

P-4G Electromechanical characteristics matrix

Stiffness coefficient matrix

$$\begin{bmatrix} C_{11}^E & C_{12}^E & C_{13}^E & 0 & 0 & 0 \\ C_{12}^E & C_{11}^E & C_{13}^E & 0 & 0 & 0 \\ C_{13}^E & C_{13}^E & C_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66}^E \end{bmatrix} = \begin{bmatrix} 17 & 10.4 & 9.7 & 0 & 0 & 0 \\ 10.4 & 17 & 9.7 & 0 & 0 & 0 \\ 9.7 & 9.7 & 12.6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 3.3 \end{bmatrix} \begin{matrix} E \\ 10^{10} N/m^2 \end{matrix}$$

$$\begin{bmatrix} C_{11}^D & C_{12}^D & C_{13}^D & 0 & 0 & 0 \\ C_{12}^D & C_{11}^D & C_{13}^D & 0 & 0 & 0 \\ C_{13}^D & C_{13}^D & C_{33}^D & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44}^D & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{55}^D & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66}^D \end{bmatrix} = \begin{bmatrix} 17.8 & 11.2 & 8.3 & 0 & 0 & 0 \\ 11.2 & 17.8 & 8.3 & 0 & 0 & 0 \\ 8.3 & 8.3 & 16.7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 5.2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 5.2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 3.3 \end{bmatrix} \begin{matrix} D \\ 10^{10} N/m^2 \end{matrix}$$

Elastic Flexibility Coefficient Matrix

$$\begin{bmatrix} S_{11}^E & S_{12}^E & S_{13}^E & 0 & 0 & 0 \\ S_{12}^E & S_{11}^E & S_{13}^E & 0 & 0 & 0 \\ S_{13}^E & S_{13}^E & S_{33}^E & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44}^E & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55}^E & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66}^E \end{bmatrix} = \begin{bmatrix} 11.6 & -3.6 & -6.2 & 0 & 0 & 0 \\ -3.6 & 11.6 & -6.2 & 0 & 0 & 0 \\ -6.2 & -6.2 & 17.5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 33.3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 33.3 & 0 \\ 0 & 0 & 0 & 0 & 0 & 30.3 \end{bmatrix} \begin{matrix} E \\ 10^{-12} m^2/N \end{matrix}$$

$$\begin{bmatrix} S_{11}^D & S_{12}^D & S_{13}^D & 0 & 0 & 0 \\ S_{12}^D & S_{11}^D & S_{13}^D & 0 & 0 & 0 \\ S_{13}^D & S_{13}^D & S_{33}^D & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44}^D & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55}^D & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66}^D \end{bmatrix} = \begin{bmatrix} 10 & -5.1 & -2.6 & 0 & 0 & 0 \\ -5.1 & 10 & -2.6 & 0 & 0 & 0 \\ -2.6 & -2.6 & 9.2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 19.4 & 0 & 0 \\ 0 & 0 & 0 & 0 & 19.4 & 0 \\ 0 & 0 & 0 & 0 & 0 & 30.3 \end{bmatrix} \begin{matrix} D \\ 10^{-12} m^2/N \end{matrix}$$

Piezoelectric constant matrix

$$\begin{bmatrix} 0 & 0 & 0 & 0 & d_{15} & 0 \\ 0 & 0 & 0 & d_{24} & 0 & 0 \\ d_{31} & d_{31} & d_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 450 & 0 \\ 0 & 0 & 0 & 450 & 0 & 0 \\ -150 & -150 & 340 & 0 & 0 & 0 \end{bmatrix} \quad 10^{12} \text{C/N}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & g_{15} & 0 \\ 0 & 0 & 0 & g_{24} & 0 & 0 \\ g_{31} & g_{31} & g_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 30.5 & 0 \\ 0 & 0 & 0 & 30.5 & 0 & 0 \\ -11 & -11 & 24.1 & 0 & 0 & 0 \end{bmatrix} \quad 10^{-3} \text{Vm/N}$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & e_{15} & 0 \\ 0 & 0 & 0 & e_{24} & 0 & 0 \\ e_{31} & e_{31} & e_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 13.7 & 0 \\ 0 & 0 & 0 & 13.7 & 0 & 0 \\ -7.5 & -7.5 & 14.4 & 0 & 0 & 0 \end{bmatrix} \quad \text{C/m}^2$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & h_{15} & 0 \\ 0 & 0 & 0 & h_{24} & 0 & 0 \\ h_{31} & h_{31} & h_{33} & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 15.7 & 0 \\ 0 & 0 & 0 & 15.7 & 0 & 0 \\ -10 & -10 & 19.3 & 0 & 0 & 0 \end{bmatrix} \quad 10^8 \text{V/m}$$

Clamped dielectric constant Matrix

$$\begin{bmatrix} \epsilon_{11}^S/\epsilon_0 & 0 & 0 \\ 0 & \epsilon_{11}^S/\epsilon_0 & 0 \\ 0 & 0 & \epsilon_{33}^S/\epsilon_0 \end{bmatrix} = \begin{bmatrix} 980 & 0 & 0 \\ 0 & 980 & 0 \\ 0 & 0 & 840 \end{bmatrix}^S$$

Free dielectric constant matrix

$$\begin{bmatrix} \epsilon_{11}^T/\epsilon_0 & 0 & 0 \\ 0 & \epsilon_{11}^T/\epsilon_0 & 0 \\ 0 & 0 & \epsilon_{33}^T/\epsilon_0 \end{bmatrix} = \begin{bmatrix} 1680 & 0 & 0 \\ 0 & 1680 & 0 \\ 0 & 0 & 1610 \end{bmatrix}^T$$

