

Deploying CNN on FPGA using OpenCL

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Outline

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步驟一

- Compile the squeezenet sample

步驟二

- Write the Linux image file into a microSD

步驟三

- Set up UART connection between DE10-Nano and PC

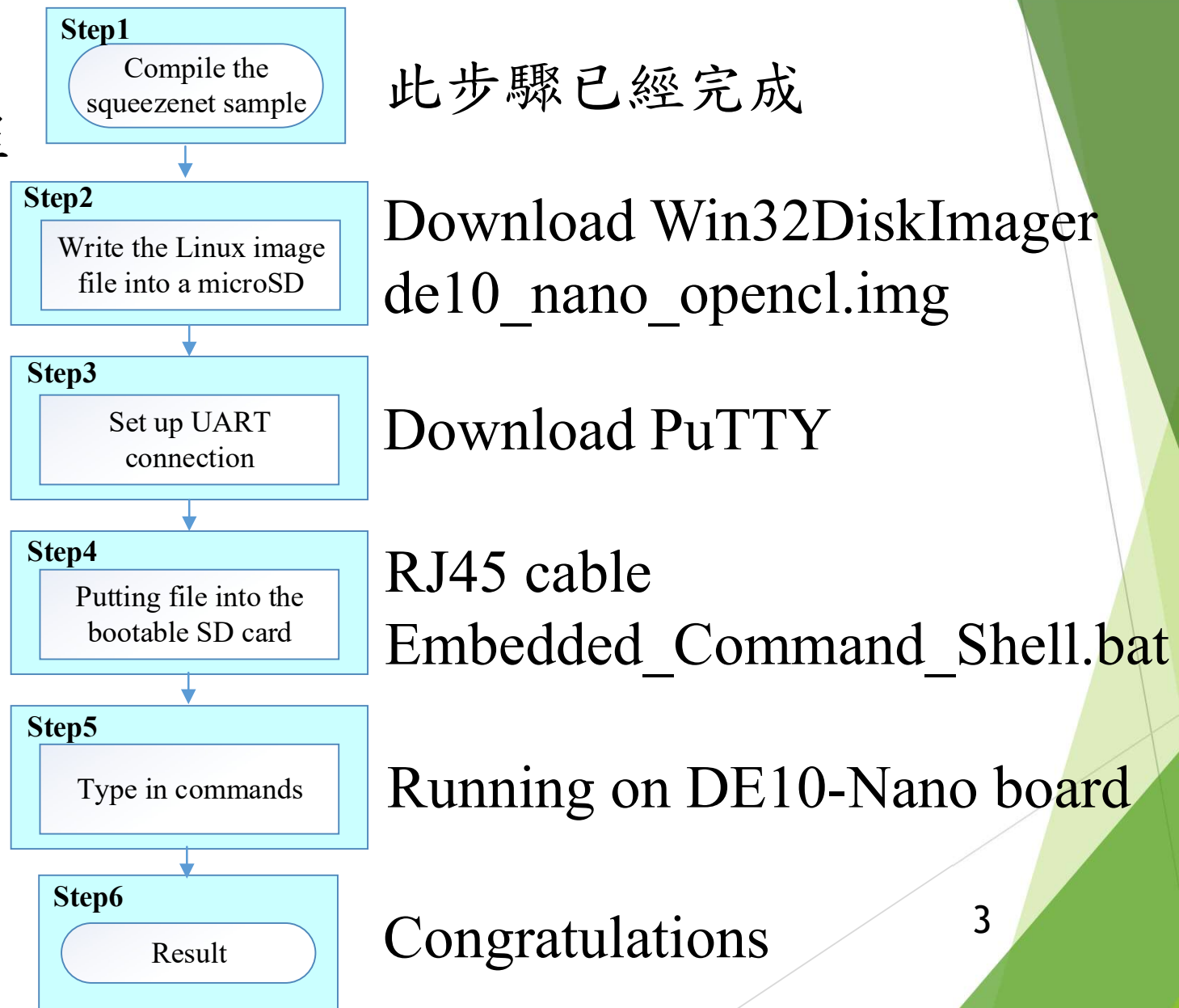
步驟四

- Putting file into the bootable SD card

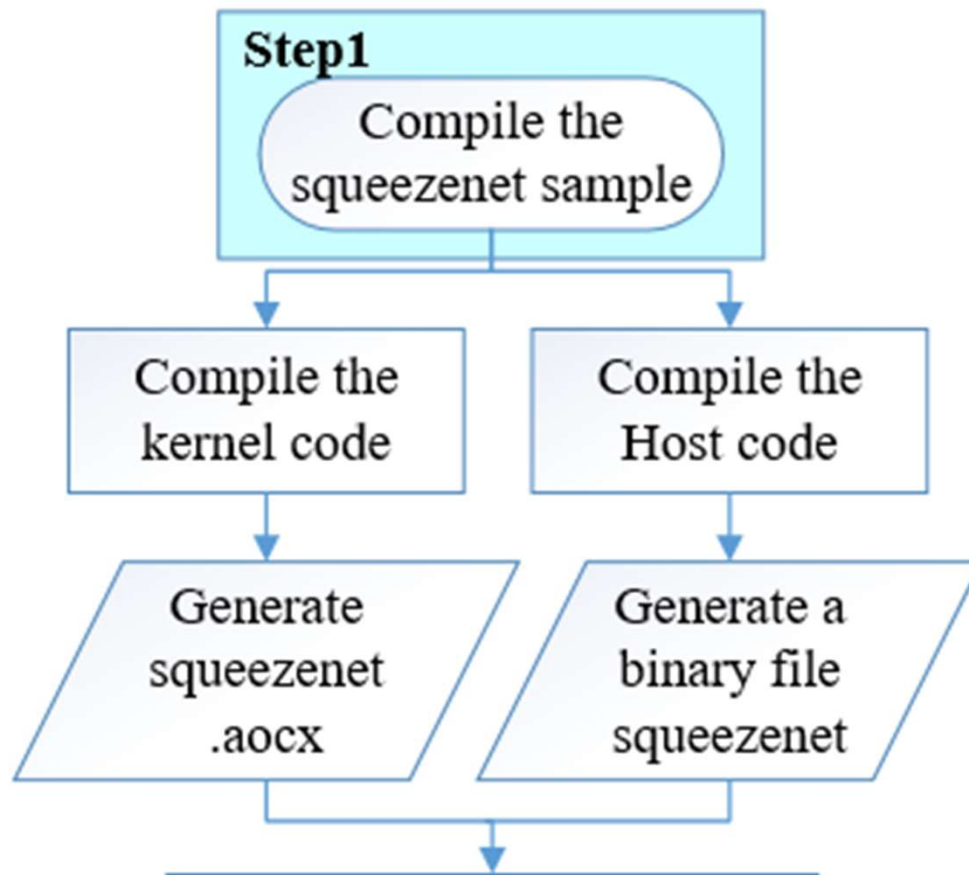
步驟五

- Type in commands

實驗流程



Compile the squeezenet sample



📄 squeezenet
📄 squeezenet.aocx

Write the Linux image file into a microSD

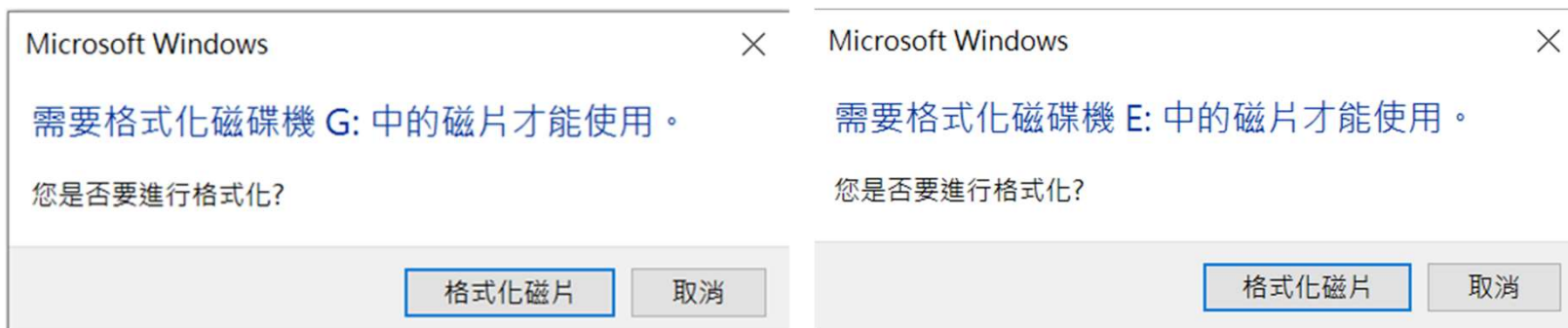
目的: 這樣FPGA就可以使用SD卡開機到Linux環境

IMG file: 磁碟的映像檔案

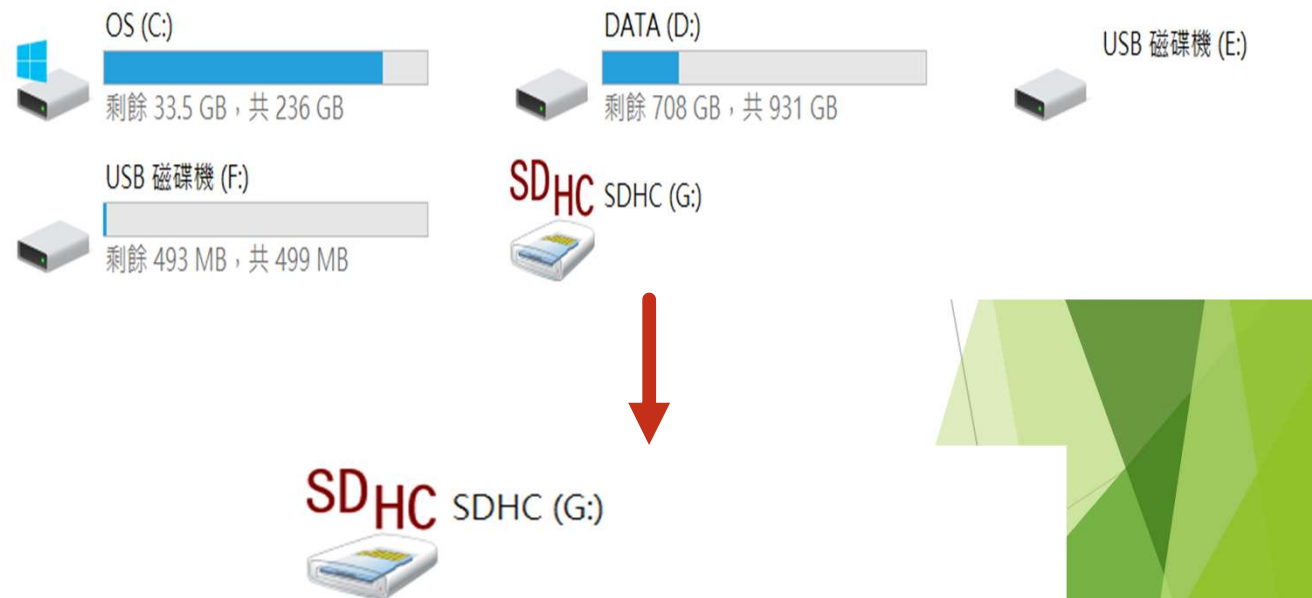
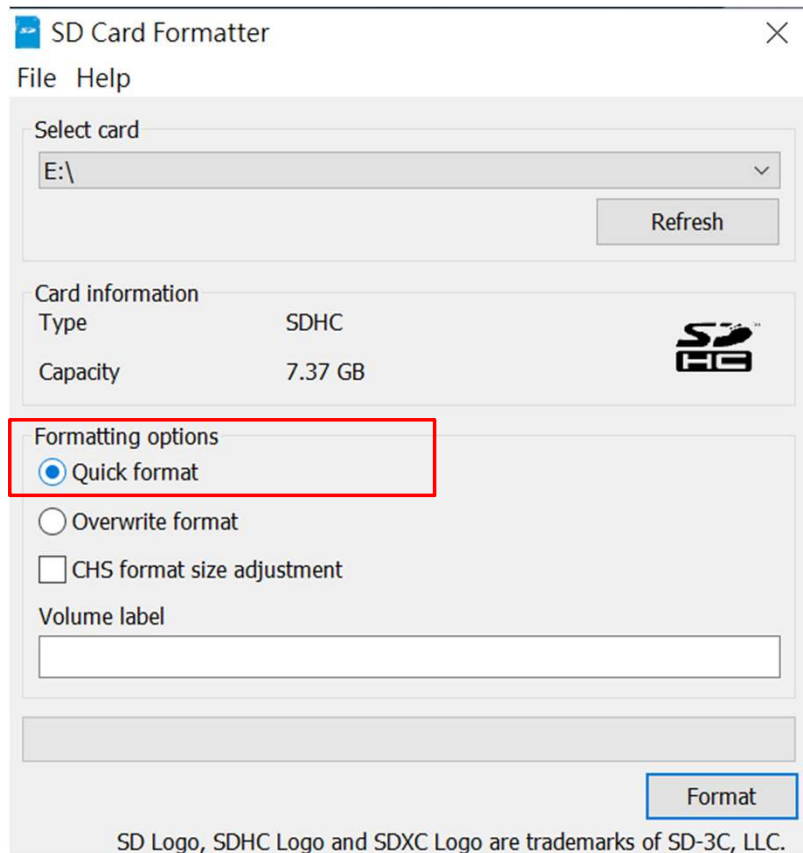
 de10_nano_openc1.img	2017/5/3 下午 01:41	光碟映像檔	1,562,624 KB
 de10_nano_openc1_18.1.img	2018/12/10 上午 10:52	光碟映像檔	1,900,000 KB

將micro SD卡插入電腦

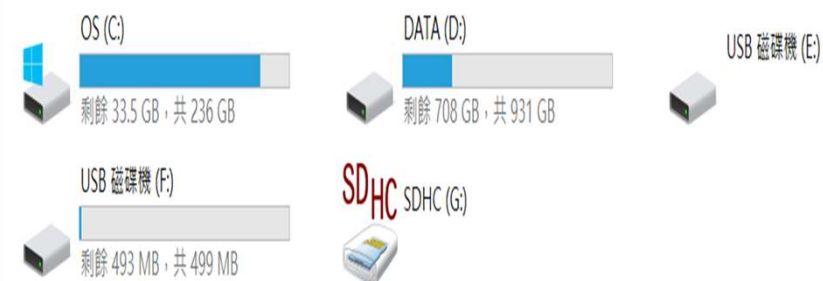
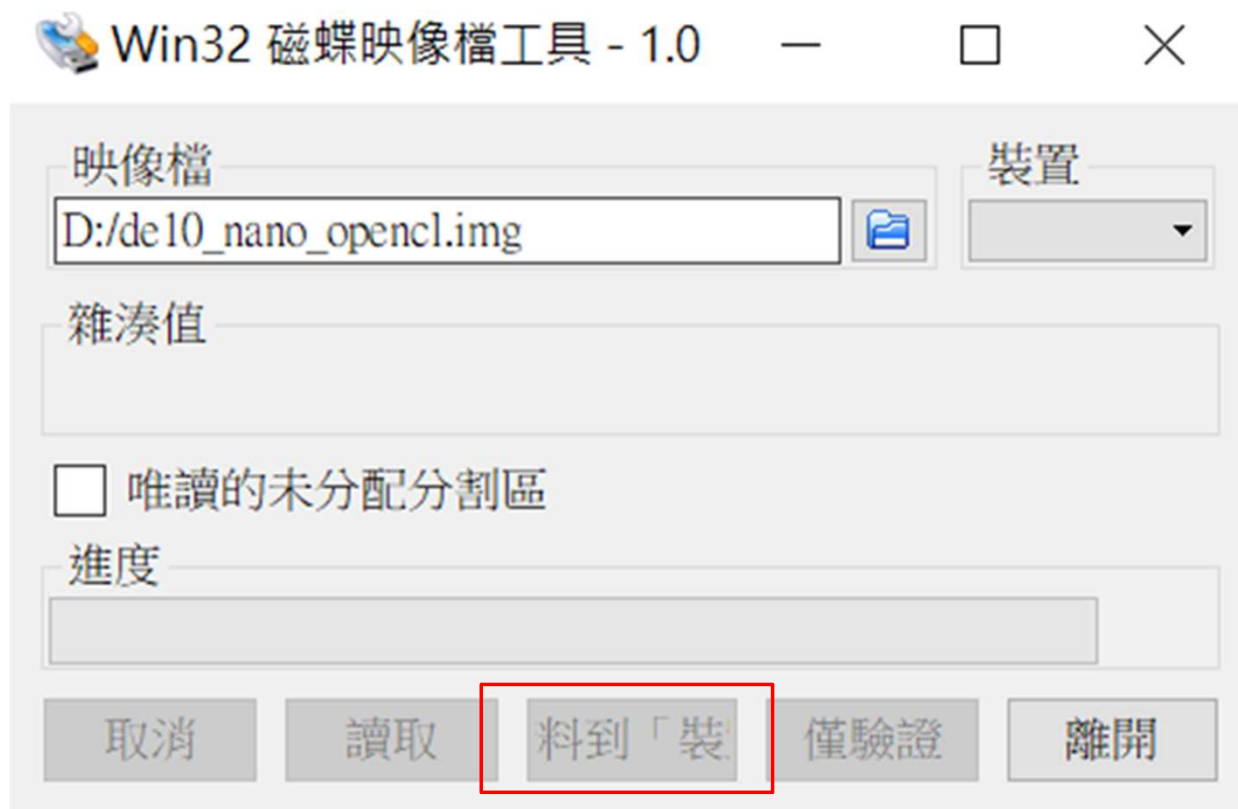
原因: 檔案格式可能與Windows 作業系統不相容。



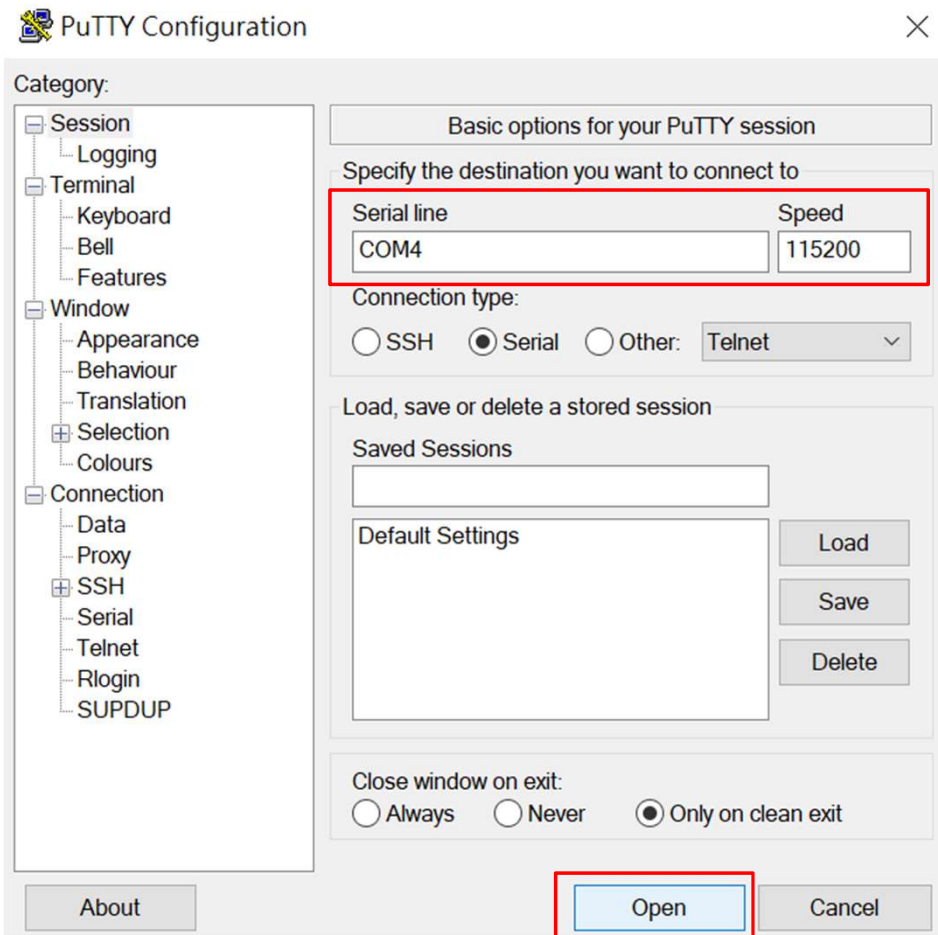
格式化



燒錄方式：直接複製貼上??



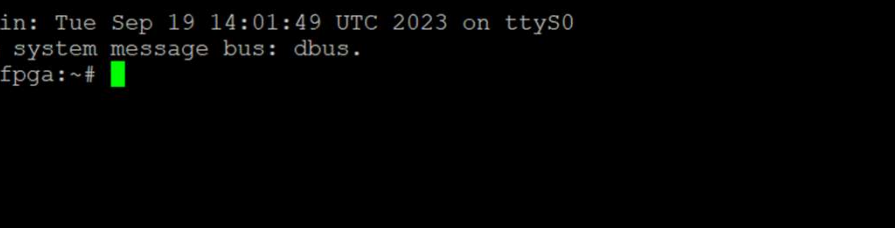
Set up UART connection



官方推薦：先進入PuTTY後開機

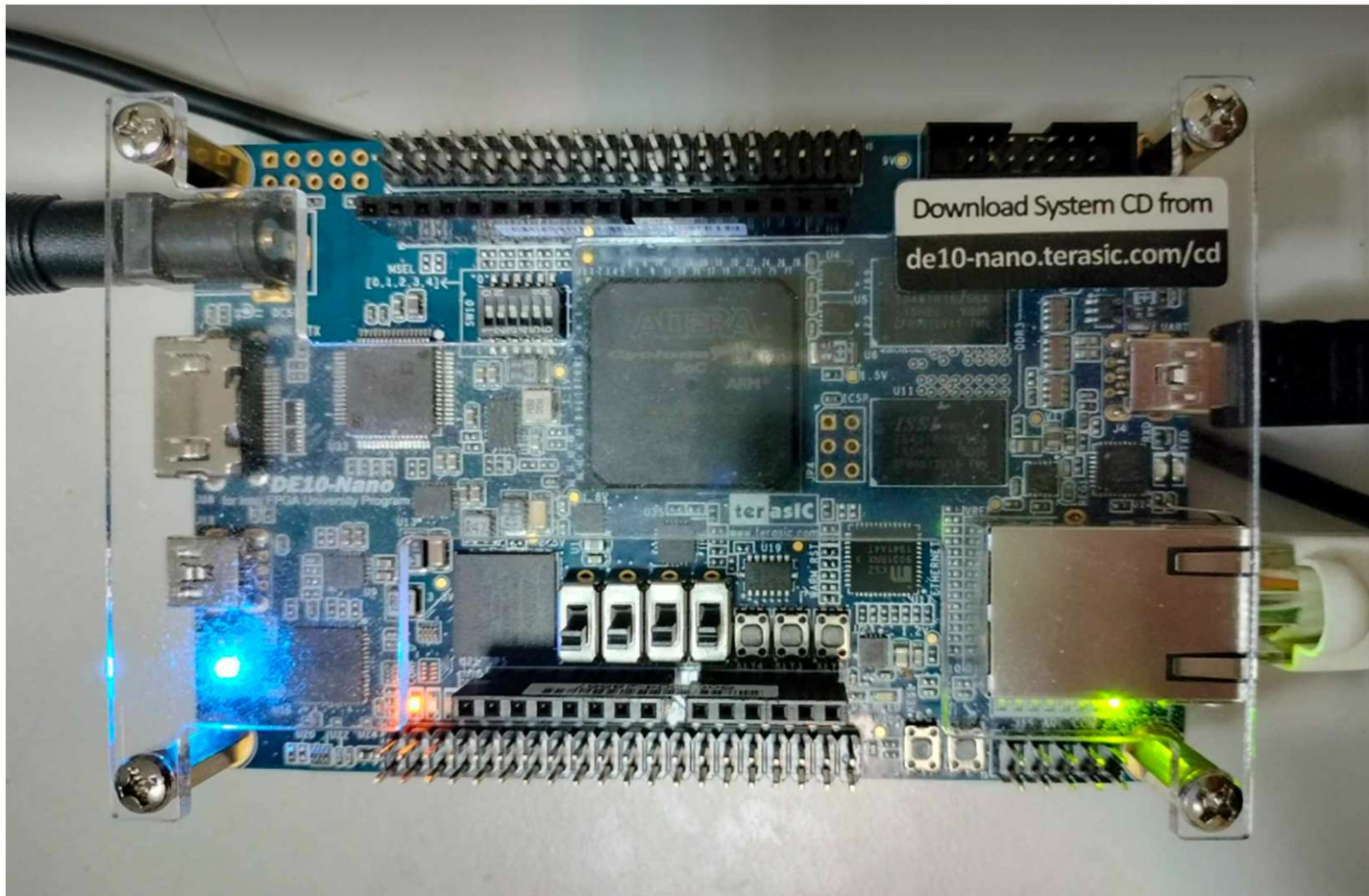
```
[ OK ] Started Avahi mDNS/DNS-SD Stack.  
Starting Network Service...  
[ OK ] Started System Logging Service.  
Starting LSB: Starts gatord...  
[ OK ] Started Timestamping service.  
Starting Network Time Service (one-shot ntpdate mode)...  
[ OK ] Started Kernel Logging Service.  
Starting Connection service...  
[ OK ] Started Network Service.  
[ OK ] Started Network Time Service (one-shot ntpdate mode).  
[ OK ] Started LSB: Starts gatord.  
[ OK ] Started Login Service.  
[ OK ] Reached target Network.  
Starting Network Name Resolution...  
Starting Target Communication Framework agent...  
[ OK ] Started Network Name Resolution.  
[ OK ] Started Connection service.  
[ OK ] Started Target Communication Framework agent.  
[ OK ] Reached target Remote File Systems.  
Starting Permit User Sessions...  
[ OK ] Started Permit User Sessions.  
[ OK ] Started Serial Getty on ttyS0.  
[ OK ] Started Getty on ttyL.  
[ OK ] Reached target Login Prompts.  
[ OK ] Reached target Multi-User System.  
Starting Update UTMP about System Runlevel Changes...  
Starting WPA supplicant...  
[ OK ] Started Update UTMP about System Runlevel Changes.  
[ OK ] Started WPA supplicant.
```

The diagram shows a sequence of connected rectangular blocks, some of which are further subdivided by dashed lines. There are several small circles and dots placed at various points within the blocks, possibly representing specific features or data points. The overall structure is horizontal and elongated, with some blocks having internal vertical and horizontal divisions.



```
COM4 - PuTTY
root
Last login: Tue Sep 19 14:01:49 UTC 2023 on ttyS0
Starting system message bus: dbus.
root@socfpga:~#
```

實際結果



開機後發現板子發燙！

DE10-Nano開發板發熱問題

Q：使用DE10-Nano開發板會有發熱的狀況，是正常的嗎？

A：DE10-Nano開發板尺寸比較小，週邊設備比較集中，這樣散熱面積小，所以上電運轉一段時間後發熱是正常狀況。

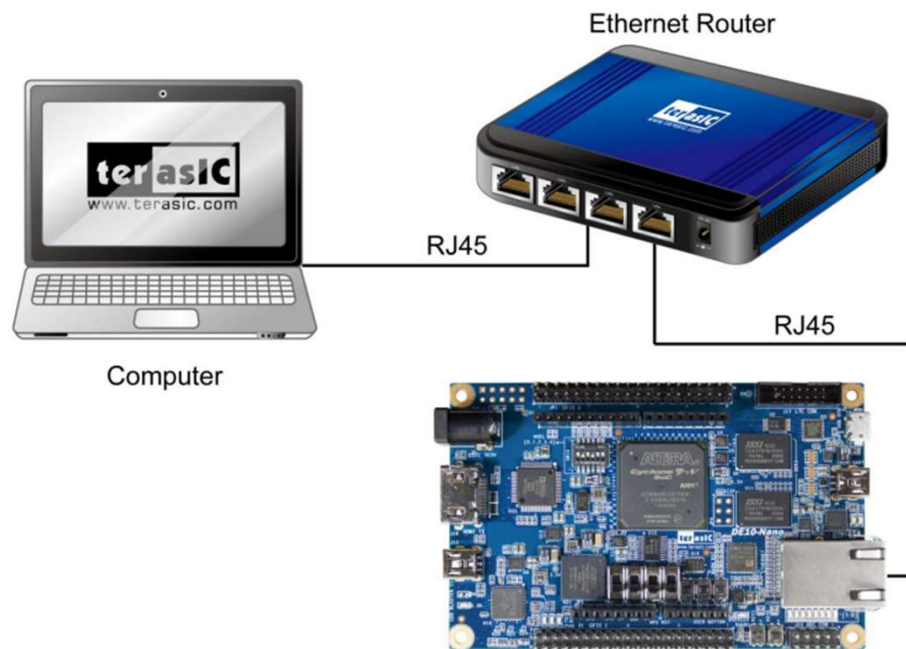
另外，DE10-Nano帶SoC，當板子ARM同時也在運作時，板子溫度會比只有FPGA工作的時候高一些。

正常情況下，版本溫度可能會達到48°C。

Putting file into the bootable SD card

To use:

- Copy 2 files in `/bin/v2.0` folder & `/src/common/synset_words.txt` to `/your_path` on the TF card for DE10-Nano with Terasic Official OpenCL BSP image



操作步驟

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-Nano board.

```
socfpga login: root
Last login: Tue Sep 19 14:01:49 UTC 2023 on ttyS0
Starting system message bus: dbus.
root@socfpga:~# udhcpc
udhcpc (v1.22.1) started
run-parts: /etc/udhcpc.d/00avahi-autoipd exited with code 1
eth0: device MAC address b6:5e:92:01:66:49
Sending discover...
libphy: stmmac-1:01 - Link is Up - 1000/Full
Sending discover...
Sending discover...
Sending select for 10.56.21.65...
Lease of 10.56.21.65 obtained, lease time 86400
run-parts: /etc/udhcpc.d/00avahi-autoipd exited with code 1
/etc/udhcpc.d/50default: Adding DNS 163.22.2.1
/etc/udhcpc.d/50default: Adding DNS 163.22.2.2
/etc/udhcpc.d/50default: Adding DNS 168.95.1.1
root@socfpga:~# ifconfig
eth0      Link encap:Ethernet  HWaddr b6:5e:92:01:66:49
          inet addr:10.56.21.65  Bcast:10.56.255.255  Mask:255.255.0.0
          inet6 addr: 2001:e10:6840:56:b45e:92ff:fe01:6649/64 Scope:Global
          inet6 addr: fe80::b45e:92ff:fe01:6649/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:157 errors:0 dropped:0 overruns:0 frame:0
          TX packets:39 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:10314 (10.0 KiB)  TX bytes:7477 (7.3 KiB)
          Interrupt:152 Base address:0x8000
```

Altera SoC command shell

Now, you can use “scp” command to copy the executable file into the SD card. In Altera SoC command shell, type “scp <file_name>root@10.56.21.167:/home/root” to copy the file into the folder “/home/root”.

"SCP" 是 Secure Copy Protocol

```
/cygdrive/C/intelFPGA/18.0/embedded/github
ctchen@R011432102 ~
$ cd /cygdrive/C/intelFPGA/18.0/embedded/github
ctchen@R011432102 /cygdrive/C/intelFPGA/18.0/embedded/github
$ scp synset_words.txt root@10.56.21.167:/home/root
Could not create directory '/home/ctchen/.ssh'.
The authenticity of host '10.56.21.167 (10.56.21.167)' can't be established.
ECDSA key fingerprint is SHA256:yiTFPtQnywM/HDIXrTTPHiUqAWYTNhjiz2aWMTYU2Yo.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/ctchen/.ssh/known_hosts).
synset_words.txt 100% 32KB 31.9KB/s 00:00
ctchen@R011432102 /cygdrive/C/intelFPGA/18.0/embedded/github
$ scp squeezeenet.aocx root@10.56.21.167:/home/root
Could not create directory '/home/ctchen/.ssh'.
The authenticity of host '10.56.21.167 (10.56.21.167)' can't be established.
ECDSA key fingerprint is SHA256:yiTFPtQnywM/HDIXrTTPHiUqAWYTNhjiz2aWMTYU2Yo.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/ctchen/.ssh/known_hosts).
squeezeenet.aocx 100% 4709KB 4.6MB/s 00:01
ctchen@R011432102 /cygdrive/C/intelFPGA/18.0/embedded/github
$ scp squeezeenet root@10.56.21.167:/home/root
Could not create directory '/home/ctchen/.ssh'.
The authenticity of host '10.56.21.167 (10.56.21.167)' can't be established.
ECDSA key fingerprint is SHA256:yiTFPtQnywM/HDIXrTTPHiUqAWYTNhjiz2aWMTYU2Yo.
Are you sure you want to continue connecting (yes/no)? yes
Failed to add the host to the list of known hosts (/home/ctchen/.ssh/known_hosts).
squeezeenet 100% 5482KB 5.4MB/s 00:00
```


確認檔案是否已經copy成功?

Type ls command

```
root@socfpga:~# ls
README boardtest hello_world init_openc1.sh openc1_arm32_rte squeezenet squeezenet.aocx swapper synset_words.txt vector_add
root@socfpga:~#
```

確認後即可按照相關指令進行

source ./init_openc1.sh 確認環境變數
cd /home/root/ 切換目錄
aocl program /dev/acl0 squeezenet.aocx
chmod +x squeezenet 賦予執行權力
./squeezenet

執行結果

Result should be like this:

```
SqueezeNet on FPGA start:  
kernel version 2.0
```

```
conv1 takes: 57.173 ms  
block1 takes: 84.526 ms  
block2 takes: 81.311 ms  
block3 takes: 113.345 ms  
classifier takes: 115.184 ms  
total: 451.539 ms
```

```
predicted label: n02106662 German shepherd, German shepherd dog, German police dog, alsatian
```

```
done
```

```
SqueezeNet on FPGA start:  
kernel version 2.0
```

```
conv1 takes: 56.338 ms  
block1 takes: 84.167 ms  
block2 takes: 82.930 ms  
block3 takes: 114.471 ms  
classifier takes: 114.200 ms  
total: 452.106 ms
```

```
predicted label: n02106662 German shepherd, German shepherd dog, German police dog, alsatian
```

```
done
```




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- 統一編號:25088684

2023年9月18日 上午9:36 (2 天前)

台灣營業時間：周一至周五 上午 9 : 00 - 下午 6 : 00

過程中遇到問題如何尋求協助



Chung Ko <zw92311@gmail.com>

寄給 sales ▾

您好，我不小心將SD卡上的內容格式化，導致原廠的檔案消失，請問有補救方法？插入電腦後SDHC(G)內的資料不見。
感謝



support02 <support@terasic.com.cn>

寄給 Terasic、我、support@terasic.com ▾

您好，

DE10-Nano出廠附帶的SD卡燒錄的是LinuxXfceDesktop鏡像檔，您可以從我們官網上下載：<https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=Taiwan&CategoryNo=173&No=1047&PartNo=4#contents>。

Linux BSP (Board Support Package): MicroSD Card Image

標題	版本	大小	日期	下載
Linux Console (kernel 4.5)	1.3		2018-03-15	↓
Linux Xfce Desktop (kernel 4.1.33-ltsi-altera)	1.0		2017-04-11	↓
Linux LXDE Desktop (kernel 4.5)	1.1		2017-04-10	↓

然後可以參考Getting Started Guide文檔的5.4CreatingAMicroSDCardImage這節步驟重新將該鏡像燒到SD卡裡。

Documents

標題	版本	大小	日期	下載
Getting Started Guide	1.4	3,159(KB)	2020-10-30	↓
DE10-Nano FAQ	1	250(KB)	2020-04-07	↓
DE10-Nano User Manual (rev. B2/C Hardware)	2.2	8,935(KB)	2020-01-02	↓

謝謝。

參考資料

1. Deploying CNN on FPGA using OpenCL

https://github.com/ErlcZ/Deploying_CNN_on_FPGA_using_OpenCL

2. DE10-Nano Kit

<https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=Taiwan&No=1047>

3. Intel® FPGA SDK for OpenCL™ Pro Edition: Best Practices Guide

<https://www.intel.com/content/www/us/en/docs/programmable/683521/22-4/eol.html>

4. Intel® FPGA SDK for OpenCL™ Pro Edition: Programming Guide

<https://www.intel.com/content/www/us/en/docs/programmable/683846/22-4/eol.html>

5. Intel® FPGA SDK for OpenCL™

<https://www.intel.com/content/www/us/en/software-kit/669526/intel-fpga-sdk-for-openc1-standard-edition-software-version-17-0.html>