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Body-Coupled, wideband antennas

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Abstract

• In this paper we present antenna solutions for maximizing microwave energy release into the human body.

• Reflections from the body surface are avoided by coupling the antennas to the body using low-loss ceramic composites.

• Both 3D and 2D antenna topologies are explored for transcutaneous radar measurements.

• Coupled antennas combined with low-loss dielectric materials are explored for maximum energy transfer.

• A novel 3D printed, light-weighted and low-cost antenna is made for improved directivity and reduced interference.

• Reactive near-field loss of body-coupled antennas is reduced using low-loss ceramics.

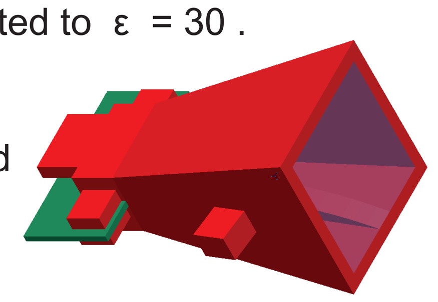
• Aiming at a multi-static radar instrument for functional brain mpedance imaging, a less challenging, single-radar instrument for left ventricle assessment is explored for antenna evalution in this paper.

• Simulations of 2D and 3D antennas as well as measured results of 2D antenna is provided.

Dual-Ridge Horn Antenna

• Body/skin dielectric constant approximated to $\varepsilon = 30$.

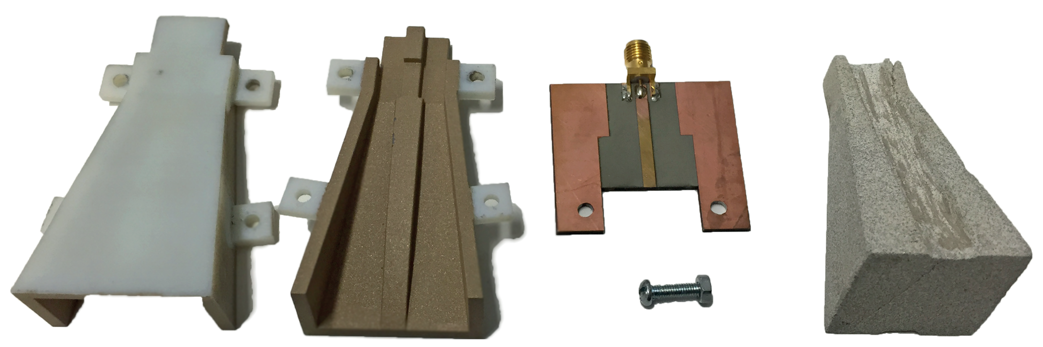
• 3D horn derivative structures are reduced to practical sizes for handheld instruments due to shorter wavelength in high ε material



• High signal loss and major interferences favoring a horn with good directionality and antenna gain

• low cost compared to metal horn

• Milling process of EccoStock material not mature resulting in air gaps between horn and filling material



3D printed horn with Eccostock HiK 500 $\varepsilon = 30$ copper/silver spray coating and PCB feed

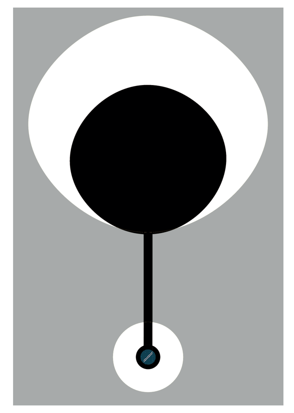
Elliptic patch

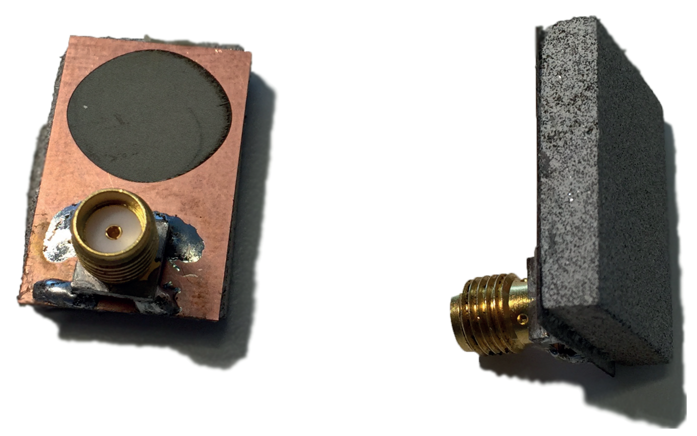
• The antenna is simple to fabricate on suitable PCB

• Small size compared to horn antennas smal

• With planar antennas the matching material is easily machined using a sectioning saw

• Low directivity





Planar elliptic patch on 0.25 mm low-loss substrate Eccostock HiK 500 $\varepsilon = 30$ matchin block 4 mm

Conclusion

• We have designed and evaluated both 2D and 3D antennas for release of wideband microwave energy in the human body

• A 3D printed double-ridged horn antenna is presented for optimal energy release of directional microwave energy with a center frequency of 3.8 GHz and a bandwidth of 2.5 GHz

• Interesting improvement of the patch antenna is observed with an insulating layer of low-loss, high dielectric insulator inserted between the body and the antenna. Based on these results an insulating layer separating antenna elements from the body surface is vital for efficient transfer of energy as well as avoiding undesirable frequency shift of backscattered signals.

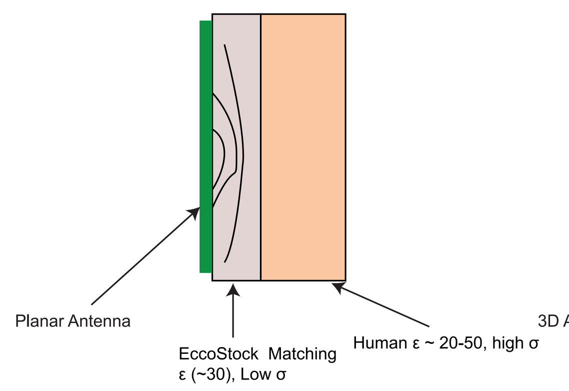
• Optimal antenna structures for brain imaging require further investigations.

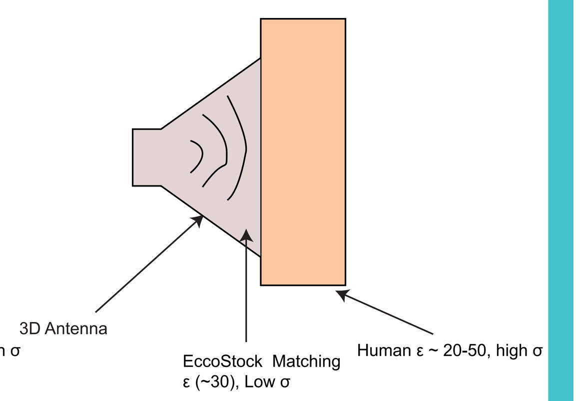
EM enery into human tissue

• Lossy human tissue in the reactive nearfield of the antenna reduce antenna efficiency

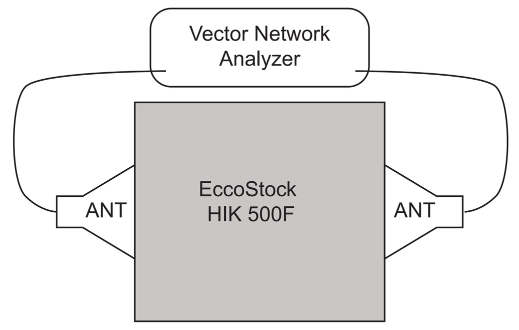
• With a low-loss matching material reactive near-field loading of the antenna. High-loss material in antenna near-field reduce efficiency drastically.

• Extending the dielectric properties of human skin towards antenna allows can reduce loading of planar antennas and 3D antenna structures without severe reflection of the skin.

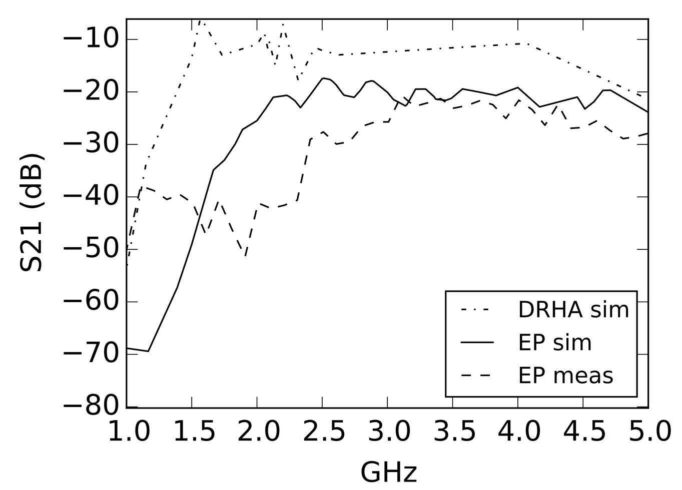




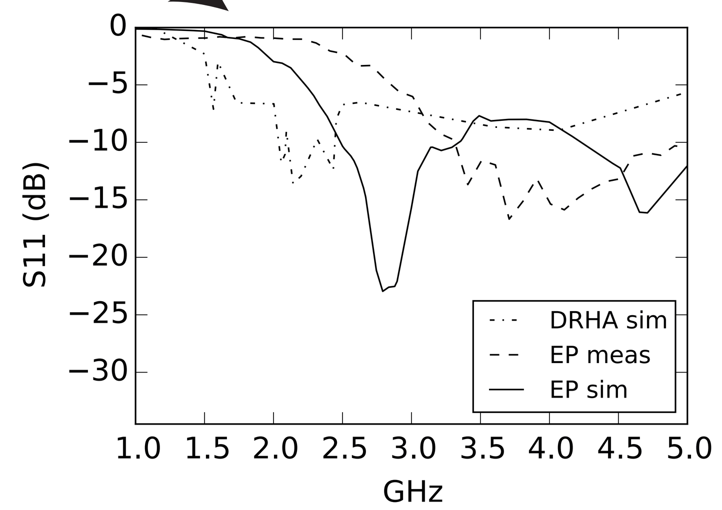
Simulations and measurements



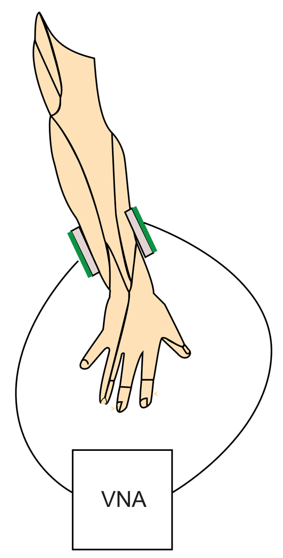
Simple and stable measurement setup using EccoStocck material and VNA



S21 trough 77 mm EccoStock boresight

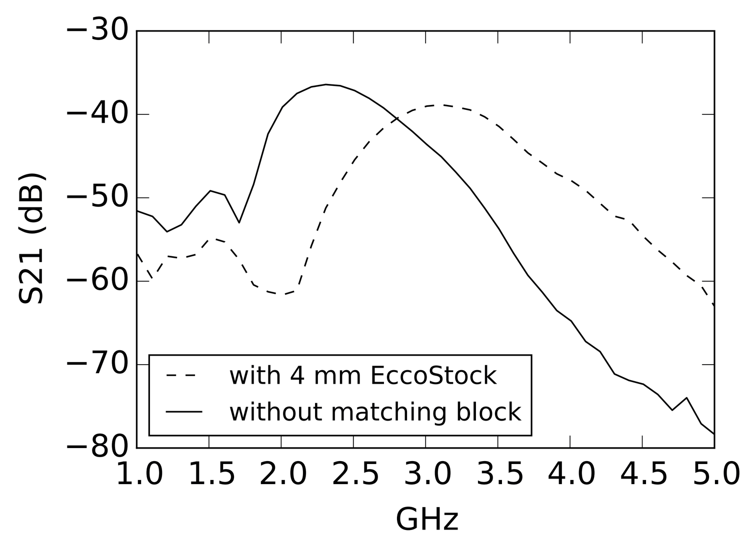


S11 on EcccoStock



The frequency respons of the antenna is shifted up with matching material. Due to less capacitive coupling from patch to ground plane.

The frequency dependent path-loss is not compensated in this plot



S21 trough lower forearm with/without EccoStock matching slab

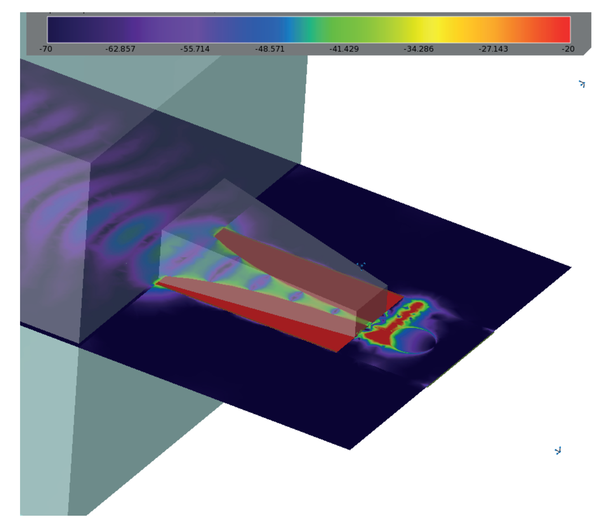
Ongoing and future work

• Development of planar antennas with higher gain by stacking patches and using array configurations

• Finding optimal thickness of matching materials for antenna head interface.

• Solve issues with filling complicated 3D stuctures with high permittivity matching material. We are looking into mixing high permittivity BariumTitante with other materials and mold the 3D structures.

• Use pcb based antennas with simple high permittivity dielectric horn structures which is easily cut using sectioning saw.



Vivaldi PCB antenna with pyramid shaped Eccostock dielectric guide simulation.

Acknowledgment

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