## Free Power Supply Circuits For SIMPLIS Offer Ready-Made Design Templates

In preparing his soon-to-be released book on small-signal modeling of power converters, How2Power contributor Christophe Basso has developed SIMPLIS simulation files for a wide range of switched-mode power converters. Most of these 63 ready-to-simulate power converter circuits will run in Elements, the free demo version of the SIMPLIS simulator (Fig. 1). Fewer than six require the full professional version to run (such as the PFCs for instance). These files, which are available at Basso's website, serve as ready-made design templates for power supply designers (Fig. 2).

All application circuits come with automated calculation windows in which you enter the desired design goals extracted from the power stage response and the Elements program calculates the compensation component values for you (Fig. 3). The values are available in the netlist and easily accessed from the development environment.

These power supply circuits stem from the author's work in deriving the control-to-output transfer functions of many converters, starting from simple dc-dc cells (buck, buck-boost or boost) to isolated versions like flyback or forward converters operated in voltage mode (VM), current mode (CM), quasi-resonance (QR), constant on-time (COT) and constant off-time (FOT). He has also derived transfer functions for various operating modes such as continuous conduction (CCM) or discontinuous conduction (DCM) and borderline conduction (BCM or CrM) for power-factor-corrected converters. You'll find the derivations of these transfer functions in Basso's book, "Transfer Functions of Switching Converters, Fast Analytical Techniques at Work with Small-Signal Analysis," which is due to be released at the end of 2020.

To access the power supply circuit files, see Basso's webpage. To access SIMPLIS' free simulation software, see the Elements page. For more information on these circuits, you can email the author.
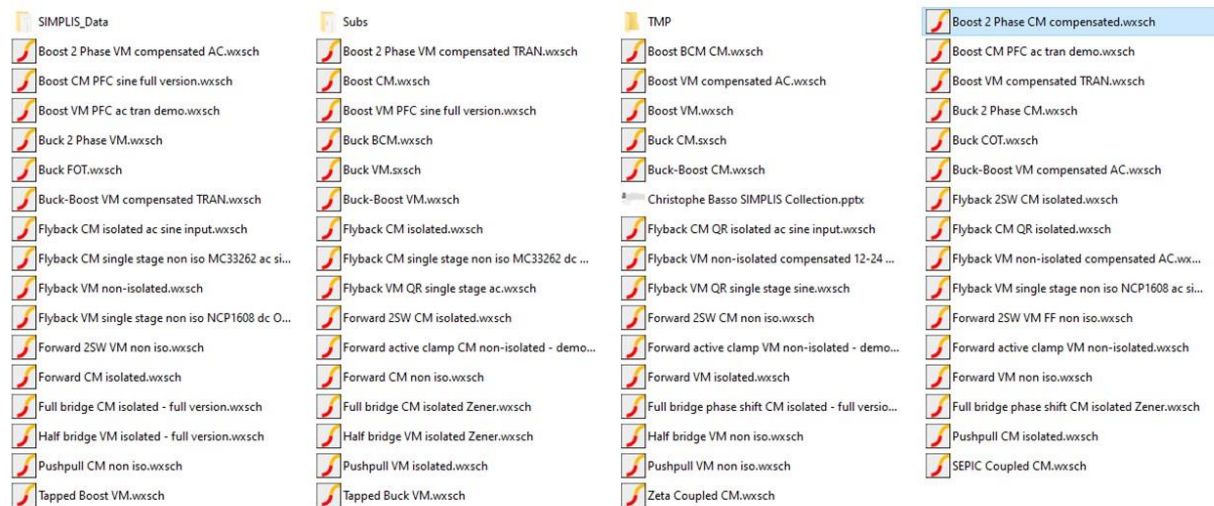
You have 63 ready-to-simulate switching converters to play with!

Fig 1. The 63 switching power converters built in SIMPLIS are free ready-to-simulate circuits that power supply designers can use as design templates, most of which can run in the free demo software, Elements.

The Template – it is a ready-to-simulate circuit. Load it, press F9 and there you go:

Transient response

Compensated loop gain

This is a fixed-frequency current-mode-controlled flyback converter delivering 19 V 3 A from a 120-V source. Enable the 6-ohm load for ac analysis and disable the PWL source (right-click after selection) to see the transient response. Check Simulator>Edit Netlist (after preprocess) to see the calculated component values.

This is a typical converter for an ac-dc notebook adapter.

- Christophe Basso - Transfer Functions of Switching Converters -
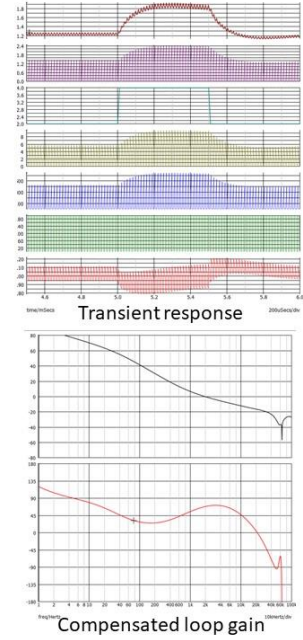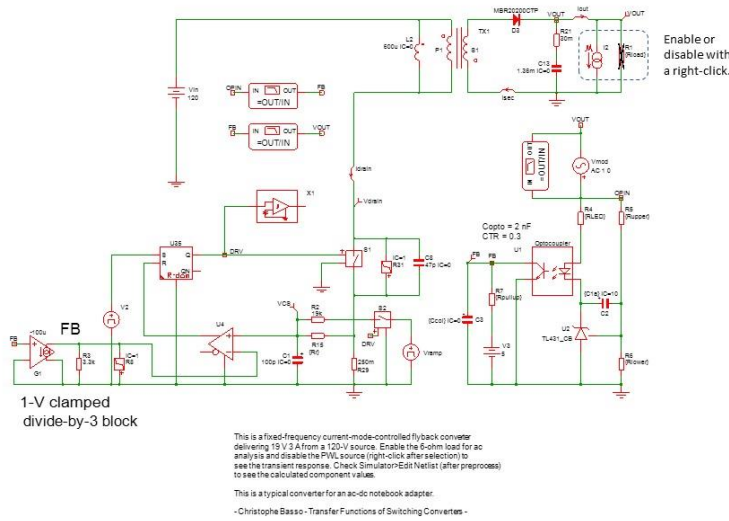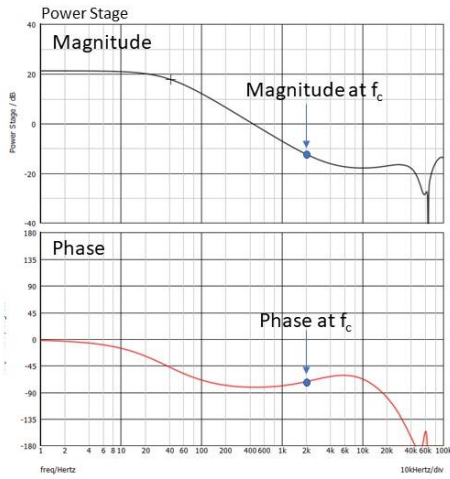
1-V clamped
divide-by-3 block

Fig. 2. Example circuit template for a fixed-frequency current-mode-controlled flyback converter with simulations of transient response and Bode plots of gain and phase.

The Compensation – display the power stage response at the selected operating point and extract parameters

Power Stage

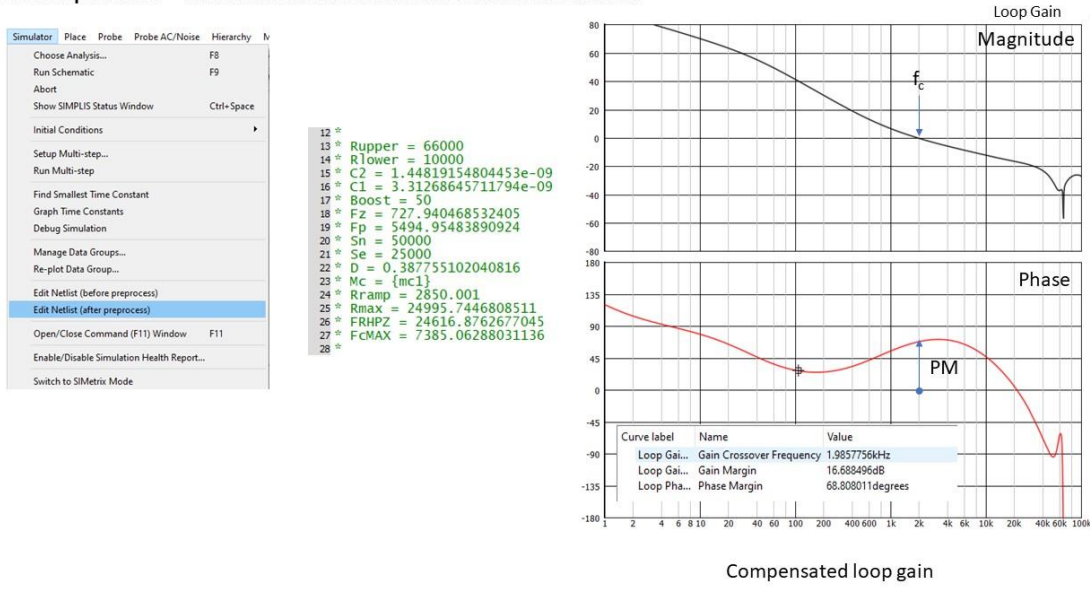Magnitude

Magnitude at f_c

Phase

Phase at f_c

Extract data at the selected crossover frequency.
Here, it is 2 kHz with a 60° phase margin as a goal.

```
*
.VAR Vin=120
.VAR Vout=19
.VAR Lp=600u
.VAR Ri=250m
.VAR N=250m
.VAR Rload=6
.VAR Ts=15u * please update clock and ramp generators *
*
.VAR D=Vout/(Vout+N*Vin) * duty ratio calculation *
.VAR mc1=0.818/(1-D) * recommended compensation value for a Q of 1 *
.VAR Sn={(Vin/Lp)*Ri}
.VAR Sramp={2.5/Ts} * 2.5 V over Ts - check your IC specs *
.VAR mc=1.5 * set this value for ramp comp *
.VAR Se={(mc-1)*Sn}
.VAR Rr={(Se/Sramp)*19k+1m}
.VAR RHPZ={((1-D)^2*Rload/(D*Lp*N^2))/(2*pi)}
.VAR fcMAX=0.3*fRHPZ
*
* Enter values extracted from the plant Bode plot
*
.VAR Gfc=-13 * magnitude at crossover *
.VAR PS=-80 * phase lag at crossover *
*
* Enter Design Goals Information Here *
*
.VAR fc=2k * targetted crossover *
.VAR PM=60 * choose phase margin at crossover *
*
* Enter the Values for Vout and Bridge Bias Current *
*
.VAR Vout=19
.VAR Ibias=250u
.VAR Vref1=2.5
.VAR Rlower=Vref1/Ibias
.VAR Rupper=(Vout-Vref1)/Ibias
*
* Optocoupler specifications *
*
.GLOBALVAR Rpullup=20k * check with the selected control chip *
.GLOBALVAR Fopto=6k
.GLOBALVAR Copto=1/(2*pi*Fopto*Rpullup)
.GLOBALVAR CTR=0.33
*
.VAR VL=0.2
.VAR VCEsat=0.3
.VAR Vdd=5
```
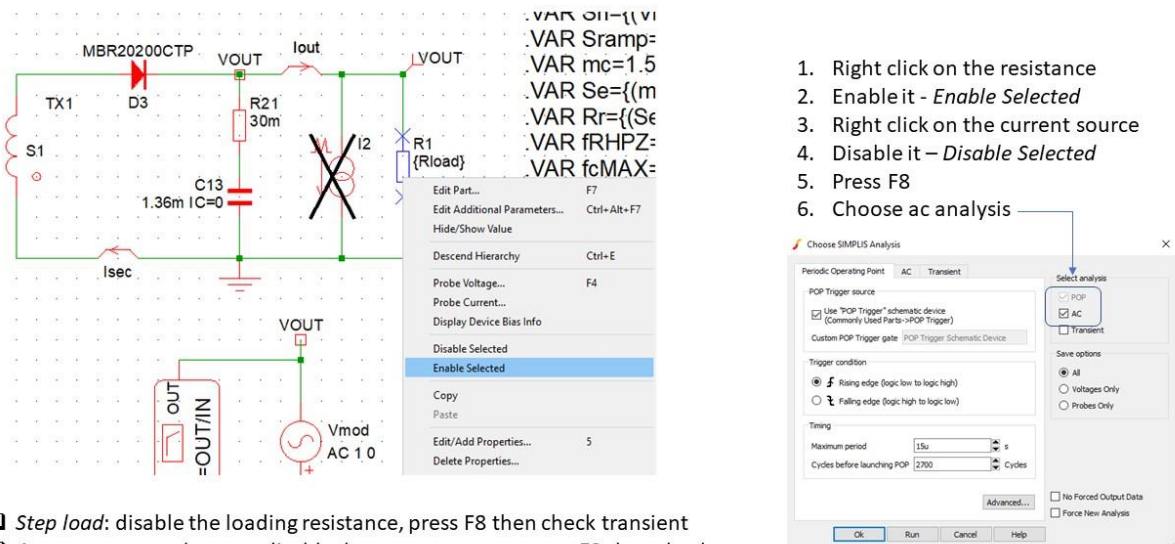
(a)

The Compensation – find all calculated values in the Edit Netlist submenu


```
12 *
13 *  Rupper = 66000
14 *  Rlower = 10000
15 *  C2 = 1.44819154804453e-09
16 *  C1 = 3.31268645711794e-09
17 *  Boost = 50
18 *  Fz = 727.940468532405
19 *  Fp = 5494.95483890924
20 *  Sn = 50000
21 *  Se = 25000
22 *  D = 0.387755102040816
23 *  Mc = {mc1}
24 *  Rramp = 2850.001
25 *  Rmax = 24995.7446808511
26 *  FRHPZ = 24616.8762677045
27 *  FcMAX = 7385.06288031136
28 *
```

| Curve label	Name	Value
Loop Gai...	Gain Crossover Frequency	1.9857756kHz
Loop Gai...	Gain Margin	16.688496dB
Loop Pha...	Phase Margin	68.808011degrees

Compensated loop gain

(b)

Fig. 3. Example of using SIMPLIS to extract the values of the compensation components from Bode plots of the power stage response (top screen). Accessing the values in the netlist (bottom screen).

The Template – change the load from a fixed resistance to a current source for the step load response

1. Right click on the resistance
2. Enable it - *Enable Selected*
3. Right click on the current source
4. Disable it – *Disable Selected*
5. Press F8
6. Choose ac analysis

❑ *Step load*: disable the loading resistance, press F8 then check transient
❑ *Ac sweep or steady-state*: disable the current source, press F8 then check ac analysis. The POP delivers the ac response and the operating waveforms.

Fig. 4. Example of simulating step load response in SIMPLIS' Elements.
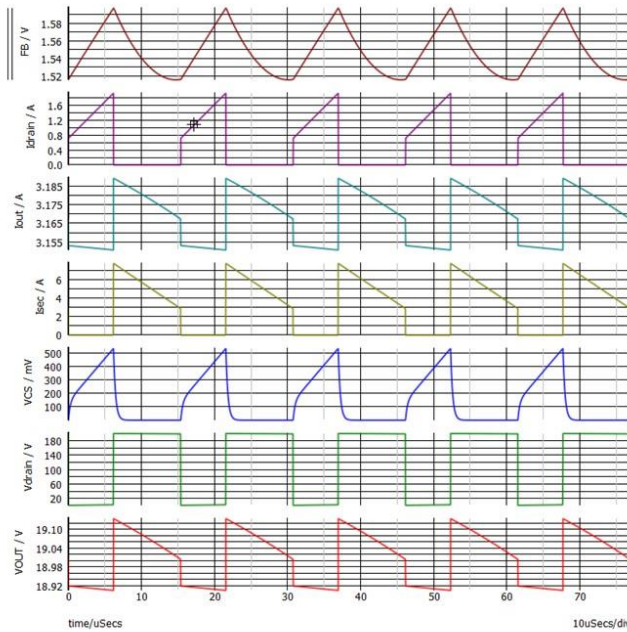
SIMPLIS® starts the ac analysis when the so-called periodic operating point or POP is found. The engine finds the exact point at which the converter is in a stable operating point also called steady-state operation. In this mode, the average current in any capacitor is extremely small (0 A in theory) while the average voltage across any inductor is also an extremely small value (0 V in theory). It happens that SIMPLIS® cannot find its POP and you have to help him converge. It can happen if you have selected a wrong target for a crossover frequency, a too aggressive phase margin or the converter can simply not be stabilized. Check the computed elements in the netlist to make sure there are no negative values. This is generally a sign of a wrong goal set for instance or a bad position of the double zeroes in the type 3 compensator. Running a transient analysis with a load resistance usually helps identify what is wrong.

Fig. 5. Example of running an ac analysis in SIMPLIS.