Power Measurement of Ethernet Physical Layer Products

National Semiconductor
Application Note 1540
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September 2007

1.0 Introduction

System designers require accurate component power consumption specifications, for the purposes of thermal management, component selection, and power distribution planning.

National Semiconductor Ethernet product datasheets provide data which accurately reflects power consumption in typical network applications.

This application note details the key factors that influence power consumption, and explains how they affect this important parameter.

The degree to which these factors affect power consumption is demonstrated by presenting power consumption data for the DP83848 under a variety of operating conditions.

This application note is applicable to the following products:

DP83848C	DP83849C
DP83848I	DP83849I
DP83848YB	DP83849ID
DP83848M	DP83849IF
DP83848T	DP83640
DP83848H	
DP83848J	
DP83848K	

Although the data presented in this document is specific to the DP83848 device, the methodologies and general conclusions also apply to other PHYTER products listed above.

2.0 Recommendations

The principal factor influencing power consumption is the current demand from the signal termination and center-tap biasing on the component side of the isolation transformer. In this test the termination and bias current represents up to 65% of the total current required.

The data also demonstrates that environmental variations can result in power demand changes of up to +/-19% from typical power consumption specifications. Among environmental factors that affect power consumption, supply voltage has the most dramatic effect (about +/-11%), while temperature variation has the least effect (less than +/-1%).

3.0 Power Consumption Factors

Factors that influence power consumption measurement include signal termination and isolation transformer center-tap bias current, the operational mode configured, packet data payload, I/O pin loading, and environmental conditions.

3.1 TERMINATION AND BIAS CURRENT

An isolation transformer is commonly used at the Ethernet physical layer to provide electrical isolation between the cable and the device and significantly reduce the common mode voltage seen by the receiver. The resistive termination and transformer center-tap bias current is important because it comprises a large percentage of the total current demand during normal operation. Component specifications that do not include termination and bias current fail to provide designers with adequate operating information for power budget planning.

3.2 OPERATIONAL CONFIGURATION

Operating configurations that influence power consumption include data rate, disconnected configuration, and power down configuration.

Data rate influences power demand through variations in the signaling (data coding, voltage and operating frequency) used for 10 Base-T and 100 Base-Tx operation.

10Mb data is comprised of +/-2.5 Volt pulses, operating at frequencies of 5 MHz and 10 MHz. 100Mb data is comprised of +/-1 Volt signals, operating at a frequency of 125 MHz. Refer to *Figure 1* for typical waveforms.

A physical layer device is disconnected when the receive signals are not connected or linked to a transmitting network signal source. In typical applications, Auto-Negotiation is enabled when a device is disconnected.

When the network interface is not active, the physical layer component can be placed in a power down mode either manually or automatically (using the Energy Detect feature), which results in minimal current demand. (See individual product datasheets for details regarding Power Down and Energy Detect features.)

3.3 TRAFFIC PAYLOAD

Network traffic payload is also a factor, in both traffic density and data content. Traffic density is maximized when maximum size packets are transmitted and received, utilizing minimum interframe gaps between packets. Traffic content that maximizes I/O data transitions also increases power consumption.

3.4 DIGITAL I/O PIN LOADING

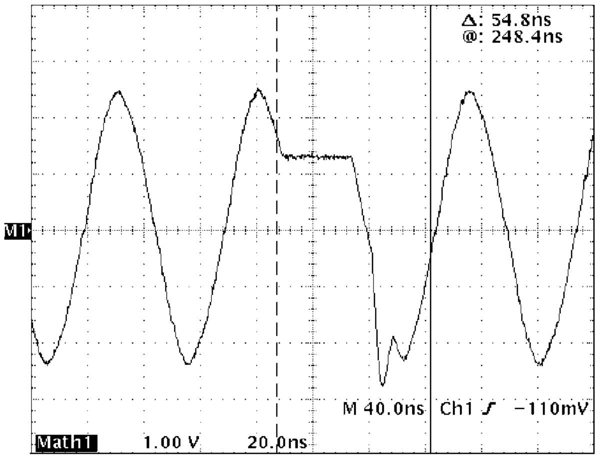
Digital output pins include clock output pins, general-purpose output pins, and MII digital output pins. Load impedance on digital I/O's can have a dramatic influence on power consumption. For example, 6 digital outputs driving 5 pF loads at 25 MHz can result in a current demand of 15 mA in a typical application. Power demand can be reduced by making MII signal traces as short as possible, and by adding series termination to the MII output signals. Some PHYTER products include integrated digital output series resistance; refer to specific datasheets for details.

3.5 ENVIRONMENTAL CONDITIONS

Ambient temperature is also an environmental factor that influences power consumption.

High ambient temperatures increase current demand, while low temperatures decrease current demand when compared to typical 25 °C. ambient conditions.

Temperature has the least amount of influence on total power consumption because PHYTER products are designed to internally compensate temperature variations.



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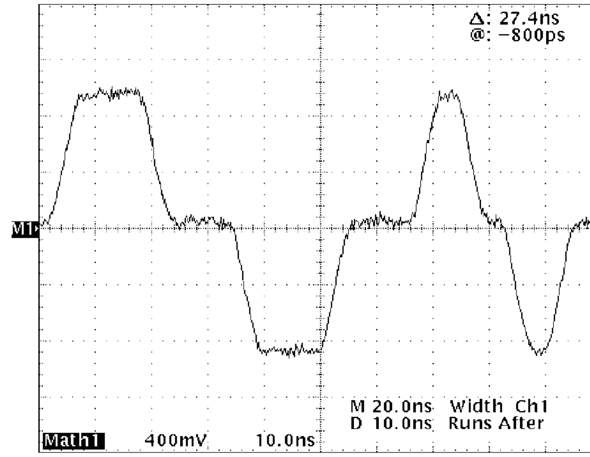
10Mb Waveform



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100Mb Waveform

FIGURE 1. Typical Waveforms

4.0 Power Consumption Data

Power consumption data was measured on several DP83848 devices that were populated in a system representing a typical end user application. Data was measured under a variety of conditions. The average results of these measurements are presented below.

Data is presented based on four basic configuration modes: power down mode (no data), Auto-Negotiation enabled disconnect mode (no data), 10MBit full duplex data mode, and 100Mbit full duplex data mode.

For each mode, the first row of data represents current demand for a typical baseline configuration using nominal environmental conditions and a medium size packet (787 bytes) with an incrementing byte count data payload, if applicable. The second and third rows of data represent highest and lowest current consumption conditions. Following these worst and best case condition data points, individual conditions are varied against the baseline condition.

The first set of five columns detail scenario and environmental conditions, including Vcc supply voltage, temperature, packet length, and packet payload data pattern. The next four columns provide actual current measurement data. These measurements are chip current excluding termination and center-tap current ($I_{\overline{CT}}$), termination and center-tap bias current (I_{CT}), total current (I_{Tot}), and the percentage of the total current utilized by the termination and center-tap bias current. The next column shows the total system power utilized (I_{Tot} * Vcc). The final four columns illustrate how much the current and power demand varies when compared to the initial baseline conditions.

4.1 POWER DOWN DATA

Table 1 shows typical DP83848 power down mode current consumption. Notice that even under power down conditions, center-tap current demand can represent up to ~6% of total current demand for the device. Also, notice that Vcc supply variation has the largest impact on overall current consumption.

TABLE 1. DP83848 Power Down Mode Current Demand

Scenario	Vcc (V)	Temp. (°C)	Data Length (bytes)	Data Pattern	$I_{\overline{CT}}$ (mA)	I_{CT} (mA)	I_{Tot} (mA)	I_{CT} (%)	P (mW)	Delta from Baseline			
										I_{Tot} (mA)	P (mW)	I_{Tot} (%)	P (%)
Baseline	3.3	25	N/A	N/A	6.90	0.43	7.34	5.9	24.22	0.00	0.00	0.0	0.0
Worst Case	3.6	85	N/A	N/A	7.43	0.52	7.95	6.6	28.61	0.61	4.40	8.3	18.2
Best Case	3.0	0	N/A	N/A	6.73	0.43	7.16	6.0	21.48	-0.18	-2.73	-2.4	-11.3
High Voltage	3.6	25	N/A	N/A	7.30	0.52	7.82	6.6	28.14	0.48	3.93	6.5	16.2
Low Voltage	3.0	25	N/A	N/A	6.76	0.43	7.19	6.0	21.56	-0.15	-2.65	-2.1	-11.0
High Temp.	3.3	85	N/A	N/A	7.06	0.43	7.48	5.7	24.70	0.15	0.48	2.0	2.0
Low Temp.	3.3	0	N/A	N/A	6.71	0.48	7.19	6.6	23.72	-0.15	-0.49	-2.0	-2.0

4.2 DISCONNECT DATA WITH AUTO-NEGOTIATION ENABLED

Table 2 shows typical current consumption required for the DP83848 in disconnect mode with Auto-Negotiation enabled. Notice that center-tap current demand represents ~50% of the total current demand for the device in this mode. Also, notice that Vcc variation continues to have the largest impact on overall current consumption.

TABLE 2. DP83848 Disconnect Mode Current Demand

Scenario	Vcc (V)	Temp. (°C)	Data Length (bytes)	Data Pattern	$I_{\overline{CT}}$ (mA)	I_{CT} (mA)	I_{Tot} (mA)	I_{CT} (%)	P (mW)	Delta from Baseline			
										I_{Tot} (mA)	P (mW)	I_{Tot} (%)	P (%)
Baseline	3.3	25	N/A	N/A	42.14	44.47	86.61	51.3	285.81	0.00	0.00	0.0	0.0
Worst Case	3.6	85	N/A	N/A	43.48	45.02	88.49	50.9	318.58	1.88	32.77	2.2	11.5
Best Case	3.0	0	N/A	N/A	40.70	44.16	84.87	52.0	254.60	-1.74	-31.21	-2.0	-10.9
High Voltage	3.6	25	N/A	N/A	43.17	44.51	87.68	50.8	315.64	1.07	29.83	1.2	10.4
Low Voltage	3.0	25	N/A	N/A	40.91	44.38	85.29	52.0	255.87	-1.32	-29.94	-1.5	-10.5
High Temp.	3.3	85	N/A	N/A	42.51	44.87	87.38	51.4	288.37	0.78	2.56	0.9	0.9
Low Temp.	3.3	0	N/A	N/A	41.77	44.19	85.96	51.4	283.67	-0.65	-2.14	-0.7	-0.7

4.3 10 BASE-T FULL DUPLEX OPERATING MODE DATA

Table 3 shows DP83848 10Mb full duplex operating mode current consumption. Notice that center-tap current demand represents up to 66% of the total current demand for the device. Notice that Vcc variation continues to have a large impact on overall current consumption. Data payload content and packet size also have more impact on current consumption than temperature variation.

TABLE 3. 10 Base-T Mode Current Demand

Scenario	Vcc (V)	Temp. (°C)	Data Length (bytes)	Data Pattern	$I_{\overline{CT}}$ (mA)	I_{CT} (mA)	I_{Tot} (mA)	I_{CT} (%)	P (mW)	Delta from Baseline			
										I_{Tot} (mA)	P (mW)	I_{Tot} (%)	P (%)
Baseline	3.3	25	787	Incrementing byte	31.84	60.43	92.27	65.5	304.49	0.00	0.00	0.0	0.0
Worst Case	3.6	85	1514	0F	33.37	61.55	94.92	64.8	341.73	2.65	37.23	2.9	12.2
Best Case	3.0	0	60	AA	30.38	52.34	82.73	63.3	248.19	-9.54	-56.31	-10.3	-18.5
High Voltage	3.6	25	787	Incrementing byte	32.80	60.64	93.44	64.9	336.39	1.17	31.89	1.3	10.5
Low Voltage	3.0	25	787	Incrementing byte	31.14	60.40	91.54	66.0	274.63	-0.73	-29.86	-0.8	-9.8
Worst Data	3.3	25	787	0F	32.26	60.66	92.92	65.3	306.64	0.65	2.14	0.7	0.7
Best Data	3.3	25	787	AA	31.06	59.88	90.93	65.8	300.08	-1.34	-4.41	-1.4	-1.4
Maximum Packet Size	3.3	25	1514	Incrementing byte	31.78	60.82	92.60	65.7	305.59	0.33	1.09	0.4	0.4
Minimum Packet Size	3.3	25	60	Incrementing byte	31.53	53.02	84.55	62.7	279.01	-7.72	-25.48	-8.4	-8.4
High Temp.	3.3	85	787	Incrementing byte	32.14	60.77	92.91	65.4	306.60	0.64	2.10	0.7	0.7
Low Temp.	3.3	0	787	Incrementing byte	31.81	60.25	92.05	65.4	303.77	-0.22	-0.72	-0.2	-0.2

4.4 100 BASE-TX FULL DUPLEX OPERATING MODE DATA

Table 4 shows DP83848 100 Base-Tx full duplex operating mode current consumption requirements. Notice that this mode requires less current when compared to 10 Base-T mode, predominantly due to decreased center-tap current demand. The use of data pattern scrambling in 100 Base-Tx mode requires less center-tap current. Notice that data payload content and Vcc variation have the largest impact on overall current consumption, while packet size and temperature variation have a lesser impact.

TABLE 4. 100 Base-Tx Operating Mode Current Demand

Scenario	Vcc (V)	Temp. (°C)	Data Length (bytes)	Data Pattern	$I_{\overline{CT}}$ (mA)	I_{CT} (mA)	I_{Tot} (mA)	I_{CT} (%)	P (mW)	Delta from Baseline			
										I_{Tot} (mA)	P (mW)	I_{Tot} (%)	P (%)
Baseline	3.3	25	787	Incrementing byte	44.86	44.42	89.29	49.8	294.65	0.00	0.00	0.0	0.0
Worst Case	3.6	85	1514	0F	48.90	44.97	93.87	47.9	337.93	4.58	43.28	5.1	14.7
Best Case	3.0	0	1514	AA	41.20	44.07	85.27	51.7	255.81	-4.02	-38.84	-4.5	-13.2
High Voltage	3.6	25	787	Incrementing byte	46.26	44.52	90.77	49.0	326.79	1.49	32.14	1.7	10.9
Low Voltage	3.0	25	787	Incrementing byte	43.58	44.37	87.96	50.4	263.87	-1.33	-30.78	-1.5	-10.4
Worst Data	3.3	25	787	0F	46.85	44.44	91.28	48.7	301.24	2.00	6.59	2.2	2.2
Best Data	3.3	25	787	AA	42.40	44.47	86.87	51.2	286.66	-2.42	-7.99	-2.7	-2.7
Maximum Packet Size	3.3	25	1514	Incrementing byte	45.08	44.38	89.46	49.6	295.22	0.17	0.57	0.2	0.2
Minimum Packet Size	3.3	25	60	Incrementing byte	43.86	44.46	88.33	50.3	291.48	-0.96	-3.17	-1.1	-1.1
High Temp.	3.3	85	787	Incrementing byte	45.39	44.87	90.26	49.7	297.86	0.97	3.21	1.1	1.1
Low Temp.	3.3	0	787	Incrementing byte	44.68	44.21	88.89	49.7	293.34	-0.40	-1.31	-0.4	-0.4

4.5 TRANSMIT LOADING CONDITION DATA

MII digital output pin loading is not typically a parameter that varies during normal operation. However, it can have a significant effect of power consumption. For example, when operating in a baseline 100Mb data mode, a device that has 50 ohm series digital output termination and is connected to a data source through a 0.3 meter shielded twisted pair MII cable requires 96.3 mA current. A typical condition where these same 50 ohm terminated digital pins are directly connected to a digital data device requires 89.29 mA. This represents a 7.9% increase in current demand when the MII cable is used.

5.0 Summary

The data presented above clearly illustrates the effect operating conditions can have on device current demand.

It has been shown that signal termination and transformer center-tap bias current demand is an integral part of the overall current demand for the physical layer interface, and represents a substantial percentage of the total current demand.

It has also been demonstrated that 10 Base-T mode represents the most demanding operational mode from a current consumption standpoint. In all modes, Vcc supply voltage has the most dramatic effect on power demand, followed by data payload content, data packet length, and temperature.

It is also important to note that digital output pin loading can have a considerable effect on current consumption.

Notes

Notes

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