

UTMC APPLICATION NOTE

UT63M1XX: POWER CONSUMPTION VS. DISSIPATION

INTRODUCTION

The monolithic UT63M1XX Series Bus Transceivers are complete transmitter and receiver pairs conforming fully to MIL-STD-1553A and B. Transceivers provide the electrical bus interface for subsystems to the MIL-STD-1553 bus. MIL-STD-1553 specifies the data bus signal's wave shape, amplitude, frequency, and power.

This application note will discuss the power consumption and dissipation of the bus transceiver as it transmits signals on the MIL-STD-1553 data bus. Specifically it will differentiate between power consumed by the bus interface (i.e., system power) versus power dissipated within the transceiver. For system designers addressing system power consumption and the sizing of power supplies, the power consumption of the bus interface (transceiver plus load) is important. Transceiver power dissipation is important for evaluating the reliability and thermal characteristics of the transceiver. This document will present examples of calculating the power dissipation and consumption for a direct-coupled transceiver transmitting onto the MIL-STD-1553 data bus.

System Power Consumption

System power consumption is defined as the power consumed by the device plus load. UTMC's UT63M1XX Bus Transceiver data sheet specifies the maximum current per voltage supply including load. To obtain the system power consumption the voltage is multiplied by the AC current. Figure 1 shows an example of the power the transceiver consumes while driving the bus.

For sizing power supplies and characterizing system current requirements, no differentiation between power consumption and dissipation is necessary.

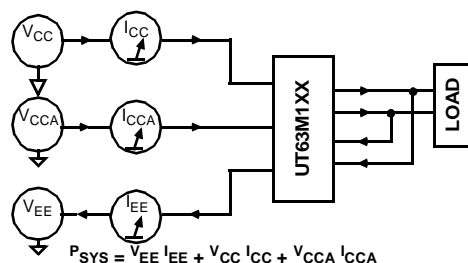


Figure 1. System Power Consumption

Transceiver Power Dissipation

Transceiver power dissipation defines the power dissipated in the device while the transceiver drives the bus load. Power supplies V_{CC} and V_{CCA} dissipate essentially all of their supplied power within the transceiver device. A small amount of the V_{CC} power is dissipated at the receiver output load but is negligible compared to the transmitter output. Therefore the power dissipated by these supplies (V_{CC} , V_{CCA}) is equal to the power consumed by these supplies.

$$\begin{aligned} P_D(V_{CC}) &= I_{CC} \times V_{CC} = 60\text{mA} \times 5\text{V} = 300\text{mW} \\ P_D(V_{CCA}) &= I_{CCA} \times V_{CCA} = 10\text{mA} \times 15\text{V} = 150\text{mW} \\ *P_D(V_{CCA}) &= I_{CCA} \times V_{CCA} = 10\text{mA} \times 5\text{V} = 50\text{mW} \end{aligned}$$

*Note : +5 and -15 volt operation (i.e., $V_{CCA} = V_{CC}$)

The power supplied by the negative source (V_{EE}) is consumed by both the load and the transceiver output stage. To calculate the power dissipated within the transceiver, perform a best- and worst-case analysis. MIL-STD-1553 specifies the output voltage level (V_O) and load impedance (Z_O) for the direct-coupled transceiver (± 15 volt version) shown in figure 2.

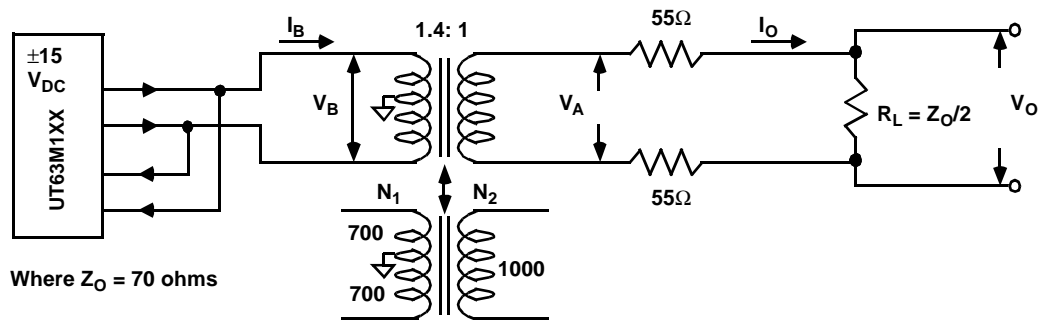


Figure 2. Transceiver Power Dissipation

The following calculations are performed on the circuit using these MIL-STD-1553B specification limits:

$$V_O = 6V_{P.P.} \text{ (min)} \quad 9V_{P.P.} \text{ (max)}$$

$$Z_O = 70 \text{ ohms} \quad 70 \text{ ohms}$$

For an ideal transformer the following equations are written for voltage and current:

$$V_B = (N_1/N_2)V_A/2 \quad \text{where } N_1/N_2 = .70$$

$$I_B = (N_2/N_1)I_O/2 \quad \text{where } N_2/N_1 = 1.43$$

Using the above limits the voltage and current supplied by the transceiver are calculated for a single-ended 1MHz cycle.

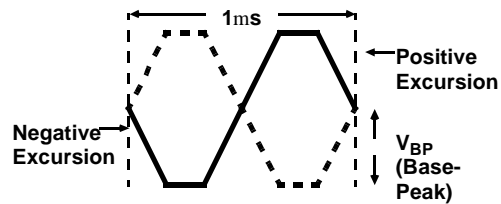


Figure 3. Single-Ended Waveform ($V_B = 4 V_{BP}$)

Negative Excursion:

$$V_O = 6V_{P.P.} \text{ L-L (p.p, Peak-Peak), (L-L, Line-Line)}$$

$$Z_O = 70 \text{ ohms}$$

$$I_O = 171\text{mA}/2 = 85\text{mA}$$

$$V_A = 4 \times V_O = 24V_{P.P.} \text{ L-L}$$

$$V_{BP} = (N_1/N_2)V_A/2 = 8.4$$

$$I_B = I_O \times 1.43 = 122\text{mA}$$

$$DV_{BP} = (V_{EE} - V_{BP}) = (6.6 \text{ V})$$

$$P_D = DV_{BP} \times I_B = 805\text{mW}$$

Where: V_{BP} = the voltage V_B measured base to peak

DV_{BP} = the voltage imposed across the transceiver

P_D = power dissipated in the transceiver due to the loading of the output (negative excursion)

$$V_O = 9V_{P.P.} \text{ L-L (p.p, Peak-Peak), (L-L, Line-Line)}$$

$$Z_O = 70 \text{ ohms}$$

$$I_O = 257\text{mA}/2 = 128\text{mA}$$

$$V_A = 4 \times V_O = 36V_{P.P.} \text{ L-L}$$

$$V_{BP} = (N_1/N_2)V_A/2 = 12.6$$

$$I_B = I_O \times 1.43 = 184\text{mA}$$

$$\Delta V_{BP} = (V_{EE} - V_{BP}) = (2.4 \text{ V})$$

$$P_D = \Delta V_{BP} \times I_B = 441\text{mW}$$

Positive Excursion:

$$V_{BP} = 8.4\text{V}$$

$$R_{IL} = 14\text{Kohms (internal resistor)}$$

$$I_L = 600\text{mA}$$

$$P_R = 5\text{mW}$$

Where: P_R = power dissipated in the transceiver (positive excursion)

$$V_{BP} = 12.6\text{V}$$

$$R_{IL} = 14\text{Kohms (internal resistor)}$$

$$I_L = 900\text{mA}$$

$$P_R = 11.3\text{mW}$$

Single-Ended Power Dissipation:

$$P_T = P_D + 2P_R$$

$$P_T = 805\text{mW} + 10\text{mW} = 815\text{mW}$$

$$P_T = P_D + 2P_R$$

$$P_T = 441\text{mW} + 22.6\text{mW} = 463.6\text{mW}$$

Blocking Diode:

$$P_D(V_D) = V_D \times I_O = .9 \times 122\text{mA} = 109\text{mW}$$

The minus supply (V_{EE}) also supplies power that is dissipated within bias circuitry and is not included with the output power dissipation. That power is defined as:

$$P_D(\text{bias}) = 40\text{mA} \times 15\text{V} = 600\text{mW}$$

Therefore:

$$P_D(V_{EE}) = P_D(\text{total}) + P_D(\text{bias})$$

The total power dissipated in transceiver (worst-case) for a complete cycle is as follows:

$$\begin{aligned} P_{CD} &= P_D(V_{EE}) + P_D(V_{CC}) + P_D(V_{CCA}) + P_D(V_D) \\ &= (.815\text{W} + .60\text{W}) + .30\text{W} + .15\text{W} + .109\text{W} \\ &= 1.974\text{W} \end{aligned}$$

$$\begin{aligned} *P_{CD} &= P_D(V_{EE}) + P_D(V_{CC}) + P_D(V_{CCA}) + P_D(V_D) \\ &= (.815\text{W} + .60\text{W}) + .30\text{W} + .05\text{W} + .109\text{W} \\ &= 1.874\text{W} \end{aligned}$$

*Note : +5 and -15 volt operation (i.e., $V_{CCA} = V_{CC}$)

Duty Cycle

Figure 4 shows transceiver power dissipation during various duty cycles. While receiving information from the bus the power dissipation is low (i.e., idle state); the receiver section of the device is active and the transmitter is inactive. When

transmitting information onto the data bus the transceiver power dissipation increase is proportional to the transmission time. Table 1 shows a breakdown of duty cycle vs. message length.

Message	Word Count	Idle	Transmitting
Receive	32	97%	3%
Receive	1	97%	3%
Transmit	32	3%	97%
Transmit	1	94%	6%

* The above calculations are based on time period $t = 680\text{ms}$

CONCLUSION

Calculation of the worst-case power dissipation for the transceiver while it transmits information onto the MIL-STD-1553 data bus is straightforward. Use the same analysis method to determine power dissipation for a transformer-coupled stub and for the various voltage versions of the UT63M1XX Transceiver.

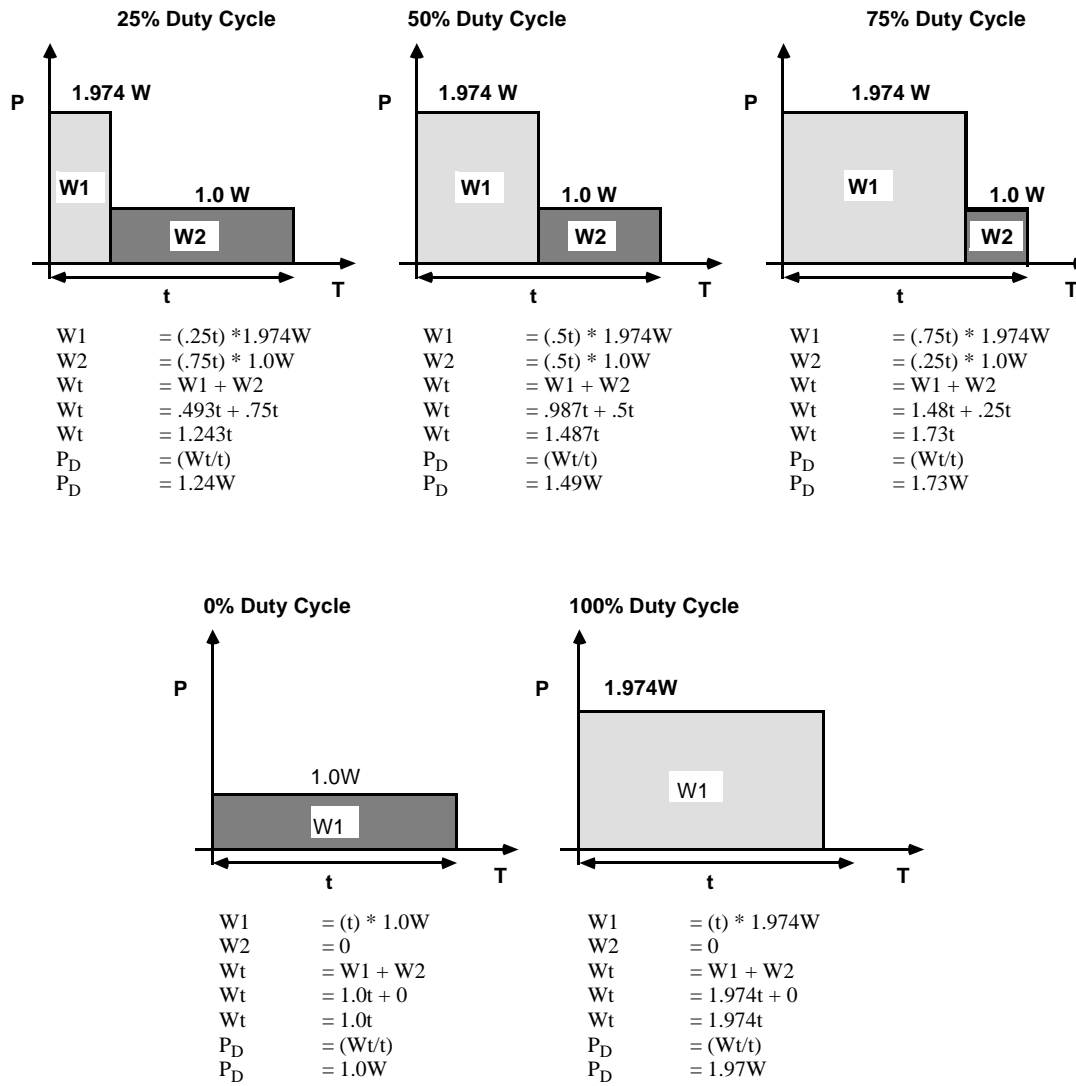


Figure 4. Duty Cycle Calculation