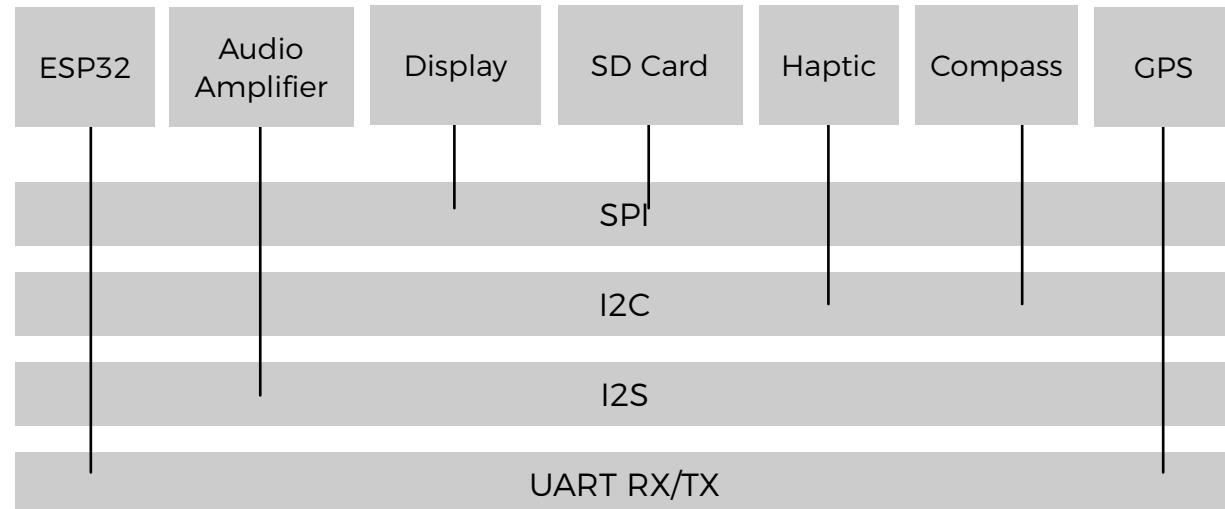


This document shows technical details of the Seuss display prototype. Our design goals:

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

Software driving the Seuss Display is at <https://github.com/frankcohen/ReflectionsOS>



Why Seuss, because Theodor Seuss Geisel was turned down 28 times before being published. Seuss Display is the second attempt for the Reflections project - Mesa Display being the first and failed attempt.

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 resistors and level-shifters.



<http://www.hiletgo.com/ProductDetail/1906566.html>

## ESP-WROOM-32 ESP32 ESP-32S Development Board 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>

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

Notes on using ESP32 with Arduino IDE:

Follow these instructions to install ESP32 to Arduino IDE

<https://github.com/espressif/arduino-esp32/blob/master/docs/arduino-ide/mac.md>

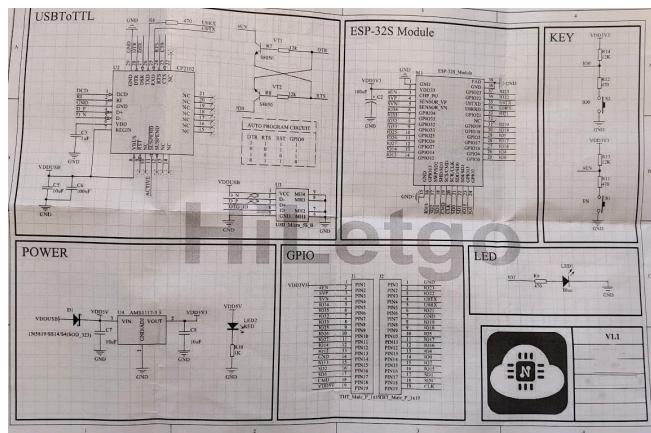
Use Nod32s as Board selection

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

I need to hold the boot button down to upload a sketch

<https://randomnerdtutorials.com/solved-failed-to-connect-to-esp32-timed-out-waiting-for-packet-header/>

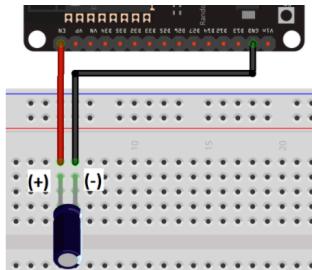


These pages came with the HiLetGo.com ESP32 Development Board

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.

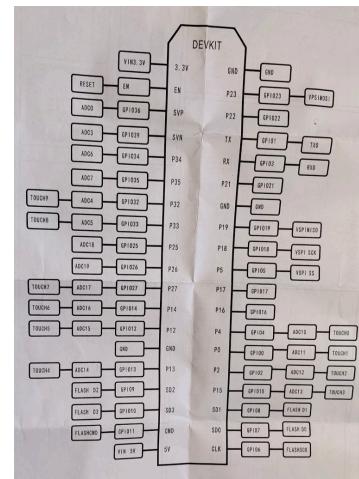
The downside of the development boards happens when people publish tutorials. Board change pinouts. For example, some boards provide access to ESP32's dual SPI bus pins, others do not.



Note: electrolytic capacitors have polarity. The white/grey stripe indicates the negative lead.

If it works, then you can solder the 10 uF electrolytic capacitor to the board. Since the EN and GND pins are far apart from each other, you can simply connect the capacitor between the EN and the GND of the ESP32 chip as shown in the schematic diagram below.

<https://randomnerdtutorials.com/solved-failed-to-connect-to-esp32-timed-out-waiting-for-packet-header/>



# Wiring

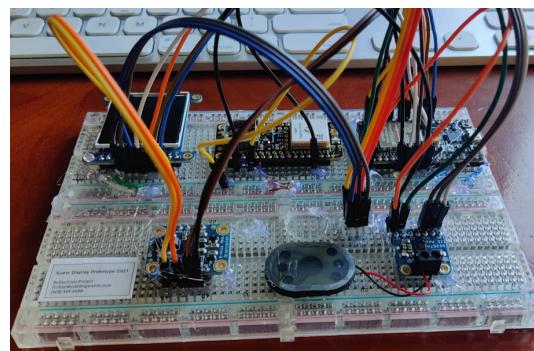
Version: March 1, 2021

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ESP32 Development Board					
	3.3v	19	GND		
RESET	EN	18	GPIO 23	VSPI MOSI	
input only Left button	GPIO 36	17	GPIO 22	SCL I2C	Compass, Hapt
input only Right button	GPIO 39	16	GPIO 01	TX0	
input only Center button	GPIO 34	15	GPIO 03	RX0	
input only GPS TX	GPIO 35	14	GPIO 21	SDA I2C	Compass, Hapt
Display CS	GPIO 32	13	GND		
Backlight LEDs	GPIO 33	12	GPIO 19	VSPI MISO	
DAC1	Audio LRCL	GPIO 25	11	GPIO 18	VSPI SCK
DAC2	Audio BCLK	GPIO 26	10	GPIO 5	VSPI SS
	Audio DIN	GPIO 27	9	GPIO 17	Display RST
HSPI SCK	GPIO 14	8	GPIO 16	Display DC	
HSPI MISO	GPIO 12	7	GPIO 4	Display SDCS	
	GND	6	GPIO 0	Boot	
HSPI MOSI	GPIO 13	5	GPIO 2	LED	
Flash D2	GPIO 9	4	GPIO 15	HSPI SS	
Flash D3	GPIO 10	3	GPIO 8	Flash D1	
Flash CMD	GPIO 11	2	GPIO 7	Flash D0	
	5V	1	GPIO 6	Flash SCK	

Pins on ESP32 development board as seen from the top, 5V and GPIO 6 are closest to the USB connector

TX	GPS	GPS TX			
SPI	Display	CS	DC	SDCS	RST
I2S	Audio	LRCL	DIN	BCLK	
I2C	Compass	SDA	SCL		
I2C	Haptic motor				
I2C	Proximity sensor				



An early version, missing backlighting, haptic, proximity, buttons

## 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>

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 Flash memory system. 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.

MEMS accelerometer, magnetometer and gyroscope

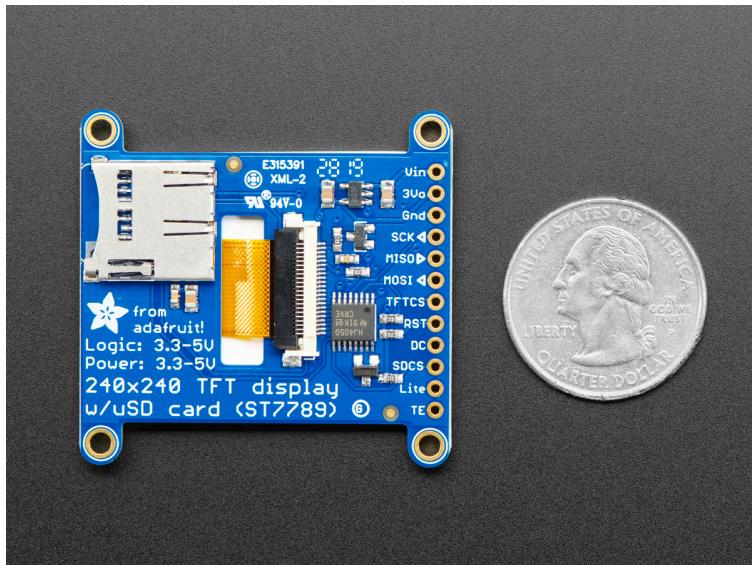
Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055  
<https://www.adafruit.com/product/2472>

Wiring guide at <https://learn.adafruit.com/adafruit-bno055-absolute-orientation-sensor/overview>

[https://github.com/adafruit/Adafruit\\_BNO055](https://github.com/adafruit/Adafruit_BNO055)

There are many accelerometers, compasses, and gyroscopes out there. And this board is relatively expensive. I decided on this one because it is all-in-one and requires only 2 I2C pins.





<https://www.adafruit.com/product/3787>

RAW/Uncompressed video playback library  
[https://github.com/cbm80amiga/ST7735\\_SDVideoPlayback](https://github.com/cbm80amiga/ST7735_SDVideoPlayback)

Video player  
<https://www.instructables.com/Play-Video-With-ESP32/>  
Works only with raw converted mpeg files, not rgb255 or anything else

```
cd /Users/frankcohen/Frank/Votsh/Models/Reflections/Seuss\  
Display/video
```

```
./ffmpeg -i startup2.mov -vf  
"fps=30,scale=-1:176:flags=lanczos,crop=240:in_h:(in_w-240)/  
2:0" -q:v 9 240_30fps.mjpe
```

```
for i in *; do /Applications/ffmpeg -i "$i" "${i%.*}.jpeg" -vf  
"fps=30,scale=-1:176:flags=lanczos,crop=240:in_h:(in_w-240)/  
2:0" -q:v 9; done
```

```
for i in *; do ffmpeg -i "$i" "${i%.*}.mp4"; done
```

I chose this display unit because it is fast - I can get 20 updates per second - and it includes an SD card reader on the breakout board. It uses SPI for both the display and SD card reader.

I am still confused by the difference between DC, TFTCS, and SDCS.



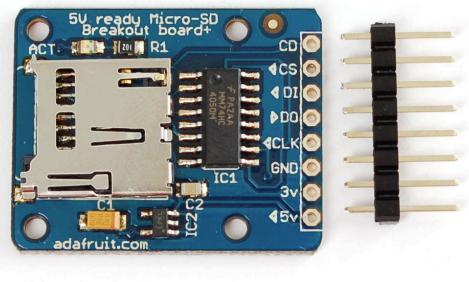
Use tutorial at <https://www.instructables.com/Play-Video-With-ESP32/>  
Software at:  
[https://github.com/moononournation/RGB565\\_video](https://github.com/moononournation/RGB565_video)

Uses Adafruit GFX library. Use examples from "Adafruit ST7735 and ST7789 Library" in the Arduino IDE examples drop-down menu

# Failed Investigations

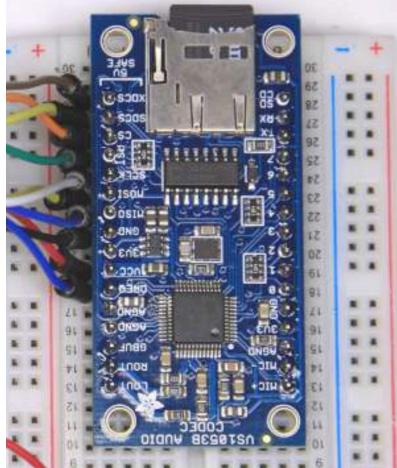
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I used this library (got cardSize errors on Adafruit's branch):  
<https://github.com/greiman/SdFat>

<https://learn.adafruit.com/adafruit-vs1053-mp3-aac-ogg-midi-wav-play-and-record-codec-tutorial/software>



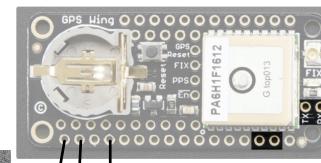
CS GPIO 16  
XDCS-> GPIO 17  
SDCS -> GPIO 32  
DREQ -> GPIO 4  
RST - GPIO25  
  
CLK - GPIO18  
MOSI - GPIO23  
MISO - GPIO19



The GPS module runs from +3.3V power and uses 3V logic. The GPS is powered directly from the 3V and GND pins on the bottom left of the Feather. Each Feather has a regulator to provide clean 3V power from USB or battery power.

I tried, and failed, with SD card readers and the Adafruit VS1053 audio player.

<https://learn.adafruit.com/adafruit-ultimate-gps-featherwing/pinouts>

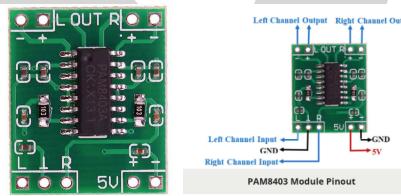


TX RX

RST 3V GND



<https://components101.com/modules/pam8403-stereo-audio-amplifier-module>



[https://www.amazon.com/DAOKI-Digital-Amplifier-PAM8403-Module/dp/B00XAGSZSK/ref=pd\\_yo\\_rr\\_rp\\_1](https://www.amazon.com/DAOKI-Digital-Amplifier-PAM8403-Module/dp/B00XAGSZSK/ref=pd_yo_rr_rp_1)

Startup sound by:

<https://freesound.org/people/eardeer/sounds/385281/>  
<https://freesound.org/people/tim.kahn/sounds/324059/>

I built the start-up video using animation from

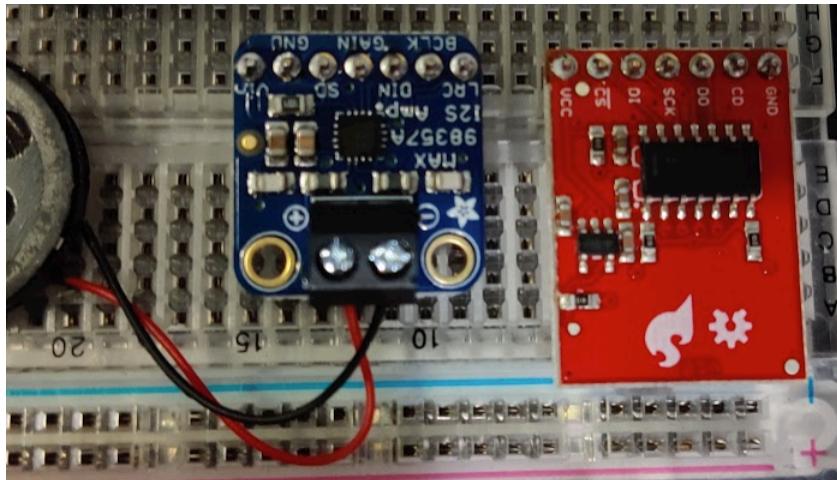
Nikita Kisan Rajiwade's project:

[https://www.youtube.com/watch?v=WwKukI0f\\_Aw](https://www.youtube.com/watch?v=WwKukI0f_Aw)

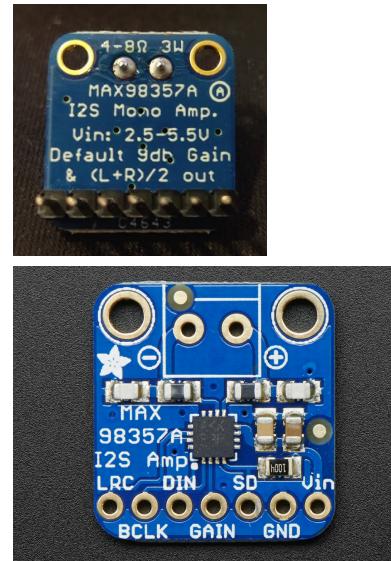
# I2S Sound Board

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<https://www.sparkfun.com/products/13743>



```
240x240@15fps
/Applications/ffmpeg -i Kermit480.mov -vf
"fps=15,scale=-1:240:flags=lanczos,crop=240:in_h:(in_w-240)/2:0" -q:v 9
Kermit480.jpeg

for i in *.mov; do /Applications/ffmpeg -i "$i" -vf
"fps=15,scale=-1:240:flags=lanczos,crop=240:in_h:(in_w-240)/2:0" -q:v 9 "$
{i%.}.jpeg"; done
```

[https://www.amazon.com/gp/product/B01CF569VQ/ref=ppx\\_yo\\_dt\\_b\\_asin\\_title\\_o01\\_s00?ie=UTF8&psc=1](https://www.amazon.com/gp/product/B01CF569VQ/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1)

Tutorial at <https://diyi0t.com/i2s-sound-tutorial-for-esp32/>

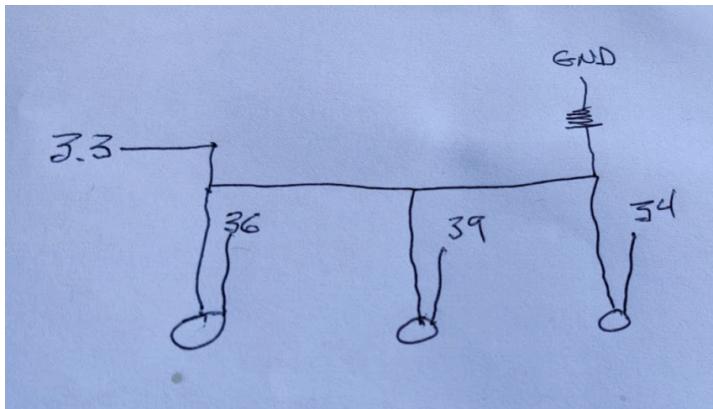
MAX98357

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  
WAVE format  
See experiments/  
Stream\_all\_videos\_audio

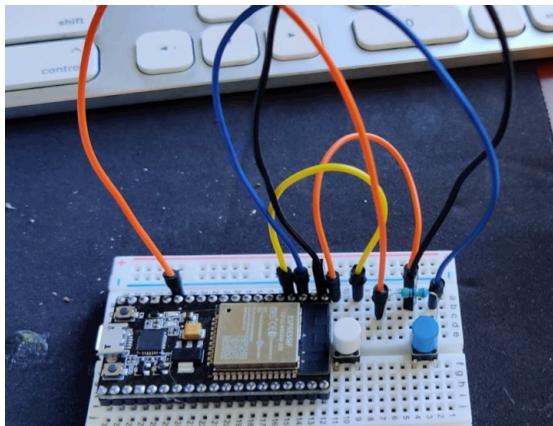
I use Audacity on a Mac Book Pro

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



40 Ohm resistor

Temporary on switches



Experiment with 2 buttons

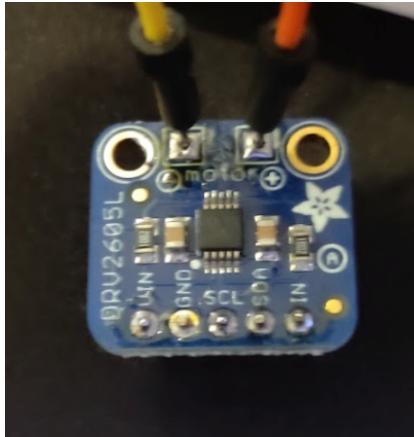
Seuss Display includes a 3 button interface for user control. Includes a left, middle, and right button.

See the [buttons.ino](#) sketch for an example of sensing three buttons

# Haptic Feedback

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Seuss 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](https://github.com/adafruit/Adafruit_DRV2605_Library)