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An Introduction to Fairchild Switch Products

New Solutions

Today more systems are being designed with basic functionality integrated as much as possible with separate modules being used to add feature functions. This pushes the cost out to only those customers who want to pay for the extra features. However, modular designs add new challenges to system design.

Modular components may require hot swapping and some may also require voltage translation. A new set of logic devices are required to isolate and translate. Normally, additional logic in the signal path would add delay and require more power due to the drive capability of standard logic devices. However, a new technology in logic devices, the bus switch, is designed specifically for applications that do not need drive, yet require simple logic functions, bus isolation and/or voltage translation. Since these devices do not add signal delay or power, timing budgets and power budgets are largely unaffected.

Fairchild Switch (FST) Bus Switch devices are just that, switches. When OPEN or OFF, the bus switch consumes no power and provides high impedance isolation between terminals. When CLOSED or ON, the bus switch acts as a low-impedance resistor (typically less than 5Ω) that can also translate the input voltage to a lower output voltage.

In addition to providing isolation to modular components and translation between dissimilar voltage components, bus switches can provide basic logic functions such as multiplexing and bus exchange without the added penalty of propagation delay or power. This technology adds a new dimension to system design not previously available from standard logic devices.

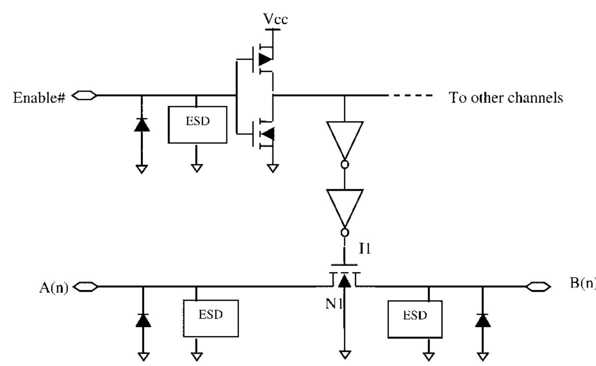

FIGURE 1. Typical NMOS Bus Switch

MOSFET Transistor Switch Operation

To better understand how FST bus switch logic can benefit the system designer, it helps to understand the theory of operation of a MOSFET pass transistor, which is the centerpiece of a bus switch device. Most bus switch devices are comprised of NMOS pass transistors. These NMOS devices provide isolation when OFF and provide voltage translation when ON. NMOS-type logic devices have become the most popular types of bus switch used today.

As illustrated in Figure 1, the Enable circuitry of the bus switch feeds the gate of the NMOS device N1. Typically $V_{Gate} = V_{CC}$ when enabled. The substrate of an NMOS device is tied to ground, and the threshold voltage (V_{TN}) is nominally 1Volt. Any voltage drop between the gate and source of the NMOS (V_{GS}) greater than 1V will cause the NMOS transistor N1 to fully turn ON. Note that since both the "A" terminal and "B" terminal of the NMOS are N-type doped, either side can become the source once a voltage is applied to that terminal. This makes a bus switch device a bi-directional device.

The ON resistance (R_{ON}) of the NMOS device is typically very low (less than 5Ω). Once the NMOS pass transistor is turned ON the drain voltage will closely track the source allowing signals to "pass" freely through the NMOS transistor. As the source voltage approaches V_{CC} the voltage passed becomes limited as the NMOS begins to shut down and R_{ON} increases. This phenomenon is described in more detail below. Since the NMOS, when turned ON, acts as a resistor there is no delay added to the signal path (typically measured well below 250 picoseconds). Thus, a zero-delay logic device is created.

Translation

Translation on an NMOS device occurs once the V_{GS} voltage reaches V_{TN}, roughly 1V, or less. At this point, the NMOS channel is closed off and R_{ON} increases dramatically clamping off any further current flow through the device. The drain, starved of current, can not exceed a voltage of V_{CC}-1V. This makes a 5V NMOS Bus Switch device a "5V-to-4V" translator (see Figure 2). An example of this type of device is the FST3384 10-Bit Bus Switch.

Since translation in typical systems today occurs between 5V and 3.3V levels, an additional 700 mV drop on the drain terminal is required. This is best accomplished by dropping the V_{Gate} to the NMOS by another 700 mV. This can be achieved by adding an internal diode between the V_{CC} terminal and the gate (see Figure 3). An example of this type of device is the Fairchild NC7SZD384 Single-Bit Bus Switch. Translation can also be achieved externally by adding a resistor divider network or diode to the V_{CC} pin of the bus switch IC. External voltage drop circuits, although requiring extra components, allow the PC designer to precisely set the value of the translation voltage.

The discussion so far has focussed on translating 5V devices on the A-side down to 3.3V devices on the B-side. If the 3.3V device were to drive from the B-side to A-side, the "A" terminal will only achieve a maximum voltage of 3.3V (V_{CC} is still 5V and no clipping occurs at 3.3V). These bus switch devices are optimal for interfacing 3.3V devices to 5V TTL-compatible level inputs. If 5V CMOS-level signals were required, external pull-up resistors would be needed to pull the A-side up to 5V. For more information on translation with FST Bus Switches, refer to Application Note 996.

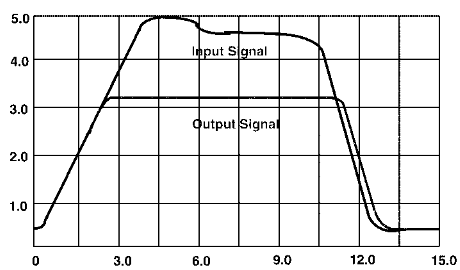

FIGURE 2. Typical NMOS Bus Switch Waveform

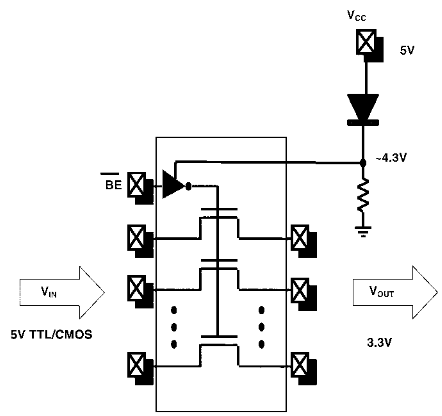

FIGURE 3. Typical 5V to 3.3V Translation Circuit

CMOS Passgate Operation

If no translation is required, and the system designer simply requires the zero-delay feature of a bus switch, there may be two possible solutions. The NMOS pass transistor can be utilized under certain input conditions, or a device known as a CMOS Pass Gate switch is required.

If the input voltage to an NMOS device, with a V_{CC} of 5V can be maintained below that of V_{CC}–1V, the output will not be clipped, or translated. If this is not possible, or if the entire 5V swing is required, then a CMOS Pass Gate must be used. CMOS Pass Gate switches are created similarly to the NMOS switch, except that a PMOS pass transistor is added in parallel to the NMOS device (see Figure 4). The gate node of the PMOS device is also tied to the enable circuit (V_{CC}) but PMOS substrates are also tied to V_{CC}.

In order to turn the PMOS device P1 ON, the V_{GS} must be less than the threshold voltage, V_{TP}, or roughly 1V. With a CMOS Pass Gate device it is now possible to have the drain terminal continue to track the source terminal voltage without clipping at V_{CC}-1V. This allows the signal to fully "pass" through the switch without delay and without clipping. These devices are also called digital or analog switches. An example of this type of device is the Fairchild NC7SZ66 Single-Bit Digital Switch.

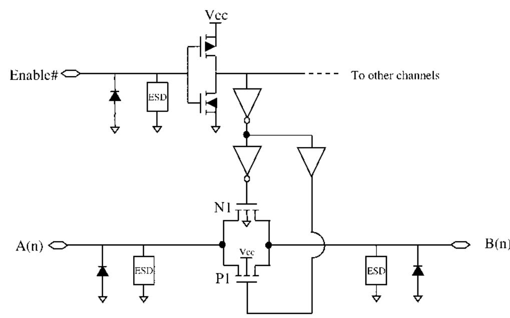

FIGURE 4. Typical CMOS Pass Gate

Types OF Bus Switches

FST Bus Switches can be configured into three basic functional types: the Bus Switch, the Multiplexer Switch, and the Bus Exchange Switch (see Figure 5). The simple Bus Switch is the most common type of switch device. This function can come in both NMOS pass transistor configuration and CMOS pass gate configuration as described above. This type of switch can also be packaged from one bit to several bits in width. The Multiplexer Switch can multiplex signals from one source to two or more separate destinations. An example of this type of switch is the Fairchild FST16232 16-to-32-Bit Multiplexer Switch. The Bus Exchange Switch can exchange signals between two buses. An example of this is the Fairchild FST3383 10-Bit Bus Exchange Switch.

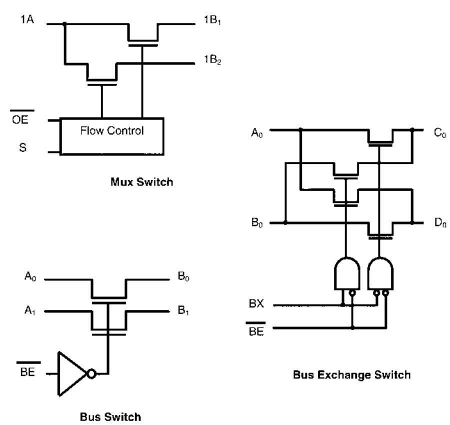

FIGURE 5. Types of Bus Switches

In addition to the functional configurations described, all three types of switches can provide the isolation and translation features without the penalty of propagation delay. These ICs are available to the system designer in a variety packages such as SOIC, TSSOP, SSOP and QSOP for the multi-bit switches, plus SOT23-5 and SC70-5 for the single-bit switches.

See Fairchild's web site at www.fairchildsemi.com for a complete list of available FST bus switch devices.

Bus Switch Applications

There are many possible applications for Fairchild Switch logic. Some applications are specifically intended for isolation or translation, those intended for multiplexing or bus exchange may also utilize the isolation and translation features of bus switch logic. The exact number of bus switch devices used varies based on the number of signals required. Examples of each of these types of bus switch applications are briefly described below.

Hot Swapping Example— Many systems such as docking stations for mobile PCs, PCI boards for servers, and line cards for telecommunications switches require the ability to handle hot-swapping. Hot-swapping can be achieved through the use of power-ramping design techniques. However, the ability to isolate the bus prior to insertion or removal through the use of bus switch allows more control over the hot-swap event. An example of this type of bus switch is the FST3384 10-Bit Bus Switch. In some situations, a designer might even wish to precharge the connector or have higher immunity to spurious undershoot voltages. An example of this type of bus device is Fairchild's FSTU6800 10-Bit Undershoot Hardened Bus Switch with Precharge.

Voltage Translation Switch Example— This application is a 3D AGP advanced graphics card for the PC. AGP graphics controllers have features such as ports and control for DVD video and CRT monitors. Many times the AGP controller IC has 3.3V I/O. Several of the video ports are 5V and translation is required between the two. An example of this type of bus switch is Fairchild's FST16211 24-Bit Bus Switch.

Bus Exchange Example— This switch application is a shared memory bus exchange circuit where a single chipset memory port can access additional memory modules without the need for additional drive or delay. A bus exchange device such as Fairchild's FST16292 Bus Exchange Switch has been implemented in Intel's most recent chipset design.

Multiplexing Bus Switch Example— A multiplexing bus switch application is the multiplexing of the 12C serial data and serial clock lines into multiple EEPROM devices for expanding the size of the nonvolatile storage capacity in large-scale computers like servers and workstations. An example of this type of device is the Fairchild FST3253 Dual 4:1 Multiplexer Switch. Another application is the multiplexing of video signals on new 3D video boards that have added TV and MPEG DVD encoders that convert RGB to VTSC/PAL TV video. Since both the CRT and the encoder require 75Ω loads, placing both in parallel will alter the desired voltage levels, corrupting the video signals. The RGB output signals need to be multiplexed to the additional loads using a Fairchild FST3257 Quad 2:1 Multiplexer Switch to multiplex the RGB signals to either the CRT DIN connector or to the TV encoder circuit.

These are just a few of the many new applications for zero-delay bus switch logic. Visit Fairchild's web site at www.fairchildsemi.com for more applications examples.

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