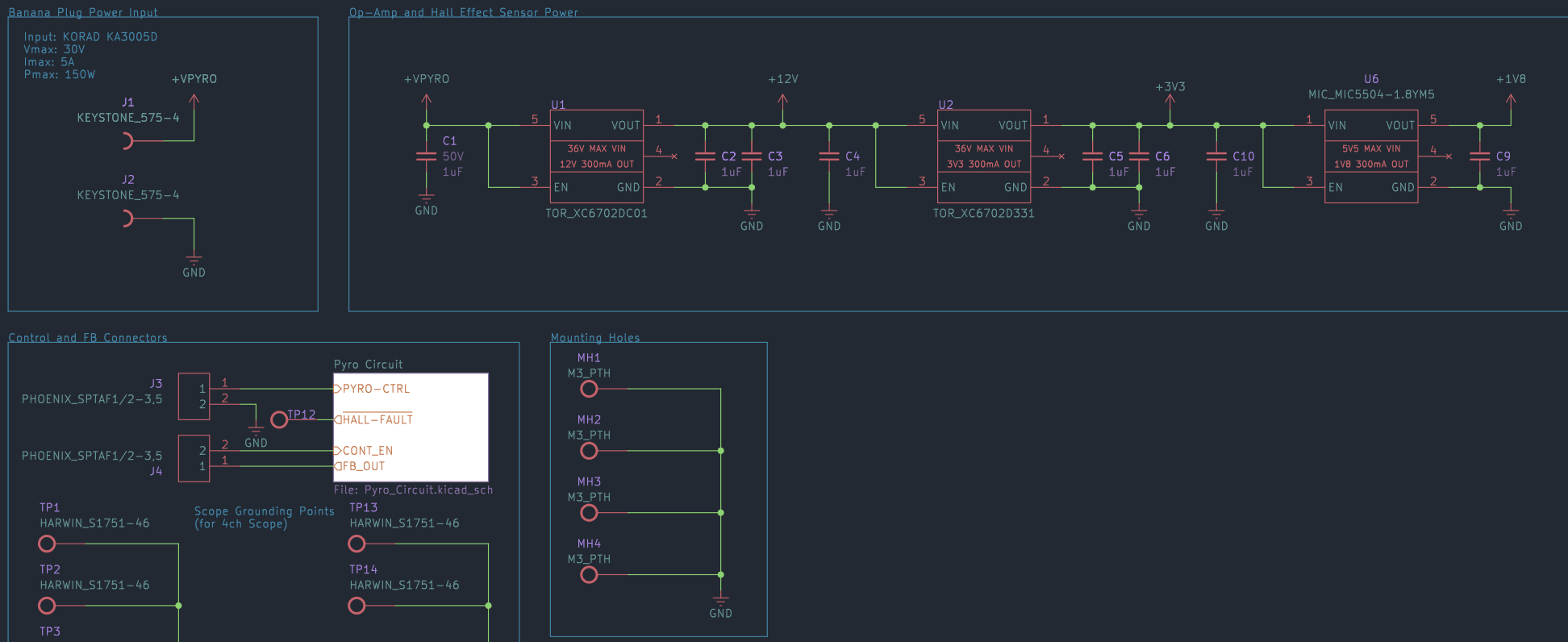
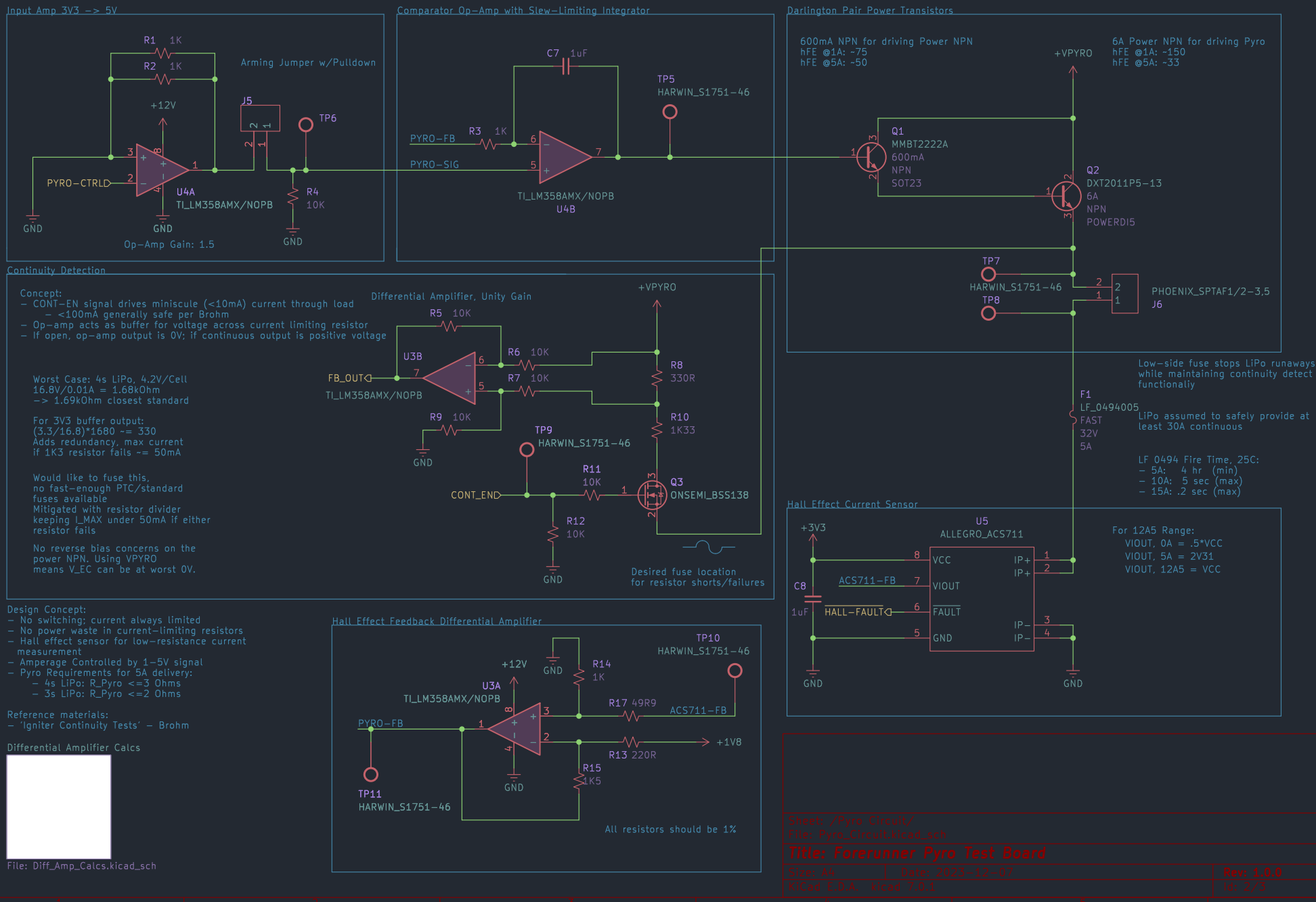


Sheet: /
File: Pyro Test Board.kicad_sch

Title: Forerunner Pyro Test Board

Size: A4	Date: 2023-12-07	**Rev: 1.0.0**
KiCad E.D.A. KiCad 7.0.1		Id: 1/3


Input Amp 3V3 -> 5V
R1 1K
R2 1K
+12V
Arming Jumper w/Pulldown
J5
TP6
PYRO-CTRLD
U4A
TI_LM358AMX/NOPB
R4
10K
GND
Op-Amp Gain: 1.5
Comparator Op-Amp with Slew-Limiting Integrator
C7 1uF
TP5
HARWIN_S1751-46
PYRO-FB
R3 1K
PYRO-SIG
TI_LM358AMX/NOPB
U4B
Darlington Pair Power Transistors
600mA NPN for driving Power NPN
hFE @1A: ~75
hFE @5A: ~50
+VPYRO
6A Power NPN for driving Pyro
hFE @1A: ~150
hFE @5A: ~33
Q1
MMBT2222A
600mA
NPN
SOT23
Q2
DXT2011P5-13
6A
NPN
POWERDI5
TP7
HARWIN_S1751-46
TP8
PHOENIX_SPTAF1/2-3,5
J6
Continuity Detection
Concept:
- CONT-EN signal drives miniscule (<10mA) current through load
- <100mA generally safe per Brohm
- Op-amp acts as buffer for voltage across current limiting resistor
- If open, op-amp output is 0V; if continuous output is positive voltage
Worst Case: 4s LiPo, 4.2V/Cell
16.8V/0.01A = 1.68kOhm
-> 1.69kOhm closest standard
For 3V3 buffer output:
(3.3/16.8)*1680 ~= 330
Adds redundancy, max current
if 1K3 resistor fails ~= 50mA
Would like to fuse this,
no fast-enough PTC/standard
fuses available
Mitigated with resistor divider
keeping I_MAX under 50mA if either
resistor fails
No reverse bias concerns on the
power NPN. Using VPYRO
means V_EC can be at worst 0V.
Differential Amplifier, Unity Gain
R5 10K
U3B
R6 10K
FB_OUT
R7 10K
TI_LM358AMX/NOPB
R8
330R
R9 10K
R10
1K33
TP9
HARWIN_S1751-46
R11
10K
CONT_END
Q3
ONSEMI_BSS138
R12
10K
Desired fuse location
for resistor shorts/failures
Low-side fuse stops LiPo runaways
while maintaining continuity detect
functionaliy
F1
LF_0494005
FAST
32V
5A
LiPo assumed to safely provide at
least 30A continuous
LF 0494 Fire Time, 25C:
- 5A: 4 hr (min)
- 10A: 5 sec (max)
- 15A: .2 sec (max)
Hall Effect Current Sensor
+3V3
U5
ALLEGRO_ACS711
C8
1uF
ACS711-FB
HALL-FAULT
VCC
VIOUT
FAULT
GND
IP+
IP-
For 12A5 Range:
VIOUT, 0A = .5*VCC
VIOUT, 5A = 2V31
VIOUT, 12A5 = VCC
Design Concept:
- No switching; current always limited
- No power waste in current-limiting resistors
- Hall effect sensor for low-resistance current measurement
- Amperage Controlled by 1-5V signal
- Pyro Requirements for 5A delivery:
- 4s LiPo: R_Pyro <=3 Ohms
- 3s LiPo: R_Pyro <=2 Ohms
Reference materials:
- 'Igniter Continuity Tests' - Brohm
Differential Amplifier Calcs
File: Diff_Amp_Calcs.kicad_sch
Hall Effect Feedback Differential Amplifier
TP10
HARWIN_S1751-46
+12V
R14
1K
U3A
TI_LM358AMX/NOPB
R17 49R9
ACS711-FB
PYRO-FB
R13 220R
+1V8
R15
1K5
TP11
HARWIN_S1751-46
All resistors should be 1%
Sheet: /Pyro Circuit/
File: Pyro_Circuit.kicad_sch
Title: Forerunner Pyro Test Board
Size: A4
Date: 2023-12-07
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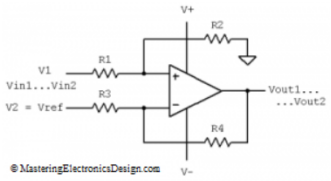
Differential Amp Calculated Design



Given Input Range

Vin1 =	1.65 V	Vin2 =	2.31 V

Required Output Range

Vout1 =	-0 V	Vout2 =	5 V

Choose a Reference Voltage

V2 =	1.8 V

Choose R2 and R3

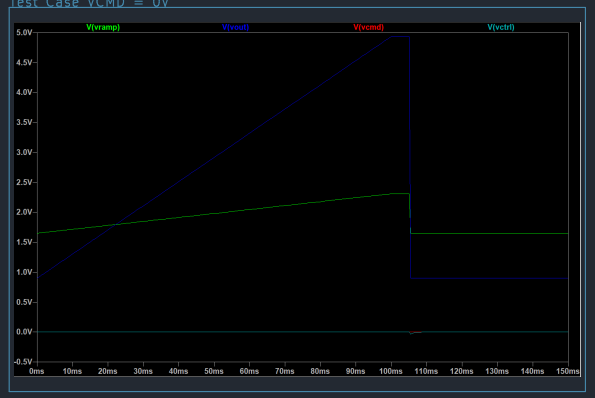
R2 =	1 kOhm	R3 =	.22 kOhm

Calculate R1 and R4

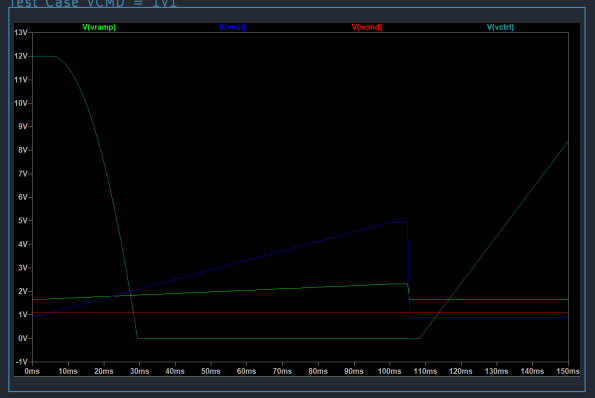
R1 =	0.05 kOhm	R4 =	1.53 kOhm

Calculator Used:
https://masteringelectronicsdesign.com/differential-amplifier-calculator-2/

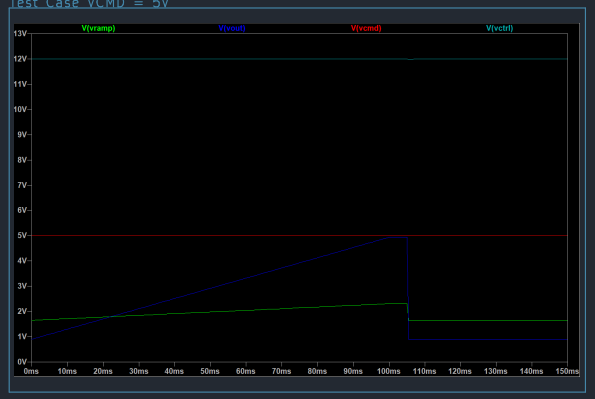
Test Case VCMD = 0V



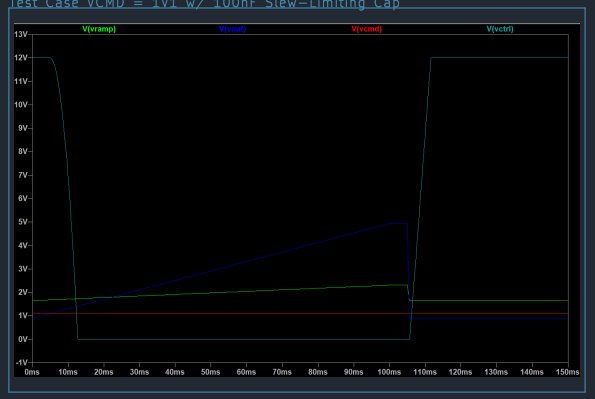
Test Case VCMD = 1V1



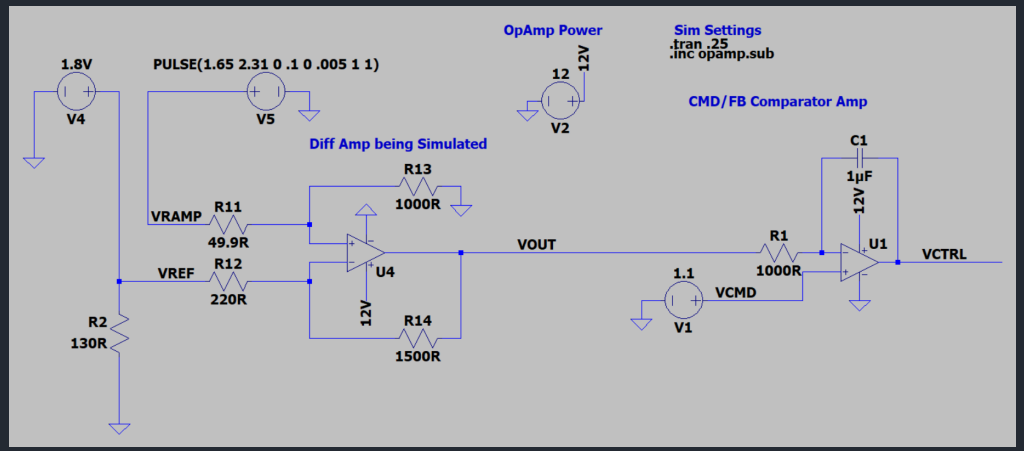
Test Case VCMD = 5V



Test Case VCMD = 1V1 w/ 100nF Slew-Limiting Cap



LTSpice Differential Amp Sim Setup



Test Cases:
VCMD = 0V -> VCTRL should remain low at all times
VCMD = 1V1 -> VCTRL should be high until VOUT exceeds VCMD, indicating desired current has been reached
VCMD = 5V -> VCTRL should be high until VOUT exceeds VCMD, indicating desired current has been reached

Test cases display control voltage (VCTRL) to the darlington pair, in response to a static command voltage (VCMD) and a constant-time ramp in feedback, thereby showing the response of the system as a function of inputs and given feedback.

For faster rise time, adjusting the slew limiting cap can decrease current rise times.

Sheet: /Pyro Circuit/Differential Amplifier Calcs/
File: Diff_Amp_Calcs.kicad_sch

Title: Forerunner Pyro Test Board

Size: A4	Date: 2023-12-07	Rev: 1.0.0
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