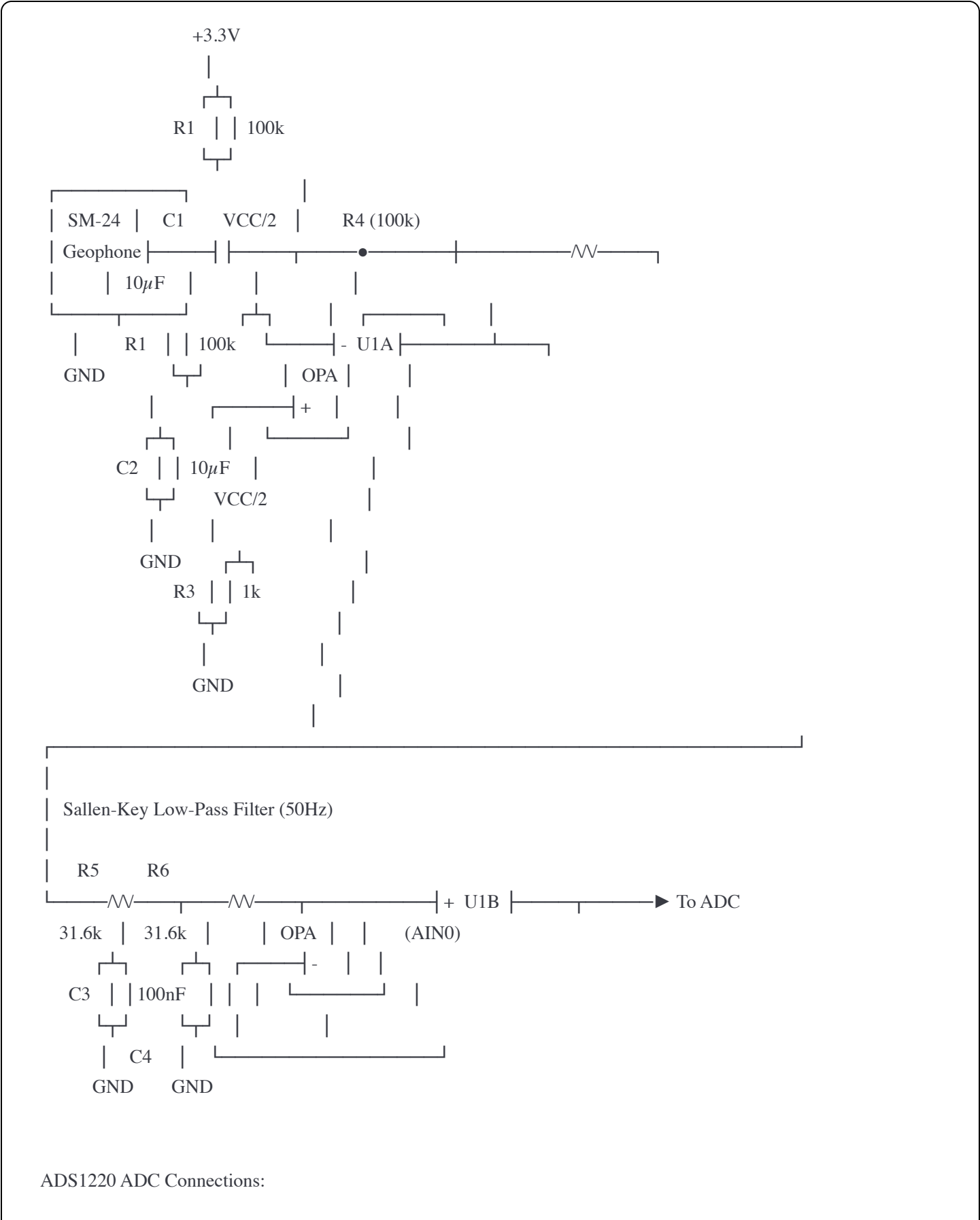
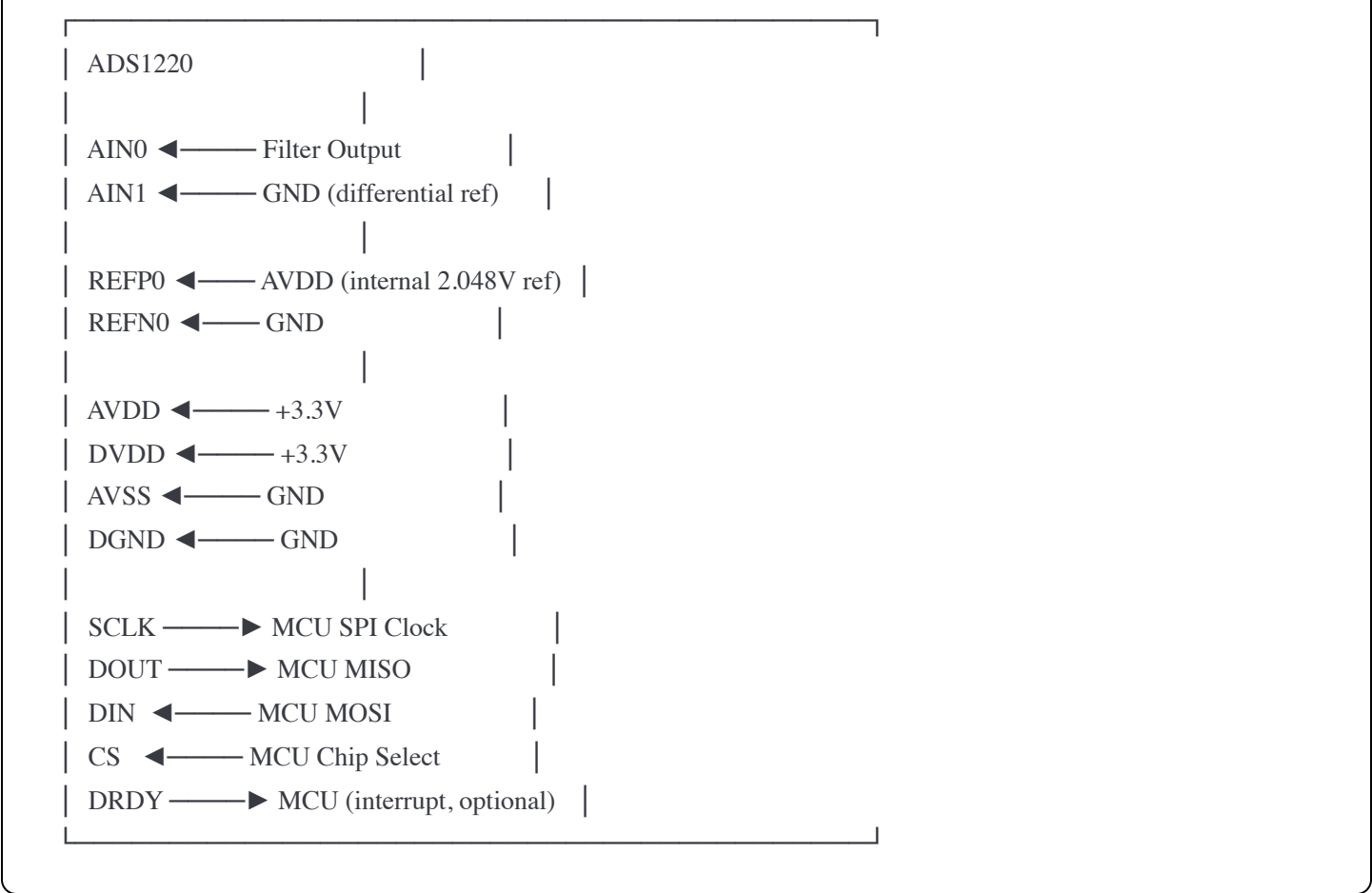


SM-24 Geophone Front-End with ADS1220 ADC

Circuit Overview





Design Parameters

Parameter	Value	Notes
Supply Voltage	3.3V	Single supply
First Stage Gain	101x (40.1 dB)	$1 + R4/R3 = 1 + 100k/1k$
Filter Cutoff	~50 Hz	Sallen-Key 2nd order
Filter Q	0.707	Butterworth response
ADC Resolution	24 bits	ADS1220 with PGA
Sample Rate	Up to 2000 SPS	Configurable

Bill of Materials

Ref	Value	Package	Description	DigiKey P/N
U1	OPA2188	SOIC-8	Low-noise dual op-amp	296-40058-1-ND

Ref	Value	Package	Description	DigiKey P/N
U2	ADS1220	TSSOP-16	24-bit delta-sigma ADC	296-35377-1-ND
C1	10 μ F	0805	Input coupling	1276-1096-1-ND
C2	10 μ F	0805	Bias bypass	1276-1096-1-ND
C3	100nF	0603	Filter capacitor	1276-1005-1-ND
C4	100nF	0603	Filter capacitor	1276-1005-1-ND
C5	100 μ F	1206	Power supply bulk	1276-6767-1-ND
C6	100nF	0603	Op-amp bypass	1276-1005-1-ND
C7	100nF	0603	ADC AVDD bypass	1276-1005-1-ND
C8	100nF	0603	ADC DVDD bypass	1276-1005-1-ND
R1	100k	0603	Bias divider (top)	311-100KHRCT-ND
R2	100k	0603	Bias divider (bottom)	311-100KHRCT-ND
R3	1k	0603	Gain set resistor	311-1.00KHRCT-ND
R4	100k	0603	Feedback resistor	311-100KHRCT-ND
R5	31.6k	0603	Filter resistor	311-31.6KHRCT-ND
R6	31.6k	0603	Filter resistor	311-31.6KHRCT-ND
J1	1x2	2.54mm	Geophone connector	952-2261-ND
J2	1x6	2.54mm	SPI connector	952-2265-ND
J3	1x2	2.54mm	Power connector	952-2261-ND

SPI Connector Pinout (J2)

Pin	Signal	Description
1	VCC	3.3V supply
2	SCLK	SPI clock
3	MISO	SPI data out (DOUT)

Pin	Signal	Description
4	MOSI	SPI data in (DIN)
5	CS	Chip select (active low)
6	GND	Ground

Component Selection Notes

Op-Amp (OPA2188)

- Very low offset voltage ($\pm 25\mu\text{V}$ max)
- Low noise (8.8 nV/ $\sqrt{\text{Hz}}$)
- Rail-to-rail output
- Alternatives: MCP6022 (cheaper), OPA1612 (lower noise)

ADC (ADS1220)

- 24-bit resolution
- Built-in PGA (gains 1, 2, 4, 8, 16, 32, 64, 128)
- Internal 2.048V reference
- Up to 2000 SPS
- Differential inputs reduce common-mode noise

Filter Component Calculations

For a 50Hz Butterworth low-pass filter with Q = 0.707:

$$f_c = 1 / (2\pi \times R \times C \times \sqrt{2})$$

With $R_5 = R_6 = 31.6\text{k}$ and $C_3 = C_4 = 100\text{nF}$:

$$f_c = 1 / (2\pi \times 31.6\text{k} \times 100\text{nF} \times 1.414) \approx 50\text{ Hz}$$

Arduino/ESP32 Code Example

```
cpp
```

```

#include <SPI.h>

// ADS1220 registers and commands
#define ADS1220_CMD_RESET  0x06
#define ADS1220_CMD_START  0x08
#define ADS1220_CMD_RDATA  0x10
#define ADS1220_CMD_RREG   0x20
#define ADS1220_CMD_WREG   0x40

const int CS_PIN = 10;
const int DRDY_PIN = 9;

void setup() {
  Serial.begin(115200);
  SPI.begin();
  pinMode(CS_PIN, OUTPUT);
  pinMode(DRDY_PIN, INPUT);
  digitalWrite(CS_PIN, HIGH);

  // Reset ADS1220
  digitalWrite(CS_PIN, LOW);
  SPI.transfer(ADS1220_CMD_RESET);
  digitalWrite(CS_PIN, HIGH);
  delay(1);

  // Configure: AIN0/AIN1 differential, gain=1, 20SPS, internal ref
  digitalWrite(CS_PIN, LOW);
  SPI.transfer(ADS1220_CMD_WREG | 0x00); // Write starting at reg 0
  SPI.transfer(0x04); // 4 bytes to write
  SPI.transfer(0x01); // Reg0: AIN0/AIN1, gain=1, PGA enabled
  SPI.transfer(0x04); // Reg1: 20 SPS, normal mode
  SPI.transfer(0x40); // Reg2: Internal 2.048V reference
  SPI.transfer(0x00); // Reg3: Default
  digitalWrite(CS_PIN, HIGH);

  // Start continuous conversion
  digitalWrite(CS_PIN, LOW);
  SPI.transfer(ADS1220_CMD_START);
  digitalWrite(CS_PIN, HIGH);
}

void loop() {
  // Wait for data ready

```

```

while (digitalRead(DRDY_PIN) == HIGH);

// Read 24-bit result
digitalWrite(CS_PIN, LOW);
SPI.transfer(ADS1220_CMD_RDATA);
int32_t result = 0;
result |= ((int32_t)SPI.transfer(0x00) << 16);
result |= ((int32_t)SPI.transfer(0x00) << 8);
result |= SPI.transfer(0x00);
digitalWrite(CS_PIN, HIGH);

// Sign extend 24-bit to 32-bit
if (result & 0x800000) {
    result |= 0xFF000000;
}

// Convert to voltage (with 2.048V reference, gain=1)
float voltage = (float)result * 2.048 / 8388608.0;

Serial.println(voltage, 6);
delay(50); // ~20 Hz sample rate
}

```

PCB Layout Tips

1. **Ground plane:** Use a solid ground plane on bottom layer
2. **Analog/digital separation:** Keep digital traces away from analog input
3. **Decoupling caps:** Place as close to IC pins as possible
4. **Input traces:** Keep short, away from digital signals
5. **Via placement:** Avoid vias in analog signal path
6. **Component placement:** Place in signal flow order (left to right)

Adjustments for Your Application

Higher sensitivity (weak signals):

- Increase R4 to 220k for gain of ~221x (47 dB)
- Add second gain stage if needed

Lower cutoff frequency (slower gait):

- Increase R5, R6 to 68k for ~25 Hz cutoff

- Or increase C3, C4 to 220nF

Higher sample rate:

- Configure ADS1220 for 330 SPS or higher
- May need to adjust filter cutoff accordingly

Battery operation:

- OPA2188 has low quiescent current ($\sim 400\mu\text{A}$)
- ADS1220 duty cycle mode for power savings