DALLAS SEMICONDUCTOR MAXIM

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APPLICATION NOTE 550: WTAs Provide Wideband, Bidirectional Drive For Coaxial Cable

Borrowing "hybrid" circuit techniques used in telephone networks to halve the cost be enabling both transmission and reception on the same twisted pair, programmable wideband transconductance amplifiers (WTAs) can provide such a wideband, bi-directional coaxial interface.

Wideband coaxial systems can borrow a technique from the telephone network: telephones incorporate "hybrid circuits" based on transformers, which halve the cost of cable by enabling transmission and reception on the same twisted pair. You can build such voice-band circuits with op amps, but for megahertz bandwidths you need high-speed amplifiers and well-controlled impedances.

Programmable wideband transconductance amplifiers can provide such a wideband, bidirectional coaxial interface **(Figure 1)**. This circuit is similar to the telephone interface and provides the same benefit-it saves the cost of a return cable. Though shown with 50Ω cables and terminations, the circuit applies equally well for inexpensive 75Ω video and other impedance levels.

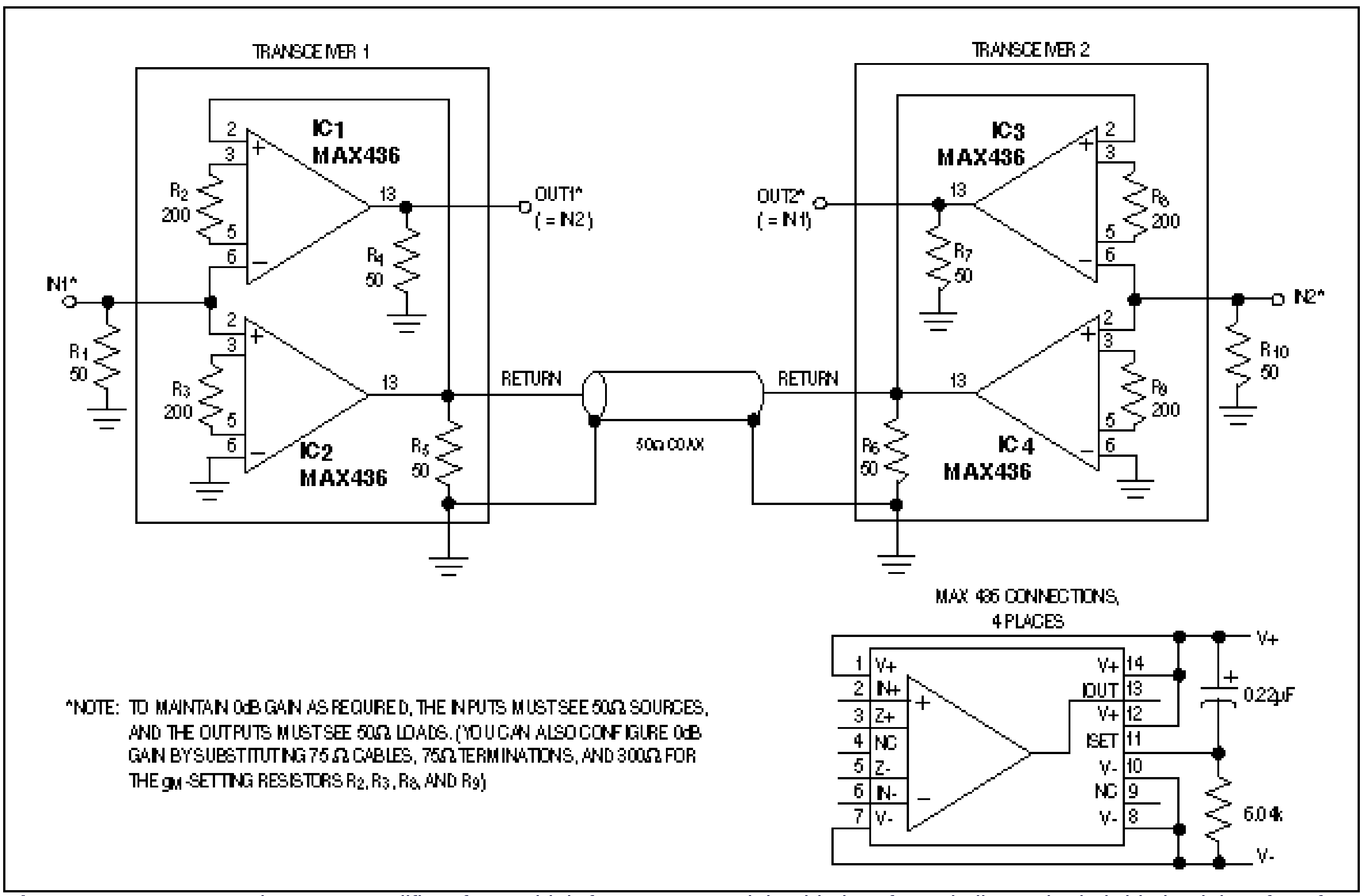

Figure 1. *Two transconductance amplifiers form a high-frequency coaxial-cable interface similar to the hybrid-circuit interface found in telephones.*

Identical circuits terminate each end of the cable. Line-driver amplifiers IC2 and IC4 drive the coax, and return amplifiers IC1 and IC3 receive signals from the other end. Each return amplifier also cancels any signal originating at its end of the cable. Signal IN1, for example, drives the inverting input of IC1 and the non-inverting input of IC2. It passes unchanged through IC2 but is inverted in passing through IC1 . Ideally, therefore, IN1 gets cancelled within IC1 while IN2 comes through the coax and appears unaffected at

OUT1. To achieve this cancellation, the amplifier transconductances (g_M) must be set for unity voltage gain throughout the system.

Several factors can degrade the cancellation. First, phase shift in the line driver prevents the return amplifier from subtracting identical signals. Second, any transconductance mismatch in the amplifiers causes the signals to have different amplitudes, again disturbing the output null. Third, any impedance mismatch along the cable causes signal reflections, and the non-adaptive circuits of Figure 1 cannot distinguish between such echoes and the desired incoming signal.

Signal cancellation depends on the tolerance of termination resistors R1, R5, R6, and R10, and their degree of mismatch with the cable impedance. Similarly, the g_M for each amplifier is affected by the gM-setting resistors R2, R3, R8, and R9, where g_M = 8/R. The "8" factor is a property of the IC, and has a guaranteed tolerance of ±2.5%.

Figure 2 shows the system outputs with 50Ω generators driving IN1 at 2MHz and IN2 at 1MHz. The resulting large output signals (2MHz at OUT2 and 1MHz at OUT1) mask any cancellation errors that may be present. To see them, replace the IN2 generator with a 50Ω terminator and observe OUT1 **(Figure 3)**. Similarly, to observe the IOUT2 leakage signal, replace the IN1 generator with a 50Ω terminator. In the circuit shown, 1% resistors provide an attainable cancellation of about 30dB for the low-megahertz range.

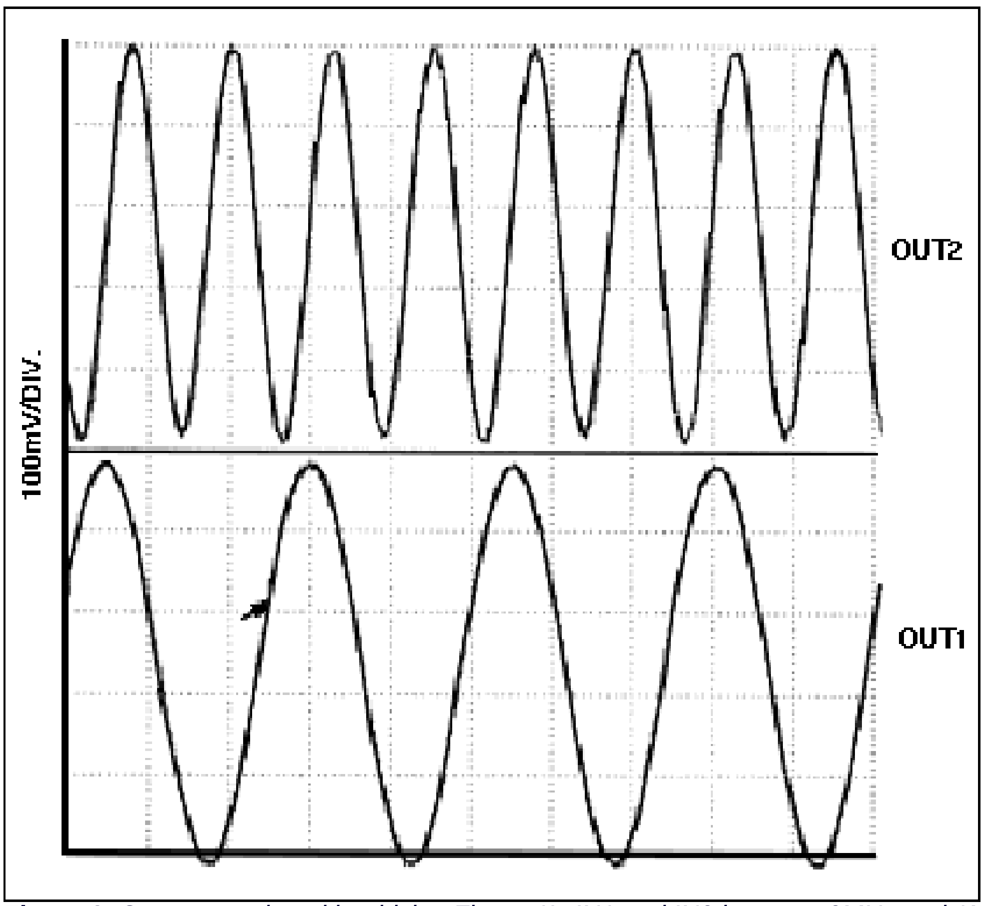

Figure 2. *Outputs produced by driving Figure 1's IN1 and IN2 inputs at 2MHz and 1MHz.*

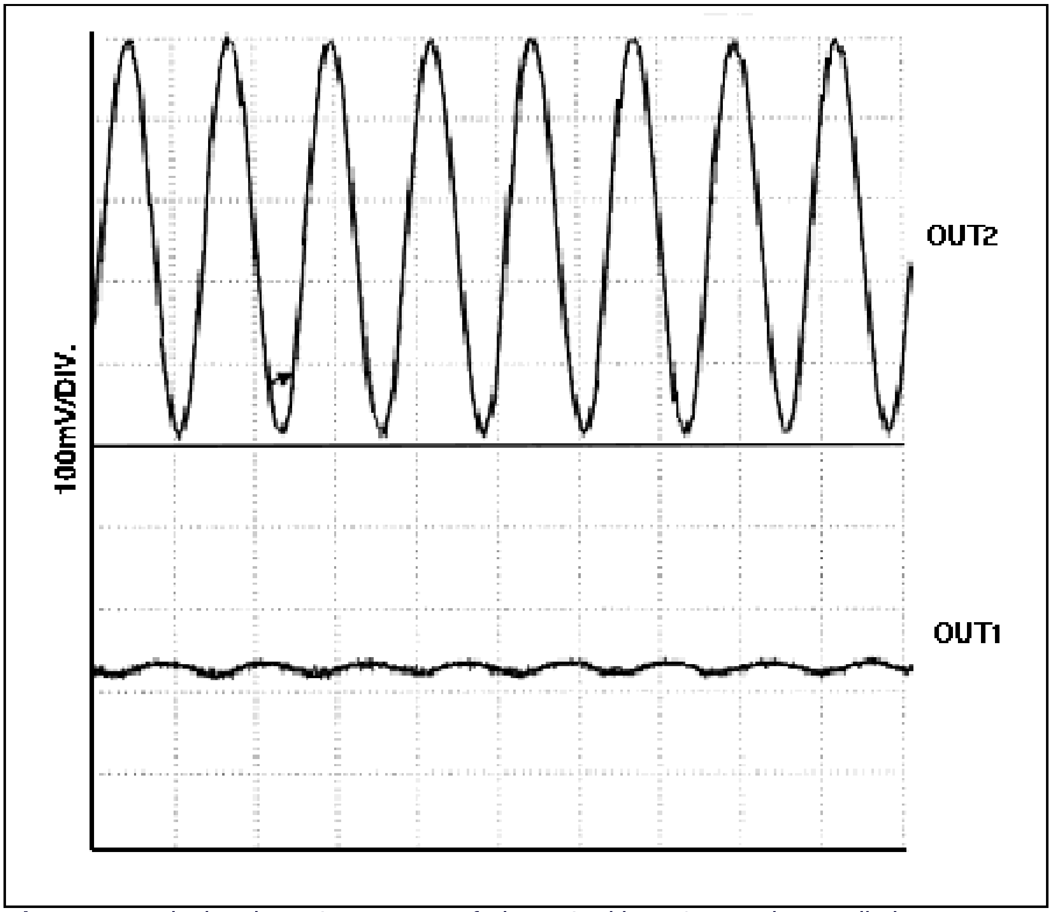

Figure 3. *Replacing the IN2 generator of Figure 2 with a 50Ω terminator eliminates 1MHz at OUT1, leaving only the cancellation error due to 2MHz at IN1.*

More Information

MAX436: QuickView -- Full (PDF) Data Sheet -- Free Samples