How are sensitive circuits affected by noise?

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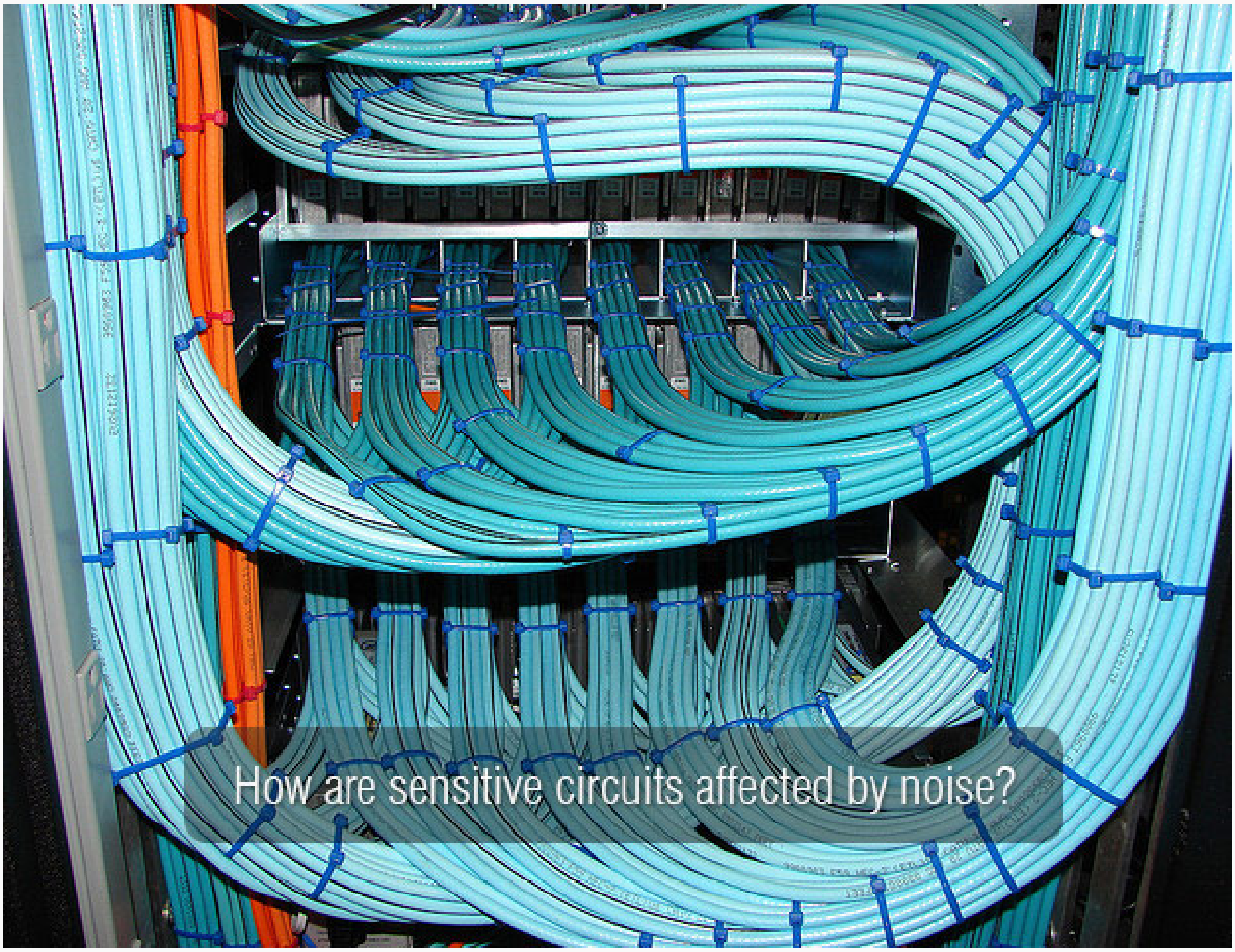

How are sensitive circuits affected by noise? (photo by Jim Hartland at Flickr)

Introduction

Noise is only important if it is measured in relation to the communication signal, which carries the ***data*** or ***information***. Electronic receiving circuits for digital communications have a broad voltage range, which determines whether a signal is binary bit '***1***' or '***0***'.

The noise voltage has to be ***high enough*** to take the signal voltage outside these limits for errors to occur.

The power and logic voltages of present day devices have been drastically reduced and at the same time, the speed of these devices has increased with propagation times now being measured in ***picoseconds***. While the speed of the equipment has gone up and the voltage sensitivity has gone down, the noise conditions coming from the power supply side have not reduced at all.

The best illustration that can be given of this condition is to consider where the signal voltage has been and what is happening to it compared to the noise voltage (***see Figure 1***).

In years gone by, signal voltages may have been ***30 V*** or more but since then have steadily been decreasing. As long as the signal voltage was high and the noise voltage was only ***1 V***, then we had what most instrument engineers would call a very high signal to noise ratio, 30:1.

Most engineers would say you have no problem distinguishing the signal as long as you have such a high

signal to noise ratio.

As the electronic equipment industry advanced, the signal strength went down further, below 10 and then below 5. Today we are fighting 1-, 2- and 3 V signals and still finding ourselves with 1, 2 and 3 V of electrical noise. When this takes place for brief periods of time, the noise signal may be larger than the actual signal.

The sensors within the sensitive equipment turn and try to run on the noise signal itself as the predominant voltage.

When this takes place, a parity check or a security check signal is sent out from the sensitive equipment asking if this particular voltage is one of the voltages the sensor should recognize.

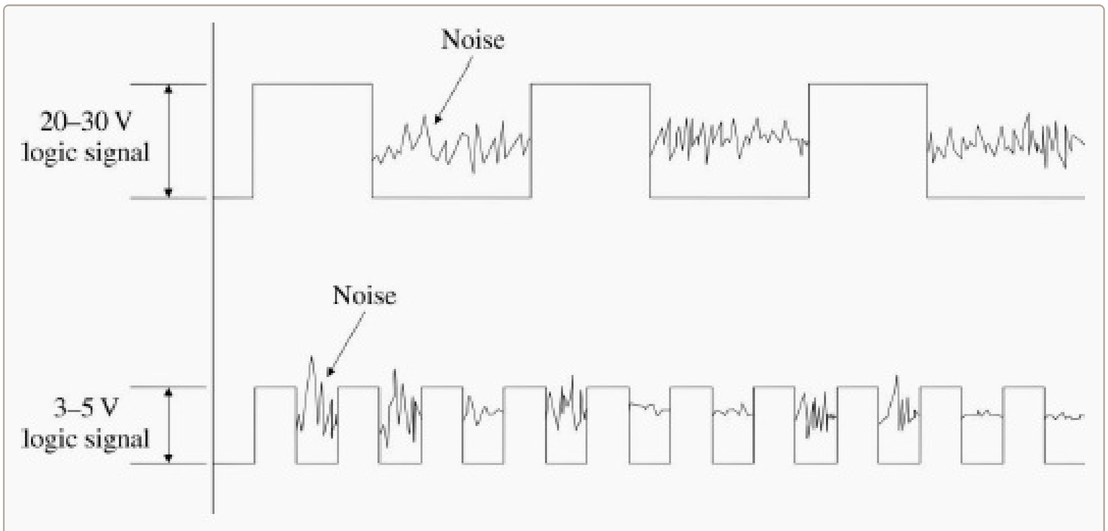

Figure 1 - Relative magnitudes of signal and noise (then and now)

Usually, this check fails when it is a noise voltage rather than the proper signal that it should be looking at and the equipment shuts down because it has no signal. In other words, the equipment self-protects when there is no signal to keep it operating.

When the signal to noise ratio has fallen from a positive direction to a negative direction, the equipment interprets that as the need to turn off so this it will not be running on sporadic signals.

In the top portion of ***Figure 1***, a 20–30-V logic signal is well in excess of the noise that is occurring between the or and off digital signal flow.

In the bottom picture, however, the noise has raised its head above the area of the logic signal which has now dropped significantly into the ***3–5 V range*** and perhaps even lower.

You will also notice that the difference between the upper and lower pictures in the graph shows the speed with which the signal was transmitted. In the upper graph, the ons and offs are relatively slow, evidenced by the large spaces between the traces.

In the lower graph, the trace is now much faster. There are many more ons and offs jammed into the same space and as such, the erratic noise behavior may now interfere with the actual transmission.

The ratio of the signal voltage to the noise voltage determines the strength of the signal in relation to the noise. This '***signal to noise ratio***' (***SNR***) is important in assessing how well the communication system will operate. In data communications, the signal voltage is relatively stable and is determined by the voltage at the source (transmitter) and the volt drop along the line due to the cable resistance (size and length).

The SNR is therefore a measure of the interference on the communication link. The SNR is usually expressed in ***decibels (dB)***, which is the logarithmic ratio of the ***signal voltage (S)*** to ***noise voltage (N)***.

An SNR of ***20 dB*** is considered low (*bad*), while an SNR of ***60 dB*** is considered high (*good*). The higher the SNR, the easier it is to provide acceptable performance with simpler circuitry and cheaper cabling.

$$\mathrm{SNR} = 10\log\left(\frac{S}{N}\right)\ \mathrm{dB}$$

In data communications, a more relevant performance measurement of the link is the ***bit error rate*** (***BER***). This is a measure of the number of successful bits received compared to bits that are in error. A BER of ***10–6*** means that one bit in a million will be in error and is considered poor performance on a bulk data communications system with high data rates.

A BER of ***10–12*** (*one error bit in a million million*) is considered to be very good. Over industrial systems, with low data requirements, a BER of ***10–4*** could be quite acceptable.

There is a relationship between SNR and BER. As the SNR increases, the error rate drops off rapidly. Most of the communications systems start to provide reasonably good BERs when the SNR is above ***20 dB***.

Resource: *Grounding, bonding, shielding and surge protection – G. Vijayaraghavan*
(Buy this book at Amazon)

Source: http://electrical-engineering-portal.com/how-are-sensitive-circuits-affected-by-noise