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GTLP: Understanding Output Drive

Abstract

Determining the performance of a device's output drive characteristics is a difficult yet important exercise. Standard specification methodology offers a cursory look into device drive performance, providing a single reference point to compare different technologies when trying to identify the correct drive in an application. The full range of performance of output drive can be evaluated with I_{OL} and I_{OH} plots of the output. This shows how much margin there is compared to the databook specification. It is important to remember that the I_{OL} and I_{OH} plots provide fully saturated drive capability, or, in other words, they best represent static drive capability. They also offer a view of the limitations of the driver when asked to perform in a dynamic drive mode. This application note clarifies the difference between static and dynamic drive, how to interpret databook specifications that try to explain device drive performance, and weighs the considerations for tradeoffs needed when determining drive needs.

Definitions

Static Output Drive

In general, static output drive is the current capacity of an output used to either maintain or change the voltage level on an output. An output that is static is not changing or switching and is thus trying to maintain a DC voltage level. Static output drive of a device is the measure of the current available at a steady state, non-switching output. Static drive is useful in applications that use resistive termination solutions.

Dynamic Output Drive

Dynamic output drive is best described as the output current available during the transition or switching of an output. Dynamic drive provides the switching strength necessary to overcome a loaded environment when changing the state of the output. The driving device must effectively transition from sinking to sourcing current or vice-versa. The dynamic drive strength of a device defines the switching speeds of a device in various applications.

Output Drive and Load Relationship

The output drive characteristics are directly related to the environment or load that the output sees during operation. Mismatched drive and load characteristics create added work for the designer who has to control signal integrity between devices. With too little drive there is a loss in V_{OH} or V_{OL} and with too much drive there is a risk of signal noise as a result of fast edge rates. The noise will reduce noise margins due to ringing, it will aggravate crosstalk, and the system as a whole may experience excessive electro-magnetic interference (EMI).

It is important to understand how the load looks during both static and dynamic operation modes. One way to view the load is as a resistive element. For static drive the load element is purely resistive, and for dynamic drive the load element is dynamic resistance or impedance. The dynamic load is made up of the resistive components of capacitive and inductive load elements due to the change of voltage and current over time. In this application note, these descriptions of load will be used in reference to output drive curves and load lines.

Drive Specifications

Static drive datasheet specifications (I_{OL}/I_{OH}) reflect the ability of an output to source or sink current. An output load is usually not a test condition in an (I_{OL}/I_{OH}) specification because the device and its technology are designed to operate in a number of different loading configurations. For technologies designed around a single output load configuration, the static drive specification can be optimized and guaranteed into that environment. Examples of these technologies include BTL, GTL and GTLP.

The data in Table 1 describe load dependent static drive specifications based on the recommended termination loads for each device technology. The calculated I_{OL} values use the maximum V_{OL} on a doubly terminated backplane.

TABLE 1. Load Dependent Drive Specifications

Device Technology	V_O (V)	V_T (V)	R_T (Ω)	I_{OL} (mA) (Note 1)
GTLP(Note 2)	0.65	1.5	25	**34**
GTL	0.40	1.2	25	**32**
BTL	1.10	2.1	19.5	**51**

Note 1: $I_{OL} = (V_{TT}–V_{OL})/R_T$

Note 2: GTLP16612 used for comparison purposes.

Technically, each of the technologies need only to guarantee the calculated I_{OL} in their respective DC drive specifications. In reality, each of the technologies have excess drive capacity to handle alternate backplane termination schemes.

When I_{OL} is measured without a termination load, the device will behave like and display only the characteristics of the device pull-down structure. The specified device performances are given in Table 2. The device I_{OL} can then be specified based on the device output characteristics versus the termination load in which it is expected to perform. A plot of the three technologies can be seen in Figure 1.

Drive Specifications (Continued)

TABLE 2. Device Dependent Drive Specifications

Device Technology	V_{CC} (V)	V_{OL} (V)	I_{OL} (mA) (Note 3)
GTLP(Note 2)	3.15/4.75	0.65	**40**
GTL	3.15/4.75	0.40	**40**
BTL	4.5	1.10	**80**

Note 3: I_{OL} = max current drive at max V_{OL} and min V_{CC}.

Determining the Drive Needed

One of the main features used to determine the correct fit in a system is the fundamental drive capability of a device. The static or dynamic nature of the drive in a device design determines its ability to function better in some systems than in others.

If, for example, the system is designed with a pull-up or pull-down termination, then it is important to account for DC (static) drive. During the time that the output drives a static load, the maximum current that the output supplies is an Ohm's Law calculation of the difference in potential across the equivalent static load resistance seen by the driver. Table 1 illustrates the calculation of I_{OL} drive needed to maintain the rated V_{OL}. The calculated I_{OL} or I_{OH} current can then be used to compare to datasheet specifications.

When determining the dynamic drive needed, it is important to look at the load environment. Since most environments demand a particular set of dynamic drive requirements, I_{OL} and I_{OH} curves can be used to effectively approximate the capability of the device to switch complex loads (represented by R, L, and C components). Figure 1 illustrates sample I_{OL} curves.

The device I_{OL} curve establishes the upper bounds of the envelope of current available for switching a complex load. The output load reduces the usable drive of a device; its characteristic can be drawn as a **load line**. The drive characteristics and load line characteristics can be mapped on the same plot to demonstrate the dynamic operating range of a device. The performance of a GTLP device in a 50Ω backplane environment has been plotted in Figure 2. The load line is 25Ω versus 50Ω because the driving device will usually see two 50Ω equivalent paths to ground making the parallel equivalent of a 25Ω load line.

The drawn load line will intersect at some point the device I_{OL} drive characteristics. The shaded area under the curve represents the available drive current in that application during a switching event from HIGH-to-LOW. The intersection of the load line and the device output drive represents the maximum drive current allowed to flow in that application. Given a fixed load line, better device drive performance will shift the intersection towards higher available dynamic drive and allow lower V_{OL} levels for static conditions. The intersection also represents the theoretical incident wave switching amplitude.

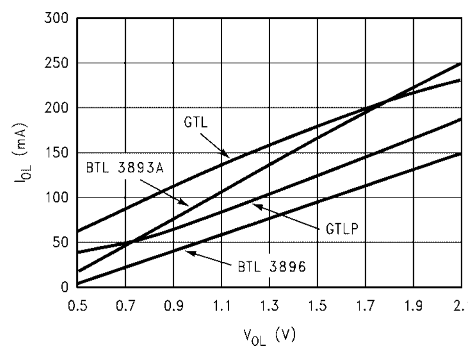

FIGURE 1. Typical Device I_{OL} Characteristics

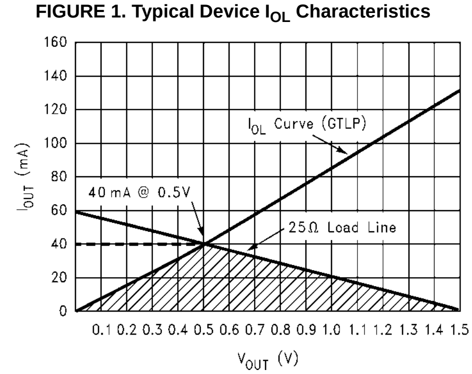

FIGURE 2. I_{OL} and Load Lines

Determining the Drive Needed (Continued)

When designing a backplane architecture, and the goal of the system is incident wave switching, it is important to consider the load line and drive curve relationship. Making trade-off decisions with backplane impedance, termination schemes and device driver technology will improve incident wave switching performance. Be sure to consider performance tradeoffs when optimizing backplane performance on incident wave switching.

Reducing the backplane characteristic impedance or opting for a higher current device driver increases the noise characteristics of overshoot and undershoot. The driver also exhibits fast edge rate characteristics that are a major culprit to system generated EMI. The optimum balance of these parameters governs the data rate performance of the backplane.

Conclusion

The complete answer for determination of drive needed in an application depends on the application. Determining the device drive needed is dependent on the load. It is important, especially in regard to cost savings, to work through the goals of the application and the calculations of drive needed before beginning to prototype. Simulations with device models in different load environments offer one of the best methods in determining the drive needed for complex loads.

Device datasheet specifications of static drive (I_{OL} and I_{OH}) help begin the search for the ideal driver. Drive curves of I_{OL} and I_{OH} play an important role in evaluation of device drive. They provide the device drive characteristics over a range of operation. With the use of load line curves, they can also reveal the static and dynamic performance of a driver in an ideal load environment.

Given these tools designers can make intelligent decisions when choosing which device technologies are needed for an evaluation in a system simulation. Modifications can be made to create that balance of system performance versus noise during simulation. Ultimately, device drive performance that is both strong enough for static loads and soft during switching events will make the best driver.