AND8101/D

Logic Level Translation, A Simple Approach

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APPLICATION NOTE

Many microcontrollers and DSPs need to operate at a very low voltage in order to conserve power and not overdissipate. Issues arise when the designer has a device such as a DSP operating at 1.8 volts and needs to interface with other semiconductors operating at 3.0 volts or more.

The problem stems from the output of the DSP only being capable of pulling up to its supply voltage. For nearly all CMOS devices, logic level high (V_{IH}) is guaranteed to be 70% of V_{CC}, and logic level low (V_{IL}) is 30%. If a device is operating at 1.8 volts, a no-load output can be expected to be 95% of V_{CC}, so the output will be ≈1.75 volts. This level of output cannot match a 3.0 V CMOS device.

Solutions

ON Semiconductor has many different gates, buffers, and inverter versions in the MiniGate™ VHC family that are low threshold or "T" versions. These products are designated as "MC74VHC1GT". The MiniGate VHC products are fabricated at 0.6 μm CMOS family of single gate and multigate devices. They offer good speed and low cost. We offer many devices available in the single gate family. The "T" version VHC devices are full/low voltage TTL compatible when operating at 5.0 volts, however, ON Semiconductor has fully characterized its VHC1GT MiniGate family at 3.0 volts as well.

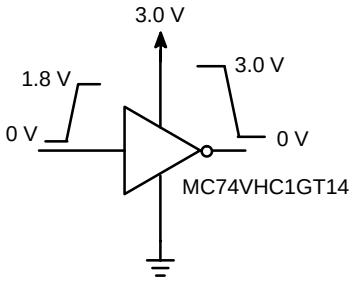

Figure 1.

Translation Low to High

Requires some sort of active device. A BRT or digital transistor might serve this function, however, the simplest solution possible is a gate or inverter/buffer that has low threshold. A logic device needs no external components, draws no current except during transition, and is many times faster than a single bipolar transistor. The CMOS gates and inverters are fabricated in silicon gate CMOS. They are quite fast (f_{MAX} > 75 MHz at 3.0 volts), require no external capacitors or resistors, and are now quite inexpensive. They are available as inverters, buffers, AND, NAND, OR, NOR, XOR, tri-state, and analog switches. A CMOS device, lightly loaded, will pull up or down to within 5% of rail. A DSP/MCU operating at 1.8 V will pull up to 1.75 V, and down to .05 V, more than meeting all the requirements for 1.8 V interface. It might be prudent to use a device like the MC74VHC1GT14 with Schmitt inputs, to minimize the effects of possible noise on the data line. ON Semiconductor has 13 devices in the MiniGate family that can be used. There are no external components needed, however, if the designer chooses not to place a bypass capacitor on the V_{CC} pin, he should make sure to place the V_{CC} pin very close physically to a bypassed V_{CC} on the device he is driving. One very inexpensive tiny device can perform this function and can operate >75 MHz.

Translation High to Low

This paper will outline two approaches to this problem:
Approach 1: ON Semiconductor offers many open- drain devices in the MiniGate family. This feature permits the device to function at one voltage, while its output is operating at a different voltage, through a separate pull- up resistor. Any of the open drain parts (gates, buffers, or inverters) can operate at the higher voltage (in the system) while its output is operating at a lower voltage. Almost any two voltages between V_{MIN} and V_{MAX} for the device may be used.
Example: How to interface a 1.2 V DSP to a 2.7 V system. Any open-drain device in our MiniGate family can be used. Just operate the part at 2.7 V and use a pull-up resistor to 1.2 V. The downside to this approach is the pull-up resistor which consumes power and adds delay to the signal. A

470 Ω pull-up would add about 5.0 ns delay and 1.5 mW to the power consumption (assuming 50% duty cycle). All of the open drain devices can drive resistor values as low as 75 Ω, which would match the lines to the device and reduce the delay, however, power consumption would be higher. The input will be a perfect match to 2.7 V. The output will match the supply voltage of the pull-up, and a perfect match to the DSP/MCU. For this illustration, the NL17SZ06 was chosen, a non-inverting open-drain buffer. ON Semiconductor offers more than 15 devices with open drain outputs in the one-gate VHC/LCX families and 2 and 3 gate LCX families. Any open drain device in the ON Semiconductor portfolio may be used.

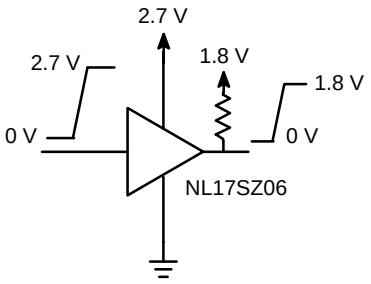

Figure 2.

Approach 2: Since nearly all the MiniGate products are Over-Voltage Tolerant (OVT) at their inputs, it is possible to operate a device at the lower of the two supply voltages, and just drive the inputs higher than V_{CC}. This is permitted because all devices in the VHC family and LCX family are constructed without input diodes that are connected to the supply voltage. Instead, these devices used a very sophisticated input structure that provides high immunity to Electro-Static-Dischar ge (ESD), without the need for protection diodes to the supply voltage. This is particularly useful when translating from two voltages that are fairly close to each other, for example 2.5 V to 3.3 V. For voltages that are far apart, it is difficult to achieve good noise margin using this approach. In this configuration a standard CMOS device will output ≈ 3.2 V for a high and 0.1 V for a low. This is well within the requirement for either the ON Semiconductor VHC single gate devices (all of the standard level devices) or the LCX one, two, or three gate products.

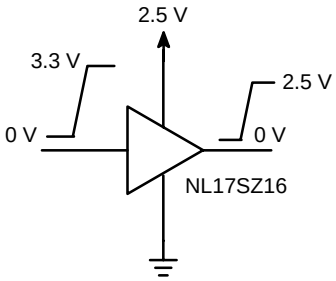

Figure 3.

Conclusion

Logic level translation from low to high, or high to low voltages can be quite easy. ON Semiconductor offers inverting/non-inverting buffers, gates, analog switches in single, dual, and triple in the MiniGate family. Open drain devices will allow interface from higher voltages (as high as 5.5 V) down to any voltage desired, in both the VHC and LCX family. These are available in singles, duals, and triples. These same two families may be over-driven at the input, to interface directly between a low voltage and a higher voltage. All solutions are either complete, with no external parts required, or just need one pull-up resistor. The choice to use a pull-up resistor should be made by the designer and his requirements for power and noise immunity.

Notes

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