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Abstract: [Discussions on Medical Implant Communication System (MICS)]

Purpose: [To provide an introduction to the Medical Implant Communication System]

Medical Implant Communication System (MICS)

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Medical Implant Communications Service (MICS) Standard

- Definition: The MICS is an ultra-low power radio service for the transmission of non-voice data for the purpose of facilitating diagnose and/or therapeutic functions.

- Frequency band: 402-405 MHz, shred with weather balloons/satellite telemetry (400-406 MHz). Hence, the output power is limited.

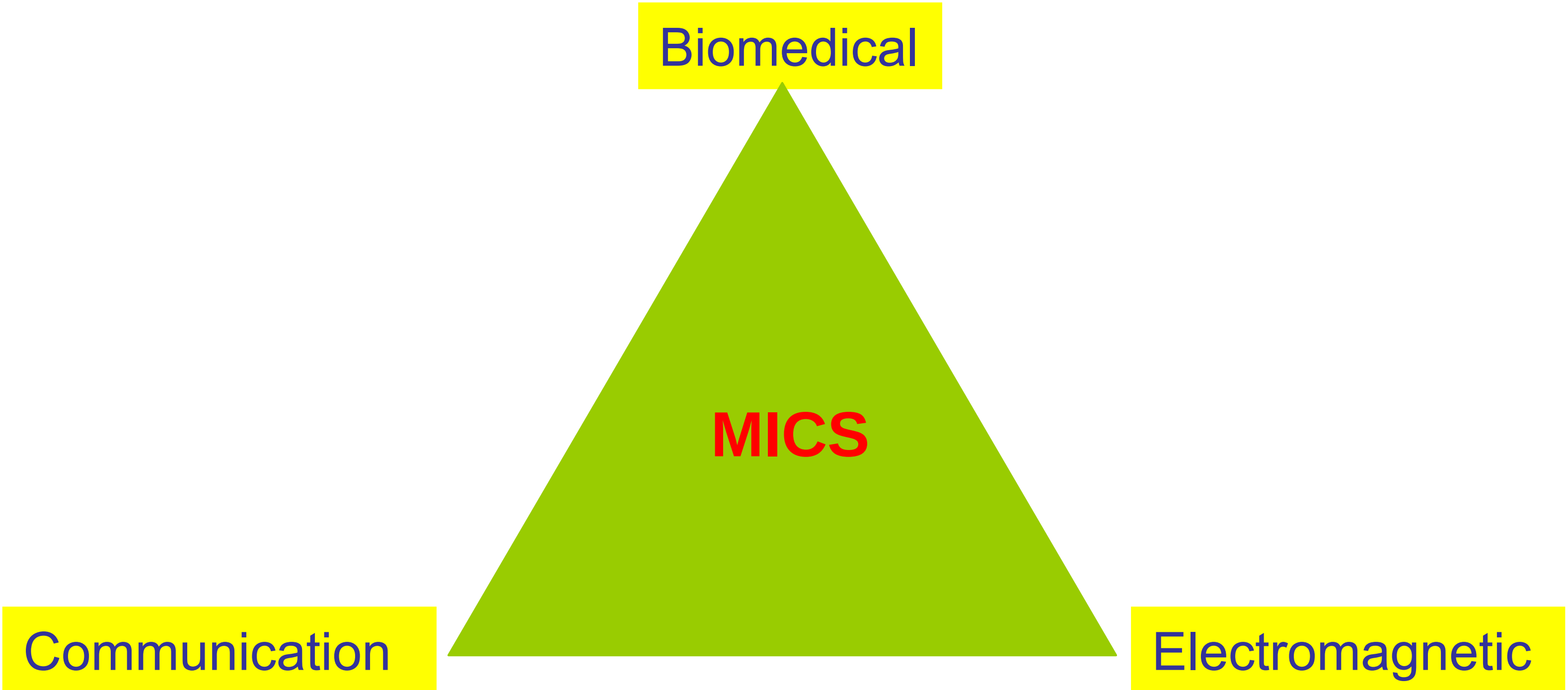
Medical Implant Communications Service Standard (cont.)

- ETSI (European Telecommunications Standards Institute): The output power is set to a maximum of 25 uW ERP.

- FCC & ITU-R: The output power is set to a maximum of 25 uW EIRP, which is 2.2 dB lower than the ERP level.

- The 25microwatts limit applies to the signal level outside of the body (total radiating system), which allows for implant power levels to be increased to compensate for body losses.

MICS Design Requirements



Communication Methods

1. Electromagnetic Method
   - Inductive link
   - RF link

2. Acoustic Method

   It uses ultrasound communication to read out data from an implanted device

3. Optical Method

   Since skin and tissue have a low, but nonzero transmission of visible light, communication to an implant device that is placed close to the skin could be possible

Wave Propagation in Biological Materials

- The antenna performance is affected by the material which an antenna is attached on it.
- At 403.5 MHz the wavelength in free space is 74 cm, but in the body is around 9 cm.
- We can not design the implant wireless device without investigating the electromagnetic properties of the body.
- The E & H-fields inside a dielectric tissue depend both on the depth and on the exact composition of the body.
- The exact field that an implant antenna operates will depend on the thickness of the skin and fat layers, which varies between individuals and with time.

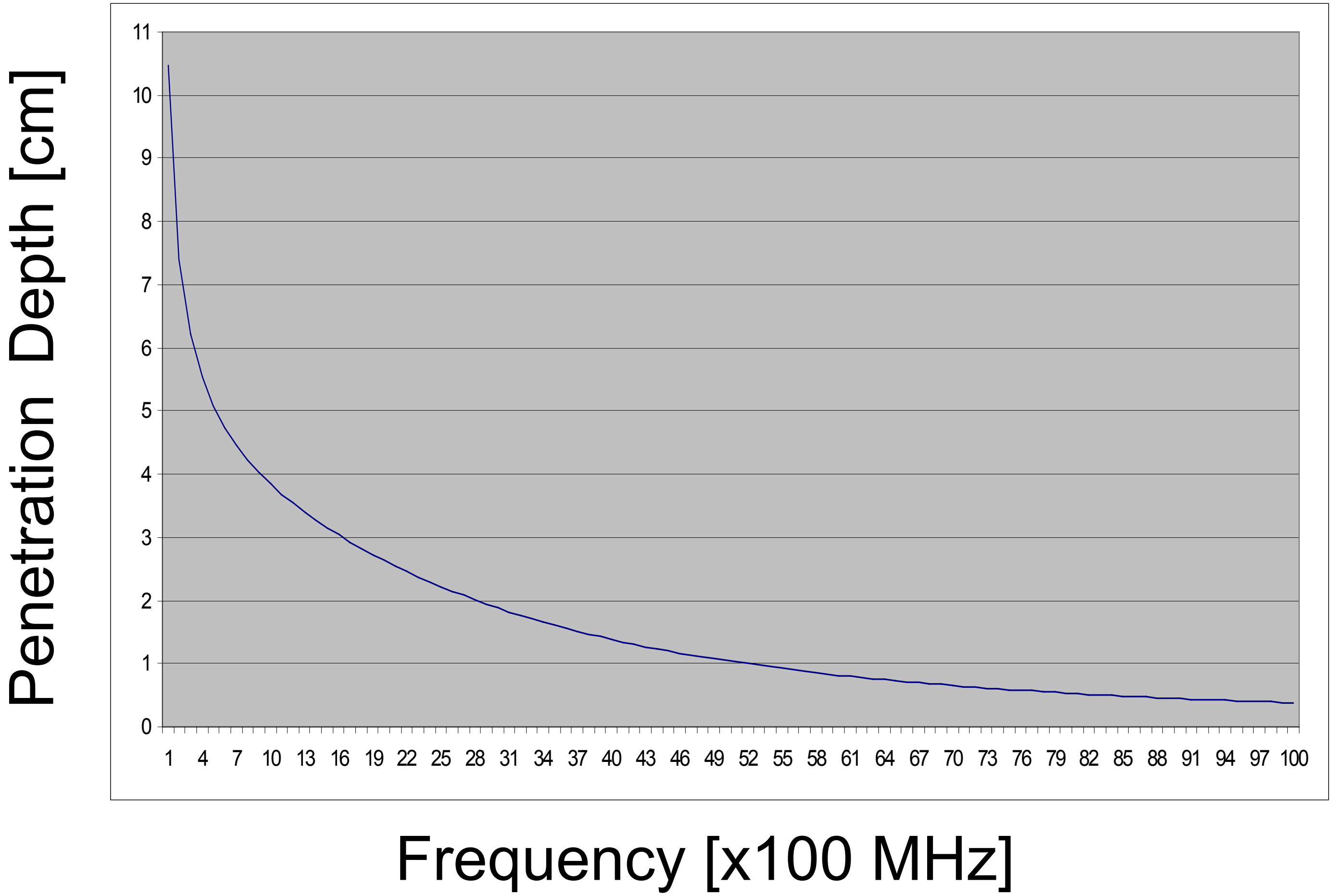
Influence of Body on Implant Device

1. The wavelength in the tissues is shorter, since the wave propagation speed is lowered.
2. The losses in the tissues will affect both the near-field and the wave propagation.
3. The efficiency of an antenna inside a body tissue is not obvious, as the far-field is attenuated to zero due to the losses.
4. The electromagnetic field from small antenna in a body material can be expressed in terms of the currents in the antenna.

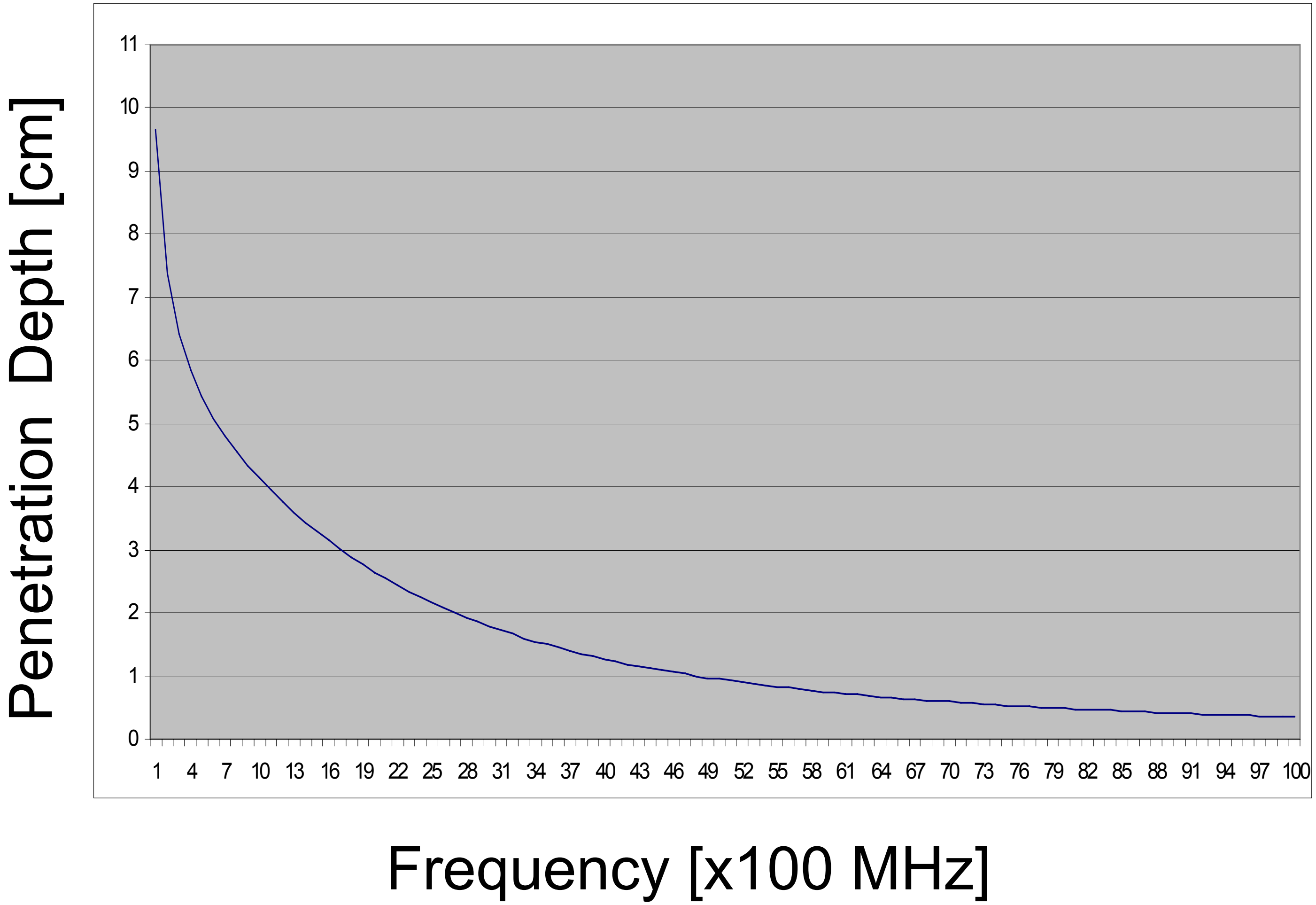
Placing a Medical Implant Device

- The area from the antenna to the point where the electromagnetic field forms ($R<\lambda/2\pi$) is called the near-field of the antenna.
- The area after the point ($R>\lambda/2\pi$) at which the electromagnetic field begins to separate from the antenna and wanders into space in the form of an electromagnetic wave is called the far-field.
- The near-field coupling is proportional to radiating element surface area, but the far-field transmission efficiency is maximized by matching the impedance of the radiating elements to free space.

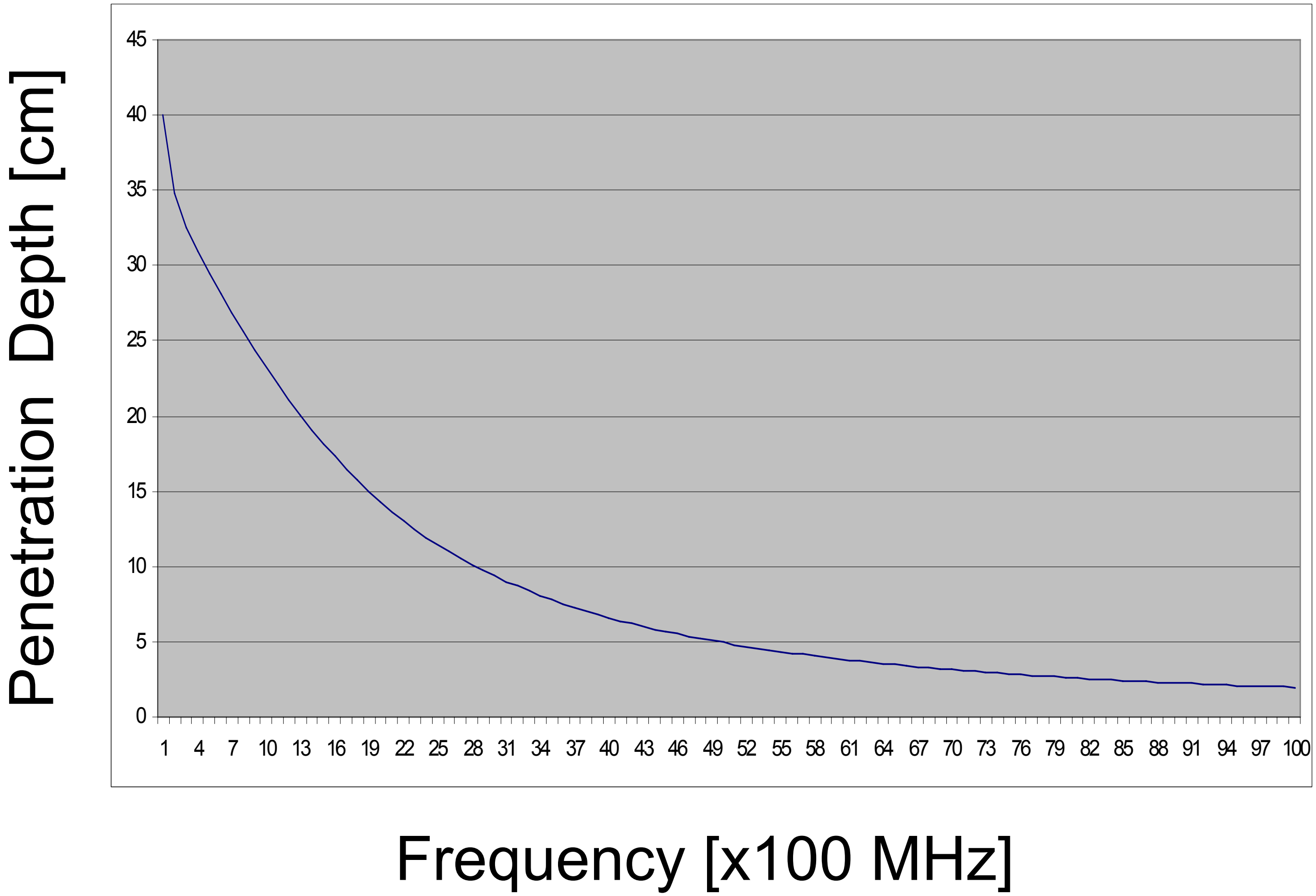
Penetration Depth of Dry Skin



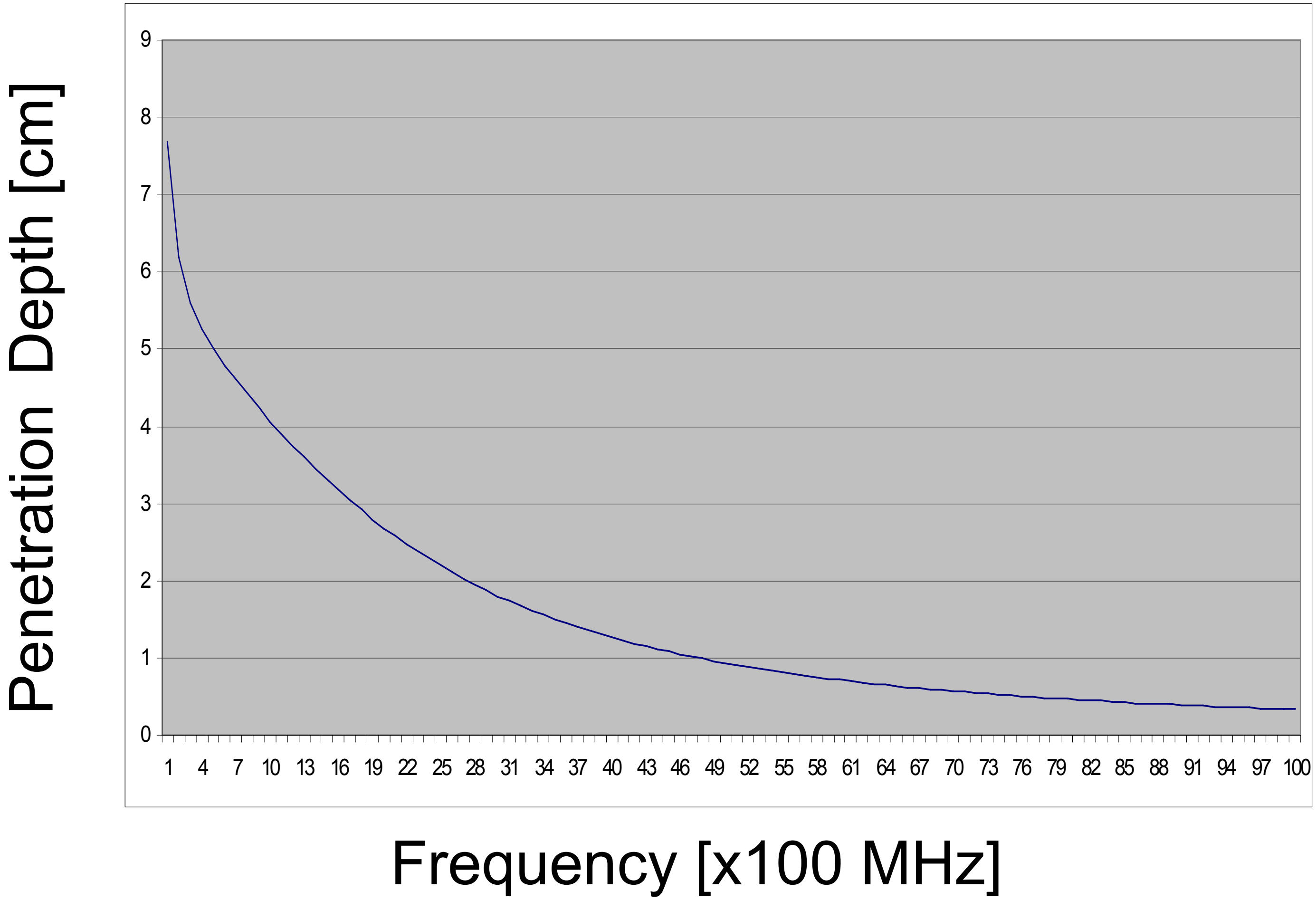
Penetration Depth of Wet Skin



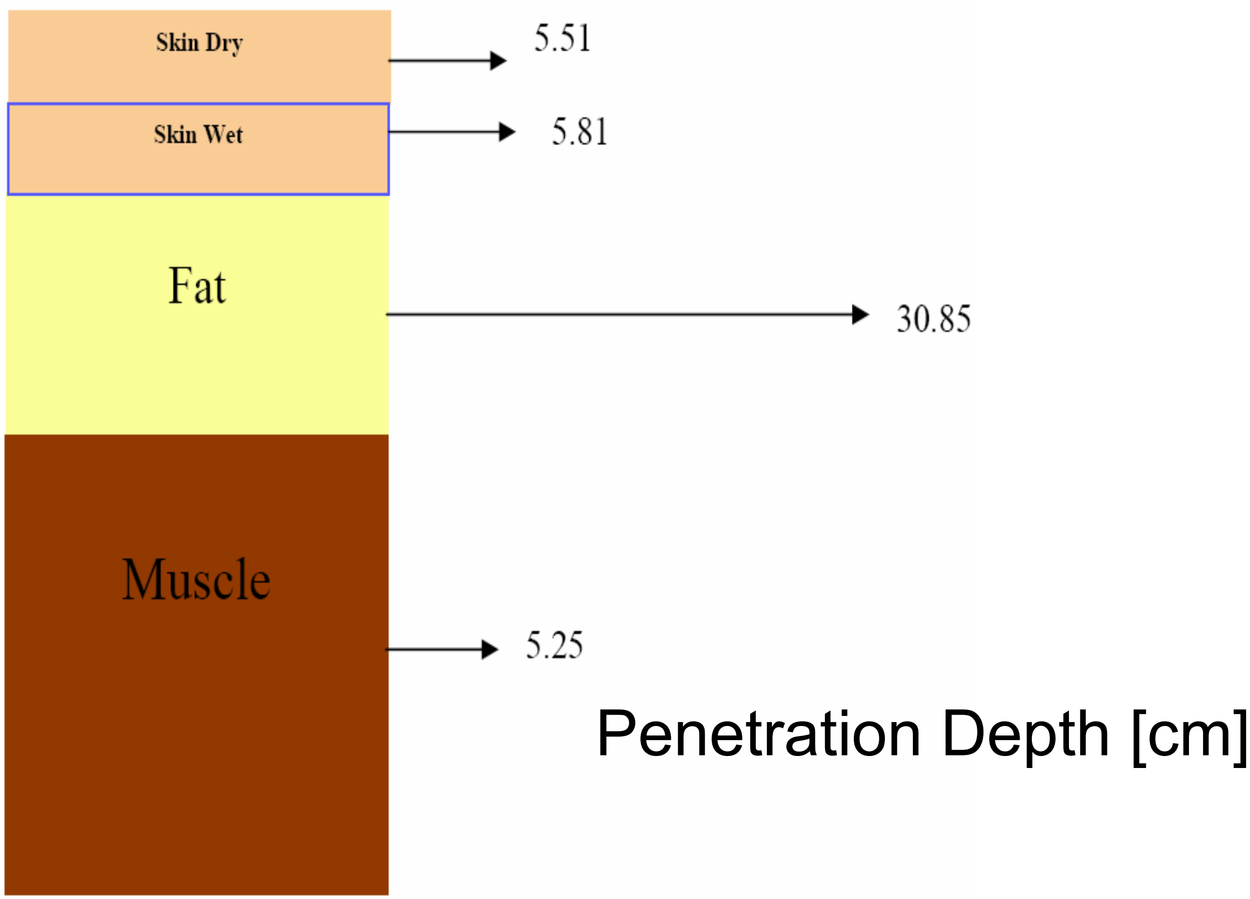
Penetration Depth of Fat



Penetration Depth of Muscle



Penetration Depth @ 403.5 MHz



Conclusion

Due to differences in the characteristics between wearable device and MICS, such as;

1- Frequency
2- Power
3- EMC issue
4- Channel Modeling

- A wearable type of BAN and an implanted type of BAN that is MICS have different requirement in propagation and SAR.
- Therefore, we should define different models in a channel and specifications in PHY but design the same MAC in order to maintain interoperability between these two types.