OpenCPI

Matchstiq-Z1 Getting Started Guide

Version 1.5

Revision History

Revision	Description of Change	Date
v1.1	Initial Release	3/2017
v1.2	Updated for OpenCPI Release 1.2	8/2017
v1.3	Updated for OpenCPI Release 1.3	2/2018
v1.4	Update descriptions and paths	9/2018
v1.5	Update for OpenCPI Release 1.5	4/2019

Table of Contents

1 References

This document assumes a basic understanding of the Linux command line (or "shell") environment. The reference(s) in Table 1 can be used as an overview of OpenCPI and may prove useful.

Title	Link
Acronyms and Definitions	`Acronyms_and_Definitions.pdf`
Getting Started	`Getting_Started.pdf`
Installation Guide	`RPM_Installation_Guide.pdf`

Table 1: References

2 Overview

This document provides steps for configuring a factory provided Epiq Solutions Matchstiq-Z1 SDR with the OpenCPI run-time environment for executing applications, configuring a development system to build OpenCPI bitstreams targeting the *matchstiq_z1* platform, and examples of executing applications on the OpenCPI configured Matchstiq-Z1. **Note: Only the Z1 version of the Epiq Solutions Matchstiq product line is supported by OpenCPI.**

3 Prerequisites

This guide assumes that, at a minimum, the following RPMs are installed:

RPM Name	Description
All prerequisite RPMs	These packages have OpenCPI-specific patches and are provided as RPMs. This packaging ensures they will not conflict with other installed copies by using a nonstandard installation location of `/opt/opencpi/prerequisites`.
`angryviper-ide-*.x86 64.rpm`	The ANGRYVIPER IDE (Eclipse with plugins). See RPM Installation Guide.pdf, Appendix D for an alternative method to set up the IDE using an existing Eclipse installation.
`opencpi-*.x86_64.rpm`	Base installation RPM includes the runtime portion of the Component Development Kit (CDK) and the source for the ocpi.core and ocpi.assets Projects containing framework essential components, workers, platforms, etc.
`opencpi-devel-*.x86_64.rpm`	Additional header files and scripts for developing new assets as HDL and/or RCC.
`opencpi-sw-platform-xilinx13_3-*.noarch.rpm`	Additional files necessary to build the framework targeting specific RCC/software platforms, independent of the final deployed hardware.
`opencpi-hw-platform-matchstiq_z1-xilinx13_3-*.noarch.rpm`	Additional files necessary to build the framework targeting specific hard-ware platform “X” when running RCC platform “Y” (“Y” can be “no sw”). This RPM also includes hardware-specific SD Card images when applicable.

3.1 Installation of provided OpenCPI projects: *core* and *assets*

This guide assumes the user has executed *ocpi-copy-projects*, accepting the default settings, to copy and register the *core* and *assets* projects from the /opt/opencpi/projects for building bitstreams for the Matchstiq-Z1. Reference the Getting Started Guide for details on *ocpi-copy-projects*. While registering of the projects is performed during the execution of ocpi-copy-projects, changes to the registry can be made via `ocpidev un/register project` or the ANGRYVIPER GUI.

```
$ ocpi-copy-projects
...

$ ls ~/ocpi_projects
assets core
$ ocpidev show registry
Project registry is located at: /opt/opencpi/cdk/../project-registry
----------------------------------------------------------------------------------------------
| Project Package-ID  | Path to Project                                       | Valid/Exists |
| ------------------  | ---------------                                       | ------------ |
| ocpi.core           | /home/user/ocpi_projects/core                         | True         |
```

```
| ocpi.assets         | /home/user/ocpi_projects/assets                   | True         |
----------------------------------------------------------------------------------------
```

3.2 Vendor Software Setup

The platform that is expected to be used is the Epiq Solutions Matchstiq-Z1 (*e.g.* matchstiq_z1). This OpenCPI-enabled platform provides the capability of deploying hardware and software workers while using Xilinx's 13.3 distribution of Linux.

The synthesizers and cross-compilers required to build HDL and RCC Workers for this platform are installed by following the instructions found in the *OpenCPI FPGA Vendor Tools Installation Guide*. This document assumes that the user has installed the appropriate versions of Vivado and the Xilinx SDK.

3.3 Building OpenCPI projects: *core* and *assets*

The *core* and *assets* projects must be built *in a specific order* for this platform. This section outlines how to build the relevant projects and provides the commands to do so.

For this document, the projects should be built as follows:

1. Build `core` for the `xilinx13_3` RCC Platform and the `matchstiq_z1` HDL Platform (approx 30 min)
2. Build `assets` for the `xilinx13_3` RCC Platform and the `matchstiq_z1` HDL Platform, but omit assemblies (approx 45 min)
3. Build the `testbias` assembly from the `assets` project. This will be used later in this guide. (approx 10 min)

```
$ cd /home/<user>/ocpi_projects/
$ ocpidev build -d core --rcc-platform xilinx13_3 --hdl-platform matchstiq_z1
$ ocpidev build -d assets --rcc-platform xilinx13_3 --hdl-platform matchstiq_z1 --no-assemblies
$ ocpidev build -d assets hdl assembly testbias --hdl-platform matchstiq_z1
```

Note: replace "`<user>`" with your username in the commands above.

Each of these build commands can also be performed via the ANGRYVIPER IDE as follows:

To perform this operation within the IDE:

1. Open the ANGRYVIPER Perspective
2. Select the asset from OpenCPI Project View
3. Import to ANGRYVIPER Operations Panel using ">" button
4. Select the RCC and/or HDL platforms for the build (use Ctrl for multiple selection)
5. Click "Build"

See the ANGRYVIPER Team's Getting Started Guide for additional information concerning the use of `ocpidev` and the ANGRYVIPER IDE to build OpenCPI assets.

3.4 Hardware Setup

- **Epiq Solutions Matchstiq-Z1 SDR Kit**

  It is expected that this SDR kit includes a power supply, two SMA/SMB adapters, micro-USB to USB cable, micro-SD card installed internally (expected).

  A micro-USB connector on the back of the Matchstiq-Z1 provides access to the serial connection. To expose this micro-USB connector, the two screws in the back plate must be removed. Historically, this connector's attachment to the PCB has been extremely fragile, **so be careful when inserting/removing the mating cable**.

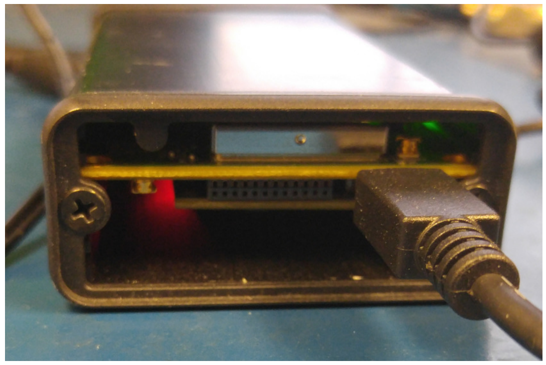


Figure 1: Connected Back Panel

- **Micro-USB to Ethernet adapter**. To allow network access when plugged into the front panel micro-USB port. The OpenCPI BSP for the Matchstiq-Z1 is configured for DHCP. An Ethernet connection is required for developing OpenCPI in Network mode.

  On the front panel of the Matchstiq-Z1, there are three labeled SMB (50 Ohm) connectors: "RX" (receive), "TX" (transmit), and "GPS". From the factory, the Matchstiq-Z1 is provided with two SMB to SMA adapters. Due to the RF performance to the transceiver device, any RF COAX cables should be rated up to at least 3GHz.

Figure 2: Connected Front Panel

- **Access to a network which supports DHCP. (Network Mode)**
- **Micro-SD card, 4GB+ (OPTIONAL, as it is possible to use internally installed card)**
- **Micro-SD card reader**

4 SD Card Setup

The Matchstiq-Z1 SDR is equipped with two SD card slots: one internal and one accessible via the front panel. It is expected that the SDRs are shipped from Epiq Solutions with an SD card installed in the internal slot that is loaded with their embedded environment. A feature of this SDR is that when an SD card is installed in the front panel SD slot, the SDR will automatically choose to operate from this SD card rather than the internal SD card. Therefore, a user can easily switch the SDR between operating in the Epiq Solutions or OpenCPI environment.

The Matchstiq-Z1's factory SD card has a non-default formatting and content, which *must* be maintained for proper operation. This guide assumes that the internal (factory) SD card is being use for OpenCPI and will be reinstalled in the front panel SD card slot. If the user desires the use of a new SD card, the user must ensure that it is initially imaged from the factory provided SD card, as there is a unique partition containing required content from the OEM.

4.1 Make a backup image of factory SD card (assumes Linux host)

This section provides the steps for creating an SD card backup image. Access the internal SD card slot by removing the screws from the front and back plates, then slide the board assembly out of the enclosure. Flip the SD card slot open and lift the card out. Insert the SD card into a USB reader and install into a host machine.

1. Determine the device file name for the SD card by executing dmesg command below. It will likely be something like `/dev/sdb` or `/dev/mmcblk0`.

   ```
   $ dmesg | tail -n 15
   ```

2. Run the following *dd* command to make a backup image, where DEVICENAME was determined above. This step should take ~ 15 minutes depending on the card size.

   ```
   $ dd if=DEVICENAME of=backup.image
   ```

4.2 Format the SD card for OpenCPI

The Matchstiq-Z1 SDR requires an SD card with a specific partition and content. The recommend method for formatting a new SD card is to begin by imaging the new card using the backup image of the factory SD card, removing factory default files and directory and copying OpenCPI content to SD card.

1. Format an SD card for OpenCPI, (restore to its original factory default captured in the previous section), run the command

   ```
   $ dd of=DEVICENAME if=backup.image
   ```

2. To prepare for OpenCPI provided content to be placed onto the SD card, remove all factory files and directories from the ATLAS partition.

4.3 Copy embedded OS files to SD card, "ATLAS" partition

WARNING: The user must ensure that the contents of the SD, match the version of the OpenCPI release that the artifacts were built against.

Copy the following files/directories into the "ATLAS" partition:

```
$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/iveia-atlas-i-z7e.dtb /run/media/<user>/ATLAS/

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/u-boot.bin /run/media/<user>/ATLAS/

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/uImage /run/media/<user>/ATLAS/

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/uramdisk.image.gz /run/media/<user>/ATLAS/
```

Any files/directories copied to the "ATLAS" partition will appear at /mnt/card on the Matchstiq-Z1.

The need to copy the */opt/opencpi/cdk/matchstiq_z1/opencpi* onto the SD card is dependent on the desired operating mode (Standalone vs Network) and is discussed in the following sections.

4.4 Copy files to SD card for desired Mode(s)

As previously discussed, Standalone and Network modes offer trade-offs for configuring the run-time environment of the platform. The following sections provide instructions for copying specific files/directories to the SD card in support of these modes. For maximum flexibility and completion of this getting started guide, it is recommended that the SD card be configured to support both modes, as covered in the next sub-section. However, instructions for configuring the SD card for each mode separately, have also been provided.

4.4.1 Standalone and Network Modes

The SD can be setup to support both modes, as there is no conflict between the files/directories for either mode. To setup the SD to support both modes:

After performing the steps from 4.3, copy the entire *opencpi* directory to the SD card.

```
$ cp -rL /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/opencpi /run/media/<user>/ATLAS/

$ cp /home/<user>/ocpi_projects/assets/hdl/assemblies/testbias/container-testbias_matchstiq_z1_base/\
target-zynq/testbias_matchstiq_z1_base.bit.gz /run/media/<user>/ATLAS/opencpi/xilinx13_3/artifacts/
```

4.4.2 Standalone Mode

After performing the steps from 4.3, copy the entire *opencpi* directory to the SD card, then copy the relevant bitstreams, artifacts into the *artifacts* directory and application XMLs into the *applications* directory. For this getting started guide, only one bitstream is required to be copied onto the SD cards, where as the required artifacts and application XML where copied to the SD along with the entire *opencpi* directory.

```
$ cp -rL /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/opencpi /run/media/<user>/ATLAS/

$ cp /home/<user>/ocpi_projects/assets/hdl/assemblies/testbias/container-testbias_matchstiq_z1_base/\
target-zynq/testbias_matchstiq_z1_base.bit.gz /run/media/<user>/ATLAS/opencpi/xilinx13_3/artifacts/
```

4.4.3 Network Mode

After performing the steps from 4.3, create a directory on the partition named "opencpi" and copy the following files into the this directory:

```
$ mkdir /run/media/<user>/ATLAS/opencpi

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/opencpi/system.xml \
/run/media/<user>/ATLAS/opencpi/

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/opencpi/default_mynetsetup.sh \
/run/media/<user>/ATLAS/opencpi/

$ cp /opt/opencpi/cdk/matchstiq_z1/sdcard-xilinx13_3/opencpi/zynq_net_setup.sh \
/run/media/<user>/ATLAS/opencpi/
```

4.5 SD Card Source

The final SD Card artifacts are distributed in `/opt/opencpi/cdk/matchstiq_z1/` via RPM as noted previously. The end user is not required nor expected to generate the files.

4.6 No changes required for "SDHOME" partition

All the files in this partition can be ignored. If space for files is required for your application, they can be deleted.

5 Script Setup

There are two type of setups or modes for running applications on any embedded radio: Network and Standalone. In Network mode, a development system hosts the OpenCPI tree as an NFS server to the Matchstiq-Z1 which is an NFS client. This configuration provides quick and dynamic access to all of OpenCPI, and presumably any applications, components and bitstreams. In Standalone mode, all the artifacts are located on the SDR's local storage (*e.g.* SD card) and no network connection is required. This may be more suited for *deployment* scenarios in which network connection is not possible or practical. Network mode is generally preferred during the development process.

5.1 Setting up the Network and Standalone Mode scripts

For each mode, a startup script is used to configure the environment of the embedded system. The OpenCPI framework provides a default script for each mode. The default scripts are to be copied and modified per the user's requirements.

5.1.1 Network Mode

1) Make a copy of the default script for editing.

$ cp /run/media/<user>/ATLAS/opencpi/default_mynetsetup.sh \
/run/media/<user>/ATLAS/opencpi/mynetsetup.sh

2) Edit the copy

1. In `mynetsetup.sh`, uncomment the following lines which are necessary for mounting *core* and *assets* project:

   mkdir -p /mnt/ocpi_core
   mount -t nfs -o udp,nolock,soft,intr $1:/home/user/ocpi_projects/core /mnt/ocpi_core
   mkdir -p /mnt/ocpi_assets
   mount -t nfs -o udp,nolock,soft,intr $1:/home/user/ocpi_projects/assets /mnt/ocpi_assets

2. Edit `/home/user/ocpi_projects/core` and `/home/user/ocpi_projects/assets` to reflect the paths to the *core* and *assets* project on the host, e.g.:

   mkdir -p /mnt/ocpi_core
   mount -t nfs -o udp,nolock,soft,intr $1:/home/johndoe/ocpi_projects/core /mnt/ocpi_core
   mkdir -p /mnt/ocpi_assets
   mount -t nfs -o udp,nolock,soft,intr $1:/home/johndoe/ocpi_projects/assets /mnt/ocpi_assets

5.1.2 Standalone Mode

In this mode, all OpenCPI artifacts that are required to run any application on the Matchstiq-Z1 must be copied onto the SD card. Building the provided projects to obtain such artifacts is discussed in Section 3.3. Once the artifacts have been created, they must be copied to the SD card in Section 4. In general, any required `.so` (RCC workers), `.bit.gz` (hdl assemblies), and application XMLs or executables must be copied to the ATLAS partition of the SD card.

1) Make a copy of the default script for editing

$ cp /run/media/<user>/ATLAS/opencpi/default_mynetsetup.sh \
/run/media/<user>/ATLAS/opencpi/mynetsetup.sh

2) Edit the copy

Unlike Network mode, there is no required modifications to this script.

3) Copy any additional artifacts to SD card's `opencpi/xilinx13_3/artifacts/` directory

5.2 Setup system time reference

If Linux system time is not required to be accurate, this step may be skipped.

For either Network or Standalone mode, the following settings that are passed by `my[net]setup.sh` to the `zynq_[net_]setup.sh` scripts *may* require modification:

- Identify the system that is to be used as a time server, where the default is "time.nist.gov" and is set in `/mnt/card/opencpi/ntp.conf`. A valid time server must support NTP.
- Identify the current timezone description, where the default is "EST5EDT,M3.2.0,M11.1.0". Change this if required for the local timezone. See `man tzset` on the host PC for more information.
- If a time server is not required, or cannot connect to a time server, the user is required to manually set the time at radio start-up. Use the `date` command to manually set the Linux system time. See `man date` on the host PC for more information.

5.3 "`rsync`" provided binary

An ARM-compiled version of "`rsync`" is provided in the included SD card image for xilinx13_3. This tool allows the use of *standalone mode* while shortening the required developer time to synchronize the artifacts being developed. For command-line usage, see the rsync home page. The easiest usage is to have the radio "pull" from the developer's workstation; this does not need any additional command-line arguments.

Implementation Details

Unfortunately, the "`rsync`" executable is not in the default path because when called remotely, it requests a non-interactive shell. For this reason, a "pull" approach is recommended. If a user for some reason requires a "push" from the workstation to the radio, the local "`rsync`" executable must be told the *remote location* of the `rsync` executable to call, *e.g.* `rsync -rsync-path=/mnt/card/opencpi/xilinx13_3/bin/rsync`

6 Hardware Setup

6.1 Establish a Serial Connection

By default, the USB to Serial adapter connects as read-only, which requires sudo privileges for establishing a serial connection. OpenCPI recognizes that sudo may not be available and has provided an alternative for configuring the device thereby allowing all users access to the device. Specifically, this is accomplished by adding `udev` rules to instruct the device connection to have read and write permissions for all users.

- If OpenCPI was installed via RPMs, the `udev` rules are automatically setup for the user.
- If OpenCPI was installed from source, then the user must manually add the `udev` rules by copying the file from the host machine's installation directory to the host machine's `/etc/udev/rules.d/`. The following command can be used as a guide:

```
$ cd /etc/udev/rules.d/
$ sudo ln -s /<install-path>/opencpi/cdk/matchstiq_z1/host-udev-rules/97-matchstiq_z1.rules \
97-matchstiq_z1.rules
```

- Whether installed via RPMs or source (and manually creating the symbolic link), the USB to Serial adapter will be connected as `/dev/matchstiq_z1_0` with read and write permissions for all users.

Once the Matchstiq-Z1 is powered on, use the following command to connect to the serial port:

```
$ screen /dev/matchstiq_z1_0 115200
```

6.2 Update U-boot Variables

1. Remove power from the Matchstiq-Z1 unit.
2. Insert the SD card into the front panel SD card slot.
3. Connect a terminal to the rear micro-USB connector of the Matchstiq-Z1 with a baud rate of 115200.
   - per the previous section, "`screen /dev/matchstiq_z1_0 115200`" can be used to connect to the serial port.
4. Apply power to the Matchstiq-Z1 with the terminal still connected and stop the boot process by hitting any key to enter the U-Boot terminal.
5. Run the following commands to setup the environment variables:
   - `setenv bootcmd 'ivmmc; run ocpiboot'`
   - `setenv ocpiboot 'setenv bootargs console=ttyPS0,115200n8 root=/dev/ram rw earlyprintk; setenv fdt_high ffffffff; setenv initrd_high 0x1000000; fatload mmc ${iv_mmc} ${dtbaddr} ${dtbfile}; fatload mmc ${iv_mmc} ${loadaddr} ${bootfile}; fatload mmc ${iv_mmc} 0x2000000 uramdisk.image.gz; bootm ${loadaddr} 0x2000000 ${dtbaddr}'`

     *Note: This should be a one-line command. Make sure there are no newlines.
   - `saveenv`
6. These U-Boot environment variables are now saved to the second partition of the SD card

Verify that the changes are correct by running the command "`env p`" and comparing to:

```
baudrate=115200
bootcmd=ivmmc;run ocpiboot
bootdelay=3
bootfile=uImage
defargs=setenv bootargs console=ttyPS0,115200n8 mem=240M iv_mb=${iv_mb} iv_io=${iv_io}
iv_bp=${iv_bp} iv_mmc=${iv_mmc} ${otherargs}
dtbaddr=0x02a00000
```

```
dtbfile=iveia-atlas-i-z7e.dtb
iv_io=205-00034-00-A0,,Atlas-II_GF_Carrier
iv_io_default=205-00034-00-A0,,Atlas-II_GF_Carrier
iv_io_ord=00034
iv_mb=205-00049-00-B1,A2WT9,Atlas-I-Z7e
iv_mb_ord=00049
iv_mmc=0
loadaddr=0x03000000
mmcdtload=fatload mmc ${iv_mmc} ${dtbaddr} ${dtbfile};fdt addr ${dtbaddr};fdt set
/chosen bootargs "${bootargs}";fdt ivclean ${iv_mb_ord}
mmcxload=axi_reset 1; fatload mmc ${iv_mmc} ${loadaddr} ${xloadfile};xload ${loadaddr}
${filesize}; axi_reset 0;
ocpiboot=setenv bootargs console=ttyPS0,115200n8 mem=240M root=/dev/ram rw earlyprintk;
setenv fdt_high ffffffff;  setenv initrd_high 0x1000000; fatload mmc ${iv_mmc} ${dtbaddr}
${dtbfile}; fatload mmc ${iv_mmc} ${loadaddr} ${bootfile};  fatload mmc ${iv_mmc} 0x2000000
uramdisk.image.gz; bootm ${loadaddr} 0x2000000 ${dtbaddr}
sdboot=run mmcxload;run defargs;fatload mmc ${iv_mmc} ${loadaddr} ${bootfile};run
mmcdtload;setenv fdt_high ffffffff;bootm ${loadaddr} - ${dtbaddr}
stderr=serial
stdin=serial
stdout=serial
xloadfile=xilinx.bit

Environment size: 1283/131068 bytes
```

7 Development Host Setup - Network Mode ONLY

7.1 Network Mounting Mode

The NFS server needs to be enabled on the host in order to run the SDR in Network Mode. The following sections are directions on how to do this for both CentOS 6 and CentOS 7 host operating systems.

7.1.1 CentOS 6

From the host, install the necessary tools using yum:

```
% sudo yum install nfs-utils nfs-utils-lib
% sudo chkconfig nfs on
% sudo service rpcbind start
% sudo service nfs start
```

From the host, add the following lines to the bottom of `/etc/exports` and change "XX.XX.XX.XX/MM" to a valid netmask for the DHCP range that the SDR will be set to for your network (*e.g.* `192.168.0.0/16`). This should be as "tight" as possible for security reasons. **Do *not* share out your top-level directory! This would allow theft of your private "ssh" keys, etc!**

```
% sudo vi /etc/exports

/opt/opencpi XX.XX.XX.XX/MM(rw,sync,no_root_squash,no_subtree_check)
<host core project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,no_subtree_check)
<host assets project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,no_subtree_check)
<host assets_ts project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,no_subtree_check)

% sudo exportfs -av
```

From the host, restart the services that have modified for the changes to take effect:

```
% sudo service nfs start
```

7.1.2 CentOS 7

From the host, install the necessary tools using yum:

```
% sudo yum install nfs-utils
```
[1]

From the host, allow NFS past SELinux[2]:

```
% sudo setsebool -P nfs_export_all_rw 1
% sudo setsebool -P use_nfs_home_dirs 1
```

From the host, allow NFS past the firewall:

```
% sudo firewall-cmd --permanent --zone=public --add-service=nfs
% sudo firewall-cmd --permanent --zone=public --add-port=2049/udp
% sudo firewall-cmd --permanent --zone=public --add-service=mountd
% sudo firewall-cmd --permanent --zone=public --add-service=rpc-bind
% sudo firewall-cmd --reload
```

Define the export by creating a new file that has the extension "`exports`". If it does not have that extension, it will be ignored. Add the following lines to that file and replace "XX.XX.XX.XX/MM" with a valid netmask for the DHCP range that the SDR will be set to for your network (*e.g.* `192.168.0.0/16`). This should be as "tight" as possible for security reasons. **Do *not* share out your top-level directory! This would allow theft of your private "ssh" keys, etc!**

[1] `nfs-utils-lib` was rolled into `nfs-utils` starting with CentOS 7.2, if using eariler versions of CentOS 7, `nfs-utils-lib` will need to be explicitly installed

[2] You can use `getsebool` to see if these values are already set before attempting to set them. Some security tools may interpret the change attempt as a system attack.

```
% sudo vi /etc/exports.d/user_ocpi.exports

/opt/opencpi XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt)
<host core project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt)
<host assets project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt)
<host assets_ts project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt)
```

If the file system that you are mounting is XFS, then each mount needs to have a unique `fsid` defined. Instead, use:

```
% sudo vi /etc/exports.d/user_ocpi.exports

/opt/opencpi XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt,fsid=33)
<host core project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt,fsid=34)
<host assets project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt,fsid=35)
<host assets_ts project location> XX.XX.XX.XX/MM(rw,sync,no_root_squash,crossmnt,fsid=36)
```

Restart the services that have modified for the changes to take effect:

```
% sudo systemctl enable rpcbind
% sudo systemctl enable nfs-server
% sudo systemctl enable nfs-lock
% sudo systemctl enable nfs-idmap
% sudo systemctl restart rpcbind
% sudo systemctl restart nfs-server
% sudo systemctl restart nfs-lock
% sudo systemctl restart nfs-idmap
```

* Note: Some of the "enable" commands may fail based on your package selection, but should not cause any problems.

8 Configuring the run-time environment on the platform

8.1 Network Mode

1. Ensure the USB to Ethernet adapter is plugged into the micro-USB port of the front panel and connected to a network configured for DHCP.

2. Ensure a micro-USB to USB cable is connected between the Matchstiq-Z1's serial port and development host.

3. Apply power to the Matchstiq-Z1

4. Use a serial terminal application to establish a serial connection, for example:

   ```
   $ screen /dev/matchstiq_z1_0 115200
   ```

5. After a successful boot to PetaLinux, login to the system, using "**root**" for user name and password.

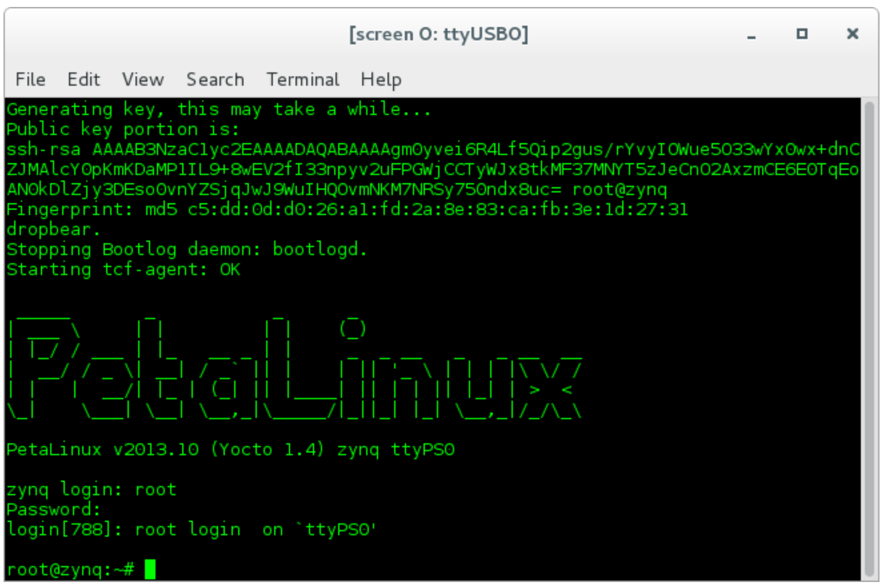


Figure 3: Successful Boot to PetaLinux

6. Setup the OpenCPI environment on remote system

   Each time the SDR is booted, the OpenCPI environment must be setup. By sourcing the `mynetsetup.sh` script, the remote system's environment is configured for OpenCPI and NFS directories are mounted for Network mode.[3]. The user must provide the network address of the development system to the script as its only argument:

   ```
   $ source /mnt/card/opencpi/mynetsetup.sh XX.XX.XX.XX
   ```

   where XX.XX.XX.XX is the IP address of the NFS host (i.e. that development host, *e.g.* 192.168.1.10). A successful run is shown in Figure 4.

[3]This script calls the `zynq_net_setup.sh` script, which should not be modifiable by the user.

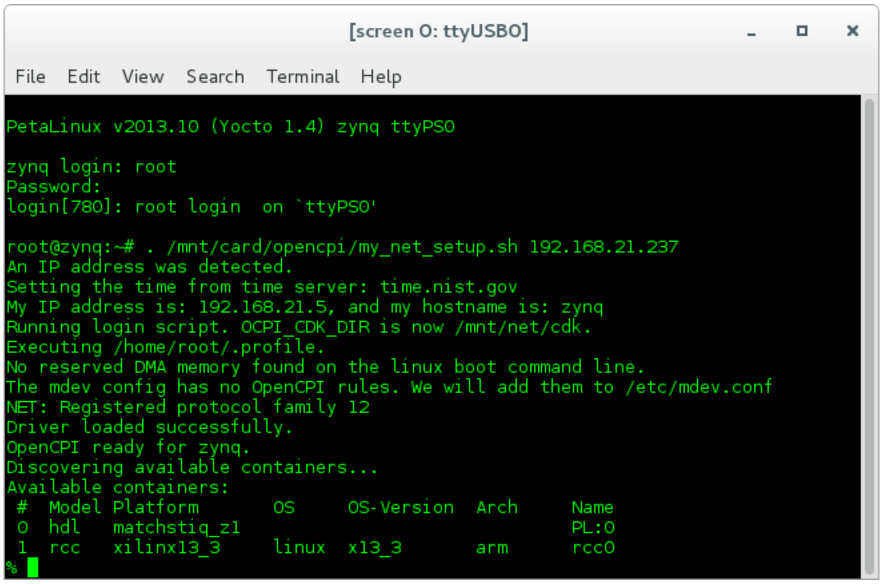


Figure 4: Successful Network Mode Setup

Note: If the output includes:

```
Attempting to set the time from time server
Alarm clock
```

`ntp` was unable to set time using servers in `ntp.conf`. For more information see Section 5.2

8.2 Standalone Mode

All artifacts (.so, .bit.gz) for any applications or tests that need to be located on the SD card must be on the ATLAS partition in the `opencpi/xilinx13_3/artifacts` folder. All of the helper utilities such as `ocpirun` and `ocpihdl` are already located on the SD card and do not need to be copied over to the SDR platform.

1. Ensure the USB to Ethernet adapter (as needed) is plugged into the micro-USB port of the front panel and connected to a network configured for DHCP.

2. Ensure a micro-USB to USB cable is connected between the Matchstiq-Z1's serial port and development host.

3. Apply power to the Matchstiq-Z1

4. Use a serial terminal application to establish a serial connection, for example:

```
$ screen /dev/matchstiq_z1_0 115200
```

5. After a successful boot to PetaLinux, login to the system, using "**root**" for user name and password.

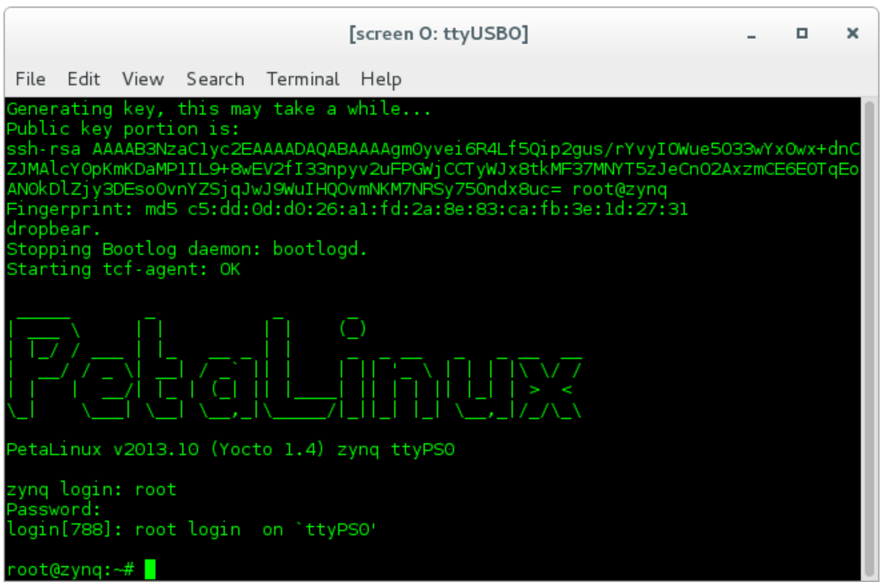


Figure 5: Successful Boot

6. WARNING: Applications (including XML-only ones) fail if there is not an IP address assigned to the platform, even when in "standalone mode." When the Ethernet port is not connected to a network configured with DHCP, a temporary IP address must be set:

```
$ ifconfig eth0 192.168.244.244
```

7. Setup the OpenCPI environment on remote system

   Each time the SDR is booted, the OpenCPI environment must be setup. By sourcing the `mysetup.sh` script, the remote system's environment is configured for OpenCPI.[4]. There are no arguments required for this script.

```
$ source /mnt/card/opencpi/mysetup.sh
```

[4] This script calls the `zynq_setup.sh` script, which should not be modifiable by the user.

A successful setup of the platform will look as follows:

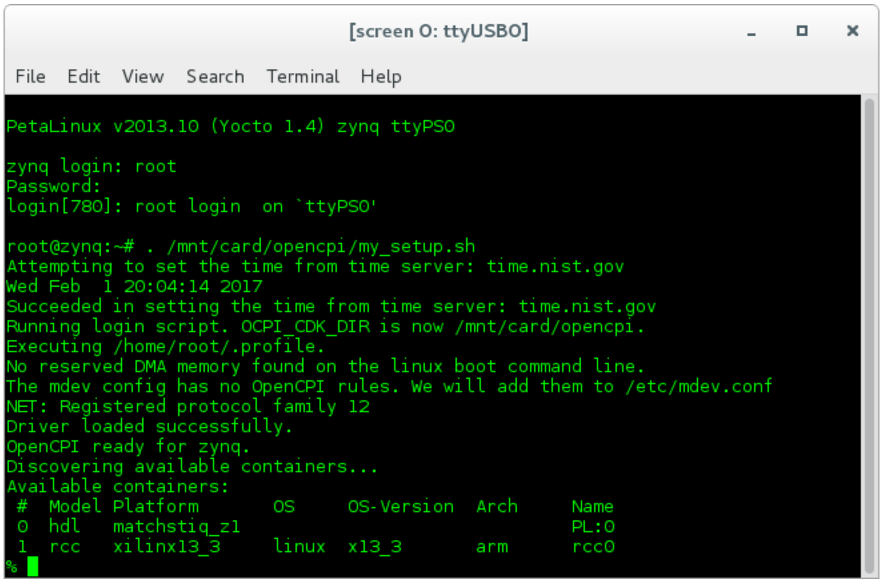


Figure 6: Successful Standalone Mode Setup

Note: If the output includes:

```
Attempting to set the time from time server
Alarm clock
```

`ntp` was unable to set time using servers in `ntp.conf`. For more information see Section 5.2

9 Build an Application

The setup of the platform can be verified by running an application that uses both RCC and HDL workers. A simple application that requires two RCC and one HDL worker is located in `assets/applications/bias.xml`, but only the RCC artifacts are provided with the installation of RPMs, and are availble on the SD card (Standard Mode) or mounted CDK directory (Network Mode). The remaining task is to build an assembly, or bitstream for loading the FPGA, which contains the HDL worker.

10 Run an Application

10.1 Network Mode

The default setup script sets the `OCPI_LIBRARY_PATH` variable to include the RCC workers that are required to execute the application, but it must be updated to include to the assembly bitstream that was built. After running the `mynetsetup.sh` script, navigate to `/mnt/ocpi_assets/applications`, then update the `OCPI_LIBRARY_PATH` variable:

```
$ cd /mnt/net/cdk/applications
$ export OCPI_LIBRARY_PATH=$OCPI_LIBRARY_PATH:/mnt/ocpi_assets/artifacts
```

Run the application using the following command:

```
$ ocpirun -v -t 1 -d -m bias=hdl bias.xml
```

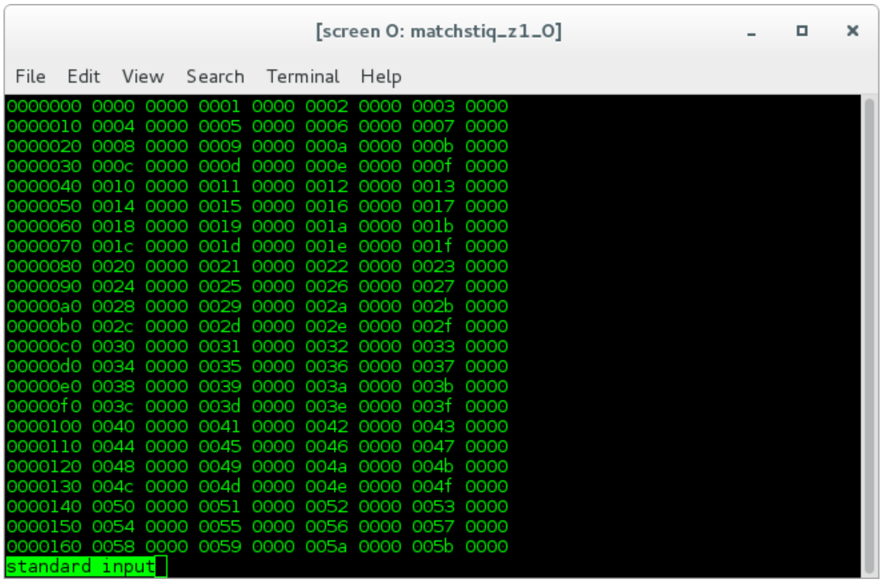
The output should be similar to Figure ??:

```
% ocpirun -v -t 1 -d -m bias=hdl bias.xml
Available containers are:  0: PL:0 [model: hdl os:  platform:
matchstiq_z1], 1: rcc0 [model: rcc os: linux platform: xilinx13_3]
Actual deployment is:
  Instance  0 file_read (spec ocpi.core.file_read) on rcc container 1: rcc0, using file_read in
  /mnt/ocpi_core/artifacts/ocpi.core.file_read.rcc.0.xilinx13_3.so
  dated Tue Apr  9 11:34:43 2019
  Instance  1 bias (spec ocpi.core.bias) on hdl container 0: PL:0, using bias_vhdl/a/bias_vhdl in
  /mnt/ocpi_assets/applications/rx_app/../../artifacts/
  ocpi.assets.testbias_matchstiq_z1_base.hdl.0.matchstiq_z1.gz
  dated Mon Apr  8 14:31:34 2019
  Instance  2 file_write (spec ocpi.core.file_write) on rcc container 1: rcc0, using file_write in
  /mnt/ocpi_core/artifacts/ocpi.core.file_write.rcc.0.xilinx13_3.so
  dated Tue Apr  9 11:34:48 2019
Application XML parsed and deployments (containers and artifacts) chosen
Application established: containers, workers, connections all created
Communication with the application established
Dump of all initial property values:
Property  0: file_read.fileName = "test.input" (cached)
Property  1: file_read.messagesInFile = "false" (cached)
Property  2: file_read.opcode = "0" (cached)
Property  3: file_read.messageSize = "16"
Property  4: file_read.granularity = "4" (cached)
Property  5: file_read.repeat = "false"
Property  6: file_read.bytesRead = "0"
Property  7: file_read.messagesWritten = "0"
Property  8: file_read.suppressEOF = "false"
Property  9: file_read.badMessage = "false"
Property 10: file_read.ocpi_debug = "false" (parameter)
Property 11: file_read.ocpi_endian = "little" (parameter)
Property 16: bias.biasValue = "16909060" (cached)
Property 17: bias.ocpi_debug = "false" (parameter)
Property 18: bias.ocpi_endian = "little" (parameter)
```

```
Property 20: bias.test64 = "0"
Property 29: file_write.fileName = "test.output" (cached)
Property 30: file_write.messagesInFile = "false" (cached)
Property 31: file_write.bytesWritten = "0"
Property 32: file_write.messagesWritten = "0"
Property 33: file_write.stopOnEOF = "true" (cached)
Property 34: file_write.ocpi_debug = "false" (parameter)
Property 35: file_write.ocpi_endian = "little" (parameter)
Application started/running
Waiting up to 1 seconds for application to finish
Application is now considered finished after waiting 1 seconds
Dump of all final property values:
Property  3: file_read.messageSize = "16"
Property  6: file_read.bytesRead = "1776"
Property  7: file_read.messagesWritten = "111"
Property  9: file_read.badMessage = "false"
Property 31: file_write.bytesWritten = "1760"
Property 32: file_write.messagesWritten = "110"
```

Run the following command to view the input. It should look like Figure 7:

```
$ hexdump test.input | less
```

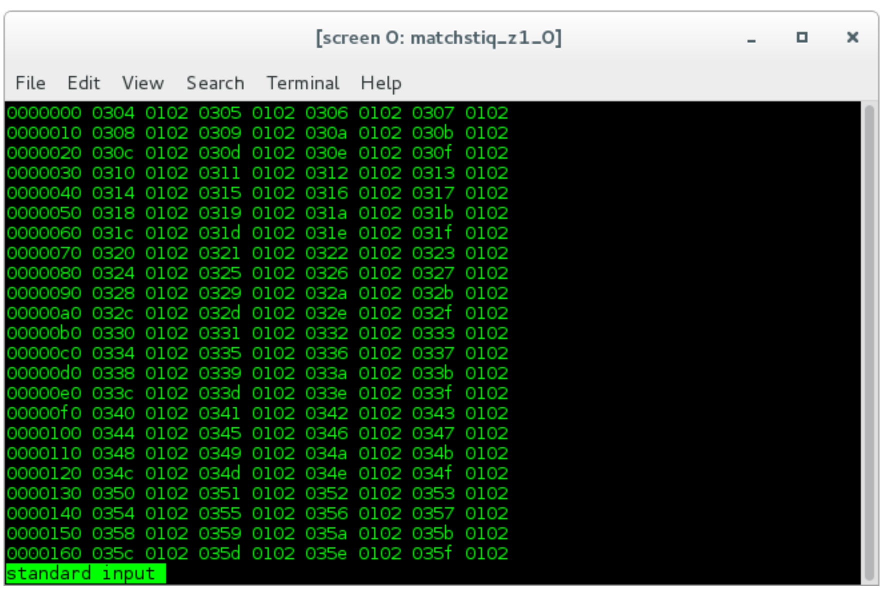



```
0000000 0000 0000 0001 0000 0002 0000 0003 0000
0000010 0004 0000 0005 0000 0006 0000 0007 0000
0000020 0008 0000 0009 0000 000a 0000 000b 0000
0000030 000c 0000 000d 0000 000e 0000 000f 0000
0000040 0010 0000 0011 0000 0012 0000 0013 0000
0000050 0014 0000 0015 0000 0016 0000 0017 0000
0000060 0018 0000 0019 0000 001a 0000 001b 0000
0000070 001c 0000 001d 0000 001e 0000 001f 0000
0000080 0020 0000 0021 0000 0022 0000 0023 0000
0000090 0024 0000 0025 0000 0026 0000 0027 0000
00000a0 0028 0000 0029 0000 002a 0000 002b 0000
00000b0 002c 0000 002d 0000 002e 0000 002f 0000
00000c0 0030 0000 0031 0000 0032 0000 0033 0000
00000d0 0034 0000 0035 0000 0036 0000 0037 0000
00000e0 0038 0000 0039 0000 003a 0000 003b 0000
00000f0 003c 0000 003d 0000 003e 0000 003f 0000
0000100 0040 0000 0041 0000 0042 0000 0043 0000
0000110 0044 0000 0045 0000 0046 0000 0047 0000
0000120 0048 0000 0049 0000 004a 0000 004b 0000
0000130 004c 0000 004d 0000 004e 0000 004f 0000
0000140 0050 0000 0051 0000 0052 0000 0053 0000
0000150 0054 0000 0055 0000 0056 0000 0057 0000
0000160 0058 0000 0059 0000 005a 0000 005b 0000
standard input
```

Figure 7: Expected Input

Run the following command to view the output. It should look like Figure 8:

```
$ hexdump test.output | less
```




```
0000000 0304 0102 0305 0102 0306 0102 0307 0102
0000010 0308 0102 0309 0102 030a 0102 030b 0102
0000020 030c 0102 030d 0102 030e 0102 030f 0102
0000030 0310 0102 0311 0102 0312 0102 0313 0102
0000040 0314 0102 0315 0102 0316 0102 0317 0102
0000050 0318 0102 0319 0102 031a 0102 031b 0102
0000060 031c 0102 031d 0102 031e 0102 031f 0102
0000070 0320 0102 0321 0102 0322 0102 0323 0102
0000080 0324 0102 0325 0102 0326 0102 0327 0102
0000090 0328 0102 0329 0102 032a 0102 032b 0102
00000a0 032c 0102 032d 0102 032e 0102 032f 0102
00000b0 0330 0102 0331 0102 0332 0102 0333 0102
00000c0 0334 0102 0335 0102 0336 0102 0337 0102
00000d0 0338 0102 0339 0102 033a 0102 033b 0102
00000e0 033c 0102 033d 0102 033e 0102 033f 0102
00000f0 0340 0102 0341 0102 0342 0102 0343 0102
0000100 0344 0102 0345 0102 0346 0102 0347 0102
0000110 0348 0102 0349 0102 034a 0102 034b 0102
0000120 034c 0102 034d 0102 034e 0102 034f 0102
0000130 0350 0102 0351 0102 0352 0102 0353 0102
0000140 0354 0102 0355 0102 0356 0102 0357 0102
0000150 0358 0102 0359 0102 035a 0102 035b 0102
0000160 035c 0102 035d 0102 035e 0102 035f 0102
standard input
```

Figure 8: Expected Output

10.2 Standalone Mode

The default setup script sets the `OCPI_LIBRARY_PATH` variable to include the all of the artifacts that are required to execute the application. Specifically, all three of the artifacts that are located on the SD card are mounted at `/mnt/card/opencpi/xilinx13_3/artifacts`. After running `mysetup.sh`, navigate to `/mnt/card/opencpi/applications` and ensure the `OCPI_LIBRARY_PATH` variable is configure as shown below:

```
$ cd /mnt/card/opencpi/applications
$ export OCPI_LIBRARY_PATH=$OCPI_LIBRARY_PATH:/mnt/card/opencpi/xilinx13_3/artifacts
```

Run the application using the following command:

```
$ ocpirun -v -t 1 -d -m bias=hdl bias.xml
```

The output should be similar to Figure 9:

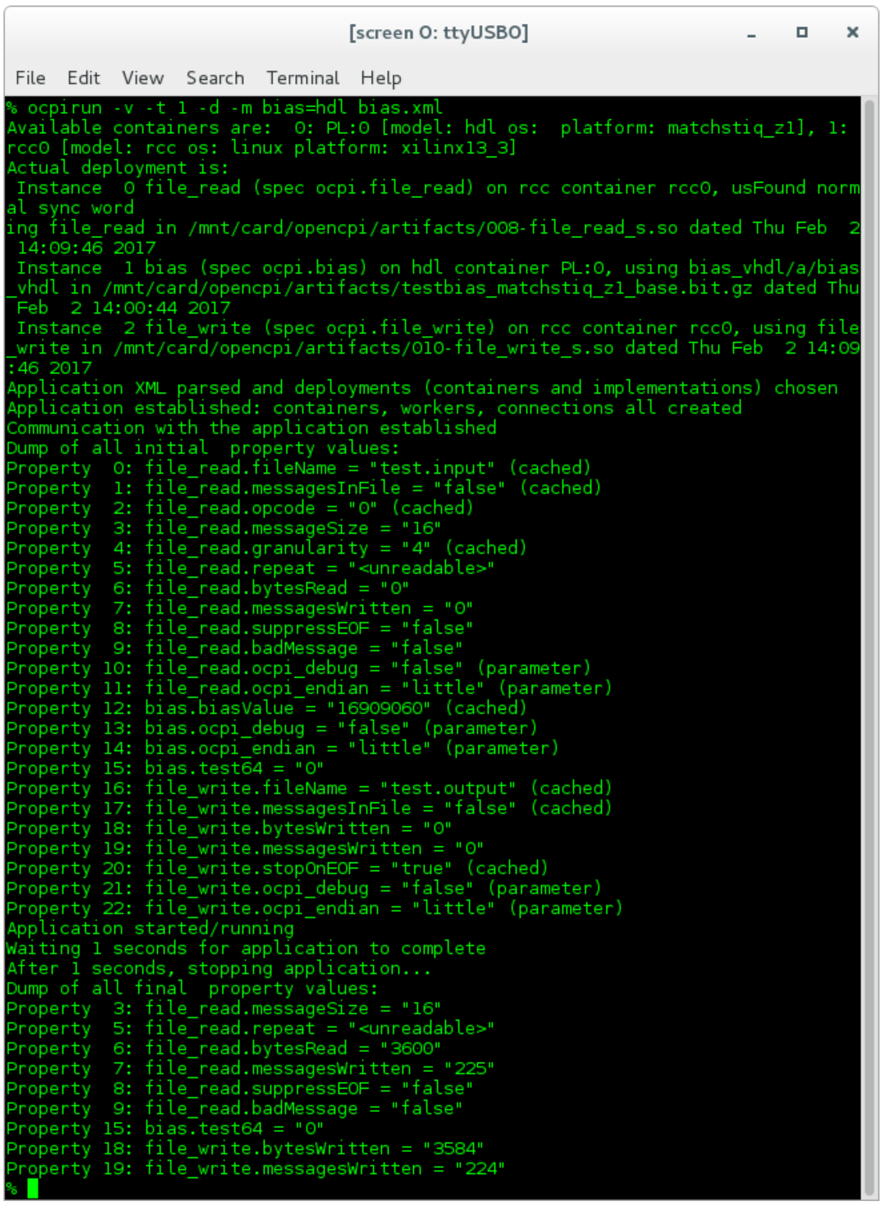


Figure 9: Successful Standalone Mode Execution

Run the following command to view the input. It should look like Figure 10:

```
$ hexdump test.input | less
```

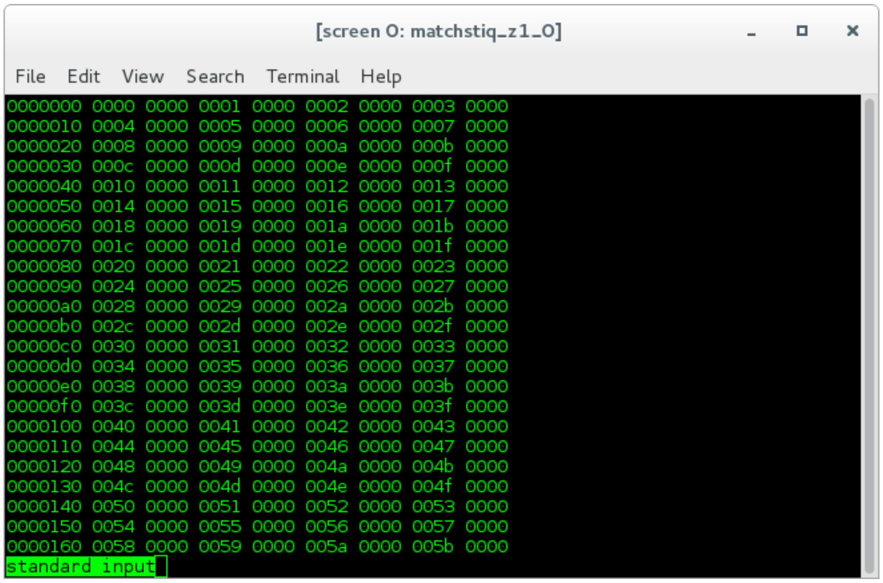


Figure 10: Expected Input

Run the following command to view the output. It should look like Figure 11:

```
$ hexdump test.output | less
```

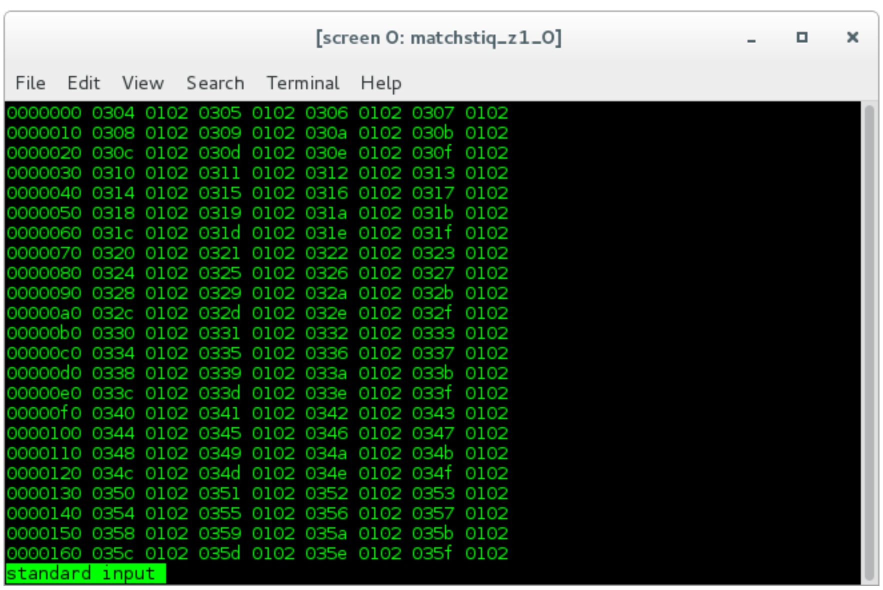


Figure 11: Expected Output

Appendices

A Intermittent Errors

Some tests have had "Segmentation Faults" or "Alignment Errors" in certain scenarios on the Z1. This seems to happen when both USB ports are used to simultaneously transmit a large amount of data, *e.g.* high log-level output to a USB serial console as well as NFS-mounted output files over a USB-to-Ethernet adapter. The default test setup avoids triggering this by limiting output that is fed to the user, but users should be aware of this issue if non-default test scenarios are attempted. If `ssh` is used to have all data routed through the USB-to-Ethernet adapter, this failure mode is avoided.

B Using ISE instead of Vivado with the Matchstiq-Z1

It is recommended that you use the default toolset (Xilinx Vivado) to build Matchstiq-Z1 bitstreams with OpenCPI. However, if you wish to use ISE instead, reference the README file in `assets/hdl/platforms/matchstiq_z1/ise_constraints/`, and perform the following steps:

1. Modify the target part in `assets/hdl/platforms/matchstiq_z1/matchstiq_z1.mk` to use the ISE alias:

   ```
   HdlPart_matchstiq_z1=xc7z020_ise_alias-1-clg484
   ```

2. Export the ISE constraints files found in `<assets/>hdl/platforms/matchstiq_z1/ise_constraints/` by modifying `ExportFiles` variable in `assets/hdl/platforms/matchstiq_z1/Makefile`:

   ```
   ExportFiles=ise_constraints/matchstiq_z1.ucf ise_constraints/matchstiq_z1.ut matchstiq_z1.mk
   ```

C Driver Notes

When available, the driver will attempt to make use of the CMA region for direct memory access. In use cases where many memory allocations are made, the user may receive the following kernel message:

```
alloc_contig_range␣test_pages_isolated([memory␣start],␣[memory␣end])␣failed
```

This is a kernel warning, but does not indicate that a memory allocation failure occurred, only that the CMA engine could not allocate memory in the first pass. Its default behavior is to make a second pass, and if that succeeded, the end user should not see any more error messages. This message cannot be suppressed, but can be safely ignored. An actual allocation failure will generate unambiguous error messages.