

# Release Notes

## CCRNGFC (WC-CP-FIO2)



<i>Driver</i>	cctrngfc (WC-CP-FIO2)	
<i>OS</i>	RedHawk (CentOS/Rocky or Ubuntu based)	
<i>Vendor</i>	Concurrent Real-Time	
<i>Hardware</i>	PCIe Next Generation FPGA I/O Card (CP-FPGA-4 & 5)	
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<i>Date</i>	November 13 <sup>th</sup> , 2023	Rev 2023.1



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# 1. Introduction

This document assists the user in installing the CCRT-PCIe-NGFC Linux **ccrtngfc** driver and related software on the RedHawk OS for use with the CCRT-PCIe-NextGen FPGA I/O Card (**NGFC**). The directions in this document supersede all others – they are specific to installing the software on Concurrent Real-Time's RedHawk systems. Other information provided as part of this release, when it may contradict these directions, should be ignored and these directions should prevail.

This release provides support for the new Cloning of data among peripheral components and main system (*CCRT US Patent US 11.281.584 B1, Inventor Darius Dubash*).

For additional information on this driver and usage, refer to the **ccrtngfc** man page.

The NGFC is a Next Generation FPGA card with a PCI express interface.

Features and Characteristics of the **NGFC** are:

- ❖ General
  - Intel Arria 10 FPGA Control
  - Six (6) MSG DMA Engines
  - Programmable Clock Generator
  - Temperature Compensated Oscillator (TCXO)
  - In System Firmware Update
  - PCI Express Gen 2 x4 Lane
  - MSI Interrupts
  - Industry Standard High-Density SCSI 68-pin Connectors
  - RJ-45 External Clock Connectors
- ❖ High Speed LVDS I/O Section
  - 32-channel LVDS Input/Output
  - Outputs Selectable per Nibble
  - Input Channel Snapshot
  - Output Channel Synchronization
  - Change Of State Sensing
- ❖ High Speed Digital I/O Section
  - 32-channel TTL Input/Output
  - 3.3V or 5V TTL Compatible Signals
  - Switchable 100 Ohm Termination
  - Input Channel Snapshot
  - Output Channel Synchronization
  - Change Of State Sensing
- ❖ Daughter Card Interface
  - Two FMC Style Positions (3" x 3.75")
  - 1.8V LPC Signaling
  - HPC Signals for I/O Connectors
  - DP Transceiver (4 Lanes & 8 Lanes)

## 2. Requirements

- CP-NGFC PCIe board physically installed in the system.
- This driver supports various versions of RedHawk. Actual supported versions depend on the driver being installed.

## 3. Documentation

- PCIe Next Generation FPGA I/O Card (NGFC) Software Interface by Concurrent Real-Time.

## 4. Installation and Removal

### 4.1. Hardware Installation

The CP-NGFC card is a Gen 1 PCI Express product and is compatible with any PCI Express slot. The board must be installed in the system before attempting to use the driver.



***Caution:*** when installing the card insure the computer is powered off and the machine's power cord is disconnected. Please observe electrostatic discharge precautions such as the use of a grounding strap.

---

The ***cctrngfc*** driver is designed to support IRQ sharing. If this device's IRQ is being shared by another device then this driver's performance could be compromised. Hence, as far as possible, move this board into a PCI slot who's IRQ is not being shared with other devices. The default driver configuration uses MSI interrupts. If the kernel supports MSI interrupts, then sharing of interrupts will not occur, in which case the board placement will not be an issue.

An '***lspci -v***' or the '***lsirq***' command can be used to determine the IRQs of various devices in the system.

```
# lspci -v -d 1542:9320
```

```
b5:00.0 System peripheral: Concurrent Real-Time Device 9320 (rev 01)
Subsystem: Concurrent Real-Time Device 0100
Flags: bus master, fast devsel, latency 0, IRQ 162, NUMA node 0
Memory at fbe40000 (32-bit, non-prefetchable) [size=32K]
Memory at fbe00000 (32-bit, non-prefetchable) [size=256K]
Capabilities: [50] MSI: Enable+ Count=1/4 Maskable- 64bit+
Capabilities: [78] Power Management version 3
Capabilities: [80] Express Endpoint, MSI 00
Capabilities: [100] Virtual Channel
Capabilities: [200] Vendor Specific Information: ID=1172 Rev=0 Len=044 <?>
Capabilities: [800] Advanced Error Reporting
```

```
# lsirq
```

```
162      b5:00.0 Concurrent Real-Time Unknown device (rev 01)
```

After installing the card, reboot the system and verify the hardware has been recognized by the operating system by executing the following command:

```
# lspci -d 1542:9320
```

For each CP-NGFC PCIe board installed, a line similar to one of the following will be printed, depending on the revision of the system's ***/usr/share/hwdata/pci.ids*** file:

```
b5:00.0 System peripheral: Concurrent Real-Time Device 9320 (rev 01)
```

If a line similar to the above is not displayed by the **lspci** command, the board has not been properly installed in the system. Make sure that the device has been correctly installed prior to attempting to use the software. One similar line should be found for each installed card.

## 4.2. Software Installation

Concurrent Real-Time™ port of the **ccrtngfc** software is distributed in RPM format for CentOS/Rocky and DEB format for Ubuntu OS on a DVD. Source for the API library and kernel loadable driver are not included, however, source for example test programs as well as documentation is provided in PDF format.

The software is installed in the **/usr/local/CCRT/drivers/ccrtngfc** directory. This directory will be referred to as the “top-level” directory by this document.



**Warning:** Before installing the software, the kernel build environment **must** be set up and match the current OS kernel you are using. If you are running one of the preconfigured kernels supplied by Concurrent and have not previously done so, run the following commands while logged in as the root user before installing the driver software:

```
# cd /lib/modules/`uname -r`/build
# ./ccur-config -c -n
```

If you have built and are running a customized kernel configuration the kernel build environment should already have been set up when that custom kernel was built.

---

To install the **ccrtngfc** package, load the DVD installation media and issue the following commands as the **root** user. The system should auto-mount the DVD to a mount point in the **/media** or **/run/media** directory based on the DVD's volume label – in this case **ccrtngfc\_driver**. The example's **[user\_name]** may be **root**, or the logged-in user. Then enter the following commands from a shell window:

```
== as root ==
    --- on RedHawk 6.5 and below ---
# cd /media/ccrtngfc_driver
    --- or on RedHawk 7.0 and above ---
# cd /run/media/[user_name]/ccrtngfc_driver

# rpm -ivh ccrtngfc_RedHawk_driver*.rpm (on a CentOS/Rocky based system)
    --or--
# dpkg -i ccrtngfc_RedHawk_driver*.deb (on an Ubuntu based system)

# cd /
# eject
```

On successful installation the source tree for the **ccrtngfc** package, including the loadable kernel module, API libraries, and test programs is extracted into the **/usr/local/CCRT/drivers/ccrtngfc** directory by the rpm installation process, which will then compile and install the various software components.

The loadable kernel module is installed in the **/lib/modules/`uname -r`/misc** directory.

Once the package is installed, the driver needs to be loaded with one of the following commands:

```
== as root ==
# cd /usr/local/CCRT/drivers/ccrtngfc
```

```
# make load
    --- or on RedHawk 6.5 and below ---
# /sbin/service ccrtnngfc start
    --- or on RedHawk 7.0 and above ---
# /usr/bin/systemctl start ccrtnngfc
```

Issue the command below to view the boards found by the driver:

```
# cat /proc/ccrtnngfc

Version          : 2023.6.0
Built            : Thu Jun 22 10:30:04 EDT 2023
Boards          : 1
  card=0: [b9:00.0] bus=185, slot=0, func=0, irq=163, msi=1, BInfo=9320.01.01
              FM=06/20/2023 12:00:00 (64.0) FLV=00000000 FWB=00000000
              IP=0 ID=706503 MC=048 RLS=350 (MultiFunc)
  DCard 0: Id=1 As=1579321-901 Rv='D' Dt=02/21/2023 Sn=729514 (High
              Speed Analog Daughter Card)
  DCard 1: Id=1 As=1579321-901 Rv='D' Dt=02/21/2023 Sn=729512 (High
              Speed Analog Daughter Card)
  Cloning [RA Users]: *** No Users Currently Granted Region Addressing
              Permission ***
```

You can issue the following command to get more information on the driver if it has loaded successfully.

```
# dmesg
[1114843.845186] ccrtnngfc: ===== Daughter Card 0 Identity =====
[1114843.845190] ccrtnngfc:           Daughter Card Id: 1
[1114843.845191] ccrtnngfc: Daughter Card Assembly: 1579321-901
[1114843.845192] ccrtnngfc:           Revision: 'D'
[1114843.845192] ccrtnngfc:           Serial Number: 729514
[1114843.845193] ccrtnngfc:           Date: 02/21/2023      (mm/dd/yyyy)
[1114843.845194] ccrtnngfc:           Description: 'High Speed Analog Daughter Card'
[1114843.845195] ccrtnngfc:           Notes: 'Calibrated 2/21/2023'
[1114843.845195] ccrtnngfc: =====
[1114843.973200] ccrtnngfc: ===== Daughter Card 1 Identity =====
[1114843.973202] ccrtnngfc:           Daughter Card Id: 1
[1114843.973203] ccrtnngfc: Daughter Card Assembly: 1579321-901
[1114843.973203] ccrtnngfc:           Revision: 'D'
[1114843.973204] ccrtnngfc:           Serial Number: 729512
[1114843.973205] ccrtnngfc:           Date: 02/21/2023      (mm/dd/yyyy)
[1114843.973205] ccrtnngfc:           Description: 'High Speed Analog Daughter Card'
[1114843.973206] ccrtnngfc:           Notes: 'Calibrated 2/21/2023'
[1114843.973206] ccrtnngfc: =====
[1114843.989242] ccrtnngfc: /dev/ccrtnngfc0: PCI Bus# 185, Device# 0.0
              BInfo=9320.01.01 FM=06/20/2023 (64.0) FLV=00000000
              FWB=00000000 IP=0 ID=706503 MC=048 RLS=350 (MultiFunc)
[1114843.989248] ccrtnngfc: driver version 2023.6.Beta.0 (Built: Thu Jun 22
              10:30:04 EDT 2023) successfully inserted.
```

Note: With RedHawk 7.5 you may see a cautionary message similar to the following when the **ccrtnngfc** driver is loaded on the system console or via *dmesg* command:

```
CHRDEV "ccrtnngfc" major number 233 goes below the dynamic allocation range
```

As documented in the kernel driver **Documentation/devices.txt** file a range of character device numbers from 234 to 254 are officially available for dynamic assignment. Dynamic assignments start at 254 and grow downward. This range is sometimes exceeded as additional kernel drivers are



loaded. Note that this was also the case with earlier kernels – the newer 7.5 kernel has added a runtime check to produce this warning message that the lower bound has been exceeded, not reduced the range of numbers officially available for dynamic assignment. If you see this message please verify the assigned number(s) isn't being used by a device installed on your system.

In addition to the above message, on some systems you may also see messages from APEI (*ACPI Platform Error Interface*) or AER (*Advanced Error Reporting*) which have these error reporting capabilities. These messages will be of the form of unrecoverable hardware errors or some other form of hardware errors for the board when the driver/firmware is loaded and started. This is because during the driver load operation, a fresh copy of the firmware is installed and started. This process of starting is equivalent to issuing a power shutdown and restart of the card. Some operating systems see the device as being no longer present, and generate the message.

On RedHawk 8.x kernels, you may see cautionary messages on the system console or via *dmesg* command similar to the following when the **ccrtngfc** driver is loaded, as this is a proprietary driver:

```
ccrtngfc: module verification failed: signature and/or required key missing - tainting kernel
```

## 4.3. Software Removal

The **ccrtngfc** driver is a dynamically loadable driver that can be unloaded, uninstalled and removed. Once removed, the only way to recover the driver is to re-install the **rpm** or **deb** from the installation DVD:



If any changes have been made to the driver package installed in `/usr/local/CCRT/drivers/ccrtngfc` directory, they need to be backed up prior to invoking the removal; otherwise, all changes will be lost.

---

```
== as root ==
# rpm -e ccrtngfc (driver unloaded, uninstalled, and deleted - on an RPM
                  based system)
--or--
# dpkg -P ccrtngfc (driver unloaded, uninstalled, and deleted - on an Debian
                  based system)
```

If, for any reason, the user wishes to unload and uninstall the driver and not remove it, they can perform the following:

```
== as root ==
# cd /usr/local/CCRT/drivers/ccrtngfc
# make unload (unload the driver from the kernel)
    --- or on RedHawk 6.5 and below ---
# /sbin/service ccrtngfc stop
    --- or on RedHawk 7.0 and above ---
# /usr/bin/systemctl stop ccrtngfc
```

To uninstall the **ccrtngfc** driver, do the following after it has been unloaded:

```
=== as root ===
# cd /usr/local/CCRT/drivers/ccrtngfc
# make uninstall (uninstall the driver and library)
```

In this way, the user can simply issue the **'make install'** and **'make load'** in the `/usr/local/CCRT/drivers/ccrtngfc` directory at a later date to re-install and re-load the driver.



On some Debian RedHawk systems, the following message may appear and can be ignored when the package is removed. “*dpkg: warning: while removing ccrtaicc, directory '/usr/local' not empty so not removed*”.

## 5. Auto-loading the Driver

The **ccrtngfc** driver is a dynamically loadable driver. Once you install the package or perform the **'make install'**, appropriate installation files are placed in the `/etc/rc.d/rc*.d` or `/usr/lib/systemd/systemd` directories so that the driver is automatically loaded and unloaded when Linux is booted and shutdown. If, for any reason, you do not wish to automatically load and unload the driver when Linux is booted or shutdown, you will need to manually issue the following command to enable/disable the automatic loading of the driver:

```
=== as root ===
    --- on RedHawk 6.5 and below ---
# /sbin/chkconfig --add ccrtnfgc      (enable auto-loading of the driver)
# /sbin/chkconfig --del ccrtnfgc     (disable auto-loading of the driver)
    --- or on RedHawk 7.0 and above ---
# /usr/bin/systemctl enable ccrtnfgc  (enable auto-loading of the driver)
# /usr/bin/systemctl disable ccrtnfgc (disable auto-loading of the driver)
```

## 6. Testing and Usage

Build and run the driver test programs, if you have not already done so:

```
# cd /usr/local/CCRT/drivers/ccrtngfc
# make test                (build the test programs)
```

Several tests have been provided in the `/usr/local/CCRT/drivers/ccrtngfc/test` directory and can be run to test the driver and board.

```
=== as root ===
# cd /usr/local/CCRT/drivers/ccrtngfc
# make test                (build the test programs)
# ./test/ccrtngfc_disp     (display board registers)
# ./test/ccrtngfc_dump     (dump all board resisters)
# ./test/ccrtngfc_rdreg    (display board resisters)
# ./test/ccrtngfc_reg      (Display board resisters)
# ./test/ccrtngfc_regedit  (Interactive board register editor test)
# ./test/ccrtngfc_tst      (Interactive test to test driver and board)
# ./test/ccrtngfc_wreg     (edit board resisters)

# ./test/Flash/ccrtngfc_dump_license (Flash: Dump License)
# ./test/Flash/ccrtngfc_flash      (Flash: Flash FPGA)
# ./test/Flash/ccrtngfc_label      (Flash: Label FPGA)

# ./test/lib/ccrtngfc_acquire_physmem (library: acquire physical memory)
# ./test/lib/ccrtngfc_adc             (library: test ADC channel registers)
# ./test/lib/ccrtngfc_adc_calibrate  (library: test ADC calibrate)
# ./test/lib/ccrtngfc_adc_fifo       (library: test ADC FIFO channels)
# ./test/lib/ccrtngfc_adc_sps        (library: test ADC samples/channel)
# ./test/lib/ccrtngfc_check_bus      (library: test system jitter)
# ./test/lib/ccrtngfc_clock          (library: test clock)
# ./test/lib/ccrtngfc_dac            (library: test DAC channels)
# ./test/lib/ccrtngfc_dac_calibrate  (library: test DAC calibrate)
```

```

# ./test/lib/ccrtngfc_dac_fifo      (Library: test DAC FIFO)
# ./test/lib/ccrtngfc_dac_setchan  (Library: test DAC channels)
# ./test/lib/ccrtngfc_daughtercard_info
                                   (Library: display daughter card info)
# ./test/lib/ccrtngfc_dio          (Library: test DIO channels)
# ./test/lib/ccrtngfc_disp        (Library: display board registers)
# ./test/lib/ccrtngfc_dma         (Library: run dma test)
# ./test/lib/ccrtngfc_example     (Library: run example test)
# ./test/lib/ccrtngfc_expires     (Library: run expires information test)
# ./test/lib/ccrtngfc_identify    (Library: identify cards in the system)
# ./test/lib/ccrtngfc_info        (Library: provide information of all
                                   boards)
# ./test/lib/ccrtngfc_ldio_intr   (Library: test DIO and LIO change-of-state
                                   interrupt)
# ./test/lib/ccrtngfc_lio         (Library: test LIO channels)
# ./test/lib/ccrtngfc_msgdma      (Library: modular scatter-gather DMA test)
# ./test/lib/ccrtngfc_msgdma_clone (Library: modular scatter-gather cloning
                                   test)
# ./test/lib/ccrtngfc_msgdma_info (Library: modular scatter-gather DMA info)
# ./test/lib/ccrtngfc_msgdma_multi_clone
                                   (Library: modular scatter-gather DMA
                                   multi-cloning test)
# ./test/lib/ccrtngfc_sensors     (Library: display/clear Power Module
                                   sensors)
# ./test/lib/ccrtngfc_smp_affinity (Library: display/set IRQ CPU affinity)
# ./test/lib/ccrtngfc_transfer    (Library: run DMA and PIO transfer test)
# ./test/lib/ccrtngfc_tst_lib     (Library: Interactive test to test driver
                                   and board)

```

## 7. Re-building the Driver, Library and Tests

If for any reason the user needs to manually rebuild and load an *installed rpm* or *deb* package, they can go to the installed directory and perform the necessary build.



**Warning:** Before installing the software, the kernel build environment **must** be set up and match the current OS kernel you are using. If you are running one of the preconfigured kernels supplied by Concurrent and have not previously done so, run the following commands while logged in as the root user before installing the driver software:

```

# cd /lib/modules/`uname -r`/build
# ./ccur-config -c -n

```

If you have built and are running a customized kernel configuration the kernel build environment should already have been set up when that custom kernel was built.

To build the driver and tests:

```

=== as root ===
# cd /usr/local/CCRT/drivers/ccrtngfc
# make clobber      (perform cleanup)
# make              (make package and build the driver, library and tests)

```

(Note: if you only wish to build the driver, you can enter the **'make driver'** command instead)

After the driver is built, you will need to install the driver. This install process should only be necessary if the driver is re-built with changes.

```
=== as root ===
# cd /usr/local/CCRT/drivers/ccrtngfc
# make install    (install the driver software, library and man page)
```

Once the driver and the board are installed, you will need to **load** the driver into the running kernel prior to any access to the CCRT NGFC board.

```
=== as root ===
# cd /usr/local/CCRT/drivers/ccrtngfc
# make load      (Load the driver)
```

## 8. Software Support

This driver package includes extensive software support and test programs to assist the user in communicating with the board. Refer to the *CONCURRENT PCIe Next Generation FPGA I/O Card (NGFC) Software Interface* document for more information on the product.

### 8.1. Device Configuration

After the driver is successfully loaded, the device to card association file ***ccrtngfc\_devs*** will be created in the ***/usr/local/CCRT/drivers/ccrtngfc/driver*** directory, if it did not exist. Additionally, there is a symbolic link to this file in the ***/usr/lib/config/ccrtngfc*** directory as well. If the user wishes to keep the default one-to-one device to card association, no further action is required. If the device to card association needs to be changed, this file can be edited by the user to associate a particular device number with a card number that was found by the driver. The commented portion on the top of the ***ccrtngfc\_devs*** file is automatically generated every time the user issues the ***'make load'*** or ***'/sbin/service ccrtngfc start'*** (on RedHawk 6.5 and below) or ***'/usr/bin/systemctl start ccrtngfc'*** (on RedHawk 7.0 and above) command with the current detected cards, information. Any device to card association edited and placed in this file by the user is retained and used during the next ***'make load'*** or ***'/sbin/service ccrtngfc load'*** or ***'/usr/bin/systemctl start ccrtngfc'*** process.

If the user deletes the ***ccrtngfc\_devs*** file and recreates it as an empty file and performs a ***'make load'*** or if the user does not associate any device number with card number, the driver will provide a one to one association of device number and card number. For more information on available commands, view the commented section of the ***ccrtngfc\_devs*** configuration file.



***Warning:*** If you edit the ***ccrtngfc\_devs*** file to associate a device to a card, you will need to re-issue the ***'make load'*** or ***'/sbin/service ccrtngfc start'*** or ***'/usr/bin/systemctl start ccrtngfc'*** command to generate the necessary device to card association. This device to card association will be retained until the user changes or deletes the association. **If any invalid association is detected, the loading of the driver will fail.**

---

### 8.2. Library Interface

There is an extensive software library that is provided with this package. For more information on the library interface, please refer to the *PCIe Next Generation FPGA I/O Card (NGFC) Software Interface by Concurrent Real-Time* document.

### 8.3. Debugging

This driver has some debugging capability and should only be enabled while trying to trouble-shoot a problem. Once resolved, debugging should be disabled otherwise it could adversely affect the performance and behavior of the driver.

To enable debugging, the **Makefile** file in **/usr/local/CCRT/drivers/ccrtngfc/driver** should be edited to un-comment the statement (remove the preceding '#'):

```
# EXTRA_CFLAGS += -DCCRTNGFC_DEBUG
```

Next, compile and install the driver

```
# cd /usr/local/CCRT/drivers/ccrtngfc/driver
# make
# make install
```

Next, edit the **ccrtngfc\_config** file in **/usr/local/CCRT/drivers/ccrtngfc/driver** to un-comment the statement (remove the preceding '#'):

```
# ccrtngfc_debug_mask=0x00002040
```

Additionally, the value of the debug mask can be changed to suite the problem investigated. Once the file has been edited, the user can load the driver by issuing the following:

```
# cd /usr/local/CCRT/drivers/ccrtngfc/driver
# make load
```

The user can also change the debug flags after the driver is loaded by passing the above debug statement directly to the driver as follows:

```
# echo "ccrtngfc_debug_mask=0x00082047" > /proc/ccrtngfc
```

Following are the supported flags for the debug mask as shown in the **ccrtngfc\_config** file.

```
#####
#
#      D_ENTER      0x00000001 /* enter routine */      #
#      D_EXIT       0x00000002 /* exit routine */       #
#
#      D_L1         0x00000004 /* level 1 */             #
#      D_L2         0x00000008 /* level 2 */             #
#      D_L3         0x00000010 /* level 3 */             #
#      D_L4         0x00000020 /* level 4 */             #
#
#      D_ERR        0x00000040 /* level error */         #
#      D_WAIT       0x00000080 /* level wait */          #
#
#      D_INT0       0x00000100 /* interrupt level 0 */   #
#      D_INT1       0x00000200 /* interrupt level 1 */   #
#      D_INT2       0x00000400 /* interrupt level 2 */   #
#      D_INT3       0x00000800 /* interrupt level 3 */   #
#      D_INTW       0x00001000 /* interrupt wakeup level */ #
#      D_INTE       0x00002000 /* interrupt error */     #
#
#      D_RUNTIME    0x00010000 /* display read times */  #
#      D_WTIME      0x00020000 /* display write times */  #
#      D_REGS       0x00040000 /* dump registers */      #
#      D_IOCTL      0x00080000 /* ioctl call */          #
#
#      D_DATA       0x00100000 /* data level */           #
#      D_DMA        0x00200000 /* DMA level */           #
#      D_DBUFF      0x00800000 /* DMA buffer allocation */ #
```

```

#
#          D_NEVER          0x00000000 /* never print this debug message */ #
#          D_ALWAYS        0xffffffff /* always print this debug message */ #
#          D_TEMP          D_ALWAYS  /* Only use for temporary debug code */ #
#####

```

Another variable `ccrtnngfc_debug_ctrl` is also supplied in the `ccrtnngfc_config` that the driver developer can use to control the behavior of the driver. The user can also change the debug flags after the driver is loaded by passing the above debug statement directly to the driver as follows:

```
# echo "ccrtnngfc_debug_ctrl=0x00001234" > /proc/ccrtnngfc
```

In order to make use of this variable, the driver must be coded to interrogate the bits in the `ccrtnngfc_debug_ctrl` variable and alter its behavior accordingly.

## 9. Notes and Errata

- PLL clock synchronization feature is not supported in the first firmware release 8/25/2023 R1.0.
- In some kernel releases, when a package is installed or uninstalled, you may see a warning message on the system console similar to **“systemd-rc-local-generator[22094]: /etc/rc.d/rc.local is not marked executable, skipping.”**. This is for informational purpose only and can be ignored.
- The DIO that is located on the mother-board has each of the 32 channels controlled by 32 independent ports. Hence, each channels direction can be controlled independent of each other. The optional DIO daughter card has groups of 4 channels controlled by a single port. Hence the direction of the channels must be controlled in groups of 4 adjacent channels.
- If a square or pulse signal is supplied to an ADC channel on a daughter card, you will observe a ringing noise on the DAC channels on the daughter card corresponding to the frequency of the ADC signal. The larger the amplitude of the signal, the larger is the resulting noise on the DAC channels.
- Each multi-function analog daughter card has multiple functions like ADC, DAC, DIO, LIO incorporated into it. It is possible that when one component is operating on the daughter card it may have a performance impact on other components within the same daughter card when operated concurrently.
- Region Addressing allows a user to supply a physical address to access memory beyond its domain. Care should be taken in supplying a valid physical address, otherwise results can be unpredictable including kernel crash or system hang. **On RH6.0 through RH7.2 kernels, a `dmesg 'ioremap' kernel-warning message may be generated when kernel I/O mapping is performed on a user supplied physical memory address that is allocated and reserved by someone other than the user. If this is exactly what the user is intending to do, the message can be ignored as this warning should have no effect on the driver operation or the system. It may appear only once since a system reboot.`**
- It is meaningless to perform Cloning on a FIFO region for two reasons. Firstly, each data in a FIFO is synchronous, however, the Cloned region is accessed asynchronously. Secondly, when the FIFO runs empty (*underflow*) or cannot accept more data (*overflow*) the results are unpredictable as there is no flow control in the Cloning operation.
- If a kernel is configured with the `CONFIG_DEBUG_LOCK_ALLOC` define, the driver will fail to compile due to `mutex_lock_nested()` call being included with GPL requirement. If you want to successfully compile the driver, you will need to remove the `CONFIG_DEBUG_LOCK_ALLOC` define and rebuild the kernel.
- Ubuntu kernels RH8.0 onwards may have the default `systemd-timesyncd` daemon installed which does not accurately adjust the system clock causing the Sample/Second test to fall out of tolerance and fail. You may want to replace the default with the `chrony` package for a more accurate time adjustment.
- On some Debian systems, the following message can be ignored when the package is removed. `“dpkg: warning: while removing ccrtnngfc, directory '/usr/local' not empty so not removed”`
- Driver and board support MSI interrupts. It can be configured for wired interrupts. MSI support is the default.

## 10. High Speed Analog Daughter Card (HSAD)

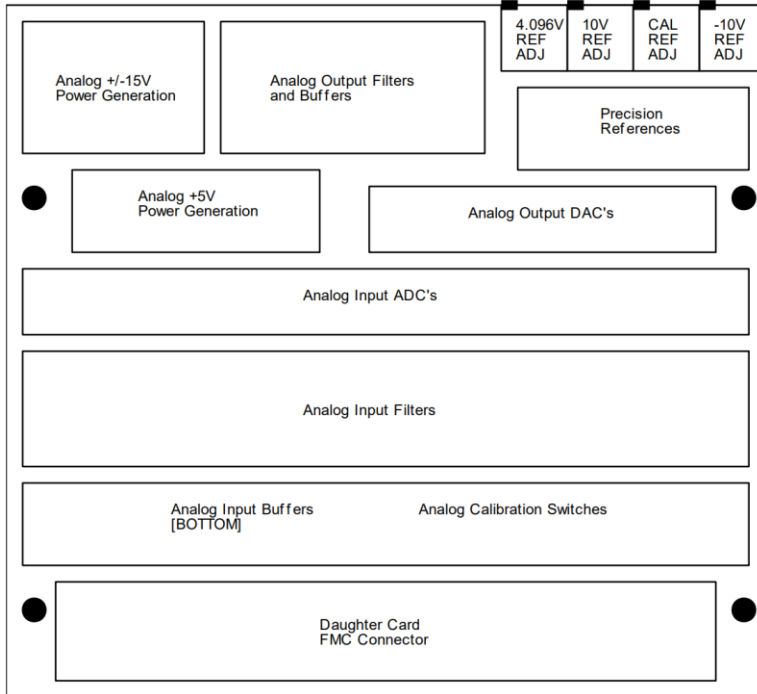
### 10.1. Overview

The High Speed Analog Daughtercard (HSAD) is a single width FMC style card for use with the Next Generation FPGA Card (NGFC or motherboard). It that contains two analog sections: 1) Twelve (12) channels of high speed 16-bit SAR analog input and 2) Twelve (12) channels of high speed 16-bit analog output. The AtoD function is implemented using Analog Devices LTC2325 ADC's. The DtoA function is implemented using Analog Devices AD5545 DAC's. All the analog I/O pins are routed to the motherboard front panel using the FMC HPC pins

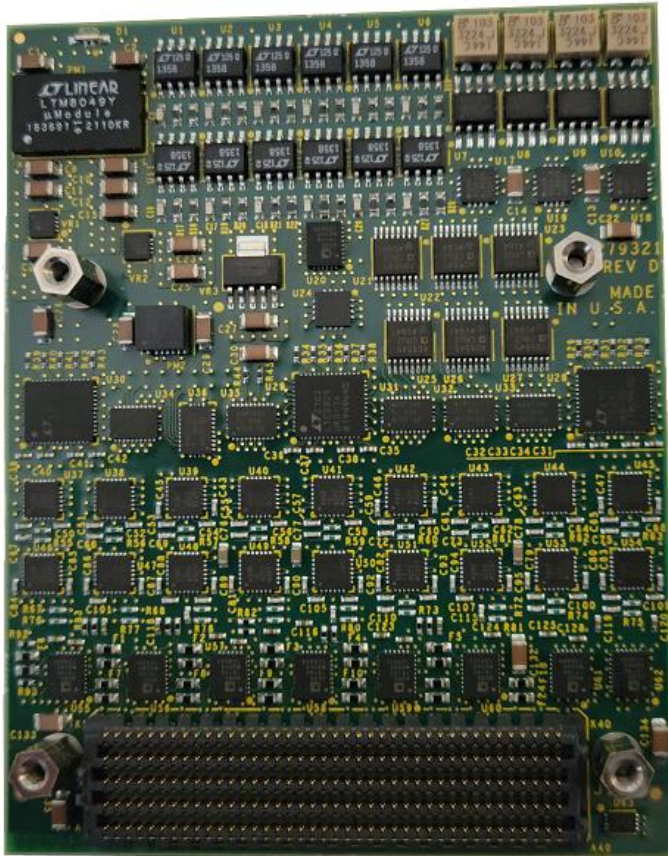
Features of the HSAD are:

- ❖ General
  - Single Width FMC (3" x 3.75")
  - Low Noise Analog Power Generation
  - In System Calibration
  - NIST Traceable Calibration Standard
  - In System Firmware Update
  - Motherboard Front Panel I/O (Using HPC Pins)
  - Industry Standard High-Density SCSI 68-pin Connectors
  
- ❖ Analog Input Section
  - 16-channel 16-bit Analog-to-Digital Conversion
  - Differential or Single-ended Input
  - +/-10V Input Range
  - Input Impedance ~1Meg ohm
  - Directly Addressable Conversion Data Registers
  - 4.5Mhz Maximum Sampling Rate
  - 2.5Mhz Active Input Filter
  - 128K Word Conversion Data FIFOs with DMA
  
- ❖ Analog Output Section
  - 16-bit Digital-to-Analog Conversion
  - 12-channel Single-ended Output or 6-channel Differential Output
  - +/-10V Single-ended Output Range
  - +/-20V Differential Output Range
  - 10 Milliamp Maximum Output Drive
  - 1Mhz Maximum Updates Per Second (12-channels)
  - 2Mhz Maximum Updates Per Second (6-channels)
  - 1.5Mhz Active Output Filter
  - 128K Word Conversion Data FIFOs with DMA

## 10.2. Block Diagram of ADC/DAC Daughter Card



## 10.3. Picture of ADC/DAC Daughter Card



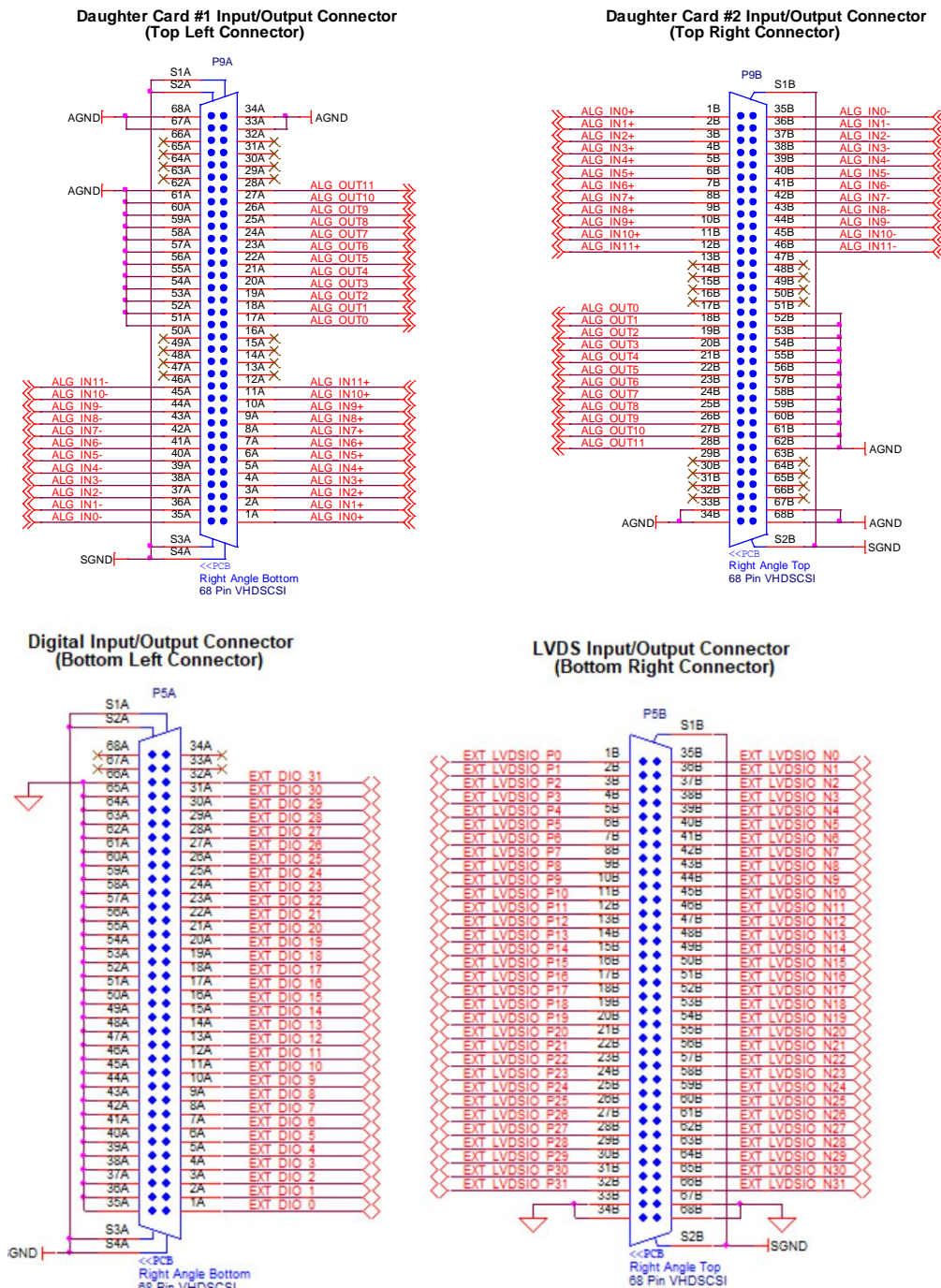


## 10.4. Physical Characteristics

The High Speed Analog Daughtercard (HSAD) is a single width FMC style card (3 inch long x 3.75 inch high). It consumes approximately 20 watts (1.5 amp @ 12 volt, 100mA @ 3.3 volt and 200mA @ 1.8 volt). Forced air cooling is required.

## 10.5. External Connectors

The NGFC I/O signals will interface to the front panel I/O connectors on the motherboard. They are industry standard 68-pin VHD SCSI type connectors with the following pin-out when looking at the motherboard:



## 10.6. External Connector Notes

- 1) The I/O signals on the HSAD are high speed and have limited protection. Do not exceed +/- 15 volt into any pin or permanent damage may occur.
- 2) An analog ground connection is required for the ESD and over/under voltage protection circuits to function correctly for the analog signals.
- 3) All other connectors on the board are used for manufacturing test and should not have anything attached to them.

## 10.7. Board Indicator

The HSAD has one bicolor LED indicator located on the edge of the board visible. If the board is in a reset state, the indicator will be dim Red. After reset is complete, the indicator will cycle through Red and Green for approximately 1 second each as a lamp test. If the indicator remains solid or flashing Red after reset is complete or during board operation it would indicate a board malfunction. See the Power Fail Code section for more information.

Board Indicator		
Color	Description	Analog I/O
Dim Red	Board Not Enabled (Reset)	Not Active
Flashing Red	<See Power Fail Code section>	Not Active
Green	Board Enabled	Active

## Appendix A: Board Indicators

The NGFC has two multicolor LED indicator located between the two front panel connector pairs. If the board is in a reset state the right indicator will be solid Red. After reset is complete, the indicators will cycle through Red, Green and Blue for approximately 1 second each as a lamp test. If the either of the indicators remain solid or flashing Red after reset is complete or during board operation it would indicate a board malfunction. See the Board Faults section for more information. Other states of the board during normal operation are indicated as follows:

Left Indicator		
Color	Description	Digital Outputs
Red	<See board faults section>	Not Active
Flashing Red	<See board faults section>	Not Active
Green	Digital Inputs Enabled	Not Active
Blue	Digital Outputs Enabled	Active

Right Indicator		
Color	Description	Analog Outputs
Red	<See board faults section>	Not Active
Flashing Red	<See board faults section>	Not Active
Green	Daughter Card Inputs Enabled	Not Active
Blue	Daughter Card Outputs Enabled	Active

Note: If either left or right LED has to represent both the blue (*output*) **and** the green (*input*) color, the Digital or Analog *Output* signals supersede the inputs and therefore the corresponding LED will display a blue color.

If the user selects to *identify* the board, both the left and right LEDs will flash approximately once every second while board identification is enabled. Once board identification is disabled, the left and right LEDs will display the Analog and Digital Input and Output settings.

If the FPGA card is running a custom firmware, it is possible that the meaning of the LED colors can change based on the custom firmware running on the card at that time.

## Appendix B: Board Faults

The NGFC has on board monitoring of the power up/down sequence and initialization of the FPGA. The front panel indicators along with the multi-board synchronization J1 connector LED indicators will provide some level of feedback if there is a problem during board initialization and operation as follows:

Front Panel		J1 Input		J1 Output		#	Description	Cause
Left	Right	R/G	Y/G	R/G	Y/G			
Off	Red	OFF	OFF	OFF	OFF	-	Board Not Programmed	N/A
Red	Red	Red	Yellow	Red	Yellow	-	Board Reset	N/A
Red	Flashing Red	OFF	OFF	OFF	OFF	00	<Reserved>	Board Malfunction
Red	Flashing Red	OFF	OFF	OFF	Yellow	01	No 12V Power Detected	Board Malfunction
Red	Flashing Red	OFF	OFF	Red	OFF	02	Internal Power Status Error	Board Malfunction
Red	Flashing Red	OFF	OFF	Red	Yellow	03	Ext Power Status Error	Board Malfunction
Red	Flashing Red	OFF	Yellow	OFF	OFF	04	ADC Start Timeout	Board Malfunction
Red	Flashing Red	OFF	Yellow	OFF	Yellow	05	ADC Convert Timeout	Board Malfunction
Red	Flashing Red	OFF	Yellow	Red	OFF	06	Internal Power Wait*	Board Malfunction
Red	Flashing Red	OFF	Yellow	Red	Yellow	07	External Power Wait*	Board Malfunction
Red	Flashing Red	Red	OFF	OFF	OFF	08	Main Power Wait*	Board Malfunction
Red	Flashing Red	Red	OFF	OFF	Yellow	09	Ground Check Wait*	Board Malfunction
Red	Flashing Red	Red	OFF	Red	OFF	10	V0.9 Off Status Error	Board Malfunction
Red	Flashing Red	Red	OFF	Red	Yellow	11	V1.03 Off Status Error	Board Malfunction
Red	Flashing Red	Red	Yellow	OFF	OFF	12	V1.8P Off Status Error	Board Malfunction
Red	Flashing Red	Red	Yellow	OFF	Yellow	13	V1.8S Off Status Error	Board Malfunction
Red	Flashing Red	Red	Yellow	Red	OFF	14	V3.3S Off Status Error	Board Malfunction
Red	Flashing Red	Red	Yellow	Red	Yellow	15	<Reserved>	Board Malfunction

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Notes:

1. Connector J1 Output is closest to the front panel side of the board.
2. \* Power & ground waits will loop indefinitely for the condition to satisfy. This could be due to a power supply not being within tolerance.

### Board Faults (continued)

Front Panel		J1 Input		J1 Output		#	Description	Cause
Left	Right	R/G	Y/G	R/G	Y/G			
Red	Flashing Red	OFF	OFF	OFF	OFF	16	<Reserved>	Board Malfunction
Red	Flashing Red	OFF	OFF	OFF	Green	17	12V Main Low Voltage	Board Malfunction
Red	Flashing Red	OFF	OFF	Green	OFF	18	V0.9 On Status Error	Board Malfunction
Red	Flashing Red	OFF	OFF	Green	Green	19	V1.03 On Status Error	Board Malfunction
Red	Flashing Red	OFF	Green	OFF	OFF	20	V0.9 On Fault Error	Board Malfunction
Red	Flashing Red	OFF	Green	OFF	Green	21	V0.9 Resistor On Check	Board Malfunction
Red	Flashing Red	OFF	Green	Green	OFF	22	V1.03 Resistor On Check	Board Malfunction
Red	Flashing Red	OFF	Green	Green	Green	23	V0.9 Resistor Off Check	Board Malfunction
Red	Flashing Red	Green	OFF	OFF	OFF	24	V1.03 Resistor Off Check	Board Malfunction
Red	Flashing Red	Green	OFF	OFF	Green	25	12V Main Low Voltage	Board Malfunction
Red	Flashing Red	Green	OFF	Green	OFF	26	V1.8P On Status Error	Board Malfunction
Red	Flashing Red	Green	OFF	Green	Green	27	V1.8P Resistor On Check	Board Malfunction
Red	Flashing Red	Green	Green	OFF	OFF	28	V1.8P Resistor Off Check	Board Malfunction
Red	Flashing Red	Green	Green	OFF	Green	29	12V Main Low Voltage	Board Malfunction
Red	Flashing Red	Green	Green	Green	OFF	30	V1.8S On Status Error	Board Malfunction
Red	Flashing Red	Green	Green	Green	Green	31	<Reserved>	Board Malfunction

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#### Notes:

1. Connector J1 Output is closest to the front panel side of the board.
2. All other combinations would be N/A and indicate a board malfunction.

### Board Faults (continued)

Front Panel		J1 Input		J1 Output		#	Description	Cause
Left	Right	R/G	Y/G	R/G	Y/G			
Red	Flashing Red	OFF	OFF	OFF	OFF	32	<Reserved>	Board Malfunction
Red	Flashing Red	Red	Yellow	Red	Green	33	V3.3S On Status Error	Board Malfunction
Red	Flashing Red	Red	Yellow	Green	Yellow	34	V1.8S Resistor On Check	Board Malfunction
Red	Flashing Red	Red	Yellow	Green	Green	35	V3.3S Resistor On Check	Board Malfunction
Red	Flashing Red	Red	Green	Red	Yellow	36	V1.8S Resistor Off Check	Board Malfunction
Red	Flashing Red	Red	Green	Red	Green	37	V3.3S Resistor Off Check	Board Malfunction
Red	Flashing Red	Red	Green	Green	Yellow	38	Internal Power Transfer Status	Board Malfunction
Red	Flashing Red	Red	Green	Green	Green	39	<Not Used>	Board Malfunction
Red	Flashing Red	Green	Yellow	Red	Yellow	40	<Not Used>	Board Malfunction
Red	Flashing Red	Green	Yellow	Red	Green	41	FPGA Pwr On Status Error	Board Malfunction
OFF	Flashing Red	Green	Yellow	Green	Yellow	42	FPGA Status Error	Board Malfunction
OFF	Flashing Red	Green	Yellow	Green	Green	43	FPGA Config Error *	Board Malfunction
OFF	Flashing Red	Green	Green	Red	Yellow	44	FPGA Status Error *	Board Malfunction
OFF	Flashing Red	Green	Green	Red	Green	45	<Not Used>	Board Malfunction
OFF	Flashing Red	Green	Green	Green	Yellow	46	<Not Used>	Board Malfunction
OFF	Flashing Red	Green	Green	Green	Green	47	<Reserved>	Board Malfunction

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#### Notes:

1. Connector J1 Output is closest to the front panel side of the board
2. \* FPGA configuration and status errors may be due to a non-programmed part or corrupted firmware.

**Board Faults (continued)**

Front Panel		J1 Input		J1 Output			Description	Cause
Left	Right	R/G	Y/G	R/G	Y/G	#		
Blue	Flashing Red	OFF	OFF	OFF	OFF	48	<Reserved>	Board Malfunction
Blue	Flashing Red	OFF	OFF	OFF	Yellow	49	V0.9 On Status Error	Board Malfunction
Blue	Flashing Red	OFF	OFF	Red	OFF	50	V1.03 On Status Error	Board Malfunction
Blue	Flashing Red	OFF	OFF	Red	Yellow	51	V1.8P On Status Error	Board Malfunction
Blue	Flashing Red	OFF	Yellow	OFF	OFF	52	V1.8S On Status Error	Board Malfunction
Blue	Flashing Red	OFF	Yellow	OFF	Yellow	53	V3.3S On Status Error	Board Malfunction
Blue	Flashing Red	OFF	Yellow	Red	OFF	54	V0.9 On Fault Error	Board Malfunction
Blue	Flashing Red	OFF	Yellow	Red	Yellow	55	IP 12V Main Low Voltage	Board Malfunction
Blue	Flashing Red	Red	OFF	OFF	OFF	56	EP 12V Main Low Voltage	Board Malfunction
Blue	Flashing Red	Red	OFF	OFF	Yellow	57	12V Main Low Voltage	Board Malfunction
Blue	Flashing Red	Red	OFF	Red	OFF	58	<Not Used>	Board Malfunction
Blue	Flashing Red	Red	OFF	Red	Yellow	59	<Not Used>	Board Malfunction
Blue	Flashing Red	Red	Yellow	OFF	OFF	60	<Not Used>	Board Malfunction
Blue	Flashing Red	Red	Yellow	OFF	Yellow	61	<Not Used>	Board Malfunction
Blue	Flashing Red	Red	Yellow	Red	OFF	62	<Not Used>	Board Malfunction
Blue	Flashing Red	Red	Yellow	Red	Yellow	63	<Reserved>	Board Malfunction

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Notes:

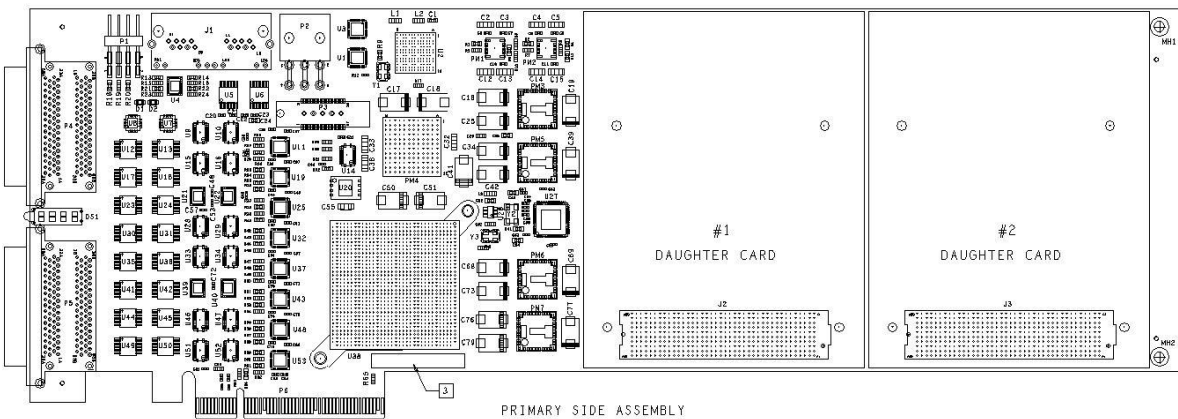
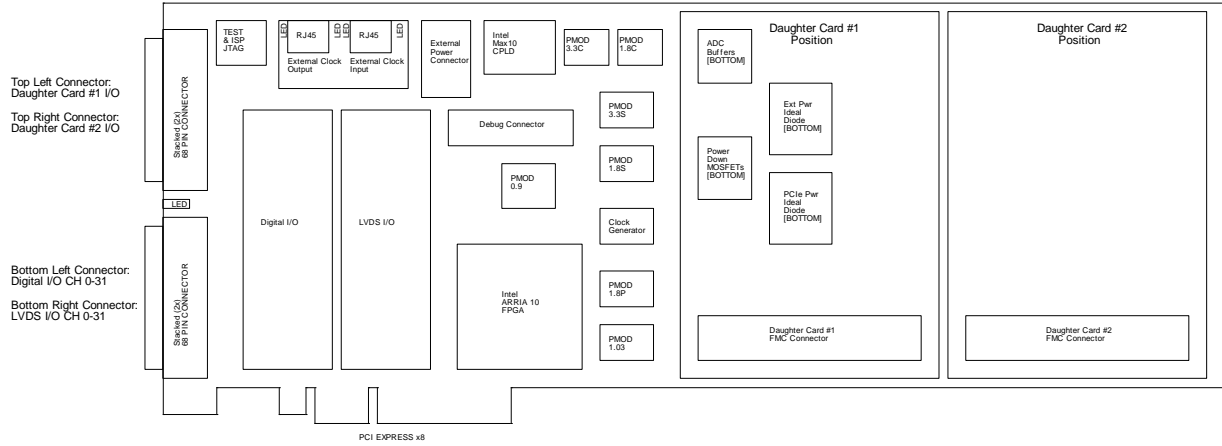
1. Connector J1 Output is closest to the front panel side of the board
2. All other combinations would be N/A and indicate a board malfunction.

## Appendix C: External Connections and Pin-outs

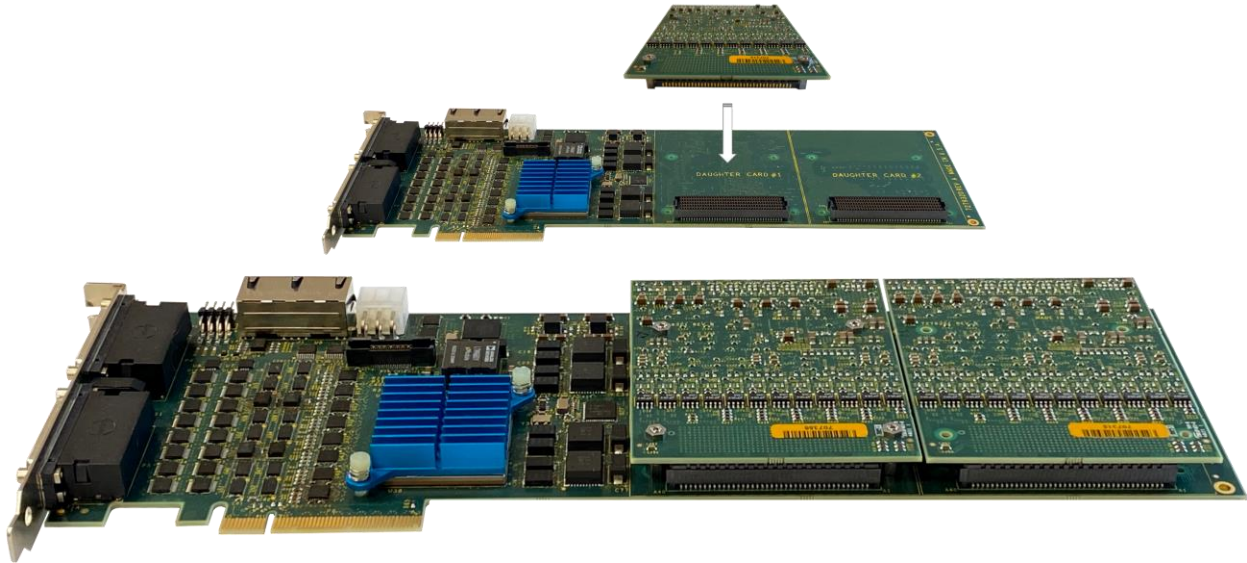
- 4) The DIO lines are 5V TTL compatible signal levels. Do not exceed TTL levels into any pin or permanent damage may occur.
- 5) The LVDS lines are LVDS signal levels. Do not exceed LVDS levels into any pin or permanent damage may occur.
- 6) Connector pair P4A/B connect to the daughter cards I/O. Consult the design specification for the appropriate daughter card for the actual pinout.
- 7) Connector J1 located near the top rear edge of the board is used for external clocking. CAT5 capable or greater shielded cable should be used. The output from the Master board is the RJ45 socket closest to the front panel. The input to the Slave board is the RJ45 socket farthest from the front panel.
- 8) All other connectors on the board are used for manufacturing test and should not have anything attached to them.



# Appendix D: The Next Generation FPGA I/O Board



# Appendix D: The Next Generation FPGA I/O Board (continued)



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