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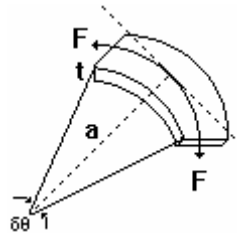
[ ]

t w a

:

$$S_1 = s_{11}T_1 + d_{31}E_3 \quad (1)$$

$$D_3 = d_{31}T_1 + \epsilon_{33}^T E_3 \quad (2)$$



$a \gg t, w$

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$F_r$   $T_1$   $E_3$

$$F_r = F \delta \theta = T_1 w t \delta \theta \quad (3)$$

$$\rho w t a \delta \theta (d^2 \epsilon / dt^2) = -T_1 w \delta \theta \quad (4)$$

$$S_1 = \epsilon / a \quad \epsilon_{33}^T \quad \rho$$

$$(d^2 \epsilon / dt^2) + (1/a^2 \rho s_{11}^E) \epsilon = (d_{31} / a \rho s_{11}^E) E_3 \quad (5)$$

$$E = 0$$

$$\omega_0 = 1/a^2 \rho s_{11}^E = (v_b^E)^2 / a^2 \quad (6)$$

$v_b^E$

$$E_3 = E_0 e^{i\omega t}$$

$$\epsilon = d_{31} E_3 / a \rho s_{11}^E (\omega_0^2 - \omega^2) \quad (V)$$

$$D_3 = (d_{31} / s_{11}^E) S_1 + \epsilon_{33}^T (1 - k_{31}^2) E_3 \quad (A)$$

$$k_{31}^2 = d_{31}^2 / s_{11}^E \epsilon_{33}^T \quad (\text{Coupling factor}) \quad k_{31}$$

$$I = 2\pi a \omega D$$

$$I = i\omega 2\pi a \omega ((d_{31}^2 / a^2 \rho (s_{11}^E)^2 (\omega_0^2 - \omega^2)) + (\epsilon_{33}^T (1 - k_{31}^2))) E_3 \quad (9)$$

$$E_3 = V/t$$

$$I = (i\omega 2\pi a \omega / t) ((k_{31}^2 \epsilon_{33}^T \omega_0 / (\omega_0^2 - \omega^2)) + (\epsilon_{33}^T (1 - k_{31}^2))) V \quad (10)$$

Y

Y

$$Y = 1/Z = (i\omega 2\pi a \omega / t) ((k_{31}^2 \epsilon_{33}^T \omega_0 / (\omega_0^2 - \omega^2)) + (\epsilon_{33}^T (1 - k_{31}^2))) \quad (11)$$

$$\omega_0^2 - \omega_r^2 = 0 \Rightarrow \omega_0 = \omega_r = 1/a^2 \rho s_{11}^E \quad (12)$$

$$\omega_{ar}^2 = \omega_r^2 / (1 - k_{31}^2) \quad (13)$$

$$k_{31}^2 = (\omega_{ar}^2 - \omega_r^2) / \omega_{ar}^2 \quad (14)$$

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z

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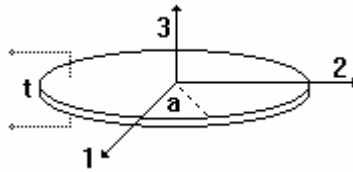
$$c_{11}^p \left( \frac{d^2 u_r}{dr^2} + \left( \frac{1}{r} \right) \left( \frac{du_r}{dr} \right) - \left( \frac{u_r}{r^2} \right) \right) = \rho \left( \frac{d^2 u_r}{dt^2} \right) \quad (15)$$

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$c_{11}^p$

$u_r$

$$c_{11}^p = s_{11}^E / \left( (s_{11}^E)^2 - (s_{12}^E)^2 \right) \quad (16)$$



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$$T_3 = c_{11}^p \left( \frac{du_r}{dr} \right) + c_{12}^p \left( \frac{u_r}{r} \right) - e_{31}^p E_3 \quad (17)$$

$$D_3 = e_{31}^p \left( \frac{1}{r} \right) \left( \frac{d}{dr} \right) (ru_r) + \epsilon_{33}^p E_3 \quad (18)$$

:

$$c_{12}^p = -s_{12}^E / \left( (s_{11}^E)^2 - (s_{12}^E)^2 \right) \quad (19)$$

$$e_{31}^p = d_{31} / (s_{11}^E + s_{12}^E) \quad (20)$$

$$\epsilon_{33}^p = (-2d_{31}^2 / (s_{11}^E + s_{12}^E)) + \epsilon_{31}^T \quad (21)$$

$$E_3 = V/t \quad (22)$$

V

:

$r=a$

$$u_r = A J_1(\omega r / v^p) e^{i\omega t} \quad (23)$$

:

$v^p$

$J_1$

$$v^p = (c_{11}^p / \rho)^{1/2} \quad (24)$$

$$Z = 1/Y = 1 / ((i\omega \varepsilon_{33}^T \pi a^2 / t) ((2(k^p)^2 / (1 - \sigma_p - J_1)) - 1)) \quad (25)$$

$$J_1(z) = 2J_0(z) / J_1(z) :$$

$$: \quad \sigma_p \quad J_0$$

$$\sigma_p = -s_{12}^E / s_{11}^E \quad (26)$$

$$: \quad k^p$$

$$k^p = e_{31}^p / (c_{11}^p \varepsilon_{33}^p)^{1/2} \quad (27)$$

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$$(k^p)^2 = ((1 + \sigma^p) / 2) / (k_p^2 / (1 - k_p^2)) \quad (28)$$

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$$Z = 1/Y = 1 / ((i\omega \varepsilon_{33}^T \pi a^2 / t) (1 - k_p^2) ((J_1(\omega a / v^p) - 1 + ((\sigma_p + k_p^2) / (1 - k_p^2))) / J_1(\omega a / v^p) - 1 + \sigma_p)) \quad (29)$$

$$. J_1(\omega a / v^p) = (\omega a / v^p) (J_0((\omega a / v^p)) / J_1(\omega a / v^p)) :$$

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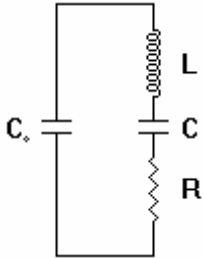
$$J_1(\omega a / v^p) = 1 - \sigma^p \quad (30)$$

$$J_1(\omega a / v^p) = 1 + \sigma^p - 2(k^p)^2 \quad (31)$$

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$$L = \rho t A / 2\phi^2 \tag{32}$$

$$C = 2t\phi^2 / \pi^2 \rho c_l^2 A \tag{33}$$

$$R = 2ZA / \phi^2 \tag{34}$$

$$C_0 = \epsilon_{33}^s A / t \tag{35}$$

:

: t

: A

:  $\rho$

$\rho_0 \quad c_0$  ) .

:  $Z = \rho_0 c_0$

(.

:

:  $\phi$

$$\phi = e_{33} A / t \tag{36}$$

:  $e_{33}$

:

$$Y = 1/Z_e = i\omega C_s + (1/(iL\omega + R + (1/i\omega C))) = i\omega C_s + (i\omega C / (1 - L\omega^2 C + i\omega CR)) \tag{37}$$

Network Spectrum Analyzer Ms4201

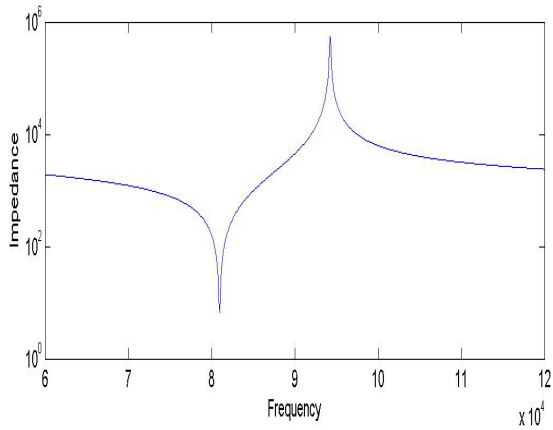
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$S_{11}^E$	$K_p$	$K_{33}^T$		(mm)	(mm)	(mm)			
/	/			/	/		BM		
/	/					/	BM		

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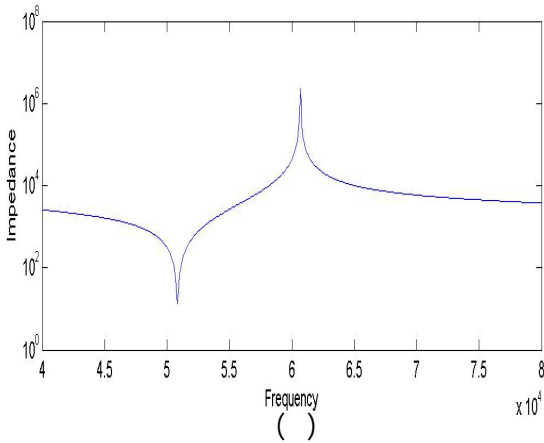
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( ) ( KHz)



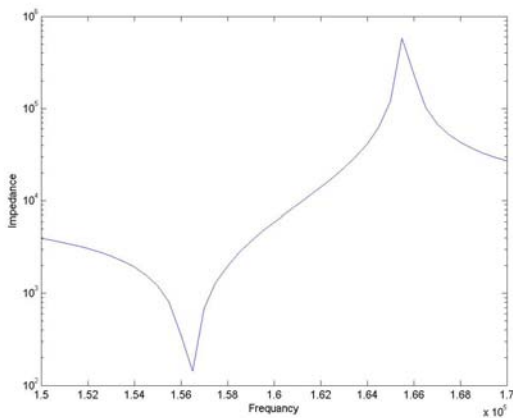
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