"BJT" VTB Model

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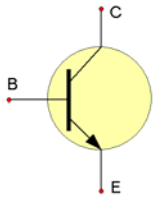
Executable file name: BJT.vtm
Version number: 1.0



Description

This model represents Bipolar Junction Transistor (BJT).

Validity Range and Limitations

The resistive companion model for BJT is developed based on the NPN type hybrid π Ebers Moll model.

Connections

Label	Description
Terminal 0	Collector connector
Terminal 1	Base connectors
Terminal 2	Emitter connector

Adjustable Parameters

Name	Description	Valid Range	Default Value	Units
Is	Saturation Current	>0	1.0E-11	Ampere
T	Absolute Temperature	> 0	300.0	Kelvin
betaF β_F	Normal current gain	9 ~ 999	100.0	NU
betaR β_R	Reverse current gain	$\beta_R << \beta_F$	10.0	NU

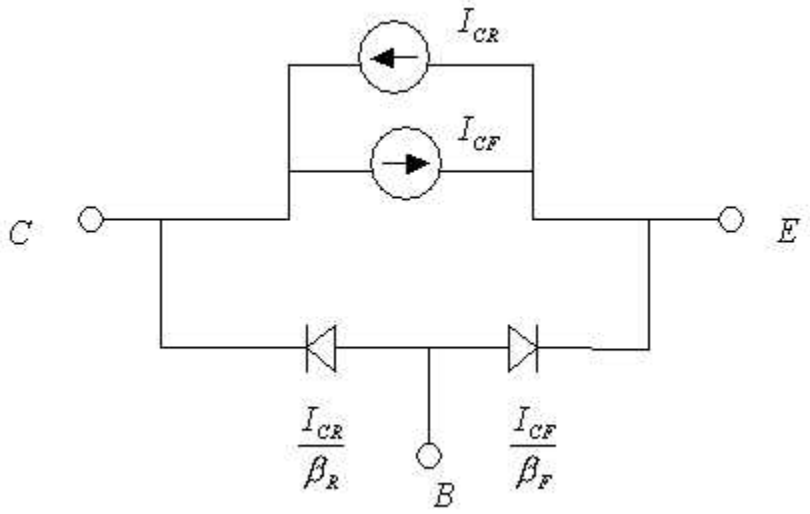
Output Variables

Name	Description	Units
Input Voltage V_B	Voltage at the base	Volt
Input Current I_B	Current into the base	Ampere
Output Voltage V_C	Voltage at the collector	Volt
Output Current I_C	Current at the collector	Ampere
Output Current V_E	Voltage at the emitter	Volt
Output Current I_E	Current at the emitter	Ampere

Model Assumptions

Mathematical Description

Summarized below is the mathematical description of the Ebers Moll model development.



For forward conduction: $$I_{CF} = I_S[\exp(\frac{V_{BE}}{V_T}) - 1]$$

where $I_S = \alpha_F I_{ES}, \beta_F = \frac{\alpha_F}{1-\alpha_F}$

Similarly, for reverse conduction: $$I_{CR} = I_S[\exp(\frac{V_{BC}}{V_T}) - 1]$$

where $I_S = \alpha_R I_{ES}, \beta_R = \frac{\alpha_R}{1-\alpha_R}$

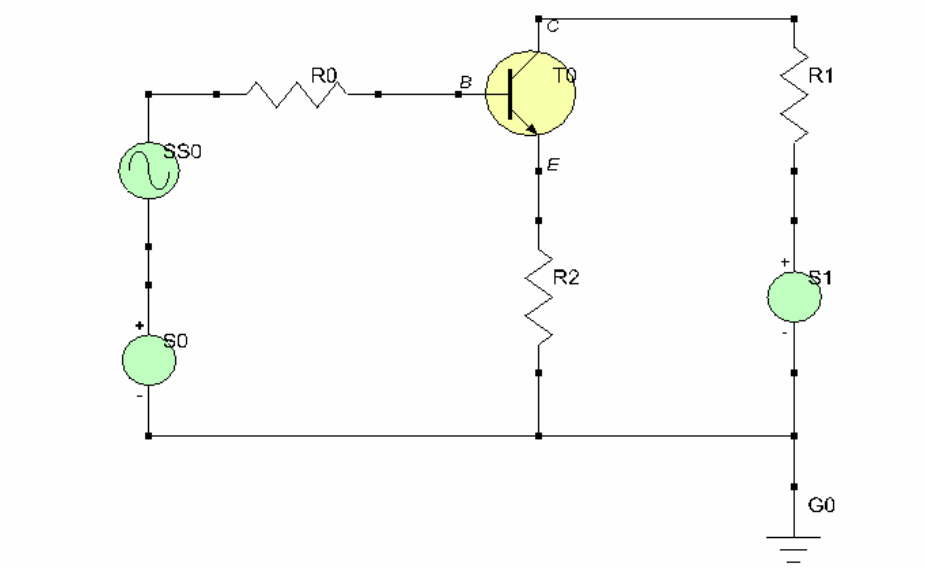
$$V_T = \frac{kT}{q}$$

subscript F	---------	forward active mode
subscript R	---------	reverse active mode
I_C	---------	collector current
I_{ES}	---------	reverse-bias B-E current
α	---------	current gain (relation between the collector and emitter currents)
β	---------	base-to-collector current amplification factor
V_{BE}	---------	voltage drop between the base and the emitter
V_{BC}	---------	voltage drop between the base and the collector
V_T	---------	equivalent voltage related with temperature
k	---------	$1.38\times10^{-23} J/K$
q	---------	$1.60\times10^{-19} C$
T	---------	absolute temperature

Model Validation

Example Application

This example is to use the BJTs together with external electrical components.

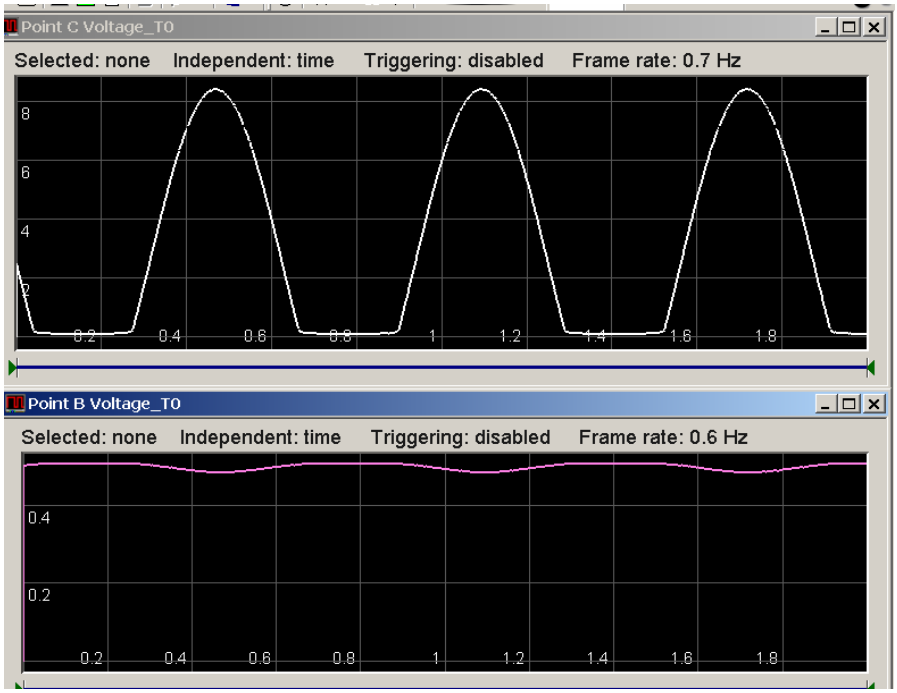


Parameter values

Sinusoidal Source			
	magnitude:	1.2	(Volts)
	resistance:	0.000001	(Ohm)
	frequency:	1.6	(Hertz)
DC Source(SS0)			
	magnitude:	3.0	(Volts)
DC Source(S1)			
	magnitude:	15	(Volts)
BJT			
	Saturation Current:	1.0 E-11	(Ampere)
	Absolute Temperature	300.0	(Kelvin)
	Normal current gain	100	(NU)
	Reverse current gain	10	(NU)
Resistor(R0)			
	resistance	1.0E05	(ohm)
Resistor(R1)			
	resistance	5.0E03	(ohm)

Resistor(R2)

resistance 0.1 (ohm)

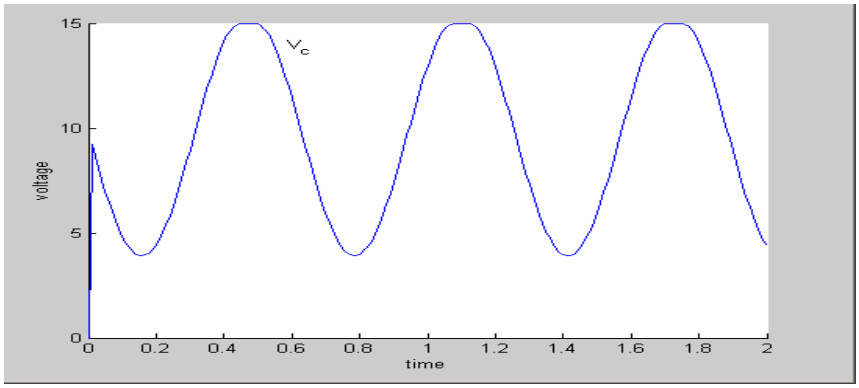


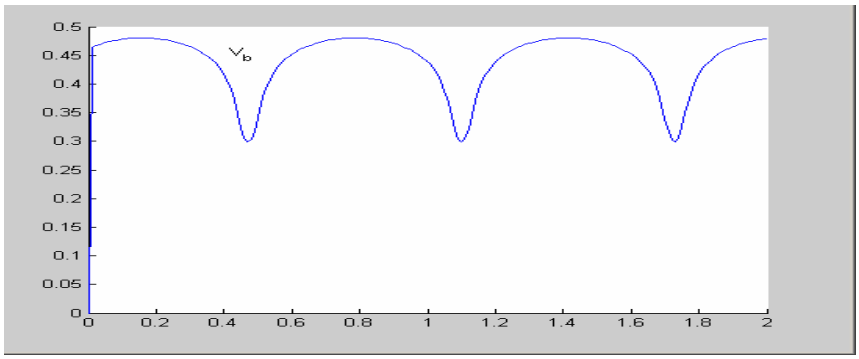
Model Verification

A MATLAB program is written to construct the same circuit as in the Testbench so as to compare the simulation results.

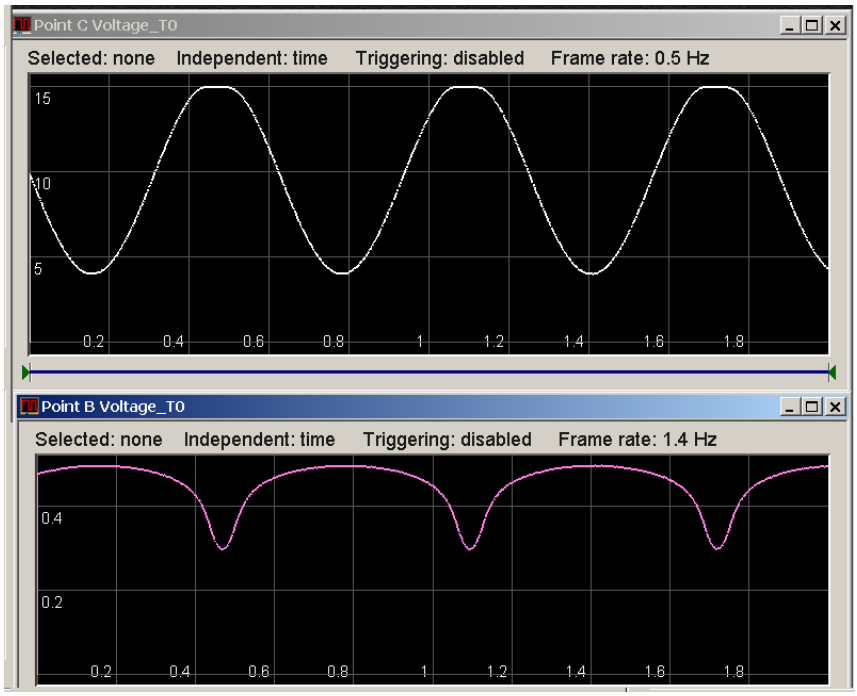
1) Simulation Results Comparison with Vbb=1.5v and Vbac=1.2sin(10t):

   a) MATLAB similation:



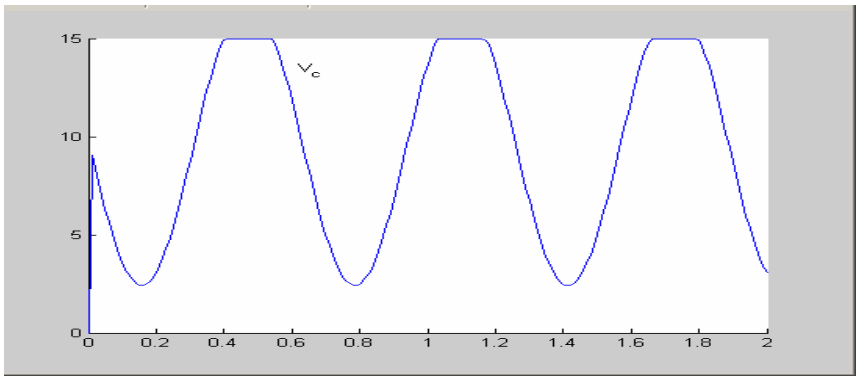


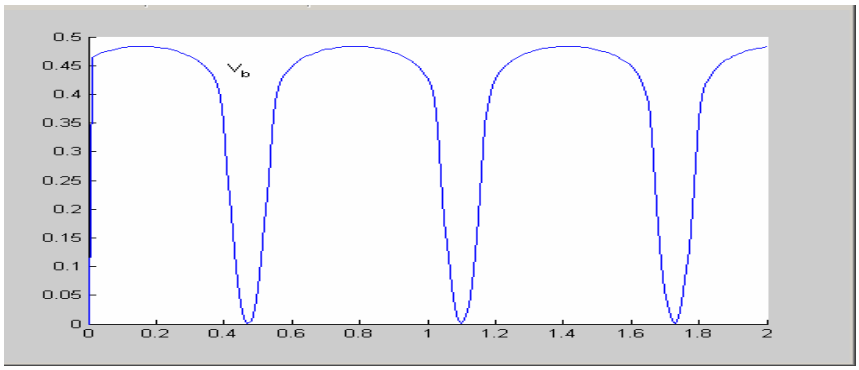
b) VTB similation:



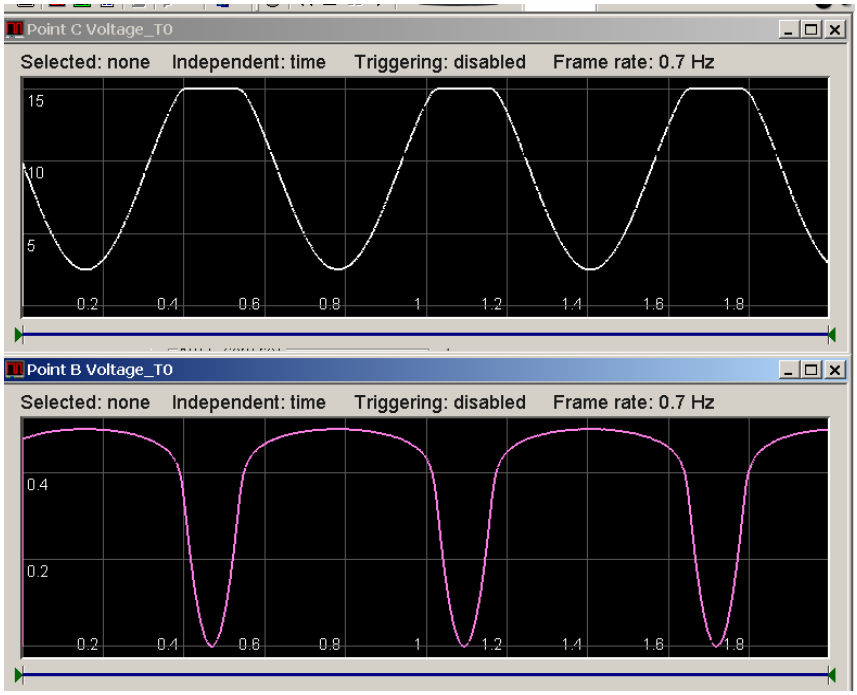
2) Simulation Results Comparison with Vbb=1.5v and Vbac=1.5sin(10t):

a) MATLAB similation:





b) VTB similation:



As seen above, the two simulations match well.

References

1. Dr. Ben G. Streetman and Sanjay Banerjee, “Solid State Electronic Devices” (5th edition)