PAGE-0: OVERVIEW

PAGE-1: POWER SUPPLY

PAGE-2: MCU + KEYS

PAGE-3: CONSTANT CURRENT ADC

PAGE-4: MOTOR + FAN DRIVER

PAGE-5: PHYSICAL CONNECTORS

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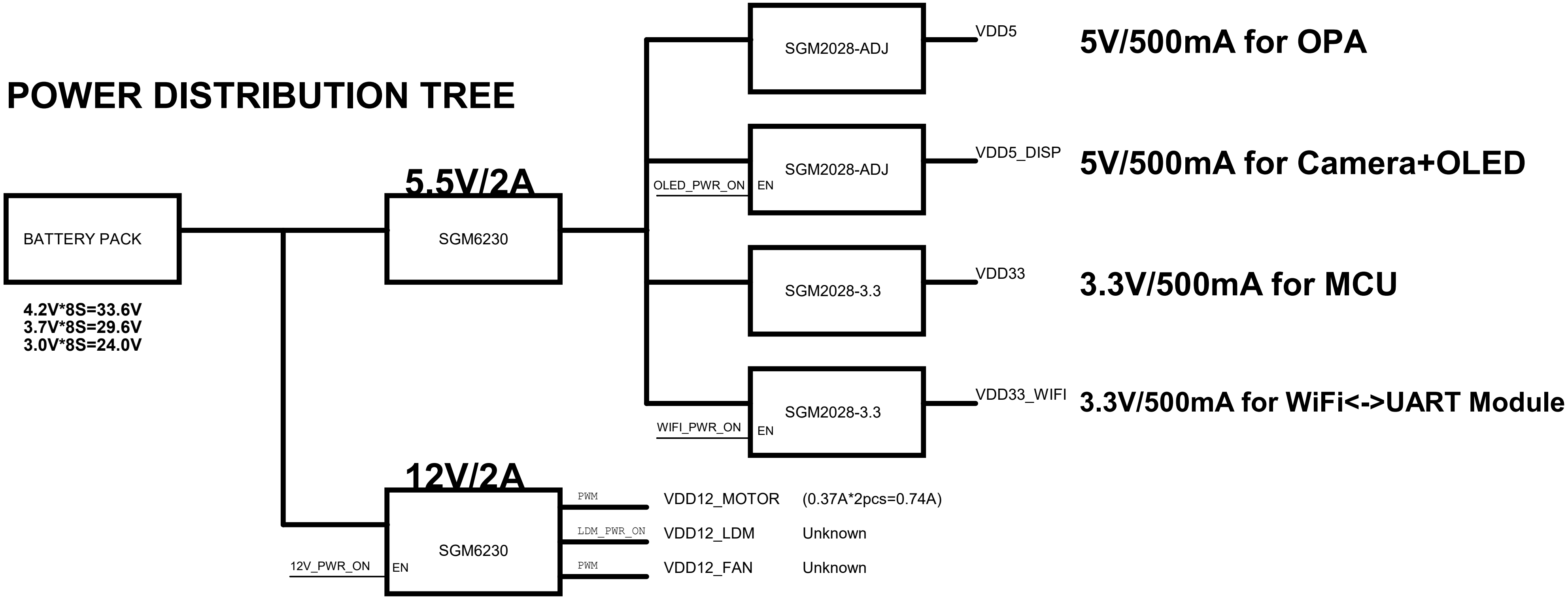
POWER DISTRIBUTION TREE



Title	0-OVERVIEW	
Size A	Document Number FLASH LIGHT	Rev A2
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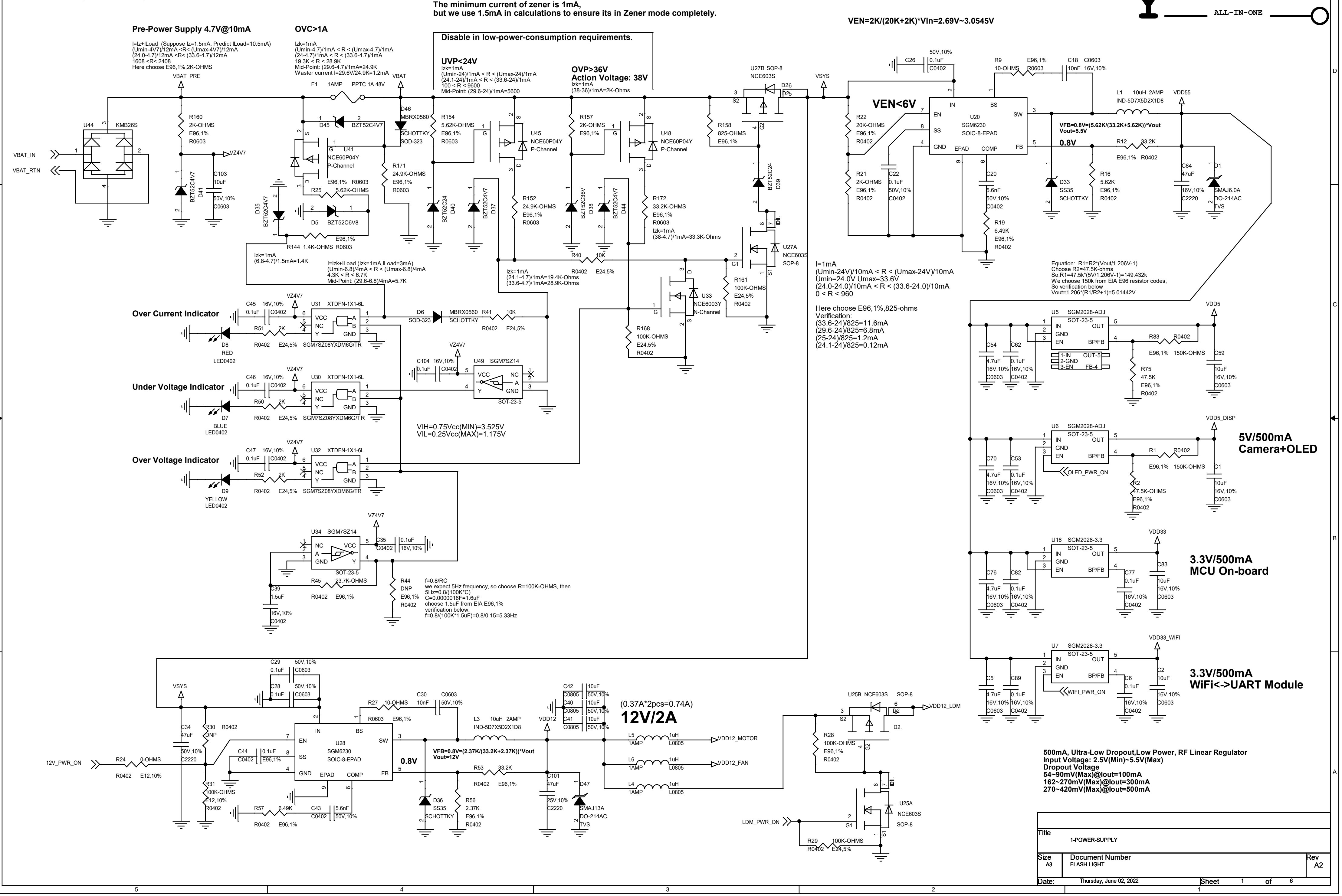
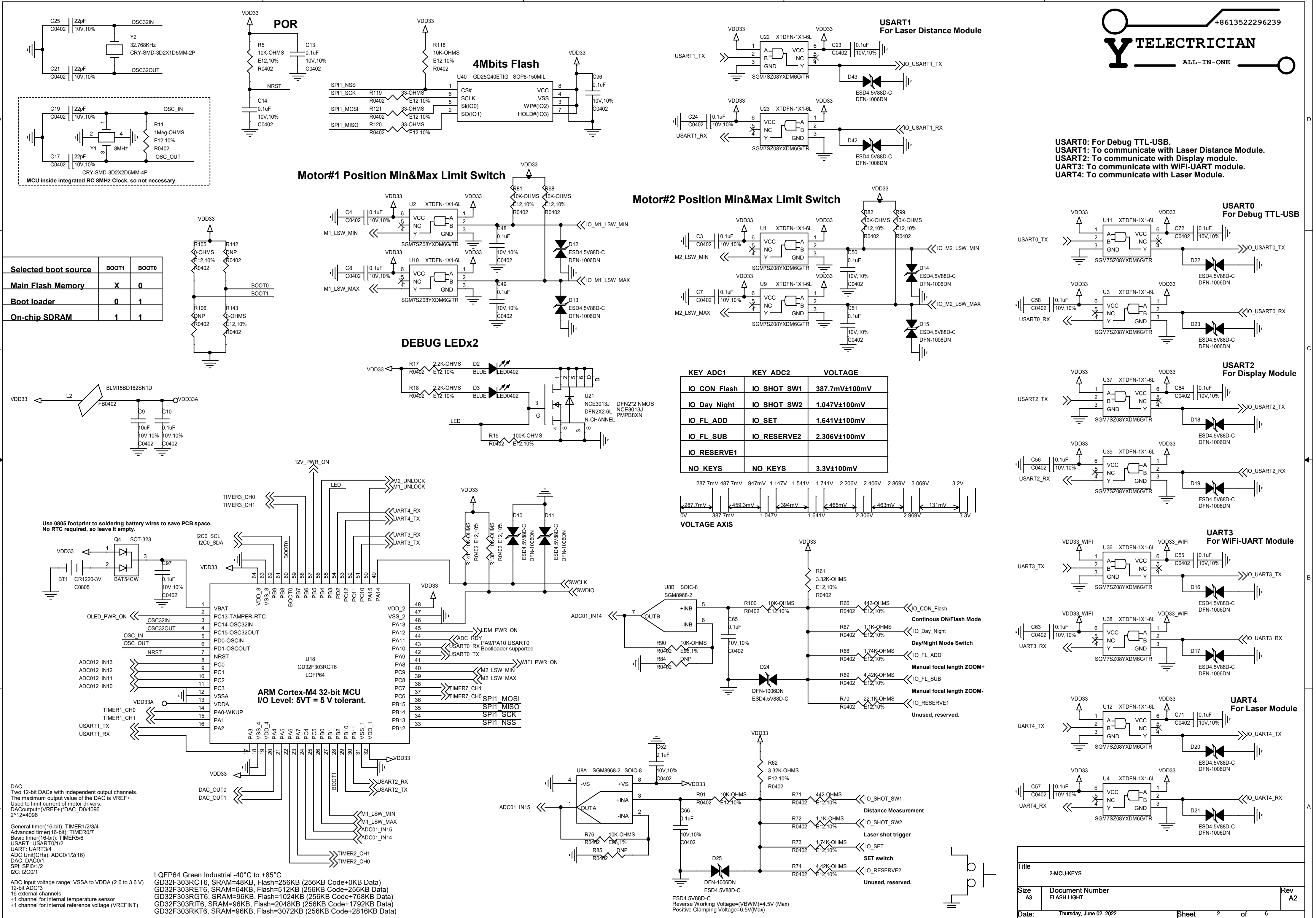
18650 Battery Pack (3.7V~4.2V)*8S=29.6V~33.6V

The charging cut-off voltage of the 3.7V battery is 4.2V and the discharge cut-off voltage is 3.0V.
4.2V*8S=33.6V, 3.7V*8S=29.6V, 3.0V*8S=24.0V

The minimum current of zener is 1mA,
but we use 1.5mA in calculations to ensure its in Zener mode completely.





Selected boot source	BOOT1	BOOT0
Main Flash Memory	X	0
Boot loader	0	1
On-chip SDRAM	1	1

KEY_ADC1	KEY_ADC2	VOLTAGE
IO_CON_Flash	IO_SHOT_SW1	387.7mV±100mV
IO_Day_Night	IO_SHOT_SW2	1.047V±100mV
IO_FL_ADD	IO_SET	1.641V±100mV
IO_FL_SUB	IO_RESERVE2	2.306V±100mV
IO_RESERVE1		
NO_KEYS	NO_KEYS	3.3V±100mV

DAC
Two 12-bit DACs with independent output channels.
The maximum output value of the DAC is VREF+.
Used to limit current of motor drivers.
DACoutput=(VREF+)*DAC_D0/4096
2^12=4096

General timer(16-bit): TIMER1/2/3/4
Advanced timer(16-bit): TIMER0/7
Basic timer(16-bit): TIMER5/6
USART: USART0/1/2
UART: UART3/4
ADC Unit(CHs): ADC0/1/2(16)
DAC: DAC0/1
SPI: SPI0/1/2
I2C: I2C0/1

ADC input voltage range: VSSA to VDDA (2.6 to 3.6 V)
12-bit ADC*3
16 external channels
+1 channel for internal temperature sensor
+1 channel for internal reference voltage (VREFINT)

LQFP64 Green Industrial -40°C to +85°C
GD32F303RCT6, SRAM=48KB, Flash=256KB (256KB Code+0KB Data)
GD32F303RET6, SRAM=64KB, Flash=512KB (256KB Code+256KB Data)
GD32F303RGT6, SRAM=96KB, Flash=1024KB (256KB Code+768KB Data)
GD32F303RIT6, SRAM=96KB, Flash=2048KB (256KB Code+1792KB Data)
GD32F303RKT6, SRAM=96KB, Flash=3072KB (256KB Code+2816KB Data)

Title: 2-MCU-KEYS		
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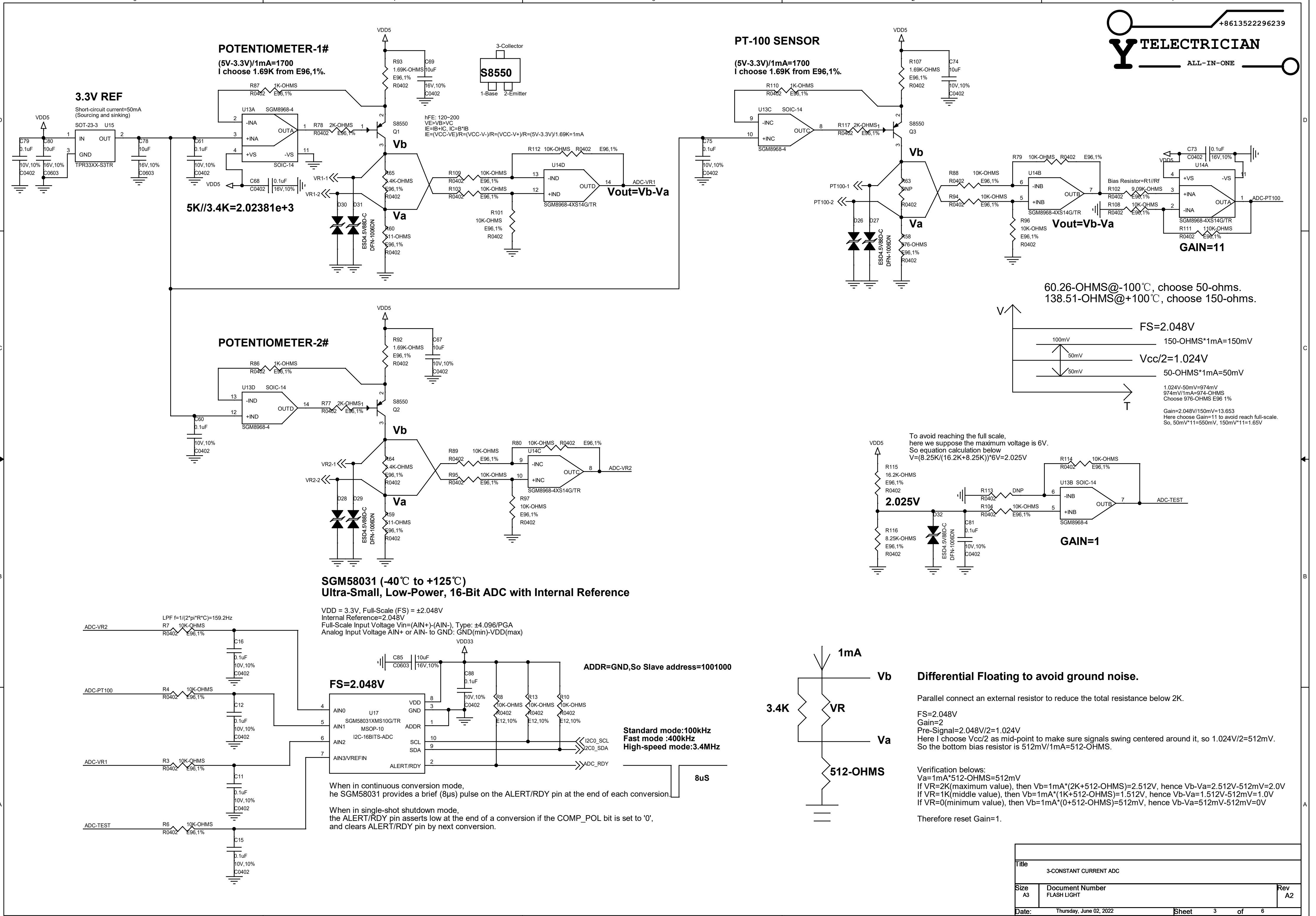

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3.3V REF
Short-circuit current=50mA
(Sourcing and sinking)
SOT-23-3 U15
TPR33XX-S3TR
POTENTIOMETER-1#
(5V-3.3V)/1mA=1700
I choose 1.69K from E96,1%.
S8550
3-Collector
1-Base 2-Emitter
hFE: 120~200
VE>VB>VC
IE=IB+IC, IC=B*IB
IE=(VCC-VE)/R=(VCC-V-)/R=(VCC-V+)/R=(5V-3.3V)/1.69K=1mA
5K//3.4K=2.02381e+3
Vb
Va
Vout=Vb-Va
ADC-VR1
POTENTIOMETER-2#
ADC-VR2
PT-100 SENSOR
(5V-3.3V)/1mA=1700
I choose 1.69K from E96,1%.
Bias Resistor=R1//Rf
ADC-PT100
GAIN=11
60.26-OHMS@-100℃, choose 50-ohms.
138.51-OHMS@+100℃, choose 150-ohms.
FS=2.048V
150-OHMS*1mA=150mV
Vcc/2=1.024V
50-OHMS*1mA=50mV
100mV
50mV
50mV
1.024V-50mV=974mV
974mV/1mA=974-OHMS
Choose 976-OHMS E96 1%
Gain=2.048V/150mV=13.653
Here choose Gain=11 to avoid reach full-scale.
So, 50mV*11=550mV, 150mV*11=1.65V
To avoid reaching the full scale,
here we suppose the maximum voltage is 6V.
So equation calculation below
V=(8.25K/(16.2K+8.25K))*6V=2.025V
2.025V
ADC-TEST
GAIN=1
SGM58031 (-40℃ to +125℃)
Ultra-Small, Low-Power, 16-Bit ADC with Internal Reference
VDD = 3.3V, Full-Scale (FS) = ±2.048V
Internal Reference=2.048V
Full-Scale Input Voltage Vin=(AIN+)-(AIN-), Type: ±4.096/PGA
Analog Input Voltage AIN+ or AIN- to GND: GND(min)-VDD(max)
LPF f=1/(2*pi*R*C)=159.2Hz
ADDR=GND,So Slave address=1001000
FS=2.048V
U17 SGM58031XMS10G/TR MSOP-10 I2C-16BITS-ADC
I2C0_SCL
I2C0_SDA
ADC_RDY
Standard mode:100kHz
Fast mode :400kHz
High-speed mode:3.4MHz
8uS
When in continuous conversion mode,
he SGM58031 provides a brief (8μs) pulse on the ALERT/RDY pin at the end of each conversion.
When in single-shot shutdown mode,
the ALERT/RDY pin asserts low at the end of a conversion if the COMP_POL bit is set to '0',
and clears ALERT/RDY pin by next conversion.
1mA
Vb
3.4K
VR
Va
512-OHMS
Differential Floating to avoid ground noise.
Parallel connect an external resistor to reduce the total resistance below 2K.
FS=2.048V
Gain=2
Pre-Signal=2.048V/2=1.024V
Here I choose Vcc/2 as mid-point to make sure signals swing centered around it, so 1.024V/2=512mV.
So the bottom bias resistor is 512mV/1mA=512-OHMS.
Verification belows:
Va=1mA*512-OHMS=512mV
If VR=2K(maximum value), then Vb=1mA*(2K+512-OHMS)=2.512V, hence Vb-Va=2.512V-512mV=2.0V
If VR=1K(middle value), then Vb=1mA*(1K+512-OHMS)=1.512V, hence Vb-Va=1.512V-512mV=1.0V
If VR=0(minimum value), then Vb=1mA*(0+512-OHMS)=512mV, hence Vb-Va=512mV-512mV=0V
Therefore reset Gain=1.
Title 3-CONSTANT CURRENT ADC
Size A3
Document Number FLASH LIGHT
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	CLOCKWISE ROTATE	ANTI-CLOCKWISE ROTATE
IN1		
IN2		

Rotate speed depends on frequency.
Torque depends on duty cycle.

DCU10025P12
Rated Voltage: 12V
No-Load Current: 4.6mA
Maximum continous current: 0.188A
Locked rotor current: 0.37A
Coil resistance: 32.4-OHMS

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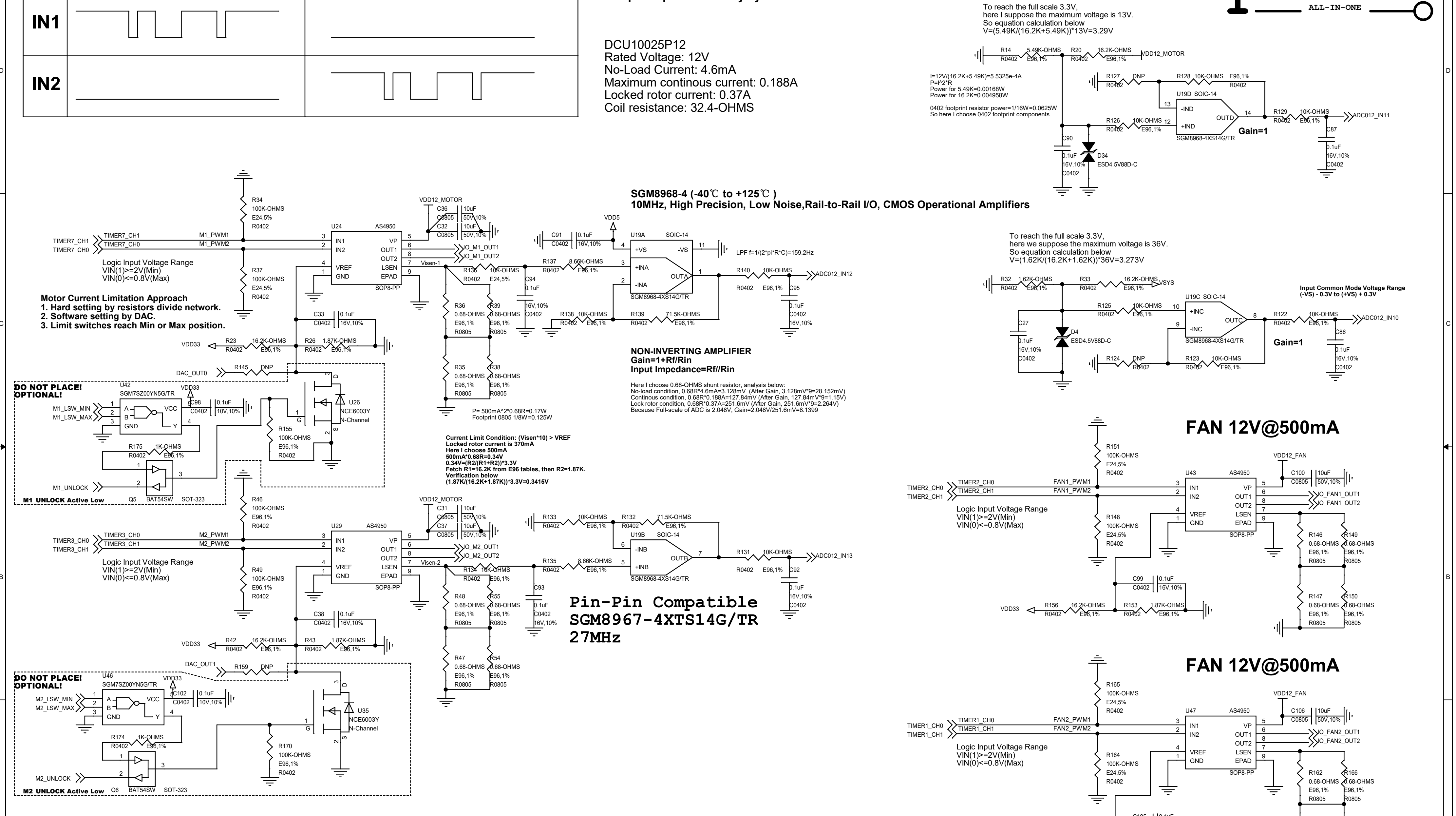
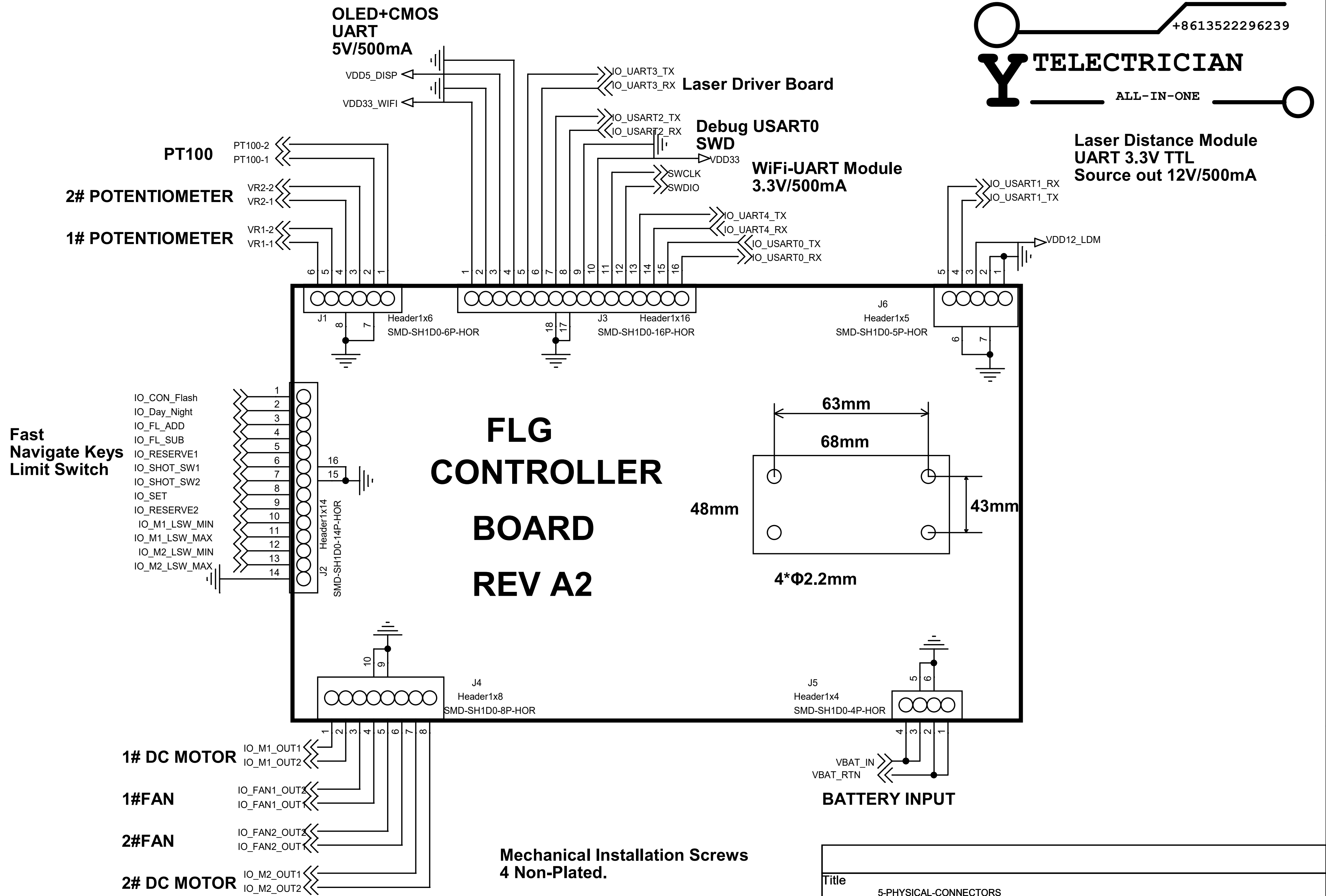


IN1	IN2	(Visen*10) > VREF	OUT1	OUT2	Function
0	1	FALSE	L	H	Reverse
1	0	FALSE	H	L	Forward
0	1	TRUE	H/L	L	Chop (mixed decay), reverse
1	0	TRUE	L	H/L	Chop (mixed decay), forward
1	1	FALSE	L	L	Brake (slow decay)
0	0	FALSE	Z	Z	Coast, enters Low Power Standby mode after 1 ms

Title	4-MOTOR+FAN DRIVER
Size A3	Document Number: FLASH LIGHT — Rev A2
Date:	Wednesday, June 08, 2022 — Sheet 4 of 6



Title	5-PHYSICAL-CONNECTORS		
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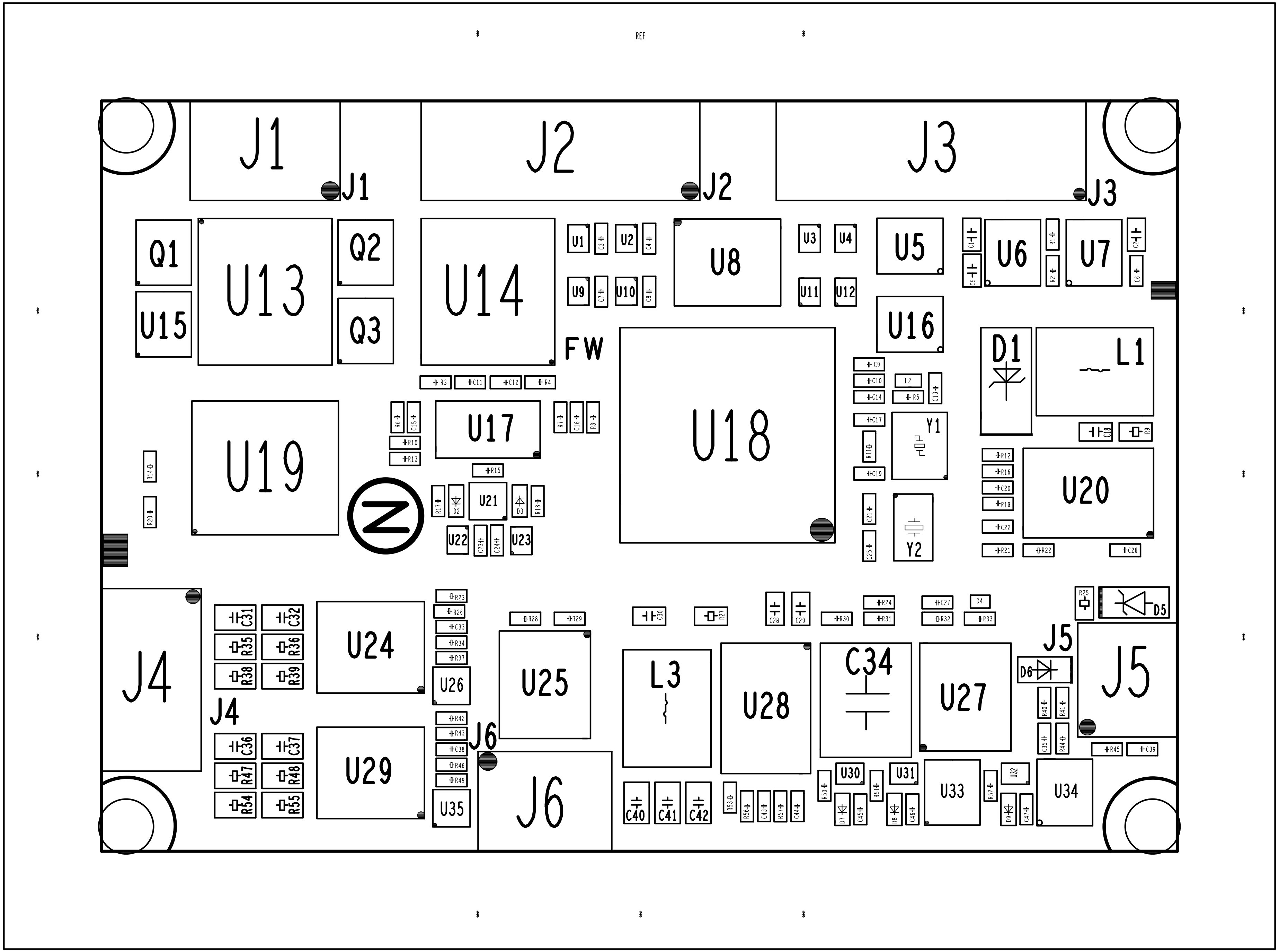
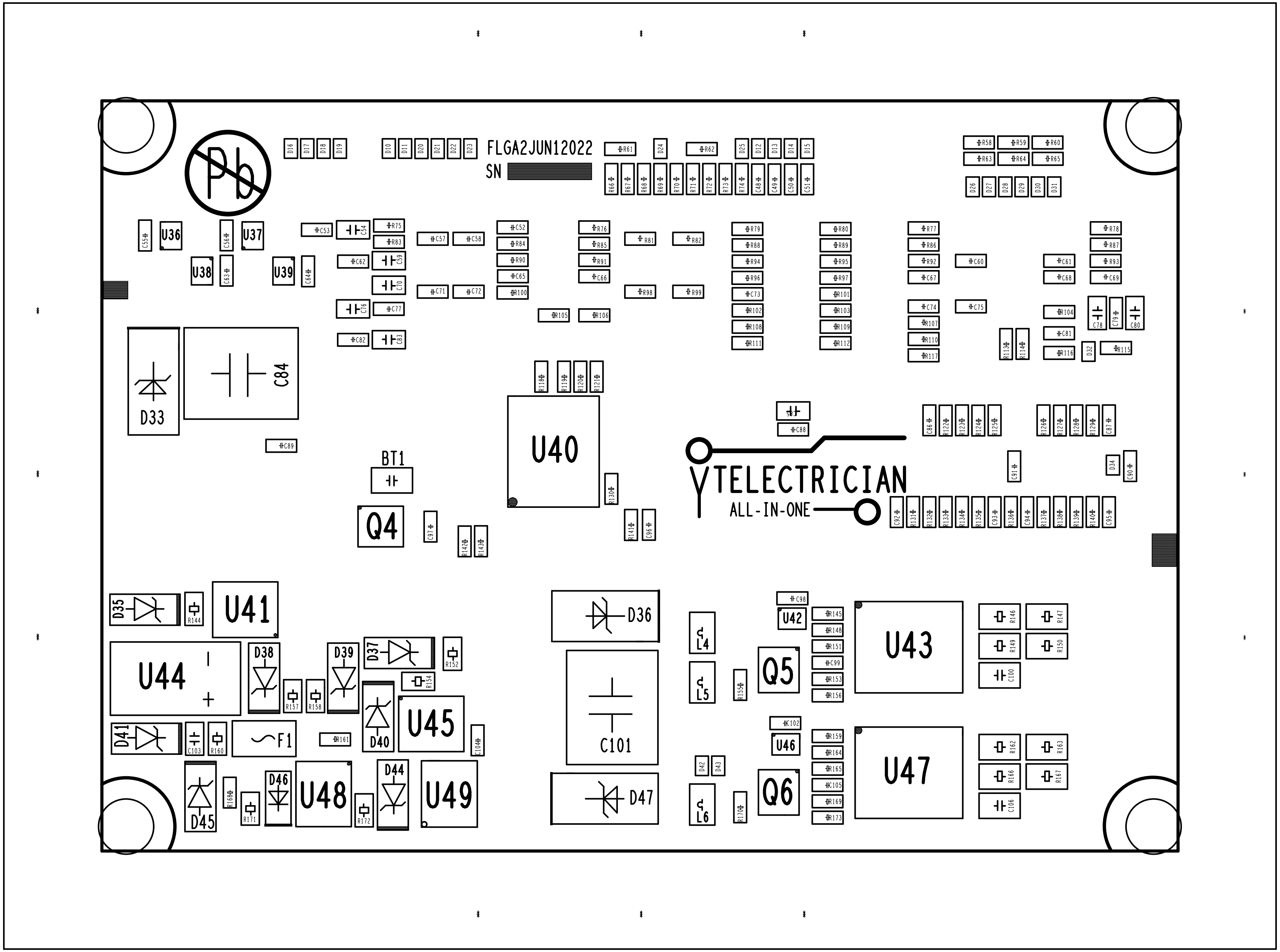
SILKSCREEN_TOP REFERENCE DESCRIPTION



SILKSCREEN_BOTTOM REFERENCE DESCRIPTION



ASSEMBLY REFERENCE DIAGRAM

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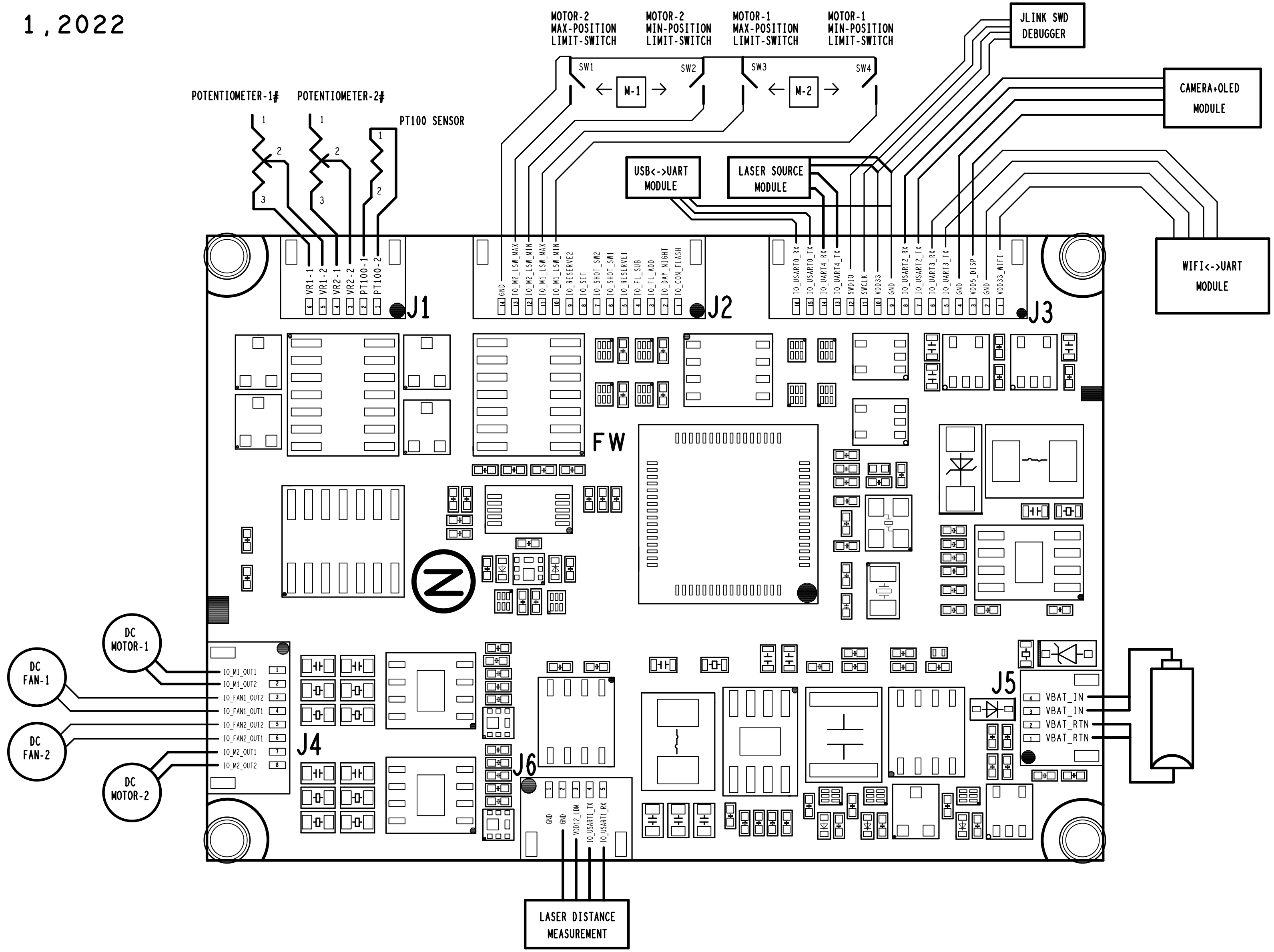
PROJECT:FLASH-LIGHT-GUN-REV-A2

JUNE 1,2022



Bill of Materials (DNP removed)

Item	Quantity	Reference	Part	PCBFootprint	Detail
2	8	C1,C2,C59,C78,C80,C83,C85,C103	10uF	C0603	CAPACITOR SMD 0603 16V ±10%
3	66	C3,C4,C6,C7,C8,C10,C11,C12,C13,C14,C15,C16,C22,C23,C24,C27,C33,C35,C38,C44,C45,C46,C47,C48,C49,C50,C51,C52,C53,C55,C56,C57,C58,C60,C61,C62,C63,C64,C65,C66,C68,C71,C72,C73,C75,C77,C79,C81,C82,C86,C87,C88,C89,C90,C91,C92,C93,C94,C95,C96,C97,C98,C99,C102,C104,C105	0.1uF	C0402	CAPACITOR SMD 0402 16V ±10%
4	4	C5,C54,C70,C76	4.7uF	C0603	CAPACITOR SMD 0603 16V ±10%
5	4	C9,C67,C69,C74	10uF	C0402	CAPACITOR SMD 0402 16V ±10%
6	4	C17,C19,C21,C25	22pF	C0402	CAPACITOR SMD 0402 16V ±10%
7	2	C18,C30	10nF	C0603	CAPACITOR SMD 0603 16V ±10%
8	2	C20,C43	5.6nF	C0402	CAPACITOR SMD 0402 16V ±10%
9	1	C26	0.1uF	C0402	CAPACITOR SMD 0402 50V ±10%
10	2	C28,C29	0.1uF	C0603	CAPACITOR SMD 0603 50V ±10%
11	9	C31,C32,C36,C37,C40,C41,C42,C100,C106	10uF	C0805	CAPACITOR SMD 0805 50V ±10%
12	3	C34,C84,C101	47uF	C2220	Multilayer Ceramic Capacitors MLCC - SMD/SMT 2220-INCH(5750-MM) 50VDC 47uF 20% X7R
13	1	C39	1.5uF	C0402	CAPACITOR SMD 0402 16V ±10%
14	1	D1	SMAJ6.0A	DO-214AC	TVS Diode Surface Mount DO-214AC (SMA) from Littelfuse Inc.
15	3	D2,D3,D7	BLUE	LED0402	LED SMD 0402 BLUE COLOR
16	27	D4,D10,D11,D12,D13,D14,D15,D16,D17,D18,D19,D20,D21,D22,D23,D24,D25,D26,D27,D28,D29,D30,D31,D32,D34,D42,D43	ESD4.5V88D-C (PESDHC2FD4V5BH)	DFN-1006DN	Transient Voltage Suppressors for ESD Protection -40℃ to +125℃
17	1	D5	BZT52C6V8	SOD-123	SURFACE MOUNT SILICON ZENER DIODES -55℃ to +150℃
18	2	D6,D46	MBRX0560	SOD-323	0.5 Amp Schottky Rectifier
19	1	D8	RED	LED0402	LED SMD 0402 BLUE COLOR
20	1	D9	YELLOW	LED0402	LED SMD 0402 BLUE COLOR
21	2	D33,D36	SS35	DO-214AC	DOWOSEMI SURFACE MOUNT SCHOTTKY BARRIER RECTIFIER -65℃ to +125℃
22	5	D35,D37,D41,D44,D45	BZT52C4V7	SOD-123	SURFACE MOUNT SILICON ZENER DIODES -55℃ to +150℃
23	1	D38	BZT52C36V	SOD-123	SURFACE MOUNT SILICON ZENER DIODES -55℃ to +150℃
24	2	D39,D40	BZT52C24	SOD-123	SURFACE MOUNT SILICON ZENER DIODES -55℃ to +150℃
25	1	D47	SMAJ13A	DO-214AC	TVS Diode Surface Mount DO-214AC (SMA) from Littelfuse Inc.
26	1	F1	1AMP	FUSE1206	
27	1	J1	Header1x6	SMD-SH1D0-6P-HOR	SH1.0mm 6-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
28	1	J2	Header1x14	SMD-SH1D0-14P-HOR	SH1.0mm 14-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
29	1	J3	Header1x16	SMD-SH1D0-16P-HOR	SH1.0mm 16-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
30	1	J4	Header1x8	SMD-SH1D0-8P-HOR	SH1.0mm 8-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
31	1	J5	Header1x4	SMD-SH1D0-4P-HOR	SH1.0mm 4-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
32	1	J6	Header1x5	SMD-SH1D0-5P-HOR	SH1.0mm 5-PINS CONNECTOR SINGLE ROW HORIZONTAL SMD/SMT
33	2	L1,L3	10uH	IND-5D7X5D2X1D8	SRP5020TA-2R2M Fixed Inductors 10uH 20% 2.5A -40℃ to +125℃
34	1	L2	BLM15BD182SN1D	FB0402	Ferrite Chip Beads SMD/SMT 0402 100mA 25% 1.8 kOhms@100MHz
35	3	L4,L5,L6	1uH	L0805	Fixed Inductors 1uH 20% 1.2A SMD/SMT 1206-INCH -40℃ to +85℃
36	3	Q1,Q2,Q3	S8550	SOT-23-3	JCST SOT-23 Plastic-Encapsulate Transistors (PNP)
37	1	Q4	BAT54CW	SOT-323	SWITCHING DIODE Low forward voltage
39	2	R1,R83	150K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
40	2	R2,R75	47.5K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W

41	42	R3,R4,R5,R6,R7,R8,R10,R13, R40,R41,R76,R79,R80,R88,R89, R90,R94,R95,R96,R97,R101,R103, R104,R108,R109,R112,R114,R118, R122,R123,R125,R126,R128,R129, R130,R131,R133,R134,R136,R138, R140,R141	10K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
42	2	R9,R27	10-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
43	1	R11	1Meg-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
44	2	R12,R53	33.2K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
45	1	R14	5.49K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
46	9	R15,R34,R37,R46,R49,R148, R151,R164,R165	100K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
47	1	R16	5.62K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
48	2	R17,R18	2.2K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
49	2	R19,R57	6.49K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
50	7	R20,R23,R33,R42,R115,R156,R173	16.2K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
51	1	R21	2K-OHMS	R0402	RESISTOR SMD 0603 ±1% 1/10W
52	1	R22	20K-OHMS	R0402	RESISTOR SMD 0603 ±1% 1/10W
53	1	R24	0-OHMS	R0402	RESISTOR SMD 0603 ±1% 1/10W
54	2	R25,R154	5.62K-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
55	4	R26,R43,R153,R169	1.87K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
56	5	R28,R29,R31,R161,R168	100K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/10W
58	1	R32	1.62K-OHMS	R0402	RESISTOR SMD 0603 ±% 1/10W
59	16	R35,R36,R38,R39,R47,R48,R54, R55,R146,R147,R149,R150,R162, R163,R166,R167	0.68-OHMS	R0805	Current Sense Resistors - SMD 0.2 OHM 3/4W
60	1	R45	23.7K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
61	6	R50,R51,R52,R77,R78,R117	2K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
62	1	R56	2.37K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
63	1	R58	976-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16
64	2	R59,R60	511-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16
65	2	R61,R62	3.32K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
66	2	R63,R127	DNP	R0402	DNP(DO NOT PLACE, RESERVED)
67	2	R64,R65	3.4K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16
68	2	R66,R71	442-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
69	2	R67,R72	1.1K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
70	2	R68,R73	1.74K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
71	2	R69,R74	4.42K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
72	1	R70	22.1K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
73	6	R81,R82,R91,R98,R99,R100	10K-OHMS	R0402	RESISTOR SMD 0402 ±% 1/16W
75	3	R86,R87,R110	1K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
76	3	R92,R93,R107	1.69K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
77	1	R102	9.09K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
78	2	R105,R143	0-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
79	1	R111	110K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
80	1	R116	8.25K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
81	3	R119,R120,R121	33-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
82	2	R132,R139	71.5K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
83	2	R135,R137	8.66K-OHMS	R0402	RESISTOR SMD 0402 ±1% 1/16W
84	1	R144	1.4K-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
85	2	R152,R171	24.9K-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
87	2	R157,R160	2K-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
88	1	R158	825-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W
89	1	R172	33.2K-OHMS	R0603	RESISTOR SMD 0603 ±1% 1/10W

90	17	U1,U2,U3,U4,U9,U10,U11,U12,U22,U23,U30,U31,U32,U36,U37,U38,U39	SGM7SZ08YXDM6G/TR	XTDFN-1X1-6L	SGM7SZ14, Small Logic Inverter with Schmitt Trigger Input -40℃ to +125℃
91	2	U5,U6	SGM2028-ADJ	SOT-23-5	SGM2028, 500mA, Ultra-Low Dropout, Low Power, RF Linear Regulator -40℃ to +85℃
92	2	U7,U16	SGM2028-3.3	SOT-23-5	SGM2028, 500mA, Ultra-Low Dropout, Low Power, RF Linear Regulator -40℃ to +85℃
93	1	U8	SGM8968-2XS8G/TR （SGM8967-2XS8G/TR , SOIC-8）	SOIC-8	SGM8968-2, 1.6mA, 10MHz, High Precision, Low Noise, Rail-to-Rail I/O, CMOS Operational Amplifiers -40℃ to +125℃
94	3	U13,U14,U19	SGM8968-4XS14G/TR （SGM8967-4XS14G/TR, SOIC-14）	SOIC-14	SGM8968-4, 1.6mA, 10MHz, High Precision, Low Noise, Rail-to-Rail I/O, CMOS Operational Amplifiers -40℃ to +125℃
95	1	U15	TPR3333-S3TR	SOT-23-3	3PEAK 3.3V Voltage Reference
96	1	U17	SGM58031XMS10G/TR	MSOP-10	SGM58031, Ultra-Small, Low-Power, 16-Bit Analog-to-Digital Converter with Internal Reference -40℃ to +125℃
97	1	U18	GD32F303RGT6	LQFP64	GigaDevice ARM Cortex-M4 32-bit MCU Green Industrial -40° C to +85° C
98	2	U20,U28	SGM6230	SOIC-8-EPAD	SGM6230, 2A, 38V, 385kHz Buck Converter -40℃ to +85℃
99	1	U21	NCE3013J	DFN2X2-6L	N-Channel Enhancement Mode Power MOSFET
100	4	U24,U29,U43,U47	AS4950	SOP8-PP	Full-Bridge DMOS PWM Motor Driver -40° C to +85° C
101	2	U25,U27	NCE603S	SOP-8	MOSFET N & P Trench 60V 6.3A,6A 2.5V @ 250uA,3.5V @ 250uA 30 m?? @ 6A,10V;80 m?? @ 5A,10V SOP-8_150mil RoHS
103	1	U33	NCE6003Y	SOT-23-3L	N-Channel Enhancement Mode Power MOSFET
104	2	U34,U49	SGM7SZ14	SOT-23-5	SGM7SZ14, Small Logic Inverter with Schmitt Trigger Input -40℃ to +125℃
105	1	U40	GD25Q40ETIG	SOP8-150MIL	GigaDevice SERIAL NOR FLASH 4Mbit SOP8 150mil -40℃ to +85℃
106	3	U41,U45,U48	NCE60P04Y	SOT-23-3L	60V 4A 120mΩ@10V,4A 1.5W 3V@250μA P Channel SOT-23-3L MOSFETs ROHS
107	1	U44	KMB26S （MB10F）	TO-269AA	Bridge Rectifier Single Phase Schottky 60 V Surface Mount MBS from SMC Diode Solutions
108	1	Y1	8MHz	CRY-SMD-3D2X2D5MM-4P	SMD CRYSTAL 3.2mmx2.5mm 4-PINS
109	1	Y2	32.768KHz	CRY-SMD-3D2X1D5MM-2P	SMD CRYSTAL 3.2mmx1.5mm 2-PINS

SCHEMATIC BRIEF DESCRIPTION

Page 1 – POWER SUPPLY

The board is feed by a 18650 battery pack. We need 8 batteries in serial connection to get a higher voltage for something particular reason. It seems the laser source module needs a high voltage, it was been done by other teammates we don't know. To avoid reverse connection damage, I add a bridge rectifier(U44) at the entrance, so the power source polarity isn't significant. There is a re-settable fuse 1AMP used to cut off power supply when a over current situation occurs. I also considered appropriate working voltage range, so a under voltage protection and a over voltage protection are necessary. According to the features of a 18650 battery, I know the charging cut-off voltage is 3.7V and discharging cut-off voltage is 3.0V. So, the threshold for under voltage I chose 3.0V*8S=24V, the threshold for over voltage I chose 36V, a little bit higher than 4.2V*8S=33.6V.

The main switcher to deliver power to backward stage is a P-MOSFET(U27). The VSYS network name is a key point after protection, once it gets power, all system gets power.

The following, I'd wanna describe protective theory in detail.

First, I need a auxiliary power to keep LED warning indication working in case of emergencies. R160 and D41 are used to generate a 4.7V voltage, it's always valid unless components crash.

If the fuse(F1) breaks, VBAT network lost power. Zener(D45) is ON, the voltage between Gate and Source of P-MOSFET(U41) now equals -4.7V enough to turn on it. So Zener(D5) starts to work to generate a 6.8V voltage and then Zener(D35) is on. Attention 2-INPUT AND Gate(U31), Pin-2(B) is feed by a 5Hz oscillator, Pin-1(A) keeps 4.7V, so Pin-4(Y) outputs to drive a RED LED(D8) frequently to indicate a over current error occurs.

All 12V power rails are controlled by MCU. As a portable device, to reduce power consumption is critical. The EN pins of step down converter is driven by network 12V_PWR_ON. Drive it to low to turn off in different software requirements. And power for Laser Distance Measurement is also controllable. I call it two-stage switcher.

Page 2 – MCU + KEYS

I add two LEDs on board to debug firmware conveniently. But the driving approach is a little difference than usual. Lacks of GPIO, so only one Pin can be used.

When LED outputs 0, D3 turns ON and D2 turns off.

When LED outputs 1, D3 turns OFF, but N-MOSFET(U21) turns ON, so D2 turns on.

If you wanna both turn ON, drive LED pin with a wave of higher frequency, 50% duty cycle is better.
Set LED GPIO pin to floating input to turn both off.

I'm sorry about this unfriendly and stupid design, but all GPIO had been gone.
There's a serial Flash IC with 4Mbits capacity on board. It's optional, parameters also can be stored inside MCU integrated Flash.

It's really, really, really difficult to expand many peripherals with a 48-Pins MCU. Please forgive me, this MCU was ideal at the beginning of project, but the requirements was changed later. And it's a challenge, unwise to change to another one. The purchase is also harder. So the software engineer must recognize keys input using a ADC. Don't worry, all inputs were processed with impedance match. See equations to learn how to recognize each key easily.

And you must notice that all UARTS interfaces are isolated by a AND gate. This is intend to protect MCU I/O to reduce repair fees.

Page 3 – CONSTANT CURRENT ADC

In this design, we use two potentiometers to measure the accurate position of motors. In order to get a high accuracy and to avoid influence of voltage ripple, we built a 1mA constant current source to excite the sensor. There's a question here, the resistor is 5K-OHMS maximum value, if excite it with 1mA, then we get 5V voltage. It exceeds the power supply voltage, we might lost resolution. So I connect an external 3.4K-OHMS resistor in parallels to reduce the total resistance. Here it is 5K//3.4K=2.02381K. I use a 511-OHMS resistor to level up the voltage and convert the single-ended signals to a differential signal. Now assume the value of potentiometer is 0-OHMS, so the voltage of Vb=Va=1mA*511-OHMS=511mV, Vb-Va=0V. If the value is 5K-OHMS, then Vb=1mA*(5K//3.4K+511)=2.02381V, Va=1mA*511=0.511V, so Vb-Va=1.51281V. It's within the range of full scale of ADC 2.048V.

There's also a exciting source for PT100 temperature sensor. I read its data sheet and know it's 60.26-OHMS@-100, 138.51-OHMS@+100. So if the environment temperature below -100, the value is about 50-OHMS, then Vb-Va=1mA*50-OHMS=0.05V, amplify with a Gain=11, we get 0.05V*11=0.55V. As the same, when it below +100, Vb-Va=1mA*150-OHMS=0.15V, the real voltage applied to ADC is 0.15V*11=1.65V.

I also apply a fixed voltage value 5V to the spare channel, then the software can check if the ADC chip works well.

Page 4 – MOTOR+FAN DRIVER

Here I will give out a brief example about how to drive DC motor. AS4950 is a H-bridge integrated chip, so we feed it with PWM. The Motor-1 connects to TIMER7_CH0/TIMER7_CH1. The Motor-2 connects to TIMER3_CH0/TIMER3_CH1. AS4950 has a built-in current limitation. The Pin-4(VREF) is used to apply a appropriate voltage outside. I offer two ways to do that. We can set up a fixed resistor network divider. Or feed it with a DAC output accurately. But may I have your attention please? In order to protect motors to avoid physical damage, there's a fast cut off mechanism active. For Motor-1, attention with U42,Q5 and U26 components. When motor-1 reaches minimum position, M1_LSW_MIN gets 0. When motor-1 reaches maximum position, M1_LSW_MAX gets 0.

To accelerate cut-off driving source, here I limit the maximum current to a lower value nearly to zero. It's all hardware driven without software attention. When M1_LSW_MIN or M1_LSW_MAX gets 0, NAND gate outputs 1 to turn on NMOS to drop VREF to GND. At this time, M1_UNLOCK must stay HIGH. So motor-1 stops without driving. In other words, right now, motor-1 reaches physical minimum or maximum position. Under this situation, if we want motor-1 to rotate toward opposite direction, we drive M1_UNLOCK to LOW to bypass limitation of switches. We must handle it carefully to avoid mechanism damage.

The working current of the motor is sampled by a shunt resistor. To get more flexibility and stability, I use four 0.68-OHMS resistors, combine them to one to replace a big one, to reduce PCB space taken up. According to the motor data sheet, we get to know current consumption under different situation. 4.6mA with no load condition, 0.188A with continuous working condition and 0.37A with lock rotor condition. So the calculating equations are below, and in order to reach the full scale of ADC input to optimize performance, a non-inverting amplifier with gain x 9 approximately is followed. Gain=8.15 in real.

0.68R * 4.6mA = 3.128mV (*8.15 = 25.4932mV)
0.68R * 0.188A = 127.84mV (*8.15 = 1.042V)
0.68R * 0.37A = 251.6mV (*8.15 = 2.05V)

We also need to monitor the power rails of 12V for motor and the whole system power. VDD12_MOTOR is divided by a resistor network connection in serial to drop down the voltage to adapt the ADC input range.
The real voltage apply into ADC pin is V=(5.49K/(5.49K+16.2K))*12V=3.037V,
meanwhile the VSYS voltage apply into ADC pin is V=(1.62K/(1.62K+16.2K))*33.6V=3.0545V

Here I still use AS4950 H-bridge Chips to drive two FANs, although a small footprint NMOSFET is enough. I consider more, once the requirement change, no need to re-layout the PCB. It's a reserved solution. No perfect solution to adapt all requirements. With a H-bridge, we can drive a FAN to rotate in two directions, clockwise and anti-clockwise. Unfortunately, there's no current monitoring due to the lack of GPIO pins.

Page 5 – PHYSICAL CONNECTORS

Nothing to be noticed. Each connector has different amount numbers of pins to allow operators to assemble easily and rapidly.

That's all. No bugs permanently! God Bless Us!

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Yanai Electrician