ESP32 Workshop

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April 27, 2019

SVFIG

Maker Faire
May 18-19, 2019

- We will get a 10’x20’ booth.
- 4 Workstations to teach people how to program ESP32 in Forth.
- Robot control through WiFi.
- Esp32forth demo.
- Short presentations on Forth programming.

2019 Maker Faire

- We need 4 assistants to manage the booth for Saturday morning and afternoon, and Sunday morning and afternoon.
- We need speakers to make short presentations on the hour in Saturday and Sunday.

ESP32 WiFi Microcontroller Workshop

- Booth #69322
  - Friday 1-5 pm
  - Saturday 10 am - 6 pm
  - Sunday 10 am - 6 pm
- Presentation #70167
  - Sunday 1-3 pm

2020 Maker Faire

- **We need a master maker to design, apply, and manage a booth for 2020 Maker Faire.**

Summary

- Affordable microcontroller kits
- NodeMCU ESP32S kit
- Arduino IDE
- AIR robot
- Plan-B robot
- Serial Monitor interface
- Web Browser interface
- Bach benchmark

Affordable Microcontroller Kits

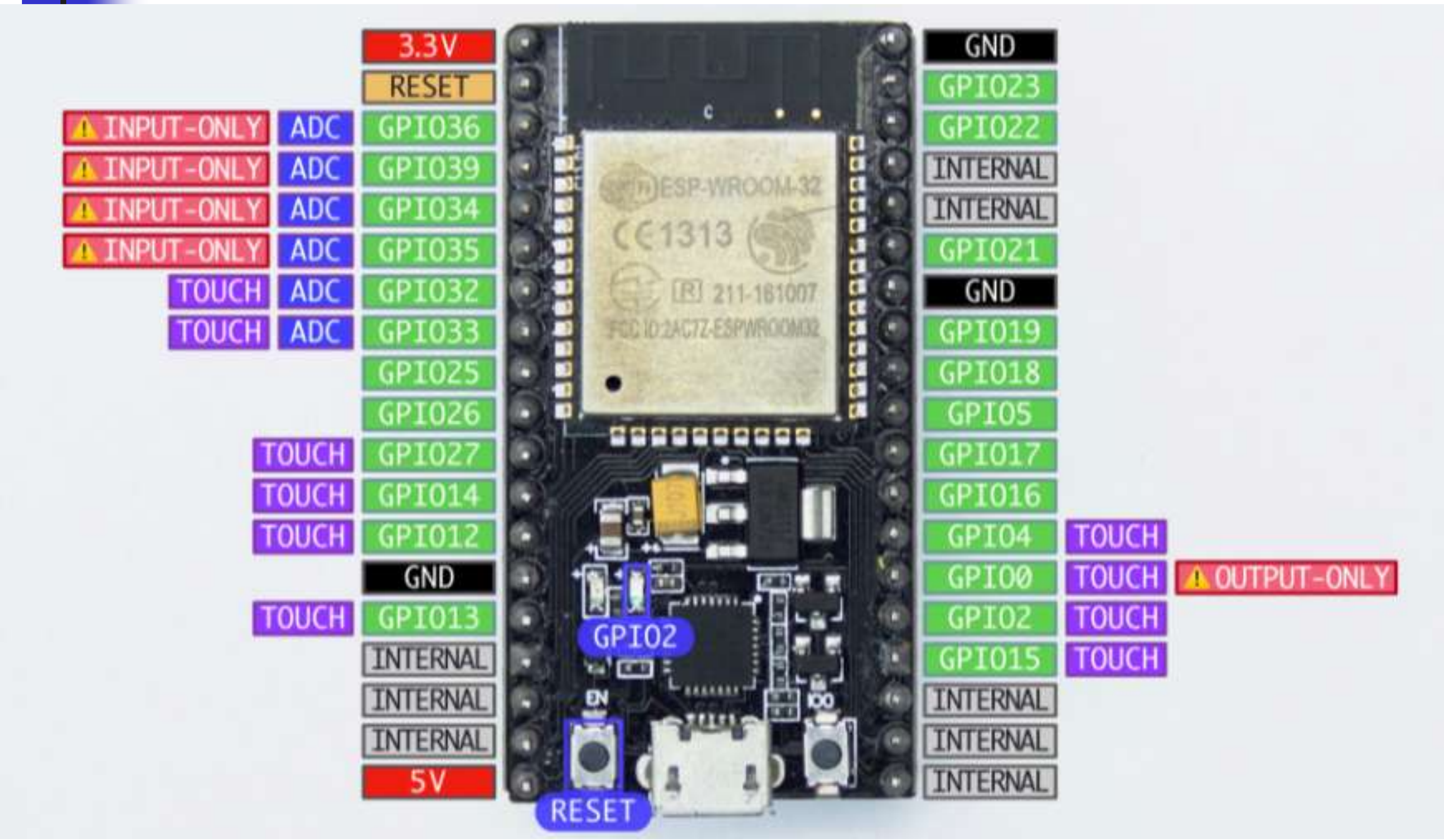
2005	ADuC7020
2009	STM8 Discovery
2011	TI LaunchPad MSP430
2014	STM32 Discovery
2015	Arduino Uno ATmega328P
2017	NodeMCU ESP8266
2019	NodeMCU ESP32

ESP32

- Dual 32-bit Xtensa LX106, 240 MHz
- 520 KB SRAM, 4 MB flash
- 28 GPIO pins, 16 PWM channels
- 8 ADC, 2 DAC, 3 UART, 2 SPI, 3 I2C
- WiFi: IEEE 802.11 b/g/n/e/I
- Bluetooth

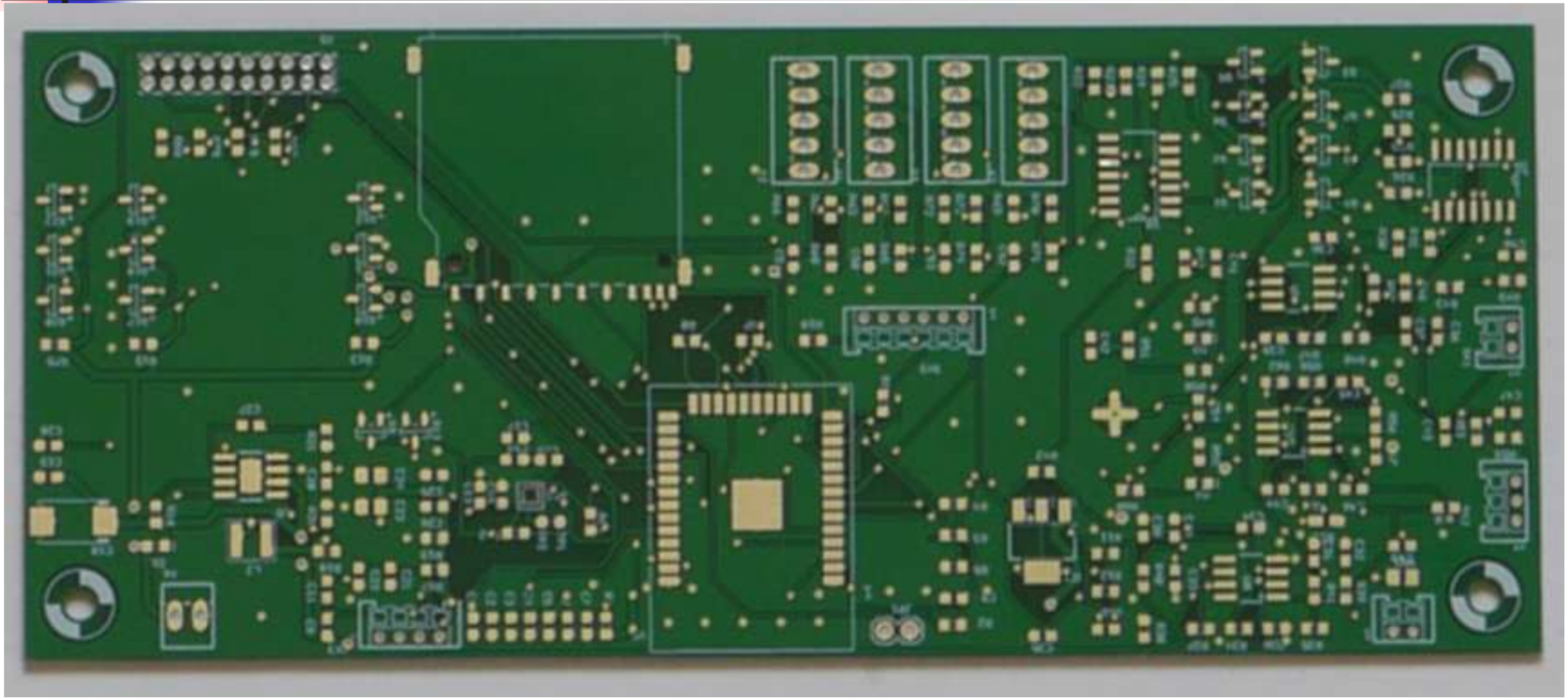
NodeMCU ESP32S

NodeMCU ESP32S



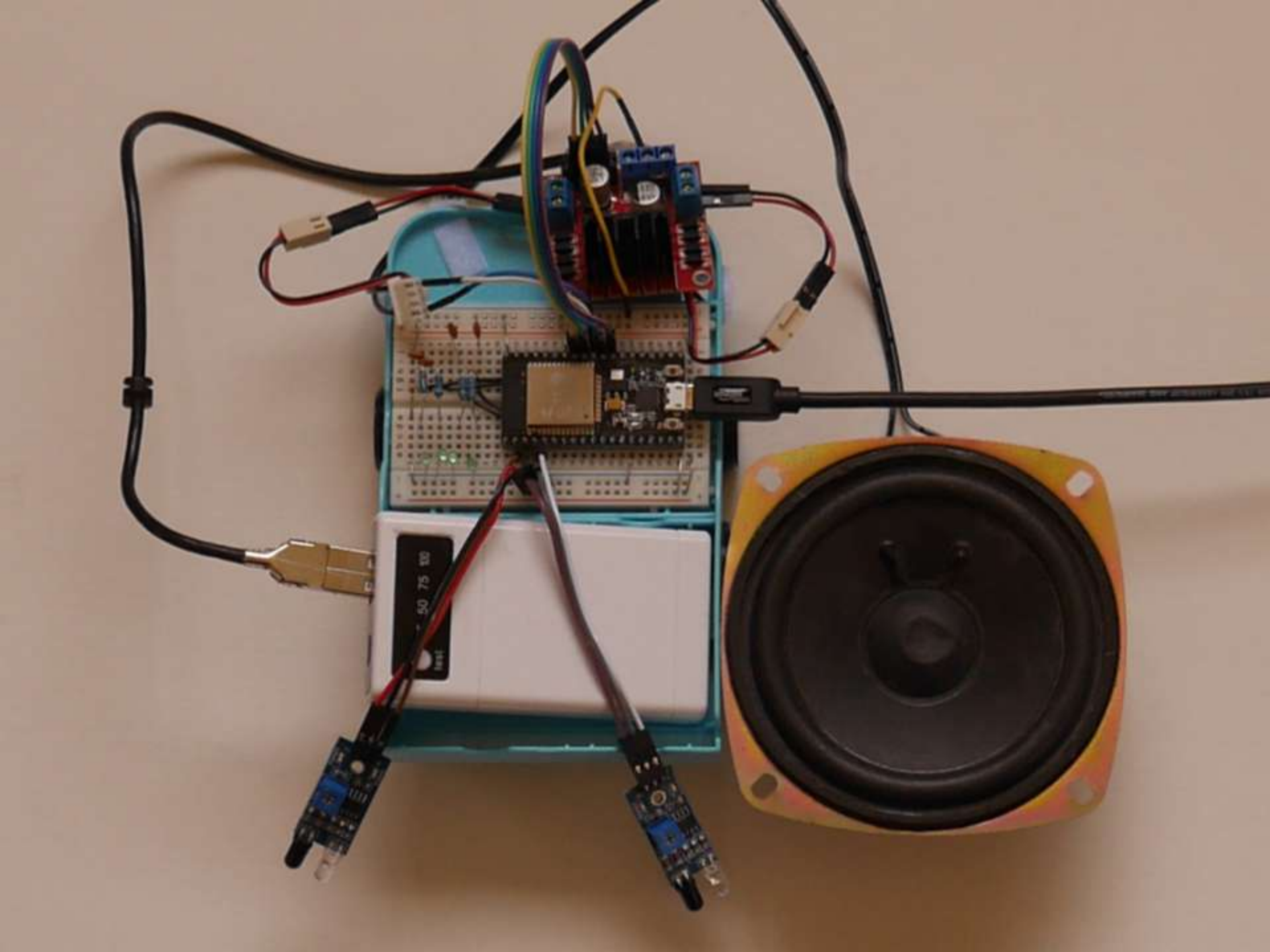
AIR-AI Robot

- Ron Golding is building his AIR Robot for Maker Faire.
- So far, I have only seen a bare PC board.



Plan-B Robot

- I received a number of robot car kits from Taiwan FIG.
- I assembled two robot car kits for Maker Faire.
- Both use NodeMCU ESP32S kits as controllers.
- I tested motors, obstacle sensors, and speaker.


50 75 100
test

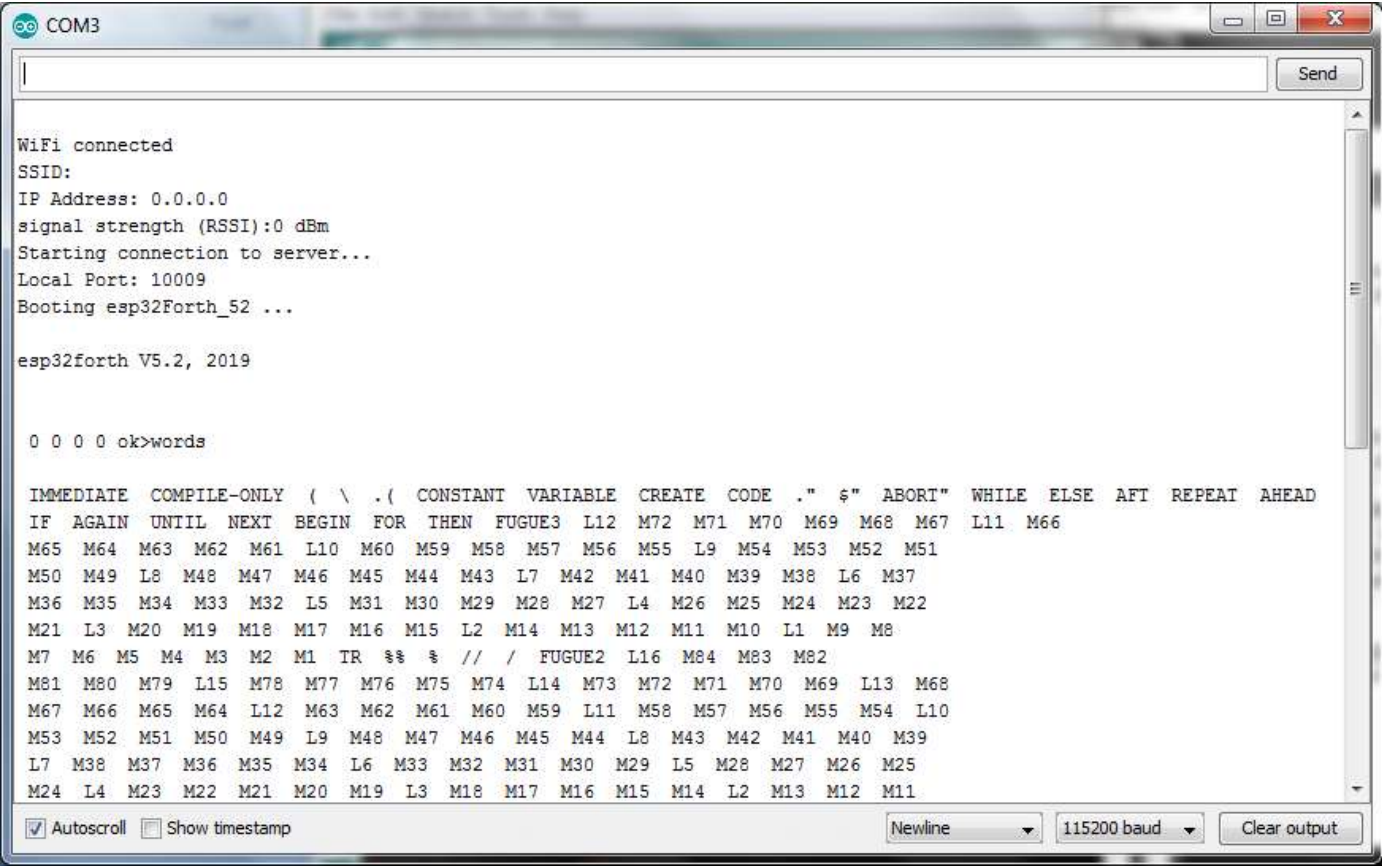
ESP32forth

- ESP32forth emulates eP32, a 32-bit Forth microcontroller.
- Virtual Forth Machine executes byte code, and is written in C as a sketch.
- ESP32forth Finite State Machine:

```
{primitives[char cData[P++]]();}
```

Serial Monitor Interface

- NodeMCU ESP32S is connected to Arduino IDE through a microUSB cable.
- User test and program ESP32 through the Serial Monitor at 11520 baud.
- Turnkey application is placed in load.txt file stored in flash.



```
WiFi connected
SSID:
IP Address: 0.0.0.0
signal strength (RSSI):0 dBm
Starting connection to server...
Local Port: 10009
Booting esp32Forth_52 ...

esp32forth V5.2, 2019



 0 0 0 0 ok>words

 IMMEDIATE  COMPILE-ONLY  (  \  .(  CONSTANT  VARIABLE  CREATE  CODE  ."  $"  ABORT"  WHILE  ELSE  AFT  REPEAT  AHEAD
 IF  AGAIN  UNTIL  NEXT  BEGIN  FOR  THEN  FUGUE3  L12  M72  M71  M70  M69  M68  M67  L11  M66
 M65  M64  M63  M62  M61  L10  M60  M59  M58  M57  M56  M55  L9  M54  M53  M52  M51
 M50  M49  L8  M48  M47  M46  M45  M44  M43  L7  M42  M41  M40  M39  M38  L6  M37
 M36  M35  M34  M33  M32  L5  M31  M30  M29  M28  M27  L4  M26  M25  M24  M23  M22
 M21  L3  M20  M19  M18  M17  M16  M15  L2  M14  M13  M12  M11  M10  L1  M9  M8
 M7  M6  M5  M4  M3  M2  M1  TR  %%  %  //  /  FUGUE2  L16  M84  M83  M82
 M81  M80  M79  L15  M78  M77  M76  M75  M74  L14  M73  M72  M71  M70  M69  L13  M68
 M67  M66  M65  M64  L12  M63  M62  M61  M60  M59  L11  M58  M57  M56  M55  M54  L10
 M53  M52  M51  M50  M49  L9  M48  M47  M46  M45  M44  L8  M43  M42  M41  M40  M39
 L7  M38  M37  M36  M35  M34  L6  M33  M32  M31  M30  M29  L5  M28  M27  M26  M25
 M24  L4  M23  M22  M21  M20  M19  L3  M18  M17  M16  M15  M14  L2  M13  M12  M11
```

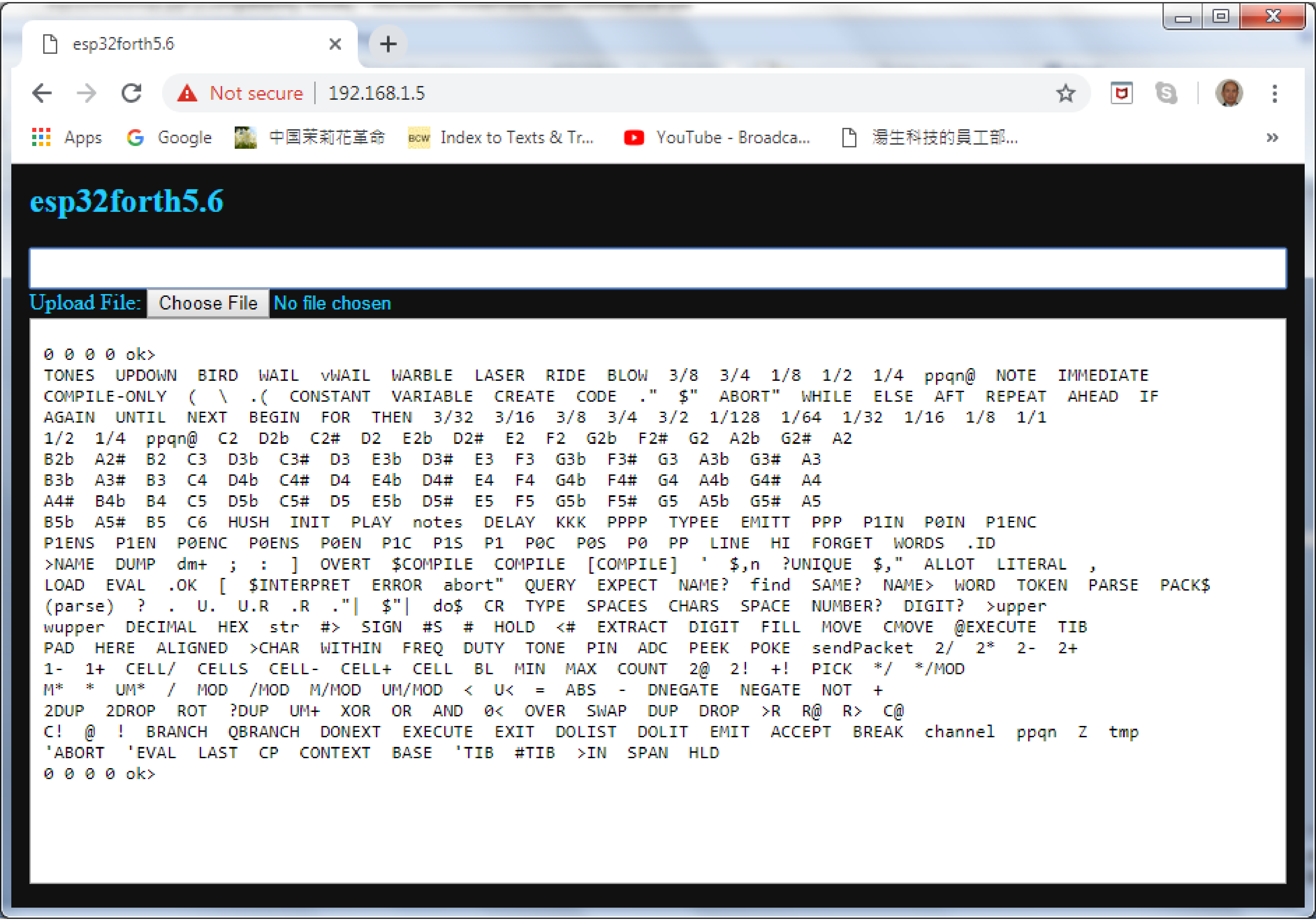
☑ Autoscroll □ Show timestamp Newline 115200 baud

Web Browser Interface

- I was using very simple HTTP protocol to send Forth commands to the robot.
- Brad Nelson changed it to Web server and implemented a true browser to send commands and to download text files.

Web Browser Interface

- ESP32forth is extended so that user can operate ESP32 through HTTP web browser.
- All interactive interpreter and compiler functions
- Direct robot control
- Source code file download



esp32forth5.6

Upload File: Choose File No file chosen

```
0 0 0 0 ok>
TONES  UPDOWN  BIRD  WAIL  vWAIL  WARBLE  LASER  RIDE  BLOW  3/8  3/4  1/8  1/2  1/4  ppqn@  NOTE  IMMEDIATE
COMPILE-ONLY  (  \  .(  CONSTANT  VARIABLE  CREATE  CODE  ."  $"  ABORT"  WHILE  ELSE  AFT  REPEAT  AHEAD  IF
AGAIN  UNTIL  NEXT  BEGIN  FOR  THEN  3/32  3/16  3/8  3/4  3/2  1/128  1/64  1/32  1/16  1/8  1/1
1/2  1/4  ppqn@  C2  D2b  C2#  D2  E2b  D2#  E2  F2  G2b  F2#  G2  A2b  G2#  A2
B2b  A2#  B2  C3  D3b  C3#  D3  E3b  D3#  E3  F3  G3b  F3#  G3  A3b  G3#  A3
B3b  A3#  B3  C4  D4b  C4#  D4  E4b  D4#  E4  F4  G4b  F4#  G4  A4b  G4#  A4
A4#  B4b  B4  C5  D5b  C5#  D5  E5b  D5#  E5  F5  G5b  F5#  G5  A5b  G5#  A5
B5b  A5#  B5  C6  HUSH  INIT  PLAY  notes  DELAY  KKK  PPPP  TYPEE  EMITT  PPP  P1IN  P0IN  P1ENC
P1ENS  P1EN  P0ENC  P0ENS  P0EN  P1C  P1S  P1  P0C  P0S  P0  PP  LINE  HI  FORGET  WORDS  .ID
>NAME  DUMP  dm+  ;  :  ]  OVERT  $COMPILE  COMPILE  [COMPILE]  '  $,n  ?UNIQUE  $,"  ALLOT  LITERAL  ,
LOAD  EVAL  .OK  [  $INTERPRET  ERROR  abort"  QUERY  EXPECT  NAME?  find  SAME?  NAME>  WORD  TOKEN  PARSE  PACK$
(parse)  ?  .  U.  U.R  .R  ."|  $"|  do$  CR  TYPE  SPACES  CHARS  SPACE  NUMBER?  DIGIT?  >upper
wupper  DECIMAL  HEX  str  #>  SIGN  #S  #  HOLD  <#  EXTRACT  DIGIT  FILL  MOVE  CMOVE  @EXECUTE  TIB
PAD  HERE  ALIGNED  >CHAR  WITHIN  FREQ  DUTY  TONE  PIN  ADC  PEEK  POKE  sendPacket  2/  2*  2-  2+
1-  1+  CELL/  CELLS  CELL-  CELL+  CELL  BL  MIN  MAX  COUNT  2@  2!  +!  PICK  */  */MOD
M*  *  UM*  /  MOD  /MOD  M/MOD  UM/MOD  <  U<  =  ABS  -  DNEGATE  NEGATE  NOT  +
2DUP  2DROP  ROT  ?DUP  UM+  XOR  OR  AND  0<  OVER  SWAP  DUP  DROP  >R  R@  R>  C@
C!  @  !  BRANCH  QBRANCH  DONEXT  EXECUTE  EXIT  DOLIST  DOLIT  EMIT  ACCEPT  BREAK  channel  ppqn  Z  tmp
'ABORT  'EVAL  LAST  CP  CONTEXT  BASE  'TIB  #TIB  >IN  SPAN  HLD
0 0 0 0 ok>
```

Bach Benchmark

- In 1984, a friend in Taiwan FIG gave me an PC IO Card with 4 8253s and 4 8255s, for machine automation.
- I built a 12 channel electronic organ, and played many organ pieces by Bach.

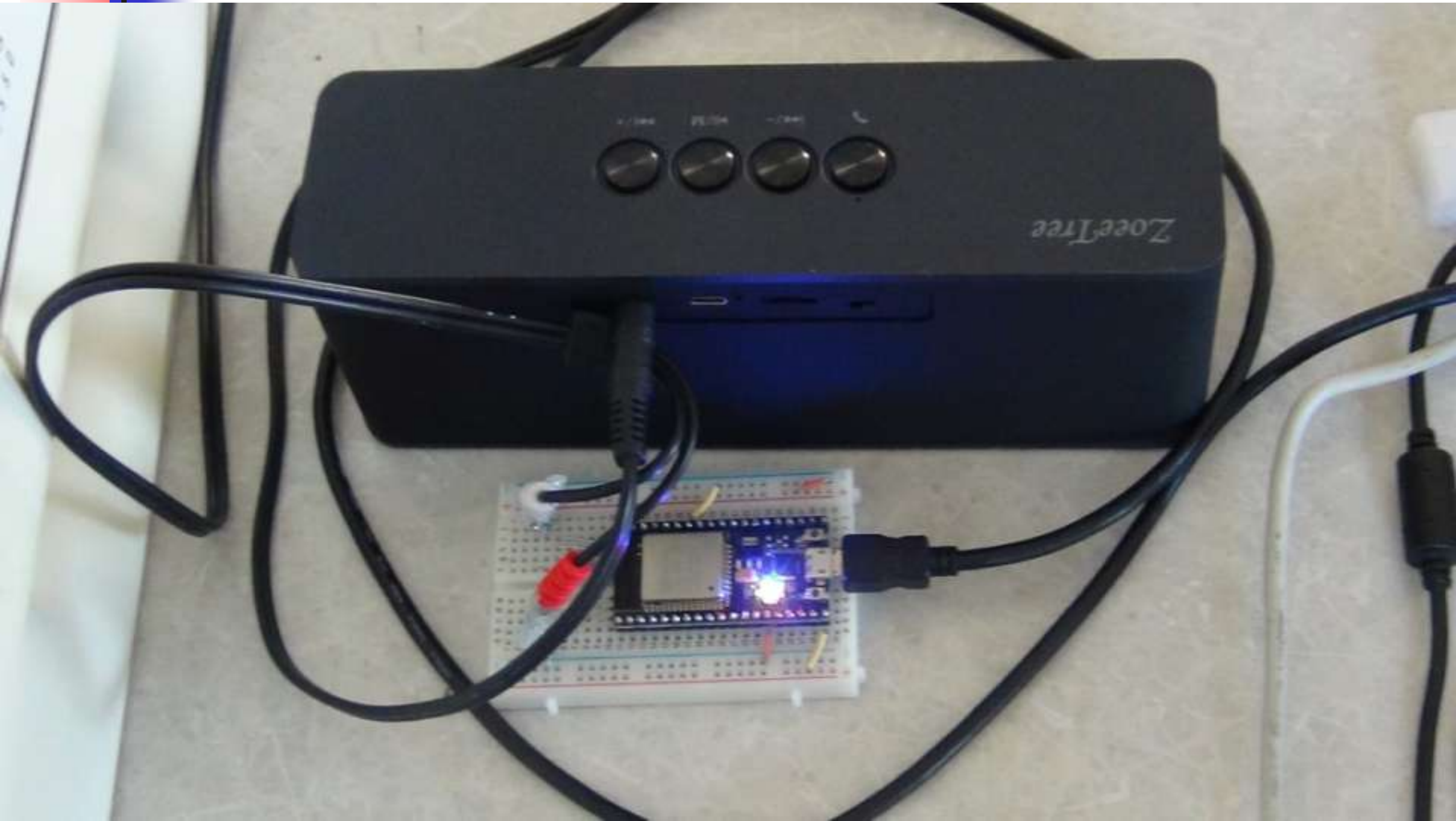
Robot Control Buttons

INIT	Initialize speaker
RIDE	Speaker demo
FORE	Drive robot forward
BACK	Drive robot backward
LEFT	Drive robot left
RIGHT	Drive robot righr
STOP	Stop robot
LED	Turn on blue LED
ADC	Test 4 analog inputs

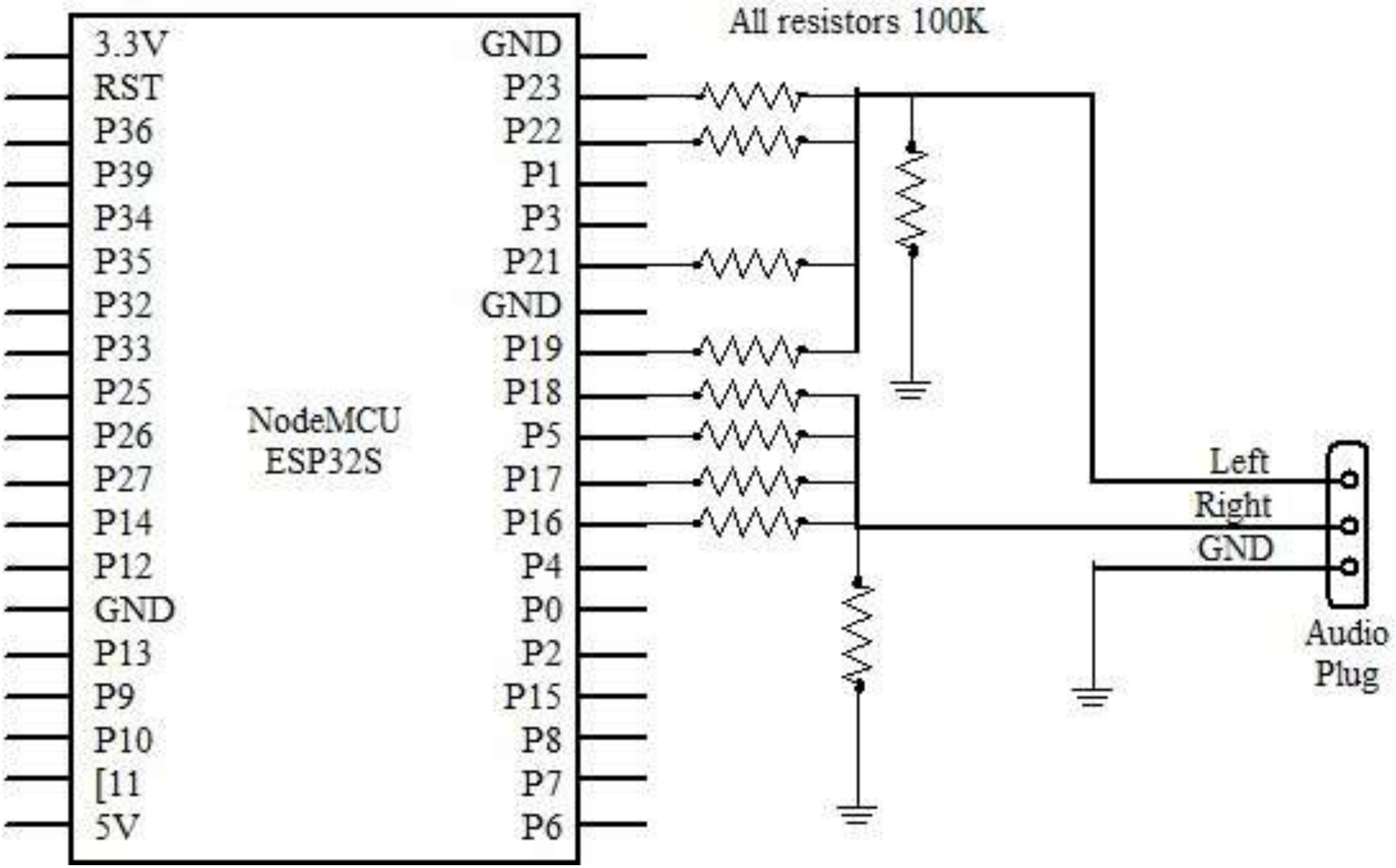
Bach Benchmark

- I tried to play Bach organ music on most of the microcontrollers I worked with.
- Only Arduino Uno could play three-voice organ pieces.
- ESP32 can play 8 voices, and passes my Bach Benchmark.

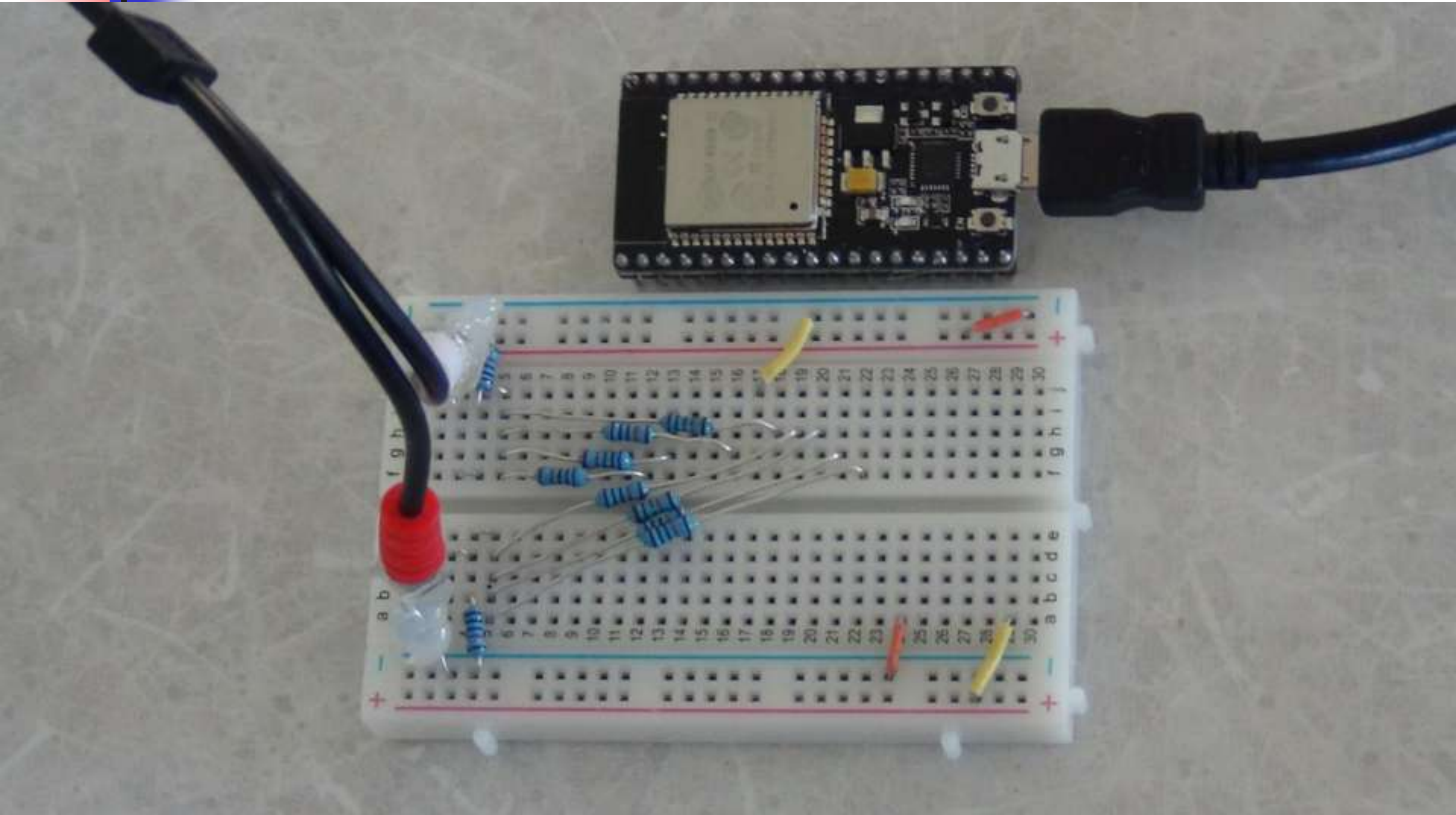
Electronic Organ



Electronic Organ



Electronic Organ



Organ Demo

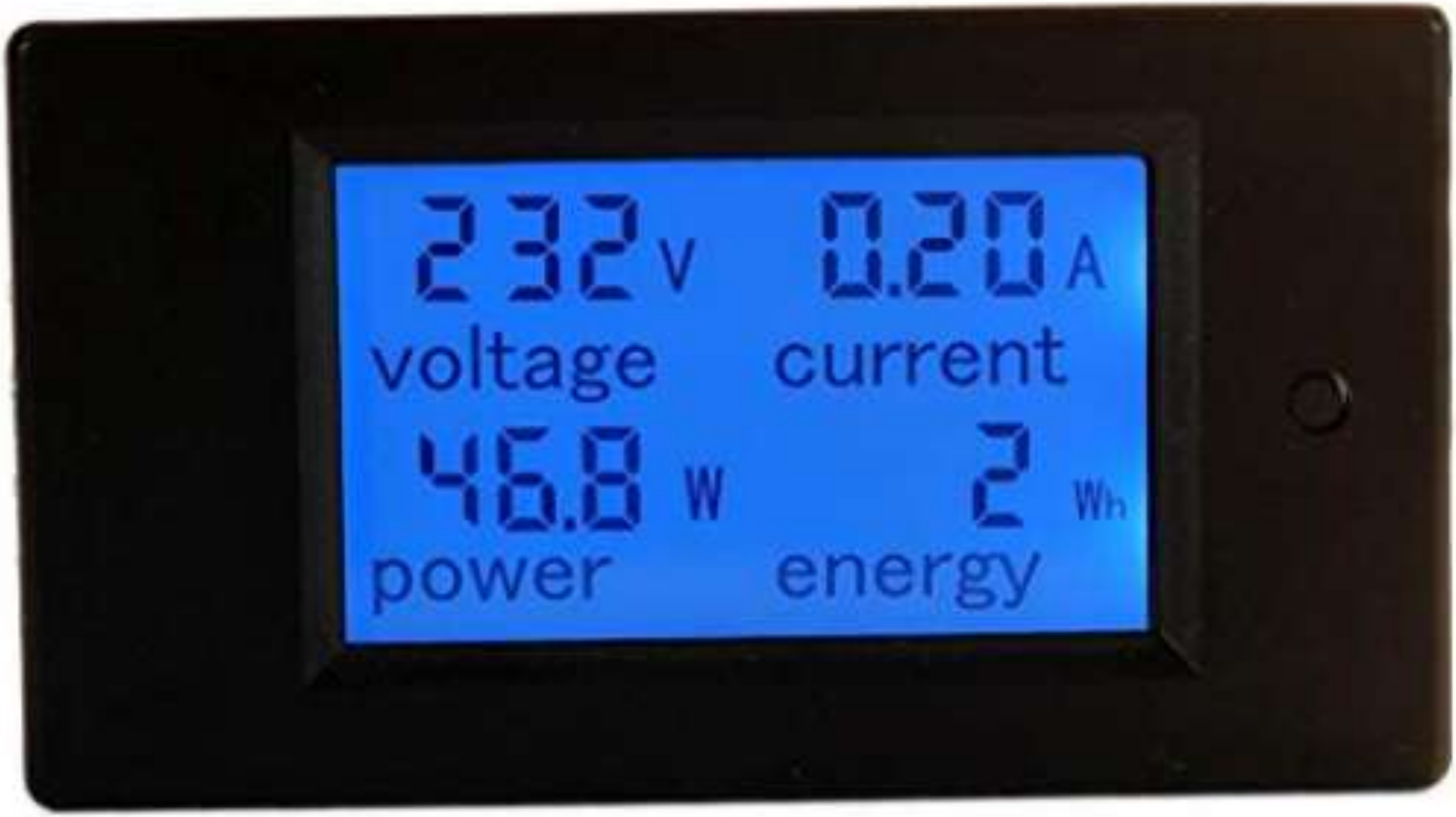
- 8 Channel electronic organ
- 8 Digital outputs are summed to a left voice and a right voice through an array of 100KΩ resistors.
- Left and right voices are amplified by a speaker.
- A musette dance and a fugue.

Questions?

AC Power Meter

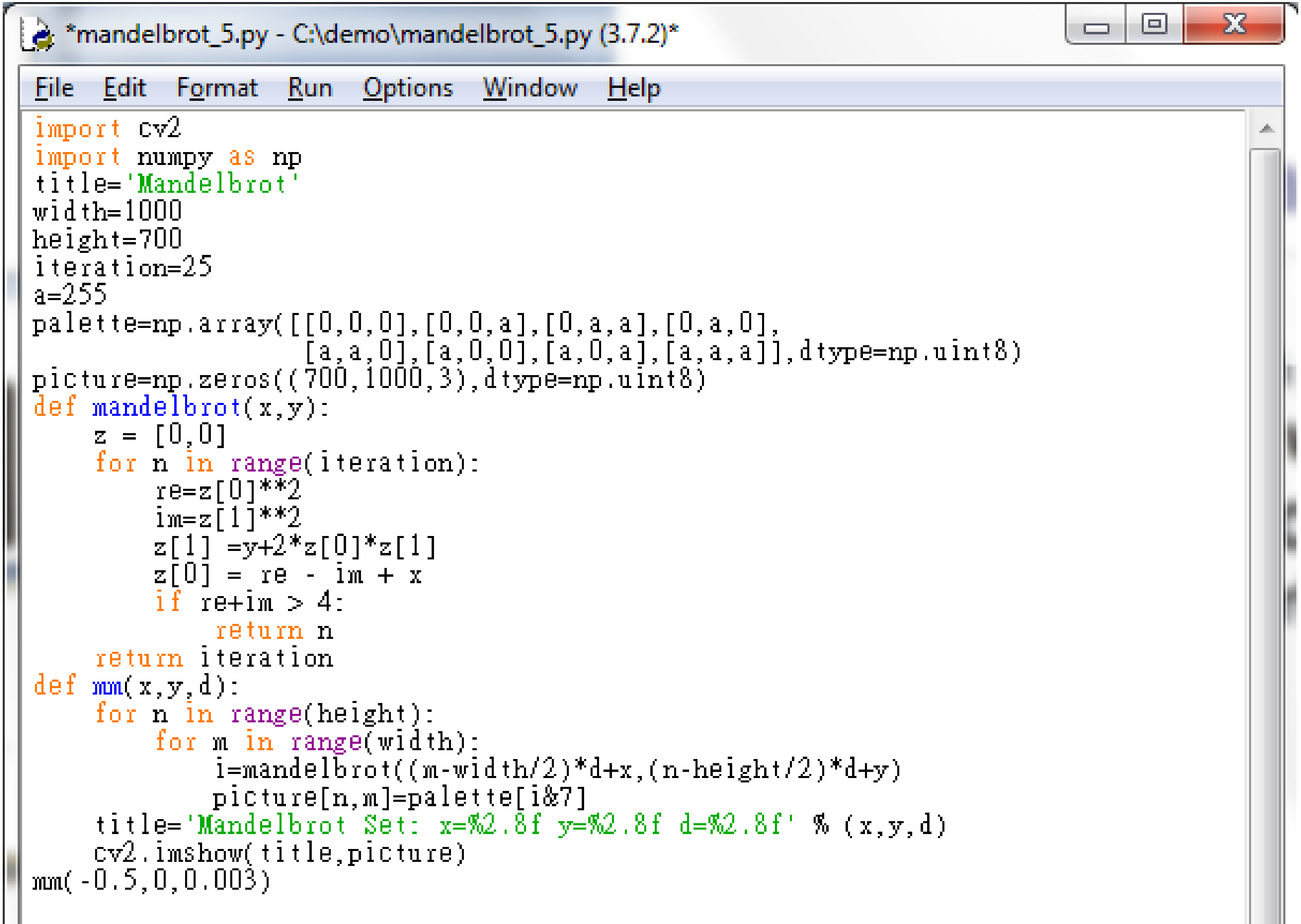
- HiLetgo Digital Multimeter AC 80-260V 100A PZEM-061
- LCD Display
- Digital Current Voltage Power Energy Multimeter

AC Power Meter

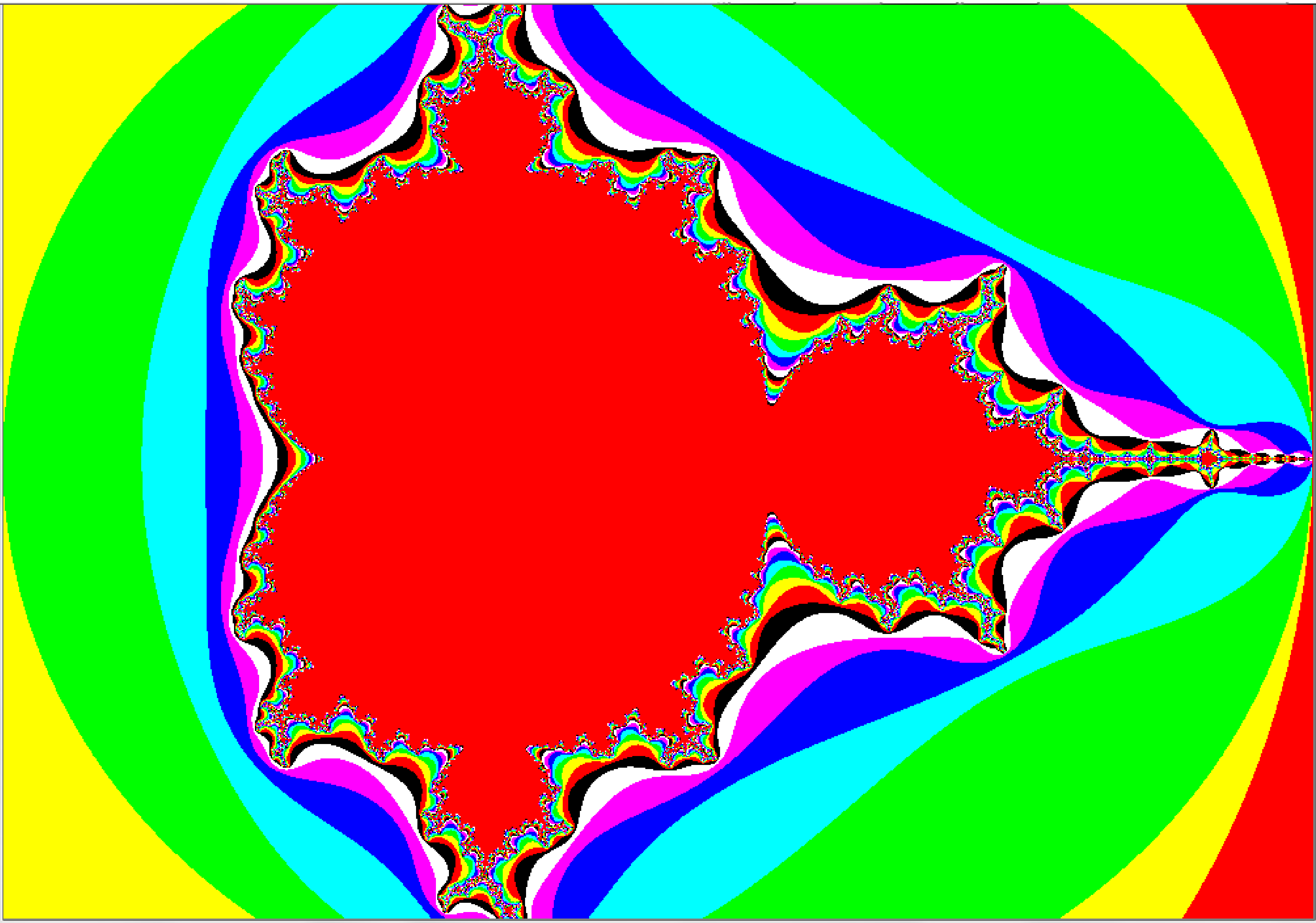


Python Mandelbrot

- I had the Forth program to draw colored digital world maps.
- I used Python CV2 to piece together a short video showing the rotating earth.



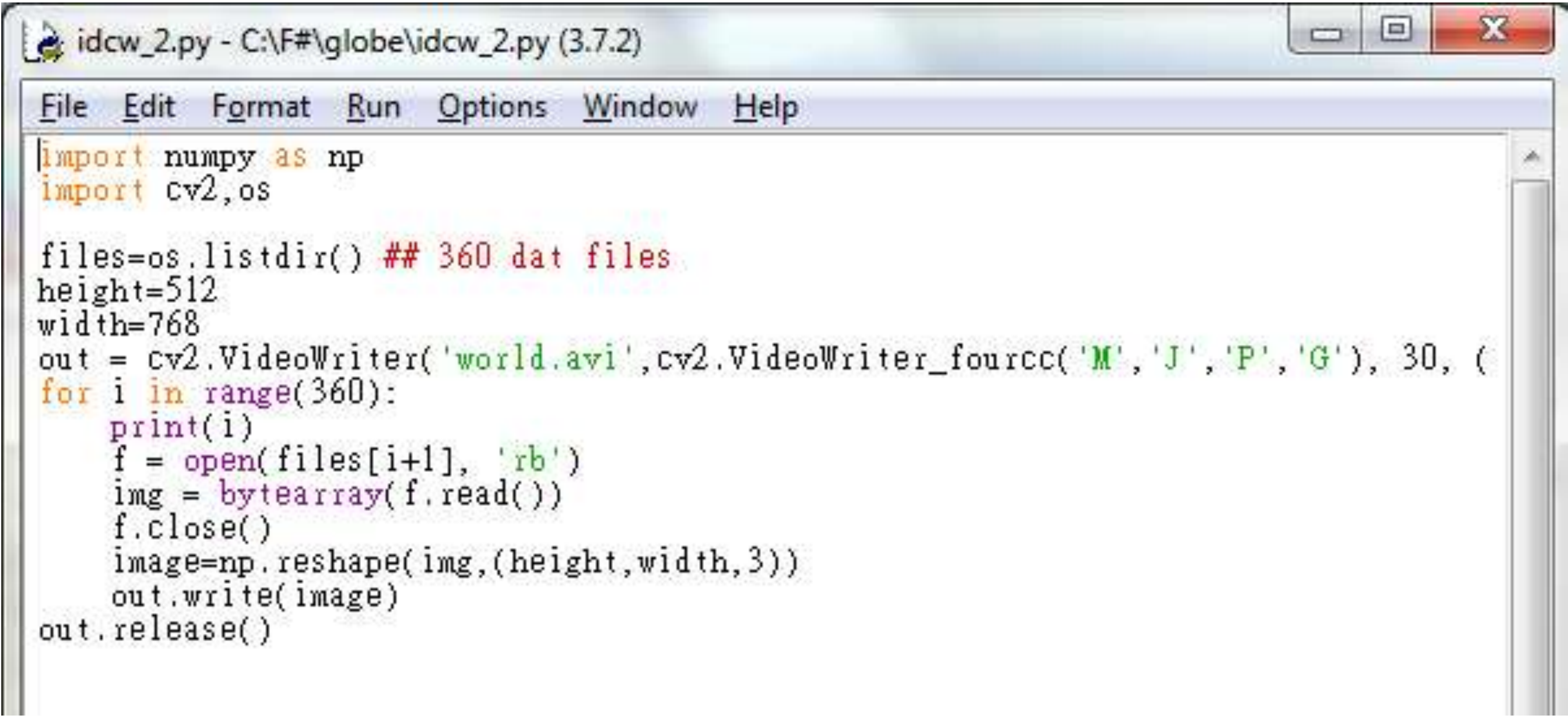
```
import cv2
import numpy as np
title='Mandelbrot'
width=1000
height=700
iteration=25
a=255
palette=np.array([[0,0,0],[0,0,a],[0,a,a],[0,a,0],
                  [a,a,0],[a,0,0],[a,0,a],[a,a,a]],dtype=np.uint8)
picture=np.zeros((700,1000,3),dtype=np.uint8)
def mandelbrot(x,y):
    z = [0,0]
    for n in range(iteration):
        re=z[0]**2
        im=z[1]**2
        z[1] =y+2*z[0]*z[1]
        z[0] = re - im + x
        if re+im > 4:
            return n
    return iteration
def mm(x,y,d):
    for n in range(height):
        for m in range(width):
            i=mandelbrot((m-width/2)*d+x,(n-height/2)*d+y)
            picture[n,m]=palette[i&7]
    title='Mandelbrot Set: x=%2.8f y=%2.8f d=%2.8f' % (x,y,d)
    cv2.imshow(title,picture)
mm(-0.5,0,0.003)
```



Digital World

- I had the Forth program to draw colored digital world maps.
- I used Python CV2 to piece together a short video showing the rotating earth.

Digital World



```
import numpy as np
import cv2,os

files=os.listdir() ## 360 dat files
height=512
width=768
out = cv2.VideoWriter('world.avi',cv2.VideoWriter_fourcc('M','J','P','G'), 30, (
for i in range(360):
    print(i)
    f = open(files[i+1], 'rb')
    img = bytearray(f.read())
    f.close()
    image=np.reshape(img,(height,width,3))
    out.write(image)
out.release()
```

MIDI and Karaoke

- Dr. Lue Liu gave me 500 songs from his HymnMaster player.
- I converted these song files into MIDI files.
- I can now add lyrics and build Karaoke files.

Thank you.