Texas Instruments
Electronics Online Challenge

Team 10A – Exothermic Actuation

"It was on fire when we got here."

EXOTHERMiC
Robotics

Final Report

Amidst the vast array of electronics, our team opted to disassemble a Samsung Galaxy S Captivate smartphone for this project (Appendix A). The challenge description lists the Samsung Galaxy line as one of the countless devices in which TI components are found. Therefore, we were interested to see if this implementation extended to 2010's Captivate model.

Through the deconstruction of the device (Appendix C, D) we discovered myriad chips. Unfortunately, none were manufactured by TI, so we researched TI products to find those with similar tasks. Since chips such as RAM and CPU have familiar functions, the following list only contains purposes of and TI products similar to those chips whose roles are unfamiliar to the typical user but important nonetheless. Appendix B catalogs all components.
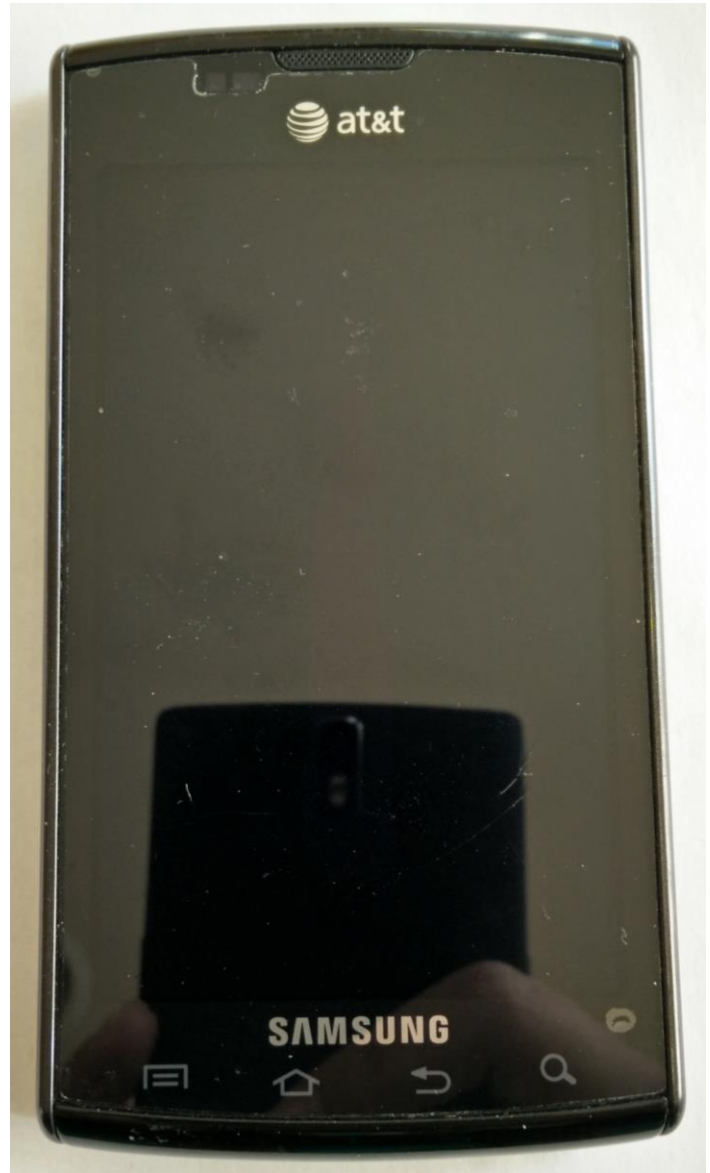
- Motherboard
  - Kyocera KT Series (1-B, 1-O)
    - Time reference to sync functions
    - TI: MSP430
  - Infineon PMB5703 (1-C)
    - Sends/receives radio signals
    - TI: CC2500/CC1100
  - Wolfson WM8994E (1-G)
    - Digital-analog audio converter
    - TI: TLV320
  - TriQuint TQM600 Series (1-K, 1-L, 1-M)
    - Transmit filter: reduces out of band noise
    - Duplexer: permits transmitter/receiver to use same antenna
  - Infineon PMB9801 (1-U)
    - Manages radio functions
    - TI: TCI6487
  - Audience A1026 (1-V)
    - Converts microphone input to signals
  - Maxim MAX8998 (1-Z)
    - Control flow of electrical power
    - TI: TPS (among many others)
- Display panel
  - Atmel MXT224 (6-C)
    - Converts touchscreen input to signals

- TI: TSC2000

We learned a great deal from this project about the electronics in mobile devices. Though we were familiar with smartphones from the consumer side, we had never analyzed their internals. We also discovered that there are numerous TI components with functions similar to the Captivate's chips. Overall, we felt like this project stimulated a greater curiosity about how modern devices work.
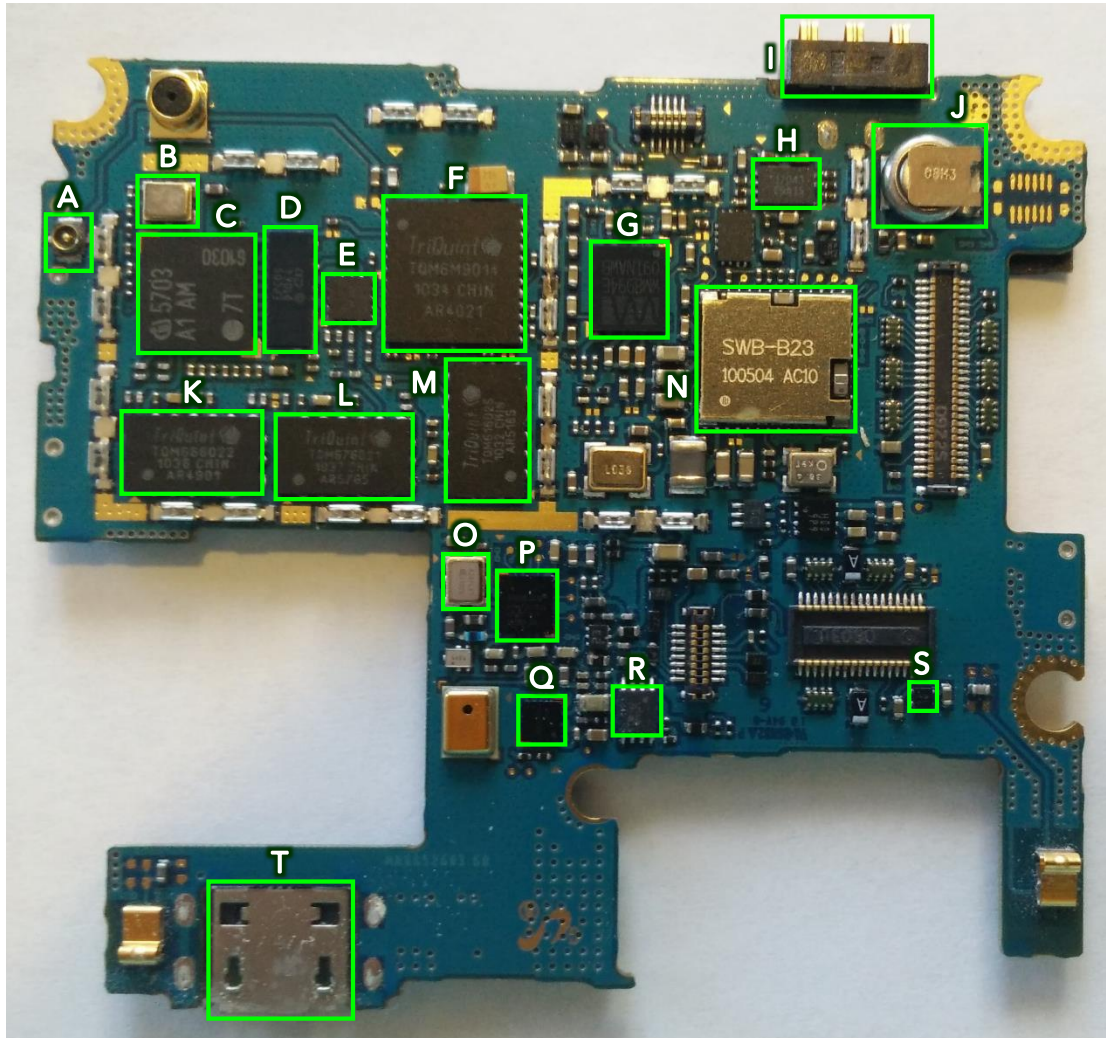
Visual Documentation

Appendix A: The device of choice, the Samsung Galaxy S Captivate (model SGH-I897)
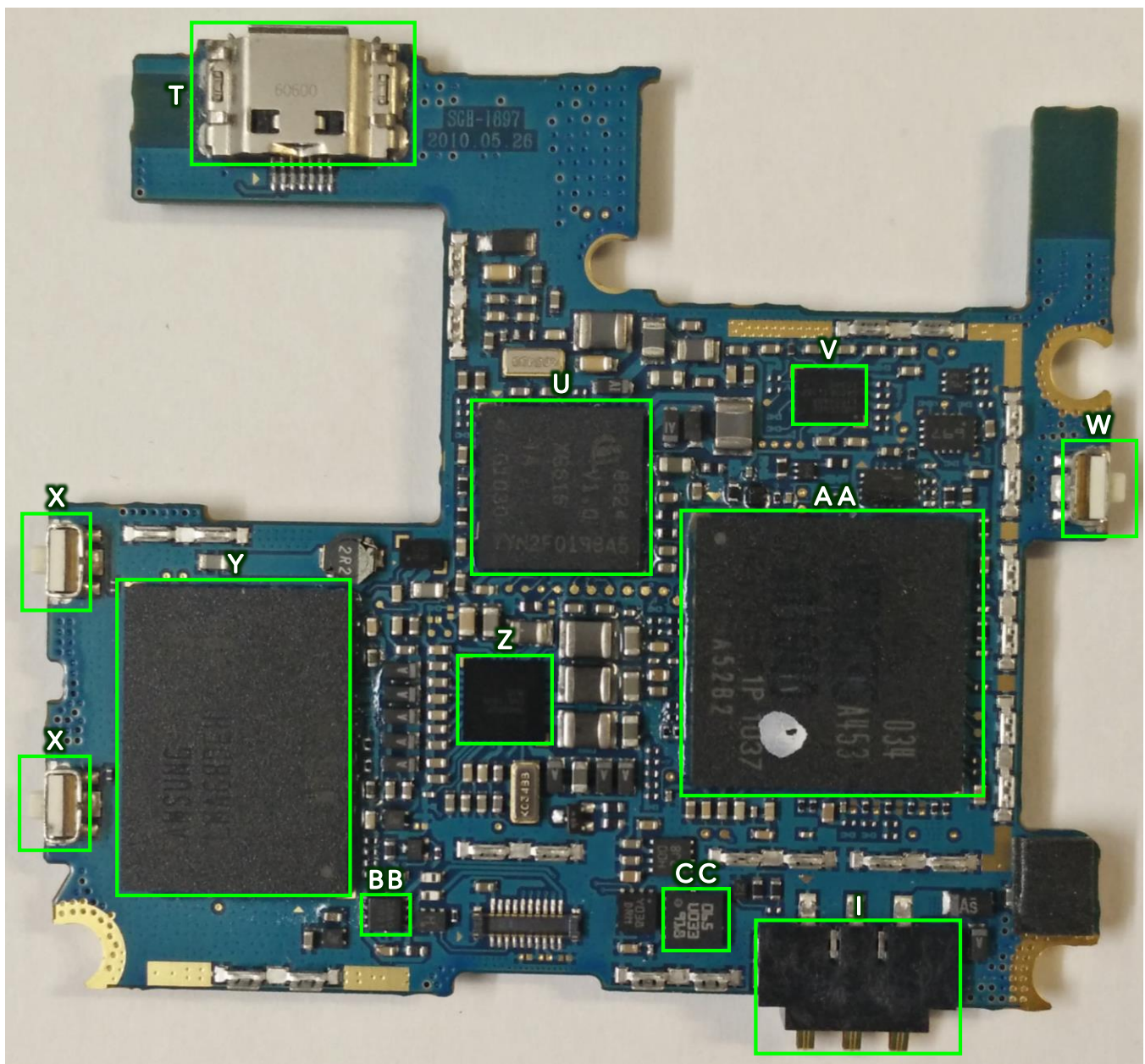
Appendix B: Component close-ups and identification

Component 1 – Motherboard

A   Antenna cable connector

B   Kyocera KT Series time compensated crystal oscillator (TCXO)

C   Infineon PMB5703 quad-band RF transceiver

D   Epcos D1064 SAW filter

E   Infineon BGA735 low noise amplifier (WCDMA)

F   TriQuint TQM6M9014 quad-band GSM/WEDGE radio transmitter module

G   Wolfson WM8994E audio codec

H   Maxim MAX17043 battery fuel gauge

I   Lithium-ion battery connector pin

J   Microphone element

K   TriQuint TQM666022 power amplifier, transmit filter module, duplexer

L   TriQuint TQM676021 power amplifier, transmit filter module, duplexer

M   TriQuint TQM616025 power amplifier, transmit filter module, duplexer

N   Samsung/Broadcom SWB-B23 Wi-Fi WLAN and Bluetooth module

O   Kyocera KT Series TCXO

P   Broadcom BCM4751 GPS receiver

Q   Fairchild Semiconductor FSA9480 USB port detector and switch

R   Toshiba TC75W56FK dual comparator

S   Ricoh RP103K Series voltage regulator

T   Micro USB port

U Infineon PMB9801 GSM/WCDMA baseband processor

V Audience A1026 voice processor

W Power button

X Volume up/down buttons

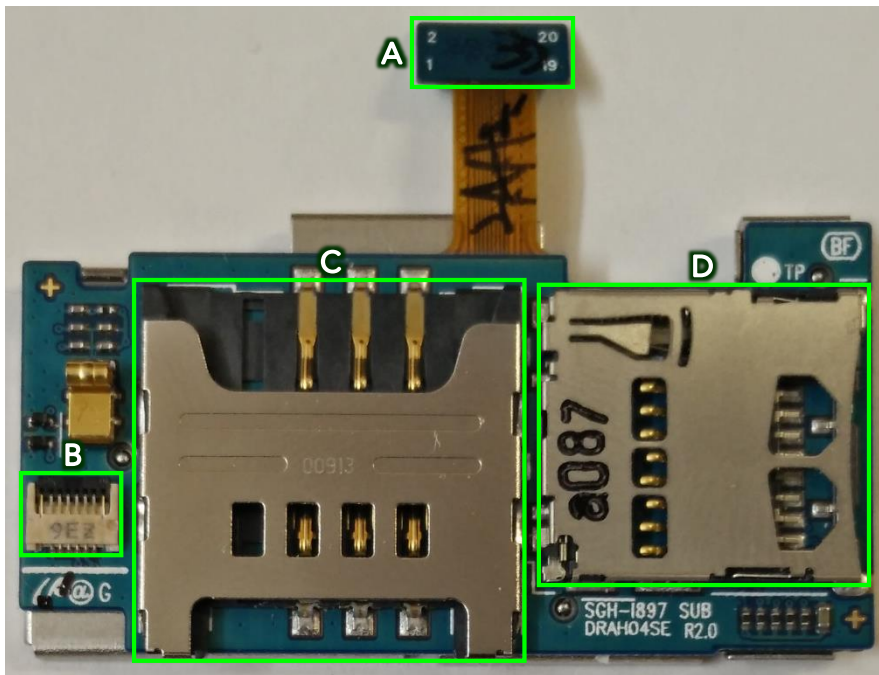Y Samsung KLMAG8DEHE-A101 16 GB flash memory

Z Maxim MAX8998 power management IC

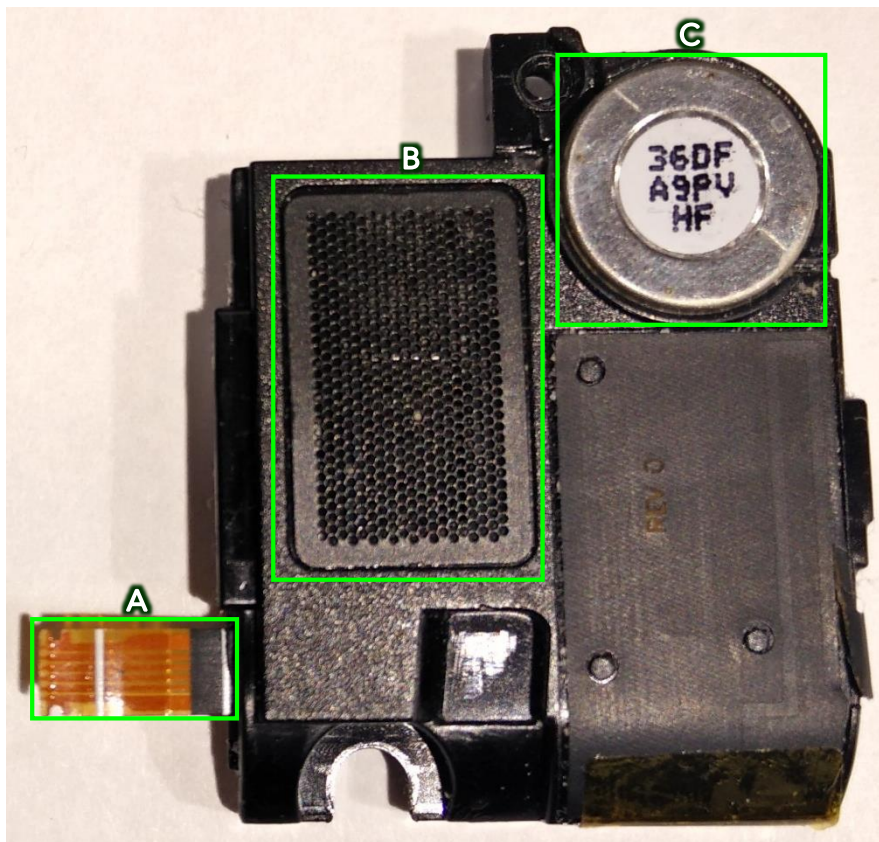AA Samsung Hummingbird CPU and 512 MB RAM

BB Imagis ISA1000 haptic driver

CC Bosch Sensortec BMA Series 3-axis accelerometer

Component 2 – SIM and microSD card reader circuit board
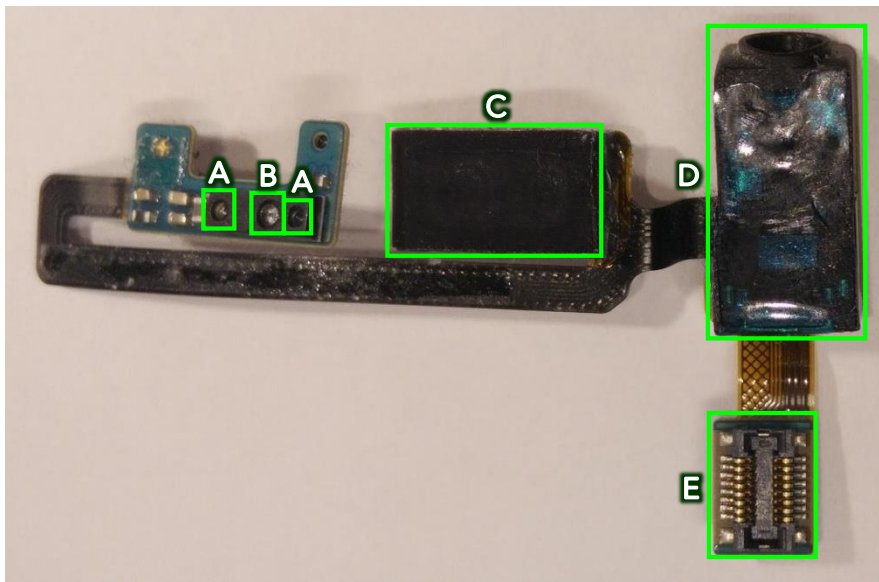

A   Motherboard connector

B   Loudspeaker and vibrator connector

C   SIM card holder/reader

D   microSD card holder/reader

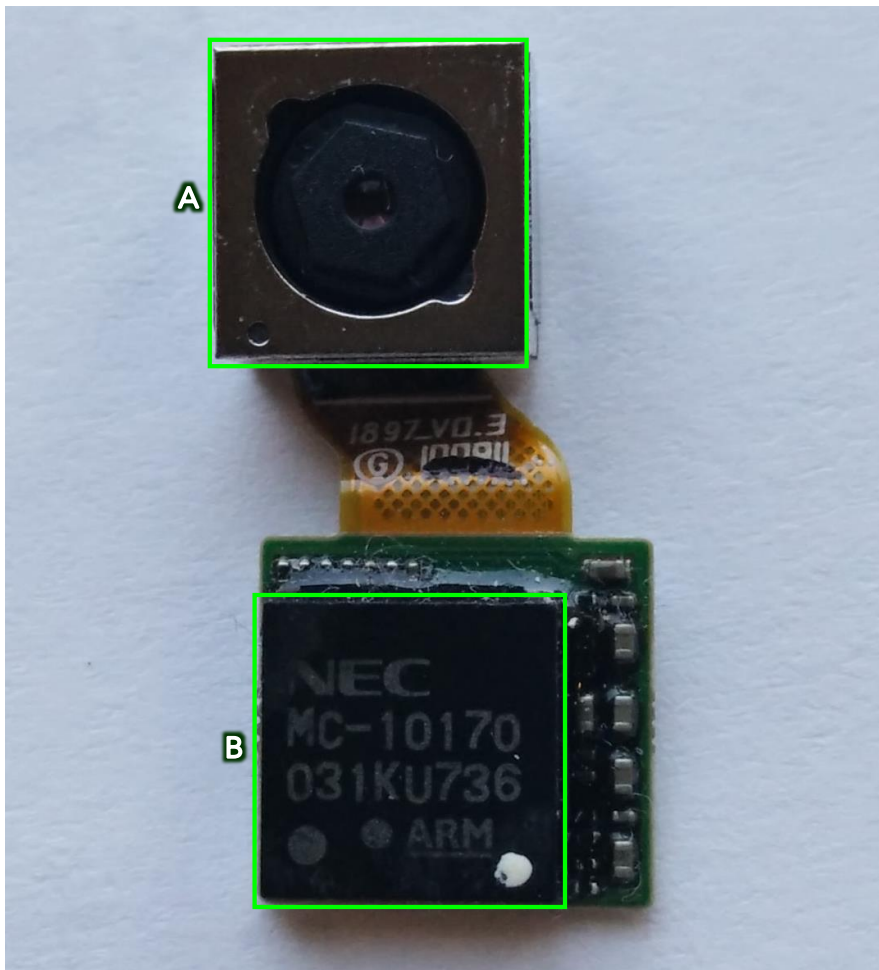## Component 3 – Loudspeaker and vibrator module

A   Motherboard connector wiring

B   Loudspeaker

C   Vibrating Motor

Component 4 – Headphone, earpiece, and proximity sensor module

A   Proximity sensor

B   Ambient light sensor

C   Earpiece

D   3.5mm headphone jack

E   Motherboard connector

Component 5 – Camera module

A   Camera

B   NEC MC-10170 ARM structure image processor

Component 6 – Front display panel
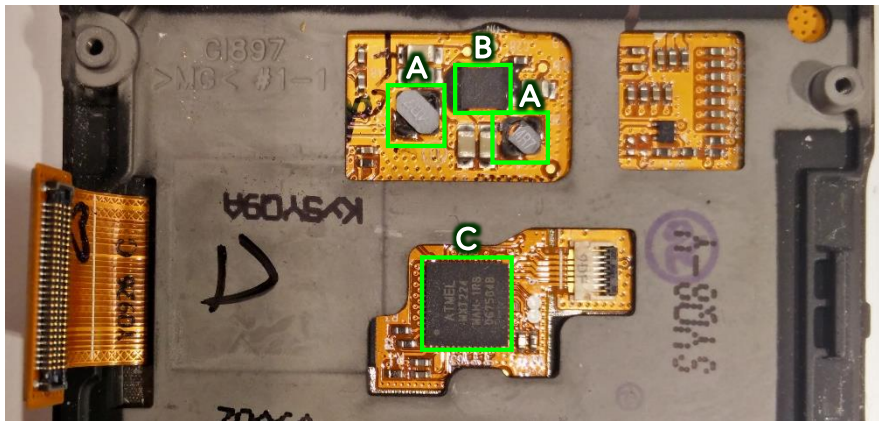
A   Ferrite core inductor

B   AKM Semiconductor AK8973B 3-axis electronic compass

C   Atmel MXT224 touchscreen controller

D   Microphone

E   Unknown (likely connected to capacitive input buttons)
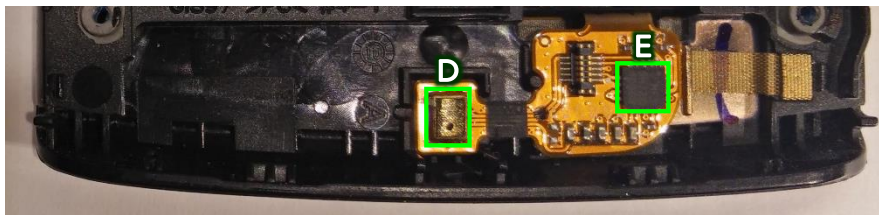
Component 7 – Antenna module
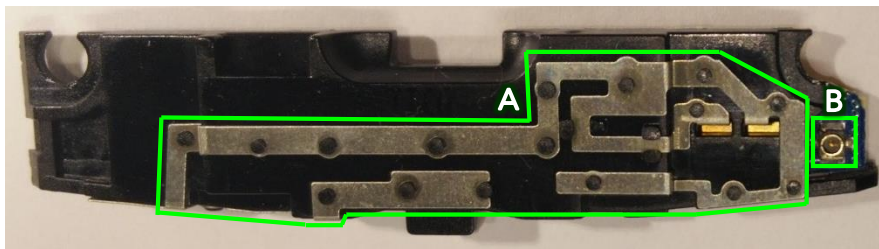
A   Antenna

B   Antenna cable connector

Tools (left to right):

- Plastic toy cards, used to pry apart screen from rear casing (didn't work, ended up using screwdriver)
- Phone
- Screwdriver set, needed for small screws that held rear casing

Appendix D: Step by step disassembly, parts placed in direction they were removed

1) Slide down back cover lock	2) Remove back cover	3) Remove Li-ion battery

4) Remove screws holding rear casing to electronics

5) Remove rear casing

6) Remove camera module and image processing chip

7) Remove screw and
disconnect motherboard
connector pins
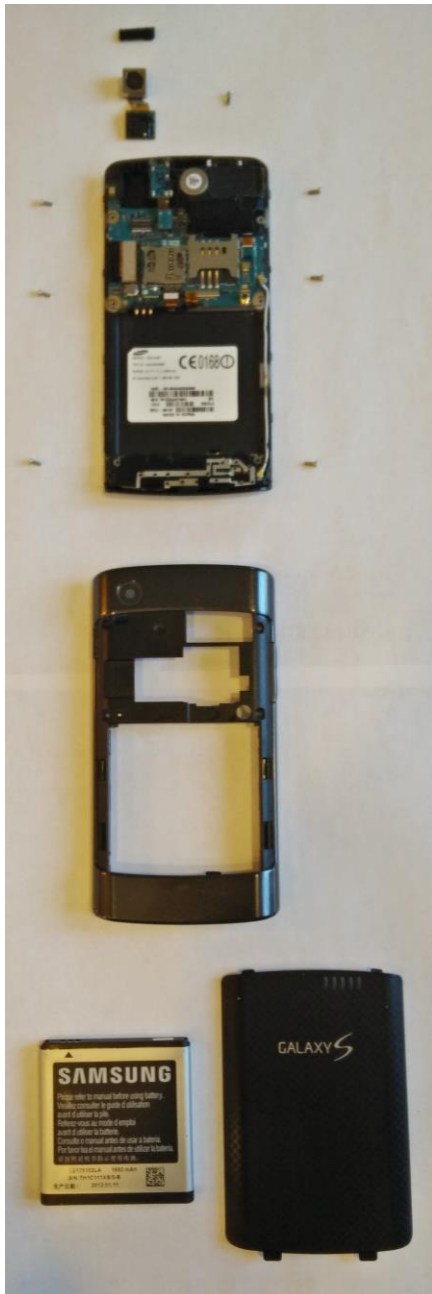
8) Remove motherboard
assembly

9) Separate loudspeaker and
vibrator module from
motherboard
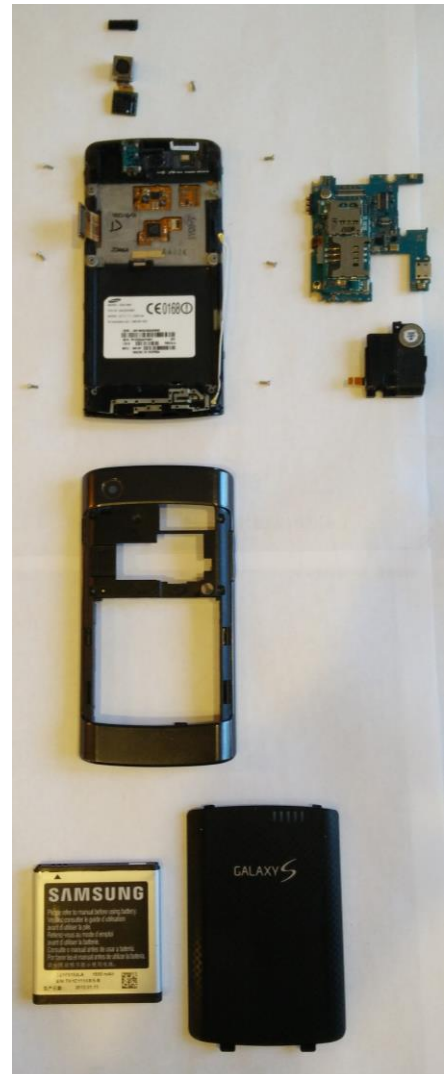
10) Separate microSD card and SIM card reader board from motherboard
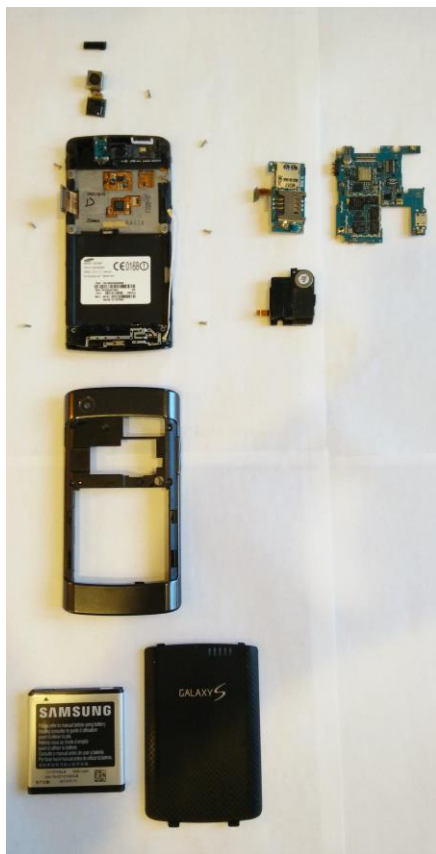
11) Remove headphone jack, earpiece, and light/proximity sensor module

12) Disconnect antenna cable from motherboard and remove antenna array
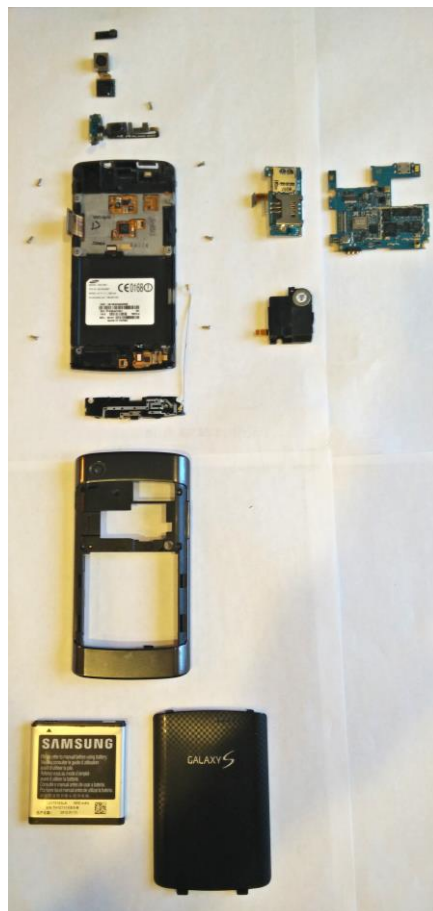
13) Detach antenna cable from antenna; pry metal covering off of back of motherboard
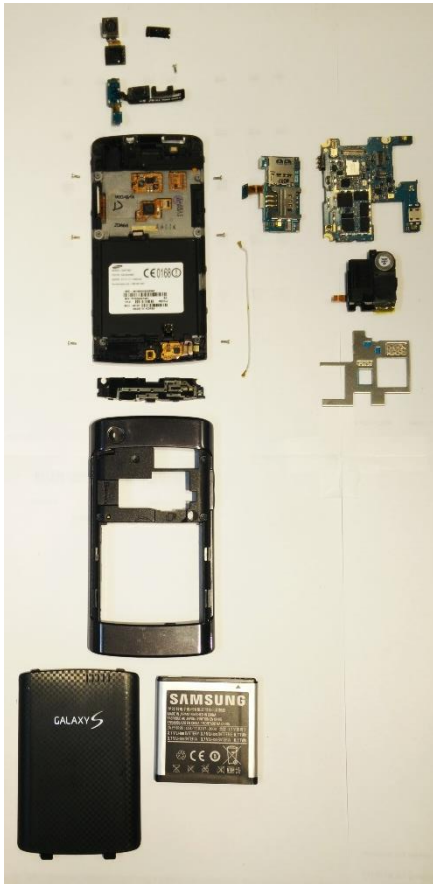
Final disassembled device
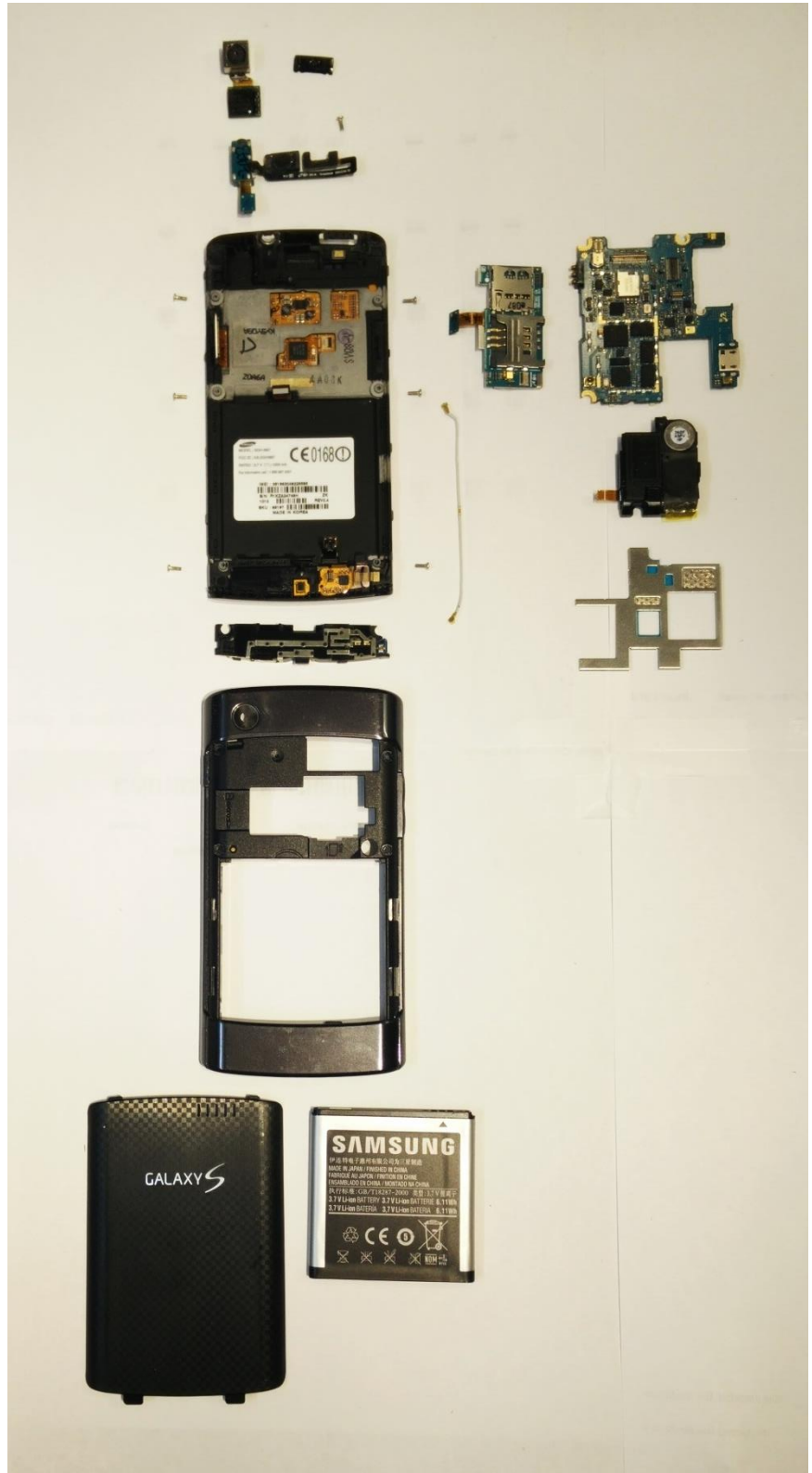
Appendix E: Miscellaneous pictures

Prying apart the display and rear casing with a screwdriver
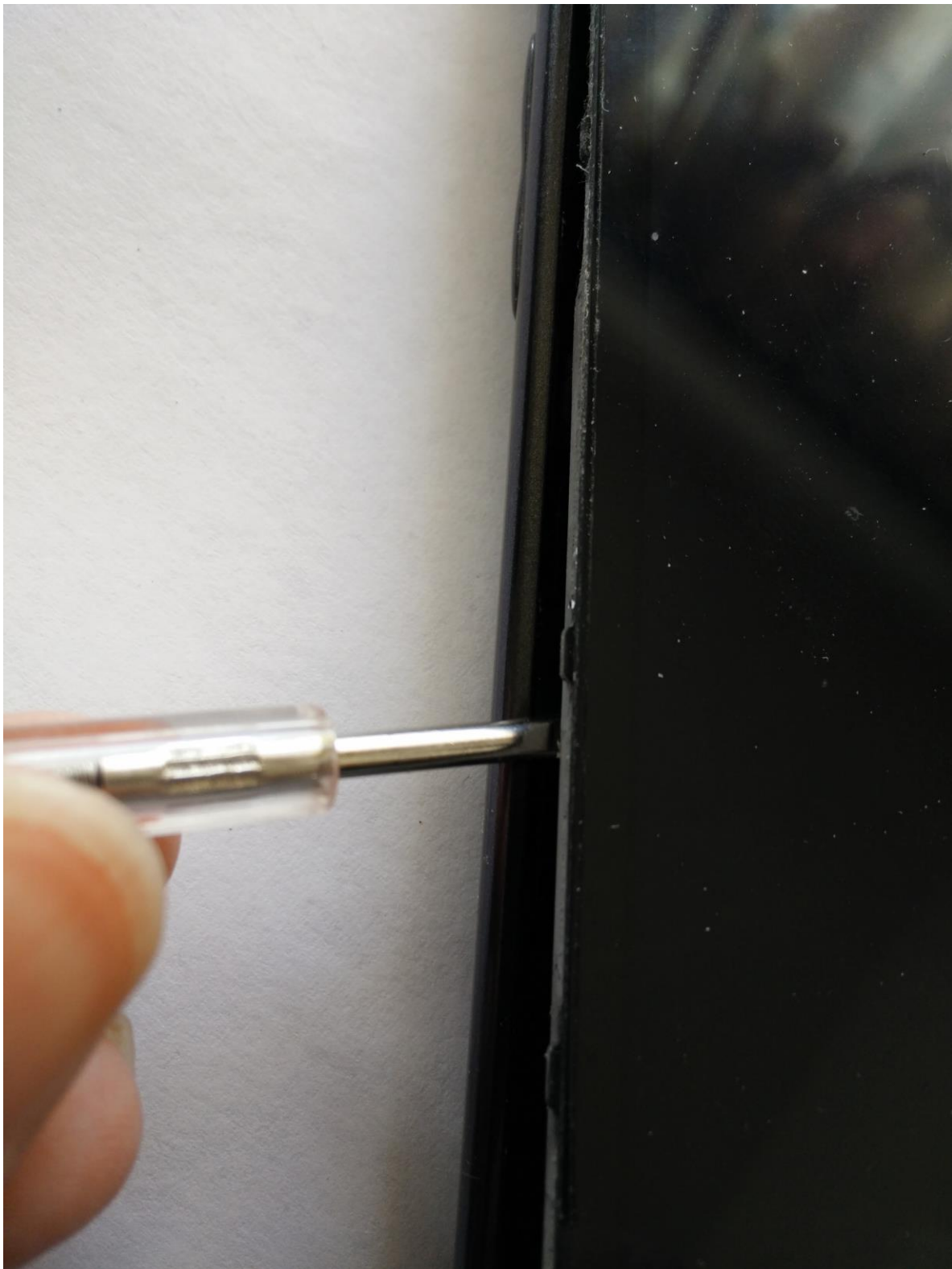
Reassembled the phone. It still works!
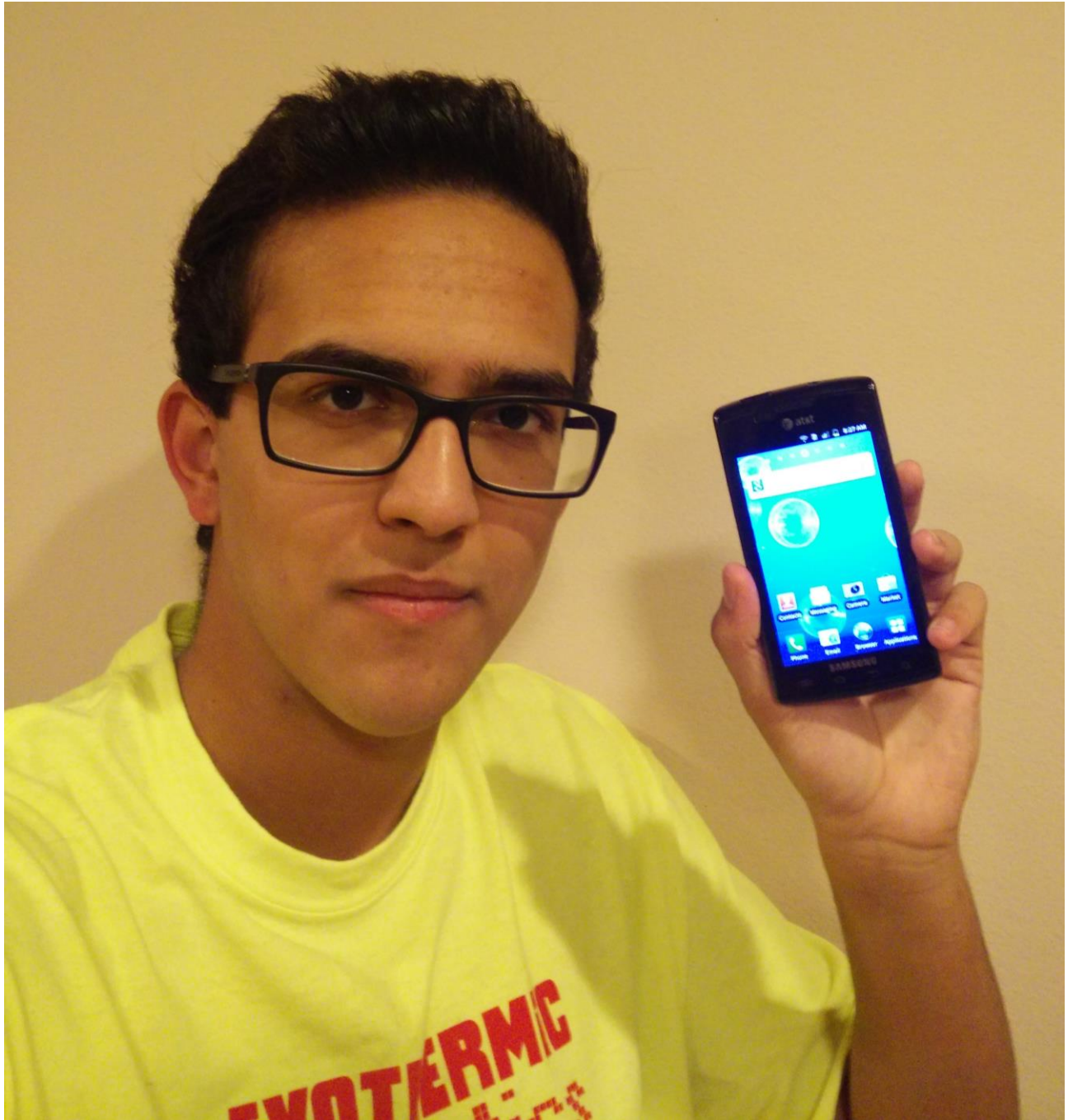
Annotated Works Cited

"16GB MoviNAND 52MHz 169-FBGA - KLMAG8DEHE-A101." *iiiC.cc.* iiiC Component, n.d.
Web. Dec. 2015.

      This chip component store helped us identify the Samsung KLMAG8DEHE-
A101 chip as 16GB flash memory. Since we knew what function the memory served
we required no more description than what this store listing required. Though it is not
a direct manufacturer source, it is a listing in a store so therefore it should be
trustable. In further assurance, the 16 GB spec matches that of GSM Arena's data.

"3-Axis Sensors." *Bosch Sensortec.* Robert Bosch GmbH, n.d. Web. Dec. 2015.

      We attempted to use this primary source to identify which of the BMA series
Bosch accelerometers is specifically in the Captivate instead of the one in the Galaxy
P1000 Tablet from the Electronic Products table. Unfortunately the product
descriptions on the site were not enough to be able to identify which specific product
is in the Captivate. However we were able to categorize the chip into the BMA series
since we saw all of the 3-axis accelerometers are in the same series.

"Audience Announces Next Generation Voice Processor for Mobile Phones." *Audience.*
Audience, a Knowles Company, 5 Jan. 2010. Web. Dec. 2015.

      This press release by Audience showcased the new (at the time) A1026 voice
processing chip. It gave a detailed but digestible report on the purpose of the chip as
well as its features and improvements upon the last generation. Highlighted was how
similarly the chip operates to the human ear. Since it's a first-hand report from the
manufacturer it is a reliable source of information, though possibly biased towards
the chips advantages due to it being a press release.

"Broadcom's New GPS Receiver Solution for Mobile Devices Sets Benchmarks for
Performance, Size and Integration." *Broadcom News Release.* Broadcom
Corporation; BRCM Mobile & Wireless, 2010. Web. Dec. 2015.

      This media post by Broadcom details the key features of the Broadcom
BCM4751 chip. This helped us recognize it as a GPS receiver and provided
information on what functions this chip contributes to mobile devices. Despite it
being first-hand since it's from the manufacturer, it might be biased because it is a
media post and Broadcom would want to advertise the chip's advantageous features.

"CC1175 High-Performance RF Transmitter for Narrowband Systems." *Texas Instruments*. Texas Instruments Incorporated, Aug. 2011. Web. Dec. 2015.

This product report helped us identify that the CC1175 is a radio frequency transmitter similar to the TriQuint TQM6M9014 GSM/WEDGE transmitter. Since it is directly from Texas Instruments, it is a reliable source.

Davis, Christopher, and Victor Vergara. "How Audio Codecs Work." *EETimes*. UBM Canon, 28 Oct. 2005. Web. Dec. 2015.

This detailed article explains how audio codecs work, as well as gives insight into some of the properties of digital sound and sound quality. This article was important in understanding the function of the Wolfson WM8994E audio codec. In addition the article outlines the importance of an audio codec and how the technology has evolved over time. The focus in the article is on the sound quality of codecs, but regardless it was useful for our understanding.

"DC/DC Switching Regulator." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This long product list of DC/DC voltage regulators helped us identify the component similar to the Ricoh RP103K Series voltage regulator found in the Captivate. Though the voltage regulators on the list may not be compatible with cellphones, they still accomplish the same task. This list is a credible source since it comes directly from the Texas Instruments website.

"Duplexers." *Microwaves101*. P-N Design, Inc and IEEE, n.d. Web. Dec. 2015.

This article by the Institute of Electronics and Electronics Engineers explains what a duplexer is. This helped us understand the duplexer task of the multi-functional TriQuint TQM600 series chips. It is a brief description but provides enough information to understand its importance in the overall cellular device. It also clarifies that duplexers are often confused with diplexers, which offset signal frequencies so filters can sort them out.

"FSA9480 - USB 2.0 Accessory Switch." *Mouser*. Fairchild Semiconductor Corporation, Aug. 2010. Web. Dec. 2015.

The Fairchild Semiconductor FSA9480 chip was identified as a USB port switch using the Electronic Products table. However, we weren't sure what a USB port switch does exactly, so we found this datasheet directly from the manufacturer that

describes in much detail the composition and function of the component. In addition, this document confirmed that the chip on the Captivate is indeed this one from Fairchild because of the listed marking.

"Fundamentals of Voltage Regulators." *Analog Devices*. Analog Devices, Inc, 2009. Web. Dec. 2015.

We used this brief article in understanding what a voltage regulator does and the role that the Ricoh RP103K series chip has in the overall device. We learned that voltage regulators maintain a constant voltage output regardless of load or input. This is important, for example, in preventing overloading of voltage when charging the phone, otherwise it would cause damage.

"Galaxy Tab Gt-P1000." *Electronic Products*. AspenCore, Inc, n.d. Web. Dec. 2015.

This source was extremely valuable to our project as the single largest source of identifying circuit board components and thus deserving of special recognition. Even though the Galaxy Tab P1000 is not the same as the device we chose, it was made by the same company at the same time. This similarity enabled us to identify chips through comparison of their properties with the ones in the Captivate. This table was valuable principally because of how extensive and detailed it is.

"GSM / GPRS / EDGE-Linear TRP Tx Module: PA / LPF / SP8T WEDGE Switch with Quad-Band WCDMA / LTE Ports." *TriQuint Qorvo*. TriQuint Semiconductor, n.d. Web. Dec. 2015.

Directly from TriQuint, this source briefly described the function of the TQM6M9014 chip. Since it was from the website of the chip's manufacturer we had the assurance that the description is accurate and credible.

"How Do Mobile Phones Work?" *Physics.org*. Institute of Physics, n.d. Web. Dec. 2015.

This post from the Institute of Physics site briefly describes the basics of how a cellphone works. This article was helpful because it was easy to understand but contained a good amount of information. The most important reason it was helpful is that it discusses more about the cellular network and transmission/reception aspects of telecommunication than other brief descriptions.

"How Does a Battery Fuel Gauge Work?" *Battery University*. Isidor Buchmann, 26 Nov. 2015. Web. Dec. 2015.

This article explains how battery fuel gauges measure the state of a device's charge. The explanation has plenty of detail for us to understand the chip's functions and inner workings. We learned that battery gauges readout the percentage of the current capacity of the battery. However, batteries lost capacity over time, so the actual runtime is not calculated, since the gauges can't take that into account, unless the battery capacity is reduced in a controlled fashion or a coulomb counter is used.

iLoki. "Captivate Teardown." *Xda-developers*. Xda-developers, 30 July 2010. Web. Dec. 2015.

Though this source was not (seemingly) created by a professional, since it is a forum post, it helped us by showing a guide on how to take the device apart. The included pictures and descriptions showcasing a step-by-step process were valuable to disassembling the Captivate without damaging any components. In addition, extra information about the chips found inside, such as the location of the Hummingbird CPU/RAM chipset, helped with identification and displayed ethos and assurance that this person knew what he/she was talking about.

Kirmayer, Andrew, and Shereen Skola. "What Is a Baseband Processor?"*WiseGeek*. Conjecture Corporation, 8 Jan. 2016. Web. Dec. 2015.

This article describes what a baseband processor is. This was helpful in identifying the function of the Infineon PMB9801 baseband processor. It turns out it is an important chip, since it controls radio functions such as signal generation, modulation, encoding, and transmission. The article also outlined benefits and disadvantages to using a baseband processor, as well as their capabilities.

Limonard, Charles. "PMICs Solve Complex Power-Management Issues Facing Multicore Processors."*Electronic Design*. Penton, 4 Dec. 2012. Web. Dec. 2015.

In the advancing age of technologies, manufacturers create and users expect more and more to be accomplished with their phones. This requires increasing peripherals and processor capabilities. In order to manage all that, the device needs a power management chip. This detailed article explained the role of a power management chip and how vital it is to a device, helping us determine the function of the Maxim MAX8998.

"LMH6882." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This product description for the LMH6882 radio frequency amplifier helped us identify it as a TI component similar to Infineon BGA735 and TriQuint amplifiers. Since this product page is directly from the Texas Instruments website, it is a credible source for this information.

Mehdi, Ammi. "Imagis." *Haptics Technical Committee*. Haptics Technical Committee, 23 Feb. 2014. Web. Dec. 2015.

This brief list helped us identify the Imagis ISA1000 haptic driver. There were quite a few chips by Imagis with the ISA or IST prefix, therefore with this product list we were able to identify the function of the chip in the Captivate specifically. This is not a first-hand source, however the Haptics Technical Committee is a division of the Institute of Electrical and Electronics Engineers, which is a large association.

"Overview for Smart RF Transceivers." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This product overview of the radio frequency transceivers that Texas Instrument manufactures currently helped in identifying the TI component similar to the Infineon PMB5703 quad-band RF transceiver. Since it is directly from Texas Instrument's website, this source is the most credible place for this information.

"PMB 5703 Product Brief." *DMCE*. Infineon Technologies AG, 2008. Web. Dec. 2015.

This source was used in conjunction with the Electronic Products source to identify the PMB5703 Infineon RF transceiver chip. This source gave a better description of what the chip does than the brief one in the Electronic Products table. In addition, this was the first chip from Infineon that we identified, so the picture of the chip showed a logo that we used to identify other Infineon chips later on.

Poole, Ian. "TCXO, Temperature Compensated Crystal Oscillator." *Radio-Electronics.com*. Adrio Communications Ltd, n.d. Web. Dec. 2015.

When we first identified that part 1B and 1O were TCXOs, we were incredibly curious to learn about what that is. This source is the most detailed yet understandable explanation of what a temperature compensated crystal oscillator is, and thus proved valuable in educating us on the function of the Kyocera chips.

"Products for Audio CODEC." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This long list of TI audio codec products helped identify the model lines most similar to the Wolfson WM8994E audio codec found on the Captivate. Since this source is directly from Texas Instruments, it is very reliable.

"Products for Comparator." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This page of nearly countless TI comparators helped us identify the product line that was most similar to the Toshiba TC75W56FK dual comparators. This source is credible for this information because it is directly from the Texas Instruments products section of their website.

"Products for Haptic Driver." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This list of TI haptic driver products helped us pinpoint which product line is most similar to the Imagis ISA1000 haptic driver found in the Captivate. Since this source is directly from Texas Instruments, it is a reliable source.

"Products for Operational Amplifier (Op Amp)." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This list of TI amplifiers helped us identify which ones are similar to the Infineon BGA735 low noise amplifier and the TriQuint amplifiers. Since this list is directly from Texas Instruments, it is a credible source for this information.

"Products for Touch Screen Controller." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This list of touch screen controller products made by TI helped us identify which one is similar to the Atmel MXT224 touchscreen controller. We noticed that this list is significantly shorter than the lists for other components, leading us to believe that TI is less focused on making a wide variety of touchscreen controllers. Since this list is directly from the TI website, it is a credible source.

Rajagopalan, Laxman. "Mobile Power Amplifiers – What About Them?" *Pixel Ballads*. WordPress, 10 Feb. 2011. Web. Dec. 2015.

This article was written by Rajagopalan, who has a Master's degree in electrical engineering from MSU, and is knowledgeable in the field of cellular technology. This article written by him outlines what mobile amplifiers are, the market opportunities in that area, and companies involved in their development and distribution. This article

helped us understand what mobile amplifiers do as well as how widespread TriQuint's (the company that made the amplifiers in the Captivate) involvement and market presence is.

"RF Transceiver Basics." *RF Wireless World*. RF Wireless World, 2012. Web. Dec. 2015.

After identifying the Infineon PMB5703 chip as an RF transceiver, we were interested in learning what an RF transceiver does. The definition written in the article provides an easy to understand explanation of what transceivers do. The extensiveness of topics the website covers solely relating to RF and wireless, including articles, tutorials, vendors, terminology, and more pins this website as a trustable source.

"RP103x Series Low Noise 150mA LDO Regulator." *Ricoh*. Ricoh Electronic Devices Co., Ltd, n.d. Web. Dec. 2015.

This webpage about the Ricoh RP103K chip on the Captivate gives an organized and easy to understand description of the IC and its features and functions in a cellphone as well as its advantages. Since it is directly from the manufacturer it is a reliable site.

"Samsung Captivate Repair." *iFixit*. iFixit, n.d. Web. Dec. 2015.

This source was a teardown of the Captivate done by the widely used iFixit website. iFixit's extensive list of manuals and the large number of solutions given indicated that it was widely used, and thus gave credibility. Information about how to disassemble the phone to remove or reveal 8 different components provided enough detail to help us take apart the device and identify some of the components.

"Samsung eMMC moviNAND Product Family." *Datasheet Directory*. Samsung Electronics, Jan. 2010. Web. Dec. 2015.

This datasheet provided much more detailed information about the Samsung KLMAG8DEHE-A101 NAND flash memory. The document mostly contained specifications and technical information about the four NAND flash memory chips of various capacities that Samsung manufactured at the time. It was mostly used as a primary source identification of one of the most important chips in the phone.

"Samsung I897 Captivate." *GSM Arena*. GSMArena.com, n.d. Web. Dec. 2015.

The full phone specifications of the Samsung Galaxy S Captivate provided by this source gave general information about the device. The information was used

after the disassembly to give us an idea of what kind of device information is presented to the end users in the specifications in relation to all the components we discovered in the disassembly. We learned that there are a lot of internal components whose tasks are hidden, since usually only the CPU, RAM, external sensors, and other components that a typical consumer is concerned with are advertised.

Siegel, Eric. "Haptics Technology: Picking up Good Vibrations." *EETimes*. UBM Canon, 24 July 2011. Web. Dec. 2015.

Though our whole team knew what haptic feedback was and the general idea of how it worked, we weren't sure of the specifics of what a haptic driver does. This detailed article explains how haptic feedback devices work, as well as the different types of haptic actuators, as well as the role of the haptic driver in the system. This source is trustable because Eric Siegel is a product marketing engineer for touch screen controllers and haptic drivers at Texas Instruments. In addition, he has an M.S. in electrical engineering from the University of Florida.

Spevak, Peter, and Peter Forstner. "MSP430 32-kHz Crystal Oscillators."*Texas Instruments*. Texas Instruments Incorporated, Aug. 2006. Web. Dec. 2015.

This source was used to identify the TI component that is similar to the Kyocera KT Series TCXOs found in the Captivate. This report on the MSP430 crystal oscillators comes directly from Texas Instruments, so it is the most trustable source for this information.

"SWB-B23 Datasheet." *Google Code*. Samsung Electro-Mechanics, 8 Feb. 2010. Web. Dec. 2015.

This datasheet is an extremely detailed report on the description, specifications, and other information about the Samsung SWB-B23 WLAN and Bluetooth module. This source helped us identify the SWB-B23 chip line as a WLAN and Bluetooth module.

"TCI6487." *Texas Instruments*. Texas Instruments Incorporated, 2006. Web. Dec. 2015.

This dedicated product site for the TCI6487 baseband processor helped us identify the TI component similar in function to the Infineon PMB9801 GSM/WCDMA baseband processor. This source is trustable because it is directly from the Texas Instruments website, though it is a separate landing page.

"Temperature Compensated Crystal Oscillators (TCXO)." *Kyocera*. Kyocera Crystal Device
Corporation, n.d. Web. Dec. 2015.

This table of Kyocera's TCXO products helped us to identify the product line
found in the Samsung Captivate. After using the Electronic Products table to identify
that these chips were Kyocera's TCXOs, we attempted to use this list to narrow down
the specific chip used in the Captivate. However, the product images were too low
resolution and all the chips were too similar to be able to match one of them with the
one on the Captivate. However, we were able to see that all of the chips belonged to
the KT series of chips, so we were able to identify at least that much.

"TOSHIBA CMOS Linear Integrated Circuit Silicon Monolithic: TC75W56FU,
TC75W56FK." *Toshiba*. Toshiba Corporation, 1 Mar. 2014. Web. Dec. 2015.

This publication by Toshiba aided us in identifying which dual comparator the
chip on the Captivate was, since there were two models that were similar in function
but slightly different in design. The diagrams of the parts helped in that process. In
addition, there was a list of features that helped with determining function. Since the
document was created by the chip manufacturer, it is credible.

"Transmit Filters." *Lorch Microwave - Wireless Filters*. Lorch Microwave, 2011. Web. Dec.
2015.

This very brief description of a transmit filter is to the point and what we
needed to understand the basic function of this component. Lorch Microwave is a
manufacturer of transmit filters, so they are knowledgeable and the information they
provide is credible.

"TRITIUM™ WCDMA / HSUPA PA-Duplexer Module; SE Input with Coupler,
Detector." *TriQuint Qorvo*. TriQuint Semiconductor, n.d. Web. Dec. 2015.

Directly from TriQuint, this source briefly described the function of the
TQM616025 chip. Since it was from the website of the chip's manufacturer we had
the assurance that the description is accurate and credible.

"TRITIUM™ WCDMA / HSUPA PA-Duplexer Module; SE Input with Coupler,
Detector." *TriQuint Qorvo*. TriQuint Semiconductor, n.d. Web. Dec. 2015.

Directly from TriQuint, this source briefly described the function of the
TQM666022 chip. Since it was from the website of the chip's manufacturer we had
the assurance that the description is accurate and credible.

"TRITIUM™ WCDMA / HSUPA PA-Duplexer Module; SE Input with Coupler, Detector." *TriQuint Qorvo*. TriQuint Semiconductor, n.d. Web. Dec. 2015.

Directly from TriQuint, this source briefly described the function of the TQM676021 chip. Since it was from the website of the chip's manufacturer we had the assurance that the description is accurate and credible.

"Tutorial: Electronic Circuits-Op-amps/Comparator Circuit." *Renesas*. Renesas Electronics Corporation, n.d. Web. Dec. 2015.

This educational tutorial helped us understand the function of the Toshiba comparator found on our device. We learned that a comparator, well, compares two voltages and outputs a signal to indicate which voltage is higher. This device is usually applied to check if an input has reached a predetermined value or not, which would be important to know in a cellphone.

"What Is a Touch Screen Controller / IC?" *Future Electronics*. Future Electronics, n.d. Web. Dec. 2015.

This quite brief description outlines what a touch screen controller is, as well as the types of controllers and their applications. This helped us understand the function of the Atmel MXT224 in the Captivate. This source is trustable because Future Electronics is a distributor of electronic components, therefore it is knowledgeable about what they are selling.

"What Is SAW Filters." *Token*. Token, 2010. Web. Dec. 2015.

When we identified the Epcos D1064 chip as a SAW filter, we were intent on knowing what the acronym meant and the function of the chip. This detailed explanation was more than enough to teach us about what a surface acoustic wave filter is and the applications of SA waves in a phone.

"What's New for Power Management." *Texas Instruments*. Texas Instruments Incorporated, n.d. Web. Dec. 2015.

This list of power management ICs shows all of the product lines of this type that Texas Instruments manufactures. This was useful in determining the TI chip closest to the Maxim MAX8998 in function. Since this page is part of the Texas Instruments website, it is a credible source.