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## Power Dissipation in Case of Bus Failure

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AMIS-30660 High Speed CAN transceiver is designed to withstand bus failures. Without any damage to the IC the CANH or CANL line may be shorted to ground,  $V_{CC}$  or the battery supply. However in some bus failure conditions an increase in power dissipation might occur. This will lead to a rise in junction temperature.

Two bus states can be distinguished: recessive and dominant. In both states both CANH and CANL can be shorted to GND,  $V_{CC}$  or  $V_{BAT}$ . In this application note we are investigating the worst case conditions therefore short to  $V_{CC}$  is not discussed.

### APPLICATION NOTE

#### Recessive State

In the recessive state  $TxD = 1$  and both CANH and CANL drivers are disabled. The figure below illustrates the equivalent schematic.  $R_{BUS}$  is the total impedance of the (split) termination on both end-sides of the CAN bus. The typical value is  $60\ \Omega$ .  $R_{i,cm}$  is the common mode input impedance with a typical value of  $25\ k\Omega$ .  $V_{CC}$  is the 5 V supply. Without power ( $V_{CC} = 0\ V$ ) the common mode voltage is still kept by a passive clamp but can be higher than  $V_{CC}/2$ . This particular condition is not taken into account in the calculations.

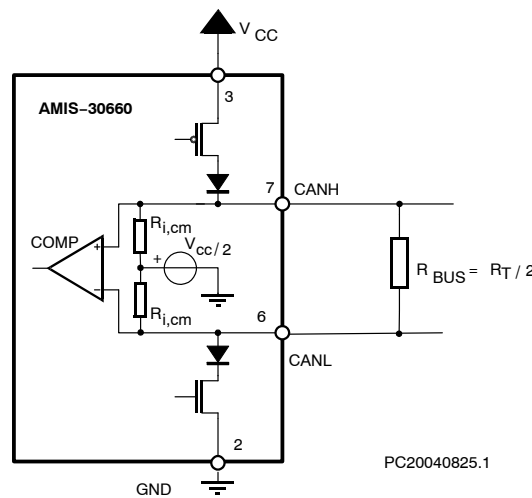


Figure 1. Equivalent Schematic in Recessive State

The power dissipation for the different bus-error conditions is given in the table below.

Table 1. POWER DISSIPATION FOR CAN-BUS ERRORS IN RECESSIVE STATE

BUS	Short to	
	GND	$V_{BAT}$
CANL	$P \approx \frac{V_{CC}^2}{2R_{i,cm}}$	$P \approx \frac{2(V_{BAT} - V_{CC}/2)^2}{2R_{i,CM}}$
CANH	$P \approx \frac{V_{CC}^2}{2R_{i,cm}}$	$P \approx \frac{2(V_{BAT} - V_{CC}/2)^2}{2R_{i,CM}}$

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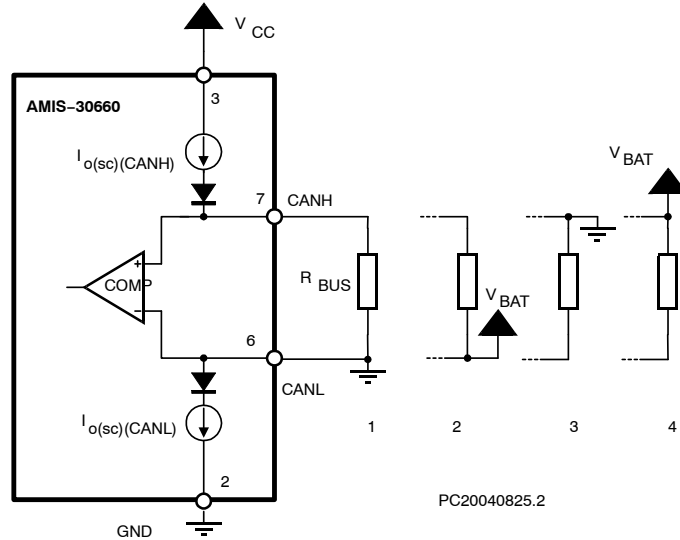
Calculated for  $V_{CC} = 5\text{ V}$ ,  $V_{BAT} = 24\text{ V}$ ,  $R_{i,cm.} = 25\text{ k}\Omega$  and  $R_{BUS} \ll R_{i,cm.}$  yields in:

**Table 2. CALCULATED POWER DISSIPATION FOR CAN-BUS ERRORS IN RECESSIVE STATE**

BUS	Short to	
	GND	$V_{BAT}$
CANL	0.5 mW	37 mW
CANH	0.5 mW	37 mW

### Dominant State

In dominant state  $TxD = 0$  and both drivers are active. In case of a short circuit the currents for both CANH and CANL are limited to  $I_{O(sc)}$  which is 120 mA in worst case condition. The figure below illustrates the equivalent schematic.



**Figure 2. Equivalent Schematic in Dominant State**

The power dissipation for the different bus-error conditions is given in the table below.

**Table 3. POWER DISSIPATION FOR CAN-BUS ERRORS IN DOMINANT STATE**

BUS	Short to	
	GND	$V_{BAT}$
CANL	<ul style="list-style-type: none"> <li>See Figure 2 Case (1)</li> <li>Bus communication possible but with bit timing limitations</li> </ul>	<ul style="list-style-type: none"> <li>See Figure 2 Case (2)</li> <li>Both CANL / CANH are on <math>V_{BAT}</math> level through <math>R_{BUS}</math> <ul style="list-style-type: none"> <li>No communication possible</li> <li>Time-out by master</li> </ul> </li> </ul>
	$P = \frac{V_{O(dom)CANH}(V_{CC} - V_{SubO(dom)CANH})}{R_{BUS}}$	$P = V_{BAT} \cdot I_{O(sc)(CANHL)}$
CANH	<ul style="list-style-type: none"> <li>See Figure 2 Case (3)</li> <li>Both CANL / CANH are on GND level through <math>R_{BUS} \rightarrow</math> <ul style="list-style-type: none"> <li>No communication possible</li> <li>Time-out by master</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>See Figure 2 Case (4)</li> <li>Bus communication possible but with bit timing limitations</li> </ul>
	$P = V_{CC} \cdot I_{O(sc)(CANH)}$	$P = V_{BAT} \cdot I_{O(sc)(CANL)} - R_{BUS} \cdot I_{O(sc)(CANL)}^2$

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Calculated for  $V_{CC} = 5\text{ V}$ ,  $V_{BAT} = 24\text{ V}$ ,  $R_{BUS} = 60\ \Omega$ ,  $I_{o(SC)(CANL)} = 120\text{ mA}$ ,  $|I_{o(SC)(CANH)}| = 95\text{ mA}$  and  $V_{o(dom)CANH} = 3.6\text{ V}$  yields in:

**Table 4. CALCULATED POWER DISSIPATION FOR CAN-BUS ERRORS IN DOMINANT STATE**

BUS	Short to	
	GND	$V_{BAT}$
CANL	84 mW	2.88 W (Note 1)
CANH	475 mW	2.02 W

1. Because no communication is possible, the master (depending on the application software) will cease the communication (= permanent recessive state) and the dissipated power drops to 37 mW.


### Average Power Dissipation and Related Increase in Junction Temperature

The worst case condition from application point of view is a short to  $V_{BAT}$  on the CANH pin in dominant state. Communication is still possible but the dissipation is 2.02 W giving the boundary conditions as stipulated in Table 4.

Calculating with a duty cycle of 50% (meaning 50% of the transmission time the bus is in dominant state) the average

power dissipation is 1.01 W (neglecting the 37 mW dissipation in recessive state)

The thermal resistance of the package is 150 K/W in free air. Soldered on a 2 layer PCB  $R_{th(vj-a)} < 100\text{ K/W}$  is expected. Calculating with 100 K/W yields in a worst case expected temperature increase of 101°C.

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