AVNET
Reach Further™

Avnet SD Card Advice for Zynq® and UlraScale+® based Products

/ZEDBOARD
/MICROZED
/PICOZED
/ULTRA96
/ULTRAZED

Version 2.0
January 2019

1. Introduction

This document is a list of suggestions as well as helpful information that will guide Engineers working with Xilinx Zynq®-7000 SoC and Xilinx Zynq® UltraScale+ MPSoC based solutions from Avnet. Advice is provided for selecting and working with SD cards for their own system designs. This document is ***not*** an all-inclusive list. There are many brands and types of SD cards available. This document contains the brands and types of cards with which Avnet has experience.

2. About SD Cards

There is a ***large*** variety of SD cards available, with no end in sight to new cards coming out. Design Engineers will find it useful to learn *how to* identify a card in order to understand selection for optimal compatibility. Information in this section is excerpted from the SD Association (Appendix A) webpage.

As of the publication of this document, there are 3 general types of SD cards to be aware of:

1. Secure Digital Standard card (SD)
2. SD High Capacity (SDHC)
3. SD Extended Capacity (SDXC)

There are also 4 BUS types to be aware of:

Type	Max Speed	Spec. Version
Default	**12.5 MB/s**	**1.01**
High Speed	**25 MB/s**	**2.00**
UHS-I	**104 MB/s**	**3.01**
UHS-II	**312 MB/s**	**4.00**

While there is no card marking for Default/Normal or High Speed, a card will have a mark to indicate UHS-I and UHS-II compatibility. This marking employs Roman Numerals similar to the examples shown here:

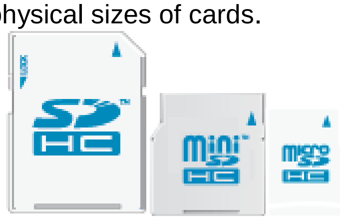
Type	Typical Marking
UHS-I	
UHS-II	

Cards are also typically marked with a symbol indicating the speed grade. Here the speed grade indicates the minimum non-fragmental Write Speed. As a result, the Write Speeds shown here are the MINIMUM performance for the class rating but the SD bus speeds can be ***much*** higher.

Minimum Write Speed	Typical Marking
2 MB/s	2
4 MB/s	4
6 MB/s	6
10 MB/s	10
10 MB/s	1
30 MB/s	3

The Standard card can have speed grades of 2, 4, 6 or 10 with capacities up to 2GB. The typical cards to use with Avnet products are the Full SD as well as microSD versions. The miniSD card is not typically used on Avnet products.

An SDHC card can have any of the speed grades or bus types, with capacities from 4GB to 32GB. They also have three (3) physical sizes of cards.



An SDXC card can also have any of the speed grades or bus types, with capacities over 32GB up to 2TB. By standard, there only appears to be Full SD and microSD size cards.

3. Review Zynq Requirements from Xilinx

First, locate the appropriate Technical Reference Manual.

- For Zynq Xilinx document UG585
- For Zynq UltraScale+ Xilinx document UG1085

The Zynq Processing System has two hard peripheral SD/SDIO Controllers. The following bulleted information came from page 35:

- Bootable SD Card mode (option)
- **Support for version 2.0 of SD specification**

Performance Information:

- Built-in DMA
- Host mode support only
- Full speed and low speed support
- 1-bit and 4-bit data interface support
- Low speed clock 0–400 kHz
- Support for high speed interface
- Full speed clock 0-50 MHz with maximum throughput at 25 MB/s
- Support for memory, I/O, and combination cards
- Support for power control modes
- Support for interrupts
- 1 KB Data FIFO interface

The Zynq UltraScale+ Processing System has two hard peripheral SD/SDIO Controllers. The following bulleted compatibility information came from page 725:

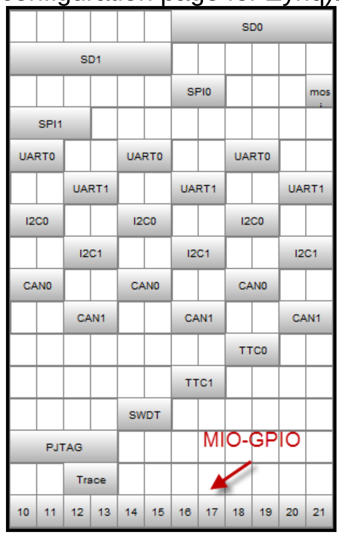
- SD host controller standard specification version 3.00
- SD memory card specification version 3.01
- SD memory card security specification version 1.01
- SDIO card specification version 3.0
- eMMC specification version 4.51
- MMC specification version 4.51

Performance Information:

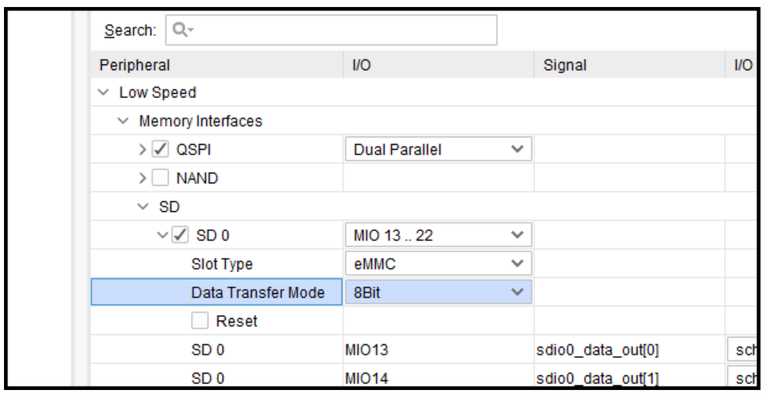
Operating mode with maximum clock rate:

- Standard mode (19 MHz)
- High-speed mode (50 MHz)
- SDR12 (25 MHz)
- SDR25 (50 MHz)
- SDR50 (100 MHz)
- SDR104 (200 MHz)
- DDR50 mode (50 MHz)
- Up to 800 Mb/s data rate using four parallel data lines (SDR104 mode).

The following image is from the MIO configuration page inside Vivado (See Appendix B for instructions on how to access this configuration page for Zynq).



The following image is from the SD configuration pages inside Vivado for Zynq UltraScale+ MPSoC (See Appendix B for instructions on how to access this configuration page for Zynq UltraScale+ MPSoC).



For Zynq, refer to page 188 in the Xilinx Zynq Technical Reference Manual (Appendix D) section “6.3.7 SD Card Boot”.

Note that Zynq supports

- **Boot from standard SD or SDHC cards**
- **FAT 16/32 file system**
- **Up to 32 GB card densities**

Note: The SD card boot mode is not supported in the 7z010 CLG225 device.
Note: The SD card boot mode does not support header search or multiboot.

The rest of this section of the Technical Reference Manual also has detailed information on the process that the SD card uses to boot from an SD card.

For Zynq UltraScale+, refer to page 236 in the Xilinx Zynq UltraScale+ Device TRM (Appendix D) section “Chapter 11 Boot Modes”.

Note that Zynq UltraScale+ supports

- **Boot from standard SD 3.0 or SDHC cards**
- **FAT 16/32 file system**
- **Up to 32 GB card densities**

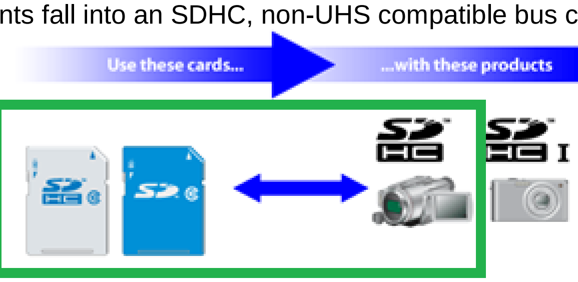
Note: The SD card boot mode is not supported in the 7z010 CLG225 device.
Note: The SD card boot mode does not support header search or multiboot.

The rest of this section of the Technical Reference Manual also has detailed information on the process that the SD card uses to boot from an SD card.

4. Summary of Requirements

Zynq:
Since the Zynq BootROM requires FAT16 or FAT32 to boot during Stage 0, we immediately know we cannot use SDXC cards for this purpose. Also note that SD card spec 2.0 is required for booting Zynq in SD mode. As such, we can also eliminate UHS-I and UHS-II cards for booting in SD mode. It is NOT recommended to use UHS compatible cards with Zynq, as it is also not a recommended compatibility path for the SD card standard (Appendix A).

Zynq BootROM requirements fall into an SDHC, non-UHS compatible bus configuration.



Zynq UltraScale+:
With Zynq UltraScale+ BootROM, it also requires FAT16 or FAT32 to boot during Stage 0, we immediately know we cannot use SDXC cards for this purpose. Also note that SD card spec 2.0 is required for booting Zynq in SD mode. As such, we can also eliminate UHS-I and UHS-II cards for booting in SD mode for Zynq UltraScale+ products.

However, the UltraScale+ family also includes the ability to have SD1 run in SD1-LS mode. This mode allows the SD controller to support SD 3.0 compliant cards. Here at Avnet, refer to your user manual to see if your product supports this mode. Generally speaking, Avnet products are not pinned out for SD1-LS mode, nor do they have the SD 3.0 level shifter (as required by UG1085). This might change for future products, so again, please refer to your User Manual for specifics related to this.

5. Troubleshooting

If you are using a compatible card and are having issues there are a few steps you can take to isolate the source of the problem.

- Look at Xilinx Answer Record AR# 59476 which can be used as a SD Programming / Booting Checklist (Appendix)
- Refer to Xilinx Answer Record AR# 65463 “Zynq UltraScale+ MPSoC - What devices are supported for configuration?”
- Refer to Xilinx Answer Record AR# 66779 “Zynq UltraScale+ MPSoC: List of tested SD cards”
- Refer to Xilinx Answer Record AR# 69006 “Zynq UltraScale+ MPSoC: SD Booting Checklist”
- Validate your boot configuration jumpers / switches are configured properly (see your hardware user guide / schematic / Zynq TRM)
- Try a prebuilt boot image from an existing out of box experience, such as the MicroZed Linux microSD Card Image Archive listed on the microzed.org website (Appendix)
- Try a different SD card to eliminate the possibility of a corrupted SD card
- Try a different brand of SD card, such as one of the recommended SD cards listed below
- Validate your hardware by changing the boot configuration to QSPI mode to verify that the Zynq device is functional
- Contact Avnet through our support forums located at www.picozed.org
- Contact your local Avnet FAE

6. Avnet Tested SD cards

Here at Avnet, we have tested a few different brands and types of SD cards across our reference designs and products. Although cards have markings or are sold as a specific type of card, in our testing of different cards with our own Zynq solutions we have found minor differences in compatibility.

Zynq devices Avnet has tested include:

	ZC7010	ZC7015	ZC7020	ZC7030	ZC7035	ZC7045	ZC7100
ZedBoard			X				
MicroZed	X		X				
PicoZed	X	X	X	X			
PicroZed SDR					X		
Mini-Module+						X	X
Zynq Mini-ITX						X	X

	XCZU3EG	XCZU7EV
Ultra96v1	X	
UltraZed-EG	X	
UltraZed-EV		X

In general a high quality name-brand card which meets Zynq requirements is most consistent. Name brand cards typically have better Write Amplification and Wear Leveling (Appendix F). Our internal testing shows SanDisk cards as well as Delkin cards, which meet the Xilinx recommended speed/type/size requirements, can work across Avnet solutions without issue. It has not been brought to our attention that there have been issues with the previously included SanDisk branded cards nor the currently included Delkin cards. We have tested various capacity/speed grade cards across compatible configurations on the above table of Avnet solutions and have not experienced issues.

Avnet has also partnered with Delkin to perform some formal testing. Delkin has performed rigorous testing across temperature with our product line and with few exceptions, have had no issues at all. Note that some of the reason there are exceptions, was due to availability of a mechanism to actually test certain hardware configurations.

Results of Delkin testing:

Model	Kit Part #	Shipping with Kit	Utility microSD -25 to +85C MLC	Utility+ microSD -40 to +85C MLC	U300 microSD -40 to +85C SLC
PicoZed 7010	AES-Z7PZ-7Z010-SOM-G (C-Temp) AES-Z7PZ-7Z010-SOM-I-G (I-Temp)	S416APG49-U3000-3	PZ720	PZ720	PZ720
PicoZed 7015	AES-Z7PZ-7Z015-SOM-G (C-Temp)	S416APG49-U3000-3	N/A	N/A	N/A
	AES-Z7PZ-7Z015-SOM-I-G (I-Temp)	S416APG49-U3000-3	S408APG49-U1000-3	S308APG49-U1000-3	S308MMZAL-U1000-4
PicoZed 7020	AES-Z7PZ-7Z020-SOM-G (C-Temp)	S416APG49-U3000-3	N/A	N/A	N/A
	AES-Z7PZ-7Z020-SOM-I-G (I-Temp)	S416APG49-U3000-3	S408APG49-U1000-3	S308APG49-U1000-3	S308MMZAL-U1000-4
PicoZed 7030	AES-Z7PZ-7Z030-SOM-G (C-Temp) AES-Z7PZ-7Z030-SOM-I-G (I-Temp)	S416APG49-U3000-3	PZ715	PZ715	PZ715
UltraZed EG	AES-ZU3EG-1-SOM-G (C-Temp) AES-ZU3EG-1-SOM-I-G (I-Temp)*	S416APG49-U3000-3 S416APG49-U3000-3	S408APG49-U1000-3	S308APG49-U1000-3	S308MMZAL-U1000-4
UltraZed EV SOM	AES-ZU7EV-1-SOM-I-G	S416APG49-U3000-3	S416APG49-U1000-3	S316APG49-U1000-3	S316MMZAL-U1000-4
Ultra96	AES-ULTRA96-G	S416APG49-U3000-3	S416APG49-U3000-3 S432APG49-U3000-3 S464APG5S-U3000-3 S41HAPGAC-U3000-3	S316APG49-U3000-3 S332APG49-U3000-3 S364APG5S-U3000-3 S31HAPGAC-U3000-3	S316MMZAL-U1000-4

* -25C was lowest operating temperature tested due to lack of I-Grade Carrier Card to power SOM

	Qualified
N/A	Not Qualifying - N/A, EOL, etc.
PZ715	As the PicoZed 7015 shares a PCB with a PicoZed 7030, it is assumed that testing at ambient is sufficient
PZ720	As the PicoZed 7010 shares a PCB with a PicoZed 7020, it is assumed that testing at ambient is sufficient

Note that the various kits that include the above listed Delkin part number, may be different as it would include a jewel case. As part of that kit, the above listed number is still the correct part number to procure the included card.

The below are other SD cards tested in specific configurations and known to work without issue. The testing performed for the following configurations is more observational in nature rather than the more rigorous testing above. Any feedback we have received from the field is anecdotal in nature and the results should be treated accordingly. Generally speaking, these have not been fully tested across temperature

Delkin Devices 4GB SDHC SD04AJEQZ-CX000-2 and Transcend 4GB SDHC have both been tested with a Zedboard without reported failures.

Kingston 4GB/8GB SDHC and Delkin Devices DDSDPRO3-32GB SDHC have been tested with the MicroZed and PicoZed product line without reported failures.

Lexar 32GB SDHC and Delkin Devices 32GB SDHC UHS-I have been tested and reported to *not* work with Mini-Module Plus.

PNY 32GB SDHC UHS-I and Delkin Devices 32GB SDHC both have been reported to work with Mini-Module Plus. Note that PNY 32GB SDHC UHS-I does not fit within the specification by Xilinx. As such, this is not a recommended card as results may vary.

Note, this list is ***not*** all inclusive! There could be SD cards that work **very** well that we have ***not*** tested. There is also a possibility that cards that do not fit within the specification from Xilinx will also work. If you have a card that works well, please let your local Avnet/Silica FAE know or contact Avnet through our support forums at the picozed.org community site. Properly documented test result information from the field will be considered for inclusion in future revisions of this document.

7. Appendix A

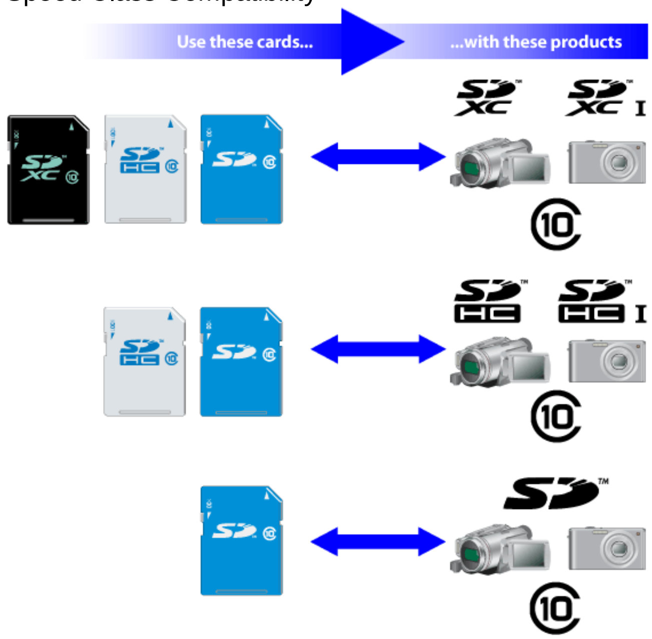
SD Association Speed Choices

https://www.sdcard.org/consumers/speed/speed_class/index.html

SD Association Optimize UHS Performance

https://www.sdcard.org/consumers/speed/uhs/index.html

Speed Class Compatibility



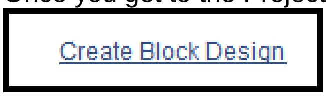
8. Appendix B

Zynq-7000 SoC Technical Reference Manual

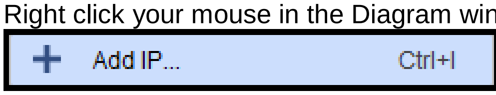
- UG585 (v1.12.2) July 1, 2018
- http://www.xilinx.com/support/documentation/user_guides/ug585-Zynq-7000-TRM.pdf

Opening Zynq7 Processing System IP configuration, from a newly created design:

1. Open Vivado
2. Create a new design
3. Walk through the wizard, making certain to choose the Zynq chip that you are intending to use.
4. Once you get to the Project Navigator page, click on “Create Block Design”

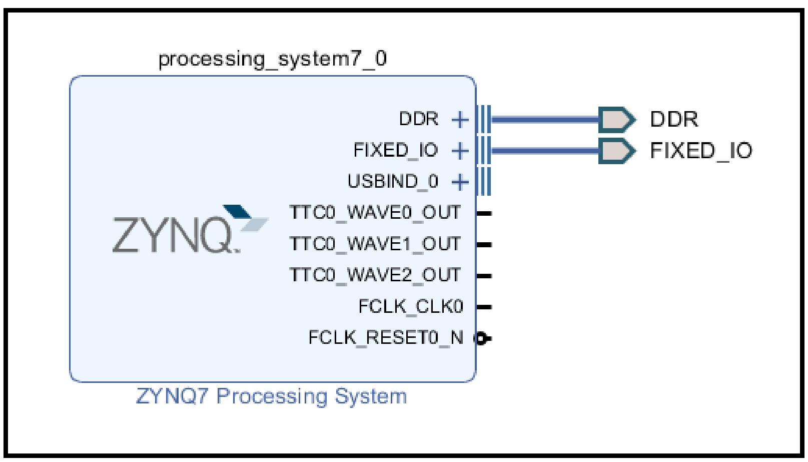


5. Right click your mouse in the Diagram window and select Add IP

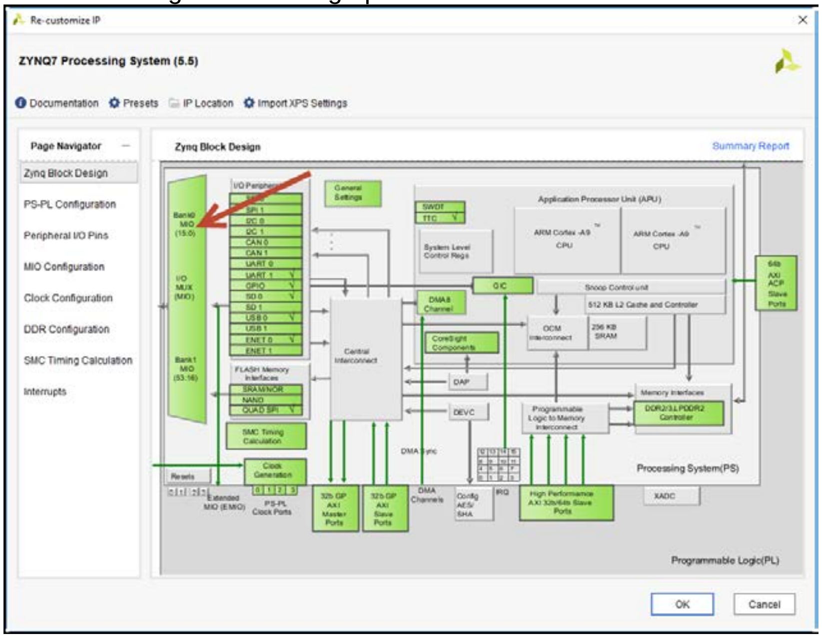


6. Choose the ZYNQ7 Processing System

7. After you select Run Block Automation, you will see a similar block to the below



8. Double clicking this will bring up the Re-customize IP Selector



9. Double click the MIO MUX, shown by the red arrow in the above image
10. From here, you can select various peripherals and see valid configurations for the multitude of peripherals

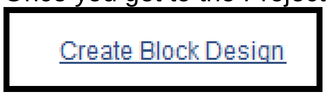
9. Appendix C

Zynq UltraScale+ Device TRM

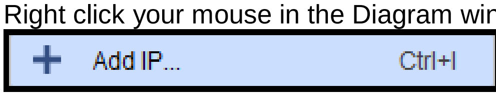
- UG1085 (v1.8) August 3, 2018
- https://www.xilinx.com/support/documentation/user_guides/ug1085-zynq-ultrascale-trm.pdf

Opening Zynq UltraScale+ MPSoC Processing System IP configuration, from a newly created design:

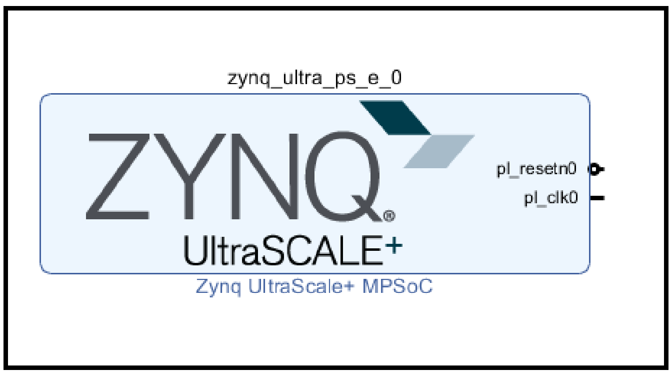
1. Open Vivado
2. Create a new design
3. Walk through the wizard, making certain to choose the Zynq chip that you are intending to use.
4. Once you get to the Project Navigator page, click on "Create Block Design"



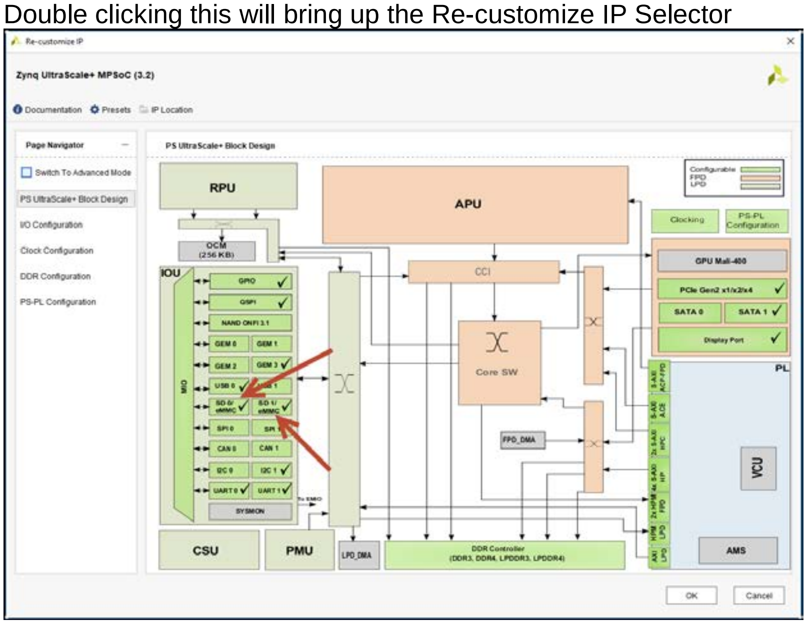
5. Right click your mouse in the Diagram window and select Add IP



6. Choose the Zynq UltraScale+ MPSoC
7. After you select Run Block Automation, you will see a similar block to the below



8. Double clicking this will bring up the Re-customize IP Selector



9. Single click the SD 0/eMMC or SD 1/eMMC elements, shown by the red arrows in the above image
10. From here, you can select various peripherals and see valid configurations for the multitude of peripherals

10. Appendix D

AR# 59476 Zynq-7000 AP SoC: SD Programming/Booting Checklist

- http://www.xilinx.com/support/answers/59476.html

AR# 69006: Zynq UltraScale+ MPSoC: SD Booting Checklist

- https://www.xilinx.com/support/answers/69006.html

11. Appendix E

MicroZed Linux microSD Card Image Archive

- http://microzed.org/support/documentation/1519
- Listed under *Getting Started Guides* section header

12. Appendix F

Various information sources regarding flash memory

- https://www.delkin.com/blog/
- http://www.sandisk.com/assets/docs/WP001_Flash_Management_Final_FINAL.pdf
- https://en.wikipedia.org/wiki/Write_amplification
- https://en.wikipedia.org/wiki/Wear_leveling
- General Information throughout documentation