Saturn – Spartan 6 FPGA Development Board with DDR SDRAM

User Manual

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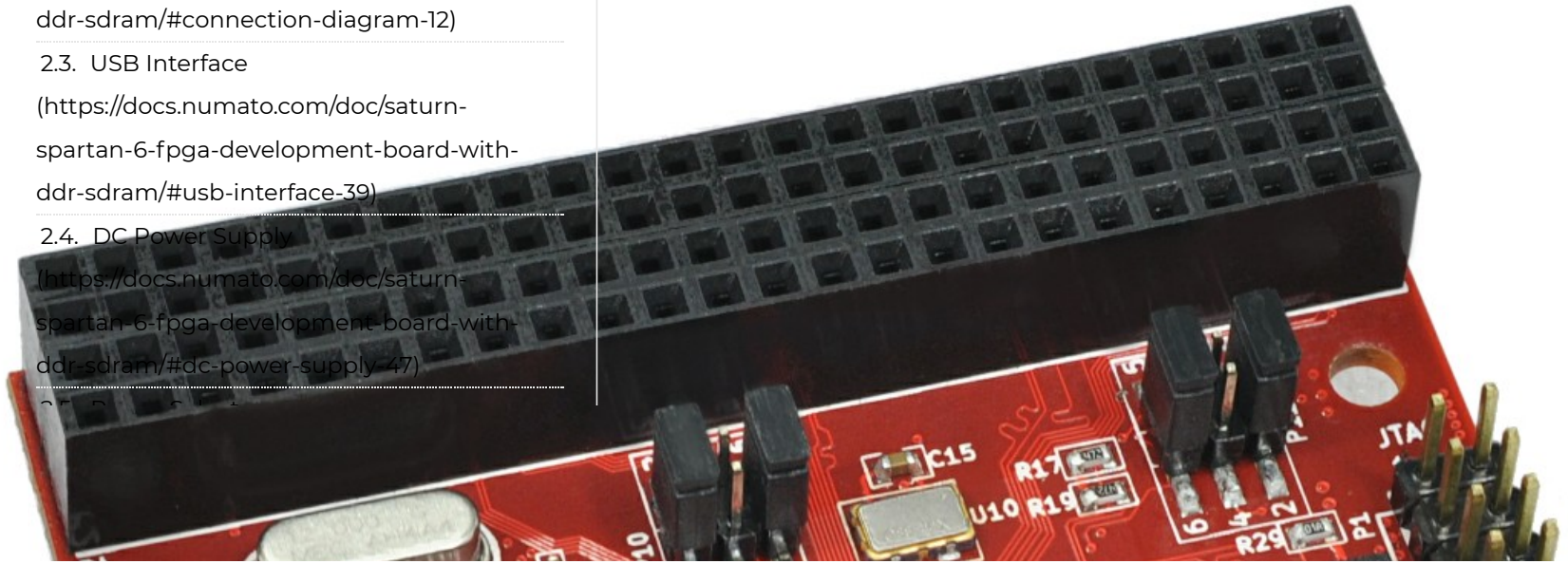
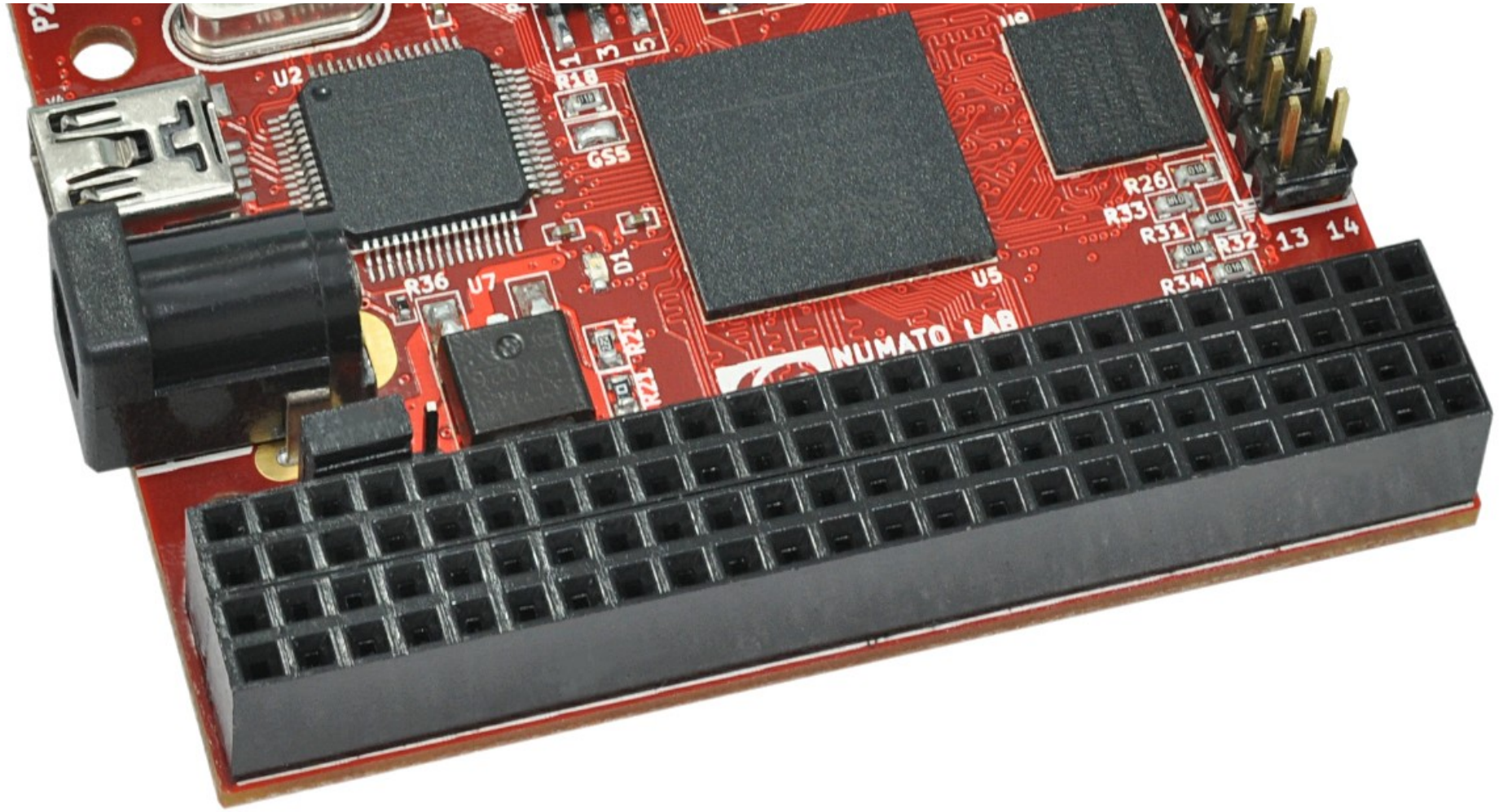
1. Introduction

↑ Back to Top





Saturn is an easy to use FPGA Development board featuring Xilinx Spartan-6 FPGA. Saturn is specially designed for experimenting and learning system design with FPGAs. This development board features Xilinx XC6SLX series FPGA with FTDI's FT2232H Dual-Channel USB device. The high speed USB 2.0 interface provides fast and easy configuration download to the on-board SPI flash. No programmer or special downloader cable is needed to download the bit stream to the board.

Applications

- Product Prototype Development
- Development and testing of custom embedded processors
- Signal Processing
- Communication devices development
- Educational tool for Schools and Universities

Board features

- FPGA: Spartan-6 XC6SLX9, LX16, LX25 or LX45 in CSG324 package
- DDR: 166MHz 512Mb LPDDR
- Flash memory: 128 Mb SPI flash memory (N25Q128A13ESE40E)
- 100MHz CMOS oscillator
- High Speed USB 2.0 interface for On-board flash programming. FT2232H Channel A is dedicated for SPI Flash /JTAG Programming. Channel B can be used for custom applications.
- On-board voltage regulators for single power rail operation
- FPGA configuration via JTAG and USB
- Maximum 158 IOs for user defined purposes XC6SLX9 – 118 IOs XC6SLX16 – 150 IOs XC6SLX25 – 144 IOs XC6SLX45 – 136 IOs FT2232H – 8 IOs

2. How to Use Saturn Spartan 6 FPGA Development Board With DDR SDRAM

↑ Back to Top

2.1. Components/Tools Required

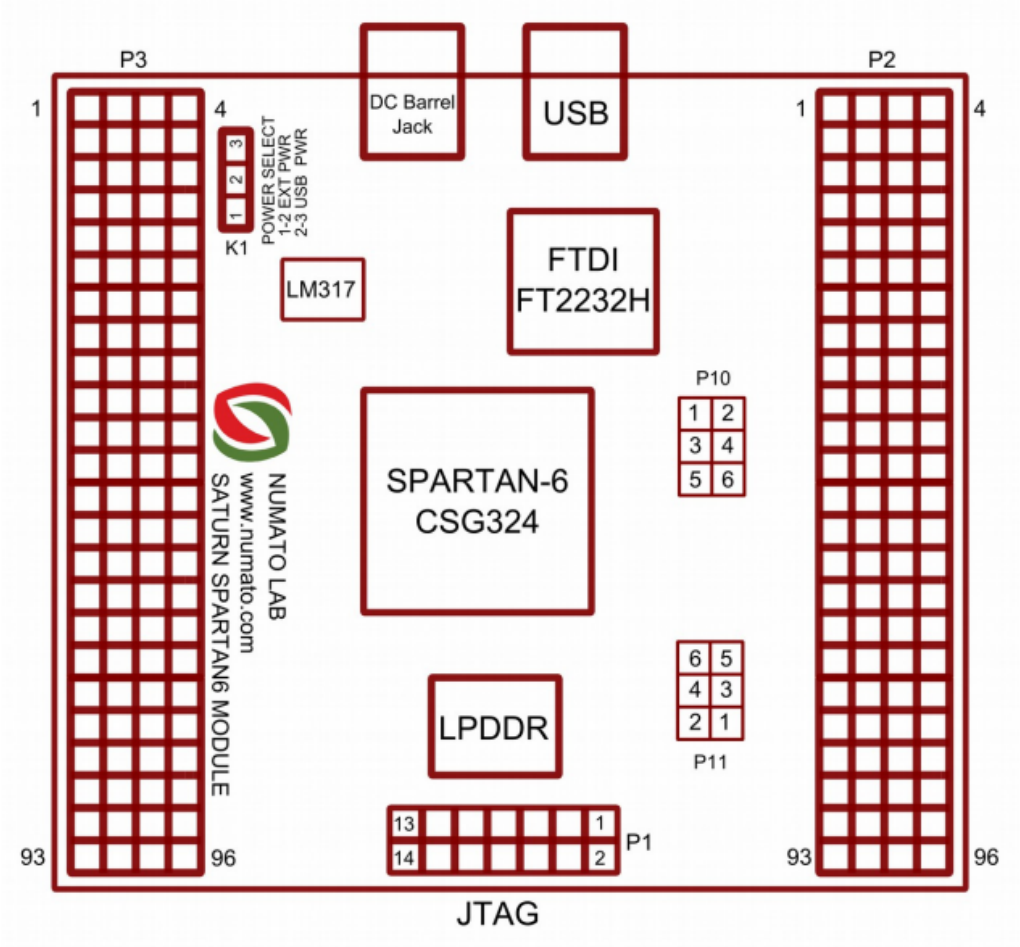
↑ Back to Top

Along with the module, you may need the items in the list below for easy and fast installation.

1. USB A to Mini B cable.
2. DC Power supply (Optional).

2.2. Connection Diagram

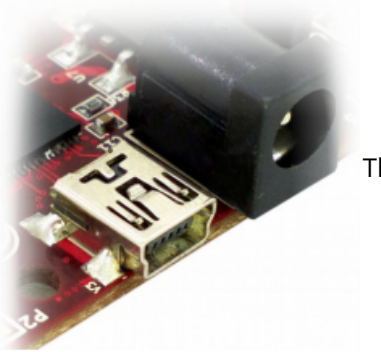
↑ Back to Top



This diagram should be used as a reference only. For detailed information, see Saturn schematics at the end of this document. Details of individual connectors are as below.

2.3. USB Interface

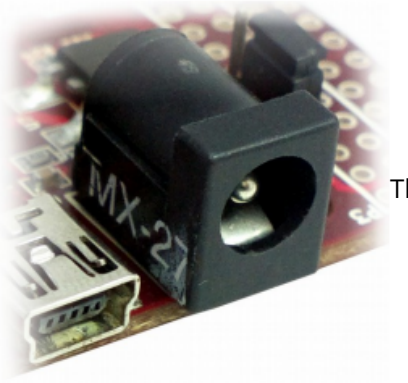
↑ Back to Top



The on board full speed USB controller helps a PC/Linux/Mac computer to communicate with this module. Use a USB A to Mini B cable to connect with a PC. By default the module is powered from USB so make sure not to overcrowd unpowered USB hubs (the picture on the right shows USB Mini connector).

2.4. DC Power Supply

↑ Back to Top



This module uses +5V power supply to function properly. By default the board is configured to use +5V supply from USB. So an external +5V power is not required unless USB port is unable to supply enough current. In most cases USB ports are capable of providing enough current for the module. Current requirement for this board largely depends on your application. Please consult FPGA data sheet for more details on power requirements. If for any reason, an external 5V power supply needs to be used for the module, the Power select jumper should be configured properly before connecting the power supply. Please refer to the marking on the board for more details.

2.5. Power Select

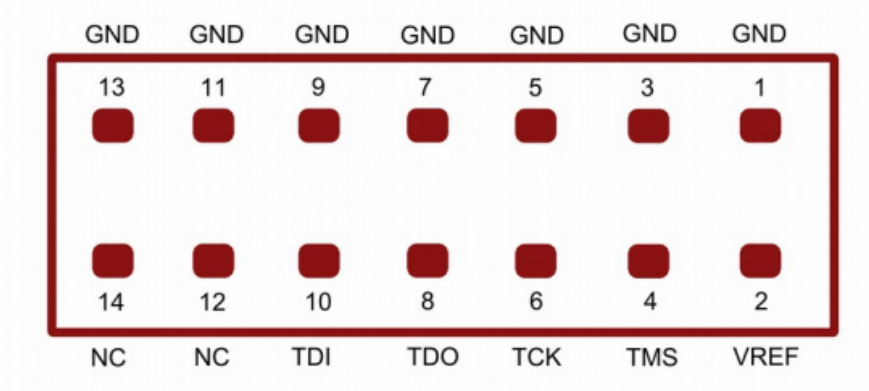
↑ Back to Top

The Power Select header K1 is used to configure the power source for the board. The jumper in pin 2 and 3 is shorted to switch the power source to on board USB port and pin 1 and 2 to use the external DC power.

2.6. JTAG Connector

↑ Back to Top

JTAG connector provides access to FPGA's JTAG pins. A XILINX platform cable can be used to for JTAG programming.



2.7. JTAG/SPI Configuration On FT2232H Channel A

↑ Back to Top

Channel A of FT2232H can be connected to the SPI bus that connects the SPI Flash chip to the FPGA or to the JTAG pins of the FPGA. By connecting SPI bus to FT2232H channel A, the SPI flash can be directly programmed to save the configuration permanently. This is the default configuration set when Saturn is shipped. When FT2232H channel A is connected to SPI, Saturn Configuration Downloader utility can be used to program the board.

When FT2232H channel A is connected to FPGA JTAG, the JTAG signals can be accessed directly through FT2232H. Saturn Configuration Downloader utility currently does not support programming FPGA SRAM through JTAG.

Please see the tables below for information about selecting SPI or JTAG for FT2232H channel A. SPI must be selected for Saturn Configuration Downloader utility to work.

Header P10

Jumper Configration for SPI	Jumper Configration for JTAG
1 - 2	2 - 4
5 - 6	3 - 5

Header P11

Jumper Configration for SPI	Jumper Configration for JTAG
1 - 2	2 - 4
5 - 6	3 - 5

2.8. GPIOs

↑ Back to Top

This device is equipped with a maximum 158 user IO pins that can be used for various custom applications. Out of 158 user IOs 56 are length matched which can be used as differential pairs.

Header P3

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
1	GND	2	3V3
3	VCCIN	4	GND
5	G13	6	H12

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
7	K14	8	J13
9	H16	10	H15
11	H14	12	H13
13	G14	14	F14
15	G18	16	G16
17	F16	18	F15
19	F18	20	F17
21	E18	22	E16
23	D18	24	D17
25	C18	26	C17
27	A16	28	B16
29	A15	30	C15
31	C14	32	D14
33	A14	34	B14
35	E13	36	F13
37	A13	38	C13
39	E12	40	F12
41	C12	42	D12
43	A12	44	B12

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
45	E11	46	F11
47	C11	48	D11
49	GND	50	GND
51	GND	52	GND
53	F10	54	G11
55	A11	56	B11
57	A10	58	C10
59	F9	60	G9
61	C9	62	D9
63	A9	64	B9
65	F8	66	G8
67	E8	68	E7
69	C8	70	D8
71	A8	72	B8
73	E6	74	F7
75	A7	76	C7
77	A6	78	B6
79	C6	80	D6
81	A5	82	C5

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
83	A4	84	B4
85	A3	86	B3
87	A2	88	B2
89	GND	90	GND
91	GND	92	GND
93	3V3	94	3V3
95	3V3	96	3V3

Header P2

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
1	ACBUS0*	2	ACBUS1
3	3V3	4	GND
5	ACBUS2	6	ACBUS3
7	K12	8	K13
9	ACBUS4	10	ACBUS5
11	L14	12	M13
13	ACBUS6	14	ACBUS7
15	M14	16	N14
17	L12	18	L13

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
19	L15	20	L16
21	K15	22	K16
23	N15	24	N16
25	T17	26	T18
27	P15	28	P16
29	U16	30	V16
31	U17	32	U18
33	T14	34	V14
35	U15	36	V15
37	T12	38	V12
39	U13	40	V13
41	R11	42	T11
43	M11	44	N11
45	GND	46	GND
47	GND	48	GND
49	GND	50	GND
51	GND	52	GND
53	N10	54	P11
55	U11	56	V11

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
57	R10	58	T10
59	M10	60	N9
61	T9	62	V9
63	R8	64	T8
65	N7	66	P8
67	M8	68	N8
69	U7	70	V7
71	U8	72	V8
73	R7	74	T7
75	N6	76	P7
77	N5	78	P6
79	T6	80	V6
81	R5	82	T5
83	U5	84	V5
85	R3	86	T3
87	T4	88	V4
89	INITB	90	3V3
91	PROGB	92	3V3
93	GND	94	GND

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
95	GND	96	GND

No Connect Pins In LX9(CSG324)

SL No.	Pin No On The Header P3	Spartan-6 (CSG324)
1	37	A13
2	38	C13
3	39	E12
4	40	F12
5	41	C12
6	42	D12
7	45	E11
8	46	F11
9	53	F10
10	54	G11
11	65	F8
12	66	G8
13	67	E8
14	68	E7
15	73	E6
16	74	F7

SL No.	Pin No On The Header P3	Spartan-6 (CSG324)
SL No.	Pin No On The Header P2	Spartan-6 (CSG324)
1	35	U15
2	36	V15
3	37	T12
4	38	V12
5	43	M11
6	44	N11
7	53	N10
8	54	P11
9	59	M10
10	60	N9
11	65	N7
12	66	P8
13	67	M8
14	68	N8
15	75	N6
16	76	P7

No Connect Pins In LX25 (CSG324)

SL No.	Pin No On The HeaderP3	Spartan-6 (CSG324)
1	65	F8

SL No.	Pin No On The HeaderP3	Spartan-6 (CSG324)
2	66	G8
3	67	E8
4	68	E7
5	73	E6
6	74	F7

No Connect Pins In LX45(CSG324)

SL No.	Pin No On The Header P3	Spartan-6 (CSG324)
1	39	E12
2	40	F12
3	41	C12
4	42	D12
5	45	E11
6	46	F11
7	53	F10
8	54	G11
9	65	F8
10	66	G8
11	67	E8
12	68	E7
13	73	E6

SL No.	Pin No On The Header P3	Spartan-6 (CSG324)
14	74	F7

FT2232H – Spartan-6 (CSG324) FPGA Connection Details

FTDI Pin No.	Pin Function (245 FIFO)	Spartan-6 Pin No.
38	D0	L17
39	D1	L18
40	D2	M16
41	D3	M18
43	D4	N17
44	D5	N18
45	D6	P17
46	D7	P18
48	RXF#	K18
52	TXE#	K17
53	RD#	J18
54	WR#	J16
55	SIWUB	H18

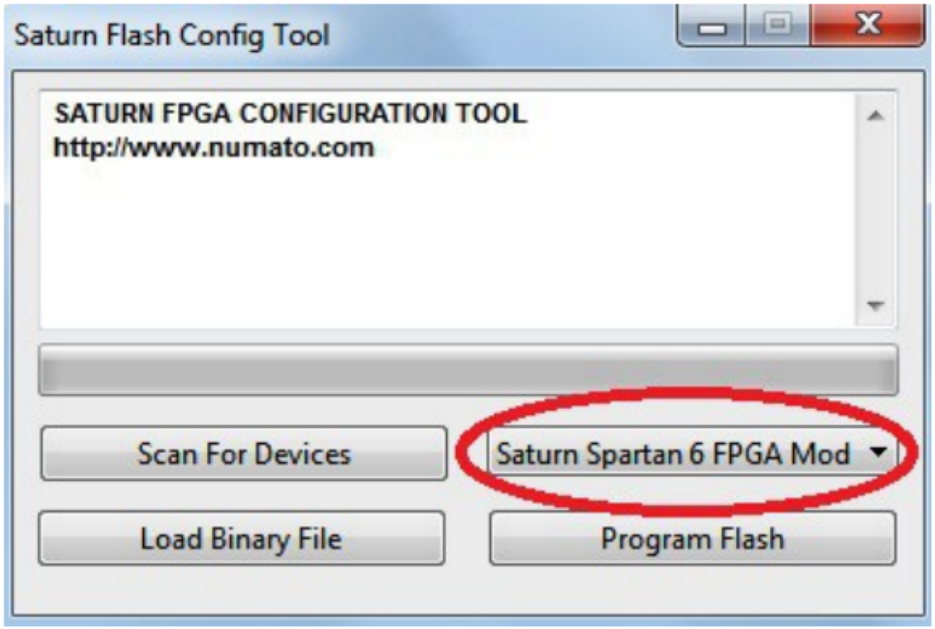
3. Driver Installation

↑ Back to Top

3.1. Installing on Windows

↑ Back to Top

This product requires a driver to be installed for proper functioning when used with Windows. The D2XX driver can be downloaded from http://www.ftdichip.com/Drivers/D2XX.htm (http://www.ftdichip.com/Drivers/D2XX.htm). Windows Users run the CDM v2.08.30 WHQL Certified.exe application that will prompt to install the FTDI CDM drivers. When driver installation is complete, the module should appear in Saturn Flash Config Tool as Saturn Spartan 6 FPGA Module (see the picture).

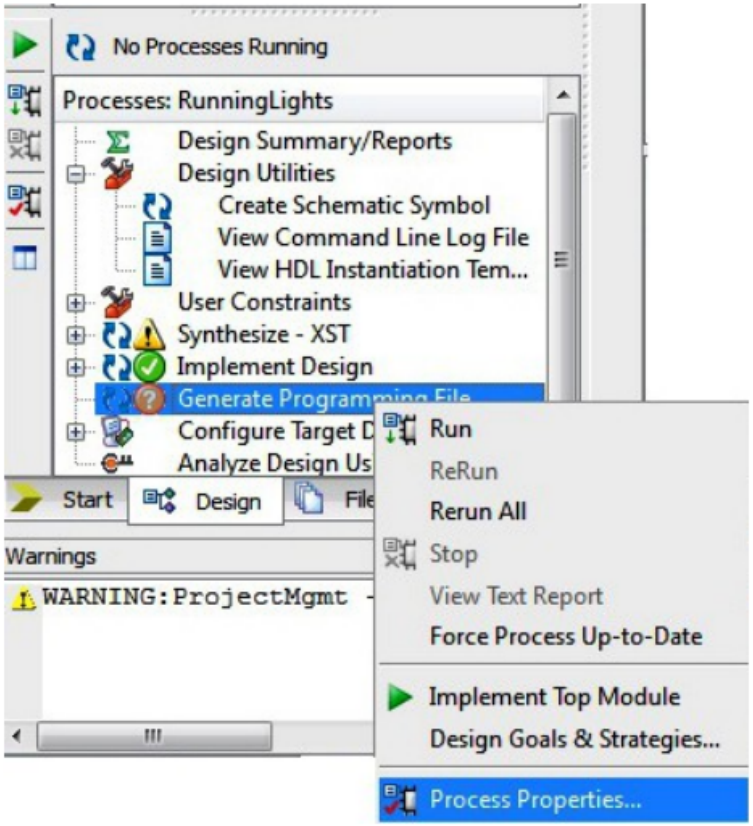


4. Generating Bit Stream for Saturn

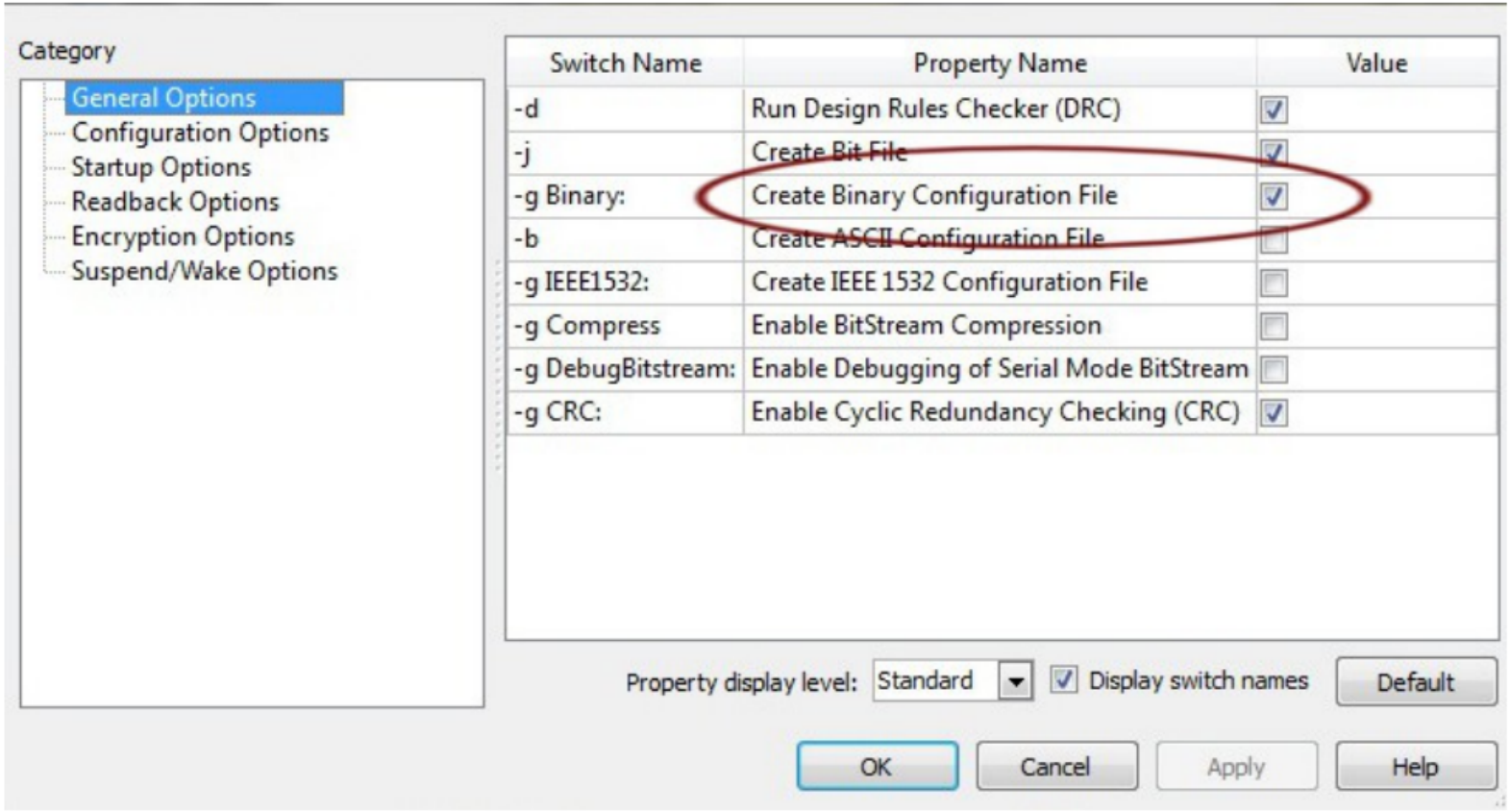
↑ Back to Top

HDL design needs to be converted to bit stream before it can be programmed to FPGA. Saturn at this time accepts only binary (.bin) bit stream created by XILINX ISE (http://www.xilinx.com/tools/webpack.htm). Once the HDL is synthesized, it is easy to create a binary bit stream out of it. Please follow the steps below to generate binary bit stream from your design using ISE Web Pack.

Step 1: Right click on the “Generate Programming File” option in “Processes” window.



Step 2: Select “Process Properties” from the pop up menu. In the dialog box, check “Create Binary Configuration File” Check box and click “Apply”.



Step 3: Click “OK” to close the dialog box. Right click on “Generate Programming File” option again and select “Run”. Now you will be able to find a “.bin” file in the project directory and that file can be used for Saturn configuration.

5. Powering Up Saturn

↑ Back to Top

Saturn is factory configured to be powered directly from USB port so make sure that you are using a USB port that can power the board properly. It is recommended to connect the board directly to the PC instead using a hub. It is practically very difficult to estimate the power consumption of the board, as it depends heavily on your design and the clock used. XILINX provides tools to estimate the power consumption. In any case if power from USB is not enough for your application, external supply can be applied to the board. Jumper PWRSEL should be set up properly (short pin 1-2) to use the board on external power. Saturn requires three different voltages, a 3.3V, a 1.8V supplies and a 1.3V supply. Onboard regulators derive these voltages from the USB/Ext power supply.

6. Configuring Saturn Spartan6 Module

↑ Back to Top

The Saturn Spartan6 module can be configured by two methods,

a) Using Spartan configuration tool through USB.
b) Using the Xilinx programming cable.

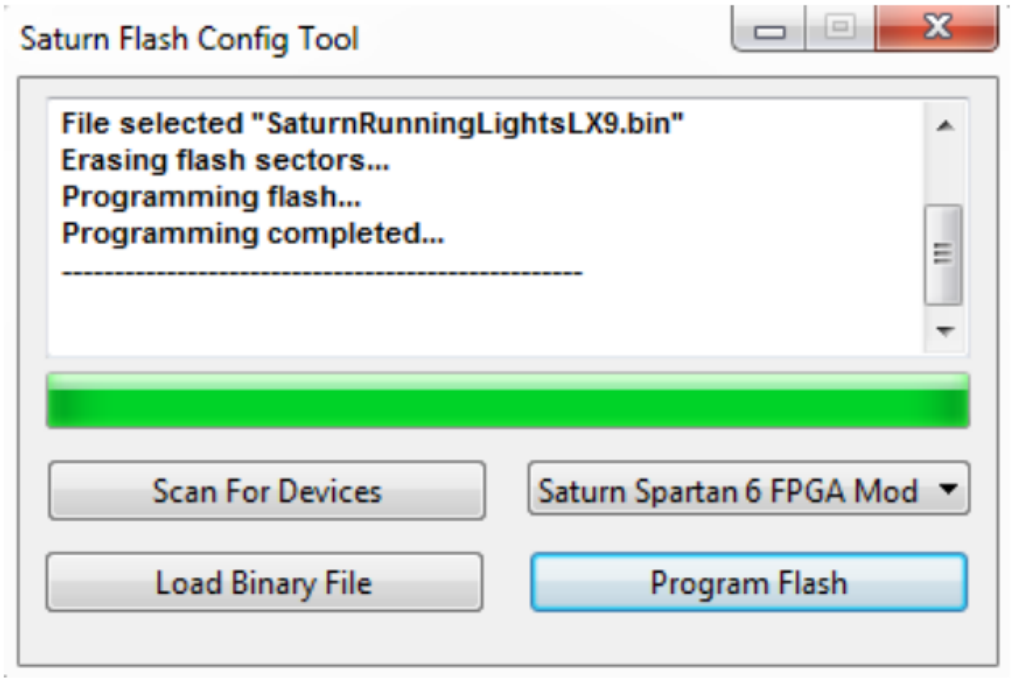
6.1. Configuring Saturn Using Configuration Tool

↑ Back to Top

Saturn has an on-board FTDI FT2232 device which facilitates easy reprogramming of on-board SPI flash through USB interface. The FTDI receives bit stream from the host application and program it in to the SPI Flash and lets the FPGA boot from the flash. The Saturn configuration application can be downloaded from www.numato.com for free.

Step 1: Open Saturn Config Tool. Click “Scan for Devices” if “Saturn Spartan 6 FPGA Module” is not detected automatically.

Step 2: Click on “Load Binary” Select the “.bin” file, then click on “Program Flash” button. Wait till “Programming Completed” appears on the screen.



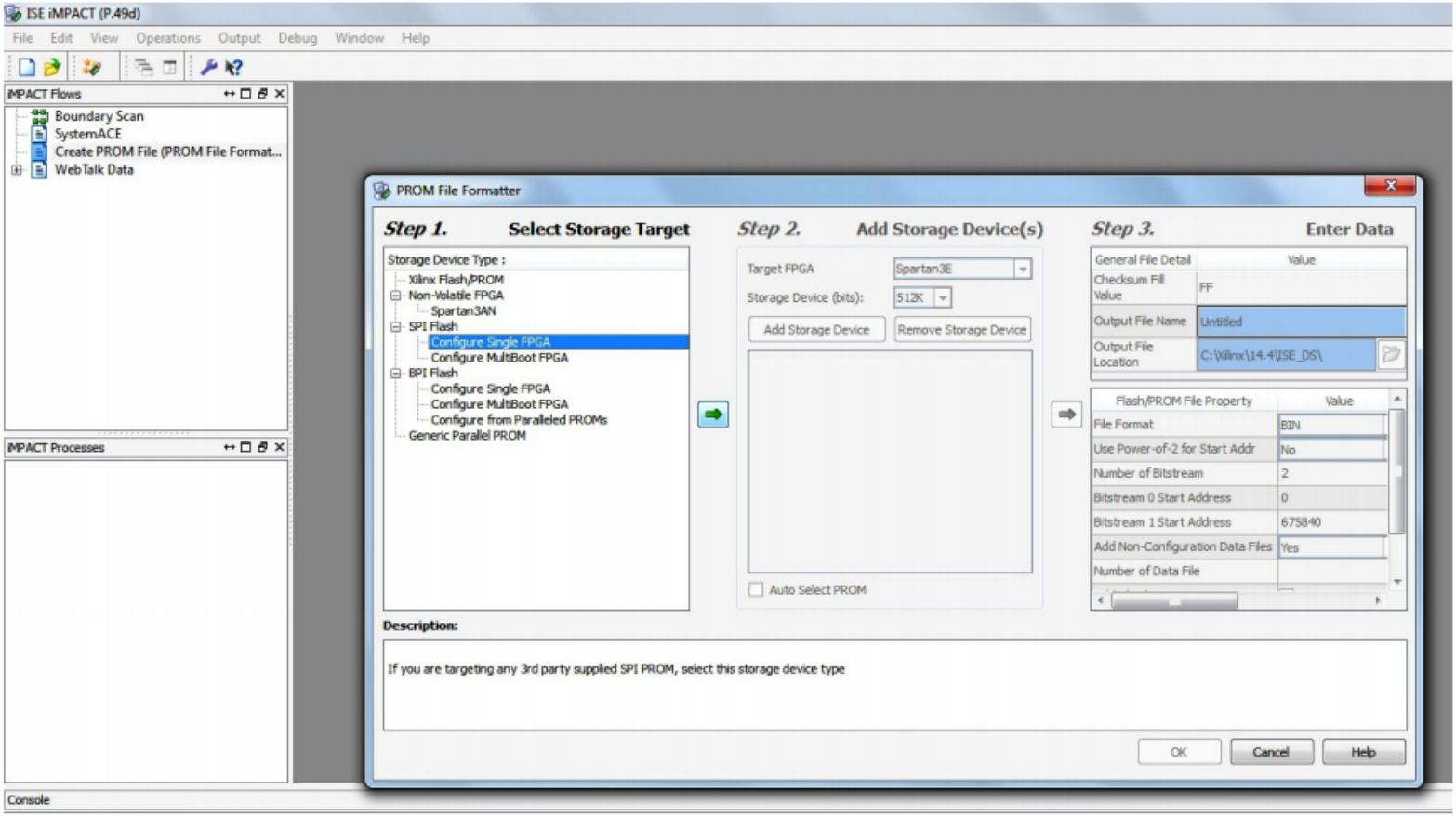
6.2. Configuring Saturn Using JTAG

↑ Back to Top

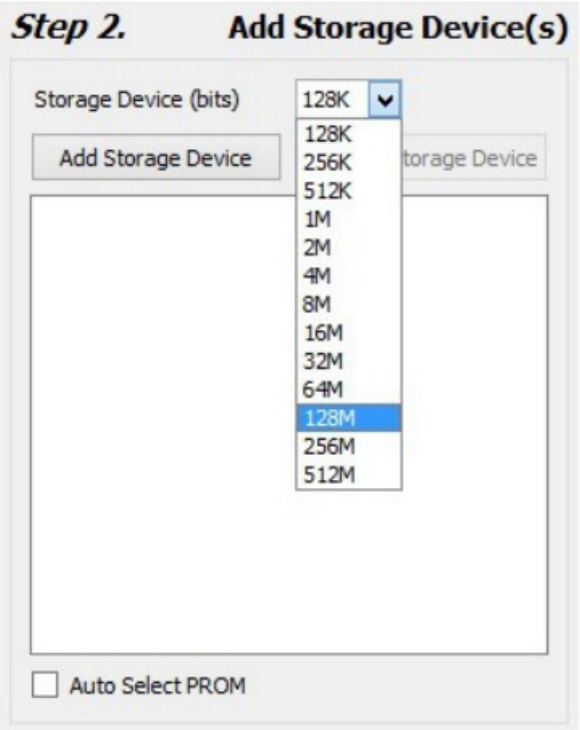
Saturn Spartan6 module features an on-board JTAG connector which facilitates easy reprogramming of SRAM and on-board SPI flash through JTAG programmer like “XILINX Platform-cable usb”. Programming Saturn using JTAG requires “XILINX ISE iMPACT” software which is bundled with XILINX ISE Design Suite. To program the SPI flash we need a “.mcs” file needs to be generated from the “.bit” file. Steps for generating “.mcs” file are as below. Programming FPGA SRAM does not require a “.mcs” file to be generated.

Generating “.mcs” file for Saturn

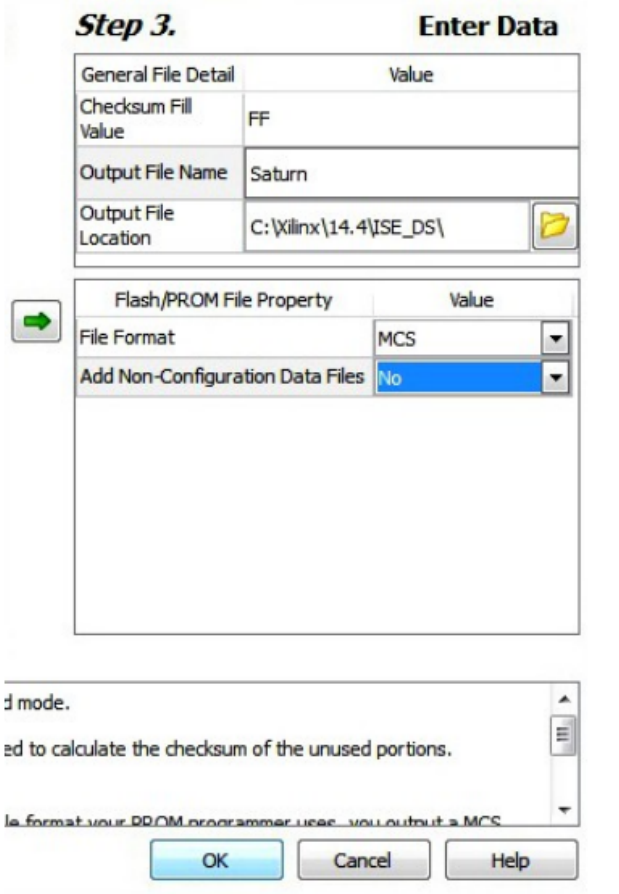
Step 1: Open ISE iMPACT. Click on “Create PROM file(PROM file formatter)”. In the dialog box, select “Configure Single FPGA” in storage device type. Then click on the green arrow on the right side.



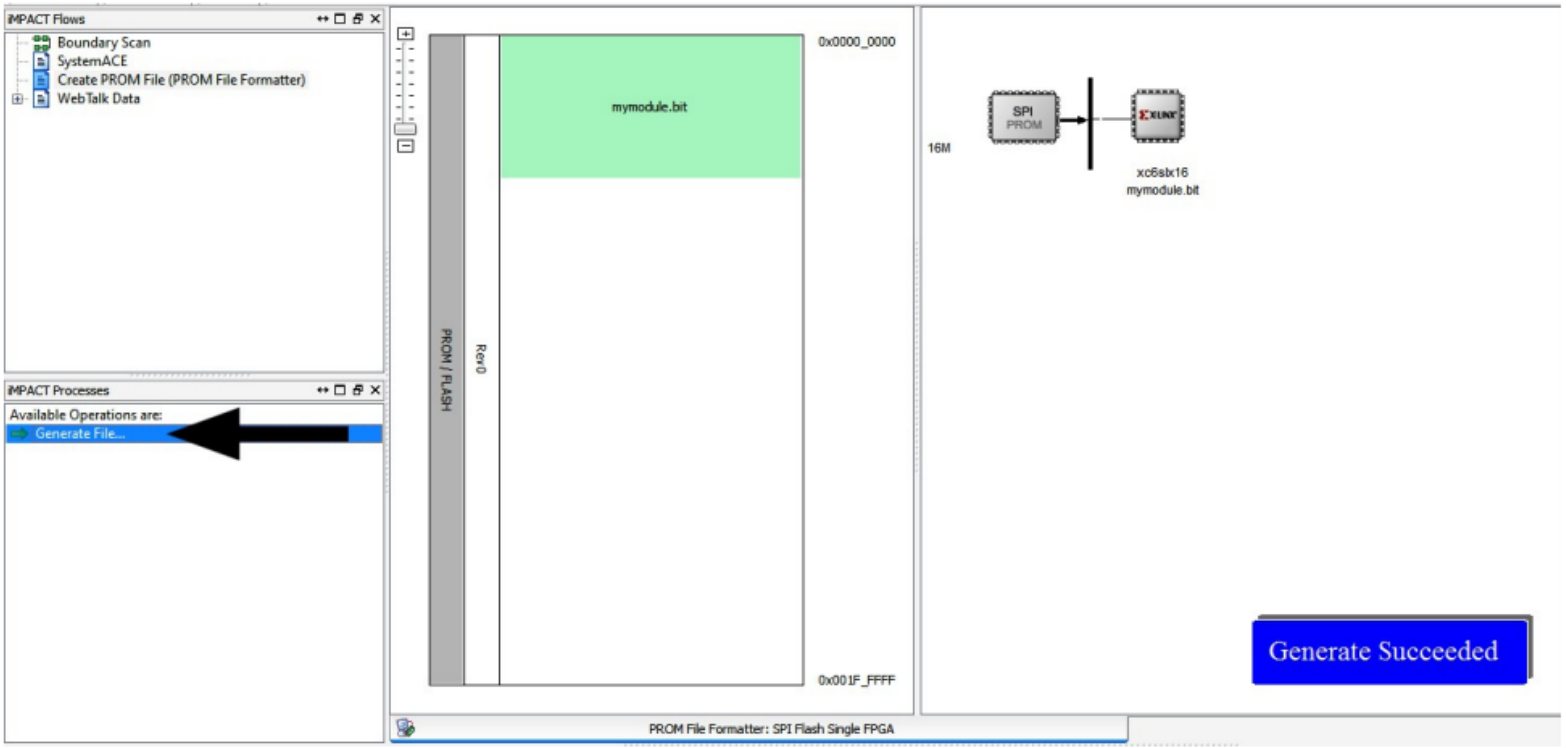
Step 2: Select 128M in Storage Device (bits).Now click on “Add Storage Device”, then the green arrow on the right side.



Step 3: Set an output file name and the output file location (the ".mcs" file will be generated at this location which will be required later for programming the FPGA), then click OK twice, then select the ".bit" file we already generated then click Open and click NO when it prompts to add another device file.



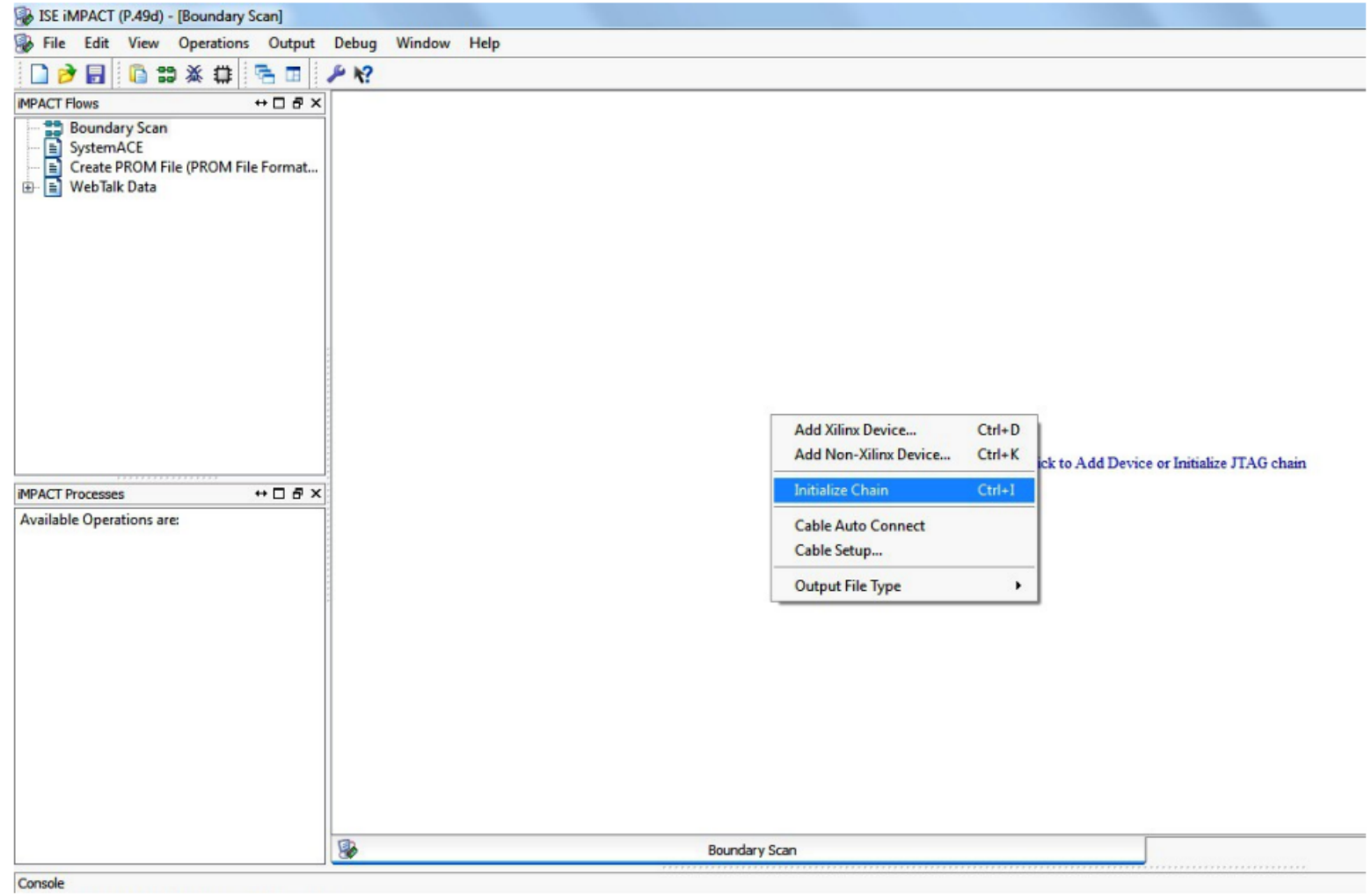
Step 4: Double click on “Generate File”. “Generate Succeeded” will be displayed as shown in fig below if the “.mcs” the file is generated successfully.



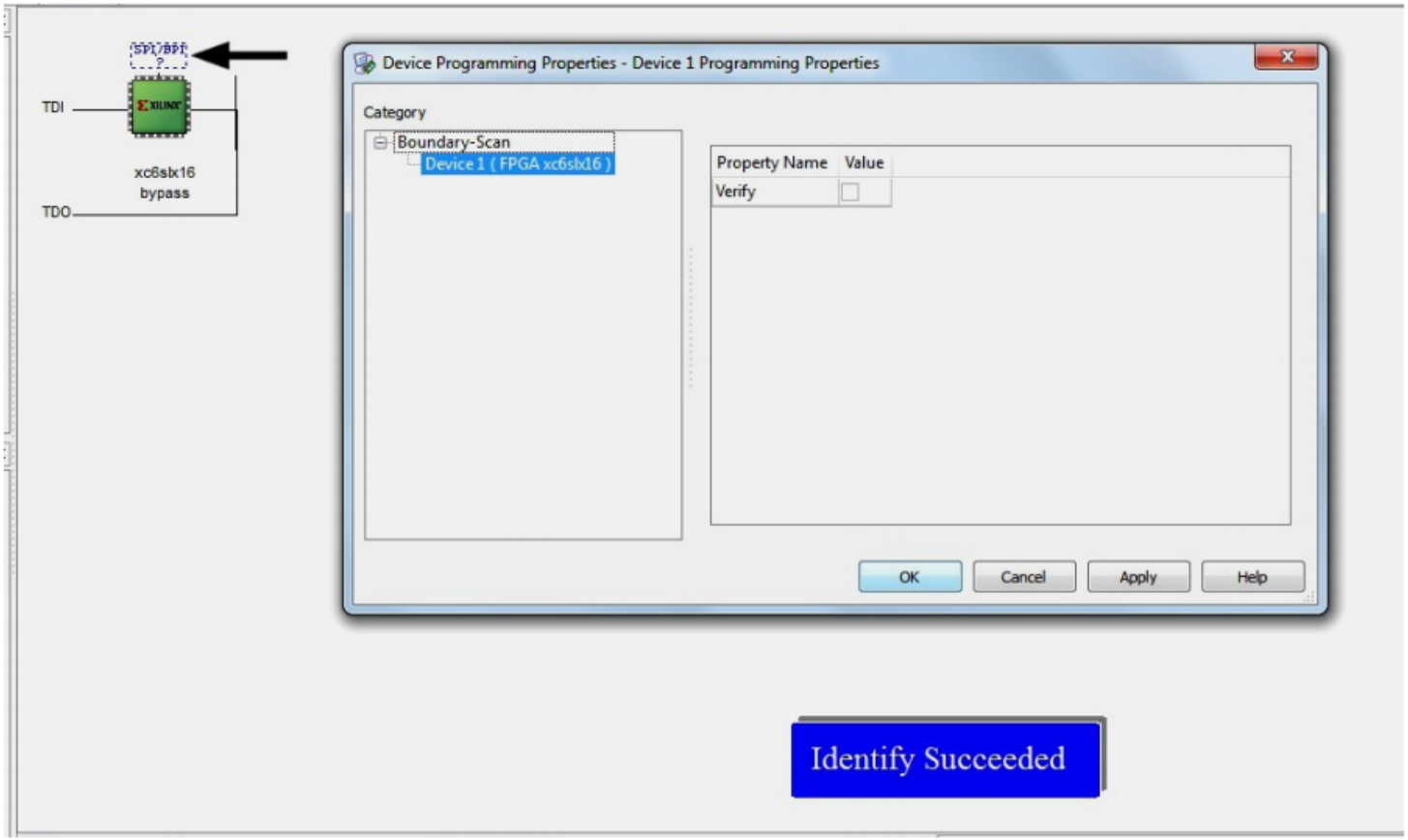
6.3. Programming FPGA Using ISE iMPACT

↑ Back to Top

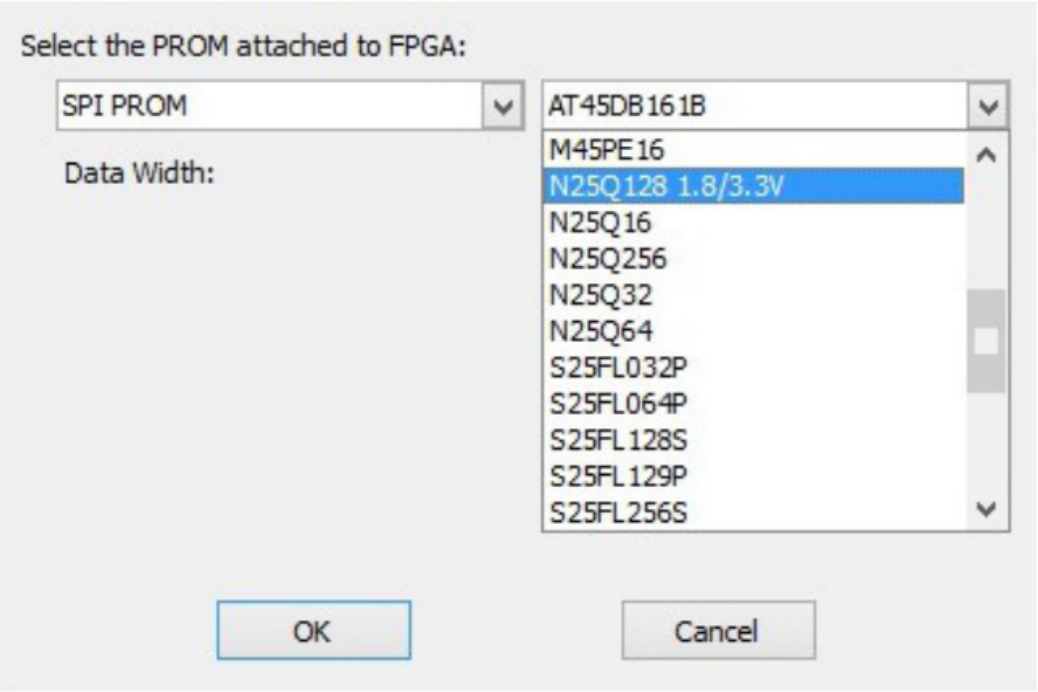
Step 1: Open ISE iMPACT. Click on “Boundary Scan” in the iMPACT flows window on the left top corner. Then right click on the window panel on the right. Select “Initialize Chain”.



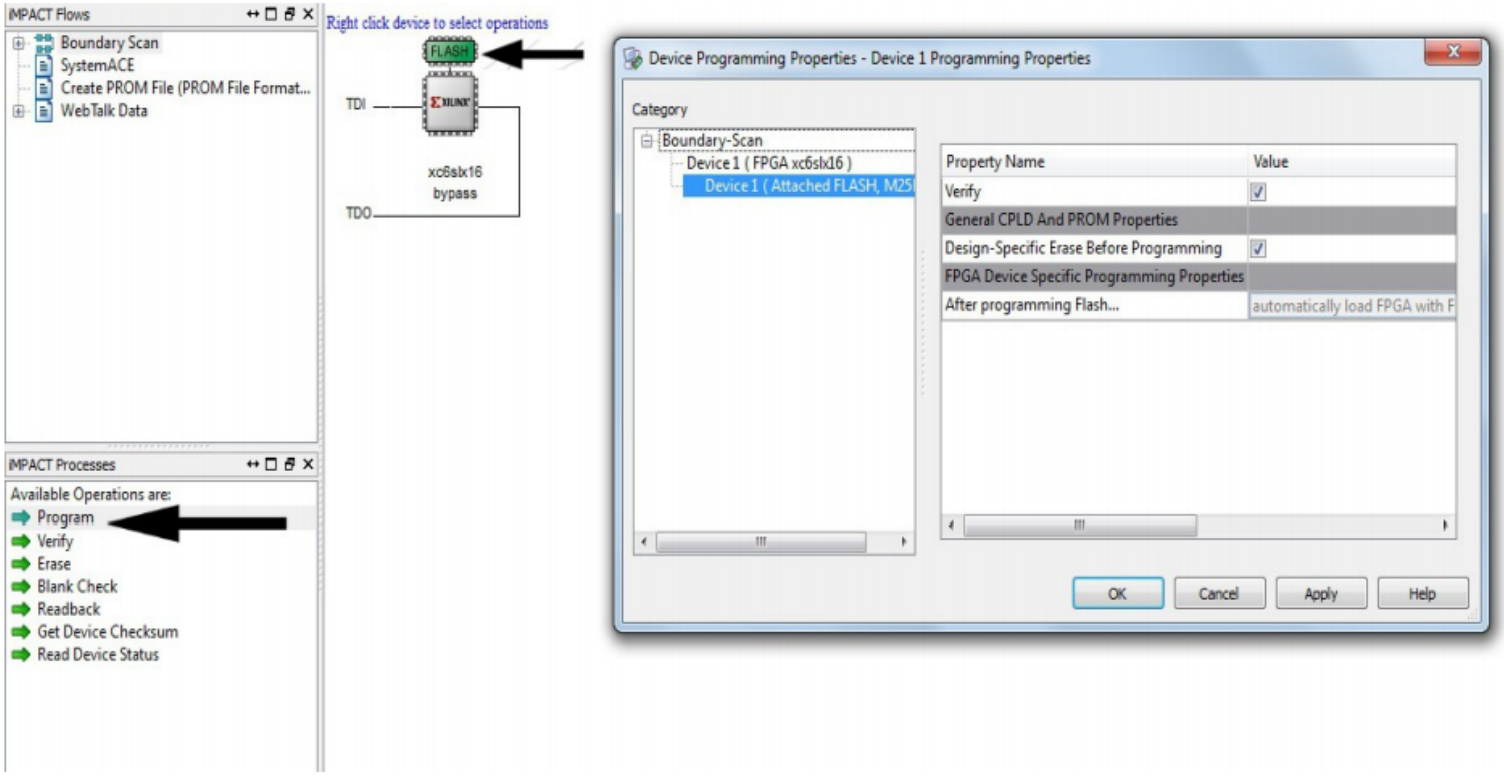
Step 2: If the device is detected properly you will get a pop up window as shown below, Click OK. Then right click on the SPI/BPI (next to the black arrow in the below fig.), select Add SPI/BPI Flash.



Step 3: Select the ".mcs" file we already created and click OK. Now choose "N25Q128" in the dialogue box appeared, then click OK.



Step 4: Click on “Flash”, Double Click on Program, select OK. If the programming is successful, a confirmation message will be displayed.



7. Length Matched GPIOs Pairs

↑ Back to Top

This device is equipped with a maximum of 158 user IOs. Of those, 45 IO pairs are length matched which can be used as differential pairs.

Pin No. on the Header P3	Spartan-6 Differential Pair
9-10	H15-H16
17-18	F16-F15
19-20	F17-F18

Pin No. on the Header P3	Spartan-6 Differential Pair
21-22	E16-E18
23-24	D17-D18
25-26	C17-C18
27-28	B16-A16
31-32	C14-D14
33-34	B14-A14
37-38	C13-A13
41-42	D12-C12
43-44	B12-A12
47-48	D11-C11
53-54	G11-F10
55-56	B11-A11
57-58	C10-A10
59-60	F9-G9
61-62	D9-C9
63-64	B9-A9
69-70	D8-C8
71-72	B8-A8
75-76	C7-A7
77-78	B6-A6

Pin No. on the Header P3	**Spartan-6 Differential Pair**
79-80	C6-D6
81-82	C5-A5
83-84	A4-B4
85-86	B3-A3
87-88	B2-A2
Pin No. on the Header P2	Spartan-6 Differential Pair
7-8	K13-K12
17-18	L12-L13
19-20	L15-L16
21-22	K15-K16
23-24	N15-N16
33-34	T14-V14
57-58	R10-T10
61-62	T9-V9
63-64	R8-T8
69-70	U7-V7
71-72	U8-V8
73-74	R7-T7
79-80	T6-V6
81-82	R5-T5

Pin No. on the Header P3	Spartan-6 Differential Pair
83-84	U5-V5
85-86	R3-T3
87-88	T4-V4

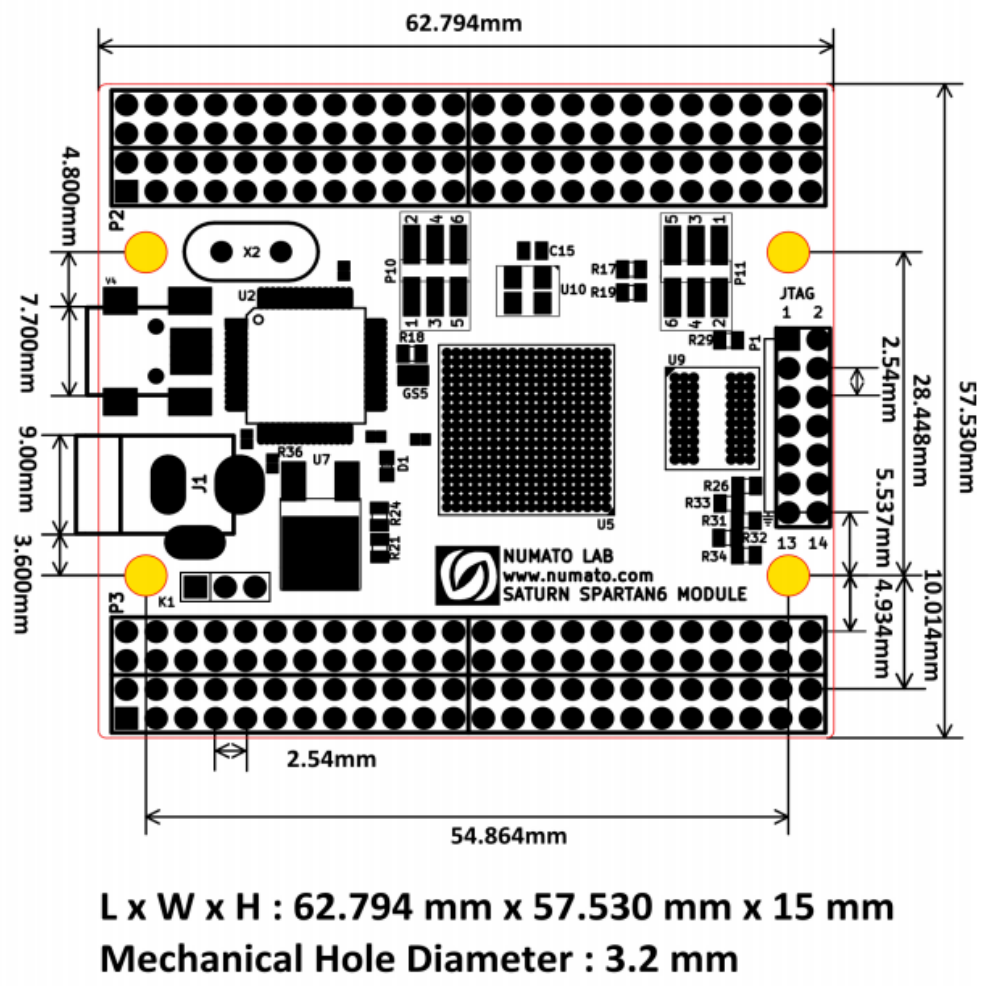
8. Technical Specifications

↑ Back to Top

Parameter *	Value	Unit
Basic Specifications		
Number of GPIOs	158 (Max)	
On-board oscillator frequency (FXO-HC536R)	100	MHz
LPDDR Capacity	512	Mb
LPDDR Clock	166	MHz
SPI Flash Memory (N25Q128A13ESE40E)	128	Mb
Power supply voltage (USB or external)	5 – 6	V
FPGA Specifications		
Internal supply voltage relative to GND	–0.5 to 1.32	V
Auxiliary supply voltage relative to GND	–0.5 to 3.75	V
Output drivers supply voltage relative to GND	–0.5 to 3.75	V

9. Mechanical Dimensions

↑ Back to Top



10. Schematics

↑ Back to Top

Saturn Spartan6 Module V3 Schematics (https://docs.numato.com/wp-content/uploads/2016/06/SaturnSpartan6ModuleV3Sch.pdf)

11. Saturn GPIO Easy Reference

↑ Back to Top

Saturn GPIO Easy Reference (https://docs.numato.com/wp-content/uploads/2016/06/Saturn-GPIO-Easy-Reference.pdf)

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