ダイポールの電気的透明化とその応用

Electrically Invisible Dipole and Its Applications

飯草 恭一(Kyoichi Iigusa)　**06D13015**

電子電気工学科

安藤・廣川研究室

目次

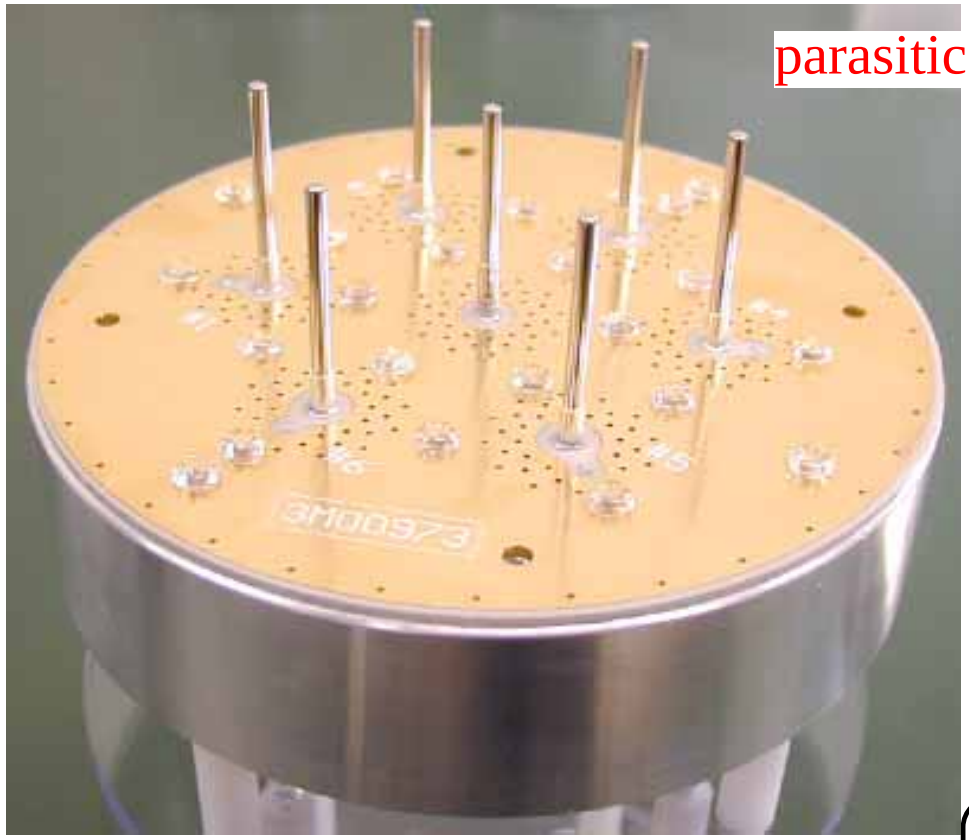
- ベクトル実効長の法則
- ダイポールの電気的透明化
  - リコンフィギャラブルアンテナ
  - アドミタンスの近似計算法
  - アドミタンスの規則性

2006/6/29

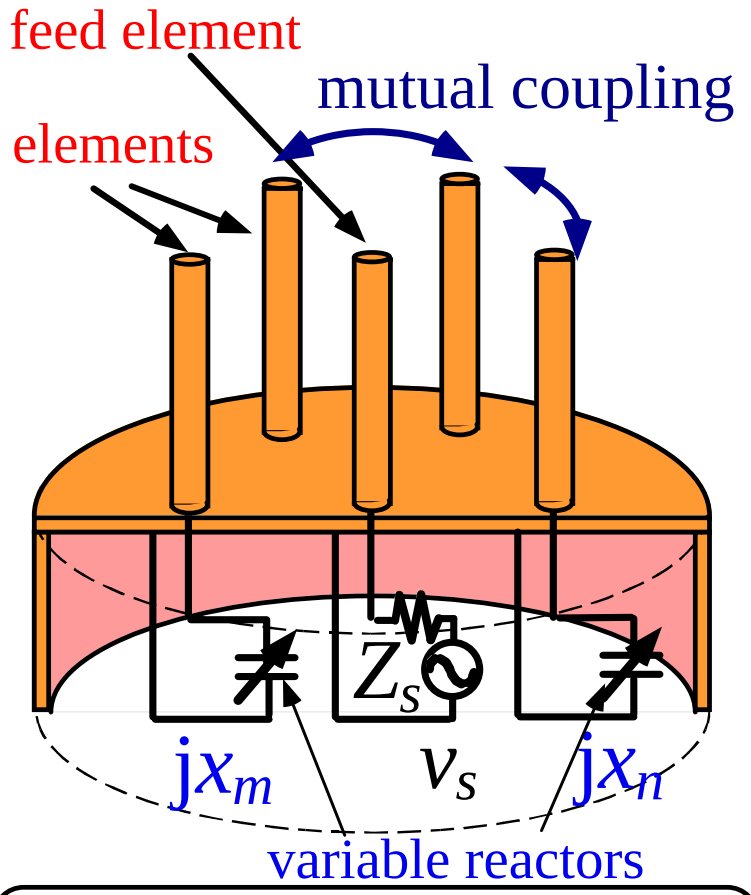
ベクトル実効長の法則

Law of Vector Effective Length

Electronically Steerable Parasitic Array Radiator Antenna



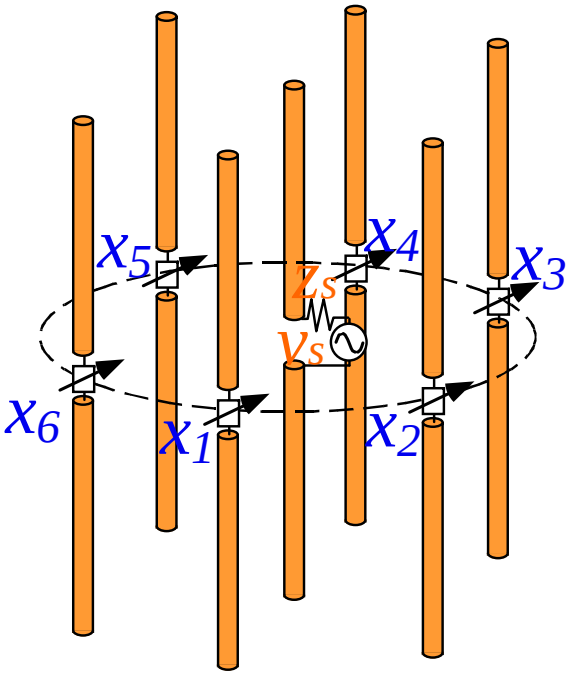
the radiation pattern can be varied by reactance control



small, lightweight, economical, and power-saving

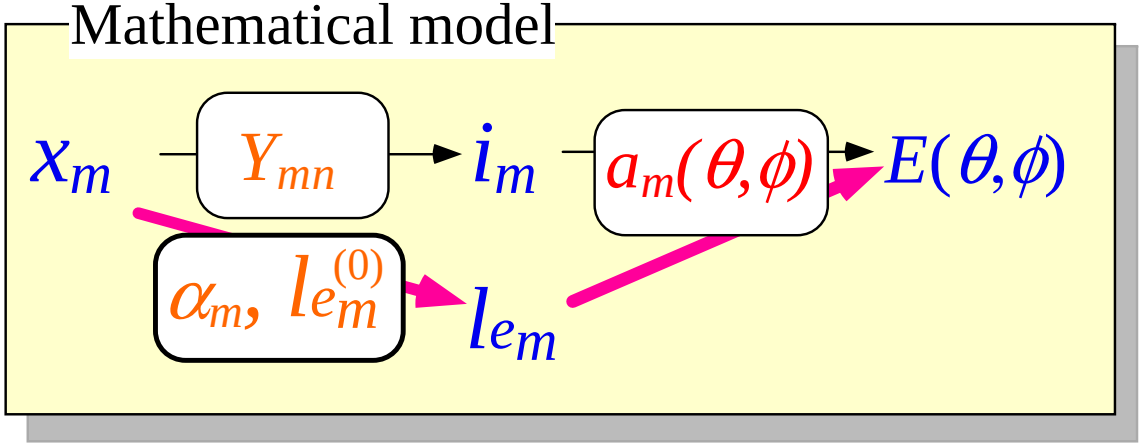
[5] T. Ohira and J. Cheng, "Analog smart antennas", Adaptive Antenna Arrays, ISBN3-540-20199-8, Berlin: Springer Verlag, 2004.

Vector Effective Lengths as Weight



$$[i_m]=([Y_{mn}]^{-1}+\mathrm{diag}[z_s,\mathrm{j}x_1,\mathrm{j}x_2,..,\mathrm{j}x_M])^{-1}[v_s]$$

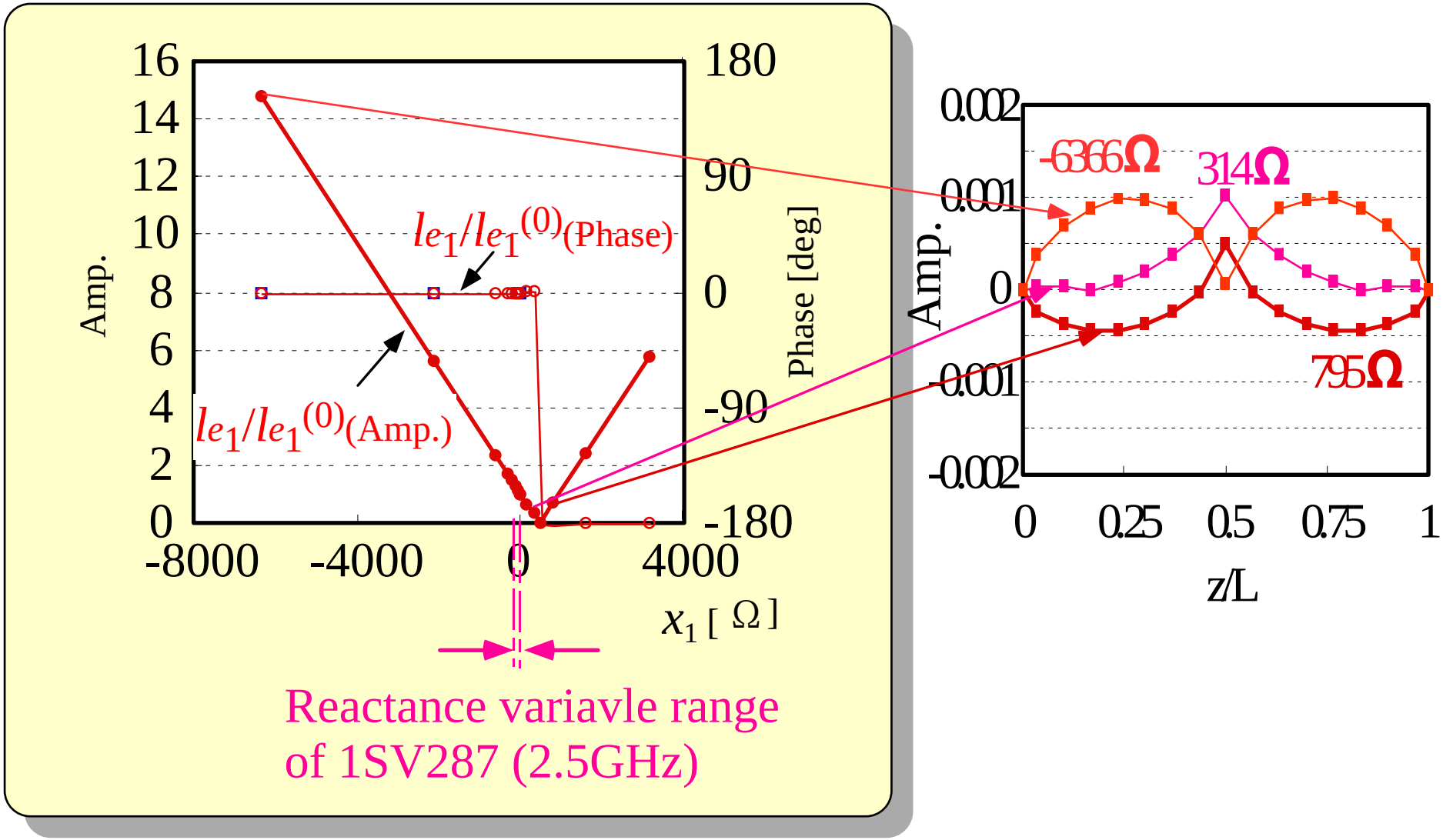
Mathematical model



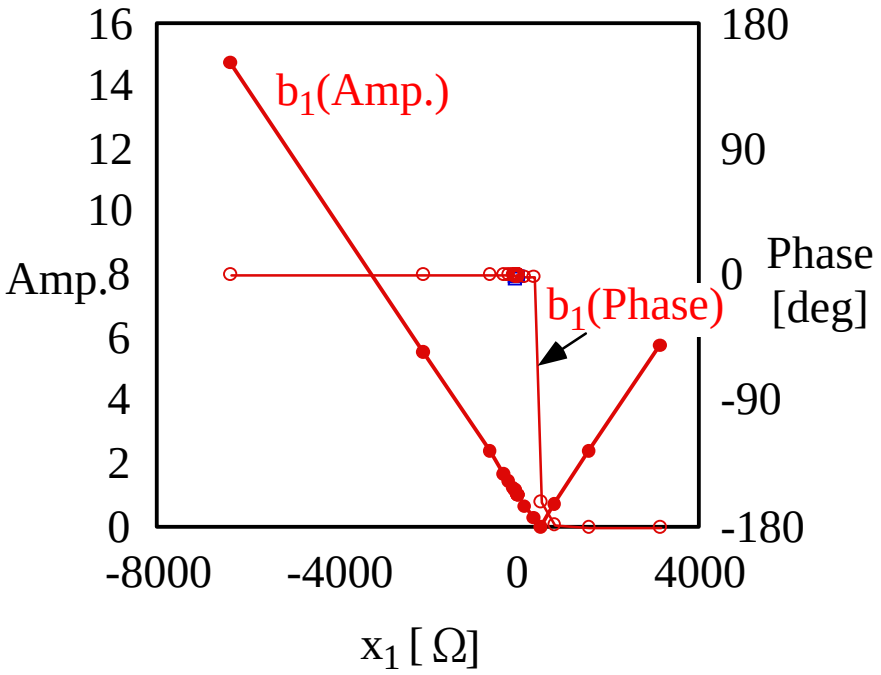
$$E(\theta,\phi)=-\mathrm{j}\,\frac{Z_0 \sin\theta\, e^{-\mathrm{j}kr}}{2\lambda r}\sum_{m=0}^{M} i_m l_{e_m} a_m(\theta,\phi)$$

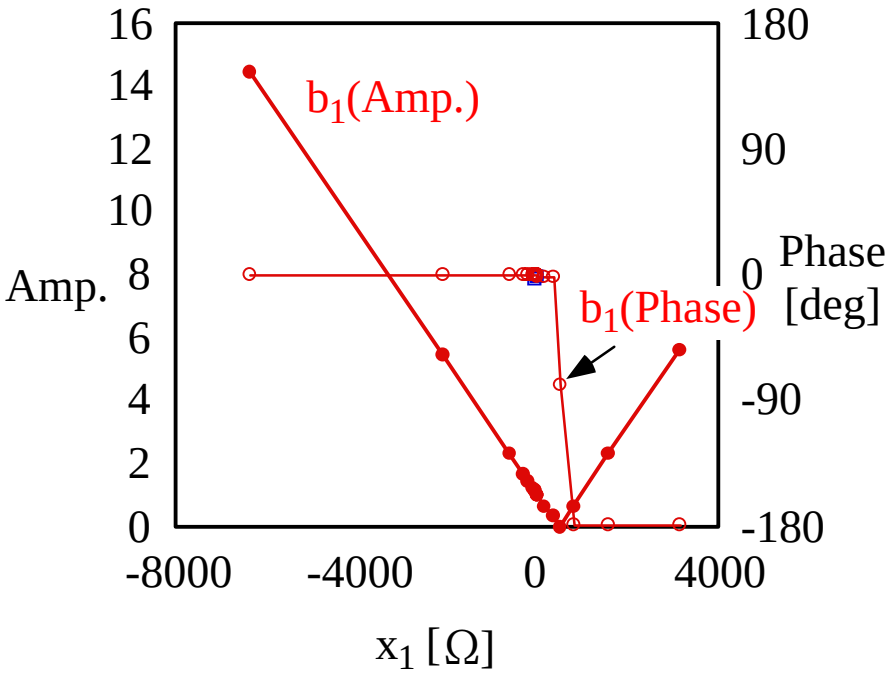
Current Distribution

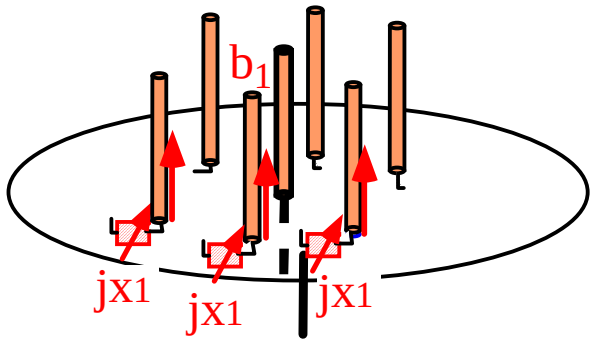
$le_m/le_m^{(0)}$ dependence on x_1

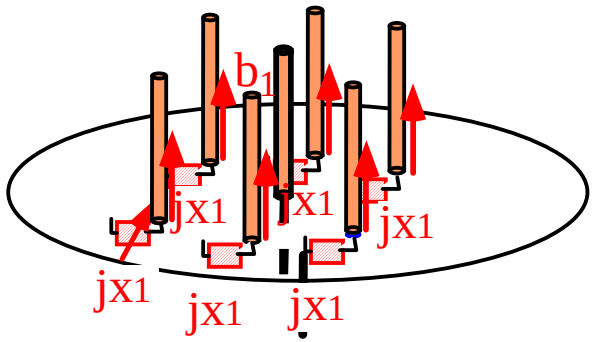


Independance of Other Element Reactance



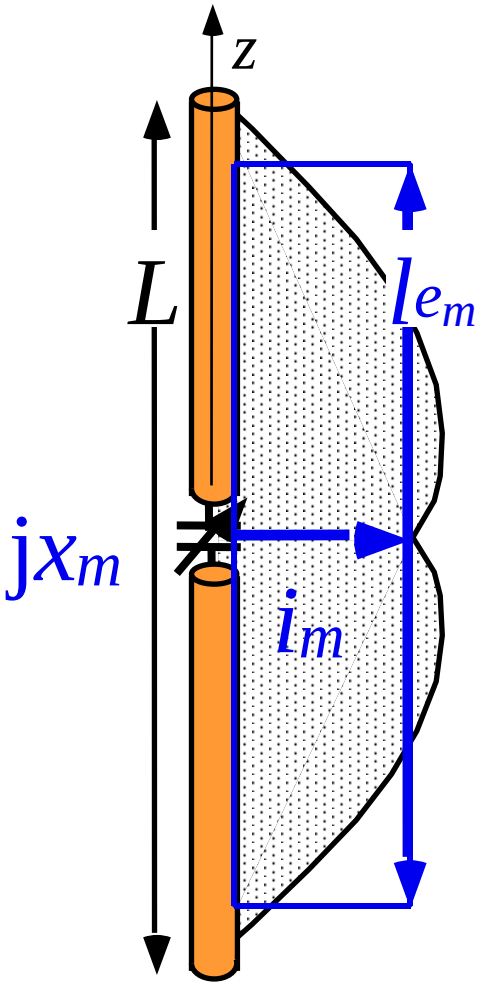






Reactances of 3 elements are varied. Reactances of 6 elements are varied.

Reactively Loaded Dipole



$$l_{em} = \int i_m(z)\,dz \,/\, i_m$$

when $L \leqq \lambda/2$

$$l_{em} = l_{em}^{(0)}(1-\alpha_m x_m)$$

$$\alpha_m = 0.0022$$

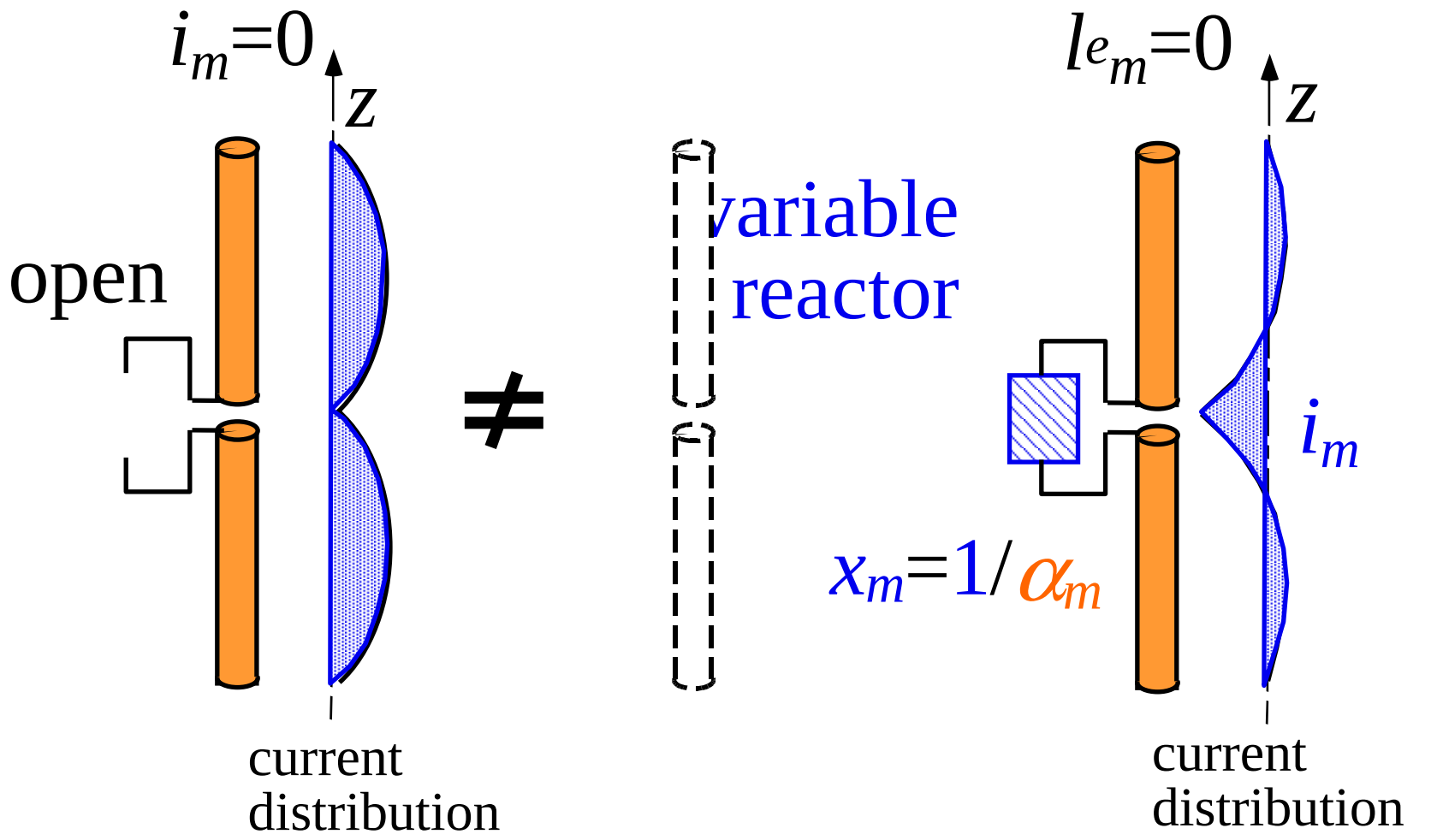
$$l_{em}^{(0)} \quad 0.7L$$

[1] K. Iigusa and T. Ohira,
"A simple and accurate mathematical model of electronically steerable parasitic array radiator antennas,"IEEE CCNC2004, E1, Jan. 2004.

ダイポールの電気的透明化

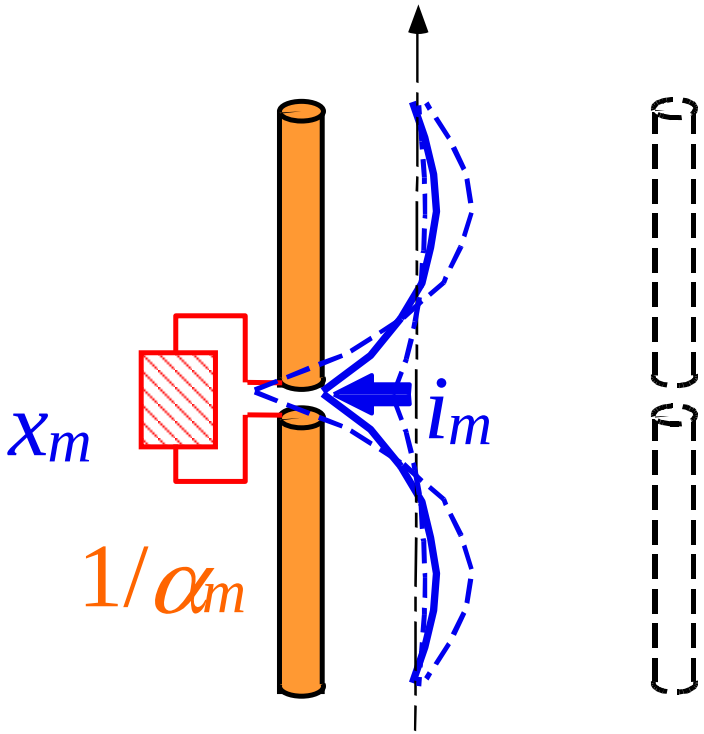
Electrically Invisible Dipole

Electrically Invisible Dipole



$$le_m = le_m^{(0)}(1-\alpha_m x_m)$$

Electrically Invisible Dipole



$$l_{em} = l_{e^{(0)}m}(1 - \alpha_m x_m)$$

- Independant of port currrent i_m
- Independant of the other varactor x_n

when $x_m = 1/\alpha_m$
always $l_{em} = 0$

α_m depends on only the elemsnt size.

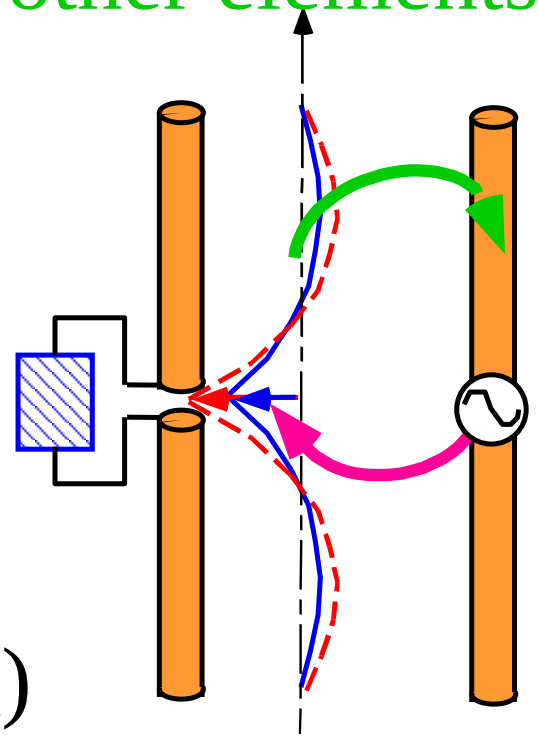
Electrical Interaction is Minimum

The influence to the other elements isminimum.

$I_m \equiv l_{em} i_m = 0$

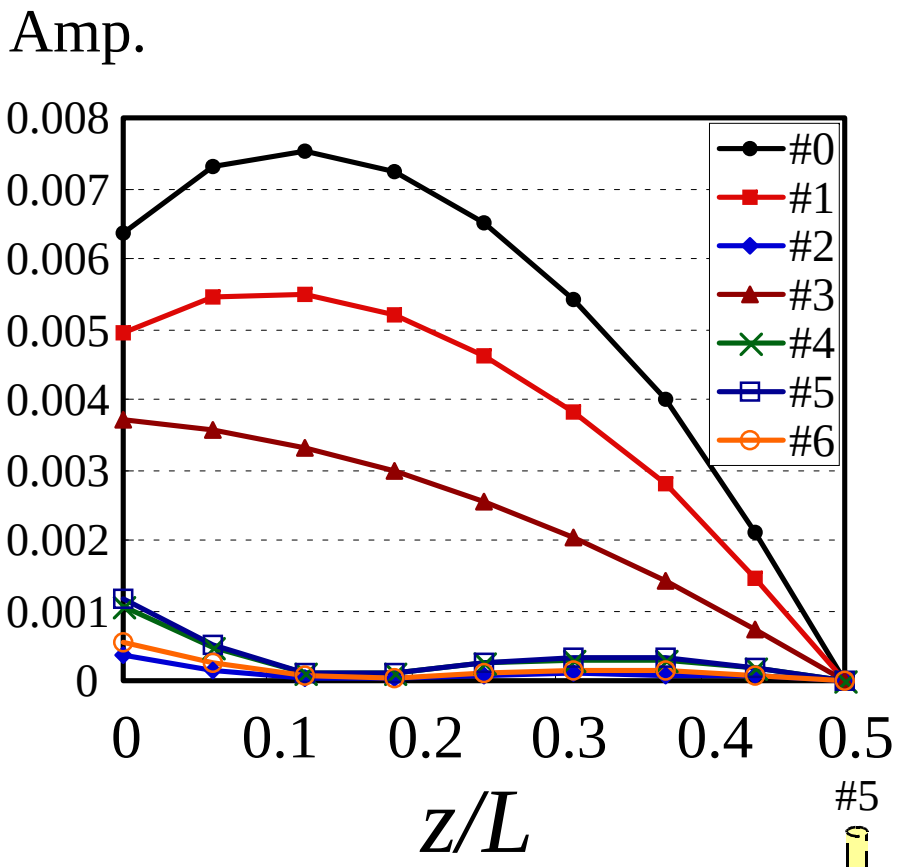
$x_m = 1/\alpha_m$

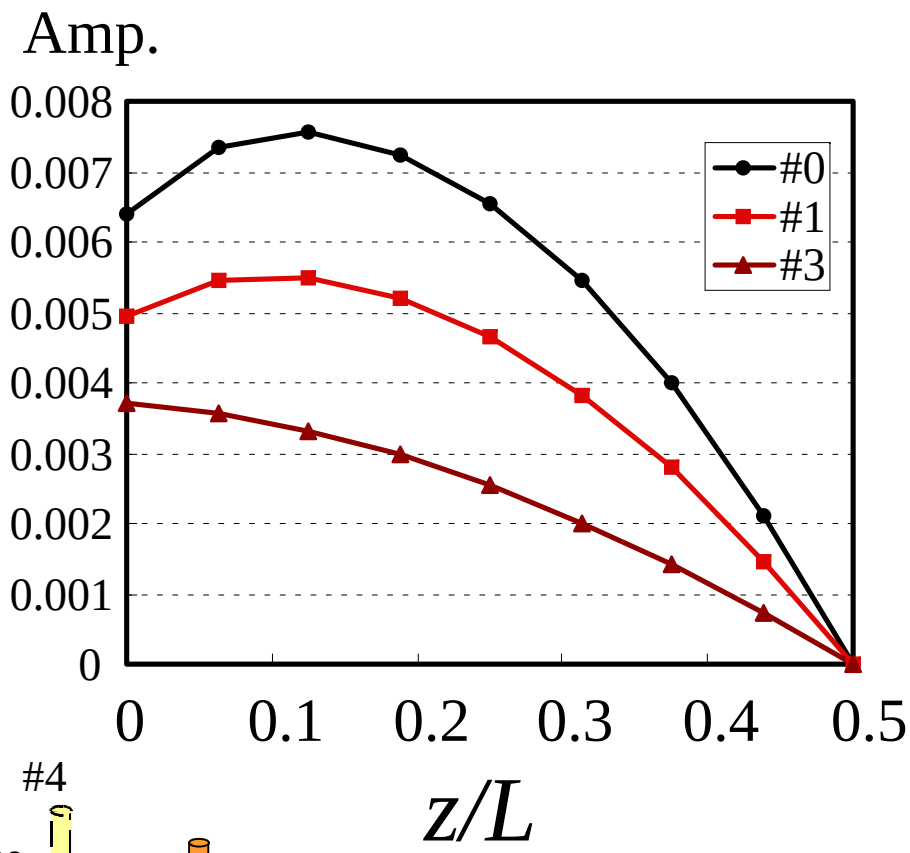
$l_{em} = l_{em}^{(0)}(1 - \alpha_m x_m)$



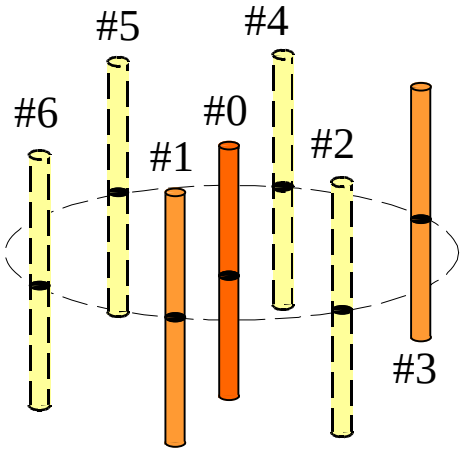
I_m is kept to 0 independently of the other elements.

Current Distribution



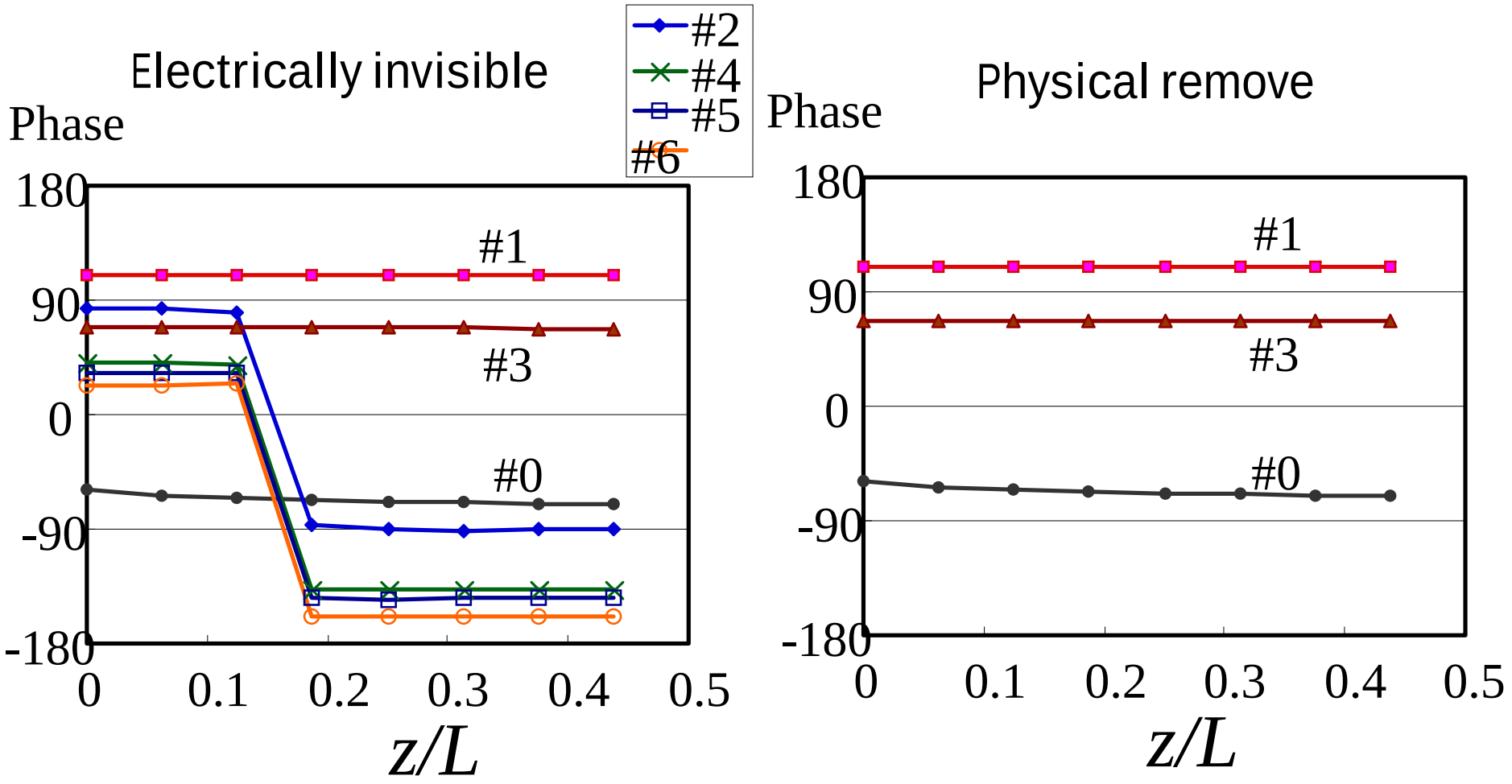


Electrically invisible



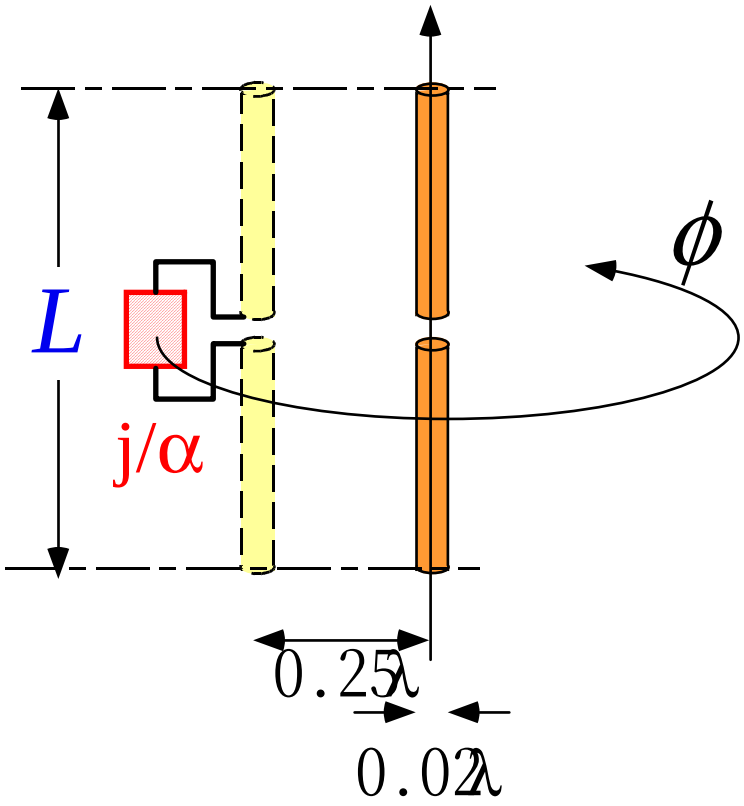
Physical remove

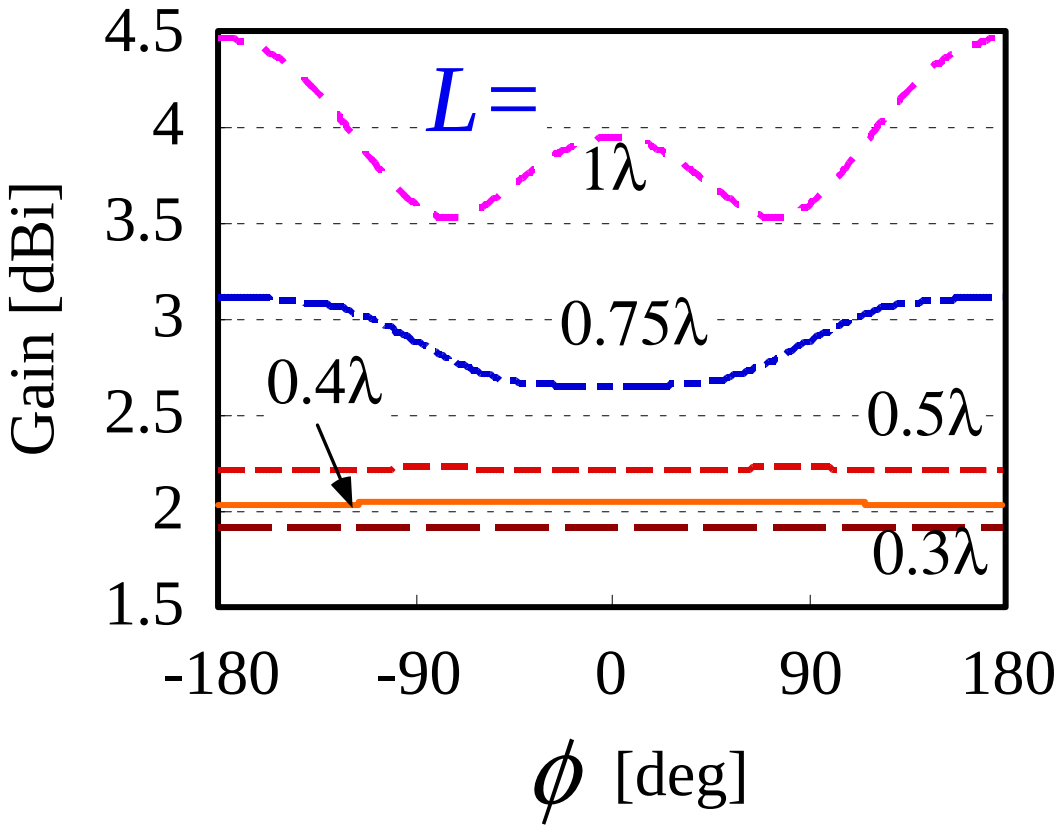
Phase Current Disttribution



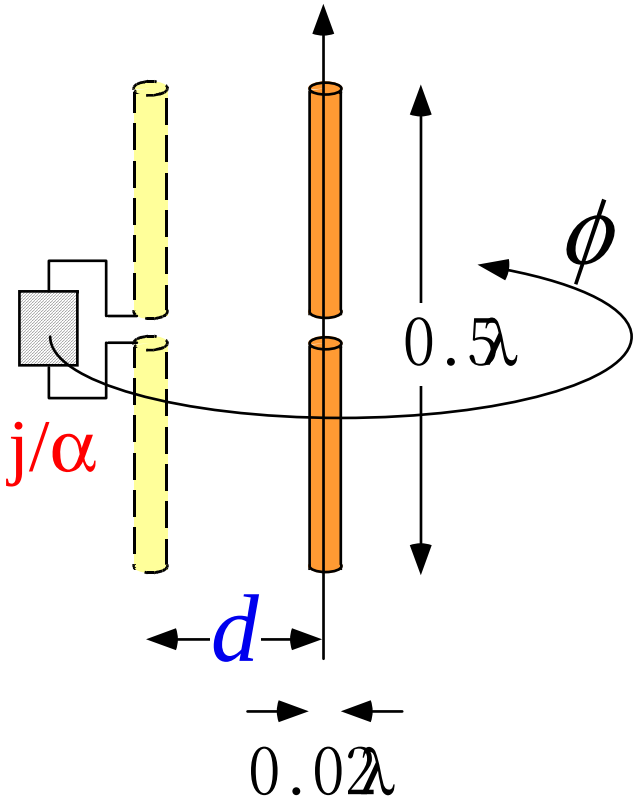
Moment method

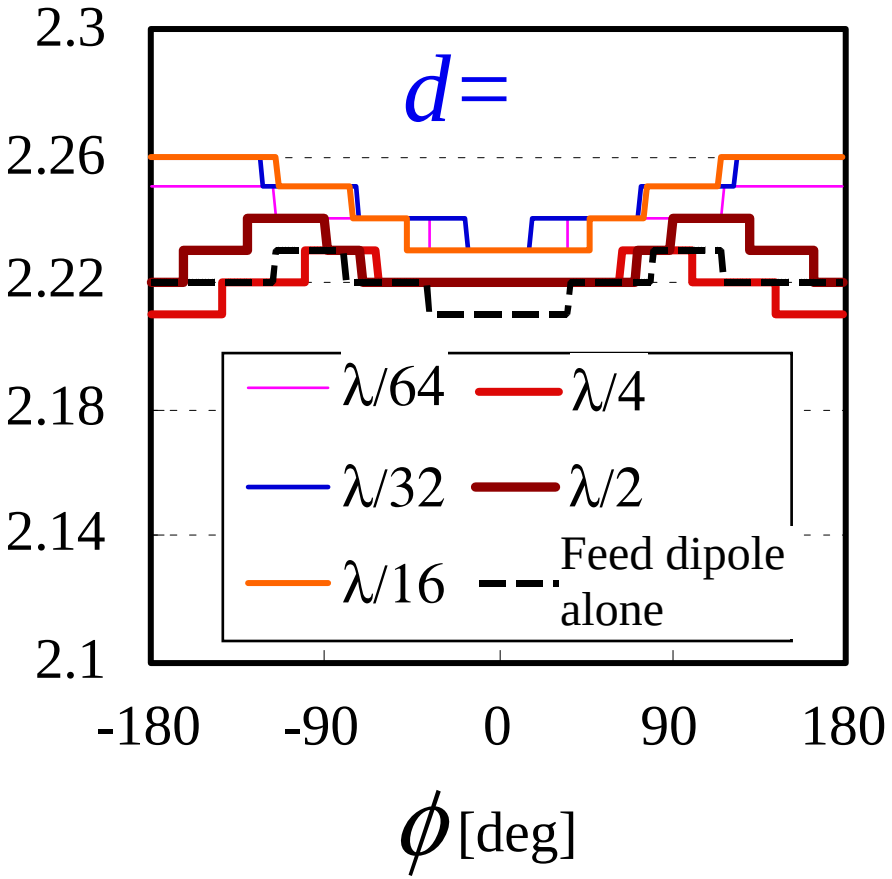
Limit Length for Electrically Invisible Dipole





Limmit Distance for Electrically Inbisible Dipole

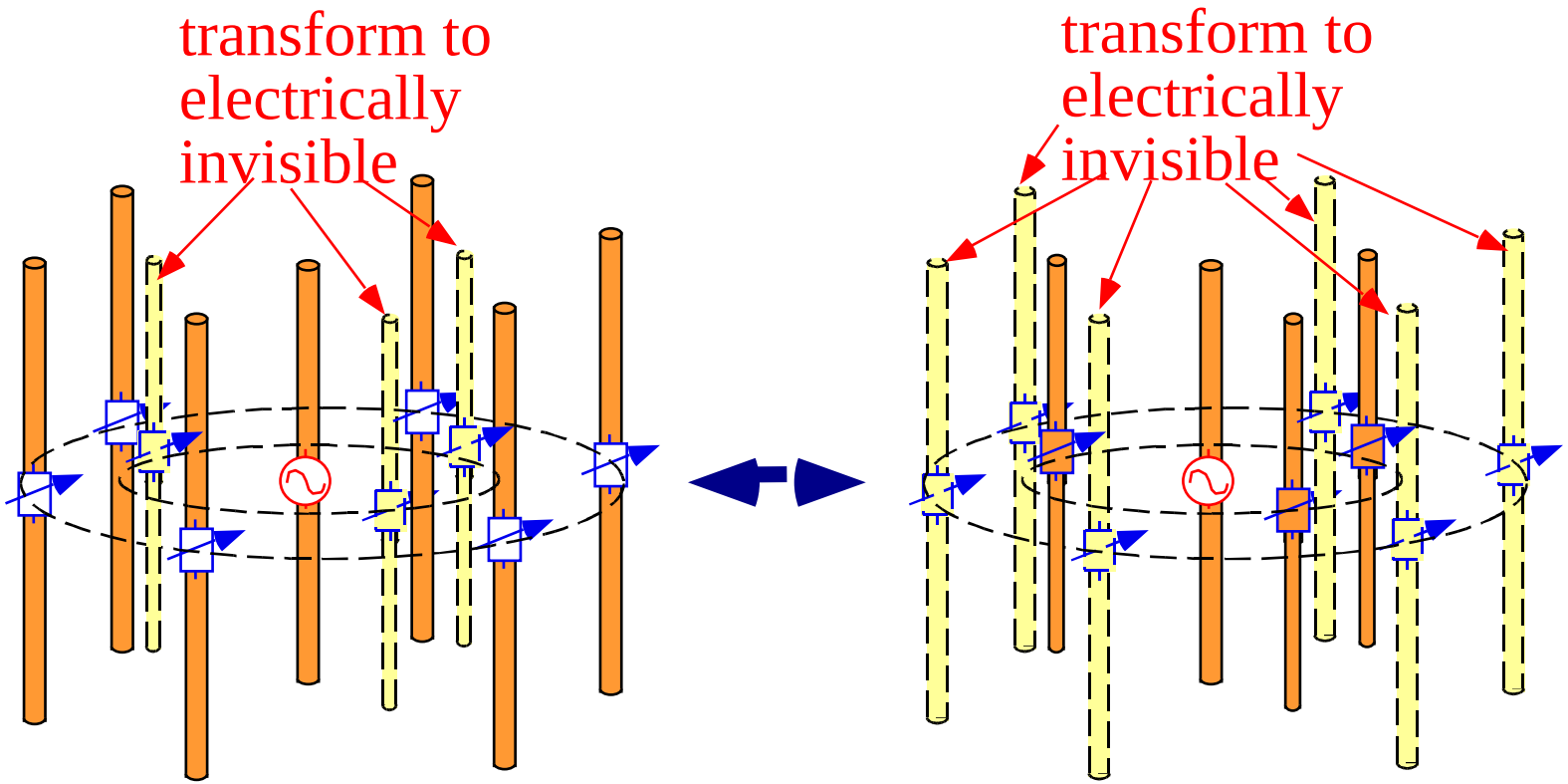




リコンフィギャラブルアンテナ

Reconfigurable Antenna

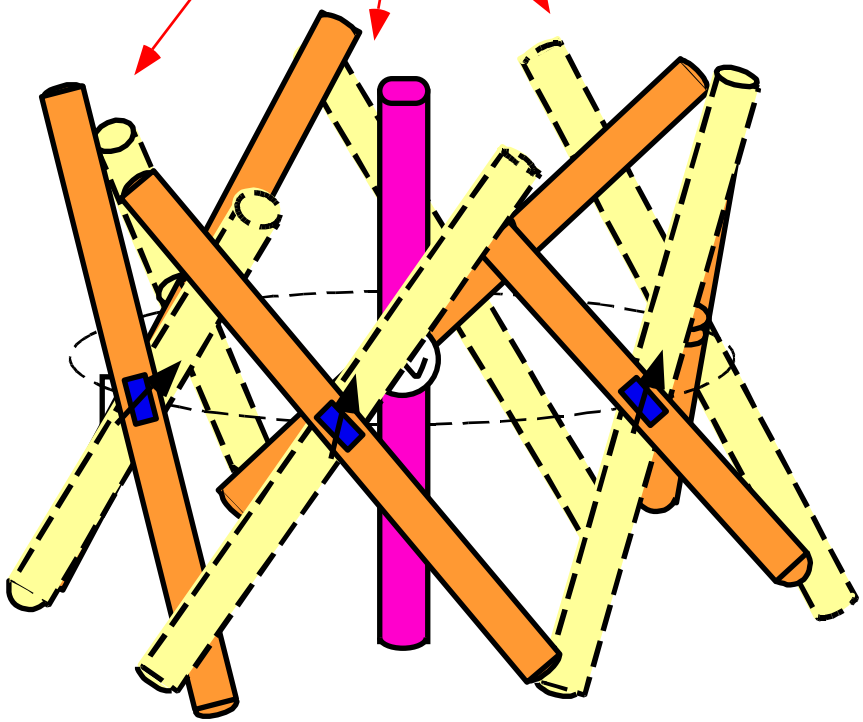
Reconfigurable ESPAR antenna



(a) Element number can be varied
(b) Element position can be varied
(c) Frequency can be varied

Reconfigurable ESPAR antenna

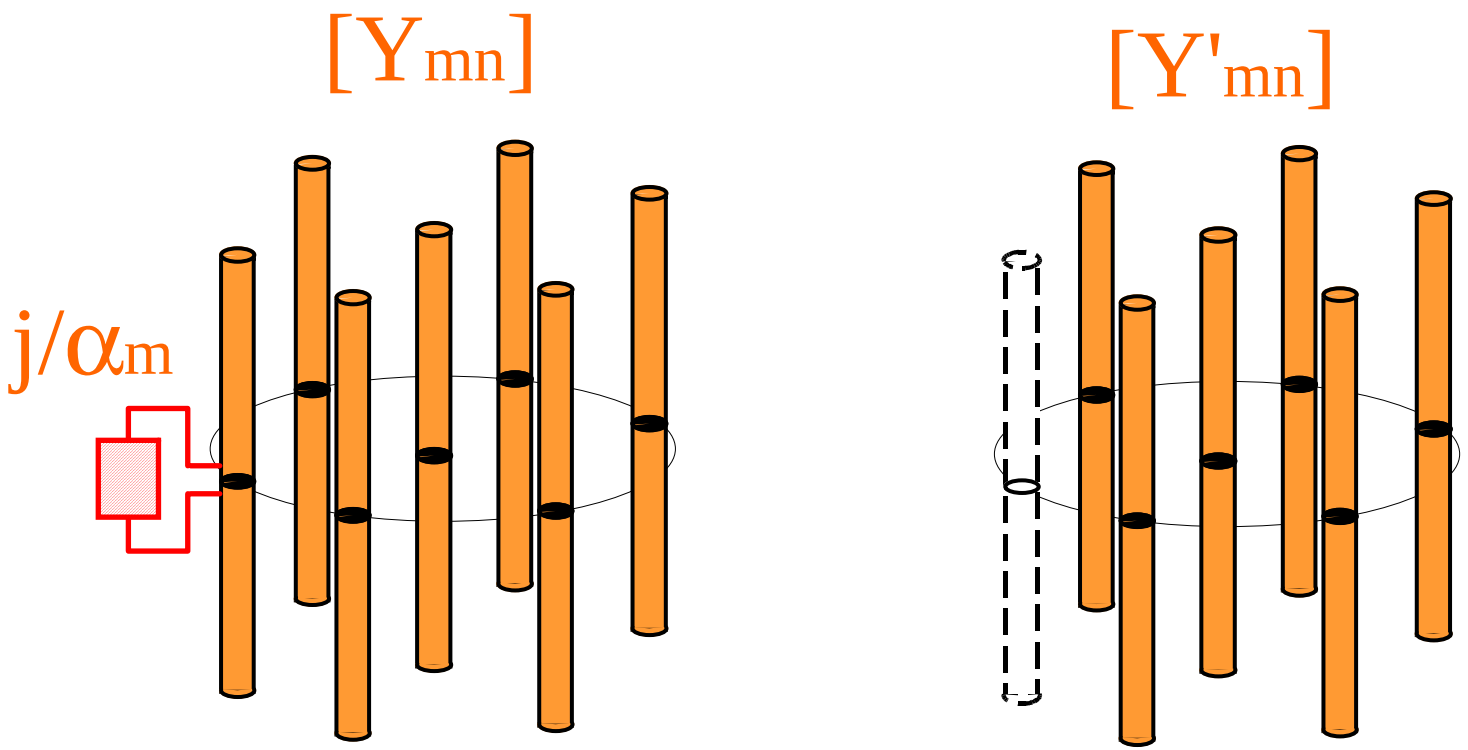
transform to electrically invisible



(d) Polarization can be varied

アドミタンスの近似計算法

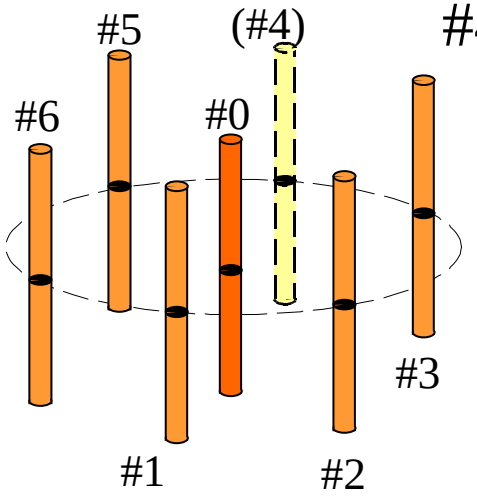
Approximate Calculation Method of Admittance



Reguration of admittances

Relations between Y_{mn} and Y'_{mn} are expressed with α_m.

Admittance Matrix Relation



The admittance matrix of the array from which #4 is removed

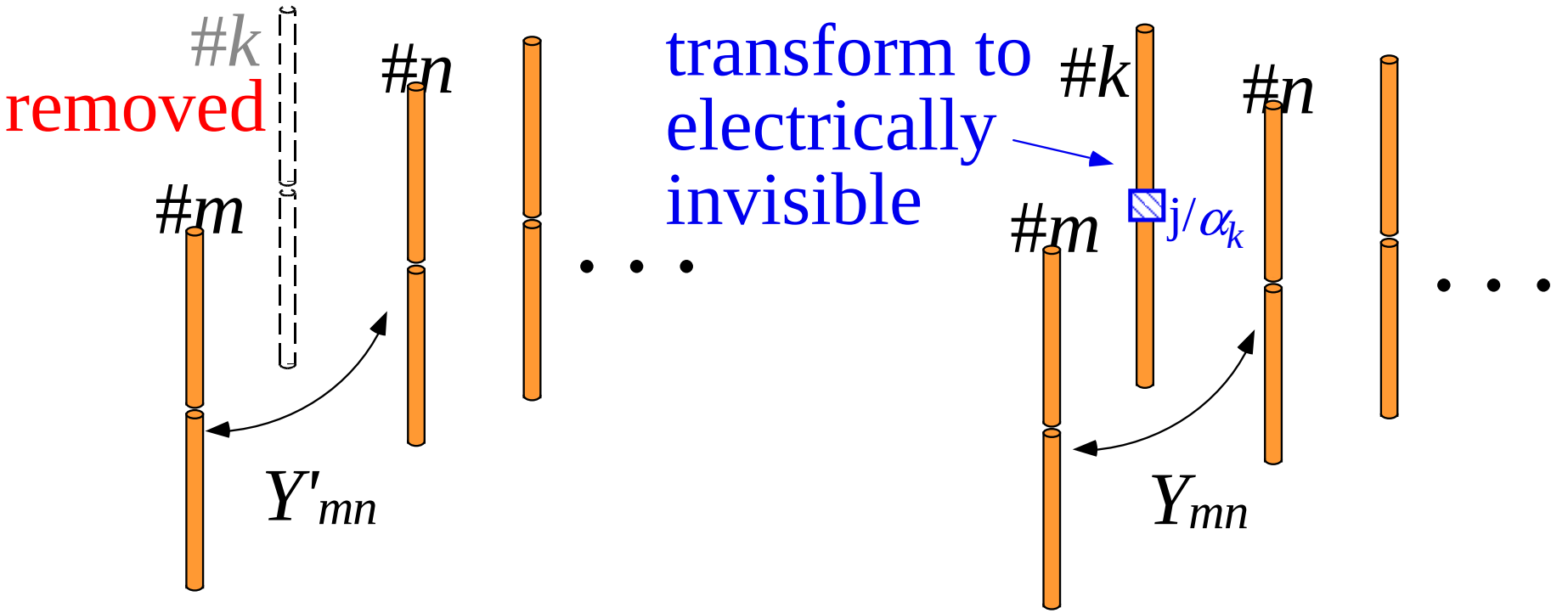
$$\begin{bmatrix} Y'_{00} & Y'_{01} & Y'_{02} & Y'_{03} & Y'_{05} & Y'_{06} \\ Y'_{10} & Y'_{11} & Y'_{12} & Y'_{13} & Y'_{15} & Y'_{16} \\ Y'_{20} & Y'_{21} & Y'_{22} & Y'_{23} & Y'_{25} & Y'_{26} \\ Y'_{30} & Y'_{31} & Y'_{32} & Y'_{33} & Y'_{35} & Y'_{36} \\ Y'_{50} & Y'_{51} & Y'_{52} & Y'_{53} & Y'_{55} & Y'_{56} \\ Y'_{60} & Y'_{61} & Y'_{62} & Y'_{63} & Y'_{65} & Y'_{66} \end{bmatrix}$$

is almost equals to

the matrix that is made removed 5 raw and 5 line from

$$\left(\begin{bmatrix} Y_{00} & Y_{01} & Y_{02} & Y_{03} & Y_{04} & Y_{05} & Y_{06} \\ Y_{10} & Y_{11} & Y_{12} & Y_{13} & Y_{14} & Y_{15} & Y_{16} \\ Y_{20} & Y_{21} & Y_{22} & Y_{23} & Y_{24} & Y_{25} & Y_{26} \\ Y_{30} & Y_{31} & Y_{32} & Y_{33} & Y_{34} & Y_{35} & Y_{36} \\ Y_{40} & Y_{41} & Y_{42} & Y_{43} & Y_{44} & Y_{45} & Y_{46} \\ Y_{50} & Y_{51} & Y_{52} & Y_{53} & Y_{54} & Y_{55} & Y_{56} \\ Y_{60} & Y_{61} & Y_{62} & Y_{63} & Y_{64} & Y_{65} & Y_{66} \end{bmatrix}^{-1} + \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & j\omega_4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \right)^{-1}$$

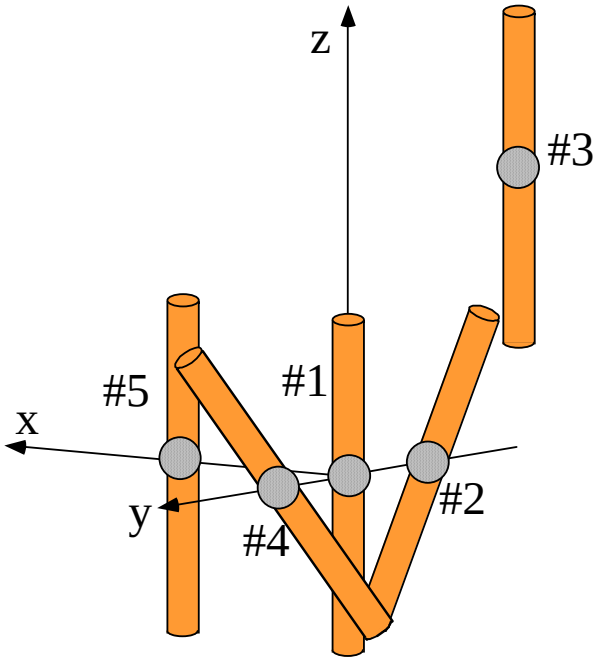
Relation of Admittance

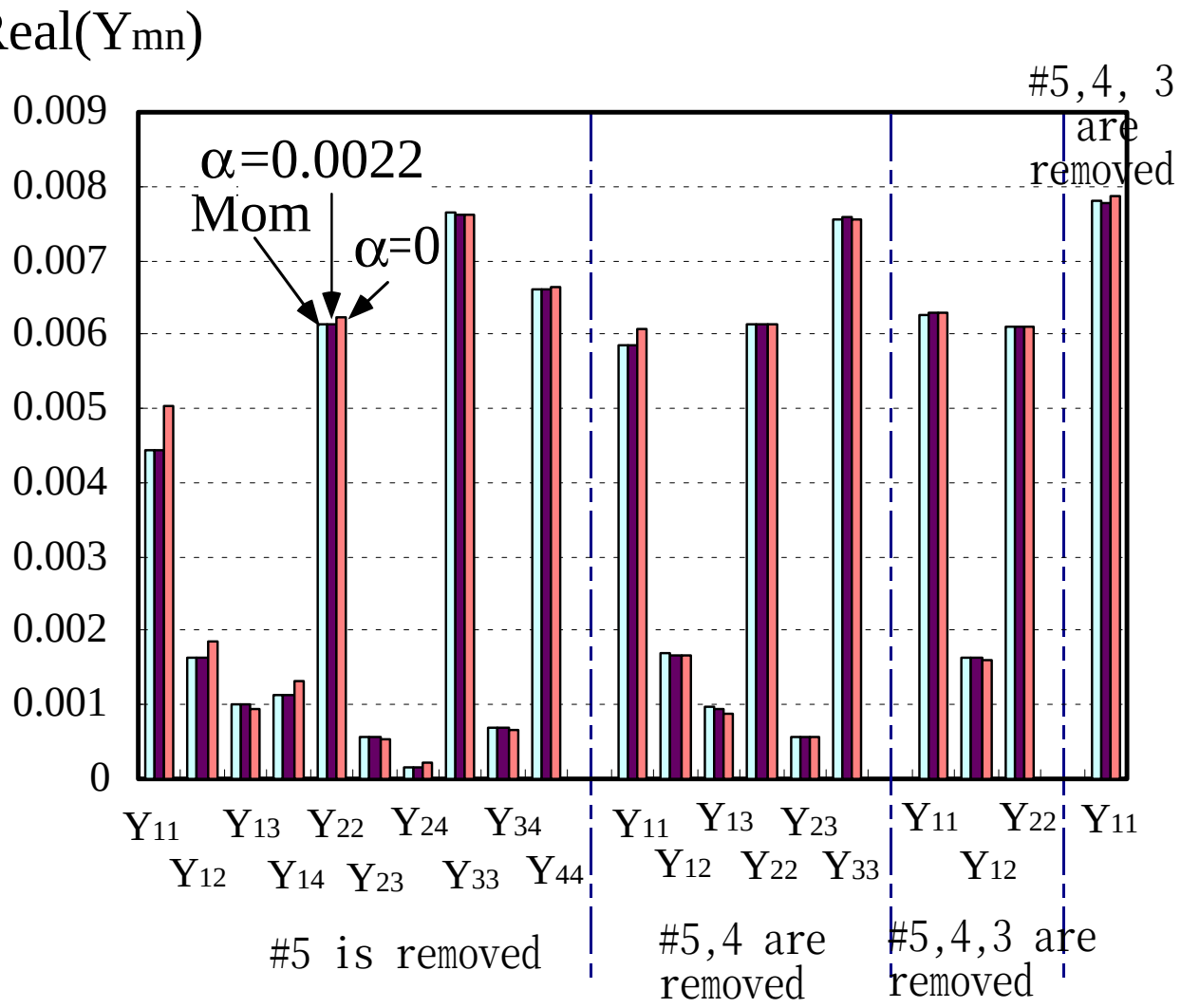


$[Y'_{mn}]$ $([Y_{mn}]^{-1}+\mathrm{diag}[0 \ldots 0\ \mathrm{j}/\boldsymbol{\alpha}_k\ 0 \ldots 0])^{-1}$

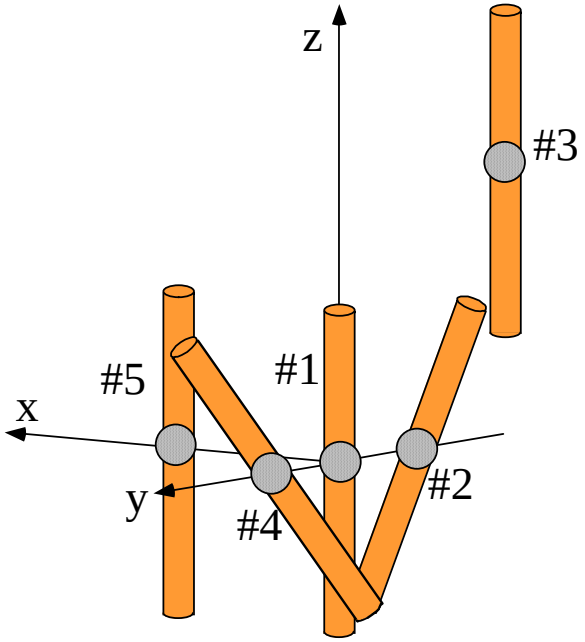
$$Y'_{mn} = Y_{mn} + \frac{Y_{mk}Y_{nk}}{Y_{kk}-\mathrm{j}\,\boldsymbol{\alpha}_k}$$

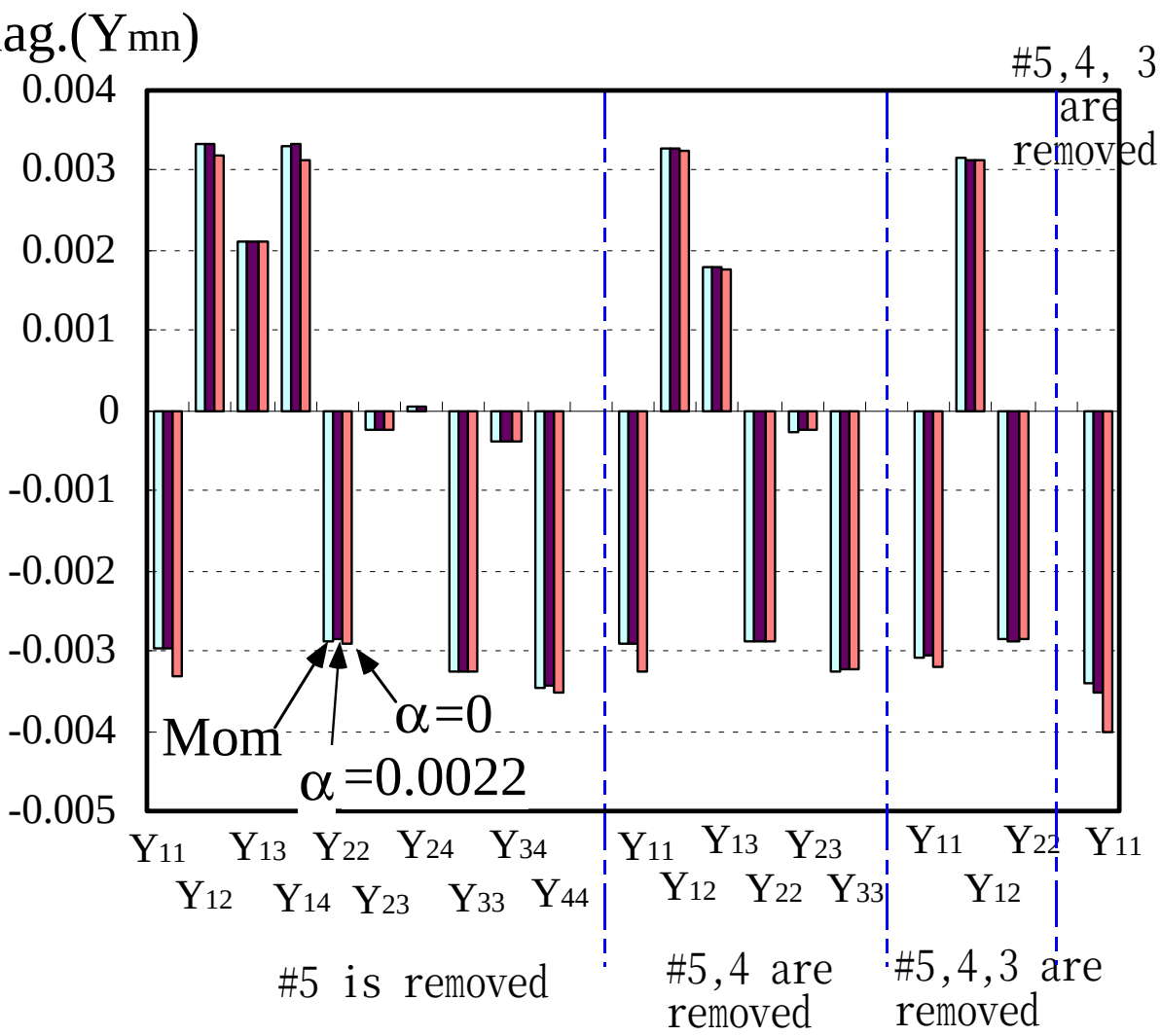
Ascertain of The Relation





Ascertain of The Relation

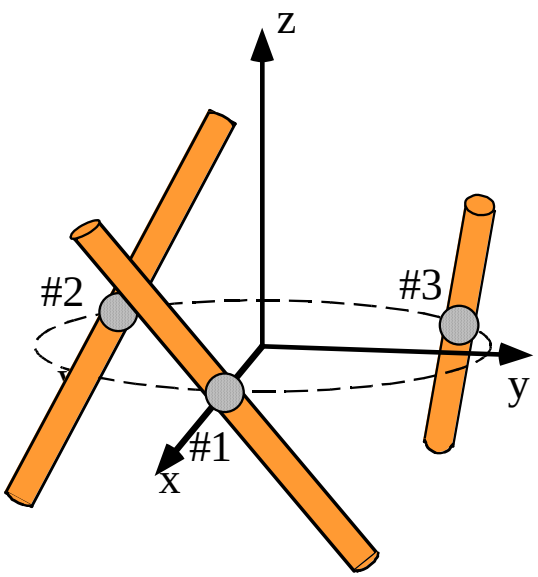




アドミタンスYmnの規則性

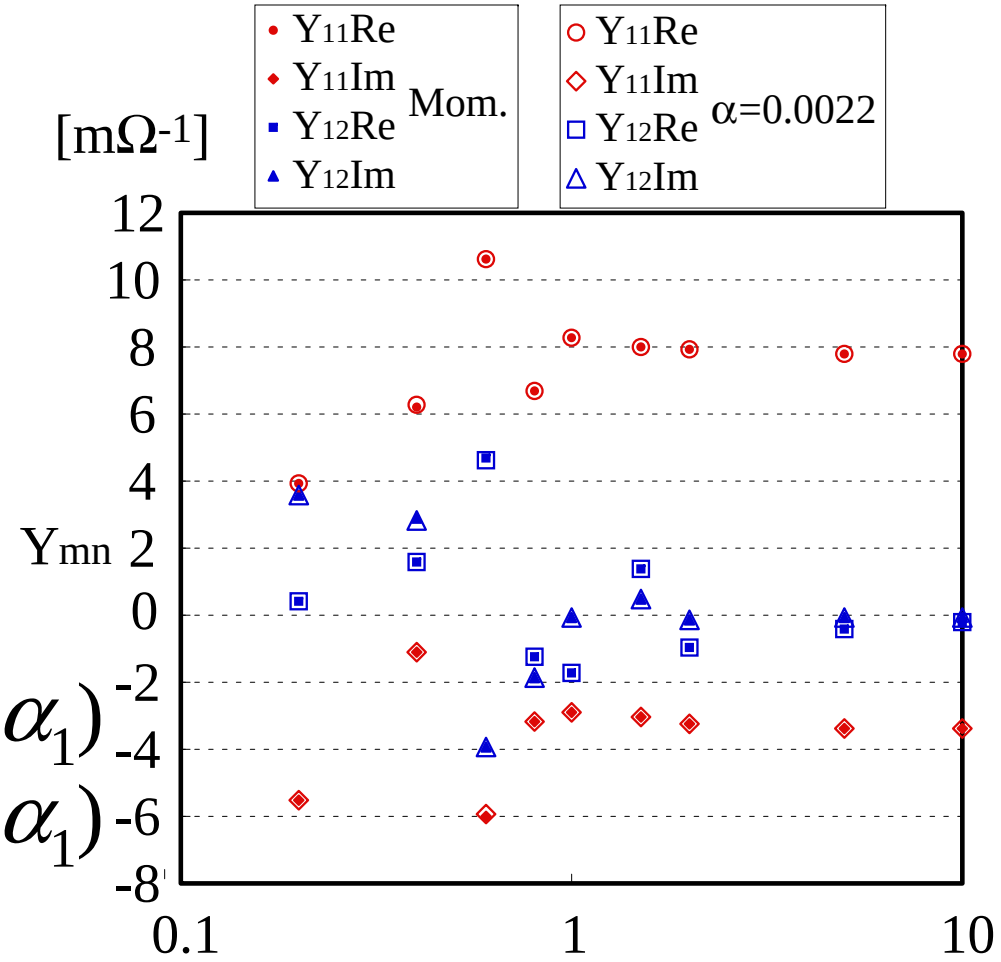
Regulation of Admittance Ymn

An Equilateral Triangle Arrangement

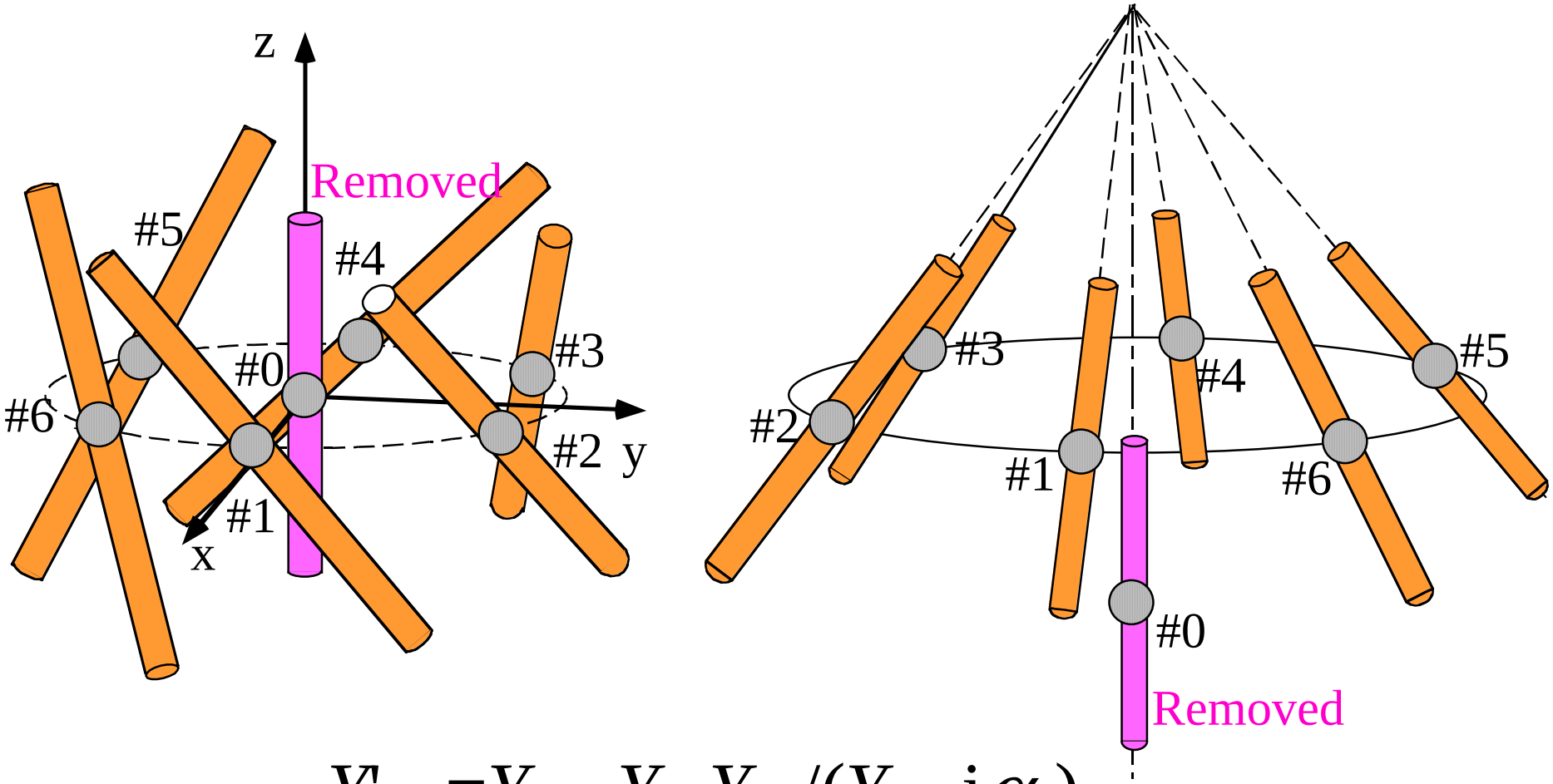


$$Y_{11}=Y'_{11}+Y'^{2}_{12}/(Y'_{11}-2Y'_{12}-j\alpha_1)$$

$$Y_{12}=Y'_{12}+Y'^{2}_{12}/(Y'_{11}-2Y'_{12}-j\alpha_1)$$



Circular Arrangement



$$Y'_{mn}=Y_{mn}-Y_{01}Y_{10}/(Y_{00}-j\alpha_0)$$

$$Y'_{mn}-Y'_{m'n'}=Y_{mn}-Y_{m'n'}$$

Summary

- Electrically *invisible* dipole is proposed.

$$x_m = 1/\alpha_m$$

- *Reconfigurable* ESPAR antenna is proposed.

element number or position, frequency, polarization

- Relation of *admittance* is presented.

$$Y'_{mn} = Y_{mn} + \frac{Y_{mk} Y_{nk}}{Y_{kk} - \mathrm{j}\alpha_k}$$