

2장 연습문제 답안

번호	답안
2.1	$\vec{E} = \left(\frac{27}{125} \vec{a}_x + \frac{36}{125} \vec{a}_z \right) \times 10^3 \text{ [V/m]}$
2.2	전체 전위 : 6.35 [V]
2.3	$ \vec{D} = \epsilon_0 \epsilon_r \vec{E} = 162\epsilon_0 \text{ [C/m}^2\text{]}$ $ \vec{P} = \epsilon_0 \epsilon_r \vec{E} = 160\epsilon_0 \text{ [C/m}^2\text{]}$
2.4	$\epsilon_1 = 4\epsilon_0$
2.5	$\vec{D}_2 = \vec{a}_x + \frac{2}{3} \vec{a}_y \text{ [C/m}^2\text{]}$ $\vec{E}_1 = \frac{\vec{D}_1}{\epsilon_0 \epsilon_r} = \frac{1}{3\epsilon_0} (\vec{a}_x + 2\vec{a}_y) \text{ [V/m]}$ $\vec{E}_2 = \frac{\vec{D}_2}{\epsilon_0} = \left(\frac{1}{\epsilon_0} \vec{a}_x + \frac{2}{3\epsilon_0} \vec{a}_y \right) \text{ [V/m]}$
2.6	(a) + z (b) $v_p = 2 \times 10^8 \text{ [m/s]}$ (c) $\lambda = \frac{2\pi}{5}$ (d) $\vec{H}(z, t) = -39.8 \cos(10^9 t - 5z) \vec{a}_x \text{ [\mu A/m]}$
2.7	$\omega = \frac{3.16}{\sqrt{\epsilon_0 \mu_0}} = 9.49 \times 10^8 \text{ [rad/s]}$
2.8	a) $\text{emf} = -\frac{d\Phi}{dt} = -10 \cos\left(\frac{\pi y}{2} - 250\pi t\right) \text{ [V]}$ (b) $\text{emf} = 0$
2.9	y방향의 선형편파
2.10	페이지 영역 : $\vec{E} = 10^{-5} e^{-j2.09z} \vec{a}_x \text{ [V/m]}$ 시간 영역 : $\vec{E}(z, t) = 10 \cos(6.28 \times 10^8 t - 2.09z) \vec{a}_x \text{ [\mu V/m]}$
2.11	(a) $\lambda \approx 0.63 \text{ [m]}$ (b) $\eta = 500 \text{ [\Omega]}$ (c) $\mu_r \approx 3.98$ (d) $\epsilon_r \approx 2.26$
2.12	(a) $\eta = 218 \text{ [\Omega]}$ (b) $ \vec{H} \approx 9.2 \text{ [mA/m]}$ (c) $P \approx 4.6 \text{ [mW]}$
2.13	(a) $d \approx 5.794 \text{ [m]}$ (b) $d \approx 579.4 \text{ [m]}$
2.14	생략
2.15	생략

2.16	$\alpha = \omega\sqrt{\mu\varepsilon} \left\{ \frac{1}{2} \left[\sqrt{1 + \left(\frac{\rho}{\omega\varepsilon} \right)^2} - 1 \right] \right\}^{\frac{1}{2}}$ $\beta = \omega\sqrt{\mu\varepsilon} \left\{ \frac{1}{2} \left[\sqrt{1 + \left(\frac{\rho}{\omega\varepsilon} \right)^2} + 1 \right] \right\}^{\frac{1}{2}}$														
2.17	<table><tr><th>입력전력</th><th>전체 삽입손실</th><th>출력전력</th></tr><tr><td>20[W]</td><td>2.5</td><td>45.5[dBm]</td></tr><tr><td>1[mW]</td><td>11</td><td>11[dBm]</td></tr><tr><td>23[dBm]</td><td>6</td><td>29[dBm]</td></tr></table>	입력전력	전체 삽입손실	출력전력	20[W]	2.5	45.5[dBm]	1[mW]	11	11[dBm]	23[dBm]	6	29[dBm]		
입력전력	전체 삽입손실	출력전력													
20[W]	2.5	45.5[dBm]													
1[mW]	11	11[dBm]													
23[dBm]	6	29[dBm]													
2.18	(a) 10^{-3} [mW]만큼 증가 (b) 10 [W]만큼 증가														

3장 연습문제 답안

번호	답안
3.1	$\alpha = 21 \times 10^{-6}$ $\beta = 687 \times 10^{-6}$ $v_p = 9.1458 \times 10^6 \text{ [m/s]}$
3.2	$R = \frac{1}{(2\pi)(13.14 \times 10^{-7})(5.87 \times 10^7)} \left[\frac{1}{0.45 \times 10^{-3}} + \frac{1}{1.475 \times 10^{-3}} \right] \text{ [\Omega/m]}$ $L = 0.24 \text{ [\mu H/m]}$ $C = 105 \text{ [pF/m]}$ $G = 0.152 \text{ [S/m]}$
3.3	$Z_L = 224.26 + j419.64 \text{ [\Omega]}$
3.4	$Z_{in} = 48.91 + j34.95 \text{ [\Omega]}$
3.5	(a) $R = 0.1151 \text{ [\Omega/m]}$ (b) $L = 0.2 \text{ [\mu H/m]}$ (c) $G = 46.04 \text{ [\mu S/m]}$ (d) $v_p = 2.5 \times 10^8 \text{ [m/s]}$
3.6	$X = -28 \text{ [\Omega]}, Z_0 = 56 \text{ [\Omega]}$
3.7	$\Gamma = 0.686 \angle -149^\circ$ $\text{VSWR} = \frac{1 + \Gamma }{1 - \Gamma } = 5.4$ $RL = -3.2 \text{ [dB]}$
3.8	$v(z, t) = 1.8 \cos(2\pi \times 10^8 t - 0.8\pi z) \text{ [V]}$ $i(z, t) = 0.024 \cos(2\pi \times 10^8 t - 0.8\pi z) \text{ [A]}$
3.9	생략
3.10	(a) $\Gamma_L = 0.097 \angle -115.5^\circ$ (b) $\text{VSWR} = 1.215$ (c) $l \approx 0.09\lambda$
3.11	연습문제 3.7과 동일
3.12	신호의 파장 $\lambda = 200 \text{ [cm]}$ $Z_L = 164.99 - j96.18 \text{ [\Omega]}$
3.13	(a) $\text{VSWR} = \frac{1}{3}$ (b) 75% 전력이 전달됨
3.14	$P_{T1} = 78.13111 \text{ [mW]}$ $P_{T2} = 63.8 \text{ [mW]}$
3.15	64%
3.16	0.1156%
3.17	$P_d = 119.008 \text{ [mW]}$
3.18	$l = 124 \text{ [mm]}$
3.19	$C = 2.62 \text{ [pF]}$

3.20	(a) $VSWR = 2$ (b) 11.1% (c) $R_L = 9.54$ [dB]
3.21	7 [GHz]
3.22	12 [GHz]에 대해 $v_g = 165.8 \times 10^6$ [m/s] 17 [GHz]에 대해 $v_g = 242.6 \times 10^6$ [m/s] $\Delta t = 955$ [ns]
3.23	$a = 3.5$ mm $\rightarrow 0.0753$ [1/m] $a = 10$ mm $\rightarrow 0.65$ [dB/m]

4장 연습문제 답안

번호	답안
4.1	$Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} Z_0 \coth(rl) & Z_0 / \sinh(rl) \\ Z_0 / \sinh(rl) & Z_0 \coth(rl) \end{bmatrix}$
4.2	$Y = \begin{bmatrix} 0.1318 & -0.0864 \\ -0.0864 & 0.1773 \end{bmatrix}$
4.3	$[ABCD] = \begin{pmatrix} 1 + Z_1 Y_2 & Z_1 \\ Y_2 & 1 \end{pmatrix}$
4.4	생략
4.5	<p>임피던스 행렬 : $\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 18 & 6 \\ 6 & 9 \end{bmatrix} [\Omega]$</p> <p>하이브리드 행렬 : $\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} 14\Omega & \frac{2}{3} \\ -\frac{2}{3} & \frac{1}{9}S \end{bmatrix}$</p>
4.6	$S_{11} = \frac{1 - j\omega c Z_0}{1 + j\omega Z}$
4.7	$\begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} = \begin{bmatrix} 0.745 \angle 116.565^\circ & 0.66 \angle -90^\circ \\ 0.66 \angle -90^\circ & 0.745 \angle -116.565^\circ \end{bmatrix}$
4.8	생략
4.9	생략
4.10	<p>(a) $d = 0.25 [\text{m}]$</p> <p>(b) $Z_0 = 212.132 [\Omega]$</p> <p>(c) $\Gamma_L = -0.1716$</p>
4.11	생략
4.12	생략
4.13	$Z_T = 102.8 [\Omega]$
4.14	<p>비율대역폭 105.5%</p> <p>G. D. Vandelin “Microwave Circuit Design Using Linear and Nonlinear Technique” 참조</p>
4.15	$818.5964 [\text{MHz}] \leq f \leq 981.4.37 [\text{MHz}]$

5장 연습문제 답안

번호	답안																									
5.1	(a) $P_{out} = 0.5$ [W] (b) 87%																									
5.2	$Z_1 = 150$ [Ω], $Z_2 = 75$ [Ω]																									
5.3	$P_{out} = -5.27$ [dBm]																									
5.4	40[dB]																									
5.5	우모드 : 59.9 [Ω] 기모드 : 41.7 [Ω]																									
5.6	생략																									
5.7	<table><tr><th>입력전력</th><th>순방향송신전력</th><th>역방향송신전력</th><th>순방향삽입손실</th><th>격리도</th></tr><tr><td>-10</td><td>-11</td><td>-30</td><td>1</td><td>20</td></tr><tr><td>0</td><td>-1</td><td>-20</td><td>1</td><td>20</td></tr><tr><td>10</td><td>9</td><td>-13</td><td>1</td><td>23</td></tr><tr><td>25</td><td>24</td><td>5</td><td>1</td><td>20</td></tr></table>	입력전력	순방향송신전력	역방향송신전력	순방향삽입손실	격리도	-10	-11	-30	1	20	0	-1	-20	1	20	10	9	-13	1	23	25	24	5	1	20
입력전력	순방향송신전력	역방향송신전력	순방향삽입손실	격리도																						
-10	-11	-30	1	20																						
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입력전력	포트2 출력	포트3 출력	삽입손실	비방향성																						
0	-1	-20	1	20																						
10	9	-13	1	23																						
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6장 연습문제 답안

번호	답안																																																						
6.1	(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%																																																						
6.2	A : 0 [dBm] @ 3 [GHz] B : -15 [dBm] @ 6 [GHz] C : -40 [dBm] @ 7 [GHz] D : -30 [dBm] @ 9 [GHz]																																																						
6.3	(a) $\angle = 0.32 \angle 171^\circ$ (b) $K = 4.75 > 1$ (c) $\Gamma_{out} = 0.56 \angle -40.7^\circ$ (d) $G_a = 6.94$ [dB] (e) $G_{amax} = 10.50$ [dB]																																																						
6.4	$G_P = 13.742$, $G_A = 14.739$, $G_T = 12.562$																																																						
6.5	$f_{IM1} = 1.820$ [GHz], $f_{IM2} = 1.790$ [GHz] 전력레벨 -20 [dBm]																																																						
6.6	<table><tr><th>B</th><th>S_{in}</th><th>N_{in}</th><th>$(S/N)_{in}$</th><th>G</th><th>NF</th><th>S_{out}</th><th>N_{out}</th><th>$(S/N)_{out}$</th></tr><tr><td>3</td><td>-80</td><td>-109</td><td>29</td><td>30</td><td>4</td><td>-50</td><td>-115</td><td>25</td></tr><tr><td>20</td><td>-84</td><td>-101</td><td>17</td><td>10</td><td>2</td><td>-114</td><td>-89</td><td>15</td></tr><tr><td>10</td><td>-90</td><td>-104</td><td>14</td><td>25</td><td>3</td><td>-65</td><td>-116</td><td>11</td></tr><tr><td>1</td><td>-90</td><td>-114</td><td>24</td><td>60</td><td>4</td><td>-30</td><td>-50</td><td>20</td></tr><tr><td>4</td><td>-80</td><td>-108</td><td>28</td><td>40</td><td>3</td><td>-40</td><td>-65</td><td>25</td></tr></table> <p style="text-align: center;">$N_{in} = N_F - 114 \text{ (dBm/Hz)} + 10 \log(B)$</p>	B	S_{in}	N_{in}	$(S/N)_{in}$	G	NF	S_{out}	N_{out}	$(S/N)_{out}$	3	-80	-109	29	30	4	-50	-115	25	20	-84	-101	17	10	2	-114	-89	15	10	-90	-104	14	25	3	-65	-116	11	1	-90	-114	24	60	4	-30	-50	20	4	-80	-108	28	40	3	-40	-65	25
B	S_{in}	N_{in}	$(S/N)_{in}$	G	NF	S_{out}	N_{out}	$(S/N)_{out}$																																															
3	-80	-109	29	30	4	-50	-115	25																																															
20	-84	-101	17	10	2	-114	-89	15																																															
10	-90	-104	14	25	3	-65	-116	11																																															
1	-90	-114	24	60	4	-30	-50	20																																															
4	-80	-108	28	40	3	-40	-65	25																																															
6.7	(a) $\angle = 0.53 \angle -79.11^\circ$ (b) $K = 0.68 < 1$																																																						
6.8	$P_{IF} = -4.5$ [dBm], $P_{leak} = -15$ [dBm]																																																						
6.9	$P_{IF82} = -70$ [dBm], $P_{IF325} = -38$ [dBm], $P_{IF243} = P_{IF407} = -48$ [dBm] $P_{RF325} = -18$ [dBm]																																																						
6.10	(a) $f_{LO} = 117.6$ 또는 96.2 [MHz] (b) $f_{RF} = 1005$ 또는 865 [MHz] (c) $f_{IF} = 472.0$ 또는 40.5 [MHz]																																																						
6.11	(a) $P_t = 22.5$ [dBm] (b) $P_{out} = -5.5$ [dBm]																																																						
6.12	스위치가 On일 때 : $P_{out} = -0.5$ [dBm] 스위치가 OFF일 때 : $P_{out} = -25$ [dBm]																																																						

6.13	스위치가 On일 때 : $P_{out} = 40 \text{ [W]}$ 스위치가 OFF일 때 : $P_{out} = 0.504 \text{ [W]}$
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7장 연습문제 답안

번호	답안
7.1	$SNR_{in} = 24 \text{ [dB]}, SNR_{out} = 21 \text{ [dB]}$
7.2	(a) 4.3 [dB] (b) 6.1 [dB]
7.3	전체 잡음인자 ≈ 3.67
7.4	전체이득 : 100 전체 잡음지수 : 2.0216 두 증폭기 위치를 바꿨을 때의 잡음지수 : 5.013 [dB]
7.5	$DR = 79.32 \text{ [dBm]}$
7.6	$P_{MBS}(1\text{MHz}) = -101 \text{ [dBm]}$ $P_{MBS}(1\text{GHz}) = -71 \text{ [dBm]}$ $P_{MBS}(10\text{GHz}) = -61 \text{ [dBm]}$
7.7	(a) $MDS = -101.7 \text{ [dBm]}$ (b) 수신기에서 복조하기 위한 최소 전력 : -81.7 [dBm]
7.8	(a) -129 [dBm] (b) 등가입력 잡음전력 : -126 [dBm] (c) 출력잡음전력 : -116 [dBm] (d) 출력신호전력 : -100 [dBm]
7.9	$IM3 = -50 \text{ [dBm]}$
7.10	(a) $f_{\text{Range}} = 100 \text{ [MHz]} \pm 250 \text{ [Hz]}$ (b) $f_{\text{Range}} = 25 \text{ [MHz]} \pm 1500 \text{ [Hz]}$
7.11	입력 3차 교차점 : $ITOI = -19 \text{ [dBm]}$ 출력 3차 교차점 : $OTOI = -1 \text{ [dBm]}$
7.12	$IIP3 = -5 \text{ [dBm]}$ $P_{1\text{dB}} = -14.7 \text{ [dBm]}$

8장 연습문제 답안

번호	답안
8.1	지향성 $D = 3.010$ [dB]
8.2	방사전력 : $P_r = 2.39 \times 10^4$ [W] 방사저항 : $R_r = 97.55 \times 10^2$
8.3	VSWR = 1.9
8.4	EIRP = 86.0206 [dBW]
8.5	(a) $D = 1.5$ (b) $A_e = 0.27$ [m ²]
8.6	안테나 이득 : $G = 87.9$ [dB] 빔폭 : $\theta = 1.8^\circ$ 유효면적 : $A_{eff} = 0.4712$
8.7	(a) 원거리장에 위치함 (b) $P_r = -31.0406$ [dBm] (c) $ E = 0.6124$ [V/m]
8.8	$(AF)_n = 2 \cos^2\left(\frac{\pi}{4} \cos \theta\right)$
8.9	$P_t = -72.8$ [dBm]
8.10	$P_r = -33.9$ [dBm]
8.11	$P_r = -59.1$ [dBm]
8.12	$P_{D(1km)} = 31.7$ [nW/m ²]
8.13	(a) EIRP = 14.15 [dBi] (b) $L = -134$ [dBW]
8.14	$P_r = -57$ [dBm]
8.15	(a) $F = -127.8$ [dBW/m ²] (b) $P_r = -124.8$ [dB] (c) $L_p = 205.17$ [dB]
8.16	$P_r \approx -94$ [dBm]
8.17	$P_r = 6.3 \times 10^{13}$ [W]
8.18	1dB의 간섭마진은 잡음레벨보다 약 5.9dB 낮은 전력값을 갖는다.

9장 연습문제 답안

번호	답안
9.1	$P_t = 50 \text{ [kW]}, d_t = 2 \times 10^{-3} \text{ [s]}$
9.2	$d_t = 10 \times 10^{-6} \text{ [s]}$
9.3	(a) $d_t = 0.2 \text{ [s]}$ (b) 10kHz의 경우, $\text{PRI} = 0.1 \text{ [ms]}$ 20kHz의 경우, $\text{PRI} = 0.05 \text{ [ms]}$ (c) 10kHz의 경우, $\tau = 20 \text{ [\mu s]}$ 20kHz의 경우, $\tau = 10 \text{ [\mu s]}$ (d) 10kHz의 경우, $E_p = 0.1 \text{ [J]}$ 20kHz의 경우, $E_p = 0.05 \text{ [J]}$
9.4	(a) $\text{PRF} = 750 \text{ [Hz]}$ (b) $\text{PRI} \approx 1.33 \text{ [ms]}$ (c) $\Delta R = 150 \text{ [m]}$ (d) $\tau = 1 \text{ [\mu s]}$
9.5	(a) $\text{PRF} = 1 \text{ [kHz]}$ (b) $P_{av} = 1.2 \text{ [kW]}$ (c) $d_t = 1.2 \text{ [ms]}$ (d) $R_{\max} = 150 \text{ [km]}$
9.6	(a) $R_{\max} = 187.5 \text{ [km]}$ (b) $\Delta R = 300 \text{ [m]}$
9.7	$\text{PRF} = 300 \text{ [Hz]}$
9.8	$S_{\min} = 834 \text{ [pW]}$
9.9	$R_{\max} = 685 \text{ [km]}$
9.10	$R_{\max} = 9.44 \text{ [km]}$
9.11	(a) $P_r = 1.1338 \times 10^{-8} \text{ [W]}$ (b) $\text{SNR} = 40.54 \text{ [dB]}$
9.12	$R_{\max} = 82 \text{ [km]}$
9.13	(a) $d_t = 0.1\%$ (b) $P_{av} = 100 \text{ [W]}$ (c) 0.0644 [s] (d) $n \approx 64 \text{ 회}$ (e) $R_{\max} = 150 \text{ [km]}$ (f) $B = 1 \text{ [mHz]}$
9.14	$f_R = 9.999986600 \text{ [GHz]}$
9.15	$f_R = 10.000016 \text{ [kHz]}$
9.16	3MHz에서 $\lambda = 100 \text{ [m]}$ 일 때 : 관찰시간 19초 3MHz에서 $\lambda = 0.1 \text{ [m]}$ 일 때 : 관찰시간 0.01 [s]

9.17	(a) $\text{PRF} = 333 \text{ [Hz]}$ (b) $d_t = 0.1\%$
9.18	(a) $R_{\text{max}} = 238.5 \text{ [km]}$ (b) $R_{\text{max}} = 126.7 \text{ [dBw}^{-1}\text{]}$

10장 연습문제 답안

번호	답안
10.1	변조주파수 : 0.0316 변조지수 $m = 0.356$
10.2	(a) $V_T = 15.8 \text{ rms}$ (b) $V_1 = 5.37 \text{ [V]}$, $V_2 = 7.74 \text{ [V]}$, $V_3 = 4.9 \text{ [V]}$ (c) $f_{USB1} = 160 \text{ MHz} + 1 \text{ kHz} = 160.001 \text{ [MHZ]}$ $f_{USB2} = 160.002 \text{ [MHZ]}$ $f_{USB3} = 160.002 \text{ [MHZ]}$ $f_{LSB1} = 159.999 \text{ [MHZ]}$ $f_{LSB2} = 159.998 \text{ [MHZ]}$ $f_{LSB3} = 159.997 \text{ [MHZ]}$ (d) $P_c = 0.338 \text{ [W]}$ $P_1 = 0.576 \text{ [W]}$, $P_2 = 1.2 \text{ [W]}$, $P_3 = 0.48 \text{ [W]}$
10.3	$(S/N)_o \text{ [dB]} = 34 \text{ [dB]}$
10.4	(a) $C = 50.3 \text{ [kb/s]}$ (b) $C = 40 \text{ [kb/s]}$
10.5	(a) $SIR = 4.26 \text{ [dB]}$ (b) $E_b/N_o = 18.26 \text{ [dB]}$
10.6	(a) 처리이득 = 10 [dB] (b) $SIR = 13 \text{ [dB]}$
10.7	$S/N @ 30 \text{ kHz} = 19 \text{ [dB]}$ $S/N @ 10 \text{ MHz} = -6 \text{ [dB]}$
10.8	$B_{RF} = 10 \text{ [MHz]}$ $(S/N)_o = 3 \text{ [dB]}$