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Basic Principles and Potential Applications of Holographic Microwave Imaging

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Series Editors' Preface

Biomedical and Nanomedical Technologies (B&NT)
This **concise** monograph series focuses on the implementation of various engineering principles in the conception, design, development, analysis and operation of biomedical, biotechnological and nanotechnology systems and applications. The primary objective of the series is to compile the latest research topics in biomedical and nanomedical technologies, specifically devices and materials.

Each volume comprises a collection of invited manuscripts, written in an accessible manner and of a concise and manageable length. These timely collections will provide an invaluable resource for initial enquiries about technologies, encapsulating the latest developments and applications with reference sources for further detailed information. The content and format have been specifically designed to stimulate further advances and applications of these technologies by reaching out to the non-specialist across a broad audience.

Contributions to *Biomedical and Nanomedical Technologies* will inspire interest in further research and development using these technologies and encourage other potential applications. This will foster the advancement of biomedical and nanomedical applications, ultimately improving healthcare delivery.

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Abstract

This monograph offers comprehensive descriptions of the most important principles so far proposed for far-field holographic microwave imaging—including reconstruction procedures and imaging systems and apparatus—enabling the reader to use microwaves for diagnostic purposes in a wide range of applications. This hands-on resource features:

- A review of the existing medical imaging methods-including theory, apparatus and challenges, introducing some new medical imaging techniques.
- A review of the existing microwave imaging techniques-including theory, apparatus, medical applications and challenges, written from an engineering perspective and with notations.
- Currently proposed holographic microwave imaging technique-including reconstruction procedures and imaging systems and apparatus-enabling the reader to use microwaves for diagnostic purposes in a wide range of applications.
- A discussion of practical applications with detailed descriptions and discussions of several specific examples (e.g., imaging dielectric object, small inclusion detection, and medical applications).
- A conclusion of the proposed holographic microwave imaging technique and discussions of future research directions.

List of Symbols and Abbreviations

Symbols

k_0	Free-space propagation
k_b	Wavenumber of host medium
$\varepsilon(s)$	Complex relative permittivity distribution inside the dielectric object
ε_b	Relative permittivity of the host medium
ε_∞	Infinite frequency dielectric constant
ε_s	Static dielectric constant
ε_0	Permittivity of free-space
ε^*	The complex dielectric constant
τ	Characteristic relaxation time of the medium
σ	Conductivity of the tissue
ω	Angle frequency
E_{inc}	Incident electric field
E_{scat}	Backscattered electric field
$E_{tot}(s)$	Total electric field at a point inside the object with position vector, **s**
E_0	Wave amplitude of TE_{10} mode at within waveguide aperture
λ_b	Wavelength in the host medium
$\hat{R}$	Unit vector parallel to the vector R
R	Position vector from a point in the object to the selected receiver
R	Distance from a point in the object to the receiver
R_0	Distance from a point in the object to the transmitter
A	Narrow aperture dimension of antenna aperture
B	Broad aperture dimension of antenna aperture
$b(\theta,\varnothing)$	Radiation pattern function
$P(\theta,\varnothing)$	Polarization vector
$H_0^2(k_bR)$	Zero-order Hankel function of the second type with argument k_bR
$H_1^2(k_bR)$	First-order Hankel function of the second type with argument k_bR
dA	Differential area element
$[I]$	Identity matrix
$[M]$	Square matrix
D	Baseline vector
ΔS	Small area element

Abbreviations

2D	Two Dimensional
3D	Three Dimensional
BLOD	Blood Oxygen Level Dependent
CSF	Cerebral Spin Fluid
CT	Computed Tomography
EM	Electromagnetic
HMI	Holographic Microwave Imaging
IFFT	Inverse Fast Fourier Transform
IHM	Indirect Holography Microwave
MIST	Microwave Imaging Via Space Time
MoM	Method of Moment
MRI	Magnetic Resonance Imaging
ORWA	Open-ended Rectangular Waveguide Antenna
PET	Positron Emission Tomography
SNR	Signal Noise Ratio
TSAR	Tissue Sensing Adaptive Radar
US	Ultrasound
UWB	Ultra-Wideband
VNA	Vector Network Analyzer