Guide on using thermocouple calibrator

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Thermocouple calibrator

The thermocouple calibrator is a precise source and measurement tool for calibrating thermocouple instruments. The device serves both as a precise temperature measurement tool using thermocouples and a reliable source for generating specific temperatures and corresponding voltages for a given thermocouple type. The calibrator sources or measures in units of °C,°F, or mV, through a thermocouple minijack.

Standards & scales

The following table list the thermocouple types supported by the calibrator, the standards and scales used for each type.

Thermocouple Type	Standard	Scale
J,K,T,E,R,S,B,N	NIST 75	ITS-90

MS7220 Thermocouple calibrator device

Properties

The following table list the thermocouple types supported by the calibrator, corresponding temperature ranges and the

Thermocouple type	Temperature ranges	Display resolution
J	-200~1200℃ / -328~2192℉	0.1℃ or℉
K	-200~1370℃ / -328~2498℉	0.1℃ or℉
T	-200~400℃ / -328~752℉	0.1℃ or℉
E	-200~950℃ / -328~1742℉	0.1℃ or℉
R	-20~1750℃ / -4~3182℉	0.1℃ or℉
S	-20~1750℃ / -4~3182℉	0.1℃ or℉
B	600~1800℃ / 1112~3272℉	0.1℃ or℉
N	-250~1300℃ / -418~2372℉	0.1℃ or℉

Resolution under measure and simulation mode

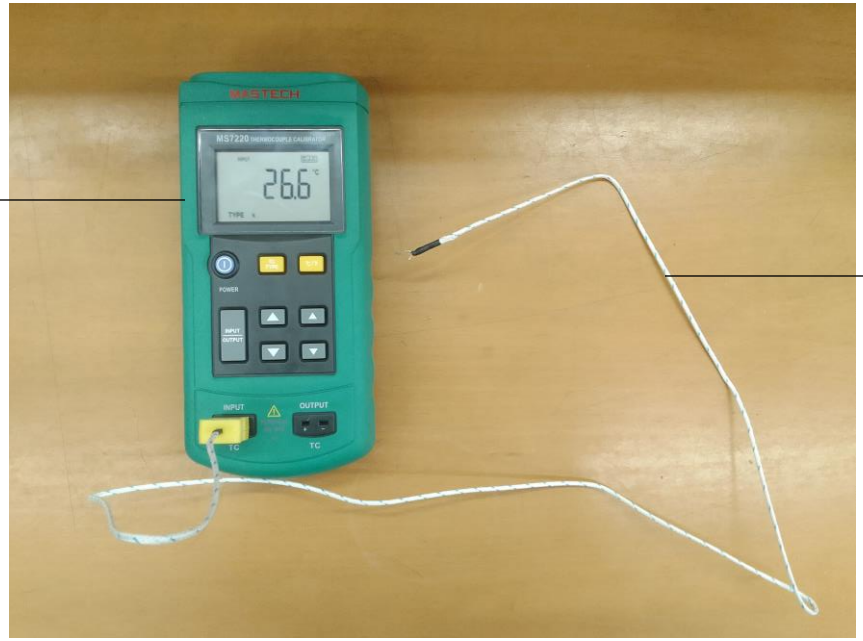
Thermocouple Type	Resolution	Error	Reference Junction Error
J,K,T,E,N	0.1℃ or℉	$\pm(0.3℃ + 10\mu V)$	$\pm 0.2℃$
R,S,B	1℃ or℉	$\pm(0.3℃ + 10\mu V)$	$\pm 0.2℃$

Voltage measure and source range

Range	Resolution	Accuracy
-10mV~75mV	0.01mV	$\pm(0.02\% + 2\mathrm{Dgt})$

How to use thermocouple calibrator as a measuring device?

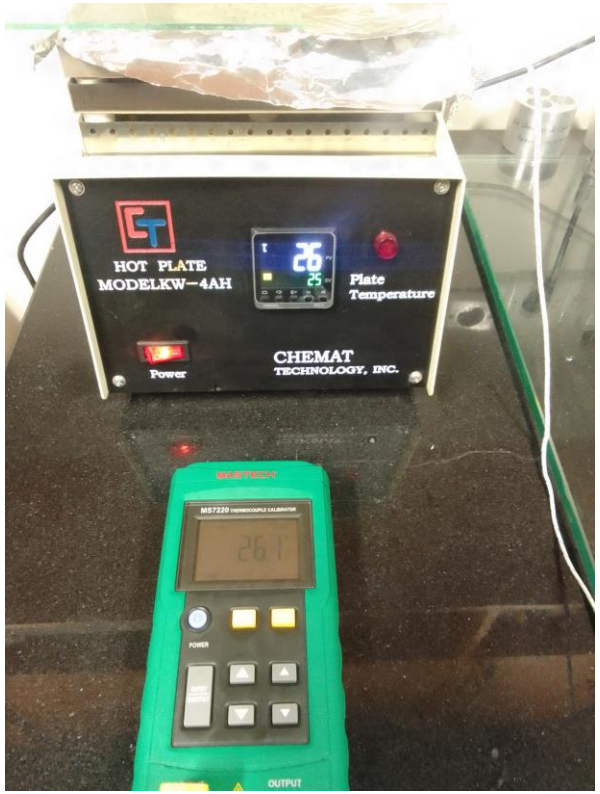
1. Power on the thermocouple calibrator.
2. Set it to **input mode** and select the appropriate thermocouple type.
3. Connect the thermocouple to the calibrator's input port as illustrated in the figure below.
4. Position the thermocouple on the surface or object where temperature measurement is required.



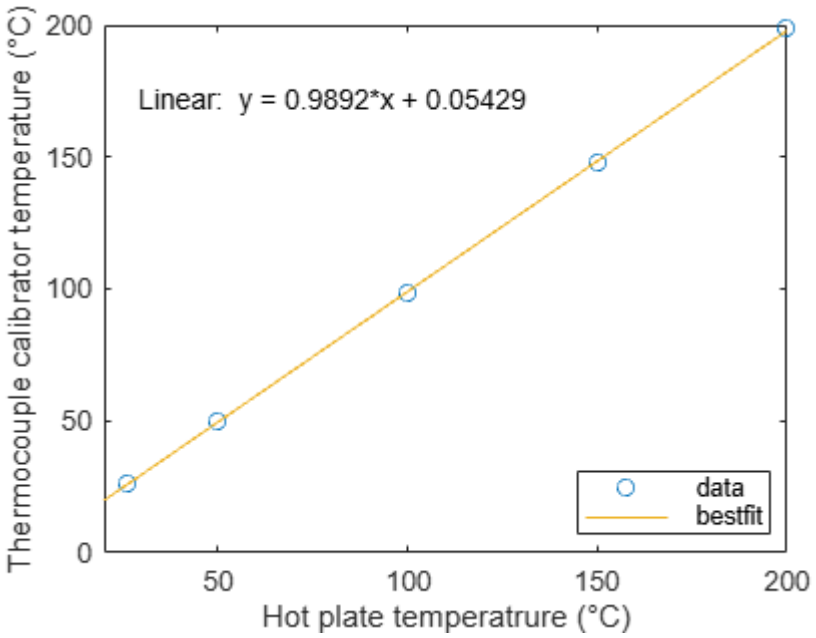
How to calibrate thermocouple?

1. We used precise digital hot plate as a temperature source (a reference device).
2. The thermocouple is wired to the thermocouple calibrator and set to input mode.
3. The readings have been taken for variation in temperature from 25-200 ℃.
4. The best fit line for the data set provides calibrated temperature.

Thermocouple calibration : as a measuring device



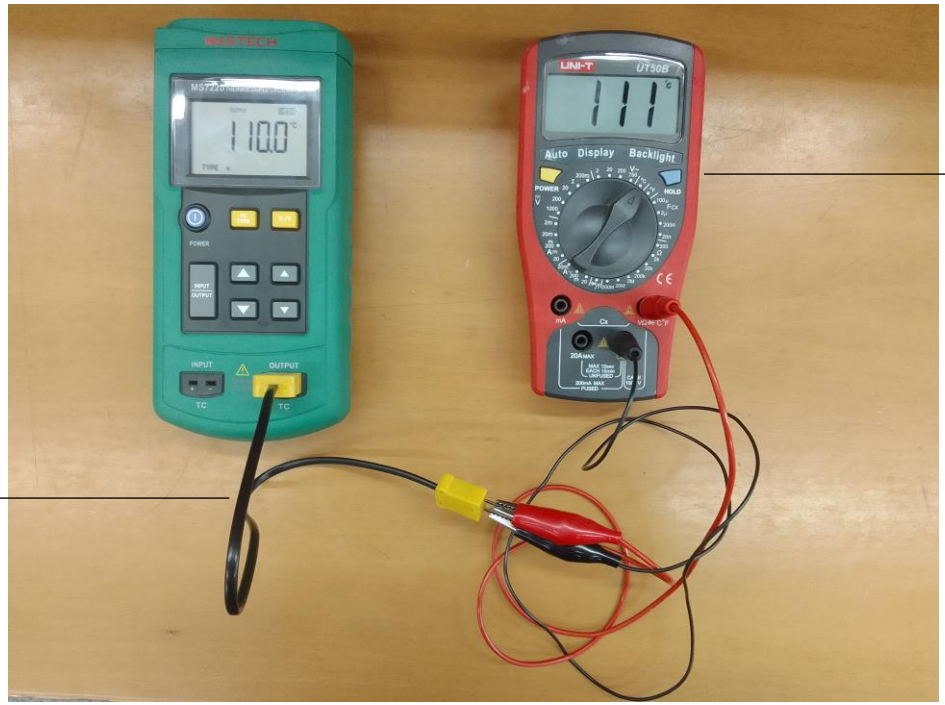
Calibration setup for a K-type thermocouple using thermocouple calibrator and a hot plate



Calibration of the K-type thermocouple: A best-fit line is drawn to correlate the temperature readings between the hot plate and the thermocouple calibrator.

How to use thermocouple calibrator as a simulating device?

1. Power on the thermocouple calibrator.
2. Set it to **output mode** and select the appropriate thermocouple type.
3. Connect the provided thermocouple miniplug to the calibrator's output port as illustrated in the figure below.
4. Use banana to crocodile clips cable to have interface between calibrator and the multimeter.
5. Set the temperature using arrowhead buttons. The calibrator generates the temperature and can be measured using user provided temperature monitor.

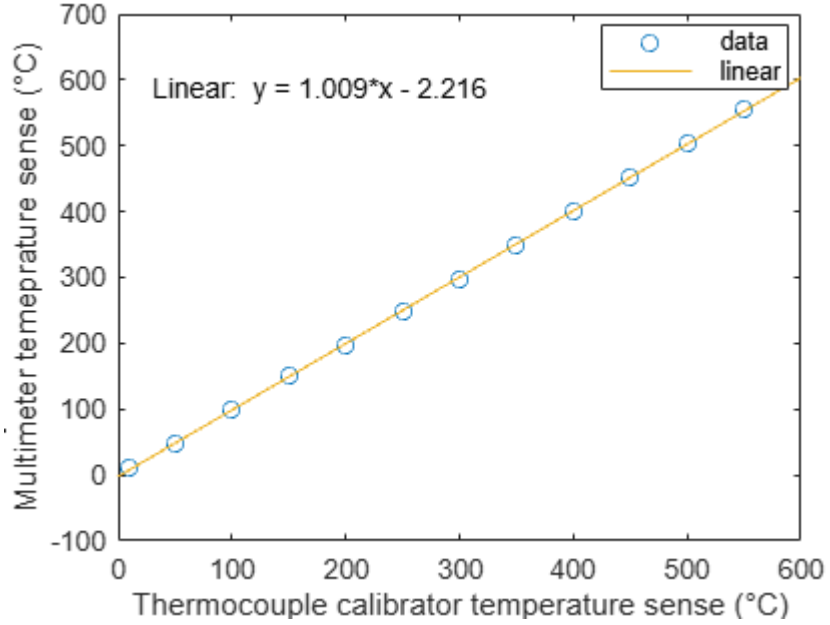


Thermocouple calibrator : as a simulating device (temperature generator)

How to calibrate thermocouple calibrator under simulation mode?

1. Set the setup as explained earlier.
2. Generate temperature from calibrator and sense it using multimeter. The best fit line for the data set provides the calibrated temperature.

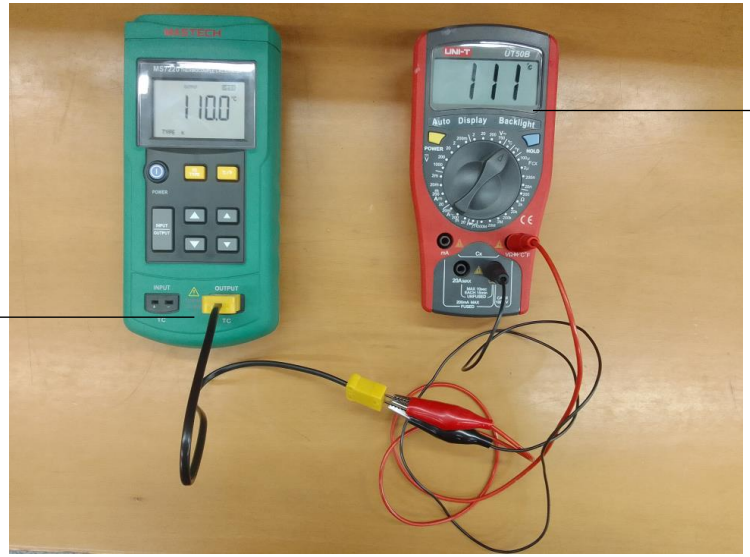
Calibration setup for a thermocouple calibrator using k-type miniplug and a digital multimeter



Calibration of thermocouple calibrator as a sensing instrument. A best-fit line is drawn to correlate the temperature readings between the thermocouple calibrator and the multimeter.

How to use thermocouple calibrator as a simulating device for temperature to voltage generator ?

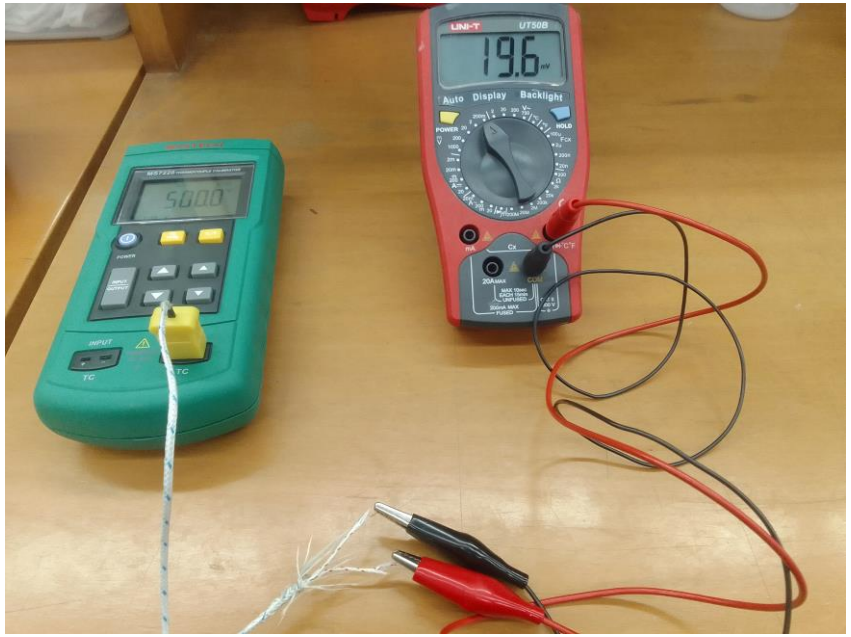
1. Power on the thermocouple calibrator.
2. Set it to **output mode** and select the appropriate thermocouple type.
3. Connect the provided thermocouple miniplug to the calibrator's output port as illustrated in the figure below.
4. Use banana to crocodile clips cable to have interface between calibrator and the multimeter.
5. Set the temperature using arrowhead buttons. The calibrator generates the temperature. Set the multimeter to read millivolts in DC.

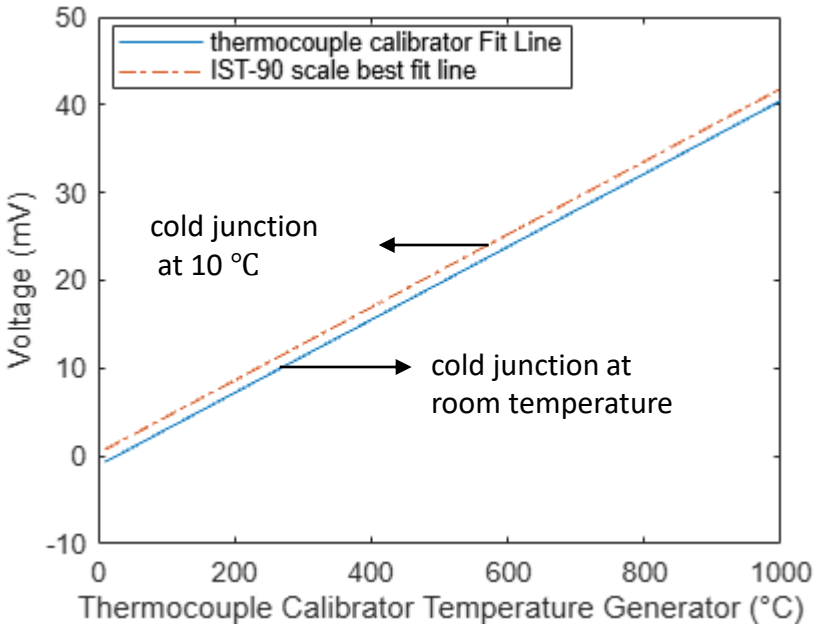


Thermocouple calibrator : temperature to voltage correlation

How to calibrate thermocouple calibrator under simulation mode?

1. Set the setup as explained earlier.
2. Generate temperature from calibrator and sense it using multimeter. Compare the plotted values with the standard temperature-to-voltage table for the selected thermocouple type to assess accuracy.





Thermocouple calibrator : as a simulating device (millivolts generator)

Specifications

Range	Resolution	Accuracy
-10mV~75mV	0.01mV	$\pm(0.02\% + 2\mathrm{Dgt})$

The thermocouple calibrator was simulated to generate millivoltages in a range of 1-18 mV. There was no observable uncertainty found in the entire reading range.

MATLAB code to generate results

```
% thermocouple calibrator as a measuring device
hot_plate=[26 50 100 150 200 ];
thermocouple_calibrator=[26.1 49.8 98.3 147.8 198.6];
plot(hot_plate, thermocouple_calibrator,'o')
xlabel('Hot plate temperatrure (°C)')
ylabel('Thermocouple calibrator temperature sense (°C)')

% thermocouple calibrator as a simulating device
thermocouple_calibrator=[10 50 100 150 200 250 300 350 400 450 500 550];
multi_meter=[10.2 49.0 100.0 150.0 198.0 247.0 298.0 349.0 400.0 452.0 504.0 556.0 ];
plot(thermocouple_calibrator,multi_meter,'o')
xlabel('Thermocouple calibrator temperature sense (°C)')
ylabel('Multimeter temeprature sense (°C)')

% thermocouple calibrator as a simulating device for temperature to voltage
thermocouple_calibrator = [10 50 100 200 300 400 500 600 700 800 900 1000];
multi_meter = [-0.6 1 3.1 7.1 11.2 15.4 19.6 24 28.1 32.3 36.3 40.3];
ref_values = [0.798 2.436 4.509 8.539 12.624 16.82 21.071 25.330 29.548 33.685 37.725 41.665];
coeff_mm = polyfit(thermocouple_calibrator, multi_meter, 1); % Best fit line for multi_meter
coeff_ref = polyfit(thermocouple_calibrator, ref_values, 1); % Best fit line for ref_values
calibrator_fit = linspace(min(thermocouple_calibrator), max(thermocouple_calibrator), 100);
mm_fit = polyval(coeff_mm, calibrator_fit);
ref_fit = polyval(coeff_ref, calibrator_fit);
% plot(thermocouple_calibrator, multi_meter, 'o', 'DisplayName', 'Multi-meter Data');
% plot(thermocouple_calibrator, ref_values, 'o', 'DisplayName', 'Reference Values');
plot(calibrator_fit, mm_fit, '-', 'DisplayName', 'thermocouple_calibrator Fit Line');
hold on;
plot(calibrator_fit, ref_fit, '-.', 'DisplayName', 'IST-90 scale best fit line');
xlabel('Thermocouple Calibrator Temperature Generator (°C)');
ylabel('Voltage (mV)');
legend('show');
hold off;
```