UT64CAN333x CAN Transceiver Node Network Primer

Table 1: Cross Reference of Applicable Products

PRODUCT NAME	MANUFACTURER PART NUMBER	SMD #	DEVICE TYPE	INTERNAL PIC NUMBER
CAN TRANSCEIVER	UT64CAN333x	5962-15232	01, 02, 03	YM04, YM05, YM06

1.0 Overview

The UT64CAN333x series CAN transceivers are low power serial communications devices developed to handle the demands of harsh terrestrial and space environments. The UT64CAN333x transceivers are compatible with the ISO 11898-2 and 11898-5 standards, operating as the physical layer between the CAN bus and the CAN controller. The CAN transceiver plays a critical role in the mitigation of unfavorable conditions that degrade the bus, such as transient voltage spikes, common mode issues, as well as battery paths through faulty nodes. This application note presents a hypothetical CAN transceiver network practical example, illustrating a best-practice application to attain the aforementioned properties.

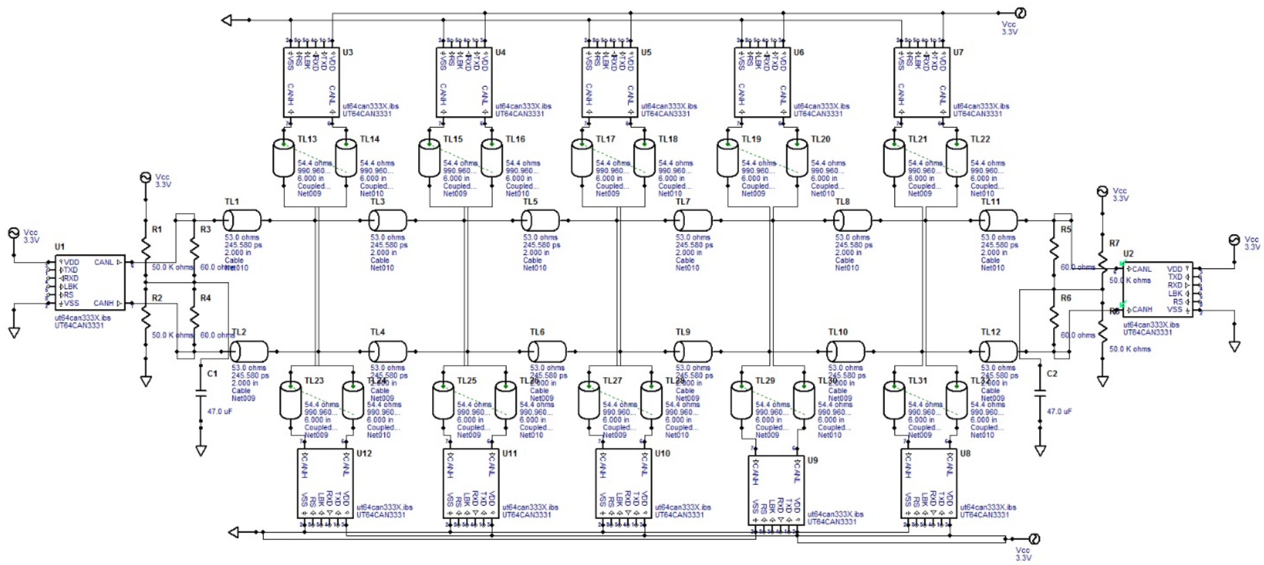

Figure 1: UT64333x CAN Transceiver Node Network Example

2.0 CAN Transceiver Node Network Configuration

Figure 1 illustrates a hypothetical CAN transceiver network comprised of a single twisted pair cable bus with split-bias terminations on each end and 12 identical CAN transceiver nodes represented by the UT64CAN333x series CAN transceivers device IBIS model. Differential pair coupled PCB striplines of 6 inches length and 100 Ohms differential impedance, connect the CAN transceiver nodes to the twisted pair cable bus with its own characteristic impedance of approximately 100 Ohms. As shown in Figure 1, the split termination is implemented as two separate 60 Ohm resistors with a center tap capacitor of 47 μF and mid-level VDD bias resistive divider, comprised of two 50 kOhm resistors to minimize the excess power dissipation. The large capacitance value of the center-tap capacitor is deliberately chosen in order to efficiently eliminate the potentially large swing and low-frequency common mode noise that could be present on the CAN bus in normal operation.

2.1 CAN Transceiver Node Network IBIS Simulation Setup

The IBIS simulations of the signaling operations are performed for two different lengths of the CAN twisted pair cable bus; 12 inches and 72 inches. The two lengths of the CAN bus are deliberately chosen to illustrate the signal integrity effects of the transmission line loading and the corresponding signal conditioning effects of the slew rate RS control pin. The shorter and the longer bus lengths are simulated for the cases of RS = 0 Ohms and RS = 10 kOhms termination options to evaluate the CAN bus signal waveforms for each simulation scenario. In addition to varying the bus length and the RS pin slew rate termination resistor value, the IBIS simulations are setup to vary the data pattern on the bus with random bit stream or alternating 1's and 0's, while using a data rate of 1 Mbps or 1 MHz for each data pattern, respectively. In all simulation scenarios the CAN node denoted as U1 in Figure 1, is operating in transmit mode, while all other nodes are in receive mode. The circuit simulation waveform monitoring probes are placed at the far-end receive node U2 as well as the mid-distance located nodes of U5, U6, U10 and U11.

3.0 CAN Transceiver Node Network IBIS Simulation Results

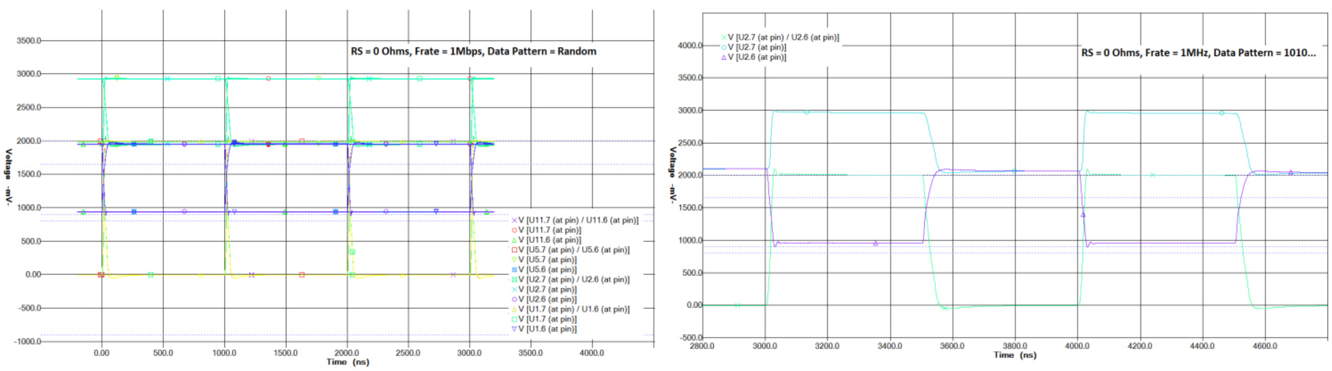

Figure 2: CAN_H/L Output waveforms for RS = 0 Ohms, 1 Mbps speed, CAN bus length of 12 inches

Figures 2 – 6 illustrate the simulation results of the IBIS-based circuit model in Figure 1, with the stated variations of the CAN bus output signal slew rate, the CAN bus length as well as the CAN signal data rate and pattern choice. Figure 2 shows the particular scenario for the slew rate termination resistor RS of 0 Ohms (fastest output signal slew rate and rise time), the CAN bus twisted pair cable length of 12 inches (approximately 30.5 centimeters) and the data pattern choice of random (left) and alternating 1's and 0's (right) for the signal speeds of 1 Mbps and 1 MHz, respectively. As seen in the plots, the resulting signal waveforms in both data pattern options are uniformly overlaid for each of the selected waveform probe locations, indicating no propagation delay and signal integrity issues for the selected CAN bus length of 12 inches.

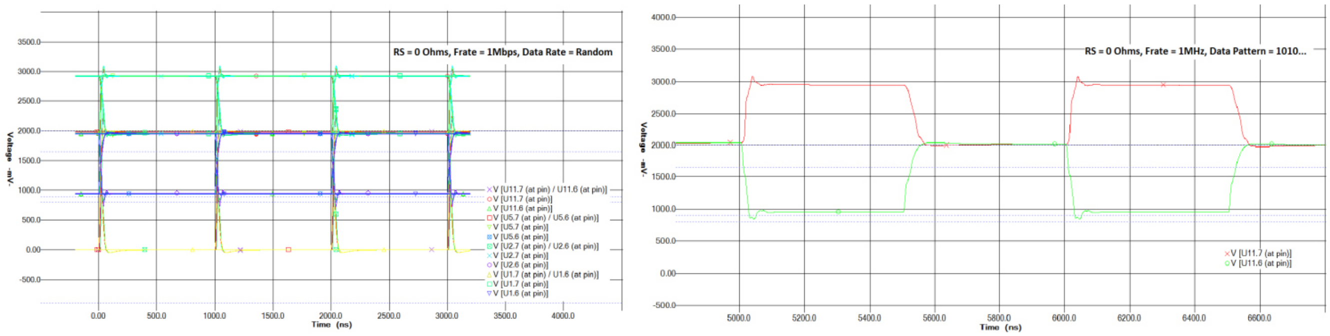

Figure 3: CAN_H/L Output waveforms for RS = 0 Ohms, 1 Mbps speed, CAN bus length of 72 inches

Figure 3 illustrates the simulation results for the same simulation scenario as the one presented in Figure 1, with the only difference being the CAN bus length, set at 72 inches (approximately 183 centimeters). As seen in the resulting signal waveforms in Figure 3, the increased parasitic loading from the longer bus length are starting to affect the integrity of the CAN_H/L output signal, resulting in visible peaking on the recessive state on each end of the differential pair. Although relatively small, this signal peaking can have significant adverse effects when combined with phenomena that occur in the actual flight application such Single Event Transient (SET) effects and common mode nose drift, as well as electromagnetic interference (EMI) effects to and from adjacent systems. To mitigate this undesirable signal integrity problem, the system designers can choose to decrease the CAN_H/L output signal rise time, by terminating the RS pin with a higher resistor value. Figure 4 illustrates the resulting output signal waveforms for the simulation scenario presented in Figures 2, with the noted difference of the RS pin termination resistor value selected at 10 kOhms.

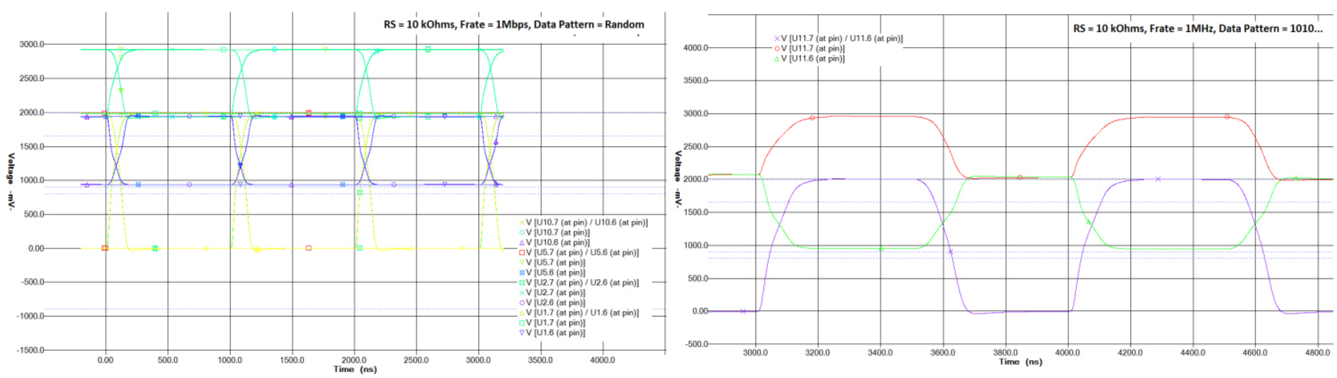

Figure 4: CAN_H/L Output waveforms for RS = 10 kOhms, 1 Mbps speed, CAN bus length of 12 inches

Figure 5 illustrates the resulting CAN output signal waveforms for the simulation scenario presented in Figure 3, with the noted difference of the RS termination resistor value chosen at 10 kOhms.

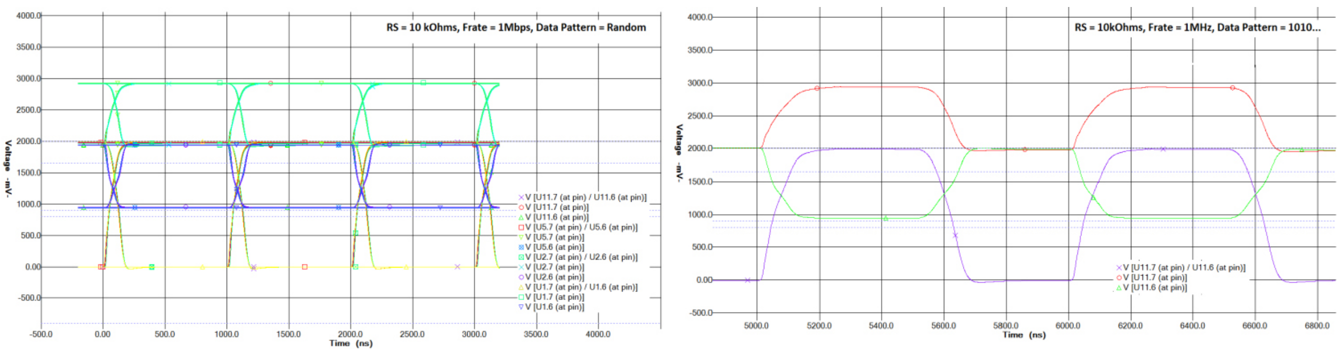

Figure 5: CAN_H/L Output waveforms for RS = 10 kOhms, 1 Mbps speed, CAN bus length of 72 inches

As seen in Figures 4 and 5, there is practically no difference in the CAN output signal waveforms plots between the two different CAN bus lengths. This is for the reasons of the slower signal rise time, eliminating the negative effects of the longer bus length by the means of removing the higher frequency spectral energy responsible for the observed signal reflections and peaking. The results in Figures 4 and 5 indicate that system designers should give careful consideration to the choice of the CAN output signal rise time when designing for slower signal speeds over longer CAN bus topologies with complex non-balanced interconnects between the various CAN transceiver nodes. To further illustrate the signal integrity effects in the CAN bus topology described in Figure 1, the CAN_H/L output signal waveforms are simulated for the case of the fastest output signal slew rate (RS = 0 Ohms) and the fastest data rate of 8 Mbps. Figure 6 shows the resulting waveforms of the CAN output signal for the fastest possible data rate and signal rise time using the longer bus length of 72 inches.

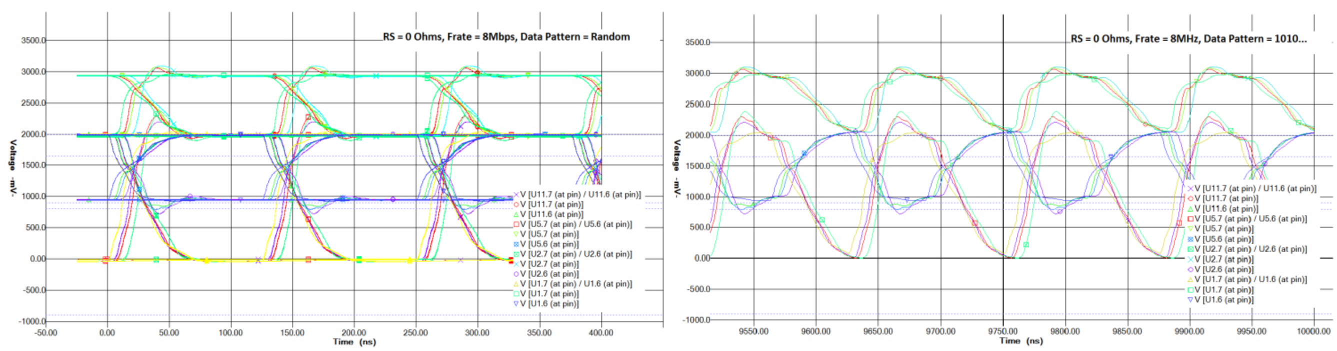

Figure 6: CAN_H/L Output waveforms for RS = 0 Ohms, 8 Mbps speed, CAN bus length of 72 inches

As shown in Figure 6, the partially distorted output signal waveforms indicate that a CAN bus length of 72 inches combined with long CAN node unbalanced connections, start to introduce significant transmission media parasitics that adversely affect the CAN bus signal integrity at the highest data rate of 8 Mbps. As evident from the waveform plots however, even with the highest data speed and arge bus loads, the UT64CAN333x CAN output drivers are capable of delivering a signal with a satisfactory eye opening that should allow for a reliable data transfer and operation of the CAN bus.

4.0 Summary and Conclusion

The CAN network node example in Figure 1 and the associated IBIS model simulation results, demonstrate that the UT64CAN333x is a robust and capable CAN transceiver that can be used in wide variety of CAN bus configurations with complex unbalanced node interconnects, up to data rates of 8 Mbps. The adjustable CAN output signal slew rate combined with the properly designed bus load terminations and common mode noise filters as well as the availability of accurate IBIS models, enable the system engineers to design and implement a CAN transceiver network that will meet the signal integrity requirements of their designs, while maintaining operational reliability and resilience to external adverse factors such as SET events and common mode nose injections from EMI effects. The IBIS model of the UT64CAN333x Can transceiver, currently supports 3 different settings for output signal rise time: RS = 0 Ohms, RS = 10 kOhms and RS = 100 kOhms all of which will produce CAN output signals with varying slew rate. Properly choosing the output signal slew rate is critical in ensuring satisfactory signal integrity and CAN bus reliable operation.

REVISION HISTORY

Date	Rev. #	Author	Change Description
01/07/2019	1.0.0	SZ	Initial Release