



ON Semiconductor

DN05086/D

## Design Note – DN05086/D

# High Efficiency, <30mW Standby QR Adapter with Peak Power Excursion Capability

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1341B1 NCP4305D NCP431A	Adapter (NCP1341GEVB)	85 to 265 Vac	65 W Nominal 130 W Peak	Quasi-Resonant Flyback	Isolated

	Output Specification
Output Voltage	19 Vdc nominal
Nominal Current	3.42 A
No Load Standby	< 30 mW
Min Current	zero

## Circuit Description

The NCP1341 is a highly-integrated quasi-resonant flyback controller suitable for designing high-performance off-line power converters. With an integrated active X2 capacitor discharge feature, the NCP1341 enables no-load power consumption below 30 mW.

The quasi-resonant operating mode features a proprietary valley-lockout circuitry ensuring stable valley switching down the 6<sup>th</sup> valley. After the 6<sup>th</sup> valley the controller transitions to a frequency foldback mode to reduce switching losses in lighter load conditions. As the load continues to decrease the NCP1341 will enter a Quiet-Skip™ mode to efficiently manage power delivery while minimizing acoustic noise.

For systems requiring high transient load capability the NCP1341 features a power excursion mode (PEM) which transitions the controller into continuous conduction mode (CCM) enabling peak transient power delivery up to 2 times the nominal load power.

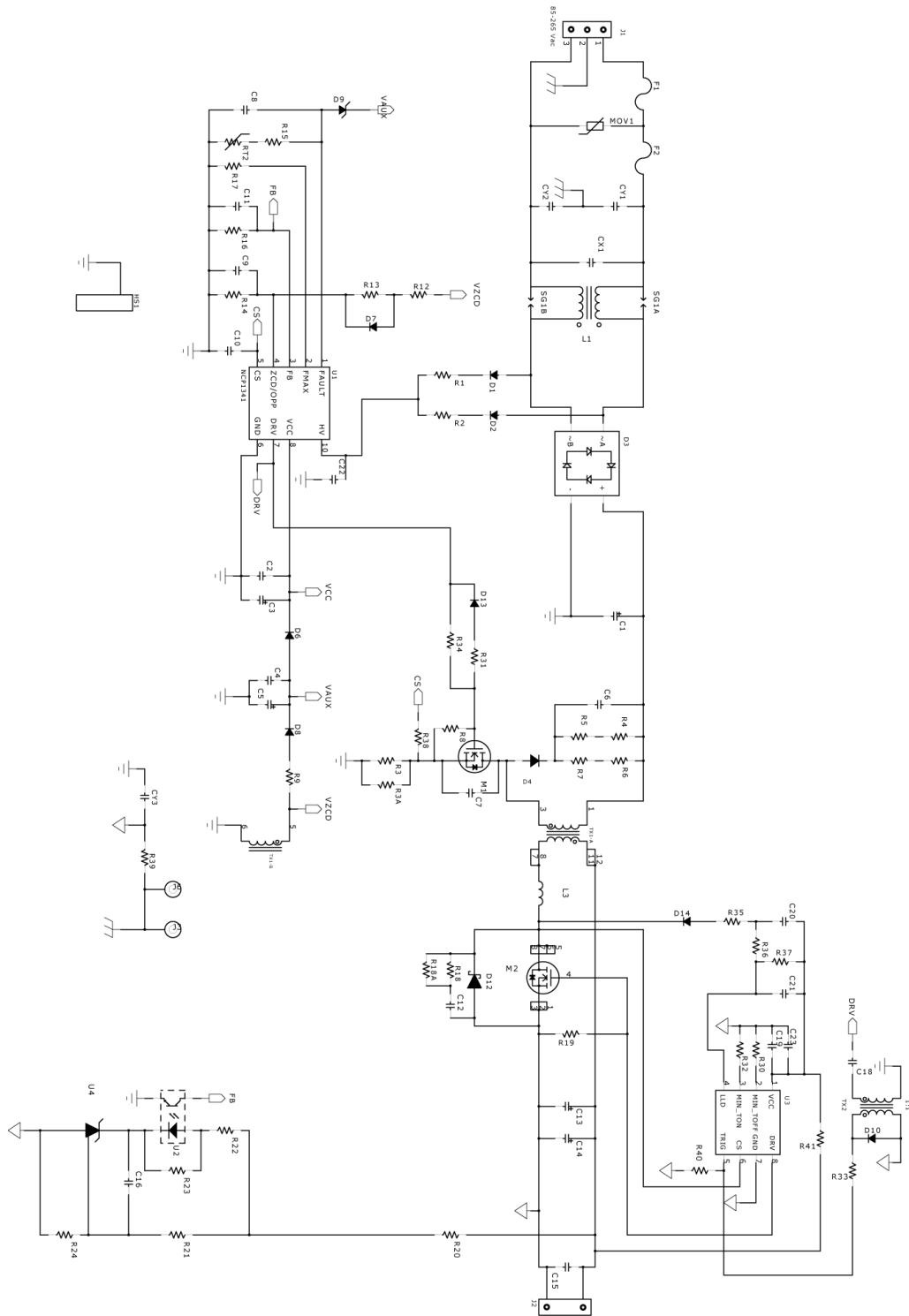
Secondary side synchronous rectification (SR) is implemented with the NCP4305 for optimized efficiency across all operating modes. The NCP4305 features precise zero current turn off and 12 ns turn-off delay from current sense to the driver allowing for the optimal SR conduction period in quasi-resonant mode. The NCP4305 also features an ultrafast turn-off interface through the TRIG/DIS pin capable of turning off the driver in 7.5ns to minimize cross conduction in CCM operation. Finally, the light load detection (LLD) feature modulates the drive voltage as the load

decreases and shuts down the driver for optimal light and no-load performance.

## Key Features

- High-Voltage Startup Circuit with Active Input Filter Capacitor Discharge and Brownout Detection for Reduced Standby Power
- Valley Switching Operation to 6<sup>th</sup> valley with Valley-Lockout for Stable Operation
- Frequency Foldback with 25 kHz Minimum Frequency Clamp
- Quiet-Skip™ Operation for Highest Performance in Light and No-Load
- Minimized Current Consumption for No Load Power Below 30 mW.
- Frequency Jitter for Reduced EMI Signature
- Adjustable Maximum Frequency Clamp
- Fault Input for Severe Fault Conditions, NTC Compatible (Latch and Auto-Recovery Options)
- Adjustable Maximum Frequency Clamp

# DN05086/D Circuit Schematic



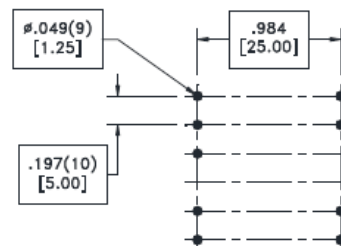
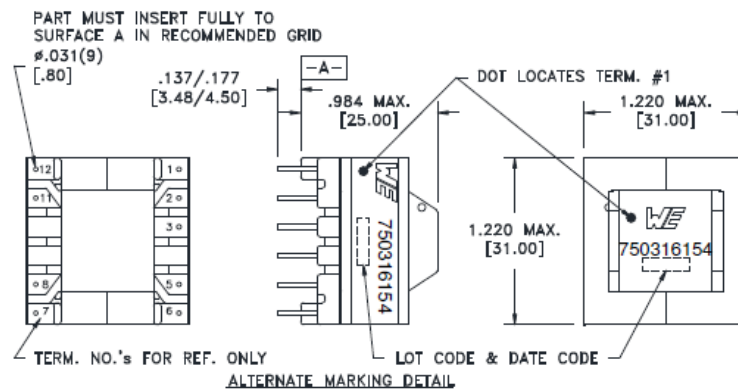
# DN05086/D

## Magnetics Design – Flyback Transformer NCP1341

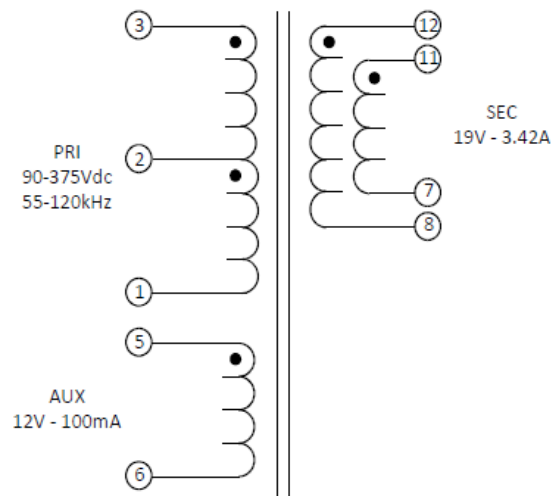


ELECTRICAL SPECIFICATIONS @ 25° C unless otherwise noted:

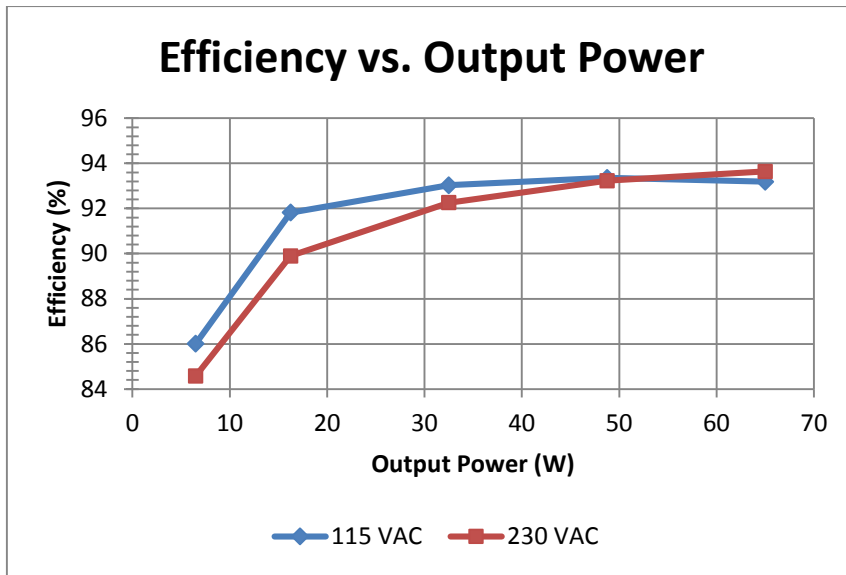
PARAMETER	TEST CONDITIONS	VALUE
D.C. RESISTANCE	3-1 @20°C	0.225 ohms ±10%
D.C. RESISTANCE	5-6 @20°C	0.050 ohms ±10%
D.C. RESISTANCE	12-8 tie(7+8, 11+12), @20°C	0.012 ohms ±30%
INDUCTANCE	3-1 10kHz, 100mV, Ls	500µH ±10%
SATURATION CURRENT	3-1 20% rolloff from initial	3.5A
LEAKAGE INDUCTANCE	3-1 tie(5+8, 7+8+11+12), 100kHz, 100mV, Ls	5.0µH typ., 10.0µH max.
DIELECTRIC	1-12 tie(3+5, 7+8), 3750VAC, 1 second	3000VAC, 1 minute
DIELECTRIC	3-5 625VAC, 1 second	
URNS RATIO	(3-2):(2-1)	1:1, ±1%
URNS RATIO	(3-1):(5-6)	9:1, ±1%
URNS RATIO	(3-1):(12-8), tie(7+8, 11+12)	6:1, ±1%



RECOMMENDED  
P.C. PATTERN, COMPONENT SIDE



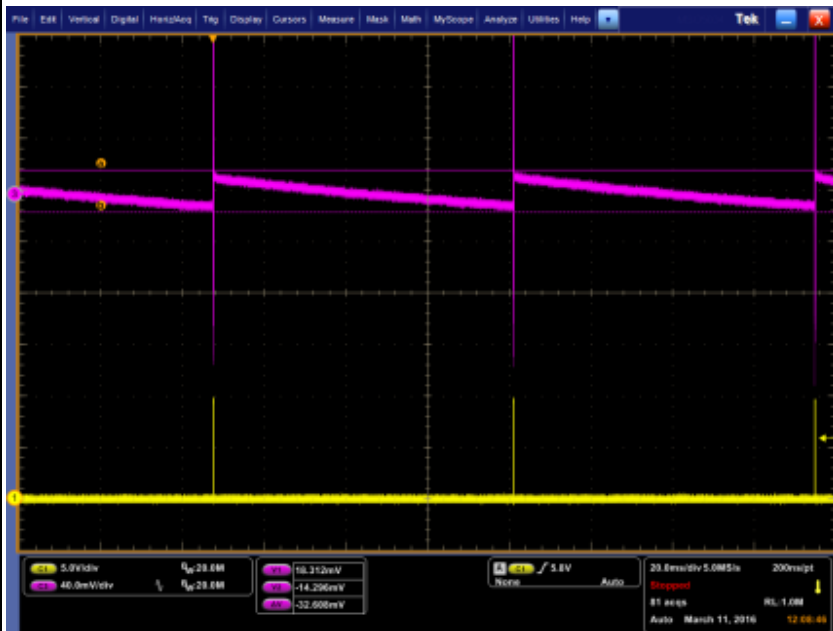
## Efficiency



VAC	Load	Efficiency (%)
115	100%	92.92
	75%	92.99
	50%	92.56
	25%	91.02
	10%	85.21
230	100%	93.11
	75%	92.62
	50%	91.56
	25%	89.13
	10%	83.81

Average efficiency = 92.38%@115Vac, 91.61%@230Vac

## No Load Standby Performance



VAC	Power Dissipation (mW)
115	21.87
230	26.60
265	29.72

The NCP1341 features low current consumption when operating in a burst mode to enable very low no load standby power operation. In no load, the system was able to achieve less than 30 mW of power dissipation across the line operating range meeting CoC Tier II and DoE requirements. The output voltage ripple while in no load was ~ 33 mV.

# Description of Key Features

## 1. Power Excursion Mode



The NCP1341 features a power excursion mode which seamlessly transitions the system into a continuous conduction mode operation to allow for increased power delivery during load transients. PEM enables the system to deliver up to 2 times the nominal load.

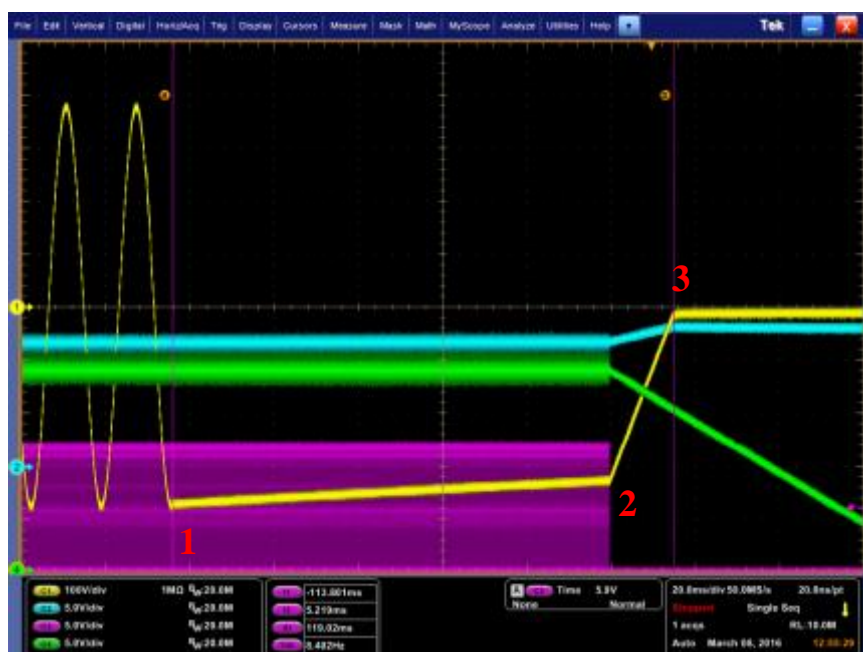
The system enters PEM when the feedback pin voltage exceeds 2.4 V (peak current limit = 800 mV). Upon entering PEM the primary switch off-time is clamped naturally forcing the system to enter continuous conduction mode as shown in the first waveform.

In PEM the primary switch on-time continues to be controlled by peak current mode control but the start of a new switching cycle is controlled by off-time modulation. Off time modulation allows the system to operate in CCM free of sub-harmonic oscillations and with no need for slope compensation as shown in the second waveform.

The peak current limit can continue to increase to 1 V. If the peak current limit reaches 1 V then the overload timer will be initiated and the controller can go into overload protection should the timer expire. Once the load transient subsides the feedback voltage will decrease below 2.4 V and the system will transition from CCM to quasi-resonant operation as shown in the third waveform.

Ch. 1 (Yellow): FB Voltage or CS  
Ch. 2 (Blue):  $I_O$   
Ch. 4 (Green): Drain-Source Voltage

## 2. Active X2 Capacitor Discharge

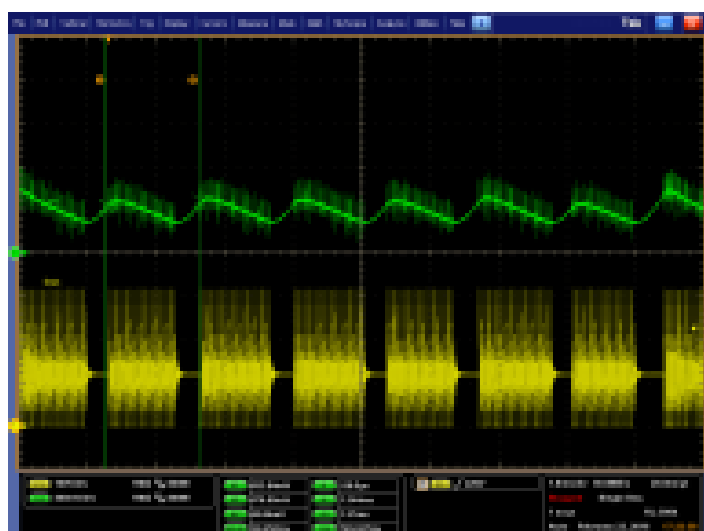
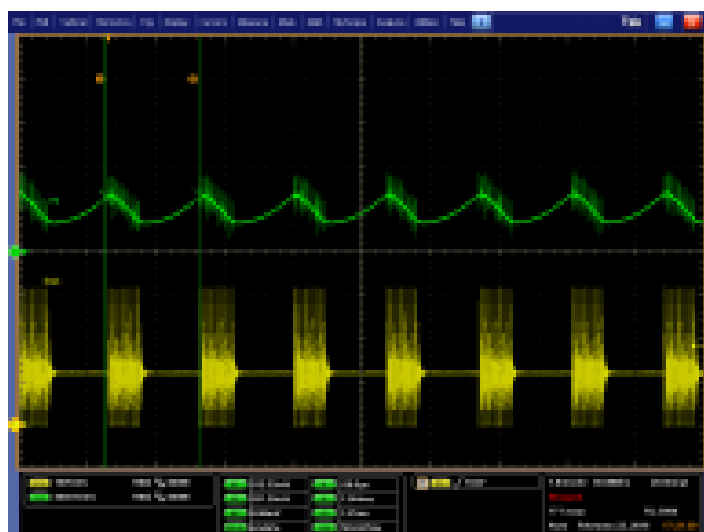
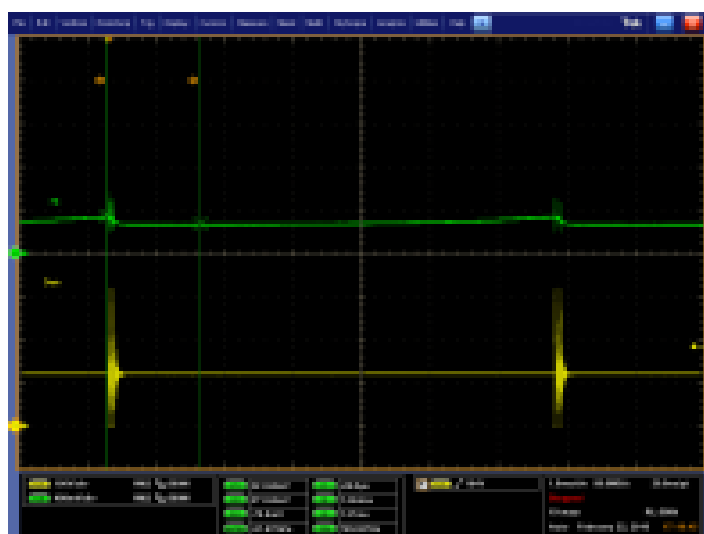


X2 Discharge at 265 VAC  
 Ch. 1 (Yellow): VAC Input  
 Ch. 2 (Blue):  $V_{CC}$   
 Ch. 3 (Purple): DRV  
 Ch. 4 (Green):  $V_{OUT}$

The NCP1341 features integrated active input filter (X2) capacitor discharge, eliminating the need for external discharge resistors which are major contributors to the total power dissipation in light load and standby mode operation. The integrated discharge circuit is virtually lossless across all operating modes and only consumes power when it is needed to discharge the X2 capacitors.

The discharge circuit works in the following manner: 1) Line voltage removal is detected at the HV when the AC input voltage becomes static. A line removal timer is then initiated. 2) When the line removal timer expires, drive pulses are halted and the HV voltage startup is turned on to charge the  $V_{CC}$  pin. The energy stored in the X2 capacitors is transferred to the  $V_{CC}$  capacitor. 3) Because the  $V_{CC}$  capacitor is much larger than the filter capacitors, the voltage on the filter capacitors will quickly discharge to a safe level within ~ 120 ms.

### 3. Quiet-Skip™



The Quiet-Skip feature implemented in the NCP1341 is intended to provide noise-free operation when the system is operating in a burst mode at lighter loads. Typically the period between bursts of drive pulses is determined by the load and the system's feedback loop, and can occur at any frequency. Quiet-Skip works by timing the period from the start of a burst of drive pulses and not allowing a second burst of drive pulses from occurring for 1.25 ms after the first pulse. This forces the burst frequency below 800 Hz operation.

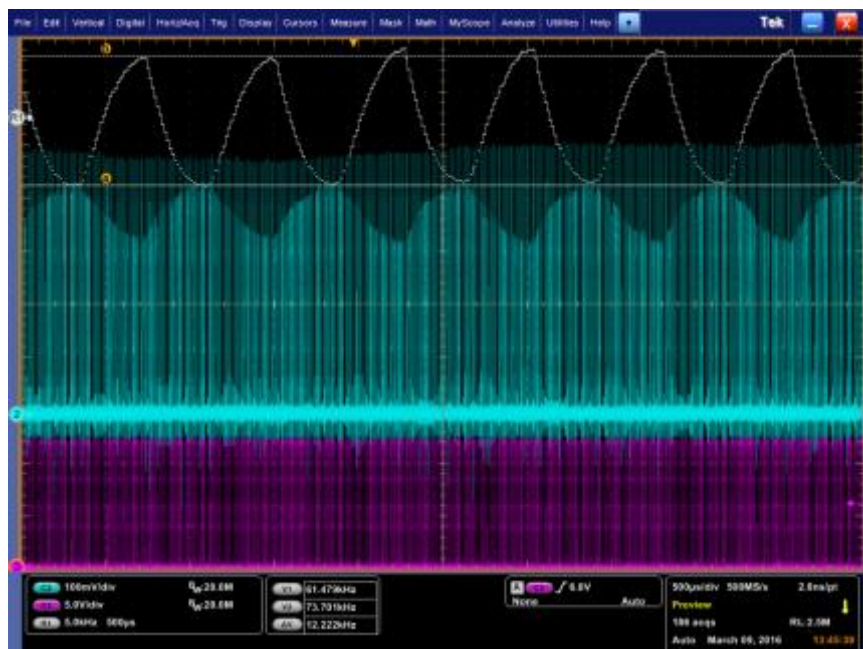
This operating mode persists provided the system remains in a constant light load operation measured by the feedback voltage remaining below 800 mV. Should a load transient be applied to the system and the feedback voltage were to rapidly rise above 800 mV, the controller will leave Quiet-Skip and immediately deliver a drive pulse to ensure that the system output voltage does not fall out of regulation.

The figures to the left show the operation of Quiet-Skip at different loads. In the first waveform the system is at no load. The second waveform shows operation at 100 mA load and the third shows operation at 190 mA, just before the system leaves burst mode operation.

**Quiet-Skip Operation**  
 Ch. 1 (Yellow): DRV  
 Ch. 4 (Green): FB Voltage



## 4. Frequency Jitter

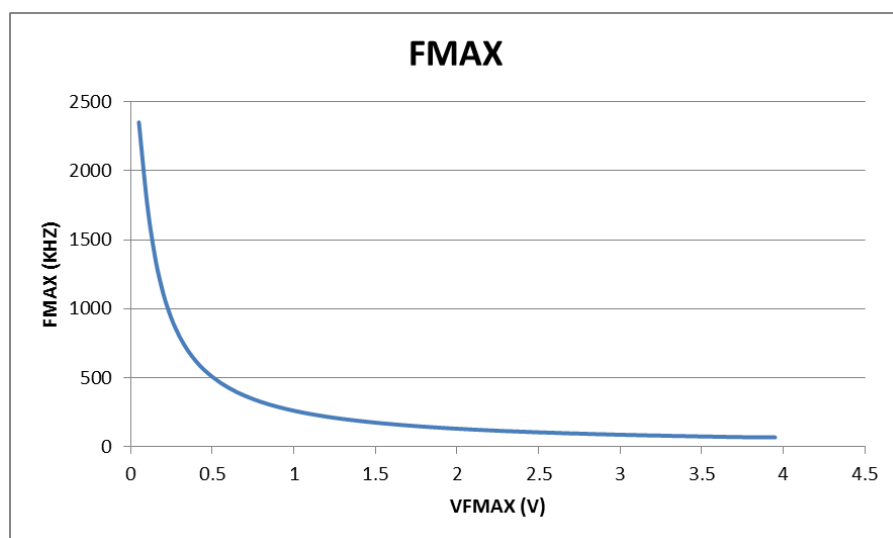


Ch. 2 (Blue): CS pin  
Ch. 3 (Purple): DRV  
Ch. R1 (Grey): Switching Frequency

Frequency jitter is a technique often used in fixed frequency controllers to provide an improved EMI signature. The NCP1341 implements frequency jitter by superimposing a 1.3 kHz, 100mVpk, triangle wave onto the internal feedback signal in the controller.

## 5. Maximum Frequency Clamp

The NCP1341 features a frequency clamp that can be used to limit the maximum switching frequency of the system. The maximum frequency clamp can serve multiple purposes. In quasi-resonant mode the clamp can be used to ensure that valley switching never exceeds a particular switching frequency. In this scenario the frequency clamp will push the system into switching at the next valley. In power excursion mode, the device will continue to decrease the off-time (thereby increasing the switching frequency) as the load demands to enable higher power deliver. Limiting the maximum frequency therefore functions as a power limiting clamp. A resistor to ground on the FMAX pin sets the voltage at the pin which is used to configure the clamp frequency clamp. The plot in figure x shows the clamp frequency as a function of the voltage on the FMAX pin. A voltage above 4 V disables the clamp which can be achieved by leaving the pin open.





# DN05086/D

## Bill of Materials

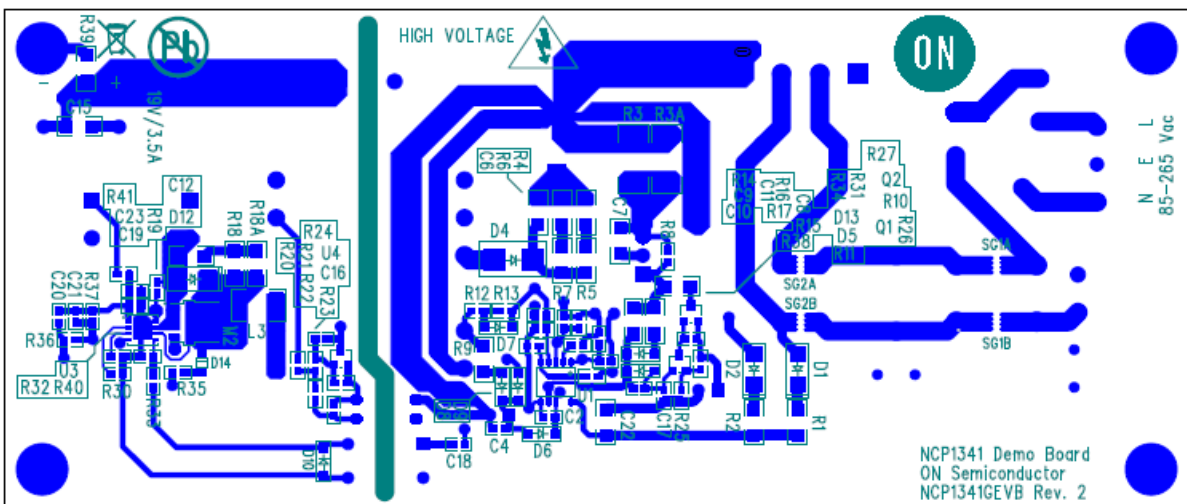
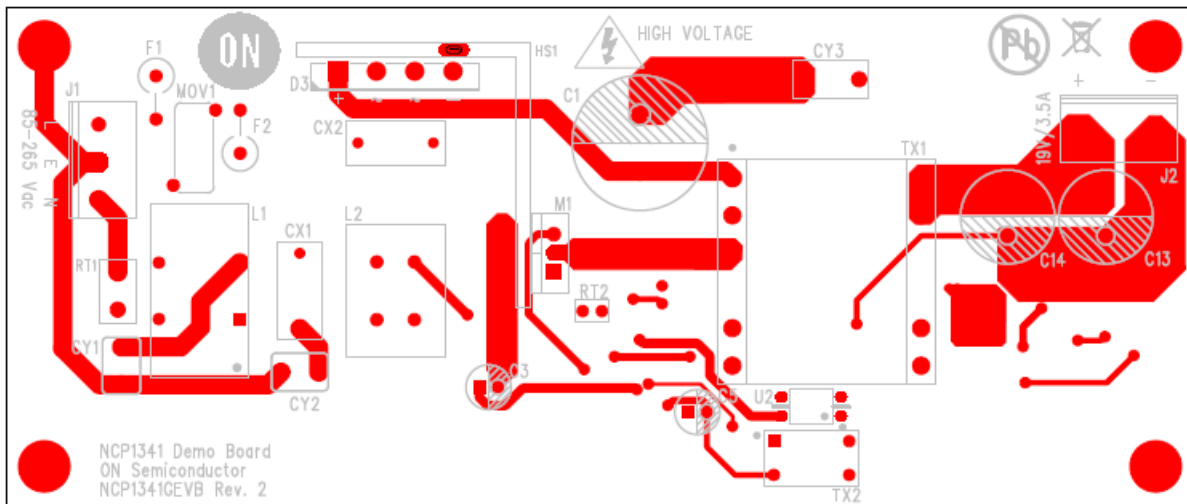
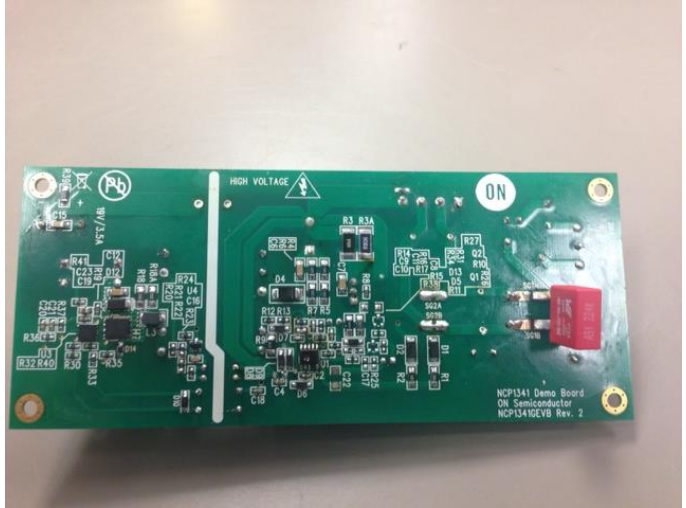
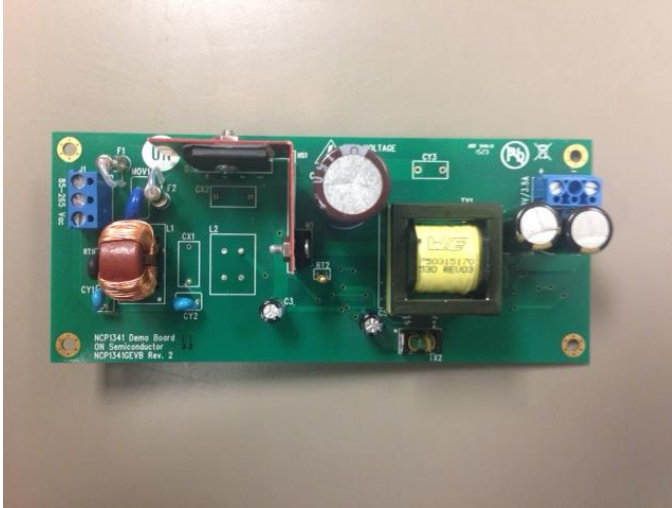
Item	Qty	Ref	Component Type	Value	Rating	Pkg / Dimensions	P/N	Supplier
1	1	C1	Electrolytic	150uF	400V	18mm x 40mm	EKXG401ELL151MM40S	UCC
1	1	C2	Ceramic	0.1u	50V	C0603W	-	-
1	1	C3	Electrolytic	47u	35V	6mm x 12.5mm	ESH476M035AE3AA	Kemet
1	1	C4	Ceramic	10n	50V	C0603W	-	-
1	1	C5	Electrolytic	100u	35V	6mm x 12.5mm	ESH107M035AE3AA	Kemet
1	1	C6	Ceramic	6800p	630V	C1206W	C3216X7R2J682M	TDK
1	1	C7	Ceramic	100p	1kV	C1206W	102R18W101KV4E	Johanson's Dielectric
1	1	C8	Ceramic	10n	50V	C0603W	-	-
1	1	C9	Ceramic	150p	50V	C0603W	-	-
1	1	C10	Ceramic	100p	50V	C0603W	-	-
1	1	C11	Ceramic	560p	50V	C0603W	-	-
1	1	C12	Ceramic	100p	1kV	C1206W	102R18W101KV4E	Johanson's Dielectric
2	2	C13, C14	Electrolytic	1000uF	35V	12.5mm x 27mm	EEU-FM1V102	Panasonic
1	1	C15	Ceramic	470n	50V	C1206W	-	-
1	1	C16	Ceramic	3.9n	50V	C0603W	-	-
1	1	C17	Ceramic	NI	NI	C0603W	NI	NI
1	1	C18	Ceramic	220p	50V	C0603W	-	-
1	1	C19	Ceramic	0.1u	50V	C0603W	-	-
1	1	C20	Ceramic	10n	50V	C0603W	-	-
1	1	C21	Ceramic	33n	50V	C0603W	-	-
1	1	C22	Ceramic	NI	NI	C1206W	NI	NI
1	1	C23	Ceramic	1u	25V	C0603W	-	-
1	1	CX1	X2	220nF	275Vac	6mm x 13mm	890334024002	Würth
1	1	CX2	X2	NI	NI	6mm x 13mm	NI	NI
2	2	CY1, CY2	Y2	1nF	250Vac	7mm Disc	DE2E3KY102MA2BM01	Murata
1	1	CY3	Y2	2.2nF	250Vac	7mm Disc	DE2E3KY222MA2BM01	Murata
1	1	F1	Fuse	6A	250V/6A	2AG	0224006.HXUP	LITTELFUSE
1	1	F2	Fuse	3A	250V/3A	2AG	0224003.HXP	LITTELFUSE
1	1	MOV1	MOV	470V	300 VAC	10mm	S10K300	EPCOS
1	1	R1	Resistor	1k	-	R1206W	-	-
2	2	R10, R11	Resistor	NI	NI	R0603W	NI	NI
1	1	R12	Resistor	1k	-	R0603W	-	-
1	1	R13	Resistor	270k	-	R0603W	-	-
1	1	R14	Resistor	1k	-	R0603W	-	-
1	1	R15	Resistor	0	-	R0603W	-	-
1	1	R16	Resistor	44.2k	-	R0603W	-	-
1	1	R17	Resistor	118k	-	R0603W	-	-
2	2	R18, R18A	Resistor	200	-	R1206W	-	-
1	1	R19	Resistor	10k	-	R0603W	-	-
1	1	R2	Resistor	1k	-	R1206W	-	-
1	1	R20	Resistor	10	-	R0603W	-	-
1	1	R21	Resistor	165k	-	R0603W	-	-
1	1	R22	Resistor	4.02k	-	R0603W	-	-
1	1	R23	Resistor	15k	-	R0603W	-	-
1	1	R24	Resistor	24.9k	-	R0603W	-	-
2	2	R25, R26	Resistor	NI	NI	R0603W	NI	NI
1	1	R27	Resistor	NI	NI	R1206W	NI	NI
1	1	R3	Resistor	0.4	-	R2512W	-	-
1	1	R30	Resistor	22k	-	R0603W	-	-
1	1	R31	Resistor	8.25	-	R1206W	-	-

# DN05086/D

1	1	R32	Resistor	25k	-	R0603W	-	-
1	1	R33	Resistor	1k	-	R0603W	-	-
1	1	R34	Resistor	20	-	R1206W	-	-
1	1	R35	Resistor	6.8k	-	R0603W	-	-
2	2	R36, R37	Resistor	39k	-	R0603W	-	-
1	1	R38	Resistor	100	-	R0603W	-	-
1	1	R39	Resistor	0	-	R1206W	-	-
1	1	R40	Resistor	10k	-	R0603W	-	-
2	2	R41, R15	Resistor	0	-	R0603W	-	-
1	1	R3A	Resistor	0.806	-	R2512W	-	-
4	4	R4, R5, R6, R7	Resistor	100k	-	R1206W	-	-
1	1	R8	Resistor	10k	-	R0603W	-	-
1	1	R9	Resistor	1.18	-	R1206W	-	-
1	1	RT1	NTC	NI	NI	5mm	NI	NI
1	1	RT2	NTC	220k	-	2.5mm	NTCLE100E3224JB0	Vishay/Dale
1	1	L1	CM Choke	10mH	2A	-	744823210	WURTH
1	1	L2	NI	NI	NI	-	NI	NI
1	1	L3	Ferrite Bead	48 Ohms	100MHz	SMD1812	28F0121-0SR-10	LAIRD
1	1	TX1	Flyback Transformer	500u	-	ER28	750316154	WURTH
1	1	TX2	Gate Transformer	15uH	1 to 1	12.5mm x 7.3mm	PA6598-AL	Coilcraft
2	2	D1, D2	Rectifier	MRA4007	1000V/1A	SMA	MRA4007T3G	ON Semiconductor
1	1	D3	Bridge	GBU406	600V/4A	18.5mm x 22mm	GBU406	Diodes
1	1	D4	Standard Recovery	S2M-E3/52T	1000V/1.5A	SMB	S2M-E3/52T	Vishay
1	1	D5	NI	NI	NI	SOD-123	NI	NI
3	3	D6, D7, D8	General Purpose	MMSD4148	100V/200mA	SOD-123	MMSD4148T1G	ON Semiconductor
1	1	D9	Zener	27V	500mW	SOD-123	MMSZ27T1G	ON Semiconductor
2	2	D10,	General Purpose	MMSD4148	100V/200mA	SOD-123	MMSD4148T1G	ON Semiconductor
1	1	D12	Schottky	MBRA1H100T3G	100V/1A	SMA	MBRA1H100T3G	ON Semiconductor
1	1	D13	General Purpose	MMSD4148	100V/200mA	SOD-123	MMSD4148T1G	ON Semiconductor
1	1	D14	General Purpose	BAS20HT1G	200V/200mA	SOD-323	BAS20HT1G	ON Semiconductor
1	1	M1	HV MOSFET	IPA60R165CP	-	TO-220FP	IPA60R165CP	Infineon
1	1	M2	SR MOSFET	NTMFS6B03N	100V/132A	POWERPAK_SO8	NTMFS6B03N	ON Semiconductor
2	2	Q1, Q2	NI	NI	NI	SOT-23	NI	NI
1	1	U1	Flyback Controller	NCP1341B1	-	SOIC-9	NCP1341B1D1R2G	ON Semiconductor
1	1	U2	Optocoupler	PS2513-1-A	-	PDIP4	PS2513-1-A	NEC
1	1	U3	SR Controller	NCP4305D	-	DFN8_4x4	NCP4305DMNTWG	ON Semiconductor
1	1	U4	Shunt Regulator	NCP431A	-	SOT-23	NCP431ACSNT1G	ON Semiconductor
1	1	HS1	Heatsink	-	-	-	-	-
1	1	J1	3T Screw Block	-	-	5mm Pitch	OSTTA030161	On Shore Technology
1	1	J2	2T Screw Block	-	-	10mm Pitch	ED200/2DS	On Shore Technology
4	4	J3, J4, J5, J6	Standoff	-	-	-	4820	Keystone Electronics

Notes: Resistor tolerances are +/- 1% unless noted otherwise  
Capacitor tolerances are +/- 10% unless noted otherwise  
Electrolytic capacitor tolerances are +/- 20% unless noted otherwise

# DN05086/D Demo Board



## References

NCP1341-D Datasheet  
NCP4305-D Datasheet  
NCP431-D Datasheet

**Disclaimer:** ON Semiconductor is providing this design note “AS IS” and does not assume any liability arising from its use; nor does ON Semiconductor convey any license to its or any third party’s intellectual property rights. This document is provided only to assist customers in evaluation of the referenced circuit implementation and the recipient assumes all liability and risk associated with its use, including, but not limited to, compliance with all regulatory standards. ON Semiconductor may change any of its products at any time, without notice.

Design note created by Alan Finkel: e-mail: [Alan.Finkel@onsemi.com](mailto:Alan.Finkel@onsemi.com)