Self-Powered Wireless Temperature Sensor Operation Manual

Senior Design Team 3

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Introduction

The Cummins KE-1000 Self-Powered Wireless Sensor is designed to be operation and maintenance free. This is possible by way of a specially designed energy harvesting component for and a built-in wireless chip for communicating with the version 12.3 or later Cummins Engine Control Module (ECM). This operation manual contains information on assembly and installation of the sensor, technical specifications, and testing the sensor and connecting it to the ECM. All instructions in this Operations Manual should be followed as written to ensure proper assembly and use. If any emergency occurs not covered in this Operations Manual, then the user should contact emergency services or use their best judgment as a final resort.

Part Descriptions

1. Adafruit Featherboard

   The circuit board for the product that supports mechanical function through electrical connections using conductive tracks. The board also has a Bluetooth Low Energy transceiver responsible for sending the information to the Engine Control Module.

2. Amplifier

   The amplifier is responsible for taking the thermocouple readings and translating them into binary for the board to read.

3. Electronics Housing

   The enclosure which contains all the electronic components.

4. Baseplate

   The steel baseplate in contact with the oil pan.

5. General Purpose Washer

   The buffer between the nut and housing meant to distribute pressure evenly over the surface and to give the nut an even surface to apply pressure.

6. Heatsink

   The part responsible for dissipating heat to lower the temperature on the cold side of the thermoelectric generator.

7. Hex Nut

   The nut on the outside of the electronics housing.

8. Hook Screws

   The screws which keep the Tie-Down Rings in place.

9. Lithium Polymer Battery

   The battery which provides power to the system before the thermoelectric generator has generated enough energy to power the system.

10. Locknut

    The nut on the inside of the electronics housing.

11. Machine Screws

    Provide a connection between parts.

12. Power Boost

    Converts the voltage from the thermoelectric generator to board.

13. Thermowell

The rigid connection to the oil pan which the thermocouple fits through.

14. Thermoelectric Generator

    The power generator of the system that uses the heat from the oil pan to generate the amount of electricity necessary to read and send data.

15. Threaded Hollow Stud

    The connecting rods which attach the electronics housing to the base.

16. Threaded Thermocouple Probe

    The temperature sensor of the oil pan.

17. Tie-Down Rings

    The connecting piece to the heatsink to ensure adequate pressure to the baseplate.

18. Screws

    The screws which attach the top of the electric box to the bottom.

Electronics

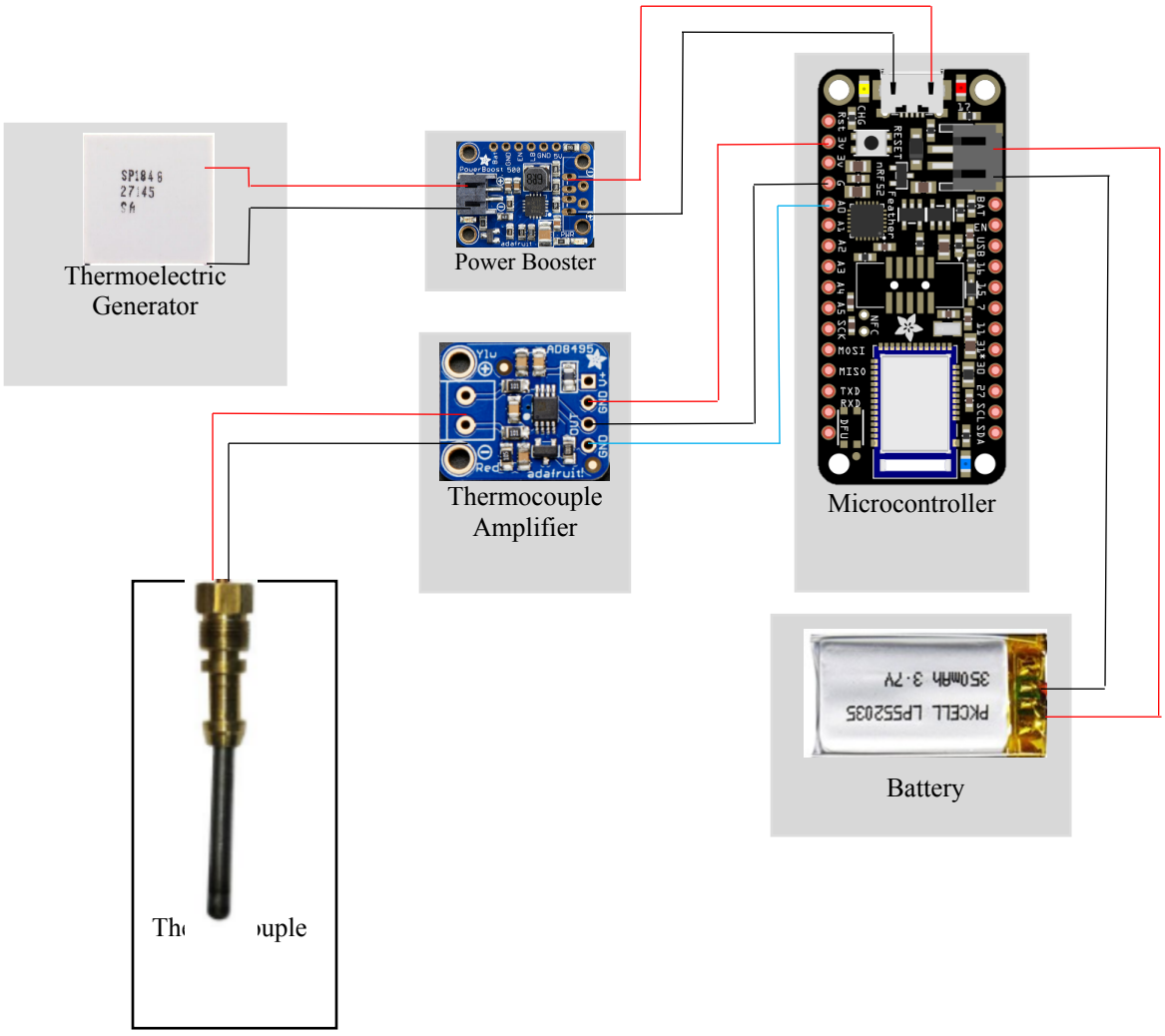

Figure 1. Electrical Diagram

Part	Description
Thermoelectric Generator	Seebeck Thermoelectric Generator, 3.5 ohms @ 27°C, 2.21℃ /Watt @ Th =230°C, 0-5V output
Power Booster	Power Boost 500 Basic - 5V output Boost @ 500mA from 1.8V+
Microcontroller	Bluetooth Low Energy board, 1.7V to 3.3V operation with internal linear and DC/DC voltage regulators
Battery	Li-Polymer Battery, cut-off charging 4.2V, cut-off discharge 3.0V.
Thermocouple Amplifier	The MAX31855K 3.3V regulator with 10uF bypass capacitors and level shifting circuitry
Thermocouple	Thermocouple Probe for Liquids & Gases, 0-5V operating input. Temperature range 0°C – 370°C

Technical Specifications

Battery Standby Time	**10 years**
Wireless Transmission Distance	**12 meters**
Operating Lifetime	**~20 years**
Sensor Error	**± 2%**
System Voltage	**3.7 V**

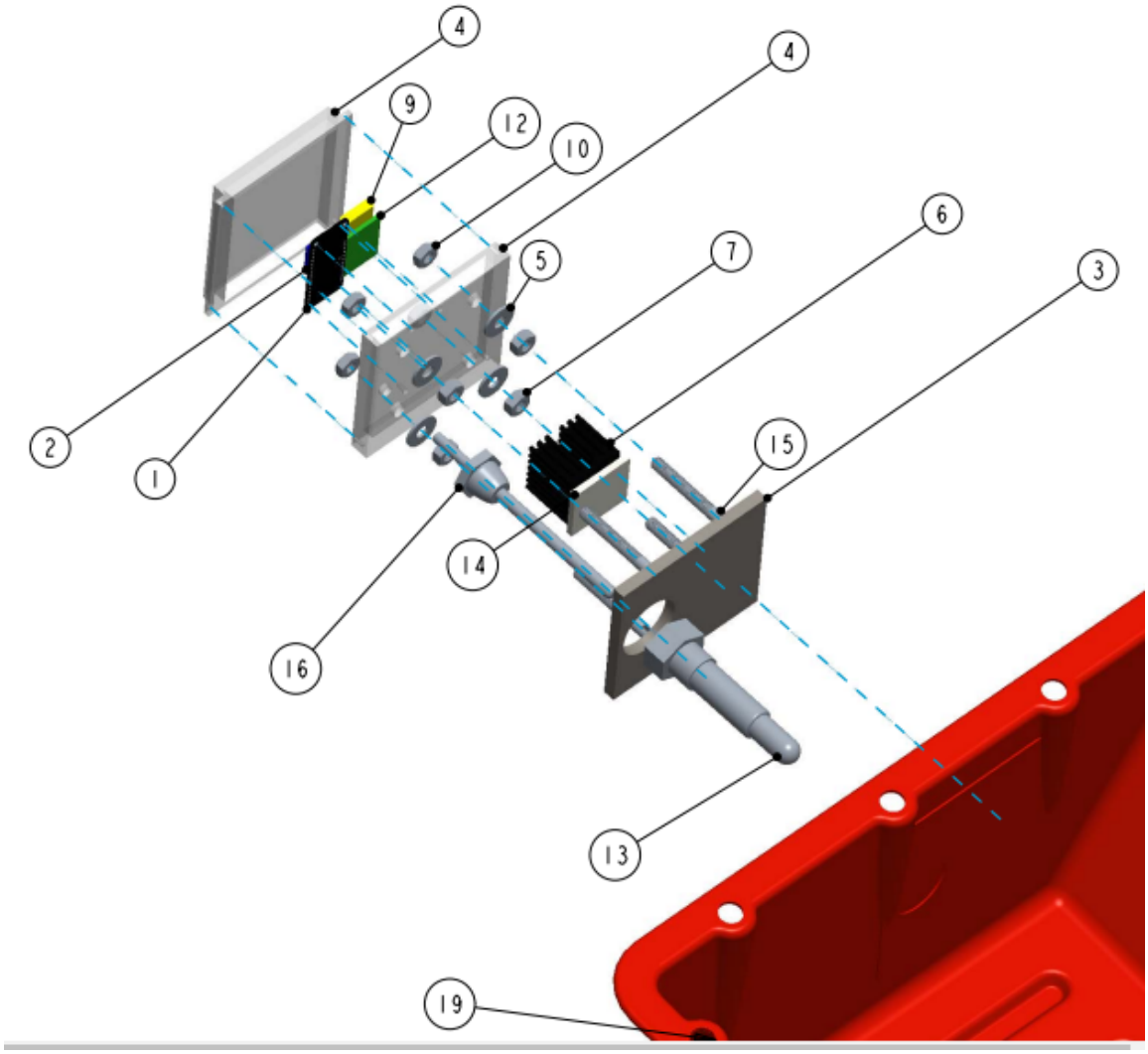

Figure 2. System Diagram

Part #	Quantity	Material
1. Adafruit Featherboard	1	Various
2. Amplifier	1	Various
3. Baseplate	1	Steel
4. Electronics Housing	1	Polycarbonate
5. General Purpose Washer	10	Aluminum
6. Heatsink	1	Aluminum
7. Hex Nut	4	Aluminum
8. Hook Screws	2	Steel
9. Lithium Polymer Battery	1	Various

10. Locknut	4	Aluminum
11. Machine Screws	2	Steel
12. Power Boost	1	Various
13. Thermowell	1	304 Stainless Steel
14. Thermoelectric Generator	1	Various
15. Threaded Hollow Studs	4	Stainless Steel
16. Threaded Thermocouple Probe	1	Stainless Steel and Fiberglass
17. Tie-Down Rings	2	Steel
18. Screws	4	Steel

Assembly & Installation

The KE-1000 comes preassembled on all version 12.3 or later Cummins Diesel engines. If the KE-1000 is to be reinstalled on a compatible oil pan with a compatible ECM then follow these steps:

1. Locate the oil pan.
2. Identify the welded bung and threaded holes.
3. Remove the thermowell from the packaging.
4. Screw the thermowell into the bung.
5. Remove the sensor assembly from the packaging.
6. Identify the holes in the baseplate of the sensor assembly.
7. Align the threaded holes and welded bung on the oil pan to the holes on the sensor assembly baseplate.
8. Remove the fasteners from the packaging.
9. Thread the washers onto the machined screws. Screw the machined screws into the holes in the base plate fastening the sensor assembly to the oil pan. Alternate tightening starting with the top hole until tight.
10. Identify the thermocouple sensor end.

11. Screw the thermocouple sensor end into the thermowell.
12. The ECM will automatically connect to the KE-1000 wireless sensor as soon as the engine is started .

Testing

Once installed on the engine oil pan, it is beneficial to test the KE-1000 wireless sensor to ensure a good installation. This is done in two steps.

1. The first step is to test the wireless connectivity. To do this, download the Adafruit Bluefruit mobile app on your smart phone. The main screen of which is shown below in Figure 3.

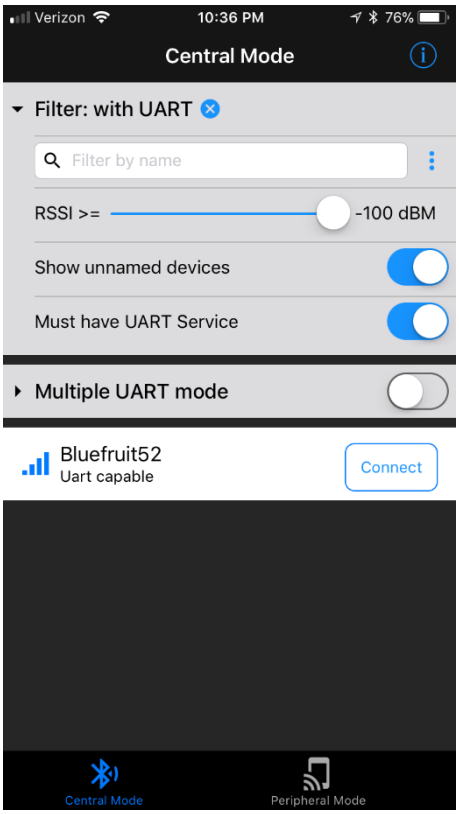

Figure 3. Interface for testing wireless connectivity

2. The current name for the Bluetooth connection to the KE-1000 is ‘Bluefruit52’. Press the blue Connect button to establish wireless connection with the system. The screen shown below should appear.

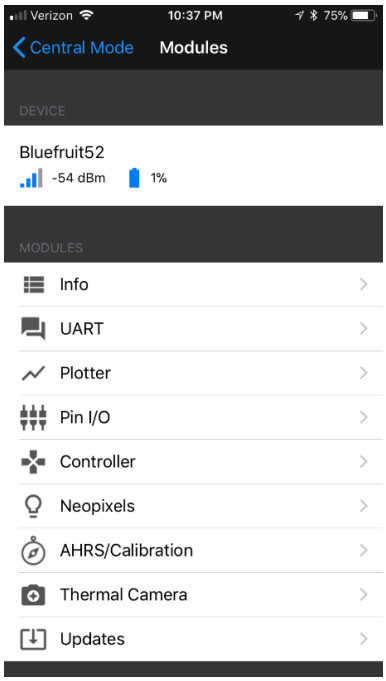

Figure 4. Interface for testing wireless connectivity

3. Once connected, press the UART button to begin streaming data.

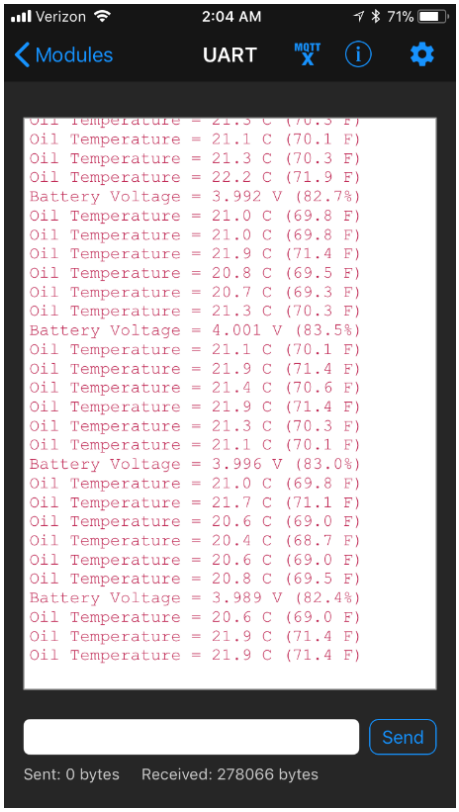

Figure 5. Interface for testing wireless connectivity

4. The current temperature of the engine oil will appear on the screen once every second (1 Hz) in both degrees Celsius and degrees Fahrenheit. Every fifth transmission (5 seconds) the battery voltage and corresponding charge level will also be displayed. If the sensor is bought new from Cummins, the battery will be fully charged (100%-75%). If the sensor or the battery are not new it is important to check ensure that the battery's voltage is above 30%, otherwise the KE-1000 may not operate according to the specifications given in this manual.
5. Walk one car length (~10 meters) in any direction from the engine and ensure your smart phone is still receiving data. This will ensure that the KE-1000 is adequately installed and working properly.

Sensor Operation

The operation of the sensor is programmed into the sensor electronics and requires “ON” and “OFF” signals from a compatible ECM that can receive temperature data via Bluetooth.

1. The Bluetooth compatible ECM must send an “ON” signal to the sensor at engine start.
2. The sensor will continuously send temperature data to the ECM via Bluetooth at a frequency of 1 Hz, or once per second.
3. The ECM must send an “OFF” signal to the sensor at engine shut off

Maintenance

In the event that the sensor becomes damaged or inoperable, an additional sensor assembly should be ordered for replacement. Replacement should only be completed when engine is cool and vehicle is stationary. Use safe vehicle jacking practices if necessary.

1. Drain the oil from the oil pan, disposing of the oil in accordance to safe environmental practices.
2. Locate the existing sensor assembly on the oil pan.
3. Use a ratchet wrench to remove the two fasteners starting with the bottom screw.
4. Use a wrench to remove the thermocouple from the thermowell.
5. Lift away the sensor.
6. Use a ratchet wrench to remove the thermowell from the welded bung.
7. Clean the surface of the oil pan.
8. Follow the installation instructions to install the new sensor assembly.