

EBG Directive Antennas

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2nd Part :

Conformal EBG structures

1 – Theory of conformal periodic structures
2 – Applications of conformal periodic structures

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Introduction

Applications of cylindrical periodic structures

- High Impedance Surfaces
Kildal et al.

Sievenpiper et al.

- Directive antennas
Kildal et al.

Z. Ying

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Planar EBG structures

2nd Part :

Conformal EBG structures
Cylindrical EBG antennas

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1 – Theory of conformal periodic structures

I. Introduction
II. Extraction of cylindrical surface characteristics
III. Example : surface of metallic wires
IV. Radially periodic structure
V. Conclusion

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Introduction

Cylindrical wave source

Bragg mirror

Incident wave
Transmitted wave
Reflected wave

⇒ Method applied to cylindrical structure

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I. Introduction

Characterization of a FSS

Plane surface

Cylindrical surface

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I. Introduction

Presence of a radial periodicity in the cylindrical case \Rightarrow deduce from 4 coefficients the 4 unknowns $T_o, R_o, T_i, R_i \Rightarrow r, t, r', t'$

Incident wave coming from center

Incident wave coming from outside

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II. Extraction of cylindrical surface characteristics

a) Wave coming from center

Outside :

$$T_o = t \sum_{n=0}^{+\infty} r^n r_c^{-n} \exp(-jn2\eta_0(kC)) = \frac{t}{1 - r.r_c \exp(-j2\eta_0(kC))}$$

$$\eta_0(kC) = \arctan\left(\frac{N_0(kC)}{J_0(kC)}\right)$$

Inside :

$$R_o = \frac{1 + r \exp(-j2\eta_0(kC) + j2\eta_0(kD))}{1 - r.r_c \exp(-j2\eta_0(kC))}$$

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II. Extraction of cylindrical surface characteristics

b) Wave coming from outside

Outside :

$$R_i = 1 + r' \exp(-j2\eta_0(kE) + j2\eta_0(kC)) + \frac{t' r_c \exp(-j2\eta_0(kE))}{1 - r.r_c \exp(-j2\eta_0(kC))}$$

Inside :

$$T_i = \frac{t'(1 + r_c \exp(-j2\eta_0(kD)))}{1 - r.r_c \exp(-j2\eta_0(kC))}$$

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II. Extraction of cylindrical surface characteristics

c) Extraction of (r, t) and (r', t')

$$r = \frac{R_o - 1}{(r_c R_o + B_D^*) B_C} \quad t = T_o (1 - r.r_c B_C)$$

$$B_C = \exp(-2j\eta_0(kC)) \quad B_D^* = \exp(2j\eta_0(kD)) \quad \eta_0(kC) = \arctan\left(\frac{N_0(kC)}{J_0(kC)}\right)$$

$$t' = \frac{(1 - r.r_c B_C) T_i}{1 + r_c B_D} \quad r' = \frac{1}{B_E B_C^*} \left(R_i - 1 - \frac{t.t' r_c B_E}{1 - r.r_c B_C} \right)$$

$$B_E = \exp(-2j\eta_0(kE)) \quad B_D = \exp(-2j\eta_0(kD)) \quad B_C^* = \exp(2j\eta_0(kC))$$

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III. Example : surface of metallic wires

N : number of metallic wires

a : wire diameter (mm)

P_θ : angular period (rad)

P_t = P_θ * C : transversal period (mm)

C : cylinder radius (mm)

Metallic wires

For this example we will calculate T_o, R_o, T_i and R_i by classical method of scattering

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III. Example : surface of metallic wires

a) Wave coming from center

$$E_{tot}(\rho) = E_{inc}(\rho) + \sum_{n=1}^N K_n E_{dn}(\rho)$$

Incident field

Scattered field

$$E_{inc}(\rho) = H_0^2(k\rho)$$

Because of the symmetry :

$$\sum_{n=1}^N K_n E_{dn}(\rho) = K \sum_{n=1}^N E_{dn}(\rho)$$

$$K = - \frac{E_{inc}(\rho)}{\sum_{n=1}^N E_{dn}(\rho)} \Big|_{\rho=C+a/2}$$

$$E_d(\rho) = H_0^2 \left(k \sqrt{C^2 + \rho^2 - 2C\rho \cos\left(\frac{(i-1)2\pi}{N}\right)} \right) \text{ for } a \ll \lambda$$

$$T_o = \frac{E_{tot}(\rho)}{E_{inc}(\rho)}, \rho \geq C + P_t$$

$$R_o = \frac{E_{tot}(\rho)}{E_{inc}(\rho)}, \rho \leq C - P_t$$

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III. Example : surface of metallic wires

b) Wave coming from outside

Incident wave

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III. Example : surface of metallic wires

b) Wave coming from outside

Incident field plus field reflected by center

$$E_{tot}(\rho) = E_{inc}(\rho)(1 + r_c \exp(-2j\eta_0(k\rho))) + \sum_{n=1}^N K_n E_{dn}(\rho)$$

Scattered field

$$E_{inc}(\rho) = H_0^2(k\rho)$$

Because of the symmetry :

$$\sum_{n=1}^N K_n E_{dn}(\rho) = K \sum_{n=1}^N E_{dn}(\rho)$$

$$K = - \frac{E_{inc}(\rho)(1 + r_c \exp(-2j\eta_0(k\rho)))}{\sum_{n=1}^N E_{dn}(\rho)} \Big|_{\rho=C+a/2}$$

$$E_d(\rho) = H_0^2 \left(k \sqrt{C^2 + \rho^2 - 2C\rho \cos\left(\frac{(i-1)2\pi}{N}\right)} \right) \text{ for } a \ll \lambda$$

$$R_i = \frac{E_{tot}(\rho)}{E_{inc}(\rho)}, \rho \geq C + P_t$$

$$T_i = \frac{E_{tot}(\rho)}{E_{inc}(\rho)}, \rho \leq C - P_t$$

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III. Example : surface of metallic wires

c) Parametric study

Radius C constant

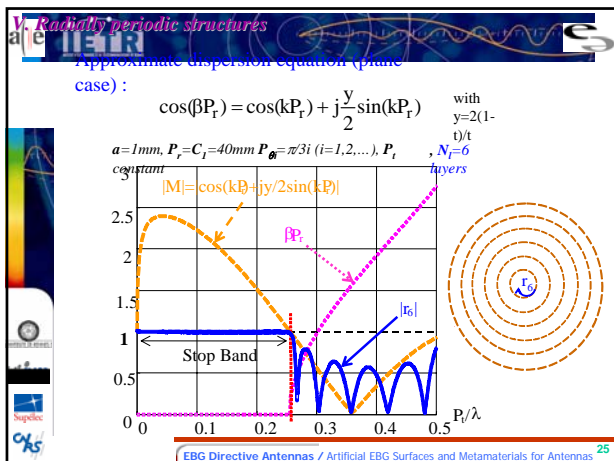
P_{θ1} = π/3

P_{θ2} = π/6

C=40mm, a=1mm

P_t < π/2 ⇒ |r'|, |t'|

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VII. Conclusion

Cylindrical surface characteristics

New method and formulas are proposed

Characteristics are constant if transversal period is constant

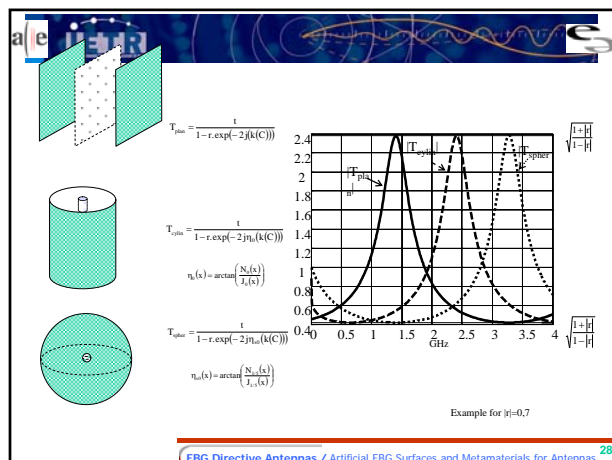
Multiple layer structures

Dispersion equation

Perspectives

Radome, High Impedance Surface, Directive antennas

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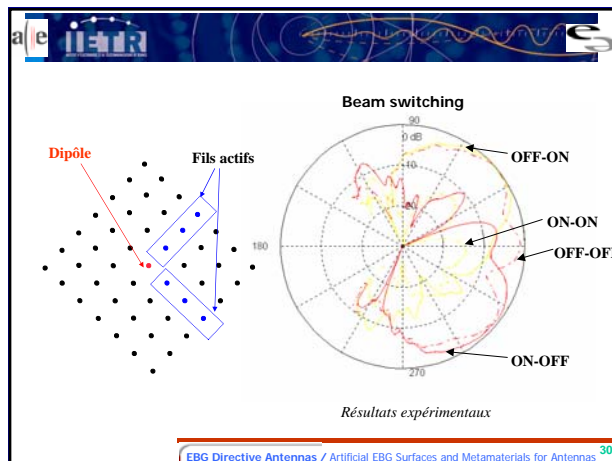
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VII. 2. Projet RNRT

Principe

Source

Station de base

Défauts programmables

diodes

Diodes ouvertestiges discontinues (l'onde passe)

Diodes ferméestiges continues (l'onde ne passe pas)

Faisceau tournant sur 360° avec une commande par tension continue.

Bande GSM/IMTS : 0,89-0,96GHz.
1,77-1,92GHz; 2,11-2,17GHz

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Beam-steering (2/3):

① **Distribution of wires:**

- **Azimuthally distribution:**
 - Constant angle:
 - Number of wire identically over each layer
 - Simple controlled system
 - Probe matching more difficult
 - Constant azimuth step:
 - Beam shape and back radiation level
 - Probe matching
 - Complex controlled system
- **Number of cylindrical layers:**
 - Beam shape and back radiation level
 - Probe matching

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VII. 2. Projet RNRT

Antenne d'excitation : monopôle

Plan de masse

$D_1=22.8\text{mm}$

$H_1=57\text{mm}$

$H_2=7.6\text{mm}$

$H_3=3\text{mm}$

$D_2=1.27\text{mm}$

$S_{11}(\text{dB})$

Fréquence (GHz)

— mesure

..... Simulation FDTD

Bandes GSM

Bande UMTS

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VII. 2. Projet RNRT

Premier prototype

Tige métallique

supports

monopôle

Plan de masse

$D_1=12\text{mm}$

$H_1=30\text{mm}$

$H_2=2\text{mm}$

$H_3=5\text{mm}$

$D_2=1.27\text{mm}$

Diagramme plan H à 2,5GHz

monopôle

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VII. 2. Projet RNRT

Deuxième prototype

Géométrie

- Diodes ouvertes
- Diodes fermées

$P_0=16^\circ$

$C=100\text{mm}$

$\epsilon=1.2$

Tige métallique

Diamètre $a=2\text{mm}$

Adaptation

$S_{11}(\text{dB})$

GHz

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