



SL811HS OTG Application Note

Introduction

In this application note, an On-The-Go (OTG) system is illustrated using the Cypress SL811HS Host/Peripheral controller along with some additional analog components. This design is provided as a proof of concept and is not optimized for high-volume production. Information specific to OTG, or to the SL811HS, is not covered here. Please refer to the OTG supplement and the SL811HS application note for further detail.

Overview of OTG

On-The-Go (OTG) is provided as a supplement to the USB 2.0 spec and is aimed at portable devices. Typical applications for OTG are in cell phones, PDAs, and set-top boxes. An example of how a PDA or set-top box could benefit from OTG is shown in Figure 1. OTG meets the following goals to provide better support for portable devices:

- Limited host capability to limit required software complexity
- A small USB connector to fit the limited form factor of portable devices
- Power conservation features to preserve battery life

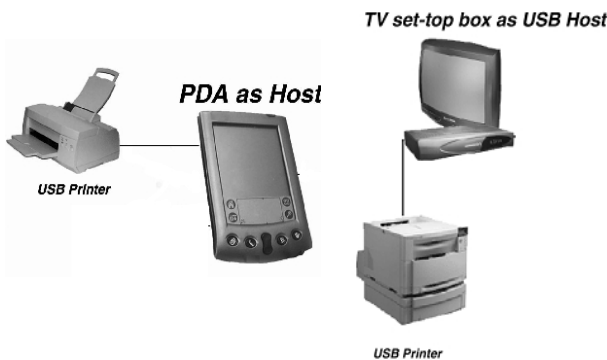


Figure 1. Typical OTG Applications

To accomplish these goals the OTG supplement introduces the Dual-Role-Device (DRD). A DRD is a USB 2.0 compliant device capable of functioning as either a Host or Peripheral with the following characteristics:

- Limited host capability
- Requires Full-speed operation (high-speed optional)
- Targeted Peripheral List
- Session Request Protocol (SRP)
- Host Negotiation Protocol (HNP)
- One, and only one, Mini-AB receptacle
- Minimum 8 mA output on VBUS

- Means for communicating messages to the user

A few of the characteristics listed above are discussed later in this application note. For detailed information please refer to the OTG supplement.

Overview of the SL811HS

The SL811HS USB Controller is an embedded Dual-Role Host/Peripheral device that can communicate with either full- or low-speed USB peripherals. The SL811HS can interface to devices such as microprocessors, microcontrollers, DSPs, or to a variety of buses such as ISA and PCMCIA. Refer to Figure 2 for a block diagram of the SL811HS.

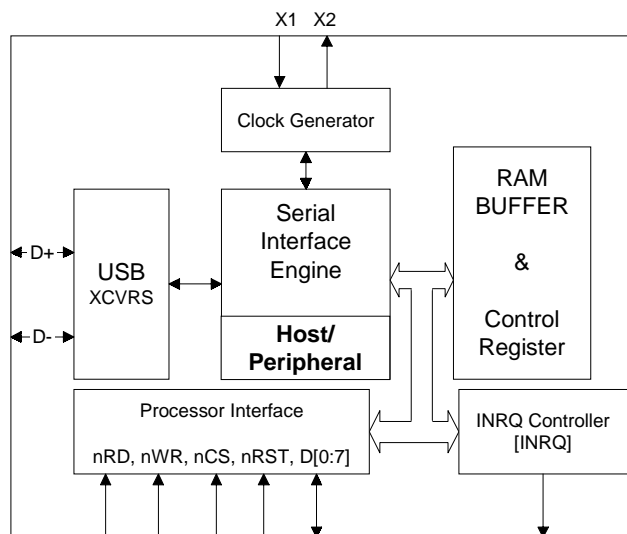


Figure 2. SL811HS Block Diagram

SL811HS-OTG DRD Reference Design

Figure 3 is a block diagram that illustrates how the SL811HS, along with some additional analog components and an external CPU, can implement an OTG DRD.

The SL811HS supports both USB Host and Peripheral modes under software control, without additional hardware. However, a small number of additional analog components are needed to meet all of the OTG requirements. These analog components are described later in this application note.

The SL11R, a general-purpose 16-bit RISC controller, is used as the external CPU. For more information on the SL11R please refer to the SL11R data sheet.

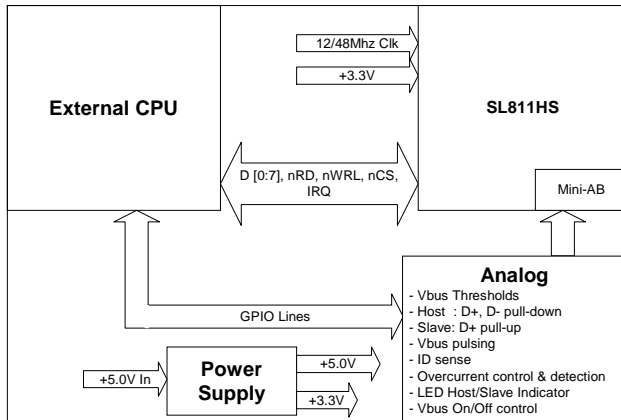


Figure 3. SL811HS_OTG Block Diagram

Description of Analog Components

VBUS Thresholds

VBUS needs to be monitored in both Host and Peripheral modes. Support for the Session Request Protocol (SRP) requires that VBUS be checked at several different levels to determine when a session begins and ends.

Over-current detection also requires monitoring of VBUS and is discussed further in the Over-Current Detection/Control section of this application note.

Four voltage comparators are used to monitor VBUS in this design and cover the following OTG parameters:

A-Device Vbus Valid:	VA_Vbus_VLD	> 4.4V
A-Device Session Valid:	VA_Sess_VLD	0.8V–2.0V
B-Device Session Valid:	VB_Sess_VLD	0.8V–4.0V
B-Device Session End:	VB_Sess_End	0.2V–0.8V

Please refer to the OTG supplement for more details on these parameters.

(Note that monitoring VBUS does not need to be as elaborate as shown in this reference design. Monitoring VBUS for voltages greater than 4.4V requires a comparator but all other parameters can be determined through timing and TTL level inputs. The additional comparators are used to provide software greater visibility of the levels of VBUS as would be needed during the debug stages of an OTG device.)

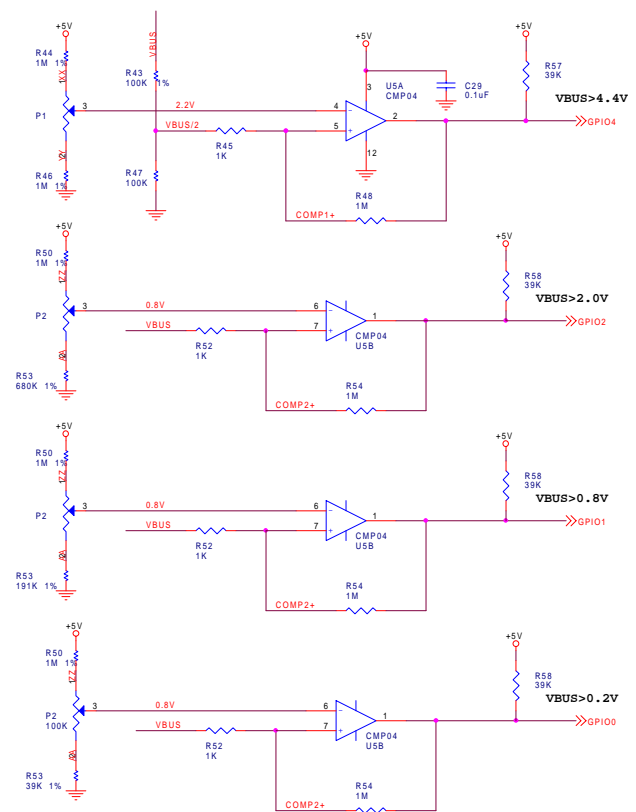


Figure 4. Voltage Comparators

VBUS Pulsing

VBUS Pulsing is part of the Session Request Protocol (SRP) which is described later. In this design, VBUS pulsing is made possible by tying a GPIO pin to VBUS through R40 as shown in *Figure 5*.

Pull-up and Pull-down Resistors on D+ and D–

In order for a device to work as both Host and Peripheral, it needs to be able to switch in and out the pull-up and pull-down resistors on D+ and D–.

There are many ways to control switching these resistors. The method shown in *Figure 5* uses the SL11R's GPIOs to switch the resistors on D+ and D– and is described below.

When the DRD is in Host mode, the GPIOy and GPIOz connect 15k pull-down resistors to ground and the GPIOx floats the 1.5k pull-up. When the DRD is in Peripheral mode, GPIOx connects a 1.5k pull-up resistor to power while GPIOy and GPIOz float the 15k pull-down resistors. (Note that the OTG supplement doesn't allow the pull-down on D- to be turned off. The switch is used in this design for debug purposes.)

ID Pin Sensing

When the user inserts a plug into the Mini-AB Receptacle the ID-pin is used to determine if the DRD is an A-device or a B-device. If ID is shorted to ground, this is an indication that a mini-A plug has been inserted which makes the DRD the A-device. Software monitors the state of the ID pin through a GPIO.

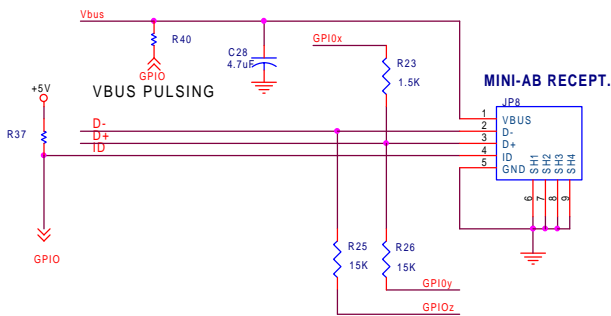


Figure 5. VBUS Pulsing, D+/D-, & ID Pin Sensing

Over-current Detection/Control

When the DRD is an A-device, it is required to provide VBUS during a session. The attached B-device may draw more current from VBUS than the A-device is able to provide. Comparator 1 in Figure 4 detects when VBUS drops below 4.4V, indicating that an over-current condition exists. Additionally, the current-limiting circuit shown in Figure 6 provides protection should software fail to turn off VBUS.

VBUS On/Off Control

VBUS On/Off is used to control VBUS as shown in Figure 6. When a DRD is an A-device, software will turn on VBUS until the end of the session. When a DRD is a B-device VBUS must be turned off.

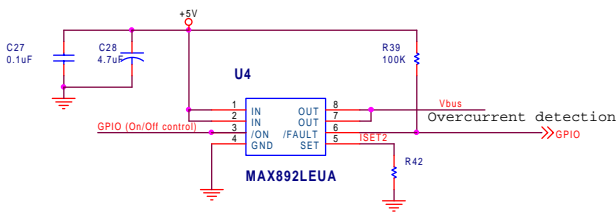


Figure 6. Over-Current Detection/Control

LED Host/Peripheral Indicator

The LED provided in this design is not required by the OTG supplement. It is provided as a debug aid and may be used to indicate, among other things, whether the DRD is performing as a Host or a Peripheral.

The circuit below uses an external GPIO to indicate the current state of the DRD. It is "On" when the DRD is in Host mode and "Off" when in peripheral mode.

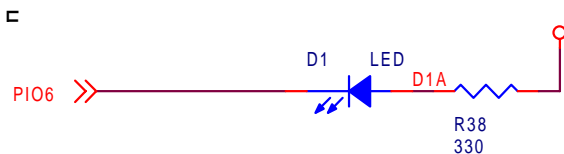


Figure 7. LED Host/Peripheral Indicator

SL811HS_OTG Software

The basic SL811HS functions for Host and Peripheral operation are described in detail in the SL811HS Application Note. This section only describes additional software for implementing OTG.

When the SL811HS is a DRD, software is needed to support all *SetFeature Commands* which are defined in section 6.4 and 6.5 of the OTG supplement. In addition, an OTG descriptor must be added as defined in the supplement.

There are two main functions of On-The-Go, SRP and HNP, and they are discussed in the following sections:

Session Request Protocol (SRP)

SRP is a protocol that allows the B-device to request the A-device to supply power on VBUS and start a session.

When the B-device initiates SRP, software causes the data line (D+) to be pulsed and then VBUS to be pulsed. The A-device may respond to either the data-line pulse or the VBUS pulse (or both) by providing power on VBUS. Here are state diagrams to illustrate two DRDs in SRP.

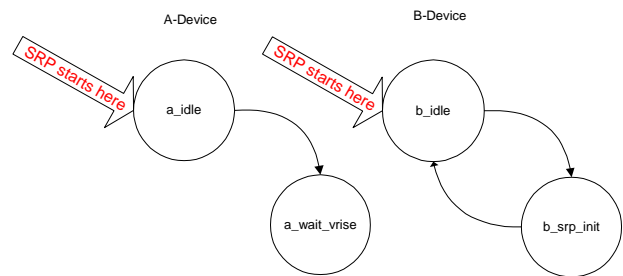


Figure 8. SRP State Diagram 1

SRP ends when the A-device turns on power. Once the A-device determines that VBUS has reached a valid level, it will become the USB Host and enumerate the B-device.

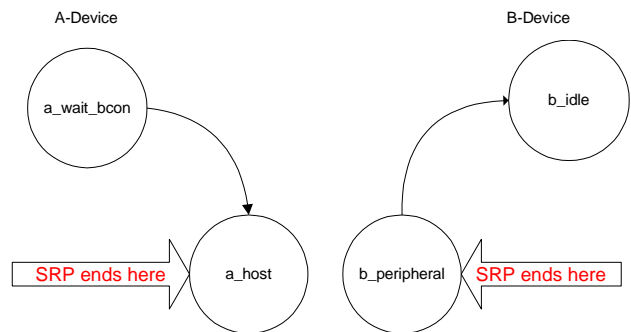


Figure 9. SRP State Diagram 2

Host Negotiation Protocol (HNP)

HNP is a protocol that allows the B-device to become the Host. This eliminates the need for an end-user to swap the Mini-AB cable around when the roles of the attached DRDs need to change (often, the users will not understand that there are different roles for the devices). (See section 6 of the OTG supplement for more detail.)

Figure 10 shows the portion of the A-device state diagram used during HNP. Figure 11 shows HNP states for the B-device.

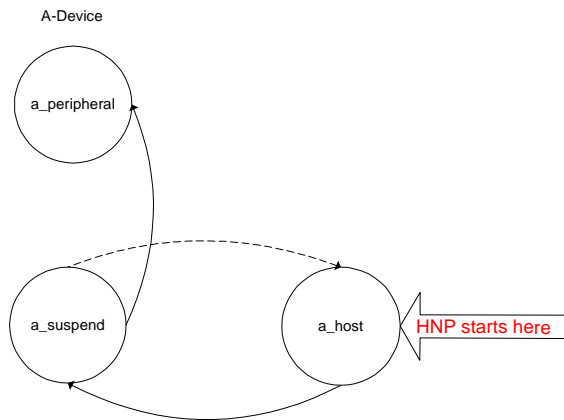


Figure 10. HNP State Diagram 1

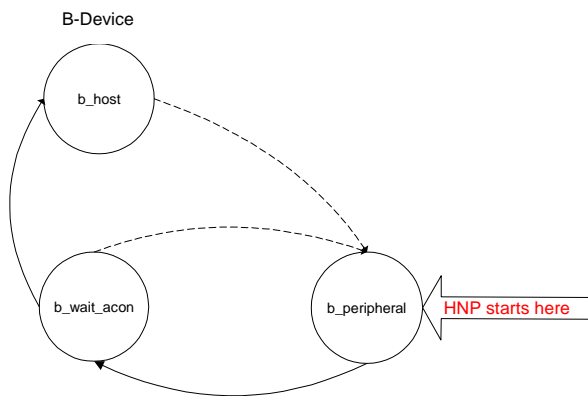


Figure 11. HNP State Diagram 2

(Note: The *a_host* state is a starting state for the transfer of control from the A-device to the B-device and the ending state when control is returned from the B-device. Similarly, *b_peripheral* is a starting and ending point for HNP on the B-device.)

The transfer of control to the B-device starts when the A-device suspends the bus. If the B-device needs to become the host, it will signal a disconnect by turning its D+ pull-up off. Since the A-device has enabled the B-device for HNP, the A-device will interpret this “disconnect” as a request from the B-device to become host. The A-device completes the transfer of control by turning on its D+ pull-up.

Control is returned to the A-device when the B-device stops all bus activity. The suspension of activity by the B-device causes the A-device to turn off its pull-up and become host. The “disconnect” condition is detected by the B-device and it once again becomes the peripheral and turns on its pull-up.

Figure 12 illustrates how an A-device returns from the *a_peripheral* state to the *a_host* state

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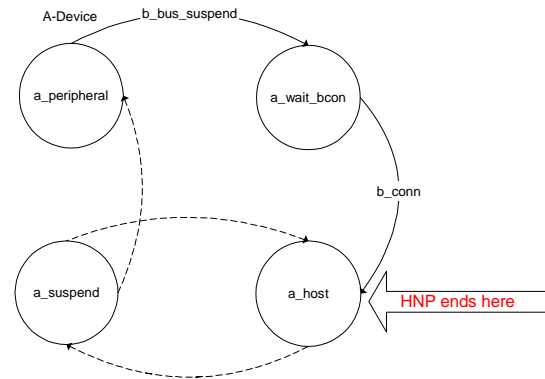


Figure 12. HNP State Diagram 3

Figure 13 illustrates how a B-device return from the *b_host* state to the *b_peripheral* state:

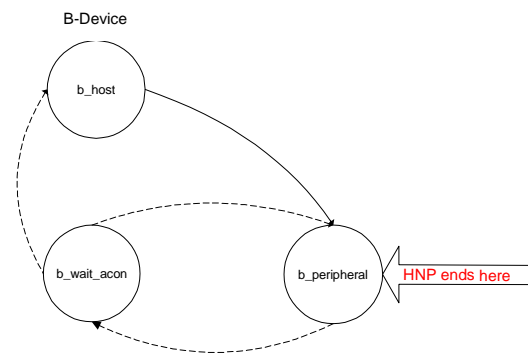


Figure 13. HNP State Diagram 4

See Figure 6.1 HNP Sequence of Events in the OTG supplement for more details.

Conclusion

The SL811HS is the first production dual-role USB host controller. By adding some additional analog components and an external CPU, developers can implement a full OTG system. For production, component selection can be optimized to lower the cost.

This product is part of Cypress’s roadmap to support embedded host devices and OTG solutions. Future products will offer higher integration and require even fewer external components.

Contact your local Cypress Sales Representative for full design details including schematics, firmware, etc.