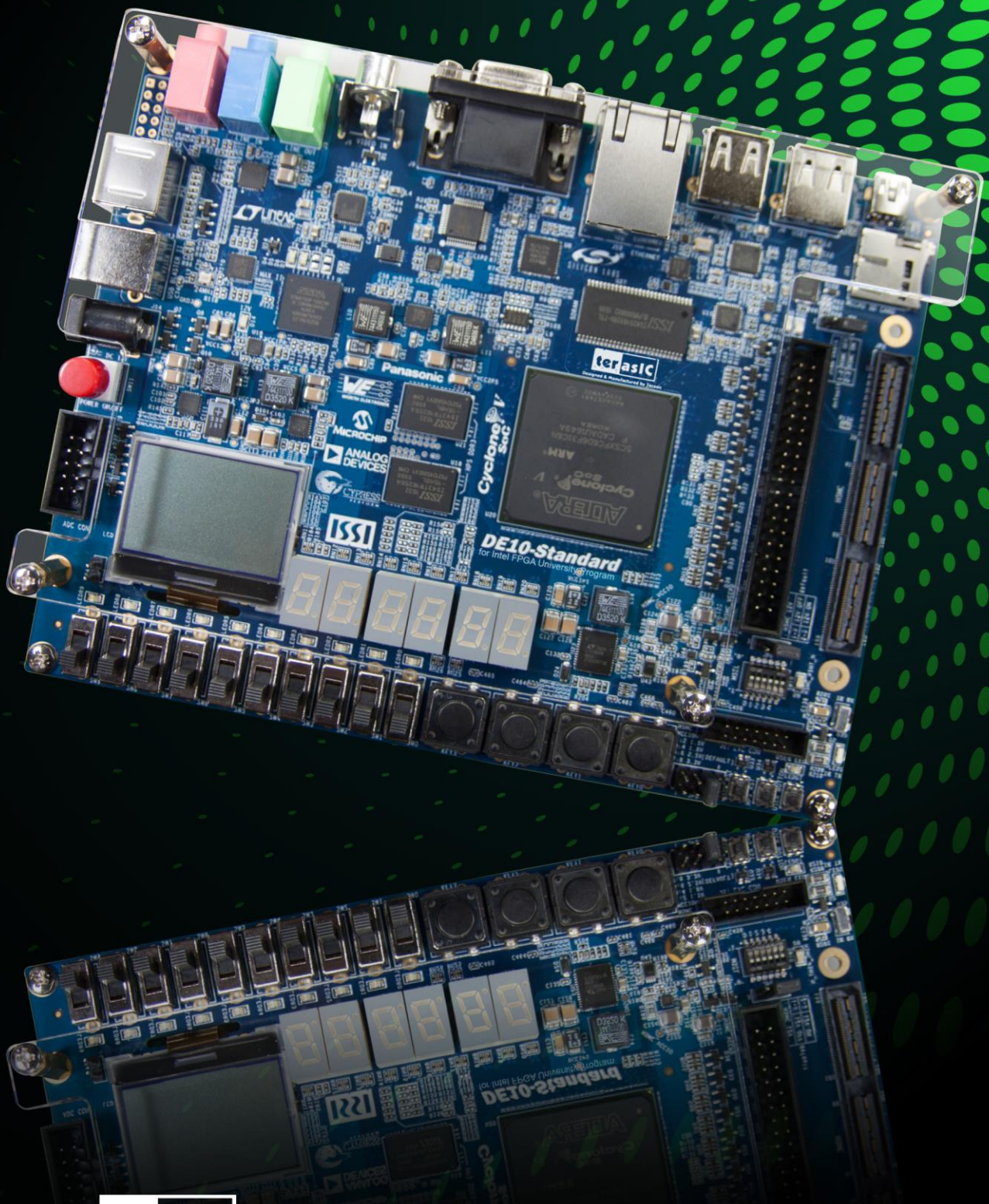
DE10-Standard

My First HPS



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CONTENTS

Chapter 1

Introduction

This tutorial provides comprehensive information that will help you understand how to create a C-language software design and run it on your ARM-included DE10-Standard development board. The following sections provide a quick overview of the design flow, explain what you need to get started, and describe what you will learn.

1.1 Software Development Flow

Figure 1-1 shows the software design flow block diagram. The development procedures are:

1. Developers need to design their C-code software project with a generic text editor. Generally, .c and .h files are needed.
2. Create a "**Makefile**" for your software design project, so the compiler knows how to generate a final object/executable files for your project.
3. Use the compile tool to generate executable file
4. Boot Linux from your DE10-Standard board.
5. Download the executable file to Linux and launch it.

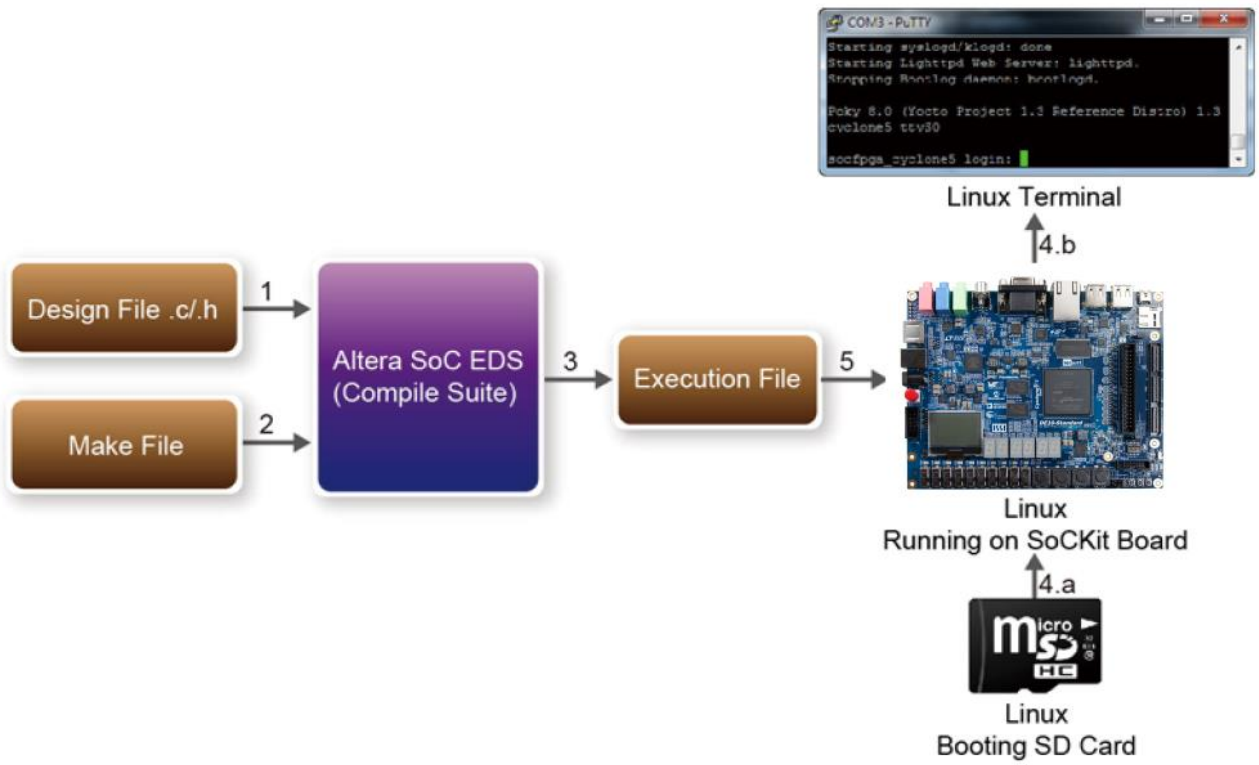

Figure 1-1 Design Flow

1.2 System Requirements

Besides the DE10-Standard board, the following software and hardware are required:

- Microsoft Windows computer with USB port and Ethernet Port
- Ethernet Router
- Altera SoC EDS(Embedded Design Suite) software tool installed
- Generic text editor tool installed
- PuTTY installed
- FTDI Virtual COM driver installed
- A bootable SD card with the Linux system

1.3 What You Will Learn

In this tutorial you will perform the following tasks:

- Create a "Hello World!" design that displays a message on the Linux terminal—This design is easy to create and gives you visual feedback that the design works. Of course, you can use your DE10-Standard board to run other designs as well.

- Become familiar with Altera SoC EDS and Linux—This tutorial will not make you an expert, but you should grasp some basic concepts about the compile tool and Linux operation in the end of this tutorial.

Chapter 2

Create and Build Your Project

This chapter describes how to create your first HPS (Hard Processer System) project and build (compile and link) it with the Altera SoC EDS software tool. We assume you have already installed the Altera SoC EDS. If not, there are installatin details in Chapter 2 of the **DE10-Standard Getting Started Guide** manual in the System CD.

2.1 Creating a Project Folder

A project usually includes the design files .c/.h and a make file. These files are generally stored under the same folder. So, it is suggested to create a project folder where you can store your design file and make file.

Developer can create a "**my_first_hps**" folder under the installed Altera SoC EDS installation folder. From this point onward, the folder's absolute path will be assumed to be:

" C:\intelFPGA\16.1\embedded\my_first_hps ".

2.2 Creating a Design File

First, please create an empty file, named "**main.c**", under "my_first_hps" folder. Then, type below code into the file and save it. The program includes the "**stdio.h**" header file for the "**printf**" function, which is used to output a "**Hello World!**" message in a standard output device. By default, the standard output device is the UART terminal.

```
#include <stdio.h>

int main(int argc, char **argv) {

        printf("Hello World!\r\n");

        return( 0 );
```

```
}
```

2.3 Creating the Makefile

A makefile is required for the Altera SoC EDS in order for it to know how to compile and link your project. First, you will need to create an empty file, named "**Makefile**", under "**my_first_hps**" folder. Then, type in the following content and save it. Inside the makefile, the "**TARGET**" variable defines the output file name. In this tutorial, the output executable file name is "**my_first_hps**". The makefile also specifies which compiler to use, in this case we use ARM gcc cross compiler. The gcc compile paramater "-I${SOCEDS_DEST_ROOT}/ip/altera/hps/altera_hps/hwlib/include" defines the searching path for the gcc including header files.

```
#
TARGET = my_first_hps

ALT_DEVICE_FAMILY ?= soc_cv_av
SOCEDS_ROOT ?= $(SOCEDS_DEST_ROOT)
HWLIBS_ROOT = $(SOCEDS_ROOT)/ip/altera/hps/altera_hps/hwlib
CROSS_COMPILE = arm-linux-gnueabihf-
CFLAGS = -g -Wall     -D$(ALT_DEVICE_FAMILY)
-I$(HWLIBS_ROOT)/include/$(ALT_DEVICE_FAMILY)
-I$(HWLIBS_ROOT)/include/LDFLAGS =    -g -Wall
CC = $(CROSS_COMPILE)gcc
ARCH= arm

build: $(TARGET)

$(TARGET): main.o
        $(CC) $(LDFLAGS)     $^ -o $@

%.o : %.c
        $(CC) $(CFLAGS) -c $< -o $@

.PHONY: clean
clean:
        rm -f $(TARGET) *.a *.o *~
```

2.4 Compiling the Project

To compile a project, developers need to launch the Altera Embedded Command Shell first. Please browse to the SoC EDS installation folder, e.g. " C:\intelFPGA\16.1\embedded ", as shown in Figure 2-1.

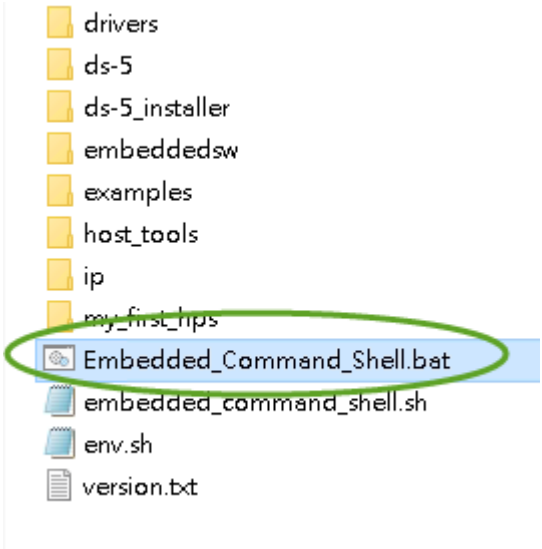

Figure 2-1 Embedded Folder of SoC EDS

Then, double-click the "Embedded_Command_Shell.bat" item to launch Command Shell as shown below.

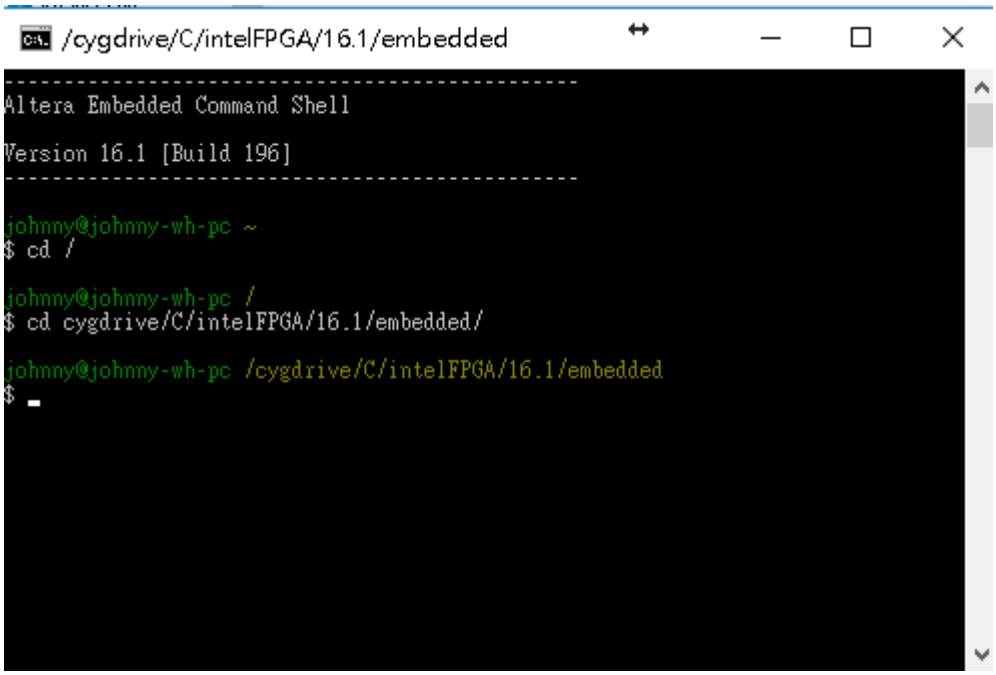

Figure 2-2 Open Embedded_Command_Shell

In the Command Shell, please use the Linux "**cd**" command to change current directory to your project folder. In this tutorial, just type "**cd my_first_hps**" to go to the project folder we just created. Then, type a "**make**" command to start the building (compiling and linking) process, as shown below.

After the building process is finished, developers can type "**ls**" to list all the files in the current directory. In this tutorial, we can see the executable file "**my_first_hps**" is generated successfully as shown below.

```
johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded
$ cd my_first_hps/

johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded/my_first_hps
$ make
arm-linux-gnueabihf-gcc -g -Wall -Werror -IC:/intelFPGA/16.1/embedded/ip/altera/hps/altera_hps/hwli
b/include -IC:/intelFPGA/16.1/embedded/ip/altera/hps/altera_hps/hwlib/include/soc_cv_av -Dsoc_cv_av
 -c main.c -o main.o
arm-linux-gnueabihf-gcc -g -Wall -Werror   main.o -o my_first_hps

johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded/my_first_hps
$ -
```

Chapter 3

Executing Your Project

This chapter describes how to execute your executable file "**my_first_hps**" on Linux on the DE0-Standard board. Here, we assume you already know how to boot Linux on the DE10-Standad board. For more details, please refer to Chapter 5 of the **DE10-Standard Getting Started Guide** manual. We assumed you have installed the following softwares.

- PuTTY
- Virtual Com Drivernano

3.1 Execute Your Executable File

Before you can run your executable file, you need to copy the executable file "**my_first_hps**" to the bootable SD card or USB storage, so you can access your file under a running Linux system on the DE0- Standard board. If you have already put your executable file under the /home/root folder, after logging in as a root user, you can type "**./my_first_hps**" to launch the executable file, and you will see "Hello World!" on the UART terminal as shown below. If you don"t know how to put the execute file "**my_first_hps**" into the SD card, please refer to the following section.

```
[  OK  ] Started Getty on tty1.
[  OK  ] Reached target Login Prompts.
[  OK  ] Started Set console scheme.
         Starting Hostname Service...
[  OK  ] Started OpenBSD Secure Shell server.
[  OK  ] Reached target Multi-User System.
[  OK  ] Reached target Graphical Interface.
         Starting Update UTMP about System Runlevel Changes...
[  OK  ] Started Hostname Service.
[  OK  ] Started Update UTMP about System Runlevel Changes.

Ubuntu 16.04.1 LTS DE10_STANDARD ttyS0

DE10_STANDARD login: root
Password:
Last login: Thu Jan 19 10:26:47 UTC 2017 on ttyS0
Welcome to Ubuntu 16.04.1 LTS (GNU/Linux 4.5.0-00185-g3bb556b armv7l)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage
root@DE10_STANDARD:~# ./my_first_hps
Hello World!
root@DE10_STANDARD:~#
```

3.2 Putting my_first_hps into the bootable SD card

The section describes how to copy the executable file "**my_first_hps**" into the SD card using Linux system command "**scp**". First, you have to use an RJ45 cable to connect both your Windows PC and the DE10-Standard board to your Ethernet router, as shown in **Figure 3-1.**

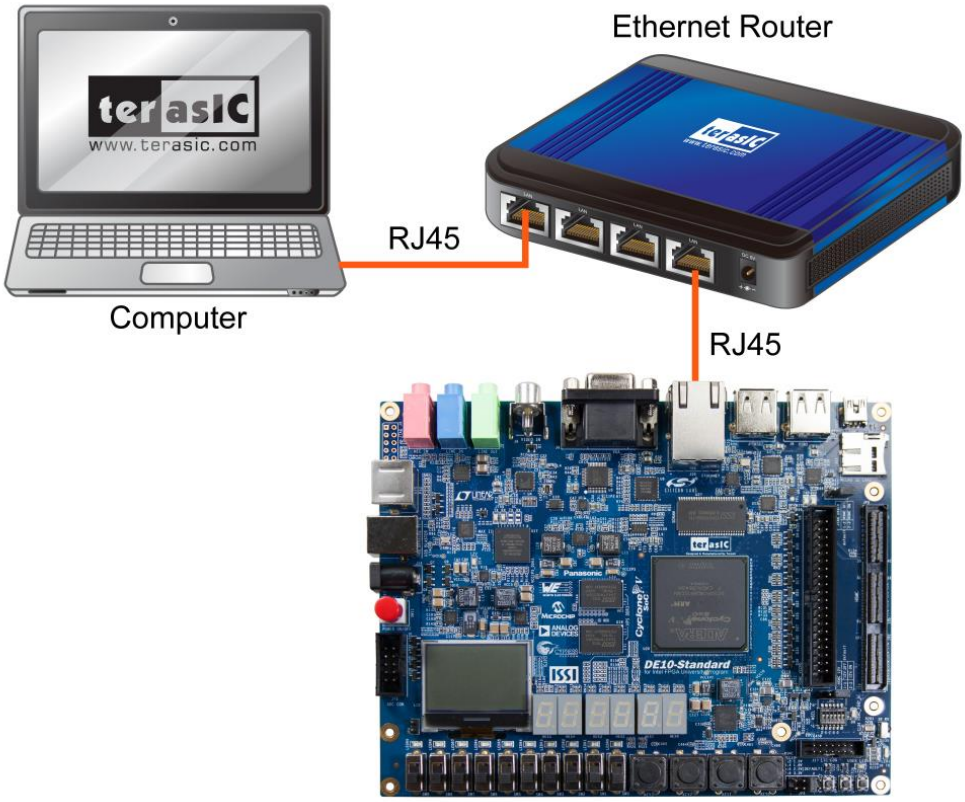

Figure 3-1 Ethernet Setup

To boot Linux, follow the below procedure to get the Ethernet IP for your DE10-Standard board.

1. Login as a root user
2. Type "**udhcpc**" to query an IP from DHCP server.
3. Type "**ifconfig**" to check the Ethernet IP for your DE0- Standard board. In this tutorial, IP "**192.168.21.134**" is assigned to the DE10-Standard board, as shown below.

```
root@DE10_STANDARD:~# udhcpc
root@DE10_STANDARD:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 9e:77:86:70:9b:0f
          inet addr:192.168.21.134  Bcast:192.168.21.255  Mask:255.255.255.0
          inet6 addr: fe80::8bf5:80f8:866f:a9de/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:11 errors:0 dropped:0 overruns:0 frame:0
          TX packets:13 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:2166 (2.1 KB)  TX bytes:2334 (2.3 KB)
          Interrupt:39 Base address:0x8000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:160 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:11840 (11.8 KB)  TX bytes:11840 (11.8 KB)

root@DE10_STANDARD:~#
```

Now, you can use “**scp**” command to copy the executable file “my_first_hps” into the SD card. In Altera SoC command shell, type “**scp my_first_hps root@192.168.21.134:/home/root**” to copy the file into the folder “/home/root”. Note that, the "192.168.21.134" IP address is obtained in the previous step. When you see the prompt message "Are you sure you want to continued connecting (yes/no)?", reply yes by typing “**yes**” and pressing ENTER. Next, when you are asked for the password, please enter the root's password and press. The default password for the root user is “terasic”.

```
johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded
$ cd my_first_hps/

johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded/my_first_hps
$ make
arm-linux-gnueabihf-gcc -g -Wall -Werror -IC:/intelFPGA/16.1/embedded/ip/altera/
hps/altera_hps/hwlib/include -IC:/intelFPGA/16.1/embedded/ip/altera/hps/altera_h
ps/hwlib/include/soc_cv_av -Dsoc_cv_av -c main.c -o main.o
arm-linux-gnueabihf-gcc -g -Wall -Werror  main.o -o my_first_hps

johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded/my_first_hps
$ scp my_first_hps root@192.168.21.134:/home/root
Could not create directory '/home/johnny/.ssh'.
The authenticity of host '192.168.21.134 (192.168.21.134)' can't be established.

ECDSA key fingerprint is SHA256:YAVGTDiDJ5Pwbx1o4bkeYZtfVcVyKJIiTZwZVRnIJP4.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/johnny/.ssh/known_hosts
).
root@192.168.21.134's password:
my_first_hps                                  100% 7149     7.0KB/s   00:00

johnny@johnny-wh-pc /cygdrive/C/intelFPGA/16.1/embedded/my_first_hps
$
```

After completing the copy process, you can type “**ls**” to list the files in the current directory. We will see that the “**my_first_hps**” appears. Before the file can be executed, you need to change the file

permission by running the command "**chmod 777 my_first_hps**" as shown below.

```
root@DE10_STANDARD:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 9e:77:86:70:9b:0f
          inet addr:192.168.21.134  Bcast:192.168.21.255  Mask:255.255.255.0
          inet6 addr: fe80::8bf5:80f8:866f:a9de/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:310 errors:0 dropped:0 overruns:0 frame:0
          TX packets:62 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:41303 (41.3 KB)  TX bytes:8329 (8.3 KB)
          Interrupt:39 Base address:0x8000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:160 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:11840 (11.8 KB)  TX bytes:11840 (11.8 KB)

root@DE10_STANDARD:~# chmod 777 my_first_hps
root@DE10_STANDARD:~#
```

Finally, you can execute the file by typing "**./my_first_hps**" as shown below.

```
          RX packets:160 errors:0 dropped:0 overruns:0 frame:0
          TX packets:160 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:11840 (11.8 KB)  TX bytes:11840 (11.8 KB)

root@DE10_STANDARD:~# chmod 777 my_first_hps
root@DE10_STANDARD:~# ./my_first_hps
Hello World!
root@DE10_STANDARD:~#
```

Chapter 4

Appendix

4.1 Headquarter & Branches

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