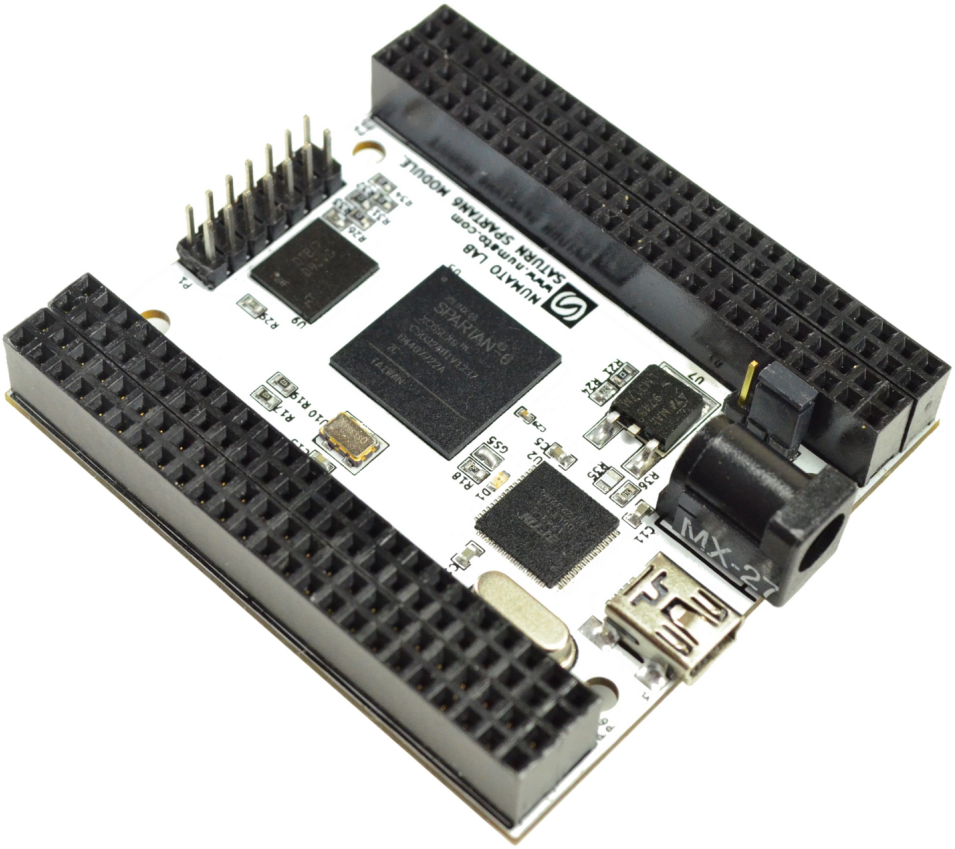

SATURN SPARTAN-6 FPGA MODULE

User Guide

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Rev 1

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Introduction

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: 16 Mb SPI flash memory (M25P16)
- 100MHz CMOS oscillator
- High Speed USB 2.0 interface for On-board flash programming. FT2232H
  Channel A is dedicated for SPI Flash 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

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How to use the module

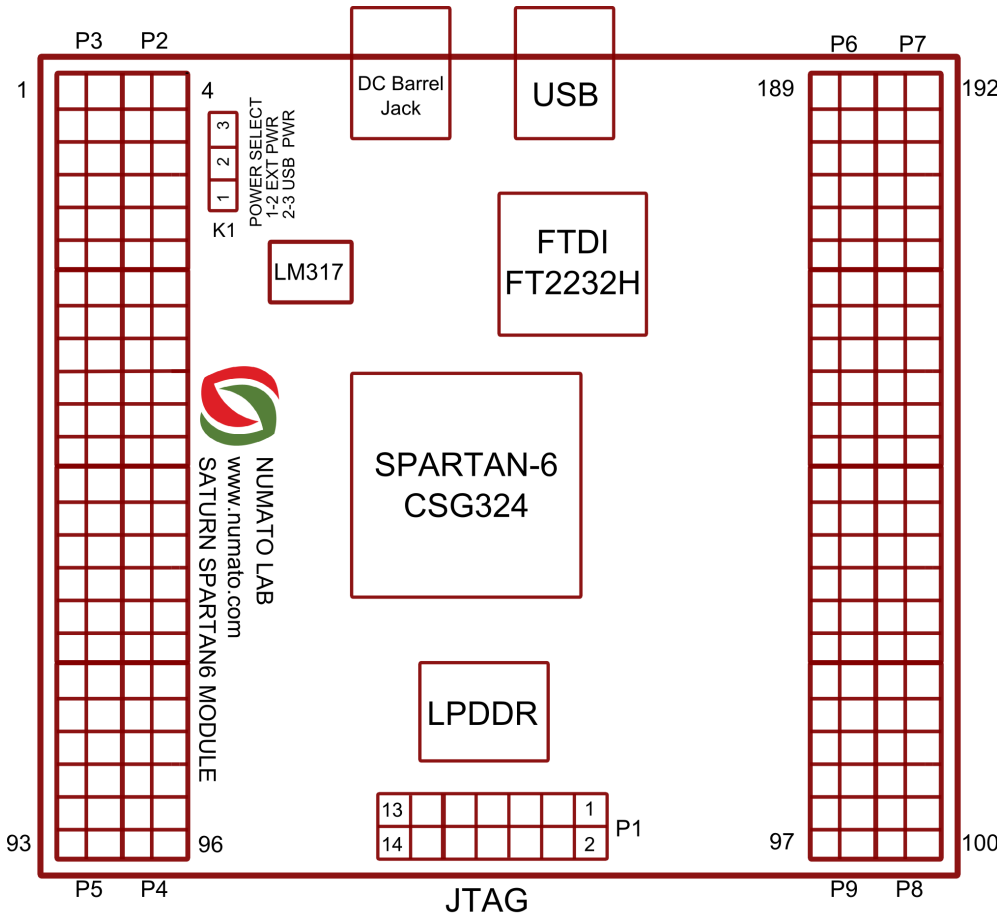
The following section describes how to use this module.

Components/Tools required

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).

Connection Diagram



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.

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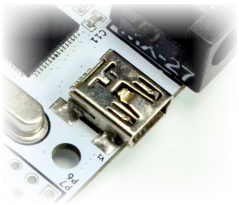
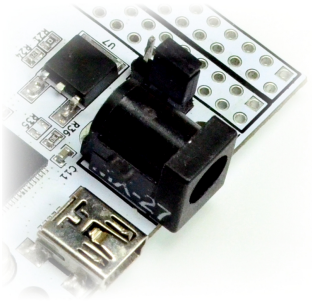
USB Interface



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)

Visit http://numato.com/cables-accessories to buy cables and accessories for this product.

DC Power Supply



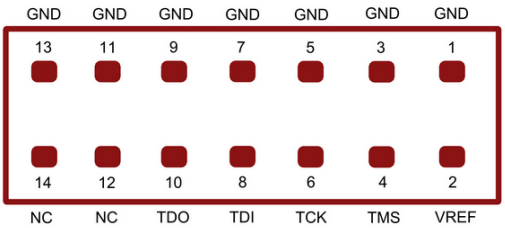
This module uses +5V power supply to function properly. **By default the board is configured to use +5V supply from USB. So an external +5V power is not required unless USB port is unable to supply enough current. In most cases USB ports are capable of providing enough current for the module. Current 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.

Power Select

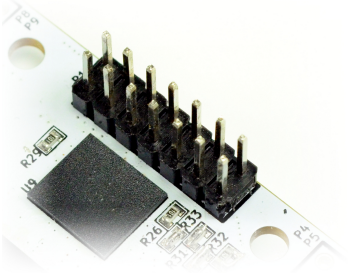
The Power Select header K1 is used to configure the power source for the board. The jumper in pin 2 and 3 is shorted to switch the power source to on board USB port and pin 1 and 2 to use the external DC power.

JTAG Connector

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



JTAG



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GPIOs

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
5	G13	6	H12
9	H16	10	H15
13	G14	14	F14
17	F16	18	F15
21	E18	22	E16
25	C18	26	C17
29	A15	30	C15
33	A14	34	B14
37	A13	38	C13
41	C12	42	D12
45	E11	46	F11

Header P2

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
3	VCCIN	4	GND
7	K14	8	J13
11	H14	12	H13
15	G18	16	G16
19	F18	20	F17
23	D18	24	D17
27	A16	28	B16
31	C14	32	D14

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35	E13	36	F13
39	E12	40	F12
43	A12	44	B12
47	C11	48	D11

Header P5

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
49	GND	50	GND
53	F10	54	G11
57	A10	58	C10
61	C9	62	D9
65	F8	66	G8
69	C8	70	D8
73	E6	74	F7
77	A6	78	B6
81	A5	82	C5
85	A3	86	B3
89	GND	90	GND
93	3V3	94	3V3

Header P4

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
51	GND	52	GND
55	A11	56	B11
59	F9	60	G9
63	A9	64	B9
67	E8	68	E7
71	A8	72	B8
75	A7	76	C7

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79	C6	80	D6
83	A4	84	B4
87	A2	88	B2
91	GND	92	GND
95	3V3	96	3V3

Header P6

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
97	GND	98	GND
101	INITB	102	3V3
105	R3	106	T3
109	R5	110	T5
113	N5	114	P6
117	R7	118	T7
121	U7	122	V7
125	N7	126	P8
129	T9	130	V9
133	R10	134	T10
137	N10	138	P11
141	GND	142	GND

Header P7

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
99	GND	100	GND
103	PROGB	104	3V3
107	T4	108	V4
111	U5	112	V5
115	T6	116	V6
119	N6	120	P7

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123	U8	124	V8
127	M8	128	N8
131	R8	132	T8
135	M10	136	N9
139	U11	140	V11
143	GND	144	GND

Header P9

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
145	GND	146	GND
149	R11	150	T11
153	T12	154	V12
157	T14	158	V14
161	U16	162	V16
165	T17	166	T18
169	K15	170	K16
173	L12	174	L13
177	ACBUS6	178	ACBUS7
181	ACBUS4	182	ACBUS5
185	ACBUS2	186	ACBUS3
189	ACBUS0*	190	ACBUS1

* ACBUS0 - ACBUS7 are pins of FTDI FT2232H Dual-Channel USB device.

Header P8

Pin No. On The Header	Spartan-6 (CSG324) Pin No.	Pin No. On The Header	Spartan-6 (CSG324) Pin No.
147	GND	148	GND
151	M11	152	N11
155	U13	156	V13
159	U15	160	V15

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163	U17	164	U18
167	P15	168	P16
171	N15	172	N16
175	L15	176	L16
179	M14	180	N14
183	L14	184	M13
187	K12	188	K13
191	3V3	192	GND

	VCC
	Ground
	GPIO
	FTDI IO

No Connect Pins In LX9(CSG324)

SL No.	Pin No On The Header	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

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16	74	F7
17	119	N6
18	120	P7
19	125	N7
20	126	P8
21	127	M8
22	128	N8
23	135	M10
24	136	N9
25	137	N10
26	138	P11
27	151	M11
28	152	N11
29	153	T12
30	154	V12
31	159	U15
32	160	V15

No Connect Pins In LX25(CSG324)

SL No.	Pin No On The Header	Spartan-6 (CSG324)
1	65	F8
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	Spartan-6 (CSG324)
1	39	E12
2	40	F12

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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
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

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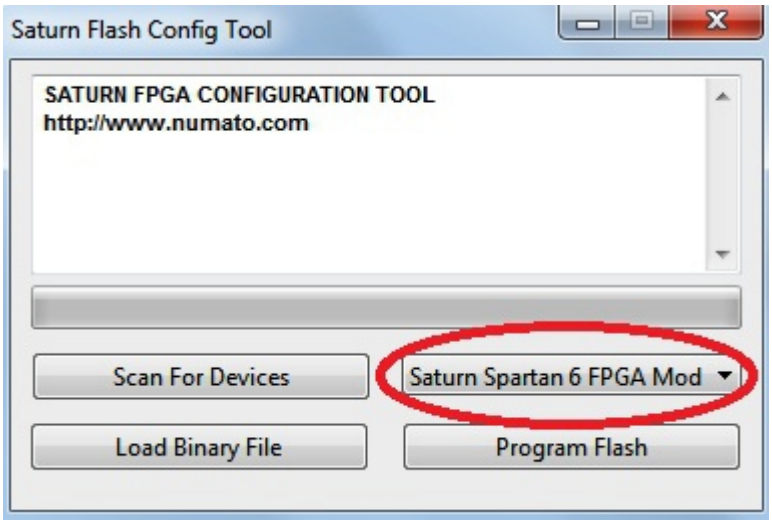
Driver Installation

Windows

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. 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).



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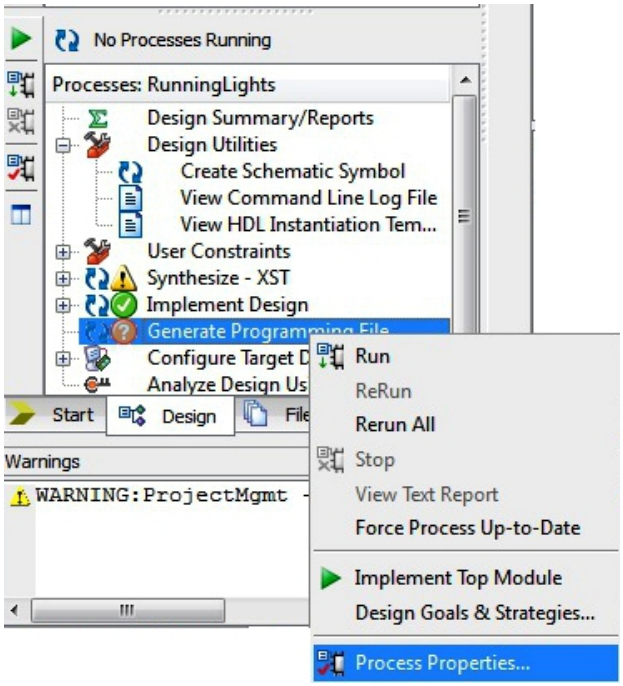
Generating Bit Stream for Saturn

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.



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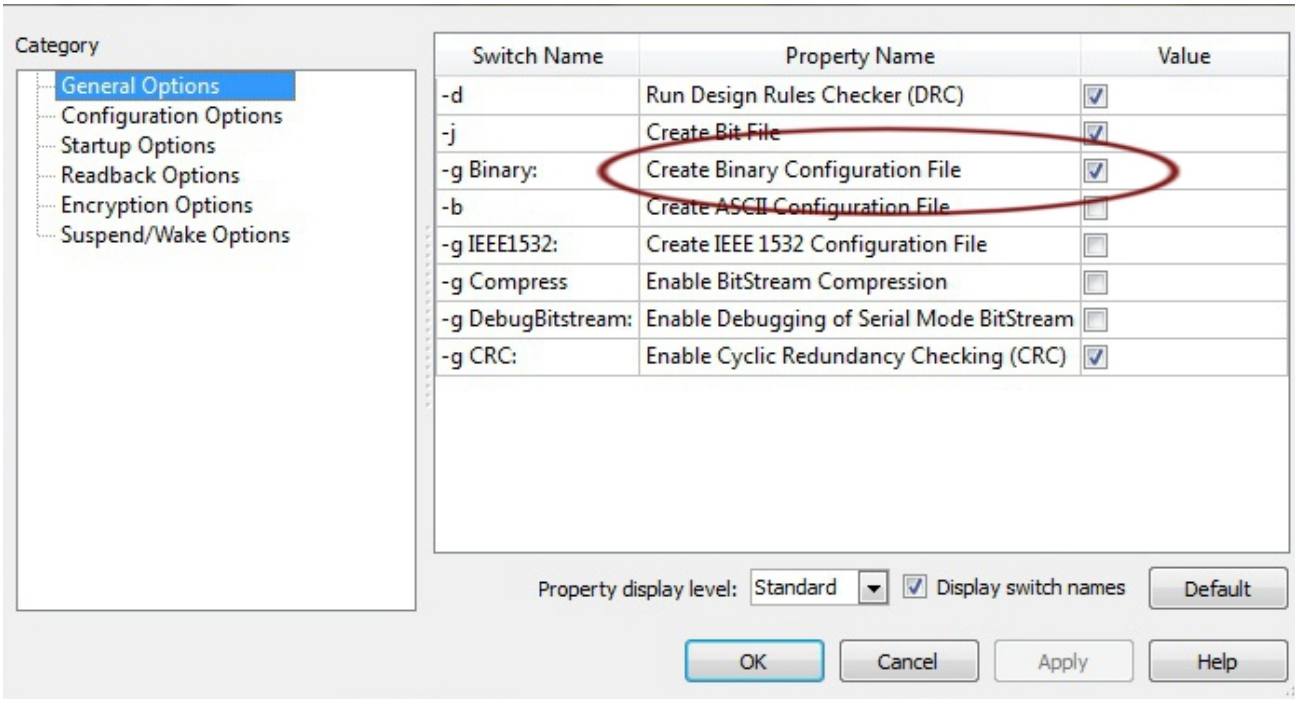
Step 2: Select “Process Properties” from the pop up menu. In the dialog box, check “Create Binary Configuration File” Check box and click “Apply”.



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.

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Powering Up Saturn

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. On-board regulators derive these voltages from the USB/Ext power supply.

Configuring Saturn Spartan6 Module

The Saturn Spartan6 module can be configured by two methods,

a) Using Spartan configuration tool through USB.

b) Using the Xilinx programming cable.

Configuring Saturn using configuration tool

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.

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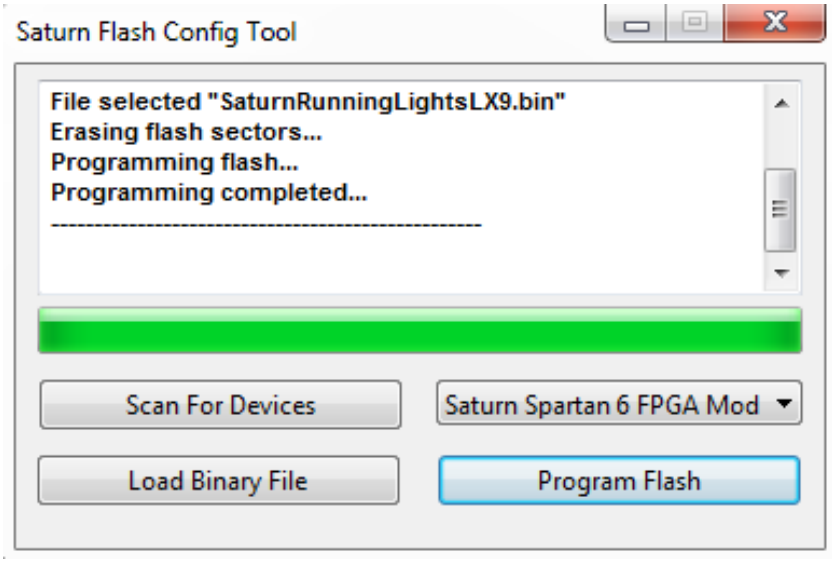
Step 1: Open Saturn Config Tool. Click “Scan for Devices” if “Saturn Spartan 6 FPGA Module” is not detected automatically.

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



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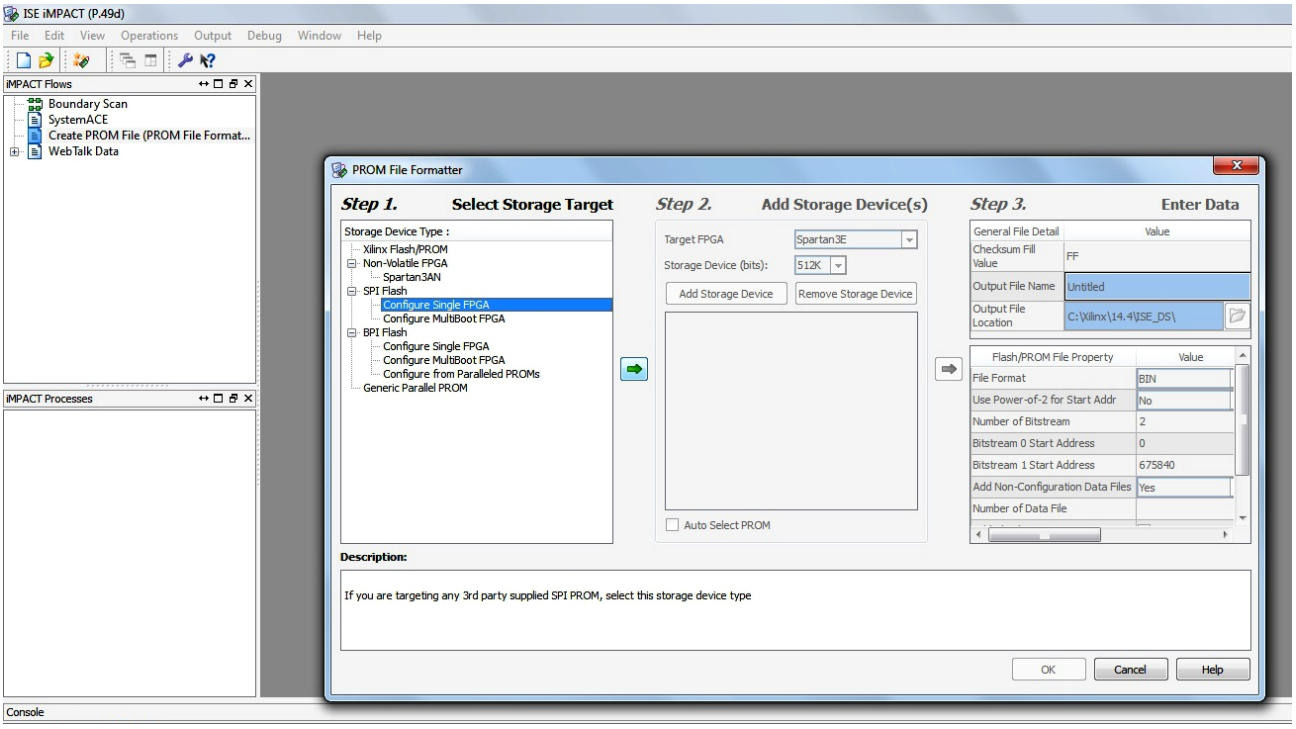
Configuring Saturn using JTAG

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.



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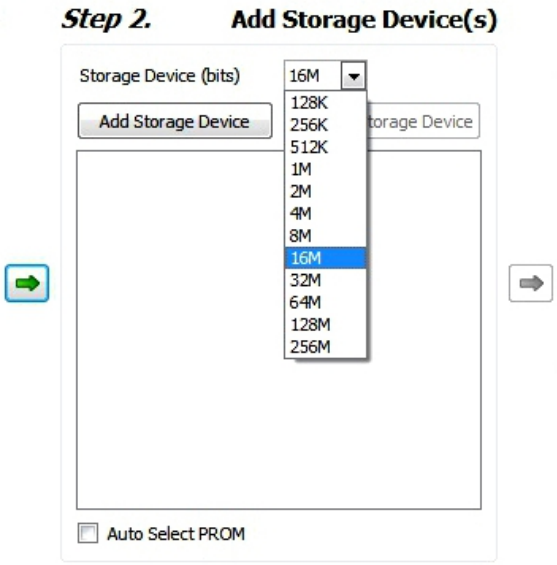
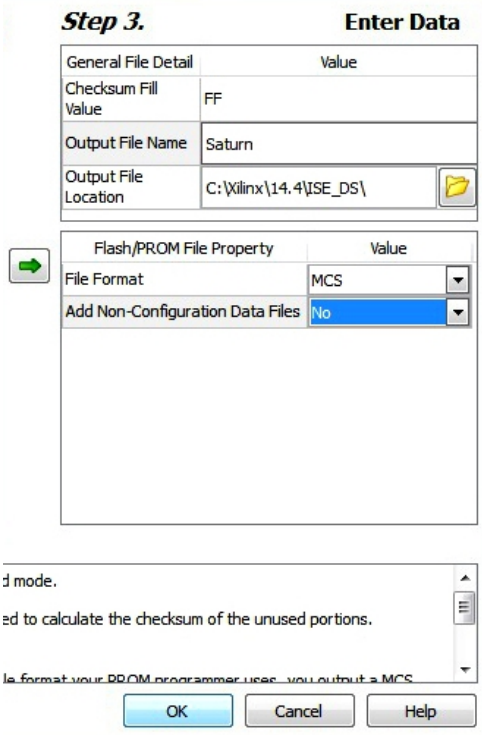
Step 2: Select 16M in Storage Device (bits).Now click on “Add Storage Device”, then the green arrow on the right side.



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.



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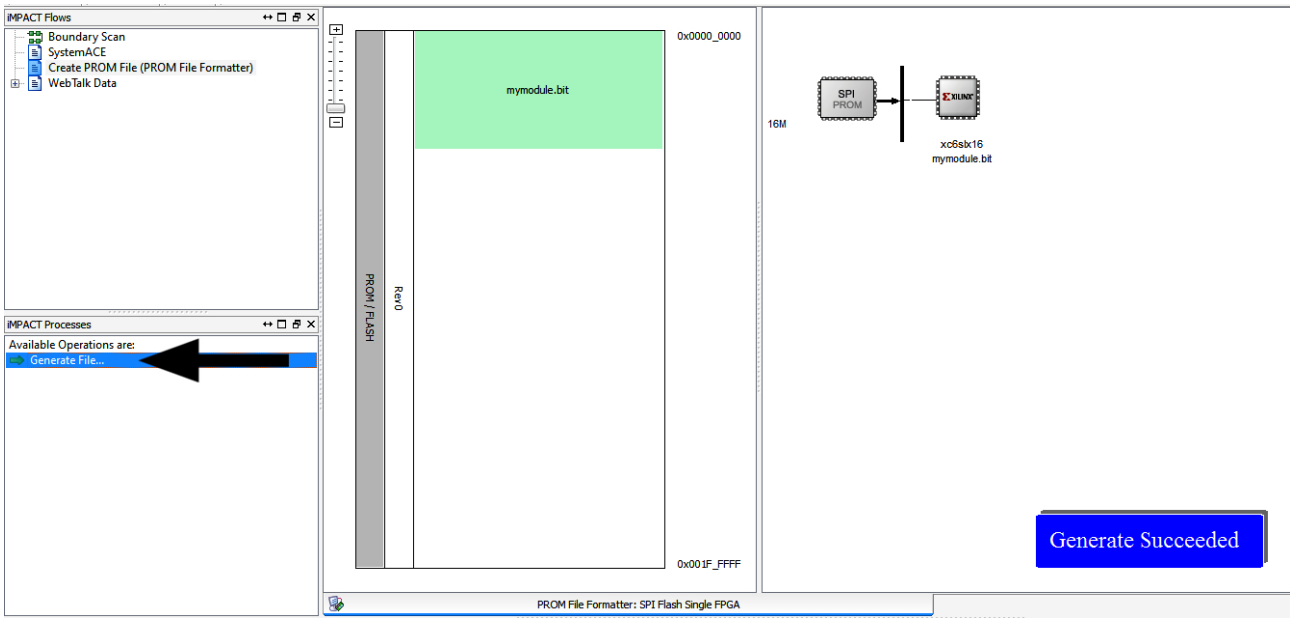
Step 4: Double click on “Generate File”. “Generate Succeeded” will be displayed as shown in fig below if the “.mcs” the file is generated successfully.



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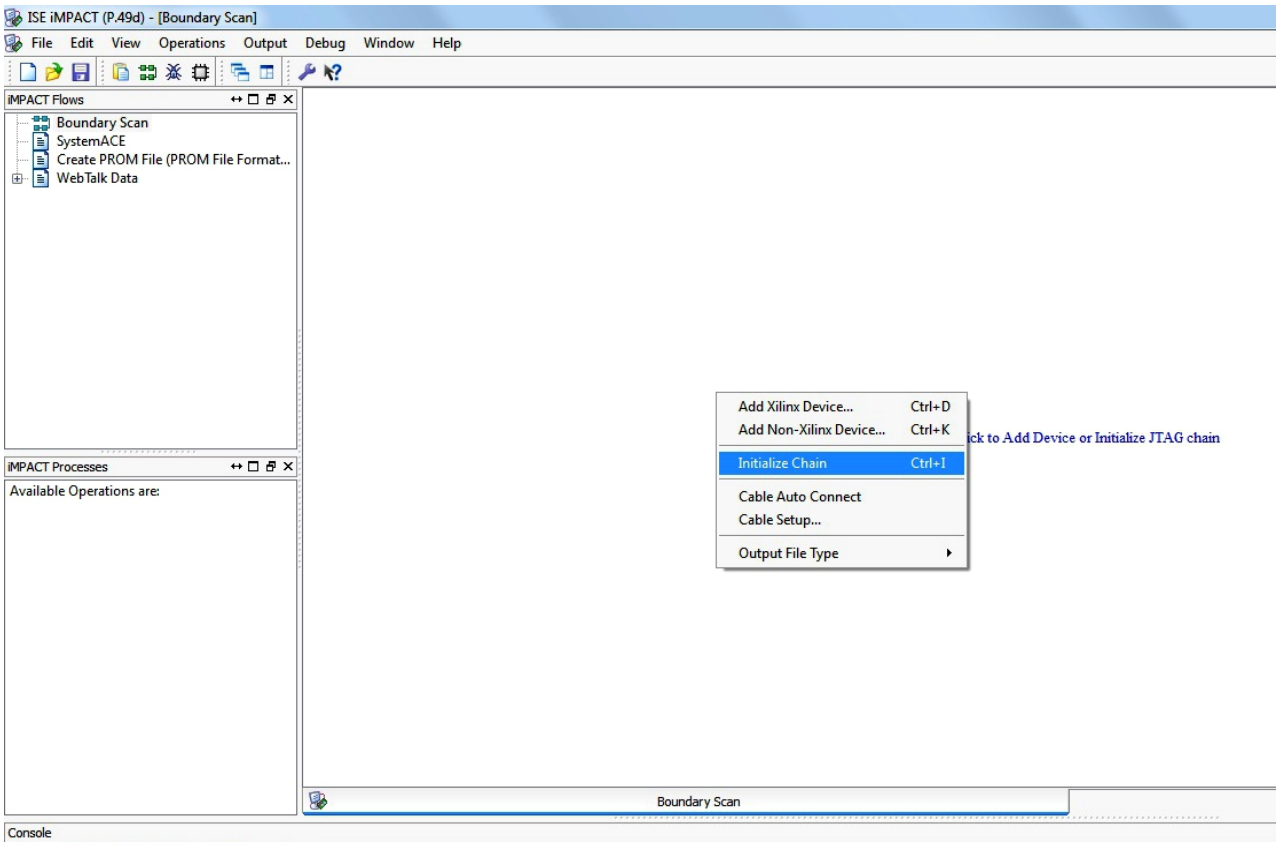
Programming FPGA using ISE iMPACT

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".



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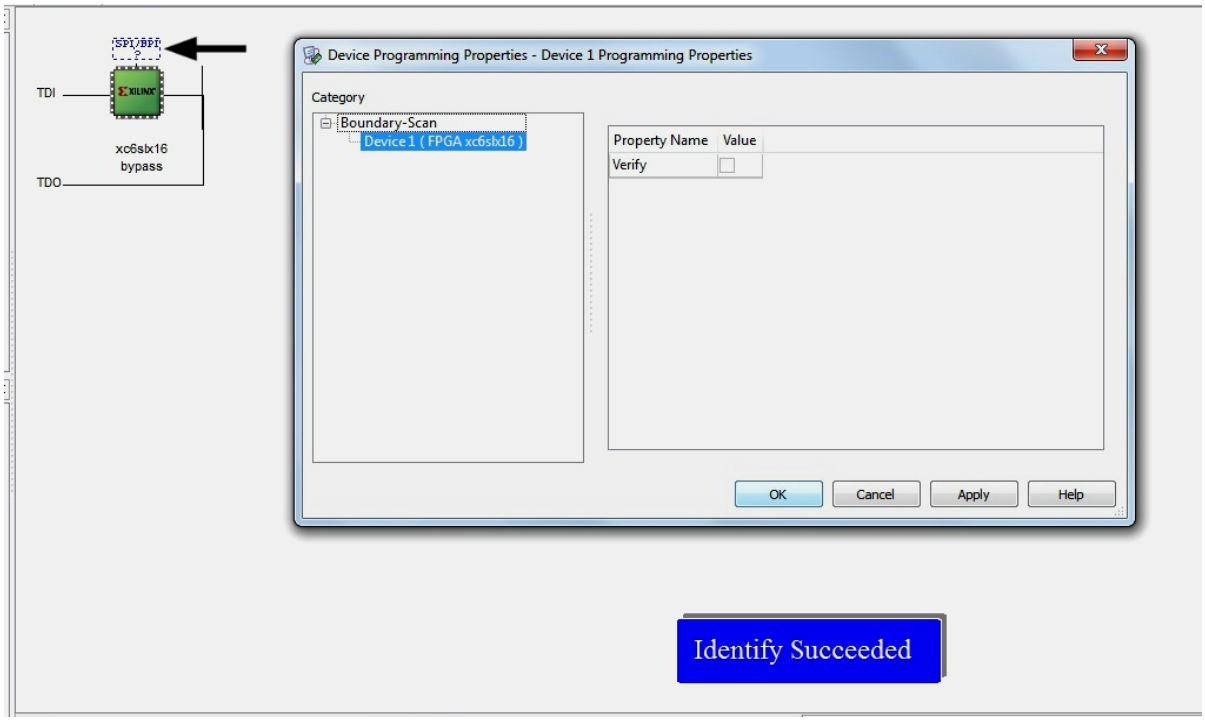
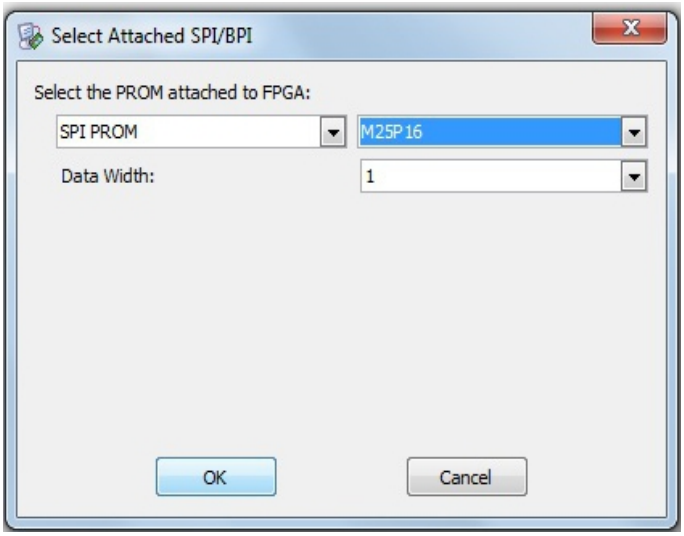
Step 2: If the device is detected properly you will get a pop up window as shown below, Click OK. Then right click on the SPI/BPI (next to the black arrow in the below fig.), select Add SPI/BPI Flash.



Step 3: Select the ".mcs" file we already created and click OK. Now choose “M25P16” in the dialogue box appeared, then click OK.



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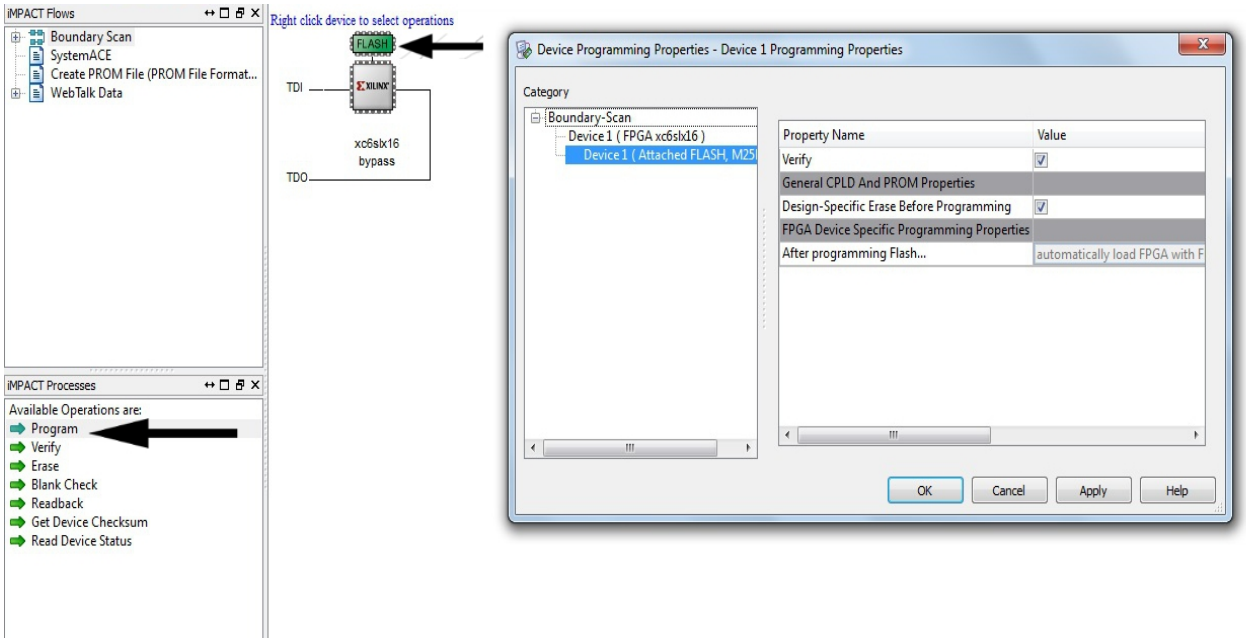
Step 4. Click on “Flash”, Double Click on Program, select OK. If the programming is successful, a confirmation message will be displayed.



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Length matched GPIOs Pairs

This device is equipped with a maximum of 158 user IOs. Of those, 56 IOs are length matched which can be used as differential pairs.

IO Header Pin No.	Spartan-6 Differential Pair
9-10	H15-H16
15-16	G16-G18
17-18	F16-F15
19-20	F17-F18
21-22	E16-E18
23-24	D17-D18
25-26	C17-C18
27-28	B16-A16
29-30	A15-C15
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

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71-72	B8-A8
75-76	C7-A7
77-78	B6-A6
79-80	C6-D6
81-82	C5-A5
83-84	A4-B4
85-86	B3-A3
87-88	B2-A2
105-106	R3-T3
107-108	T4-V4
109-110	R5-T5
111-112	U5-V5
115-116	T6-V6
117-118	R7-T7
121-122	U7-V7
123-124	U8-V8
129-130	T9-V9
131-132	R8-T8
133-134	R10-T10
139-140	U11-V11
149-150	R11-T11
153-154	T12-V12
155-156	U13-V13
157-158	T14-V14
159-160	U15-V15
161-162	U16-V16
163-164	U17-U18

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165-166	T17-T18
167-168	P15-P16
169-170	K15-K16
171-172	N15-N16
173-174	L12-L13
175-176	L15-L16
187-188	K13-K13

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Technical Specifications

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 (M25P16)	16	Mb
Power supply voltage (USB or external)	5 – 7	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

All parameters considered nominal. Numato Systems Pvt Ltd reserve the right to modify products without notice.

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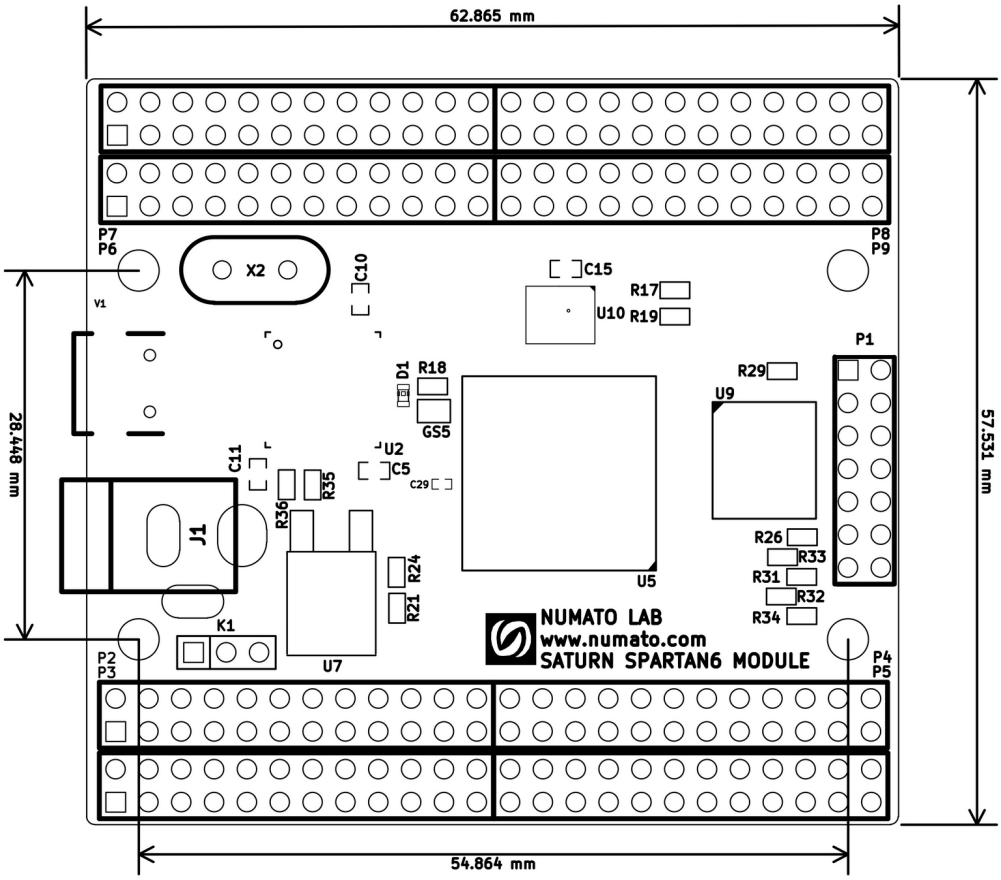
Physical Dimensions



Schematics

See next page.

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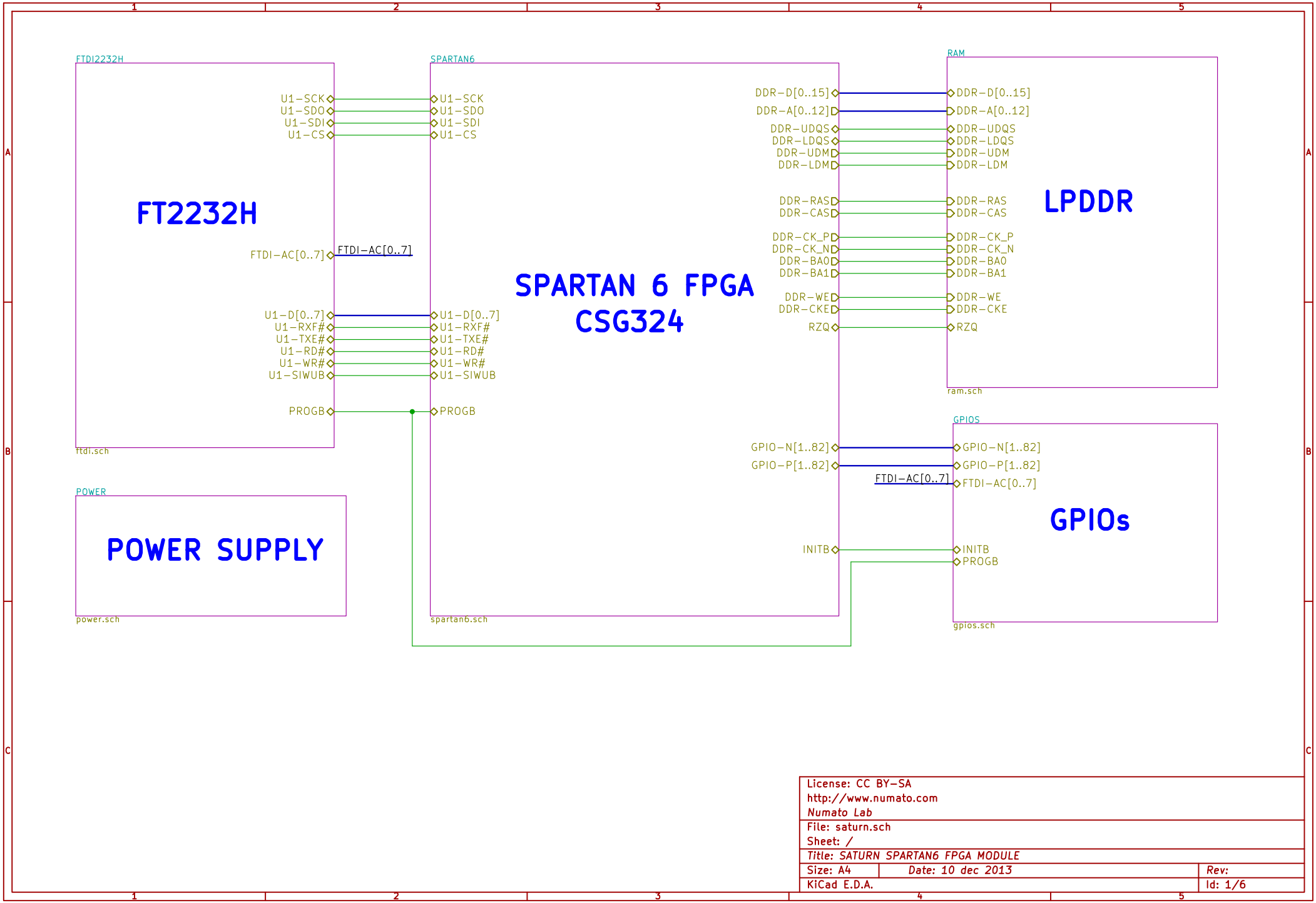
FTDI2232H
SPARTAN6
RAM
U1-SCK
U1-SDO
U1-SDI
U1-CS
FT2232H
FTDI-AC[0..7]
U1-D[0..7]
U1-RXF#
U1-TXE#
U1-RD#
U1-WR#
U1-SIWUB
PROGB
ftdi.sch
SPARTAN 6 FPGA
CSG324
DDR-D[0..15]
DDR-A[0..12]
DDR-UDQS
DDR-LDQS
DDR-UDM
DDR-LDM
DDR-RAS
DDR-CAS
DDR-CK_P
DDR-CK_N
DDR-BA0
DDR-BA1
DDR-WE
DDR-CKE
RZQ
LPDDR
ram.sch
GPIOS
GPIO-N[1..82]
GPIO-P[1..82]
GPIOs
INITB
gpios.sch
POWER
POWER SUPPLY
power.sch
spartan6.sch
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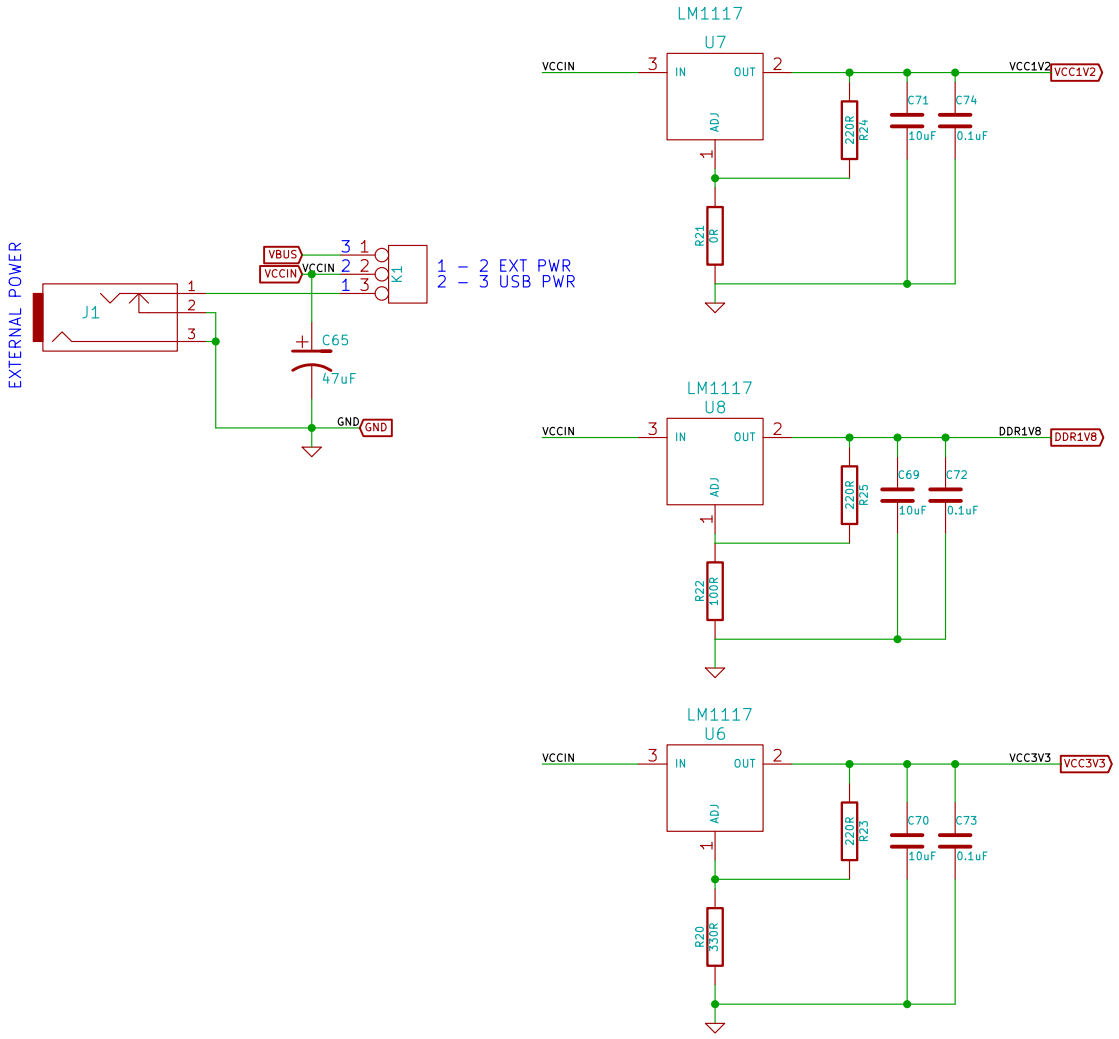
Size: A4
Date: 10 dec 2013
Rev:
KiCad E.D.A.
Id: 1/6



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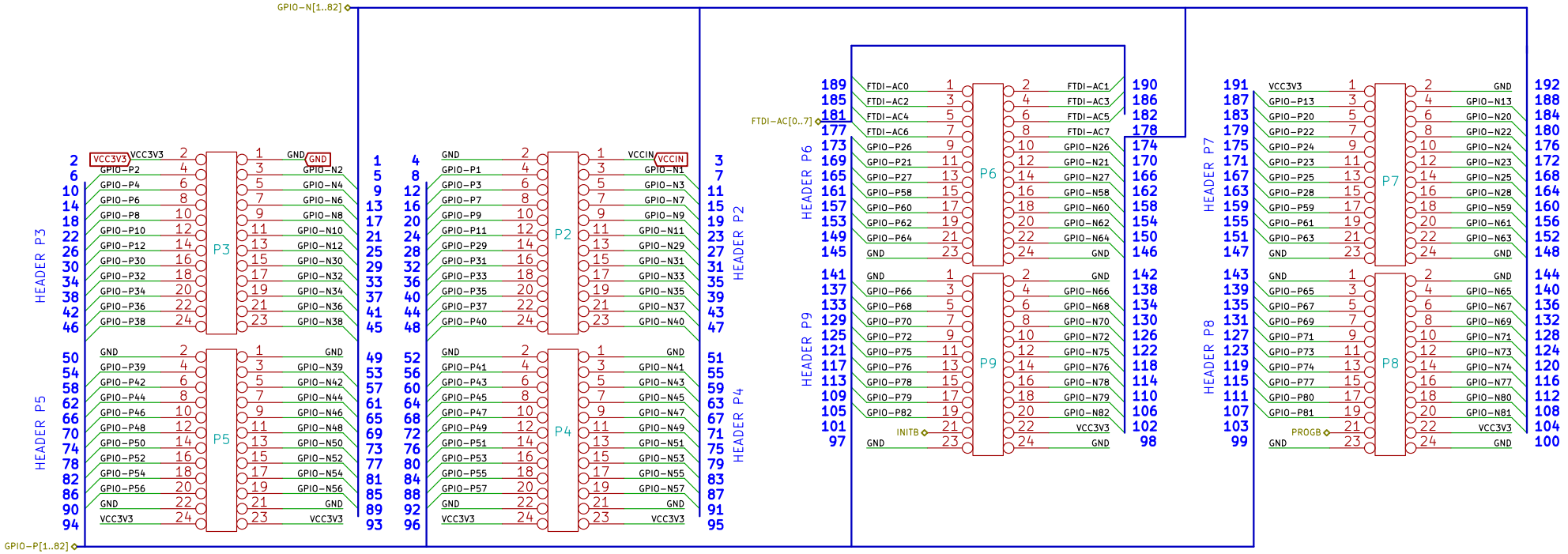

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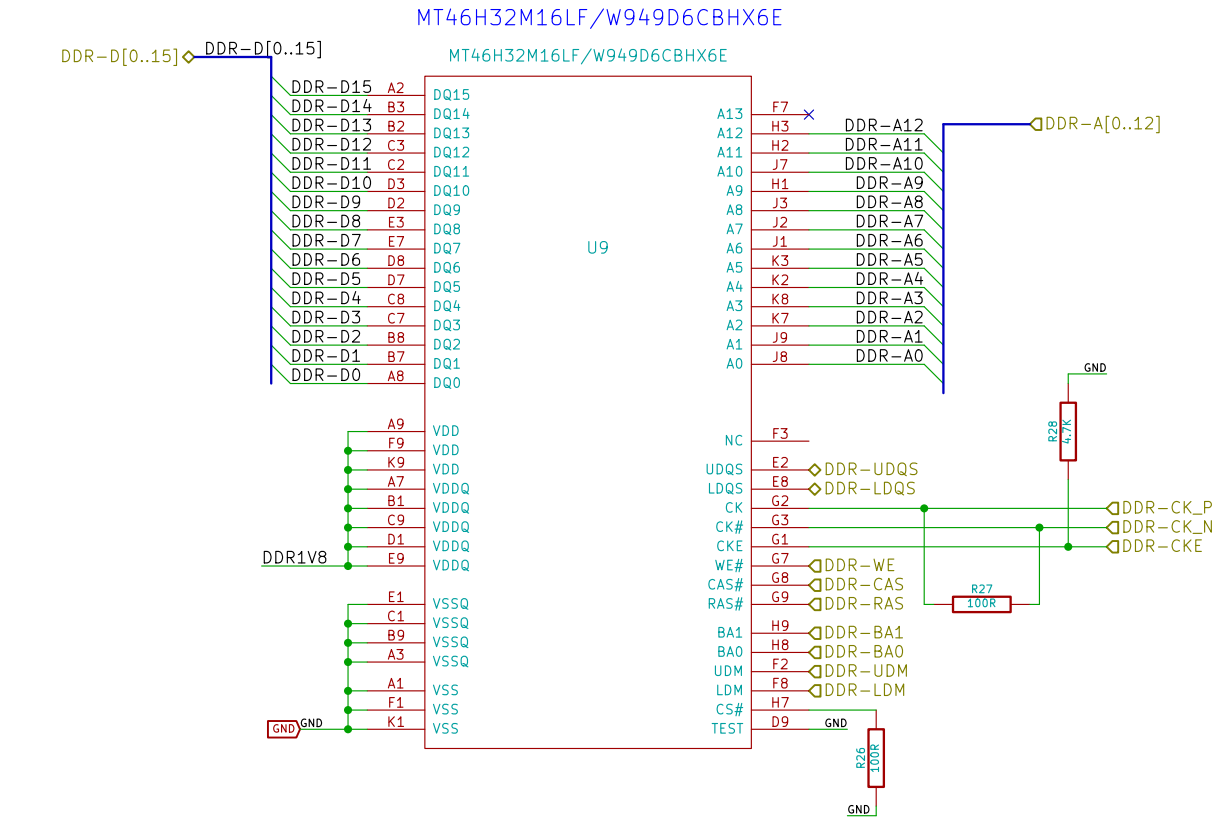

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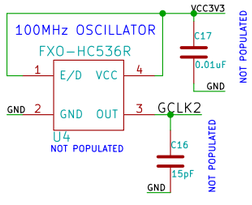

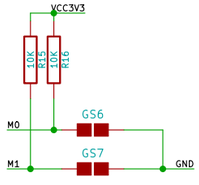

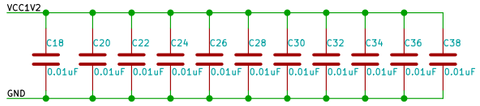

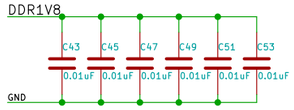

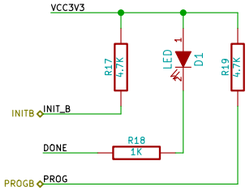

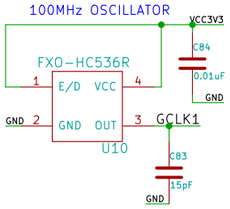

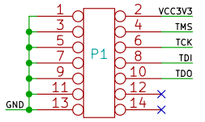

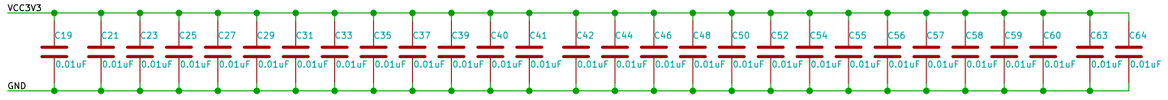

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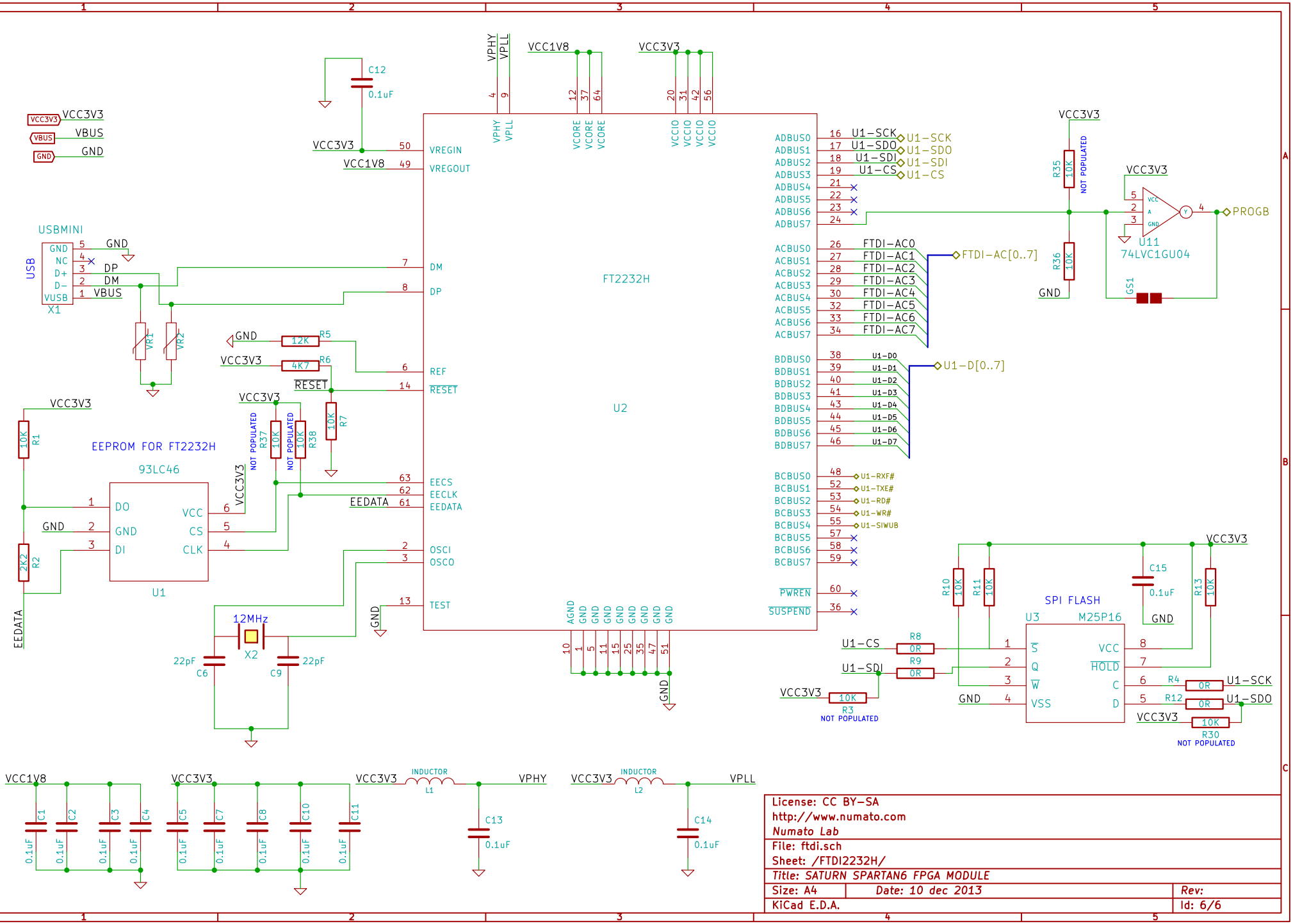
VCC3V3
VBUS
GND
C12
0.1uF
VPHY
VPLL
VCC1V8
VCC3V3
VREGIN
VREGOUT
VCORE
VCCIO
FT2232H
U2
ADBUS0
ADBUS1
ADBUS2
ADBUS3
U1-SCK
U1-SDO
U1-SDI
U1-CS
ACBUS0
ACBUS1
ACBUS2
ACBUS3
ACBUS4
ACBUS5
ACBUS6
ACBUS7
FTDI-AC0
FTDI-AC1
FTDI-AC2
FTDI-AC3
FTDI-AC4
FTDI-AC5
FTDI-AC6
FTDI-AC7
FTDI-AC[0..7]
BDBUS0
BDBUS1
BDBUS2
BDBUS3
BDBUS4
BDBUS5
BDBUS6
BDBUS7
U1-D0
U1-D1
U1-D2
U1-D3
U1-D4
U1-D5
U1-D6
U1-D7
U1-D[0..7]
BCBUS0
BCBUS1
BCBUS2
BCBUS3
BCBUS4
BCBUS5
BCBUS6
BCBUS7
U1-RXF#
U1-TXE#
U1-RD#
U1-WR#
U1-SIWUB
PWREN
SUSPEND
AGND
DM
DP
REF
RESET
EECS
EECLK
EEDATA
OSCI
OSCO
TEST
USBMINI
USB
X1
VR1
VR2
R5
12K
R6
4K7
R7
10K
EEPROM FOR FT2232H
93LC46
U1
DO
DI
CS
CLK
R1
R2
2K2
R37
R38
NOT POPULATED
12MHz
X2
C6
C9
22pF
R35
R36
U11
74LVC1GU04
PROGB
GS1
SPI FLASH
U3
M25P16
VSS
VCC
HOLD
R8
R9
R10
R11
R12
R13
R4
R3
R30
0R
C15
U1-CS
U1-SDI
U1-SCK
U1-SDO
C1
C2
C3
C4
C5
C7
C8
C10
C11
INDUCTOR
L1
L2
C13
C14
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