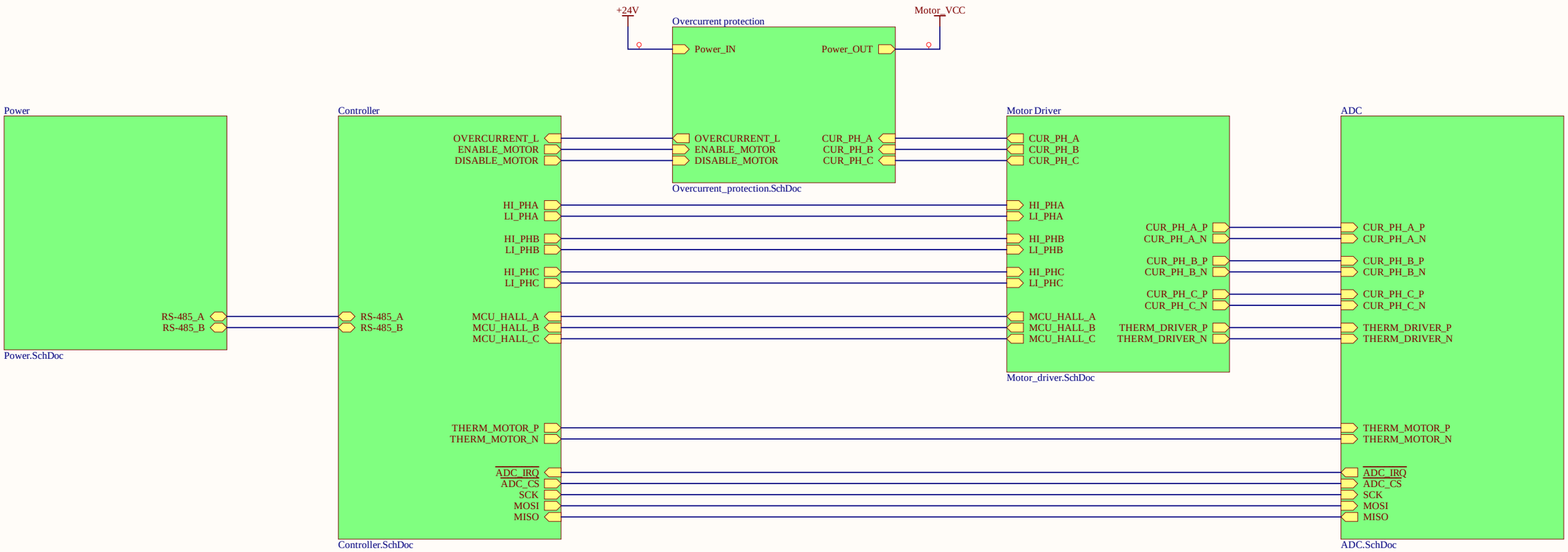
REVISION	DESCRIPTION	DATE	APPROVED



Maksim Inozemtsev
Nigiritka@gmail.com
https://www.linkedin.com/in/maksim-inozemtsev/

APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU

PROJECT REVISION: | DOCUMENT REVISION: | DESIGN ITEM: PCBA-JCU_BLDC-DEF

TITLE: Block Diagram

SIZE	CAGE CODE	DWG NO.	REV
A3			A.2

SCALE: | FILE NAME: Top_level.SchDoc | SHEET 1 OF 7

REVISION	DESCRIPTION	DATE	APPROVED

X1 — Molex 205338-0004: 1 +24V; 2 GND; 3 RS-485_A; 4 RS-485_B; M1 GND; M2 GND

D8 SMBJ26A

C2 100 µF 35.0 V; C3 100 µF 35.0 V; C79 22.0 µF 35.0 V; C80 22.0 µF 35.0 V

Q14 BC857C,215; R79 100 kΩ; R81 2.00 kΩ; R82 10.0 kΩ; R83 1.00 kΩ; R80 10.0 kΩ; U19 TL431BCDBZR,215; Q15 BC847C,215; D6 BAT54C-7-F; EN_5V; EN_3V3

OVLO for the PCB:
Check the design description document (5.2.1.7.)
UVLO = 28V;

U16 AP63200: C36 10.0 µF 35.0 V; R77 158 kΩ; R78 10.0 kΩ; EN_5V; C42 50.0 V 100 nF; L4 10.0 uH; C44 100 pF 50.0 V; R53 158 kΩ; R51 30 kΩ; R92 0.0 Ω; C37 22.0 µF 10.0 V; C38 22.0 µF 10.0 V; C7 22.0 µF 10.0 V; C39 100 nF 50.0 V

UVLO for DC/DC:
Check the design description document (5.2.1.1.)
UVLO = 20V;

Efficiency:
83%
Current at 5V:
38mA
Power losses:
38mW

For debug purposes

X2 — Molex 205338-0004: 1 +24V; 2 GND; 3 RS-485_A; 4 RS-485_B; M1 GND; M2 GND

RS-485_A; RS-485_B

P dissapation = 12V voltage drop * 3mA current = 36 mW

Q16 SQS401ENW-T1_GE3; R84 10.0 kΩ; R85 10.0 kΩ; Gate-source voltage (Vgs) max: -20V.

Q7 DZT2222A-13; R72 7.5 kΩ; R74 7.5 kΩ; R73 2.00 kΩ; U18 TL431BCDBZR,215; C52 10.0 µF 25.0 V; C81 100 nF 50.0 V

12V regulater is enabled when 3V3 regulator ON. It means UVLO/OVLO of 3V3 regulator will work for 12V regulator as well.

R87 1.00 kΩ; EN_12V; Q17 BC847C,215; R86 10.0 kΩ

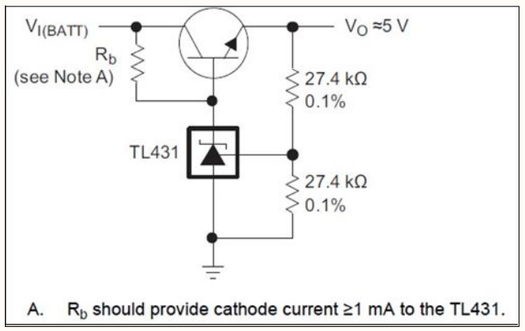
U7 AP63200: C35 10.0 µF 35.0 V; R76 158 kΩ; R75 10.0 kΩ; EN_3V3; C41 50.0 V 100 nF; L3 6.8 uH; C43 100 pF 50.0 V; R52 182 kΩ; R66 62 kΩ; R106 0.0 Ω; C32 22.0 µF 10.0 V; C33 22.0 µF 10.0 V; C67 22.0 µF 10.0 V; C34 100 nF 50.0 V

R52 180k was installed

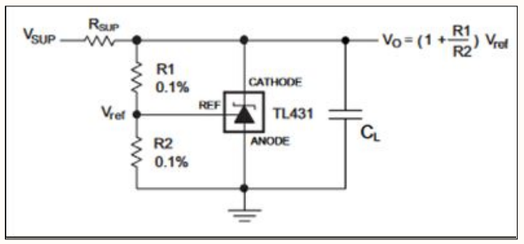
Efficiency:
80%
Current at 3V3:
30mA
Power losses:
24mW

For debug purposes

R12 10.0 kΩ; D10



A. R_b should provide cathode current ≥1 mA to the TL431.



Adjust R50 in order to find suitable current for the load

Q18 BC847C,215; R50 100 Ω; R89 51.0 Ω; R88 10.0 kΩ; D7 BAT42W-TP; U4 NC LM4040AEX3-3.0+T; C46 100 nF 50.0 V; R67 10.0 kΩ ±0.1%; C30 470 pF 50.0 V; R68 10.0 kΩ ±0.1%; C51 50.0 V 100 nF

3V3, 1mA

U15 MCP6V86T-E/OT; R69 51.0 Ω; C47 470 pF 50.0 V

5V, 1mA

+1V5 - Reference voltage for mid point of current sense amplifier, as well as for mid point of the fully differential amplifier
+3V0 - Reference voltage for ADC

Ika = 2 mA
R1 = 2k
R2 = 10k

R33 1.00 kΩ; R34 2.00 kΩ; R35 10.0 kΩ; C16 50.0 V 100 nF; U11 TL431BCDBZR,215

3V3, 1mA

Power consumption:

+3V3:
MAX3097ECSE+ - 4mA;
MCP3462-E/ST - 3mA;
ASE-20.000MHZ-LR-T - 5mA;
LM4040AEX3-3.0+T - 1mA;
PI4IOE5V9554ZHEX - 1mA;
STM32L432KC - 10mA;
MAX3485ESA+ - 1mA;
TL431BCDCKR - 1mA;
SN74AUP1G98DCKR - <1uA * 3;
INA185A2IDRLR - 1mA * 3

+5V:
Incremental Encoder - 15mA;
MCP6D11T-E/MS - 2mA * 3;
MCP6V86T-E/OT - 1mA;
MIC7221YM5 TR - 0.1mA * 3;
AS5048A - 15mA;

+12V:
MIC4604YM-TR - 1mA * 3;

Total at 24V line:
- 17.7mA (0.425W)

APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU — Altium

PROJECT REVISION: | DOCUMENT REVISION: | DESIGN ITEM: PCBA-JCU_BLDC-DEF

TITLE: Power

SIZE	CAGE CODE	DWG NO.	REV
A3			A.2

SCALE: | FILE NAME: Power.SchDoc | SHEET 2 OF 7

REVISION	DESCRIPTION	DATE	APPROVED

PA15 not available at Nucleo
Consider Encoder Z is not used in current PCB, instead of, CS of the Mag encoder to be connected to PC15

Nucleo-L432 modification:
1) Remove SB5
2) Remove SB7
3) Place SB6
4) Place SB8
5) Remove SB16
6) Remove SB18
7) Remove SB2
8) Remove SB3

U2 — STMicroelectronics NUCLEO-L432KC

3V3, 10mA

R97 1.00 kΩ LED_BLUE
R98 1.00 kΩ LED_RED
R99 1.00 kΩ LED_WHITE
D12, D9, D3

TIM1_CH1 R62B 10.0 Ω HI_PHA
TIM1_CH1N R62A 10.0 Ω LI_PHA
TIM1_CH2 R62D 10.0 Ω HI_PHB
TIM1_CH2N R62C 10.0 Ω LI_PHB
TIM1_CH3 R63A 10.0 Ω HI_PHC
TIM1_CH3N R63B 10.0 Ω LI_PHC
R64C, R64D, R64A, R64B, R65A, R65B, R65C, R65D 10.0 kΩ

THERM_MOTOR_P
THERM_MOTOR_N
ADC_IRQ
ADC_CS
SCK
MOSI
MISO
HALL_A_MOSI R127A 10.0 Ω MCU_HALL_A
HALL_B_SCK R127B 10.0 Ω MCU_HALL_B
HALL_C_MISO R127C 10.0 Ω MCU_HALL_C
R127D 10.0 Ω

C19 100 nF 50.0 V
U1 — MAX3485ESA+
RS-485_A, RS-485_B, R37 120.0 Ω
R3A, R3B, R3C 10.0 Ω
R38 1.00 kΩ, R40 10.0 kΩ, D11
D26 STS232120U58

3V3, 1mA

C20 100 nF 50.0 V

U14 — Maxim Integrated MAX3097ECSE+

Z index is not used in current encoder!!!!

Alarm delay about 100 us

3V3, 4mA

$t_D = 10 + 0.187 \times C_{DELAY}$ (for V_{CC} = 3V)
where t_D is in µs and C_{DELAY} is in pF.

C65 100 nF 50.0 V
R10A, R10B, R10C, R10D 10.0 kΩ

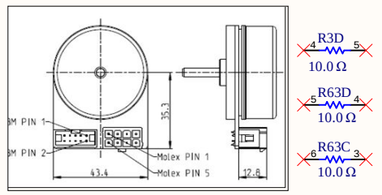
Address: 0100 000"R/W bit"

U17 — Diodes Inc. PI4IOE5V9554ZHEX

I2C expander interrupt cannot be used in this version of the PCB because pins is not available at Nucleo Board

3V3, 1mA

Encoder
Pin 1 N.C.
Pin 2 V_{CC}
Pin 3 GND
Pin 4 N.C.
Pin 5 Channel $\overline{A}$
Pin 6 Channel A
Pin 7 Channel $\overline{B}$
Pin 8 Channel B
Pin 9 Do not connect
Pin 10 Do not connect



R3D, R63D, R63C 10.0 Ω

C21 100 nF 50.0 V

X7 — Würth Elektronik 61201021621

5V, 15mA

ESD does not required, because MAX3097 has ±15kV ESD-Protected

Pinpuller can be 12V or 24V

R44 10.0 kΩ, R60 100 Ω, C40 100 nF 50.0 V, D19 CG0402MLC-3.3LGA
R105 0.0 Ω, R107 10.0 kΩ
D4 BAT42W-TP
R115 51.0 Ω, Q10 NTR3C21NZT1G, R114 10.0 kΩ
D21, D20 CG0402MLC-3.3LGA

X5 — Molex78171-5006 / Molex 78171-5006

X6 — FCI 68000-406HLF

If SPI1 is needed, hall sensor can be disconnected

X3 — Molex 52746-0633

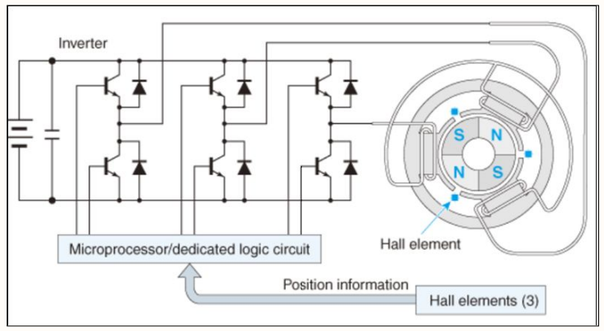
R129A, R129B, R129C, R129D 10.0 Ω
D22, D23, D24, D25 CG0402MLC-3.3LGA

3V3, 15mA

APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU
PROJECT REVISION:
DOCUMENT REVISION:
DESIGN ITEM: PCBA-JCU_BLDC-DEF
TITLE: Controller
SIZE: A3
CAGE CODE:
DWG NO.
REV: A.2
SCALE:
FILE NAME: Controller.SchDoc
SHEET 3 OF 7

REVISION	DESCRIPTION	DATE	APPROVED



+12V
C66 10.0 µF 25.0 V
GND
+12V
D1 BAT42W-TP
IC1
1 VDD
HO 3 HO_PHASE_A
HB 2
C8 100 nF 50.0 V
PHASE_A
HI_PHA 5 HI
LI_PHA 6 LI
HS 4
7 VSS
LO 8 LO_PHASE_A
MIC4604YM-TR
GND
12V, 1mA

+12V
C1 10.0 µF 25.0 V
GND
+12V
D2 BAT42W-TP
IC2
1 VDD
HO 3 HO_PHASE_B
HB 2
C9 100 nF 50.0 V
PHASE_B
HI_PHB 5 HI
LI_PHB 6 LI
HS 4
7 VSS
LO 8 LO_PHASE_B
MIC4604YM-TR
GND
12V, 1mA

+12V
C6 10.0 µF 25.0 V
GND
+12V
D5 BAT42W-TP
IC3
1 VDD
HO 3 HO_PHASE_C
HB 2
C4 100 nF 50.0 V
PHASE_C
HI_PHC 5 HI
LI_PHC 6 LI
HS 4
7 VSS
LO 8 LO_PHASE_C
MIC4604YM-TR
GND
12V, 1mA

R103D 10.0 Ω
R113D 10.0 kΩ
R104D 10.0 kΩ

Motor_VCC
HO_PHASE_A
R1 0.0 Ω
R5 10.0 kΩ
Q1
PHASE_A
LO_PHASE_A
R2 0.0 Ω
R6 10.0 kΩ
Q3
GND

Motor_VCC Motor_VCC Motor_VCC Motor_VCC Motor_VCC Motor_VCC Motor_VCC Motor_VCC
C59 22.0 µF 35.0 V
C60 22.0 µF 35.0 V
C61 22.0 µF 35.0 V
C62 22.0 µF 35.0 V
C63 22.0 µF 35.0 V
C64 22.0 µF 35.0 V
C77 22.0 µF 35.0 V
C78 22.0 µF 35.0 V
GND

Current Sense
IN OUT MOTOR_A
CURRENT_P CUR_PH_A_P
CURRENT_N CUR_PH_A_N
CUR_SIN_END CUR_PH_A
Current_Sense.SchDoc

Motor_VCC
HO_PHASE_B
R119 0.0 Ω
R118 10.0 kΩ
Q2
PHASE_B
LO_PHASE_B
R120 0.0 Ω
R123 10.0 kΩ
Q4
GND

Current Sense
IN OUT MOTOR_B
CURRENT_P CUR_PH_B_P
CURRENT_N CUR_PH_B_N
CUR_SIN_END CUR_PH_B
Current_Sense.SchDoc

+3V3
R104A 10.0 kΩ
MCU_HALL_A
Q19 BC847C,215
R103A 10.0 Ω
HALL_A
R113A 10.0 kΩ
GND

+3V3
R104B 10.0 kΩ
MCU_HALL_B
Q20 BC847C,215
R103B 10.0 Ω
HALL_B
R113B 10.0 kΩ
GND

+3V3
R104C 10.0 kΩ
MCU_HALL_C
Q21 BC847C,215
R103C 10.0 Ω
HALL_C
R113C 10.0 kΩ
GND

Rt1
ERT-J0ET102J
THERM_DRIVER_P
THERM_DRIVER_N

Motor_VCC
HO_PHASE_C
R121 0.0 Ω
R124 10.0 kΩ
Q11
PHASE_C
LO_PHASE_C
R122 0.0 Ω
R125 10.0 kΩ
Q12
GND

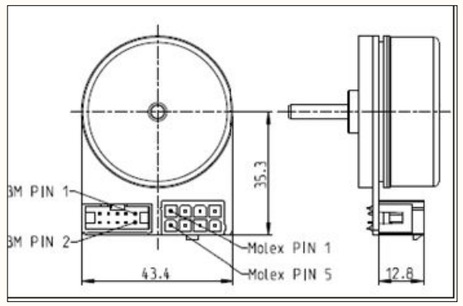
Current Sense
IN OUT MOTOR_C
CURRENT_P CUR_PH_C_P
CURRENT_N CUR_PH_C_N
CUR_SIN_END CUR_PH_C
Current_Sense.SchDoc

X4
MOTOR_A 1
MOTOR_B 2
MOTOR_C 3
Molex 55932-0310
D15 D14 D13
SMBJ26A
GND

+5V
C82 22.0 µF 10.0 V
GND

X9
HALL_A 1
HALL_B 2
HALL_C 3
4
5
M1
M2
Molex 781710005
D16 D17 D18
CG0402MLC-3.3LGA
GND
+5V
GND

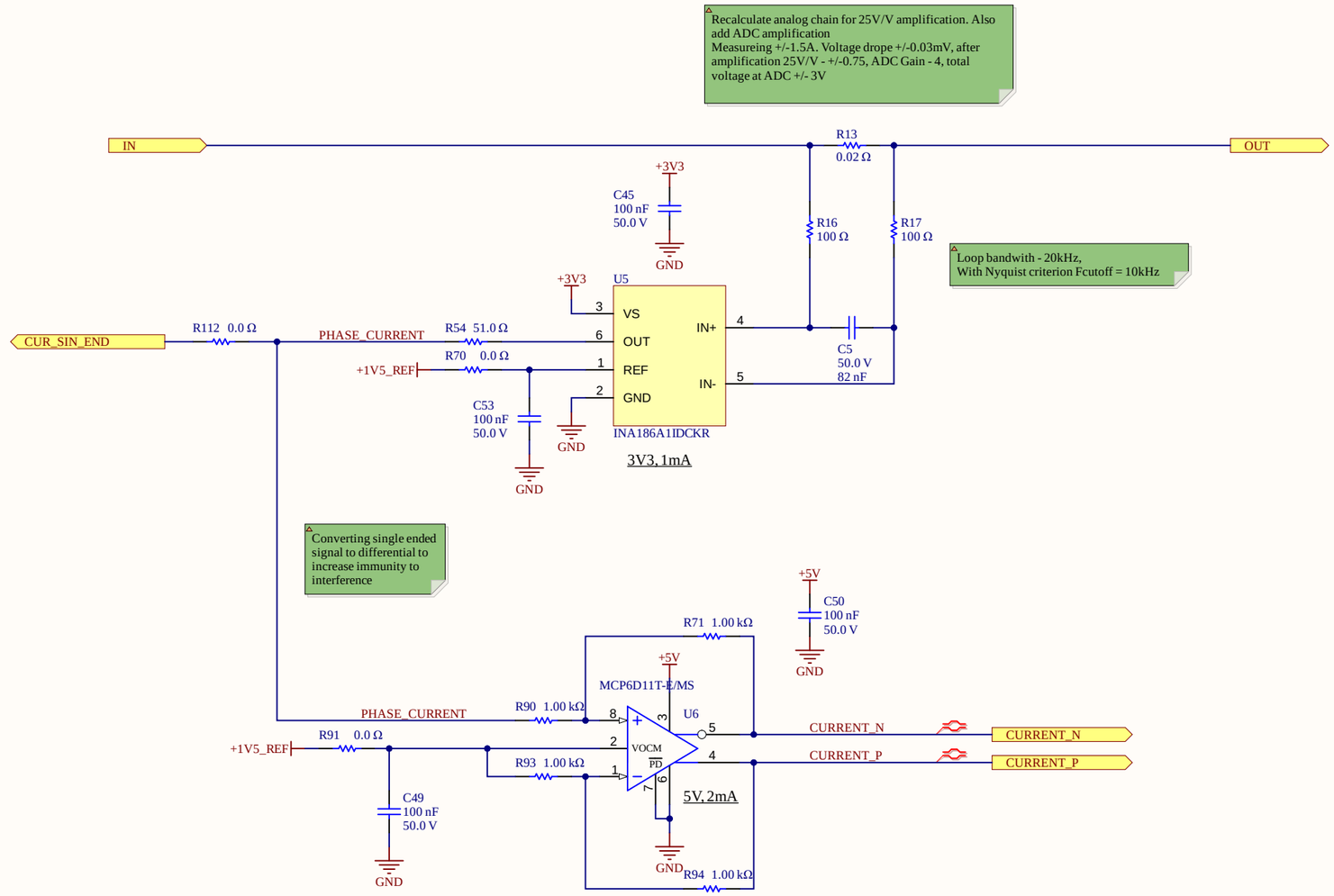
Motor + Sensors
Pin 1 Hall sensor 1
Pin 2 Hall sensor 2
Pin 3 V_{Hall} 4.5...18 VDC
Pin 4 Motor winding 3
Pin 5 Hall sensor 3
Pin 6 GND
Pin 7 Motor winding 1
Pin 8 Motor winding 2



APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU
PROJECT REVISION: | DOCUMENT REVISION: | DESIGN ITEM: PCBA-JCU_BLDC-DEP
TITLE: Motor Driver
SIZE: A3 | CAGE CODE | DWG NO. | REV: A.2
SCALE: | FILE NAME: Motor_driver.SchDoc | SHEET 4 OF 7

REVISION	DESCRIPTION	DATE	APPROVED



APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU

PROJECT REVISION: | DOCUMENT REVISION: | DESIGN ITEM: PCBA-JCU_BLDC-DEF

TITLE: Current Sense

SIZE	CAGE CODE	DWG NO.	REV
A3			A.2

SCALE: | FILE NAME: Current_Sense.SchDoc | SHEET 5 OF 7

REVISION	DESCRIPTION	DATE	APPROVED

Monostable multivibrator

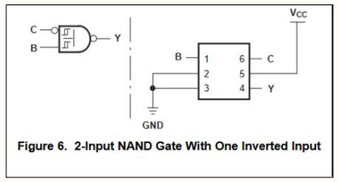


Figure 6. 2-Input NAND Gate With One Inverted Input

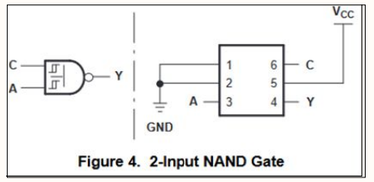
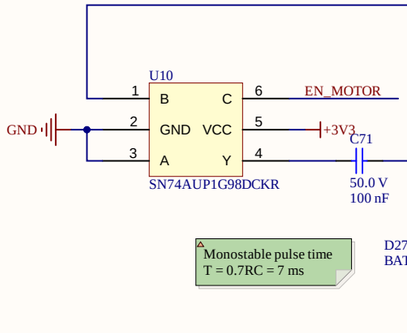
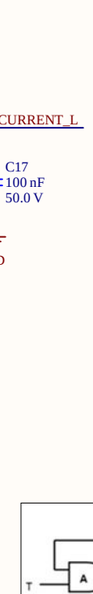


Figure 4. 2-Input NAND Gate



SET_L



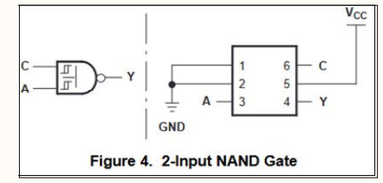


Figure 4. 2-Input NAND Gate

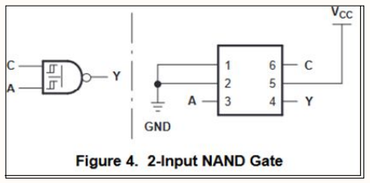
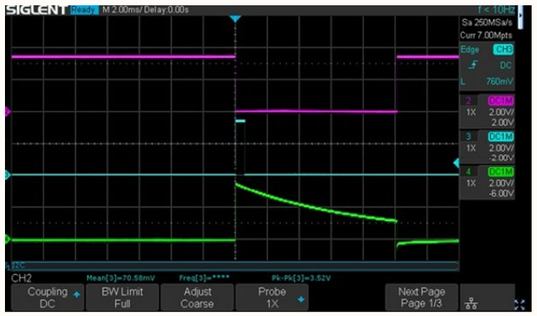


Figure 4. 2-Input NAND Gate

T	Q	X
0	0	1
0	1	1
1	0	1
1	1	0

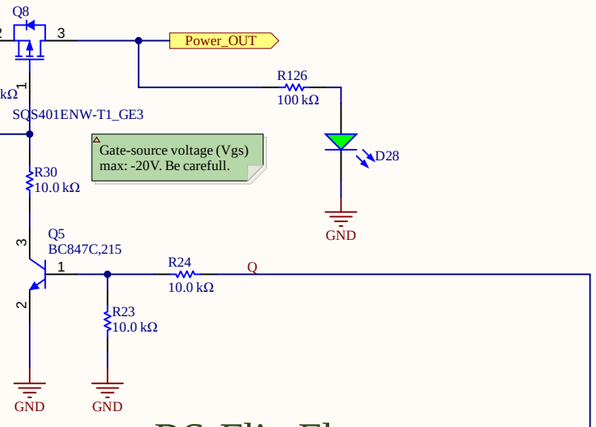
R	S	Q	State
1	1	Last State	No Change
1	0	1	Set
0	1	0	Reset
0	0	Not Applied (?)	Forbidden

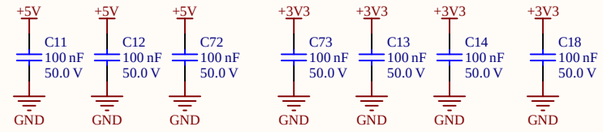


Blue - Point T
Violet - Point Q
Green - Point Y

Once SET impuls has come - circuit is activated, and power provided to the motor. RS Flip-Flop in SET state.

If Overcurrent event or Disable signal has arrived - RESET is activated, circuit switches to RESET state, power is removed from the motor





APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	
REFERENCE DOCUMENTS	
BOM:	
ASSY DWG:	
FAB DWG:	
PCB DWG:	

PROJECT: JCU

PROJECT REVISION: | DOCUMENT REVISION: | DESIGN ITEM: PCBA-JCU_BLDC_DEF

TITLE: Overcurrent Protecting

SIZE	CAGE CODE	DWG NO.	REV
A3			A.2

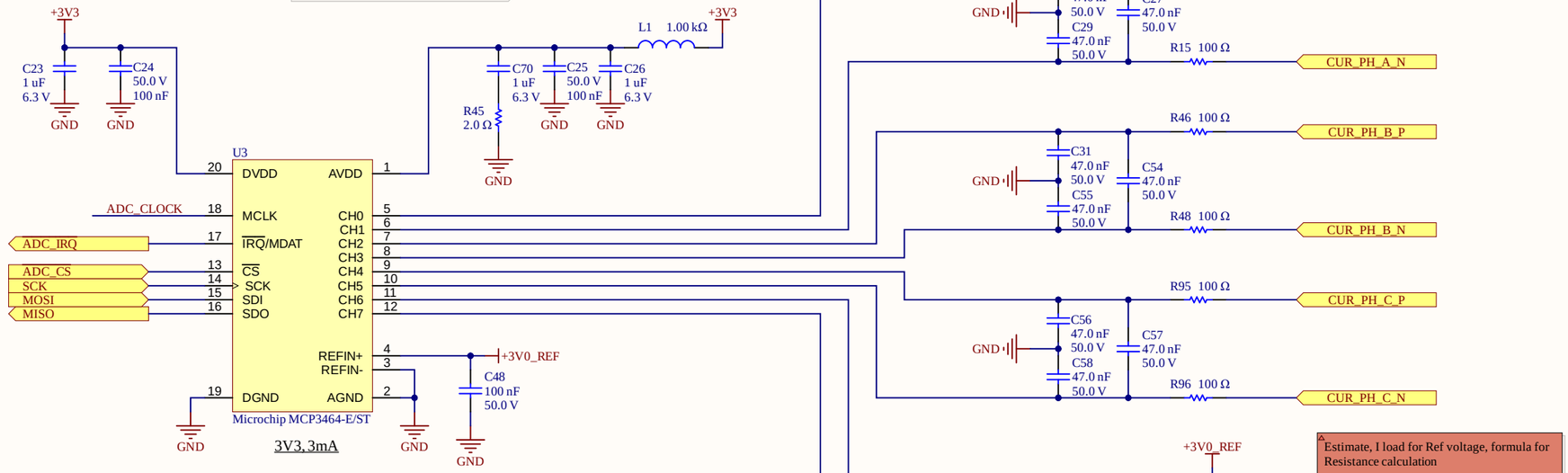
SCALE: | FILE NAME Overcurrent_protection.SchDoc | SHEET 6 OF 7

REVISION	DESCRIPTION	DATE	APPROVED

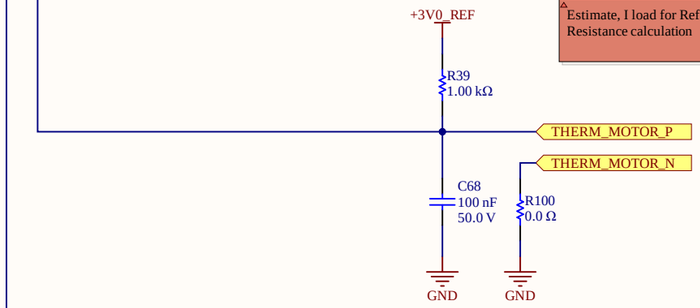
Fc = 8.4 kHz

Play with C70 to decrease resosnance ampitude,
Play with capacitance of C25/C26 to decrease cutoff frequency

Inductance at L1 is about 1.7uH



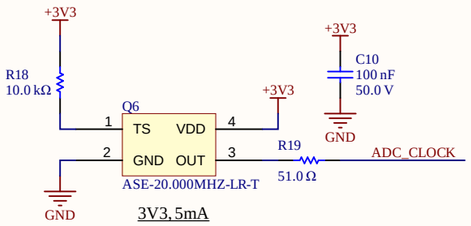
Estimate, I load for Ref voltage, formula for Resistance calculation



Available at Microchip

Input impedance of ADC

Differential Input Impedance (Note 5)	Z_{IN}	—	510	—	kΩ	GAIN = 0.33x, proportional to 1/AMCLK
		—	260	—	kΩ	GAIN = 1x, proportional to 1/AMCLK
		—	150	—	kΩ	GAIN = 2x, proportional to 1/AMCLK
		—	80	—	kΩ	GAIN = 4x, proportional to 1/AMCLK
		—	40	—	kΩ	GAIN = 8x, proportional to 1/AMCLK
		—	20	—	kΩ	GAIN ≥ 16x, proportional to 1/AMCLK



APPROVALS	DATE
ENG: Maksim Inozemtsev	
DSN: Maksim Inozemtsev	
CHK: Maksim Inozemtsev	

REFERENCE DOCUMENTS			
BOM:			
ASSY DWG:			
FAB DWG:			
PCB DWG:			

PROJECT: JCU			
PROJECT REVISION:	DOCUMENT REVISION:	DESIGN ITEM: PCBA-JCU_BLDC-DEF	
TITLE: ADC			
SIZE: A3	CAGE CODE	DWG NO.	REV: A.2
SCALE:	FILE NAME: ADC.SchDoc	SHEET 7 OF 7	