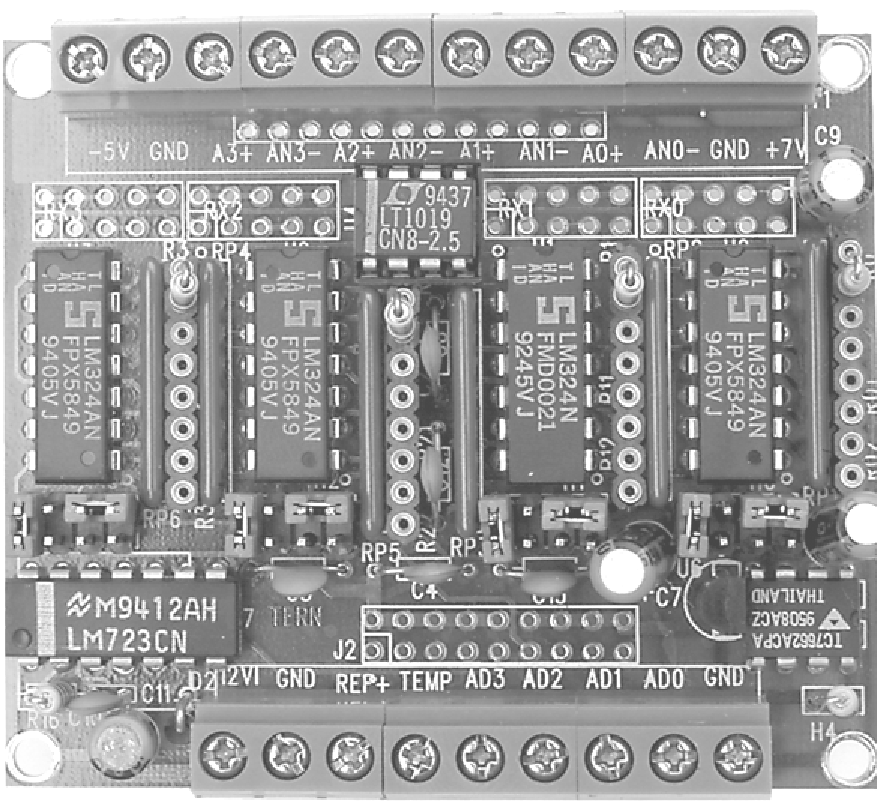
OPS™

Four Low Cost Instrumentation Operational Amplifiers



Technical Manual

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Chapter 1: Introduction

1.1 Functional Description

Do you need a direct interface to low-voltage output sensors, such as EKG electrodes, thermocouples, or strain gauges? If so, OPS is the small analog signal conditional circuit board for you.

Measuring 2.8x2.4 inches, the OPS has 4 channels of instrumentation with high input impedance (up to 100MΩ) adjustable-gain (>1000) and differential inputs. The gain can be varied by a single resistor. The CMRR, ratio of differential signal gain to common-mode signal gain, is typically 70db.

A precision 3 ppm/ºC 2.5V reference and temperature sensor are on-board. All analog input and output signals are connected via screw terminals. The OPS output can be voltage or current, with filter or without filter, by setting jumpers.

1.1.1 Features

- 2.8 x 2.4 inches
- Low power, 10 mA at 9V input
- On board temperature sensor for cold-junction compensation
- 2.5V, 3ppm/°C precision reference voltage
- Four channels of instrumentation operational amplifiers
- User configurable gain up to 1000
- High gain and high input impedance
- Direct interface with thermal couples or strain gauges
- On board front end prototyping area for bridge resistors
- Jumper settings for offset, filter options
- Voltage or current output
- On board power supply for +5V, -5V, +7V, -12V
- Input analog signal conditioning for ADC
- Output analog signal conditioning for DAC

1.1.2 Physical Description

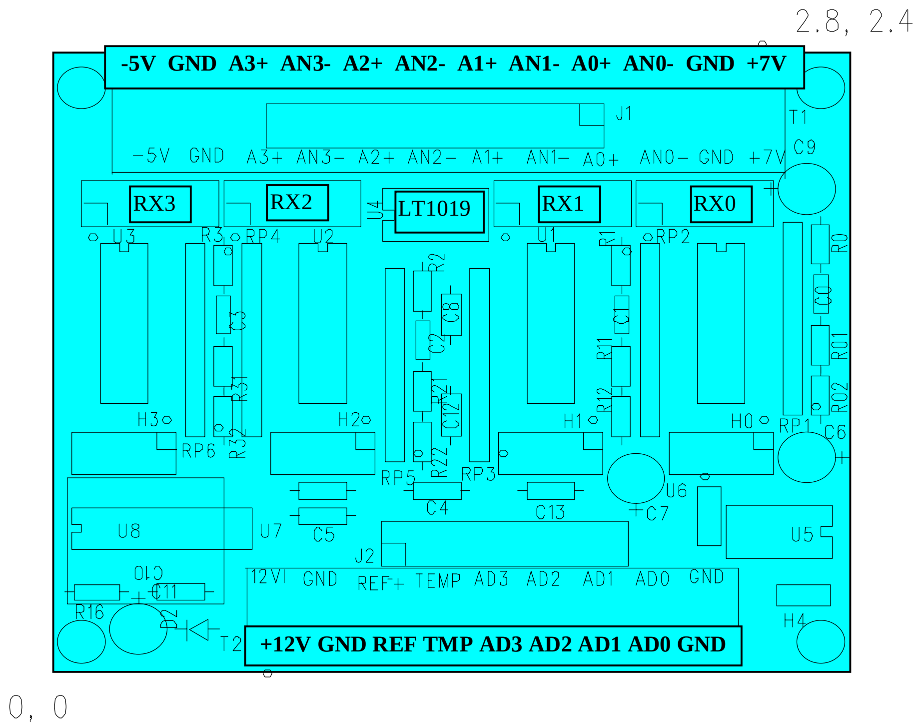


Figure 1.1 Layout of OPS

1.2 Installation

You can power the OPS with unregulated +9V to +12V via the screw terminal.

1.3 Hardware

1.3.1 Operational Amplifiers

The analog signal conditioning circuit provides 4 channels of instrumentation operational amplifiers with high gain (>1000) and high input impedance (>10^{12} Ω). The instrumentation ops allows direct interfacing to low-voltage output sensors, such as EKG electrodes, thermocouples, or strain gauges.

The high input impedance adjustable-gain differential amplifier is constructed with three operational amplifiers. Two operational amplifiers, UxD and UxC, are operated in the noninverting mode. Depending on the type of OPs used, the input impedance at each input pin of the differential amplifier is the common-mode input impedance of the OP chips. For example, the input impedance of LM324 is typically 2M, LT1014 is typical 300M.

The UxD and UxC constitute a differential buffer amplifier with a gain of ***G=1+RP1A/R0*** (see schematics channel 0) for differential signals. The gain can be varied by a single resistor, R0. If RP1A=RP1C=10K, R0=10K, then G=2, as factory setting. The effects of mismatch in RP1A and RP1C is only created a gain error without affecting the Common-Mode Rejection Ratio (CMRR). The CMRR, in terms of the ratio of differential signal gain to common-mode signal gain, is typically 70db for LM324, and typically 110db for LT1014. The third OP, U0A, is a differential-input to single-input converter with G=RP2A/RP1B=100K/10K=10 as the factory setting.

The offset voltages and the offset drifts of U0D and U0C are significant in determining the output offset. Since the output voltage drift is proportional to the differences of the voltage offsets of U0D and U0C, it is desirable to use low temperature drift OPs. For LM324 the maximum input offset voltage drift is 30 uV per ºC and the typical offset drift is 7 uV per ºC. For LT1014, the maximum offset drift is 2.5 uV/C. The typical input offset drift is 0.4 uV/ºC. The RP2 is 100K and RP1 is 10K. The second stage gain is default of 10.

Type J thermocouples have a thermoelectric voltage change of 4.906 mV at 93 ºC (reference to 0 ºC). It is about 0.0528 mV/ºC. For a 12-bit ADC with 2.5V reference, the resolution is 1.2207mV/LSB. For a gain of 200, the sensitivity can be 8 LSBs per ºC.

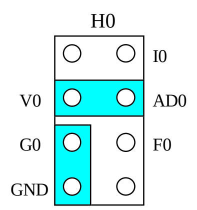
1.3.2 Terminals

See schematics for details.

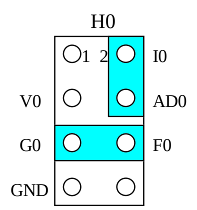
1.3.3 Headers and Jumpers

H0 to H3 are headers for selecting the ops output.

For voltage output, a jumper on Hx pin 3-4, AD0 = V0 and pin 5-7, G0=GND.

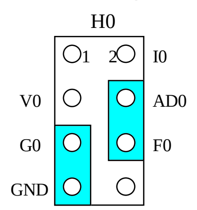


For current output, a jumper on Hx pin 2-4, AD0 = I0 and pin 5-6 G0=F0.



For current output, Iout = G x (V1-V2) / R01. where Iout is the output current at T2 AD0 pin. G is the gain of the instrument op system. V1-V2 is the voltage difference at A0+ and A0-. R01 is the current resistor.

For use filter and offset voltage output, a jumper on Hx pin 4-6, AD0 = F0 and pin 5-7, G0=GND.



1.3.4 Reference and Temperature Sensor

We use LT1019-2.5(3ppm/ºC) as a precision reference voltage. The LT1019 has a typical ultra low temperature drift - 3ppm/ºC. It can sink and source up to 10 mA. The LT1019 has a TEMP pin. The voltage on this pin is directly proportional to absolute temperature (PTAT) with an approximate slope of 2.1 mV/ºC. Room temperature (295ºK) voltage is therefore approximately 2.1 x 295 ºK=620 mV. The TEMP pin can be used to sense chip or board temperatures in applications where the LT1019 is forced to sense ambient temperature. The typical chip temperature rise over ambient is 2 ºC. In the application using thermocouples, TEMP could be used to sense the connector block temperature, if the temperature difference between block and chip is tolerable or can be calibrated out. The temperature difference between the block and chip may be reduced by a thermoconductive contact.

The TEMP voltage is connected to T2 pin 4.

1.3.5 Power Supply

You may power the OPS with +9V to +12V unregulated DC.

OPS can support upto 5 mA from REF+, 5 mA from TEMP, 50 mA from +7V, and 10 mA from -5V.

1.3.6 Prototyping and Bridge Area.

At the front end of the instrumentation op input, there are 10 pads (RX0) for bridge resistors or prototyping. A typical bridge application may connect the RTD and bridge arm resistors as shown in Figure 1.2.

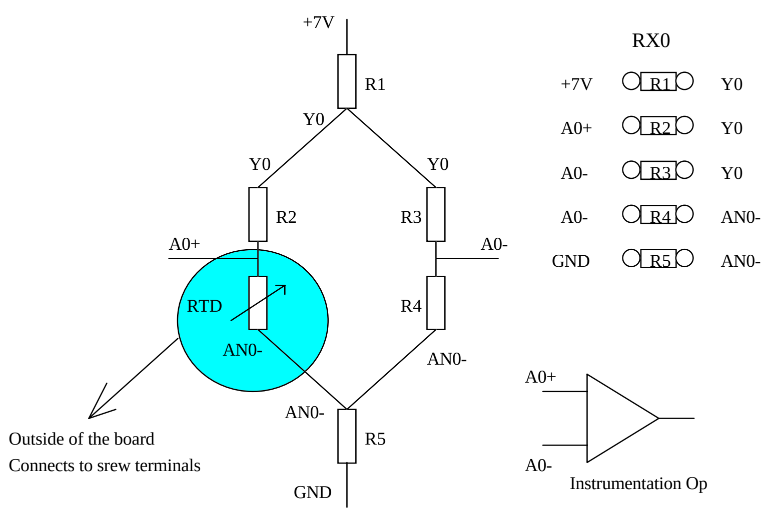


Figure 1.2 How to use the Rx0 pads for a bridge application.

As factory default, only R4=0 is installed.

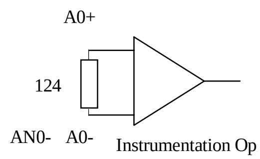
1.3.7 Modifications for 4-20 mA signal inputs

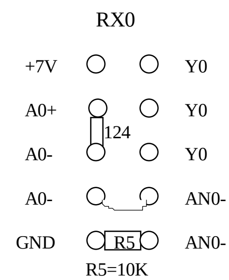
In order to convert 4-20 mA input to voltage output for ADC, a 124 Ω resistor can be installed in the prototyping area at Rx0 pin3=A0+ to Rx0 pin5=A0-. The 124Ω will convert 4 mA to 0.496 V input voltage to the instrument operational amplifier.

The OPS can be setup to a Gain=2. It will output 1-5V at AD0. A 10K resister is installed in R0. The RP2A must be shorted to 0 Ω. A 10 K reference resistor is in H0.9 to H0.10. The jumper at H0 5-7 is not connected and leave G0 open.

4-20 mA input,
AD0 voltage
output 1-5V DC

Gain=2:
R0=10K,
RP2A=0,
G0=NC,
Rx=124,
AN0-=A0-,





1.3.8 G2 Modifications for 0-4.095V inputs and 0-10V outputs

In order to convert DAC's 0-4.095V analog signal to 0-10V analog signal, modifications on the gain resistors and power supplies must be made.

1) Remove U7 LM723, and short U8 pin 1=+12V and pin 3=+7V. The on-board +7V becomes +12V
2) Remove U6 LM79L05, and short U6 pin 1=-5V and pin 2=-7V. The on-board –7V becomes –12V
3) Add a jumper wire in the prototyping area at Rx0-3 pin9=GND to pin10=ANIx-.
4) Replace the RP2 and RP4 from 100K to 20K, so the second stage Gain=2.
5) Install 100K resistors in the 1st stage gain resistor R0, R1, R2, R3.
6) The system over all gain = (1+2x (10 / ***100***))x2 = 2.4.
7) If you change the ***100K*** resistor (R0, R1, R2, R3) to ***90.9K,*** the gain will be 2.44.
8) Power the OPS with +12V at T2 pin 1 and pin 2.
9) Apply the 0-4.095 V DAC signal to OPS T1 pin 4=A0+, and connect the GND of DAC and OPS at T1 pin 2.
10) The T2 pin 8=AD0 should output 0-9.8V corresponding to 0-4V inputs.

1.3.9 G1/2 Modifications for 0-10V inputs and 0-5V outputs

In order to convert DAC's 0-10V analog signal to 0-5V analog signal, modifications on the gain resistors and power supplies must be made.

1) Remove U7 LM723, and short U8 pin 1=+12V and pin 3=+7V. The on-board +7V becomes +12V
2) Remove U6 LM79L05, and short U6 pin 1=-5V and pin 2=-7V. The on-board –7V becomes –12V
3) Add a jumper wire in the prototyping area at Rx0-3 pin9=GND to pin10=ANIx-.
4) Replace the RP2 and RP4 from 100K to 4.99K, so the second stage Gain=0.5.
5) DO NOT install R0, R1, R2, R3.
6) The system overall gain = (1 x 0.5) = 0.5.
7) Power the OPS with +12V at T2 pin 1 and pin 2.
8) Apply 0-10V DC signal to OPS T1 pin 4=A0+.
9) The T2 pin 8 =ADO should output 0-5V corresponding to 0-10V inputs.