Digilent Nexys Board Reference Manual

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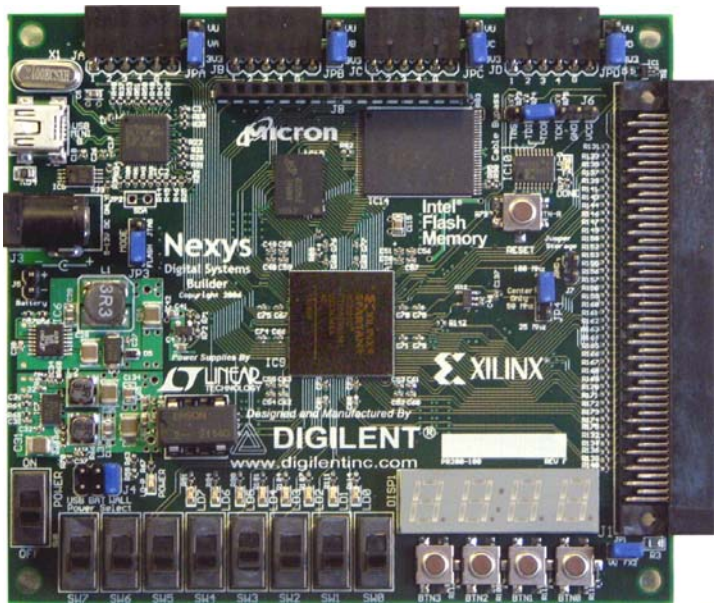
Overview

Digilent's Nexys circuit board is an integrated circuit development platform based on a Xilinx Spartan 3 FPGA. The Nexys board provides large external memory arrays, a collection of useful I/O devices, and numerous ports, making it an ideal platform for experiments with FPGA-based digital systems, including embedded cores like Xilinx's MicroBlaze.



The Nexys board is suitable for designs ranging from simple logic circuits to complex digital systems, without needing any other components. All external signals are ESD and short-circuit protected, ensuring a long operating life in any environment.

The Nexys is fully compatible with all versions of the Xilinx ISE tools, including the free WebPack. Nexys features include:

- 200K-gate Xilinx XC3S200 FPGA with 500+MHz operation (400K and 1M gate versions available)
- USB2 port for FPGA configuration and high-speed data transfers (using the free Adept Suite Software)
- USB-powered (batteries and/or wall-plug can also be used)
- 16MB of fast Micron PSDRAM and 4MB of Intel StrataFlash Flash ROM
- Xilinx Platform Flash ROM that stores FPGA configurations indefinitely
- High efficiency switching power supplies (good for battery powered applications)
- 50MHz oscillator
- Connector for 1/8 VGA hi-res graphics LCD panel or 16x2 character LCD display
- 60 FPGA I/O's routed to expansion connectors (one high-speed Hirose FX2 connector and four 6-pin headers)
- 8 LEDs, 4-digit seven-segment display, 4 pushbuttons, 8 slide switches
- Ships in a convenient plastic carry case (together with USB cable)

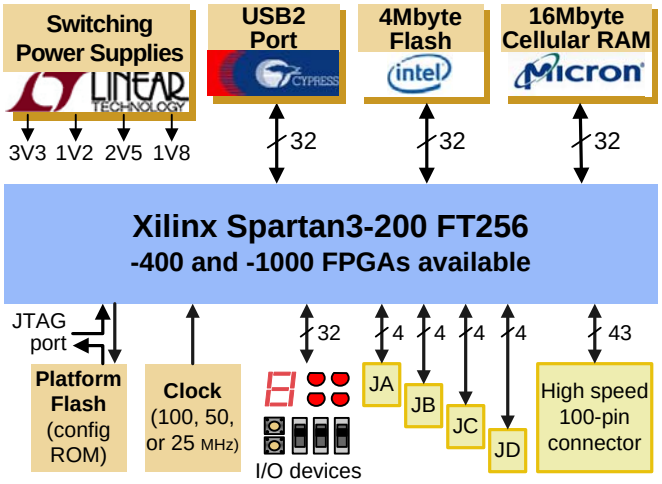


Figure 1: Nexys block diagram

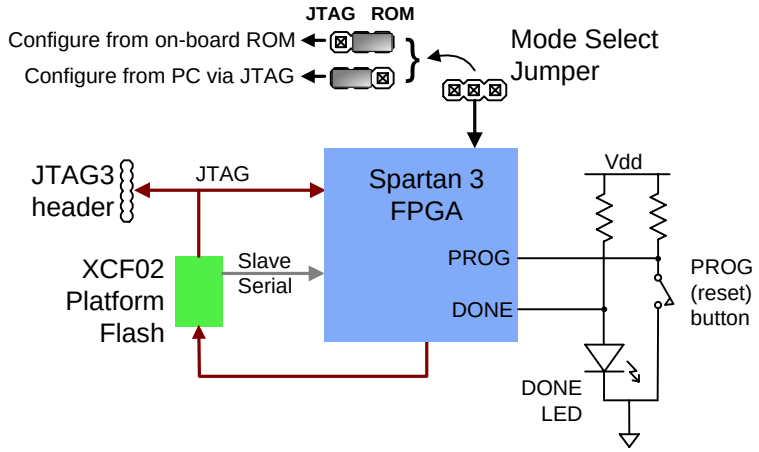
Functional Description

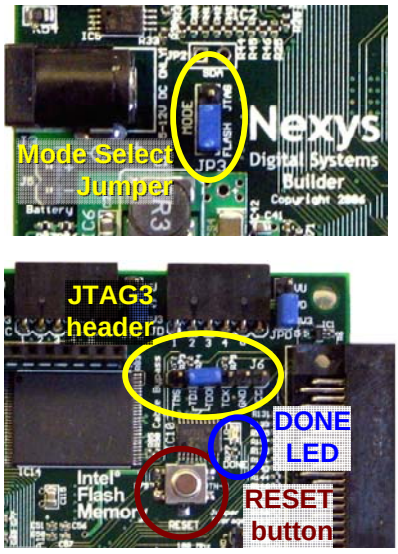
The Nexys board provides an inexpensive, robust, and easy-to-use platform that anyone can use to gain experience with FPGA devices and modern design methods. It is centered on the Spartan 3 FPGA, and it contains all needed support circuits so designs can get up and running quickly. The large collection of on-board devices allow many designs to be completed without the need for any other hardware, making the Nexys an ideal platform for experimenting with new designs or learning about FPGAs and CAD tools. The 100-pin high-speed connector and four 6-pin expansion connectors allow designs to grow beyond the Nexys board, either with user-designed boards or breadboards and/or peripheral module (Pmod) boards offered by Digilent. (Pmods are inexpensive analog and digital I/O modules that offer A/D conversion, D/A conversion, motor drive, sensor input, and a host of other features). Signals on each 6-pin expansion connector are protected against damage from ESD and short-circuit connections, ensuring a long operating life in any environment. The Nexys board works seamlessly with all versions of the Xilinx ISE tools, including the free WebPack tools. The Nexys recieves power from the USB interface and it ships with a USB cable, so designs can be implemented immediately without the need for any additional hardware.

FPGA and Platform Flash Configuration

The FPGA on the Nexys board must be configured (or programmed) by the user before it can perform any functions. Design software, like the free WebPack from Xilinx, can be used to define any number of circuits that can be programmed into the FPGA. Once programmed, the FPGA will retain its configuration only as long is power is applied. The FPGA can be programmed in two ways: directly from a PC, and from an on-board Platform Flash ROM that is also user-programmable. A jumper on the Nexys board determines which source (PC or ROM) the FPGA will use to load its configuration. The FPGA can automatically load a configuration at power-on from the Platform Flash ROM by setting the Mode Select Jumper JP3 to “FLASH”.

Note that a demonstration configuration is loaded into the Nexys board during manufacturing. If that configuration has not been overwritten, it can be automatically loaded into the FPGA by setting the Mode Select Jumper JP3 to “FLASH”, and cycling power or pressing the reset button.





The FPGA and the Platform Flash ROM can be programmed from a PC using Digilent's Adept software or Xilinx's iMPACT software (both are available for free download). Digilent's Adept Software works with the USB circuit, and Digilent's JTAG3 parallel cable is compatible with iMPACT. When using the USB circuit, a "cable bypass" jumper must be loaded on the JTAG header at J6 to connect the TDI and TDO signals.

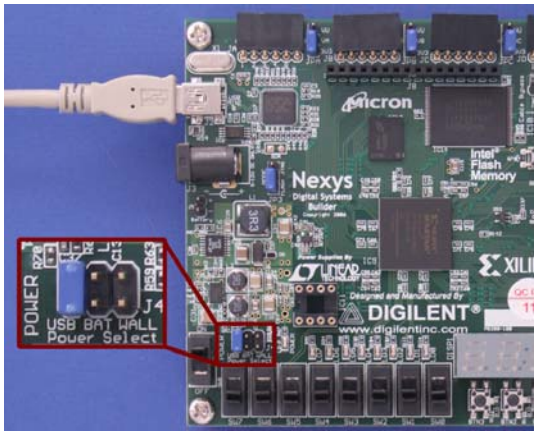
To program the Nexys board, connect the programming cable to the board and to a PC, and apply power to the board. Start the programming software, and wait for the FPGA and the Platform Flash ROM to be automatically identified. To program the FPGA, select the desired .bit file; to program the Platform Flash, select the desired .mcs file. Right-click on the device to be programmed, and select the "program" function. The configuration file will be sent to the FPGA or Platform Flash, and the software will indicate whether programming was successful. For more information on device programming, refer to the Adept or iMPACT reference manual.

Both the FPGA and Platform Flash ROM will always appear in the scan chain. After the Platform Flash ROM has been loaded with a configuration file, the FPGA can automatically load that file at power-on if programming mode control jumper is loaded in the ROM position.

A reset button is provided (labeled "reset") that can erase the configuration in the FPGA, and start a new programming cycle. An LED labeled "done" will illuminate whenever the FPGA has been successfully configured.

Power Supply

The Nexys board can be powered from the USB port or any DC supply that produces a voltage in the 5VDC-9VDC range. The power jack on the Nexys board requires a center-positive, 2.1mm power supply connector as is commonly found on wall-plug power supplies. Voltages higher than 10V may permanently damage Nexys.



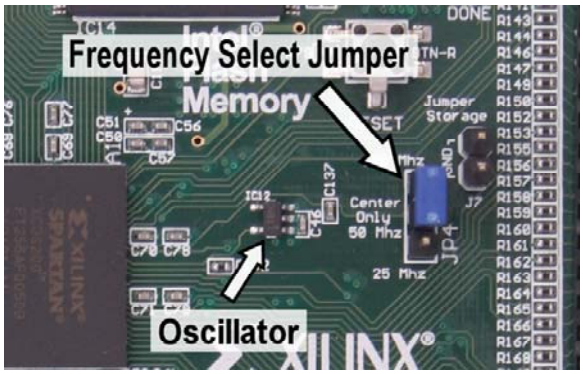
The "raw" voltage from the power jack is routed to the four 6-pin expansion connectors, the 16-pin expansion connector, and to a 3.3V voltage regulator. The 2.5V and 1.2V supplies required by the FPGA are generated from the 3.3V supply. Total board current is dependant on FPGA configuration, clock frequency, and external connections. In test circuits with roughly 20K gates routed, a 50MHz clock source, and all LEDs illuminated, about 200mA of current is drawn from the 1.2V supply, 50mA from the 2.5V supply, and 100mA from the 3.3V supply. Required current will increase if larger circuits are configured in the FPGA, and if peripheral boards are attached. The table below summarizes the power supply parameters.

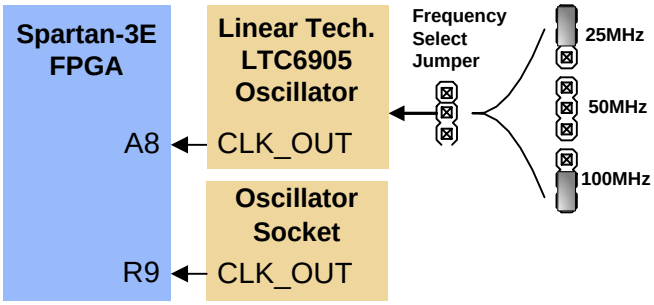
Vendor	Technology	Use	Supply	PN	Current (Max/typ)
Linear Technology	Switcher	Main power	3.3V (IC6)	LTC1765	3A/100mA
Linear Technology	Switcher (dual)	FPGA V*aux*	2.5V (IC7)	LTC3417	1.4A/50mA
Linear Technology	Switcher (dual)	FPGA V*core*	1.2V (IC7)	LTC3417	1.4A/200mA
Linear Technology	Linear	V*sram*	1.8V (IC8)	LTC1844	150mA/90mA
Linear Technology	Linear	V*usb*	3.3V (IC4)	LTC1844	150mA/60mA

The Nexys board uses a six layer PCB, with the inner layers dedicated to VCC and GND planes. The FPGA and the other ICs on the board all have a large complement of bypass capacitors placed as close as possible to each VCC pin. The power supply routing and bypass capacitors result in a very clean, low-noise power supply.

Oscillators

The Nexys board includes a primary, user-settable silicon oscillator that produces 25MHz, 50MHz, or 100MHz based on the position of the clock select jumper at JP4. A socket for a second oscillator is also provided at IC11 (the IC11 socket can accommodate any 3.3V CMOS oscillator in a half-size DIP package). The primary and secondary oscillators are connected to global clock input pins at pin A8 and pin R9 respectively. Both clock inputs can drive the clock synthesizer DLL on the Spartan 3, allowing for a wide range of internal frequencies, from 4 times the input frequency to any integer divisor of the input frequency.



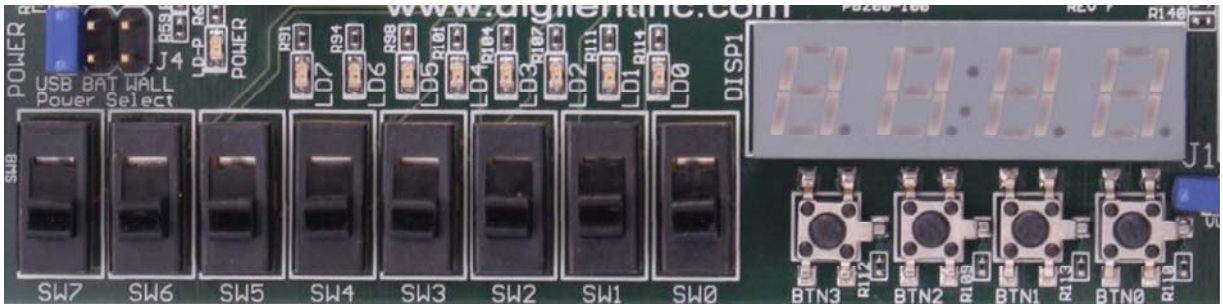


User I/O

The Nexys board includes several Input and Output devices, and several data ports so that many designs can be implemented without the need for any other components.

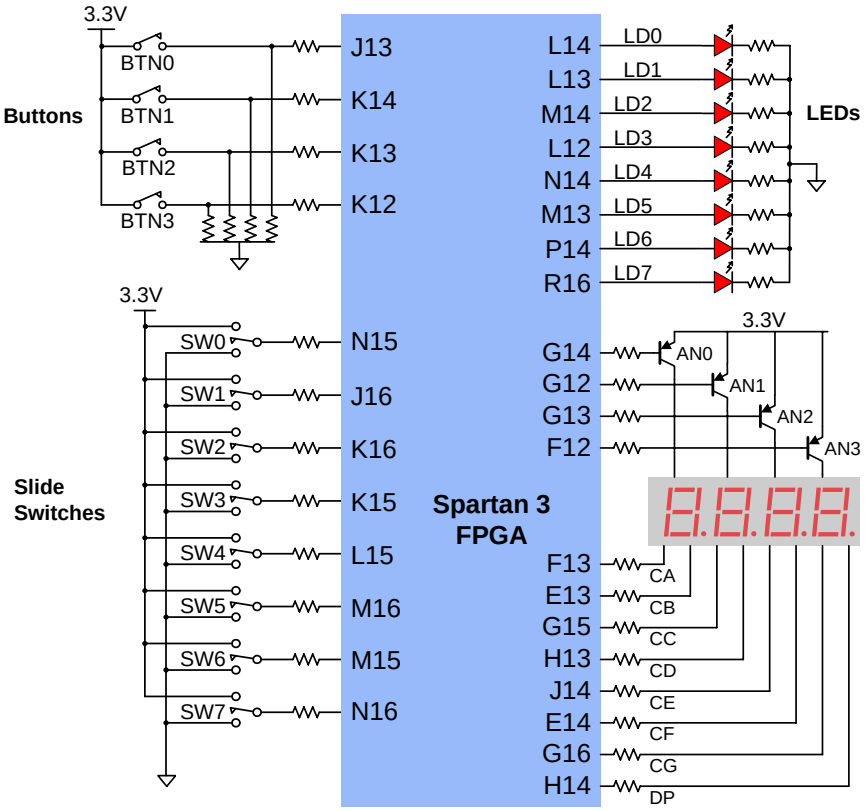
Eight Individual LEDs

Seven-segment LED Display



Eight Slide Switches

Four Pushbuttons



Inputs: Slide Switches and Pushbuttons

Four pushbuttons and eight slide switches are provided for circuit inputs. Pushbutton inputs are normally low, and they are driven high only when the pushbutton is pressed. Slide switches generate constant high or low inputs depending on their position. Pushbutton and slide switch inputs use a series resistor for protection against short circuits (a short circuit would occur if an FPGA pin assigned to a pushbutton or slide switch was inadvertently defined as an output).

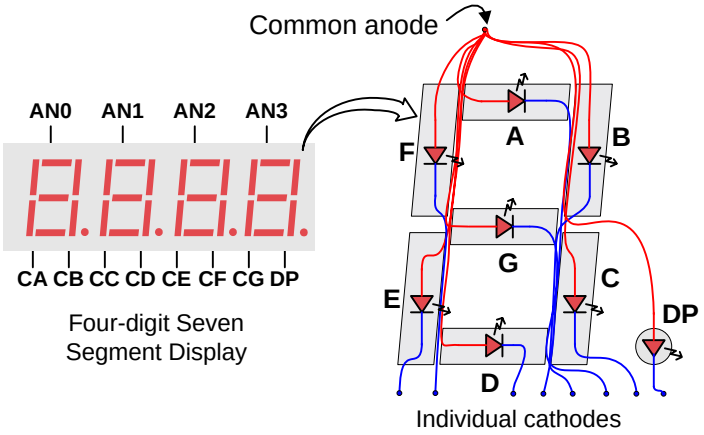
Outputs: LEDs

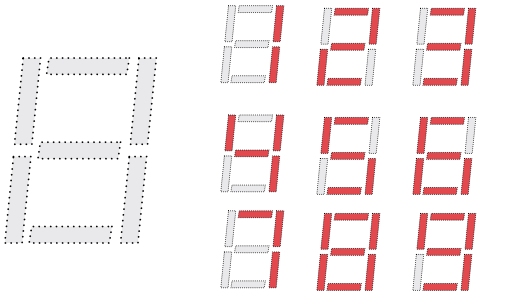
Eight LEDs are provided for circuit outputs. LED anodes are driven from the FPGA via 390-ohm resistors, so a logic '1' output will illuminate them with 3-4ma of drive current. A ninth LED is provided as a power-on LED, and a tenth LED indicates FPGA programming status.

Outputs: Seven-Segment Display

The Nexys board contains a four-digit common anode seven-segment LED display. Each of the four digits is composed of seven segments arranged in a "figure 8" pattern, with an LED embedded in each segment. Segment LEDs can be individually illuminated, so any one of 128 patterns can be displayed on a digit by illuminating certain LED segments and leaving the others dark. Of these 128 possible patterns, the ten corresponding to the decimal digits are the most useful.

The anodes of the seven LEDs forming each digit are tied together into one "common anode" circuit node, but the LED cathodes remain separate. The common anode signals are available as four "digit enable" input signals to the 4-digit display. The cathodes of similar segments on all four displays are connected into seven circuit nodes labeled CA through CG (so, for example, the four "D" cathodes from the four digits are grouped together into a single circuit node called "CD"). These seven cathode signals are available as inputs to the 4-digit display. This signal connection scheme creates a multiplexed display, where the cathode signals are common to all digits but they can only illuminate the segments of the digit whose corresponding anode signal is asserted.

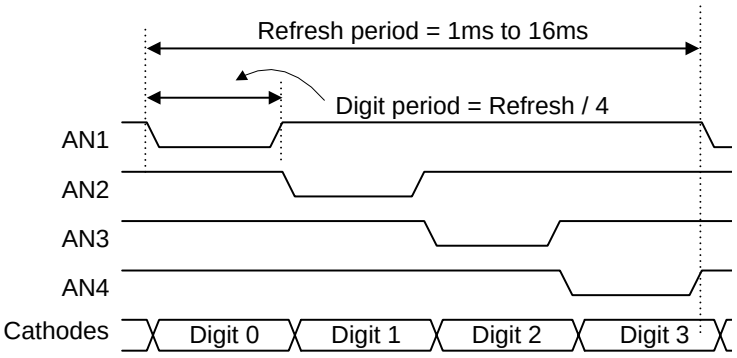




An un-illuminated seven-segment display, and nine illumination patterns corresponding to decimal digits

A scanning display controller circuit can be used to show a four-digit number on this display. This circuit drives the anode signals and corresponding cathode patterns of each digit in a repeating, continuous succession, at an update rate that is faster than the human eye can respond. Each digit is illuminated just one-quarter of the time, but because the eye cannot perceive the darkening of a digit before it is illuminated again, the digit appears continuously illuminated. If the update or "refresh" rate is slowed to a given point (around 45 hertz), then most people will begin to see the display flicker.

In order for each of the four digits to appear bright and continuously illuminated, all four digits should be driven once every 1 to 16ms (for a refresh frequency of 1KHz to 60Hz). For example, in a 60Hz refresh scheme, the entire display would be refreshed once every 16ms, and each digit would be illuminated for ¼ of the refresh cycle, or 4ms. The controller must assure that the correct cathode pattern is present when the corresponding anode signal is driven. To illustrate the process, if AN0 is asserted while CB and CC are asserted, then a "1" will be displayed in digit position 1. Then, if AN1 is asserted while CA, CB and CC are asserted, then a "7" will be displayed in digit position 2. If AN0 and CB, CC are driven for 4ms, and then A1 and CA, CB, CC are driven for 4ms in an endless succession, the display will show "17" in the first two digits. An example timing diagram for a four-digit controller is provided.

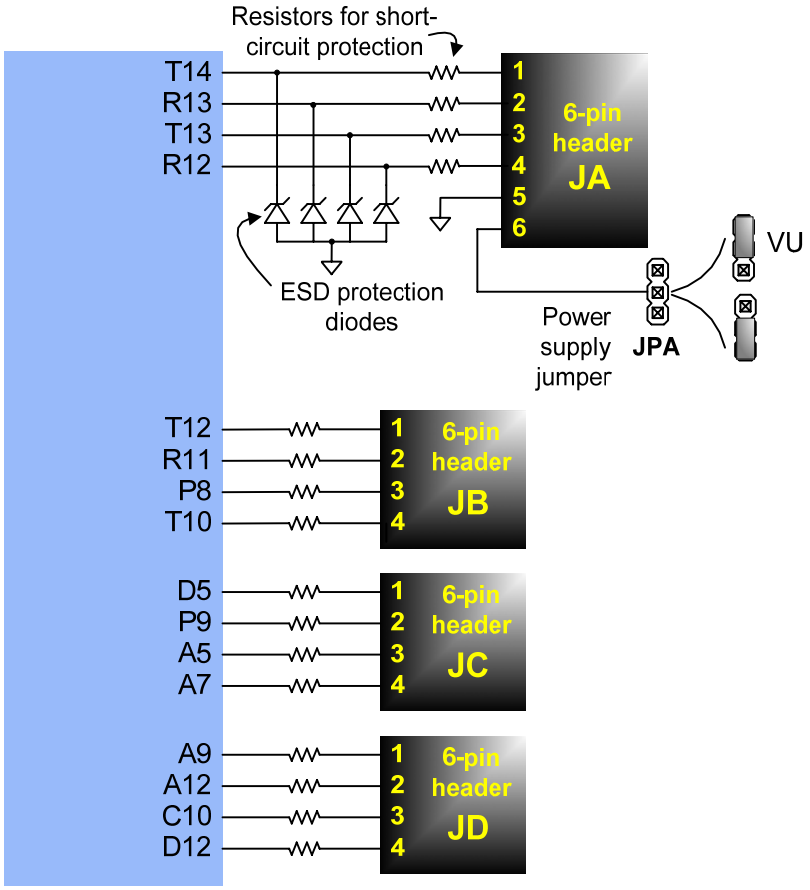


Ports and External Connectors

USB Port

The Nexys contains an integral USB2 circuit based on a Cypress CY7C68013 USB controller. The USB port can be used to program the on-board Xilinx devices, to perform user-data transfers at up to 37Mbytes/sec, and to provide power to the board. Programming is accomplished with Digilent's free Adept Suite Software. The power source for the board is determined by shorting the appropriate pins at J4. Programming files are generated with a number of software packages (Digilent recommends the free ISE WebPack from Xilinx). Once the programming files are generated programming the board is accomplished via the Export function included in the Adept Suite download.

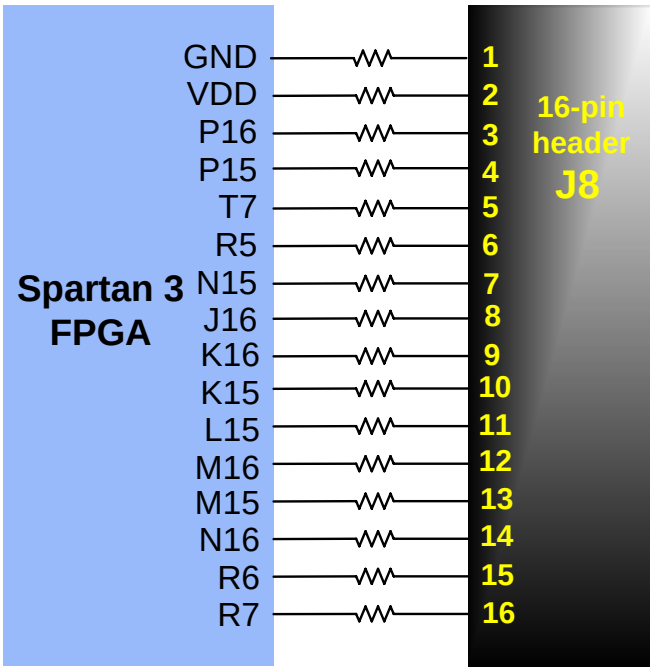
The USB port on the Nexys board can also accommodate data transfer with the PC. The Adept Suite provides a software interface to assist the user with this function as well. The USB circuit on the Nexys allows great flexibility when using the board.



6-pin header connectors

The Nexys board provides four 6-pin peripheral module connectors. Each connector provides Vdd, GND, and four unique FPGA signals. All four 6-pin header circuits have short circuit protection resistors and ESD protection Diodes.

Several 6-pin module boards that can attach to this connector are available from Digilent, including speaker boards, H-bridge boards, sensor boards, etc. Please see www.digilentinc.com for more information.



16-pin header connectors

The Nexys board provides a 16-pin header connector for use with several

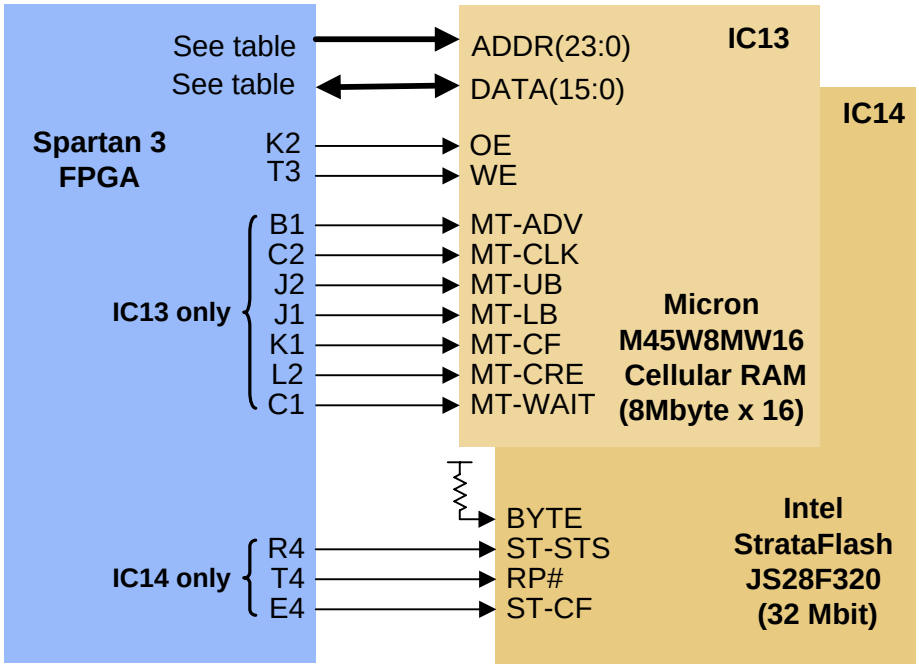
16-pin interface modules that are currently in design or production. The 16-pin interface is designed to provide for the use of a VGA module, a character LCD module and a Graphic LCD Module. The connector provides Vdd, GND, and fourteen unique FPGA signals. The 16 pin header has short circuit protection resistors.

Several 6-pin module boards that can attach to this connector are available from Digilent, including speaker boards, H-bridge boards, sensor boards, etc. Please see www.digilentinc.com for more information.

Memory

The Nexys contains an Intel JS28F320J3, 32 Mbit StartaFlash and a Micron MT45W8MW16 128Mbit Cellular RAM. These two devices share the OE, WE and all ADDRESS and DATA control signals.

FPGA Pin Assignment Tables



Hirose FX2 Connector Pin Assignments					
J1A	**Name**	**FPGA**	**J1B**	**Name**	**FPGA**
1	VCC3V3		1	SHIELD	
2	VCC3V3		2	GND	
3	TMS	C13	3	TDO-ROM	
4	JTSEL		4	TDK	C14
5	TDO-FX2		5	GND	
6	FX2-IO1	B4	6	GND	
7	FX2-IO2	A4	7	GND	
8	FX2-IO3	C5	8	GND	
9	FX2-IO4	B5	9	GND	
10	FX2-IO5	E6	10	GND	
11	FX2-IO6	D6	11	GND	
12	FX2-IO7	C6	12	GND	
13	FX2-IO8	B6	13	GND	
14	FX2-IO9	E7	14	GND	
15	FX2-IO10	D7	15	GND	
16	FX2-IO11	C7	16	GND	
17	FX2-IO12	B7	17	GND	
18	FX2-IO13	D8	18	GND	
19	FX2-IO14	C8	19	GND	
20	FX2-IO15	A10	20	GND	
21	FX2-IO16	B10	21	GND	
22	FX2-IO17	D10	22	GND	
23	FX2-IO18	E10	23	GND	
24	FX2-IO19	B11	24	GND	
25	FX2-IO20	C11	25	GND	
26	FX2-IO21	D11	26	GND	
27	FX2-IO22	E11	27	GND	
28	FX2-IO23	B12	28	GND	
29	FX2-IO24	C12	29	GND	
30	FX2-IO25	A13	30	GND	
31	FX2-IO26	B13	31	GND	
32	FX2-IO27	A14	32	GND	
33	FX2-IO28	B14	33	GND	
34	FX2-IO29	B16	34	GND	
35	FX2-IO30	C16	35	GND	
36	FX2-IO31	C15	36	GND	
37	FX2-IO32	D14	37	GND	
38	FX2-IO33	D15	38	GND	
39	FX2-IO34	D16	39	GND	
40	FX2-IO35	E15	40	GND	
41	FX2-IO36	E16	41	GND	
42	FX2-IO37	F14	42	GND	
43	FX2-IO38	F15	43	GND	
44	FX2-IO39	H15	44	GND	
45	FX2-IO40	H16	45	GND	
46	GND		46	FX2-CLKIN	C9
47	FX2-CLKOUT	D9	47	GND	
48	GND		48	FX2-CLKIO	B8
49	VCCFX2		49	VCCFX2	
50	VCCFX2		50	SHIELD	

Memory Pin Assignments			
ADDR Pin	**FPGA Pin**	**DATA Pin**	**FPGA Pin**
ADR23	C3	DB15	D2
ADR22	A3	DB14	E2
ADR21	M4	DB13	D1
ADR20	D3	DB12	E1
ADR19	G5	DB11	F2
ADR18	H3	DB10	G2
ADR17	G4	DB9	G1
ADR16	L4	DB8	H1
ADR15	F3	DB7	R3
ADR14	M3	DB6	R1
ADR13	L5	DB5	P1
ADR12	N3	DB4	P2
ADR11	F5	DB3	N1
ADR10	F4	DB2	N2
ADR9	E3	DB1	M1
ADR8	G3	DB0	M2
ADR7	K4		
ADR6	H4		
ADR5	K3		
ADR4	J4		
ADR3	L3		
ADR2	K5		
ADR1	J3		

PMOD Expansion Connector Pin Assignments											
Pin	**Name**	**FPGA Pin**	**Pin**	**Name**	**FPGA Pin**	**Pin**	**Name**	**FPGA Pin**	**Pin**	**Name**	**FPGA Pin**
1	JA-1	T14	1	JB-1	T12	1	JC-1	D5	1	JD-1	A9
2	JA-2	R13	2	JB-2	R11	2	JC-2	P9	2	JD-2	A12
3	JA-3	T13	3	JB-3	P8	3	JC-3	A5	3	JD-3	C10
4	JA-4	R12	4	JB-4	T10	4	JC-4	A7	4	JD-4	D12
5	GND		5	GND		5	GND		5	GND	
6	VCC		6	VCC		6	VCC		6	VCC	