

Newton-Raphson Method Parameters

The Newton-Raphson (NR) method, described in Chapter 3 of Part-1, is used in a variety of situations: DC, transient, SSW, and start-up (see Chapters 3, 6, 7, 8 in Part-1). The NR process is the same in all of these situations, and the NR method parameters are therefore common¹. In the following, we describe these parameters.

- * **itmax_newton**: (integer) maximum number of NR iterations (default: 500). Typically, the NR method converges in less than ten iterations, but the default value of **itmax_newton** has been made large to take care of special cases for which convergence is very slow (e.g., when there are exponential functions in the circuit/system being simulated, and the initial guess is poor.).

In transient simulation, when the **back_euler_auto** or **trapezoidal_auto** option is used, **itmax_newton** should be set to a much smaller number, say, 5.

- * **dmp**: (yes/no) decides whether damping (see Eq. 3.19 in Part-1) should be used (default: no)
- * **dmp_k**: (real number) damping factor k where $0 < k < 1$ (see Eq. 3.19 in Part-1, default: 0.2). Not relevant when **dmp** is set to no.
- * **dmp_newt_max**: (integer) number of NR iterations for which damping is applied (default: 50). Not relevant when **dmp** is set to no.
- * **chk_rhs2**: (yes/no) decides whether the 2-norm (see Eq. 3.9 in Part-1) should be used to check for convergence. If there are electrical elements in the system, **chk_rhs2** is set to no by default; otherwise, it is set to yes.
- * **chk_only_rhs2**: (yes/no) Setting this flag to yes is equivalent to setting **chk_rhs2** to yes and all other coverage flags to no.
- * **norm_2**: (real number) tolerance value for the 2-norm (default: 10^{-10}). Not relevant when **chk_rhs2** is no.
- * **write_rhs2**: (yes/no) decides whether the 2-norm should be written to the console (for each NR iteration). default: no.
- * **chk_delx_volt**: (yes/no) decides whether ΔV , the node voltage difference between successive NR iterations, should be used to check for convergence (see Sec. 3.3 in Part-1). Default: no.
- * **delxmax_volt**: (real number) tolerance value for ΔV (default (in Volts): 10^{-4}). Not relevant when **chk_delx_volt** is no.
- * **write_delx_volt**: (yes/no) decides whether ΔV^{\max} should be written to the console (for each NR iteration). default: no.

¹There are some exceptions such as NR parameters for the outer loop in SSW analysis (see Fig. 7.3 in Part-1) and NR parameters used during g_{\min} stepping (see Sec. 3.5.2 in Part-1); these parameters are described separately.

- * **chk_only_delx_volt**: (yes/no) Setting this flag to **yes** is equivalent to setting **chk_delx_volt** to **yes** and all other convergence flags to **no**.
- * **chk_spice**: (yes/no) decides whether the SPICE convergence criteria (see Sec. 3.3 in Part-1) should be used to check for convergence. If there are electrical elements in the circuit/system, **chk_spice** is set to **yes** by default; otherwise, it is set to **no**.
- * **chk_only_spice**: (yes/no) Setting this flag to **yes** is equivalent to setting **chk_spice** to **yes** and all other convergence flags to **no**.
- * **norm_spice_rel**: (real number) k_{rel} in Eq. 3.10 of Part-1 (default: 10^{-3}).
- * **norm_spice_nodcv**: (real number) τ_{abs} for node voltages (see Eq. 3.10 of Part-1, default in Volts: 10^{-6}).
- * **norm_spice_cur**: (real number) τ_{abs} for currents (default in Amps: 10^{-12}).
- * **norm_spice_eaux**: (real number) τ_{abs} for EBE auxiliary variables (default: 10^{-4}).
- * **norm_spice_locvar**: (real number) τ_{abs} for EBE local variables (default: 10^{-4}).
- * **norm_spice_gvar**: (real number) τ_{abs} for GBE main variables (default: 10^{-4}).
- * **norm_spice_gaux**: (real number) τ_{abs} for GBE auxiliary variables (default: 10^{-4}).

In general, it is difficult to set **norm_spice_eaux**, **norm_spice_locvar**, **norm_spice_gvar**, and **norm_spice_gaux** in a meaningful manner because they correspond to variables of different kinds. For example, an auxiliary variable in an EBE may be a voltage or a current or a charge. They are made available to the user mainly for the sake of completeness.

- * **write_spice**: (yes/no) decides whether information about SPICE convergence parameters should be written to the console (for each NR iteration). Default: **no**.

As we have seen in Chapter 3 of Part-1, convergence of the NR process depends on the initial guess. Convergence at the very first time point in transient simulation is more difficult because we may not have a good initial guess to start the NR process. For subsequent time points, the solution obtained at the previous time point generally serves as an excellent initial guess, and convergence is easier. For this reason, NR parameters for the first solution are made available separately, as given below.

- * **itmax_newton_first**: (integer) maximum number of NR iterations for the first solution (default: 500).
- * **dmp_first**: (yes/no) decides whether damping should be used for the first solution (default: **no**).
- * **dmp_k_first**: (real number) damping factor k ($0 < k < 1$) for the first solution (default: 0.1). Not relevant when **dmp_first** is set to **no**.
- * **dmp_newt_max_first**: (integer) number of NR iterations for which damping is applied for the first solution (default: 50). Not relevant when **dmp_first** is set to **no**.