Design of a Radiation-Hardened Controller Area Network (CAN) Transceiver in .35μ Triple-well CMOS

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Introduction
In recent years there has been a drive to promote the use of the CAN bus for communications in spacecraft. Many small satellites are now built using the CAN bus as a means of communication. A standardised CAN bus is a robust message distribution system that each node is able to receive every message transmitted on the bus. As shown in Figure 1, a CAN network is designed so that a node is ready to initiate a message (transmit) when the bus voltage is at the high level, while it is ready to receive a message (receive) when the bus voltage is at the low level. A comparison of the CAN transceiver to the dominant state of the node is shown in Table 1. The corresponding differential voltage levels for the necessary state are shown in Table 2.

CAN ISO 11898-2 Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Unit</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential voltage output</td>
<td>VDIFF</td>
<td>V</td>
<td>0.25</td>
<td>3.5</td>
</tr>
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<td>Differential voltage output</td>
<td>VDIFF</td>
<td>mV</td>
<td>0.25</td>
<td>3.5</td>
</tr>
<tr>
<td>Input resistance</td>
<td>RIN</td>
<td>Ω</td>
<td>2.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 1: Minimum voltage of bus states and of a CAN node

3.3 V CMOS CAN Transceiver

6. Recessive Common-Mode Shift

During the recessive state the common-mode voltage must be between 2 and 3.3 V. Since the response to input state changes into either CM is relatively easy to achieve, the receiver currents for the recessive state are defined in Table 2. A recessive common-mode shift will cause a transition from one level to another. The transition is defined as follows:

Substrate-current State Transition

When the bus voltage is taken below ground and the CAN node is in the recessive state, the substrate currents will flow between the substrate and the node. The transition from one level to another is defined as a substrate-current state transition. The transition from one level to another is defined as a substrate-current state transition.

Results
The floating-wire structure achieves the required voltages to differentiate between the recessive and dominant states, as shown in Figure 2. The requirements for output voltages when the bus is fully loaded, as shown in Tables 3 and 4, can be satisfied using a voltage (V) of the CAN node which may vary between the common-mode voltage and the internal resistance of the remaining CAN nodes. At the extremes of common-mode voltage, the driver achieves the required voltage swings. However, the designer must ensure that the current requirements are met, as the internal resistance of the remaining CAN nodes may vary.

Design Features
1. State Differentiation

The state differentiator in the receiver switches the gate of both the pMOS and nMOS devices in the can receiver. This provides the differential output voltage of the CAN bus. In the dominant state, the pMOS is ON, and the nMOS is OFF. In the recessive state, the nMOS is ON, and the pMOS is OFF. The voltage levels are controlled by the CAN bus. The CAN bus is designed to be compatible with the CAN standard, with the CAN bus being able to operate in the recessive state.

References
[3] SN65HVD333 3.3 V CAN Transceivers [Datasheet], Texas Instruments, January 2009