LINMIC+: a European Family of CAD Tools for MIC and MMIC Design

Report on European CAD Capabilities

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LINMIC+/N (current commercial version V3.1) is one of the advanced CAD packages for linear and non-linear design of hybrid and monolithic microwave integrated circuits and the most complete CAD solution for MIC/MMIC design that is of European origin. Presently, it consists of a family of compatible CAD tools integrated for high functionality and user friendliness. Since some of its key portions are based on rigorous full-wave electromagnetic field theory, it can handle complex configurations with multidielectric layers, multiple coupled conductors with one or two metal levels, irregular conductor shapes, coupled discontinuities for both, strip type and CPW type structures.

LINMIC+/N distinct from other microwave CAD packages in so far as it combines a library of MIC/MMIC structures/components using essentially Field-theory based models, with generalized EM simulation, device modelling, parameter extraction, harmonic balance, layout generation, etc., in one package. **LINMIC+/N** consists of 9 subpackages that provide all the necessary functions to design linear and non-linear circuits (no other CAD packages are required) in layout-oriented and physics-related form.

Analysis/Optimisation

- accurate for general strip type media up to high mm-wave frequencies;
- user defined strip configurations with up to 6 dielectric layers and up to two metal levels; inclusion of coplanar ground metal;
- powerful optimisation including sensitivity analysis;
- data file exchange with other major CAD packages;
- component with up to 40 ports each; up to 40 external circuit ports;
- automated port connectivity, geometric and electric compatibility checking;
- unlimited number of internal network nodes;
- full set of component/multicomponent library modules including non-linear devices.

Non-linear Simulation/Optimisation

- based on a non-linear Harmonic Balance Simulator
- non-linear analysis and optimisation of circuits with single frequency input (amplifiers, doublers, etc.)
- non-linear analysis and optimisation of mixers using up to three different input frequencies (also intermodulation, etc.);
- non-linear analysis and optimisation of oscillators;
- up to five different non-linear devices per circuit are possible;
- two non-linear GaAs FET models and Schottky diode model included;
- highly flexible output formats for output power, voltage wave form, gain, efficiency, dynamic load-line, etc.
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Noise Analysis

- a generic noise analysis of active and passive (M)MICs (no restrictions regarding circuits);

- an algorithm based on the correlation matrix concept (Hillbrand);
- able to analyse noise behaviour even for circuits in which the passive subcircuits are at different temperatures or where the external ports of a circuit can be at different temperatures, too.

Device modelling

- generation of equivalent circuit parameters for diodes, bipolar or FET microwave transistors using measured S-parameter data as inputs;
- well documented device models included packaged and power FETs;
- monitoring of broadband device modelling accuracy obtained with the parameter extraction process.

Layout Generation

- layout generation is fully integrated into analysis and optimisation;
- geometric layout always reflects latest version of the circuit design;
- the specific way of circuit segmentation as chosen by the user can be visualised by switching on and off component/macro reference plane;
- interactive zooming, moving and layout rotation;
- communicates with various layout systems via HPGL, IGES or DXF format (e.g. AutoCAD).

Look-up Tables

- full-wave look-up table generation for arbitrary multistrip config.;
- tables are process related, i.e. have to be generated only once when working with a fixed process/substrate medium;
- extends analysis and optimisation capabilities to complex geometries;
- calculation and automated use of multistrip characteristics (up to 20 coupled strips and up to 6 dielectric layers);
- accurate loss computation, inclusion of coplanar ground, package, etc.;
- graphics output for field and current distributions and graphical visualisation of multilayer/multistrip geometries.

Complex Components

- 16 rectangular spiral inductor config. and 10 spiral transformer config.
- 2 types of interdigital capacitors and 6 interdigital (Lange) couplers;
- models included for airbridges, dielectric bridges or underpasses;
- 0.5 to a few seconds of CPU time per one frequency simulation;
- generation of accurate ECMs for storing inductors, transformers and interdigital capacitors in a library.

3D EM Simulation

- full-wave EM analysis of irregular (M)MIC conductor geometries;
- surface wave/parasitic package field effects included;
- analysis using the spectral operator expansion (SOE) technique;
- handles structures with up to 4 ports and up to 6 dielectric layers;

- results data files include irregular shape layout info for direct use in LINMIC+ simulator;
- visualisation of analysis results in all LINMIC+ output formats;
- the unified EM simulator UNISIM added to LINMIC+; the use of regular grid discretisation and an optional iterative matrix solver allows to handle a much higher number of unknowns (50 000 tested).

NWA Measurements

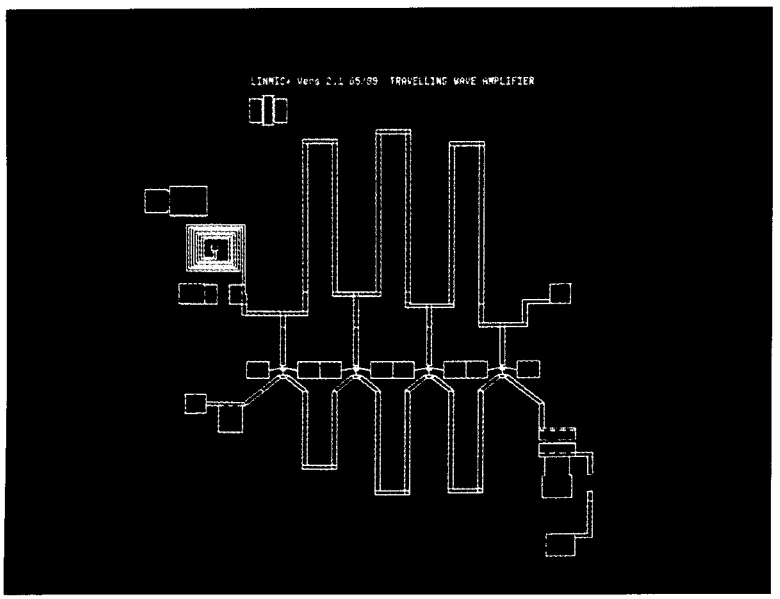
- de-embedded S-parameter measurements of one- and two-part devices;
- interfacing with both Wiltron and HP network analysers;
- de-embedding using freq. domain data and NWA time domain option;
- calibration does not require additional external calibration kit;
- visualisation of measurement results in all LINMIC+ output formats.

Future developments of LINMIC+/N

Work is in a progress on a new physics-related and layout-oriented interface (not schematic capture) which will be the first unified interface that will control different levels of model descriptions up to full-wave rigorous EM simulation. This interface has features directly related to the standardisation of foundry models and with this interface foundry models could be easily implemented. Also, a new diakoptics simulation approach is to be implemented in **LINMIC+**. This allows to perform chip level EM simulation without requiring any network approach and is able to account for parasitic coupling across a circuit.

Standard platforms

LINMIC+ is supported by SunSPARC Stations, HP9000/700/800 series, VAX stations, IBM RISC RS/6000, but it can be installed on other platforms as well upon request.



Layout generated using LINMIC+