

## **Next Generation Medical Microwave Generators - A Step Forward for Patient Safety**

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The flexibility of microwave technology drives innovation in a growing, global market place and no more so than in the development of state-of-the-art medical treatments.

Applications harnessing microwave power extend from soft tissue ablation (typically the desiccation of tumours) to effective pain management solutions, but while significant attention is paid to the design of the microwave applicator, organisations often overlook the microwave power source itself - and as a consequence leave patients open to a number of risks: from ineffective and inefficient treatment, to serious patient injury.

As products and technology continually evolve, biomedical engineers and medical research teams are learning more about how microwave energy can offer new treatment options and change the way operations are carried out – but there are significant safety issues which must be considered in the design stage of any microwave based medical treatment.

### **Medical microwave systems**

In medical microwave systems the measurement of forward and reflected power is often used as a safety mechanism. This safety function can be used to monitor treatments, detect and react to device failures, connection issues and potential misuse. The advantage of these measurements is that blind treatments can be monitored in real time without requiring the user to inspect the treatment site.

Any inaccuracy in these measurements has the potential to result in either insufficient power being delivered - resulting in poor treatments and a perception of unreliability, or excessive power being administered - inadvertently causing serious patient injury.

### **The challenge of medical applications**

To ensure an efficient transfer of power into the body, a microwave applicator must be carefully designed to present a good impedance match to the generator when in contact with tissue. However in the case of medical applications, the applicator match is often poorer than the typical industry standard component simply due to the complexity of design.

Any degree of mismatch creates a standing wave – energy that is reflected from the target load and back down the guide. Medical treatments are made even more difficult to measure by the changing properties of human tissue. As a treatment progresses and more energy is absorbed by the tissue its unique properties change and subsequently the impedance match changes. As a result, the microwave applicator suffers from changing efficiency and a Voltage Standing Wave Ratio (VSWR) is created. When this mismatch is considerable i.e. 12dB or worse, standard power measurement techniques are no longer accurate.

The challenge in medical microwave generators is to accommodate the measurement of varying impedance and phase using standard components that are generally calibrated for typical industrial applications, where the impedance match is fixed. Generator systems are frequently constructed around existing industrial amplifiers or standard magnetron based power sources. As a result a number of problems can occur when these devices are employed in medical applications.

### **A false sense of security**

Typically power is measured using standard coupler arrangements where a fixed proportion sample (coupling factor) of the

forward and reflected power from a load under optimal conditions are measured and used to monitor performance and progress.

In the situation of medical microwave procedures, where as the procedure advances the match of the applicator is at best 12dB, this change in coupling factor makes the actual power value measurement an unknown quantity.

These effects are further exacerbated by phase changes. In a typical medical microwave system where the chosen method is to have the energy output fixed at a single continuous wave (CW) frequency, a small change in phase caused by tissue changes or physical manufacturing tolerances in interconnecting cables and thermal expansion of components can rapidly shift the point of measurement between the standing wave maximum or minimum, resulting in a compromised and inaccurate reflection measurement. This is even more noticeable at higher frequencies where the wavelength is shorter.

Phase variation has therefore the potential to provide a false sense of security in reflected power measurements. From a safety perspective, for example where an initially high level of reflected power is associated with placement in healthy tissue, VSWR and phase variation could lower the reflection measurement allowing the procedure to inadvertently continue resulting in a serious injury to the individual receiving the treatment. Conversely, measuring an excessively high reflected power could result in an otherwise valid treatment being unnecessarily abandoned.

### **The Emblation Safe Sweep<sup>®</sup> solution**

As the standing wave changes with phase, the solution is to vary the operating frequency of the signal over a predetermined frequency band, which as a result shifts the position of the standing wave. This can be accomplished using new transistor technologies such as

Gallium Nitride (GAN) which possess the necessary bandwidth capability. By sweeping across an appropriate frequency range the full VSWR peak to dip or “ripple” can be measured, and real time data processing can completely eliminate this measurement uncertainty.

This problem has been addressed for medical and industrial applications in the MSYS245 (fig.1) and ISYS245 microwave generators designed and manufactured by Emblation Microwave. These systems feature the Safe Sweep™ technology which provides users with a more accurate and reliable measurement of reflected power allowing for treatment progress to be easily and safely monitored and controlled. The use of Safe Sweep™ demonstrates a significant improvement over the standard CW measurement by offering a measurement system that is independent of phase and mismatch impedance.

Fig.1



### **About Emblation**

Emblation Limited is a world leader in the field of microwave technology, specialising in the development and manufacture of compact, state-of-the-art microwave solutions for use in medical, industrial & scientific applications.

The requirement for low cost, light weight, compact and portable microwave generators is becoming more commonplace in industry. Emblation's systems are fully functional and certified to meet medical and industrial standards, ideal for those in the fields of thermal ablation, communication, chemistry, plasma and material heating and curing.