OptiSPICE

Element Library

Opto-Electronic Circuit Design Software

Version 5.1

Optiwave

OptiSPICE

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Electrical Elements Library

This section contains information on the following elements

Notes:

INDSOURCE

Syntax

Style	Form
SPICE	**General Form**
	Vxxx n+ n- <<DC=> dcval><tranfun><AC=acmag, <acphase>>
	Ixxx n+ n- <<DC=> dcval><tranfun><AC=acmag, <acphase>>
	Pulse Source Function
	Vxxx n+ n- PU<LSE>< (>v1 v2 <td <tr <tf <pw <per>>>>><) >
	Ixxx n+ n- PU<LSE>< (>v1 v2 <td <tr <tf <pw <per>>>>><) >
	Sinusoidal Source Function
	Vxxx n+ n- SIN < (> vo va <freq <td <q <j>>>><) >
	Ixxx n+ n- SIN < (> vo va <freq <td <q <j>>>><) >
	Piecewise Linear Source Function
	Vxxx n+ n- PWL < (> t1 v1 <t2 v2 t3 v3><R <=repeat>>
	Ixxx n+ n- PWL < (> t1 v1 <t2 v2 t3 v3><R<=repeat>>
	Gaussian Source Function
	Vxxx n+ n- GAUSSIAN < (> vo va <freq <t0 <sigma >>><) >
	Ixxx n+ n- GAUSSIAN < (> vo va <freq <t0 <sigma >>><) >
	Modulated Gaussian Source Function
	Vxxx n+ n- MODGAUSSIAN < (> vo va <freq <t0 <sigma <j>>>><) >
	Ixxx n+ n- MODGAUSSIAN < (> vo va <freq <t0 <sigma <j>>>><) >
	Piecewise Linear Source Function - Data points given by file
	Vxxx n+ n- tranMode=FILE File=filename
	Ixxx n+ n- tranMode=FILE File=filename
OptiSPICE	Osp INDSOURCE Nodes=[n+ n-] *<param1=val1> <param2=val2>* ....

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Source type Independent source type (current or voltage). Only required for OptiSPICE syntax.	EL_Type	V_SOU	-	V_SOU, I_SOU,
Enable AC mode Option to enable the independent source to be an AC source. Only required for OptiSPICE syntax.	acMode	0	-	0, 1
Enable DC mode Option to enable the independent source to be a DC source. Only required for OptiSPICE syntax.	dcMode	0	-	0, 1
Transient mode Transient mode function type. Only required for OptiSPICE syntax.	tranMode	-	-	NONE, AM, EXP, PAT, PULSE, PWL, SFFM, SIN, FILE, BITSTREAM
AC magnitude Magnitude of AC source	acValue	0	V or A	]-INF, +INF[
AC Phase Phase of AC source	Phase	0	Deg	]-180, 180[
DC magnitude Magnitude of DC source	dcValue	0	V or A	]-INF, +INF[
Initial value Initial value (at t=0) of the source	v1	0	V or A	]-INF, +INF[
Pulsed value Pulsed value of the source	v2	0	V or A	]-INF, +INF[
Delay time Delay time before the start of the signal	td	0	sec	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Rise time Rise time of the source	tr	0	sec	[0, +INF[
Fall time Fall time of the source	tf	0	sec	[0, +INF[
Pulse width Pulse width of a pulse function source	pw	0	sec	[0, +INF[
Period Period of the source function	per	0	sec	[0, +INF[
DC offset DC offset for the voltage or current	vo	0	V or A	]-INF, +INF[
Amplitude Voltage or current amplitude source function	va	0	V or A	]-INF, +INF[
Frequency Frequency of the source function	freq	0	Hz	[0, +INF[
Damping factor Damping factor of the source function	q	0	1/sec	[0, +INF[
Phase delay Phase delay of the source function	j	0	degree	]-180, 180[
Time value points List of source values at specific time points (used for piece-wise linear function)	Tpoints	-	sec, V or A	-
Filename Filename of the data driven piece wise linear source function	File	-	-	-
Gaussian pulse peak time value Time point where Gaussian pulse gain its peak value	t0	0	sec	[0, +INF[
Gaussian pulse half duration Duration taken for a Gaussian pulse to obtain 1/e of its peak value	Sigma	0	sec	[0, +INF[

Technical Background

An independent source is used to excite DC, AC, or transient voltage or current that does not depend on any branch currents or voltages. Voltage source generates DC, AC, or transient voltage between nodes n+ and n-. For current source, positive current is assumed to flow from n+, through the source, to n-. A zero valued voltage sources may also be used for measuring current.

DC sources provide constant amount of voltage or current throughout the simulation. When performing DC analysis these sources can be swept for a given range of DC values. AC sources provide voltage or current with constant magnitude and constant phase difference when performing AC analysis. Frequency points for AC sources are provided in AC analysis statement. Transient functions such as SIN, PULSE, PWL, GAUSSIAN, and MODGAUSSIAN, are used to generate time varying voltage or current with a specific waveform.

SIN source

It generates a sinusoidal waveform. For $t \le t_d$, it is given by

$$v(t) = v_o + v_a \cdot \sin\left(\frac{2 \cdot \pi \cdot j}{360}\right) \tag{1}$$

For $t > t_d$, it is given by

$$v(t) = v_o + v_a \cdot e^{-(t - t_d) \cdot q} \cdot \sin\left\{2 \cdot \pi\left(f \cdot (t - t_d) + \frac{j}{360}\right)\right\} \tag{2}$$

where t is the time, f is the parameter *freq*, and v_o, v_a, t_d, q, and j are the parameters *vo*, *va*, *td*, *q* and *j*.

PULSE source

It generates a trapezoidal pulse function which remains with initial value *v1* for $t \le t_d$, rises linearly to the pulsed value *v2* for $t_d < t \le t_1$, remains at the pulsed value *v2* for $t_1 < t \le t_2$, falls linearly to the initial value *v1* for $t_2 < t \le t_3$, and remains at *v1* for $t_3 < t \le t_4$. Where

- $t_1 = t_d + t_r$, t_r is the parameter *tr*
- $t_2 = t_1 + t_{pw}$, t_{pw} is the parameter *pw*
- $t_3 = t_2 + t_f$, t_f is the parameter *tf*

- $t_4 = t_d + t_p$, t_p is the parameter *per*

If a non-zero period (*per*) is provided, the trapezoidal waveform for $t_d < t \le t_d + t_p$ is repeated until the end of transient simulation.

PWL source

It generates a piece-wise linear waveform using the given time-voltage/current points. Each pair of values (Ti, Vi) specifies that the value of the source is Vi (in Volts or Amps) at time=Ti. The value of the source at intermediate values of time is determined by using linear interpolation on the input values.

GAUSSIAN source

It generates a Gaussian pulse waveform which is given by

$$v(t) = v_o + v_a \cdot e^{-(t-t_0)^2/\sigma^2} \tag{3}$$

where v_o , v_a , t_0 , and σ are the parameters *vo*, *va*, *t0*, and *sigma*. If a non-zero period is provided the waveform for $0 < t \le t_p$ (t_p is the parameter *per*) is repeated until the end of the transient simulation.

MODGAUSSIAN source

It generates a Amplitude modulated Gaussian pulse waveform which is given by

$$v(t) = v_o + v_a \cdot e^{-(t-t_0)^2/\sigma^2} \cdot \sin\left\{2 \cdot \pi\left(f \cdot t + \frac{j}{360}\right)\right\} \tag{4}$$

where v_o , v_a , t_0 , σ , f , and j are the parameters *vo*, *va*, *t0*, *sigma, freq,* and *j*. If a non-zero period is provided the waveform for $0 < t \le t_p$ (t_p is the parameter *per*) is repeated until the end of the transient simulation.

Examples

For a DC voltage source with the name Vdd connected between nodes VIN and GND, with 5 V, the statement can be written as follows:

```
Vdd VIN GND 5
```

For an AC voltage source with the name Vac connected between nodes IN and GND, with 1.5V magnitude and 90° phase delay, the statement can be written as follows:

```
Vac IN GND AC 1.5 90
```

For a current source with the name Isrc1 that generates a current flow from GND to IN with DC current = 1 mA, with AC magnitude = 1 mA and AC phase = 90°, and with sinusoidal transient function with amplitude = 1.5 mA and frequency = 1 GHz, the statement can be written as follows:

```
Isrc1 GND IN DC=1m AC=1m 90 SIN 0 1.5 1G 0
```

For a pulse voltage source with device name Vpulse connected between nodes IN2 and GND, with initial voltage = 0.1 V, pulsed voltage = 2 V, time delay = 2 ns, rise/fall time = 0.5 ns, pulse width = 1.2 ns, and period = 3 ns, the statement can be written as follows:

```
Vpulse IN2 GND PULSE 0.1 2 2n 0.5n 0.5n 1.2n 3n
```

For a PWL voltage source with device name Vpwl connected between nodes 1 and 2, with time voltage pair {0s, 0V}, {0.1ns, 1V}, {0.3ns, 2.5V}, {0.6ns, 2.5V}, {0.7ns, 1.8V}, and {1.0 ns, 0V}, the statement can be written as follows:

```
Vpwl 1 2 PWL 0.0 0.0 0.1n 1 0.3n 2.5 0.6n 2.5 0.7n 1.8 1n 0.0
```

DEPSOURCE

Syntax

Style	Form
SPICE	**Voltage Controlled Voltage Source (VCVS) - linear** E*xxx n+ n-* <VCVS> *in+ in- gain* <MAX=*val*> <MIN=*val*> **VCVS - polynomial** E*xxx n+ n-* <VCVS> POLY(*NDIM*) *in1+ in1-... p0 p1 p2 ...* <MAX=*val*> <MIN=*val*> **Current Controlled Current Source (CCCS) - linear** F*xxx n+ n-* <CCCS> *vsrc gain* <MAX=*val*> <MIN=*val*> **CCCS - polynomial** F*xxx n+ n-* <CCCS> POLY(*NDIM*) *vsrc1 vsrc2 ... p0 p1 p2 ...* <MAX=*val*> <MIN=*val*> **Voltage Controlled Current Source (VCCS) - linear** G*xxx n+ n-* <VCCS> *in+ in- transconductance* <MAX=*val*> <MIN=*val*> **VCCS - polynomial** G*xxx n+ n-* <VCCS> POLY(*NDIM*) *in1+ in1-... p0 p1 p2 ...* <MAX=*val*> <MIN=*val*> **Voltage Controlled Resistor (VCR) - linear** G*xxx n+ n-* VCR *in+ in- transfactor* <MAX=*val*> <MIN=*val*> **VCR - polynomial** G*xxx n+ n-* VCR POLY(*NDIM*) *in1+ in1-... p0 p1 p2 ...* <MAX=*val*> <MIN=*val*> **Current Controlled Voltage Source (CCVS) - linear** H*xxx n+ n-* <CCVS> *vsrc transresistance* <MAX=*val*> <MIN=*val*> **CCVS - polynomial** H*xxx n+ n-* <CCVS> POLY(*NDIM*) *vsrc1 vsrc2 ... p0 p1 p2 ...* <MAX=*val*> <MIN=*val*>

Style	Form
OptiSPICE	**Voltage dependent sources - linear** Osp DEPSOURCE Name=*name* EL_Type=*TYPE* Nodes=[*n+ n-*] CNodes = [*in+ in-*] + Gain=*val* <MAX=*val*> <MIN=*val*> **Voltage dependent sources - polynomial** Osp DEPSOURCE Name=*name* EL_Type=*TYPE* Nodes=[*n+ n-*] + CNodes = [*in1+ in1- ...*] Mode = POLY nPoly=*NDIM* Pcoeff = [*p0 p1 ...*] + <MAX=*val*> <MIN=*val*> **Current dependent sources - linear** Osp DEPSOURCE Name=*name* EL_Type=*TYPE* Nodes=[*n+ n-*] Ielems=*vsrc* + Gain=*val* <MAX=*val*> <MIN=*val*> **Current dependent sources - polynomial** Osp DEPSOURCE Name=*name* EL_Type=*TYPE* Nodes=[*n+ n-*] + Ielems=[*vsrc1 vsrc2 ...*] Mode = POLY nPoly=*NDIM* Pcoeff = [*p0 p1 ...*] + <MAX=*val*> <MIN=*val*> **Voltage source depndence expressed by equation** Osp DEPSOURCE Name=*name* Nodes=[*n+ n-*] Mode = VOL EQ='*expr*' + <MAX=*val*> <MIN=*val*> **Current dependence expressed by equation** Osp DEPSOURCE Name=*name* Nodes=[*n+ n-*] Mode = CURR EQ='*expr*' + <MAX=*val*> <MIN=*val*>

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node

Control Nodes (CNodes)

Name	Signal Type	Description
in1, in2, ...	Electrical	Controlling positive and negative nodes

Controlling Currents (Ielems)

Name	Signal Type	Description
vsrc1, vscr2, ...	Electrical	Name of voltage sources through which controlling currents flow

Parameters

Name and description	Symbol	Default value	Units	Value range
Dependant source type Type of dependent source.	EL_Type	VCVS	-	VCVS, CCCS, VCCS, CCVS, VCR
Control current elements List of voltage source elements through which the control current flows.	Ielems	-	-	-
Dependent source function mode Function types to represent special behavior of the dependent source. VOL and CURR are used to mathematically express (as equations) voltage and current respectively as a function of node voltages and/or current through voltage sources.	Mode	POLY	-	POLY, VOL, CURR
Polynomial dimension Number of polynomial dimension	nPoly	1	-	[0, +INF[
Polynomial coefficients Polynomial coefficients to describe the polynomial function of controlled source	Pcoeff	-	-	]-INF, +INF[
Gain Gain of dependent source in case of linear dependency	GAIN	1	-	]-INF, +INF[
Equation Equation that models the behavior of the controlled source	EQ	-	-	-
Maximum magnitude value The maximum voltage, current or resistance of the dependent element	MAX	1e12	A, V or ohm	]-INF, +INF[
Minimum magnitude value The minimum voltage, current or resistance of the dependent element	MIN	-1e12	A, V or ohm	]-INF, +INF[

Technical Background

The DEPSOURCE are linear dependent (or controlled) sources. They are characterized by linear relationships between voltage and current. If we use *i* to represent the current and *v* to represent the voltage, the relationships can be defined by $i = Gv$, where *G* is the transconductance; $v = Ev$, where *E* is the voltage gain; $i = Fi$, where *F* is the current gain; and $v = Hi$, where *H* is the transresistance.

Examples

For a voltage controlled voltage source (VCVS) with the name E1 connected between nodes 1 and 2, controlled by voltage difference between IN1 and IN2 with a gain of 10 and maximum limit of 15 V, the statement can be written as follows:

```
E1 1 2 IN1 IN2 10 MAX=15
```

For a polynomial VCVS with the name Eply connected between nodes 3 and 4, and controlled by voltage differences between nodes {IN1, IN2} and {IN3,IN4} with polynomial coefficients p0 = 3, p1 = 0.8, p2 = 0.5, the statement can be written as follows:

```
Eply 3 4 POLY(2) IN1 IN2 IN3 IN4 3 0.8 0.5
```

For a current controlled current source (CCCS) with the name F1 connected between nodes n1 and n2, controlled by current through voltage source Vs with a gain of 25 and initial control current of 0.5 mA, the statement can be written as follows:

```
F1 n1 n2 Vs 25 IC=0.5m
```

For a polynomial (second order) CCCS with the name Fply connected between nodes 6 and ground, controlled by currents flowing through Vsrc1 and Vsrc2, with polynomial coefficients p0 = 2, p1 = 1.5, p2 = 0.8, p3 = 0.2, p4 = 0.1, p5 = 0.05, the statement can be written as follows:

```
Fply 6 0 POLY(2) Vsrc1 Vsrc2 2 1.5 0.8 0.2 0.1 0.05
```

For a voltage controlled current source (VCCS) with the name Gs connected between nodes 8 and 9, controlled by voltage difference between IN1 and IN2 with a transconductance of 1.5 and maximum limit of 10 mA, the first order temperature coefficient 0.5 mA/Deg.C and second order temperature coefficient 0.1 mA/Deg.C^2, the statement can be written as follows:

```
Gs 8 9 IN1 IN2 1.5 MAX=10m TC1=0.5m TC2=0.1m
```

For a voltage controlled resister (VCR) with device name Gres1 connected between nodes 11 and 12, controlled by voltage difference between IN1 and IN2 with a voltage-to resistance ratio of 1000, with minimum resistance 50 ohms, the statement can be written as follows:

```
Gres1 11 12 VCR IN1 IN2 1000 MIN=50
```

For a polynomial (second order) VCR with the name Gply connected between nodes 15 and 16, controlled by voltage differences between nodes IN1 and IN2 with polynomial coefficients p0 = 100, p1 = 10, and p2 = 5, and with a minimum resistance 1 ohm, he statement can be written as follows:

```
Gply SIG1 SIG2 VCR POLY(1) IN1 IN2 100 10 5 MIN=1
```

For a dependent current source, which is expressed as an equation, a sample netlist statement is given below:

```
Osp DEPSOURCE Name=Vdep1 Nodes=[ 3 0 ] Mode = CURR

+ Eq = '1e-12 * exp(40*(v(1) - v(2)))'
```

Notes:

NOISESOURCE

Syntax

Style	Form
OptiSPICE	Osp NOISESOURCE Nodes=[n1 n2] <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
n1	Electrical	
n2	Electrical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Noise source type Type of noise source (voltage or current)	Type	I	-	I, V
Noise source mode Frequency dependence mode of the noise source	Mode	Res	-	Res, White, Pink
Noise distribution Probability distribution functions to generate noise based on a Monte-Carlo method	Dist	Gaussian	-	Gaussian, Poisson, WMC
Resistance Resistance of the noise source	R	0	ohm	[0, +INF[
Noise spectral density Magnitude of noise spectral density	Magnitude	0	(V or A)^2/Hz	[0, +INF[
Temperature Noise source temperature	Temp	0	K	]-INF, +INF[
Pink noise calculation method Method used to compute noise for frequency dependent Pink noise	Method	Default	-	Default, Sequence,

Name and description	Symbol	Default value	Units	Value range
Flicker noise exponent Flicker noise exponent used to compute a frequency dependent Flicker or Pink noise	AF	1.0	-	]-INF, +INF[

Technical Background

Noise source generates transient noise (current or voltage) between two nodes. A noise value is generated at any given time point based on a Monte-Carlo method using given noise spectral density and probability density function.

The parameter *Mode* sets the frequency dependence of the noise as given by

- *Res* - white noise resistor mode, noise spectral density = $\sqrt{4KT/R}$ where *K* is the Boltzmann constant, *T* is the temperature in Kelvin, and *R* is the resistance
- *White* - noise spectral density = given by parameter *Magnitude*
- Pink - noise spectral density = M/f^{AF} , where *M* is the parameter *Magnitude, f* is a frequency value from the internally computed frequency spectrum, and *AF* is the parameter *AF.*

Having the magnitude as the mean value, a probability density function is applied such that the Monte-Carlo method will generate a noise value based on the probability distribution: *Gaussian*, *Poisson* or *WMC* (given by Webb, McIntyre, and Conradi [1] - [3] for photodiode noise).

If the *Method* is set to *Sequence*, a sequence of noise is added at each time point. The magnitude of the noise sequence is computed based on the frequency bandwidth of the internal time step the simulator takes. If the Mode is set to Pink, then noise is computed based on *Sequence* method such that a noise spectral density is computed for a bandwidth which depends on the internal time step, and then it is converted to time domain by applying inverse Fourier transform.

Examples

For a white noise source (current source) with the name WhiteNoiseSrc connected between NIN and ground with the noise density 1.5e-11 A^2/Hz, the statement can be written as follows:

```
Osp NOISESOURCE Name = WhiteNoiseSrc Type = I Nodes = [NIN 0]
+ Mode=White Magnitude = 1.5e-11
```

References

[1] P. P. Webb, R. J. McIntyre, and J. Conradi, “Properties of avalanche photo diodes,” RCA Rev., vol. 35, pp. 234-276, June 1974.

[2] Baker, K.R, "On the WMC density as an inverse Gaussian probability density", IEEE Trans. on Commun., Vol. 44, No. 1, 1996, pp. 15-17.

[3] Ascheid, G., "On the generation of WMC-distributed random numbers", IEEE Trans. on Commun., Vol. 38, No. 12, 1990, pp. 2117 - 2118.

Notes:

OPTISYSINELEC

Syntax

Style	Form
OptiSPICE	Osp OPTISYSINELEC Name=*devname* Nodes=[n+ n-] SignalFile=*filename* + tranMode=FILE EL_Type=I_SOU/V_SOU

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Signal file Name of the text file that contain electrical signal data (generated by OptiSystem).	SignalFile	-	-	-
Transient data input mode Format for input signal data. For OptiSystem input only FILE mode is supported.	tranMode	NONE	-	NONE, FILE
Element type Defines the type of the element whether it is a current source (I_SOU) or a voltage source (V_SOU)	EL_Type	0.0	V	I_SOU, V_SOU

Technical Background

The element OPTISYSINELEC is essentially an independent source (INDSOURCE) that receives electrical input from OptiSystem during OptiSystem - OptiSPICE co-simulation. The input electrical signal data file given by *SignalFile* contains two columns: time and amplitude values. Depending on *EL_Type* it can act either as a current or a voltage source.

Notes:

RESISTOR

Syntax

Style	Form
SPICE	Rxxx n+ n- <modelname> <R = >resistance <<TC1 = >val> <<TC2 = >val> + <SCALE = val> <M = val> <AC = val> <DTEMP=val> <L = val> <W = val> <C = val>
OptiSPICE	Osp RESISTOR Name = name <MoName = modelname> Nodes=[n+ n-] + *<param1=val1> <param2=val2> ....*

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Resistance Resistance value	R	0	ohms	[0, +INF[
AC resistance Resistance for AC analysis	AC	0	ohms	[0, +INF[
Scaling factor Scaling factor for resistance value or resistor physical properties	SCALE	1	-	[0, +INF[
Multiply factor Parallel instances of this element	M	1	-	[1, +INF[
Temperature Difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
First order temperature coefficient First order coefficient for the resistance calculation due to change in temperature	TC1	0	ohm/Deg. C	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Second order temperature coefficient Second order coefficient for the resistance calculation due to change in temperature	TC2	0	ohm/ Deg. C^2	]-INF, +INF[
Width The physical width of the resistor wire model	W	1e-4	m	[0, +INF[
Length The physical length of the resistor for resistor wire model	L	1e-4	m	[0, +INF[
Capacitance Parasitic capacitance connected from node 2 to ground	C	0	F	[0, +INF[
Exclude Noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

A resistor is a two terminal electrical element that produces a voltage drop across its terminals proportional to the current flowing through it as given by Ohm's law

$$v_R = R \cdot i_R \tag{1}$$

where R is the resistance measured in Ohms, v_R is the voltage drop across its terminals in Volts, and i_R is the current in Amperes.

Resistance as a function of temperature can be expressed as:

$$R(T) = R(T_{nom}) \cdot (1 + TC1 \cdot DTEMP + TC2 \cdot DTEMP^2) \tag{2}$$

where T_{nom} : is the nominal temperature in Kelvin.

If noise simulation is performed and the parameter *NoNoise* is 0 (default choice), then the noise spectral density of the current (unit A^2/Hz) can be calculated as

$$N_i = \frac{4 \cdot K \cdot T}{R} \tag{3}$$

where K is the Boltzmann constant

The resistance value can be specified as a value or an equation. A resistor model may be provided to define physical characteristics of the wire model of a resistor. If parameters *C*, *W*, *L*, *TC1*, and *TC2* are provided in the element, they will replace corresponding model parameters. For more details about resistor model see Technical Background of resistor model.

Example

For a resistor with the name R1 connected between nodes 1 and 2 with 10 kilo-ohms, and temperature coefficients (TC1 and TC2) of 0.01 and 0.001, the netlist statement can be generated as follows:

```
R1 1 2 R=10k TC1=0.01 TC2=0.001
```

RESISTOR

Notes:

CAPACITOR

Syntax

Style	Form
SPICE	Cxxx n+ n- <modelname> <C = >capacitance <<TC1 = >val> <<TC2 = >val> + <SCALE = val> <IC = val> <M = val> <W = val> <L = val> <DTEMP = val>
OptiSPICE	Osp CAPACITOR Name = name <MoName = modelname> Nodes=[n+ n-] + *<param1=val1> <param2=val2> ....*

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Capacitance Capacitance value	C	0	F	[0, +INF[
Initial voltage Initial voltage across the capacitor	IC	0	V	]-INF, +INF[
Temperature Difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
First order temperature coefficient First order coefficient for the capacitance calculation due to change in temperature	TC1	0	F/Deg. C	]-INF, +INF[
Second order temperature coefficient Second order coefficient for the capacitance calculation due to change in temperature	TC2	0	F/ Deg. C^2	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Scaling factor Scaling factor for capacitance value or capacitor physical properties	SCALE	1	-	[0, +INF[
Multiply factor Parallel instances of this element	M	1	-	[1, +INF[
Width Width of the capacitor to replace physical capacitor model parameter	W	1e-4	m	[0, +INF[
Length Length of the capacitor to replace physical capacitor model parameter	L	1e-4	m	[0, +INF[

Technical Background

This is a linear capacitor element which has two conductors separated by an insulator to store electric charge when a voltage is applied across its conductors. Current through the capacitor is given by

$$i_c = C \cdot \frac{dv_c}{dt} \tag{1}$$

where C is the capacitance measured in Farads, v_c is the voltage drop across its terminals in Volts, and t is the time in seconds.

Capacitance as a function of temperature can be expressed as:

$$C(T) = C(T_{nom}) \cdot (1 + TC1 \cdot DTEMP + TC2 \cdot DTEMP^2) \tag{2}$$

where T_{nom} : is the nominal temperature in Kelvin.

Capacitor model may be provided to define physical characteristics of a capacitor. For more details about resistor model see Technical Background of capacitor model.

Example

For a capacitor with device name C1 connected between nodes 1 and 2 with 2 pF, and initial voltage of 0.05 V, the statement can be written as follows:

```
C1 1 2 C=2p IC=0.05
```

INDUCTOR

Syntax

Style	Form
SPICE	Lxxx n+ n- <L = >inductance <IC = val> <DTEMP = val> <TC1 = val> <TC2 = val> + <SCALE = val> <M = val> <ExtTnode = nodename> <Rth = val> <Cth = val>
OptiSPICE	Osp INDUCTOR Name = *name* Nodes=[*n+ n-*] *<param1=val1> <param2=val2> ....*

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node.
n-	Electrical	Negative node.

Parameters

Name and description	Symbol	Default value	Units	Value range
Inductance The inductance value of the inductor	L	1e-4	H	[0, +INF[
Initial current Initial current flowing through the inductor	IC	0	A	]-INF, +INF[
Temperature Difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
First order temperature coefficient First order coefficient for the inductance calculation due to change in temperature	TC1	0	H/Deg. C	]-INF, +INF[
Second order temperature coefficient Second order coefficient for the inductance calculation due to change in temperature	TC2	0	H/ Deg. C^2	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Scaling factor Scaling factor for inductance value or inductor physical properties	SCALE	1	-	[0, +INF[
Multiply factor Parallel instances of this element	M	1	-	[1, +INF[

Technical Background

The Inductor is a two terminal element that can store energy in magnetic field when a current is passing though. The voltage induced across the terminals of the inductor is given by

$$v_L = L \cdot \frac{di_L}{dt} \tag{1}$$

where L is the inductance measured in Henries, i_L is the current through the inductor in Amperes, and t is the time in seconds.

Inductance as a function of temperature can be expressed as:

$$L(T) = L(T_{nom}) \cdot (1 + TC1 \cdot DTEMP + TC2 \cdot DTEMP^2) \tag{2}$$

where T_{nom} : is the nominal temperature in Kelvin.

An optional, physical-based, Inductor model can also be used with the Inductor element. Please see the “Electrical Models” section (Inductor Model) for further details.

Example

For an inductor with the name L1 connected between nodes N1 and N2 with 10 nH, initial current = 0.01 mA, the statement can be written as follows:

```
L1 N1 N2 L=10n IC=0.01m
```

NRESISTOR

Syntax

Style	Form
OptiSPICE	Osp NRESISTOR Name=name Nodes=[*n+ n-*] *<param1=val1> <param2=val2>* ....

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node
n-	Electrical	Negative node.

Parameters

Name and description	Symbol	Default value	Units	Value range
Element type Element's current-voltage relationship expression type: RES - resistance, COND - conductance, CURR - current	Type	RES	-	RES, COND, CURR
Function mode Non-linear function mode: POLY - polynomial function of voltage; EQ - resistance function as a mathematical expression	Mode	POLY	ohm	POLY, EQ
Polynomial coefficients List of coefficients representing polynomial function from zeroth order to higher order	coeff	-	-	]-INF, +INF[
Equation Equation expression	Eq	-	ohms	-
Maximum voltage Maximum voltage across the terminals for resistance calculation	Vmax	1e50	V	]-INF, +INF[
Minimum voltage Minimum voltage across the terminals for resistance calculation	Vmin	-1e50	V	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Temperature polynomial coefficients Temperature polynomial coefficients for the dependency of current on temperature	Tcoeff	-	-	]-INF, +INF[
Offset temperature Offset value from the device temperature	Toff	0	K	]-INF, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The NResistor (non-linear resistor) can be used to express resistance as a non-linear function of nodal voltages, branch currents, and time. This element can be expressed either as a resistance function (voltage/current), conductance function (current/voltage), or a function expressing current through resistor (voltage/resistance) depending on the parameter *Type* values RES, COND, or CURR respectively.

There are two function modes available: polynomial (POLY) and equation (EQ). If set to POLY (default choice), then the function need to be expressed as a polynomial function of voltage difference between nodes *n*+ and *n*- as follows.

$$f(v) = p_0 + p_1 v + p_2 v^2 + \ldots + p_N v^N \quad (1)$$

where v is the voltage difference between nodes *n*+ and *n*-, $[p_0, p_1, p_2, \ldots, p_N]$ are the polynomial coefficients given by the *coeff* parameter, and N is the order of polynomial.

If the Mode is EQ, then it can be expressed as a function of any nodal voltages, currents through voltage sources, and time by defining a mathematical expression to the *Eq* parameter.

Parameters *Vmax* and *Vmin* restrict the voltage across the n+ and n- not to go beyond the limit for the resistance calculation.

Thermal Operation

Parameters *Rth* and *Cth* can be set to create a simple thermal sub-circuit for the device. However, the parameter *ExtTnode* can be used to specify an external temperature node to which an external thermal network can be attached.

The temperature dependence are specified by the polynomial list parameter *Tcoeff*=$[p_{T_0}, p_{T_1}, p_{T_2}, \ldots, p_{T_M}]$, where M is the order of the polynomial. The current through the element as a function of temperature in Kelvin T can be expressed as:

$$i(T) = i(T_{nom}) \cdot (p_{T_0} + p_{T_1} T_d + p_{T_2} T_d^{\,2} + \ldots + p_{T_M} T_d^{\,M}) \quad (2)$$

where

- T_{nom} is the nominal temperature in Kelvin
- $T_d = T - T_{off}$
- T_{off} is the parameter *Toff* (offset temperature) in Kelvin

Example

For a polynomial non-linear resistor with the name NR1 connected between nodes 1 and ground with a polynomial coefficients p0 = 1000, p1 = -500, p2 = 3000, and p3 = 500, the statement can be written as follows:

```
Osp NResistor Name=NR1 Nodes=[1 0] coeff=[ 1000 -500 3000 500 ]
```

For a polynomial non-linear resistor that need to be expressed current function $i = 0.05 + 0.01 \cdot v + 0.001 \cdot v^2$ with the name NCur1 connected between nodes 1 and 2, the statement can be written as follows:

```
Osp NResistor Name=NCur1 Nodes=[1 2] Type=CURR
+ coeff = [ 0.05 0.01 0.001]
```

For a non-linear resistor with name R1 connected between node 1 and 2, and its value expressed mathematically as $R = 50 + 10 \cdot (v_{in1} - v_{in2}) \cdot e^{-kt}$ where $k = 1.5 \times 10^9$, the statement can be expressed as:

```
Osp NResistor Name=R1 Nodes=[1 2] Mode = EQ
+ Eq = '50 + 10 * V(in1,in2) * exp(1.5e9*TIME)'
```

NCAPACITOR

Syntax

Style	Form
OptiSPICE	Osp NCAPACITOR Name=name Nodes=[*n+ n-*] *<param1=val1> <param2=val2>* ....

Nodes

Name	Signal Type	Description
n+	Electrical	Positive node.
n-	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Capacitor type To define capacitor as a charge function (QDEF) or capacitance function (CDEF)	Type	QDEF	-	QDEF, CDEF
Zeroth order polynomial coefficient Zeroth order polynomial coefficient value for the capacitance function represented as a polynomial function of voltage	D	0	-	]-INF, +INF[
First order polynomial coefficient First order polynomial coefficient value for the capacitance function represented as a polynomial function of voltage	C	0	-	]-INF, +INF[
Second order polynomial coefficient Second order polynomial coefficient value for the capacitance function represented as a polynomial function of voltage	B	0	-	]-INF, +INF[
Third order polynomial coefficient Third order polynomial coefficient value for the capacitance function represented as a polynomial function of voltage	A	0	-	]-INF, +INF[

Technical Background

The NCapacitor (non-linear capacitor) can be used to express capacitance as a polynomial function of voltage across its terminals. If the parameter *Type* is defined as QDEF (default choice), the non-linear charge (*Q*) stored in the capacitor, is expressed as a function of *v* (voltage difference between node *n*+ and *n*-) as given by:

$$Q(v) = Av^3 + Bv^2 + Cv + D \tag{1}$$

where *A*, *B*, *C*, and *D* are the element parameters representing third, second, first, and zeroth order polynomial coefficients respectively.

If Type is set to CDEF, then capacitance (C) is expressed as a function of voltage across *n*+ and *n*- as follows

$$C(v) = Av^3 + Bv^2 + Cv + D \tag{2}$$

Examples

For a non-linear capacitor to be expressed as a nonlinear charge with the name NC1, connected between nodes 1 and ground with polynomial coefficients A = 1e-9, B = 1.5e-8, C=2e-7, and D = 1e-7, the netlist statement can be written as:

```
Osp NCapacitor Name=NC1 Nodes=[1 0] A=1e-9 B=1.5e-8 C=2e-7 D=1e-7
```

For a non-linear capacitor to be expressed as a nonlinear capacitance with the name NC2, connected between nodes 2 and ground with polynomial coefficients (for charge) B = 3e-11, C=2.5e-10, and D = 1e-12, the netlist statement can be written as:

```
Osp NCapacitor Name=NC2 Nodes=[2 0] Type=CDEF B=3e-11 C=2.5e-10
+ D=1e-12
```

MUTUALIND

Syntax

Style	Form
SPICE	Kxxx Lyyy Lzzz <K = >couplingcoeff
OptiSPICE	Osp MUTUALIND Name = name Inductors = [ind1_name ind2_name] K=val

Parameters

Name and description	Symbol	Default value	Units	Value range
Inductors Names of coupling inductors	Inductors	-	-	-
Coupling coefficient Coefficient for coupling between the two inductors	K	0	-	[0, 1]

Technical Background

The MUTUALIND is a mutual or coupled inductor that represents coupling between two inductors. The mutual inductance, M, is defined by

$$M = k\sqrt{L_1 L_2} \tag{1}$$

where

- k is the coupling coefficient
- L_1 is the inductance of first inductor in Henries
- L_2 is the inductance of second inductor in Henries

Example

For a mutual inductor K1 forming coupling between two inductors L1 and L2 with coupling coefficient = 0.75, the statement can be written as follows:

```
K1 L1 L2 K=0.75
```

Notes:

TRANLINE

Syntax

Style	Form
SPICE	UXXX IN1 IN2 ... INN INREF OUT1 OUT2 ... OUTN OUTREF modelname <L=val> + <LUMPS=val> ....
OptiSPICE	Osp TRANLINE Name = name Mode = U + Nodes = [N1 IN2 ... INN INREF OUT1 OUT2 ... OUTN OUTREF] + Model = modelname <L=val> <LUMPS=val>

Nodes

Name	Signal Type	Description
n1	Electrical	
n2	Electrical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Length of conductor The length of the conductors	L	1e-4	m	[0, +INF[
Number of lump segments The number of sections (lumps) in a transmission line model that representing a small length (small fraction of a wavelength) of the transmission line operating at the highest frequency	LUMPS	20	-	[0, +INF[

Technical Background

Transmission line characteristics are in general described by Telegrapher's equations.

Transmission line element is represented as lumped elements having series resistance and inductance, and shunt conductance and capacitance (RLGC). Per-unit-length (p.u.l) RLGC parameters are given using Transmission line model (U). For more details see Technical Background of Lumped Transmission Line (U) Model.

Example

For two conductor lumped transmission lines with device name U2 connected to nodes IN1, IN2, OUT1, and OUT2 (ground input and output references) with a length of 12 cm and 60 lumped segments, and represented by the model name LUMPMODEL, the statement can be written as follows:

```
U2 I1 I2 GND O1 O2 GND LUMPMODEL L=0.12 LUMPS=60
```

IDEALTRANLINE

Syntax

Style	Form
SPICE	TXXX In RefIn Out RefOut Z0 TD
OptiSPICE	Osp IDEALTRANLINE Name = name Nodes = [In RefIn Out RefOut] <Z0=val> + <TD=val>

Nodes

Name	Signal Type	Description
In	Electrical	Input node
Refin	Electrical	Input reference node
Out	Electrical	Output node
RefOut	Electrical	Output reference node

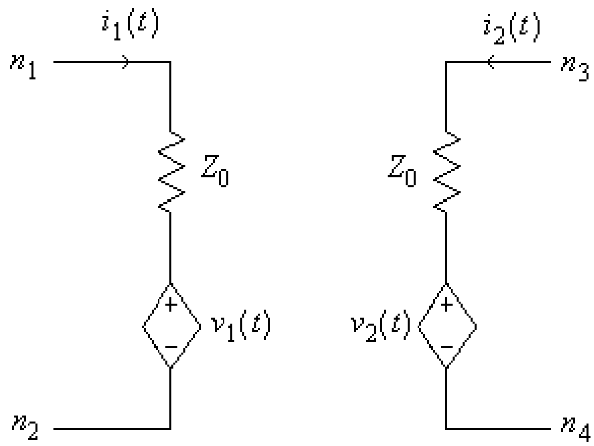
Parameters

Name and description	Symbol	Default value	Units	Value range
Characteristic impedance Characteristic impedance of the line	Z0	50	Ohm	[0, +INF[
Time delay Propagation delay of the line	TD	0	sec	[0, +INF[

Technical Background

Ideal transmission line is a single conductor transmission line without loss and it is characterized by propagation delay and characteristic impedance. Equivalent circuit is given by Figure 1.

Figure 1 Equivalent circuit for ideal transmission line



The equations representing this element can be given by.

$$
\begin{aligned}
v_1(t) &= v_{n3,\,n4}(t - TD) + Z_0 \cdot i_2(t - TD) \\
v_2(t) &= v_{n1,\,n2}(t - TD) + Z_0 \cdot i_1(t - TD)
\end{aligned}
\quad (1)
$$

where

- n_1, n_2, n_3, and n_4 are nodes *In*, *RefIn*, *Out*, and *RefOut* respectively
- $v_{n1,\,n2}(t) = v_{n1}(t) - v_{n2}(t)$
- $v_{n3,\,n4}(t) = v_{n3}(t) - v_{n4}(t)$

Example

For an ideal transmission line with the name T1, connected to node In1, GND, Out1, and GND with characteristic impedance = 100 Ohms and line delay = 2 ns, the statement can be written as follows:

```
T1 In1 GND Out1 GND 100 2n
```

DELAY

Syntax

Style	Form
OptiSPICE	Osp DELAY Name=name Nodes=[n1 n2] <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
n1	Electrical	
n2	Electrical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Gain Gain of the delay element	A (Gain ,Atten)	1.0	-	]-INF, +INF[
Delay Delay time	Del	1.0	sec	[0, +INF[

Technical Background

For a input voltage $v(t)$ the delay element produces an output voltage of $A \cdot v(t-\tau)$ where A is the parameter *A* and τ is the parameter *Del*.

Example

For a delay element with the name Delay1, connected to node Din and Dout having a delay of 10 ns and a gain of 0.75, the statement can be written as follows:

```
Osp DELAY Name = Delay1 Nodes= [Din Dout] Del = 10n A = 0.75
```

DELAY

Notes:

SPARAM

Syntax

Style	Form
OptiSPICE	Osp SPARAM Name=name Nodes=[1 2 3 ... N] Vref = Ref <param1=val1> + <param2=val2> ....

Nodes

Name	Signal Type	Description
1, 2, 3, ..., N	Electrical	Ports 1 to N

Vref node

Name	Signal Type	Description
Ref	Electrical	Reference node

Parameters

Name and description	Symbol	Default value	Units	Value range
Touchstone file Name of the Touchstone file that contain the measured S-parameter data	tstonefile	-	-	-
Number of poles The total number of poles for the S-parameter element	NPoles	10	-	[0, +INF[
Real poles Option to specify whether all poles must be real (1) or not (0)	RealPoles	0	-	0, 1
Poles in log scale Option to specify whether poles are represented in logarithmic scale (1) or not (0)	PolesLogScale	0	-	0, 1

Name and description	Symbol	Default value	Units	Value range
Pole-residue file File generated by OptiSPICE Filter Parameter Extractor containing the poles and residues that describes the filter	rfmfile	-	-	-

Technical Background

This element is a multi-port linear network element that allows users to define S-(Scattering) parameter data through following two ways:

- Touchstone file - S-parameter measurement data file
- Pole-residue file - created with OptiSPICE Filter Parameter Extractor.

Touchstone file is an de facto industry-standard file format for providing S-parameter measurement data. The file name is given by the parameter *tsonefile*. If this file is given a Vector Fitting algorithm [1] is internally used to generate poles and residues for the linear network element. Number of poles are specified by the parameter *NPoles*. If the parameter *RealPoles* is set to 1 all the poles generated by the fitting algorithm will be real. However, this type of fitting will be suitable if the measured data is smooth (no oscillations).

Instead of providing Touchstone file directly to the netlist, the Touchstone file can be given as an input for the OptiSPICE Filter Parameter Extractor tool in order to obtain pole-residue data output file, which is given by the parameter *rfmfile*. Filter Parameter Extractor tool provides in interactive user interface to change number of poles and view the fitting results in order to ensure accuracy of fitting. For more details see OptiSPICE Filter Parameter Extractor documentation.

Example

For a two port S-parameter with device name S1 connected to nodes P1 and P2 with reference node Ref, and represented by pole-residue file having a file path C:\Filter\Bessel.prf, the statement can be written as follows:

```
Osp SPARAM Name=S1 Nodes=[ P1 P2 ] Vref=Ref
+ rfmfile="C:\Filter\Bessel.prf"
```

For a four port S-parameter represented with Touchstone file (filter.s4p) with device name S2 connected to nodes 1, 2, 3, and 4 with ground reference, and number of poles to be generated are 25, the statement can be written as follows:

```
Osp SPARAM Name=S2 Nodes=[1 2 3 4] tstonefile = filter.s4p Npoles = 25
```

Reference

[1] B. Gustavsen and A. Semlyen, “Rational approximation of frequency domain responses by Vector Fitting", *IEEE Trans. Power Delivery*, vol. 14, no. 3, pp. 1052- 1061, July 1999.

Notes:

DIODE

Syntax

Style	Form
SPICE	Dxxx n1 n2 modelname <<AREA = >area> <<PJ = >val> <IC = vd> <M = val> + <RS=val> <NoNoise=0/1> <DTEMP = val> <ExtTnode=nodename> <Rth=val> + <Cth=val>
OptiSPICE	Osp DIODE Nodes=[n+ n-] *<param1=val1> <param2=val2>* ....

Nodes

Name	Signal Type	Description
n1	Electrical	Positive node.
n2	Electrical	Negative node.

Parameters

Name and description	Symbol	Default value	Units	Value range
Junction area PN junction area of the Diode	AREA	1	m^2	[0, +INF[
Junction periphery Periphery of the PN junction of the diode	PJ	0	m^2	[0, +INF[
Initial condition Initial voltage across the diode	IC	0	V	]-INF, +INF[
Multiply factor Multiplying Factors refers to the number of the same elements connected in parallel	M	1	-	[1, +INF[
Diode series resistance Series resistance associated with the diode	RS	0	Ohm	[0, +INF[
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Name and description	Symbol	Default value	Units	Value range
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

A diode is an active electrical element that is formed by regions of p and n-type semiconducting materials and exhibits non-linear voltage(V)-current(I) characteristics in a circuit network. For supported model details see Technical Background of Diode Model.

Example

For a diode with the name Dx connected between nodes 1 and 2 with a model name DMOD and initial voltage = 0.23V, the statement can be written as follows:

```
Dx 1 2 DMOD IC=0.23
```

BITGEN

Syntax

Style	Form
OptiSPICE	Osp BITGEN Name=name Nodes=[n1 n2] <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
n1	Electrical	First port.
n2	Electrical	Second port.

Parameters

Name and description	Symbol	Default value	Units	Value range
Line code Binary code used to represent the voltage waveform	LineCode	NRZ	-	NRZ, RZ
Rectange shape Determines the shape for the edges of the pulse: EXP - exponential; LIN - linear	PuseShape	EXP	-	EXP, LIN
Bit amplitude Peak-to-peak amplitude of the pulse	BitMag	1	V	]-INF, +INF[
Bias DC offset of the pulse	DCOffSet	0	V	]-INF, +INF[
Bit length Length of time that constitutes a bit	Length	1e-8	sec	[0, +INF[
Rise time Defined as the time from when the rising edge reaches 10% of the amplitude to the time it reaches 90% of the amplitude	RiseTime	0	sec	[0, +INF[
Fall time Defined as the time from when the falling edge reaches 90% of the amplitude to the time it reaches 10% of the amplitude	FallTime	0	sec	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Duty cycle for RZ pulse Ratio (in percentage) of the pulse duration with respect to bit length. The pulse duration defined to be the time interval between 50% of the peak amplitude points.	DutyCycle	50	%	[0, 100]
Bit stream User defined bit sequence. If not given, random bits will be generated	BitStream	-	-	-
Number of bits in one period Number of bits to be repeated as a cycle when bit stream is given. If Period is -1 (default) then only one cycle of bits in the Bitstream are generated. If number of bits in period are greater than the number of bits in Bitstream, then rest of the bits are filled with 0s, otherwise, number of bits in Bitstream are capped by number of bits in Period.	Period	-1	-	[0, +INF[

Technical Background

The BitGen element is a voltage source that generates voltage pulses for an internally generated pseudorandom bit sequence or for a user given bit stream. It generates a Non Return to Zero (NRZ) or Return to Zero (RZ) coded signal depending on the *LineCode* parameter.

The high and low logic voltage levels are determined by the parameters *BitMag* and *DCOffset* such that magnitude of logic 1 will be at *BitMag* + *DCOffset* while logic 0 will be at *DCOffset*.

By default, with no user defined bit stream, pseudorandom bits are generated until the end of simulation time. If a specific bit stream is given using *BitStream* parameter, the bit stream can be repeated as a cycle for a given number of bits, given by parameter *Period*. If *Period* is -1, then only one cycle is generated. If number of bits in period are greater than the number of bits in *Bitstream*, then rest of the bits are filled with 0s, otherwise, number of bits in *Bitstream* are capped by number of bits in *Period*.

The parameter *PulseShape* determines the shape for the edges of the pulse during rise and fall transitions.

NRZ Pulse

In case of an NRZ pulse the the waveform changes only during transitions: 0 to 1, rising transition, and 1 to 0, falling transition. In other times the waveform remain unchanged.

If the *PulseShape* is set to *EXP* (exponential), waveforms (normalized to the peak-to peak pulse amplitude) for the rising and falling transitions are given by

$$v_r(t) = 1 - e^{-(t/t_r)^2}$$
$$v_f(t) = e^{-(t/t_f)^2} \tag{1}$$

where

- $t_r = T_r/K$ and $t_f = T_f/K$
- $K = \sqrt{-\ln(0.1)} - \sqrt{-\ln(0.9)}$
- T_r and T_f are the parameters *RiseTime* and *FallTime* respectively

If *PulseShape* is set to *LIN* (linear), the waveforms for rising and falling transitions are given by

$$v_r(t) = t/t_{r_L}$$
$$v_f(t) = 1 - t/t_{f_L} \tag{2}$$

where $t_{r_L} = T_r/0.8$ and $t_{f_L} = T_f/0.8$.

RZ Pulse

Unlike the NRZ pulse, for each 1-bit, the waveform rise to the high value V_H and immediately fall towards the low value V_L during the bit period T (by parameter *Length*).

If the *PulseShape* is set to *EXP*, waveform for logic 1 normalized to the peak-to-peak pulse amplitude is given by

$$v(t) = \begin{cases} 1 - e^{-(t/t_r)^2}, 0 \le t \le t_\alpha \\ e^{-\left(\frac{t - t_\alpha}{t_f}\right)^2}, t_\alpha < t \le T \end{cases} \quad (3)$$

where

- $t_\alpha = \sqrt{\ln(2)} \cdot (t_r - t_f) + t_{pulse}$
- $t_{pulse} = T \cdot DutyCycle / 100$

If *PulseShape* is set to *LIN*, normalized pulse waveform for logic 1 is given by

$$v(t) = \begin{cases} t/t_{r_L}, 0 \le t < t_1 \\ 1,\ t_1 \le t < t_2 \\ 1 - (t - t_2)/t_{f_L}, t_2 \le t < t_3 \\ 0,\ t_3 \le t < T \end{cases} \quad (4)$$

where

- $t_1 = t_{r_L}$
- $t_2 = 0.5 \cdot (t_{r_L} - t_{f_L}) + t_{pulse}$
- $t_3 = t_2 + t_{f_L}$

Example

For a bit generator with name B1 generating NRZ coded random bits with a magnitude of 1 V, bit length of 0.1 ns, and rise and fall time of 0.01 ns, the netlist statement can be written as follows:

```
Osp BITGEN Name=B1 Nodes=[In 0] BigMag=1 Length=0.1n
+ RiseTime=0.01ns FallTime=0.01ns
```

For a bit generator with the name B2 generating RZ coded random bits with linear pulse shape, and with a magnitude of 5 V, bit length of 0.25 ns, rise time of 0.05 ns, fall time of 0.07 ns, and 40% duty cycle, the netlist statement can be written as follows:

```
Osp BITGEN Name=B2 Nodes=[In2 0] LineCode=RZ PulseShape=LIN
+ BigMag=5 Length=0.25n RiseTime=0.05ns FallTime=0.07ns
+ DutyCycle=40
```

For a BitGen element with the name B3 with a bit stream of 011010, bit magnitude of 2.5 V, bit length of 10ns, rise and fall time of 2 ns, , and the bit stream cycle to be repeated for every six bits, the statement can be written as follows:

```
Osp BITGEN Name=B3 Nodes=[In3 0] BitStream = 011010
+ BitMag=2.5 Length=10n RiseTime=2n FallTime=2n Period=6
```

NONLINVI

Syntax

Style	Form
OptiSPICE	Osp NONLINVI Name=name Nodes=[n1 n2] <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
n1	Electrical	
n2	Electrical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Coefficients Polynomial coefficients	coeff	-	-	]-INF, +INF[
Maximum current The maximum current that the non-linear voltage current element can endure	Imax	1e50	A	]-INF, +INF[
Minimum current The minimum current that the non-linear voltage current element can endure	Imin	-1e50	A	]-INF, +INF[
Temperature polynomial coefficients Temperature polynomial coefficients for the dependency of current on temperature	Tcoeff	-	K	]-INF, +INF[
Offset temperature Offset value from the device temperature	Toff	0	K	]-INF, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The NONLINVI can be used to express current as a polynomial function of nodal voltages. The current, i , can be expressed as a polynomial function of voltage, v , difference between nodes *n+* and *n-* as follows.

$$i = p_0 + p_1 v + p_2 v^2 + \ldots + p_N v^N \qquad (1)$$

where $[p_0, p_1, p_2, \ldots, p_N]$ are the polynomial coefficients given by the *coeff* parameter, and N is the order of polynomial.

Thermal Operation

Parameters *Rth* and *Cth* can be set to create a simple thermal sub-circuit for the device. However, the parameter *ExtTnode* can be used to specify an external temperature node to which an external thermal network can be attached.

The temperature dependence are specified by the polynomial list parameter *Tcoeff*= $[p_{T_0}, p_{T_1}, p_{T_2}, \ldots, p_{T_M}]$, where M is the order of the polynomial. The current through the element as a function of temperature in Kelvin T can be expressed as:

$$i(T) = i(T_{nom}) \cdot (p_{T_0} + p_{T_1} T_d + p_{T_2} T_d^2 + \ldots + p_{T_M} T_d^M) \qquad (2)$$

where

- T_{nom} is the nominal temperature in Kelvin
- $T_d = T - T_{off}$
- T_{off} is the parameter *Toff* (offset temperature) in Kelvin

Example

For a non-linear current element whose current voltage relationship is expressed as $i = -0.001 + 0.02 \cdot v + 0.025 \cdot v^2$, with maximum current of 250 mA and minimum current of -250 mA, the statement can be written as follows:

```
Osp NonLinVI Name=VI1 Nodes = [1 2] coeff = [ -0.001 0.02 0.025 ]
+ Imax = 250mA Imin = -250mA
```

Notes:

MOSFET

Syntax

Style	Form
SPICE	Mxxx nd ng ns <nb> modelname <<L = >length> <<W = >width> <AD = val> + <AS = val> <PD = val> <PS = val> <NRD = val> <NRS = val> <RDC = val> + <RSC = val> <OFF> <<IC = vdsval,vgsval,vbsval> *or* <VdsIC=val> <VgsIC=val> + <VbsIC=val>> <DELVTO = val> <GEO = val> <M = val> <NoNoise=0/1> + <DTEMP = val> <ExtTnode=nodename> <Rth=val> <Cth=val>
OptiSPICE	Osp MOSFET Name = name MoName = modelname Nodes=[nd ng ns <nb>] + <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
nd	Electrical	Drain terminal node
ng	Electrical	Gate terminal node
ns	Electrical	Source terminal node
nb	Electrical	Bulk/body terminal node (optional)

Parameters

Name and description	Symbol	Default value	Units	Value range
Channel length Channel length of the MOSFET	L	1e-4	m	[0, +INF[
Channel width Channel width of the MOSFET	W	1e-4	m	[0, +INF[
Drain diffusion area Diffusion area of the drain terminal of the MOSFET	AD	0	m^2	[0, +INF[
Source diffusion area Source terminal diffusion area of the MOSFET	AS	0	m^2	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Drain junction perimeter Drain junction perimeter (includes the channel edge) of the MOSFET	PD	0	m	[0, +INF[
Source junction perimeter Source junction perimeter (include the channel edge) of the MOSFET	PS	0	m	[0, +INF[
Drain diffusion resistance squares Number of squares of drain diffusion for resistance calculations	NRD	0	-	[0, +INF[
Source diffusion resistance squares Number of squares of source diffusion for resistance calculations.	NRS	0	-	[0, +INF[
Drain-contact resistance Additional drain resistance due to the contact	RDC	0	ohm	[0, +INF[
Source-contact resistance Additional source resistance due to the contact	RSC	0	ohm	[0, +INF[
MOSFET OFF The option allows the user to set the initial condition of the MOSFET to OFF in the DC analysis	OFF	0	-	-
Initial condition Initial condition for drain-source, gate-source, and bulk-source voltages.	IC	-	V	]-INF, +INF[
Initial drain source voltage If not given using parameter IC, the initial drian-source voltage can be separately defined by this parameter	VdsIC	0	V	]-INF, +INF[
Initial gate source voltage If not given using parameter IC, the initial gate-source voltage can be separately defined by this parameter	VgsIC	0	V	]-INF, +INF[
Initial bulk source voltage If not given using parameter IC, the initial bulk-source voltage can be separately defined by this parameter	VbsIC	0	V	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Zero bias threshold voltage variation Threshold voltage variation when the bias voltage is zero	DELVTO	0	V	]-INF, +INF[
Share source/drain selector The option allows the user to define wether the drain or source alone is connected to another device or both are being connected to the one device	GEO	0	-	[0, +INF[
Define Element Multiply Factor Multiplying Factors refers to the number of the same elements connected in parallel	M	1	-	[1, +INF[
Exclude Noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The MOSFET is a four terminal electrical element that called metal oxide field-effect transistor that is based on the modulation of charge concentration by a metal oxide silicon capacitance between a body electrode and a gate electrode located above the body and insulated from all other element regions by a gate dielectric layer which in the case of a MOSFET is an oxide. Two additional terminals (source and drain), each connected to individual highly doped regions that are separated by the body region. These regions can be either p or n type, but they must both be of the same type, and of opposite type of the body region. Using the gate contact on the oxide, the operations of the MOSFET can be modified to the desired function. This transistor is widely used in digital logic and analogue design. For supported models see Technical Background of MOSFET Model.

Example

For a n-channel MOSFET with a device name M1 connected to nodes VDD, VI, VSS, and GND, with model name MNMOS, channel width = 2 µm, and channel length = 0.13 µm, the statement can be written as follows:

```
M1 VDD VI VSS GND MNMOS W=2u L=0.13u
```

BJT

Syntax

Style	Form
SPICE	Qxxx nc nb ne <ns> modelname <AREA = area> <AREAB = val> <AREAC = val> + <OFF> <<IC=vbeval,vceval> *or* <VbeIC = vbeval> <VceIC = vceval>> <M = val> + <NoNoise=0/1> <DTEMP = val> <ExtTnode=nodename> <Rth=val> <Cth=val>
OptiSPICE	Osp BJT Name = name MoName = modelname Nodes=[nc nb ne <ns>] + <param1 = val1> <param2 = val2> ...

Nodes

Name	Signal Type	Description
nc	Electrical	Carrier terminal node
nb	Electrical	Base terminal node
ne	Electrical	Emitter terminal node
ns	Electrical	Substrate terminal node

Parameters

Name and description	Symbol	Default value	Units	Value range
Emitter area Area of the emitter junction	AREA	1	m^2	[0, +INF[
Base area Area of the base junction	AREAB	0	m^2	[0, +INF[
Collector area Area of the collector junction	AREAC	0	m^2	[0, +INF[
BJT off The option allows the user to set the initial condition of the BJT to OFF in the DC analysis	OFF	0	-	-
Initial condition Initial condition for base-emitter and collector-emitter voltages.	IC	-	V	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Initial base-emitter voltage If not given using parameter IC, the initial base-emitter voltage can be separately defined by this parameter	VbeIC	0	V	]-INF, +INF[
Initial collector-emitter voltage If not given using parameter IC, the initial collector-emitter voltage can be separately defined by this parameter	VceIC	0	V	]-INF, +INF[
Multiply factor Multiplying Factors refers to the number of the same elements connected in parallel	M	1	-	[1, +INF[
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The BJT is called a bipolar junction transistor. It contains three different semiconductor doped regions with doping types of npn or pnp with three different corresponding region contacts (collector, base and emitter) that generate two diode (PN junctions) like structures that share a connection. The operation of the transistor depends on the bias condition on each of the two junctions. For details on supported BJT model types see Technical Background of BJT Model.

Example 1

For an NPN transistor with the name Q1 connected to nodes C, B, and E with model name NPNMOD, area factors of 1.2, 2.1, and 2.8 (for emitter, base, and collector respectively), and initial voltages V_{BE} = 0.4 V, and V_{CE} = 5 V, the statement can be written as follows:

```
Q1 C B E NPNMOD AREA=1.2 AREAB=2.1 AREAC=2.8 IC=0.4, 5
```

Example 2 (Mextram)

For an NPN transistor with the name Q1 connected to nodes C, B, and E utilizing a Mextram level 504 model (with model name “mextram”), the statement can be written as follows:

```
Q1 C B E mextram

.model mextram NPN level = 504
```

Example 3 (Agilent)

For an PNP transistor with the name Q3 connected to nodes C, B, and E utilizing an Agilent model (with model name “agilent”), the statement can be written as follows:

```
Q3 C B E agilent

.model agilent PNP level = 101
```

Notes:

SWITCH

Syntax

Style	Form
OptiSPICE	**Voltage controlled switch** Osp SWITCH Name=name Nodes=[n1 n2] CNodes=[in1 in2] <VON=val> + <VOFF=val> <RON=val> <ROFF=val> **Current controlled switch** Osp SWITCH Name=name Nodes=[n1 n2] VSRC=name <ION=val> <IOFF=val> + <RON=val> <ROFF=val>

Nodes

Name	Signal Type	Description
n1	Electrical	Positive node
n2	Electrical	Negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Switch type Option to specify the type of the switch: voltage controlled (VCSW) or current controlled (CCSW)	SWTYPE	VCSW	-	VCSW, CCSW
ON control voltage Control voltage to be applied in order to change the resistance value to RON	VON	1.0	V	]-INF, +INF[
OFF control voltage Control voltage to be applied in order to change the resistance value to ROFF	VOFF	0.0	V	]-INF, +INF[
ON control current Control current to be applied in order to change the resistance value to RON	ION	1e-3	A	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
OFF control current Control current to be applied in order to change the resistance value to ROFF	IOFF	0.0	A	]-INF, +INF[
Controlling voltage source name Name of the voltage source through which the control current flows	VSRC	-	-	-
ON resistance Resistance value when the switch is ON	RON	1.0	Ohm	[0+, +INF[
OFF resistance Resistance value when the switch is OFF	ROFF	1e6	Ohm	[0+, +INF[

Technical Background

The switch element is a voltage or current controlled resistor having two different resistance values RON and ROFF when turned on and off externally controlled by a voltage or current.

For a voltage controlled switch, if *VOFF* < *VON*, the resistance, *R*, as a function of controlling voltage, *Vc*, can be given as follows:

- For *Vc* $\leq$ *VOFF, R = ROFF*
- For *Vc* $\geq$ *VON, R = RON*
- For *VOFF* < *Vc* < *VON*, *R* can be expressed as

$$R = \exp\left(Lm + \frac{3 \cdot Lr \cdot Vx}{2 \cdot Vd} - \frac{2 \cdot Lr \cdot Vx^3}{2 \cdot Vd^3}\right) \tag{1}$$

where

- $Lm = \ln(\sqrt{RON \cdot ROFF})$
- $Lr = \ln(RON/ROFF)$
- $Vx = Vc - (VON + VOFF)/2$
- $Vd = VON - VOFF$

If *VOFF* > *VON*, then R = RON for *Vc* $\leq$ *VON* and R = ROFF for *Vc* $\geq$ *VOFF*. For *VOFF* < *Vc* < *VON*, the relationship above equation will still hold.

Current controlled switch has similar form where one needs to replace VON and VOFF by ION and IOFF respectively for a controlling current *Ic*.

Examples

For a voltage controlled switch with the name SW1 connected to nodes 1 and 2, controlled by voltage difference between nodes 4 and 5, and having VON=2V, VOFF=1.5V, RON=0.1 Ohm, ROFF=5 Mega Ohm, the statement can be generated as follows:

```
Osp Switch Name=SW1 Nodes=[1 2] CNodes=[4 5]

+ VON=2 VOFF=1.5 RON=0.1 ROFF=5MEG
```

For a current controlled switch with the name SW2 connected to nodes A and B, controlled by a current through a voltage source name V1, and having ION=10mA, IOFF=2mA, RON=0.5 Ohm, ROFF=2 Mega Ohm, the statement can be generated as follows:

```
Osp Switch Name=SW2 SWTYPE=CCSW Nodes=[A B] VSRC=V1

+ ION=10m IOFF=2m RON=0.5 ROFF=2MEG
```

Notes:

JFET

Syntax

Style	Form
SPICE	JXXX D G S MNAME <W=val> <L=val> <AREA=val> + <<IC=vdsval,vgsval> *or* <VdsIC=val> <VgsIC=val>> <ON/OFF> <M=val> + <NoNoise=0/1> <DTEMP=val> <ExtTnode=NODENAME> <Rth=val> <Cth=val>
OptiSPICE	Osp JFET Name = name MoName = modelname Nodes=[nd ng ns] + <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
nd	Electrical	Drain terminal node
ng	Electrical	Gate terminal node
ns	Electrical	Source terminal node

Parameters

Name and description	Symbol	Default value	Units	Value range
Gate width JFET channel width	W	1e-4	m	[0, +INF[
Gate length JFET channel length	L	1e-4	m	[0, +INF[
Area factor Area multiplying factor	AREA	1	-	[0, +INF[
Initial condition Initial condition for drain-source and gate-source voltages	IC	-	V	]-INF, +INF[
Initial drain-source voltage If not given using parameter IC, the initial drain-source voltage can be separately defined by this parameter	VdsIC	0.0	V	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Initial gate-source voltage If not given using parameter IC, the initial gate-source voltage can be separately defined by this parameter	VgsIC	0.0	V	]-INF, +INF[
Set initial condition Set initial condition to set the initial DC values	ON/OFF	ON	-	[ON, OFF]
Multiplier Multiplier to simulate parallel elements	M	1	-	[1, +INF[
Exclude Noise Exclude element noise (1) or not (0)	NoNoise	0	-	]-INF, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The element JFET is the Junction Field Effect Transistor. For more details see Technical Background of JFET Model.

Example

For a n-channel JFET with a device name J1 connected to nodes VDD, VI, and VSS, with model name JMOD, gate width = 2 μm, and gate length = 0.13 μm, the netlist statement can be written as follows:

```
J1 VDD VI VSS JMOD W=2u L=0.13u
```

MESFET

Syntax

Style	Form
SPICE	ZXXX D G S MNAME <AREA=val> <<IC=vdsval,vgsval> *or* <VdsIC=val> + <VgsIC=val>> <ON/OFF> <M=val> <NoNoise=0/1> <DTEMP=val> + <ExtTnode=NODENAME> <Rth=val> <Cth=val>
OptiSPICE	Osp JFET Name = name MoName = modelname Nodes=[nd ng ns] + <param1=val1> <param2=val2> ....

Nodes

Name	Signal Type	Description
nd	Electrical	Drain terminal node
ng	Electrical	Gate terminal node
ns	Electrical	Source terminal node

Parameters

Name and description	Symbol	Default value	Units	Value range
Area factor Area multiplying factor	AREA	1	-	[0, +INF[
Initial condition Initial condition for drain-source and gate-source voltages	IC	-	V	]-INF, +INF[
Initial drain-source voltage If not given using parameter IC, the initial drain-source voltage can be separately defined by this parameter	VdsIC	0.0	V	]-INF, +INF[
Initial gate-source voltage If not given using parameter IC, the initial gate-source voltage can be separately defined by this parameter	VgsIC	0.0	V	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Set initial condition Set initial condition to set the initial DC values	ON/OFF	ON	-	[ON, OFF]
Multiplier Multiplier to simulate parallel elements	M	1	-	[1, +INF[
Exclude Noise Exclude element noise (1) or not (0)	NoNoise	0	-	]-INF, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The element MESFET is the Metal Semiconductor Field Effect Transistor. For more details see Technical Background of MESFET Model.

Example

For a n-channel MESFET with a device name Zn connected to nodes VDD, VI, and VSS, with model name NMFMOD netlist statement can be given by

```
Zn VDD VI VSS NMFMOD
```

Optoelectronic Elements Library

This section contains information on the following elements

- CWSOURCE
- LASER
- MACHZEHNDER
- OPTELECABS
- OPTPHASEDELAY
- PHOTODIODE
- LED

Notes:

CWSOURCE

Syntax

Style	Form
OptiSPICE	Osp CWSOURCE Name=ELEMENT_NAME Nodes=[n1 n2 Output] + MoName=MODEL_NAME <Wavelength=val> <Frequency=val> + <FrequencyUnit=Hz/THz/nm> <FreqShift=val> + <GainCoeff=val> <PhaseCoeff=val> + <RealEfieldCoeff=val> <ImagEfieldCoeff=val> + <dPhidt_DC=val> <CarrierFreqNode=NODE_NAME>

Nodes

Name	Signal Type	Description
n1	Electrical	Input voltage node controlling magnitude
n2	Electrical	Input voltage node controlling phase
Output	Optical	Optical output

Parameters

Name and description	Symbol	Default value	Units	Value range
Wavelength Wavelength	Wavelength	1550	nm	[0, +INF[
Frequency Center frequency	Frequency	193.1	-	[0, +INF[
Frequency unit Channel frequency unit	FrequencyUnit	THz	-	Hz, THz, nm
Frequency shift Carrier Frequency offset of the source	FreqShift	0.0	-	[0, +INF[
Gain coefficient Output optical signal gain coefficient	GainCoeff	1.0	-	]-iNF +INF[
Phase coefficient Output optical signal phase coefficient	PhaseCoeff	1.0	-	]-iNF +INF[

Name and description	Symbol	Default value	Units	Value range
Real electric field coefficient Coefficient for real part of the output electric field	RealEfieldCoeff	1.0	V/m	]-iNF +INF[
Imaginary electric field coefficient Coefficient for imaginary part of the output electric field	ImagEfieldCoeff	1.0	-	]-iNF +INF[
DC phase slope Slope of the phase at DC	dPhidt_DC	0	rad/s	]-iNF +INF[
Carrier frequency node External node to input varying carrier frequency value	CarrierFreqNode	-	-	-

Technical Background

Generates a continuous wave (CW) optical signal controlled by electrical inputs. CWSOURCE model is used to model this element. For more details see Technical Background of CWSOURCE Model.

Example

For a CW laser with device name CW1, model CWModel, connected to nodes SIG1, SIG2 and SIG3, with center frequency of 193.1 THz the netlist statement can be given by

```
Osp CWSOURCE Name=CW1 Nodes=[SIG1 SIG2 SIG3] MoName=CWModel
+ Frequency=193.1 FrequencyUnit=THz
```

LASER

Syntax

Style	Form

OptiSPICE	`Osp LASER Name=ELEMENT_NAME Nodes=[n1 n2 Output]`
	`+ MoName=MODEL_NAME <Wavelength=val> <Frequency=val>`
	`+ <FrequencyUnit=Hz/THz/nm> <FreqShift=val> <InitId=val>`
	`+ <Rth=val> <Cth=val> <DTEMP=val> <ExtTNode=NODE_NAME>`
	`+ <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
n1	Electrical	Laser diode positive node
n2	Electrical	Laser diode negative node
Output	Optical	Optical output

Parameters

Name and description	Symbol	Default value	Units	Value range
Wavelength Laser wavelength	Wavelength	1550	nm	[0, +INF[
Frequency Center frequency	Frequency	193.1	-	[0, +INF[
Frequency Unit Frequency unit selection	FrequencyUnit	THz	-	Hz, THz, nm
Frequency Shift Carrier Frequency Offset of the source	FreqShift	0.0	-	[0, +INF[
Initial DC Current Initial condition of DC current	InitId	-1	A	-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

An optical element that uses stimulated emission of radiation to generate EM waves, based on laser rate-equations. A LASER model is used to model this element. For more details see Technical Background of LASER model.

Example

For a Laser with device name LS1, model LSModel, connected to nodes SIG1, SIG2 and SIG3, with center frequency of 193.1 THz the netlist statement can be given by

```
Osp LASER Name=LS1 Nodes=[SIG1 SIG2 SIG3] MoName=LSModel
+ Frequency=193.1 FrequencyUnit=THz
```

MACHZEHNDER

Syntax

Style	Form

OptiSPICE	`Osp MACHZEHNDER Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ CNodes=[RF1 RF2] BNodes=[Bias1 Bais2]`
	`+ MoName=MODEL_NAME <Rth=val> <Cth=val> <DTEMP=val>`
	`+ <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	Optical in
Output	Optical	Optical out

Control Nodes (CNodes)

Name	Signal Type	Description
RF1	Electrical	Node for controlling RF voltage 1
RF2	Electrical	Node for controlling RF voltage 2

Bias Nodes (BNodes)

Name	Signal Type	Description
Bias1	Electrical	Node for bias voltage 1
Bias2	Electrical	Node for bias voltage 2

Parameters

Name and description	Symbol	Default value	Units	Value range
Extinction ratio Extinction ratio of the modulator in dB	ExtinctionRatio	20	dB	]0, +INF[
Switching bias voltage DC voltage required to turn the modulator from the OFF state to the ON state, or vice versa	SwitchBiasVoltage	4	V	]0, +INF[

Name and description	Symbol	Default value	Units	Value range
Switching RF voltage RF voltage required to turn the modulator from the OFF state to the ON state, or vice versa	SwitchRFVoltage	4	V	]0, +INF[
Insertion loss The insertion loss of the Machzehdner interferometer	InsertionLoss	5	dB	]0, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element is an Mach-Zehnder modulator which consists of an input optical branch, which splits the incoming light into two arms, followed by two independent optical arms, which are subsequently recombined by the output optical branch. MACHZEHNDER model is used to model this element. For more details see Technical Background of MACHZEHNDER model.

Example

For a modulator with device name MZ1, model MZModel, connected to optical nodes SIG1 and SIG2, RF nodes SIG3 and SIG4, and bias nodes SIG5 and SIG6 with extinction ratio of 20 dB, switching bias voltage 4.5V, switching RF voltage of 4.5V, and insertion loss of 3dB, the netlist statement can be given by

```
Osp MACHZEHNDER Name=MZ1 Nodes=[SIG1 SIG2] CNodes=[SIG3 SIG4]
+ BNodes=[SIG5 SIG6] MoName=MZModel ExtinctionRatio=20
+ SwitchBiasVoltage=4.5 SwitchRFVoltage=4.5 InsertionLoss=3
```

OPTELECABS

Syntax

Style	Form
OptiSPICE	Osp OPTELECABS Name=ELEMENT_NAME Nodes=[Input Output] + CNodes=[Control1 Control2] MoName=MODEL_NAME + <InitId=val> <Rth=val> <Cth=val> + <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>

Nodes

Name	Signal Type	Description
Input	Optical	Optical input
Output	Optical	Optical output

Control Nodes (CNodes)

Name	Signal Type	Description
Control1	Electrical	Control voltage positive node
Control2	Electrical	Control voltage negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Initial Current Initial current of opto electronic absorber	InitId	-1	A	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element is an electroabsorption modulator which is typically used to modulate a constant amplitude optical source to produce a bit stream. OPTELECABS model statement is used to model this element. For more details see Technical Background of OPTELECABS Model.

Example

For a modulator with device name EA1, model EAModel, connected to nodes SIG1, and SIG2, and controlled by nodes SIG3 and SIG4, the netlist statement can be given by

```
Osp OPTELECABS Name=EA1 Nodes=[SIG1 SIG2] CNodes=[SIG3 SIG4]
+ MoName=EAModel
```

OPTPHASEDELAY

Syntax

Style	Form

OptiSPICE	`Osp OPTPHASEDELAY Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ CNodes=[Control1 Control2] MoName=MODEL_NAME`
	`+ <PhaseDelay=val> <Gain=val> <Rth=val> <Cth=val>`
	`+ <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	Optical input
Output	Optical	Optical output

Control Nodes (CNodes)

Name	Signal Type	Description
Control1	Electrical	Phase delay controlling voltage positive node
Control2	Electrical	Phase delay controlling voltage negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Phase Delay The option allows the user to define the optical phase delay	PhaseDelay	0	Rad	]-INF, +INF[
Gain The option allows the user to define the gain of the optical phase delay, default is unity	Gain	1.0	-	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

A optical element that adds phase shift to the optical field. See Technical Background of OPTPHASEDELAY Model for more details.

Examples

For a phase delay with element name OP1, model OPModel, connected to nodes SIG1 and SIG2, and controlled by SIG3 and SIG4, the netlist statement can be given by

```
Osp OPTPHASEDELAY Name=OP1 Nodes=[SIG1 SIG2] CNodes=[SIG3 SIG4]
+ MoName=OPModel
```

PHOTODIODE

Syntax

Style	Form

OptiSPICE	`Osp PHOTODIODE Name=ELEMENT_NAME Nodes=[Input n1 n2]`
	`+ MoName=MODEL_NAME <Rth=val> <Cth=val> <DTEMP=val>`
	`+ <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	Optical input
n1	Electrical	Diode positive node
n2	Electrical	Diode negative node

Parameters

Name and description	Symbol	Default value	Units	Value range
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

Photodiode is an element that converts light into an electrical signal. PHOTODIODE Model statement is used to model this element. For more details see Technical Background of PHOTODIODE Model.

Example

For a phase delay with device name PD1, model PDModel, connected to nodes SIG1, SIG2 and SIG3, the netlist statement can be given by

```
Osp PHOTODIODE Name=PD1 Nodes=[SIG1 SIG2 SIG3] MoName=PDModel
```

LED

Syntax

Style	Form

OptiSPICE	`Osp LED Name=ELEMENT_NAME Nodes=[n1 n2 Output]`
	`+ MoName=MODEL_NAME <Frequency=val> <Bandwidth=val>`
	`+ <FrequencyUnit=Hz/THz/nm> <Rth=val> <Cth=val>`
	`+ <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
n1	Electrical	Diode positive node
n2	Electrical	Diode negative node
Output	Optical	Optical output

Parameters

Name and description	Symbol	Default value	Units	Value range
Frequency Center frequency	Frequency	193.1	-	[0, +INF[
Bandwidth 3-dB bandwidth	Bandwidth	6	-	[0, +INF[
Frequency Unit Frequency unit selection	FrequencyUnit	THz	-	Hz, THz, nm
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-

Name and description	Symbol	Default value	Units	Value range
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element simulates Light Emitting Diode (LED). A LED model is used to model this element. This element only works for transient analysis with noise enabled. For more details see Technical Background of LED model.

Example

For a LED with device name led1, model LEDModel, connected to nodes Vp, Vm and Lout, with center wavelength of 650 nm and a 3-dB bandwidth of 30 nm, the netlist statement can be given by

```
Osp LED Name=LS1 Nodes=[Vp Vm Lout] MoName=LEDModel
+ Frequency=650 Bandwidth=30 FrequencyUnit=nm
```

Optical Elements Library

This section contains information on the following elements

- OPTGAIN
- XCOUPLER
- SMFIBER
- MMFIBER
- FREESPACE
- OCONN (OPTISO, POLARIZER)
- OPTCIRC
- MIRROR
- SPLITTER
- OMNIOCONN
- OPTCHANNELFILTER
- OPTFFT
- MULTILAYERFILTER
- WAVEGUIDE
- OPTRING
- OPTISYSINOPT

Notes:

OPTGAIN

Syntax

Style	Form

OptiSPICE	`Osp OPTGAIN Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ MoName=MODEL_NAME <Gain=val> <Atten=val> <RevGain=val>`
	`+ <RevAtten=val> <GaindB=val> <AttendB=val> <RevGaindB=val>`
	`+ <RevAttendB=val> <PhaseShift=val> <RevPhaseShift=val>`
	`+ <Rth=val> <Cth=val> <DTEMP=val> <ExtTNode=NODE_NAME>`
	`+ <NoNoise=0/1>`

Nodes

Name	Signal Type	Description-
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Gain Power gain factor (port 1 to port 2)	Gain	1	-	]-INF, +INF[
Attenuation Power loss factor (port 1 to port 2)	Atten	1	-	]-INF, +INF[
Reverse gain Power gain factor (port 2 to port 1)	RevGain	1	-	]-INF, +INF[
Reverse attenuation Power loss factor (port 2 to port 1)	RevAtten	1	-	]-INF, +INF[
Gain in dB Power gain in dB (port 1 to port 2)	GaindB	0	dB	]-INF, +INF[
Attenuation in dB Power loss in dB (port 1 to port 2)	AttendB	0	dB	]-INF, +INF[
Reverse gain in dB Power gain in dB (port 2 to port 1)	RevGaindB	0	dB	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Reverse attenuation in dB Power loss in db (port 2 to port 1)	RevAttendB	0	dB	]-INF, +INF[
Noise figure Determines the amplifier noise figure (port 1 to port 2)	NoiseFigure	0	dB	]-INF, +INF[
Reverse Noise figure Determines the amplifier noise figure (port 2 to port 1)	RevNoiseFigure	0	dB	]-INF, +INF[
Phase shift Phase shift (port 1 to port 2)	PhaseShift	0	rad	]-INF, +INF[
Reverse phase shift Phase shift (port 2 to port 1)	RevPhaseShift	0	rad	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element amplifies the optical signal power. The attenuation or gain of the element can be specified by using *Gain/Atten/RevGain/RevAtten* and corresponding dB parameters (*GaindB, AttendB*, etc.). For more details see Technical Background of OPTGAIN model.

Example

For a gain device with name OA1, model OGModel, connected to nodes SIG1 and SIG2, with 3 dB of forward gain, -100 dB of reverse gain, forward noise figure of 6 dB, and reverse noise figure of -100 dB, the netlist statement can be given by

```
Osp OPTGAIN Name=OA1 Nodes=[SIG1 SIG2] MoName=OGModel GaindB=3
```

```
+ RevGaindB=-100 NoiseFigure=6 RevNoiseFigure=-100
```

Notes:

XCOUPLER

Syntax

Style	Form
OptiSPICE	Osp XCOUPLER Name=ELEMENT_NAME Nodes=[in1 in2 out1 out2] + MoName=MODEL_NAME <C=val> <Conjugate=0/1> <Rth=val> <Cth=val> + <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>

Nodes

Name	Signal Type	Description
in1	Optical	Input 1
in2	Optical	Input 2
out1	Optical	Output 1
out2	Optical	Output 2

Parameters

Name and description	Symbol	Default value	Units	Value range
Coupling Ratio Coupled power ratio between the input and output optical pairs	C	0.5	-	[0, 1]
Input/Output Conjugate The option allows the user to specify which the inputs/outputs pair conjugates	Conjugate	1	-	0, 1
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-

Name and description	Symbol	Default value	Units	Value range
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

An optical cross-coupler is a device that physically couples two input signals and produces two output signals. For more details see Technical Background of XCOUPLER model.

Example

For a cross coupler with device name XC1, model XCModel, connected to nodes SIG1, SIG2, SIG3 and SIG4, with 0.5 coupling coefficient and conjugate mode enabled, the netlist statement can be given by

```
Osp XCOUPLER Name=XC1 Nodes=[SIG1 SIG2 SIG3 SIG4] MoName=XCModel C=0.5
+ Conjugate=1
```

SMFIBER

Syntax

Style	Form

OptiSPICE	`Osp SMFIBER Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ MoName=MODEL_NAME <Length=val> <Rth=val> <Cth=val>`
	`+ <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Length Fiber length	Length	10	km	[0, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

The SM Fiber element simulates the propagation of an optical field in a single-mode fiber with the dispersive and nonlinear effects taken into account by a direct numerical integration of the modified nonlinear Schrödinger (NLS) equation. For more details see Technical Background of SMFIBER Model.

Example

For a fiber with device name SM1, model SMFModel, connected to nodes SIG1 and SIG2, with 1 km, the netlist statement can be given by

```
Osp SMFIBER Name=SM1 Nodes=[SIG1 SIG2] MoName=SMFModel Length=1
```

MMFIBER

Syntax

Style	Form
OptiSPICE	Osp MMFIBER Name=ELEMENT_NAME Nodes=[Input Output] + MoName=MODEL_NAME <Length=val> <Rth=val> <Cth=val> + <DTEMP=val> <ExtTNode=NODE_NAME> <NoNoise=0/1>

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Length Fiber length	Length	0	km	[0, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element is a multimode fiber. It is a spatially dependent device that models the transverse field profiles and propagation constants for each mode supported by the fiber. For more details see Technical Background of MMFIBER Model.

Example

For a fiber with device name MMF1, model MMFModel, connected to nodes SIG1 and SIG2, with 1 km, the netlist statement can be given by

```
Osp MMFFIBER Name=MMF1 Nodes=[SIG1 SIG2] MoName=MMFModel Length=1
```

FREESPACE

Syntax

Style	Form

OptiSPICE	`Osp FREESPACE Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ MoName=MODEL_NAME <D=val> <XOff=val> <YOff=val>`
	`+ <XTilt=val> <YTilt=val> <Rth=val> <Cth=val>`
	`+ <DTEMP=val> <ExtTnode=val> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Distance Freespace distance	D	0	m	[0, +INF[
X offset Defines the amount of translation of the mode shape in the X-direction	XOff	0	um	[0, +INF[
Y offset Defines the amount of translation of the mode profile in the Y-direction	YOff	0	um	[0, +INF[
X tilt Defines the amount of rotation of the mode profile around the X-axis	XTilt	0	rad	]-INF, +INF[
Y tilt Defines the amount of rotation of the mode profile around the Y-axis	YTilt	0	rad	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

Freespace devices represent the optical connection formed between two devices with possibly different mode structures where a region of free-space is present at the interface. For more details see Technical Background of FREESPACE Model.

Example

For a free space propagation with device name FSO1, model FSOModel, connected to nodes SIG1 and SIG2, with a distance of 10 um, the netlist statement can be given by

```
Osp FREESPACE Name=FSO1 Nodes=[SIG1 SIG2] MoName=FSOModel D=10u
```

OCONN (OPTISO, POLARIZER)

Syntax

Style	Form
OptiSPICE	Osp OCONN Name=ELEMENT_NAME Nodes=[Input Output] + MoName=MODEL_NAME <Ref=val> <RevRef=val> <RefdB=val> + <RevRefdB=val> <PhaseShift=val> <RevPhaseShift=val> + <RefPhaseShift=val> <RevRefPhaseShift=val> <Gain=val> + <RevGain=val> <Atten=val> <RevAtten=val> <XOff=val> + <YOff=val> <XTilt=val> <YTilt=val> <GaindB=val> + <RevGaindB=val> <AttendB=val> <RevAttendB=val> + <PolarMode=None/X/Y/Am45/...> <JonesMatrix=[val1 val2 ...]> + <PolAngle=val> <CNodes=[Control1 Control2]> + <IsoMode=FWD/REV> <Rth=val><Cth=val> <DTEMP=val> + <ExtTNode=NODE_NAME> <NoNoise=0/1>

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Reflection Power return loss (port 1 to port 1)	Ref	0	-	]-INF, +INF[
Reverse reflection Power return loss (port 2 to port 2)	RevRef	0	-	]-INF, +INF[
Reflection in dB Power return loss (port 1 to port 1) in dB	RefdB	100	dB	]-INF, +INF[
Reverse reflection in dB Power return loss (port 2 to port 2) in dB	RevRefdB	100	dB	]-INF, +INF[
Forward phase shift Phase shift (port 1 to port 2)	PhaseShift	0	rag	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Reverse phase shift Phase shift (port 2 to port 1)	RevPhaseShift	0	rad	]-INF, +INF[
Return phase shift Phase shift (port 1 to port 1)	RefPhaseShift	pi/2	rad	]-INF, +INF[
Reverse return phase shift Phase shift (port 2 to port 2)	RevRefPhaseShift	pi/2	rad	]-INF, +INF[
Gain Power gain factor (port 1 to port 2)	Gain	1	-	]-INF, +INF[
Reverse gain Power gain factor (port 2 to port 1)	RevGain	1	-	]-INF, +INF[
Attenuation Power loss factor (port 1 to port 2)	Atten	1	-	]-INF, +INF[
Reverse attenuation Power loss factor (port 2 to port 1)	RevAtten	1	-	]-INF, +INF[
Gain in dB Power gain in dB (port 1 to port 2)	GaindB (FwdGaindB)	0	dB	]-INF, +INF[
Reverse gain in dB Power gain in dB (port 2 to port 1)	RevGaindB	0	dB	]-INF, +INF[
Attenuation in dB Power loss in dB (port 1 to port 2)	AttendB (FwdAttendB)	0	dB	]-INF, +INF[
Reverse attenuation in dB Power loss in dB (port 2 to port 1)	RevAttendB	0	dB	]-INF, +INF[
X offset Defines the amount of translation of the mode shape in the X-direction	XOff	0	um	[0, +INF[
Y offset Defines the amount of translation of the mode profile in the Y-direction	YOff	0	um	[0, +INF[
X tilt Defines the amount of rotation of the mode profile around the X-axis	XTilt	0	rad	]-INF, +INF[
Y tilt Defines the amount of rotation of the mode profile around the Y-axis	YTilt	0	rad	]-INF, +INF[

Name and description	Symbol	Default value	Units	Value range
Isolation mode Direction of Isolation for optical connection	IsoMode	FWD	-	FWD, REV
Polar mode Polar mode type	PolarMode	-	-	None, X, Y, A45, Am45, Angle, LeftCir, RightCir, QWPX, QWPY, HWPX, HWPY, VDEP
Control nodes Nodes to control polarization if PolarMode is VDEP	CNodes	-	-	-
Jones matrix coefficients Jones Matrix coefficients -- J11.r J11.i J12.r J12.i J21.r J21.i J22.r J22.i	JonesMatrix	-	-	]-INF, +INF[
Polarization rotation Polarization rotation angle	PolAngle	0	rad	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element is an optical connector/isolator used to connect two elements with differing mode shapes, the mode shapes of the two elements will be used to calculate the mode mixing for signals travelling between the two elements using overlap integrals. For more details see Technical Background of OCONN Model.

Example

For a connector with name OC1, model OCModel, connected to nodes SIG1 and SIG2, with attenuation of of 0.5 dB, the netlist statement can be given by

```
Osp OCONN Name=OC1 Nodes=[SIG1 SIG2] MoName=OCModel AttendB=0.5
```

OPTCIRC

Syntax

Style	Form
OptiSPICE	`Osp OPTCIRC Name=DEVICE_NAME Nodes=[I1 I2 I3]` `+ <IsoMode=FWD/REV>`

Nodes

Name	Signal Type	Description
I1	optical	Port 1
I2	optical	Port 2
I3	optical	Port 3

Parameters

Name and description	Symbol	Default value	Units	Value range
Isolation mode Direction of isolation	IsoMode	FWD	-	[FWD, REV]
Number of modes Number of modes involved	Nmodes	1	-	[0, +INF[
Mode type Optical circulator mode type	Modetype	GAUSSIAN_MODE	-	GAUSSIAN_MODE, FILE_MODE, BESSEL_0_MODE, BESSEL_1_MODE, HERMITE_GAUSSIAN_MODE, LAGUERRE_GAUSSIAN_MODE, UNIFORM_MODE

Technical Background

This element is an ideal optical circulator. If *IsoMode* is set to *FWD*, input from port 1 is received as output at port 2, input from port 2 is received as output at port 3, and input from port 3 is received as output at port 1 without any loss. If I*soMode* is set to

REV, input from port 1 is received as output at port 3, input from port 3 is received as output at port 2, and input from port 2 is received as output at port 1 without any loss. This element do not require any model statement.

Example

For a circulator with name OC1, connected to nodes SIG1, SIG2 and SIG3, working with clockwise direction, the netlist statement can be given by

```
Osp OPTCIRC Name=OC1 Nodes=[SIG1 SIG2 SIG3]
```

MIRROR

Syntax

Style	Form

OptiSPICE	`Osp MIRROR Name=ELEMENT_NAME Nodes=[Inout]`
	`+ MoName=MODEL_NAME <Ref=val> <RefdB=val>`
	`+ <PhaseShift=val> <Rth=val> <Cth=val> <DTEMP=val>`
	`+ <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Inout	Optical	Mirror node for incident and reflected optical signal

Parameters

Name and description	Symbol	Default value	Units	Value range
Reflection coefficient Ratio of reflected power from mirror	Ref	0	-	]-INF, +INF[
Reflection coefficient in dB Ratio of reflected power from mirror in dB	RefdB	100	dB	]-INF, +INF[
Phase shift Phase shift of reflected wave	PhaseShift	0	rad	]-INF, +INF[
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-

Name and description	Symbol	Default value	Units	Value range
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

The mirror simply reflects all incident modes and channels of whatever polarity is incident from the input element. The parameters *Ref* and *RefdB* set the value of the reflected power. The parameter *PhaseShift* sets the phase shift of the reflected wave. For more details see MIRROR model.

Example

For an mirror with name OM1, model OMModel, connected to signal SIG1, with 50 % reflection, the netlist statement can be given by

```
Osp MIRROR Name=OM1 Nodes=[SIG1] MoName=OMModel Ref=0.5
```

SPLITTER

Syntax

Style	Form

OptiSPICE	`Osp SPLITTER Name=ELEMENT_NAME Nodes=[in o1 o2 ... oN]`
	`+ MoName=MODEL_NAME <SplitRatio=val>`
	`+ <Rth=val> <Cth=val> <DTEMP=val> <ExtTNode=NODE_NAME>`
	`+ <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
in	Optical	Splitter input port
o1, o2, ..., oN	Optical	Splitter N output ports

Parameters

Name and description	Symbol	Default value	Units	Value range
Split ratio Power split ratio	SplitRatio	0.5	-	[0, 1]
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element represents an optical power splitter. It has one input port and a number of (*N*) user given output ports. The model type required for this element is OMNIOCONN. If the model parameter *LossType* is set to *UNITY*, input power is simply duplicated at each output port. If the *LossType* is set to *CONST_LOSS* (default choice), the power splitting has two cases: 1) if the number of output ports are two, the parameter *SplitRatio* is used such that

$$P_{o1} = SplitRatio \cdot P_{in}$$
$$P_{o2} = (1 - SplitRatio) \cdot P_{in} \quad (1)$$

where P_{o1} and P_{o2} are the powers at the output port 1 and 2 respectively and P_{in} is the input power; 2) if the number of output ports are more than two, the input power will be split equally among for *N* output ports (*1/N* of the input power in each output port). For more details see Technical Background of OMNIOCONN Model.

A splitter can also be used as a joiner if all output ports are used as inputs and input port is used as an output.

Example

For an SPLITTER element with name SPT1, model SPTModel, connected to nodes SIG1, SIG2 and SIG3, with 50% splitting ratio, the netlist statement can be given by

```
Osp SPLITTER Name=SPT1 Nodes=[SIG1 SIG2 SIG3] MoName=SPModel
+ SplitRatio=0.5
```

OMNIOCONN

Syntax

Style	Form
OptiSPICE	Osp OMNIOCONN Name=DEVICE_NAME InputNodes=[i1 i2 ... iM] + OutputNodes=[o1 o2 ... oN] MoName=MODEL_NAME + <Rth=val> <Cth=val> <DTEMP=val> <ExtTNode=NODE_NAME> + <NoNoise=0/1>

Input Nodes

Name	Signal Type	Description
i1, i2, ..., iM	Optical	M input nodes

Output Nodes

Name	Signal Type	Description
o1, o2, ..., oN	Optical	N output nodes

Parameters

Name and description	Symbol	Default value	Units	Value range
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element can represent a general multi-input multi-output optical connector. For more details see Technical Background of OMNIOCONN Model.

Example

For an OMNIOCONN element with name omc1, model Omodel, with five input ports (in1,in2,..in5) and three output ports (out1, out2, and out3), the netlist statement can be given by

```
Osp OMNIOCONN  Name=omc1 InputNodes = [in1 in2 in3 in4 in5 ]
+ OutputNodes = [out1 out2 out3] MoName=Omodel
```

OPTCHANNELFILTER

Syntax

Style	Form

OptiSPICE	`Osp OPTCHANNELFILTER Name=ELEMENT_NAME`
	`+ Nodes=[Input Output] MoName=MODEL_NAME`
	`+ <PassBands=[val1 val2 ...]> <FrequencyUnit=Hz/THz/nm>`
	`+ <Bandwidth=val> <BandwidthUnit=Hz/GHz/nm>`
	`+ <PassBandMode=ListOfBands/CenterFreqAndBW/...>`
	`+ <Rth=val> <Cth=val> <DTEMP=val> <ExtTNode=NODE_NAME>`
	`+ <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Frequency list List of channel center frequencies	PassBands	-	-	[0, +INF[
Frequency unit Channel frequency unit	FrequencyUnit	THz	-	Hz, THz, nm
Bandwidth Channel bandwidth	Bandwidth	50	-	[0, +INF[
Bandwidth unit Channel bandwidth unit	BandwidthUnit	GHz	-	Hz, GHz, nm
Passband mode Passband mode selection to define the way center frequencies and bandwidths to be entered	PassBandMode	ListOfBands	-	ListOfBands, CenterFreqAndBW, CenterFreqAndConstBW
Thermal resistance Thermal resistance of the element	Rth	0	K/W	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Thermal capacitance Thermal capacitance of the element	Cth	0	J/K	[0, +INF[
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

This element is an idealized optical filter used for allowing desired optical channels while blocking unwanted channels. For more details see Technical Background of OPTCHANNELFILTER Model.

Examples

For a channel filter with device name OF1, model OFModel, connected to nodes SIG1 and SIG2, filtering 193.1 THz and 193.2 THz, bandwidth of 50 GHz, the netlist statement can be given by

```
Osp OPTCHANNELFILTER Name=OF1 Nodes=[SIG1 SIG2]
+ MoName=OFModel PassBandMode=CenterFreqAndConstBW
+ PassBands=[193.1 193.2] FrequencyUnit=THz Bandwidth=50
+ BandwidthUnit=GHz
```

OPTFFT

Syntax

Style	Form

OptiSPICE	`Osp OPTFFT Name=ELEMENT_NAME Nodes=[Input Output]`
	`+ MoName=MODEL_NAME <CenterFilterLambda=val>`
	`+ <Frequency=val> <FilterFreqShift=val>`
	`+ <FrequencyUnit=Hz/THz/nm> <DTEMP=val>`
	`+ <ExtTNode=NODE_NAME> <NoNoise=0/1>`

Nodes

Name	Signal Type	Description
Input	Optical	Filter input
Output	Optical	Filter ouptut

Parameters

Name and description	Symbol	Default value	Units	Value range
Frequency Center frequency of the filter	Frequency	193.1	-	[0, +INF[
Filter frequency shift Frequency shift from center frequency value	FilterFreqShift	0	-	[0, +INF[
Frequency unit Frequency unit for Frequency and FilterFreqShift parameters	FrequencyUnit	THz	-	Hz, THz, nm
Filter type Filter transfer characteristics type	FilterType	BESSEL	-	BESSEL, BUTTERWORTH
Bandwidth 3 dB filter bandwidth	FilterBW	10	GHz	]0,+INF[
Insertion loss Insertion loss of the filter	FilterIL	0	dB	[0,+INF[
Order Order of the function	FilterOrder	1	-	1,2,3, ...

Name and description	Symbol	Default value	Units	Value range
Filter file Filename with the measured data	FilterFile	-	-	-
File frequency unit Determines the frequency unit of the file with the measurements	FileFreqUnit	Hz	-	Hz, GHz, THz, m, nm
File format Determines the format of the file with the measurements	FileFormat	POWERPHASE	-	POWERPHASE, REALIMAG
File power scale Determines whether the measured data is in linear scale or in dB	FilePowScale	LINEAR	-	LINEAR, DB
Touchstone file Touchstone file name containing two port S-parameters for the optical filter	Tstonefile	-	-	-
Temperature difference The temperature difference between the element and the circuit	DTEMP	0	K	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-
Exclude noise Exclude element noise (1) or not (0)	NoNoise	0	-	0, 1

Technical Background

OPTFFT element is an optical filter or frequency dependent element that can be either a user defined filter type or a measured filter. User defined filter is defined by the parameters: *FilterType*, *FilterBW*, *FilterIL*, and *FilterOrder,* while measured filter is defined by parameters: *FilterFile*, *FileFreqUnit*, *FileFormat* and *FilePowScale*. Measured filter can also be expressed using Touchstone file (*tstonefile* parameter). For more details see Technical Background of OPTFFT Model.

Examples

For an optical Butterworth filter with the name OptFilter1 connected between nodes in and out with center frequency 193.2 THz, 3-dB bandwidth of 50 GHz, filter order of 4, and insertion loss of 0.75 dB, the netlist statement can be written as

```
Osp OPTFFT Name=OptFilter1 Nodes=[in out] MoName=OPTFFTModel
```

```
+ Frequency=193.2 FrequencyUnit=THz FilterType=BUTTERWORTH
+ FilterBW=50 FilterOrder=4 FilterIL=0.75
```

For a measured filter given by a measured filter file ‘filter.dat’ where frequency unit is given in nm and power is expressed in dB, the netlist statement can be written as

```
Osp OPTFFT Name=OptFilter2 Nodes=[in2 out2] MoName=OPTFFTModel
+ Frequency=193.2 FrequencyUnit=THz FilterFile=”filter.dat”
+ FileFreqUnit=nm FileFormat=POWERPHASE FilePowScale=DB
```

For an optical filter represented by a two port S-parameter given by a Touchstone file ‘filter.s2p’, the netlist statement can be written as

```
Osp OPTFFT Name=OptFilter3 Nodes=[in3 out3] MoName=OPTFFTModel
+ Frequency=193.4 FrequencyUnit=THz TstoneFile=”filter.s2p"
```

Notes:

MULTILAYERFILTER

Syntax

Style	Form

OptiSPICE	`Osp MULTILAYERFILTER Name=ELEMENT_NAME Nodes=[In Out]`
	`+ MoName=MODEL_NAME`
	`+ <FilterCnodes=[{N1+ N1-} {N2+ N2-} ... {NL+ NL-}]>`
	`+ <InitialVs=[vi1 vi2 ...viL]>`
	`+ <FilterTnodes=[TN1 TN2 ... TNL]>`
	`+ <DefLambda=val> <InitialT=val> <DTemp=val>`
	`+ <ExtTNode=NODE_NAME> <Rth=val> <Cth=val>`

Nodes

Name	Signal Type	Description
In	Optical	Input
Out	Optical	Output

Parameters

Name and description	Symbol	Default value	Units	Value range
List of connected voltage pairs to layers List containing node names (in pairs) that are connected as controlling voltage for each layer	FilterCNodes	-	-	-
Initial values for connected voltages List containing initial voltage difference for the node pairs given by LayerCnodes	InitialVs	-	V	]-INF, +INF[
List of connected temperature nodes to layers List containing temperature node names that set the temperature for each layer	FilterTNodes	-	-	-
Defined wavelength Unless channel wavelength is known from the source (laser,cw), this wavelength value is used to calculate the filter characteristics.	DefLambda	1550	nm	]0, +INF[

Name and description	Symbol	Default value	Units	Value range
Transmission line name Name of the transmission line that controls the refractive indices of the multilayer filter.	TranslineName	-	-	-
Expected rise in initial temperature Initial expected temperature at t=0; used for robust DC convergence.	InitialT	0.0	C	]-INF, +INF[
Temperature difference Temperature difference between the element and the circuit	DTemp	0.0	C	]-INF, +INF[
Temperature node Name of the external temperature node. Only used if FilterTnodes are not given.	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

A multi-layer element is a thin film interference where the interference is often exploited to produce filtering in optical systems. A multi-layer structure consisting of layers of material of differing optical index will produce a complex series of interfering waves formed by the reflection at and transmission through each interface. A MULTILAYERFILTER model is used to characterize this element. For more details see Technical Background of MULTILAYERFILTER Model.

Example

For a multi-layer filter with three layers connected to nodes in and out, represented by model FilterEx, and controlled by an external voltage from node, vcnt, at the second layer, the netlist statement can be written as follows:

```
Osp MultiLayerFilter Name=MLFilter Nodes=[in out] MoName=FilterEx
+ FilterCnodes=[{0 0} {vcnt 0} {0 0}]
```

WAVEGUIDE

Syntax

Style	Form

OptiSPICE	`Osp WAVEGUIDE Name=DEVICE_NAME Nodes=[Input Output]`
	`+ MoName=MODEL_NAME <Neff=[n1 n2 ...nL]> <Length=val>`
	`+ <Atten=[a1 a2 ... aL]> <InitialT=val> <DTemp=val>`
	`+ <ExtTNode=NODE_NAME> <Rth=val> <Cth=val>`

Nodes

Name	Signal Type	Description
Input	Optical	
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
List of mode effective indexes List containing effective index for each mode of the waveguide	Neff	-	-	]0, +INF[
Waveguide length Length of the waveguide	Length	1.0	um	]0, +INF[
List of mode attenuations List containing attenuation for each mode	Atten	-	-	]0, +INF[
Expected rise in initial temperature Initial expected temperature at t=0; used for robust DC convergence.	InitialT	0.0	C	]-INF, +INF[
Temperature difference The temperature difference between the element and the circuit	DTemp	0.0	C	]-INF, +INF[
Temperature Node The name of the external temperature node	ExtTNode	-	-	-

Name and description	Symbol	Default value	Units	Value range
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

A multi-mode waveguide element is similar to the multimode fiber element. However, index can be modeled as temperature dependent. WAVEGUIDE model is used to model the characteristics of the waveguide element since it supports multi-mode device with a specified effective index for each mode. For more details see Technical Background of MULTILAYERFLITER (WAVEGUIDE) Model.

Example

For a waveguide with device name WG, model WgModel, connected to nodes IN and OUT, with the mode effective index of 1.47, length of 20 um, and attenuation of 0.95, the netlist statement can be written as follows:

```
Osp WAVEGUIDE Name=WG Nodes=[IN OUT] MoName=WgModel
+ Neff=[1.47] Length=20 Atten = 0.95
```

OPTRING

Syntax

Style	Form
OptiSPICE	Osp OPTRING Name=ELEM_NAME Nodes=[P1 P2 <P3 P4>] + MoName=MODEL_NAME <Radius=val> <C<1>=val> <C2=val> + <LayerCnodes=[{N1+ N1-} {N2+ N2-} ... {NL+ NL-}]> + <InitialVs=[vi1 vi2 ...viL]> + <LayerTnodes=[TN1 TN2 ... TNL]> <Conjugate<1>=0/1> + <Conjugate2=0/1> <DefLambda=val> <InitialT=val> + <DTemp=val> <ExtTNode=NODE_NAME> <Rth=val> <Cth=val>

Nodes

Name	Signal Type	Description
P1	Optical	Port 1
P2	Optical	Port 2
P3	Optical	Port 3
P4	Optical	Port 4

Parameters

Name and description	Symbol	Default value	Units	Value range
Radius Radius of ring resonator	Radius	10	um	]0, +INF[
Coupling coefficient for XCoupler 1 Coupling ratio for the cross coupler	C1	0.5	-	[0, 1]
Coupling coefficient for XCoupler 2 Coupling ratio for the cross coupler	C2	0.5	-	[0, 1]
List of connected voltage pairs to layers List containing node names (in pairs) that are connected as controlling voltage for each layer	LayerCnodes	-	-	-

Name and description	Symbol	Default value	Units	Value range
Initial values for connected voltages List containing initial voltage differences for the node pairs given by LayerCnodes	InitialVs	-	V	]-INF, +INF[
List of connected temperature nodes to layers List containing temperature node names that set the temperature for each layer	FilterTNodes	-	-	-
Conjugate 1 Complex conjugate option for the cross coupler 1	Conjugate1	1	-	[0, 1]
Conjugate 2 Complex conjugate option for the cross coupler 2	Conjugate2	1	-	[0, 1]
Defined wavelength Unless channel wavelength is known from the source (laser, cw), this wavelength value is used to calculate the filter characteristics.	DefLambda	1550	nm	]0, +INF[
Expected rise in initial temperature Initial expected temperature at t=0; used for robust DC convergence.	InitialT	0.0	C	]-INF, +INF[
Temperature difference Temperature difference between the element and the circuit	DTemp	0.0	C	]-INF, +INF[
Temperature node Name of the external temperature node. Only used if FilterTnodes are not given.	ExtTNode	-	-	-
Thermal resistance Thermal resistance of element	Rth	0	K/W	[0, +INF[
Thermal capacitance Thermal capacitance of element	Cth	0	W sec/K	[0, +INF[

Technical Background

The optical ring resonator is a two or four port ring comprised of one/two cross-couplers and one/two explicit multilayer filters. An OPTRING model is used to characterize this element. Cross-couplers and explicit filter model names are given in the OPTRING model statement. For more details see Technical Background of OPTRING Model.

Example

For a four port optical ring with device name Ring4, model RingMod, connected to nodes 1, 2, 3, and 4 with radius of 12 um and coupling coefficient for the first and second cross-coupler with 0.3 and 0.4 respectively, and with the third layer controlled by the voltage from node Vcnt, the netlist statement can be given by

```
Osp OPTRING Name=Ring4 Nodes=[1 2 3 4] MoName=RingMod Radius=12 C1=0.3
+ C2=0.4 LayerCnodes=[{0 0} {0 0} {Vcnt} {0 0} {0 0}]
```

Notes:

OPTISYSINOPT

Syntax

Style	Form
OptiSPICE	`Osp OPTISYSINOPT Name=ELEMENT_NAME Nodes=[Output]` `+ MoName=MODEL_NAME SignalFile=filename`

Nodes

Name	Signal Type	Description-
Output	Optical	

Parameters

Name and description	Symbol	Default value	Units	Value range
Signal file Name of the text file that contain optical signal data generated by OptiSystem.	SignalFile	-	-	-

Technical Background

The element OPTISYSINOPT is used to receive optical input signal generated by OptiSystem during OptiSystem - OptiSPICE co-simulation. This element functions as an optical source in the OptiSPICE design. The optical input data is obtained through a the text file given by *SignalFile*. First column of this file contains time, and next columns contain magnitude and phase for each mode and for each channel. Mode and channel details are specified through OPTISYSINOPT Model statement which is generated by OptiSystem.

Notes:

Thermal Elements Library

This section contains information on the following elements

- THERMALRESISTOR
- THERMALCAPACITOR
- THERMSOURCE

Notes:

THERMALRESISTOR

Syntax

Style	Form

OptiSPICE	`Osp THERMALRESISTOR Name=ELEMNAME Nodes=[ 1 2 ] <Rth=val>`
	`+ <Mode=Const/TempDep> <Material=DEF/GaAs> <Tnom=val>`
	`+ <Tmax=val> <A=val> <B=val> <C=val> <D=val>`

Nodes

Name	Signal Type	Description
1	Thermal	Thermal node 1
2	Thermal	Thermal node 2

Parameters

Name and description	Symbol	Default value	Units	Value range
Thermal resistance Nominal thermal resistance that is independent of temperature	Rth	0.0	K/W	[0, +INF[
Mode Mode option that defines whether the thermal resistance is temperature dependent (TempDep) or not (Const)	Mode	TempDep		Const, TempDep
Material Material that conducts the thermal power between the two thermal nodes. DEF is the user defined material where user has to define the following parameters. For GaAs it used predefined values.	Material	DEF		DEF, GaAs
Nominal operational temperature Nominal temperature of the user defined material (Material = DEF)	Tnom	300.0	K	[0, +INF[
Maximum operational temperature Nominal temperature of the user defined material (Material = DEF)	Tmax	600.0	K	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Third order polynomial coefficient Third order polynomial coefficient for modeling temperature dependent thermal resistance for the user defined material (Material = DEF)	A	0.0	W/K^3	[-INF, +INF]
Second order polynomial coefficient Second order polynomial coefficient for modeling temperature dependent thermal resistance for the user defined material (Material = DEF)	B	0.0	W/K^2	[-INF, +INF]
First order polynomial coefficient First order polynomial coefficient for modeling temperature dependent thermal resistance for the user defined material (Material = DEF)	C	0.0	W/K	[-INF, +INF]
Zeroth order polynomial coefficient Zeroth order polynomial coefficient for modeling temperature dependent thermal resistance for the user defined material (Material = DEF)	D	0.0	W	[-INF, +INF]

Technical Background

The heat flow can be modeled by analogous to an electrical circuit where heat flow is represented by current, temperature is represented by voltage, and thermal resistance is represented by resistor. Thermal resistance, R_t unit (K/W), can be given by

$$R_t = \frac{\Delta T}{P} \tag{1}$$

where

- ΔT is the temperature drop
- P is the dissipated thermal power due to the heat flow

The thermal resistance given above is temperature independent and for this type of thermal resistor parameter *Mode* must be set to *Const*.

Thermal resistance is temperature dependent for some materials (for example, semiconductors). For these type of materials *Mode* must be set to *TempDep* (default choice). To model the temperature dependent thermal resistance a non-linear resistor based on polynomial function is connected in parallel with the nominal thermal resistance. The dissipated thermal power, P_{nl}, through this non-linear thermal resistor is given by

$$P_{nl} = AT^3 + BT^2 + CT + D \quad (2)$$

where $T = T_{cir} - T_{nom} + (T_1 + T_2)/2$, where

- T_{cir} is the circuit temperature which can be set by .OPTION TNOM command (by default 25°C),
- T_{nom} is the nominal temperature of the thermal material given by the element parameter *Tnom*, T_1 and T_2 are the temperature at node 1 and 2 respectively.

If the *Material* is set to *GaAs* values are predefined such that *Tnom = 300*, *Tmax = 600*, *A= 0*, *B = 5.1e-6*, *C = -0.0035*, and *D = 0*.

Examples

For a thermal resistor with a thermal resistance of 50 K/W independent of temperature an example netlist statement can be given by:

```
Osp THERMALRESISTOR Name=ThRes Nodes=[T1 T2] Mode = Const Rth = 50
```

For a thermal resistor with nominal thermal resistance of 500 K/W and made of the material GaAs an example netlist statement can be given by:

```
Osp THERMALRESISTOR Name=ThRes2 Nodes=[T3 T4] Rth = 500 Material = GaAs
```

For a thermal resistor with nominal thermal resistance of 300 K/W and with user defined material, an example netlist statement can be given by:

```
Osp THERMALRESISTOR Name=ThRes3 Nodes=[T4 T5] Rth = 300 Material = DEF
+ A = 1.02e-5 B = 4.3e-6 C = 0.015 D = -0.02
```

Notes:

THERMALCAPACITOR

Syntax

Style	Form
OptiSPICE	`Osp THERMALCAPACITOR Name=ELEMNAME Node=TNODE <Cth=val>`

Nodes

Name	Signal Type	Description
TNODE	Thermal	Thermal node of the material

Parameters

Name and description	Symbol	Default value	Units	Value range
Thermal capacitance Thermal capacitance of the material	Cth	0.0	K/W	[0, +INF[

Technical Background

Thermal capacitance, C_t unit (J/K), is given by

$$C_t = \frac{Q}{\Delta T} \quad (1)$$

where

- Q is the thermal power transferred to the material
- ΔT is the change of temperature in the material

When considering analogy of modeling heat flow with electrical circuit, a thermal capacitance is represented by an electrical capacitor. However unlike electrical capacitor, thermal capacitor must be placed between a thermal node. Therefore, user has to provide only a single node and the node 2 will be automatically become thermal ground.

Example

For a thermal capacitor with thermal capacitance 0.001 J/K, an example netlist statement can be given by:

```
Osp THERMALCAPACITOR Name=ThCap Node=T1 Cth = 0.001
```

THERMSOURCE

Syntax

Style	Form
OptiSPICE	`Osp THERMSOURCE Nodes=[1 2] <param1=val1>` `+ <param2=val2> ....`

Nodes

Name	Signal Type	Description
1	Thermal	Thermal node 1
2	Thermal	Thermal node 2

Parameters

Name and description	Symbol	Default value	Units	Value range
DC mode flag When given this flag enables the independent source to generate a DC temperature	dcMode	-	-	-
DC temperature Magnitude of DC source	dcValue	0	°C	]-INF, +INF[
Transient mode Transient mode function type	tranMode	-	-	PULSE, PWL, SIN, FILE, GAUSSIAN, MODGAUSSIAN
Initial value Initial value (at t=0) of the source	v1	0	°C	]-INF, +INF[
Pulsed value Pulsed value of the source	v2	0	°C	]-INF, +INF[
Delay time Delay time before the start of the signal	td	0	sec	[0, +INF[
Rise time Rise time of the source	tr	0	sec	[0, +INF[

Name and description	Symbol	Default value	Units	Value range
Fall time Fall time of the source	tf	0	sec	[0, +INF[
Pulse width Pulse width of a pulse function source	pw	0	sec	[0, +INF[
Period Period of the source function	per	0	sec	[0, +INF[
DC offset DC offset for the temperature	vo	0	°C	]-INF, +INF[
Amplitude Amplitude of the source function	va	0	°C	]-INF, +INF[
Frequency Frequency of the source function	freq	0	Hz	[0, +INF[
Damping factor Damping factor of the source function	q	0	1/sec	[0, +INF[
Phase delay Phase delay of the source function	j	0	degree	]-180, 180[
Time value points List of source values at specific time points (used for piece-wise linear function)	Tpoints	-	sec, °C	-
Filename Filename of the data driven piece wise linear source function	File	-	-	-
Gaussian pulse peak time value Time point where Gaussian pulse gain its peak value	t0	0	sec	[0, +INF[
Gaussian pulse half duration Duration taken for a Gaussian pulse to obtain 1/e of its peak value	Sigma	0	sec	[0, +INF[

Technical Background

An independent thermal source that sets the temperature difference between given two thermal nodes. At GROUND thermal node (node 0) the temperature is set to be the global circuit temperature set by .OPTION TNOM command (by default the global circuit temperature is 25°C).

The operation of this independent source is identical to the electrical independent source. It supports all the transient source functions such as SIN, PULSE, and PWL as the electrical independent source. For more details on the transient functions see Technical Background of INDSOURCE in the Electrical Element library.

Examples

To set a constant temperature difference of 10°C for the node TNode from the global circuit temperature, the netlist statement can be written as

```
Osp THERMSOURCE Name=ThSrc Nodes=[TNode 0] dcMode dcValue=10
```

To set a a time varying temperature difference given by piecewise linear (PWL) function to the TNODE from the global circuit temperature, the netlist statement can be written as

```
Osp THERMSOURCE Name=ThSrc2 Nodes=[ TNODE 0 ] tranMode=PWL
+ Tpoints = [ {0 0} {1e-6 10} {5e-6 15} {10e-6 5} {30e-6 0}]
```

To set a a time varying temperature difference fed by a pulse source to the TNode2 from the node Tnode1, the netlist statement can be written as

```
Osp THERMSOURCE Name=ThSrc3 Nodes=[TNode Tnode1] tranMode=PULSE
+ v1=0 v2=20 td = 10u tr = 1u tf = 1u pw = 20u
```

Notes:

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