An Introduction to VCX Logic

Prepared by: Fred Zlotnick
ON Semiconductor

ON Semiconductor

http://onsemi.com

APPLICATION NOTE

ON Semiconductor is introducing a .35 micron family of logic, called VCX. This family achieves a maximum propagation delay of < 3ns and can operate between 3.3 and 1.8 Volts. The family is compatible with mixed voltages, since the I/Os are tolerant to any voltage within its specification, regardless of operating voltage. Not only does VCX offer high speed, it also offers balanced drive, and is able to source or sink 24 mA.

The VCX family was defined several years ago by the "Low Voltage Alliance"; an organized alliance comprised of Toshiba, Fairchild, and the SCG division of Motorola (now ON Semiconductor). It was designed to meet the needs of the standard logic market for lower operating power and increasing speed components. Basically, there are only two ways to reduce power in a CMOS system. One is to lower the operating voltage, and the other is to reduce the speed. In most cases, reducing the speed is not an option.

$$Pd = ((C_L + C_{PD}) * V_{CC} * V_S * f) + (I_Q * V_{CC})$$

C_L = load capacitance, C_{PD} = device power dissipation capacitance, V_{CC} = power supply voltage, V_S = output swing, f = frequency, and I_Q = quiescent current

By reducing the operating voltage and the Vs output swing voltage, the total circuit power is reduced. With the advent of TTL in the 1960s, the 5.0–Volt power supply remained as the standard choice of supply for nearly 35 years. Since then, designers have come to realize that the only feasible approach to reducing power was to drop the power supply voltage. By the early 1990's, the 3.3–volt supply began to replace portions of traditional 5.0 Volts line operated equipment. The need for speed, and the ability to generate multiple voltages from high efficiency switching regulators, has made it possible to mate different portions of a circuit to different voltages. In general, the lowest supply voltage possible will yield the lowest power. Today, it is not unusual to see a system with +5.0 Volt, +3.3 Volt, and +1.8 Volt power supplies. Many of the latest high–speed microprocessors must operate below 2.0 Volts or risk being damaged from heat.

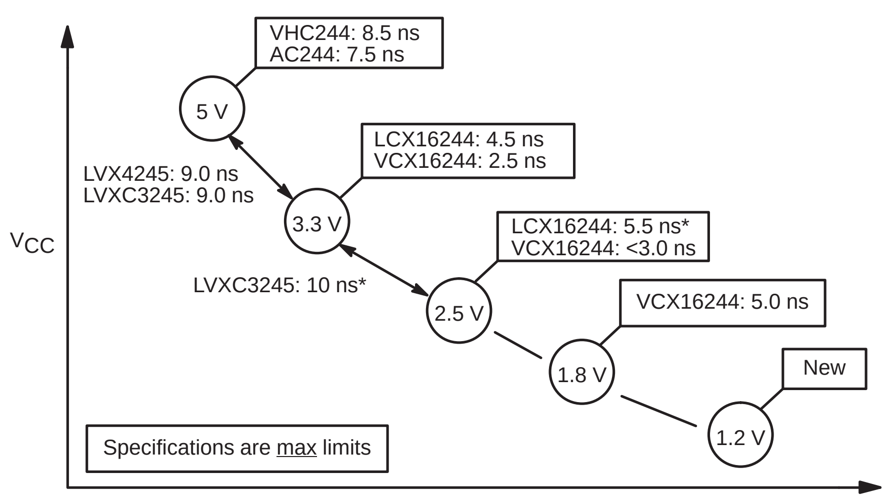
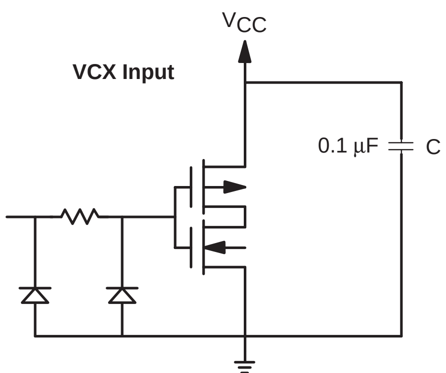


Figure 1. Operating Voltage–Reduction Migration Path

A system utilizing a myriad of voltages, presents many problems to a designer. ON Semiconductor produces three low–voltage product families that operate in 5.0–Volt environments. VHC, LVX, and LCX can operate between 5.0 and 2.5 Volts, but the VCX family was specifically designed to operate between 1.8 and 3.3 volts. It should be noted that virtually all standard CMOS families could be used together on the same board, when operating from the same voltage. This also applies to non–Low Voltage Alliance families such as AHC, LVC ALVC. A system designer has the flexibility to pick the logic family he needs from any of the suppliers he chooses, provided the parts themselves meet the key parameters. In addition to VHC, LVX, and LCX, the FST/CBT family will also be available from On Semiconductor in the near future, to perform specific bus switch logic level translation.



Flexibility: VCX offers the user unparalleled flexibility and speed in low voltage operation. In its initial offering, ON Semiconductor will offer a wide variety of 16 Bit functions, in very small 48 TSSOP packages to solve the most critical bus applications. The ON Semiconductor VCX family mates perfectly to the LCX family for gate and octal functions, as well as to the devices offered by the other Low–Voltage Alliance members. Future plans for VCX call for additional gate and octal functions, as well as wider, 18 bit devices.

Description: VCX was designed and optimized to yield near optimum performance at 2.5 Volts. It has very strong symmetrical drive of +/– 16 mA at this operating voltage, and logic gate delays of less than 5 ns. The ultra–small geometry (.35 micron CMOS technology) applied to logic devices, improves speed while reducing overall power consumption. William Blood, in the *MECL Design Handbook*, shows that a trace on a typical PC board varies between 80 and 140 Ω[1]. The outputs of VCX are capable of driving high capacitance of 50 pf or more with a termination resistance as low as 120 Ω. This permits an almost perfect match to a trace, and a nearly perfect transfer from output to input, with a minimum of over/undershoot.

[1]Blood, William – MECL Design Handbook, pg. 46, Rev 1, 1988, Motorola HB205

Family Features:

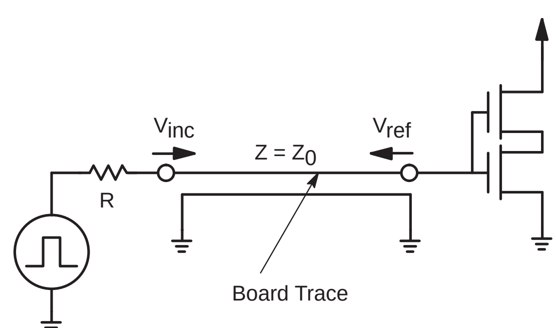
a. **Bus Hold** is a feature that will be introduced in specific functions within the VCX family. CMOS devices have always required that the designer tie–off all unused inputs to either Vcc or GND. The designer may not have been aware of the purpose for doing this. CMOS devices have very high input impedance, in many cases, as much as several hundred Meg–Ohms or more. Consequently, the input can accumulate charge, and cause the device to approach the unstable switching region. In this region, the device is neither on nor off, drawing current. Bus Hold, designated by the letter “H” in the part number, employs a weak feedback gate tied back to the input to cause any input state to stay latched. This is very useful in a bus application for times when the bus goes into its 3–state mode, any device card with an “H” device will remain in the last state it was in, without the need for pull–up or pull down resistors. A new signal coming into the device, can easily overcome the weak feedback device, and cause its value to be asserted.

b. **Series R** is a second feature that will be available on many of the bus oriented devices. VCX devices are so fast, that care must be taken to account for transmission line effects. The output of a CMOS device looks like a very low impedance when turned “on”. In essence, we have a voltage source with a small resistor value of about 5 Ω driving a transmission line. Transmission line theory allows us to calculate, both the incident and reflected wave. If the line impedance Z_0 is assumed to be 50 Ohms then the formula is:

$$V_{inc} = V_0 * (1 - Z_0/(5 + Z_0), \text{ in this case } .09 * V_0,$$
$$\text{if } V_0 \text{ is 3.3 Volts, then } V_{inc} = .3 \text{ Volts}$$

The reflected wave back at the same node, will see the same 3.3 volts less the negative of twice the difference between the incident and reflected wave, or –2.7 Volts. This reflected wave is nearly as large as the incident signal. If a 20 Ohm resistor were added to the output, so that the total R value was 25 ohms, then:

$$V_{inc} = 3.3 * (1 - (25/25 + 50)) = 1.1 \text{ Volts},$$
$$\text{and the reflected wave is now } - 1.1 \text{ Volts}$$

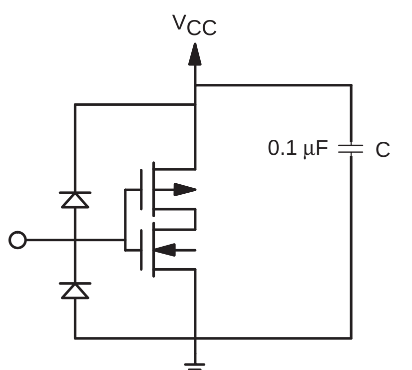


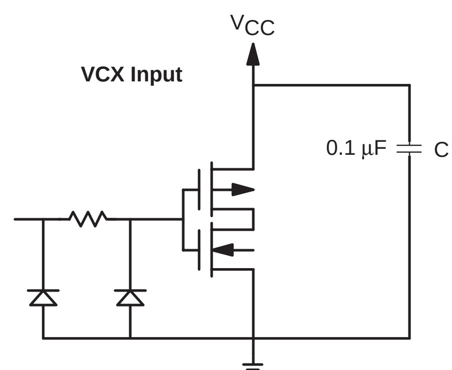
The addition of a 25 Ohm resistor has dampened the reflection by a factor of 2.5 times!

In practice, the circuit will almost assuredly have a terminating resistor on the load side as well. This further improves the match, and reduces the reflections. It is beyond the scope of this article to go further into transmission line theory. Suffice it to say, the series resistor improves the quality of a signal immensely, without sacrificing other important qualities.

c. **Hot Swap:** In many arenas, the need to keep a system running 24 hours a day, 7 days a week is critical. If a board needs to be added, replaced or updated, the entire system cannot be taken down to accommodate this. The designer cannot simply take for granted the ability for a part to function in a hot swap mode. There are some things the designer must do to make sure the board can be inserted into a system and not cause any glitches. The first thing is to physically make the ground traces a bit longer than the other traces, so that when the board is inserted, ground is firmly established. If the wrong kind of logic is used, hot swapping cause problems. If the designer selects one of the familiar standby families such as AC/ACT, he may have a problem in a hot swap environment. When a board is plugged into a bus, the first thing that makes contact is ground.

This is intentionally done to establish reference, and is done by making the fingers of the multiple ground traces a bit longer than the other traces. With ground established, the supply pins and the signal pins now begin to make contact. With supply voltage of zero, and the signal pins making contact, there is a momentary forward–biased diode from the signal input to VCC. In addition, there is nearly always a hefty bypass capacitor across the VCC pin to ground, which means the forward–biased diode will conduct and charge up the capacitor. The near short–circuit caused by this action will assuredly cause a glitch. All the newer families from the Low Voltage Alliance, VHC, LVX, LCX, and the latest VCX family, does not have this protection diode at the input to cause this problem.





Summary: ON Semiconductor is introducing its new VCX standard logic family fabricated with .35 micron technology. This family represents a major step towards increasing gate speeds and output drive. These new devices are over–voltage tolerant at both input and output so that they can interface with nearly any logic family operating below 4.7 volts. They offer many new features, such as bus–hold and series resistance, not previously available in a single family. The Low Voltage Alliance, comprised of ON Semiconductor, Fairchild, and Toshiba, all work to one common set of specifications, so that the user can obtain nearly identical products from three viable suppliers. Specifications are set and remain constant throughout the life of the product, so that the designer and purchasing community do not have to be concerned about specifications constantly changing. The new VCX products are fast, low voltage, low power, and offer features that represent the new thinking in family logic design.

PUBLICATION ORDERING INFORMATION

NORTH AMERICA Literature Fulfillment:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303–675–2175 or 800–344–3860 Toll Free USA/Canada
Fax: 303–675–2176 or 800–344–3867 Toll Free USA/Canada
Email: ONlit@hibbertco.com
Fax Response Line: 303–675–2167 or 800–344–3810 Toll Free USA/Canada

N. American Technical Support: 800–282–9855 Toll Free USA/Canada

EUROPE: LDC for ON Semiconductor – European Support
German Phone: (+1) 303–308–7140 (M–F 1:00pm to 5:00pm Munich Time)
Email: ONlit–german@hibbertco.com
French Phone: (+1) 303–308–7141 (M–F 1:00pm to 5:00pm Toulouse Time)
Email: ONlit–french@hibbertco.com
English Phone: (+1) 303–308–7142 (M–F 12:00pm to 5:00pm UK Time)
Email: ONlit@hibbertco.com

EUROPEAN TOLL–FREE ACCESS*: 00–800–4422–3781
*Available from Germany, France, Italy, England, Ireland

CENTRAL/SOUTH AMERICA:
Spanish Phone: 303–308–7143 (Mon–Fri 8:00am to 5:00pm MST)
Email: ONlit–spanish@hibbertco.com

ASIA/PACIFIC: LDC for ON Semiconductor – Asia Support
Phone: 303–675–2121 (Tue–Fri 9:00am to 1:00pm, Hong Kong Time)
Toll Free from Hong Kong & Singapore:
001–800–4422–3781
Email: ONlit–asia@hibbertco.com

JAPAN: ON Semiconductor, Japan Customer Focus Center
4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan 141–0031
Phone: 81–3–5740–2745
Email: r14525@onsemi.com

ON Semiconductor Website: http://onsemi.com

For additional information, please contact your local Sales Representative.