/ ULTRA96

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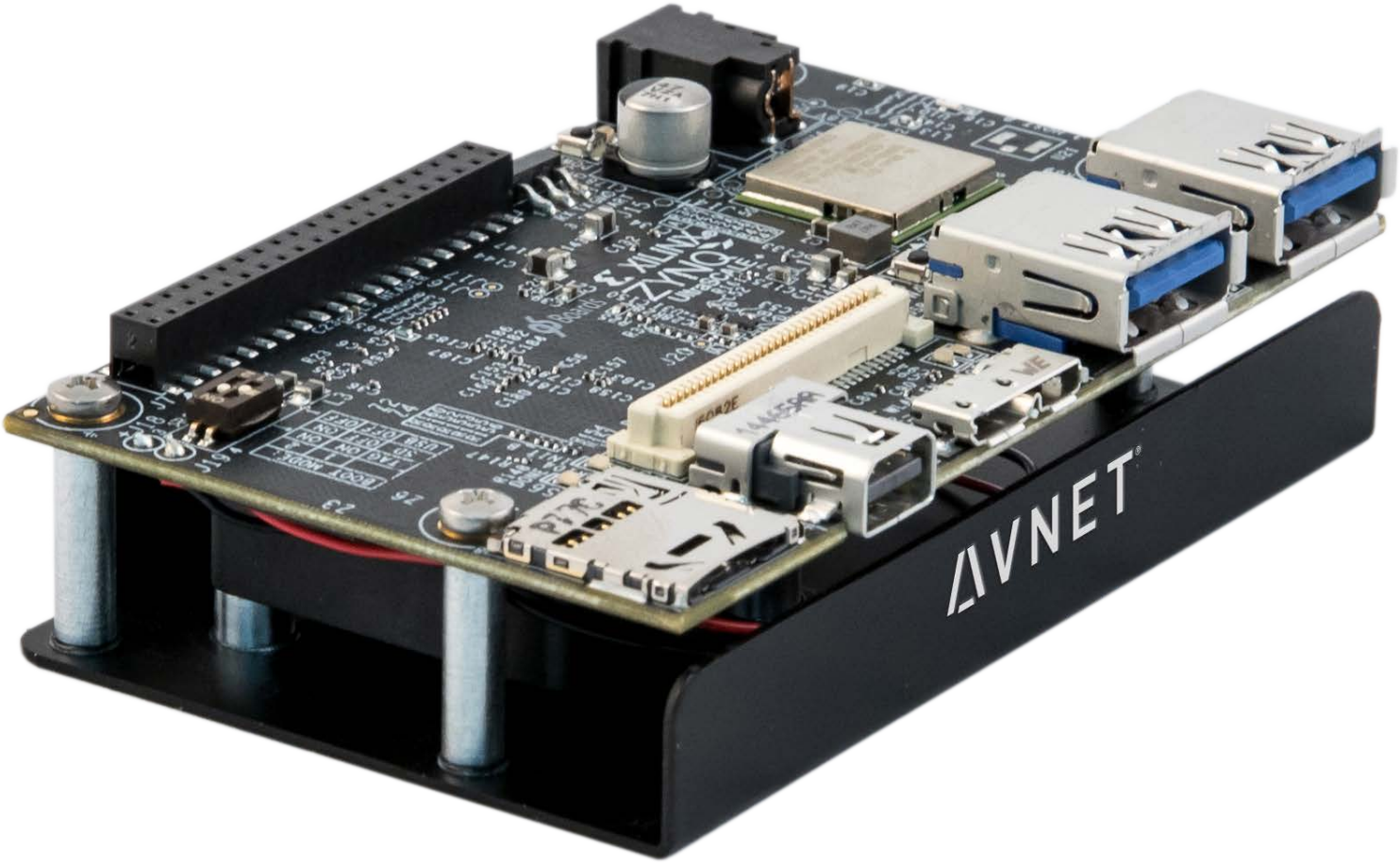

Ultra96-V1 Single Board Computer Hardware User's Guide

Version 1.1

LIT# Ultra96-HW-User-Guide-rev-1-0-V1.1

Contents

1 Document Control

Document Version: 1.1

Document Date: 25 February 2020

2 Version History

Version	Date	Comment
0.9	18 Mar 2018	Preliminary release of Ultra96-V1 Hardware User's Guide
1.0	07 Aug 2018	Updated release
1.1	25 Feb 2020	Added info regarding EOL

3 End of Life

The original Ultra96 Single Board Computer was released in 2018 and shipped until April 2019. After that time, it was replaced with an updated version, called Ultra96-V2. To help with the nomenclature, the original Ultra96 is now referred to as Ultra96-V1. The term Ultra96 may be used to refer to the family, meaning both Ultra96-V1 and Ultra96-V2.

Information about Ultra96-V1 is still available at http://avnet.me/ultra96-v1.

Information about Ultra96-V2 is available at http://avnet.me/ultra96-v2.

4 Introduction

The main purposes of the Ultra96-V1 Single Board Computer are:

- Provide a Xilinx entry in the 96Boards community
- Combine ARM processing with programmable logic in a convenient and expandable board
- Showcase a wide range of potential peripherals and acceleration engines in the programmable logic that is not available from other 96Boards offerings
- Be a low-cost starter kit for Zynq UltraScale+ MPSoC developers
- Showcase hardware acceleration for software bottlenecks
- Allow expansion to a variety of sensors and peripherals through the 96Boards mezzanine connectors
- Target applications for development, including:
    - Artificial Intelligence
    - Machine Learning
    - IoT/Cloud connectivity for add-on sensors
    - Embedded Computing
    - Robotics
    - Wireless design and demonstrations using Wi-Fi and Bluetooth

4.1 Glossary

Term	Definition
PS	Zynq UltraScale+ MPSoC Processing System
PL	Zynq UltraScale+ MPSoC Programmable Logic
MIO	PS Multiplexed Input Output Pins
POR	Power On Reset
APU	Application Processing Unit
RPU	Real-time Processing Unit
GPU	Graphics Processing Unit
SYSMON	System Monitor
HD	High Density PL I/O Pins
HP	High Performance PL I/O Pins
PMBus	Power Management Bus

4.2 Reference Documents

[1] Zynq UltraScale+ MPSoC Overview

[2] Zynq UltraScale+ MPSoC DC and AC Switching Characteristics

[3] Zynq UltraScale+ MPSoC Technical Reference Manual

[4] Zynq UltraScale+ MPSoC Packaging and Pinout Product Specification

[5] Zynq UltraScale+ MPSoC PCB Design Guide

[6] UltraScale Architecture SelectIO Resources

[7] SBVA484 Package File

[8] Xilinx Vivado Design Suite

[9] Xilinx Software Development Kit

[10] 96Boards Specification

[11] WiLink8 2.4GHz WiFi + Bluetooth Module

[12] USB3320 Hi-Speed USB 2.0 ULPI Transceiver

[13] USB5744 Smart Hub

[14] Micron MT53B512M32D2NP-062 WT:C LPDDR4 SDRAM datasheet

[15] Delkin Devices Utility Industrial MLC microSD

5 Ultra96-V1 Architecture and Features

This section summarizes the features of the development board, followed by functional descriptions of each circuit.

5.1 List of Features

The Ultra96-V1 Single Board Computer supports the following features:

- Zynq UltraScale+ MPSoC ZU3EG SBVA484
- Storage
    - Micron 2 GB (512M x32) LPDDR4 Memory
    - MicroSD Socket
        - Ships with Delkin Utility MLC Industrial 16GB card
- Wi-Fi / Bluetooth
- DisplayPort
- 1x USB 3.0 Type Micro-B upstream port
- 2x USB 3.0 Type A downstream ports
- 40-pin Low-speed expansion header
- 60-pin High speed expansion header
- Mounted on thermal bracket with fan

Note that there is no on-board, wired Ethernet interface. All communications must be done via USB, Wi-Fi, JTAG, or expansion interface.

5.2 Ultra96-V1 Block Diagram

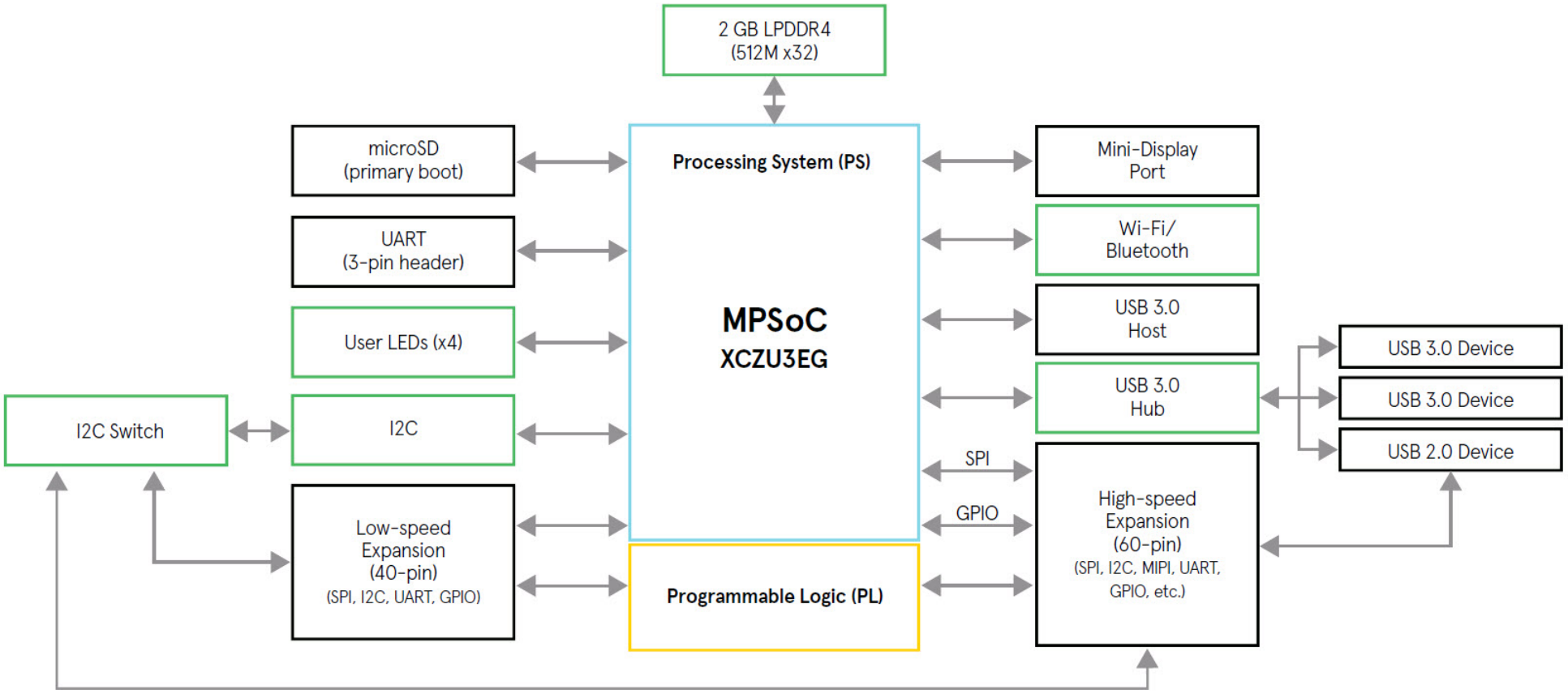

Figure 1 – Ultra96-V1 Block Diagram

6 Functional Description

The following sections provide brief descriptions of each feature provided on the Ultra96-V1 board.

6.1 Zynq UltraScale+ MPSoC

The Zynq UltraScale+ MPSoC ZU3EG device (in the SBVA484 package) contains:

- Processor System (PS):
  - **Application Processing Unit**
    Quad-core ARM Cortex-A53 MPCore with CoreSight; NEON & Single/Double Precision Floating Point; 32KB/32KB L1 Cache, 1MB L2 Cache
  - **Real-Time Processing Unit**
    Dual-core ARM Cortex-R5 with CoreSight; Single/Double Precision Floating Point; 32KB/32KB L1 Cache, and TCM
  - **Embedded and External Memory**
    256KB On-Chip Memory w/ECC; External DDR4; DDR3; DDR3L; LPDDR4; LPDDR3; External Quad-SPI; NAND; eMMC
  - **General Connectivity**
    214 PS I/O; UART; CAN; USB 2.0; I2C; SPI; 32b GPIO; Real Time Clock; WatchDog Timers; Triple Timer Counters
  - **High-Speed Connectivity**
    4 PS-GTR; PCIe Gen1/2; Serial ATA 3.1; DisplayPort 1.2a; USB 3.0; SGMII
  - **Graphic Processing Unit**
    ARM Mali™-400 MP2; 64KB L2 Cache

- Programmable Logic (PL)
  - System Logic Cells 154,350
  - CLB Flip-Flops 141,120
  - CLB LUTs 70,560
  - Distributed RAM (Mb) 1.8
  - Block RAM Blocks 216
  - Block RAM (Mb) 7.6
  - UltraRAM Blocks 0
  - UltraRAM (Mb) 0
  - DSP Slices 360
  - CMTs 3
  - System Monitor 2

- I/O
  - Max PS MIO 78
    MIO = multiplexed I/O (up to three banks of 26 I/Os) with support for I/O voltage of 1.8V or 3.3V
  - Max. PS Transceiver I/O 4 transmit and 4 receive pairs
  - Max. PL HP I/O 156
    HP = High-performance I/O with support for I/O voltage from 1.0V to 1.8V
  - Max. PL HD I/O 96
    HD = High-density I/O with support for I/O voltage from 1.2V to 3.3V
  - Max. PL Transceiver I/O 4 transmit and 4 receive pairs

6.1.1 SBVA484 Package

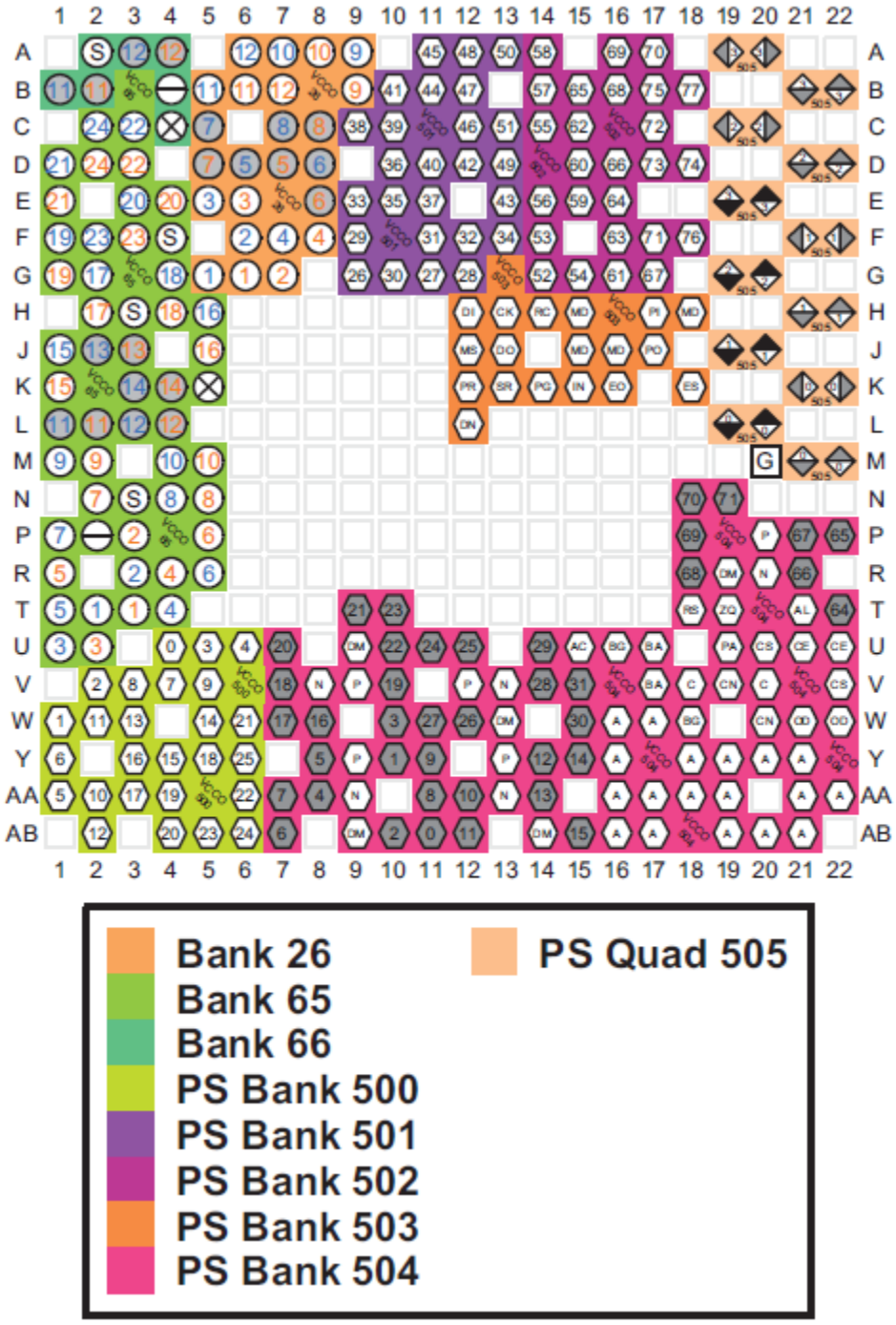

Figure 2 – SBVA484 Package Diagram

6.1.2 PL I/Os (Banks 26, 65, 66)

Zynq UltraScale+ MPSoC Promammable Logic (PL) provides two types of I/O banks: High-density (HD) banks and high-performance (HP) banks. HD banks support a limited number of single-ended I/O standards with speeds up to 250Mbps and VCCO voltages up to 3.30V. HP banks support a large variety of high-speed I/O standards, including differential I/O, and support VCCO voltages up to 1.80V.

ZU3EG provides one HD bank (Bank 26) with 24 pins, one HP bank (Bank 65) with 52 pins, and another HP bank (Bank 66) with 6 pins.

The PL I/Os on Ultra96-V1 are tied to the Low-Speed 96Boards Mezzanine, the High-Speed 96Boards Mezzanine, Bluetooth, and the fan.

Table 1 – PL IO Bank 26

MPSoC Pin Number	Bank	MPSoC Site Name	Function
C8	26	IO_L8P_HDGC_AD4P_26	Bluetooth
A8		IO_L10P_AD2P_26	
A9		IO_L9N_AD3N_26	
B9		IO_L9P_AD3P_26	
B5		IO_L11N_AD1N_26	
B7		IO_L12P_AD0P_26	
E8		IO_L6P_HDGC_AD6P_26	HS Expansion
D8		IO_L6N_HDGC_AD6N_26	
D7		IO_L5P_HDGC_AD7P_26	LS Expansion
F8		IO_L4P_AD8P_26	
E5		IO_L3N_AD9N_26	
D6		IO_L5N_HDGC_AD7N_26	
D5		IO_L7P_HDGC_AD5P_26	
C7		IO_L8N_HDGC_AD4N_26	
B6		IO_L11P_AD1P_26	
C5		IO_L7N_HDGC_AD5N_26	
F7		IO_L4N_AD8N_26	
G7		IO_L2P_AD10P_26	
F6		IO_L2N_AD10N_26	
G5		IO_L1N_AD11N_26	
A6		IO_L12N_AD0N_26	
A7		IO_L10N_AD2N_26	
G6		IO_L1P_AD11P_26	
E6		IO_L3P_AD9P_26	

Table 2 – PL IO Bank 65

MPSoC Pin Number	Bank	MPSoC Site Name	Function
F4	65	IO_T3U_N12_65	Fan
P1		IO_L7N_T1L_N1_QBC_AD13N_65	HS Expansion
N2		IO_L7P_T1L_N0_QBC_AD13P_65	
N4		IO_L8N_T1L_N3_AD5N_65	
N5		IO_L8P_T1L_N2_AD5P_65	
M1		IO_L9N_T1L_N5_AD12N_65	
M2		IO_L9P_T1L_N4_AD12P_65	
M4		IO_L10N_T1U_N7_QBC_AD4N_65	
M5		IO_L10P_T1U_N6_QBC_AD4P_65	
L1		IO_L11N_T1U_N9_GC_65	
L2		IO_L11P_T1U_N8_GC_65	
T2		IO_L1N_T0L_N1_DBC_65	
T3		IO_L1P_T0L_N0_DBC_65	
R3		IO_L2N_T0L_N3_65	
P3		IO_L2P_T0L_N2_65	
U1		IO_L3N_T0L_N5_AD15N_65	
U2		IO_L3P_T0L_N4_AD15P_65	
H5		IO_L16N_T2U_N7_QBC_AD3N_65	
J5		IO_L16P_T2U_N6_QBC_AD3P_65	
F1		IO_L19N_T3L_N1_DBC_AD9N_65	
G1		IO_L19P_T3L_N0_DBC_AD9P_65	
E3		IO_L20N_T3L_N3_AD1N_65	
E4		IO_L20P_T3L_N2_AD1P_65	
D1		IO_L21N_T3L_N5_AD8N_65	
E1		IO_L21P_T3L_N4_AD8P_65	
C3		IO_L22N_T3U_N7_DBC_AD0N_65	
D3		IO_L22P_T3U_N6_DBC_AD0P_65	
C2		IO_L24N_T3U_N11_PERSTN0_65	
D2		IO_L24P_T3U_N10_PERSTN1_I2C_SDA_65	NC
F2		IO_L23N_T3U_N9_65	
F3		IO_L23P_T3U_N8_I2C_SCLK_65	
G2		IO_L17N_T2U_N9_AD10N_65	
G4		IO_L18N_T2U_N11_AD2N_65	
H2		IO_L17P_T2U_N8_AD10P_65	
H3		IO_T2U_N12_65	
H4		IO_L18P_T2U_N10_AD2P_65	
J1		IO_L15N_T2L_N5_AD11N_65	

J2		IO_L13N_T2L_N1_GC_QBC_65	
J3		IO_L13P_T2L_N0_GC_QBC_65	
K1		IO_L15P_T2L_N4_AD11P_65	
K3		IO_L14N_T2L_N3_GC_65	
K4		IO_L14P_T2L_N2_GC_65	
K5		VREF_65	
L3		IO_L12N_T1U_N11_GC_65	
L4		IO_L12P_T1U_N10_GC_65	
N3		IO_T1U_N12_65	
P5		IO_L6P_T0U_N10_AD6P_65	
R1		IO_L5P_T0U_N8_AD14P_65	
R4		IO_L4P_T0U_N6_DBC_AD7P_SMBALERT_65	
R5		IO_L6N_T0U_N11_AD6N_65	
T1		IO_L5N_T0U_N9_AD14N_65	
T4		IO_L4N_T0U_N7_DBC_AD7N_65	
P2		IO_T0U_N12_VRP_65	VRP

Table 3 – PL IO Bank 66

MPSoC Pin Number	Bank	MPSoC Site Name	Function
A2	66	IO_T3U_N12_66	HS Expansion
A3	66	IO_L12N_T1U_N11_GC_66	NC
A4	66	IO_L12P_T1U_N10_GC_66	
B1	66	IO_L11N_T1U_N9_GC_66	
B2	66	IO_L11P_T1U_N8_GC_66	
B4	66	IO_T0U_N12_VRP_66	
C4	66	VREF_66	

6.1.3 PS MIOs (Banks 500, 501, 502)

Table 4 – MIO Overview

Bank 500 1.80V	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	UART1		UART0		I2C1		SPI1	WE	BE	SPI1			I2C	SD0				LED				SD0		PB	SD0	USB
Bank 501 1.80V	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
	PI	DPAUX				INA	PMIC		PK	TP	LSE		SPI0	LSE		SPI0			LSE		SD1					
Bank 502 1.80V	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
	USB0												USB1												IW	PMI

UART1 - Header
UART0 - Bluetooth (+ PL RTS/CTS)
I2C1 - I2C Hub
SPI1 - HS Expansion Header
WE - (GPIO) WiFi Enable
BE - (GPIO) Bluetooth Enable
I2C - (GPIO) I2C Hub Reset
SD0 - SD Card (3.3V level shifter)
LED - (GPIO) User LEDs
PB - (GPIO) User Pushbutton
USB - (GPIO) USB Hub Vbus detect
PI - (GPIO) Power Pushbutton Controller INT_B (PMU input)
DPAUX - DiplayPort Auxiliary Signals
INA - (GPIO) INA226 PMBUS Alert (PMU Input)
PMIC - (GPIO) FPU, PL power control (PMU Output)
PK - (GPIO) Power Pushbutton Controller KILL_B (PMU output)
TP - (GPIO) Test Point (PMU Output)
LSE - (GPIO) LS Expansion Header GPIO[A..L]
SPI0 - LS Expansion Header
SD1 - WiFi
USB0 - Upstream USB
USB1 - Downstream USB, Hub
IW - (GPIO) WiFi IRQ
PMI - (GPIO) PMIC Interrupt

Table 5 – MIO Bank 500 (MIOs 0 to 25)

Bank	Pin #	Device	Signal	I/O	Notes
500	0	UART1	MIO0_UART1_TX	O	UART Header J6
	1		MIO1_UART1_RX	I	
	2	UART0	MIO2_UART0_RX_BT_HCI_TX	I	WL1831 B
	3		MIO3_UART0_TX_BT_HCI_RX	O	
	4	I2C1	MIO4_I2C1_SCL	O	I2C Mux
	5		MIO5_I2C1_SDA	IO	
	6	SPI1	MIO6_SPI1_SCLK	O	Hi-speed Expansion Header
	7	GPIO	MIO7_WLAN_EN	O	WL1831 WiFi enable
	8	GPIO	MIO8_BT_EN	O	WL1831 BT enable
	9	SPI1	MIO9_SPI1_CS	O	Hi-speed Expansion Header
	10		MIO10_SPI1_MISO	I	
	11		MIO11_SPI1_MOSI	O	
	12	GPIO	MIO12_I2C_MUX_RESET_B	O	I2C Mux reset
	13	SD0	MIO13_SD0_DAT0	IO	SDIO0 Data 0
	14		MIO14_SD0_DAT1	IO	SDIO0 Data 1
	15		MIO15_SD0_DAT2	IO	SDIO0 Data 2
	16		MIO16_SD0_DAT3	IO	SDIO0 Data 3
	17	GPIO	MIO17_PS_LED3	O	User LED 3
	18		MIO18_PS_LED2	O	User LED 2
	19		MIO19_PS_LED1	O	User LED 1
	20		MIO20_PS_LED0	O	User LED 0
	21	SD0	MIO21_SD0_CMD	IO	SDIO0 Command
	22		MIO22_SD0_CLK	O	SDIO0 Clock
	23	GPIO	MIO23_GPIO_PB	I	User Pushbutton
	24	SD0	MIO24_SD0_DETECT	I	SDIO Card Detect
	25	GPIO	MIO25_VBUS_DET	O	USB Hub VBUS

Table 6 – MIO Bank 501 (MIOs 26 to 51)

Bank	Pin #	Device	Signal	I/O	Notes
501	26	GPIO	MIO26_POWER_INT_B	I	Pushbutton On/Off Controller Interrupt, Pushbutton turn-off event detected
	27	DPAUX	MIO27_DP_AUX_OUT	O	DPAUX single-ended output
	28		MIO28_DP_HPD	I	DPAUX Hot Plug Detect
	29		MIO29_DP_OE	O	DPAUX Output Enable
	30		MIO30_DP_AUX_IN	I	DPAUX single-ended input
	31	GPIO	MIO31_INA226_PMBUS_ ALERT	I	INA226 Alert
	32	GPIO	MIO32_PS_FP_PWR_EN	O	PMU power off Full Power Domain
	33	GPIO	MIO33_PL_PWR_EN	O	PMU power off PL
	34	GPIO	MIO34_POWER_KILL_B	O	LTC2950 Pushbutton On/Off Controller Release enable output, power off system
	35	GPIO		IO	Test Point
	36	GPIO	MIO36_PS_GPIO1_0	IO	Low-speed Expansion GPIO-C
	37	GPIO	MIO37_PS_GPIO1_1	IO	Low-speed Expansion GPIO-D
	38	SPI	MIO38_SPI0_SCLK	O	SPI Serial Clock
	39	GPIO	MIO39_PS_GPIO1_2	IO	Low-speed Expansion GPIO-E
	40	GPIO	MIO40_PS_GPIO1_3	IO	Low-speed Expansion GPIO-F
	41	SPI0	MIO41_SPI0_CS0	O	SPI Chip Select 0
	42	SPI0	MIO42_SPI0_MISO	I	SPI Data In
	43	SPI0	MIO43_SPI0_MOSI	O	SPI Data Out
	44	GPIO	MIO44_PS_GPIO1_4	IO	Low-speed Expansion GPIO-G
	45	GPIO	MIO45_PS_GPIO1_5	IO	Low-speed Expansion GPIO-H
	46	SDIO	MIO46_SD1_D0	IO	SDIO1 Data 0
	47	SD1	MIO47_SD1_D1	IO	SDIO1 Data 1
	48	SD1	MIO48_SD1_D2	IO	SDIO1 Data 2
	49	SD1	MIO49_SD1_D3	IO	SDIO1 Data 3
	50	SD1	MIO50_SD1_CMD	O	SDIO1 Command
	51	SD1	MIO51_SD1_CLK	O	SDIO1 Clock

Table 7 – MIO Bank 502 (MIOs 52 to 77)

Bank	Pin #	Device	Signal	I/O	Notes
502	52	USB0	MIO52_USB0_CLK	I	USB0 Clock
	53		MIO53_USB0_DIR	I	USB0 Data bus direction
	54		MIO54_USB0_DATA2	IO	USB0 Data 2
	55		MIO55_USB0_NXT	I	USB0 Data flow
	56		MIO56_USB0_DATA0	IO	USB0 Data 0
	57		MIO57_USB0_DATA1	IO	USB0 Data 1
	58		MIO58_USB0_STP	O	USB0 Stop transfer
	59		MIO59_USB0_DATA3	IO	USB0 Data 3
	60		MIO60_USB0_DATA4	IO	USB0 Data 4
	61		MIO61_USB0_DATA5	IO	USB0 Data 5
	62		MIO62_USB0_DATA6	IO	USB0 Data 6
	63		MIO63_USB0_DATA7	IO	USB0 Data 7
	64	USB1	MIO64_USB1_CLK	I	USB1 Clock
	65		MIO65_USB1_DIR	I	USB1 Data bus direction
	66		MIO66_USB1_DATA2	IO	USB1 Data 2
	67		MIO67_USB1_NXT	I	USB1 Data flow
	68		MIO68_USB1_DATA0	IO	USB1 Data 0
	69		MIO69_USB1_DATA1	IO	USB1 Data 1
	70		MIO70_USB1_STP	O	USB1 Stop transfer
	71		MIO71_USB1_DATA3	IO	USB1 Data 3
	72		MIO72_USB1_DATA4	IO	USB1 Data 4
	73		MIO73_USB1_DATA5	IO	USB1 Data 5
	74		MIO74_USB1_DATA6	IO	USB1 Data 6
	75		MIO75_USB1_DATA7	IO	USB1 Data 7
	76		MIO76_WLAN_IRQ	I	WL1831MOD WLAN Interrupt
	77		PMIC IRQ	I	PMIC IRQ

6.1.4 PS Bank 503

Bank 503 contains system-level pins, including Mode, config, PSJTAG, error, SRST, and POR.

Table 8 – PS Bank 503

MPSoC Pin Number	Bank	MPSoC Site Name
K16	503	PS_ERROR_OUT_503
K18		PS_ERROR_STATUS_503
K15		PS_INIT_B_503
H15		PS_MODE1_503
J15		PS_MODE2_503
H18		PS_MODE3_503
H17		PS_PADI_503
J17		PS_PADO_503
K12		PS_POR_B_503
H14		PS_REF_CLK_503
K13		PS_SRST_B_503

6.1.5 PS Bank 504

Bank 504 contains the DDR Controller pins which are connected to LPDDR4 on Ultra96-V1.

Table 9 – PS Bank 504

MPSoC Pin Number	Bank	MPSoC Site Name
AA22	504	PS_DDR_A0_504
AB20		PS_DDR_A1_504
AB17		PS_DDR_A2_504
AB19		PS_DDR_A3_504
AB21		PS_DDR_A4_504
AB16		PS_DDR_A5_504
Y21		PS_DDR_A10_504
AA21		PS_DDR_A11_504
AA18		PS_DDR_A12_504
AA19		PS_DDR_A13_504
AA17		PS_DDR_A14_504
AA16		PS_DDR_A15_504
W20		PS_DDR_CK_N0_504
V19		PS_DDR_CK_N1_504
V20		PS_DDR_CK0_504
V18		PS_DDR_CK1_504
U22		PS_DDR_CKE0_504
U21		PS_DDR_CKE1_504
V22		PS_DDR_CS_N0_504
U20		PS_DDR_CS_N1_504
AB9		PS_DDR_DM0_504
AB14		PS_DDR_DM1_504
U9		PS_DDR_DM2_504
W13		PS_DDR_DM3_504
AB11		PS_DDR_DQ0_504
Y10		PS_DDR_DQ1_504
AB10		PS_DDR_DQ2_504
W10		PS_DDR_DQ3_504
AA8		PS_DDR_DQ4_504
Y8		PS_DDR_DQ5_504
AB7		PS_DDR_DQ6_504
AA7		PS_DDR_DQ7_504
AA11		PS_DDR_DQ8_504
Y11		PS_DDR_DQ9_504

AA12		PS_DDR_DQ10_504
AB12		PS_DDR_DQ11_504
Y14		PS_DDR_DQ12_504
AA14		PS_DDR_DQ13_504
Y15		PS_DDR_DQ14_504
AB15		PS_DDR_DQ15_504
W8		PS_DDR_DQ16_504
W7		PS_DDR_DQ17_504
V7		PS_DDR_DQ18_504
V10		PS_DDR_DQ19_504
U7		PS_DDR_DQ20_504
T9		PS_DDR_DQ21_504
U10		PS_DDR_DQ22_504
T10		PS_DDR_DQ23_504
U11		PS_DDR_DQ24_504
U12		PS_DDR_DQ25_504
W12		PS_DDR_DQ26_504
W11		PS_DDR_DQ27_504
V14		PS_DDR_DQ28_504
U14		PS_DDR_DQ29_504
W15		PS_DDR_DQ30_504
V15		PS_DDR_DQ31_504
AA9		PS_DDR_DQS_N0_504
AA13		PS_DDR_DQS_N1_504
V8		PS_DDR_DQS_N2_504
V13		PS_DDR_DQS_N3_504
Y9		PS_DDR_DQS_P0_504
Y13		PS_DDR_DQS_P1_504
V9		PS_DDR_DQS_P2_504
V12		PS_DDR_DQS_P3_504
T18		PS_DDR_RAM_RST_N_504
T19		PS_DDR_ZQ_504

6.1.6 PS Bank 505

Bank 505 contains the transceivers.

Table 10 – PS Bank 505

MPSoC Pin Number	Bank	MPSoC Site Name
L20	505	PS_MGTREFCLK0N_505
L19		PS_MGTREFCLK0P_505
J20		PS_MGTREFCLK1N_505
J19		PS_MGTREFCLK1P_505
K22		PS_MGTRTXN0_505
K21		PS_MGTRTXP0_505
F22		PS_MGTRTXN1_505
F21		PS_MGTRTXP1_505
D22		PS_MGTRRXN2_505
D21		PS_MGTRRXP2_505
C20		PS_MGTRTXN2_505
C19		PS_MGTRTXP2_505
B22		PS_MGTRRXN3_505
B21		PS_MGTRRXP3_505
A20		PS_MGTRTXN3_505
A19		PS_MGTRTXP3_505
M20		PS_MGTRREF_505
E19		PS_MGTREFCLK3P_505
E20		PS_MGTREFCLK3N_505
G19		PS_MGTREFCLK2P_505
G20		PS_MGTREFCLK2N_505
H21		PS_MGTRRXP1_505
H22		PS_MGTRRXN1_505
M21		PS_MGTRRXP0_505
M22		PS_MGTRRXN0_505

6.2 LPDDR4 Memory

Ultra96-V1 provides 2GB (512Mbit x 32) of 533MHz (1066Mbps) LPDDR4 memory using Micron MT53B512M32D2NP-062 WT:C.

6.3 microSD Card

Ultra96-V1 provides a microSD card socket as the primary boot device. VCCO for MIO1 is 1.80V thus a level shifter is required. A Maxim MAX13035E is used.

When available, the Ultra96-V1 kit ships with a Delkin Devices “Utility” 16 GB Industrial MLC microSD card, pre-programmed with Linux boot. The Delkin Part Number is S416APG49-U3000-3, rated at Read Performance = 95MB/s and Write Performance = 55MB/s (measured using CrystalDiskMark).

There are several advantages to using MLC over the typical retail TLC that is readily available.

Table 11 – Comparison of TLC vs. MLC microSD Cards

	Retail TLC	Delkin Utility MLC
CrystalDiskMark Read Performance	80MB/s	95 MB/s
CrystalDiskMark Write Performance	20MB/s	55 MB/s
Lifecycle	<12 months	18-24 months
Endurance (Program/Erase cycles)	300-600	3000
SMART data enabled (card life stats)	No	Yes
Embedded mode – aligned to efficiently work with Linux based OS as opposed to FAT only	No	Yes

6.4 USB

Ultra96-V1 provides one upstream (device) and two downstream (host) USB 3.0 connections. A USB 2.0 downstream (host) interface is provided on the high speed expansion bus.

Two Microchip USB3320 USB 2.0 ULPI Transceivers and one Microchip USB5744 4-Port SS/HS USB Controller Hub are specified.

Figure 3 below shows the Ultra96-V1 USB Setup.

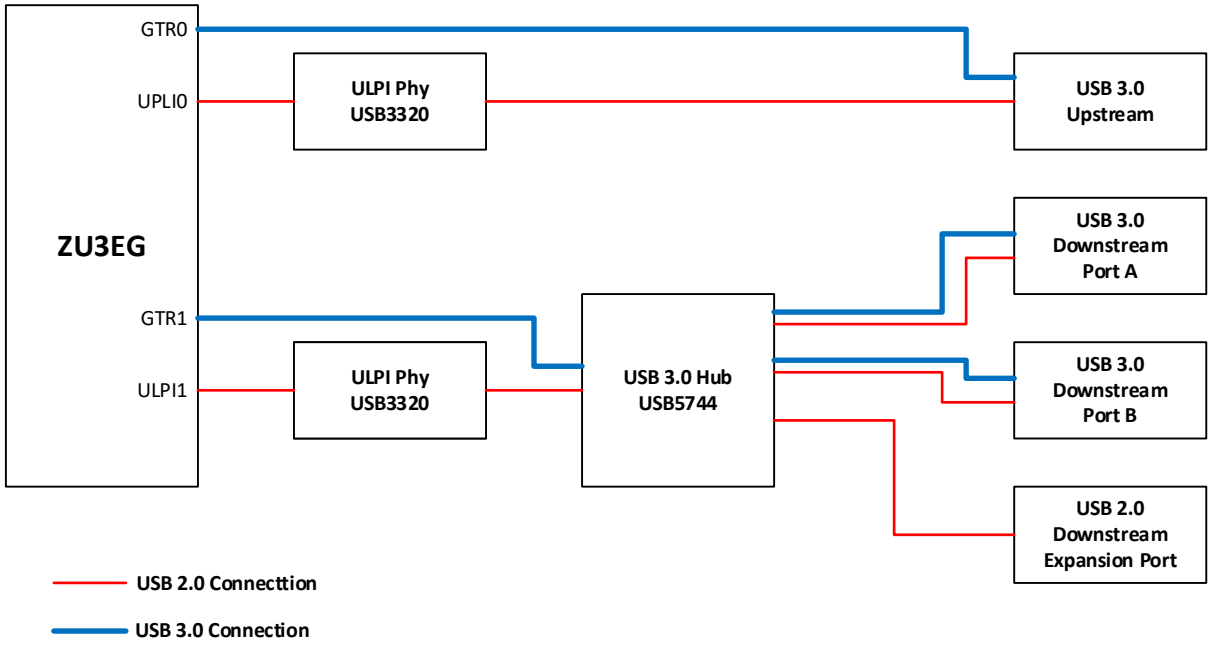

Figure 3 – USB Setup

6.4.1 USB5744 Implementation Details

Refer to the USB5744 datasheet (http://ww1.microchip.com/downloads/en/DeviceDoc/00001855C.pdf) and the EVB-USB5744 Evaluation Board schematics (http://ww1.microchip.com/downloads/en/DeviceDoc/EVB-USB5744_A1-sch.pdf) for implementation details.

NOTE: USB 3.0 Downstream Port A/B VUBS is controlled by a Microchip/Micrel MIC2009YML USB Power Switch following the Evaluation Board implementation

NOTE: USB2.0 Downstream Port VBUS is provided by the Low Speed Expansion Header 5V supply (see 6.11.1). A Power switch is not required and the corresponding USB5744 PRT_CTLx pin for that port is left n/c.

6.5 Wi-Fi / Bluetooth

Ultra96-V1 supports Wi-Fi (802.11a/b/g/n) and Bluetooth 4.1.

A TI WL1831MOD WiLink 8 Single Band Combo Wi-Fi, Bluetooth & Bluetooth low energy module is specified.

6.5.1 Wi-FI

The WL183xMOD WLAN interface connects to the MPSoC through the Secure Digital SD1 interface. The WLAN interrupt WL_IRQ is connected to PS MIO76, the WLAN enable signal WL_EN is connected to PS MIO7. A yellow LED is connected to WL_EN to indicate that Wi-Fi is enabled.

6.5.2 Bluetooth

The WL183xMOD Bluetooth interface connects through a UART interface. Since the Bluetooth UART interface requires hardware flow-control (RTS/CTS), which is only available through the PL, the UART RX/TX signals are connected to PS UART0 (MIO2, MIO3) and the RTS/CTS signals are connected to the PL High-Density (HD) bank. A blue LED is connected to BT_EN to indicate that Bluetooth is enabled.

6.5.3 Bluetooth Audio

WL183xMOD Bluetooth Audio connects through a PCM/I2S interface. Since MPSoC does not provide a PCM/I2S interface, this has to be implemented as a soft-IP core in the PL. The Bluetooth Audio is connected to the PL High-Density (HD) bank.

6.6 Mini DisplayPort

Ultra96-V1 supports one Mini DisplayPort output. A TE Connectivity 2129320-3 provides the Mini DisplayPort connectivity.

6.7 UART

Ultra96-V1 provides access to one UART on the baseboard. PS UART1 (MIO0, MIO1) is connected to a 3-pin 2mm header (J6).

Table 12 – Pinout for the J6 UART Header

Connector	Pin	PCB Signal	Zynq Pinout
J6	1	MIO1_UART1_RX_LS	U4
	2	MIO0_UART1_TX_LS	W1
	3	GND	N/C

6.8 I2C

Ultra96-V1 supports one I2C bus. A TI TCA9544A Low-Voltage 8-Channel I2C Switch is specified to isolate the I2C sub-buses from each other. All I2C buses operate at 1.80V.

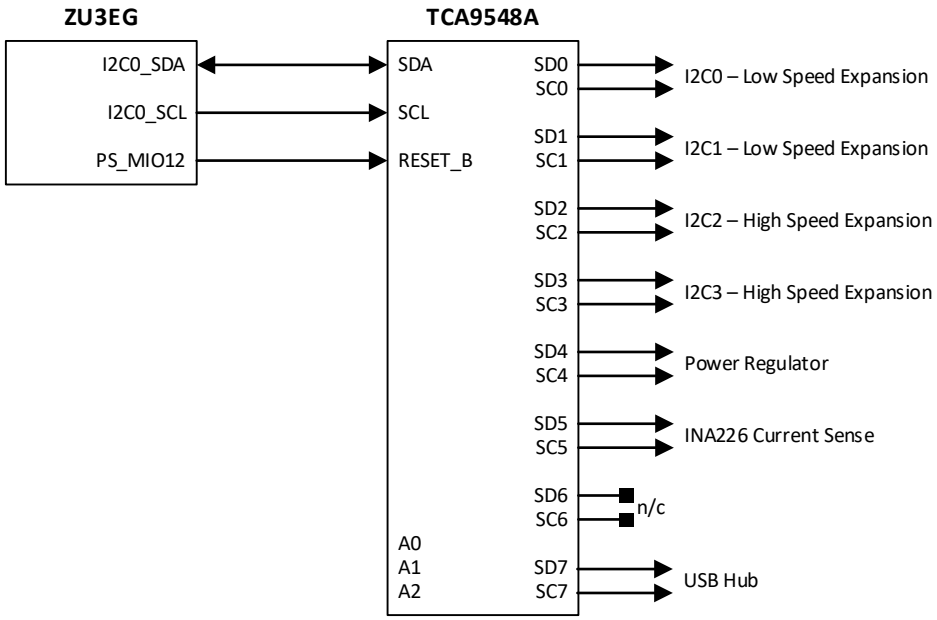

Figure 4 – MPSoC I2C to I2C Switch

6.9 User LEDs

Ultra96-V1 provides four user-controllable LEDs connected to PS_MIO[17..20]. All User LEDs are green.

6.10 MPSoC Thermal Bracket with Fan

The Ultra96-V1 uses a thermal bracket with fan for the MPSoC device. The bracket is mounted to the bottom side of the Ultra96-V1 to help dissipate heat. A Sunon MC30060V1-000U-A99 fan is used, connected to 5V and GND at J18 and J19. Users can control the fan using signal FAN_PWM from PL IO F4 on Bank 65.

6.11 Expansion Connectors

6.11.1 Low Speed Expansion Connector (J7)

Ultra96-V1 provides a 96Boards compatible Low Speed Expansion Connector. A Molex 87381-4063 (or compatible) 40 pin low profile female 2mm receptacle (20x2) 4.5mm height is specified. Table 13 shows the pinout of the Low Speed Expansion Header (Ultra96-V1 column) and the differences from the 96Boards specification (96Boards column). With the exception of I2C0 and I2C1, all dedicated interfaces specified by 96Boards are replaced with GPIO.

Table 13 – Low Speed Expansion Connector

Ultra96	96Boards	Pin #
GND	GND	1
HD_GPIO0	UART0_CTS	3
HD_GPIO1	UART0_TxD	5
HD_GPIO2	UART0_RxD	7
HD_GPIO3	UART0_RTS	9
HD_GPIO4	UART1_TxD	11
HD_GPIO5	UART1_RxD	13
PS_I2C0_SCL	I2C0_SCL	15
PS_I2C0_SDA	I2C0_SDA	17
PS_I2C1_SCL	I2C1_SCL	19
PS_I2C1_SDA	I2C1_SDA	21
PS_MIO36	GPIO-A	23
PS_MIO39	GPIO-C	25
PS_MIO44	GPIO-E	27
HD_GPIO6	GPIO-G	29
HD_GPIO7	GPIO-I	31
HD_GPIO8	GPIO-K	33
+1V8	+1V8	35
+5V0	+5V0	37
GND	GND	39

Pin #	96Boards	Ultra96
2	GND	GND
4	PWR_BTN_N	PWR_BTN_N
6	RST_BTN_N	RST_BTN_N
8	SPI0_SCLK	PS_MIO38
10	SPI0_DIN	PS_MIO42
12	SPI0_CS	PS_MIO41
14	SPI0_DOUT	PS_MIO43
16	PCM_FS	HD_GPIO9
18	PCM_CLK	HD_GPIO10
20	PCM_DO	HD_GPIO11
22	PCM_DI	HD_GPIO12
24	GPIO-B	PS_MIO37
26	GPIO-D	PS_MIO40
28	GPIO-F	PS_MIO45
30	GPIO-H	HD_GPIO13
32	GPIO-J	HD_GPIO14
34	GPIO-L	HD_GPIO15
36	SYS_DCIN	SYS_DCIN
38	SYS_DCIN	SYS_DCIN
40	GND	GND

6.11.2 High Speed Expansion Connector

Ultra96-V1 provides a 96Boards compatible High Speed Expansion Connector. An Amphenol FCI 61082-061409LF (or compatible) 60 pin low profile 0.8mm receptacle is specified.

Table 14 shows the pinout of the High Speed Expansion Header (Ultra96-V1 column) and the differences from the 96Boards specification (96Boards column). With the exception of SD, I2C2 and I2C3, all dedicated interfaces specified by 96Boards are replaced with GPIO. All HP_GPIO are routed as differential pairs.

Table 14 – High Speed Expansion Connector

Xilinx	96Boards	Pin #
PS_SPI0_MOSI	SD_DAT0/SPI1_DOUT	1
n/c	SD_DAT1	3
n/c	SD_DAT2	5
PS_SPI0_CS	SD_DAT3/SPI1_CS	7
PS_SPI0_SCLK	SD_SCLK/SPI1_SCLK	9
PS_SPI0_MISO	SD_CMD/SPI1_DIN	11
GND	GND	13
HD_GPIO_CC	CLK0/CSI0_MCLK	15
HD_GPIO_CC	CLK1/CSI1_MCLK	17
GND	GND	19
HP_GPIO_CC+	DSI_CLK+	21
HP_GPIO_CC-	DSI_CLK-	23
GND	GND	25
HP_GPIO+	DSI_D0+	27
HP_GPIO-	DSI_D0-	29
GND	GND	31
HP_GPIO+	DSI_D1+	33
HP_GPIO-	DSI_D1-	35
GND	GND	37
HP_GPIO+	DSI_D2+	39
HP_GPIO-	DSI_D2-	41
GND	GND	43
HP_GPIO+	DSI_D3+	45
HP_GPIO-	DSI_D3-	47
GND	GND	49
USB_D+	USB_D+	51
USB_D-	USB_D-	53
GND	GND	55
HP_GPIO	HSIC_STR	57
HP_GPIO	HSIC_DATA	59

Pin #	96Boards	Xilinx
2	CSI0_C+	HP_GPIO+
4	CSI0_C-	HP_GPIO-
6	GND	GND
8	CSI0_D0+	HP_GPIO+
10	CSI0+D0-	HP_GPIO-
12	GND	GND
14	CSI0_D1+	HP_GPIO+
16	CSI0_D1-	HP_GPIO-
18	GND	GND
20	CSI0_D2+	HP_GPIO+
22	CSI0_D2-	HP_GPIO-
24	GND	GND
26	CSI0_D3+	HP_GPIO+
28	CSI0_D3-	HP_GPIO-
30	GND	GND
32	I2C2_SCL	PS_I2C0_SCL
34	I2C2_SDA	PS_I2C0_SDA
36	I2C3_SCL	PS_I2C1_SCL
38	I2C3_SDA	PS_I2C1_SDA
40	GND	GND
42	CSI1_D0+	HP_GPIO+
44	CSI1_D0-	HP_GPIO-
46	GND	GND
48	CSI1_D1+	HP_GPIO+
50	CSI1_D1-	HP_GPIO-
52	GND	GND
54	CSI1_C+	HP_GPIO+
56	CSI1_C-	HP_GPIO-
58	GND	GND
60	Reserved	Reserved

7 Configuration and Debug

7.1 Boot Mode

Ultra96-V1 supports booting from JTAG and microSD Card. A DIP switch (SW2) is installed to allow selecting the desired boot mode.

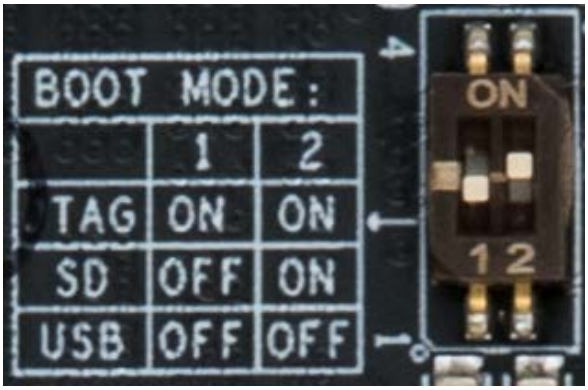

Figure 5 – Boot Mode Switch (SD Boot Mode Shown)

7.2 JTAG Configuration and Debug

JTAG access to the MPSoC is available through a 1x7 header (J2). An external JTAG pod with flyleads or the Avnet Ultra96 JTAG/UART Pod is required to interface to the board.

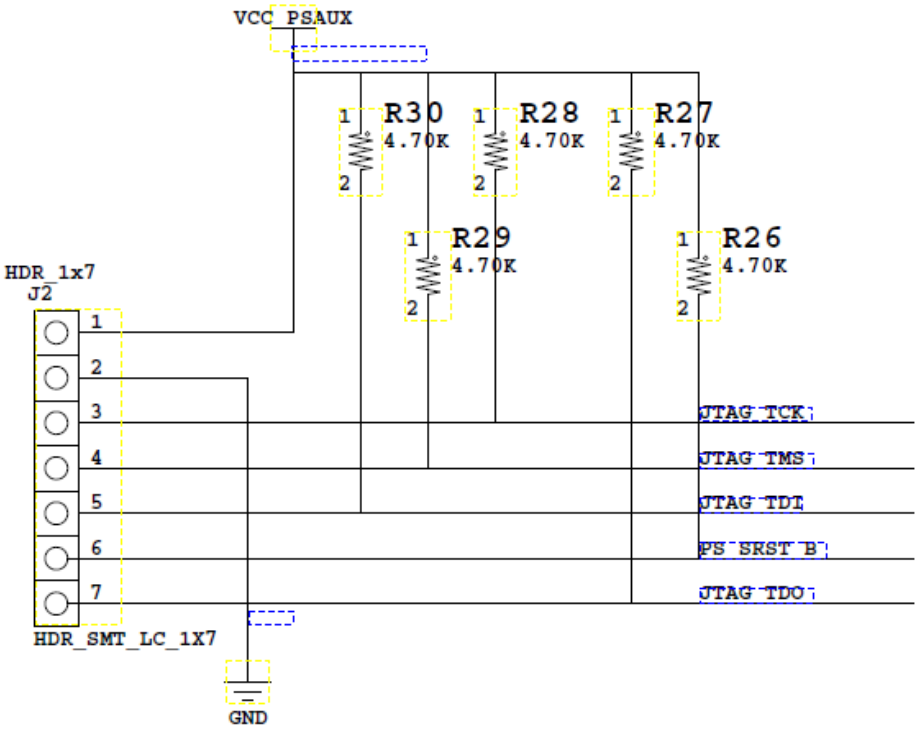

Figure 6 – Ultra96-V1 JTAG Connection

8 Power

8.1 External Power Connection

Board power is supplied by an external 12V AC/DC Power Supply based on the 96Boards specification, located at http://avnet.me/96Board4APower

Here are the requirements from the 96Boards site:

- EIAJ-3 compliant DC plug available up to 2A, which is 4.75 mm outer diameter with 1.7mm center pin (4.75/1.7), for the power supply
- https://en.wikipedia.org/wiki/EIAJ_connector

However, there is a bit of flexibility. Avnet offers a 12V supply as an accessory (part number: AES-ACC-U96-4APWR) with the following specifications:

- Input: AC 100-240v, 50/60HZ
- Output: DC 12V, 4A
- 1.2m US AC cable with C8 socket
- 1.2m EU AC cable with C8 socket
- 1.2m UK AC cable with C8 socket
- 1.2m AU AC cable with C8 socket
- 4.7mm x 1.7mm x 10mm DC plug

Figure 7 – Ultra96-V1 12V @ 4A AC/DC Supply

8.2 Power Estimation Using XPE

Xilinx Power Estimator (XPE) should be used to generate worst case power estimations. The Xilinx Power Estimator (XPE) spreadsheet is available on Xilinx' website that can help you get started with your own power estimation. Avnet has also provided an example of this spreadsheet filled out for the Ultra96-V1 under Documentation on the Ultra96-V1 website.

8.3 Power Regulators

A configurable multi-rail PMIC provides all power for the Ultra96-V1. The power rail configuration is shown below:

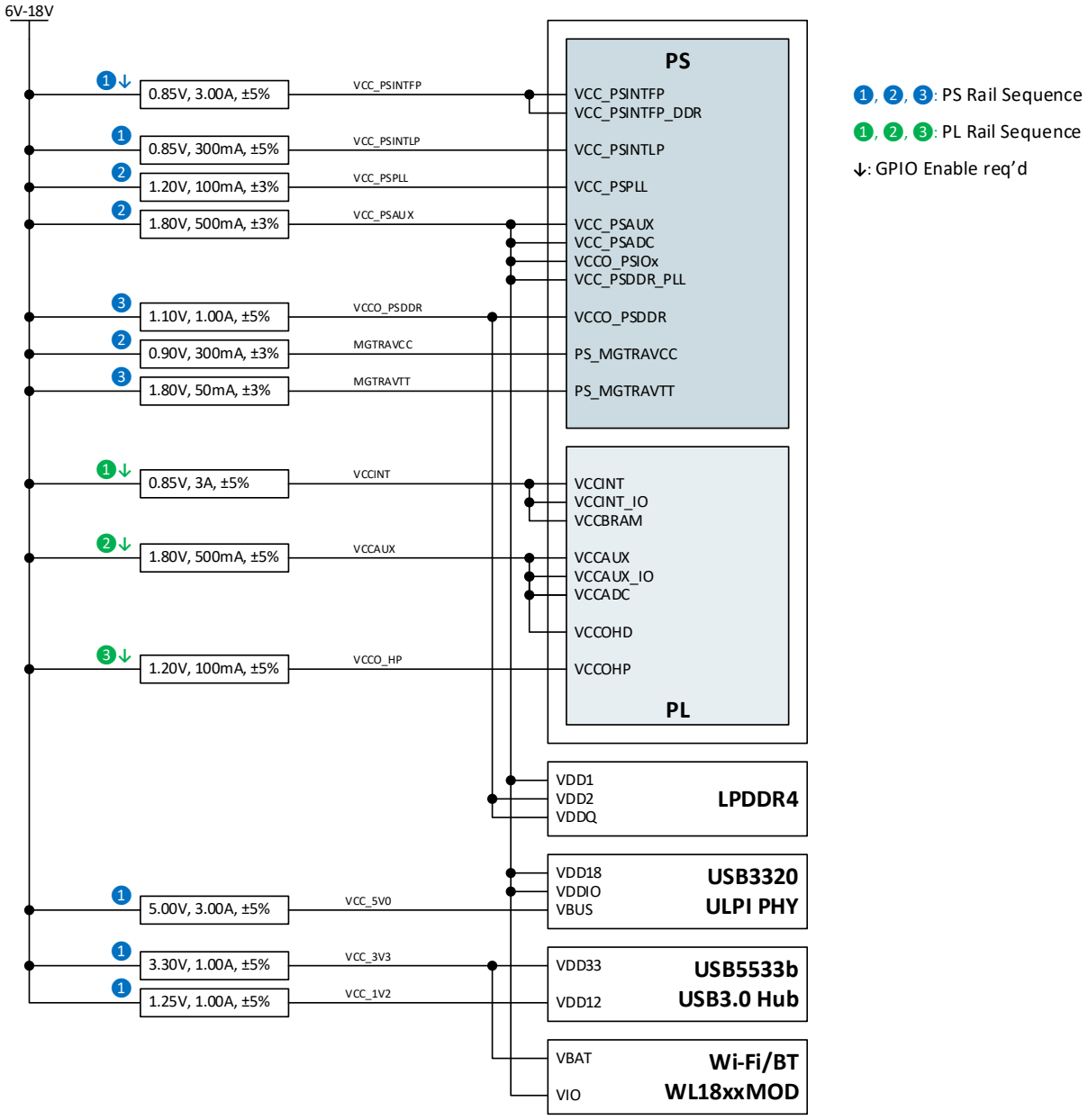

Figure 8 – Power Regulation

8.4 Power Sequence

The diagram below shows the power sequence:

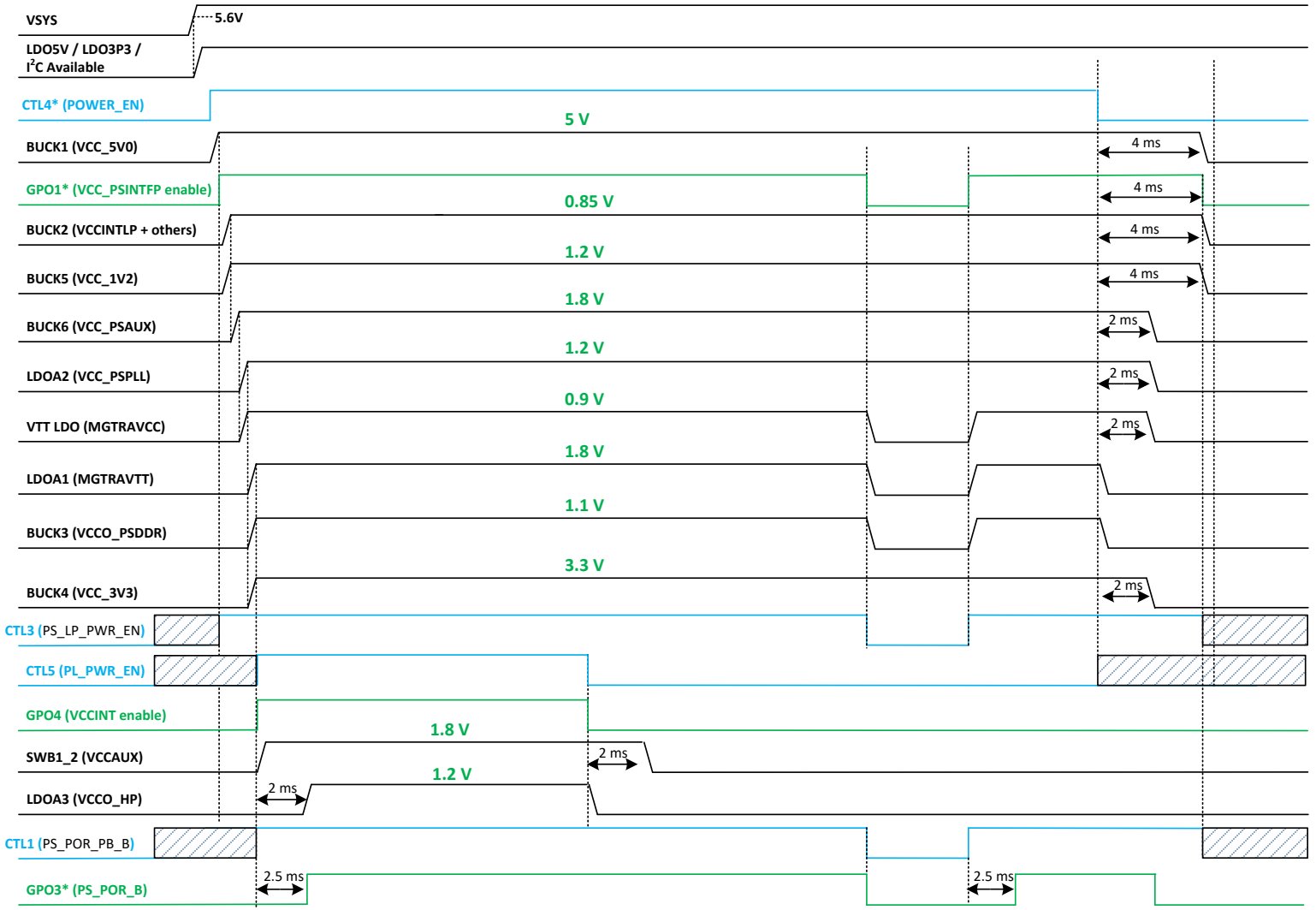

Figure 9 – Ultra96-V1 Power Sequencing

9 Clocks

Ultra96-V1 provides the following system clocks to the MPSoC:

- PS_CLK: PS reference clock 100MHz/3 ($33.\overline{3}\text{MHz}$), 1.8V LVCMOS
- GTR_CLK0: USB 3.0 26MHz, LVDS
- GTR_CLK1: DisplayPort 27MHz, LVDS

These clocks are generated by a Customizable Quad Clock Generator.

10 Reset

Ultra96-V1 Reset is managed by the TI PMIC. At power-up, the ZU3EG is held in reset until all power rails have ramped up and are stable. A pushbutton allows manually resetting the ZU3EG.

11 Getting Help and Support

If additional support is required, Avnet has many avenues to search depending on your needs.
For general question regarding Ultra96-V1, please visit our website at **Error! Hyperlink reference not valid.**http://avnet.me/ultra96-v1. Here you can find documentation, technical specifications, videos and tutorials, reference designs and other support.

Detailed questions regarding Ultra96-V1 hardware design, software application development, using Xilinx tools, training and other topics can be posted on the Ultra96 Support Forums at http://avnet.me/Ultra96_Forum. Avnet's technical support team monitors the forum during normal business hours.

Those interested in customer-specific options on Ultra96-V1 can send inquiries to customize@avnet.com.