Circuit Design

① MOSFET — Electronic Load

Vout+ & Vout−

LM324 → Vref vs Vsense (0V ~ 12V power supply)

↑

LM324, PWM filter + voltage follower

4 stages & 1 stages

AD623AN → Instrumention Amp (0 ~ 12V power supply)

Vpowerresistor × 5 (gain) = 2.5V → Vsense

(0 ~ 0.5V for 0.5Ω)

↓

1A max

Vpowerresistor × 6 (gain) = 3V

② Sense ADS1115 system.

→ Vout+
→ Vout−
→ Vsense (be amplified)
→ Vref (be filtered)

} ADS1115 0x48

→ Vtemp1
→ Vtemp2
→ Vtemp3
→ Vtemp4

} ADS1115 0x49

$$Temp\_avg = \frac{Vtemp1 \sim 4}{4}$$

⇒ 4 stages ☆

Temp_avg = Vtemp1

⇒ 1 stage.

(1 stage thermal analysis ☆ not a big problem)

③ Arduino Control

① ADS1115 measurement SDA & SCL
② LCD Display SDA & SCL

} ※ I²C communication (Addresses)

③ 1 or 4 stage Control → Rely
④ short circuit Control → Rely
⑤ PWM output → Vref ⑥ Fan Control → turn on MOSFET

PCB Modification

↙

Separate – stack PCB (Heat concern) ✓

Track ~~cross~~ cross – separate 1, 4 stages Electronic Load

separate Electronic Load & thermal control. ✓

2 layer PCB – LAB only provide 1 & 2 layer PCB manufacture

↙

Impossible – since cannot make no cross tracks on the board

Try 2 layer PCB

separate Electonic Load & Thermal Control

↙

one & 4 stages

LM324 & AD623AN

Vref filter & ADS1115

LCD Display

- 1/4 stage
- [Vout+ – Vout-] outside [outside pin Vout+ & Vout-
- [Vref – CC/CR] 12V power GND
- [Id _ from Vsense] Arduino [5V power GND, SDA & SCL

↙

Vsense/Gain/Rpower

Vref Vsense Vout+ Vout- differential.

LCD Display

- Temp – 1/4 stage
- Fan on/off

outside pin

12V power GND

5V power GND

SDA & SCL

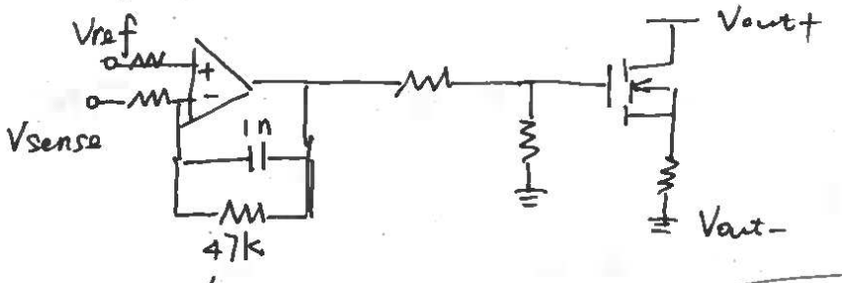
Temp sensor & Temp monitor

PT100 ADS1115

Fan Control (LM324AN)

Procedures

① why we need error amplifier design on LM324 NMOSFET comparator



if not → output – Gate Voltage

↙

has freq since ~~input~~

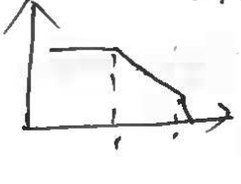
there some oscillation within the amplifier

Act as a filter

Avoid self-exciation, ~~Avoid~~

More stable (Whole device)

hole ~~e~~



② Why we need In-Amp AD623

↓

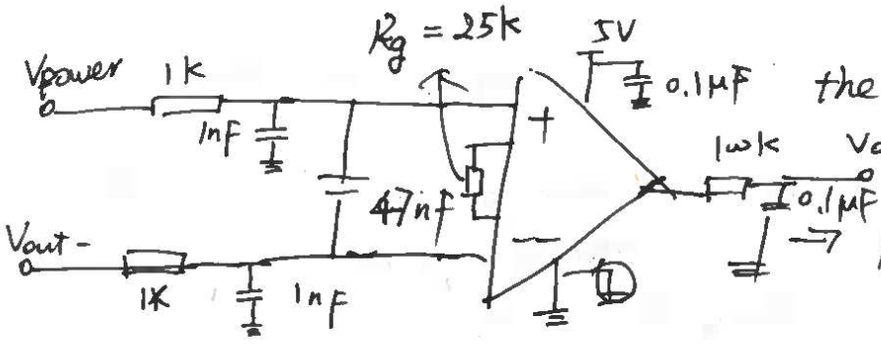
more precise, accuracy

remove drift current or offset voltage in LM324

achieve better control when requires very small current

↙

the Vpower resistor = Id x 0.5 Ω



even smaller.

⇒ prone to noise, drift, offset

↙ AD623 Application — $G = \frac{1wk}{Rg} + 1$

Calculate freq — drif — .. BW

③ Why we use ADS 1115?

Arduino — analog pin — input can do voltage measurement

⇒ Show results : x x x x

Resolution : 5/1023 ≈ 4.8 mV (too big)

↙

Hard to Vref control

Hard to Vtemp monitor

ADS1115 . up to +/- 6.144V 1 bit = 0.1875 mV

+/- 0.256V 1 bit = 0.0078125 mV

< 0.1875mV sufficient.

measure range — 6.144V ~ 6.144V sufficient

Best Choice

Good for test, Design usage — External device may affect orginal circuit (measure)

Also good at Electronic Load (give user accurate results)

the data was from 10mV to 40mV by step 1mV (2. 3. 4. 5. 6. 7. 8)/1023

35mV to 505mV by step 20mV → 3f → (7 steps)

(7. 11, 15. 1f, 24. 28. 32. 36. 40. 44. 4f 53. 57. 61, 65. 6f. 74. 78. 82. 86. 8a 94. 9f. 103.)/1023

24 → (24 steps)

Ins-Amp Gain = 6

60mV to 240mV by step 6mV

each 1mV → map to 2 steps in PWM.

Resolution was. 4.8mV → 1.6mA at Current. → 1023 - timerOne (10 bits)

In-Amp ⇒ Resolution now $\frac{4.8mV}{6} = 0.8mV$ → 1.6mA at Current.

Extension — PWM servo driver PCA 9685 12-bits — 4096 steps.

3.3V/4096

give it lower value to gain high resolution. → 0.8mV resolution

In-Amp ⇒ $\frac{0.8057}{6}$ ⇒ 0.1343mV ⇒ 0.269mA

Another 6 times more resolution gained.