Power & Analog program

European Multi System Market Competence Center

POWER CONVERSION - agenda

- Power conversion
  - **SMPS**
    - Main topologies quick roundup
    - Power Factor Correction
    - PWM (offline & HV DCDC)
    - Low Voltage DC-DC Converters
  - Lighting
    - Fluorescent ballast
      - Analog driven
      - Digital driven / advanced
    - HID
    - LED / DISPLAY DRIVER
      - DC / DC driven
      - Offline driven
      - Display control

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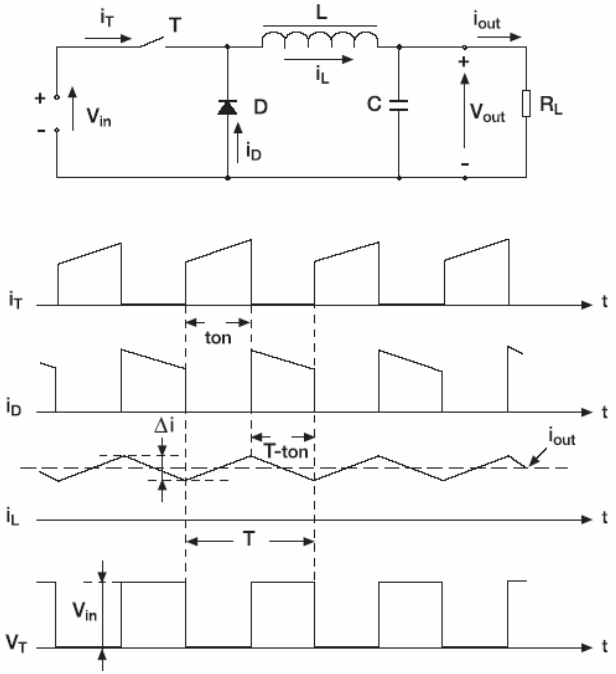
NOT isolated topologies

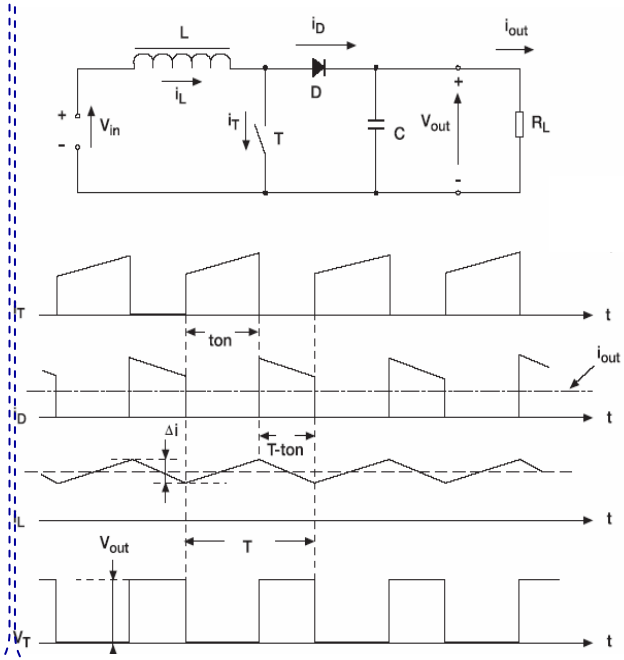
BUCK (STEP-DOWN)

$V_{OUT} = V_{IN} \times D$



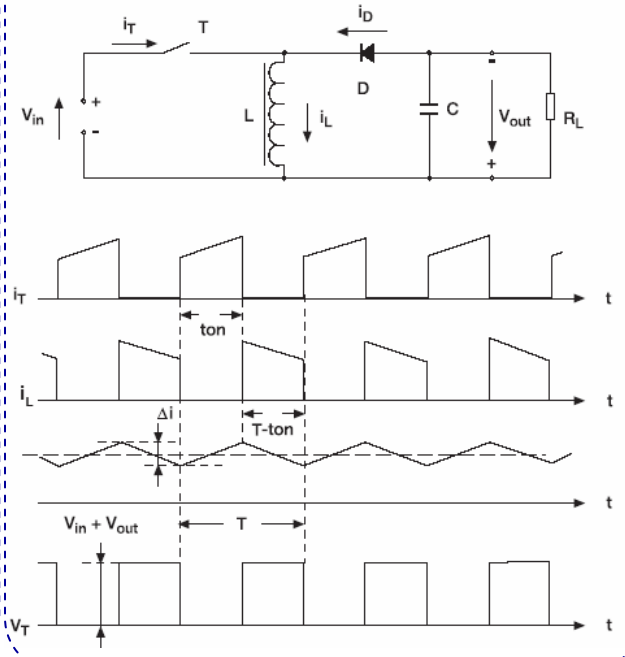
BOOST (STEP-UP)

$V_{OUT} = V_{IN} / (1-D)$



BUCK / BOOST

$V_{OUT} = - V_{IN} \times D / (1-D)$

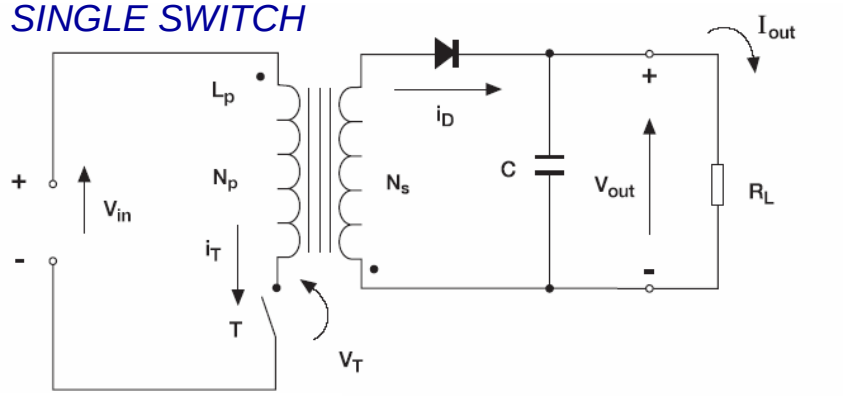


Isolated topologies

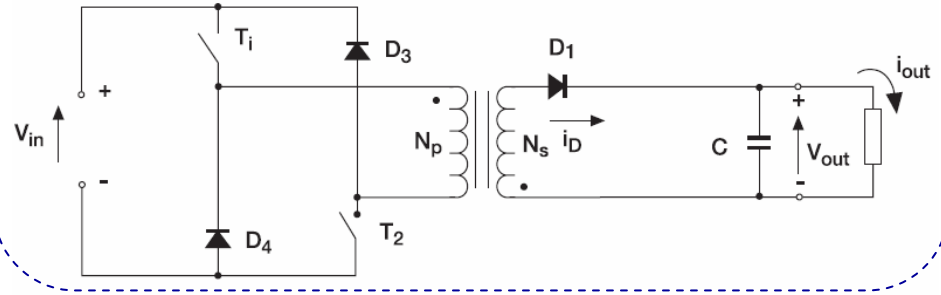
FLYBACK

$V_{OUT} = V_{IN} \times D / (N \times (1-D))$

SINGLE SWITCH



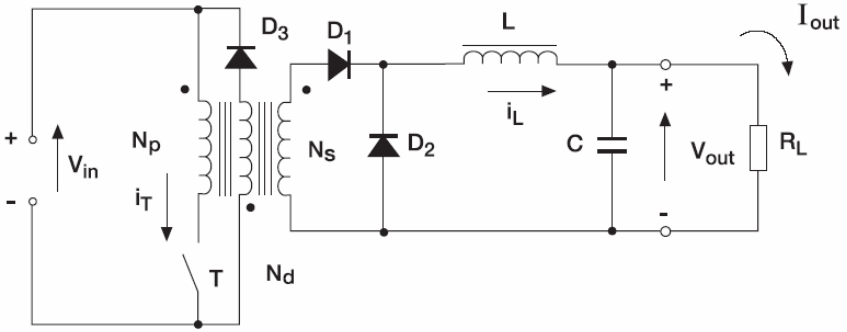
DOUBLE SWITCH



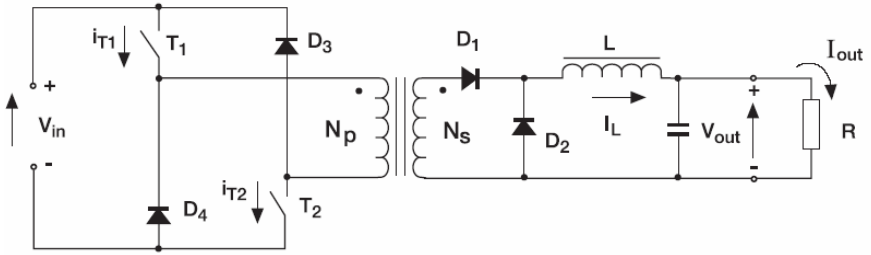
FORWARD

$V_{OUT} = V_{IN} \times D \times N$

SINGLE SWITCH



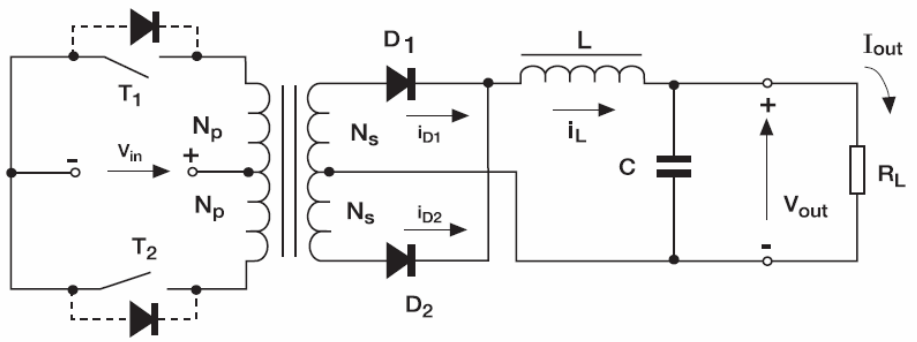
DOUBLE SWITCH (asymmetrical half-bridge)



Isolated topologies

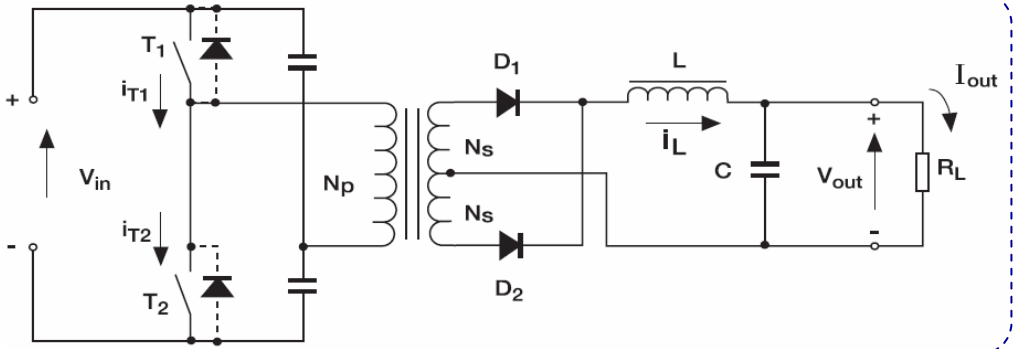
PUSH-PULL

$V_{OUT} = 2 \times V_{IN} \times D / N$



HALF-BRIDGE

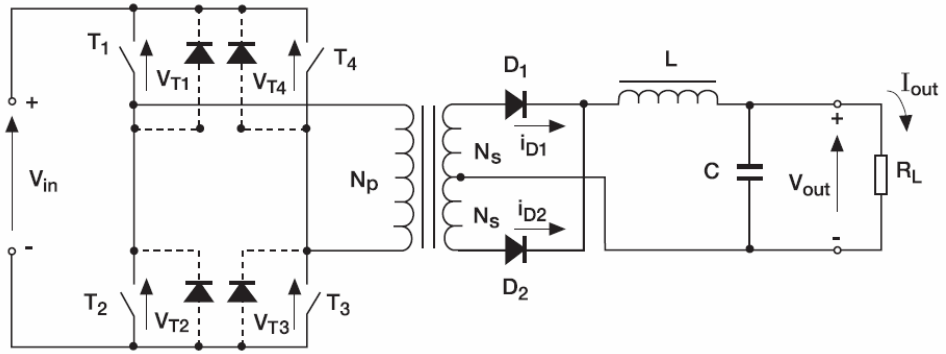
$V_{OUT} = V_{IN} \times D / N$

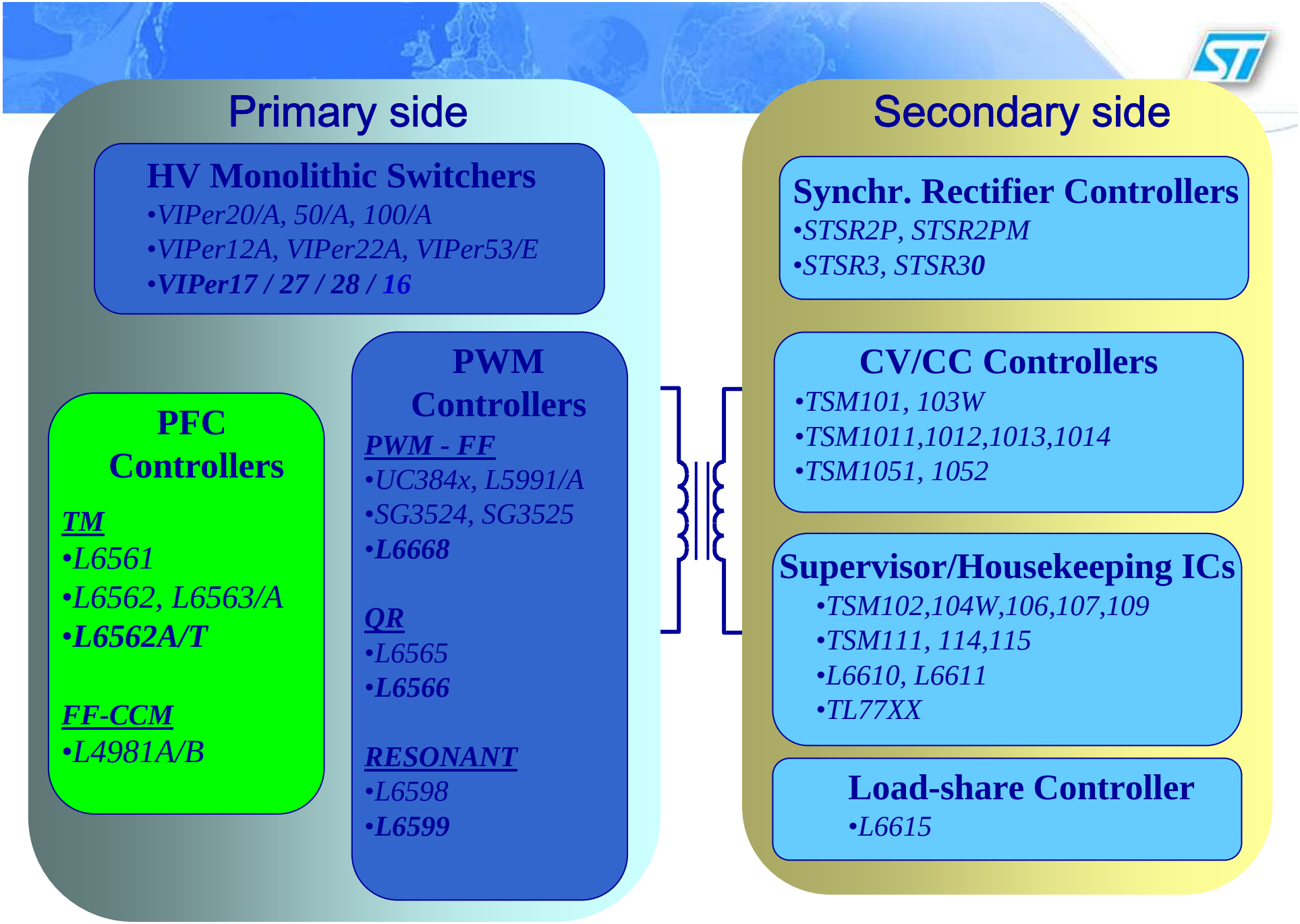


FULL-BRIDGE

$V_{OUT} = 2 \times V_{IN} \times D / N$

Because of the number of components, the full bridge is for high power applications, ranging from 500 up to 2000W.




Primary side
HV Monolithic Switchers
•VIPer20/A, 50/A, 100/A
•VIPer12A, VIPer22A, VIPer53/E
•VIPer17 / 27 / 28 / 16
PFC Controllers
TM
•L6561
•L6562, L6563/A
•L6562A/T
FF-CCM
•L4981A/B
PWM Controllers
PWM - FF
•UC384x, L5991/A
•SG3524, SG3525
•L6668
QR
•L6565
•L6566
RESONANT
•L6598
•L6599
Secondary side
Synchr. Rectifier Controllers
•STSR2P, STSR2PM
•STSR3, STSR30
CV/CC Controllers
•TSM101, 103W
•TSM1011,1012,1013,1014
•TSM1051, 1052
Supervisor/Housekeeping ICs
•TSM102,104W,106,107,109
•TSM111, 114,115
•L6610, L6611
•TL77XX
Load-share Controller
•L6615

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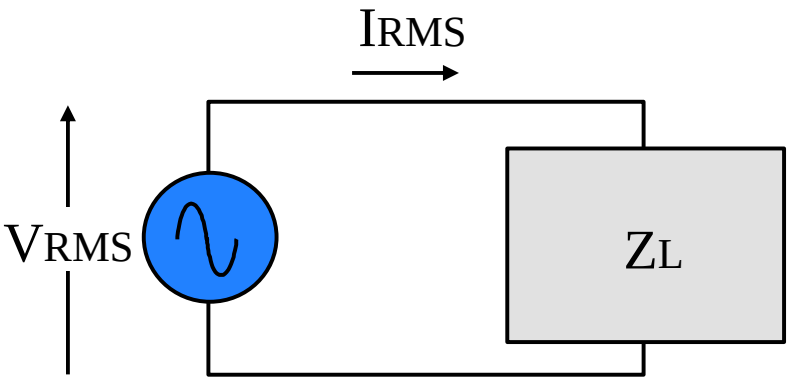
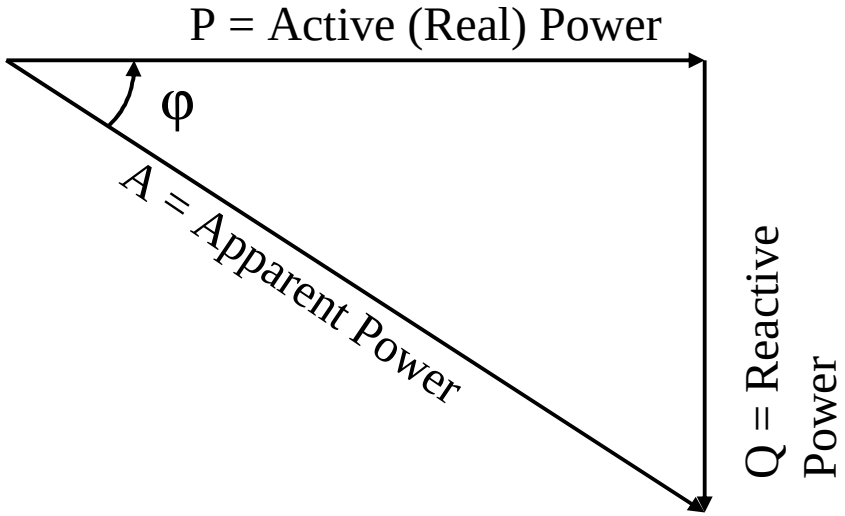
- **Power Factor (PF) Concept**
  - Theorethical meaning and practical aspects
- **Power Factor Correction (PFC)**
  - Regulations and economical considerations
  - General PFC characteristics and impact on SMPS' performance
  - Topologies and control methods
  - PFC, application examples and design issues

PF Definition Sinusoidal Current

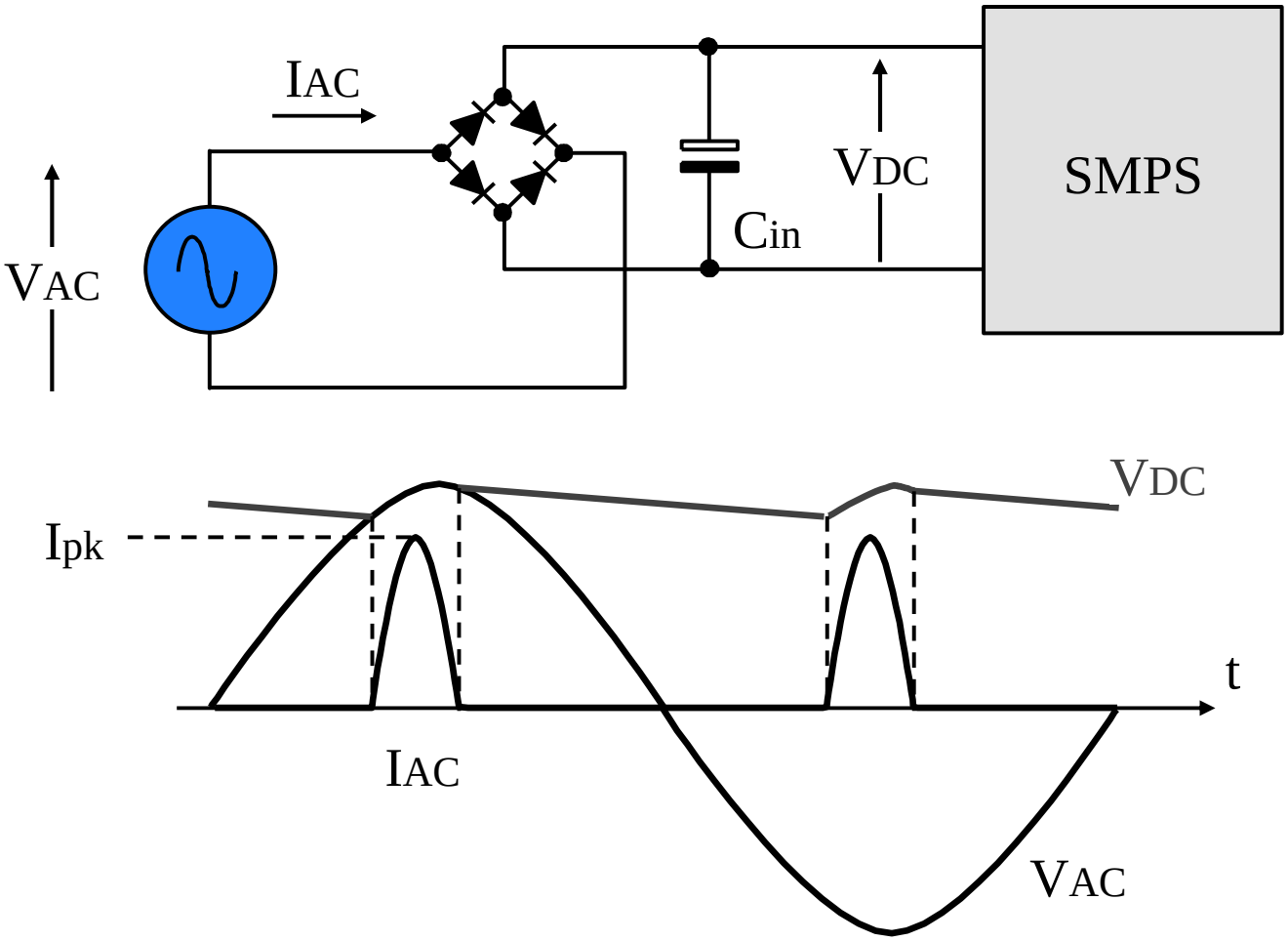
$$P = V_{RMS} \cdot I_{RMS} \cdot \cos\varphi = Re\,[A]$$
$$Q = V_{RMS} \cdot I_{RMS} \cdot \sin\varphi = Im\,[A]$$
$$|A| = V_{RMS} \cdot I_{RMS} = \sqrt{P^2 + Q^2}$$
$$\varphi = \arg(Z_L)$$





$$\mathbf{PF = \frac{P}{|A|} = \cos\varphi}$$

Line Current Distorsion at an SMPS Input



PF Definition Non-Sinusoidal Current

$$I_{RMS} = \sqrt{I_{RMS1}^2 + \sum_{n=2}^{\infty} I_{RMSn}^2}$$

$$\varphi 1 = \angle I_{RMS1} \quad ; \quad \cos\theta = \frac{I_{RMS1}}{I_{RMS}}$$

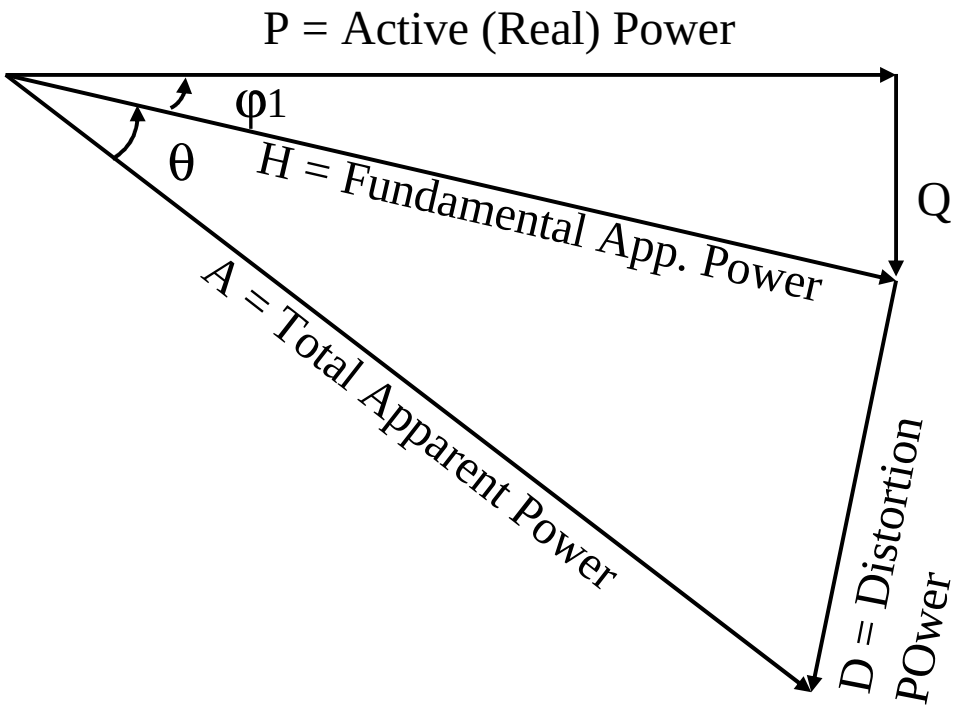
$$P = V_{RMS} \cdot I_{RMS1} \cdot \cos\varphi 1$$

$$Q = V_{RMS} \cdot I_{RMS1} \cdot \sin\varphi 1$$

$$D = V_{RMS} \cdot \sqrt{\sum_{n=2}^{\infty} I_{RMSn}^2}$$

$$|H| = V_{RMS} \cdot I_{RMS1} = \sqrt{P^2 + Q^2}$$

$$|A| = V_{RMS} \cdot I_{RMS} = \sqrt{H^2 + D^2}$$



$$\mathbf{PF} = \frac{\mathbf{P}}{|\mathbf{A}|} = \mathbf{\cos\varphi \cdot \cos\theta}$$

$$\mathbf{THD} = \frac{\sqrt{\sum_{n=2}^{\infty} I_{RMSn}^2}}{\mathbf{I_{RMS1}}}$$

- **FOR POWER DISTRIBUTION COMPANY**
  - Better efficiency in energy transportation and distribution networks
  - Cables cross-section may be reduced
  - Transformers' size reduction
  - Reduction of disturbances on the line

- **FOR USERS**
  - More total power available
  - More power available on each outlet

- **COMPLIANCE WITH REGULATIONS**
  - EN 61000-3-2 regulation is mandatory from year 2001 for input power > 75W
- **ECONOMICAL CONSIDERATIONS**
  - PFC causes additional costs, partly compensated by a cost reduction of the downstream converter

EN61000-3-2 Regulation

- **Concerns harmonic current emission limits for equipment having an input current >16A per phase**

- **Equipment is divided up in 4 classes:**
  - A: Balanced three-phase equipment and that not included in the other classes
  - B: Portable equipment
  - C: Lighting equipment
  - D: Equipment with special input current waveshape and input active power > 600W.

- **No limitation is imposed on equipment with input active power <75W.**

Limits for Class A, B & C Equipment

Class A

Harmonic order "n"	Max. harmonic current A
Odd harmonics	
3	2.30
5	1.14
7	0.77
9	0.40
11	0.33
13	0.21
15≤n≤39	0.15 · 15 / n
Even harmonics	
2	1.08
4	0.43
6	0.30
8≤n≤40	0.23 · 8 / n

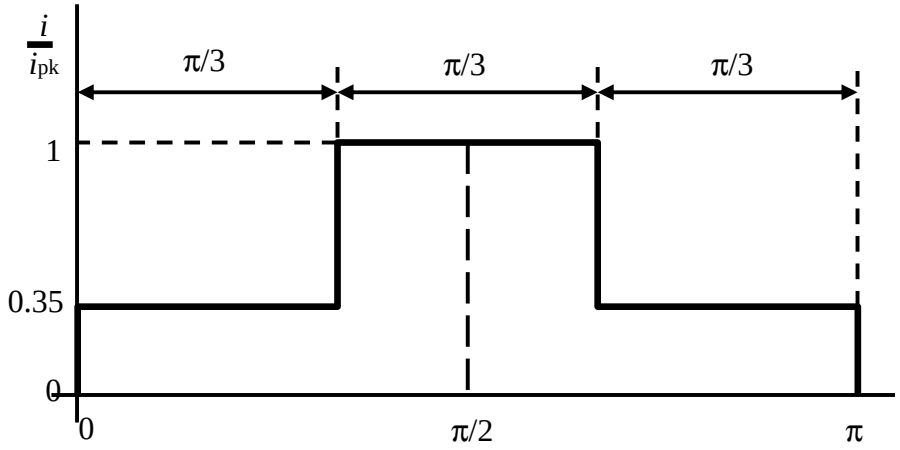
Class B

Harmonic order "n"	Max. harmonic current A
Odd harmonics	
3	3.45
5	1.71
7	1.16
9	0.60
11	0.50
13	0.32
15≤n≤39	0.23 · 15 / n
Even harmonics	
2	1.62
4	0.65
6	0.45
8≤n≤40	0.35 · 8 / n

Class C

Harmonic order n	Max. harmonic current (% of fundamental)
2	2
3	30 · PF
5	10
7	7
9	5
11≤n≤39	3

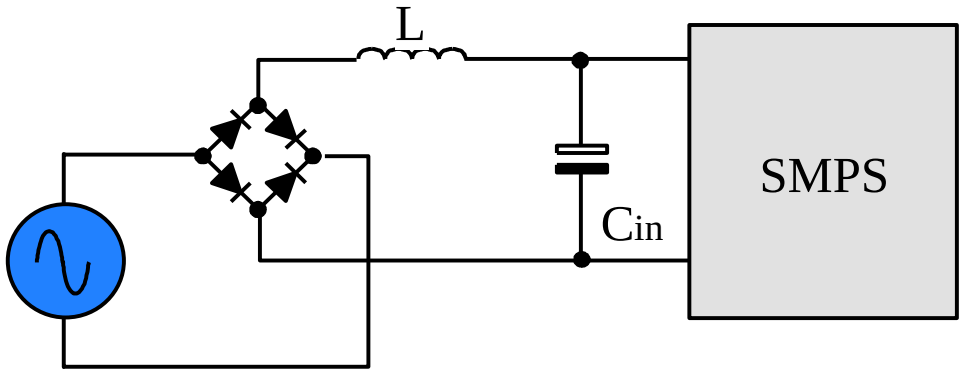
Limits for Class D Equipment



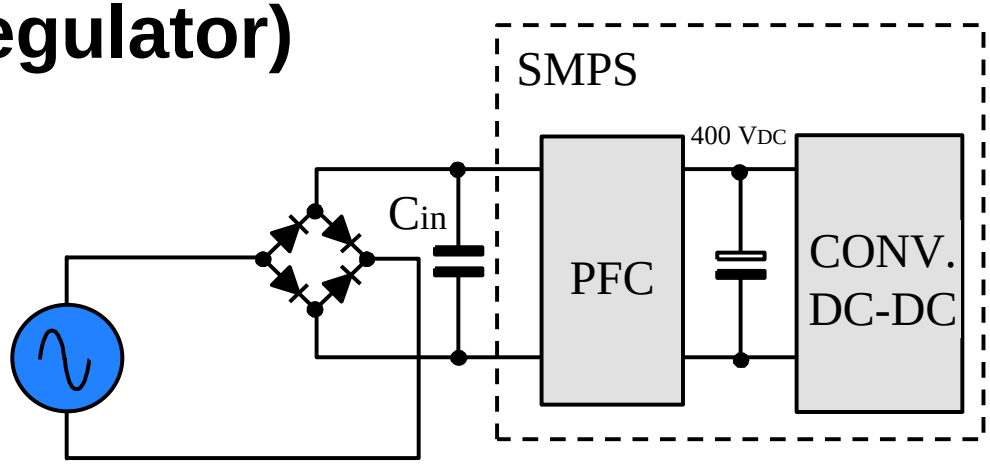
Class D

Harmonic order n	Max. harmonic current per Watt (mA/W)	Max. harmonic current A
3	3.4	2.30
5	1.9	1.14
7	1.0	0.77
9	0.5	0.40
11	0.35	0.33
13≤n≤39 (odd harm. only)	3.85 / n	see class A

- **Passive PFC**
  - Pros
    - Simple and reliable
  - Cons
    - PF@0.7-0.8, THD still high
    - large L, big chokes

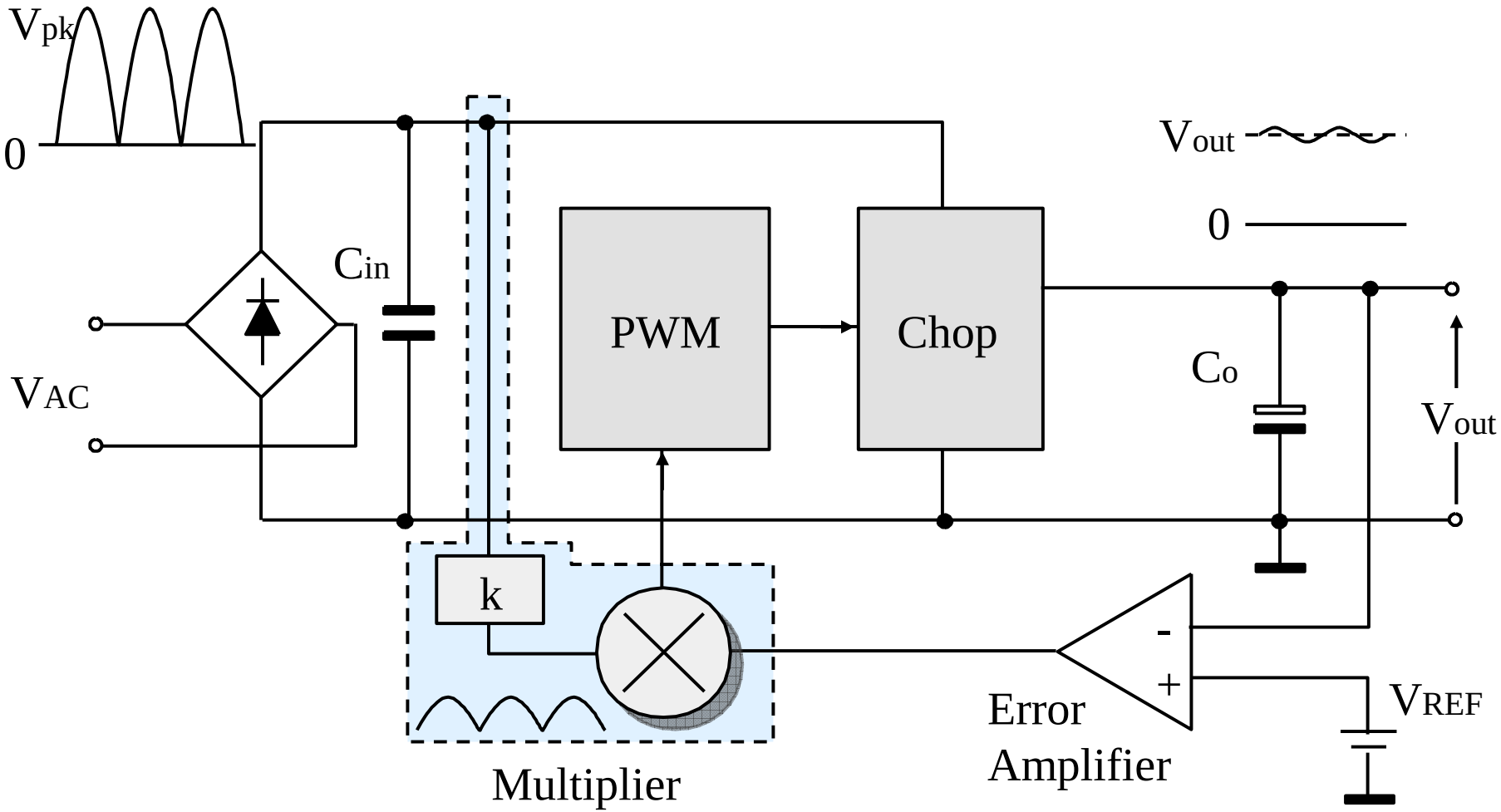


- **Active PFC (PFC Preregulator)**
  - Pros
    - PF=0.999, THD<3%
    - Wide-range Mains
    - SMPS optimization
  - Cons
    - Complexity and cost



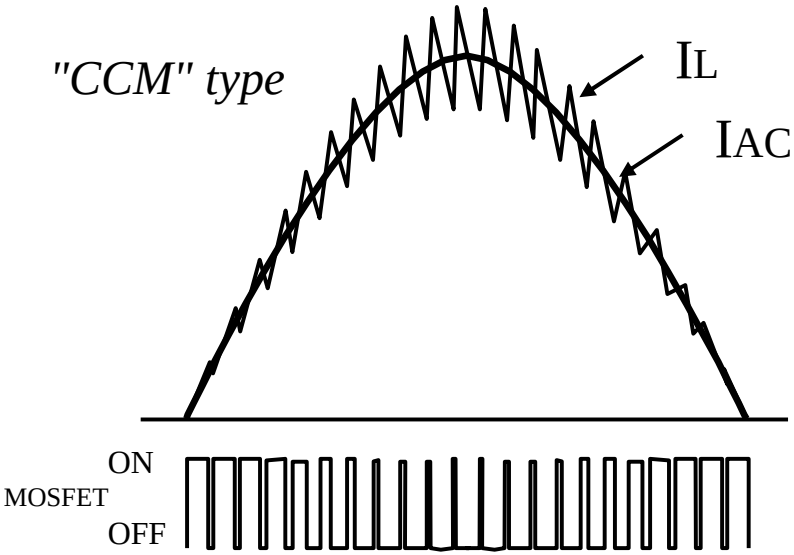
- **EMI filter**
  - might need reinforcing
- **Bridge rectifier**
  - Diode current rating reduction or heatsink size reduction
- **On the downstream converter**
  - Converter's input bulk capacitor (= PFC output) reduced at 1/4
  - Power switch size reduction (RDS(on) can be 1/4), or heatsink size reduction
  - Transformer's size reduction and optimization (it is operated with low current and a nearly constant primary voltage)
  - Greater efficiency
  - Control loop dynamics not used to compensate input voltage changes, entirely available to control load changes

PFC Block Diagram

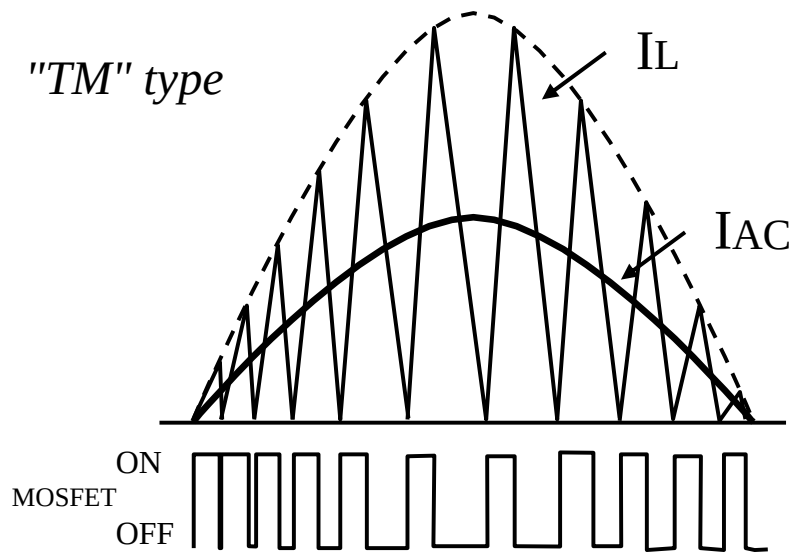


- **Boost topology**
- **Wide-range mains operation (88 to 264 VAC)**
- **400 V output voltage (in general, > Vpk)**
- **Small input cap**
  - larger values cause input voltage waveform distortion and hurt PF
  - higher EMI level
- **Current mode control**
  - 2-loop control
- **Narrow bandwidth voltage loop (typ. 20 Hz)**
  - 100/120 Hz output ripple
  - Poor dynamic response
    - Input overcurrent and output overvoltage protections needed

PFC Control Methods



- Fixed frequency, duty cycle modulation
- Continuous conduction mode: I_L never falls to zero.
- Average current mode control, complexity, high performance, higher cost.
- Suitable for higher power levels (>300W) approximately



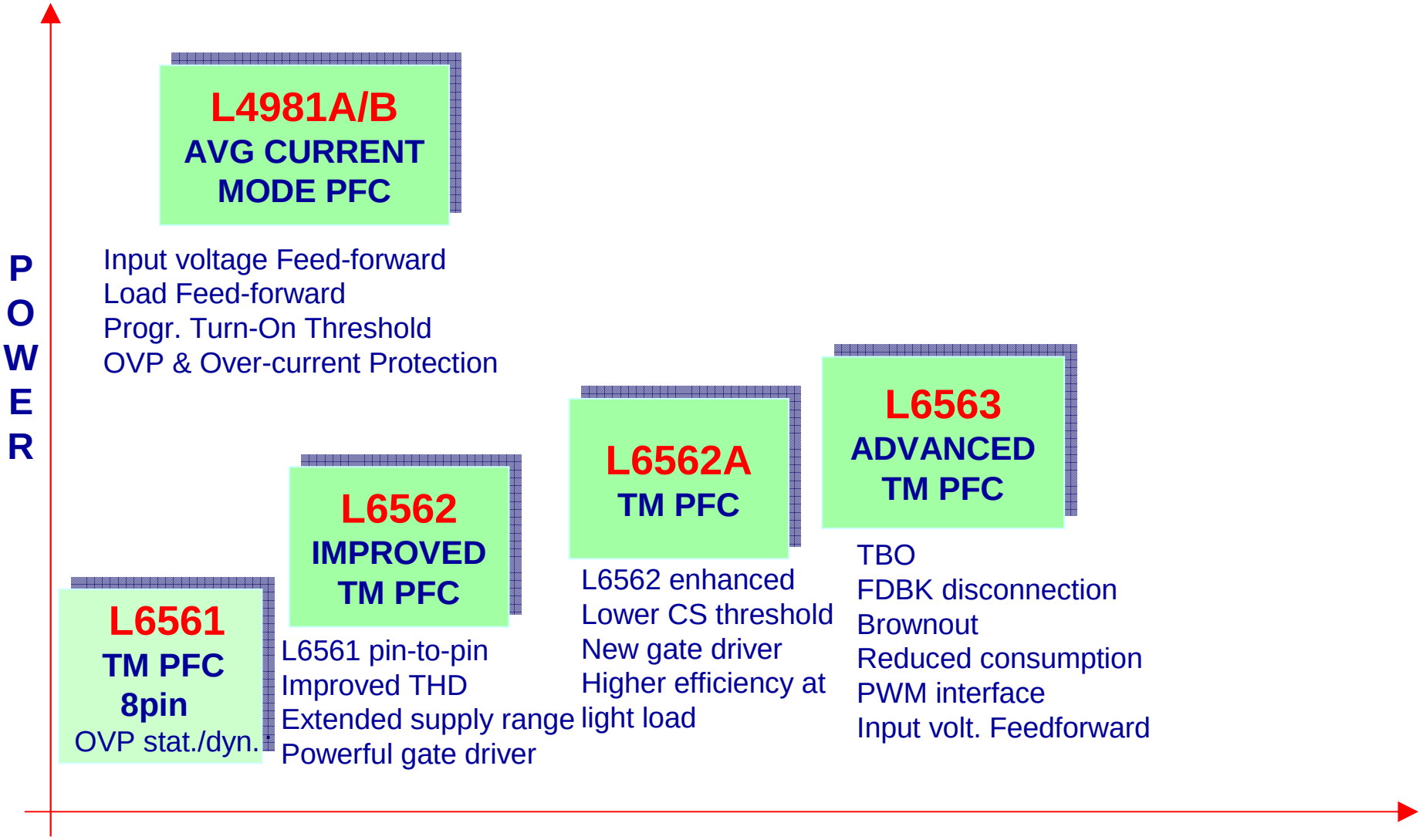
- Variable switching frequency, constant T_{ON}
- Operation on the boundary between continuous and discontinuous conduction mode, @ZVS
- Peak current mode control, simple, low-cost.
- Suitable for lower power levels (<300W) approximately

FF-CCM or TM Type : which should I use ?

	FF-CCM	TM
EMI Filter	It must filter a current ripple usually equal to 20-40% of the line current	It must filter a current ripple as high as twice the line current
Boost Inductor	Inductance is usually higher, saturation current is lower, core and copper losses are lower	Inductance is usually lower, saturation current is higher, core and copper losses are higher; litz or multi-strand wire
MOSFET	Lower conduction losses (better current form-factor), high capacitive and switching losses. Additional losses due to boost diode reverse-recovery	Higher conduction losses (worse current form-factor), capacitive and switching losses significant at high line only (when ZVS at turn-on is lost)
Diode	Reverse-recovery characteristics are critical: additional losses in itself and in the MOSFET, higher EMI. Higher V_F and conduction losses	Reverse-recovery not invoked: no additional losses and lower EMI. Lower V_F and conduction losses.
Control	Average current-mode: more complex, higher part count, expensive control IC	Peak current-mode: simpler, lower part count, cheap control IC

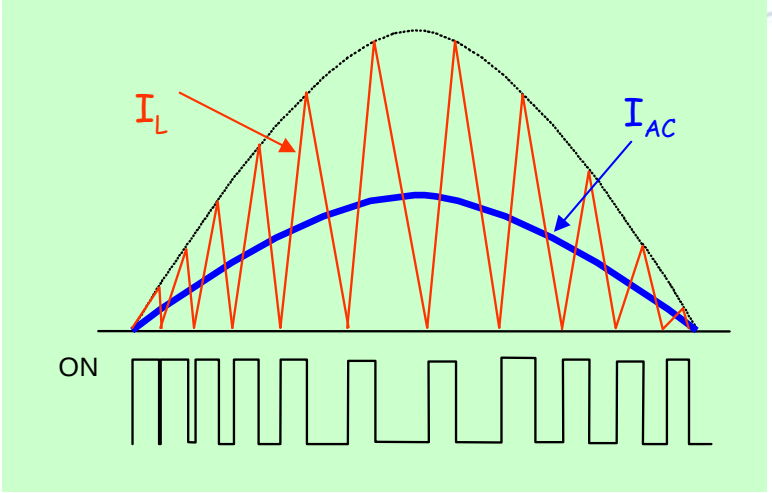
☞CONCLUSION: for Pout<100W definitely TM, for Pout>500W FF-CCM; careful (and complex!) trade-off required for intermediate levels

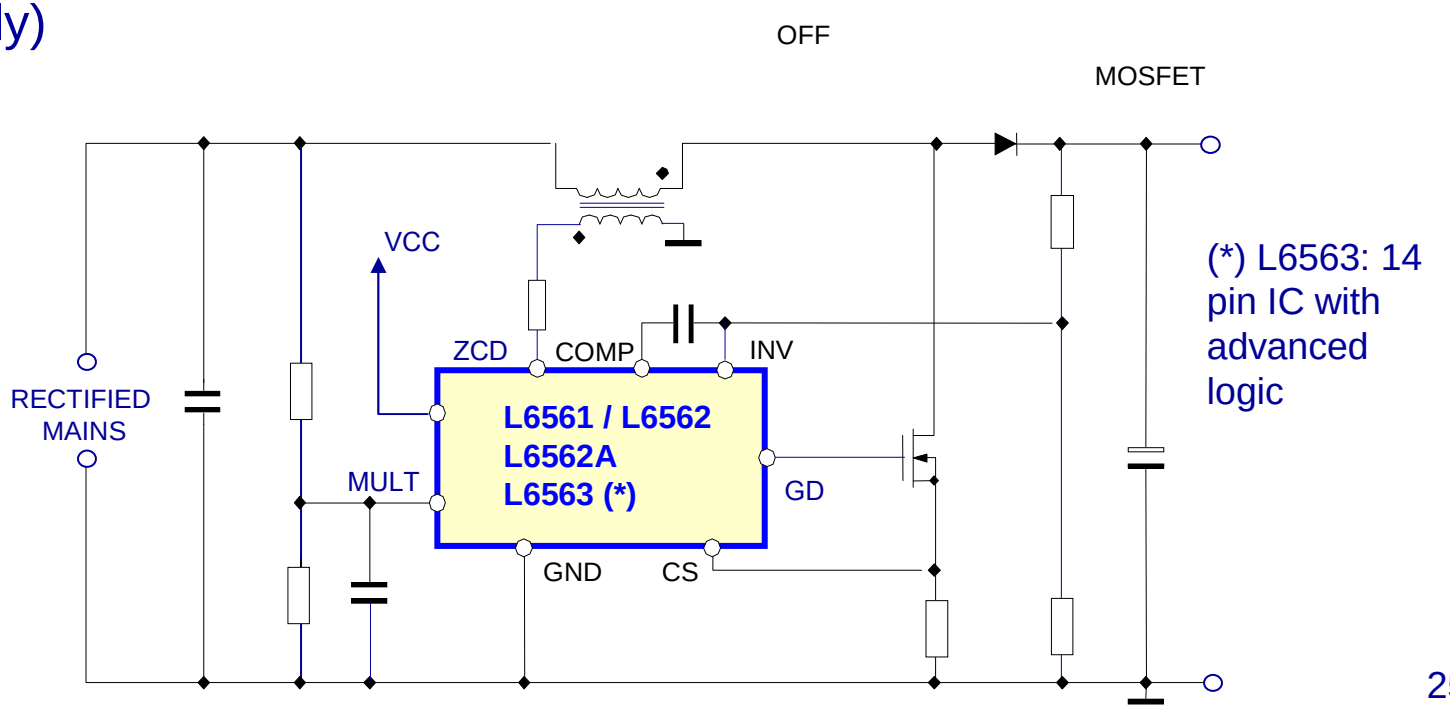
STM PFC Roadmap



PFC: transition mode (TM) control

- Variable switching frequency, constant TON
- Operation close to the boundary between continous and discontinuous conduction mode, @ZVS
- Peak current mode control, simple, low-cost.
- Suitable for lower power levels (< @150W approximately)

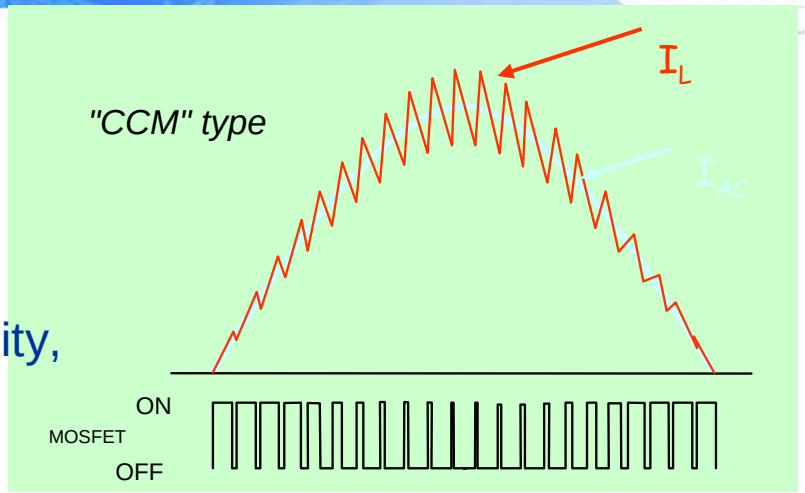


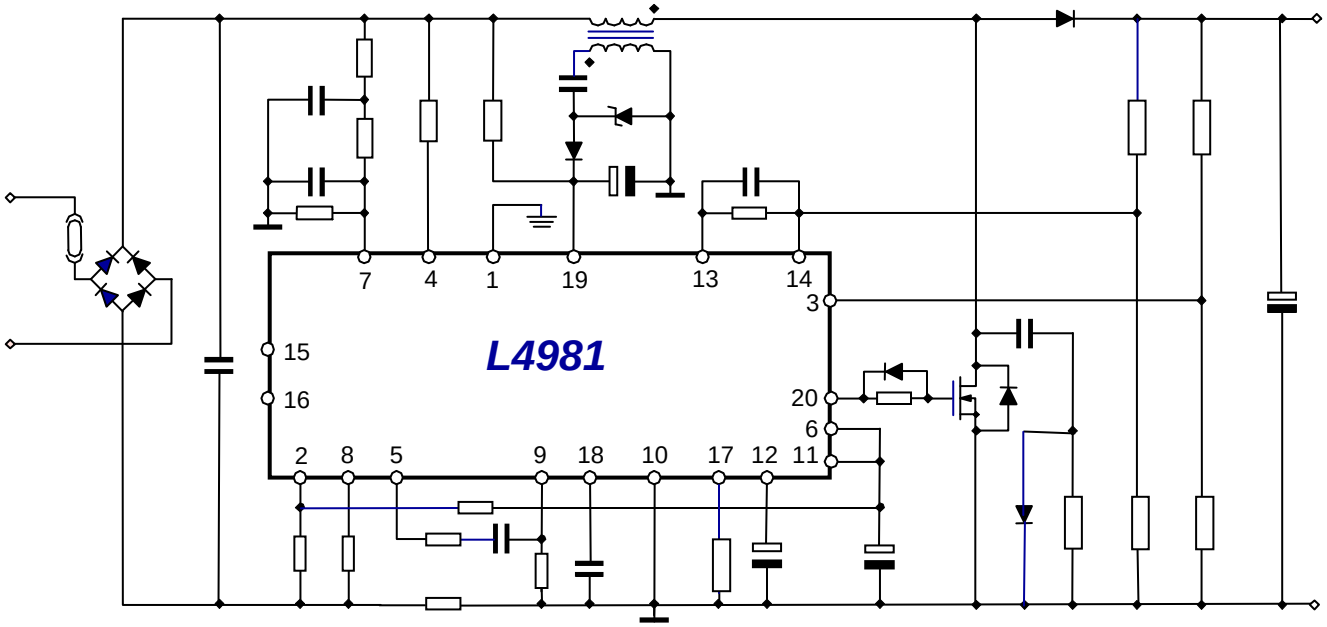


(*) L6563: 14 pin IC with advanced logic

PFC: continuos current mode (CCM) conti

- Fixed frequency, duty cycle modulation
- Continuous conduction mode: IL never falls to zero (except for close to zero-crossings)
- ΔIL/IAC ratio < 1 (typ. 0.2-0.4)
- Average current mode control, greater complexity, high performance, higher cost.
- Suitable for higher power levels (> 250W approximately)





PFC: fixed-off-time (FOT) control

TYPICAL QR CONTROL

TURN-OFF → PWM COMPARATOR (current peak)

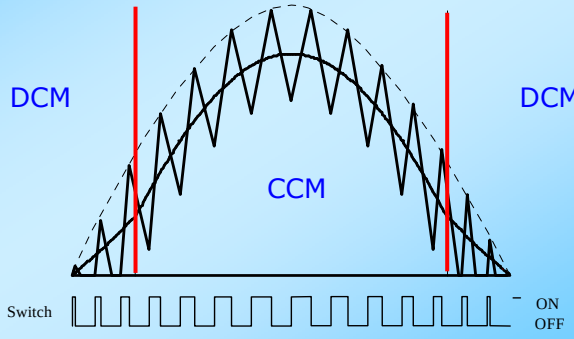
TURN-ON → INDUCTOR DEMAGNETIZATION (Aux. winding or RC on the drain)

TRANSITION MODE
(boundary between DCM and CCM)

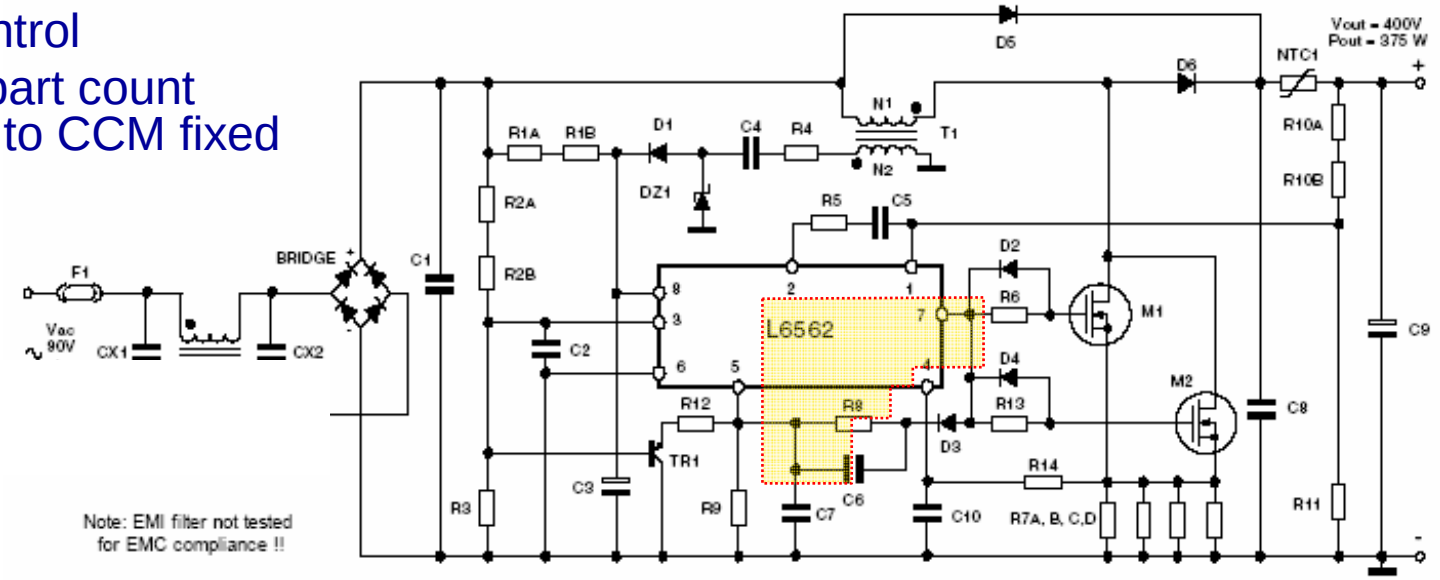
CONSTANT T_{OFF}

TURN-OFF → PWM COMPARATOR (current peak)

TURN-ON → **R-C NETWORK DISCHARGING**



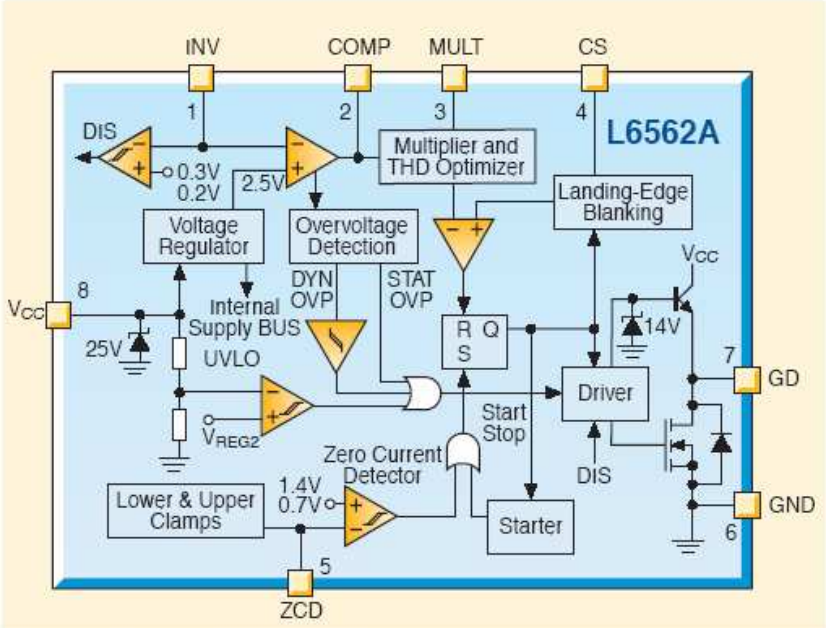
- **Benefits:**
  - 200-400W target
  - High efficiency (>92%)
  - Simple control
  - Reduced part count compared to CCM fixed frequency



L6562A

NEW

- **Proprietary multiplier design for minimum THD of AC input current**
- **Very low power losses current sense for improved system efficiency**
- **Variable switching frequency, constant TON**
- **-600/+800mA totem-pole gate driver with UVLO**
- **Disable function on Fb input**
- **Precise adjustable output overvoltage protection**

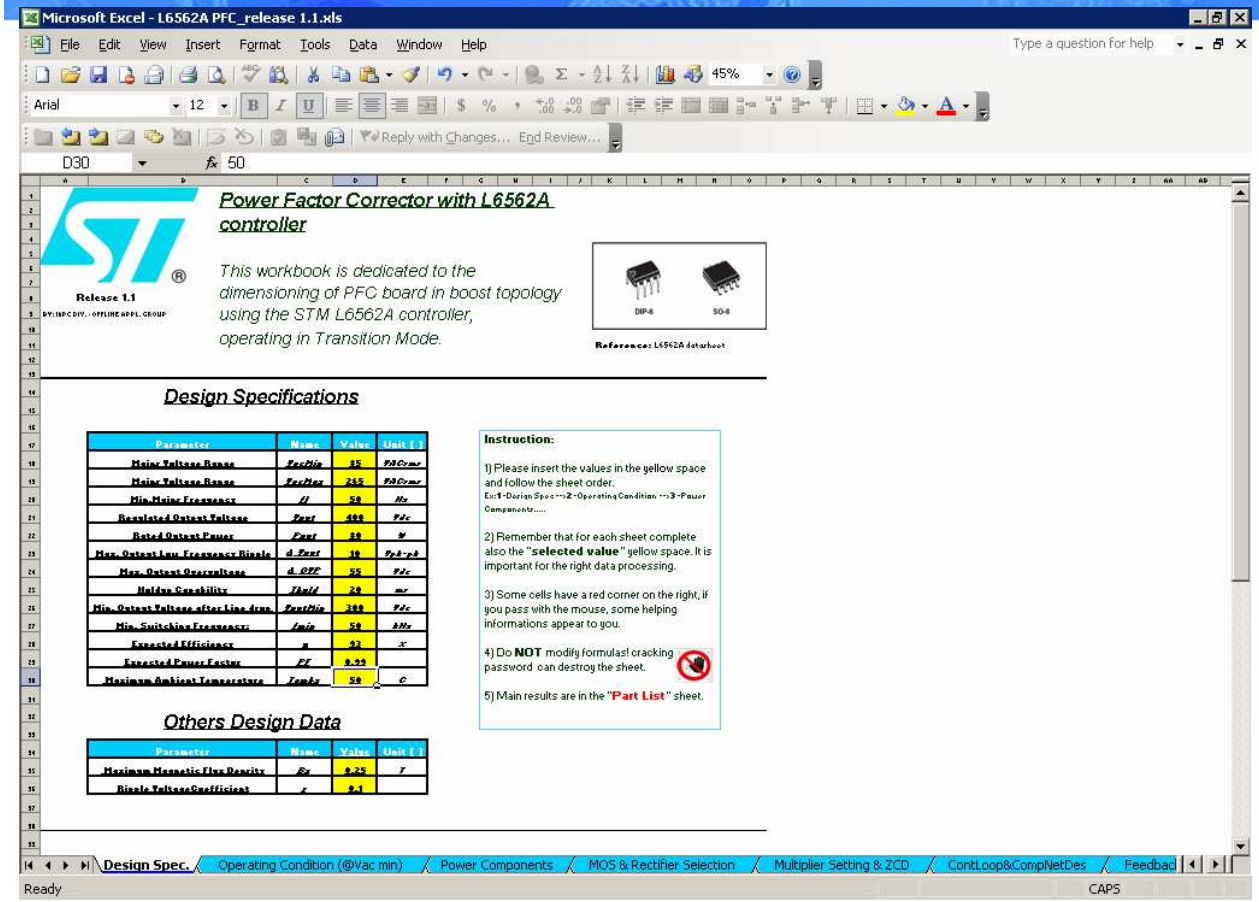


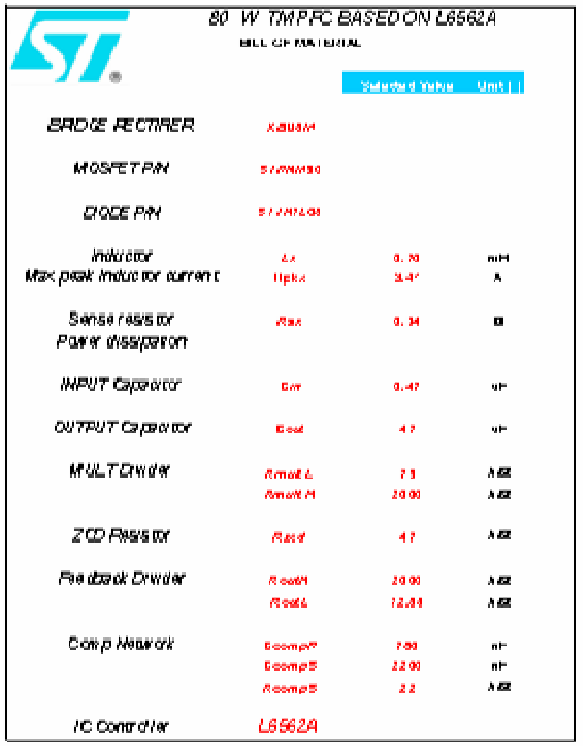
L6562A internal block diagram

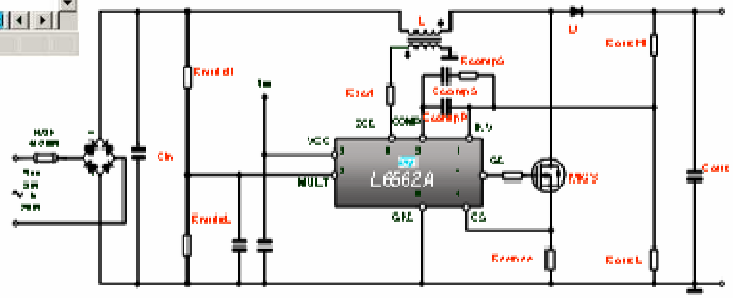
L6562A vs L6562

Parameter / Function	L6562	L6562A
Current sense dynamics (typ.)	1.7V	1.1V
Disable function by grounding FB input	No	Yes
IC operating consumption @ 70kHz (typ.)	3.5mA	3.0mA
Dynamic OVP trigger current (typ.)	40µA	27µA
Digital Blanking time on current sense	No	Yes
ZCD arm/trigger/clamp thresholds (typ.)	2.1/1.6/0.7V	1.4/0.7/0V
IC turn-on & turn-off thresholds (typ.)	12/9.5V	12.5/10V
Current sense propagation delay (typ.)	200ns	120ns
Turn-off threshold spread (max.)	±0.8V	±0.5V
Multiplier gain (typ.)	0.6	0.38

L6562A TM PFC Calculation Spreadsheet



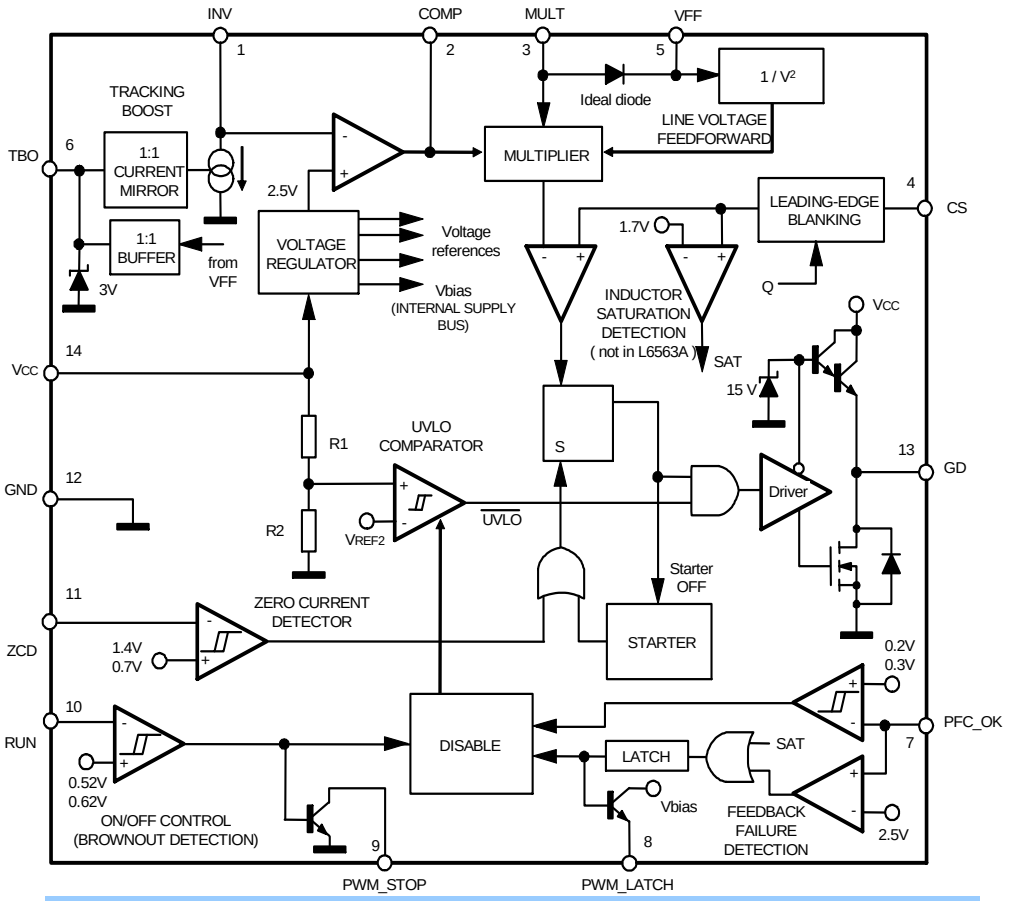




- SAMPLES: **AVAILABLE ON REQUEST**
- DATASHEETs: **AVAILABLE ON THE WEB**
  http://www.st.com/stonline/products/literature/ds/13198/l6562a.pdf
- APPLICATION NOTES:
  - AN2761 : Solution for designing a 80W TM PFC using the L6562A
    http://www.st.com/stonline/products/literature/anp/14690.pdf
  - AN2782 :Solution for designing a 400W FOT PFC using the L6562A
    http://www.st.com/stonline/products/literature/anp/14763.pdf
  - AN2755 : 400W FOT-controlled PFC pre-regulator with the L6562A
    http://www.st.com/stonline/products/literature/anp/14663.pdf
  - AN2711 : 15W Off Line TRIAC Dimmable LED Driver
    http://www.st.com/stonline/products/literature/anp/14425.pdf
- DEMO BOARDS:
  - EVL6562A-TM-80W (AVAILABLE)
    http://www.st.com/stonline/products/literature/bd/13799/evl6562a-tm-80w.pdf
  - EVL6562A-400W (AVAILABLE)
    http://www.st.com/stonline/products/literature/bd/14416.pdf
- SOFTWARE TOOLS:
  - DESIGNING A TM PFC USING THE L6562A (AVAILABLE UPON REQUEST)
    http://ims.st.com/ipc/off-line/controller/soft/l6562apfc_release%201.1.xls
  - DESIGNING A FOT PFC USING THE L6562A (AVAILABLE UPON REQUEST)
    http://ims.st.com/ipc/off-line/controller/soft/l6562a_fot_release%201.3.xls

L6563A

- ✓ Can manage output power in excess of 300W
- ✓ Input voltage Feed-forward
- ✓ Tracking-boost operation option
- ✓ AC Brownout Detection
- ✓ THD optimizer
- ✓ Power management interface with PWM section
- ✓ Feedback disconnection detection
- ✓ Protection against boost inductor saturation
- ✓ Internal 200ns LEB on Current Sense
- ✓ Low Start-up & Quiescent Current
- ✓ Package: SO-14



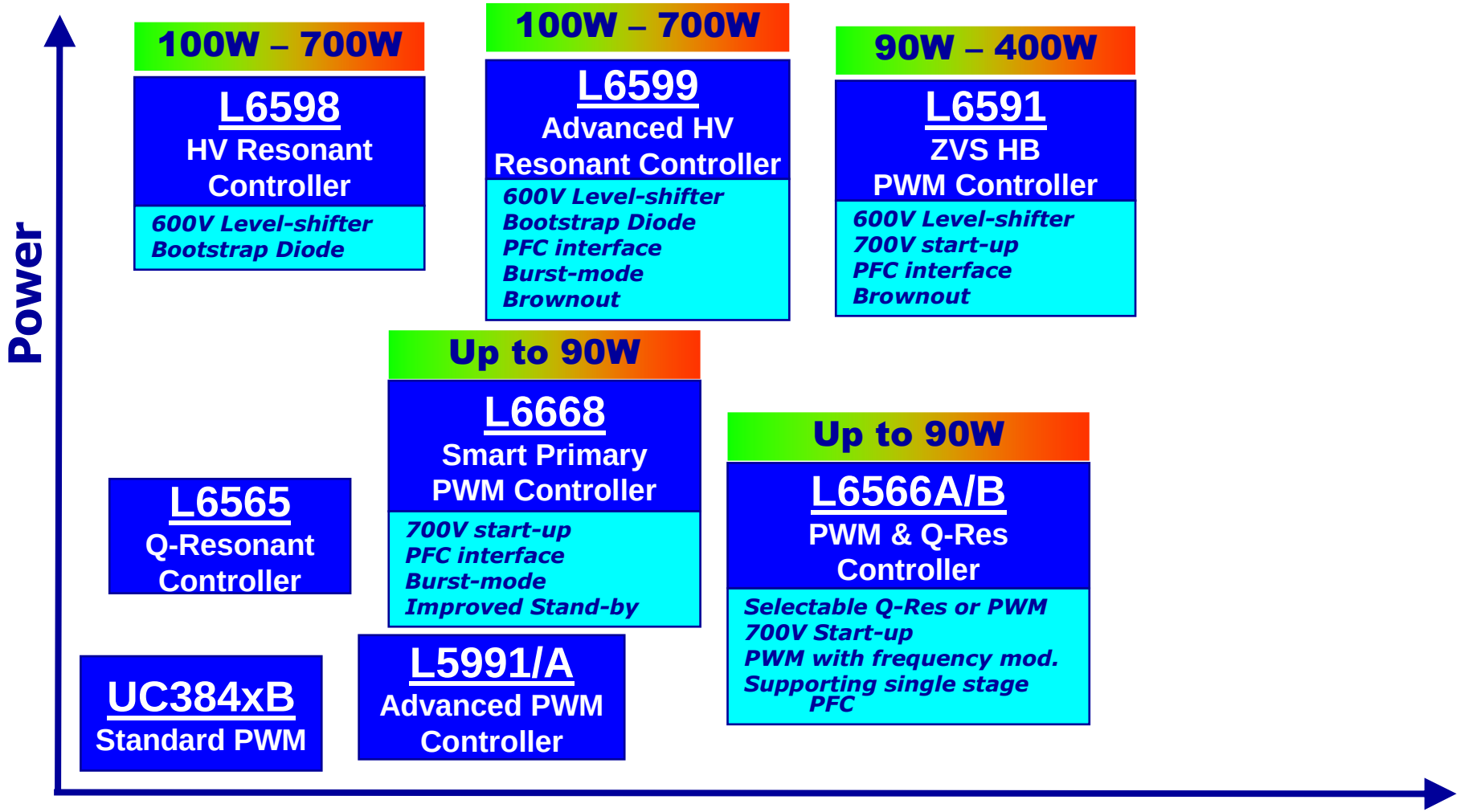
MAIN APPLICATIONS:

- **IEC61000-3-2 Compliant SMPS**
- **Hi-end AC-DC Adapter/Charger**
- **SMPS for Desktop PC's, Entry-level Servers**

POWER CONVERSION - agenda

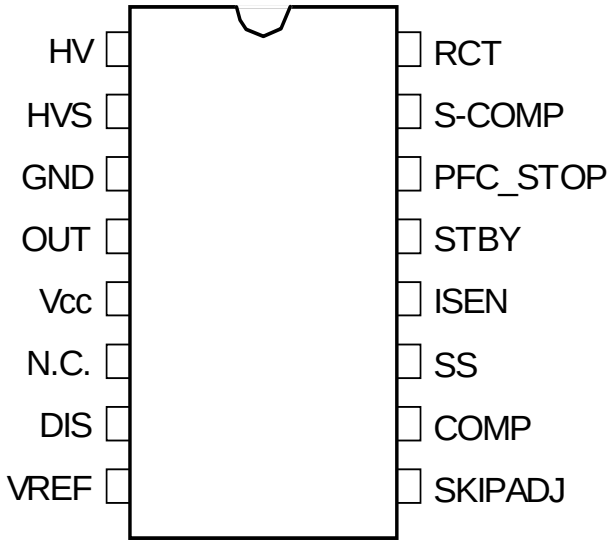
- Power conversion
  - **SMPS**
    - Main topologies quick roundup
    - Power Factor Correction
    - **PWM (offline & HV DCDC)**
    - Low Voltage DC-DC Converters
  - Lighting
    - Fluorescent ballast
      - Analog driven
      - Digital driven / advanced
    - HID
    - LED / DISPLAY DRIVER
      - DC / DC driven
      - Offline driven
      - Display control

STM PWM Roadmap



L6668 main features

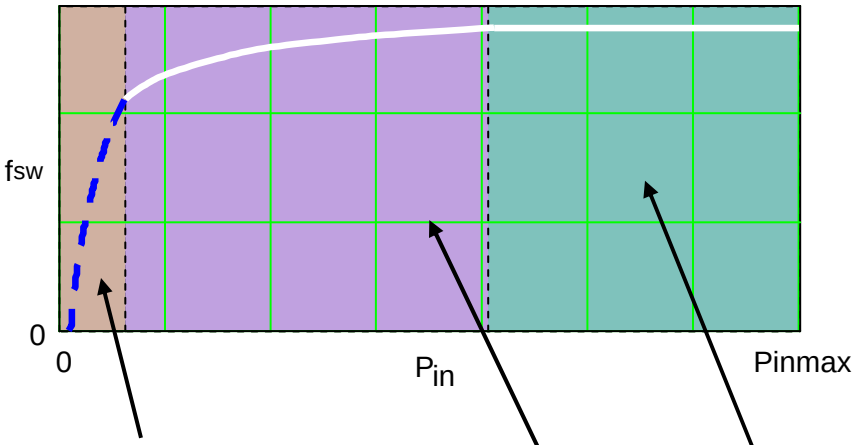
- ON-BOARD HIGH-VOLTAGE START-UP
- IMPROVED STANDBY FUNCTION
- LOW QUIESCENT CURRENT (< 2 mA)
- SLOPE COMPENSATION PIN
- PULSE-BY-PULSE & HICCUP-MODE OCP
- INTERFACE WITH PFC CONTROLLER
- DISABLE FUNCTION (ON/OFF CONTROL)
- LATCHED DISABLE FOR OVP/OTP FUNCTION
- PROGRAMMABLE SOFT-START
- 2% PRECISION REFERENCE VOLTAGE AVAILABLE
- ±800 mA TOTEM POLE GATE DRIVER WITH INTERNAL CLAMP AND UVLO PULL-DOWN
- SO16N PACKAGE

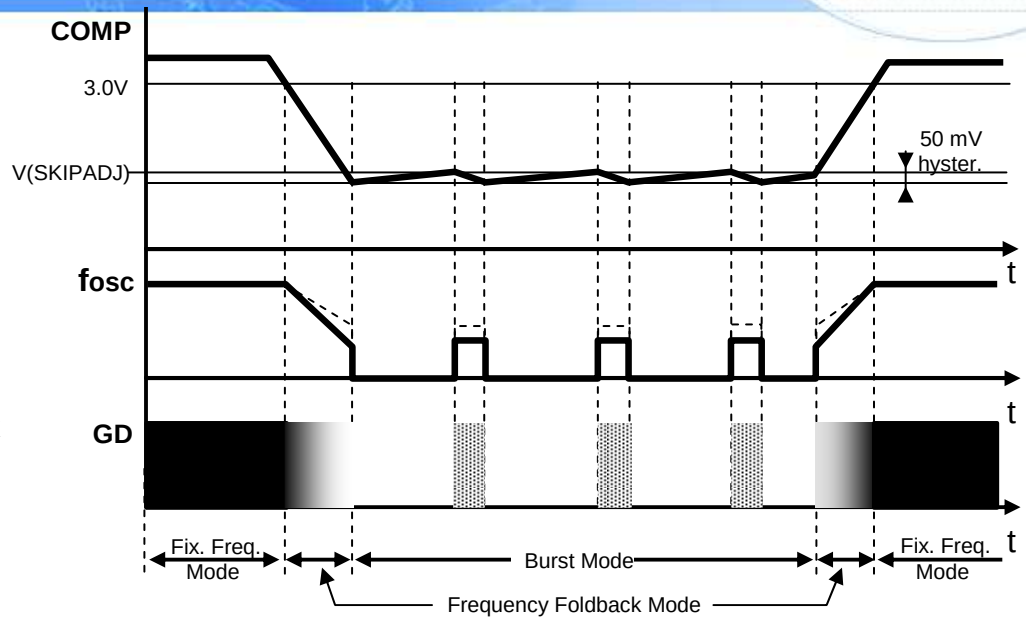


MAIN APPLICATIONS:

- HI-END AC-DC ADAPTERS & CHARGERS
- LCD/CRT MONITORS and LCD/CRT TV
- DIGITAL CONSUMER

L6668 load-dependent operating mode





Burst-Mode @ No-load

- Most of switching cycles are skipped
- Constant switch peak current
- Programmable threshold for noise-free operation
- Pin<0.2W@Pout=0 in an 80W-rated system achievable

Fixed-frequency Mode @ Heavy Load

- Identical to UC384x-based operation
- 75% Max. duty cycle

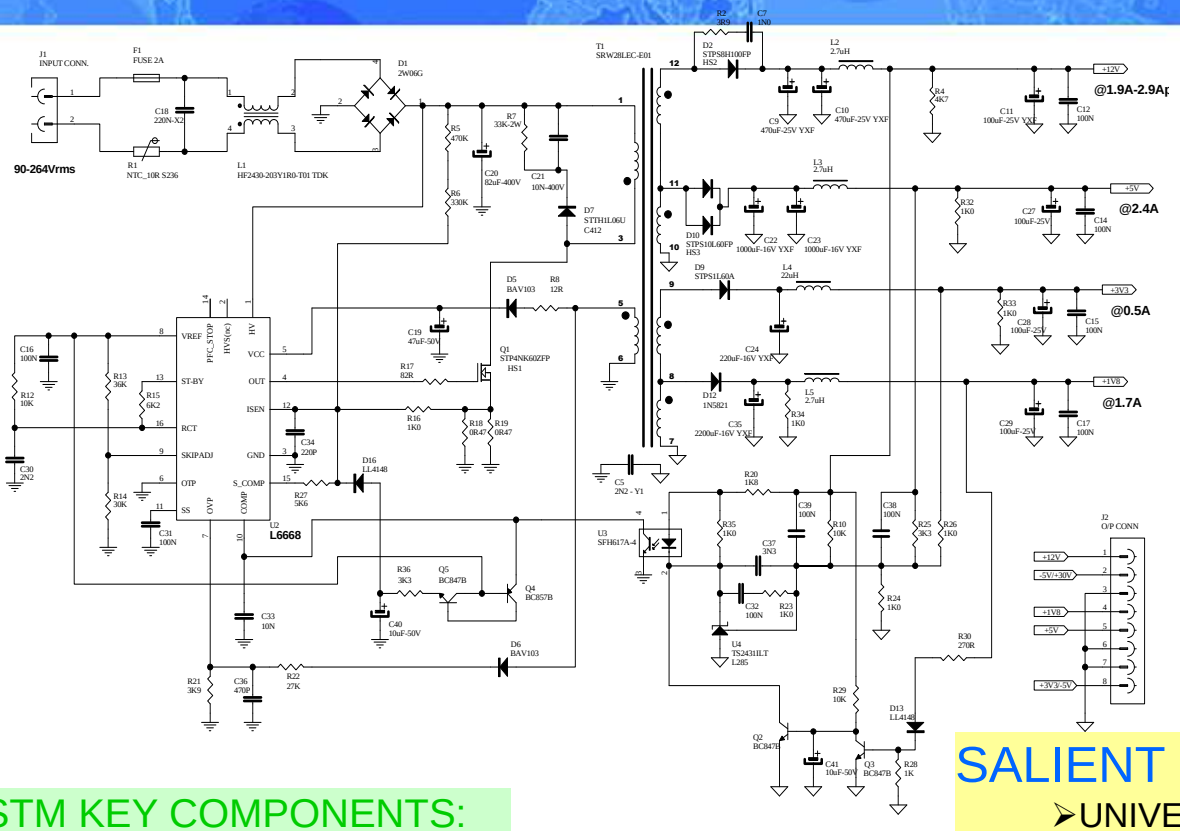
Frequency foldback Mode @ Light Load

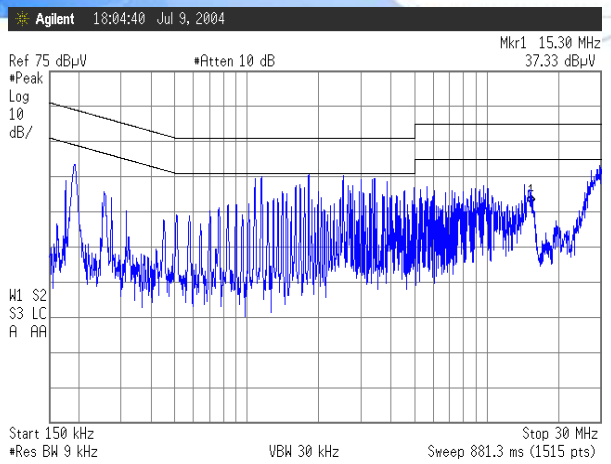
- Frequency is progressively reduced with the load
- Programmable reduction rate for optimum efficiency vs. input power

SMPS Compliant with Blue Angel, Energy Star, EU Code of Conduct, …..

®

L6668 – 40W/51Wpk HDD SET-TOP BOX SMPS





Measured at maximum load and 230Vac.
Limits according to EN55022 Class-B.

STM KEY COMPONENTS:

- L6668 + STP4NK60ZFP
- TL2431
- RECT. DIODES
  - STPS10L60CT
  - STPS8H100FP
  - 1N5821
  - STTH1L06U
  - STPS1L60A

OUTPUT VOLTAGES

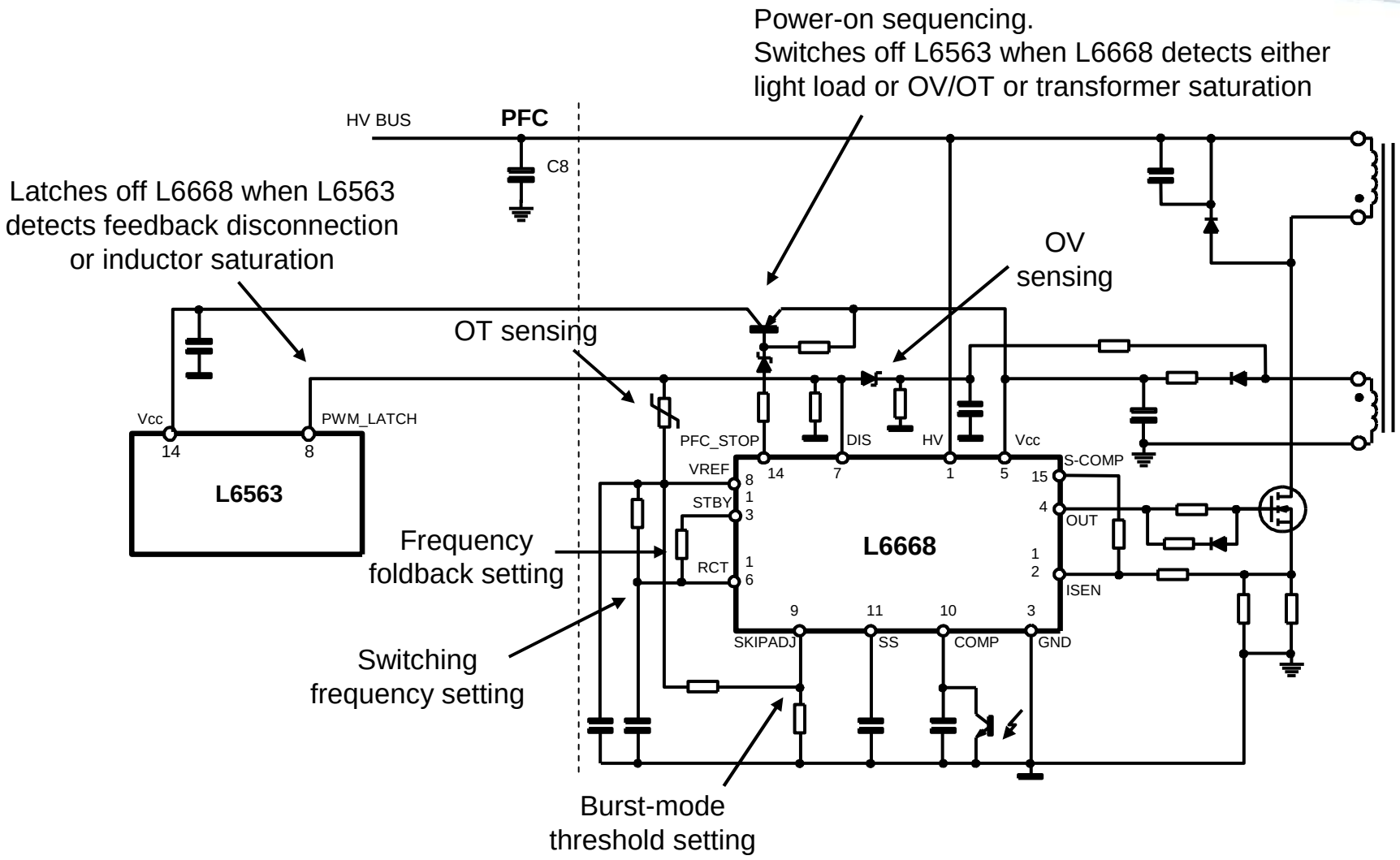
+1.8:	**@1.7A**
+3V3:	**@0.5A**
+5V:	**@2.4A**
+12V:	**@1.9A/2.9Apk**

SALIENT FEATURES:

- UNIVERSAL INPUT MAINS RANGE (90÷264Vac)
- EFFICIENCY BETTER THAN 78% AT FULL LOAD
- ST-BY POWER <0,75W@230Vac & 5V-50mA load
- MEETS EN55022 CLASS B (EMI)
- MEETS EN60950 (SAFETY)
- PCB SINGLE LAYER 75x150 mm
- LOW PART COUNT & DIVERSITY
- LOW-COST APPROACH
- SMT USE FOR LABOR COST REDUCTION

®

L6668 load-dependent operating mode



NEW
L6566A/B primary
Multi-mode
PWM/Q-RES Controller

L6566A/B Multimode Controller

SELECTABLE QR/FF OPERATION → FLEXIBILITY

ON-BOARD HV START-UP GEN.
LOW QUIESCENT CURRENT (<3mA)
BURST MODE @ LIGHT LOAD → POWER CONSUMPTION

PULSE-BY-PULSE OCP
TRANSFORMER SAT. DETECTION
LATCHED OR AUTORESTART OVP
BROWNOUT PROTECTION
ADAPTIVE UVLO
LINE FEEDFORWARD → SAFETY

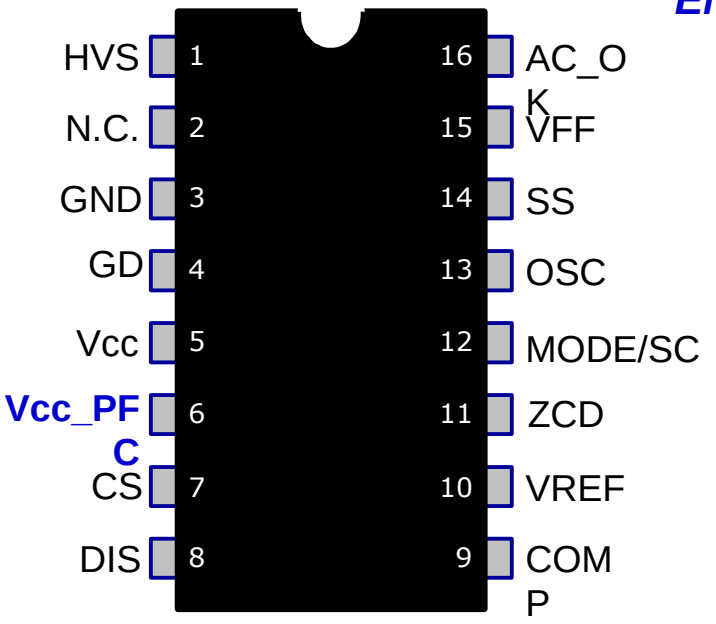
L6566A → PFC INTERFACE → POWER CONSUMPTION

L6566B → FREQ MODULATION → EMI REDUCTION

L6566A/B Multimode Controller

S2

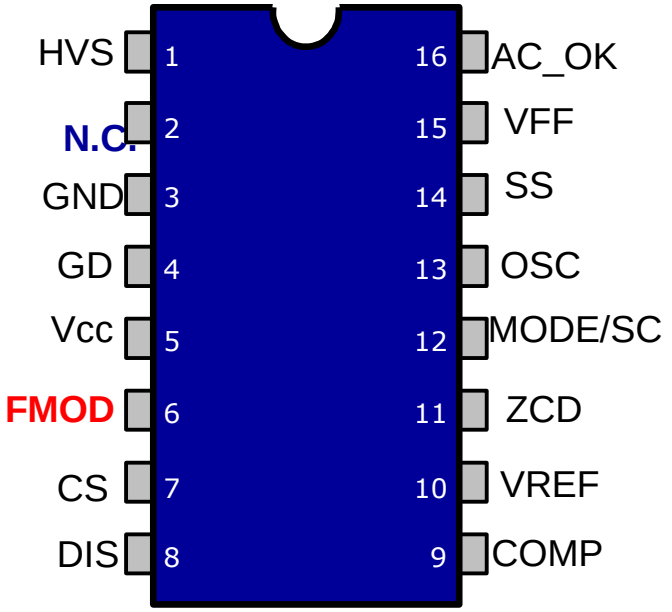
L6566A: FOR SMPS WITH PFC FRONT-END



MAIN APPLICATIONS:

- *High Power (75-120W) AC-DC adapt/Chargers*
- *SMPS for Printers*
- *LCD monitors, Small size LCD TV (21-28”)*

L6566B: FOR SINGLE STAGE SMPS



MAIN APPLICATIONS:

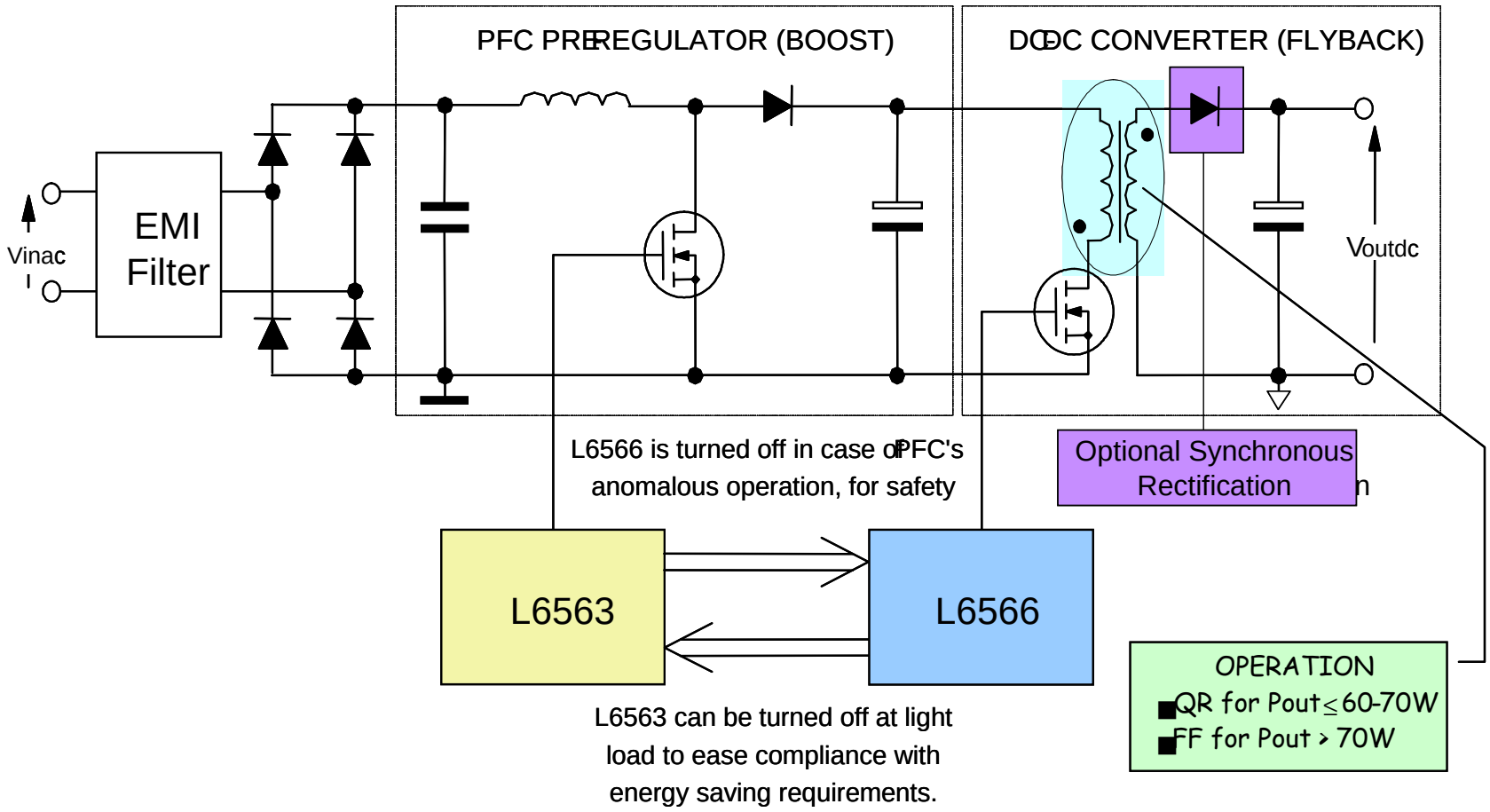
- *Low Power (30-75W) AC-DC Adapt/Chargers*
- *SMPS for Printers, Digital Consumer*
- *LCD monitor, Small size LCD TV (up to 21”)*
- *Single-stage PFC*

S2

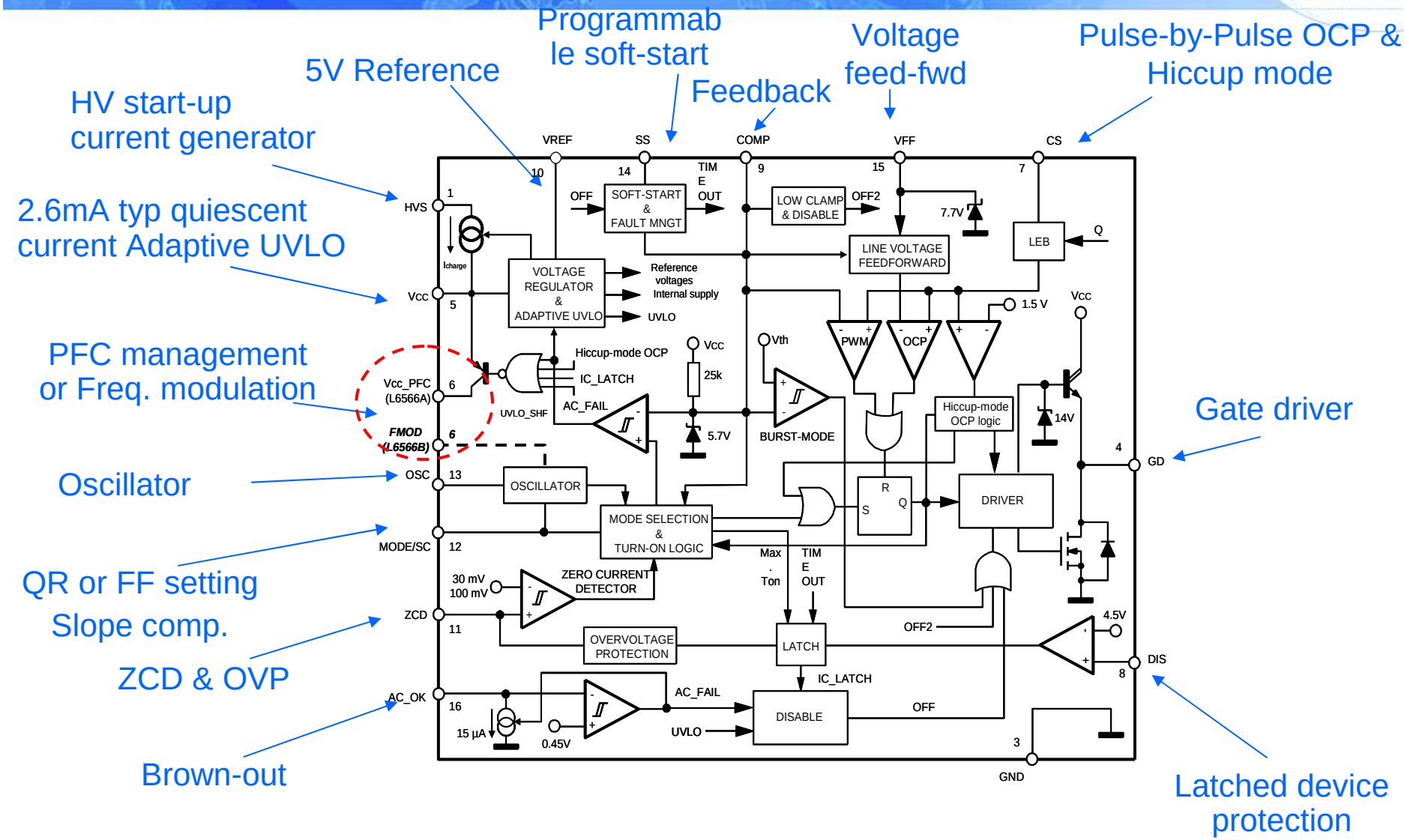
The L6566 is an extremely versatile current-mode primary controller IC specifically designed for high-performance offline flyback converters in applications supposed to comply with EN61000-3-2 or JEITA-MITI regulations.Both Fixed-frequency (FF) and Quasi-resonant (QR) operation are supported. The user can pick either of the two depending on application needs. The device features an externally programmable oscillator: it defines converter's switching frequency in FF mode and the maximum allowed switching frequency in QR mode. When FF operation is selected, the IC works like a standard current-mode controller with a maximum duty cycle limited at 70% min. QR operation, when selected, occurs at heavy loads and is achieved through a transformer demagnetization sensing input that triggers MOSFET's turn-on. Under some conditions, ZVS (Zero-voltage Switching) can be achieved. Converter's power capability rise with the input voltage is compensated by line voltage feedforward. At medium and light load, as the QR operating frequency equals the oscillator frequency, a function (valley skipping) is activated to prevent further frequency rise and keep the operation as close to ZVS as possible. With either FF or QR operation, at very light load the IC enters a controlled burst-mode operation that, along with the built-in non-dissipative high-voltage start-up circuit and a reduced quiescent current, helps keep low the consumption from the mains and meet energy saving recommendations. To allow meeting them in two-stage power-factor-corrected systems as well, the L6566A provides an interface with the PFC controller that enables to turn off the pre-regulator at light load.An innovative adaptive UVLO helps minimize the issues related to the fluctuations of the self-supply voltage due to transformer's parasitics.The protection functions included in this device are: not-latched input undervoltage (brownout), output OVP (auto-restart or latch-mode selectable), a first-level OCP with delayed shutdown to protect the system during overload or short circuit conditions (auto-restart or latch-mode selectable) and a second-level OCP that is invoked when the transformer saturates or the secondary diode fails short. A latched disable input allows easy implementation of OTP with an external NTC, while an internal thermal shutdown prevents IC overheating. Programmable soft-start, leading-edge blanking on the current sense input for greater noise immunity, slope compensation (in FF mode only), and a shutdown function for externally controlled burst-mode operation or remote ON/OFF control complete the equipment of this device.

STMicroelectronics; 22/10/2007

Typical System Block Schematics



L6566A/B Block Diagram

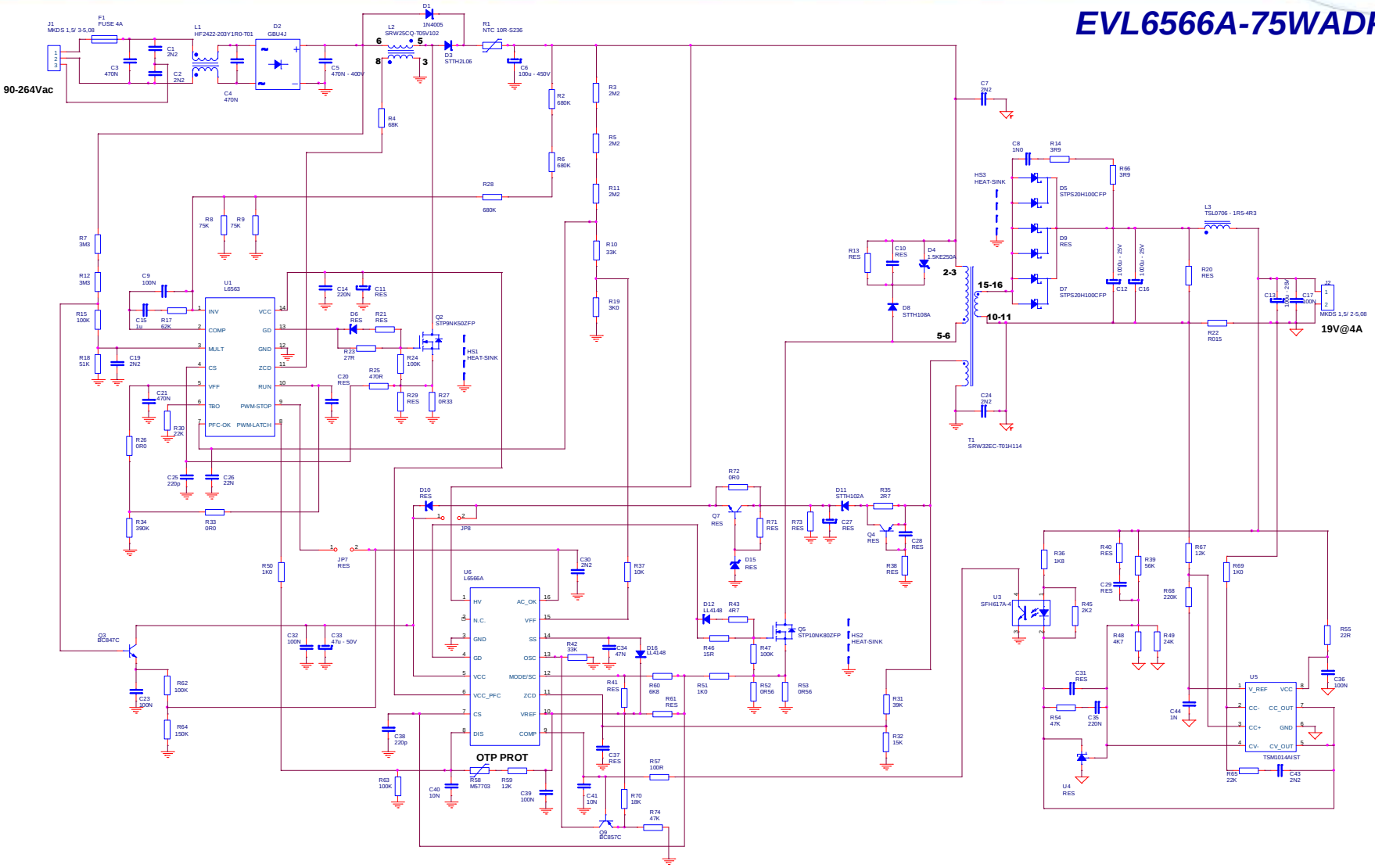


L6566A/B: Main Features

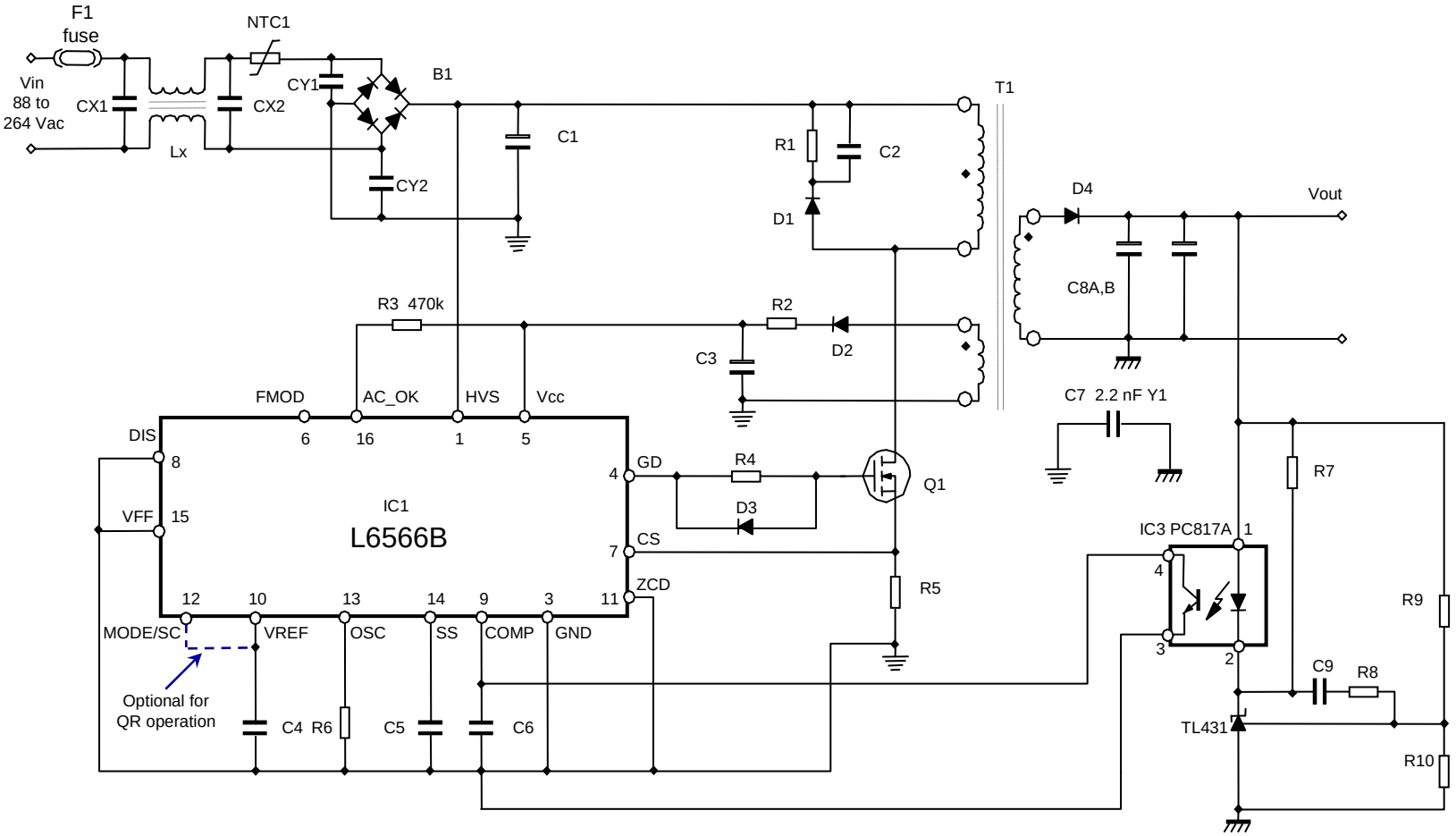
- SELECTABLE QUASI-RESONANT (QR) or FIXED FREQUENCY (FF) OPERATION
- LOAD-DEPENDENT CURRENT-MODE CONTROL: QUASI-RESONANT, VALLEY SKIPPING OR BURST-MODE
- ON-BOARD HIGH-VOLTAGE START-UP GENERATOR
- LOW QUIESCENT CURRENT (< 3 mA)
- ADAPTIVE UVLO
- LINE FEEDFORWARD FOR CONSTANT POWER CAPABILITY
- PULSE-BY-PULSE OCP WITH DELAYED SHUTDOWN
- TRANSFORMER SATURATION DETECTION
- LATCHED OR AUTORESTART OVP
- BROWNOUT PROTECTION WITH HYSTERESIS
- PROGRAMMABLE SOFT-START
- 2% PRECISION REFERENCE VOLTAGE EXTERNALLY AVAILABLE
- -600/+800 mA TOTEM POLE GATE DRIVER
- *SWITCHED SUPPLY RAIL FOR PFC CONTROLLER (L6566A)*
- *PROGRAMMABLE FREQUENCY MODULATION FOR EMI REDUCTION (L6566B)*
- SO16N PACKAGE

Blue Angel, Energy Star, EU Code of Conduct Compliant

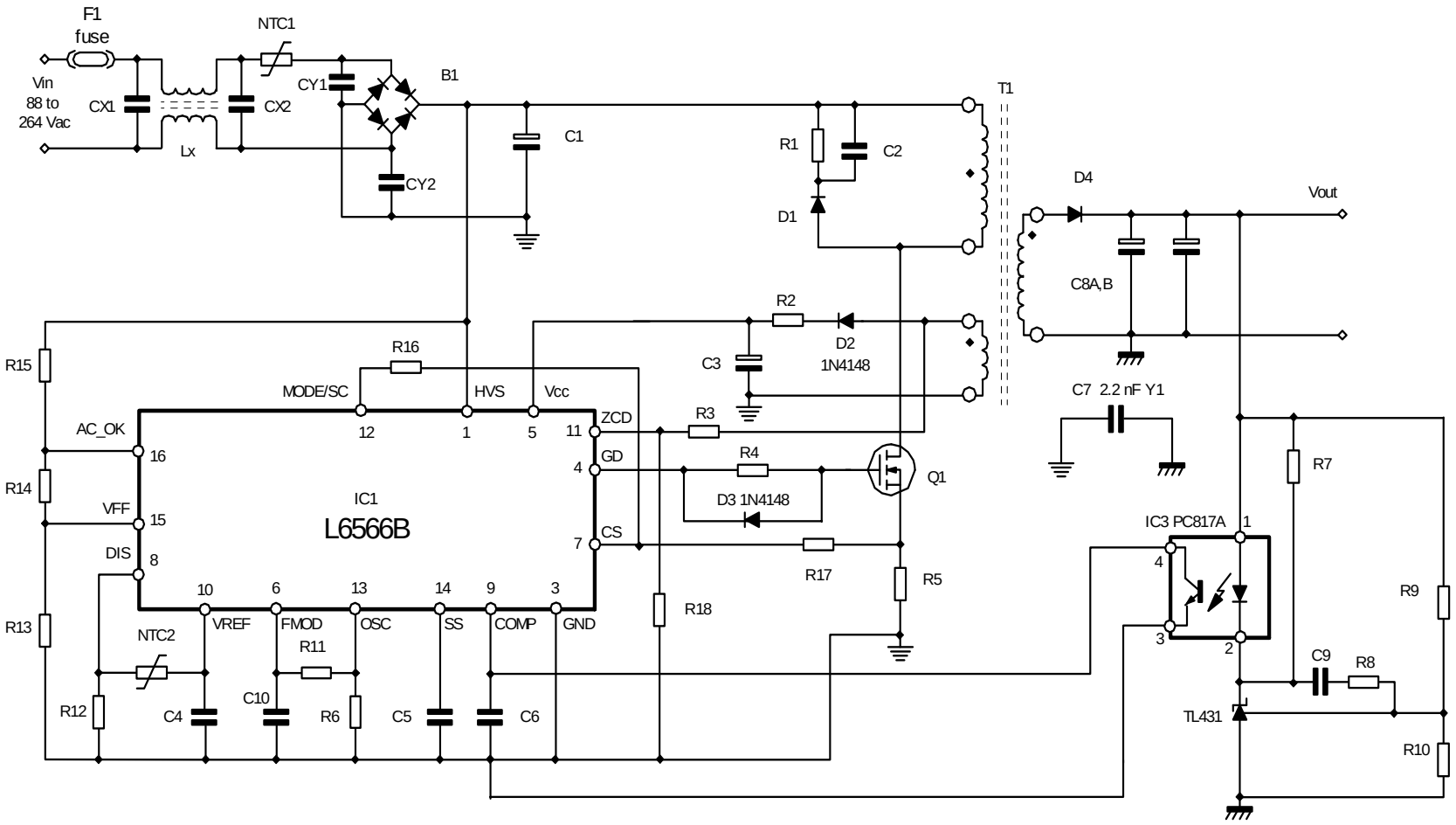
75W Adapter with PFC, using L6566A and L6563



Typical low-cost application schematic



Typical full-feature application schematic



L6566A/B Promotional Tools

- SAMPLES: AVAILABLE NOW (PRODUCTION PHASE)
- DATASHEETs: AVAILABLE ON THE WEB
  - **L6566A** http://www.st.com/stonline/products/literature/ds/13794.pdf
  - **L6566B** http://www.st.com/stonline/products/literature/ds/13795/l6566b.pdf
- DEMO BOARDS:
  - **EVL6566A-75WADP in FF mode (AVAILABLE)**
    - **19V/3.9A adapter with PFC pre-regulator, using L6563, L6565A and TSM1014**
      http://www.st.com/stonline/products/literature/bd/13897/evl6566a-75wadp.pdf
  - **EVL6566A-75WADP in QR mode (IN PROGRESS)**
    - **19V/3.9A adapter with PFC pre-regulator, using L6563, L6565A and TSM1014, EPA 4.0 Compliant**
  - **EVL6566B-65W in FF mode (AVAILABLE)**
    - **12V/5.4A wide-range mains adapter using L6566B and TSM1014**
  - **EVL6566B-60WQR in QR mode (AVAILABLE)**
    - **12V/5A wide range mains adapter using L6566B**
  - **EVL6566B-60WFF in FF mode (AVAILABLE)**
    - **12V/5A wide range mains adapter using L6566B**
  - **EVL6566B-40WSTB in FF mode (multiple output) (AVAILABLE)**
    - **12V, 5V, 3.3V and 1.8V 40W Fly-Back converter for digital consumer market**
- DESIGN SOFTWARE: UNDER DEVELOPMENT

NEW
L6591
high performance PWM controller for Asymmetrical Half Bridge

S1

L6591: HB ZVS PWM Primary Controller

HALF BRIDGE TOPOLOGY → POWER DENSITY

ZERO VOLTAGE SWITCHING → NO SWITCHING LOSSES @ TURN ON

SOFT SWITHCING

UP TO 500KHz OPER. FREQ. → SMALL MAGNETICS AND CAP, SHORT RESPONSE TIMES, SMALL FILTERS, LOW NOISE LEVELS

ON-BOARD HV START-UP GEN.
LOW QUIESCENT CURRENT (<3mA)
BURST MODE @ LIGHT LOAD
INTERFACE PIN WITH PFC → POWER CONSUMPTION

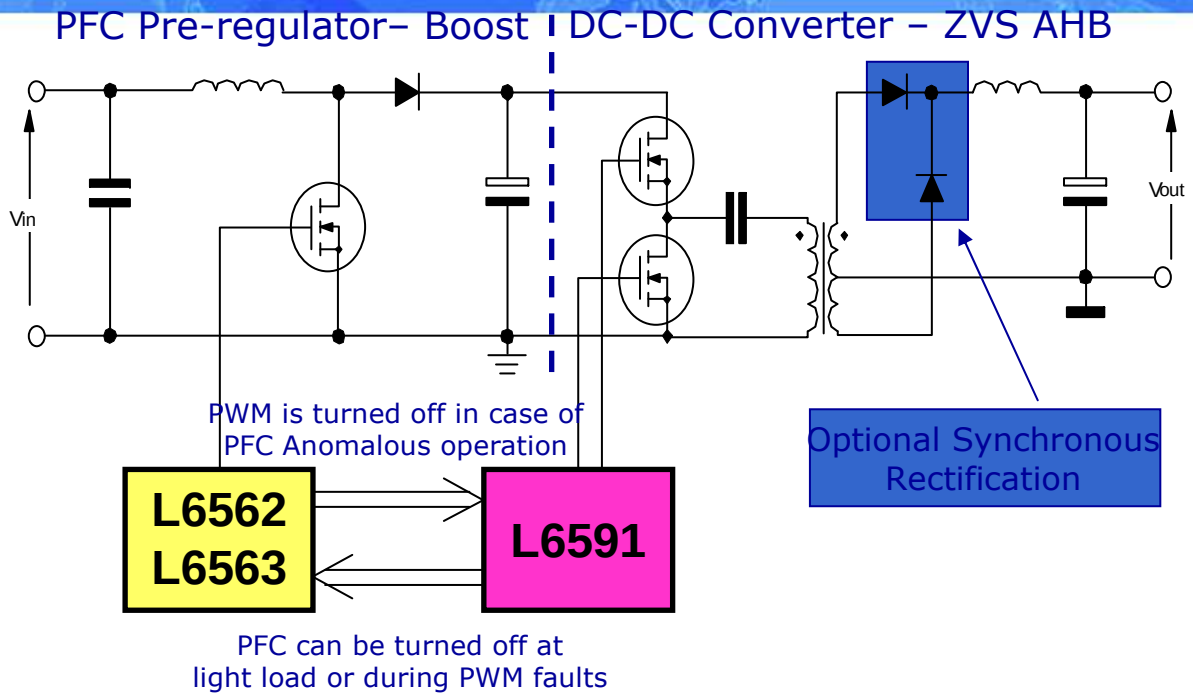
PULSE-BY-PULSE OCP
TRANSFORMER SAT. DETECTION
LATCHED OR AUTORESTART OVP
BROWNOUT PROTECTION
ADAPTIVE UVLO → SAFETY

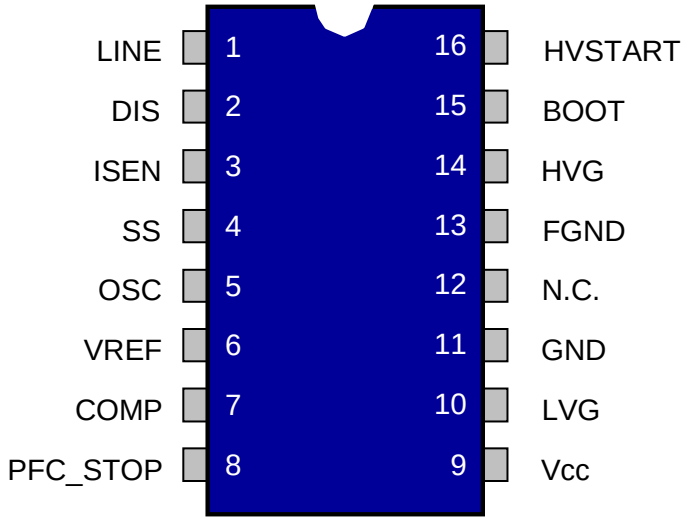
S1

The L6591 is a double-ended PWM controller specific for the soft-switched half-bridge topology. It provides complementary PWM control, where the high-side switch is driven ON for a duty cycle D and the low-side switch for a duty cycle 1-D, with D≤50%. An externally programmable dead-time inserted between the turn-off of one switch and the turn-on of the other one guarantees soft-switching and enables high-frequency operation.
To drive the high-side switch with the bootstrap approach, the IC incorporates a high-voltage floating structure able to withstand more than 600V with a synchronous-driven high-voltage DMOS that replaces the external fast-recovery bootstrap diode. The IC enables the designer to set the operating frequency of the converter by means of an externally programmable oscillator: the maximum duty cycle is digitally clipped at 50% by a T-flip-flop, so that the operating frequency will be half that of the oscillator. At very light load the IC enters a controlled burst-mode operation that, along with the built-in non-dissipative high-voltage start-up circuit and the low quiescent current, helps keep low the consumption from the mains and be compliant with energy saving recommendations. To allow compliance with these standards in two-stage power-factor-corrected systems as well, an interface with the PFC controller is provided that enables to switch off the pre-regulator between one burst and the following one. An innovative adaptive UVLO helps minimize the issues related to the fluctuations of the self-supply voltage with the output load, due to transformer's parasitics. IC's protection functions include: not-latched input undervoltage (brownout), a first-level OCP with delayed shutdown able to protect the system during overload and short circuit conditions (either auto-restart or latch mode can be selected) and a second-level OCP that latches off the IC when the transformer saturates or one of the secondary diodes fails short. Finally, a latched disable function allows easy implementation of OTP or OVP. Programmable soft-start and digital leading-edge blanking on current sense input pin complete the equipment of the IC.

The L6591 is an advanced current-mode PWM controller specific for fixed-frequency, peak-current-mode-controlled ZVS half-bridge converters. In these converters the switches (MOSFET's) are controlled with complementary duty cycle: the high-side MOSFET is driven ON for a duty cycle D and the low-side MOSFET for a duty cycle 1-D. For a proper operation the maximum allowed duty cycle must be limited below 50%.
An externally programmable dead-time TD inserted between the turn-off of one MOSFET and the turn-on of the other one ensures soft-switching and enables high-frequency operation with high efficiency and low EMI emissions. See "Oscillator and dead-time programming" section for more information on how to program TD.
STMicroelectronics; 14/11/2007

L6591: HB ZVS PWM Primary Controller

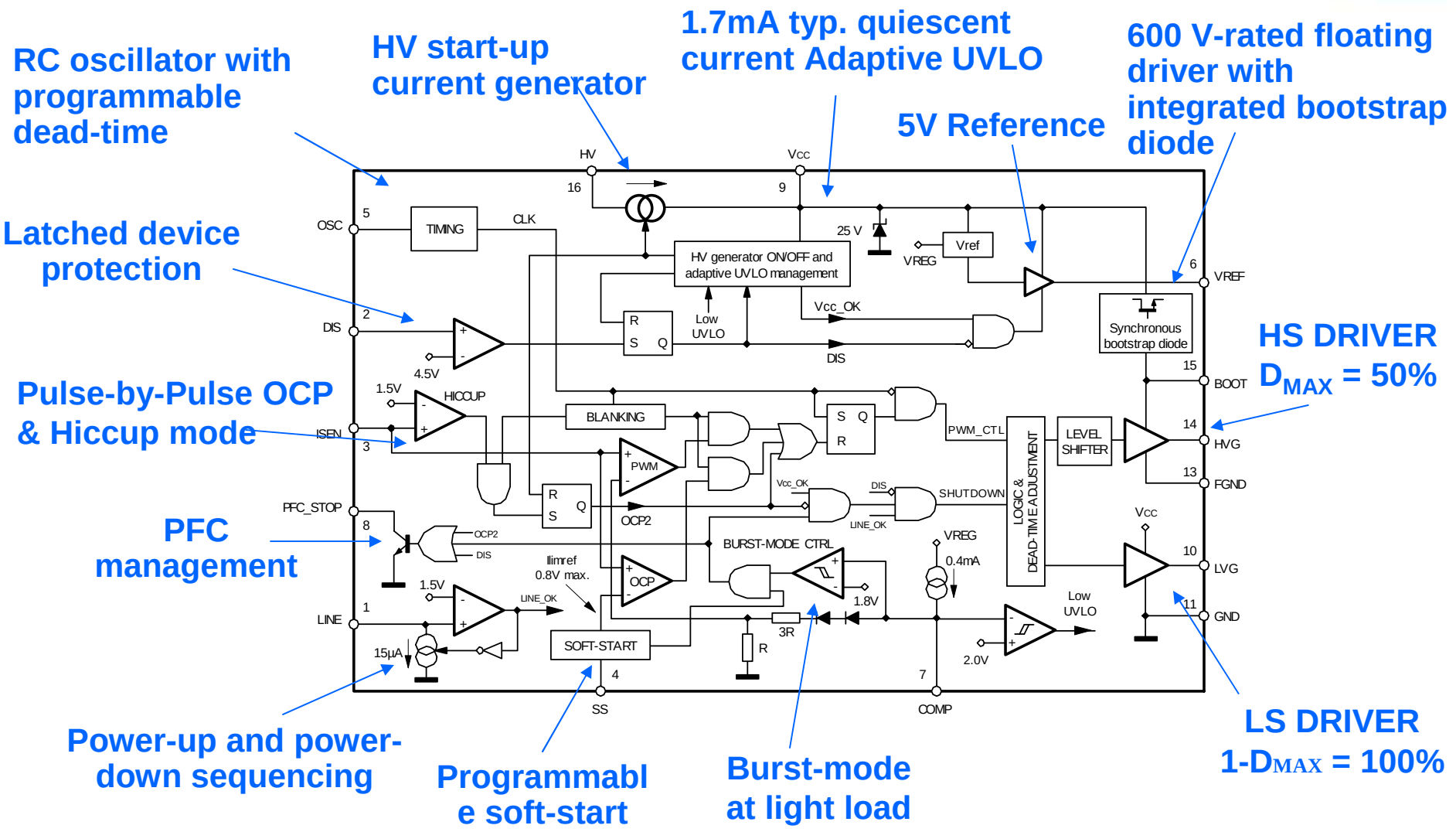




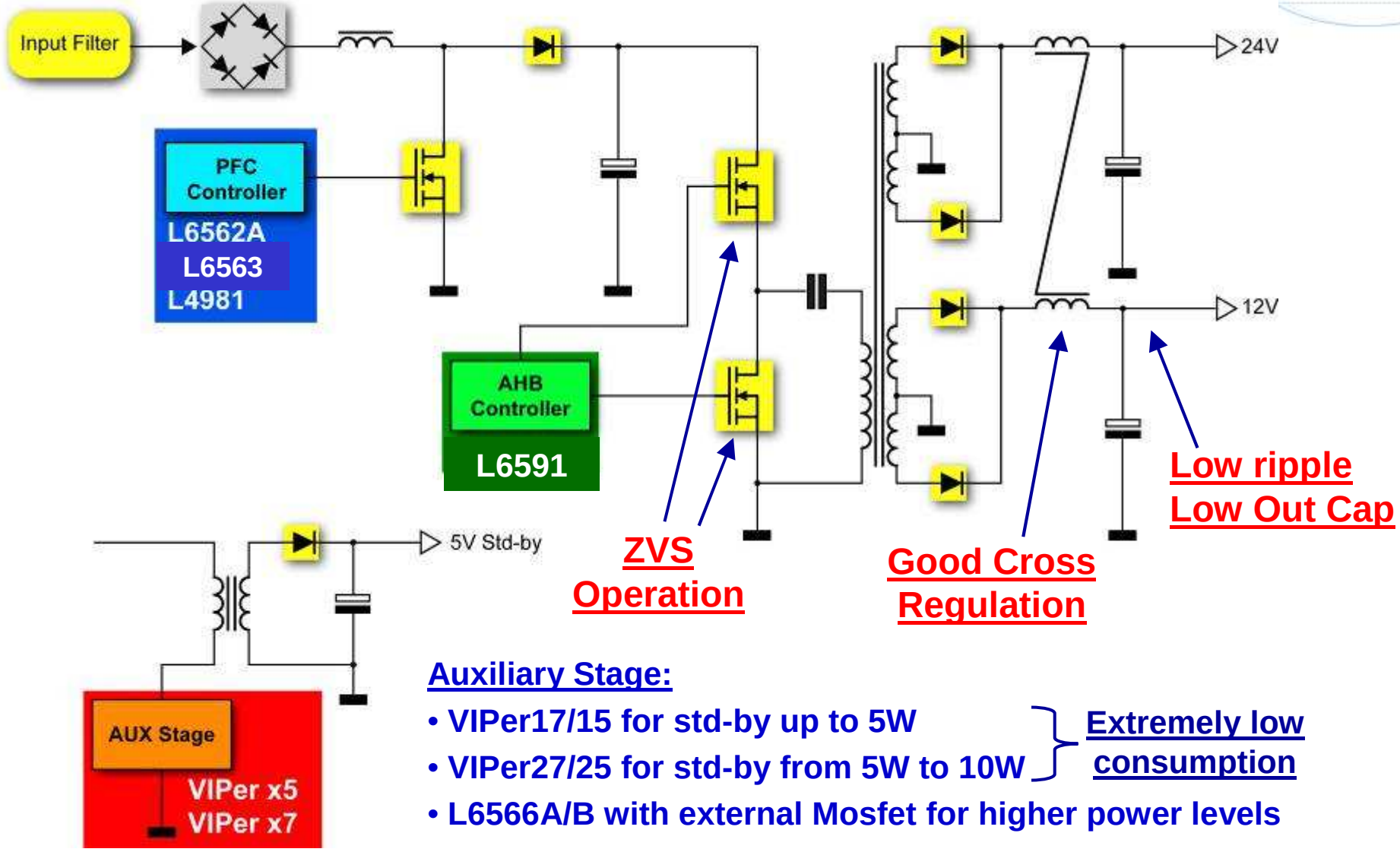
Application:

- High Power AC-DC Adapters/Chargers > 90W
- ATX Desktop PCs (80+, 85+ initiative)
- Telecom SMPS
- Audio Applications
- printers

L6591 block diagram



Typical Asymmetrical Half Bridge Architecture



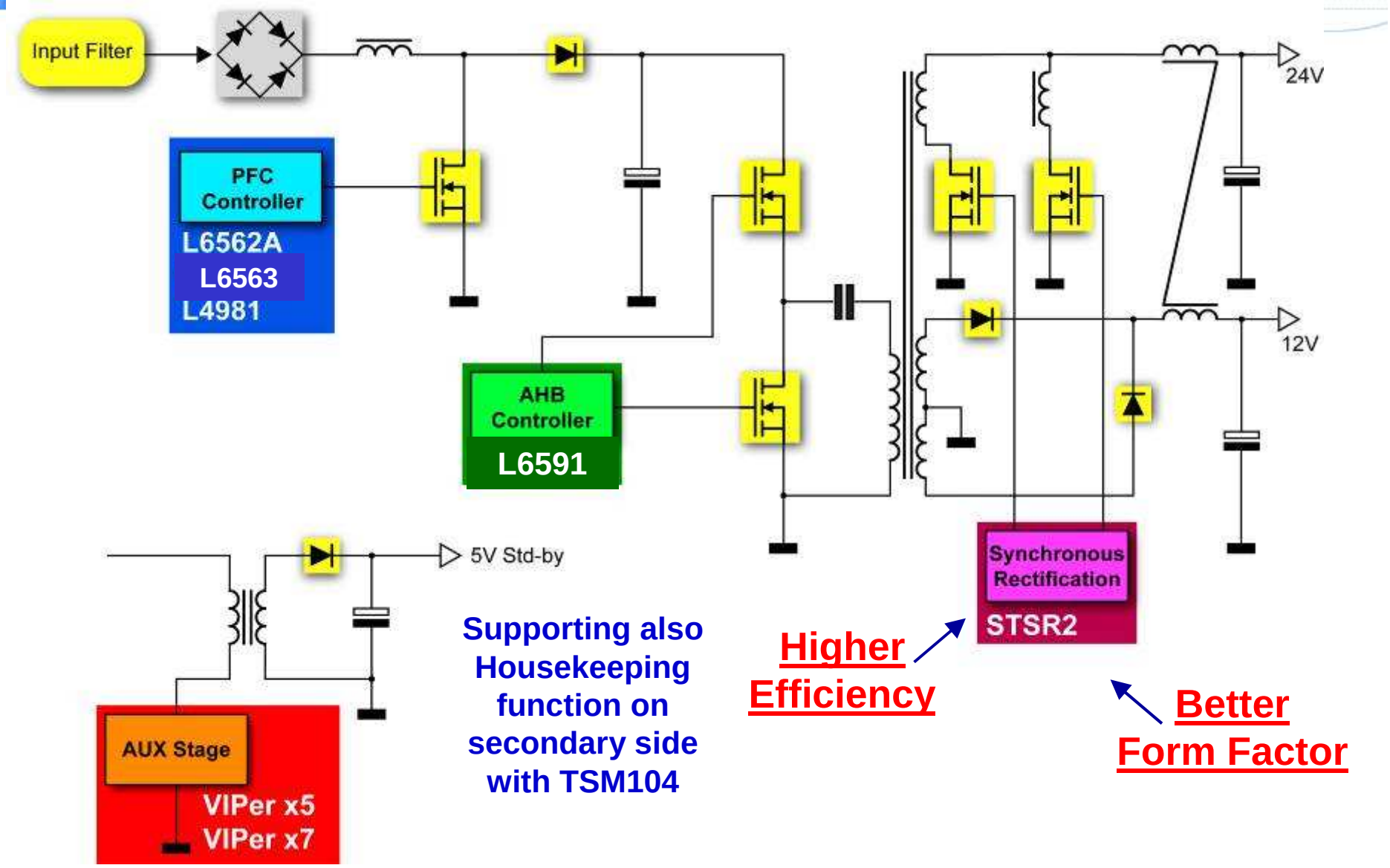
Auxiliary Stage:

- VIPer17/15 for std-by up to 5W
- VIPer27/25 for std-by from 5W to 10W

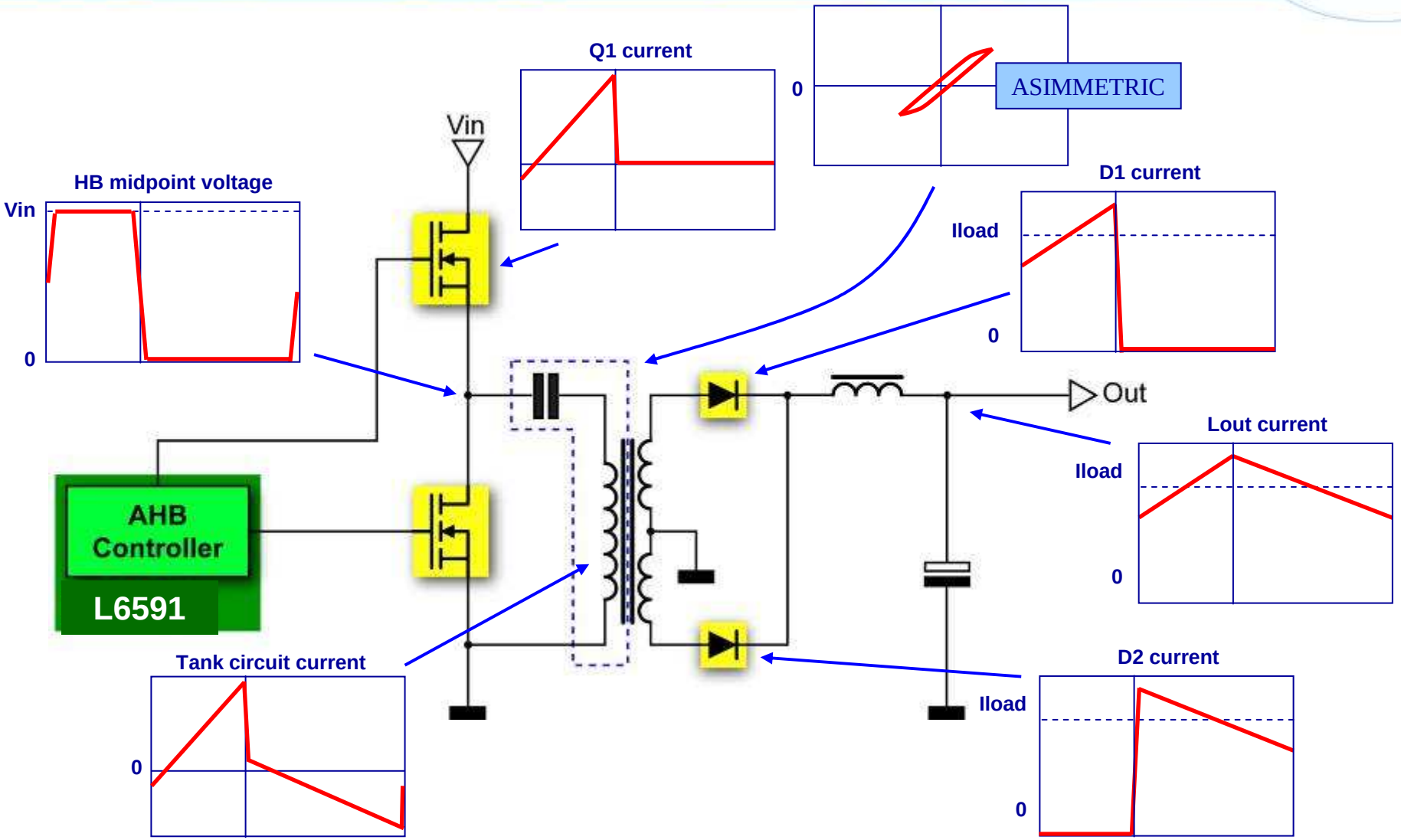
} Extremely low consumption

- L6566A/B with external Mosfet for higher power levels

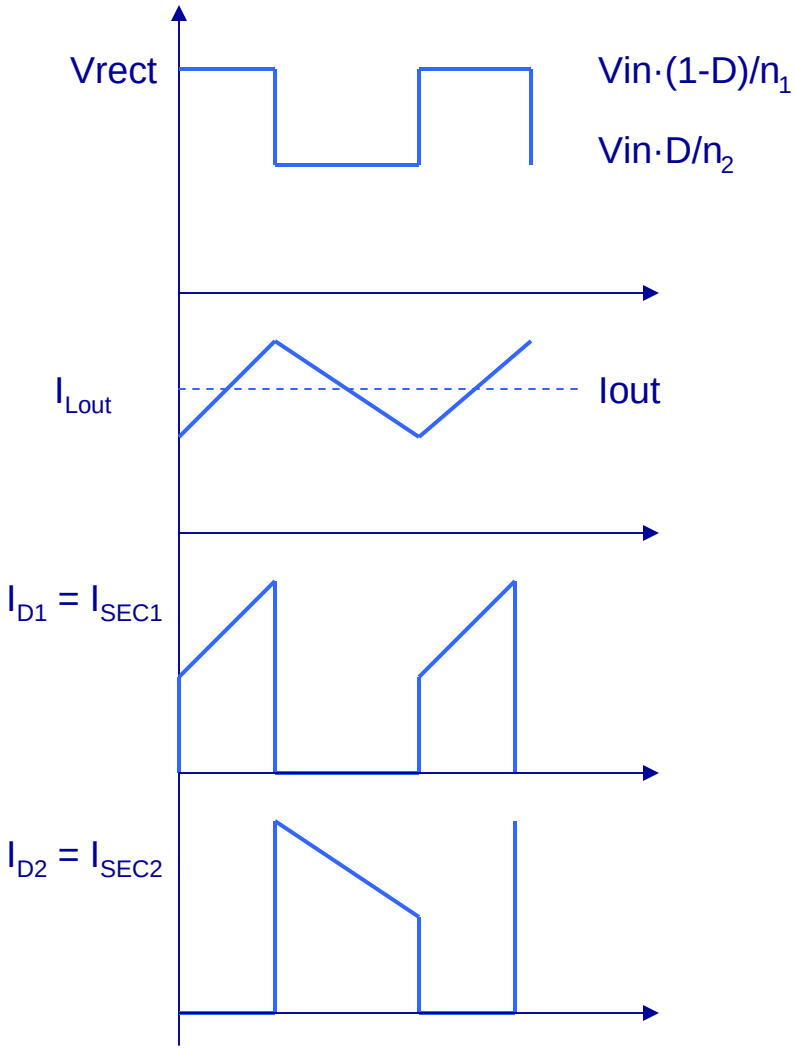
AHB Architecture with Synchronous Rectification

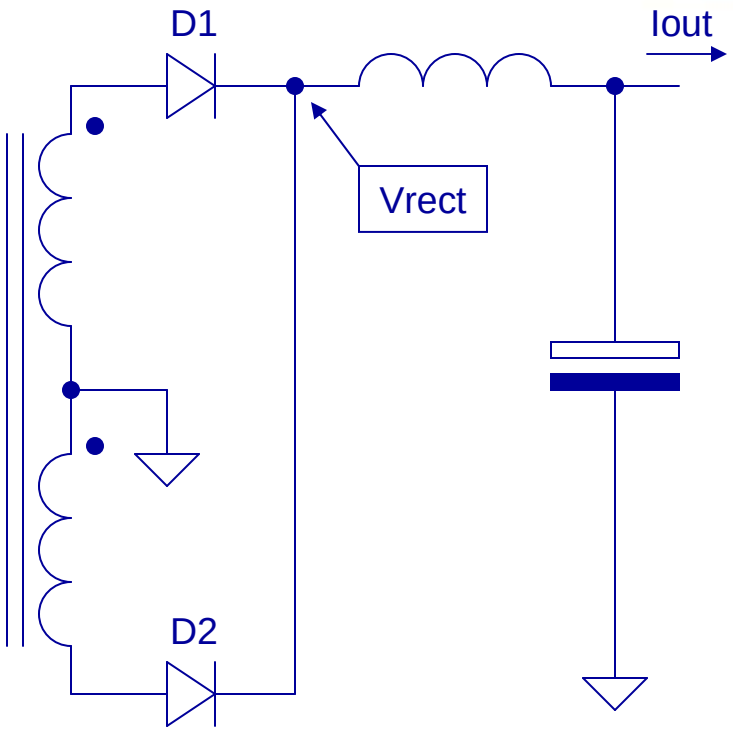


Asymmetrical Half Bridge Waveforms



AHB secondary side waveforms



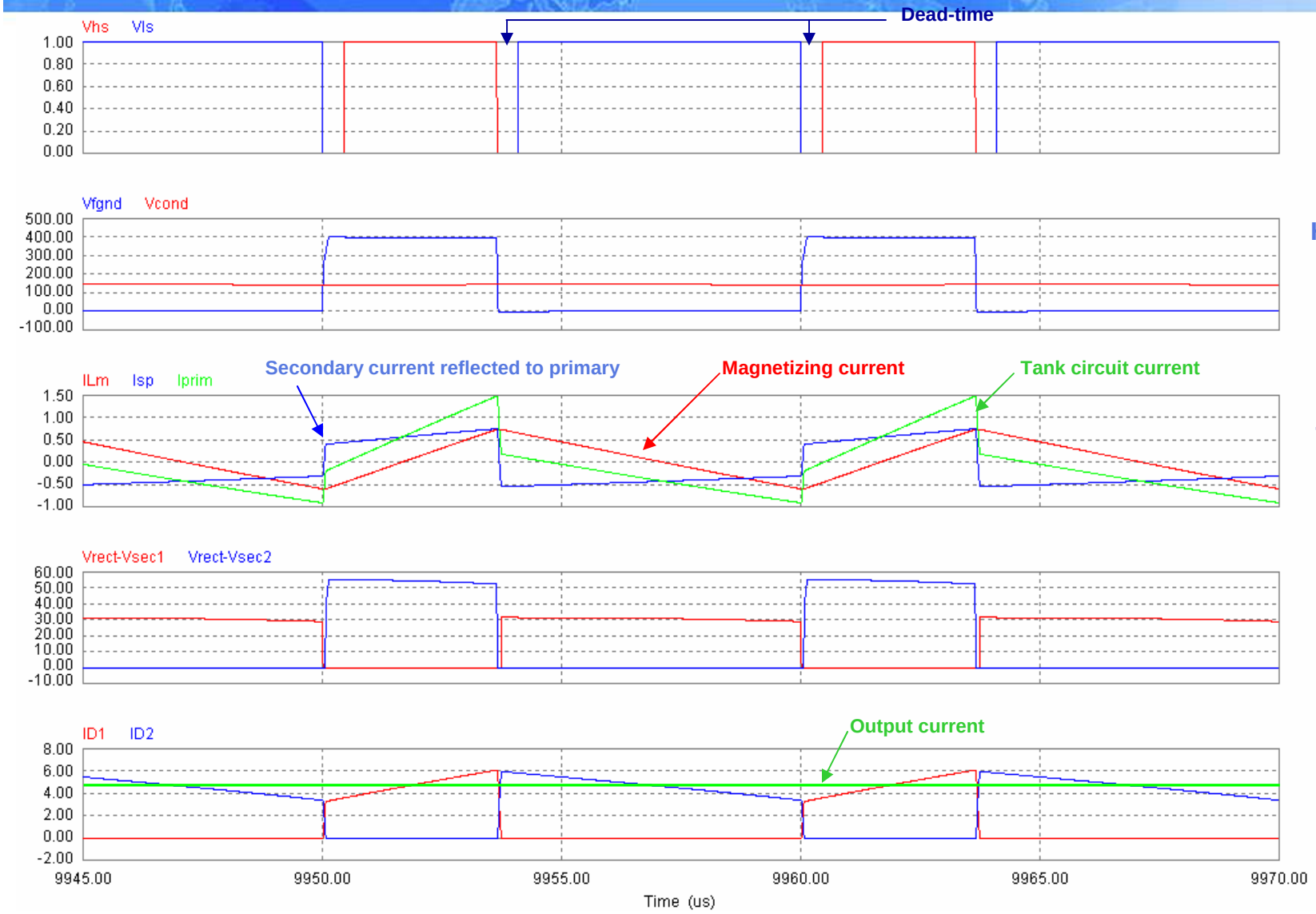


Rectifiers reverse voltages

$$V_{D1} = V_{in} \cdot D \cdot \left(\frac{1}{n_1} + \frac{1}{n_2} \right)$$

$$V_{D2} = V_{in} \cdot (1 - D) \cdot \left(\frac{1}{n_1} + \frac{1}{n_2} \right)$$

AHB waveforms summary



Gate-drive signals

HB mid-point Voltage
DC blocking cap voltage

Transformer currents

Diode voltages

Diode currents

- **CONTROL**
  - PWM fixed frequency (Dmax = 50%)
  - Dead time between HG and LG to allow ZVS
- **HALF BRIDGE**
  - ZVS operation: Soft Switching - No switching losses @ turn-on
- **SECONDARY SIDE**
  - Balanced or unbalanced (Ns1≠Ns2) transformer
  - Output inductor needed
    - Can be coupled for multiple outputs
- **TRANSFORMER**
  - Unbalanced transformer: no need of high Llk to obtain ZVS

90W-19V Adapter with PFC using L6591+L6563 (2)

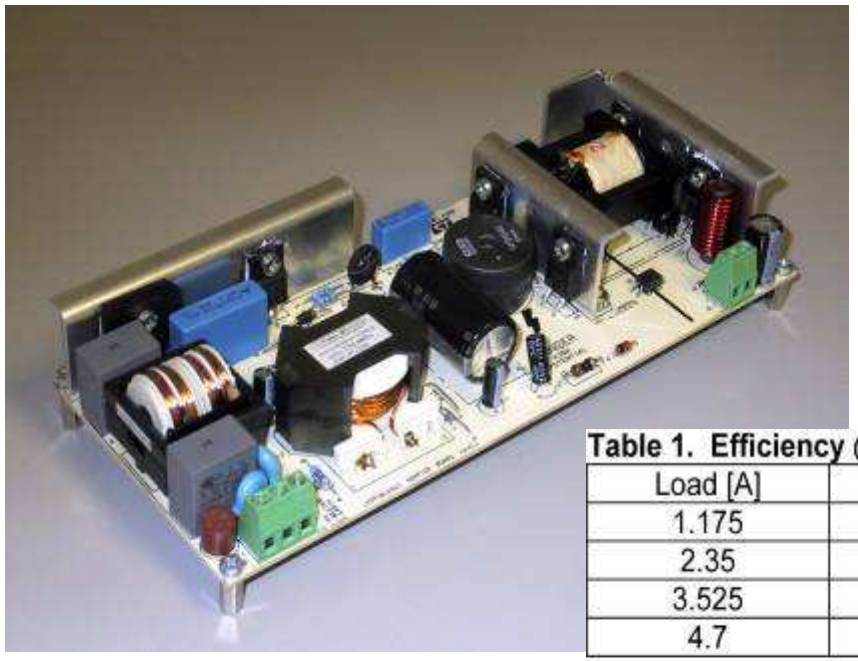


Table 1. Efficiency @ 115Vrms

Load [A]	Pin [W]	Vout [V]	Pout [W]	Eff [%]
1.175	27.74	19.12	22.55	**81.3**
2.35	51.96	19.11	44.87	**86.4**
3.525	76.61	19.11	67.25	**87.8**
4.7	102	19.11	89.90	**88.1**

Table 2. Efficiency @ 230Vrms

Load [A]	Pin [W]	Vout [V]	Pout [W]	Eff [%]
1.175	27.6	19.11	22.54	**81.7**
2.35	51.26	19.11	44.87	**87.5**
3.525	75.34	19.11	67.25	**89.3**
4.7	100	19.10	89.83	**89.9**

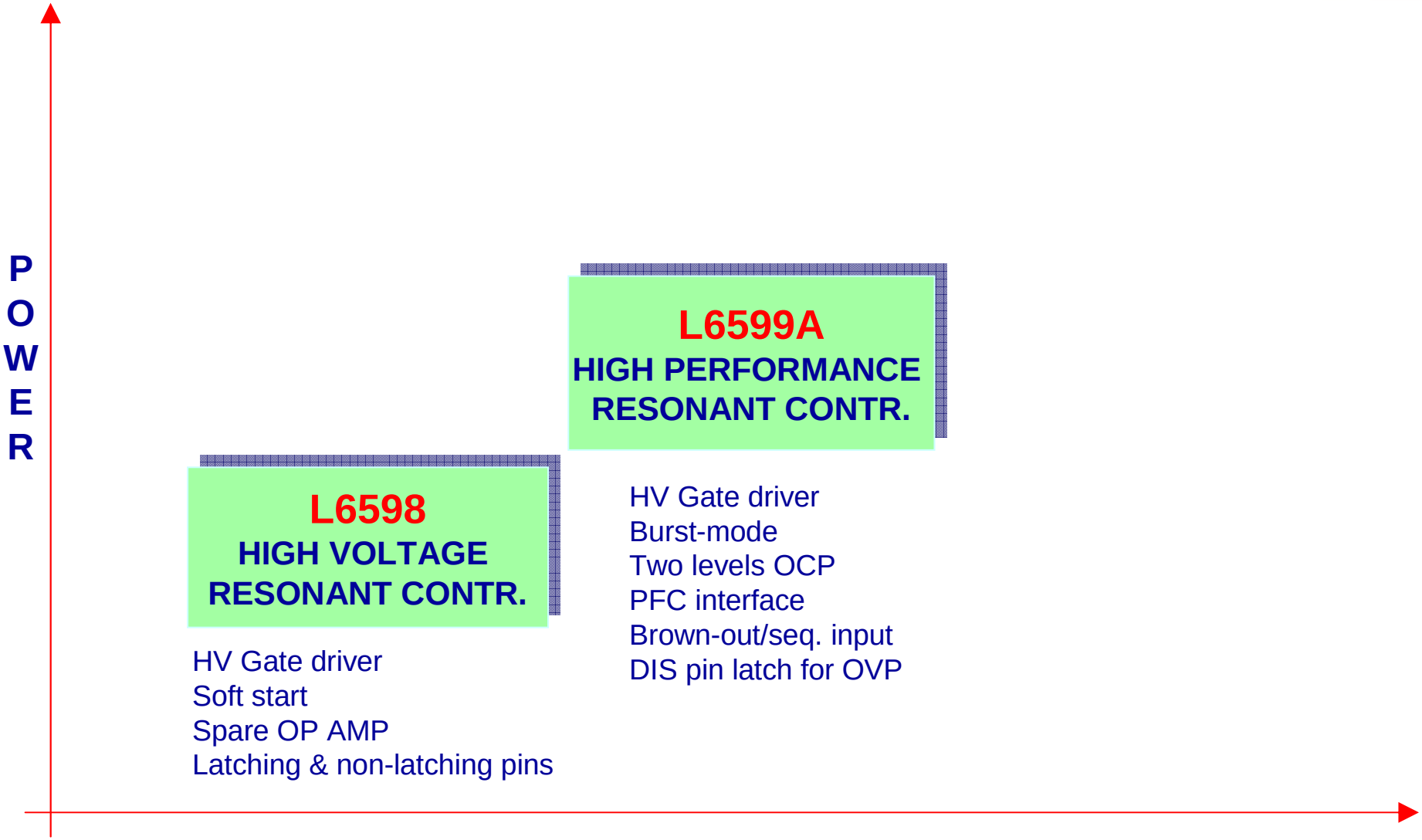
Table 3. No load consumption

	88Vac	115Vac	230Vac	264Vac
Pin [W]	**0.24**	**0.25**	**0.31**	**0.34**

L6591: Promotional Tools

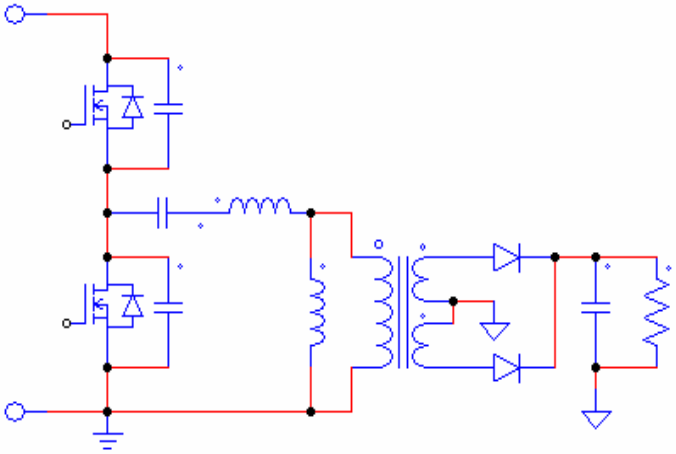
- SAMPLES: AVAILABLE NOW (PRODUCTION PHASE)
- DATASHEETs: AVAILABLE ON REQUEST
- APPLICATION NOTES:
  - **12V/90W AC-DC ADAPTER WITH PFC USING L6563 AND L6591 (IN PROGRESS)**
  - **400W (85+ COMPLIANT) L6591-BASED AHB ZVS CONVERTER WITH PFC FOR DESKTOP PC (COMING NEXT)**
- DEMO BOARDS:
  - **12V/90W AC-DC ADAPTER WITH PFC USING L6563 + L6591** (IN PROGRESS)
  - **400W ATX (85+ COMPLIANT), 12V and 5V outputs** (COMING NEXT)
- DESIGN SOFTWARE:
  - UNDER DEVELOPMENT

Off-line Resonant Controllers Roadmap

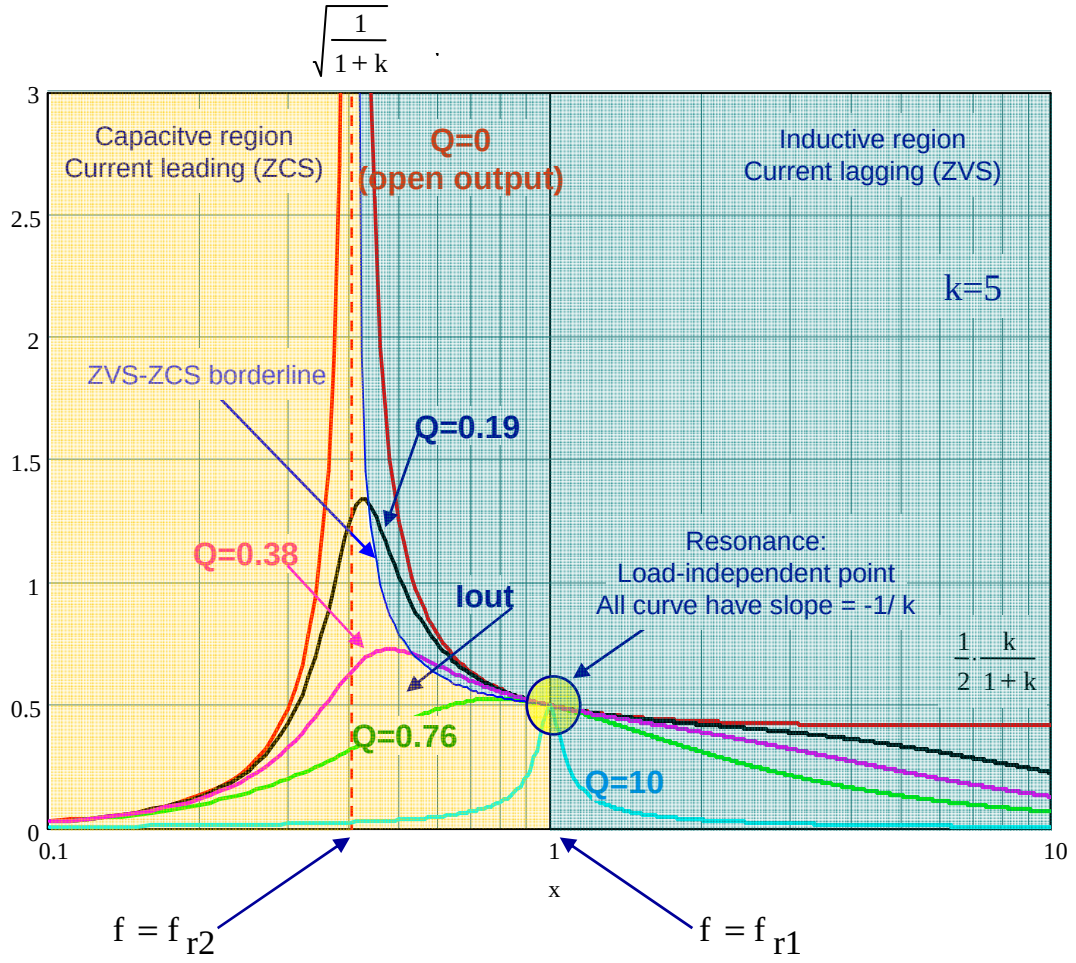


Resonant SMPS: LLC Topology

Resonant SMPS : LLC Circuit



$$M = \frac{a \cdot Vout}{Vin}$$



3 reactive elements, 2 resonant frequencies

$$f_{r1} = \frac{1}{2\cdot\pi\cdot\sqrt{LsCr}}$$

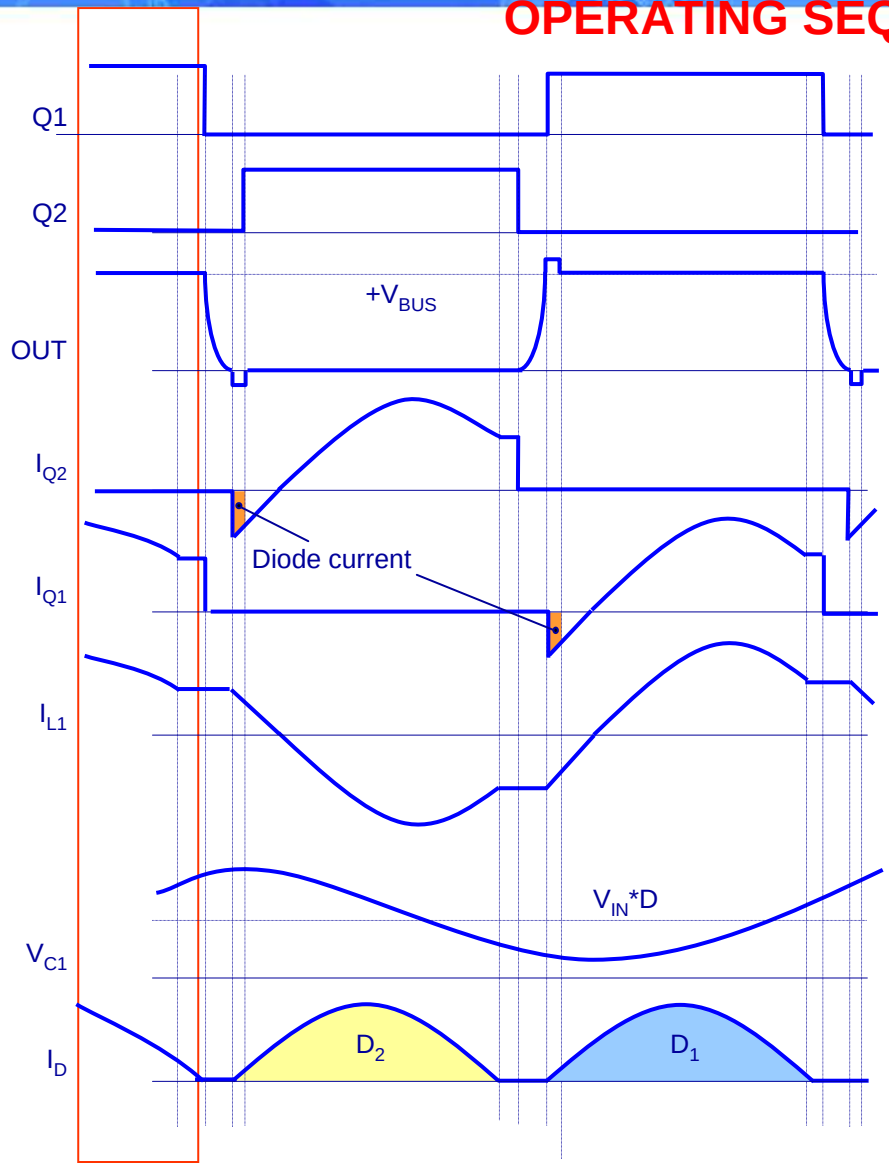
$$f_{r1} > f_{r2}$$

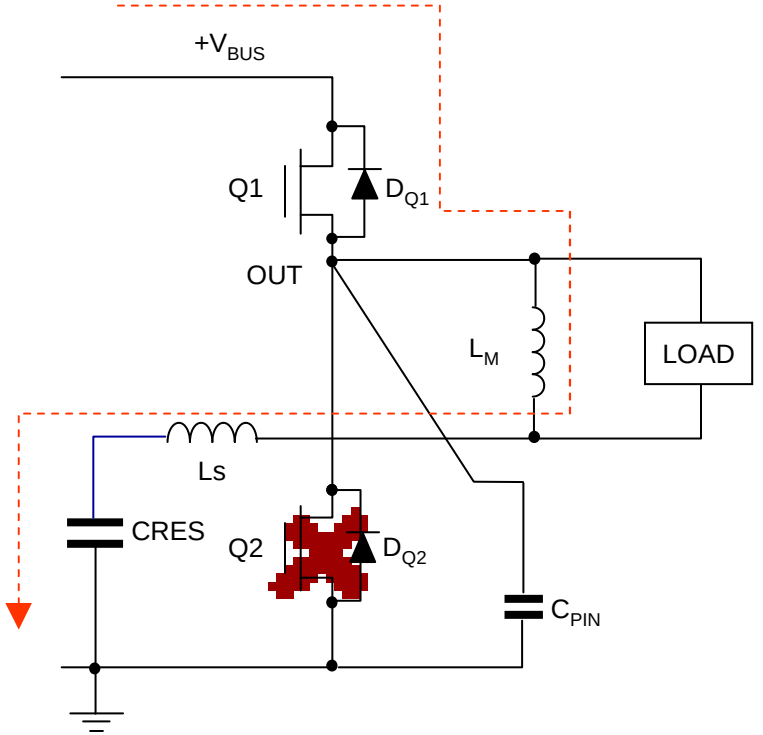
$$f_{r2} = \frac{1}{2\cdot\pi\cdot\sqrt{(Ls+Lp)\cdot Cr}}$$

OFF-LINE RESONANT CONTROLLERS

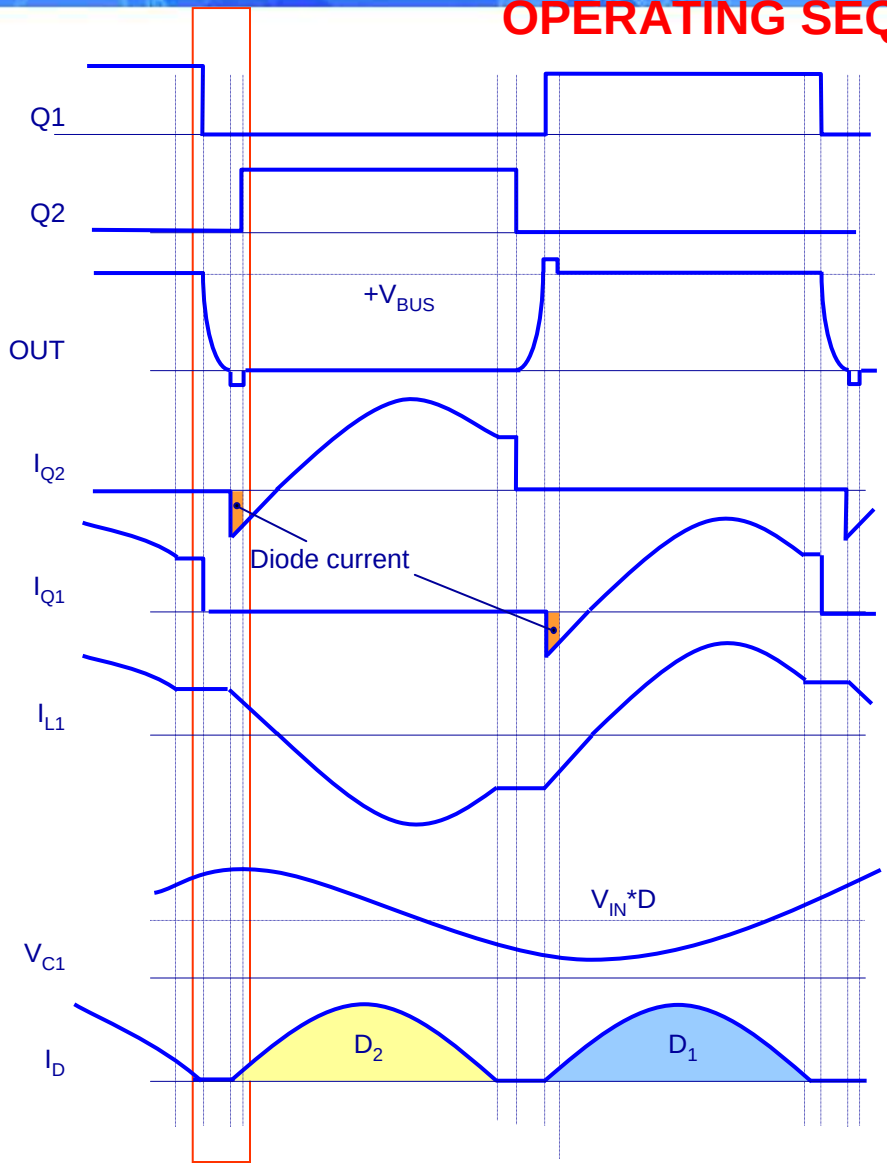
- CONTROL:
  - **Variable frequency control, fixed 50% duty cycle for both MOSFETs**
  - **Dead-time between LG and HG to allow MOSFET's ZVS @ turn-on**
- HALF BRIDGE:
  - **ZVS operation: no switching losses @turn-on**
  - **fsw ≈ fr, sinusoidal waveforms: low turn-off losses, low EMI**
- SECONDARY SIDE:
  - **Equal voltage & current stress for both rectifiers**
  - **No output choke required: cost saving**
  - **ZCS: no recovery losses, less EMI**
  - **V_{RRM} = 1.25x2Vout if secondary is CT,**
- TRANSFORMER
  - **Integrated magnetics: both L's can be realized with the transformer**
- HIGH EFFICIENCY: >96% achievable

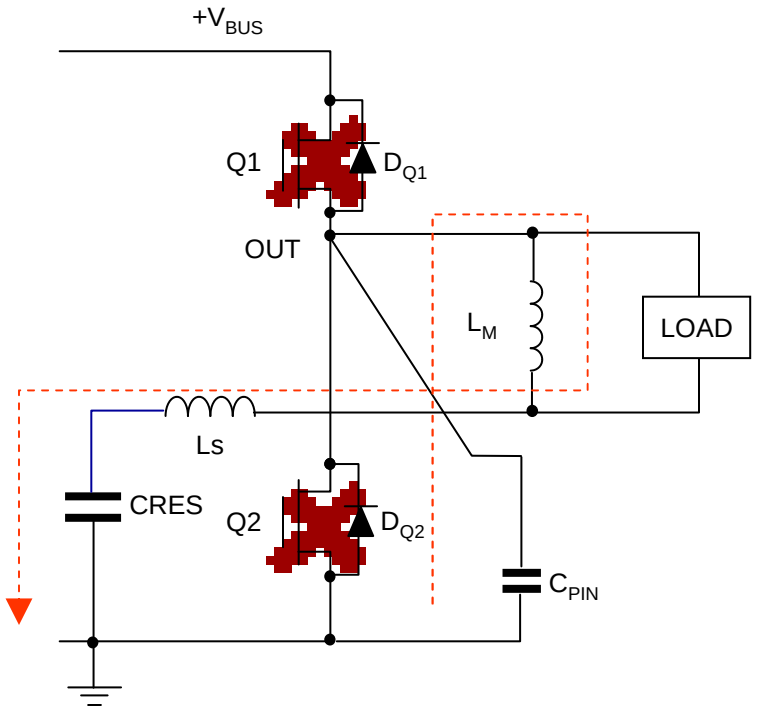
OPERATING SEQUENCE (1 of 5)



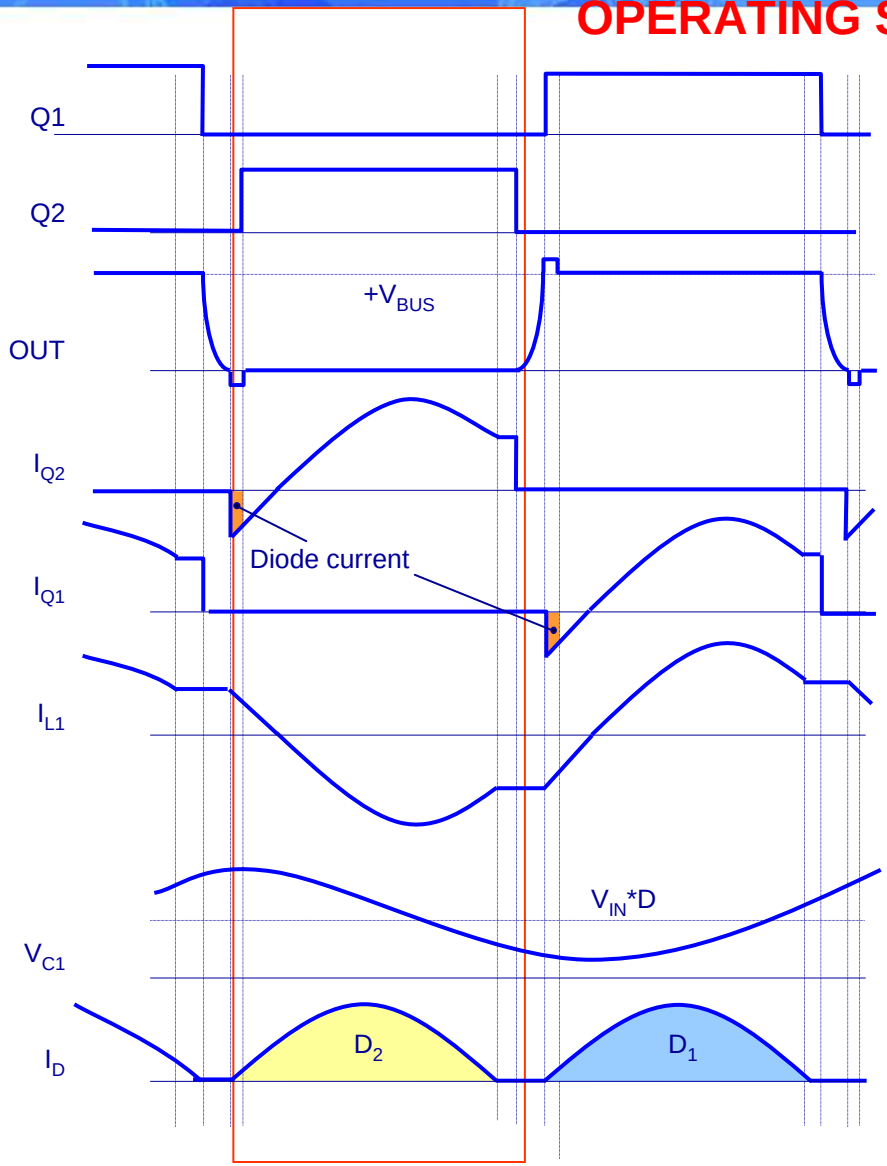


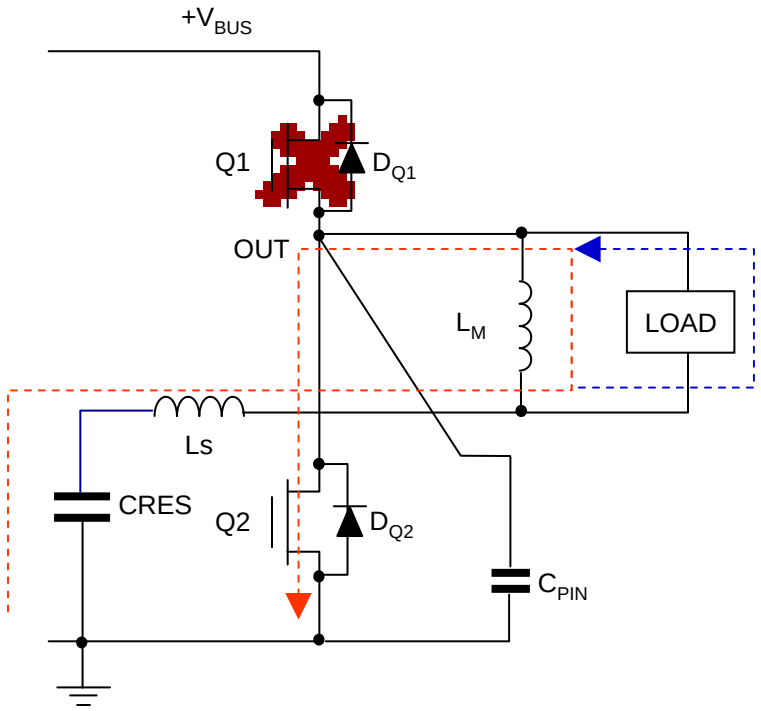
OPERATING SEQUENCE (2 of 5)



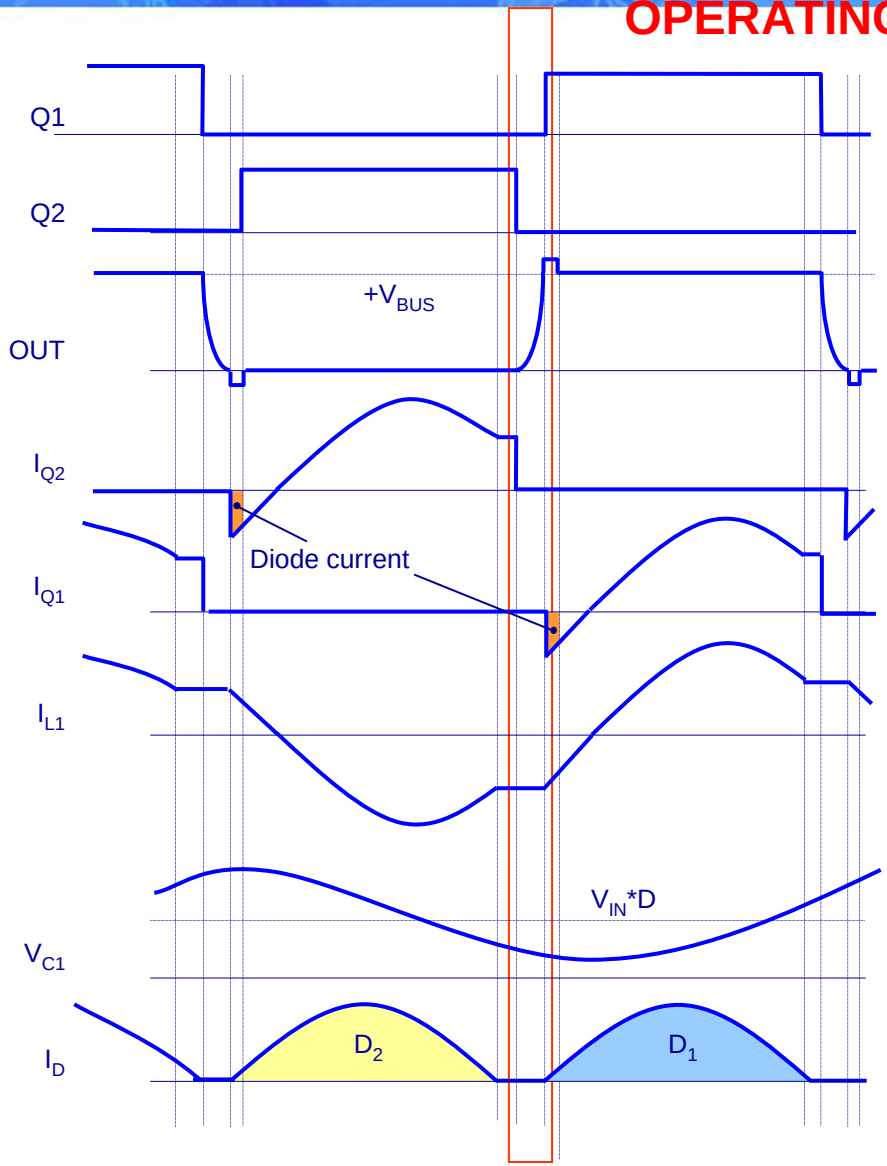


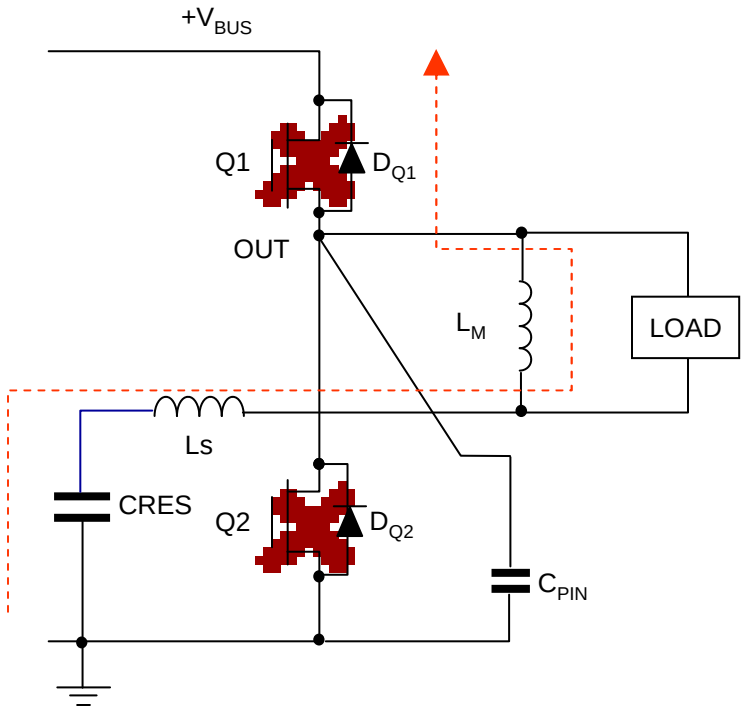
OPERATING SEQUENCE (3 of 5)



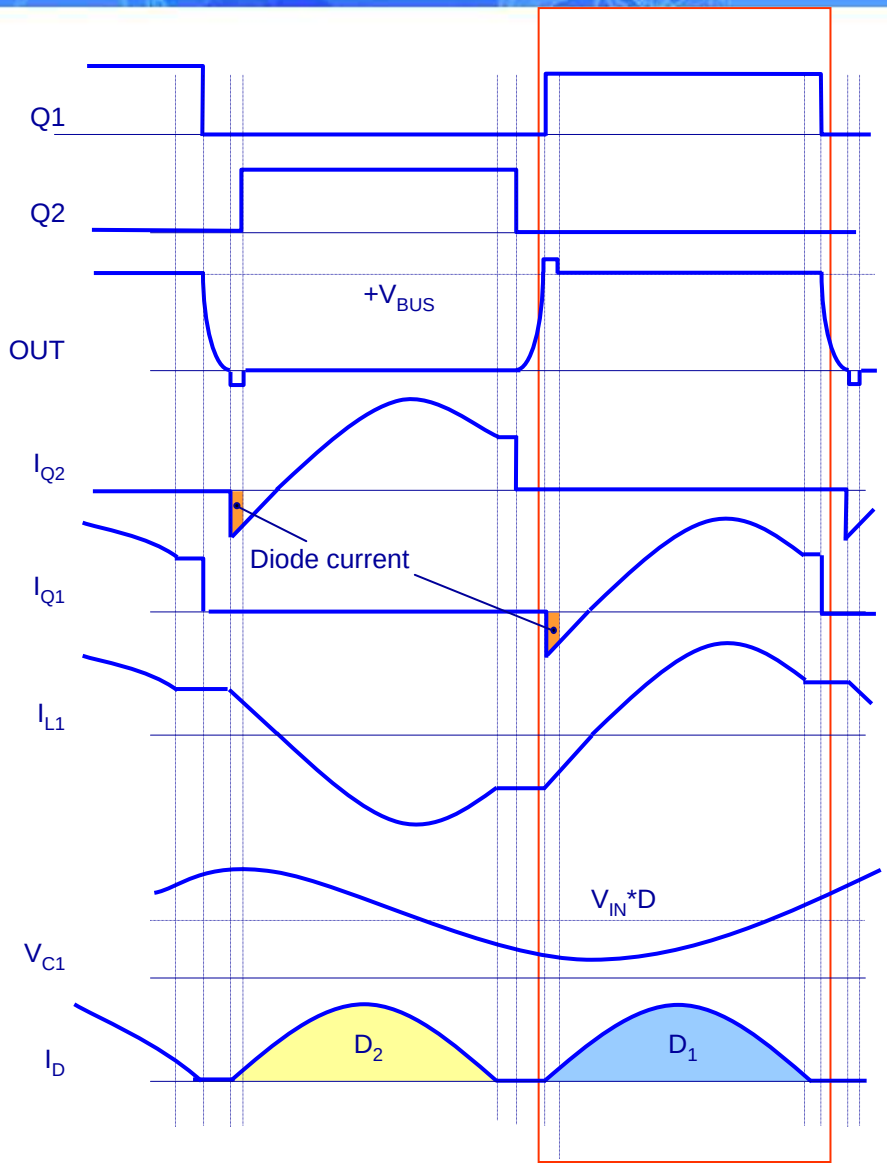


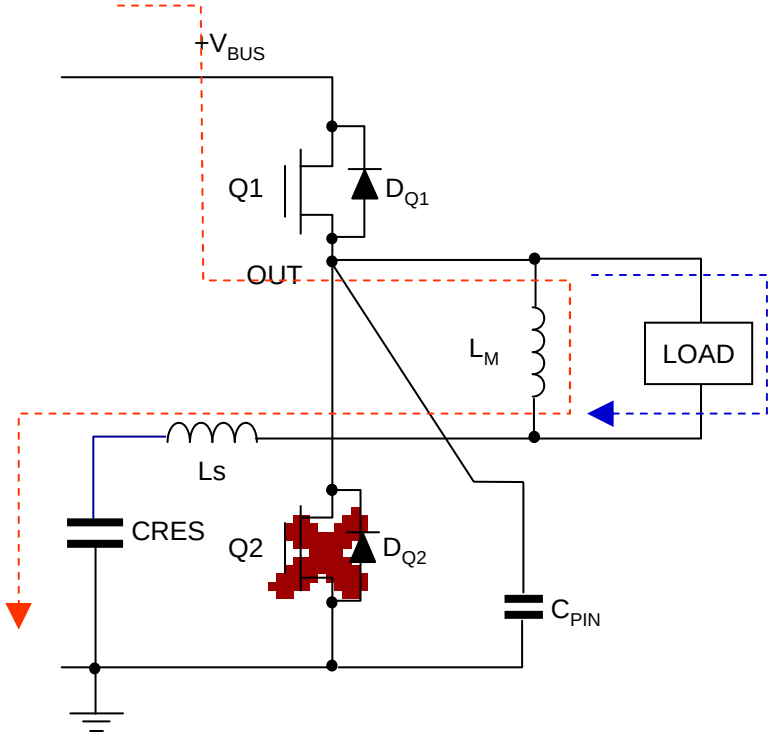
OPERATING SEQUENCE (4 of 5)





OPERATING SEQUENCE (5 of 5)



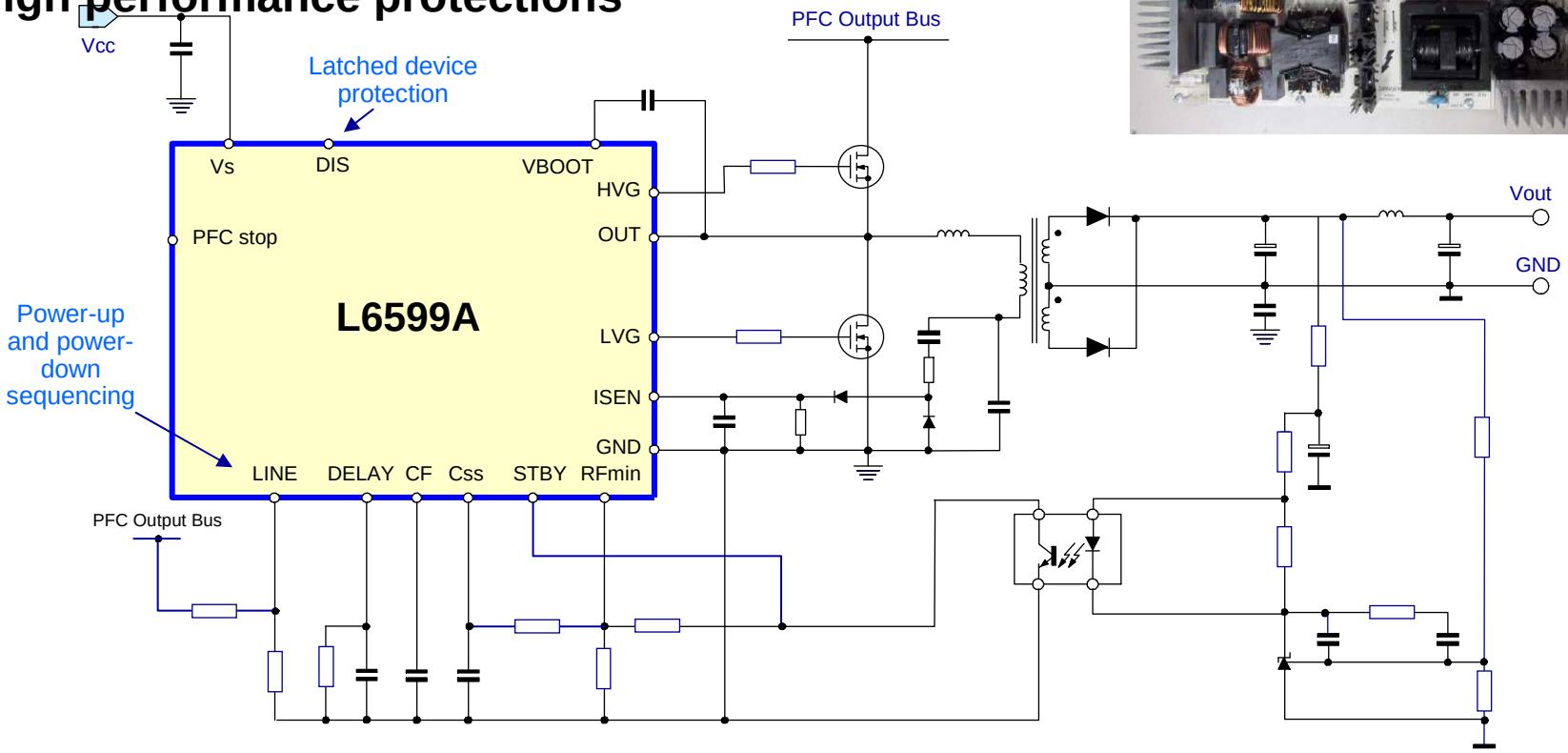


L6599A: an IC to remember

NEW

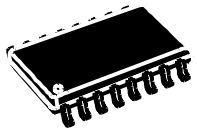
- **Superior stand-by performance (burst-mode operation at light load)**
- **Interface with PFC controller (L6561/62/63)**
- **High performance protections**

200/400W demoboard with L6563

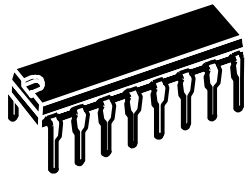


L6599A: an IC to remember

- **50% Duty Cycle, variable frequency control of ZVS resonant Half Bridge (HB)**
- **Up to 500KHz operating frequency**
- **Superior stand-by performance**
  - Burst-mode operating at light load
  - Direct interface with PFC controller



SO16N



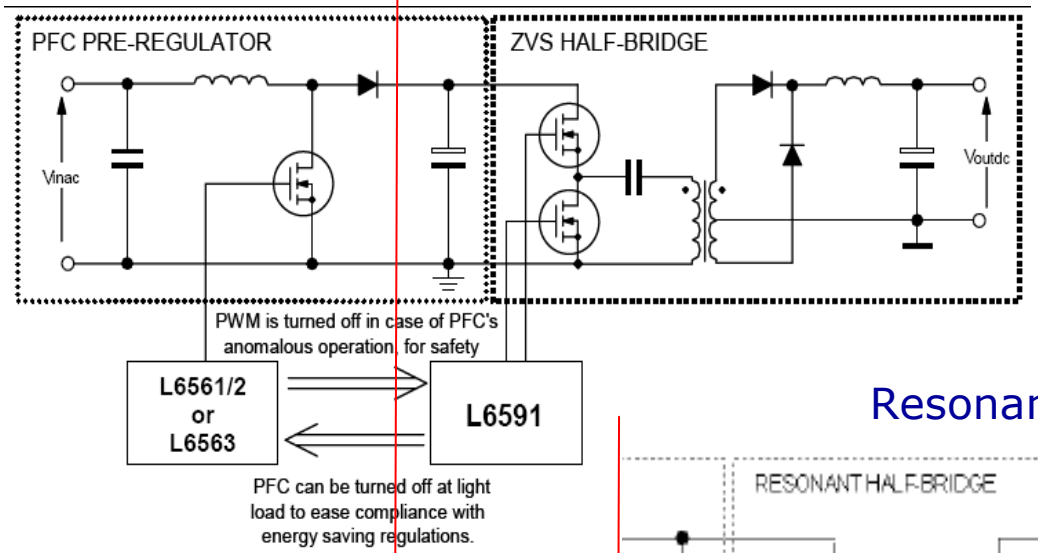
DIP16

- **High performance protections**
  - Two-level OCP: frequency-shift and latched shutdown
  - Latched disable input
  - Input for brownout protection or power ON/OFF sequencing
- **Non linear soft-start for monotonic output voltage rise**
- **High accuracy oscillator**
- **600V rail compatible high side gate driver with integrated bootstrap diode and high dV/dt immunity**
- **300/800 mA high side and low side gate drivers with UVLO pull-down**
- **Available in PDIP16 and SO16N packages**

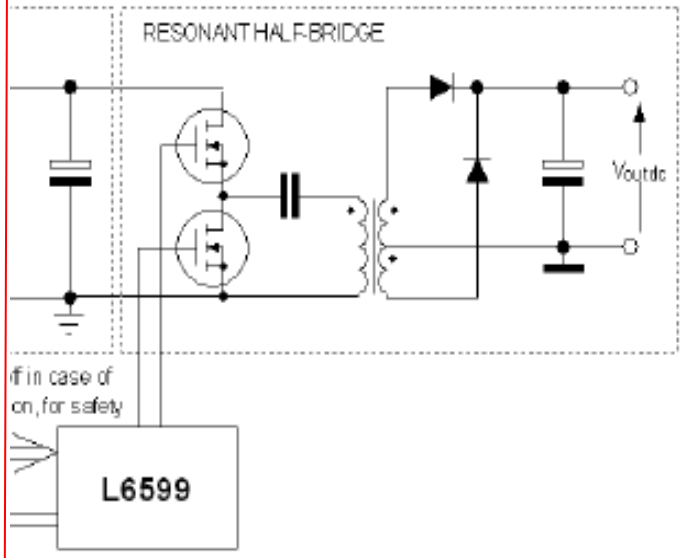
L6599A: promotional tools

- DATA SHEET: **AVAILABLE ON THE WEB**
- APPLICATION NOTES:
  - LLC RESONANT HALF-BRIDGE CONVERTER DESIGN GUIDELINE (***AN2450***)
  - 19V-90W ADAPTER BOARD WITH PFC USING L6599 AND L6563 (***AN2321***)
  - 400W L6599-BASED HB LLC RESONANT CONVERTER FOR PDP (***AN2492***)
  - 200W L6599-BASED HB LLC RESONANT CONVERTER FOR LCD TV & FLAT PANELS (***AN2393***)
- DEMO BOARDS:
  - 19V-90W BOARD WITH PFC USING L6599 AND L6563 (***EVAL6599-90W***)
  - 200W SMPS FOR LCD TV, USING L6599, L6563 and VIPer12A (***EVAL6599-200W***)
  - 400W SMPS FOR PDP USING L6599, L6563 and VIPer12A (***EVAL6599-400W-S)***
  - 400W GENERIC SMPS USING L6599, L6563 and VIPer12A (***EVAL6599-400W-T***)
  - 350W 80+ DESKTOP SMPS (IN DESIGN)
- DESIGN SOFTWARE:
  - L6599 RESONANT CONVERTER DESIGN WORKBOOK (EXCEL SPREADSHEET, AVAILABLE ON REQUEST)

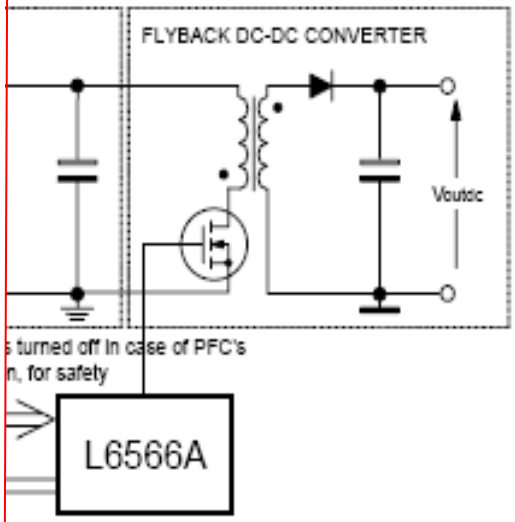
Fixed frequency pwm



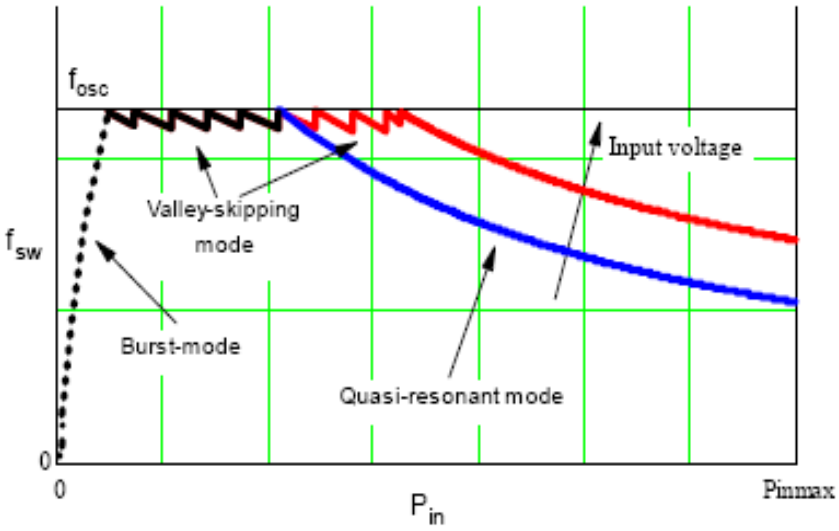
Resonant



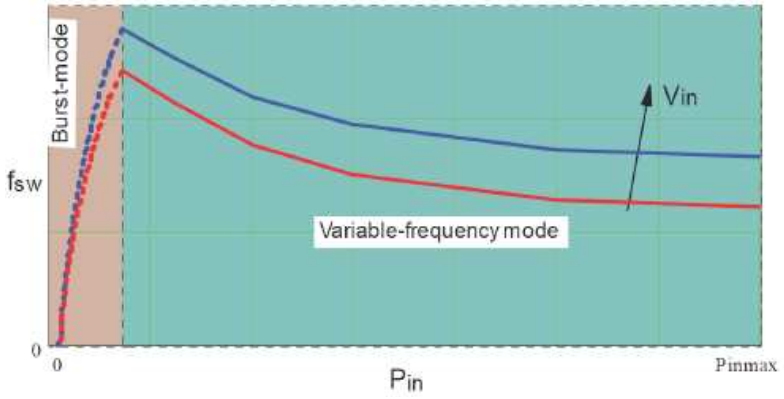
Quasi-resonant



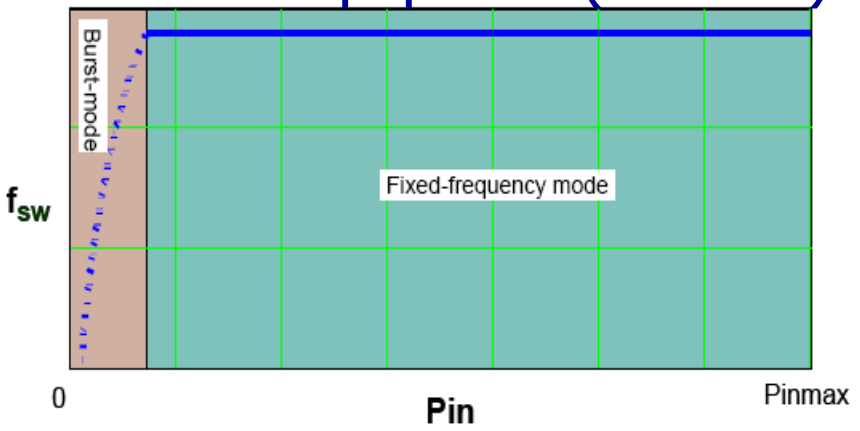
Quasi-resonant (L6566)



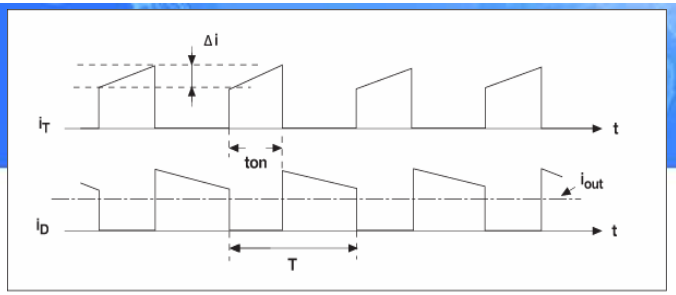
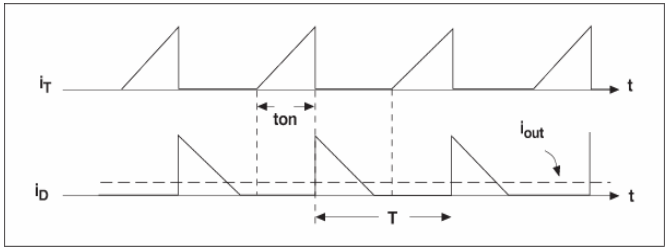
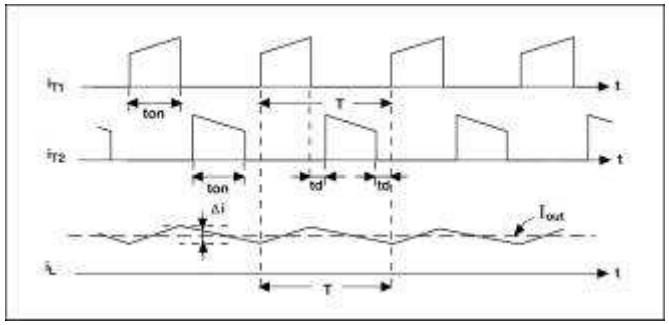
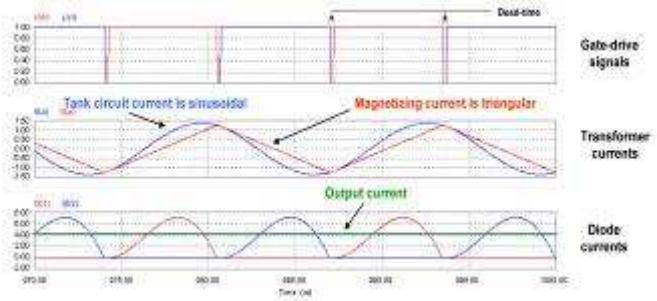
Resonant (L6599)



Fixed freq. pwm (L6591)



Summary

L6566	**PWM QR**	**Flyback**	**CCM**		Low peak current in rectifier and switch Low output current/voltage ripple respect to DCM (Cout lower than DCM) Recovery time rectifier losses (fast recovery diodes needed) Feedback loop difficult to stabilize – 2nd order system (2 poles and right half plane zero)
			DCM		Zero turn-on losses for the power switch Good transient line/load response (1st order system), feedback loop (single pole) easy to stabilize Recovery time rectifier not critical: current is zero well before reverse voltage is applied High peak current (high RMS) in rectifier and switch High output current/voltage ripple (Cout higher than CCM)
L6591	**PWM**	**ZVS Half Bridge**	**CCM**		High power capability ZVS: No switching losses @ on High operating frequency Low output peak current Low output ripple (Cout lower than Flyback) Recovery time rectifier losses (not symmetrical) Feedback loop difficult to stabilize – 2nd order system (2 poles and right half plane zero)
L6599	**RES**	**LLC**	**CCM DCM**		High power capability ZVS of HB MOSFETs & ZCS of output diodes: No switching losses @ on, very low @ off High operating frequency No recovery losses of output diode Very high noise immunity Complexity Feedback loop difficult to stabilize Peak current (RMS) in rectifiers and switches Output ripple

Application Summary

L6566A	PWM	AC-DC Adapters from 70 to 120W, High End Consumer
	QR	LCD TVs and Monitors (20 to 28”), SPMS for Printers > 70W, Auxiliary
L6566B	PWM	AC-DC Adapters from 25 to 70W, Low End Consumer
	QR	LCD TVs and Monitors < 20”, SPMS for Printers < 70W, Auxiliary
L6591	PWM	High Power AC-DC Adapters > 90W High Output Current SMPS Multiple output SMPS SMPS for Audio applications > 75W ATX Desktop PCs (80+, 85+ initiative)
L6599	RES	High Power AC-DC Adapters > 90W SMPS for Video application – LCD/PDP TVs > 28” High Output Voltage SMPS Servers (90+ initiative)

Robustness and effectiveness SMPS…..

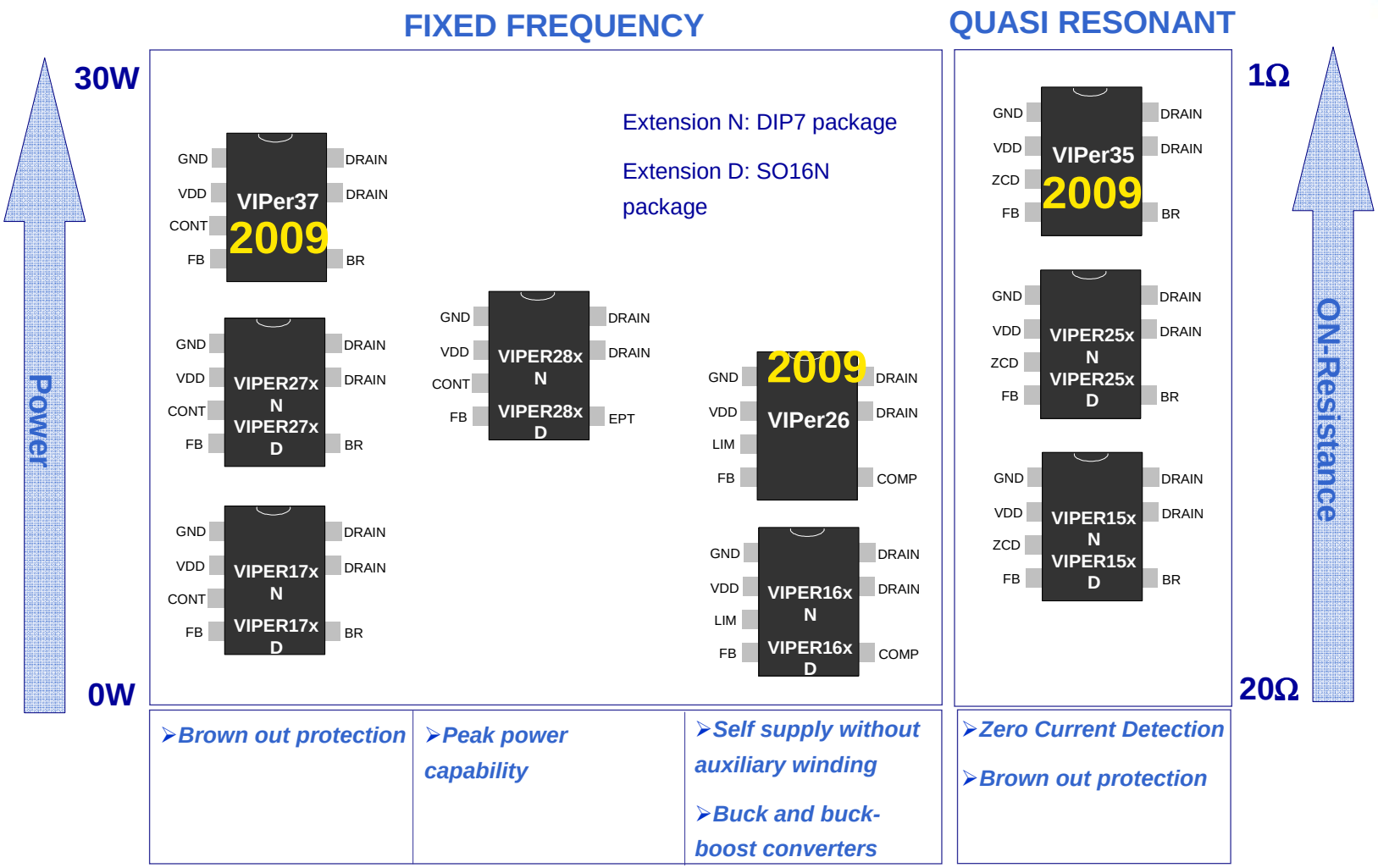
HIGH PERFORMANCES LOW CONSUMPTION HIGH RELIABILITY LOW COMPONENTS COUNTS ADVANCED TECNOLOGY HIGH PERFORMANCES LOW

…..with VIPer +

VIPer+ introduces:

- **AGGRESSIVE stand-by losses**
- **ROBUSTNESS power section and high level protection**
- **REDUCTION of total SMPS components count and EASY SMPS design**
- **PORTFOLIO differentiation: better TAILORED to specific applications**

VIPer+ introduces: +differentiation



* VIPER16xD, VIPER28xD, VIPER15xD: engineering samples available on request

* VIPER27xD, VIPER25xD, VIPER25xN: engineering samples on Q2/2009

VIPer+ selection ()	POWER SECTION: 800V avalanche rugged						
	20 Ohm			7 Ohm			
	400mA VIPER15	400mA VIPER16	400mA VIPER17	700mA VIPER25	700mA VIPER26	700mA VIPER27	800mA VIPER28
Fixed Frequency PWM current mode controller			√			√	√
Quasi Resonant PWM current mode controller	√			√			
Fixed frequency PWM current mode controller with embedded FA		√			√		
Limiting Drain current with adjustable set point	√	√	√	√	√	√	√
Fixed frequency (60kHz or 115kHz) with JITTERING		√	√		√	√	√
Advanced Stand-by management	√	√	√	√	√	√	√
Automatic Autorestart after fault	√	√	√	√	√	√	√
Advanced Over Load and short circuit management	√	√	√	√	√	√	√
Accurate Over Voltage Protection	√		√	√		√	√
Open loop failure detection		√			√		
Feed Forward Compensation	√			√			
On board soft start up	√	√	√	√	√	√	√
Hysteretic Thermal shut-down	√	√	√	√	√	√	√
Brown-out protection			√			√	
Extra Power Timer for Peak Power management							√
Eliminates bias winding supply		√					
Packages	DIP7 & SO16N			DIP7 & SO16N			
Maximum output power with European range	up to 10W			up to 20W			

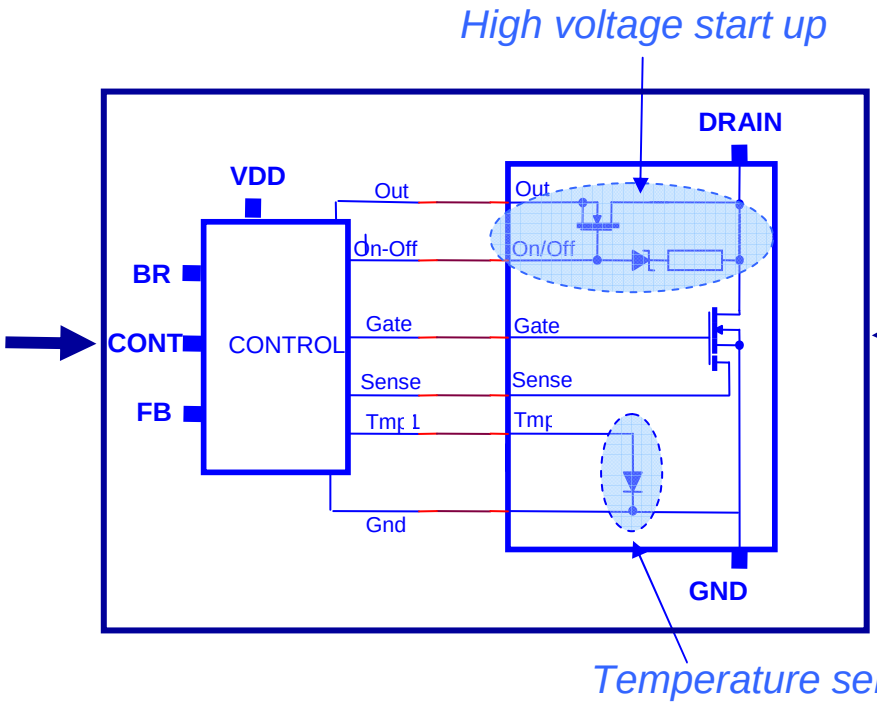
VIPer+ selection (by SMPS topology)	800V avalanche rugged						
	20 Ohm			7 Ohm			
	400mA	400mA	400mA	700mA	700mA	700mA	800mA
	VIPER15	VIPER16	VIPER17	VIPER25	VIPER26	VIPER27	VIPER28
Buck converter		√			√		
Buck-Boost converter		√			√		
Fly-back isolated converter	√	√	√	√	√	√	√
Fly-back primary regulation converter	√	√ ☺	√	√	√ ☺	√	√
Fly-back non isolated converter	√	√ ☺	√	√	√ ☺	√	√
	up to 10W			up to 20W			

Home appliances	Consumer equipments	Metering equipments	Battery Charger	Lighting
2-10W	5-40W	4-8W	4-6W	2-8 Leds
VIPer17	VIPer17	VIPer16	VIPer16	VIPer16
VIPer16	VIPer27	VIPer17	VIPer17	VIPer17
VIPer27	VIPer28	VIPer27	VIPer15	VIPer27
VIPer28	VIPer15	VIPer28		VIPer28
VIPer15	VIPer16	VIPer15		VIPer15
	VIPer53x			

New double chip approach helps in flexibility

BCD6

Mixed Signal



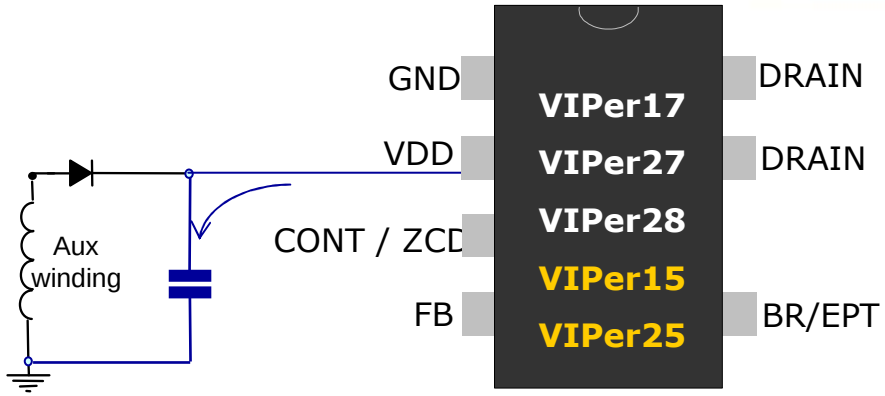
SuperMESH ,

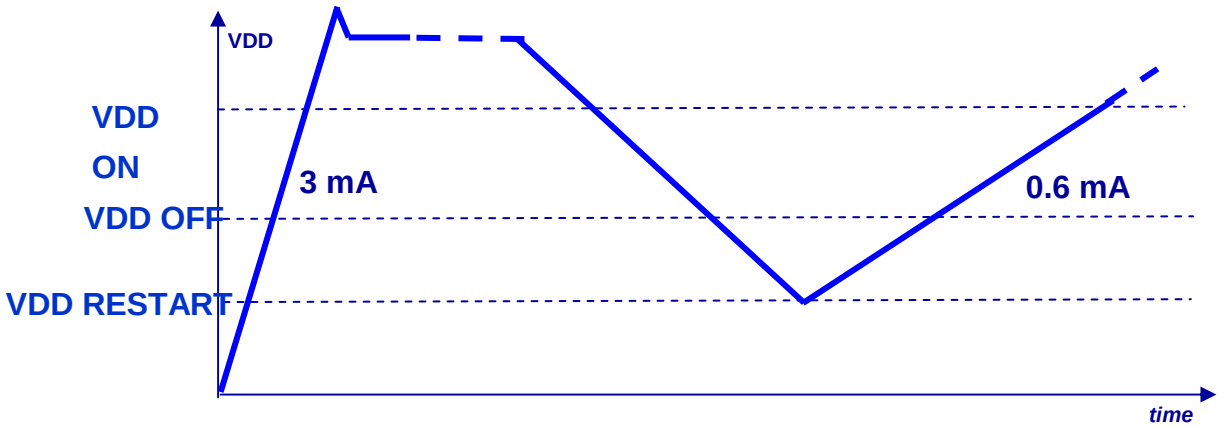
800V avalanche rugged

VDD pin

- HV start up current generator

  (typ, 3mA or 600uA after a fault)
- Start up threshold (typ, 14V)
- Auto-restart threshold (typ, 4.5V)
- Turn-off threshold (typ, 8.5V)
- VDD from 8.5V to 23V (with clamp)
- VDS START 80V





VDD

- HV Current Source:

  enabled only if V(DRAIN)>$V_{DRAIN\ START}$ (50V typ.)

  I_{DDch1} **(typ, 1mA):** **during start up**

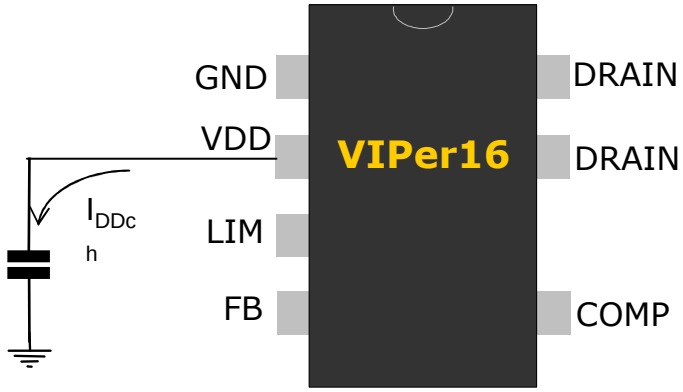
  I_{DDch2} **(typ, 10mA)** **during steady state**

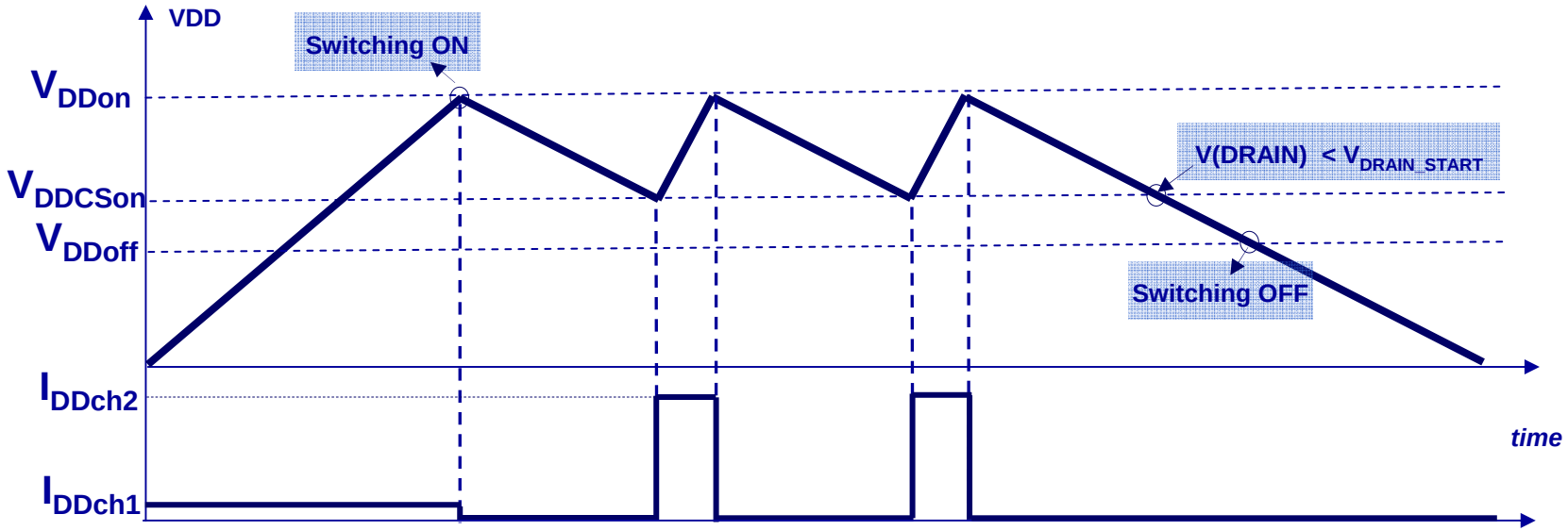
- Three VDD thresholds:

  V_{DDon} **(typ, 13V):** **Start Up threshold**

  V_{DDoncs} **(typ, 10.5V):** **Current Source ON threshold**

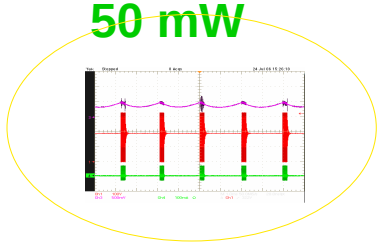
  V_{DDoff} **(typ, 7V):** **Switching OFF threshold**

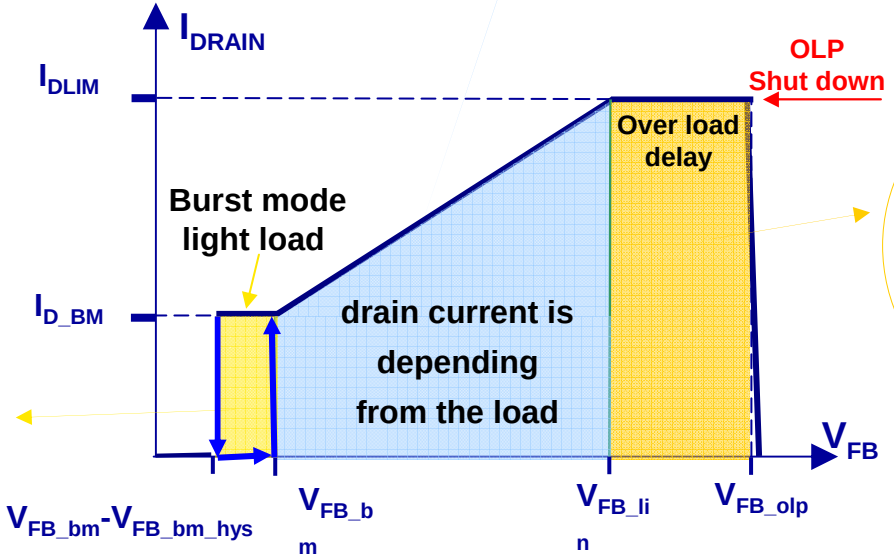


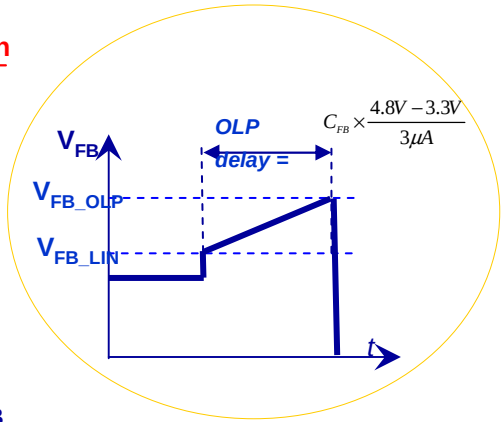


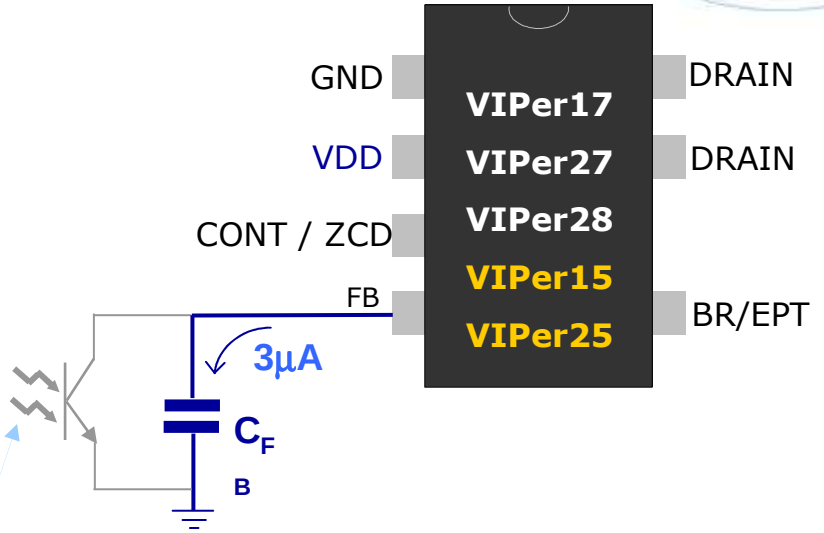
FB pin

- Loop compensation for PWM operations
- Over load protection
- Burst mode sensing









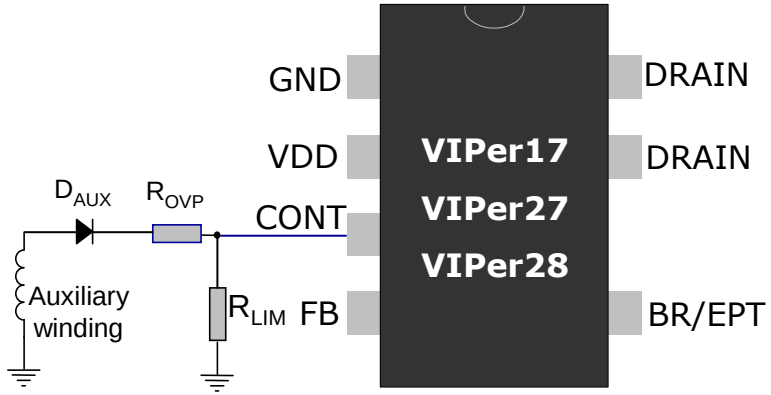
CONT pin

- Adjustment of the current limit set point

  default value when the pin is floating (or R_{LIM}>100kOhm)

- Over voltage protection (OVP)

  with digital filter for noise immunity



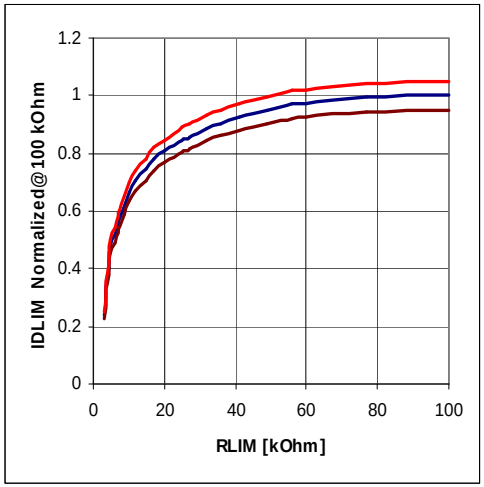
I_{DLIM} default value	
VIPER17	400mA
VIPER27	700mA
VIPER28	800mA

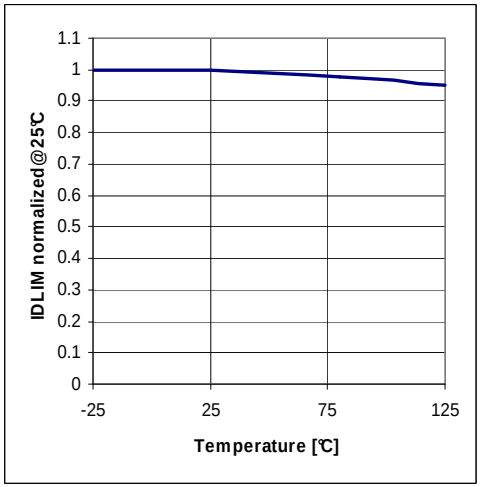
I_{DLIM} ± 5%

T_J 27℃

I_{DLIM} ± 10%

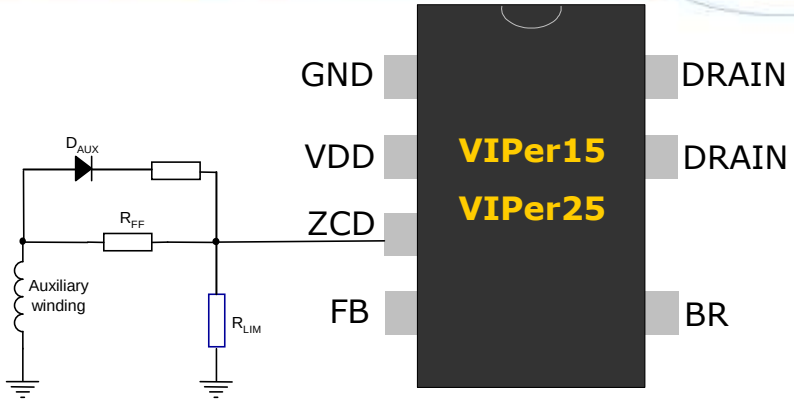
T_J *from* **-25℃** *to* **125℃**

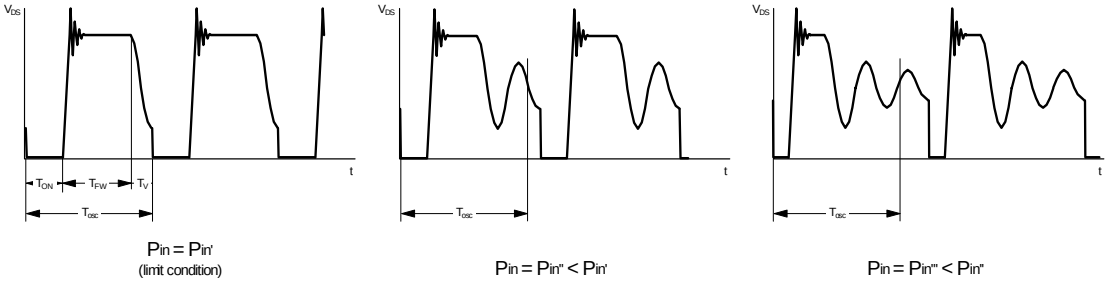




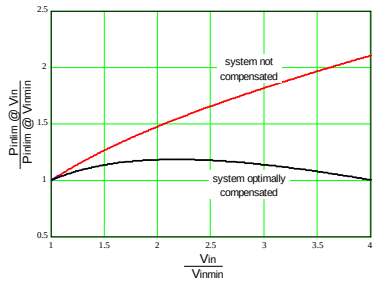
ZCD pin *(only for quasi-resonant VIPer15 & 25)*

- Zero Current Detection
- Line feed-forward compensation
- Current Limit set point (I_{DLIM})
- Output over voltage protection (OVP)

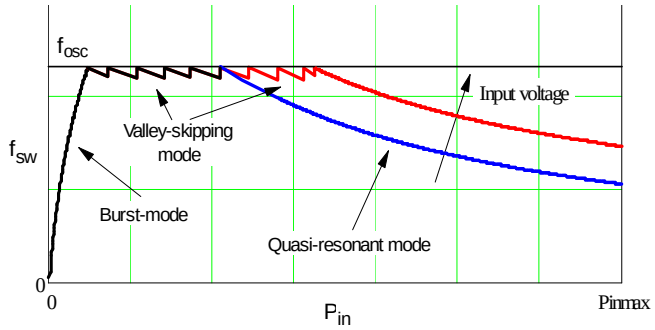




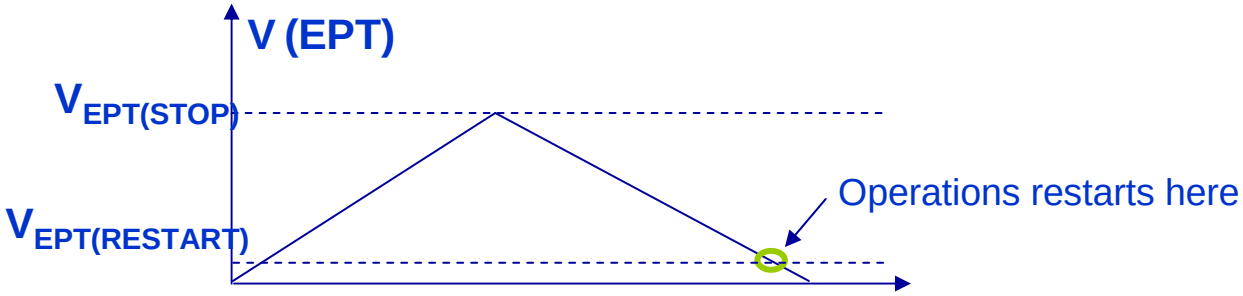
Feed forward compensation

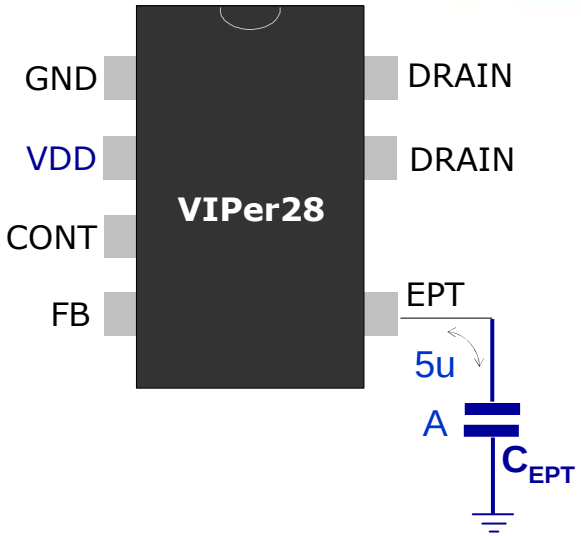


QR operation with top frequency limited



EPT pin *(Only VIPer28)*



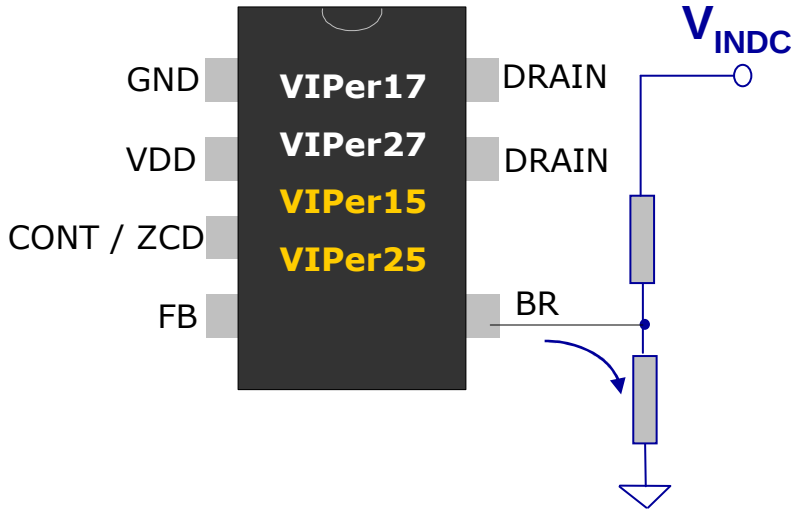


Extra Power Timer ***for extra power capability***

- **I_{Dlim} = 800mA**
- **I_{Dlim_EPT} = 85% I_{DLIM}**
- ***When I_{DRAIN} is higher then I_{Dlim_EPT} a delay time starts: the time depends from C_{DOVL}***
- ***After the delay time if the over load is still present the converters is switched OFF***

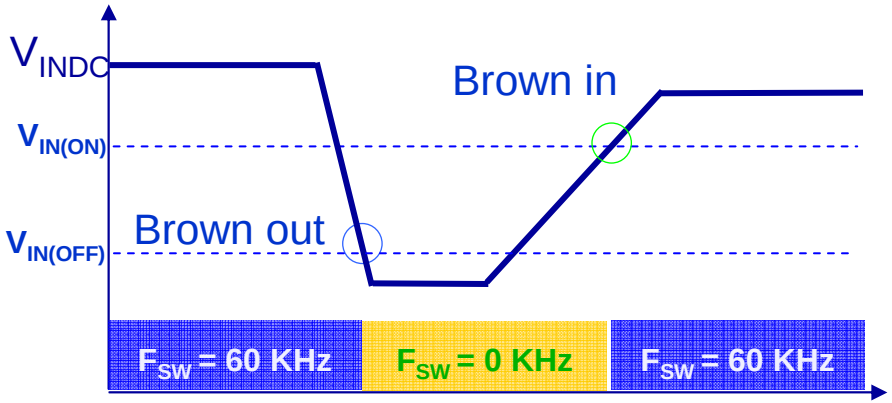
BR pin *(only VIPer17, 27, 15 &25)*

BROWN OUT PROTECTION



Switching is stopped* **if the BR pin voltage (V_{BR}) fall down the V_{BRTH} threshold (450mV, typ value).**

Double V_{BRTH} hysteresis: current and voltage.



Feature

STOP CONVERSION WITH LOW INPUT VOLTAGE

Advantages

1) Reduce the RMS current

2) Monotonic output voltage during the turn off

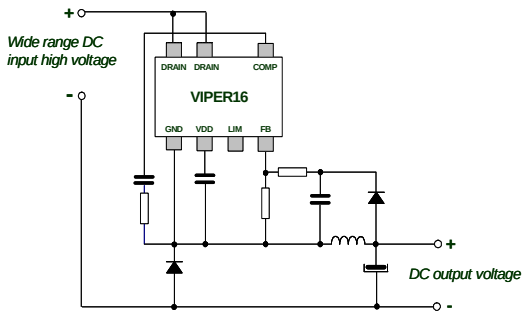
**** Function is disabled if BR is connected to GND.***

VIPer16

Innovation and

Solutions for replacement of capacitive power supply

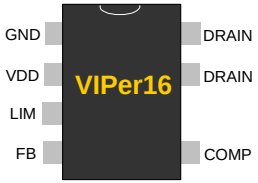
Auxiliary power supply for: Home appliances, Power metering, LED drivers



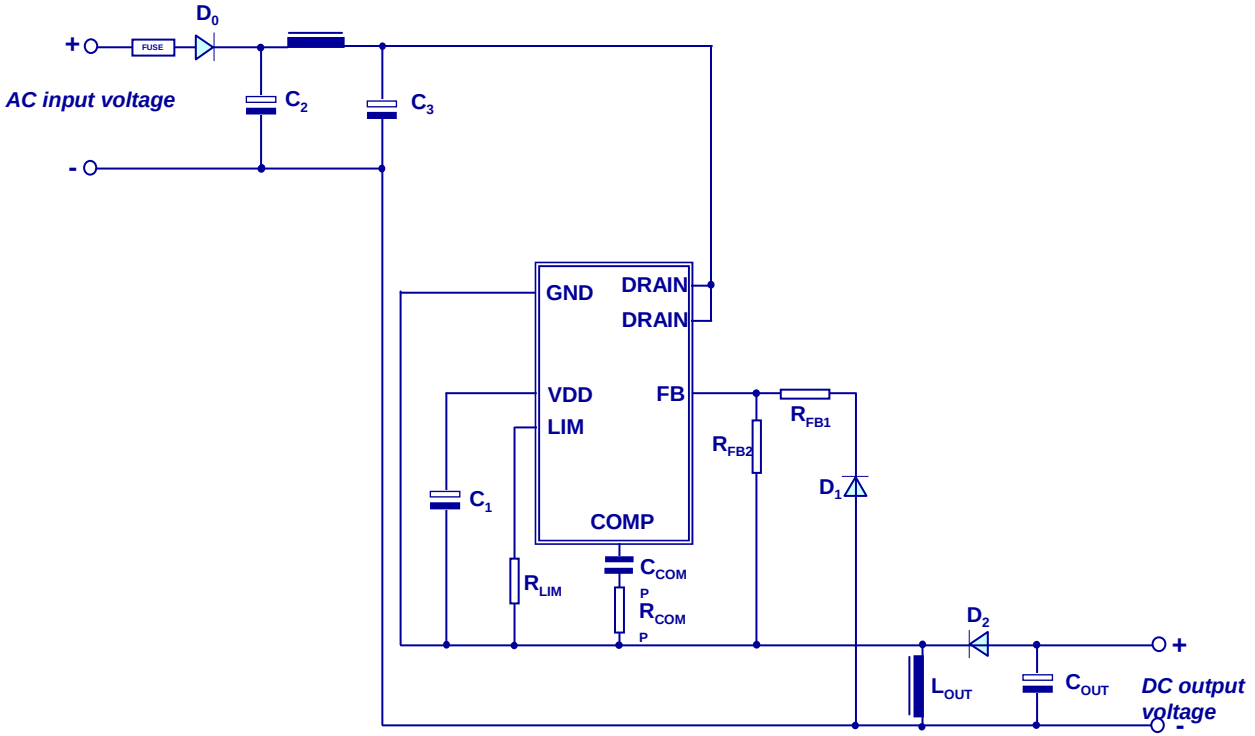
- **800V avalanche rugged power section**
- **Frequency jitterring for low EMI**
- **Two operating fixed frequency: 60 or 115 kHz**
- **Automatic self-supply**
- **Limiting current with adjustable set point**
- **Safe auto restart after a fault condition**
- **Hysteretic thermal shutdown**
- **Advanced protections: over load and feedback loop failur**

Buck-Boost converter

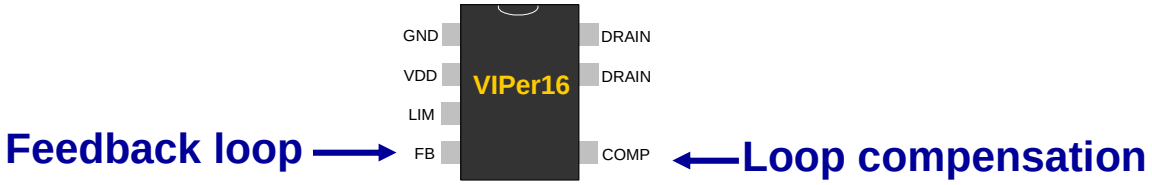
Innovation and

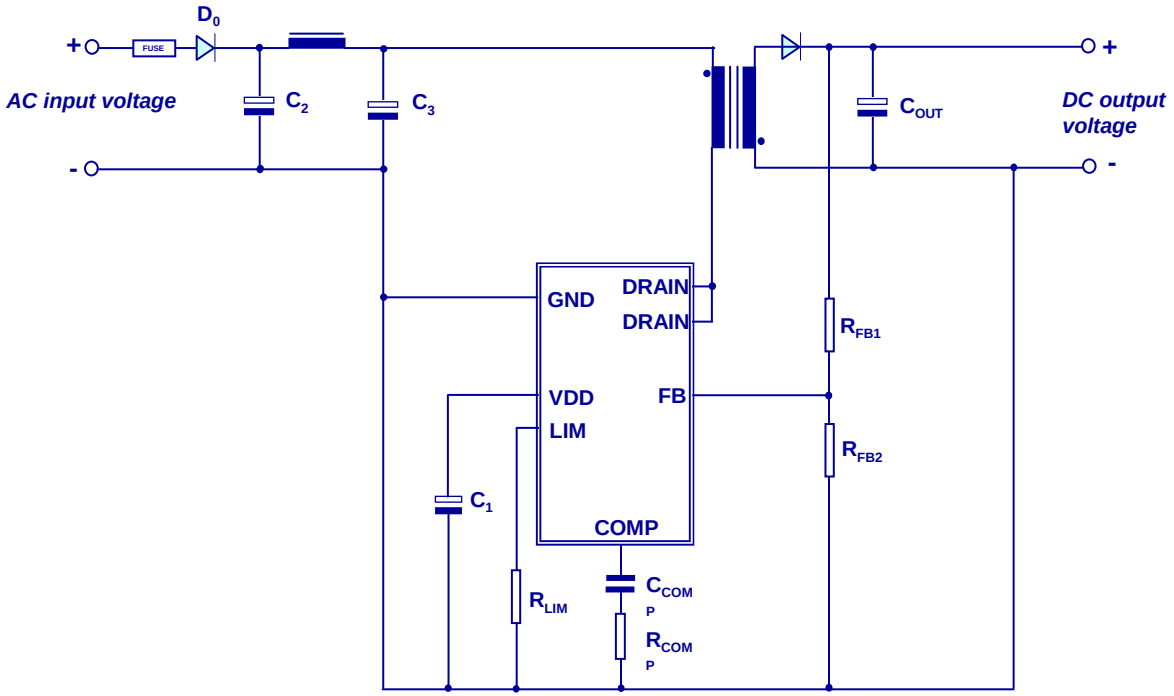


Feedback loop → ← **Loop compensation**

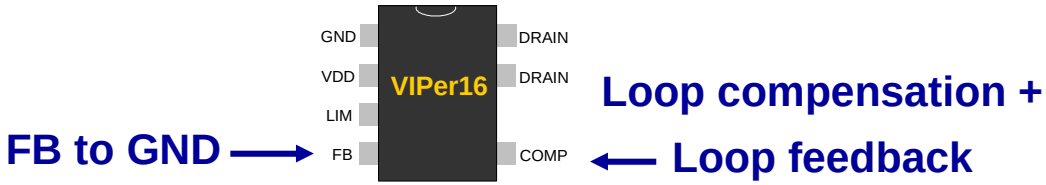


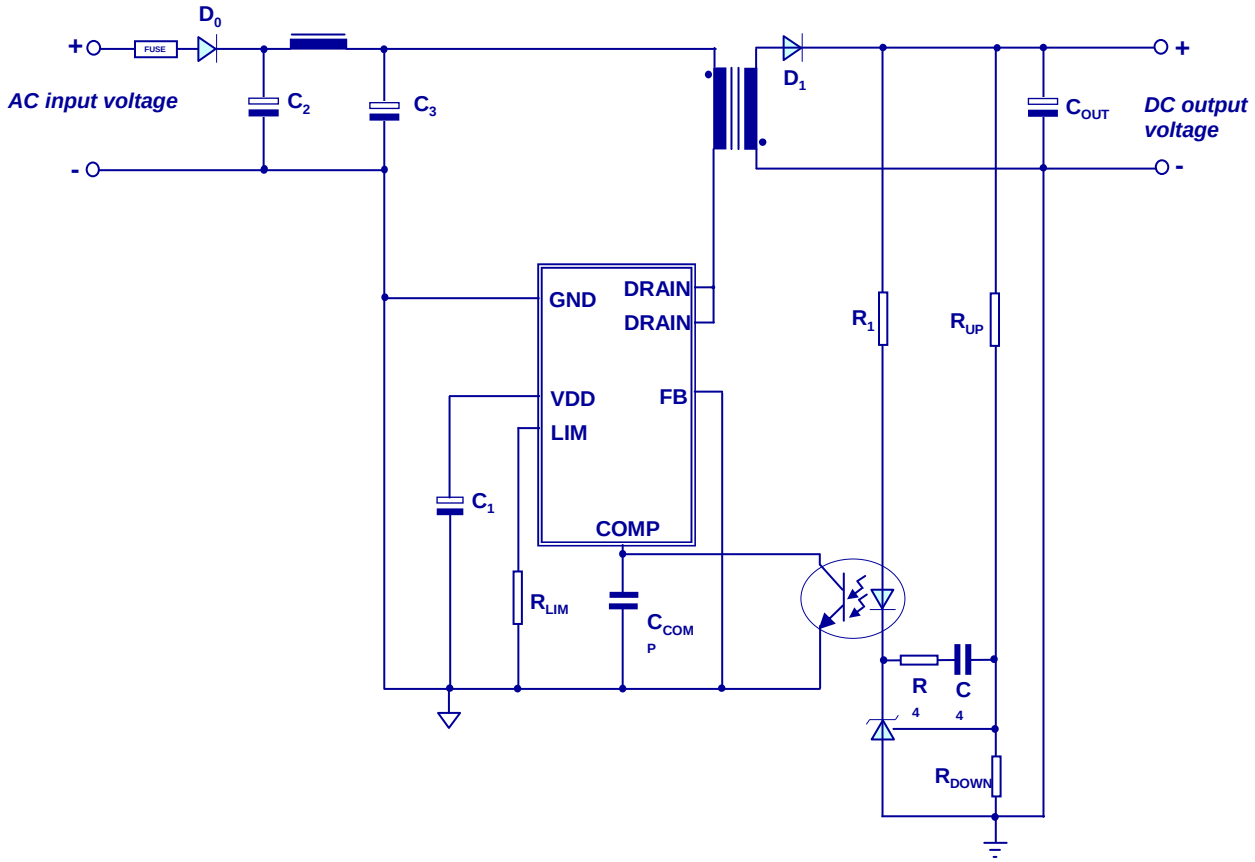
Fly-back converter, nonisolated





Fly-back converter, isolated





Evaluation Boards

ORDER CODE	PART NUMBER	DESCRIPTION	APPLICATION NOTE	INPUT VOLTAGE	OUTPUT VOLTAGE	OUTPUT CURRENT
STEVAL-ISA060V1	**VIPER17HN**	**Off line isolated FLY-BACK**	**AN2753**	**85-265VAC**	**12V**	**500mA**
EVALVIPER17L-6W	**VIPER17LN**	**Off line isolated FLY-BACK**	**AN2803**	**85-265VAC**	**12V**	**500mA**
EVLVIP17-5WCHG	**VIPER17HN**	**Off line isolated FLY-BACK for Battery Charger**	**TBD**	**85-265VAC**	**5V**	**1A**
STEVAL-ISA058V1	**VIPER17LN**	**High performance VIPER17LN Demo (Low consumption in Stand-by and low low Load).**	**TBD (draft document)**	**85-265VAC**	**5V**	**1A**
STEVAL-ILL017V1	**VIPER17HN**	**Off line non isolated FLY-BACK for constant current LED driver**	**AN2811**	**220VAC ±20%**	**7V max**	**500mA**
EVLVIPER28H-10W	**VIPER28HN**	**Off line isolated FLY-BACK**	**TBD**	**85-265VAC**	**5V**	**2.4A**
EVLVIPER28L-10W	**VIPER28LN**	**Off line isolated FLY-BACK**	**TBD**	**85-265VAC**	**5V**	**2.4A**
EVLVIPER16H-4WFN	**VIPER16HN**	**Off line non isolated FLY-BACK**	**TBD**	**85-265VAC**	**16V**	**250mA**
EVLVIPER16L-4WFN	**VIPER16LN**	**Off line non isolated FLY-BACK**	**TBD**	**85-265VAC**	**16V**	**250mA**
EVLVIPER16H-4WFL	**VIPER16HN**	**Off line isolated FLY-BACK**	**TBD**	**85-265VAC**	**16V**	**250mA**
EVLVIPER16L-4WFL	**VIPER16LN**	**Off line isolated FLY-BACK**	**TBD**	**85-265VAC**	**16V**	**250mA**
TBD	**VIPER16LN**	**Buck converter with ultra input wide range**	**AN_TBD (draft document available)**	**85-500VAC**	**+12V, +5V**	**150mA (total)**

Power & Analog program

European Multi System Market Competence Center

POWER CONVERSION - agenda

- Power conversion
  - **SMPS**
    - Main topologies quick roundup
    - Power Factor Correction
    - PWM (offline & HV DCDC)
    - **Low Voltage DC-DC Converters**
  - Lighting
    - Fluorescent ballast
      - Analog driven
      - Digital driven / advanced
    - HID
    - LED / DISPLAY DRIVER
      - DC / DC driven
      - Offline driven
      - Display control

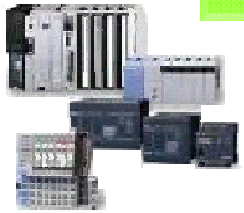
High Efficiency Monolithic Switching Regulators to suit different markets

Major area of focus:* enlarge *product portfolio for: Industrial, Consumer, Peripheral, Telecom and Battery powered equipments

Computer & Peripheral → Peripherals: Printers, Mouse, Ext./Int. Data storage — **L497x, L597x, L598x**

Consumer →
- Office/Home entertainment: PDP/LCD TV Monitors, STB, DVD, Games — **L497x, L597x, L598x**
- Hand-Held Equipment: PDA, MP3, DSC, GPS — **L692x**

Automotive & Industrial → Power train, car body, PLC, PLA — **L497x, L597x, L598x A597x**



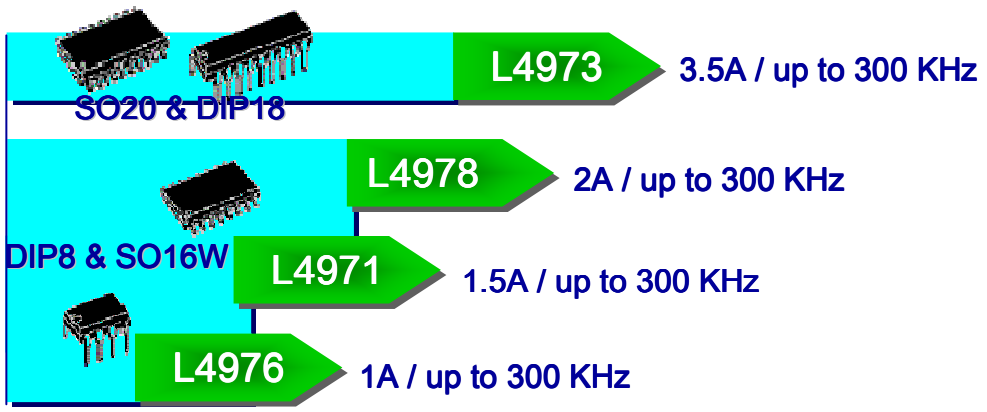
Data-Com. →
- XDSL Modems
- Video Phone
- WLess Access point

— **L597x, L598x**

L497x family

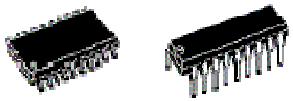
- Up to 3.5A available both in DIP and SO packages
- Wide voltage input range (8V up to 55V) and output range (0.5V up to 50V)
- Internal current limit
- Inhibit pin*
- OVP*
- External reference**

Suggested for new projects When Vin>36V and Iout>2A



Device	Package	Ipk [A]	Iout [A]	Vin (V)	Vout (V)	Fsw [KHz]	Extra functions
L4976	DIP8, SO16W	1.5	1	8V to 55V	0.5 to 50	up to 300	Vref
L4971	DIP8, SO16W	2	1.5	8V to 55V	3.3 to 50	up to 300	Inhibit
L4978	DIP8, SO16W	2.5	2	8V to 55V	3.3 to 50	up to 300	Inhibit
L4973 v.3.3	DIP18, SO20	4	3.5	8V to 55V	0.5 to 50	up to 300	Inhibit, Vref, Sync
L4973 v.5	DIP18, SO20	4	3.5	8V to 55V	5.1 to 50	up to 300	Inhibit, Vref, Sync

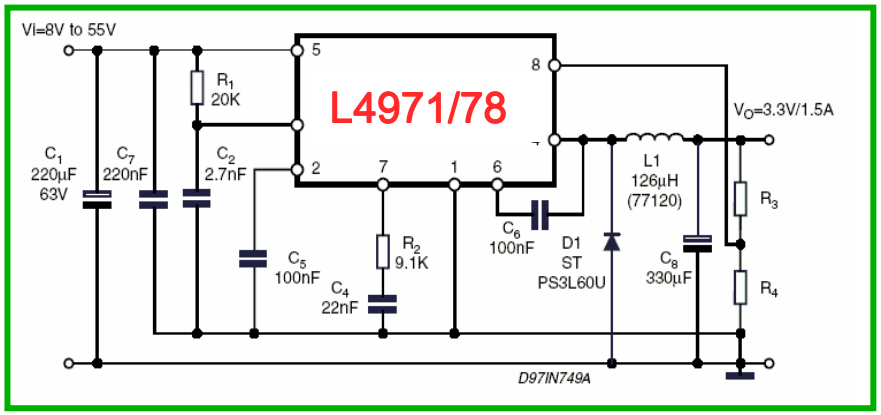
* all but L4976 , **L4976 and L4973

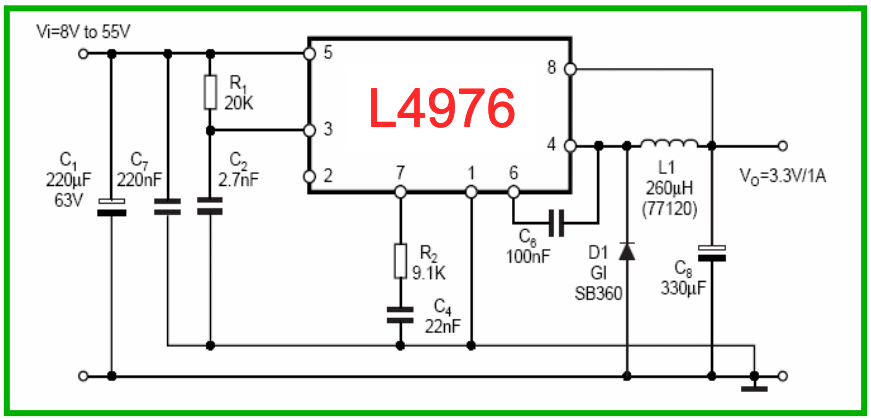


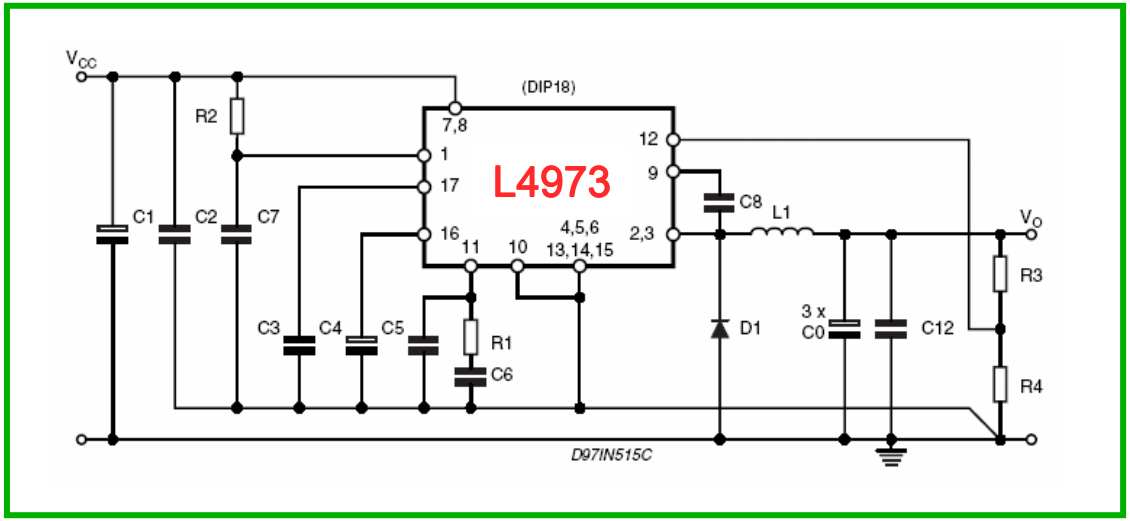
DIP18 & SO20

DIP8 & SO16W

L497x: Application Circuits

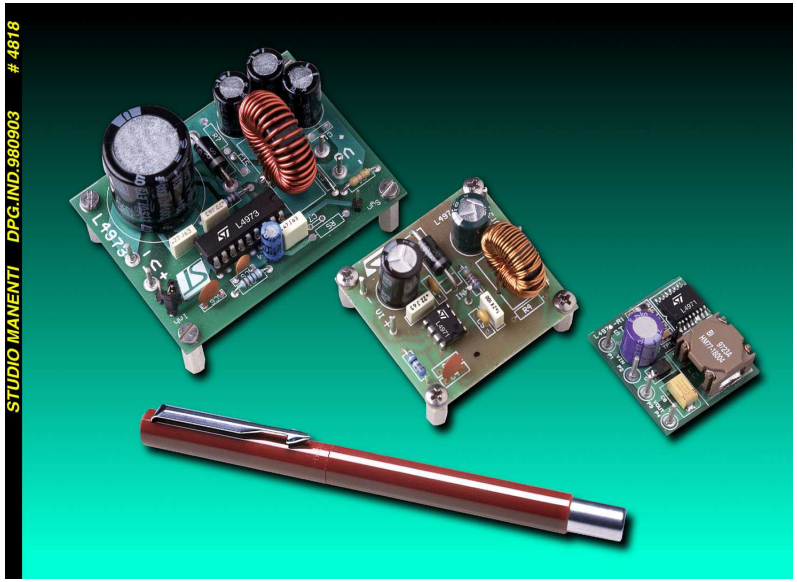






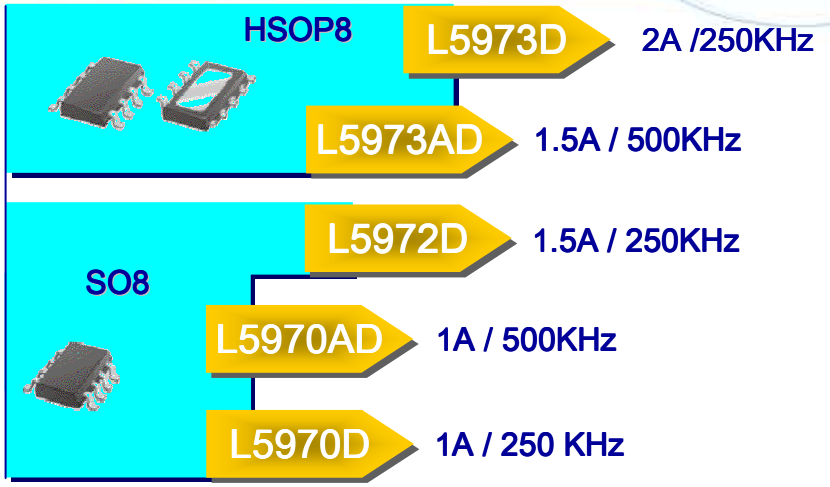
L497x Promotional Tools

P/N	Datasheet	Application note	Evaluation Board
L4976	available	-	-
L4971	available	AN937	EVAL4971
L4978	available	AN1061	EVAL4971
L4973	available	AN938, AN1126	EVAL4973



L597x Family

- More than 2A in small SO8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (4.4V up to 36V)
- High switching frequency (250KHz/500KHz, sync up to 700KHz*)
- Inhibit pin*
- Embedded protection features
- Typ R_{DSon}=250mΩ

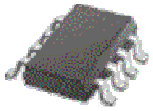


Suggested for new projects When Vin>18V

Device	Package	Ipk [A]	Iout [A]	Vin (V)	Vout (V)	Fsw [KHz]	Extra functions
L5970D	SO8	1.5	1	4.4V to 36V	0.5V to Vin	250	Inhibit, Vref, Sync
L5970AD	SO8	1.5	1	4.4V to 36V	0.5V to Vin	500	Inhibit, Vref, Sync
L5972D	SO8	2	1.5	4.4V to 36V	1.23V to Vin	250	-
L5973AD	HSOP8	2	1.5	4.4V to 36V	0.5V to Vin	500	Inhibit, Vref, Sync
L5973D	HSOP8	2.5	2	4.4V to 36V	0.5V to Vin	250	Inhibit, Vref, Sync

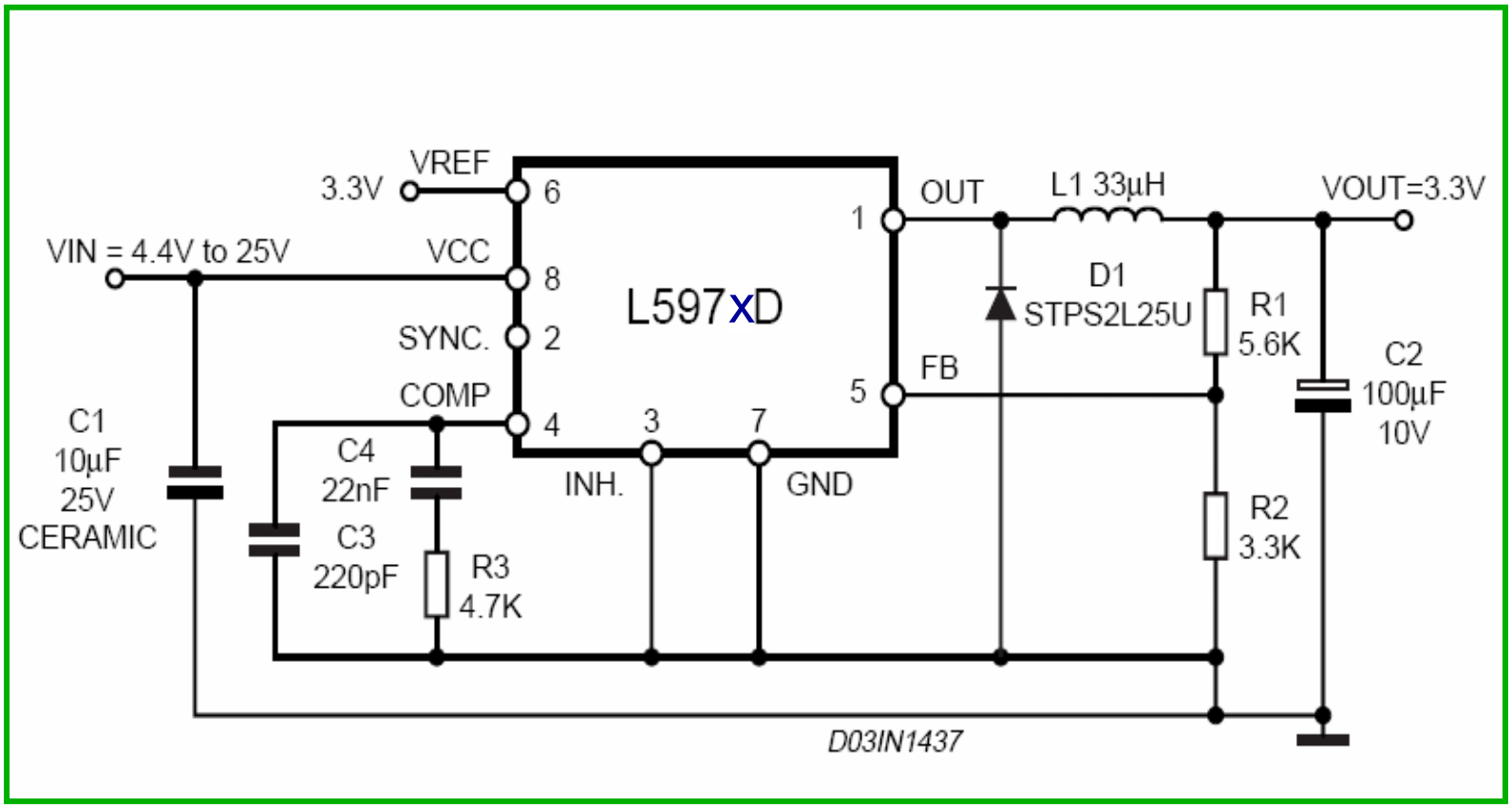
* all but L5972D

HSO8 - Rth j-amb 40C/W



SO8 - Rth j-amb 115C/W
Rth j-amb 62C/W for L5972D

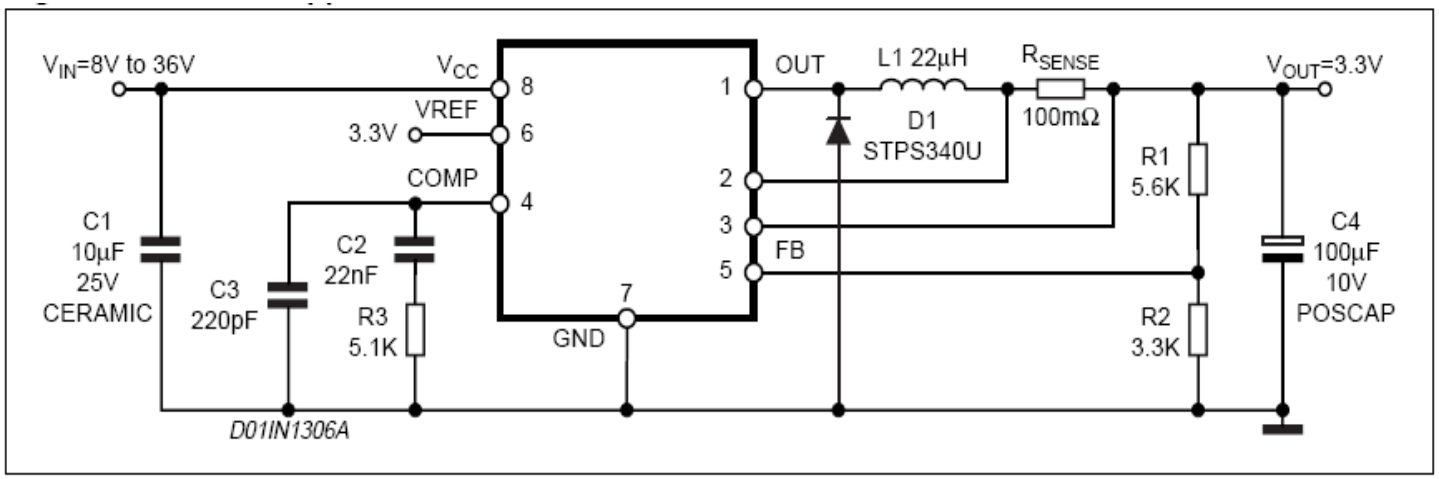
L597x: Test Application Circuit



L6902D Key Features

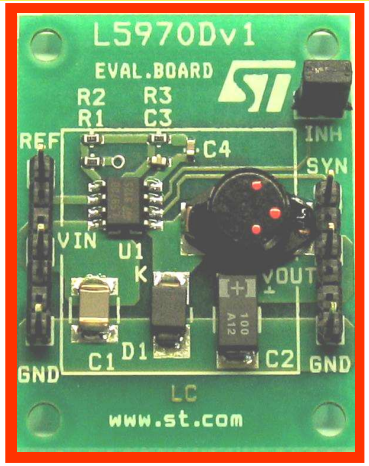
- 1A in small SO8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (8V up to 36V)
- Adjustable current limit (V_{CS+} - V_{CS-}=100mV)
- High switching frequency (250KHz)
- External V_{REF} available
- Embedded protection features
- OVP available when driving LED

SO8 - Rth j-amb 115°C/W



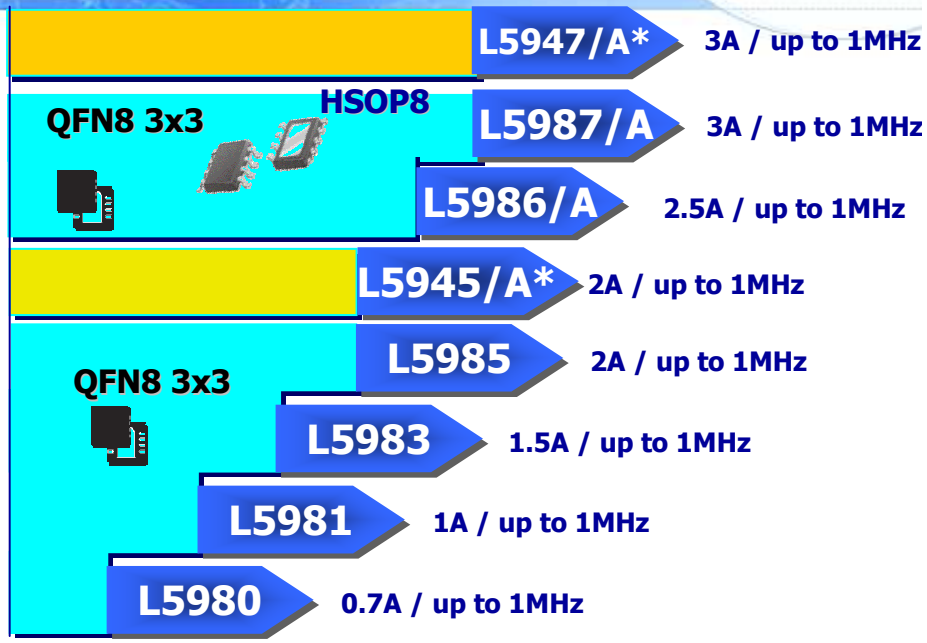
L597x promotional tools

P/N	Datasheet	Application note	Evaluation board
L5970D	available	AN1330	EVAL5970D
L5970AD	available	--	
L5972D	available	AN1517	EVAL5972D
L5973D	available	AN1518	EVAL5973D
L5973AD	available	AN1723	EVAL5973AD
L6902D	available	Data brief	EVAL6902D



L598x Family

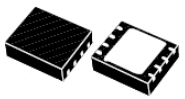
- Up to 3A in small QFN3x3-8L or HSOP8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (2.9V up to 18V)
- High switching frequency (250KHz, adjustable up to 1MHz) with Synchronization capability (180° out of phase)
- Internal Soft-start
- Inhibit pin
- Embedded protection features
- Suitable for MLCC output filter
- Typ R_{DSon}=140mΩ



Suggested for new projects When Vin<18V

* Low cost versions with cheaper testing procedure

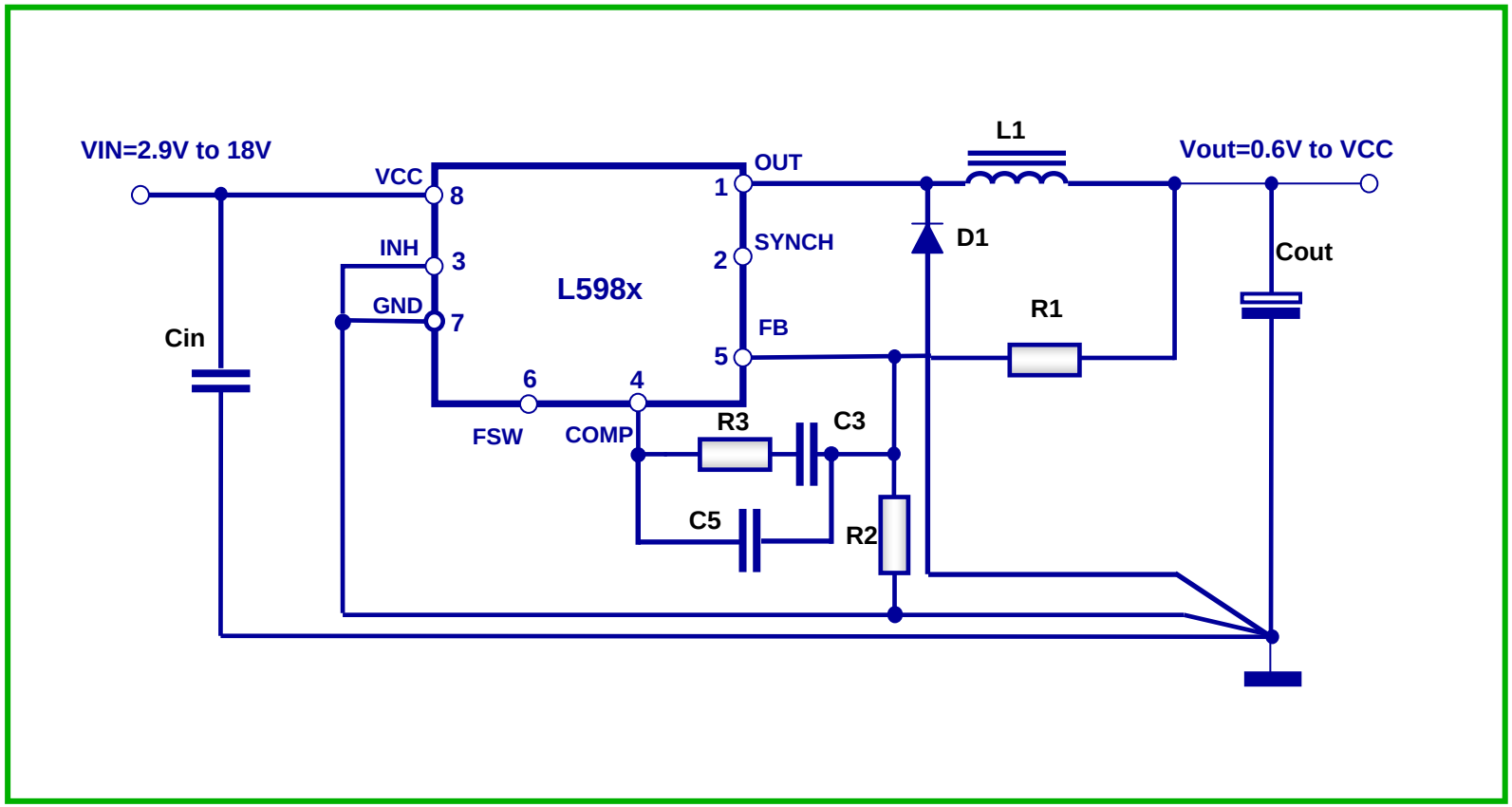
Device	Package	Ipk [A]	Iout [A]	Vin [V]	Vout [V]	Fsw [kHz]	Extra Functions
L5980	**QFN3x3-8L**	**1**	**0.7**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**
L5981	**QFN3x3-8L**	**1.5**	**1**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**
L5983	**QFN3x3-8L**	**2**	**1.5**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**
L5985	**QFN3x3-8L**	**2.5**	**2**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**
L5986/A	**QFN3x3-8L / HSOP8**	**3**	**2.5**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**
L5987/A	**QFN3x3-8L / HSOP8**	**3.5**	**3**	**2.9V to 18V**	**0.6V to Vin**	**250**	**Inh, AdjFsw, Sync**



QFN 3x3 8L - Rth j-amb 60°C/W

HSO8 - Rth j-amb 40° C/W

L598x Application Test Circuit



L598x Promotional tools

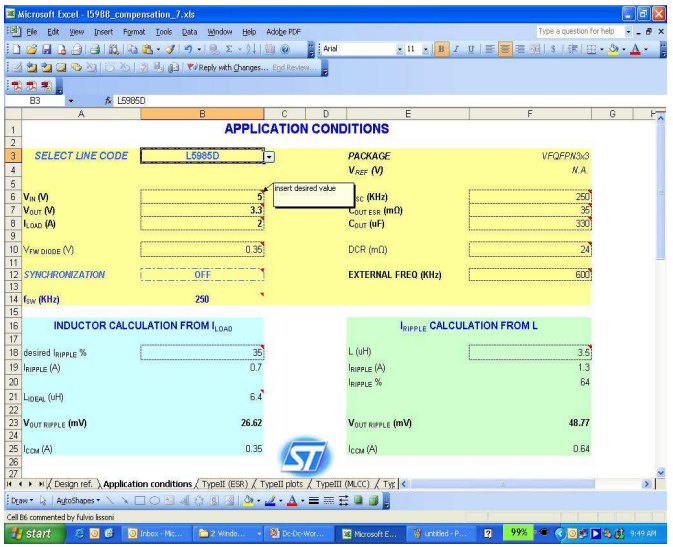
P/N	Datasheet with App. info	Evaluation Board
L5980	Available	EVAL5980
L5981	Available	EVAL5981
L5983	Available	EVAL5983
L5985	Available	EVAL5984
L5945	Available	EVAL5945
L5986	Available	EVAL5986
L5987	Available	EVAL5986
L5947	Available	EVAL5947

Evaluation board available also for the" A" versions as: EVAL5945A, EVAL5986A, EVAL5987A and EVAL5947A

SPREAD SHEET:

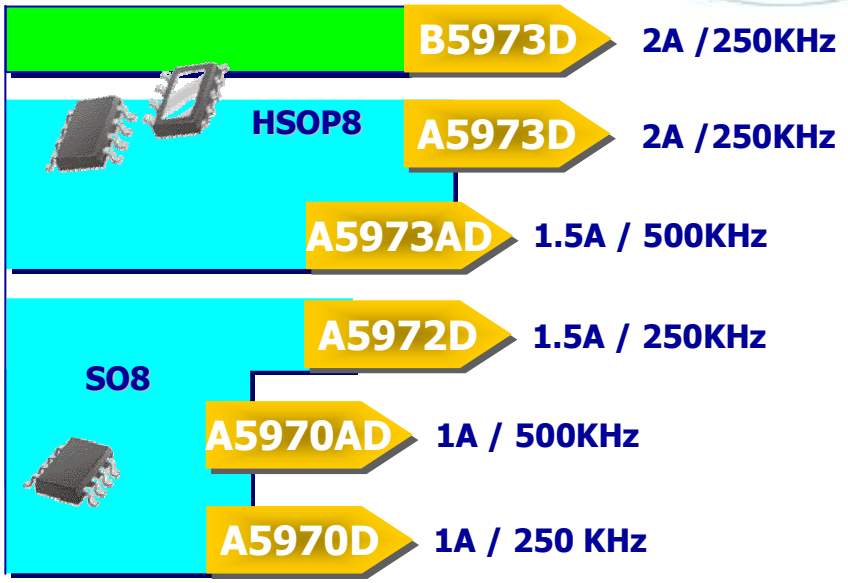
- to dimension output filter
- to compensate the loop
- to estimate Tj and efficiency

Now available on request



A597x Key Features

- More than 2A in small SO8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (4V up to 36V)
- High switching frequency (250KHz/500KHz, synch up to 700KHz*)
- Inhibit pin*
- Embedded protection features
- All Parameters tested over the -40℃ to + 125℃ junction temperature range
- BURN-IN test for high reliability (B5973D)



Suggested for new Automotive projects

Device	Package	Ipk (A)	Iout (A)	Vin (V)	Vout (V)	Fsw (kHz)	Tj Operating	Extra functions
A5970D	SO8	1.5	1	4V to 36V	0.5V to Vin	250	-40°C to +150°C	Inhibit, Vref, Sync
A5970AD	SO8	1.5	1	4V to 36V	0.5V to Vin	500	-40°C to +150°C	Inhibit, Vref, Sync
A5972D	SO8	2	1.5	4V to 36V	1.23V to Vin	250	-40°C to +150°C	-
A5973AD	HSOP8	2	1.5	4V to 36V	0.5V to Vin	500	-40°C to +150°C	Inhibit, Vref, Sync
A5973D	HSOP8	2.5	2	4V to 36V	0.5V to Vin	250	-40°C to +150°C	Inhibit, Vref, Sync
B5973D	HSOP8	2.5	2	4V to 36V	0.5V to Vin	250	-40°C to +150°C	Inhibit, Vref, Sync

HSO8 - Rth j-amb 40° C/W

SO8 - Rth j-amb 115° C/W
Rth j-amb 62° C/W for L5972D

*all but A5972D

The A597x family is tailored for Automotive applications, qualified following the AEC-Q100* specifications

*PPAP available for details

A597x Customers & Applications

MAJOR CUSTOMERS

harman international

DELPHI

BOSCH

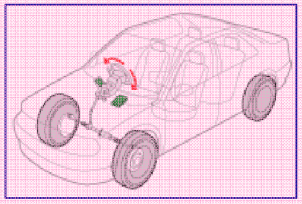
Continental

Visteon

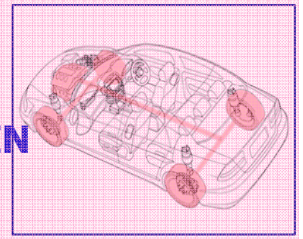
HELLA
Ideas today for the cars of tomorrow

MAGNETI MARELLI

MAJOR APPLICATIONS

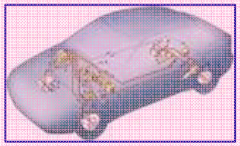


ELECTRONIC POWER STEERING

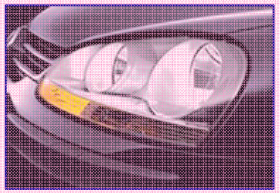


TRANSMISSION & POWER TRAIN

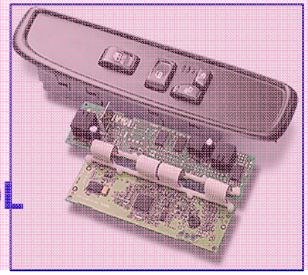
CAR INFOTAINMENT



ANTI-LOCK SYSTEM



LIGHTING



DOOR & WINDOW CONTROL

Few examples…

harman international **L5973D in integrated navigation system**

A597xD rear camera Modules and lighting Modules

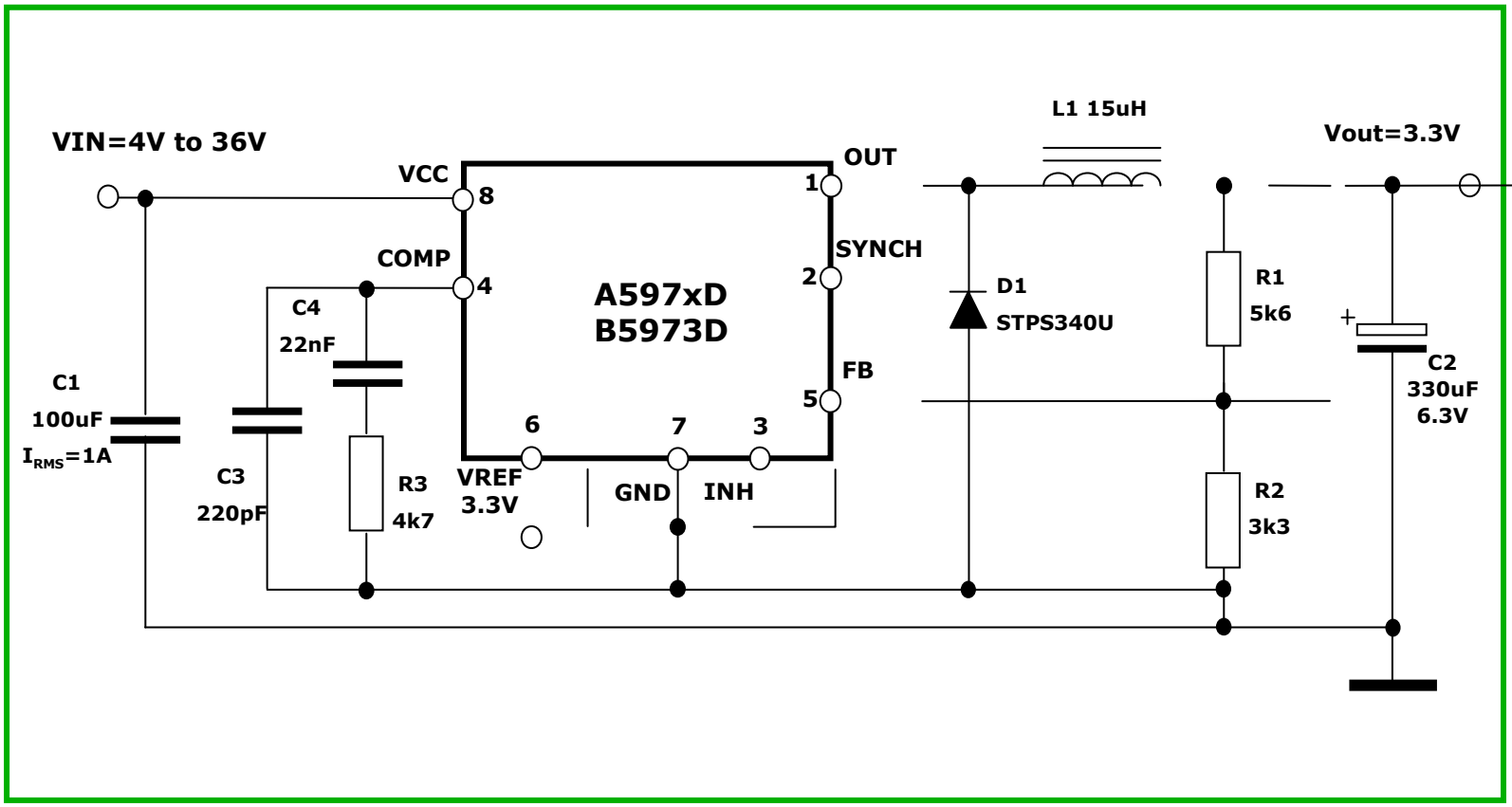
HELLA
Ideas today for the cars of tomorrow

MAGNETI MARELLI **5973D/AD in integrated navigation systems**

Continental **L5970D in integrated navigation systems And car audio**

preh **B5973D in electronic control unit for active steering**

A597x: Application Circuit Example



A6902D Key Features

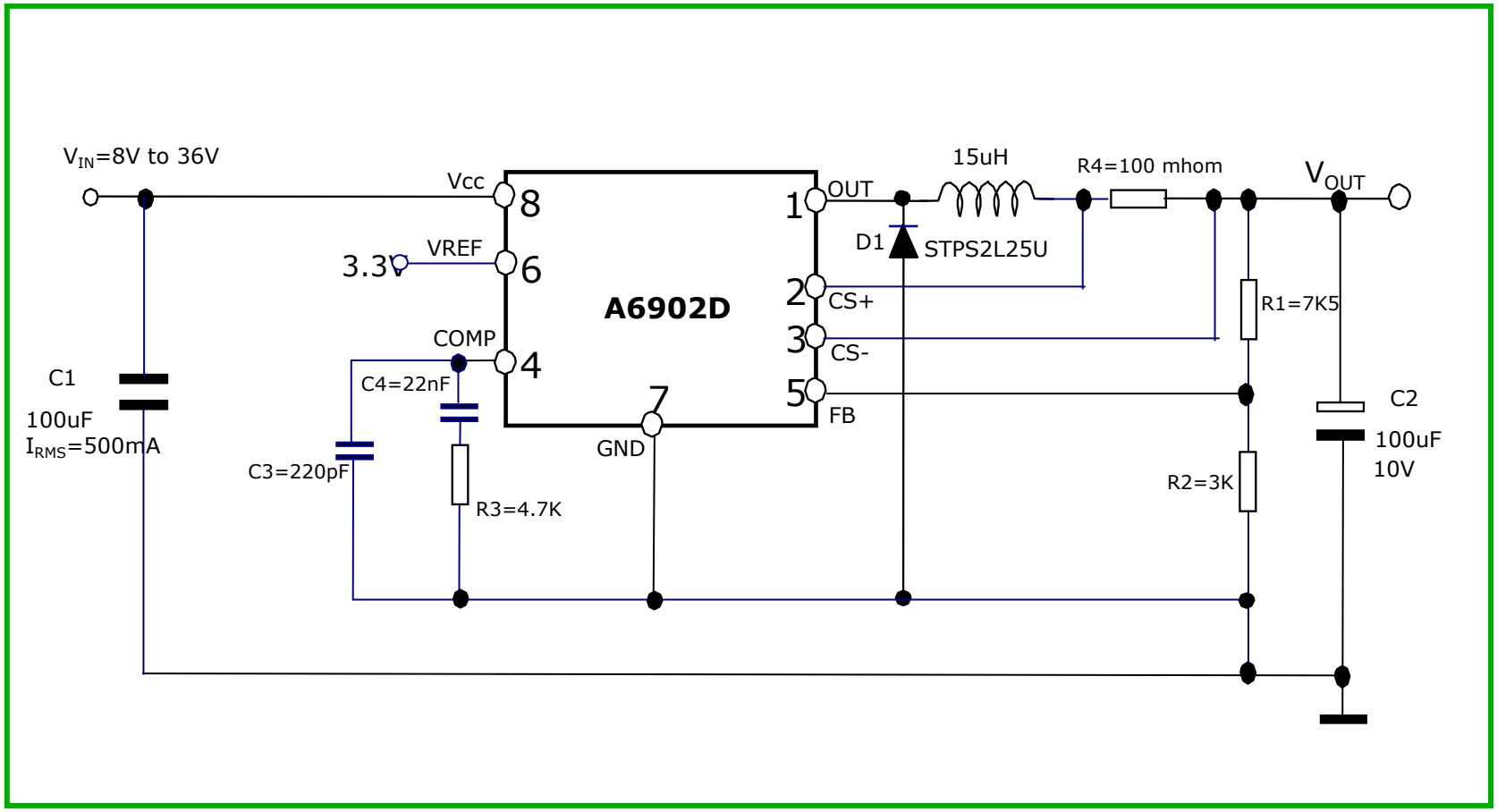
- 1A in small SO8 package with minimum external component count
- P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (8V up to 36V)
- High switching frequency (250KHz)
- External V_{REF} available
- Embedded protection features
- Operates over the -40℃ to +125℃ junction temperat ure range

SO8 - Rth j-amb 115°C/W

The A6902D is tailored for Automotive applications, qualified following the AEC-Q100* specifications

*PPAP available for details

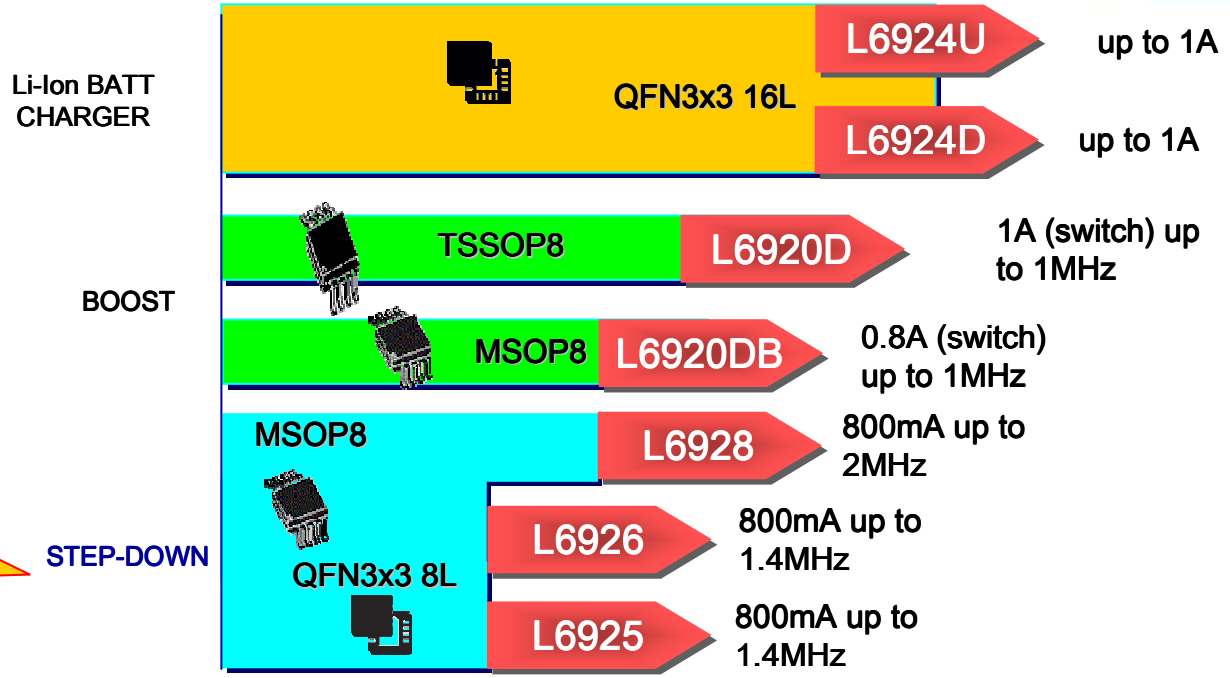
A6902D: Application Circuit Example



L692x Key Features

- Very small packages
- Internal synchronous switch
- Small number of external components
- Micro power consumption
- High efficiency
- Short circuit protection, OVP, thermal shutdown
- Battery detection

Suggested for Portable application



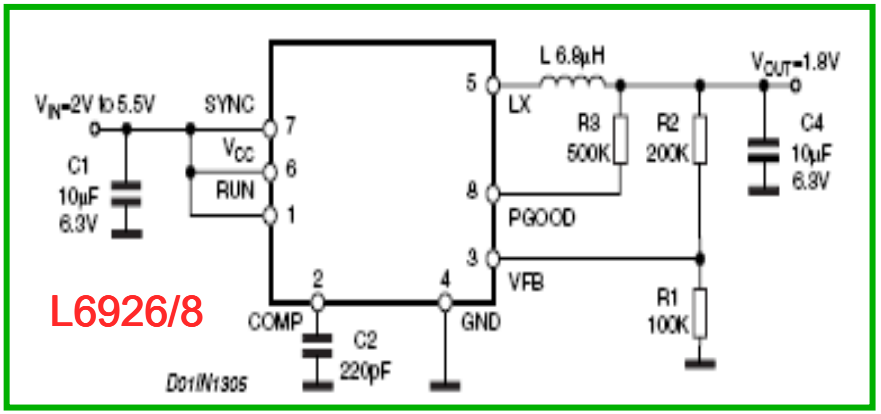
Device	Package	Type	Ipk [A]	Iout [A]	Vin [V]	Vout [V]	Fsw [KHz]	Extra functions
L6920D	TSSOP8	SU	1	0.5	0.6 - 5.5	2 - 5.2	up to 1000	LBI&LBO, Vref, SHDN
L6920DB	MSOP8	SU	0.8	0.4	0.6 - 5.5	1.8- 5.2	up to 1000	LBI&LBO, Vref, SHDN
L6925D	MSOP8	SD	1.2	0.8	2.7 - 5.5	0.6 - Vin	600	UVLO2.7V, LBI&LBO
L6926	MSOP8	SD	1.2	0.8	2 - 5.5	0.6 - Vin	600	PGOOD, RUN, SYNC
L6926Q1	QFN3x3-8L	SD	1.2	0.8	2 - 5.5	0.6 - Vin	600	PGOOD, RUN, SYNC
L6928D	MSOP8	SD	1.2	0.8	2 - 5.5	0.6 - Vin	1400	PGOOD, RUN, SYNC
L6928Q1	QFN3x3-8L	SD	1.2	0.8	2 - 5.5	0.6 - Vin	1400	PGOOD, RUN, SYNC

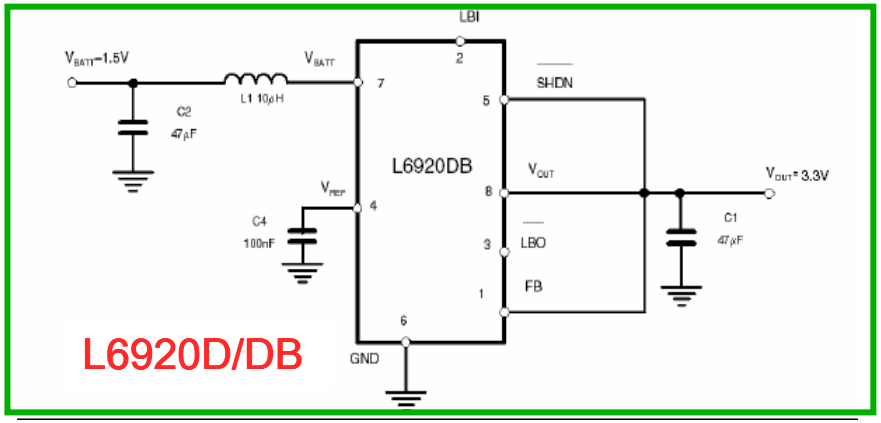

TSSOP8

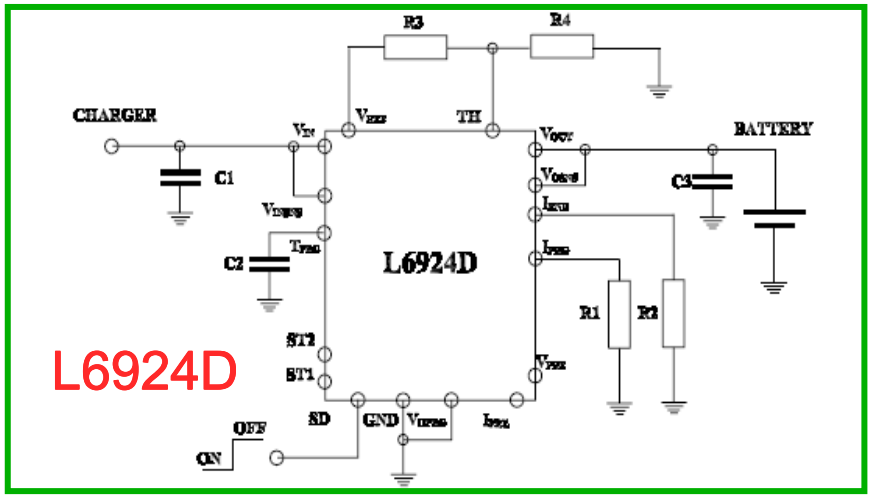

QFN3x3

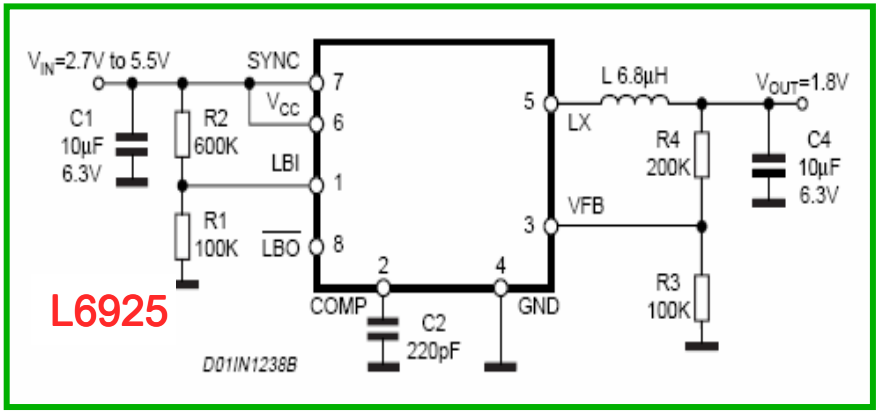
MSOP8 

L692x: Application Circuits









L6924x Key Features

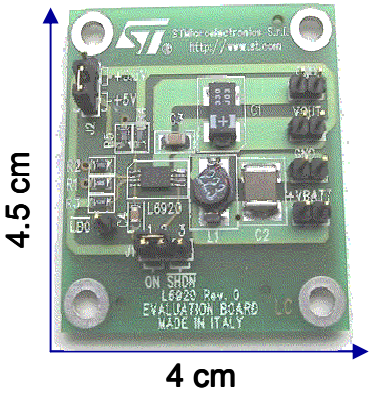
- Fully integrated solution, with a power MOSFET, reverse blocking diode, sense resistor, and thermal protection
- Both linear and quasi-pulse operation
- Closed loop thermal control
- Vin from 2.5V to 12V
- USB BUS-compatible (L6924U)
- Programmable charge current up to 1A
- Programmable charge current up to 500 mA in USB mode (L6924U)
- Programmable pre-charge current (L6924D)
- Support for USB high and low power input (L6924U)
- Programmable end-of-charge current
- Programmable pre-charge voltage threshold (L6924D)
- Programmable charge timer
- Programmable output voltage at 4.1V and4.2V, with ±1% output voltage accuracy (L6924D)
- NTC or PTC thermistor interface for battery temperature monitoring and protection
- Flexible charge process termination (L6924D)
- Full set of default charging parameters
- Status outputs to drive LEDs or to interface with a host processor
- Small VFQFPN 16-leads package (3mm x 3mm)

QFN3x3 16L

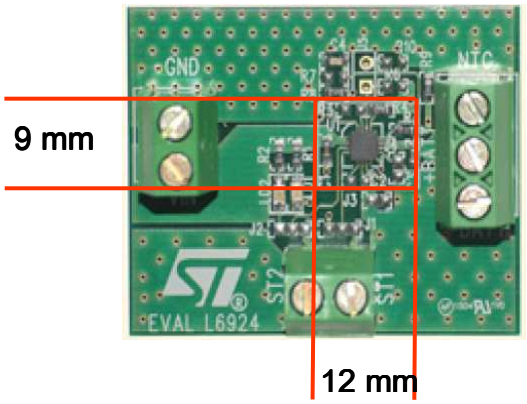
L692x promotional tools

P/N	Datasheet	Application note	Evaluation board
L6920D	Available	--	EVAL6920D
L6920DB	Available	AN2206	EVAL6920DB1
L6924D	Available	--	EVAL6924D
L6924U	Available	--	EVAL6924U
L6925	Available	AN1893	On request *
L6926	Available	AN1881	EVAL6926
L6928	Available	AN2115	EVAL6928

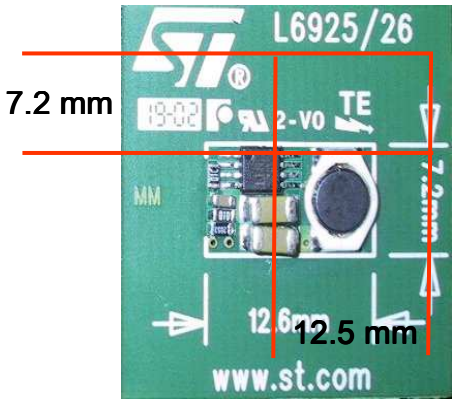
* please refer to the I&PC division application lab



L6924D



L6925D/26/28D



NEW COMERS!!!
Soon in Mass Production

Suggested in new projects only when:

Vin<18V
Iout>3A

L5988-9D Key Features

- Up to 4A in small HTSSOP 16 package with minimum external component count
- Synchronous rectification with P-channel power MOS: no bootstrap capacitor
- Wide input voltage range (2.9V up to 18V)
- High switching frequency (400KHz, adjustable up to 1MHz)
- Adjustable Soft-start and Inhibit function
- Embedded over current (adjustable threshold), over voltage and thermal protection
- PGood signal (L5989D) Synchronization capability(180° out of phase) (L5988D)
- Pre-bias start-up capability
- Multifunction pin (adjustable UVLO, latched/no latched OVP and sink-mode capability)
- 1.8v ± 2% reference voltage
- Suitable for MLCC output filter
- Typ R_{DSon}=75mΩ for HS and 65mΩ for the LS

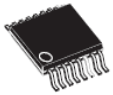
For an higher EFFICIENCY
SYNCH. RECT.

HTSSOP16

L5989D up to 4A /
L5988D up to 1MHz

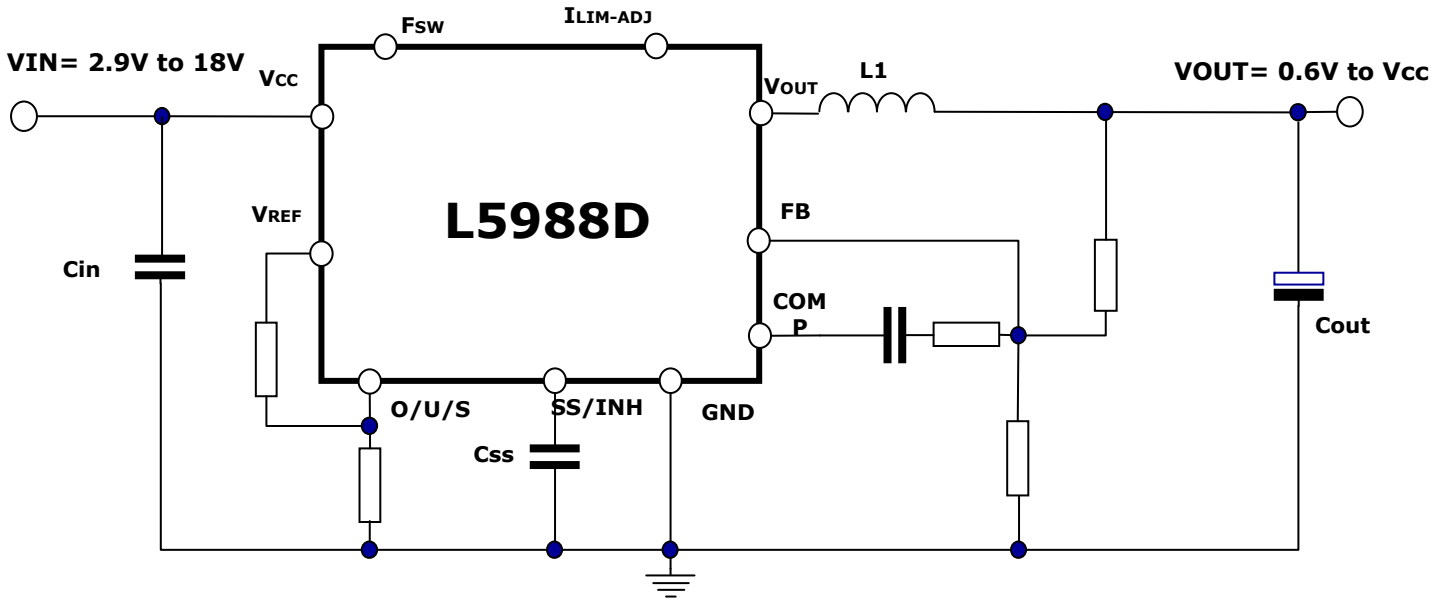
ES available
Mass Prod. End Q1-'09

Device	Package	Ipk [A]	Iout [A]	Vin (V)	Vout (V)	Fsw [KHz]	Extra functions
L5988D	HTSSOP 16	5	4	2.9V to 18V	0.6V to Vin	400	Synchronization
L5989D	HTSSOP 16	5	4	2.9V to 18V	0.6V to Vin	400	Pgood



HTSSOP 16 - Rth j-amb 40°C/W

L5988D Application Test Circuit

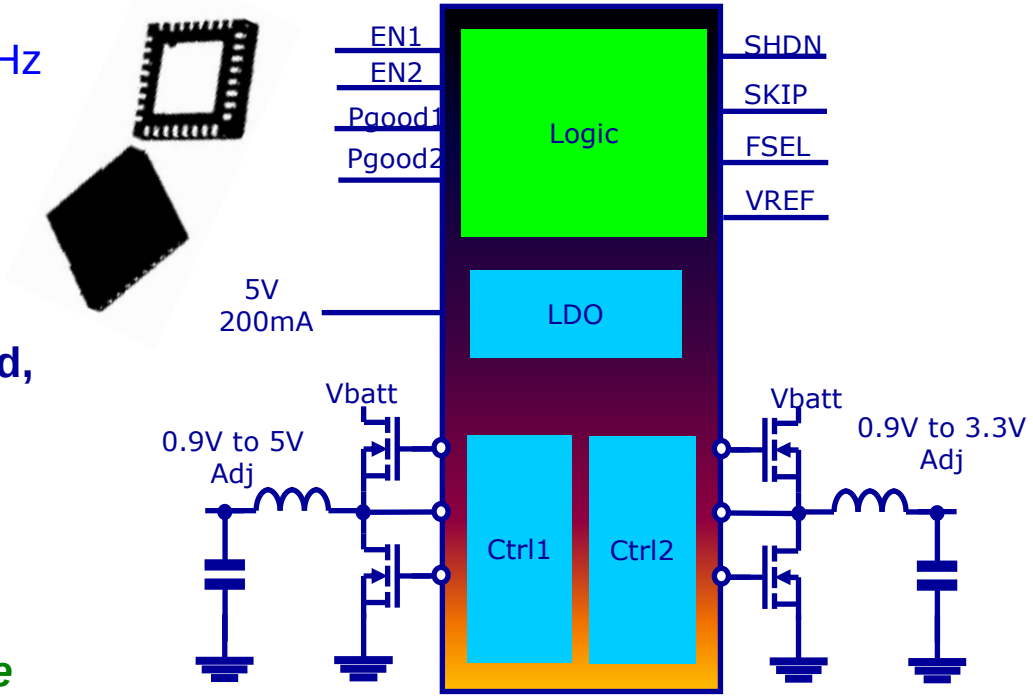


PM668x: dual step-down controller

NEW

- **Vin Range:** 4.5V to 36V
- **Frequency selectable** 200kHz to 500kHz
- **SENSORLESS Current sense (LS MOSFET RDSON)**
- **Protections: UVL, OVP, ILIM, Power Good**
- **PLUS: Internal Soft Start, Power Good, Soft Off discharge COUT**
- LINEAR REGULATOR:
  - 5V -200mA peak
- ***Excel worksheet available to facilitate the design***

Package: QFN32 5x5

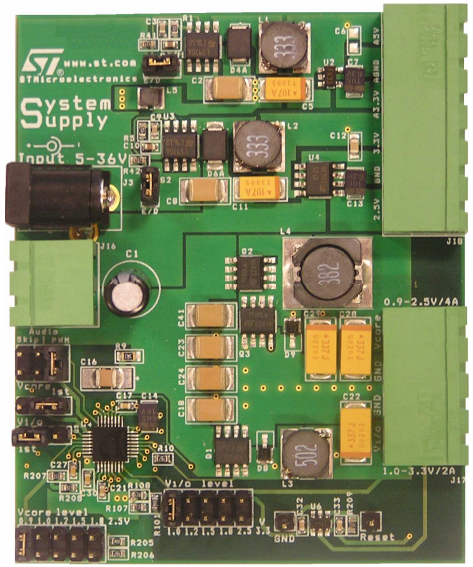


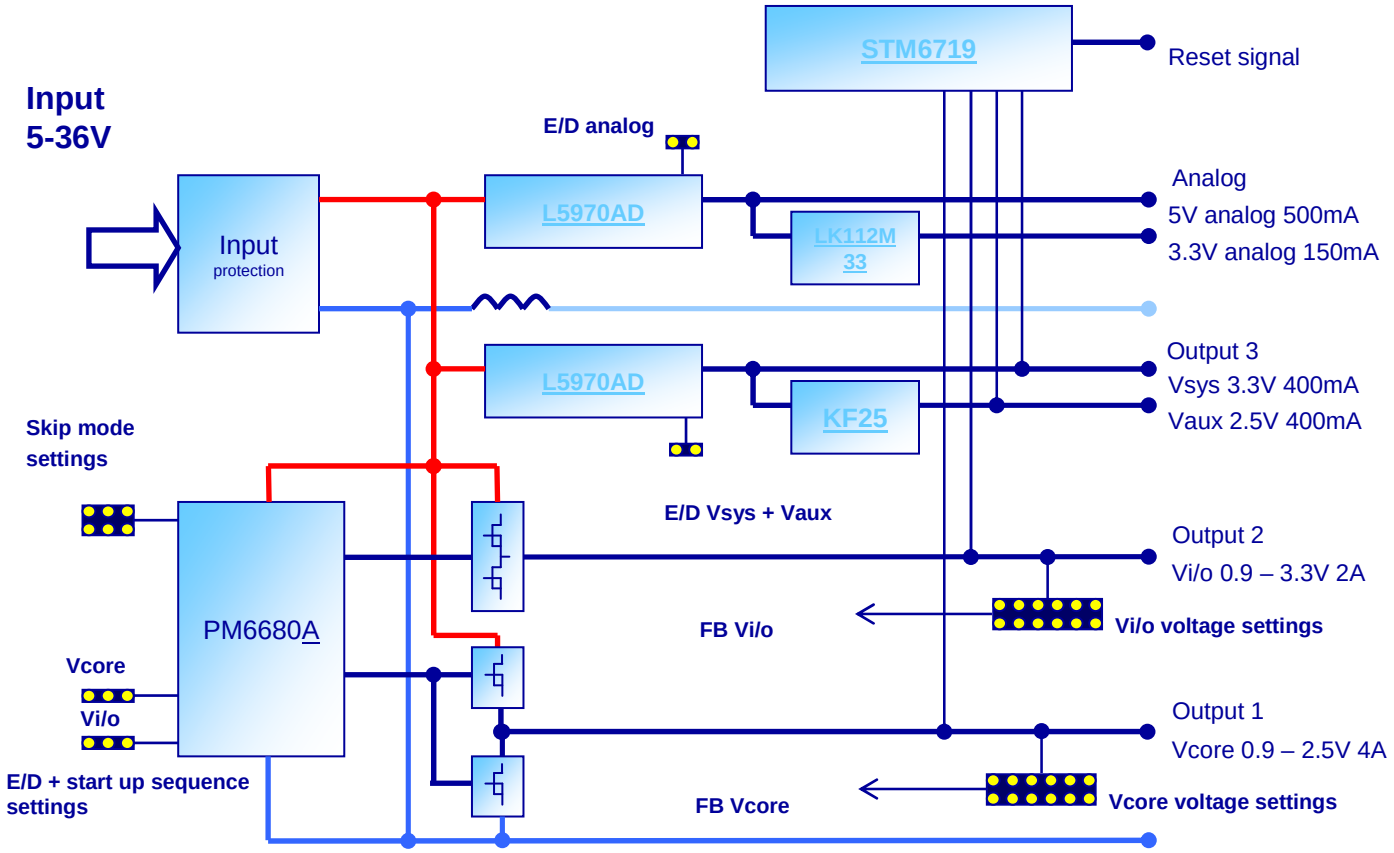
PN	V_{OUT} # (SW +LDO)	V_{OUTSW} 1	V_{OUTSW} 2	V_{OUTLDO}	I_{LDO}	V_{IN} range	package
PM6680	2+1	Adj.	Adj.	5V	200mA	Up to 28V	QFN 5x5
PM6680A	2+1	Adj.	Adj.	5V	200mA	Up to 36V	QFN 5x5
PM6685	2+2	3.3V	5V	(1)3.3V + (2)5V	100mA	up to 28V	QFN 5x5

PM6680A: application

NEW

STEVAL-PSQ001V1: PM6680A + L5970A - System Supply Board for FPGA and MPU





STxS0yy family

NEW

Single / dual synchronous rectification with reset or inhibit

DEVICE	*I_{OUT}(A)*	*V_{OUT} (V)*	*V_{IN}(V)*	*Fsw(MHz)*	*Note*
ST1S03	1.5	Adj from 0.8V to 12V	2.7 to 6V	1.5	
ST1S06 ST1S06A	1.5	Adj from 0.8V to 5.5V	2.5 to 7V	1.5	SR I + SR
ST1S09	2	Adj from 0.8 to 5V	4.5 to 5.5V 2.7 to 5.5V	1.5	PG I
ST1S10	*3*	*Adj from 0.8 to 15V*	*2.5 to 18V*	*1*	*Ext Synch from 0.4Mhz to 1.2MHz*
ST2S06A ST2S06B	0.5+0.5	Adj from 0.8 to 5V	From 2.5 to 5.5V	1.5	Ro I

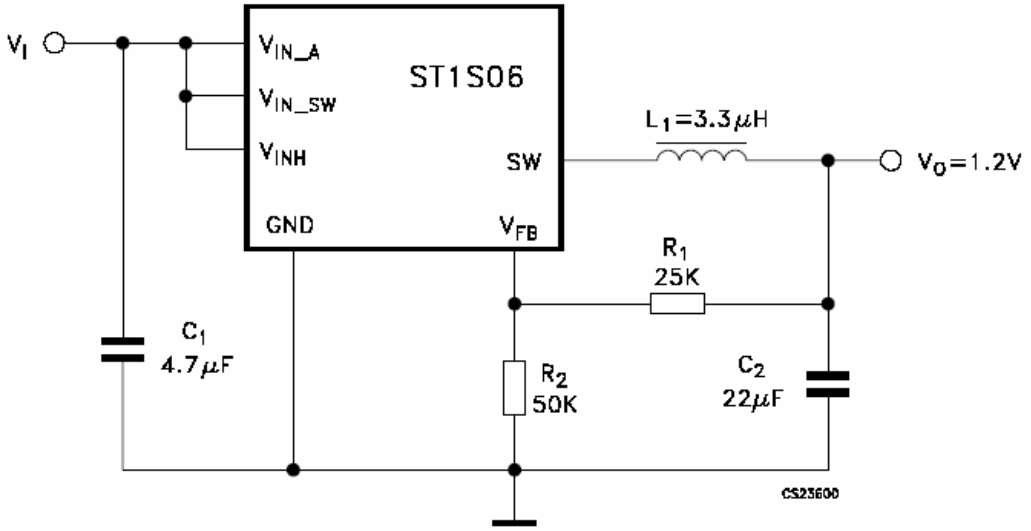
I= Inhibit PG= Power Good SR = Synchronous Rectification

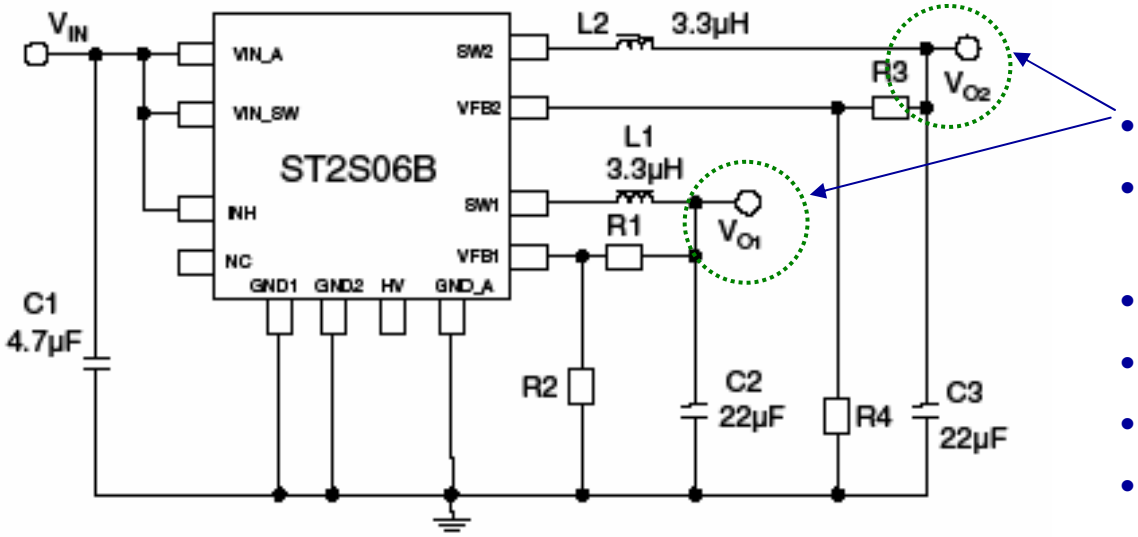
Ri,o=Reset input, output

STxS0yy family – typ application

NEW

- Single output
- Current mode with internal 1.5A power switch.
- Internal compensation.
- Switching frequency reduction in light load condition (<250mA typ.)
- Soft Start
- Thermal Shut down Tj=150℃
- Cycle-by-cycle Current Limiting





- Dual output
- Current mode with internal 0.5A power switch.
- Internal compensation.
- Soft Start
- Thermal Shut down Tj=150℃
- Cycle-by-cycle Current Limiting

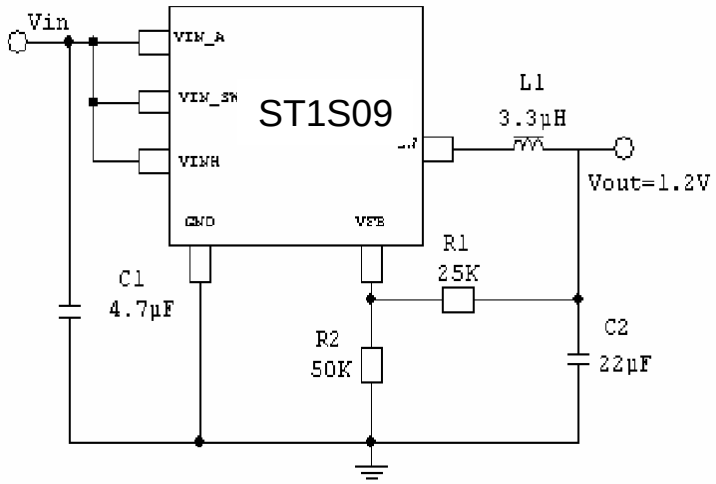
ST1S09/09I

2A Step-Down DC-DC Converter with internal

DFN – 6L
3x3

Main Characteristics:

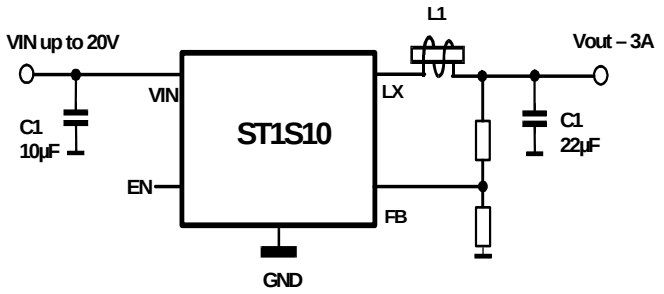
- Switching Frequency: 1.5MHz
- Output Current Capability: 2A max over all operating conditions
- Output Voltage: Adjustable from 0.8V or 1.2, 1.5,1.8, 2.5, 3, 3.3V
  Fixed Output Voltages under customer request
- Max Operating input Voltage: 5.5V
- Soft-Start circuit to reduce inrush current
- Efficiency: up to 95%
- Fast Transient Response
- Short Circuit and Thermal Protection
- Power-on Delay (50-100µs)
- QFN 3x3mm Package Type
- ST1S09 with Power Good Function (on PIN 6)
- ST1S09I with Inhibit Function (on PIN6)



ST1S10
3A Step-Down DC-DC with Synchronous Rectification

Main Characteristics:

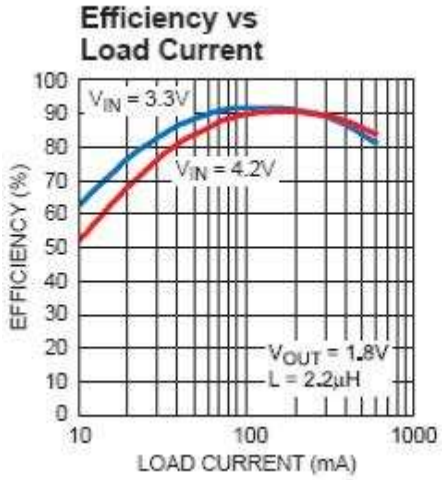
- **PWM fixed frequency 900KHz. It can be ext synch from 0.4 to 1.2MHz**
- **Output Current Capability: 3A max over all operating conditions**
- **Output Voltage: Adjustable from 0.8V feedback voltage**
- **Ceramic Capacitors and small Inductor**
- **3.3V, 5V Fixed Output Voltages under customer request**
- **Max Operating Input voltage up to 18**
- **Soft-Start circuit to reduce inrush cur**
- **Efficiency: up to 90%**
- **Fast Transient Response**
- **Available with logic control Electronic Shutdown**
- **SO8-EP and DFN 4*4 6L**



ST1S12

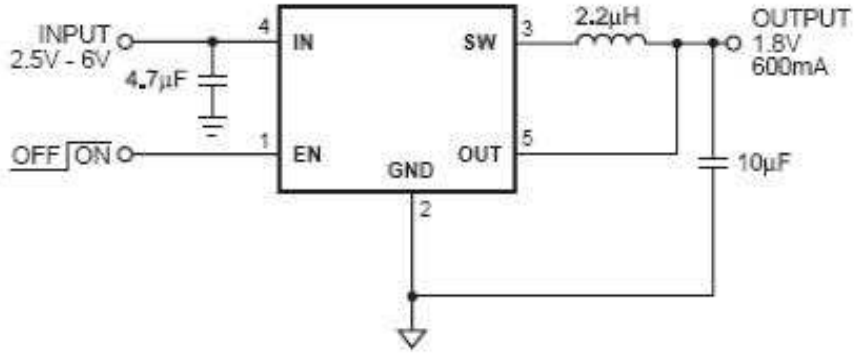
Synchronous Rectification

SOT23-5L



Main Characteristics:

- **PWM fixed frequency 1.7MHz.**
- **Output Current Capability: 0.7A max over all operating conditions**
- **Output Voltage: Adjustable from 0.6V or fixed (1V to 3.3V under customer request)**
- **Input Voltage: from 2.5V to 6V**
- **Ceramic Capacitors and small Inductor (2.2uH suggested value)**
- **Soft-Start circuit to reduce inrush current**
- **Efficiency: up to 93%**
- **Fast Transient Response**
- **Logic control Electronic Shutdown**
- **SOT23-5L Package**



ST2S06
Dual ADJ Step-Down DC-DC Converter with Reset/Inhibit

Main characteristics:

- Adjustable Output Voltage: from 0.8V to 5V
- DC-DC Switching Frequency: 1.5MHz
- Output Current 1: up to 500mA
- Output Current 2: up to 500mA
- Internal Synchronous Rectification
- Efficiency up to 95%
- Logic Control Electronic Shutdown
- Reset

Typical Applications:

- Optical Storage: CD, DVD-RW
- Hard Disk Drives
- Cameras
- Video cameras
- Cellular phones
- Palmtops
- Battery powered equipments

QFN-8L 4x4mm

ST8R00
1A Synchronous Step-Up DC-DC Converter

Main characteristics:

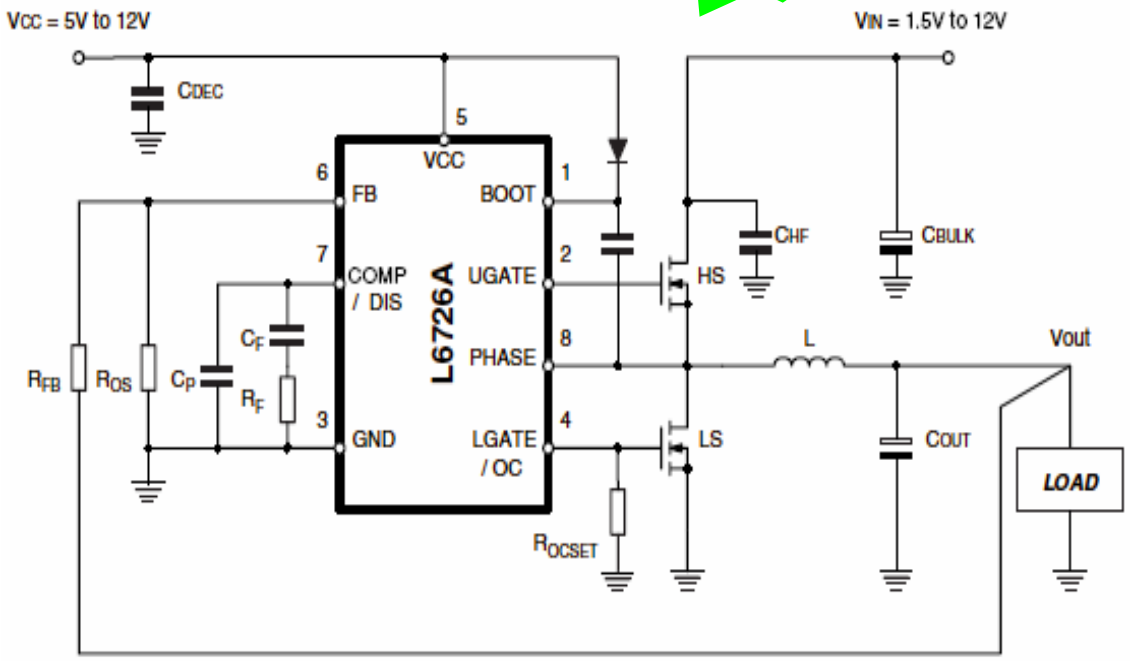
- Adjustable Output Voltage: from 6V to 12V
- DC-DC Switching Frequency: 1.2MHz or 600Khz
- Output Current: up to 1A
- Internal Synchronous Rectification
- Efficiency up to 90% (Output set to 9V)
- Logic Control Electronic Shutdown
- True Shutdown

QFN-8L
4x4mm

L6726 / L6727 / L6728: PWM controllers

NEW

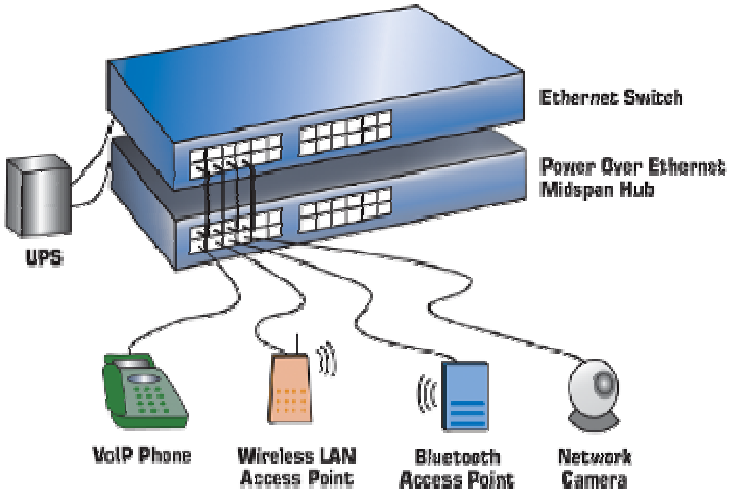
- **Minimum part count conversion from 5V / 12V bus (Vin up to 19V) up to higher current**
- **High precision regulation (<1%)**
- **Protection on board:**
  - Sensor-less OCP → no RSENSE
  - Programmable OCP
  - Feedback disconnection
- **Features:**
  - Disable & Soft Start
    - → to ensure regulation control
- Pin to pin compatible **with:**
    - ISL6520,FAN6520,
    - NCP1583, SC2608, etc.

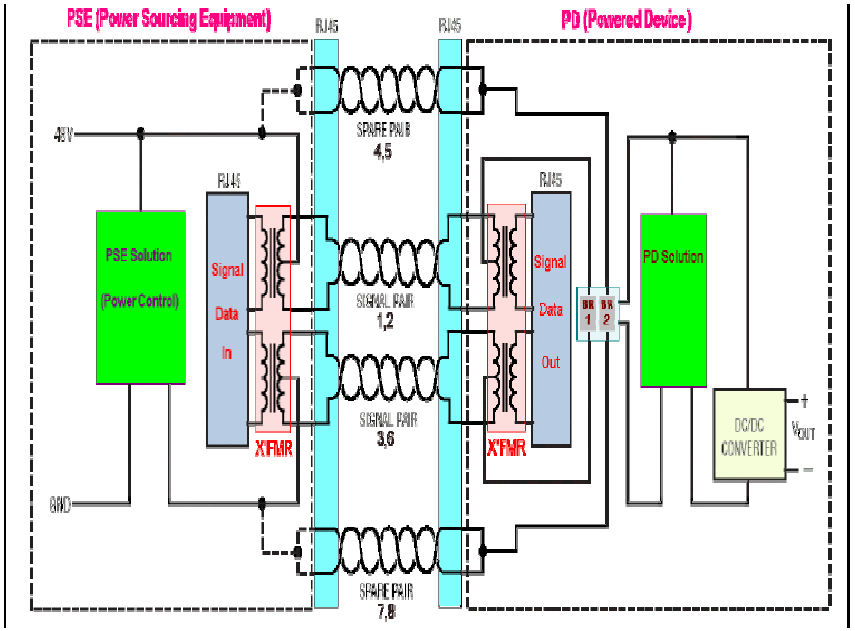


Part Number	*V_{INPUT}/V_{OUT} range*	*F_{SW}*	*features*	*Package*
L6726A	**4.1V to 13.2V/19V(*) V_{INPUT}, 0.8V min V_{OUT}**	**270KHz**	**EN, SS, OCP, fixed F_{SW} 270KHz**	**SO8**
L6727	**4.1V to 19V V_{INPUT}, 0.8V min V_{OUT}**	**300KHz**	**EN, SS, OVP, UVP, OCP, fixed F_{SW} 300KHz**	**SO8**
L6728	**4.1V to 13.2V V_{INPUT}, 0.8V min V_{OUT}**	**300KHx**	**EN, SS, OVP, OCP, PGOOD, fixed F_{SW} 300KHz**	**DFN10 3x3**

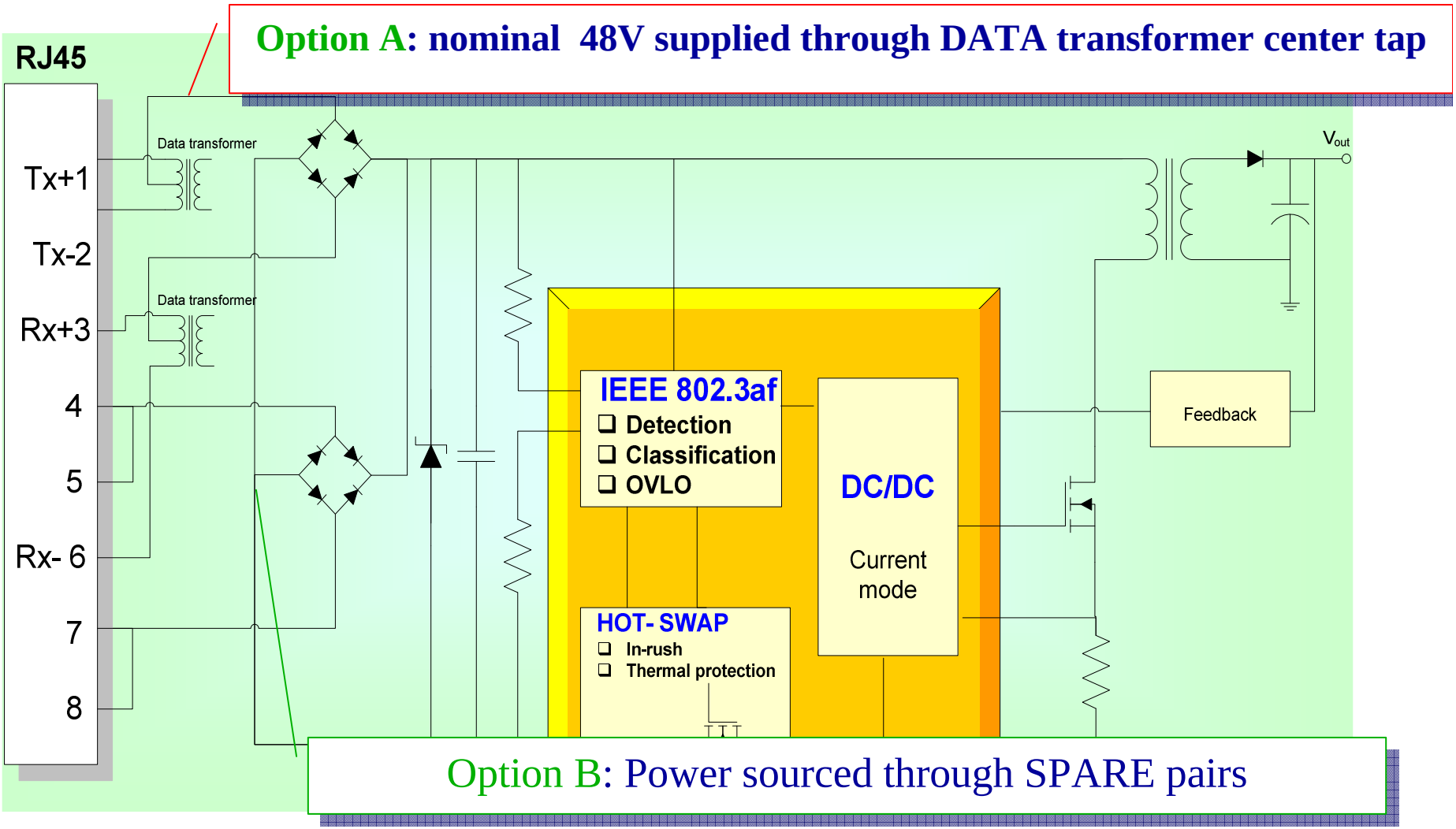
PoE: Introduction

- Power over Ethernet (PoE) **is a widely adopted technology used to transfer both data and electrical power over an RJ-45 cable**
- **Safely powers devices of up to 13W (IEEE 802.3af)**
- **New on-going standardization process for powering devices of up to 60W (IEEE 802.3at), called** PoE+

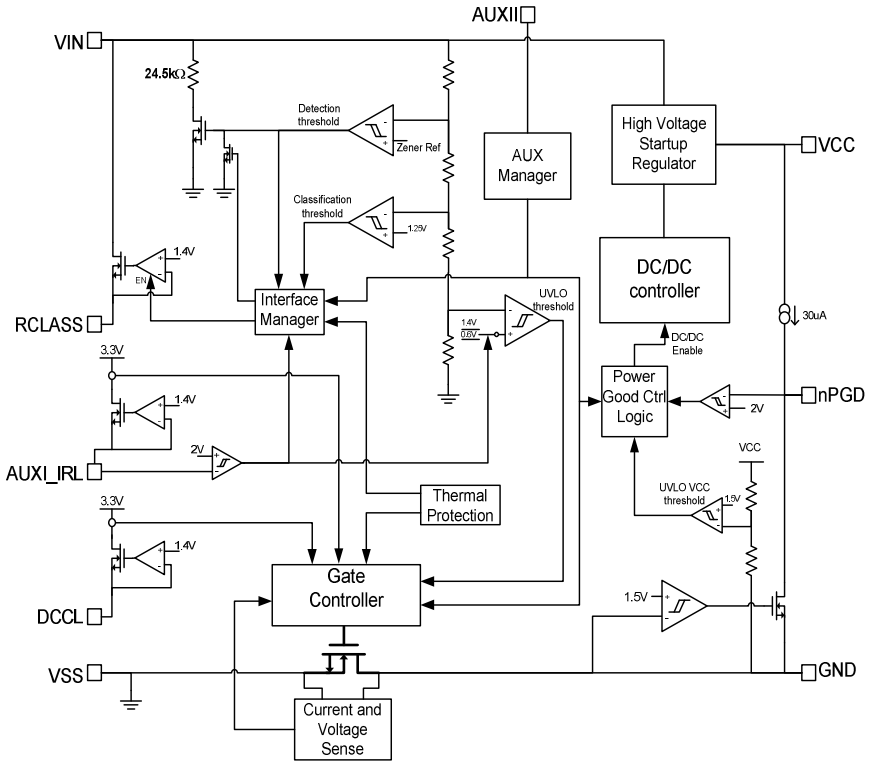




Powered Device architecture

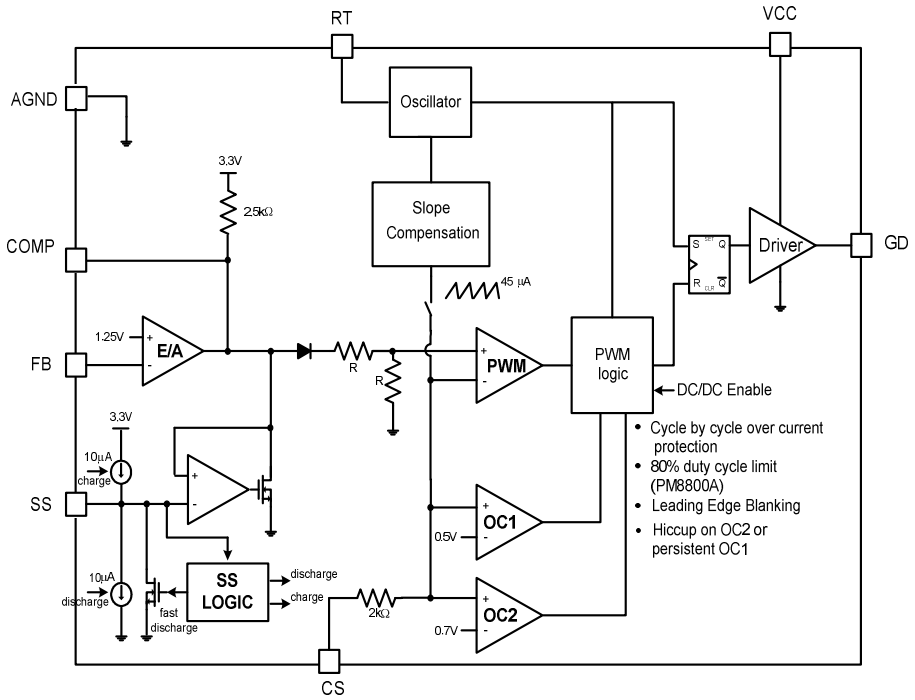


PM8800A: PoE interface



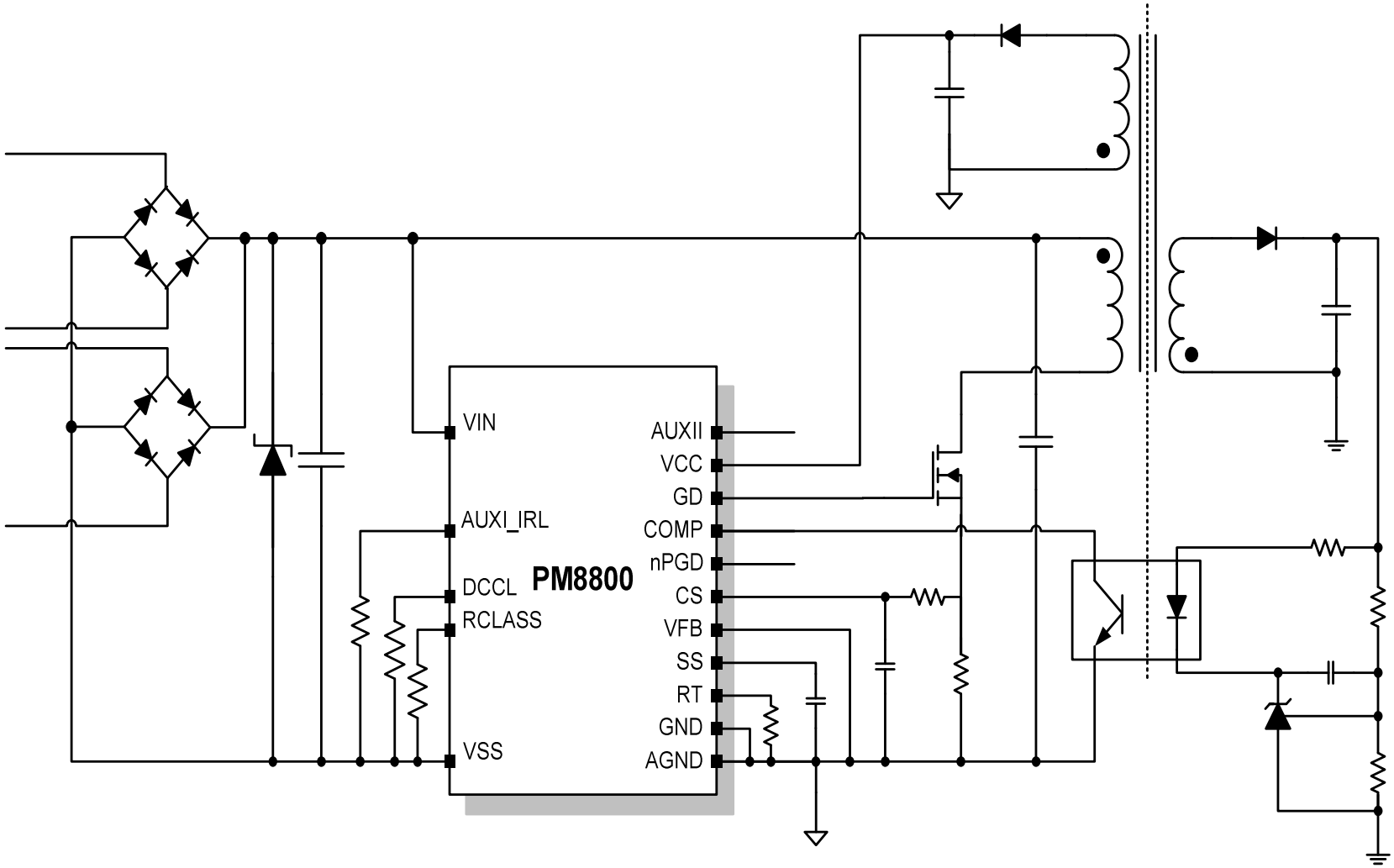
- IEEE802.3af Compliant
- 100V, 0.5Ω, 800mA hot-swap MOSFET
- PoE+ Layer2 compatible, allowing power >12.95W
- Under-Voltage Lockout thresholds
- Programmable Inrush and DC Current
- Signature and classification Resistor Disconnection
- UVLO override for auxiliary sources < 38.5V
- Inrush and DC protection with auxiliary sources
- Thermal Overload Protection

PM8800A: Integrated PWM controller



- **Internal Start-up Bias Regulator**
- **Current Mode Control**
- **Error Amplifier disabled in case of optocoupler connection**
- **Internal Slope Compensation**
- **Cycle-by-Cycle Over-Current Protection**
- **Leading Edge Blanking**
- **Programmable Soft-Start**
- **Programmable Oscillator freq. y**
- **Thermal Shutdown**

PM8800A: 802.3af IF+PWM ctrl.



PM8800A: 802.3af IF+PWM ctrl.