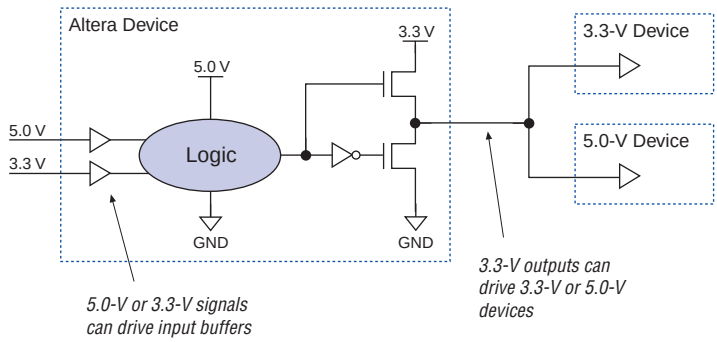
Advantages of Hybrid I/O for Mixed-Voltage Systems

TECHNICAL BRIEF 9 JULY 1996

Hybrid I/O capability enables the inputs and outputs of a device to support the electrical requirements of both 5.0-V and 3.3-V devices. Since programmable logic often acts as the glue-logic that ties the various devices on a board together, high-performance programmable logic devices with hybrid I/O capability provide the ideal interface solution for mixed-voltage systems. The hybrid I/O capability of FLEX 10K, FLEX 8000, MAX 9000, MAX 7000, and FLASHlogic devices makes these families excellent for mixed-voltage interfacing. See Figure 1.

Figure 1. Altera Two-Way Mixed-Voltage Interfacing

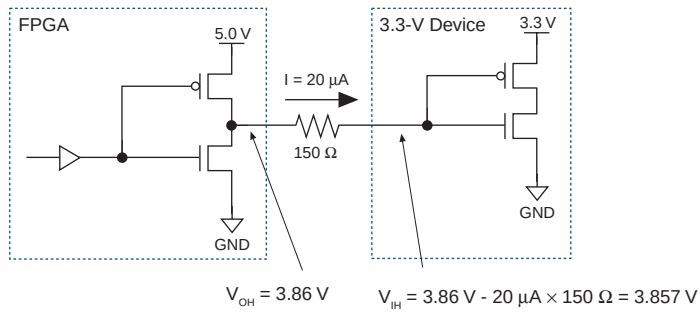


5.0-V FPGA Families Cannot Drive 3.3-V Devices

Since most 5.0-V FPGA families do not offer hybrid I/O, they may produce undesirable results when driving 3.3-V devices. Some FPGA families have true CMOS outputs with a high-level output voltage (V_{OH}) range of 3.86 V (minimum) to 5.0 V (maximum). However, the maximum high-level input voltage (V_{IH}) for any 3.3-V device is 3.6 V. Thus, the outputs of these families exceed the maximum V_{IH} specification. Providing an option for TTL outputs is not a foolproof solution, because even in TTL mode, the high-level output (V_{OH}) may reach 3.7 V, still violating the V_{IH} specification. The most severe penalty for violating the V_{IH} specification is latch-up, which may destroy a 3.3-V device. Additionally, excess current may flow from the 5.0-V power supply to the 3.3-V power supply, potentially raising the 3.3-V power bus to a higher level and damaging other 3.3-V devices connected to the bus.

One FPGA vendor recommends placing a 150-Ω resistor between the two devices to minimize this current flow. See Figure 2. While this patchwork solution may help limit the current, it cannot guarantee reliable operation because the V_{IH} specification is still not met. Placing extra resistors on the board is also an inconvenient solution due to potential board constraints and board layout requirements. Finally, driving an input voltage higher than specified may adversely affect the long-term reliability of the device.

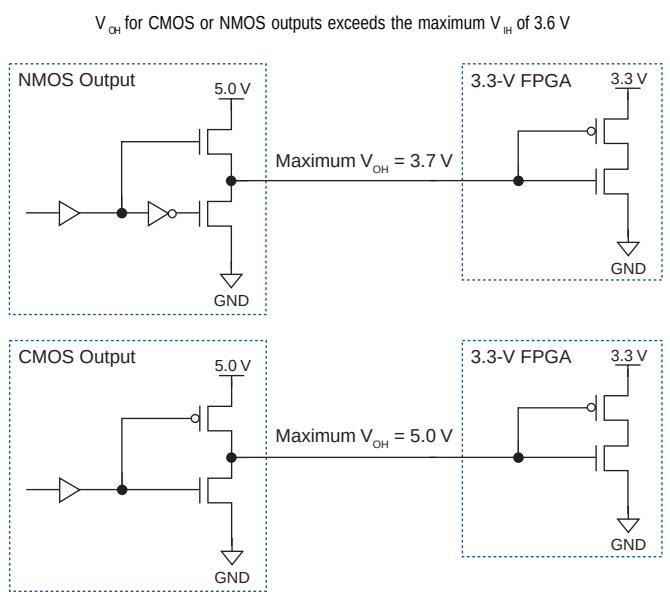
Figure 2. 5.0-V FPGAs With CMOS Output Cannot Drive 3.3-V Devices



3.3-V FPGA Families Cannot Be Driven By 5.0-V Devices

Customers designing mixed-voltage systems may run into problems with 3.3-V devices because the inputs are not 5.0-V tolerant. Regardless of whether the driving 5.0-V device has a CMOS or an NMOS output, the maximum V_{OH} (5.0 V or 3.7 V, respectively) may exceed the maximum V_{IH} of 3.6 V for the device. Again, the V_{IH} specification is violated, and consequently, this configuration may have the same latch-up, current flow, and reliability issues as previously discussed. See Figure 3.

Figure 3. 3.3-V FPGAs Are Not 5.0-V Tolerant



The hybrid I/O capability of Altera 5.0-V devices offers the flexibility to interface with inputs and outputs of both 3.3-V and 5.0-V devices. Furthermore, future 3.3-V devices from Altera will offer 5.0-V tolerant inputs, making them suitable for mixed-voltage systems.

Altera Provides Mixed-Voltage Flexibility

Altera provides the broadest mixed-voltage product offering with its FLEX 10K, FLEX 8000, MAX 9000, MAX 7000, and FLASHlogic device families. The inputs of these devices can easily accommodate both 3.3-V and 5.0-V signals, and the outputs of these devices can drive both 3.3-V and 5.0-V devices without violating the V_{IH} specification. See Figure 4.

Figure 4. Mixed-Voltage Solution Comparison

Device Density (Gates)	Altera	AMD	Lucent	Lattice	Xilinx
0 – 5,000	MAX 7000 FLASHlogic	Mach 5	—	—	XC7300
5,000 – 10,000	FLEX 8000 MAX 9000	Mach 5	—	—	XC9500
10,000 – 25,000	FLEX 10K FLEX 8000	—	—	—	—
25,000 – 50,000	FLEX 10K	—	—	—	—
50,000 – 100,000	FLEX 10K	—	—	—	—

The documents listed below provide more detailed information. Part numbers are in parentheses.

Data Sheets

FLEX 10K Embedded Programmable Logic Family Data Sheet (A-DS-F10K-01)
FLEX 8000 Programmable Logic Device Family Data Sheet (A-DS-F8000-08)
MAX 9000 Programmable Logic Device Family Data Sheet (A-DS-M9000-04
MAX 7000 Programmable Logic Device Family Data Sheet (A-DS-M7000-04)
FLASHlogic Programmable Logic Device Family Data Sheet (A-DS-FLSH-02)

You can request these documents from:

- Altera Express fax service at (800) 5-ALTERA
- World-Wide Web at **http://www.altera.com**
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