NXP RF POWER SOLUTION FOR ADVANCED MEDICAL APPLICATIONS

FTF-MHW-N1999

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MAY 18, 2016
AGENDA

• Applications using RF Power in Medical
• Brief History of RF in Medical
• RF Medical Technologies and Benefits of LDMOS
• Microwave Ablation
• Cosmetic Therapy
• Diathermy
• NXP RF Power Solutions for Medical
But Before We Begin…

We won’t be covering the use of RF for patient monitoring or other communications applications.

We’ll exclusively be discussing invasive (surgical) and non-invasive (cosmetic) applications in which RF Power is the key enabler.
RF Power

\[ \text{Over-The-Air Communication} \quad + \quad \text{High Power Generation} \]

- Cellular
- Radio & TV broadcast
- Radars & Air Traffic Control
- Land Mobile Radios

- Laser & plasma generation
- Particle acceleration
- Medical
- Industrial welding, drying, heating
Medical Applications Using RF Power

- MRI
- Ablation
- Diathermy
- Cosmetic Therapy
BRIEF HISTORY OF RF IN MEDICAL
Brief History of RF in Medical

• In 1891 Nikola Tesla noted that high frequency currents produce heat in the body and suggested its use in medicine

• D’Arsonval discovered that frequencies above 10 kHz did not cause the physiological reaction of electric shock, but warming

• In 1899 von Zaynek determined that the rate of heat production in tissue is a function of frequency
How Does Frequency Heat Materials

Example at 915 MHz

The alternating current wave reverses between positive and negative polarity 915,000,000 times per second.

The water dipole flips every time the microwaves reverse polarity. This motion causes friction and hence heat.
What Frequency Bands

- The industrial, scientific and medical (ISM) radio bands are reserved internationally for the use of RF energy for industrial, scientific and medical purposes other than telecommunications.
- Unlicensed operations are typically permitted to use these bands. No government permit required.

<table>
<thead>
<tr>
<th>ISM band</th>
<th>Wavelength</th>
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</thead>
<tbody>
<tr>
<td>6.78 MHz*</td>
<td>44 m / 48 yards</td>
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<tr>
<td>(6.78 MHz ±15kHz)</td>
<td></td>
</tr>
<tr>
<td>13.56 MHz</td>
<td>22 m / 24 yards</td>
</tr>
<tr>
<td>(13.56 MHz ±15kHz)</td>
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</tr>
<tr>
<td>27 MHz</td>
<td>11 m / 12 yards</td>
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<tr>
<td>(27.12 MHz ±163 kHz)</td>
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</tr>
<tr>
<td>41 MHz</td>
<td>7 m / 8 yards</td>
</tr>
<tr>
<td>(40.68 MHz ±20 kHz)</td>
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</tr>
<tr>
<td>434 MHz* (433.92 MHz ±870 kHz)</td>
<td>69 cm / 2.25 feet</td>
</tr>
<tr>
<td>915 MHz</td>
<td>33 cm / 1 foot</td>
</tr>
<tr>
<td>(902-928 MHz)</td>
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<tr>
<td>2.45 GHz (2400-2500 MHz)</td>
<td>12 cm / 4.8 inches</td>
</tr>
</tbody>
</table>

* Band needing special authorization in some countries
RF Power Technologies in Medical

- **Vacuum tubes**, primarily magnetrons like those used in microwave ovens

- **Solid-state devices** such as bipolar junction transistors (BJTs) and Vertical MOSFETs (VMOS) were the first solid-state devices used in medical applications, almost always at low frequencies

- **LDMOS RF power transistors** are ramping up today
Advantages of Transistors Over Magnetrons

1. Precise control
2. Ease of use
3. Reliability
4. Size and weight
Advantages of **LDMOS** Transistors Over Older Transistors (BJT and VMOS)

<table>
<thead>
<tr>
<th>Advantages over VMOS</th>
<th>Advantages over BJT</th>
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<tbody>
<tr>
<td>• Performance doesn’t fall quickly above 100 MHz</td>
<td>• High ruggedness</td>
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<tr>
<td>• Good thermal capability</td>
<td>• Good thermal capability</td>
</tr>
<tr>
<td>• High gain</td>
<td>• High gain</td>
</tr>
<tr>
<td>• No BeO in packages (banned material)</td>
<td>• No BeO in packages</td>
</tr>
<tr>
<td></td>
<td>• Many bipolar transistors are EOL</td>
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</table>

BeO: Beryllium oxide
MRI
MRI – Magnetic Resonance Imaging

- MRI scanners rely on detecting a RF signal emitted by excited hydrogen atoms in the body (water molecules), using energy from an RF magnetic field applied at the appropriate resonance frequency

- 1.5 Tesla MRI: typically 61-64 MHz
- 3 Tesla MRIs: typically 123-128 MHz

- MRI have been using RF transistors for decades, now migrating to LDMOS

[Diagram of MRI components: CPU, Waveform Generator, ADC's, Power Amplifier, X, Y, Z Gradient Amplifier, RF receiver, Magnet, Gradient Coils, RF Coil]
MICROWAVE ABLATION
Ablation

Ablation is a procedure in which tissue is either reduced in size or removed through surgery

Typical Applications

- **Removing** skin lesions
- **Shrinking** the size of lung, liver, kidney, and bone tumors
- **Destroying** abnormal electrical pathways in the heart that cause cardiac arrhythmia or nerve roots in the spinal cord to relieve the symptoms
Types of Ablation

• **Radio frequency (RF) ablation – most popular now**
  - Frequency: from hundreds of kHz to 5 MHz

• **Microwave ablation – emerging**
  - Comparatively new, operates at either 915 MHz or 2456 MHz
Microwave Ablation

**Benefits of microwave ablation over RF ablation:**

- Higher temperature (higher power density)
- Faster ablation time
- Able to use multiple applicators (antennas)
- Less procedural pain
- Allows for deeper penetration, high frequency can pass through all types of tissue
- Larger tumor ablation volumes
Neuwave’s Ablation System based on Prescient Wireless PA module: 140 W ablation system at 2456 MHz
Renal Denervation (RDN)

One of the newest and potentially promising applications of RF power

It has the potential for lowering blood pressure in people who for various reasons do not respond to any other approach, whether lifestyle changes or medication.
How Renal Denervation Works

• A small catheter at right is placed in the femoral artery providing access to the nerves through the renal artery
• The nerves are ablated by passing energy into the artery and transmitting low-dose RF power through the catheter tip placed in the kidneys
• The energy is transmitted through the vessel wall to damage the renal nerves

After the procedure, the patient can resume activities within hours and can leave the facility the following day
NXP Solutions for Microwave Ablation

Example: 250 W at 2.45 GHz

Pre-driver: MMG20271H9
Driver: MHT1006N (10 W)
Final stage: MRF7S24250N

All solutions for ablation:

<table>
<thead>
<tr>
<th>Medical Frequency</th>
<th>NXP RF Power Solutions for Medical</th>
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<tbody>
<tr>
<td></td>
<td>Reference circuit</td>
</tr>
<tr>
<td>915 MHz</td>
<td>MRF8VP13350N</td>
</tr>
<tr>
<td>2.45 GHz</td>
<td>MRF7S24250N</td>
</tr>
<tr>
<td></td>
<td>MRF7S24250N 3-stage</td>
</tr>
<tr>
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<td>MRF24300N</td>
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SKIN TREATMENT & MEDICAL LASERS
Cosmetic Therapy

Many ways of using RF power are on the market for skin treatment:

- Lasers (using RF as an energy source)
- RF power directly applied to the skin
- Combination of the 2 above
- Combination of RF + IPL

* Thermage, also a registered trademark of Solta Medical.
Medical Laser

- RF is used to ignite a plasma that turns to laser
- Applications:
  - Skin surgery
  - Scars
  - Anti-aging and wrinkles
  - Pigmented lesions
  - Skin tightening/rejuvenation

DEKA's Smartxide² based on El.En PA design using MRFE6VP61K25H, 1250W transistor from NXP

https://www.youtube.com/watch?v=ZVLLS_RblM
Honkon Medical

Honkon is a leading medical device manufacturer in AP, using RF devices in their thermage machines.

This is another way of using RF to heat the skin from inside and contract collagen.

Honkon-M600E+
Intense Pulse Light (IPL) + RF

IPL+RF is employed in performing a number of medical aesthetic treatments including
• removal of unwanted hair
• skin blemishes
• improving skin tone and other

The combination of ILP and RF have been shown to be more effective together as the addition of RF energy adds the benefit of skin rejuvenation
DIATHERMY
Diathermy

• Diathermy is another example of how RF power can be used for heating

• Medical uses: arthritis, back pain, muscle spasms, myositis, neuralgia, sprains and strains, tenosynovitis, tendonitis, bone injuries, and bursitis

• Types of diathermy
  - **Shortwave diathermy**
    (13.56 MHz, 27 MHz and 40 MHz)
  - **Microwave diathermy**
    (915 MHz or 2.45 GHz)
How Diathermy Works

• Diathermy is a way to electrically induce heat through the use of RF energy that produces heat deep into a targeted tissue
• Can reach up to 2 inches below the surface
• Diathermy doesn't actually directly apply the heat but rather the current it produces lets the body generate heat from within the tissue itself
• As heat increases, blood flow is increased, which can improve flexibility in stiff joints and connective tissue

The patient feels a warm or tingling sensation during the treatment.
NXP SOLUTIONS FOR MEDICAL
## NXP Solutions for Medical

### Why choose NXP LDMOS transistors
- Light weight and compact size
- High ruggedness
- High gain
- High efficiency
- High thermal performance
- Longevity program

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<th>ISM Band</th>
<th>Medical Application</th>
<th>NXP RF Power Reference Circuit for Medical</th>
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<tr>
<td></td>
<td></td>
<td>Transistor</td>
</tr>
<tr>
<td>13 MHz</td>
<td>RF Ablation</td>
<td>MRFE6VP61K25H</td>
</tr>
<tr>
<td></td>
<td>Skin Rejuvenation</td>
<td>MRFE6VP6300H</td>
</tr>
<tr>
<td></td>
<td>Diathermy</td>
<td>MRFE6VP61K25H</td>
</tr>
<tr>
<td>27 MHz</td>
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<tr>
<td></td>
<td>Diathermy</td>
<td>MRFE6VP5150N</td>
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