



# USBHS-OTG-SD

## USB2.0 On-The-Go Controller Megafunction

Implements a hi-speed USB OTG port that can serve as a host (for a single device) or as a peripheral when connected to other USB devices.

This dual-role behavior conforms to the USB 2.0 specification and its On-The-Go Supplement. The megafunction is designed for processing efficiency — with hardware implementing the Host Negotiation Protocol, Session Request Protocol, and other critical functions — and is competitive in performance and area usage.

Standard USB transceivers can be used through the megafunction's UTMI+ Level 2 interface, and a UTMI+ Low Pin Interface (ULPI) is available. The megafunction's system connection is through a standard PVIC interface (AMBA™ and other standard interfaces are also available). Configurable endpoints and other USB characteristics can be customized prior to synthesis to match the megafunction to a specific application. The megafunction also supports USB power saving functions.

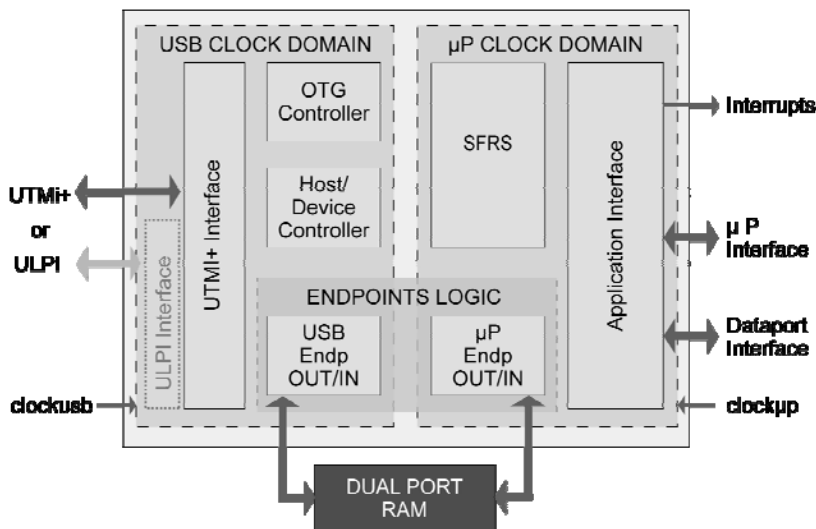
The USBHS-OTG-SD is a testable, microcode-free design developed for reuse in ASICs and FPGAs. A complete test environment helps designers verify the functioning and compliance of the megafunction, and includes a USB PHY behavioral model to facilitate transaction simulation.

### Applications

USB OTG is primarily intended for portable devices that may function as a host or a peripheral depending on how they are connected. The dual-role device uses a USB mini-AB port that can receive a mini-A plug to trigger host mode or a mini-B plug for peripheral mode. For example:

- A PDA connects to a PC for contacts and calendar syncing (peripheral mode), to a printer (host mode), or to another PDA with USB OTG (host and device negotiated as needed).
- Two MP3 players with OTG ports might connect directly, one acting as a host to copy files from the other acting as a peripheral.

### Block Diagram



### Features

- Complies with the USB 2.0 specification and its On-The-Go supplement
- Supports one Low-Speed, Full-Speed, or High-Speed peripheral device in Host mode
- Supports Full-Speed and High-Speed data transfer in Peripheral mode
- Provides hardware-based support for the Host Negotiation Protocol (HNP) and the Session Request Protocol (SRP)
- Includes endpoint 0 for USB control transfers
- Configurable for up to 15 IN and 15 OUT additional endpoints, each with:
  - Configurable and programmable size & buffering (single, double, triple or quad)
  - Programmable type (bulk, ISO, interrupt)
- UTMI+ Level 2 (USB 2.0 Transceiver Macrocell Interface Plus) for use with any compliant transceiver macrocell
- Optional ULPI (UTMI+ Low Pin Interface)
- 32-bit Peripheral Virtual Component Interface (PVCI) to microprocessor (other standard interfaces available)



*The single-port RAM version of this megafunction has received USB-IF certification (through development partner Evatronix).*

- Offers direct access to the endpoint buffers via a configurable 16/32-bit dataport interface
- Optional software stack
- Ready for an external DMA module
- Synchronous dual-port RAM interface for endpoint buffers (single-port RAM version available)
- Suspend and resume power management functions
- Remote wake-up function
- Strictly synchronous design with positive-edge clocking, no internal tri-states and a synchronous reset; therefore scan insertion is straightforward.
- Sophisticated self-checking Testbench (Verilog versions use Verilog 2001)

## Functional Description

The USBHS-OTG-SD megafunction is partitioned into modules as shown in the block diagram and described below.

### UTMI+ Interface

The megafunction requires an external transceiver that is compatible with the USB 2.0 UTMI+ specification (Philips USB 2.0 Transceiver Macrocell Interface Plus, version 1.0).

### OTG Controller

Supports the tasks specified in the OTG Supplement. It includes hardware implementations of the Host Negotiation Protocol (HNP) and the Session Request Protocol (SRP), and special function registers for their control.

This block manages the upstream and downstream activity on the USB OTG port, and chooses between them. The default operation mode is determined by which end of the USB OTG cable the user has inserted into the port: one end makes the megafunction operate as a host, the other end a peripheral.

### Host Controller

Functions when the megafunction operates as a host, with the main tasks of generating suspend/resume and USB reset signals, generating Start of Frame (SOF) tokens, managing USB data transactions, and generating host interrupts. It includes a hardware Host Transaction Scheduler and a frame generator.

### Device (Peripheral Mode) Controller

Supports all types of USB 2.0 data transfers in peripheral mode, and performs additional standard operations such as receiving SOF tokens, detecting suspend/resume signals, and controlling the remote wakeup function.

### Endpoints Logic Blocks

Includes endpoint 0 to support USB control requests, and up to 15 additional endpoints for custom requests. Supports all four types of USB data transfers:

- Control transfer – interactions with standard endpoint 0,
- Interrupt transfer – transfer for small, non-periodic, low-frequency data,
- Bulk transfer – transfer for a large amount of data, and
- Isochronous transfer – for applications requiring constant data transfer rates.

Generates read/write signals for two dual synchronous RAM blocks, one for OUT and one for IN endpoints. The number, size, and buffering of up to 15 IN and 15 OUT endpoints can be configured before synthesis.

## SFRS

Contains a set of Special Function Registers that control the megafunction's operation.

### Application Interface

Provides an interface to the system microprocessor using PVCI, the VSIA's Peripheral Virtual Component Interface standard (OCP, AMBA, and other standard interfaces are available). Also generates interrupt signals for the microprocessor, and includes the Dataport Interface that provides direct access to the endpoint buffers.

## Software

A complete software stack with the most popular device classes is available. It has been designed for portability in a variety of embedded applications.

## Implementation Results

USBHS\_OTG\_SD reference designs have been evaluated in a variety of technologies. The following are sample Altera results optimized for area and configured for operation with IN 1 - 1024 bytes single buffered and OUT 1 - 1024 bytes single buffered.

Altera Device	LEs / ALUTs	MEM bits	MEM Blocks	Fmax (uP clock)	Fmax (usb clock)
Cyclone EP1C20-6	3980	19200	9 M4Ks	43 MHz	56 MHz
Cyclone-III <sup>1</sup> EP3C80-6	4471	32768	6 M9Ks	105 MHz	30 MHz
Stratix EP1S10-5	3980	19200	9 M4Ks	60 MHz	58 MHz
Stratix II EP2S15-3	3353	19200	9 M4Ks	82 MHz	91 MHz

<sup>1</sup> Endpoint size 512 bytes double buffered

## Support

The megafunction as delivered is warranted against defects for ninety days from purchase. Thirty days of phone and email technical support are included, starting with the first interaction. Additional maintenance and support options are available.

## Verification

The megafunction has been verified through extensive simulation and rigorous code coverage measurements, and has been implemented and tested in a demonstration application.

## Deliverables

The megafunction includes everything required for successful implementation: The Altera Implementation includes:

- Post-synthesis EDIF netlist
- An example chip implementation
- Sophisticated self-checking Testbench (Verilog versions use Verilog 2001) including external endpoint buffers, a USB PHY behavioral model, and a clock generator
- Simulation script, vectors, expected results, and comparison utility
- Place and route script
- Comprehensive user documentation, including detailed specifications and a system integration guide