RF Energy Alliance: Advancing Next Generation Microwave Heating Applications

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Solid-state generated radio frequency (RF) is a well-known technical concept. All modern communications, including cellular tele-communications, radio and video broadcasting, Wi-Fi and Bluetooth, make use of complex, highly modulated RF signals, which are created and amplified by solid-state, semiconductor-based devices (Figure 1). For reasons of reliability and functionality, solid-state technology eventually replaced legacy, tube-based technologies for the purposes of data transmission[1].

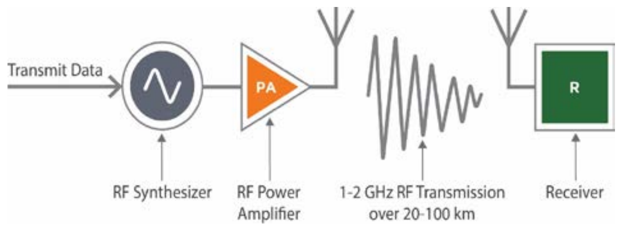

Figure 1. Typical RF data transmission block diagram.

Solid-state RF technology can also be used to “power” a localized chemical or physical process, rather than to transmit data. With an ever-increasing performance-to-price ratio, the practical use cases of solid-state RF energy (SSRFE) are expanding to heating and power delivery applications, such as industrial heating and consumer microwave ovens[2,3]. These high barrier markets, currently dominated by cheap magnetron RF sources, are beginning to see SSRFE developments and projects taking hold. Additionally, SSRFE’s capabilities are making it an increasingly attractive option in fields once considered inaccessible for RF powered systems (e.g., automotive ignition[4] and medical cancer treatment[5]).

Solid-State RF Energy – the Difference Maker

The design and performance differences between SSRFE and tube-driven heating applications are significant and wide ranging (Figures 2 and 3). The first notable distinction is a SSRFE system’s ability to assess feedback from forward and reflected power levels. This allows the application to easily measure and track the energy levels being put into the load.

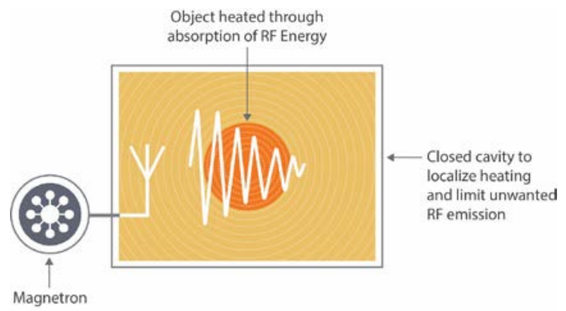

Figure 2. Magnetron-tube powered RF energy application.

Another important difference is the capability of an SSRFE application to alter frequency within the ISM (industrial, scientific and medical) unlicensed frequency band. As an SSRFE system’s controller determines the precise load conditions during operation via feedback, as mentioned early, it can also react accordingly and adjust frequency as needed.

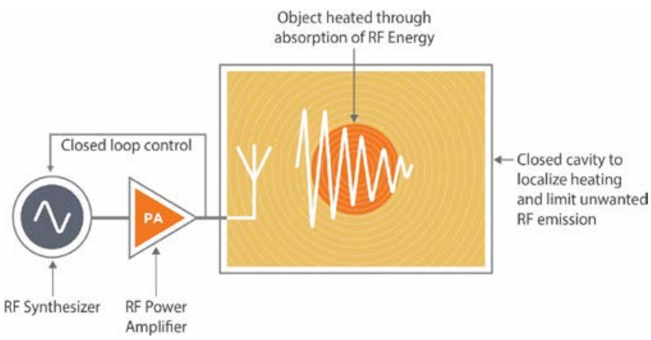

Figure 3. Solid-state powered RF energy application.

Aside from superior RF signal measurement and control, SSRFE modules feature excellent reliability, scalability, and design freedom with respect to form factor and system integration. The combination of these features lead to the following possibilities and advantages over magnetron-powered systems:

- Great reproducibility and repeatability;
- Precise control over power levels and energy doses;
- Enhanced process control – higher yields;
- High reliability of the generator, with no unpredicted down-time or production loss;
- No single point of failure in industrial or scientific systems;
- Utilization of full ISM band band-width;
- Dynamic frequency hopping and/or phase shifting;
- Homogeneous energy distribution inside the system cavity;
- Efficient use of the generated RF energy;
- Very agile control of the RF signal (frequency, phase, On/Off, gain, etc.);
- Fast load condition feedback to tune RF signal and process; e.g. prevent damage upon arcing;
- Spectrally clean frequency source; predictive use of frequency hops; benefit to co-existent wireless communications technologies;
- Low-voltage electronics – easier maintenance, simpler integration, smaller form factor;
- Compatible with electronics cost base.

An Alliance with a Mission, a Vision and a Plan

SSRFE's target markets present ultra-high volume opportunities for businesses operating in the RF technology industry, and offer alternative revenue potential to maturing markets such as cellular infrastructure. While SSRFE has massive potential, two main challenges in particular still hamper its rapid adoption.

The first obstacle lies in the fact that current cost structures on reasonably powerful SSRFE systems are limiting for consumer markets. The second hurdle relates to the specialized engineering knowledge needed to design SSRFE systems, which is typically lacking among RF engineers that are more familiar with data transmission systems or magnetron-based heating applications.

The RF Energy Alliance[6] can resolve both issues through the development standards for SSRFE components, modules, interfaces and systems for each target application, focusing first on solid-state cooking. These specifications will be backed by roadmaps to guide critical elements in an application's supply chain and to aid design and implementation efforts. By addressing the necessary economical, technological, regulatory and organizational challenges, our ever-expanding membership is convinced that SSRFE technology will successfully penetrate very high volume, consumer-oriented markets in the near future.

Members of the RF Energy Alliance have the opportunity to contribute to the evolution of existing SSRFE applications as well as the creation of new ones. Their profiles range from OEM's and suppliers to service providers and institutions - all dedicated to realizing SSRFE's many possibilities. We encourage all companies that are active in the solid-state RF generation industry to join our movement. For information about membership levels and instruction on how to join, visit www.rfenergy.org/membership.

For further reading:

1. F.H. Raab, P. Asbeck, S. Cripps, P.B. Kenington, Z.B. Popovic, N. Pothecary, J.F. Sevic, and N.O. Sokal, "RF and microwave power amplifier and transmitter technologies – Part 1," *High Frequency Electronics*, May 2003, pp. 22-36.
2. R.J. Meredith, *Engineers' Handbook of Industrial Microwave Heating*, IEE, 1998.
3. J. Thuery, *Microwaves: Industrial, Scientific and Medical Applications*, Artech House, 1992.
4. K. Werner, H. Heuermann, and A. Sadeghfam, "The potential of RF energy for the ignition of microplasmas," *High Frequency Electronics*, Nov. 2012, pp. 38-43.
5. J.F. Bakker, M.M. Paulides, A.H. Westra, H. Schippers, and G.C. van Rhoon, "Design and test of 434 MHz multi-channel amplifier system for targeted hyperthermia applicators," *Int. J. Hyperthermia*, March 2010; 26(2), pp. 158-170.
6. www.rfenergy.org

About the Author:

Dr. Klaus Werner is the owner of kw tec b.v., a company active in the fields of metrology, automation and consultancy. Currently, he focuses on RF energy market development as the RF Energy Alliance (RFEA) executive director. Dr. Werner was previously with NXP Semiconductors as the solid-state RF Energy markets business development manager. He studied physics at the RWTH Aachen University, Germany, and holds a Ph.D. in Semiconductor Device Technology from Delft University of Technology, Netherlands. Dr. Werner started his professional career as a process engineer at Philips Semiconductors. Prior to his assignment in the RF power device business, he worked in several engineering and operational management functions.