0.0.1 Voltage Controlled Switch

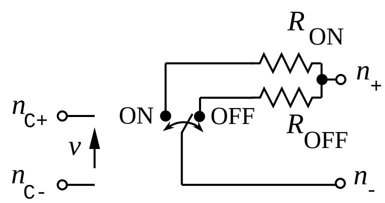

Figure 1: S — voltage controlled switch element.

`SPICE` *Form:*

Sname N_+ N_- N_{C+} N_{C-} *ModelName* [`ON`] [`OFF`]

N_+	is the positive node of the switch.
N_-	is the negative node of the switch.
N_{C+}	is the positive controlling node of the switch.
N_{C-}	is the negative controlling node of the switch.
ModelName	is the model name and is required.
`ON`	is the optional initial condition. It is intended for use with the `UIC` option on the `.TRAN` line, when a transient analysis is desired starting from other than the quiescent operating point. It is also the initial condition on the device for `DC` analysis.
`OFF`	is the optional initial condition. If specified the `DC` operating point is calculated with the terminal voltages set to zero. Once convergence is obtained, the program continues to iterate to obtain the exact value of the terminal voltages. The OFF option is used to enforce the solution to correspond to a desired state if the circuit has more than one stable state.

Example:

```
S1 1 2 3 4 SWITCH1
S2 5 6 3 0 SM2
SWITCH1 1 2 10 0 SMODEL1
```

Description:

The initial conditions are optional. For the voltage controlled switch, nodes N_{C+} and NC- are the positive and negative controlling nodes respectively. For the current controlled switch, the controlling current is that through the specified voltage source. The direction of positive controlling current flow is from the positive node, through the source, to the negative node.

Model Type

`VSWITCH`

VSWITCH Model — Voltage-Controlled Switch Model

VSWITCH

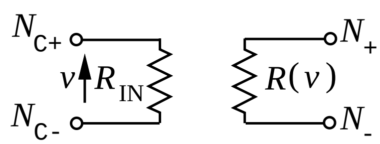

Figure 2: VSWITCH — voltage controlled switch model.

The voltage-controlled switch model is supported by both SPICE3 and PSPICE. However the model keywords differ slightly.

SPICE3 *keywords:*

Name	**Description**		**Units**	**Default**
`VT`	threshold voltage	(V_{ON})	V	0.0
`VH`	hysteresis voltage	(V_{OFF})	V	0.0
`RON`	on resistance	(R_{ON})	Ω	1.0
`ROFF`	off resistance	(R_{OFF})	Ω	1/GMIN

Care must be exercised in using the switch. An instantaneous switch is highly nonlinear and will very likely lead to convergence problems. This problem is alleviated in the `VSWITCH` model by ramping the resistance of the switch from its off value to its on value. For this ramping action to be effective the difference between V_{ON} and V_{OFF} must not be too small. Also the values of R_{ON} and R_{OFF} should not be extreme. The ration $R_{\mathrm{ON}}/R_{\mathrm{OFF}}$ should be be as small as possible.

If $R_{\mathrm{ON}}/R_{\mathrm{OFF}}$ is large, e.g. $R_{\mathrm{ON}}/R_{\mathrm{OFF}} > 10^{12}$, then the default error tolerances `TRTOL` and `CHGTOL`, specified in a `.OPTIONS` statement may need to be changed.

`TRTOL` Change to 1.0 from 7.0 idf there are convergence problems during transient analysis.

`CHGTOL` If a switch is across a capacitor then `CHGTOL` should be reduced to 10^{-16} if there are convergence problems during transient analysis.

Switch Model

The switch is modeled by a voltage variable resistor R and an input input resistance R_{IN}, see figure 2. $R_{\mathrm{IN}} = 1/G_{\mathrm{MIN}}$ to ensure that the controlling nodes are not floating and that the voltage v between the controlling nodes cannot change instantaneously.

Standard Calculations

$$
\begin{aligned}
R_{\mathrm{MEAN}} &= \sqrt{R_{\mathrm{ON}} + R_{\mathrm{OFF}}} && (1)\\
R_{\mathrm{RATIO}} &= R_{\mathrm{ON}}/R_{\mathrm{OFF}} && (2)\\
V_{\mathrm{MEAN}} &= \sqrt{V_{\mathrm{ON}} + V_{\mathrm{OFF}}} && (3)\\
V_{\Delta} &= \left(\frac{v - V_{\mathrm{MEAN}}}{V_{\mathrm{ON}} - V_{\mathrm{OFF}}}\right) && (4)
\end{aligned}
$$

If $V_{\mathrm{ON}} > V_{\mathrm{OFF}}$ the switch resistance

$$
R = \begin{cases} R_{\mathrm{ON}} & v \geq V_{\mathrm{ON}} \\ R_{\mathrm{OFF}} & v \leq V_{\mathrm{OFF}} \\ R_{\mathrm{MEAN}}\, R_{\mathrm{RATIO}}^{1.5V_{\Delta}}\, R_{\mathrm{RATIO}}^{1.5V_{\Delta}^3} & V_{\mathrm{OFF}} < v < V_{\mathrm{ON}} \end{cases} \tag{5}
$$

If $V_{\mathrm{ON}} < V_{\mathrm{OFF}}$ the switch resistance

$$
R = \begin{cases} R_{\mathrm{ON}} & v \leq V_{\mathrm{ON}} \\ R_{\mathrm{OFF}} & v \geq V_{\mathrm{OFF}} \\ R_{\mathrm{MEAN}}\, R_{\mathrm{RATIO}}^{1.5V_{\Delta}}\, R_{\mathrm{RATIO}}^{1.5V_{\Delta}^3} & V_{\mathrm{OFF}} < v < V_{\mathrm{ON}} \end{cases} \tag{6}
$$

Noise Analysis

The voltage controlled switch noise model accounts for thermal noise generated in the switch resistance. The rms (root-mean-square) values of thermal noise current generators shunting the switch resistance is

Noise Analysis

Noise Model

$$
I_n = \sqrt{4kT/R}\ \mathrm{A}/\sqrt{\mathrm{Hz}} \tag{7}
$$

where T is the analysis temperature in kelvin (K), and k ($= 1.3806226\,10^{-23}$ J/K) is Boltzmanns constant.

Notes:
There is no equivalent element in *f*REEDA™.

Credits:

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