Driver Circuits for RS-485

The design of a RS-485 physical layer must set a maximum baud rate appropriate for the link to select a RS-485 driver circuit that is capable of running at the required speed. A driver circuit may be selected that is rated at a speed equal to or greater than the required baud rate. Knowing this, you might wonder if there are any disadvantages in choosing the fastest devices available, if they might be overkill. The answer is yes!

Although it is true that fast driver circuits can be used for both high and low baud rates, there are drawbacks in using a driver that supports a baud rate higher than needed...

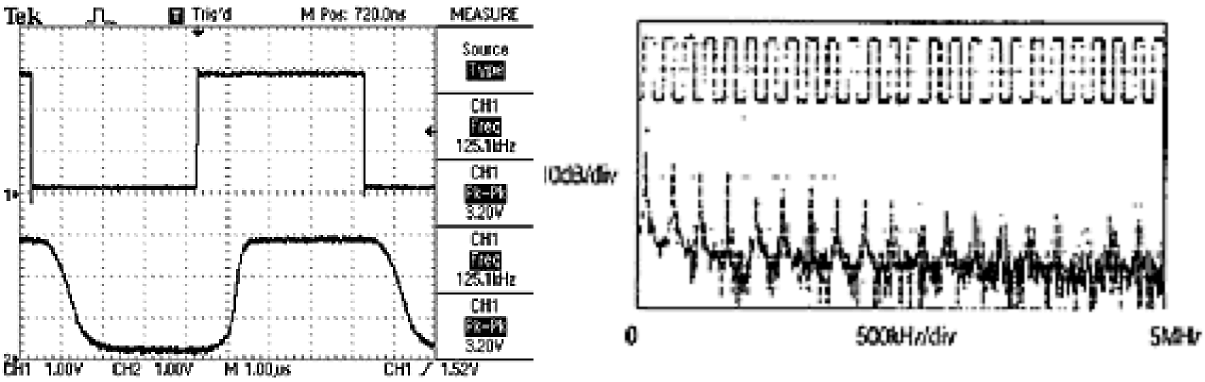

Figure 1: Plots for a 125kHz (250kbaud) test signal, without limiting slew-rate
(a) driver input (TTL) and non-inverted output waveform
(b) driver output waveform and corresponding frequency domain signal

Figure 1 shows the signal (a) and the (b) Fourier transform for a driver specified for high-speed operation at many Mbaud. The frequency domain signal (b) shows frequency components well past 2MHz. These high-frequency components are necessary to produce the nice square edges needed for higher baud rate. (Note also the propagation delay through the driver circuit visible in (a).

A driver circuit therefore includes an output filter to control the slew-rate of the signal. This shapes the signal to reduce signal harmonics at frequencies above the baud rate. Without this the signal will have spikes in the frequency domain that make it much more likely to induce interference to other signals.

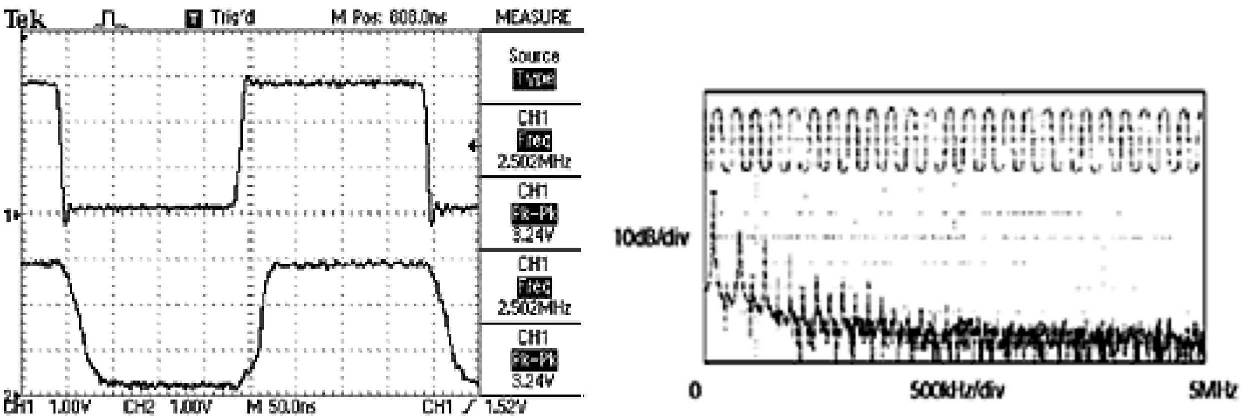

Figure 2: Plots for a 125kHz (250kbaud) test signal, with an appropriate limiting slew-rate.
(a) driver input (TTL) and non-inverted output waveform
(b) driver output waveform and corresponding frequency domain signal

The Fourier transform of the slew-rate-limited signal (b) shows that the frequency components above 2MHz are virtually eliminated.

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The differential transmission used by RS-485 tries to minimize radiated emissions by using twisted-pair cabling and balanced transmitters. The idea behind this is that the balanced transmitter, as the name implies, will generate two equal but opposite signals that are sent down the two wires in a twisted pair. Because the wires are virtually on top of each other, they will tend to radiate the exact opposite signal that the other wire is transmitting. This has the effect of canceling each other out, and ideally results in no net radiated emissions. This tends to work fairly well, but, like everything in engineering, it isn't perfect. Inevitably, so some radiated emissions will usually leak out. As a general rule, the higher the frequency components in the signal and the longer the cable, the worse the situation becomes, resulting in this being especially noticeable at higher frequencies.

In summary, slew-rate limiting at the transmitter works by slowing the edges of the RS-485 signal down and therefore reducing the signal's high-frequency components An appropriate choice of driver/receiver circuit at the transmitter/receiver hence reduces radiated emissions and reduces susceptibility to noise and improper termination. This results in distortion of the signal (clearly visible in figure 3).

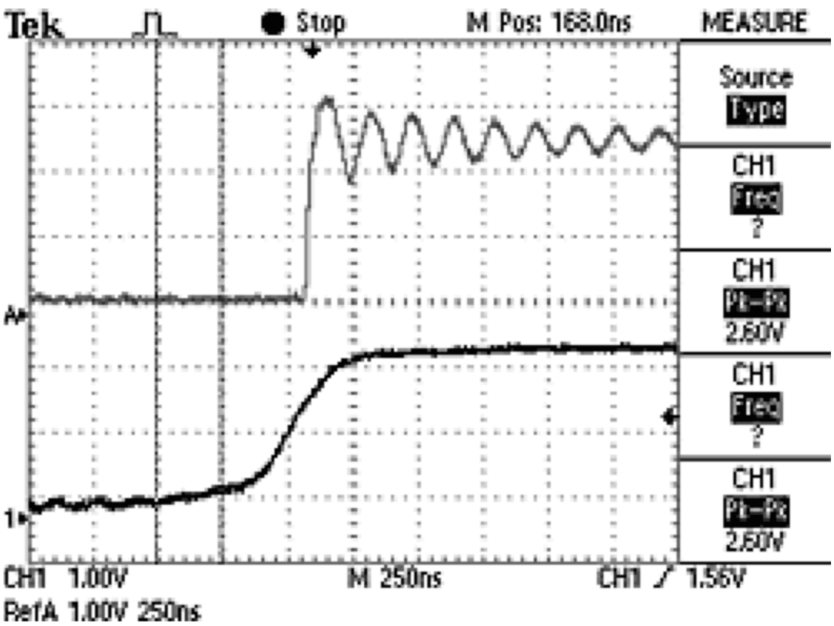

Figure 3: Time domain plots from an oscilloscope showing the start of a pulse sent with slew-rate limiting at 2.5 Mbaud (above) and one shaped to 250 kbaud (below).

A driver circuit normally includes both a transmitter and a receiver. A receiver circuit that supports a higher baud rate will be designed to accept a wider bandwidth input signal, this makes the receiver more susceptible to interference at higher frequencies and more vulnerable to noise.

Cable terminations are also important. Both ends of an RS-485 cable should be properly terminated in the characteristic impedance of the cable to prevent reflections. Resistor and cable tolerances, among other things, can result in mismatches between these two impedances. This will result in reflections that increase the noise and can ultimately lead to corruption of data. Similar to radiated emissions, the higher the frequency components and the longer the cable, the more likely it is that reflections will affect the performance.

Selecting an appropriate driver chip therefore impacts the performance of a serial communications system!