

## Abstract

QuickSwitch bus switch devices can be used to convert TTL logic to "hot plug" operation. Hot plug means the ability to replace a card in a system without powering down the system. This is a requirement in zero downtime, 24-hour operation systems such as systems for transaction processing (airline reservations, etc.), manufacturing control, communication (telephone) and power plant control. Hot plug operation has special requirements. When the card is plugged in, it must not disturb the operation of the system even though the card initially has no power applied to it. Some families of TTL logic, such as QSI's 74FCTT logic, provide this capability; however, other TTL logic families, special functions and gate arrays do not. The QuickSwitch can be used to convert these devices to hot plug operation by providing the necessary isolation from the system bus until power is applied to the hot plugged card.

## Background

In a hot plug situation, a card is plugged into a system while the system is running. An example of such a system is shown in Figure 1. The card connector is designed so that the ground pin contacts first, followed by the various signal pins and the power pin(s). When the signal pins are connected to the system bus, the logic on the card which has been plugged in will initially be unpowered. In this condition, the logic must guarantee that it will not disturb the system bus when it is unpowered, i.e., that it draws no current from the bus.

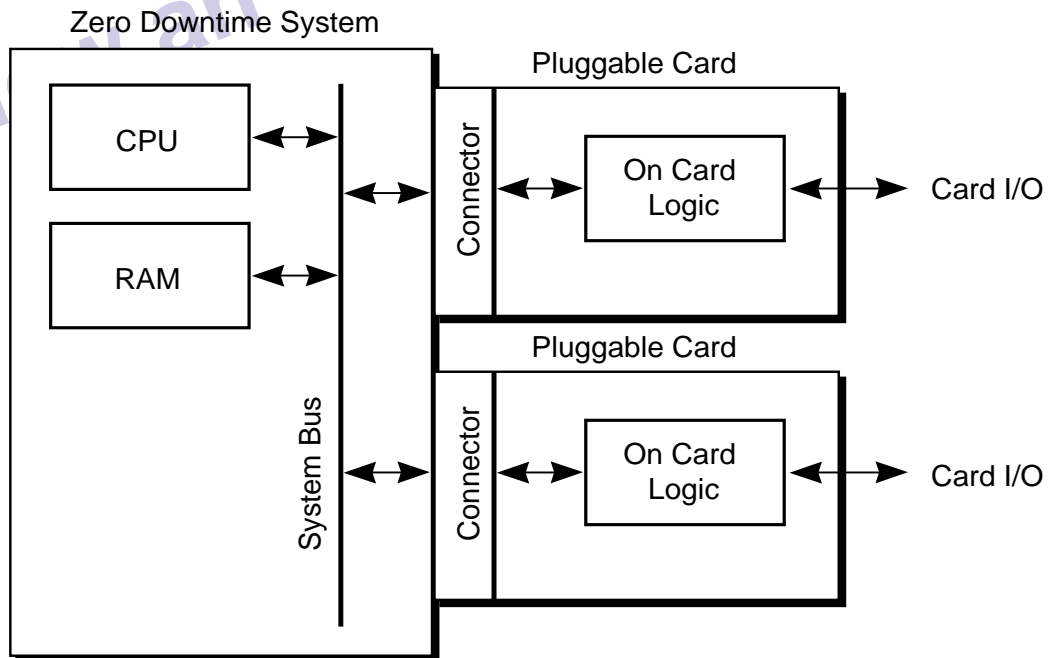


Figure 1. Hot Plug Cards in a Zero Downtime System

Some logic types cannot guarantee that they will not disturb the bus when they are unpowered, for example logic and gate arrays with CMOS outputs. CMOS outputs contain P channel MOS transistors which allow the outputs to be pulled to  $V_{CC}$  for full CMOS levels. These P channel transistors provide an inherent diode between the output and  $V_{CC}$  that is forward biased when the output is driven above  $V_{CC}$ . This means that if the part is powered down, this diode will pull the bus down with it. TTL HIGH signals on the bus will be shunted through this diode to the local  $V_{CC}$  on the card. Since this  $V_{CC}$  goes to all devices on the card as well as large decoupling capacitors, this diode will pull the system bus signals down to approximately one diode drop, 0.7V, above ground. This definitely violates the principle of not disturbing the system bus.

Another requirement of hot plugging is that the logic on the hot plugged card does not disturb the bus while the card is being powered up. This means that the logic must remain off as the power on the card transitions from zero to its nominal value, which will typically take several microseconds. If any on-card initialization or self test is required after power up, this activity must also be isolated from the system bus until the card is ready for operation.

As part of the requirement that the hot plugged card does not disturb the system bus, the capacitance of

the logic on the card as seen by the system bus must be relatively low. This is so that when the card is plugged and this capacitance is charged up by the bus, the disturbance caused by this charging will not cause a system error. This may be a problem if there are several devices on the hot plugged card that connect to the system bus. In this case, the total capacitance of these devices may be enough to disturb the bus at card plug in.

One solution to the hot plug isolation problem is to put a layer of hot plug rated buffers and transceivers, such as QSI's 74FCTT logic, between the card connector and the logic on the card. This has the disadvantage of introducing additional propagation delay, and this logic must be controlled in the case of bidirectional buses, i.e., each transceiver must know which way the data is flowing.

### QuickSwitch as a Logic Isolator for Hot Plug Applications

Another solution is to interpose QuickSwitch bus switch devices such as the QS3384 between the hot plug card logic and the connector to the system bus. An example of this is shown in Figure 2. Each QS3384 serves as a solid state relay to connect the logic on the card to the system bus when the card is ready. Each QS3384 provides connection for 10 signal lines.

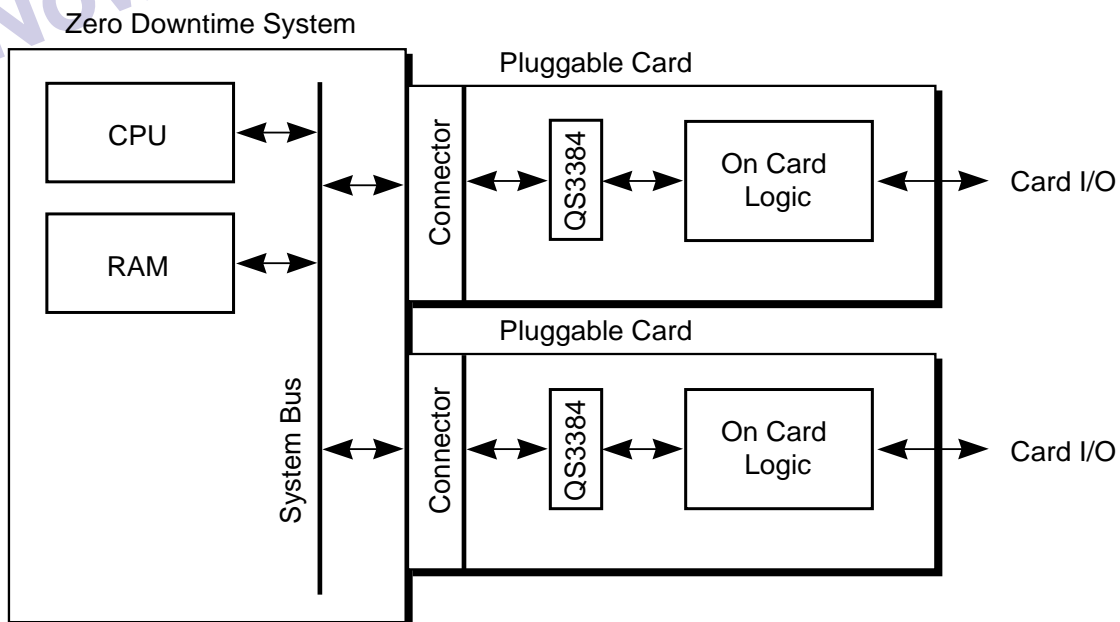


Figure 2. QS3384 QuickSwitch as Hot Plug Card Isolator

The QS3384 QuickSwitch devices serve as isolating switches. When they are on, they directly connect the bus on the card to the system bus with an on resistance of 5. When on, these devices act “just like a wire”. Like a wire, they introduce negligible delay in the data path and are inherently bidirectional.

It is the OFF state of the QS3384 QuickSwitch that is most interesting for hot plug applications. When it is off, it presents low (6pF) capacitance and a few nanoamperes of leakage to either side of the switch. It is a normally off device, and is off when no power is applied, i.e.,  $V_{CC}$  is 0V. Since the QS3384 uses only N channel switches and no P channel devices, there is no diode to  $V_{CC}$  and no current flows when any of the inputs is taken above  $V_{CC}$ . This means that when the QuickSwitch device is powered down and connected to an active bus no current flows into the device and active signals from the device are not propagated through the device.

The QS3384 will also remain off during power up until commanded to turn on by asserting the enable

lines. It is recommended that pull-up resistors be added from the QS3384 enable inputs to  $V_{CC}$  to hold the QS3384's disabled until the logic that drives them is also powered up.

In the example shown in Figure 3, the  $V_{CC}$  ramp up is slow enough to insure that the QuickSwitch device remains disabled during power up. Since the  $\overline{BE}$  pin is being pulled to  $V_{CC}$  through a resistor and has some capacitive load, its ramp up will be determined by an RC time constant. In this example, a 10K pull-up is used, however, if a larger resistor is used, the power up ramp must be slower to maintain the QuickSwitch device in the disabled state.

If the power up ramp to the QuickSwitch device is too fast, there can be a region in which the switch is enabled. This situation is illustrated in Figure 4. This can have adverse effects on the overall system behavior since the possibility of bus contention has been introduced. It is important to match the power up ramp characteristics of the circuit to the appropriate pull-up resistor value.

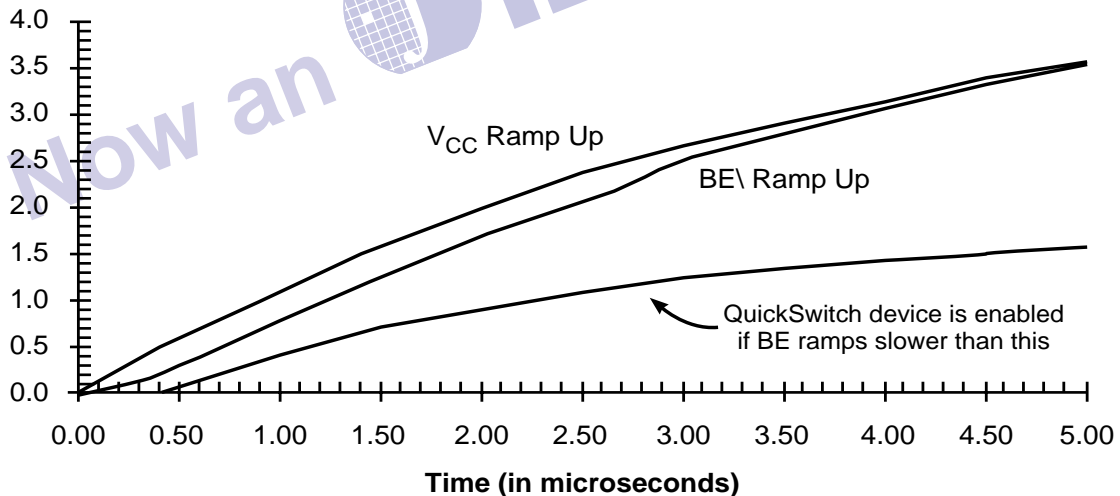


Figure 3. Slow Ramp Power Up Example

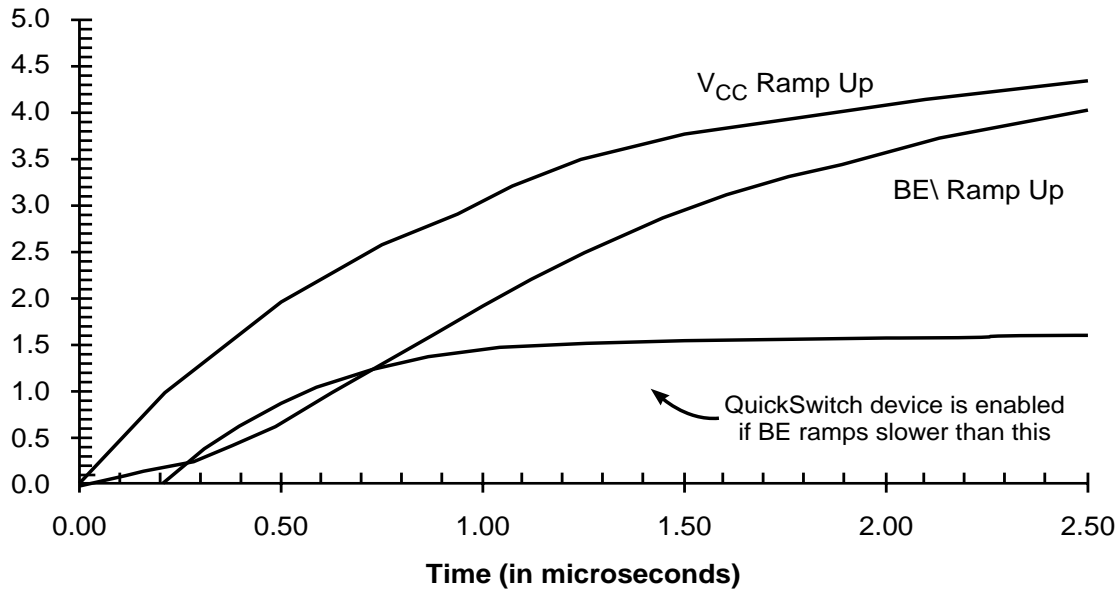


Figure 4. Fast Ramp Power Up Example

The trade off for a smaller value pull-up resistor and, hence, a faster power up time is more current through the resistor when the circuit is in the normal operation mode. Table 1 illustrates the power up time versus current consumption through the resistor for several pull-up resistor values.

Once the card has been powered up and any card initialization has been done, the card bus can be connected to the system bus by activating the QS3384 enables. The timing of this enable signal can be chosen to provide minimal disturbance when the capacitance of the card bus is connected to the system bus. In fact, the QS3384's can be

used to selectively connect the card to the bus only when the card is being accessed. This would reduce the capacitance seen by the system bus for operations other than those which access the card.

Figure 3 shows a different version of QuickSwitch isolation. In this case, the QS3384 isolators are mounted on the backplane. The QS3384's remain powered up with the system and are turned on and off as the cards are plugged and unplugged, respectively, from the system. The QS3384 enables can be a combination of a ready signal from the card plus a timing signal from the bus indicating a safe time to connect the card.

Table 1.  $V_{CC}$  Ramp Up vs. Current Consumption

$R_{PULL\ UP}$ Value	$V_{CC}$ Rise Time	Current thru $R_{PULL\ UP}$ *
10K	11 $\mu$ s	500 $\mu$ A
47K	46 $\mu$ s	106 $\mu$ A
100K	103 $\mu$ s	50 $\mu$ A
470K	314 $\mu$ s	11 $\mu$ A

\* When  $\overline{BE}$  node is pulled to 0V.

Note that it is possible to have QS3384's on both the backplane and the hot plugged cards. The QS3384's would be in series, like two sets of relay contacts. The system sees a 10 resistance rather than 5, and negligible propagation delay between the card and system buses is maintained. Having QS3384's on new designs would allow these cards to be added to existing systems, and having QS3384's on the backplanes of new systems would allow these new systems to be able to accommodate older design cards which were not designed for hot plugging.

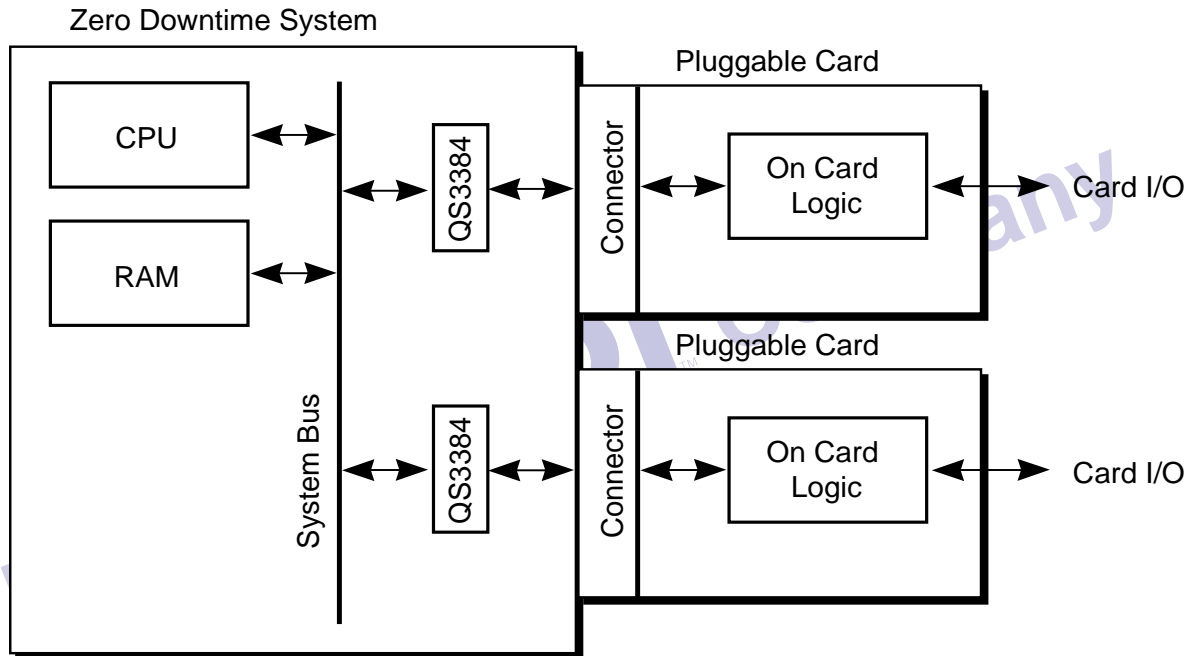


Figure 5. QS3384 QuickSwitch as System Bus Isolator