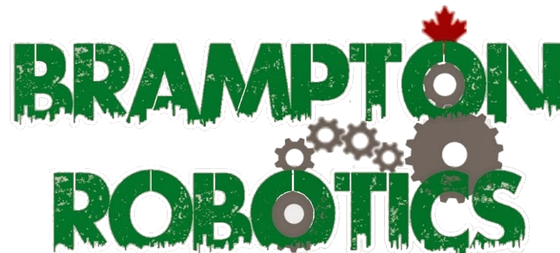
Exploring Mobile Platform Development: Samsung Galaxy S III

A Comprehensive Summary of the Integrated Circuits
Found Within the Galaxy S III

Team 1104A of Brampton Robotics
Discobots Alliance

A submission to the
Texas Instruments Electronics Online Challenge



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1 Introduction

The Samsung Galaxy III (model SGH-i747M) smartphone was chosen to explore the concepts of mobile technology development, as well as examining the advancement of mobile hardware development (when compared with current technology) and various other engineering concepts.

1.1 Concepts Explored

Many concepts are explored. However, the main concepts explored are:

- The types of integrated circuit (IC)s used on mobile platforms,
- The jobs of different ICs,
- How these ICs interact to create a functional system.

2 Findings

Many ICs are found within the circuitry of the phone. However, not all ICs can be fully identified. Difficulties in finding the data-sheets for some parts are in part to:

- Unclear printing on the ICs,
- Wear and tear resulting in labels being smudged,
- Patents withholding the data-sheets from public domain,
- The obsolescence of the part.

Despite the difficulties, there are many observable findings, a few of which are outlined within this section. A full list of named ICs (identified or not) can be found in Appendix A. Photos of the ICs can be found in Appendix B.

2.1 TriQuint Semiconductor TQM7M5013

It is a Global Systems for Mobile Communications (GSM)/Enhanced Data Rates for GSM Evolution (EDGE) power amplifier module (PAM) [4]. The function of this radio frequency (RF) PAM IC in the phone is to drive the transmitting antenna for quad-band GSM/EDGE transmission to cellular towers as part of the cellular network. The circuit is also designed to fit within a small form factor with minimal I/O impedance [4].

2.2 Qualcomm Inc. PM8921

It is a multipurpose IC which contains the following:

- Input and output power management,
- General housekeeping,
- User interfaces (UIs),
- IC interfaces,
- Configurable pins to function within some of the listed categories [2].

Because this IC has such diverse functionality, the proposal is that this IC handles UI tasks (such as haptic feedback, battery and charging regulation, various housekeeping tasks, I/O tasks, and tasks that support the central processing unit (CPU).

2.3 Qualcomm Inc. Snapdragon S4 Plus MSM8960

As an system on a chip, this IC is the core of the phone. As far as basic information goes, this IC contains:

- The CPU,
- The graphics processing unit (GPU),
- The digital signal processor (DSP) [1],
- The image signal processor (ISP),
- Memory buses,
- The modem,
- Various connectivity-related circuits [3].

Containing the CPU, it handles all the basic arithmetic, logic, controlling, and I/O operations on the system. With the rest of the units, the IC handles graphics processing, image processing of camera data, data and memory management, and other jobs too numerous to completely list. The IC also interacts with many other subsystems on the motherboard to accomplish various tasks.

3 Conclusion

Overall, there are a diverse number of ICs used on mobile platforms. From accelerometers to buck converters and the CPU itself, each IC has a unique tasks it performs. In concert, these ICs interact with each other to perform the many tasks required to solve the problem of a portable computer and communications device.

References

[1] Qualcomm Incorporated. *Hexagon SDK - DSP Processor - Qualcomm Developer Network*. n.d. URL: https://developer.qualcomm.com/software/hexagon-dsp-sdk/dsp-processor.

[2] Qualcomm Incorporated. *PMM8920 Power Management ModuleDevice Specification*. 2016. URL: https://developer.qualcomm.com/download/sd600/pmm8920-power-management-module-device-specification.pdf.

[3] Qualcomm Incorporated. *Snapdragon S4, S3, S2, S1 Processor Specs and Details — Qualcomm*. 2014. URL: https://www.qualcomm.com/snapdragon/processors/s4-s1.

[4] TriQuint Semiconductor. *TQM7M5013 - Quad-Band Input Power Controlled EDGE PAM*. 2014. URL: https://datasheetspdf.com/pdf-file/720888/TriQuintSemiconductor/TQM7M5013/1.

Glossary

central processing unit the integrated circuit responsible for the execution of basic arithmetic, logic, controlling, and input/output (I/O) operations specified by the instructions in a program. 3

digital signal processor a specialized integrated circuit responsible for the measuring, filtering, compressing, and/or algorithmic processing of analog data. 3

Enhanced Data Rates for GSM Evolution sometimes referred to as 2.5G, a variant of GSM capable of enhanced data speeds. 2

Global Systems for Mobile Communications a standard created by the European Telecommunications Standards Institute (ETSI) to describe protocols for 2G digital cellular networks. 2

graphics processing unit a specialized integrated circuit responsible for rapid manipulation and alteration of image memory to accelerate the creation of images, intended for output to a display device. 3

haptic feedback any technology that can create an experience of touch by applying forces, vibrations, or motions to the user. 3

housekeeping a standard entry or exit routine appended to a user-written block of code or any other automated or manual software process whereby a computer is ”cleaned up” after usage. 3

image signal processor a specialized integrated circuit responsible for the algorithmic compilation of data into images. 3

impedance the measure of the opposition that a circuit presents to a current when a voltage is applied. 2

integrated circuit an electronic circuit formed on a small piece of semiconducting material, performing the same function as a larger circuit made from discrete components. 2

modem a combined device for modulation and demodulation, for example, between the digital data of a computer and the analog signal of a phone line, typically used to encode digital information for transmission. 3

motherboard a printed circuit board containing the principal components of a computer or other device, with connectors into which other circuit boards can be slotted. 3

obsolescence the process of becoming obsolete or outdated and no longer used. 2

power amplifier module a type of electronic amplifier that converts a low-power radio-frequency signal into a higher power signal. 2

radio frequency a frequency or band of frequencies in the range 10^4 to 10^{11} or 10^{12} Hz, suitable for use in telecommunications. 2

smartphone a mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, internet access, and an operating system capable of running downloaded applications. 2

system on a chip an integrated circuit which integrates all or most components of a computer, typically including primary components: a central processing unit, memory, input/output ports, and secondary storage. 3

User interface the means by which the user and a computer system interact, in particular the use of input devices and software. 3

Acronyms

CPU central processing unit. 3

DSP digital signal processor. 3

EDGE Enhanced Data Rates for GSM Evolution. 2

GPU graphics processing unit. 3

GSM Global Systems for Mobile Communications. 2

I/O input/output. 2, 3

IC Integrated Circuit. 1–3, 16

ISP image signal processor. 3

PAM power amplifier module. 2, 17

RF radio-frequency. 2

UI user interface. 3

Appendices

A List of Components

List of Components				
Manufacturer	*Product*	*Part Number*	*Identified*	*Datasheet*
Qualcomm Inc.	Snapdragon S4 Plus SoC	MSM8960	✓	Proprietary datasheet
Qualcomm Inc.	Power management and utility IC	PM8921	✓	Datasheet
Qualcomm Inc.	RF transceiver	RTF8600	✓	Proprietary datasheet
Samsung Electronics Co., Ltd.	16GB eMMC Storage Device	KLMAG4FE4B-B002	✓	Datasheet
Samsung Electronics Co., Ltd.	16GB density LPDDR2 Mobile DRAM (2GB)	K3PE0E000A-XGC2	✓	Proprietary datasheet
InvenSense Inc.	3-axis accelerometer and gyroscope	MPU-6050M	✓	Datasheet
Melfas Inc.	Touchscreen controller	8PL590	✓	Proprietary datasheet
Melfas Inc.		MPL60521225		N/A
TriQuint Semiconductor	Quad-band GSM/EDGE RF Power Amplifier Module	TQM7M5013	✓	Datasheet
ON Semiconductor	PowerTrench MOSFET	FDMC510P	✓	Datasheet
		7245 K5OG		N/A
		77737-4 60905.1 1219 MX		N/A
		7244 K3NE		N/A
		7241 K4V8		N/A
NXP Semiconductors		65N30		N/A
Silicon Image Inc.		924480 NC6666B 10L2225		N/A
		SWSGAD48		N/A
		V2GCJ		N/A
		CML0801		N/A

B Photos

B.1 Phone - Pre-disassembly

Front side of the phone.

Back side of the phone.

Back cover removed. Absence of battery noted. Phone fully discharged.

B.2 Phone - Structural Disassembly

Back plate removed. Circuitry exposed.

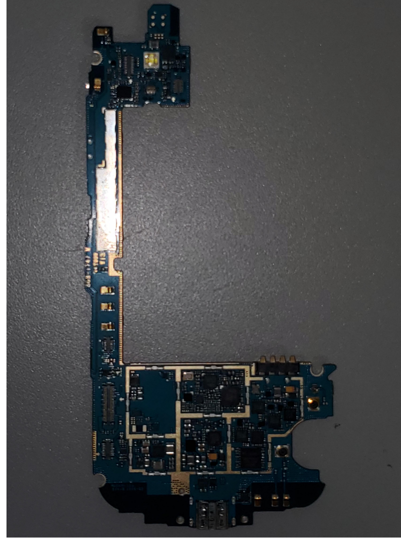
Clearer view of internal circuitry.

Rear camera and speaker removed.

SD card holder and SIM card holder plate removed.

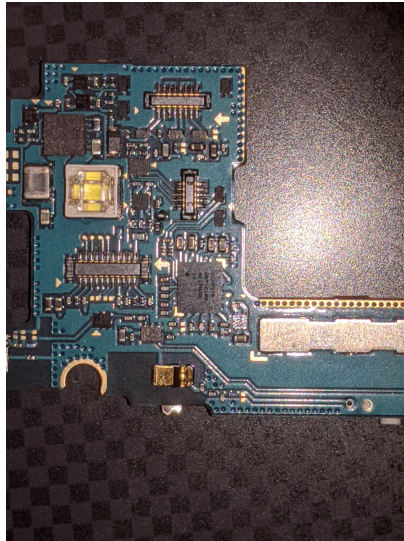
Motherboard removed from phone.

B.3 Circuitry - Motherboard Overview

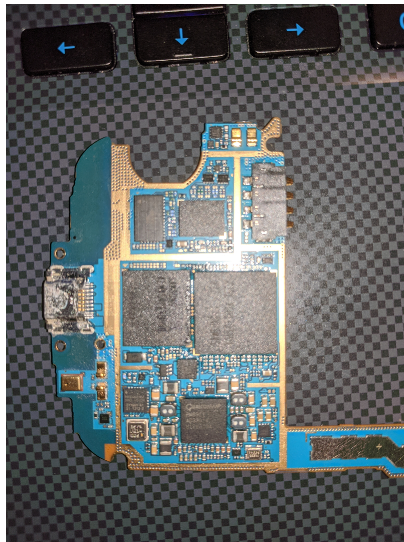


Front side of motherboard.

Back side of motherboard.



Top part of motherboard. Electronics presumed to work with the camera, speakers, flash, etc.



Bottom part of motherboard. Bulk of electronics on this side.

B.4 Circuitry - Specific ICs

B.4.1 Qualcomm Inc. RTF8600

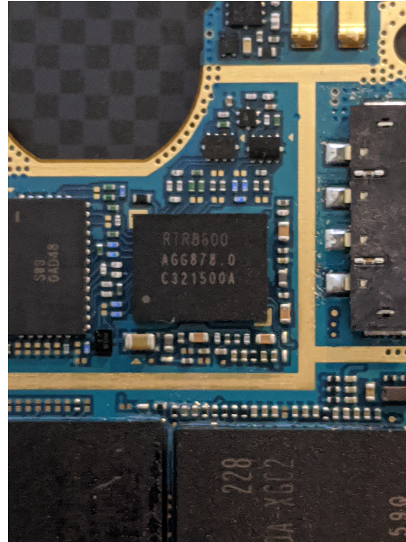


Image of the RF transceiver from Qualcomm Inc.
Center of photo.

B.4.2 Qualcomm Inc. PM8921

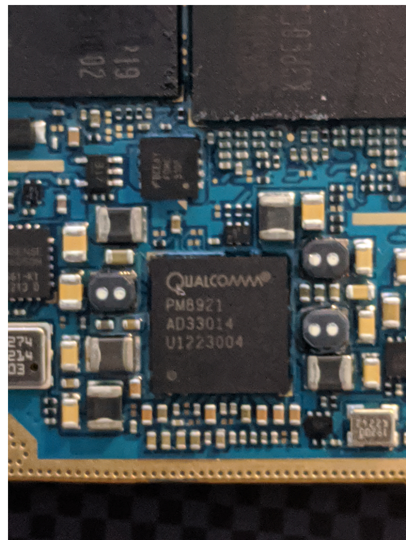
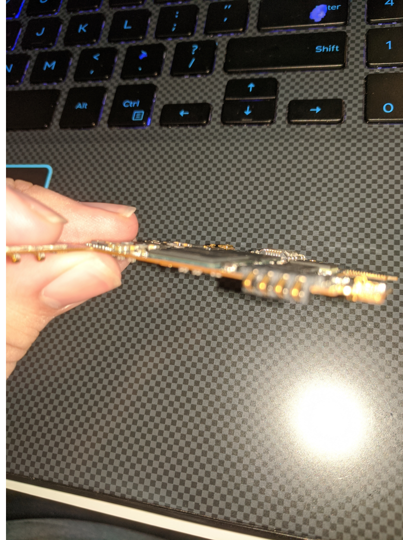


Image of the power management, housekeeping,
and device management IC from Qualcomm.

B.4.3 Qualcomm Inc. Snapdragon S4 Plus MSM8960



Main SoC underneath Samsung DRAM chip.
Center of photo, slightly green.

B.4.4 TriQuint Semiconductor TQM7M5013

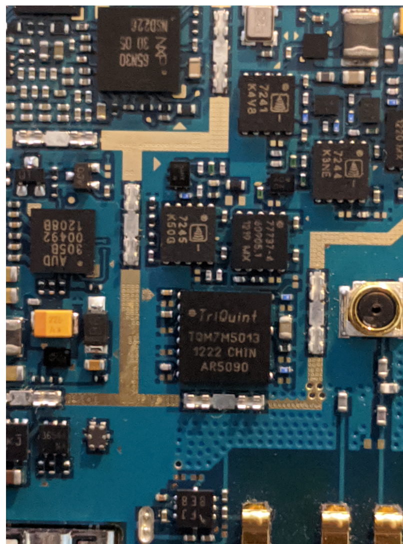


Image of the PAM used with the RTF8600.

B.4.5 Melfas Inc. 8PL590

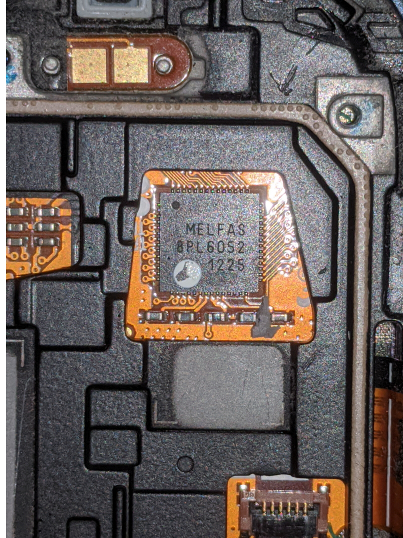


Image of the Melfas Inc. touch screen controller.

B.4.6 Samsung Electronics Co., Ltd. KLMAG4FE4B-B002

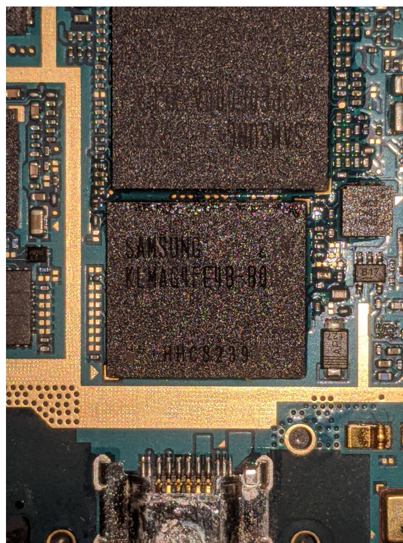


Image of the Samsung 16GB eMMC storage device.
Bottom-most large IC.

B.4.7 Samsung Electronics Co., Ltd. K3PE0E000A-XGC2

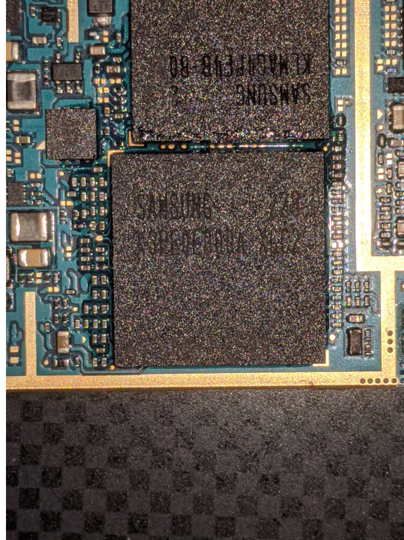


Image of the Samsung 2GB LDDR2 mobile DRAM IC.
Bottom-most large IC.