Mainline Linux on Qualcomm SoCs, are we here now ?

Yes, and we're in pretty good shape!

Neil Armstrong - Linaro Developers Services

FOSDEM'24
Brussels / 3 & 4 February 2024

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Introduction

- Qualcomm Landing Team @ Linaro
  - Qualcomm upstream maintenance
  - U-Boot Qualcomm baseport co-maintainer
  - Bringup/addition of new platforms
- I also maintain other upstream pieces
  - Amlogic SoCs
    - Linux & U-Boot architecture
    - Clocks
    - Pinctrl, Serial, CEC ...
  - DRM
    - Bridge drivers
    - Panel drivers
    - Amlogic Display driver
- Primarily focussed on Linux Kernel
  - 1194 patches in mainline from v3.1 to v6.8-rc1, 176 Qualcomm related
- But also in U-Boot (265 patches in mainline as v2024.01)

Linaro is the software engine of the Arm Ecosystem

Linaro empowers rapid product deployment within the dynamic Arm Ecosystem.

- Our cutting-edge solutions, services and collaborative platforms facilitate the swift development, testing, and delivery of Arm-based innovations, enabling businesses to stay ahead in today's competitive technology landscape.
- Our expertise and contributions spread from Testing & LTS, Security, Cloud & Edge Computing, IoT, AI, CI/CD, Toolchain and Virtualization to vertical projects like Windows on Arm and Android Ecosystem enabling and maintenance.
- Linaro fosters and environment of collaboration, standardization and optimization among businesses and open source ecosystems to accelerate the deployment of Arm-based products and technologies along with representing a pivotal role in open source discovery and adoption.

Linaro has enabled trust, quality and collaboration since 2010

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Linaro & Qualcomm

- Qualcomm joined Linaro in 2014
  - When a company joins as a member, they work together on joint engineering projects
  - Originally focused on the Linux kernel but now collaborate in many other areas
    - OpTEE, U-Boot, QEMU, SOAFEE, ...
  - Member companies also participate in setting Linaro's strategic direction
  - Qualcomm Membership included the Landing Team
    - Linaro engineers work closely with Qualcomm on their objectives
    - Everyone involved is happy with how things are going
    - Has increased its cooperation with Linaro over the years

Linaro & Qualcomm

- Collaborated on multiple key pieces of the Android and Linux ecosystem
  - Power frameworks
  - Energy Aware Scheduler
  - Arm servers – standards and software architecture
  - 96Boards DragonBoards (410c, 820c, RB1, RB2, RB3, RB5, etc,...)
  - CodeLinaro
    - Became the principal development platform for Linaro projects
  - Flagship mobile platforms upstreaming
    - Snapdragon 8 Gen 1 - upstream support in the year after the announcement
    - Snapdragon 8 Gen 2 - upstream support in the 6 months after the announcement
    - Snapdragon 8 Gen 3 - upstream support in the 2 months after the announcement

Agenda

1. Where we came from
2. Where we are now
3. A tour of supported devices
4. Demo time!
5. What's remaining
6. We need your help!

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Qualcomm Downstream Changes in 2015

Linaro

Kernel Mainline Status of Mobile Chipsets

September, 2015

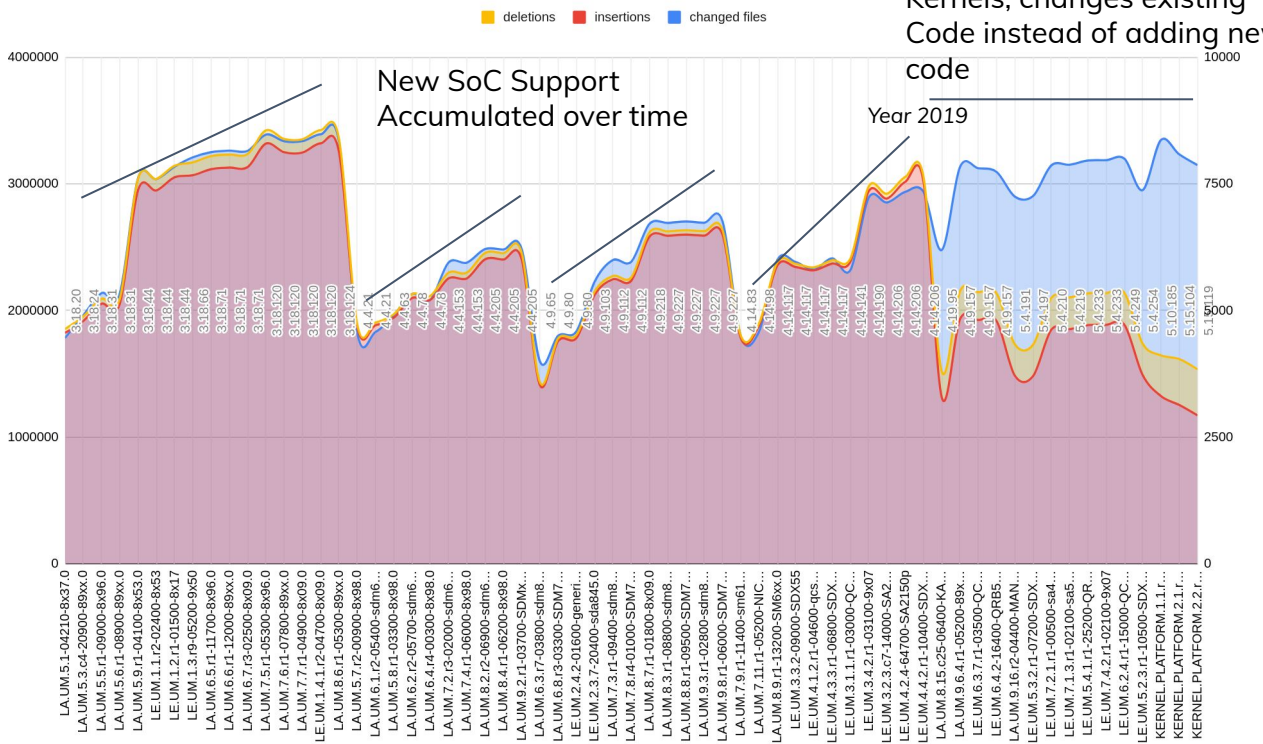
Tim Bird
LF CE Workgroup

Downstream Changes for mobile phones

Company	SOC	Files	Insertions	Deletions
LG	Msm	5775	2.616M	40K
Motorola	Msm	4490	1.795M	40K
Samsung	Exynos	2877	1.100M	51K
Samsung	Msm	6096	3.105M	53K
Sony	Msm	4625	1.784M	41K
Sony	Mediatek	3689	1.935M	7K
Acer	Mediatek	3122	1.411M	6K
Asus	Atom	7351	2.163M	22K
Huawei	Hisilicon	5082	2.659M	43K

Qualcomm Downstream Kernel Changes

Changes across releases:



Better alignment to LTS Kernels, changes existing Code instead of adding new code

Qualcomm Upstream State in 2016

ELC-E 2016 Neil Armstrong - No, it's never too late to upstream your legacy linux based platform

Why should I push code for my (legacy) linux based platform ?

Hopefully, we can count some vendors that really participate in the upstream work like :

- Intel
- IBM
- Texas Instruments
- Atmel (Microchip)
- Broadcom
- Renesas
- Freescale (NXP)
- ...

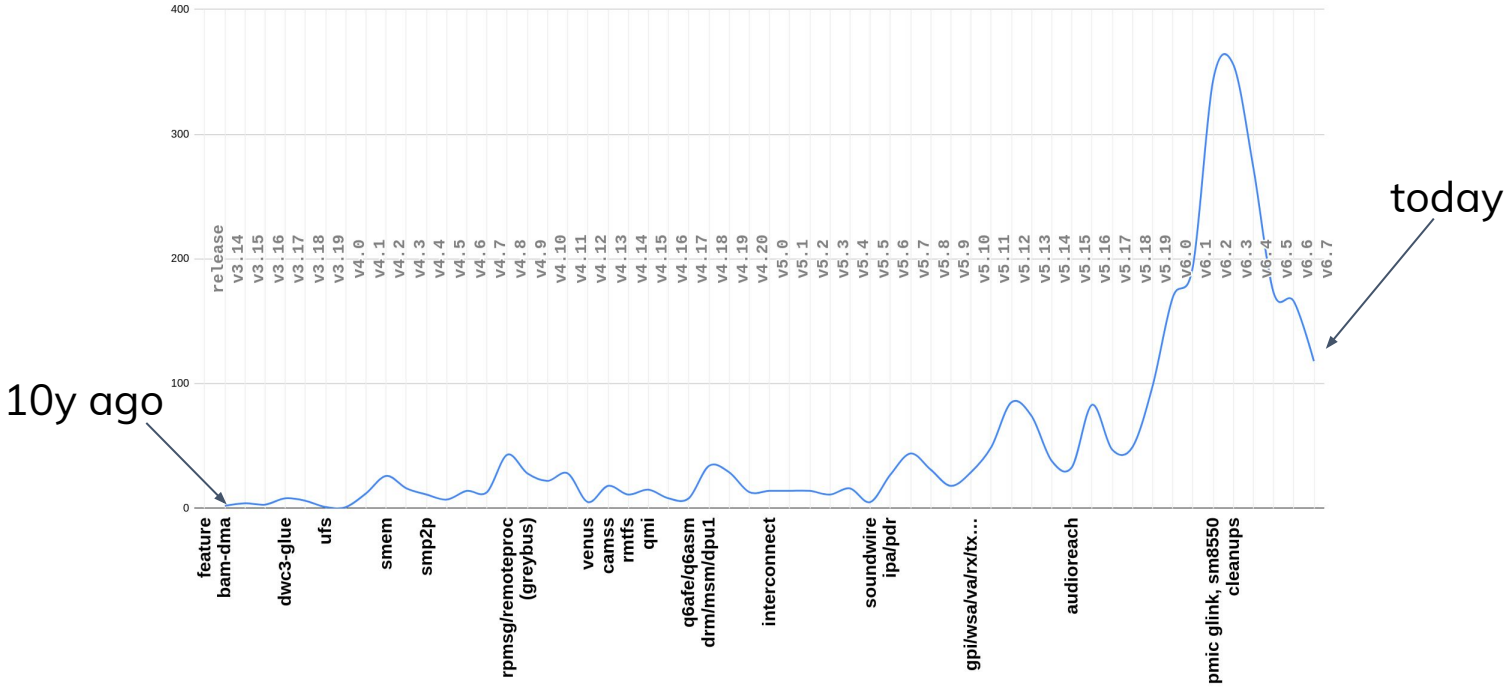
Linaro Qualcomm Landing Team work

Linaro has worked on big features in the last 10 years:

- RemoteProc/rpmsg to handle DSPs
- Interconnect
- Venus Video Encoder/Decoder
- DSP Audio/Audioreach
- MSM DRM Driver
- Soundwire
- And plenty of other time-consuming subjects!

Qualcomm Linaro Upstream Contributions

Timeline of Qualcomm major changes vs Qualcomm Related commits:




```
for id in $(git tag | grep -E "^v[0-9].[0-9]+$" | sort -V); do echo -n $id, ; git log --oneline --author=linaro -G "qcom|msm|qualcomm" $PREV..$id | wc -l; PREV=$id; done
```

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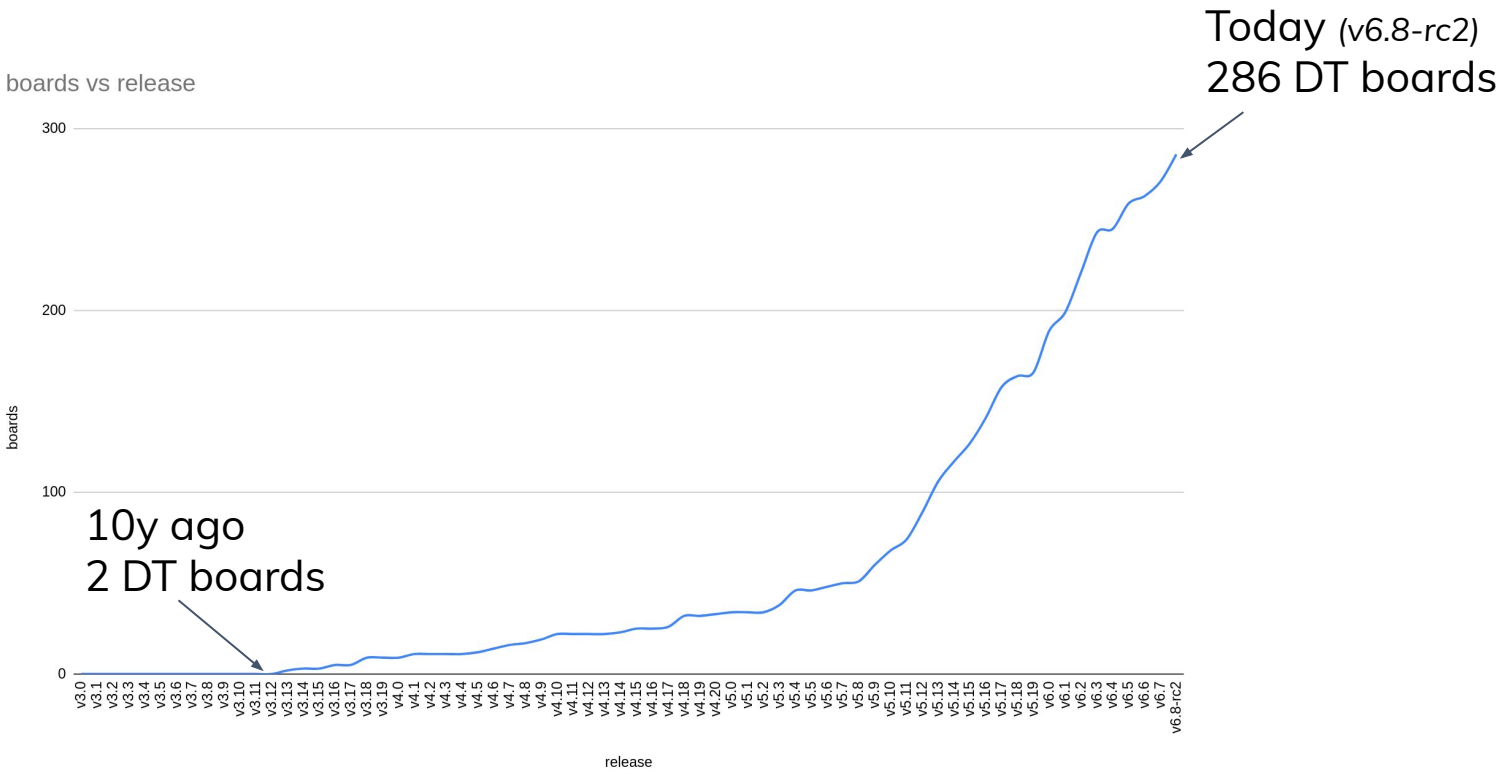
Mainline Supported boards over time




```
for id in $(git tag | grep -E "^v[0-9].[0-9]+$" | sort -V); do echo -n $id, ; git ls-tree --name-only -r $id | grep -E "arch/.*/boot/dts/*qcom.*.dts$" | wc -l; done
```

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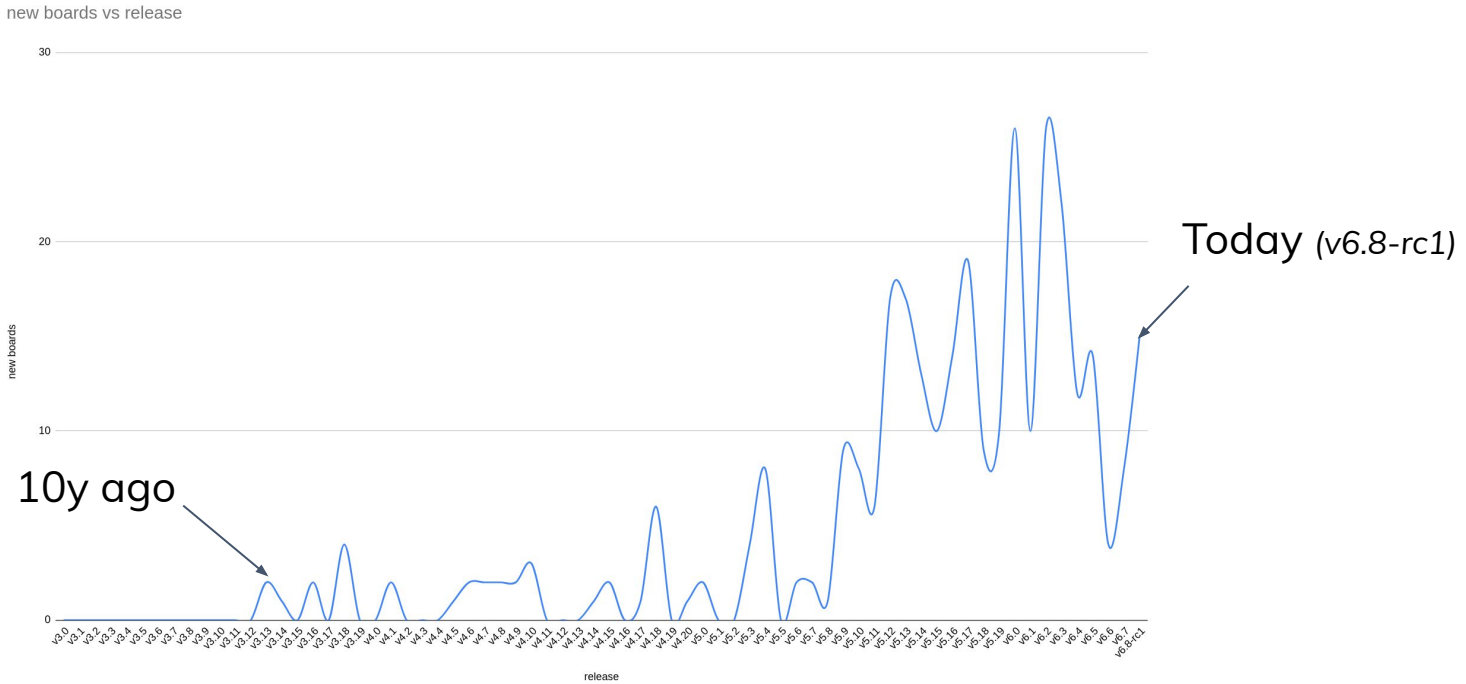
New Supported boards over time



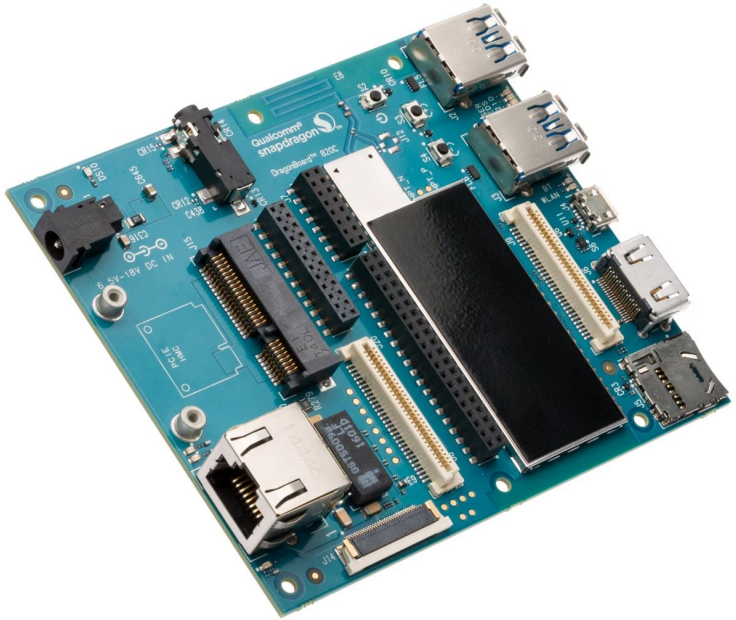
Manually corrected since arm32 DTs were moved in subdirectories in V6.5...

```
for id in $(git tag | grep -E "^v[0-9].[0-9]+$" | sort -V); do echo -n $id, ; BOARDS=$(git ls-tree --name-only -r $id | grep -E "arch/.*/boot/dts/*qcom.*.dts$"); diff -u <(git ls-tree --name-only -r $PREREV | grep -E "arch/.*/boot/dts/*qcom.*.dts$") <(git ls-tree --name-only -r $id | grep -E "arch/.*/boot/dts/*qcom.*.dts$") | grep "\+arch" | wc -l; PREREV=$id; done
```

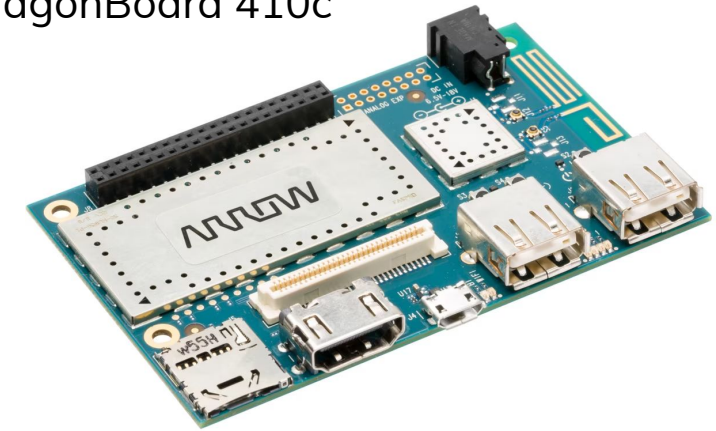
Historical Dragonboards

The 96board DragonBoards were the first widely available Qualcomm Development platforms in SBC form-factor and boosted the upstreaming effort.

DragonBoard 820C



DragonBoard 410c

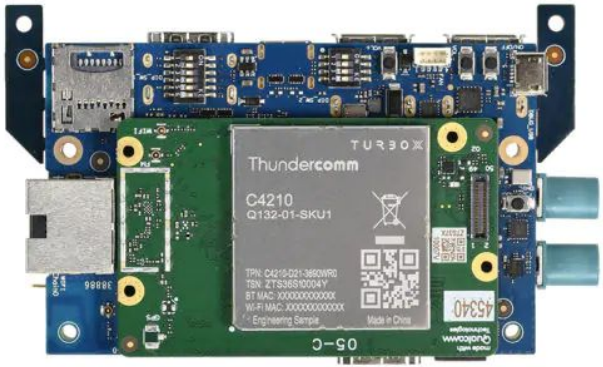


Qualcomm Robotic Boards

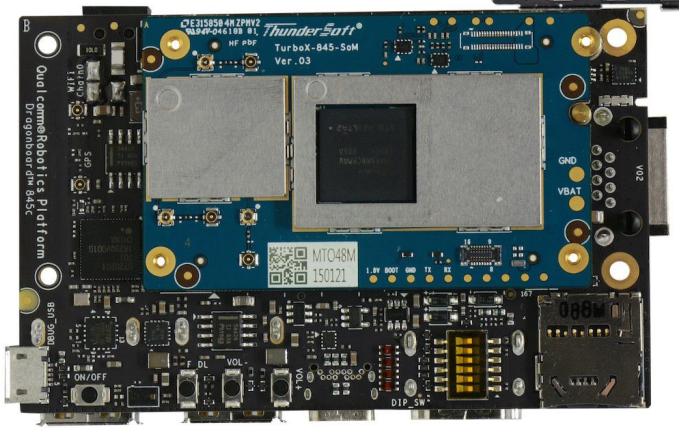
These are the mid-end development boards offered by Qualcomm, using robust and well-supported platforms

RB5

RB1 / RB2



RB3



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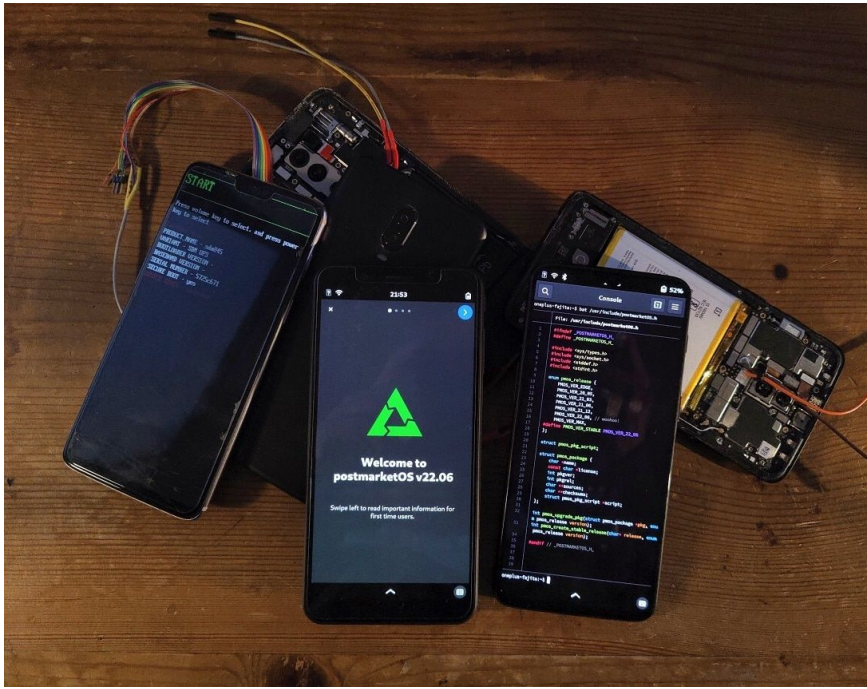
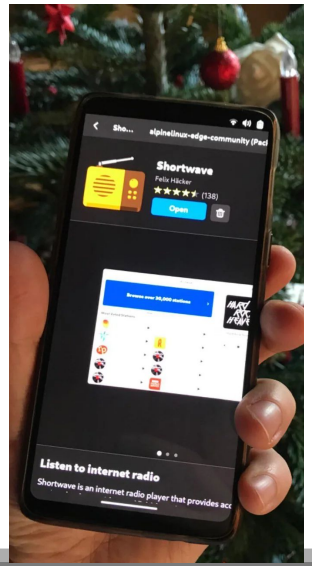
Commercial Phones

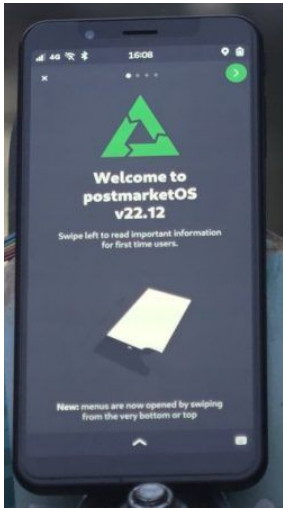
An handful of commercial phones are running mobile oriented mainline Linux-based distros like postmarketOS



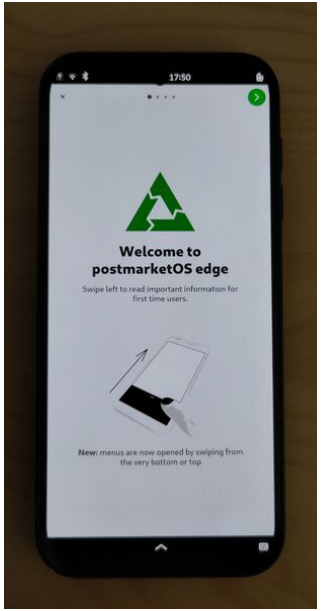
OnePlus 6T



FairPhone 4



FairPhone 5



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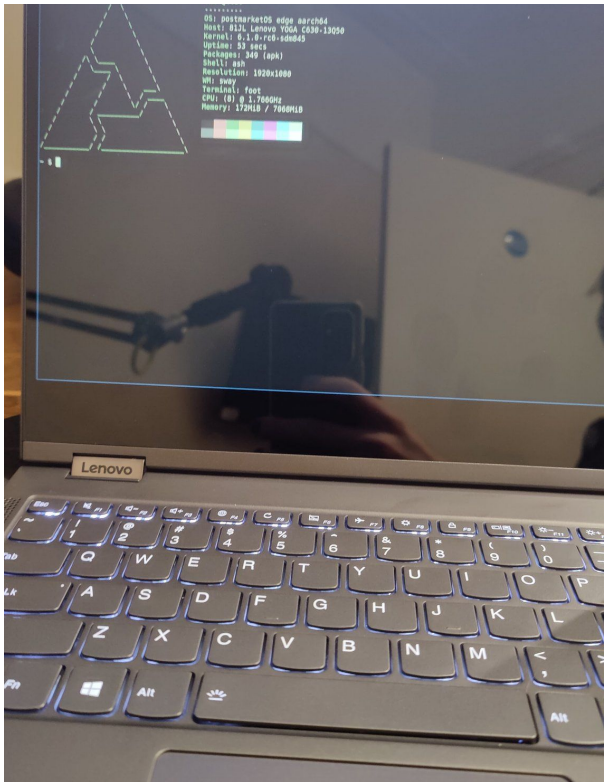
Tablets/Convertibles

An handful of *tablets/convertibles can* run mobile oriented mainline Linux-based distros like postmarketOS or bare Ubuntu

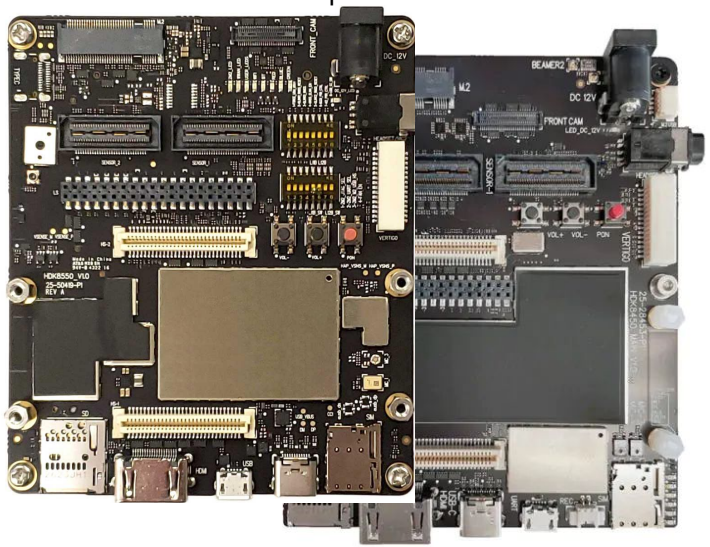
Lenovo Yoga C630



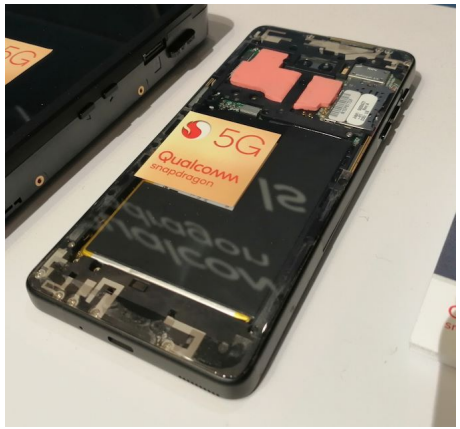
Qualcomm High-End Reference Devices

The Qualcomm Reference Devices & Development Kits
are the primary development devices for upstreaming

Snapdragon 8 Gen 1 & 2
Hardware Development Kits



Qualcomm Reference Devices
with debug test points & connectors



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Snapdragon 8 Gen 3 Support Status

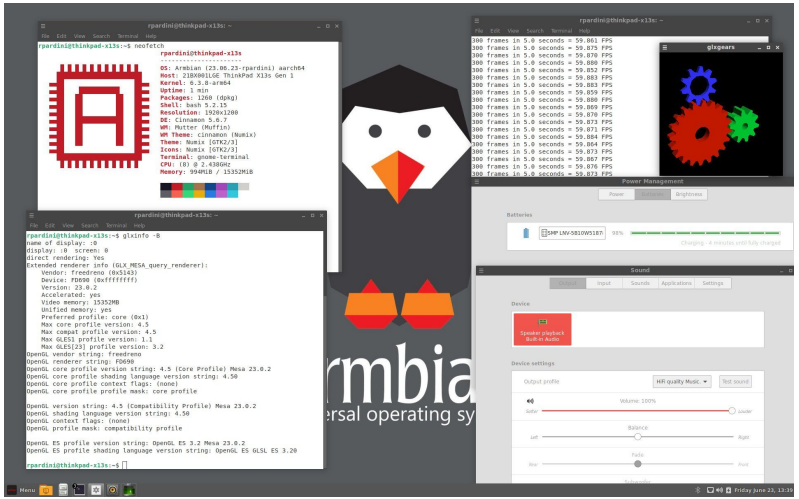
- Supported as Linux v6.8-rc1
  - Display👍
  - UFS, PCIe, USB & Bluetooth 👍
  - Thermal Sensors & CPU Frequency Scaling 👍
  - USB-C 👍
  - Suspend/Resume 👍
  - Crypto Accelerators 👍
- Work in Progress
  - Audio (Codec, USB-C Audio Accessory Mode)
  - DisplayPort Altmode *(👍 on Gen 1 & Gen 2)*
  - DSPs (Modem, Compute & Audio DSP) *(👍 on Gen 1 & Gen 2)*
  - USB-C PD/Charger *(👍 on Gen 1 & Gen 2)*
  - GPU *(👍 on Gen 1 & Gen 2)*

Lenovo X13s

Qualcomm SC8280xp based Laptop

Status maintained by Johan Hovold:
https://github.com/jhovold/linux/wiki/X13s

X13s Running KDE on Armbian



X13s Running Crysis with FEX Emu

https://www.youtube.com/watch?v=7HuPhM03aBw

X13s Running Quake3

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Lenovo X13s

Support Status (also for SC8280xp SoC):

- GPU Acceleration, Display & Backlight 👍
- PCIe, WiFi & Bluetooth 👍
- NVMe 👍
- KeyBoard & Trackpad 👍
- Thermal Sensors & CPU Frequency Scaling 👍
- USB-C and DisplayPort Altmode 👍
- Suspend/Resume 👍
- Audio 👍
- UEFI Boot with EFI Variables 👍

But there’s obviously some Work In Progress !

Lenovo X13s

Work In Progress:

- Built-in Camera is a work in progress and is not available upstream/publicly
- Embedded Controller is a work in progress
  - Needed to support Keyboard's Special Keys and system events
- Active Work to improve power management
  - Constant incremental improvements being made there (Suspend/Resume, ...)
- Some WiFi and Bluetooth issues remain, but they are relatively minor.
- Audio works, requires Active speaker protection
  - DisplayPort Audio is a work in progress
- Miscellaneous
  - Fingerprint reader
  - Video acceleration
  - USB-C Power Delivery

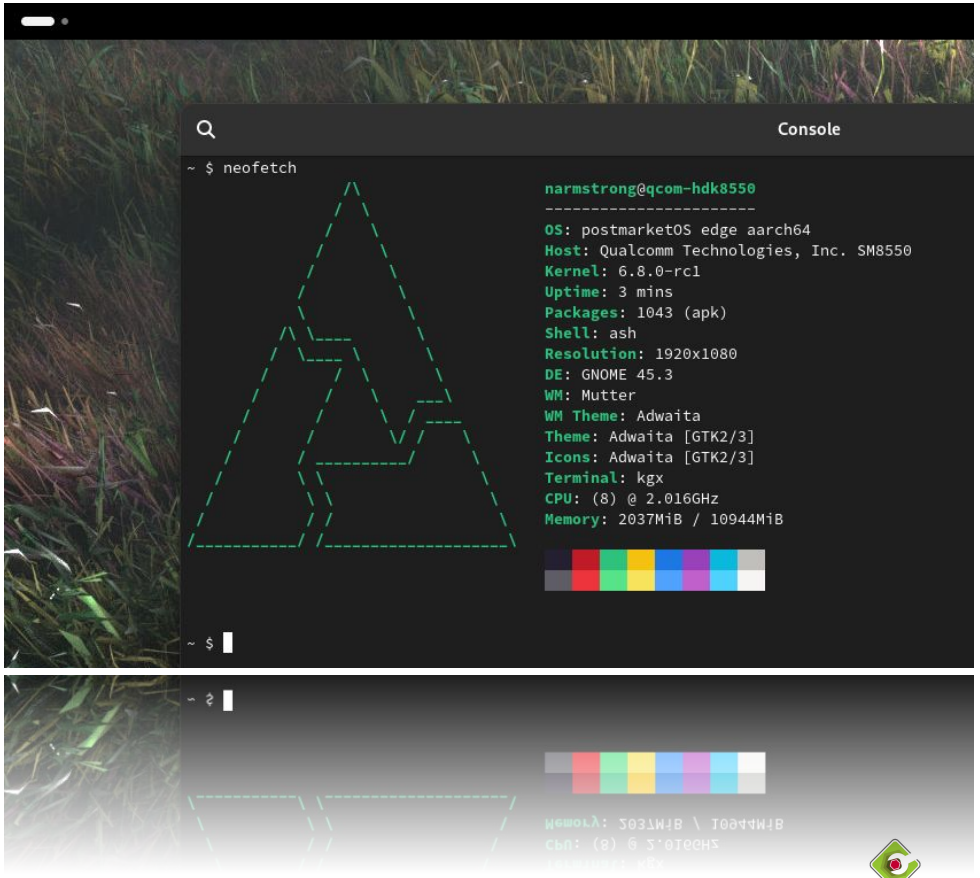
Linux Distributions for the X13s

- *Fedora Rawhide images are bootable as of the 15th of December, 2023*
  - https://fedoraproject.org/wiki/Thinkpad_X13s
- Armbian Maintained Port
  - https://www.armbian.com/lenovo-x13s/
- Ubuntu 23.10 will install “as is”
  - May require some slight configurations
- *As of October 11 2023, Debian Trixie can be installed on the Thinkpad X13s using the daily **netinst** image.*
  - https://wiki.debian.org/InstallingDebianOn/Thinkpad/X13s
- Scripts Available to boot other distros
  - Arch Linux/EndeavourOS

Demo time!

If everything went fine, presentation should run on a Qualcomm platform!

If not, I'll show you a running device !



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What’s remaining

- Power optimization
  - Qualcomm SoCs are known to be very complex in this regard
- Performance Optimization
  - Add Bus scaling on all needed busses (PCIe, UFS, ...)
- Advanced Graphics Features (HDR, ...)
- Video Decoding Accelerator
  - Support for Snapdragon 8 Gen 2 is on the lists
- Camera support on new platforms
- Audio support on new platforms
  - + DisplayPort Audio
  - Speaker Protection
- Miscellaneous features
  - Sensor Hub
  - Haptic Feedback & Vibrator
- Next platforms !

We need your help!

- The Upstream Linux Qualcomm is a very active community!
  - Has the largest ARM64 changes in the last year
- Now ready to support mainstream devices
  - Phones
  - Laptops
  - Modem
  - Accessories
- Work is also in Progress in U-boot
  - Universal Bootloader becomes true!
- Global status: https://linaro.github.io/msm/ ->
- => linux-arm-msm@vger.kernel.org
- => #linux-msm on https://www.oftc.net/

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https://linaro.github.io/msm/

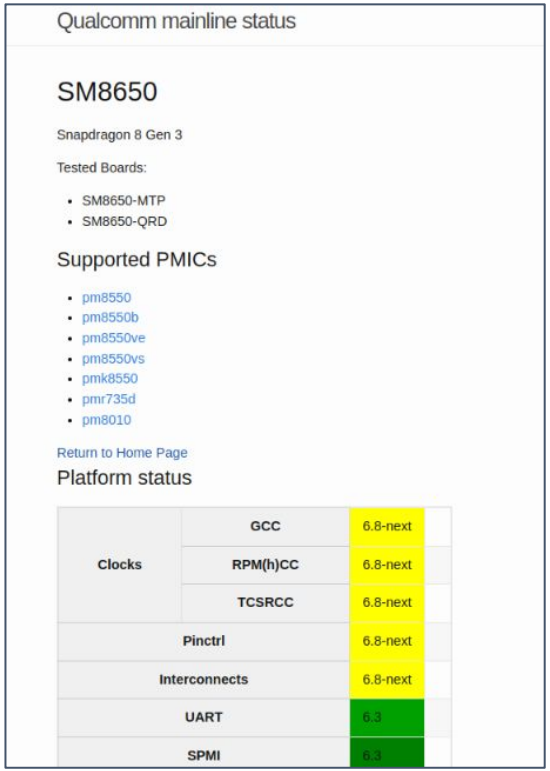
Platform	Clocks		Pinctrl	Interconnects	UART	SPMI	I2C	SPI	PCIe	SMMU	Storage			CPU			Remoteproc	Connectivity			GNSS (GPS)	Audio				USB	Display			
	GCC	RPM(h)CC									NAND	UFS	SD/eMMC	CPUfreq (DVFS)	CPUidle	SMP		Bluetooth	WLAN	IPA		Analog Codec	DMIC	Soundwire	ADSP (AudioReach)		DSI	HDMI	DisplayPort	GPU
APQ8064	3.16	4.6	3.18	N	3.16 (*)	3.16 (*)	3.18	4.6	4.5	4.1	N/A	N/A	3.18	WIP	4.1	3.16	4.7	4.11 (*)	4.11 (*)	N/A						4.2	4.1	4.1	N/A	4.1
MSM8916	4.1	4.6	4.1	5.9	4.1	4.2	4.3	4.3	N/A	4.14	N/A	N/A	4.3	4.17	4.8	4.8	4.1	4.11	4.11	N/A						4.3	4.9	N/A	N/A	4.14
MSM8939	5.12	5.11	5.9	5.12	4.1	4.2	4.3	4.3	N/A	4.14	N/A	N/A	4.3	WIP	N	WIP (*)	4.1	4.1	4.11	N/A						4.3	4.9	N/A	N/A	4.14
MSM8996	4.6	4.15	4.6	6.0	4.6	4.6	4.8	4.8	4.15	4.21	N/A	4.18	4.8	5.14 (*)	5.3	4.6 (*)	4.12	4.18	4.18	N/A						4.14	5.14	5.2	N/A	5.2
QDU1000 / QRU1000	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3		6.3	N/A	N/A	6.5	6.3	6.3	6.3	WIP	N/A	N/A	N/A		N/A	N/A	N/A	N/A	WIP	N/A	N/A	N/A	N/A
SC7180	5.6	5.6	5.6	5.7	5.6	5.6	5.6	5.6		5.6	N/A		5.7	5.6	5.8	5.6	5.8		5.9	5.8						5.6	5.7	N/A	5.15	5.8
SC7280	5.13	5.13	5.13	5.14	5.13	5.13	5.16	5.16	5.16	5.13	N/A		5.15	5.14	5.13	5.13	5.16		5.19	5.15			6.1	6.1		5.15	5.18	N/A	5.18	5.16
SC8280XP / SA8540P	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.3	6.0	6.0	N/A	6.0	6.5	6.0	6.0	6.0	6.0	WIP				6.3	6.3	6.3	6.0			N/A	6.3	6.5
SDM845	4.18	4.19	4.18	5.7	4.19	4.18	4.19	4.19	5.7	5.1	N/A	5.1	5.1	5.1	5.3	4.18	5.2	4.19	5.1	5.7		5.7			5.7	4.2	5.1	N/A	6.2	5.3
SDX65	5.17	5.17	5.17	5.19	5.17	5.19	N/A	N/A	6.5	5.19	6.0	N/A	5.19	6.0		N/A	6.0	N/A	N/A	6.4	N/A	N/A	N/A	N/A	N/A	6.0	N/A	N/A	N/A	
SM8150	5.4	5.4	5.4	5.1	5.4	5.4	5.13	5.14	5.19	5.11	N/A	5.6	5.19	5.6	5.12	5.4	5.6		5.11							5.9	6.3	N/A		5.9
SM8250	5.7	5.7	5.8	5.1	5.7	5.7	5.9	5.9	5.12	5.11	N/A	5.8	5.8 / 5.11	5.1	5.19	5.7	5.8					5.12	5.12	5.12		5.11	5.12	N/A	WIP	5.9
SM8350	5.12	5.12	5.12	5.13	5.12	5.13	5.17	5.17	6.3	5.13	N/A	5.13	6.2	5.13	5.16	5.12	5.13			5.14						5.13	6.3	N/A	6.4	6.3
SM8450	5.17	5.17	5.17	5.17	5.17	6.3	5.17	5.19	5.18 (*)	5.17	N/A	5.17	6.1	5.17	5.17	5.17	5.18					6.2		6.2	6.2	5.18	6.3	N/A	6.4	WIP
SM8550	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4 (*)	6.3	N/A	6.3	6.3	6.3	6.3	6.3	6.3	6.6						6.6		6.3 (*)	6.3	N/A	6.5	WIP
SM8650	6.8-next	6.8-next	6.8-next	6.8-next	6.3	6.3	6.3	6.3	6.8-next	6.3	N/A	6.8-next	6.3	6.6	6.3	6.3	WIP	6.6		6.8-next		WIP		6.8-next	WIP	6.8-next	6.8-next	N/A	WIP	WIP

Platform	Clocks		Pinctrl	Interconnects	UART	SPMI	I2C	SPI	PCIe	SMMU	Storage			CPU			Remoteproc	Connectivity			GNSS (GPS)	Audio				USB	Display			
	GCC	RPM(h)CC									NAND	UFS	SD/eMMC	CPUfreq (DVFS)	CPUidle	SMP		Bluetooth	WLAN	IPA		Analog Codec	DMIC	Soundwire	ADSP (AudioReach)		DSI	HDMI	DisplayPort	GPU

https://linaro.github.io/msm/

https://raw.githubusercontent.com/Linaro/msm/trunk/_soc/sm8650.md

```
---
name: SM8650
layout: soc
status-audio-adspaudio: WIP
status-audio-adspelite:
status-audio-analogcodec: WIP
status-audio-dmic:
status-audio-headset: WIP
status-audio-i2s:
status-audio-lpascodecs: 6.8-next
status-audio-lpasslpi: 6.8-next
status-audio-slimbus:
status-audio-soundwire: 6.8-next
status-audio-spdif:
status-camera: N
status-camera-csi:
status-camera-datapath:
status-camera-eva:
status-camera-i2c:
status-camera-sfe:
status-camera-vfe:
status-camera-vfelight:
status-clock-gcc: 6.8-next
status-clock-rpmhcc: 6.8-next
status-clock-tcsrcc: 6.8-next
status-connectivity-bluetooth: 6.6
status-connectivity-ethernet:
status-connectivity-ipa: 6.8-next
status-connectivity-wlan:
status-cpu-bwmon: 6.3
status-cpu-cachetop:
status-cpu-cpufreq: 6.6
status-cpu-cpuidle: 6.3
status-cpu-ddrfreq:
status-cpu-l3cache:
status-cpu-llcc: 6.8-next
status-cpu-smp: 6.3
status-crypto-qcrypto: 6.4
status-crypto-rng: 6.8-next
status-debug-coresight:
status-debug-dcc:
status-debug-eud:
status-display-dp: WIP
status-display-dsi: 6.8-next
status-display-hdmi: N/A
status-display-hdmiaudio: N/A
status-display-hdmicec: N/A
status-display-gpu: WIP
status-display-lvds: N/A
…
```



Qualcomm mainline status

SM8650

Snapdragon 8 Gen 3

Tested Boards:

- SM8650-MTP
- SM8650-QRD

Supported PMICs

- pm8550
- pm8550b
- pm8550ve
- pm8550vs
- pmk8550
- pmr735d
- pm8010

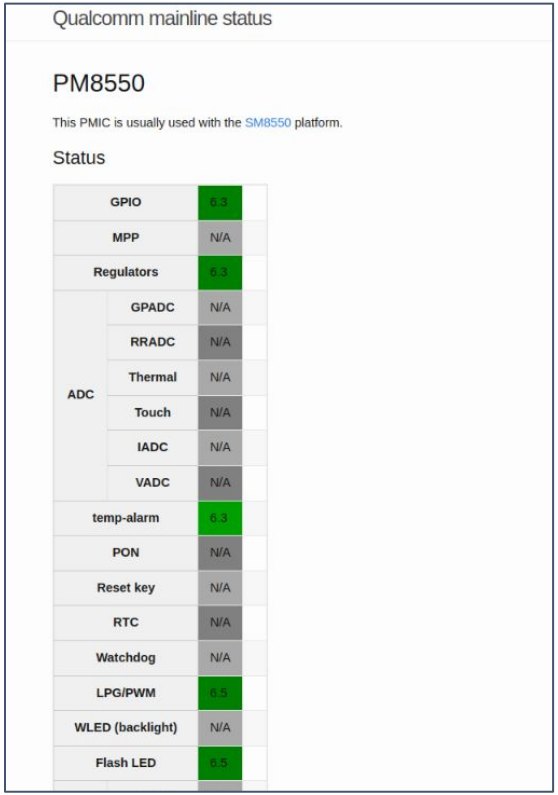
Return to Home Page

Platform status

Clocks	GCC	6.8-next
	RPM(h)CC	6.8-next
	TCSRCC	6.8-next
Pinctrl		6.8-next
Interconnects		6.8-next
UART		6.3
SPMI		6.3

https://raw.githubusercontent.com/Linaro/msm/trunk/_pmic/pm8550.md

```
---
name: PM8550
layout: pmic
pmic-adc-gpadc: N/A
pmic-adc-iadc: N/A
pmic-adc-rradc: N/A
pmic-adc-thermal: N/A
pmic-adc-touch: N/A
pmic-adc-vadc: N/A
pmic-audiocodec: N/A
pmic-bms: N
pmic-clkdiv: N/A
pmic-coincell: N/A
pmic-eusb2repeat: N/A
pmic-flash: 6.5
pmic-fuelgague: N/A
pmic-gpio: 6.3
pmic-haptics: N/A
pmic-keypad: N/A
pmic-labib: N/A
pmic-lpg: 6.5
pmic-mpp: N/A
pmic-pon: N/A
pmic-qnovo: N/A
pmic-regulators: 6.3
pmic-resin: N/A
pmic-rtc: N/A
pmic-tempalarm: 6.3
pmic-usb-extcon: N/A
pmic-usb-typecpd: N/A
pmic-watchdog: N/A
pmic-wled: N/A
…
```



Qualcomm mainline status

PM8550

This PMIC is usually used with the SM8550 platform.

Status

GPIO		6.3
MPP		N/A
Regulators		6.3
ADC	GPADC	N/A
	RRADC	N/A
	Thermal	N/A
	Touch	N/A
	IADC	N/A
	VADC	N/A
temp-alarm		6.3
PON		N/A
Reset key		N/A
RTC		N/A
Watchdog		N/A
LPG/PWM		6.5
WLED (backlight)		N/A
Flash LED		6.5

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Thank you

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Visit www.linaro.org

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or *narmstrong* on Libera.Chat & OFTC

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