FET Switches in Docking Stations

Stephen M. Nolan
Standard Linear & Logic

ABSTRACT

Docking stations for portable electronics require the capability to connect a system with a live-running bus to a disabled or powered-down system. This hot-docking event must not cause any electrical damage, electrical signal glitches, or data corruption. This application report explains the use of TI FET bus-switch products with precharge to accomplish this connection.

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Introduction

The popularity of mobile electronics is increasing steadily. The use of mobile phone handsets, personal digital assistants (PDAs), laptops, game sets, and other portable devices is ubiquitous. Many of these devices are made more functional by the use of a docking system that allows for connection to power supplies, computers, printers, networks, and other fixed infrastructure.

The design of a docking system for portable electronics usually includes a method for connecting the system in the dock to an actively running high-impedance (reflective-wave switching) bus (for example, PCI bus) in the portable device. Connection of the electronic devices in the docking system, which are powered down or are in a standby state, can cause electrical signal glitches, data corruption, or electrical damage if the system has been designed without regard to certain fundamental criteria. Because of these concerns, typically, FET switch devices are used to enable and disable the connection between the live bus in the portable equipment and the systems in the docking station during docking and removal. This application report explains the recommended procedures and some devices that can be used.

System Considerations

A typical bus in a portable device usually is driven by high-impedance drivers and is not parallel terminated to any power-supply voltage (see Figure 1). This results in quiescent power savings, but causes the bus to be sensitive to changes in the electrical load capacitance.

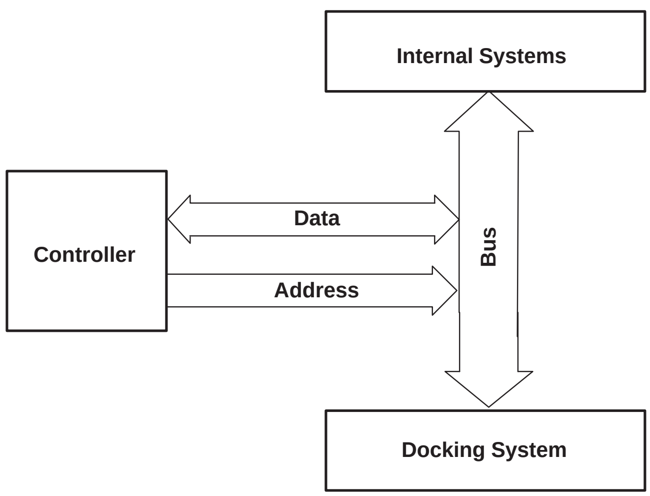

Figure 1. Typical Bus Structure

Connecting a docking system that is powered down or in a standby state can cause a glitch on the bus (see Figure 2).

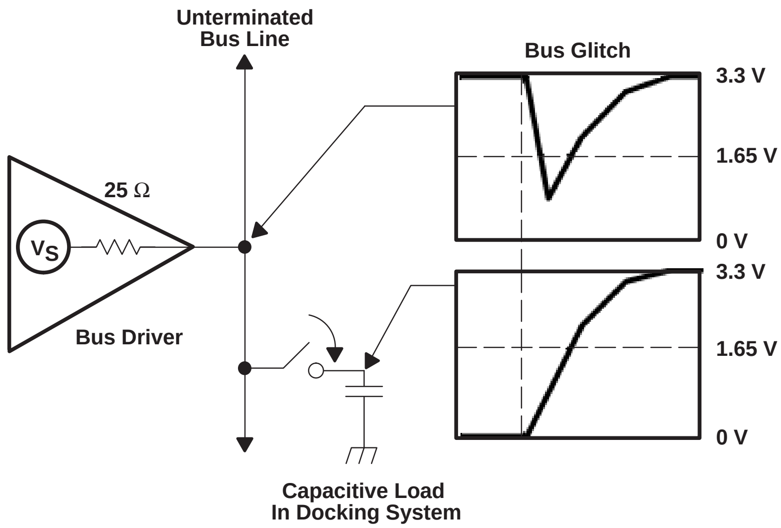

Figure 2. Bus Glitch

The connector pins, PCB traces, and device I/Os in the docking system form a large capacitor that, essentially, is charged to 0 V. If a bus line is at a logic-high level (e.g., 3.3 V) when a low-impedance connection is made to a discharged capacitive load (the docking system), the voltage on that line immediately will droop or glitch, possibly below the switching threshold voltage, while the energy from the relatively high-impedance driver slowly charges the large capacitance of the docking system. This is a slow RC delay. In addition to the obvious electrical glitch, there is a tremendous surge current required from the power supply. This results in potential data corruption.

Solution

The amplitude of the electrical glitch must be reduced to prevent data corruption and other detrimental system effects. The solution to reduce the glitch on the active data bus is to precharge the discharged capacitive load to a voltage level that is halfway between a logic high and a logic low prior to connecting the active bus to the load (see Figure 3).

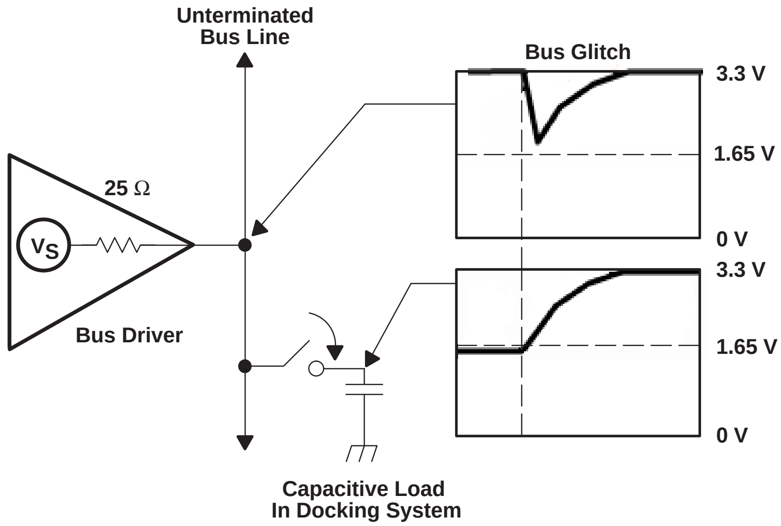

Figure 3. Reduced Glitch With Precharged Load

If the load is at a voltage that is halfway between a high and a low when the connection is made to the active bus, the amplitude of the glitch is reduced to a level that does not cross the threshold level and corrupt data.

FET Switches for Docking

TI provides the crossbar technology (CBT) family of devices for a variety of purposes. CBT devices are a 5-V family; basically, they are field-effect transistors (FETs) that system design engineers use for isolation. The 5-V CBT family of devices isolates one part of a system from another. Because the devices essentially are FET switches, when the transistor is on, they operate as a short circuit, and the voltage on the input is passed through to the output. When the transistor is off, it functions as an open circuit, and the input is completely isolated from the output. CBT devices are useful for docking or live-insertion applications when a 5-V power-supply voltage is available.

With the reduction of power-supply voltages from 5 V to 3.3 V, TI also has created a family of low-voltage crossbar technology (CBTLV) devices that operate from a 3.3-V power supply. The CBTLV is a 3.3-V logic family with a variety of uses similar to those of the CBT. As with the CBT family, CBTLV devices can be used for isolation purposes, and they can be used for hot-plug or docking applications where a 3.3-V power-supply voltage is available.

For systems with a 5-V supply and 5-V or 3.3-V signals, TI recommends the use of the SN74CBT6800A 10-bit FET switch with precharged outputs. Alternatives include the SN74CBTS6800 and SN74CBTK6800 devices, which include additional undershoot clamping for use in systems where signal integrity on the bus is an issue. For systems with a 3.3-V supply and 3.3-V signals, TI recommends the use of the SN74CBTLV16800 low-voltage 20-bit FET switch with precharged outputs. These devices provide precharge voltage to the outputs, which reduces system glitches. By using the recommended TI FET switches with precharged outputs to switch the I/O signals, a complete solution can be designed that provides a robust docking system.

FET Switches Onboard the Mobile System

System Configuration

One method of achieving isolation is to place the bus switches in the mobile system between the mobile system bus and the docking system connector (see Figure 4).

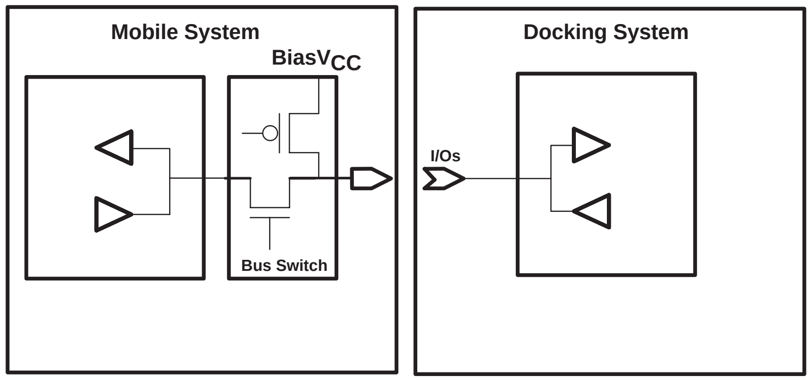

Figure 4. System Diagram With FET Switch in the Mobile System

In this configuration, the precharged port of the FET switch should be connected to the external connector. After insertion, the I/Os in the docking system are precharged by the FET switch to the bias voltage prior to enabling the switch connection between the active bus in the mobile system and the docking system circuitry. This is the recommended implementation; however, it might be undesirable due to the board area and power consumed by the addition of the FET switch devices in the mobile system.

Docking Sequence

With the use of FET switches in the configuration shown in Figure 4, consideration should be given to the sequence of events during a hot-docking event.

Prior to insertion of the mobile device into the dock, the ground, V_{CC} and BiasV_{CC} voltages should be applied to the FET switch. The FET switch should be disabled by placing the OE control line into the inactive state. This enables the precharge voltage to be applied to the port on the connector side. When the mobile device is inserted into an inactive dock system, the I/Os of the devices in that system become precharged to the BiasV_{CC} voltage level. Typically, this BiasV_{CC} voltage is set at a level that is at the threshold voltage. Therefore, it is best if the devices in the docking station remain powered down at this time or that the receivers be disabled because it never is good design practice to leave a CMOS input at its threshold voltage. If the devices within the dock remain powered down while the FET switch is enabled, they must have the I_{off} feature to prevent bus loading after the FET switch connection is made. The I_{off} feature prevents the outputs or I/Os of a device from loading the live signaling on a bus to ground through parasitic paths to V_{CC} when V_{CC} is grounded. At this time, the FET switch connection can be enabled, and the temporary, but reduced, glitch will be seen on the mobile system bus. Then, the devices in the dock system should be powered up, with their control inputs actively driven to a disabled mode until everything is initialized into a valid state.

FET Switches On the Docking Station

System Configuration

The other configuration is to place the FET switch into the docking system, with the precharged port connected to the docking connector (see Figure 5).

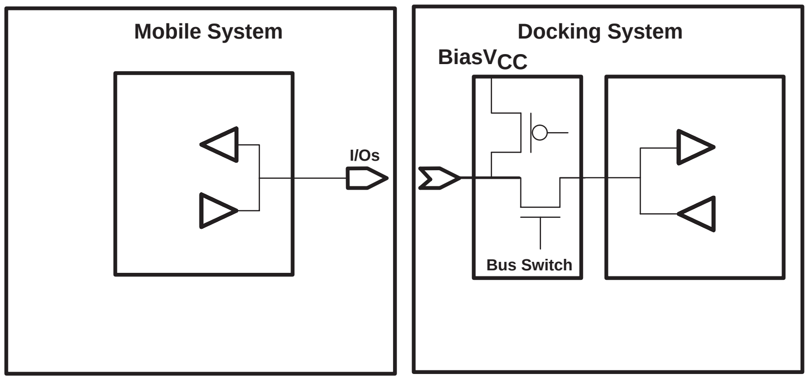

Figure 5. System Diagram with FET Switches in the Docking System

In this configuration, the docking system connections create a glitch during the insertion of the mobile device, and there also is a glitch when the FET switch is enabled. The advantage is that the space and power consumed by the FET switches is inside the docking system, not onboard the mobile device.

Docking Sequence

With the use of FET switches in the configuration shown in Figure 5, the following sequence of events should be followed during a hot-docking event.

Prior to insertion of the mobile device into the dock, the ground, V_{CC} and BiasV_{CC} voltages should be applied to the FET switch. The FET switch should be disabled by placing the /OE control line in the inactive state. This enables the precharge voltage to be applied to the port on the connector side. When the mobile device is inserted into an inactive docking system, there is a temporary, but reduced, glitch as the capacitance of the connector, lead-in PCB trace, and FET-switch I/O becomes charged from the BiasV_{CC} level to the active voltage levels on the mobile-system bus.

Upon recognizing the insertion into the docking station, the mobile system should temporarily halt activity on its internal bus. At this time, the FET switch connection can be enabled, and another glitch will be seen on the mobile system bus as the capacitance of the I/Os in the docking system becomes charged. If the I/O capacitance and bus capacitance in the docking system is large, this glitch can be considerable. If bus activity has been halted, this glitch should have no effect on data integrity. If it is not possible to halt bus activity prior to enabling the switch connection, it may be necessary to manage the glitch by precharging the docking system internal bus. However, this also would require that the devices in the docking system be powered down and that they support I_{off}. After the devices in the docking system are stabilized, they can be enabled, and activity on the bus can be restored to normal.

Summary and Conclusion

The use of TI FET bus switches with integrated precharge onboard a mobile device is a recommended method to reduce bus glitches during live insertion into an inactive docking system. By precharging the I/Os of the docking station to the threshold voltage level prior to enabling the bus switch, the resultant glitch is reduced to a level that does not disturb active data on the bus.

If the addition of bus switches to the mobile device is undesirable due to space or power constraints, the switches can be employed in the docking station. However, the activity on the bus in the mobile device should be temporarily disabled prior to enabling the switch connection to the docking station. This reduces the effect the secondary glitch might create.

TI FET switch products that support precharged outputs include the SN74CBT6800A, SN74CBTS6800, SN74CBTK6800, and SN74CBTLV16800. Data sheets and information on pricing and availability can be found at http://www.ti.com.

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