

Application Note 101 Transducer Calibration and Signal Rescaling

Note: The calibration and signal rescaling procedures detailed in this application note are intended for *AcqKnowledge* versions 4.0 and earlier. For *AcqKnowledge* 4.1 and higher, it's recommended to use the MP160 or MP150 > Set Up Channels > Add New Module feature, which automatically scales the signal based on the selected transducer or hardware. If additional scaling modifications are desired, they may be manually applied via the "View by Channels > Setup" option.

Overview

AcqKnowledge has a feature that allows for the rescaling of any given signal being acquired. Instead of simply measuring voltage, there is capability to rescale and rename the signal to more meaningful units. The rescaling function can also be used to calibrate a force transducer, or similar device, so that the recorded data matches the physical units measured by the transducer. The only requirement is that the data being acquired is an analog signal. Analog channels are the most common type of acquired channel and should be used to acquire any data with continuous values. The range of input voltages for analog channels, using the MP160/150, is ± 10 volts.

There are various applications and uses for calibrating and rescaling different signals. A general knowledge of the three applications listed below will help address and hopefully solve any problems encountered.

- [Skin temperature measurement using the SKT100C](#)
- [Displacement transducer calibration](#)
- [Accurate signal measurement](#)

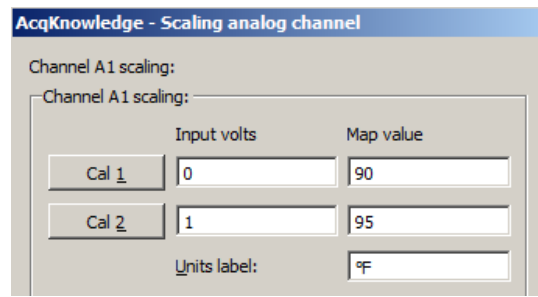
Skin Temperature Measurement using the SKT100C:

Starting with the least complicated application, accurate skin temperature measurement can be obtained assuming the scaling is adjusted correctly. The SKT100C has several options to accommodate proper scaling. These include two High Pass (HP) filter switches that permit the acquiring of temperature data in relative or absolute terms. To measure absolute skin temperature, place both HP filter switches to DC. For measurement of airflow (respiration rate) or relative skin temperature changes, place the lower HP switch to 0.05 Hz. The SKT100C also includes a gain setting switch for the degree of sensitivity with which data is acquired. Depending on the range of temperatures desired (see table below), an appropriate sensitivity level can be determined.

Absolute Temperature Range Anticipated	Relative Temperature Range Anticipated	Sensitivity (Gain Setting)
40° F to 140° F	$\pm 50^\circ$ F	5.0° F/V
65° F to 115° F	$\pm 25^\circ$ F	2.5° F/V
80° F to 100° F	$\pm 10^\circ$ F	1.0° F/V
85° F to 95° F	$\pm 5^\circ$ F	0.5° F/V

Temperature ranges and corresponding gain settings

Absolute Temperature Measurement: Select DC for both HP filter switches. Two known temperature to voltage readings are required to calibrate a measurement. In the case of the SKT100C, both of these readings are already factory established. The first known reading is that the SKT100C is programmed at the factory to center, or zero, at 90 degrees F. When 0 volts is output by the SKT100C amplifier, the amplifier will indicate a temperature of 90 degrees F. Accordingly, in the channel scaling window enter "0" for Input Volts and "90" for Map Scale Value for "Cal 1." The second temperature to voltage reading will be 90 degrees F + Gain Setting (F degrees /V). For example, if an amplifier gain setting of 5 degrees F/V is selected, then simply add 90 degrees and 5 degrees to get 95 degrees for the second Map Scale Value. Also, enter "1" for the "Cal 2" Input Volts box, since it's known that a 1 Volt change will correspond to a 5 degree temperature change at a gain setting of 5 degrees F/V (see figure below). Enter the appropriate units label in the space provided.



Scaling setup window set to correspond to 5 deg/V setting on SKT100C

The Input Volts and Map Scale Value boxes rescale the voltage of the input signal for plotting and numerical display purposes. Given two incoming signals and their corresponding Map Scale Value, *AcqKnowledge* will perform linear extrapolation for signals falling outside this range, as well as a linear interpolation for values in this range (in the temperature example above, between 0 to 1 volt). Therefore, only need two known points are needed to calibrate a signal.

Relative Temperature Change Measurement: Select either 0.05 Hz or 0.5 Hz on one of the HP filter switches. The higher of the filter setting chosen takes precedence. The 0.05 Hz setting is to monitor slow temperature changes, with a time constant of about 3 seconds. The 0.5 Hz setting is to monitor faster temperature changes, with a time constant of about 0.3 seconds. Next, choose the appropriate gain setting on the SKT100C amplifier that best represents the temperature range for the experiment. With these settings, 0 volts maps to the mean (average) temperature measured during the recording. Typically, the average temperature is assumed to be some constant value “X”. Accordingly, in the channel scaling window, enter “0” for Input Volts and “X” for Map Scale Value for “Cal 1”. The second temperature to voltage reading will be “X” degrees F + Gain Setting (F degrees /V). For example, if a gain setting of 1 degree F/V is selected, then simply add “X” degrees and 1 degree to get “X + 1” degrees for the second Map Scale Value. Also, enter “1” for the “Cal 2” Input Volts box, since it's known that a 1 volt change will correspond to a 1 degree temperature change at a gain setting of 1 degrees F/V. Enter the appropriate units label in the space provided.

It's also possible to calculate the relative temperature from the data acquired when the absolute (DC) settings are chosen. This can be performed, in real time, by setting up a calculation (difference) channel or after the recording is finished by performing a transformation (difference) on the DC waveform.

Displacement Transducer Calibration:

A displacement transducer (such as SS14L used with TCI114) interfaced with the DA100C can be used to measure very slight motions in physiological experiments. The transducer can be calibrated in the scaling window so that the units being measured by *AcqKnowledge* are the same as those measured by the transducer.

Hardware setup:

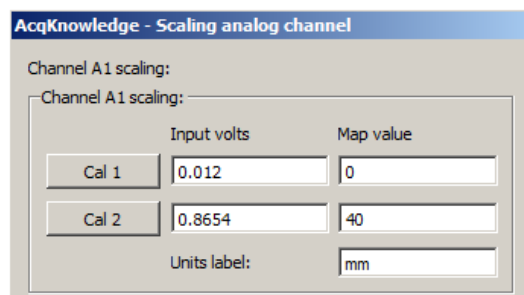
1. Set the DA100C amplifier to the lowest possible gain (50).
2. Set the Lowpass (LP) filter to 10 Hz.
3. Set the Highpass (HP) filter to DC.
4. Setup the transducer in its stand and let the blade hang freely (parallel to the ground).

Software setup:

Similarly to the temperature scaling example, two known displacement to voltage readings are used for calibration:

1. Under **MP > Set Up Data Acquisition > Channels**, choose “**View by Channels**,” select the transducer channel and click “**Setup**.”
2. Click “**Cal 1**” to measure the voltage output by the transducer in its neutral state (no displacement).
3. Enter “0” in the Map Value box for **Cal 1** (see figure below). This is the zero point from which to measure future displacement variations (usually, in millimeters).
4. To find the second reference point, bend the blade down, or add weights, so the blade tip sits at a known displacement. Simultaneously, click “**Cal 2**” and measure the displacement (40 mm, for example) from the tip of the flexed blade back to its neutral “0” point.
5. Enter this distance in the Map Value box for **Cal 2**.

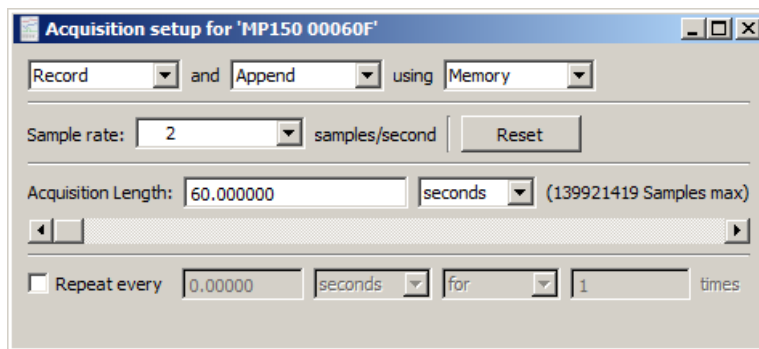
6. Change the Units label to mm and click **OK** (see figure below).



Scaling window used for calibration of displacement transducer

7. Under **MP > Set Up Data Acquisition > Length/Rate**, choose a sample rate according to the speed of activity being acquired (see figure below). Acquisition length should be set to the recording time period required.

- For fast activity, choose a higher sample rate (e.g. 200 Hz).
- For slow activity, choose a lower sample rate (e.g. 2 Hz).

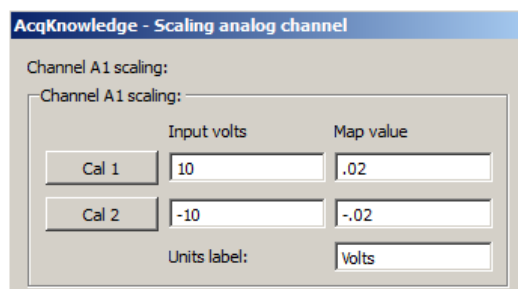


Acquisition setup for slow activity research

Accurate Signal Measurement:

When an MP amplifier measures a signal (V_s) from electrodes, that signal is multiplied by the gain (A_v) setting indicated on the associated amplifier's controls. The resulting signal will be displayed on the screen with an amplitude of ($V_s * A_v$). To measure just V_s , the ($V_s * A_v$) signal is rescaled by dividing it by the value of the gain setting (A_v).

1. In **MP > Set Up Data Acquisition > Channels**, choose “**View by Channels**” and click “**Setup**” for the appropriate channel.
 - o All of the MP amplifiers are limited to an input voltage range of ± 10 volts. These are the default settings you see in the channel scaling window.
2. In order to rescale this signal accurately, simply divide 10 and -10 by the value of the gain setting (example shown is A_v of 500) and enter these values respectively in the Map Scaling Values box.
 - o The MP amplifier is now scaled to acquire the measured signal as recorded at the input of the amplifier.



Calculating exact signal measurement with a gain setting of 500

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