0.0.1 Independent Current Source **I**

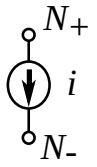

Figure 1: I — independent current source.

Form:
Iname N_+ N_- [[DC] [*DCvalue*]
+ [AC [*ACmagnitude* [*ACphase*]]]
+ [DISTOF1 [*F1Magnitude* [*F1Phase*]]] + [DISTOF2 [*F2Magnitude* [*F2Phase*]]]

N_+	is the positive current source node. (Current flow is out of the positive to the negative node.)
N_-	is the negative current source node.
DC	is the optional keyword for the DC value of the source.
DCvalue	is the DC current value of the source. (Units: A; Optional; Default: 0; Symbol: I_{DC})
AC	is the keyword for the AC value of the source.
ACmagnitude	is the AC magnitude of the source used during ACanalysis. That is, it is the peak AC current so that the AC signal is $ACmagnitude \sin(\omega t + \text{ACphase})$.
ACmagnitude	is ignored for other types of analyses. (Units: A; Optional; Default: 1; Symbol: I_{AC})
ACphase	is the ac phase of the source. It is used only in AC analysis. (Units: Degrees; Optional; Default: 0; Symbol: ϕ_{AC})
DISTOF1	is the distortion keyword for distortion component 1 which has frequency F1.
F1magnitude	is the magnitude of the distortion component at F1. (Units: A; Optional; Default: 1; Symbol: I_{F1})
F1phase	is the phase of the distortion component at F1. (Units: Degrees; Optional; Default: 0; Symbol:ϕ_{F1})
DISTOF2	is the distortion keyword for distortion component 2 which has frequency F2.
F2magnitude	is the magnitude of the distortion component at F2. (Units: A; Optional; Default: 1; Symbol:I_{F2})
F2phase	is the phase of the distortion component at F2. (Units: Degrees; Optional; Default: 0; Symbol:ϕ_{F2})
TransientSpecification	is the optional transient specification described more fully below.

Note

1. The independent current source has three different sets of parameters to describe the source for DC analysis (see `.DC` on page **??**), AC analysis (see `.AC` on page **??**), and transient analysis (see `.TRAN` on page **??**). The `DC` value of the source is used during bias point evaluation and `DC` analysis is *DCValue*. It is also the constant value of the current source if no *TransientSpecification* is supplied. It may also be used in conjunction with the `PWL` transient specification if a time zero value is not provided as part of the transient specification. The `AC` specification, indicated by the keyword `AC` is independent of the `DC` parameters and the *Transient Specification*.

2. The original documentation distributed with SPICE2G6 and SPICE3 incorrectly stated that if a *TransientSpecification* was supplied then the time-zero transient current was used in `DC` analysis and in determiniong the operating point.

Transient Specification

Five transient specification forms are supported: pulse (`PULSE`), exponential (`EXP`), sinusoidal (`SIN`), piece-wise linear (`PWL`), and single-frequency FM (`SFFM`). The default values of some of the parameters of these transient specifications include `TSTEP` which is the printing increment and `TSTOP` which is the final time (see the `.TRAN` statement on page **??** for further explanation of these quantities). In the following t is the transient analysis time.

Sinusoidal:
`SIN(` I_O I_A [F] [T_D] [θ] `)`
Parameters:

Name	Description	Units	Default
I_O	voltage offset	V	REQUIRED
I_A	voltage amplitude	V	REQUIRED
F	frequency	Hz	1/`TSTOP`
T_D	time delay	s	0
Θ	damping factor	1/s	0
ϕ	phase	degree	0

Example:
```
ISIGNAL 20 5 SIN(0.1 0.8 2 1 0.3)
```

Description:
The sinusoidal transient waveform is defined by

$$i = \begin{cases} I_0 & t \le T_D \\ I_0 + I_1 e^{-[(t-T_D)\Theta]} \sin 2\pi[F(t-T_D) + \phi/360] & t > T_D \end{cases} \quad (1)$$

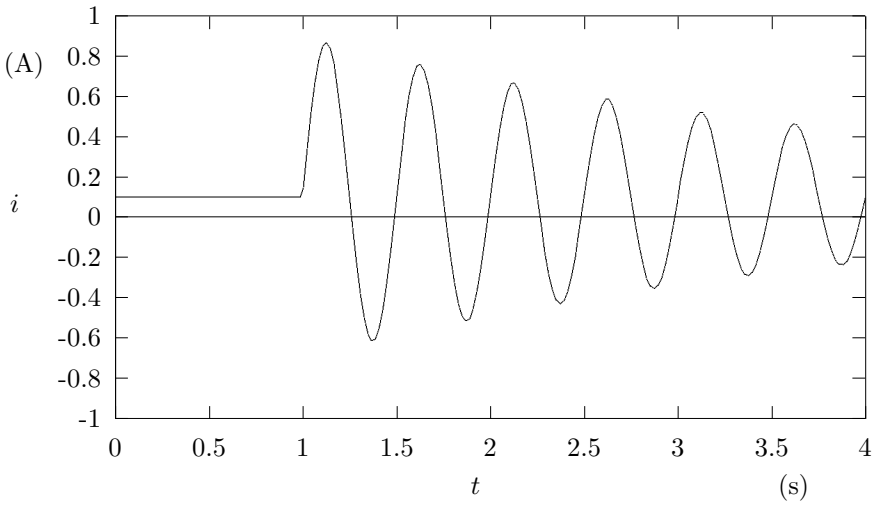

Figure 2: Current source transient sine (`SIN`) waveform for `SIN(0.1 0.8 2 1 0.3 )`.

Exponential:
`EXP(`I_1 I_2 [T_{D1}] [τ_1] [T_{D2}] [τ_2] `)`
Parameters:

Name	Description	Units	Default
I_1	initial voltage	V	REQUIRED
I_2	pulsed voltage	V	REQUIRED
T_{D1}	rise delay time	s	0.0
τ_1	rise time constant	s	`TSTEP`
T_{D2}	fall delay time	s	`TSTEP`
τ_2	fall time constant	s	`TSTEP`

Example:
```
ISIGNAL  2 0 EXP(0.1 0.8 1 0.35 2 1)
```

Description:
The exponential transient is a single-shot event specifying two exponentials. The current is I_1 for the first T_{D1} seconds at which it begins increasing exponentially towards I_2 with a time constant of τ_1 seconds. At time T_{D2} the current exponentially decays towards I_1 with a time constant of τ_2. That is,

$$i = \begin{cases} I_1 & t \le T_{D1} \\ I_1 + (I_2 - I_1)(1 - e^{(-(t - T_{D1})/\tau_1)}) & T_{D1} < t \le T_{D2} \\ I_1 + (I_2 - I_1)(1 - e^{(-(t - T_{D1})/\tau_1)}) + (I_1 - I_2)(1 - e^{(-(t - T_{D2})/\tau_2)}) & t > T_{D2} \end{cases} \quad (2)$$

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

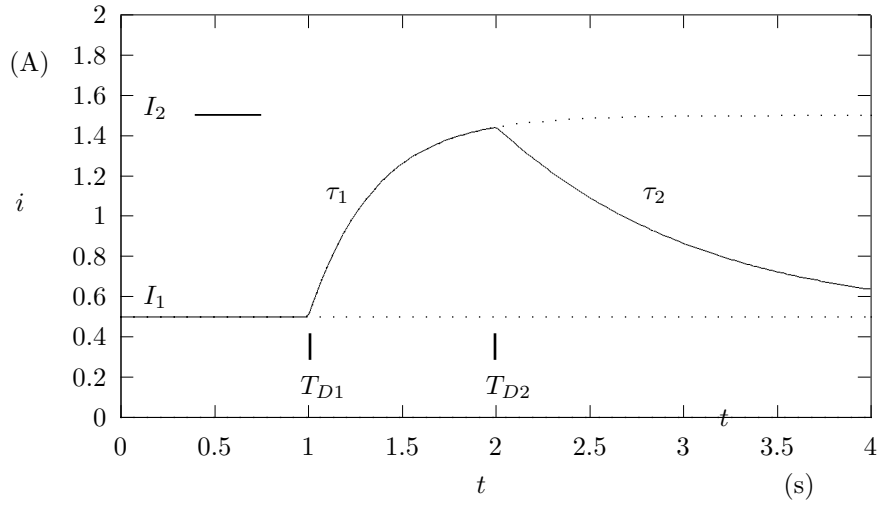

Figure 3: Current source exponential (`EXP`) waveform for `EXP(0.1 0.8 1 0.35 2 1)`

Pulse:
`PULSE(` I_1 I_2 [T_D] [T_R] [T_F] [W] [T] `)`
Parameters:

Name	Description	Units	Default
I_1	initial voltage	V	REQUIRED
I_2	pulsed voltage	V	REQUIRED
T_D	delay time	s	0.0
T_R	rise time	s	`TSTEP`
T_F	fall time	s	`TSTEP`
W	pulse width	s	`TSTOP`
T	period	s	`TSTOP`

Example:
```
ISIGNAL 20 5 PULSE(0 5 1N 2N 1.5N 21.9N 5N 20N)
```

Description:
The pulse transient waveform is defined by

$$i = \begin{cases} I_1 & t \le T_D \\ I_1 + \frac{t'}{T_R}(I_2 - I_1) & 0 < t' \le T_R \\ I_2 & T_R < t' < (T_R + W) \\ I_2 - \frac{t' - W}{T_F}(I_1 - I_2) & (T_R + W) < t' < (T_R + W + T_F) \\ I_1 & (T_R + W + T_F) < t' < T \end{cases} \tag{3}$$

where

$$t' = t - T_D - (n-1)T \tag{4}$$

and t is the current analysis time and n is the cycle index. The effect of this is that after an initial time delay T_D the transient waveform repeats itself every cycle.

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

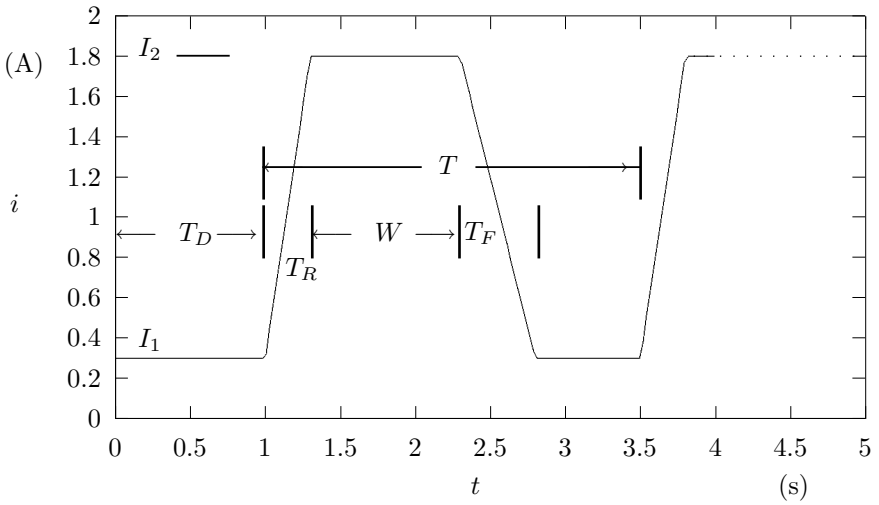

Figure 4: Current source transient pulse (`PULSE`) waveform for
`PULSE(0.3 1.8 1 2.5 0.3 1 0.7)`

Piece-Wise Linear:
`PWL(`T_1 I_1 [T_2 I_2 ... T_i I_i ... T_N I_N] `)`

Example:
`ISIGNAL 20 5 PWL(1 0.25 1 1 2 0.5 ... 3 0.5 4 1 ... 4.5 1.25 ...)`

Description:
Each pair of values (T_i, I_i) specifies that the value of the source is I_i at time = T_i. At times between T_i and T_{i+1} the values are linearly interpolated. If $T_1 > 0$ then the voltage is constant at *DCValue* (specified on the element line) until time T_1.

$$i = \begin{cases} DCvalue & t < T_1 \\ I_i & t = T_i \\ I_{i+1} & t = T_{i+1} \\ I_i + \left(\frac{t-T_i}{T_{i+1}-T_i}\right)(I_{i+1} - I_i) & T_i < t \leq T_{i+1} \\ I_N & t > T_N \end{cases} \tag{5}$$

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

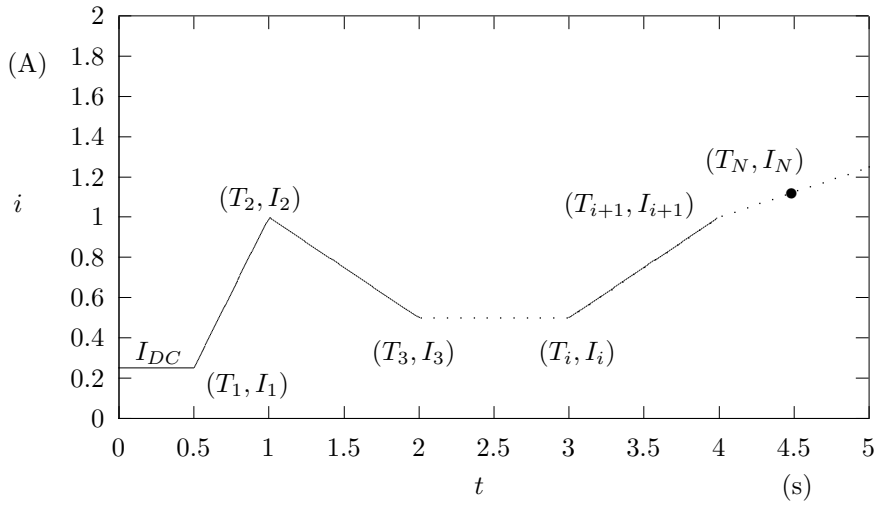

Figure 5: Current source transient piece-wise linear (`PWL`) waveform for `PWL(1 0.25 1 1 2 0.5 ... 3 0.5 4 1 ... 4.5 1.25 ...)` with *DCValue = 0.25*.

Single-Frequency FM:
`SFFM(`I_O I_A F_C μ F_S`)`
Parameters:

Name	Description	Units	Default
I_O	offset current	A	
I_A	peak amplitude of `AC` current	A	
F_C	carrier frequency	Hz	1/`TSTOP`
μ	modulation index	-	0
F_S	signal frequency	Hz	1/`TSTOP`

Example:
```
ISIGNAL 8 0 SFFM(0.2 0.7 4 0.9 1)
```

Description:
The single frequency frequency modulated transient response is described by

$$i = I_O + I_A \sin\left(2\pi\, F_C t + \mu \sin\left(2\pi F_S t\right)\right) \tag{6}$$

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

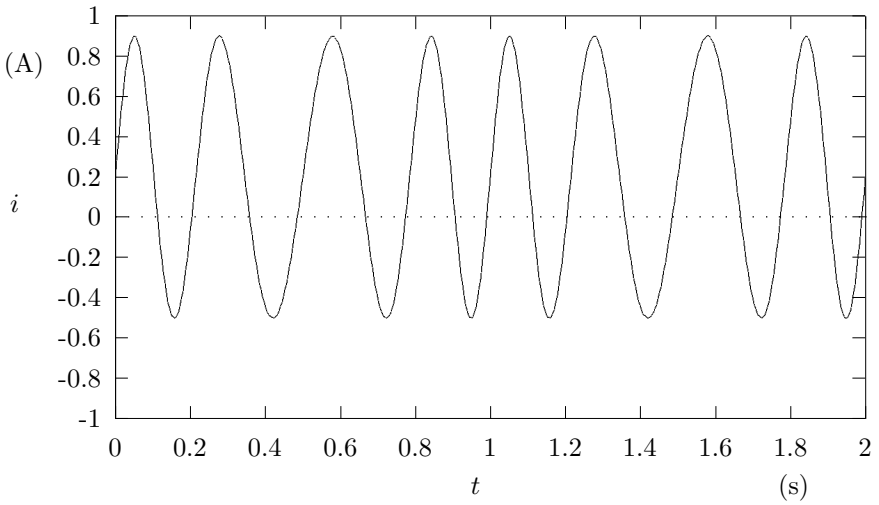

Figure 6: Current source single frequency frequency modulation (`SFFM`) waveform for `SFFM(0.2 0.7 4 0.9 1)` .

Amplitude Modulation:

`AM (sa oc fm fc td)`

Parameters:

Name	Description	Units	Default
sa	signal amplitude	V	0.0
fc	carrier frequency	Hz	0.0
fm	modulation frequency	Hz	1/`TSTOP`
oc	offset constant	dimensionless	0.0
td	delay time before start of signal	s	0.0

Example:

```
ISIGNAL 20 5 AM(10 1 100 1K 1M)
```

Description:

The waveform for this source is

$$i = sa(oc + \sin[2.\pi.fm.(t - td])sin[2.\pi.fc.(t - td)] \quad (7)$$

Notes:

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

Credits:

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