ADS/SIV: All: Why do S-parameters not agree with hand calculations?

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Problem

You may observe that s-parameters do not agree with hand calculations when using complex terminations in your network. Why?

Solution / Workaround

The Linear simulator uses generalized scattering parameters (*see note below*). While there are numerous texts that discuss s-parameters, not all give definitions for the generalized case. The generalized case means that Z0 can be complex. Often, text books will define s-parameters but an implicit assumption is made that the Z0 is real (this makes sense to the extent that measurement equipment such as network analyzers work with real terminations). However, for the generalized case,

```
Sii = (Zi - conj(Z0i) / (Zi + Z0i)
```

where

Sii is the input reflection coefficient at the ith port
Zi is the input impedance at the ith port
Z0i is the terminating impedance attached to the ith port

The conjugation operator does not appear for the real Z0 case.

Note: HP-EEsof has chosen to use Kurokawa's power wave formulation for generalized s-parameters. We presently have a program enhancement request entered to offer as a simulation option, the R.B. Marks and D.F. Williams formulation.

References and Related items

The following references contain the generalized scattering parameter definition:

Microwave Transistor Amplifiers - Analysis and Design
Guillermo Gonzalez
Prentice-Hall, Inc. Englewood Cliffs, N.J. 07632
page 22

Solid State Microwave Amplifier Design
Tri .T. Ha
John Wiley and Sons, Inc. New York
page 32

K.Kurokawa,"Power waves and the scattering matrix",IEEE Trans. Microwave Theory Tech., vol. 1, pp.141-143, June 1991

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Problem

The user has an one-port network. On the data display, he calculates the Z11 from this equation:

Z11= ZTerm * (1+S11) / (1-S11).

With a ZTerm of 50 Ohms, this equation gives the same answer as Z11 is alculated from the ADS simulator. However, when the ZTerm is a complex value, the result is not the same as what ADS simulator outputs.

Solution / Workaround

In case of a complex termination, the user has to use this equation
Sii = (Zi - conj(Z0i) / (Zi + Z0i)

$$S = \frac{Z - Z_0^*}{Z + Z_0}$$

$$S(Z + Z_0) = Z - Z_0^*$$

$$Z(S - 1) = -SZ_0 - Z_0^*$$

$$Z = \frac{Z_0^* + SZ_0}{1 - S}$$

where

Sii is the input reflection coefficient at the ith port

Zi is the input impedance at the ith port

Z0i is the terminating impedance attached to the ith port

For the notation mentioned above, Sii=S11, Zi=Z11 ;Z0i= ZTerm

Solving for Z11= ((S11*ZTerm)+conj(ZTerm))/(1- S11)

Using this equation, there won't be any discrepancies between ADS data display and simulator outputs.

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page 22

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