

Texas Instruments System Power Solution

德州仪器系统电源解决方案

Power Management

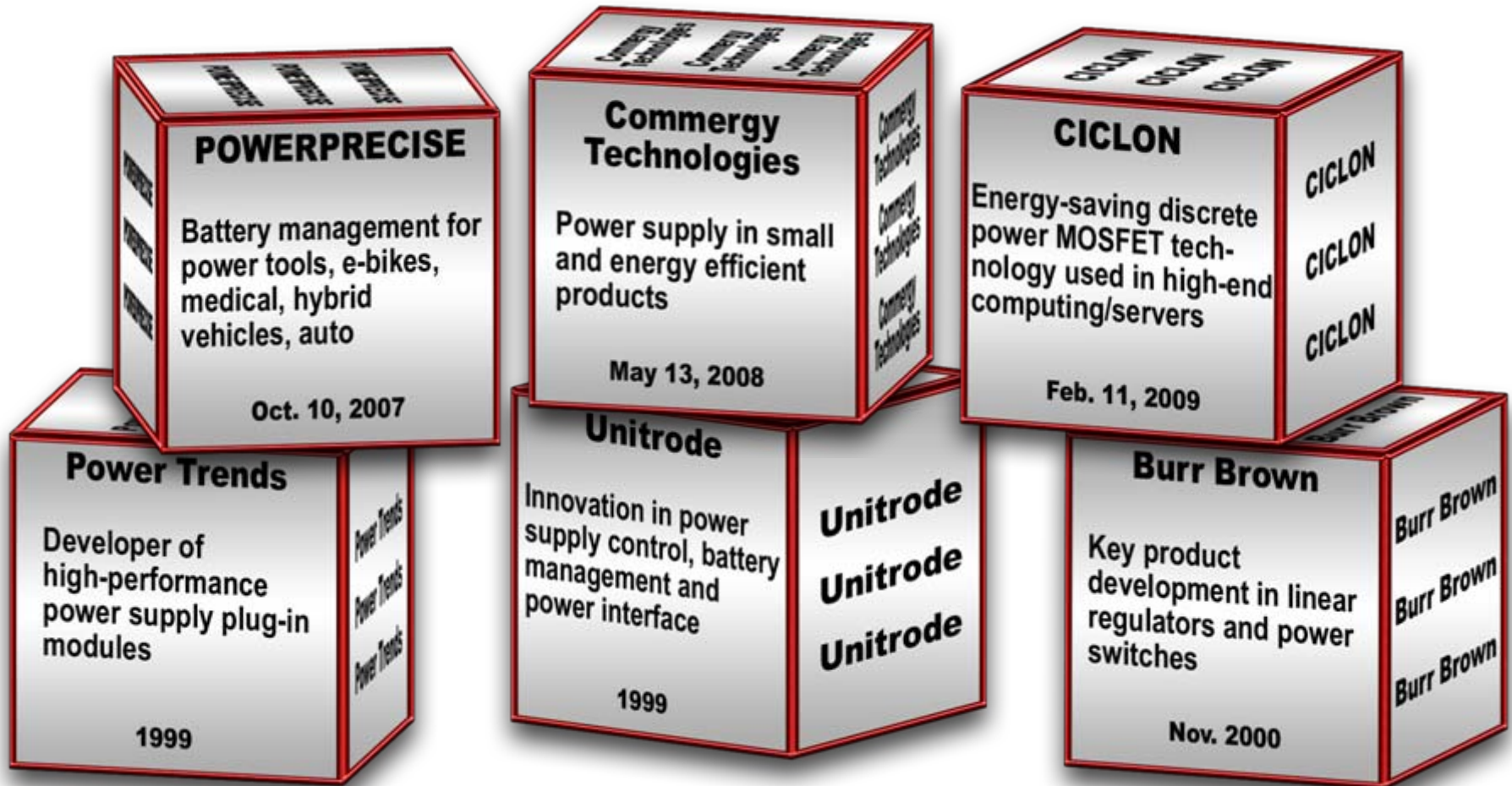
Nov 2009

Outline

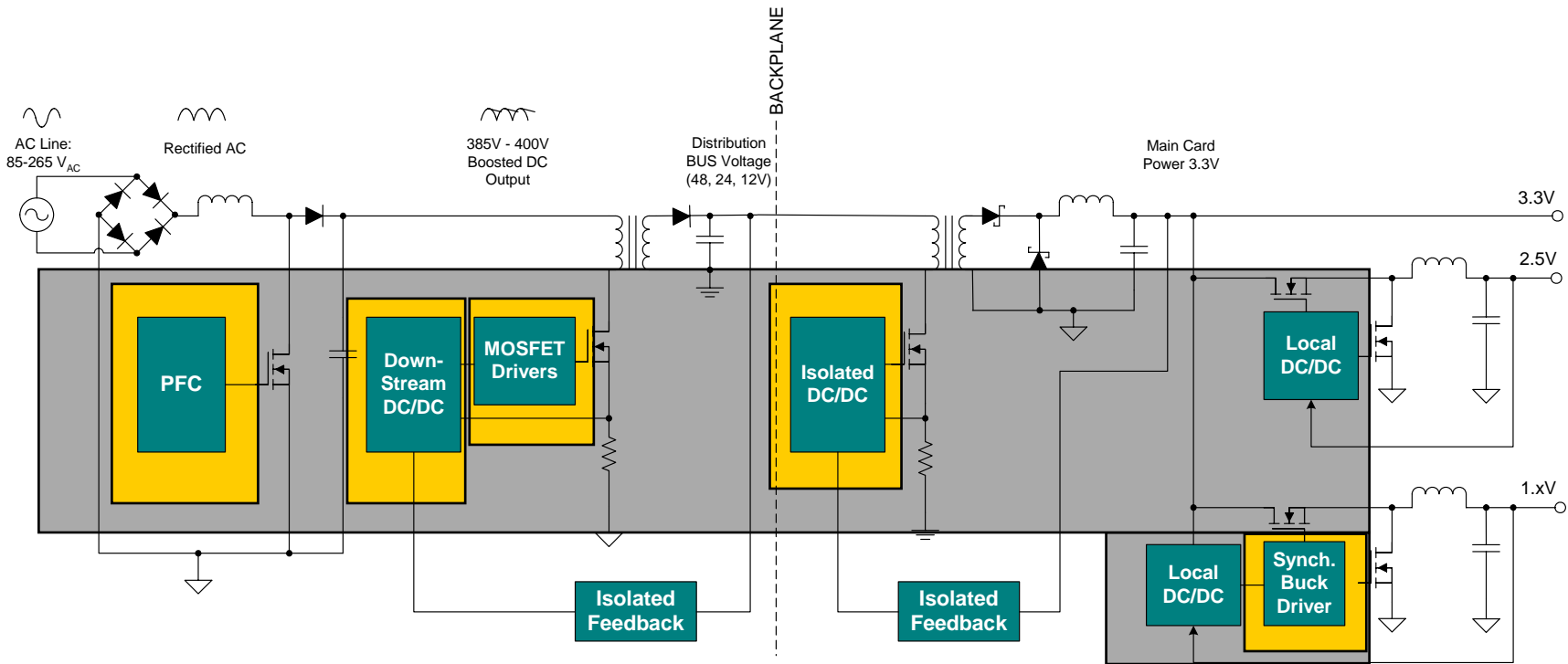
- TI Power Management Focus
- TI System Power Supply Update (PFC, PWM, etc.)
- TI Design Tools

TI Power History

TI has built the leading power management business



TI Total System Power Solutions



Boost
Interleaved Boost
Flyback

Flyback
Forward
2-switch Forward
Half-Bridge
Phase-Shifted Full-Bridge
Resonant Mode

Flyback
Forward
2-switch Forward
Push-Pull
Half-Bridge
Phase-Shifted Full-Bridge

Synchronous Buck
Boost
Multiphase Sync Bucks
Push-Pull

MOSFET
Ciclon MOSFET

Outline

- TI Power Management Focus
- TI System Power Supply Update (PFC, PWM, etc.)
- TI Design Tools

Complete System Power Solutions from TI



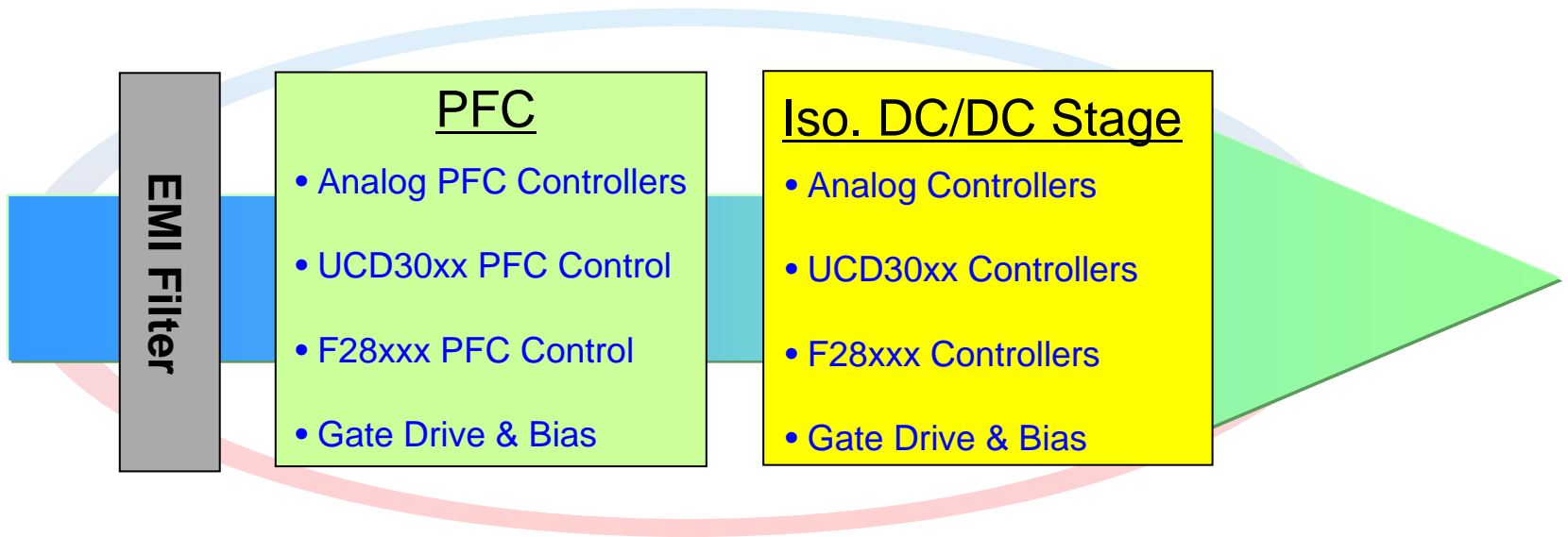
High Performance
Analog Solutions



Power-Optimized
Digital Controllers



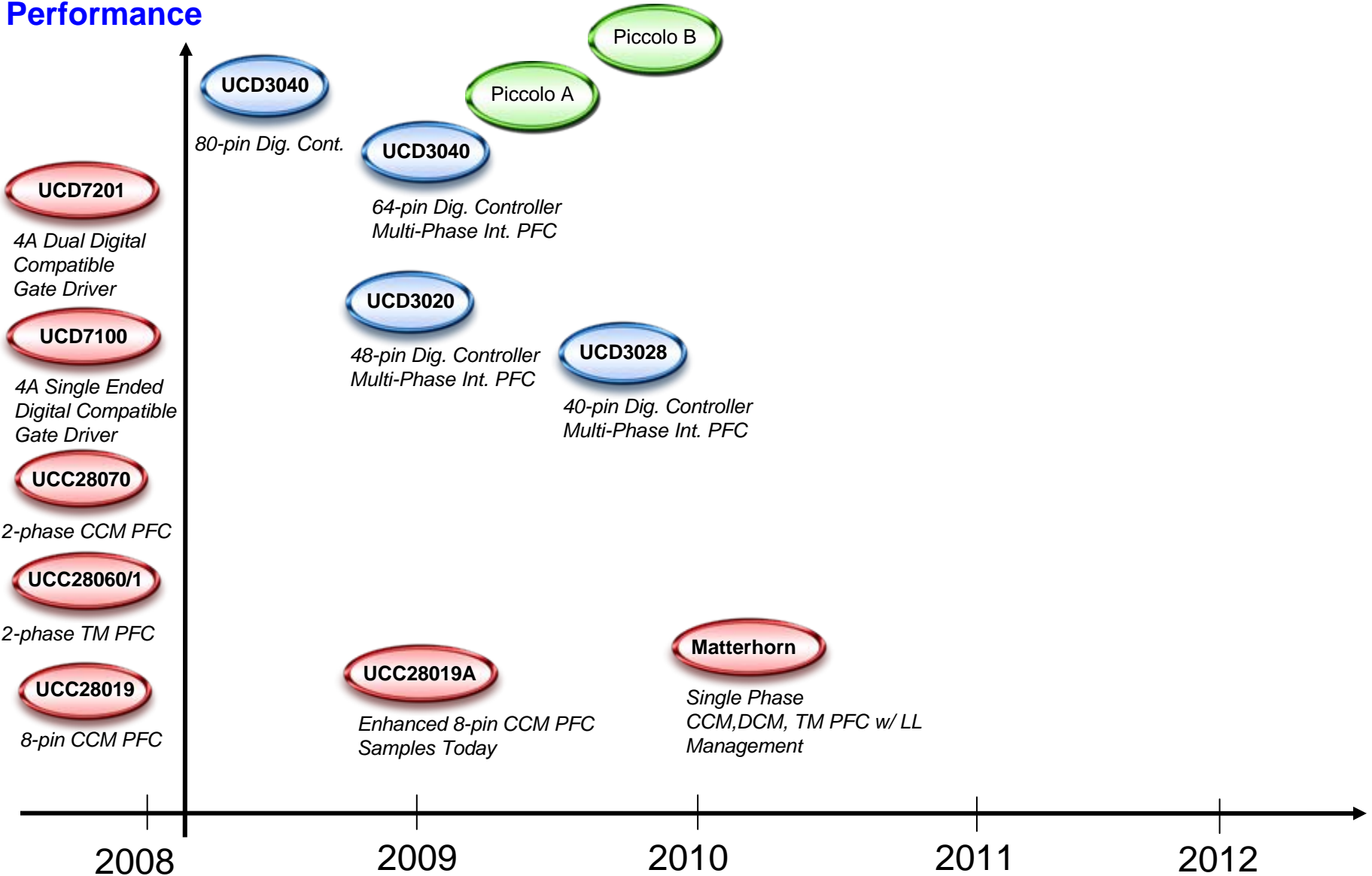
Fully Programmable
Digital Controllers



TI Solutions Cover the Spectrum of Power Applications

PFC Roadmap

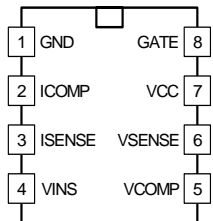
Price /
Performance



UCC28019A 8-Pin CCM (ACM) PFC Controller

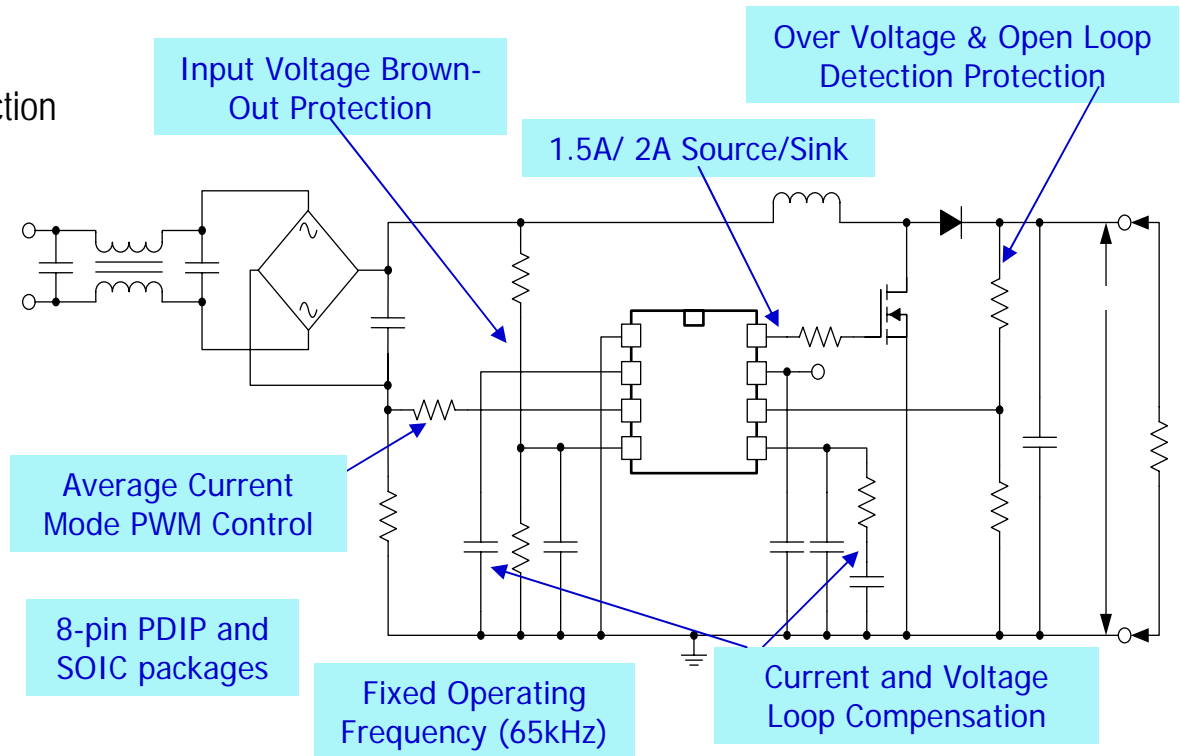
Features

- Complete 8-pin Power Factor Solution using Few External Components
- Average Current Mode PWM Control
- External Current and Voltage Loop Compensation
- Fixed Operating Frequency (65kHz)
- Cycle-by-Cycle Peak Current Limiting
- VCC Under-Voltage Lockout
- Open Loop Detection; Over-Voltage Protection
- Output Under-Voltage Detection
- Input Voltage Brown-Out Protection
- Enhanced Dynamic Response
- Soft-Start to Limit Start Up Current
- 8-pin PDIP (P) and SOIC (D) packages



Applications

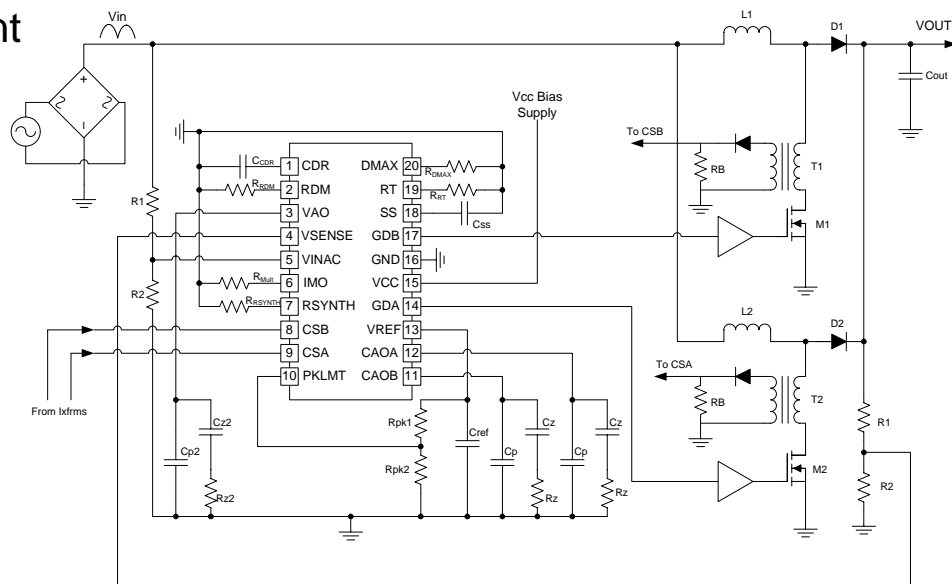
- ◆ Desktop and Server P/S
- ◆ LCD-TV and PDP-TV
- ◆ Hi-Power Adapters



UCC28070 Interleaved-CCM PFC

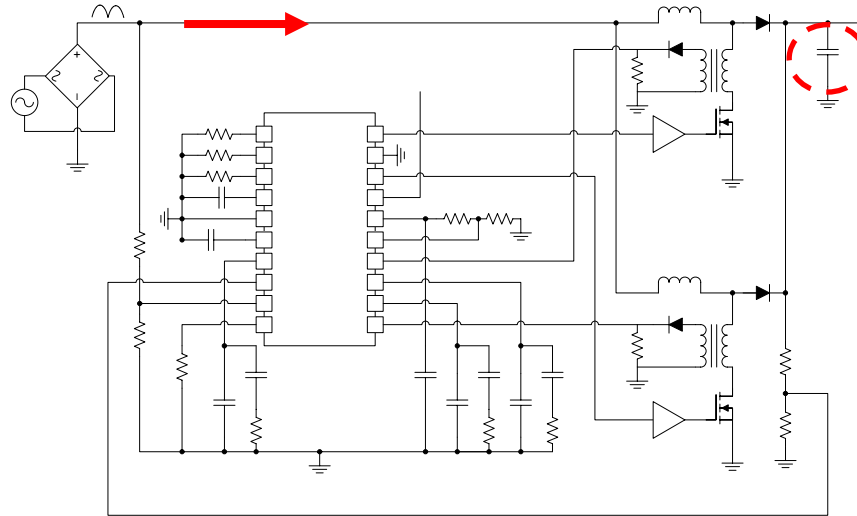
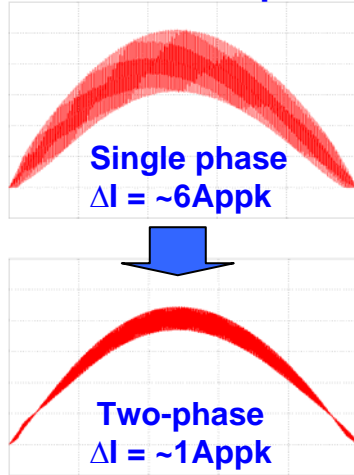
UCC28070 enables the benefits of a 2-phase interleaved CCM architecture and more in a single-chip Power Factor Correction (PFC) IC solution

- Current ripple cancellation on input filter and reduction on output capacitor
- Current Synthesis eliminates 2 current sense transformers and improves efficiency
- Frequency dithering reduces EMI
- Improved transient response
- Complete system-level protection
 - IC protection
 - Under-Voltage Lockout
 - Thermal Shutdown
 - Output protection (non-latched)
 - Soft-Start
 - Over-Voltage
 - Open-Loop
 - Peak Current Limit
 - Power Limit

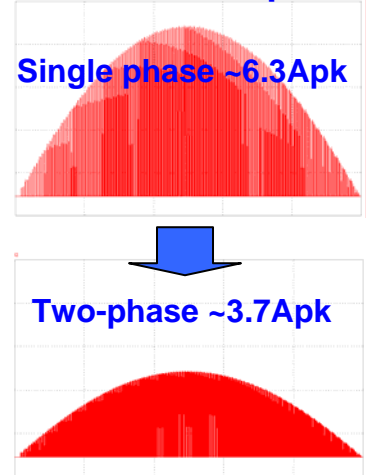


UCC28070 180° Interleaved-PFC Benefits

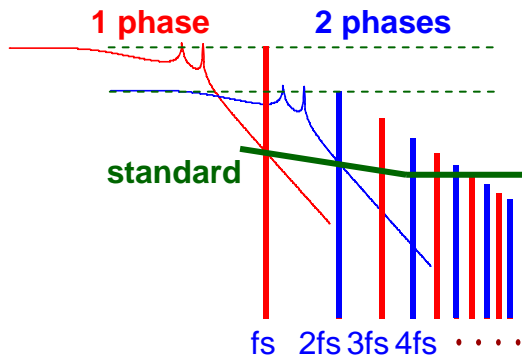
110V input
1200W output



110V input
1200W output



Differential Mode Noise



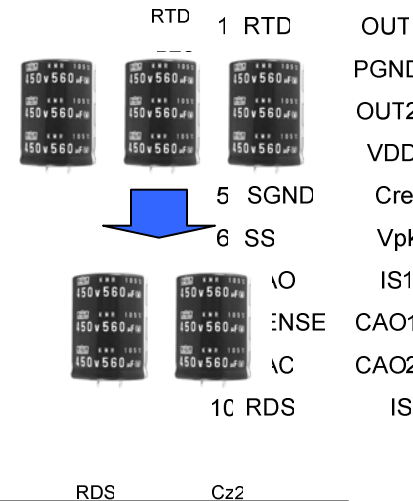
- Cancellation Effects by Interleaving reduces input current ripple dramatically.

- Reduced ripple allows smaller EMI filter design.

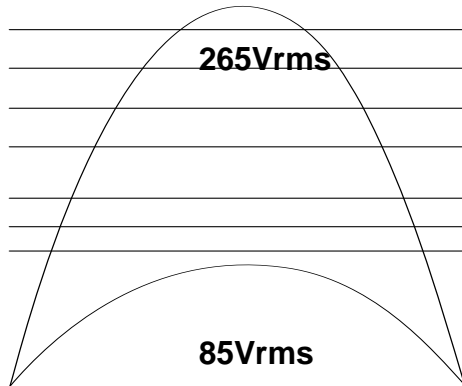
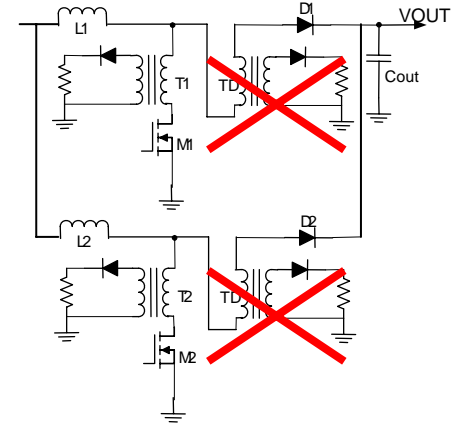
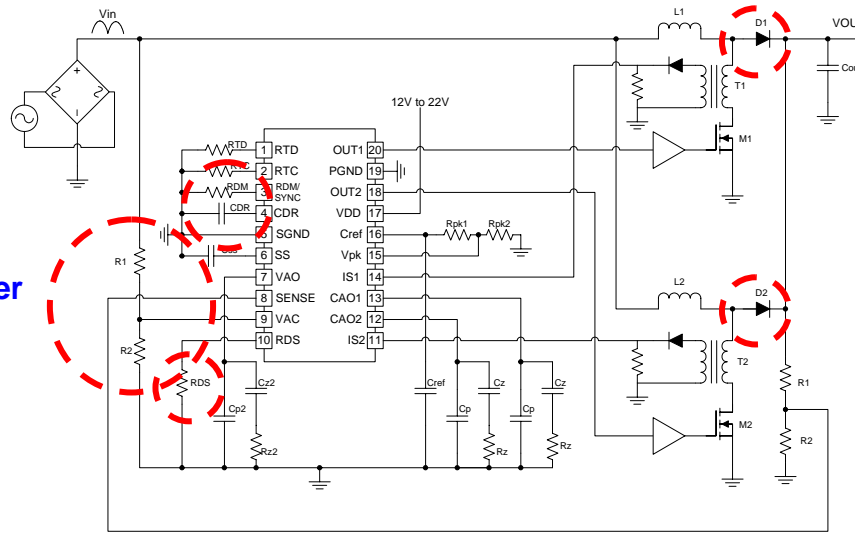
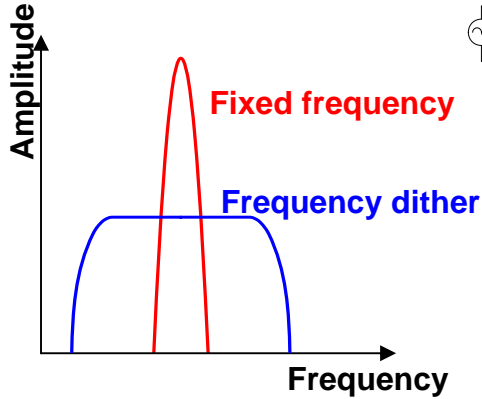
- Interleaving also reduces rms current in output capacitor.

- Lower rms current allows smaller, fewer or cheaper caps and higher reliability.

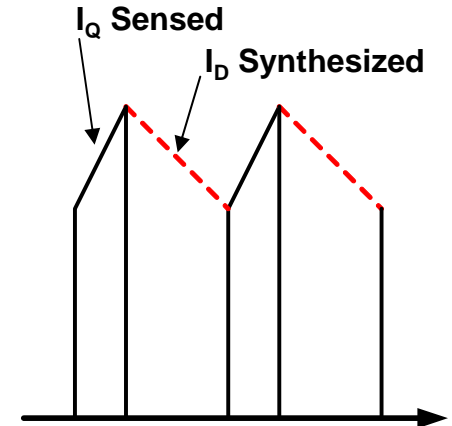
V_{in}



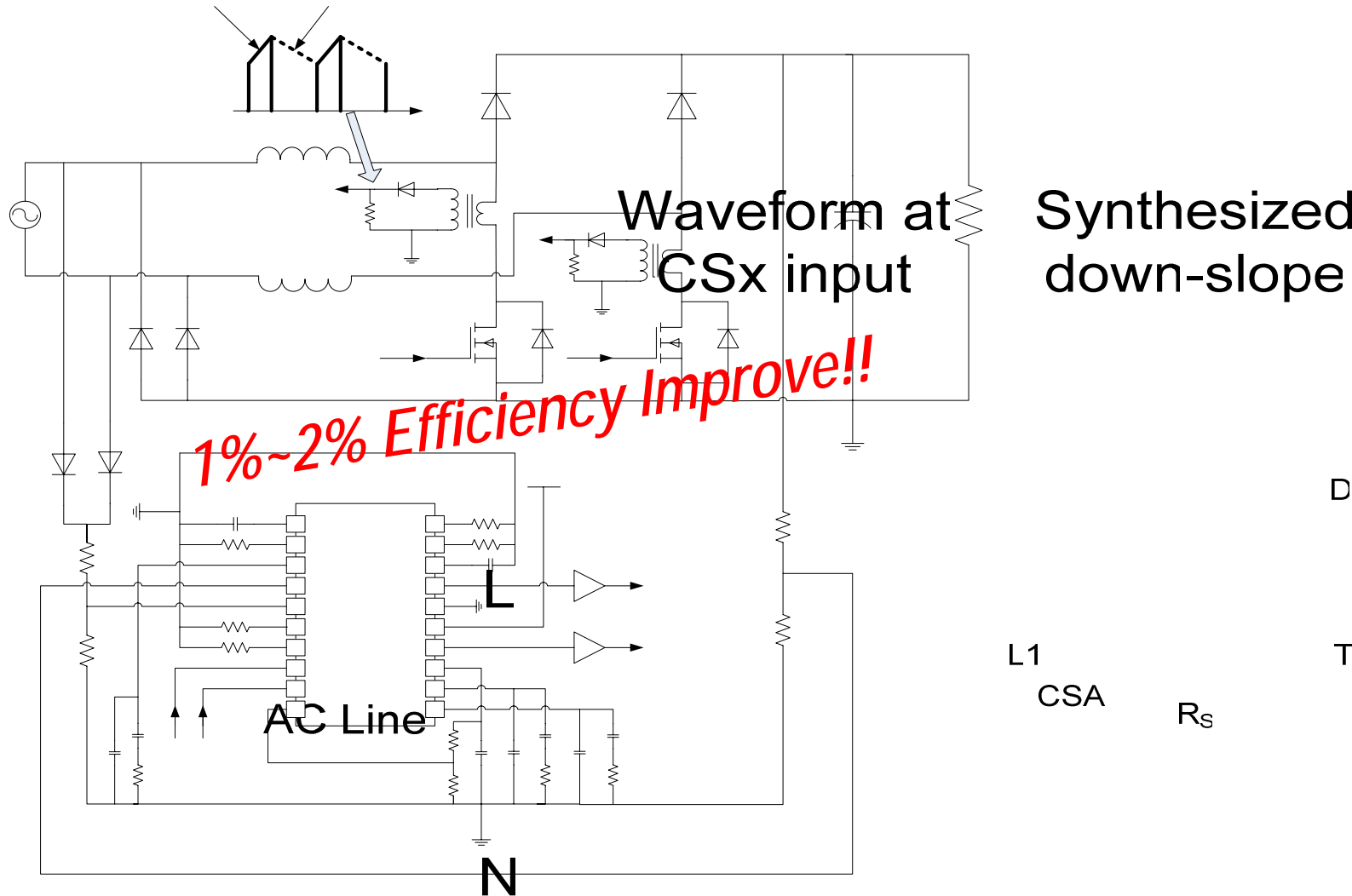
UCC28070 Innovations and Benefits



- Frequency dithering reduces EMI peak signatures, allowing smaller filter design.
- Discrete Vrms detection levels eliminate THD contribution and increase response to line changes with minimized gain variations.
- Current synthesis eliminates 3 lossy resistors or 2 of 4 sense transformers.
- Higher efficiency, smaller volume, less complexity, lower cost.

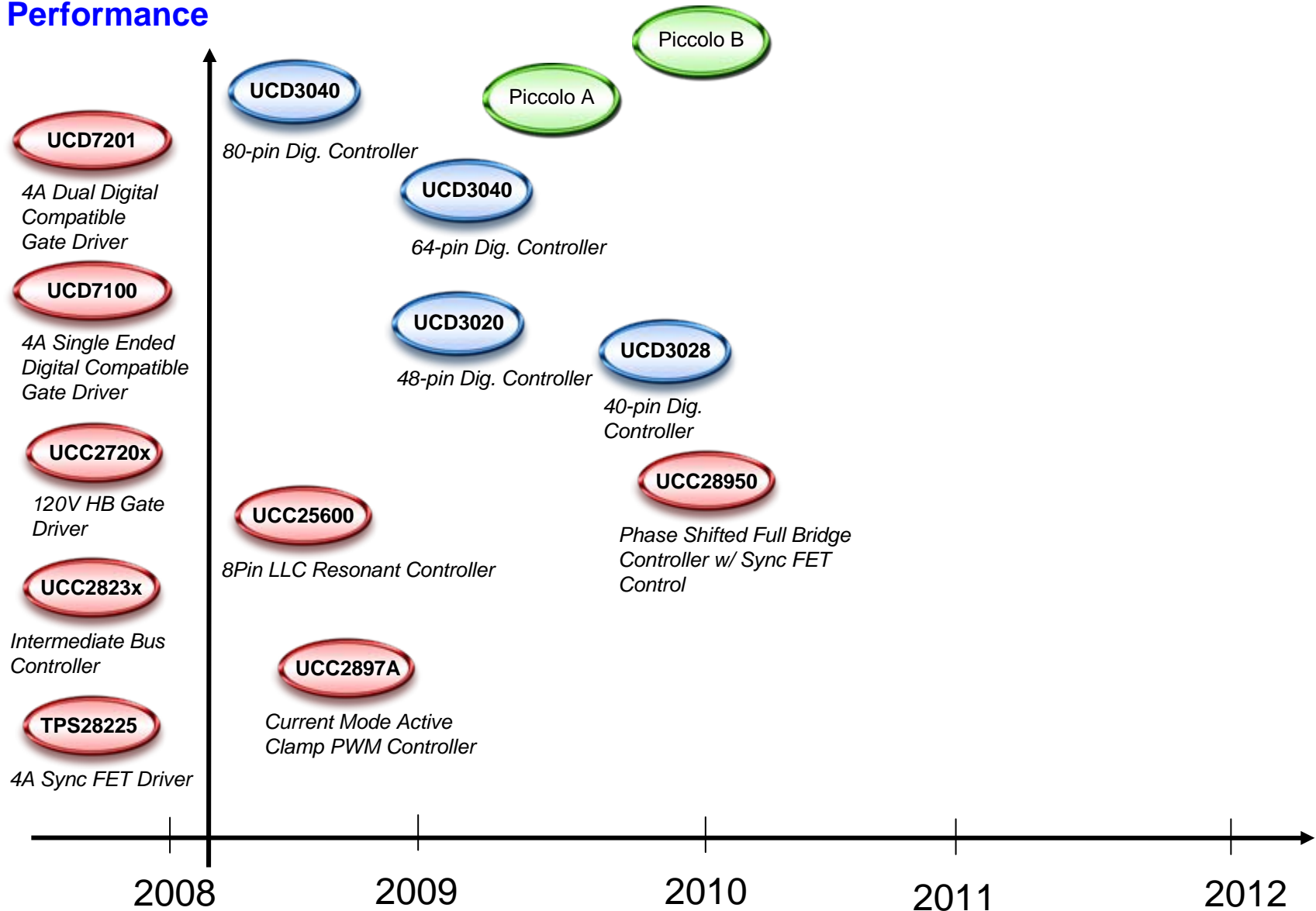


UCC28070 Implement Bridgeless PFC



Isolated DC/DC Controller Roadmap

Price /
Performance



TI UCC25600

8 Pin Resonant Half Bridge Controller

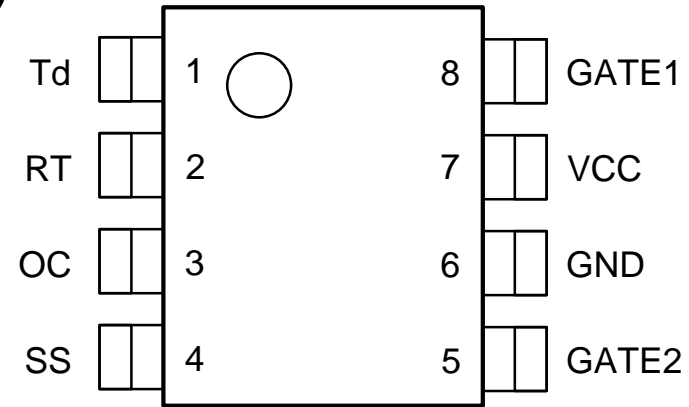
Features

- Adjustable Soft start (1ms to 500ms)
- Adjustable dead time
- Adjustable F_{swmax} & F_{swmin} (3% accuracy)
- $I_o = +1A / -1.5A$
- Enable (ON/OFF control)

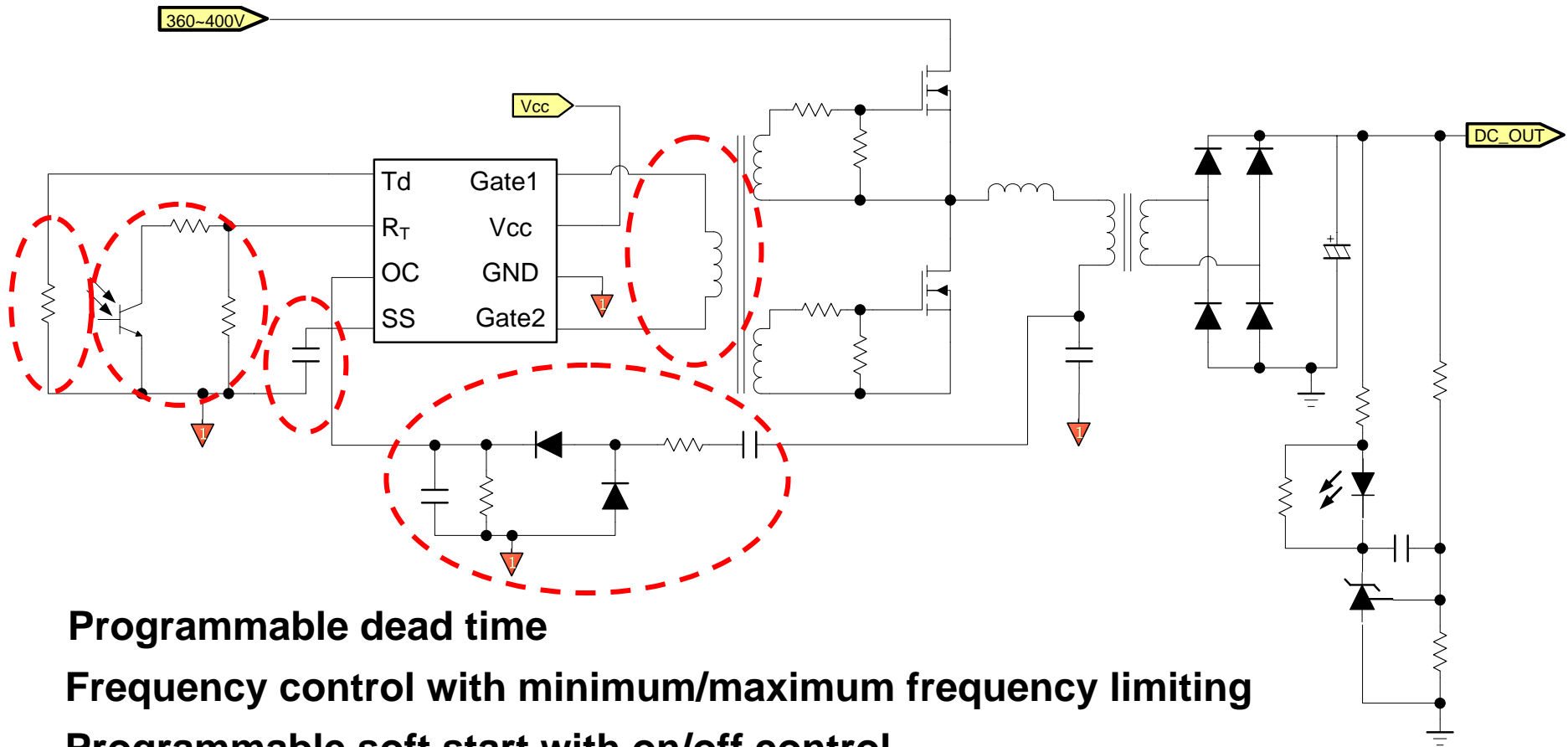
Protection functions

- Two levels over current protection
 - auto recovery
 - latch
- Bias voltage UV and OV protection
- Over temperature protection
- Soft start after all fault conditions

SOT 8 pin package= Easy design and layout



Application Circuit



Programmable dead time

Frequency control with minimum/maximum frequency limiting

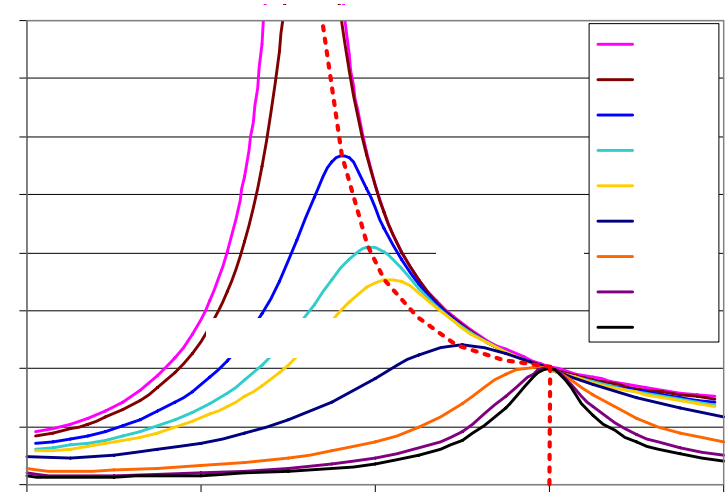
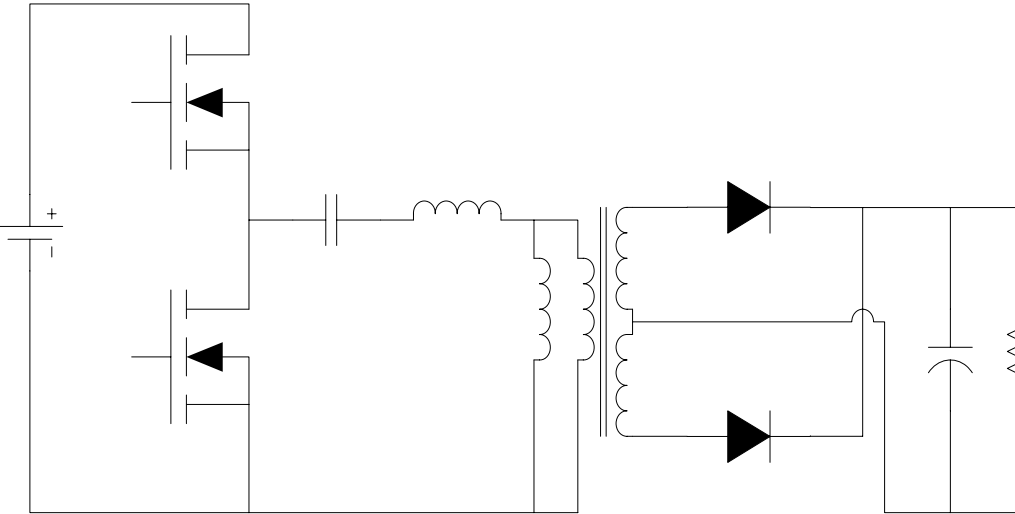
Programmable soft start with on/off control

Two level over current protection, auto-recovery and latch up

Matching output with 50ns tolerance



LLC Resonant Converter with Wide Operation Range



Resonant
frequency

$$f_0 = \frac{1}{2\pi\sqrt{L_r C_r}}$$

Transformer
turns-ratio

$$n = \frac{V_{in} / 2}{V_o}$$

C_r

L_r

$n:1:1$

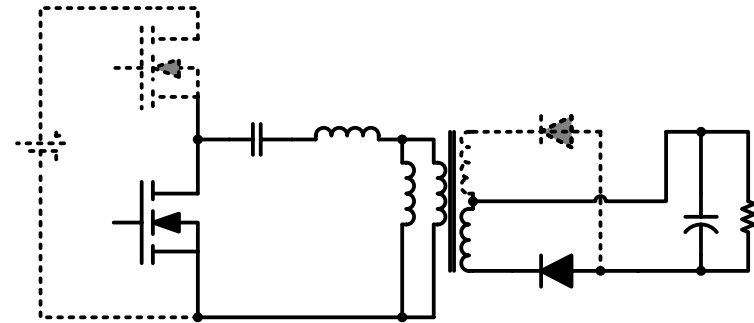
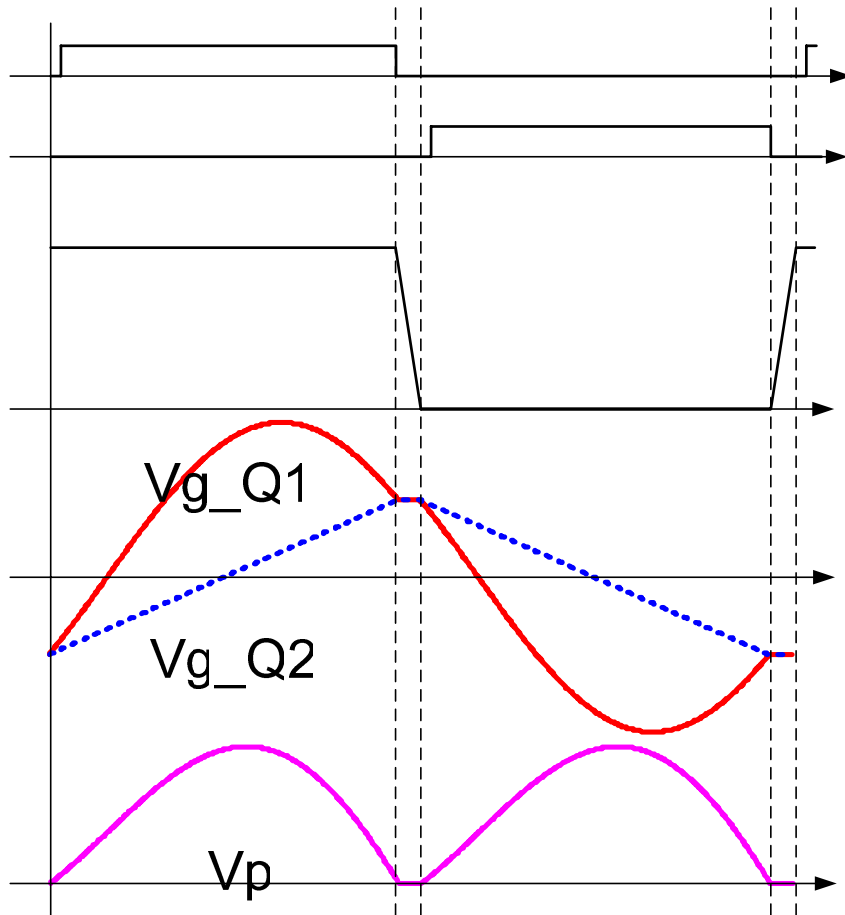
➤ At 400V input, switching frequency is resonant frequency

➤ During V_{in} holdup time, switching frequency is reduced

L_m

Operation Principles

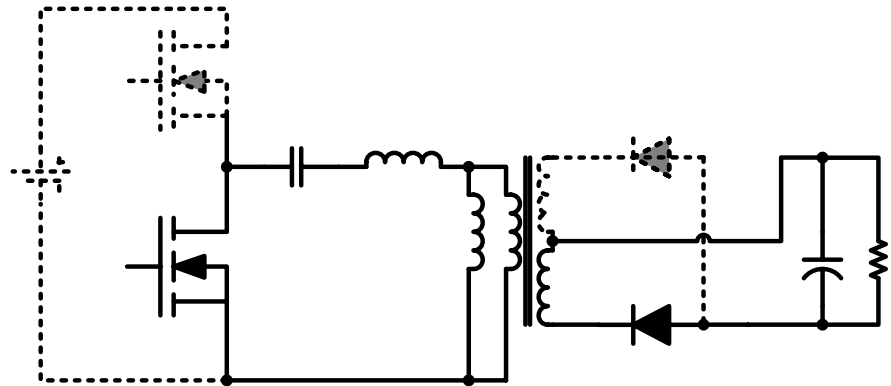
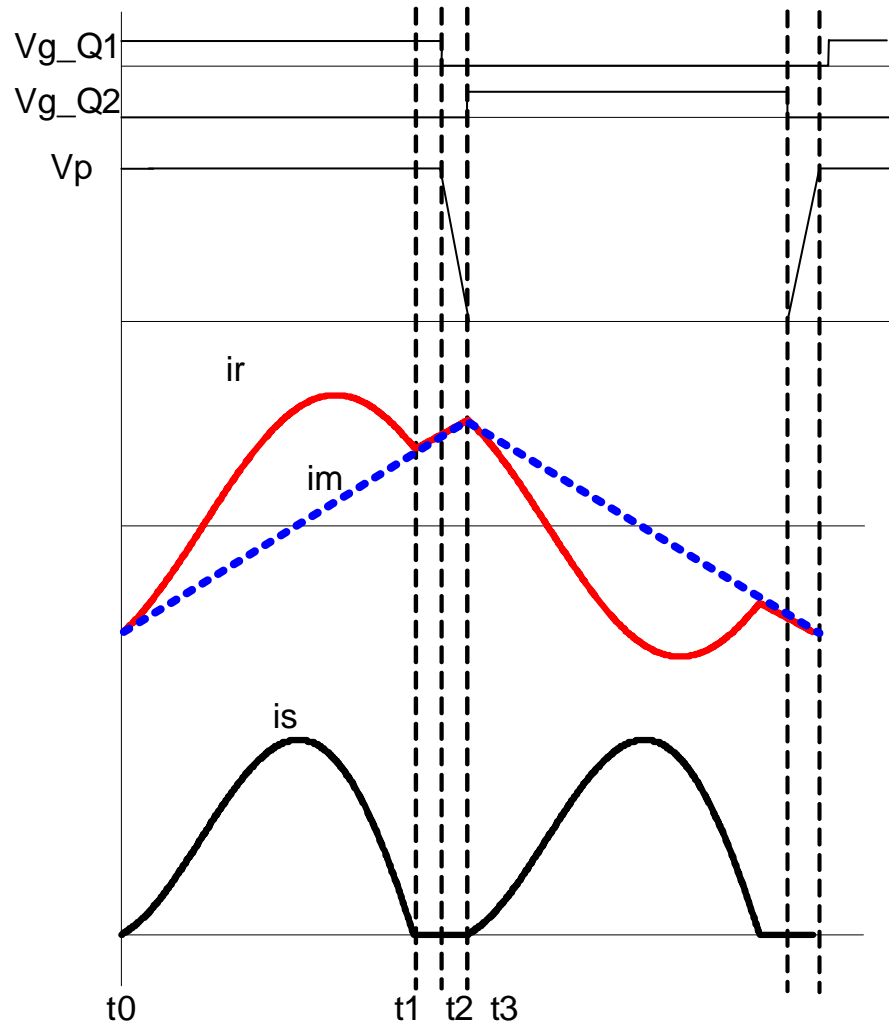
At Resonant Frequency



➤ At resonant frequency, maximum efficiency is expected

Operation Principle

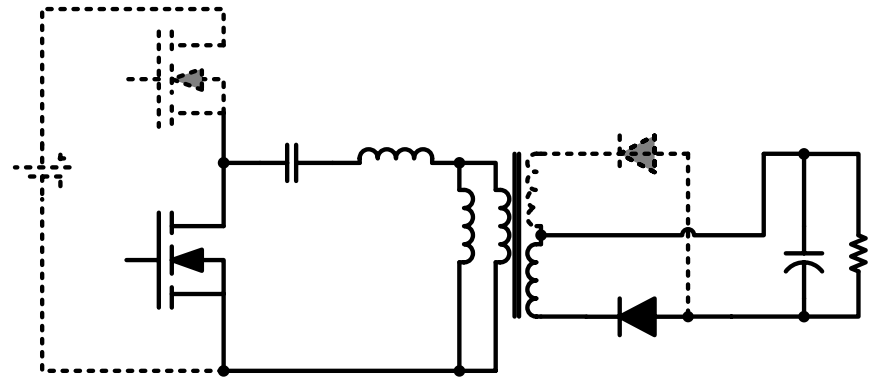
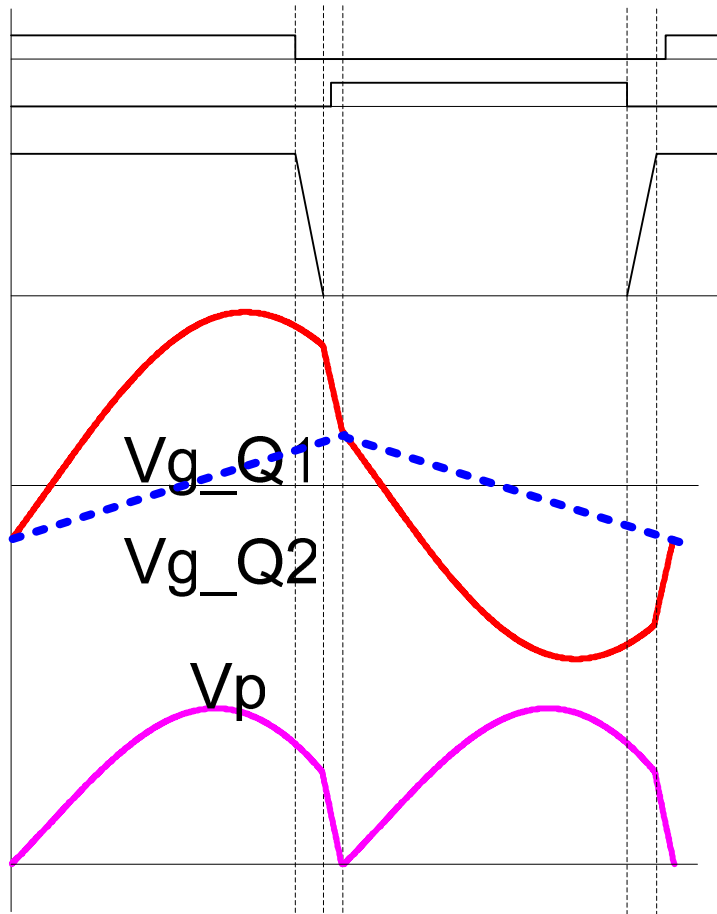
Below Resonant Frequency



- When switching frequency is below resonant frequency, magnetizing inductor begins to participate in resonant and increase voltage gain
- Secondary diode becomes discontinuous

Operation Principle

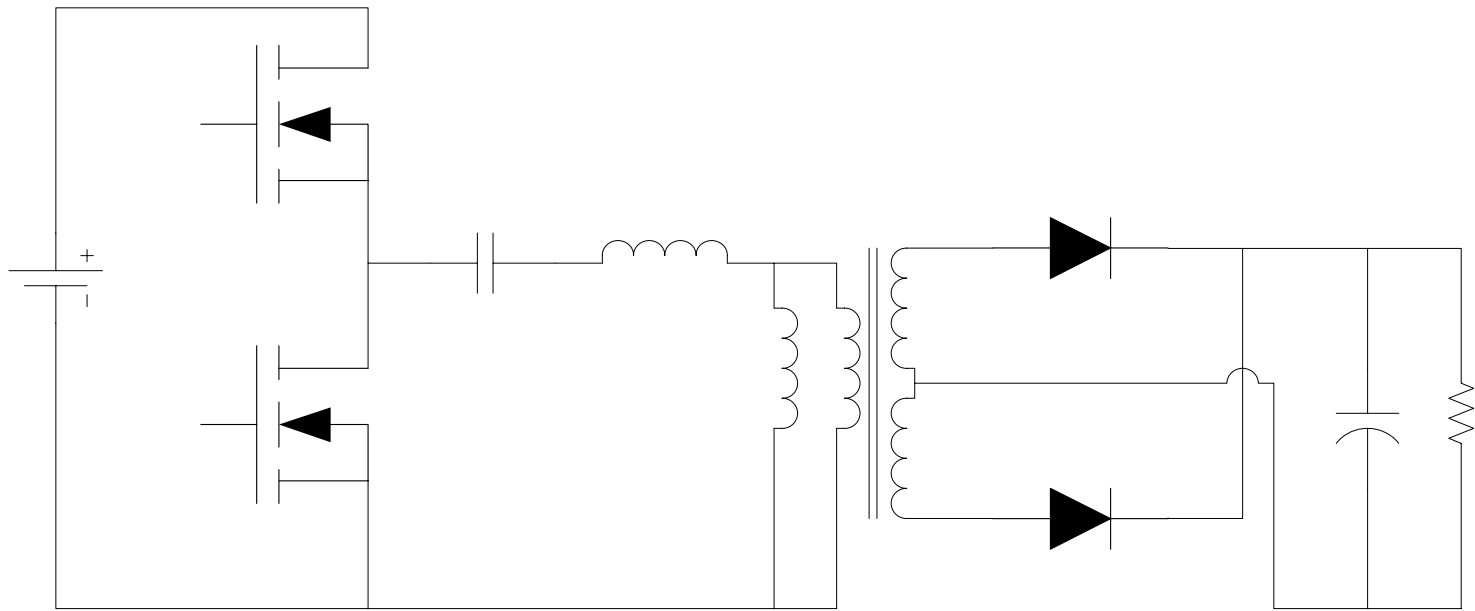
Above Resonant Frequency



- When switching frequency is above resonant frequency, circuit behaves as SRC
- Secondary current becomes CCM, reverse recovery loss increases

i_r

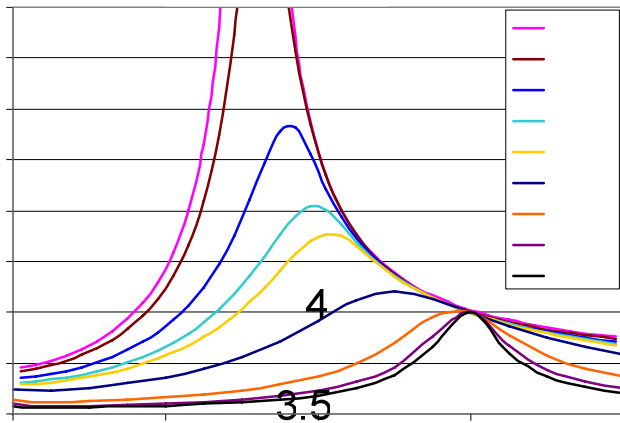
Benefits of LLC Resonant Converter



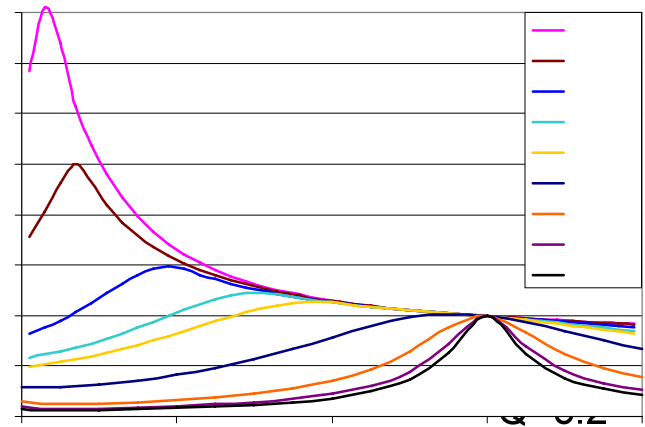
C_r

- ZVS can be achieved by utilizing transformer magnetizing inductor
- Capacitor filter, less voltage stress on rectifiers
- Smaller switching loss due to small turn off current
- Variable switching frequency control, not sensitive to load change
- Wide operation range without reducing normal operation efficiency

Impacts of Circuit Parameters



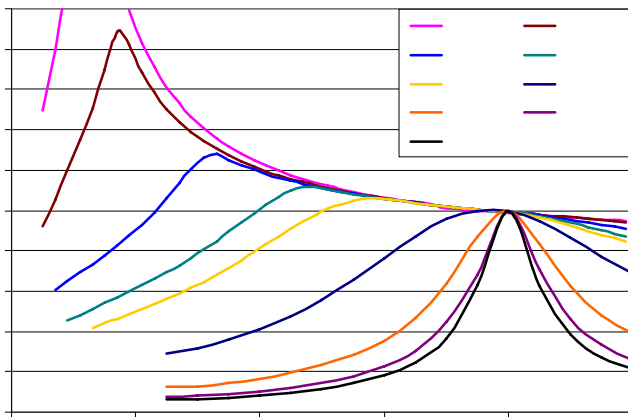
$L_n = 3$



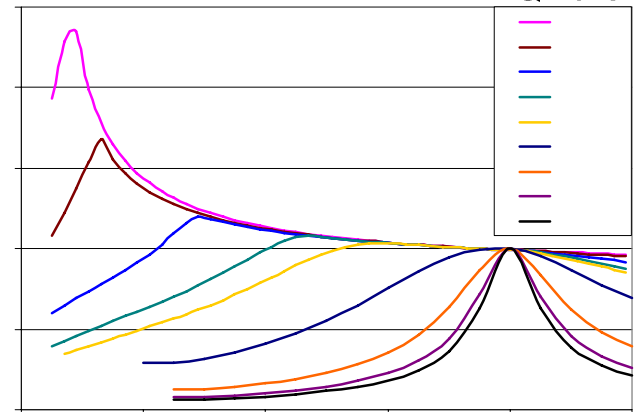
$L_n = 5$

$Q = 0.5$

$Q = 0.8$

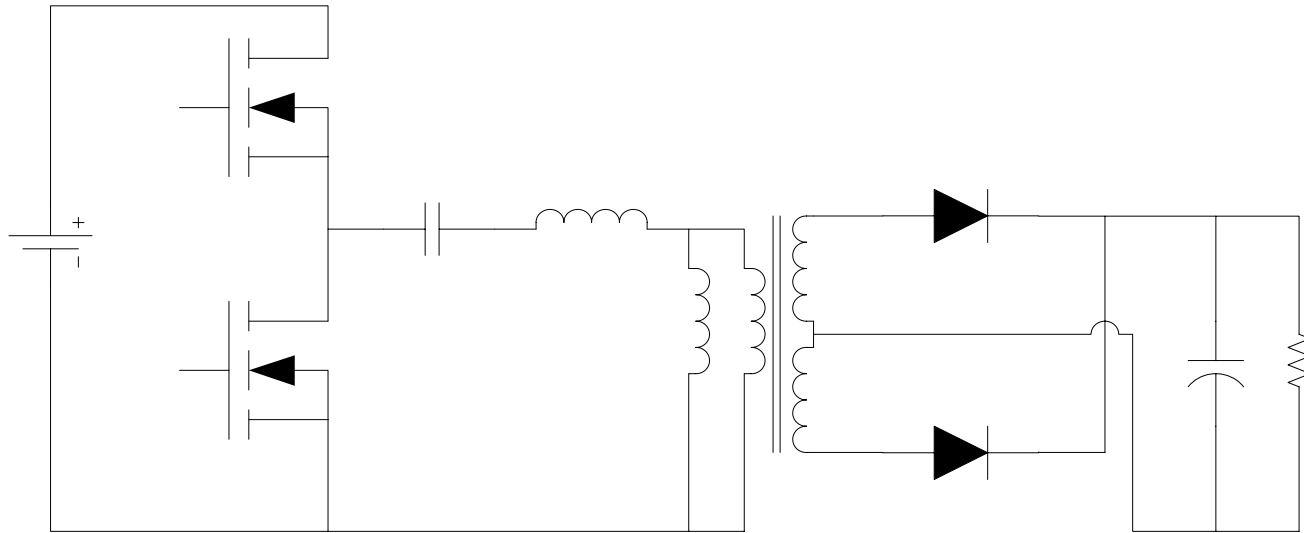


$L_n = 10$



$L_n = 15$

Design Goals for LLC Resonant Converter



Inductor Ratio

$$L_n = \frac{L_m}{L_r}$$

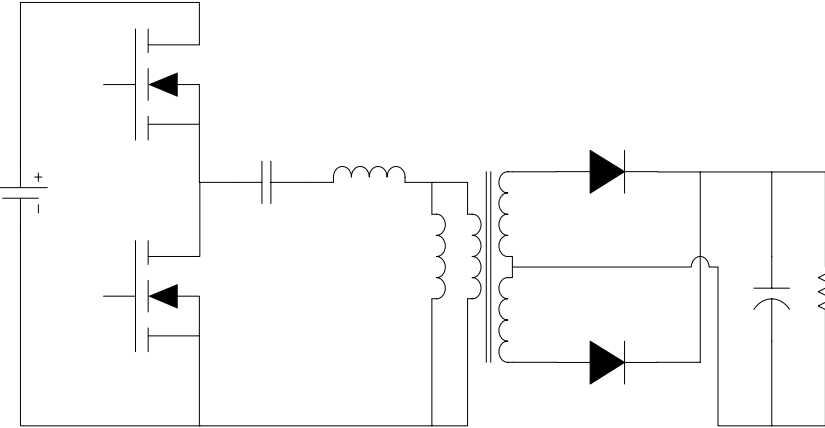
Quality factor

$$Q = \frac{\sqrt{L_r / C_r}}{n^2 R_L}$$

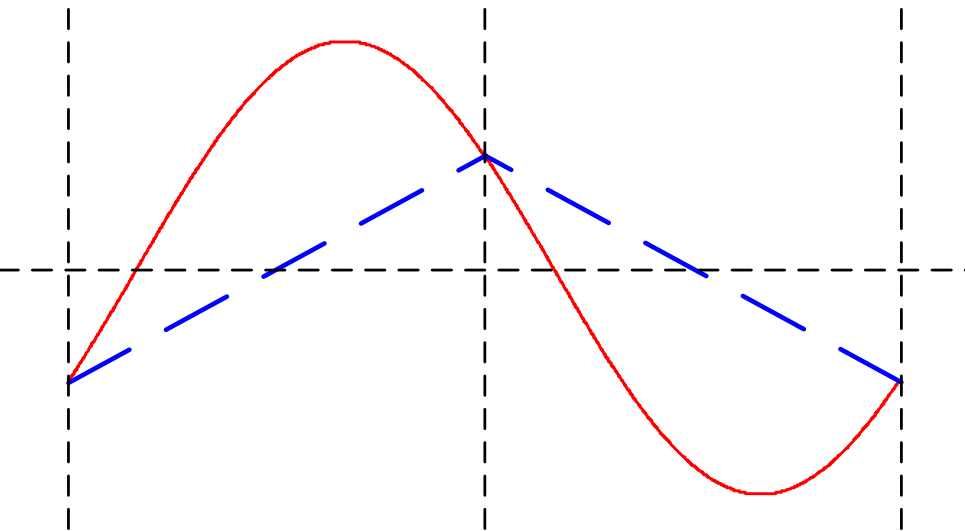
- Minimize RMS current under normal operation condition
- Ensure ZVS operation
- Ensure desired operation range

Choice of L_m

Criteria 1: Primary RMS Current at Normal Operation



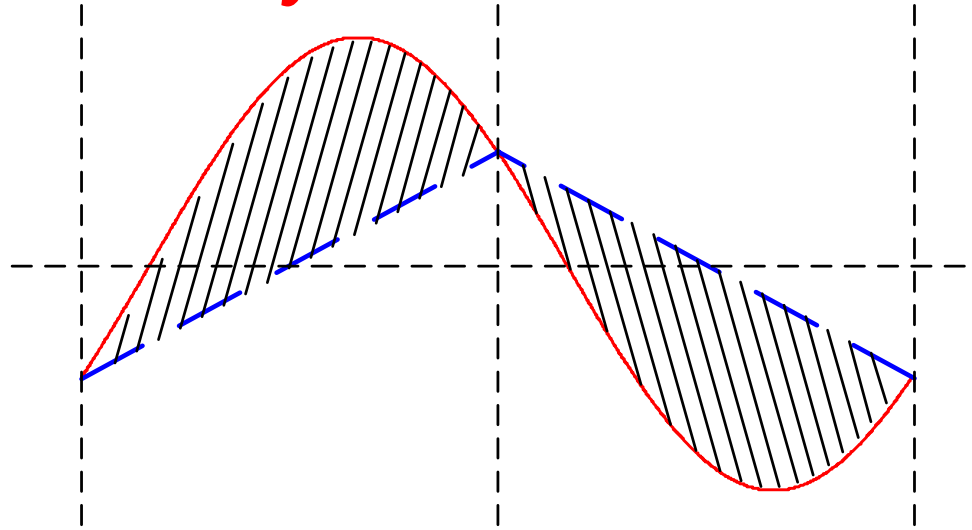
$$I_{RMS_P} = \frac{1}{4\sqrt{2}} \frac{V_o}{nR_L} \sqrt{\frac{n^4 R_L^2 T^2}{L_m^2} + 4\pi^2}$$



- $n:1:1$
- Primary side RMS current is determined by magnetizing inductor
 - Larger L_m the better

Choice of L_m

Criteria 2: Secondary RMS Current



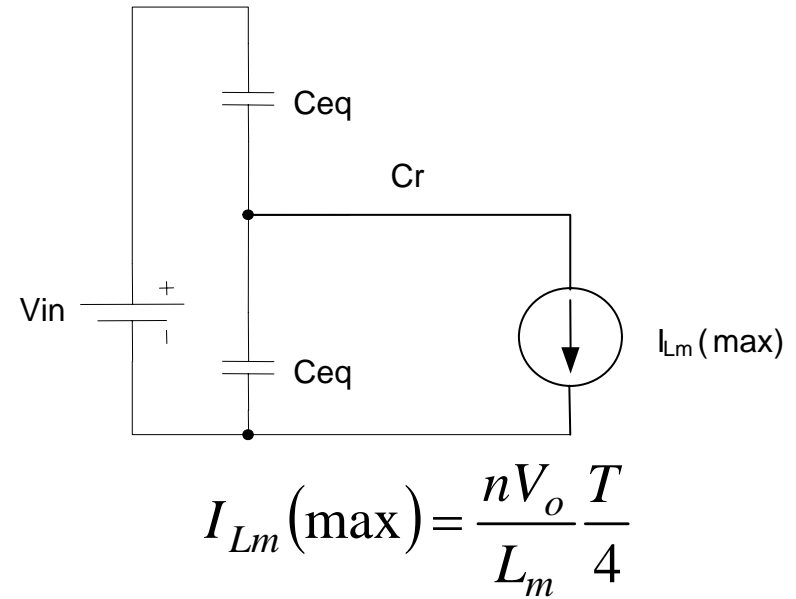
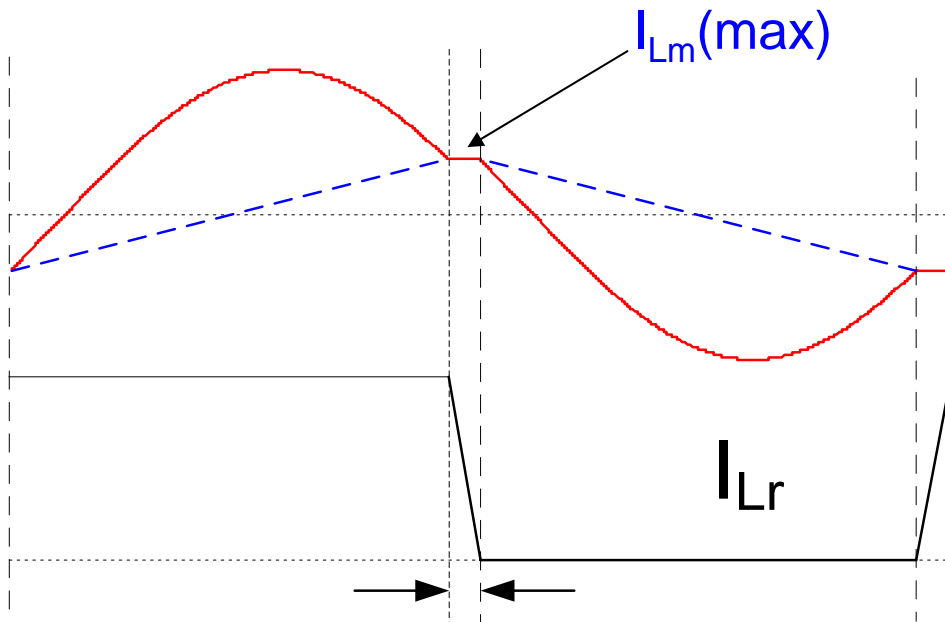
Primary side current

$$I_{RMS_S} = \frac{1}{4} \frac{V_o}{nR_L} \sqrt{\frac{5\pi^2 - 48 n^4 R_L^2 T^2}{12\pi^2 L_m^2} + 1}$$

- Secondary side current is the difference between resonant tank current and magnetizing current
- Larger L_m the better

Choice of L_m

Criteria 3: Zero Voltage Switching



- Turn off current should be able to discharge junction caps during dead-time

$$L_m \leq \frac{T \cdot t_{dead}}{16C_{eq}}$$

Trade-off Design of Dead Time

t_{dead} ↑

L_m ↑

- Smaller turn off current
- Smaller magnetizing current
- Increase RMS current due to duty cycle loss

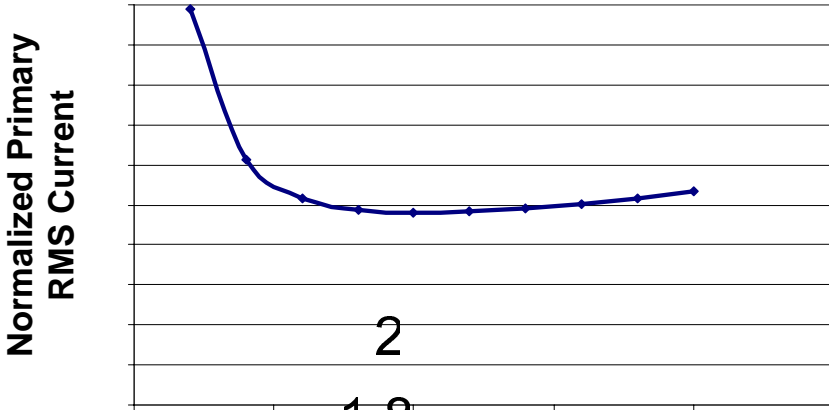
t_{dead} ↓

L_m ↓

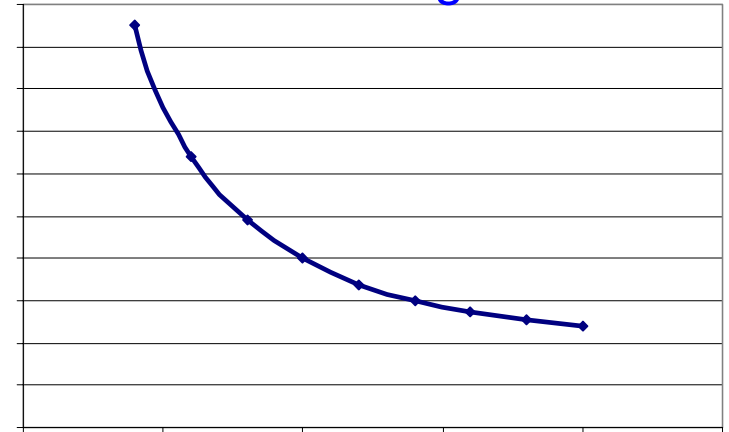
- Smaller duty cycle loss
- Larger magnetizing current
- Larger turn off loss

Trade-off Design of Dead Time

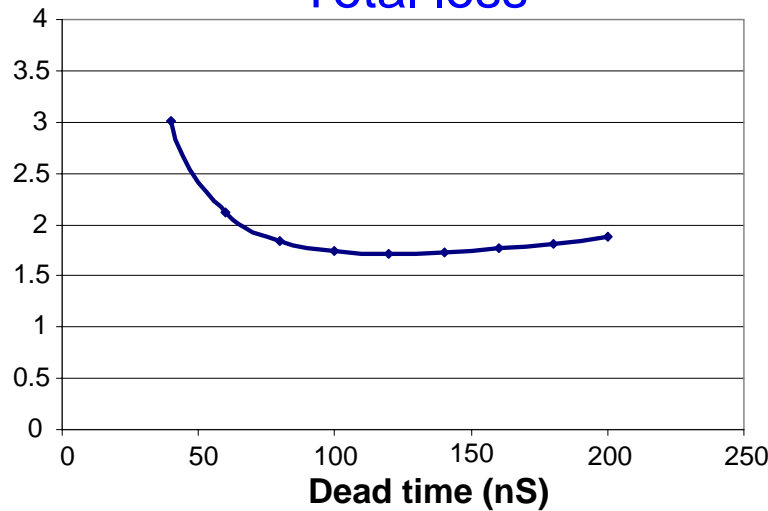
Conduction loss



Switching loss

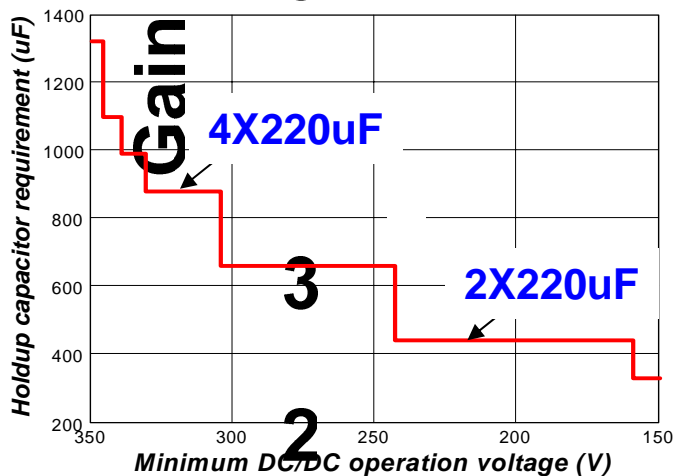
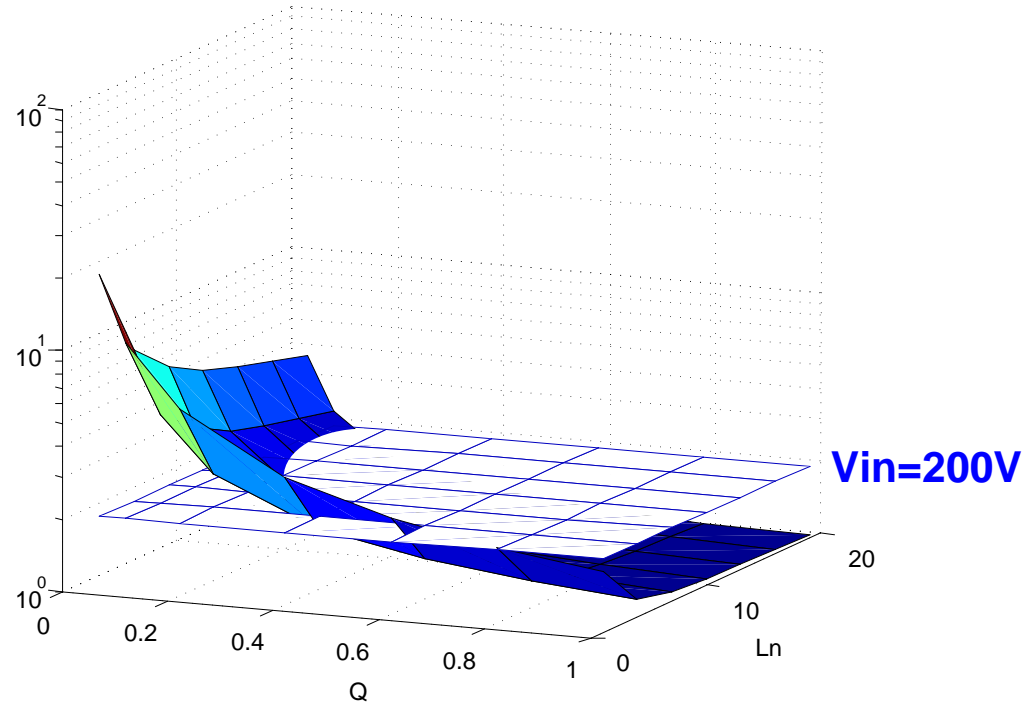
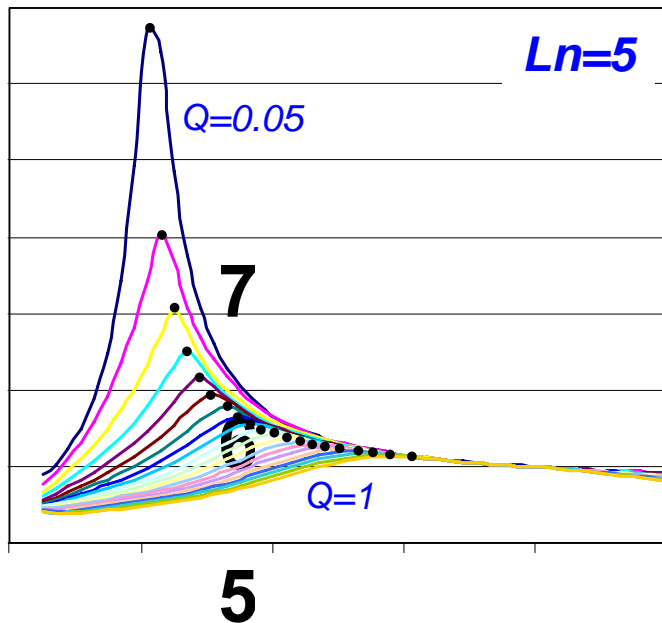


Total loss



➤ 100nS shows the trade-off between the switching loss and conduction loss

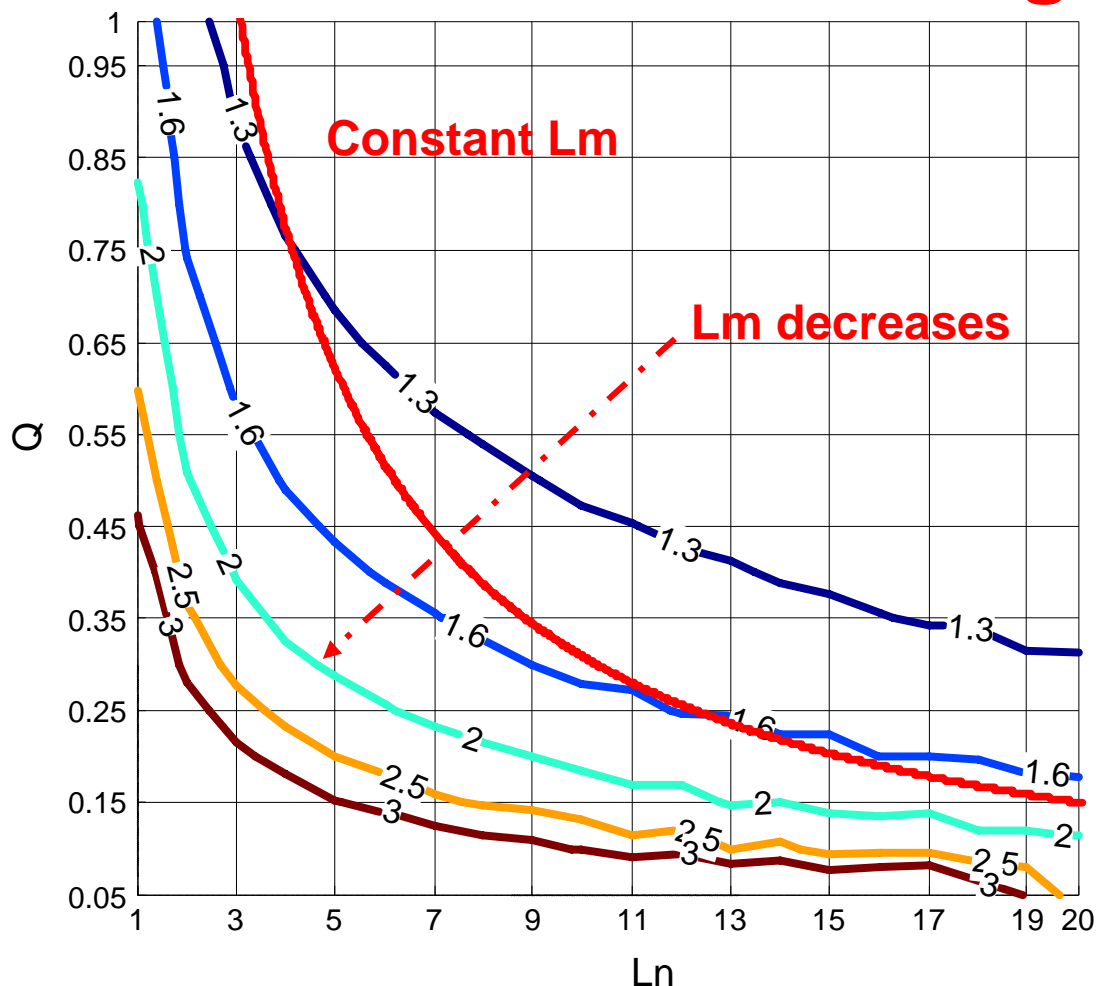
Achievable Peak Gain for Different Ln and Q



- For each Ln and Q combination, the maximum gain can be achieved is determined
- Colored surface represent the maximum gain for different Ln and Q combinations
- Only certain Ln and Q region can meet gain requirement

Gain

Peak Gains for Different Designs



$$Q = \frac{\sqrt{L_r/C_r}}{n^2 R} \quad L_n = \frac{L_m}{L_r}$$

$$L_m = \frac{n^2 R}{2\pi f_0} L_n Q$$

- To keep L_m constant and achieve low conduction loss and switching loss at normal operation, product of L_n and Q is expected to be constant
- Reduce L_m can help achieve higher peak gain

Start Up Current Consideration

$$I_p^* = \begin{cases} \frac{\pi^2}{4 \cdot Q} & 1 < \Omega_s \leq 2 \\ \frac{\pi^2}{4 \cdot Q} \cdot \sin\left(\frac{\pi}{\Omega_s}\right) & \Omega_s > 2 \end{cases} \quad \Omega_s = \frac{f_{s-startup}}{f_0}$$

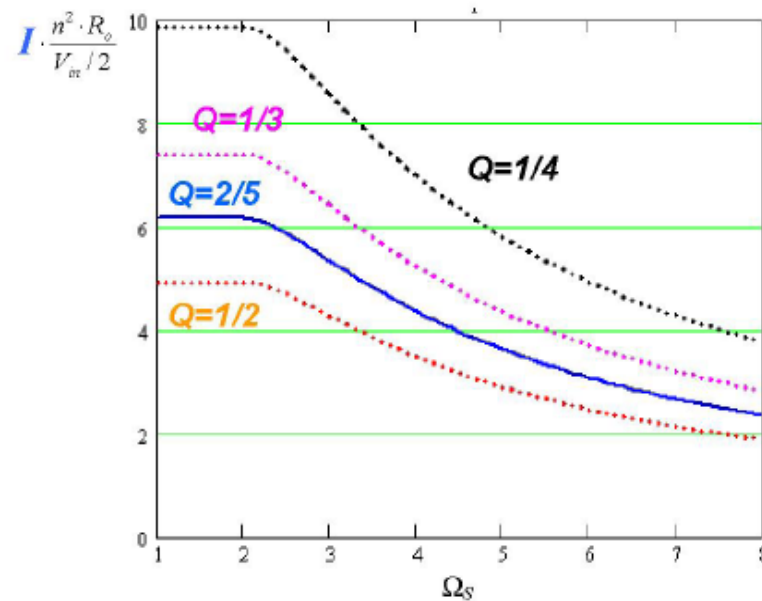


Fig.9 Normalized start-up first peak current

- Larger Q value gives smaller start up current with less frequency range

“A Novel Precise Design Method for LLC Series Resonant Converter”, Teng liu, etc., INTELEC '06

Design Flow Chart for LLC Resonant Converter

Converter Specification

$$n = \frac{V_{in}}{2V_o}$$

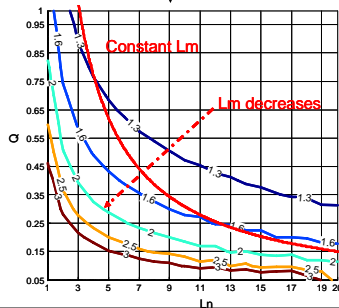
Primary switching Device

$$L_m = \frac{T \cdot t_{dead}}{16C_j}$$

Magnetizing inductor

Reduce L_m

$$L_n Q = \frac{L_m}{n^2 R} 2\pi f_0$$



Peak gain enough?

No

Yes

Resonant capacitor

$$f_0 = \frac{1}{2\pi\sqrt{L_r C_r}}$$

Resonant inductor

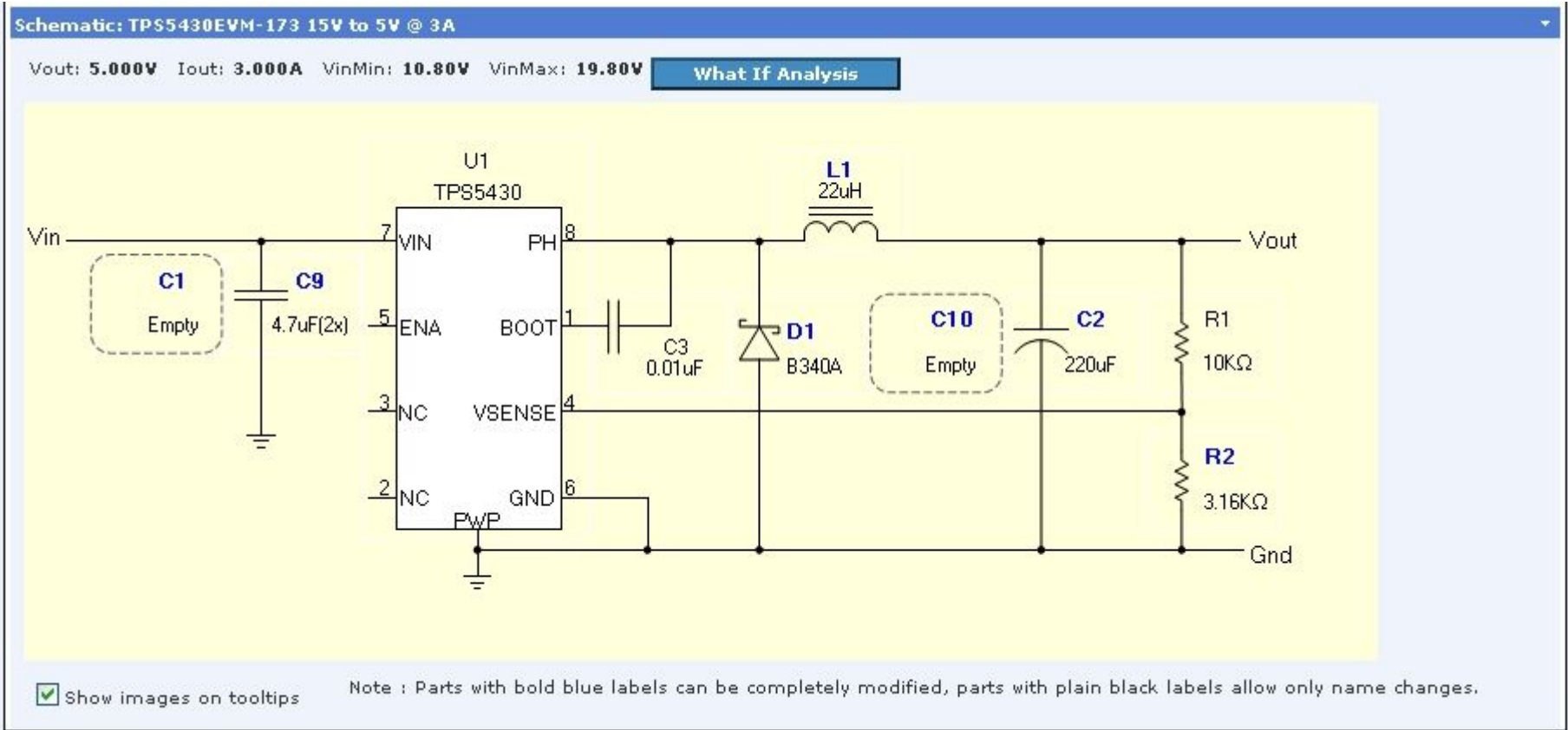
$$L_r = \frac{L_m}{L_n}$$

Choose cross section of required gain and constant L_m

Outline

- TI Power Management Focus
- TI System Power Supply Update (PFC, PWM, etc.)
- TI Design Tools

Switcher Pro Design Software



On-Line Beta Version Available at www.ti.com/analogelab

Power Quick Search Tool

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Keyword Go

Part Number Go

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- Enter Vin, Vout, Iout
- Tool Recommends products across all lines

Product Types

- AC/DC
- Batteries
- Hot Swapping
- Linear
- Plug-in
- Power Management Special Functions
- Supervisory Circuits (199)
- Non-Isolated Switching DC/DC Regulators
- Application Specific Multi-Output Solutions (4)
- Fusion Digital Power(TM) Control Solutions
- Lighting and Display Solutions
- References

Selection Guides

Power Management Selection Guide (slvt145d.pdf, 2 MB) Download

Quick Search

* Required

Input	Output 1	
*Nominal Vin (V)	Vout (V)	Iout (A)
<input type="text"/>	<input type="text"/>	<input type="text"/>

View Additional Criteria

Reset Search

Resources

SWIFT Designer Software

Design Step-Down DC/DC Circuits Quickly with SWIFT (Switcher with Integrated FET Technology) Designer Software

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Power Management

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Power Solutions for Your Processor of Choice

Choose Processor Type: Show All Types

Choose Processor Family: Select a Family

- TMS320DM355
- TMS320DM64x
- TMS320DM643x
- TMS320DM644x
- TMS320DM645x
- TMS320C6455
- TMS320F280x/F2601x
- TMS320F281x
- IMX31
- Spartan-3A / XC3S_A Series
- Spartan-3A DSP / XC3SD_A Series
- Spartan-3E / XC3S_E Series
- Spartan-3 / XC3S Series
- Virtex-5 / XC5VLX Series
- Virtex-5 / XC5VLXT Series
- Virtex-5 / XC5V5XT Series
- Virtex-4 / XC4VLX Series
- Virtex-4 / XC4VFX Series
- Virtex-4 / XC4V5X Series
- MAX II: EPM series
- Cyclone II: EP2C series
- Stratix II: EP2S series

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Many Processors Supported

Specific Details Provided

Download Reference Designs

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Power Management

Cross Reference Application Notes Training Tools & Software Block Diagram

TMS320DM643x

Back to Processor/Family Selector Tool

TMS320DM643x Power Requirements

	Pin Name	Voltage (V)	I _{max} (mA)	Voltage Tolerance	Sequencing Order	Timing Delay
Vcore	CYDD, VDDA_LP3V	1.2*	1400	±5%	3	All supplies must be stable within 200ns after power begins.
I/O	DVDD33	3.3	40	±1%	1	
I/O	DVDDRE, DCR_VDDOEL, PLL0PW25, VDDA_1P3V, MVDD	1.8	140	±5%	2	

*Note: 1.2V CYDD for CPU frequencies > 400MHz. 1.05V CYDD is only supported on v6 device running at 150MHz & 400 MHz.

Resources for TMS320DM643x

- TMS320DM643x DSGs
- DSP Starter Kit (DAK) Technical Reference & Schematic (TUMDM6437_TechRef.pdf, 1.39 MB) Download
- TMS320DM643x Power Consumption Summary (sprs44.pdf, 154 KB) Apr 2006 Download
- TMS320DM643x Spec: Card (sprM12.pdf, 156 KB) Download
- Power Spreadsheet (sprs46-zh, 399 KB) Download

TMS320DM643x Reference Designs

Name	Download	Date
5 V _{IN} Input		
5 V _{IN} solution with 1.2 V Core	Download (slvr202.pdf, 197 KB)	10 Jan 02
5 V _{IN} solution using a single PPU to provide 900 mA	Download (slvr382.pdf, 93 KB)	02 Feb 02

Find power requirements and reference designs at www.ti.com/processorpower

TI Power Management Service and Support

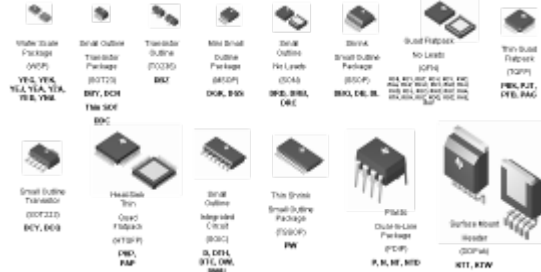
Qualification Reports and Documentation on Request

Part Number	Package	Temperature Range	Operating Voltage	Operating Current	Operating Power	Operating Efficiency	Operating Frequency	Operating Duty Cycle	Operating Load Regulation	Operating Line Regulation	Operating Load Regulation	Operating Line Regulation	Operating Load Regulation	Operating Line Regulation	Operating Load Regulation	Operating Line Regulation	Operating Load Regulation	Operating Line Regulation	Operating Load Regulation	Operating Line Regulation
TP5430	SOIC-8	-40 to 125	5.0	0.3	1.5	95%	100 kHz	50%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%
TP5430	SOIC-8	-40 to 125	5.0	0.3	1.5	95%	100 kHz	50%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	
TP5430	SOIC-8	-40 to 125	5.0	0.3	1.5	95%	100 kHz	50%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	
TP5430	SOIC-8	-40 to 125	5.0	0.3	1.5	95%	100 kHz	50%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	
TP5430	SOIC-8	-40 to 125	5.0	0.3	1.5	95%	100 kHz	50%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	±0.1%	

Free Samples and EVMs



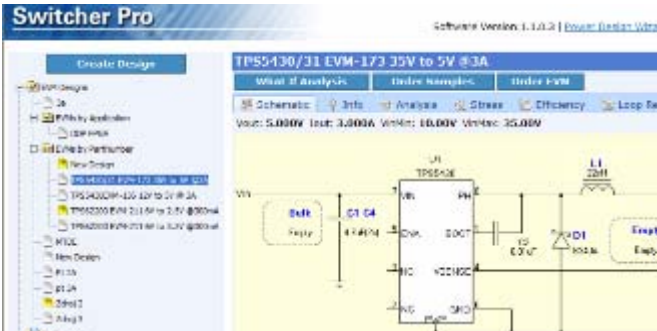
Broad Power Portfolio



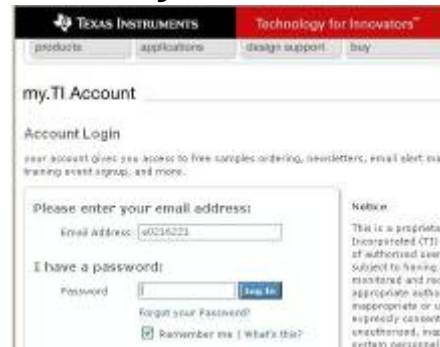
Wide Sales Network



Software Tools

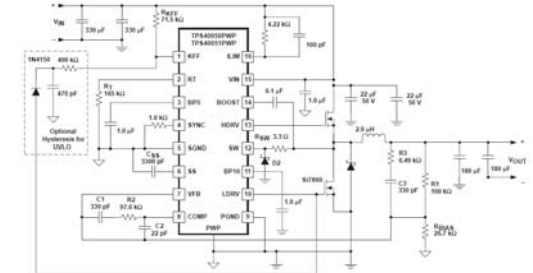


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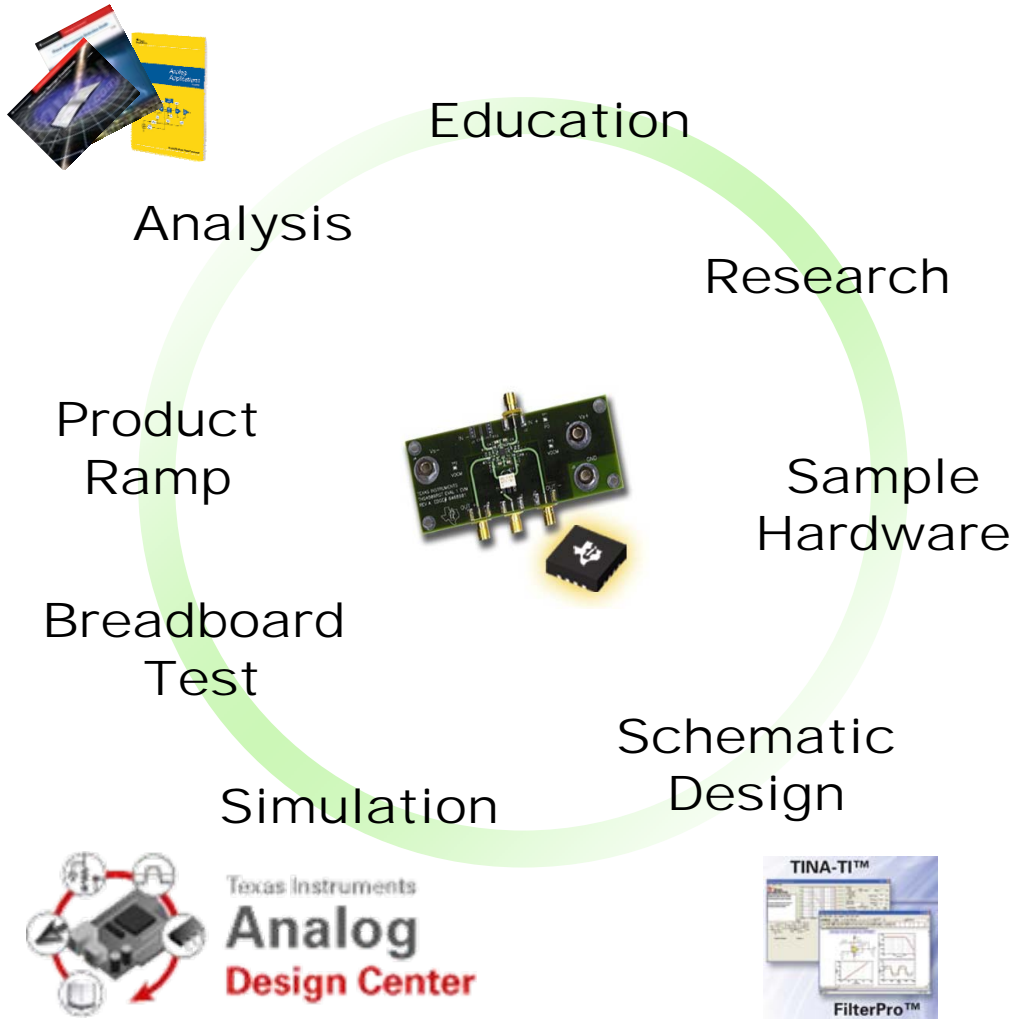


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