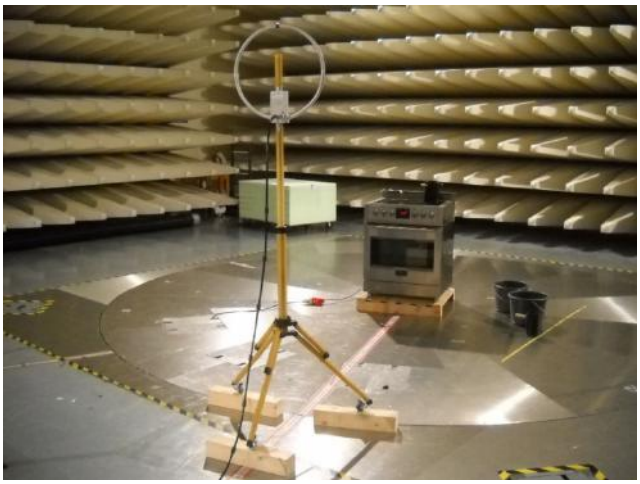
Characterizing the Electromagnetic Fields and Testing of Induction Ranges



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Introduction

Michael Faraday's landmark discovery in 1831 of how to induce electricity to flow through a copper wire with a moving magnet is the foundation how most electricity is made today, and is one of the most studied topics in physics and engineering.

Induction cooking ranges use this well-understood process. But rather than using a magnet to make electricity in a copper wire, induction reverses the process and *uses* electricity in a copper wire to make a magnetic field. Above this field sits your cooking vessel, which must be either made of iron or stainless steel (which contain iron), or have a plate of iron within an aluminum pan or pot. Iron resist letting electricity flow, and instead will convert the magnetic field into heat.

Because electromagnetism is invisible and requires an education in physics to understand deeply, non-experts can justifiably worry about the unknown. This document aims to show how induction stoves work and explain the safety testing regimen induction stoves are put through before they are sold to the public.

Figure 2: A photo of a single-burner induction range taken at a testing facility (Bay Area Compliance Labs Corp 2015)

Figure 1: Single-burner induction range with its faceplate removed showing internal components; the copper coil (center) produces the magnetic fields which heat cookware (Bay Area Compliance Labs Corp 2015)

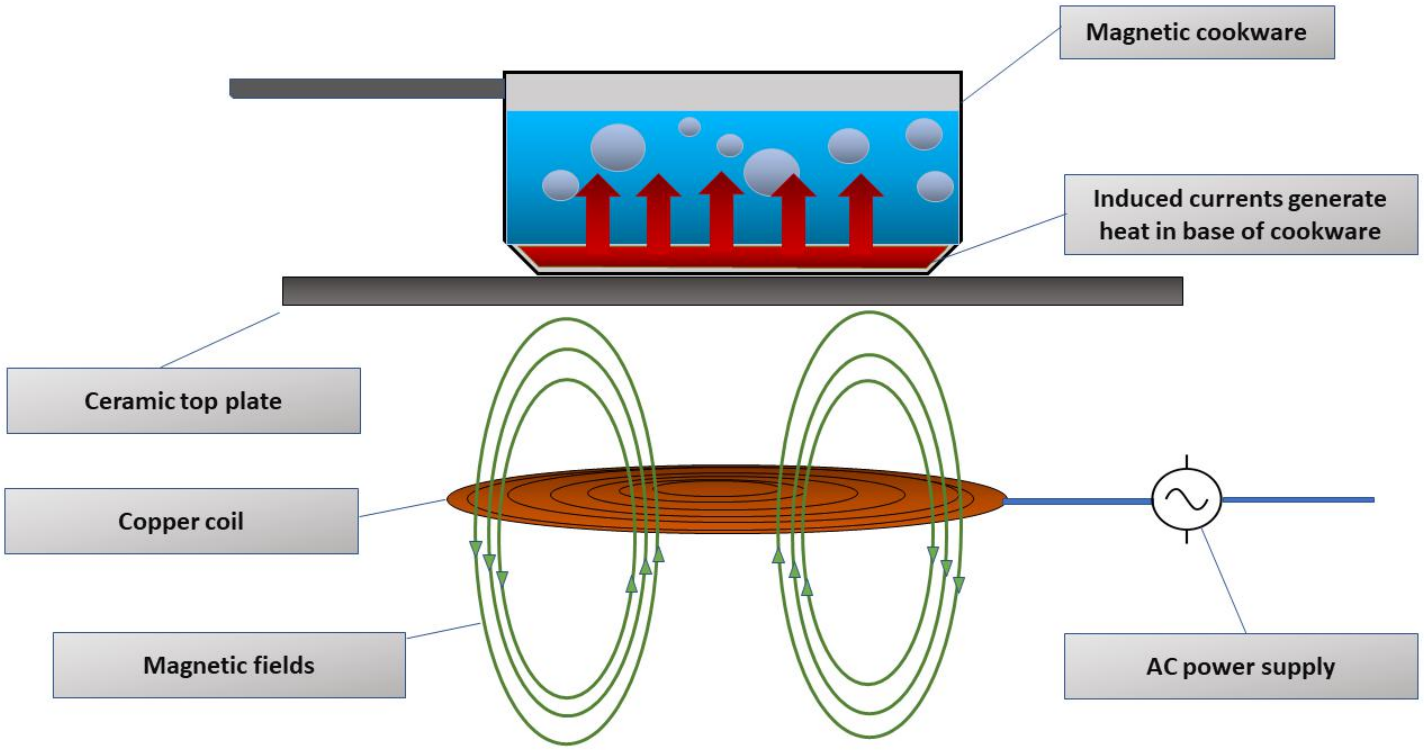

Figure 3: A diagram of the mechanisms by which an induction range creates cooking heat (Sander 2020).

What is electromagnetic radiation?

"Photons" are what we call packets of electromagnetism. Radio waves, microwaves, magnetic fields, ultraviolet rays, x-rays—all of those are types of photons. Photons of electromagnetism can be tightly packed (e.g. x-rays) or loosely packed (e.g. magnetism). The looser packed photons act like a wave, while tightly packed photons act like a particle. Induction stoves make an electromagnetic "field," which is another way of saying they create very loosely packed photons.

Ionizing vs. non-ionizing electromagnetic/photon energy

Photons of electromagnetism are classified into two broad groups by physicists, based on whether they have enough energy to break a molecular bond, which is called "ionizing." Ultraviolet photons can cause cancer because they have enough energy to breaks molecular bonds in DNA—they ionize. Non-ionizing photons have less energy and don't interact with molecular bonds, such as magnetic waves used by an induction range, or radio waves used for TV broadcasts and music radios. **Figure 4** illustrates that magnetic waves used by induction stoves have 1/1,000,000,000,000 as much energy as visible light—way, way less—and cannot influence molecular bonds. Note that Figure 4 has a logarithmic scale, so that each tick marks 100 times more energy—if it weren't compressed, it would take many pages to show.

Induction ranges produce magnetic fields/loose photons with less energy than radio signals, but are close enough to radio signals that they are regulated by the Federal Communication Commission. So induction stoves are carefully tested by the FCC to ensure one can listen to the radio while cooking without static or interference from the induction range.

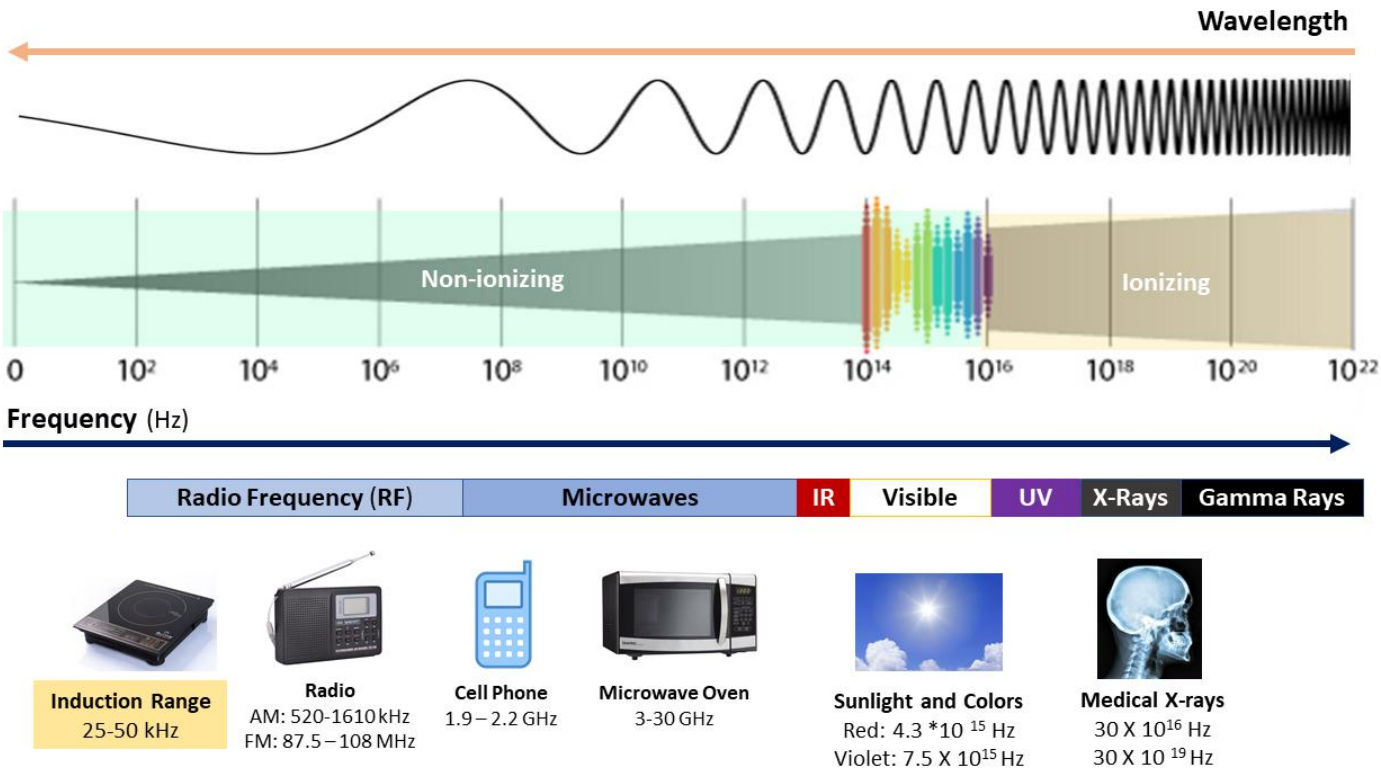

Figure 4: The spectrum of electromagnetic radiation on a logarithmic scale showing the location of induction cooking range EMFs compared with other sources of EMFs. (Modified from National Institute of Environmental Health Sciences).

What is currently known about health risks from induction ranges?

An extensive literature review was conducted to ascertain the health effects of EMF exposure, specifically those in the range of EMFs emitted from induction cooking appliances.

A 2016 document from the Swiss Federal Office of Public Health (FOPH) identifies potential risks and strategies to protect consumers from these risks. Consequently the exposure limits for induction electromagntism is set at 1/50th the threshold of nervous stimulation. Magnetic fields are known to induce small electric currents in the human body, which at a certain level can stimulate nervous tissue (FOPH 2016). Another risk identified by the FOPH is the possibility that stray magnetic fields emitted from induction can affect implanted medical devices. Hence the regulation induction field leakage from the range of no more than 1/50th (2%) of what could stimulate nervous tissue or pacemakers is permitted.

A 2011 study titled “Pre- and post-natal exposure of children to EMF generated by domestic induction cookers” published in the Physics in Medicine and Biology journal from the Institute of Physics and Engineering in Medicine (IPEM) measured electric and magnetic fields induced in children and pregnant adults from the use of induction stoves. The study found that even the maximum induced fields in users of induction stoves at a distance of 30 cm from the edge of the stove were below the risk levels specified by the ICNIRP (Kos et al 2011).

A 2015 document from the European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) titled "Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF)" addresses potential health impacts from exposure to various frequency ranges of EMFs and includes a section on the use of induction ranges. The authors noted that in some cases the reference levels set forth by the ICNIRP for IF field exposure can be exceeded when the user is within close proximity to the induction range, i.e. within the 30 cm distance specified by ICNIRP (SCENIHR 2015). Still, too few epidemiological studies on human exposure to induction frequency fields had been conducted to conclusively determine any significant human health effects. Further studies are expected in the coming years as a result of increasing worker and consumer exposure to induction fields (SCENIHR 2015), but no further documents have been released by SCENIHR regarding EMFs as of 2020.

It is important to note that while the health effects of induction range EMFs, if any, are not demonstrated by existing science, a large body of science shows significant health effects from natural gas stove combustion pollution such as PM2.5, NO_2, CO and Formaldehyde.

Can the health risks of induction ranges, if any, be mitigated?

To minimize the risk of unlikely and as-yet unknown health impacts from induction ranges discussed in the previous section, the Swiss FOPH suggests that the following steps be taken (FOPH 2016).

- Maintain at least a 2-inch distance from the range to decrease the risk of electric induction in the body.
- Those with implanted medical devices (pacemakers, defibrillators) should consult a doctor before using an induction range and refrain from using metal cooking utensils to minimize the risk of transmission of electricity to the body.
- Use cookware which is certified by the manufacturer as suitable for induction cooking.
- Use the right diameter of cookware for the range to limit stray magnetic fields.

What are the standards for Electromagnetic exposure from induction ranges?

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommends a reference value of 6.25 microtesla (μT) for public exposure to time-varying electromagnetic fields between 3 and 150 kHz in frequency (ICNIRP 1998). The technical standard for induction cookers is EN 62233 by the International Electrotechnical Commission (IEC). The standard requires that the ICNIRP reference level be met at a distance of 30 cm from the cooking field when one adequately sized cooking vessel is centered on the cooking zone (SCENIHR 2015). Countries which use this standard test products to ensure their compliance with the standard.

Table 1: ICNIRP (1998) established reference levels for EMF exposure in the range of 3-150 kHz.

Standard	Value
Frequency range	3-150 kHz
Exposure limit	6.25 microtesla (μT)
Distance	30 cm

How are induction ranges tested for electromagnetic emissions in the US?

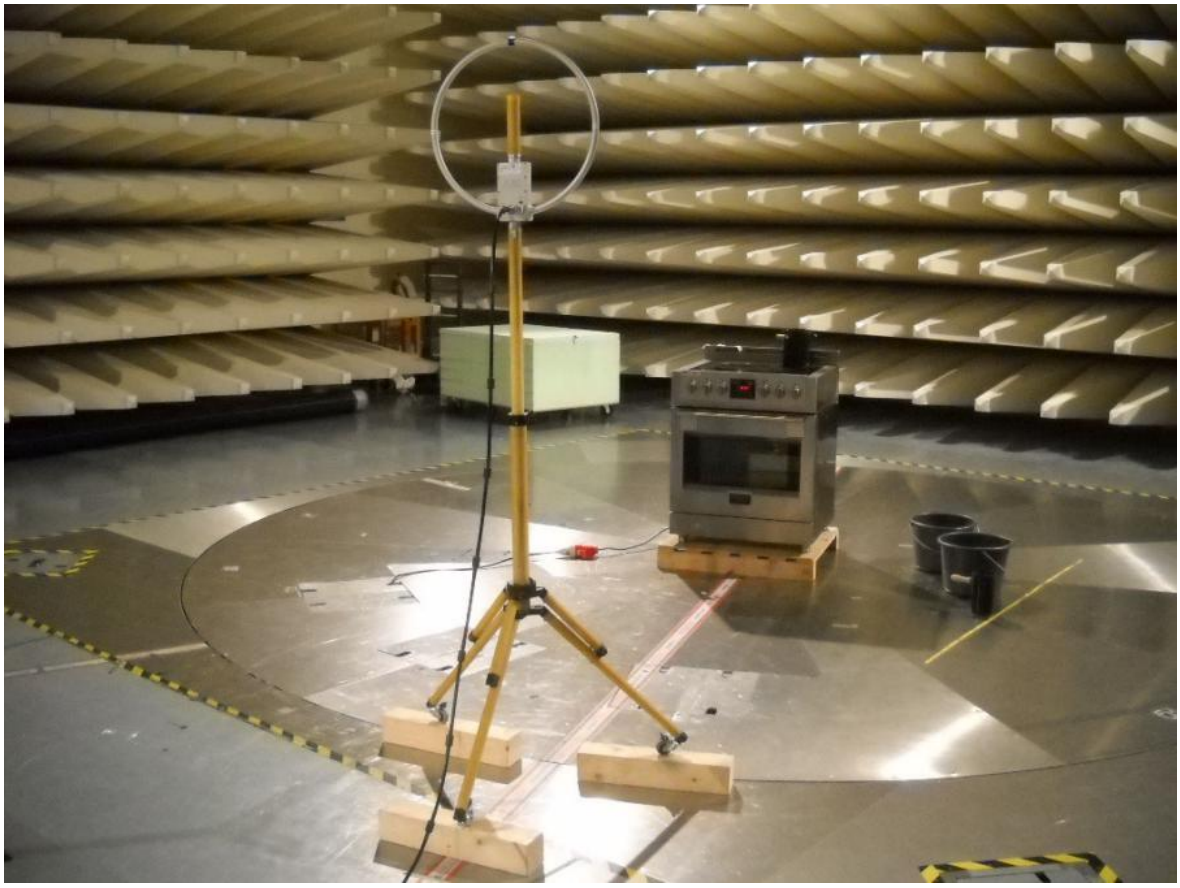

Figure 5: An example of a radiated emissions test showing anechoic chamber and loop antenna (VDE Testing and Certification Institute 2016).

FCC Certification

The Federal Communications Commission (FCC) regulates EMF emissions from electronic products manufactured or sold in the United States to ensure that electronics do not cause radio communications interference. Part 18 of the FCC rules sets forth standards for EMF strength for a variety of electronic equipment ranging from industrial, scientific, and medical equipment to consumer electronics.

Induction ranges are tested using FCC Measurement Procedure 5 (MP-5). FCC Office of Science and Technology (OST) established Measurement Procedure 5 (MP-5) to standardize testing of EMF emissions from electronic equipment based on Part 18 of the FCC rules and ensure that EMFs from electronics sold in the US are within acceptable limits. All equipment that is manufactured or sold in the US must demonstrate conformity to FCC rule 18.305 for radiated field strengths, which states that radiated fields below 90kHz should not surpass 1,500 microvolts per meter, and those on or above 90 kHz should not exceed 300 microvolts per meter measured at 30 feet (FCC 1987a). The test procedure involves using a radio antenna in an "anechoic" (EMF-proof) chamber to measure EMF emissions from a piece of electronic equipment (FCC 1987b). The testing occurs in various certification laboratories around the world depending on where the induction range was manufactured. A diagram of the test set up for MP-5 is illustrated in Figure 6 and an actual photograph of an induction range test from a testing document is shown in Figure 5.

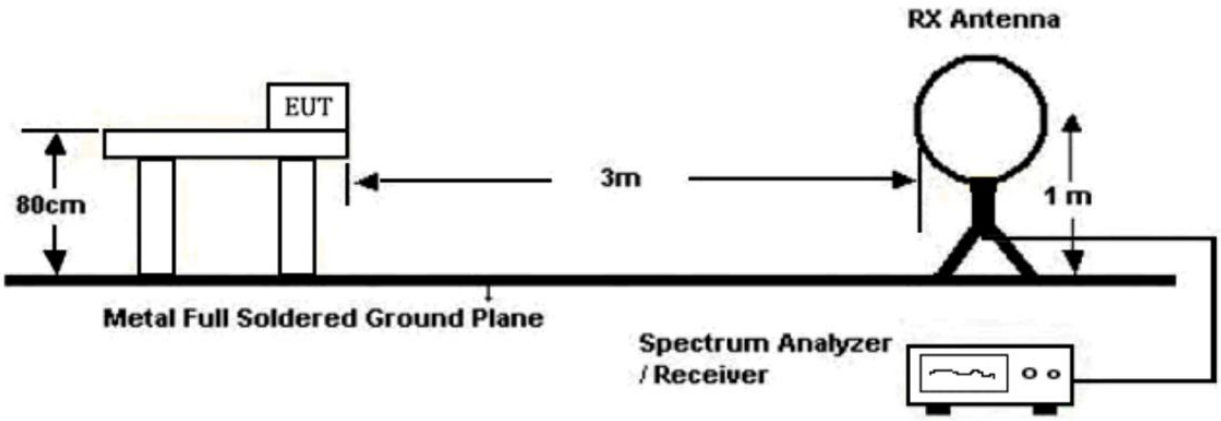

Figure 6: Diagram of an experimental set up used to test radiated emissions from induction stoves in accordance with FCC Rule 18.305.

References

European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). (2015). *Opinion on potential health effects of exposure to electromagnetic fields (EMF).*

Fairchild Semiconductor. (2000). *AN-9012: Induction Heating System Topology Review*

FCC. (1987a). *47 CFR § 18.305 - Field strength limits.*

FCC. (1987b). *Methods of measurement of radio noise emissions from industrial, scientific, and medical equipment.*

FCC. (2020). *RF Safety FAQ*.

Kos, B., Valic, B., Miklavcic, D., Kotnik, T., Gajsek, J. (2011). "Pre- and post- natal exposure of children to EMF generated by domestic induction cookers.". Phys. Med. Biol. 56 (2011) 6149–6160

Sweeney, M., Dols, J., Fortenbery, B., and Sharp, F. (2014). *Induction Cooking Technology Design and Assessment*.

Acknowledgements

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