random component of current flowing through a semiconductor junction. Flicker noise is also called 1/f noise because its power density decreases with increasing frequency or increasing offset from a signal.

Types of Extrinsic Noise

The main types of extrinsic noise are stated as follows;

- Electromagnetic interference
- Radio frequency interference
- Cross talk

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Extrinsic noise is generated by design aspects external to the intrinsic nature of the power semiconductor devices. Electromagnetic inference (EMI) is coupled into an amplifier circuit through radiated or conducted emissions. Also EMI is generated from currents flow through cables. On the other hand, radio frequency interference is caused by radio systems radiating signals. While cross talk is caused by cables separated by a small distance.