

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

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SECURE CONNECTIONS
FOR A SMARTER WORLD

EXTERNAL

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OVERVIEW

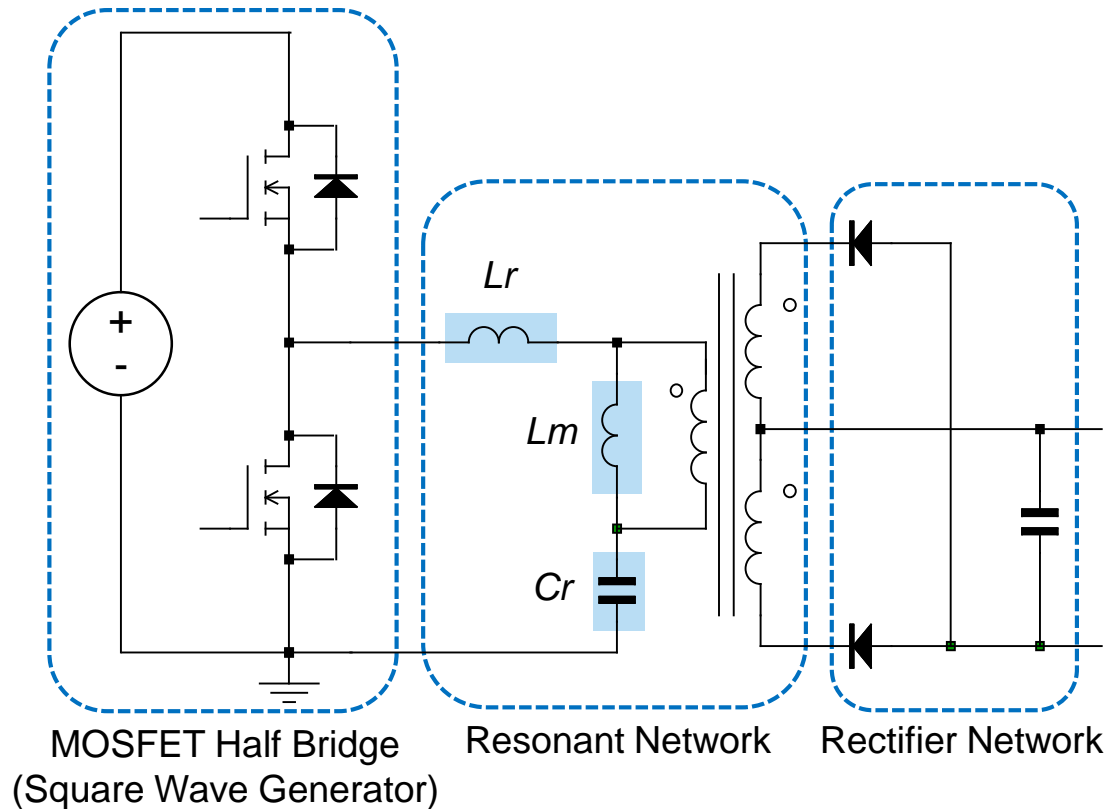
- LLC Recap and NXP Solutions
- Design Objectives and Challenges
- NXP's New LLC Design Tool
- Simulation Benefits
- Get Start - Collaterals



LLC Recap and NXP Solutions

LLC RESONANT CONVERTER RECAP

- 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

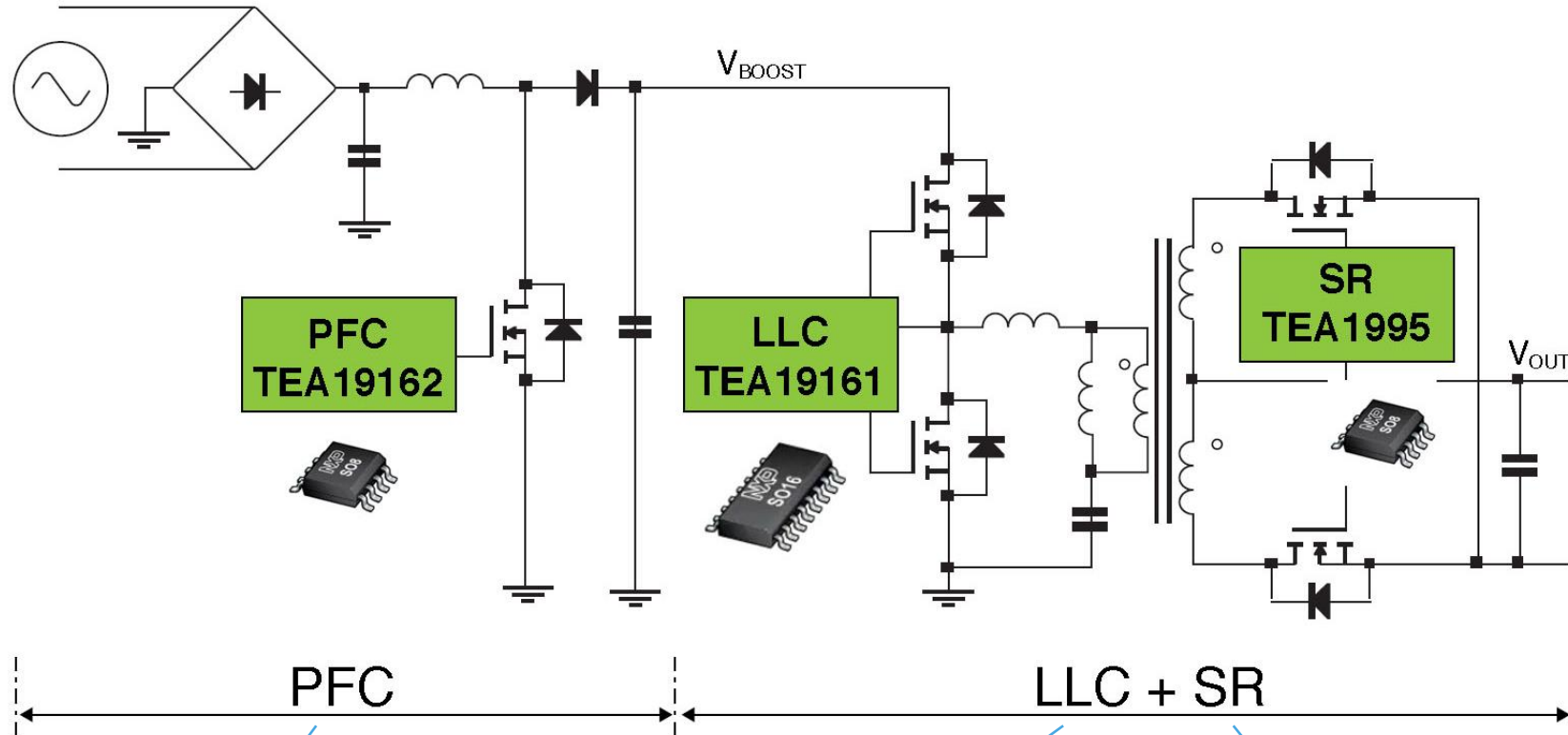


Key Applications

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



NXP AC-DC SOLUTIONS



- TEA19162T/HT: PFC controller

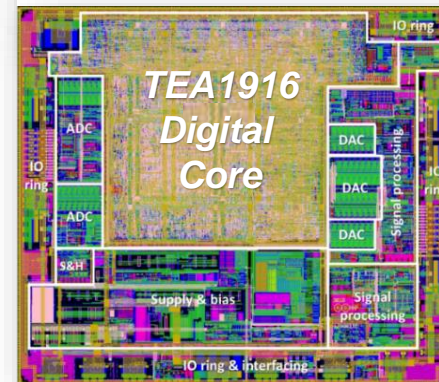
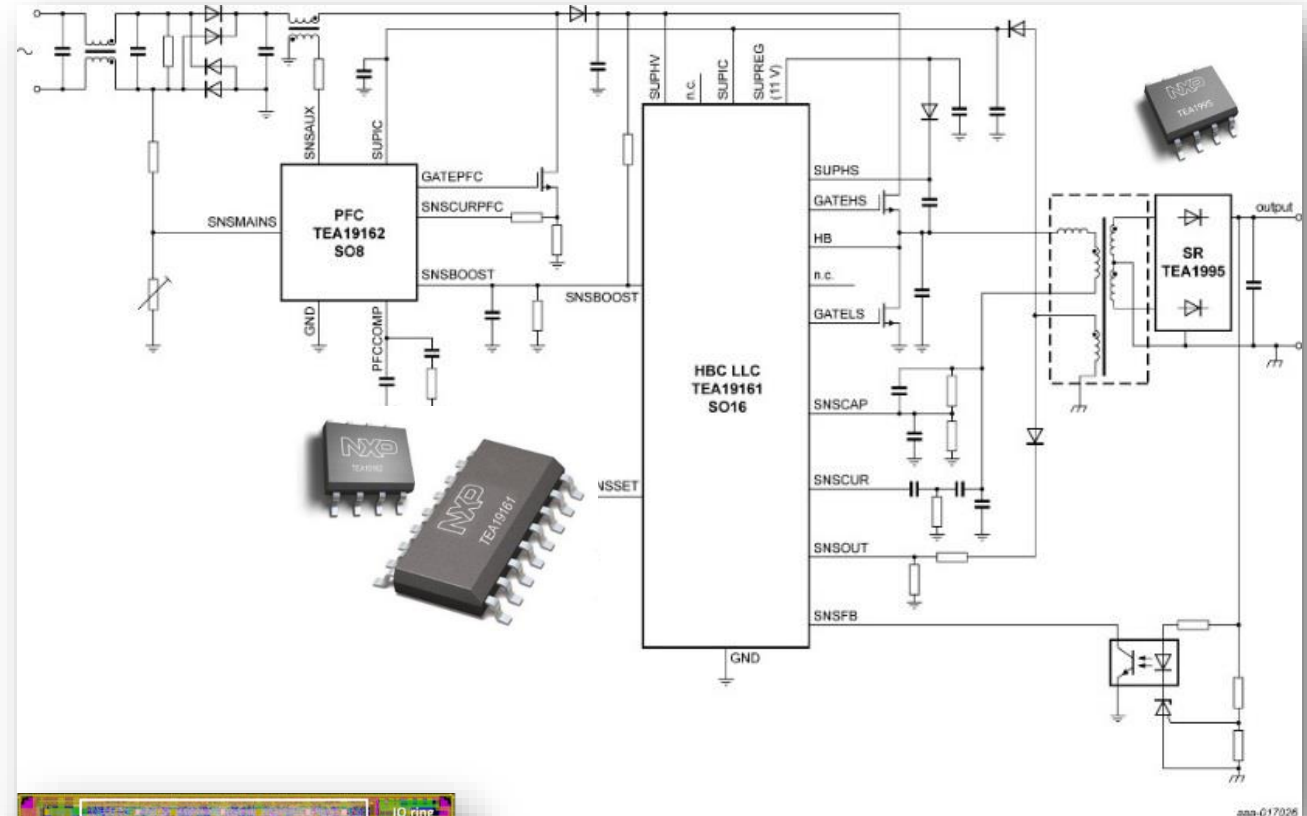
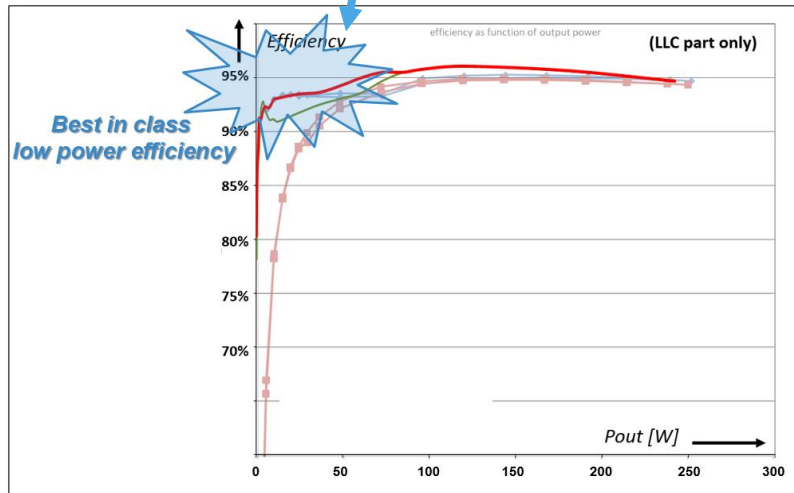
- TEA19161T: Digital controller for high-efficiency resonant power supply

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

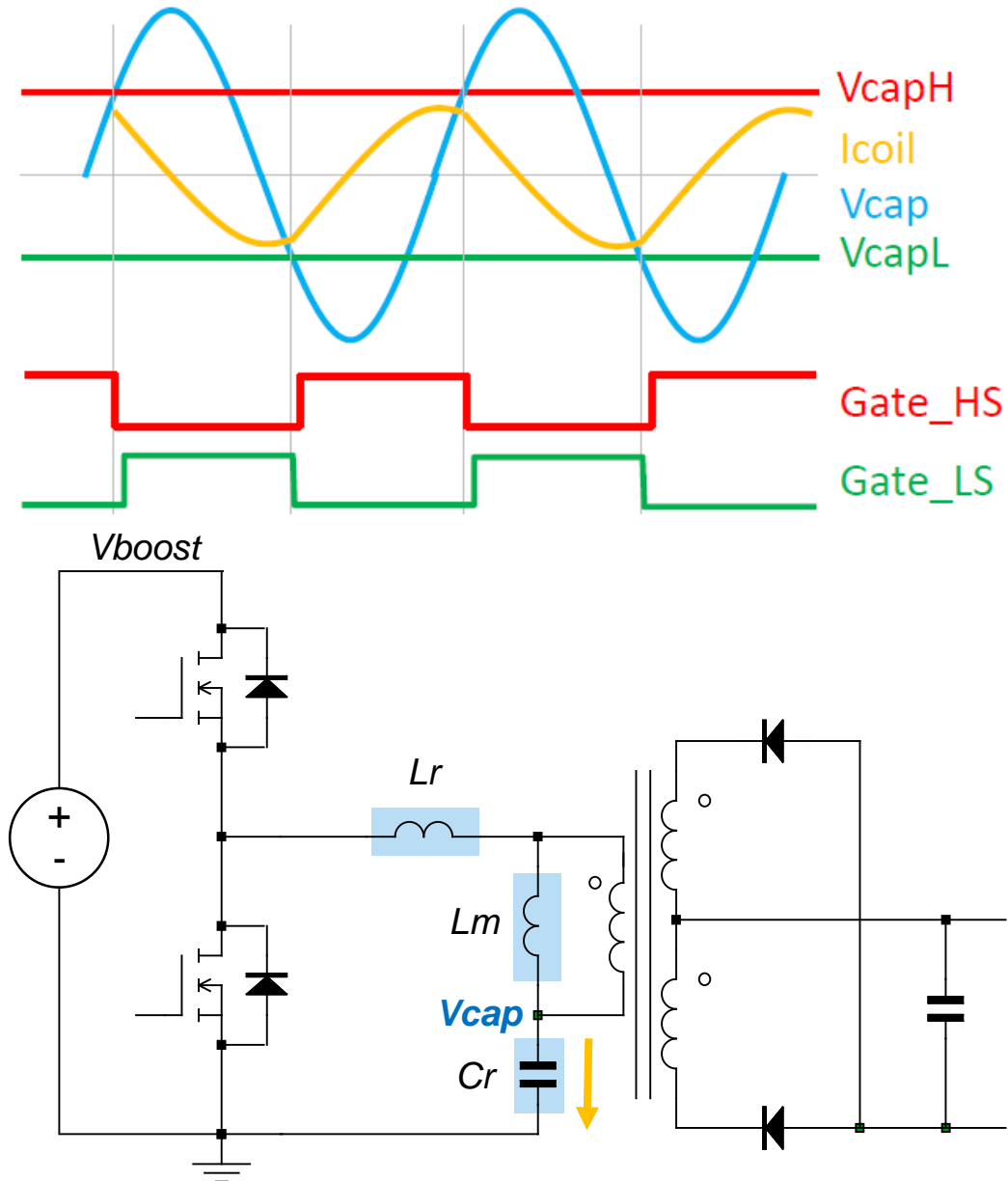
- Works the best for ~90W to ~500W Applications

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

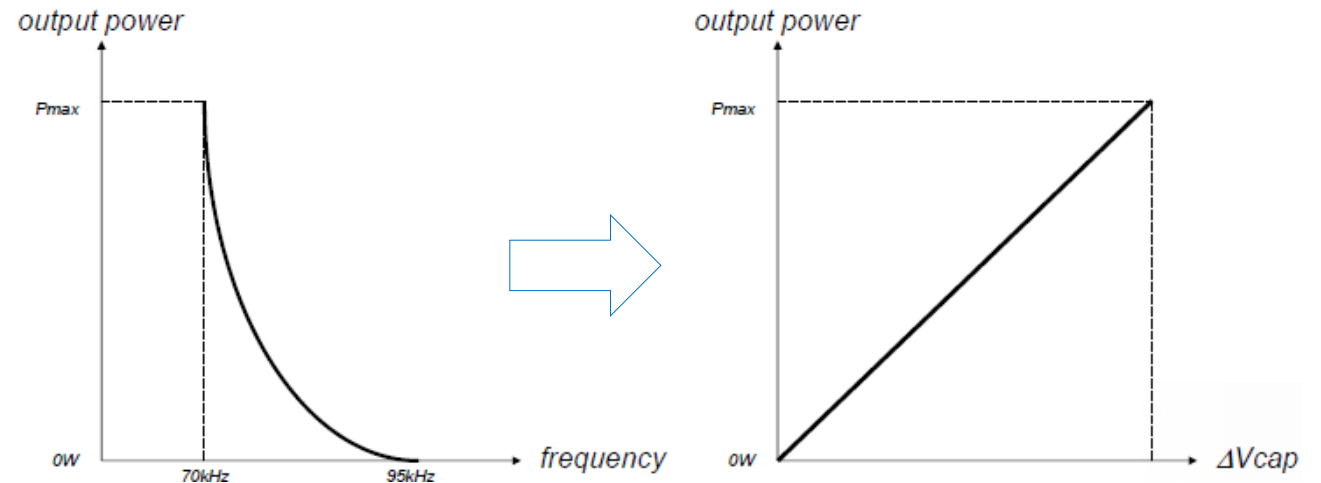


PROPRIETARY CYCLE-BY-CYCLE (VCAP) CONTROL OF TEA19161



$$P_{out} = P_{in} \cdot \eta = V_{boost} \cdot I_{in} = V_{boost} \cdot \Delta V_{cap} \cdot C_r \cdot f_s \cdot \eta$$

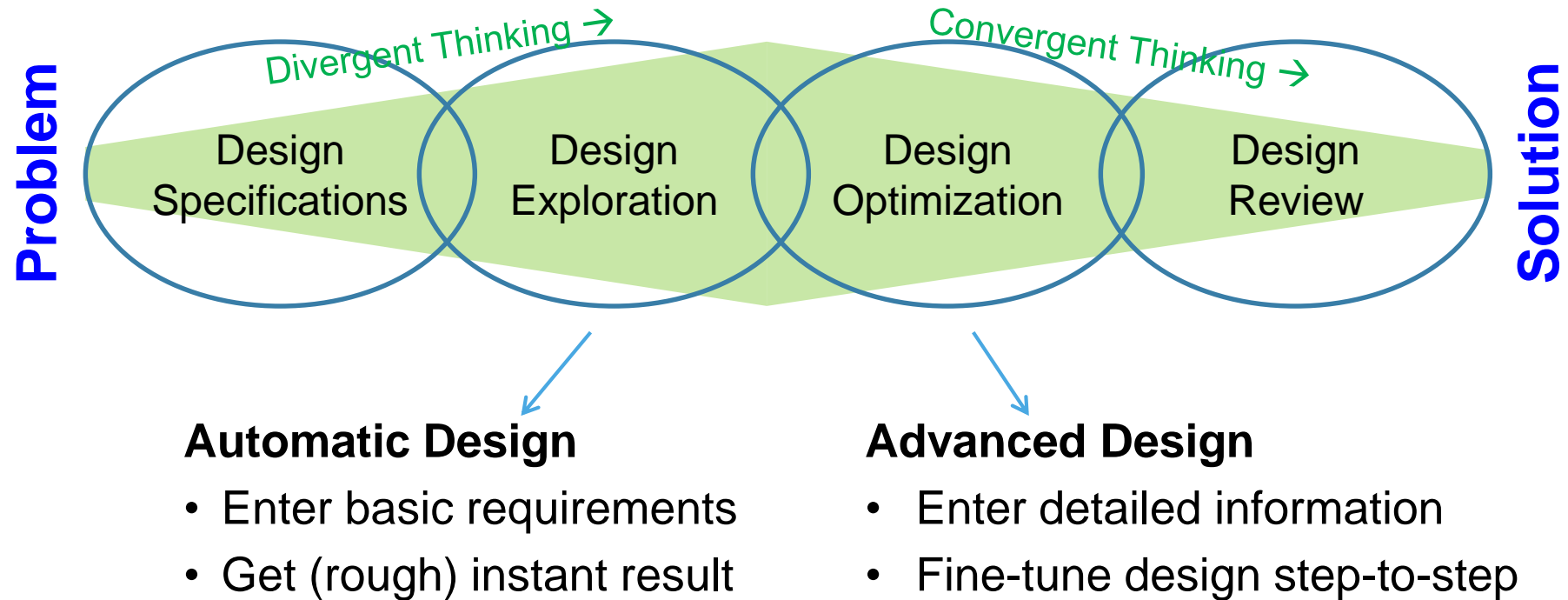
- P_{out} – frequency characteristic is exponential
- P_{out} – ΔV_{cap} characteristic is linear





Design Objectives and Challenges

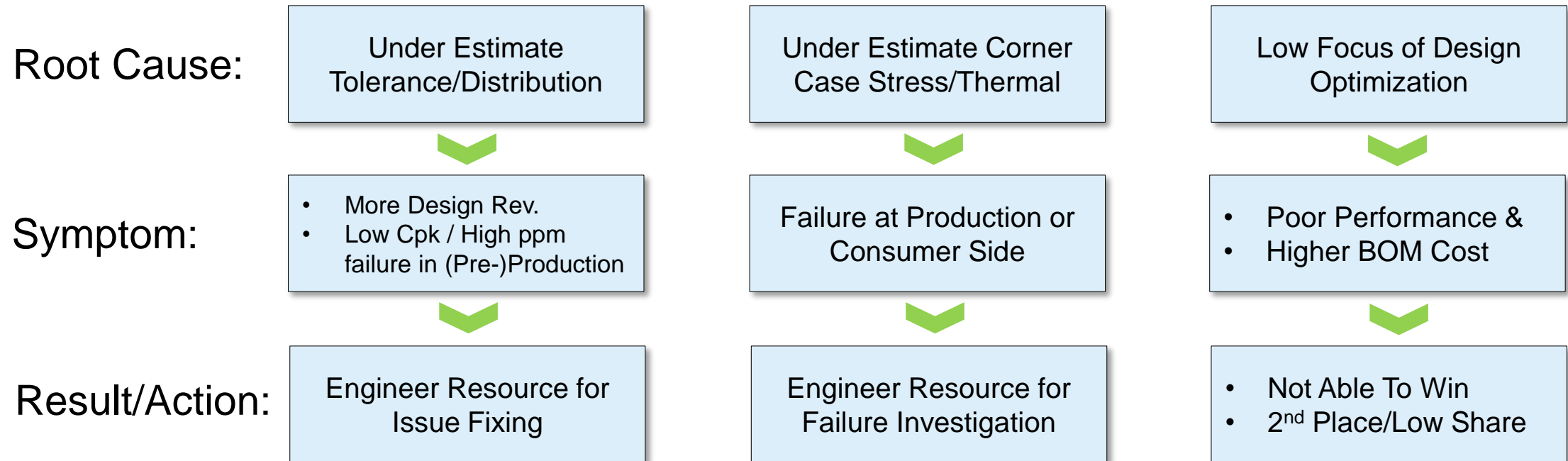
WHAT TO FOCUS – DESIGN THINKING



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

WHY DESIGN TOOL GETS COMPREHENSIVE?

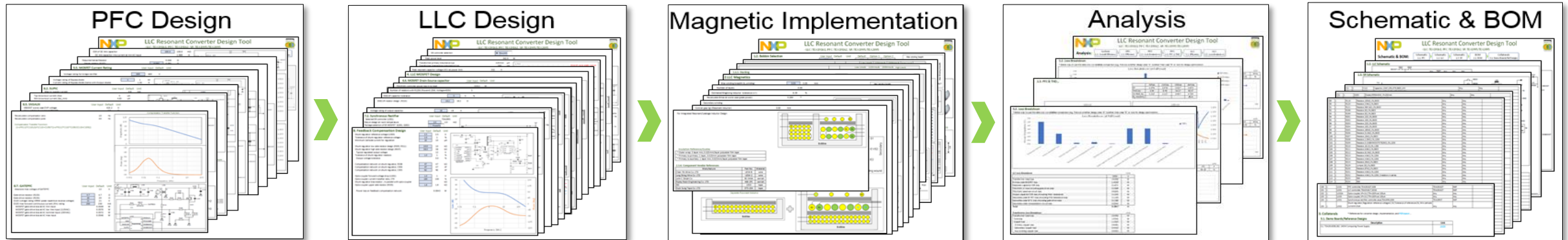
- Over simplified design typically UNDER estimate design challenges, so end up with
 - Poor/no conversion
 - Extra rev & engineer supporting effort/cost
 - Low share/revenue even design in/win...



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 TOOL UI


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



LLC Resonant Converter Design Tool

- LLC: TEA19161, PFC: TEA19162, SR: TEA1995

LLC Design:

Step 1. In/Out Spec.

Step 2. Ext. Settings

Step 3. Power Train

Step 4. LLC MOSFET

Step 5. TEA19161 Rel.

Step 6. Output Cap

Step 7. Output Rectifier

Step 8. Compensation

Note: "User Input" is for users to enter typical design or component parameter; "Default" is recommended typical parameter or calculation result;

1. Input/Output Specifications

1.1. Input Specifications

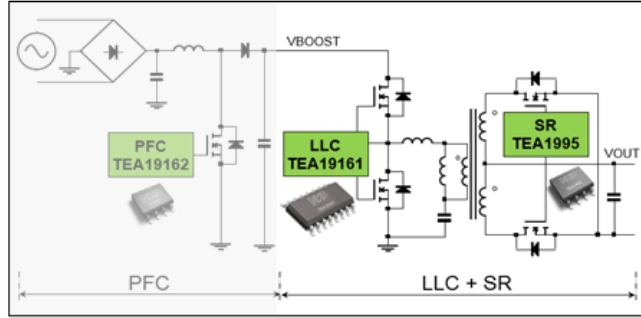
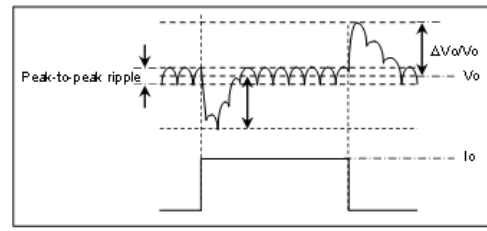
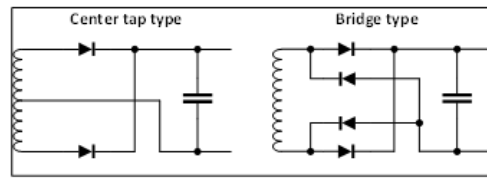
	User Input	Default	Unit
Min AC line voltage	90	90	Vrms
Max AC line voltage	264	264	Vrms
Max ambient temperature	45	45	C
Min PFC output voltage for hold-up time		297.8	V
Min PFC regulated output voltage (Min VBOOST)		388.7	V
Typ PFC regulated output voltage (Typ VBOOST)		395.0	V
Max PFC regulated output voltage (Max VBOOST)		401.3	V
Max PFC output OVP voltage (OVP VBOOST)		419.2	V

1.2. Output Specifications

	User Input	Default	Unit
Nominal output voltage (Vo)	12	12	V
Max nominal output current (Io)	20	20	A
Max nominal output power		240.0	W
Over power output current	25	25	A
Over Power output power		300.0	W
CV regulation tolerance (+/-)	3	3	%
Max output voltage ripple (+/-)	3	3	%
Max output peak-to-peak ripple (+/-)		360	mV
Peak transient voltage deviation at load release ($\Delta V_o/V_o$)	5	5	%
Output over voltage protection (OVP) ratio	125	125	%
Max output voltage (at OVP)		15	V

1.3. Output Rectifier Design Concept

	User Input	Default	Unit
Rectifier winding type	<input checked="" type="radio"/> Center tap <input type="radio"/> Bridge		
Rectification type	<input checked="" type="radio"/> SR rec <input type="radio"/> Diode rec		

PFC_Design

LLC_Design

Magnetic_Implementation

Analysis

Schematic_BOM

Design Blocks

EXTERNAL

1 2

DESIGN TOOL GUIDES

Design Sub-Step Overview

1.4. Core Gap and Loss	User Input	Default	Unit
Core air gap (lg)			
Total gap length along main magnetic path of the core.			
Typically between around 0.2mm and 1.5mm: if < 0.2mm, Lm tolerance maybe larger than desired; if > 1.5mm, fringing loss near the gap becomes too large.			

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

1.4. Core Gap and Loss	User Input	Default	Unit
Core air gap (lg)	2.00	1.35	mm
Caution: The gap is too large, so magnetic field fringing may cause excessive heating of the windings near the gap. To shorten the gap, choose a different core with a smaller Ae and/or a smaller AL			

User Input Default/Recommend Graphic

LLC Resonant Converter Design Tool

- LLC: TEA19161, PFC: TEA19162, SR: TEA1995

LLC Design: Step 1. In/Out Spec. → Step 2. Ext. Settings → Step 3. Power Train → **Step 4. LLC MOSFET** → Step 5. TEA19161 Rel. → Step 6. Output Cap → Step 7. Output Rectifier → Step 8. Compensation

Note: "User Input" is for users to enter typical design or component parameter; "Default" is recommended typical parameter or calculation result;

1. Input/Output Specifications

1.1. Input Specifications

User Input	Default	Unit
90	90	Vrms
264	264	Vrms
45	45	C
	297.8	V
	388.7	V
	395.0	V
	401.3	V
	419.2	V

1.2. Output Specifications

User Input	Default	Unit
12	12	V
20	20	A
	240.0	W
25	25	A
	300.0	W
3	3	%
3	3	%
	360	mV
5	5	%
125	125	%
	15	V

1.3. Output Rectifier Design Concept

Rectifier winding type

☒ Center tap
☐ Bridge

Rectification type

☒ SR rec
☐ Diode rec

PFC_Design **LLC_Design** Magnetic_Implementation Analysis Schematic_BOM

DESIGN FLOW

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

NXP **LLC Resonant Converter Design Tool**
- LLC: TEA19161, PFC: TEA19162, SR: TEA1995/TEA2095

ESR of DC link capacitor: 100.0 mΩ
DC link capacitor rms current at min AC input: 1.969 A

Required Sense Resistor: 0.046 Ω
Sense resistor (R107): 0.092 Ω

5.5. MOSFET Current Rating
User Input Default Unit
Max Peak MOSFET Current at nominal Pout: 9.533 A

Voltage rating for bridge rectifier: 600 V
Voltage rating of Bypass diode: 1 KV
Current rating of Bypass diode (Same with Output diode): 1.35 A

8.2. SUPIC
Max lcc supply current: 0.8 mA

Typ brownout current (Ibo): 5 uA
Min brownout current (Ibo_min): 4.65 uA
Max brownout current (Ibo_max): 5.35 uA

8.5. SNSAUX
User Input Default Unit
VBOOST worst case OVP voltage: 419.2 V
Vaux voltage at nominal VBOOST: 2.5 V

Recalculate compensator zero: 10 Hz
Recalculate compensator pole: 40 Hz

Compensator Transfer Function:
$$(1+s*R112*C110)/[s*(C110+C109)*[1+s*R112*C110*C109/(C110+C109)]]$$

8.7. GATEPFC
Absolute max voltage of GATEPFC: 12 V

Gate drive resistor (R103): 4.7 Ω
Gate drive resistor (R104): 20 Ω
D103 voltage rating VRRM (peak repetitive reverse voltage): 21 V
D103 max forward continuous current (Ifm) rating: 250 mA

MOSFET gate drive loss at AC min input: 0.0549 W
MOSFET gate drive loss at AC low line input (110VAC): 0.0570 W
MOSFET gate drive loss at AC nominal input (230VAC): 0.0572 W
MOSFET gate drive loss at AC max input: 0.0546 W

Compressor Transfer Function

Magnitude (dB)

Phase (deg)

Frequency (kHz)

Example

R112

C110

U101

TEA19162

SNSAUX

SNSMAIN

SUPIC

SUPREG

PG3

PG1

PG2

PG4

PG5

PG6

PG7

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PG1137

PG1138

DESIGN FLOW

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

NXP LLC Resonant Converter Design Tool
- LLC: TEA19161, PFC: TEA19162, SR: TEA1995/TEA2095

SR controller selection
☒ TEA1995
☐ TEA2095

Peak power level: 342.9 W
 Estimated efficiency at min. input & max. load: 95.5 %
 Transformer primary inductance (Lp): 429.914 µH
 Transformer magnetizing inductance (Lm): 392 µH
 Peak resonant capacitor voltage (Vcr) at power limit: 332 V
 Peak resonant capacitor current (Icr) at max. nominal load: 2.05 A

4. LLC MOSFET Design

4.4. MOSFET Drain-Source capacitor
 Capacitance between drain-source of LLC MOSFET: 330 nF
 TEA19161 controller power loss in no load: 0.012 W
 Number of resistors with R1206 (Power=0.25W, Voltage=400V): 5

SNSCAP capacitor tolerance: 5 %
 Derating of SNSCAP capacitor voltage: 20 %

SNSCUR resistor design (R210): 18.2 Ω

Voltage rating of output capacitor: 18 V
 Tolerance of output capacitance: 20 %
 Max. time delay to leave burst mode in dynamic load: 40 µs

7.2. Synchronous Rectifier
 Selected SR controller (U301): TEA1995
 Rds,on design at room temperature: 2.0 mΩ
 Package selection of SR MOSFET (Q301, Q302): ☒ Power56 ☐ DPAK

8. Feedback Compensation Design

User Input	Default	Unit
Shunt-regulator reference voltage (U303)	2.5	V
Tolerance of shunt-regulator reference voltage	1.0	%
Minimum Cathode current for regulation	10	µA
Shunt-regulator low side resistor design (R309, R311)	10.0	kΩ
Shunt-regulator high side resistor design (R307)	38.0	kΩ
Typical regulated output voltage	12	V
Tolerance of shunt-regulator resistors	1.0	%
Output voltage tolerance	3.0	%
Compensation network on shunt-regulator, R308	47	kΩ
Compensation network on shunt-regulator, C306	47	nF
Compensation network on shunt-regulator, C305	NC	nF
Opto-coupler forward voltage drop (U202)	1.0	V
Opto-coupler current transfer ratio, CTR	100	%
Shunt-regulator bias resistor; in parallel with opto-coupler	1.8	kΩ
Opto-coupler upper side resistor (R305)	1.8	kΩ
Power loss on feedback compensation network	0.0043	W

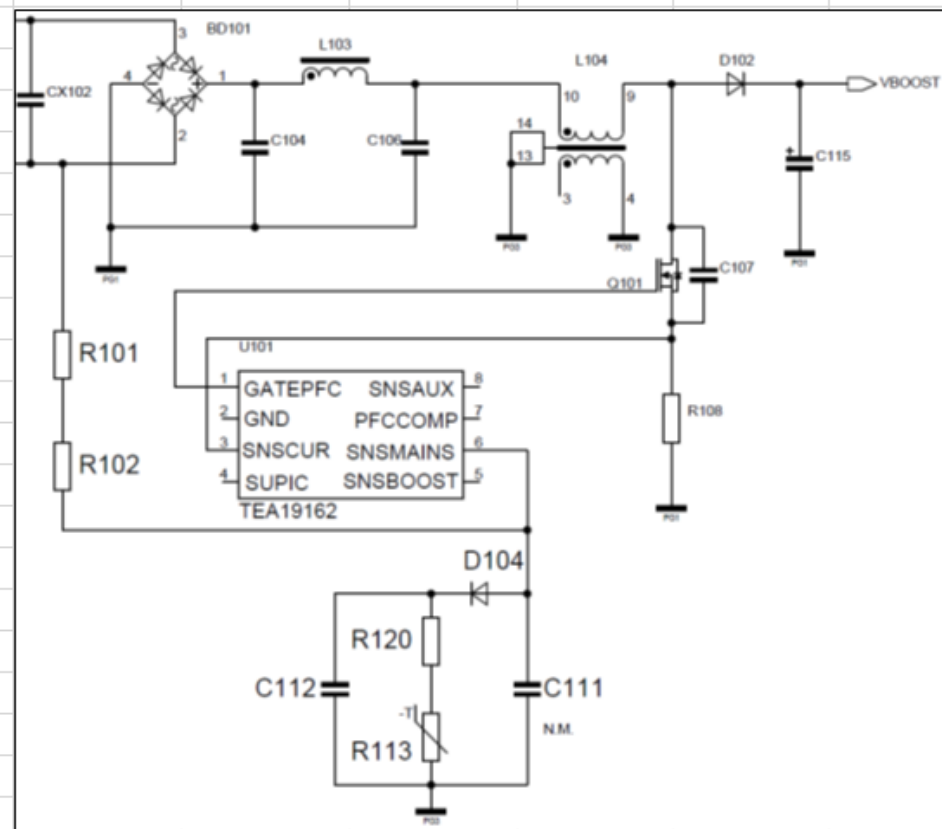
Schematic diagram of the LLC resonant converter circuit, showing the MOSFET, diode, transformer, and feedback components.

Worst case gain curve

Gain [dB] vs frequency [kHz] and Phase [deg] vs frequency [kHz] plot.

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

LLC Resonant Converter Design Tool
- LLC: TEA19161, PFC: TEA19162, SR: TEA1995/TEA2095

1.2. Bobbin Selection

User Input	Default	Unit	Default	Option 1	Option 2
Coil-former diameter (d_tube)	12.5	mm	12.5	12.5	12.5

Core Loss Summary

Unit	Low Line & Max Load	115Vrms & Max Load	230Vrms & Max Load	High Line & Max Load

Winding/Copper Loss Summary

Unit	Low Line & Max Load	115Vrms & Max Load	230Vrms & Max Load	High Line & Max Load

1.6.3. Stacking

2. LLC Magnetics

Max winding breadth (b_winding)	3.05	mm
Max winding height	3.05	mm
Number of layers	0.00	
Check current density	0.00	A/mm ²
Estimated Magnetizing inductor tolerance (+/-)	8.39	%
Recalculate B _{max} at worst case (peak power)	0.286	T

Secondary winding

AC-to-DC resistance ratio at nominal boost voltage & full load	1.03
AC-to-DC resistance ratio at nominal boost voltage & OPP load	1.03
winding AC resistance at nominal boost voltage & full load	0.278 Ω

Core air gap (lg) (Resonant inductor) 0.00 mm
Core air gap (lg) (Transformer) 0.25 mm

2.3.2. Schematic Diagram

User Input	Default	Unit
Winding number of turns (Resonant inductor)	29	
number of strands wound in parallel (Resonant inductor)	3	
winding total layers (Resonant inductor)	4	
Winding number of turns (Transformer)		
primary	37	
Secondary	2	
Aux.	3	
Number of strands wound in parallel (Transformer)		
primary	20	
	76	
	1	

Separate Resonant Inductor

Transformer

Primary: S, E
Auxiliary: S3, E3
Secondary: S1, E1/S2, E2

Starting wound

Transformer for Separate Resonant Inductor

Bobbin

For Integrated Resonant/Leakage Inductor Design

Insulation Reference/Guides

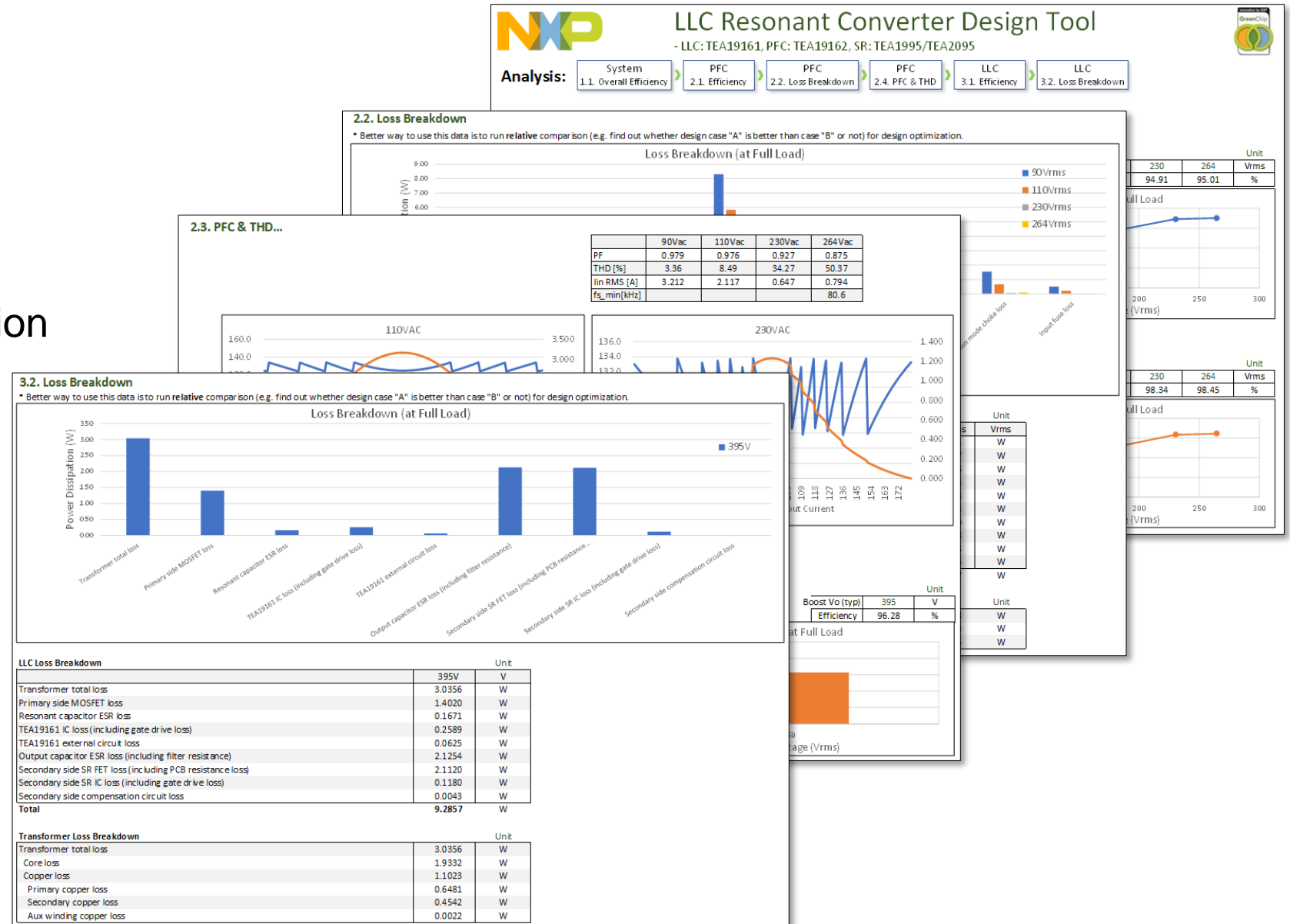
- Outer wrap: 3 layer min, 0.025mm/layer polyester film tape
- Primary to primary: 1 layer, 0.025mm polyester film tape
- Primary to auxiliary: 1 layer min, 0.025mm/layer polyester film tape

2.3.4. Component Vendor References

Manufacture	Part No.	Material
Chen Yih Wire Co. LTD	UEW-8	wire
Jung Shing Wire Co. LTD	UEW-2	wire
John C Dolph Co	BC-346A	varnish
Ripley Resin Engineering Co. LTD	468-2FC	varnish
3M	1350	tape
Duck Sung Tape Co. LTD	DTS-204	tape

DESIGN FLOW

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



DESIGN FLOW

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

NXP **LLC Resonant Converter Design Tool**
- LLC: TEA19161, PFC: TEA19162, SR: TEA1995/TEA2095

Schematic & BOM: Schematic 1.1. PFC > Schematic 1.2. LLC > Schematic 1.3. SR > BOM 2.1. BOM > Collaterals 3.1. Demo Boards/Ref Designs

1. Schematic

1.2. LLC Schematic

1.3. SR Schematic

Ref	Qty	Part	Description	Value	Unit	Notes
11	1	C112	Capacitor, 10nF, 10%, X7R, 0603, 14V		Any	Any
12	1	C113	Capacitor, 100nF, 10%, X7R, 0603, 38V		Any	Any
52	1	D203	Diode, VRRM=94V, IF=250mA		Any	Any
53	1	D204	Diode, VRRM=140V, IF=21mA		Any	Any
89	1	R118	Resistor, 100kΩ, 1%, 0603		Any	Any
90	1	R120	Resistor, 3.9kΩ, 1%, 0603		Any	Any
91	1	R121	Resistor, NM (kΩ), 1%, 0603		Any	Any
92	1	R198	Resistor, 0Ω, 1%, 0603		Any	Any
93	1	R199	Resistor, 0Ω, 1%, 0603		Any	Any
94	1	R201	Resistor, 22Ω, 1%, 0603		Any	Any
95	1	R202	Resistor, 10Ω, 1%, 0603		Any	Any
96	1	R203	Resistor, 22Ω, 1%, 0603		Any	Any
97	1	R204	Resistor, 10Ω, 1%, 0603		Any	Any
98	1	R205	Resistor, 180kΩ, 1%, 0603		Any	Any
99	1	R206	Resistor, 51.8kΩ, 1%, 0603		Any	Any
100	1	R207	Resistor, 10kΩ, 1%, 0603		Any	Any
101	1	R208	Resistor, 2.2MΩ, 1%, 1206		Any	Any
102	1	R209	Resistor, 0.156849433070782MΩ, 1%, 1206		Any	Any
103	1	R210	Resistor, 18.2Ω, 1%, 1206		Any	Any
104	1	R211	Resistor, 6.8kΩ, 1%, 0603		Any	Any
105	1	R212	Resistor, 61.9kΩ, 1%, 0603		Any	Any
106	1	R213	Resistor, 4.6kΩ, 1%, 1206		Any	Any
107	1	R214	Resistor, 4.6kΩ, 1%, 1206		Any	Any
108	1	R215	Resistor, 20kΩ, 1%, 0805		Any	Any
109	1	R229	Jumper, 0Ω, 1%, 0603		Any	Any
110	1	R230	Resistor, 87kΩ, 1%, 0603		Any	Any
111	1	R231	Resistor, 4.6kΩ, 1%, 1206		Any	Any
112	1	R232	Resistor, 4.6kΩ, 1%, 1206; 2 resistors in series		Any	Any
113	1	R233	NM		Any	Any
114	1	R234	NM		Any	Any
115	1	R235	NM		Any	Any
130	1	U101	PFC controller, TEA19162T, SO8	TEA19162T	NXP	
131	1	U201	LLC controller, TEA19161T, SO16	TEA19161T	NXP	
132	1	U202A	Opto-coupler, VF=1V, CTR=100% at 100uA	Any	Any	
133	1	U203	Opto-coupler, VF=1V, CTR=100% at 100uA	Any	Any	
134	1	U301	Synchronous rectifier controller, dual, TEA1995, SO8	TEA1995T	NXP	
135	1	U302	Shunt regulator, Regulation reference voltage=2.5V, Tolerance of reference=1%, Min cathode current=10uA	Any	Any	

3. Collaterals * References for converter design, implementation, and PCB layout...

3.1. Demo Boards/Reference Designs


Description	Link
3.1. TEA1916DB1262: 240W Computing Power Supply	240W

Demo Board/Ref Design Links



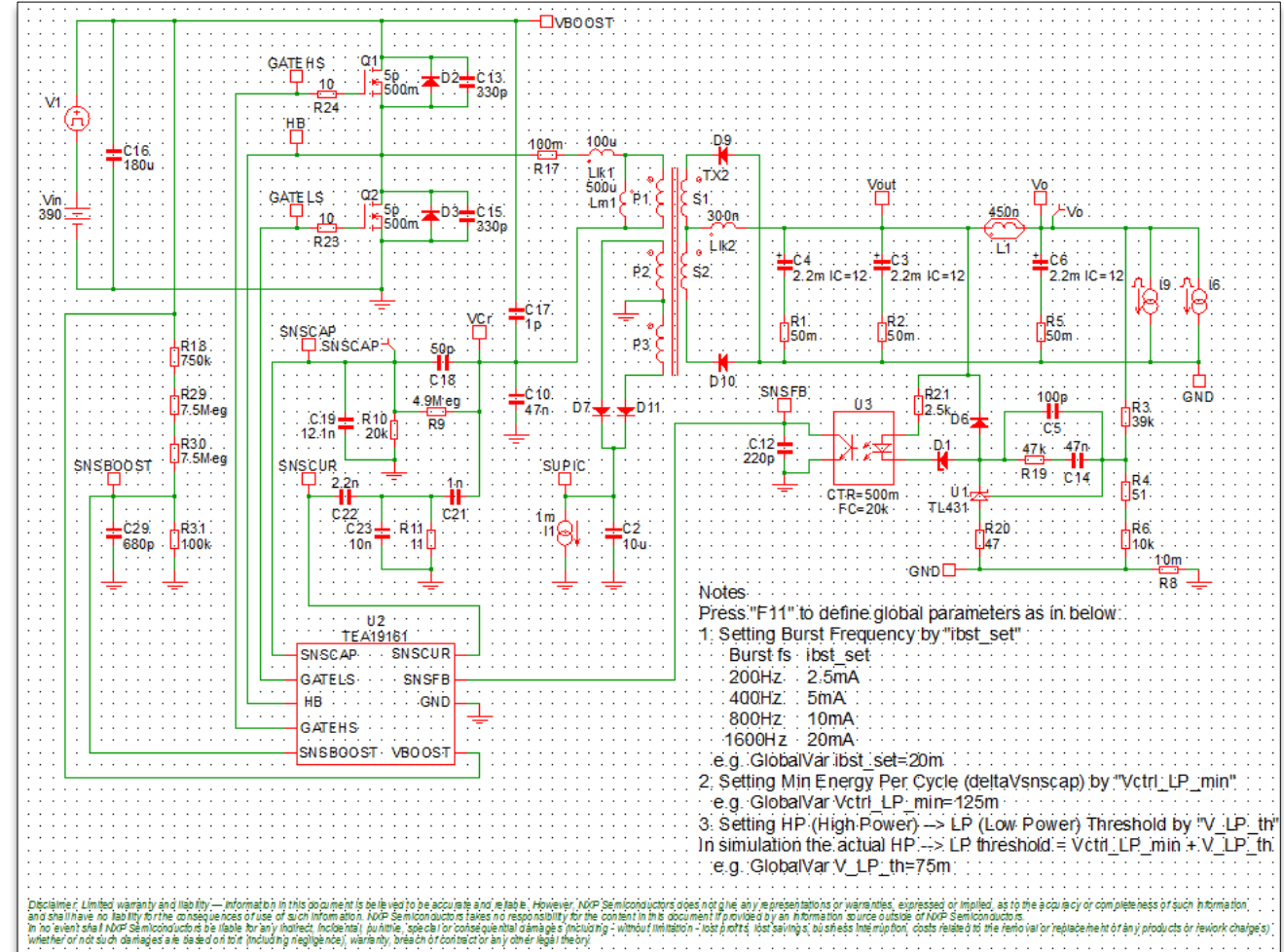
Simulation Benefits

BEHAVIOR LEVEL SIMULATION

- Operation only at f_o can remove FHA, hence show good agreement with bench. When operates away from f_o , 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

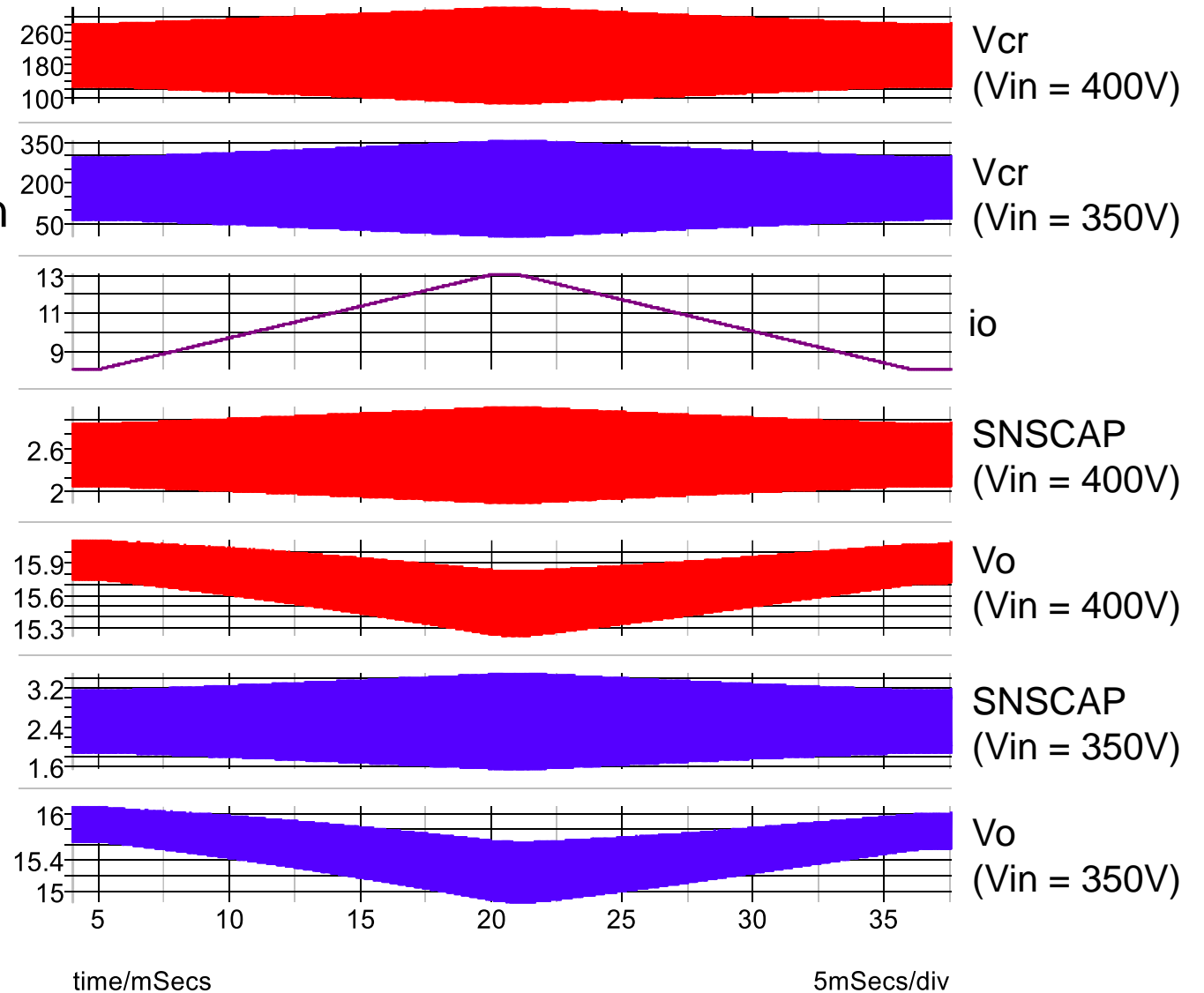
TEA19161 (LLC) SIMPLIS BEHAVIOR LEVEL SIMULATION MODEL

- 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...



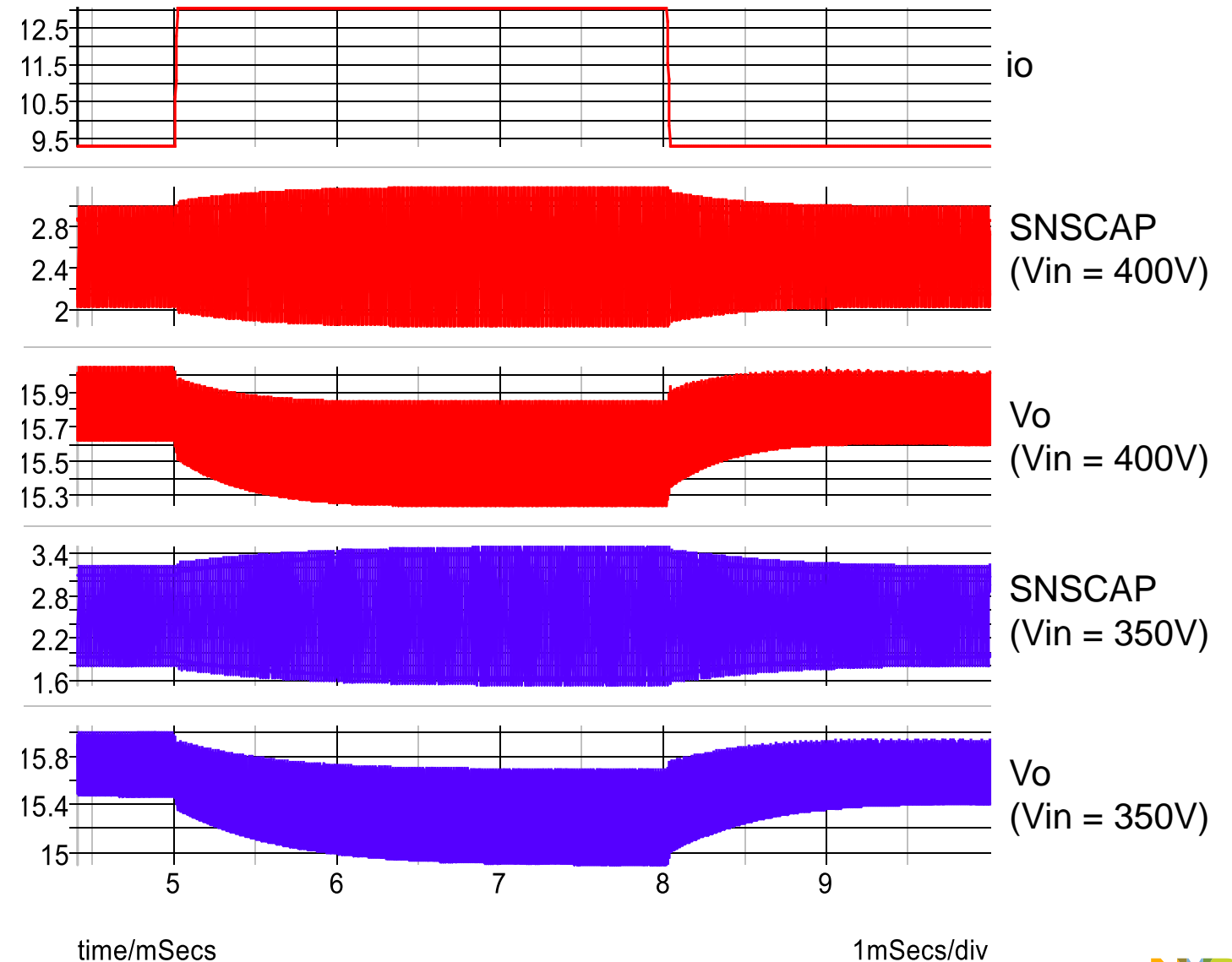
QUASI-STEADY STATE DC OPERATING POINTS

- Slowly sweep load at min and max V_{in} respectively to verify “DC” operation across various operating points

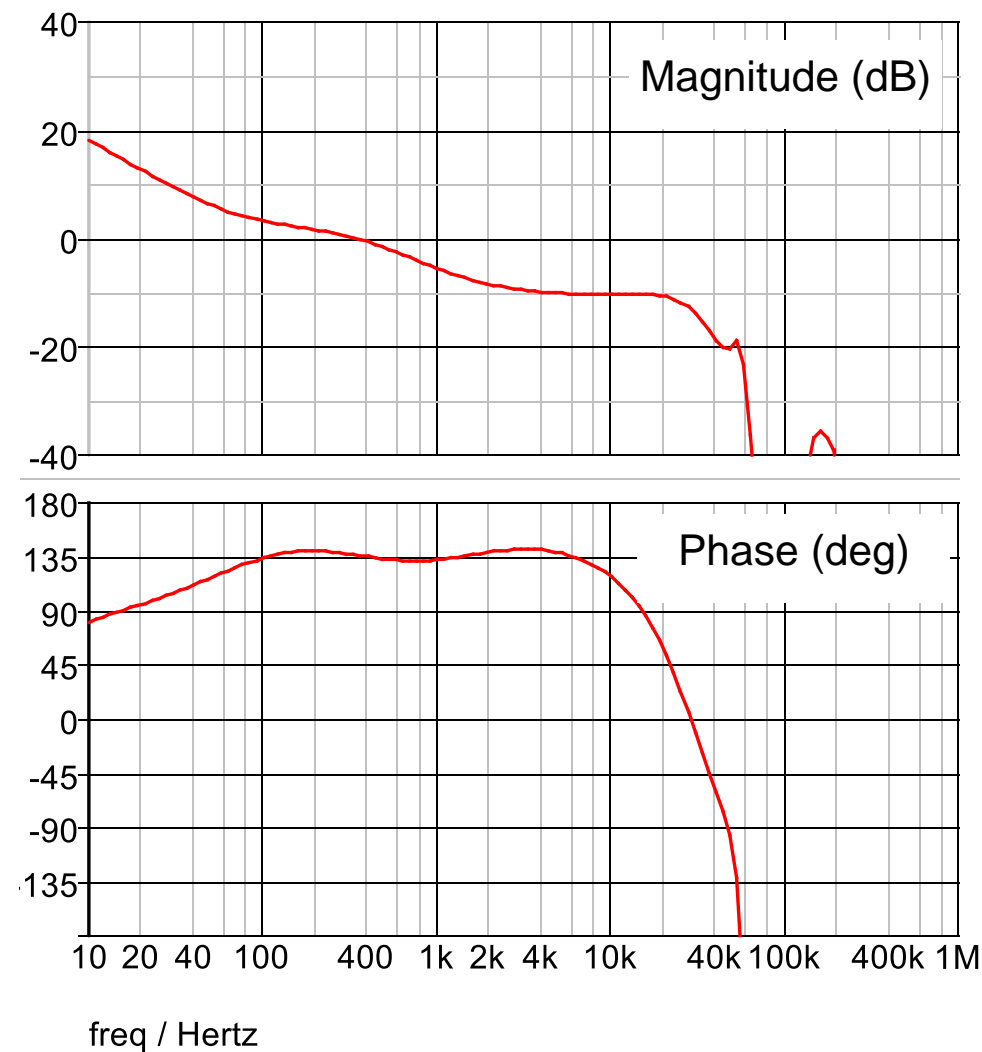
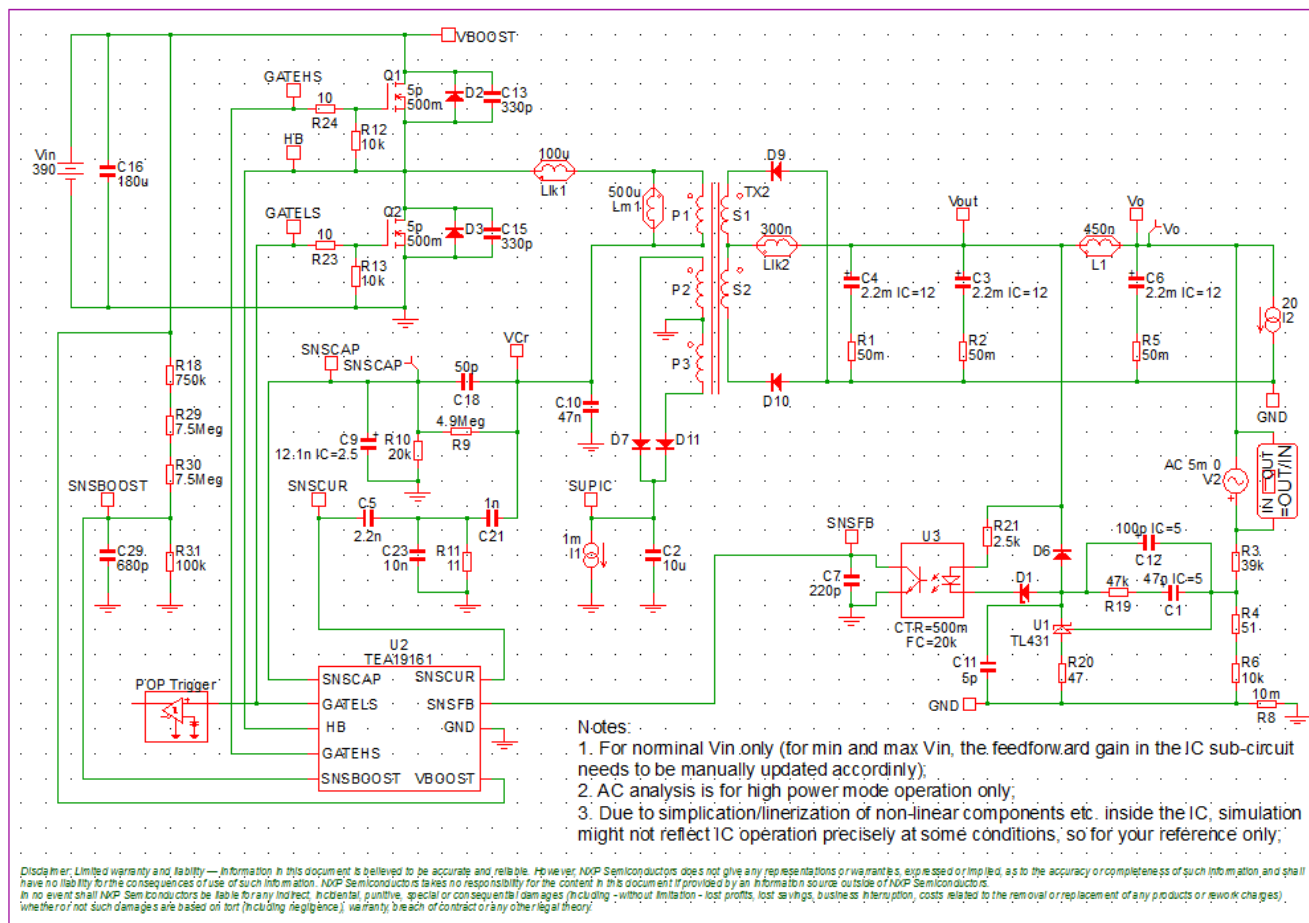


CORNER CASE TRANSIENT RESPONSE

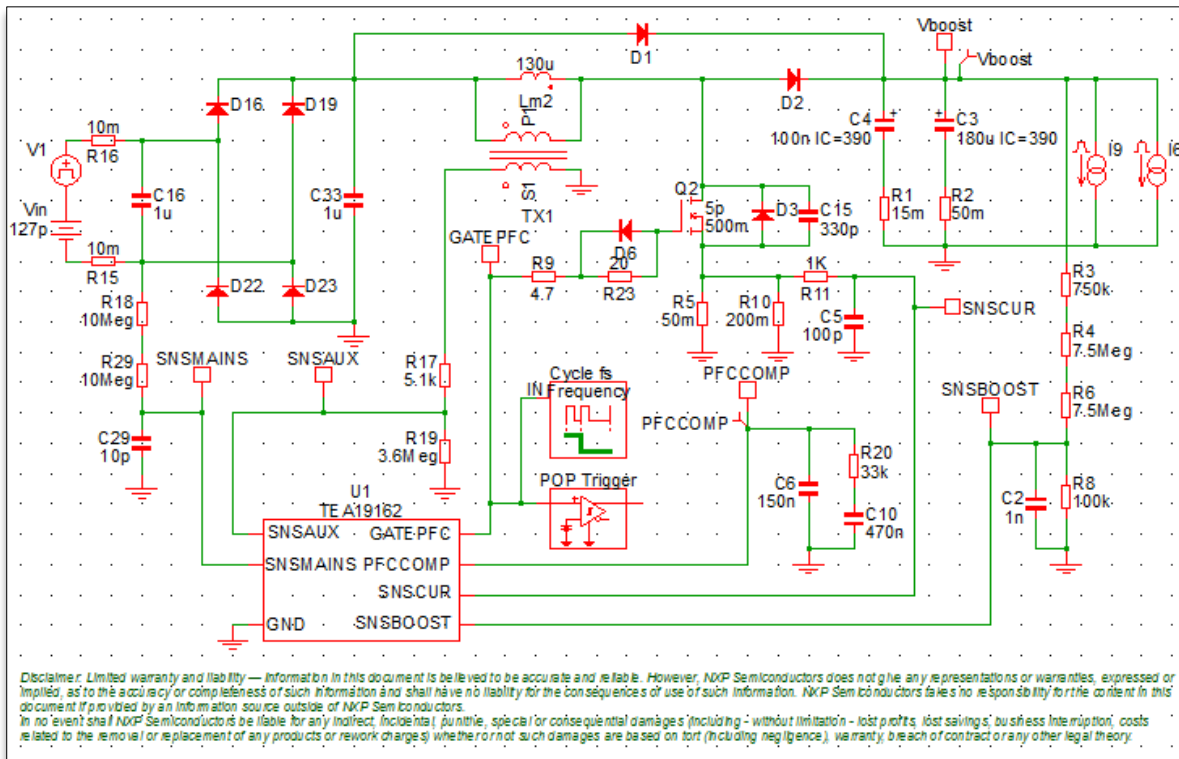
- Verify worst case load transient response at min and max V_{in} ...



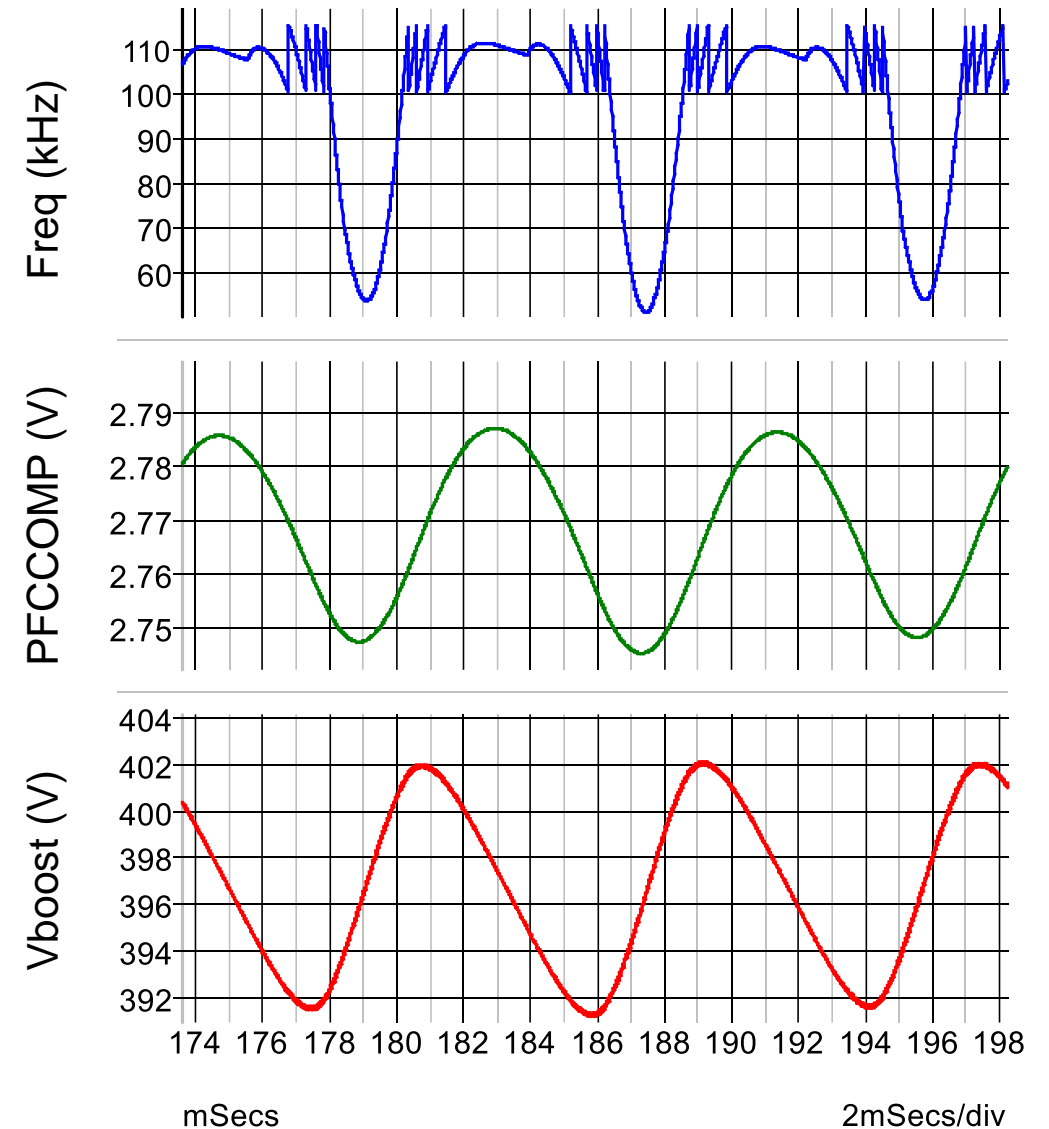
AC ANALYSIS: CLOSED-LOOP GAIN BODE PLOT (FOR REFERENCE ONLY)



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

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Power Management > AC-DC Solutions > AC-DC Controllers with Integrated PFC > LLC Resonant Converter Design Tool

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LLC Resonant Converter Design Tool ^{NEW}

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Overview

Completing and optimizing a near production-ready resonant converter design can be tricky, tedious, and even challenging. 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.



LLC Resonant Converter Design Tool

- LLC: TEA19161, PFC: TEA19162, SR: TEA1995

Step 1: Input SpecStep 2: Ext. SettingsStep 3: Power TransStep 4: LLC FilterStep 5: TEA19161 RefStep 6: Output CapStep 7: Output RectifierStep 8: Compensation

Note: "User Input" is for users to enter typical design or component parameter; "Default" is recommended typical parameter or calculation result.

1. Input/Output Specifications

1.1. Input Specifications

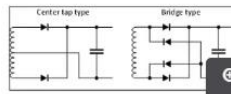
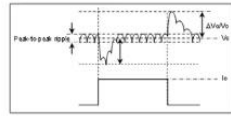
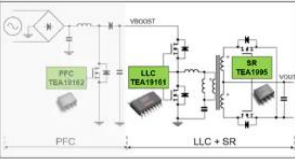
User Input	Default	Unit
Min AC line voltage	90	Vrms
Max AC line voltage	264	Vrms
Max ambient temperature	45	°C
Min PFC output voltage for hold-up time	297.8	V
Min PFC regulated output voltage (Min VBOOST)	388.7	V
Typ PFC regulated output voltage (Typ VBOOST)	395.0	V
Max PFC regulated output voltage (Max VBOOST)	401.3	V
Max PFC output OVP voltage (OVP VBOOST)	419.2	V

1.2. Output Specifications

User Input	Default	Unit
Nominal output voltage (Vo)	12	V
Max nominal output current (Io)	20	A
Max nominal output power	240.0	W
Over power output current	25	A
Over Power output power	300.0	W
CV regulation tolerance (%)	3	%
Max output voltage ripple (v _r)	3	mV
Max output peak-to-peak ripple (v _r)	960	mV
Peak transient voltage deviation at load release (ΔVo/Vo)	5	%
Output over voltage protection (OVP) ratio	125	%
Max output voltage (at OVP)	15	V

1.3. Output Rectifier Design Concept

User Input	Default	Unit
Rectifier winding type	<input checked="" type="radio"/> Center tap <input type="radio"/> Bridge	
Rectification type	<input checked="" type="radio"/> SR rec. <input type="radio"/> Diode rec.	



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)

[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

Analytical (Excel) Design Tool

[TEA19161 Simplis Model \(for HP Mode Only\)](#) (REV 2)

TEA19161 Simplis Model (for HP Mode Only)

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[TEA19161 Simplis Model \(with All Operating Modes\)](#) (REV 2)

TEA19161 Simplis Model (with All Operating Modes)

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[TEA19161 Simplis Model \(for AC Analysis\)](#) (REV 2)

TEA19161 Simplis Model (for AC Analysis)

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[TEA19162 Simplis Model](#) (REV 1)

TEA19162 Simplis Model

ZIP 48.7 kB 2020-05-06 14:57:00 TEA19162-SIMPLIS-MODEL

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Simplis Simulation Models

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

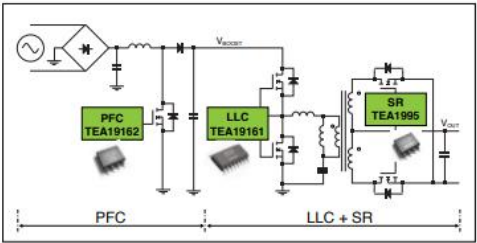


SUPPORTING PRODUCTS

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)

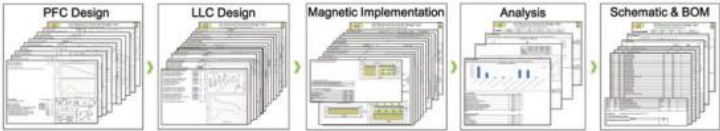
SYSTEM CONFIGURATION: PFC + LLC RESONANT CONVERTER + SR



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.

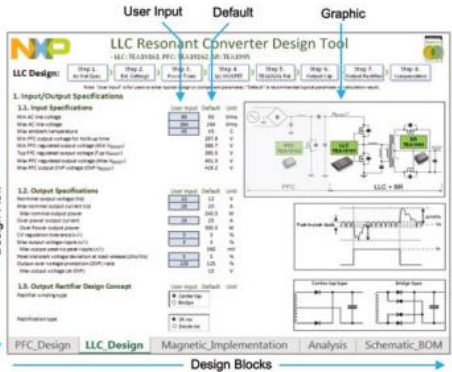
- **PFC Design:** Cover all powertrain and IC-related component design
- **LLC Design:** Cover all powertrain and IC-related component design
- **Magnetic Implementation:** Design all magnetic components and recommend Magnetic Build Sheets used for magnetic vendors to construct magnetic samples
- **Analysis:**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



DESIGN FLOW

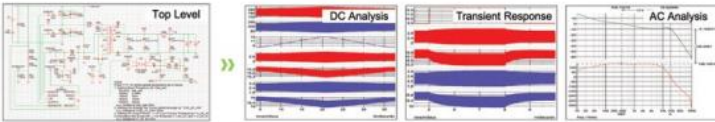
For each design block the flow runs from top to bottom sequentially.

- **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.

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Date of Release: 02/2020
Document Number: LLCRESCONFTPS REV D
Alpha Number: 000-00000 REV A

GET START NOW

Overview

Completing and optimizing a near production-ready resonant converter design can be tricky, tedious, and even challenging. 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.

LLC Resonant Converter Design Tool

LLC Design: Step 1. Input Spec, Step 2. Est. Settings, Step 3. Power Train, Step 4. LLC MOSFET, Step 5. TEA19161 Rd, Step 6. Output Cap, Step 7. Output Rectifier, Step 8. Competition

1. Input/Output Specifications

User Input	Default	Unit
Min AC line voltage	90	Vrms
Max AC line voltage	264	Vrms
Max ambient temperature	45	°C
Min PFC output voltage for hold-up time	297.8	V
Min PFC regulated output voltage (Max VBOOST)	388.7	V
Typ PFC regulated output voltage (Full VBOOST)	395.0	V
Max PFC regulated output voltage (Max VBOOST)	401.3	V
Max PFC output OVP voltage (OVP VBOOST)	419.2	V

1.2. Output Specifications

User Input	Default	Unit
Nominal output voltage (Vo)	12	V
Max nominal output current (Io)	20	A
Max nominal output power	240.0	W
Over power output current	25	A
Over Power output power	300.0	W
CV regulation tolerance (%/V)	3	%
Max output voltage ripple (%/V)	3	%
Max output peak-to-peak ripple (mV)	380	mV
Peak transient voltage deviation at load release (ΔVo/Vo)	5	%
Output over voltage protection (OVP) ratio	125	%
Max output voltage (at OVP)	15	V

1.3. Output Rectifier Design Concept

Rectifier winding type: ☒ Center tap, ☐ Bridge

Rectification type: ☒ SR rec, ☐ Diode rec

- Get start by visiting design tool site: [LLC Resonant Converter Design Tool](http://www.nxp.com/LLC-DESIGN-TOOL) (www.nxp.com/LLC-DESIGN-TOOL)
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- 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





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