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# ADC-20/ADC-24 Terminal Board

User's Guide



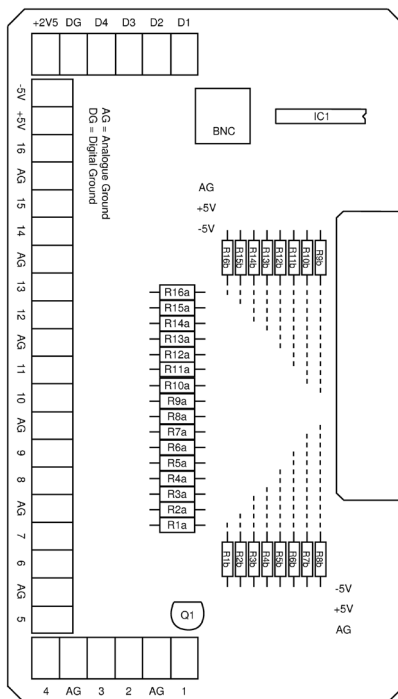
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# 1. Overview

## 1.1 Introduction

The ADC-20/ADC-24 Terminal Board is designed for use with the 8-channel ADC-20 and 16-channel ADC-24 High-Resolution Data Loggers. For simple applications, you can simply connect sensor wires to the screw terminals on the terminal board, without the need for soldering. For more advanced applications, the terminal board enables you to design and build sensor circuits that condition measurements for the data loggers to process. The board has empty locations for extra components (not supplied), as described later in this manual.



**Layout of ADC-20/ADC-24 Terminal Board**

## 1.2 Terminals and component sites

The table below shows the purpose of each of the terminals and empty component sites.

Terminal or site	Description
1 to 16	Connections to ADC Channels 1 to 16
AG	Connections to analog ground*
DG	Connections to digital ground*
+5 V and -5 V	Low-current power supply (up to 2 mA) for sensors, if required
+2.5 V	Reference voltage
R1a to R16a	Sites for series resistors in voltage dividers. Referred in this document as $R_a$ . R1a is connected to Channel 1, R2a to Channel 2 and so on. If you use one of these sites, you must cut the thin track beneath the resistor.
R1b to R16b	Sites for shunt resistors in voltage dividers. Referred to in this document as $R_b$ . R1b is connected to Channel 1, R2b to Channel 2 and so on.
Q1	Site for LM35 temperature sensor
BNC	Site for upright BNC socket
IC1	Site for a 14-pin DIL integrated circuit. You can use wires to link pins to channels.

\* We do not recommend that you connect AG and DG together, as this would degrade measurement accuracy.

### Terminals and component sites

## 1.3 Connecting to the data logger

You can plug the terminal board directly into the analog connector on the ADC-20 and ADC-24 data loggers. Alternatively, you can use a standard 25-way male-D to female-D parallel cable to connect the terminal board to the data logger.

## 2. Taking measurements

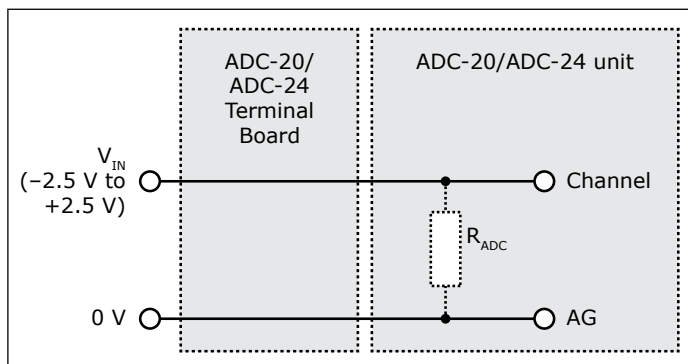
### 2.1 Voltage

#### 2.1.1 General

When using the ADC-20/ADC-24 Terminal Board with the ADC-20 or ADC-24 to measure voltages, you can connect the voltage source in one of two ways: directly, by plugging straight into the channel, or indirectly, via a voltage divider.

#### 2.1.2 Direct connection

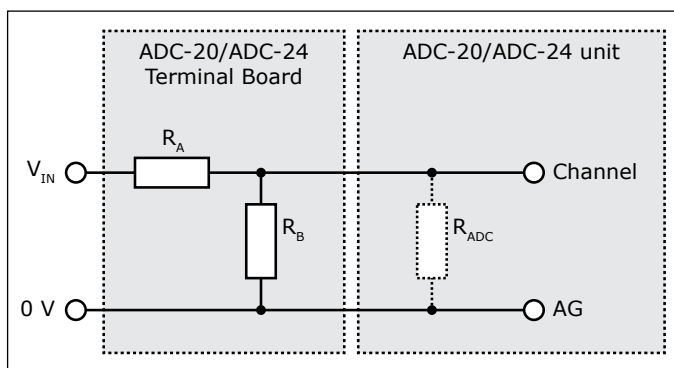
For voltage sources measuring from  $-2.5\text{ V}$  to  $+2.5\text{ V}$ , use a direct connection to any channel.



**Direct input to channel**

#### 2.1.3 Voltage divider connection for single-ended measurements

For voltages beyond  $-2.5\text{ V}$  to  $+2.5\text{ V}$ , use a voltage divider connection.



**Single-ended voltage divider**

The voltage that the ADC sees,  $V_{ADC}$ , depends on  $V_{IN}$  and the values of  $R_A$  and  $R_B$ , and is given by the following equation:

$$V_{ADC} = V_{IN} \times \frac{R_B}{R_A + R_B}$$

Choose values of  $R_A$  and  $R_B$  so that  $V_{ADC}$  is approximately +2.5 V when  $V_{IN}$  is at its highest.

To minimize errors in the measured voltage,  $V_{ADC}$ , caused by loading of the source voltage  $V_{IN}$ , ensure that the combined resistance of  $R_A + R_B$  is much greater than the resistance of the voltage source. If you are unsure of the resistance of the voltage source, use large values for  $R_A$  and  $R_B$  such that  $R_A + R_B$  is about 10 k $\Omega$ .

If you have chosen a value for  $R_B$  that is greater than 10 k $\Omega$ , and you need high accuracy, then you will need to take into account the ADC's input resistance  $R_{ADC}$ , which acts in parallel with  $R_B$ . Use the following equation to obtain a value for the parallel equivalent resistance of  $R_B$  and  $R_{ADC}$ ,  $R_{BEQ}$ , then use  $R_{BEQ}$  instead of  $R_B$  in the previous equation:

$$R_{BEQ} = \frac{R_B \times R_{ADC}}{R_B + R_{ADC}}$$

where  $R_{ADC} = 1 \text{ M}\Omega$

The following four noise problems are often associated with potential divider circuits:

- Noise from source voltage. Try fitting a capacitor as described below.
- RF interference is picked up at high-impedance points. Smaller values for  $R_A$  and  $R_B$  may help.
- Noise on the earth connections.
- The signal 0 V line is connected to mains earth. Try to avoid this situation

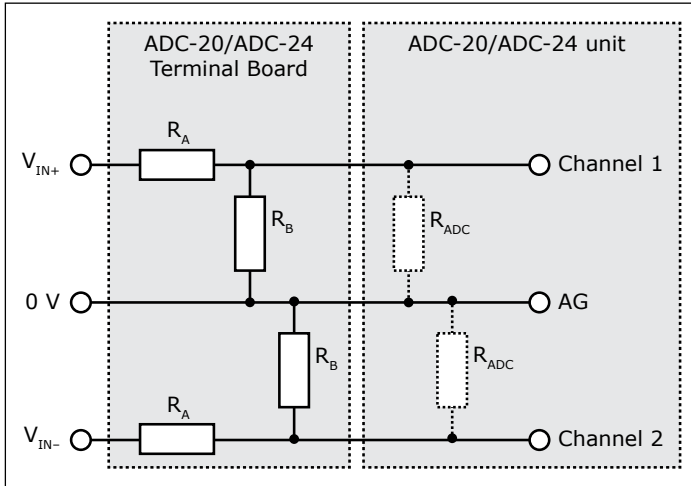
If the first or second of these occurs, and you want to try a capacitor, ensure that you have fitted resistor  $R_A$  and cut the corresponding track beneath the resistor. Fit the capacitor in place of or in parallel with  $R_B$ , as necessary. Use the following equation for  $C$ , the value of the capacitor:

$$C = \frac{1}{2\pi f \times R}$$

where  $R$  is  $R_A$  or the smaller of  $R_A$  and  $R_B$ , and  $f$  is the highest signal frequency in hertz.

## 2.1.4 Voltage divider connection for differential measurements

For differential voltages beyond  $-2.5\text{ V}$  to  $+2.5\text{ V}$ , use a double voltage divider connection:



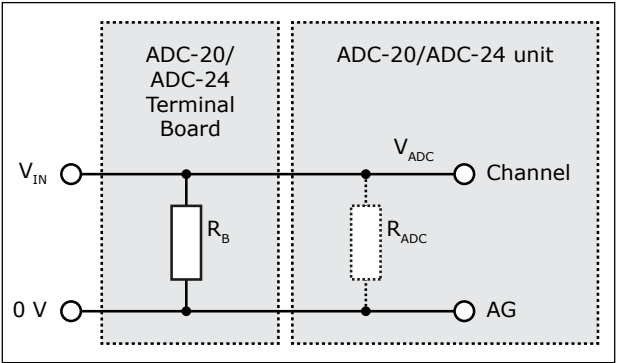
**Differential voltage divider**

Place a potential divider on each half of the differential input as in the diagram above. Connect the bottoms of both dividers together and tie them to the channel and AG. Run the middle of each divider to the data logger input channel and the top of each divider to the measurement voltage.

Each half must use the same value components in order to give the same ratio and the same impedance. Even small mismatches in attenuation will affect the common mode rejection ratio, so you should use 1% (40 dB) or 0.1% (60 dB) resistors.

## 2.2 Current

You can use the ADC-20 or ADC-24 with terminal board to measure current. If the current returns through ground, you can use a simple shunt resistor to convert the current into a voltage before measuring with the ADC. The diagram below shows a circuit with a shunt resistor  $R_B$ .



**Shunt resistor circuit**

Calculate the resistor value  $R_B$  using the following equation:

$$R_B = \frac{V_{RANGE}}{I_{MAX}}$$

where  $I_{MAX}$  is the highest current you expect to measure and  $V_{RANGE}$  is the selected input range.



**WARNING**

Do not use this method to measure mains (line power) current.  
Seek professional advice!

## 2.3 Light level

In order to measure light levels using the ADC-20 or ADC-24 with terminal board, you will also need a light-dependent resistor (LDR) and a fixed resistor.

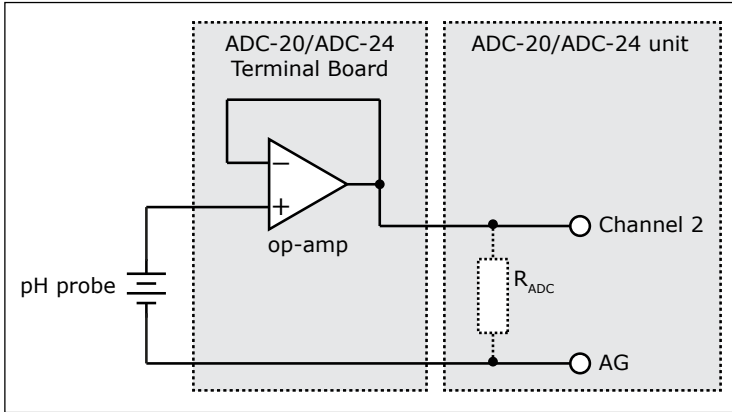
Use the +5 V output to supply power to the circuit. Use a resistor of around 1 M $\Omega$  for  $R_A$ , and place the LDR in location  $R_B$ .



## 2.4 pH

It is possible to carry out basic pH measurements using your ADC-20 or ADC-24 with terminal board. However, as the pH of a liquid can vary widely with temperature, we recommend using the USB DrDAQ Data Logger and a temperature sensor for more accurate measurements.

The diagram below shows the connections required to measure pH with an ADC-20 or ADC-24 with terminal board. The circuit allows you to use any standard pH probe, including the DrDAQ pH sensor (part number DD011).



**pH sensor circuit**

Note that the op-amp should have very high input impedance: an LT1114 would be suitable.

Following this method, you will need to calibrate the probe using two or three buffer solutions of known pH.

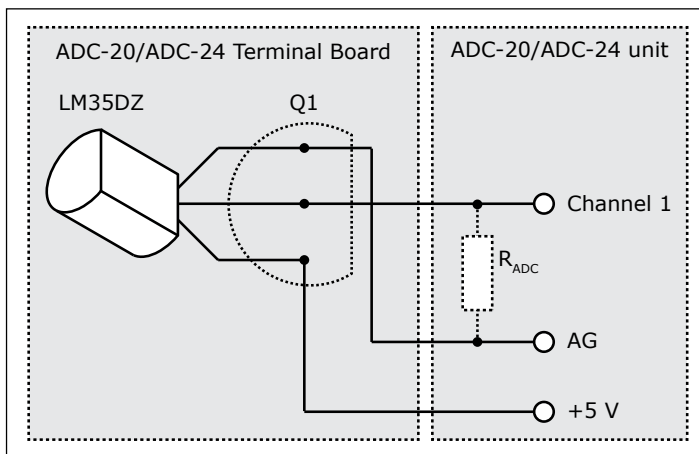
## 2.5 Temperature

You can measure temperature accurately using the ADC-20 or ADC-24 with the terminal board and a suitable sensor. There are three methods of doing so, each using one of the following sensors:

- LM35DZ integrated circuit (IC) sensor
- Precision thermistor
- Thermocouple used with AD595 IC

### 2.5.1 LM35DZ IC sensor

The LM35DZ IC is a combined precision temperature sensor and signal conditioner in a three-pin TO-92-style casing, and the easiest of the three temperature-sensing options to fit to the ADC-20/ADC-24 Terminal Board. The device measures temperatures in the range 0 °C to +100 °C and includes the electronics required to convert temperatures to a linear voltage of 10 mV/°C.

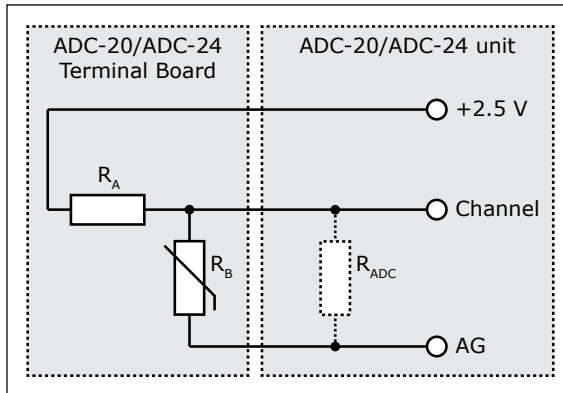


**Temperature sensor circuit with precision thermistor**

Fit the sensor to the terminal board in position Q1, as illustrated above. To convert the voltage to a temperature reading, use the **parameter scaling** facility in the PicoLog software, with **scaling method** set to **Equation**. Set the scaling equation to  $X * 100$ . For more information, see the *PicoLog User's Guide* or the onboard help file.

### 2.5.2 Precision thermistor

The precision thermistor works with the reference output of the data logger, connected as illustrated below. The thermistor in the diagram is an NTC (negative temperature coefficient) type, and should be fitted in position  $R_B$ . Resistor  $R_A$  is a precision metal film type, with a value of  $49.9\ \Omega$  and a tolerance of 0.1%.



**Temperature sensor circuit with precision thermistor**

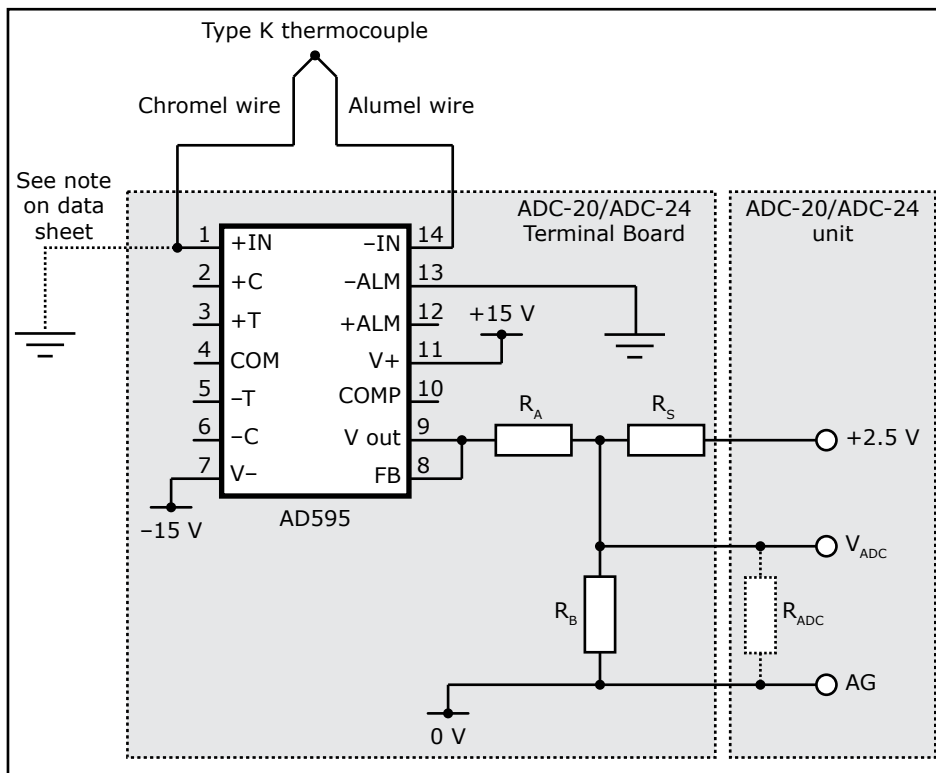
The thermistor outputs a voltage value: you will need to use the PicoLog software to convert this to a temperature, using values from the conversion table in the thermistor data sheet.

## 2.5.3 Thermocouple

In order to use a thermocouple to measure temperature with your ADC-20 or ADC-24 and terminal board, you will also need to use an AD595 IC from Analog Designs. The circuitry involved in connecting this to the data logging equipment is the most complex of the three temperature-measurement options, so you should take great care if you do choose this method.

The AD595 is an integrated thermocouple instrumentation amplifier with built-in cold-junction compensation. The diagram below shows how to connect a Type K thermocouple and AD595 to the terminal board.

As with the precision thermistor circuit described above, you will need to convert voltage values to temperatures. A conversion table is supplied in Appendix 1 of this document.



**Temperature sensor circuit with precision thermistor**

The circuit illustrated can measure temperatures from  $-200\text{ }^{\circ}\text{C}$  to  $+1250\text{ }^{\circ}\text{C}$ . The component values are as follows:

$R_A = 44.2\text{ k}\Omega$  0.1% metal film

$R_B = 11\text{ k}\Omega$  0.1% metal film

$R_S = 75\text{ k}\Omega$  0.1% metal film

Please note that the AD595 requires a separate power supply. For full information on this component, see the Analog Devices website, <http://www.analog.com>. Ensure that you observe all electrostatic discharge (ESD) precautions when constructing this circuit, to avoid damage to the AD595 IC.

## Appendix 1. Thermocouple conversion table

Temp (°C)	V <sub>ADC</sub> (V)	Temp (°C)	V <sub>ADC</sub> (V)	Temp (°C)	V <sub>ADC</sub> (V)
-200	0.003	180	0.587	660	1.474
-180	0.018	200	0.622	760	1.658
-160	0.036	220	0.657	780	1.695
-140	0.057	240	0.693	800	1.731
-120	0.081	260	0.729	820	1.767
-100	0.107	280	0.765	840	1.803
-80	0.135	300	0.802	860	1.838
-60	0.164	320	0.856	880	1.874
-40	0.196	340	0.875	900	1.909
-20	0.229	360	0.912	920	1.944
-10	0.246	380	0.949	940	1.979
0	0.263	400	0.984	960	2.014
10	0.281	420	1.024	980	2.049
20	0.298	440	1.061	1000	2.083
25	0.307	460	1.098	1020	2.117
30	0.316	480	1.136	1040	2.151
40	0.334	500	1.173	1060	2.185
50	0.352	520	1.211	1080	2.221
60	0.371	540	1.249	1100	2.253
80	0.407	560	1.286	1120	2.286
100	0.444	580	1.324	1140	2.319
120	0.480	600	1.361	1160	2.352
140	0.516	620	1.399	1180	2.384
160	0.552	640	1.436	1200	2.417

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