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Xyce™ Parallel Electronic Simulator Release Notes

Release 3.1

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Scope/Product Definition

The **Xyce** Parallel Electronic Simulator has been written to support, in a rigorous manner, the simulation needs of the Sandia National Laboratories electrical designers. Specific requirements include, among others, the ability to solve extremely large circuit problems by supporting large-scale parallel computing platforms, improved numerical performance and object-oriented code design and implementation.

The **Xyce** release notes describe:

- Hardware and software requirements
- New features and enhancements

- Any defects fixed since the last release
- Current known defects and defect workarounds

For up-to-date information not available at the time these notes were produced, please visit the **Xyce** web page at http://www.cs.sandia.gov/xyce.

Hardware/Software

This section gives basic information on supported platforms and hardware and software requirements for running **Xyce** 3.1.

Supported Platforms

Xyce 3.1 currently supports any of the following operating system (all versions imply the earliest supported – **Xyce** generally works on later versions as well) platforms. These platforms are supported in the sense that they have been subject to certification testing for the **Xyce** version 3.1 release.

- Redhat Linux®, Enterprise version 4 on Intel Pentium® architectures (serial and parallel using MPICH version 1.2.5.2 or LAM MPI version 7.0.6)
- FreeBSD 5.4 on Intel Pentium® architectures (serial only)
- Microsoft Windows® (serial)
- Apple® OS X (serial and parallel)
- NWCC (spirit) (serial and parallel)

Build Capability but Not Supported

The platforms listed in this section are "not supported" in the sense that they are not subject to nightly regression testing, and they also were not subject to certification testing for the **Xyce** version 3.1 release.

- ICC (serial and parallel).
- Thunderbird
- Red Storm

Hardware Requirements

The following are estimated hardware requirements for running **Xyce**:

- 128MB memory recommended, 64 MB memory minimum – *memory requirements increase with circuit size*
- 50MB disk space (not including space needed for output files)

Software Requirements

Several libraries (all freely available from Sandia National Laboratories and other sites) are required to build **Xyce** on a platform. These are only required when building **Xyce** from source. These are:

- Trilinos Solver Library version 6.0 (Sandia, http://software.sandia.gov/Trilinos) . This is a suite of libraries including Amesos, KLU, AztecOO, Belos, Epetra, EpetraExt, Ifpack, NOX, LOCA, and y12m.
- SuperLU (http://www.nersc.org)
- Xyce Expression library (libexpr.a).
- BLAS (libblas.a).
- LAPack (liblapack.a).
- UMFPACK version 4.1 and AMD version 1.0 (libumfpack.a, libamd.a) (http://www.cise.ufl.edu/researc

For parallel builds, the following are additionally required:

- MPI (http://www-unix.mcs.anl.gov/mpi/) library for message passing (version 1.1 or higher), such as MPICH or LAM. The version used to build Xyce must be the same that is used for building Trilinos.
- Zoltan (Sandia, http://www.cs.sandia.gov/Zoltan) and its associated libraries (libzoltan.a, libzoltanCPP.a, libparmetis.a, libmetis.a)

Xyce Release 3.1 Documentation

The following **Xyce** documentation is available at the **Xyce** internal website in pdf form. Some of this documentation is in “Draft” mode and is incomplete.

- **Xyce** Users’ Guide, Version 3.1

- **Xyce** Reference Guide, Version 3.1
- **Xyce** Release Notes, Version 3.1
- **Xyce** Theory Document
- **Xyce** Test Plan

New Features and Enhancements

This release is the first release following the Version 3.0.2 release. It encompasses many key bug fixes as well as key robustness and performance enhancements. Highlights for this release include:

- New device model: VDMOS with photocurrent effects.
- New device model: Level 2 diode with PSPICE enhancements for more accurate representation of Zener diodes.
- New device model: Level 5 BJT with empirical neutron damage effects and photocurrent model.
- NK parameter added to BJTs for improved representation of high-current rolloff.
- More advanced temperature compensation for VDMOS, B3SOI and BJT that utilizes quadratic interpolation of coefficients extracted from data.
- Several new homotopy options, including multi-parameter homotopy, gmin stepping and pseudo-transient stepping.
- Two-Level nonlinear solves, which make it possible to simulate power-node parasitics in very large (parallel) problems. This capability can be used either as a partitioning enhancement tool, or as a tool for applying different solver options to different phases of a problem. [bug 653]

For details of each of these new features, see the **Xyce** Users' Guide, and the **Xyce** Reference Guide.

Device Support

Table 1 contains a complete list of devices for **Xyce** Release 3.1. A number of the devices have been revised to improve robustness, and additional model levels for some devices have been added (the level=2 Diode, the level=20 MOSFET and the level=5 BJT).

Device	Comments
Capacitor	Age-aware, semiconductor

Device	Comments
Inductor	Nonlinear mutual inductor (see below)
Nonlinear Mutual Inductor	Sandia Core model (not fully PSpice compatible) Stability improvements.
Resistor	Semiconductor
Diode (Level 1)	
Diode (Level 2)	Addition of PSPICE enhancements
Diode (Level 3)	Prompt and delayed photocurrent radiation model
Diode (Level 4)	Generic photocurrent source model
Independent Voltage Source (VSRC)	
Independent Current Source (ISRC)	
Voltage Controlled Voltage Source (VCVS)	
Voltage Controlled Current Source (VCCS)	
Current Controlled Voltage Source (CCVS)	
Voltage Controlled Current Source (CCCS)	
Nonlinear Dependent Source (B Source)	
Bipolar Junction Transistor (BJT) (Level 1)	
Bipolar Junction Transistor (BJT) (Level 2)	Prompt photocurrent radiation model.
Bipolar Junction Transistor (BJT) (Level 3)	Neutron-effects model.
Bipolar Junction Transistor (BJT) (Level 4)	Prompt photocurrent radiation model (same as level 2).
Bipolar Junction Transistor (BJT) (Level 5)	Deveney-Wrobel Neutron model, with photocurrent.
Junction Field Effect Transistor (JFET) (Level 1)	SPICE-compatible JFET model.
Junction Field Effect Transistor (JFET) (Level 2)	Shockley JFET model.
MESFET	
MOSFET (Level 1)	
MOSFET (Level 3)	
MOSFET (Level 9)	BSIM3 model. Initial condition support.

Device	Comments
MOSFET (Level 10)	BSIM SOI model with initial condition support.
MOSFET (Level 18)	VDMOS general model.
MOSFET (Level 19)	VDMOS total dose radiation model.
MOSFET (Level 20)	VDMOS photocurrent model.
Transmission Line	Lossless.
Controlled Switch (S,W) (VSWITCH/ISWITCH)	Voltage or current controlled.
Generic Switch (SW)	Controlled by an expression.
PDE Devices (Level 1)	one-dimensional
PDE Devices (Level 2)	two-dimensional
Digital (Level 1)	Behavioral Digital
EXT (Level 1)	External device, used for code coupling and power-node parasitics simulations.
OP AMP (Level 1)	Ideal operational amplifier

Table 1: Devices Supported by Xyce.

Robustness Improvements

- It is now possible to use voltage limiting with homotopy, which makes all homotopy algorithms much more robust. (previous versions of the code would allow you to set voltlim=1 in homotopy netlists, but it didn't work correctly). This was mostly fixed for the Xyce 3.0.1 minor release, but it is a very important issue. This fix makes it much easier to simulate mixed analog/digital circuits in Xyce.

New Device Types

- Behavioral digital devices.
- Ideal OPAMP.
- "External device" for coupling of external device or circuit codes.

New Model Levels

- Level 2 diode with PSPICE enhancements to better represent Zeners.
- Level 20 VDMOS with photocurrent effects.
- Level 5 BJT with empirical neutron damage and photocurrent effects.

Improved Temperature Compensation

- Quadratic or piecewise linear temperature compensation based on parameters extracted from data is now available for JFET, MESFET, VDMOS, BJT and B3SOI.

Enhanced Solver Stability and Features

- Xyce now uses an enhanced version of the Trilinos solver library version 6.0.
- Xyce now has the capability to do user-specified multi-parameter homotopy.
- Xyce now has a new two-level nonllinear solve capability, which can be used to handle power node parasitics in very large problems, without breaking singleton removal (in other words without breaking parallelism). [bug 653]

Interface Improvements

- Global parameters that can be changed during a simulation.
- Xyce -info command line option which gives information about device and model parameters.
- Lead current are available for output and in dependent source expressions
- Minimum lead resistance and junction capacitance may be set globally to improve convergence.
- Global nodes are available.
- Improved netlist error checking and syntax reporting.
- More straightforward syntax allowed for simple use of parameters defined in `.PARAM` statements.
- Enhanced statistics reporting; **Xyce** now reports breakdown of device types used in a netlist, number of unknowns in the system, and time spent on operating point and transient phases.

Defects of Release 3.0 Fixed in this Release

Defect	Description
Confusing error messages resulting from subcircuit syntax errors. [Bug 852]	Xyce requires that subcircuit parameter declarations and definitions be separated from the subcircuit node list and subcircuit name by the `PARAMS:` keyword. Previous versions would give an unhelpful error message when encountering a subcircuit definition that uses parameters without the `PARAMS:` keyword. The error reporting has been improved.
Simple parameter usage required expression syntax [Bug 842]	Previous versions of Xyce required that all usage of parameters defined in `.PARAM` statements be within curly braces, denoting "expression" syntax, even if no arithmetic was being performed. It is now possible to use these parameters in this simple case directly without the curly braces.
Expression in `.OPTIONS` lines silently ignored [Bug 1017]	Xyce does not allow use of parameters or expressions in the `.OPTIONS` lines. Previous releases of Xyce silently ignored such attempts and used the incorrect value of zero instead of what was intended. Xyce now properly reports the erroneous usage and exits.
Improper handling of `MEG` suffix when passed in subcircuit parameters [Bug 1038]	Some recent versions of Xyce improperly ignored the "eg" at the end of the `MEG` scaling suffix when constants were passed into subcircuits as parameters, leading to 1e-3 scaling instead of 1e+6 as intended. This defect was fixed for the current release.
Voltlim now works correctly with homotopy algorithms. [Bug 822]	This was mostly fixed for the Xyce 3.0.1 and 3.0.2 minor releases, but a few more issues were corrected for 3.1. Also, it is an important enough fix that it is worth mentioning again. Old homotopy netlists which had voltlim=0 can be modified to let voltlim=1 (the default).

Table 2: Fixed Defects.

Known Defects and Workarounds

Defect	Description
`.DC` sweep output.	`.DC` sweep calculation does not automatically output sweep results. *Workaround:* Use `.PRINT` statement to output sweep variable results.
BJT Current Crowding	"Timestep too small" failures can result when IRB nonzero with level 2 and level 4 BJT *Workaround:* If such failure observed, disable current crowding effect by setting IRB to zero in all BJT models. Please feed back such circuits to the **Xyce** development team so that this bug can be characterized and eliminated.
Microsoft Windows installation restrictions	Users with insufficient privileges (i.e. `Limited Account`) are not permitted to install **Xyce** into folders on the System Drive (usually `C:`). *Workaround:* First, manually create the desired folder on the System Drive. It is then possible to install **Xyce** into this folder by following the standard Setup procedure.
MPICH parallel runs may not exit cleanly	**Xyce** may not exit cleanly if it encounters certain errors during parsing. *Workaround:* If **Xyce** appears to hang, manually terminate each process. Usually a `SIGTERM` or `^C` is sufficient to halt the job. Users running on the Alpha should manually check for zombie processes after **Xyce** error exits, and kill them if necessary.
Incompatible proprietary file formats.	Netlists created with programs like Microsoft Word and Microsoft Wordpad will not run in **Xyce**. **Xyce** does not recognize proprietary file formats. *Workaround:* It is best not to use such programs to create netlists, unless netlists are saved as *.txt files. If you must use a Microsoft editor, it is better to use Microsoft Notepad. In general, the best solution is to use a Unix-style editor, such as Vi, Gvim, or Emacs.
One known instance of restart results not matching original run results.	There is one case for a customer's parallel run of a large digital circuit of BSIM3's where the restart output does not match the original results for the same time range. *Workaround:* The only choice for now is to check the restart results against the baseline results for some block if the run results have a very tight tolerance for success. It is suggested to overlap the original run time with the restart time allowing comparison.

Defect	Description
Lead currents in B/E/F/G/H source and switch expressions [bug 801]	Use of lead currents in B/E/F/G/H source and switch expressions will lead to incorrect results. A fatal diagnostic should be generated for such usage, but is not. The only supported use of lead currents is on `.PRINT` lines in Xyce 3.1.
Restart does not work with 2-level Newton technique [bug 1069]	In Release 3.1 the restart capability (`.OPTIONS RESTART`) does not work when using the two-level newton method (using the `YEXT` device). This defect will be fixed in Release 3.1.1.
Time-dependent parameter definitions do not trigger error in parse phase. [bug 951]	**Xyce**'s `.PARAM` function is powerful, but it is not a generic macro preprocessing capability. All parameters defined in `.PARAM` statments must be written in terms of quantities that can be evaluated at parse time. It is not correct to use the `time` variable in `.PARAM` definitions, but it is legal: since `time` is zero at the time the netlist is parsed, the value zero will be used in the evaluation of the parameter. The parser should detect the attempt to use time-dependent parameter definitions and generate an error, but it does not, and the result is that the parameter is defined to have a constant, time-independent value that is used silently by the code. *Workaround:* Do not use the `.PARAM` capability to attempt to define time-dependent parameters. Use the `.FUNC` capability instead to define a function that can take time as an argument, and pass it the `time` variable when you use it in expressions. It is also possible to use the `.global_param` feature to define a time-dependent parameter at global scope.
Photocurrent diode contains expression that can produce NaNs [bug 1057]	The level 3 diode has an incorrect expression for the high-injection coefficient for the forward diode current. This expression could attempt to take the square root of a negative number when the photocurrent is large enough. The effect of this is that sometimes **Xyce** will inexplicably exit with "timestep too small" errors during runs with photocurrent diodes. This bug will be fixed in Release 3.1.1 *Workaround:* The expression in question is never used if the IKF diode parameter is zero. Until this bug is fixed, you should not set IKF to a nonzero value when using the level 3 diode.

Defect	Description
Defective expression for low-dose behavior in all photocurrent devices [bug 1079]	All photocurrent devices in **Xyce** contain an expression for the minority carrier lifetime that is numerically unstable at low dose rates. This can lead to mysterious "timestep too small" errors late in runs when the radiation pulse has died down to almost nothing. The problem is made worse and the netlist more likely to fail when `GRORDER` is high. This issue is extremely dependent on platform due to the nature of the numerical instabilty; subtle differences in how arithmetic is performed can either obscure or exacerbate the problem. This bug is well understood but was discovered too late to fix in Release 3.1. There is no workaround to this problem. It will be fixed in Release 3.1.1.
Xyce installation on Windows fails if user already has Cygwin installed [bug 835]	The installation zip file for Windows assumes that the user does not have cygwin installed, and attempts to use a small subset of Cygwin utilities to install **Xyce**. Unfortunately, this causes a conflict if the user already has Cygwin installed on the target machine. *Workaround:* It is possible to install **Xyce** on a machine that already has Cygwin installed, but it involves bypassing the installer. If you want to install **Xyce** on a windows PC that already has Cygwin installed, please contact the **Xyce** development team for assistance.
Infinite-slope transitions in B-sources causes "time step too small" errors [bug 772]	The nonlinear dependent source ("B-source") allows the user to specify expressions that could have infinite-slope transitions, such as `Bcrtl OUTA 0 V={ IF( (V(IN) > 3.5), 5, 0 ) }` This can lead to "timestep too small" errors when **Xyce** reaches the transition point. Infinite-slope transitions in expressions dependent only on the `time` variable are a special case, because **Xyce** can detect that they are going to happen in the future and set a "breakpoint" to capture them. Infinite-slope transitions depending on other solution variables cannot be predicted in advance, and cause the time integrator to scale back the timestep repeatedly in an attempt to capture the feature until the timestep is too small to continue. *Workaround:* Do not use step-function or other infinite-slope transitions dependent on variables other than `time`. Smooth the transition so that it is more easily integrated through.

Defect	Description

Epetraext uses bad address in parallel, causing Xyce core dump [bug 1072]	If **Xyce** is run in parallel on a netlist that is so small that all devices are assigned to the same processor, **Xyce** can core dump when the processor with no work attempts to access invalid memory.
	Workaround: It is best not to try to run **Xyce** on very small problems in parallel, as this capability is intended for and optimzed for very large problems; small problems should be run in serial. If trying to run medium-sized problems in parallel and these core dumps are observed, try running with Zoltan partitioning and singleton removal turned off:
	`.OPTIONS LINSOL TR_partition=0`
	`+ TR_singleton_filter=0`

Table 3: Known Defects and Workarounds.

Incompatibilities With Other Circuit Simulators

Issue	Comment
`.SAVE` does not work.	**Xyce** does not support this. Use `.PRINT` instead.
`.OP` is not complete	A `.OP` netlist will run in **Xyce**, but will not produce the extra output normally associated with the `.OP` statement.
Pulsed source rise time of zero.	A requested pulsed source rise/fall time of zero really is zero in Xyce. In other simulators, requesting a zero rise/fall time causes them to use the printing interval found on the `.TRAN` line.
Mutual Inductor Model.	Not the same as PSpice. This is a Sandia developed model but is compatible with Cadence PSpice parameter set.
`.PRINT` line shorthand.	Output variables have to be specified as V(node) or I(source). Specifying the node alone will not work. Also, specifying V(*) or I(*) (to get all voltages or currents) will not work.
BSIM3 level.	In **Xyce** the BSIM3 level=9. Other simulators have different levels for the BSIM3.
BSIM SOI v3.2 level.	In **Xyce** the BSIM SOI (v3.2) level=10. Other simulators have different levels for the BSIM SOI.
Node names vs. device names.	Currently, circuit nodes and devices MUST have different names in **Xyce**. Some simulators can handle a device and a node with the same name, but **Xyce** cannot.
Interactive mode.	**Xyce** does not have an interactive mode.
ChileSPICE-specific "operating point voltage sources."	These are not currently supported within **Xyce**. *However...* **Xyce** does support "`IC=<value>`" statements for capacitors, inductors, and the two BSIM devices which will automatically set these voltage drops at the beginning of a transient simulation.
Syntax for `.STEP` is different.	The manner of specifying a model parameter to be swept is slightly different. Also, it is not possible to do a .STEP sweep over a global parameter. See the Users' and Reference Guides for details.

Table 4: Incompatibilities with other circuit simulators.

Important Changes to **Xyce** Usage Since the Last Release.

Table 5 lists some usage changes for **Xyce**.

Issue	Comment
Some homotopy options can now be specified as strings rather than numbers	Old netlists will still work, but now it is possible to specify (for example) `.options stepper=natural predictor=constant stepcontrol=adaptive` instead of `.options stepper=0`, etc. See the Users and Reference guides for details.

Table 5: Changes to netlist specification since the last release.

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