Lattice™ Semiconductor Corporation

Driving CMOS Inputs with GAL® Devices

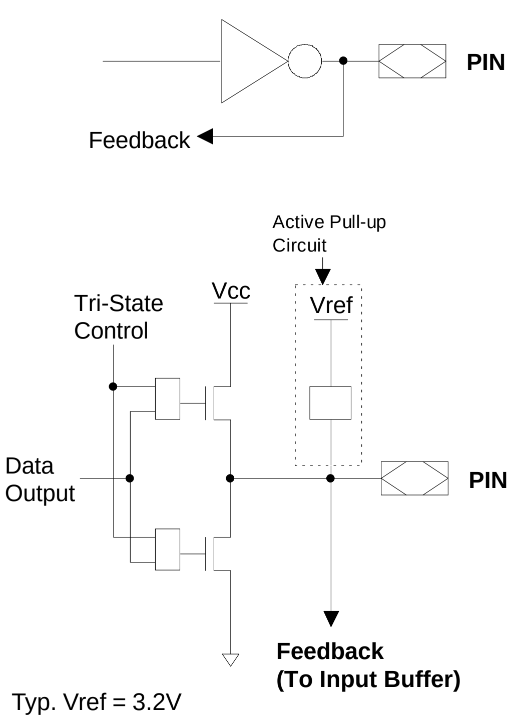
Introduction

While GAL devices do not have a true CMOS output structure, in most cases they are able to reliably drive CMOS inputs. GAL devices are designed with TTL-level input and output specifications. There are two reasons for this.

First, because GAL devices are as fast, or faster than the fastest equivalent bipolar devices, they are often used as bipolar replacements. While a design may initially be implemented with bipolar devices, often the designer has the opportunity to replace the bipolar device with the lower-power and better-tested GAL device. In these cases, the GAL device must drop into the same socket with identical functionality.

Second, switching noise is greatly reduced by using TTL-level outputs. Switching an output from Vcc to Ground will generate considerably more noise than switching from a TTL high to a TTL low.

Figure 1. Typical Output



NMOS Outputs

GAL devices use a NMOS output structure, which does not allow the output signal to go to the rail but still gives plenty of margin to TTL specs. The NMOS output structure also completely eliminates any possibility of latch-up.

Under typical conditions of room temperature and nominal Vcc, GAL devices will exhibit a V_{OH} of about 4.2 volts. This value will change somewhat with temperature, Vcc and normal process variations. Process and temperature are the most important factors, since they affect the amount of voltage drop between Vcc and the output pin. Therefore, the most valuable way to specify a V_{OH} value is to specify the difference between Vcc and V_{OH}. In this manner, a designer with greater control over Vcc can know exactly what the true worst-case V_{OH} value will be. The tables below show the V_{OH} values that can be expected under different conditions.

As the output voltage of the GAL device drops with Vcc, the input transition point of the CMOS devices being driven also drop.

Using pull-up resistors on the outputs of the GAL device helps to assure proper CMOS output levels. A 10 Kohm pull-up resistor will pull a GAL device's output to the rail. Of course the time required to do so depends on the total capacitance on the output pin, which includes the I/O capacitance of the GAL device output, the input capacitance of the devices being driven and the parasitic capacitances on the board.

As for the GAL16/20V8Z and GAL16/20V8ZD zero-power devices, the DC specification guarantee the CMOS output specification at I_{OH} of -100µA at V_{OH} of Vcc-1V. These devices will be able to drive CMOS inputs without the pull-up resistors on the output of the GAL devices.

Table 1. Commercial and Industrial Devices

Specification	Condition	Min. Value
V_{OH}	I_{OH} = -3.2 mA	2.4 V

Table 2. Military Devices

Specification	Condition	Min. Value
V_{OH}	I_{OH} = -2.0 mA	2.4 V

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