

# U-Boot

## Release cycle

Mtk uboot: <https://github.com/mtk-openwrt/u-boot>

Mtk atf: <https://github.com/mtk-openwrt/arm-trusted-firmware>

My uboot: <https://github.com/frank-w/u-boot/tree/2022-10-r3>

## building

Uboot needs to build into atf bl33.

- <https://github.com/frank-w/u-boot/tree/2022-10-r3>
- <https://github.com/frank-w/u-boot/tree/r3-atf>

So basically do these in both branches (first uboot then atf)

```
./build.sh importconfig  
./build.sh
```

Then flash build/mt7986/release/ bl2.img to bl2-partition and fip.bin to fip-partition

```
sudo dd if=build/mt7986/release/bl2.img of=/dev/sdb1  
sudo dd if=build/mt7986/release/fip.bin of=/dev/sdb4
```

ATF branch contains gpt file (gpt\_sdmmc\_100m6g.img) for flashing first and script to create basic image with bootchain

```
./build.sh createimg
```

## booting kernel

```
setenv kaddr 0x46000000  
ls mmc 0:5  
fatload mmc 0:5 ${kaddr} bpi-r3-5.19.0-rc1-r3.itb  
#setenv bootargs "earlycon=uart8250,mmio32,0x11002000 console=ttyS0"  
bootm ${kaddr}
```

board seems to hang in 5.19-rc1 when console=ttyS0 is passed

with my environment it is easy to boot kernel from usb

```
BPI-R3> usb start  
BPI-R3> setenv device usb #was mmc before
```

```
BPI-R3> setenv partition 0:1 #was 0:5 before for mmc
BPI-R3> setenv fit bpi-r3-sfp.itb #change filename if needed
BPI-R3> run newboot #will load bpi-r3.itb
```

load fip with alternate dtb (like from my current 5.19-r3 branch, second config contains emmc dtb)

```
BPI-R3> fatload usb 0:1 $loadaddr bpi-r3.itb
17032308 bytes read in 1427 ms (11.4 MiB/s)
BPI-R3> bootm ${loadaddr}#conf-2
```

load external initrd (run before „run newboot“):

```
BPI-R3> setenv rdaddr 0x48000000
BPI-R3> setenv root "/dev/ram0 rw"
BPI-R3> setenv bootopts "debug=7 initrd=${rdaddr},20M"
BPI-R3> fatload usb 0:1 ${rdaddr} rootfs.cpio.zst
```

latest uboot with usb, initrd and bootconf

```
BPI-R3> run useusb
BPI-R3> setenv initrd rootfs.cpio.zst
BPI-R3> setenv fit bpi-r3-sfp-no-rd.itb
BPI-R3> setenv bootconf "#conf-2" #
BPI-R3> run newboot
```

```
#using dt-overlay config
BPI-R3> setenv bootconf "#conf-sd-nor" #conf-sd-nor=sd base dts + nor dt
overlay
```

```
setenv buildargs 'setenv bootargs "board=${board}
earlycon=uart8250,mmio32,0x11002000 ${bootopts} root=${root}" '
```

## bootmedium selection

	top		bottom	
	sw1/A	sw2/B (spi/mmc)	sw5/C (nor/nand)	sw6/D (sd/emmc)
spim-nor	low	low	low	x
spim-nand	high	low	high	x
emmc	low	high	x	low
sd	high	high	x	high

To access emmc you need to go over spi-nand/nor:

Bootup with sdcard (put spi-nand bl2 + fip with emmc-and usb-support as files on card) and flash them like described [here](#) then boot from spi (sw2 to boot from spi-nand + change sw6 to have access to emmc) and then [flash emmc](#). Finally change sw2 back to boot from emmc and sw1 has to be changed too.

## nand flash

<https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/tree/arch/arm64/boot/dts/mediatek/mt7986a-bananapi-bpi-r3-nand.dts>

```
BPI-R3> ls mmc 0:5
17019020  bpi-r3.itb
579401   fip_nand.bin
217712   bl2_nand.img

3 file(s), 0 dir(s)

BPI-R3> mtd list
List of MTD devices:
* spi-nand0
- device: spi_nand@1
- parent: spi@1100a000
- driver: spi_nand
- path: /spi@1100a000/spi_nand@1
- type: NAND flash
- block size: 0x20000 bytes
- min I/O: 0x800 bytes
- OOB size: 64 bytes
- OOB available: 24 bytes
- 0x0000000000000-0x0000008000000 : "spi-nand0"
* nmbm0
- type: Unknown
- block size: 0x20000 bytes
- min I/O: 0x800 bytes
- OOB size: 64 bytes
- OOB available: 24 bytes
- 0x0000000000000-0x0000007800000 : "nmbm0"
  - 0x0000000000000-0x0000001000000 : "bl2"
  - 0x0000001000000-0x0000001800000 : "u-boot-env"
  - 0x0000001800000-0x0000003800000 : "factory"
  - 0x0000003800000-0x0000005800000 : "fip"
  - 0x0000005800000-0x0000004580000 : "ubi"

BPI-R3> printenv loadaddr
loadaddr=0x46000000

BPI-R3> mtd erase spi-nand0
Erasing 0x00000000 ... 0x07ffffff (1024 eraseblock(s))
BPI-R3> fatload mmc 0:5 $loadaddr bl2_nand.img
217712 bytes read in 24 ms (8.7 MiB/s)
BPI-R3> mtd write spi-nand0 $loadaddr 0x0 0x100000
Writing 1048576 byte(s) (512 page(s)) at offset 0x00000000

BPI-R3> fatload mmc 0:5 $loadaddr fip_nand.bin
579401 bytes read in 60 ms (9.2 MiB/s)
```

```
BPI-R3> mtd write spi-nand0 $loadaddr 0x380000 0x200000
Writing 2097152 byte(s) (1024 page(s)) at offset 0x00380000
```

## **nor flash**

<https://git.kernel.org/pub/scm/linux/kernel/git/torvalds/linux.git/tree/arch/arm64/boot/dts/mediatek/mt7986a-bananapi-bpi-r3-nor.dts>

```
MT7986> sf probe
SF: Detected w25q256 with page size 256 Bytes, erase size 4 KiB, total 32 MiB
MT7986> sf erase 0 0x180000
SF: 1572864 bytes @ 0x0 Erased: OK
MT7986> fatload usb 0:1 ${loadaddr} 2023.04/bpi-r3_nor_bl2.img
202160 bytes read in 21 ms (9.2 MiB/s)
MT7986> sf write ${loadaddr} 0 0x40000
device 0 offset 0x0, size 0x40000
SF: 262144 bytes @ 0x0 Written: OK
MT7986> fatload usb 0:1 ${loadaddr} 2023.04/bpi-r3_nor_fip.bin
255509 bytes read in 25 ms (9.7 MiB/s)
MT7986> sf write ${loadaddr} 0x100000 0x80000
device 0 offset 0x100000, size 0x80000
SF: 524288 bytes @ 0x100000 Written: OK
```

if you get this error on bootup

```
NOTICE: BL31: Built : 20:24:28, Apr  5 2023
No valid device tree binary found at 0000000041e92f20
initcall sequence 0000000041e621a8 failed at call 0000000041e57800 (err=-2)
### ERROR ### Please RESET the board ###
```

you need to compress bl31

```
xz -f -e -k -9 -C crc32 u-boot.bin
```

and use the resulting u-boot.bin.xz as BL33

## **kernel/initrd**

currently untested...

```
label = "recovery"; //initrd max 10MB
reg = <0x180000 0xa80000>;

label = "fit"; //kernel max 20MB
reg = <0xc00000 0x1400000>;
```

```
MT7986> sf probe
SF: Detected w25q256 with page size 256 Bytes, erase size 4 KiB, total 32
MiB
MT7986> sf erase 0x180000 0xa80000
SF: 11010048 bytes @ 0x180000 Erased: OK
MT7986> fatload usb 0:1 ${loadaddr} rootfs_bpi-r3.cpio.zst
9501203 bytes read in 798 ms (11.4 MiB/s)
MT7986> sf write ${loadaddr} 0x180000 ${filesize}
device 0 offset 0x180000, size 0x90fa13
SF: 9501203 bytes @ 0x180000 Written: OK
MT7986> sf erase 0xc00000 0x1400000
SF: 20971520 bytes @ 0xc00000 Erased: OK
MT7986> fatload usb 0:1 ${loadaddr} bpi-r3-6.1.itb
8424540 bytes read in 708 ms (11.3 MiB/s)
MT7986> sf write ${loadaddr} 0xc00000 ${filesize}
device 0 offset 0xc00000, size 0x808c5c
SF: 8424540 bytes @ 0xc00000 Written: OK
```

loading it:

```
MT7986> setenv useinitrd 'setenv root "/dev/ram0 rw";setenv bootopts
"${bootopts} initrd=${rdaddr},20M";'
MT7986> sf read ${rdaddr} 0x180000 0xa80000
device 0 offset 0x180000, size 0xa80000
SF: 11010048 bytes @ 0x180000 Read: OK
MT7986> sf read ${kaddr} 0xc00000 0x1400000
device 0 offset 0xc00000, size 0x1400000
SF: 20971520 bytes @ 0xc00000 Read: OK
MT7986> setenv bootnor 'run useinitrd;run setbootconf; run buildargs; bootm
${kaddr}${bootconf};'
MT7986> run bootnor
```

## usb

```
BPI-R3> usb start
starting USB...
Bus xhci@11200000: xhci-mtk xhci@11200000: hcd: 0x0000000011200000, ipcc:
0x0000
xhci-mtk xhci@11200000: ports disabled mask: u3p-0x0, u2p-0x0
xhci-mtk xhci@11200000: u2p:2, u3p:1
Register 300010f NbrPorts 3
Starting the controller
USB XHCI 1.10
scanning bus xhci@11200000 for devices... 3 USB Device(s) found
    scanning usb for storage devices... 1 Storage Device(s) found
BPI-R3> ls usb 0:1
    efi/
1023582 ramdisk.img
1365903 initrd.img
```

```
2956137  install.img
456908800 system.sfs
4767728  kernel
```

5 file(s), 1 dir(s)

BPI-R3>

from testing usb-sockets near gpio-header (connected to an usb2-hub):

```
BPI-R3> usb tree
USB device tree:
 1 Hub (5 Gb/s, 0mA)
 | U-Boot XHCI Host Controller
 |
+-2 Hub (480 Mb/s, 100mA)
 | USB 2.0 Hub
 |
+-3 Mass Storage (480 Mb/s, 200mA)
    USB      Flash Disk      906B030002F4
```

## writing emmc



newest atf for mediatek needs gpt with fip partition so it must be created first (maybe copy first 1mM from sdcard to emmc).

get emmc/gpt information:

```
BPI-R3> mmc info
Device: mmc@11230000
Manufacturer ID: 11
OEM: 0
Name: 008GB0
Bus Speed: 52000000
Mode: MMC High Speed (52MHz)
Rd Block Len: 512
MMC version 5.1
High Capacity: Yes
Capacity: 7.3 GiB
Bus Width: 8-bit
Erase Group Size: 512 KiB
HC WP Group Size: 4 MiB
User Capacity: 7.3 GiB WRREL
Boot Capacity: 4 MiB ENH
RPMB Capacity: 4 MiB ENH
Boot area 0 is not write protected
Boot area 1 is not write protected
```

```
BPI-R3> gpt read mmc 0
Partition 1:
Start 0MiB, size 0MiB
Block size 512, name gpt
Type U-Boot, bootable 0
UUID df7a38f6-9df4-11ec-ae0-1c1b0d6d28f5

Partition 2:
Start 4MiB, size 0MiB
Block size 512, name u-boot-env
Type U-Boot, bootable 0
UUID 19a4763a-6b19-4a4b-a0c4-8cc34f4c2ab9

Partition 3:
Start 4MiB, size 2MiB
Block size 512, name factory
Type U-Boot, bootable 0
UUID 8142c1b2-1697-41d9-b1bf-a88d76c7213f

Partition 4:
Start 6MiB, size 2MiB
Block size 512, name fip
Type U-Boot, bootable 0
UUID 18de6587-4f17-4e08-a6c9-d9d3d424f4c5

Partition 5:
Start 8MiB, size 32MiB
Block size 512, name kernel
Type U-Boot, bootable 0
UUID 971f7556-ef1a-44cd-8b28-0cf8100b9c7e

Partition 6:
Start 40MiB, size 256MiB
Block size 512, name rootfs
Type U-Boot, bootable 0
UUID 309a3e76-270b-41b2-b5d5-ed8154e7542b

success!
```

load gpt file and flash it

```
BPI-R3> usb start
starting USB...
Bus xhci@11200000: xhci-mtk xhci@11200000: hcd: 0x0000000011200000, ippc:
0x0000
xhci-mtk xhci@11200000: ports disabled mask: u3p-0x0, u2p-0x0
xhci-mtk xhci@11200000: u2p:2, u3p:1
Register 300010f NbrPorts 3
Starting the controller
USB XHCI 1.10
```

```
scanning bus xhci@11200000 for devices... 3 USB Device(s) found
  scanning usb for storage devices... 1 Storage Device(s) found
BPI-R3> ls usb 0:1
      efi/
1365903  initrd.img
2956137  install.img
4767728  kernel
606240   uboot_mtk_emmc_usb.bin
217712   bl2_snand_usb.img
631937   fip_snand_usb.bin
634345   fip_emmc_usb.bin
601344   uboot_emmc_usb.bin
17408    gpt_emmc_100m6g.img
200072   bl2_emmc_usb.img
17032308 bpi-r3.itb
```

```
11 file(s), 1 dir(s)
```

```
BPI-R3> fatload usb 0:1 $loadaddr gpt_emmc_100m6g.img
```

```
17408 bytes read in 4 ms (4.2 MiB/s)
```

```
BPI-R3> mmc erase 0x0 0x400;mmc write ${loadaddr} 0x0 0x400
```

```
MMC erase: dev # 0, block # 0, count 1024 ... 1024 blocks erased: OK
```

```
MMC write: dev # 0, block # 0, count 1024 ... 1024 blocks written: OK
```

verify gpt is changed (kernel is now 100MiB - 32 before, rootfs 6144MiB - 256 before):

```
BPI-R3> gpt read mmc 0
Partition 1:
Start 0MiB, size 0MiB
Block size 512, name gpt
Type U-Boot, bootable 0
UUID 4a32da88-f334-11ec-94f0-112beaedcdcb
```

```
Partition 2:
Start 4MiB, size 0MiB
Block size 512, name u-boot-env
Type U-Boot, bootable 0
UUID 19a4763a-6b19-4a4b-a0c4-8cc34f4c2ab9
```

```
Partition 3:
Start 4MiB, size 2MiB
Block size 512, name factory
Type U-Boot, bootable 0
UUID 8142c1b2-1697-41d9-b1bf-a88d76c7213f
```

```
Partition 4:
Start 6MiB, size 2MiB
Block size 512, name fip
```



```
Type U-Boot, bootable 0
UUID 18de6587-4f17-4e08-a6c9-d9d3d424f4c5

Partition 5:
Start 8MiB, size 100MiB
Block size 512, name kernel
Type U-Boot, bootable 0
UUID 971f7556-ef1a-44cd-8b28-0cf8100b9c7e

Partition 6:
Start 108MiB, size 6144MiB
Block size 512, name rootfs
Type U-Boot, bootable 0
UUID 309a3e76-270b-41b2-b5d5-ed8154e7542b

success!
BPI-R3>
```

now flash bl2 to boot0 block and fip to fip partition

short way using my environment:

```
MT7986> setenv bl2file 2023.04/bpi-r3_emmc_bl2.img
MT7986> setenv fipfile 2023.04/bpi-r3_emmc_fip.bin
MT7986> run wremmc
bl2file=2023.04/bpi-r3_emmc_bl2.img
195976 bytes read in 20 ms (9.3 MiB/s)
MMC erase: dev # 0, block # 0, count 1024 ... 1024 blocks erased: OK
MMC write: dev # 0, block # 0, count 1024 ... 1024 blocks written: OK
fipfile=2023.04/bpi-r3_emmc_fip.bin
645001 bytes read in 58 ms (10.6 MiB/s)
MMC erase: dev # 0, block # 13312, count 4096 ... 4096 blocks erased: OK
MMC write: dev # 0, block # 13312, count 4096 ... 4096 blocks written: OK
```

manual way:

```
BPI-R3> mmc dev 0
switch to partitions #0, OK
mmc0(part 0) is current device
#switch to boot0 block
BPI-R3> mmc partconf 0 1 1 1
BPI-R3> mmc erase 0x0 0x400
BPI-R3> fatload usb 0:1 $loadaddr bl2_emmc_usb.img
200072 bytes read in 19 ms (10 MiB/s)
BPI-R3> mmc write ${loadaddr} 0x0 0x400

MMC write: dev # 0, block # 0, count 1024 ... 1024 blocks written: OK
#switch back to user-partition
BPI-R3> mmc partconf 0 1 1 0
```

```
#fip partition starts at blockoffset 0x3400 (start-value from json 13312 in
hex)
BPI-R3> mmc erase 0x3400 0x1000

MMC erase: dev # 0, block # 13312, count 4096 ... 4096 blocks erased: OK
BPI-R3> fatload usb 0:1 $loadaddr fip_emmc_usb.bin
634345 bytes read in 55 ms (11 MiB/s)
BPI-R3> mmc write ${loadaddr} 0x3400 0x1000

MMC write: dev # 0, block # 13312, count 4096 ... 4096 blocks written: OK
BPI-R3>
```

If boot from emmc does not work, maybe bootbus needs to be changed to 0:

```
mmc bootbus 0 0 0 0
```

instead of writing the gpt image file you can bootup a linux with initrd

you get all files here:

[https://drive.google.com/drive/folders/1ZsJ2jsOieg\\_6HM4LHWUimROX5p5Kx7vo?usp=share\\_link](https://drive.google.com/drive/folders/1ZsJ2jsOieg_6HM4LHWUimROX5p5Kx7vo?usp=share_link)

```
BPI-R3> run useusb
BPI-R3> setenv initrd rootfs.cpio.zst
BPI-R3> setenv fit bpi-r3.itb
BPI-R3> run newboot
```

and create gpt like i do it for [sdcard](#), original gpt uses same values for partitions and use a partition named gpt (0..33) instead of bl2 (34..8191)

```
sudo sgdisk -o ${LDEV}
#sudo sgdisk -a 1 -n 1:34:8191 -A 1:set:2 -t 1:8300 -c 1:"bl2"
${LDEV} #sdcard only
sudo sgdisk -a 1 -n 1:0:33 -A 1:set:2 -t 1:8300 -c 1:"gpt"          ${LDEV}
#emmc only
sudo sgdisk -a 1 -n 2:8192:9215 -t 2:8300 -c 2:"u-boot-env"      ${LDEV}
sudo sgdisk -a 1 -n 3:9216:13311 -t 3:8300 -c 3:"factory"        ${LDEV}
sudo sgdisk -a 1 -n 4:13312:17407 -t 4:8300 -c 4:"fip"           ${LDEV}
sudo sgdisk -a 1024 -n 5:17408:${bootend} -t 5:8300 -c 5:"boot"  ${LDEV}
sudo sgdisk -a 1024 -n 6:${rootstart}:${rootend} -t 6:8300 -c 6:"rootfs" ${LDEV}
```

## chainload uboot

u-boot.bin (without mtk header and not fip) can be chainloaded from another uboot for testing uboot-features without flashing

```
BPI-R3> fatload usb 0:1 $loadaddr uboot_emmc_usb.bin
```

```
601344 bytes read in 52 ms (11 MiB/s)
BPI-R3> go $loadaddr
## Starting application at 0x46000000 ...

U-Boot 2022.04-00557-g726479add2f1 (Jul 05 2022 - 18:14:31 +0200)
```

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