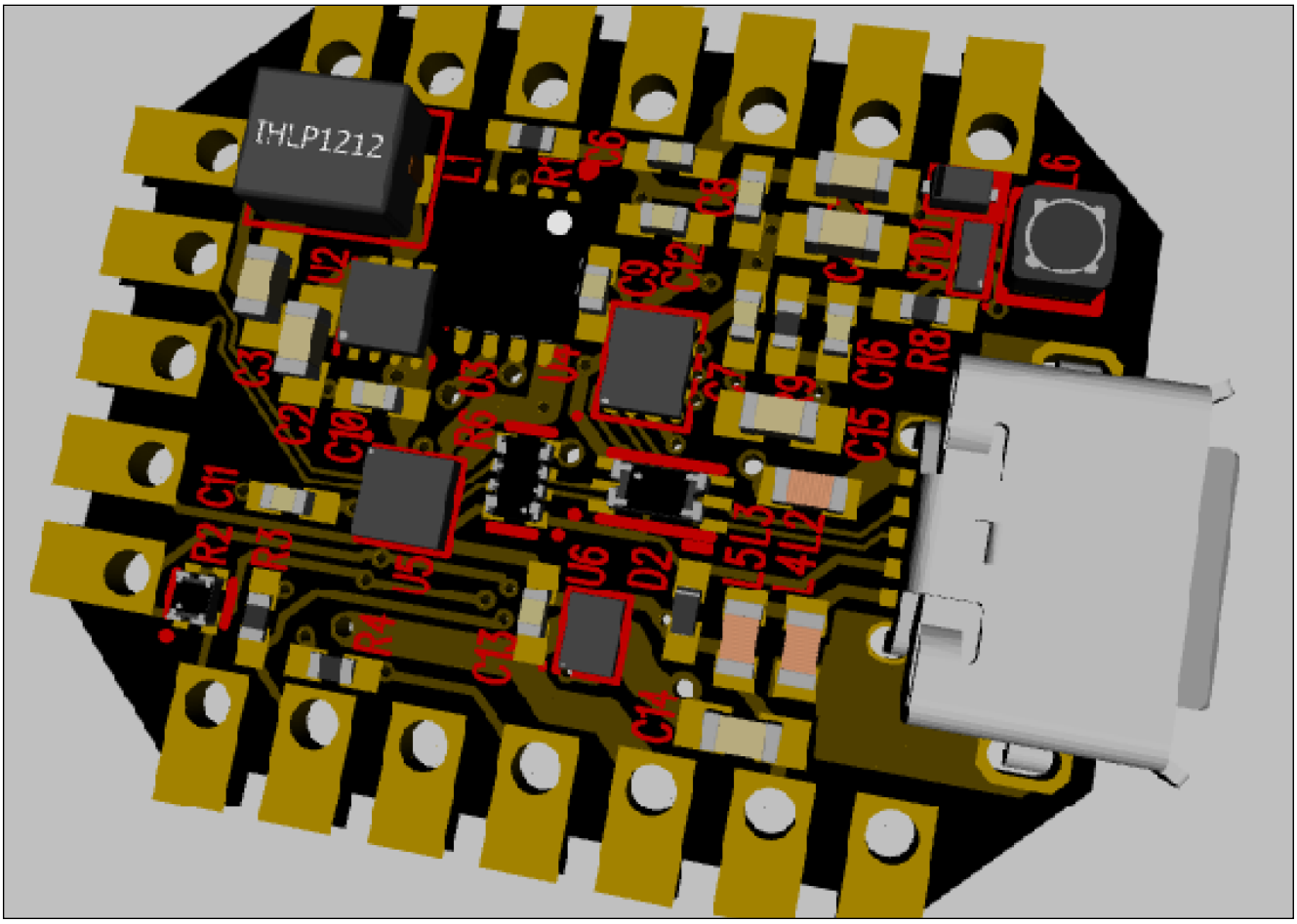
USB BiPower OTG

3.3V and -3.3V rails from USB or battery

Chris Hamilton - March 10, 2015



Design

USB BiPower OTG supports up to 2A VBUS input at 5V or 3A from the BQ24296 VSYS which is 4.2-3.5V depending on battery charge. The BQ24296 is on the Qi/USB Flex Module that pairs with board castellations on either side. The top castellations are meant to connect to a USB OTG supported micro controller such as the STM32F401 based STM32 Flex Module.

The MAX3353 charge pump is optional to the design and only utilized for OTG charging with microcontrollers that do not support OTG natively. BQ24296 boost mode switching should be fast enough to negotiate OTG.

Power Supplies

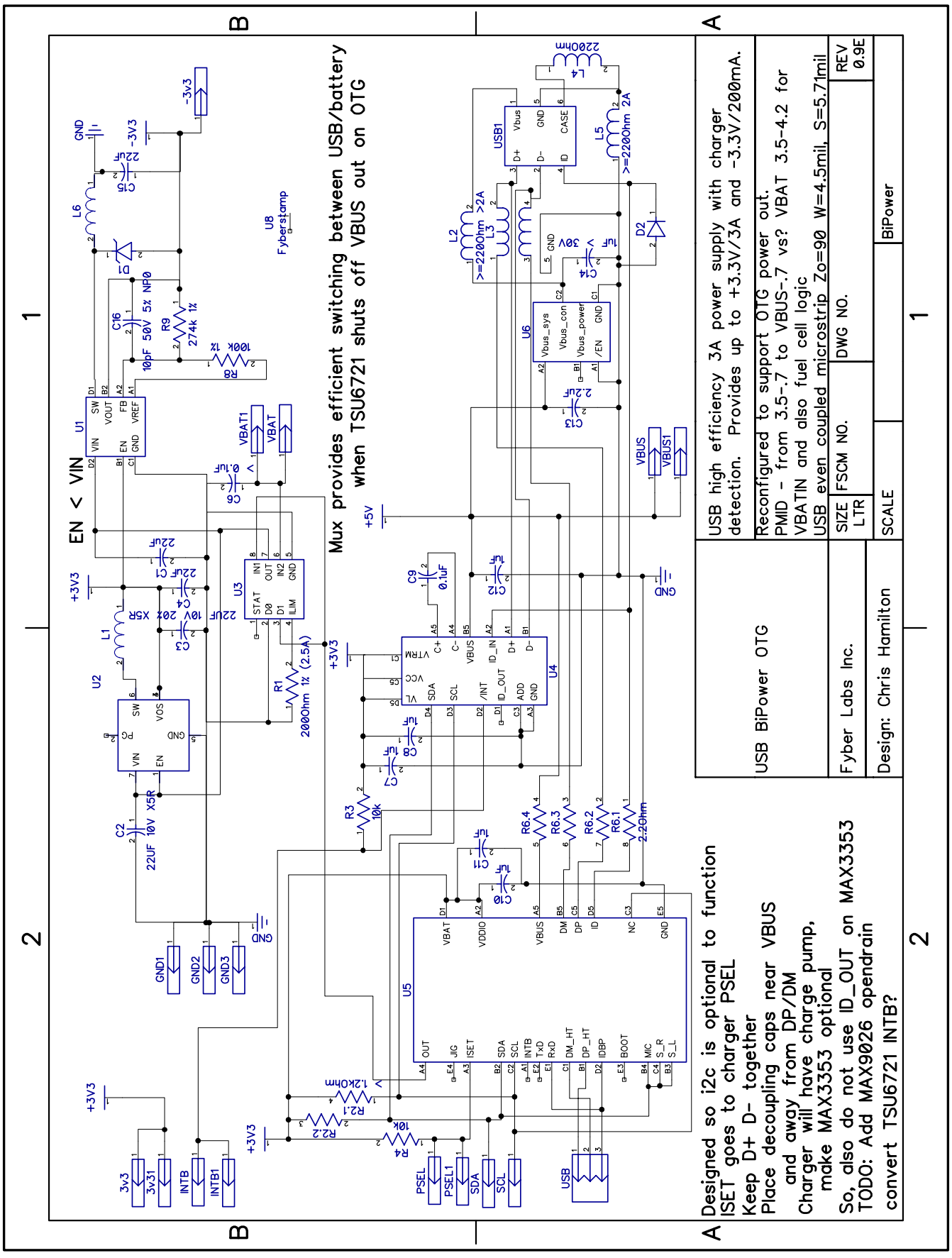
TPS2115A determines whether the source of the power supplies is battery or VBUS. TPS2115A can switch up to 2.5A. The TPS62086 provides 3.3v at up to 3A from the input. The LMR70503 can provide up to 300mA of -3.3v.

Control logic

i2c control of the TSU6721 and MAX3353 is available, though default operation will negotiate USB or battery based power to drive the TPS62086 3.3v power supply. The TPS2115A should pull VBUS power through the TSU6721 once negotiated. The TSU6721 VBUS switch can be turned off when providing on system OTG based VBUS power to draw VSYS power directly. INTB is open drain. TSU6721 INTB is push/pull, so it is not used.

Schematic

USB micro A/B on the bottom right with ferrite core isolation from the case, ground, and VBUS. Protection is D+/- common choke/ESD ECMF02-2AMX6 and VBUS OVP/ESD provided by the TPD1S514. The MAX3353 which routes around the choke is ESD protected. Power supplies are reference designs from Webench. TSU6721 pins are shorted to support i2c layout without via in pad.


Mux provides efficient switching between USB/battery when TSU6721 shuts off VBUS out on OTG
EN < VIN
USB BiPower OTG
USB high efficiency 3A power supply with charger detection. Provides up to +3.3V/3A and -3.3V/200mA.
Reconfigured to support OTG power out.
PMID - from 3.5-.7 to VBUS-.7 vs? VBAT 3.5-4.2 for VBATIN and also fuel cell logic
USB even coupled microstrip Zo=90 W=4.5mil, S=5.71mil
Fyber Labs Inc.
SIZE LTR
FSCM NO.
DWG NO.
REV 0.9E
Design: Chris Hamilton
SCALE
BiPower
Designed so i2c is optional to function
ISET goes to charger PSEL
Keep D+ D- together
Place decoupling caps near VBUS and away from DP/DM
Charger will have charge pump, make MAX3353 optional
So, also do not use ID_OUT on MAX3353
TODO: Add MAX9026 opendrain convert TSU6721 INTB?

BOM

#	RefDes	Value	Part
1	-3v3		Part 1
2	3v3		Part 1
3	3v31		Part 1
4	C1	22uF	CL10A226MP8NUNE
5	C2	22UF 10V X5R	CL10A226MP8NUNE
6	C3	22UF 10V 20% X5R	CL10A226MP8NUNE
7	C4	22uF	CL10A226MP8NUNE
8	C6	> 0.1uF	CL05B104KO5NNNC
9	C7	1uF	CL05A105KO5NNNC
10	C8	1uF	CL05A105KO5NNNC
11	C9	0.1uF	CL05B104KO5NNNC
12	C10	1uF	CL05A105KO5NNNC
13	C11	1uF	CL05A105KO5NNNC
14	C12	1uF	CL05A105KO5NNNC
15	C13	2.2uF	CL05A225MP5NSNC
16	C14	1uF > 30V	CL10A105KB8NNNC
17	C15	22uF	CL10A226MP8NUNE
18	C16	10pF 50V 5% NP0	GRM1555C1H100JA01D
19	D1		PMEG3005ELD,315
20	D2		TPD1E05U06DPYT
21	GND1		Part 1
22	GND2		Part 1
23	GND3		Part 1
24	INTB		Part 1
25	INTB1		Part 1
26	L1		IHLP1212AEERR47M11
27	L2	>=2200hm >2A	BLM18SG221TN1D
28	L3		ECMF02-2AMX6
29	L4	2200hm	BLM18SG221TN1D
30	L5	>=2200hm 2A	BLM18SG221TN1D
31	L6		VLS2012ET-6R8M
32	PSEL		Part 1
33	PSEL1		Part 1
34	R1	2000hm 1% (2.5A)	ERJ-2GEJ201X
35	R2	> 1.2k0hm	EXB-24V152JX
36	R3	10k	ERJ-2RKF1002X
37	R4	10k	ERJ-2RKF1002X
38	R6	2.20hm	EXB-N8V2R2JX
39	R8	100k 1%	ERJ-2RKF1003X
40	R9	274k 1%	ERJ-2RKF2743X
41	SCL		Part 1
42	SDA		Part 1
43	U1		LMR70503TM/NOPB
44	U2		TPS62086RLTR
45	U3		TPS2115ADRBRG4
46	U4		MAX3353EEBP-T
47	U5		TSU6721YFPR
48	U6		TPD1S514-1YZR
49	U8		Part 1
50	USB		Part 1
51	USB1		47590-0001
52	VBAT		Part 1
53	VBAT1		PMEG3005L
54	VBUS		Part 1
55	VBUS1		Part 1

Ferrite cores are in the 200Ohm+ range which seems to be standard for USB isolation.

Inductors are from TI design recommendations.

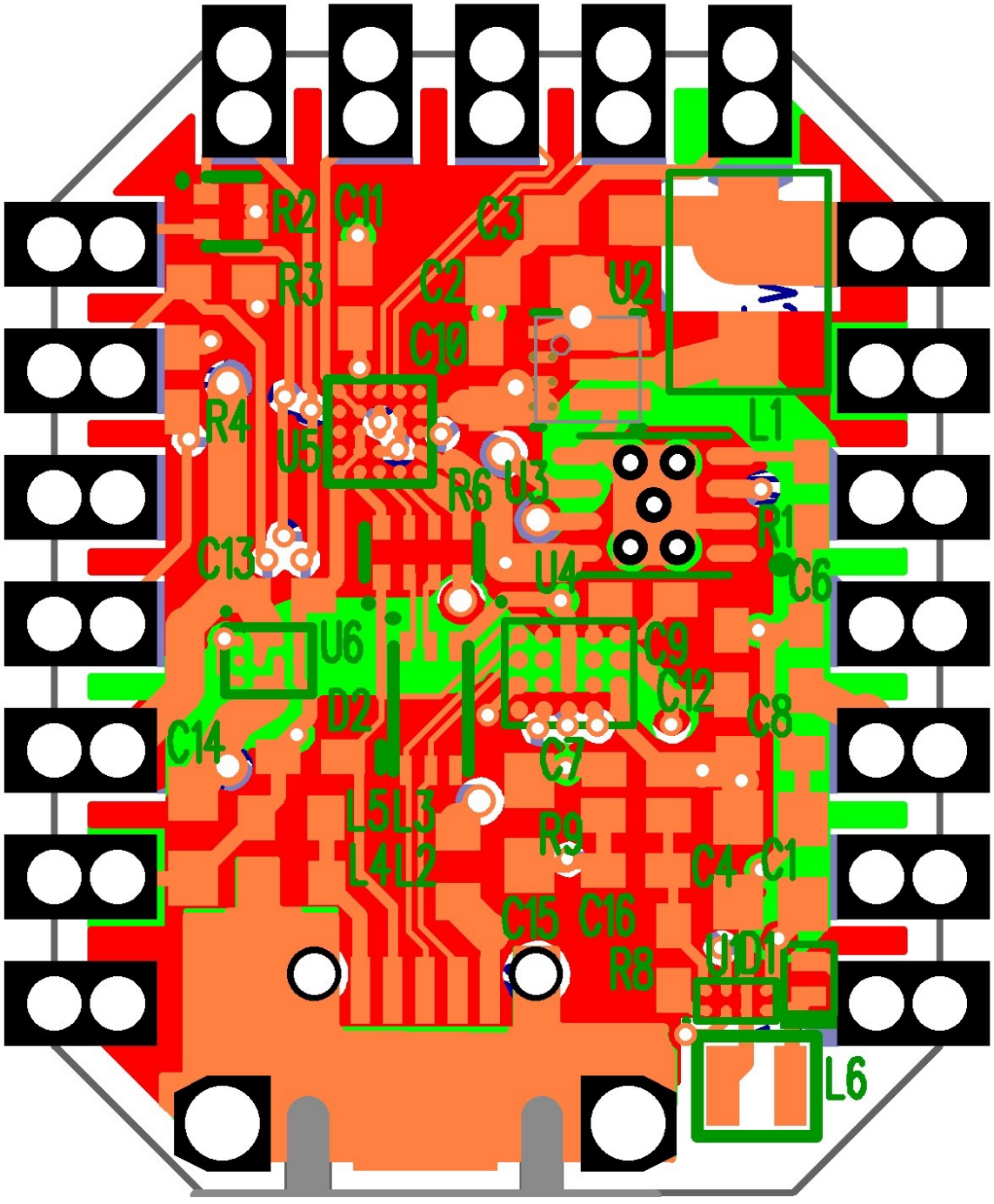
I specified Samsung capacitors are they are common among distributors now and appear to have stock of larger values in small sizes. The reference designs for bulk caps were 1206, but 0603 can now be found with the same V and F.

I similarly picked Panasonic resistors based on availability and price.

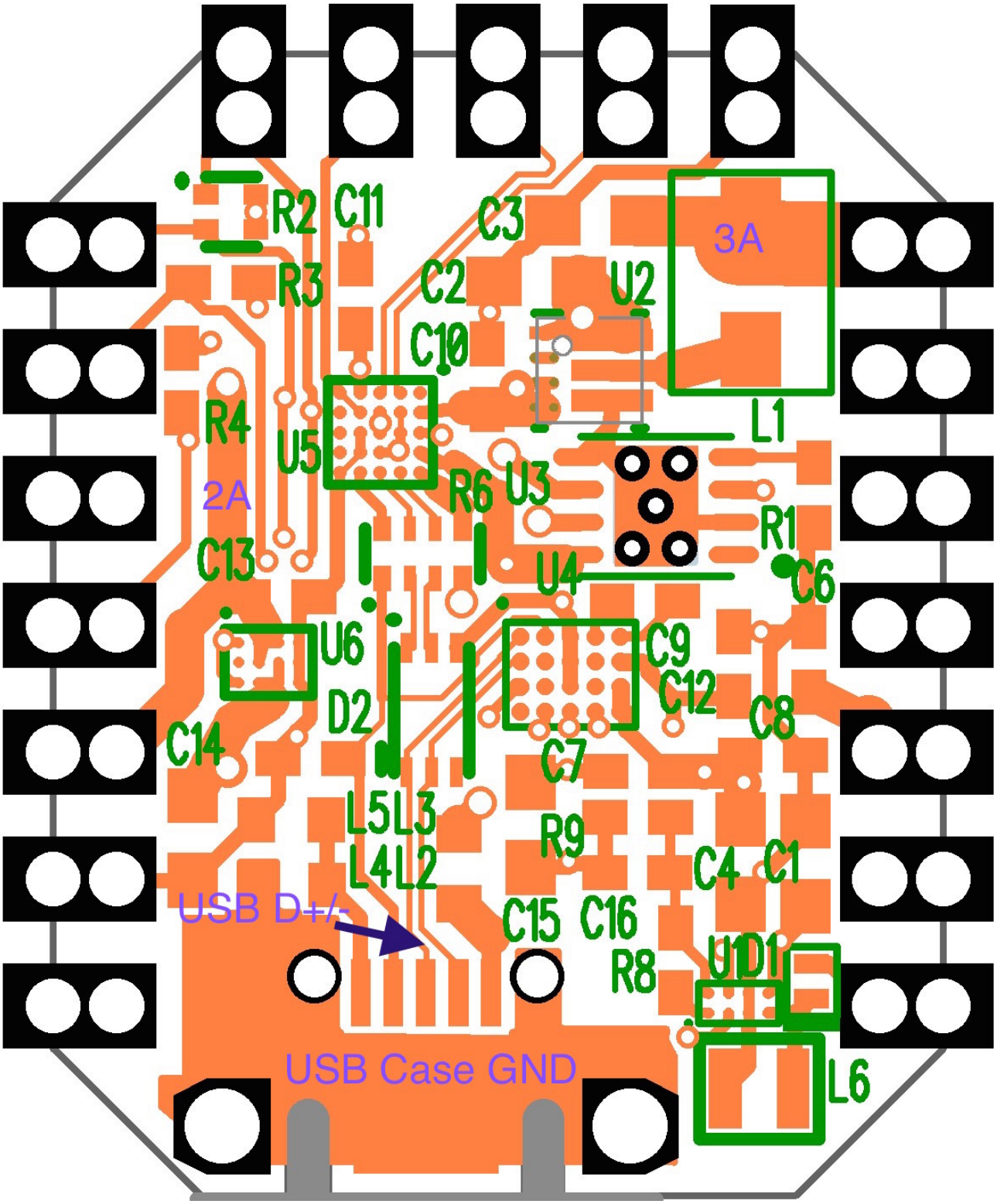
Diodes should be correct, but there is limited spec.

Layout

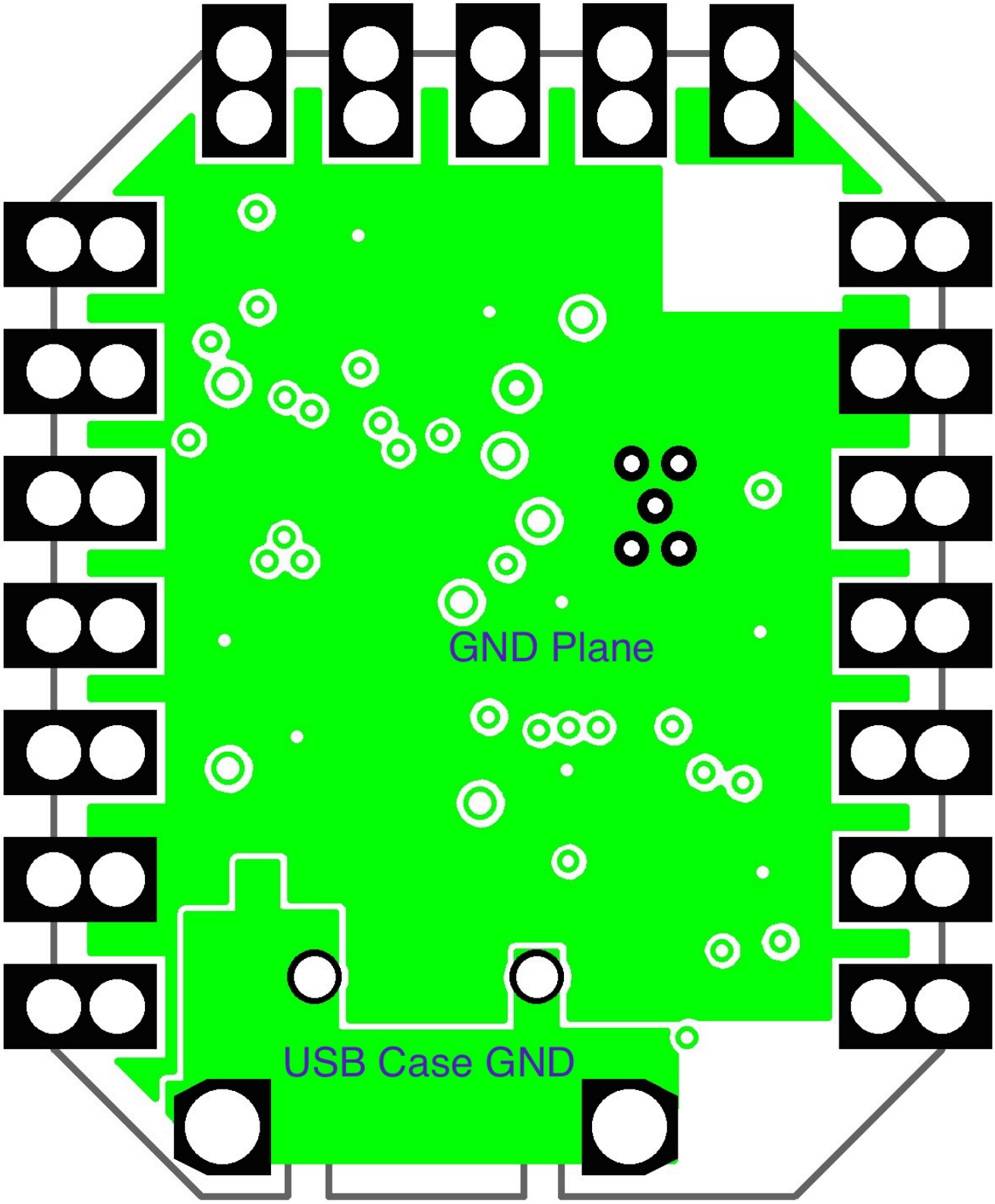
Traces are correct for the required currents - 2A VBUS/5V and 3A for VSYS/BAT. USB Case ground plane and general ground plane are isolated. TSU6721 internal vias are aligned to be on unused output pads. They should not interfere with i2c as long as firmware does not switch those pins.



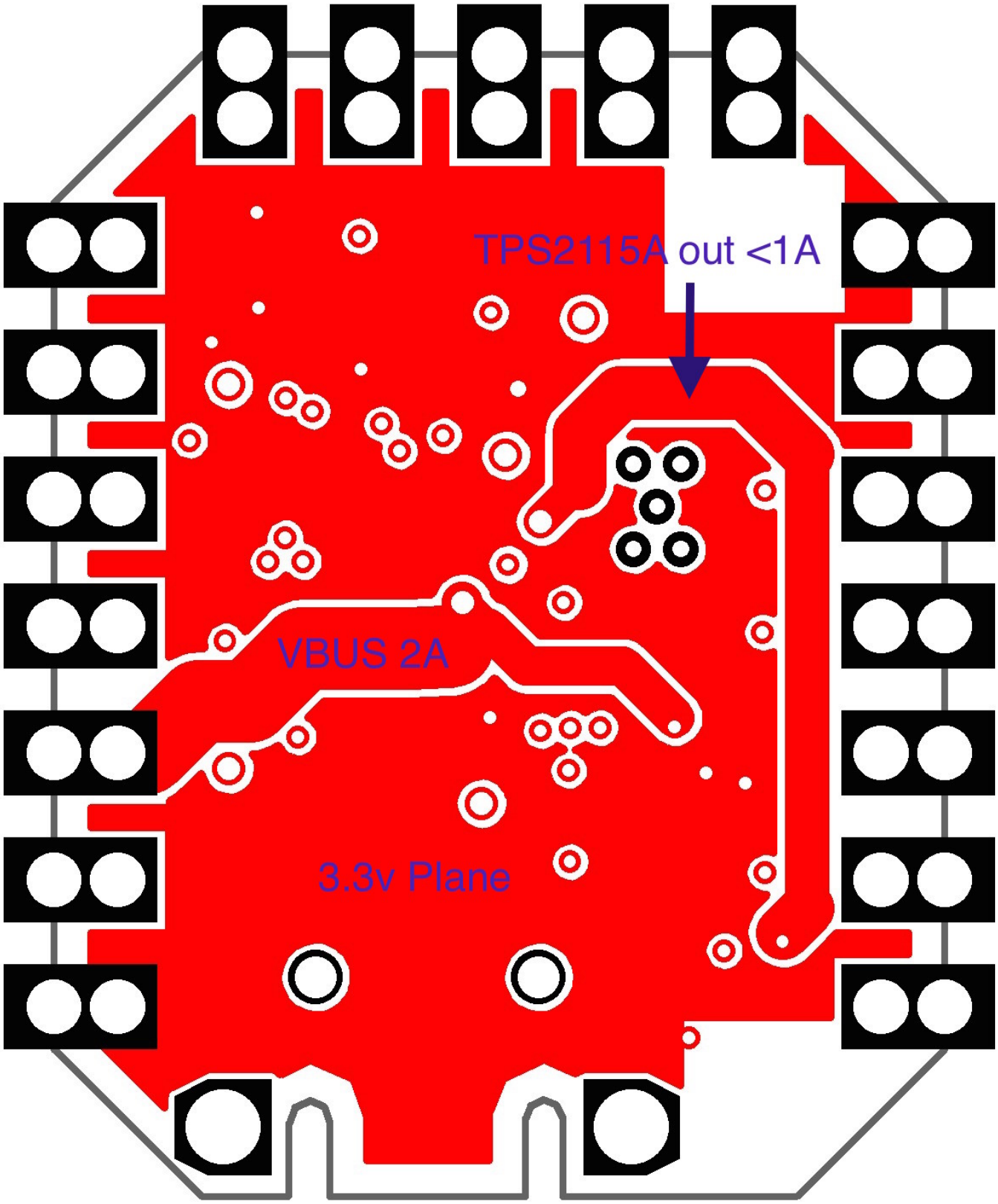
Top Layer 1oz



2nd/GND Layer 0.5oz



3rd/3.3v/VDD Layer 0.5oz



Bottom Layer 1.0oz