

EE 481/581 Microwave Engineering

Quiz #1 (Fall 2025)

Name

Key A

Instructions: Open book & notes. Place answers in indicated spaces and show all work for credit.

You are given a ShengYi S1141 PCB datasheet excerpt. At 1 MHz, determine the typical complex permittivity ϵ_c and effective conductivity σ . Then, find the attenuation constant (Np/m & dB/m), phase constant, and intrinsic impedance seen by a plane wave propagating through the non-magnetic PCB. Put complex numbers in rectangular format.

From datasheet, $\epsilon_r = 4.6$ & $\tan \delta = 0.015$ at 1 MHz.

$$\text{Per notes, } \epsilon' = \epsilon_r \epsilon_0 = 4.6 (8.8541878 \times 10^{-12}) \\ = 4.072926 \times 10^{-11} \text{ F/m}$$

$$\epsilon'' = \epsilon' \tan \delta = 4.073 \times 10^{-11} (0.015) \\ = 6.1093896 \times 10^{-13} \text{ F/m}$$

$$\epsilon_c = \epsilon' - j\epsilon'' = 4.073 \times 10^{-11} - j6.109 \times 10^{-13} \text{ F/m}$$

$$\sigma = \omega \epsilon'' = 2\pi (1 \times 10^6) 6.1094 \times 10^{-13} = 3.83864 \times 10^{-6} \text{ S/m}$$

Table 1.1 $\gamma = j\omega \sqrt{\mu \epsilon'} \sqrt{1 - j\frac{\sigma}{\omega \epsilon'}}$

$$= j2\pi (10^6) \sqrt{4\pi \times 10^{-7} (4.073 \times 10^{-11})} \sqrt{1 - j0.015}$$

$$= 0.000337122 + j0.04495213 \text{ m}^{-1} = \alpha + j\beta$$

$$\alpha = \text{Re}(\gamma) = 0.000337122 \text{ Np/m} \stackrel{\times 8.686}{=} 0.002928 \text{ dB/m}$$

$$\beta = \text{Im}(\gamma) = 0.04495 \text{ rad/m}$$

$$\eta = \frac{j\omega \mu}{\gamma} = \frac{j2\pi 10^6 (4\pi \times 10^{-7})}{0.000337 + j0.04495} = 175.6366 + j1.3172 \Omega$$

$$\epsilon_c = 40.73 - j0.6109 \text{ pF/m} \quad \sigma = 3.8386 \text{ nS/m}$$

$$\text{atten. constant} = 3.371 \times 10^{-4} \frac{\text{Np}}{\text{m}} = 0.002928 \frac{\text{dB}}{\text{m}} \quad \text{phase constant} = 0.04495 \text{ rad/m}$$

$$\text{intrinsic impedance} = 175.6366 + j1.3172 \Omega$$

S1141

(UL ANSI:FR-4)UV Blocking

- 特点
- Tg140℃ (DSC)。
 - UV Blocking/AOI兼容。
 - 优良的机械加工性能。

- FEATURES
- Tg140℃ (DSC)。
 - UV Blocking/AOI Compatible.
 - Excellent mechanical processability.

应用领域

电脑、仪器仪表、摄像机、通讯设备、
电子游戏机、汽车、航空等。

APPLICATIONS

Computer,Instrumentation,VCR,
communication equipment,electronic
game machine,automotive electronics,
aviation,and etc.

GENERAL PROPERTIES

Test Item	Treatment Condition	Unit	Property Data	
			SPEC	Typical Value
Tg	DSC	℃	≥130	140
Flammability	C-48/23/50	Rating	V-0	V-0
	E-24/125			
Volume Resistivity	After moisture resistance	MΩ-cm	≥10 ⁹	5.2×10 ⁸
	E-24/125		≥10 ⁹	5.2×10 ⁸
Surface Resistivity	After moisture resistance	MΩ	≥10 ⁴	5.4×10 ⁷
	E-24/125		≥10 ³	5.6×10 ⁶
Arc Resistance	D-48/50+D-0.5/23	S	≥60	120
Dielectric Breakdown	D-48/50+D-0.5/23	KV	≥40	60
Dielectric Constant (1MHz)	C-24/23/50	-	≤5.4	4.6
Dissipation Factor (1MHz)	C-24/23/50	-	≤0.035	0.015

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EE 481/581 Microwave Engineering

Quiz #1 (Fall 2025)

Name Key B**Instructions:** Open book & notes. Place answers in indicated spaces and show all work for credit.

You are given a ShengYi S1165 PCB datasheet excerpt. At 1 MHz, determine the typical complex permittivity ϵ_c and effective conductivity σ . Then, find the attenuation constant (Np/m & dB/m), phase constant, and intrinsic impedance seen by a plane wave propagating through the non-magnetic PCB. Put complex numbers in rectangular format.

From datasheet, $\epsilon_r = 4.8$ & $\tan \delta = 0.007$ @ 1 MHz

$$\text{Per notes, } \epsilon' = \epsilon_r \epsilon_0 = 4.8 (8.8541878 \times 10^{-12}) \\ = 4.25001 \times 10^{-11} \text{ F/m}$$

$$\epsilon'' = \epsilon' \tan \delta = 4.25 \times 10^{-11} (0.007) \\ = 2.975007 \times 10^{-13} \text{ F/m}$$

$$\epsilon_c = \epsilon' - j\epsilon'' = 4.25 \times 10^{-11} - j 2.975 \times 10^{-13} \text{ F/m}$$

$$\sigma = \omega \epsilon'' = 2\pi \times 10^6 (2.975 \times 10^{-13}) = 1.86925 \times 10^{-6} \text{ S/m}$$

Table 1.1 $\gamma = j\omega \sqrt{\mu \epsilon'} \sqrt{1 - j\sigma/\omega \epsilon'}$

$$= j 2\pi \times 10^6 \sqrt{4\pi \times 10^{-7} (4.25 \times 10^{-11})} \sqrt{1 - j 0.007}$$

$$= 0.000160711 + j 0.04591794 \text{ m}^{-1} = \alpha + j\beta$$

$$\alpha = \text{Re}(\gamma) = 0.0001607 \text{ Np/m} \stackrel{\times 8.686}{=} 0.0013959 \text{ dB/m}$$

$$\beta = \text{Im}(\gamma) = 0.045918 \text{ rad/m}$$

$$\eta = \frac{j\omega \mu}{\gamma} = \frac{j 2\pi \times 10^6 (4\pi \times 10^{-7})}{0.00016 + j 0.04592} = 171.9499 + j 0.60181 \Omega$$

$$\epsilon_c = 42.5 - j 0.2975 \text{ pF/m} \quad \sigma = 1.8693 \text{ nS/m}$$

$$\text{atten. constant} = 0.0001607 \frac{\text{Np}}{\text{m}} = 0.001396 \frac{\text{dB}}{\text{m}} \quad \text{phase constant} = 0.045918 \text{ rad/m}$$

$$\text{intrinsic impedance} = 171.95 + j 0.6018 \Omega$$

S1165

(UL ANSI:No ANSI) High Performance Halogen-Free

特点

- 无铅兼容FR-4板材。
- UV Blocking与AOI兼容。
- 高Tg无卤产品，Tg 170℃ (DSC)。
- 板材具备较低的z轴膨胀系数。
- 较低的介电损耗，Df<0.01。

FEATURES

- Lead-free compatible FR-4 laminate.
- UV Blocking/AOI compatible.
- High Tg Halogen-free product, Tg 170℃(DSC).
- Lower Z-axis CTE.
- Lower dissipation, Df<0.01.

应用领域

手机、电脑、仪器仪表、摄像机、电视机、电子游戏机、通讯设备等。

APPLICATIONS

Mobile phone, computer, instrumentation, VCR, TV, electronic game machine, communication equipment, and etc.

GENERAL PROPERTIES

Test Item	Treatment Condition	Unit	Property Data	
			SPEC	Typical Value
Tg	DSC	℃	≥ 165	170
Flammability	C-48/23/50	Rating	V-0	V-0
	E-24/125			
Volume Resistivity	After moisture resistance	MΩ-cm	≥ 10 ⁶	2.0×10 ⁸
	E-24/125		≥ 10 ³	2.0×10 ⁶
Surface Resistivity	After moisture resistance	MΩ	≥ 10 ⁴	1.0×10 ⁷
	E-24/125		≥ 10 ³	4.0×10 ⁶
Arc Resistance	D-48/50+D-0.5/23	S	≥ 60	127
Dielectric Breakdown	D-48/50+D-0.5/23	KV	≥ 40	55
Dielectric Constant (1MHz)	C-24/23/50	-	≤ 5.4	4.8
Dissipation Factor (1MHz)	C-24/23/50	-	≤ 0.035	0.007

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