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## AMIS-30660 - Power Dissipation in Case of Bus Failure

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### APPLICATION NOTE

#### Introduction

The 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.

#### Recessive State

In the recessive state  $TxD = 1$  and both CANH and CANL drivers are disabled. Figure 1 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  $25 \text{ k}\Omega$ .  $V_{CC}$  is the 5 V supply. Without power ( $V_{CC} = 0 \text{ V}$ ) 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.

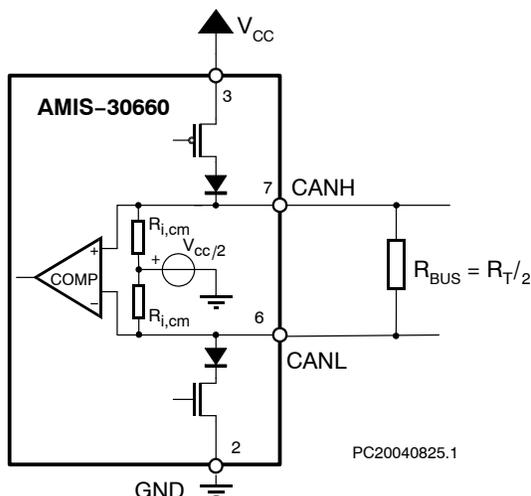


Figure 1. Equivalent Schematic in Recessive State

The power dissipation for the different bus-error conditions is given in Table 1.

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	$P \approx \frac{V_{CC}^2}{2R_{i,cm}}$	$P \approx \frac{2(V_{BAT} - V_{CC}/2)^2}{2R_{i,cm}}$

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. Figure 2 illustrates the equivalent schematic.

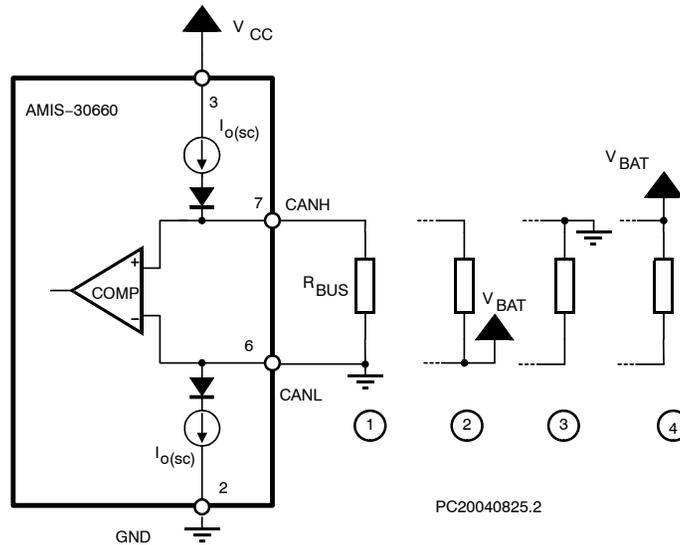


Figure 2. Equivalent Schematic in Dominant State

The power dissipation for the different bus-error conditions is given in Table 3.

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

Bus	Short To	
	GND	V <sub>BAT</sub>
CANL	See Figure 2 Case (1) Bus Communication Possible but with Bit Timing Limitations	See Figure 2 Case (2) Both CANL/CANH are on V <sub>BAT</sub> Level through R <sub>BUS</sub> → No Communication Possible Time-Out by Master
	$P = \frac{(V_{CC} - V_{O(dom)CANH})^2}{R_{BUS}}$	$P = V_{BAT} \cdot I_{O(sc)}$
CANH	See Figure 2 Case (3) Both CANL/CANH are on GND Level through R <sub>BUS</sub> → No Communication Possible Time-Out by Master	See Figure 2 Case (4) Bus Communication Possible but with Bit Timing Limitations
	$P = V_{CC} \cdot I_{O(sc)}$	$P = V_{BAT} \cdot I_{O(sc)} - R_{BUS} \cdot I_{O(sc)}^2$

Calculated for V<sub>CC</sub> = 5 V, V<sub>BAT</sub> = 24 V, R<sub>BUS</sub> = 60 Ω, I<sub>O(SC)</sub> = 120 mA and V<sub>O(dom)CANH</sub> = 3.6 V yields in:

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

Bus	Short To	
	GND	V <sub>BAT</sub>
CANL	108 mW	2.88 W (Note 1)
CANH	350 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<sub>BAT</sub> 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 .

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 two layer PCB R<sub>th(vj-a)</sub> < 100 K/W is expected. Calculating with 100 K/W yields in a worst case expected temperature increase of 101°C.

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