Continuous, non-invasive core body temperature measurements for the next generation of fitness and health wearables

www.greenTEG.com
Health care is shifting from reactive to preventive medicine. With data gathered through sensors, the onset of health problems becomes visible in the vital parameters of a person.

In addition, more accurate data on each individual’s health status will allow for tailored, personalized medical and preventive interventions.

The next generation of fitness and health wearables will therefore have additional features for monitoring vital parameters.

Currently, only three of the five most relevant vital parameters can be measured continuously.
Measuring the five most relevant vital parameters

Continuous measurement solution available for:

- Respiration: √ LED on wrist, accelerometer
- Oxygen saturation: √ LED on wrist or finger
- Heart rate: √ LED on wrist, ECG

Continuous measurement solution not available for:

- Blood pressure
  - Inflation cuff needed
- Core body temperature
  - Non continuous monitoring via
    - Standard thermometer
    - Ear thermometer

With greenTEG’s solution, accurate, continuous, and non-invasive core body temperature (CBT) measurements become feasible for the first time!
CBT applications of greenTEG’s customers

Sleep
Monitor and analyze sleep quality

Patient Monitoring
Saving costs by releasing patients earlier from the hospital

Work Safety
Preventing heat stroke and dehydration

Ovulation
Fertility and contraception

Sports
Prevent overheating and determine ideal performance level

Animal Monitoring
Health and breeding control

Early Diagnostic
Detecting on-set of health problems

The greenTEG CBT measurement solution gathers more accurate data and enables new applications.
**Health status monitoring with CBT measurements**

Significant health problems of humans often show a signature in the circadian cycle. The simplest way to monitor this natural day-night temperature cycle of a person is by measuring core body temperature (CBT).

- Current solutions are all invasive (radio pill, rectal probe)
- greenTEG offers the 1st non-invasive sensor to measure the circadian cycle

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Amplitude Shift</th>
<th>Phase Shift</th>
</tr>
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<tbody>
<tr>
<td>Jetlag</td>
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<td>✓</td>
</tr>
<tr>
<td>Narcolepsy</td>
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<td>Insomnia</td>
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<td>Burnout</td>
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<td>Parkinson’s</td>
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<td></td>
<td>✓</td>
</tr>
<tr>
<td>Sport</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Medical study confirms accuracy of greenTEG’s solution

In a study conducted in 2017 at the sleep lab of the university hospital in Bern, Switzerland, the measurement accuracy of better than ±0.2°C of the gSKIN® CBT sensor on the chest could be demonstrated.

An independent study demonstrates the accuracy of gSKIN® CBT sensors

Experiment conducted on 2017-10-05 at the sleep lab of the university hospital in Bern, Switzerland. The measurement was interrupted between 7-9 because of battery re-charging.
**CBT measurements on the wrist: internal study**

In an internal study (available upon request), we present an unique solution to accurately measure core body temperature (CBT) on the wrist during low to moderate physical activity like sleep and daily life (free-living study).

The CBT measurements made with greenTEG’s solution showed a higher accuracy than skin temperature measurements when compared to the reference signal of an ingested temperature measurement pill.

*greenTEG’s solution to measure CBT on the wrist yields more accurate data than skin temperature measurements*
**Design in: we support you with our expertise**

At greenTEG, we have a dedicated team of specialists with in-depth know-how in thermal engineering ready to support you in the design in process.

**Technical specifications**
- 3mm x 3mm x 0.5 on a PCB by SMD
- Thermal integration solution for housing and patch (~5mm diameter at the skin and on PCB)
- Electrical readout solution
- Algorithm for µP

**Support & consulting**
- Integration support
- Thermal characterization of your device
- Customization of the algorithm to your device
**CBT measurements for your application: evaluation**

For the evaluation of our solution for your application, we offer the gSKIN® BodyTemp Patch for wireless measurements of CBT on any part of the body.

**Features**
- a) Skin temperature, CBT, accelerometer data or
- b) Skin temperature, heat flux, accelerometer data
- Body attachment with medical tape
- >70h battery life and data storage
- Sensor placement: Any spot on the body suitable for temperature measurements
- Read-out by Android app (CSV download)

**Evaluate greenTEG's CBT measurement solution for your application with the gSKIN® BodyTemp Patch developer kit.**
Working principle of the gSKIN CBT sensor

Other inputs such as different thermal resistances of the skin during different activities are taken into account for our CBT measurement method.

Algorithm uses heat flux and skin temperature to calculate CBT

1 Other inputs such as different thermal resistances of the skin during different activities are taken into account for our CBT measurement method.
**CBT measurements vs. skin temperature measurements**

Today’s health and fitness wearables use skin temperature measurements to determine physiological states and events. However, these readings are always strongly influenced by environmental conditions.

With the gSKIN® sensor you can now measure the true body temperature signal.

*Conventional skin temperature measurements are easy to misinterpret. greenTEG’s CBT measurement solution solves this problem!*
How to cooperate with us

• Contact us to briefly discuss whether a collaboration makes sense.
• Read our case studies
• If we agree to further collaborate: sign an NDA
• Get our developer kit to make your own measurements
• Get our support for the thermal and electrical integration of our sensors into your device

Contact us: info@greenTEG.com or call +41 44 632 04 20
Resources: case studies and measurements

We have conducted several case studies and measurements to demonstrate the accuracy of our CBT sensing solution. Send an email to info@greenTEG.com and we will send you the full text.

- **Non-invasive core body temperature measurement on the wrist during sleep and daily life using the greenTEG BodyTemp Patch**
  
  **Summary:** In this study we present an unique solution to accurately measure core body temperature (CBT) on the wrist during low to moderate physical activity like sleep and daily life (free-living study).

- **Non-invasive core body temperature measurements during sleep and daily life with greenTEG gSKIN® BodyTemp KIT measured on the wrist**
  
  **Summary:** In this study, we present the world’s first solution to accurately measure core body temperature (CBT) for low activity, e.g. sleep, on the wrist.

- **Case study: Non-invasive core body temperature measurements during sleep and daily life with greenTEG gSKIN® BodyTemp KIT.**
  
  **Summary:** This case study presents body temperature measurements obtained with the gSKIN® BodyTemp KIT. The measurements were taken on the forehead, on the chest, and on the upper arm during sleep, daily life and physical activity.
greenTEG: A Trusted Expert in Thermal Sensing

greenTEG develops, manufactures and markets thermal sensor solutions. The company was founded in 2009 as an ETH Zurich spin-off and has since built up an international customer base coupled with a global distributor network.

greenTEG’s thermal sensors are integrated into diverse applications by customers active in markets such as laser, building technologies, medtech, automotive, processing industry, and R&D.

Photonics
greenTEG’s Laser power detectors increase the productivity of OEM Laser systems. Since July 2017, greenTEG is Thorlabs exclusive supplier for thermal power detectors.

Building Physics
greenTEG’s IoT solution enables U-value and humidity measurements in building physics.

Wearables and Med-tech
greenTEG’s technology for core body temperature measurement is able to improve health monitoring.