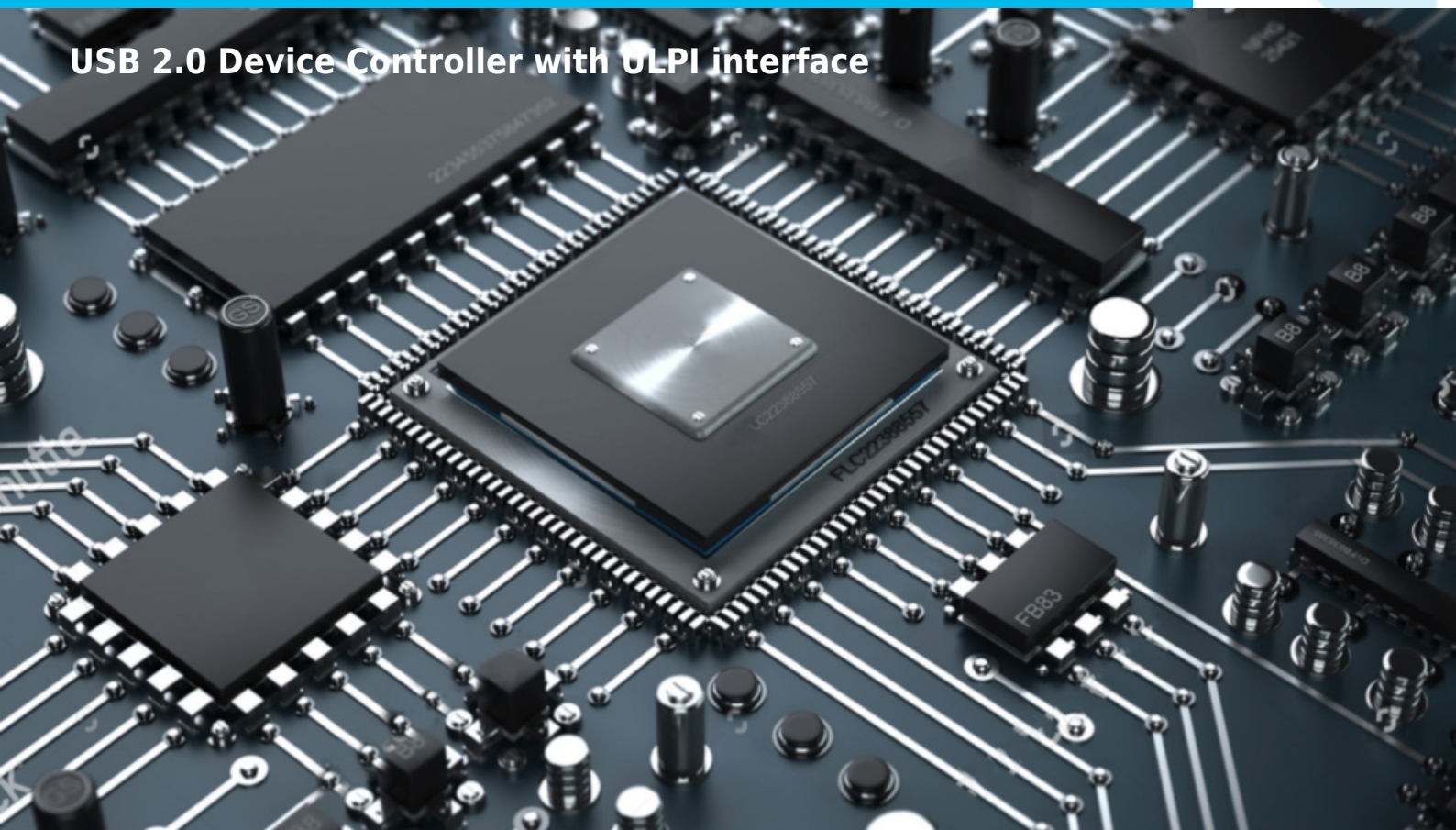
DIGITAL CORE DESIGN

DUSB2-ULPI

USB 2.0 Device Controller with ULPI interface



COMPANY OVERVIEW

Digital Core Design is a leading IP Core provider and a System-on-Chip design house. The company was founded in 1999 and since the very beginning has been focused on IP Core architecture improvements. Our innovative, silicon proven solutions have been employed by over 300 customers and with more than 500 hundred licenses sold to companies like Intel, Siemens, Philips, General Electric, Sony and Toyota. Based on more than 70 different architectures, starting from serial interfaces to advanced microcontrollers and SoCs, we are designing solutions tailored to your needs.

IP CORE OVERVIEW

DUSB2-ULPI – Full/High-Speed USB Peripheral Controller IP Core

The **DUSB2-ULPI** is a **hardware implementation of a USB 2.0 full/high-speed peripheral controller**, designed for seamless integration with ULPI bus transceivers. Optimized for **FPGA and ASIC designs**, this IP core handles all USB packet and transaction processing, including PID and address recognition, state machine control, endpoint number detection, and FIFO management.

Key Features:

- Supports **12 Mb/s Full-Speed (FS)** and **480 Mb/s High-Speed (HS)** operation.
- Interfaces with ULPI bus transceivers for high-speed USB PHY integration.
- Includes endpoint FIFO control logic for efficient data buffering.
- Technology-independent design, easily implemented across various **process technologies**.
- Fully compliant with **USB Specification v2.0** and **ULPI v2.0** standards.
- Delivered with a **complete automated test bench** for full SoC integration validation.

Benefits for Engineers:

- Streamlines high-speed USB peripheral integration with minimal CPU overhead.
- Reduces design complexity by providing ready-to-use hardware logic for packet processing.
- Ideal for **FPGA or ASIC projects** requiring ULPI PHY support.
- Ensures rapid development and testing with fully validated RTL and automated test suites.

Typical Applications:

- USB-based communication peripherals
- Mass storage devices
- Embedded USB controllers
- High-speed USB interface integration

DUSB2-ULPI is the ultimate solution for engineers looking to **implement USB 2.0 peripherals with ULPI PHY support**, delivering reliable performance and full compliance with modern USB standards.

USB IP Core	USB Version	Bus Interface	CPU / MCU	Software Stack	Debug Tools	Key Features	Ideal Applications
MS Platform	USB 2.0 Full/High-Speed	APB, AHB, AXI	DP8051XP 8-bit MCU	HID software stack optimized for DP8051XP	HAD2 Debugger, DoCD™ software, Keil & IAR drivers	Complete HID design solution, preprogrammed FPGA example, ready-to-use	Mice, keyboards, tablets, other HID devices
DUSB2	USB 2.0 Full/High-Speed	APB, AHB, AXI	Standalone or host MCU	N/A	DoCD™ optional	Full/high-speed controller, ULPI support, ready-to-use RTL	General USB 2.0 devices, mass storage, communication peripherals
DUSB2-ULPI	USB 2.0 High-Speed	APB, AHB, AXI	Standalone or host MCU	N/A	DoCD™ optional	ULPI-compliant high-speed controller, optimized for external PHY integration	Devices requiring ULPI PHY, high-speed USB
USB 2.0 HID Design Platform	USB 2.0 Full/High-Speed	APB, AHB, AXI	DP8051XP 8-bit MCU	HID software stack	HAD2 Debugger, DoCD™ software, Keil & IAR drivers	Turnkey HID solution, preprogrammed example, easy FPGA integration	Mice, keyboards, tablets, game controllers
USB 2.0 Audio Design Platform	USB 2.0 Full/High-Speed	APB, AHB, AXI	DP8051XP 8-bit MCU	Audio software stack	HAD2 Debugger, DoCD™ software, Keil & IAR drivers	Ready-to-use audio solution, preprogrammed FPGA example	USB microphones, speakers, audio interfaces

ALL DCD'S IP CORES ARE TECHNOLOGY AGNOSTIC, ENSURING 100% COMPATIBILITY WITH ALL FPGA AND ASIC VENDORS.

For further details, email info@dcd.pl.

KEY FEATURES

- Full compliance with the USB 2.0 specification
- Full-speed 12 Mbps operation
- High-speed 480 Mbps operation
- Software configurable EP0 control endpoint size 8-64 bytes
- Software configurable 15 IN/OUT endpoints:

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- configurable number of endpoints
- configurable type of each endpoint: INTERRUPT, BULK or ISOCHRONOUS
- configurable direction of each endpoint
- configurable size of each endpoint: 8-1024 bytes

- Supports ULPI Transceiver Macrocell Interface
- Synchronous RAM interface for FIFOs
- Suspend and resume power management functions
- Simple interface allows easy connection to the 8-, 16-, 32-bit CPUs
- Allows operation from a wide range of CPU clock frequencies
- Fully synthesizable
- Static synchronous design
- Positive edge clocking
- No internal tri-states
- Scan test ready

UNITS SUMMARY

ULPI Interface – The ULPI interface is clocked by ULPICLK clock @60MHz and manages communication with USB 2.0 Transceiver Macrocell. It is responsible for reset detection, speed handshake, token, data and handshake packet reception and transmission.
CPU Interface – The CPU interface module is clocked by CPUCLK clock and manages communication with some CPU. In this module DUSB2-ULPI core configuration and status registers are being located. CPU bus size is configurable as 8, 16 or 32-bit wide.
SRAM Interface – The SRAM interface module manages communication with Synchronous Random Access Memory. It generates address, read and write signals for the SRAM memory and buffers data bytes during the FIFO read and write operations.
EP0 endpoint –The EP0 control endpoint is special bidirectional endpoint, used for device configuration. It allows generic USB control and status access.
EP1-EP15 endpoints – The EP1 to EP15 data endpoints are unidirectional configurable double-buffered endpoints, used for application specific data transmission.

CONFIGURATION

At the synthesis level, the following parameters of the DUSB2-ULPI core can be easily adjusted to requirements of a dedicated application and technology. The CPU interface is configurable as 8, 16 or 32-bit wide. Each data endpoint can be effortlessly enabled and disabled, by simply changing an appropriate constant in the package file. There is no need to change any parts of the code, to prepare DUSB2-ULPI core with requested number of data endpoints.

– EP1_ENABLE: *TRUE (1) / FALSE (0)*
– EP2_ENABLE: *TRUE (1) / FALSE (0)*
– EP3_ENABLE: *TRUE (1) / FALSE (0)*
– EP4_ENABLE: *TRUE (1) / FALSE (0)*
– EP5_ENABLE: *TRUE (1) / FALSE (0)*
– EP6_ENABLE: *TRUE (1) / FALSE (0)*
– EP7_ENABLE: *TRUE (1) / FALSE (0)*
– EP8_ENABLE: *TRUE (1) / FALSE (0)*
– EP9_ENABLE: *TRUE (1) / FALSE (0)*
– EP10_ENABLE: *TRUE (1) / FALSE (0)*
– EP11_ENABLE: *TRUE (1) / FALSE (0)*
– EP12_ENABLE: *TRUE (1) / FALSE (0)*
– EP13_ENABLE: *TRUE (1) / FALSE (0)*
– EP14_ENABLE: *TRUE (1) / FALSE (0)*
– EP15_ENABLE: *TRUE (1) / FALSE (0)*

Besides synthesis level configuration parameters mentioned above, there is a portion of device and endpoints parameters configured at software level, after the USB bus reset condition. The following parameters can be configured at software level:

– Endpoint 0 FIFO size to 8, 16, 32 or 64 bytes
– Endpoints 1-15 FIFO size to 8, 16, 32, 64, 128, 256, 512 or 1024 bytes
– Endpoints 1-15 direction to IN or OUT
– Endpoints 1-15 mode to INTERRUPT, BULK or ISOCHRONOUS

APPLICATIONS

- Human Interface Devices e.g. keyboards, mouse and game peripherals
- Mass Storage devices like flash disk, mp3 and mp4 player
- GPS navigation system
- Digital Camera
- Cellular phone
- Audio devices like microphone and speakers
- Printer
- Scanner

PERFORMANCE

The following tables give a survey about the Core area and performance in **AMD FPGA** Devices after Place & Route.

Family	Device	Speed grade	LUT	Slice	cpu F_{max}
Spartan-3	xc3s200	-5	1 761	1 360	121 MHz
Spartan-3E	xc3s250e	-5	1 784	1 357	135 MHz
Spartan-6	xc6slx4	-3	1 510	588	212 MHz
Virtex-4	xc4vfx12	-12	1 780	1 358	256 MHz
Virtex-5	xc5vlx20t	-2	1 453	840	300 MHz
Virtex-6	xc6vlx75t	-3	1452	692	312 MHz
Virtex-7	xc7vx330t	-3	1 510	742	384 MHz
Kintex-7	xc7k70t	-3	1 510	714	384 MHz
Artix-7	xc7a100t	-3	1 400	700	263 MHz
Virtex UltraScale	xcvu065	-3	1 253	272	500 MHz
Zynq-7000	xc7z010	-3	1 252	492	330 MHz

The area utilized by a typical configuration of the DUSB2-ULPI core suitable for HID and Mass Storage devices in vendor specific technologies, is summarized in the following table.

Component	Area	
	[Slices]	[FFs]
CPU interface	225	170
ULPI interface	315	280
SRAM interface	115	95
EP0 endpoint	150	140
EP1 endpoint	160	155

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EP2 endpoint	160	155
Total area	**1 125**	**995**

Core components area utilization in XILINX devices except VIRTEX-5 family

Component	**Area**	
	[Slices]	**[FFs]**
CPU interface	120	170
ULPI interface	165	280
SRAM interface	65	95
EP0 endpoint	80	140
EP1 endpoint	85	155
EP2 endpoint	85	155
Total area	**600**	**995**

Core components area utilization in XILINX VIRTEX-5 devices

DELIVERABLES

- HDL Source Code
- Testbench environment
  - Automatic Simulation macros
  - Tests with reference responses
- Synthesis scripts
- Technical documentation
- 12 months of technical support

LICENSING

Comprehensible and clearly defined licensing methods without royalty-per-chip fees make use of our IP Cores easy and simple.

– Single-Site license option – dedicated to small and middle sized companies which run their business at one place.

– Remote Access license option – allows authorized users to access and use the licensed product from a remote location.

In all cases the number of IP Core instantiations within a project and the number of manufactured chips are unlimited. There are no restrictions regarding the time of use.

The IP is delivered in HDL Source code suitable for ASIC and FPGA projects.

CONTACT

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