

Focus on LLC Resonant



www.itacoilweb.com



LLC resonant topology is rapidly growing on the market, it is becoming the most used in the projects of 50...500W range power converters

Benefits	Drawbacks
• High efficiency	• Tank design complexity
• Low EMI-EMC	
• Reduced component stress	
• Very high transformer power density	
• High power peaks management	

We have the solution!



2007

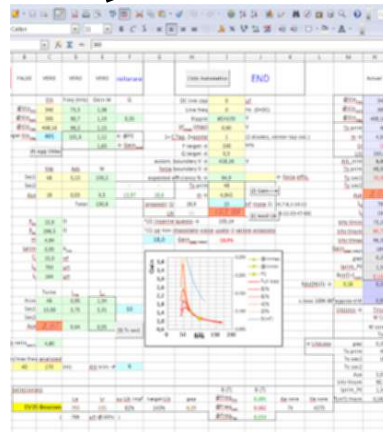
2008

2013

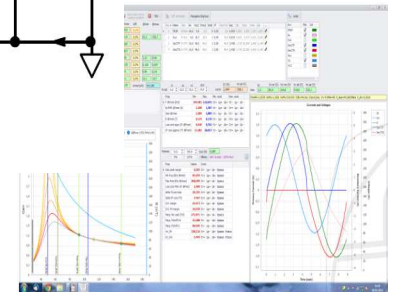
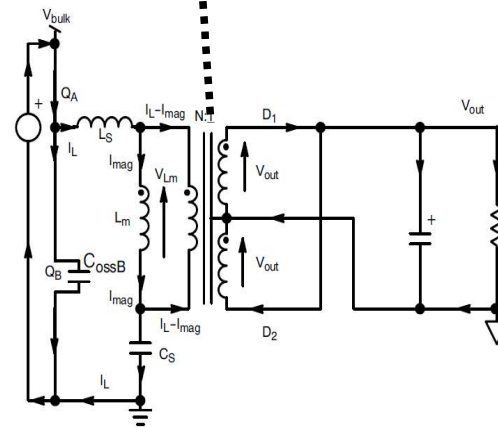
2014



Empirical approach



FHA based approach



The FHA (First Harmonic Approximation) calculation method is the most commonly used BUT it introduces large approximations

Our design platform based on a high frequency SPICE engine allows:

- Check that the Zero Voltage Switching(ZVS) is kept in all the conditions considering the worse components tolerance
- Specific optimization for Fixed, Programmable or Adaptive Dead Time
- Algorithms to define the most effective resonant tank
- Evaluation of all the transformer related constraints
- Accurate power loss calculation
- Tank behavior simulation
- Report with tank parameters and simulated waveforms

- All specific parameters of the LLC tank are defined by our design (Freq. Range, Resonant Capacity, Resonant Inductance, etc.)
- No troubles even with the first LLC project
- Developing time dramatically reduced → shorter Time-to-Market
- Time to focus on the other design aspects that are common to all the other topologies (components selection, protections and feedback setup, etc...)

- Nowadays we are recognized as a technological leader in the resonant tank and transformer design
- We are cooperating with the leading IC manufacturers in the development of resonant demo-boards and special projects



public examples on

<https://www.itacoilweb.com/portfolio/original-demo-boards/>

→ wide range of standard LLC
integrated transformers on the market

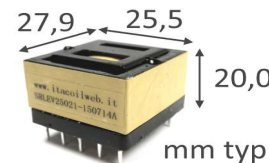
→ best power density on the market:
last developed size up to 185W
13 W/cm³ with 50°C Trise (>40Vdc out)

→ particular dimensional requirements can be sampled in few weeks
even with new bobbin design

→ qualified electronic design consultancy service on request

more info on: <https://www.itacoilweb.com/>

Latest products launched: <https://www.itacoilweb.com/news/>



Comparative Transformers on commercial demo-boards^(*):

Evaluation board	full load efficiency	transformer power density
Fairchild® FEB212-003 - 200W 24V	+0,60%	+116%
NXP® UM10450 - 90W V 19,5	+0,16%	+59%
STMicroelectronics® EVL130W-SL-EU – 130W 48V	+0,84%	+65%
Power Integrations® RDR-239 – 150W 24V	+0,23%	+108%

(*) detailed comparative test reports on our website:

<https://www.itacoilweb.com/portfolio/improved-demo-boards/>

Efficiency improvement using larger Mosfet BUT with a Δ cost

LLC stage Output power (W)	Tank current (Arms)	Mosfet Type	Rds_on	conduction loss (W)	efficiency impact	mosfet cost (€ for 5k pcs)
200	1,7	FCP11N60F	380	1,10	0,55%	1,41
200	1,7	FCP190N65F	190	0,55	0,27%	1,48

efficiency improvement → +0,27%

BOM impact → +0,14 €



LLC stage Output power (W)	Tank current (Arms)	Mosfet Type	Rds_on	conduction loss (W)	efficiency impact	mosfet cost (€ for 5k pcs)
200	1,7	STP11NM60	400	1,16	0,58%	1,34
200	1,7	STP20NM60	250	0,72	0,36%	2,23

efficiency improvement → +0,22%

BOM impact → +1,78 €

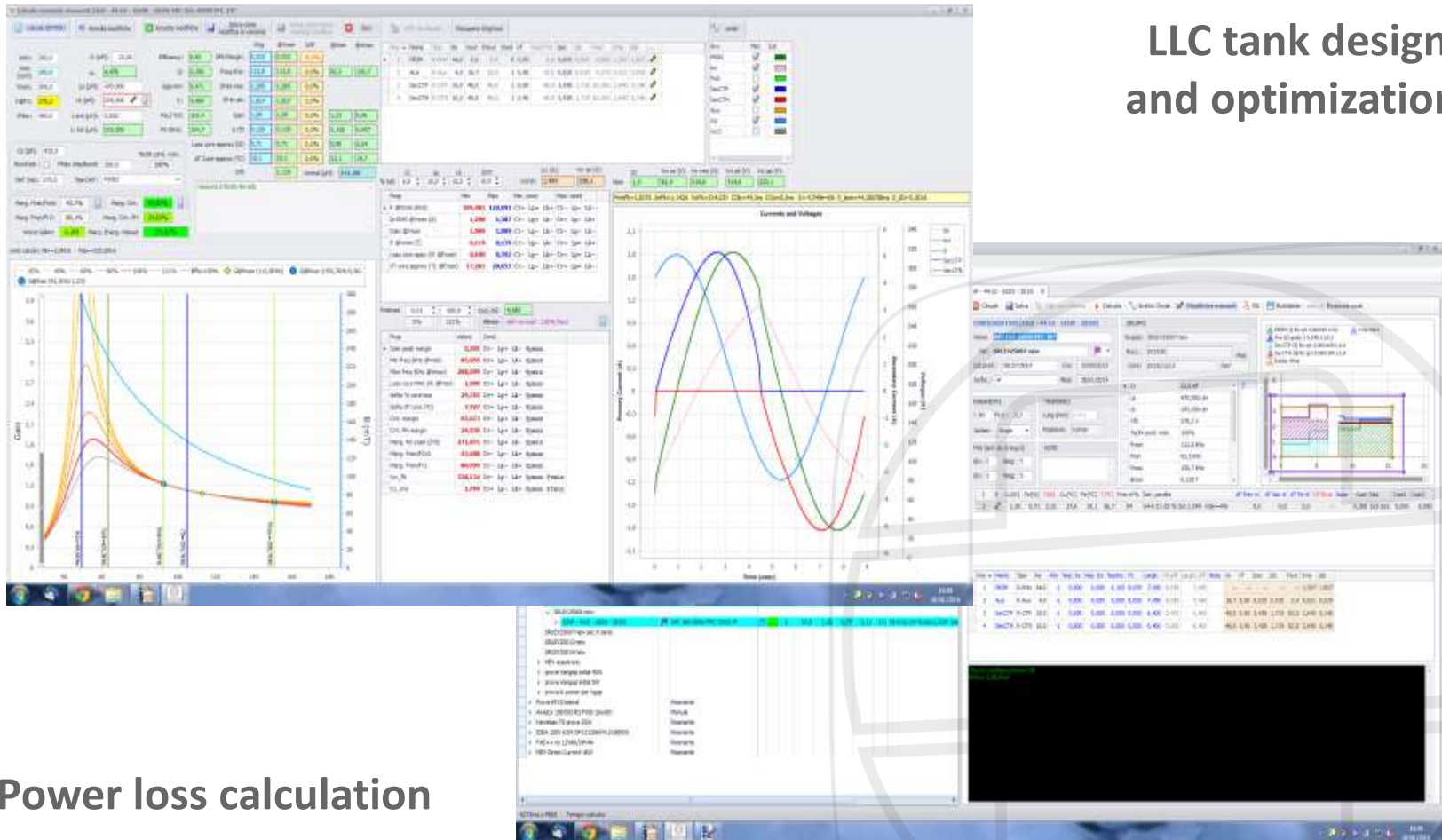


Demo Board	Full load efficiency	Transformer power density	Cost Saving (*)
Fairchild® FEB212-003 - 200W 24V	+0,60%	+116%	€ 0,12
NXP® UM10450 - 90W V 19,5	+0,16%	+59%	€ 0,15
STMicroelectronics® EVL130W-SL-EU – 130W 48V	+0,74%	+38%	€ 0,18
Power Integrations® RDR-239 – 150W 24V	+0,23%	+108%	€ 0,04

(*) : Cost for 5k transformers

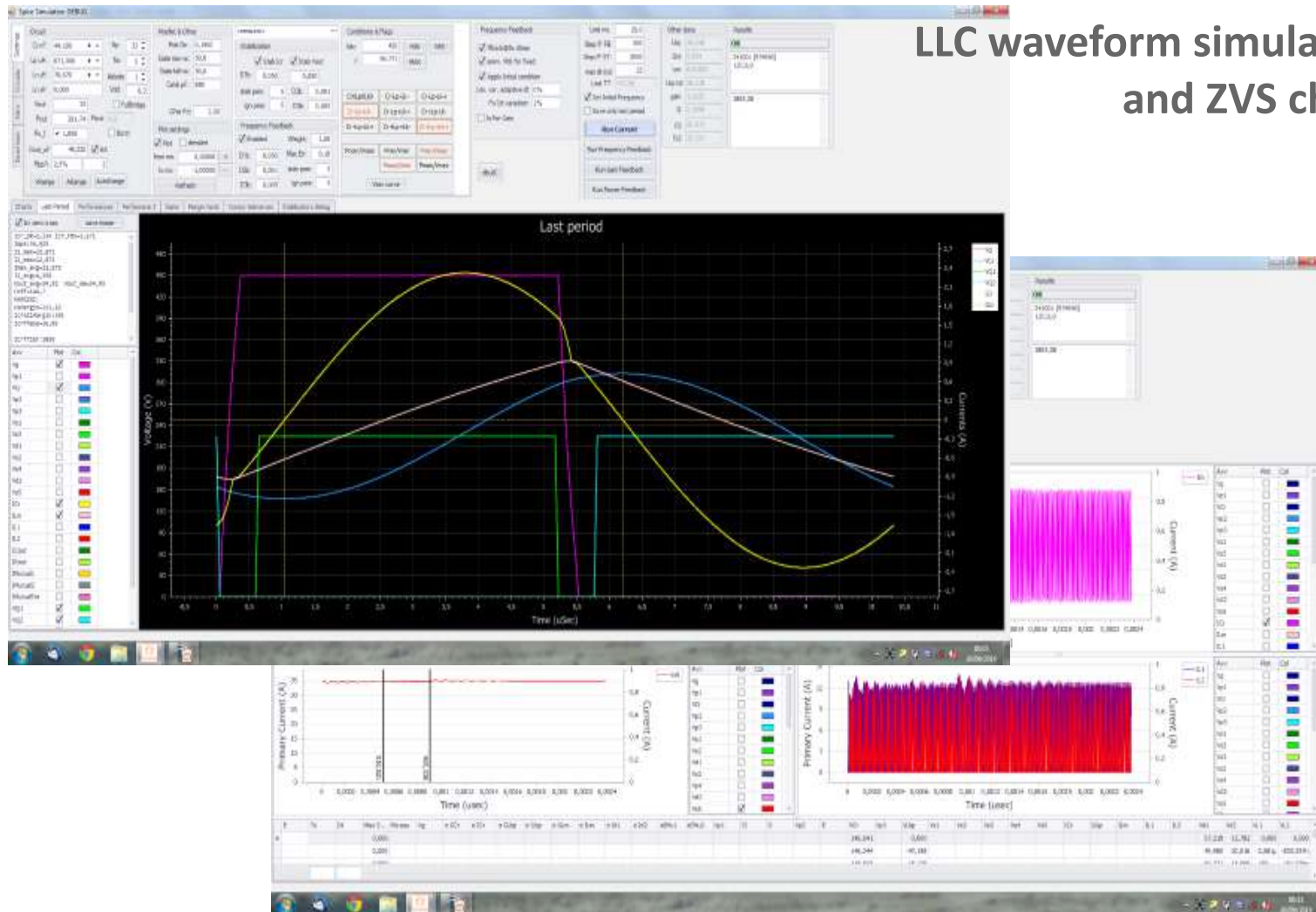


LLC tank design and optimization

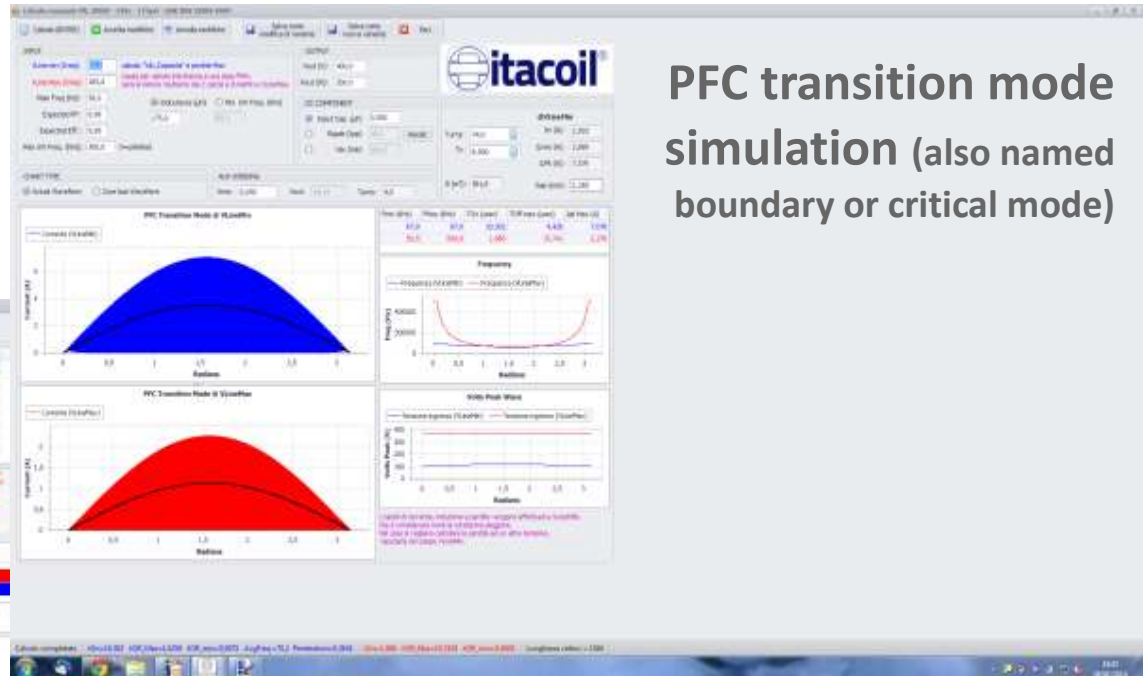
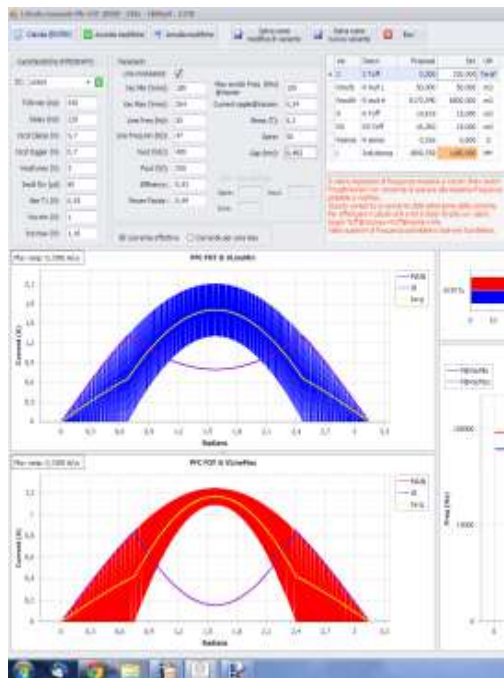


Power loss calculation

LLC waveform simulations and ZVS checks



PFC transition mode simulation (also named boundary or critical mode)

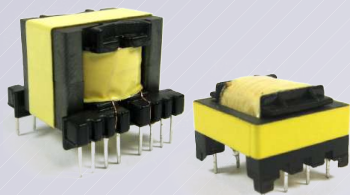


PFC fixed off time (FOT) mode simulation

LLC
Resonant Tr.



PFC Inductors



One-stop-shop



EMI/EMC and
Smoothing filters



Common Mode
Chokes

