Power

File: control_Power.kicad_sch

Digital

File: control_Digital.kicad_sch

Analog

File: control_Analog.kicad_sch

Ultrasonic Sound Steering Capstone

Control PCB Master Sheet

K. Harper 03/06/2024

To do:

Change tantalum footprints for 0603 to indicate polarities
Remove silly fills between all bus routes

NOTE:
MOSI/MISO has been swapped in software; move terminators local to driven pin
Alternatively, a proper custom implementation of some SPI HDL
could ensure the validity of this pin during program uploading.
Unfortunately, swapping MISO and MOSI from their shown pins causes
issues with data rates as the internal IOMUX must be used to route the signals.

ESD diodes used are clamping everything to <1V... supposedly PESD7351XV2T1G....
These are unidirectional TVS's... My symbol is bidirectional; all of their polarities
are currently reverse on the PCB. I should take this opportunity to design in some beefier
TVS's if there is ever another order.

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File: Ultrasonic Sound Steering – Control Rev. B.kicad_sch

Title:

Size: A4	Date:	**Rev:**
KiCad E.D.A. kicad (6.0.11)		Id: 1/4

Controller PCB — ANALOG

Auxiliary ECM Input

ECM Mic
2.5mm
USE POM-3535P-3-R OR SIMILAR

S R2 R1 T
11
Ø2.5 MATING PLUG

P11
SJ1-42516
1 S
2 R2
3 R1
4 RS_NC
5 TS_NC
6 T

0ZCM0001FF2G
PTC11
PTC12
CMDD4448
D12
D17
D10
D14
D27
D29
ESD7351XV2T1G

ECM_OPEN-
R2 0Ω DNP
R4 0Ω DNP
R1 100kΩ
+3.3VA
GND

15Ω nom.
10mA hold
30mA trip

Use twisted pair conductor cable with shield and drain wire. Tie shield and drain to sleeve at this end and then to system ground

Worst case mic sensitivity is −40dBV/PA. Design for gain of 40dB such that for a 1cm distance to the microphone corresponding to roughly 10mVRMS input magnitude, output magnitude is 1VRMS about VCM

VCM
DNP R13 0Ω
DNP R15 0Ω
R16 1kΩ
R17 1kΩ
R18 0Ω
R19 0Ω
R22 0Ω DNP
R23 68Ω
C6 10µF
GND C18 10µF DNP
C20 100nF
C15 22nF
C16 22nF

U3
TS472IQT
VCC
STBY-
IN+
IN-
BIAS
GS
OUT+
OUT-
BYP
EPAD
C1
C2

Set fL to just above 20Hz 3dB

Place either R6 or R8 to set gain
Place either R98 or R97 to configure ECM bias source

Alt. configure mic amp for some mono audio source:

Remove R19, PTC11, place either R14, R18, or R8 to set VREF.

Shorting GS to Bias output results in 20dB gain
The best noise performance is advertised at 20dB
This is our only gain stage...
1k for 30dB, 68 ohms for 40dB

Set fH to just below 20kHz 3dB
C25 220pF
C24 22pF
Add pole to fL
C28 220nF
C29 220nF
C27 10µF
R27 10kΩ
R28 10kΩ

14kHz Active Audio Filter
R36 3.9kΩ
R33 15kΩ
R34 15kΩ
R35 3.9kΩ
R30 3.9kΩ
R31 3.9kΩ
C32 3.3nF
C36 680pF
C37 680pF
C48 100nF
C51 10µF
C47 10nF
C52 100nF
C43 100nF
10µF C35
R41 10kΩ
R43 10kΩ

U5A
ADA4940-2ACPZ-R7

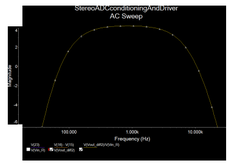
C55 2.2µF
C56 2.2µF

Follower drive stage with optional comp.
R92 1kΩ
R93 1kΩ
C59 150pF DNP
R96 1kΩ
R97 1kΩ DNP
C61 150pF
10µF C63
C139 100nF
C143 100nF
C145 10µF
C147 10nF
C150 100nF
R102 33Ω
R115 33Ω
C160 330pF
C169 68pF
C170 68pF

U5B
ADA4940-2ACPZ-R7

ecm_p
ecm_n

These amplifiers comprise bandlimited buffers 100Hz – 10kHz. Each −3dB pt has multiple orders.



Stereo 3.5mm Audio Input

Calibrate with inputs removed. Check of coupling caps force input to null like would be the case if you deliberately shorted input to gnd with barrel switch

Analog Audio In
3.5mm
S R T
14
Ø3.5 MATING PLUG

P12
SJ1-3525NG
1 S
2 R
3 R_NC
4 T_NC
5 T
StereoR
StereoL

AUX_OPEN-
R5 0Ω DNP
R3 100kΩ
PTC13
PTC14
0ZCM0001FF2G
D13
D11
D26
D15
D16
D28

15Ω nom.
10mA hold
30mA trip

Use stereo conductor cable, with three conductors (LRG) and a shield and drain wire. Tie shield, ground, and drain to sleeve at this end and then to system ground. Play with shield configuration if issues with noise.

Input stereo average and gain
C22 1nF
R26 2.2kΩ
C23 100nF
C26 10µF
C12 2.2µF
C13 2.2µF
R24 2kΩ
R25 2kΩ
R12 10kΩ
R14 10kΩ
C19 100nF
C21 10nF

U4
OPA837IDBVT

14kHz Audio Filter + single ended-differential converter
R29 3.9kΩ
R32 3.9kΩ
C30 1.5nF
C31 1.5nF
R40 3.9kΩ
R37 15kΩ
R38 15kΩ
R39 3.9kΩ
C38 680pF
C39 680pF
C50 100nF
C53 10µF
C49 10nF
C54 100nF
10µF C41
C45 100nF
R42 10kΩ
R87 10kΩ
C57 2.2µF
C58 2.2µF

U6A
ADA4940-2ACPZ-R7

Follower drive stage with optional compensation components
R95 1kΩ
R94 1kΩ
C64 150pF
R100 1kΩ
R101 1kΩ DNP
150pF C65
10µF C66
C144 10nF
C146 100nF
C149 10µF
C148 10nF
C159 100nF
R116 33Ω
R117 33Ω
C168 330pF
C171 68pF
C172 68pF

U6B
ADA4940-2ACPZ-R7

stereo_avg_p
stereo_avg_n

Drive Voltage FB Buffer

Keep away from 16 bit section

NOTE!
If alternative switcher solution is used (XL6009), R39 MUST BE CHANGED TO ~20kΩ
Otherwise, 13kΩ or so works for voltages up to 15V.

R11 5.1kΩ
C7 100nF
+3V3
C10 10µF
C11 100nF
+VSW
R6 20kΩ
R9 5.1kΩ
R7 1kΩ
C4 100nF
R21 50Ω
C17 100nF
U2
OPA837IDBVT
VDRIVE_BUFF

NTC Temperature Buffer

The NTC circuitry uses the NTC as the load element of a resistive voltage divider, so the input impedance here is not well known cannot be used to account for input Vos.

Locate output RC components near MCU pin. Sample @ <1kHSa/s

R10 5.1kΩ
C5 100nF
C8 10µF
C9 100nF
R8 0Ω
C3 100nF
R20 50Ω
C14 100nF
U1
OPA837IDBVT
NTC
NTC_BUFF

2 Channel 16-bit SAR ADC 1MSPS

U28
AD4680BCPZ-RL7
VCC
VLOGIC
AINA+
AINA-
AINB+
AINB-
REFIO
REFCAP
REGCAP
GND
SCLK
SDI
SDOB/*ALERT
SDOA
*CS

C40 10µF
C44 100nF
C62 100nF
C138 10µF
C33 1µF
C34 100nF
C42 100nF
C46 1µF
R98 100Ω
R99 100Ω
ADC_VREF
adc_SCK
adc_SDI
adc_SDOB/~ALERT
adc_SDOA
adc_CS~

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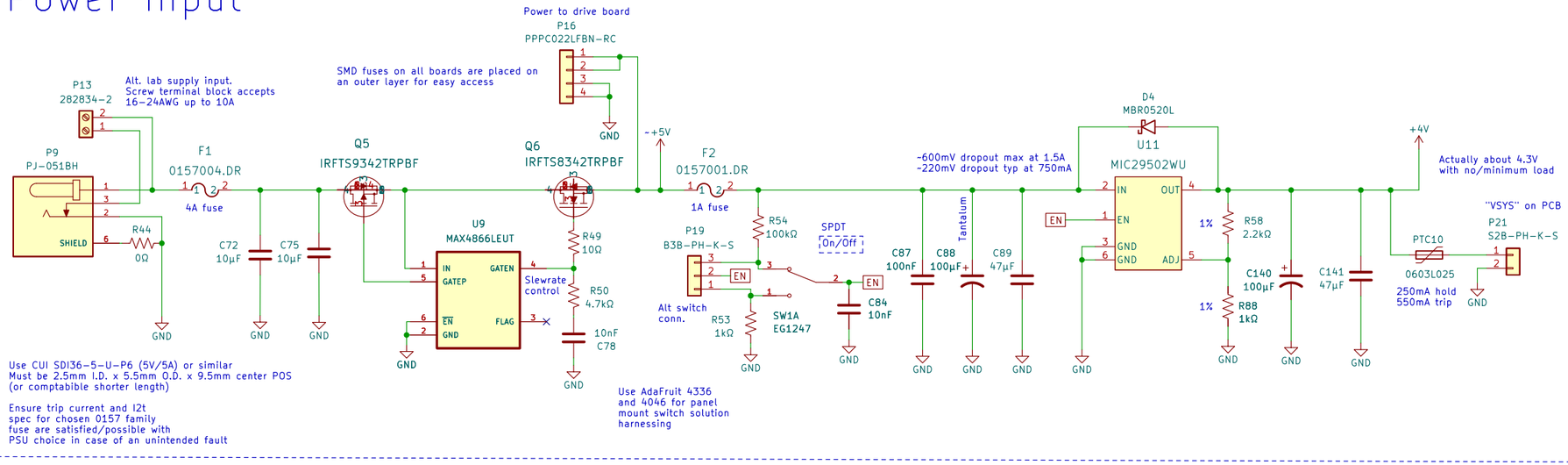
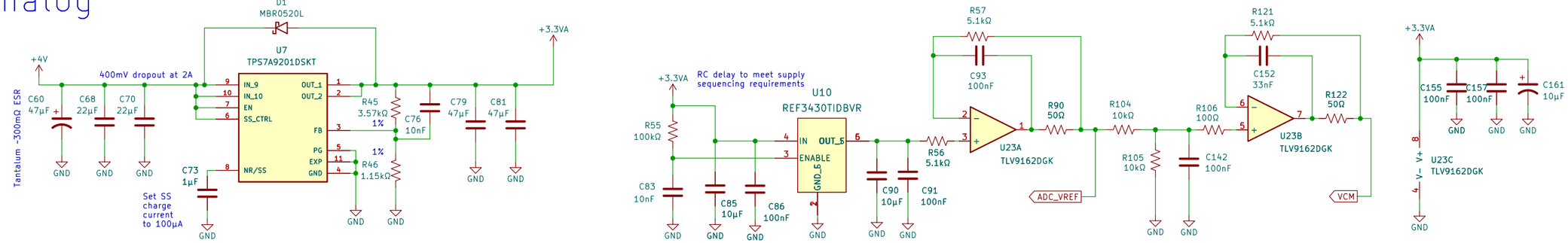
Controller PCB – POWER

Power Input



**Derate ALL capacitors 50%

Analog



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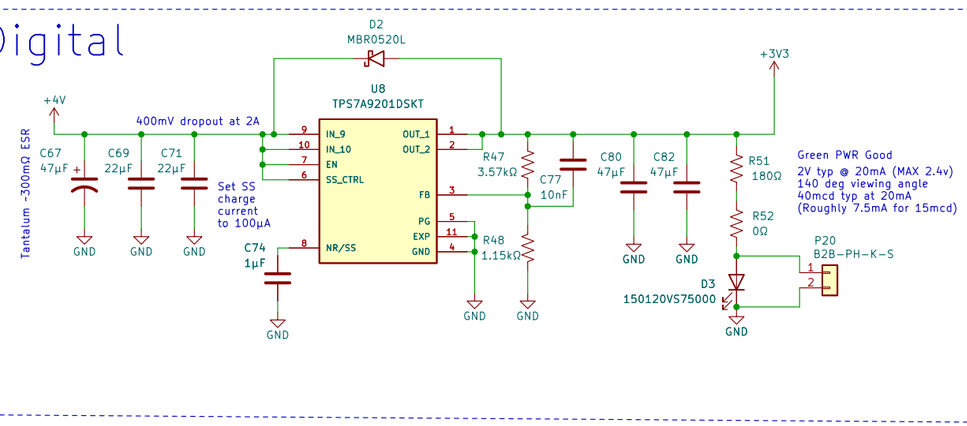

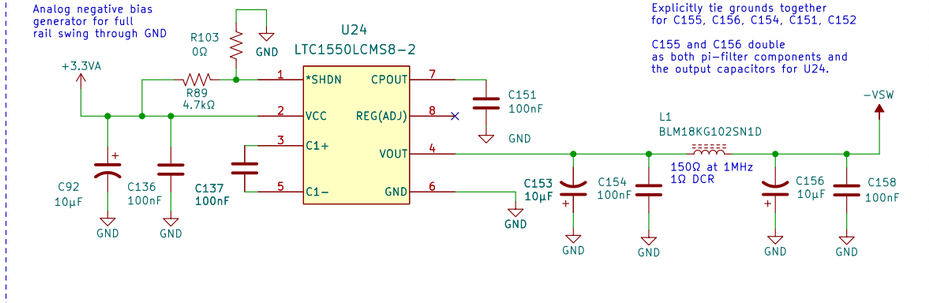

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Controller PCB – DIGITAL

Headers P1–P8 correspond 1:1
to headers P1–P8 on the ultrasonic
drive board

Desired height from board - 10mm

2.5mm spacer common to pinheaders
7.5mm female receptacle for 6mm long pins
then use 10mm standoffs for mounting
Add 0.5mm – 1mm washers to increase
height of mounting posts for better fit.

This board requires the following
additional hardware for mating with
the driver PCB:
- 4x 20mm threaded male M2.5 brass standoffs
- 8x 0.5mmH M2.5 brass washers
- 4x 10mm threaded female M2.5 brass standoffs
- 4x 5mm threaded male M2.5 brass standoffs

In addition, the following hardware
is required to mount the FPGA:
- 4x 5mm threaded male M2.5 brass standoffs
- 2x 5mm threaded female M2.5 brass standoffs
- 4x 0.5mmH M2.5 brass washers

Program with PN TE-0790-xx (xx == REV)
and mini-B cable.
Note: L variant does not have the EEPROM
programmed on the board for compatability with
Xilinx build tools. Don't get the L-variant
https://www.mouser.com/ProductDetail/Trenz-Electronic/TE0790-03?qs=EBDBIbfErPzapZHmu1NYxAX3D%3D

Remember to talk to one another
when you shut off the PWM buffers

Both fpga and mcu
must drive their pins
low in order to enable
sound output

NMOS buffers ensure
disabled on startup/idle

Ultrasonic PWM
Drive Signal
Output Buffer En
(to SN74LVC540)

Shorter Net Alias

Externally exposed pins are rail
clamped and current limited
with polyfuse and/or resistor

Blue
2.8V typ. at 5mA (3.2V max)
15mcd luminious intensity at 5mA,
120deg viewing angle

Use AdaFruit PN 4714
and PN 3814 mating
harnesses for panel
mount LED solution.
3x needed for this
board.

Micro-B USB programming
header for ESP32

Remote board uses header
with Rx, Tx flipped and
a 1:1 harness

Use partsExpress
PN 320-343 for 3pos
shielded UART

This harness should be 1:1
The TX/RX reversal is taken care
of between the board-mounted headers
on each of the controller and remote PCB.

Extra GPIO output
3x MCU, 3x FPGA GPIO,
3V3, and GND

CP2102 takes control
of rst during ICSP

Program with ESP-IDF v5.1.2
using vscode or other IDE with
a micro-B cable.

ESP32 has strapping pins for boot mode:
GPIO0 (outputs PWM signal at boot, must be low
to enter flashing mode),
GPIO2 (must be floating or
low to enter flashing mode),
GPIO5 (outputs PWM signal at boot),
GPIO12 (boot fails if pulled high),
GPIO14 (outputs PWM signal at boot), and
GPIO15 (outputs PWM signal at boot)
GPIO34–39 input only!

Note: ADC2 has a few limitations,
some undocumented (thanks Espressif)...

When using WIFI, ADC2 is unavailable.
When using I2S0, ADC2 is unavailable.
When using adc continuous mode driver,
ADC2 data can not be piped via DMA.

Tx Active is
a 1/1000 scaled
output to an LED
of the PWM data

3V3 rail on driver board

Drive PCB load switch
enable for SMPS input

3.6dBi µ.FL antenna
2.4GHz/5GHz

The WROOM32UE has
a connector populated
that accepts a µFl
compatible antenna.

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