# NetFPGA-1G-CML™ Board Reference Manual

**Revised February 15, 2018**
**This manual applies to the NetFPGA-1G-CML rev. F**

## Overview

The NetFPGA-1G-CML is a versatile, low-cost network hardware development platform featuring a Xilinx® Kintex®-7 XC7K325T FPGA and includes four Ethernet interfaces capable of negotiating up to 1 GB/s connections. 512 MB of 800 MHz DDR3 can support high-throughput packet buffering while 4.5 MB of QDRII+ can maintain low-latency access to high demand data, like routing tables. Rapid boot configuration is supported by a 128 MB BPI Flash, which is also available for non-volatile storage applications. The standard PCIe form factor supports high speed x4 Gen 2 interfacing. The FMC carrier connector provides a convenient expansion interface for extending card functionality via Select I/O and GTX serial interfaces. The FMC connector can support SATA-II data rates for network storage applications. The FMC connector can also be used to extend functionality via a wide variety of other cards designed for communication, measurement, and control.



*The NetFPGA-1G-CML board.*

- Xilinx Kintex-7 XC7K325T-1FFG676 FPGA
- Low-jitter 200 MHz oscillator
- Four 10/100/1000 Ethernet PHYs with RGMII
- X4 Gen 2 PCI Express
- X16 4.5 MB QDRII+ static RAM (450 MHz)
- X8 512 MB DDR3 dynamic RAM (800 MHz)
- 1-Gbit BPI Flash
- SD card slot
- 32-bit PIC microcontroller
- USB microcontroller
- Real time clock
- Crypto-authentication chip
- High pin count FMC connector (VITA 57) with 100 Select-IO and 4 GTX serial pairs
- Two Pmod ports
- Four on-board LEDs and four on-board general-purpose buttons

The NetFPGA-1G-CML is designed to support the Stanford NetFPGA architecture with reference designs available through the NetFPGA GitHub Organization (www.github.com/organizations/NetFPGA). It is fully compatible with Xilinx Vivado™ and ISE® Design Suites as well as Xilinx SDK for embedded software design.

The Kintex-7 XC7K325T-1FFG676 FPGA has ample logic and I/O capacity for supporting a wide range of designs with the following capabilities:

- 50,950 slices, each containing four 6-input LUTs and eight flip-flops
- Over 16 Mbit of fast on-chip block RAM
- Ten clock management tiles with one PLL and one mixed-mode clock manager each
- 840 DSP slices
- Integrated PCI Express
- Integrated AES bitstream encryption and SHA-256 authentication with battery-backed encryption key
- 400 Select I/O ports (250 high range, 150 high speed)
- Eight 6.6 Gb/s GTX serial transceivers
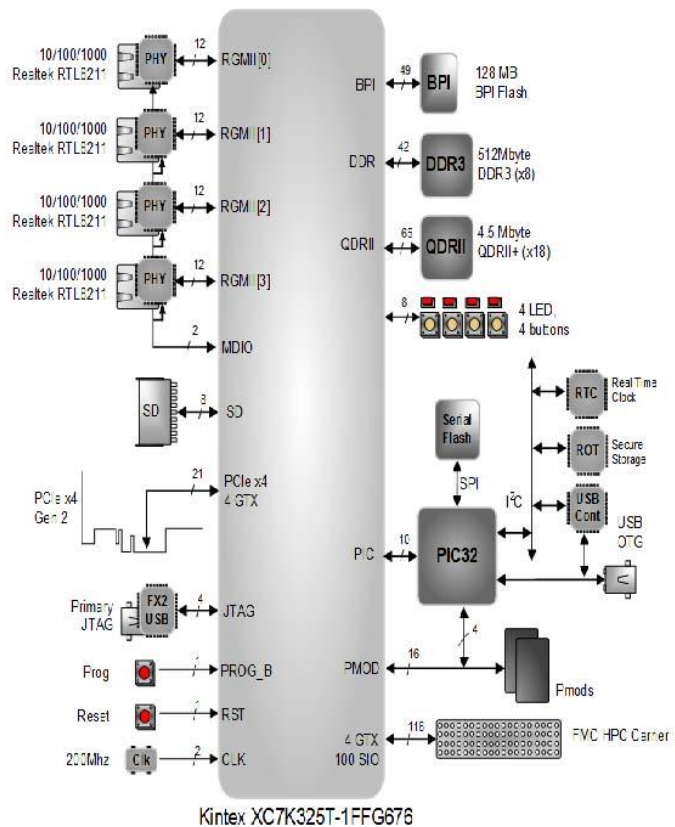
# 1    FPGA Configuration

The system logic configuration is stored within the FPGA in SRAM-based memory cells. This data defines the FPGA's logic functions and circuit connections, but it is volatile since it remains valid only as long as power is applied. Because of this, the device is configured (i.e., programmed) every time it is turned-on. In addition, it may also be re-configured at any time power is applied. Once power is removed, the most recently programmed logic configuration is lost. The configuration data is commonly called a bitstream which is most often contained in files of type ".bit" or ".mcs". These files may be created several different ways using Xilinx development software.

The FPGA may be configured from three different sources. These include the on-board BPI flash, an off-board USB flash drive, or via a PC. The NetFPGA-1G follows a specific configuration sequence when it powers up and comes out of reset. If a valid "download.bit" file is detected on an attached UBS flash drive, that bitstream will be used to program the FPGA. The flash drive must be FAT formatted, contain a single "download.bit" file, and be attached to the USB-HOST port (J13) with jumper JP4 in place. If no flash drive bitstream is detected, an attempt will be made to configure the device from the on-board BPI flash address 0x0. If no flash bitstream is available, the board idles until it is programmed from a PC. PC programming can be done either via a USB cable connected to the USB PROG port (J12), or a JTAG programming cable connected to the Xilinx PROG CABLE port (J15). Any flash drive bitstreams that are not built for the Xilinx XC7K325T FPGA will be ignored. This power-on programming sequence can be re-initiated at any time after power is applied by depressing the red PROG button (BTN5).

Both Digilent and Xilinx distribute free software that can be used to transfer bitstreams from a PC as well as create bitstream files to load via a flash drive. Digilent's Adept and Xilinx's iMPACT applications can directly program the FPGA using a .bit file a standard USB A to Micro B cable connected to J12 or through any of several Digilent JTAG programming cables connected to J15. The on-board BPI flash is programmed via similar means. When

programming the BPI, iMPACT transfers a .mcs format bitstream to the flash in a two-step process. iMPACT first programs the FPGA directly with a special purpose BPI flash interface. It will then transfer the .mcs bitstream to the flash through that interface. This process is fully automated by the iMPACT program, so a designer only needs to be concerned with the creation of the .mcs file using Xilinx's design software.

More details on configuring the XC7K325T FPGA via the on-board BPI (using Master BPI mode), via the PIC USB-HOST (using Slave Serialmode), and via the JTAG mode can be found in the Xilinx *7 Series FPGAs Configuration User Guide* (UG470).

# 2    Power Supplies

The NetFPGA-1G requires a 12V, 5A, or greater power source. Power is supplied via the J17 Molex connector at the rear of the PCB, as is often done with high performance PC graphics cards. *No power is supplied via the PCIe motherboard bus connector.*

The NetFPGA-1G can be powered using the 6-pin PCIe power supply connector (Fig. 1) of any standard ATX power supply. When installed on a PC motherboard, you can directly plug the 6-pin PCIe power supply connector of your PC power supply into J17. When used standalone (without a motherboard), you need to short pins 15 and 16 (pulling down PS_ON signal) of the main 20-pin connector of the standard ATX power supply to power-on the ATX unit (Fig.1).



*Figure1. Left: NetFPGA-1G can be powered by plugging the 6-pin PCIe power connector in J17; Right: Pin 16 and 17 are shorted using a jumper to power on a standard ATX power supply when used standalone.*

Analog Devices voltage regulators provide a number of on-board power and reference voltages that are derived from the main 12V supply, as shown in Table 1. Supply power-on and power-off sequencing follows manufacturer recommendations. The on-board battery that supports encryption key storage and the real-time clock is charged when the PCB is powered on and should not need to be replaced during the lifetime of the board.

VADJ controls the signal levels used between the FMC connector and two FPGA Select I/O banks and can be set to 1.2 V, 1.8 V, 2.5 V, or 3.3 V as needed. The board is shipped with the VADJ supply turned off. To turn on VADJ, jumper JP5 is installed and the FPGA is configured to drive the VADJ_EN pin (AD16) high. The VADJ voltage is selected via the FPGA configuration using pins AF19 and AF20 as shown in Table 1.

When jumper JP4 is in place, the USB HID connector provides 5V at up to 0.5 A to external USB devices, including keyboards, mice, and thumb drives. An Analog Devices ADM1177 hot swap controller and power monitor is used to allow safe device attachment and removal while the board is powered up. The PIC can also measure USB current and voltage by accessing the on-chip power monitor via the PIC I2C peripheral bus.

The Xilinx *Kintex-7 Data Sheet: DC and AC Switching Characteristics* (DS182) provides more information on the power supply requirements of the FPGA board.

| Supply | Derived From | Application | | |
|---|---|---|---|---|
| 5.0 V | 12.0 V | USB HID; FMC | | |
| 3.3 V | 12.0 V | SD Card; Ethernet PHYs; Cypress FX2LP; Microchip PIC; BPI Flash; FPGA I/O Banks 14,15; FMC; Pmods | | |
| 2.0 V | 5.0 V | FPGA auxiliary supply, $VCC_{BAT}$; Backup battery; Real-time clock backup. | | |
| 1.8 V | 12.0 V | QDRII+ supply | | |
| 1.8 V | 3.3 V | FPGA GTX transceiver Quad PLL | | |
| 1.5 V | 12.0 V | DDR3; FPGA I/O Bank 34 | | |
| 1.2 V | 12.0 V | FPGA GTX transceiver termination | | |
| 1.0 V | 12.0 V | FPGA GTX analog supply | | |
| 1.0 V | 3.3 V | FPGA Core | | |
| 0.9 V | 3.3 V | QDRII+ reference | | |
| 0.75 V | 3.3 V | DDR3 reference | | |
| VADJ | 12.0 V | FPGA I/O Banks 12, 13; FMC; Configurable. | | |
| | | SET_VADJ2 FPGA AF20 | SET_VADJ1 FPGA AF19 | VADJ |
| | | 0 | 0 | 1.2 V |
| | | 0 | 1 | 1.8 V |
| | | 1 | 0 | 2.5 V |
| | | 1 | 1 | 3.3 V |

*Table 1. On-board power supplies.*

# 3    Oscillators and Clocks

On-board oscillators support various board subsystems. A low-jitter 125 MHz oscillator is provided for the Ethernet PHYs and a 50 MHz oscillator drives the FPGA master configuration clock. The Cypress FX2LF and Microchip PIC microcontroller each contain on-chip oscillators running at 24 MHz and 8 MHz, respectively.

The main FPGA system clock is provided by an ultra-low-jitter 200 MHz differential oscillator connected to pins AA2 and AA3 in I/O bank 34. This can drive up to ten internal PLLs (Phase Locked Loops) and MMCMs (Mixed-Mode Clock Managers) on the FPGA for high-performance multi-clock-domain designs. Please refer to the Xilinx *7-Series Clock Resources User Guide* (UG472) for more details on FPGA internal clocking resources.

# 4    FPGA Memory

The XC7K325T FPGA includes 445 on-chip Block RAMs (BRAMs) of 36Kb, or 4096 bytes with two-bit error correction, which amounts to a total of 1.78 MB of on-chip, error-corrected static RAM that can be used for a variety of purposes ranging from program storage for deeply embedded "bare metal" applications to data

buffering and table lookup. Each 36Kb BRAM can be partitioned into two completely independent 18Kb RAMs to help facilitate more efficient hardware utilization. Furthermore, each BRAM can be configured for dual-port operation and includes register infrastructure tp support FIFO functionality. These BRAM ports can be organized in either single or dual-clock configurations. The Xilinx tool chain includes a rich selection of resources for on-chip BRAM configuration and initialization. Further information is provided in the Xilinx *7-Series FPGAs Memory Resources User Guide* (UG473).

# 5    DDR3 Memory

The NetFPGA-1G includes a Micron MT41K512M8 512 MB DDR3 SDRAM which employs an 800 MHz byte-wide data bus capable of operating at a data rate of 1600 MT/s. Project development with the SDRAM involves using the Xilinx Memory Interface Generator (MIG) in either the XPS design tool or the Vivado Design Suite. The MIG is an interface generation wizard for selecting part types and configuring FPGA Select I/O resources for the memory hardware interface. The interface is automatically configured by the MIG for use with the AXI4 system bus and provides options for 2:1 or 4:1 memory-to-bus clock ratios. The NetFPGA-1G uses a VCC$_{AUX-IO}$ of 2.0V to support high performance DDR3 frequency settings. Please see the Xilinx *7 Series FPGAs Memory Interface Solutions User Guide* (UG586) and the Micron *4Gb:x4,x8,x16 DDR3L SDRAM* data sheet for more details.

# 6    QDRII+ Memory

A 4.5 MB Cypress CY7C2263KV18 QDRII+ Quad Data Rate SRAM is provided for applications that require high speed, low-latency memory. Common applications include FIFO buffers and table lookups. The notion of "Quad" data rate comes from the ability to simultaneously read from a unidirectional read port and write to a unidirectional write port on both clock edges. The NetFPGA-1G QDRII+ is capable of operating at up to 450MHz to yield data transfer rates of up to 900 MT/s per 2-byte port. This yields a peak bandwidth of up to 3.6 GB/s. The Xilinx Memory Interface Generator (MIG) is able to generate and configure an AXI4 based interface into the QDRII+ via the user friendly wizard tool. More information regarding the QDRII+ memory part and the Xilinx MIG tool can be found in the Cypress *CY7C2263KV18/CY7C2265KV18 data sheet*, the Cypress Application Note *QDR-II, QDR-II+, DDR-II, DDR-II+ Design Guide* (AN4065), and the Xilinx *7 Series FPGAs Memory Interface Solutions User Guide* (UG586).

# 7    BPI Flash Memory

A 1-Gbit Numonyx BPI (Byte Peripheral Interface) flash memory in a 128 MB x16 configuration is provided to support high-speed FPGA configuration after board reset. High-speed single-step configuration enables enumeration via the PCIe interface within 100 mS, as required by the PCI specification. In BPI configuration mode, the FPGA acts as the bus master, driving the flash address and control signals to transfer previously stored bitstream data into the configuration SRAM.

The BPI flash has enough capacity to store multiple device configurations. This facilitates multi-stage configuration boot as well as applications that utilize dynamic reconfiguration. Configuration bitstreams are not the only data which can be stored in the BPI flash. After configuration is complete, the BPI programming pins may be used as normal Select I/O within the design. As a result, non-volatile data of any type can also be stored to and retrieved from the BPI after device configuration is complete. More information regarding BPI based device configuration is

available in the Xilinx *7-Series FPGAs Configuration User Guide* (UG470) and application note XAPP587 *BPI Fast Flash Memory* data sheet for more specifics regarding device operation.

# 8    SD Card

The NetFPGA-1G SD card connector supports a second non-volatile storage resource which is also removable. This connector supports a standard size SD memory card and meets all physical layer requirements of both SPI and SD bus protocols. It supports the UHS-I pin assignment standard (but *not* UHS-II) and provides high speed signaling at 3.3V to support SC, HC, and XC class SD cards. Please see *SD Specifications Part 1 Physical Layer Simplified Specification* by the Technical Committee of the SD Card Association for more details regarding the use of SD memory cards with this connector.

# 9    PCIe Interface

The NetFPGA-1G is designed with a PCI-Express form factor to support interconnection with common processor motherboards. Four of the FPGA's eight high speed serial GTX transceivers are dedicated to implementing up to four-lanes of Gen. 2.0 (5 GB/s) PCIe communications with a host processing system. These transceivers work in conjunction with the on-chip 7 Series Integrated PCI Express Block and synthesizable on-chip logic to provide a scalable, high performance PCI Express I/O core.

This core is configured and incorporated into designs using either the Xilinx ISE Coregen tool or via instantiation and customization from the Vivado Design Suite IP catalog. Please refer to the Xilinx *7 Series FPGAs Integrated Block for PCI Express V2.0* (PG054) product guide and *7 Series FPGAs GTX/GTH Transceivers* (UG476) user guide for more information.

# 10   Ethernet PHYs

Four Realtek RTL8211 Ethernet transceivers (PHYs) are provided to interface to network connections via on-board RJ-45 connectors. Each RJ-45 has two LEDs to indicate link status and activity. Each PHY controls three LEDs: two on an associated RJ-45 and a third on-board (LD5-LD8). The Phys are programmed via a shared MDIO bus and are accessed via MDIO addresses 1 through 4: corresponding to connectors ETH1 through ETH4 on the PCB. At reset, each PHY defaults to 1Gbps with the LED configuration shown in Table 2.

On each RJ45, the bottom LED is the one that is closest to the PCIe connector. The default behavior of the on-board LED is to mimic that of the top RJ45 LED. The default auto-negotiation behavior allows each PHY to independently adjust its rate to 10/100 Mbps or 1Gbps as needed.

Data is transferred to and from the PHYs via a Reduced Gigabit Media Independent Interface (RGMII). This is similar to the Gigabit Media Independent Interface (GMII), which uses eight bits for both transmit and receive data. RGMII achieves the same data rate with half the number of data bits and double-data-rate clocking. 1 Gbps data transfers are thereby achieved using a 125MHz clock with four bits transferred on each clock edge for both send and receive. This provides a significant reduction in the number of FPGA I/O pins required to support the four Ethernet interfaces.

Xilinx provides Ethernet MAC IP that will support 10/100/1000 Mb/s via the ISE Design Suite Coregen tool and the Vivado design suite. Please refer to Xilinx Product Guide PG051 *LogiCORE IP Tri-Mode Ethernet MAC* for more information.

| LED | Action | Meaning |
| --- | --- | --- |
| RJ45 Top | Slow blink | Connection Negotiation Complete |
| | On | Link activity present |
| RJ45 Bottom | Off | No link activity |
| | Fast blink | Link activity present |

*Table 2. RJ-45 Ethernet Connector LED Function.*

# 11    PIC Subsystem

NetFPGA-1G includes a 32-bit PIC microcontroller for managing USB OTG, real-time clock, and secure storage interfacing. The PIC is pre-programmed with manufacturing test code and an ability to load FPGA bitstreams from a USB memory stick. It is possible to re-program the PIC to support end-user applications that make use of various other PIC subsystem features. This may be done via J14 using a PICKit 3 In-Circuit Debugger (Digilent p/n PG164130).

To run the pre-programmed manufacturing test, first set up the NetFPGA-1G and host PC as described in Appendix A: Manufacturing Test. When the board is powered on, the factory-loaded PIC firmware will search for the bitstream "mfg_test.bit" on the USB flash drive and use it to configure the FPGA in slave serial mode. After the FPGA has been configured, a test menu will be displayed on the terminal emulator window connected to the PmodUSBUART, and the user can run the tests by following the menu prompts. If the board is set up as described in Appendix A, all tests should pass.

The address map of the PIC I2C peripherals is shown in Table 3. The PIC is also connected to an MX25L12835E SPI Serial Flash using general-purpose I/O ports for increased data storage. The flash's pins are connected to the PIC ports as shown in Table 4.

To program the PIC device, connect a PICkit 3 to the NetFPGA-1G by placing a 1x6 pin header in the zig-zag connector J14 and connect it to the PICkit 3 using a 6-pin cable. If Digilent's 6-pin Pmod cable is used, the white indicator dot on the NetFPGA-1G side should be above pin 6, and the dot on the PICkit 3 side will be face-up and opposite the white arrow on the PICkit 3. The PIC can then be programmed from Microchip's MPLAB X or MPLAB IPE by selecting the PICkit 3 as the programming tool.

| Component Name | PIC I2C Controller | I2C 7-bit Address |
| --- | --- | --- |
| AD5274 Digital Rheostat | I2C2 | 0101110 |
| ADM1177 Hot Swap Controller | I2C2 | 1011011 |
| ATSHA204 CryptoAuthentication | I2C2 | 1100100 |
| M41T62 Real-Time Clock | I2C2 | 1101000 |
| 24LC128 Serial EEPROM | I2C1 | 1010001 |

*Table 3. PIC I²C peripheral address map.*

| Flash Pin | PIC Port |
|-----------|----------|
| CS | RB10 |
| SCLK | RB11 |
| SI | RB12 |
| SO | RB13 |
| WP | RB14 |
| HOLD | RB15 |

*Table 4. PCI Flash connections.*

# 12   On-Board I/O

Built-in on-board I/O includes four LEDs and six buttons. Four of the buttons are general-purpose and two are set aside for special functions. The red special function buttons are reserved for use as an on-chip reset (BTN4 - RESET) to reset the design logic and a configuration reset (BTN5 – PROG) which initiates a new FPGA configuration sequence like that which occurs at power-on. It is important to note that the buttons and LEDs are not all constrained to the same IOSTANDARD on their associated ports, since they are connected to otherwise un-allocated ports in different FPGA IO banks. Please refer to Appendix B for specific details regarding the button and LED IO port constraints.

# 13   Pmod Expansion Connectors

The NetFPGA-1G has two 12-pin ports to support I/O expansion via Digilent Pmods. Digilent manufactures Pmod accessories that support a large variety of external interfaces that increase system flexibility. The Pmod ports are 2x6 right-angle 100-mil female connectors that work with the standard 2x6 headers available from a variety of distributors. On the NetFPGA-1G, each 12-pin Pmod ports provides two 3.3V VCC supply connections (pins 6 and 12), two Ground connections (pins 5 and 11), and eight logic signals (Fig. 2). The supply pins can provide up to 1A of current to connected Pmod devices. The logic signals are not matched pairs. They are routed without impedance control or delay matching. Note also that the ports are not keyed, so care should be taken to verify that any connected devices have Pin 1 aligned with Pin 1 on the connector. Pin 1, VCC, and GND are clearly labeled on the PCB to help simplify proper connection.
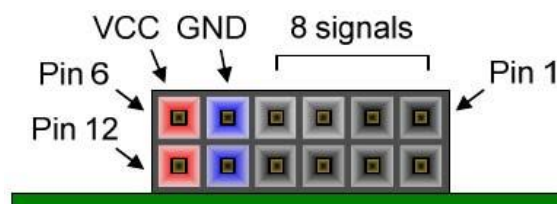


*Figure 2. Pmod ports, end view.*

# 14   Expansion Connector

The NetFPGA-1G includes a VITA-57 compatible FMC (FPGA Mezzanine Card) carrier connector. A High Pin Count (HPC) connector is used to provide the maximum possible compatibility with a variety of commercially available mezzanine cards. Select I/O ports on the XC7K325T are connected to all of the standard Low Pin Count (LPC) signals on the connector, but only 22 of the HPC signals are supported due to the limitations of the FF676 package. Up to four differential send/receive pairs for GTX transceivers are also supported.

The FMC interface signals are driven by two Select I/O banks within the FPGA. Signal drive voltages within these banks are configured together to match the various requirements of different mezzanine cards. These banks are disabled on the board when shipped, but jumper JP5 (VADJ ENABLE) can be installed to prepare these I/O banks for use with the FMC connector. Three control outputs are then included in the FPGA design configuration to set the FMC signaling voltage and enable it. Those signals are VADJ_EN, SET_VADJ1, SET VADJ2, and are set according to Table 1. Keep in mind that the IOSTANDARD required by the pin constraints associated with the FMC interface will depend upon the VADJ selected, and that these VADJ programming signals should be set to constants within the design.

Please refer to the American National Standards Institute *ANSI/VITA 57.1 FPGA Mezzanine Card (FMC) Standard* for additional detail regarding standard FMC module and carrier requirements. Refer to Appendix B for specific I/O constraints relating FPGA pins to their associated FMC control and connector pins.

# Appendix A: Manufacturing Test

The following hardware is required to run all NetFPGA-1G Manufacturing tests:

- 1x HiTechGlobal PCI Express Test/SMA Breakout Board
- 8x SMA to SMA cable, 24"
- 2x Ethernet cables
- 1x NetFGPA-7 FMC Test Card
- 1x SD card, any size, loaded with an ASCII text file named "message.txt"
- 1x Micro (male) to Type A (female) USB adapter
- 1x USB thumb drive loaded with the production test bitstream, "mfg_test.bit"
- 1x PmodUSBUART
- 2x 6 pin connector cable, 6"
- 1x Micro (male) to Type A (male) USB cable
- 2x 1x6 pin headers
- 46x 2 pin block jumpers
- 12 V power supply

If debug information in addition to pass/fail messages regarding manufacturing tests related to the FPGA is desired, an additional PmodUSBUART, 6 pin connector cable, and micro (male) to type A (male) USB cable is needed.

The following summary describes how to set up the manufacturing test hardware with the NetFPGA-1G:

a) Load jumpers JP4 (USB HOST) and JP5 (VADJ ENABLE)
b) For both Pmod headers JA and JB, plug a 1x6 pin header in the bottom row (pins 7-12) and place a jumper across pins 7-8 and another across pins 9-10
c) Connect the NetFPGA-7 FMC Test Card to the FMC connector J11 and load all the jumper blocks horizontally (1 <-> 2, 3 <-> 4, 5 <-> 6, etc.)
d) Connect one Ethernet cable between ETH1 and ETH2, and another between ETH3 and ETH4
e) Connect the USB thumb drive containing "nf7_test.bit" to J13 using the micro to type A adapter cable
f) Plug the SD card containing "message.txt" into the SD connector J10
g) Connect a PmodUSBUART to pins 1-6 of JA using a 6 pin connector cable, and connect the PmodUSBUART to a host machine using a micro to type A USB cable
h) Plug the NetFPGA-7 into the HTG PCIe test card. Loop the RX0-3 pairs on the HTG card to the TX0-4 pairs using SMA cables (RX0P <-> TX0P, RX0N <-> TX0N, etc.). Set switches 1-3 on the HTG card to 000. Additionally, power the HTG card with a Molex connector from a standard PC power supply, and ensure the power switch is set to ATX
i) Plug a PCIe power connector from a standard PC power supply into J17 on the NetFPGA-7
j) If FPGA debug information is desired, connect the additional PmodUSBUART, 6 pin connector cable, and micro (male) to type A (male) USB cable to pins 1-6 of Pmod port JB and a host machine

Many tests can be run independently without the need for additional hardware. For example, the HiTech Global Breakout Board is only needed to test the PCIe edge connector. More details regarding individual tests are provided in the *NetFPGA-1G Manufacturing Test Reference Manual* available on the Digilent web site.

# Appendix B: FPGA Pin Constraints

The following list provides LOC and IOSTANDARD constraints for the main peripheral pins connected to the FPGA. This information can be used in a design UCF file with Xilinx ISE Design Suite, a design XDC file with Xilinx Vivado Design Suite, or with various interface generators included with Xilinx Coregen and MIG. Please see the Xilinx *Constraints Guide* (UG625) for ISE Design Suite based designs and Xilinx *Vivado Design Suite User Guide: Using Constraints* (UG903) for Vivado based designs.

Depending upon the design suite selected, this information can be expressed in either a UCF file or an XDC file as follows:

*UCF format used with ISE Design Suite*
```
NET <port name> LOC=<io location> | IOSTANDARD=<io standard type>;
```

*XDC format used with Vivado Design Suite*
```
set_property IOSTANDARD <io standard type> [get_ports { <port list> }]
set_property LOC <io location> [get_ports <port name>]
```

The information is presented in UCF format to express a clear association between the pin and the desired IO standard for the NetFPGA-1G, although it can be readily translated into the XDC format. LOC information is provided here for all pins. IOSTANDARD information is provided for SelectIO pins. Other useful properties are suggested where appropriate.

## System Clock and Reset

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET reset | LOC = AA8 | IOSTANDARD=LVCMOS18; # RESET button (BTN4) |
| NET system_clk_p | LOC = AA3 | IOSTANDARD=LVDS; |
| NET system_clk_n | LOC = AA2 | IOSTANDARD=LVDS; |

## DDR3 SDRAM

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET ddr3_dq[0] | LOC = AE5 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[1] | LOC = AE3 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[2] | LOC = AD4 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[3] | LOC = AF3 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[4] | LOC = AE1 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[5] | LOC = AF2 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[6] | LOC = AD1 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_dq[7] | LOC = AE2 | IOSTANDARD = SSTL15_T_DCI; |
| NET ddr3_addr[0] | LOC = Y3 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[1] | LOC = Y2 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[2] | LOC = W3 | IOSTANDARD = SSTL15; |

| | | |
|---|---|---|
| NET ddr3_addr[3] | LOC = W5 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[4] | LOC = AB2 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[5] | LOC = W1 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[6] | LOC = AC2 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[7] | LOC = U2 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[8] | LOC = AB1 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[9] | LOC = V1 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[10] | LOC = AD6 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[11] | LOC = Y1 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[12] | LOC = AC3 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[13] | LOC = V2 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[14] | LOC = AC1 | IOSTANDARD = SSTL15; |
| NET ddr3_addr[15] | LOC = AD5 | IOSTANDARD = SSTL15; |
| NET ddr3_ba[0] | LOC = AA5 | IOSTANDARD = SSTL15; |
| NET ddr3_ba[1] | LOC = AC4 | IOSTANDARD = SSTL15; |
| NET ddr3_ba[2] | LOC = V4 | IOSTANDARD = SSTL15; |
| NET ddr3_ras_n | LOC = Y6 | IOSTANDARD = SSTL15; |
| NET ddr3_cas_n | LOC = Y5 | IOSTANDARD = SSTL15; |
| NET ddr3_we_n | LOC = U5 | IOSTANDARD = SSTL15; |
| NET ddr3_reset_n | LOC = U1 | IOSTANDARD = LVCMOS15; |
| NET ddr3_cke[0] | LOC = AB5 | IOSTANDARD = SSTL15; |
| NET ddr3_odt[0] | LOC = U7 | IOSTANDARD = SSTL15; |
| NET ddr3_cs_n[0] | LOC = U6 | IOSTANDARD = SSTL15; |
| NET ddr3_dm[0] | LOC = AE6 | IOSTANDARD = SSTL15; |
| NET ddr3_dqs_p[0] | LOC = AF5 | IOSTANDARD = DIFF_SSTL15_T_DCI; |
| NET ddr3_dqs_n[0] | LOC = AF4 | IOSTANDARD = DIFF_SSTL15_T_DCI; |
| NET ddr3_ck_p[0] | LOC = AA4 | IOSTANDARD = DIFF_SSTL15; |
| NET ddr3_ck_n[0] | LOC = AB4 | IOSTANDARD = DIFF_SSTL15; |

## QDRII+

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET qdriip_d[0] | LOC = V8 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[1] | LOC = V7 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[2] | LOC = W9 | IOSTANDARD = HSTL_I; |

| NET qdriip_d[3] | LOC = Y11 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[4] | LOC = Y8 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[5] | LOC = Y7 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[6] | LOC = W10 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[7] | LOC = Y10 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[8] | LOC = V9 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[9] | LOC = AF8 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[10] | LOC = AE8 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[11] | LOC = AF9 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[12] | LOC = AF10 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[13] | LOC = AE10 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[14] | LOC = AD10 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[15] | LOC = AD11 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[16] | LOC = AF13 | IOSTANDARD = HSTL_I; |
| NET qdriip_d[17] | LOC = AE13 | IOSTANDARD = HSTL_I; |
| NET qdriip_q[0] | LOC = AA14 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[1] | LOC = AD14 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[2] | LOC = Y15 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[3] | LOC = AA15 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[4] | LOC = AC14 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[5] | LOC = AB14 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[6] | LOC = Y16 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[7] | LOC = AB15 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[8] | LOC = AC16 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[9] | LOC = AE20 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[10] | LOC = AD19 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[11] | LOC = AD18 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[12] | LOC = AC19 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[13] | LOC = AB20 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[14] | LOC = AA20 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[15] | LOC = AD20 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[16] | LOC = AC17 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_q[17] | LOC = AB17 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_sa[0] | LOC = AC9 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[1] | LOC = AF7 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[2] | LOC = AA9 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[3] | LOC = AD8 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[4] | LOC = AC8 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[5] | LOC = AB7 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[6] | LOC = AB12 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[7] | LOC = AD13 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[8] | LOC = AC11 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[9] | LOC = AC12 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[10] | LOC = Y12 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[11] | LOC = AB11 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[12] | LOC = AB10 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[13] | LOC = AA13 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[14] | LOC = AC13 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[15] | LOC = Y13 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[16] | LOC = AA12 | IOSTANDARD = HSTL_I; |
| NET qdriip_sa[17] | LOC = AA10 | IOSTANDARD = HSTL_I; |

| NET qdriip_sa[18] | LOC = AB9 | IOSTANDARD = HSTL_I; |
| NET qdriip_w_n | LOC = AD9 | IOSTANDARD = HSTL_I; |
| NET qdriip_r_n | LOC = AE7 | IOSTANDARD = HSTL_I; |
| NET qdriip_dll_off_n | LOC = AC7 | IOSTANDARD = HSTL_I; |
| NET qdriip_bw_n[0] | LOC = W11 | IOSTANDARD = HSTL_I; |
| NET qdriip_bw_n[1] | LOC = V11 | IOSTANDARD = HSTL_I; |
| NET qdriip_cq_p[0] | LOC = AB16 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_cq_n[0] | LOC = AC18 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_qvld[0] | LOC = AA19 | IOSTANDARD = HSTL_I_DCI; |
| NET qdriip_k_p[0] | LOC = AE12 | IOSTANDARD = DIFF_HSTL_I; |
| NET qdriip_k_n[0] | LOC = AF12 | IOSTANDARD = DIFF_HSTL_I; |

## BPI Flash

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET bpi_clk_out | LOC = C8 | IOSTANDARD = LVCMOS33; |
| NET bpi_we_n | LOC = L18 | IOSTANDARD = LVCMOS33; |
| NET bpi_oe_n | LOC = M17 | IOSTANDARD = LVCMOS33; |
| NET bpi_ce_n | LOC = C23 | IOSTANDARD = LVCMOS33; |
| NET bpi_adv | LOC = D20 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<0> | LOC = J23 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<1> | LOC = K23 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<2> | LOC = K22 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<3> | LOC = L22 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<4> | LOC = J25 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<5> | LOC = J24 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<6> | LOC = H22 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<7> | LOC = H24 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<8> | LOC = H23 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<9> | LOC = G21 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<10> | LOC = H21 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<11> | LOC = H26 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<12> | LOC = J26 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<13> | LOC = E26 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<14> | LOC = F25 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<15> | LOC = G26 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<16> | LOC = K17 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<17> | LOC = K16 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<18> | LOC = L20 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<19> | LOC = J19 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<20> | LOC = J18 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<21> | LOC = J20 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<22> | LOC = K20 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<23> | LOC = G20 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<24> | LOC = H19 | IOSTANDARD = LVCMOS33; |
| NET bpi_addr_cmd<25> | LOC = E20 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<0> | LOC = B24 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<1> | LOC = A25 | IOSTANDARD = LVCMOS33; |

| | | |
|---|---|---|
| NET bpi_data<2> | LOC = B22 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<3> | LOC = A22 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<4> | LOC = A23 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<5> | LOC = A24 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<6> | LOC = D26 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<7> | LOC = C26 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<8> | LOC = C24 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<9> | LOC = D21 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<10> | LOC = C22 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<11> | LOC = B20 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<12> | LOC = A20 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<13> | LOC = E22 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<14> | LOC = C21 | IOSTANDARD = LVCMOS33; |
| NET bpi_data<15> | LOC = B21 | IOSTANDARD = LVCMOS33; |

## SD Card Connector

| Port Name | IO Location | IO Standard Type | |
|---|---|---|---|
| NET sd-cd | LOC = AE15 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET sd-wp | LOC = AF15 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET sd-cclk | LOC = AA18 | IOSTANDARD = LVCMOS18; | |
| NET sd-cmd | LOC = AF18 | IOSTANDARD = LVCMOS18; | |
| NET sd-d0 | LOC = AE17 | IOSTANDARD = LVCMOS18; | |
| NET sd-d1 | LOC = AF17 | IOSTANDARD = LVCMOS18; | |
| NET sd-d2 | LOC = AD15 | IOSTANDARD = LVCMOS18; | |
| NET sd-d3 | LOC = AE18 | IOSTANDARD = LVCMOS18; | |

## PCI Express

| Port Name | IO Location | IO Standard Type | | |
|---|---|---|---|---|
| NET pcie-rx0_p | LOC = H2; | | | |
| NET pcie-tx0_p | LOC = J4; | | | |
| NET pcie-rx0_n | LOC = H1; | | | |
| NET pcie-tx0_n | LOC = J3; | | | |
| NET pcie-rx1_p | LOC = K2; | | | |
| NET pcie-tx1_p | LOC = L4; | | | |
| NET pcie-rx1_n | LOC = K1; | | | |
| NET pcie-tx1_n | LOC = L3; | | | |
| NET pcie-rx2_p | LOC = M2; | | | |
| NET pcie-tx2_p | LOC = N4; | | | |
| NET pcie-rx2_n | LOC = M1; | | | |
| NET pcie-tx2_n | LOC = N3; | | | |
| NET pcie-rx3_p | LOC = P2; | | | |
| NET pcie-tx3_p | LOC = R4; | | | |
| NET pcie-rx3_n | LOC = P1; | | | |
| NET pcie-tx3_n | LOC = R3; | | | |
| NET pcie-clk_p | LOC = H6; | | | |
| NET pcie-clk_n | LOC = H5; | | | |
| NET pcie-perstn | LOC = L17 | IOSTANDARD = LVCMOS33 | PULLUP | NODELAY; |
| NET pcie-wake | LOC = K18 | IOSTANDARD = LVCMOS33; | | |
| NET pcie-prsnt | LOC = AA7 | IOSTANDARD = LVCMOS18; | | |

## Ethernet PHYS

| Port Name | IO Location | IO Standard Type | |
|---|---|---|---|
| NET mdc | LOC = V13 | IOSTANDARD = LVCMOS18; | |
| NET mdio | LOC = W13 | IOSTANDARD = LVCMOS18; | |
| NET phy_rstn_1 | LOC = D18 | IOSTANDARD = LVCMOS33; | |
| NET phy_rstn_2 | LOC = E25 | IOSTANDARD = LVCMOS33; | |
| NET phy_rstn_3 | LOC = K21 | IOSTANDARD = LVCMOS33; | |
| NET phy_rstn_4 | LOC = L23 | IOSTANDARD = LVCMOS33; | |
| NET phy_intrn_1 | LOC = J8 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET phy_intrn_2 | LOC = J14 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET phy_intrn_3 | LOC = K15 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET phy_intrn_4 | LOC = M16 | IOSTANDARD = LVCMOS18 | PULLUP; |
| NET rgmii_rxd_1[0] | LOC = B11 | IOSTANDARD = LVCMOS18; | |
| NET rgmii_rxd_1[1] | LOC = A10 | IOSTANDARD = LVCMOS18; | |
| NET rgmii_rxd_1[2] | LOC = B10 | IOSTANDARD = LVCMOS18; | |

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NET rgmii_rxd_1[3]      LOC = A9     IOSTANDARD = LVCMOS18;
NET rgmii_txd_1[0]      LOC = A8     IOSTANDARD = LVCMOS18;
NET rgmii_txd_1[1]      LOC = D8     IOSTANDARD = LVCMOS18;
NET rgmii_txd_1[2]      LOC = G9     IOSTANDARD = LVCMOS18;
NET rgmii_txd_1[3]      LOC = H9     IOSTANDARD = LVCMOS18;
NET rgmii_rx_ctl_1      LOC = B12    IOSTANDARD = LVCMOS18;
NET rgmii_rxc_1         LOC = E10    IOSTANDARD = LVCMOS18;
NET rgmii_tx_ctl_1      LOC = H8     IOSTANDARD = LVCMOS18;
NET rgmii_txc_1         LOC = B9     IOSTANDARD = LVCMOS18;
NET rgmii_rxd_2[0]      LOC = A13    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_2[1]      LOC = C9     IOSTANDARD = LVCMOS18;
NET rgmii_rxd_2[2]      LOC = D11    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_2[3]      LOC = C11    IOSTANDARD = LVCMOS18;
NET rgmii_txd_2[0]      LOC = D10    IOSTANDARD = LVCMOS18;
NET rgmii_txd_2[1]      LOC = G10    IOSTANDARD = LVCMOS18;
NET rgmii_txd_2[2]      LOC = D9     IOSTANDARD = LVCMOS18;
NET rgmii_txd_2[3]      LOC = F9     IOSTANDARD = LVCMOS18;
NET rgmii_rx_ctl_2      LOC = A12    IOSTANDARD = LVCMOS18;
NET rgmii_rxc_2         LOC = C12    IOSTANDARD = LVCMOS18;
NET rgmii_tx_ctl_2      LOC = F8     IOSTANDARD = LVCMOS18;
NET rgmii_txc_2         LOC = J10    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_3[0]      LOC = A14    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_3[1]      LOC = B14    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_3[2]      LOC = E12    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_3[3]      LOC = D13    IOSTANDARD = LVCMOS18;
NET rgmii_txd_3[0]      LOC = G12    IOSTANDARD = LVCMOS18;
NET rgmii_txd_3[1]      LOC = F13    IOSTANDARD = LVCMOS18;
NET rgmii_txd_3[2]      LOC = F12    IOSTANDARD = LVCMOS18;
NET rgmii_txd_3[3]      LOC = H11    IOSTANDARD = LVCMOS18;
NET rgmii_rx_ctl_3      LOC = C13    IOSTANDARD = LVCMOS18;
NET rgmii_rxc_3         LOC = E11    IOSTANDARD = LVCMOS18;
NET rgmii_tx_ctl_3      LOC = F10    IOSTANDARD = LVCMOS18;
NET rgmii_txc_3         LOC = E13    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_4[0]      LOC = B15    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_4[1]      LOC = F14    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_4[2]      LOC = C14    IOSTANDARD = LVCMOS18;
NET rgmii_rxd_4[3]      LOC = H12    IOSTANDARD = LVCMOS18;
NET rgmii_txd_4[0]      LOC = J13    IOSTANDARD = LVCMOS18;
NET rgmii_txd_4[1]      LOC = G14    IOSTANDARD = LVCMOS18;
NET rgmii_txd_4[2]      LOC = H14    IOSTANDARD = LVCMOS18;
NET rgmii_txd_4[3]      LOC = H13    IOSTANDARD = LVCMOS18;
NET rgmii_rx_ctl_4      LOC = A15    IOSTANDARD = LVCMOS18;
NET rgmii_rxc_4         LOC = G11    IOSTANDARD = LVCMOS18;
NET rgmii_tx_ctl_4      LOC = J11    IOSTANDARD = LVCMOS18;
NET rgmii_txc_4         LOC = D14    IOSTANDARD = LVCMOS18;
```

## PIC Interface

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET pic2fpga_sck | LOC = AA17 | IOSTANDARD = LVCMOS18; |
| NET pic2fpga_sdo | LOC = V16 | IOSTANDARD = LVCMOS18; |
| NET pic2fpga_ss_n | LOC = W16 | IOSTANDARD = LVCMOS18; |

| | | |
|---|---|---|
| NET pic2fpga_gpio0 | LOC = W18 | IOSTANDARD = LVCMOS18; |
| NET pic2fpga_gpio1 | LOC = V17 | IOSTANDARD = LVCMOS18; |
| NET pic2fpga_sdi | LOC = W15 | IOSTANDARD = LVCMOS18; |
| NET fpga2pic_sck | LOC = W14 | IOSTANDARD = LVCMOS18; |
| NET fpga2pic_sdi | LOC = V14 | IOSTANDARD = LVCMOS18; |
| NET fpga2pic_ss_n | LOC = V18 | IOSTANDARD = LVCMOS18; |
| NET fpga2pic_sdo | LOC = V19 | IOSTANDARD = LVCMOS18; |

## On-Board LED and Button I/O

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET led_0 | LOC = E17 | IOSTANDARD = LVCMOS33; |
| NET led_1 | LOC = AF14 | IOSTANDARD = LVCMOS18; |
| NET led_2 | LOC = F17 | IOSTANDARD = LVCMOS33; |
| NET led_3 | LOC = W19 | IOSTANDARD = LVCMOS18; |
| NET btn_0 | LOC = W6 | IOSTANDARD = LVCMOS15; |
| NET btn_1 | LOC = E18 | IOSTANDARD = LVCMOS33; |
| NET btn_2 | LOC = AC6 | IOSTANDARD = LVCMOS15; |
| NET btn_3 | LOC = AB6 | IOSTANDARD = LVCMOS15; |

## Pmod Ports

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET pmod_ja_1 | LOC = D19 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_2 | LOC = E23 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_3 | LOC = D25 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_4 | LOC = F23 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_7 | LOC = F19 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_8 | LOC = G22 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_9 | LOC = D24 | IOSTANDARD = LVCMOS33; |
| NET pmod_ja_10 | LOC = E21 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_1 | LOC = F20 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_2 | LOC = E15 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_3 | LOC = H18 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_4 | LOC = G19 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_7 | LOC = H17 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_8 | LOC = J21 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_9 | LOC = L19 | IOSTANDARD = LVCMOS33; |
| NET pmod_jb_10 | LOC = F18 | IOSTANDARD = LVCMOS33; |

## FMC Connector

IOSTANDARD depends upon VADJ for LA, HA, and CLK pins.

| Port Name | IO Location | IO Standard Type |
|---|---|---|
| NET VADJ_EN | LOC = AD16 | IOSTANDARD = LVCMOS18; |
| NET SET_VADJ1 | LOC = AF19 | IOSTANDARD = LVCMOS18; |
| NET SET_VADJ2 | LOC = AF20 | IOSTANDARD = LVCMOS18; |
| NET FMC_LA00_P | LOC = Y22; | |

| | | |
|---|---|---|
| NET FMC_LA00_N | LOC = AA22; | |
| NET FMC_LA01_P | LOC = N21; | |
| NET FMC_LA01_N | LOC = N22; | |
| NET FMC_LA02_P | LOC = AB22; | |
| NET FMC_LA02_N | LOC = AC22; | |
| NET FMC_LA03_P | LOC = AF24; | |
| NET FMC_LA03_N | LOC = AF25; | |
| NET FMC_LA04_P | LOC = AA25; | |
| NET FMC_LA04_N | LOC = AB25; | |
| NET FMC_LA05_P | LOC = AE23; | |
| NET FMC_LA05_N | LOC = AF23; | |
| NET FMC_LA06_P | LOC = W20; | |
| NET FMC_LA06_N | LOC = Y21; | |
| NET FMC_LA07_P | LOC = AB26; | |
| NET FMC_LA07_N | LOC = AC26; | |
| NET FMC_LA08_P | LOC = AD26; | |
| NET FMC_LA08_N | LOC = AE26; | |
| NET FMC_LA09_P | LOC = Y25; | |
| NET FMC_LA09_N | LOC = Y26; | |
| NET FMC_LA10_P | LOC = W21; | |
| NET FMC_LA10_N | LOC = V21; | |
| NET FMC_LA11_P | LOC = W25; | |
| NET FMC_LA11_N | LOC = W26; | |
| NET FMC_LA12_P | LOC = W23; | |
| NET FMC_LA12_N | LOC = W24; | |
| NET FMC_LA13_P | LOC = U22; | |
| NET FMC_LA13_N | LOC = V22; | |
| NET FMC_LA14_P | LOC = R26; | |
| NET FMC_LA14_N | LOC = P26; | |
| NET FMC_LA15_P | LOC = T24; | |
| NET FMC_LA15_N | LOC = T25; | |
| NET FMC_LA16_P | LOC = V23; | |
| NET FMC_LA16_N | LOC = V24; | |
| NET FMC_LA17_P | LOC = R22; | |
| NET FMC_LA17_N | LOC = R23; | |
| NET FMC_LA18_P | LOC = P23; | |
| NET FMC_LA18_N | LOC = N23; | |
| NET FMC_LA19_P | LOC = T22; | |
| NET FMC_LA19_N | LOC = T23; | |
| NET FMC_LA20_P | LOC = R25; | |
| NET FMC_LA20_N | LOC = P25; | |
| NET FMC_LA21_P | LOC = M24; | |
| NET FMC_LA21_N | LOC = L24; | |
| NET FMC_LA22_P | LOC = M25; | |
| NET FMC_LA22_N | LOC = L25; | |
| NET FMC_LA23_P | LOC = P24; | |
| NET FMC_LA23_N | LOC = N24; | |
| NET FMC_LA24_P | LOC = U17; | |
| NET FMC_LA24_N | LOC = T17; | |
| NET FMC_LA25_P | LOC = T18; | |
| NET FMC_LA25_N | LOC = T19; | |
| NET FMC_LA26_P | LOC = M21; | |

| | | |
|---|---|---|
| NET FMC_LA26_N | LOC = M22; | |
| NET FMC_LA27_P | LOC = N26; | |
| NET FMC_LA27_N | LOC = M26; | |
| NET FMC_LA28_P | LOC = R16; | |
| NET FMC_LA28_N | LOC = R17; | |
| NET FMC_LA29_P | LOC = K25; | |
| NET FMC_LA29_N | LOC = K26; | |
| NET FMC_LA30_P | LOC = N19; | |
| NET FMC_LA30_N | LOC = M20; | |
| NET FMC_LA31_P | LOC = P19; | |
| NET FMC_LA31_N | LOC = P20; | |
| NET FMC_LA32_P | LOC = P16; | |
| NET FMC_LA32_N | LOC = N17; | |
| NET FMC_LA33_P | LOC = N18; | |
| NET FMC_LA33_N | LOC = M19; | |
| NET FMC_HA00_P | LOC = U19; | |
| NET FMC_HA00_N | LOC = U20; | |
| NET FMC_HA01_P | LOC = T20; | |
| NET FMC_HA01_N | LOC = R20; | |
| NET FMC_HA02_P | LOC = AD23; | |
| NET FMC_HA02_N | LOC = AD24; | |
| NET FMC_HA03_P | LOC = AB21; | |
| NET FMC_HA03_N | LOC = AC21; | |
| NET FMC_HA04_P | LOC = U24; | |
| NET FMC_HA04_N | LOC = U25; | |
| NET FMC_HA05_P | LOC = V26; | |
| NET FMC_HA05_N | LOC = U26; | |
| NET FMC_HA06_P | LOC = AD25; | |
| NET FMC_HA06_N | LOC = AE25; | |
| NET FMC_HA07_P | LOC = AD21; | |
| NET FMC_HA07_N | LOC = AE21; | |
| NET FMC_HA08_P | LOC = AE22; | |
| NET FMC_HA08_N | LOC = AF22; | |
| NET FMC_HA09_P | LOC = R18; | |
| NET FMC_HA09_N | LOC = P18; | |
| NET FMC_HA10_P | LOC = U16; | |
| NET FMC_HA10_N | LOC = N16; | |
| NET FMC_HA11_P | LOC = Y20; | |
| NET FMC_HA11_N | LOC = U21; | |
| NET FMC_CLK0_M2C_N | LOC = P21; | |
| NET FMC_CLK0_M2C_P | LOC = R21; | |
| NET FMC_CLK1_M2C_N | LOC = AC24; | |
| NET FMC_CLK1_M2C_P | LOC = AC23; | |
| NET FMC_CLK2_M2C_N | LOC = AB24; | |
| NET FMC_CLK2_M2C_P | LOC = AA23; | |
| NET FMC_CLK3_M2C_N | LOC = AA24; | |
| NET FMC_CLK3_M2C_P | LOC = Y23; | |
| NET FMC_DP0_M2C_N | LOC = C3; | |
| NET FMC_DP0_M2C_P | LOC = C4; | |
| NET FMC_DP0_C2M_N | LOC = A3; | |
| NET FMC_DP0_C2M_P | LOC = A4; | |
| NET FMC_DP1_M2C_N | LOC = E3; | |
| NET FMC_DP1_M2C_P | LOC = E4; | |

| NET FMC_DP1_C2M_N | LOC = D1; | |
| NET FMC_DP1_C2M_P | LOC = D2; | |
| NET FMC_DP2_M2C_N | LOC = B5; | |
| NET FMC_DP2_M2C_P | LOC = B6; | |
| NET FMC_DP2_C2M_N | LOC = A3; | |
| NET FMC_DP2_C2M_P | LOC = A4; | |
| NET FMC_DP3_M2C_N | LOC = G3; | |
| NET FMC_DP3_M2C_P | LOC = G4; | |
| NET FMC_DP3_C2M_N | LOC = F1; | |
| NET FMC_DP3_C2M_P | LOC = F2; | |
| NET FMC_GBTCLK0_M2C_N | LOC = F5; | |
| NET FMC_GBTCLK0_M2C_P | LOC = F6; | |
| NET FMC_GBTCLK1_M2C_N | LOC = D5; | |
| NET FMC_GBTCLK1_M2C_P | LOC = D6; | |