恩智浦數字設定諧振電源方案TEA1916 的全新設計開發軟件工具

Jason Guo
Director - Technical Marketing of AC-DC Solutions

JUNE 30, 2020

SECURE CONNECTIONS
FOR A SMARTER WORLD

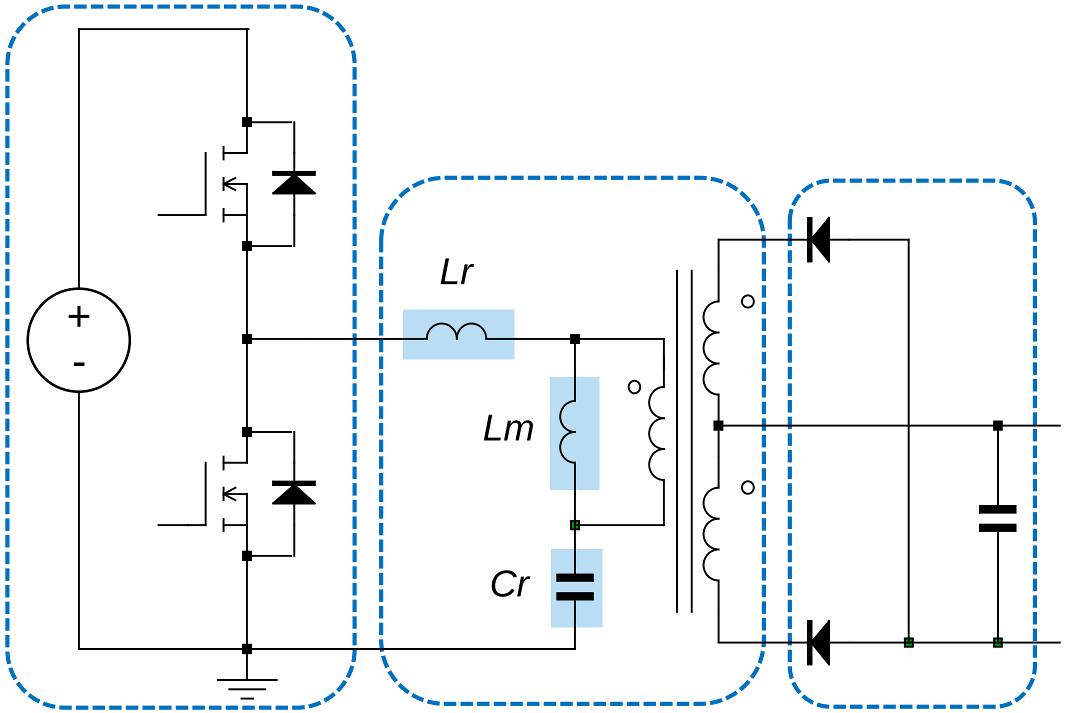
EXTERNAL

OVERVIEW

- LLC Recap and NXP Solutions
- Design Objectives and Challenges
- NXP's New LLC Design Tool
- Simulation Benefits
- Get Start - Collaterals

LLC Recap and NXP Solutions

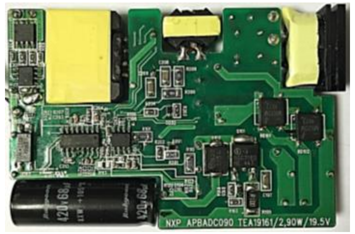
- Save switching loss by compromise conduction loss due to circulation current
- Works good in high input voltage applications where switching loss dominant
- Typically require narrow input and fixed output



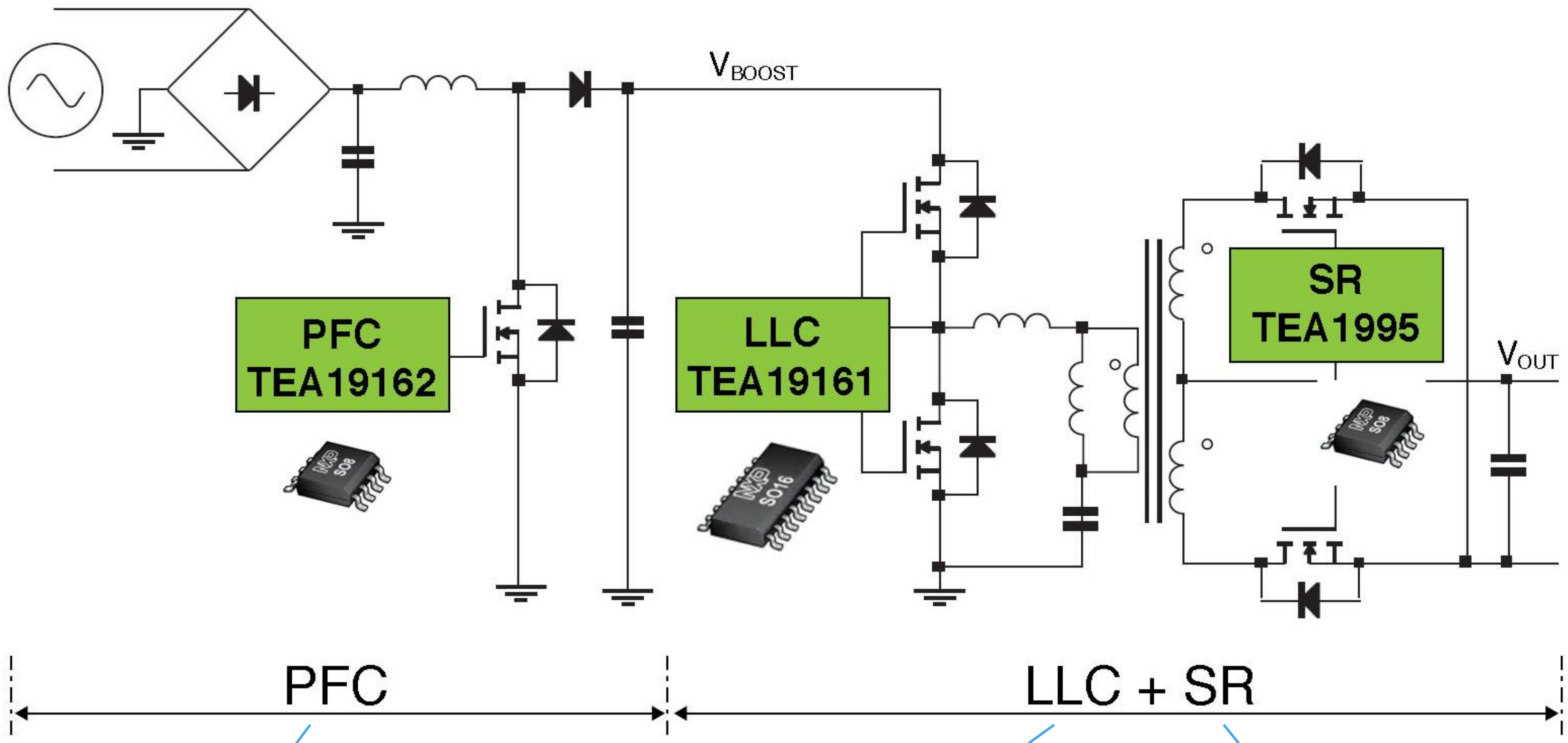
MOSFET Half Bridge (Square Wave Generator)
Resonant Network
Rectifier Network

Key Applications

- Desktop and all-in-one PCs
- LCD television
- Notebook adapter
- Printers…



NXP AC-DC SOLUTIONS



- TEA19162T/HT: PFC controller

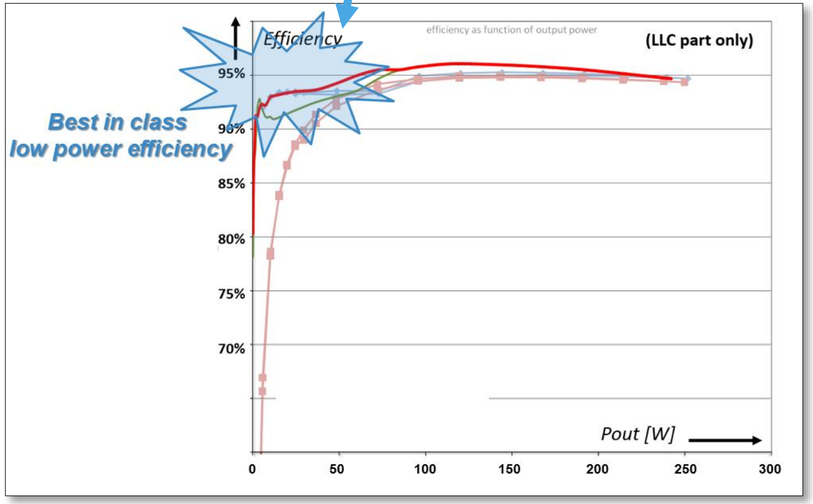
- TEA19161T: Digital controller for high-efficiency resonant power supply

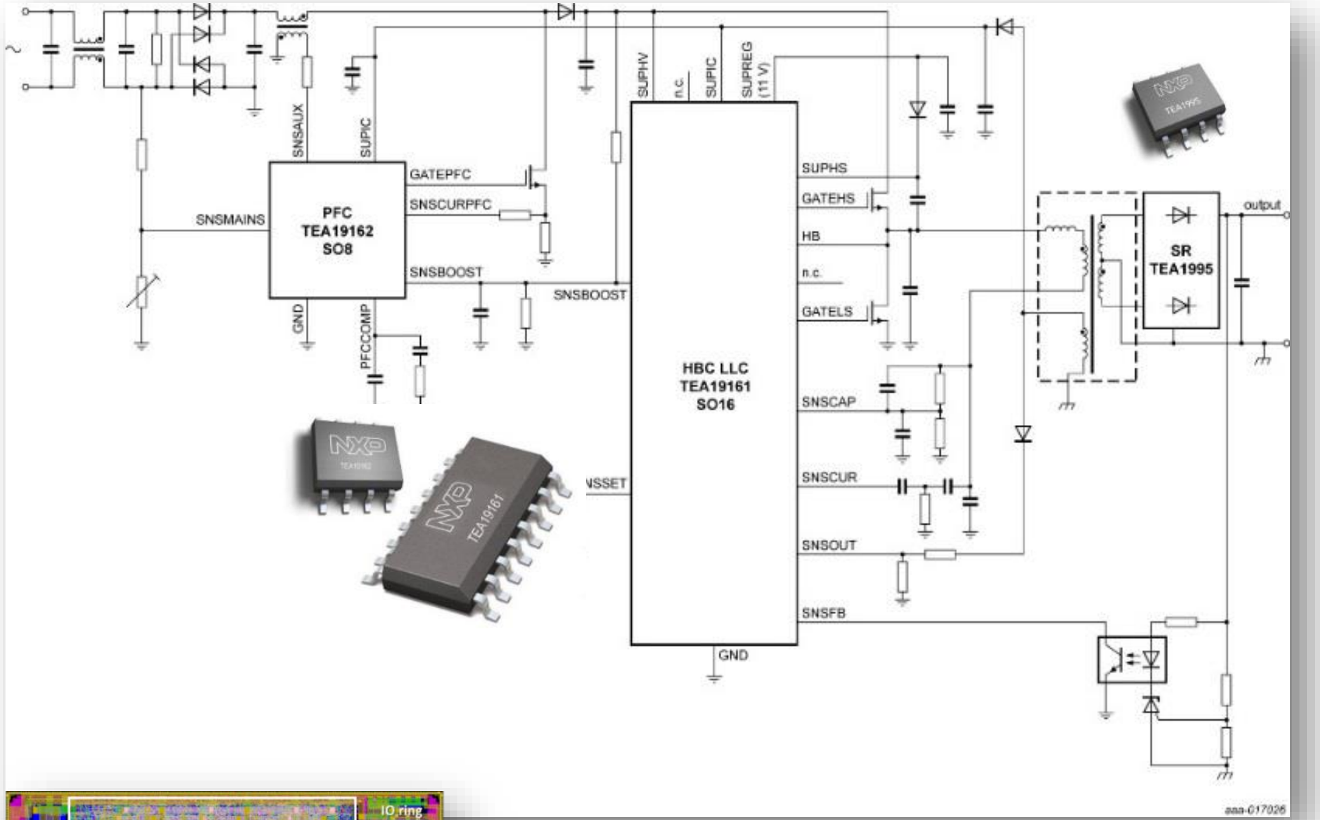
- TEA1995T: Dual synchronous rectifier controller
- TEA2095T/TE: Dual synchronous rectifier controller

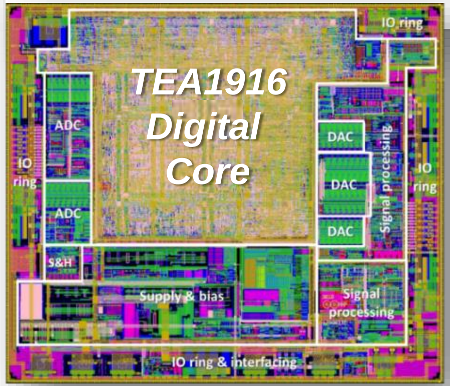
- Works the best for ~90W to ~500W Applications

TEA19161 HIGHLIGHT

- Most innovative resonant platform in market
- Digital cycle-by-cycle control by state machine for stable operation enabled by NXP’s patented Vcap control
- Ease of use – pre-configured with limited settings
- Accurate burst-mode level and reduced audible noise
- Very high efficiency at light load, and very low no-load
- Save standby supply



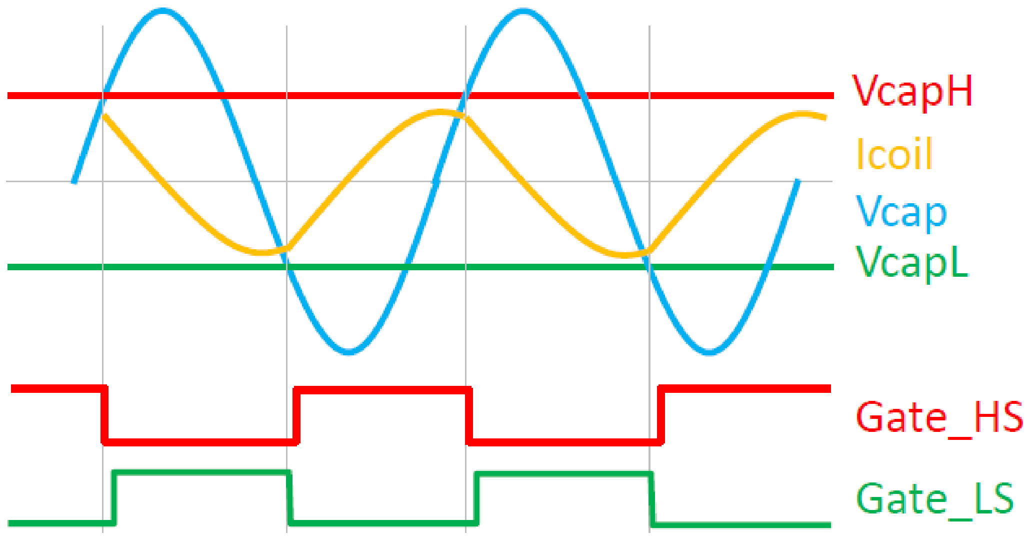


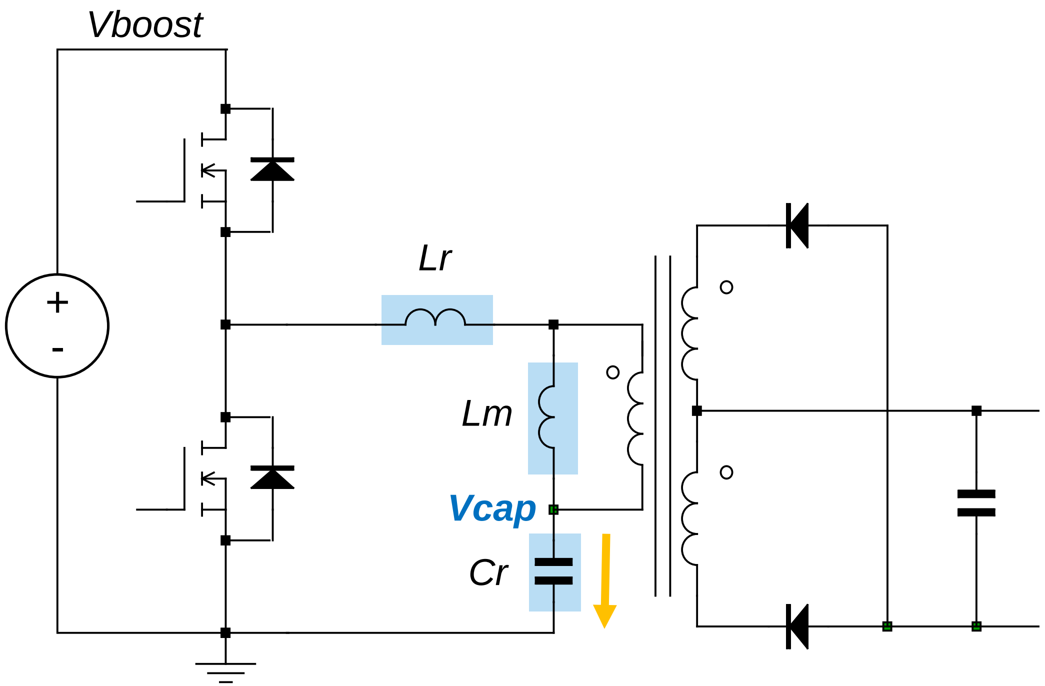


EuP 2010
Lot 6
Compliant

80 PLUS PLATINUM

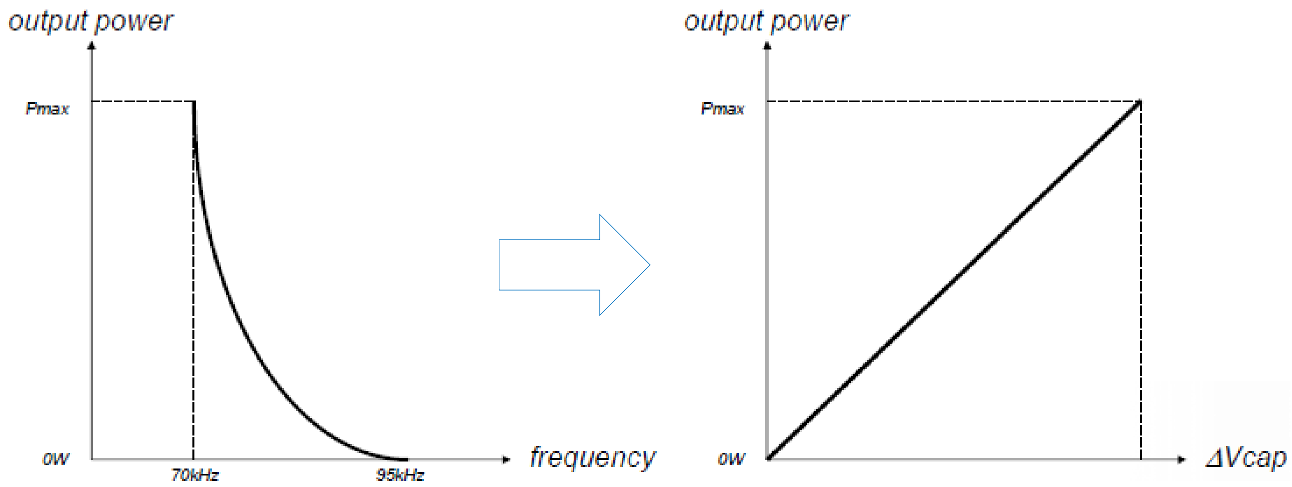
PROPRIETARY CYCLE-BY-CYCLE (VCAP) CONTROL OF TEA19161





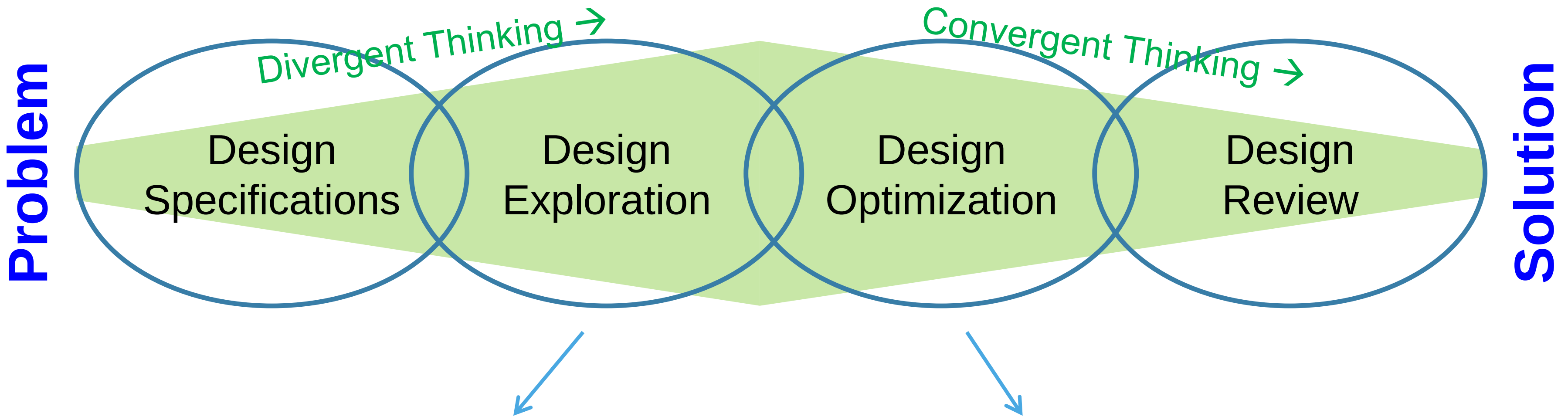
Pout = *Pin*η = Vboost*Iin = Vboost*Δ***Vcap***Cr*fs*η*

- Pout – frequency characteristic is exponential
- Pout – ΔVcap characteristic is linear



Design Objectives and Challenges

WHAT TO FOCUS – DESIGN THINKING



Automatic Design

- Enter basic requirements
- Get (rough) instant result

Advanced Design

- Enter detailed information
- Fine-tune design step-to-step

- The ultimate goal of design tool is to close all design/decision making gaps between *Problem* and *Solution*

WHY DESIGN TOOL GETS COMPREHENSIVE?

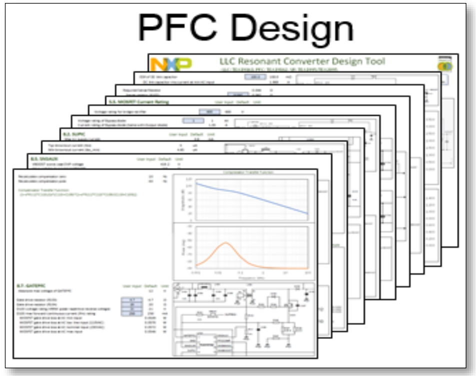
- Over simplified design typically UNDER estimate design challenges, so end up with
  - Poor/no conversion
  - Extra rev & engineer supporting effort/cost
  - Low share/revenue even design in/win…

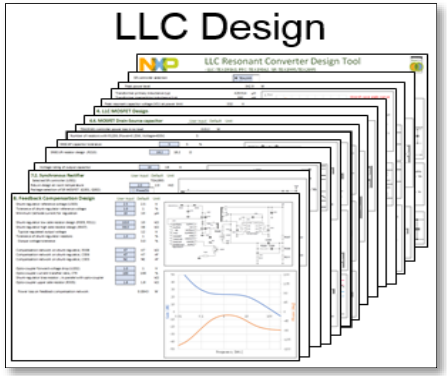
Root Cause:	Under Estimate Tolerance/Distribution	Under Estimate Corner Case Stress/Thermal	Low Focus of Design Optimization
Symptom:	• More Design Rev. • Low Cpk / High ppm failure in (Pre-)Production	Failure at Production or Consumer Side	• Poor Performance & • Higher BOM Cost
Result/Action:	Engineer Resource for Issue Fixing	Engineer Resource for Failure Investigation	• Not Able To Win • 2nd Place/Low Share

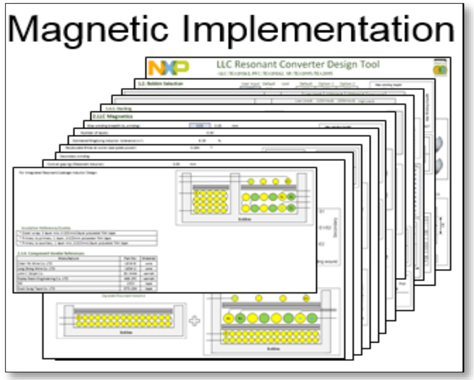
OBJECTIVES - WHAT CAN I GET FROM THE DESIGN TOOL?

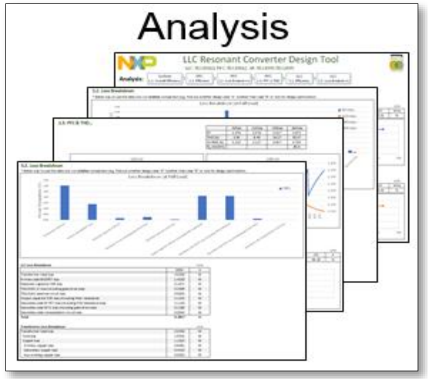
- Detailed step-by-step sequential flow helps engineers easily follow & complete designs
- **Proactively assess worst and corner case stress/thermal of devices**
- **Proactively assess device tolerance/distribution effect to system performance**
- **Fine knobs & guidelines to help engineers fine-tune design towards optimization**
- Complete paper design with schematic, BOM, and magnetic build sheets for whole system
- Combining FHA-based LLC design with a downloadable SIMPLIS simulation model helps save iteration cycles

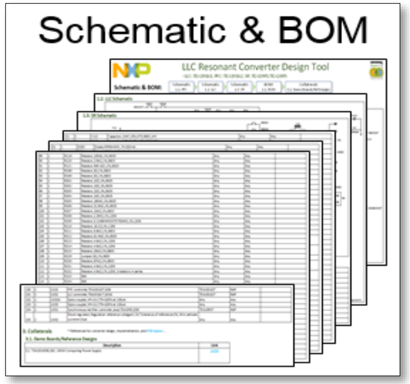
Design Blocks/Flow

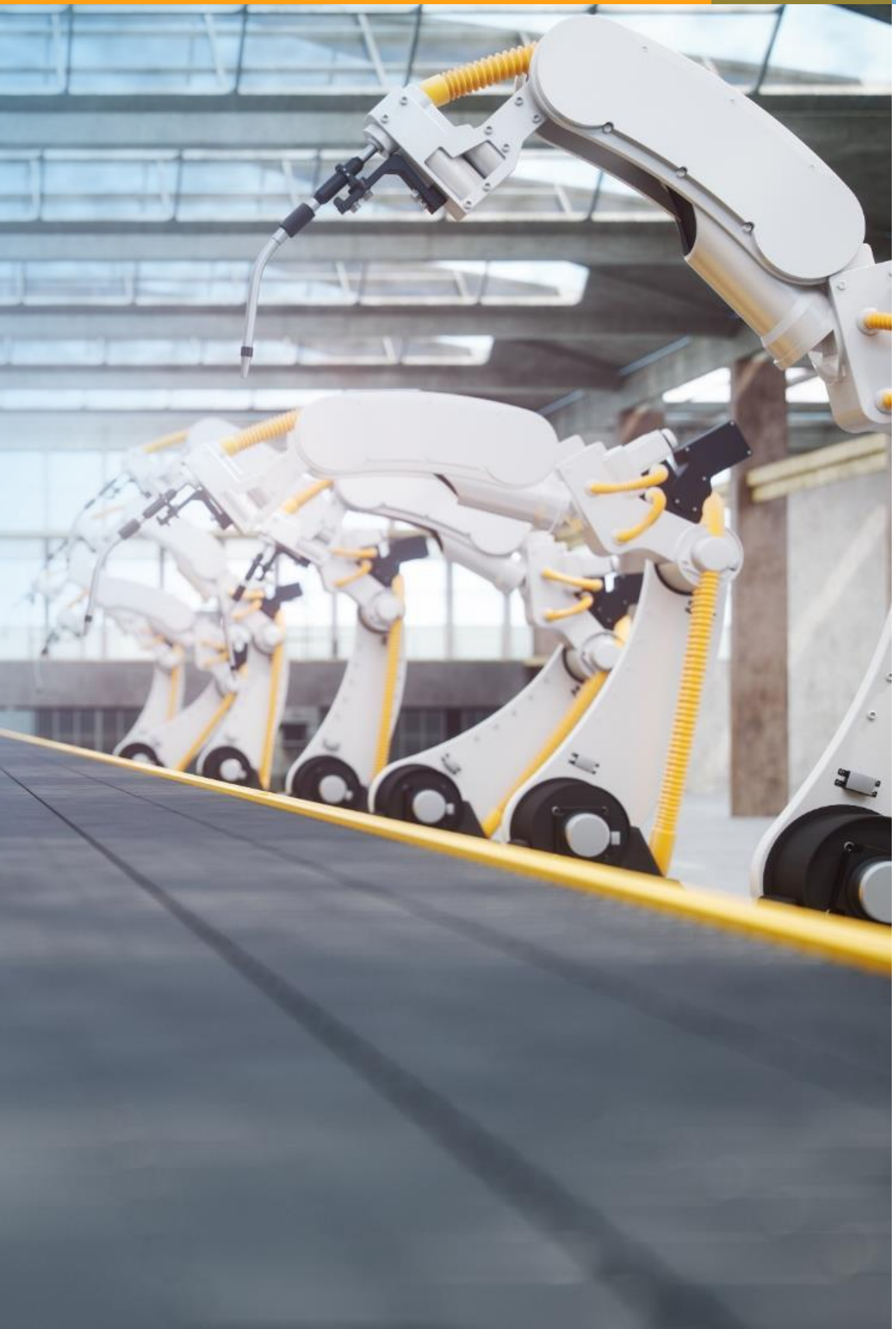












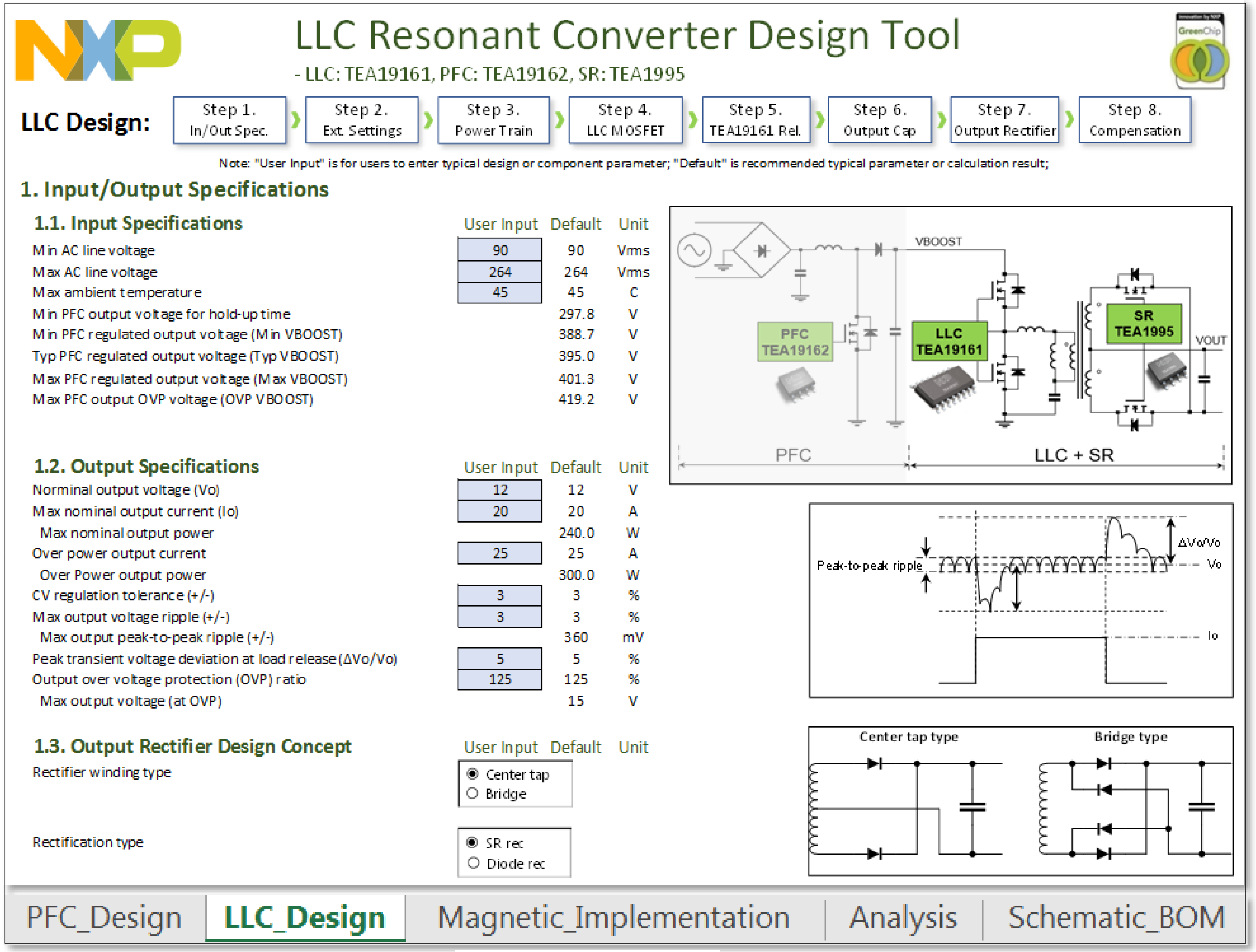
NXP's New LLC Design Tool

Design Blocks/Flow

- PFC Design
- LLC Design
- Magnetic Implementation
- Analysis
- Schematic & BOM

Pipeline/Sequential flow running from

- Left to right
  - Top to bottom



Design Flow

Design Blocks

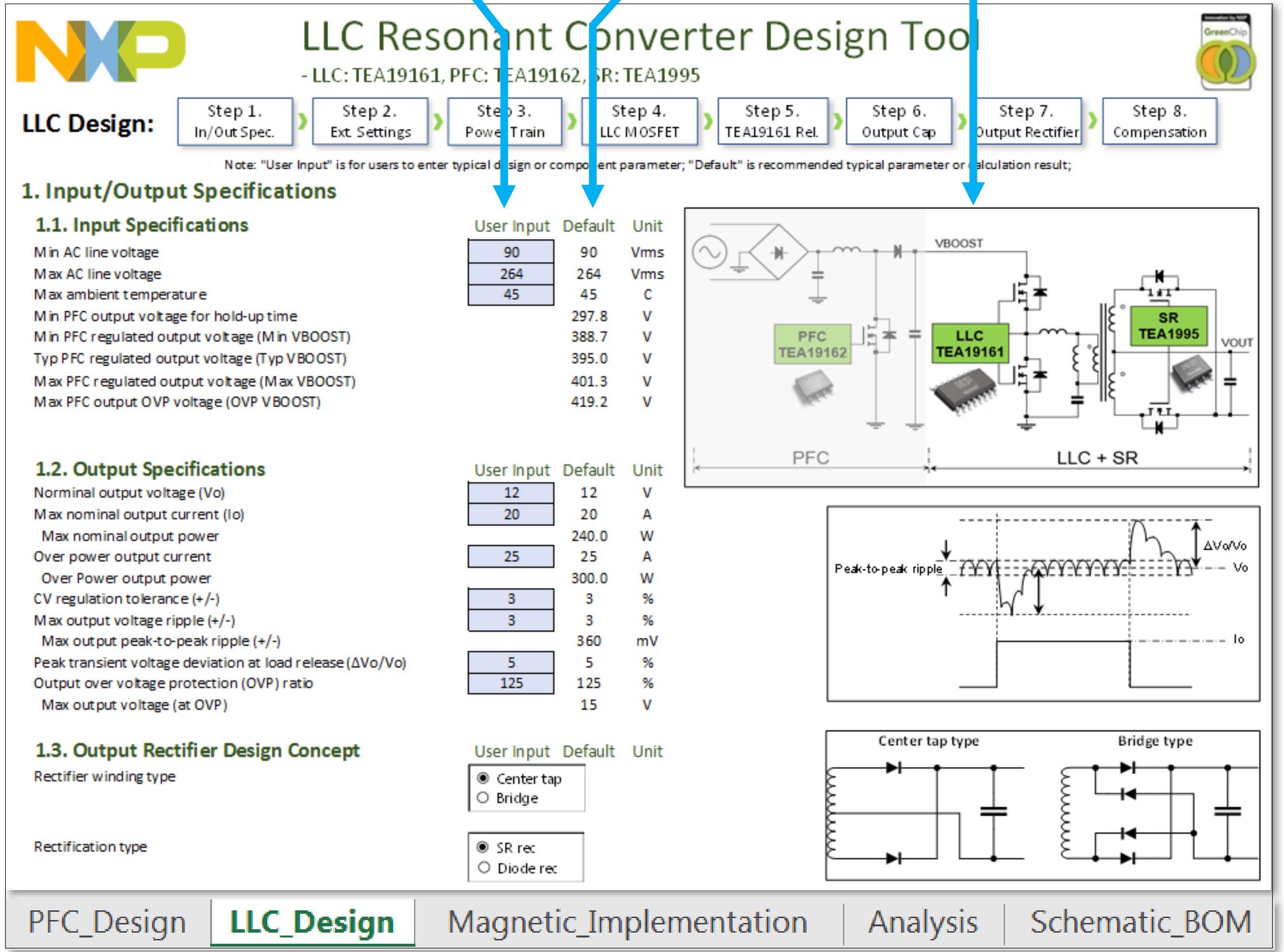
DESIGN TOOL GUIDES

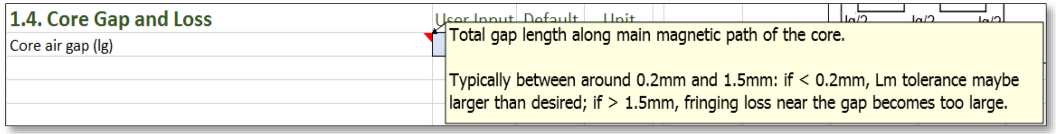
User Input

Default/ Recommend

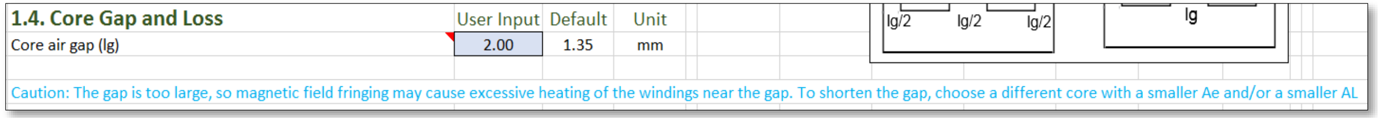
Graphic

Design Sub-Step Overview



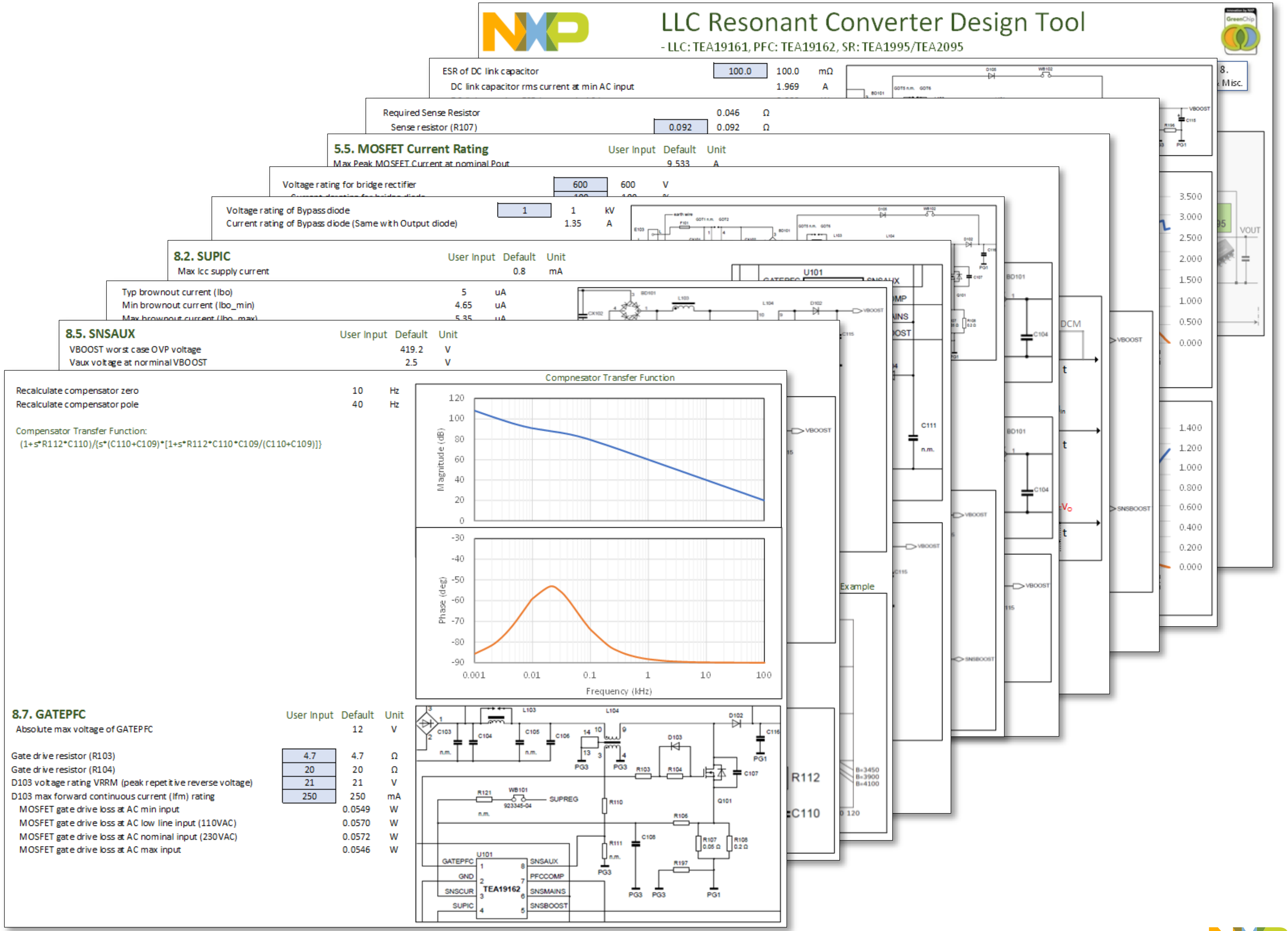


- Info Notes – Real Time App Notes
- Min/Max Limits and/or Caution/Warning Messages



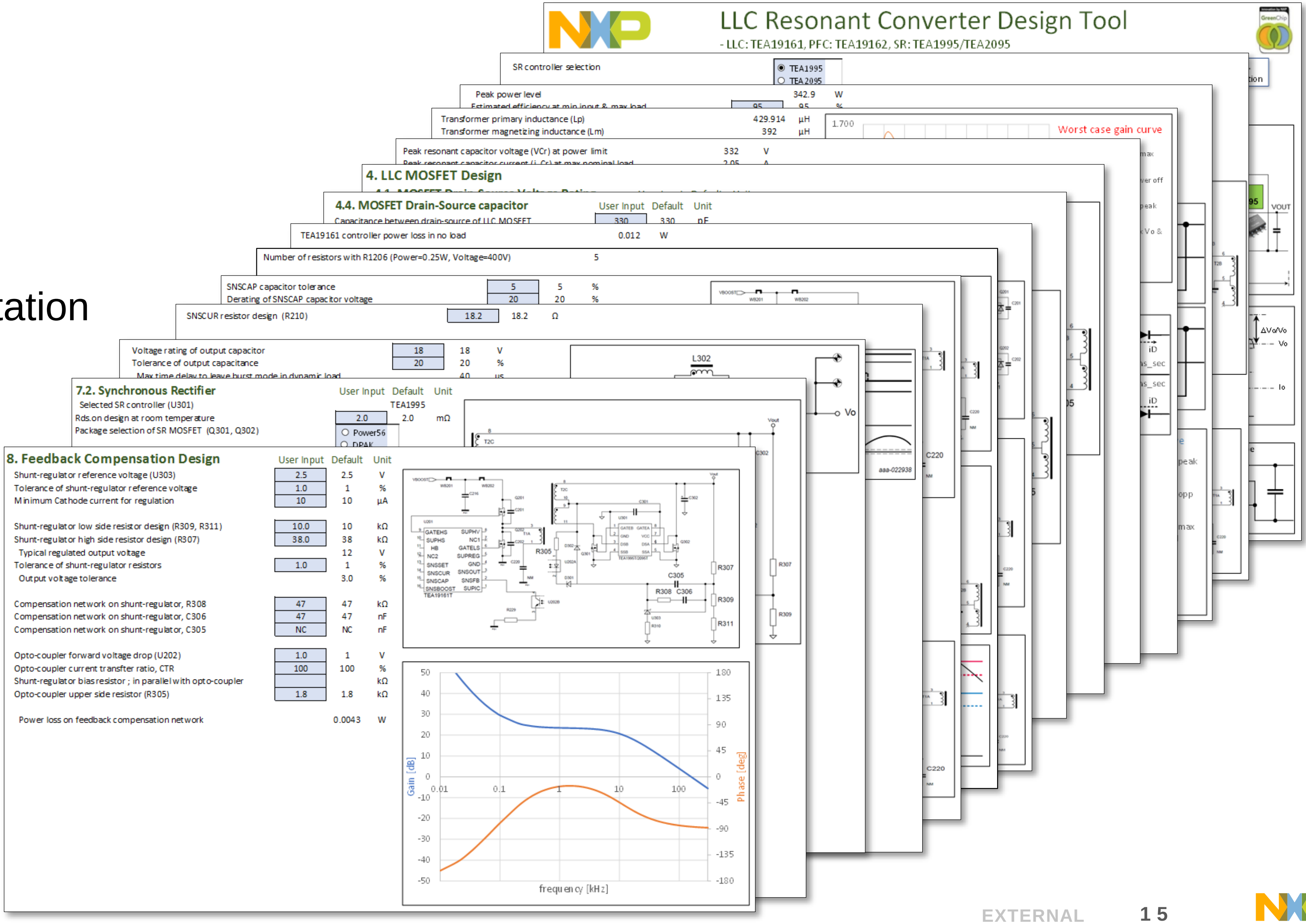
DESIGN FLOW

- **PFC Design**
- LLC Design
- Megnetic Implementation
- Analysis
- Schematic & BOM



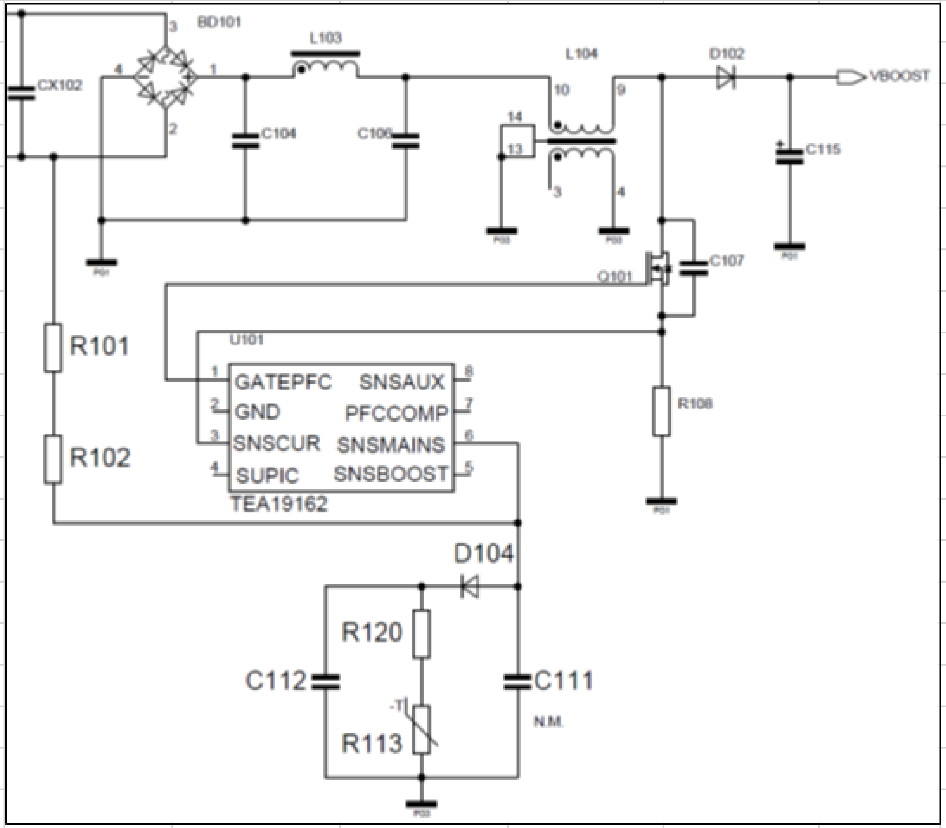
DESIGN FLOW

- PFC Design
- **LLC Design**
- Megnetic Implementation
- Analysis
- Schematic & BOM



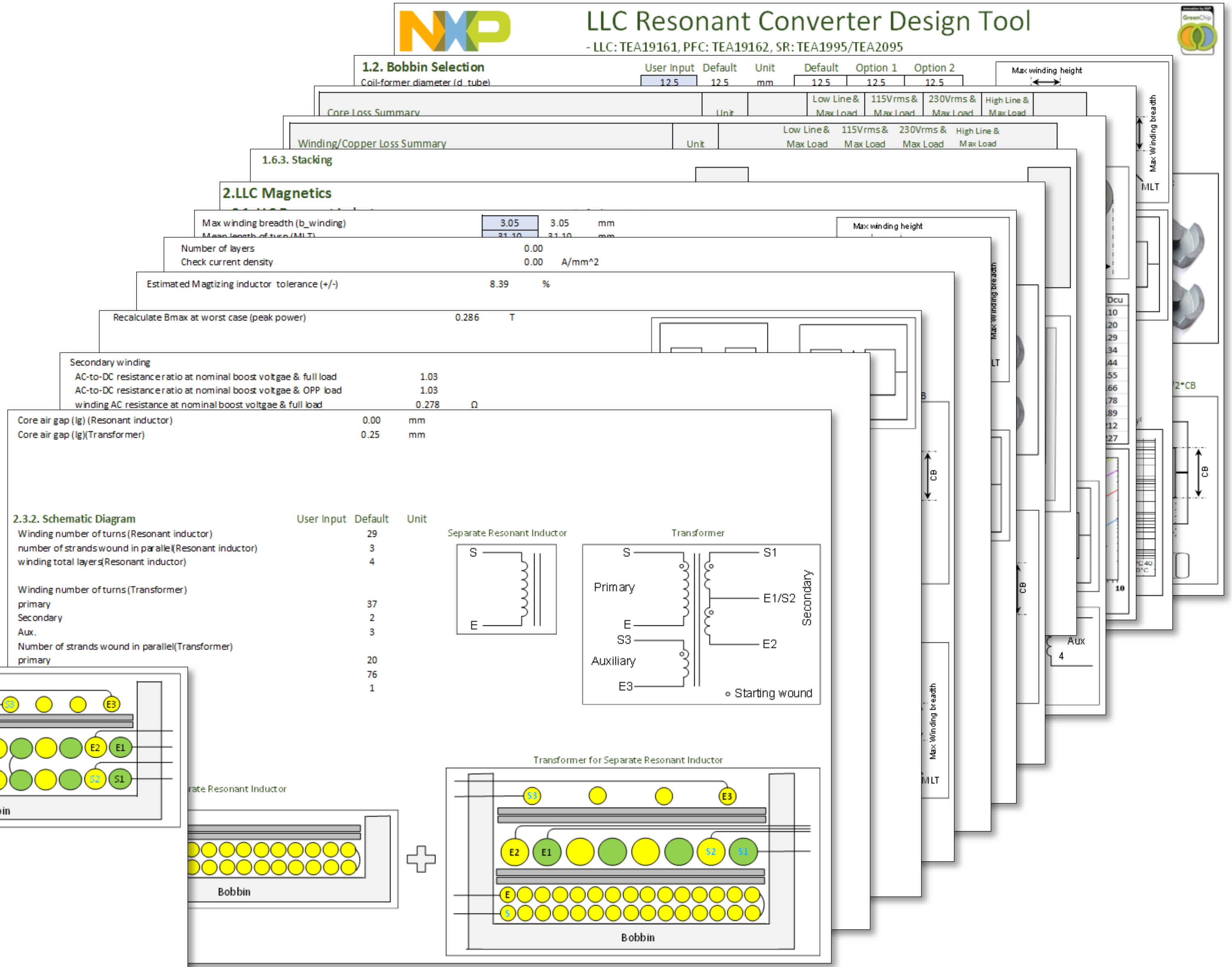
DESIGN EXAMPLE: DISTRIBUTION

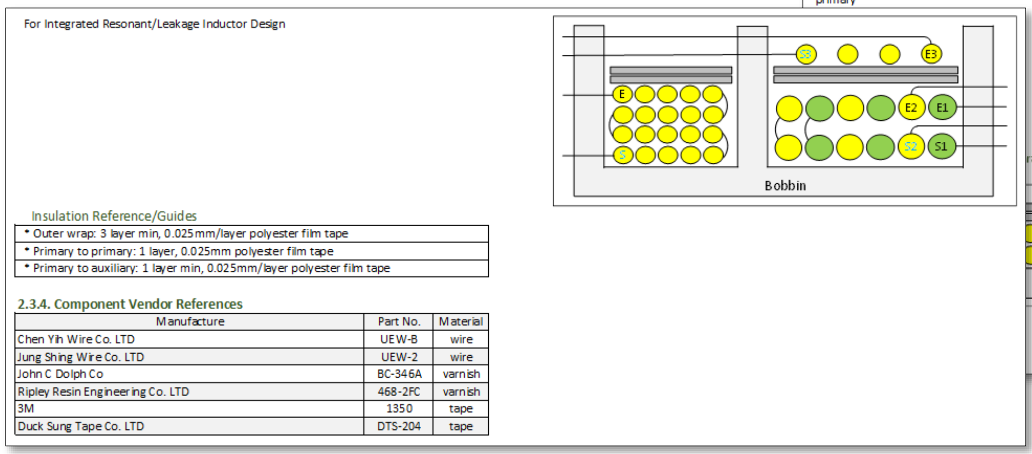
8.4. SNSMAINS	User Input	Default	Unit
Typ brownin current (Ibi)		5.75	uA
Min brownin current (Ibi_min)		5.35	uA
Max brownin current (Ibi_max)		6.15	uA
Typ brownout current (Ibo)		5	uA
Min brownout current (Ibo_min)		4.65	uA
Max brownout current (Ibo_max)		5.35	uA
Typ regulated voltage on pin SNSMAINS		0.25	V
Absolute max voltage on pin SNSMAINS		12	V
Top resistor (R101)	8.6	8.6	MegΩ
Top resistor (R102)	8.6	8.6	MegΩ
Worst case SNSMAINS power loss		0.0081	W
Typ brownin voltage (rms)		70.0	V
Min brownin voltage (rms)		65.1	V
Max brownin voltage (rms)		74.9	V
Typ brownout voltage (rms)		60.9	V
Min brownout voltage (rms)		56.6	V
Max brownout voltage (rms)		65.1	V



DESIGN FLOW

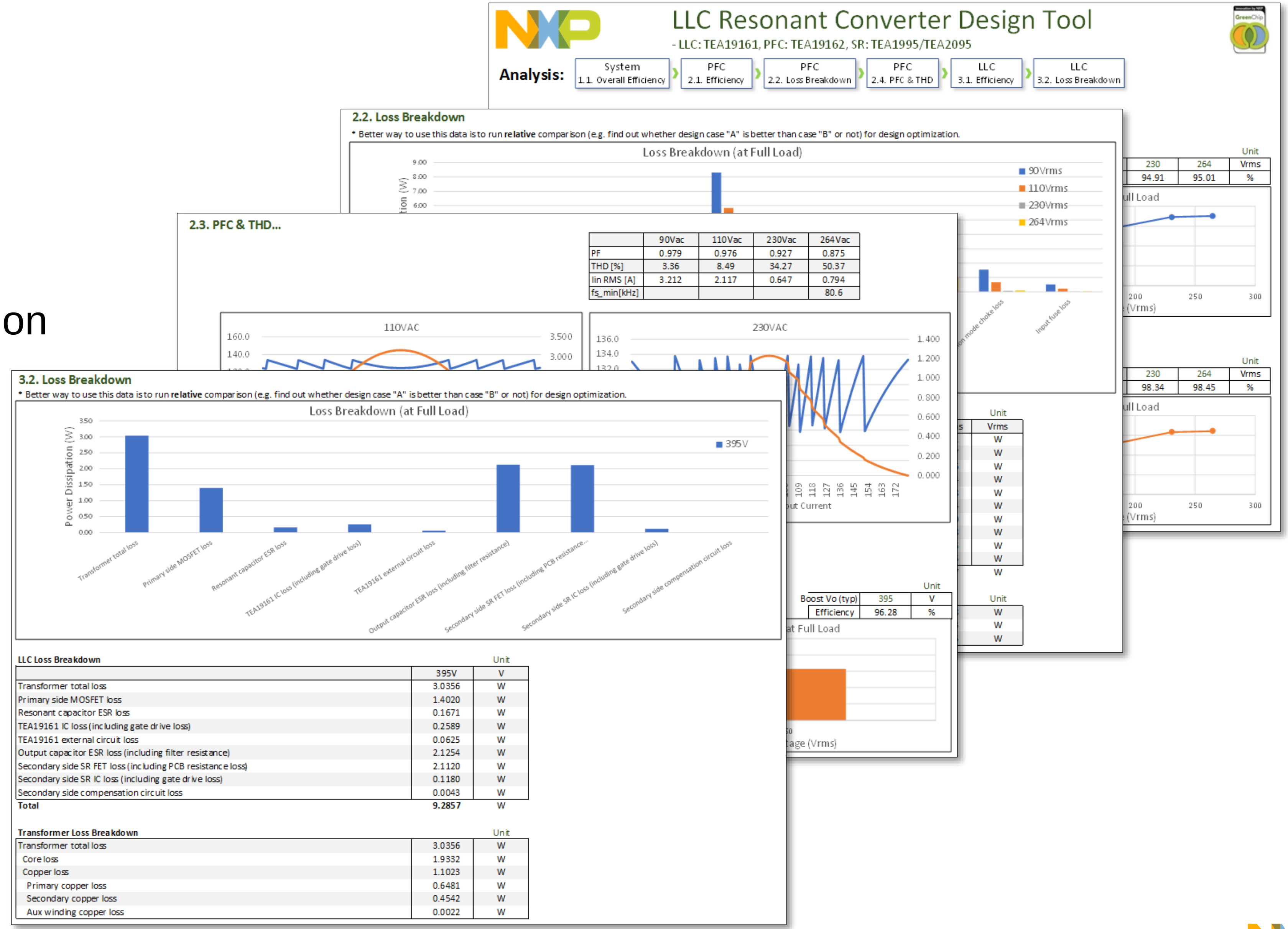
- PFC Design
- LLC Design
- **Magnetic Implementation**
- Analysis
- Schematic & BOM





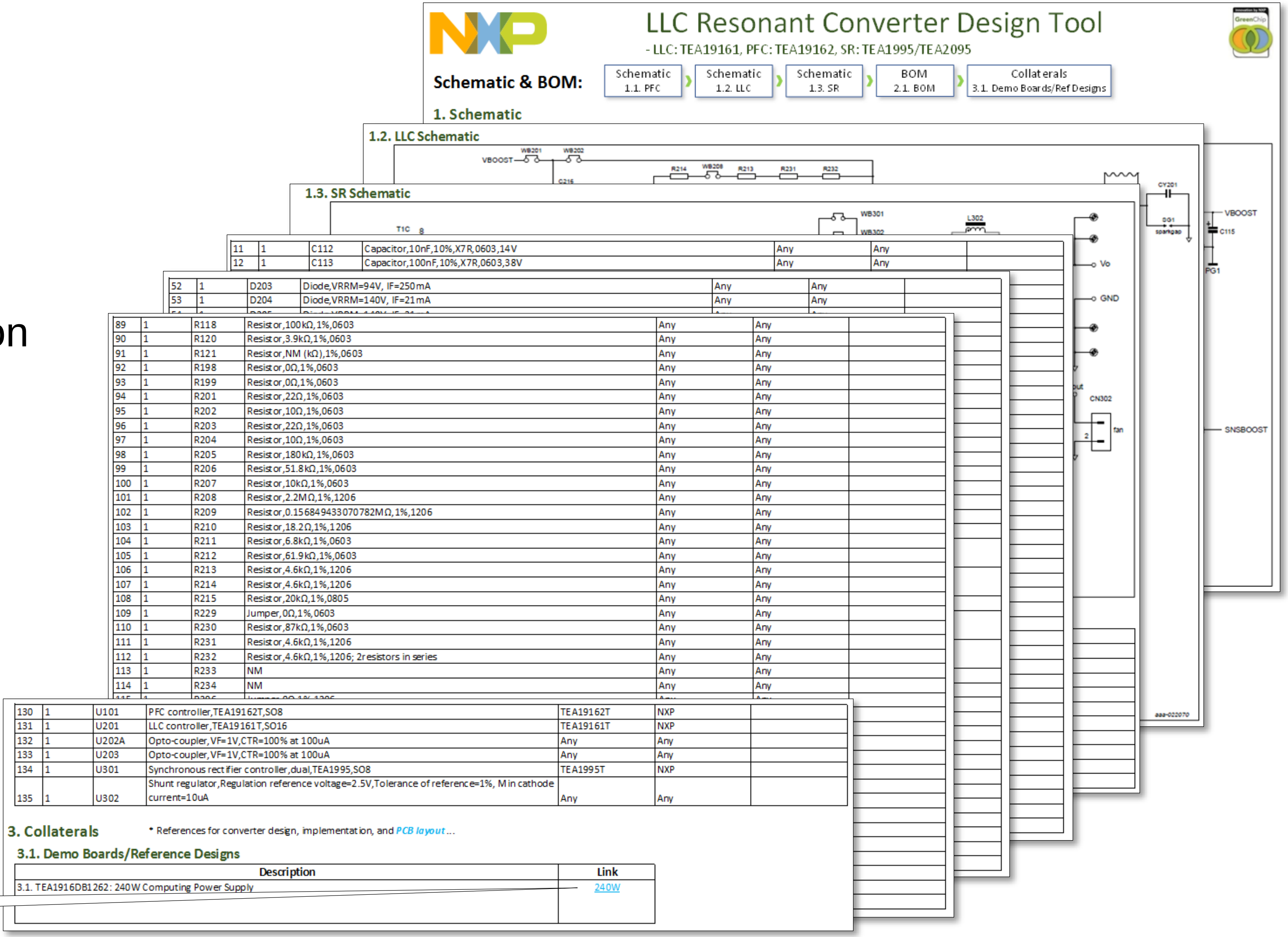
DESIGN FLOW

- PFC Design
- LLC Design
- Megnetic Implementation
- **Analysis**
- Schematic & BOM



DESIGN FLOW

- PFC Design
- LLC Design
- Megnetic Implementation
- Analysis
- **Schematic & BOM**



Demo Board/Ref Design Links

Simulation Benefits

BEHAVIOR LEVEL SIMULATION

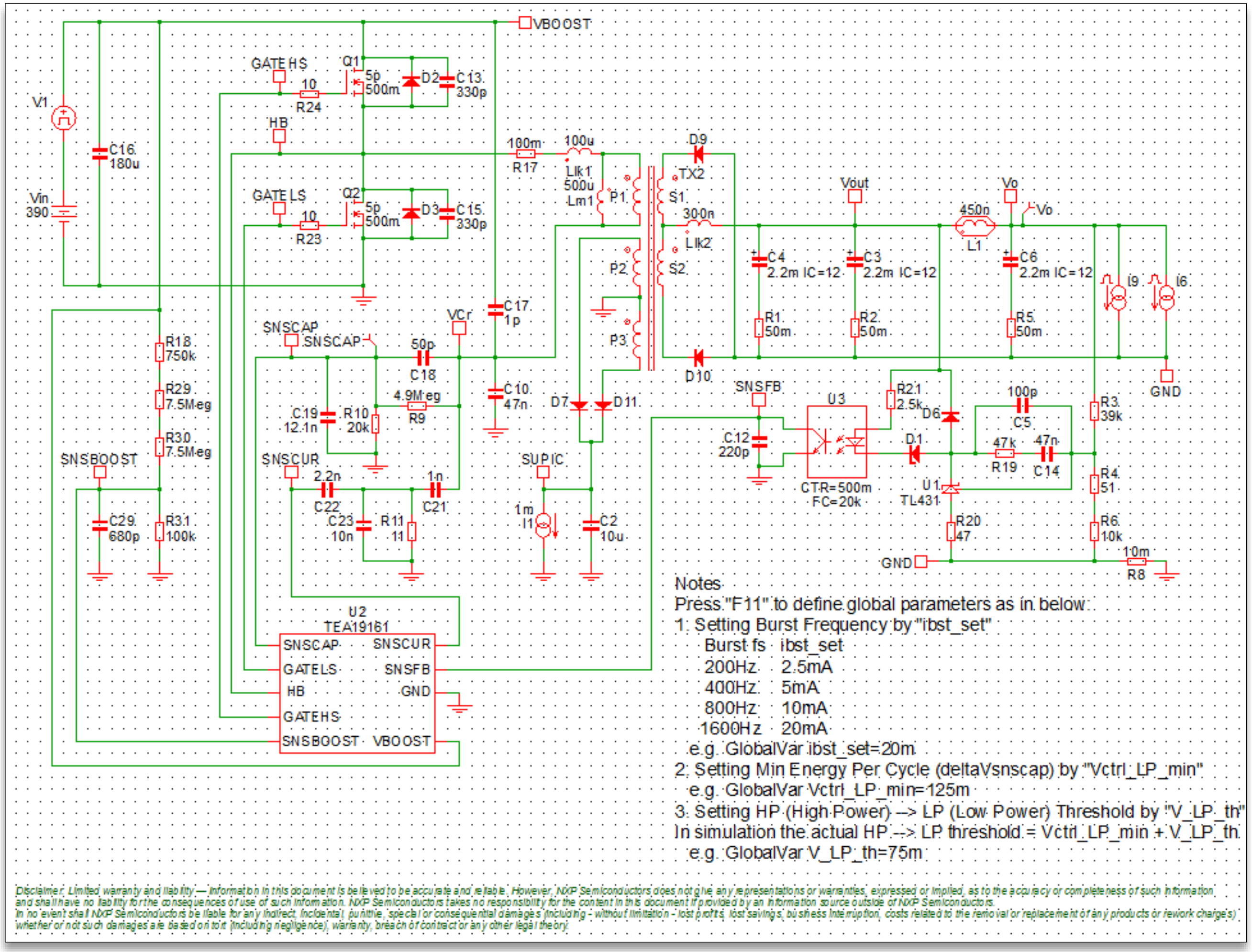
- Operation only at *fo* can remove FHA, hence show good agreement with bench. When operates away from *fo*, design error starts to show up
- FHA design approach helps to create an initial design with clear physical meanings, but
- Iterative bench tuning/optimization maybe necessary

- Computer based simulation compensates FHA weakness and provides accurate design values, hence plays an important role in LLC design, therefore
- Combining FHA design with simulation can effectively save iteration cycles

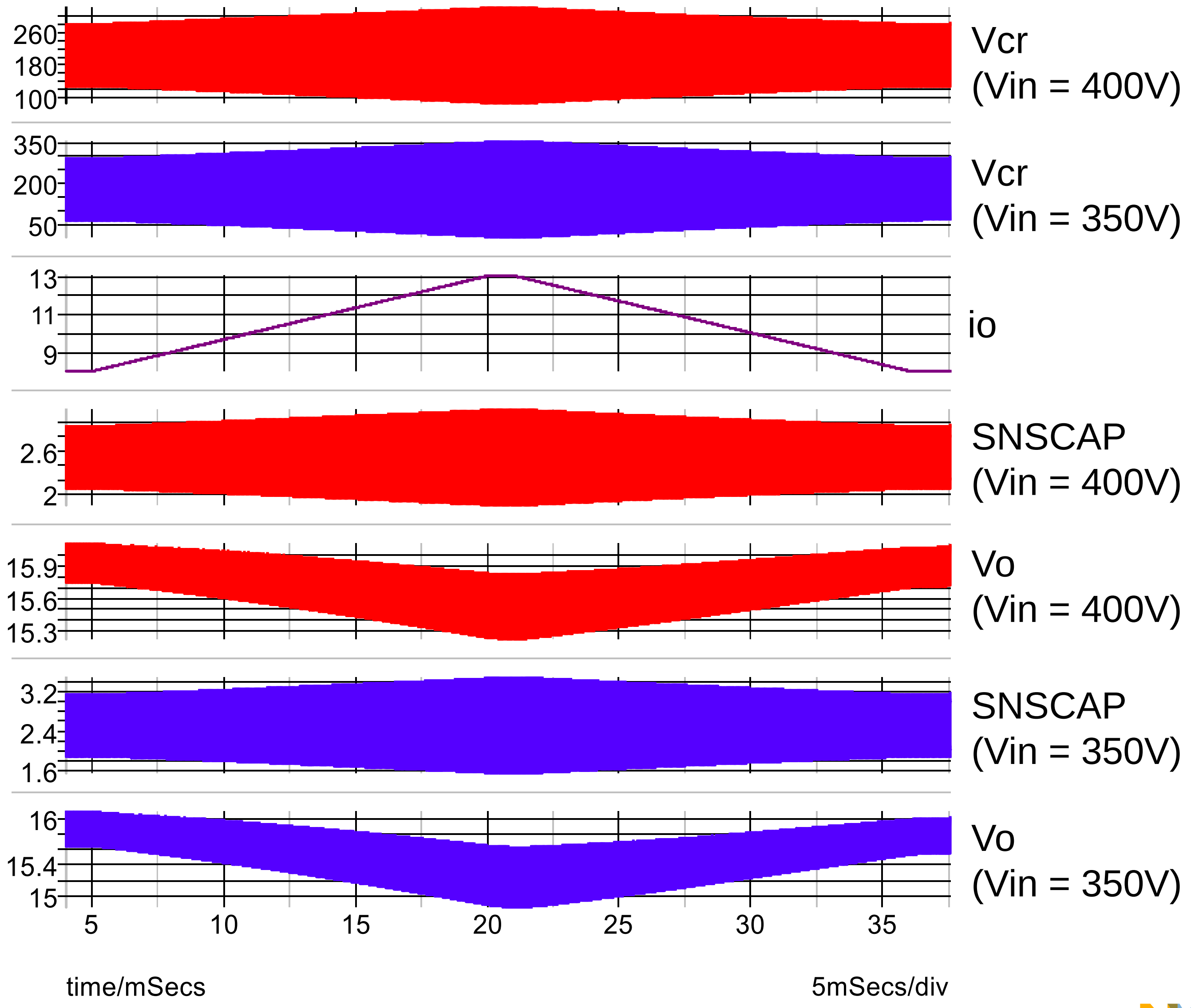
→ HIGHLY RECOMMENDED

TEA19161 (LLC) SIMPLIS BEHAVIOR LEVEL SIMULATION MODEL

- More effective to fine-tune a design on simulation than on bench
- Bridge gaps between Excel-based paper design and bench performance
- Simulate DC, AC, and transient response…

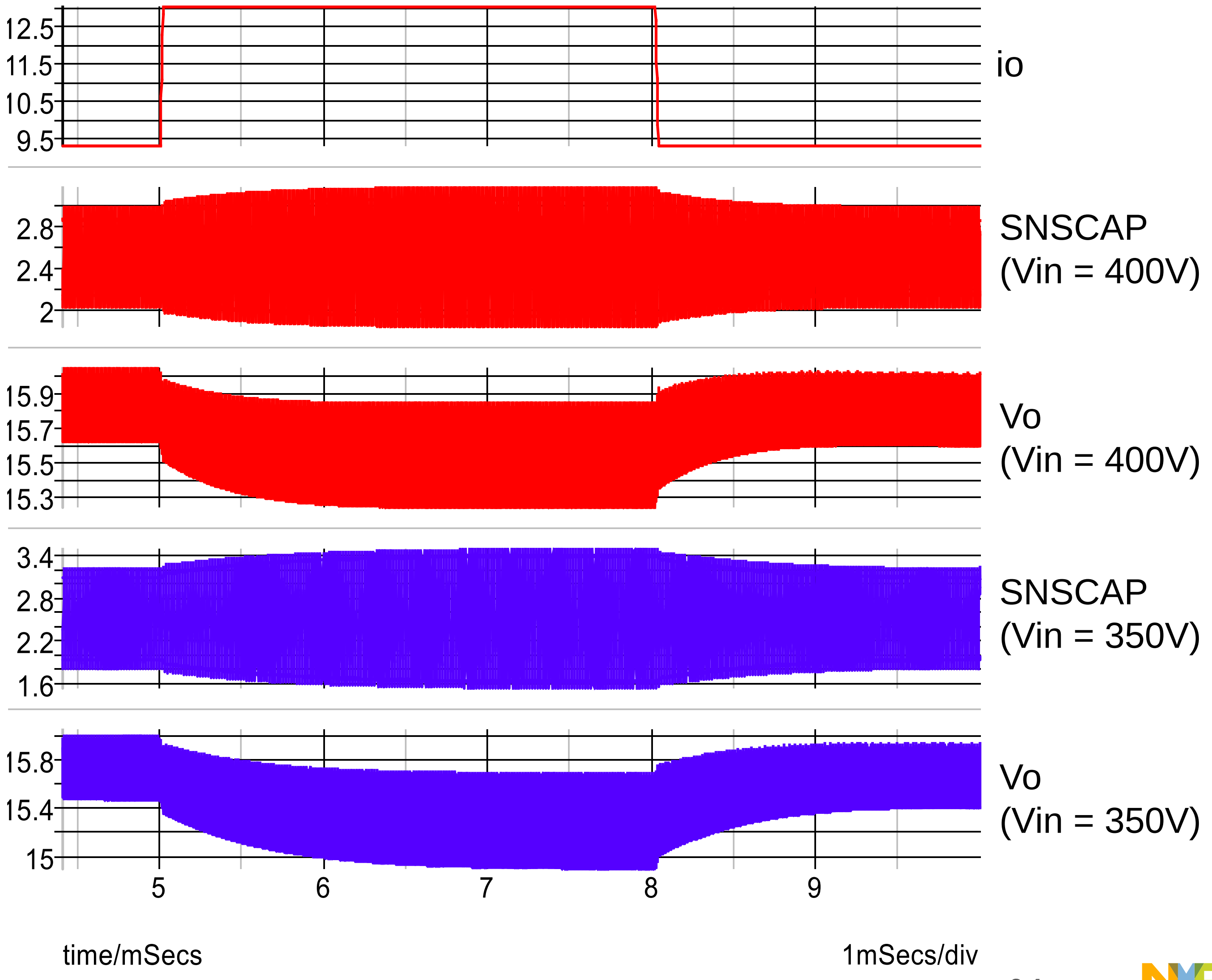


- Slowly sweep load at min and max Vin respectively to verify "DC" operation across various operating points

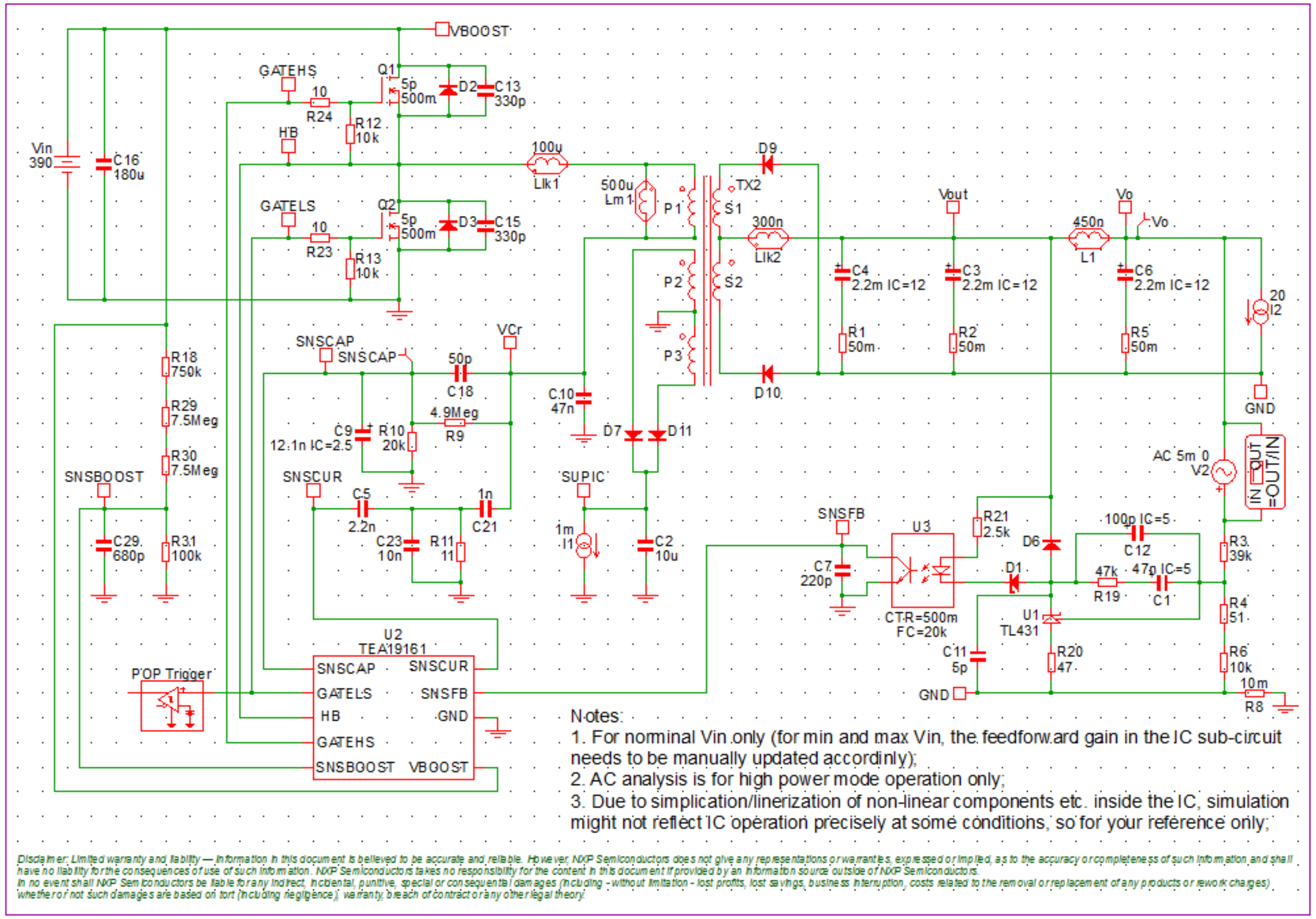


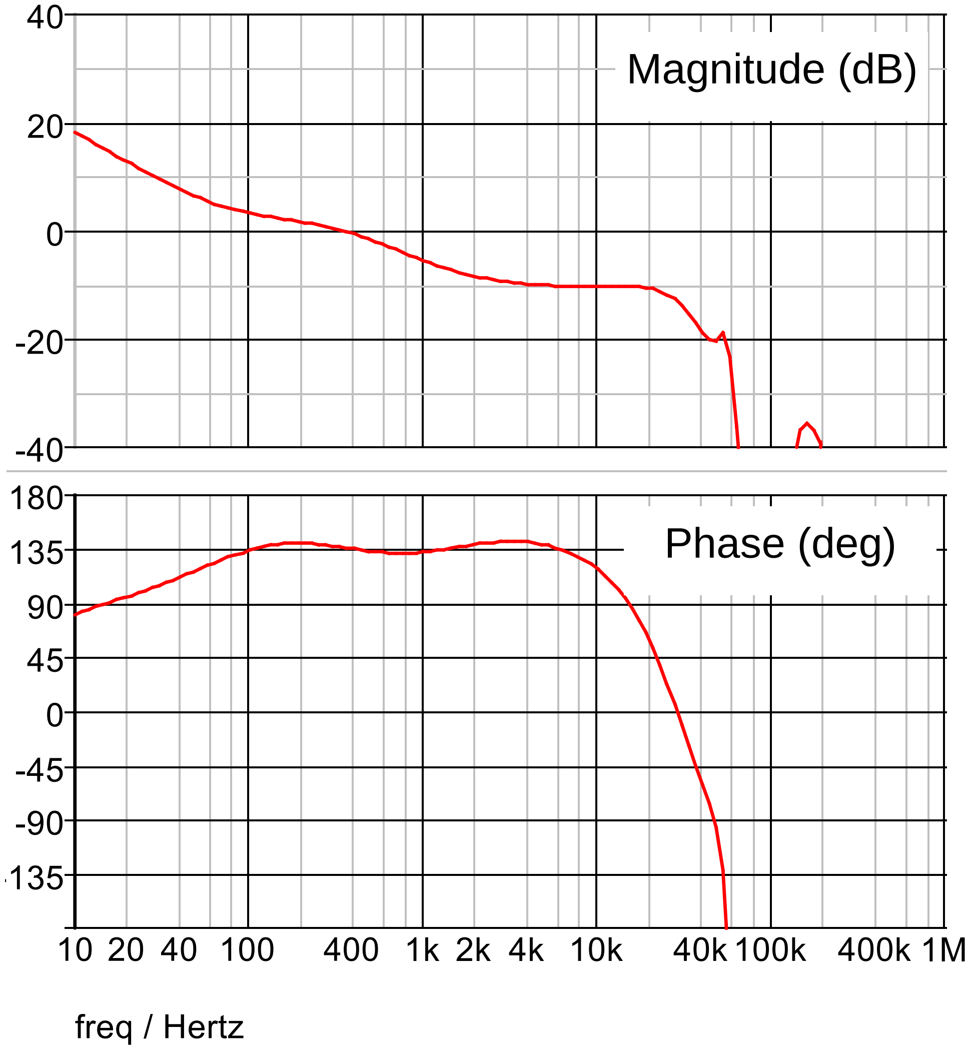
CORNER CASE TRANSIENT RESPONSE

- Verify worst case load transient response at min and max Vin…

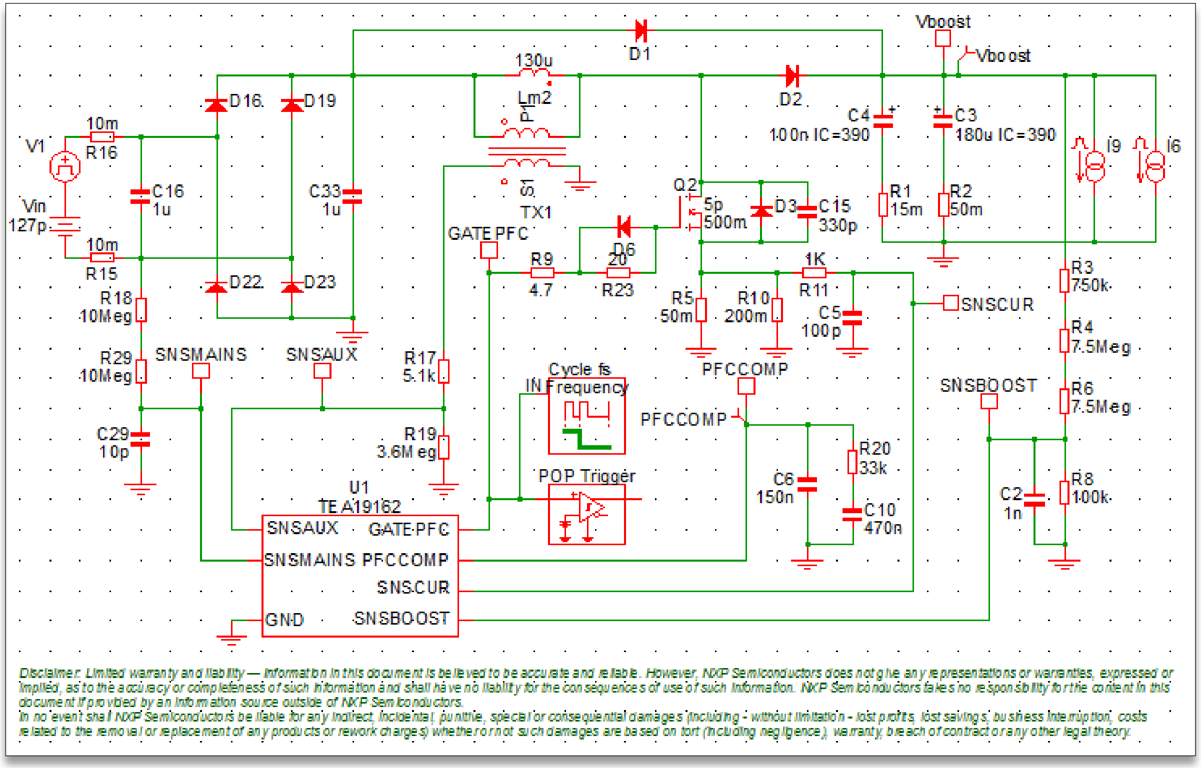


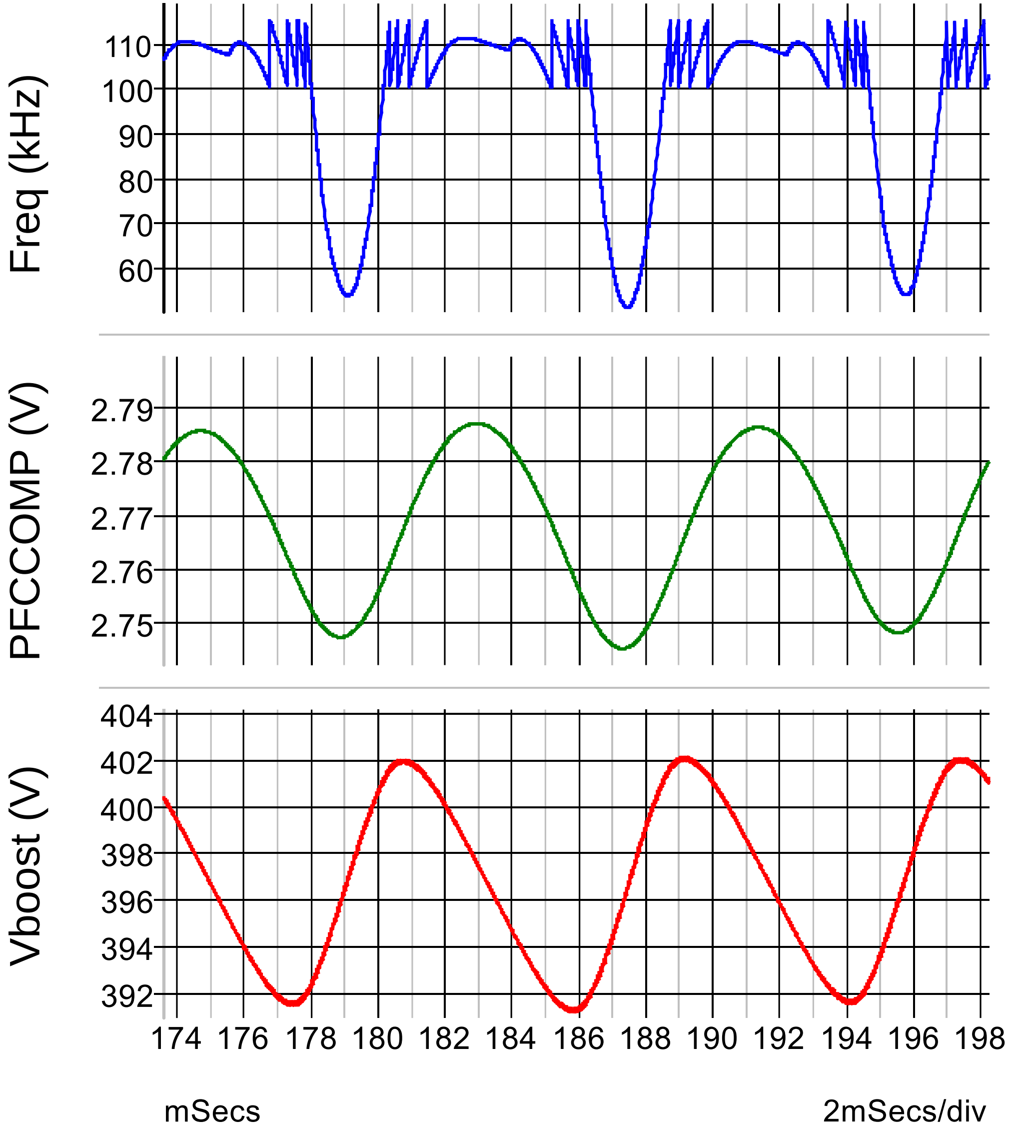
AC ANALYSIS: CLOSED-LOOP GAIN BODE PLOT (FOR REFERENCE ONLY)





TEA19162 (PFC) SIMPLIS BEHAVIOR LEVEL SIMULATION MODEL



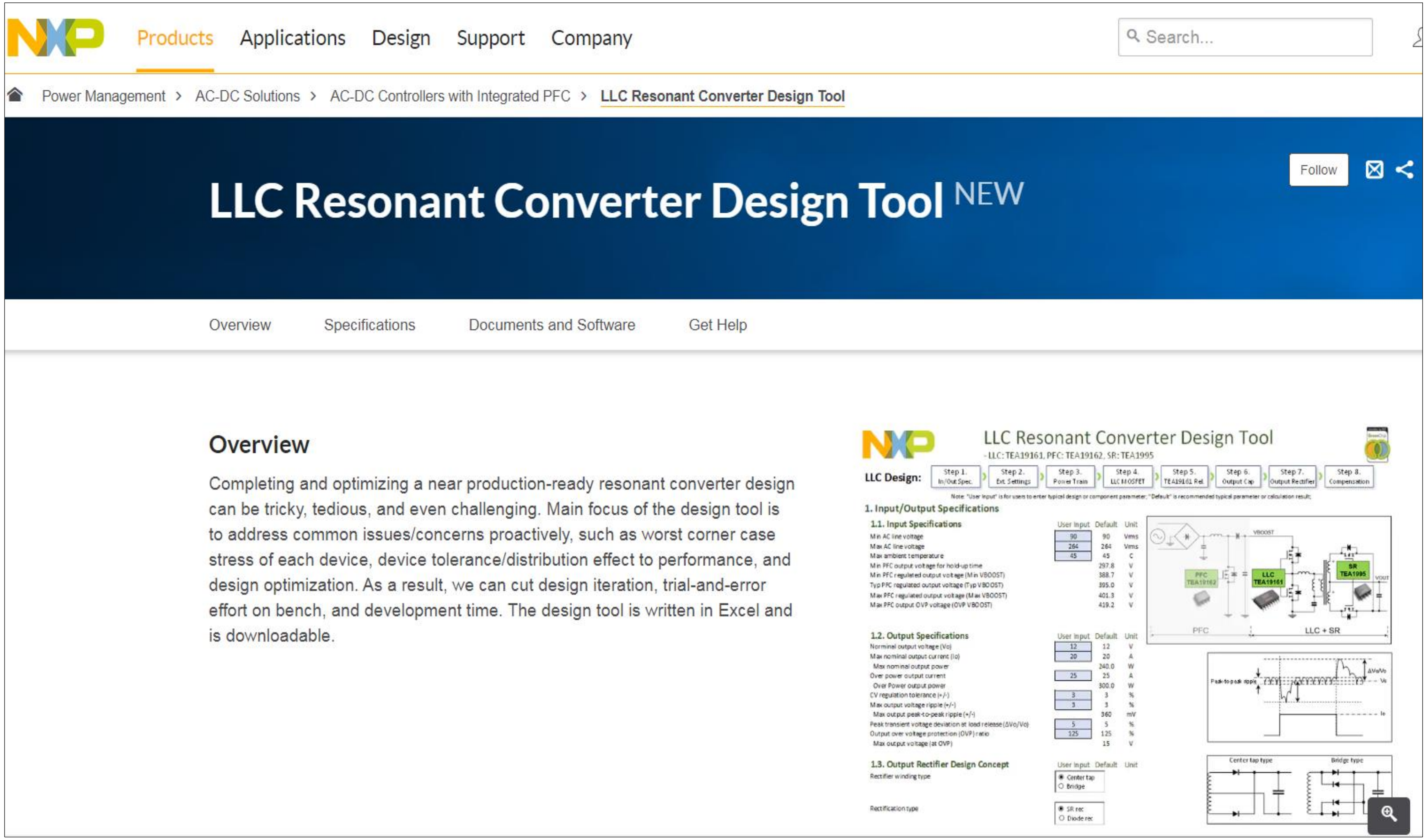


- For completeness of the system design
- Not as critical as that of LLC
- Typically longer simulation time

Get Start - Collaterals

NEWLY LAUNCHED

www.nxp.com/LLC-DESIGN-TOOL



NEWLY LAUNCHED

www.nxp.com/LLC-DESIGN-TOOL

Documents and Software

DOCUMENTS (7)

- Data Sheet (6)
- Fact Sheet (1)

DESIGN RESOURCES (5)

- Design Tools & Files (5)

Design Files - miscellaneous (5)

Analytical (Excel) Design Tool

LLC Resonant Converter Design Tool (REV 2) UPDATED
LLC Resonant Converter Design Tool
XLSX 14.8 MB 2020-05-30 00:01:00 TEA1916-DESIGN-TOOL
DOWNLOAD

Simplis Simulation Models

TEA19161 Simplis Model (for HP Mode Only) (REV 2)
TEA19161 Simplis Model (for HP Mode Only)
ZIP 69.9 kB 2020-05-16 22:24:00 TEA19161-SIMPLIS-MODEL-HP
DOWNLOAD

TEA19161 Simplis Model (with All Operating Modes) (REV 2)
TEA19161 Simplis Model (with All Operating Modes)
ZIP 104.0 kB 2020-05-16 22:11:00 TEA1916-SIMPLIS-MODEL-ALL-MODES
DOWNLOAD

TEA19161 Simplis Model (for AC Analysis) (REV 2)
TEA19161 Simplis Model (for AC Analysis)
ZIP 71.2 kB 2020-05-16 22:28:00 TEA19161-SIMPLIS-MODEL-AC
DOWNLOAD

TEA19162 Simplis Model (REV 1)
TEA19162 Simplis Model
ZIP 48.7 kB 2020-05-06 14:57:00 TEA19162-SIMPLIS-MODEL
DOWNLOAD

FACT SHEET

Streamlining design and optimization time

NXP LLC Resonant Converter Design Tool

The NXP LLC resonant converter design tool helps engineers bridge design and decision-making gaps from system specifications to a complete set of paper designs with the help of a simple, sequential design flow.

OVERVIEW

Completing and optimizing a near production-ready resonant converter design can be tricky, tedious, and even challenging. The main focus of the design tool is to address common issues/concerns proactively, such as worst corner case stress of each device, device tolerance/distribution effect to performance, and design optimization. As a result, we can cut design iteration, trial-and-error effort on bench, and development time. The design tool is written in Excel and is downloadable.

FEATURES AND BENEFITS

- Detailed step-by-step sequential flow helps engineers to easily follow and complete designs
- Proactively assess worst and corner case stress and thermal of devices
- Proactively assess device tolerance/distribution effect to system performance
- Fine knobs and guidelines to help engineers fine-tune design towards optimization
- Complete a paper design with schematic, BOM, and magnetic build sheets for the whole system
- Combining FHA-based LLC design with a downloadable SIMPLIS simulation model helps to save iteration cycles

APPLICATIONS

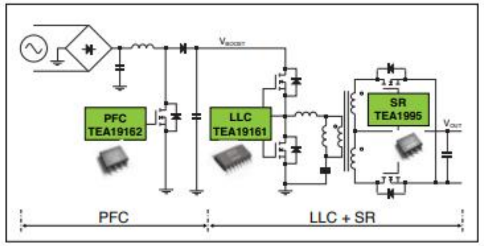
- Desktop and all-in-one (AIO) PCs
- Gaming consoles
- TV power supplies (Ultra HD, 4K)
- Notebook adapters

SUPPORTING PRODUCTS

The TEA19161T and TEA19162T/HT are combined controller ICs for a LLC resonant converter including a PFC. They provide high efficiency across all power levels. Combining with the TEA1995T/TEA2095T(TE) dual LLC resonant SR controller further enhances system efficiency at relatively low cost.

- **TEA19161T:** Digital controller for high-efficiency resonant power supply
- **TEA19162T/HT:** PFC controller
- **TEA1995T:** Dual synchronous rectifier controller (Product is an NXP GreenChip® solution)
- **TEA2095T/TE:** Dual synchronous rectifier controller (Product is an NXP GreenChip® solution)

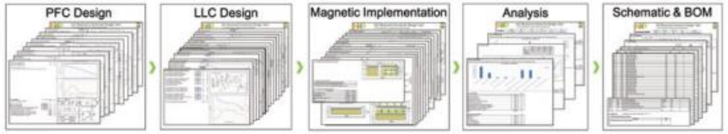
SYSTEM CONFIGURATION: PFC + LLC RESONANT CONVERTER + SR



DESIGN BLOCKS

The Excel-based design tool is self-explanatory. Five design blocks are available: PFC design, LLC design, magnetic implementation, analysis, and schematic & BOM. The sequential flow runs from left to right as shown on spreadsheets at the bottom of the Excel file.

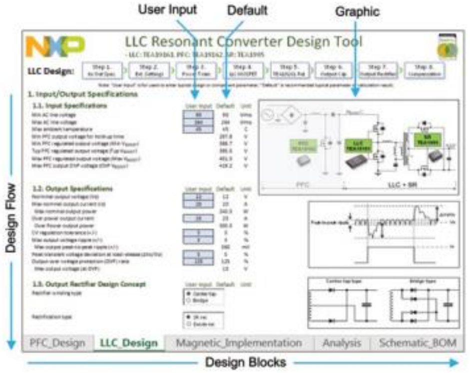
- **PFC Design:** Cover all powertrain and IC-related component design
- **LLC Design:** Cover all powertrain and IC-related component design
- **Magnetic Implementation:** Design all magnetic components and recommend Magnetic Build Sheets used for magnetic vendors to construct magnetic samples
- **Analysis:** Facilitate design case comparison and design optimization
- **Schematic & BOM:** Complete system schematic and BOM for PCB layout and part ordering



DESIGN FLOW

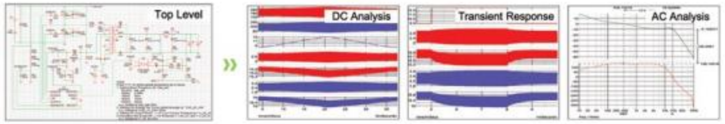
For each design block the flow runs from top to bottom sequentially.

- **User Input:** For users to enter design or component parameters
- **Default:** Recommended parameters or calculation results
- **Graphic area:** To better illustrate contents
- **Real-time design guides:** Hover over "User Input" or a description and a note pops up with an explanation or a design recommendation
- **Precaution:** If an entered "User Input" is way off reasonable design range, a "Caution" or "Warning" message pops up with an explanation or guidelines



SIMULATION VERIFICATION

The FHA approach of the LLC design helps to create an approximate initial design with a clear physical meaning, but bench tuning/optimization may be necessary. Computer-based simulation compensates FHA design weakness and provides accurate design values, so it plays an important role in LLC design. NXP provides downloadable LLC SIMPLIS simulation models, which help to secure a more solid design.



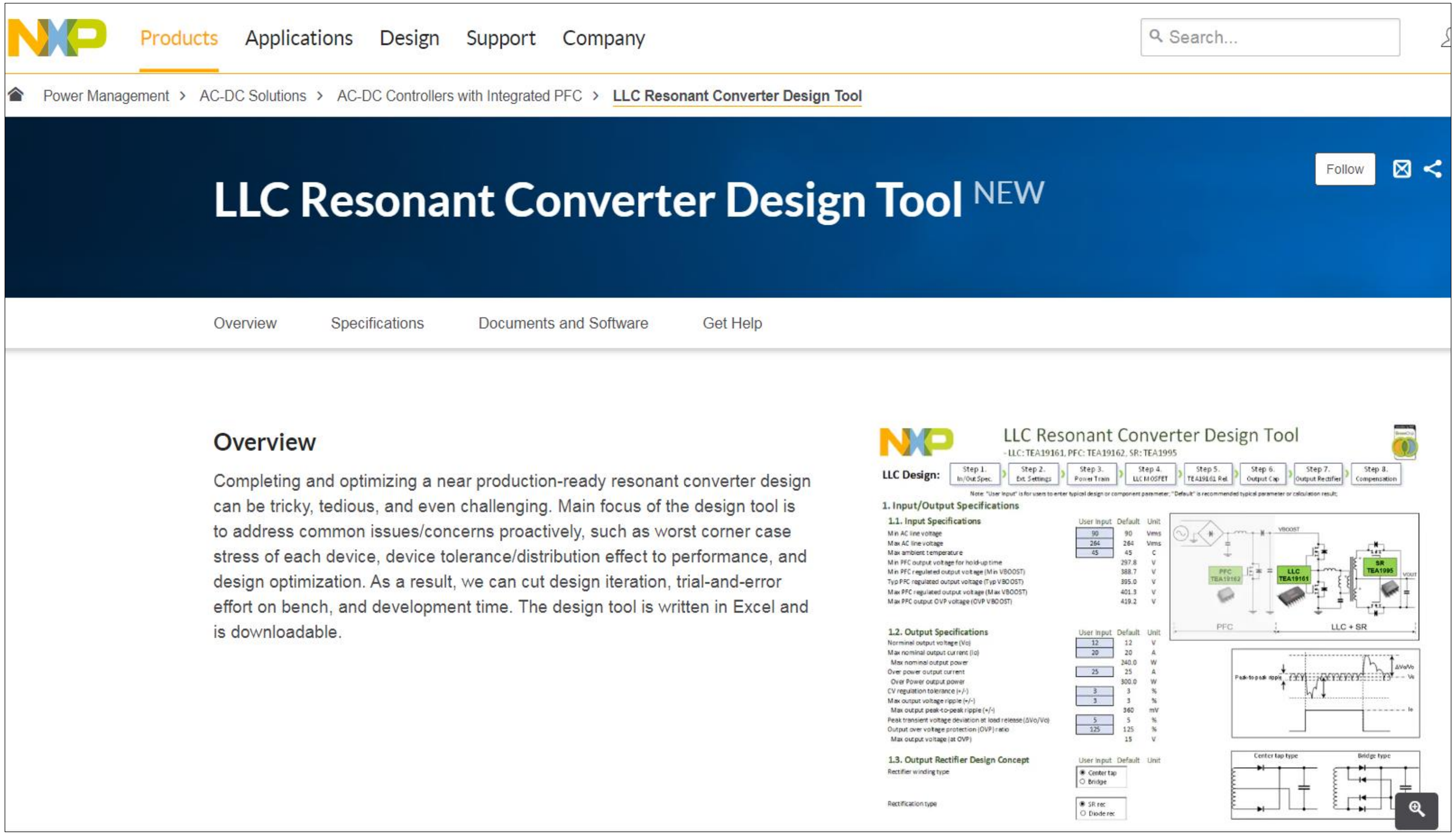
NXP GREENCHIP SOLUTIONS

The NXP GreenChip power solutions portfolio enables smarter, more compact, and energy-efficient power solutions. Complete GreenChip system solutions help optimize applications such as highly efficient power supplies and system protection.

www.nxp.com and imxcommunity.org

Date of Release: 02/2020
Document Number: LLCRESCONDTFS REV 0
Agile Number: 000-00000 REV A

GET START NOW



- Get start by visiting design tool site: *[LLC Resonant Converter Design Tool](www.nxp.com/LLC-DESIGN-TOOL)* (*www.nxp.com/LLC-DESIGN-TOOL*
-)
- Learn more by reading a short design tool fact sheet: *LLC Resonant Converter Design Tool Fact Sheet*

SUMMARY

Why Should I Use Design Tools?

- Detailed step-by-step flow helps to fine tune a design towards optimization
- Platform for juniors to learn good design practice besides finishing a design
- Improve supporting level, design in/win likelihood, and grow product shares

How Can I Trust Design Tools?

- Systematical validation and calibration process
- Cross check engineers’ own designs

What Can I Get from Design Tools?

- Minimize design iterations and try-and-error effort on bench
- Increase productivity and reduce time-to-market

SECURE CONNECTIONS
FOR A SMARTER WORLD