

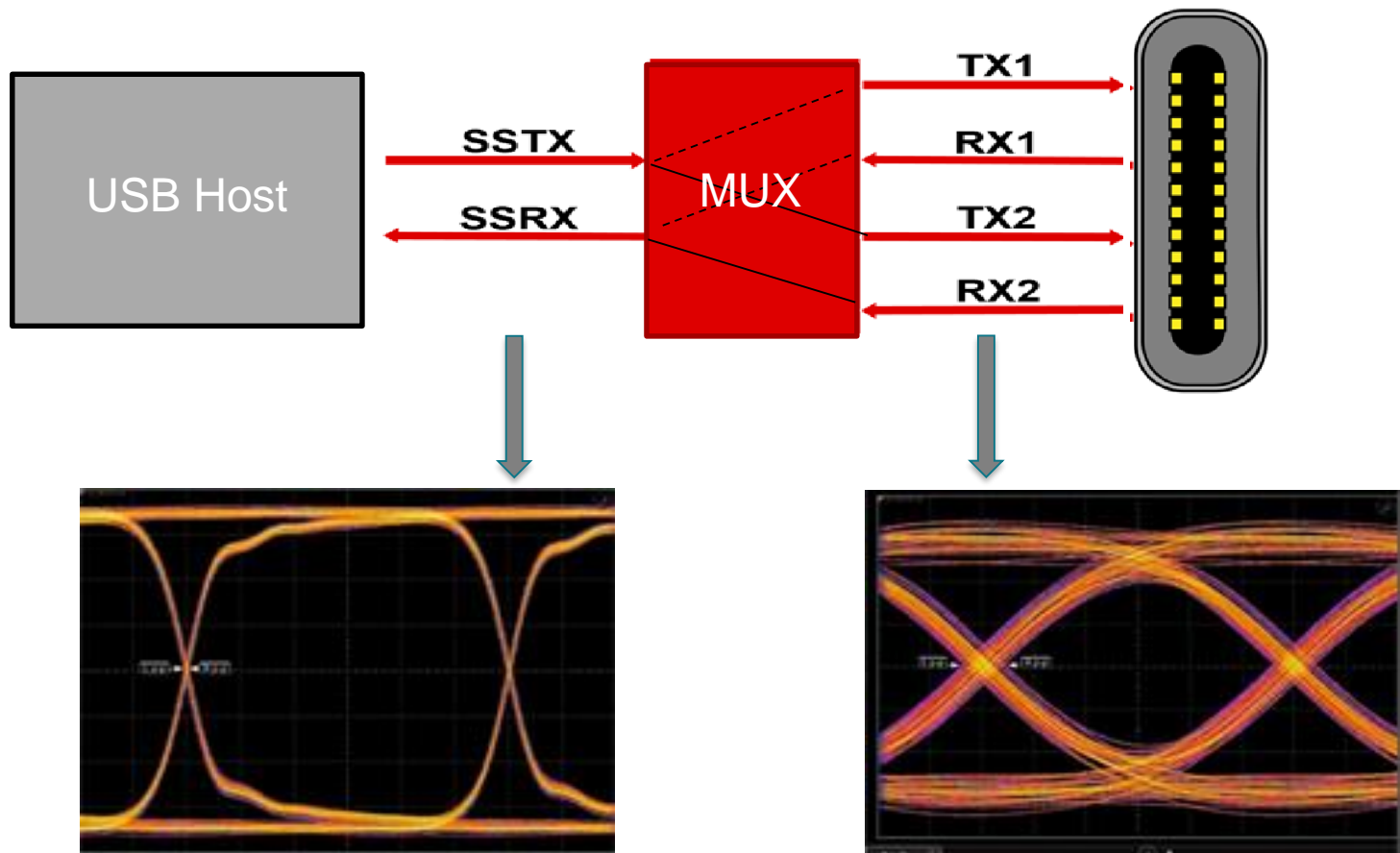
Understanding S-Parameters of High Speed Multiplexers

TI Precision Labs – Switches and Multiplexers

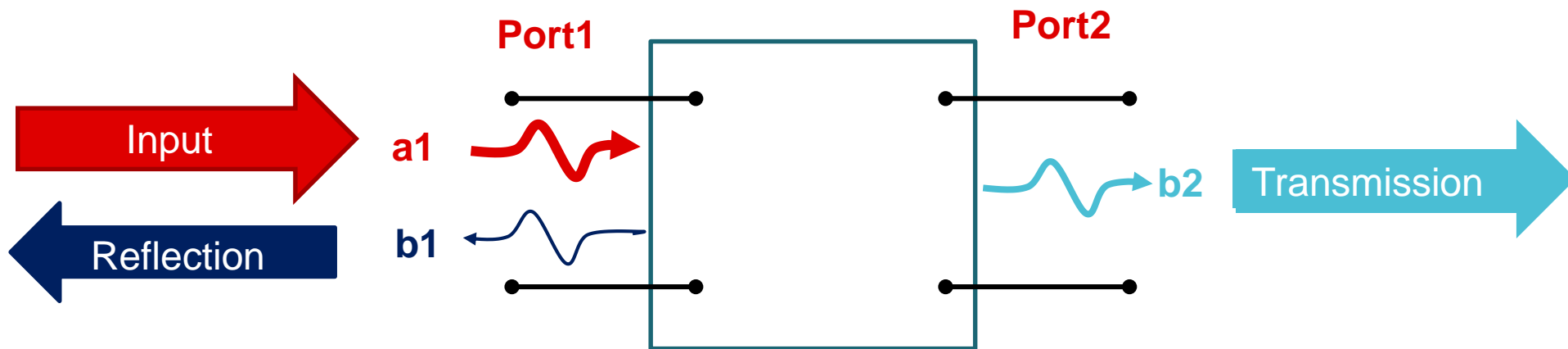
Prepared by Brian Zhou

Presented by Nicholas Malone

Why should you use S-parameters?



Traveling wave S-parameters



Complex matrix S-parameters

$$\begin{bmatrix} S_{11} & \cdots & S_{1N} \\ \vdots & \ddots & \vdots \\ S_{N1} & \cdots & S_{NN} \end{bmatrix}$$



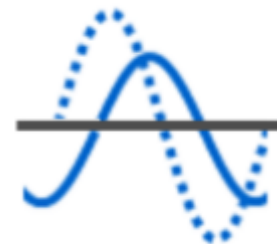
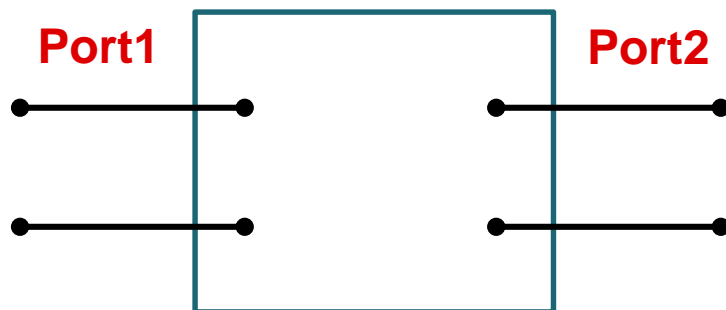
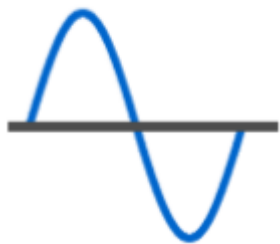
$$S_{xy}$$



output port input port

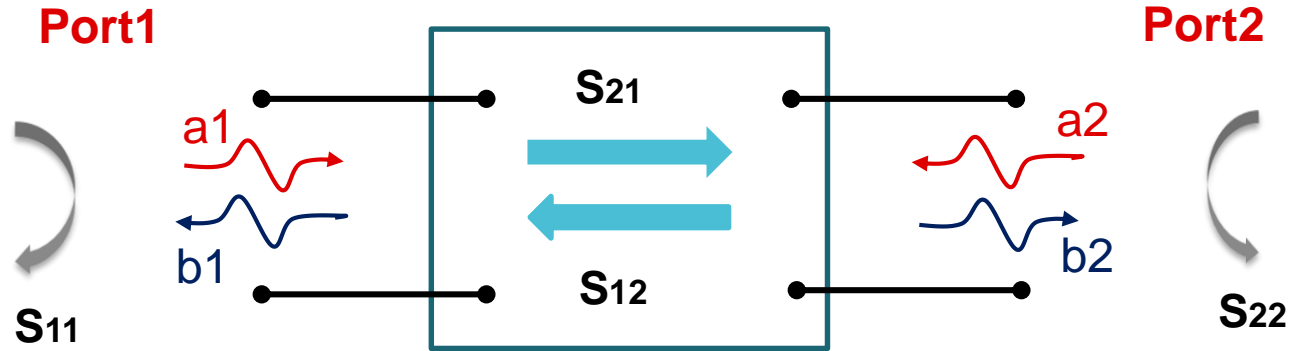


complex values with magnitude and phase in frequency domain



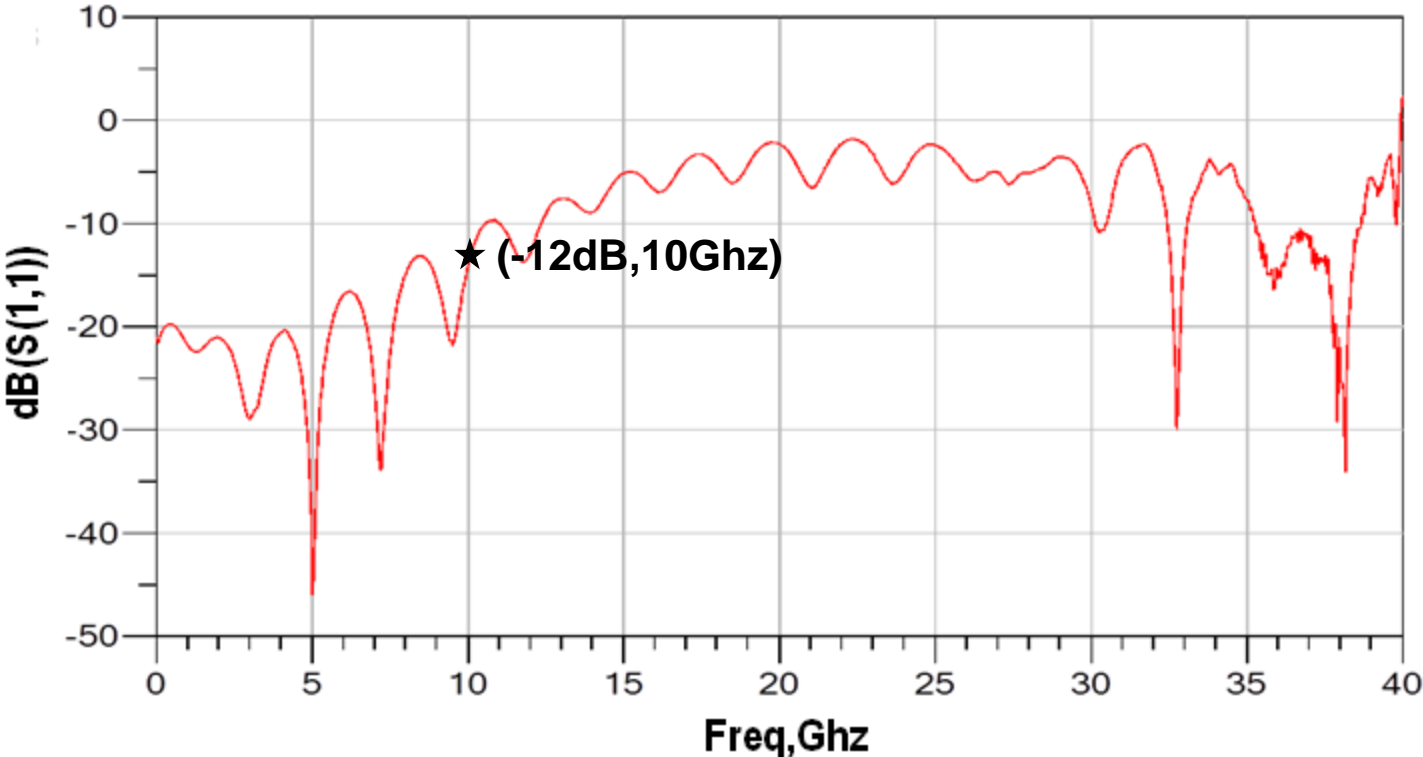
How to measure S-parameters?

In a two port network, there are four S-parameters: S_{11} , S_{12} , S_{21} , S_{22}



$$\begin{aligned} S_{11} &= b_1/a_1 \\ S_{12} &= b_1/a_2 \\ S_{21} &= b_2/a_1 \\ S_{22} &= b_2/a_2 \end{aligned} \quad \longrightarrow \quad \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

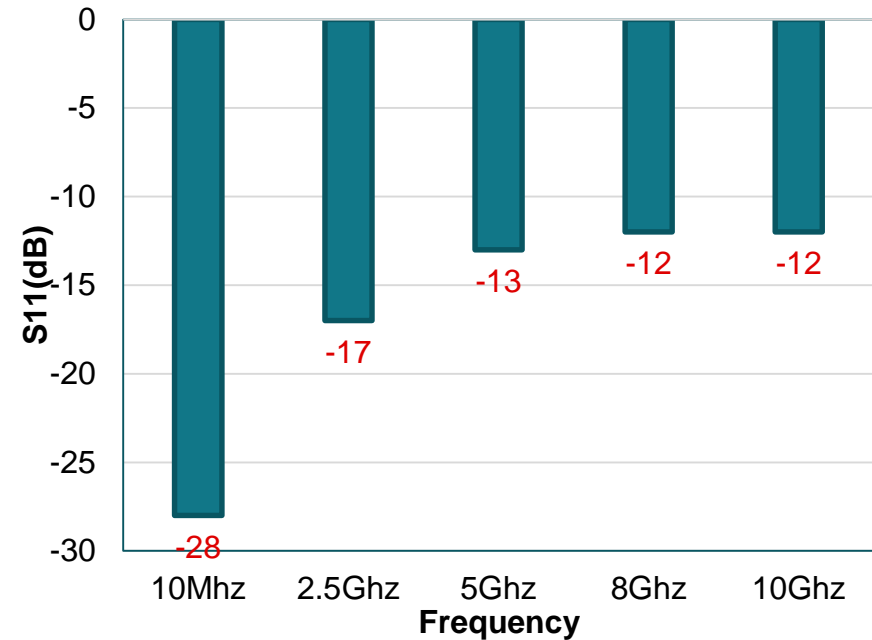
Reflection coefficient: S_{11}/S_{22}



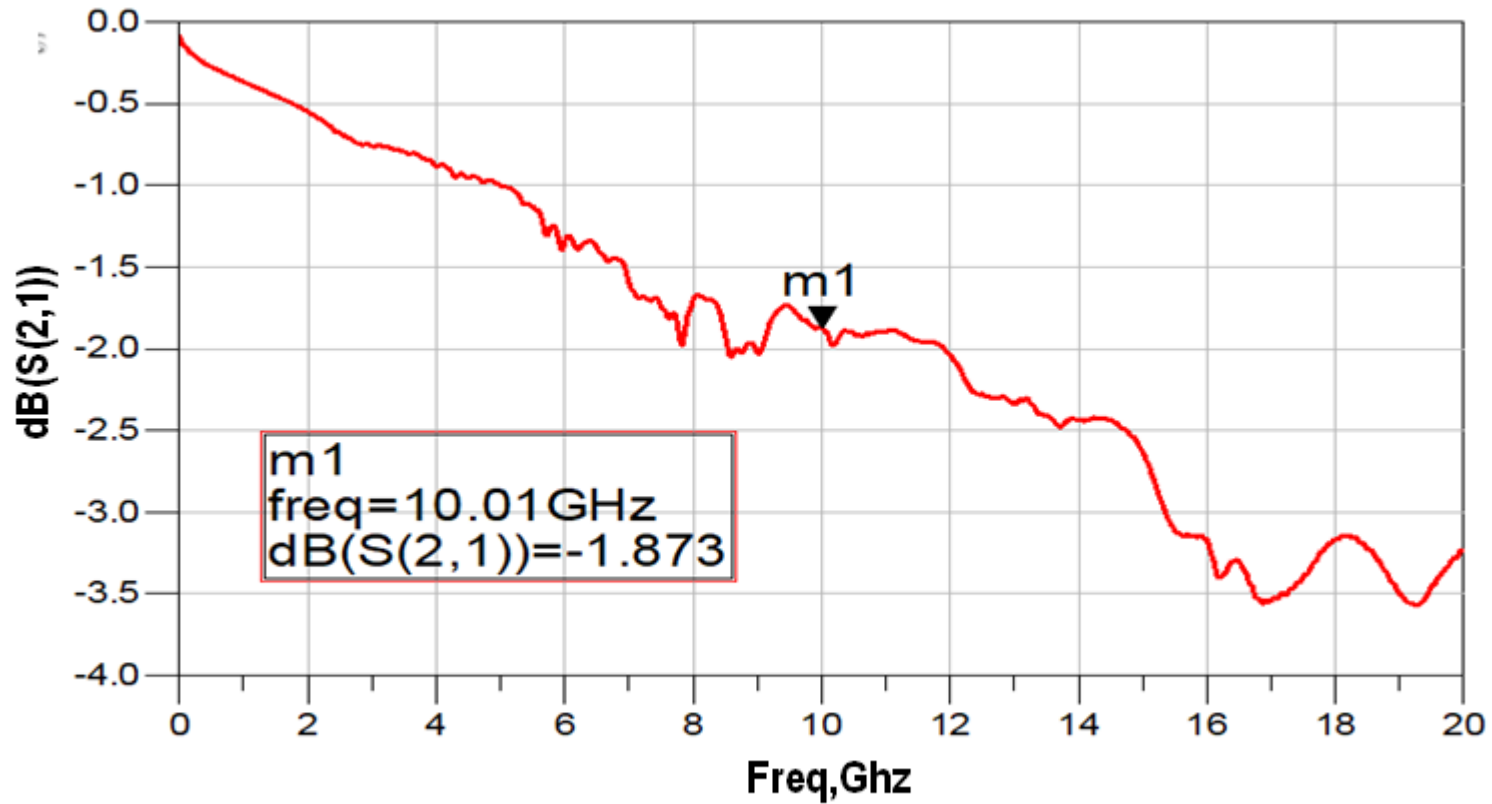
Return loss

S_{11} and S_{22} can be quantified as return loss : Return Loss [dB = -20 Log | S_{11} |

PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
I_L	Differential insertion loss	$f = 10$ MHz		-0.5		dB
		$f = 2.5$ GHz		-0.8		
		$f = 4$ GHz		-1.1		
		$f = 5$ GHz		-1.3		
		$f = 8$ GHz		-1.8		
		$f = 10$ GHz		-2.1		
BW	-3-dB bandwidth			13		GHz
R_L	Differential return loss	$f = 10$ MHz		-28		dB
		$f = 2.5$ GHz		-17		
		$f = 4$ GHz		-13		
		$f = 5$ GHz		-13		
		$f = 8$ GHz		-12		
		$f = 10$ GHz		-12		



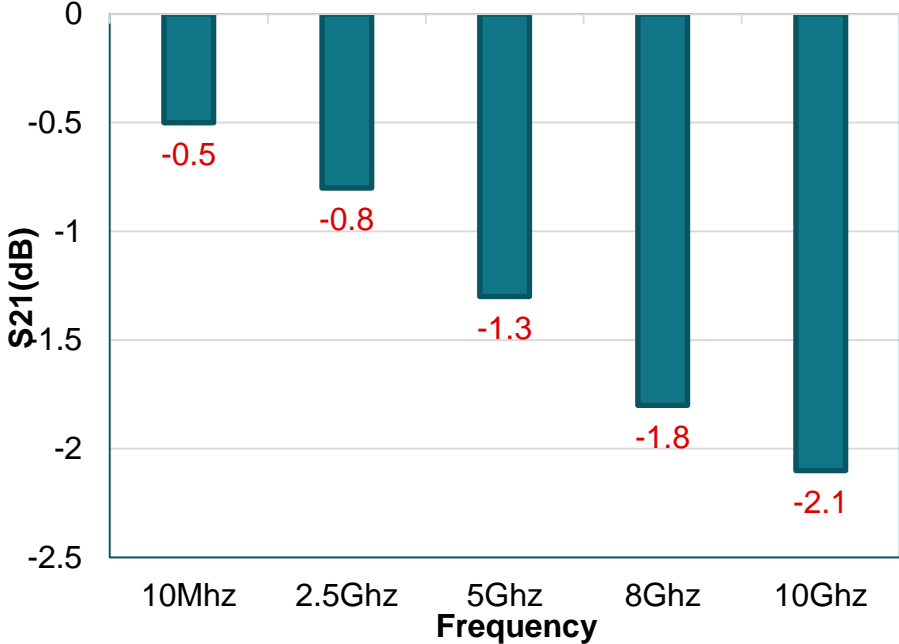
Transmission coefficient: S_{12}/S_{21}



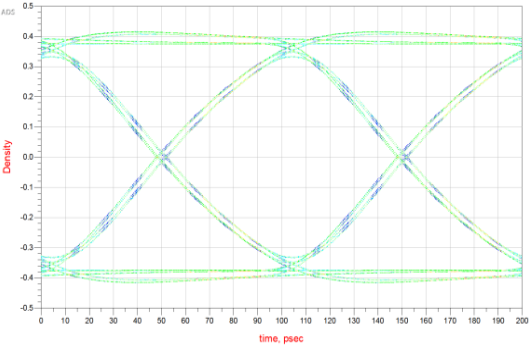
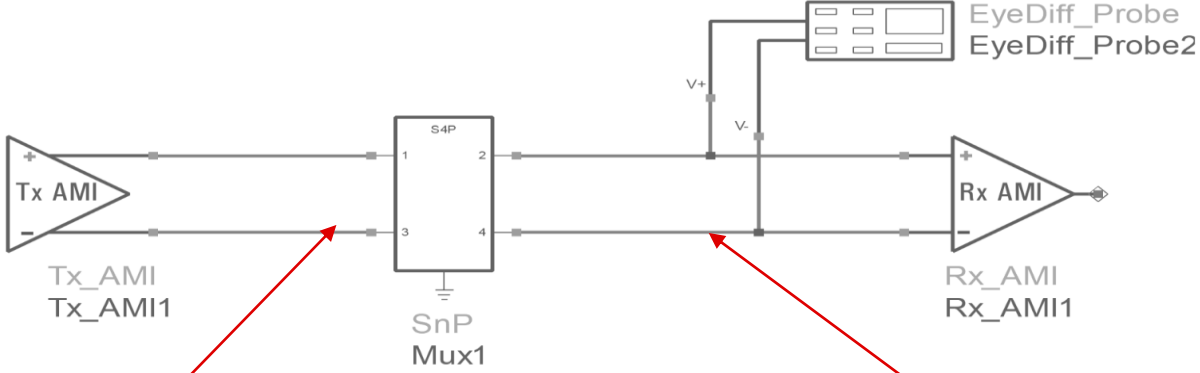
Insertion loss

S_{21} and S_{12} can be quantified as insertion loss: Insertion Loss [dB = -20 Log |S12|

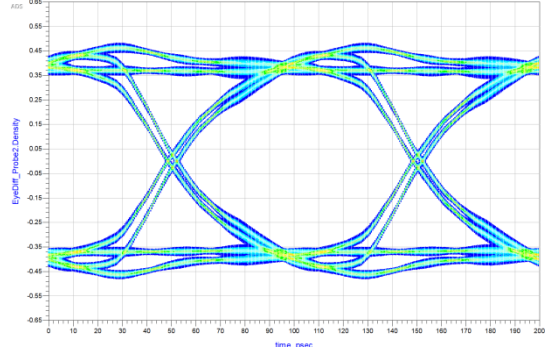
PARAMETER		TEST CONDITION	MIN	TYP	MAX	UNIT
I _L	Differential insertion loss	f = 10 MHz		-0.5		dB
		f = 2.5 GHz		-0.8		
		f = 4 GHz		-1.1		
		f = 5 GHz		-1.3		
		f = 8 GHz		-1.8		
		f = 10 GHz		-2.1		
BW	-3-dB bandwidth			13		GHz
R _L	Differential return loss	f = 10 MHz		-28		dB
		f = 2.5 GHz		-17		
		f = 4 GHz		-13		
		f = 5 GHz		-13		
		f = 8 GHz		-12		
		f = 10 GHz		-12		



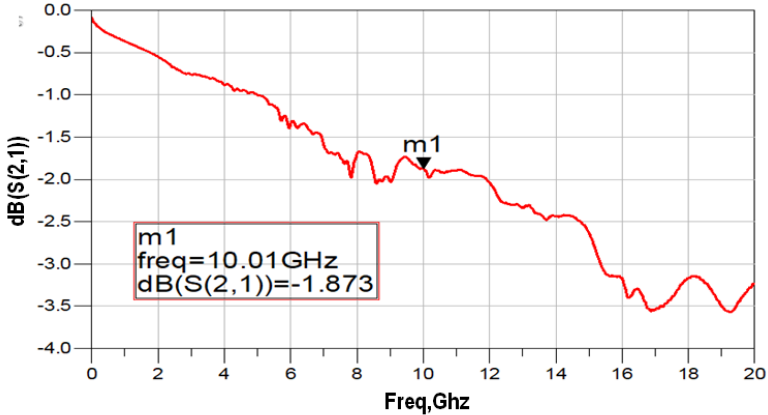
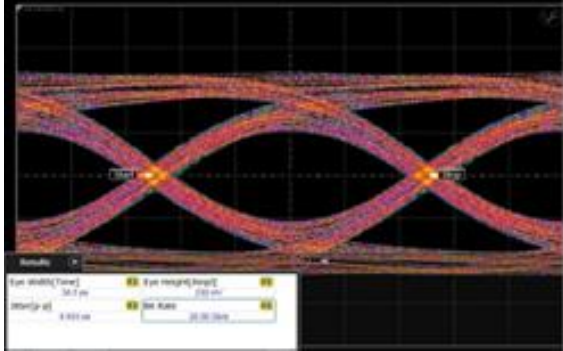
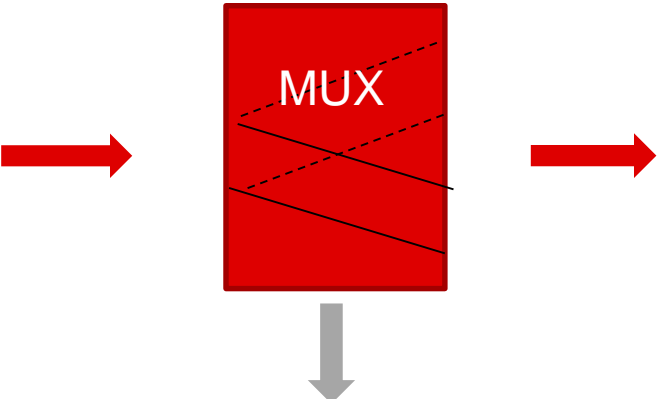
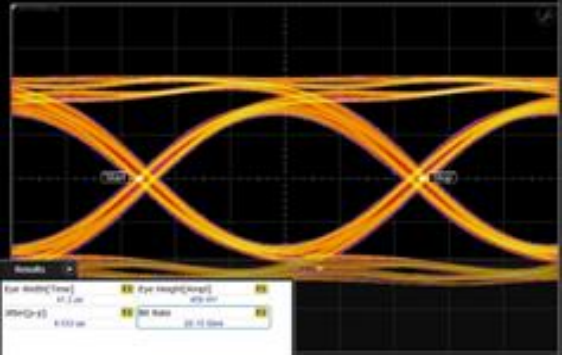
How to use S-parameter: simulation software



PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Differential insertion loss	$f = 10 \text{ MHz}$		-0.5		dB
	$f = 2.5 \text{ GHz}$		-0.8		
	$f = 4 \text{ GHz}$		-1.1		
	$f = 5 \text{ GHz}$		-1.3		
	$f = 8 \text{ GHz}$		-1.8		
	$f = 10 \text{ GHz}$		-2.1		



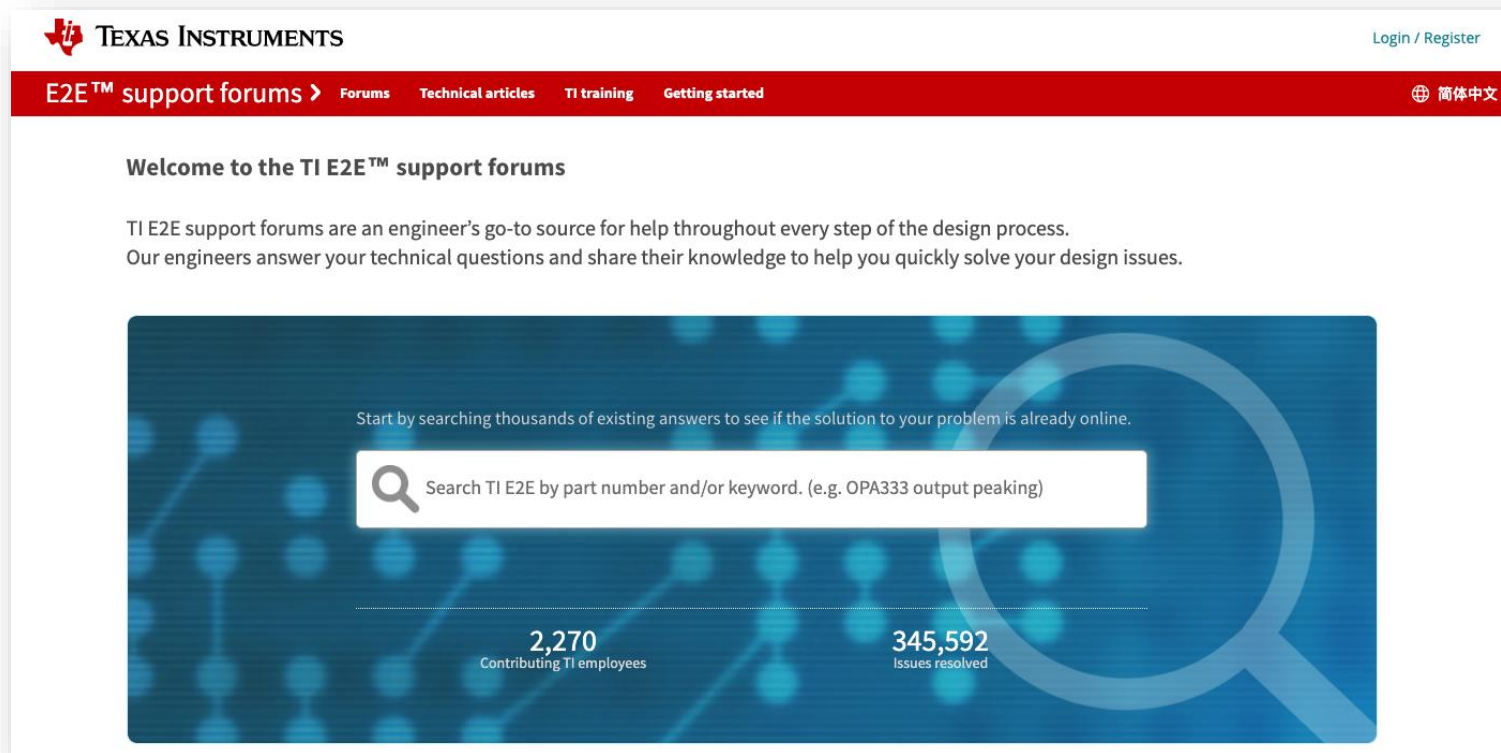
How do S-parameters affect system performance?



Thank you

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[TI Precision Labs - What is an Eye Diagram?](#)



The screenshot shows the TI E2E support forums homepage. At the top left is the Texas Instruments logo. To the right is a 'Login / Register' link. Below this is a red navigation bar with 'E2E™ support forums >' and links for 'Forums', 'Technical articles', 'TI training', and 'Getting started'. A globe icon and '简体中文' are on the far right. The main content area has a heading 'Welcome to the TI E2E™ support forums' followed by a paragraph: 'TI E2E support forums are an engineer's go-to source for help throughout every step of the design process. Our engineers answer your technical questions and share their knowledge to help you quickly solve your design issues.' Below this is a search bar with a magnifying glass icon and the text 'Search TI E2E by part number and/or keyword. (e.g. OPA333 output peaking)'. At the bottom of the search area, two statistics are displayed: '2,270 Contributing TI employees' and '345,592 Issues resolved'.



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Short quiz

True or false: S-parameters are complex matrix

Short quiz

TRUE

True or false: S-parameters are complex matrix

Short quiz

True or false: S_{21} is also called return loss

Short quiz

FALSE

True or false: S_{21} is also called return loss

Short quiz

True or false: S-parameters can be measured by TDR

Short quiz

FALSE

True or false: S-parameters can be measured by TDR

Short quiz

True or false: S-parameters are frequency domain

Short quiz



True or false: S-parameters are frequency domain