



Metamaterial-Inspired Highly Compact Wearable Antenna for 406 MHz Cospas-Sarsat Personal Locator Beacons (PLBs)

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Contents

- Background: Cospas-Sarsat
- Wearable Electronics
- Specific Absorption Rate Issue
- Proposals in Literature
- The Simulation
- Results and Discussion

Background: Cospas-Sarsat

- Search and Rescue Satellite Communication System
- Covers the whole world
- >67.000 people are rescued
- International organization
- 406 MHz frequency channel



References

- [1] W. Wang and S. Wang, "Overview of the international satellite-based COSPAS-SARSAT system," Space Information Networks (SINC 2018), CCIS 972, pp. 52–61, 2019, doi: 10.1007/978-981-13-5937-8_7.

Wearable Electronics

- Emerging technology since 1990s
- Dual-Use technology
- Focusing on miniaturization & flexibility
- Highlights the embroidered electronics



References

[6] P. Salonen and Y. Rahmat-Samii, "Textile antennas: Effects of antenna bending on input matching and impedance bandwidth," *IEEE Aerospace and Electronic Systems Magazine*, vol. 22(12), pp. 18–22, Jan. 2008, doi: 10.1109/MAES.2007.4408597.

Specific Absorption Rate (SAR)

- SAR limit of **1.6 W/kg** over 1g of human tissue for **head / torso**

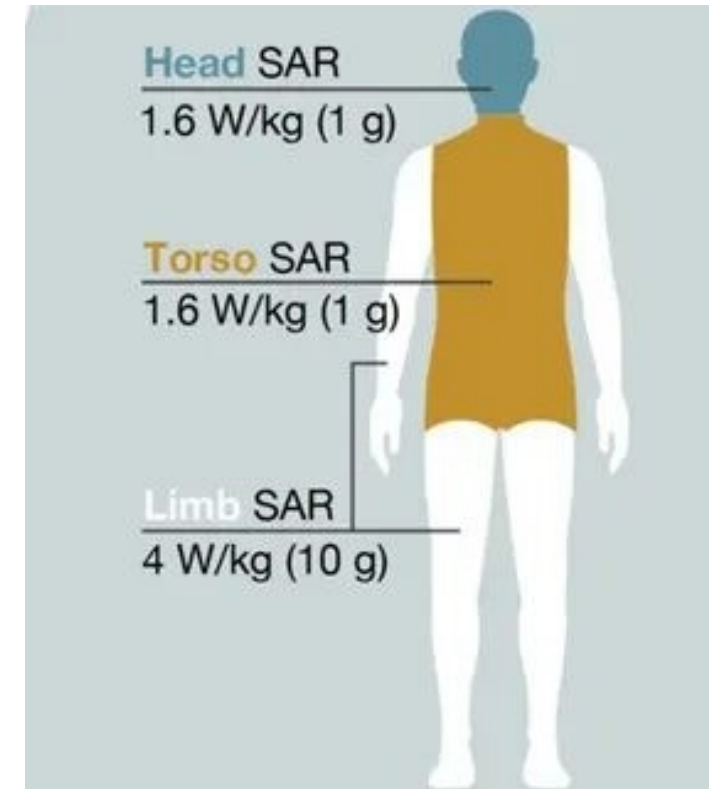


References

- [6] P. Salonen and Y. Rahmat-Samii, "Textile antennas: Effects of antenna bending on input matching and impedance bandwidth," IEEE Aerospace and Electronic Systems Magazine, vol. 22(12), pp. 18–22, Jan. 2008, doi: 10.1109/MAES.2007.4408597.
- [7] Y. Hao et al., "Antennas and propagation for body centric wireless communications," IEEE/ACES International Conference on Wireless Communications and Applied Computational Electromagnetics 2005, pp. 586-589, April 2005, doi: 10.1109/WCACEM.2005.1469656.

Specific Absorption Rate (SAR)

- SAR limit of **1.6 W/kg** over 1g of human tissue for **head / torso**
- SAR limit of **4.0 W/kg** over 1g of human tissue for **limbs**



References

- [6] P. Salonen and Y. Rahmat-Samii, "Textile antennas: Effects of antenna bending on input matching and impedance bandwidth," IEEE Aerospace and Electronic Systems Magazine, vol. 22(12), pp. 18–22, Jan. 2008, doi: 10.1109/MAES.2007.4408597.
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Proposals in Literature

- *Aldrigo (2013)*: Magneto-dielectric substrates
- *Karmakar (2020)*: Fractal designs

References

[3] M. Aldrigo et al., “Numerical and experimental characterization of a button-shaped miniaturized UHF antenna on magneto-dielectric substrate,” *International Journal of Microwave and Wireless Technologies*, vol. 5, special issue 3, pp. 231–239, 2013, doi: 10.1017/S1759078713000445.

[4] A. Karmakar, “Fractal antennas and arrays: a review and recent developments,” *International Journal of Microwave and Wireless Technologies*, vol. 13, pp. 173–197. July 2020, doi: 10.1017/S1759078720000963

Proposals in Literature

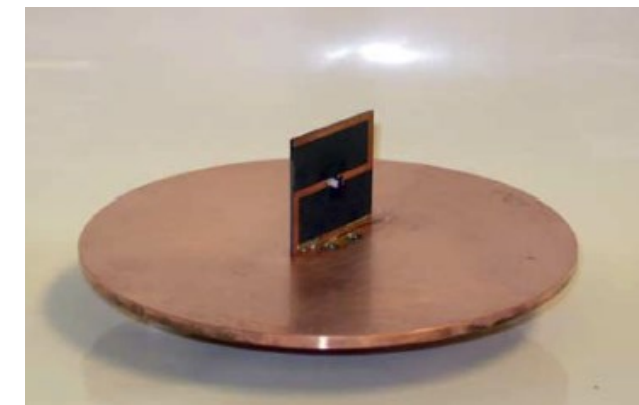
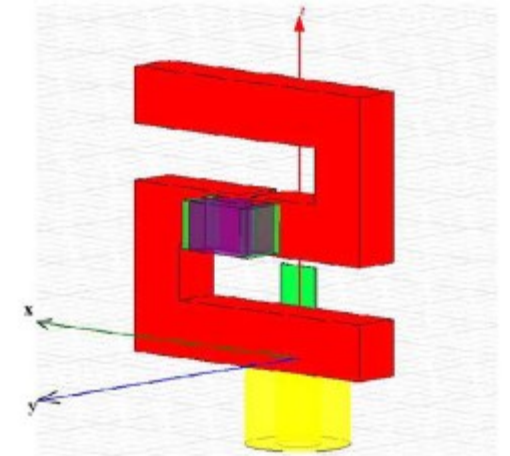
- *Aldrigo (2013)*: Magneto-dielectric substrates
- *Karmakar (2020)*: Fractal designs
- *Ziolkowski (2005)*: Meta-material inspired design

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- [3] M. Aldrigo et al., “Numerical and experimental characterization of a button-shaped miniaturized UHF antenna on magneto-dielectric substrate,” *International Journal of Microwave and Wireless Technologies*, vol. 5, special issue 3, pp. 231–239, 2013, doi: 10.1017/S1759078713000445.
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- [5] R. W. Ziolkowski, “An Efficient, electrically small antenna designed for VHF and UHF applications,” *IEEE Antennas and Wireless Propagation Letters*, vol. 7, pp. 217-220, Feb. 2008, doi: 10.1109/LAWP.2008.921635.

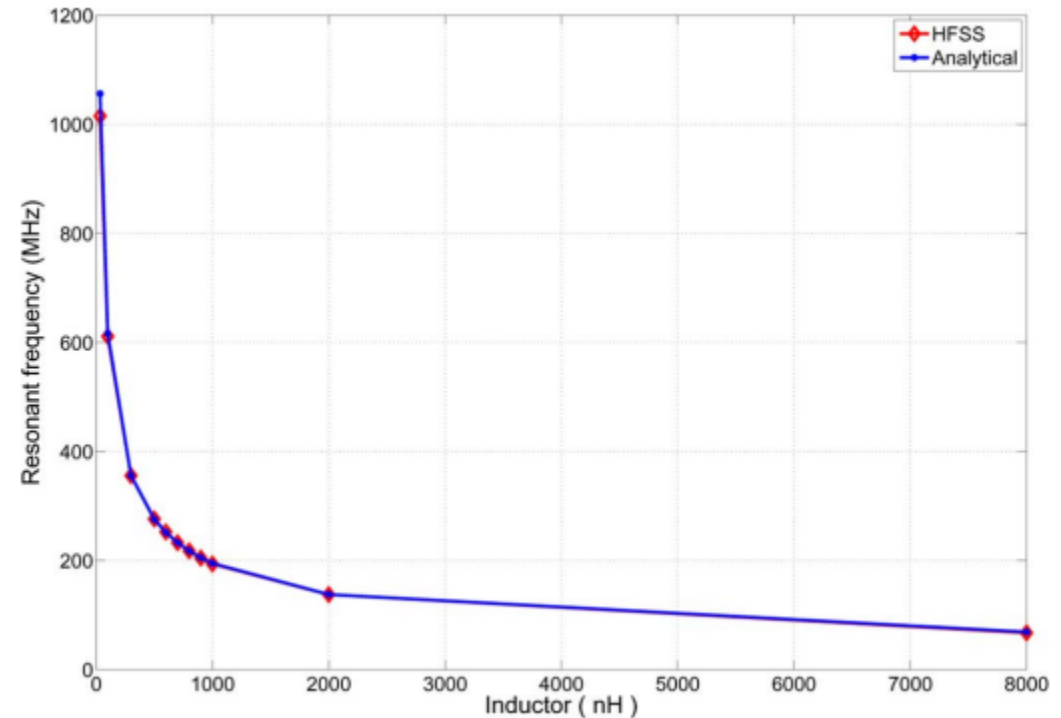
Ziolkowski's Proposal

- R. Ziolkowski proposes:
 - **Ultra-miniaturization**
 - **Coaxial fed monopole**
 - **Parasitic lumped inductor inside near-field of the monopole**
 - **Lumped element provides metamaterial inspired behaviour**



Ziolkowski's Proposal

$$f_r = \frac{1}{2\pi} \frac{1}{\sqrt{L_{eff}C_{eff}}}$$



References

- [5] R. W. Ziolkowski, "An Efficient, electrically small antenna designed for VHF and UHF applications," *IEEE Antennas and Wireless Propagation Letters*, vol. 7, pp. 217-220, Feb. 2008, doi: 10.1109/LAWP.2008.921635.
- [8] R. W. Ziolkowski, P. Jin, J. A. Nielsen, M. H. Tanielian, and C. L. Holloway, "Experimental verification of Z antennas at UHF frequencies," *IEEE Antennas and Wireless Propagation Letters*, vol. 8, pp. 1329-1333, Oct. 2009, doi: 10.1109/LAWP.2009.2038180.
- [9] P. Jin and R. W. Ziolkowski, "Broadband, efficient, electrically small metamaterial-inspired antennas facilitated by active near-field resonant parasitic elements," *IEEE Antennas and Wireless Propagation Letters*, vol. 8, no. 2, pp. 318-327, Feb. 2010, doi: 10.1109/TAP.2009.2037708.

The Simulation

Our simulation focuses on:

- **Wearable Electronics** Implementation
- **Suitability** for Cospas-Sarsat 406 MHz

References

- [7] Y. Hao et al., "Antennas and propagation for body centric wireless communications," IEEE/ACES International Conference on Wireless Communications and Applied Computational Electromagnetics 2005, pp. 586-589, April 2005, doi: 10.1109/WCACEM.2005.1469656.
- [11] X. Jin, C. Hua, Z. Lu, and L. Liu, "A Metamaterial-inspired RFID tag antenna" 2019 International Conference on Microwave and Millimeter Wave Technology (ICMMT), May. 2019, pp. 1-3, ISBN: 978-1-7281-2168-0.

The Simulation

Our simulation focuses on:

- **Wearable Electronics** Implementation
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By using:

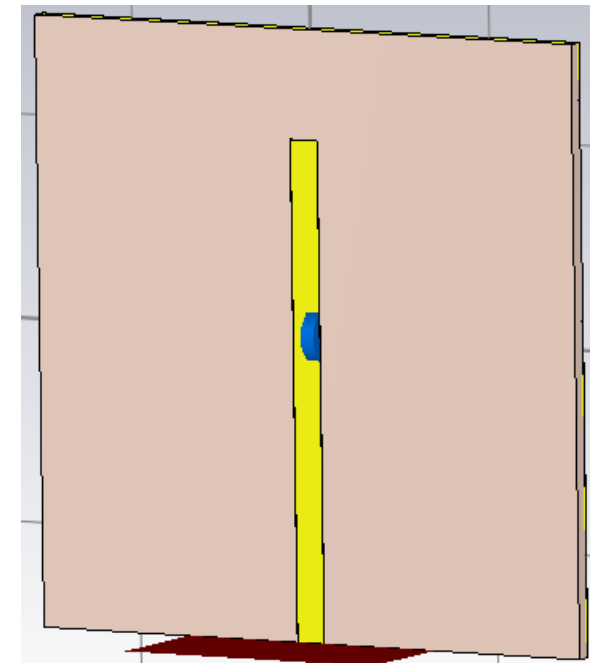
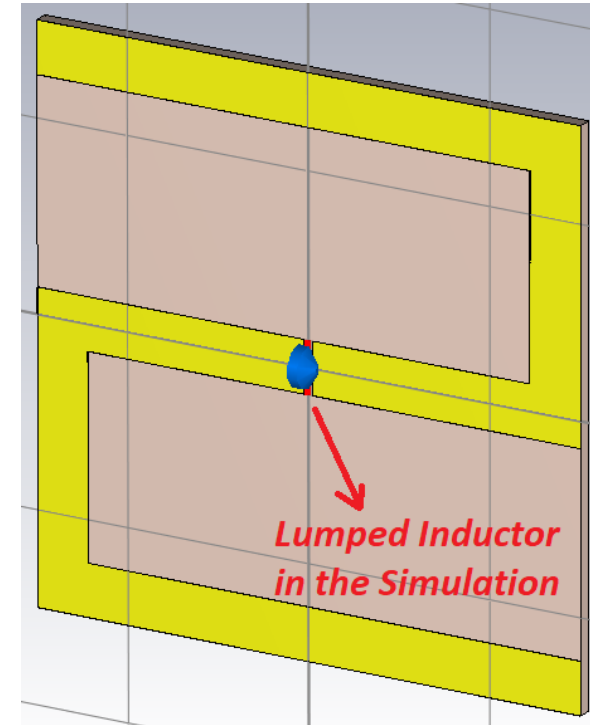
- Flexible **Polyimide** substrate ($\epsilon_r = 3.5$)
- **Inductor** of 60 nH

References

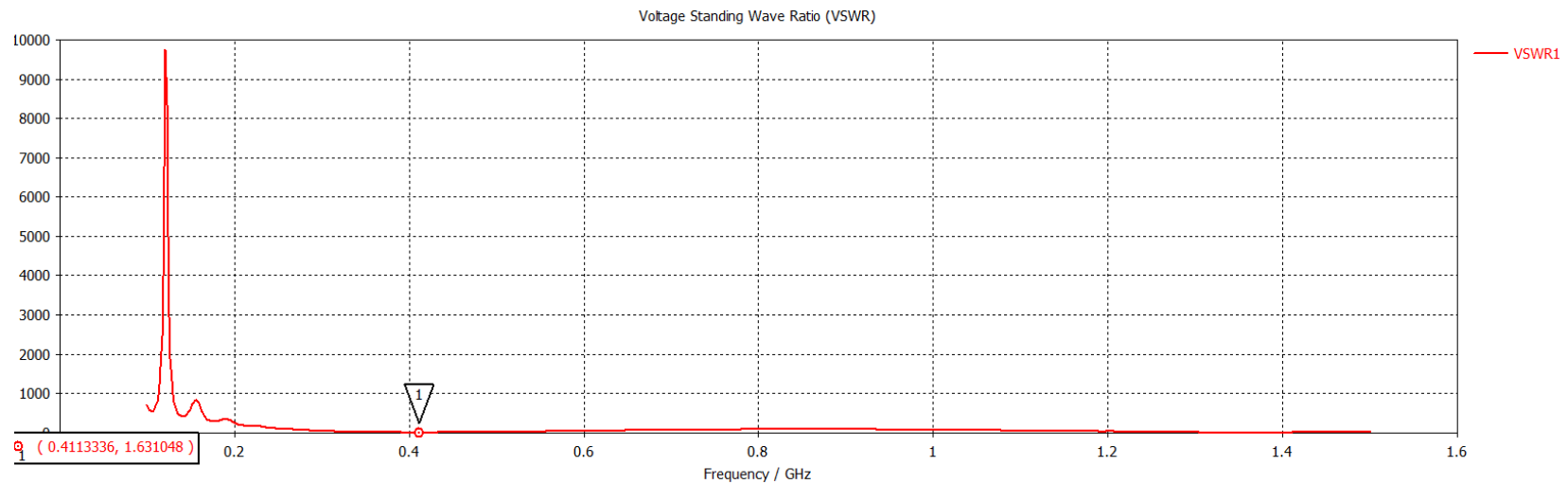
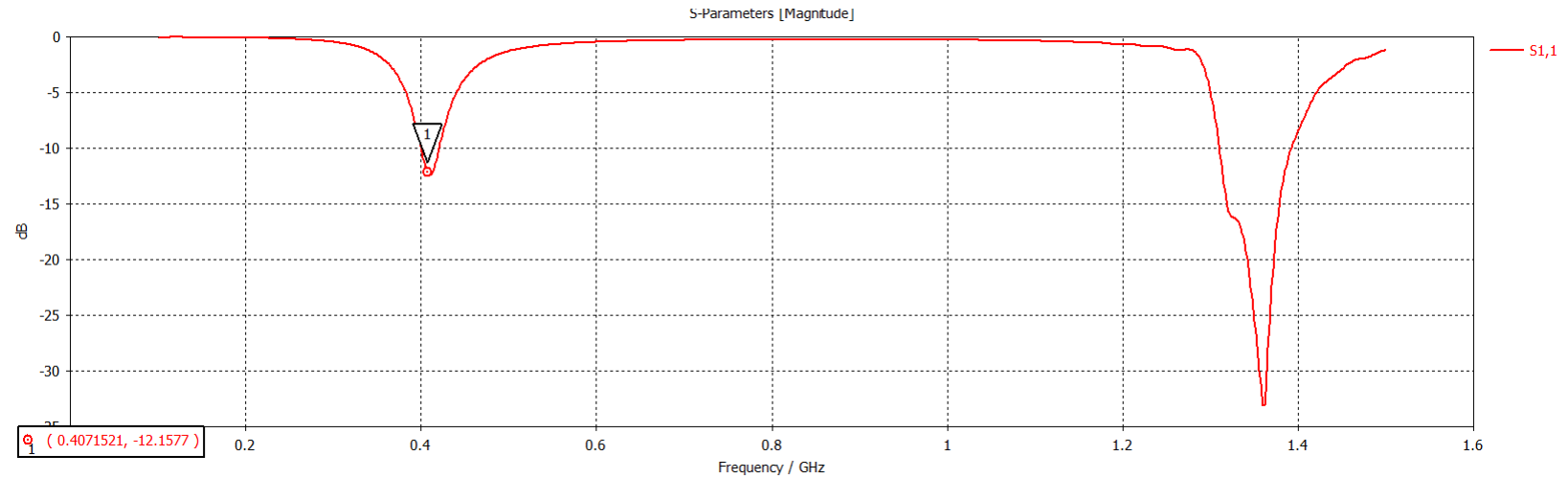
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The Simulation

- **Operating Frequency:** 406 MHz
(*Narrow-band Emergency Beacon channel*)
- **Width:** 30 mm
- **Length:** 30 mm
- **Thickness:** 0.5 mm

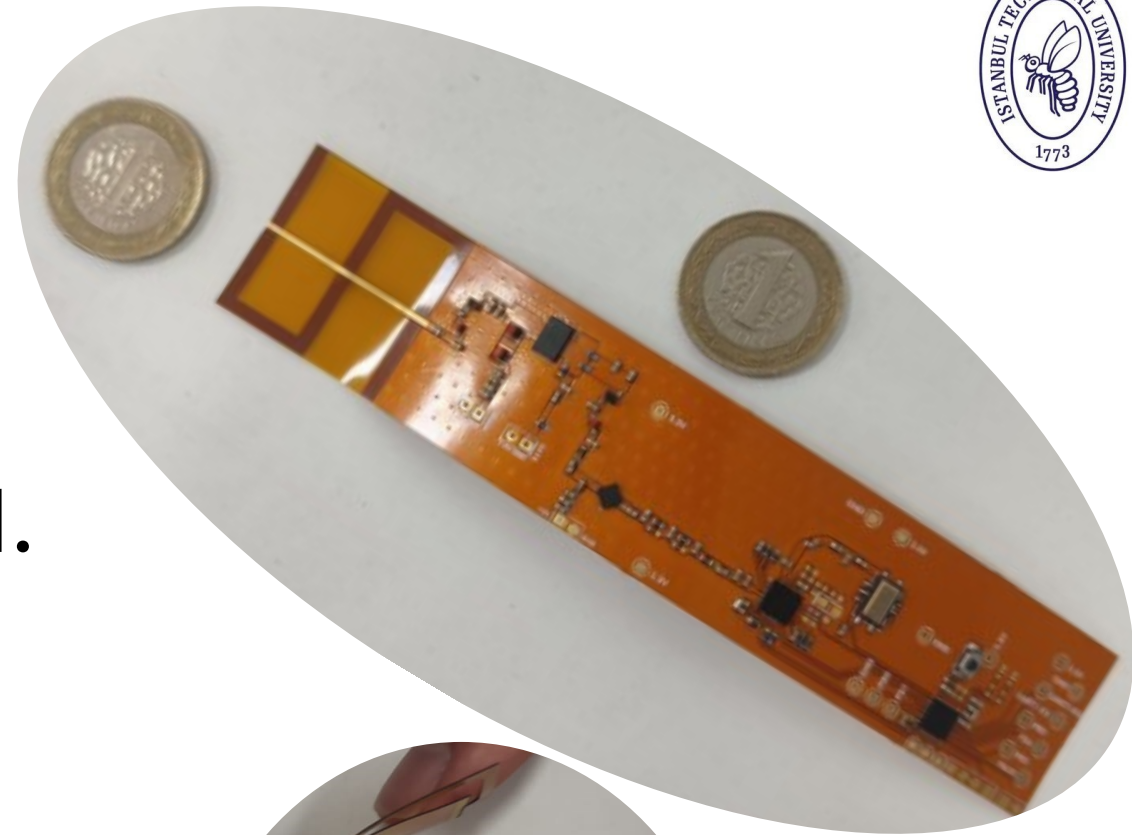


Results and Discussion



Further Studies

- **Suitability for Implementation** is provided.
- The **wearable emergency beacon** is manufactured
- Antenna radiation analysis for the **wearable emergency beacon** will be provided.



Thanks! / *Teşekkürler!*

THANK YOU FOR LISTENING.

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