UOS EEE Society LTSPICE Lectures

Introduction to LTSPICE

The University Of Sheffield.

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What is SPICE?

What is SPICE?

Technical Jargon:

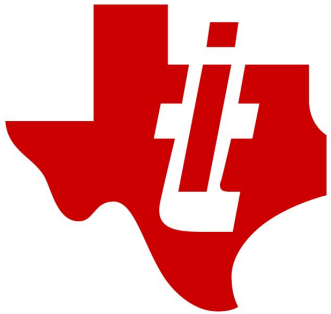
SPICE (Simulation Program with Integrated Circuit Emphasis) is a general-purpose, open-source analogue electronic circuit simulator [1].

What does that actually mean?

SPICE is a piece of software that can simulate almost any analogue electronic circuit, even ones that have integrated circuits in!

Software that uses SPICE

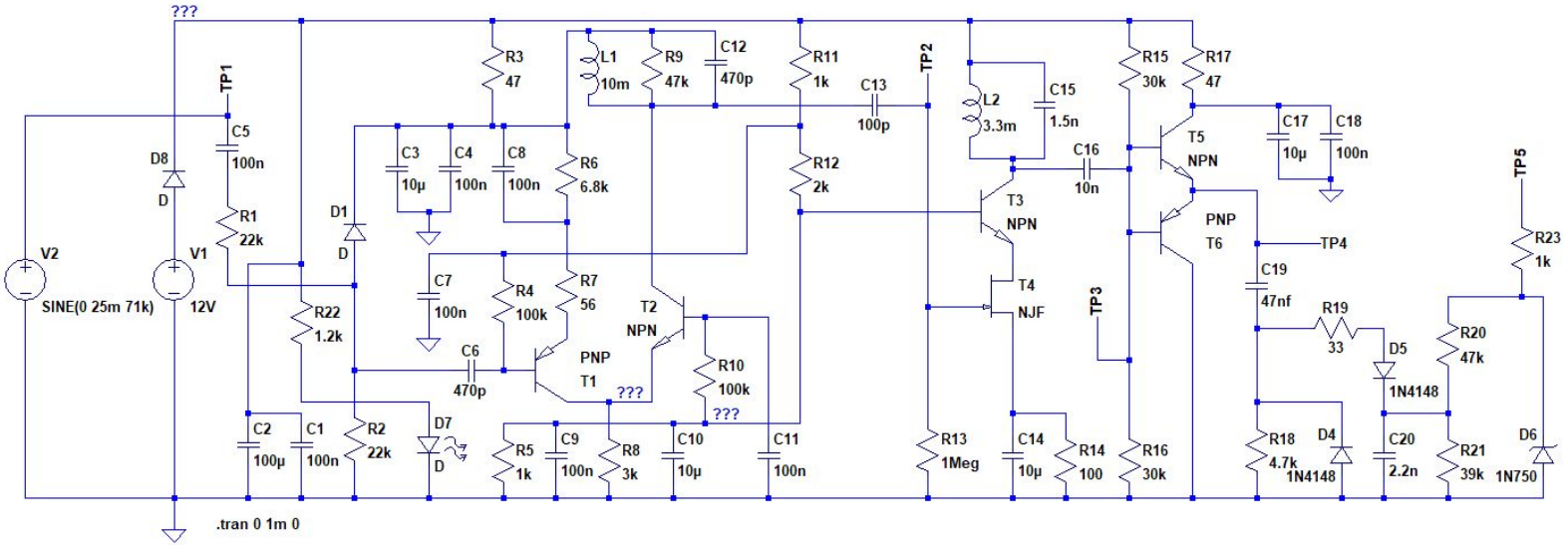
- Analog Devices ⇒ ADICE, **LTSPICE** (Originally developed by Linear Technology)
- Freescale Semiconductor ⇒ MICA
- Texas Instruments ⇒ TINA-TI
- Open Source ⇒ ngspice



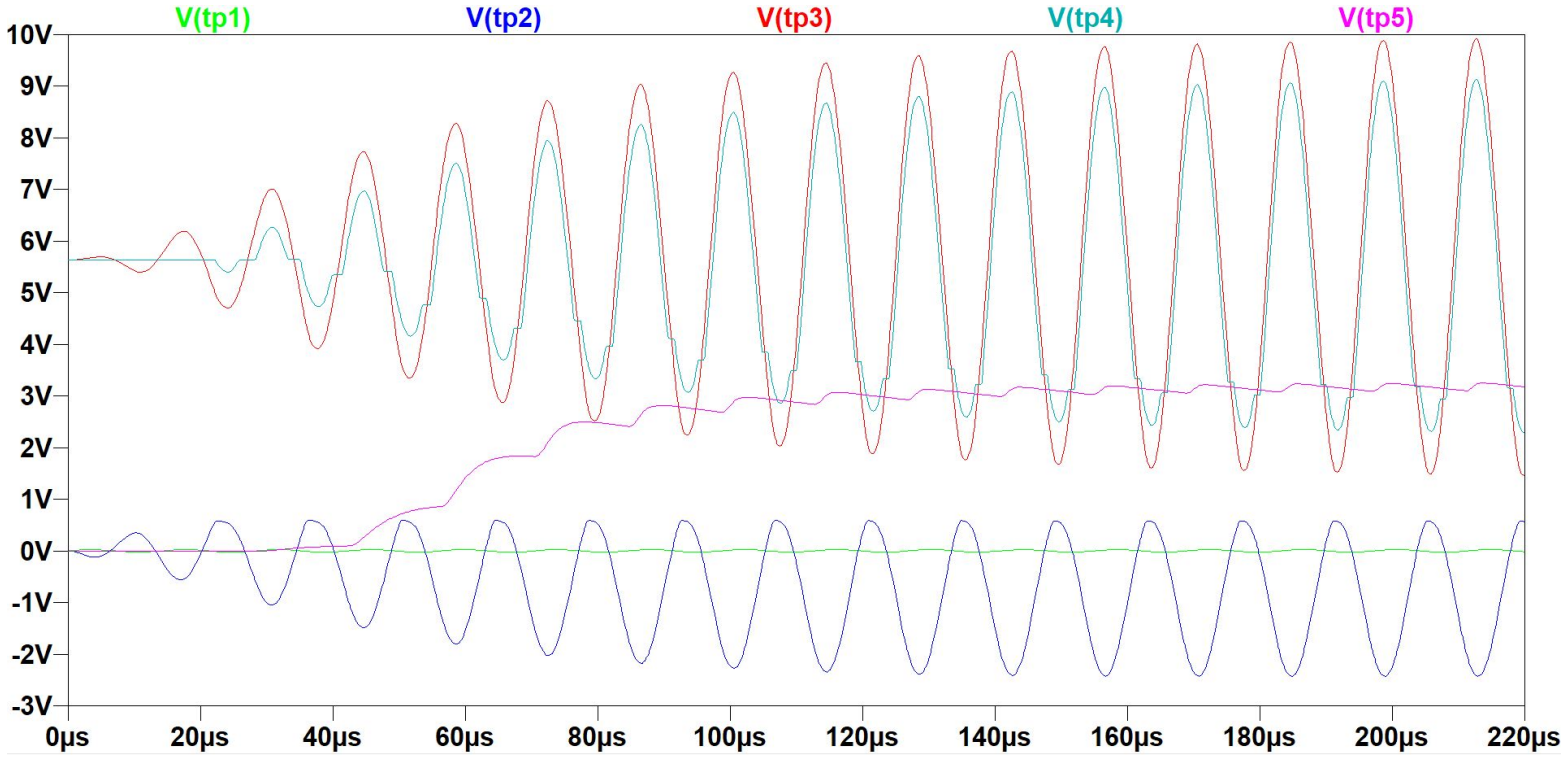
SPICE is still used by IC Designers today and a number of companies are still developing it!

Why should I learn how to use SPICE?

SPICE allows you to simulate circuits like this:



Why should I learn how to use SPICE?



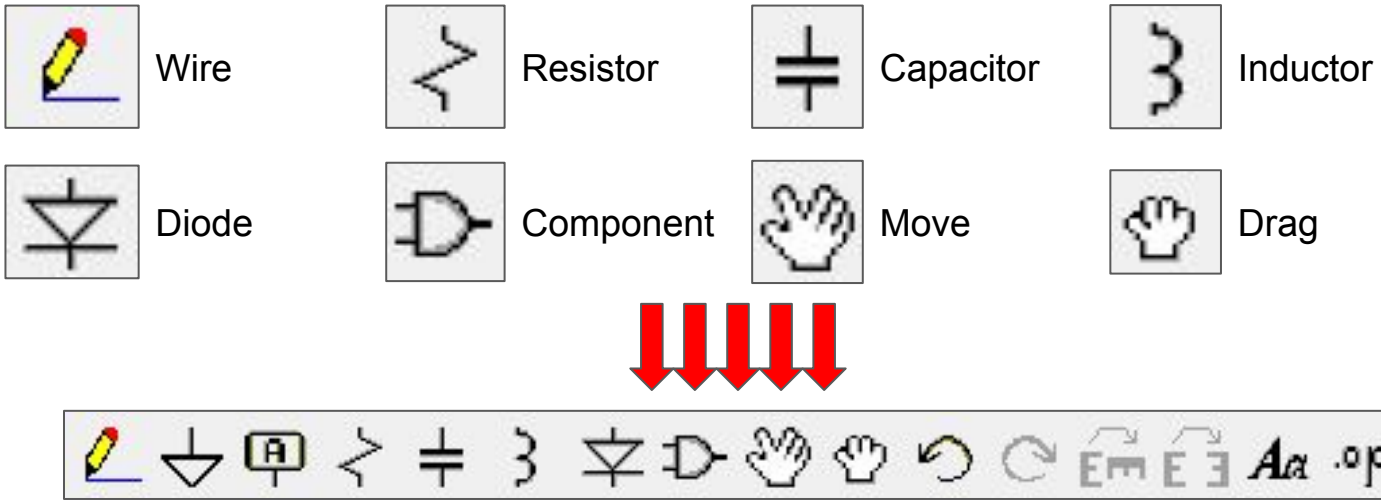
Why should I learn how to use SPICE?

- Still used by Industry today.
- Allows quick simulation of complex analogue circuits.
- Gives you an immediate understanding of what a circuit does.
- Very useful for University reports and lab sessions.

We will be using LTSPICE because its free!

Drawing Schematics

- Similar method to many PCB Design tools.
- Involves placing components and connecting them using wires.
- Uses schematic symbols.



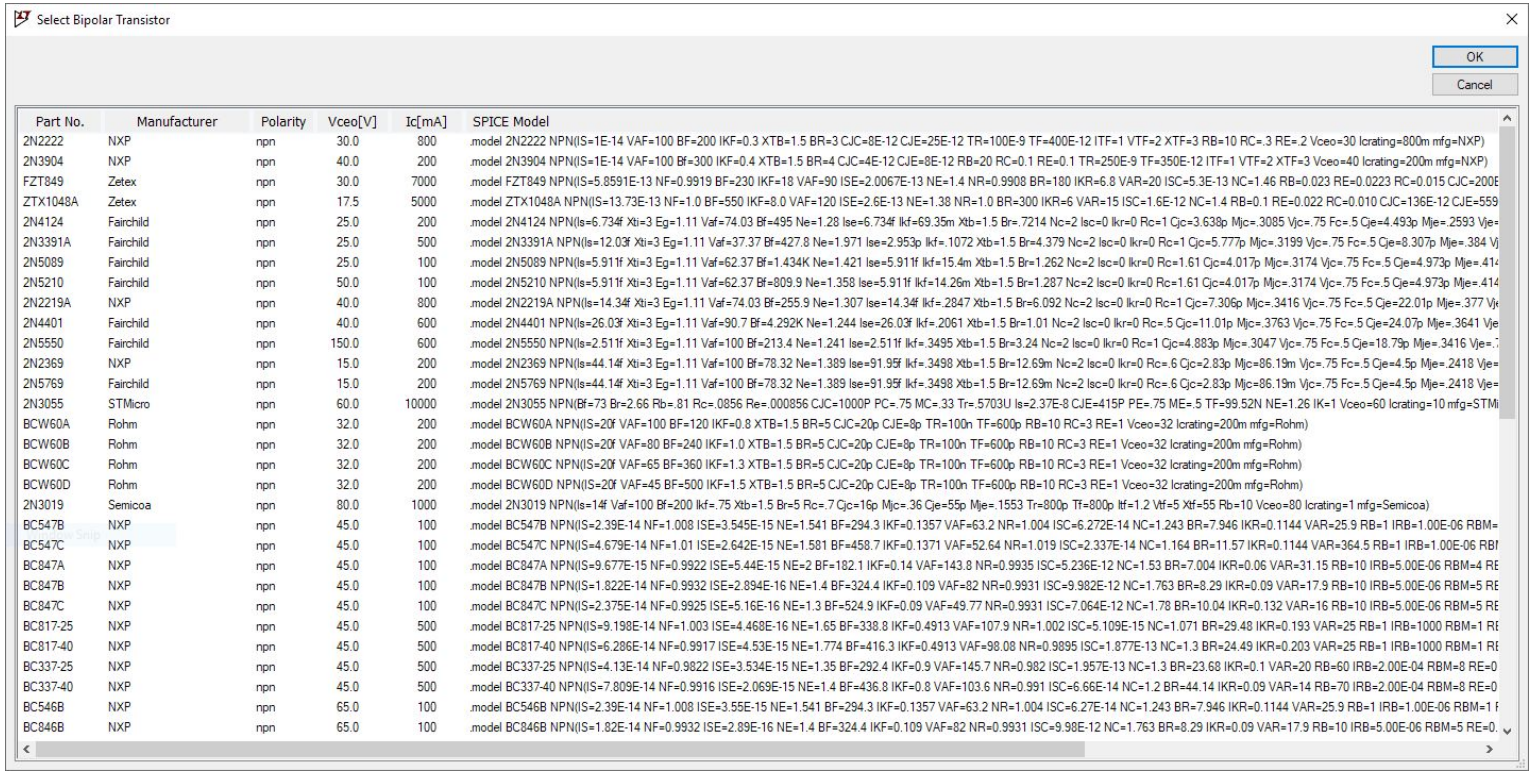
Keyboard Shortcuts

The following keyboard shortcuts can be used to speed things up:

- T ⇒ Text
- S ⇒ SPICE Directive
- R ⇒ Resistor
- C ⇒ Capacitor
- L ⇒ Inductor
- D ⇒ Diode
- F2 ⇒ Component
- F3 ⇒ Draw Wire
- F4 ⇒ Label Net (Wire)
- G ⇒ Place Ground
- F5 ⇒ Delete
- F6 ⇒ Duplicate
- F7 ⇒ Move
- F8 ⇒ Drag
- Ctrl+R ⇒ Rotate
- Ctrl+E ⇒ Mirror

Potential Divider Example

Component Models



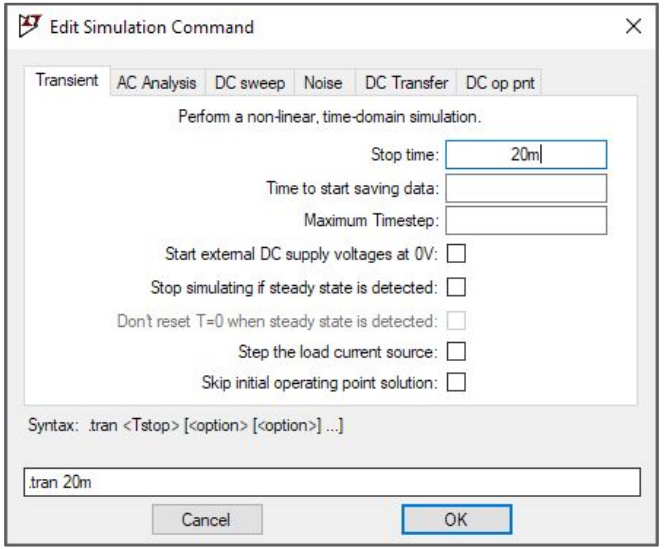
Part No.	Manufacturer	Polarity	Vceo[V]	Ic[mA]	SPICE Model
2N2222	NXP	npn	30.0	800	.model 2N2222 NPN(IS=1E-14 VAF=100 BF=200 IKF=0.3 XTB=1.5 BR=3 CJC=8E-12 CJE=25E-12 TR=100E-9 TF=400E-12 ITF=1 VTF=2 XTF=3 RB=10 RC=.3 RE=.2 Vceo=30 Icrating=800m mfg=NXP)
2N3904	NXP	npn	40.0	200	.model 2N3904 NPN(IS=1E-14 VAF=100 Bf=300 IKF=0.4 XTB=1.5 BR=4 CJC=4E-12 CJE=8E-12 RB=20 RC=0.1 RE=0.1 TR=250E-9 TF=350E-12 ITF=1 VTF=2 XTF=3 Vceo=40 Icrating=200m mfg=NXP)
FZT849	Zetex	npn	30.0	7000	.model FZT849 NPN(IS=5.8591E-13 NF=0.9919 BF=230 IKF=18 VAF=90 ISE=2.0067E-13 NE=1.4 NR=0.9908 BR=180 IKR=6.8 VAR=20 ISC=5.3E-13 NC=1.46 RB=0.023 RE=0.0223 RC=0.015 CJC=200E
ZTX1048A	Zetex	npn	17.5	5000	.model ZTX1048A NPN(IS=13.73E-13 NF=1.0 BF=550 IKF=8.0 VAF=120 ISE=2.6E-13 NE=1.38 NR=1.0 BR=300 IKR=6 VAR=15 ISC=1.6E-12 NC=1.4 RB=0.1 RE=0.022 RC=0.010 CJC=136E-12 CJE=559
2N4124	Fairchild	npn	25.0	200	.model 2N4124 NPN(Is=6.734f Xti=3 Eg=1.11 Vaf=74.03 Bf=495 Ne=1.28 Ise=6.734f Ikf=69.35m Xtb=1.5 Br=.7214 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=3.638p Mjc=.3085 Vjc=.75 Fc=.5 Cje=4.493p Mje=.2593 Vje=
2N3391A	Fairchild	npn	25.0	500	.model 2N3391A NPN(Is=12.03f Xti=3 Eg=1.11 Vaf=37.37 Bf=427.8 Ne=1.971 Ise=2.953p Ikf=.1072 Xtb=1.5 Br=4.379 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=5.777p Mjc=.3199 Vjc=.75 Fc=.5 Cje=8.307p Mje=.384 Vj
2N5089	Fairchild	npn	25.0	100	.model 2N5089 NPN(Is=5.911f Xti=3 Eg=1.11 Vaf=62.37 Bf=1.434K Ne=1.421 Ise=5.911f Ikf=15.4m Xtb=1.5 Br=1.262 Nc=2 Isc=0 Ikr=0 Rc=1.61 Cjc=4.017p Mjc=.3174 Vjc=.75 Fc=.5 Cje=4.973p Mje=.414
2N5210	Fairchild	npn	50.0	100	.model 2N5210 NPN(Is=5.911f Xti=3 Eg=1.11 Vaf=62.37 Bf=809.9 Ne=1.358 Ise=5.911f Ikf=14.26m Xtb=1.5 Br=1.287 Nc=2 Isc=0 Ikr=0 Rc=1.61 Cjc=4.017p Mjc=.3174 Vjc=.75 Fc=.5 Cje=4.973p Mje=.414
2N2219A	NXP	npn	40.0	800	.model 2N2219A NPN(Is=14.34f Xti=3 Eg=1.11 Vaf=74.03 Bf=255.9 Ne=1.307 Ise=14.34f Ikf=.2847 Xtb=1.5 Br=6.092 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=7.306p Mjc=.3416 Vjc=.75 Fc=.5 Cje=22.01p Mje=.377 Vj
2N4401	Fairchild	npn	40.0	600	.model 2N4401 NPN(Is=26.03f Xti=3 Eg=1.11 Vaf=90.7 Bf=4.292K Ne=1.244 Ise=26.03f Ikf=.2061 Xtb=1.5 Br=1.01 Nc=2 Isc=0 Ikr=0 Rc=.5 Cjc=11.01p Mjc=.3763 Vjc=.75 Fc=.5 Cje=24.07p Mje=.3641 Vje
2N5550	Fairchild	npn	150.0	600	.model 2N5550 NPN(Is=2.511f Xti=3 Eg=1.11 Vaf=100 Bf=213.4 Ne=1.241 Ise=2.511f Ikf=.3495 Xtb=1.5 Br=3.24 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=4.883p Mjc=.3047 Vjc=.75 Fc=.5 Cje=18.79p Mje=.3416 Vje=.7
2N2369	NXP	npn	15.0	200	.model 2N2369 NPN(Is=44.14f Xti=3 Eg=1.11 Vaf=100 Bf=78.32 Ne=1.389 Ise=91.95f Ikf=.3498 Xtb=1.5 Br=12.69m Nc=2 Isc=0 Ikr=0 Rc=.6 Cjc=2.83p Mjc=86.19m Vjc=.75 Fc=.5 Cje=4.5p Mje=.2418 Vje=
2N5769	Fairchild	npn	15.0	200	.model 2N5769 NPN(Is=44.14f Xti=3 Eg=1.11 Vaf=100 Bf=78.32 Ne=1.389 Ise=91.95f Ikf=.3498 Xtb=1.5 Br=12.69m Nc=2 Isc=0 Ikr=0 Rc=.6 Cjc=2.83p Mjc=86.19m Vjc=.75 Fc=.5 Cje=4.5p Mje=.2418 Vje=
2N3055	STMicro	npn	60.0	10000	.model 2N3055 NPN(Bf=73 Br=2.66 Rb=.81 Rc=.0856 Re=.000856 CJC=1000P PC=.75 MC=.33 Tr=.5703U Is=2.37E-8 CJE=415P PE=.75 ME=.5 TF=99.52N NE=1.26 IK=1 Vceo=60 Icrating=10 mfg=STMi
BCW60A	Rohm	npn	32.0	200	.model BCW60A NPN(IS=20f VAF=100 BF=120 IKF=0.8 XTB=1.5 BR=5 CJC=20p CJE=8p TR=100n TF=600p RB=10 RC=3 RE=1 Vceo=32 Icrating=200m mfg=Rohm)
BCW60B	Rohm	npn	32.0	200	.model BCW60B NPN(IS=20f VAF=80 BF=240 IKF=1.0 XTB=1.5 BR=5 CJC=20p CJE=8p TR=100n TF=600p RB=10 RC=3 RE=1 Vceo=32 Icrating=200m mfg=Rohm)
BCW60C	Rohm	npn	32.0	200	.model BCW60C NPN(IS=20f VAF=65 BF=360 IKF=1.3 XTB=1.5 BR=5 CJC=20p CJE=8p TR=100n TF=600p RB=10 RC=3 RE=1 Vceo=32 Icrating=200m mfg=Rohm)
BCW60D	Rohm	npn	32.0	200	.model BCW60D NPN(IS=20f VAF=45 BF=500 IKF=1.5 XTB=1.5 BR=5 CJC=20p CJE=8p TR=100n TF=600p RB=10 RC=3 RE=1 Vceo=32 Icrating=200m mfg=Rohm)
2N3019	Semicoa	npn	80.0	1000	.model 2N3019 NPN(Is=14f Vaf=100 Bf=200 Ikf=.75 Xtb=1.5 Br=5 Rc=.7 Cjc=16p Mjc=.36 Cje=55p Mje=.1553 Tr=800p Tf=800p Itf=1.2 Vtf=5 Xtf=55 Rb=10 Vceo=80 Icrating=1 mfg=Semicoa)
BC547B	NXP	npn	45.0	100	.model BC547B NPN(IS=2.39E-14 NF=1.008 ISE=3.545E-15 NE=1.541 BF=294.3 IKF=0.1357 VAF=63.2 NR=1.004 ISC=6.272E-14 NC=1.243 BR=7.946 IKR=0.1144 VAR=25.9 RB=1 IRB=1.00E-06 RBM=
BC547C	NXP	npn	45.0	100	.model BC547C NPN(IS=4.679E-14 NF=1.01 ISE=2.642E-15 NE=1.581 BF=458.7 IKF=0.1371 VAF=52.64 NR=1.019 ISC=2.337E-14 NC=1.164 BR=11.57 IKR=0.1144 VAR=364.5 RB=1 IRB=1.00E-06 RBI
BC847A	NXP	npn	45.0	100	.model BC847A NPN(IS=9.677E-15 NF=0.9922 ISE=5.44E-15 NE=2 BF=182.1 IKF=0.14 VAF=143.8 NR=0.9935 ISC=5.236E-12 NC=1.53 BR=7.004 IKR=0.06 VAR=31.15 RB=10 IRB=5.00E-06 RBM=4 RE
BC847B	NXP	npn	45.0	100	.model BC847B NPN(IS=1.822E-14 NF=0.9932 ISE=2.894E-16 NE=1.4 BF=324.4 IKF=0.109 VAF=82 NR=0.9931 ISC=9.982E-12 NC=1.763 BR=8.29 IKR=0.09 VAR=17.9 RB=10 IRB=5.00E-06 RBM=5 RE
BC847C	NXP	npn	45.0	100	.model BC847C NPN(IS=2.375E-14 NF=0.9925 ISE=5.16E-16 NE=1.3 BF=524.9 IKF=0.09 VAF=49.77 NR=0.9931 ISC=7.064E-12 NC=1.78 BR=10.04 IKR=0.132 VAR=16 RB=10 IRB=5.00E-06 RBM=5 RE
BC817-25	NXP	npn	45.0	500	.model BC817-25 NPN(IS=9.198E-14 NF=1.003 ISE=4.468E-16 NE=1.65 BF=338.8 IKF=0.4913 VAF=107.9 NR=1.002 ISC=5.109E-15 NC=1.071 BR=29.48 IKR=0.193 VAR=25 RB=1 IRB=1000 RBM=1 RE
BC817-40	NXP	npn	45.0	500	.model BC817-40 NPN(IS=6.286E-14 NF=0.9917 ISE=4.53E-15 NE=1.774 BF=416.3 IKF=0.4913 VAF=98.08 NR=0.9895 ISC=1.877E-13 NC=1.3 BR=24.49 IKR=0.203 VAR=25 RB=1 IRB=1000 RBM=1 RE
BC337-25	NXP	npn	45.0	500	.model BC337-25 NPN(IS=4.13E-14 NF=0.9822 ISE=3.534E-15 NE=1.35 BF=292.4 IKF=0.9 VAF=145.7 NR=0.982 ISC=1.957E-13 NC=1.3 BR=23.68 IKR=0.1 VAR=20 RB=60 IRB=2.00E-04 RBM=8 RE=0
BC337-40	NXP	npn	45.0	500	.model BC337-40 NPN(IS=7.809E-14 NF=0.9916 ISE=2.069E-15 NE=1.4 BF=436.8 IKF=0.8 VAF=103.6 NR=0.991 ISC=6.66E-14 NC=1.2 BR=44.14 IKR=0.09 VAR=14 RB=70 IRB=2.00E-04 RBM=8 RE=0
BC546B	NXP	npn	65.0	100	.model BC546B NPN(IS=2.39E-14 NF=1.008 ISE=3.55E-15 NE=1.541 BF=294.3 IKF=0.1357 VAF=63.2 NR=1.004 ISC=6.27E-14 NC=1.243 BR=7.946 IKR=0.1144 VAR=25.9 RB=1 IRB=1.00E-06 RBM=1 I
BC846B	NXP	npn	65.0	100	.model BC846B NPN(IS=1.82E-14 NF=0.9932 ISE=2.89E-16 NE=1.4 BF=324.4 IKF=0.109 VAF=82 NR=0.9931 ISC=9.98E-12 NC=1.763 BR=8.29 IKR=0.09 VAR=17.9 RB=10 IRB=5.00E-06 RBM=5 RE=0.

Component Models

- Allow you to produce a much more accurate simulation based upon specific electronic components rather than generic models.
- Models can be produced for any active component.
- LTSPICE includes a set of preloaded models to use.
- You can also create your own models using information from the manufacturers datasheet.

Transient Analysis

- Essentially runs the circuit for a short period and simulates it’s response.
- The run time can be specified (Stop Time).
- The timestep can be specified.
- The time to start saving data can be specified to reduce output from long computations.



Power Amplifier Example

Quiz Time!

What does SPICE stand for?

Simulation Program with Impossible Circuit Emphasis

Simulation Program with Integrated Circuit Emphasis

Somersault Pizza with Interesting Cake Emphasis

What are components connected with on a schematic?

Is SPICE still used by Industry today?

What is the keyboard shortcut for an Inductor?

What is the keyboard shortcut for a component?

Component Models let you?

When poll is active, respond at **PollEv.com/sammaxwell637**

Text **SAMMAXWELL637** to **020 3322 5822** once to join

More accurately simulate a circuit using specific component characteristics.

Have little figurines on your desk.

Less accurately simulate a circuit using specific component characteristics.

Transient Analysis allows you to?

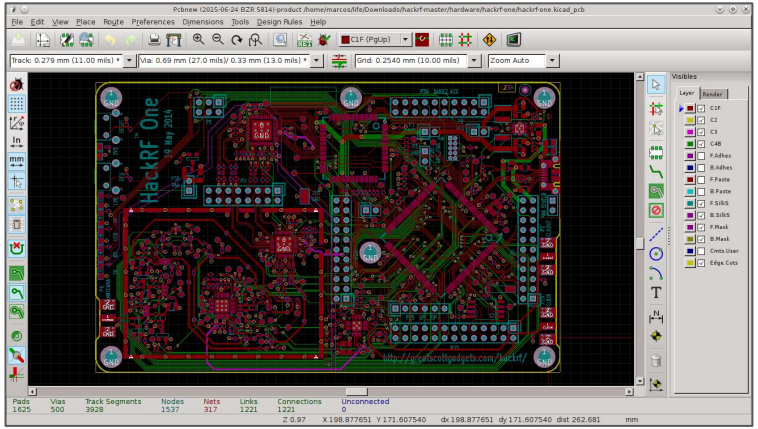
Simulate the circuit running for a short period of time.

Simulate the circuits frequency response.

Generally feel unhappy that you have to do a transient simulation.

KiCAD Lectures

- First lecture starting next week on Monday 11th February from 5-6pm!
- Free sessions!
- Teaches you about circuit board design and schematic capture!
- DON'T MISS OUT!



Thanks for listening!

Next time we will be:

1. AC Analysis
2. DC Sweep Analysis
3. Noise Analysis
4. MORE EXAMPLES!

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Written by Sam Maxwell

The Original SPICE Paper

[1] Nagel, L. W, and Pederson, D. O., SPICE (Simulation Program with Integrated Circuit Emphasis), Memorandum No. ERL-M382, University of California, Berkeley, Apr. 1973