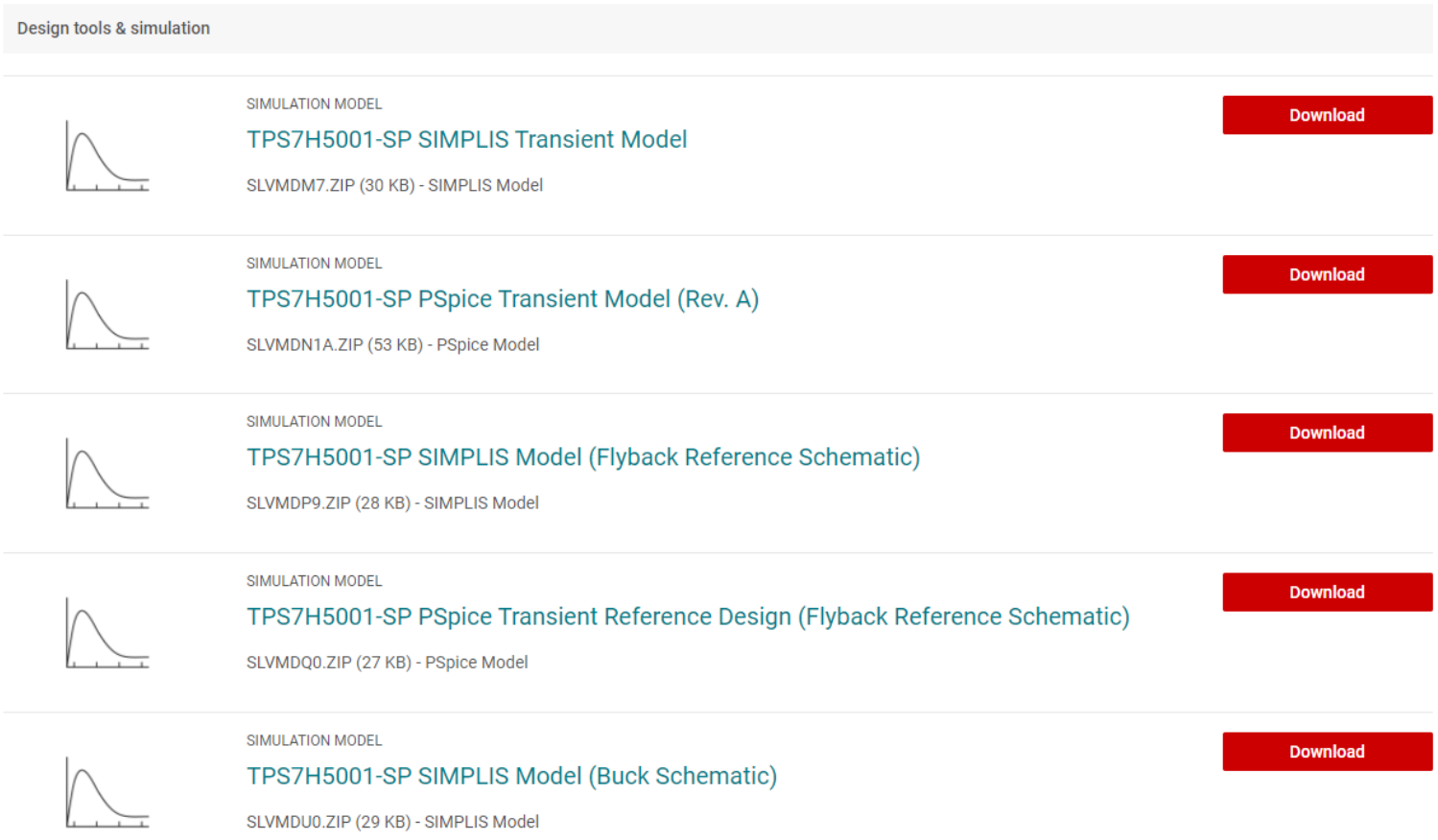
Flyback Design with TPS7H500X-SP family of controllers

Agenda

- Basic Overview
- Getting Started on Converter Design
  - Utilizing Power Stage Designer
- Starting with SIMPLIS Models
  - Basics
  - Worst Case Analysis
  - Radiation Effects

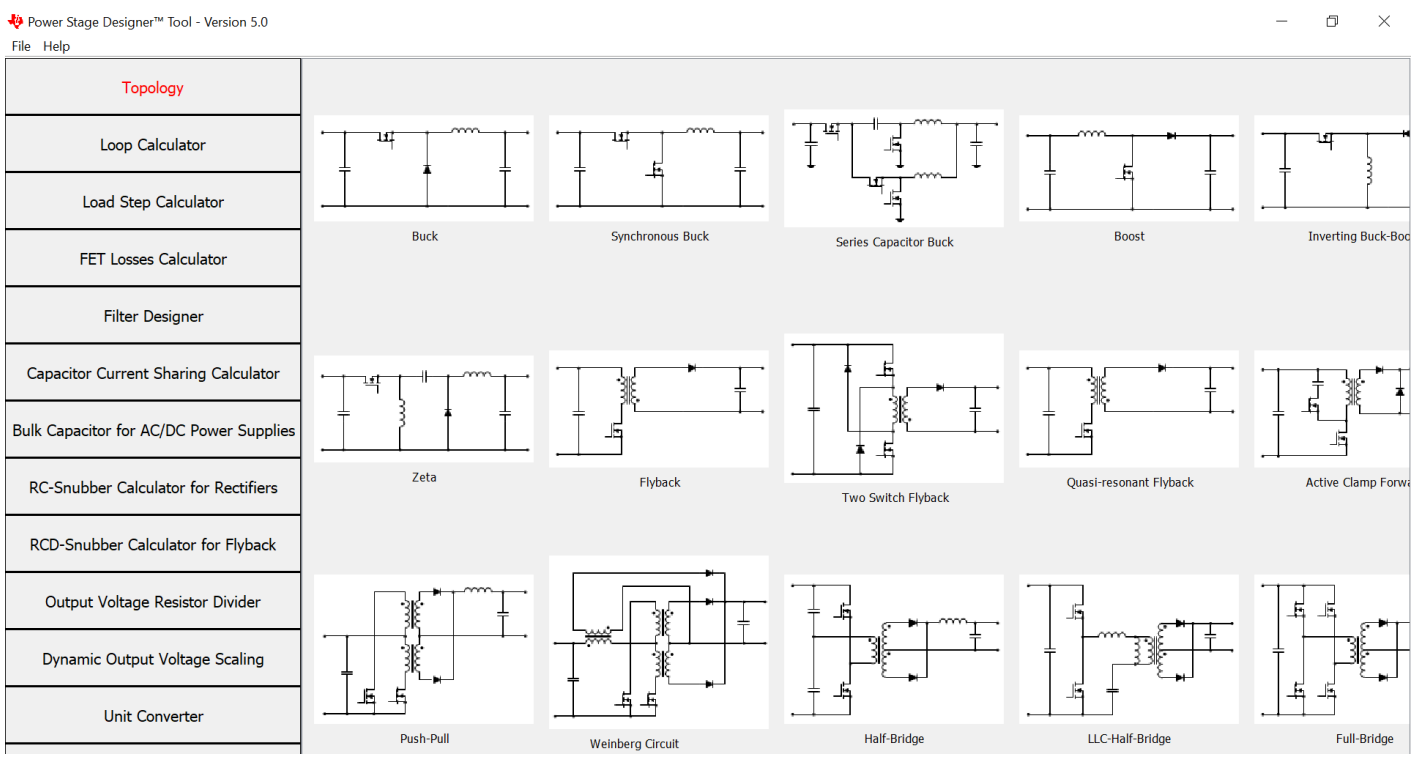
Basic overview

- Basic converter schematics are available on ti.com
- Too many to fit on single page
- Can be used as a starting point for designs
- All models come with a basic schematic, with the default being a push-pull converter



Getting started on Converter Design

- Power stage designer is a great tool to look at the basics of the converter
- Works for multiple different topologies
- Has many different calculators to help with different aspects of the design



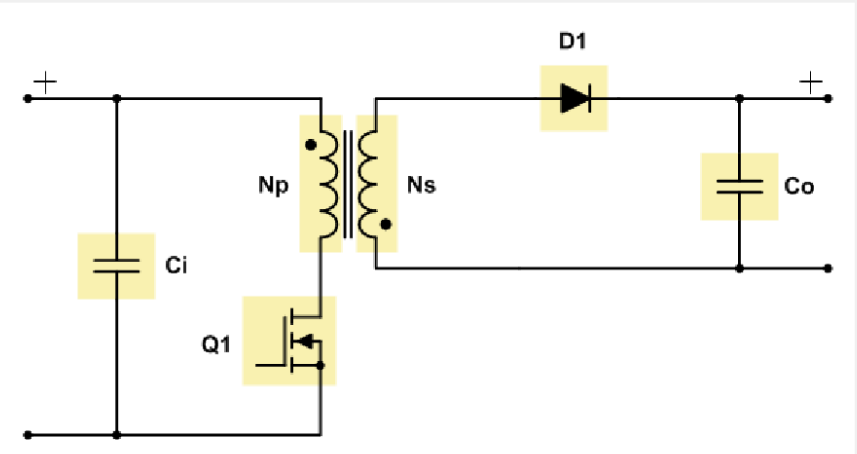
Getting started on Converter Design

- Looking at each converter you can see suggestions on transformer design as well as inductor design
- Basic calculations are listed at the bottom
- Information on the equations are listed under the help tab at the top (not shown here)

Design Values

Minimum Input Voltage:	28	V
Maximum Input Voltage:	28	V
Output Voltage:	5	V
Output Current:	10	A
Switching Frequency:	500	kHz
Diode Voltage Drop:	0.7	V
Current Ripple:	30	%
Maximum Duty Cycle:	30	%

- ○ Discontinuous Conduction Mode
- ○ Boundary Mode
- ◉ Continuous Conduction Mode
- ○ Transition Mode



Recommended Values

Turns Ratio:	2.11	: 1
Inductance:	8.25	µH

Choose Values

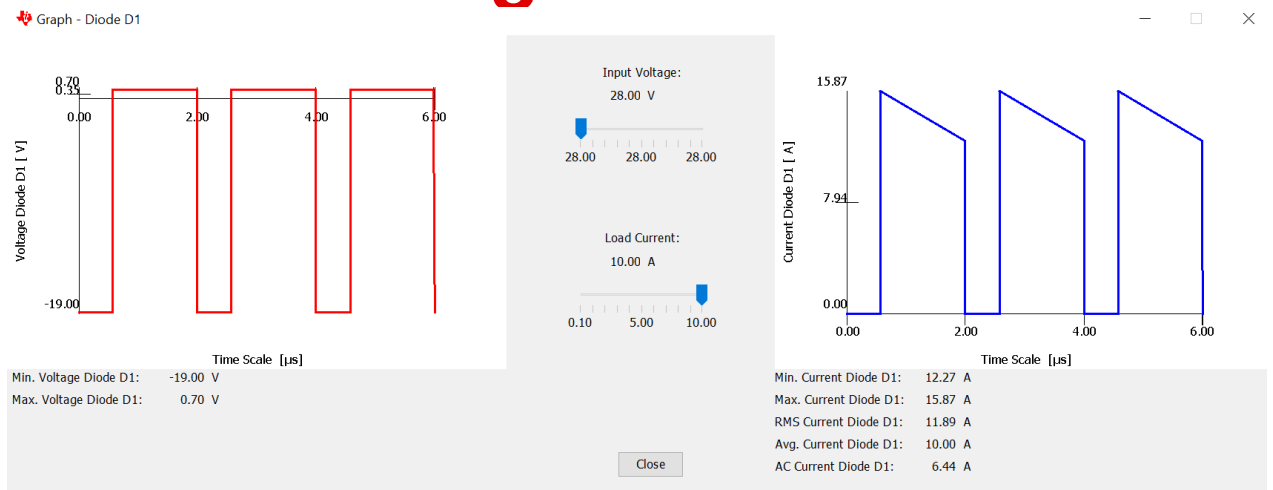
Turns Ratio:	2	: 1
Inductance:	9	µH

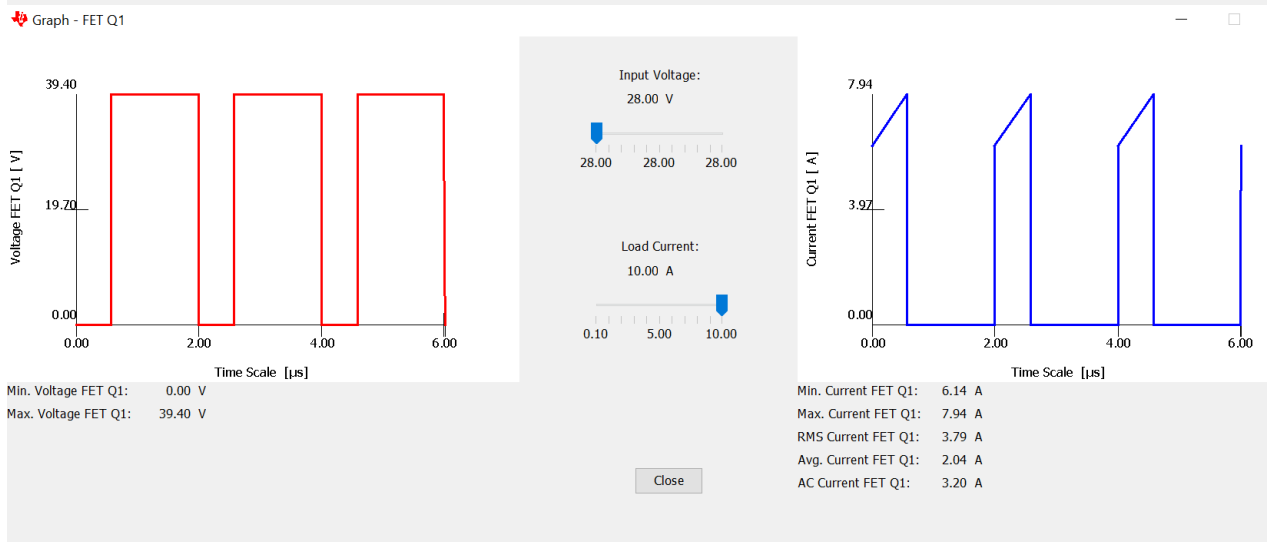
Calculated Values at Input Voltage: 28.00 V **Load Current: 10.00 A**

Switch. Freq.:	500.00 kHz	Input Power:	57.00 W	L_{sec}:	2.25 µH
Period:	2.00 µs	Output Power:	50.00 W	Input Current:	2.04 A
Duty Cycle:	28.93 %	Diode Losses:	7.00 W	Current Ripple:	1.80 A
On-Time:	0.58 µs				25.59 %
Off-Time:	1.42 µs				
Zero-Time:	0.00 µs				
RHPZ:	61.73 kHz				

Getting started on Converter Design

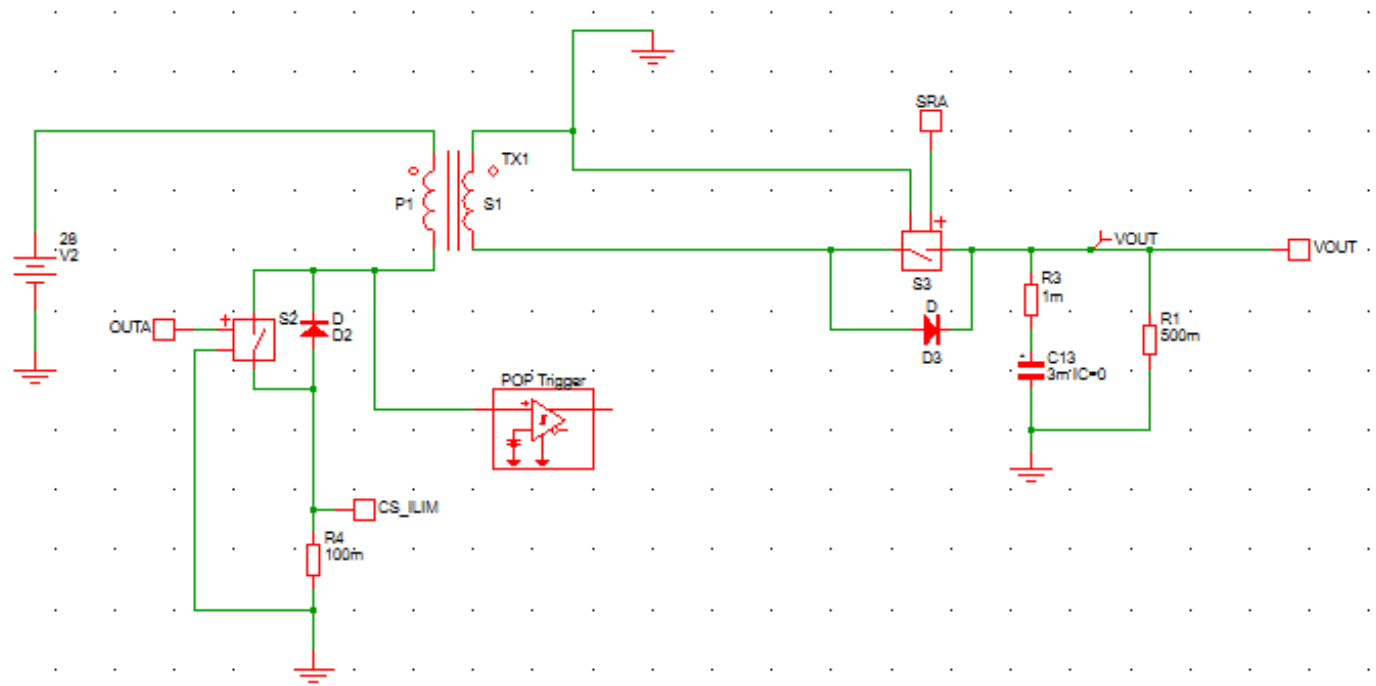
- Clicking on the yellow sections shows basic current and voltage stresses on the parts
- This does not include spikes from parasitics or increases in current from efficiency
- This can be looked at for different output currents and input voltages





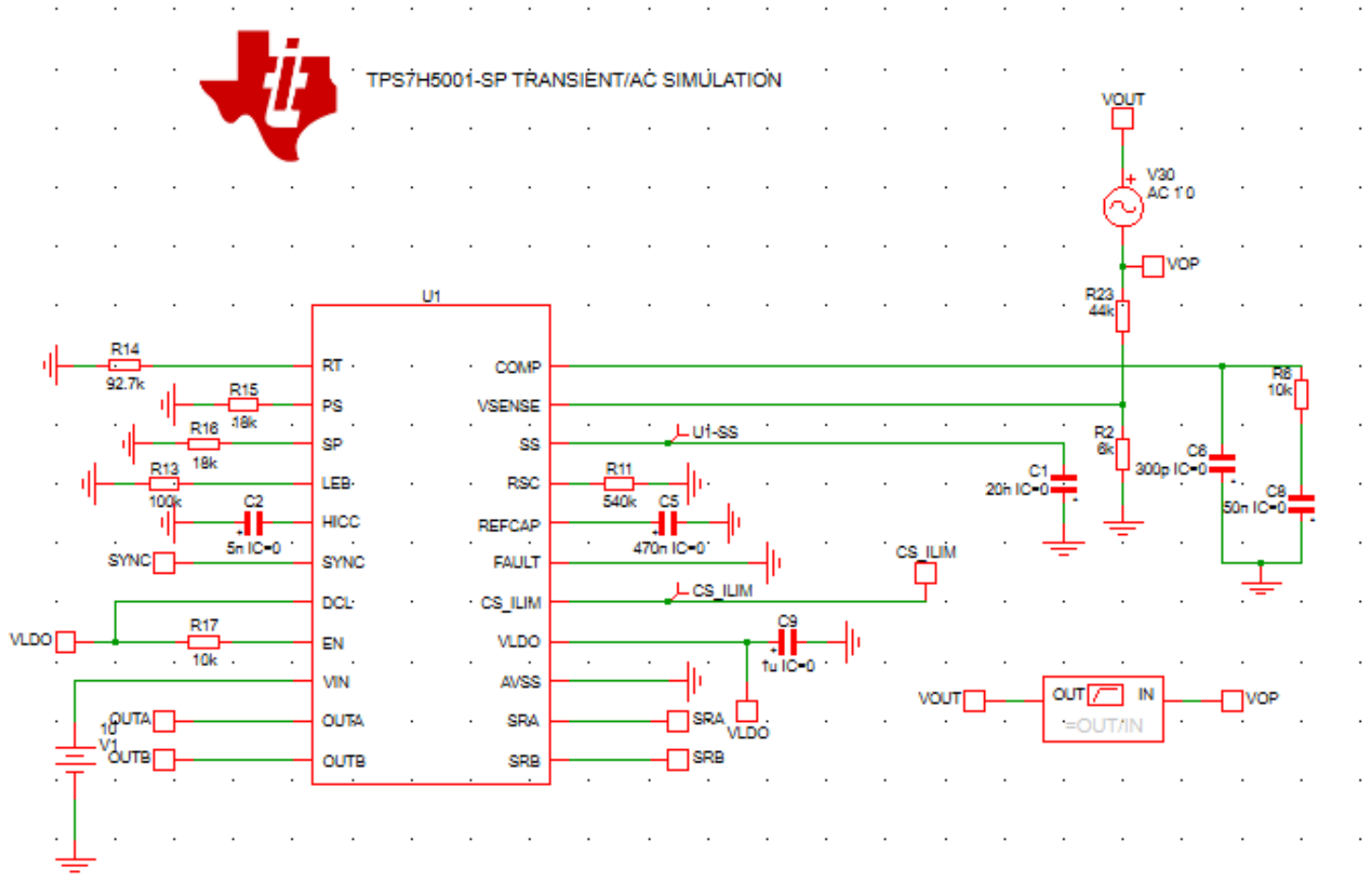
Starting with SIMPLIS models

- Can be used as a starting point for designs
- POP trigger is important for AC analysis and will be gone over more later
- Basic models are used by default, can be replaced with more complicated models



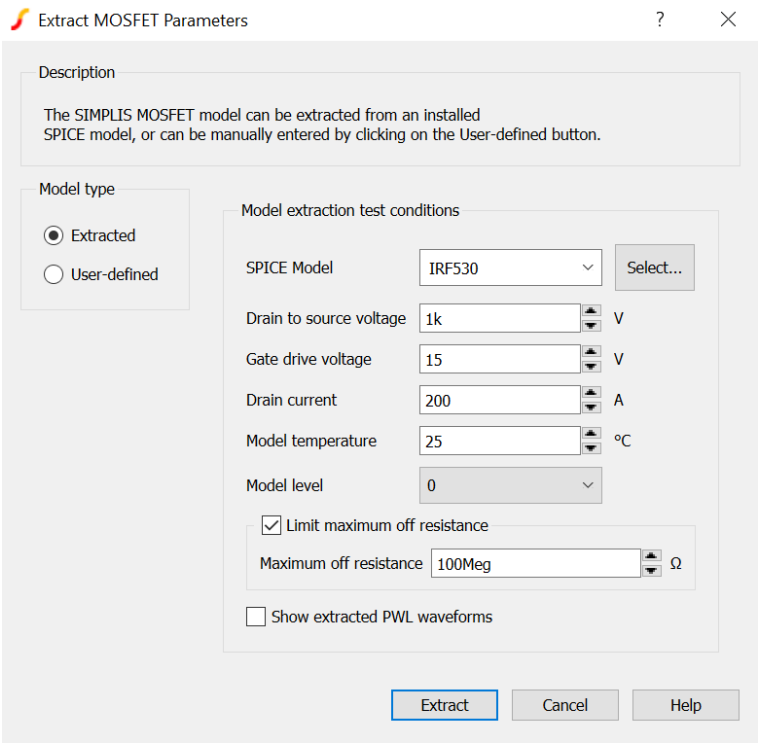
Starting with SIMPLIS models

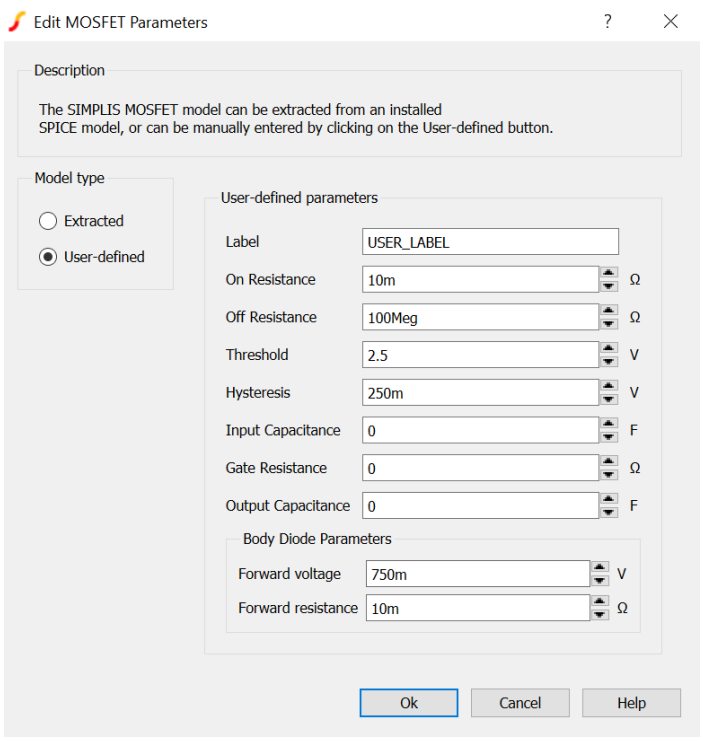
- This is the TPS7H5001-SP model that was developed
- V30 and OUT/IN block are used for AC analysis and don’t affect transient analysis
- Note that no driver is included in supplied schematics, but is needed in final design.
- Note SS value is generally placed lower during debug



Starting with SIMPLIS models

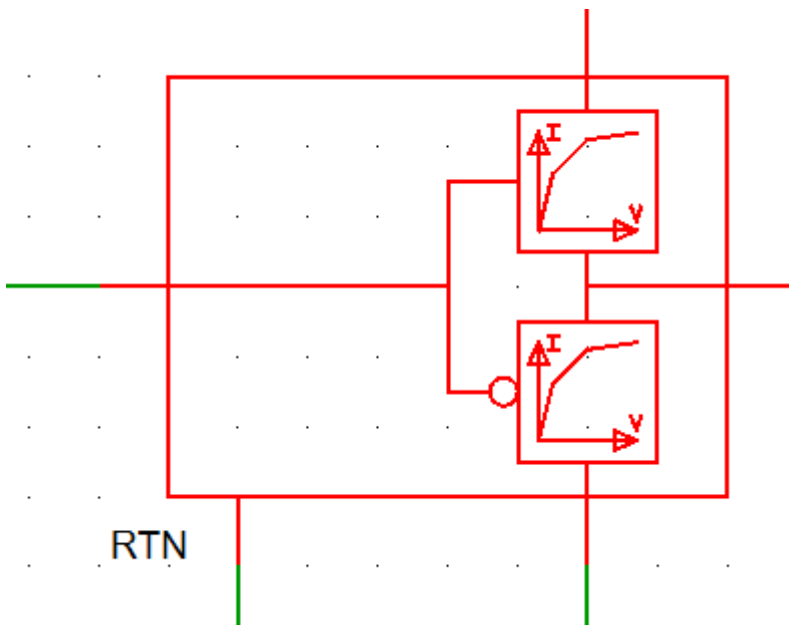
- Switches in design can be replaced
- Both imported models and user defined models are supported
- Note that some non-linearities and a slow down of simulation is to be expected

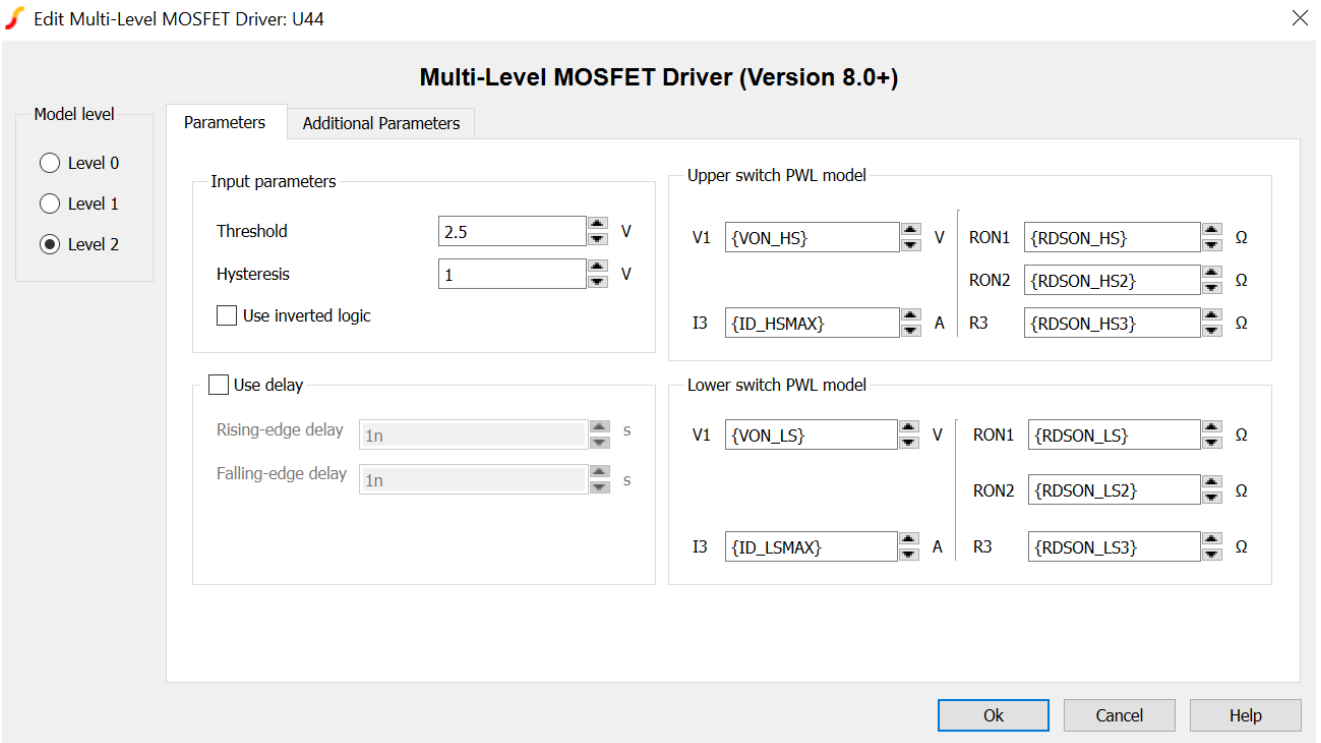




Starting with SIMPLIS models

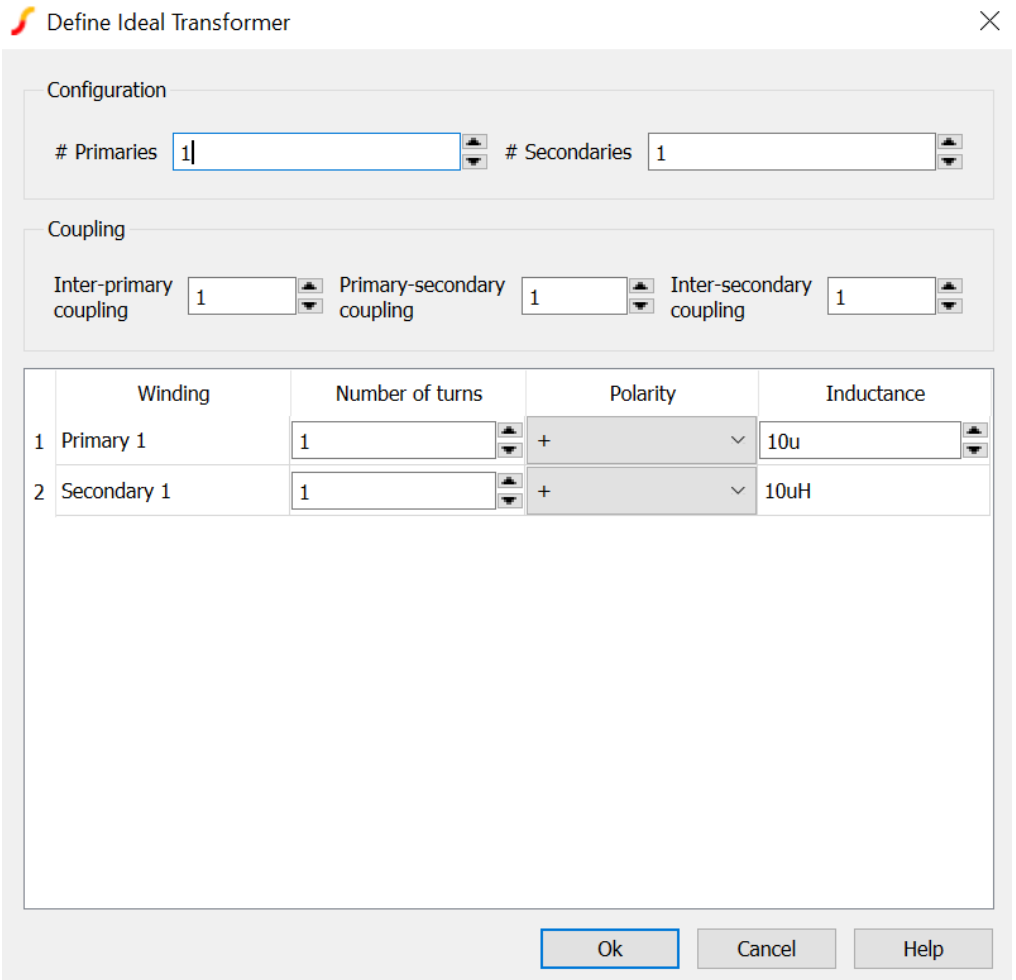
- A driver model is required in order to use the MOSFET models properly
- Refer to SIMPLIS website





Starting with SIMPLIS models

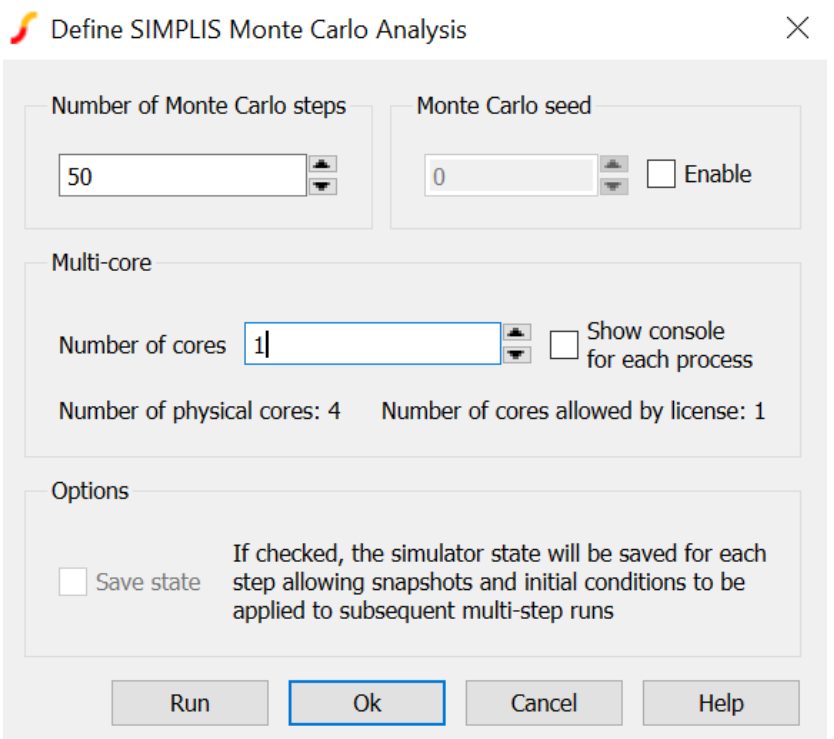
- Ideal transformers are suggested to be used
- Putting the number of turns as well as the primary inductance auto fills the secondary inductance
- Coupling can be changed as well as number of turns on each side



Starting with SIMPLIS models

- WCA modeling can be done when model is released with F11 window
- Parameters GMEA, VREF, and CCSR can be varied using the SIMPLIS functions
- SIMPLIS has different variations based on 6 sigma, or even just looking at corners
- Monte Carlo -> Set-up brings up the window to the right
- Monte Carlo will be ran on whatever simulation you have prepared.

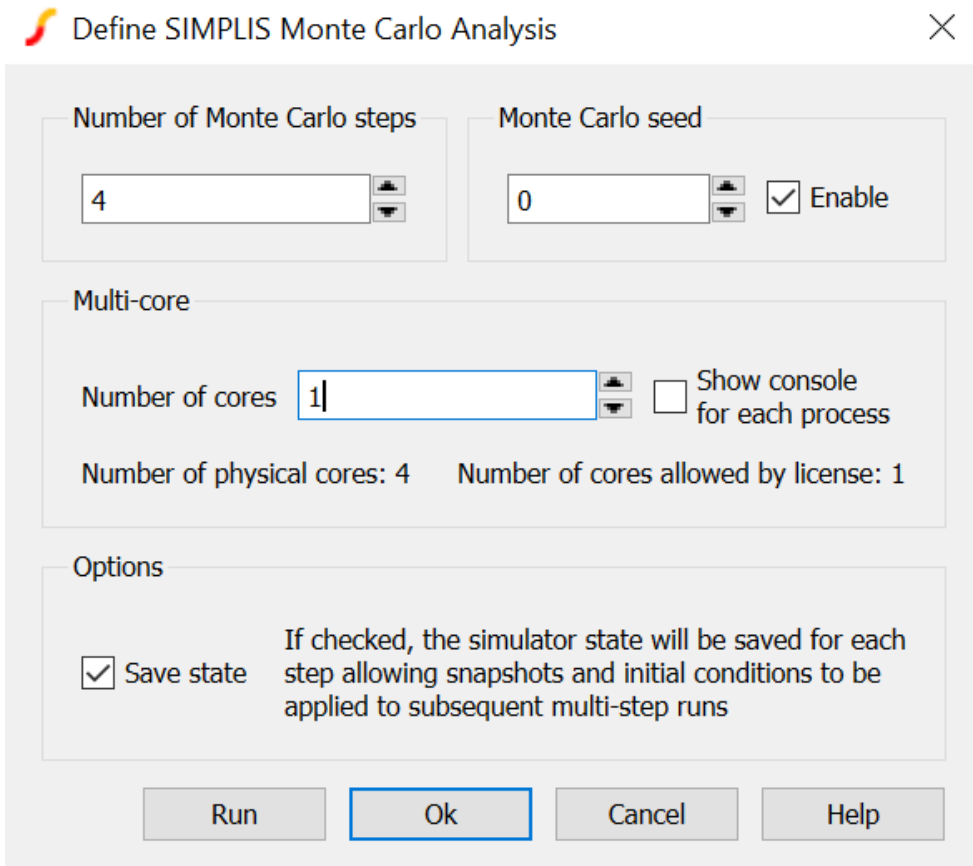
```
25 .GLOBALVAR gmea = 1.825m*WC(0.37)
26 .GLOBALVAR Vr = 0.613*WC(0.01)
27 .GLOBALVAR Rtt = (1.23-Vr)*1000/Vr
28 .GLOBALVAR IDComp = 1/(2.06*WC(0.029))
```



Starting with SIMPLIS models

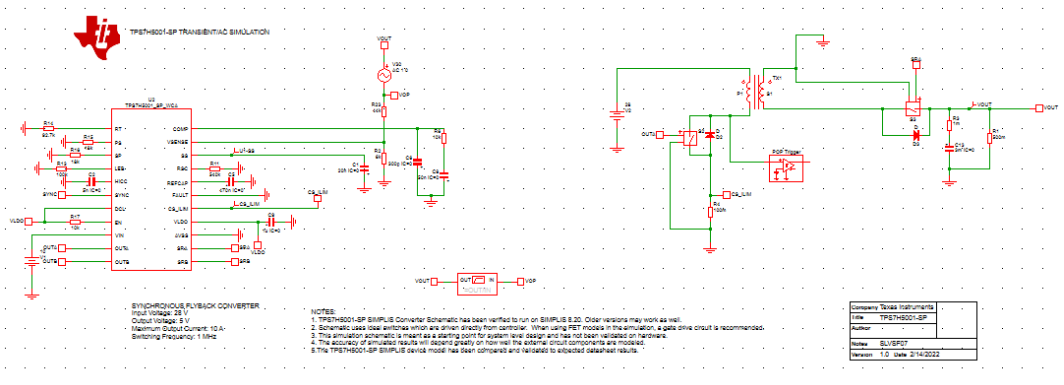
- Monte Carlo analysis will be run with a number of runs equal to the number of steps you provide

- To look at a specific run that was previously looked at, the Monte Carlo seed can be put in to re-run those specific parameters



Starting with SIMPLIS models

- Worst Case Analysis can be ran on 3 different internal parameters
- These parameters were determined to be most influential on transient performance
- The default schematic provided is a flyback



Parameter	Description	Default Mean Value	Default Tol- Value
gmea	Model variable for the error amplifier transconductance	1825 µS	37 %
Vr	Model variable for the reference voltage	0.613 V	1 %
Rtt	Internal variable related to the voltage reference. Changing the equation will cause model to work improperly.	N/A	N/A
IDCOMP	Model variable for CCSR parameter	2.06	2.9%

Starting with SIMPLIS models

- By pressing F11 in SIMPLIS simulator you can access the variables
- Changing the names of the variables can cause issues with the model
- By default the simulator only considers the edges of the ranges
- If a typical run is wanted, simply comment out the range the value is being multiplied by with a *.

```
.simulator SIMPLIS
.ac DEC 25 100m 1Meg
.print
+ ALL
.options
+ PSP_NPT=1001
+ POP_ITRMAX=20
+ POP_USE_TRAN_SNAPSHOT
+ POP_OUTPUT_CYCLES=5
+ POP_SHOWDATA
+ SNAPSHOT_INTVL=0
+ SNAPSHOT_NPT=11
+ NEW_ANALYSIS
+ MIN_AVG_TOPOLOGY_DUR=1a
+ AVG_TOPOLOGY_DUR_MEASUREMENT_WINDOW=128
.pop
+ TRIG_GATE={TRIG_GATE}
+ TRIG_COND=0_TO_1
+ MAX_PERIOD=2u
+ CONVERGENCE=10p
+ CYCLES_BEFORE_LAUNCH=4000
+ TD_RUN_AFTER_POP_FAILS=-1
*.tran 30m 0

*.Do not change the names of these global variables or the model will not work
.GLOBALVAR gmea = 1.825m*WC(0.37)
.GLOBALVAR Vr = 0.613*WC(0.01)
.GLOBALVAR Rtt = (1.23-Vr)*1000/Vr
.GLOBALVAR IDComp = 1/(2.06*WC(0.029))
.simulator DEFAULT

```

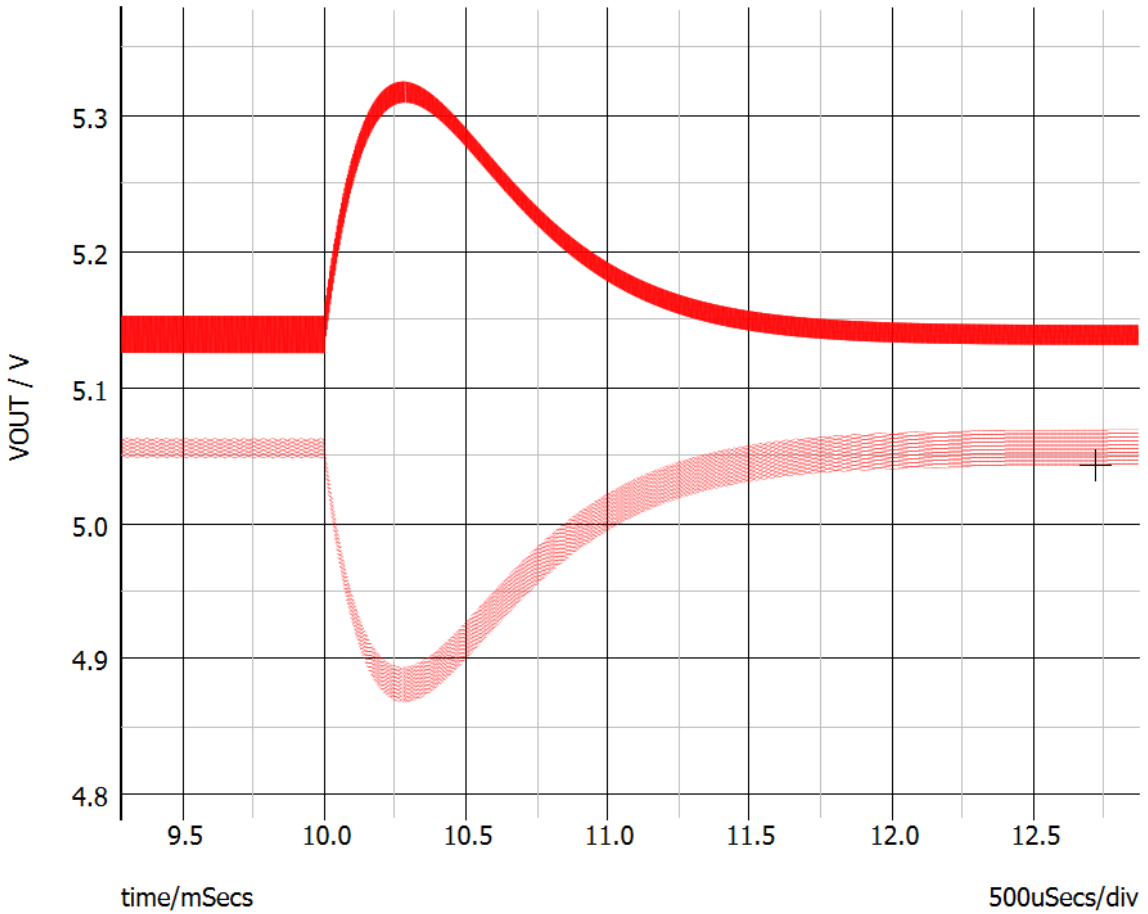
Starting with SIMPLIS models

- What values can be picked in worst case analysis can be changed depending on what is needed for your design
- Values in-between the two extremes can be picked with any of the other distributions

Distribution Name	Definition
WC(tol)	Worst-Case. Returns either 1.0-**tol** or 1.0+**tol** chosen at random.
Unif(tol)	Uniform. Returns a random value in the range 1.0 +/- **tol** with a uniform distribution.
GaussTrunc(tol)	Truncated Gaussian. As with Gauss() but values greater than (1 + **tol**) and less than (1 - **tol**) are rejected, and the program picks another random number inside the Gaussian distribution.
Gauss(tol)	Gaussian. Returns a random number with a mean of 1.0 and a standard deviation of **tol**/3. Random values have a Gaussian or Normal distribution.

Starting with SIMPLIS models

- Changing the values in the WCA model also allow for looking at worst case transients due to the selected parameters
- Here the slowest/lowest value of GMPS is used as well as changing the VREF value in order to get the worst case transient range
- Very useful for looking at how much room there is for tolerances



Starting with SIMPLIS models

- If SIMPLIS is not your simulator of choice for worst case analysis all information used to create the model is in the Worst Case Analysis model user guide

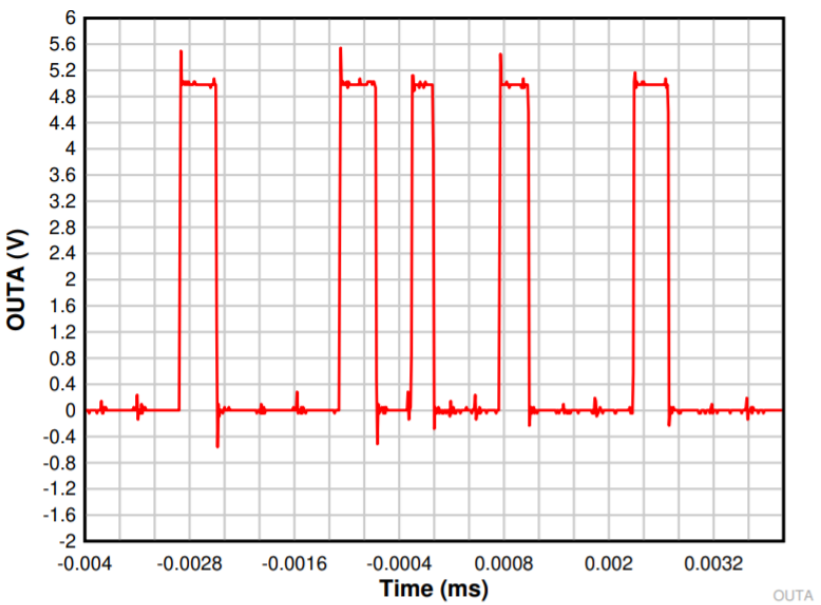
- This allows users to change values in both the SIMPLIS model as well as any model they plan to make to fit their exact needs.

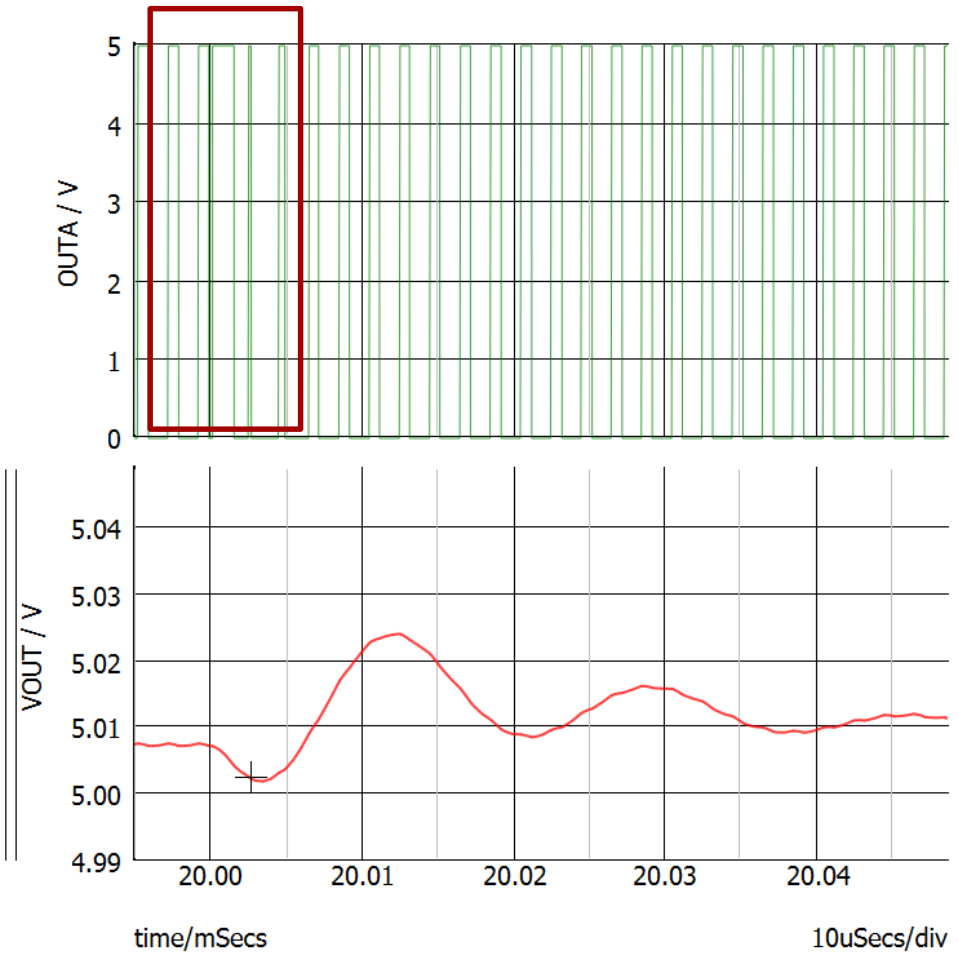
Table 1-3. COMP to CS_ILIM Ratio Variation

Test	Temperature	Min	Mean	Max	Standard Deviation	Population
Pre-Life/Pre-Radiation	-55°C	2.030	2.048	2.072	0.00956	30
Pre-Life/Pre-Radiation	25°C	2.030	2.047	2.083	0.0121	30
Pre-Life/Pre-Radiation	125°C	2.041	2.055	2.083	0.0116	30
Post-Life	-55°C	2.030	2.048	2.083	0.00992	87
Post-Life	25°C	2.025	2.049	2.089	0.0137	87
Post-Life	125°C	2.036	2.057	2.094	0.0133	87
Post-LDR Radiation	25°C	2.030	2.049	2.089	0.0102	80
Post-HDR Radiation	25°C	2.025	2.053	2.117	0.0162	70

Starting with SIMPLIS models

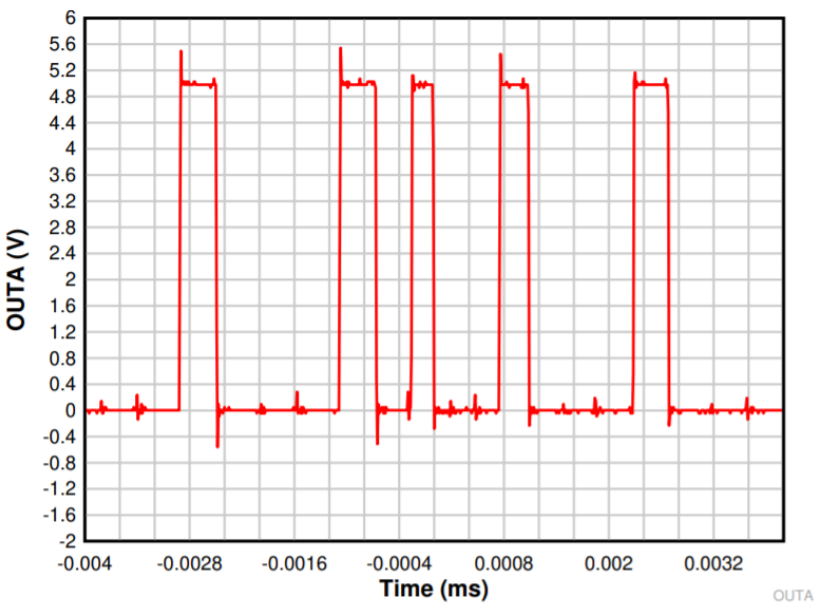
- SET performance can be simulated by pulling current out of the RT pin
- 1 mA of current was pulled out of RT pin for 1 us in order to cause event

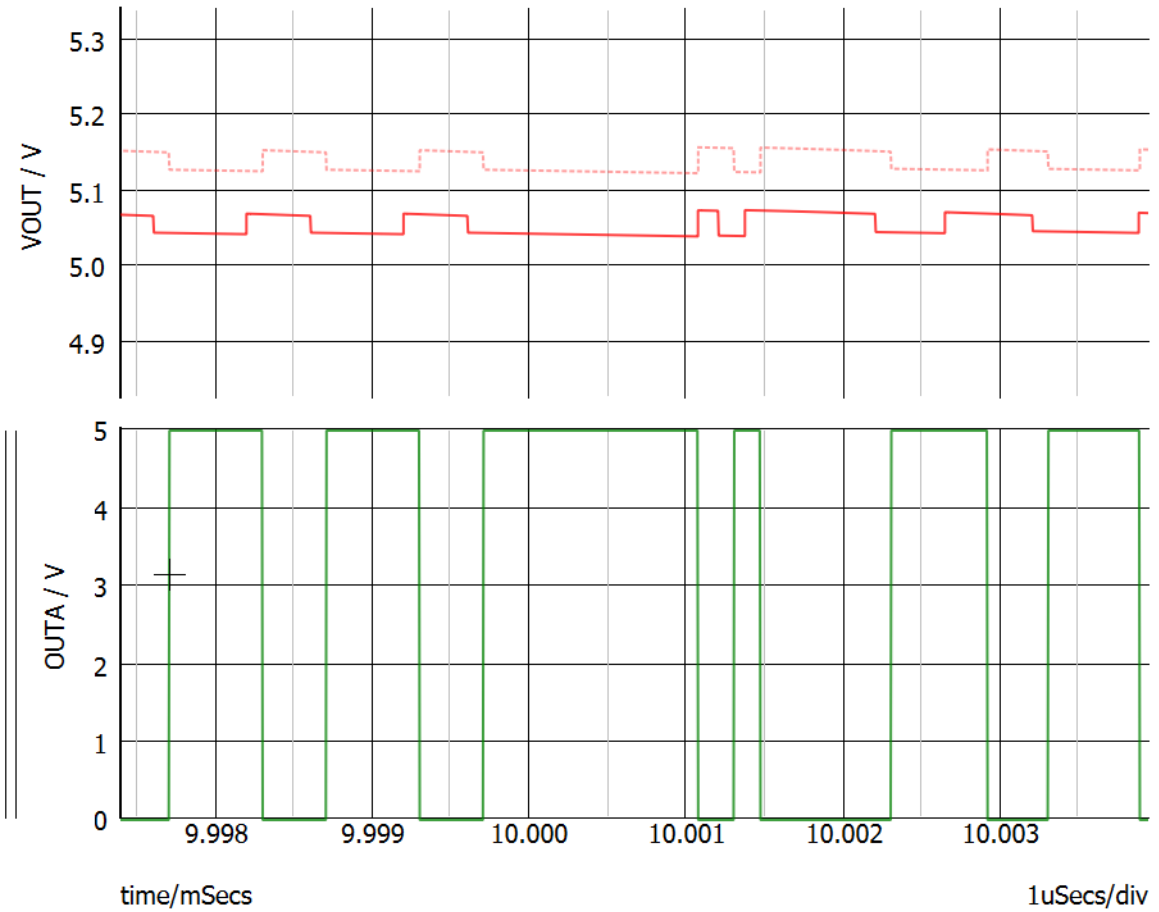




Starting with SIMPLIS models

- This can be combined with WCA in order to look at multiple different parameters or even different radiation effects





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