High-Speed, Current-Feedback Amplifier Drives and Equalizes Up to 100-m VGA Cables

By Charly El-Khoury

In classrooms, lecture halls, and conference rooms, PCs are connected to projectors through VGA cables to transmit red-green-blue (RGB) video signals. The average cable length depends on the room size and ceiling height, but most cables are shorter than 100 m. This article shows how the ADA4858-3[1] triple high-speed current-feedback op amp with integrated charge pump (see Appendix) can drive and equalize up to 100 m of VGA cable. This convenient, inexpensive, easy-to-implement solution—added between the PC and the cable—requires only a few passive components and a single 3.3-V to 5-V supply that can be generated from a USB port.

Driving and Equalizing a 45-m VGA Cable

Figure 1 shows one channel of a VGA cable equalizer based on the ADA4858-3 amplifier. Three channels are required for a complete RGB equalizer. The 150-Ω load resistor represents the 75-Ω terminated cable and its impedance-matching drive resistor.

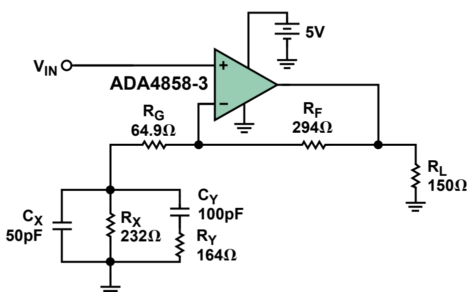

Figure 1. Schematic for 45-m VGA cable equalizer (single channel).

Figure 2 shows the large-signal frequency response of a 45-m VGA cable, the equalizer, and the equalizer/cable combination. In addition to the 6-dB attenuation inherent in the impedance-matched cable drive, the VGA cable has a 0.6-dB loss for frequencies lower than 1 MHz and an 8-dB loss at 100 MHz. To restore the signal strength, the equalizer must deliver 6.6-dB gain at low frequency and 14-dB gain at 100 MHz to boost the original signal by 6 dB for RGB video applications. The cable/equalizer combination shows a 100:1 improvement in 1-dB flatness, from 1.6 MHz unequalized to 160 MHz with equalization.

Equalization also improves the transient response, as shown in Figure 3. The high and low frequencies are restored, providing a sharper image without the smearing caused by the cable.

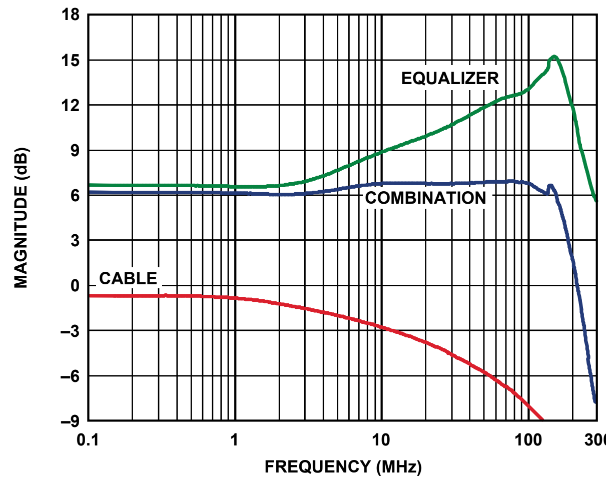

Figure 2. Large-signal frequency response (45-m VGA).

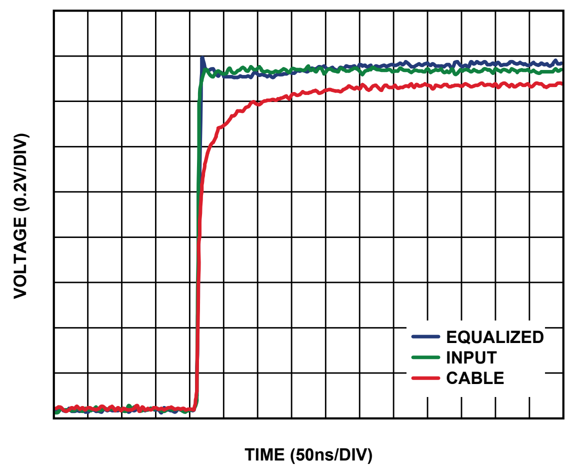

Figure 3. Transient response before and after equalization (45-m VGA).

The transfer function of this circuit is given by Equation 1. The magnitude is given by Equation 2.

$$\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_F}{R_G + R_X \,||\, Z_{Cx} \,||\, (Z_{Cy} + R_Y)} \quad (1)$$

$$\left|\frac{V_{OUT}}{V_{IN}}\right| = \frac{C_X C_Y (R_F + R_G) R_X R_Y \omega^2 + [C_X (R_F + R_G) R_X + C_Y (R_F (R_X + R_Y) + R_G (R_X + R_Y) + R_X R_Y]\omega + R_F + R_G + R_X}{C_X C_Y R_X R_Y R_G \omega^2 + [C_X R_X R_G + C_Y (R_G (R_X + R_Y) + R_X R_Y)]\omega + R_X + R_G} \quad (2)$$

Driving and Equalizing a 105-m VGA Cable

Figure 4 shows the schematic for driving a 105-m cable. This length was chosen because it is close to the maximum equalization of which the ADA4858-3 is capable. The schematic is similar to Figure 1, except for the addition of the $R_Z C_Z$ feedback network that creates a pole to reduce the value of R_F at the higher frequencies.

Figure 5 shows the large-signal frequency response of the 105-m cable, the corresponding equalizer, and the combination of the two. The −3-dB bandwidth of the cable is about 2 MHz before equalization and 90 MHz after equalization; the −1-dB bandwidth has improved from 0.7 kHz to 75 MHz.

Figure 6 shows the transient response. Both high- and low frequencies have been restored. With more tweaking, better flatness between 1 MHz and 10 MHz could have been achieved for even better fidelity to the input signal.

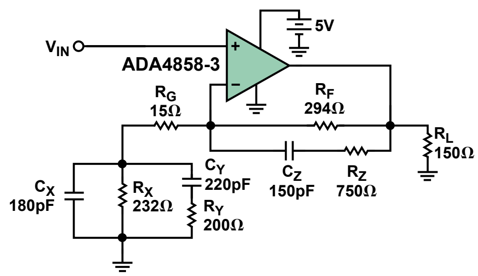

Figure 4. Schematic for 105-m VGA cable equalizer (single channel).

Figure 7 shows the schematic for all three channels (R, G, B), including all of the components required for a standalone solution. A mini USB port powers the overall system. R4, R5, and R6 are chosen to match the characteristic impedance of the cable.

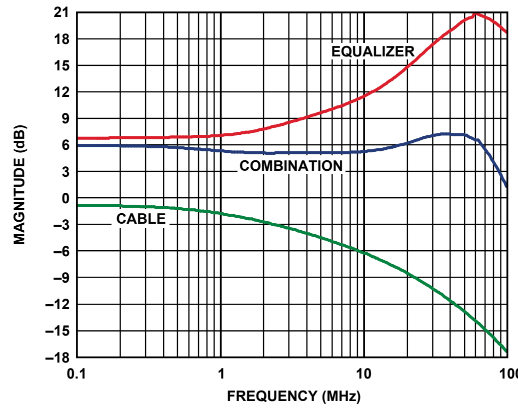

Figure 5. Large-signal frequency response (105-m VGA).

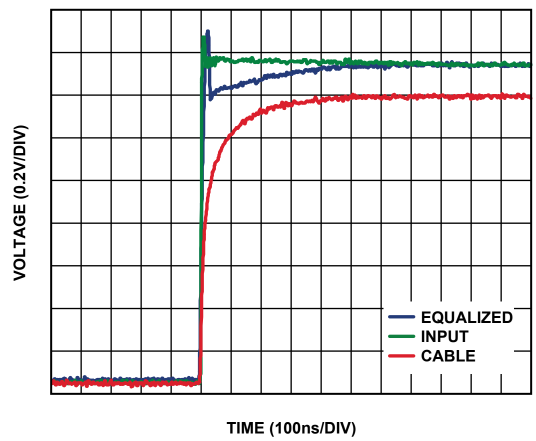

Figure 6. Transient response before and after equalization (105-m VGA).

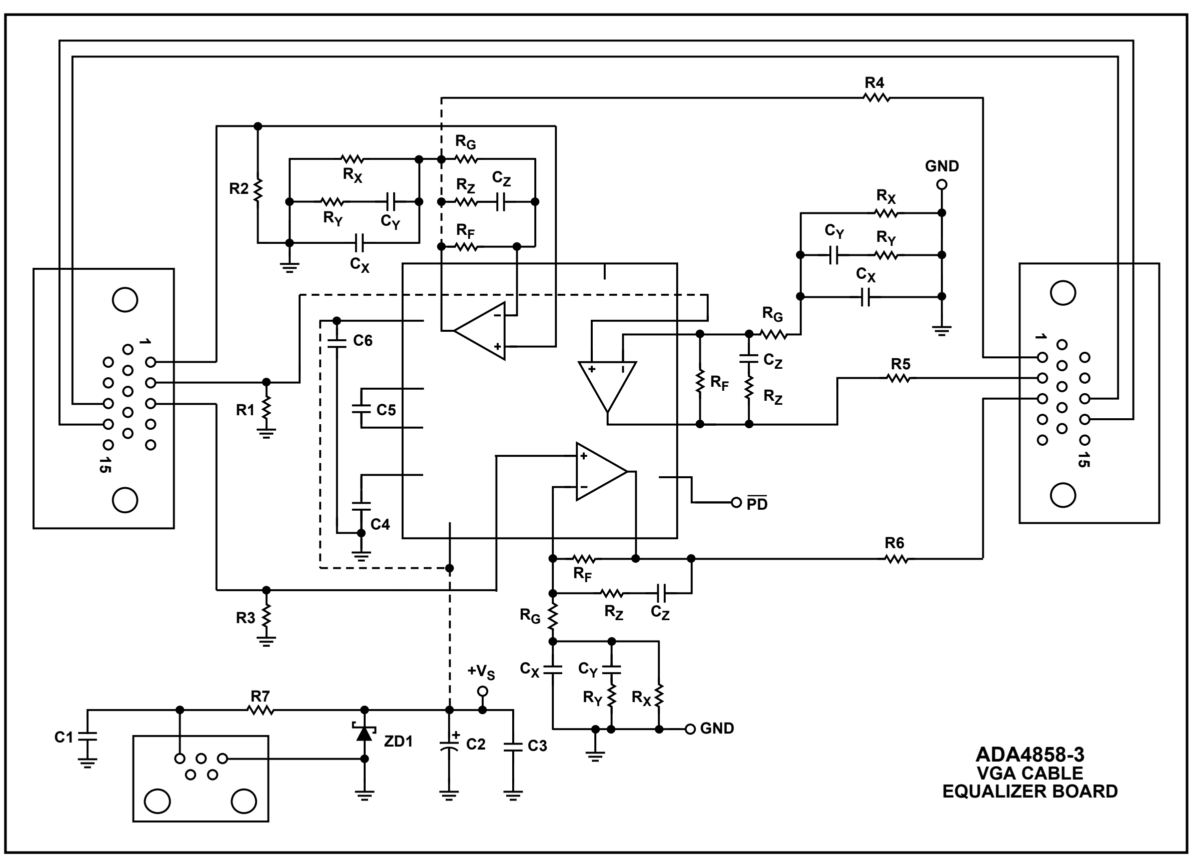

Figure 7. Complete board schematic showing all three equalization channels.

Conclusion

This article describes how to use the ADA4858-3 triple video driver to drive and equalize up to 100 m of VGA cable when transmitting RGB video. Two examples based on 45-m and 105-m cables are shown, but the solution can be scaled to accommodate various cable lengths. Convenient, inexpensive, and easy to implement, it combines the ADA4858-3, a few passive components, and a single 3.3-V to 5-V supply, which can be generated from a USB port.

Appendix

The ADA4858-3 triple current-feedback op amp draws only 42 mA of total quiescent current—including the charge pump. To further reduce the power consumption, a power-down feature lowers the total supply current to 2.5 mA when the amplifier is not being used; the charge pump, which eliminates the need for negative supplies, can still power external components in this mode. The ADA4858-3's wide input common-mode voltage range extends from 1.8 V below ground to 1.2 V below the positive rail (in 5-V operation). The 600 MHz bandwidth and 600 V/µs slew rate make it well suited for many high-speed applications, and the 0.1-dB flatness at frequencies up to 85 MHz (G = 2, 150-Ω load) make it well suited for professional- and consumer video. In addition, current-feedback amplifiers avoid the gain-bandwidth limitation of voltage-feedback amplifiers.

The on-chip charge pump creates a negative supply whose voltage depends on the positive supply voltage. With a 5-V positive supply, the charge pump generates a −3-V negative supply with 150 mA output current; with a 3.3-V supply, the charge pump generates a −2-V negative supply with 45 mA output current. External capacitors, C1 and C2, should have capacitance between 1 µF and 4 µF, with low ESR and low ESL, and should be placed as closely as possible to the ADA4858-3. C1 is connected between C1_a and C1_b; C2 is connected between CPO and ground.

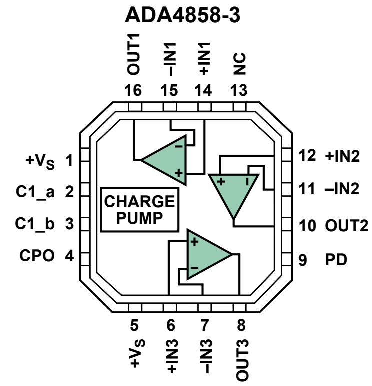

Figure A. Functional block diagram.

References

[1] www.analog.com/en/audiovideo-products/video-ampsbuffersfilters/ada4858-3/products/product.html.

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