0.0.1 Transmission Line T

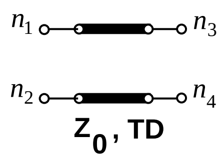

Figure 1: T — transmission line element.

SPICE *Form:*
Tname n_1 n_2 n_3 n_4 [*ModelName*] ZO=*CharacteristicImpedance* TD=*TimeDelay* [IC=V_1, I_1, V_2, I_2
]

Tname n_1 n_2 n_3 n_4 [*ModelName*] ZO=*CharacteristicImpedance*
+ F=*ReferenceFrequency* + [NL=*NormalizedElectricalLength*] [IC=V_1, I_1, V_2, I_2]
where

n_1	positive node at port 1.
n_2	negative node at port 1.
n_3	positive node at port 2.
n_4	negative node at port 2.
ModelName	is the model name.
ZO	is the characteristic impedance. (Z-zero) (Units: Ω; Required; Symbol: Z_0; Default: none)
TD	transmission line delay. (Units: s; Either TD or F Required; Symbol: T_D; Default: none)
F	reference frequency. (Units: Hz; Either TD or F Required; Symbol: F; Default: none)
NL	normalized electrical length. Normalization is with respect to the wavelength in free space at the reference frequency F. (Units: none; Optional; Symbol: $L_{\text{NORMALIZED}}$; Default: 0.25)
IC	is the optional initial condition specification using IC= V_1, I_1, V_2, I_2 is intended for use with the UIC option on the .TRAN line, when a transient analysis is desired starting from other than the quiescent operating point. Specification of the transient initial conditions using the .IC statement is preferred and is more convenient.

Example:
```
T1 1 0 2 0 ZO=50 TD=10NS
```

```
TLONG 1 0 2 0 Z0=50 F=1G NL=10

TLONG 1 0 2 0 Z0=50 F=1G
```

Description:

The length of the line may be expressed in either of two forms. The transmission delay, *TD*, may be specified directly (as TD=10ns, for example). Alternatively, a frequency F may be given, together with NL, the normalized electrical length of the transmission line with respect to the wavelength in the line at the frequency F. If a frequency is specified but NL is omitted, 0.25 is assumed (that is, the frequency is assumed to be the quarter-wave frequency). Note that although both forms for expressing the line length are indicated as optional, one of the two must be specified.

Note that only 3 distinct nodes should be specified as this element describes a single propagating mode. With four distinct nodes specified, two propagating modes may exist on the actual line. If there are four distinct nodes then two lines are required.

The transmission line `T` element is modeled as a bidirectional ideal delay element as shown in figure **??**. The maximum time step in SPICE is limited to half of the time delay along the line. Thus short transmission lines can result in many time steps in a transient analysis. Unnecessary short transmission lines should be avoided.

tmodel.ps

Model Type

`URC`

URC Model — Lossy RC Transmission Line Model

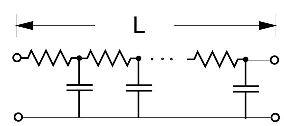

Figure 2: URC — lossy RC transmission line model.

Form

`.MODEL` *ModelName* `URC(` [[*keyword* = *value*] ...] `)`

Example

```
.MODEL LONGLINE URC( )
```

Table 1: URC model parameters.

Name	Description		Units	Default
K	Propagation Constant		-	2.0
FMAX	Maximum Frequency of interest		Hz	1.0G
RPERL	Resistance per unit length	$(I_{S,\mathsf{PERL}})$	Ω/m	1000
CPERL	Capacitance per unit length	$(I_{S,\mathsf{PERL}})$	F/m	1.0E-15
ISPERL	Saturation current per unit length	$(I_{S,\mathsf{PERL}})$	A/m	
RSPERL	Diode Resistance per unit length	$(I_{S,\mathsf{PERL}})$	Ω/m	0

The URC model was originally proposed by Gertzberrg [?] In this model a transmission line is represented by the cascade of a number of transmission line segments each of which is modeled by an RC or R-Diode subcircuit. The lengths of the line segments increases in a geometric progression towards the middle of the line. The number of line segments is

$$N = \tag{1}$$

and the length of the ith line segment is

$$l_i = \tag{2}$$

If `ISPERL` is not specified then a linear transmission line is modeled, see figure 2, with `ISPERL` omitted

$$R_i = R_{\mathrm{PERL}} l_i \tag{3}$$

$$C_i = C_{\mathrm{PERL}} l_i \tag{4}$$

If `ISPERL` is not then a diode loaded nonlinear transmission line is modeled, see figure 2, `ISPERL` specified with

$$R_i = R_{\mathrm{PERL}} l_i \tag{5}$$

$$R_{S,i} = R_{S,\mathrm{PERL}} l_i \tag{6}$$

$$C_i = C_{J,i} \left(1 - \frac{\phi}{V_{J,i}}\right)^{-\frac{1}{2}} \tag{7}$$

$$I_S = I_{S,i} \left(e^{\frac{V_{J,i}}{V_{\mathrm{TH}}}} - 1 \right) \tag{8}$$

where the zero-bias capacitance of the ith diode is

$$C_{J,i} = C_{\mathrm{PERL}} l_i \tag{9}$$

its reverse saturation current is

$$I_{S,i} = I_{S,\mathrm{PERL}} \tag{10}$$

Notes:
The actual element in *f*REEDA™is the `tlinp4` element. See `tlinp4` for full documentation.

Credits:

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