Electromagnetic vector sensors

An, Delie

2009

An, D. (2009, March). Electromagneti vector sensors. Presented at Discover URECA @ NTU poster exhibition and competition, Nanyang Technological University, Singapore.

https://hdl.handle.net/10356/94472

NANYANG TECHNOLOGICAL UNIVERSITY

URECA

Undergraduate Research Experience on CAmpus

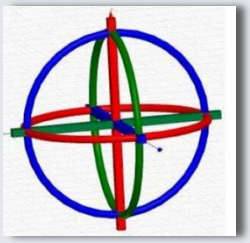
Category: 3
Project ID: EEE08038
Student: An Delie
School of Electrical and Electronic Engineering

ELECTROMAGNETIC VECTOR SENSORS

Introduction

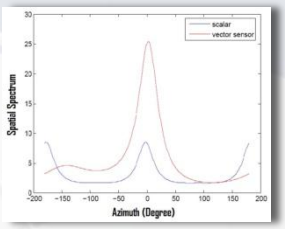
A vector sensor consists of three orthogonal dipoles and three orthogonally oriented loops.

- It measures direction of arrival (DOA).
- It measures all six components of incident electromagnetic wave; hence, all available degrees of freedom are exploited.
- It performs better than scalar array antennas in terms of accuracy.

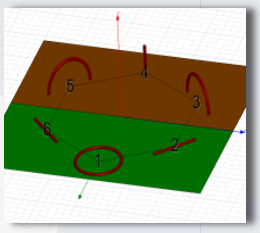


An ideal vector sensor

A vector sensor by Orbit FR



Vector V.S. scalar antenna

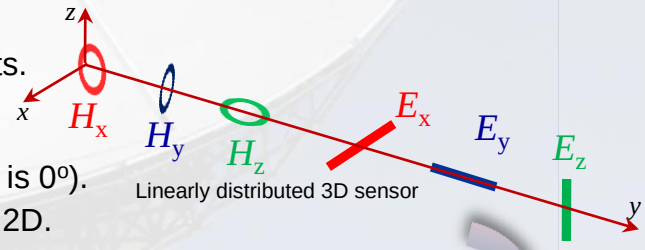


Circularly distributed 3D sensor

Distributed Vector Sensors

Why distributed?

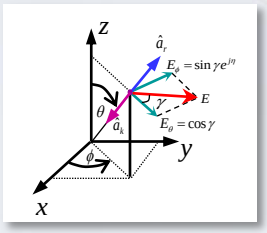
- Impossibility to fabricate the collocated 6 components at a single point in space.
- Strong mutual coupling among the components.

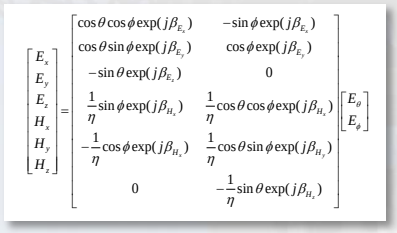


Linearly distributed 3D sensor

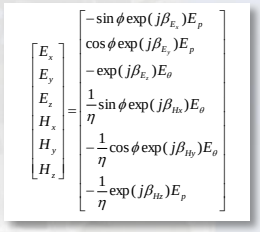
Low Grazing Angle Applications

- The zenith angle, θ is 90º (the elevation angle is 0º).
- The 3D transformation formula is simplified to 2D.

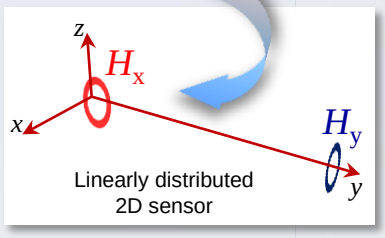




$$\begin{bmatrix} E_x \\ E_y \\ E_z \\ H_x \\ H_y \\ H_z \end{bmatrix} = \begin{bmatrix} \cos\theta\cos\phi\exp(j\beta_{E_x}) & -\sin\phi\exp(j\beta_{E_x}) \\ \cos\theta\sin\phi\exp(j\beta_{E_y}) & \cos\phi\exp(j\beta_{E_y}) \\ -\sin\theta\exp(j\beta_{E_z}) & 0 \\ \frac{1}{\eta}\sin\phi\exp(j\beta_{H_x}) & \frac{1}{\eta}\cos\theta\cos\phi\exp(j\beta_{H_x}) \\ -\frac{1}{\eta}\cos\phi\exp(j\beta_{H_y}) & \frac{1}{\eta}\cos\theta\sin\phi\exp(j\beta_{H_y}) \\ 0 & -\frac{1}{\eta}\sin\theta\exp(j\beta_{H_z}) \end{bmatrix} \begin{bmatrix} E_\theta \\ E_\phi \end{bmatrix}$$

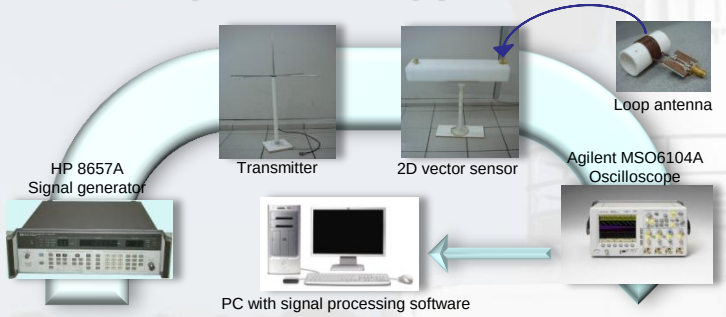


$$\begin{bmatrix} E_x \\ E_y \\ E_z \\ H_x \\ H_y \\ H_z \end{bmatrix} = \begin{bmatrix} -\sin\phi\exp(j\beta_{E_x})E_p \\ \cos\phi\exp(j\beta_{E_y})E_p \\ -\exp(j\beta_{E_z})E_\theta \\ \frac{1}{\eta}\sin\phi\exp(j\beta_{Hx})E_\theta \\ -\frac{1}{\eta}\cos\phi\exp(j\beta_{Hy})E_\theta \\ -\frac{1}{\eta}\exp(j\beta_{Hz})E_p \end{bmatrix}$$

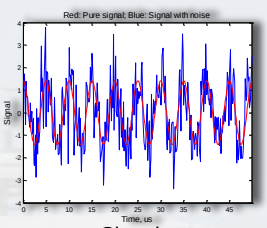


Linearly distributed 2D sensor

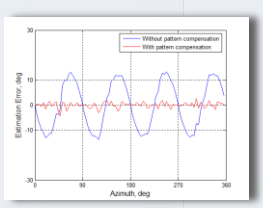
Experiment Apparatus



Simulated Result



Signals



Incident angles and errors

Project Title: Study of Electromagnetic Vector Sensors for Low Grazing Angle Source Localization
Supervisor: Prof LU Yilong