ALMACONSULTING

mKTL v1.1

1 Overview

- temperature logger with 3 channels
- resolution: 1 milli Kelvin [a]
- relative accuracy: better than 10mK
- total power: 0.6W or less
- Datalogging uses Real-Time Clock for times-tamping and SD card as mass storage
- Auto-resume after loss of power
- Option: Real-Time echoing through Serial (USB)

[a] if using 3kOhm NTCs, min temperature=17degC

2 Description

The mKTL has the role of making inexpensive, background records of temperatures time-histories over long periods, using a microcontroller and a series of RTD amplifiers. (both PT and NTCs are accepted, 2 or 4 wires).

- sample rate between 1 and 12 samples/channel/minute
- error minimization through re-calibration against 0.01% accurate etalon resistors.
- noise minimization through optimized sensing current selection and built-in rejection filters (50 or 60Hz)
- data are securely written onto a SD card (10years/Gb/channel)
- Using an on-board Real-Time Clock, all data will be correctly time-stamped, even in the case of loss of power.
- Data can also be interrogated remotedly, via Serial port.
- Auto diagnostic: includes detection of defective sensors and/or faulty conditionners.

It can also be used to provide simple statistics (average, standard deviation, and histograms), although the preferred method will be to move the data onto a computer and work from there. Its main application is for high-precision, high-stability systems. Target applications are primarily signal analysis of combined temperature and data of interest (beam positions, sample deviations, etc.), in order to identify and build error budgets for disturbance sources.

3 Technical specifications

	Unit	Value
Power voltage	V	7 to 9 (if using the 5.5/2.1mm jack), or USB (preferred)
Maximum current	A	<0.1
Dimensions	$mm * mm * mm$	160*105*50 (without cable)[1]
Weight	g	237
Temperature range	C	17 ÷ 25
n° of inputs	$--$	3

On-board RTC is powered through a CR1220 button sized cell battery, with an expected battery life in exceedance of 3 years. SD card with either FAT16 or FAT32 format are accepted.

4 Real-time Analysis capabilities

By default, the logger will display for each channel the following quantities:

- T_{ins}: instantaneous temperature in degree Celsius $[degC]$
- R: instantaneous temperature drift rate in milliKelvin per hour $[mK/h]$
- T_{avg}: averaged temperature value using the current hour as an observation window $[degC]$
- std: standard deviation value using the current hour as an observation window $[mK]$

The last two quantities are reset every hour.

5 Useful Numbers

5.1 Usable range

For a PT1000, the reference resistor value of 4300 Ohm will never be exceeded, so that the temperature range is controlled by that of the sensor.
For a NTC sensor, the reference value might be exceeded, and therefore this will induce a *lower limit* on the measured temperature range.
For a NTC with 3kOhm reference value (at 25degC) (EPCOS ref B557861SF045), this will happen at a temperature so that the ratio is 4300/3000=1.433, or 16.9degC.

5.2 Resolution

The 15bit resolution of the MAX31865 module allows to resolve resistance variations of
$\Delta R = 4300/2^{15} = 0.13Ohm$
For a PT1000, this corresponds to a temperature variation of $\delta T = 0.13/(3850.10^{-6} * 1000) = 34mK$.

For a NTC sensor, resolution will change with temperature.
Assuming again an NTC with 3kOhm reference value (EPCOS ref B557861SF045), the CTE at 21degC is about 4.4%, hence the corresponding variation at 21degC would be:
$\delta T = 0.13/(4.4.10^{-2} * 3000 * 1.2) = 0.8mK$

5.3 Correction due to cable length

Using an additionnal cable with $0.14mm^2$ section, the additionnal resistance is about 0.12 Ohm/m.
For a PT1000, this amounts to a additionnal[2] offset in temperature reading of:
$\Delta T_{cable} = 2 \times (0.12/1000)/3850.10^{-6} = 0.062K/m$.
For a NTC with temperature coefficient of about 4.5%, this amounts to an substractive offset in temperature reading of: $\Delta T_{cable} = 2 \times (0.12/1000)/4.510^{-2} = 0.006K/m$.

5.4 Instrument Thermal Immunity

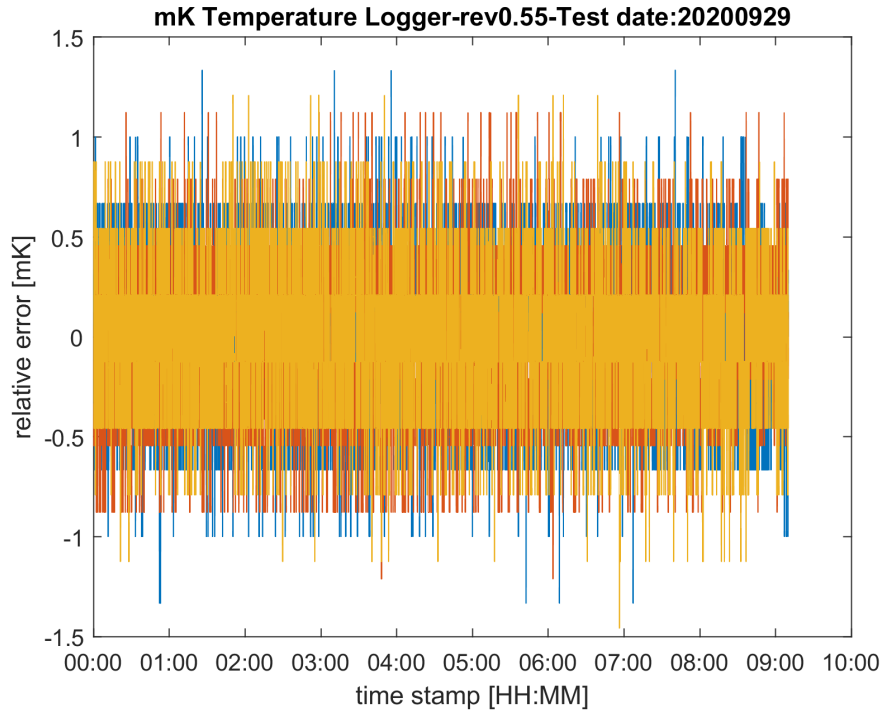
Even in the case where the datalogger itself can not be placed in a temperature controlled environement, the consequence on the readings should remain minimal. Exposing the reference resistors to direct sunlight (without cover), we identified a temperature coefficient of about -1mK/K for the temperature readings (using NTC sensors). In the case of a RTD (PT1000) sensor, this would correspond to about +26mK/K.

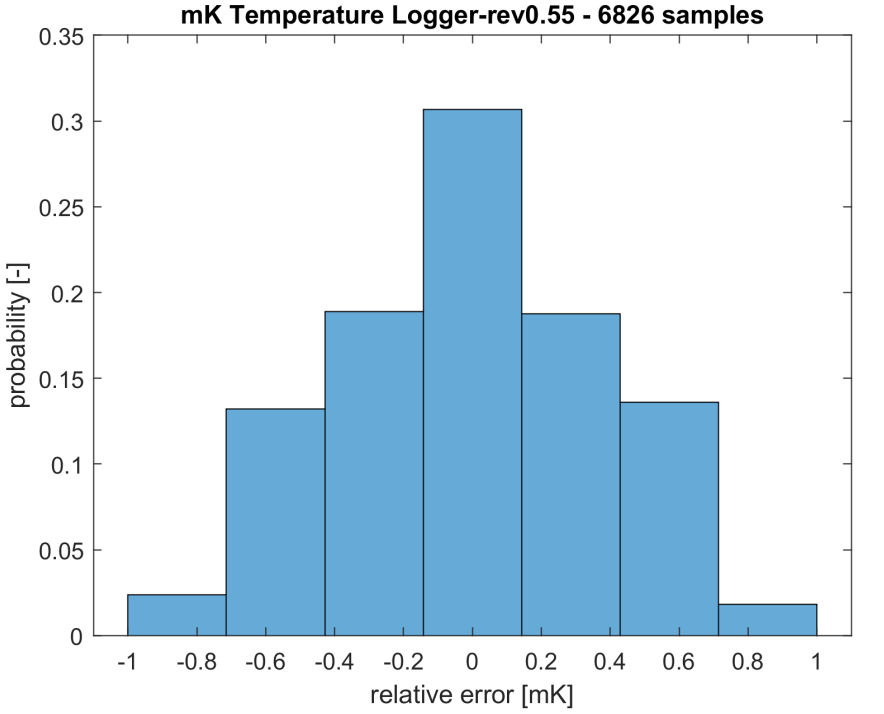
[2]the factor of 2 takes into account the total cable length, arrival and departure

6 Performance Assesment

Performance has be assessed by placing a number of sensors in a thermal enclosure and running long-term temperature measurements. The relative accuracy can then be obtained, as plotted on the next two figures. Based on the distribution, it can be seen that the $\pm 3\sigma$ interval has a width of about $1.4mK$.

This result has been obtained using the raw results produced by the electronics. No smoothing or averaging has been applied.





7 Revision History

Rev	Date	Scope
1.0	Aug, 2020	Fully functionnal version
1.1	Sept, 2021	Device detects if SD card is correctly inserted