Power consumption of LVPECL and LVDS

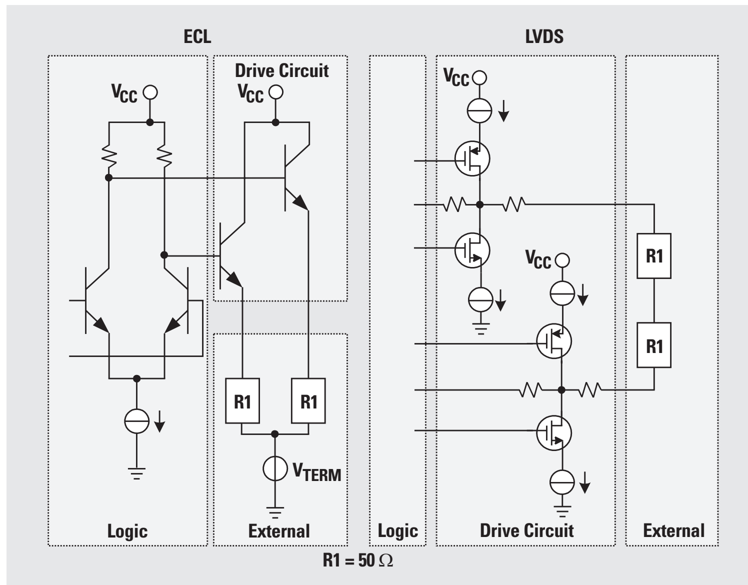
By Chris Sterzik
Applications Specialist, Interface Products

Introduction

Single-ended emitter-coupled logic (ECL) has been in existence for over 30 years and is a proven high-speed technology. More recently, differential ECL has been introduced along with the variants of positive ECL (PECL) and low-voltage PECL (LVPECL). The common feature of all these devices is high signaling rates. ECL and its variants use bipolar technology to obtain these high data rates. The major benefit of bipolar technology is the relatively constant consumption of power over frequency, while a major cost of bipolar technology is the required termination.

Even more recent than the introduction of differential ECL is the TIA/EIA-644 introduction of LVDS. While the standard does not specify a technology, CMOS and BiCMOS are common implementations. CMOS technology is often generalized as being low-power and low-speed. While it is true that the power consumption of CMOS devices increases linearly with speed,[1-2] new technologies using LinBiCMOS, such as the Texas Instruments LVDS product line, provide the benefits of both high speed and low power consumption.

Figure 1. Models of ECL and LVDS output drivers and terminations



Power definition

Power, in the context of this document, is broken down into categories of external, drive circuit, and logic power, as shown in Figure 1. The external power consumption is simply the power consumed in the external termination. The drive circuit power is dissipated within the device and is a function of the output currents and the voltage drop across the driver circuit. The logic power is best described as the switch and bias power required by the IC.

The following discussion presents a theoretical approach to calculating the quiescent power dissipation for each of the categories. The devices being compared are LVPECL 1 to 10, LVDS 1 to 8 (SN65LVDS108), and LVDS 1 to 16 (SN65LVDS116) channel repeaters. Table 1 shows the values provided in the data sheets for the LVPECL and LVDS devices.

Logic power dissipation

The logic power dissipation includes quiescent and active power. The bipolar device consumes a significant amount of quiescent power but almost no active power; that is to say, the power consumption is expected to be constant over frequency. In contrast, the BiCMOS device consumes very little quiescent power, but more power is consumed as the frequency increases. Since no real insight is given about the bias structures or the switching nodes for either device, the 250 and 330 mW calculated from the LVPECL device parameters represents the quiescent logic power dissipation. This assumption is made because only I_{EE} is provided in the LVPECL parameters and not I_{CC}. The LVDS logic power is calculated by subtracting the drive circuit and external power from the total quiescent power dissipation of 205 mW and 264 mW in Table 1.

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Table 1. Data sheet power consumption

	LVPECL	LVPECL	SN65LVDS108	SN65LVDS116
V_{CC}	2.5 V	3.3 V	3.3 V	3.3 V
V_{EE}	GND	GND	NA*	NA*
I_{EE} (typical)	100 mA	100 mA	NA*	NA*
I_{CC} (typical)	Not given**	Not given**	62 mA	80 mA
Power	250 mW	330 mW	204.6 mW	264 mW

* NA = Not applicable. V_{EE} and I_{EE} are defined only on the LVPECL data sheet.
** I_{CC} is not provided in the LVPECL data sheet.

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Drive circuit dissipation

The drive circuit power consumption does not include power dissipated in the line or the termination. The active components of the circuit driver are also difficult to calculate from the data sheet. However, by using Figure 1 and Equations 1 and 2 (pp. 49 and 51 in Reference 2), the amount of quiescent power consumed in the output structures for both the LVDS and LVPECL repeaters can be calculated. Table 2 lists the output specifications and the calculated drive circuit dissipation.

External power dissipation

The external power consumption is assumed to have no active component, and any capacitive effects are negligible. The power loss through the media to the load is also considered to be negligible. Therefore, the only source of power dissipation is in the load and termination voltage. Table 3 shows the external power consumption obtained from Equations 3 and 4.

Table 2. Theoretical quiescent power consumption of driver circuit

	LVPECL 1:10	LVPECL 1:10	SN65LVDS108	SN65LVDS116
V_{CC}	2.5 V	3.3 V	3.3 V	3.3 V
R1	50 Ω	50 Ω	50 Ω	50 Ω
V_{OH} (typical)	1.48 V	2.28 V	1.41 V	1.41 V
V_{OL} (typical)	0.68 V	1.48 V	1.09 V	1.09 V
V_{TERM} (V_{CC}–2 V)	0 V*	1.3 V*	NA**	NA**
Power/channel	54.9 mW	26.5 mW	9.55 mW	9.55 mW
Number of channels	10	10	8	16
Total power	549 mW	265 mW	76.4 mW	152.8 mW

* V_{TERM} is the recommended data sheet value.
** NA = Not applicable. No termination voltage is required for LVDS.

Table 3. Calculated external power consumption

	LVPECL 1:10	LVPECL 1:10	SN65LVDS108	SN65LVDS116
V_{CC}	2.5 V	3.3 V	3.3 V	3.3 V
Power/channel	53.1 mW	50.0 mW	1.156 mW	1.156 mW
Number of channels	10	10	8	16
Total power	531 mW	500 mW	9.25 mW	18.5 mW

$$P_{ECL} = \frac{(V_{CC} - V_{OH})(V_{OH} - V_{TERM}) + (V_{CC} - V_{OL})(V_{OL} - V_{TERM})}{R1} \quad (1)$$

$$P_{LVDS} = R_B \times I^2 + R_A \times I^2 \quad (2)$$

$$I = \frac{(V_{OH} - V_{OL})}{2 \times R1}$$

$$R_B = \frac{(V_{CC} - V_{OH})}{I}; \quad R_A = \frac{(V_{OL} - V_{GND})}{I}$$

$$V_{GND} = 0\ V$$

$$P_{ECL} = \frac{(V_{OH} - V_{TERM})^2}{R1} + \frac{(V_{OL} - V_{TERM})^2}{R1} + V_{TERM}\left[\frac{(V_{OH} - V_{TERM})}{R1} + \frac{(V_{OH} - V_{TERM})}{R1}\right] \quad (3)$$

$$P_{LVDS} = \frac{(V_{OH} - V_{OL})^2}{2 \times R1} \quad (4)$$

Expected power dissipation of the LVPECL 1:10 repeater and LVDS repeaters

Figure 2 combines the quiescent power calculated from Tables 2 and 3 and uses the quiescent logic power of the LVPECL device and the total quiescent power of the LVDS devices in Table 1. The quiescent power consumption for the LVPECL device is much greater than that for the LVDS devices, even when only a 2.5-V V_{CC} is used. The only caveat is that this is quiescent power. While this is not significant for the bipolar LVPECL device, it is very significant for the CMOS devices, since the power consumption increases as a function of frequency. Figure 3 shows the expected power consumption of the three devices over frequency and extrapolated beyond the 622 Mbps maximum of the LVDS devices. The data over frequency is taken from the SN65LVDS108 and SN65LVDS116 data sheets, and the LVPECL device is assumed to be constant with no active power dissipation over frequency. With the data sheet values, the LVDS repeaters have an obvious power advantage over the LVPECL repeaters.

Figure 2. Expected quiescent power allocation

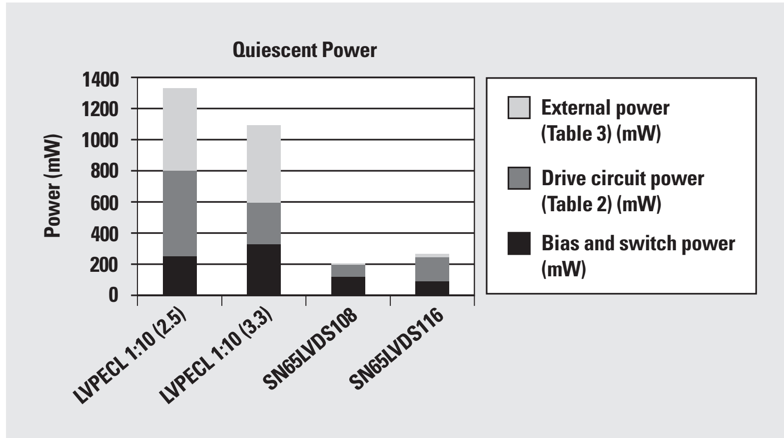
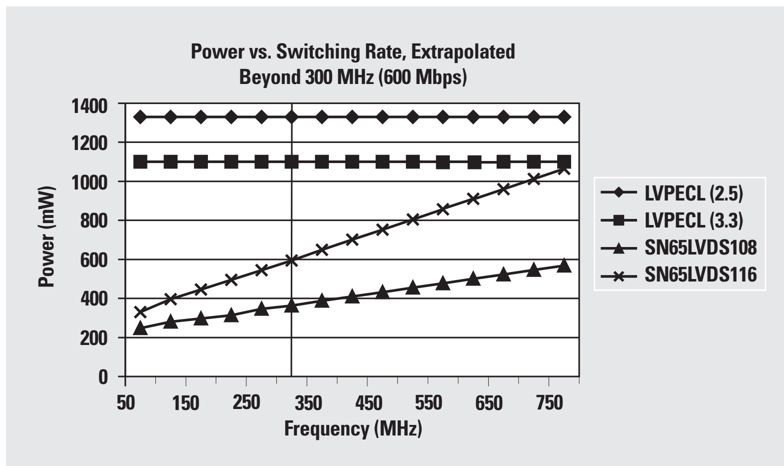


Figure 3. Expected power consumption over frequency



Conclusion

Actual results of the SN65LVDS116 and the LVPECL repeater are presented in Reference 5. The variances in the LVDS measurements with the expected values in Figure 3 are attributed to differences in the loads used; the values in Figure 3 are taken from the SN65LVDS116 and SN65LVDS108 data sheets, where the loads have a capacitive component. The differences between expected and measured values for the 2.5-V and 3.3-V LVPECL are 9.8% and 4.8%, respectively. While there is a variance between the results in Figure 3 and the actual measurements, the trends are the same and the LVDS device provides low-power performance over the LVPECL from 50 to 600 Mbps operation.

References

For more information related to this article, you can download an Acrobat Reader file at www-s.ti.com/sc/techlit/*litnumber* and replace *"litnumber"* with the **TI Lit. #** for the materials listed below.

Document Title	TI Lit. #
1. *High-Speed CMOS Data*, Data Book, DL129/D Rev. 7 (ON Semiconductor, March 2000).	—
2. Howard Johnson and Martin Graham, *High-Speed Digital Design, A Handbook of Black Magic* (Prentice-Hall PTR, 1993).	—
3. "SN65LVDS116 16-Port LVDS Repeater," Data Sheet	slls370
4. "SN65LVDS108 8-Port LVDS Repeater," Data Sheet	slls399
5. "LVPECL and LVDS Power Comparison," Application Report	slla103

Related Web sites

www.ti.com/sc/docs/products/analog/sn65lvds108.html
www.ti.com/sc/docs/products/analog/sn65lvds116.html

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