Some embodiments described herein provide a surface acoustic wave (SAW) temperature sensor that is in thermal contact with the electrical conductor. The SAW temperature sensor includes an antenna to receive a wireless signal. The received signal can be converted into a SAW signal that can vary with the temperature of the electrical conductor. The temperature of the electrical conductor can be sensed, measured, or monitored by measuring the SAW signal.

In one aspect, a temperature-sensing apparatus for sensing a temperature of an electrical conductor enclosed in at least a (semi)conductive layer, is provided. The apparatus includes a surface acoustic wave (SAW) temperature sensor including a substrate having a major surface, a transducer disposed on the major surface of the substrate, and one or more sensor antennas electrically connected to the transducer. The one or more sensor antennas are configured to receive or send an electromagnetic signal, and the transducer is configured to conduct conversion between the electromagnetic signal and a SAW signal that propagates on the major surface of the substrate. At least a portion of the substrate of the SAW temperature sensor is disposed in thermal contact with the electrical conductor, and the SAW signal varies with the temperature of the electrical conductor.

In another aspect, an electrical cable assembly includes an electrical conductor, a (semi)conductive layer enclosing the electrical conductor, and a temperature-sensing apparatus. The temperature-sensing apparatus includes a surface acoustic wave (SAW) temperature sensor including a substrate having a major surface, a transducer disposed on the major surface of the substrate, and one or more sensor antennas electrically connected to the transducer. The one or more sensor antennas are configured to receive or send an electromagnetic signal, and the transducer is configured to conduct conversion between the electromagnetic signal and a SAW signal that propagates on the major surface of the substrate. At least a portion of the substrate of the SAW temperature sensor is disposed in thermal contact with the electrical conductor, and the SAW signal varies with the temperature of the electrical conductor. The SAW temperature sensor is disposed between the electrical conductor and the (semi)conductive layer, and is enclosed by the (semi)conductive layer. The (semi)conductive layer is configured to provide electromagnetic shielding for the power carried by the electrical conductor, while allowing the electromagnetic signal of the one or more sensor antennas to pass therethrough.

In yet another aspect, a method of sensing a temperature of an electrical conductor enclosed in at least a (semi)conductive layer, is provided. The method includes providing a surface acoustic wave (SAW) temperature sensor. The SAW temperature sensor includes a substrate having a major surface, a transducer disposed on the major surface of the substrate, and one or more antennas electrically connected to the transducer. The one or more antennas are configured to

receive or send an electromagnetic signal, and the transducer is configured to conduct conversion between the electromagnetic signal and a SAW signal that propagates on the major surface of the substrate. The method further includes disposing at least a portion of the substrate to be in thermal contact with the electrical conductor, the SAW signal being variable with the temperature of the electrical conductor, providing a transceiver unit configured to be in electromagnetic communication with the one or more antennas of the SAW temperature sensor, detecting, via the electromagnetic communication between the transceiver unit and the one or more antennas, the SAW signal that is variable with the temperature of the electrical conductor, and determining the temperature of the electrical transmission line based on the detected SAW signal.

Various unexpected results and advantages are obtained in exemplary embodiments of the disclosure. One such advantage of exemplary embodiments of the present disclosure is that some passive SAW temperature sensors used herein are hermetically sealed to provide accurate temperature measurement with no external physical stress or change in the mechanics of the device even in harsh temperature environments. In addition, the embodiments described herein allow the passive SAW temperature sensors to be in efficient electromagnetic communication with an outside, remote transceiver unit.

Listing of Exemplary Embodiments

Exemplary embodiments are listed below as aspects. It is to be understood that any of embodiments 1 to 14 and 15 to 17 can be combined.

Embodiment 1 is a temperature-sensing apparatus for sensing a temperature of an electrical conductor enclosed in at least a (semi)conductive layer, the apparatus comprising:

a surface acoustic wave (SAW) temperature sensor including a substrate having a major surface, a transducer disposed on the major surface of the substrate, and one or more sensor antennas electrically connected to the transducer, the one or more sensor antennas being configured to receive or send an electromagnetic signal, and the transducer being configured to conduct conversion between the electromagnetic signal and a SAW signal that propagates on the major surface of the substrate,

wherein at least a portion of the substrate is disposed in thermal contact with the electrical conductor, and the SAW signal varies with the temperature of the electrical conductor.

Embodiment 2 is the apparatus of embodiment 1, wherein the transducer includes an interdigital transducer (IDT).

Embodiment 3 is the apparatus of embodiment 1 or 2, wherein the SAW temperature sensor further includes one or more reflectors disposed on the major surface of the substrate, the one or

9. The apparatus of claim 1, wherein the electromagnetic signal has a frequency in a VHF/UHF range.

10. The apparatus of claim 1, wherein the electrical conductor carries an electrical power having a frequency of 60 Hz.

11. An electrical cable assembly comprising:

an electrical conductor;

a (semi)conductive layer enclosing the electrical conductor; and

the temperature-sensing apparatus of claim 1,

wherein the SAW temperature sensor is disposed between the electrical conductor and the (semi)conductive layer, and is enclosed by the (semi)conductive layer, and

wherein the (semi)conductive layer is configured to provide electromagnetic shielding for the power carried by the electrical conductor, while allowing the electromagnetic signal of the one or more sensor antennas to pass therethrough.

12. The electrical cable assembly of claim 11, wherein the (semi)conductive layer includes strips of electrically conductive tapes that extend along a longitudinal axis of the electrical conductor.

13. The electrical cable assembly of claim 11, wherein the (semi)conductive layer includes one or more electrically conductive tapes that are configured to have gaps serving as windows to allow the electromagnetic signal of the one or more antennas to pass therethrough.

14. The electrical cable assembly of claim 13, wherein the (semi)conductive layer includes an insulating base layer that allows for wrapping the one or more electrically conductive tapes around the electrical conductor.

15. A method of sensing a temperature of an electrical conductor enclosed in at least a (semi)conductive layer, the method comprising:

providing a surface acoustic wave (SAW) temperature sensor, the SAW temperature sensor including a substrate having a major surface, a transducer disposed on the major surface of the substrate, and one or more antennas electrically connected to the transducer, the one or more antennas being configured to receive or send an electromagnetic signal, and the transducer being configured to conduct conversion between the electromagnetic signal and a SAW signal that propagates on the major surface of the substrate;