Long lines on a PCB

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 On a list I belong to (which prefers to remain anonymous), there has been a long discussion on how to terminate lines on a PCB that uses parts with fast rise times. Of course, circumstances vary and it depends on the rise time, but for rise times on the order of one nanosecond (TTL, AHC, LVC, etc), a resistor from 22 to 50 ohms in series with the source seems to work well. The more modern chips (LVC etc) have a built-in output impedance of about 25 ohms, so in many cases no onboard resistor is required. This is especially true for lines under one rise time in electrical length. For TTL, that means a line of about one foot in length. For lines less than one rise time in electrical length, you don't need terminations in any technology. I was fortunate to have looked into that deeply when I worked for Raytheon Computer, characterizing TTL for a large wire wrapped computer. A handy calculator for determining the impedance of top or bottom surface lines on PCBs with a ground plane can be found at Microstrip Line [1].

Time for a war story. I worked on contract for a famous automotive instrument company. They needed some help to get a product out the door. You can call them Solar Automotive. For some odd reason, they designed a board (CMOS processor and 74AC and 74HC gates) with all the analog in the middle and all the processor stuff on the outside. The longest lines (the board was about 12" on a side) were about 36 inches long and the test bus (to exercise the board with the processor not enabled) went to an edge connector. I insisted that the connector be buffered on the receiver side within a tenth of an inch of the connector (as close as I could get it). I didn't want to add any more length to those lines than necessary.

I also said "this board will not run in production." I was laughed at. Worse was to come. The 10 preproduction prototypes ran PERFECTLY through test. The tester board was a built and tested production board - very clever - and it saved money, too. Well I was now an "old lady" - scared of my shadow. Afraid to push the envelope a little. Too scared engineer on the edge. I took it well ... as well as I could, anyway.

In production, they had a 90% failure rate (probably due to "better" parts - read *faster*), and nothing they did could move product out the door. What little went out

the door was returned as defective.

All because of lines too long to run unterminated and an unwillingness to take a one-month hit to conform to worst-case specifications. They treated it like a hobby project and went with typicals and were unlucky enough during the testing phase to get parts that were typical or slower. There is nothing wrong with that approach for quick and dirty. But if you are making hundreds and up, that is no way to do design. Worst case is the way to go when you design a "volume" project. And if you are doing safety/production critical stuff, even a one-of, worst-case it. Why? Because some time down the road, it may get repaired with better (in this case, *worse*) parts.

M. Simon's e-mail can be found on the sidebar at Space-Time Productions [2]. A link to the Microstrip Calculator is also on the sidebar.

Engineering is the art of making what you want from what you can get at a profit.

Links:
[1] http://www.ekswai.com/en_microstrip.htm
[2] http://spacetimepro.blogspot.com/