+12V

D1
LED

Resistor value
might need
adjustment for
brightness

R1
3.3k

GND

+12V   PWR_FLAG

GND   PWR_FLAG

J1
PWR

J2
IN

SD
RTDI
GPIO_IN_2
GPIO_IN_1
APPS_1
APPS_2
BPS

GND

{DIGITAL_INPUTS}

{ANALOG_INPUTS}

J3
CAN

CAN_S+
CAN_S−
CAN_C+
CAN_C−

J4
DRS

DRS
+12V   GND

J5
OUT

RTDS+
RTDS−
STATUS
GPIO_OUT_1
GPIO_OUT_2

+12V   GND

GND

{CAN, DIGITAL_OUTPUTS, SPEAKER}

H1 M3   H3 M3   H5 M3   H7 M3
H2 M3   H4 M3   H6 M3   H8 M3

CAN
DIGITAL_OUTPUTS
SPEAKER

CAN

CAN−C Bus Transceiver

CAN_C_RX   CAN_RX   CAN_H   CAN_C+
CAN_C_TX   CAN_TX   CAN_L   CAN_C−

File: can-transceiver.kicad_sch

CAN−S Bus Transceiver

CAN_S_RX   CAN_RX   CAN_H   CAN_S+
CAN_S_TX   CAN_TX   CAN_L   CAN_S−

File: can-transceiver.kicad_sch

CAN−C: critical systems
CAN−S: sensors / telemetry

{CAN_INTERNAL}

PWR_FLAG   +3V3   +12V

STM32−F746ZG

VIN
+3V3

Input Shift

BPS   BPS_IN   BPS_OUT   BPS
APPS_1   APPS_1_IN   APPS_1_OUT   APPS_1
APPS_2   APPS_2_IN   APPS_2_OUT   APPS_2

SD   SD_IN   SD_OUT   SD
RTDI   RTDI_IN   RTDI_OUT   RTDI

GPIO_IN_1 EXTRA_IN_1   EXTRA_OUT_1   GPIO_IN_1
GPIO_IN_2 EXTRA_IN_2   EXTRA_OUT_2   GPIO_IN_2

Spare inputs x2

File: input-shift.kicad_sch

CAN1_TXD   CAN_C_TX
CAN1_RXD   CAN_C_RX
CAN2_TXD   CAN_S_TX
CAN2_RXD   CAN_S_RX

GPIO_OUT_1D
GPIO_OUT_2D

DRSD
STATUSD
RTD_SIRESD

EEPROM_WCD   EEPROM_WC
SDA   EEPROM_SDA
SCLD   EEPROM_SCL

Output Level Shifting

GPIO_IN_1   GPIO_OUT_1D   GPIO_OUT_1
GPIO_IN_2   GPIO_OUT_2D   GPIO_OUT_2

DRS_IN   DRS_OUT   DRS
STATUS_IN   STATUS_OUT   STATUS

File: output-shift.kicad_sch

File: mcu.kicad_sch

{EEPROM_I2C}

EEPROM (Config Memory)

+3V3   +3V3
U1
M24256−DRD

1 E0   VCC 8
2 E1   WC   7   EEPROM_WC
3 E2   SCK 6   EEPROM_SCL
4 VSS   SDA 5   EEPROM_SDA

GND

C1
100n

GND

RTD Speaker Driver

KP1600

99db @ 2m
2kHz−4kHz
260mA (max)

RTDS−

R2
1k

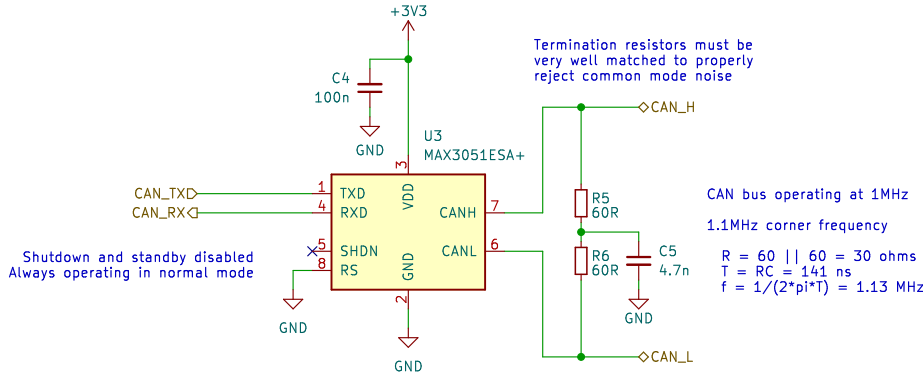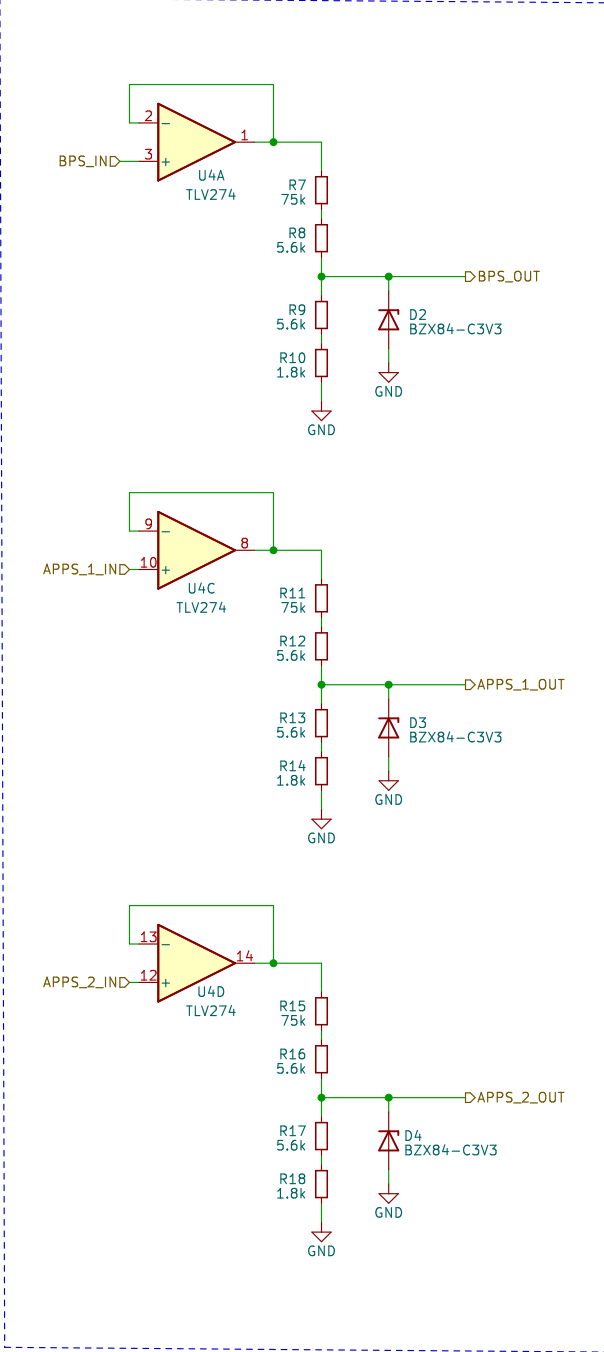Resistance?
FSUK requires >90dB so R = 0
FSG requires <90dB so R > 0?

R35
3k3

Q1
FDN359BN
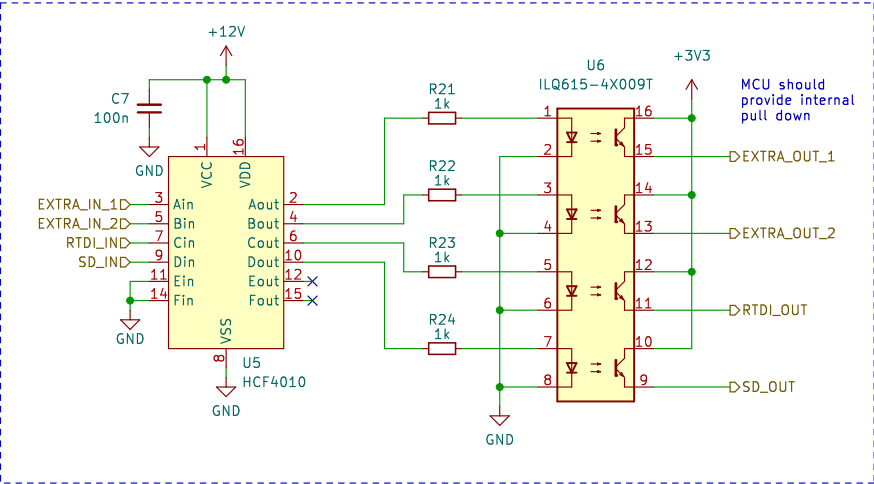
Vehicle: STAG 9
Drawn By: Tim Brewis
Checked By: Max O'Brien
CAD Part:
SUFST
Sheet: /
File: vcu.kicad_sch

Title: VCU

Size: A3   Date: 2023−03−03   Rev: 1.2.0
KiCad E.D.A. kicad (6.0.11−0)   Id: 1/6

+3V3

C2
100n

GND

U2
MAX3051ESA+

Termination resistors must be
very well matched to properly
reject common mode noise

CAN_TXD — 1 TXD
CAN_RX — 4 RXD

VDD 3

CANH 7
CANL 6

CAN_H

R3
60R

R4
60R

CAN bus operating at 1MHz

1.1MHz corner frequency

Shutdown and standby disabled
Always operating in normal mode

5 SHDN
8 RS

GND 2

GND

C3
4.7n

$R = 60 \parallel 60 = 30$ ohms
$T = RC = 141$ ns
$f = 1/(2\cdot pi \cdot T) = 1.13$ MHz

GND

GND

CAN_L

+3V3

C4
100n

GND

U3
MAX3051ESA+

Termination resistors must be
very well matched to properly
reject common mode noise

CAN_H

CAN_TXD — 1 TXD
CAN_RX — 4 RXD

VDD 3

CANH 7

CAN bus operating at 1MHz

1.1MHz corner frequency

Shutdown and standby disabled
Always operating in normal mode

5 SHDN
8 RS

CANL 6

GND 2

R5
60R

R6
60R

C5
4.7n

R = 60 || 60 = 30 ohms
T = RC = 141 ns
f = 1/(2*pi*T) = 1.13 MHz

GND

GND

GND

CAN_L

Analogue (12V -> 3.3V)

BPS_IND
U4A TLV274
R7 75k
R8 5.6k
BPS_OUT
R9 5.6k
D2 BZX84-C3V3
R10 1.8k
GND

APPS_1_IND
U4C TLV274
R11 75k
R12 5.6k
APPS_1_OUT
R13 5.6k
D3 BZX84-C3V3
R14 1.8k
GND

APPS_2_IND
U4D TLV274
R15 75k
R16 5.6k
APPS_2_OUT
R17 5.6k
D4 BZX84-C3V3
R18 1.8k
GND

Digital (12V -> 3.3V)

+12V
C7 100n
GND
VCC VDD
Ain Aout
Bin Bout
Cin Cout
Din Dout
Ein Eout
Fin Fout
VSS
U5 HCF4010
GND

EXTRA_IN_1
EXTRA_IN_2
RTDI_IND
SD_IND

R21 1k
R22 1k
R23 1k
R24 1k

U6 ILQ615-4X009T
+3V3
MCU should provide internal pull down

EXTRA_OUT_1
EXTRA_OUT_2
RTDI_OUT
SD_OUT

GND

IC Power and Unused

+12V
U4E TLV274
C6 100n
GND

+12V
R19 10k
R20 10k
GND
U4B TLV274

TI tech note SBOA204A suggests this configuration for unused single supply op amps

Vehicle: STAG 9
Drawn By: Tim Brewis
Checked By: Max O'Brien
CAD Part:
SUFST
Sheet: /Input Shift/
File: input-shift.kicad_sch
Title: VCU
Size: A3 | Date: 2023-03-03 | **Rev: 1.2.0**
KiCad E.D.A. kicad (6.0.11-0) | Id: 5/6

STM32 F746ZG Nucleo-144 Zio

Nucleo-144 dev board has
built in LD1117 regulator
supplied from VIN which
provides 3.3V power for
rest of circuit, up to 800mA

+3V3

To set bus
time constant
(RC < 400ns)

R25   R26
10k   10k

J8
ZIO_CN7

EEPROM_WC	PC6	2	1	PB8		SCL
	PB15	4	3	PB9		SDA
	PB13	6	5	AVDD	
CAN2_RXD	PB12	8	7	GND	
	PA15	10	9	PA5	GND
	PC7	12	11	PA6	
	PB5	14	13	PA7	
	PB3	16	15	PD14	
	PA4	18	17	PD15	
	PB4	20	19	PF12	

J6
ZIO_CN8

NC	2	1	PC8
IOREF	4	3	PC9
RESET	6	5	PC10
+3V3	8	7	PC11
+5V	10	9	PC12
GND	12	11	PD2
GND	14	13	PG2
VIND	VIN	16	15	PG3

+3V3

GND

J9
ZIO_CN10

	AVDD	2	1	PF13	
	AGND	4	3	PE9	STATUS
	GND	6	5	PE11	GPIO_OUT_1
	PB1	8	7	PF14	GPIO_OUT_2
	PC2	10	9	PE13	
	PF4	12	11	PF15	RTD_SIREN
CAN2_TX	PB6	14	13	PG14	
	PB2	16	15	PG9	
	GND	18	17	PE8	
	PD13	20	19	PE7	
	PD12	22	21	GND	
	PD11	24	23	PE10	
	PE2	26	25	PE13	
	GND	28	27	PE14	
DRS	PA0	30	29	PE15	
	PB0	32	31	PB10	
	PE0	34	33	PB11	

GND

GND

GND

J7
ZIO_CN9

APPS_1	PA3	2	1	PD7
BPS	PC0	4	3	PD6
APPS_2	PC3	6	5	PD5
GPIO_IN_1	PF3	8	7	PD4
GPIO_IN_2	PF5	10	9	PD3
RTDID	PF10	12	11	GND
	NC	14	13	PE2
	PA7	16	15	PE4
	PF2	18	17	PE5
SDD	PF1	20	19	PE6
	PF0	22	21	PE3
	GND	24	23	PF8
CAN1_RXD	PD0	26	25	PF7
CAN1_TX	PD1	28	27	PF9
	PG0	30	29	PG1

GND

Title: VCU

| Size: A3 | Date: 2023-03-03 | Rev: 1.2.0 |
| KiCad E.D.A. kicad (6.0.11-0) | | Id: 6/6 |

Digital (3.3V -> 12V)

U7
ILQ615-4X009T

+12V

Practical tests
put the maximum
opto switching
frequency at
about 10kHz

R27 220
STATUS_IND

R28 220
GPIO_IN_1

R29 220
GPIO_IN_2

R30 220
DRS_IND

GND

C8
100n

GND

+12V

VCC VDD

Ain   Aout
Bin   Bout
Cin   Cout
Din   Dout
Ein   Eout
Fin   Fout

VSS

GND

U8
HCF4010

GND

STATUS_OUT
GPIO_OUT_1
GPIO_OUT_2
DRS_OUT

R31   R32   R33   R34
10k   10k   10k   10k

GND   GND   GND   GND