# NCP1404 Series

*Product Preview*

# 350 mA PWM/PFM Step-Up DC-DC Converter with Low Battery Detector

The NCP1404 series are monolithic PWM/PFM step–up DC to DC converters which can automatically change operation mode from PWM to PFM at light loads to improve efficiency at light loads. With only four external components, this series allow a simple means to implement highly efficient converters for powering up portable equipment up to 350 mA loading.

Additionally, this series is featured with a Low Battery Detector to monitor battery voltage. The NCP1404 device series are available in space–saving TSOP–6 package with five standard regulated output voltages. Additional voltages that range from 1.8 V to 5.0 V in 100 mV steps can be manufactured.

### Features

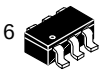
- Low Start–Up Voltage of 0.8 V
- PWM Oscillator Frequency of 600 kHz at 20% Accuracy
- High Efficiency 85% at $I_{OUT}$ = 200 mA, $V_{IN}$ = 2.5 V, $V_{OUT}$ = 3.3 V
- Output Current up to 350 mA at $V_{IN}$ = 2.5 V, $V_{OUT}$ = 3.3 V
- Duty Ratio: 17% to 85% typ. PWM Control
  17% typ. PFM Control
- Output Voltage Accuracy ±2.5%
- Low Battery Detection with Open–drain Detector Output
- Separated Power Supply Pin
- Low Profile and Minimum External Parts
- Micro Miniature TSOP–6

### Typical Applications

- Digital Cameras
- Cellular Telephones
- Personal Digital Assistants (PDA)
- Camcorders
- Electronic Games
- Pagers
- Portable Audio (MP3)
- Handheld Instruments

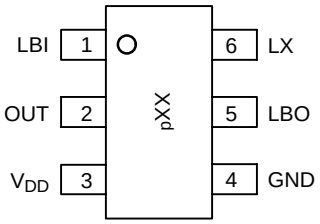
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**TSOP–6**
**SN SUFFIX**
**CASE 318G**

**PIN CONNECTIONS AND MARKING DIAGRAM**




(Top View)

XX = Specific Device Code
d = Date Code

See specific marking information in the ordering information table on page 3 of this data sheet.

**ORDERING INFORMATION**

| Device | Package | Shipping |
|---|---|---|
| NCP1404SN19T1 | TSOP–6 | 3000/Tape & Reel |
| NCP1404SN27T1 | TSOP–6 | 3000/Tape & Reel |
| NCP1404SN30T1 | TSOP–6 | 3000/Tape & Reel |
| NCP1404SN33T1 | TSOP–6 | 3000/Tape & Reel |
| NCP1404SN50T1 | TSOP–6 | 3000/Tape & Reel |

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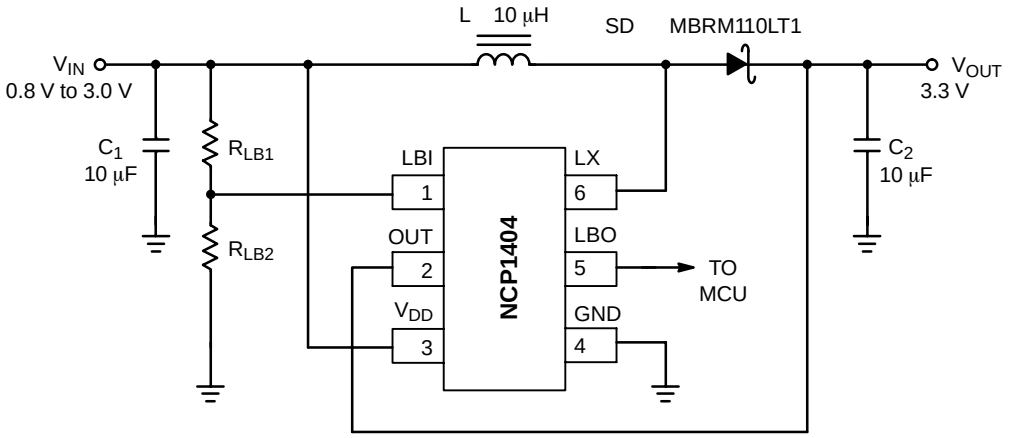



**Figure 1. Typical Step–Up Converter Application**

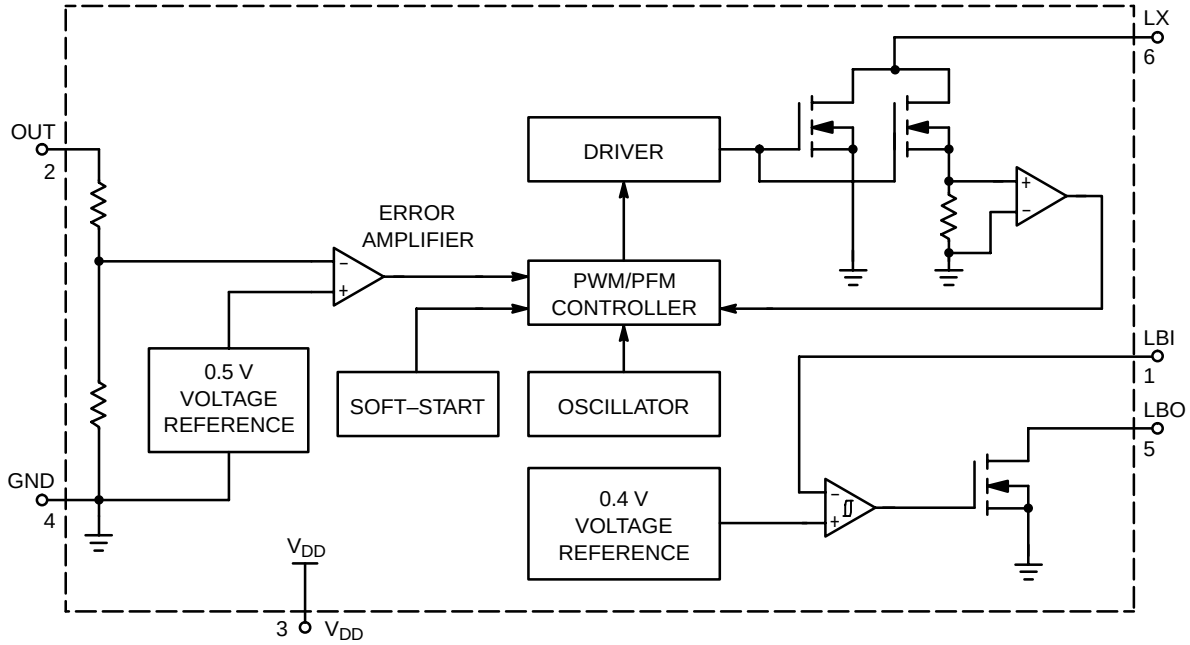



**Figure 2. Representative Block Diagram**

## PIN FUNCTION DESCRIPTIONS

| Pin | Symbol | Description |
|---|---|---|
| 1 | LBI | Low battery detection input pin |
| 2 | OUT | Output voltage monitor pin |
| 3 | $V_{DD}$ | Power supply pin |
| 4 | GND | Ground pin |
| 5 | LBO | Low battery detection output pin |
| 6 | LX | External inductor connection pin to power switch drain |

## ORDERING INFORMATION

| Device | Output Voltage | Frequency | Device Marking | Package | Shipping |
|---|---|---|---|---|---|
| NCP1404SN19T1 | 1.9 V | 600 kHz | DB? | TSOP–6 | 3000 Units per 7 Inch Reel |
| NCP1404SN27T1 | 2.7 V | 600 kHz | DB? | | |
| NCP1404SN30T1 | 3.0 V | 600 kHz | DB? | | |
| NCP1404SN33T1 | 3.3 V | 600 kHz | DB? | | |
| NCP1404SN50T1 | 5.0 V | 600 kHz | DB? | | |

NOTE: The ordering information lists five standard output voltage device options. Additional device with output voltage ranging from 1.8 V to 5.0 V in 100 mV increments can be manufactured. Contact your ON Semiconductor representative for availability.

## MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Power Supply Voltage (Pin 3) | $V_{DD}$ | –0.3 to 6.0 | V |
| Input/Output Pins<br>Pin 1, Pin 2, Pin 5, Pin 6 Voltage | $V_{IO}$ | –0.3 to 6.0 | V |
| LX Pin Peak Sink Current | $I_{LX}$ | 1000 | mA |
| Thermal Resistance Junction to Air | $R_{\theta JA}$ | 250 | °C/W |
| Operating Ambient Temperature Range | $T_A$ | –40 to + 85 | °C |
| Operating Junction Temperature Range | $T_J$ | –40 to + 125 | °C |
| Storage Temperature Range | $T_{stg}$ | –55 to +150 | °C |

1. This device series contains ESD protection and exceeds the following tests:
   Human Body Model (HBM) ±2.0 kV per JEDEC standard: JESD22–A114.
   Machine Model (MM) ±200 V per JEDEC standard: JESD22–A115.
2. Latch–up Current Maximum Rating: ±150 mA per JEDEC standard: JESD78.
3. Moisture Sensitivity Level (MSL): 1 per IPC/JEDEC standard: J–STD–020A.

**ELECTRICAL CHARACTERISTICS** (For all values $T_A$ = 25°C unless otherwise noted.)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OSCILLATOR** | | | | | |
| Frequency ($V_{OUT}$ = $V_{SET}$ × 0.96) (Note 4) | $f_{OSC}$ | 480 | 600 | 720 | kHz |
| Frequency Temperature Coefficient ($T_A$ = –40 to +85°C) | Δf | – | 0.11 | – | %/°C |
| Maximum PWM Duty Cycle ($V_{OUT}$ = $V_{SET}$ × 0.96) | $D_{MAX}$ | 70 | 78 | 86 | % |
| PFM Duty Cycle | $D_{PFM}$ | 12 | 17 | 22 | % |
| Minimum Start–up Voltage ($I_O$ = 0 mA, $V_{DD}$ = $V_{OUT}$ = $V_{SET}$) | $V_{start}$ | – | 0.8 | 0.95 | V |
| Minimum Start–up Voltage Temperature Coefficient ($T_A$ = –40 to +85°C) | $\Delta V_{start}$ | – | –1.6 | – | mV/°C |
| Soft–Start Time ($V_{OUT}$ = $V_{SET}$) | $t_{SS}$ | 0.3 | 2.0 | – | ms |
| **LX (PIN 6)** | | | | | |
| Internal Switching N–Channel FET Drain Voltage | $V_{LX}$ | – | – | 6.0 | V |
| LX On–State Current ($V_{DD}$ = $V_{OUT}$ = $V_{SET}$ × 0.96, $V_{LX}$ = 0.6 V) | $V_{LX}$ | | | | mA |
| Device Suffix: 19T1 | | 350 | 400 | – | |
| 27T1 | | 550 | 600 | – | |
| 30T1 | | 550 | 600 | – | |
| 33T1 | | 550 | 600 | – | |
| 50T1 | | 600 | 650 | – | |
| Current Limit | $I_{LXLIM}$ | 700 | 750 | 800 | mA |
| Off–State Leakage Current ($V_{LX}$ = 6.0 V, $T_A$ = –40 to +85°C) | $I_{LKG}$ | – | 0.5 | 1.0 | mA |
| **LBI (PIN 1)** | | | | | |
| LBI Threshold Voltage Falling | $V_{LBI}$ | 0.396 | 0.400 | 0.404 | V |
| LBI Hysteresis | $V_{HYS}$ | – | 30 | – | mV |
| LBI Input Current | $I_{LBI}$ | – | 1.5 | 8.0 | nA |
| **LBO (PIN 5)** | | | | | |
| LBO Low Output Voltage | $V_{LBO(low)}$ | – | – | 0.05 | V |
| LBO Off–State Leakage Current | $I_{LBOLKG}$ | – | 1 | 100 | nA |
| **TOTAL DEVICE** | | | | | |
| Supply Voltage | $V_{DD}$ | 0.8 | | 5.5 | V |
| Output Voltage | $V_{OUT}$ | | | | V |
| Device Suffix: 19T1 | | 1.853 | 1.9 | 1.948 | |
| 27T1 | | 2.632 | 2.7 | 2.768 | |
| 30T1 | | 2.925 | 3.0 | 3.075 | |
| 33T1 | | 3.218 | 3.3 | 3.383 | |
| 50T1 | | 4.875 | 5.0 | 5.125 | |
| Output Voltage Temperature Coefficient ($T_A$ = –40 to +85°C) | $\Delta V_{OUT}$ | – | 100 | – | ppm/°C |
| Operating Current ($V_{OUT}$ = $V_{SET}$ × 0.96, $V_{DD}$ = $V_{SET}$ × 0.6) (Note 5) | $I_{DD1}$ | – | 220 | 300 | μA |
| No Switching Operating Current ($V_{OUT}$ = $V_{SET}$ + 0.5 V) | $I_{DD2}$ | – | 40 | 55 | μA |
| No Load Operating Current ($V_{DD}$ = $V_{SET}$ × 0.6, $I_{OUT}$ = 0 mA ) (Note 7) | $I_{DD(no\ load)}$ | – | 65 | 80 | μA |
| Maximum Output Current ($V_{DD}$ = $V_{OUT}$, $V_{IN}$ = $V_{SET}$ × 0.8, Voltage Regulation < 3%) | $I_{OUT}$ | | | | mA |
| Device Suffix: 19T1 | | 150 | 200 | – | |
| 27T1 | | 300 | 350 | – | |
| 30T1 | | 300 | 350 | – | |
| 33T1 | | 300 | 350 | – | |
| 50T1 | | 350 | 400 | – | |

4. $V_{SET}$ means setting of output voltage.
5. Operating current is the current consumption of the device in PWM mode.
6. No switching operating current is the current consumption of the device when there is no switching.
7. No load operating current is the current consumption of the device in PFM mode at no load.

## Other Application Circuit

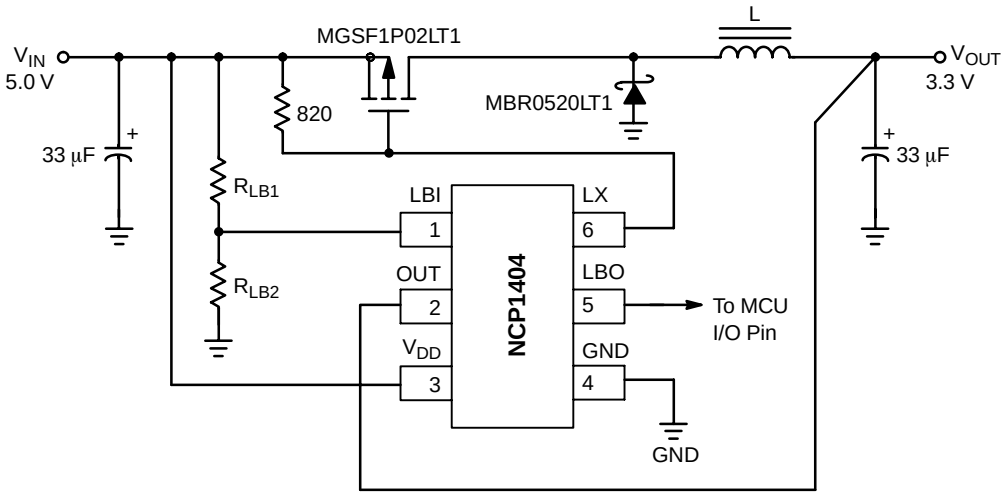
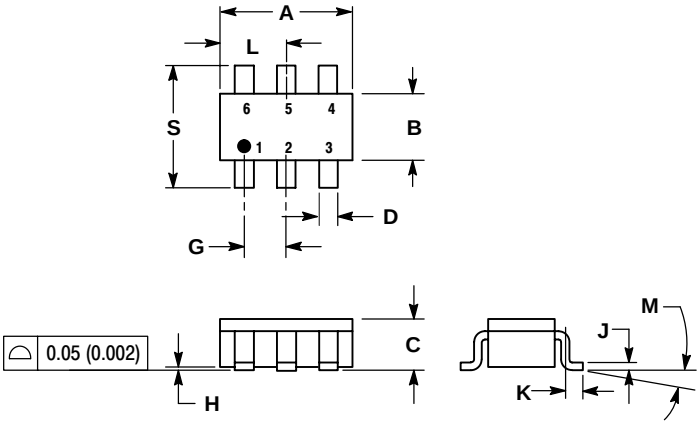



**Figure 3. Step−down Application**

## PACKAGE DIMENSIONS

**TSOP–6**
CASE 318G–02
ISSUE H




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 2.90 | 3.10 | 0.1142 | 0.1220 |
| B | 1.30 | 1.70 | 0.0512 | 0.0669 |
| C | 0.90 | 1.10 | 0.0354 | 0.0433 |
| D | 0.25 | 0.50 | 0.0098 | 0.0197 |
| G | 0.85 | 1.05 | 0.0335 | 0.0413 |
| H | 0.013 | 0.100 | 0.0005 | 0.0040 |
| J | 0.10 | 0.26 | 0.0040 | 0.0102 |
| K | 0.20 | 0.60 | 0.0079 | 0.0236 |
| L | 1.25 | 1.55 | 0.0493 | 0.0610 |
| M | 0° | 10° | 0° | 10° |
| S | 2.50 | 3.00 | 0.0985 | 0.1181 |

# Notes

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