ADSL CO Driver Distortion and Backmatch Resistor Trade-Offs

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Digital Subscriber Lines have enjoyed almost instant success as they expand among Internet access, fiber optics, and cable uses. One stumbling block in the integration of a complete digital system is the power required from the CO (central office) driver. Many current solutions burn excess power and add unnecessary distortion. A trade-off with the backmatch resistor will allow a well-designed amplifier to operate more efficiently and effectively. Optimizing the performance in conjunction with the power dissipation will allow greater numbers of lines into each central card, while providing the capability to service more customers.

An ADSL CO driver are must supply peak line power of 20dBm on POTS line impedance of 100Ω, with a crest factor of 14.5dB.

We can calculate average output line voltage current, from output line power and line impedance:

$$P_{OUT} = (V_{OUT(rms)})^2 / R_{LINE} \qquad V_{OUT(rms)} = 3.16V \qquad \text{(EQ. 1)}$$

The crest factor determines the ratio of peak to average signal on the line. Given the recent calculations of average signal, the maximum allowed swing on the line can then be calculated.

$$CF(\text{crest factor}) = 20\log(PAR) = 14.5dB$$
$$PAR\ (\text{peak to average ratio}) = 5.3 \qquad \text{(EQ. 2)}$$
$$\text{Differential } V_{OUT(P\text{-}P)} = V_{OUT(rms)} \times PAR \times 2 = 33.52V$$

Figure 1 shows a typical differential driver circuit configuration. As calculated previously, the peak to peak output voltage is 33.52V. The required driver output to produce this line voltage is determined by the transformer turns ratio, N, and back termination resistor value, R_{TERM}.

If N is selected as 1.41 (a typical value), the peak to peak differential voltage at the driver side of the transformer is:

$$33.52V / 1.41 = 23.8V \qquad \text{(EQ. 3)}$$

Given the dual driver configuration, the swing from each side is 11.88V. The output swing required of each amplifier is greater, though, to account for the loss across the back termination resistance.

Why is there a resistor in series with our output? The answer lies not in driving the line, but in handling any power reflected back to the driver by imperfect terminations and connections on the line encountered by the signal. The termination resistor serves to match the impedance of the line and to dissipate any of this power reflected back to the source.

For 100% termination, the resistor value is 25Ω (half the line impedance divided by the square of the turns ratio of the transformer). The output swing required from the driver amplifier is 23.1V. For 60% termination, the resistor value reduces to 15Ω. Likewise, the output swing decreases to 18.45V. While this relaxes the requirements for the output of the driver, it also allows a portion of any reflected power to reach the driver amp. The output circuitry of this amplifier must be designed to handle such reflections.

The distortion at the two output swing levels are included in Figure 2. These linearity curves are from the EL1503, a DSL driver. With positive and negative 12V supplies, the output is quite linear for any output voltage range less than 20V. Specifically, the distortion of the 2nd and 3rd order harmonics remain below -68dB. However, when the device is configured with 100% termination, it must provide an output swing of 23.1V. The distortion graph displays a sharp increase for swings larger than 20V, a 10dB increase for 2nd harmonic results as well as a 25dB increase for 3rd

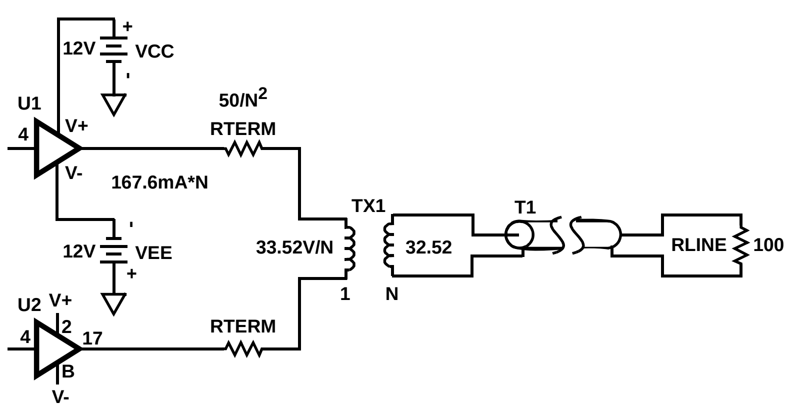

FIGURE 1. DRIVER CIRCUITRY

harmonic results. This distortion will degrade the channel capacity of the system.

If the driver cannot handle any reflected power at its output and 100% termination is required, then the only option is to increase the power supply from ±12V to ±15V, or some nonstandard value between them. Of course, if the power supply is increased, the power dissipation and amount of heat generated will also increase. Not all available drivers operate with 15V supplies. The best choice for power dissipation, performance, and temperature considerations is a driver with partial termination.

Partial termination relaxes the output swing requirements on the driver. The goal is to use as small percentage of termination as possible that doesn't overwhelm the driver with reflected power. Empirical testing has lead to the conventional use of 60% termination. If a 60% termination, or 15Ω resistor, is chosen, the driver's output swing becomes 18.5V. This output swing is within the driver's linear range and thus significantly improves the driver performance.

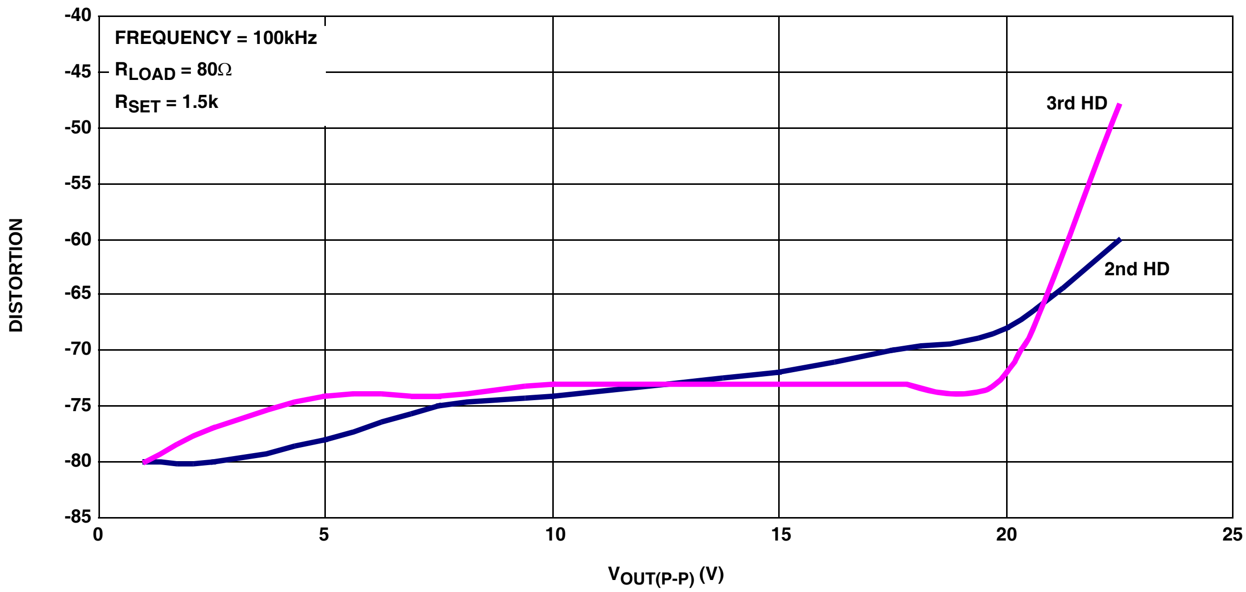

FIGURE 2. DISTORTION OF EL1503 DRIVER vs OUTPUT SWING AT FULL POWER