

* These are additional circuit elements.
 NSX
 K1 Lpwr1 Lpwr2 0.5
 K2 Lpwr2 Lpwr3 0.5
 K3 Lpwr3 Lpwr1 0.5

Mains and Surge Generator Models:

Mains modeled as 100 feet of conduit with line-line inductance of 100 uH, partially coupled with the additional circuit elements in the text box to the left of this note. <http://www.steelconduit.org/pdf/groundingpart1.PDF>

Surge generator and CDN models come from a presentation given by Douglas Powell and Bryce Hesterman of Advanced Energy at PELS Denver Chapter Meeting, Sept. 18, 2007: http://www.denverpels.org/Downloads/Denver_PELS_20070918_Hesterman_Voltage_Surge_Immunity.pdf.

Running the Simulation:

Changes to default options to get it to simulate when using Littelfuse MOV models:
 Integration method: trapezoidal -> gear 2
 ITL4: 40 -> 400
 Adjustments to ABSTOL, RELTOL, and VNTOL.

I changed to simplified MOV models that I made, (in the simpleMOVmodel.ckt file), rather than the Linelfuse models that have discontinuous derivatives. After that, I did not need to change ABSTOL, RELTOL, or VNTOL, but kept the changed integration method and iteration limits.

Choose simulation components as needed, making sure to ground unused ones.

Choose a surge voltage level by adjusting the value of Vsurge.

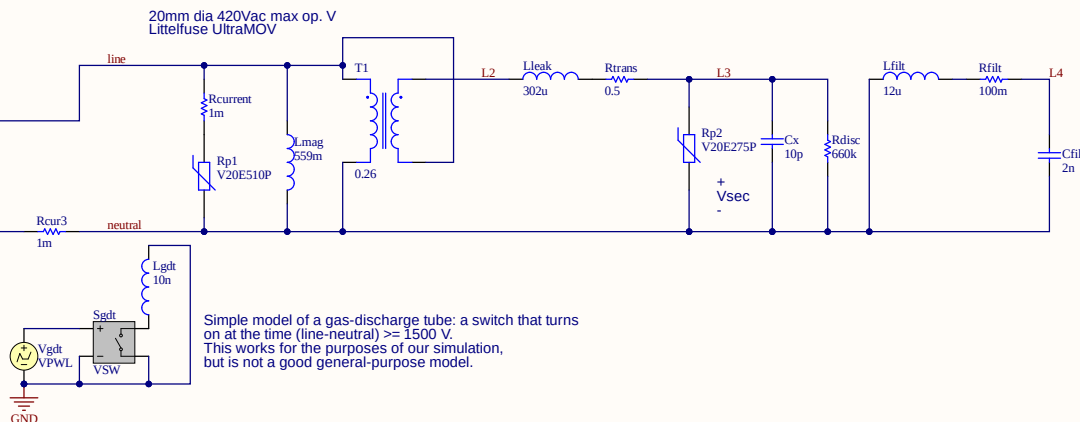
Surge generator is a 2-ohm source impedance for Line-Neutral tests. Add a 10-ohm resistor in series with Cc4 if the surge is applied between Line or Neutral and GND (Protective Earth).

Validate those simple MOV models with the "MOV_validation" schematic.
 Simulate this circuit with the "Transient" simulation profile.

autotransformer from COTS regular range 230 V voltage stabilizer
 pri: 559 mH, sec: 38.7 mH, output leakage 302 uH
 Modeled with ideal transformer, Lmag, and Lleak

optional additional output filter

turns ratio as autotransformer: out/in = 1.26/1



Simple model of a gas-discharge tube: a switch that turns on at the time (line-neutral) >= 1500 V.
 This works for the purposes of our simulation, but is not a good general-purpose model.

Second stage clamping:
 With 1 mH, 0.5 ohm, 10pF (not much filtering): Vsec is 566V for "typ" and 651V for "max" clamping voltage models.
 With simulated Sollatek boosting 1.2x and 10 pF, +695V, ~ 643V.
 With simulated Sollatek boosting and 500uH 4.7uF filter: +420V at output of filter.
 With simulated Sollatek 1:1 (0.6 ohms between MOVs), Vsec is 731V.

File History:

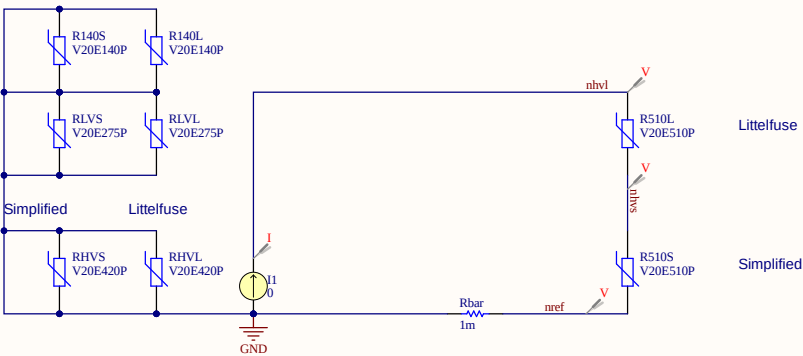
Original sim. schematic was in Rod's folder: C:\NH\Projects\SurgeSuppress\Circuits, since moved to Z:\Shared\Projects\MetaFridge\Archive MetaFridge\Folders\RodHinman\PreliminarySurgeSuppress.

2021-01 This simulation project created for PQS VS Application Note, based on above. 2021 sim. circuit has a transformer coupled inductor model for T1 from the "Miscellaneous Devices" library, and is in the RegularRangeSim_orig.SchDoc file in this project's folder, but not added as part of the project.

2022-08 Simulation software update seems to have created an error in the coupled-inductor transformer. Change to use the ideal transformer from the "Simulation Generic Components" Altium library.

Title: PQS VS01 Impulse Simulation		
Size: B	Sheet: Surge (Combo) Transient	Revision: 1.0
Date: 5/24/2025	Sheet 1 of 2	Drawn by: Rod Hinman
File: C:\Users\Public\Documents\Altium\Protection_module_sim\ComboWaveSim.SchDoc		





Compares simplified MOV models I made for max clamp voltage to Littelfuse models that I think model the typical clamping voltage (it is lower).

Varistors_UltraMOV_PSPICE_model_lib.ckt contains models made by Littelfuse that don't simulate too well for transients. I suspect that discontinuities (in output or first derivative) cause time step adjustments until "timestep too small" error is reached.

Models named:
V20ExxxP: Where xxx is the maximum working voltage of the part.

simpleMOVmodel.ckt has models that I made:
V20ExxxM: for the maximum clamping voltage, and
V20ExxxT: roughly match Littelfuse's models for the parts, which I suspect are for typical clamping voltages.

Note that I've needed to remove the model library file from the project and re-add it if I change the name of the models or add new ones. For some reason, Altium reads changes to parameters in the file if it is saved again, but does not rescan for new models, and doesn't recognize new ones.

Changes to default options to get it to simulate:
Integration method: trapezoidal -> gear 2
ITL4: 40 -> 400
I did not need to change ABSTOL, RELTOL, or VNTOL.

Simulate this circuit with the "MOVmodel" simulation profile.

Comment	Description	Designator	Footprint	LibRef	Quantity
1u	Capacitor	Cc1, Cc2, Cc3	RAD-0.3	Cap	3
18u	Capacitor	Cc4	RAD-0.3	Cap	1
2n	Capacitor	Cfilt	RAD-0.3	Cap	1
6.04u	Capacitor	Cs	RAD-0.3	Cap	1
10p	Capacitor	Cx	RAD-0.3	Cap	1
1.082	Voltage Controlled Voltage Source	E1		ESRC	1
ISRC	Current Source	I1		ISRC	1
1.5mH	Inductor	Lc1, Lc2	0402-A	Inductor	2
12u	Inductor	Lfilt	0402-A	Inductor	1
10n	Inductor	Lgdt	0402-A	Inductor	1
302u	Inductor	Lleak	0402-A	Inductor	1
559m	Inductor	Lmag	0402-A	Inductor	1
100u	Inductor	Lpwr1, Lpwr2, Lpwr3	0402-A	Inductor	3
10.4u	Inductor	Ls	0402-A	Inductor	1
V20E140P	Varistor (Voltage-Sensitive Resistor)	R140L, R140S	6-0805_L	Res Varistor	2
V20E510P	Varistor (Voltage-Sensitive Resistor)	R510L, R510S, Rp1	6-0805_L	Res Varistor	3
1m	Resistor	Rbar, Rc1, Rc2, Rc3, Rcur3, Rcurrent	AXIAL-0.3	Res1	6
660k	Resistor	Rdisc	AXIAL-0.3	Res1	1
100m	Resistor	Rfilt	AXIAL-0.3	Res1	1
V20E420P	Varistor (Voltage-Sensitive Resistor)	RHVL, RHVS	6-0805_L	Res Varistor	2
V20E275P	Varistor (Voltage-Sensitive Resistor)	RLVL, RLVS, Rp2	6-0805_L	Res Varistor	3
0.1	Resistor	Rpwr1, Rpwr2, Rpwr3	AXIAL-0.3	Res1	3
1K	Resistor	Rs1	AXIAL-0.3	Res1	1
25.1	Resistor	Rs2	AXIAL-0.3	Res1	1
0.94	Resistor	Rs3	AXIAL-0.3	Res1	1
19.8	Resistor	Rs4	AXIAL-0.3	Res1	1
0.5	Resistor	Rtrans	AXIAL-0.3	Res1	1
VSW	Voltage Controlled Switch	Sgdt, Ss		VSW	2
Ideal Transformer	Ideal Transformer	T1		Transformer Ideal	1
VPWL	Piecewise Linear Voltage Source	Vgdt, Vs		VPWL	2
0	Voltage Source	Vmains		VSRC	1
2kV	Voltage Source	Vsurge		VSRC	1