Mixed Supply Design with MACH 1 & 2 SP Devices

ABSTRACT

Vantis provides robust and feature-rich I/O structures on members of its MACH® 1 & 2 SP families. To make the most use of these features, it is helpful to understand their characteristics. This technical note will describe mixed supply design as it pertains to the MACH 1 & 2 SP[1] families.

MIXED SUPPLY DESIGN

As more and more devices move from a 5-volt to a 3.3-volt process technology, the need to be able to design in a mixed supply environment becomes increasingly important. Interfacing a 5-volt device with a 3.3-volt device requires special I/O buffer designs that prevent the 5-volt device from damaging the 3.3-volt device either by putting it into latch-up or by putting too high a voltage across the gate oxides. When a device latches-up, a low-impedance path to ground is formed within the device, and the device begins to sink large currents. If the situation is not rectified quickly (i.e., by cycling the system power), the device could be thermally destroyed, necessitating its replacement. When excessive voltages are driven across a gate oxide, long-term reliability problems could develop. There are two features semiconductor manufacturers provide to avoid the problems in interfacing 5-volt and 3.3-volt devices:

- *3.3-Volt Safety* — The maximum output voltage of a 5-volt device is limited to a level that is compatible with 3.3-volt devices.
- *5-Volt Tolerance* — The maximum allowable input voltage of a 3.3-volt device is such that it is compatible with the typical maximum output voltage of a 5-volt device.

This brief describes 3.3-volt safety in more detail and how the MACH 1 & 2 SP devices can be used in environments that require the use of a 3.3-volt safe device.

3.3-Volt Safe Specifications

For a 5-volt device to be safe for 3.3-volt devices, its outputs must drive no higher than the V_{IH} (max) of the 3.3-volt device when V_{CC} (3.3-volt device) is at a minimum, the V_{CC} (5-volt device) is at its maximum value and the source current of the pin being driven is 0 mA. Additionally, the same device must meet the minimum requirements needed to reliably interface with devices that conform to the TTL level specification. The TTL specification requires that the outputs drive no less than the V_{IH} (min) of the 5-volt TTL device when V_{CC} (5-volt TTL device) is at a minimum and with a load current of 3.2 mA. The ideal specifications are shown in Table 1, below. The specifications are derived from the requirements needed for both 5-volt TTL devices and 3.3-volt CMOS devices. The value for V_{OH} (max) is given for a 5-volt device driving into a 3.3-volt device operating at a minimum V_{CC} (3.0 volts for a 3.3-volt device). In this condition, the determining

Application Notes

1. The information contained in this technical note pertains to the revision B versions of the MACH211SP and MACH231SP. Revision A material for these devices has characteristics similar to those found in the 5-volt M5-128, M5-192, and M5-256 devices. Information about those devices is found in the technical note *Hot Socketing and Mixed Supply Design with MACH 4 and MACH 5 Devices*. The revision information is found after the date code on the package (e.g., 9750 XXX **B**)

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factor is set by the V_{IH} (max) requirements of V_{CC} + 0.3 with a V_{CC} of 3.0 volts. All of the devices will meet the specification, set by the need to be 5-volt TTL compatible, for V_{OH} (min) when V_{CC} = Min and I_{OH} = -3.2 mA.

Table 1. 5-Volt Tolerant/3.3-Volt Safe Ideal Specifications

Parameter Symbol	Parameter Description	Test Description	MIn	Max	Unit
V_{OH}	Output High Voltage	V_{CC} = Min, I_{OH} = -3.2 mA	2.4		V
V_{OH}	Output High Voltage	V_{CC} = Max, I_{OH} = 0 mA		3.3	V

MACH 1 & 2 SP Mixed Supply Design Characteristics

These devices were not originally designed to meet the ideal specifications given above, and as a result do not meet them. This does not, however, mean these devices cannot be used in a mixed supply design environment because many designs are not designed to minimum and maximum specifications but rather to more typical specifications. When V_{CC} is at 5.25 volts, an output will typically need to source less than 25 µA to provide an output voltage of 3.6 volts. Additionally, many systems will not be designed to operate at both the maximum 5-volt V_{CC} of 5.25 volts and the minimum 3.3-volt V_{CC} of 3.0 volts, but rather will operate at the more typical 5.0 volts and 3.3 volts. The design of the output buffer is such that V_{OH} drops linearly with V_{CC} such that if V_{CC} drops 0.1 volts, so does V_{OH}. As a result, a more typical V_{OH}, when V_{CC} is at 5.0 volts, will be around 3.4 volts. Additionally, the V_{IH} of a device running at 3.3 volts is 3.6 volts, which further ensures that a 5-volt device can drive a 3.3-volt device without causing damage.

The specifications for MACH 1 & 2 SP devices stated that at V_{CC} (min) = 4.75 volts and with a source current of -3.2 mA, V_{OH} will be no greater than 3.3 volts. All of these devices will meet this specification, but this specification does not meet the requirements for being safe to drive a 3.3-volt device. To further ensure that these devices meet a specification which can be considered safe, they are tested to meet a V_{OH} of 3.5 volts when V_{CC} = 5.25 volts and I_{OH} = -300 µA. The MACH 1 & 2 SP test specifications are shown in Table 2.

Table 2. MACH 1 & 2 SP 3.3-Volt Safe V_{OH} Specifications

Parameter Symbol	Parameter Description	Test Description	MIn	Max	Unit
V_{OH}	Output High Voltage	V_{CC} = Min, I_{OH} = -3.2 mA	2.4		V
V_{OH}	Output High Voltage	V_{CC} = 5.25 V, I_{OH} = -300 µA		3.5	V

Additional safety can be included as a part of a system design either by using series current limiting resistors or by using bleeder resistors to ground. The series resistor will be placed between the MACH device and the 3.3-volt device and should be no less than 150 Ω which will limit the maximum amount of current which could be driven into a pin and through the ESD structure to less than 10 mA. This current value is almost always considered safe in terms of latch-up specifications that are typically on the order of 200 mA into a pin. If a 12 KΩ resistor to ground is used, it will guarantee that V_{OH} does not go above 3.6 volts when V_{CC} of the MACH device is at 5.25 volts.

CONCLUSION

The MACH 1 & 2 SP devices offer several advanced features that can be invaluable in a system design. To take full advantage of these features, the designer must be fully aware of the characteristics of the features in each of the device types. The mixed supply design capability is a feature that allows for advanced system design using parts from different technologies but requires an understanding of the specifications needed for a 3.3-volt safe design in terms of V_{CC} and V_{OH} levels. In all situations, MACH 1 & 2 SP devices can be used in these designs given the proper design techniques and considerations.