

# Precise Low Voltage Synchronous Buck Controller with Power Saving Mode

## NCP81147

The NCP81147 is a simple single phase solution with differential phase current sensing, power saving operation, and gate drivers to provide accurately regulated power.

The adaptive non overlap gate drive and power saving operation circuit provide a low switching loss and high efficiency solution for server, notebook, and desktop systems. A high performance operational error amplifier is provided to simplify compensation of the system. The NCP81147 features also include soft-start sequence, accurate overvoltage and over current protection, UVLO for VCC and VCCP, and thermal shutdown.

### Features

- High Performance Operational Error Amplifier
- Internal Soft-Start/Stop
- $\pm 0.5\%$  Internal Voltage Accuracy, 0.8 V voltage reference
- OCP accuracy, Four Re-entry Times Before Latch
- “Lossless” Differential Inductor Current Sensing
- Internal High Precision Current Sensing Amplifier
- Oscillator Frequency Range of 100 kHz – 1000 kHz
- 20 ns Adaptive FET Non-overlap Time of Internal Gate Driver
- 5.0 V to 12 V Operation
- Support 1.5 V to 19 V  $V_{in}$
- $V_{out}$  from 0.8 V to 3.3 V (5 V with 12 V $_{CC}$ )
- Chip Enable through OSC pin
- Latched Over Voltage Protection (OVP)
- Internally Fixed OCP Threshold
- Guaranteed Startup Into Pre-Charged Loads
- Thermally Compensated Current Monitoring
- Thermal Shutdown Protection
- Integrated MOSFET Drivers
- Integrated BOOST Diode with internal  $R_{bst} = 2.2 \Omega$
- Automatic Power Saving Mode to Maximize Efficiency During Light Load Operation
- Sync Function
- Remote Ground Sensing
- This is a Pb-Free Device\*

### Applications

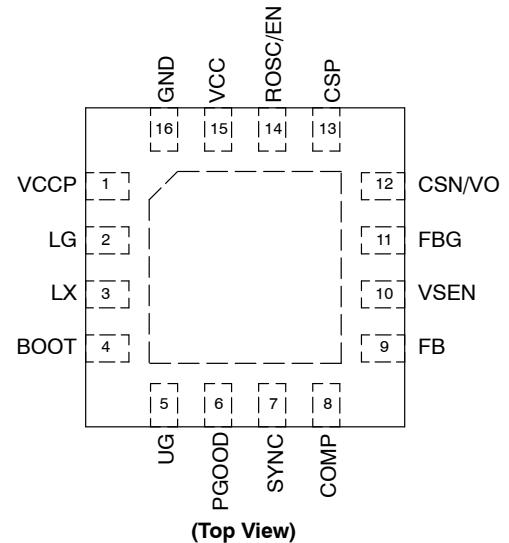
- Desktop and Server Systems

\*For additional information on our Pb-Free strategy and soldering details, please download the **onsemi** Soldering and Mounting Techniques Reference Manual, [SOLDDERM/D](http://SOLDDERM/D).

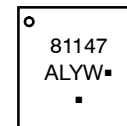


QFN16  
CASE 485G

### PIN CONNECTIONS



### MARKING DIAGRAMS



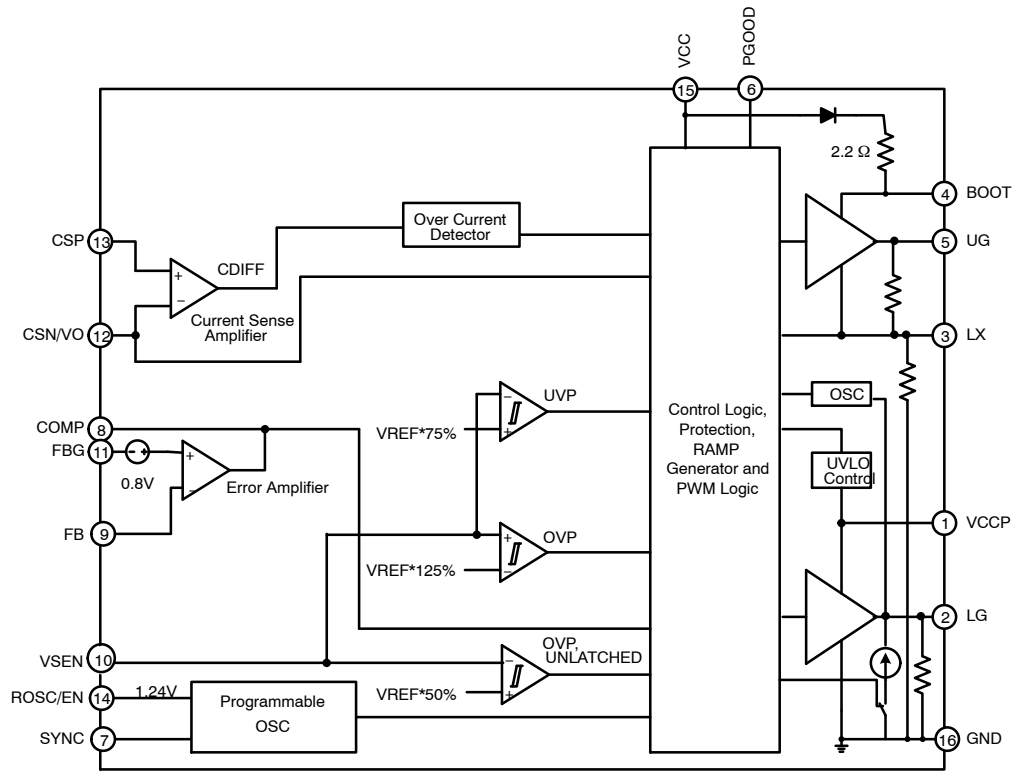
81147 = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package  
(Note: Microdot may be in either location)

### ORDERING INFORMATION

| Device        | Package            | Shipping               |
|---------------|--------------------|------------------------|
| NCP81147MNTXG | QFN16<br>(Pb-Free) | 3,000 /<br>Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, [BRD8011/D](http://BRD8011/D).

# NCP81147



**Figure 1. NCP81147 BLOCK DIAGRAM**

## PIN DESCRIPTIONS

| Pin No. | Symbol      | Description                                                                                                                                                    |
|---------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | VCCP        | Power supply for bottom gate MOSFET drivers                                                                                                                    |
| 2       | LG          | Bottom gate MOSFET driver pin                                                                                                                                  |
| 3       | LX          | Switch node                                                                                                                                                    |
| 4       | BOOT        | Supply rail for the floating top gate driver                                                                                                                   |
| 5       | UG          | Top gate MOSFET driver pin                                                                                                                                     |
| 6       | PGOOD       | Power Good. It is an open-drain output, set free after SS (with 3x clock delay) as long as the output voltage monitored through VSEN is within specifications. |
| 7       | SYNC        | Synchronization Pin. The controller synchronizes on the falling edge of a square wave provided to this pin. Short to GND if not used.                          |
| 8       | COMP        | Output of the error amplifier                                                                                                                                  |
| 9       | FB          | Inverting input to the error amplifier                                                                                                                         |
| 10      | VSEN        | Output Voltage Sense                                                                                                                                           |
| 11      | FBG         | Remote Ground Sense                                                                                                                                            |
| 12      | CSN/VO      | Inductor differential sense inverting input                                                                                                                    |
| 13      | CSP         | Inductor differential sense non-inverting input                                                                                                                |
| 14      | ROSC/EN     | Programs the switching frequency; EN: Pull-low to disable the device                                                                                           |
| 15      | VCC         | Supply rail for the controller internal circuitry                                                                                                              |
| 16      | GND         | Ground reference                                                                                                                                               |
|         | THERMAL PAD | Connects with the silicon substrate for good thermal contact with the PCB. Connect to GND plane.                                                               |

# NCP81147

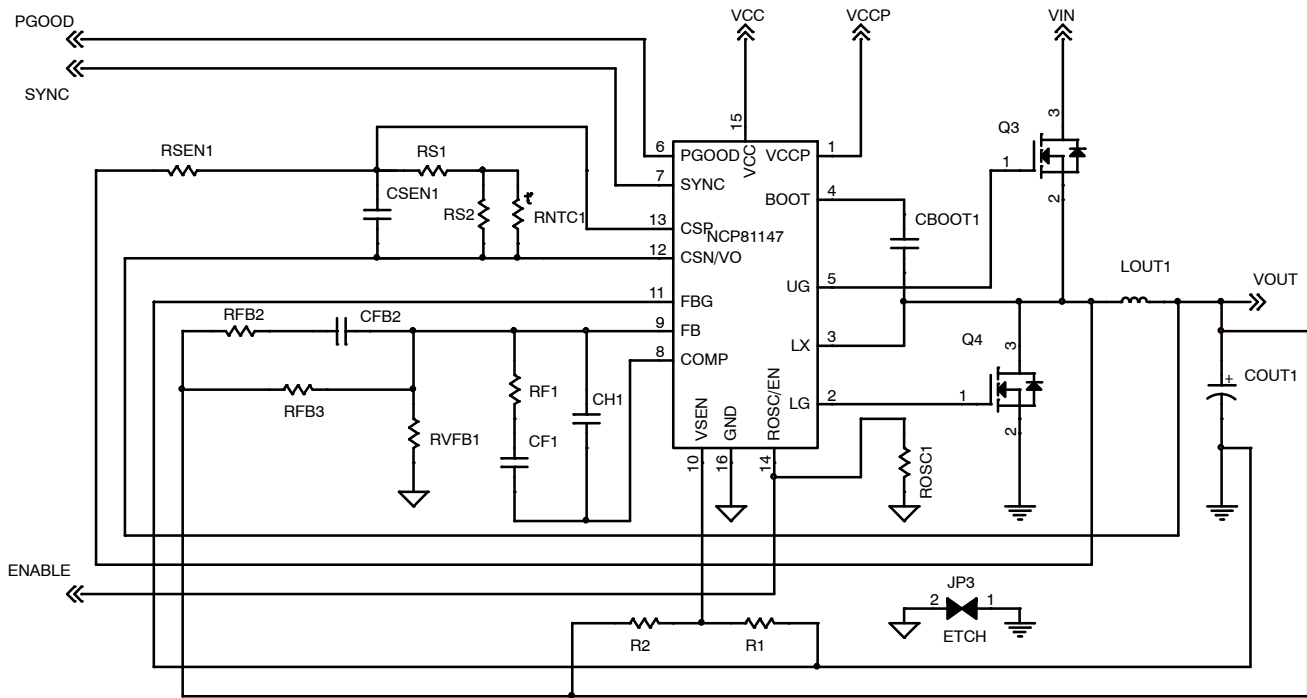


Figure 2. Typical Application Circuit

## ABSOLUTE MAXIMUM RATINGS

| Symbol                                     | Rating                                      | V <sub>MAX</sub>                                     | V <sub>MIN</sub>             | Unit |
|--------------------------------------------|---------------------------------------------|------------------------------------------------------|------------------------------|------|
| VCC, VCCP                                  | Controller Power Supply Voltages to GND     | 15                                                   | -0.3                         | V    |
| BOOT                                       | Boost Supply Voltage Input                  | 35V wrt/GND<br>40 V < 100 ns<br>wrt/GND<br>15 wrt/LX | -0.3                         | V    |
| UG                                         | High-Side Driver Output<br>(Top Gate)       | 35<br>40 V ≤ 50 ns<br>wrt/GND<br>15 wrt/LX           | -0.3 wrt/LX<br>-5 V < 200 ns | V    |
| LX                                         | Switching Node<br>(Bootstrap Supply Return) | 35<br>40 < 100 ns                                    | -5<br>-10 V < 200 ns         | V    |
| LG                                         | Low-Side Driver Output<br>(Bottom Gate)     | 15                                                   | -0.3<br>-5 V < 200 ns        | V    |
|                                            | All Other Pins                              | 6                                                    | -0.3, -1 V < 1 μs            | V    |
| PGOOD                                      | PGOOD                                       | 7                                                    | -0.3, -1 V < 1 μs            | V    |
| SYNC                                       | SYNC                                        | 7                                                    | -0.3, -1 V < 1 μs            | V    |
| CSP, CSN/VO with<br>V <sub>CC</sub> = 12 V | Current Sense Amplifier                     | 10                                                   | -0.3, -1 V < 1 μs            | V    |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

\*All signals referenced to GND unless noted otherwise.

## THERMAL INFORMATION

| Symbol          | Rating                                      | Typ         | Unit |
|-----------------|---------------------------------------------|-------------|------|
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient     | 60          | °C/W |
| $R_{\theta JC}$ | Thermal Resistance, Junction-to-Case        | 18          | °C/W |
| $T_J$           | Operating Junction Temperature Range        | -40 to +125 | °C   |
| $T_A$           | Operating Ambient Temperature Range         | -40 to +85  | °C   |
| $T_{STG}$       | Maximum Storage Temperature Range           | -55 to +150 | °C   |
| MSL             | Moisture Sensitivity Level      QFN Package | 1           | –    |

## ELECTRICAL CHARACTERISTICS

Unless otherwise stated:  $-40^{\circ}\text{C} < T_A < 85^{\circ}\text{C}$ ;  $4.5\text{ V} < V_{CC} < 13.2\text{ V}$ ;  $C_{VCC} = 0.1\text{ }\mu\text{F}$

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|-----------|-----------------|-----|-----|-----|------|
|-----------|-----------------|-----|-----|-----|------|

## SUPPLY OPERATING CONDITIONS

|                        |  |     |   |      |                  |
|------------------------|--|-----|---|------|------------------|
| VCC Voltage Range      |  | 4.5 | – | 13.2 | V                |
| VCCP Voltage Range     |  | 4.5 | – | 13.2 | V                |
| dV/dt on VCC (Note 1)  |  | –10 | – | 10   | V/ $\mu\text{s}$ |
| dV/dt on VCCP (Note 1) |  | –10 | – | 10   | V/ $\mu\text{s}$ |

## VCC AND BOOT INPUT SUPPLY CURRENT

|                       |                                                                         |   |   |     |               |
|-----------------------|-------------------------------------------------------------------------|---|---|-----|---------------|
| VCC Operating Current | $V_{CC} = 5\text{ V}$ , EN = High<br>$V_{CC} = 12\text{ V}$ , EN = High | – | – | 5.0 | mA            |
| VCC Supply Current    | $V_{CC} = 5\text{ V}$ , EN = Low<br>$V_{CC} = 12\text{ V}$ , EN = Low   | – | – | 400 | $\mu\text{A}$ |

## VCCP INPUT SUPPLY CURRENT

|                                          |                                                                           |   |     |     |               |
|------------------------------------------|---------------------------------------------------------------------------|---|-----|-----|---------------|
| VCCP Operating Current<br>UG and LG Open | $V_{CCP} = 5\text{ V}$ , EN = High<br>$V_{CCP} = 12\text{ V}$ , EN = High | – | 3.5 | 5.0 | mA            |
| VCCP Supply Current                      | $V_{CCP} = 5\text{ V}$ , EN = Low<br>$V_{CCP} = 12\text{ V}$ , EN = Low   | – | –   | 200 | $\mu\text{A}$ |

## VCC SUPPLY VOLTAGE

|                          |                            |   |     |      |    |
|--------------------------|----------------------------|---|-----|------|----|
| VCC UVLO Start Threshold | $V_{CC}$ Rising            | – | –   | 4.50 | V  |
| VCC UVLO Hysteresis      | $V_{CC}$ Rising or Falling | – | 300 | –    | mV |

## VCCP SUPPLY VOLTAGE

|                           |  |   |     |     |    |
|---------------------------|--|---|-----|-----|----|
| VCCP UVLO Start Threshold |  | – | –   | 4.2 | V  |
| VCCP UVLO Hysteresis      |  | – | 200 | –   | mV |

## ERROR AMPLIFIER COMP

|                                         |                                  |    |     |   |                  |
|-----------------------------------------|----------------------------------|----|-----|---|------------------|
| Open Loop DC Gain (Note 1)              |                                  | –  | 120 | – | dB               |
| Open Loop Unity Gain Bandwidth (Note 1) |                                  | 15 | 18  | – | MHz              |
| Slew Rate (Note 1)                      | COMP pin to GND with 100 pF load | –  | 8.0 | – | V/ $\mu\text{s}$ |

## VREF

|                            |                                                                |      |       |     |   |
|----------------------------|----------------------------------------------------------------|------|-------|-----|---|
| Internal Reference Voltage |                                                                | –    | 0.800 | –   | V |
| Output Voltage Accuracy    | $V_{out}$ to FBG excluding external resistor divider tolerance | –1.5 | –     | 1.5 | % |

## CURRENT SENSE AMPLIFIERS

|                                                                       |                            |      |   |     |   |
|-----------------------------------------------------------------------|----------------------------|------|---|-----|---|
| Common Mode Input Voltage Range<br>(Note 1, GNG, output within 10mV)  | $V_{CC} \leq 7.5\text{ V}$ | –0.3 | – | 3.5 | V |
| Common Mode Input Voltage Range<br>(Note 1, GNG, output within 10 mV) | $V_{CC} > 7.5\text{ V}$    | –0.3 | – | 5.5 | V |

# NCP81147

## ELECTRICAL CHARACTERISTICS (continued)

Unless otherwise stated:  $-40^{\circ}\text{C} < T_A < 85^{\circ}\text{C}$ ;  $4.5\text{ V} < V_{CC} < 13.2\text{ V}$ ;  $C_{VCC} = 0.1\text{ }\mu\text{F}$

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|-----------|-----------------|-----|-----|-----|------|
|-----------|-----------------|-----|-----|-----|------|

### OSCILLATOR (with no ROSC Resistor Defaults to 200 kHz)

|                              |                                         |     |    |      |                     |
|------------------------------|-----------------------------------------|-----|----|------|---------------------|
| Switching Frequency Accuracy | $R_{OSC}$ open                          | -15 | -  | 15   | %                   |
| OSC Gain (Note 1)            |                                         | -   | 10 | -    | kHz / $\mu\text{A}$ |
| Disable threshold            | $R_{OSC}/\text{EN pin}$ , $V_{dis\_th}$ | -   | -  | 0.75 | V                   |

### MODULATORS (PWM Comparators)

|                               |                                                                  |     |      |     |     |
|-------------------------------|------------------------------------------------------------------|-----|------|-----|-----|
| Minimum Pulse Width           | $F_{SW} = 200\text{ kHz}$ , OSC open                             | -   | 90   | -   | ns  |
| Minimum Turn Off Time (LG on) | $F_{SW} = 200\text{ kHz}$ , OSC open                             | 250 | 350  | 450 | ns  |
| Magnitude of the PWM Ramp     | $V_{IN} = 5\text{ V}$ or $12\text{ V}$                           | -   | 1.50 | -   | V   |
| Maximum Duty Cycle            | OSC/EN = OPEN                                                    | 80  | -    | 95  | %   |
| Minimum Skip mode frequency   | In light load, maximum time for LG to turn on after HG turns off | 30  | -    | -   | kHz |

### SOFT-START

|                           |                                |   |      |   |    |
|---------------------------|--------------------------------|---|------|---|----|
| Soft Start Time @ 200 kHz | 1024 clock cycles, OSC/EN open | - | 5.12 | - | ms |
|---------------------------|--------------------------------|---|------|---|----|

### SOFT-OFF

|                            |           |   |     |   |          |
|----------------------------|-----------|---|-----|---|----------|
| Soft OFF bleeding resistor | $R_{dis}$ | - | 120 | - | $\Omega$ |
|----------------------------|-----------|---|-----|---|----------|

### OVER CURRENT PROTECTION

|                               |                           |    |    |    |    |
|-------------------------------|---------------------------|----|----|----|----|
| First Over Current Threshold  | CSP-CSN, 4xMasking        | 17 | 20 | 23 | mV |
| Second Over Current Threshold | CSP-CSN, Immediate action | -  | 30 | -  | mV |

### SYNC PIN

|                       |                        |     |   |     |   |
|-----------------------|------------------------|-----|---|-----|---|
| Synchronization Input | $V_{IL}$ , square wave | -   | - | 1.0 | V |
| Synchronization Input | $V_{IH}$ , square wave | 2.5 | - | -   | V |

### PROTECTION AND PGOOD

|                                 |                                                |     |     |     |               |
|---------------------------------|------------------------------------------------|-----|-----|-----|---------------|
| Output Voltage                  | Logic Low, Sinking 4 mA                        | -   | -   | 0.4 | V             |
| OVP Threshold                   | $V_{SEN}$ rising above $1.25 * V_{ref}$        | 110 | 125 | 140 | %             |
| UVP Threshold                   | $V_{SEN}$ falling below $0.75 * V_{ref}$       | 70  | 75  | 80  | %             |
| Unlatched Overvoltage Threshold | $V_{th\_disoff}$ with respect to $0.5 V_{ref}$ | 40  | 50  | 60  | %             |
| Power Good High Delay (Note 1)  |                                                | -   | -   | 50  | $\mu\text{s}$ |
| Power Good Low Delay (Note 1)   |                                                | -   |     | 1   | $\mu\text{s}$ |

### ZERO CURRENT DETECTION (LX Pin)

|                                                                         |                                                                                          |     |     |     |               |
|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------|-----|-----|-----|---------------|
| Blanking Time before Zero Current Detection (Note 1)                    | Blanking Time after LG is $< 1.0\text{ V}$                                               | -   | -   | 40  | ns            |
| Capture Time for LX Voltage (Note 1)                                    | Time to capture LX voltage once LG is $< 1.0\text{ V}$ (must be within dead time limits) | -   | -   | 20  | ns            |
| Negative LX detection voltage                                           | $V_{bdls}$                                                                               | 150 | 300 | 450 | mV            |
| Positive LX detection voltage                                           | $V_{bdhs}$                                                                               | 0.2 | 0.5 | 1.0 | V             |
| Time for $V_{th}$ adjustment and settling time (Note 1)                 | 300 kHz                                                                                  | 3.0 | -   | 3.7 | $\mu\text{s}$ |
| Initial Negative Current Detection Threshold Voltage Set Point (Note 1) | LX-GND, Includes $\pm 2\text{ mV}$ Offset Range                                          | -   | 1.0 | -   | mV            |
| $V_{th}$ adjustable Range (Note 1)                                      |                                                                                          | -16 | 0   | 15  | mV            |

### HIGH SIDE DRIVER UG

|                                         |                                                                                       |   |     |   |          |
|-----------------------------------------|---------------------------------------------------------------------------------------|---|-----|---|----------|
| $R_{H\_TG}$ Output Resistance, Sourcing | $V_{BOOT} - V_{LX} = 12\text{ V}$ , $C_{load} = 3\text{ nF}$ , $V_{CC} = 12\text{ V}$ | - | 2.5 | 5 | $\Omega$ |
|-----------------------------------------|---------------------------------------------------------------------------------------|---|-----|---|----------|

**ELECTRICAL CHARACTERISTICS** (continued)

Unless otherwise stated:  $-40^{\circ}\text{C} < T_A < 85^{\circ}\text{C}$ ;  $4.5\text{ V} < V_{CC} < 13.2\text{ V}$ ;  $C_{VCC} = 0.1\text{ }\mu\text{F}$

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|-----------|-----------------|-----|-----|-----|------|
|-----------|-----------------|-----|-----|-----|------|

**HIGH SIDE DRIVER UG**

|                                              |                                                                                              |   |     |     |           |
|----------------------------------------------|----------------------------------------------------------------------------------------------|---|-----|-----|-----------|
| $R_{H\_TG}$ Output Resistance, Sinking       | $V_{BOOT} - V_{LX} = 12\text{ V}$ , $V_{CC} = 12\text{ V}$                                   | – | 2.0 | 2.5 | $\Omega$  |
| $T_{rDRVH}$ Transition Time                  | $C_{LOAD} = 2\text{ nF}$ , $V_{CC} = 12\text{ V}$                                            | – | 16  | –   | ns        |
| $T_{fDRVH}$ Transition Time                  | $C_{LOAD} = 2\text{ nF}$ , $V_{CC} = 12\text{ V}$                                            | – | 11  | –   | ns        |
| $T_{pdhDRVH}$ Propagation Delay (Notes 1, 2) | Driving High, $C_{LOAD} = 3\text{ nF}$ ,<br>$V_{CC} = 12\text{ V}$ , $V_{CCP} = 12\text{ V}$ | – | 15  | 30  | ns        |
| UG Internal Resistor to LX                   | Unbiased, $BOOT - LX = 0$                                                                    | – | 45  | –   | $k\Omega$ |

**LOW SIDE DRIVER LG**

|                                              |                                                                                               |    |     |     |           |
|----------------------------------------------|-----------------------------------------------------------------------------------------------|----|-----|-----|-----------|
| $R_{H\_BG}$ Output Resistance, Sourcing      | $V_{LX} = \text{GND}$ , $C_{load} = 3\text{ nF}$ , $V_{CC} = 12\text{ V}$                     | –  | 2.0 | 3.0 | $\Omega$  |
| $R_{L\_BG}$ Output Resistance, Sinking       | $V_{LX} = V_{CC}$ , $V_{CC} = 12\text{ V}$                                                    | –  | 1.0 | 1.5 | $\Omega$  |
| $T_{rDRVL}$ Transition Time                  | $C_{LOAD} = 3\text{ nF}$ , $V_{CC} = 12\text{ V}$                                             | –  | 16  | –   | ns        |
| $T_{fDRVL}$ Transition Time                  | $C_{LOAD} = 3\text{ nF}$ , $V_{CC} = 12\text{ V}$                                             | –  | 11  | –   | ns        |
| $T_{pdhDRVL}$ Propagation Delay (Notes 1, 2) | Driving High, $C_{LOAD} = 3\text{ nF}$ , $V_{CCP} = 12\text{ V}$ ,<br>$V_{CCP} = 12\text{ V}$ | 10 | 20  | 35  | ns        |
| LX Internal Resistor to GND                  |                                                                                               | –  | 45  | –   | $k\Omega$ |

**THERMAL SHUTDOWN**

|                                                  |  |     |     |   |                    |
|--------------------------------------------------|--|-----|-----|---|--------------------|
| $T_{sd}$ Thermal Shutdown (Note 1)               |  | 150 | 180 | – | $^{\circ}\text{C}$ |
| $T_{sdhys}$ Thermal Shutdown Hysteresis (Note 1) |  | –   | 50  | – | $^{\circ}\text{C}$ |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. Guaranteed by design.
2. For propagation delays, "tpdh" refers to the specified signal going high "tpdl" refers to it going low. Reference Gate Timing Diagram.

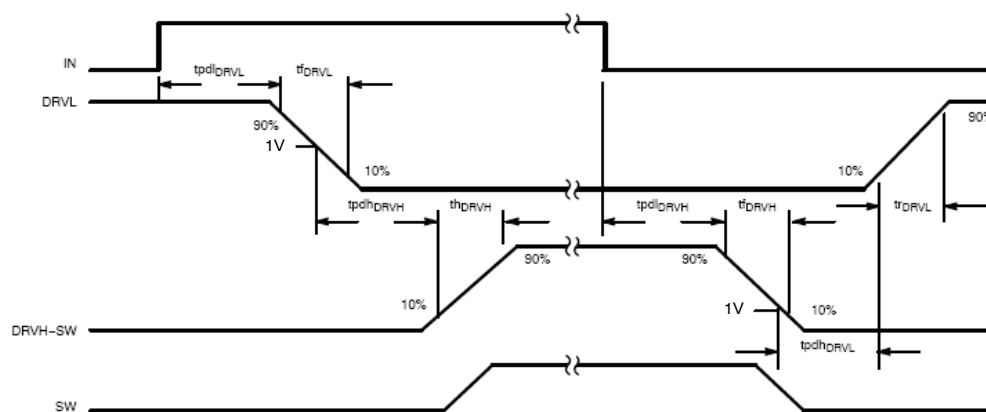


Figure 3. Gate Timing Diagram

### Switching Frequency

Connecting a resistor from ROSC/EN to an external voltage source  $V_{pu}$  will configure the switching frequency. Normal range would be 100 kHz to 1 MHz. With no resistor connected to the pin, the oscillator frequency is 200 kHz. The switching frequency will follow the relationship:

$$F_{SW} = 200 \text{ kHz} - \frac{V_{pu} - 1.240}{R_{OSC}} \cdot 10 \frac{\text{kHz}}{\mu\text{A}} \quad (\text{eq. 1})$$

When  $R_{osc} = \text{infinity}$  (no resistor connected),  $F_{sw} = 200 \text{ kHz}$ ; when  $V_{pu} = \text{ground}$ , the frequency programmed will be higher than 200 kHz. Pulling  $R_{osc}/\text{EN}$  pin to ground solidly with a less than 10 k $\Omega$  resistor will result in the part being disabled.

### Soft-Start

Soft-Start will begin if VCC, VCCP are both above their UVLO thresholds and EN pin is set free. IC initially waits a fixed delay time and then ramps the reference in 5.12 ms (1024 clock cycles when  $R_{osc}$  open) in closed-loop regulation. After soft-start, PGOOD signal will be released with 3 clock cycles delay.

Protection active during soft-start:

- Overvoltage Protection always enabled;
- Undervoltage Protection is enabled after reference voltage ramps up to 80% of the final value. During soft-start, a UVP fault will initiate a complete soft restart.

### Synchronization Function

Synchronize through the SYNC pin. Synchronization function allows different converters to share the same input filter reducing the resulting RMS current and reducing the need for total caps to sustain the load. Synchronized systems also exhibit higher EMI noise immunity and better regulation.

The device synchronizes to the Falling edge of the SYNC pin external input signal (eg. high side gate signal, switch node signal, distribution clock signal), and locks the phase

of an internal ramp signal correspondingly with a fixed delay time. The external signal has to sit within a 0-40% frequency window above the local frequency configured by the  $R_{osc}$  resistor to allow the synchronization function working properly.

### Power Good

The PGOOD pin is an open drain connection with no internal pullup resistor. An active high output signals the normal operation of the converter. PGOOD is pulled low during soft-start cycle, and if there is an overvoltage or undervoltage fault. If the voltage on the VSEN pin is within  $\pm 10\%$  of  $V_{ref}$  (0.8 V) then the PGOOD pin will not be pulled low.

### Overvoltage Protection (OV)

If the voltage on the VSEN pin exceeds the overvoltage threshold (1000 mV or 125%  $V_{ref}$ ), the NCP81147 will latch an overvoltage fault. During an overvoltage fault event the UG pin will be pulled low, and the LG pin will stay high until the voltage on the VSEN pin goes below 400 mV or 50%  $V_{ref}$ , then a soft-bleeding resistor will be connected from switch node to ground to continuously discharge the output voltage softly. To clear the overvoltage fault, toggling VCC or EN is needed.

### Undervoltage Protection (UV)

If the voltage on the FB pin falls below the undervoltage threshold after the softstart cycle completes, the NCP81147 will latch an undervoltage fault. During an undervoltage fault, both the UG and LG pins will be pulled low. Toggling VCC power or EN will reset the undervoltage protection.

### PreOVP Protection

If the NCP81147 is powered on but not enabled, the VSEN pin will be monitored for preOVP condition. If the VSEN exceeds the preset threshold, the device will force LG pin high to protect the load. The PreOVP function will be disabled when the device is enabled and the normal OV function will operate instead.

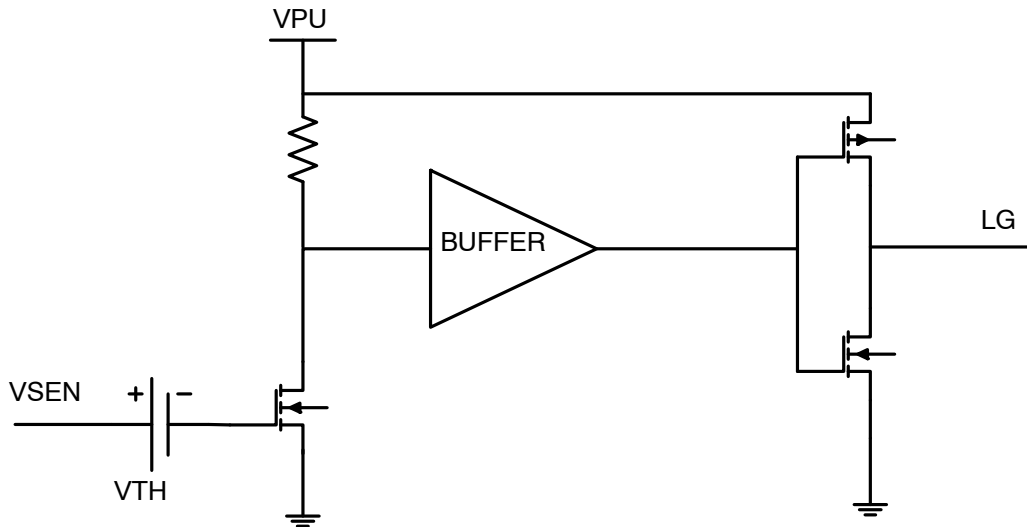


Figure 4. PreOVP circuit

#### Vin Detection

During the soft start after the VSEN pin exceeds 80%  $V_{ref}$ , UV protection will be enabled; If a UV fault is triggered in the softstart, it will restart SS after a fixed delay. The UV protection is to avoid IC to startup without Vin or with insufficient Vin voltage.

#### Overcurrent Protection

NCP81147 measures the differential current sensing signal through CSP and CSN/VO pin. There are two current protection levels: OCP1 and OCP2. If the differential voltage across pin CSP and CSN/VO is over 20 mV (but below 30 mV) for four consecutive cycles, OCP1 will be tripped. Both UG and LG will be forced to low to turn off the high side and low side FETs, it is a latched condition; If the differential voltage across pin CSP and CSN is over 30 mV,

OCP2 will be tripped, the UG and LG will be pulled low and latched immediately. Toggling VCC power or EN will reset the Overcurrent protection.

The current sensing R/C network should be selected to match the inductor time constant as below,

$$(RCS1 // RCS2) \cdot C = \frac{L}{DCR}$$

(Notes: the actual RC network time constant may be slightly higher)

Thus, OCP1 and OCP2 levels can be configured as,

$$OCP1 = \frac{20 \text{ mV}}{DCR} \cdot \frac{RCS1 + RCS2}{RCS2}$$

$$OCP2 = \frac{30 \text{ mV}}{DCR} \cdot \frac{RCS1 + RCS2}{RCS2}$$

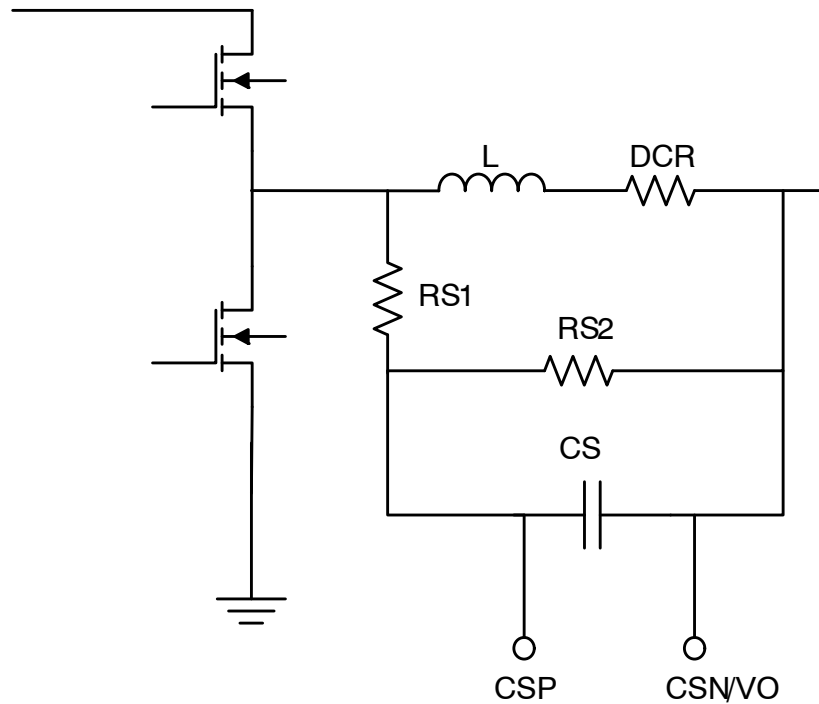


Figure 5. Differential Current Sense Network

#### Light Load Operation

In the light load condition, NCP81147 will work in a diode emulation mode with bottom gate turning off if the inductor current is below zero. The system therefore works in discontinuous conduction mode (DCM). The zero current detection is done by sensing switch node and automatically adjusted to minimize the low side FET body diode conduction time (right after LG turns off) in diode emulation mode.

If the load reduces further, COMP signal will be close or below the internal ramp bottom triggering minimum on time operation, the system will start skipping pulses, working in a reduced frequency range. NCP81147 has an internal ultrasonic timer to keep the device from working in an audio frequency and below. This timer initiates after high side gate off signal and expires after ~30  $\mu$ s.

Normally high side gate signal will reset this ultrasonic timer repeatedly before it expires. In a very light load or load release, if there is no high side gate pulses until the timer expires, the low side MOSFET(s) will be forced to turn on to discharge the output. Through properly compensated network the comp signal will climb up to generate next burst of switching pulses and the converter will regulate the output voltage to its target level. This can last a few cycles or continuously depending on the system load level.

In light load operation, if synchronization is enabled, NCP81147 will also check the SYNC pin input signal cycle by cycle. If the external sync signal is within the synchronization frequency range, the NCP81147 will interleave its switching pulses with it after a proper delay. In

this way, the ripple variation during transition between the discontinuous and continuous current mode can be minimized.

#### Voltage Feedback

The NCP81147 allow the output voltage to be adjusted from 0.8 V to 5 V via an external resistor divider network (R1, R2). The controller will regulate the output voltage to maintain the FB pin voltage to 0.8 V reference voltage. The relation between the resistor divider network and the output voltage is as below;

$$R2 = R1 \cdot \left( \frac{0.8 \text{ V}}{V_{\text{out}} - 0.8 \text{ V}} \right)$$

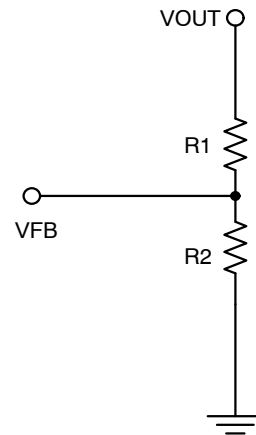


Figure 6. Feedback Voltage

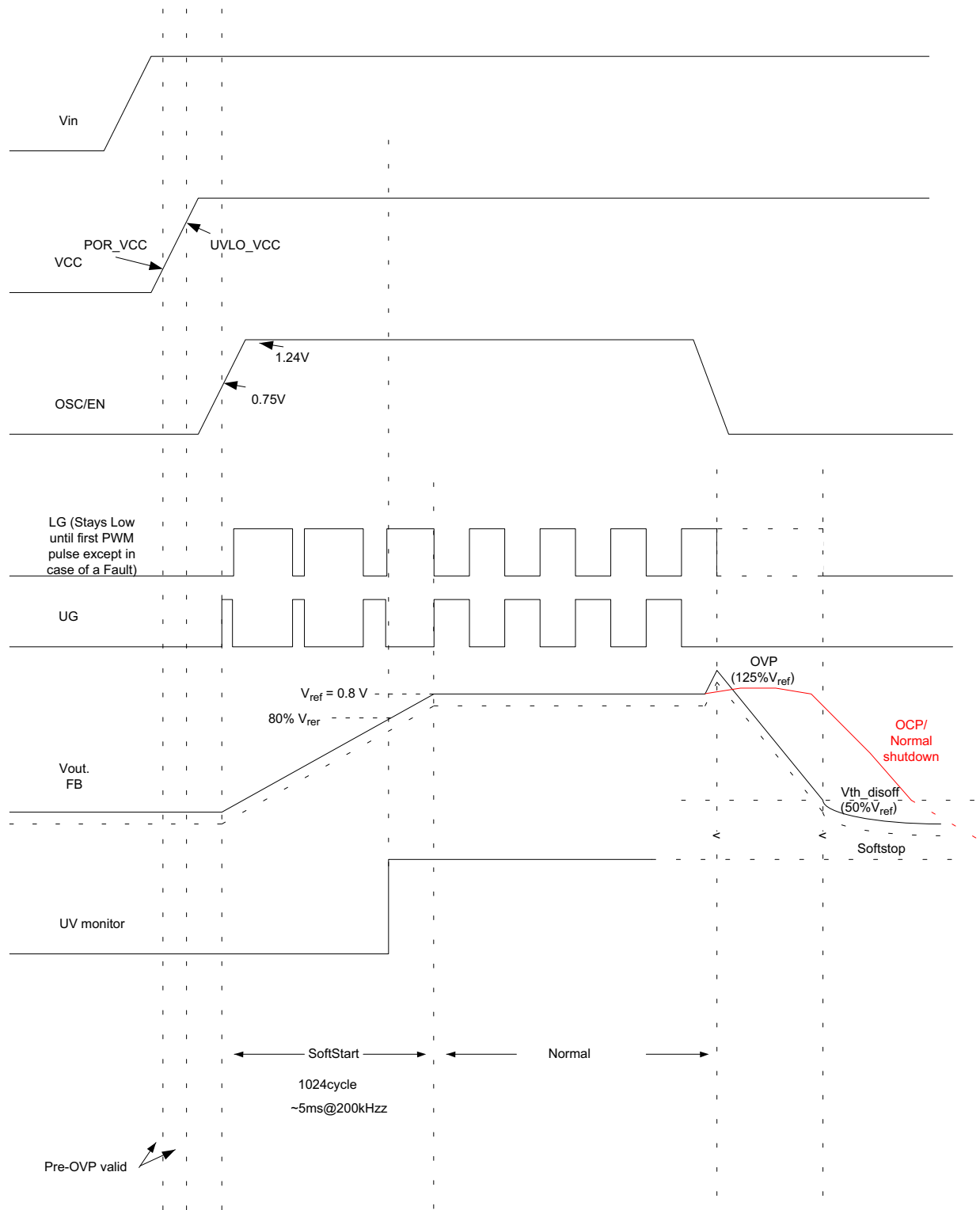


Figure 7. Start Up and Shutdown Timing Diagram

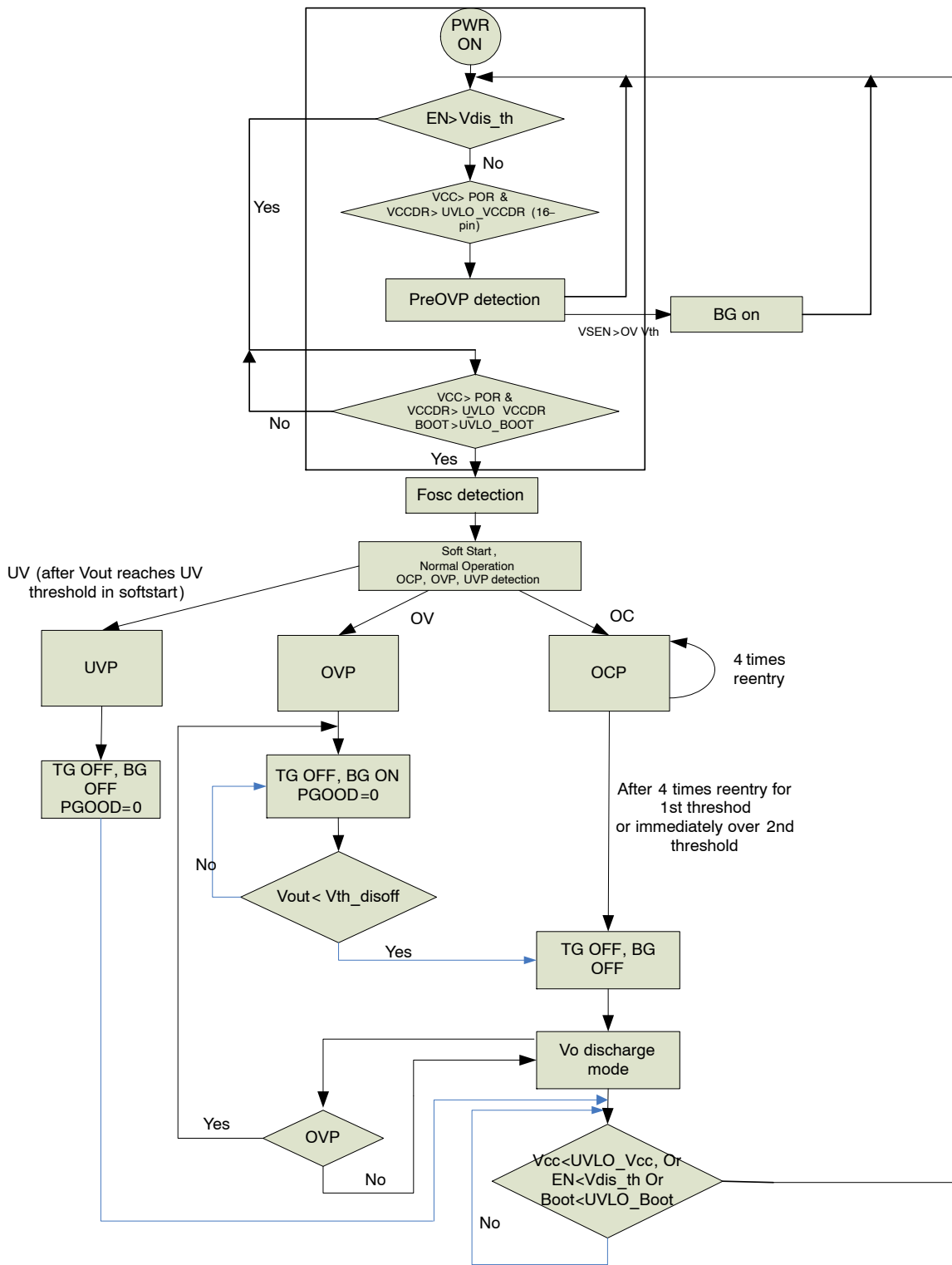


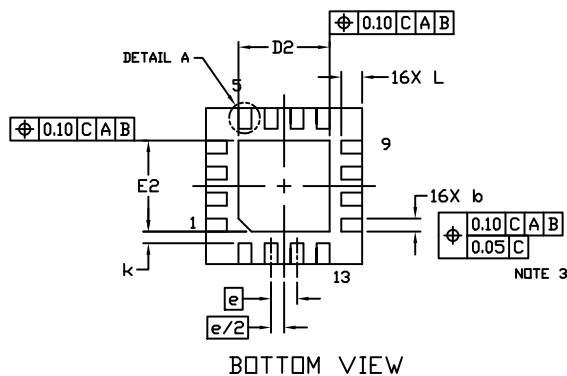
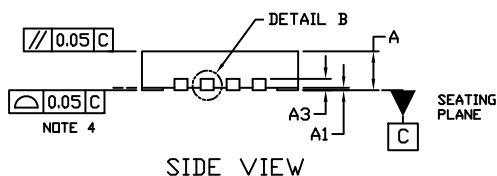
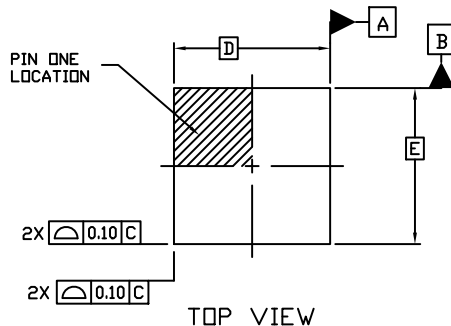
Figure 8. State Diagram



SCALE 2:1

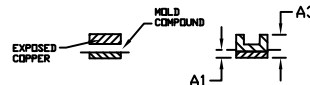
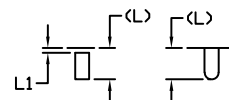
**QFN16 3x3, 0.5P**  
CASE 485G  
ISSUE G

DATE 08 OCT 2021



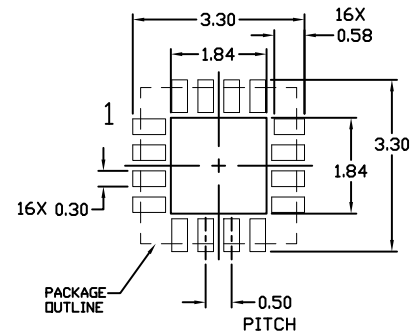
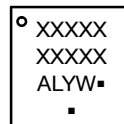
## NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.


DETAIL B  
ALTERNATE  
CONSTRUCTIONS

DETAIL A  
ALTERNATE TERMINAL  
CONSTRUCTIONS

| DIM | MILLIMETERS |      |      |
|-----|-------------|------|------|
|     | MIN.        | NOM. | MAX. |
| A   | 0.80        | 0.90 | 1.00 |
| A1  | 0.00        | 0.03 | 0.05 |
| A3  | 0.20 REF    |      |      |
| b   | 0.18        | 0.24 | 0.30 |
| D   | 3.00 BSC    |      |      |
| D2  | 1.65        | 1.75 | 1.85 |
| E   | 3.00 BSC    |      |      |
| E2  | 1.65        | 1.75 | 1.85 |
| e   | 0.50 BSC    |      |      |
| k   | 0.18 TYP    |      |      |
| L   | 0.30        | 0.40 | 0.50 |
| L1  | 0.00        | 0.08 | 0.15 |

## MOUNTING FOOTPRINT


**GENERIC  
MARKING DIAGRAM\***


XXXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

|                         |                        |                                                                                                                                                                                  |
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