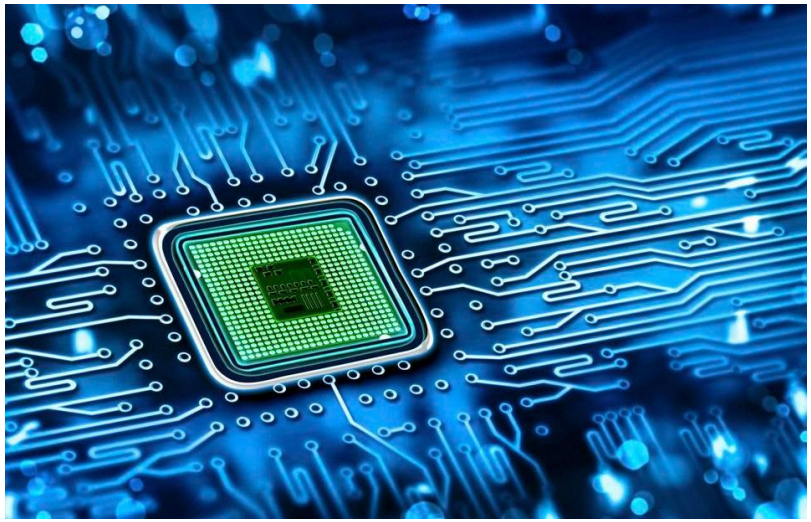
# PROPERTIES OF S PARAMETERS



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Depending on the properties of the $S$ parameters, the structures can be classified into the following categories:

- *Reciprocity*. A two-port system is said to be *reciprocal* if the $S$ matrix is equal to its transpose:

$$(S) = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} = (S)^{\mathrm{T}} = \begin{pmatrix} S_{11} & S_{21} \\ S_{12} & S_{22} \end{pmatrix}$$

In other words, the forward transmission coefficient and the reverse transmission coefficient are equal (e.g., $S_{21} = S_{12}$).

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- *Symmetry*. A two-port system is said to be *symmetrical* if in addition to the reciprocity, the input and output reflection coefficients are identical (e.g., $S_{11} = S_{22}$), and *antisymmetrical* if they are opposite in sign (e.g., $S_{11} = -S_{22}$).

- *Lossless*. A two-port system is said to be *lossless* if power is conserved. In this case the complex conjugate of the $S$ matrix is equal to its transpose:

$$(S)^* = \begin{pmatrix} S_{11}^* & S_{12}^* \\ S_{21}^* & S_{22}^* \end{pmatrix} = (S)^T = \begin{pmatrix} S_{11} & S_{21} \\ S_{12} & S_{22} \end{pmatrix}$$

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In the case of lossless structures, additional relations exist between the transmission and reflection coefficients:

$$|S_{11}|^2 + |S_{12}|^2 = 1$$
$$|S_{21}|^2 + |S_{22}|^2 = 1$$
$$S_{11}S_{21}^* + S_{22}^*S_{12} = 0$$

In the case of a lossless and reciprocal two-port system, the input reflection coefficient and the forward transmission coefficient are such that $|S_{11}|^2 = 1 - |S_{21}|^2$.


Thank
you