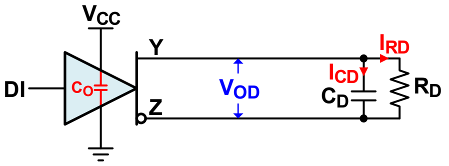
RS-422 Drivers

Calculating the Power Dissipation

Abstract

This tech brief explains how to calculate the power dissipation of an RS-422 driver under a load condition. Figure 1 shows the simplified system block diagram together with the associated system parameters.



$V_{CC\text{-}typ}$	3.3V
$I_{CC\text{-}max}$ (no load)	0.8mA = 0.2mA/Channel
C_O	250pF/Channel
R_L	100Ω
C_L	50pF
$V_{OD\text{-}min}$ at 100Ω	2.0V
DR	20Mbps ≡ 10MHz

Figure 1. System Block Diagram and System Parameters

The total power dissipation is determined by calculating the individual power components for DC and AC under a no-load condition, followed by the calculations for the internal power consumption of the driver when only driving R_D, and when only driving C_D. The sum of these power components yields the total power dissipation of the driver.

Note: The index TX stands for a transmitter.

1. Driver DC Power Dissipation (no load)

The DC power consumption of the driver is the product of the maximum supply current per driver with no load, and the nominal supply voltage, V_{CC}:

(EQ. 1) $$P_{TX-DC} = I_{CC} \cdot V_{CC} = 0.2\text{mA} \cdot 3.3\text{V} = 0.66\text{mW}$$

2. Driver AC Power Dissipation (no load)

The AC power consumption of the driver with no load equals the power dissipation of a capacitor, P_C = C·V2·f. In this case, the capacitor is the combined parasitic capacitance of the driver output stage, C_O. C_O has been measured with 250pF, representing a good average value for a wide range of RS-422 and RS-485 drivers. Voltage (V) is the nominal supply voltage, and frequency (f) represents the ideal case of a high-low sequence of data bits, therefore resembling a data clock, with a frequency half the data rate: f = DR/2. Therefore, a data rate of 20Mbps translates into a 10MHz clock frequency.

(EQ. 2) $$P_{TX-AC} = C_O \cdot V_{CC}^2 \cdot f = 250\text{pF} \cdot 3.3\text{V}^2 \cdot 10\text{MHz} = 27.2\text{mW}$$

3. Driver Power Dissipation when Driving R_D Only

When driving the termination resistor, R_D, driver internal voltage drops occur from V_{CC} to the Y output and from the Z output to GND, while the differential output voltage, V_{OD}, of the driver drops across R_D. The internal voltage drops (V_{TXD} = V_{CC} - V_{OD}) accompanied by the current through the termination resistor (I_{RD} = V_{OD}/R_D) causing another internal power dissipation:

(EQ. 3) $$P_{TX-RD} = V_{TXD} \cdot I_{RD} \quad \text{with} \quad V_{TXD} = V_{CC} - V_{OD} \quad \text{and} \quad I_{RD} = V_{OD}/R_D$$

(EQ. 4) $$P_{TX-RD} = (V_{CC} - V_{OD})V_{OD}/R_D = (3.3V - 2V) \cdot 2V/100\Omega = 26mW$$

4. Driver Power Dissipation when Driving C_D Only

Likewise, when driving the load capacitance (C_D), the driver internal voltage drops ($V_{TXD} = V_{CC} - V_{OD}$) accompanied by the current through the load capacitance ($I_{CD} = C_D \cdot V_{OD} \cdot f$) causing internal power dissipation.

(EQ. 5) $$P_{TX-CD} = V_{TXD} \cdot I_{CD} \quad \text{with} \quad V_{TXD} = V_{CC} - V_{OD} \quad \text{and} \quad I_{CD} = C_D \cdot V_{OD} \cdot f$$

(EQ. 6) $$P_{TX-CD} = (V_{CC} - V_{OD})C_D \cdot V_{OD} \cdot f = (3.3V - 2V) \cdot 50pF \cdot 2V \cdot 10MHz = 1.3mW$$

5. Total Power Dissipation of the Driver

The total power consumption of the driver is the sum of the individual power consumptions previously calculated.

(EQ. 7) $$P_{TX} = P_{TX\text{-}DC} + P_{TX\text{-}AC} + P_{TX\text{-}RD} + P_{TX\text{-}CD} = (-0.66 + 27.2 + 26 + 1.3)mW = 55.2mW$$

6. Total Power Dissipation of the Channel

To ensure enough drive capability for the voltage regulator of the system, the power dissipation of the load (P_{LD}) that is the sum of the power dissipation of the termination resistor (P_{RD}) and the load capacitance (P_{CD}) must be considered:

(EQ. 8) $$P_{RD} = V_{OD-min}{}^2 / R_D = 2V^2/100\Omega = 40mW$$

and

(EQ. 9) $$P_{CD} = C_D \cdot V_{OD}{}^2 \cdot f = 50pF \cdot 2V^2 \cdot 10MHz = 2mW$$

Therefore, the power dissipation of the load is: $P_{LD} = P_{RD} + P_{CD}$ = 42mW and that of the entire channel is $P_{CH} = P_{TX} + P_{LD}$ = 97.2mW.

7. Conclusion

The previous calculations also hold true for RS-485 drivers. Except here V_{OD-min} = 1.5V and R_D = 54Ω.

8. Revision History

Rev.	Date	Description
1.00	Mar.24.20	Initial release

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