

## <IT CookBook, 원리로 이해하는 마이크로파 공학> 공개용 답안

### 2장 답안

- $\vec{E} = \left( \frac{27}{125} \vec{a}_x + \frac{36}{125} \vec{a}_z \right) \times 10^3 \text{ [V/m]}$
- $V = V_1 + V_2 = \frac{1 \times 10^{-9}}{2\pi} \epsilon_0 \sqrt{8} \approx 6.36 \text{ [V]}$
- $|\vec{D}| = \epsilon_0 \epsilon_r |\vec{E}| = 162 \epsilon_0 \text{ [C/m}^2\text{]}$   
 $|\vec{P}| = \epsilon_0 \chi_e |\vec{E}| = 160 \epsilon_0 \text{ [C/m}^2\text{]}$
- $\epsilon_1 = 4 \epsilon_0 \text{ [F/m]}$
- ① 영역에서의  $\vec{E}_1 = \frac{1}{3 \epsilon_0} (\vec{a}_x + 2 \vec{a}_y) \text{ [V/m]}$   
② 영역에서의  $\vec{E}_2 = \frac{1}{\epsilon_0} \vec{a}_x + \frac{2}{3 \epsilon_0} \vec{a}_y \text{ [V/m]}$ ,  $\vec{D}_2 = \vec{a}_x + \frac{2}{3} \vec{a}_y \text{ [C/m}^2\text{]}$
- (a)  $+z$  방향  
(b)  $2 \times 10^8 \text{ [m/s]}$   
(c)  $\lambda = 1.26 \text{ [m]}$   
(d)  $\vec{H}(z, t) = -39.8 \cos(10^9 t - 5z) \vec{a}_x \text{ [\mu A/m]}$
- $\omega = 9.49 \times 10^8 \text{ [rad/s]}$
- (a)  $emf = -10 \cos\left(\frac{\pi y}{2} - 250\pi t\right) \text{ [V]}$   
(b)  $emf = 0$
- $y$  방향의 선형편파
- 페이지 영역 :  $E = 10^{-5} e^{-j2.09z} \vec{a}_x \text{ [V/m]}$   
시간 영역 :  $10 \cos(6.28 \times 10^8 t - 2.09z) \vec{a}_x \text{ [\mu V/m]}$
- (a)  $\lambda = \frac{2\pi}{10} \approx 0.63 \text{ [m]}$   
(b)  $\eta = 50 \text{ [\Omega]}$   
(c)  $\mu_r = 3.98$   
(d)  $\epsilon_r \approx 2.26$
- (a)  $Z = 218 \text{ [\Omega]}$   
(b)  $|H| = 9.2 \text{ [mA/m]}$   
(c)  $P = 4.6 \text{ [mW]}$
- (a) 약  $5.79 \text{ [m]}$   
(b) 약  $500 \text{ [m]}$
- 증명 생략
- 증명 생략

$$16. \alpha = \omega \sqrt{\mu \epsilon} \left\{ \frac{1}{2} \left[ \sqrt{1 + \left( \frac{\sigma}{\omega \epsilon} \right)^2} - 1 \right] \right\}^{\frac{1}{2}}$$

$$\beta = \omega \sqrt{\mu \epsilon} \left\{ \frac{1}{2} \left[ \sqrt{1 + \left( \frac{\sigma}{\omega \epsilon} \right)^2} + 1 \right] \right\}^{\frac{1}{2}}$$

| 입력전력    | 전체 삽입손실 | 출력전력      |
|---------|---------|-----------|
| 20[W]   | 2.5     | 45.5[dBm] |
| 1[mW]   | 11      | 11[dBm]   |
| 23[dBm] | 6       | 29[dBm]   |

### 3장 답안

1. 감쇄상수 :  $\alpha = 21 \times 10^{-6}$   
 위상상수 :  $\beta = 687 \times 10^{-6}$   
 위상속도 :  $u_p = 9.1458 \times 10^6 [\text{m/s}]$
2.  $R = \frac{1}{2\pi(13.14 \times 10^{-7})(5.87 \times 10^7)} \left( \frac{1}{0.45 \times 10^{-3}} + \frac{1}{1.475 \times 10^{-3}} \right) [\Omega/\text{m}]$   
 $L = 0.24 [\mu\text{H}/\text{m}]$   
 $C = 105 [\text{pF}/\text{m}]$   
 $G = 0.512 [\text{S}/\text{m}]$   
 $Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$
3.  $Z_L = 224.26 + j419.64 [\Omega]$
4.  $Z_{in} = 48.91 + j34.95 [\Omega]$
5. 예제 3-8 과 동일함
6. (a)  $R = 0.1151 [\Omega/\text{m}]$   
 (b)  $L = 0.2 [\mu\text{H}/\text{m}]$   
 (c)  $G = 46.04 [\mu\text{S}/\text{m}]$   
 (d)  $u_p = 2.5 \times 10^8 [\text{m/s}]$
7. (a)  $\Gamma_L = 0.097 \angle -115.5^\circ$   
 (b)  $VSWR = 1.215$   
 (c)  $\ln = \frac{1.126\lambda}{4\pi} \approx 0.09\lambda$
8. ①  $\Gamma_L = 0.686 \angle -149^\circ$   
 ②  $VSWR = 5.4$   
 ③  $RL = 3.27 [\text{dB}]$
9. 신호의 파장 :  $\lambda = 2 \times 1.5 = 3 [\text{cm}]$   
 안테나 임피던스 :  $Z_L = 67.4013 - j41.7089 [\Omega]$
10. (a)  $VSWR = \frac{1}{3}$   
 (b) 75%
11.  $P_{T2} = 63.8 [\text{mW}]$
12. 64%
13. 0.1156%
14.  $C = 2.62 [\text{pF}]$
15. (a)  $VSWR = 2$   
 (b) 11.1%  
 (c)  $RL = 9.54 [\text{dB}]$
16.  $a = 3.5 [\text{mm}] \rightarrow \alpha_{cTE01} = 0.0753 [\text{l}/\text{m}]$ ,  $a = 20 [\text{mm}] \rightarrow \alpha_{cTE01} = 1.14 \times 10^{-3} [\text{l}/\text{m}]$

## 4장 답안

$$1. Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} Z_0 & \coth(rl) \\ Z_0/\sinh(rl) & Z_0 \coth(rl) \end{bmatrix}$$

$$2. A = \left[ \frac{V_1}{V_2} \right]_{I_2=0} = \frac{Z_{11}}{Z_{21}}, \quad B = \left[ -\frac{V_1}{I_2} \right]_{V_2=0} = Z_{11} \frac{Z_{22}}{Z_{21}} - Z_{12}$$

$$C = \left[ \frac{I_1}{V_2} \right]_{I_2=0} = \frac{1}{Z_{21}}, \quad D = \left[ -\frac{I_1}{I_2} \right]_{V_2=0} = \frac{Z_{22}}{Z_{21}}$$

3. 생략

$$4. \text{임피던스 행렬} : \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 18 & 6 \\ 6 & 9 \end{bmatrix}$$

$$\text{하이브리드 행렬} : \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} 14[\Omega] & \frac{2}{3} \\ -\frac{2}{3} & \frac{1}{9}[\text{S}] \end{bmatrix}$$

$$5. S_{11} = \frac{1 - j\omega CZ_0}{1 + j\omega CZ_0}$$

$$6. \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} = \begin{bmatrix} 0.745 \angle 116.565^\circ & 0.66 \angle -90^\circ \\ 0.66 \angle -90^\circ & 0.745 \angle -116.565^\circ \end{bmatrix}$$

7. 생략

8. 생략

9. (a)  $d = 0.25\text{m}$

$$(b) Z_0 = 212.132\Omega$$

$$(c) |\Gamma_L| = 0.176$$

10.  $R_1 = R_3 = 61.36\Omega$

$$R_2 = 15.15\Omega$$

11. 생략

12. 전송선로 거리 :  $0.171\lambda$

$$1/4\text{파장 임피던스 변환기의 임피던스} : Z_T = \sqrt{50 \times 211.5} = 102.8\Omega$$

13. 생략

## 5장 답안

1. (a)  $P_{out} = 0.5\text{W}$   
 (b)  $\eta = 87\%$
2.  $Z_1 = 3Z_C = 150\Omega$   
 $Z_2 = \frac{3}{2}Z_C = 75\Omega$
3.  $P_{out} = -5.27[\text{dBm}] (0.297[\text{mW}])$
4.  $I = 40[\text{dB}]$
5.  $Z_{oe} = 59.9\Omega$  ,  $Z_{oo} = 41.7\Omega$
6. 생략
- 7.

| 입력전력 | 순방향송신전력 | 역방향송신전력 | 순방향삽입손실 | 거리도 |
|------|---------|---------|---------|-----|
| -10  | -11     | -30     | 1       | 20  |
| 0    | -1      | -20     | 1       | 20  |
| 10   | 9       | -13     | 1       | 23  |
| 25   | 24      | 5       | 1       | 20  |

8.

| 입력전력 | 포트 2 출력전력 | 포트 3 출력전력 | 삽입손실 | 방향성 |
|------|-----------|-----------|------|-----|
| 0    | -1        | -20       | 1    | 20  |
| 10   | 9         | -13       | 1    | 23  |
| 15   | 14        | -10       | 1    | 25  |

## 6장 답안

1. (a) 출력전력: 0[dBm] , 이득: 30[dB], 효율: 0.1%  
 (b) 출력전력: 20[dBm] , 이득: 20[dB], 효율: 10%  
 (c) 출력전력: 14[dBm] , 이득: 29[dB], 효율: 2.5%
2. A : 3[GHz]  $\rightarrow$  0[dBm]  
 B : 6[GHz]  $\rightarrow$  -15[dBm]  
 C : 7[GHz]  $\rightarrow$  -40[dBm]  
 D : 9[GHz]  $\rightarrow$  -30[dBm]
3. (a)  $\Delta = 0.32 \angle 171^\circ$   
 (b)  $K = 4.75 > 1$   
 (c)  $\Gamma_{out} = 0.56 \angle -40.7^\circ$   
 (d)  $G_a = 6.94$ [dB]  
 (e)  $G_{a\max} = 10.50$ [dB]
4.  $G_T = 13.742$   
 $G_A = 14.739$   
 $G_P = 12.562$
5.  $f_{IM1} = 1.820$ [GHz]  
 $f_{IM2} = 1.790$ [GHz]  
 $f_{IM1}, f_{IM2}$ 의 전력레벨 : -20[dBm]
- 6.

6.6  $\Rightarrow NF = -174(\text{dBm/Hz}) + 10 \log(B)$

| B(MHz) | $S_{in}$ (dBm) | $N_{in}$ (dBm) | $(S/N)_{in}$ | G(dB) | NF(dB) | $S_{out}$ (dBm) | $N_{out}$ (dBm) | $(S/N)_{out}$ (dB) |
|--------|----------------|----------------|--------------|-------|--------|-----------------|-----------------|--------------------|
| 3      | -80            | -109           | 29           | 30    | 4      | -50             | -75             | 25                 |
| 20     | -84            | -101           | 17           | 10    | 2      | -74             | -89             | 15                 |
| 10     | -90            | -104           | 14           | 25    | 3      | -65             | -76             | 11                 |
| 1      | -90            | -114           | 24           | 60    | 4      | -30             | -50             | 20                 |
| 4      | -80            | -108           | 28           | 40    | 3      | -40             | -65             | 25                 |

7. (a)  $\Delta = 0.53 \angle -79.11^\circ$   
 (b)  $K = 0.68 < 1$
8.  $P_{leak} = -15$ [dBm]
9.  $P_{IF82MHz} = -70$ [dBm]  
 $P_{IF325MHz} = -38$ [dBm]  
 $P_{IF243MHz} = P_{IF407MHz} = -48$ [dBm]  
 $P_{RF325MHz} = -18$ [dBm]  
 $f_{IF} = 325 \pm 82 = 243$ [MHz]/407[MHz]
10. (a)  $P_t = 22.5$ [dBm]  
 (b)  $P_{out} = -5.5$ [dBm]

11. 스위치가 on일 때 :  $P_{out} = -0.5[\text{dBm}]$   
스위치가 off일 때 :  $P_{out} = -25[\text{dBm}]$
12. 스위치가 on일 때 :  $P_{out} = 40[\text{W}]$   
스위치가 off일 때 :  $P_{out} = 0.504[\text{W}]$

## 7장 답안

1.  $\text{SNR}_{\text{in}} = 24[\text{dB}]$  ,  $\text{SNR}_{\text{out}} = 21[\text{dB}]$
2. (a)  $G_1 = 4.3[\text{dB}]$   
(b)  $N_{FT} = 6.1[\text{dB}]$
3. 3.67
4. 전체 잡음지수 :  $F = 2.0216$   
증폭기 위치를 바꾸었을 때 전체 잡음지수 :  $F = 5.013[\text{dB}]$
5.  $DR = 79.32[\text{dBm}]$
6.  $D_{MDS}(1\text{MHz}) = -101[\text{dBm}]$   
 $D_{MDS}(1\text{GHz}) = -71[\text{dBm}]$   
 $D_{MDS}(10\text{GHz}) = -61[\text{dBm}]$
7. (a)  $N_o = -129[\text{dBm}]$   
(b) 등가입력 잡음전력 :  $-126[\text{dBm}]$   
(c) 출력 잡음전력 :  $-116[\text{dBm}]$   
(d) 출력 신호 전력 :  $-100[\text{dBm}]$
8.  $IM3 = -50[\text{dBm}]$
9. (a)  $f_{\text{Range}} = 100[\text{MHz}] \pm 250[\text{Hz}]$   
(b)  $f_{\text{Range}} = 25[\text{MHz}] \pm 1500[\text{Hz}]$
10.  $\text{ITOI} = -19[\text{dBm}]$   
 $\text{OTOI} = -1[\text{dBm}]$
11.  $\text{IIP3} = -5[\text{dBm}]$   
 $P_{1dB} = -14.7[\text{dBm}]$



## 8장 답안

1.  $D = 3.010[\text{dB}]$
2. 방사전력  $S = 9.54 \times 10^{-4}[\text{W}/\text{m}^2]$   
방사저항  $R_r = 97.55 \times 10^2[\text{k}\Omega]$
3.  $VSWR = 1.9$
4.  $EIRP = 86.0206[\text{dBW}]$
5. (a)  $D = 1.5$   
(b)  $A_e = 0.27[\text{m}^2]$
6. 안테나 이득 :  $38[\text{dB}]$   
빔폭 :  $1.8^\circ$   
유효면적 :  $0.5[\text{m}^2]$
7. (a)  $df = 9.6[\text{cm}]$   
(b) 수신전력 :  $0.0007114[\text{W}]$   
(c)  $|E| = 0.487[\text{V}/\text{m}]$
8.  $(AF)_n = 2\cos^2\left(\frac{\pi}{4}\cos\theta\right)$
9. (a)  $EIRP = 26[\text{W}]$   
(b)  $L = 148.3[\text{dB}]$
10. (a)  $F = -127.8[\text{dBW}/\text{m}^2]$   
(b)  $P_r = -124.8[\text{dB}]$   
(c)  $L_p = 205.17[\text{dB}]$
11.  $P_r = -57[\text{dBm}]$
12.  $P_r = 3.979 \times 10^{-10}[\text{mW}]$
13.  $P_r = 6.3 \times 10^{-13}[\text{W}]$
14. 잡음전력보다  $15.9[\text{dBm}]$ 의 허용마진을 갖는다.