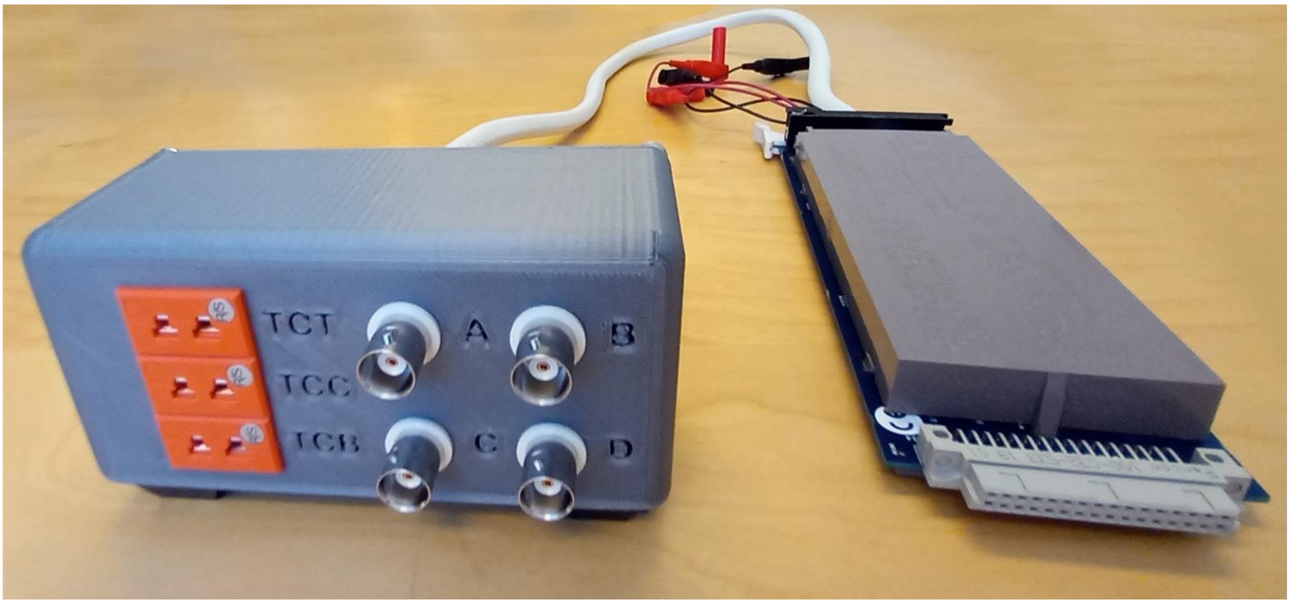
Engervannsveien 39
1337 Sandvika
Norway



1 Introduction

A multimeter has many functions, but only one set of terminals to connect to, allowing only one thing to be measured at a time (well actually two set of terminals, the front set, and the back set, only one set of which can be used at a time).

To measure more complex things, one would constantly need to swap cables between sample and instrument. The solution is a switch card. It has a number of channels, each of which can be connected to the measuring terminals using the front panel of the instrument, or even better, using external software.

The combination of software control, and the multiple channel card, the multimeter becomes flexible system that can perform complex tasks fully automated. To automate a measurement is not exactly straightforward, but it is not extremely complicated either.

The “Channel preparation kit/work” option that is sold with the multimeter, is aimed to benefit especially ProboStat users. The switch card included in this package has some pre-made connections so help a new user get started.

This document briefly describes the channel setup and wiring for 2-wire, 4-wire and cold junction compensation as typically used with Omega. The purpose here is a ‘Quick reference’, not full tutorial or manual. Elaborate information can be found in the instrument (K2000, K2010, SCAN2000), and Omega manuals.

The card itself is in most cases already installed inside the multimeter with some wiring and thermocouple connection sockets installed.

2 Circuit

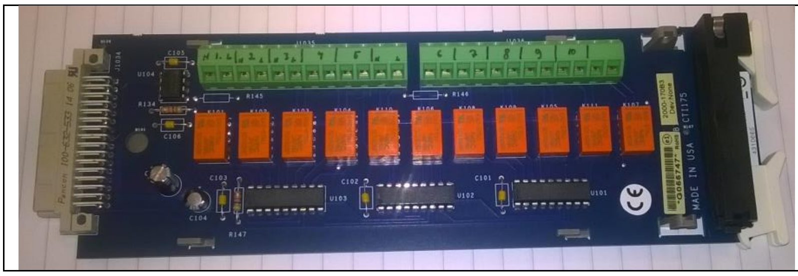
The end user should understand the whole measurement circuit from the sample, sample electrodes, electrode contacts, ProboStat pins, ProboStat internal wiring and switches, BNC cables, multichannel card or switchboard, and finally the measuring instrument. It often helps to sketch the whole setup onto paper, as the manuals only cover the aspects directly relating to the manual subject. Furthermore each manual uses different terms for different things, often conflicting and misleading. It is good to remember, those are just ‘labels’ given to help identifying the part of the setup, what the lead actually does, may be altogether different.

3 Card terminology

The instrument has 5 inputs, called Input high, input low, sense high, sense low and amps. We can ignore the amps connection since measuring only the current is often done with specialized instruments and not generic low cost multimeter.

All other 2-wire measurements are done with the input (high and low) connections. The sense connections are only needed for 4-wire measurements. In such setup the inputs are current, and the sense wires are voltage.

The switch card has 10 input channels (each for two leads called high and low), each of which can be separately (from front panel or from software) connected to the instrument inputs, or as a pair of channels when 4-wire measurement is done. The connection to the instrument inputs are made by connecting the last two screw terminals on each bank to the instrument terminals on the back of the instrument.



Channels as marked, 1 to 5 on left bank, 6 to 10 on right bank.

Channel high (+) left, low (-) on right.

Card Connections and Installation 2-7

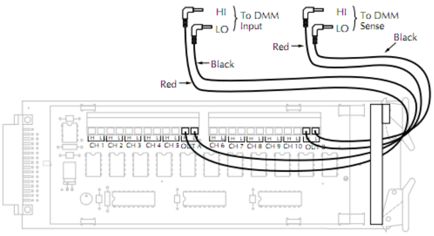
Output connections

Use the supplied test leads for scanner output connections. Connect red leads to the output (OUT A and OUT B) HI terminals, and connect black leads to the output LO terminals. See Figure 2-3 for details. Dress output test leads through the cable clamp, as described in "Dressing leads" on page 2-8. After all wires are connected and secure, close the plastic shield, and secure it with the locking tab.

NOTE *If you intend to use the scanner card only in the 2-pole mode, it is not necessary to connect output leads to both OUT A and OUT B. Use only OUT A for the 2-pole mode.*

After the scanner card is installed, the output leads must be connected to the multimeter rear panel input jacks. See "Output connections to multimeter" on page 2-17 for details.

Figure 2-3
Output connections



Note: OUT B connections not required for 2-pole operation. Plastic shield not shown.

The left bank is often referred as "input" and the right bank as "sense", which is mostly logical (except for example when the instrument is commanded to perform a 2-wire measurement such as voltage measurement on channel 7).

On the image is visualized the connection from the banks to the instrument terminals on the back of the instrument.

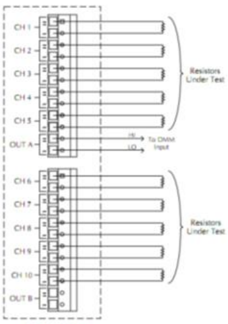
2-10 Card Connections and Installation

Resistance connections

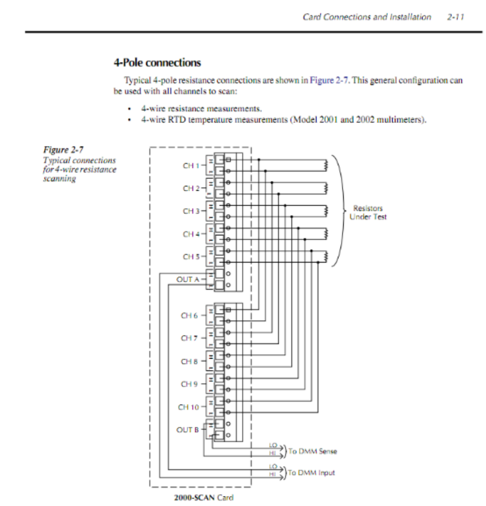
2-Pole connections

Figure 2-6 shows typical 2-pole resistor test connections. The 2-pole resistance configuration can be used to test up to ten DUTs.

Figure 2-6
Typical connections for 2-wire resistance scanning



When the instrument is in "2-wire resistance measurement"-mode, the channels connection scheme/operation is very straightforward.



Things get more complicated when 4-wire resistance measurement is performed.

Each channel on the left bank is paired with a channel on the right bank, so that total of four wires gets connected to the instrument input terminals.

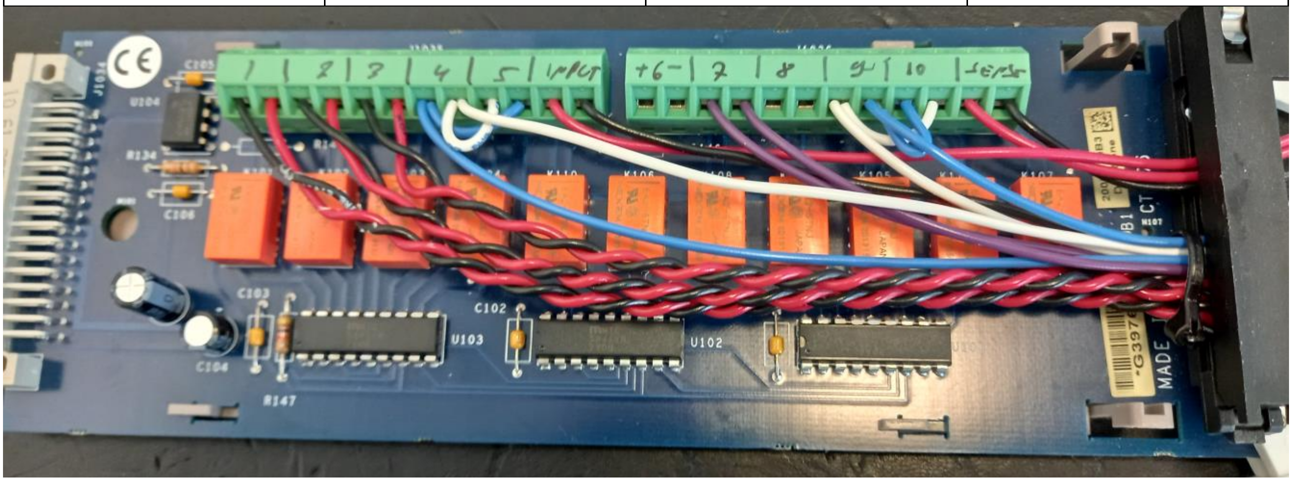
For example if current wires connect to channel three, the sense wires of the measurement must connect to channel eight (n+5).

It is rare for all the channels to be used for one purpose, and instead a mixture of roles is more realistic. For example, reserve channel 1, 2 and 3 for two wire voltage measurements (reading thermocouples), and always use those for that. Then reserve channels 4 and 5 for any 2 wire or 4 wire measurement, (and keep channels 9 and 10 for those 4-wire setups), and so forth. If such scheme is used, one can pre-mount wires and appropriate connectors on each channel and never or rarely have to re-arrange the used setup-scheme.

4 Channel preparation kit CEA

Channels are prepared in this way:

Channel	High	Low	QC (Internal notes)
1	TCT +	TCT -	Ok
2	TCC +	TCC -	Ok
3	TCB/I +	TCB/I -	Recheck
4	A	B	Ok
5	B	A	Ok
6			
7	Thermistor	Thermistor	
8			
9	C	D	
10	D	C	



The image is for illustration purposes and may not match the actual wiring.

There is no one correct way, channels can be used in any way suitable for the task at hand, and the ‘channel preparation work’ acts just as an example and a way to get quickly into speed allowing the typical needs for a ProboStat user; 3 separate thermocouples to be measured with cold junction compensation, and two double BNC channels, including possibility for four wire resistance with forward, and reverse current.

The channels 4 (using A and B) and 9 (using C and D) can be used for regular 2 lead measurements such as sample voltage or two wire resistance.

When in 4-wire measurement mode, the channel 4 pairs with channel 9 to form ‘normal’ four-wire measurement circuit where current in A, high voltage C, low voltage D, current out B.

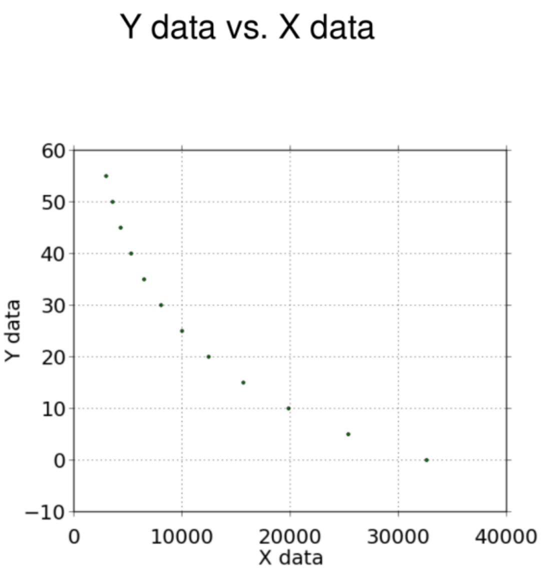
A powerful trick is that channel 5 (paired with 10) uses the same wires but the connections are inversed, allowing user to measure again four-wire resistance but with reverse current (to eliminate the thermovoltage contribution from the resistance when using reverse and average for the two results from channel 4, and then 5). This and everything else can be automated with Omega software (or calculated by hand).

The wire colours in the picture have no significance. Note how the pair 5&10 is a copy of pair 4&9 but with current/input leads inverted.

All wires are of same make and material, and the junction to dissimilar materials take place at the end of the wires (that may be loose, mounted on adapters, or mounted on a box).

4.1 Thermistor

The channel 7 is connected to a thermistor that can be used to determine the cold junction temperature of the box (where thermocouple compensation wire changes into identical wire pair).



Thermistor type is Epocs B57861S

In the image:
Y=Temperature °C
X=Thermistor resistance

y = a*pow(ln(x+b),c) + Offset

Fitting target of lowest sum of squared absolute error = 2.2723066534597489E-05

a = 1.3731696074919496E+03
b = 5.2676757508279636E+01
c = -2.9879165925419210E-01
Offset = -6.8218613236490091E+02

Or use Omega software, it has conversion function for this.

4.2 Thermocouple calculations

Remember, the correct way to calculate thermocouple tip temperature is to convert the cold junction temperature into thermocouple voltage, then add that voltage to the measured thermocouple voltage, and then read back that sum from conversion table or formula. Or use Omega software with built-in functions.

The colour coding of the thermocouple sockets (green for K or orange for S) on the connector box has a marginal impact on the measurements, as the compensation (lead dissimilarity) ends right at the box.*

5 Front panel operation

Have the “Front/Rear INPUTS” button at bottom to have the instrument measure from the terminals on its back side. The “Open” button disconnects any and all channel and results in open circuit. The “Close” button next shows a dialog to select a channel between 1 and 10. If the instrument is in a mode requiring 4 wire measurement (such as Ω4), it automatically pairs the selected channel (1 to 5) with a channel on sense bank channel (6 to 10).

6 Control from the software

The Omega software has its own manual, but in short terms a measuring node type corresponds with instrument mode. Each node allows for 'Internal switching' which is a text field of GPIB commands that are sent to the instrument before and after the measurement command and reading of the result. In these fields the user writes in GPIB language what channel to close (and remembers to open all channels after the measurement). In addition to the Omega manual examples in the NORECS webpage in the "application notes" section has some relevant info, as well as some example measurement files in the software downloads section.

6.1 Simple voltage measurement example

Once your device is validated, create new measurement, and add a new node. Select MV type node and the instrument to use, then click apply.

On the 'Instrument Commands' tab are the default commands to control the instrument, in this case 'Before measurement':

Command	Explanation
***CLS**	Clear instrument errors
:SENS:FUNC "VOLT:DC", (@1)	Configure a channel for dc voltage measurement
:ROUT:DEL 1, (@1)	Configure the instrument to wait 1 second in order to allow good settling on the channel
:ROUT:CLOSE (@1)	Command the device to engage the channel 1
:READ?	Initiate and fetch the measurement result

These commands can be edited by the user, for example the channel can be changed. If for example measureing with the connection box between C and D, we can refer to earlier tables on this manual, that those two are connected into the switch card channel 9 (and in reverse order to channel 10).

To measure voltage between BNC connectors C and D, one would use:

```
*CLS
:SENS:FUNC "VOLT:DC", (@9)
:ROUT:DEL 1, (@9)
:ROUT:CLOSE (@9)
:READ?
```

It is important to disengage the channel after the measurement, so that other nodes or measurements have 'pristine' circuit without unwanted connections interfering, so the 'After measurement' commands must disengage the closed channel:

Command	Explanation
:ROUT:OPEN:ALL	Open all possibly closed channels

If the commands are superseded with // the software ignores them. // is called commenting prefix, and uncommenting a line means removing the // so that the software sends the line to the instrument.

Engervannsveien 39
1337 Sandvika
Norway

7 Using MOSE with Omega

Multichannel multimeter is needed, as there are two voltages to be measured, and one resistance (to acquire cold junction compensation temperature). K6500 with 10 channel scanner card is suitable. Input impedance must be >1GΩ.

From measuring two voltages and one resistance, it is still long way to knowing the pO_2. Here the built-in functions of Omega can be very useful in automating the data collection, and plotting it on screen.

Two voltage nodes are needed. MV for thermocouple voltage, and MV for sensor voltage. We assume these to be Node1 and Node2 with expression variable $N1.MV and $N2.MV accordingly. One resistance node, the node 3, with type M2 for resistance and it's expression variable $N3.M2

With the thermocouple voltage and the resistance, we can solve for the exact temperature of the oxygen sensor tip. The formula is TTS($N1.MV, TT2($N3.M2)) and returns a temperature in °C. Further details and explanations why and how this is done, can be found in Omega manual (page ~24) and generic thermocouple knowledge.

To solve for the pO_2 use the MOSE(T,E,A,B) function with the above as parameter T, N2.MV as paramter E, and calibration constants as A and B, resulting in expression something like:
MOSE(TTS($N1.MV, TT2($N3.M2)), $N2.MV, 28328.07263, -21.8154612)