How long a stub is too long?: Rule of Thumb #18

Eric Bogatin - October 23, 2014

Spoiler summary: The maximum acceptable stub length is roughly Len[in] < 0.3/BR[Gbps], or, Len[cm] < 0.75/BR[Gbps].

Remember: before you start using rules of thumb, be sure to read the Rule of Thumb #0: Use rules of thumb wisely.

Previous: Rule of Thumb #17: The quarter wave stub resonance frequency

In the last rule of thumb, #17, we identified the frequency of the dip in the insertion loss from the quarter wave stub resonance. The effect of a stub routing topology, from whatever source, can suck out a significant fraction of the signal energy at and near the quarter wave stub resonance frequency. We identified that the resonant frequency depends on the length of the stub.

If we know the bandwidth of the signal, we can estimate the longest stub length before the quarter wave stub resonance begins to affect the signal quality.

As a rough rule of thumb, for the presence of the stub resonance to have little impact on the signal, we would like to engineer the stub length so it is short enough to push the resonant frequency well above the bandwidth of the signal.

We translate “well above” into a resonant frequency at least twice the signal bandwidth.

This condition for the stub length having little impact is:

$$f_{res} > 2 \times BW_{signal}$$

In the case of a high speed serial link, in the best case, the bandwidth of the signal is about 2.5 × Bit Rate (BR). This is Rule of Thumb # 11.

The quarter wave stub resonant frequency = 1.5/Len[inches], Rule of Thumb #17. Combining these, we have:

$$\frac{1.5}{Len[inches]} > 2 \times 2.5 \times BR[Gbps]$$

After a little algebra, we arrive at:

$$\text{Len[in]} < \frac{0.3}{\text{BR[Gbps]}} \quad \text{or} \quad \text{Len[cm]} < \frac{0.75}{\text{BR[Gbps]}}$$

If the data rate is 1 Gbps, the longest stub length, in FR4, before the stub begins to affect the signal quality is 0.3/1 = 0.3 inches, or 0.75 cm. This says that trying to engineer an interconnect channel operating at 1 Gbps or higher is very tough to do with any appreciable routing or test line stubs.

In the gigabit regime, only point-to-point routing architectures will work. This is one reason engineering a dual bank DDR4 design at 2.3 Gbps is such a challenge. Point-to-point, with all routing stubs shorter than 0.15 inches, makes the design possible.

Now you try it:

1. What is the longest via stub before problems may arise with a PCIe gen II design?

2. In a 28 Gbps design, what is the longest routing stub before problems may arise?

Next rule of thumb #19: How much crosstalk is too much?

Additional information on this and other signal integrity topics can be found at the Signal Integrity Academy, www.beTheSignal.com.

Also see:

- Bogatin's Rules of Thumb