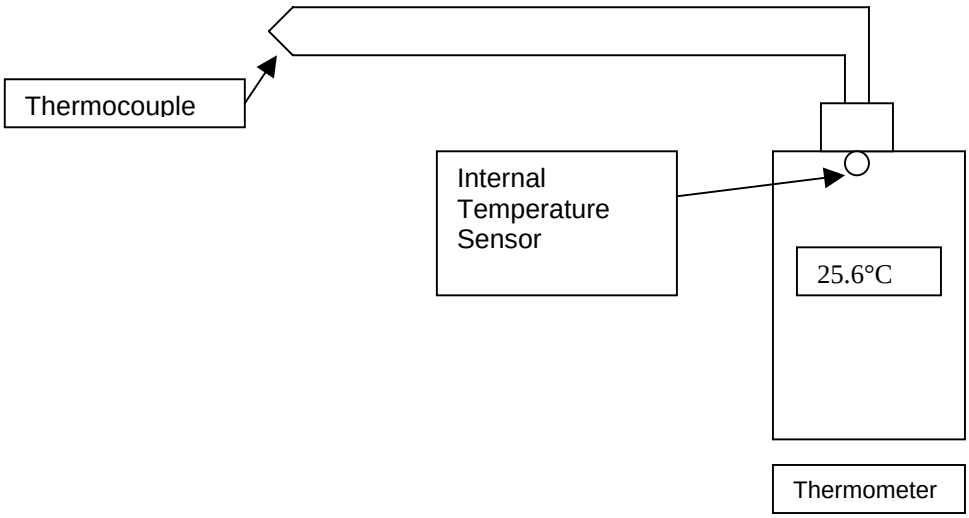
Calibration of Thermometers using Thermocouples.

Thermocouples are simply two wires made of different metals joined at one end.
They give out a voltage when there is a temperature difference due to the thermoelectric effect. Thermocouples can be made of many types of wire.

A thermocouple only measures temperature difference between its 'hot end' and its 'cold end'. The voltage output end is normally referred to as the cold junction.

To measure temperature using a thermocouple it is necessary to measure both the millivolts output from the temperature difference across the thermocouple and also the temperature of the cold junction end of the thermocouple. In a typical digital thermometer an internal temperature sensor measures the temperature of the socket into which the thermocouple is plugged into. This is called cold junction compensation CJC.



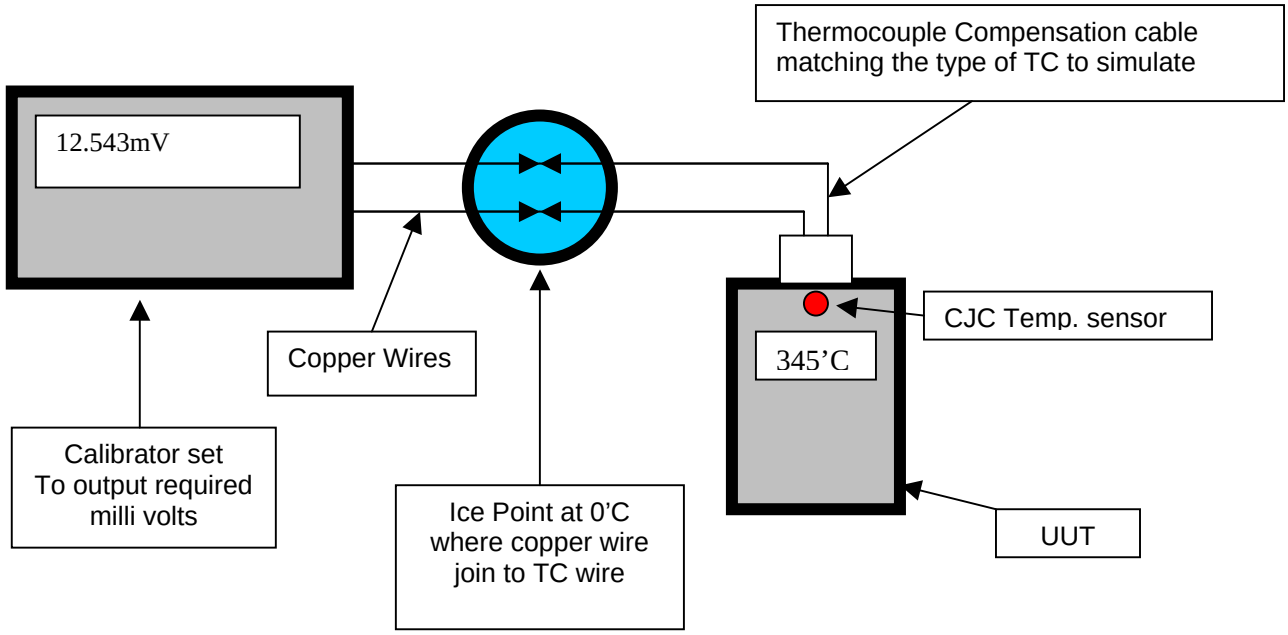
Inside the thermometer the CJC sensor is located as close as possible to where the metal of the thermocouple changes to copper, Note that thermocouples are supplied with special plugs (colour coded) made of the same metals of the thermocouple itself. If it is necessary to extend a thermocouple then it can only be extended with the same metal. The whole effect of a thermocouple is due to connecting different metals together, so great care must be taken to avoid large errors.

Calibrating a digital thermometer can be performed by placing the thermocouple in a known temperature bath, or by simulating the voltage output from the thermocouple using a voltage source. Note that there are two parts to a digital thermometer which need to be calibrated - the CJC and the 'Linearisation circuit' which converts the thermocouples milli volt output to temperature.

It should be noted that the largest uncertainties when calibrating in thermocouple thermometers come from firstly the CJC measurement, and secondly from connection emf of different metals, the voltages when calibrating thermocouple being very small. In comparison uncertainty from the voltage source/calibrator are very small as most calibrators are very accurate.

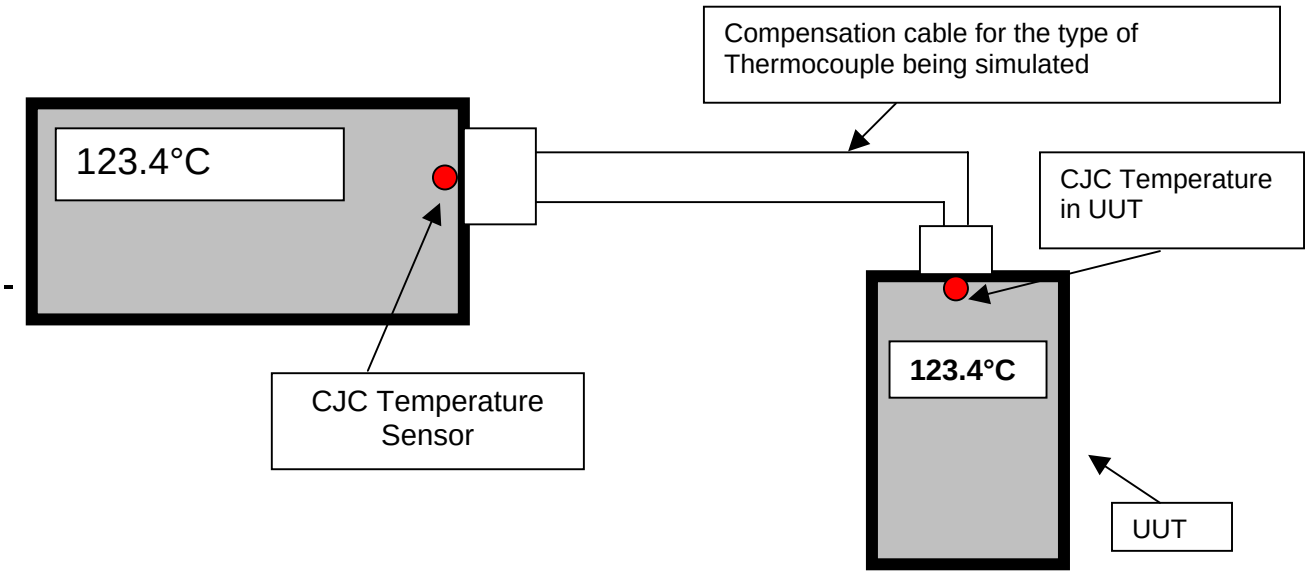
There are three methods to electronically simulate thermocouples, in each case the CJC has to be compensated for.

1: Use a 0°C Ice Point As a Reference



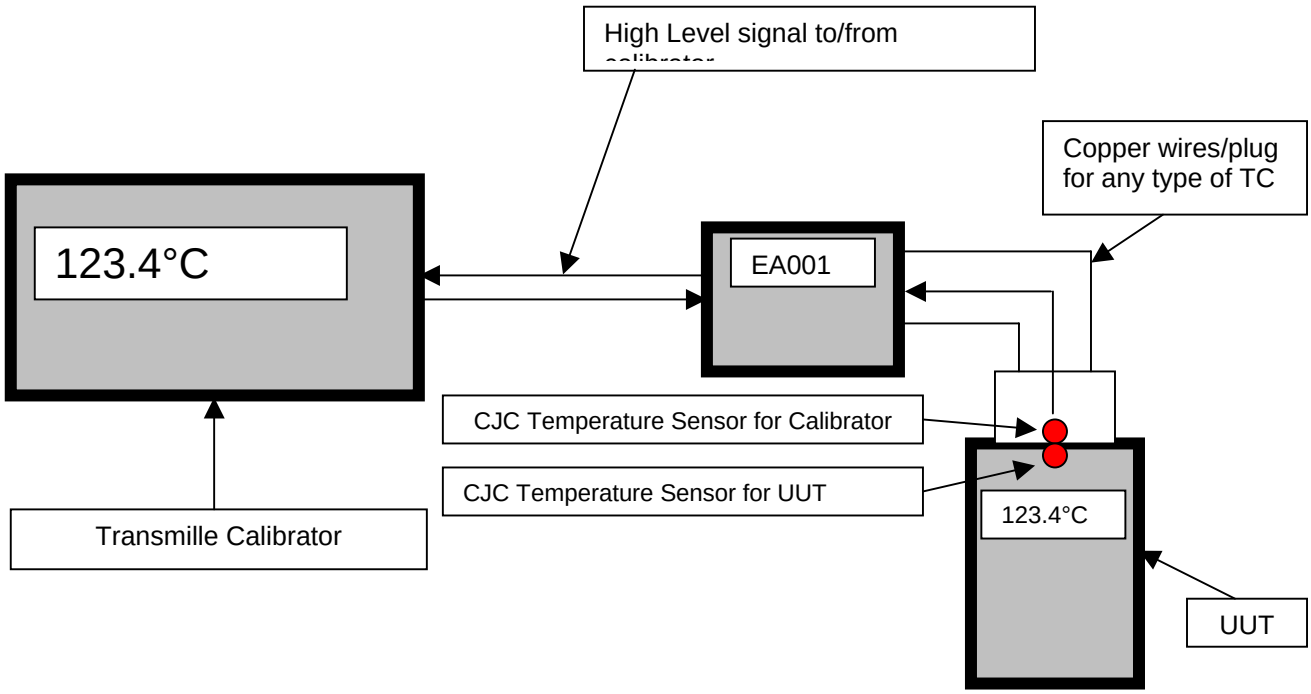
This method is accurate, but requires an ice point reference and also characterised Thermocouple compensation wire is needed for each type of TC to simulate.

2: Simulation Direct From Calibrator



This method still requires characterised compensation cable for each type of thermocouple to be simulated. Additional uncertainties are introduced from the errors in using compensation cable between the UUT and the CJC in the calibrator. Also as the calibrator will have self-heating the error is greater due to the thermal gradient across the cable and plugs producing thermal emf.

3: Measuring the CJC at the UUT



Using this method the measurement of the CJC temperature is as close as possible to the sensor in the UUT The Transmille EA001 has a high accuracy resistance temperature sensor mounted inside the copper plug, the measured temperature is used by the firmware in the calibrator to calculate the millivolt output required. This method allows any type of thermocouple to be calibrated without the need for compensation cables, and also reduces the number of connections, with only high-level signal connections to the calibrator. Transmille have adopted this method for 3 major advantages.

1: There is **no need for a compensation cable for each type of thermocouple** to be simulated, greatly reducing the number of additional compensating leads required and reducing errors introduced by using compensation cables.

2: There is **only the need for one Thermocouple plug working at low levels** to connect to the UUT. Other connections to the calibrator are at high levels and are unaffected by thermal emf.

3: By allowing the calibrator to work at high levels, and dividing the signal down to uV levels in an external unit produces a **quieter, more thermally and emf stable output** than available directly from the calibrator due to the self heating within the calibrator.