Innovative Use Cases for Handheld Analyzers in the Medical Field

Introduction

Handheld radio-frequency (RF) analyzers provide multiple measurement capabilities in an affordable, portable form factor. Engineers from various industries, including the wireless, satellite, and medical sectors, use handheld analyzers to test and validate their RF and microwave innovations. This white paper discusses the use of handheld analyzers in two unique and innovative applications: cancer detection and spinal cord stimulation.

Cancer Detection and Prevention Using Handheld RF Analyzers

In 2018, breast cancer was the most common cancer in women worldwide, making up more than a fourth of the total number of new cases diagnosed that year. [1] Furthermore, since 2008, breast cancer incidence increased by more than 20% worldwide and mortality increased by 14%. While incidence rates are highest in developed regions, mortality is highest in less-developed countries that lack early detection and access to treatment. [2]

1 "Worldwide cancer data: Global cancer statistics for the most common cancers." World Cancer Research Fund International. Accessed July 24, 2020. https://www.wcrf.org/dietandcancer/cancer-trends/worldwide-cancer-data.

2 "Latest world cancer statistics." IARC – International Agency for Research on Cancer. Accessed July 22, 2020. https://www.iarc.fr/wp-content/uploads/2018/07/pr223_E.pdf.

In recent times, research scientists discovered a novel method to better prevent and detect breast cancer — RF analysis. The method examines the difference between the dielectric constants of normal breast tissue and cancerous tissue. The dielectric constant is a complex number that represents the response of a dielectric material to an electric field. The real part, also called permittivity, is the energy stored in the dielectric. The imaginary part, also known as the loss factor, is the energy dissipated. The tangent value (tan θ) of the loss angle is the ratio of the loss factor to the permittivity. It represents the coupling capacity of the material and the microwave pulse. The larger the loss tangent value, the stronger the material couples with the microwave. The testing setup, shown in Figure 1, consists of a coaxial probe, normal breast tissue, breast cancer tissue, a handheld analyzer, and materials measurement software on a PC.

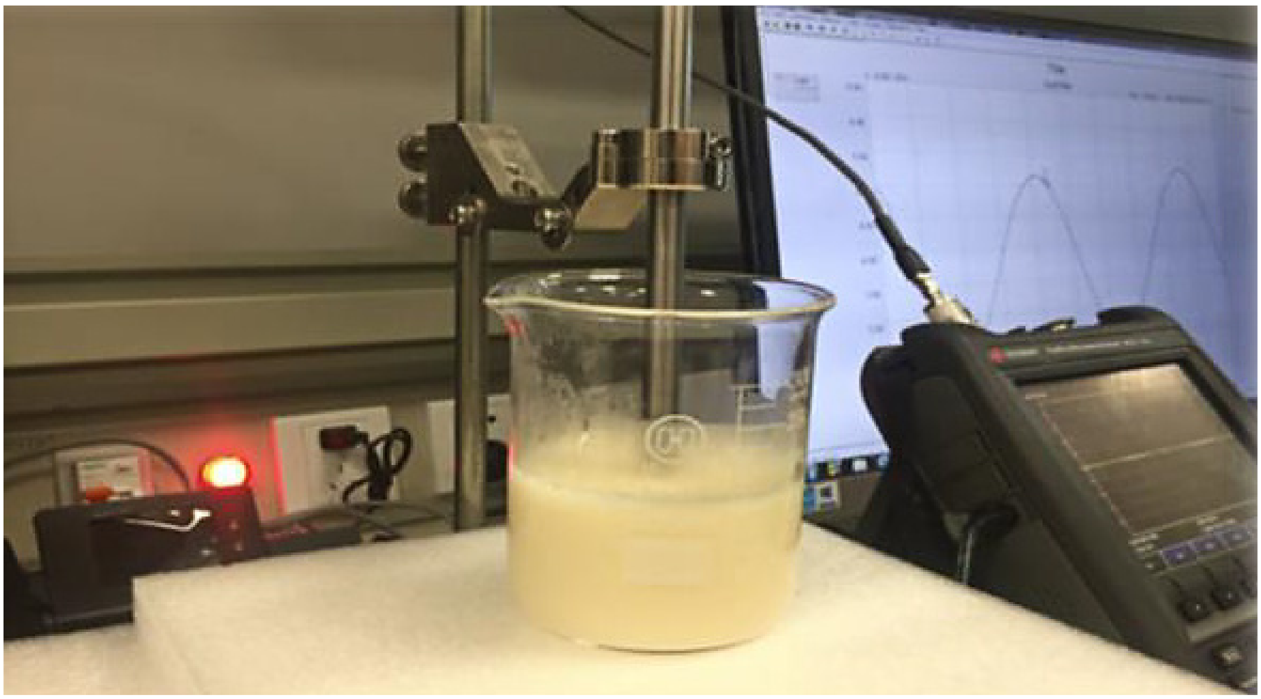

Figure 1. The test configuration

First, scientists measure the dielectric constant of deionized water to serve as a reference point. Then, they measure the dielectric constant of normal breast tissue and obtain a clear image of the tissue via dielectric constant imaging. Finally, they use network analysis and the S11 function to test the dielectric constant of the cancerous tissue. Figure 2 shows the dielectric constant of the malignant tissue and the healthy tissue versus frequency. The dielectric constant of the malignant tumor is consistently higher than the healthy tissue at each frequency tested.

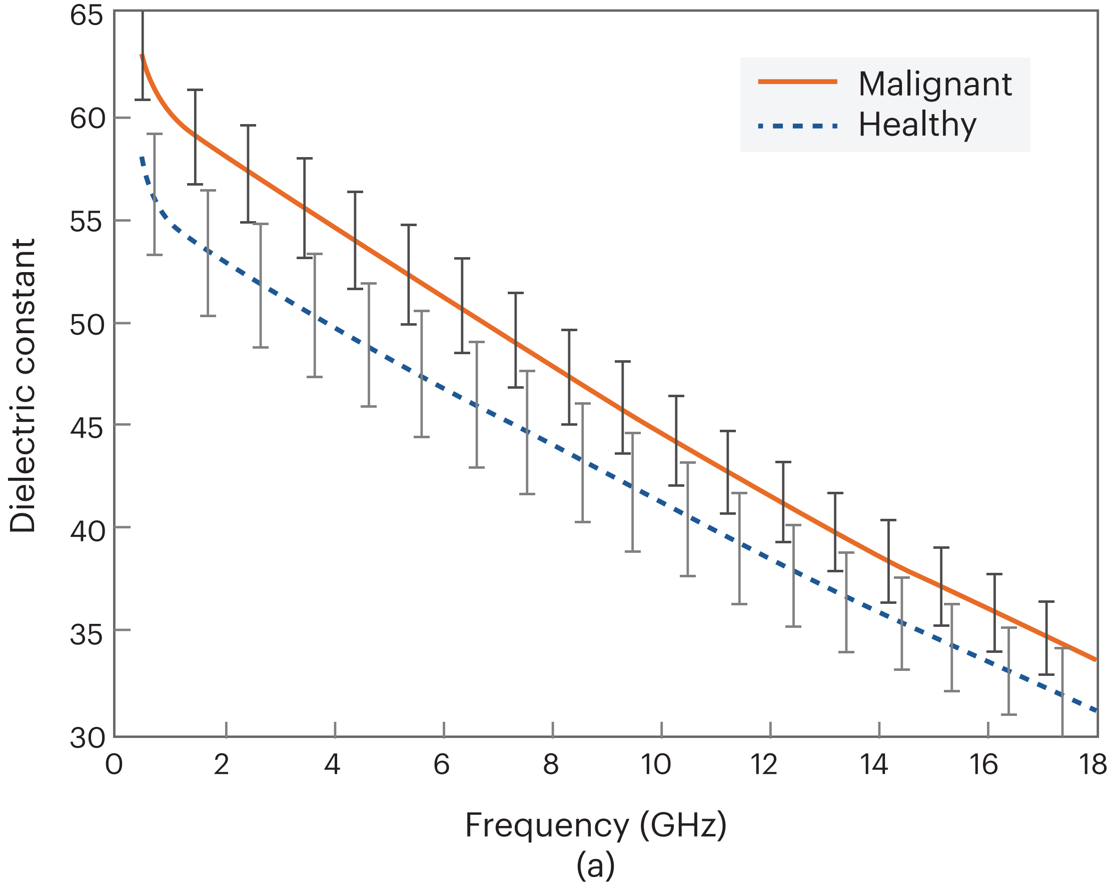

Figure 2. Dielectric constant curves of malignant tissue and healthy tissue measured in different frequency bands

Handheld analyzers enable students to have a better understanding of S-parameter RF measurements while also performing materials testing. The lightweight and flexible design of a handheld analyzer, such as Keysight's FieldFox, makes it convenient and easy to operate in practical research applications. In addition to enabling the teaching of materials testing in groups, a handheld analyzer like FieldFox, paired with Keysight's N1500A materials measurement software, verifies the feasibility of dielectric constant imaging. And in the end, the usage of handheld RF analyzers to develop a methodology for the identification of breast cancer could improve diagnosis and treatment times in the future, potentially earlier than traditional methods.

The innovative application discussed in this paper is research-based. FieldFox is not intended to be used for any medical application, including in-vitro diagnostics.

Handheld RF Analyzers in Neurology

About 540 million people worldwide suffer from lower back pain at any given time, making it one of the most common symptoms people experience.[3] To relieve lower back pain, some patients elect to receive an electrical stimulator implant, as shown in Figure 3. The stimulator sends low levels of electricity directly into the spinal cord.

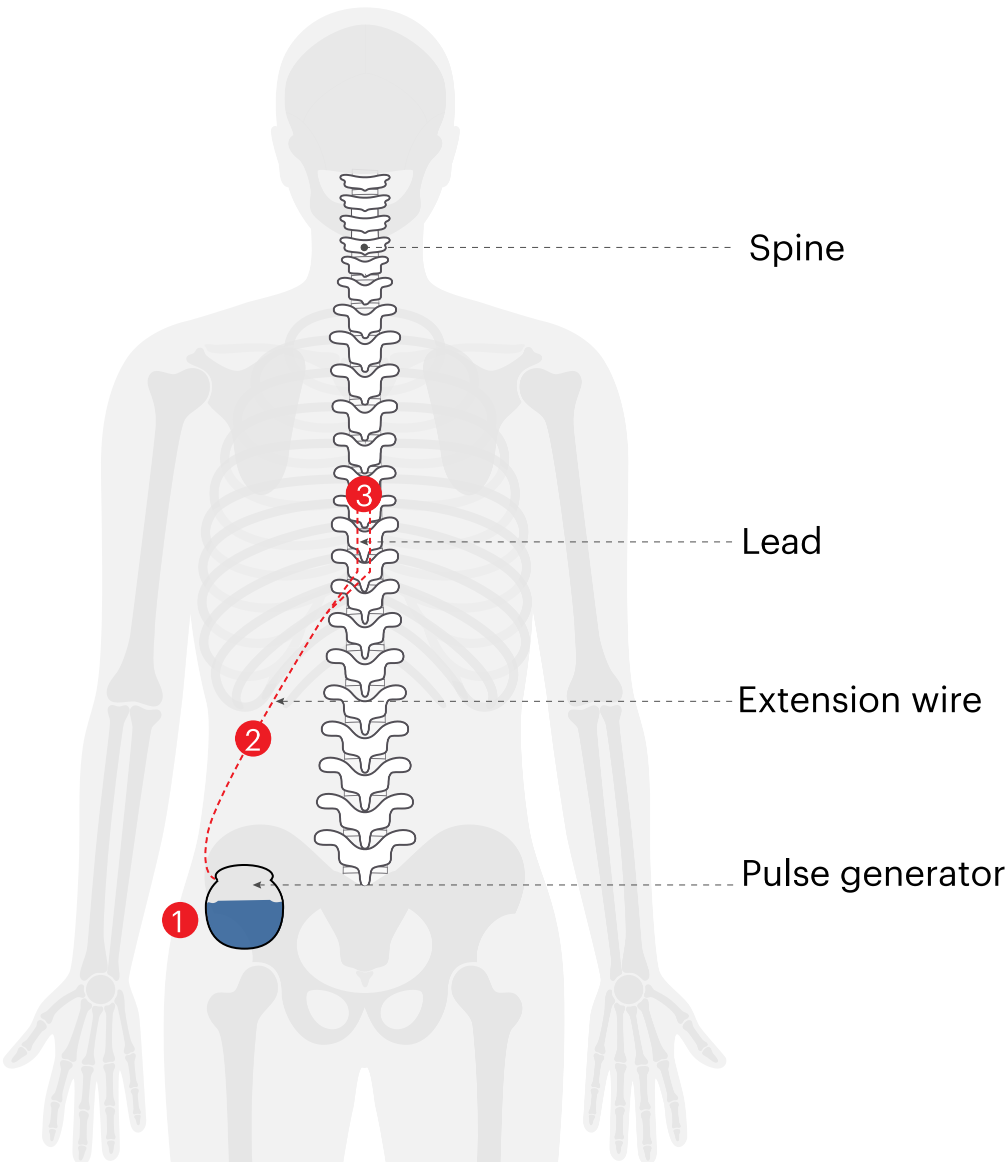

Figure 3. An example of a spinal cord stimulation system implanted in the body

3 "What low back pain is and why we need to pay attention." The Lancet. Accessed July 22, 2020. https://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(18)30480-X.pdf.

The coils shown in Figure 4 are the key components that keep the implant charged. Because implanted products need to charge wirelessly, spinal cord stimulation equipment manufacturers use network analyzers to perform impedance matching and inductance measurements of the coils, as depicted in Figure 5.

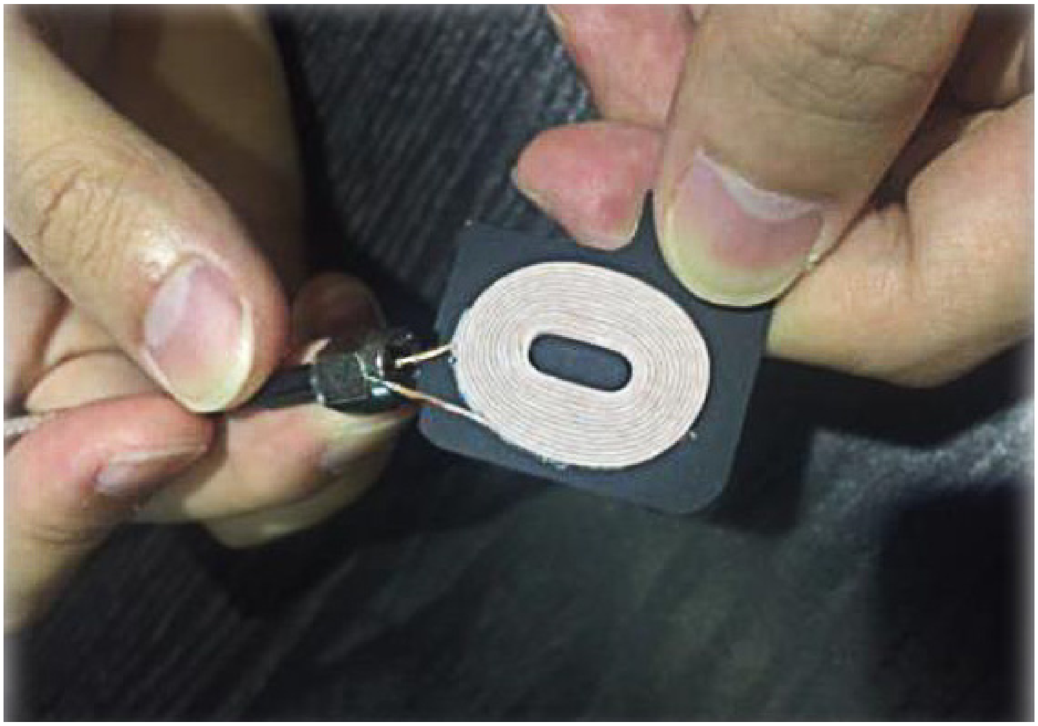

Figure 4. Transmit-receive coils in the spinal cord stimulation implant

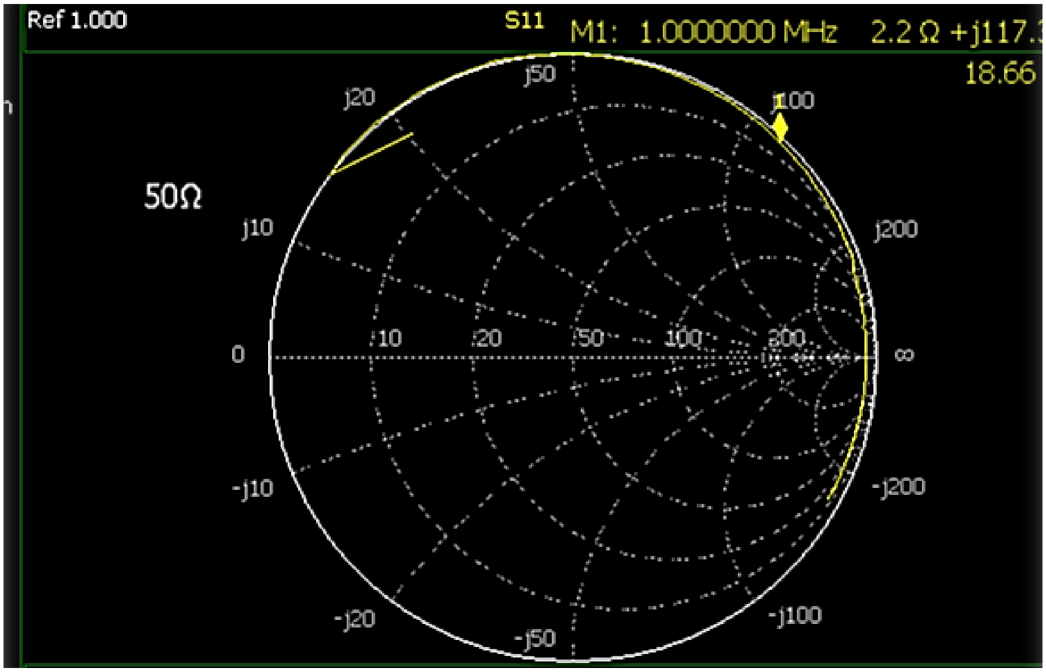

Figure 5. Impedance matching and inductance measurement of the coils using a FieldFox handheld analyzer

To ensure the safety of implantable devices and avoid interference with other electronics, manufacturers also use spectrum analyzers to measure various device parameters. These parameters include intermediate frequency (IF) bandwidth, power, and broad noise.

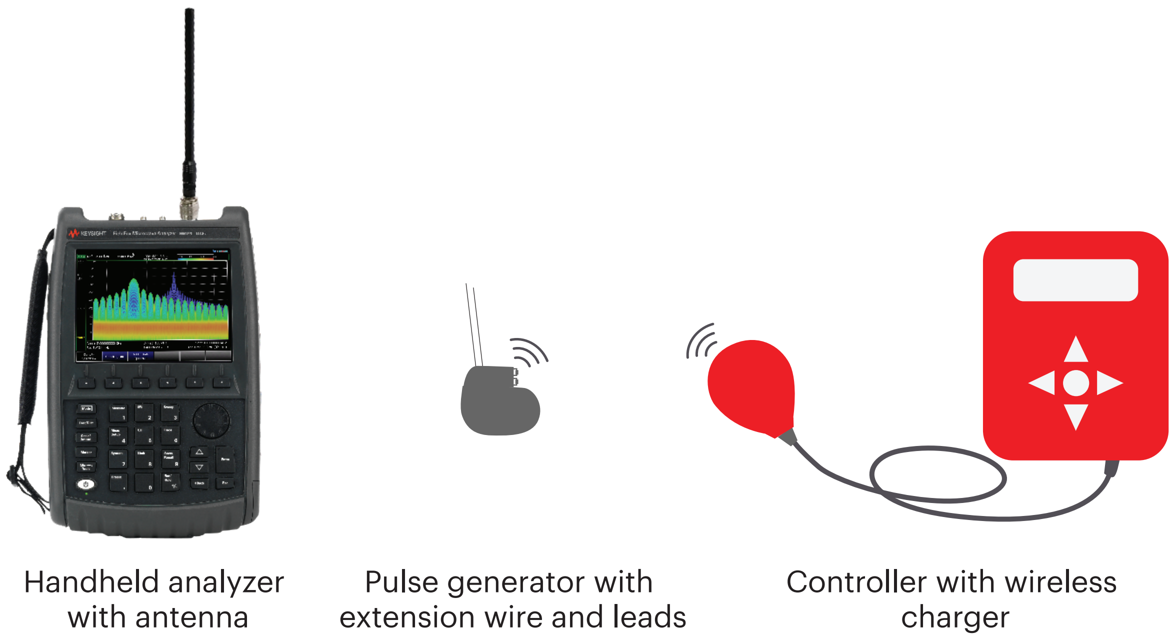

Figure 6. IF bandwidth and power measurement set up using a FieldFox handheld analyzer

Manufacturers measure noise to evaluate electromagnetic interference (EMI). EMI refers to unwanted radiated or conducted emissions, such as emissions from an electronic device or power lines. Electronic products must undergo EMI compliance testing to ensure that emission levels adhere to government or industry regulations. Figures 7 and 8 portray the EMI testing setup and an example EMI measurement. Manufacturers frequently use software, such as Keysight's PathWave Vector Signal Analysis, to demodulate digital signals to confirm that the data transmits correctly.

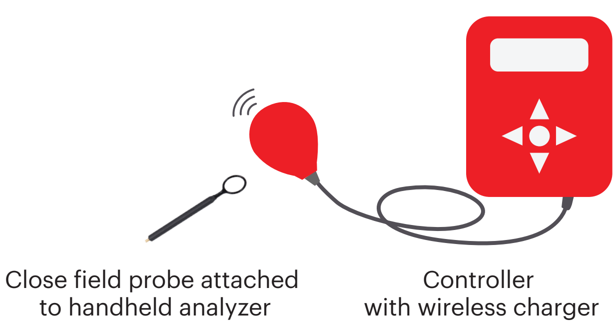

Figure 7. EMI evaluation testing setup

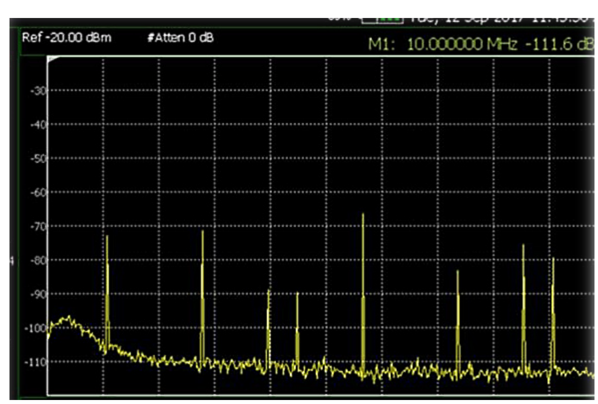

Figure 8. EMI measurement using FieldFox

Conclusion

Handheld analyzers, like Keysight's FieldFox, play an increasingly important role in accelerating innovations. The applications discussed in this paper serve as positive examples for the future use of handheld RF analysis in medical innovation. The impact of the handheld analyzer will be even greater as it plays a role in connecting the medical world with 5G. Patients in one city will undergo an operation from robots controlled by a surgeon in another city.

FieldFox handheld analyzers are not only accurate and reliable, but their flexibility allows users to configure them as a cable and antenna analyzer, a vector network analyzer, a spectrum analyzer, or a combination analyzer. FieldFox supports more than 20 software-enabled measurements that are field-upgradable. When measurement needs change, users can install keys on their own without returning the unit. Because of FieldFox's handheld form factor, flexibility, and multifunctionality, you never have to sacrifice capability or portability.