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Wireless SAW Temperature Sensing System for Culinary Applications

Food Probe

Abstract

Food thermometers are used to measure the core temperature of meat, poultry and egg dishes, to make sure that they are cooked to preference and become safe for consumption. Some oven manufacturers offer wired food probes in their endeavor to provide a greater degree of convenience. The probe is inserted into the food before the heating process begins and is used to monitor temperature throughout the cooking process. Wired food probes, however, have the distinct disadvantage of requiring the user to maneuver around the wire at high temperatures. Additional wires can be difficult to clean and maintain.

Surface Acoustic Wave (SAW) technology can be used to monitor temperature wire and batteryless and be applied in wireless food probes. Thereby, the SAW Temperature Sensor is placed close to the tip of the food probe. An antenna which is placed within the probe's handle enables a link between the sensor and a wireless interrogation unit that is integrated within the oven.

Figure 1: Food Probe with Wireless SAW Reader

Why Monitor Food Temperature?

According to the Partnership for Food Safety Education [1] and the United States Department of Agriculture (Food Safety and Inspection Service) [2] insufficient cooked food can be harmful since bacteria may survive moderately high temperatures and thus can cause food poisoning and serious illness. Statistically, every sixth American suffers illness due to foodborne bacteria every year, whereby especially children, elderly, pregnant women and people with a weakened immune system are on high risk.

Therefore, food safety is a major reason for monitoring internal temperature of food. Food borne illnesses caused by pathogens like Norovirus, Salmonella and E Coli can be easily exterminated by ensuring that food is well cooked at prescribed temperatures. And this, in point of fact, can save lives!

It is for that reason that oven users are strongly encouraged to use food thermometers/food probes.

Considering the several cooking grades for different tastes at beef there are the following temperature range recommendations:

- *Extra-rare: cooked between 115–120°F (46–49°C) to provide very red and cold meat*
- *Rare: cooked between 125–130°F (52–55°C) to provide soft meat with a cold red center*
- *Medium rare: cooked between 130–140°F (55–60°C) to provide firmer meat with a warm red center*
- *Medium: cooked between 140–150°F (60–65°C) to provide pink and firm meat*
- *Medium well: cooked between 150–155°F (65–69°C) to provide a small amount of pink in center*
- *Well done: cooked above 160°F (>71°C) to provide evenly spread gray-brown meat*

However, fresh beef should be prepared at least 145°F (63°C), better 160°F (71°C) to ensure all germs are killed.

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Wired Food Probes and Thermometers

Conventional, wired food probes greatly reduce the overall burden of monitoring food temperatures. By providing an embedded solution, wired food probes eliminate the need to have external gadgets to monitor food temperature. However, the wire that links the probe to the oven has disadvantages associated with it:

- The wire can cause injury when hot, so the user has to be extra cautious while handling.
- The wire can either be too long or too short.
- If too long, it has to be coiled up and neatly arranged within the oven cavity.
- If too short the probe can only be inserted at certain angles causing the user to potentially struggle with the placement of the food within the oven cavity.
- Cleaning the wired food probe can be difficult and unwieldy. This can greatly discourage use of the probe.
- Wires are likely to be damaged, which increases maintenance costs.

Wireless Surface Acoustic Wave (SAW) based Temperature Sensing

Today, the technology to make the food probe completely wire and batteryless exists. Surface Acoustic Wave (SAW) Technology allows passively powered sensors to be wirelessly interrogated to obtain temperature measurement values. Using this technology, many of the before mentioned disadvantages with wired food probes are completely eliminated:

- The shape of the wireless food probe enables an easy handling and removal even when hot.
- There is no need to worry about wire length as the probe is wirelessly linked to the oven.
- The wireless food probe can be cleaned easily since it is dishwasher-safe.
- Ease of use
- Reduce the maintenance cost due to absence of the wires and batteries.

Surface Acoustic Wave (SAW) Sensor Technology

SAW based temperature sensors take advantage of the controlled change in material properties of a crystal. The sensing mechanism involves electrically inducing a surface acoustic wave into a piezoelectric material and then reconverting the energy of the wave (influenced by the temperature to which the sensing element is exposed) back into an electrical signal for temperature measurement. One significant advantage of SAW devices is their passive operation, which makes them very amenable to operation in harsh environments via wireless interrogation. A wireless SAW based temperature sensing solution consists of a reader (RF Transceiver) which is electromagnetically linked to a SAW sensor element as shown in Figure 2.

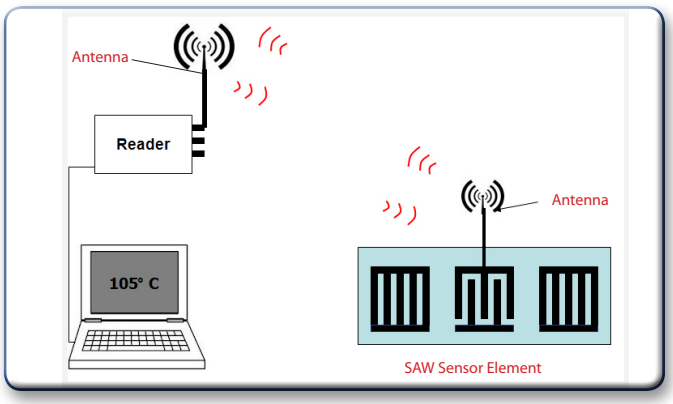

Figure 2: Wireless SAW Temperature Sensing System

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A typical sensing cycle includes the following steps:

- The wireless reader generates a sequence of Radio Frequency (RF) bursts which are transmitted by the reader antenna.
- This signal is received by the sensor antenna and is used to induce a surface acoustic wave in the piezoelectric sensing element via an Interdigital Transducer (IDT).
- The resonant frequency of the surface acoustic wave resonator is influenced by the temperature it is exposed to. It is this phenomenon that is exploited to obtain a temperature measurement.
- The IDT converts the natural oscillation of the surface acoustic wave resonator into an RF signal, which in- turn, is transmitted back to the reader unit via the same antenna set.
- A change in the frequency of the received RF signal is indicative of a change in the measured temperature.
- The reader unit converts the received signal frequency to temperature values.

Wireless Food Probes using SAW Temperature Sensors

The small size of SAW wireless temperature sensor element (5mm x 3.2mm x 1.4mm) make them ideal for insertion into the small confines of a food probe as shown in Figure 3.

The sensor is placed within the hollow cavity of the food probe close to the tip. The SAW temperature sensor is connected to an antenna that is placed in the handle area of the probe.

A wireless reader unit is embedded within oven electronics and the interrogator antenna is placed in close proximity of the oven cavity. An electromagnetic link is established between the probe antenna and oven antenna when the sensor is interrogated. As explained in the previous section, changes in temperature are translated into changes in the frequency of the sensor response signal. The response signal is converted into accurate temperature measurements by calibration algorithms within the interrogator. Thus, a simple temperature measurement system is established by making use of an embedded SAW temperature sensor within the food probe and appropriate interrogation electronics embedded within the oven.

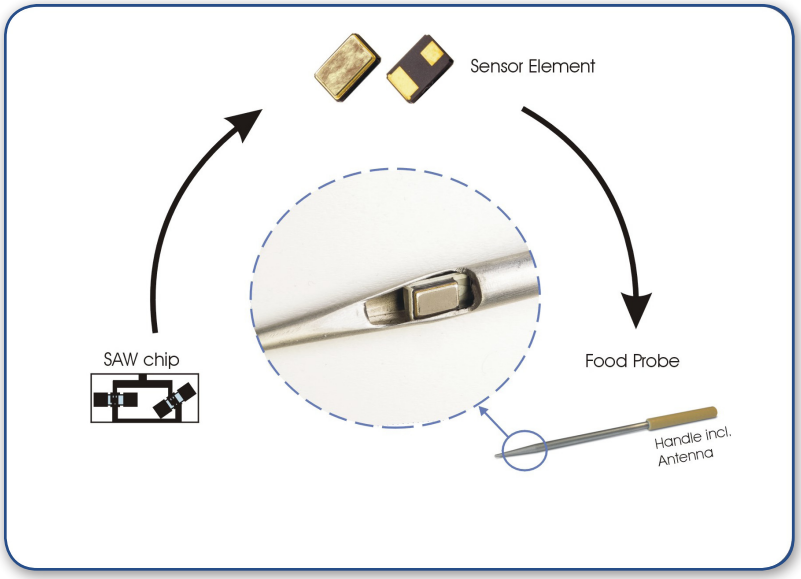

Figure 3: Build up of Food Probe

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References

[1] http://fightbac.org/
[2] http://www.fsis.usda.gov/wps/portal/fsis/home

Contact Information

Please contact our Application Engineering group at support@sengenuity.com for more information about our Wireless Food Probe Products.

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