# ESP32
# LCD Controller Manual


This manual describes the features of the LCD Controller module as a stand-alone entity. All information about lab instruments that use this controller is contained in their individual manuals.

This manual is intended as a reference, construction and commissioning details are available in the relevant Silicon Chip article.

## Contents

# Features

| | |
|---|---|
| Processor: | ESP32. 32-bit, 240MHz, dual core. |
| Memory: | 4MB Flash, 520k RAM, full-size and micro SD CARD sockets |
| Display: | 2.8” or 3.5” colour LCD touch screen. Jumper-selectable touch screen interrupt. |
| User interface: | LCD touch panel<br>Rotary encoder and up/down buttons<br>Separate start/stop buttons with LED indicator |
| Flexible configuration: | Switches and encoder are detachable, allowing flexibility of controls and panel layout.<br>Several functions |
| IO and Expansion: | 20 pin connector carrying power,<br>Serial RXD/TXD,<br>I2C with an optional second channel<br>SPI – shared with the LCD display and SD-CARD<br>2 x 8-bit DAC (200kHz)<br>2 x 12-bit ADC (27kHz under non-DMA operation)<br>3 uncommitted GPIO pins.<br>17 total GPIO pins. All specialist pins other than SPI, can be repurposed as GPIO and PWM.<br>Additional GPIO pins are available if onboard switches and encoder are not required, via the REM_ON_OFF and REM_SCRUB headers. |
| Communication: | WiFi (802.11 b/g/n 2.4GHz). 150 Mbps maximum throughput.<br>QoS (802.11 e) for multimedia applications.<br>Station or soft-AP modes, TCP, UDP, mDNS over IPV4 and IPV6.<br>Webserver and web client functions.<br>Bluetooth and BLE<br>TTL and USB serial.<br>Extensive examples provided for all communication modes. |
| Powering: | USB<br>5-12V via barrel jack and regulator<br>5V via expansion header<br>3.3V up to 50mA available, via the ESP32’s onboard regulator. |
| Updating | Arduino (and other IDE) native programming<br>Off-the-air (OTA) binary uploads. |

SCPI over WiFi (802.11 b/g/n/e/i) for PC control or master control of multiple modules.

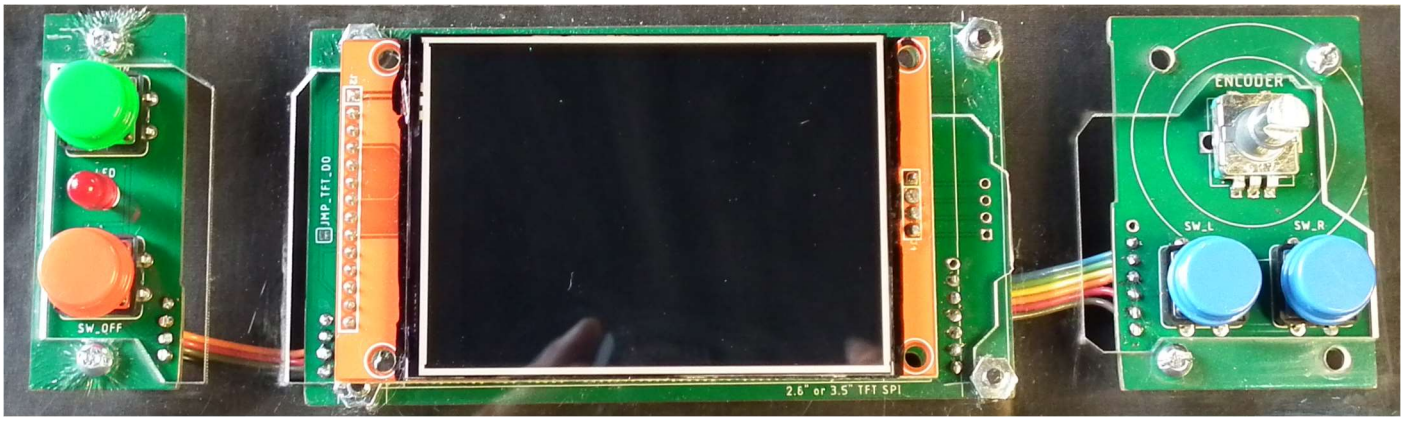
# Overview

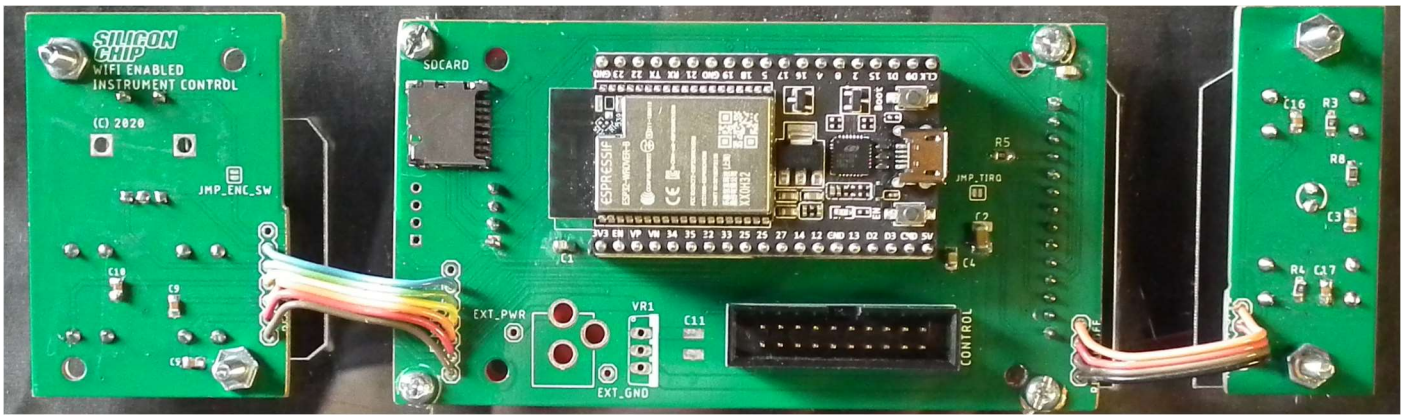
The controller module consists of a central section with the display on the front and the ESP32 DevKitC module plugged into headers on the rear. Standard 2.8” or 3.5” SPI touchscreen LCD modules are supported.

To one side of the LCD is a detachable panel containing a LED and two tactile switches, intended as on/off buttons.

On the other side two momentary switches and a rotary encoder are mounted on a second detachable panel, intended to complement the on-screen touch menu, in setting the instrument’s configuration and control values.

The controller’s expansion capabilities are provided on a 20 pin header and include I2C, SPI, serial, GPIO, ADC, DAC and power (3.3V and 5V) pins. It can be powered via a USB cable, an external 7-12V plugpack, or from the ‘controlled’ board.




In the pictures above, the side panels have been separated from the central section, and the components for external powering (barrel jack and regulator) have been omitted.

While 3.3V power is available from the EPS32 module, a maximum of 50mA should be drawn from this source.

ESP32 IO pins are not 5V tolerant.

# ESP32 Pinout and Expansion Connector

Any ESP32 pin, other than SPI, may be repurposed as a GPIO or PWM pin.

Several ESP32 pins (GPIO 0, 2, 12, 14, 15, TXD, RXD) have special functions during the boot cycle and should be used carefully for other purposes.

## Expansion Header

| Exp. Pin | Function | GPIO | ESP32 Pin |
|---|---|---|---|
| 1 | GND | | 14, 32, 38 |
| 2 | | | |
| 3 | SPI: MISO | 19 | 31 |
| 4 | SPI: SCK | 18 | 30 |
| 5 | I2C: SDA | 21 | 33 |
| 6 | SPI: MOSI | 23 | 37 |
| 7 | I2C: SCL | 22 | 36 |
| 8 | GPIO or I2C: SDA-1 | 0 | 25 |
| 9 | GPIO 2 | 2 | 24 |
| 10 | TTL Serial: RXD-2 | 16 | 27 |

| Exp. Pin | Function | GPIO | ESP32 Pin |
|---|---|---|---|
| 11 | TTL Serial: TXD-2 | 17 | 28 |
| 12 | SW_ON | 4 | 26 |
| 13 | DAC1 or GPIO | 25 | 9 |
| 14 | DAC2, GPIO or SCL-1 | 26 | 10 |
| 15 | ADC1-7 or GPIO (input) | 35 | 6 |
| 16 | SW_OFF | 12 | 13 |
| 17 | ADC1-6 or GPIO (input) | 34 | 5 |
| 18 | +5V | | 19 |
| 19 | +3.3V | | 1 |
| 20 | +5V | | 19 |

## REM_ON_OFF Header

| Exp. Pin | Function | GPIO pin |
|---|---|---|
| 1 | GND | |
| 2 | +3.3V | |
| 3 | SW_OFF | 12 |
| 4 | SW_ON | 4 |

## REM_ENC Header

| Exp. Pin | Function | GPIO pin |
|---|---|---|
| 1 | GND | |
| 2 | +3.3V | |
| 3 | CRTL_L | 14 |
| 4 | CTRL_R | 27 |
| 5 | ENC_A | 33 |
| 6 | ENC_B | 32 |
| 7 | Encoder switch (jumper LK3) | 26 |

## ESP32 Pin Assignments

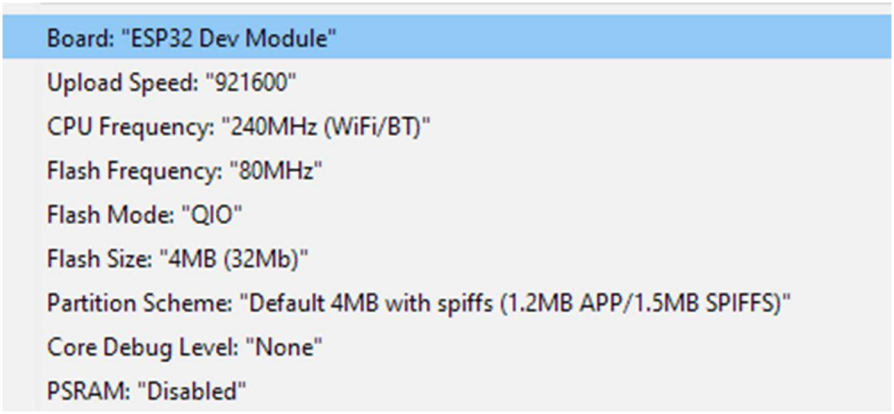
| ESP32 Pin | Function | GPIO pin | | ESP32 Pin | Function | GPIO pin |
|---|---|---|---|---|---|---|
| 1 | 3V3 power (output) | | | 20 | DO NOT USE | |
| 2 | DO NOT USE | | | 21 | SD0, SD1, CLK | |
| 3 | EN, SVP, SVN | | | 22 | | |
| 4 | | | | 23 | Touch CS | 15 |
| 5 | ADC1-6 or GPIO | 34 | | 24 | SD CS | 2 |
| 6 | ADC1-7 or GPIO | 35 | | 25 | GPIO, SDA-1 | 0 |
| 7 | Encoder | 32 | | 26 | On switch | 4 |
| 8 | Encoder | 33 | | 27 | GPIO, RXD2 | 16 |
| 9 | DAC1 or GPIO | 25 | | 28 | GPIO, TXD2 | 17 |
| 10 | DAC2, GPIO or SCL-1 | 26 | | 29 | TFT CS | 5 |
| 11 | Switch R (rotary encoder side) | 27 | | 30 | SCK | 18 |
| 12 | Switch L (rotary encoder side) | 14 | | 31 | MISO | 19 |
| 13 | Off switch | 12 | | 32 | GND | |
| 14 | GND | | | 33 | SDA | 21 |
| 15 | D_C (TFT) | 13 | | 34 | RXD | RXD |
| 16 | DO NOT USE | | | 35 | TXD | TXD |
| 17 | SD2, SD3, CMD | | | 36 | SCL | 22 |
| 18 | | | | 37 | MOSI | 23 |
| 19 | 5v power (input) | | | 38 | GND | |

# Software and Libraries

The controller can be programmed using the Arduino IDE by loading the ESP32 files into Board Manager.

- Add the entry https://dl.espressif.com/dl/package_esp32_index.json to the *Additional Boards Manager URLs* list in the File > Preferences menu.
- Open the Boards Manager (*Tools* > *Board* > *Board Manager*) search for ESP32 and click 'Install.'

- The board settings used for the Expressif DevKitC (WROOM 32) boards are:




The controller has been tested with the following general Arduino libraries:

- Adafruit GFX graphics.
- Adafruit ILI9488 and ILI9341.
- XPT2046_Touchscreen (Paul Stoffregen) in polled mode.
- ESProtary and Button2 (Lennart Hennigs) – ESP8266 libraries work on ESP32.
- ESP32 WiFi and EEPROM libraries.
- Adafruit ADS1015.

The ESP32 DevKitC example programs *File* > *Examples* > *Examples for ESP32 Dev Module* should function correctly.

The board may be programmed via USB serial or over WiFi, as explained in the ESP32 *Update* > *OTA example.*

Other programming environments, compatible with the ESP32, may also be used.

# Communications

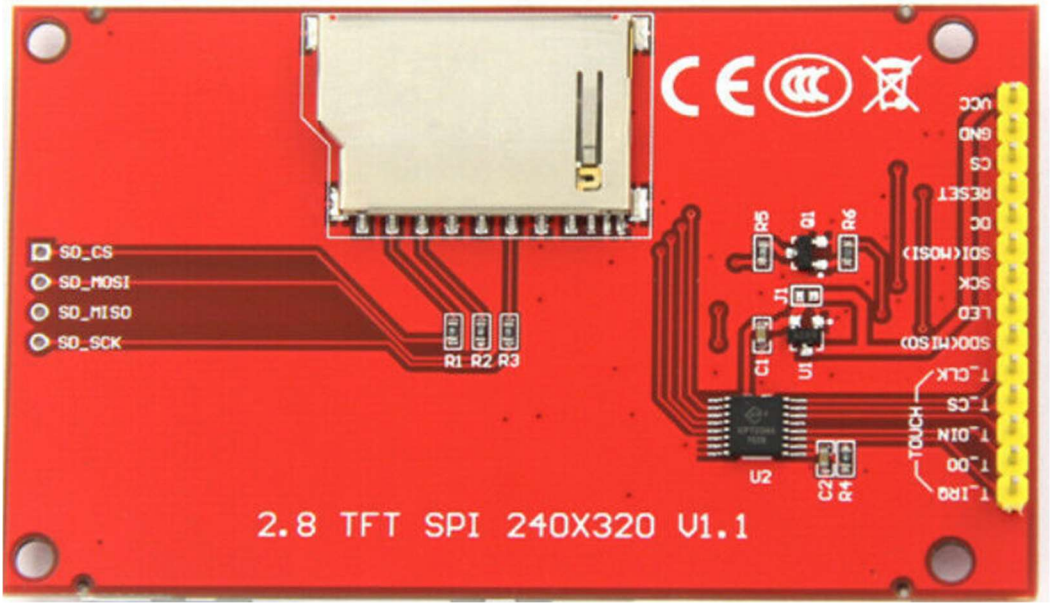
Multiple comms channels are supported, and can be used as described in the example programs for the ESP32.

- USB serial – which should be *isolated* if an alternate ground path is possible.
- WiFi - TCP/IP, UDP and Telnet are all supported.
  Note: WPS connection does not function reliably with the ESP32 modules (as at January 2021).
- Serial (logic-level) up to 1MHz or more.

ESP32 pins have only modest protection against static electricity and wrong voltages (they are not 5V tolerant). Therefore, they should not be connected directly to remote equipment. Use opto-isolators or a RS232 or RS485 converter for serial communications.

# Display

The controller can support any SPI LCD module with the same pinouts as the popular ILI9341 (2.8” 240 x 320) or ILI9488 (3.5” 320 x 480) Arduino modules. The SD card pins on the controller are aligned specifically for these two displays.




MOSI and SCK are shared between the LCD screen, touch panel and the onboard SD card.

Do not connect MISO if using an ILI9488 controller as it does not release the MISO line when CS is inactive. MISO is available to the TFT via a jumper LK4 for other controllers.

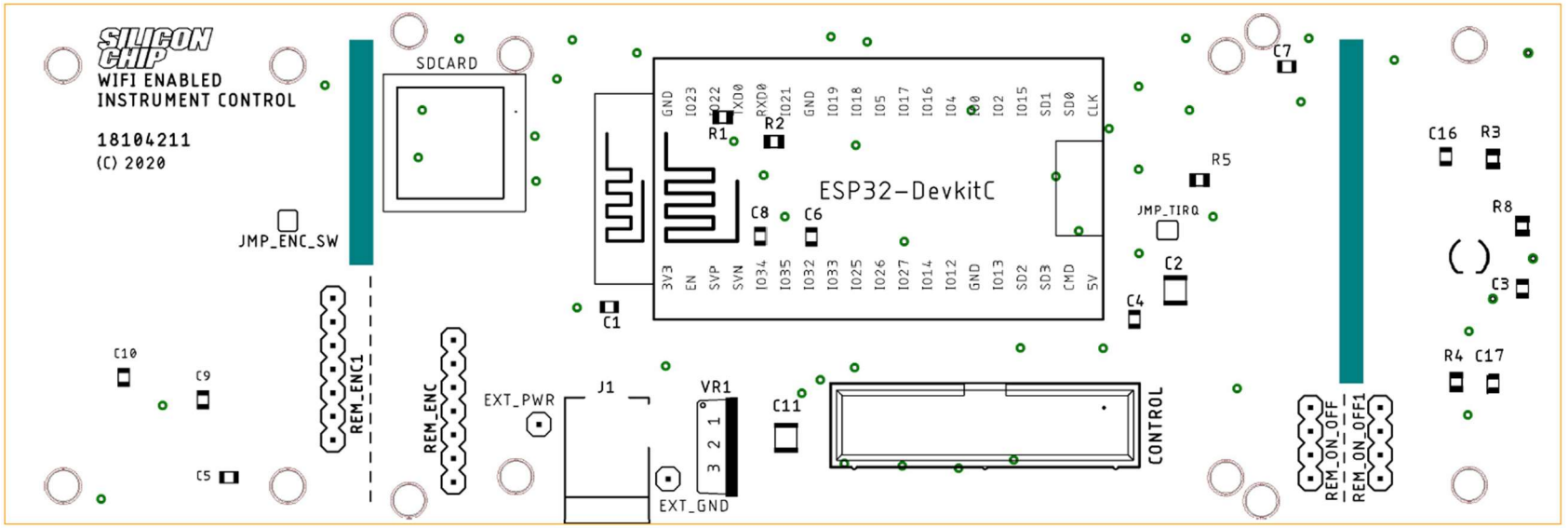
The interrupt pin for the touch panel controller is shared with SD_CS and is enabled by bridging LK1.

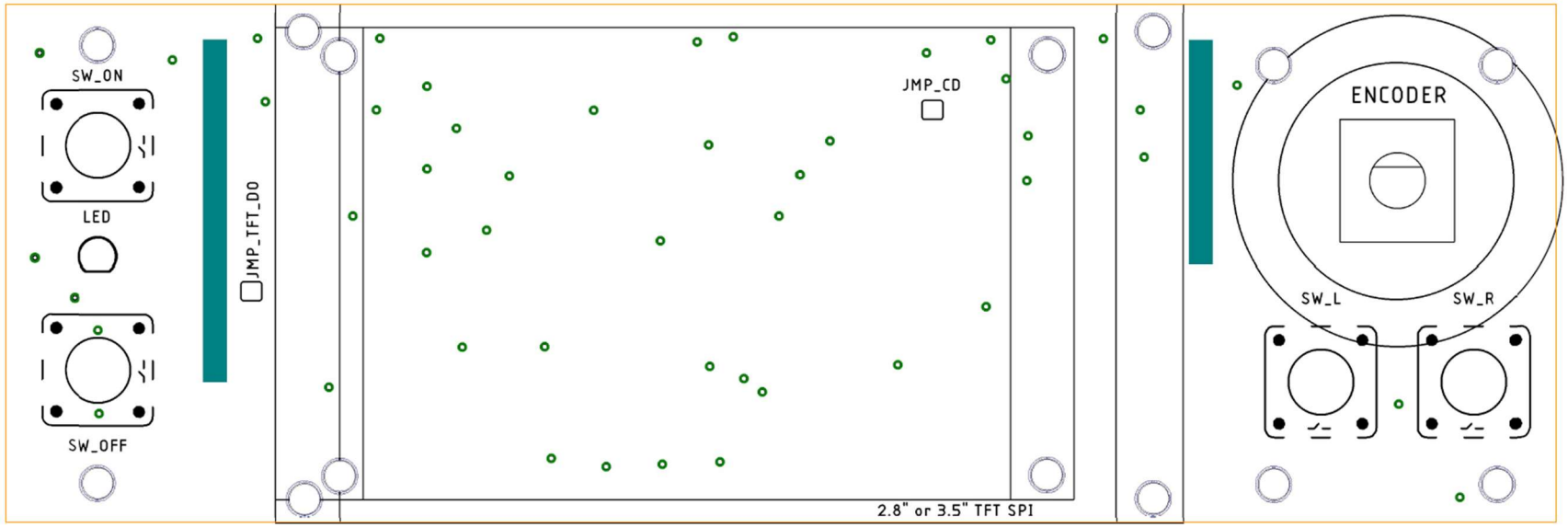
| **Signal** | **Pin (ESP 32 DevKitC)** | **ESP Logical** | **Use** |
|---|---|---|---|
| MOSI | 37 | IO 23 | TFT, Touch, SD |
| MISO | 31 | IO 19 | Touch, SD (Jumper for TFT) |
| SCK | 30 | IO 18 | TFT, Touch, SD |
| RST | N/C – pullup | – | TFT |
| DC | 15 | IO 13 | TFT |
| CS | 29 | IO 5 | TFT |
| T_CS | 23 | IO 15 | Touch |
| SD_CS | 24 | IO 2 | SD |
| T_IRQ | 24 | IO 2 | Touch |
| LED & VCC | 5V | – | All |

# Troubleshooting

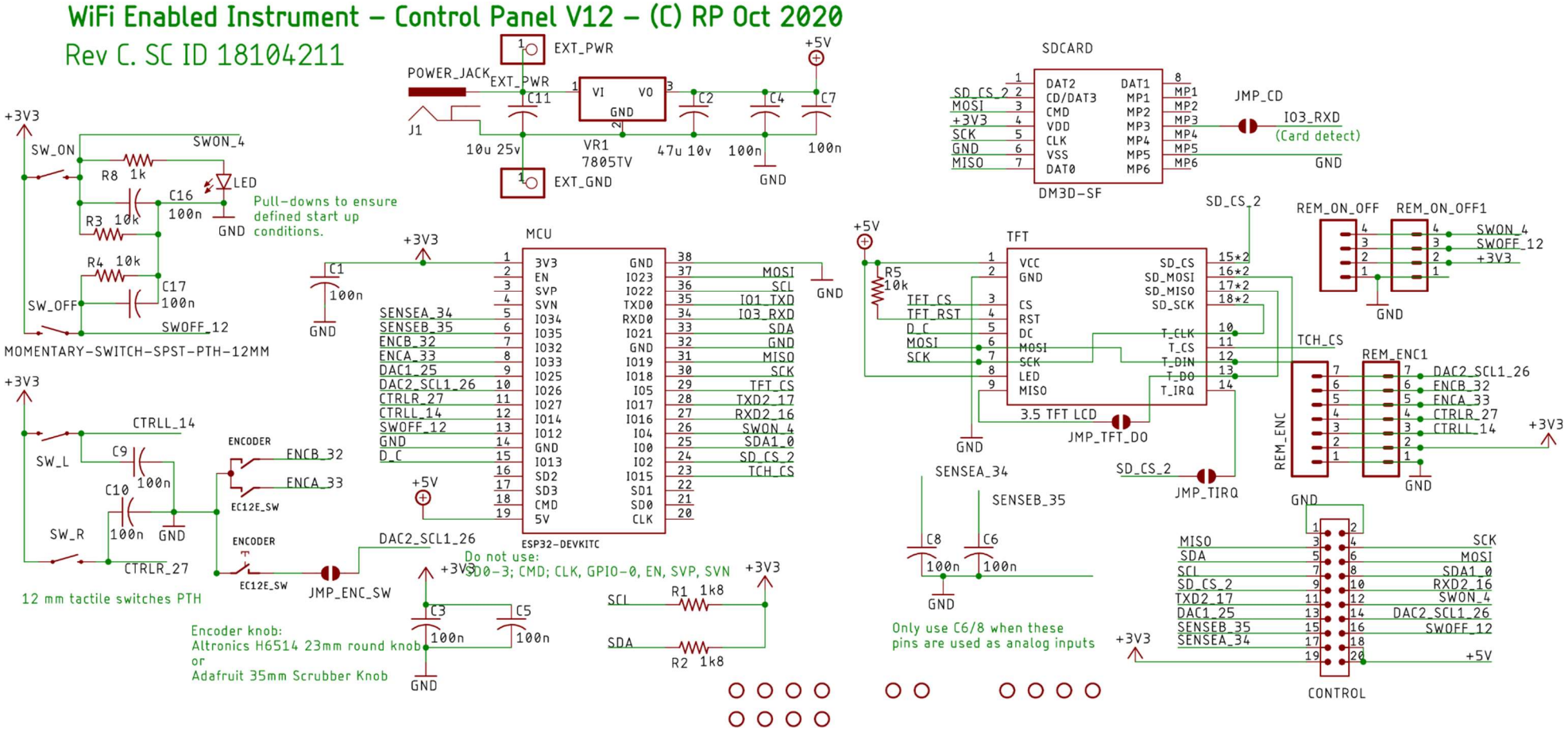
| Symptom | Likely cause | Remediation |
|---|---|---|
| Touch panel not responding. | Touch panel is rotated 180° from LCD. | Rotate the touch panel 180° by changing the touchscreen's screenRotation() parameter (1 or 3 is usually correct for horizontal screen orientation) |
| Touch not centred on required screen coordinates. | Touch panel out of register with LCD. | Calibrate the touch panel (library dependent). |
| Rotary encoder skipping values or moving multiple steps per click. | Processing too slow to capture all pulses. | Faster processing cycle – particularly using non-blocking code, interrupt-driven encoder processing. |
| | Encoder missing steps or not scaling steps : clicks correctly. | Faster processing cycle (see above).<br>Change the encoder steps_per_click setting.<br>Buy a new encoder! |

# PCB Layouts


SILICON CHIP
WIFI ENABLED
INSTRUMENT CONTROL
18104211
(C) 2020
SDCARD
JMP_ENC_SW
REM_ENC1
REM_ENC
EXT_PWR
J1
EXT_GND
VR1
ESP32-DevkitC
JMP_TIRQ
CONTROL
REM_ON_OFF
REM_ON_OFF1


SW_ON
LED
SW_OFF
JMP_TFT_DO
JMP_CD
2.8" or 3.5" TFT SPI
ENCODER
SW_L
SW_R

# Schematic


WiFi Enabled Instrument – Control Panel V12 – (C) RP Oct 2020
Rev C. SC ID 18104211
POWER_JACK
EXT_PWR
EXT_GND
VR1
7805TV
10u 25v
47u 10v
100n
+5V
GND
+3V3
SW_ON
SWON_4
R8 1k
LED
C16
R3 10k
R4 10k
C17
SW_OFF
SWOFF_12
MOMENTARY-SWITCH-SPST-PTH-12MM
Pull-downs to ensure defined start up conditions.
MCU
ESP32-DEVKITC
SENSEA_34
SENSEB_35
ENCB_32
ENCA_33
DAC1_25
DAC2_SCL1_26
CTRLR_27
CTRLL_14
SWOFF_12
D_C
MOSI
SCL
IO1_TXD
IO3_RXD
SDA
MISO
SCK
TFT_CS
TXD2_17
RXD2_16
SWON_4
SDA1_0
SD_CS_2
TCH_CS
CTRLL_14
SW_L
SW_R
CTRLR_27
ENCODER
EC12E_SW
JMP_ENC_SW
12 mm tactile switches PTH
Encoder knob:
Altronics H6514 23mm round knob
or
Adafruit 35mm Scrubber Knob
Do not use:
SDD0-3; CMD; CLK, GPIO-0, EN, SVP, SVN
R1 1k8
R2 1k8
SDCARD
DM3D-SF
JMP_CD
IO3_RXD
(Card detect)
TFT
3.5 TFT LCD
JMP_TFT_DO
JMP_TIRQ
REM_ON_OFF
REM_ON_OFF1
REM_ENC
REM_ENC1
SENSEA_34
SENSEB_35
Only use C6/8 when these pins are used as analog inputs
CONTROL