ESP32 Microcontroller (TTGO-T1 or DevKit-C) module.

+5V +3V3

RESET
SW1
GND

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

GND 5V 3v3 EN

ESP32-Module
U1

Pin	Signal		Pin	Signal
23	I2C-SDA		39	PROG-SENSE
22	LED		36	OPS-SENSE
21	I2C-SCL		35	CAN-RX
19	PROG-SIG		34	FACTORY-RESET
18	PROG-EN		33	RAILCOM-DATA
17	OPS-SIG		32	CAN-TX
16	UART1-RX		27	RAILCOM-EN
15	SD-MOSI		26	RAILCOM-DIR
14	SD-CLK		25	OPS-BRAKE
13	SD-CS			
12				

0 1 2 3 4 5

UART1-TX
OPS-EN
SD-MISO

Track Output connections

OPS   PROG
J1

OPS-1
OPS-2
PROG-A
PROG-B

Command Station expansion ports

I2C   J2   I2C   J3   UART1   J4

GND   GND   GND
+5V   +5V   +5V

I2C-SDA
I2C-SCL
I2C-SDA
I2C-SCL
UART1-RX
UART1-TX

I2C is only used today for OLED/LCD
devices. UART1 currently unused but
will be in the future.

SD Module connection

SDCARD   J5

+3V3   GND

SD-CS
SD-MOSI
SD-CLK
SD-MISO
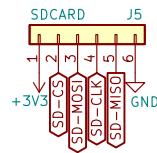
When using a DevKit-C (or compatible)
ESP32 module it is recommended to
use an SD card SPI module. This is to
reduce the wear on the on-board
FLASH and to allow updating the CS
in the future. For the TTGO-T1 this
is not used since it has this on-board.

+3V3
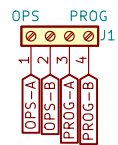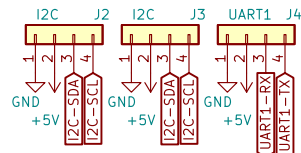
R1
10K   Factory Reset

FACTORY-RESET
SW2   GND

The factory reset jumper can be used to clear
all persistent configuration data during startup.
It is not recommended to keep this jumper in
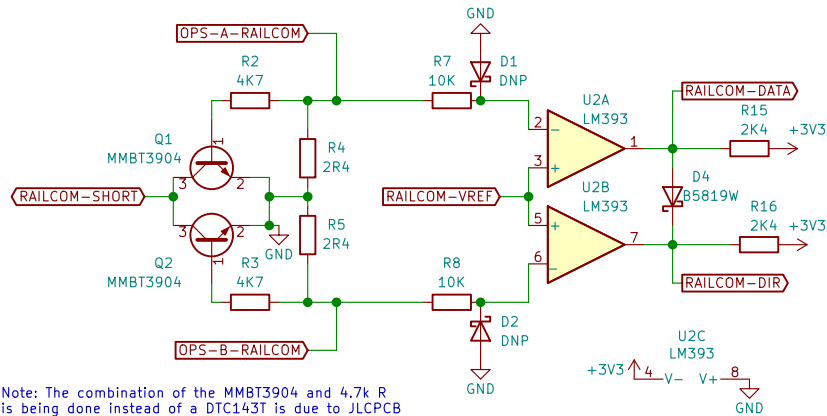place during normal operation.

H1
MountingHole
H2
MountingHole
H3
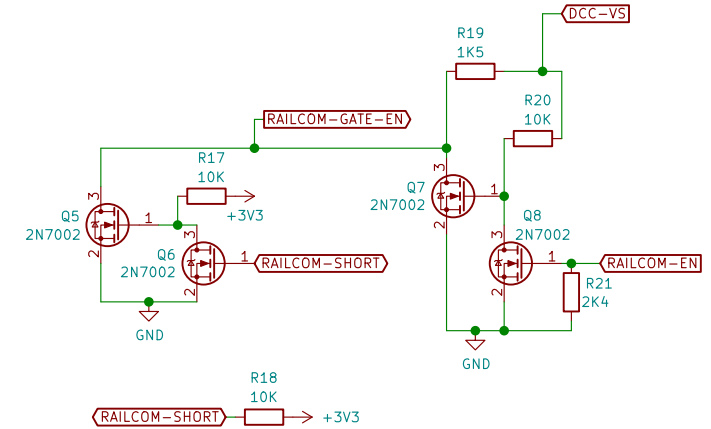MountingHole
H4
MountingHole

Sheet: /
File: pcb.sch

Title: ESP32 Command Station with LCC and RailCom

Size: B   Date: 2020-06-21   Rev: 1.3
KiCad E.D.A. kicad 5.1.6   Id: 1/8
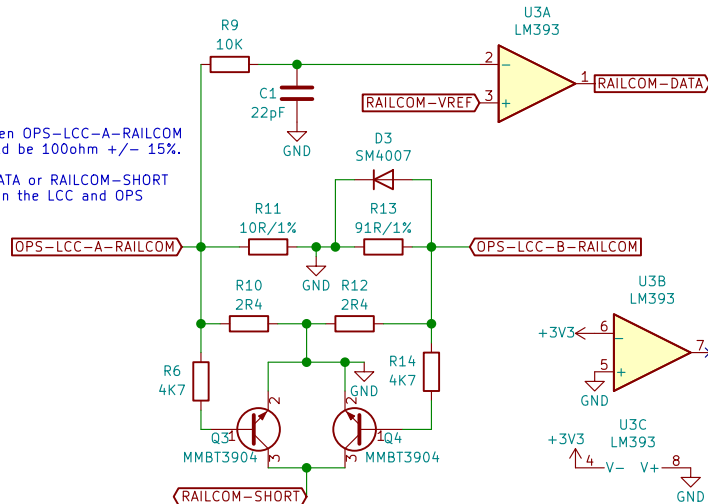
OPS Track RailCom detector circuit

RailCom FET gate enable circuit

OPS-A-RAILCOM
GND
R2 4K7
R7 10K
D1 DNP
RAILCOM-DATA
R15 2K4 +3V3
U2A LM393
Q1 MMBT3904
R4 2R4
RAILCOM-SHORT
R5 2R4
R3 4K7
GND
RAILCOM-VREF
U2B LM393
D4 B5819W
R16 2K4 +3V3
Q2 MMBT3904
OPS-B-RAILCOM
R8 10K
D2 DNP
GND
RAILCOM-DIR
+3V3
U2C LM393
+3V3 V- V+ 8
GND

Note: The combination of the MMBT3904 and 4.7k R is being done instead of a DTC143T is due to JLCPCB having the DTC143T as an "extended part" wheras MMBT3904 is a "basic part"

DCC-VS
R19 1K5
R20 10K
RAILCOM-GATE-EN
R17 10K
+3V3
Q7 2N7002
Q5 2N7002
Q6 2N7002
RAILCOM-SHORT
Q8 2N7002
RAILCOM-EN
R21 2K4
GND
GND
GND

R18 10K
RAILCOM-SHORT
+3V3
Force RailCom short to be HIGH by default.

Power Station Feedback Interface via LCC ports

R9 10K
U3A LM393
RAILCOM-DATA
C1 22pF
RAILCOM-VREF
GND

Note: The total resistance between OPS-LCC-A-RAILCOM and OPS-LCC-B-RAILCOM should be 100ohm +/- 15%.

No P/U is added to RAILCOM-DATA or RAILCOM-SHORT as these nets are shared between the LCC and OPS detectors.

D3 SM4007
R11 10R/1%
R13 91R/1%
OPS-LCC-A-RAILCOM
GND
OPS-LCC-B-RAILCOM
R10 2R4
R12 2R4
R6 4K7
R14 4K7
GND
Q3 MMBT3904
Q4 MMBT3904
RAILCOM-SHORT

U3B LM393
+3V3 6
5
7
+
GND

U3C LM393
+3V3 4 V- V+ 8
GND

Note: The combination of the MMBT3904 and 4.7k R is being done instead of a DTC143T is due to JLCPCB having the DTC143T as an "extended part" wheras MMBT3904 is a "basic part"

NOTE: The usage of two LM393 instead of one LM339 is due to JLCPCB having LM339 as an "extended part" and LM393 as a "basic part"

TP1 RAILCOM-EN
RAILCOM-EN
TP2 RAILCOM-DATA
RAILCOM-DATA
TP3 RAILCOM-SHORT
RAILCOM-SHORT

DCC signal generator for PROG track

350mA PTC fuses

C2
100nF
GND

C3
100nF

PROG-DCC-VS

F1
0ZCG0035AF2C
PROG-A

F2
0ZCG0035AF2C
PROG-B

DCC signal smoothing
R29   C6
2R4   10nF
PROG-B   PROG-A

U5
DRV8801PWPR

9	VBB	OUT+	7
14	VCP	OUT−	10
11	CP1		
12	CP2	SENSE	8 PROG-SENSE
2	MODE1		
16	MODE2	FAULT	1
3	PHASE	VPROPI	15
6	ENABLE		
5	SLEEP		

PROG-CP1
PROG-CP2
PROG-MODE1
PROG-MODE2

U4C
74HC08D
PROG-SIG   9
PROG-EN   10
8

PROG-EN

+5V
R24
10K

R25
10K   +5V

PROG-VPROPI

GND(PPAD)
GND
GND
17
4
13
GND

DCC activity LEDs
D5   R30
LED   10K
PROG-A

D6   R31
LED   10K
PROG-B

JP1
Enable PROG LEDs
1   2
GND

Note: these are using YELLOW 0805 LEDs,
alternatives can be substituted if desired.

U4E
74HC08D
7   GND   VCC   14   +5V
GND

R26
10K
PROG-VPROPI   PROG-SENSE

PROG-SENSE
R27
1R5
C5
33nF
GND

TP4   PROG-EN
PROG-EN
TP5   PROG-SIG
PROG-SIG

R22   R23
0R   0R
PROG-MODE1   PROG-MODE2
GND   GND

C4
100nF
PROG-CP1   PROG-CP2

PROG-EN
R28
10K
GND

C8
100nF
GND

C9
100nF

+12V

R35
10K
GND

+12V

D7
B5819W

350mA PTC Fuses

F3
0ZCG0035AF2C
OPS-LCC-A

F4
0ZCG0035AF2C
OPS-LCC-B

U6
DRV8801PWPR

9	VBB	OUT+	7
14	VCP	OUT−	10
11	CP1		
12	CP2	SENSE	8
2	MODE1		
16	MODE2		
3	PHASE	FAULT	1
6	ENABLE	VPROPI	15
5	SLEEP		

LCC-CP1
LCC-CP2
LCC-MODE1
LCC-MODE2

U4B
74HC08D
OPS-SIG
OPS-EN

4
5
6
3

OPS-EN

+5V
R34
10K

GND(PPAD)
GND
GND

17
4
13

GND

R36
1R

R37
10K

D8
B5819W

+12V

C7
100nF
LCC-CP1   LCC-CP2

R32
0R
LCC-MODE1
GND

R33
0R
LCC-MODE2
GND

RailCom FET Bridge for LCC Booster Feedback

Q9A
IRF7351TRPBF
OPS-LCC-A   8   1   OPS-LCC-A-RAILCOM

2

RAILCOM-GATE-EN

4

OPS-LCC-B   5   3   OPS-LCC-B-RAILCOM

Q9B
IRF7351TRPBF

PCB and DCC power supply connection

DCC-POWER
J6
3 2 1
GND GND

reverse
polarity
protection

D9
SS54 (5A)

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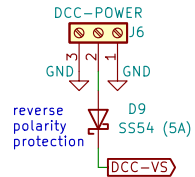
Note: Either DCC-POWER pin 1 or 3 should
be used as BOOSTER-COMMON

5V 1A switching step−down converter

DCC-VS

U8
LM2675N-5

7 VIN   FB 4
5 ON/OFF CB 1
     GND
6   VSW 8

C12
10nF

C11
100uF/50V

C15
10nF

+5V

L1
68uH

D10
SS210 (2A)

C16
100uF/50V

GND
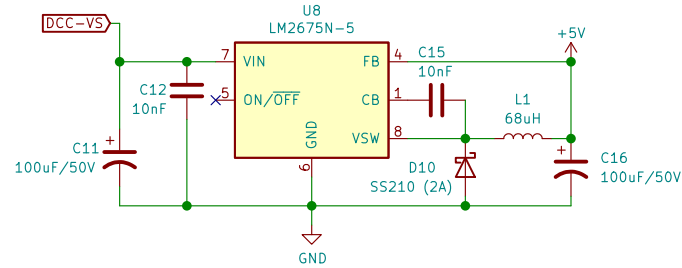
**Programming track DCC current limited
voltage supply (approx 250mA)**

DCC-VS

R41
2R7

R42
4K7

Q10
MMBT3906

Q11
DMP3099L-7

R40
4K7

GND

PROG-DCC-VS

RailCom Reference Voltage

+3V3

R38
160K/1%

RAILCOM-VREF

R39
10K/1%

C10
1uF

GND

RAILCOM-VREF = (3v3 x R38) / (R37 + R38)
RAILCOM-VREF = (3.3 x 10000) / (160000 + 10000)
RAILCOM-VREF = approx 19mv
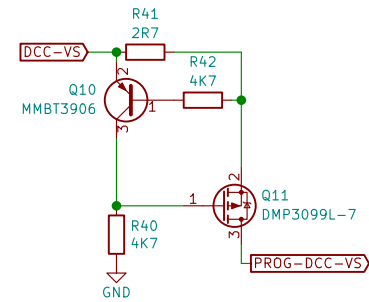
12V 500mA step−down converter for LCC−DCC signal output
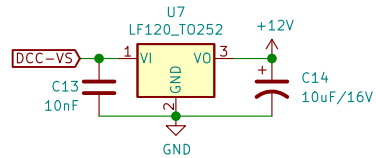
DCC-VS

U7
LF120_TO252

1 VI   VO 3
     GND
      2

C13
10nF

C14
10uF/16V

+12V

GND

U9
TJA1057

CAN-TX —— 1 TXD   VCC 3 —— +5V
CAN-RX —— 4 RXD
                 CANH 7 —— CAN-H
+3V3 ←—— 5 VIO   CANL 6 —— CAN-L
         8 S
             GND 2
                 GND

Note: The TJA1057 is being used to allow split voltage
levels between the MCU and the CAN bus.

CAN-PWR —— 8
GND ←—— 7
GND ←—— 6
OPS-LCC-A —— 5   CAN1
OPS-LCC-B —— 4   LCC-CAN
GND ←—— 3
CAN-L —— 2
CAN-H —— 1
              SH
              GND

CAN-PWR —— 8
GND ←—— 7
GND ←—— 6
OPS-LCC-A —— 5   CAN2
OPS-LCC-B —— 4   LCC-CAN
GND ←—— 3
CAN-L —— 2
CAN-H —— 1
              SH
              GND
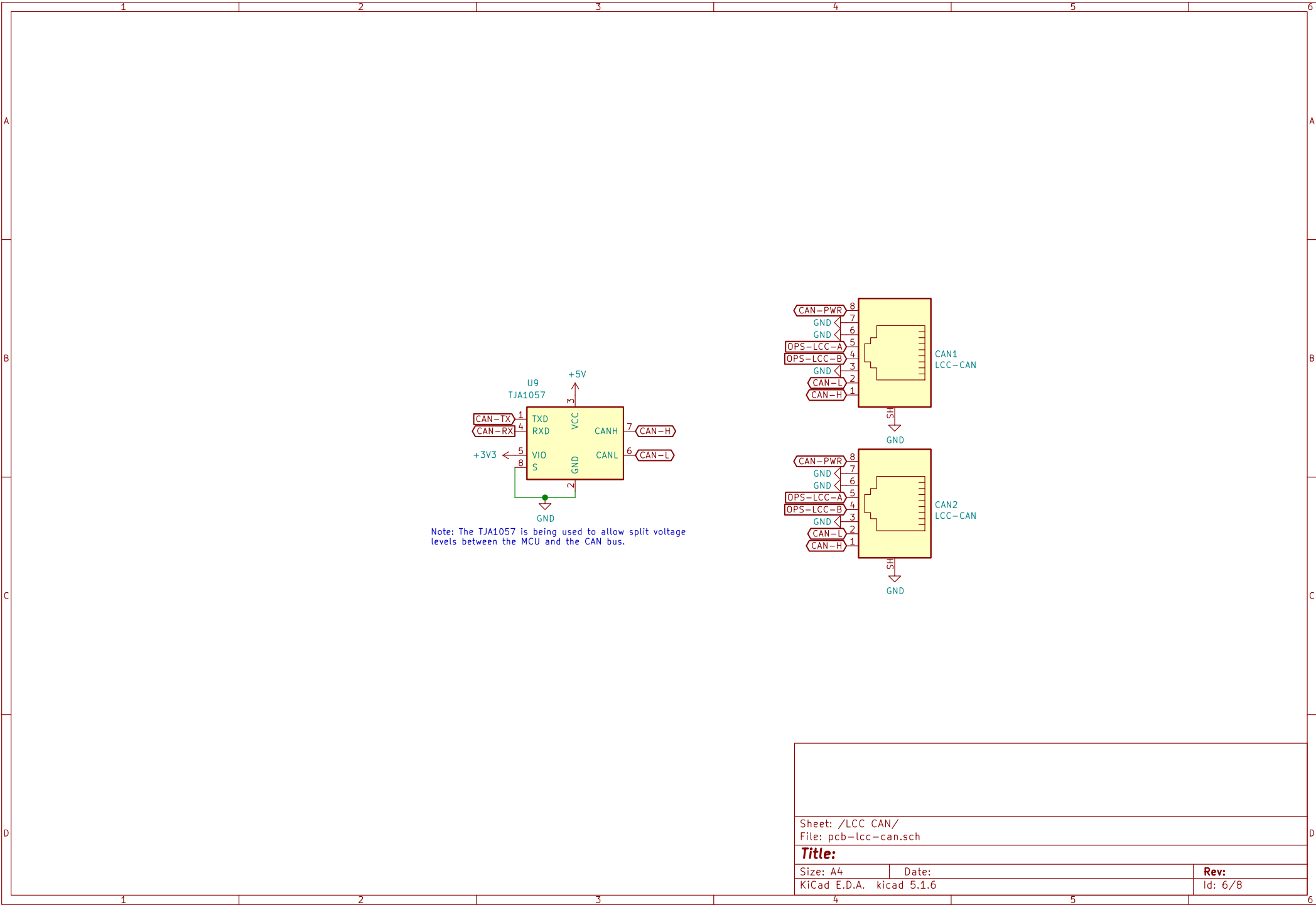
LMD18200 h-bridge (3A continous, 6A peak) for OPS track DCC signal generation.

C20 1uF
DCC-VS
GND

LMD18200
U10

F5
0ZRB0300FF1A
OPS-A
OUTPUT1 2
VS 6

C17
10nF
BOOTSTRAP1 1
PWM 5 OPS-EN

BOOTSTRAP2 11
DIRECTION 3 OPS-SIG

F6
0ZRB0300FF1A
OPS-B
C18
10nF
OUTPUT2 10
BRAKE 4 OPS-BRAKE

CURRENT_SENSE_OUTPUT 8
OPS-THERM THERMAL_FLAG_OUTPUT 9

OPS-SENSE
R43
2K7
GND 7

C19
100nF
GND
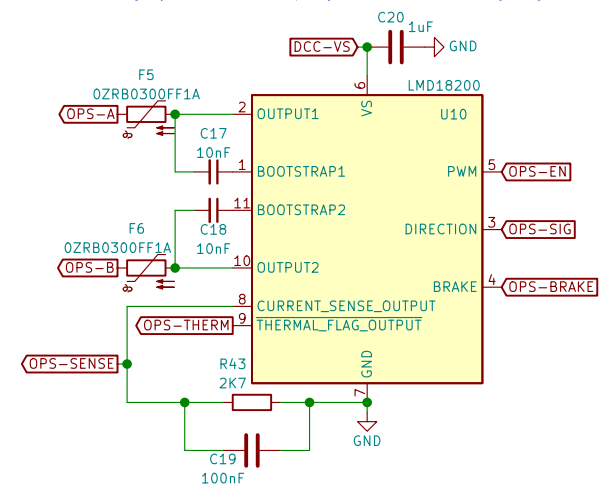
Note: The CURRENT_SENSE_OUTPUT is an INLINE output from the h-bridge.
The PWM and DIR have a PULL-DOWN and BRAKE has a PULL-UP to force
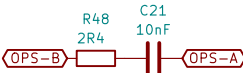the LMD18200 into a known state on startup (IE: OFF).

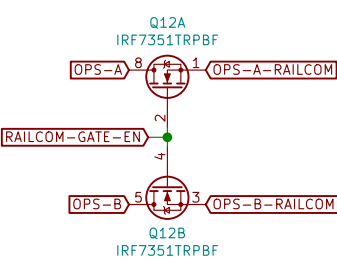P/U and P/D to force LMD18200
into a known state on startup.

R44
10K
OPS-BRAKE +3V3

R45
10K
OPS-SIG GND

R46
10K
OPS-EN GND
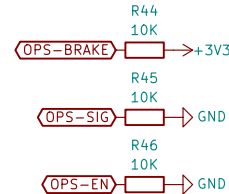
Thermal alert LED (RED), when ON the LMD18200 is
detecting a temperature of at least 145C.

R47 D13
2.2k THERMAL
OPS-THERM DCC-VS

DCC Signal smoothing

R48 C21
2R4 10nF
OPS-B OPS-A

RailCom FET bridge for OPS track

Q12A
IRF7351TRPBF
OPS-A 8 1 OPS-A-RAILCOM

RAILCOM-GATE-EN 2
4

OPS-B 5 3 OPS-B-RAILCOM
Q12B
IRF7351TRPBF

DCC activity LEDs

D11 R49
LED 10K
OPS-A

D12 R50
LED 10K
OPS-B

JP2
Enable OPS LEDs
1 2
GND
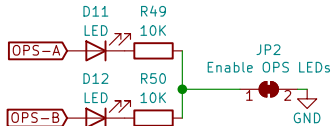
Note: these are using YELLOW 0805 LEDs,
alternatives can be substituted if desired.

TP6 OPS-SIG
OPS-SIG

TP7 OPS-EN
OPS-EN

TP8 OPS-BRAKE
OPS-BRAKE

Sheet: /OPS Track DCC/
File: pcb-ops-dcc.sch
Title:
Size: A4   Date:
KiCad E.D.A. kicad 5.1.6
Rev:
Id: 7/8

Command Station status output RGB LEDs

LED-PIN1
GND — 1 — +5V
                   2
WiFi   OPS   PROG   EXT-1   EXT-2
D14   D15   D16   D17   D18

LED — DIN DOUT — DIN DOUT — DIN DOUT — DIN DOUT — DIN DOUT

LED-PIN2
GND — 3 — +5V
         1

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

LED color indications:

WiFi:
GREEN [ON] = connected
GREEN [FLASHING] = connecting
RED = disconnected
BLUE = SoftAP available

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

EXT-1 and EXT-2 LEDs are currently unused
and can safely be left unpopulated.