ON Semiconductor

Is Now

To learn more about onsemi™, please visit our website at www.onsemi.com

Is Now Part of

ON Semiconductor®

To learn more about ON Semiconductor, please visit our website at
www.onsemi.com

AN-5006

Fairchild Semiconductor
Application Note
March 1999
Revised September 1999

FAIRCHILD SEMICONDUCTOR™

Designing with Bushold

What is Bushold?

The bushold feature is an innovative approach to solving the problem of floating inputs. This circuitry maintains a valid logic state on an unloaded input and eliminates the need for external conditioning components for floating or undriven inputs.

Bushold circuitry is designed to tolerate floating input conditions. If non-bushold devices were used, these floating input conditions would lead to increased leakage, oscillations, and compromises in system data integrity.

Another feature of bushold circuitry is the ability to hold an undriven data-bus line in a valid logic state. Through the bus, the bushold device can condition the other inputs on the bus.

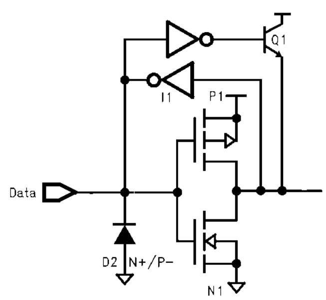

FIGURE 1.
Simplified Schematic Diagram of Bushold Circuitry

How Does It Work?

Bushold circuitry works by using a low drive inverter in the device input stage that provides feedback to the input of the device and the bus (see Figure 1). When the signal driving the input is removed, the inverter will maintain the last received valid signal level on the device input and bus line until it is overdriven by the next in-coming signal.

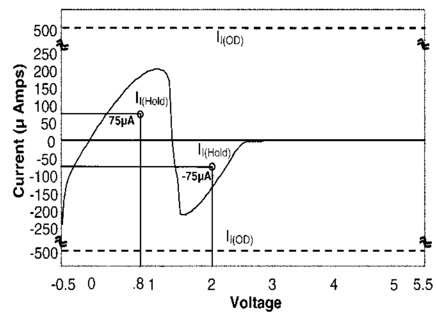

FIGURE 2. Voltage-In versus Current-In Sweep of *CROSSVOLT* LVT Device with Bushold (74LVTHxxx)

Fairchild Semiconductor provides two types of bushold inverter specifications (see Figure 2). $I_{I(HOLD)}$ is the bushold input minimum drive. This is the minimum amount of current the circuit is capable of supplying. $I_{I(OD)}$ is the bushold input over-drive current to change state. This is the minimum amount of current that is necessary to overcome the bushold circuit, and cause the input to change states (See Table 1).

TABLE 1. Bushold Specifications

Family	Symbol	V_{CC} (V)	Conditions	Min	Units
LVT	$I_{I(HOLD)}$	3.0	V_{IN} = 0.8V	75	µA
(Note 1)		3.0	V_{IN} = 2.0V	–75	µA
	$I_{I(OD)}$	3.6	(Note 2)	500	µA
		3.6	(Note 3)	–500	µA
VCX	$I_{I(HOLD)}$	3.0	V_{IN} = 0.8V	75	µA
(Note 4)		3.0	V_{IN} = 2.0V	–75	µA
		2.3	V_{IN} = 0.7V	45	µA
		2.3	V_{IN} = 1.6V	–45	µA
		1.65	V_{IN} = 0.57V	25	µA
		1.65	V_{IN} = 1.07V	–25	µA
		3.6	(Note 2)	450	µA
		3.6	(Note 3)	–450	µA
		2.7	(Note 2)	300	µA
		2.7	(Note 3)	–300	µA
		1.95	(Note 2)	200	µA
		1.95	(Note 3)	–200	µA

Note 1: Designated as 74LVTHxxx

Note 2: An external driver must source at least the specified current to switch from LOW-to-HIGH

Note 3: An external driver must sink at least the specified current to switch from HIGH-to-LOW

Note 4: Designated at 74VCXHxxx

CROSSVOLT™ is a trademark of Fairchild Semiconductor

When is Bushold Used?

Devices with bushold are designed for use in systems where devices or data-bus lines will be left in an undriven condition. As noted, bushold circuitry will maintain a floating input or data-bus line in a valid state.

Non-bushold inputs must be maintained in a valid logic state. Leaving an input floating will allow it to oscillate and cause invalid data on the output. False data problems can lead to bus contention, high current draw, and device or system damage.

System data-buses must be maintained in a valid logic state for the same reasons that individual device inputs require conditioning.

Data integrity problems and device or system damage can occur if a bus is allowed to float. With a data-bus however, the number of device inputs on the bus multiplies the problem.

Fairchild's *CROSSVOLT* products with bushold work especially well on boards where spacing is tight. Here the bushold feature eliminates the need to have additional pads for conditioning resistors as well as added trace lines for ground or power.

By holding the device or bus at the last received valid logic high or low, devices with bushold can also serve a pseudo memory function. In contrast, a conditioning resistor will always pull the bus to the same state.

When designing a data-bus using devices with bushold, consideration must be given to the bushold drive and current requirements. With $I_{I(HOLD)}$ specified at ±75µA, a single device with bushold will hold a large data-bus, with power dissipation held at a low level. Calculations for the I_{IN} (Input current) of all device inputs on the bus must be taken into consideration. I_{IN} is typically in the range of 1µA to 5µA for CMOS devices.

With $I_{I(OD)}$ specified at ±500µA, the data-bus will still switch easily. CMOS devices typically have drives in the ±24mA range or greater.

When Should Bushold Not Be Used?

There are design applications where bushold technology is either not appropriate or should not be overly used. In these designs, use of an equivalent performance device without bushold circuitry is recommended. Fairchild Semiconductor offers *CROSSVOLT* devices (see Figure 3) that have the same drive and AC specifications as the *CROSSVOLT* products with bushold, but without the bushold circuit on the inputs.

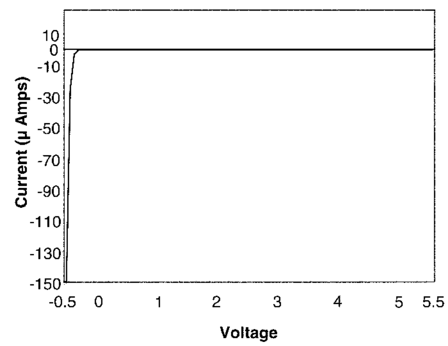

FIGURE 3. Voltage-In versus Current-In Sweep of *CROSSVOLT* Device without Bushold

Bushold circuitry on all system or data bus inputs can create problems. On a data-bus with multiple receiver drops, bushold circuitry should be used on the minimum number of devices that are needed to hold the data-bus in a valid state. The $I_{I(OD)}$ specification is additive for every bushold circuit on the data-bus. For example, using LVT with an $I_{I(OD)}$ specification of ± 500 µA, if 10 inputs on a data-bus have bushold circuitry, it will take at least 5mA to overcome and switch the data-bus. Using LVT with an $I_{I(HOLD)}$ specification of ±75µA, 750µA of drive will be available to hold this theoretical 10-input bus. This much drive is not required on an all-CMOS-input bus, and unnecessarily adds to the power budget needed for the system.

The bushold circuit is designed for use in place of conditioning pull-up or pull-down resistors. Using bushold inputs in conjunction with conditioning resistors can cause high power dissipation. If the load of the conditioning resistors and bushold inputs is high enough, the driver may not be able to switch the load in the required time.

Although not recommended, there are instances when systems with bushold use input conditioning resistors.

An example of this is when a device with bushold may be powered down, but the bus still needs to be held in a valid state, a 50 kΩ or greater value is recommended here. This will allow the bushold circuit to operate correctly when powered up, with a minimum of extra power dissipation. See appendix A for a formulatic explanation.

On a system data-bus with Thevenin or parallel termination designs, power and speed requirements must be accurately calculated if bushold inputs are to be used. Otherwise, the same high power dissipation and switching problems experienced using bushold with conditioning resistors may be seen.

Mixed-voltage buses may also experience problems if devices with bushold are not used appropriately. A device with bushold cannot pull a bus higher than its own V_{CC}. Allowing a bus to hold at a 3-volt level with 5-volt device inputs on the bus will cause significant levels of ΔI_{CC} and I_{CCT} due to the 5-volt inputs being held partially on.

In point-to-point data flow designs (e.g., one data output to one data input) bushold is unnecessary if the driver will not be 3-stated or disconnected from the receiver.

Summary

Fairchild Semiconductor's *CROSSVOLT* low-voltage logic products with the bushold feature eliminate the need for external components to place undriven inputs into a valid logic state. This allows a device or data-bus to tolerate floating input conditions that would otherwise lead to increased leakage, oscillations, and compromises in system data integrity if a non-bushold device were used.

The bushold circuit works by using an inverter in the device input stage that provides feedback to the input of the device and the bus. When the input driver signal is removed, the bushold circuit will maintain the last received valid signal level on the device input and bus line until it is overdriven by the next in-coming signal.

Bushold is designed for systems where device inputs or data-bus lines may be left floating, and should be used in place of conditioning resistors. The system may experience high power dissipation and timing problems if used in addition to conditioning components rather than in place of them. This can also be a problem when using Thevenin and parallel termination designs, or on voltage interface buses.

Appendix A:

Current calculations for a bushold input conditioning resistor (LVT is used in this example).

For a pull-up resistor:

V_{CC} = 3.0V

V_{IN} = 2.0 V (0.8V is the I_{HOLD} 75µA specification)

(3.0V - 0.8V) / 0.000075A = 29 KΩ

29K = (Maximum on-resistance)
Choosing a value of 50K,

[(3.0V - 0.8V)/50K] = 44µA
Thus, 50K reduces the minimum bushold low current from 75µA to (75µA – 44µA) or 31 µA.

For a pull-down resistor:

V_{CC} = 3.0V

V_{IN} = 2.0 V (2.0V is the I_{HOLD} – 75µA specification)

2.0V / 0.000075A = 26.7 KΩ

26.7K = (Maximum on-resistance)
Choosing a value of 50K,

2.0/50K = 40µA
Thus, 50K reduces the minimum bushold low current from 75µA to (75µA – 40µA) or 35 µA.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 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: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81−3−5817−1050

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative