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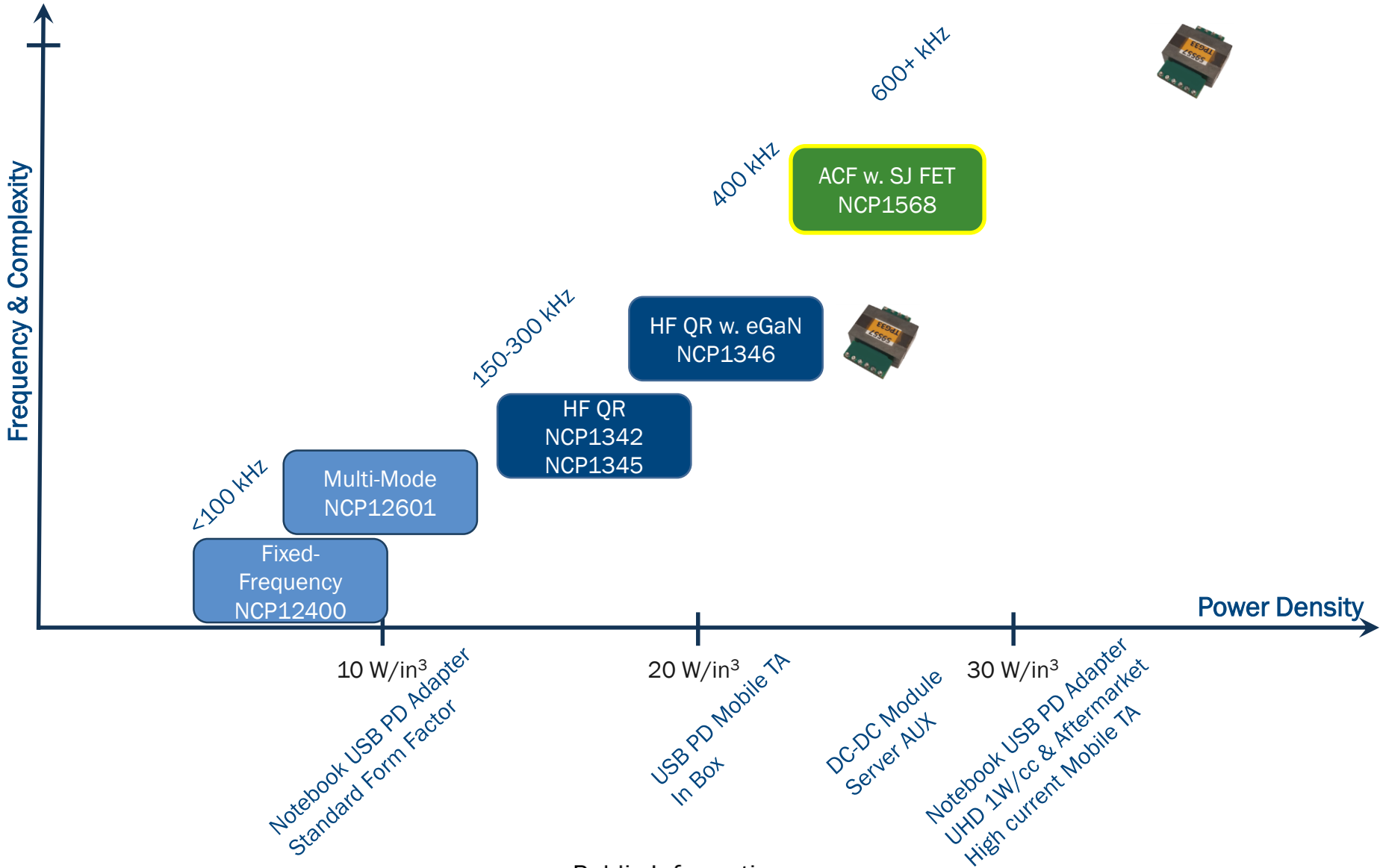
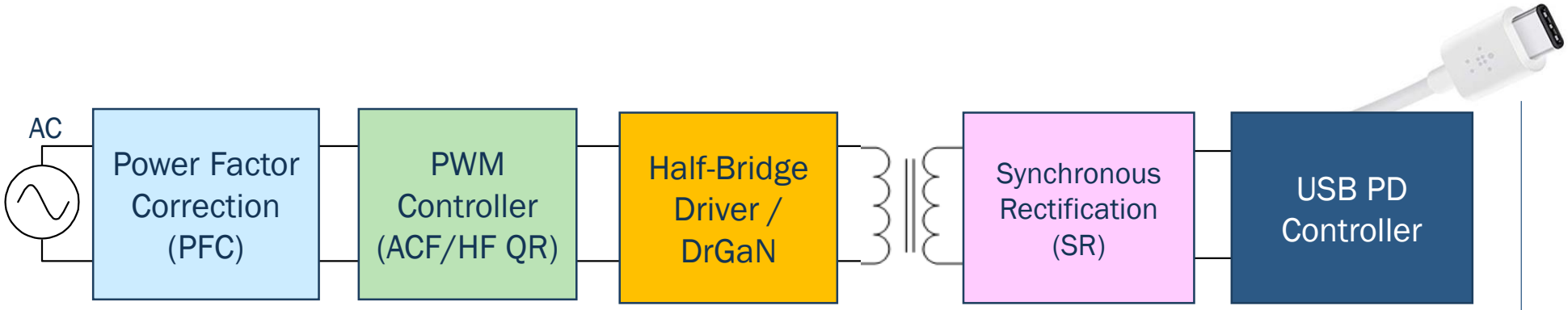
AC/DC & Isolated DC/DC Controller Solutions

Flyback Solutions

Drive for Higher Power Density (<150 W)



<150W High Density Bundle Opportunity



Today	**NCP1622**	**NCP1342 (HF QR)** Mid Power Density Ctrl **NCP1568 (ACF)** Highest Power Density	**NCP51530 HB** Half Bridge Gate Driver **NCP51820 HB** Half Bridge GaN Driver NEW	**NCP4306** Single SR
2021 Platform	**NCP1623 RTM Q1'21** Improved Perf.	**NCP1345 RTM Q3' 21** USB PD Optimized **NCP15681 RTM Q3' 21** Int. Driver, USB PD Optimized		**NCP4307 RTM Q1'21** Higher Integration

NCP1345 & NCP4307 Sampling in Q3 '20

60W Current vs. ON

30W Current vs. 90W ON

25W Current vs. 39W ON

NCP1342 High Frequency QR Controller

Value Proposition

The NCP1342 is a highly integrated quasi-resonant flyback controller capable of controlling rugged and high-performance off-line power supplies as required by adapter applications. With an integrated active X2 capacitor discharge feature, the NCP1342 can enable no-load power consumption below 30 mW for USB PD Notebook Adapters from 45W to 100W.

Unique Features

- QR Frequency Jittering
- New Quiet-Skip Technology
- Rapid Frequency Foldback

Benefits

- Reduces EMI Signature
- Ensures Operation Outside Audible Range
- Enhanced Light Load Efficiency

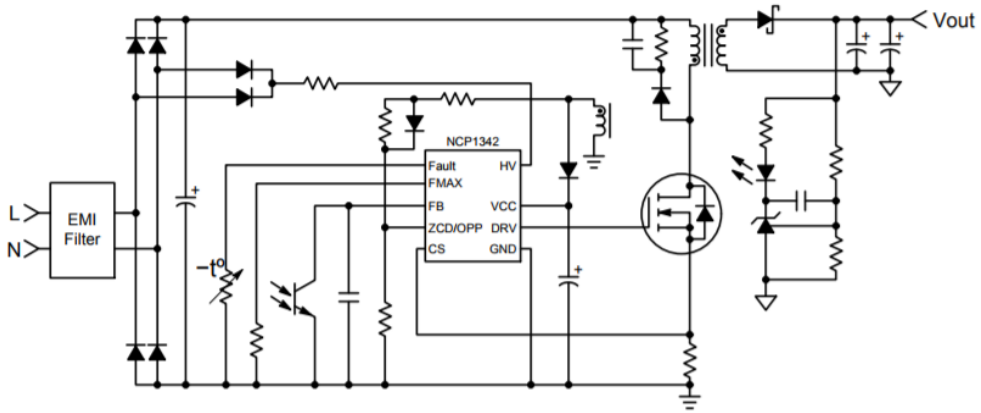
Other Features

- High voltage startup circuit with Integrated Brownout
- Valley Switching Operation with Valley Lockout
- Frequency Foldback with 25 kHz Minimum Frequency
- V_{CC} Overvoltage Detection
- NTC Compatible Fault Pin
- Soft-Start for Smooth Start-up Operation
- High Drive Capability: -500 mA / +800 mA

Market & Applications

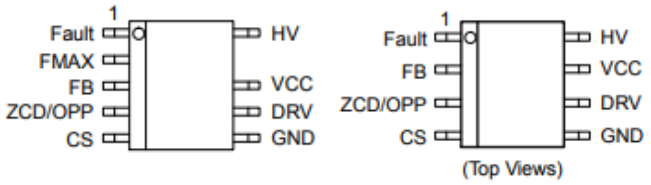
- Low/Medium USB PD Adapters
- Notebook Computer Adapters
- Auxiliary Power

Typical Application Circuit



Ordering & Package information

- SOIC-8 and SOIC-9
- Pin compatible with NCP1340



(Top Views)

NCP4306 Secondary Side Synchronous Rectification Driver

Value Proposition

The NCP4306 is high performance driver tailored to control a synchronous rectification MOSFET in switch mode power supplies. Thanks to its high performance drivers and versatility, it can be used in various topologies such as DCM or CCM flyback, quasi resonant flyback, forward and half bridge resonant LLC.

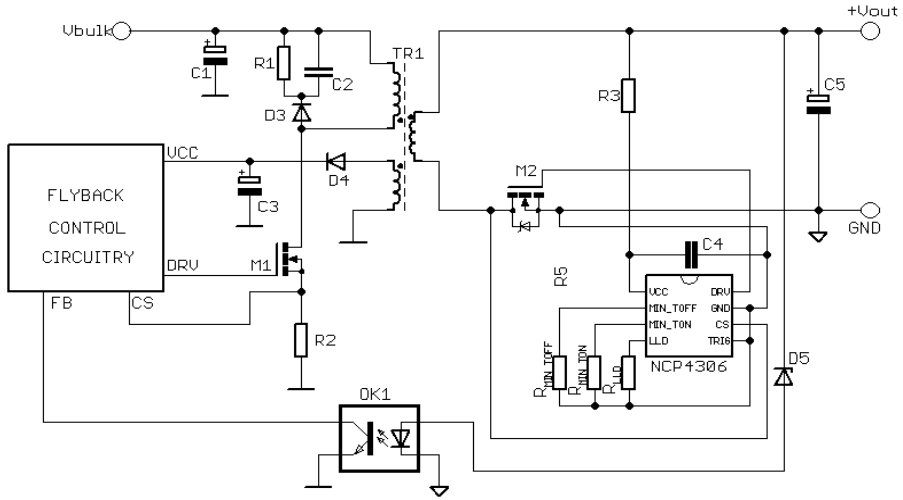
Unique Features

- Operates in CCM, DCM and QR for Flyback or in Forward and LLC
- 15 ns Turn off Delay
- Optional Ultrafast (10.5ns) Trigger Input
- Adjustable Min ON & OFF Time
- dV/dt detection
- 7 A Sink, 2 A Source Drive capability
- GaN Transistor Driving Capability

Benefits

- Flexible solution fits many topologies
- Maximizes conduction time to increase efficiency
- Improves deep CCM performance
- Prevents accidental MOSFET turn on or turn off due to ringing
- Enhanced Operation for USB-PD
- Fast turn off of MOSFET for optimized conduction period

Typical Application Schematic



Other Features

- Operational Voltage up to 36 V
- Precise True Secondary ZCD
- Adjustable Automatic Light Load Disable Mode
- Maximum operation frequency: Up to 1 MHz
- Low Startup and Disable Current Consumption ~ 50mA

Package information

- Driver clamp 5 / 10 V
- Flyback, LLC and universal version
- DFN, SOIC8, TSOP6 package variants

Market & Applications

- Notebook Adapters
- High Power Density AC/DC PS
- USB Wireless Adapters

45-W USB PD3.0/QC3.0 Adapter

Value Proposition

This design uses ON Semiconductor's NCP1342 HF PWM controller, NCP4306 synchronous rectified controller in a compact profile with high power density. This design supports USB Type-C™ interface PD3.0 and QC3.0 Class A quick charge protocols.

Specifications and Features

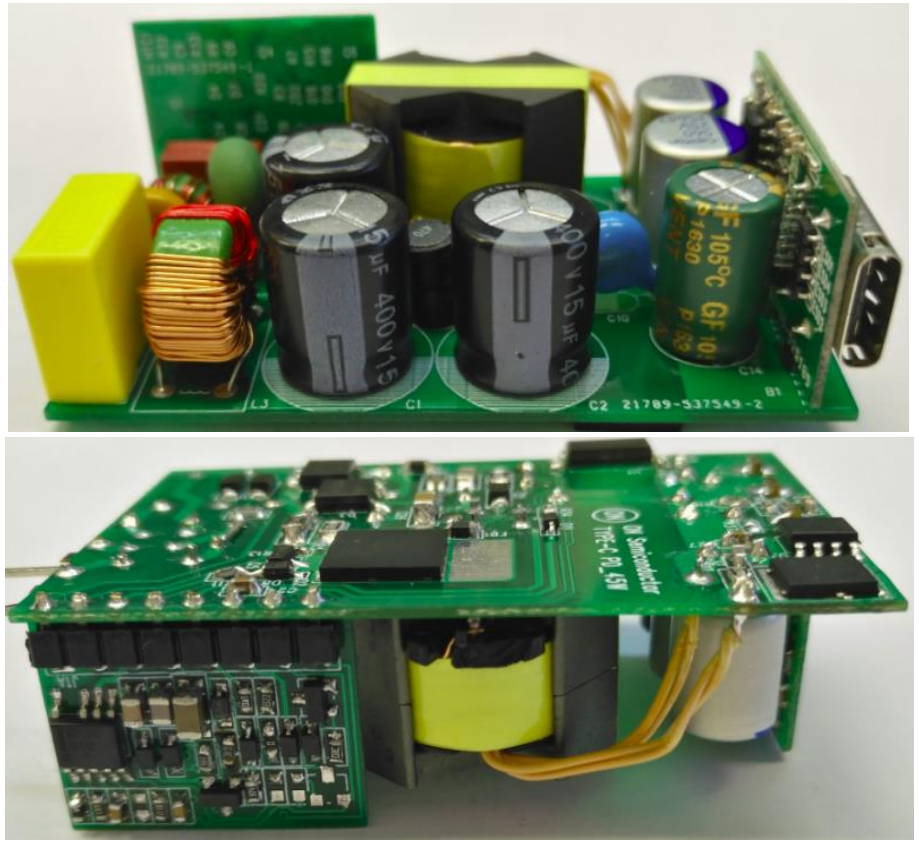
- High operation frequency up to 150 KHz
- RM7 (35 W) / RM8 (45 W) transformer
- Support PD3.0 and QC3.0 protocols
- Rated Output power: 30 W & 45 W versions
- Avg. Efficiency:
  - 45 W >91%@20V2.25A at board end, 115&230Vac
- Board Size & Power Density
  - 45 W: 57mmx36mmx19mm, 1.15W/cm^3
- Standby power: <30 mW in Universal(No cable plug in)
- Adaptive Output OVP and UVP
- Output OCP, SCP
- Cable voltage drop compensation
- Open loop protection
- High switching frequency: ~110 KHz @230 Vac and full load

Market & Applications

- Smart phone, tablet and notebook adapters

Design Note

Demoboard Photo



NCP1342 60-W USB PD Demo Board

Value Proposition

The NCP1342PD65WGEVB showcases the NCP1342 Quasi-Resonant Flyback Controller in a USB Power Delivery (PD) application. The evaluation board delivers 60 W of power using a compact RM8 transformer. The NCP1342 is suitable for designing high-performance off-line power converters and USB PD adapters, and features Rapid Frequency Foldback (RFF) for improved efficiency over the load range. An integrated active X2 capacitor discharge feature eliminates discharge resistors which enables no-load power consumption below 40 mW.

Specifications and Features

- RM8 transformer
- Support PD3.0 and QC3.0 protocols
- 90 to 265 Vac Input
- Rated Output power: 60 W/ 3 A
  - 5/9/15/20 Vdc
- Standby power: <50 mW in Universal(No cable plug in)
- Avg. Efficiency: >91%
- Adaptive Output OVP and UVP
- Output OCP, SCP

Demoboard Photo

Market & Applications

- Notebook adapters, tablets, smart phones

Design Note

NCP1342 90-W USB PD Demo Board

Value Proposition

The NCP1342PD90WGEVB showcases the NCP1342 Quasi-Resonant Flyback Controller and NCP1622 PFC Controller in a USB Power Delivery (PD) application. The board is capable of delivering 90 W of power. The NCP1342 is suitable for designing high-performance off-line power converters and USB PD adapters, and features Rapid Frequency Foldback (RFF) for improved efficiency over the load range. An integrated active X2 capacitor discharge feature eliminates discharge resistors which enables low no-load power consumption.

Specifications and Features

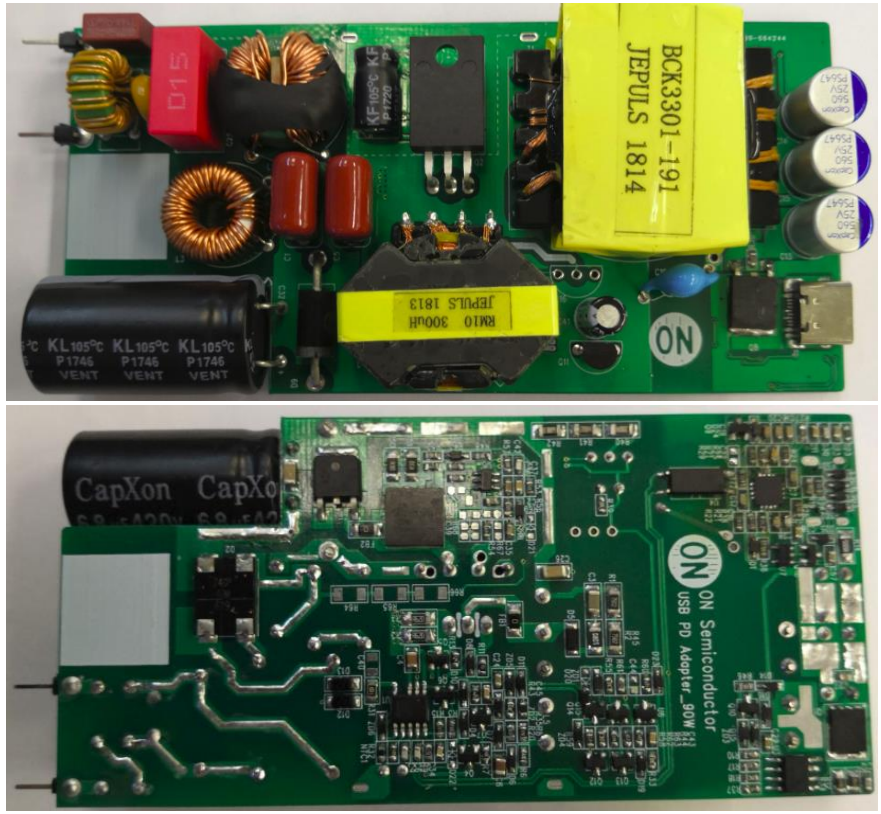
- Input voltage: 90Vac to 264Vac
- PD Output spec: 5V/3A, 9V/3A, 12V/3A, 15V/3A, 20V/4.5A
- Standby power: 40mW @ 5V output, 230Vac
- Efficiency: 91.3% @115Vac&20V4.5A
- 92.2% @230Vac&20V4.5A
- Avg. efficiency: >91% at 115Vac&230Vac
- PFC switching frequency: 150kHz @ full load, 230Vac
- QR Flyback switching frequency: 80kHz @ full load
- Board size: 111mmx53mmx16mm
- Power density: 0.96W/cm3 or 15.7W/in3
- Controllers:
  - PFC: NCP1622AEC
  - QR Flyback: NCP1342ANDBDD1R2G
  - SR: NCP4306AADZZZA

Market & Applications

- Notebook adapters, displays

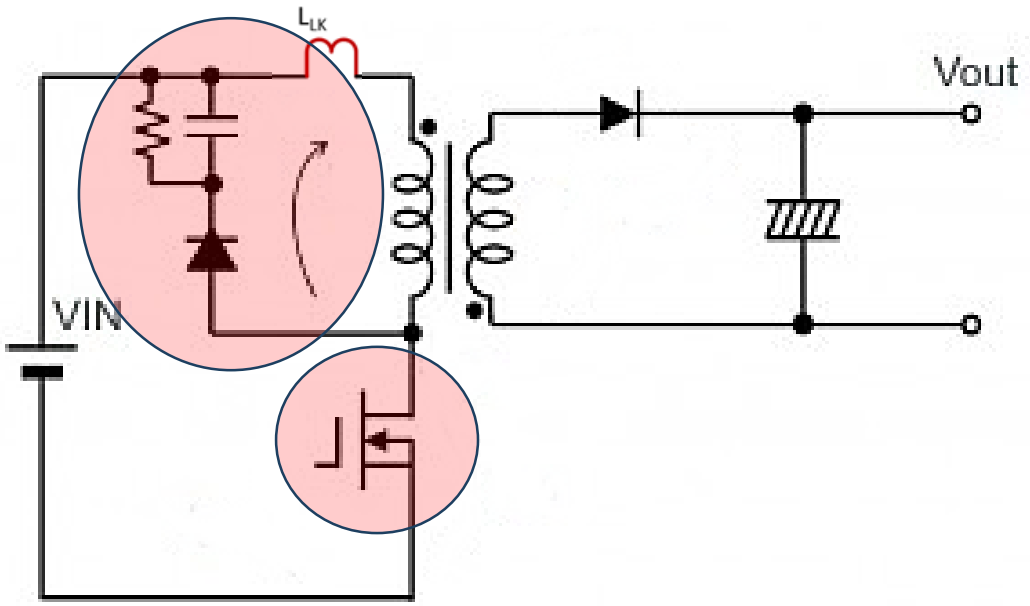
Design Note

Demo Board Photo



Benefits of Active Clamp Flyback

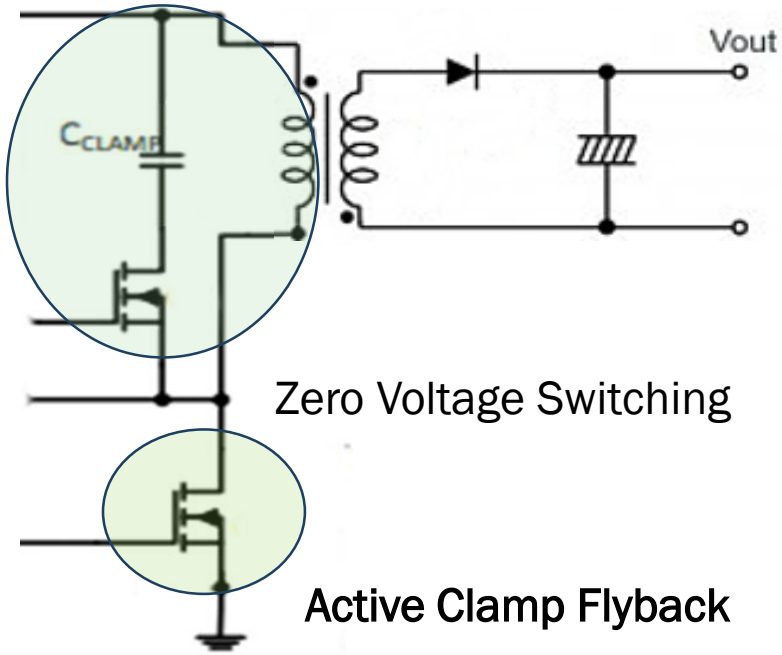
- In a traditional flyback, energy stored in the leakage inductance of the transformer is dissipated by a snubber circuit, which becomes excessive at higher frequencies
- Switching losses also become significant as frequency increases



Traditional Single Ended Flyback with RCD Snubber

- ACF recycles leakage energy by storing it in a capacitor and delivering it to the output
- ACF enables Zero Voltage Switching, switching while voltage across FETs is zero, eliminating power loss
- **Allows switching frequencies up to 1 MHz**

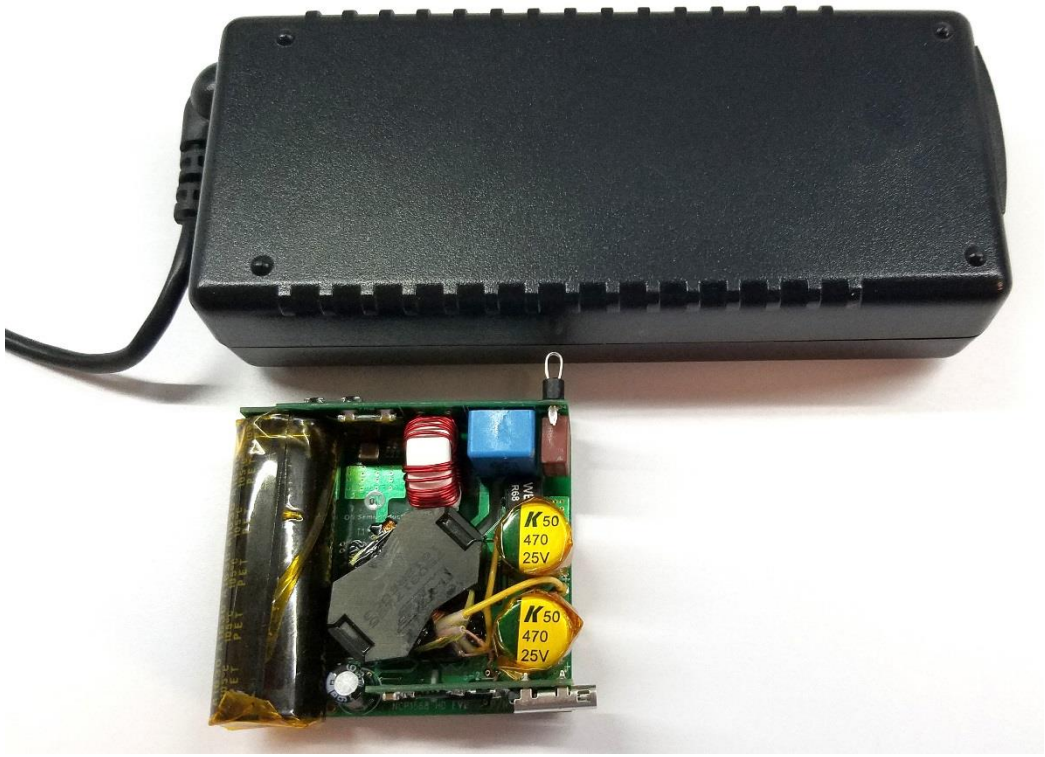
Active Clamp



Zero Voltage Switching

Active Clamp Flyback

60-W Notebook Adapter Comparison



USB PD Enabled Active Clamp Flyback Design

Power Density:	31.1 W/in^3 using SJ FETs
	1.91 W/cm^3
Board Dimensions:	1.66” x 1.78” x 0.70”
	4.22 cm x 4.52 cm x 1.78 cm

NCP1568 Active Clamp Flyback Controller

Value Proposition

The NCP1568 is a highly integrated AC-DC PWM controller designed to implement an active clamp flyback (ACF) topology, which enables zero voltage switching (ZVS) for high efficiency, high switching frequency up to 1 MHz for high power density applications. Discontinuous Conduction (DCM) operation allows for high efficiency in light load conditions.

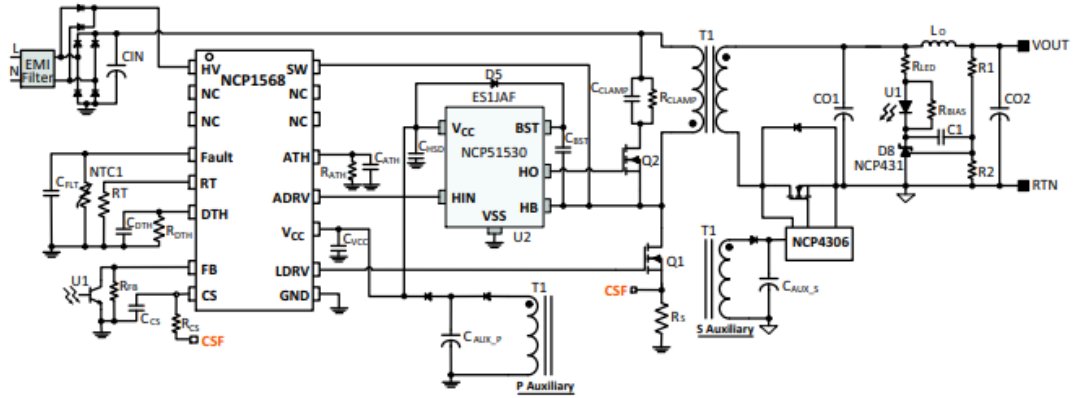
Unique Features

- ACF topology
- Adaptive ZVS frequency modulation
- Frequency Jittering
- Quiet-Skip Technology
- Multi-mode operation

Benefits

- High frequency operation
- Allows high fsw & variable Vout
- Reduces EMI
- Noiseless operation
- High efficiency at light loads

Typical Application



Other Features

- Programmable frequency form 100 kHz to 1 MHz
- Programmable optional transition to DCM mode
- High voltage startup circuit with X2 capacitor discharge
- Frequency Foldback with 31 kHz Minimum Frequency
- NTC Compatible Fault Pin
- Winding & output diode short-circuit protection
- Option for auto-recovery & latched for various faults

Market & Applications

- High Density USB PD Adapters
- Notebook Computer & Mobile Adapters
- Battery Pack Chargers
- Server Auxiliary Power

Ordering & Package information

- TSSOP-16
- NCP1568SxxDBR2G recommended for SJ FETs
- NCP1568GxxDBR2G recommended for GaN FETs

NCP1568 60 W UHD USB PD Demo Board

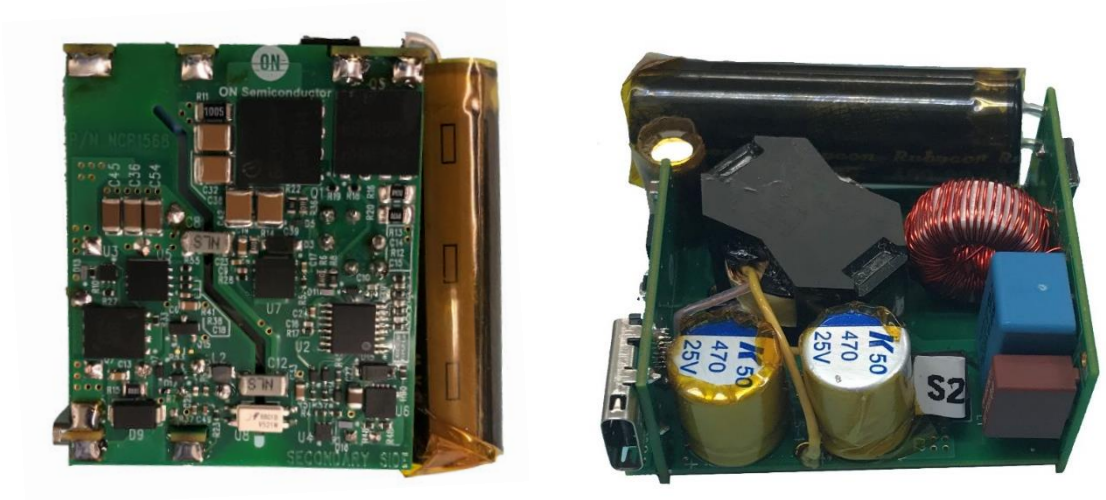
Value Proposition

This design demonstrates the potential of the active-clamp flyback topology utilizing ON Semiconductor's NCP1568 PWM controller, NCP51530 HB Driver, NCP4305 SR controller in a 60W ultra-high density design. It is universal input and 5V, 9 V, 12 V, 15 V and 20 V output for USB PD applications. High switching frequency allows the use of an RM 8 LP transformer

Specifications and Features

- 60W, 3A max output
- Universal AC input operation: 90 -265 Vac
- Output Voltage: 5V/9V/12V/15V/20V
- High frequency operation up to 450 kHz
- RM 8 LP Transformer
- High full load and average efficiency
- Low standby power
- Very low ripple and noise
- Inherent SCP and OCP protection
- Thermal and OVP protection
- Adaptive frequency operation based on AC input and output load conditions
- Adaptive ZVS operation.
- Smaller EMI components.
- Multiple probe points for evaluation
- Smooth startup operation

Demo Board Photo



- Transformer Type: RM 8 LP
- Power Density: 29 W/in3
- Board Dimensions: 1.66" x 1.78" x 0.70

Market & Applications

- Notebook Adapters
- USB PD Adapters

Design Note

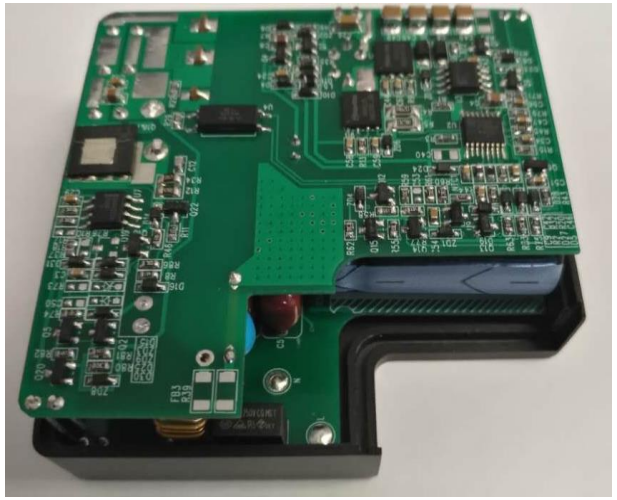
NCP1568 USB PD 90-W UHD Demo Board

Specifications and Features

- PFC: NCP1622 CRM VSFF PFC with boost follower control
- ACF: NCP1568
- SR: NCP4306
- Support PD3.0, QC4.0 and PPS protocol
- Rated Output power: 90W
- PD3.0 specification: 5V/3A, 9V/3A, 12V/3A,15V3A , 20V/4.5A
- High operation frequency between 100kHz and 420kHz
- High switching frequency: ~150kHz @90Vac and full load
- Board size: 63mmx63mmx21mm (2.48 x 2.48 x 0.83”)
- Power density: 21 W/in^3
- Standby power: <75mW in Universal (No cable plug in)
- Avg. Efficiency: >91%@20V at board end, 115&230Vac
- Adaptive Output OVP and UVP
- Output OCP, SCP
- Cable voltage drop compensation
- ACF Open loop protection
- ACF two stage OPP for 45W and 90W output

Demo Board Photo

Same form factor as existing 30W USB PD



Market & Applications

- Smart phone, Tablet and Notebook

Design Note

Active Clamp Flyback UHD 48-W Server AUX DC-DC Demo

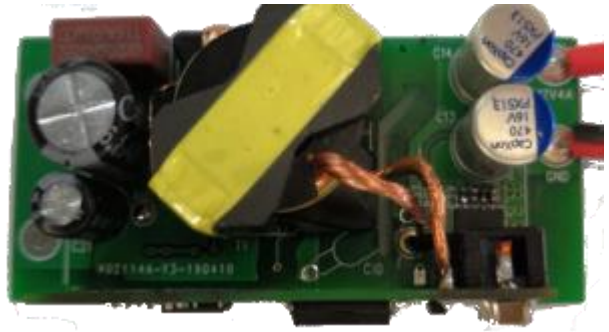
Value Proposition

NCP1568DC48WGEVB, intended for Server AUX power and others DC input applications requiring fixed voltage output, low profile, high efficiency and high power density. The NCP1568DC48WGEVB uses an Active Clamp Flyback (ACF) topology utilizing ON Semiconductor NCP1568 ACF controller, NCP51530A half−bridge driver, NCP4306 synchronous rectified controller and secondary NTMFS6B03 synchronous MOSFET. .

Specifications and Features

- DC Input from 120 V to 400 V
- Rated Output Power: 12 V, 4 A
- Efficiency: >94% at 156 Vdc and 320 Vdc @ Full Load
- ACF Topology with ZVS Operation
- High Voltage Startup
- High Frequency Operation to allow Low Profile
- ACF Operation Frequency Range from 110 kHz to 400 kHz
- Quite Skip and Flyback DCM Operation with
- Frequency Foldback at No Load and Light Load
- Ripple and Noise <80 mV

Demo Board Photo



- Transformer Type: RM7
- Power Density: 48 W/in3
- Board Dimensions: 40x24x17mm

Market & Applications

- Server & Networking Auxiliary Power
- DC-DC Power Modules

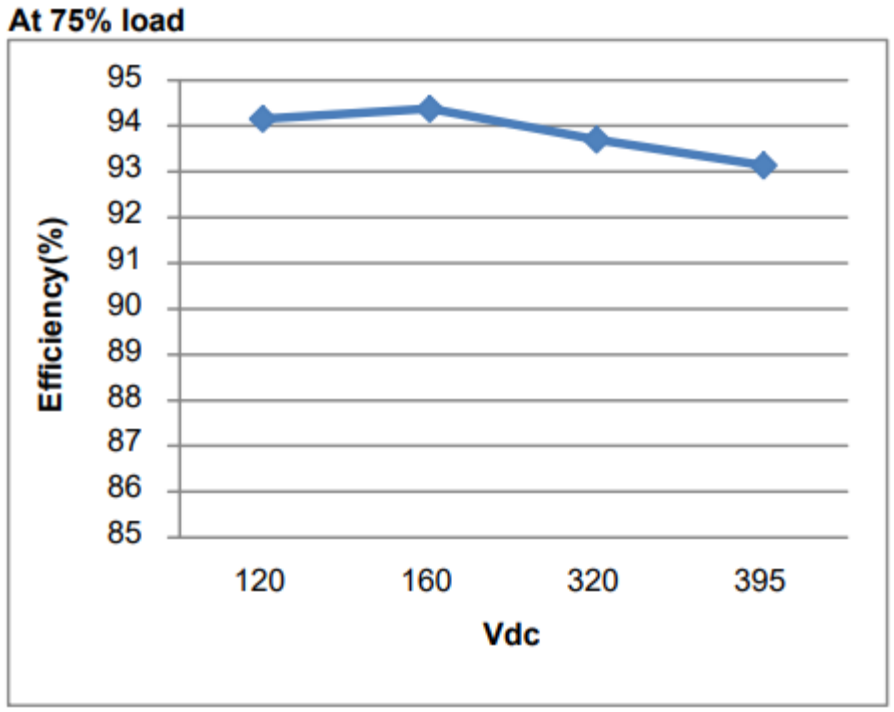
OPN: NCP1568DC48WGEVB

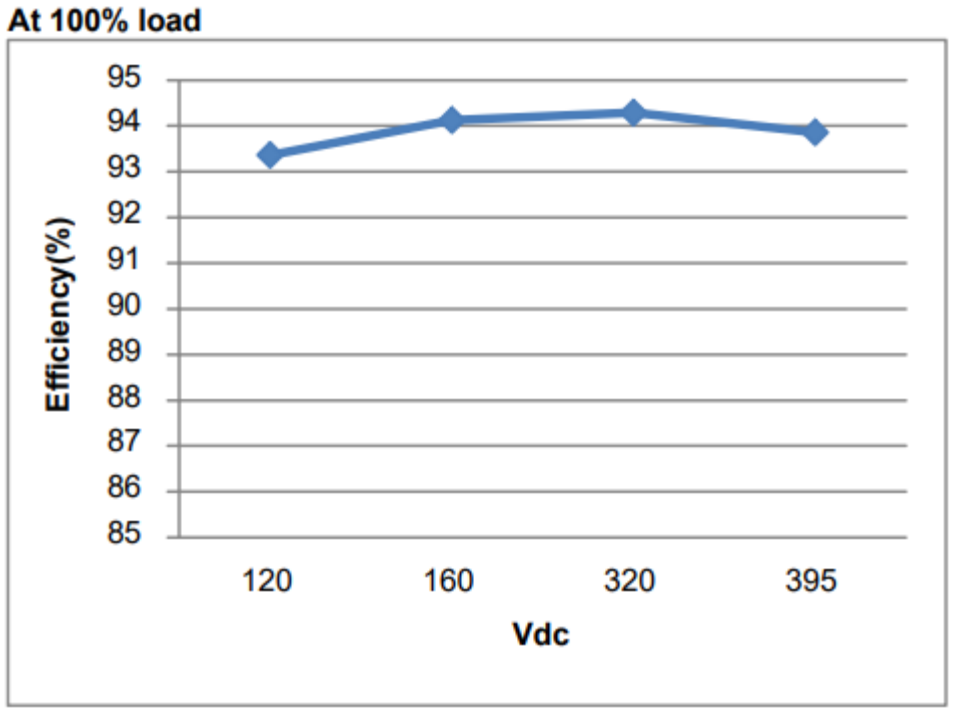
Design Note

Public Information

Efficiency Performance

Efficiency graph of NCP12601PD65WGEVB for 115 V_{rms} / 60 Hz





NCP12400 Fixed Frequency Controller

Value Proposition

The NCP12400 is a low cost flyback controller with integrated HV startup and X2 discharge capabilities. It offers excellent light load efficiency and no-load power consumptions, enable customers to meet the latest CoC tier 2 standards.

Unique Features

- No-load standby power < 30 mW
- Integrated HV Startup
- Integrated X2 discharge
- Integrated BO protection
- Monolithic 700V process

Benefits

- Low cost integrated flyback solution to customers
- With low standby power loss
- And low acoustic noise

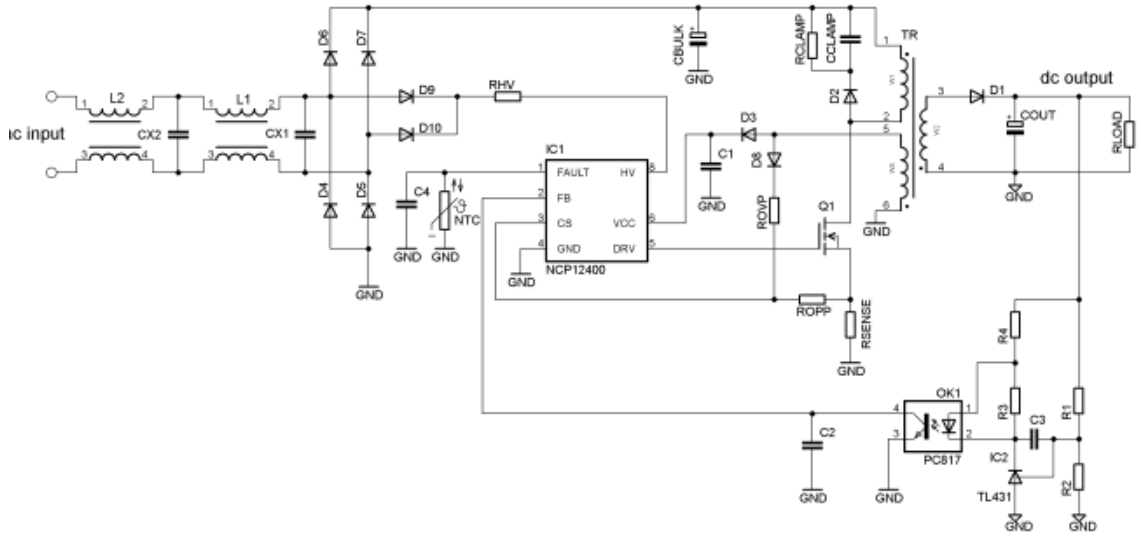
Other Features

- Frequency Foldback then Skip Mode for Maximized Performance in Light Load and Standby Conditions with no acoustic noise. (Quiet skip)
- Frequency Modulation for Softened EMI Signature
- 10 ms Soft-Start
- Internal Thermal Shutdown

Market & Applications

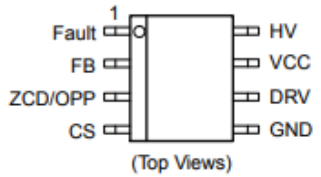
- Low cost AC/DC Power Adapters
- Auxillary Power
- Industrial Power

Typical Application Circuit



Ordering & Package information

- SOIC-7



(Top Views)

NCP4307 Synchronous Rectifier Controller

Future Product

Sampling end Q3'20, RTM Q4'20

Value Proposition

The NCP4307 is high performance driver tailored to control a synchronous rectification MOSFET in switch mode power supplies. Thanks to its high performance drivers and versatility, it can be used in various topologies such as DCM or CCM flyback, quasi resonant flyback, active clamp flyback and forward. Self-supply capability and dual VCC pin option optimizes designs for wide V_{OUT} range applications, such as USB PD, and can be configured for high side or low side operation.

Unique Features

- Self-supply capability
- Dual VCC Pins
- Internal Min off-time & on-time blanking periods

Unique Features

- Allows high side operation or low V_{OUT} without aux winding
- Optimize Power Consumption in Wide V_{OUT} range applications
- Reduces ringing affects induced by parasitics

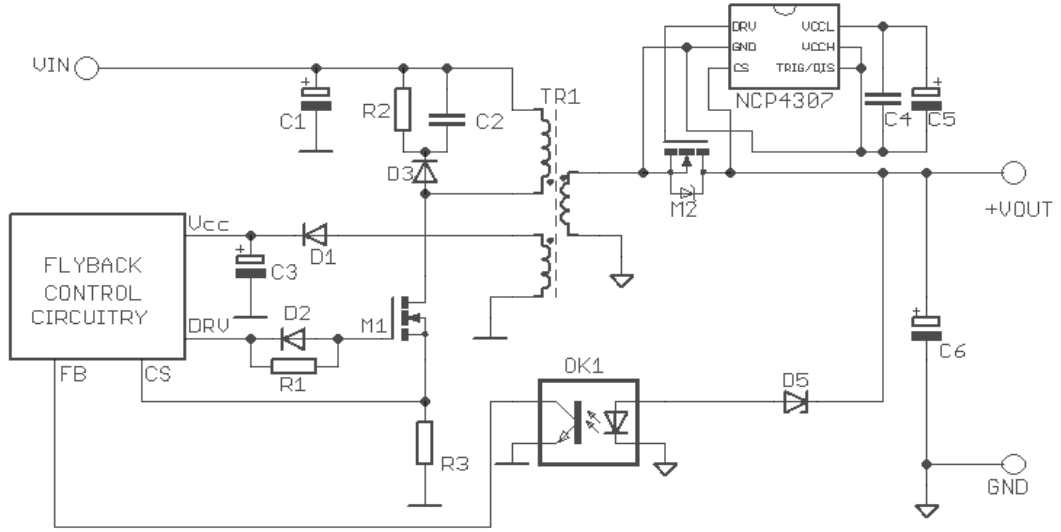
Other Features

- Wide Voltage Range V_{CC} = 35 V
- Two VCC Pins to Optimize Power in USB PD Applications
- Precise True Secondary Zero Current Detection
- Rugged Current Sense Pin (200 V)
- Ultrafast Turn-off Trigger Interface/Disable Input (10.5 ns)
- Automatic Light-load Disable Mode
- 7 A / 2 A Peak Current Sink / Source Drive
- Reverse current detection

Market & Applications

- USB-PD Adapters
- High Power Density Ac-Dc Power Supplies
- Dc-Dc Modules & Telecom

Typical Application Schematic & Pin Out



Ordering & Package information

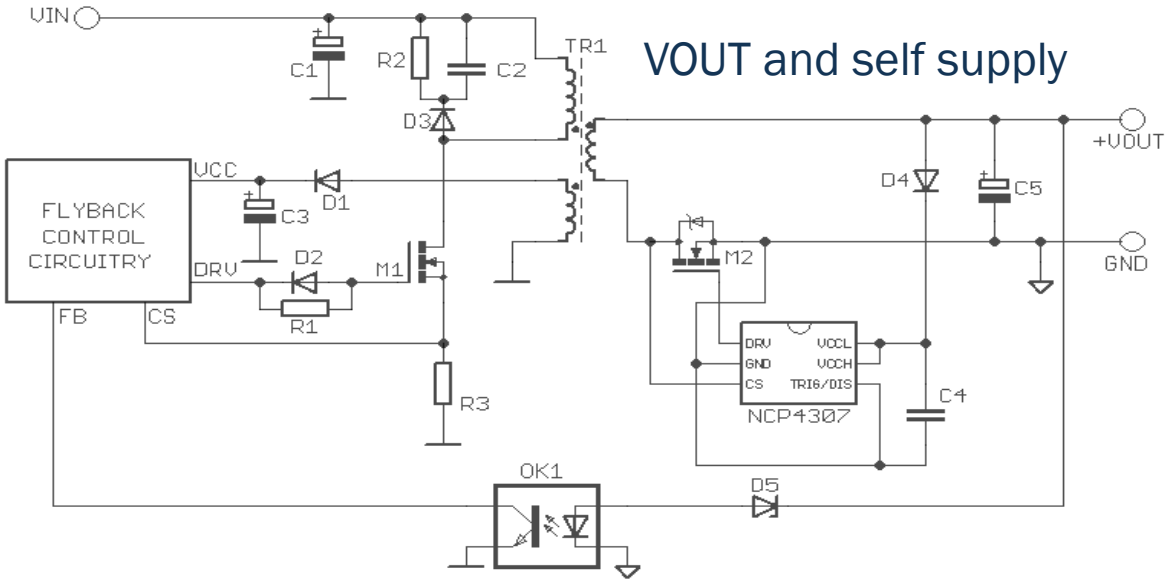
- NCP4307xxx
- TSOP-6, 2x2.2 DFN-8, 4x4 DFN-8

Sampling Q3'20

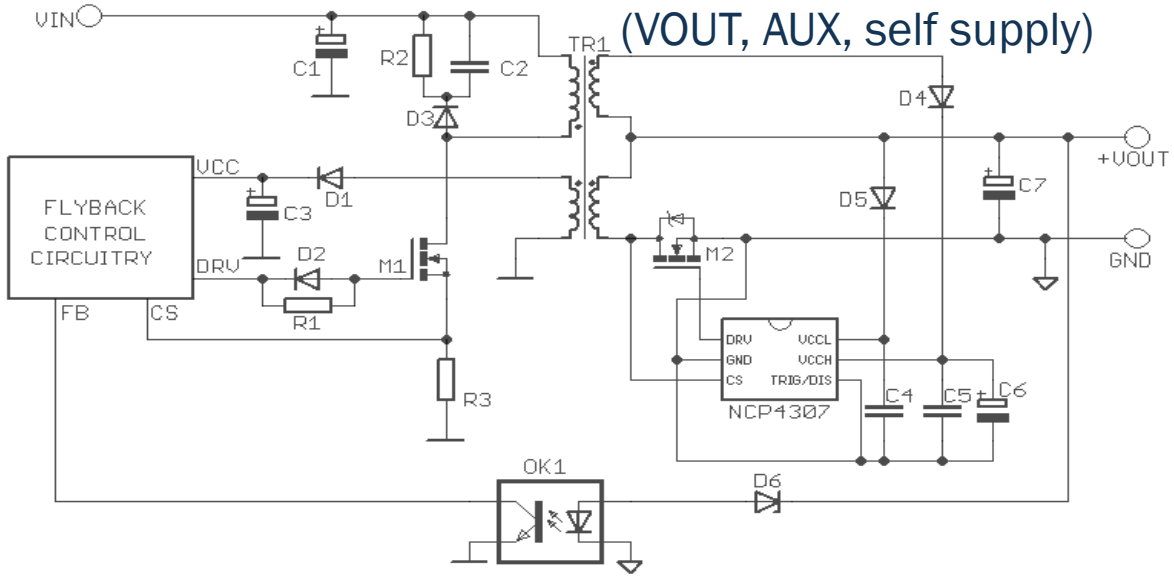
Flyback (DCM, CCM) Low Side

Future Product

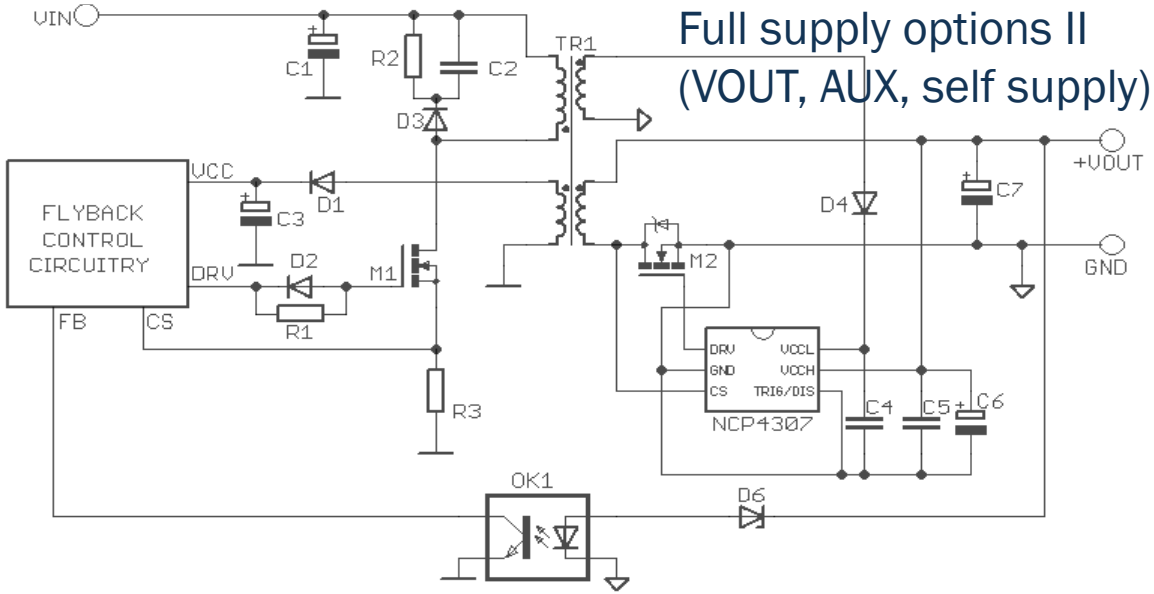
VOUT and self supply



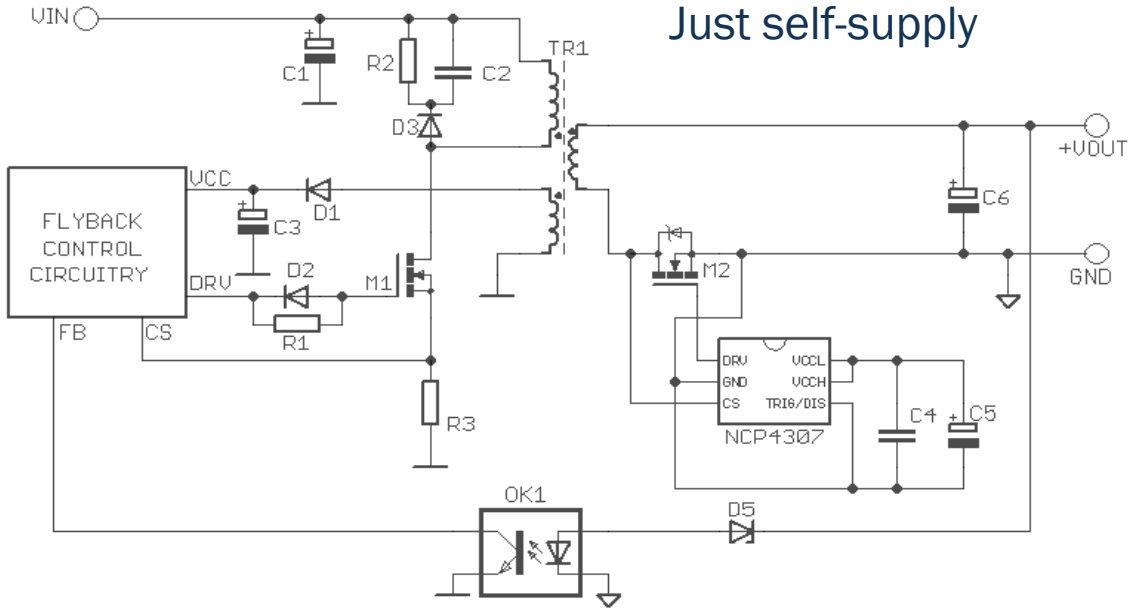
Full supply options (VOUT, AUX, self supply)



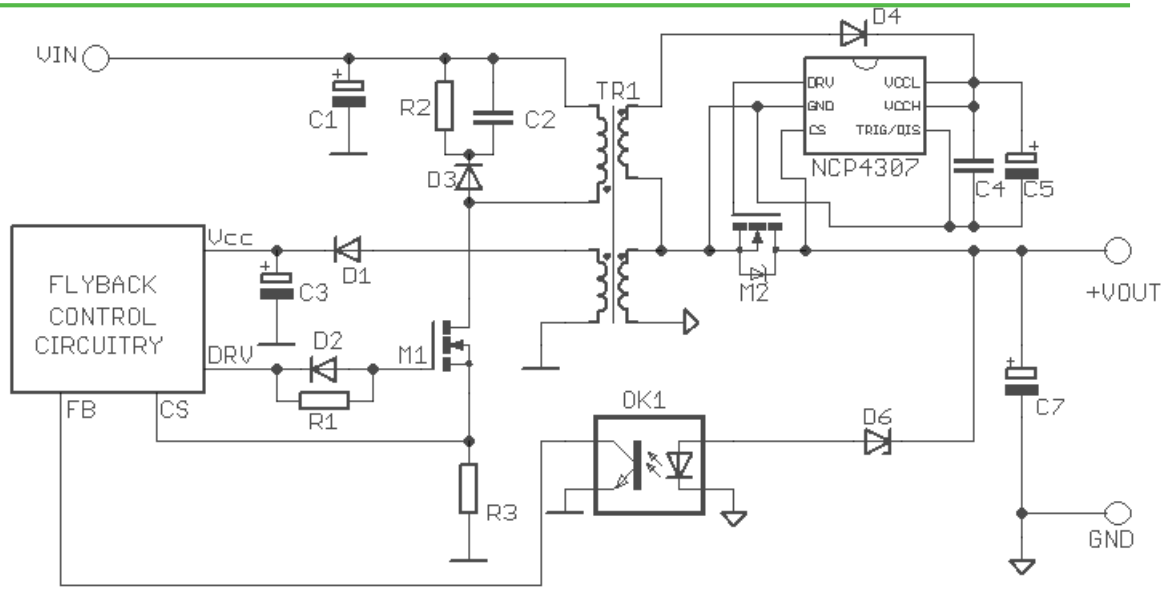
Full supply options II (VOUT, AUX, self supply)



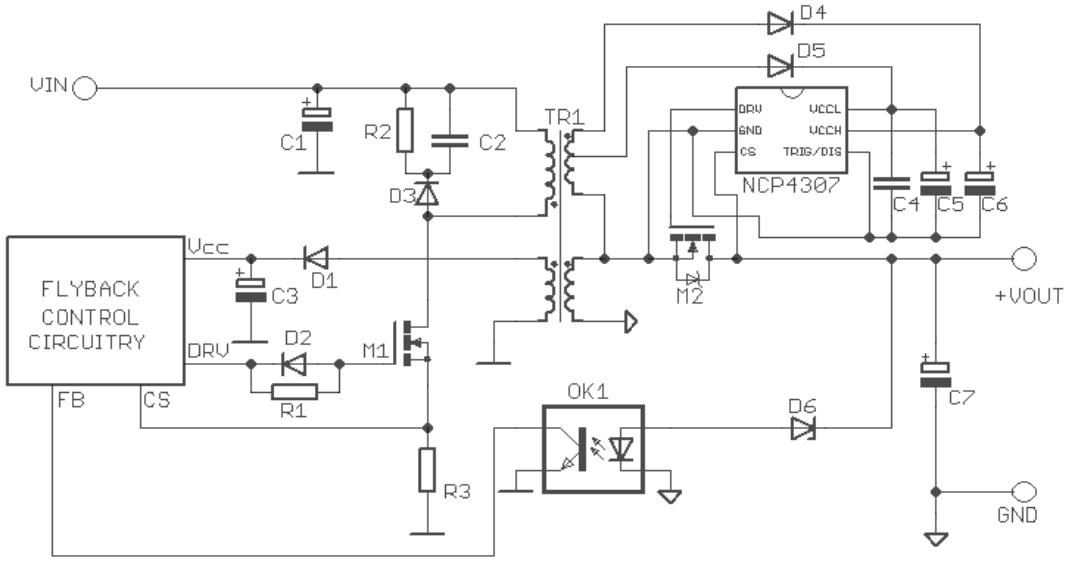
Just self-supply



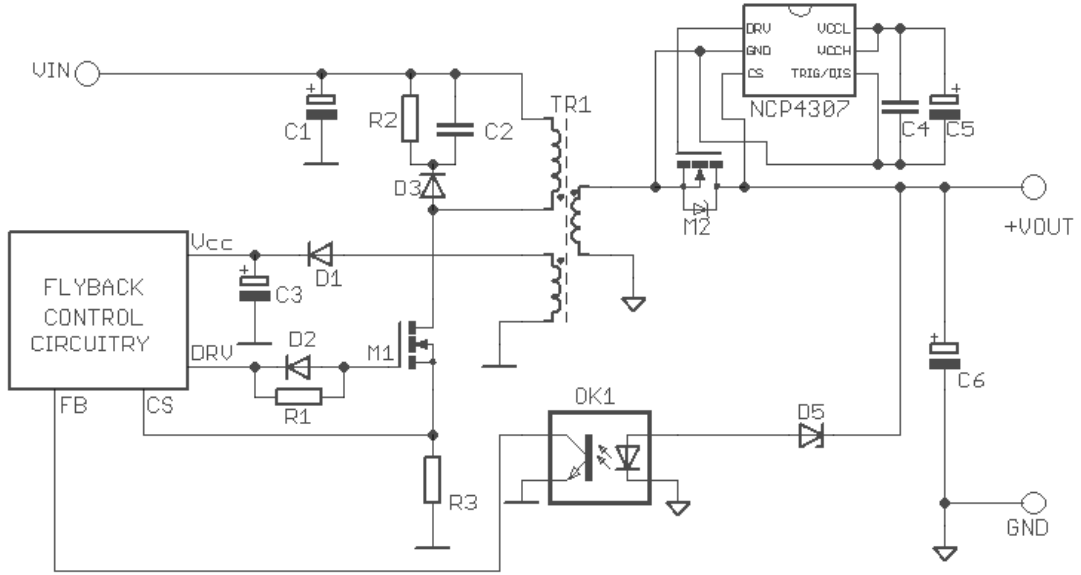
Flyback (DCM, CCM) High Side



VOUT supply



Full supply options
(VOUT, AUX, self supply)

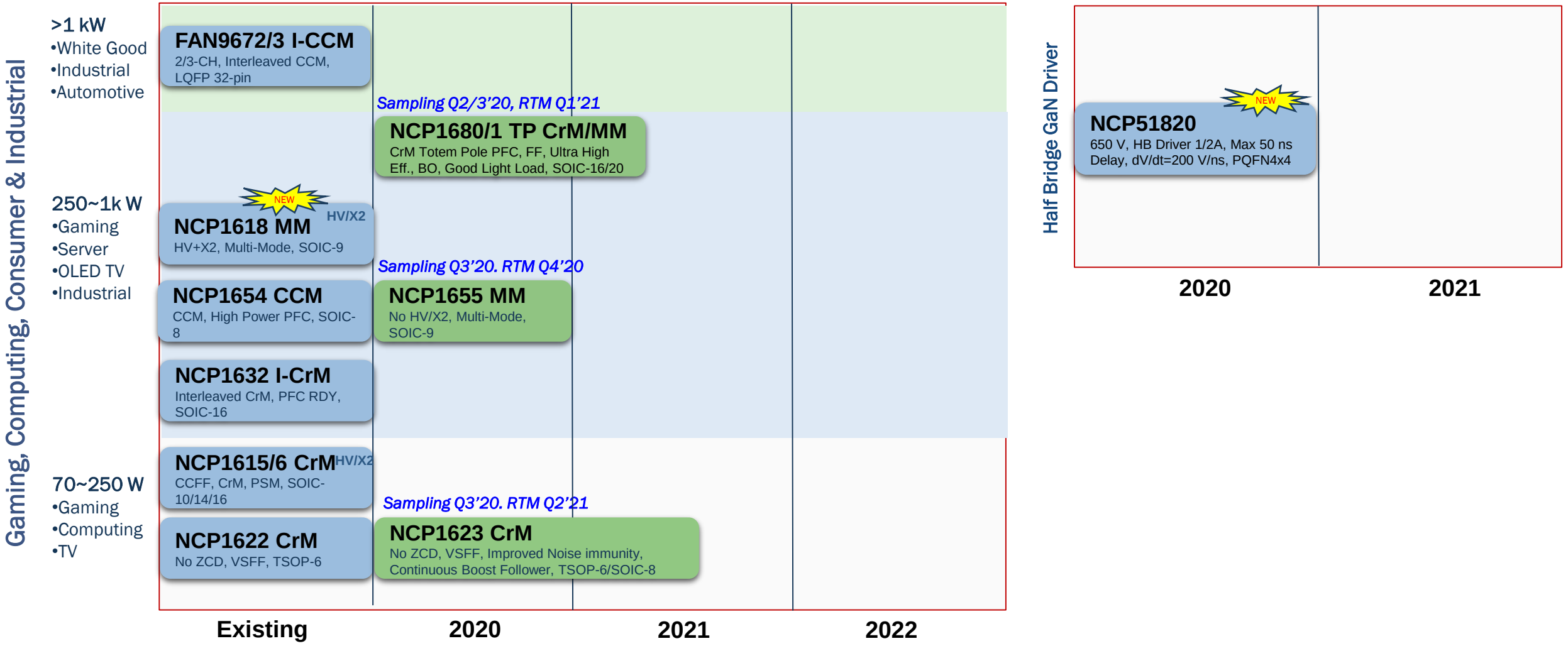


Just self-supply

NCP4307 Daughter Card

PFC Solutions

PFC Roadmap



*HV/X2 = Integrated high voltage startup and X2 capacitor discharge

NCP1618 – High-Voltage, Multi-mode Power Factor Controller

Value Proposition

The NCP1618 is an innovative multimode power factor controller. Depending on the current cycle duration, the circuit naturally selects the optimal operation mode from CCM, CrM or DCM with frequency foldback for an optimized efficiency over the line/load range. In very light load, the circuit enters the soft-skip mode. In addition, its high-voltage capability eliminates the need for external startup and X2 capacitor discharge circuitries and saves the permanent leakage they cause. Housed in a SOIC-9 package, the NCP1618 incorporates all the features necessary for robust and compact PFC stages, with few external components.

Unique Features

- Multi-Mode Operation
- Frequency Foldback / Soft-SKIP mode

Benefits

- Optimized Functioning over a large load range
- Optimized light load Efficiency

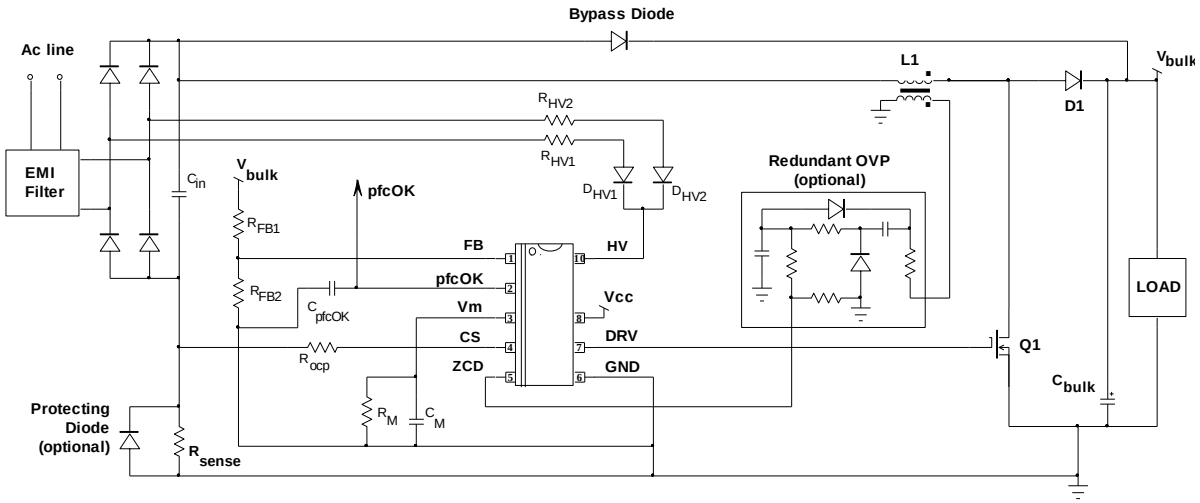
Other Features

- Near-Unity Power Factor in all modes (CrM/DCM/CCM)
- Fast Line / Load Transient Compensation
- HV Circuit for Startup and X2 Capacitors Discharge
- High safety level: OCP, OVP, BO, BUV, Inrush detect…
- pfcOK Signal for Sequencing Control
- High Drive Capability: -500 mA / +800 mA
- Jittering in CCM (10% pk-pk - 2.5, 3.3 or 5.0 kHz)

Market & Applications

- Gaming, servers PSU
- All off-line Appliances over 200 W

Typical Application Schematic



Ordering & Package information

NCP1618: SOIC-9

NCP1616 – CrM PFC controller

Value Proposition

The NCP1616 is a highly efficient & compact CrM PFC controller with HV start-up capability. Current controlled frequency foldback (CCFF) technique enables superior nominal and light load efficiency.

Unique Features

- HV Start-Up Circuit with Brownout & X2 Discharge
- Current Controlled Frequency Foldback (CCFF)
- Combined Fault/Standby Input
- Skip Mode Near Zero Crossing

Benefits

- Low Standby Mode Current
- Low Pin Count
- High efficiency
- Robust PFC Stage

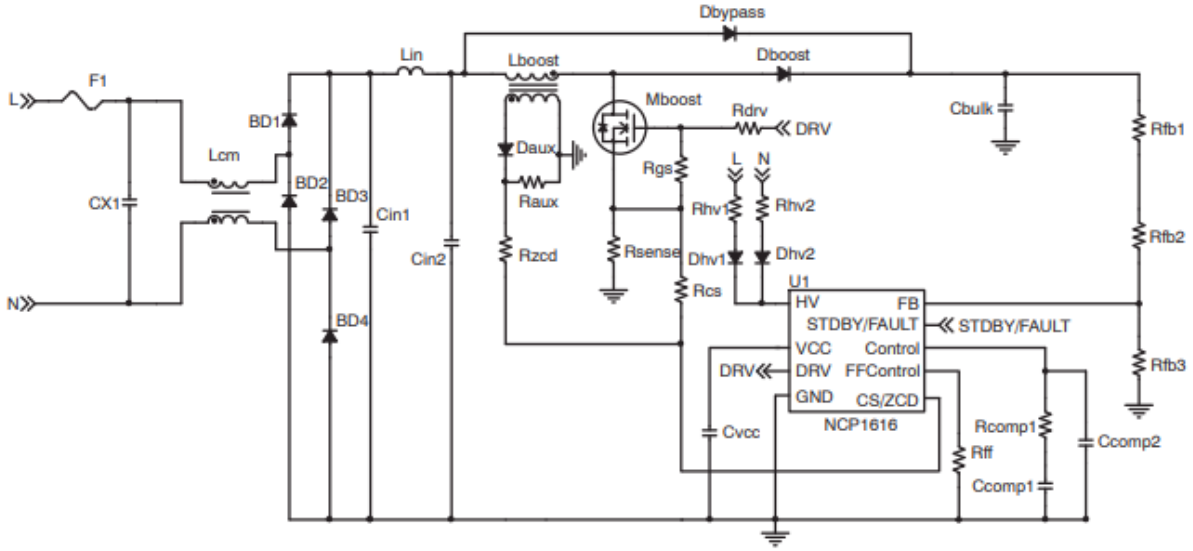
Other Features

- Latch Input for OVP Fault
- Line Overvoltage Protection
- Open Pin Protection
- Internal Thermal Shutdown
- Bypass/Boost Diode Short Protection
- Open Ground Protection

Market & Applications

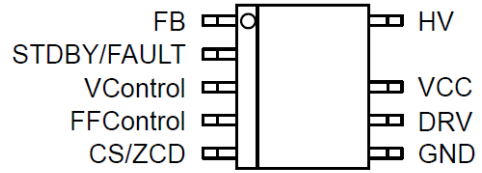
- Notebook Adapters
- High Power Density AC/DC PS
- Off Line Appliances Requiring Power Factor Correction
- Flat TVs

Typical Application Schematic



Ordering & Package information

Available in SOIC-9



NCP1616 9 Pins (Top View)

NCP1632 – Upgraded Interleaved FCCrM PFC controller

Value Proposition

The NCP1632 is an interleaving, 2-phase PFC controller which has inherited most of the NCP1631 functions and operation modes. In particular, like the NCP1631, the NCP1632 is designed to operate in critical conduction mode (CrM) in heavy load conditions and in discontinuous conduction mode (DCM) with frequency foldback in light load for an optimized efficiency over the whole power range with a minimized boost inductors size.

Unique Features

- Robust out-of-phase control
- Frequency Foldback / SKIP mode

Benefits

- No discontinuity in operation including in transient phases
- Optimizes efficiency over the load range

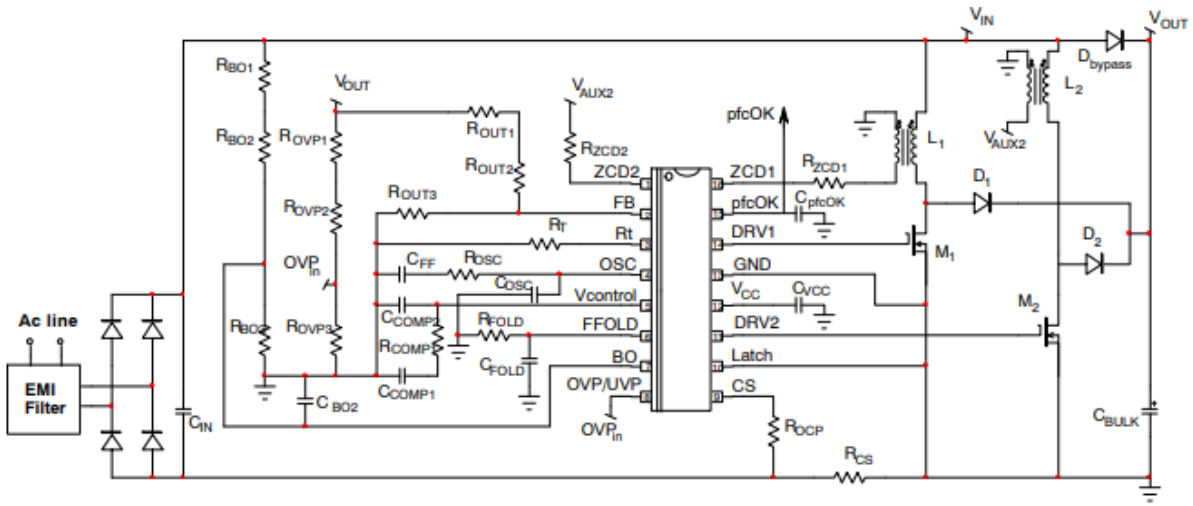
Other Features

- Near-Unity Power Factor in all modes (CrM/DCM)
- Fast Line / Load Transient Compensation
- Programmable adjustment of the maximum power
- 180˚ phase shift control
- High safety level: OCP, OVP, UVLO, BO, Inrush detection…
- High Drive Capability: -500 mA / +800 mA

Market & Applications

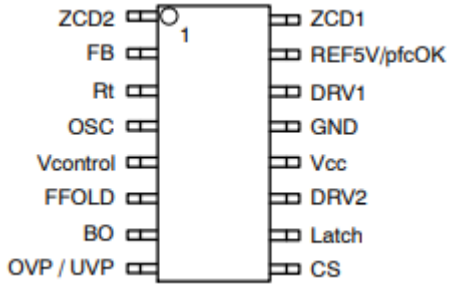
- High-end LED TV's
- High Power Gaming SMPS
- High-efficiency applications

Typical Application Schematic



Ordering & Package information

Available in SOIC-16



FAN9672/3: 2/3-Channel Interleaved CCM PFC Controller

Value Proposition

The FAN9672 is an interleaved two−channel Continuous Conduction Mode (CCM) Power Factor Correction (PFC) controller IC intended for PFC pre−regulators. Incorporating circuits for leading edge, average current, and “boost”−type power factor correction; the FAN9672 enables the design of a power supply that fully complies with the IEC1000−3−2 specification. .

Unique Features

- 2/3-Channel PFC Control
- Continuous Conduction Mode Control
- Average Current−Mode Control
- PFC Slave Channel Management Function

Benefits

- Interleaved operation
- Meets IEC1000-3-2 spec
- Improved transient response

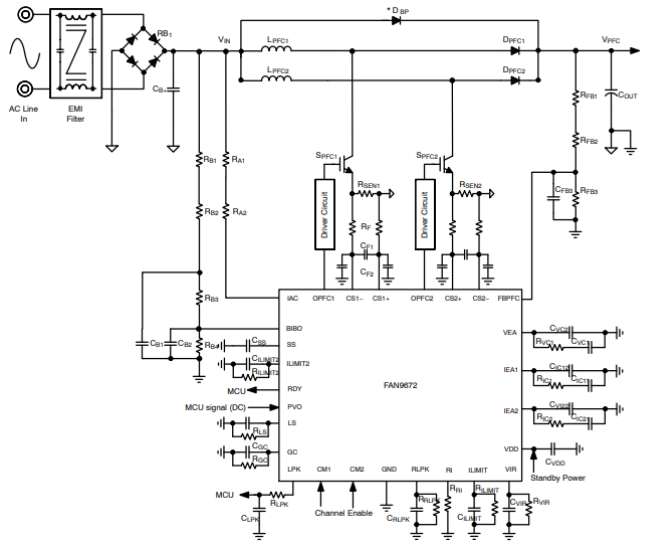
Other Features

- Programmable Operation Frequency Range: 18 kHz ~ 40 kHz or 55 kHz ~ 75 kHz
- Programmable PFC Output Voltage
- Dual Current Limit Functions
- TriFault Detect Protects Against Feedback Loop Failure
- Sag Protection
- Programmable Soft−Start
- Under−Voltage Lockout (UVLO)
- Differential Current Sensing

Market & Applications

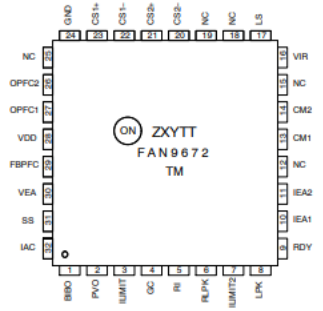
- High Power AC−DC Power Supply
- DC Motor Power Supply
- White Goods; e.g. Air Conditioner Power Supply

Typical Application Schematic



Ordering & Package information

Available in 32-pin LQFP



NCP1654 – Fixed Freq. CM PFC Controller

Value Proposition

The NCP1654 is a Power Factor Controller to efficiently drive Continuous Conduction Mode step-up pre-converters. This circuit is an improvement over the largely successful NCP1653: brown-out, fast transient response.

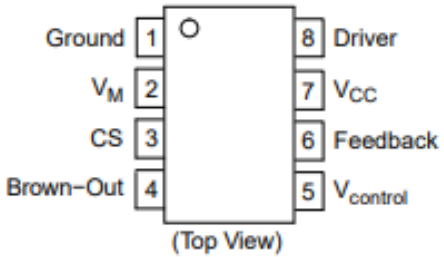
Unique Features

- Pin to pin compatible with industry standard
- Safety features: inrush currents detection, over & under voltage protection, brown-out, over-current and over power limitation.
- Fast transient response

Benefits

- Reduce design efforts
- Rugged design and very few external components
- Avoid excessive over or under-shoot

Pin-Out



(Top View)

Other Features

- Very low start-up (<75 µA) and shut-down currents (< 400 uA)
- Accurate Fully Integrated 65 kHz oscillator. 100, 133, 200, 266 kHz on demand
- 2 versions of UVLO (A & B options)
- Soft Start (B version only)

Market & Applications

- High power AC Adapters
- Flat TVs
- Desktop PCs
- > 300 W applications

Ordering & Package information

Available in SOIC-8

NCP1622 – Small Size, CrM, Freq. Foldback PFC

Value Proposition

The NCP1622 is a compact, and robust feature-rich Valley Switching Frequency Fold back PFC controller optimized to achieve high efficiency across a broad range of load while offering a complete suite of system level safety protection.

Unique Features

- Valley Sync Freq Foldback
- Skip Mode near zero cross
- Combined CS and ZCD

Benefits

- Maximizes efficiency at both normal and light load.
- Low Cost Solution

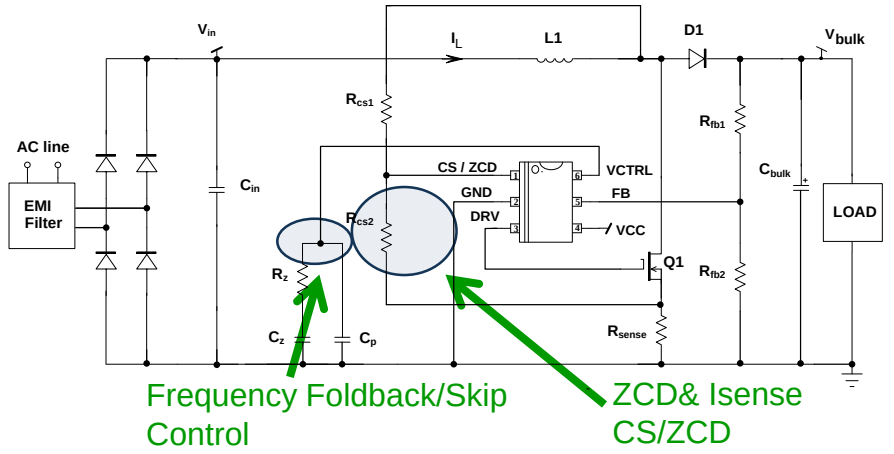
Other Features

- Near-Unity Power Factor
- Critical Conduction Mode (CrM) / Valley Turn On
- On-time modulation to maintain a proper current shape during Frequency Foldback
- High Drive Capability (-500mA / 800mA)
- Thermal Shutdown, Non-latching OVP, Brown Out Detection

Market & Applications

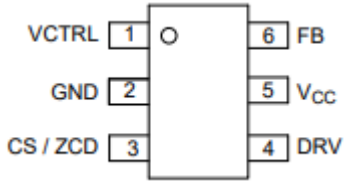
- LCD TVs
- Notebook Adapters
- Lighting Ballasts

Typical Application Schematic



Ordering & Package information

Available in TSOP-6



NCP1655 – Multimode Power Factor Controller

Future Product

Sampling end Q3'20, RTM Q4'20

Value Proposition

The NCP1655 is an innovative multimode power factor controller. Depending on the current cycle duration, the circuit naturally selects the optimal operation mode from CCM, CrM or DCM with frequency foldback for an optimized efficiency over the line/load range. In very light load, the circuit enters the soft-skip mode. Housed in a SOIC-9 package, the NCP1655 incorporates all the features necessary for robust and compact PFC stages, with few external components.

Unique Features

- Multi-Mode Operation
- Frequency Foldback / Soft-SKIP mode

Benefits

- Optimized Functioning over a large load range
- Optimized light load Efficiency

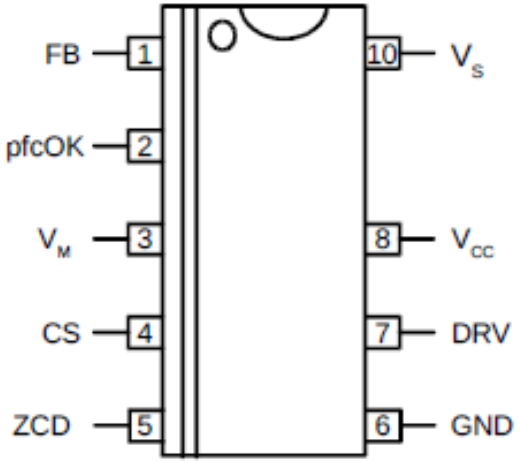
Other Features

- Near-Unity Power Factor in all modes (CrM/DCM/CCM)
- Fast Line / Load Transient Compensation
- High safety level: OCP, OVP, BO, BUV, Inrush detect…
- pfcOK Signal for Sequencing Control
- High Drive Capability: -500 mA / +800 mA
- Jittering in CCM (10% pk-pk - 2.5, 3.3 or 5.0 kHz)

Market & Applications

- Gaming desktop, servers PSU
- Industrial

Typical Application Schematic

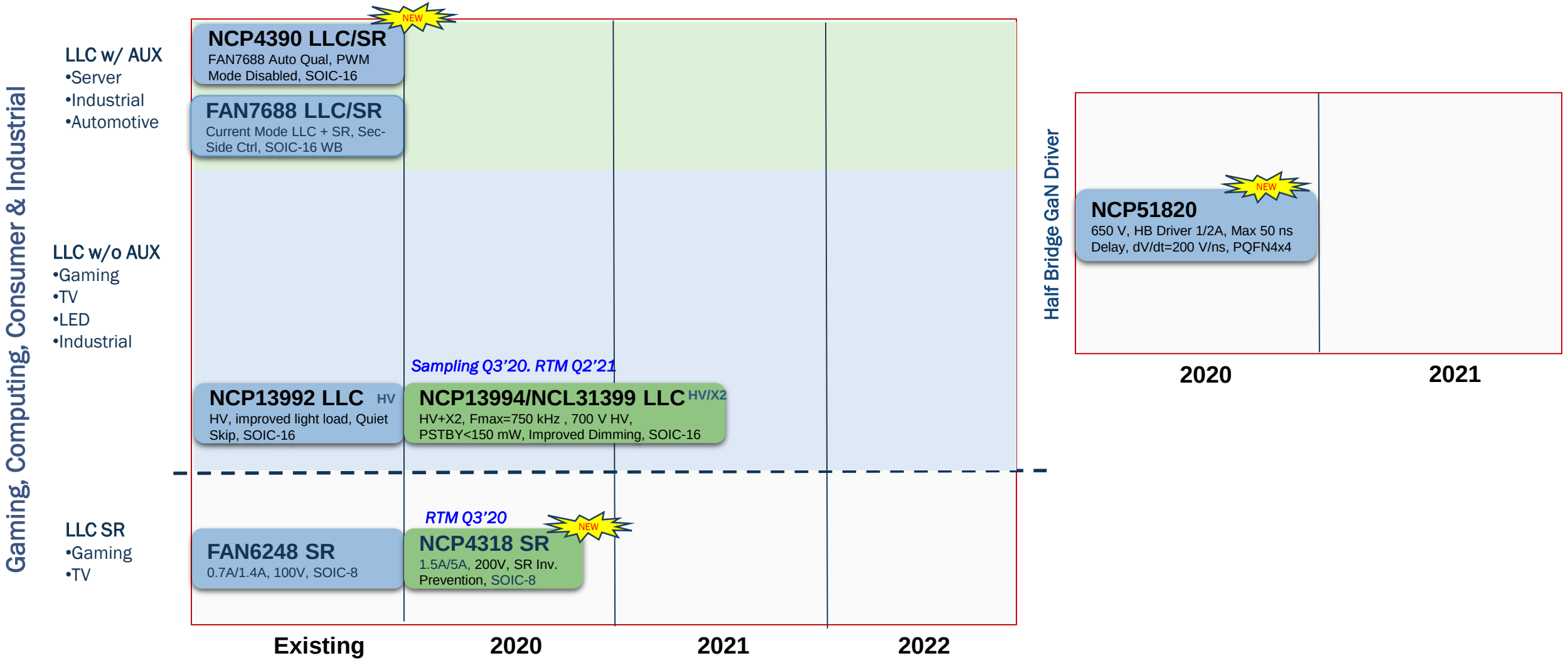


Ordering & Package information

NCP1655: SOIC-9

LLC Solutions

LLC & SR Roadmap



*HV/X2 = Integrated high voltage startup and X2 capacitor discharge

Existing | Developing | Planning | Exploring

NCP13992 – Current Mode LLC Controller

Value Proposition

The NCP13992 is a high performance controller for half bridge LLC resonant converters supporting operation over a wide range of bulk or line voltages. Current mode controller and enhanced light load efficiency makes it ideal for high power designs. The controller also implements proprietary light load and quiet skip mode operation that improve light load efficiency, reduce no load power consumption as well as significantly reduce audible noise.

Unique Features

- Built-in 600 V/1 A Driver
- Current Mode Control
- High Frequency 20 kHz to 750 kHz
- Light Load Mode for Improved Efficiency
- Quiet Skip Mode for Reduced Audible Noise

Unique Features

- Compact Design
- Inherent Anti-Capacitive Switching Protection
- <30 mW Off-mode
- <100 mW No Load

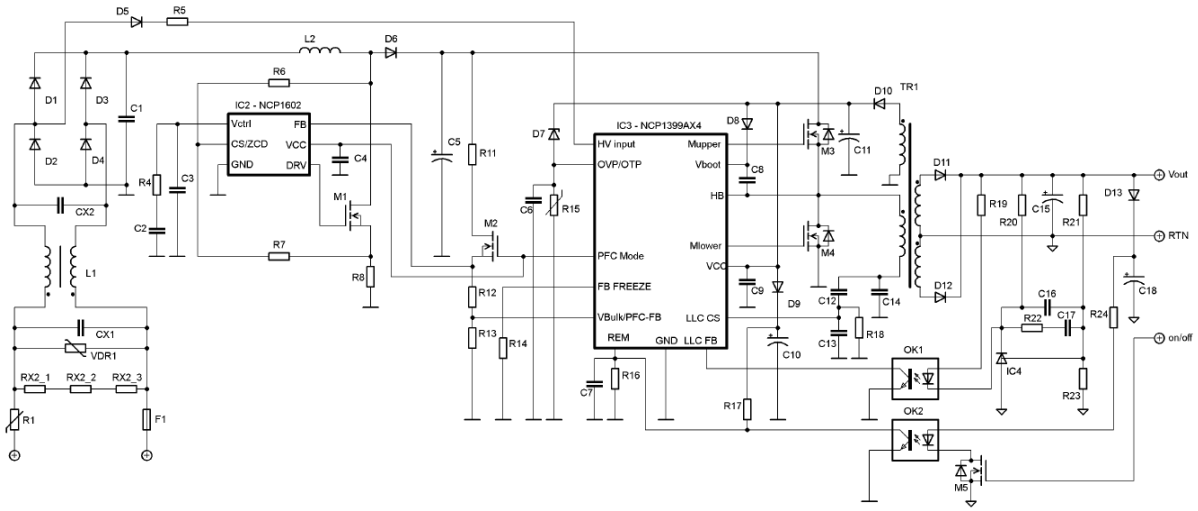
Other Features

- BO Protection
- PFC Stage Operation Control According to Load Conditions
- Automatic or Fixed Dead-Time Adjust Options
- Safety Design for Pin-Pin Short and Open/Short
- High Flexibility Via Custom Options

Market & Applications

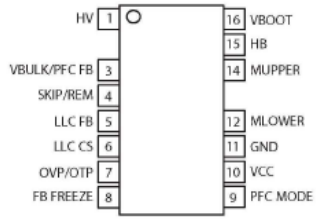
- Desktop PCs and All-In-One PCs
- Gaming Console Power Supplies
- Flat TVs
- High Power Notebook PC Adapters

Typical Application Schematic



Ordering & Package information

- SOIC-16 NB



NCP51820 – High Speed 650 V GaN HB Driver

Value Proposition

NCP51820 driver is designed to meet the stringent requirements of driving GaN power switches in off-line applications half-bridge topologies. It offers short and matched propagation delays. Advanced level shift technology provides -3.5 V to +650 V (typical) common mode voltage range operation for the high side gate driver and -3.5 V to +3.5 V common mode voltage range for the low side gate driver. Latest generation common-mode noise canceling technique provides stable operation up to 200 V/ns dV/dt rating for both driver output stages.

Unique Features

- 650 V, High and Low Side Drive
- Typical 1 A/2 A Source/Sink Current
- 1 ns Rise and Fall Time
- At least 100 V/ns dV/dt Immunity
- Regulated 5.2 V Gate Drive Amplitude

Benefits

- Enables ultra high density design
- Efficient switching of GaN for ultra high efficiency
- Reliable operation

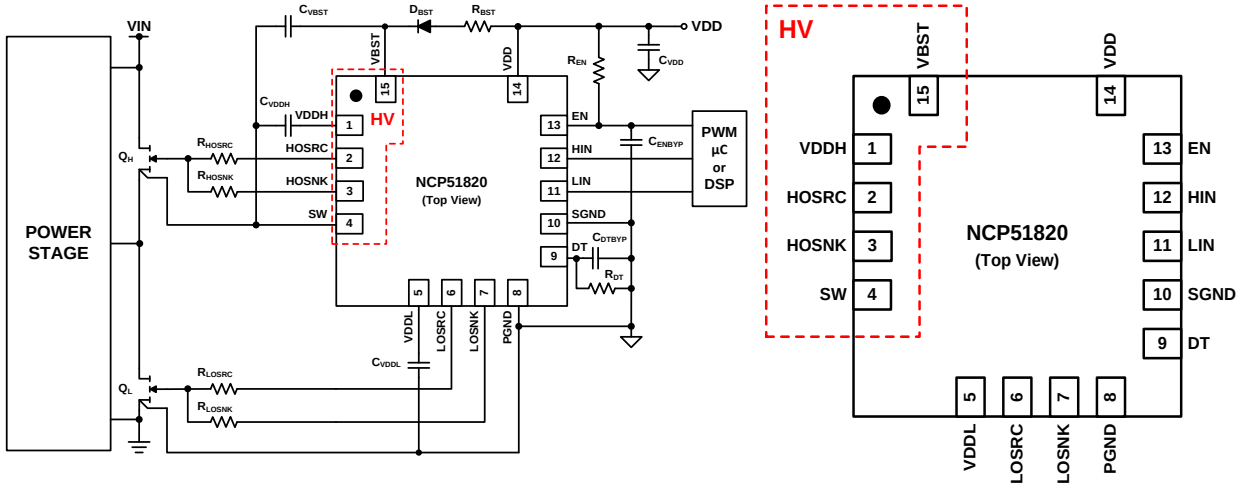
Other Features

- Independent UVLO Protections for High and Low Side Drivers
- Separated Driver Output Stages
- SW and PGND Withstands Negative Voltage Transient up to 3.5 V below SGND
- Max Propagation Delay of 50 ns
- Shoot-Through Prevention, Adjustable Dead-time, TSD
- MLP-15L 4mm x 4mm package

Market & Applications

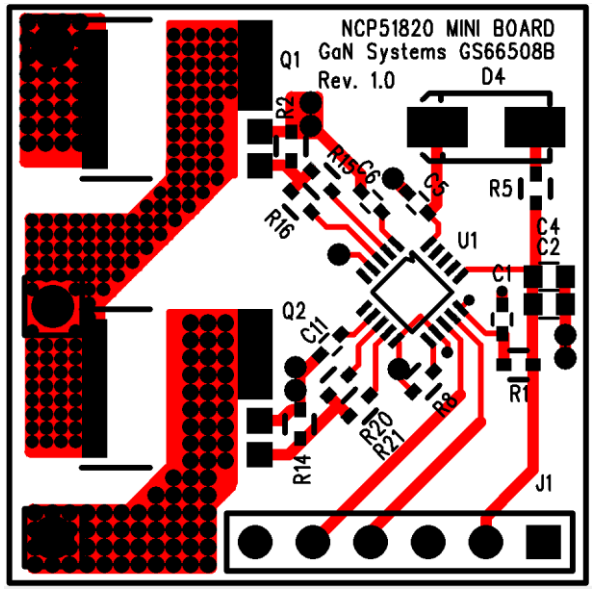
- Low to medium power Ultra High Density SMPS

Typical Application Schematic

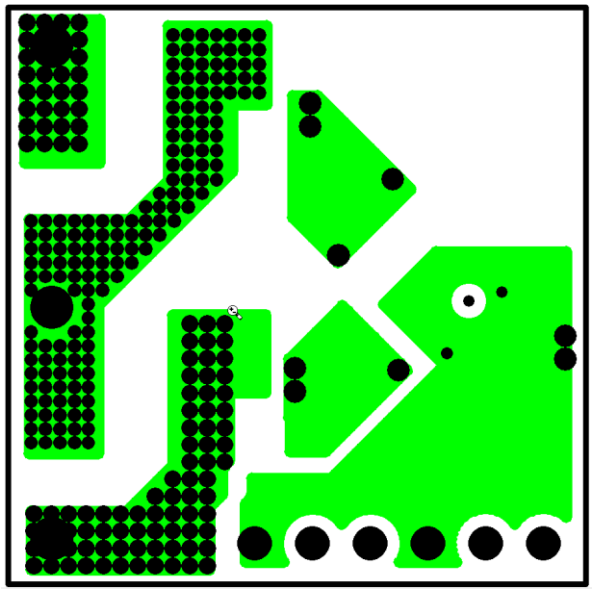


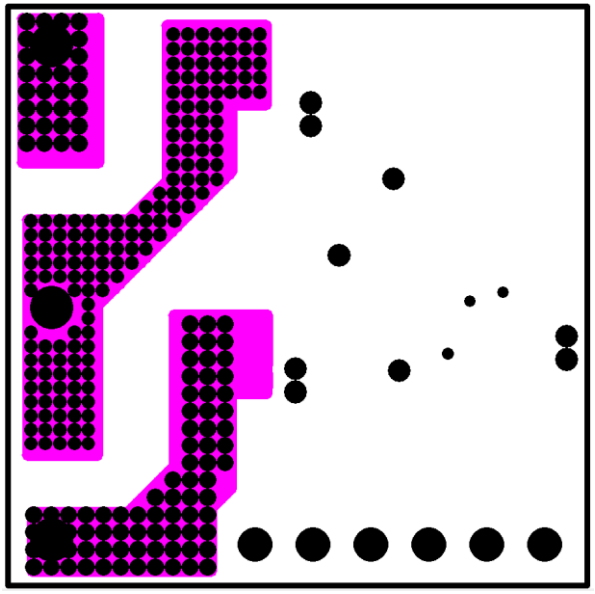
Package Information

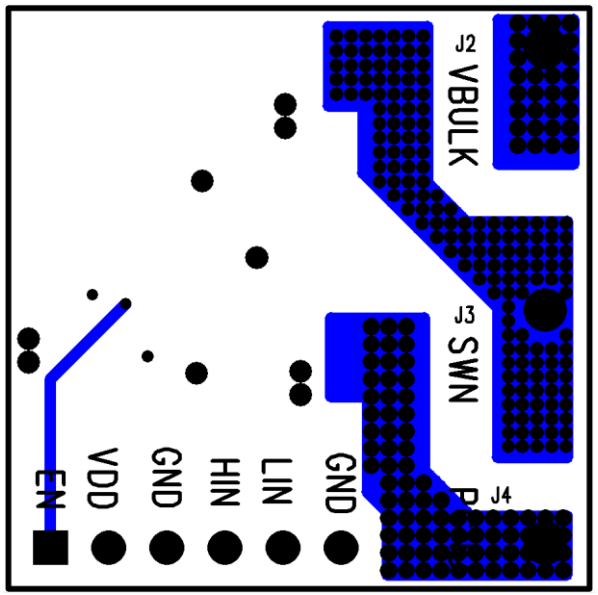
NCP51820+GS66508B Mini EVB: Four Layer PCB



Layer 1

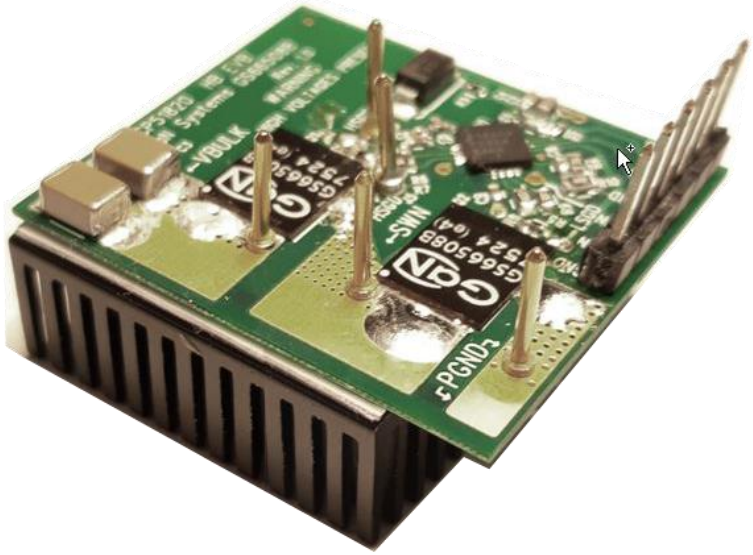

Layer 2


Layer 3

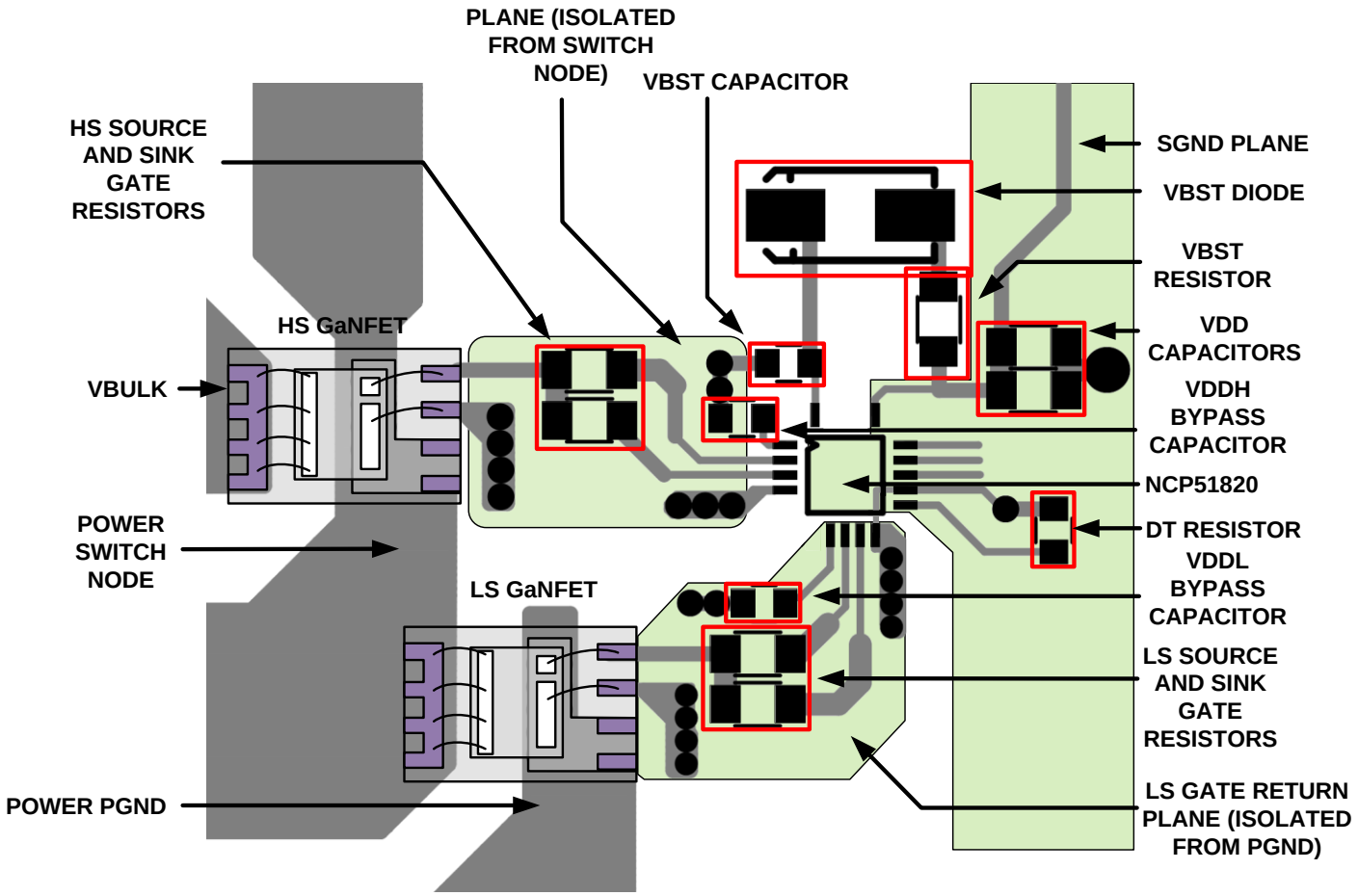


Layer 4

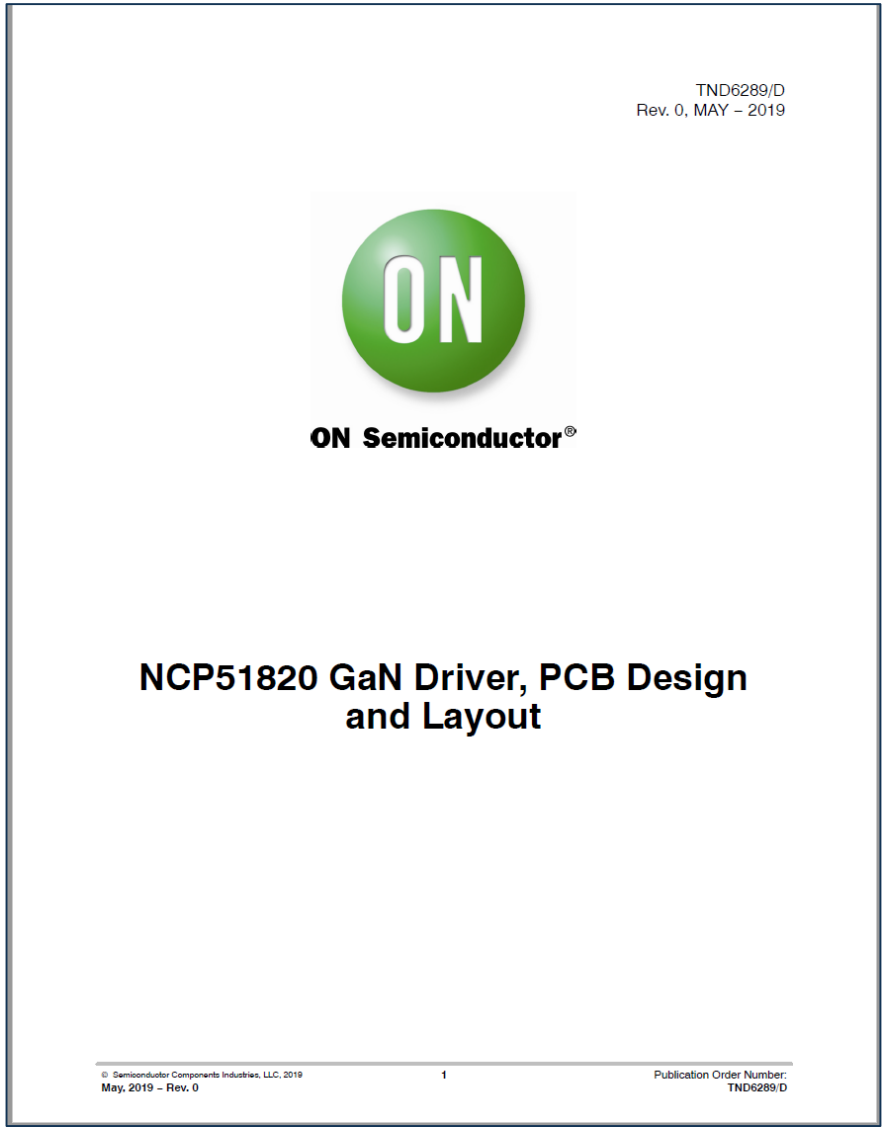
- GaN Systems HEMT, GS66508B GaN EVB shown
  - Shown with heatsink (orderable without heatsink)
  - For high-power applications, customer needs to provide their own heatsink and/or fan cooling



NCP51820 PCB Design: Part Placement



- TND6289, NCP51820 GaN Driver, PCB Design and Layout
  - PCB design for GaN is critical for performance
  - RF type PCB design practices are applied


TND6289/D
Rev. 0, MAY – 2019

ON Semiconductor®

NCP51820 GaN Driver, PCB Design and Layout

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May, 2019 – Rev. 0

1

Publication Order Number:
TND6289/D

NCP4318 –Dual Channel Synchronous Rectification Controller

Future Product

Sampling Now, RTM Q3'20

Value Proposition

NCP4318 is a mixed mode, which uses instantaneous drain voltage and previous dead time information, Synchronous Rectification (SR) controller for LLC resonant converter with minimum external components. The adaptive dead time control compensates induced parasitic inductance voltage to maximize SR MOSFET conduction and the efficiency. Multi-step turn-off threshold control and SR current inversion detection function prevent inversion current during fast load transient and allows stable SR operation over entire load range. In addition, to improve light load efficiency, V_{GATE} is adaptively reduced from 10V to 6V/5V.

Unique Features

- Adaptive dead time control
- Current inversion detection
- Adaptive gate voltage control

Benefits

- Maximized efficiency
- Stable load transient
- Reduced switching losses at light load condition

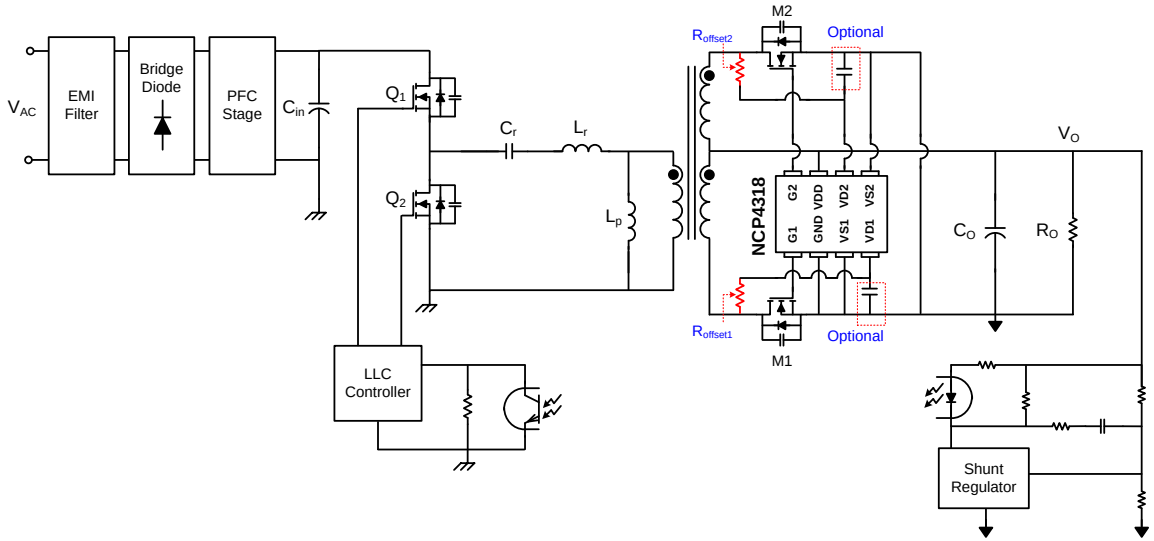
Other Features

- 200V rated drain sensing pins for two channel MOSFET control
- Anti shoot-through control
- SR turn-on time increase limitation
- Advanced adaptive minimum on-time
- Protections: primary side shut-down, abnormal drain sensing
- High Drive Capability: 1.5A source / 4.5A sink, fs range : 22kHz ~ 500kHz
- Low operating current in green mode : 100uA typ.

Market & Applications

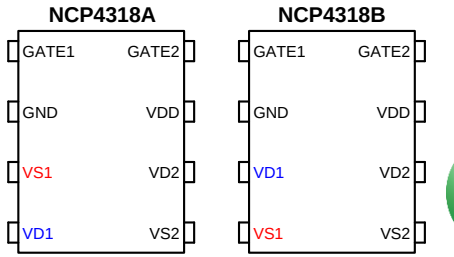
- Gaming, servers, network, telecom PSU
- Laptop adapter, LED TV

Typical Application Schematic



Ordering & Package information

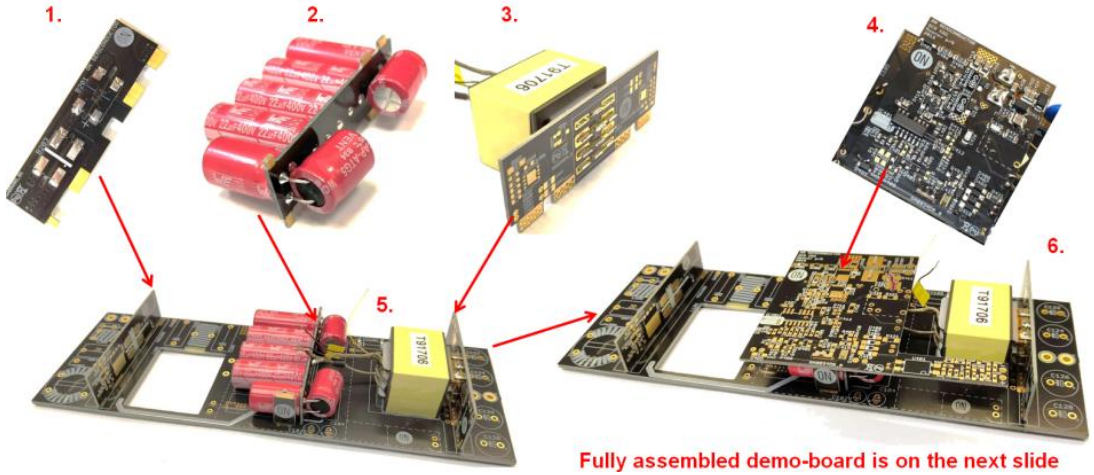
NCP4318ALC, BLC: SOIC-8, SOIC-8E(TBD)



Ultra High Power Density 300 W GaN PFC LLC 500kHz Design

Key spec

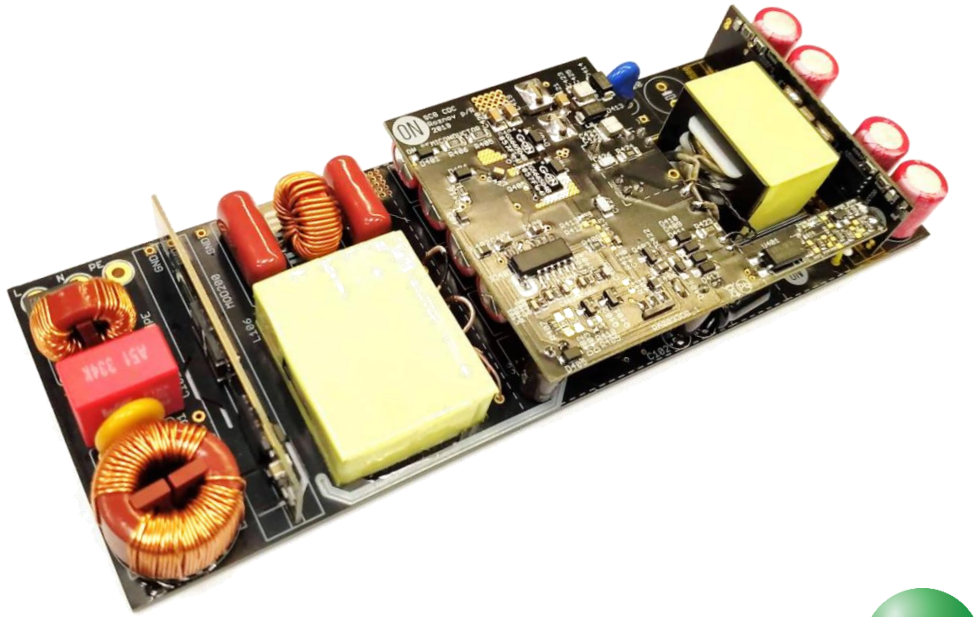
- Input: 90–265 VAC
- Output: 19 V/ 15 A typ., 18 A max
- Vout ripple <300 mW @ full load
- No load power <150 mW @ 230 VAC



Fully assembled demo-board is on the next slide

Form factor:

- Size: 160 x 56 x 18 mm
- Up to 34 Watt/inch^3

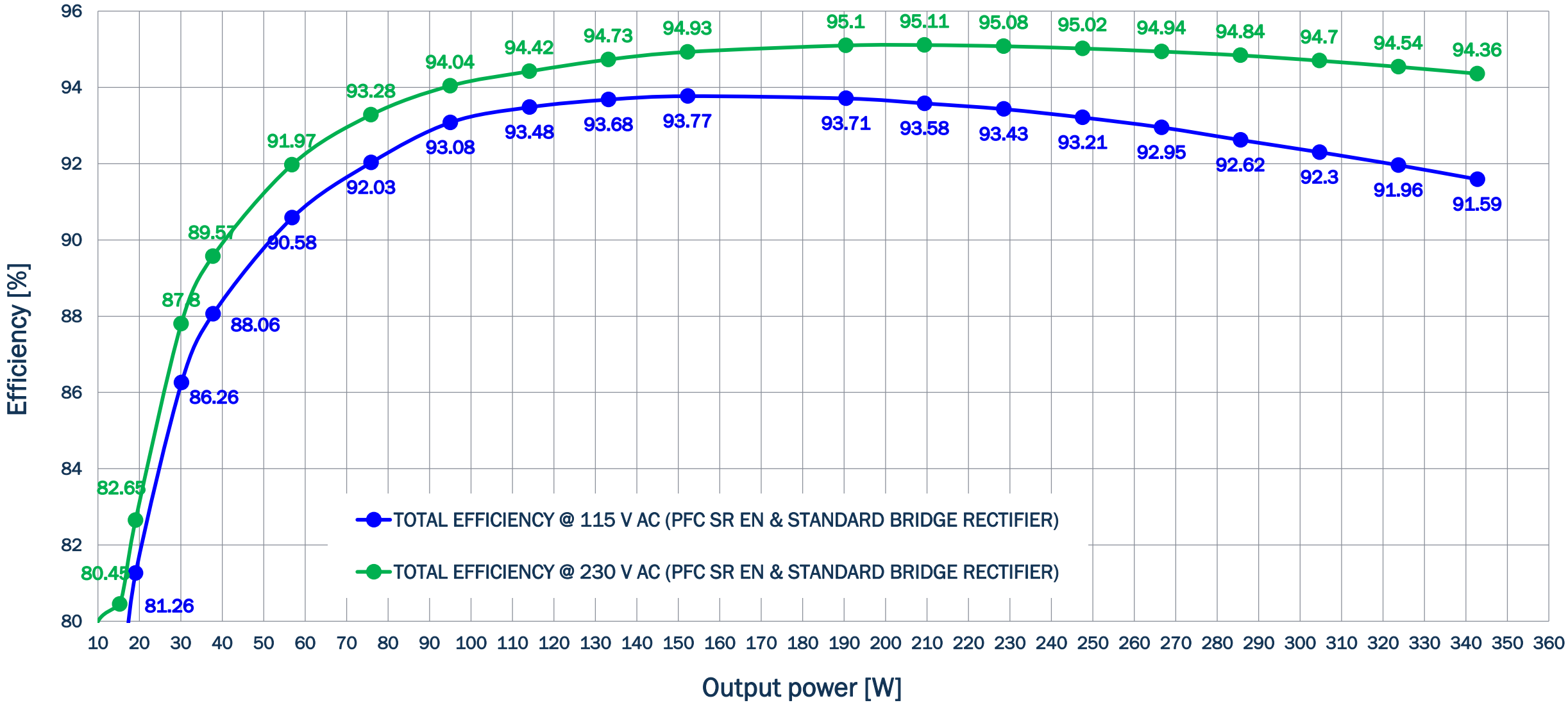


Key controllers:

- PFC: NCP1616
- LLC: NCP13992
- GaN HB Driver: NCP51820
- SR: NCP4306

Sampling Now

Ultra High Power Density 300 W Adapter Total Efficiency



NCP1618 PFC + NCP13992 LLC 240 W Design

Key spec

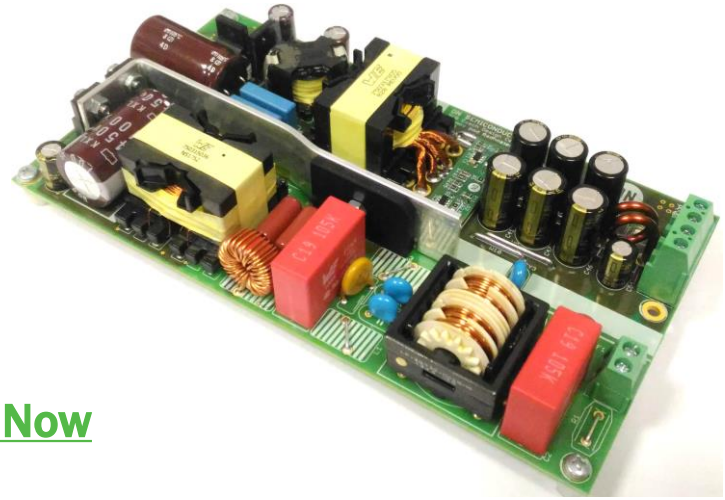
- Input: 90–265 VAC
- Output: 12 V/ 20 A, 240W
- Vout ripple <150 mV @ full load
- No load power <150 mW @ 230 VAC
- LLC Fsw: 96.3 kHz @ F.L., 87.7 kHz @ H.L.
- PFC Fsw: 66 kHz CCM @ 90 Vac, 60 kHz CrM @ 110 Vac, 108 kHz DCM@ 230 Vac

Form factor:

- Size: 173 x 95 x 30 mm
- 8 Watt/inch^3

Key controllers:

- PFC: NCP1618
- LLC: NCP13992
- SR: NCP4306



Sampling Now

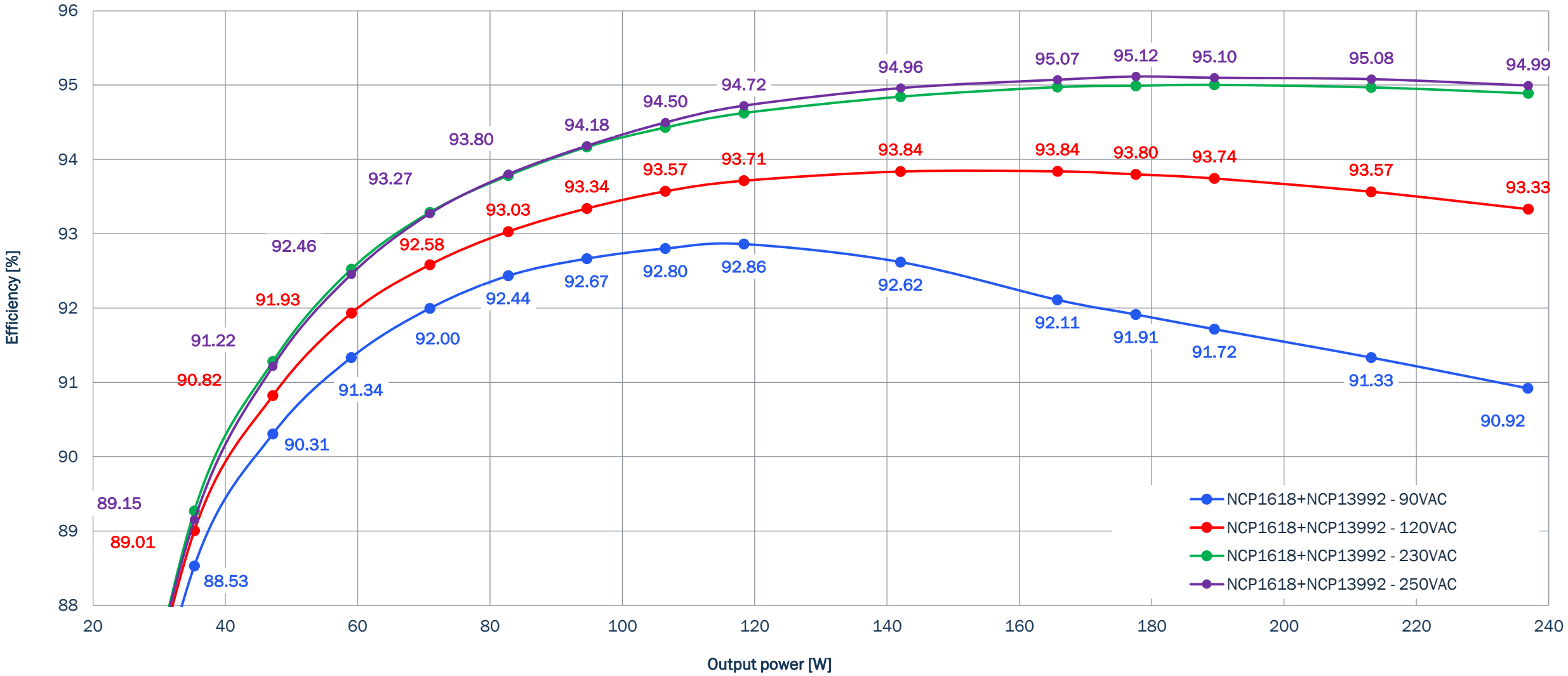
Averaged efficiency from measured 5 EVBs

Load	Consumption [mW] or efficiency [%]		required @ 230Vac
	120Vac	230Vac	
No-Load	< 110mW	< 125mW	< 150mW
Load 250mW	472mW	473mW	< 500mW
Load 500mW	844mW	826mW	< 1000mW
Load 20%	90.37*	91.04*	> 90%
Load 25%	91.59	92.39	
Load 50%	93.38	94.5	> 94%
Load 75%	93.34	94.81	
Load 100%	92.8	94.66	> 91%
4 point AVG	92.78	94.09	

*, frequency foldback is not activated

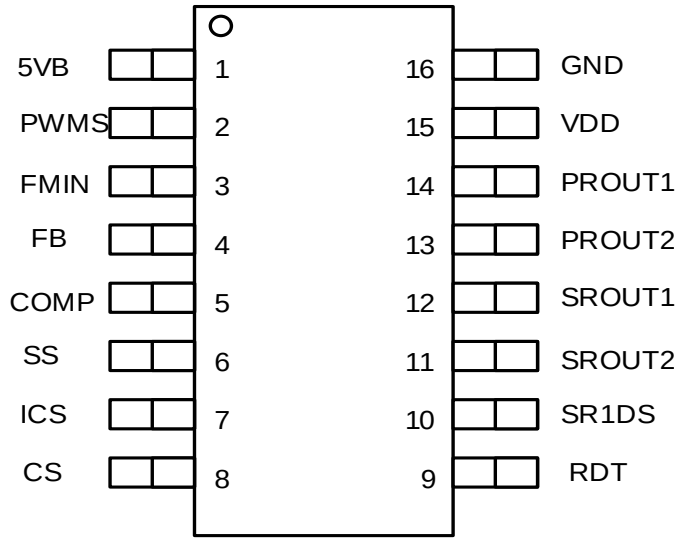
80 PLUS PLATINUM

NCP1618+NCP13992+NCP4306, Overall efficiency



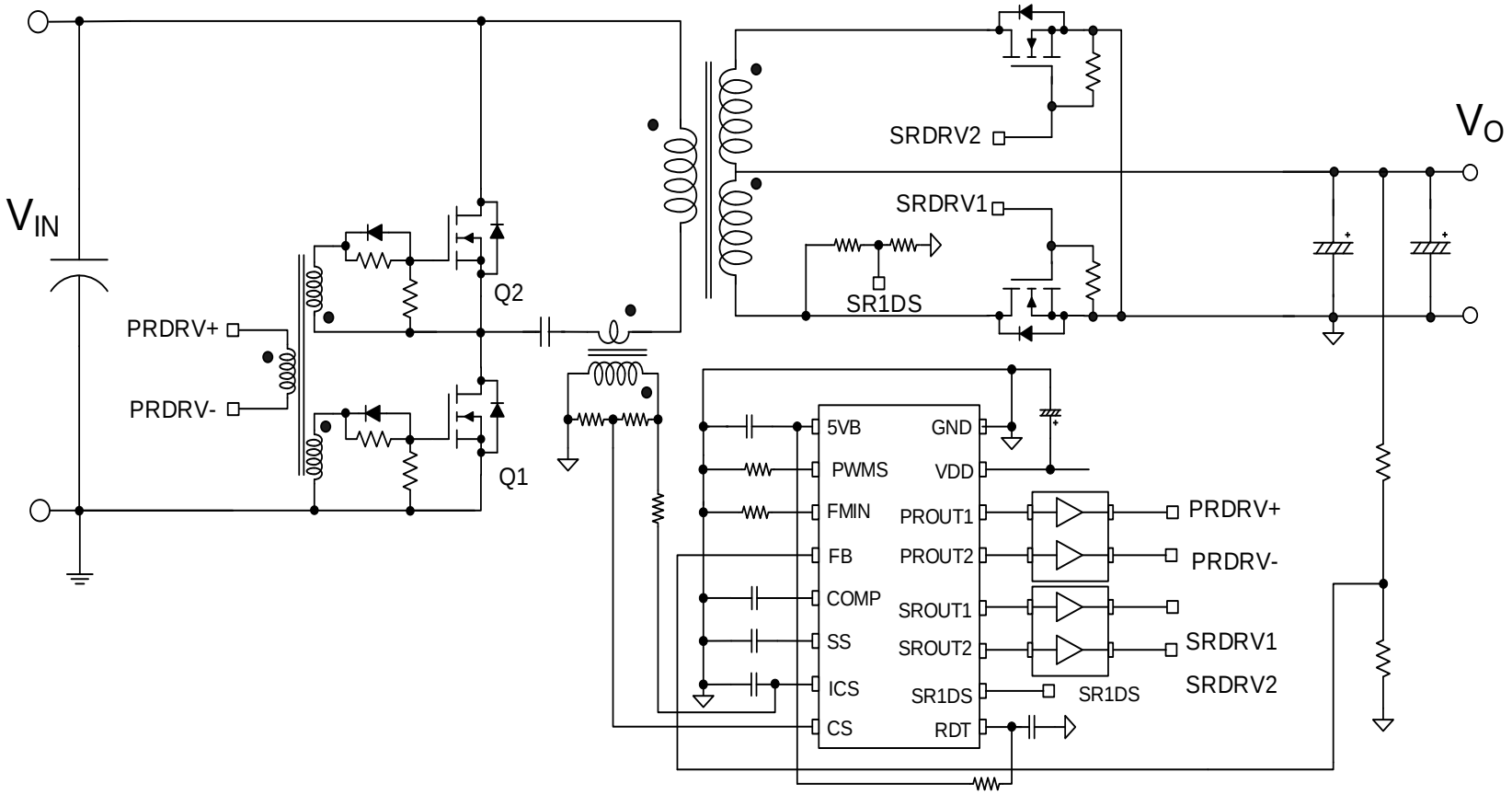
NCP/V4390 Key Features

- Metal Change Derivative of Existing FAN7688
- Secondary Side PFM Controller for LLC Resonant Converter with Synchronous Rectifier Control
- Charge current control for better transient response and easy feedback loop design
- Synchronous Rectification Control with dual edge tracking
- Closed loop soft-start for monotonic buildup of the output voltage
- Wide operating frequency (39kHz ~ 690kHz)
- Green Functions to improve Light Load Efficiency
  - Symmetric PWM control at light load to limit the switching frequency while reducing switching losses
  - Programmable PWM mode entry point
  - SR Gate signal shrinking at light load condition to prevent negative resonant current
  - Disabling SR at extremely light load condition
- Protection Functions with auto-restart
  - NON ZVS prevention (NZP) by compensation cutback (frequency shift)
  - Over Current Protection (OCP)
  - Output Short Protection (OSP)
  - Power limit by compensation cutback (frequency shift)
  - Over Load Protection (OLP) with programmable shutdown delay time
  - Over temperature protection (OTP)
- Programmable dead times for Primary Side Switches and SR switches
- Wide Operating Temperature Range –40°C To 125°C



Typical Application Circuit

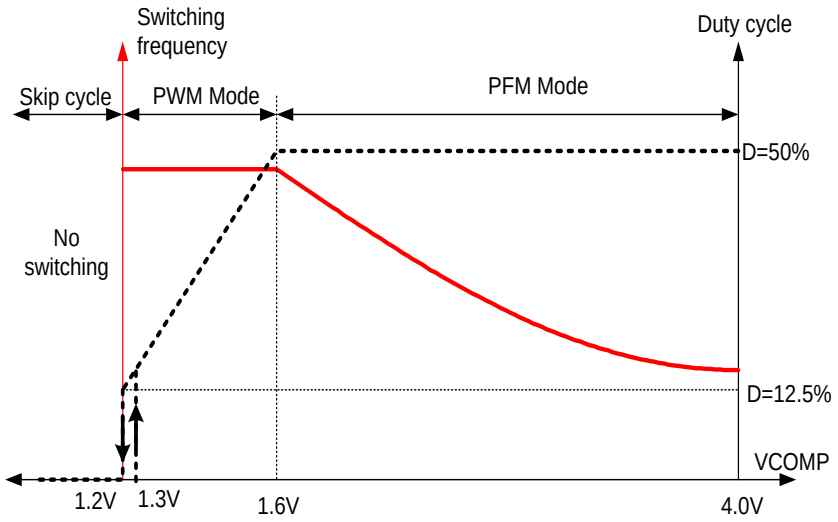
- NCP/V4390 is located in the secondary side
- Current transformer for sensing primary-side current
- Gate drive transformer for driving primary-side MOSFET



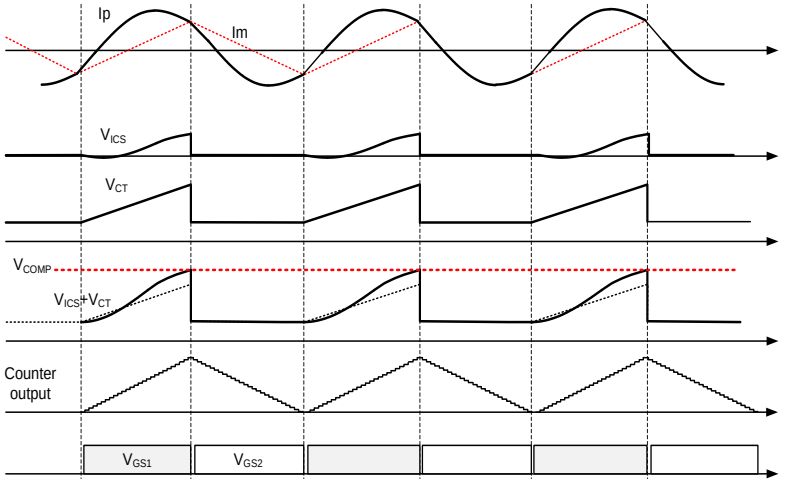
Comparison

Devices	NCP/V4390	FAN7688
Package	SOIC-16 NB	SOIC-16 WB
Programmable PWM-Mode Entry Threshold Voltage ($V_{COMP.PWM}$)	1.07~2.05 or fully disabled	1.5~2.05
Thermal Shutdown	No	Yes

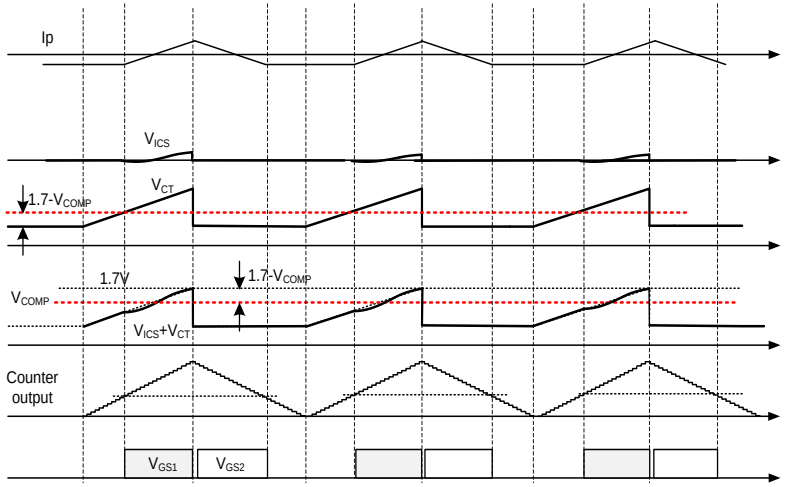
2. Hybrid Control (PFM+PWM) – How do we get PWM?



- Medium to heavy load : PFM
- Light load : PWM
- Even in PWM mode, ZVS for Q2 (OUT2) can be achieved allowing higher efficiency than conventional PWM
- PWM mode removes current overshoot during startup or burst mode operation



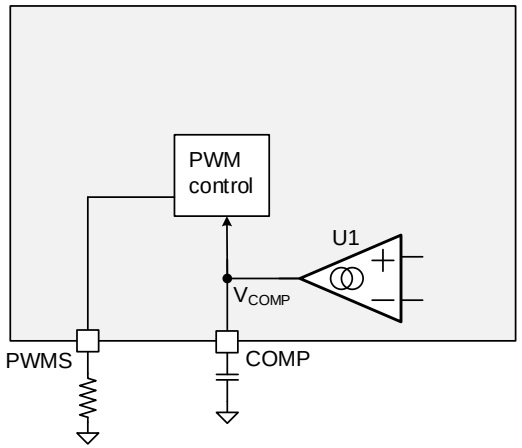
PFM Mode

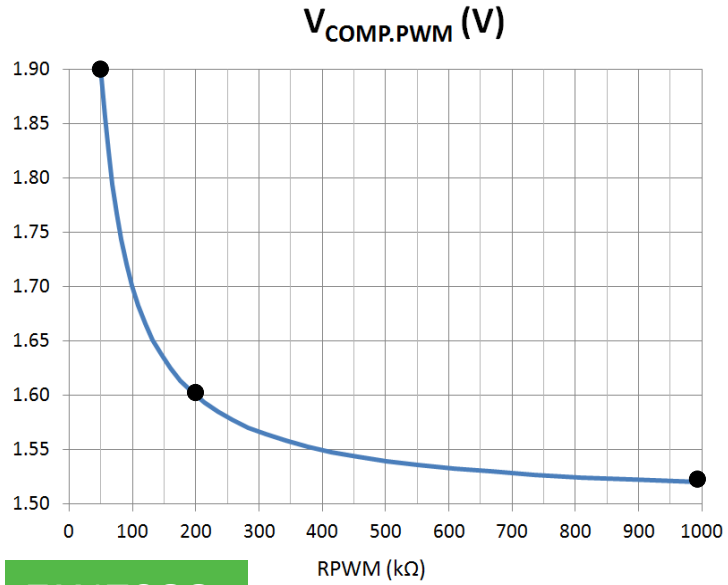


PWM Mode

PWMS sets threshold of PWM mode

- In NCP4390, the threshold can be programmed lower than skip-mode threshold (1.25 V), identical to disabling PWM mode.
- V_{COMP} threshold for PWM mode is programmable via PWMS-pin resistor.





FAN7688

NCP4390

NCP13994 – High Performance Current Mode LLC Controller

Future Product

Sampling end Q3'20, RTM Q2'21

Value Proposition

The NCP13994 is a high performance controller for half bridge LLC resonant converters supporting operation over a wide range of bulk or line voltages. Current mode controller and enhanced light load efficiency makes it ideal for high power designs. The controller also implements proprietary light load and quiet skip mode operation that improve light load efficiency, reduce no load power consumption as well as significantly reduce audible noise.

Unique Features

- 700 V HV Startup & Driver
- High Frequency 20 kHz to 750 kHz
- Light Load Mode
- X2 Discharge
- Quiet Skip Mode
- Option for Longer Dead-time Max
- 3-Level OCP

Benefits

- Enhanced Robustness
- Support UHD Design with GaN
- <150 mW No Load w/ PFC or <270 mW @ 120 mW Load w/ PFC
- Reduced Audible Noise
- Wide Dimming Range for LED
- LED Fault Protection

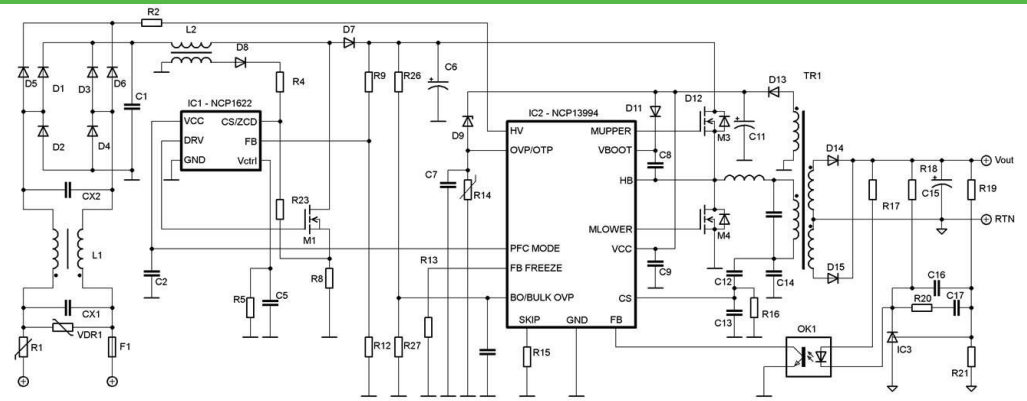
Other Features

- Line BO & OVP Protection
- Clamped Drive Output
- VCC rated to 30 V
- PFC Stage Operation Control According to Load Conditions
- Automatic Dead-time Max Clamp
- Safety Design for Pin-Pin Short and Open/Short

Market & Applications

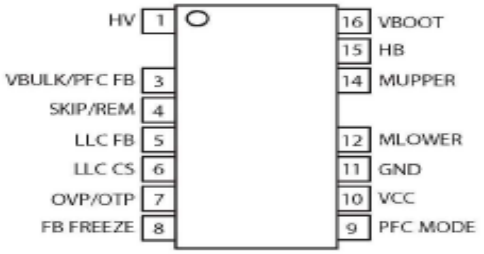
- High Power Gaming/Computing Adapter
- TV Power
- LED Lighting
- Industrial

Typical Application Schematic



Ordering & Package information

- NCP13994xy



Isolated DC-DC Controllers

Isolated DC-DC Flyback Controllers Roadmap






Power Level

NCL30125 – 2-SW Forward
Enhanced Forward Controller with HB drivers for Lighting, Current & Voltage Ctrl– QFN24

NCP1566 120V ACForward
Enhanced Active Clamp Forward Controller Current & Voltage Ctrl– QFN24

NCP12700 – 9-160 V
Current Mode Flyback Controller
MSOP-10/WQFN10

Samples Available, RTM Q4'20

NCP1568D
NCP1568 option for DC-DC & POE Applications, TSSOP-18

Samples Q3'20, RTM Q2,'21

NCV/NCP12710 – 4-45 V
Current Mode Flyback Controller, 50 V transient
MSOP-10/DFNW-10

Samples Available, RTM Q4'20

NCP11157 Switcher
9 – 120Vin, 150-V 67-mΩ FET
QFN-24

Samples Available, RTM Q4'20

NCV/NCP1362 – QR PSR
No opto, CC.CV with BO. Target Auto AUX

Existing | **2020** | **2021**

*AEC-Q100 version

Existing | Developing | Planning

NCP12700 – 9 V to 160 V Flyback Controller

Value Proposition

The NCP12700 is a wide-input range, fixed frequency, peak current mode PWM controller with a highly integrated feature set suitable for implementing single-ended power converter topologies.

Unique Features

- Ultra Wide Range HV (9 – 200 V) startup regulator
- User Adjustable Over-Power Protection
- Fault pin for thermal and
- output over-voltage protection

Unique Features

- Eliminate external startup components
- Easier design across input voltage range
- Interface for thermal and output OVP eliminates external protection

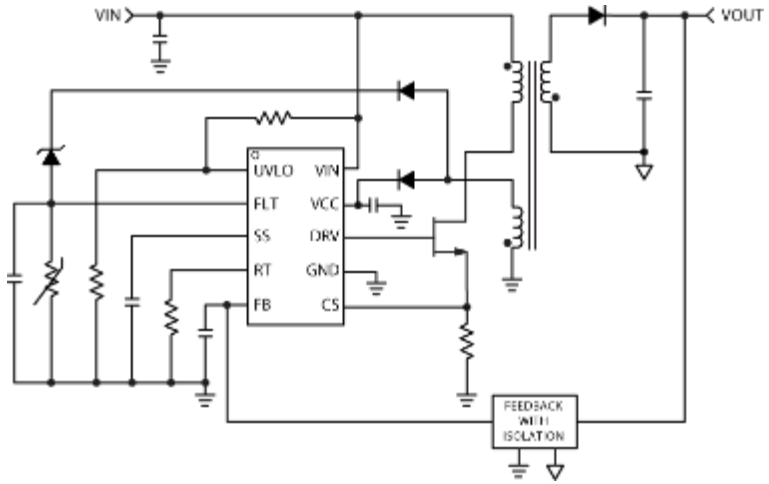
Other Features

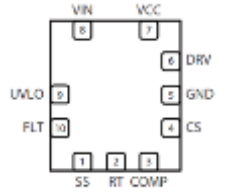
- Programmable oscillator: 100 kHz – 1 MHz
- Internal slope compensation
- Adjustable Soft-Start Ramp
- Input Voltage UVLO with hysteresis
- Shutdown Threshold for External Disable
- Overload Protection with 30 ms Overload Timer
- 1 A / 2.5 A Source / Sink Gate Driver

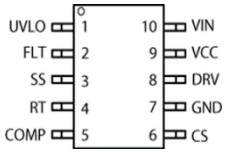
Market & Applications

- Industrial
- Telecom
- Transportation
- Suitable for 2:1, 4:1, 8:1 input range designs

Typical Application Schematic & Pin Out







Ordering & Package information

- NCP12700xDMR2G in Micro10 3*3 (9-100 V)
- NCP12700xMNTWG in WQFN10 3*4 (9-200 V

NCP12700 9 – 36 V Input Demoboard

Specifications and Features

- 4:1 Input Voltage Range: 9 – 36 V
- Output: 12 V/1.25 A, 15 W
- Full Load Efficiency: > 88 % / 91% peak
- Startup time: < 30 ms
- Transient Response: < 250 µs
- No Load Output Ripple: 200 mVpp Max
- No Load Power: 120 mW Max
- Overvoltage Protection: 16 VDC Max

Demo Board Photo

OPN: NCP12700LOWVINGEVB

Market & Applications

- DC/DC Power
- DC/DC Modules

Design Note

NCP12700 18 – 160 V Input Demoboard

Specifications and Features

- 9:1 Input Voltage Range: 18 – 160 V
- Output: 12 V/1.25 A, 15 W
- Full Load Efficiency: > 86 % / 90% peak
- Startup time: < 20 ms
- Transient Response: < 250 µs
- No Load Output Ripple: 150 mVpp Max
- No Load Power: 500 mW Max
- Overvoltage Protection: 16 VDC Max

Demo Board Photo

Market & Applications

- DC/DC Modules
- Telecom
- Power Over Ethernet

Design Note

OPN: NCP12700WIDEVINGEVB

NCP12700 45 W, 24 V Power over Ethernet Flyback Converter

Specifications and Features

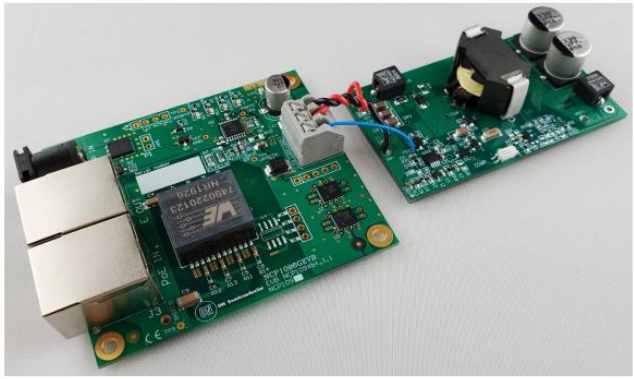
- Power Over Ethernet Compatible Input Range: 37 V to 57 V
- High Full Load Efficiency: >90%
- and Average Efficiency
- Very Low Ripple and Noise
- Smooth Startup Operation
- Low Parts Count
- Inherent SCP And OCP Protection
- Thermal and OVP Protection
- Multiple Probe Points for Evaluation
- Compatible with the NCP1096GEVB

Market & Applications

- Power Over Ethernet

Design Note

Demo Board Photo



Connected to the NCP1096GEVB POE PD Demo

NCP12700 45 W POE TO USB PD Demo

Specifications and Features

- Power Over Ethernet Compatible Input Range:37 V to 57 V
- USB−PD 5V−20V Operation
- High Full Load and Average Efficiency
- Very Low Ripple and Noise
- Smooth Startup Operation
- Low Parts Count
- Inherent SCP And OCP Protection
- Thermal and OVP Protection
- Multiple Probe Points for Evaluation
- Compatible with the NCP1096GEVB

Market & Applications

- Power Over Ethernet to USB PD

Design Note

Demo Board Photo

Connected to the NCP1096GEVB POE PD Demo

NCP1566 Active Clamp Forward Controller

Value Proposition

The NCP1566 is a highly integrated dual-mode active-clamp PWM controller to implement an isolated active clamp forward or asymmetric half-bridge converter. It which can be configured in either voltage mode control with input voltage feed-forward or peak current mode control. Peak current mode control may be implemented with input voltage feedforward as well.

Unique Features

- Voltage Mode & Current Mode Control
- Line feedforward
- Adaptive Overlap Time Control
- Integrated 120 V HV Startup

Unique Features

- Flexible Topology Solution
- Stable Constant Crossover Across Input Voltage Range
- Extended ZVS Across Input & Output
- Lossless Startup & Reduced Vcc Capacitor

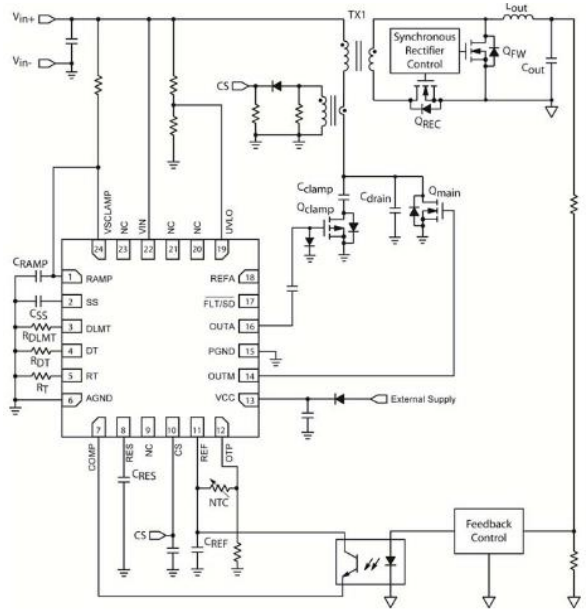
Other Features

- Vcc: 6.5 V to 20 V
- Programmable UVLO
- Cycle by Cycle Peak Current Limiting
- Adjustable Over Power Production & Overcurrent Protection
- Programmable Duty Ratio Clamp
- Programmable Oscillator with 1-MHz Max Frequency & Synchronization Pin
- Main Switch Drive: -2 A/3 A, Active Clamp Drive: -2 A/1 A

Market & Applications

- 24 V & 48 V Telecom Systems
- Server Power Supplies
- 48 V Automotive Applications

Typical Application Schematic & Pin Out



Ordering & Package information

- NCP1566MNTXG in QFN-24

NCP1566 3.3-V/30-A Demoboard for Telecom

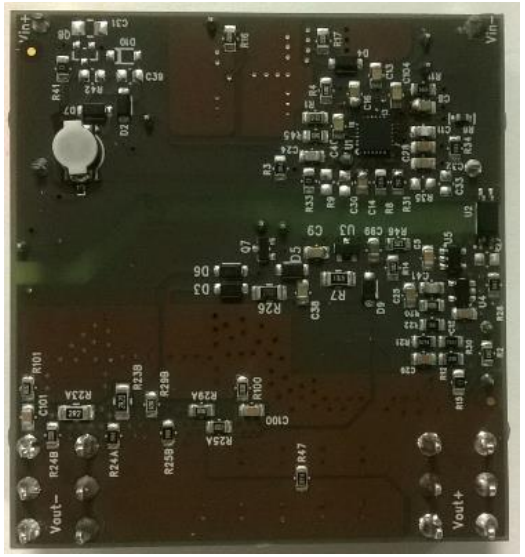
Value Proposition

This design is based around active-clamp forward converter operated in current-mode control. This controller offers many features to build an energy efficient converter with all the needed protections like cycle-by-cycle current limit with a 500-mV sense voltage, over current protection (OPP) for a stable maximum output current limit, over temperature protection with a dedicated NTC pin and a pin to sense an output voltage runaway (loop failure for instance).

Key Features

- 36-72 V dc input
- 3.3-V/30-A output
- >90% efficiency
- Internal 120-V start-up source operated in dynamic self-supply during start-up or skip mode.
- Voltage- or current-mode control operation
- Adaptive dead time for improved efficiency
- Line compensation for over power protection
- Maximum V-s limit and duty ratio clamp
- Short circuit protection
- Over voltage protection
- 5-V/2% voltage reference
- Over temperature protection via an NTC
- Fault reporting pin also used for shutdown
- Synchronization capability via dedicated pin

Demo Board Photo



OPN: NCP1566TELECGEVB

NCP1566 5-V/10-A Active Clamp Foward Demo Board

Value Proposition

This design is based around active-clamp forward converter operated in current-mode control. This controller offers many features to build an energy efficient converter with all the needed protections like cycle-by-cycle current limit with a 500-mV sense voltage, over current protection (OPP) for a stable maximum output current limit, over temperature protection with a dedicated NTC pin and a pin to sense an output voltage runaway (loop failure for instance).

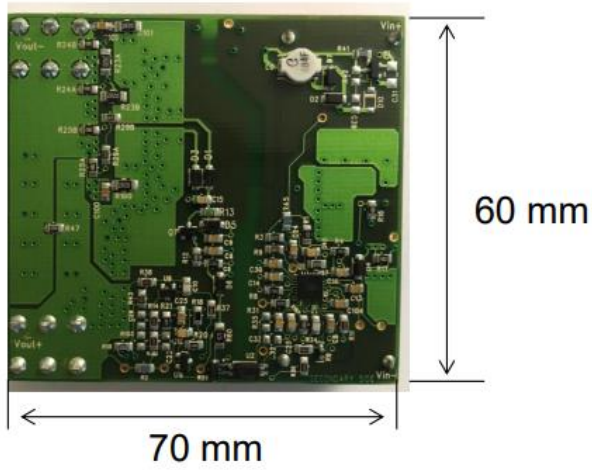
Key Features

- Internal 120-V start-up source operated in dynamic self-supply during start-up or skip mode.
- Voltage- or current-mode control operation
- Adaptive dead time for improved efficiency
- Line compensation for over power protection
- Maximum V-s limit and duty ratio clamp
- Short circuit protection
- Over voltage protection
- 5-V/2% voltage reference
- Over temperature protection via an NTC
- Fault reporting pin also used for shutdown
- Synchronization capability via dedicated pin

Design Note

Devices	Applications	Input voltage	Output power	Topology	Board Size
NCP1566	Telecom	37-57 V dc	50 W	Active-Clamp Forward	70 x 60 x 20 mm
Output spec.	**Turn on time**	**Efficiency**	**Operating temperature**	**Cooling**	**Standby power**
5 V/10 A	< 100 ms	above 92 % @ full load	0 – 50 °C	Open Frame in Still Air	Does not apply

Demo Board Photo



OPN: NCP1566TEL5V10AGEVB

12-V/6-A for Power over Ethernet Demo Board

Value Proposition

This design is based around active-clamp forward converter operated in current-mode control. This controller offers many features to build an energy efficient converter with all the needed protections like cycle-by-cycle current limit with a 500-mV sense voltage, over current protection (OPP) for a stable maximum output current limit, over temperature protection with a dedicated NTC pin and a pin to sense an output voltage runaway (loop failure for instance).

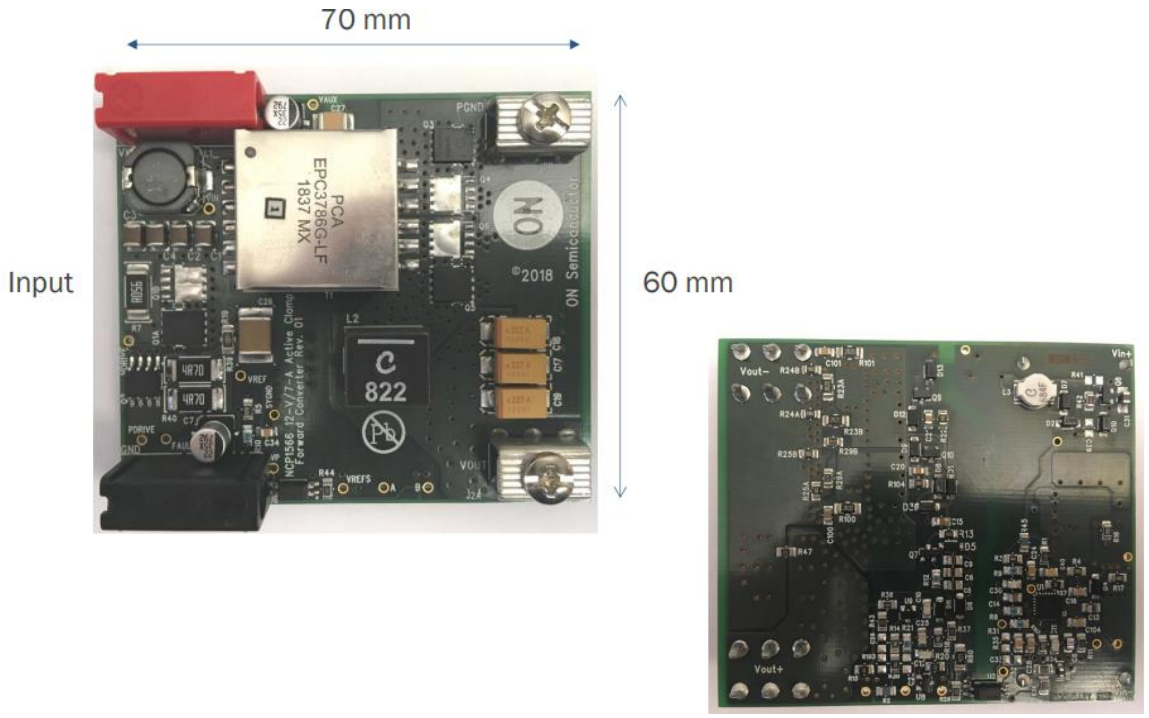
Key Features

- Internal 120-V start-up source operated in dynamic self-supply during start-up or skip mode.
- Voltage- or current-mode control operation
- Adaptive dead time for improved efficiency
- Line compensation for over power protection
- Maximum V-s limit and duty ratio clamp
- Short circuit protection
- Over voltage protection
- 5-V/2% voltage reference
- Over temperature protection via an NTC
- Fault reporting pin also used for shutdown
- Synchronization capability via dedicated pin

Design Note

Devices	Applications	Input voltage	Output power	Topology	Board Size
NCP1566	Power Over Ethernet	37-57 V dc	72 W	Active-Clamp Forward	70 x 60 x 20 mm
Output spec.	**Turn on time**	**Efficiency**	**Operating temperature**	**Cooling**	**Standby power**
12 V/6 A	< 100 ms	above 92 % @ full load	0 – 50 °C	Open Frame in Still Air	Does not apply

Demo Board Photo



OPN: NCP1566POE12V6AGEVB

Future Product

NCP12710/NCV12711 Low Vin DC-DC Flyback Controller

Sampling Q4'20, RTM Q2'21

Value Proposition

The NCP12710/NCV12711 is a fixed-frequency peak-current-mode PWM controller containing all of the features necessary for implementing single-ended power converter topologies. The device operates from 4 V to 40 V without auxiliary winding and can accept transient spikes up to 45 V.

Unique Features

- Low Voltage Operation
- Adjustable Over Power Protection
- NTC-Compatible Fault Interface
- Frequency Jitter
- Error Amplifier Option (NCV12711)
- AEC-Q100 Qualified (NCV12711)

Unique Features

- 4 – 40 V Input Range
- Limits Total Power Capability
- Provides Thermal Protection
- Improves EMI signature
- For PSR/non-isolated designs
- For automotive applications

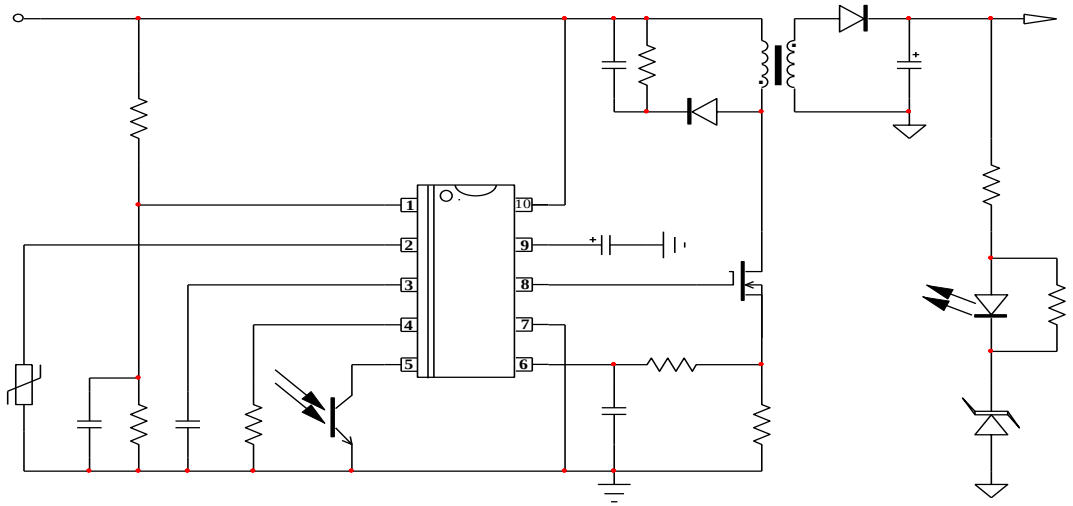
Other Features

- Internal 7.5-V Regulator
- 0% Duty Ratio Operation in No-Load Condition
- Internal Over Power Protection
- Single Resistor Programmable Oscillator – 100 kHz to 1 MHz
- Adjustable Soft-Start on Peak Current and Frequency
- Output OVP Fault Interface
- 1 A / 2.8 A Source / Sink Gate Driver

Market & Applications

- DC-DC Converters for Modules
- Industrial Power
- Automotive 12 V Auxiliary Power Supply

Typical Application Schematic & Pin Out



Ordering & Package information

- Standard Part #: NCP12710
- Package: MSOP-10, DFN-10 3x3 with Wettable Flank
- AEC-Q100: NCV12711 in MSOP-10

Sampling Q4'20

NCV/NCP1362: Primary Side PWM Controller

Future Product

Sampling Now, RTM Q4'20

Value Proposition

The NCV/NCP1362 is a new quasi−resonant peak current mode control mode controller targeting output power levels from a few watts up to 50 W in a flyback application. It is primary side regulated for Constant Voltage and Constant Current regulation, achieving excellent line and load regulation of 5% without requiring the typical opto-coupler and voltage reference for lower cost and improved system reliability. The controller features improved light load efficiency and stand-by performance.

Unique Features

- Dual Frozen Peak Current
- Constant Voltage & Current PSR < ±5%
- AEC-Q100 Qualified (NCV1362)

Unique Features

- Optimize Light Load Efficiency and Standby
- Regulated Output without Opto-Coupler
- Automotive Applications

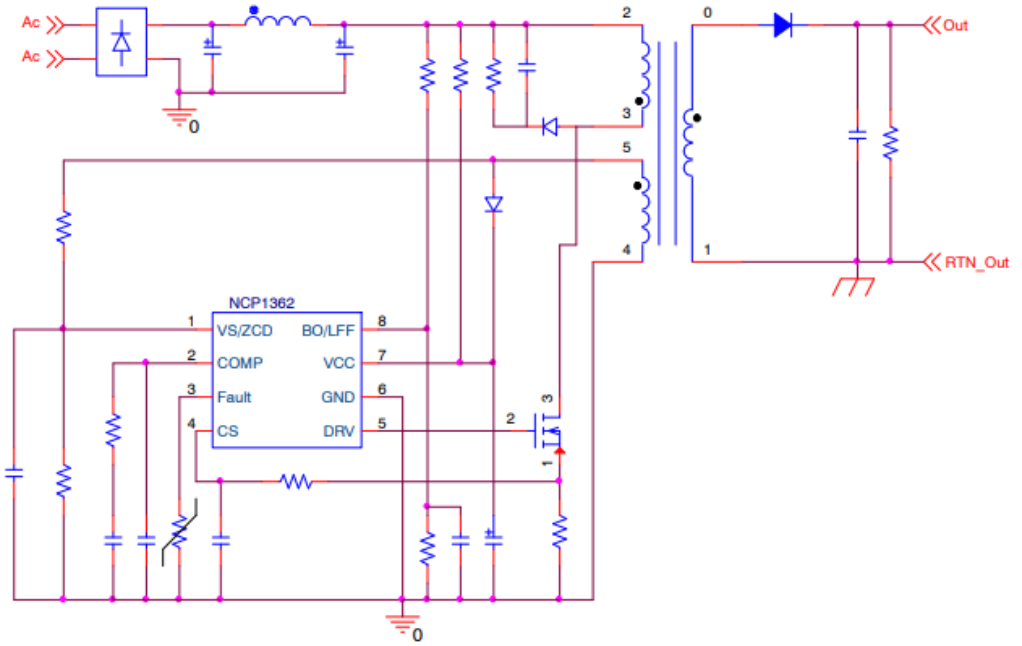
Other Features

- Quasi-Resonant with Valley Lockout
- Max Frequency Clamp (80, 110, 140 kHz and no Clamp)
- Frequency Jittering
- LFF and BO on Dedicated Pin

Market & Applications

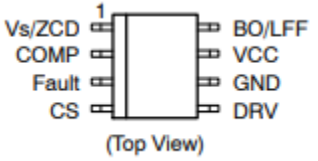
- AC/DC Adapters and Power
- Industrial Auxiliary Power
- Automotive Auxiliary Power

Typical Application Schematic & Pin Out



Ordering & Package information

- Standard Part #: NCP1362
- Package: SOIC-8
- AEC-Q100: NCV1362



Sampling Now

Controller Configurations

IPT Configuration

ON Semiconductor's latest devices contain contains an in package trim (IPT) register

- used to trim device behaviors to meet spec table and to set device configuration
- done by burning internal poly-fuses not EEPROM, and is very reliable and cannot be changed
- Each new IPT combination goes through a qualification process before being released to production

Table 1. PART NUMBER DECODE – NCP1342ABCDEF

NCP1342	A	B	C	D	E	F*
Device	OTP/Overload	Jitter Frequency/Amplitude	Quiet–Skip	CS Min	CS Min Shift	Additional
	A – AR/AR	A – 1.55 kHz/75 mV	A – 800 Hz	A – 200 mV	A – 400 mV	–
	B – Latch/AR	B – 1.55 kHz/92 mV	B – 1.2 kHz	B – 150 mV	B – 350 mV	A
	C – AR/Latch	C – 1.55 kHz/55 mV	C – 1.56 kHz	C – 100 mV	C – 300 mV	C
	D – Latch/Latch	D – 1.55 kHz/61 mV	D – Disabled	D – 250 mV	D – 250 mV	D
		E – 1.3 kHz/75 mV			E – Disabled	
		F – 1.3 kHz/92 mV				
		G – 1.3 kHz/55 mV				
		H – 1.3 kHz/61 mV				
		J – 3.9 kHz/75 mV				
		K – 3.9 kHz/92 mV				
		L – 3.9 kHz/55 mV				
		M – 3.9 kHz/61 mV				
		N – Disabled				

*Not present in all parts. See Table 2 for details.

Table 2. ADDITIONAL PART OPTIONS

F	Description
–	Default Configuration
A	X2 Discharge Disabled, $V_{BO(stop)}$ = 84 V, $V_{BO(start)}$ = 94 V
C	Overload Disabled
D	X2 Discharge Disabled, $V_{BO(stop)}$ = 84 V, $V_{BO(start)}$ = 94 V, Resettable Overload Timer

Cheers!