Enabling high-speed USB OTG functionality on TI DSPs

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High-speed USB On-The-Go (OTG) enables connectivity between portable consumer electronic devices over the industry's most popular peripheral interface, USB. Currently, USB devices require a PC host—laptop or desktop—to transfer data. High-speed USB OTG removes the need to find a bulky PC host to transfer pictures, music, and data to/from a cell phone, digital camera, MP3 player, memory stick, etc. Power is not much of an issue with today's PC host-centric USB, but is of increasing concern as portable devices take on more functionality and the demand for longer battery life increases. The problem of USB direct connection and power-management complexities is solved with the new USB 2.0 high-speed OTG controllers and power-management devices from Texas Instruments (TI). These devices allow developers to add full high-speed OTG capability to their platforms in small-form-factor, low-power designs. TI's OTG devices are available with a muxed NOR-flash or VLYNQ host interface for easy connectivity to TI's OMAP processors and many other DSPs.

What is USB OTG?

The terms USB 1.1, USB 2.0, USB OTG, WUSB, and OTG are all in common use today. In many cases they have created confusion among engineers and end users. The original USB 1.0 specification was released in January 1996. It defined two speeds for devices, low speed (LS) at 1.5 Mbps and full speed (FS) at 12 Mbps. The specification was revised in July 1998 and released as USB 1.1 with major clarifications/updates. In April 2000, the specification underwent a major revision and was released as USB 2.0, the current version that fully superseded USB 1.1. The beauty of USB 2.0 is that it maintains full backwards compatibility with USB 1.1 devices. However, it adds a much needed third speed node, high speed at 480 Mbps, while keeping support for both low speed and full speed. In July 2003, the USB OTG addendum was released, defining a new class of devices for portable, battery-powered products with limited host capabilities. Finally, in May 2005, the Wireless USB (WUSB) specification was released.

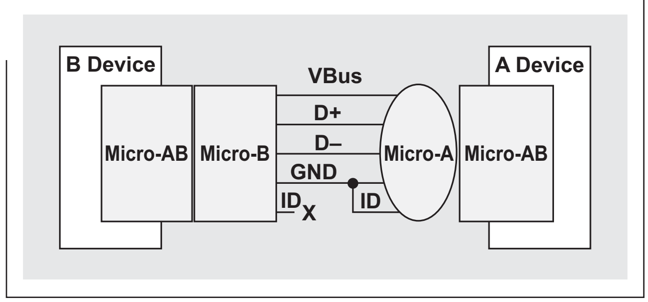
USB OTG is an addendum to the USB 2.0 specification that defines a new class of devices that extends the functionality of a peripheral product to include limited host capabilities. As the name implies, the original target of the specification was consumer portable devices with which end users may have wanted to share data when a computer was not available. Usage examples included sharing contact information between two PDAs or cell phones, sharing pictures from one digital still camera or camera phone with another, or printing directly from a digital still camera or PDA. Like standard USB, OTG is a point-to-point, host-centric bus and is not intended as a peer-to-peer networking connection. An OTG product must act as a standard peripheral when connected to a standard USB host such as a PC. The OTG addendum mainly addresses how a device must act when it is in host mode.

Just like a standard USB host port, an OTG host must supply power; but the required supply current is limited to 8 mA. Unlike a standard USB host in a PC, an OTG device may not have a simple way to add drivers for "unrecognized" devices. Therefore, an OTG device must supply what is called a Targeted Peripheral List (TPL), which allows device manufacturers to specify exactly what peripherals they will support. The specification also mandates messaging that will communicate to the end user that an unsupported device has been plugged in and will not work. This messaging can be as simple as an LED or as complex as a text display.

Since the target end products were primarily small portable consumer electronics, a standard USB connector was too large. Therefore the USB Implementers Forum introduced new mini and micro connectors. The mini-B connector has been in common use as a small-form-factor receptacle on many USB peripherals. The micro-AB receptacle is what a dual-role OTG device must use. This connector accepts either a micro-A plug or a micro-B plug. The orientation of the cable determines which device in an OTG connection acts as the host (A side) and which acts as the peripheral (B side), as shown in Figure 1. The new connector has an additional pin (ID) that is left open on the micro-B plug and is grounded in the micro-A plug to determine initial roles.

Although cable orientation determines which role, host or peripheral, each OTG device will initially assume at connection, the roles can be reversed via a dynamic switching method called Host Negotiation Protocol (HNP).

Figure 1. Cable orientation determines initial state

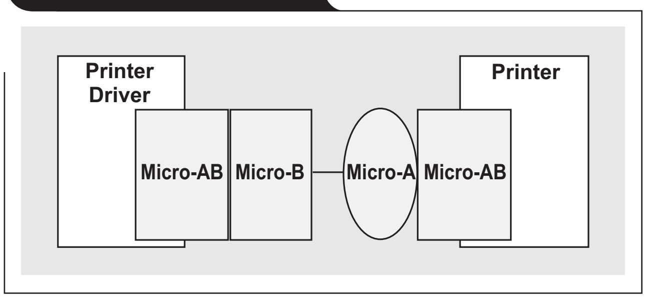


Why switch roles? The need for this can be understood if we look at Figure 2 and consider that every OTG device must include a TPL. The device on the left has the printer on its TPL, but it is *not* on the printer's TPL. If the user plugs in the cable backwards as shown in Figure 2, then communication between the two devices will not be possible without reversing the roles. HNP allows the roles to be reversed silently and automatically, thus enabling the communication and enhancing the end-user experience by eliminating the need to disconnect the cable and reverse it.

Session Request Protocol (SRP) is a method for turning bus power off/on at the discretion of the host device to save power when communication is not needed. Many of the target devices for OTG are battery-powered. Extending battery life is of utmost importance to both the manufacturer and the end user. With this in mind, the A device (as indicated by cable orientation) in an OTG connection can power off the bus and go into a sleep mode, extending battery life. This also allows the B device to go to sleep if it so desires. However, if the end user desires the communication to start up again and initiates this request on the B device, SRP allows the B device to request the A device to turn on VBus power and start a session. An OTG session is defined as the time during which the A device is furnishing VBus power. To wake up the A device, the B device pulses first the D+ wire and then the VBus wire. The A Device, which can respond to either pulsing, detects the pulse, causing it to switch on VBus and start a session.

SRP is more complex than this simple illustration. The B device, for example, must first measure VBus to ensure that a session is not in progress. It must also be able to differentiate between a classic PC or an OTG device at the other end of the cable. It does this by delivering measured amounts of current to the VBus wire and noting the resulting voltage.

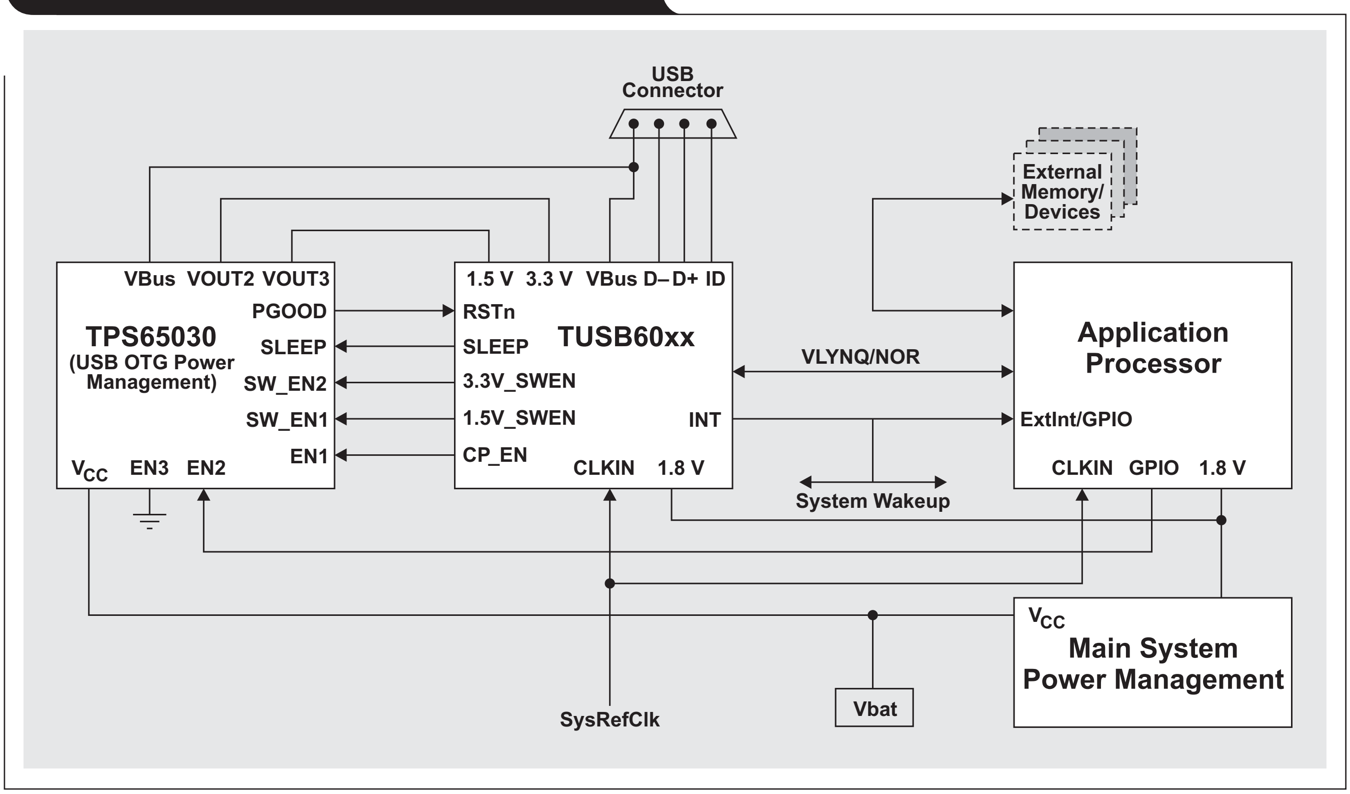
Figure 2. HNP example



TUSB60xx: The family of high-speed, OTG-interface-solution devices

This family of devices enables application processors (DSPs, OMAP™, and MCUs) that do *not* have integrated USB cores to function as either a USB 2.0 high-speed peripheral, an embedded USB 2.0 high-speed host controller, or a full USB 2.0 high-speed OTG device. The TUSB60xx devices serve as bridges between a USB 2.0 high-speed bus and a local processor host interface. Figure 3 shows a typical system implementation. The TUSB60xx family is

Figure 3. TUSB60xx typical system implementation



fully compliant with high-speed USB OTG. These devices come in a space-saving 5 × 5-mm MicroStar Junior™ BGA package and support an ultralow-power idle mode that consumes less than 100 µA. Both of these features are critical to small portable consumer devices that feature USB OTG. An application processor is required to support software needs. These include the operating system for host mode, the drivers for the TPL devices when they are in OTG host mode, and the application functionality when the TPL devices are in peripheral mode. A summary of the TUSB60xx family's features and benefits is given in Table 1.

The TPS65030 is a companion power-management device to the TUSB60xx devices. In addition to providing all of the power requirements of the TUSB60xx, it can provide 5 V at 100 mA on the VBus line when a TUSB60xx device is in OTG host mode.

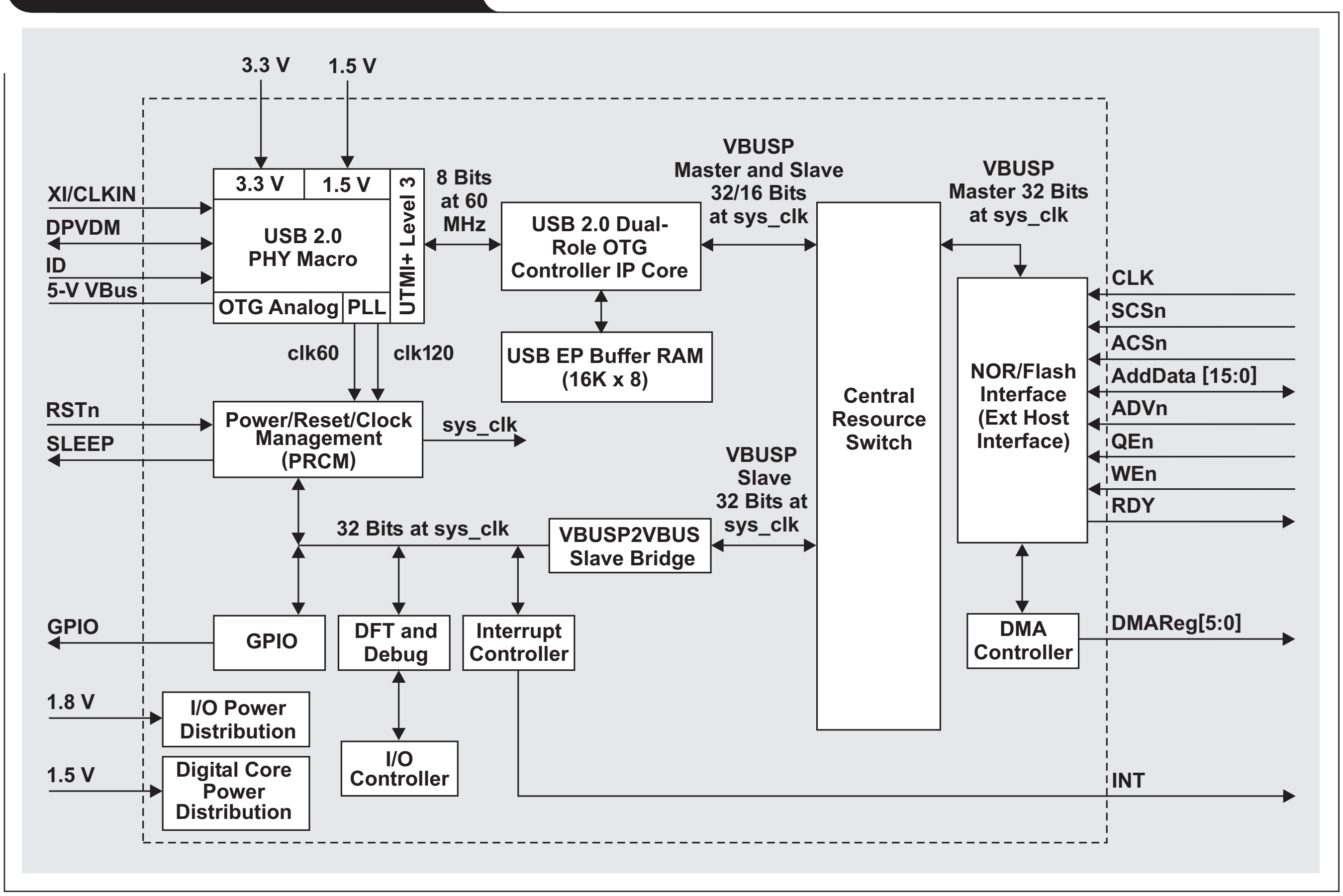
The first two members of the TUSB60xx family are the TUSB6010B and the TUSB6020. The only difference between the two devices is the external processor interface.

The TUSB6010B (Figure 4) features a 16-bit muxed NOR-flash interface that supports both synchronous and asynchronous transfers. The TUSB6010B supports single and burst read/write access with a programmable burst size of up to 16 half words. It can also support 6 external direct-memory-access (DMA) requests. The TUSB6010B will gluelessly interface to the OMAP1710 and the OMAP2420 processors. When the device is used with the OMAP2420 with the GPMC running at 55 MHz, the throughput measures a sustained 250-Mbps bulk input and bulk output with DMA. When the TUSB6010B is connected to the OMAP1710 with the external memory interface running at 55 MHz, the throughput measures a sustained 250-Mbps

Table 1. TUSB60xx family

Features	Benefits
• USB 2.0 high-speed, OTG-compliant device	• Certified compliance and interoperability
• Multiple external processor interface options	• Flexible architectures to interface to multiple processors
• Ultralow-power (<100-µA) idle mode; small form factor = 5 x 5-mm MicroStar Junior™ BGA	• Designed to meet the critical demands of portable, battery-powered target devices

Figure 4. TUSB6010B block diagram



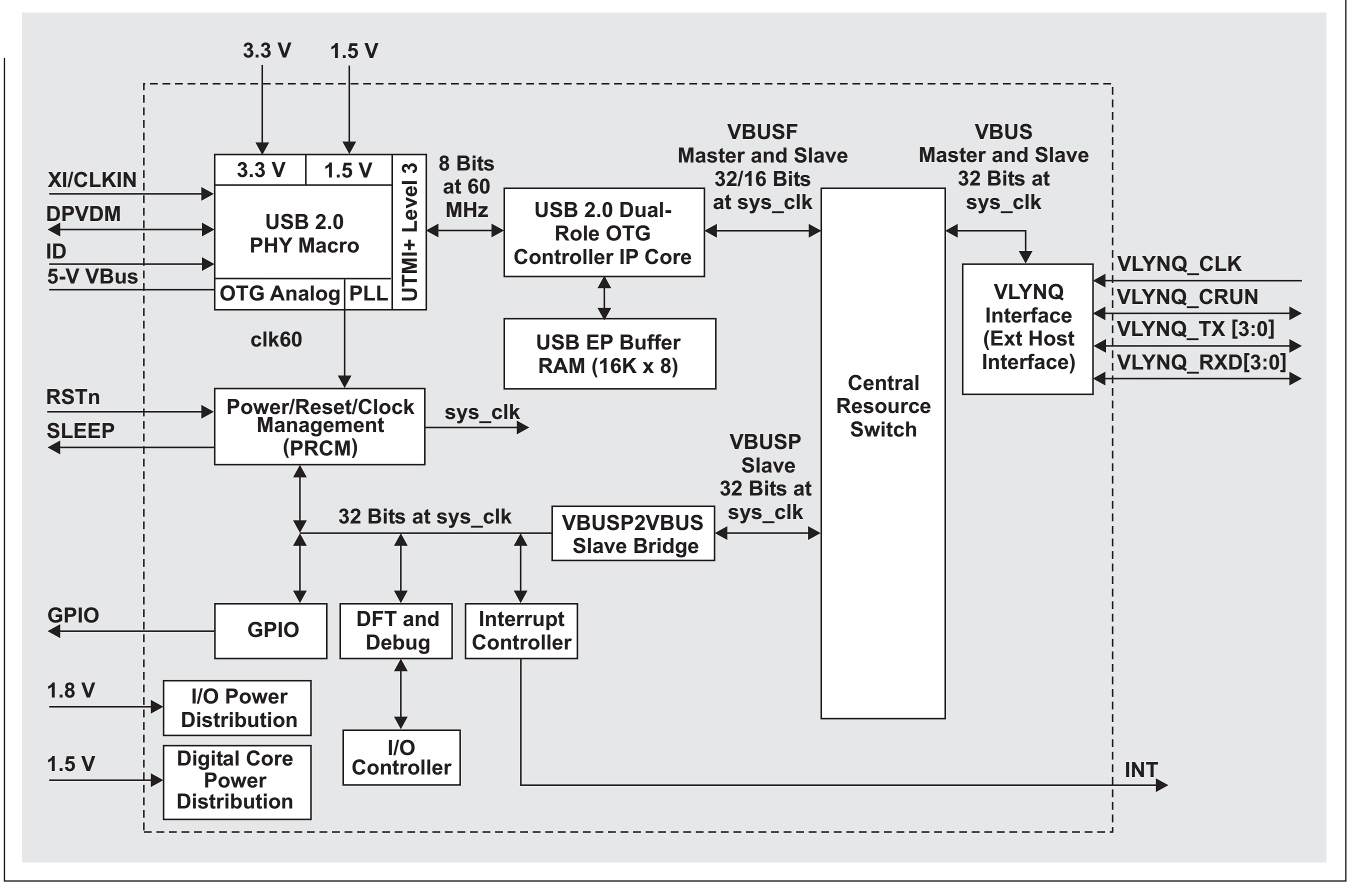
bulk output with synchronous DMA and a sustained 100-Mbps bulk input with asynchronous DMA.

The TUSB6020 (Figure 5) features a VLYNQ interface, which is a high-speed, low-pin-count, point-to-point serial specification developed by TI. The TUSB6020 features a 10-pin interface supporting 4 receive lines and 4 transmit lines that run at 150 MHz. It works as a memory-mapped master/slave interface with a multichannel DMA controller. The integrated list processor is capable of parsing CPPI 3.0-compliant buffer descriptors. The TUSB6020 will gluelessly interface to any TI processor that supports a VLYNQ interface. These processors include (but are not limited to) the DaVinci™ family, the DM320, and the OMAP5912. Utilizing an 8-pin VLYNQ interface running at 125 MHz, the TUSB6020 will enable a sustained 267-Mbps bulk input and bulk output.

Related Web sites

interface.ti.com
www.ti.com/davinci
www.ti.com/sc/device/*partnumber*
Replace *partnumber* with OMAP5912, TUSB6020, or TPS65030

Figure 5. TUSB6020 block diagram



Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

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