

Introduction

The difference between differential and single-ended output voltage swing is vital to understand when interpreting data. This note will explain each type of signal, the difference between the two signals, and how to interpret them on a datasheet.

Single-Ended Signals

A Single-Ended signal is a signal that is carried on only one conductor. In terms of a transceiver being referred to its electrical side, this signal is either TX+ or TX-. This is the signal that would be physically measured on an oscilloscope from one side of the electrical output of a transceiver (TX+ or TX-). The amplitude of one side (TX+) is equal to the amplitude of the inverted side (TX-). This is shown in the figure below.

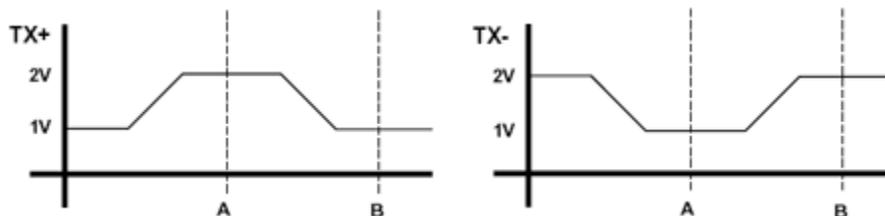


Figure 1: Single-Ended Output Voltage Swing

Both inputs are the exact same amplitude, just inverted to each other. Since most oscilloscopes have an internal ground reference, this is what is measured when connecting an oscilloscope to one output terminal, TX+ or TX-. All of our test data is taken from a single-ended measurement on an oscilloscope.

Differential Signals

A differential signal represents the difference between two signals. In terms of a transceiver, these signals are TX+ and TX-. This is the industry standard method of quantifying a differential signal pair's amplitude. Using this method, signal distortion and noise are minimized. Setting an oscilloscope in differential mode and using both inputs (TX+ and TX-) will produce an output whose amplitude is twice the value of the single-ended amplitude and centered at 0V. Setting the oscilloscope in differential mode performs the math equation:

$$V_{pp} = A(TX^+ - TX^-)$$

The output for the two signals in Figure 1 will become:

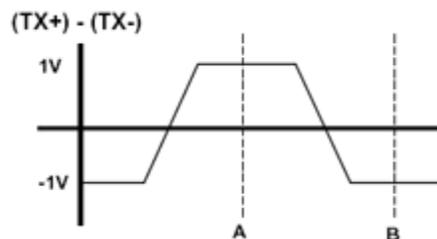


Figure 2: Differential Output Voltage Swing

Measuring the Difference Between Single-Ended and Differential Signals

An experiment was conducted by connecting the positive and negative electrical outputs of a transceiver into two channels of an oscilloscope and using the math function on the oscilloscope to subtract the two input signals. The oscilloscope has an input impedance of 50 Ohms.

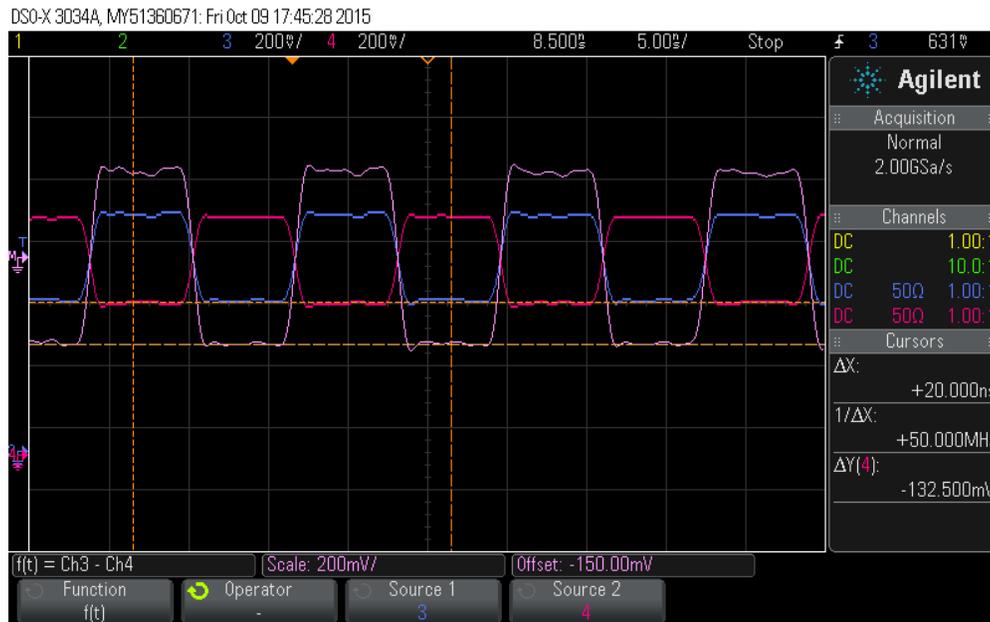


Figure 3: Results of Experiment

Figure 3 shows both the inverted (blue line) and non-inverted (pink line) signal from the transceiver on channel 3 and 4 in the oscilloscope. The purple waveform is from the math function where it is subtracting the two channels. Both input signals have single-ended amplitudes of about 300mV. To clarify the equation for converting to a differential signal, look at the equation applied to the outputs at each vertical dotted line:

At line 1:

$$V_{p1} = 300mV(0 - 1) = -300mV$$

At line 2:

$$V_{p2} = 300mV(1 - 0) = 300mV$$

The amplitude of a signal is the difference between its maximum and minimum value:

$$V_{pp} = |300 - (-300)| = 600mV$$

When taking the amplitude, the differential amplitude is about twice as large as each individual signal and is centered at ground. This reflects the equation for the differential amplifier. These equations and results are valid for any output signal that is produced by our transceivers.

Datasheet Interpretation

When referring to “differential output voltage swing” in our datasheets, we are using the single-ended value that we use to measure our data and multiplying it by two. When we refer to the single-ended eye amplitude on our datasheets, we are referring to the signal that we see and take measurements from.