Design Models

How to Use LTspice® Models: Tips for Improving Convergence

An analysis error or unstable result from the LTspice simulation suggests a problem with the convergence. The convergence problem can be avoided by changing the simulator settings. This application note introduces methods for improving the convergence mainly in circuits containing the subcircuit models by changing the LTspice settings. The countermeasures introduced below are not effective to all circuits. Use this application note as reference for avoiding the simulation errors.

How to change the simulator option settings

In case a simulation does not converge, LTspice provides options to change the settings. As shown in Figure 1, you can open the "Control Panel" and then change the settings defined in the "SPICE" tab. In addition, the ".OPTION" command allows you to change the parameters not displayed in the panel, including "itl1" and "itl2".

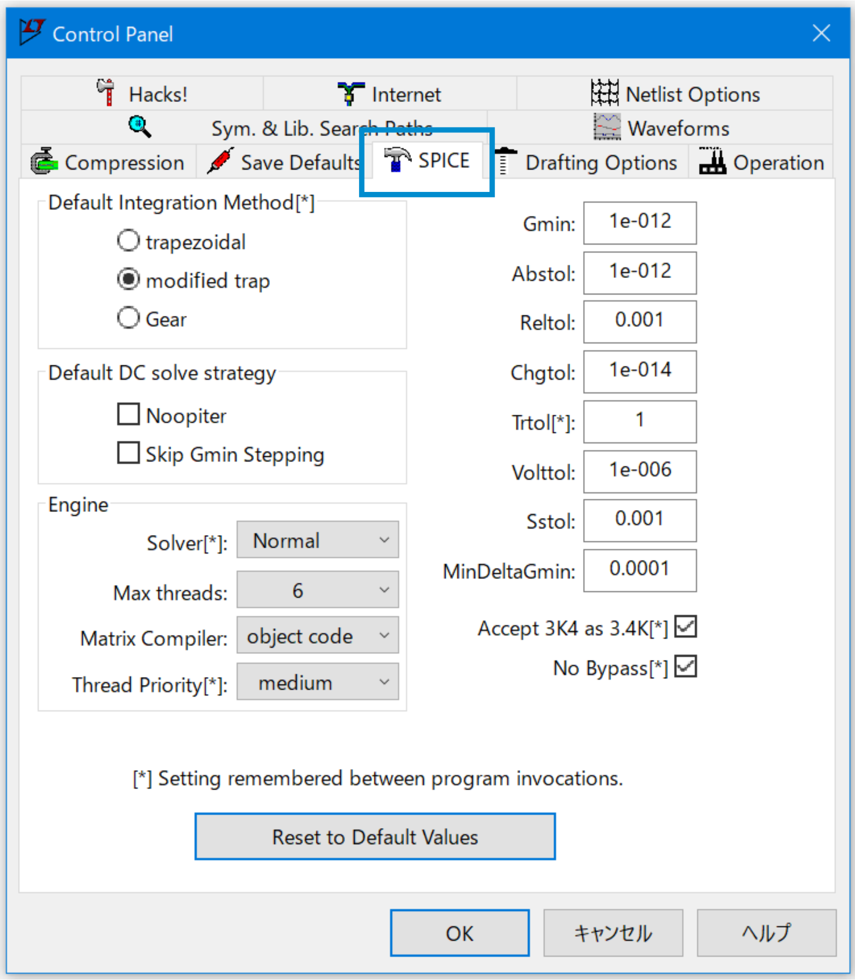

Figure 1. Option settings defined in the SPICE tab of the "Control Panel"

LTspice® is a registered trademark of Analog Devices, Inc.

Option settings for the device models

Simulations of only the device models used with bipolar transistors, diodes, and LEDs converge using the default settings shown in Figure 1 in most cases, depending on the circuit scale and configuration. Table 1 shows the option parameters defined in the right column of the "Control Panel". If a simulation does not converge with the device model, the convergence can be improved by increasing the default values of the parameters to the upper limits provided in Table 1, thereby relaxing the tolerance of convergence.

Table 1. Option parameters defined in the right column of the "Control Panel"

Parameter	Default value	Upper limit (Reference)	Summary
Gmin	1e-012 [S]	1e-009	Electrical conductivity added to all PN junctions for facilitating the convergence
Abstol	1e-012 [A]	1e-006	Absolute tolerance of current error
Reltol	0.001	0.01	Tolerance of relative error
Chgtol	1e-014 [C]		Absolute tolerance of charge
Trtol	1	7	Tolerance of temporary error coefficient in transient analysis
Volttol	1e-006 [V]	1e-003	Absolute tolerance of voltage error
Sstol	0.001		Relative error for detecting steady state
MinDeltaGmin	0.0001		Setting a limit for the end of the adaptive Gmin stepping

Option settings of the subcircuit models

For MOSFET with a macro model used in the subcircuit model, SiC power devices with a behavior model, and IGBT, performing simulations with the default settings causes problems including errors and incorrect display of the plot waveform as described below.

- "Analysis: Time step too small …" error occurs and stops the simulation.
- The plot waveform is not displayed, or stops being displayed during the simulation.
- The waveform fluctuates to an excessive value during the simulation.

These errors occur if variation in the waveform is abrupt. The simulation is stopped if the time step required for calculating the abrupt variation is too small. In addition, the waveform cannot be displayed if the variation is too abrupt to perform the calculation correctly.

The abrupt variation in the waveform cannot be avoided in the SMPS (Switched Mode Power Supply) circuits. Therefore, use the following methods to avoid errors. Contrary to the countermeasures for the device models, the convergence can be improved by decreasing errors in the simulation values, thereby increasing the calculation precision.

Method 1: Solver setting

In "Control Panel", set "SPICE > Engine > Solver" to "Alternate" (Figure 2). According to the LTspice XVII manual, changing the setting from "Normal" to "Alternate" increases the internal precision 1,000 times.

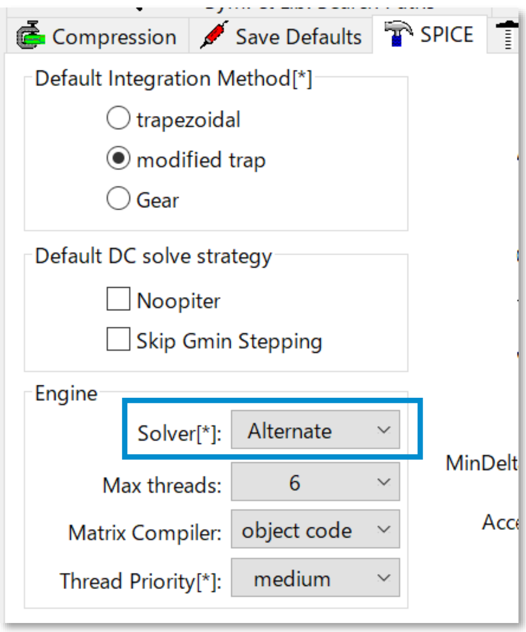

Figure 2. Set "Solver" defined in the SPICE tab of the "Control Panel" to "Alternate"

Method 2: Maximum Timestep setting

In the simulation setting, set “Maximum Timestep” of the transient analysis to 10 nsec or 1 nsec. This setting improves the convergence by decreasing the amount of variation within one step of the calculation.

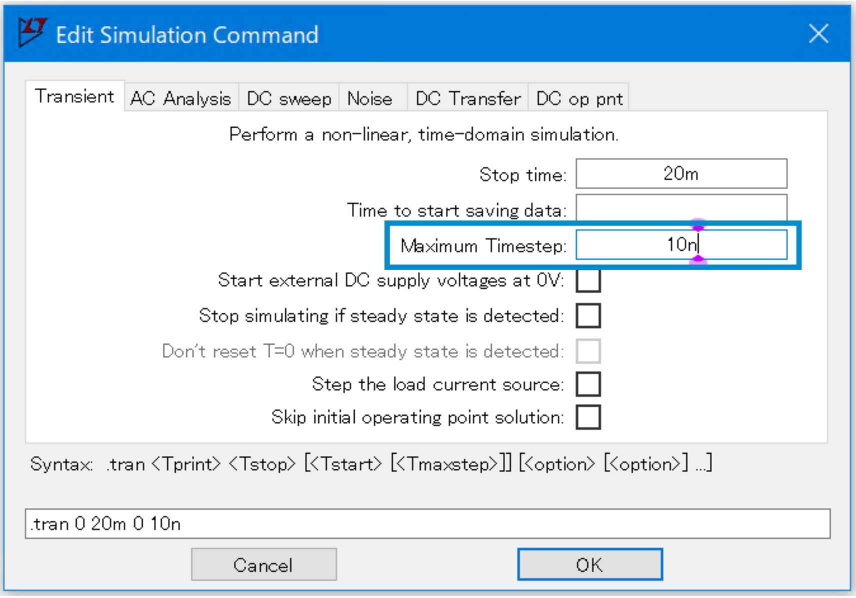

Figure 3. Set “Maximum Timestep” of the transient analysis

Method 3: Option parameters setting

Change the option parameters defined in the right column of the “Control Panel” (Figure 1). The recommended values are shown in Table 2. Change the values of “Reltol” and/or “Trtol” to the recommended values. Determine a suitable combination by repeating the simulation.

Table 2. Recommended values for the option parameters

Parameter	Default value	Recommended value
Gmin	1e-012 [S]	
Abstol	1e-012 [A]	
Reltol	0.001	0.0001
Chgtol	1e-014 [C]	
Trtol	1	0.1
Volttol	1e-006 [V]	
Sstol	0.001	
MinDeltaGmin	0.0001	

Method 4: Sloped start of the power supply

If the simulation is stopped immediately after starting, provide a slope for the rise of the voltage source to avoid the problem. Figure 4 shows a typical voltage source. Since the setting voltage is generated as soon as the simulation is started, the voltage variation is abrupt in the components on the circuit. Set the rise time to slow the voltage variation. Click "Advanced" to open the setting window as shown in Figure 5. Although details may depend on the circuits, select "PULSE" and provide an adequate time for the "Trise" parameter.

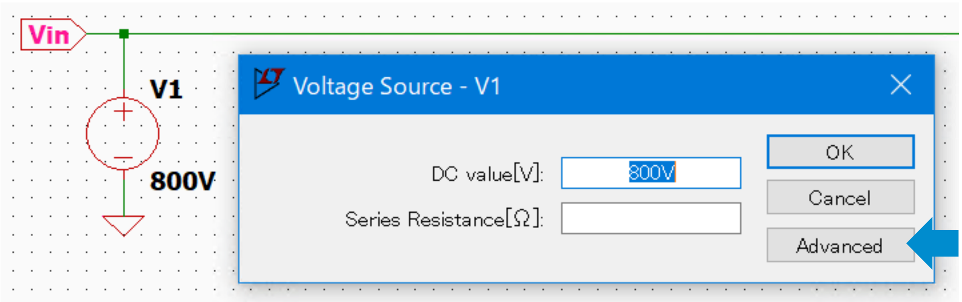

Figure 4. Setting for a typical voltage source

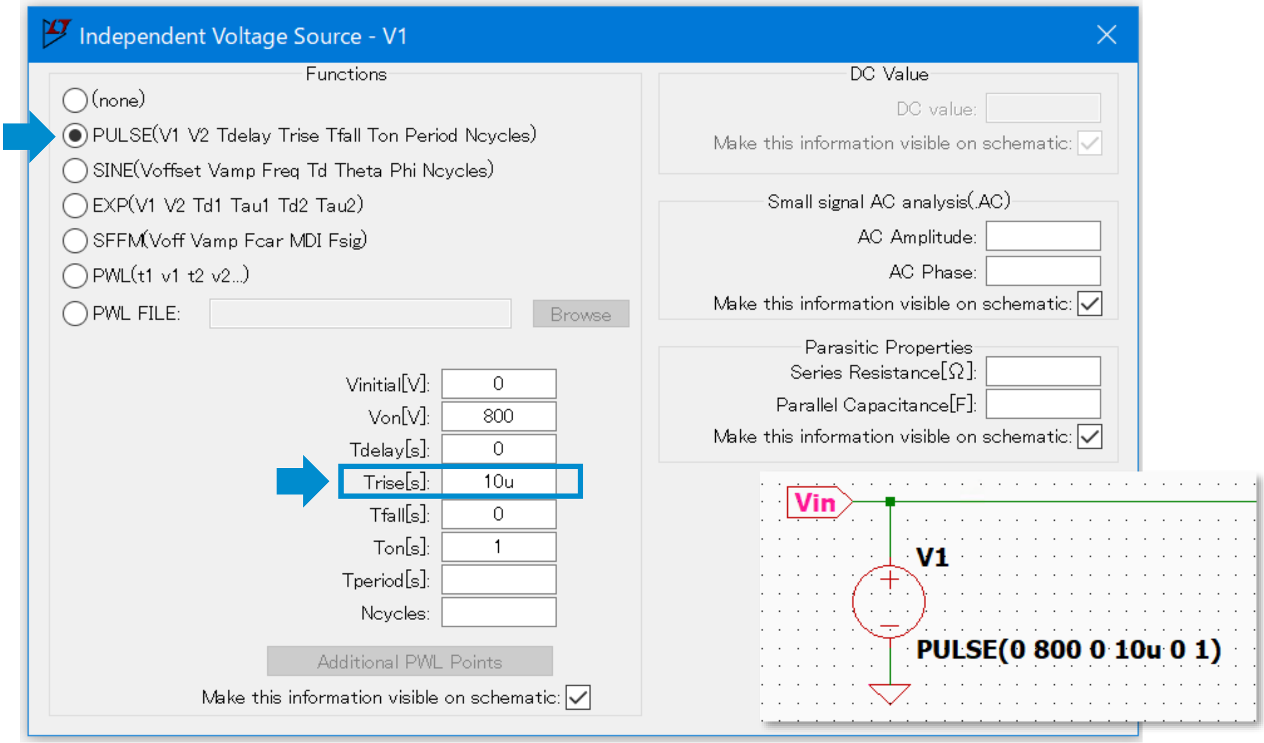

Figure 5. Set the rise time in the advanced settings window for the voltage source

Other problems and countermeasures

Ideal passive elements

Inductors, transformers, and capacitors available as general symbols of the LTspice are ideal elements. Therefore, their impedance is infinite in the LC parallel resonance and zero in the serial resonance. This may prevent the convergence of the calculation.

Inductor

The default value for the inductors is 1mΩ in the LTspice even if no serial resistance is set, mitigating the problem of extreme impedance. If 1mΩ is still too small for the serial resistance, set the values individually.

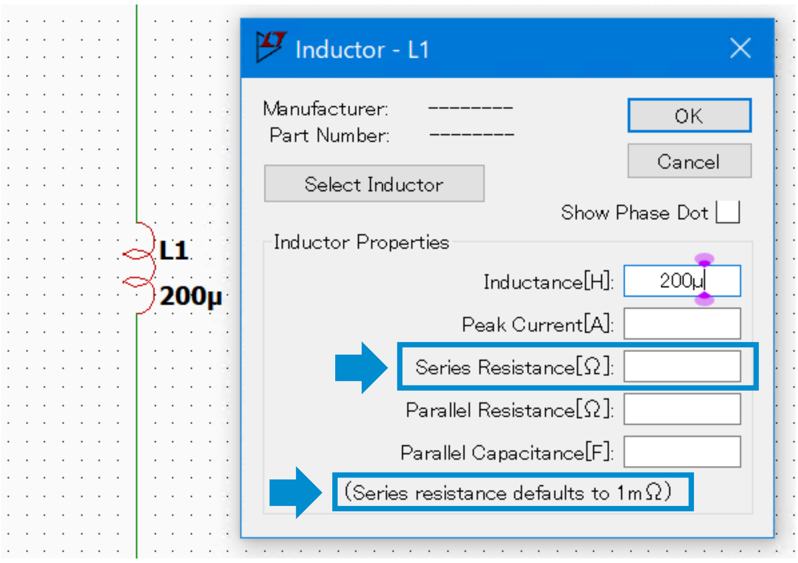

Figure 6. Set the serial resistance for the inductors. Default value is 1mΩ

Transformer

A transformer is created by combining the inductors. Although the serial resistance is set to 1mΩ for the inductors by default, it becomes zero in the transformer configuration. Therefore, set “Series Resistance” to 1mΩ or a greater value.

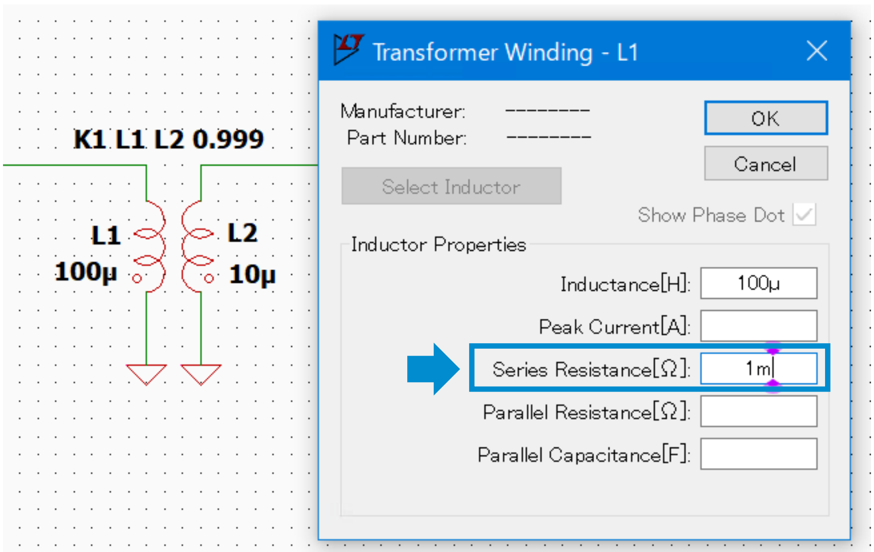

Figure 7. Set the serial resistance for the transformers

No. 65AN082E Rev.001
DECEMBER 2022

Capacitor

Since the serial resistance is zero by default, set “Equiv. Series Resistance” to 1mΩ or a greater value.

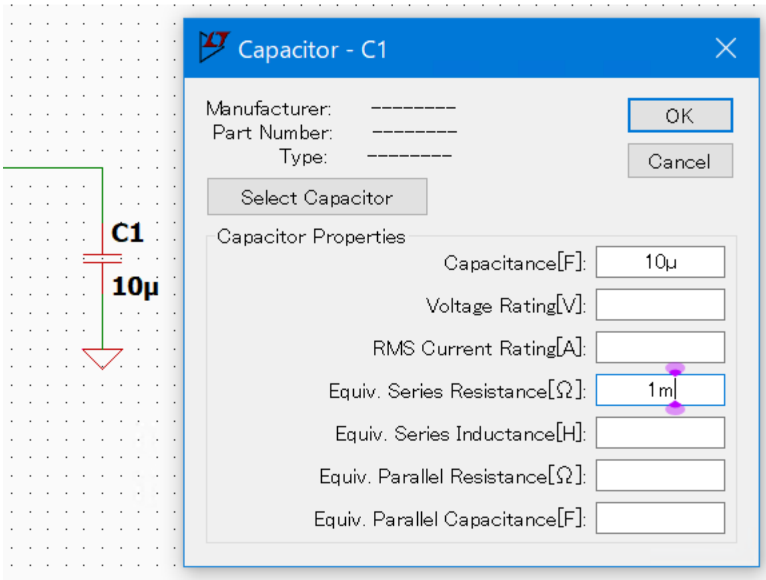

Figure 8. Set the equivalent serial resistance for capacitor

Notes

1) The information contained herein is subject to change without notice.

2) Before you use our Products, please contact our sales representative and verify the latest specifications :

3) Although ROHM is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors.
Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Poducts beyond the rating specified by ROHM.

4) Examples of application circuits, circuit constants and any other information contained herein are provided only to illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.

5) The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.

6) The Products specified in this document are not designed to be radiation tolerant.

7) For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a ROHM representative : transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.

8) Do not use our Products in applications requiring extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters.

9) ROHM shall have no responsibility for any damages or injury arising from non-compliance with the recommended usage conditions and specifications contained herein.

10) ROHM has used reasonable care to ensure the accuracy of the information contained in this document. However, ROHM does not warrants that such information is error-free, and ROHM shall have no responsibility for any damages arising from any inaccuracy or misprint of such information.

11) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. For more details, including RoHS compatibility, please contact a ROHM sales office. ROHM shall have no responsibility for any damages or losses resulting non-compliance with any applicable laws or regulations.

12) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.

13) This document, in part or in whole, may not be reprinted or reproduced without prior consent of ROHM.