HVD17xx Survives Direct Short-Circuit Faults to High Voltage

High-Voltage Survivability

The HVD17xx family of RS-485 devices are designed to survive overvoltage faults such as direct shorts to power supplies, mis-wiring faults, connector failures, cable crushes, and tool mis-applications. The internal current-limit circuits allow fault survivability without causing the high bus currents that otherwise might damage external components or power supplies. They are also robust to ESD events, with high levels of protection to the JEDEC or IEC human-body-model (HBM) specifications.

The HVD17xx family of devices will survive bus pin voltages up to ±70V, as demonstrated in the following test cases. These devices will also survive quick transient ESD events up to 15 kV. For surge voltages which are longer in duration than ESD and higher in voltage than ±70V, the addition of transient voltage suppression diodes is recommended.

The slow and medium-speed devices in this family have Absolute Maximum ratings of ±70V on the bus pins, corresponding to the high breakdown voltages of the integrated components in the driver and receiver circuits. As seen in the plot of Figure 1, the pin current does not exceed about 500 uA for applied voltages in the range -70V to +70V. For applied voltages beyond this range, the current must be externally limited to avoid damage to the device. The fast (10 Mbps) devices in the family have similar ratings, but in some conditions the bus-pin fault voltage is limited to -30V to +30V.

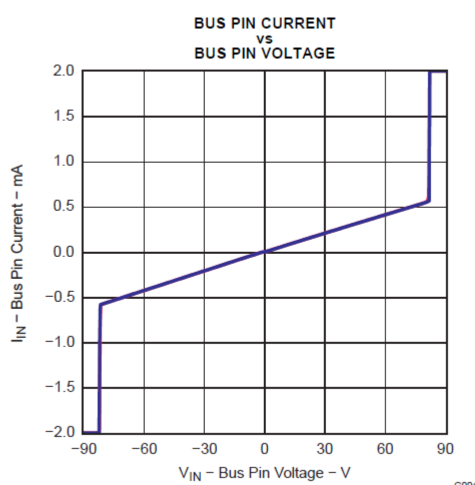

Figure 1 HVD17xx Bus Pin Protection Limits Current for Voltages up to ±70V

Laboratory Demonstration of High-Voltage Survivability – DC Voltages

To clearly demonstrate the survivability of these devices to high-voltage faults, several tests have been performed with a typical HVD1785 transceiver. In the following oscilloscope plots:

Channel 1 is the D input to the driver (yellow) with 960 bps data
Channel 2 is the A output from the driver (blue)
Channel 3 is the B output from the driver (purple)
Channel 4 is the R output from the receiver (green)

In all cases, one of the bus pins (A or B) was directly tied to a bench power supply set to 50V. After a short period, the test lead to the power supply was manually removed, and in all cases normal operation resumed.

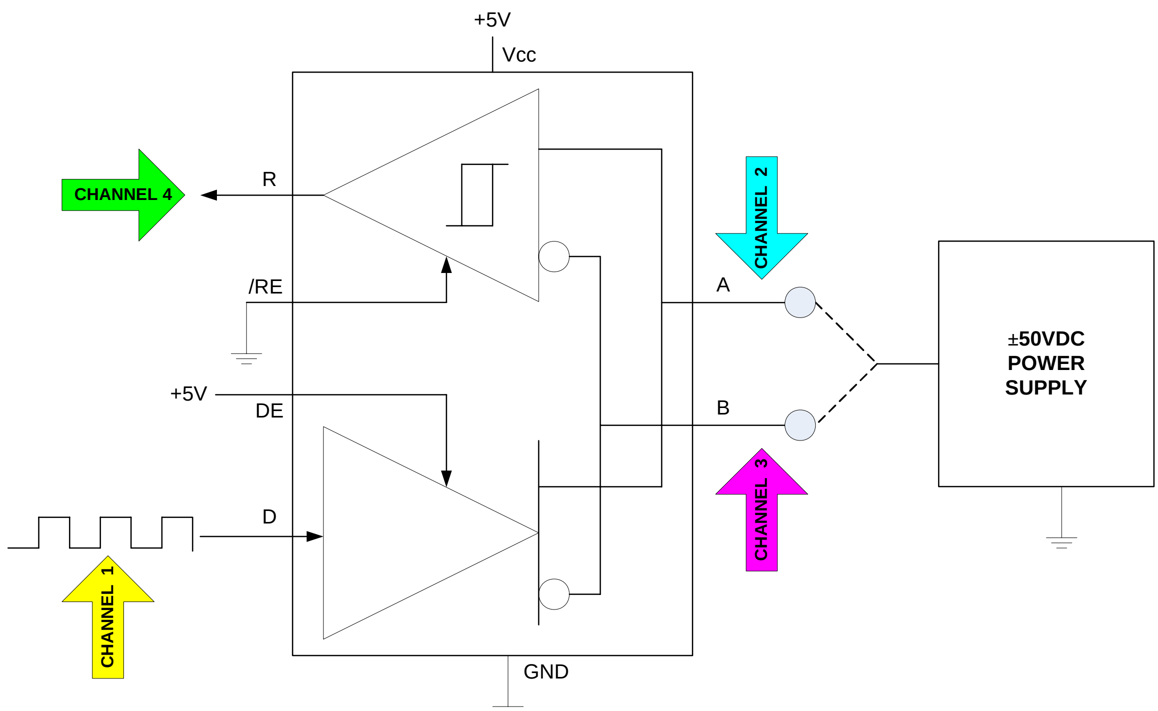

Figure 2 Set-up for 50VDC survivability tests

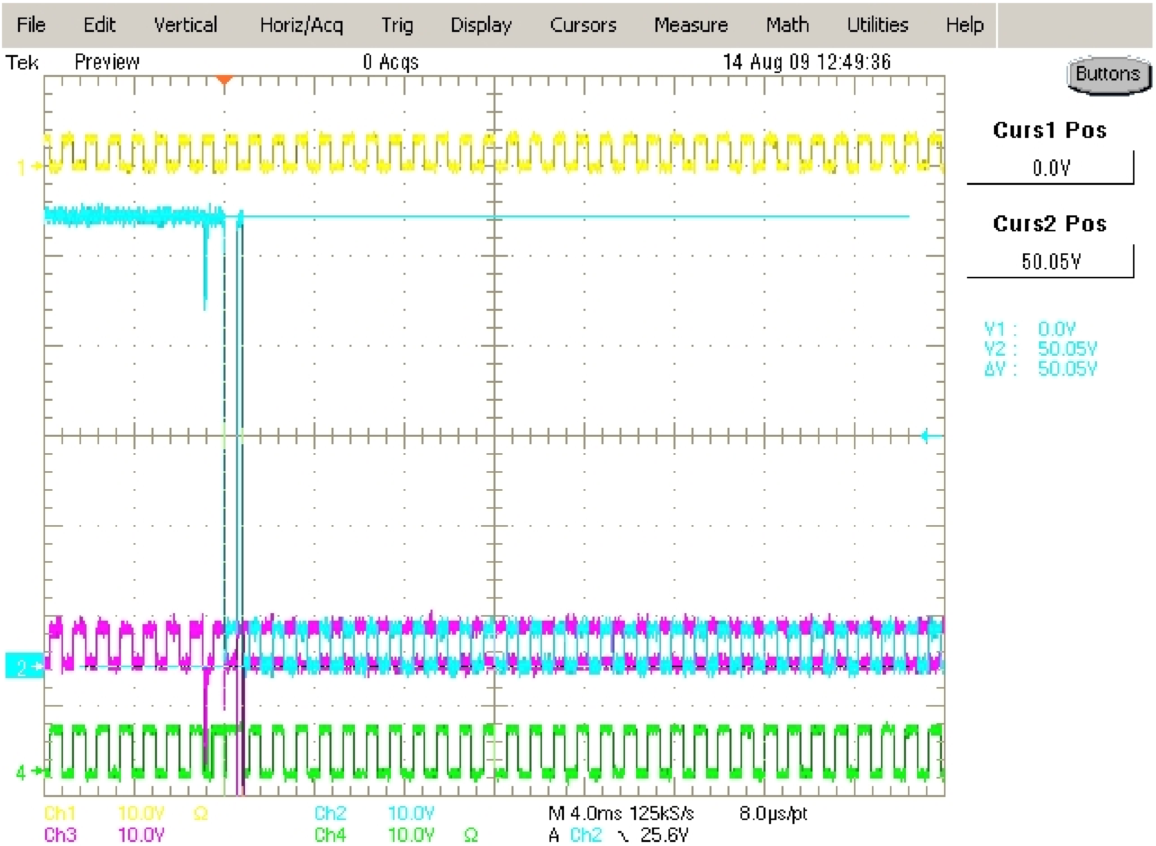

Figure 3 HVD17xx Survives +50V Fault on A pin

Note that in the case of these faults, the receiver output state toggles in response to the bus pin voltages, functioning even during the application of the +50V fault. However, the receiver output state does not in all cases correspond to the driver input state, so the receiver output should not be interpreted as reliable *during* the fault. The ±70V survivability of the HVD17xx does not imply normal operation during the fault condition.

Note also that normal operation resumes immediately after the high voltage fault is removed. Both the non-inverting output (pin A) and the receiver state (pin R) resume normal states in less than millisecond after removal of the 50V fault condition.

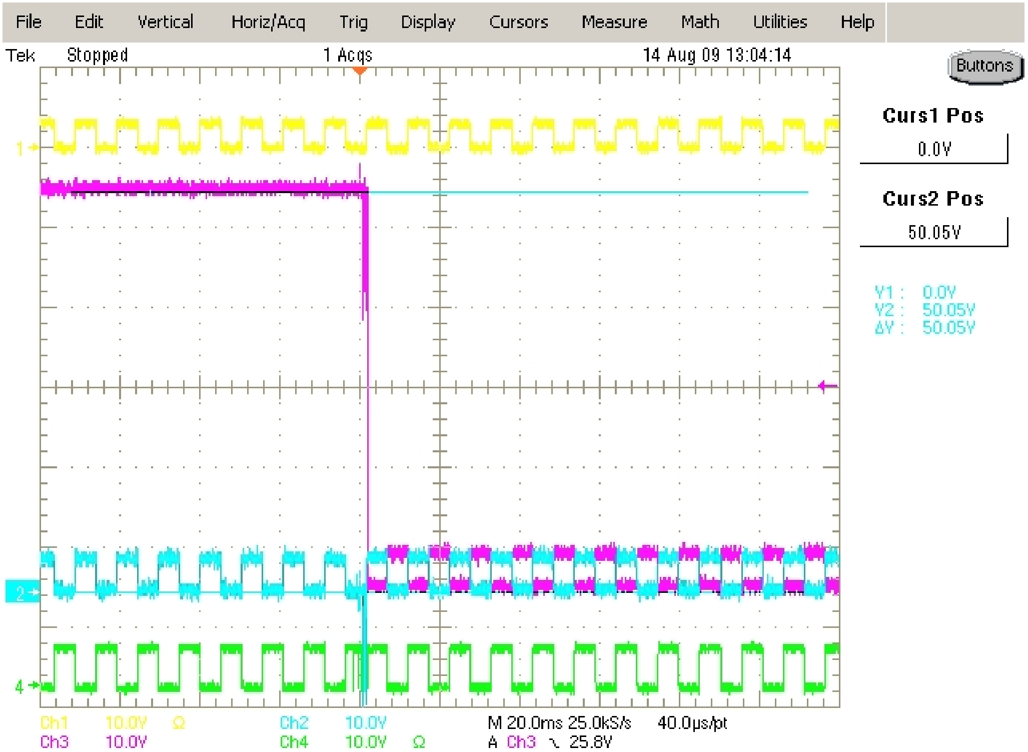

Figure 4 HVD17xx Survives +50V Fault on B pin

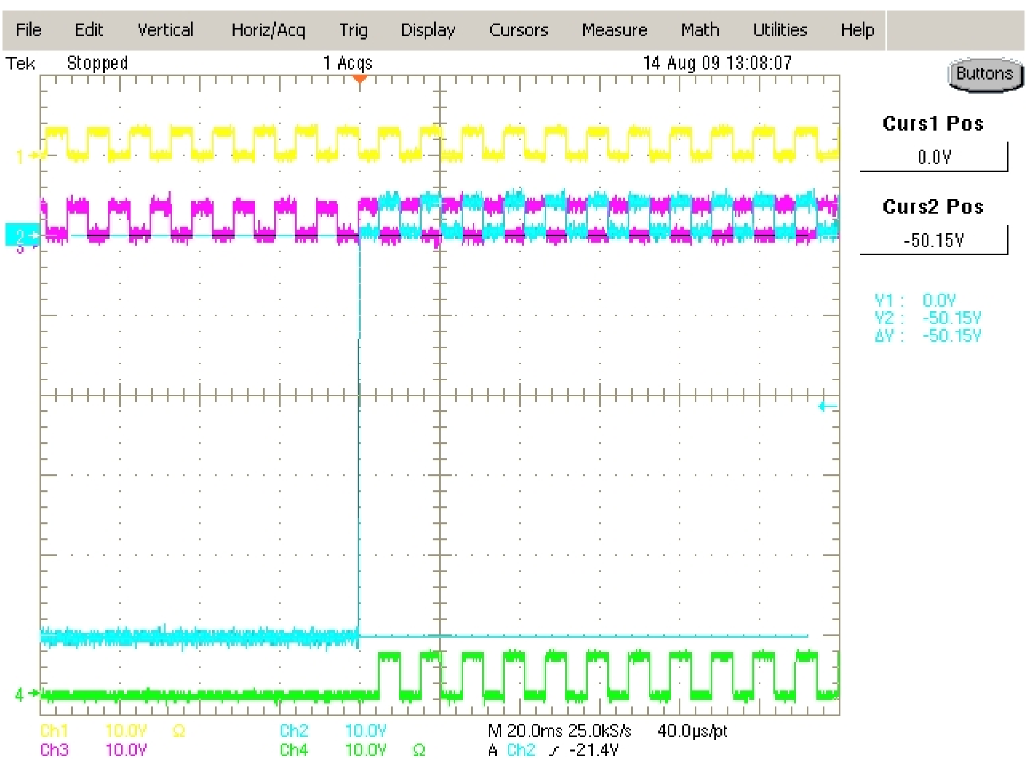

Figure 5 HVD17xx Survives -50V Fault on A pin

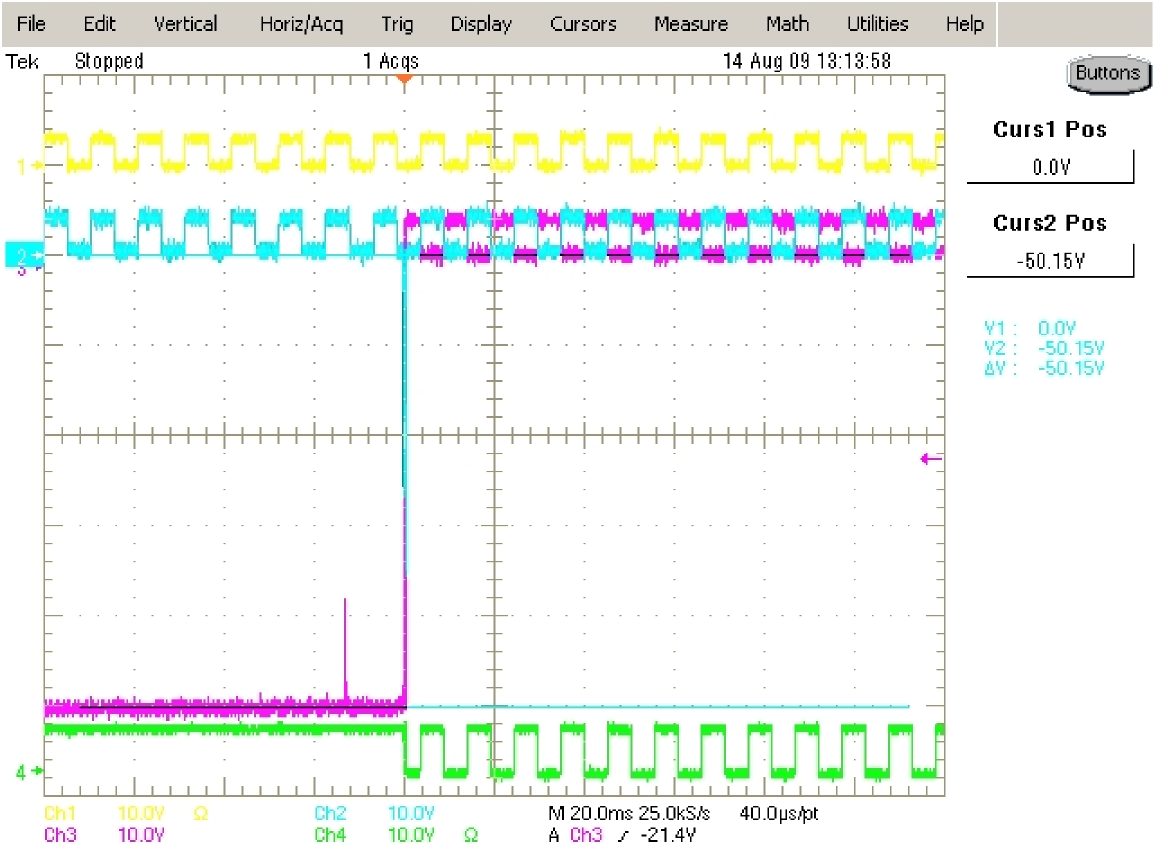

Figure 6 HVD17xx Survives -50V Fault on B pin

Notes:

1. The slow input signaling rate was selected so that the relative time scale between the removal of the fault (manually) and the data rate allows visual confirmation of normal operation after a steady-state fault event.
2. Survival to higher voltages can also be demonstrated. A fault voltage of 50V was selected to fit easily onto the oscilloscope screen.
3. High voltage oscilloscope probes (for example Tektronix P5210) or a voltage attenuation circuit are needed to make these measurements. **Designers should not attempt to reproduce these measurements with low-voltage probes, as oscilloscope damage may occur.**

Laboratory Demonstration of High-Voltage Survivability – AC Voltages

To clearly demonstrate the survivability of these devices to high-voltage AC faults, several tests have been performed with a typical HVD1785 transceiver. In the following oscilloscope plots the channel assignments are the same as the previous cases:

Channel 1 is the D input to the driver (yellow)
Channel 2 is the A output from the driver (blue)
Channel 3 is the B output from the driver (purple)
Channel 4 is the R output from the receiver (green)

In the cases below, one of the bus pins (A or B) was directly tied to a 24Vac 60 Hz power source typical of applications such as HVAC, lawn sprinkler systems, etc. After a short period, the test lead to the AC power source was manually removed, and normal operation resumed.

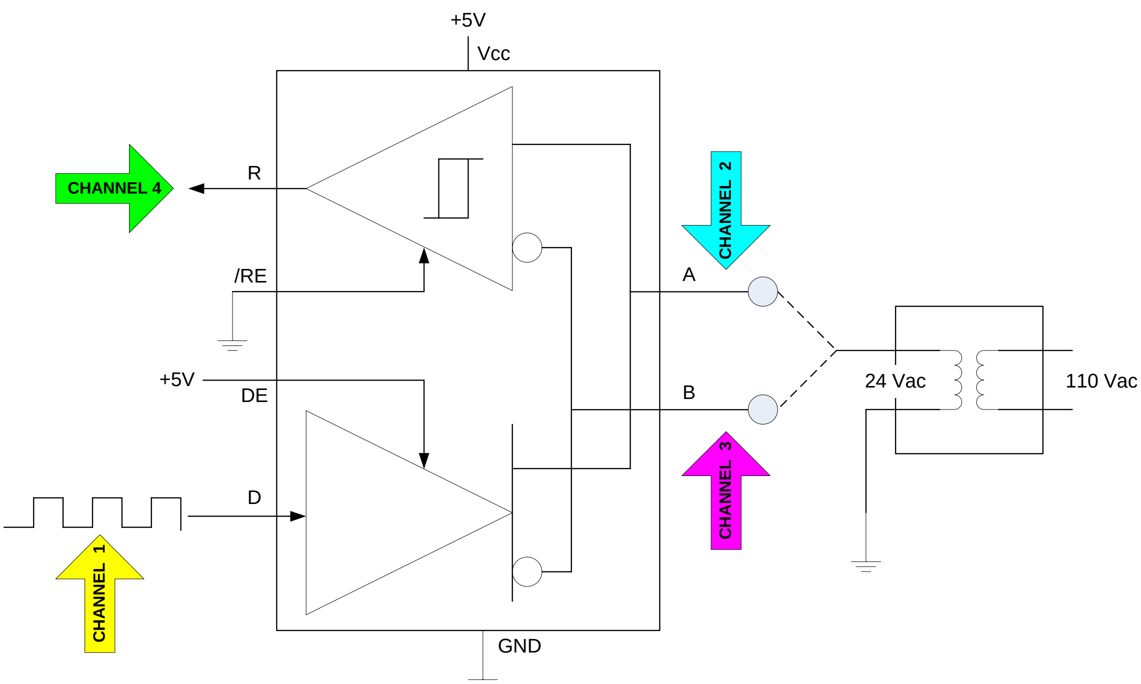

Figure 7 Set-up for 24Vac survivability tests

Notes:

4. The slow input signaling rate was selected so that the relative time scale between the removal of the fault (manually) and the data rate allows visual confirmation of normal operation *after* a bus-pin fault event.
5. High voltage oscilloscope probes (Tektronix P5210) are needed to make these measurements. **Designers should not attempt to reproduce these measurements with low-voltage probes, as oscilloscope damage may occur.**
6. Note that the receiver output R (green Channel 3) toggles during the 24 VAC fault, but the signal does not correspond to the correct input signal. The receiver output is correct after the AC fault condition is removed.

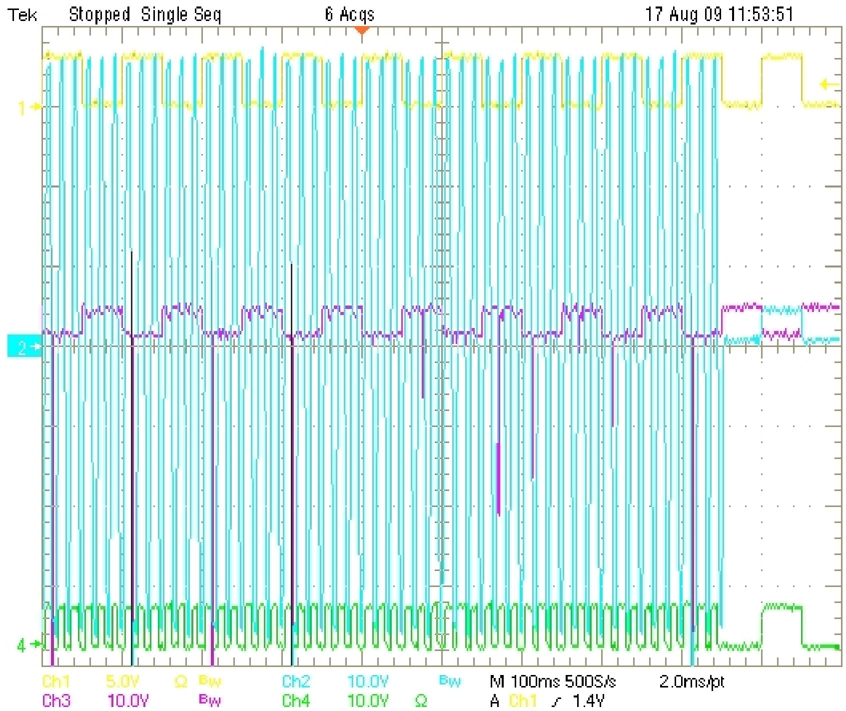

Figure 8 HVD17xx Functions Normally After Removal of 24Vac Fault on pin A

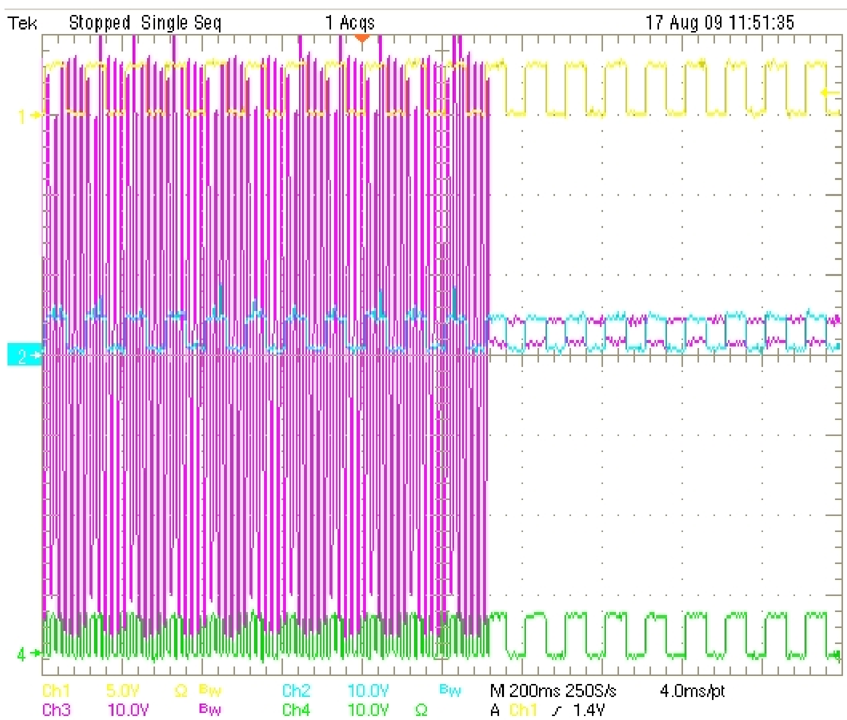

Figure 9 HVD17xx Functions Normally After Removal of 24Vac Fault on pin B

Detection of Bus Wire Faults to 24Vac

The HVD17xx receiver circuits not only survive these faults, but continue to function, responding to the differential bus voltages even during a short to 24Vac power. In the plot below, the driver has been turned off (DE = Logic Low) and a bus fault condition has been applied to pin A, with a direct short to the 24Vac power. The differential voltage between pins A and B causes the receiver output R to toggle with the same frequency (60 Hz) as the 24Vac power.

In some applications, it would be possible to use this feature in a diagnostic manner, thereby giving the system operator a method to debug communication errors caused by cable faults.

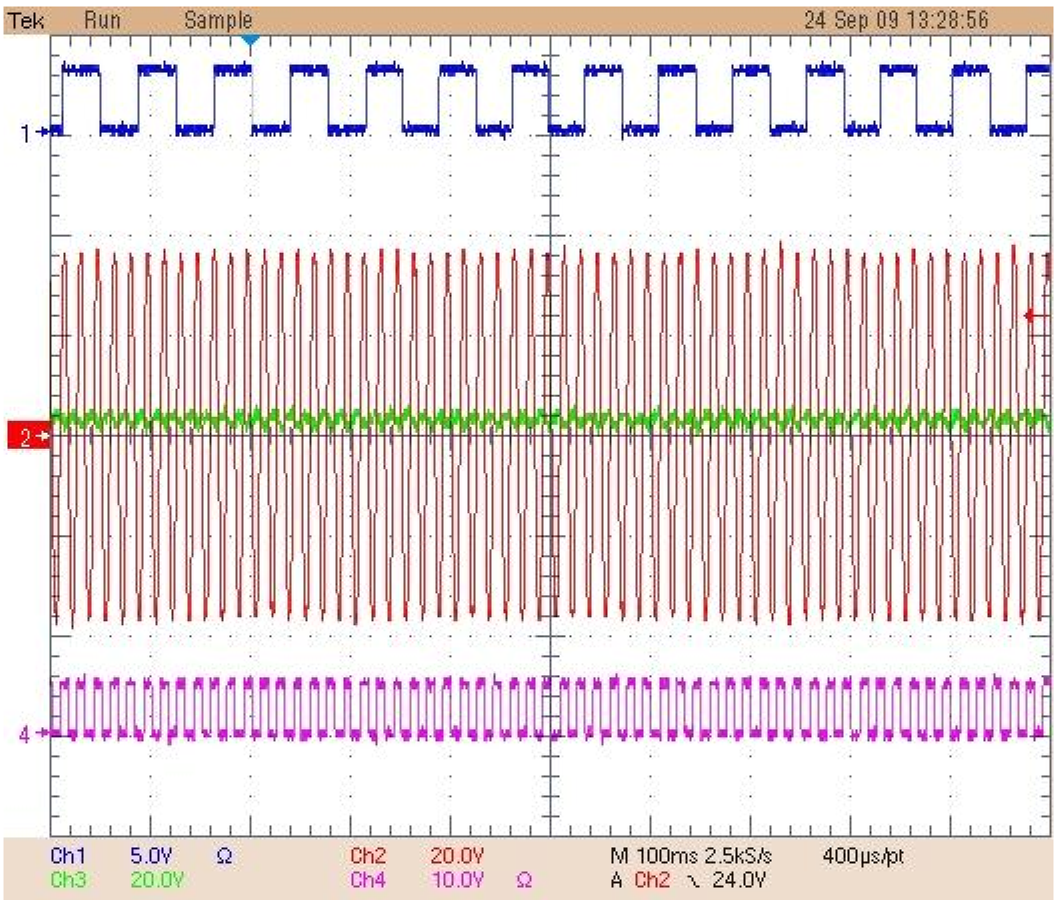

Figure 10 HVD17xx Receiver Responds to 60 Hz Power during Cable Fault

Protection Against Kilovolt Transient Surge Events

The HVD17xx devices have internal ESD protection to protect against expected ESD risks during handling and installation. In some applications additional protection for risks such as secondary lighting surges may be desired.

The high standoff voltage of the HVD17xx transceivers makes protecting these devices against transient surges events relatively straightforward. In selecting external transient voltage suppression (TVS) protection elements, the breakdown voltage should be beyond the range expected for any possible long-term faults. For example, if cable faults to 24Vac are possible, the TVS diode breakdown voltage should be at least 34V ($\sqrt{2} \cdot 24V$) so that the TVS diodes are not destroyed if a cable fault occurs. The breakdown voltage should also be within the Absolute Maximum Ratings of the device being protected; in the case of the HVD17xx family of transceivers, this is 70V. Bi-directional TVS diodes such as the SMAJ43CA are available from several manufacturers. These devices have a breakdown of around 50V and clamp several Amps of current at less than 70V, making them suitable for TVS protection in a 24Vac system. Similar devices are suitable for systems where faults to other voltages are at risk.

Conclusions

As expected, the HVD1787 transceiver survived direct bus pin faults to a 50VDC supply, regardless of polarity, and similarly survived direct bus pin faults to a 24VAC power source. This family of RS-485 devices is recommended whenever the possibility of cross-wiring to these supplies or similar bus pin faults exists. The complete family of devices is listed in Table 1.

Table 1 HVD17xx Family of RS-485 Devices

FOOTPRINT/FUNCTION	Supply Voltage	Signaling Rate		
		SLOW	MEDIUM	FAST
Half-duplex	3.15 – 5.5V	80	81	82
Half-duplex	5V	85	86	87
Full-duplex no enables		88	89	90
Full-duplex with enables		91	92	93
Half-duplex with cable invert		94	95	96
Full-duplex with cable invert and enables		97	98	99
J1708		08	09	10