

Xylon d.o.o.

Fallerovo setaliste 22
 10000 Zagreb, Croatia
 Phone: +385 1 368 00 26
 Fax: +385 1 365 51 67
 E-mail: support@logicbricks.com
 URL: www.logicbricks.com

Features

- Supports all Xilinx[®] FPGA families, Zynq[®]-7000 All Programmable SoC and Zynq[®] UltraScale+[™] MPSoC
- Supports up to eight individual I²S instances with the following features:
 - Configurable as receiver or transmitter
 - Configurable as clock master or slave
 - Configurable as word select master or slave
 - Configurable active clock edge
 - Supports three different justification modes: normal (corresponds to the mode specified in the I2S specification by Philips), left and right
 - Configurable TX and RX FIFO depth, from 512 up to 4096 samples (L + R word)
 - Supports word length up to 16 bits
- ARM[®] AMBA[®] AXI4-Lite compliant register interface
- Prepared for Xilinx Vivado[®] Design Suite (IP Integrator) and ISE[®] Design Suite (XPS)

Core Facts	
Provided with Core	
Documentation	User's Manual
Design File Formats	Encrypted VHDL
Constraints Files	Reference design XDC
Verification/Validation	Hardware validated
Reference Designs & Application Notes	Reference designs available for the ZedBoard development platform from Avnet Electronics Marketing
Additional Items	
Simulation Tool Used	
Mentor Graphics' Modelsim	
Support	
Support provided by Xylon	

Table 1: Example Implementation Statistics for Xilinx[®] FPGAs

Family (Device)	Fmax (MHz)	LUT ¹⁾	FF ¹⁾	IOB ²⁾	BRAM	MULT/DSP48/E	DCM/CMT	BUFG	GTx	Design Tools
	rclk									
Kintex [®] -7 (XC7K70T-2)	200	522	601	6	2	0	0	2	N/A	Vivado 2016.4
ZYNQ [®] -7000 (XC7Z010-2)	200	421	548	6	2	0	0	1	N/A	Vivado 2018.3
Zynq [®] MPSoC (XCZU9EG- 2L)	200	436	548	6	2	0	0	1	N/A	Vivado 2018.3

Notes:

- 1) Assuming logiI2S is configured to have one RX and one TX instance, clock and word select masters, normal FIFO size.
- 2) Assuming only audio inputs and outputs are routed off-chip and register interface is connected internally.

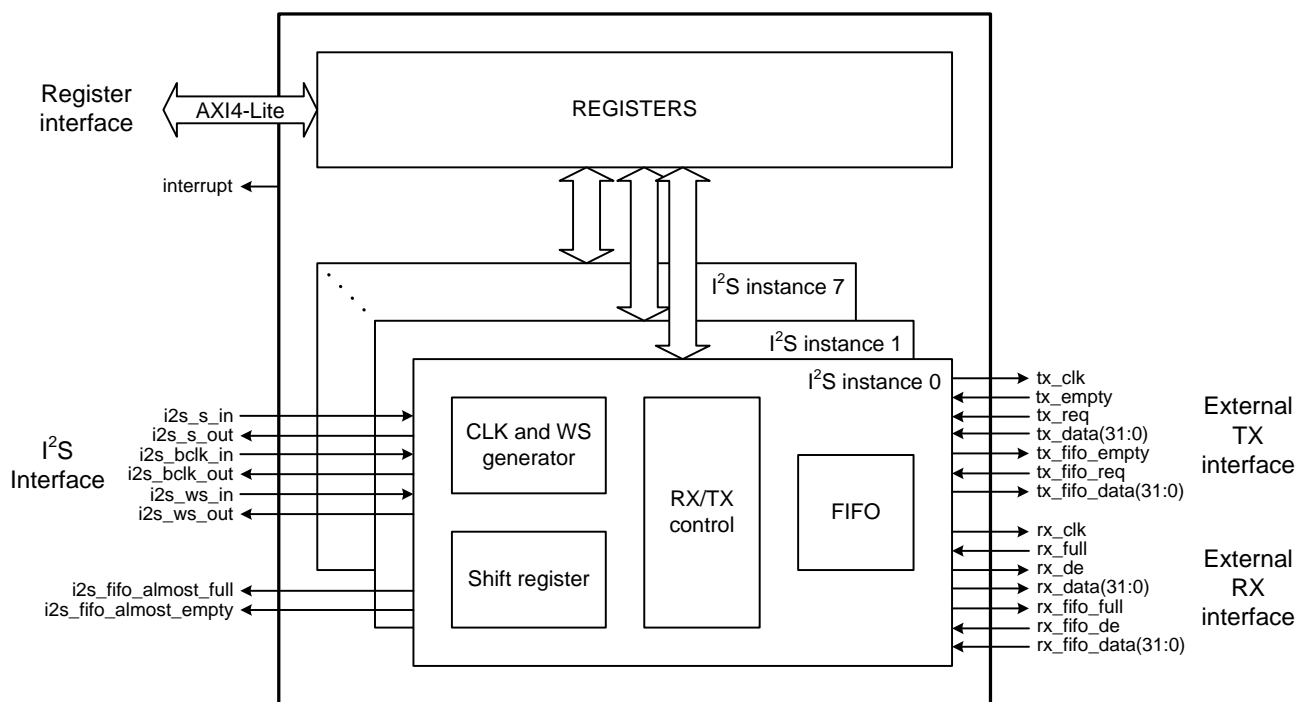


Figure 1: logil2S Architecture

Applications

Human Machine Interfaces (HMI) for industrial and medical, car infotainment, defense systems, etc.

General Description

The logil2S is an audio receiver and transmitter IP core from the Xylon logicBRICKS™ IP core library. It enables rapid integration of multi-channel audio functionality in Xilinx All Programmable devices and supports IP configurations with up to eight I²S transmitters and receivers, stereo audio transport between processors and codecs, configurable clock master and slave modes, etc. The logil2S IP core is fully embedded into Xilinx Vivado IP Integrator and ISE Xilinx Platform Studio implementation tools, and its integration with the on-chip AXI4 bus is very simple. Parametrizable VHDL design allows for tuning of slice consumption and features set through an easy-to-use GUI interface. The logil2S can be smoothly integrated with other logicBRICKS, Xilinx or third-party IP cores for building of advanced GUI embedded systems.

Functional Description

The Figure 1 presents internal logil2S architecture. The logil2S functional blocks are: I²S Instance and Registers. I²S Instance consists of the Clock and Word select generator, Shift register, TX and RX control logic and FIFO.

I²S Instance

I²S instance can be configured either as an audio receiver or audio transmitter. The I²S instance configured as the audio receiver performs serial to parallel audio data conversion and stores the audio data to RX FIFO. The I²S instance configured as the audio transmitter takes data from TX FIFO and performs parallel to serial audio data conversion.

Additionally, I²S instance supports word length of up to 16 bits per channel, three sample justifications modes, four different FIFO depths, bit clock master or slave and active edge, word select master or slave and invert, left/right channel swap and configurable FIFO almost full/empty flag levels.

Registers

The logil2S Registers are used for configuration, data streaming and interrupt handling. The logil2S's register interface is ARM AMBA AXI4-Lite compatible.

Core Modifications

The core is supplied in an encrypted VHDL format compatible with Xilinx Vivado IP Integrator and ISE Platform Studio implementation tools. The logil2S has configuration parameters that are selectable prior to VHDL synthesis, and the following table presents a selection from a list of available parameters:

Table 2: logil2S VHDL Configuration Parameters

Parameter ¹⁾	Description
C_NUM_OF_I2S	Number of I ² S instances (1-8)
C_I2S_n_DIRECTION	I ² S instance direction (RX, TX)
C_I2S_n_CLOCKMASTER	I ² S instance clock slave or master
C_I2S_n_WSMMASTER	I ² S instance word select slave or master
C_I2S_n_CLOCKEDGE	I ² S instance active clock edge
C_I2S_n_WS_INV	I ² S instance word select invert
C_I2S_n_LR_SWAP	I ² S instance left/right channel swap
C_I2S_n_FIFO_SIZE	I ² S instance FIFO size (512-4096)
C_I2S_n_ALMOST_FULL	I ² S instance FIFO almost full level
C_I2S_n_ALMOST_EMPTY	I ² S instance FIFO almost empty level
C_I2S_n_EXT_INTERFACE	I ² S instance external interface usage

1. n is the number of I²S instance. Range is from 1 to 8.

There may be instances where source code modification is necessary. If you wish to adopt the logil2S IP core to your specific needs and/or to supplement the IP core's features set, you can allow us to tailor the logil2S IP core to your requirements.

Core I/O Signals

The core I/O signals have not been fixed to any specific device pins to provide flexibility for interfacing with user logic. Descriptions of all I/O signals are provided in Table 3.

Table 3: Core I/O Signals

Signal ¹⁾	Signal Direction	Description
Global Signals		
interrupt	Output	logil2S interrupt signal, level sensitive, high active
Register Interface		
AXI4-Lite Slave Interface	Bus	Refer to ARM AMBA AXI4 specification
I²S Interface		
i2s_n_s_out ²⁾	Output	Serial I ² S data output
i2s_n_s_in ³⁾	Input	Serial I ² S data input
i2s_n_bclk_out ⁴⁾	Output	I ² S bit clock output

Signal ¹⁾	Signal Direction	Description
i2s_n_bclk_in ⁵⁾	Input	I ² S bit clock input
i2s_n_ws_out ⁶⁾	Output	I ² S word select output
i2s_n_ws_in ⁷⁾	Input	I ² S word select input
i2s_n_fifo_almost_empty	Output	I ² S FIFO almost empty status
i2s_n_fifo_almost_full	Output	I ² S FIFO almost full status
External TX interface		
tx_clk_n ^{2, 8)}	Output	External TX interface clock
tx_empty_n ^{2, 8)}	Input	External TX interface empty input
tx_req_n ^{2, 8)}	Output	External TX interface request output
tx_data_n[31:0] ^{2, 8)}	Input	External TX interface data input
tx_fifo_empty_n ^{2, 8)}	Output	External TX interface FIFO empty status
tx_fifo_req_n ^{2, 8)}	Input	External TX interface FIFO request input
tx_fifo_data_n[31:0] ^{2, 8)}	Output	External TX interface FIFO data output
External RX interface		
rx_clk_n ^{3, 8)}	Output	External RX interface clock
rx_full_n ^{3, 8)}	Input	External RX interface full input
rx_de_n ^{3, 8)}	Output	External RX interface data enable output
rx_data_n[31:0] ^{3, 8)}	Output	External RX interface data output
rx_fifo_full_n ^{3, 8)}	Output	External RX interface FIFO full status
rx_fifo_de_n ^{3, 8)}	Input	External RX interface FIFO data enable input
rx_fifo_data_n[31:0] ^{3, 8)}	Input	External RX interface FIFO data input

1. n is the number of I²S instances. Range is from 1 to 8.
2. Valid only for transmitter I²S instances
3. Valid only for receiver I²S instances
4. Valid only when I²S instance is configured as clock master
5. Valid only when I²S instance is configured as clock slave
6. Valid only when I²S instance is configured as word select master
7. Valid only when I²S instance is configured as word select slave
8. Valid only if generic parameter C_I2S_n_EXT_INTERFACE is set to 1

Verification Methods

The logil2S is fully supported by the Xilinx Vivado and ISE Design Suites. This tight integration tremendously shortens IP integration and verification. A full logil2S implementation does not require any particular skills beyond general Xilinx tools knowledge. The ISE compatible version of the encrypted IP is shipped with compiled simulation libraries for Mentor Graphics' ModelSim. For information about Vivado compatible IP core simulations, please contact Xylon.

The logil2S evaluation IP core can be downloaded from Xylon web site and fully evaluated in hardware:

URL: www.logicbricks.com/Products/logil2S.aspx

Recommended Design Experience

The user should have experience in the following areas:

- Xilinx design tools
- ModelSim

Available Support Products

Xylon provides free pre-verified reference designs to showcase the logiBITBLT graphics accelerator, other Xylon's logicBRICKS 2D and 3D graphics hardware accelerators and display controller IP cores on the most popular Xilinx Zynq-7000 AP SoC based development kits. Reference designs include evaluation logicBRICKS IP cores and hardware design files, OS image, software drivers, demo applications and documentation. To check a full list of Xylon reference designs please visit the web:

URL: <http://www.logicbricks.com/logicBRICKS/Reference-logicBRICKS-Design.aspx>

The logiREF-MEDIA-ZED Human Machine Interfaces pre-verified logicBRICKS reference design showcases the logil2S audio data receiver/transmitter and other logicBRICKS IP solutions on the ZedBoard kit from Avnet Electronics Marketing.

To download this reference designs, learn more about the design's availability for the ZedBoard development kit, contact Xylon or visit the web:

Email: support@logicbricks.com

URL: <http://www.logicbricks.com/logicBRICKS/Reference-logicBRICKS-Design/Multimedia-for-Zynq-AP-SoC-ZedBoard.aspx>

Ordering Information

This product is available directly from Xylon under the terms of the Xylon's IP License. Please visit our web shop or contact Xylon for pricing and additional information:

Email: sales@logicbricks.com

URL: www.logicbricks.com

This publication has been carefully checked for accuracy. However, Xylon does not assume any responsibility for the contents or use of any product described herein. Xylon reserves the right to make any changes to product without further notice. Our customers should ensure that they take appropriate action so that their use of our products does not infringe upon any patents. Xylon products are not intended for use in the life support applications. Use of the Xylon products in such appliances is prohibited without written Xylon approval.

Related Information

Xilinx Programmable Logic

For information on Xilinx programmable logic or development system software, contact your local Xilinx sales office, or:

Xilinx, Inc.

2100 Logic Drive

San Jose, CA 95124

Phone: +1 408-559-7778

Fax: +1 408-559-7114

URL: www.xilinx.com

Revision History

Version	Date	Note
1.00	23.05.2012.	Initial Xylon release – new doc template
1.01	29.06.2012.	Added possibility to independently select master/slave for clock and word select.
2.00	06.12.2012.	Up to eight I ² S TX or RX instances, external interface support, FIFO depth configurable up to 8x, interrupt handling changed (mask and status), almost full and empty configurable per I ² S instance.
2.01	23.01.2013.	Added tx_empty and rx_full signals to the external interfaces.
2.02	09.06.2014.	Data sheet corrections.
2.2	03.12.2014.	New versioning scheme introduced for Vivado packaged IP core.
2.3	21.04.2017.	Added Xilinx Ultrascale/Ultrascale+ architecture support.
	11.04.2019.	Updated Table 1.