Application Note

How to Linux Fast Boot on DRA821U

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ABSTRACT

This application report is used to describe the procedure to achieve fast boot using Linux on the DRA821/J7200/J7VCL platform. The details captured here are directed towards replicating the results on the DRA821. However, this concept can be very easily extended to other devices in the Jacinto 7 family.

This document enables achieving a Linux prompt in approximately 3 seconds using an optimized filesystem (tisdk-tiny-image) and reduced DTSI.

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Trademarks

1 Hardware and Software Required Stuff

- Hardware:
  - TI DRA821U EVM
- Software
  - J7200XSOMXEVM
  - Linux SDK version: ti-processor-sdk-linux-j7200-evm-08_00_00_05
  - RTOS SDK version: ti-processor-sdk-rtos-j7200-evm-08_00_00_12

Regarding how to build the Linux/RTOS for DRA821U, see the Understanding bootloaders in Processor SDK J7200 (RTOS/Linux) section.

Regarding how to set up the EVM to test, see the *Jacinto7 DRA821 Evaluation Module (EVM) User's Guide*.

2 DRA821U Boot Mode With Fast Boot Method

Figure 2-1 shows the current Linux boot flow with the SDK.

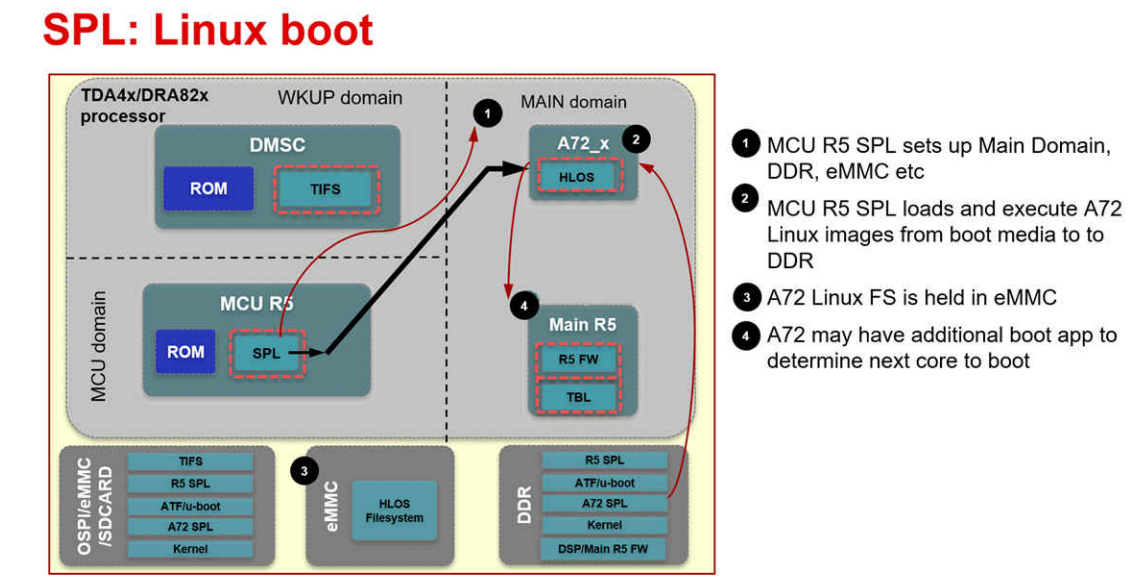

Figure 2-1. Jacinto DRA821U Linux Boot Flow

R5 SPL --> A72 ATF --> A72 SPL --> A72 U-Boot --> A72 Linux.

In the above boot flow each phase is optimized to achieve faster boot time:

- Optimize U-Boot to remove UART prints.
- Enable only the peripherals that are mandatory for booting Linux and disable the rest.
- Switch to booting from xSPI instead booting from SD card.
- Switch to file system in eMMC as against using SD card for hosting the file system.

The time spent in booting to Linux kernel is approximately 3 Seconds.

3 Detailed Steps

The process is broken down into seven steps. Follow the steps exactly.

- Step1: patch and build / copy the u-boot onto your SD card “Boot Partition”.
- Step2: Optimize boot time by switching to xSPI boot, so we copy the bootloaders from SD card onto xSPI Flash.
- Step3: Optimize the device tree by disabling nodes not mandatory for Linux Boot.
- Step4: Create bootable SD card, and Switch to TinyFS.
- Step5: Switch to eMMC TinyFS filesystem (Very important step!!)

- Step6: Optimizations with bootargs in the uboot.
- Step7: Hijack the init.

Understand this:

- When a brand new SD card that has **never** be formatted is used: Following this sequence:
  - Step4 > step1 > step2 > step3 > step5 > step6 > step7
- If using a DRA821 bootable SD card follow the below sequence:
  - Step1 > step2 > step3 > step4 > step5 > step6 > step7

Regarding the boot switch jumper setting on the DRA821U EVM, see Table 3-1.

Table 3-1. Jacinto DRA821U EVM Boot Switch Setting

WKUP Bootmode	2	3	4	5	6	7	8	9
DIP SW9	(SW9.1)	(SW9.2)	(SW9.3)	(SW9.4)	(SW9.5)	(SW9.6)	(SW9.7)	(SW9.8)
SD Boot (Default)	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
eMMC	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
OSPI	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
UART	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
USB	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
No Boot	OFF	ON	ON	ON	OFF	OFF	OFF	OFF

Main Bootmode	0	1	2	3	4	5	6	7
DIP SW8	(SW8.1)	(SW8.2)	(SW8.3)	(SW8.4)	(SW8.5)	(SW8.6)	(SW8.7)	(SW8.8)
SD Boot (Default)	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
eMMC	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
OSPI	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
UART	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
USB	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
No Boot	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF

There are boot switches need to be matched correctly in each step as shown above. Two boot switch settings are summarized in this document: one is the SD card switch and one is the xSPI switch.

In the step2:

- The SD card to boot is used
- Perform some actions that is copying the uboot onto xSPI flash.
- Switch to the xSPI flash.

The switch setting in each step should be marked.

3.1 Step1: Patch and Build/Copy the u-boot

Assume you are familiar with TI Jacinto SDK build setting up. Make sure your NB is connecting to the network while building. Because the uboot might referencing the ti github. The working copy cmd is as this, you need to change according the red parameters (root).

Boot Switch setting:

This step is no needing to touch the boot switch on the EVM.

Patches:

- 01 - Remove-prints-to-optimize-U-Boot-time.patch (this patch is here: https://tidrive.ext.ti.com/u/py97LpOveyy1L3sp/84cdc714-8480-4b2f-95f4-4c7e7bdfbe44?l)

Cmds: (Do this on ubuntu, not the EVM)

```
cd $PSDKLA/board-support/u-boot-2021.01+gitAUTOINC+53e79d0e89-g53e79d0e89/
git am 0001-Remove-prints-to-optimize-U-Boot-time.patch
cd ../..
make u-boot
```

cp board-support/k3-image-gen-2021.05/tiboot3.bin board-support/u-boot_build/a72/tispl.bin board-support/u-boot_build/a72/u-boot.img /media/root/boot/

3.2 Step2: Optimizations by switching to xSPI boot: copy bootloaders to xSPI

This step is to copy the SD card uboot files onto the xSPI.

So, there are 2 boot switch settings in this step2.

The SD card is used to boot first, then the xSPI switch is used.

1st time Boot Switch setting:

#EVM to set **SD Boot** Mode, refer /psdk_rtos_auto/docs/user_guide/J7_EVM_SETUP.html

SW8[1-8] = 1000 0010

SW9[1-8] = 0000 0000 <--Rio: Read EVM user guide

SW3[1-10] = 0110001001

Commands:

When in uboot prompt, do these. **(Do this on the EVM!)**

sf probe

fatload mmc 1 ${loadaddr} tiboot3.bin; sf update $loadaddr 0x0 $filesize;

fatload mmc 1 ${loadaddr} tispl.bin; sf update $loadaddr 0x100000 $filesize;

fatload mmc 1 ${loadaddr} u-boot.img; sf update $loadaddr 0x300000 $filesize;

After doing those actions above, do this:

1. Turn off the board.
2. Change the dip switch settings to xSPI as below:

2nd time Boot switch setting:

#EVM to set **xSPI Boot** Mode

SW8[1-8]: 1000 0010

SW9[1-8]: 0011 0000

SW3[1-10]: 0111 0010 10

After this point, **do not change** the SW8/SW9/SW3.

Now, hereafter, you only can use this setting, no need to change again.

3.3 Step 3: Optimize the DTSI by Disabling Nodes not Mandatory for Linux Boot

Boot switch setting:

No need to change the boot switches in this step.

Insert the SD card to Host PC

Patches:

0001-arch-arm64-boot-dts-ti-k3-j7200-Optimize-DT-for-earl.patch

This patch is here: https://tidrive.ext.ti.com/u/py97LpOveyy1L3sp/84cdc714-8480-4b2f-95f4-4c7e7bdfbe44?l

Commands: (Do this on the ubuntu, not the EVM)

gedit $PSDKLA/Rules.make

Change this line: DESTDIR=/media/$USER/rootfs

Insert the SD card to Host P

```
cd $PSDKLA/board-support/linux-5.10.41+gitAUTOINC+4c2eade9f7-g4c2eade9f7/
git am 0001-arch-arm64-boot-dts-ti-k3-j7200-Optimize-DT-for-earl.patch
cd ../..
make linux
sudo make linux_install
```

3.4 Step 4: Create Bootable SD Card, Switch to TinyFS

Boot switch setting:

No need to change the boot switches in this step:

Commands: (Do this on the ubuntu, not the EVM)

Open $PSDKLA/bin/mksdboot.sh **(This is to switch the TinyFS)**

Do the following change from:

root_fs="$sdkdir/filesystem/tisdk-default-image-j7200-evm.tar.xz"

to

root_fs="$sdkdir/filesystem/**tisdk-tiny-image-j7200-evm.tar.xz**"

Do this:

sudo dpkg-reconfigure dash **(This is very important Step!)**

sudo ./mksdboot.sh --device /dev/sdb --sdk /opt/ti-processor-sdk-linux-j7200-evm-08_00_00_05/

or

sudo ./mksdboot.sh --device /dev/sdc --sdk /opt/ti-processor-sdk-linux-j7200-evm-08_00_00_05/

Re insert the SD card onto ubuntu.

make linux

sudo make linux_install

Go to TargetNFS, find the lib + usr/lib + sbin , do those 3 copy actions, then "sync".

Do this:

```
sudo cp -r lib/* /media/root/rootfs/lib    (See the “root”, you need to change this according your
ubuntu env).
sudo cp -r usr/lib/* /media/root/rootfs/usr/lib
cp sbin/mkfs.ext4 /media/root/rootfs/mnt/    (This is very important!!)
sync
```

3.5 Step 5: Switch to eMMC Filesystem

Boot switch setting:

#EVM to set **xSPI Boot** Mode

SW8[1-8]: 1000 0010

SW9[1-8]: 0011 0000

SW3[1-10]: 0111 0010 10

Commands: (Do this on the EVM)

Insert your SD card onto EVM.

do this in uboot prompt

- gpt write mmc 0 ${partitions}

Do this in kernel console

- mkfs.ext4 /dev/mmcblk0p1
- mount /dev/mmcblk0p1 /mnt/emmc
- mount /dev/mmcblk1p2 /mnt/sd
- cp -r /mnt/sd/* /mnt/emmc/
- sync

3.6 Step 6: Optimizations With Bootargs

Boot switch setting:

#EVM to set **xSPI Boot** Mode

SW8[1-8]: 1000 0010

SW9[1-8]: 0011 0000

SW3[1-10]: 0111 0010 10

Commands: (Do this on the EVM)

Beware!

You can see there is the **mmcblk0p1**, so, you need to make sure you have this partition by issuing “fdisk -l” in there kernel to check.

in uboot prompt, do these:

```
setenv bootdelay 0
setenv mmcdev 0
setenv bootpart 0
setenv args_mmc "run finduuid;setenv bootargs console=ttyS2,115200n8 root=/dev/mmcblk0p1 rw
rootfste=ext4 rootwait loglevel=0"
saveenv
boot
```

3.7 Step 7: Hijack the init

Boot switch setting:

#EVM to set **xSPI Boot** Mode

SW8[1-8]: 1000 0010

SW9[1-8]: 0011 0000

SW3[1-10]: 0111 0010 10

Commands: (Do this on the EVM)

Once you get to Linux shell prompt. Create file /home/root/init.sh with contents below:

- #!/bin/sh
- mount -t proc proc /proc
- mount -n -t sysfs none /sys
- mount -n -t tmpfs none /run
- echo "entering init script"
- /bin/sh

Then, do these, this is called “hijack”.

- chmod +x init.sh
- cd /sbin/
- rm init
- ln -s /home/root/init.sh init

4 Debug Commands

Here are some basic cmds set for assisting you to debug the partitions/mount devices.

4.1 SF Probe

When issuing the SF probe, you will send this kind of result.

You can see those three uboot files is flashing onto the xSPI flash.

Cmds:

Sf probe

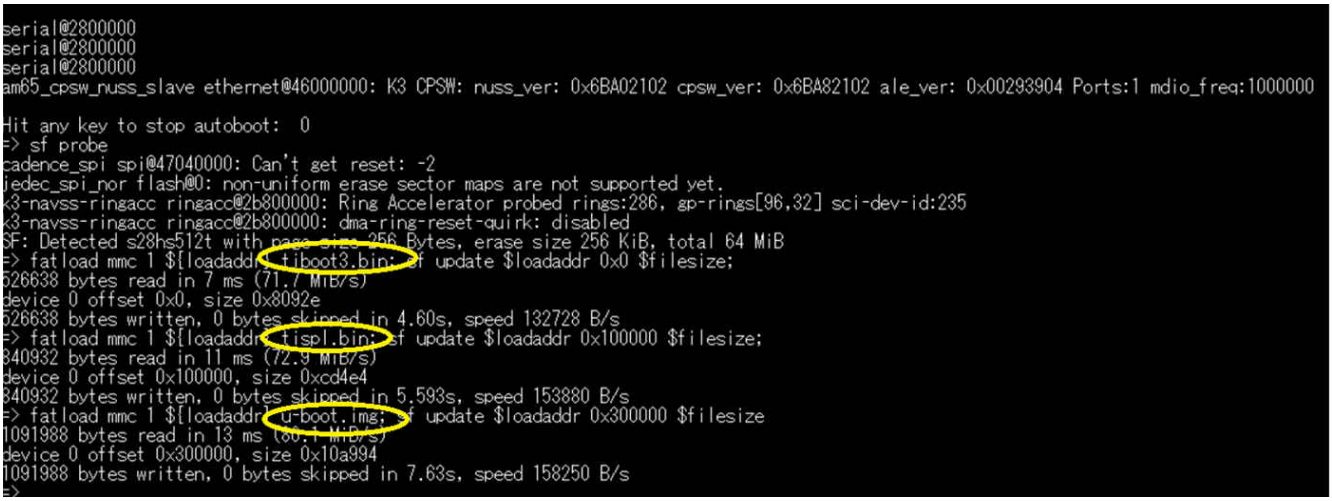

Figure 4-1. Jacinto DRA821U SF probe in uboot

4.2 mmcblk

This is how to check the mmcblk

Cmds:

→ ls /dev/mmcblk*

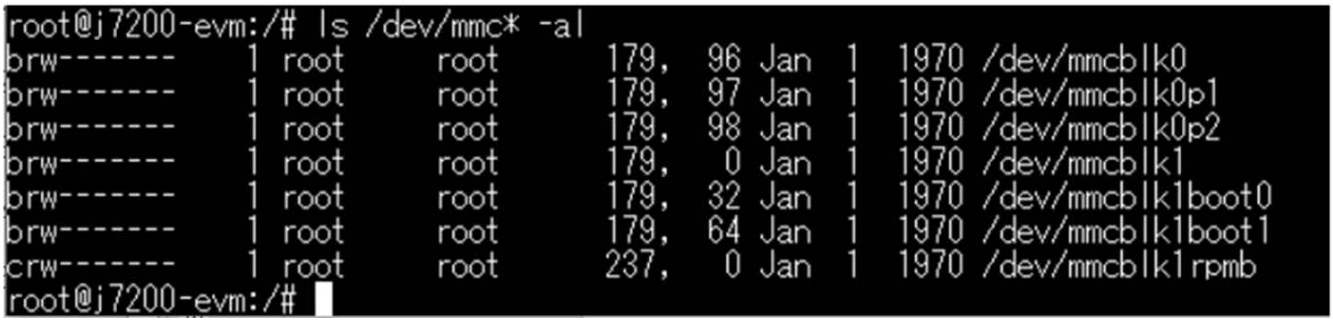

Figure 4-2. Jacinto DRA821U mmcblk

4.3 How to Check Mounted Devices?

Cmds:

cat /proc/mtd

```
root@j7200-evm:/# cat /proc/mtd
dev:    size   erasesize  name
mtd0: 00100000 00040000 "ospi.tiboot3"
mtd1: 00200000 00040000 "ospi.tispl"
mtd2: 00400000 00040000 "ospi.u-boot"
mtd3: 00040000 00040000 "ospi.env"
mtd4: 00040000 00040000 "ospi.env.backup"
mtd5: 037c0000 00040000 "ospi.rootfs"
mtd6: 00040000 00040000 "ospi.phypattern"
root@j7200-evm:/#
```

Figure 4-3. Jacinto DRA821U Check Mounted Devices

4.4 How to Check Your Partitions?

Cmds:

cat /proc/partitions

```
root@j7200-evm:/# cat /proc/partitions
major minor  #blocks  name

   1        0       4096 ram0
   1        1       4096 ram1
   1        2       4096 ram2
   1        3       4096 ram3
   1        4       4096 ram4
   1        5       4096 ram5
   1        6       4096 ram6
   1        7       4096 ram7
   1        8       4096 ram8
   1        9       4096 ram9
   1       10       4096 ram10
   1       11       4096 ram11
   1       12       4096 ram12
   1       13       4096 ram13
   1       14       4096 ram14
   1       15       4096 ram15
  31        0       1024 mtdblock0
  31        1       2048 mtdblock1
  31        2       4096 mtdblock2
  31        3        256 mtdblock3
  31        4        256 mtdblock4
  31        5      57088 mtdblock5
  31        6        256 mtdblock6
 179        0   15540224 mmcblk0
 179       96   60817408 mmcblk1
 179       97      63488 mmcblk1p1
 179       98   60752896 mmcblk1p2
root@j7200-evm:/#
```

Figure 4-4. Jacinto DRA821U Check Partitions

4.5 How to Restore Your Boot Setting?

When you are doing the boot debug, if boot failed and as long as your SD card contain is not broken, switch your Boot setting to the SD card, and do the following cmd. Your DRA821U will be boot-able again.

Cmds:

- env default -f –a
- setenv board_name j7200
- setenv default_device_tree k3-j7200-common-proc-board.dtb

5 Fast Boot Result Review

This is the cold boot until the Kernel login, the cost time is about ~3 seconds.

From the log result in the following picture, we have (10.070 – 7.098) = 2.972 seconds.

Comparing the original Linux boot (2X~4X seconds), this fast boot result is good enough for automotive applications.

User can base on this to do those following developing:

- Addon their DTSI devices.
- Addon their application based on the tiny rootfs.

```
[0 00:00:07.0985]
[0 00:00:07.0985] U-Boot SPL 2021.01-00001-g3837b8de19-dirty (Oct 15 2021 - 09:41:00 +0800)
[0 00:00:08.0047] Trying to boot from SPI
[0 00:00:08.0219] NOTICE:  BL31: v2.5(release):08.00.00.004-dirty
[0 00:00:08.0219] NOTICE:  BL31: Built : 07:25:50, Aug  7 2021
[0 00:00:08.0328]
[0 00:00:08.0328] U-Boot SPL 2021.01-00001-g3837b8de19-dirty (Oct 15 2021 - 09:39:45 +0800)
[0 00:00:08.0516] Trying to boot from SPI
[0 00:00:08.0547] cadence_spi spi@47040000: Can't get reset: -2
[0 00:00:08.0547] jedec_spi_nor flash@0: non-uniform erase sector maps are not supported yet.
[0 00:00:09.0110]
[0 00:00:09.0110]
[0 00:00:09.0110] U-Boot 2021.01-00001-g3837b8de19-dirty (Oct 15 2021 - 09:39:45 +0800)
[0 00:00:09.0110]
[0 00:00:09.0110] 4 GiB
[0 00:00:09.0156] Flash: 0 Bytes
[0 00:00:09.0156] MMC:   sdhci@4f80000: 0, sdhci@4fb0000: 1
[0 00:00:09.0360] serial@2800000
[0 00:00:09.0360] serial@2800000
[0 00:00:09.0360] serial@2800000
[0 00:00:09.0516] am65_cpsw_nuss_slave ethernet@46000000: K3 CPSW: nuss_ver: 0x6BA02102 cpsw_ver: 0x6BA82102 ale_ver: 0x00293904 Ports:1 mdio_freq:1000000
[0 00:00:09.0531]
[0 00:00:09.0531] Hit any key to stop autoboot:  0
[0 00:00:09.0735] switch to partitions #0, OK
[0 00:00:09.0735] mmc0(part 0) is current device
[0 00:00:09.0953] SD/MMC found on device 0
[0 00:00:09.0953] Failed to load 'boot.scr'
[0 00:00:09.0969] ** Unrecognized filesystem type **
[0 00:00:10.0031] 19137024 bytes read in 59 ms (309.3 MiB/s)
[0 00:00:10.0047] 45699 bytes read in 2 ms (21.8 MiB/s)
[0 00:00:10.0047] ## Flattened Device Tree blob at 88000000
[0 00:00:10.0047]    Booting using the fdt blob at 0x88000000
[0 00:00:10.0063]    Loading Device Tree to 000000008fef1000, end 000000008fffffff ... OK
[0 00:00:10.0078]
[0 00:00:10.0078] Starting kernel ...
[0 00:00:10.0078]
[0 00:00:10.0688] entering init script
[0 00:00:10.0688] /bin/sh: can't access tty; job control turned off
[0 00:00:10.0703] / #
```

Figure 5-1. Jacinto DRA821U Fast Boot Result

6 References

The first four documents listed below are a must-read material before making this fast-boot Linux working. It will be better to read all of the following documents.

- Texas Instruments: *Jacinto7 DRA821 Evaluation Module (EVM) User's Guide*
- Texas Instruments: *DRA821 Jacinto™ Processors Data Sheet*
- TI Docs for DRA821U u-boot
- Fast boot related E2E
- Texas Instruments: *J7200 DRA821 Processor Silicon Revision 1.0 Texas Instruments Families of Products Technical Reference Manual*
- TI Docs for DRA821U emmc flashing
- LDconfig

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