An outline of Qucs-S compact device modelling: History and capabilities: Part 2 XSPICE Code Models; basic properties to model synthesis, and beyond

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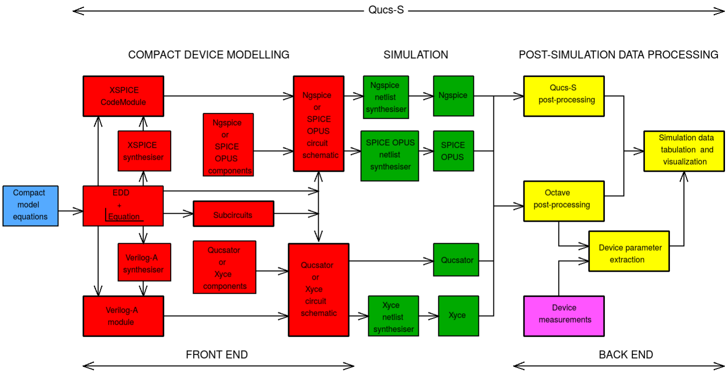
A flow chart showing Qucs-S compact modelling facilities and data movement

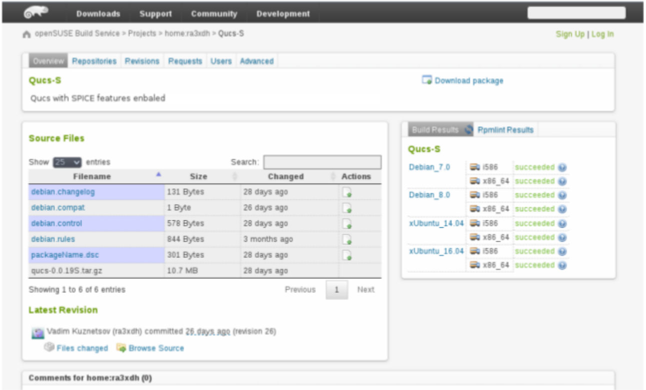


NOTES:

1. Qucs-S allows the selection of the simulation engine to use.
2. Available simulation components depends on the simulation engine chosen.
3. Users may select either Qucs-S or Qctave post-processing of simulator data.

Qucs-S binary packages

- Debian packages are available here: `http://download.opensuse.org/repositories/home:/ra3xdh/`
- Windows Installer: `https://github.com/ra3xdh/qucs/releases/download/0.0.19S/qucs-0.0.19S-setup.zip`



Qucs-S a maturing GPL software package: Qucs-S Help documentation

Search docs

Qucs-S Help documentation

User Manual and Reference Material

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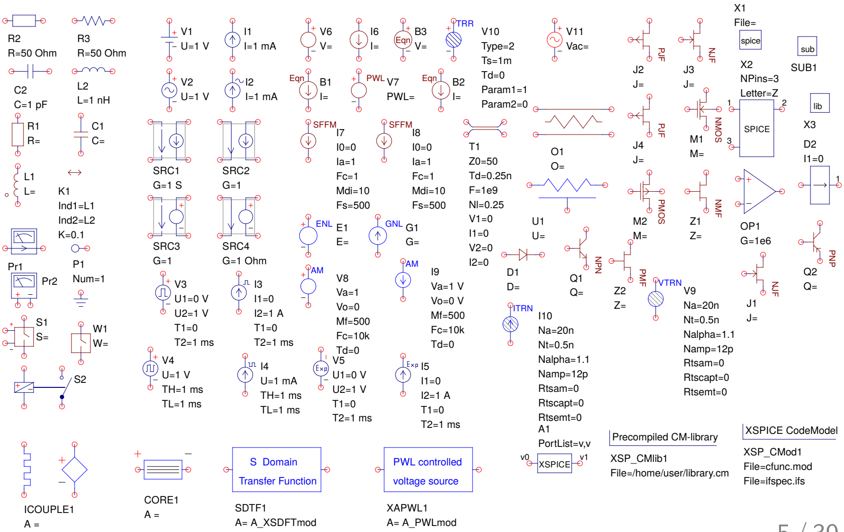
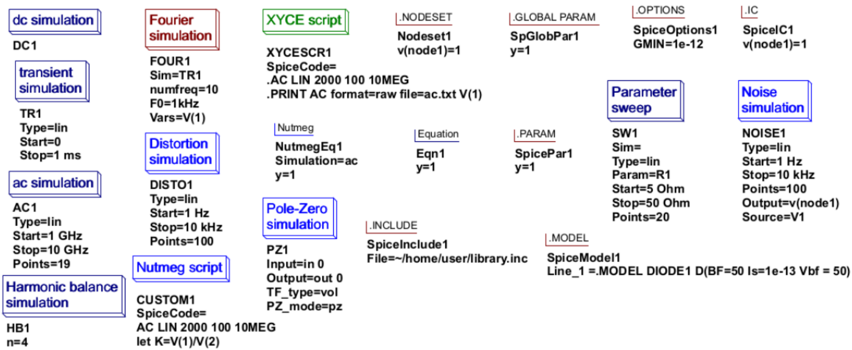
Contents:

Qucs-S a maturing GPL software package: Ngspice, Xyce and SPICEOPUS built in components

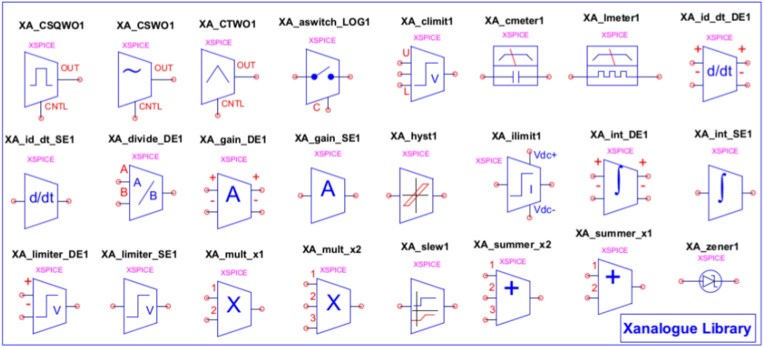


Qucs-S a maturing GPL software package: Available semiconductor device models

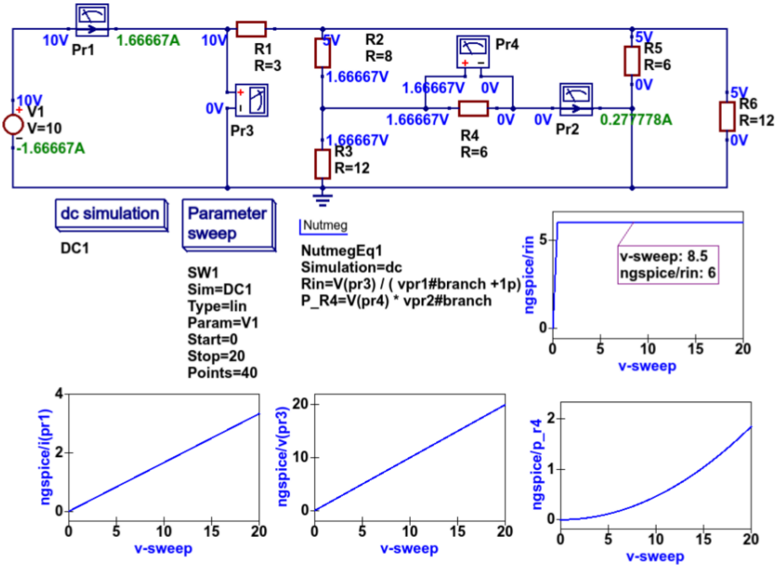
Type	Description	Level	Ngspice	Xyce	SPICEOPUS
D	Legacy	1	X	X	X
		2		X	
		3			X
BJT	Legacy	1	X	X	X
	VBIC	10,11,12		X	
	FBH HBI_X	23		X	
	MEXTRAM	504,505			X
JFET		1	X	X	X
		2	X	X	X
MESFET		1 (Statz)	X	X	X
		2 (Ytterdel)	X		
MOSFET	Legacy	1	X	X	X
		2	X		X
		3	X	X	X
		4(BSIM1)	X		X
		5(BSIM2)	X		X
		6	X	X	X
	BSIM3v2	47			X
		8	X		
		9		X	
	BSIM3v3	53			X
		49	X		
	BSIM4	60			X
		14	X	X	
		54	X		
	BSIM3SOIv1	55			X
	BSIMOIv2	56	X		X
		58,55,57	X		
		10	X	X	
	STAGSOI3	57			X
	UFSOI	58			X
	SOI3	60	X		
	UFET	7			X
	EKVv2p6	44	X		X
	HISIM2	61,68	X		
	HISIM_HV	62,63	X		
	VDMOS	18		X	
	BSIM 6p1	77		X	
	PSP 103p1	103		X	


dc simulation
DC1
transient simulation
TR1
Type=lin
Start=0
Stop=1 ms
ac simulation
AC1
Type=lin
Start=1 GHz
Stop=10 GHz
Points=19
Harmonic balance simulation
HB1
n=4
Fourier simulation
FOUR1
Sim=TR1
numfreq=10
F0=1kHz
Vars=V(1)
Distortion simulation
DISTO1
Type=lin
Start=1 Hz
Stop=10 kHz
Points=100
Nutmeg script
CUSTOM1
SpiceCode=
AC LIN 2000 100 10MEG
let K=V(1)/V(2)
XYCE script
XYCESCR1
SpiceCode=
.AC LIN 2000 100 10MEG
.PRINT AC format=raw file=ac.txt V(1)
Nutmeg
NutmegEq1
Simulation=ac
y=1
Pole-Zero simulation
PZ1
Input=in 0
Output=out 0
TF_type=vol
PZ_mode=pz
.NODESET
Nodeset1
v(node1)=1
Equation
Eqn1
y=1
.INCLUDE
SpiceInclude1
File=~/home/user/library.inc
.GLOBAL PARAM
SpGlobPar1
y=1
.PARAM
SpicePar1
y=1
.MODEL
SpiceModel1
Line_1 =.MODEL DIODE1 D(BF=50 Is=1e-13 Vbf = 50)
.OPTIONS
SpiceOptions1
GMIN=1e-12
Parameter sweep
SW1
Sim=
Type=lin
Param=R1
Start=5 Ohm
Stop=50 Ohm
Points=20
.IC
SpiceIC1
v(node1)=1
Noise simulation
NOISE1
Type=lin
Start=1 Hz
Stop=10 kHz
Points=100
Output=v(node1)
Source=V1

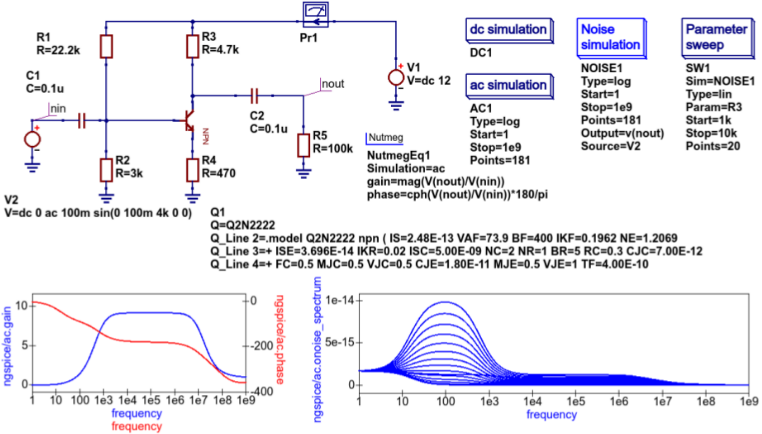
Qucs-S a maturing GPL software package: XSPICE analogue component models



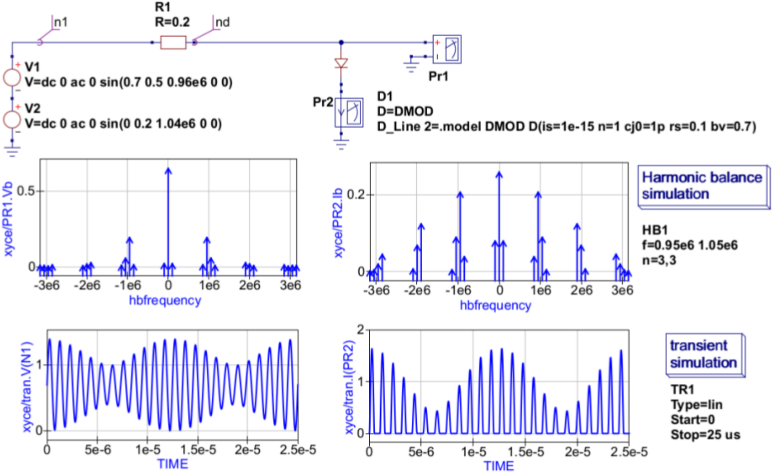
Qucs-S a maturing GPL software package: Qucs-S extended circuit simulation Part 1. SPICE .OP to visual DC by pressing key F8



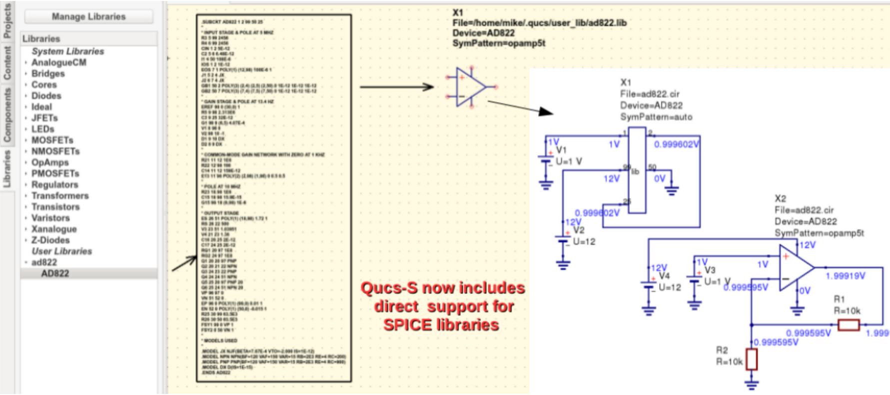
Qucs-S a maturing GPL software package: Qucs-S extended circuit simulation Part 2. Noise spectral response



Qucs-S a maturing GPL software package: Qucs-S extended circuit simulation Part 3. Multi-tone Harmonic balance analysis



Qucs-S a maturing GPL software package: Qucs-S extended circuit simulation Part 4. Direct support for SPICE libraries

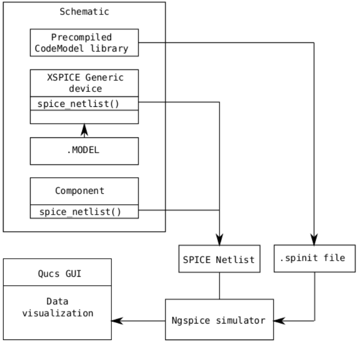


Qucs-S a maturing GPL software package: Modelling tool additions and new features

- Qucs-S includes for the first time a turn-key XSPICE "code level modelling" package for use with the Ngspice and SPICE OPUS circuit simulators,
- Qucs-S has also been extended to include a new Qucs/Octave integrated tool set for compact device model and circuit macromodel parameter extraction. The technique employed is based on data fitting and optimization using measured, or manufacturers published device data, compared against simulated circuit data.

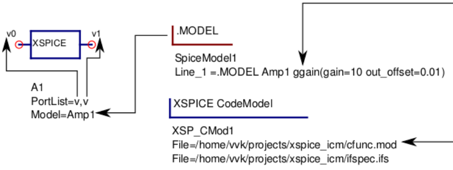
Qucs-S a maturing GPL software package: XSPICE Code Model support subsystem

- The XSPICE generic device component is the foundation for
  - Precompiled XSPICE device (*.cm) library support, and
  - Dynamic XSPICE "Code Model" compilation system which allows Code Model sources to be attached to a schematic and compiled automatically at simulation time.



Qucs-S a maturing GPL software package: XSPICE Turn-Key Model Generation; compiler system building blocks

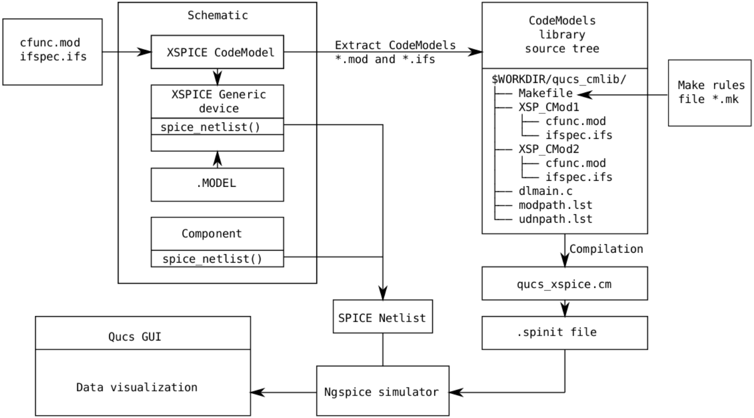
- The XSPICE generic device component is a building block for the construction of user-defined A-devices. It is defined by a comma separated port list, plus XSPICE port designators. These are attached to a SPICE .MODEL statement



Source code: cfunc.mod file

```
void cm_ggain(ARGS)
{
    Mif_Complex_t ac_gain;
    if(ANALYSIS != MIF_AC) {
        OUTPUT(out) = PARAM(out_offset)+PARAM(gain)*
                     (INPUT(in)+PARAM(in_offset));
        PARTIAL(out,in) = PARAM(gain);
    } else {
        ac_gain.real = PARAM(gain);
        ac_gain.imag= 0.0;
        AC_GAIN(out,in) = ac_gain;
    }
}
```

Qucs-S a maturing GPL software package: XSPICE Turn-Key Model Generation; compiler system dataflow diagram

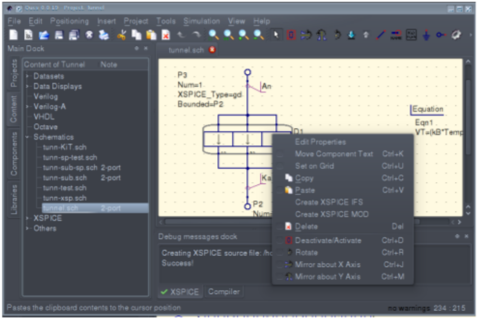


Main features of the XSPICE CodeModel synthesizer

Main features:

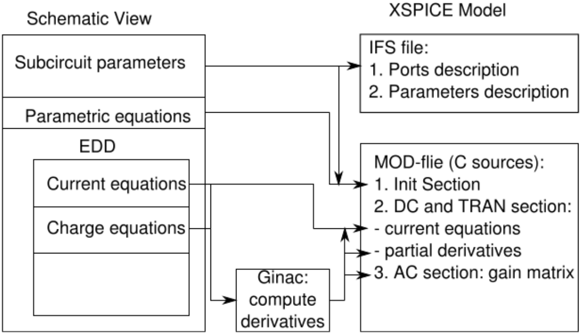
- Synthesize XSPICE C-code and interface description from EDD schematic view;
- Access to code synthesizer from right-click on the EDD component;
- Synthesizer generates a pair of MOD and IFS files from a single EDD;
- Automatic recognition of model parameters and dependent variables;
- Automatic symbolic computation of partial derivatives and AC gain matrix using Ginac embedded CAS library;

- XSPICE synthesizer context menu



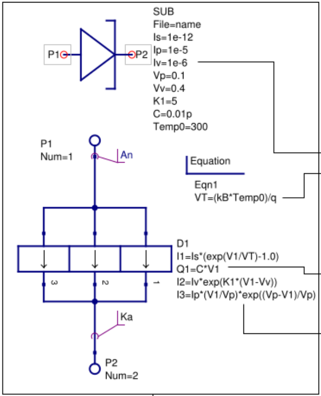
The structure of the XSPICE model synthesizer

- Ginac `http://www.ginac.de/` library is used for symbolic computation of partial derivatives and AC gain matrix;
- Interface description file (*.IFS) is generated from subcircuit symbol or from the EDD and attached equations;
- Model description (C-code *.MOD) is generated from individual EDDs;



Tunnel diode XSPICE model

Schematic view



Press button "Generate MOD"

XSPICE sources

```
/* XSPICE codemodel tunnel auto-generated template */

#include <math.h>
#include "xspice_mathfunc.h"

void cm_tunnel(ARGS)
{
 Complex_t ac_gain00;
 static double Is,Iv,K1,Vv,Ip,Vp,C,Temp0;
 static double VT;
 static double V1,V1_old;
 double Q0, cQ0; double delta_t;

 if(INIT) {
  Is = PARAM(is); Iv = PARAM(iv);
  K1 = PARAM(k1); Vv = PARAM(vv);
  Ip = PARAM(ip); Vp = PARAM(vp); C = PARAM(c);
  Temp0 = PARAM(temp0);
  VT=8.6173402243760290e-05*Temp0;
 }
 if (ANALYSIS != AC) {
 if (TIME == 0) {
  V1_old = V1 = INPUT(An_Ka);
  Q0=0.0; cQ0=0.0;
 } else {
  V1 = INPUT(An_Ka);
  delta_t=TIME-T(1);
  Q0 = (C)*(V1-V1_old)/(delta_t+1e-20);
  cQ0 = (C)/(delta_t+1e-20);
  V1_old = V1;
 }
  OUTPUT(An_Ka) =  Is*( exp(1.0/VT*V1)-1.0)+
    exp(-( Vv-V1)*K1)*Iv+exp(( Vp-V1)/Vp)*Ip/Vp*V1 + Q0;
  PARTIAL(An_Ka,An_Ka) = Ip*exp(1.0/Vp*(Vp-V1))/Vp+
    1.0/VT*exp(V1/VT)*Is-Ip*exp(1.0/Vp*(Vp-V1))/(Vp*Vp)*V1+
    Iv*K1*exp((V1-Vv)*K1) + cQ0;
 } else {
  ac_gain00.real = Ip*exp(1.0/Vp*(Vp-V1))/Vp+
     1.0/VT*exp(V1/VT)*Is-Ip*exp(1.0/Vp*(Vp-V1))/(Vp*Vp)*V1+
     Iv*K1*exp((V1-Vv)*K1);
  ac_gain00.imag = (C)*RAD_FREQ;
  AC_GAIN(An_Ka,An_Ka) = ac_gain00;
 }
}
```

Two-port testbench model: vacuum triode

- Triode is one of the simplest possible compact models. Triode equations:

$$I_{grid} = 0 \tag{11}$$

$$I_{plate} = \frac{1}{K_g}\left(V_{grid} + \frac{V_{plate}}{\mu}\right)^{1.5} \tag{12}$$

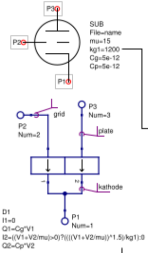
- Model parameters are: μ, K_g, C_{grid}, and C_{plate};
- Additional equations are required to implement XSPICE model (two partial derivatives and AC gain matrix):

$$g_{plate} = \frac{\partial I_{plate}}{\partial V_{plate}} = \frac{1.5}{\mu K_g}\sqrt{\frac{V_{plate}}{\mu} + V_{grid}} \tag{13}$$

$$g_{p.k.} = \frac{\partial I_{plate}}{\partial V_{grid}} = \frac{1.5}{K_g}\sqrt{\frac{V_{plate}}{\mu} + V_{grid}} \tag{14}$$

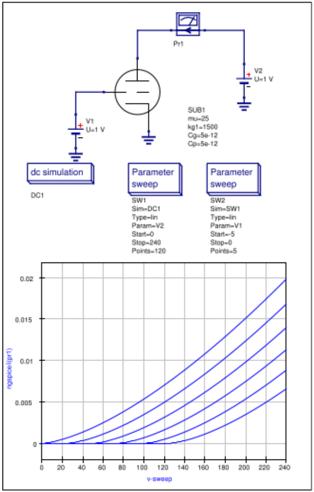
$$(G_{AC}) = \begin{pmatrix} j\omega C_g & g_{p.k.} \\ 0 & g_{plate} + j\omega C_{plate} \end{pmatrix} \tag{15}$$

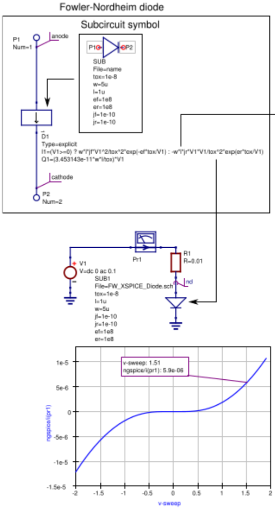
Triode EDD implementation and auto-generated XSPICE Code




```
/* XSPICE codemodel triode auto-generated template */

#include <math.h>
#include "xspice_mathfunc.h"

void cm_triode(ARGS)
{
 Complex_t ac_gain00, ac_gain01, ac_gain10, ac_gain11;
 static double Cg,mu,kg1,Cp, V1,V2,V1_old,V2_old;
 double Q0, cQ0, Q1, cQ1; double delta_t;

 if(INIT) {
  Cg = PARAM(cg);  mu = PARAM(mu); kg1 = PARAM(kg1); Cp = PARAM(cp);
 }
 if (ANALYSIS != AC) {
 if (TIME == 0) {
  V1_old = V1 = INPUT(grid_kathode); V2_old = V2 = INPUT(plate_kathode);
  Q0=0.0;  cQ0=0.0;  Q1=0.0;  cQ1=0.0;
 } else {
  V1 = INPUT(grid_kathode); V2 = INPUT(plate_kathode);
  delta_t=TIME-T(1);
  Q0 = (Cg)*(V1-V1_old)/(delta_t+1e-20);
  cQ0 = (Cg)/(delta_t+1e-20);
  Q1 = (Cp)*(V2-V2_old)/(delta_t+1e-20);
  cQ1 = (Cp)/(delta_t+1e-20);
  V1_old = V1;  V2_old = V2;
 }
  OUTPUT(grid_kathode) = 0.0 + Q0;
  OUTPUT(plate_kathode) = ((V1+V2/mu)>0)?pow( V1+V2/mu,1.50)/kg1:0.0 + Q1;
  PARTIAL(grid_kathode,grid_kathode) = 0.0 + cQ0;
  PARTIAL(grid_kathode,plate_kathode) = 0.0;
  PARTIAL(plate_kathode,grid_kathode) =
    ((V1+V2/mu)>0)?1.50*Xpow(V1+V2/mu,0.50)/kg1:0.0;
  PARTIAL(plate_kathode,plate_kathode) =
    ((V1+V2/mu)>0)?1.50*Xpow(V2/mu+V1,0.50)/mu/kg1:0.0 + cQ1;
 } else {
  ac_gain00.real = 0.0;
  ac_gain00.imag = (Cg)*RAD_FREQ;
  AC_GAIN(grid_kathode,grid_kathode) = ac_gain00;
  ac_gain01.real = 0.0; ac_gain01.imag = 0.0;
  AC_GAIN(grid_kathode,plate_kathode) = ac_gain01;
  ac_gain10.real = ((V1+V2/mu)>0)?1.50*Xpow(V1+V2/mu,0.5)/kg1:0.0;
  ac_gain10.imag = 0.0;
  AC_GAIN(plate_kathode,grid_kathode) = ac_gain10;
  ac_gain11.real = ((V1+V2/mu)>0)?1.50*Xpow(V2/mu+V1,0.5)/mu/kg1:0.0;
  ac_gain11.imag = (Cp)*RAD_FREQ;
  AC_GAIN(plate_kathode,plate_kathode) = ac_gain11;
 }
}
```

DC sweep simulation result

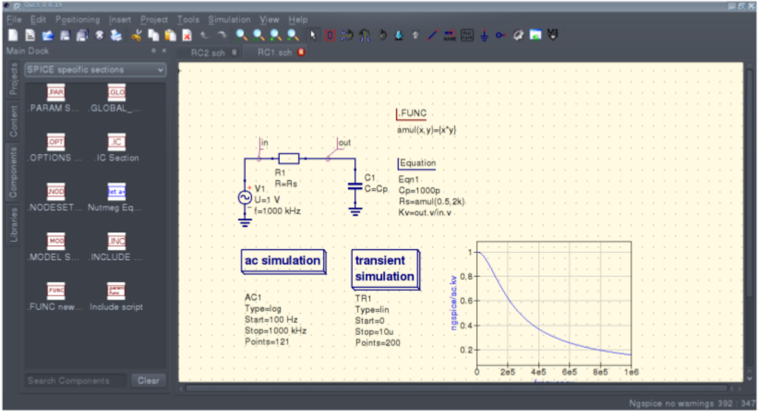




Auto-synthesized XSPICE code

```c
/* XSPICE codemodel fw_diode auto-generated template */

#include <math.h>

#define D_0_step(x) (0)
#define step(x) ((x)>0.0?1.0:(((x)==0)?0.5:0.0))

#define Xpow(x,p) pow(fabs((x)),(p))

void cm_fw_diode(ARGS)
{
 Complex_t ac_gain00;
 static double w,l,jf,tox,ef,jr,er;
 static double V1,V1_old;
 double Q0, cQ0;
 double delta_t;

 if(INIT) {
  w = PARAM(w);
  l = PARAM(l);
  jf = PARAM(jf);
  tox = PARAM(tox);
  ef = PARAM(ef);
  jr = PARAM(jr);
  er = PARAM(er);
 }
 if (ANALYSIS != AC) {
 if (TIME == 0) {
  V1_old = V1 = INPUT(anode_cathode);
  Q0=0.0;
  cQ0=0.0;
 } else {
  V1 = INPUT(anode_cathode);
  delta_t=TIME-T(1);
  Q0 = (3.4531430000000001e-11*l/tox*w)*(V1-V1_old)/(delta_t+1e-20);
  cQ0 = (3.4531430000000001e-11*l/tox*w)/(delta_t+1e-20);
  V1_old = V1;
 }
  OUTPUT(anode_cathode) = (V1>=0)?
     jf*(V1*V1)*w*exp(-ef/V1*tox)/(tox*tox)*l:
     -jr*exp(er/V1*tox)*(V1*V1)*w/(tox*tox)*l + Q0;
  PARTIAL(anode_cathode,anode_cathode) = (V1>=0)?
    2.0*1.0/(tox*tox)*l*exp(-tox*ef/V1)*jf*V1*w+1.0/tox*l*exp(-tox*ef/V1)*jf*ef*w:
    -2.0*1.0/(tox*tox)*l*jr*V1*w*exp(tox*er/V1)+1.0/tox*l*jr*er*w*exp(tox*er/V1) + cQ0;
 } else {
  ac_gain00.real = (V1>=0)?
    2.0*1.0/(tox*tox)*l*exp(-tox*ef/V1)*jf*V1*w+1.0/tox*l*exp(-tox*ef/V1)*jf*ef*w:
    -2.0*1.0/(tox*tox)*l*jr*V1*w*exp(tox*er/V1)+1.0/tox*l*jr*er*w*exp(tox*er/V1);
  ac_gain00.imag = (3.4531430000000001e-11*l/tox*w)*RAD_FREQ;
  AC_GAIN(anode_cathode,anode_cathode) = ac_gain00;
 }
}
```

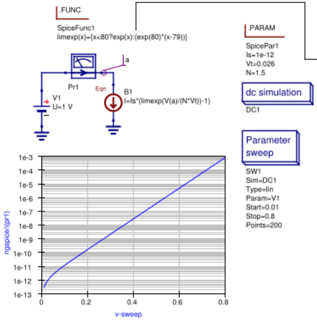
- .FUNC pseudo-component is placed at the "SPICE specific section group"
- .FUNC entries prepend components description in the auto-generated netlist



- Diode model implementation with Ngspice and limexp() function:

$$I = Is\left(\exp\left(\frac{V}{NV_t}\right) - 1\right)$$

- Schematic and auto-generated SPICE netlist:

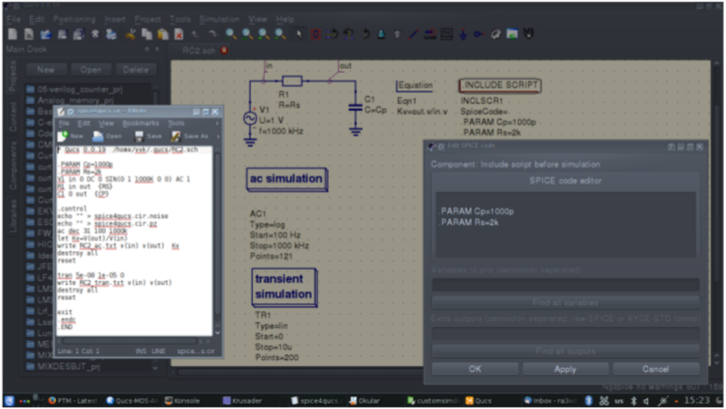


SPICE netlist

```
* Qucs 0.0.19  /tmp/func_demo.sch
.FUNC limexp(x) = {x<80?exp(x):(exp(80)*(x-79))}
.PARAM Is = 1e-12
.PARAM Vt = 0.026
.PARAM N = 1.5
V1 _net0 0 DC 1

VPr1 _net0 a DC 0
B1 a  0  I = Is*(limexp(V(a)/(N*Vt))-1)
.control
echo "" > spice4qucs.cir.noise
echo "" > spice4qucs.cir.pz
dc v1 0.01 0.8 0.00395
write func_demo_dc.txt VPr1#branch v(a)
destroy all
reset

exit
.endc
.END
```

Include scripts: run some SPICE code before components initialized

- Include scripts allow to place some custom SPICE code (parameters, options, function definitions) before components initialization and edit this code manually.



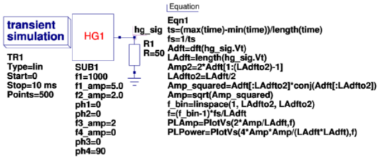
Post-simulation data processing : 1. using Qucs

Equation blocks + simulation data sets → **Data processing** → **Tables and plots**

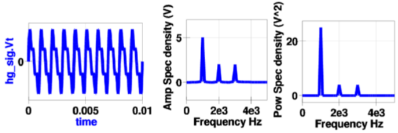
Constants: i, j, pi, e, kB, q
Immediate: 2.5, 1.4+j5.1, [1, 3, 4, 5, 7], [11, 12; 21, 22]
Ranges: Lo:Hi, :Hi, Lo:, :
Logical operators: !x, x&&y, x||y, x^^y, x?y:z, x==y, x!=y, x<y, x<=y,x>y, x>=y

Number suffixes: E, P, T, G, M, k, m, u, n, p, f, a
Matrices: M, M[2,3], M[:,3]
Arithmetic operators: +x, -x, x+y, x-y, x*y, x/y, x%y, x^y

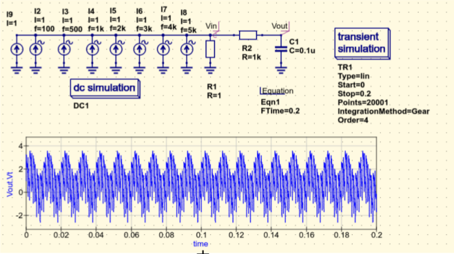
abs adjoint angle arccos arccosec arccot arcosech arcosh arcoth arcsec arcsin arctan arg arsech arsinh artanh avg besseli0 besselj bessely ceil conj cos cosec cosech cosh cot coth cumavg cumprod cumsum dB dbm dbm2w deg2rad det dft diff erf erfc erfcinv erfinv exp eye fft fix floor Freq2Time GaCircle GpCircle hypot idft ifft imag integrate interpolate inverse kbd limexp linspace ln log10 log2 logspace mag max min Mu Mu2 NoiseCircle norm phase PlotVs polar prod rad2deg random real rms Rollet round rtoswr rtoy rtoz runavg sec sech sign sin sinc sinh sqr sqrt srandom StabCircleL StabCircleS StabFactor StabMeasure stddev step stos stoy stoz sum tan tanh Time2Freq transpose twoport unwrap variance vt w2dbm xvalue ytor ytos ytoz yvalue ztor ztos ztoy

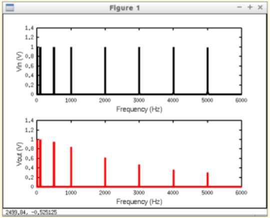


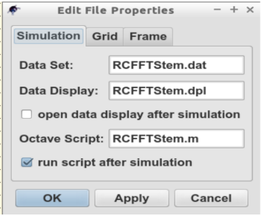
Limitations: NO user defined functions or control loops



Post-simulation data processing : 2. using Octave







RCFFTStem.m

```
% test RC transient simulation plus FFT of output.
clear;
Data = "RCFFTStem.dat";
qdset = loadQucsDataSet(Data);
[time] = getQucsVariable(qdset,  "time");
[Vin_Vt] = getQucsVariable(qdset,  "Vin.Vt");
[Vout_Vt] = getQucsVariable(qdset,  "Vout.Vt");
[FTime] = getQucsVariable(qdset,  "FTime");
showQucsDataSet(qdset);
[Y1 , Y2, freq] = plotFFT2V( "Stem", "Frequency (Hz)",0,6000,
                  Vin_Vt, "Vin (V)", "black",
                      Vout_Vt,"Vout (V)", "red", 4, FTime);
```

Python script

```
# Basic Python script to demonstrate Qucs simulation with Qucsator
#
import subprocess
import parse_result as pr
import numpy as np
import matplotlib.pyplot as plt
#
from string import Template
#
def runSim():
  netfile = open('RC.net', 'r')
  outfile = open('sim_result.dat', 'w')
  process = subprocess.Popen('qucsator', stdin = netfile, stdout = outfile)
  process.wait()
  netfile.close()
  outfile.close()
#
# Undertake simulation and plot output results
#
runSim()
data = pr.parse_file('sim_result.dat')
x = data['acfrequency']
y = np.abs(data['out.v'])
plt.loglog(x, y, '-kD')
plt.grid()
plt.title('RC voltage transfer function')
plt.xlabel('Frequency (Hz)')
plt.ylabel('Vout (V)')
plt.show()
```

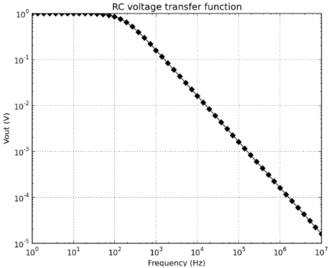
Qucs netlist

```
# File RC.net
#
Vac:V1 in gnd U = "1V"  f = "1 kHz"
R:R1 out in R = "1 k"
C:C1 out gnd C = "1 u"
.AC:AC1 Start = "1 Hz" Stop = "10 MHz" Points = "50" Type ="log"
```

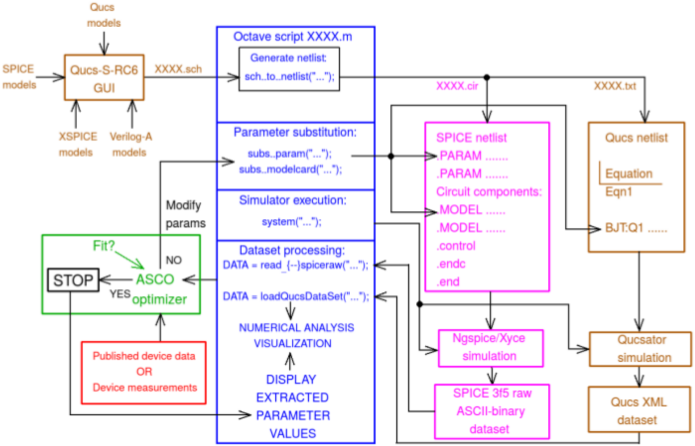
Qucsator

Parse Qucsator output data in Python format

Plot with matplotlib



Qucs-S/Ngspice/Xyce Circuit Analysis and Compact Device Parameter Extraction from Manufacturers Data or Measurements Controlled by Octave Script Files: Part I Structure Diagram



Qucs-S/Ngspice/Xyce Circuit Analysis and Compact Device Parameter Extraction from Manufacturers Data or Measurements Controlled by Octave Script Files: Part II Octave Package

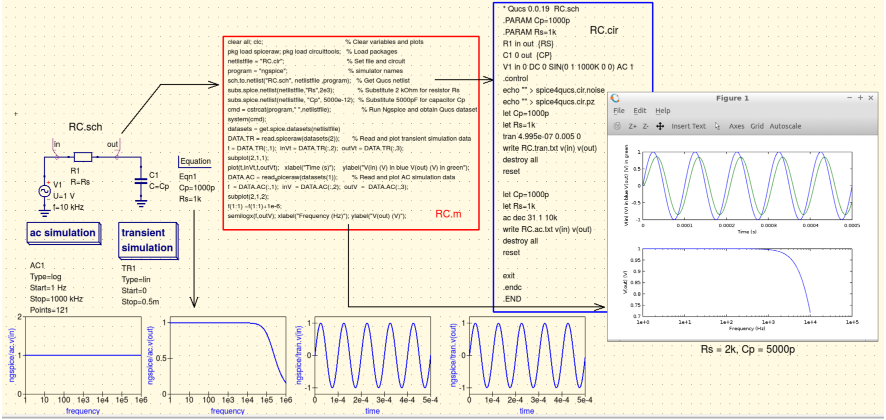
- The main purposes of Octave integration are:
  - Parameter substitution in Qucs and SPICE netlists,
  - Simulation process control from Octave,
  - Simulator output dataset (SPICE3f5-raw and Qucs XML) loading into Octave matrix structures,
  - Compact model parameter extraction from simulation and manufacturer's, or measured, data using curve fitting and optimization with the ASCO package.
- Example Octave package functions:
  - $subs\_spice\_netlist(FILE, PARAM, VALUE)$,
  - $subs\_qucs\_netlist(FILE, PARAM, VALUE)$,
  - $subs\_spice\_model\_netlist(FILE, MODEL, PARAM, VALUE)$,
  - $DATA = read\_spiceraw(FILE)$.

Where FILE – represents SPICE or Qucs netlist files

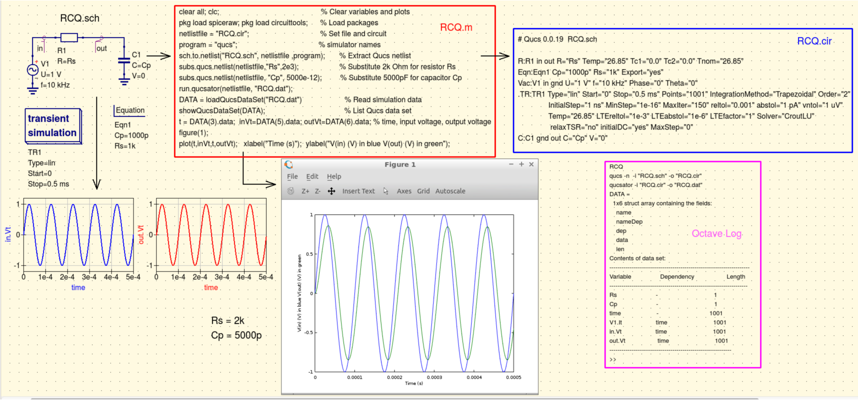
PARAM – represents a SPICE or Qucs variable or .MODEL parameter name

VALUE – represents a parameter value to replace its original quantity

Qucs-S/Ngspice/Xyce Circuit Analysis and Compact Device Parameter Extraction from Manufacturers Data or Measurements Controlled by Octave Script Files: Part III Simple Ngspice example



Qucs-S/Ngspice/Xyce Circuit Analysis and Compact Device Parameter Extraction from Manufacturers Data or Measurements Controlled by Octave Script Files: Part IV Simple Qucs example



Qucs-0.0.19S : Qucs with SPICE 1

Qucs-S: Qucs with SPICE

Download links

The latest stable release is Qucs-0.0.19S. It is based on stable Qucs-0.0.19:

- Documentation at readthedocs.io
- Source tarball: qucs-0.0.19S.tar.gz
- Debian repository (32 and 64 bit), buit with openSUSE OBS:
  - Debian 8 "Jessy" at: download.opensuse.org
  - Debian 7 "Wheezy" at: download.opensuse.org
- Windows installer (Zipped EXE): qucs-0.0.19S-setup.zip

(Installation instructions...)

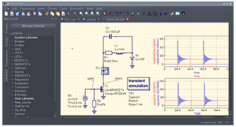
Contibuition guide

Qucs-S is open for everyone's contribution. See here for contribution guide.

News

- *January, 26, 2017* Qucs-S 0.0.19 is released! The first stable release. Release announcement
- *November 8, 2016* Qucs-S RC8 released. Release notes and download link
- *September 3, 2016* Qucs-S RC7 released. Release notes and download link
- *May 15, 2016* Qucs-S RC6 released. Release notes and download link
- *March 23, 2016* Qucs-S RC5 released. Release notes and download link
- *January 31, 2016* Qucs-S RC4 released. Release notes and download link
- *August 29, 2015* Qucs-S RC3 released.
- *July 28, 2015* Qucs-S RC2 released.
- *July 25, 2015*Qucs-S RC1 released.

Simulation example with Qucs-S and Ngspice



(More screenshots...)

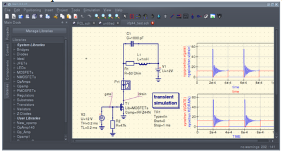
What is Qucs-S?

Qucs-S is a spin-off of the Qucs cross-platform circuit simulator. "S" letter indicates SPICE. The purpose of the Qucs-S subproject is to use free SPICE circuit simulation kernels with the Qucs GUI. It merges the power of SPICE and the simplicity of the Qucs GUI. Qucs intentionally uses its own SPICE incompatible simulation kernel Qucsator. It has advanced RF and AC domain simulation features, but the most of existing industrial SPICE models are incompatible with it. Qucs-S is not a simulator by itself, but it requires to use a simulation backend with it. The schematic document format of Qucs and Qucs-S are fully compatible. Qucs-S allows to use the following simulation kernels with it:

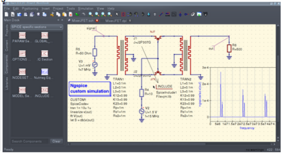
- Ngspice is recommended to use. Ngspice is powerful mixed-level/mixed-signal circuit simulator. The most of industrial SPICE models are compatible with Ngspice. It has an excellent performance for time-domain simulation of switching circuits and powerful postprocessor.
- XYCE is a new SPICE-compatible circuit simulator written by Sandia from the scratch. It supports basic SPICE simulation types and has an advances RF simulation features such as Harmonic balance simulation.
- SpiceOpus is developed by the Faculty of Electrical Engineering of the Ljubljana University. It based on the SPICE-3f5 code
- Qucsator as backward compatible

Qucs-0.0.19S : Qucs with SPICE 2

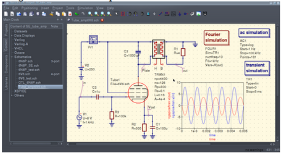
- MOSFET power switch



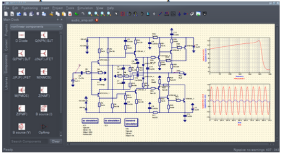
- JFET mixer



- Single-ended tube amplifier



- Hi-Fi bipolar transistor audio amplifier



(to top...)

Main features

- Backward compatible with Qucs by the component types and simulations
- Direct support of SPICE models from components datasheets. SPICE model could be added to schematic without any adaptation.
- Basic SPICE components: RCL, BJT, MOSFET, JFET, MESFET, switches;
- Advanced SPICE components: Equation-defined sources and RCLs, transmission lines;
- Direct support of SPICE Modelcards, SPICE sections (.IC, .NODESET);
- Parametric circuits (.PARAM) and SPICE postrprocessor (Nutmeg)
- Basic SPICE simulations: DC, AC, TRAN;
- Advanced SPICE simulation: DISTO, NOISE, Spectrum analysis;
- Single-tone and Multitone Harmonic balanace analysis with XYCE backend;
- Nutmeg script simulation: direct access to the SPICE code and construct your own simulation;
- XYCE script simulation type;

Qucs-S : Plans for the future 1; the next release

Plans for the next Qucs-S 0.0.20 release:

- Include an XSPICE code synthesizer;
- The support for .FUNC and Include scripts;
- Improvements in XYCE support: new components and .SENS analysis;
- Ngspice digital library;
- Synchronize code base with mainline Qucs and bugfixing;
- Release date scheduled: Summer 2017;

Source code available at:

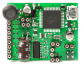
- Stable and release candidates:
  `https://github.com/ra3xdh/qucs/tree/qucs-s-stable`
- Development branch:
  `https://github.com/ra3xdh/qucs/tree/spice4qucs_current`

Qucs-S : Plans for the future 2; more software features – Possible new directions for XSPICE synthesizer development

- Synthesize more complex XSPICE models: for example GaN HEMT, photodiodes and photoBJTs;
- Introduce a new generation of source based components, where their C code can be dynamically synthesized and compiled before simulation;
- Allow the linking of symbolic computation libraries to the XSPICE kernel to introduce symbolic computations at simulation time;
- Extend the number of devices in the pre-synthesized XSPICE libraries which are shipped with Qucs-S (currently very limited);

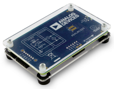
Qucs-S : Plans for the future 3; Adding Open Source Hardware to Qucs-S – current low cost open source measurement hardware choices

Labrador (Espotek)
$29



Oscilloscope (2 channel, 750ksps)
Arbitrary Waveform Generator (2 channel, 1MSPS)
Power Supply (4.5 to 15V, 1.5W max, closed-loop)
Logic Analyzer (2 channel, 3MSPS per channel, with serial decoding)
Multimeter (V/I/R/C)
Software compatible with Windows, OSX, and Linux

ADALM1000 (Analog Devices)
£38



USB powered learning tool
Measuring and sourcing current (- 200 to +200mA) and voltage (0 to 5V) simultaneously on same pin
Oscilloscope (100 kSPS), function generator (100 kSPS)
PixelPulse 2 (open source) supports Windows, Linux, OS X
16-bit (0.05%) basic measure accuracy with 4 digit resolution
Source and sink (2-quadrant) operation
C, C++ and Python bindings
MATLAB Data Acquisition Toolbox Support
Open source hardware
ADALP2000 Analog Parts Kit offers wide selection of analog components and allows solderless breadboarding

open source hardware
open source initiative

Qucs-S : Plans for the future 4; Adding Open Source Hardware to Qucs-S – current low cost open source measurement hardware choices 2

adalm2000 (Analog Devices)
$99

open source hardware
open source initiative

Two-channel USB digital oscilloscope

Two-channel arbitrary function generator

16-channel digital logic analyzer (3.3V CMOS and 1.8V or 5V tolerant, 100MS/s)

16-channel pattern generator (3.3V CMOS, 100MS/s)

16-channel virtual digital I/O

Two input/output digital trigger signals for linking multiple instruments (3.3V CMOS)

Single channel voltmeter (AC, DC, ±20V)

Network analyzer – Bode, Nyquist, Nichols transfer diagrams of a circuit. Range: 1Hz to 10MHz

Spectrum Analyzer – power spectrum and spectral measurements (noise floor, SFDR, SNR, THD, etc.)

Digital Bus Analyzers (SPI, I²C, UART, Parallel)

Two programmable power supplies (0…+5V , 0…-5V)

Qucs-S : Plans for the future 5; Adding Open Source Hardware to Qucs-S – current low cost open source measurement hardware choices 3

Analog Discovery 2 (Digilent)
$279

Two-channel USB digital oscilloscope (1 MΩ, ±25 V, differential, 14-bit, 100 MSPS, 30 MHz+ bandwidth - with the Analog Discovery BNC adapter board, 1286-1073-ND sold separately)

Two-channel arbitrary function generator (±5 V, 14-bit, 100 MSPS, 20 MHz+ bandwidth - with the Analog Discovery BNC adapter board, 1286-1073-ND sold separately)

Stereo audio amplifier to drive external headphones or speakers with replicated AWG signals

16-channel digital logic analyzer (3.3 V CMOS, 100 MSPS)

16-channel pattern generator (3.3 V CMOS, 100 MSPS)

16-channel virtual digital I/O including buttons, switches, and LEDs which are perfect for logic training applications

Two input/output digital trigger signals for linking multiple instruments (3.3 V CMOS)

open source hardware open source initiative