Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Reference antenna model with side lobe for TG3c evaluation]
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Source: [Ichihiko Toyoda[1], Tomohiro Seki[1], Kyoichi Iigusa[2], Hirokazu Sawada[2], Yoshitsugu Fujita[3], Amane Miura[4], Naoyuki Orihashi[5]]
Company [NTT[1], NiCT[2], Kyocera[3], ATR[4], NEC[5]]
Address [1-1 Hikari-no-oka, Yokosuka-shi, Kanagawa 239-0847, Japan][1], [3-4 Hikari-no-oka, Yokosuka-shi, Kanagawa 239-0847, Japan][2], [6 Takeda Tobadono-cho Fushimi-ku, Kyoto 612-8501 Japan][3], [2-2-2 Hikari-dai, Keihanna Science City, Kyoto 619-0288, Japan][4], [Seiran 2-9-1, Otsu Siga, 520-7689, Japan][5]
Voice:[+81-46-859-2366[1], +81-46-847-5093[2], +81-75-604-3412[3], +81-774-95-1576[4], +81-77-537-7683[5]]
FAX: [+81-46-855-1497[1], +81-46-847-5089[2], +81-75-604 3411[3], +81-774-95-1508[4], +81-77-537-7689[5]]
E-Mail:[{toyoda.ichihiko,seki.tomohiro}@lab.ntt.co.jp[1], {iigusa, sawahiro}@nict.go.jp[2], yoshitsugu.fujita.gt@kyocera.jp[3], amane@atr.jp[4], orihahsi@cb.jp.nec.com[5]]

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Abstract: [Mathematical model of radiation patterns including side-lobe effect is proposed for TG3c PHY/MAC simulations]

Purpose: [To be considered in 15.3c Document]

Reference antenna model with side lobe for TG3c evaluation

Ichihiko Toyoda, Tomohiro Seki (NTT)
Kyouichi Iigusa, Hirokazu Sawada (NiCT)
Yoshitsugu Fujita (Kyocera)
Amane Miura (ATR)
Naoyuki Orihashi (NEC)

Summary

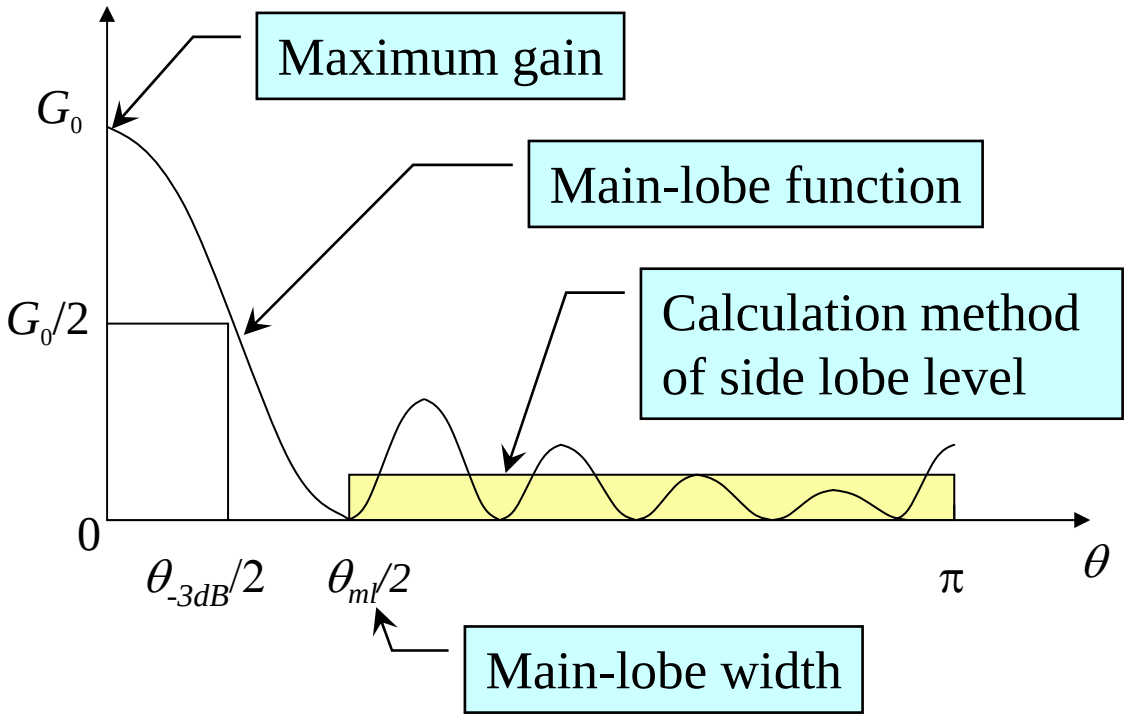
- Reference antenna model including side-lobe effect is proposed for TG3c PHY/MAC simulations.

Basic Concept

- Side-lobe level is basically small
- Radiation patters, i.e. side-lobe level, can be modified by antenna design.
- Simple mathematical model employing an averaged side lobe is good enough for simulations.

Topics to be Considered

- Four topics to be considered to create a model.



Note: Phase pattern is assumed to be constant.

Main-lobe Function

- Employed circular symmetric Gaussian distribution due to its simple formulation.

$$G(\theta,\phi) = G_0 \exp(-\alpha\theta^2)$$

where α is determined by the half-power beam width θ_{-3dB} as follows;

$$\alpha = \frac{4 \cdot \ln 2}{\theta_{-3dB}^2}$$

- Main lobe can be expressed by a simple equation in dB.

$$G(\theta,\phi)\ [\mathrm{dB}] = G_0[\mathrm{dB}] - 3.01 \cdot \left(\frac{2\theta}{\theta_{-3dB}} \right)^2 \qquad (1)$$

Main-lobe Width

- Considered -20 dB from the maximum gain as a main lobe.
- Main-lobe width is derived from eq.(1) in Slide 6.

$$\theta_{ml} = 2.6 \cdot \theta_{-3dB}$$

- This result is consistent with the theoretical value of an ideal circular aperture antenna with its half-power beam width of around 30 degrees.

Maximum Gain

- Employed the formula of an ideal circular aperture antenna with uniform field distribution.

$$G_0 = (ka)^2$$

$$ka \cdot \sin(\theta_{-3dB} / 2) = 1.6162$$

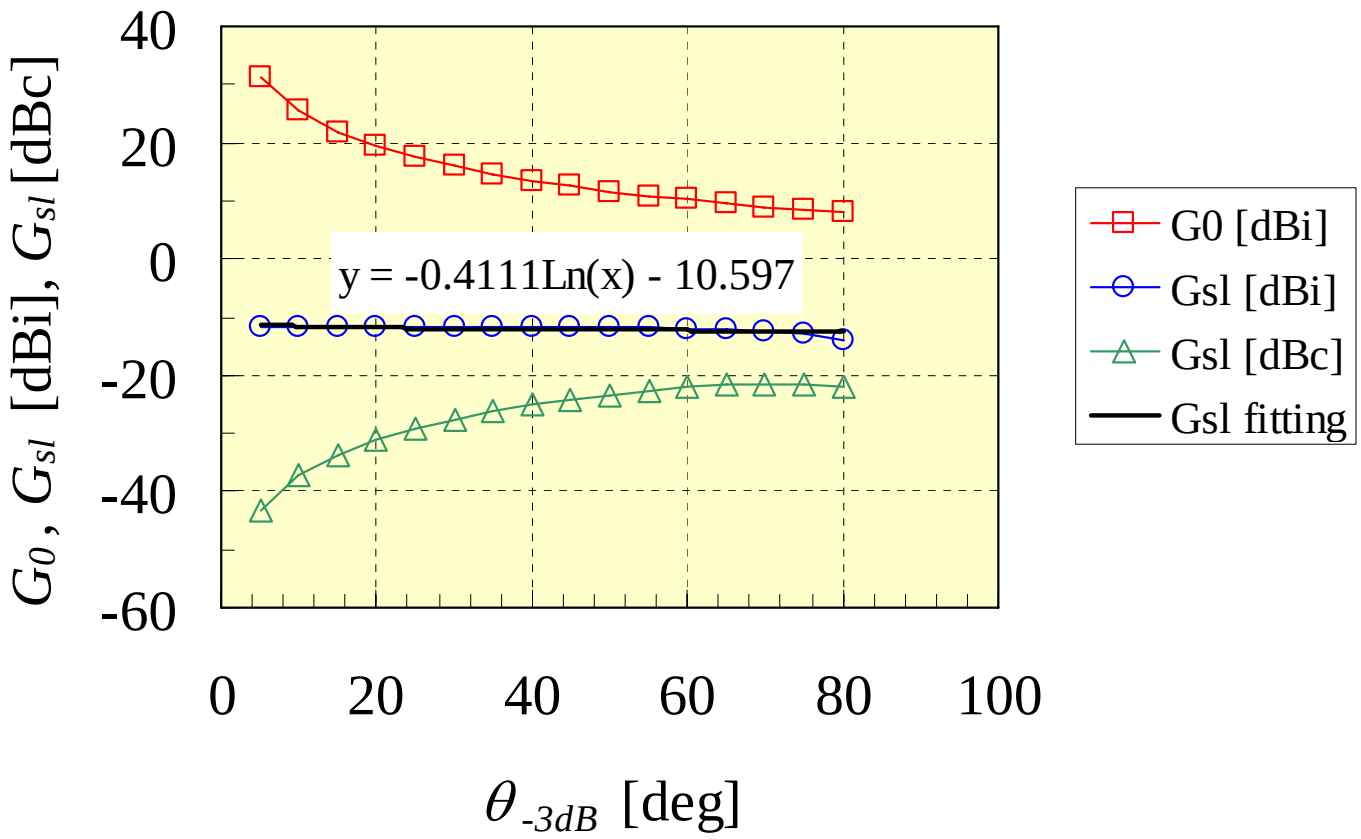
where k and a are the wavenumber and radius of the aperture, respectively.

Calculation Method of Side-lobe Level

- Side-lobe power is averaged over the solid angle out of the main lobe.

$$G_{sl} = \frac{4\pi - G_0 \overbrace{\int_0^{\theta_{ml}/2} \exp(-\alpha\theta^2) \cdot \sin\theta d\theta \int_0^{2\pi} d\phi}^{\text{Total power of the main lobe}}}{\underbrace{\int_{\theta_{ml}/2}^{\pi} \sin\theta d\theta \int_0^{2\pi} d\phi}_{\text{Solid angle out of the main lobe}}}$$

Numerical Results



Proposed Model

$$G(\theta,\phi)\ [\mathrm{dB}] = G_0 - 3.01 \cdot \left(\frac{2\theta}{\theta_{-3dB}} \right)^2 \qquad 0 \le \theta \le \theta_{ml} / 2$$

$$G(\theta,\phi)\ [\mathrm{dB}] = G_{sl} \qquad \theta_{ml} / 2 \le \theta \le 180^\circ$$

$$\theta_{ml} = 2.6 \cdot \theta_{-3dB}$$

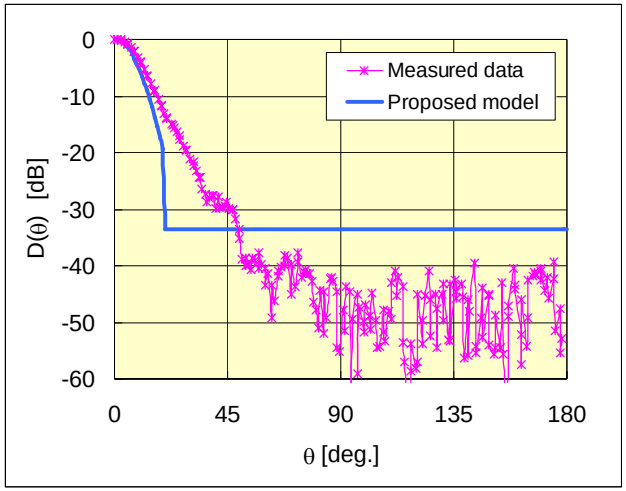
$$G_0 = 10 \log \left(\left(\frac{1.6162}{\sin(\theta_{-3dB}/2)} \right)^2 \right)$$

$$G_{sl} = -0.4111 \cdot \ln(\theta_{-3dB}) - 10.597$$

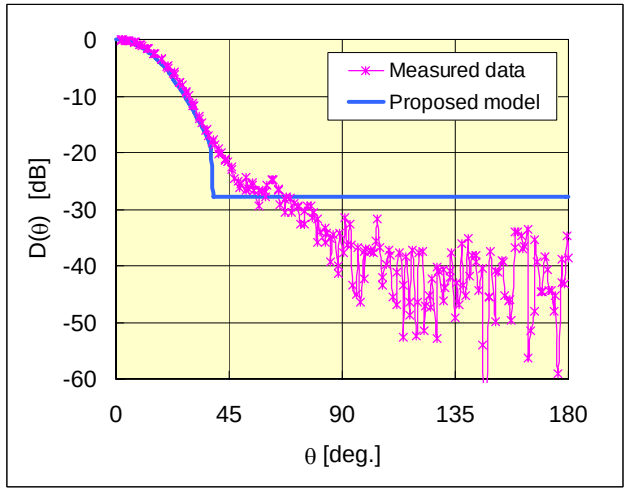
Examination of Proposed Model

- Proposed model is compared with measured data.
- Good agreement has been achieved.

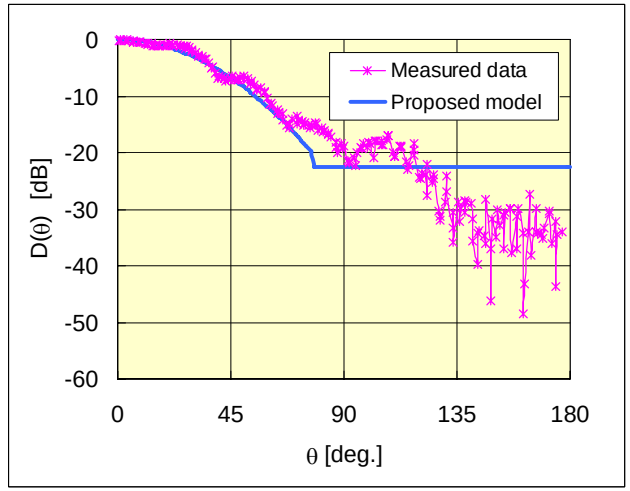
$\theta_{-3dB} = 15^\circ$



$\theta_{-3dB} = 30^\circ$



$\theta_{-3dB} = 60^\circ$



Note: Measured data are for rectangular horn antennas.

Conclusion

- Reference antenna model with averaged side lobe is proposed for TG3c PHY/MAC simulations.
- Proposed model is a simple mathematical model and examined by comparing with the measured data of 15, 30 and 60-degree antennas.
- Good agreement between the model and measured results.