SENGENUITY
sensor engine technology
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Wireless Food Probes Using Surface Acoustic Wave Technology

Summary

Food thermometers are used to measure the internal temperature of cooked meat, poultry and egg dishes, to make sure that they are cooked to preference and become safe for consumption. Some oven manufacturers provide 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 handle around the wire at high temperatures. Wires can also be difficult to clean and maintain. Surface Acoustic Wave (SAW) Technology can be used to wirelessly monitor temperature and be applied to the development of wireless food probes. A wireless SAW Temperature Sensor is placed close to the tip of the food probe. An antenna enables a link between the sensor and a wireless interrogation unit that resides within the oven.

Why Monitor Food Temperature?

The two primary reasons for monitoring internal food temperature are taste and safety. Beef, for example is cooked at different temperatures for varying periods of time to provide very distinct taste and texture[1]:

- *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*

Food safety is also a major reason to monitor the internal temperature of food. Food borne illnesses caused by pathogens like Clostridium perfringens, Salmonella and E coli can be easily exterminated by ensuring that food is well cooked and cooked at prescribed temperatures. The US Government sponsored Partnership for Food Safety Education, for example, recommends that poultry be cooked at 165°F as measured by a food thermometer[2]. Likewise there are specific recommended temperatures at which other food products should be cooked. It is for this reason that oven users are strongly encouraged to use food thermometers and food probes.

Wired Food Probes

Conventional, wired food probes greatly reduce the overall burden of monitoring food temperatures. By providing an embedded solution, wired food probes do away with 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 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.
- When hot, the wire can cause injury causing the user to be extra cautious to be careful while handling it.
- Cleaning the wired food probe can be difficult and unwieldy. This can greatly discourage use of the probe.

Today, the technology to make the food probe completely wireless exists. Surface Acoustic Wave (SAW) technology allows for passively powered (no batteries) sensors to be wirelessly interrogated to obtain temperature measurements. Using this technology, many of the disadvantages associated with a wired food probe are completely eliminated by wireless food probes:

- There is no need to worry about wire length as the probe is wirelessly linked to the oven.
- When hot, the form factor of the wireless food probe makes it very easy to remove and handle.
- The wireless food probe, just as any other utensil, can be easily cleaned.

The following sections explore SAW based temperature sensing technology and how it can be used to make wireless food probes.

Wireless Surface Acoustic Wave (SAW) based Temperature Sensing

SAW based temperature sensors take advantage of the controlled change in material properties of a crystal, converted to an electrical signal automatically via the piezoelectric effect. 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) electromagnetically linked to a SAW sensing element as shown in Figure 1.

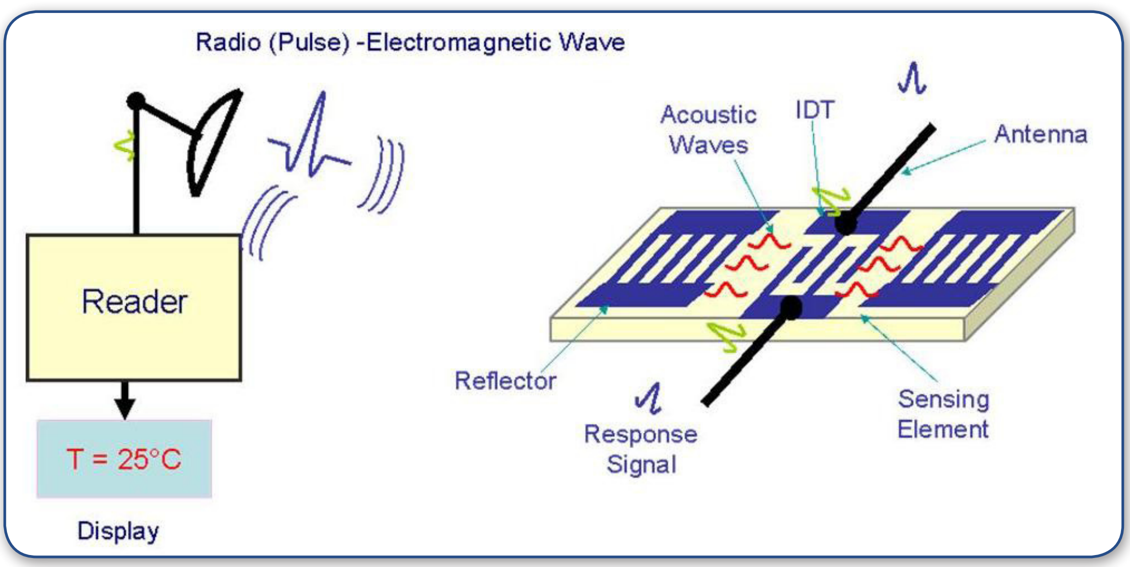

Figure 1: Wireless SAW Temperature Sensing System

A typical read 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 to which the sensing element is exposed. 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 interrogator via the same antenna set.
- Because of the high Q of the resonator, the returned signal contains a well defined frequency even though the interrogation pulse has a 50 KHz nominal bandwidth. As a result the resonant frequency is easily known.
- A change in the frequency of the received RF signal is indicative of a change in the measured temperature.

Wireless Food Probes using SAW Temperature Sensors

The small size of SAW wireless temperature sensors (~3.8 mm^2) make them ideal for insertion into the small confines of a food probe as shown in Figure 2.

The sensor is placed within the hollow cavity of the food probe as close to the tip as possible. The SAW temperature sensor is connected to an antenna that is placed in the handle area of the probe. Some food items provide an excellent ground plane and therefore the overall effectiveness of the probe is enhanced when it is inserted into meat, for example.

A wireless interrogator 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 oven temperature are directly 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.

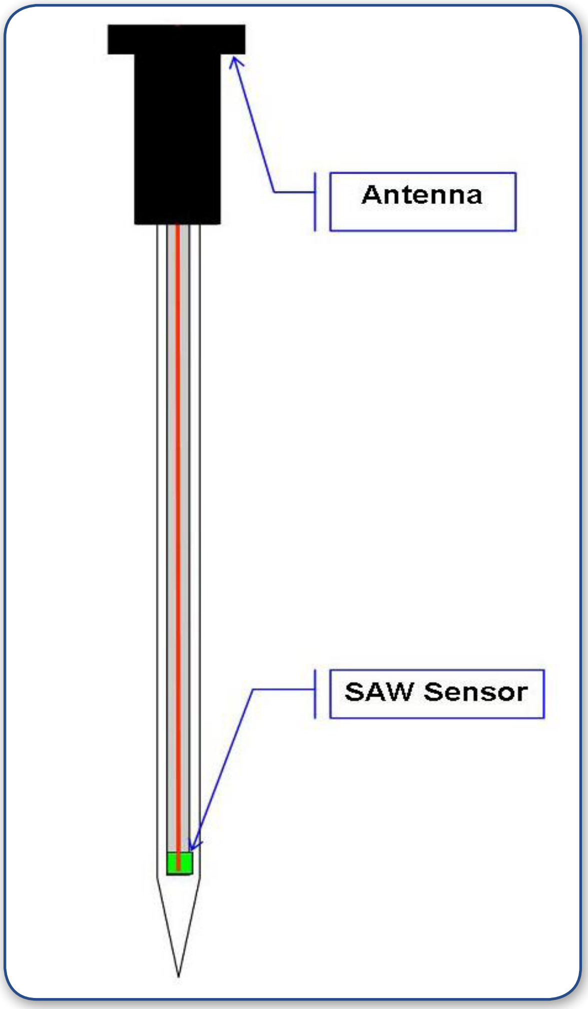

Figure 2: SAW Temperature Sensor and Antenna in Food Probe

References

1. www.wikipedia.org, 2009
2. www.fightbac.org, 2009

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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