TEXAS INSTRUMENTS

2018 Texas Instruments
Electronics Online Challenge

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Introduction:

We chose to deconstruct an Apple iPhone 5s for our Vex Texas Instruments Online Challenge submission. We selected this device because of its advanced technology and the improvements it made in the mobile phone industry when it was announced in 2013. It was one of the first mainstream mobile devices to include biometric security (Touch ID). It also included a revolutionary new motion coprocessor for more efficient processing and power usage. Along with iPhone 5s Apple released iOS 7, a complete revamp of the popular mobile operating system.

Parts Overview:

- Logic Board
  - Processor
  - Co-processor
  - Flash Storage
  - Wi-Fi Module
  - Power management IC
  - Touchscreen controller and Interface
  - Accelerometer and Gyro
  - LTE Modem
  - Mobile Transceiver
  - SIM Card
- Touch ID and Home button
- Cameras
- Speakers
- Microphones
- Haptic Motor
- Power port
- Audio Mini-jack
- Ambient light sensor
- Proximity sensor
- Antenna
- Battery


iPhone


ESD-15

Parts in Depth:

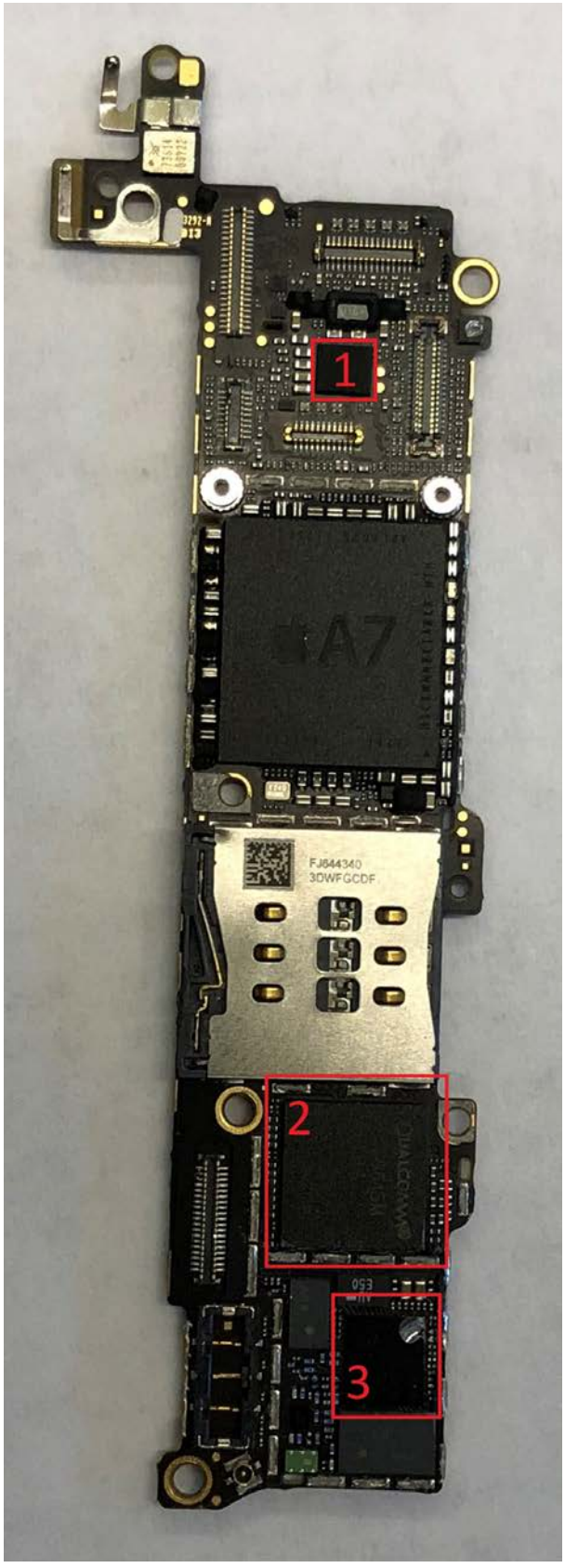

Image 1

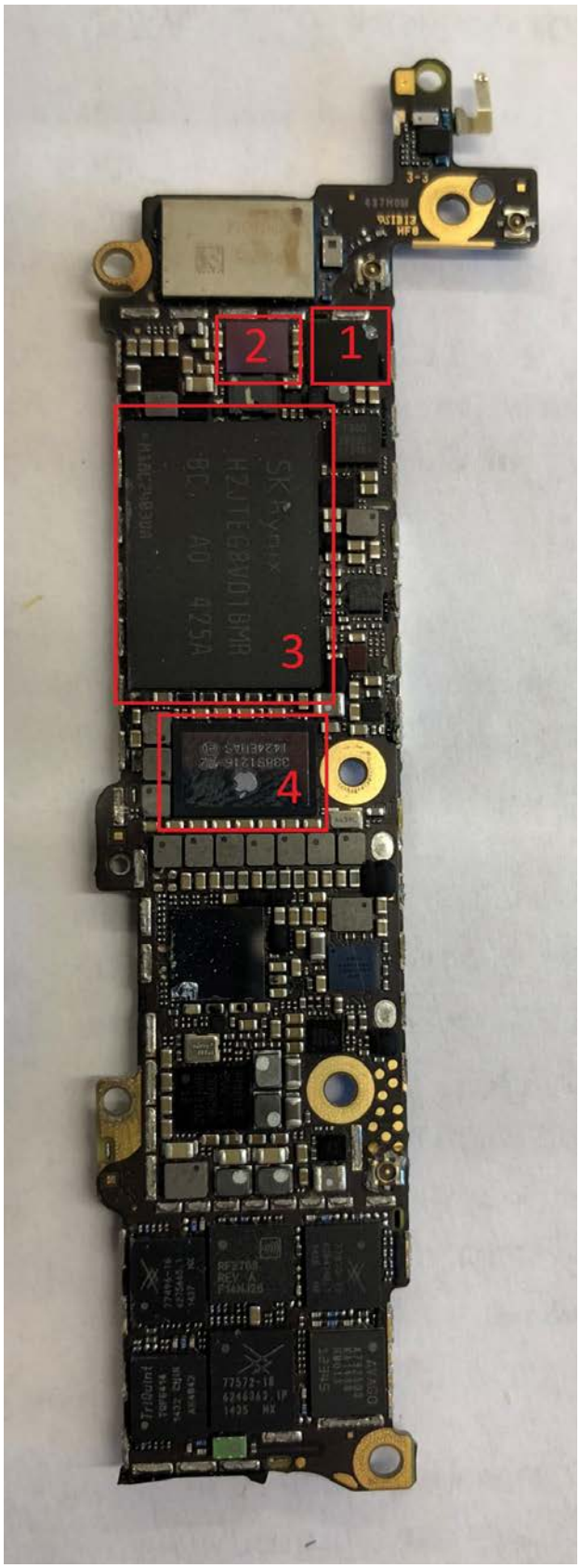

Image 2

Logic Board (Images 1, 2, and 11-4)

The logic board houses all major computing components for the iPhone, as well as ribbon cable connectors for the battery and other components.

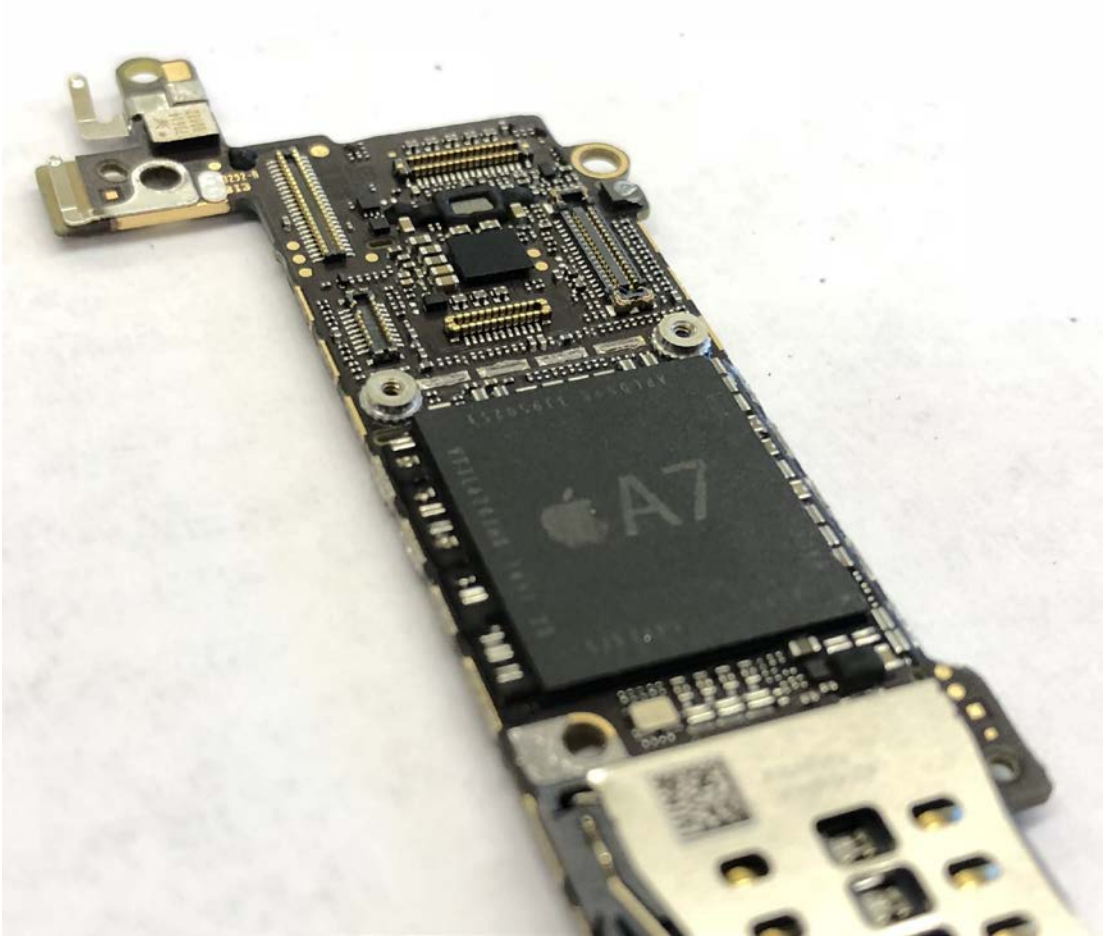

Image 3

Logic Board: Apple A7 SOC (Image 3)

The A7 (APL0698) is a system on a chip. It includes the 64-bit ARMv8 Cyclone processor, 1GB LPDDR3 DRAM, PowerVR G6430 GPU, and “Secure Enclave” for storing and protecting biometric data from Touch ID. The Cyclone processor is responsible for the majority of computing done on iPhone 5s. The DRAM (dynamic random access memory) holds the present and most recent tasks for quick access by the processor. The PowerVR GPU (graphics processing unit) is responsible for graphics and image rendering.

Similar to: TI OMAP

Logic Board: M7 Processor (Image 1-1)

The M7 (LPC18A1) is a motion co-processor used to collect data from sensors such as the gyroscope, compass, and accelerometer. The M7 relieves tasks from the main A7

processor, improving battery life and allowing for background tasks to be run without powering up the main A7 processor.

Logic Board: NAND Flash storage (Image 2-3)

The NAND flash (SK hynix H2JTEG8VD1BMR) stores all information including OS, apps, and documents. The chip is comprised of NAND and NOR logic gates. Since it does not include a spinning disk like a traditional hard disk drive, it is perfect for mobile solutions such as a smartphone due to its size, durability, and low power consumption. NAND flash is also significantly faster than disk storage because it can read and write data across several chips at once, rather than reading a single point on a spinning disk.

Similar to: TI SM28VLT32-HT Flash Memory

Logic Board: Wi-Fi module

The Wi-Fi module (Murata 339S0205) enables the iPhone to connect to wireless networks for internet access. It can connect to 802.11n 2.4GHz and 5GHz networks, enabling speeds up to 150MPs.

Similar to: TI WiLink and SimpleLink

Logic Board: Power management IC (Image 2-4)

The power management IC (Apple 338s1216-A2) manages power from the battery or charger and distributes it to various system components.

Similar to: TI TPS65913 PMIC

Logic Board: Touchscreen controller (Image 2-2) **and interface** (Image 2-1)

The touch controller receives data from the capacitive touch panel and converts it into data for the processor and OS to use.

Controller: Broadcom BCM5976

Interface: Texas Instruments 343S0645

Logic Board: Three-axis gyro and Accelerometer

The gyro and accelerometer measure orientation and movement. These sensors allow your phone to know how you are holding it and are frequently used in games and navigation.

Similar to: TI SensorTAG

Logic Board: LTE modem (Image 1-2)

The LTE modem (Qualcomm MDM9615M) receives voice and data transfer over mobile LTE networks such as Verizon and AT&T.

Logic Board: Mobile Transceiver (Image 1-3)

The transceiver (WTR1605L) aids the modem in supporting additional network bands. It also acts as a GPS receiver.

Logic Board: SIM Card (Image 11-5)

The Subscriber Identity Module (SIM) card allows the phone to communicate with your specific mobile carrier's network. It can also store your phone number and contacts for use in another phone.

Image 4 (Front)

Image 5 (Back)

Touch ID and Home button (Images 4 and 5)

The iPhone 5s home button is equipped with Touch ID, a form of biometric security that reads the user's fingerprint. Touch ID is composed of capacitive touch sensors that create an image of your finger to be stored locally on the phone.

Similar to: TI C5515 Fingerprint Kit

Image 6

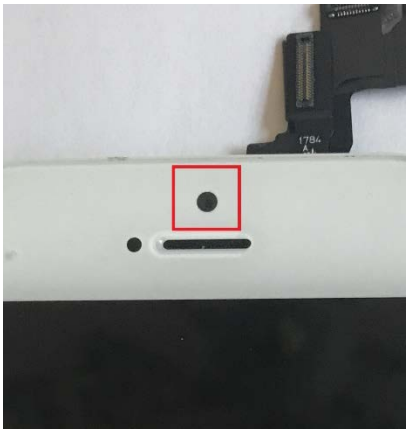

Image 7

Primary camera (Image 6 and 11-2)

The digital iSight camera (DNL333 41WGRF 4W61W) takes high resolution photos and videos from the back of the phone. Specifically, the camera has an 8 MP, $f/2.2$ aperture sensor with a 5 element lens and hybrid IR filter. It is capable of recording 1080p video at 30 fps.

Secondary camera (Image 7)

The digital FaceTime camera (821-1613) takes 1.2 MP photos at $f/2.4$ aperture. It is capable of recording video at 720p video.

Dual flash

The dual LED True Tone Flash is primarily used to enhance low-light photographs, but can also be used as a handy flashlight. The unit is comprised of a white LED and an amber LED, allowing for more natural lighting in photographs.

Image 8

Image 9

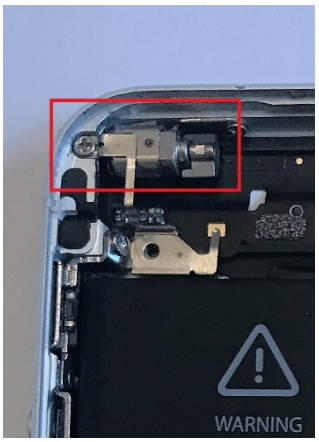

Image 10


1
2
3
4
WARNING
Authorized Service Provider Only
Potential for fire or burning. Do not disassemble, puncture, crush, heat, or burn.
Li-ion Polymer Battery
3.8V ⎓ 5.92Whr
APN: 616-0722
VPN: DAK220156-W0G0H02HT
TIS 2217-2548
Apple South Asia (Thailand) Limited
1560mAh
Apple Japan
Li-ion
DX3NMH
WDFFFK
5
4
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Image 11

Earpiece (Image 8)

The earpiece is a small speaker used for making phone calls.

Speaker (Image 9 and 11-6)

The main speaker is used to play back audio, including movies, music, games, phone rings, etc. It emits sound by vibrating a drum via electromagnetic signals.

Microphones (Image 11-8)

There are two microphones in iPhone 5s. One is located at the bottom of the phone and is used to capture voice during phone calls or when recording voice memos. Another microphone is located next to the rear camera and is used to capture audio during video recording.

Haptic Feedback Motor (Image 10 and 11-1)

The haptic feedback motor is a simple electric motor attached to the chassis that spins a half cylinder, causing the phone to vibrate when silent mode is activated.

Lightning port (Image 11-7)

The 8-pin Lightning port is used to power the phone and battery as well as transferring data and audio to external sources such as a speaker dock or computer. The unique pin configuration allows the cable to be inserted in either orientation.

Audio mini-jack (Image 11-9)

The 3.5-mm stereo headphone mini-jack is most frequently used to connect to external audio devices such as speakers, headphones, and car stereo systems. It is also capable of receiving audio input from microphones and digital musical instruments.

Ambient light sensor

The ambient light sensor is a photoresistor that informs the phone of surrounding light conditions. It is used to automatically adjust the brightness of the display for a balance between battery life and visibility. A photoresistor is less resistive (more conductive) when exposed to light.

Proximity sensor

The proximity sensor detects nearby objects, such as your face, to turn off the display and touch input when you are making a phone call. The sensor emits an IR signal. If there is an object nearby it bounces off onto a photoresistor.

Antenna

The antennas aid the wireless modems and transceivers in sending and receiving wireless communications. The iPhone 5s antennas are housed along the sides and back of the chassis.

Image 12

Battery (Image 11-3)

The rechargeable 1560 mAH Lithium Ion Battery powers the entire system including the display, processors, and cameras.

Similar to: TI Rechargeable Battery 3.7L1200SPA

LCD Display (Images 12 and 13)

The 4 inch IPS Retina display is used to display graphics such as applications, SMS, and games. The resolution is 1136 x 640 (326 ppi) and the display is capable of 500 cd/m2 brightness.

Touch Panel (Image 12)

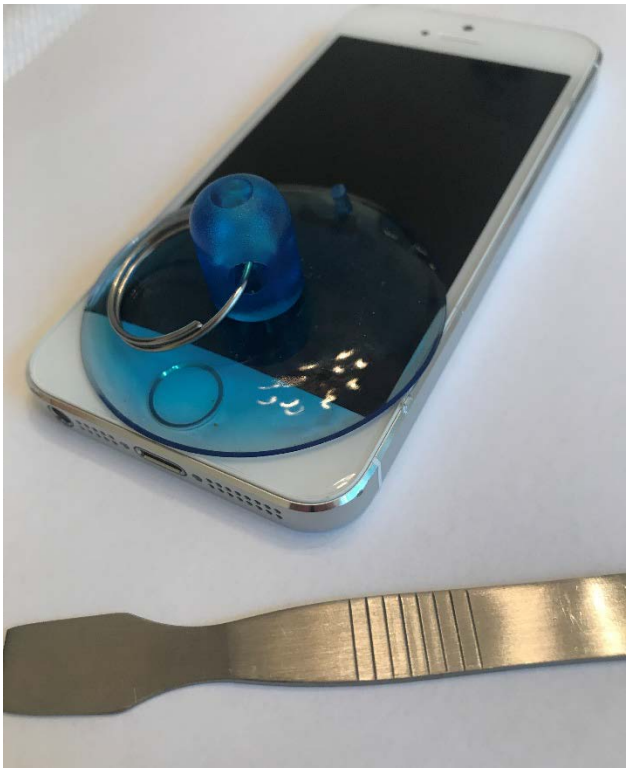
The capacitive touch panel allows the user to interact with the phone with their fingers. Uses include typing, system navigation, and note taking.

Image 13

Teardown Instructions:

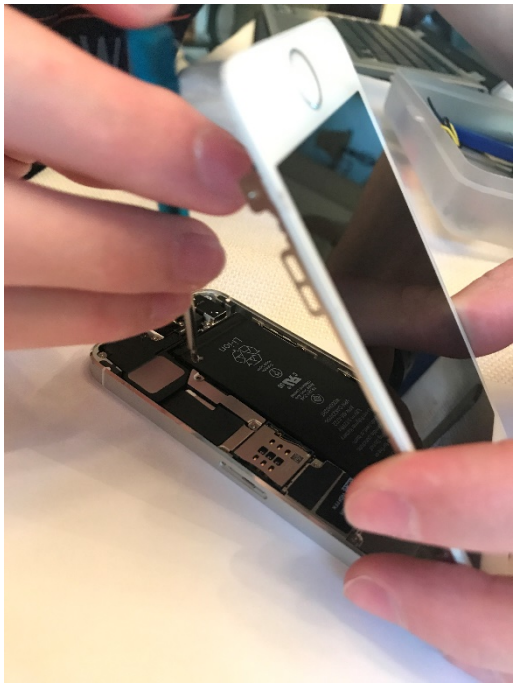
General Deconstruction

1. Power off device
2. Remove sim card
3. Remove bottom pentalobe screws
4. Remove front display with suction cup



5. Remove Touch ID ribbon cable

6. Remove all screws



6. Remove metal plate over display connections

7. Remove 3 display ribbon cables

8. Completely remove front panel

11. Remove antenna cable

12. Remove tape covering the camera flash

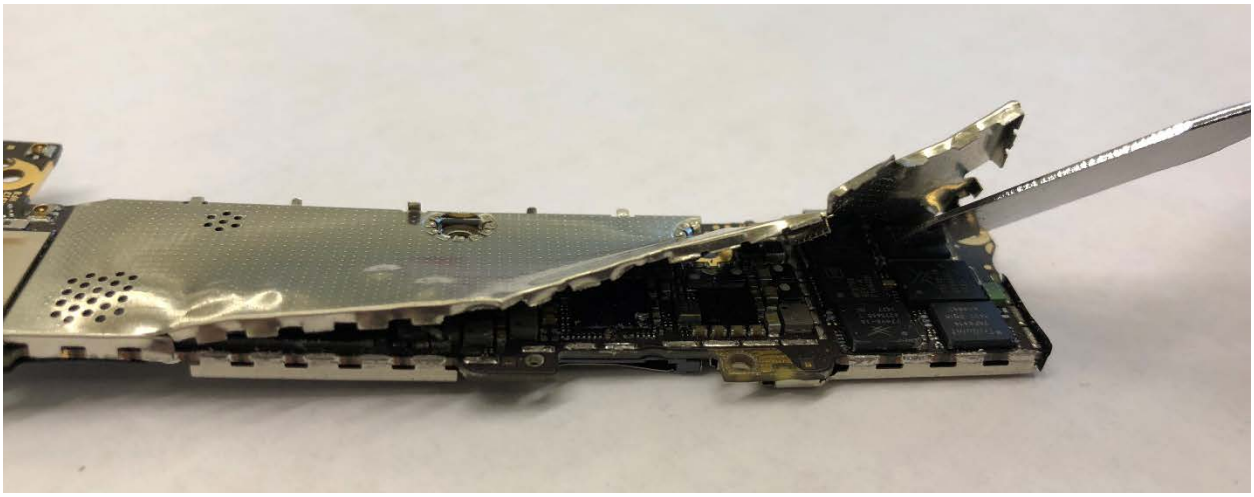
13. Remove screw under tape

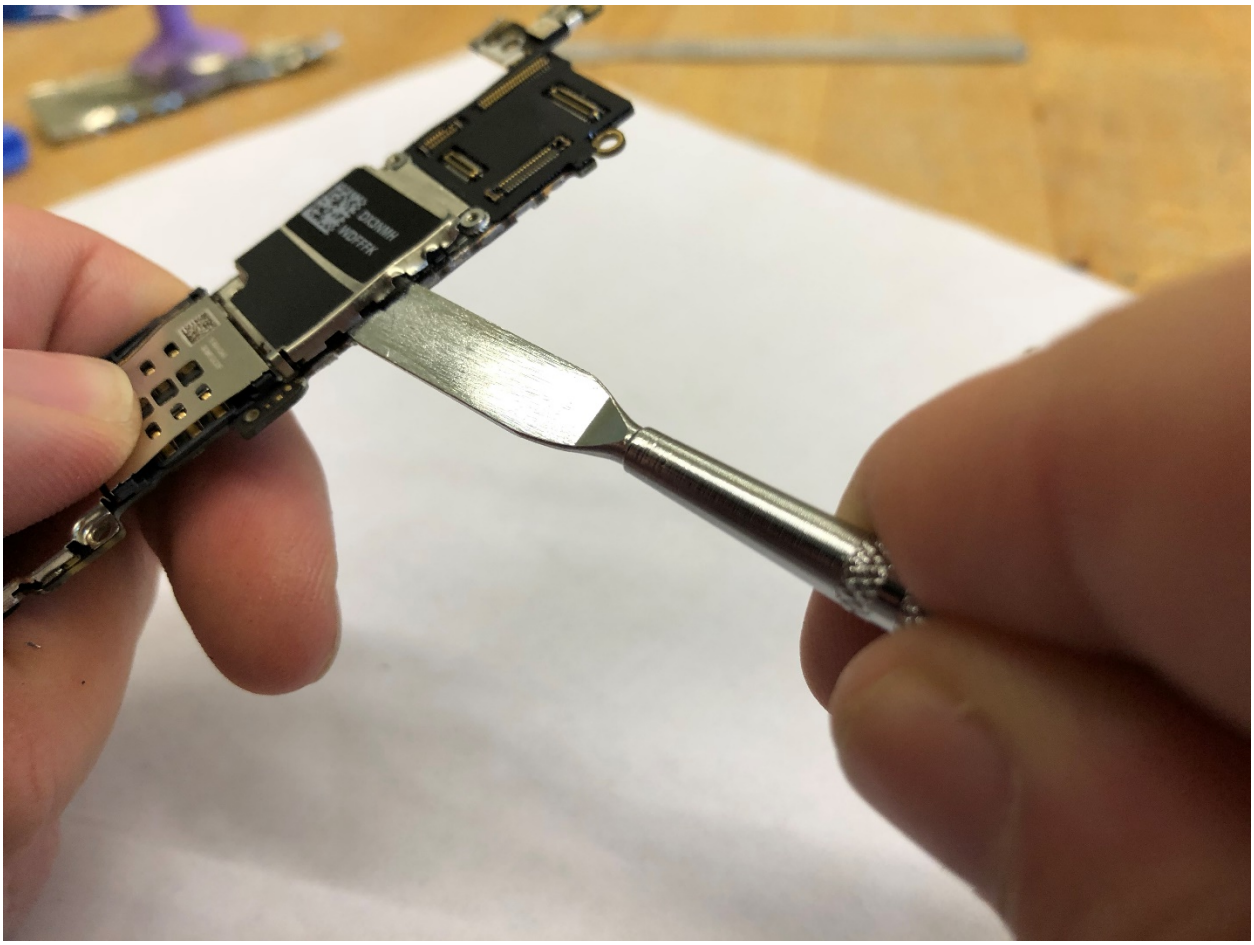
14. Remove speaker

15. Remove logic board from the housing

16. Remove camera

17. Pry protective metal casing from chips on logic board

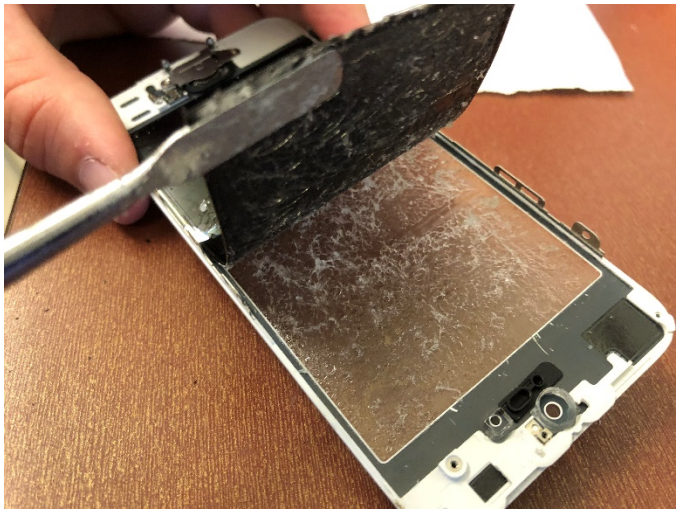




Additional Deconstruction for Front Panel

1. Remove screws and clips from home button assembly
2. Remove home button assembly
3. Remove screws and clips from sensors, earpiece, and camera
4. Remove sensors, earpiece, and camera
5. Remove metal plate from rear

6. Heat glass with blow dryer and carefully pry LCD front glass panel



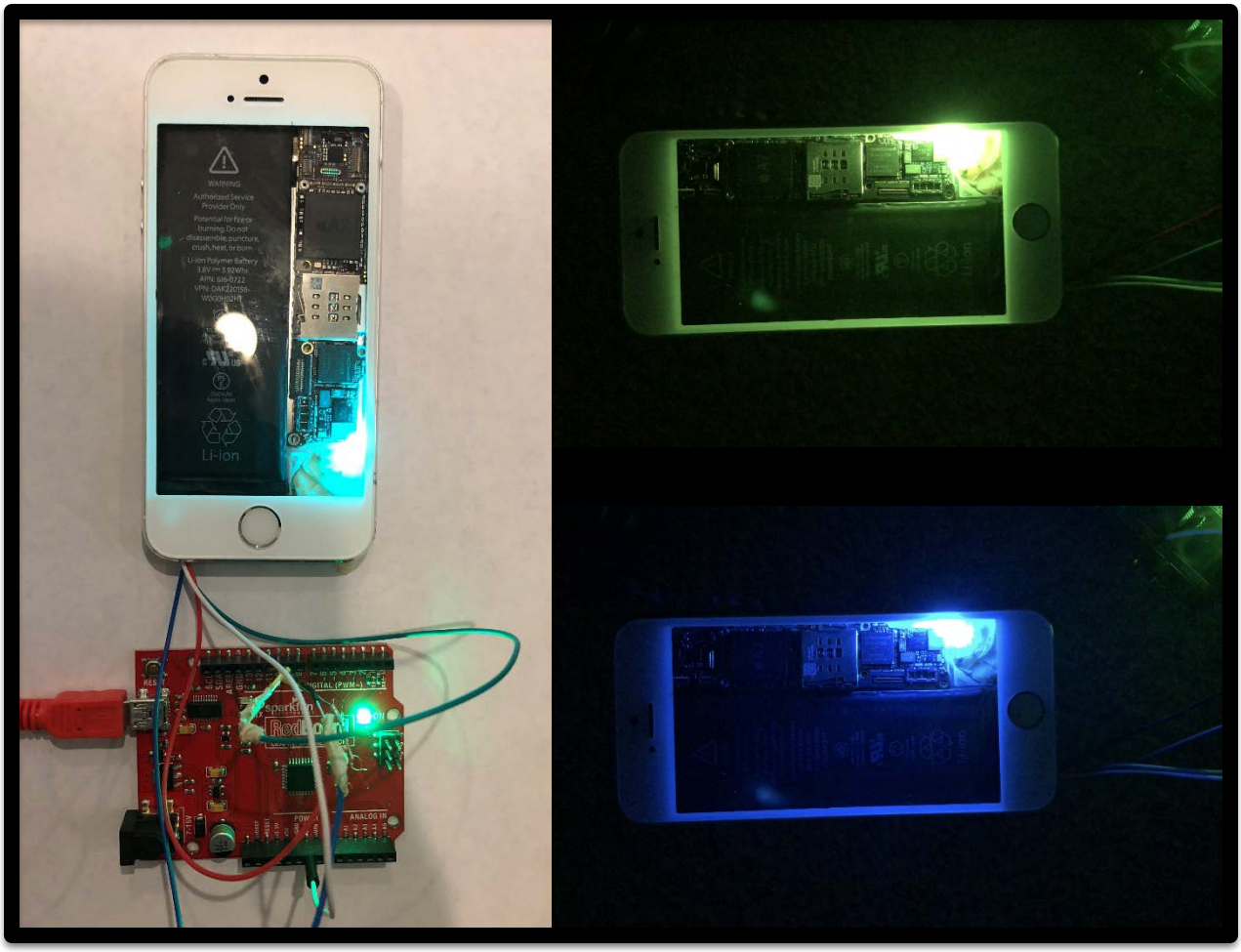
7. Use Goo-B-Gone to remove adhesive from glass.

Conclusion:

In the process of completing the TI Deconstruction Challenge, we learned a great deal. One thing we learned is that there are many companies involved in the design and production of a single electronic device: there were several companies representing within the phone including Apple, Qualcomm, Texas Instruments, Broadcom, and SK Hynix. We also discovered a fantastic, innovative type of screw. Within the iPhone, there were tiny screws that can screw into the head of other screws, saving space for layered components. Another thing we learned is that the LCD is glued to the glass touch panel and difficult to separate. We enjoyed completing the project and look forward to a future career in electronics and computer science.

Aftermath:

After deconstructing and reconstructing the iPhone several times, we decided to make use of the phone in a creative manner. We separated the LCD panel from the glass to create a window into the phone. We then removed the headphone jack, lightning port, and main speaker to allow space for an RGB LED. We then fed cables out of the headphone jack towards an Arduino microcontroller, which we programmed to slowly fade from color to color. The final product is a memorial to the iPhone 5s, showing off the beautiful internals in colorful light.



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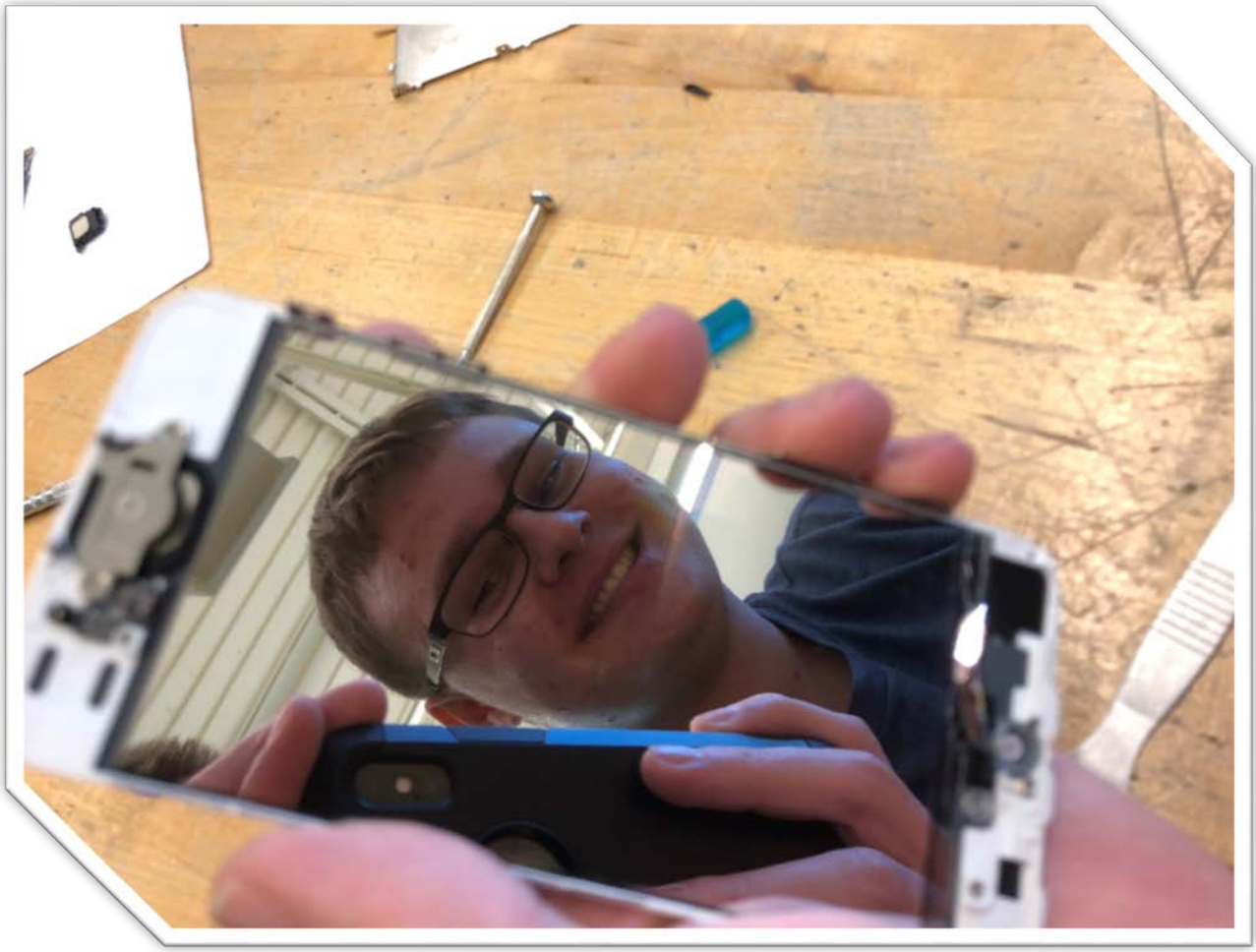

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