Hoober Wiring Guide

Version: August 18, 2022

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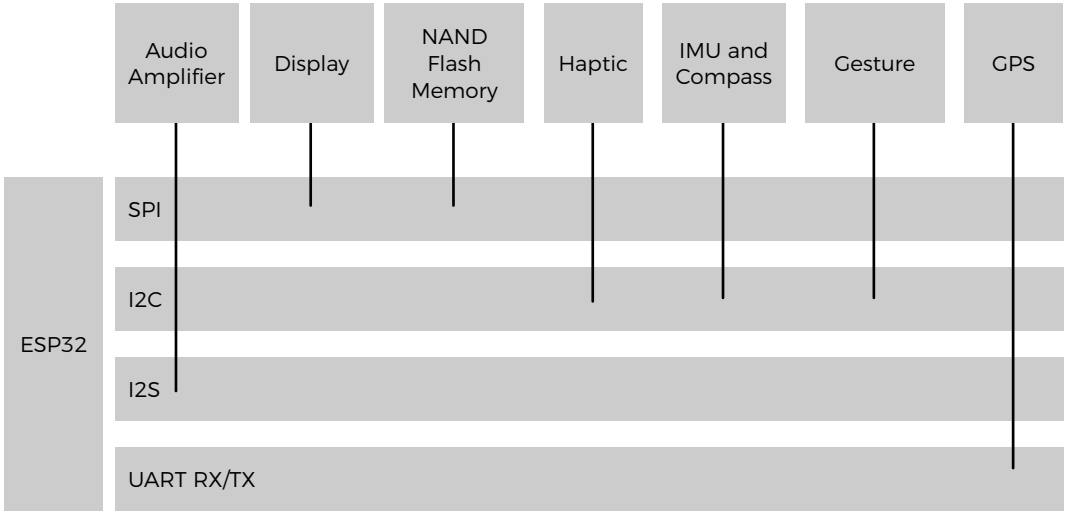
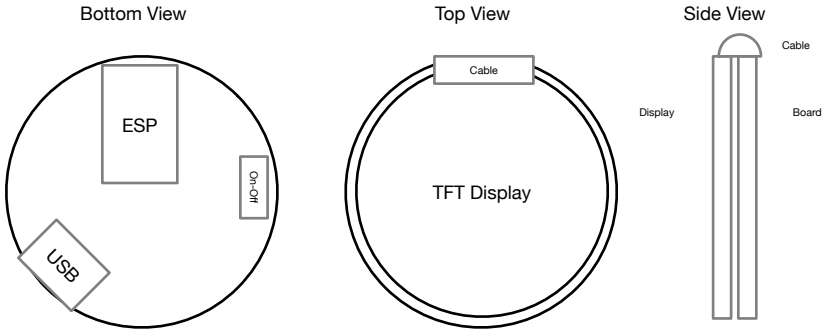
This document shows technical details of the Seuss display prototype. Our design goals:

1) Inexpensive off-the-shelf components
2) Provide an integration to run animated and musical shows
3) Publish the design under an open-source license so all Makers may benefit from it

Hoober has: ESP32, 1.28 Inch Round LCD display, gesture sensor, IMU, audio amp, haptic motor driver, SPI Flash memory (NAND, https://www.adafruit.com/product/4899), and GPS

Software for Hoober is at https://github.com/frankcohen/ReflectionsOS/tree/main/Devices/Hoober/Software





GPS antenna, pads for battery, gesture, etc, need to be on the back side (non display side)
On-off is side mounted, for a pin-hole through the outer case. Press to turn-on, press and hold to turn-off.

Hoober is a general purpose ESP-32 main board to power storytelling experiences. I named the board versions from Dr. Seuss' writing because Theodor Seuss Geisel was turned down 28 times before being published. I've tried many times to build the display for the Reflections project.

None of this is complicated. However, putting it all together was difficult and time consuming. For example, all but one GPIO pin is used in this design.

The design uses mostly breakout boards from Adafruit. They provide needed pull-up resisters and level-shifters. The finished board is entirely 3.3 volts and delivered in a 34 mm diameter round board.

Hoober 2022

Reflections Project
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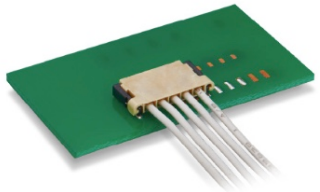
Previous board (codename Sox) used solder pads. Hoober removes the solder pads.

Hoober uses a Hirose DF65 Series connector:

Speaker (2 wires)
Haptic motor (2 wires)
Battery wire (2 wires)



https://www.hirose.com/product/series/DF65

ESP32-S3-Mini and Feather

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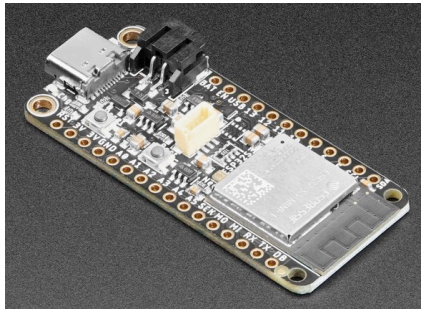

https://www.adafruit.com/product/5323

Adafruit ESP32-S3 Feather No PSRAM derived Arduino IDE board definition.
https://www.adafruit.com/product/5323
Schematic at
https://learn.adafruit.com/assets/110822
other files at:
https://learn.adafruit.com/adafruit-esp32-s2-feather/downloads

Based on Adafruit ESP32-S3 Feather development board.

ESP32-S3 features 2.4GHz Dual-Mode WiFi + Bluetooth Dual Cores Microcontroller The ESP32 integrated with Antenna switches, RF Balun, power amplifiers, low-noise amplifiers, filters, and management modules, and the entire solution occupies the least area of PCB. 2.4 GHz Wi-Fi plus Bluetooth dual-mode chip, with TSMC Ultra-low power consumption 40nm technology, power dissipation performance and RF performance is the best, safe and reliable, easy to extend to a variety of applications.

Espressif - based in Shanghai, China - makes ESP32. It's an open-source design.

Software drivers and utilities for ESP32 are at:
https://github.com/espressif/arduino-esp32

Tutorial on installing ESP32 boards on Arduino IDE:
https://docs.espressif.com/projects/arduino-esp32/en/latest/installing.html

https://github.com/nodemcu/nodemcu-firmware/tree/dev-esp32

Notes on using ESP32 with Arduino IDE:
Use ESP32 Dev Board for Board selection
To reference GPIO pins in code use just the number, for example "digitalWrite(13, HIGH)" sets GPIO13 high.
~/Library/Python/2.7/bin. I needed to patch esptool.py following https://github.com/espressif/arduino-esp32/issues/4408 and changing the +x perms too
https://randomnerdtutorials.com/solved-failed-to-connect-to-esp32-timed-out-waiting-for-packet-header/
https://github.com/me-no-dev/EspExceptionDecoder to decode stack traces

ESP32 provides the easy-of-use of the Arduino environment (forums, experts, IDE), a 32-bit 2 core, and Bluetooth and Wifi networking.

ESP32 development boards provide a breadboard-friendly package with a USB programming interface and power supply.

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TX	GPS	GPS TX		
VSPI	Display	Display CS	DC	RST
VSPI	SD memory	SD memory CS		
I2S	Audio	LRCL	DIN	BCLK
I2C	Compass	SDA	SCL	
I2C	Haptic motor			
I2C	Proximity sensor			
HSPI unused				

Breakout Boards

GPS https://www.adafruit.com/product/3133
Compass https://www.adafruit.com/product/2472
Display with SD Card https://www.adafruit.com/product/3787
Audio https://www.adafruit.com/product/3006
Haptic motor https://learn.adafruit.com/adafruit-drv2605-haptic-controller-breakout
Proximity sensor https://www.adafruit.com/product/466, APDS9960

This is the wiring guide. Use it as a top-of-board legend for all the components.

The most difficult part of this project was to keep track of the multiple uses of each pin. For example, GPIO 35 is input only. GPIO 2 looks normal but has an LED off of it.

In the end all of the available GPIOs are used. GPIO 14, 12, 13, 15, 4 are used by the internal Wifi system. 9, 10, 11, 6, 7, 8 are used by the ESP32's Flash memory system (different than the SD card in this project). and 1, 3 are used by the USB adaptor.

I found conflicting tutorials, how-to guides, and references to data sheets (that turned out to be for different ESP32 development boards). One tutorial had a typo and kept referring to GPIO 20, which does not exist on the HiLetGo development board.

I also found I could not depend on translating tutorials and wiring guides for Arduino Uno and Arduino Mega to the ESP32 development boards.

Seuss uses the SD Card reader built into the Adafruit display breakout board - Display SDCS GPIO 4. I tried 2 SD Card reader boards and 2 SD cards. I could not get them to work. I have also read GPIO 4 is not available when using Wifi.

Many tutorials will reference pin numbers. While that works on Arduino Uno, the GPIO numbers are referenced here.

ESP-prog JtAG Debugger

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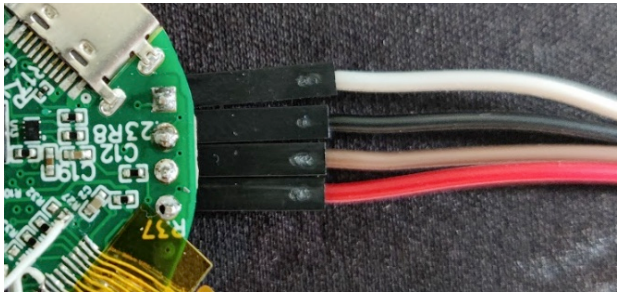
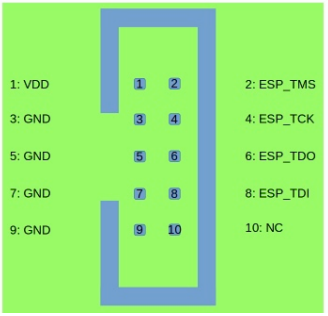
https://medium.com/@manuel.bl/low-cost-esp32-in-circuit-debugging-dbbee39e508b



Hoober JTAG debugger connections:
J1 1 TMS - 2
J1 2 TDI - 8
J1 3 TDO - 6
J1 4 TCK - 4

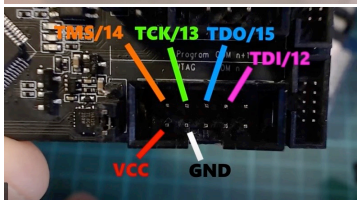
Platformio.ini:
debug_tool = esp-prog
debug_init_break = tbreak setup

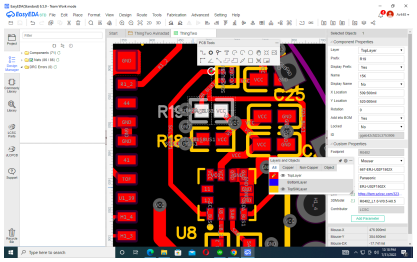


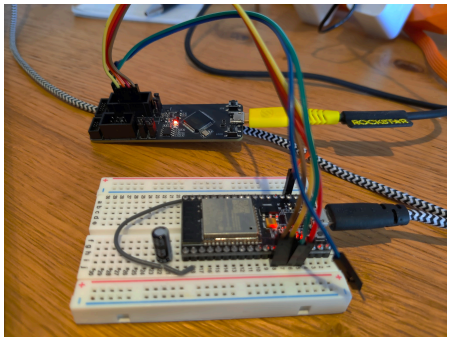
Hoober is compatible with Platform.io and ESP-prog for in-circuit debugging.

I did my research on JTAG, at the end I do not really know the answer, so I need you to do something special for GPIO3... Set it up to put ESP32 S3 into JTAG USB mode on boot (GPIO3 is high on reset) AND make it possible for me to desolder a resistor to change GPIO3 to be low on reset.

If you need to pull GPIO3 low, remove resistor R19



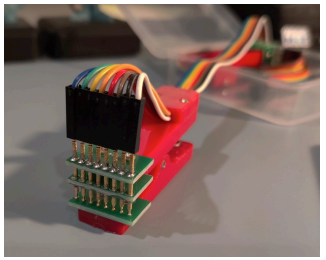




ESP32 WROOM JTAG debugger connections:
TDI - GPIO 12
TMS - GPIO 14
TCLK - GPIO 13
TDO - GPIO 15

Platformio.ini:
debug_tool = esp-prog
debug_init_break = tbreak setup

Pogo pin adaptor for JTAG pads



Single row Test programming fixture pogo pin pitch 2.54mm 8P/9P/10P/11P/ 3P~12P with wire

https://www.ebay.com/itm/143924370628?var=443188826270

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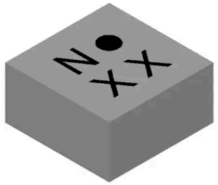
MEMS accelerometer, magnetometer/compass and gyroscope

LIS2DH12 - 3 axis MEMS accelerometer
https://www.sparkfun.com/products/15760
https://jlcpcb.com/parts/componentSearch?isSearch=true&searchTxt=LIS2DH12

and

Magnetometer - MMC5603NJ
https://datasheet.lcsc.com/lcsc/1912111437_MEMSIC-MMC5603NJ_C404328.pdf



Previous versions used:
https://lcsc.com/product-detail/Attitude-Sensors_STMicroelectronics-LSM6DS3TR-C_C967633.html
Tutorial for MPU-92-65
https://www.youtube.com/watch?v=V4NdsBjUAO0
BNO055 and BNO085, now out of stock and maybe out of existence. https://www.adafruit.com/product/2472. Wiring guide at https://learn.adafruit.com/adafruit-bno055-absolute-orientation-sensor/overview, https://github.com/adafruit/Adafruit_BNO055

Display

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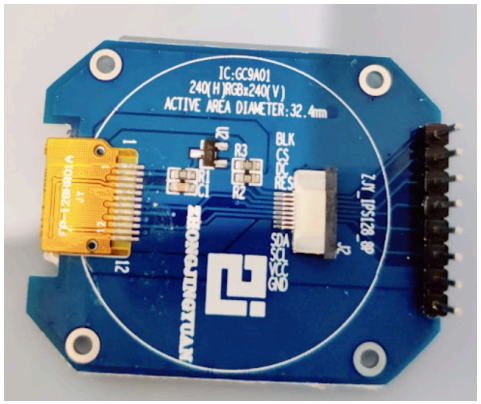


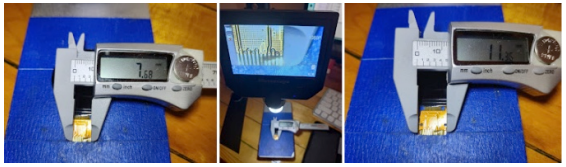
GND
+3.3
SCL - SCK (GPIO 18)
SDA - MOSI (GPIO 23)
RES - GPIO 17
DC - GPIO 16
CS - GPIO 32
BLK - +3.3

I chose this display unit because it is fast - I can get 15 frames per second - and inexpensive. It uses SPI for both the display.

GC9A01A

https://es.aliexpress.com/item/1005002389910393.html?gatewayAdapt=glo2esp
13 pin cable connector welds to the display board

Previous versions:
https://www.buydisplay.com/download/ic/GC9A01A.pdf
https://www.buydisplay.com/1-28-inch-tft-ips-lcd-display-module-240x240-spi-for-arduino-raspberry-pi
https://github.com/PaintYourDragon/Adafruit_GC9A01A



Shrink video files to no compression,

```
#! /bin/bash
cd /Users/frankcohen/Desktop/ReflectionsExperiments/ReadyForTrial
for i in *.mp4; do /Applications/ffmpeg -i "$i" -vf
"fps=15,scale=240:240:flags=lanczos,crop=240:in_h:(in_w-240)/2:0" -q:v 9 "/Users/
frankcohen/Frank/Votsh/Models/Reflections/Reflections\ Project\ Updates/Sox\
Development\ Board/Demo\ Files/10fps/${i%.*}.mjpeg"; done

for i in *.mov; do /Applications/ffmpeg -i "$i" -vf
"fps=10,scale=240:240:flags=lanczos,crop=240:in_h:(in_w-240)/2:0" -q:v 9 "/Users/
frankcohen/Frank/Votsh/Models/Reflections/Reflections\ Project\ Updates/Sox\
Development\ Board/Demo\ Files/10fps/${i%.*}.mjpeg"; done

/Applications/ffmpeg -i "./earth.mp4" -vf
"fps=15,scale=240:240:flags=lanczos,crop=240:in_h:(in_w-240)/2:0" -q:v 9
"earth.mjpeg"
```

Audio I2S Sound Board

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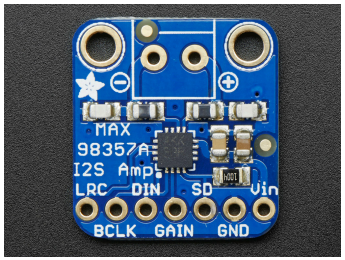

https://learn.adafruit.com/adafruit-max98357-i2s-class-d-mono-amp

```
libfdk_aac for converting wav to m4a (aac) is not installed by default in
ffmeg. I used these commands to install fumes with libfdk_aac on Mac OS X:

brew tap homebrew-ffmpeg/ffmpeg
brew install homebrew-ffmpeg/ffmpeg/ffmpeg --with-fdk-aac --HEAD

Then create an AAC audio file from an mp4 video
ffmpeg -i input.wav -c:a libfdk_aac -b:a 8k output.m4a

Using this library to play I2S audio on ESP32:
https://github.com/schreibfaul1/ESP32-audioI2S

Audacity on Mac. Open an MP3, File -> Export, Export As MP3…, Bit rate mode:
Constant, 40 KPS, save with .mp3 file extension
```

Use I2S audio library from https://github.com/schreibfaul1/ESP32-audioI2S

Previous version used Earle F. Philhower, III, earlephilhower@yahoo.com, for the WAV audio player library at https://github.com/earlephilhower/ESP8266Audio

Use ffmpeg to create AAC audio files from mp4 video file input: https://trac.ffmpeg.org/wiki/Encode/AAC

Tutorial on I2S at https://diyi0t.com/i2s-sound-tutorial-for-esp32/

MAX98357

The processor takes input files with:
sample rate of 44.1 kHz,
stereo format
16 bits
WAVE format

However, to play 240x240 MJPEG uncompressed files requires:
sample rate of 8000 kHz
16 bits
stereo format
WAV format
See experiments/Stream_all_videos_audio

I use Audacity on a Mac Book Pro

Note: Connect the Gain pin on the MAX board to GND. Do not leave it open/floating.

Haptic Feedback

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https://learn.adafruit.com/adafruit-drv2605-haptic-controller-breakout/arduino-code

Hoober includes a haptic feedback system using the Adafruit DRV2605 breakout board. https://learn.adafruit.com/adafruit-drv2605-haptic-controller-breakout

Software is at: https://github.com/adafruit/Adafruit_DRV2605_Library

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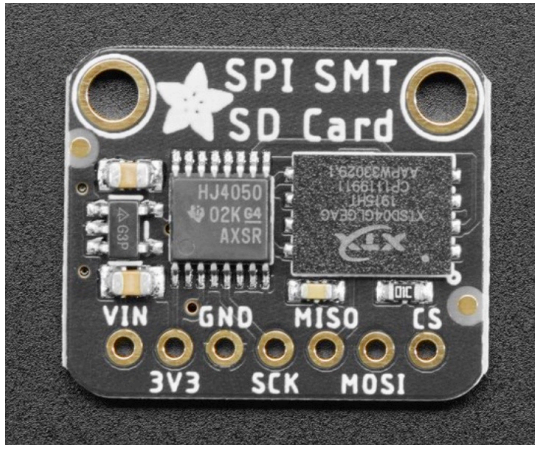

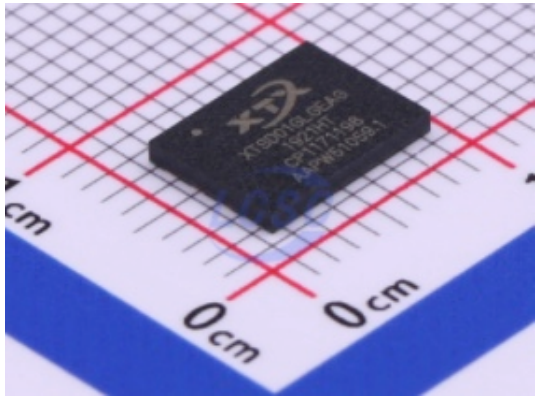

Adafruit SPI Flash SD Card - XTSD 512 MB PID: 4899

https://www.adafruit.com/product/4899

1 Gb NAND - LGA8-8x6mm NAND FLASH ROHS is at https://lcsc.com/product-detail/NAND-FLASH_XTX-XTSD01GLGEAG_C558837.html

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Changing from APDS-9960 gesture sensor to VL53L5CX sensor.
https://www.st.com/resource/en/datasheet/vl53l5cx.pdf

Depends on SparkFun Electronics VL53L5CX library
https://learn.sparkfun.com/tutorials/qwiic-tof-imager--vl53l5cx-hookup-guide

Finger Gesture Sensor (FGS)
https://github.com/frankcohen/ReflectionsOS/tree/main/Devices/Sox/Software/14Gestures

Gesture Power controlled on GPIO 44, low = powered, high = off
SCL Bus 2 GPIO 2
SDA Bus 2 GPIO 1

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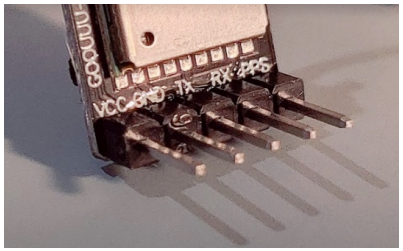
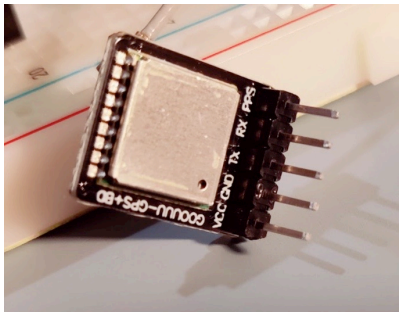
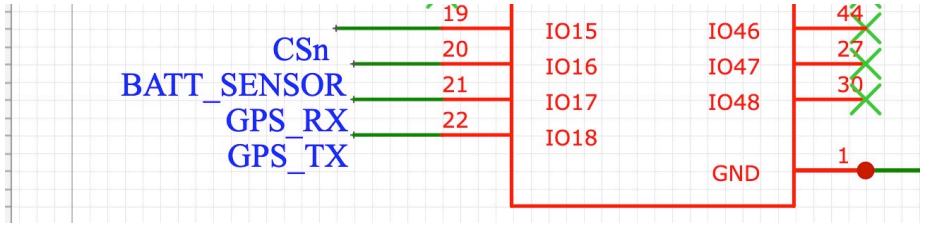
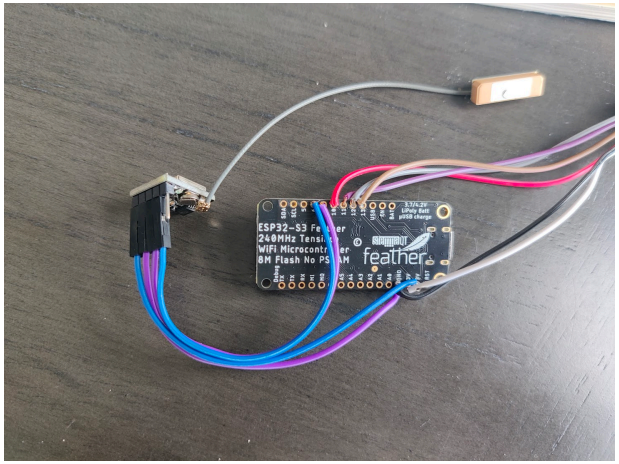


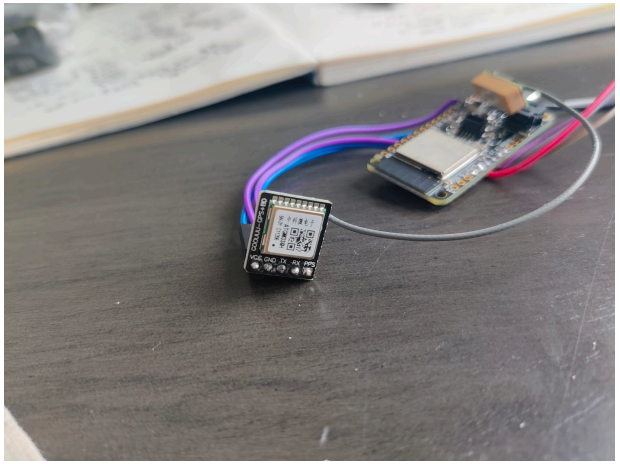




ThingTwo replaces GPS circuit with ATGM336H module

Uses GPIO17 for GPS RX, and GPIO18 for GPS TX





Power Consumption

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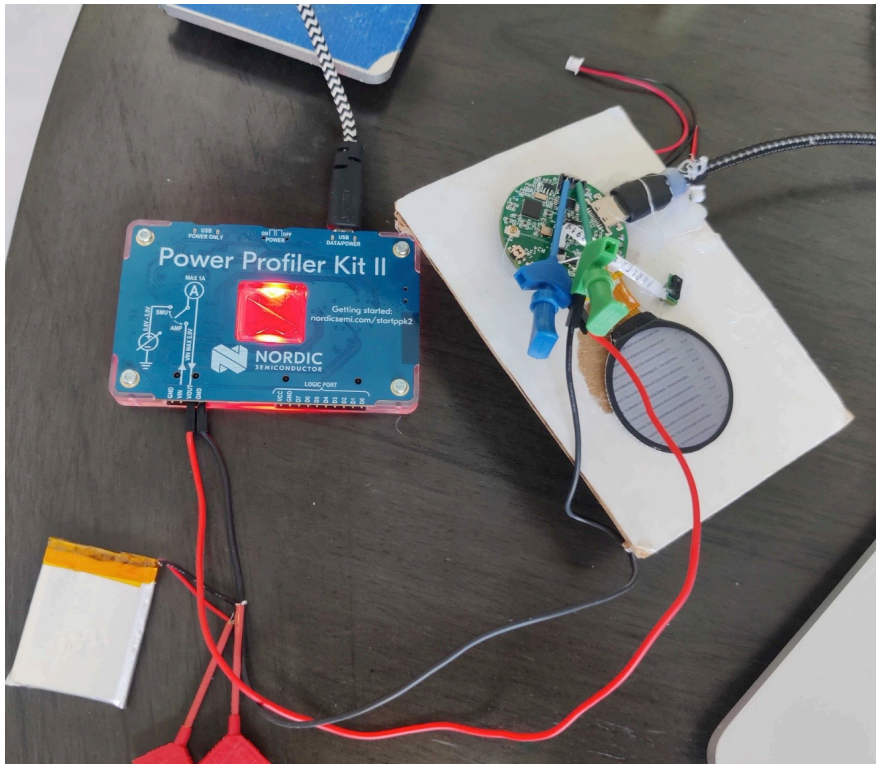

Reflections goal is to achieve 4-8 hours of operation while playing video shows.

Observations with the Hoober board showed 107 milliAmperes being used while streaming video from the NAND storage to the TFT display.

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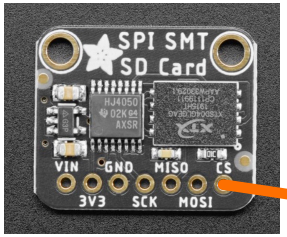
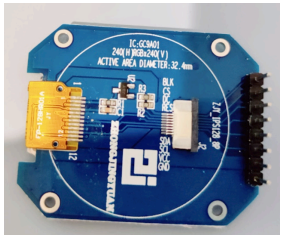
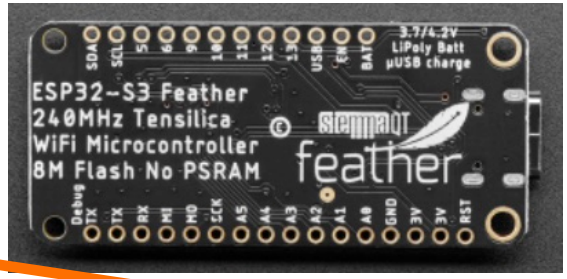
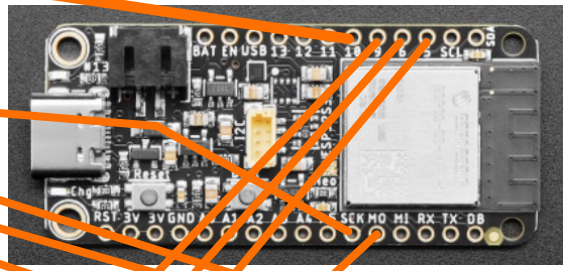




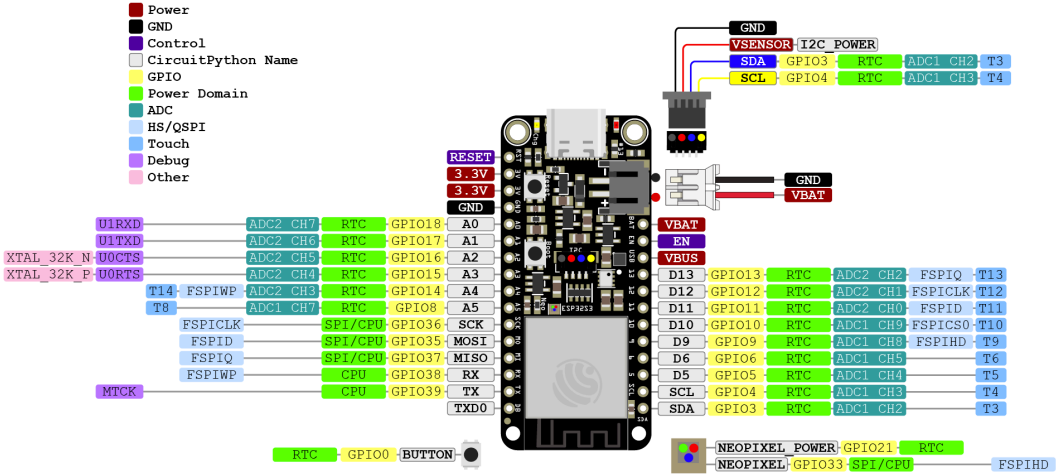
GND
+3.3
SCL - SCK (GPIO 36)
SDA - MOSI (GPIO 35)
RES - GPIO 9
DC - GPIO 6
CS - GPIO 5
BLK - +3.3





Adafruit ESP32-S3 Feather

https://www.adafruit.com/product/5323



For low power usage, manually cut power to the STEMMA QT port completely by setting GPIO 7 (I2C_POWER) to an output and LOW. This will disable power to the pullup resistors and connector.

Firmware uploads are automatic. Does not need to hold-down the Boot nor EN buttons to initiate Firmware Download mode for downloading firmware through the serial port. This is the real difference from Adafruit ESP32-S3 Feather.

Board Manufacturing

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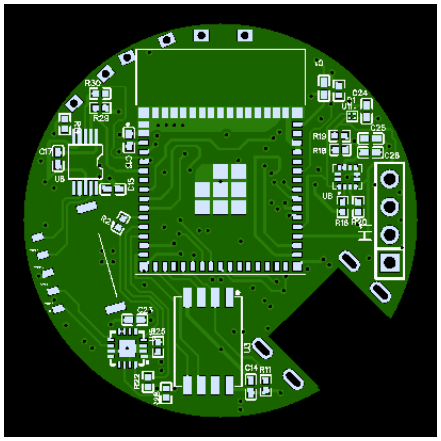
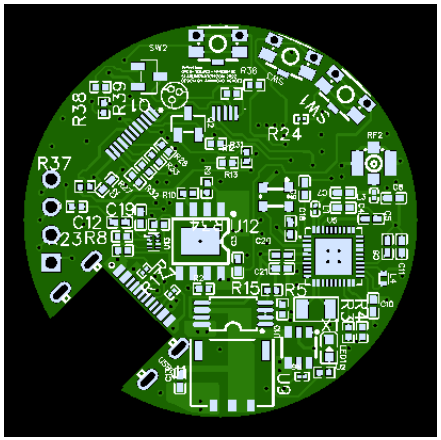
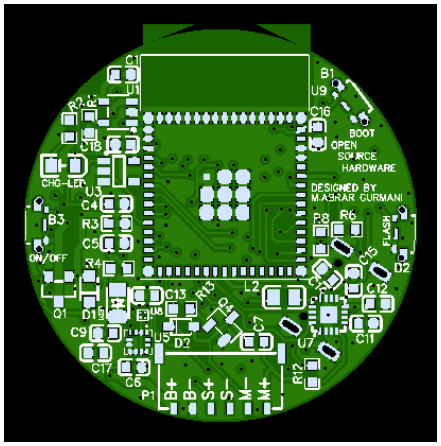
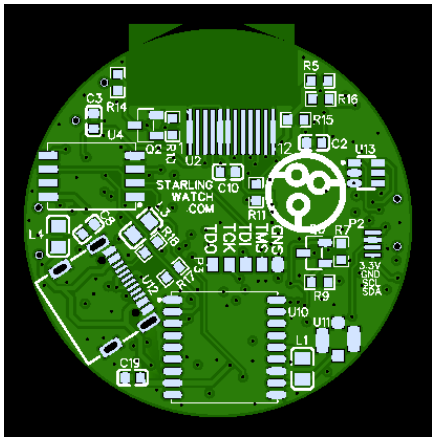


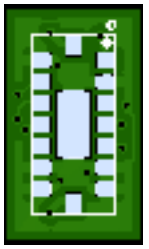


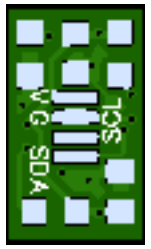
Avinidad design for main board 45.88x73.77mm 4 Layers,Thickness:1.6 mm, Finished Copper:1,Surface Finish:HASL with lead





Muhammad design for main board



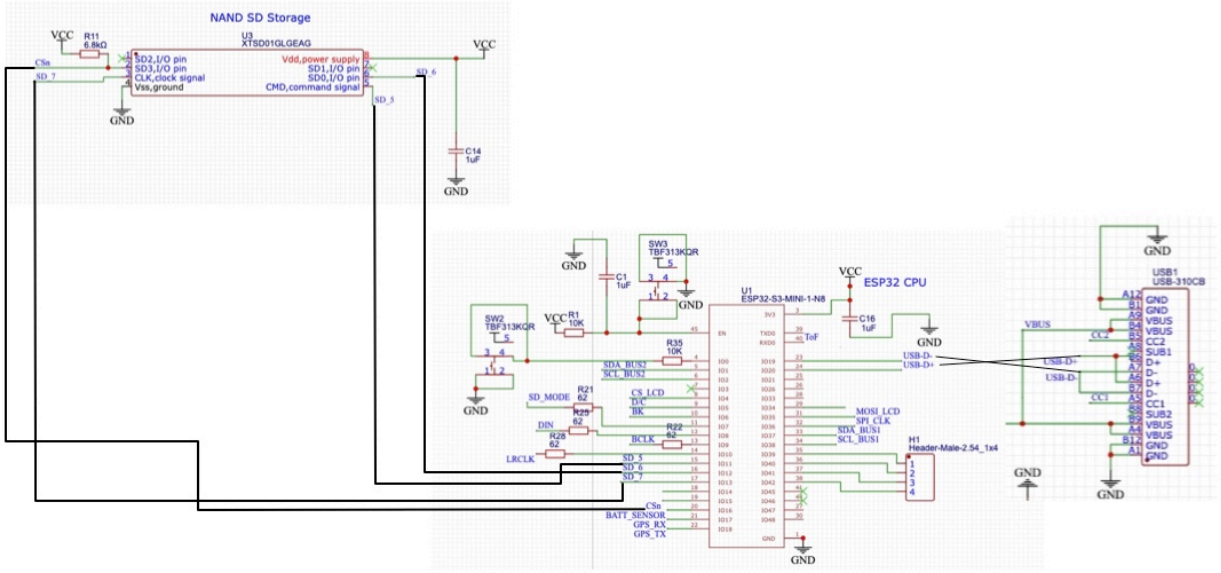


Muhammad design for daughter board

USB MSC for Hoober research

Version: August 18, 2022

fcohen@starlingwatch.com, (408) 364-5508



Turns an ESP32 with NAND SD storage into a USB PCMCIA flash mass storage device. Connect the board to the USB port of your Mac or other laptop and the NAND SD card contents appear as a disk drive. Drag-and-drop files into the device from your desktop. Edit files on your Arduino directly from your laptop. Copy over movies, images, fonts, and data.

https://www.reddit.com/r/esp32/comments/w4oddi/making_an_esp32_and_nand_storage_appear_as_a_disk/