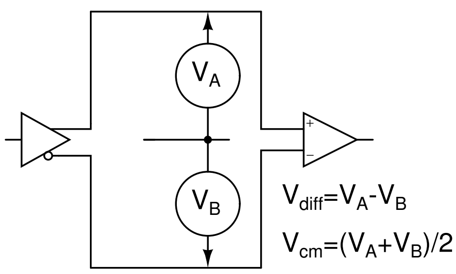
Differential Signalling

This lecture covers differential signalling.
After this lecture you should be able to: compute common-mode and differential voltages.

Differential Signalling

The voltage between the two wires is the differential voltage. The average of the two voltages (each referred to a common voltage) is called the common-mode voltage:



The differential transmitter outputs a different voltage on its two outputs. For example, $V_A = +5$ V and $V_B = 0$ V for a logical '1' and $V_A = 0$ V and $V_B = +5$ V for a logical '0'. The differential receiver ignores the common-mode voltage by subtracting the two voltages (resulting in +5 V and -5 V for this example).

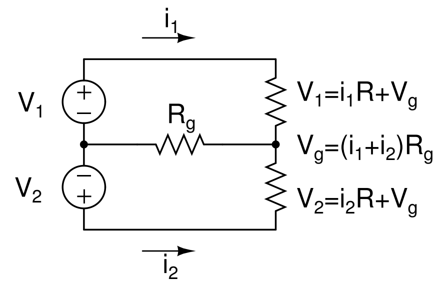
Data transmitted using the differential voltage (or current) is called differential signalling. Differential signalling is commonly used at higher speeds and longer distances where the use of a shared ("common") ground path can add noise as described below.

Noise From Shared Grounds

Some communication channels transmit over one conductor and use a return path that is shared with other circuits. These other circuits could be other communication links or for power distribution.

One problem with common grounds is that the "ground" voltage will be affected by all the return currents multiplied by the resistance of the return path. This results in a noise signal at the receiver that is proportional to the product of the sum of the currents on the return path and and the resistance of the return path. Therefore the common-ground approach is only practical where the shared circuit resistance and the current are small.

For example, in the figure below the current on one circuit (i_1) affects the "ground" voltage (V_g) and thus the voltage seen on the second circuit (V_2):

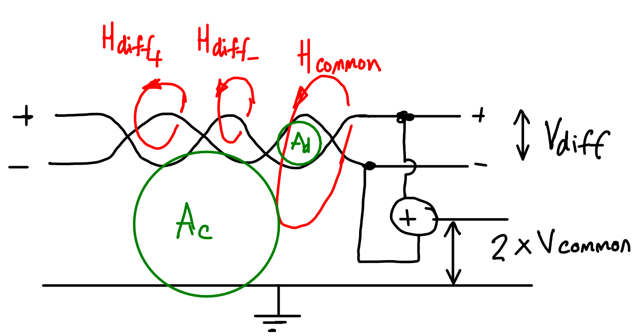


These effects can be particularly severe when the shared ground circuit is used as the return path for a power supply.

Differential signalling avoids this problem because the receiver only measures the voltage difference between the two conductors and ignores the ground voltage.

Inductive Noise

The following diagram shows the differential and common-mode voltages and the two loops through which magnetic fields could flow to cause differential and common-mode noise (imagine the magnetic field direction perpendicular to the page):



Since the two conductors of the twisted pair are next are next to each other the area between the wires (A_d) will be much smaller than the area between the wires and ground (A_c). This will result in a smaller voltage being induced on the differential signal. In addition, the voltages induced on the twisted pair by the magnetic field (the parts of the field H_{diff+} and H_{diff-}) will cancel out due to the twisting.

Shielding and Grounding

Some communication cables have a braided shield (similar to co-ax) to limit radiation from the signals carried by the cable. To avoid inducing noise on these signals and radiation from the shield the shield should not act as a return path for other circuits.

In some cases the shield can be left disconnected at one end. Other techniques to prevent current flow along the shield are connecting the shield through a capacitor to block low-frequency currents and/or placing a ferrite cylinder around the shield to blocks high-frequency currents.