

3.8V TO 40V INPUT, 3.5A LOW IQ SYNCHRONOUS BUCK WITH PROGRAMMABLE SOFT-START TIME

Description

The AP64351 is a 3.5A, synchronous buck converter with a wide input voltage range of 3.8V to 40V. The device fully integrates a 75mΩ high-side power MOSFET and a 45mΩ low-side power MOSFET to provide high-efficiency step-down DC-DC conversion.

The AP64351 device is easily used by minimizing the external component count due to its adoption of peak current mode control.

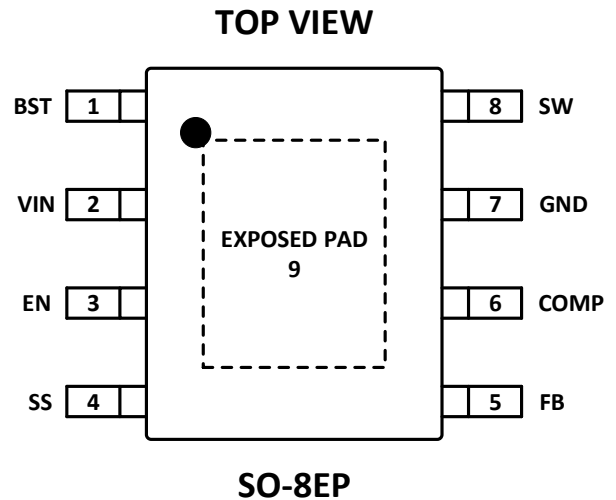
The AP64351 design is optimized for Electromagnetic Interference (EMI) reduction. The device has a proprietary gate driver scheme to resist switching node ringing without sacrificing MOSFET turn-on and turn-off times, which reduces high-frequency radiated EMI noise caused by MOSFET switching. AP64351 also features Frequency Spread Spectrum (FSS) with a switching frequency jitter of $\pm 6\%$, which reduces EMI by not allowing emitted energy to stay in any one frequency for a significant period of time.

The device is available in an SO-8EP package.

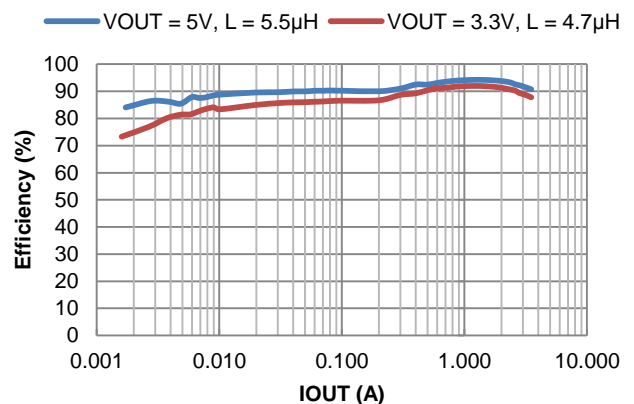
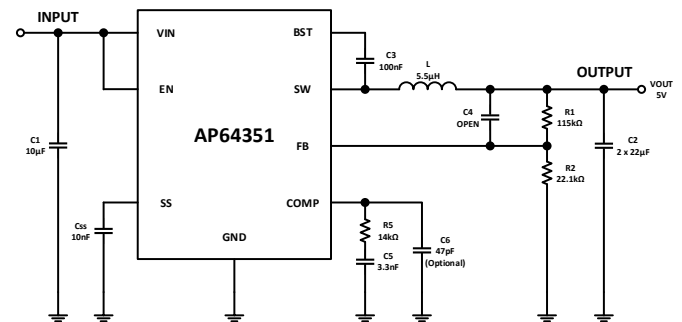
Features

- VIN 3.8V to 40V
- 3.5A Continuous Output Current
- $0.8V \pm 1\%$ Reference Voltage
- 22 μ A Low Quiescent Current (Pulse Frequency Modulation)
- 570kHz Switching Frequency
- Programmable Soft-Start Time
- Up to 85% Efficiency at 5mA Light Load
- Proprietary Gate Driver Design for Best EMI Reduction
- Frequency Spread Spectrum (FSS) to Reduce EMI
- Low-Dropout (LDO) Mode
- Precision Enable Threshold to Adjust UVLO
- Protection Circuitry
 - Undervoltage Lockout (UVLO)
 - Output Overvoltage Protection (OVP)
 - Cycle-by-Cycle Peak Current Limit
 - Thermal Shutdown
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Pin Assignments



Typical Application Circuit



- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
 2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Pin Descriptions

| Pin Name | Pin Number | Function |
|-------------|------------|--|
| BST | 1 | High-Side Gate Drive Boost Input. BST supplies the drive for the high-side N-Channel power MOSFET. A 100nF capacitor is recommended from BST to SW to power the high-side driver. |
| VIN | 2 | Power Input. VIN supplies the power to the IC as well as the step-down converter power MOSFETs. Drive VIN with a 3.8V to 40V power source. Bypass VIN to GND with a suitably large capacitor to eliminate noise due to the switching of the IC. See Input Capacitor section for more details. |
| EN | 3 | Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator and low to turn it off. Connect to VIN or leave floating for automatic startup. The EN has a precision threshold of 1.18V for programming the UVLO. See Enable section for more details. |
| SS | 4 | Soft-start. Place a ceramic capacitor from this pin to ground to program soft-start time. An internal 4 μ A current source pulls the SS pin to VCC. See Programming Soft-Start Time section for more details. |
| FB | 5 | Feedback sensing terminal for the output voltage. Connect this pin to the resistive divider of the output. See Setting the Output Voltage section for more details. |
| COMP | 6 | Compensation. Connect an external RC network to the COMP pin to adjust the loop response. See External Loop Compensation Design section for more details. |
| GND | 7 | Power Ground. |
| SW | 8 | Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. |
| EXPOSED PAD | 9 | Heat dissipation path of the die. The exposed thermal pad must be electrically connected to GND and must be connected to the ground plane of the PCB for proper operation and optimized thermal performance. |

Absolute Maximum Ratings (Note 4) (At $T_A = +25^\circ\text{C}$, unless otherwise specified.)

| Symbol | Parameter | Rating | Unit |
|------------------------------------|--------------------------|--|------|
| VIN | Supply Pin Voltage | -0.3 to +42.0 (DC) | V |
| | | -0.3 to +45.0 (400ms) | |
| V _{BST} | Bootstrap Pin Voltage | V _{SW} - 0.3 to V _{SW} + 6.0 | V |
| V _{EN} | Enable/UVLO Pin Voltage | -0.3 to +42.0 | V |
| V _{SS} | Soft-Start Pin Voltage | -0.3 to +6.0 | V |
| V _{FB} | Feedback Pin Voltage | -0.3 to +6.0 | V |
| V _{COMP} | Compensation Pin Voltage | -0.3 to +6.0 | V |
| V _{SW} | Switch Pin Voltage | -0.3 to VIN + 0.3 (DC) | V |
| | | -2.5 to VIN + 2.0 (20ns) | |
| T _{ST} | Storage Temperature | -65 to +150 | °C |
| T _J | Junction Temperature | +160 | °C |
| T _L | Lead Temperature | +260 | °C |
| ESD Susceptibility (Note 5) | | | |
| HBM | Human Body Model | 2000 | V |
| CDM | Charged Device Model | 500 | V |

- Notes:
- Stresses greater than the **Absolute Maximum Ratings** specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.
 - Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Thermal Resistance (Note 6)

| Symbol | Parameter | Rating | | Unit |
|---------------|---------------------|--------|----|-----------------------------|
| | | SO-8EP | | |
| θ_{JA} | Junction to Ambient | SO-8EP | 45 | $^{\circ}\text{C}/\text{W}$ |
| θ_{JC} | Junction to Case | SO-8EP | 5 | $^{\circ}\text{C}/\text{W}$ |

Note: 6. Test condition for SO-8EP: Device mounted on FR-4 substrate, four-layer PC board, 2oz copper, with minimum recommended pad layout.

Recommended Operating Conditions (Note 7) (At $T_A = +25^{\circ}\text{C}$, unless otherwise specified.)

| Symbol | Parameter | Min | Max | Unit |
|--------|--------------------------------------|-----|------|--------------------|
| VIN | Supply Voltage | 3.8 | 40 | V |
| VOUT | Output Voltage | 0.8 | VIN | V |
| T_A | Operating Ambient Temperature Range | -40 | +85 | $^{\circ}\text{C}$ |
| T_J | Operating Junction Temperature Range | -40 | +125 | $^{\circ}\text{C}$ |

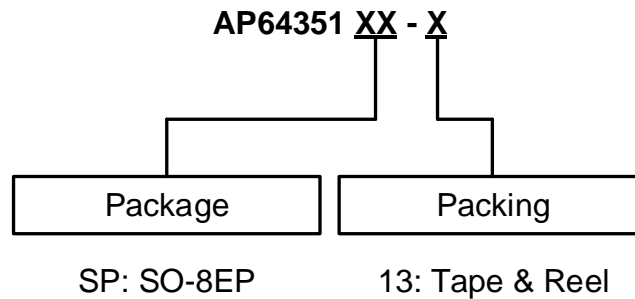
Note: 7. The device function is not guaranteed outside of the recommended operating conditions.

Electrical Characteristics (At $T_A = +25^{\circ}\text{C}$, VIN = 12V, unless otherwise specified. Min/Max limits apply across the recommended ambient temperature range, -40°C to $+85^{\circ}\text{C}$, and input voltage range, 3.8V to 40V, unless otherwise specified.)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---------------------------|---|--|------|------|------|--------------------|
| I _{SHDN} | Shutdown Supply Current | $V_{EN} = 0\text{V}$ | — | 1 | 5 | μA |
| I _Q | Quiescent Supply Current | $V_{EN} = \text{Floating}, V_{FB} = 1.0\text{V}$ | — | 22 | — | μA |
| UVLO | VIN Undervoltage Rising Threshold | — | — | 3.5 | 3.7 | V |
| | VIN Undervoltage Hysteresis | — | — | 400 | — | mV |
| R _{DS(ON)1} | High-Side Power MOSFET On-Resistance (Note 8) | — | — | 75 | — | m Ω |
| R _{DS(ON)2} | Low-Side Power MOSFET On-Resistance (Note 8) | — | — | 45 | — | m Ω |
| I _{PEAK_LIMIT} | HS Peak Current Limit (Note 8) | — | 4.25 | 5 | 5.75 | A |
| I _{VALLEY_LIMIT} | LS Valley Current Limit (Note 8) | — | — | 5.5 | — | A |
| I _{PFMPK} | PFM Peak Current Limit | — | — | 750 | — | mA |
| I _{ZC} | Zero Cross Current Threshold | — | — | 0 | — | mA |
| f _{SW} | Oscillator Frequency | — | 510 | 570 | 630 | kHz |
| t _{ON_MIN} | Minimum On-Time | — | — | 100 | — | ns |
| V _{FB} | Feedback Voltage | CCM | 792 | 800 | 808 | mV |
| V _{EN_H} | EN Logic High Threshold | — | — | 1.18 | 1.25 | V |
| V _{EN_L} | EN Logic Low Threshold | — | 1.03 | 1.09 | — | V |
| I _{EN} | EN Input Current | $V_{EN} = 1.5\text{V}$ | — | 5.5 | — | μA |
| | | $V_{EN} = 1\text{V}$ | 1 | 1.5 | 2 | μA |
| t _{SS} | Soft-Start Time | $C_{SS} = 10\text{nF}$ | — | 2 | — | ms |
| T _{SD} | Thermal Shutdown (Note 8) | — | — | 160 | — | $^{\circ}\text{C}$ |
| T _{Hys} | Thermal Shutdown Hysteresis (Note 8) | — | — | 25 | — | $^{\circ}\text{C}$ |

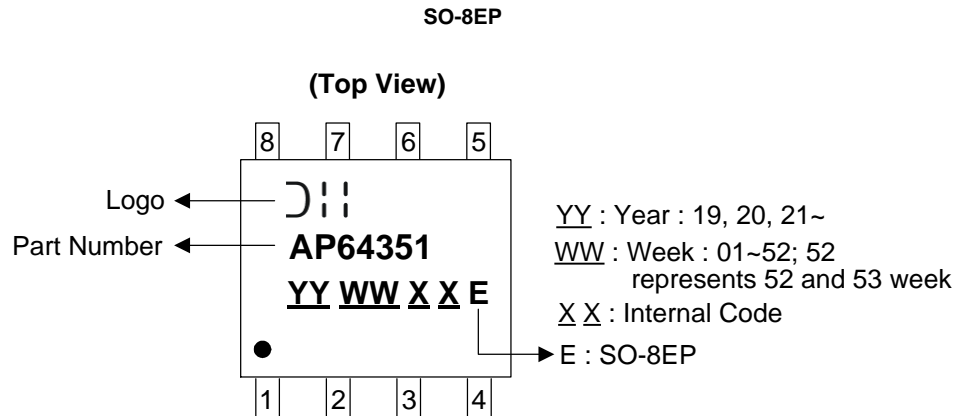
Note: 8. Compliance to the datasheet limits is assured by one or more methods: production test, characterization, and/or design.

Ordering Information



| Orderable Device | Package Code | Tape and Reel | |
|------------------|--------------|---------------|--------------------|
| | | Quantity | Part Number Suffix |
| AP64351SP-13 | SP | 4000 | -13 |

Marking Information



Device Comparison Table

| Part Name | VIN (V) | VOUT (V) | Output Current (A) | HS / LS R _{DS(ON)} (mΩ) | Switching Frequency (kHz) | I _q (μA) | Key Features | Ambient Temperature (°C) | Package |
|-----------|-----------|------------|--------------------|----------------------------------|---------------------------|---------------------|---------------------------------|--------------------------|---------|
| AP64350 | 3.8 to 40 | 0.8 to VIN | 3.5 | 75 / 45 | 100 to 2200 | 22 | Prog. Fsw, Ext. Sync, Ext. Comp | -40 to +85 | SO-8EP |
| AP64351 | 3.8 to 40 | 0.8 to VIN | 3.5 | 75 / 45 | 570 | 22 | Prog. SS, Ext. Comp | -40 to +85 | SO-8EP |
| AP64352 | 3.8 to 40 | 0.8 to VIN | 3.5 | 75 / 45 | 100 to 2200 | 22 | Prog. Fsw, Ext. Sync, Ext. SS | -40 to +85 | SO-8EP |
| AP64500 | 3.8 to 40 | 0.8 to VIN | 5.0 | 45 / 20 | 100 to 2200 | 25 | Prog. Fsw, Ext. Sync, Ext. Comp | -40 to +85 | SO-8EP |
| AP64501 | 3.8 to 40 | 0.8 to VIN | 5.0 | 45 / 20 | 570 | 25 | Prog. SS, Ext. Comp | -40 to +85 | SO-8EP |

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