USB On-the-Go Solutions

Wes Ray, Applications Engineer
Dan Harmon, Product Marketing
Texas Instruments
Digital Interface Business Unit
Agenda

- Why USB On-the-Go (OTG)?
  - What is USB OTG?
  - TI USB-OTG Solutions
  - Demonstration
The need for USB OTG?

• Plethora of new portable consumer electronics requires a new connection when away from the personal computer (PC).
• This capability to share data among consumer electronics has historically been limited by the lack of an industry standard.
• With vast majority of these devices communicating with the PC via USB, the USB is a natural candidate for mobile point-to-point connectivity. HOWEVER:
  – USB’s master-slave protocol (relying on the power of the PC) may be too complex to implement on these portable devices - typically over-kill
  – A standard USB host will significantly cripple the battery life of a low-powered device
  – Connectors are also too large for the form factor of those devices

The birth of USB OTG!

• The USB OTG specification simply upgrades the current peripherals to feature limited host functions to interconnect a certain number of devices.
• Example target end-equipment include (but is not limited to):
  – Digital Cameras
  – Portable Audio Player
  – Personal Digital Assistants (PDAs)
  – Mega-Pixel Camera Phones
  – Smart Phones
  – Web-Tables
Alternatives to USB-OTG

**Bluetooth**
- **Strengths:**
  - Designed to connect consumer electronics
  - Established within the market
  - Wireless connection
- **Weakness:**
  - Speed

**FireWire or IEEE 1394a**
- **Given a face-lift to the digital video industry since its inception**
- **Strengths:**
  - Solid isochronous transfer
  - Multiple bandwidth modes
  - Ultra-high speed
  - Peer-to-peer architecture that USB 2.0 lacks
- **Weaknesses:**
  - Power requirements may be too high to be practical on target devices
- **Realistically, has a different application focus than USB-OTG**
Agenda

• Why USB On-the-Go (OTG)?

What is USB OTG?

• TI USB-OTG Solutions

• Demonstration
What is USB OTG?

• USB OTG is an addendum to the USB 2.0 Specification that defines:
  – A new type of “dual-role” device intended to extend the functionality of a peripheral product to include limited host capabilities.
    • OTG host must supply power; however, the required supply current is limited to 8 mA.
  – New negotiation rules
    • Host Negotiation Protocol (HNP) defines a method for dynamic switching between host and device roles.
    • Session Request Protocol (SRP) enables a method for bus power to be turned off/on at the discretion of the “host” device.
  – New mini connectors

• Target applications are portable devices with which end-users want to share data when a computer is not available.
  – Sharing contact information between two PDAs or cell phones
  – Sharing pictures from one DSC or camera phone with another
  – Sharing music between portable audio players
  – Printing directly from a DSC 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.
Dual Role OTG Devices

- Extends the functionality of a peripheral product to include limited host capabilities.

- Must act as a standard USB peripheral when connected to standard USB host.

- When a device is acting as the host (A-device):
  - Must be able to source a minimum of 8mA to the connected peripheral (B-device).
  - Unlike a standard USB host in a PC, an OTG device may not have a simple way to add drivers for “unrecognized” devices.
  - An OTG device must supply what is called a Targeted Peripheral List that allows the device manufacturer to specify exactly what devices they will support.
  - The specification also requires some type of messaging display to enable communicating to the end-user that an unsupported device has been plugged in and that it will not work.
Host Negotiation Protocol (HNP)

- An OTG device can operate either as a host or peripheral.
  - Cable orientation determines the initial roles
  - Grounded ID pin is the default A-Device → initial host
  - Floating ID pin is the default B-Device → initial peripheral

- HNP enables devices to exchange roles.

- Why switch roles?
  - Devices are connected as shown
  - The PDA has a printer driver inside - this setup is backwards!
  - HNP enables the roles to reverse automatically and silently, rather than bothering the user to reverse the cable
Session Request Protocol (SRP)

- SRP allows a B-Device to request an A-Device to turn on VBUS power and start a session.
  - An OTG session is defined as the time that the A-Device is furnishing VBUS power.
    - A-Device always supplies VBUS power

- A-Device can power down the VBUS wire ending the session, which the B-Device can detect and it can enter a low-power state.
  - A button is then pushed on the left phone to request a session (i.e. synchronize address books).
    - The B-device pulses first the D+ wire, and then the VBUS wire to wake up the A-Device
    - The A-Device then detects the pulse, causing it to switch on VBUS and start a session (A-Device can respond to either pulsing)
New Mini Connectors

- Dual Role device must use the Mini-AB Receptacle.
  - When connected to a mini-A plug, device initially acts as the “host”
  - When the mini-B plug is connected, the device initially acts as the “peripheral”
- OTG-compatible cable provides a mini-A plug at one end and a mini-B plug at the other.
- Mini-A is for host–only devices.
- Mini-B is for peripheral–only devices.
Potential USB OTG Issues?

- To consumers, the additional OTG USB cables may be confusing.
  - Users would be using one cable for exchanging data between their PDA and MP3 player, and another for hooking them up to a PC.
  - Will users remember to bring both cables for the different usage scenarios?

- Consumers will also have to learn how to plug the cables correctly to suit their needs.
  - Are the connectors sufficiently different to allow easy usage scenarios?

- Some users will find that the 'Targeted Peripheral List' to be somewhat lacking.
  - Messaging needs to clearly identify unsupported peripherals or user confusion will result.
Usage Scenario #1

- OTG enabled Device is required to act as a standard USB peripheral.
  - Could be class device such as Media Transfer Protocol (MTP) complaint MP3 Player or Mass Storage Class Peripheral (MSC)
  - Could require user to load a customized driver on to PC to enable functionality
- Example applications:
  - Syncing PDA/Phone Contacts
  - Syncing music library for MP3 Players
  - Copying pictures from DSC to PC for editing/printing
Usage Scenario #2

- Device is USB OTG host to target peripheral
- OTG enabled device is required to implement the “operating system”
  - Drivers must be included in support of Target Peripheral List (TPL)
  - Messaging must be enabled to notify for non-supported peripheral connection event
  - Must supply a minimum of 8mA (5V) of USB Power
- Example applications:
  - Adding KB or mouse to a PDA
  - Updating contents of PDA/Phone from USB Flash Memory
  - Copying pictures from DSC to USB Flash Memory
Usage Scenario #3

• “Host” Device is required to implement the operating system – including drivers – in support of the targeted peripherals.

• “Peripheral” Device is required to implement the desired type of USB Peripheral.

• Host Negotiation Protocol can enable role reversal if cable connected backwards.

• Example applications:
  – Sharing PDA/Phone Contacts
  – Sharing music between MP3 Players
Agenda

• Why USB On-the-Go (OTG)?

• What is USB OTG?

 TI USB-OTG Solutions

• Demonstration
TI USB-OTG Enabled Solutions

• Many DSP/OMAP™/IAG devices have integrated USB OTG digital cores
  – Some are USB 2.0 full-speed only (12 Mbps), while some support USB 2.0 high-speed (480 Mbps).
  – Most require an external analog transceiver to operate as a USB OTG device.
    • TI is working on discrete transceivers
  – Some newer processors have fully integrated high-speed USB OTG functionality – core and transceiver.

• To enable processors which do not have the USB digital core integrated – or which only natively support full-speed USB and the application requires high-speed USB, we have developed a family of high-speed OTG bridge devices.
IDLE Mode Definition

- OTG Phy is in suspend state
  - PLL is disabled
  - Analog OTG should be on in order to detect:
    - VBUS status change
    - ID status change
    - HostDiscon status change in a Host mode
- Single ended receivers should be on to detect:
  - DP/DM status change (LineStates)
- All internal clocks turned off with proper sequence:
  - Disable any peripheral clock
  - Disable system clock source
  - Disable crystal clock feedback path
- Digital core disables oscillator feedback path to stop reference crystal clock
- I/Os initialized to state that minimize I/O leakage (controlling direction, pull-up/pull-down, etc.). This is controlled by external Host Controller through register access.
- IDLE Mode current <100uA
TUSB60xx
USB 2.0 High-speed OTG Interface Bridge Family

**Features**
- USB 2.0 High-speed OTG Compliant Device
- Multiple External Host Interface Options
- Ultra low power (<100uA) IDLE Mode
- Small form factor = 5x5 mm JrBGA

**Benefits**
- Certified compliance and interoperability
- Flexible Architectures to interface to multiple processors
- Designed to meet the critical demands of portable, battery-powered target devices
- Meets the demands of small form factor portable device
System Block Diagram

• Application processor is required to support software needs including:
  – Operating system for Host mode
  – Drivers for target peripheral list when in OTG Host mode
  – Application functionality when in peripheral mode
TPS65030
OTG Companion Power Management

- 4 Regulated Output Voltages with 3% tolerance
  - Fractional charge pump for 5V/100mA
  - Fractional charge pump for 1.5V/200mA
  - Doubling Charge pump with LDO mode for 3.3V/20mA
  - LDO for 1.8V/60mA
- Switching Frequency 1 MHz
- 3.0V to 5.25V Operating Input Voltage Range
- Sleep mode:
  - Sets Vout2 into LDO mode
  - Reduces quiescent current of Vout2, Vout3 and Vout4 to 8uA each
- Internal bus switch
- Vbus comparator
- Internal Soft Start limits Inrush Current
- Low Input Ripple and Low EMI
- Over Current and Over Temperature Protected
- Under Voltage Lockout with Hysteresis
- Ultra-Small 2.5mm x 2.7 mm chip scale Package
ZQE Package Information
TUSB6010A
USB 2.0 High-Speed OTG to Muxed NOR Interface

- NOR FLASH-like External Host Interface
  - 16-bit multiplexed
  - Synchronous/Asynchronous
  - Single and burst read/write access
  - Programmable burst size up to 16 half words
  - Support for six external DMA requests
  - Little endian

- Glueless Interface to OMAP1710, OMAP2420, and eCOSTO
TUSB6010A Performance

• OMAP2420, NOR Interface
  – GPMC running at 55 MHz
  – Sustained 250 Mbps Bulk In and Bulk Out with DMA.

• OMAP1710, NOR Interface
  – EMIF running at 55 MHz
  – Sustained 250 Mbps Bulk Out with sync DMA.
  – Sustained 100 Mbps Bulk In with async DMA.
TUSB6010A Software Solutions

- TI Solution
- Linux-based
- Based on OMAP2420/1710 Processors
- In Peripheral Mode
  - Act as Mass Storage Class Peripheral
  - Act as Human Interface Device Class Peripheral
- In Host Mode
  - Service Mass Storage Class Peripherals
  - Service Human Interface Device Class Peripherals
- Source Code will be available:
  - Port to different processor
  - Support for additional peripheral types

- Alternatives Solutions
- Symbian Licensee
  - For OMAP2420 or OMAP1710
  - Contact Symbian for more information
- Mentor Graphics Linux Support
  - Available directly from Mentor
  - Processor Agnostic
  - Customer will need to port to chosen processor and OS
  - TI has not evaluated this stack for use with the TUSB6010A

Estimated Development Schedule:
Beta SDK: Late 3Q07
Full-release: Late 4Q07
TUSB6020
USB 2.0 High-Speed OTG to VLYNQ™ Interface

- 10-pin VLYNQ External Host Interface:
  - High speed (150 MHz) point-to-point serial interface
  - Supports 4x RX and 4x TX lines
  - Memory mapped master/slave
  - Hardware flow control
  - Internal loop-back mode
  - Multi-channel Direct Access Memory (DMA) Controller
  - Integrated List Processor capable of parsing CPPI 3.0 compliant Buffer Descriptors

- Glueless Interface to multiple TI Processors including
  - DaVinci™
  - OMAP5912
TUSB6020 Performance

• DaVinci VLYNQ Throughput
  – Eight pin VLYNQ Interface running at 125 MHz
  – Sustained 267 Mbps Bulk In and Bulk Out
TUSB6020 Software Solution

- DSP/BIOS™-Based
- Based on DM64x™ (DaVinci) Processors
- In Peripheral Mode
  - Act as Mass Storage Class Peripheral
  - Act as Human Interface Device Class Peripheral
- In Host Mode
  - Service Mass Storage Class Peripherals
  - Service Human Interface Device Class Peripherals
- Source Code will be available:
  - Port to different processor and OS
  - Support for additional peripheral types
Agenda

- Why USB On-the-Go (OTG)?
- What is USB OTG?
- TI USB-OTG Solutions

Demonstration
Resources and References

- USB Implementer’s Forum Website
  - http://www.usb.org/developers/ontheego
- Everything USB Website
  - http://www.everythingusb.com/usbbontheego/
- Beyond Logic Website
  - http://www.beyondlogic.org/usb/otghost.htm
USB On-the-Go Solutions

Wes Ray  
wes.ray@ti.com; 214-480-1120

Dan Harmon  
dharmon@ti.com; 214-480-4609
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

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

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplifiers</td>
<td>Audio</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Automotive</td>
</tr>
<tr>
<td>DSP</td>
<td>Broadband</td>
</tr>
<tr>
<td>Interface</td>
<td>Digital Control</td>
</tr>
<tr>
<td>Logic</td>
<td>Military</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Optical Networking</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Security</td>
</tr>
<tr>
<td>Low Power Wireless</td>
<td>Telephony</td>
</tr>
<tr>
<td></td>
<td>Video &amp; Imaging</td>
</tr>
<tr>
<td></td>
<td>Wireless</td>
</tr>
</tbody>
</table>

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2007, Texas Instruments Incorporated