Miscellaneous: Why does RS485 (and RS422) require to connect the logic Ground?

With RS485 serial interfaces you have to connect the logic Ground between all connected devices. This is necessary because the specifications of RS485 require this. Unfortunately many demonstration graphics focus on the data lines, and omit the ground line for simplicity.

The ground connection is not written explicitly in the specifications. Instead a so called Common Voltage Range (CVR) is defined. The specification -7V to +12V for the CVR allows to design and manufacture less complex and hence low-cost circuits. Without somehow connecting the logic Ground an installation can not ensure this requirement is met on all stations. A device without such an option is possibly not conforming to RS485 specifications.

The transmission happens in a balanced fashion. Two wires are used to carry one logic signal. A positive differential voltage represents a logic 1, a negative differential voltage represents a logic 0.

The transmitting device produces voltages within the CVR, typical +5V for high and 0V for low level. These voltages of course are generated with respect to the logic ground of the *transmitter*. Any measurement must check the voltage between the signal line and logic Ground. When the signals connect to a device, it must evaluate the voltages with respect to the logic Ground of the **receiver**. If both Ground levels differ by more than +7V, on the receiver side one or both voltages may be not within the CVR. If the levels are not within the defined CVR, the logic value may not be understood, causing errors on receiving.

Basically this is also discussed on Wikipedia, and for example in application notes from manufacturers like Maxim and Analog Devices. The connection of ground may happen implicit, because the logic ground of all devices is connected to some global protective ground level. If this is nearly the same on all devices, an extra wire is not required.

If the ground levels are different, without an explicit connection all equalising currents run on the data lines, hence pass the logic circuits for transmit and receive. This can damage the devices, and often does over time.

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When the serial interface is galvanically isolated, sometimes there is no contact for the isolated logic ground. In such networks it may be possible to make a simulated connection. On the receiver side one resistor connects the positive signal line with ground, and another resistor connects the negative signal line with ground. As a net effect now the logic ground of the receiver is in the middle of the positive and negative voltages. So both data lines are in the CVR with respect to the receiver. It is difficult to give reasonable values for these resistors. If there are only two devices connected, resistors in the range of 2k Ohm should do the job. But in any installations this requires explicit calculations.

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