DAVE Embedded Systems

AN-BELK-006: Enabling dual Gigabit Ethernet support on BoraEVB

Application Note

Table of Contents

1 Introduction.....3
2 Block diagram.....4
3 Vivado Design.....5
4 Enabling dual Ethernet configuration in linux kernel.....0
4.1 Performance tests.....2
4.1.1 Test #1.....3
4.1.2 Test #2.....4

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1 Introduction

Thanks to the migration to linux kernel 3.10.17, BELK 2.2.0 allows to cleanly support dual Gigabit Ethernet configuration on BoraEVB. This application note describes how to implement such configuration, providing a reference design for Vivado 2014.4 and linux kernel configuration instructions.

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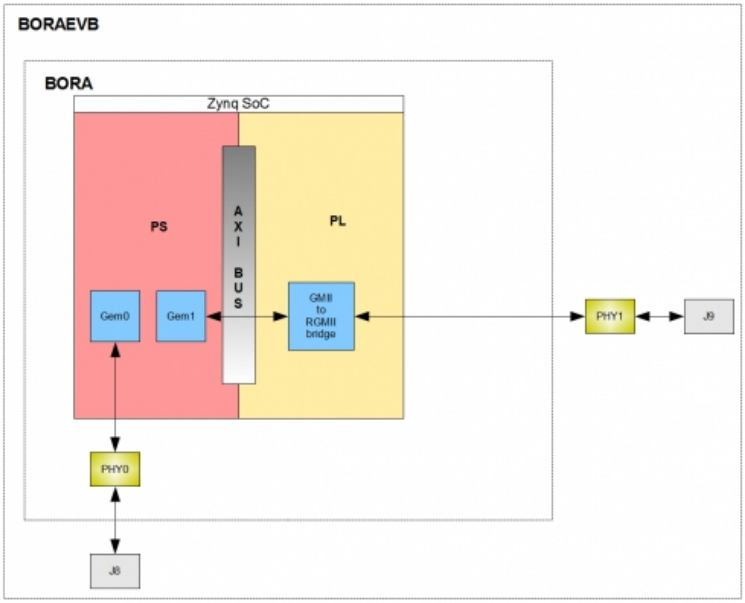
2 Block diagram

Simplified block diagram of dual Ethernet configuration is shown in the following picture.



First Ethernet port refers to J8 connector of BoraEVB carrier board and is based on Zynq's Gigabit Ethernet Controller 0 (Gem0). This controller is mapped at physical address 0xE000B000.

Second Ethernet port refers to J9 connector of BoraEVB carrier board and is based on Zynq's Gigabit Ethernet Controller 1 (Gem1). This controller is mapped at physical address 0xE000C000.

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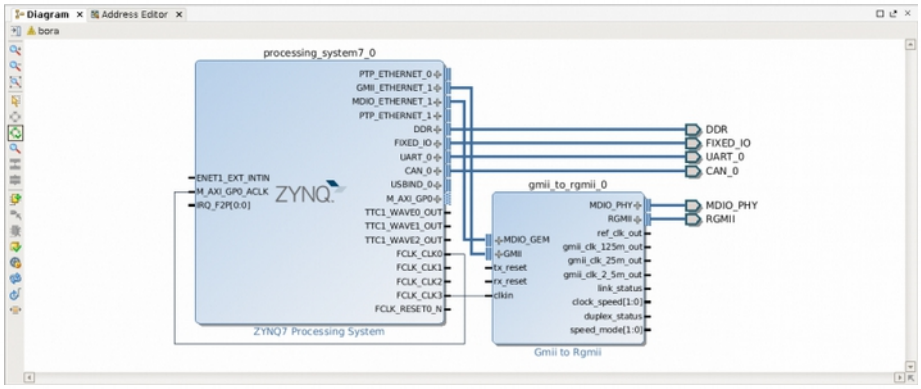
The fundamental difference between the two interfaces is the PHY interfacing. In case of Gem0, PHY is mounted on Bora SoM and it is interfaced directly to Processor Subsystem (PS) via MIO pads. In case of Gem1 instead, PHY is populated on BoraEVB (U9) and it is interfaced to Programmable Logic (PL) pads that belong to bank #34. Thus it is necessary to enable EMIO routing and to instantiate a GMII to RGMII bridge in PL as per PHY's interface requirement. Since bank #34 is powered at 3.3V (High Range I/O mode), RGMII duty cycle distortion specification is not matched. In case of carrier board designed for production environments, it is recommended to use a lower voltage levels and thus a different PL bank.

For more details please see section I/O Standard and Placement of PG160 GMII to RGMII LogiCORE IP Product Guide and this page.

3 Vivado Design

The following picture shows the block diagram of the Vivado project:



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The project archive can be downloaded here[1]

4 Enabling dual Ethernet configuration in linux kernel

To enable dual Ethernet user needs to get the pre-built binaries from this link[2].

Alternatively kernel and device tree can be built from sources with the following procedure:

- update Bora kernel repository (as described here)
- apply the patch `0001-dts-bora-add-ETH1-phy-support.patch` included in the pre-build binaries package
- build the updated kernel source as usual.

Here is the patch to enable dual Ethernet:

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```
diff --git a/arch/arm/boot/dts/bora.dts b/arch/arm/boot/dts/bora.dts
index 654770e..35697cd 100644
--- a/arch/arm/boot/dts/bora.dts
+++ b/arch/arm/boot/dts/bora.dts
@@ -59,6 +59,25 @@
        };
 };

+&gem1 {
+       status = "okay";
+       phy-mode = "rgmii-id";
+       phy-handle = <&phy1>;
+       gmii2rgmii-phy-handle = <&phy2>;
+
+       phy1: phy@6 {
+               compatible = "micrel,ksz9031";
+               device_type = "ethernet-phy";
+               rxc-skew-ps = <1860>;
+               txc-skew-ps = <1860>;
+               reg = <6>;
+       };
+
+       phy2: phy@8 {
+               reg = <8>;
+       };
+};
+
 &sdhci0 {
        status = "okay";
        broken-cd = <0x1>;
```

Put the binaries on the first (FAT32) partition of your BELK 2.2.0 SD card, overwriting the original one if needed. Please note that you need the following files:

- boot.bin
- bora.dtb
- uImage
- fpga.bin
- uEnv.txt

Insert the SD card into BoraEVB and turn on the board.

During kernel boot, user can check if the second ethernet

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interface has been loaded succesfully:

```
root@bora:~# ifconfig -a
can0      Link encap:UNSPEC  HWaddr 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00
          NOARP  MTU:16  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:10
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
          Interrupt:60

eth0      Link encap:Ethernet  HWaddr 00:50:C2:B9:CF:82
          inet addr:192.168.0.209  Bcast:192.168.0.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:8424 errors:5 dropped:418 overruns:0 frame:0
          TX packets:5964 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:7562500 (7.2 MiB)  TX bytes:922668 (901.0 KiB)
          Interrupt:54 Base address:0xb000

eth1      Link encap:Ethernet  HWaddr 66:94:55:CB:B1:3E
          BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
          Interrupt:77 Base address:0xc000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:11 errors:0 dropped:0 overruns:0 frame:0
          TX packets:11 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:788 (788.0 B)  TX bytes:788 (788.0 B)

root@bora:~# ifconfig eth1 192.168.12.209
root@bora:~# [  228.492886] xemacps e000c000.ethernet: Set clk to 0 Hz
[  228.498079] xemacps e000c000.ethernet: link up (1000/FULL)
root@bora:~#
```

4.1 Performance tests

To test the performances of the second Ethernet interface `iperf` based tests have been executed.

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4.1.1 Test #1

In this test bed the two interfaces are connected on the same host machine (a PC running linux) via a Gigabit switch but are associated to two different subnets:

- ETH0: 192.168.0.xxx
- ETH1: 192.168.12.xxx

On the linux host machine `iperf` application is run in server mode:

```
bash# iperf -s
```

Here are the results of the test on the two Ethernet interfaces launched sequentially:

```
root@bora:~# iperf -c 192.168.0.210 && iperf -c 192.168.12.210
------------------------------------------------------------
Client connecting to 192.168.0.210, TCP port 5001
TCP window size: 43.8 KByte (default)
------------------------------------------------------------
[  3] local 192.168.0.209 port 59288 connected with 192.168.0.210 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   899 MBytes   754 Mbits/sec
------------------------------------------------------------
Client connecting to 192.168.12.210, TCP port 5001
TCP window size: 43.8 KByte (default)
------------------------------------------------------------
[  3] local 192.168.12.209 port 42238 connected with 192.168.12.210 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   889 MBytes   745 Mbits/sec
root@bora:~#
```

In case two `iperf` clients are run simultaneously on target, each instance's bandwitdh is roughly halved:

```
root@bora:~# iperf -c 192.168.0.210
------------------------------------------------------------
Client connecting to 192.168.0.210, TCP port 5001
TCP window size: 43.8 KByte (default)
------------------------------------------------------------
```


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```
[  3] local 192.168.0.209 port 59290 connected with 192.168.0.210 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   364 MBytes   305 Mbits/sec
root@bora:~#
```

```
root@bora:~# iperf -c 192.168.12.210
------------------------------------------------------------
Client connecting to 192.168.12.210, TCP port 5001
TCP window size: 48.1 KByte (default)
------------------------------------------------------------
[  3] local 192.168.12.209 port 42240 connected with 192.168.12.210 port 5001
[ ID] Interval       Transfer     Bandwidth
[  3]  0.0-10.0 sec   385 MBytes   323 Mbits/sec
root@bora:~#
```

4.1.2 Test #2

ETH0 set up is the same used in previous test. ETH1 is point-to-point connected to a second linux host machine instead.

This configuration allows to achieve better performance on the single ETH1 `iperf` test (780-820 Mb/s):

```
root@bora:~# iperf -c 192.168.12.208 -i 1 -t 6000
------------------------------------------------------------
Client connecting to 192.168.12.208, TCP port 5001
TCP window size: 43.8 KByte (default)
------------------------------------------------------------
[  3] local 192.168.12.209 port 50715 connected with 192.168.12.208 port 5001
[ ID] Interval       Transfer     Bandwidth
....
[  3] 368.0-369.0 sec  94.6 MBytes   794 Mbits/sec
[  3] 369.0-370.0 sec  92.4 MBytes   775 Mbits/sec
[  3] 370.0-371.0 sec  97.1 MBytes   815 Mbits/sec
[  3] 371.0-372.0 sec  97.1 MBytes   815 Mbits/sec
[  3] 372.0-373.0 sec  96.1 MBytes   806 Mbits/sec
[  3] 373.0-374.0 sec  94.1 MBytes   790 Mbits/sec
[  3] 374.0-375.0 sec  96.6 MBytes   811 Mbits/sec
[  3] 375.0-376.0 sec  96.8 MBytes   812 Mbits/sec
[  3] 376.0-377.0 sec  97.8 MBytes   820 Mbits/sec
[  3] 377.0-378.0 sec  93.9 MBytes   787 Mbits/sec
[  3] 378.0-379.0 sec  95.9 MBytes   804 Mbits/sec
[  3] 379.0-380.0 sec  98.2 MBytes   824 Mbits/sec
[  3] 380.0-381.0 sec  93.2 MBytes   782 Mbits/sec
[  3] 381.0-382.0 sec  96.9 MBytes   813 Mbits/sec
[  3] 382.0-383.0 sec  92.0 MBytes   772 Mbits/sec
```


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In case of simultaneous `iperf` instances on ETH0 and ETH1 ports, ETH1 bandwidth drops down to 330-350 Mb/s:

```
[  3] 383.0-384.0 sec  42.6 MBytes   358 Mbits/sec
[  3] 384.0-385.0 sec  41.4 MBytes   347 Mbits/sec
[  3] 385.0-386.0 sec  40.9 MBytes   343 Mbits/sec
[  3] 386.0-387.0 sec  40.9 MBytes   343 Mbits/sec
[  3] 387.0-388.0 sec  40.9 MBytes   343 Mbits/sec
[  3] 388.0-389.0 sec  41.2 MBytes   346 Mbits/sec
[  3] 389.0-390.0 sec  41.4 MBytes   347 Mbits/sec
[  3] 390.0-391.0 sec  39.8 MBytes   333 Mbits/sec
[  3] 391.0-392.0 sec  40.8 MBytes   342 Mbits/sec
[  3] 392.0-393.0 sec  39.9 MBytes   334 Mbits/sec
[  3] 393.0-394.0 sec  42.2 MBytes   354 Mbits/sec
```


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