AN-6040
Video and Cable Driving Fundamentals

Summary

Any transmission path; such as transmission lines, long trace lengths (utilizing strip line or micro strip techniques), and cables, must be properly terminated to maintain optimum signal quality. Also, most high-speed amplifiers are not designed to remain stable when driving large capacitive loads. This application note explains the need for proper termination techniques and methods for driving capacitive or reactive loads.

Driving a Capacitive Load or Reactive Load

Driving a capacitive load directly reduces the phase margin of an amplifier. The capacitive load and the amplifier's output impedance cause phase lag, which results in an under-damped pulse response or oscillation. Some amplifiers are capable of directly driving large capacitive loads, but others require a series resistance to buffer the output stage. Refer to the amplifier datasheet to determine to which category the amplifier belongs. A small series resistance (R_s) at the output of the amplifier, illustrated in Figure 1, improves stability and settling performance. Figure 2 shows the resulting pulse responses for a high-speed amplifier driving a 100pF capacitive load with and without series resistance.

Driving a coaxial cable without using a series resistor can cause frequency peaking or oscillation. Figure 3 illustrates a typical circuit configuration for driving coaxial cable. The resistors R_s and R_L are equal to the characteristic impedance, Z_o, of the cable or transmission line. The amplifier's output impedance increases with increased frequency. The capacitor, C, can be used to match the cable over a greater frequency range: it compensates for the amplifier's increasing output impedance.

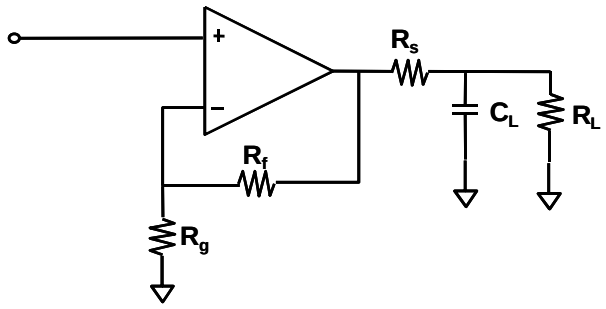

Figure 1. Typical Topology for Driving a Capacitive Load

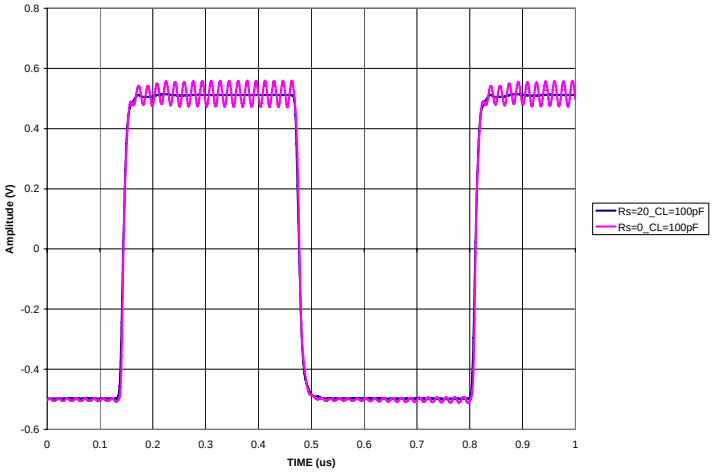

Figure 2. Pulse Response with and without R_S

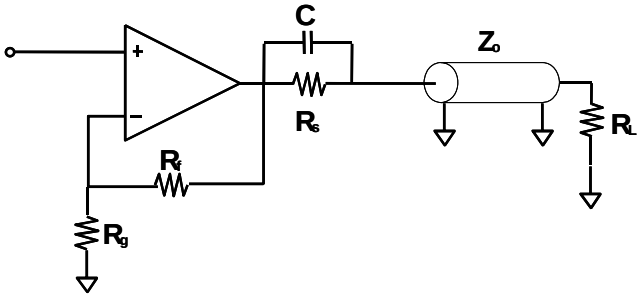

Figure 3. Driving Cable or Transmission Line

Driving Video Loads

When driving a video load, usually a 75Ω coaxial cable, it is important to utilize a doubly terminated configuration, similar to Figure 4. To ensure maximum stability and performance, it is important to use both a source termination resistor and an end termination resistor. When a 75Ω cable is used, make both termination resistors 75Ω. The termination resistors attenuate the signal by a factor of 2 or 6dB. Set the amplifier's gain to counter this effect. If a $1V_{pp}$ signal is applied to the input and $1V_{pp}$ is desired at output of the cable, set the amplifiers gain to 6dB or 2V/V.

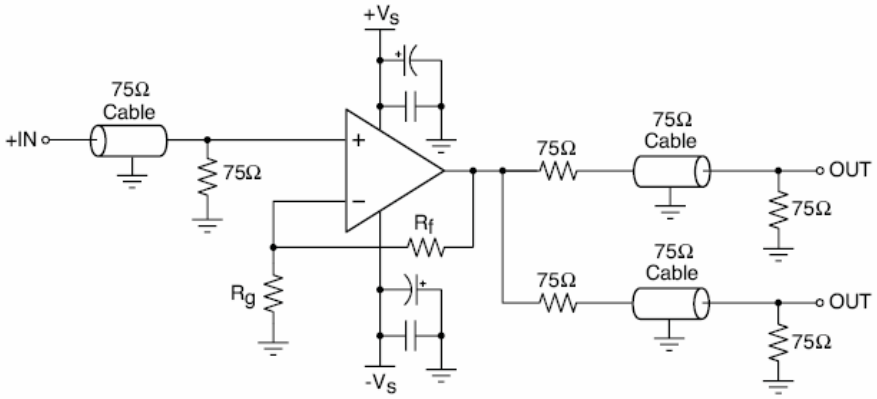

Figure 4. One Channel of FHP3xx0 Driving Two Video Loads, Illustrating Doubly Terminated Configuration

Figure 5 shows a pulse response at various probe points of a circuit using only source termination. The noticeable "blip" in the pulse response is the reflection caused by the seven feet of cable. Figure 6 shows only end termination with the same "blip" visible. With proper source and end termination, a clean pulse response is received, as shown in Figure 7.

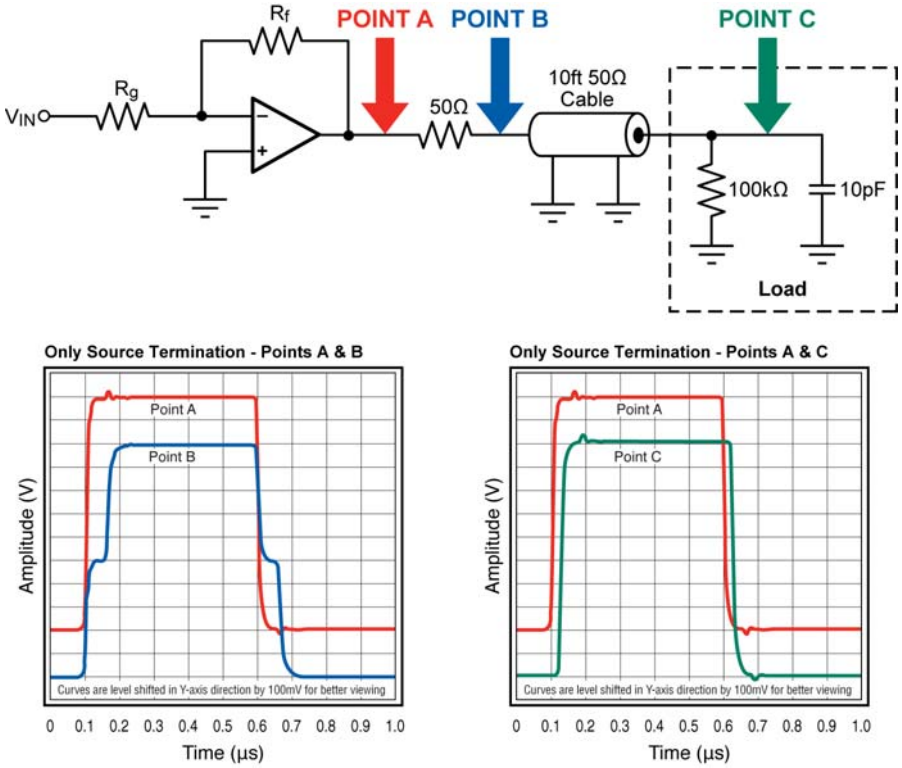

Figure 5. Source Termination

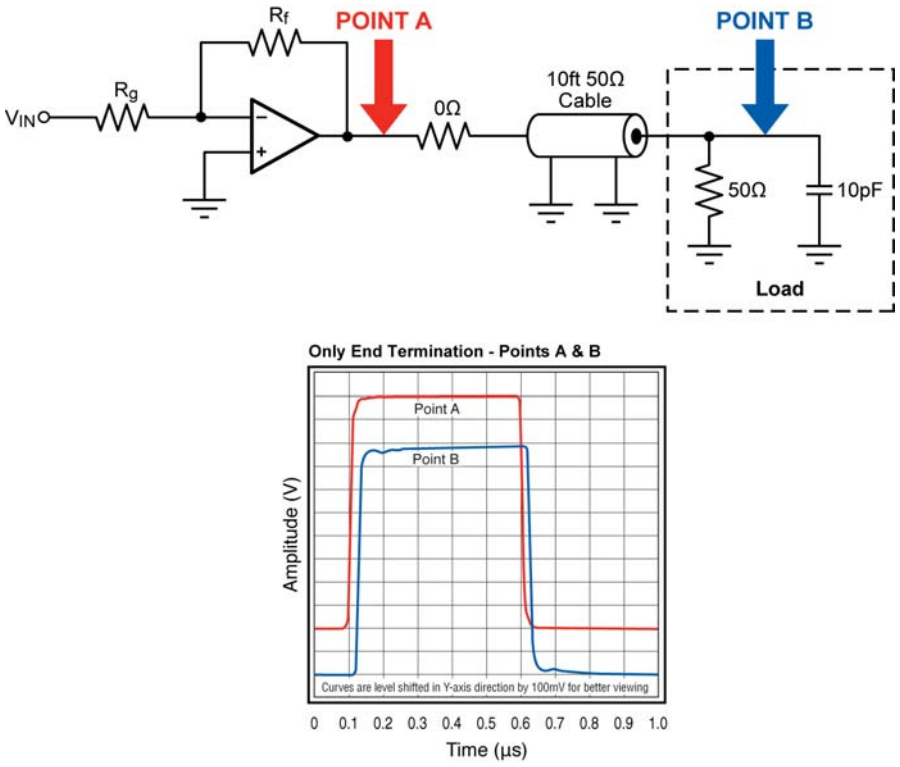

Figure 6. End Termination

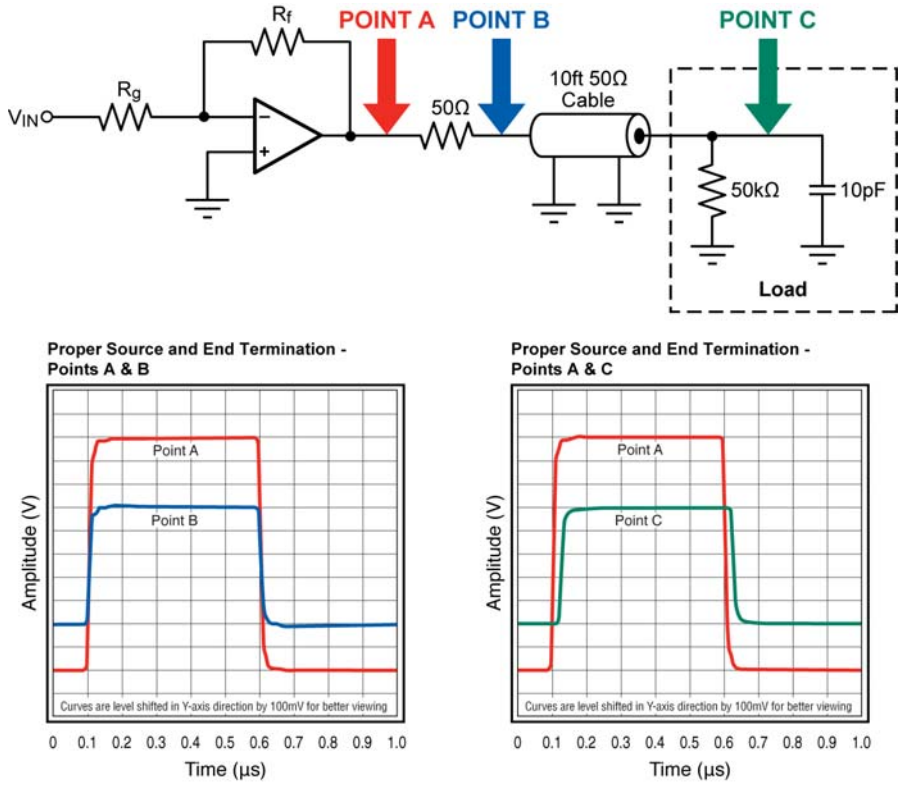

Figure 7. Proper Source and End Termination

Driving Multiple Video Loads

Both the FHP3x30 and FHP3x50 family of amplifiers offer ample output current for driving long cable lengths or multiple video loads. The FHP3230 can easily drive four video loads, but having enough drive capability is not the only concern. As an amplifier drives multiple video loads, its differential gain and phase contribution increase. The usefulness of the extremely low differential gain and phase of the FHP3x30 family becomes evident as it drives more loads. Figure 8 shows the resulting differential gain and phase (less than 0.2% and 0.2°) of the FHP3230 driving four video loads or 32.5Ω.

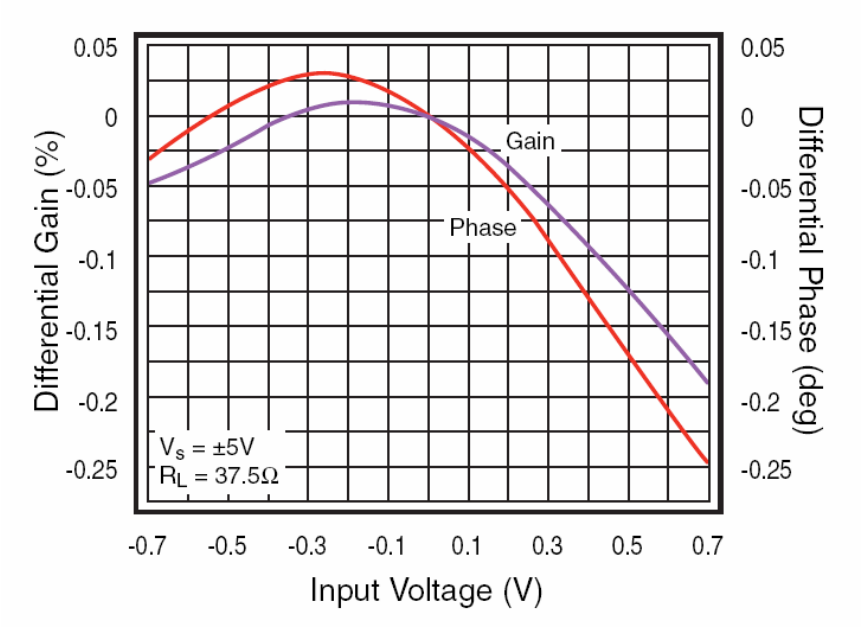

Figure 8. Differential Gain / Phase Driving Four Video Loads

Summary

A few simple steps ensure maximum stability and high-speed performance driving capacitive or reactive loads.

- When driving a capacitive load, review the amplifier datasheet to determine if a series resistance is needed. Fairchild's amplifier datasheets provide a plot showing the recommended value for a given capacitive load.
- Use proper (matched) termination resistors to ensure optimum signal performance and prevent reflections.
- When using a doubly terminated load, double the amplifier gain to maintain the desired voltage signal levels at the output.

Related Datasheets

FHP3130, FHP3230, FHP3430 — Single, Dual, and Quad, High Speed, 2.7V to 12V, Rail-to-Rail Amplifiers
http://www.fairchildsemi.com/ds/FH/FHP3230.pdf

FHP3350, FHP3450 — Triple and Quad Voltage Feedback Amplifiers
http://www.fairchildsemi.com/ds/FH%2FFHP3350.pdf

FHP3194 — 4:1 High-Speed Multiplexer
http://www.fairchildsemi.com/ds/FH%2FFHP3194.pdf