

如何将电脑上编译好的可执行文件放到开发板上执行？

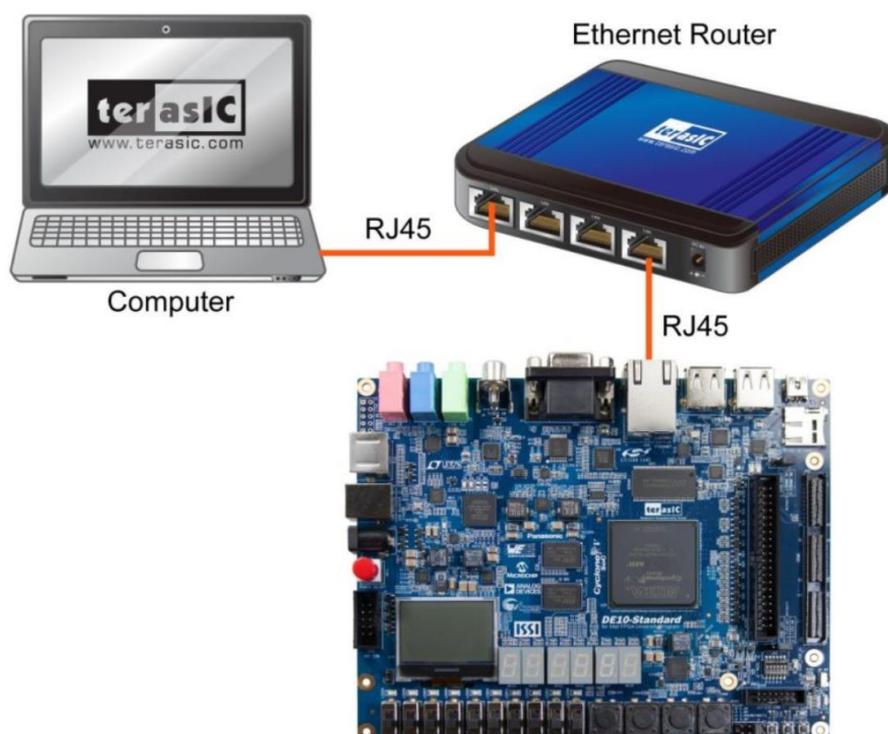
在使用 SoC 类的 FPGA 开发板启动 Linux 系统, 进行开发或测试时, 将电脑主机编译好的可行执行文件拷贝到开发板的 SD 卡 Linux 系统中再执行的情况屡见不鲜, 那么该如何将编译好的可行执行文件拷贝到开发板的 SD 卡中呢? 今天, 以 DE10-Standard 开发板为例整理了三种可行方法。

说明:

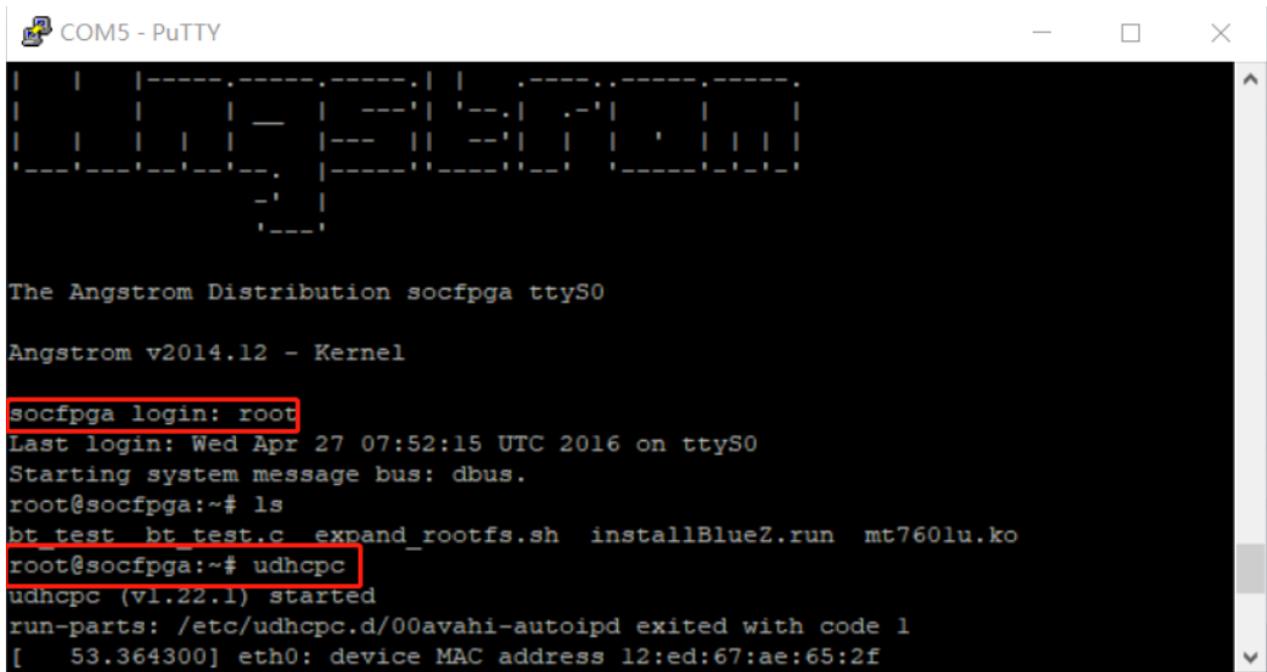
1. 全文以友晶官网上的 *DE10-Standard Linux Console* 镜像文件为 Linux 启动系统;
2. 为分辨可执行文件是否成功拷贝, 三种方法中编译好的可执行文件分别命令为 `my_first_hps_1`, `my_first_hps_2`, `my_first_hps_3`。

方法一: 使用网口自动获取 IP, 用 scp 命令进行拷贝

- 1-1. 将电脑和 DE10-Standard 开发板通过 RJ45 网线连接到同一个路由器上, 使其在同一个局域网中, 如下图:

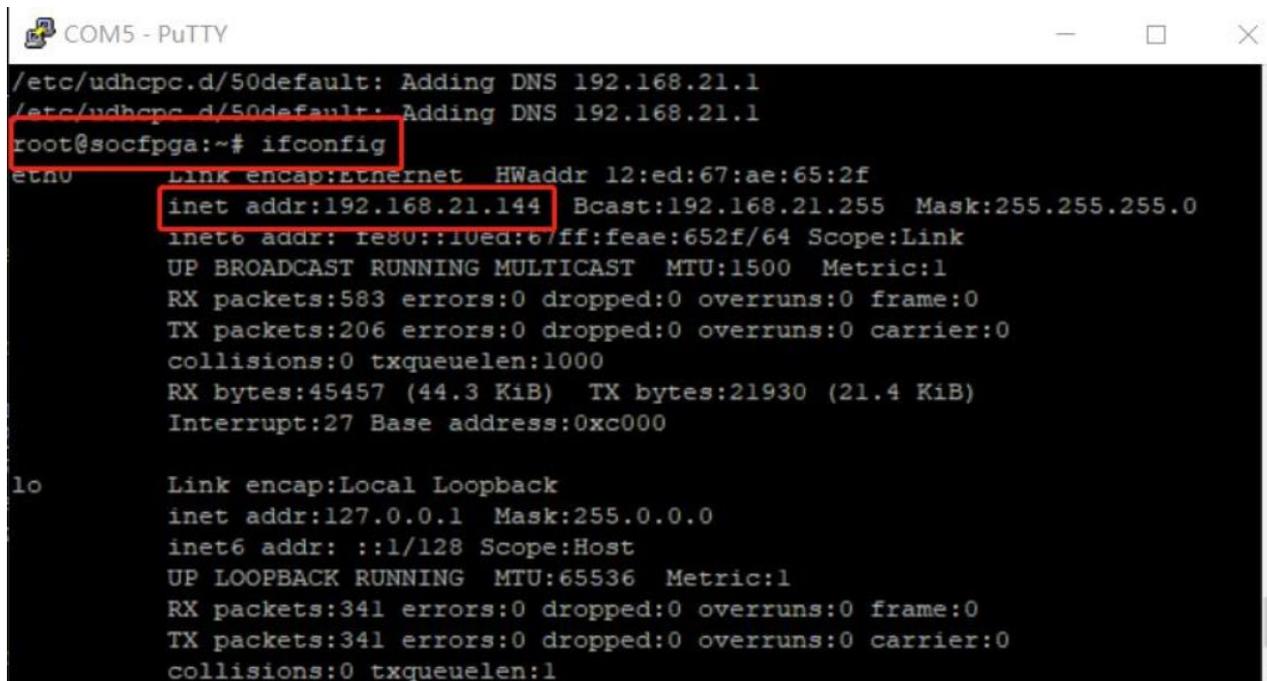


1-2. 使用 root 登录 Linux 系统, 并输入 udhcpd 命令从 DHCP 服务器自动获取 IP:



```
COM5 - PuTTY
[... ASCII art ...]
The Angstrom Distribution socfpfga ttyS0
Angstrom v2014.12 - Kernel
socfpfga login: root
Last login: Wed Apr 27 07:52:15 UTC 2016 on ttyS0
Starting system message bus: dbus.
root@socfpfga:~# ls
bt_test bt_test.c expand_rootfs.sh installBlueZ.run mt760lu.ko
root@socfpfga:~# udhcpd
udhcpd (v1.22.1) started
run-parts: /etc/udhcpd.d/00avahi-autoipd exited with code 1
[ 53.364300] eth0: device MAC address 12:ed:67:ae:65:2f
```

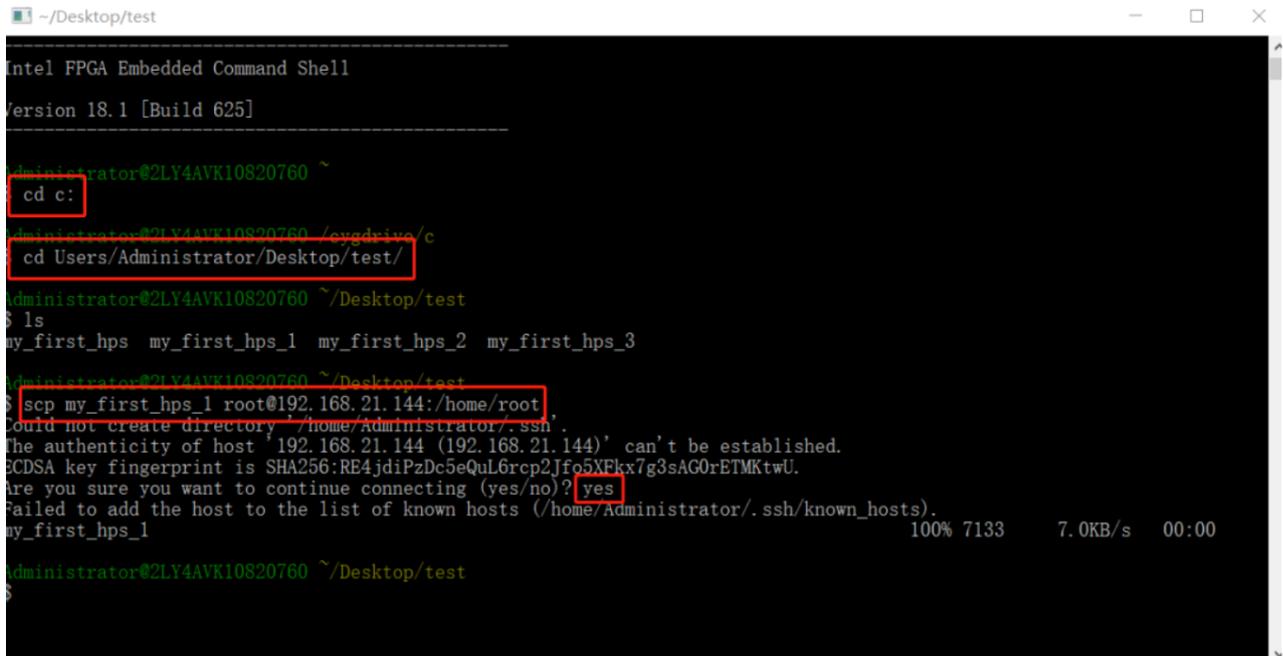
1-3. 使用 ifconfig 命令查询 DE10-Standard 获取到的 IP 地址, 为 "192.168.21.144";



```
COM5 - PuTTY
/etc/udhcpd.d/50default: Adding DNS 192.168.21.1
/etc/udhcpd.d/50default: Adding DNS 192.168.21.1
root@socfpfga:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 12:ed:67:ae:65:2f
          inet addr:192.168.21.144  Bcast:192.168.21.255  Mask:255.255.255.0
          inet6 addr: fe80::10ed:67ff:feae:652f/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:583 errors:0 dropped:0 overruns:0 frame:0
          TX packets:206 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:45457 (44.3 KiB)  TX bytes:21930 (21.4 KiB)
          Interrupt:27 Base address:0xc000

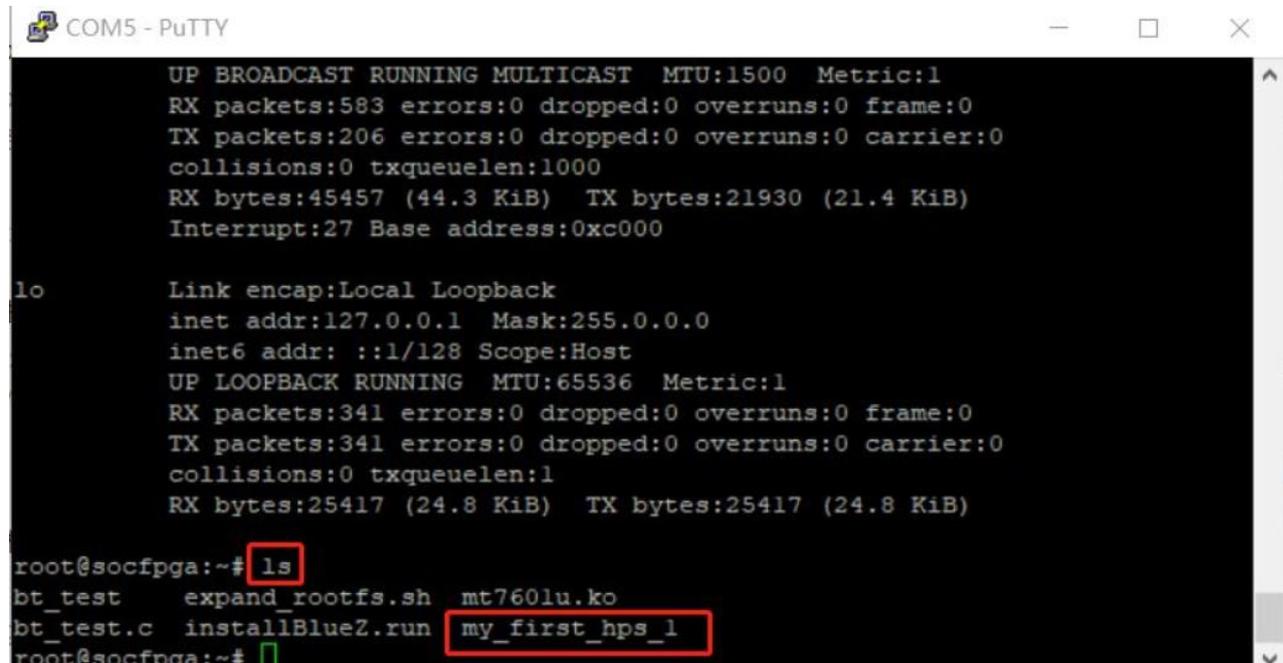
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:341 errors:0 dropped:0 overruns:0 frame:0
          TX packets:341 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
```

- 1-4. 此时, 便可以使用 scp 命令将 "my_first_hps_1" 可执行文件拷贝到 SD 卡中。打开 Intel SoC EDS command shell 窗口, 使用 cd 命令进入 "my_first_hps_1" 的路径, 然后输入 [scp my first hps 1 root@192.168.21.144:/home/root](#) 命令, 将文件拷贝到 SD 卡 "/home/root" 路径下。注意, 在弹出 Are you sure you want to continued connecting (yes/no)? 命令后输入 yes 并按下 enter 键;



```
~/Desktop/test
Intel FPGA Embedded Command Shell
Version 18.1 [Build 625]
Administrator@2LY4AVK10820760 ~
cd c:
Administrator@2LY4AVK10820760 /c
cd Users/Administrator/Desktop/test/
Administrator@2LY4AVK10820760 ~/Desktop/test
$ ls
my_first_hps  my_first_hps_1  my_first_hps_2  my_first_hps_3
Administrator@2LY4AVK10820760 ~/Desktop/test
$ scp my_first_hps_1 root@192.168.21.144:/home/root
Could not create directory '/home/Administrator/.ssh'.
The authenticity of host '192.168.21.144 (192.168.21.144)' can't be established.
ECDSA key fingerprint is SHA256:RE4jdiPzDc5eQuL6rcp2Jfo5XFlkx7g3sAG0rETMKtWU.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/Administrator/.ssh/known_hosts).
my_first_hps_1                               100% 7133    7.0KB/s   00:00
Administrator@2LY4AVK10820760 ~/Desktop/test
$
```

- 1-5. 完成拷贝之后, 在 putty 终端输入 ls 命令, 就可以看到 "my_first_hps_1" 文件已经被成功拷贝进来。



```
COM5 - PuTTY
UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
RX packets:583 errors:0 dropped:0 overruns:0 frame:0
TX packets:206 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:1000
RX bytes:45457 (44.3 KiB)  TX bytes:21930 (21.4 KiB)
Interrupt:27 Base address:0xc000

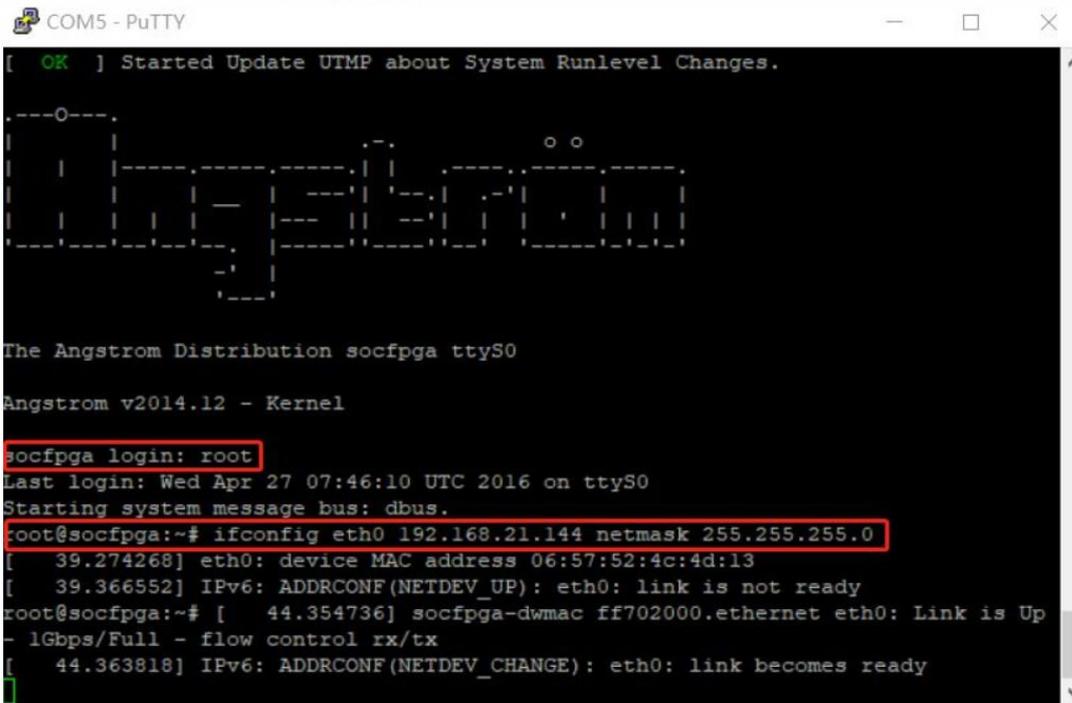
lo
  Link encap:Local Loopback
  inet addr:127.0.0.1  Mask:255.0.0.0
  inet6 addr: ::1/128 Scope:Host
  UP LOOPBACK RUNNING  MTU:65536  Metric:1
  RX packets:341 errors:0 dropped:0 overruns:0 frame:0
  TX packets:341 errors:0 dropped:0 overruns:0 carrier:0
  collisions:0 txqueuelen:1
  RX bytes:25417 (24.8 KiB)  TX bytes:25417 (24.8 KiB)

root@socfpga:~# ls
bt_test  expand_rootfs.sh  mt760lu.ko
bt_test.c  installBlueZ.run  my_first_hps_1
root@socfpga:~#
```

方法二：网线直连开发板和电脑, 用 scp 命令进行拷贝

2-1. 网线将电脑的网口和 DE10-Standard 开发板的网口连接起来:

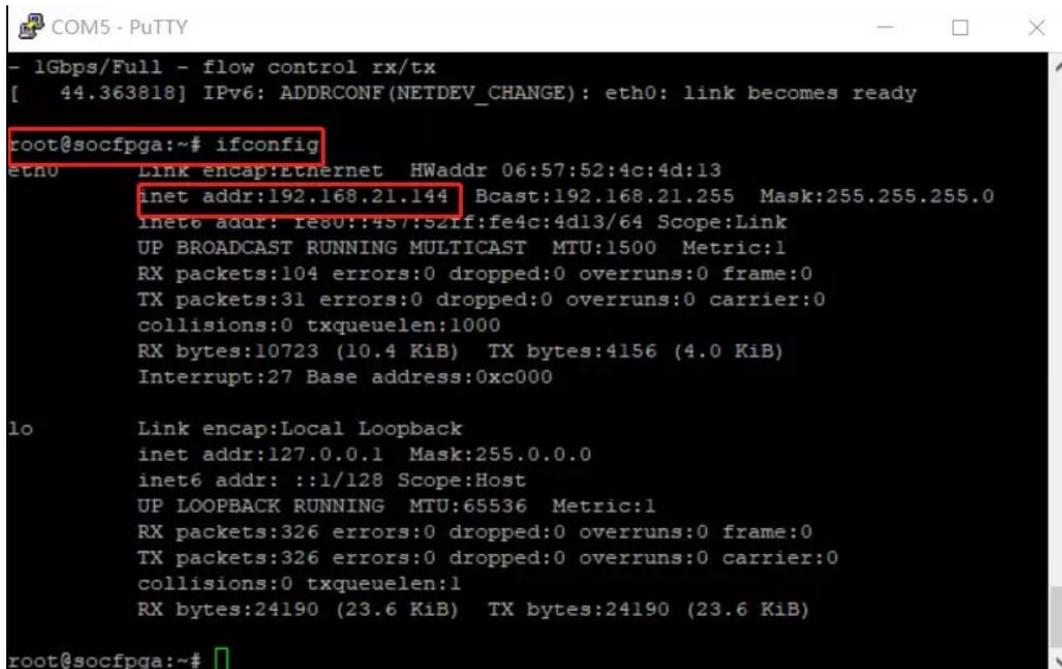
2-2. 用 root 登录 Linux 系统, 并使用命令 `ifconfig eth0 192.168.21.144 netmask 255.255.255.0` 将开发板的 IP 手动设置为 192.168.21.144 (这里 IP 可以自由设置, 但是要保证跟电脑的 IP 在同一个网段);



```
COM5 - PuTTY
[ OK ] Started Update UTMP about System Runlevel Changes.

The Angstrom Distribution socfpfga ttyS0
Angstrom v2014.12 - Kernel
socfpfga login: root
Last login: Wed Apr 27 07:46:10 UTC 2016 on ttyS0
Starting system message bus: dbus.
root@socfpfga:~# ifconfig eth0 192.168.21.144 netmask 255.255.255.0
[ 39.274268] eth0: device MAC address 06:57:52:4c:4d:13
[ 39.366552] IPv6: ADDRCONF(NETDEV_UP): eth0: link is not ready
root@socfpfga:~# [ 44.354736] socfpfga-dwmac ff702000.ethernet eth0: Link is Up
- 1Gbps/Full - flow control rx/tx
[ 44.363818] IPv6: ADDRCONF(NETDEV_CHANGE): eth0: link becomes ready
```

2-3. 然后, 用 `ifconfig` 命令查看开发板的 IP 是否设置成功;

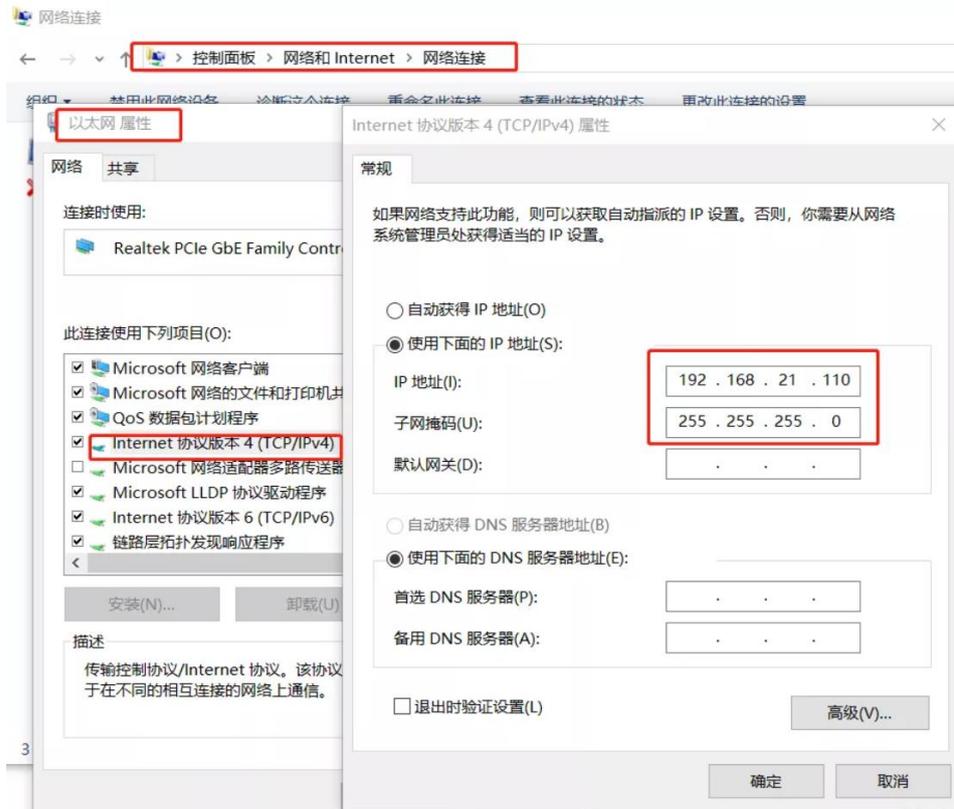


```
COM5 - PuTTY
- 1Gbps/Full - flow control rx/tx
[ 44.363818] IPv6: ADDRCONF(NETDEV_CHANGE): eth0: link becomes ready
root@socfpfga:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 06:57:52:4c:4d:13
          inet addr:192.168.21.144  Bcast:192.168.21.255  Mask:255.255.255.0
          inet6 addr: fe80::457:521f:fe4c:4d13/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:104 errors:0 dropped:0 overruns:0 frame:0
          TX packets:31 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:10723 (10.4 KiB)  TX bytes:4156 (4.0 KiB)
          Interrupt:27 Base address:0xc000

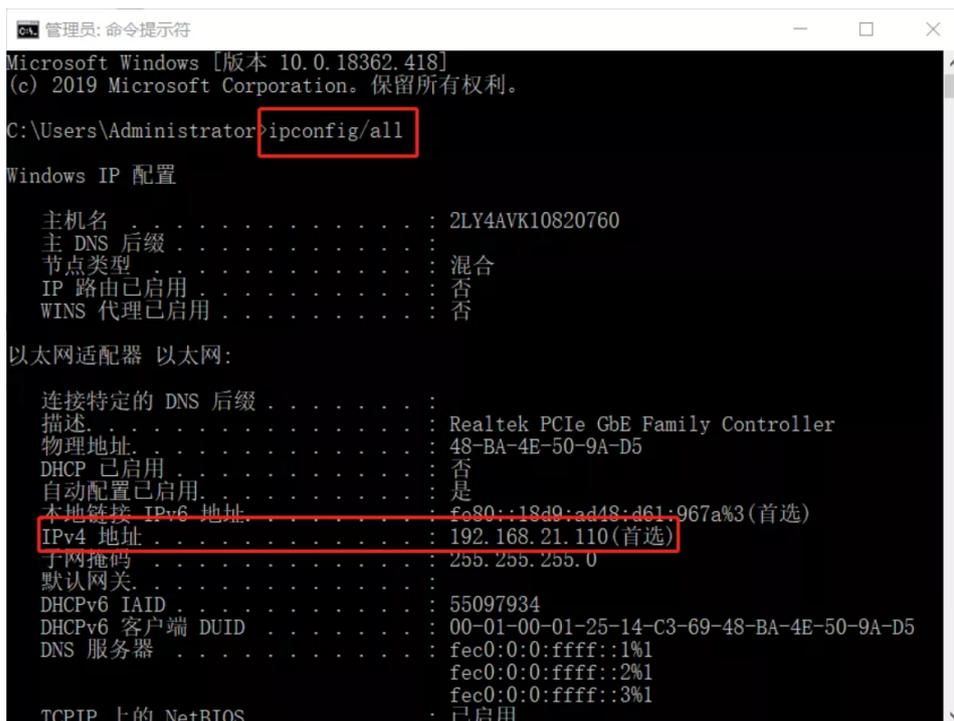
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:326 errors:0 dropped:0 overruns:0 frame:0
          TX packets:326 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:24190 (23.6 KiB)  TX bytes:24190 (23.6 KiB)

root@socfpfga:~#
```

- 2-4. 打开电脑的控制面板 → 网络和 Internet → 网络和共享中心 → 以太网 → 属性 → Internet 协议版本 4 (TCP/IPv4), 设置电脑的 IP, 如下图。(注意: 这里设置的 IP 需要保证和第二步设置的开发板的 IP 在同一个网段, 默认网关和 DNS 可以不用设置);



- 2-5. 进入电脑的 cmd 命令查看符窗口, 用 ipconfig/all 命令查看 IP 地址是否设置正确; 并使用 ping 192.168.21.144 命令来查看网络是否连通;



```
管理员: 命令提示符

以太网适配器 蓝牙网络连接:

    媒体状态 . . . . . : 媒体已断开连接
    连接特定的 DNS 后缀 . . . . . :
    描述. . . . . : Bluetooth Device (Personal Area Network)
    物理地址. . . . . : CC-2F-71-46-49-79
    DHCP 已启用 . . . . . : 是
    自动配置已启用. . . . . : 是

C:\Users\Administrator>ping 192.168.21.144

正在 Ping 192.168.21.144 具有 32 字节的数据:
来自 192.168.21.144 的回复: 字节=32 时间=2ms TTL=64
来自 192.168.21.144 的回复: 字节=32 时间<1ms TTL=64
来自 192.168.21.144 的回复: 字节=32 时间<1ms TTL=64
来自 192.168.21.144 的回复: 字节=32 时间<1ms TTL=64

192.168.21.144 的 Ping 统计信息:
    数据包: 已发送 = 4, 已接收 = 4, 丢失 = 0 (0% 丢失),
    往返行程的估计时间(以毫秒为单位):
        最短 = 0ms, 最长 = 2ms, 平均 = 0ms

C:\Users\Administrator>
```

2-6. IP 设置完成后, 便可以使用 scp 命令将 "my_first_hps_2" 可执行文件拷贝到 SD 卡中。打开 Intel SoC EDS command shell 窗口, 使用 cd 命令进入 "my_first_hps_2" 的路径, 然后输入 [scp my_first_hps_2 root@192.168.21.144:/home/root](#) 命令, 将文件拷贝到 SD 卡 "/home/root" 路径下。

注意, 在弹出 [Are you sure you want to continued connecting \(yes/no\)?](#) 命令后输入 [yes](#) 并按下 enter 键

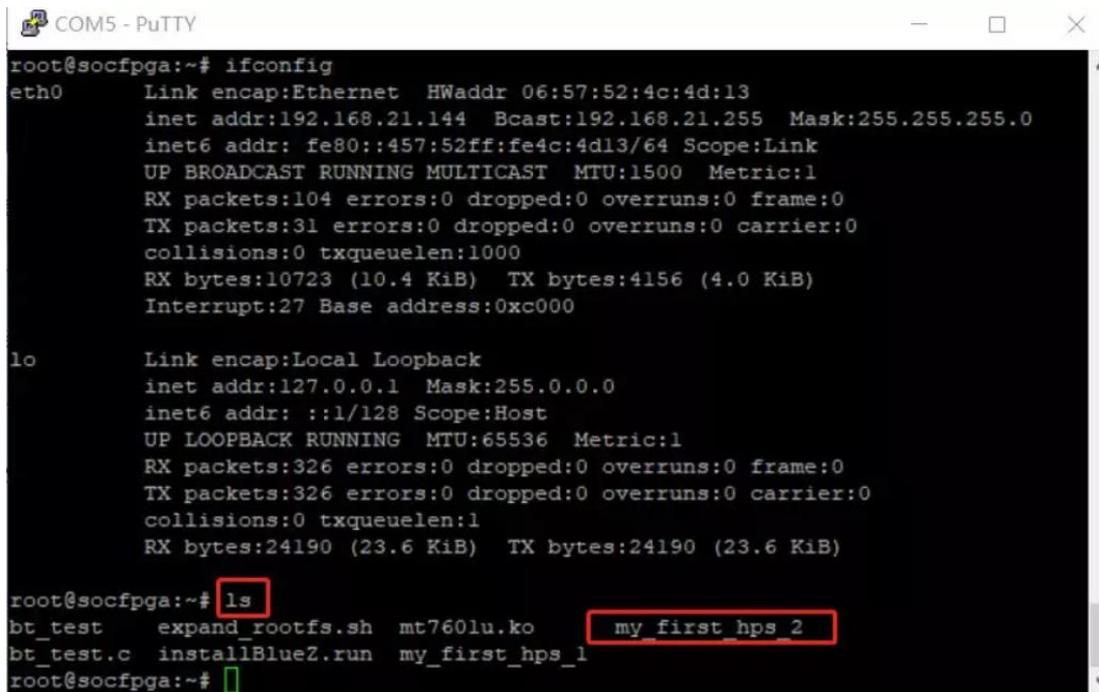
```
选择~/Desktop/test

Intel FPGA Embedded Command Shell
Version 18.1 [Build 625]

Administrator@2LY4AVK10820760 ~
$ cd c:
Administrator@2LY4AVK10820760 /cygdrive/c
$ cd Users/Administrator/Desktop/test/
Administrator@2LY4AVK10820760 ~/Desktop/test
$ scp my_first_hps_2 root@192.168.21.144:/home/root
Could not create directory /home/Administrator/.ssh .
The authenticity of host '192.168.21.144 (192.168.21.144)' can't be established.
ECDSA key fingerprint is SHA256:RE4jdiPzDc5eQul6rcp2Jfo5XEKx7g3sAGOrETMKtWU.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/Administrator/.ssh/known_hosts).
my_first_hps_2
100% 7133 7.0KB/s 00:00

Administrator@2LY4AVK10820760 ~/Desktop/test
$
```

2-7. 完成拷贝之后, 在 putty 终端输入 ls 命令, 就可以看到 "my_first_hps_2" 文件已经被成功拷贝进来。



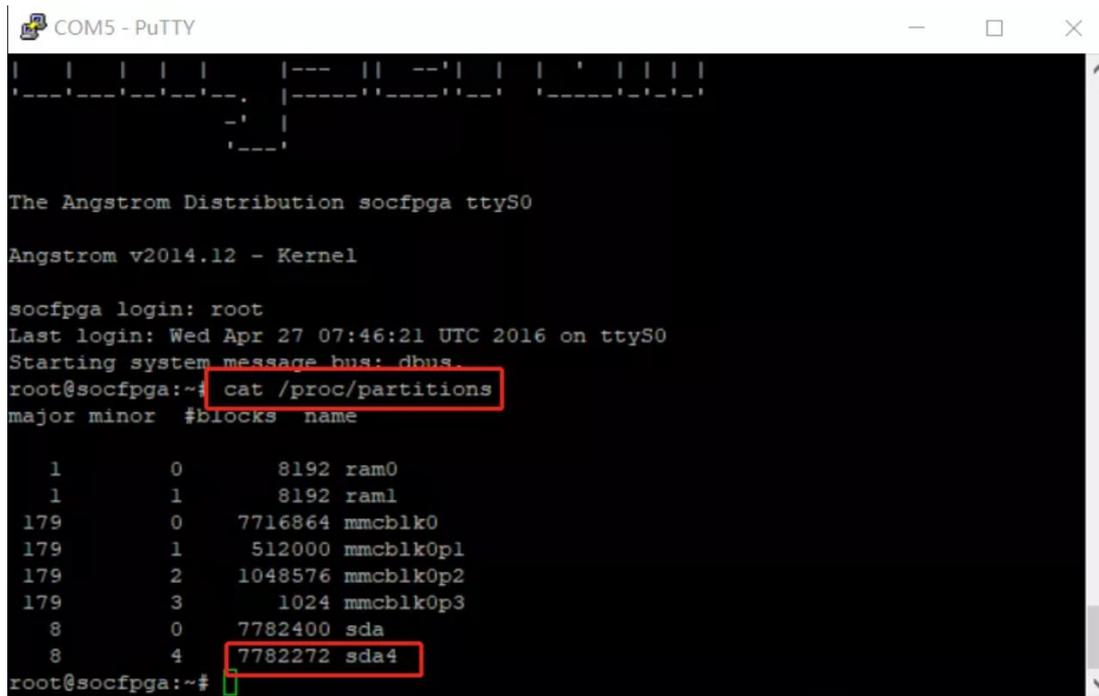
```
COM5 - PuTTY
root@socfpga:~# ifconfig
eth0      Link encap:Ethernet  HWaddr 06:57:52:4c:4d:13
          inet addr:192.168.21.144  Bcast:192.168.21.255  Mask:255.255.255.0
          inet6 addr: fe80::457:52ff:fe4c:4d13/64  Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:104 errors:0 dropped:0 overruns:0 frame:0
          TX packets:31 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:10723 (10.4 KiB)  TX bytes:4156 (4.0 KiB)
          Interrupt:27 Base address:0xc000

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:326 errors:0 dropped:0 overruns:0 frame:0
          TX packets:326 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:24190 (23.6 KiB)  TX bytes:24190 (23.6 KiB)

root@socfpga:~# ls
bt_test  expand_rootfs.sh  mt7601u.ko  my_first_hps_2
bt_test.c  installBlueZ.run  my_first_hps_1
root@socfpga:~#
```

方法三: 用 U 盘拷贝进行拷贝

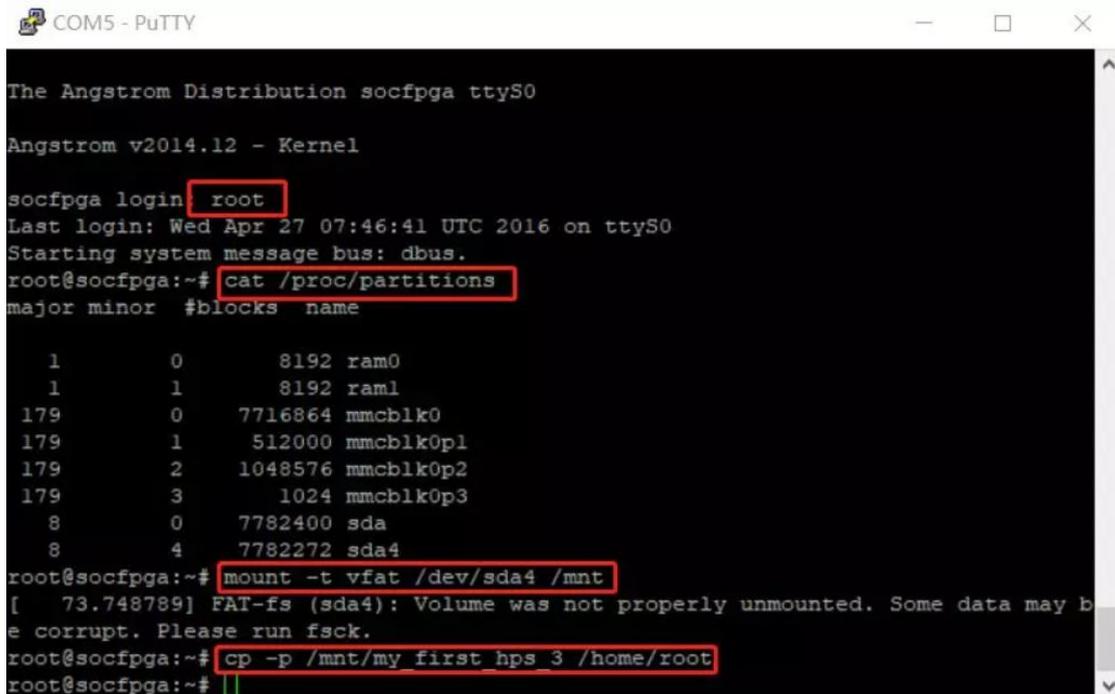
- 3-1. 首先将 my_first_hps 从 PC 拷贝到 U 盘, 把 U 盘插到开发板的 USB1/USB2 接口 (这里选择的是 USB2 接口);
- 3-2. 使用 root 登录 Linux 系统, 用 cat /proc/partitions 命令来查看开发板上的硬盘信息;



```
COM5 - PuTTY
The Angstrom Distribution socfpga ttyS0
Angstrom v2014.12 - Kernel

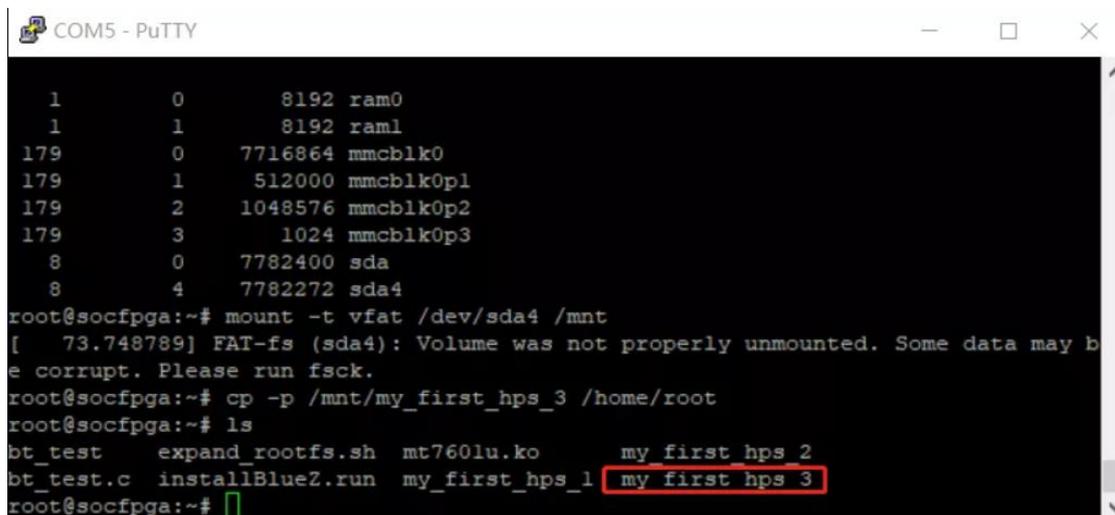
socfpga login: root
Last login: Wed Apr 27 07:46:21 UTC 2016 on ttyS0
Starting system message bus: dbus.
root@socfpga:~# cat /proc/partitions
major minor #blocks name
1 0 8192 ram0
1 1 8192 ram1
179 0 7716864 mmcblk0
179 1 512000 mmcblk0p1
179 2 1048576 mmcblk0p2
179 3 1024 mmcblk0p3
8 0 7782400 sda
8 4 7782272 sda4
root@socfpga:~#
```

3-3. 用 `mount -t vfat /dev/sda4 /mnt` 加载 U 盘至 `"/mnt"` 下 (该命令中的 `sda4` 是实际使用的 U 盘名称, 用户需要根据自己的 U 盘信息进行修改), 然后使用 `cp -p /mnt/my_first_hps_3 /home/root` 命令将可执行文件 `"my_first_hps_3"` 复制到 `"/home/root"` 路径下;



```
COM5 - PuTTY
The Angstrom Distribution socfpfga ttyS0
Angstrom v2014.12 - Kernel
socfpfga login root
Last login: Wed Apr 27 07:46:41 UTC 2016 on ttyS0
Starting system message bus: dbus.
root@socfpfga:~# cat /proc/partitions
major minor #blocks name
1 0 8192 ram0
1 1 8192 ram1
179 0 7716864 mmcblk0
179 1 512000 mmcblk0p1
179 2 1048576 mmcblk0p2
179 3 1024 mmcblk0p3
8 0 7782400 sda
8 4 7782272 sda4
root@socfpfga:~# mount -t vfat /dev/sda4 /mnt
[ 73.748789] FAT-fs (sda4): Volume was not properly unmounted. Some data may be corrupt. Please run fsck.
root@socfpfga:~# cp -p /mnt/my_first_hps_3 /home/root
root@socfpfga:~#
```

3-4. 输入 `ls` 命令, 就可以看到 `"my_first_hps_3"` 文件已经被成功拷贝进来。



```
COM5 - PuTTY
1 0 8192 ram0
1 1 8192 ram1
179 0 7716864 mmcblk0
179 1 512000 mmcblk0p1
179 2 1048576 mmcblk0p2
179 3 1024 mmcblk0p3
8 0 7782400 sda
8 4 7782272 sda4
root@socfpfga:~# mount -t vfat /dev/sda4 /mnt
[ 73.748789] FAT-fs (sda4): Volume was not properly unmounted. Some data may be corrupt. Please run fsck.
root@socfpfga:~# cp -p /mnt/my_first_hps_3 /home/root
root@socfpfga:~# ls
bt_test expand_rootfs.sh mt7601u.ko my first hps 2
bt_test.c installBlue2.run my_first_hps_1 my first hps 3
root@socfpfga:~#
```

注意

方法一和方法二都用到了 `scp` 命令, 使用的镜像文件必须支持 `ssh` 功能, 才能实现 `scp` 拷贝。