Non-Isolated, Half-Duplex, RS-485 Repeater

Long distance RS-485 networks apply half-duplex transmission to reduce cable and wiring cost. Extending a half-duplex bus beyond the suggested maximum of 1200 m (4000 ft) requires a half-duplex repeater (Figure 1).

Because the ground potential differences (GPD) between remote located nodes can exceed the maximum ±7 V specified in EIA-485, transceivers with high a common-mode voltage (Vcm) range, such as the SN65HVD1785, are recommended. This device has a Vcm range of -20 V to +25 V, supports data rates of up to 115 kbps, and has reduced rise and fall times of 1.7 µs typical, which is ideal for low-EMI transmissions over long distances.

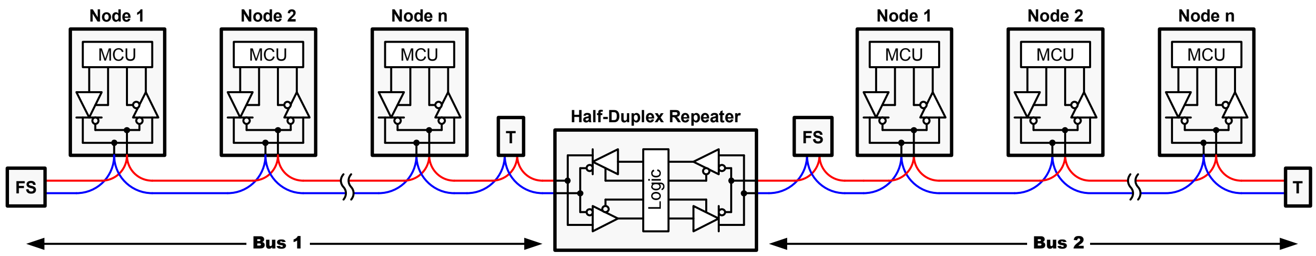

Figure 1. Bus extension with half-duplex repeater

The actual repeater design comprises two half-duplex transceivers and a control logic that performs a bit dependent control of enabling and disabling the repeater's driver and receiver sections (see Figure 2).

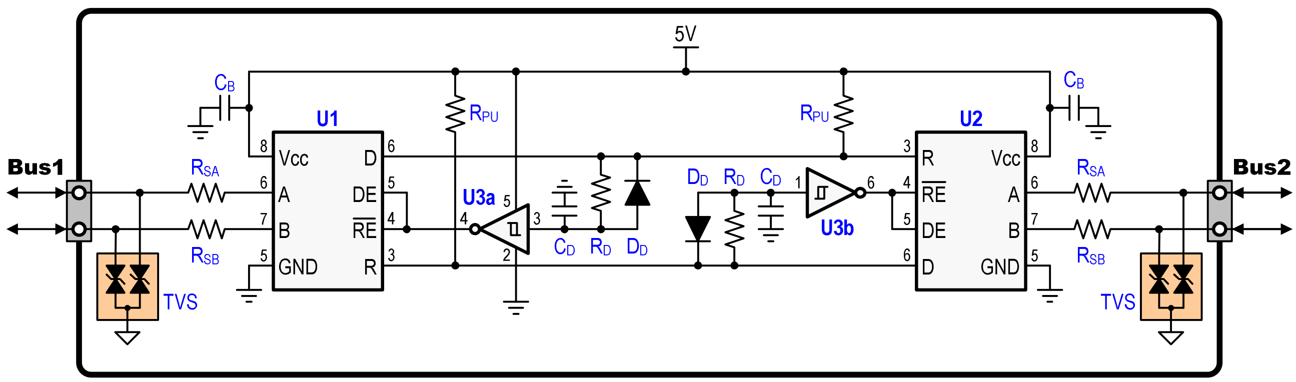

Figure 2. Half-duplex repeater design

The underlying principle of the repeater is that logic low states are actively driven while logic high states are passively represented by the bus failsafe voltage, V_{FS}.

Stepping through the functional sequence of the repeater clarifies its operation.

- During bus-idling the receiver outputs of both repeater ports are high due to V_{FS}. The delay capacitors, C_D, are fully charged, driving the inverter outputs low to maintain both transceivers in receive mode.
- Then a negative bus voltage on bus 1 (representing a low-bit) drives the receiver output of U1 low, thus rapidly discharging C_D and enabling the driver in U2.
- When the bus voltage turns positive (V_{Bus1} > 200 mV) the receiver output of U1 turns high, thus forcing the driver output of U2 high while slowly charging C_D via R_D. The minimum time constant (R_D x C_D) is so calculated that at the maximum supply voltage, $V_{CC\text{-}max}$, and the minimum positive inverter input threshold, $V_{TH+\ min}$, the delay time, t_D, exceeds the maximum low-to-high propagation delay, $t_{PLH\text{-}max}$, of the driver by say 30 %. For a given capacitance the required resistor value for R_D thus calculates to:

$$R_D \geq \left| \frac{1.3 \cdot t_{PLH-max}}{C_D \cdot \ln\left(1 - V_{IT+min} / V_{CC-max}\right)} \right|$$

The driver enable time is extended beyond the bit length by the delay time, t_D. This method establishes a valid high signal on the bus before the driver in U2 is disabled and its receiver enabled. Thus the receiver output of U2 is kept continuously high. Due to design symmetry the same operational sequence applies to the opposite direction from bus 2 to bus 1.

Table 1. Bill of material for the half-duplex repeater

Designator	Function	Device	Manufacturer
U1, U2	115 kbps, half-duplex transceiver	SN65HVD1785D	Texas Instruments
U3	Dual Schmitt-trigger inverter	SN74LVC2G14DBV	Texas Instruments
R_{PU}	10 k, 5%, 1/16W thick-film resistor	RC0402JR-0710KL	Yageo
R_D	51 k, 5%, 1/16W thick-film resistor	RC0402JR-0751KL	Yageo
C_B	0.1 µF, 50V, Ceramic bypass capacitor	GRM188R71H104KA93D	Murata
C_D	100 pF, 50 V, Ceramic delay capacitor	C0603C101J5RACTU	Kemet
D_D	1N4448 Discharge diode	1N4448WT	Fairchild
R_{SA},R_{SB}	10 Ω Pulse-proof thick-film resistor	CRCW060310R0FKEAHP	Vishay
TVS	400 W Transient Suppressor	CDSOT23-SM712	Bourns

Because a repeater is most likely connected to the end of an existing bus (i.e. bus 1) that already provides termination and failsafe biasing (see Figure 1), no further external components are required on this side of the repeater. However, the opposite repeater port usually builds the beginning of a new bus (i.e. bus 2). Here the implementation of a termination plug with failsafe biasing is necessary. The end of bus 2 can then be terminated with a simple termination plug.

Of course it is possible to include the termination and failsafe networks of both ports on the repeater board and provide jumper options for various resistor settings. However, as explained in the design tip ***Robust RS-485 Bus and Node Design***, the added jumpers and resistors contribute to unnecessary cost increase and bare the risk of wrong jumper settings which can cause signal distortions and transmission errors.

Instead, rather integrate transient suppressors and current limiting resistors on the board that protect your repeater design in harsh industrial environment.

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