USB On-the-Go Solutions

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Agenda

➤ **Why USB On-the-Go (OTG)?**

- What is USB OTG?

- TI USB-OTG Solutions

- Demonstration

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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
  - Personal Digital Assistants (PDAs)
  - Smart Phones
  - Portable Audio Player
  - Mega-Pixel Camera Phones
  - Web-Tablets

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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

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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.

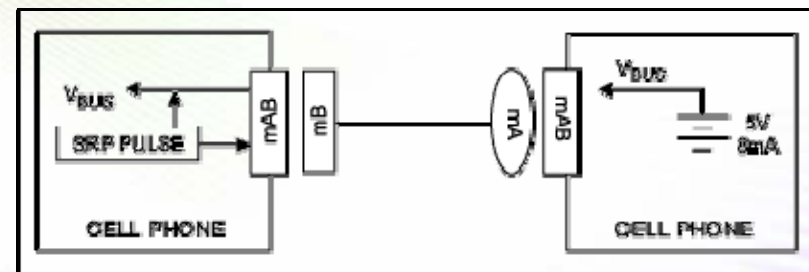**Minds in Motion**

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
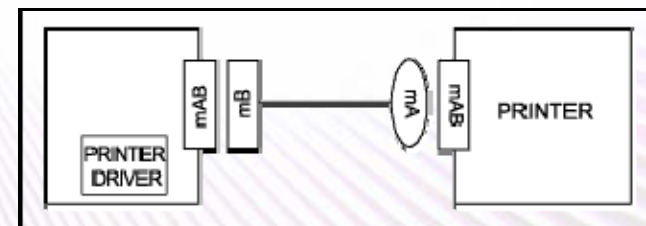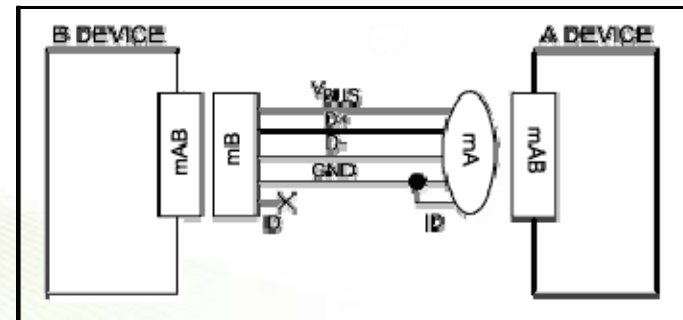
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Session Request Protocol (SRP)

- 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)
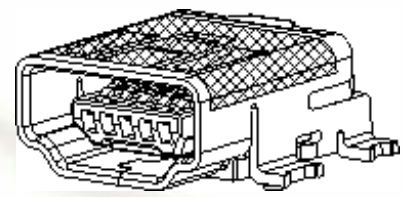
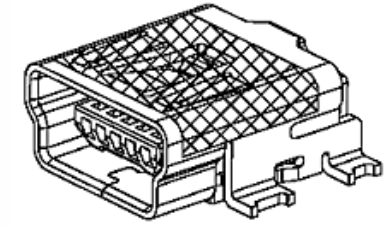**Minds in Motion**

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New Mini Connectors
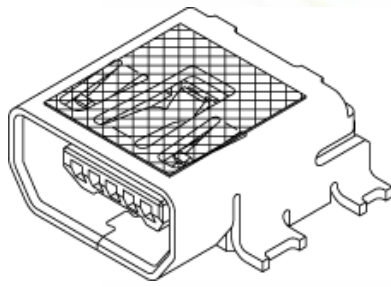
Mini-AB Receptacle

Mini-A Receptacle

Mini-B Receptacle

Mini-B   Mini-A
Plugs

- 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.

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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.

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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

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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

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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

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▷ TI USB-OTG Solutions

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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.

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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 u*JrBGA

Benefits

- Certified compliance and inter–operability

- 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
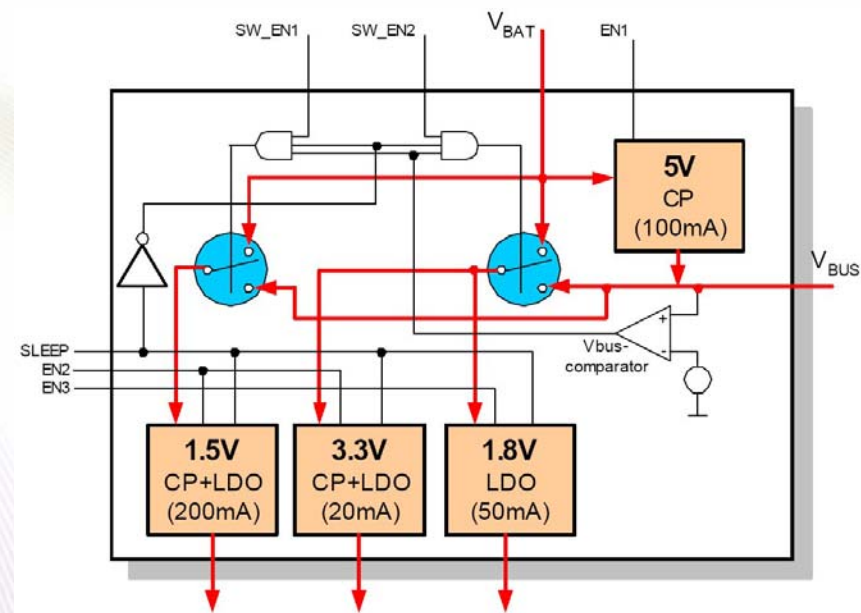
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System Block Diagram
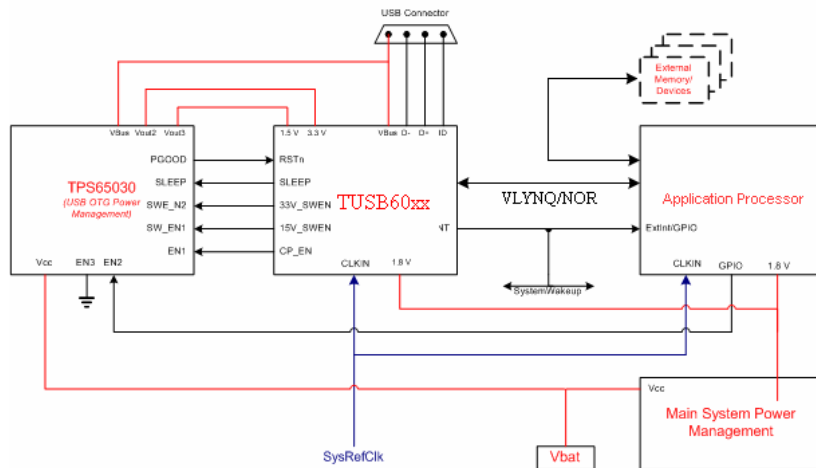
- Application processor is required to support software needs including:
  - Operating system for Host mode
  - Drivers for target peripheral list when in OTG Host mode
  - Application functionality when in peripheral mode

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
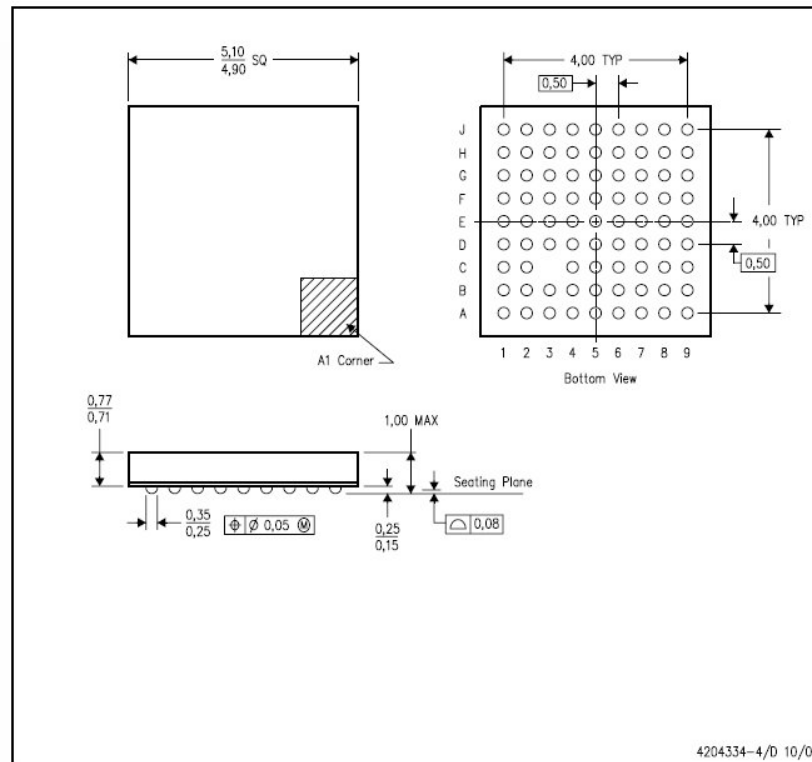- Ultra-Small 2.5mm x 2.7 mm chip scale Package

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
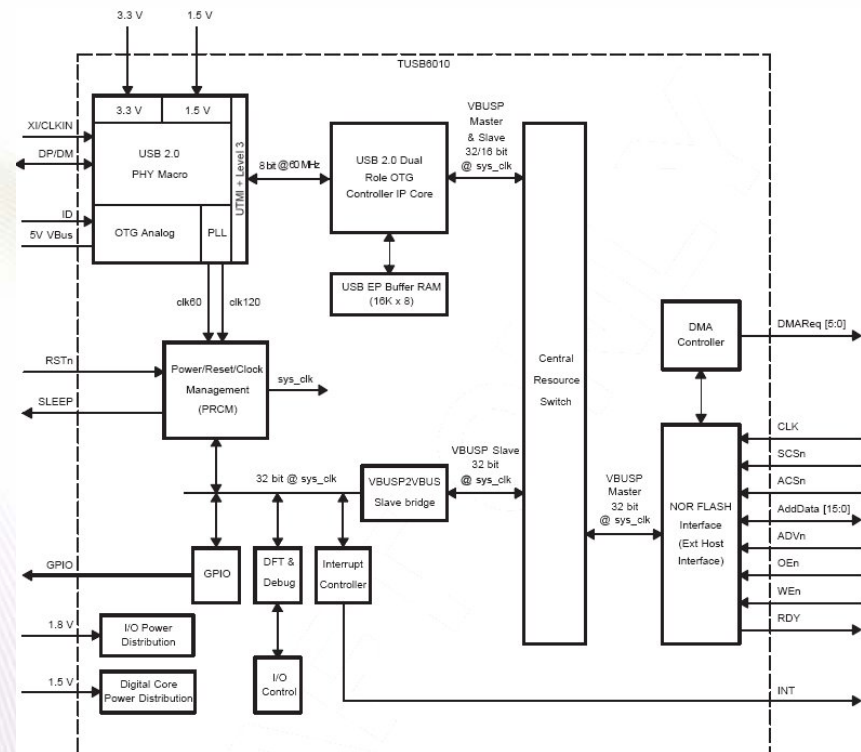
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TUSB6010A Performance

- 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.

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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

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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
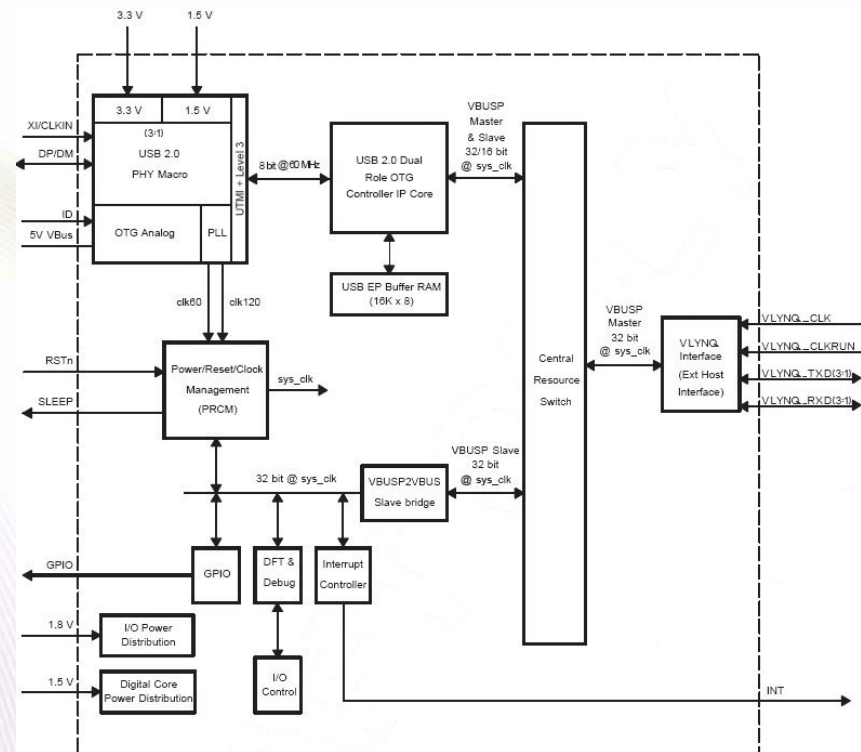
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TUSB6020 Performance

- DaVinci VLYNQ Throughput
  - Eight pin VLYNQ Interface running at 125 MHz
  - Sustained 267 Mbps Bulk In and Bulk Out

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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

Resources and References

- USB Implementer's Forum Website
  - http://www.usb.org/developers/onthego
- Everything USB Website
  - http://www.everythingusb.com/usbonthego/
- Beyond Logic Website
  - http://www.beyondlogic.org/usb/otghost.htm

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