ESP32 Command Station with LCC, I2C and RailCom

5V Supply
U1 LM2675N-5
DCC-VS — VIN 7, ON/OFF 5, GND 6, FB 4, CB 3, VSW 8 — +5V
C1 100uF, C2 0.1uF, C3 0.01uF, L1 68uH, C4 47uF, C13 DNP
D1 SB240, D5 SB530

DCC Power and Track Output connections
J1 DCC-POWER, GND, DCC-VS
J3 OPS PROG
C6 10nF, C7 10nF, R17 2R4, R18 2R4
OPS-A, OPS-B, PROG-A, PROG-B

Note: Either DCC-POWER pin 1 or 3 should be used as BOOSTER-COMMON

LCC CAN interface
U4 MCP2551
CAN-TX — TXD 1, VDD 3, CANH 7 — CAN-H
CAN-RX — RXD 4, CANL 6 — CAN-L
Vref 5, Rs 8, VSS 2
R20 5K, R19 10K, R21 10K
CAN1 LCC-CAN, CAN2 LCC-CAN
CAN-PWR, GND, OPS-LCC-A, OPS-LCC-B, CAN-L, CAN-H

CAN-RX = (5v + R14) / (R15 + R14)
CAN-RX = (5v + 10000) / (5000 + 10000)
CAN-RX = 3.3v

DCC signal generator for PROG track and LCC ALT-H/L outputs
U5 L298 (PROG/LCC-DCC)
C10 100nF
PROG-SIG — IN1 5, PROG-SIG-INV — IN2 7, PROG-EN — EnA 6
OPS-SIG — IN3 10, OPS-SIG-INV — IN4 12, OPS-EN — EnB 11
OUT1 2 — PROG-A, OUT2 3 — PROG-B, OUT3 13 — OPS-LCC-A, OUT4 14 — OPS-LCC-B
PROG-DCC-VS
U6C LM358
R22 0R15, R23 1K, R26 10K, U6A LM358 — PROG-SENSE

Note: LOW side current sense is being used for the PROG track output. OPS-LCC output is not monitored.

PROG/LCC-DCC Supply
R2 2R7, R4 4K7, Q2 2N3906, Q5 TP0606, R1 4K7
DCC-VS — PROG-DCC-VS
Note: current limited to 250mA.

RailCom Reference Voltage
R11 3.5K 1%, R12 20 1%, C5 1uF — RAILCOM-VREF
RAILCOM-VREF = (3v3 + R9) / (R8 + R9)
RAILCOM-VREF = (3v3 + 20) / (3500 + 20)
RAILCOM-VREF = 19mA

RailCom FET gate enable circuit
R8 1K5 1/2W, R10 10K
Q1 2N7000, Q3 2N7000, Q7 2N7000, Q9 2N7000
R3 10K, R13 2K4
RAILCOM-GATE-EN, RAILCOM-SHORT, RAILCOM-EN
DCC-VS

ESP32 Microcontroller (TTGO-T1 or DevKit-C) module.
U3 ESP32-Module
RESET SW1
I2C-SDA 23, I2C-SCL 22, LED, PROG-SIG 19, PROG-EN 18, OPS-SIG 17, OPS-EN 16
SD-MOSI-MTDO 15, SD-CLK-MTDI 14, SD-CS-MTCK 13, MTMS 12
PROG-SENSE 39, OPS-SENSE 36, RAILCOM-DIR 35, RAILCOM-SHORT 34, RAILCOM-DATA 33, OPS-BRAKE 32
RAILCOM-EN 27, UART1-TX 26, UART1-RX 25
OPS-THERM, CAN-TX, CAN-RX, SD-MISO

Note: The reset switch connected to EN does not have a pull-up to 3v3 as the module has this already.

DCC Signal generation for OPS track
U7 LMD18200 OPS
DCC-VS, C12 1uF
OPS-A — OUTPUT1 1, C8 10nF, C9 10nF(.10nF), BOOTSTRAP1, BOOTSTRAP2, OUTPUT2 10 — OPS-B
PWM 5 — OPS-EN, DIRECTION 3 — OPS-SIG, BRAKE 4 — OPS-BRAKE
CURRENT_SENSE_OUTPUT, THERMAL_FLAG_OUTPUT
OPS-THERM, OPS-SENSE
R25 2K7, C11 .1uF

Note: The CURRENT_SENSE_OUTPUT is an INLINE output from the h-bridge

When using a DevKit-C (or compatible) ESP32 module it is recommended to use an SD card SPI module.
SD-MODULE J2
+3V3, SD-CS-MTCK, SD-MOSI-MTDO, SD-CLK-MTDI, SD-MISO, GND

JTAG debugger connection
JTAG J4
GND, +5V, SD-MOSI-MTDO, SD-CLK-MTDI, SD-CS-MTCK, MTMS

Note: There are shared pins with the SD card module and it may be necessary to eject the SD card when debugging/flashing.

Command Station expansion ports
J5 I2C: GND, +5V, I2C-SDA, I2C-SCL
J6 I2C: GND, +5V, I2C-SDA, I2C-SCL
J7 UART1: GND, +5V, UART1-RX, UART1-TX

OPS track RailCom detection circuit
U2A LM393, U2B LM393, U2C LM393
R6 10K, D2 DNP, R15 2K4, R16 2K4, R14 10K, D3 DNP, D4 1N5817
RAILCOM-DATA, RAILCOM-DIR, RAILCOM-VREF
R5 2R4, R9 2R4, R7 10K
Q4 STD12NF06, Q10 STD12NF06, Q6 DTC143E, Q8 DTC143E
OPS-A, OPS-B
RAILCOM-GATE-EN, RAILCOM-SHORT
+3V3

Command Station status output RGB LEDs
LED-PIN1, LED-PIN2
WIFI D6, OPS D7, PROG D8, APA106
GND, +5V, LED

WiFi:
GREEN = connected
GREEN [FLASHING] = connecting
RED = disconnected
YELLOW = connection failure
YELLOW [FLASHING] = SSID not found

OPS:
GREEN = ON
BLACK = OFF
RED = FAULT/SHORT
RED [FLASHING] = THERMAL FAULT

PROG:
GREEN = ON
BLACK = OFF
RED = FAULT/SHORT

Note: LED-PIN1 and LED-PIN2 set to the APA106 (included in PCB kit).
For WS2812B LEDs cut the traces and add a solder bridge to the opposite pad.

OPS Track expansion port
OPS-EXT J8
GND, +5V, OPS-SIG

PROG track signal split for L298 h-bridge
R24 1K, Q11 2N3904
PROG-SIG-INV, PROG-SIG, +5V

OPS track signal split for L298 h-bridge
R27 1K, Q12 2N3904
OPS-SIG-INV, OPS-SIG, +5V

H1 MountingHole, H2 MountingHole, H3 MountingHole, H4 MountingHole