Compact Antenna for Medical Wireless Communications Applications

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Topics Outline

- Basics Antenna & needs
- Antenna Frequency ranges and types antennas
- Compact ceramic antenna introduction
- Overview of wireless frequency bands
  - Short range
  - Long range
- Vishay Compact Ceramic antenna
  - Suited for UHF band MICS, MEDS,MMN, WMTS
  - Compact Ceramic antenna advantages
- Tuning capability of the Compact Ceramic antenna
- Ground plane optimization
- Summary

Basic wireless transmission:

Lower the frequency longer the wavelength, larger antenna is needed

Frequency in Megahertz(MHz)

Very High Frequency ←→ Ultra high Frequency ←→

100	200	300	400	500	600	700	800	900	1000	1200
3.0	1.5	1.0	0.75	0.6	0.5	0.43	0.375	0.333		

Wave length in meters

C (Speed of light) =L Wavelength X Frequency

Basic Antenna & Needs

- Antenna like air-core inductor
- The antenna size and construction is based upon operating frequency. Higher the frequency shorter the wavelength. Example:2.4GHz , quarter wavelength size =3cm
- Resonance occurs at fractions/multiples of the fundamental frequency. Antennas can be made smaller because they can operate OK at fractions or multiples of the frequency
- The frequency corresponds to the wavelength $\lambda = c/f$
- Detuning/ Fading of the RF signal when placed close to another object…due too low bandwidth
- Antennas constructed with ceramic(dielectrics),can have major advantages over traditional metal (conductive) antennas

Basic Antenna types

- Antennas common to Medical devices:
  - Monopole
  - Dipole
- Types:
  - Metal Telescopic
  - Loop, whip
  - Flat Wire or helix
  - Printed PCB
  - Ceramic/Chip
  - Patch

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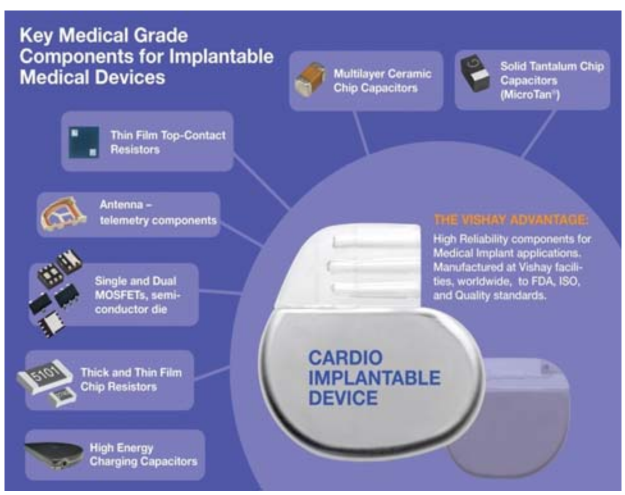
Antennas rule the air space!

Inside a medical device: challenging high density circuitry



Ceramic Antenna introduction

- Effective wavelength of a radio wave is shorter in a ceramic dielectric material than in free space
- Therefore Antennas constructed with Ceramic dielectrics can be made smaller than conventional metal antennas.
- Many medical devices made with high density circuits require very small size antennas, good efficiency
- New low loss Ceramics can be used to construct an antenna with some nice advantages:
  - Antenna size can be reduced by 10 to 20 times
  - Multi – tuning capability
  - Surface mountable
  - Radiates efficiently since the size is comparable with the half-wavelength dipole antenna

Ceramic Antenna construction

- Antennas construction problem.. the size is a fraction of the wavelength effecting the bandwidth(lowering)
- However Antenna size can be decreased by increasing the dielectric or magnetic constant ε around the antenna
- An Antenna dimension should be ~ = $\lambda/4\sqrt{\varepsilon}$, where λ is the wave length and ε the Dielectric Constant of the media.
- Example, For Frequency= 300 MHz, λ = 1 meter.
  In Air, ε = 1, so the equivalent antenna should measure a large electrical length of 250mm

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Ceramic Antenna at Medical Freq.

- Example: Antenna operating @ Medical Freq.
  - 403MHz in air
  - Requires a wavelength of this frequency of ~750mm
  - Therefore a ½ wave dipole antenna would need to be a large electrical length of about 375mm or >1 foot in length!
  - Not practical for most medical devices
- Using Ceramic Antenna the electrical length(size) can be decreased by use a low permittivity ceramic dielectric around the antenna

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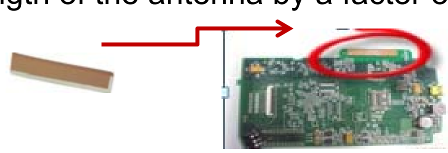
Why is Ceramic antenna smaller ?

- Using ceramic dielectric material greatly impacts the effective length of the antenna by a factor of $\sqrt{\varepsilon}$



- So for example, if the dielectric ε is = 400 , $\sqrt{400} = 20$. Therefore the antenna length can be reduced by up to 20X fitting is a smaller space inside the device
- Higher the dielectric constant results in higher electrical losses. Dielectric material used in Vishay Compact Ceramic antenna is a compromise between Dielectric constant and losses.

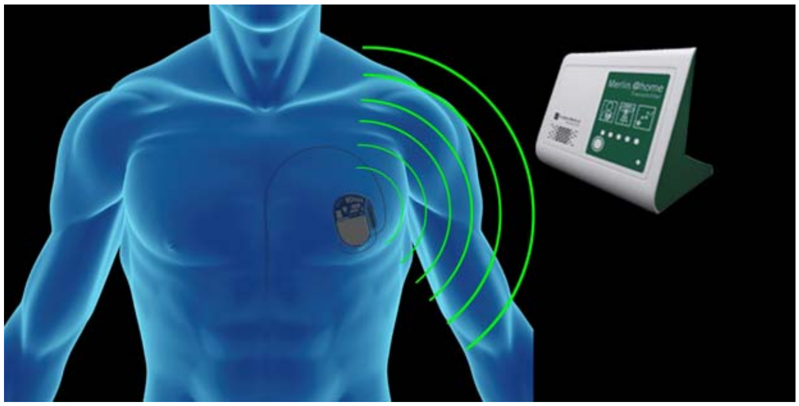
Benefits: Patient centered wireless medical device communication

- Smaller Devices using a ceramic antenna can facilitate remote monitoring of patients vital signs or download patient history for the clinician
- Wireless Neurostimulator devices with small antenna not only monitor but can program devices to move artificial limbs
- Wireless capability provides fast data access which can reduce health care cost and provide better treatment actions
- *FINDINGS: People* accessing their charts took better care of themselves… California HealthCare Foundation (CHCF). April 2010

Device benefits

- Small Wireless medical devices can be worn on the body or implanted with embedded antenna
- Antenna in wireless medical devices allow :
  - 2-way communication system between device and external control unit or directly to nurse station
  - Capability for close-range and long-range data exchange so the clinician can respond quickly and efficient
  - Most implantable devices provide short range communicate to bedside receivers which in turn are connected to the internet for longer range communication

Wireless communication implantable devices



Freq. Medical devices Short distance applications

Type	Frequency	Distance
Bluetooth , Wi-Fi and Zigbee	900MHz, 2.4GHz, 5.8GHz	60 meters
Medical Body Networks or PAN- Personal Area	2.4GHz	1 meter
Ultra -Wideband	>500MHz	1 meter & >
MMN- Medical Micropower Networks	413-457MHz	1 meter
MICS- Medical Implant Communications Systems	401-406MHz	2-4 meters
Inductive Implants	<200KHz	<<1meter

Freq. Medical devices
Long distance applications

Type	Frequency	Distance
WiMax	2.5GHz	>1000 meters
WMTS Wireless Medical Telemetry Systems	600MHz to 1.4GHz	60 meters

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Wireless Medical Communication

- **Implantable** devices; operate in MICS , MEDS and MMN band

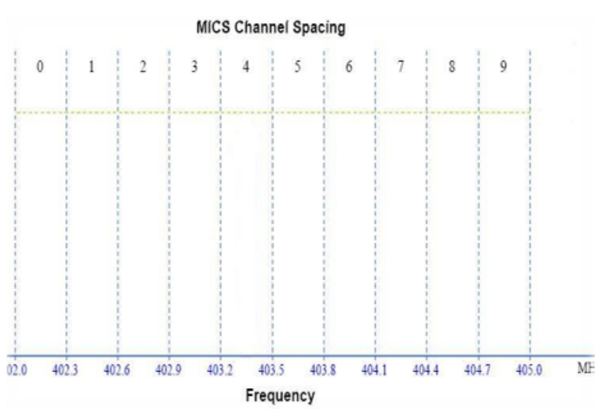
- **Non-implanted devices**; For example Robots operate in WMTS (Wireless Medical Telemetry Service) band or IEEE standard 802.15.4

Telemetry systems for Medical devices

Some medical devices use multiple frequencies:

- Robots used in hospitals use:
  - Antenna Frequency(400, 868, 915MHz) per IEEE standard 802.15.4
- Implant devices use MICS band 401-406 MHz combined with multiple higher frequency ISM bands (Industrial, Scientific and Medical)2.4-2.5 GHz +.
- Multiple frequencies can better meet power budgets
- Multiple-frequency band telemetry have different carrier frequencies for the power and data signals.

MICS Channel spacing



The maximum transmit power for MICs is very low EIRP=25milliwatts

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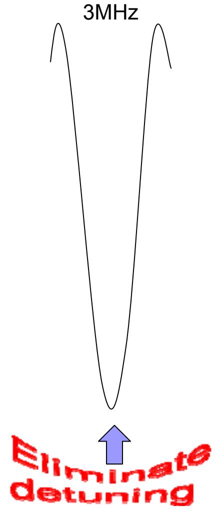
Example :Compact Ceramic antenna bandwidth advantage



Medical Implant Communication Service

- MICS 402–405 MHz, setup by FCC
- MICS provides up to 10 channels with bandwidth of 3MHz
- Vishay Antenna in monitor Solves Detuning
- Vishay antenna covers a 100MHz bandwidth !

- MICS solutions:
  - Use a radio-frequency (RF) link to achieve high data rates 800/400/200 Kb/sec
  - range of ~ 2-4 meters

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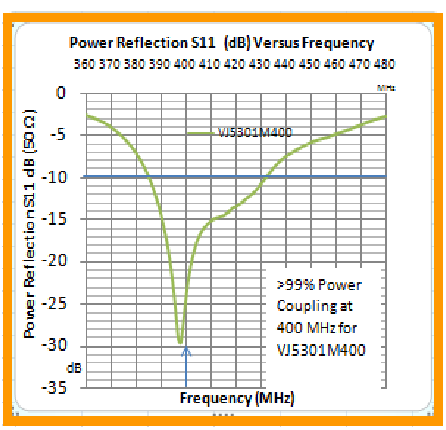
Example :Vishay antenna tuned to a center frequency of 400-MHz



Ceramic Chip Antenna features

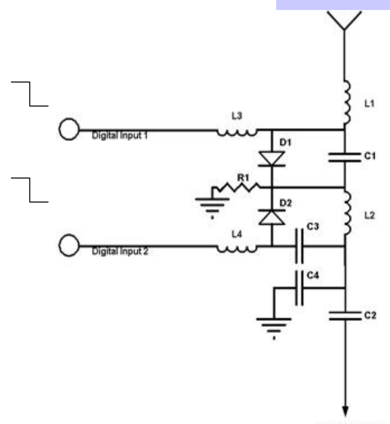
- Tunable across the UHF band
- Small outline SMD
  10 x 15 x 1mm
  35 x 5 x 1.2mm
- Omni directional, linear polarization
- Optimized with tuning circuit & ground plane
- 50 Ohm unbalanced interface
- Operating Temperature Range:
- -40°C to +85°C
- RoHS compliant
- High Dielectric Constant Ceramic
- Vishay Proprietary ceramic formulation
- Low Loss Factor
- Ideal for medical devices MICS, MMN and WMTS bands

Vishay Antenna can transmit & receive signals in the UHF band (400MHz -860MHz) and up to 1.1GHz

Wide Band Tuning with Vishay Compact Ceramic antenna

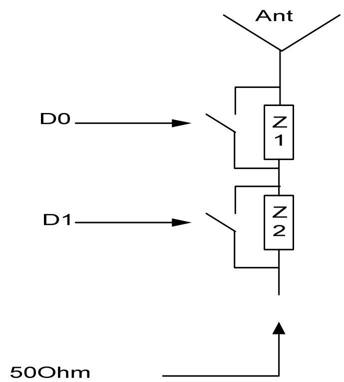
- Easy to tune using only two Digital Control lines
- No Software Overloading
- Covers the entire UHF Band (470 MHz to 860 MHz)
- Can be adapted to cover other frequencies

Compact Ceramic Antenna



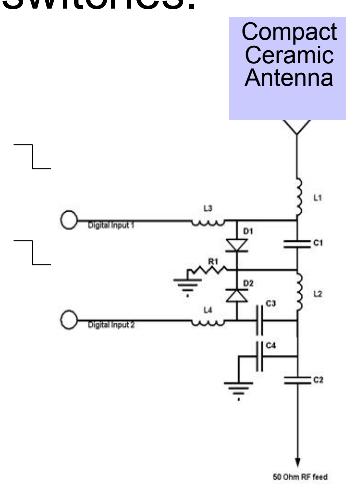
Digital Tuning circuit concept: Switch reactance to generate the appropriate tuning impedance.

D0	D1	Z
0	0	Z1+Z2
0	1	Z1
1	0	Z2
1	1	0



Tuning circuit application: use low cost PIN diodes as switches.

Digital In1	Digital In2	PIN 0	PIN 1
0	0	High Z	High Z
0	1	High Z	2Ω
1	0	2Ω	High Z
1	1	2Ω	2Ω



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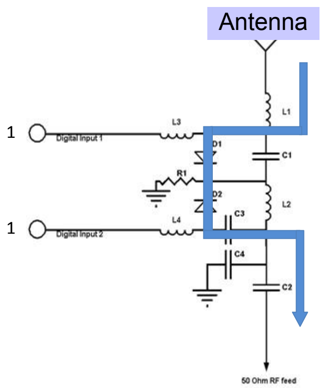
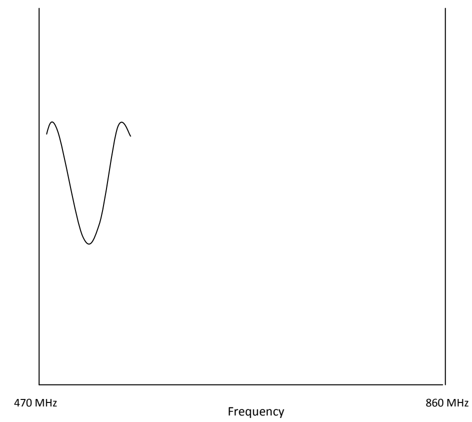
How Tuning Works





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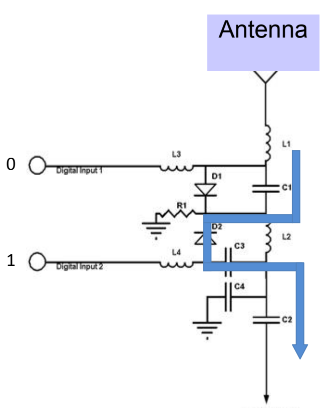

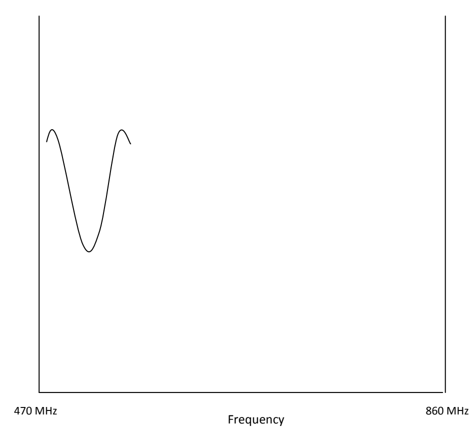

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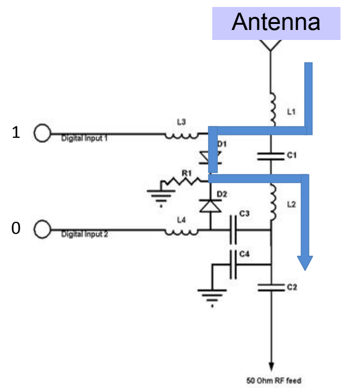

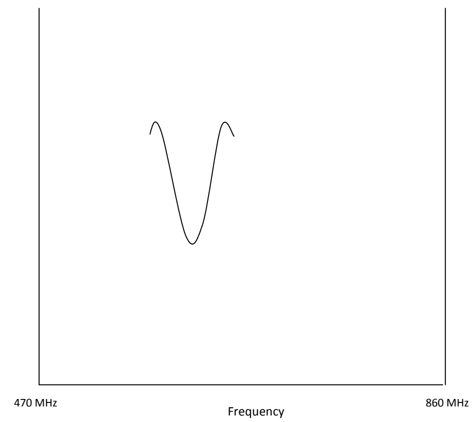

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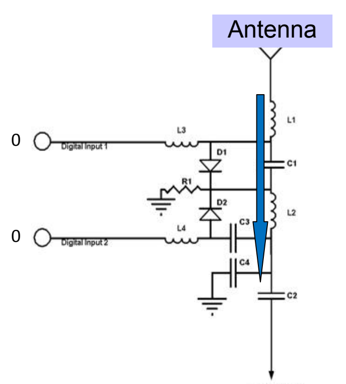
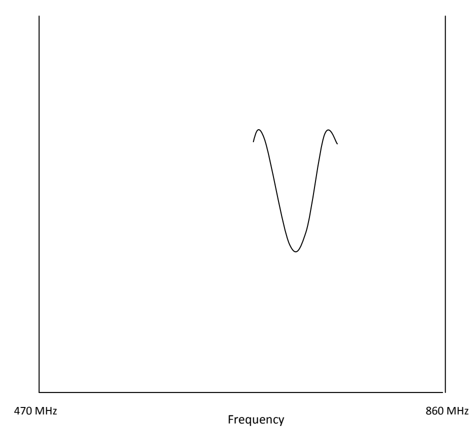
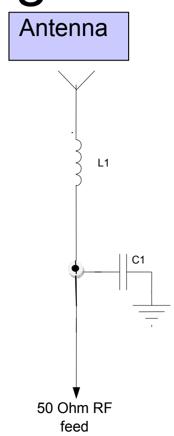


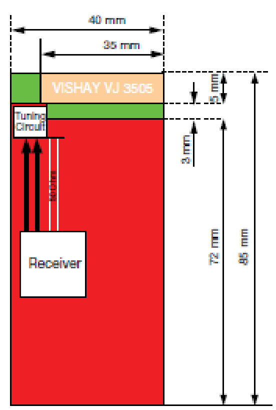


Single Channel Tuning



- The Compact ceramic antenna can be tuned to <u>any</u> single frequency of active range (460 MHz to ~ 1.1 GHz)
- **Simple** LC tuning circuit
- No need for Digital Control
- Example:
  - To tune the antenna @ 725 MHz, L1 = 47nH, C1 = 3.9pF

Design in support:Vishay Antenna Evaluation board and ground plane



Complete info can be found at :
http://www.vishay.com/chip-antenna/

Summary -Compact Antenna for Medical Wireless Applications

- Medical Devices with wireless capability will increase even more because of the Patient / Physician benefits
- Remote monitoring for wireless control of therapeutic medical devices is a reliable, robust method and can be implemented at multiple frequencies
- MICS and newly announced MMN frequency bands are safe, and effective for medical implantable devices
- Antenna efficiency should be considered especially where space is constrained for the ground plane.
- Vishay Compact Ceramic antenna offer significant advantages over conductive metal antennas