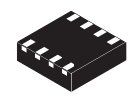
Document Number: MC34726
Rev. 2.0, 1/2014

√RoHS

300 mA High Efficiency Low Quiescent Current Synchronous Buck Regulator With Z-mode

34726

POWER MANAGEMENT IC



FC SUFFIX (PB-FREE)
98ASA10787D
8-PIN UDFN
2X2

ORDERING INFORMATION		
Device	**Temperature Range (T_A)**	**Package**
Refer to Table 1, Device Variations	-25°C to 85°C	8-UDFN

The 34726 is a high efficiency, low quiescent current (I_Q), synchronous buck regulator, implementing Freescale's innovative Z-mode architecture. Freescale's Z-mode architecture greatly improves the ripple performance during light load currents, but still maintains a low quiescent current of 65µA, at no load in "Sleepy" Z-mode.

The 34726 accepts an input voltage in the range of 2.7 to 5.5 V, making it ideally suited for single cell Li-Ion based applications. Factory preset output voltages, ranging from 0.8 to 3.3 V, reduce the number of required auxiliary components. The part is able to provide 300 mA of continuous load current across the input and the output voltage ranges.

The 34726 switches at 2.0 MHz to allow the use of small, surface mount inductors and capacitors to save precious board space.

The 34726 is available in the small, space saving, and low cost, 2x2 UDFN-8 packages. The part is guaranteed for operation over the -25°C to 85°C temperature range.

Features

- 94% peak efficiency
- 2.0 MHz switching frequency
- 2.7 to 5.5 V input voltage range
- Automatic transition to energy saving light load Z-mode (low ripple)
- Fixed output voltage options from 0.8 to 3.3 V
- 65 µA quiescent current during sleepy Z-mode
- 300 mA maximum continuous output current
- Internal 2.0 ms soft start
- Thermal and over-current protection
- 0.1 µA quiescent current in shutdown (disabled)
- Ultra thin 2x2 UDFN package
- Pb-free packaging designated by suffix code FC

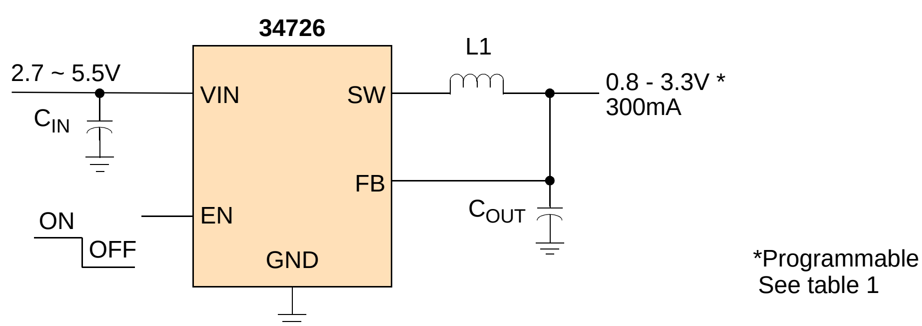


Figure 1. 34726 Typical Operating Circuit

* This document contains certain information on a new product.
Specifications and information herein are subject to change without notice.

DEVICE VARIATIONS

Table 1. Device Variations

Freescale Part No.	V_{IN} Range	Output Voltage[1]	Maximum Load Current	Switch Frequency (MHz)[2]
MC34726AFC	2.7 - 5.5 V	1.2 V	300 mA	2.0
MC34726BFC	2.7 - 5.5 V	1.8 V	300 mA	2.0
MC34726CFC	3.6 - 5.5 V	3.3 V	300 mA	2.0
MC34726DFC	2.7 - 5.5 V	1.5 V	300 mA	2.0
MC34726EFC	2.7 - 5.5 V	2.5 V	300 mA[3]	2.0

Notes

1. Output voltages of: 0.8 V, 0.9 V, 1.0 V, 1.1 V, 1.3 V, 1.4 V, 1.85 V, 2.0 V options available on request. Contact Freescale sales.
2. Factory programmable at 2.0 MHz or 4.0 Mhz. Contact Freescale sales for availability of the 4.0 MHz functionality.
3. The minimum input voltage must be higher than 2.8 V for 300 mA of load current.

INTERNAL BLOCK DIAGRAM

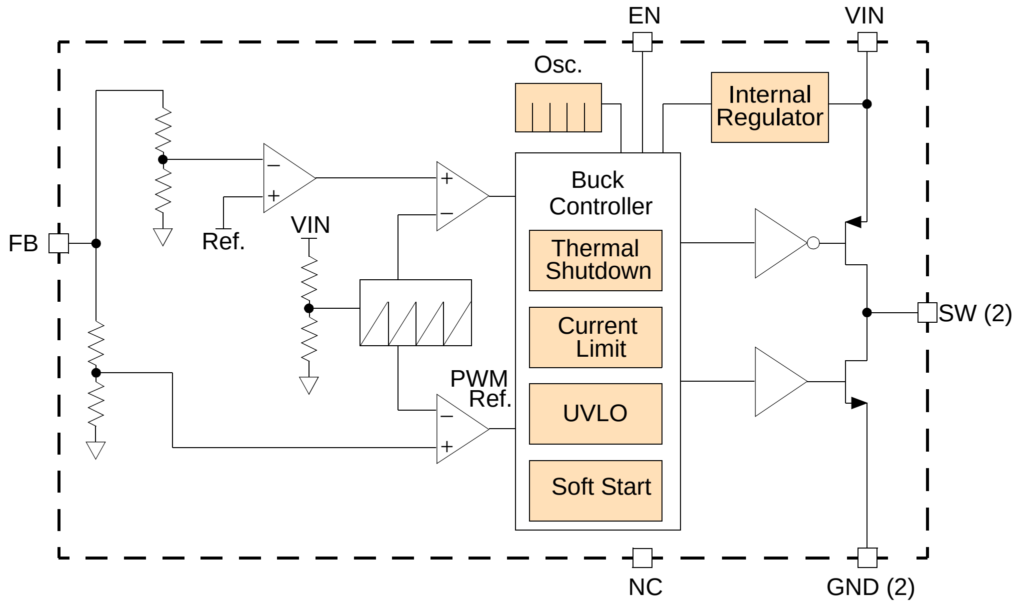
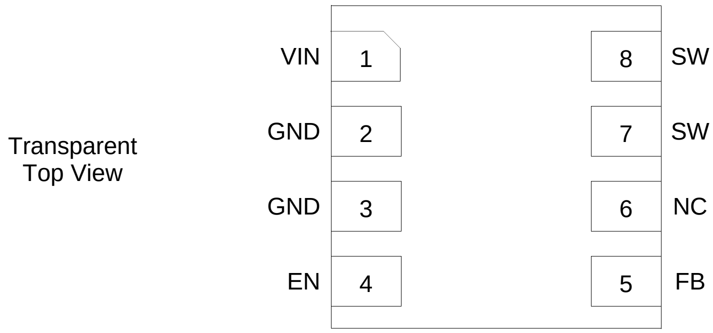


Figure 2. 34726 Simplified Internal Block Diagram

PIN CONNECTIONS



2x2 UDFN-8 (Non EP)

Figure 3. 34726 Pin Connections

Table 2. 34726 Pin Definitions

A functional description of each pin can be found in the Functional Pin Description section beginning on page 10.

Pin Number	Pin Name	Pin Function	Formal Name	Definition
1	VIN	Input	Supply Voltage Input	Power input
2	GND	Ground	Ground	Ground
3	GND	Ground	Ground	Low noise ground
4	EN	Input	Enable	Active high enable input
5	FB	Input	Feedback Input	Feedback of the output voltage
6	NC	N/A	No Connection	Internally not connected. Connect to GND externally
7	SW	Output	Switching Node	This terminal connects to the output inductor
8	SW	Output	Switching Node	This terminal connects to the output inductor

ELECTRICAL CHARACTERISTICS

MAXIMUM RATINGS

Table 3. Maximum Ratings

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Ratings	Symbol	Value	Unit
ELECTRICAL RATINGS			
All pins voltages	V_{IN}, V_{EN}, V_{FB}, V_{SW}	-0.3 to 6.0	V
ESD Voltage[1] Human Body Model (HBM) Machine Model (MM)	V_{ESD}	 ±2000 ±200	V
THERMAL RATINGS			
Operating Ambient Temperature Range	T_A	-25 to +85	°C
Storage Temperature Range	T_{STG}	-25 to +150	°C
Maximum Lead Temperature[2],[3]	T_{PPRT}	Note 3	°C
Junction Temperature Operating Junction Temperature Maximum Junction Temperature	T_J	 125 +150	°C
Thermal Resistance[4] Junction-to-Case Junction-to-Ambient	 $R_{\theta JC}$ $R_{\theta JA}$	 104 122	°C/W
Power Dissipation Continuous (Derate 3.0 mW/°C and over T_A = 70°C)	P_D	 0.5	W

Notes

1. ESD testing is performed in accordance with the Human Body Model (HBM) (C_{ZAP} = 100 pF, R_{ZAP} = 1500 Ω), and the Machine Model (MM) (C_{ZAP} = 200 pF, R_{ZAP} = 0 Ω).
2. Pin soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause malfunction or permanent damage to the device.
3. Freescale's Package Reflow capability meets Pb-free requirements for JEDEC standard J-STD-020C. For Peak Package Reflow Temperature and Moisture Sensitivity Levels (MSL). Go to www.freescale.com, search by part number [e.g. remove prefixes/suffixes and enter the core ID to view all orderable parts. (i.e. MC33xxxD enter 33xxx), and review parametrics.
4. Device mounted on the Freescale EVB test board per JEDEC DESD51-2.

STATIC ELECTRICAL CHARACTERISTICS

Table 4. Static Electrical Characteristics

Characteristics noted under conditions; 2.7 V ≤ V_{IN} ≤ 5.5 V, 0.8 V ≤ V_{OUT} ≤ 3.3 V, -25°C ≤ T_A ≤ 85°C, C_{IN} = C_{OUT} = 4.7 µF, L1 = 4.7 µH (See Figure 1), unless otherwise noted. The typical specifications are measured at the following conditions; T_A = +25°C, V_{IN} = 3.6 V, f_{SW} = 2.0 MHz with the typical operating circuit (See Figure 1), unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{IN}	2.7	-	5.5	V
Output Voltage (Factory preset)	V_{OUT}	0.8	-	3.3	V
Output Current	I_{OUT}	300	-	-	mA
Total Supply Current[(5)] Regulator disabled	I_{DIS}	- 	0.1	1.0	µA
Quiescent Current (Switching) Sleepy Z-mode and I_{LOAD} = 0 mA	I_Q	-	65	85	µA
Current Limit Current rising at high side	I_{PK}	-	450	-	mA
Output Voltage Accuracy (% of output voltage) Overload and temperature	ΔV_{OUT}	-3%	-	3%	V_{OUT}
UVLO Threshold[(6)] V_{IN}: 2.7 -5.5 V V_{IN} rising V_{IN} falling	V_{UVLO}	 - 2.5	 - -	 2.7 -	V
Enable Voltage Regulator operating Regulator shutdown	V_{EN}	 1.6 -	 - -	 - 0.4	V
High Side Power MOSFET On Resistance V_{IN} = 3.6 V, V_{OUT} = 1.8 V, T_A = 40°C, I_{LOAD} = 150 mA	$R_{DS(ON)H}$	-	250	-	mΩ
Low Side Power MOSFET On Resistance V_{IN} = 3.6 V, V_{OUT} = 1.8 V, T_A = 40°C, I_{LOAD} = 150 mA	$R_{DS(ON)L}$	-	350	-	mΩ
Load Regulation 1.0 mA < I_{LOAD} < 300 mA and V_{OUT} = 1.8 V	$\Delta V_{OUT}/\Delta I_{OUT}$	-	0.5	-	%
Line Regulation V_{IN} = 2.7 to 5.5 V	$\Delta V_{OUT}/\Delta V_{IN}$	-	0.5	-	%
Start-up Overshoot (% of output voltage) I_{LOAD} = 0 mA, V_{OUT} = 1.8 V and C_{OUT} = 4.7 µF	V_{STO}	-	3%	-	V_{OUT}
Thermal Shutdown Threshold (Junction Temperature)	T_{STDN}	-	140	-	°C
Thermal Shutdown Hysteresis (Junction Temperature)	T_{HYSTR}	-	10	-	°C

Notes

5. Maximum I_{DIS} measured at V_{IN} = 3.6 V and T_A = 25°C.
6. For a product with a V_{OUT} of 3.3 V and a V_{IN} minimum less than 3.6 V, the V_{OUT} value will track (drop below 3.3 V) V_{IN} down to a value of 2.5 V, where the UVLO shutdown mechanism will activate.

DYNAMIC ELECTRICAL CHARACTERISTICS

Table 5. Dynamic Electrical Characteristics

Characteristics noted under conditions; 2.7 V ≤ V_{IN} ≤5.5 V, 0.8 V ≤ V_{OUT} ≤3.3 V, -20°C ≤ T_A ≤ 85°C, C_{IN} = C_{OUT} = 4.7 µF, L1 = 4.7 µH (See Figure 1), unless otherwise noted. The typical specifications are measured at the following conditions; T_A = +25°C, V_{IN} = 3.6 V, f_{SW} = 2.0 MHz with the typical operating circuit (See Figure 1), unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
Switching Frequency[7]	f_{SW}	1.8	2.0	2.2	MHz
Maximum Duty Cycle[8] Measured from SW pin	D_{MAX}	95	-	100	%
Internal Soft-start Timer V_{OUT} Rise Time	t_S	-	2.0	-	ms

Notes

7. f_{SW} can be factory programmed to ±20% of nominal 2.0 MHz.
8. The maximum duty limits the range of output voltages achievable for a given input voltage.

ELECTRICAL PERFORMANCE CURVES

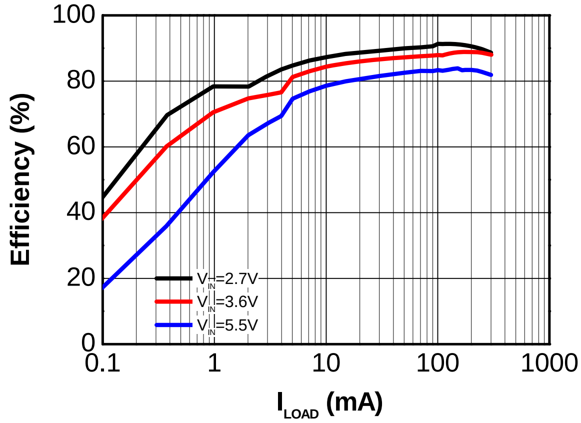


Figure 4. Efficiency vs. Load Current
V_{IN} = 3.6 V, V_{OUT} = 1.8 V, T_A=25°C

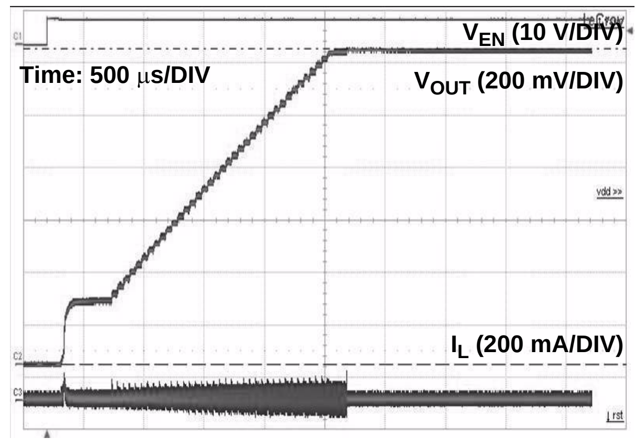


Figure 7. Start-up Response
I_{LOAD} = 0 mA, V_{OUT}=1.2 V

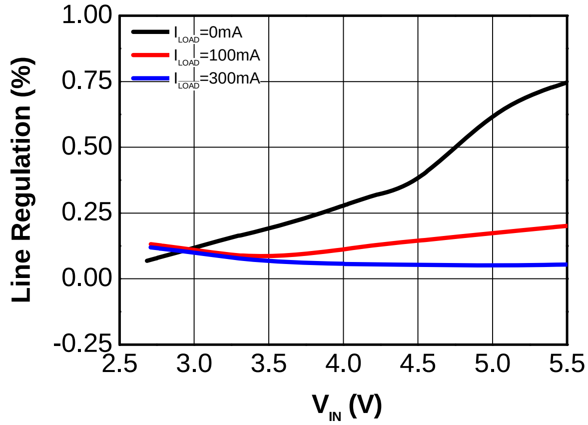


Figure 5. Line Regulation
V_{IN} is 2.7 V to 5.5 V and V_{OUT} is 1.8 V, T_A=25°C

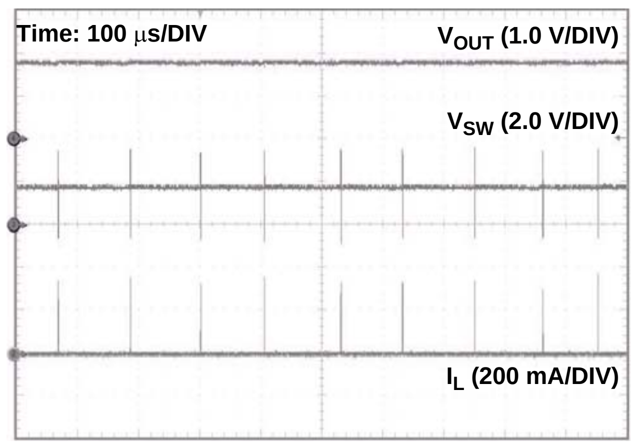


Figure 8. Sleepy Z-Mode™ Switching Waveforms
V_{IN} = 3.6 V, V_{OUT} = 1.8 V and I_{LOAD} = 1.0 mA

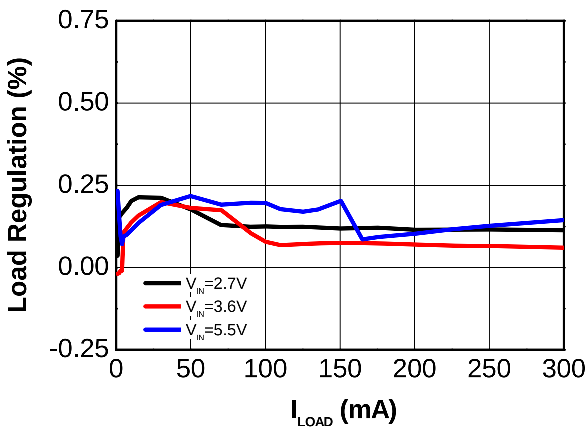


Figure 6. Load Regulation
1.0 mA < I_{LOAD} < 300 mA, V_{OUT} = 1.8 V

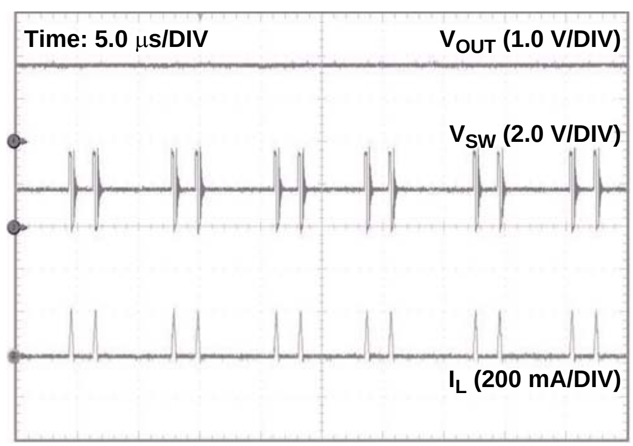


Figure 9. Z-Mode™ Switching Waveforms
V_{IN} = 3.6 V, V_{OUT} = 1.8 V and I_{LOAD} = 10 mA

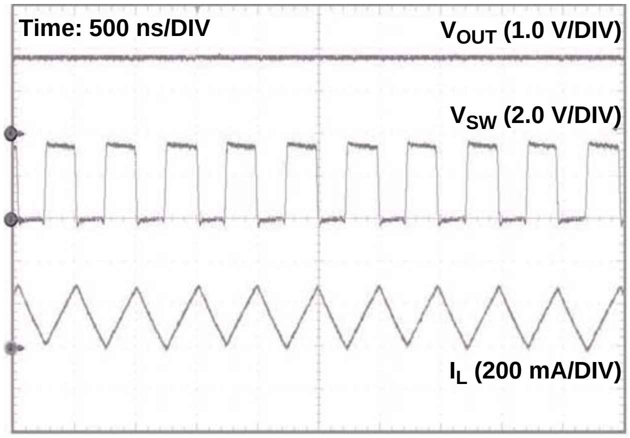


Figure 10. CCM Switching Waveforms
V_{IN} = 3.6 V, V_{OUT} = 1.8 V and I_{LOAD} = 150 mA

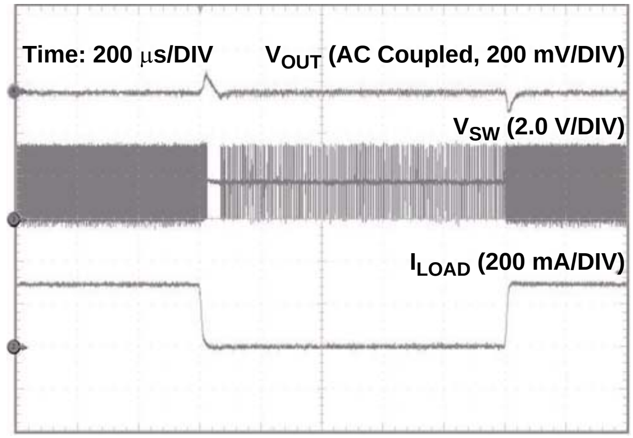


Figure 12. Load Transient in Z-Mode™
V_{IN} = 3.6 V, I_{LOAD} =10 to 300 mA

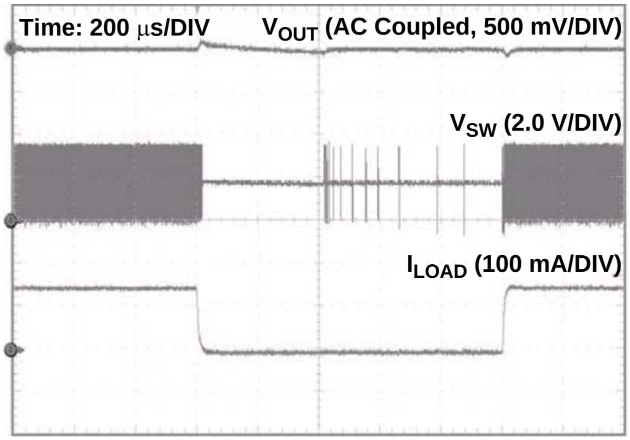


Figure 11. Load Transient in Sleepy Z-Mode™
V_{IN} = 3.6 V, I_{LOAD} =1.0 to 150 mA

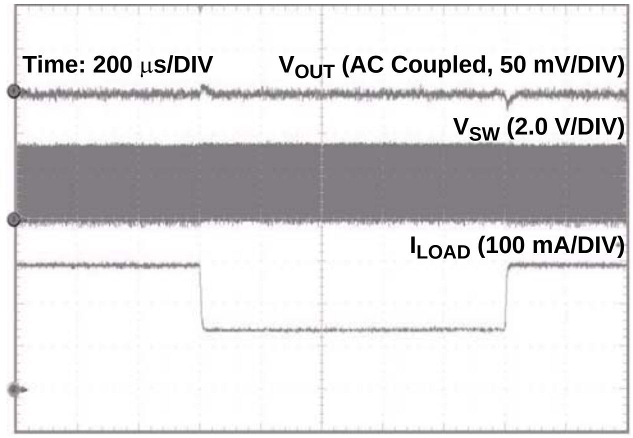


Figure 13. Load Transient in CCM
V_{IN} = 3.6 V, I_{LOAD} = 150 to 300 mA

FUNCTIONAL DESCRIPTION

INTRODUCTION

The 34726 is a high efficiency, synchronous, buck regulator, utilizing a voltage mode control architecture with feed forward. It is capable of providing a 300 mA load current for output voltages of 0.8 to 3.3 V, from a single input voltage rail between 2.7 and 5.5 V.

In a buck converter, most of the losses at high output loads are due to conduction losses in the power train, but at light output loads, the conduction losses are reduced and most of the losses become switching losses. Using Freescale's Z-mode architecture, the 34726, at light output loads, will smoothly transition into a lower switching frequency, thus improving its efficiency.

FUNCTIONAL PIN DESCRIPTION

SUPPLY VOLTAGE INPUT (VIN)

2.7 to 5.5 V DC power input. Bypass with a 4.7 μF ceramic capacitor as close as possible to the VIN and GND pins.

GROUND (GND)

Ground.

ENABLE (EN)

Active high enable input. EN is over-voltage protected to 6.0 V, independent of the supply voltage. Drive with a logic high signal (or connect to VIN) for normal operation. Drive with a logic low signal, or connect to GND will disable the 34726.

FEEDBACK INPUT (FB)

Feedback of the output voltage.

SWITCHING NODE (SW)

This terminal connects to the output inductor. The node internally connects the drain of both high side MOSFET and low side MOSFET.

NO CONNECTION (NC)

Internally not connected. Connect to GND externally.

FUNCTIONAL INTERNAL BLOCK DESCRIPTION

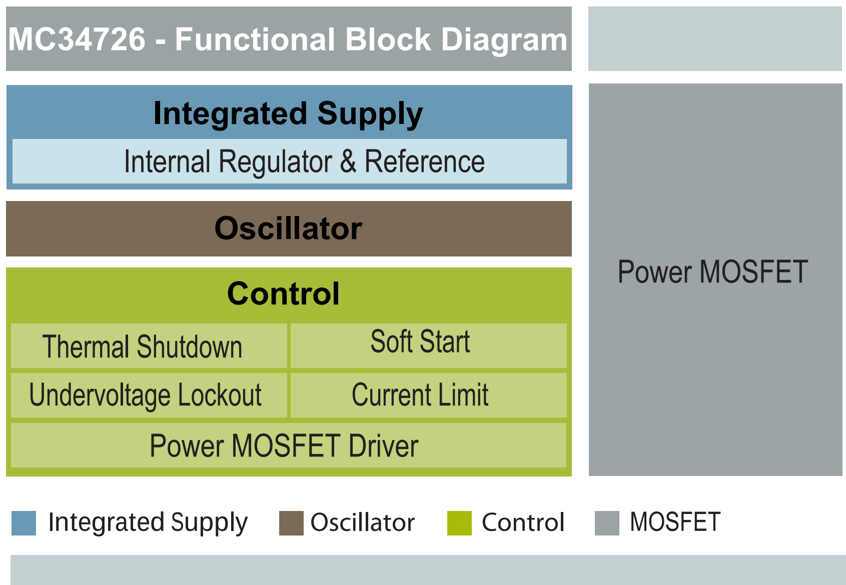


Figure 14. 34726 Functional Internal Block Diagram

INTEGRATED SUPPLY

INTERNAL REGULATOR AND REFERENCE

The internal regulator and reference block steps down the high input voltage to lower voltage to power all the internal blocks, and provides the reference voltage for the other internal blocks.

OSCILLATOR

The oscillator block provides 2.0 MHz clock signal to the controller.

CONTROLLER

THERMAL SHUTDOWN

The thermal shutdown block monitors the die temperature. Once the die temperature reaches its threshold, this block turns off the device to prevent the further die temperature rise.

SOFT-START

The soft-start block controls the output voltage ramp after the device is enabled, to limit the in-rush current. The start-up time is internally set to approximately 2.0 ms, and is independent of input voltage, output voltage, or load current. The soft-start sequence also occurs upon recovery from any fault condition.

UVLO

The UVLO block monitors the input voltage. Once the input voltage is lower than the falling threshold voltage, this block turns off the device, to avoid unpredictable circuit behavior.

CURRENT LIMIT

The current limit block monitors the inductor current. When the peak inductor current reaches its current limit, this block turns off the high side MOSFET, to prevent the device and external components from damage.

POWER-MOSFET DRIVER

The power-MOSFET-driver block controls the phase of the diver signals and enhances the drive capability of these.

POWER-MOSFET

The power-MOSFET block contains two power MOSFETs. One is a PMOS that passes the current from the input to the output, and the other one is an NMOS that provides the inductor current loop when PMOS is turned off.

FUNCTIONAL DEVICE OPERATION

OPERATIONAL MODES

Z-MODE OPERATION

The 34726 operates as a typical fixed frequency, PWM regulator, at moderate to heavy load currents. As the load is decreased, such that operation transitions from continuous conduction mode (CCM) to discontinuous conduction mode (DCM), the duty cycle is reduced until it approaches 85% of the full load duty cycle. At this point the 34726 transitions into Z-mode operation, where the Z-mode Factor is 0.85. In Z-mode, the regulator skips pulses whenever the duty cycle is below 85% of the CCM duty cycle. As the load decreases, this pulse skipping reduces the switching frequency and the switching losses thus improving efficiency. For example, if a light load demanded a 30% duty cycle at 2.0 MHz, with Z-mode this same load will require only $(0.3/0.85)^2$ x 2.0 MHz = 0.249 MHz switching frequency, hence switching losses will be reduced by almost ten fold. Figure 15 illustrates the transition to and the exit from Z-mode.

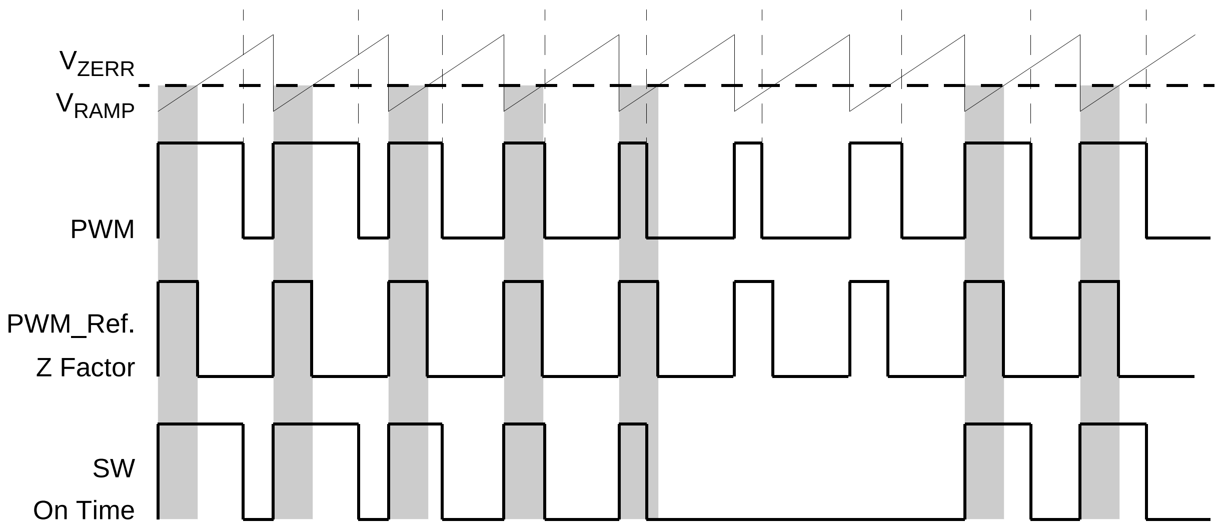


Figure 15. Z-mode Operation

SLEEPY Z-MODE OPERATION

To improve low current efficiency, the 34726 transitions into the Sleepy Z-mode at load currents of approximately 1.0 mA and lower. This is accomplished by powering down internal circuit blocks to lower the device's quiescent current. Additionally, the oscillator frequency drops to 250 kHz and the low side switch is turned off to emulate the operation of an asynchronous buck converter.

DETAILED FUNCTIONAL DEVICE OPERATION

OVER-CURRENT PROTECTION

The 34726 implements two layers of protection during overload conditions. The first is a current limit feature to prevent the device and external components from damage. When the peak inductor current reaches the over-current limit, nominally 450 mA, the high side MOSFET turns off to provide cycle by cycle protection. If the over-current condition persists and the die temperature surpasses the over-temperature protection (OTP) threshold, this second layer of protection shuts down the device.

SHORT-CIRCUIT PROTECTION

When a short-circuit condition occurs on the output, typical regulators will tend to operate at maximum duty cycle. This condition can saturate the inductor and produce severe peak currents, resulting in damage to the device. The 34726 avoids this scenario by detecting output voltages below 0.5 V. Upon detection, the part re-starts continuously until the short circuit condition is removed, or the part surpasses its OTP threshold.

OVER-TEMPERATURE PROTECTION

To limit its operating temperature, the 34726 shuts down if the junction temperature of the switching MOSFET surpasses 140°C. If the junction temperature subsequently drops to 130°C, the 34726 restarts.

SOFT-START OPERATION

To limit the in-rush current, an internal timer controls the output voltage ramp after the part is enabled. The start-up time is internally set to approximately 2.0 ms and is independent of input voltage, output voltage, or load current. The soft-start sequence also occurs upon recovery from any fault condition.

UNDER-VOLTAGE LOCK-OUT

The UVLO threshold is set to 2.7 V for rising V_{IN}, and to 2.5 V for falling V_{IN}. For a V_{OUT} of 3.3 V or 2.5 V, the V_{OUT} value will track V_{IN} below 3.6 V or 2.8 V until the 2.5 V falling V_{IN} threshold is reached.

If the UVLO falling threshold is met, the part shuts down and will power-up again with soft-start, when the UVLO rising threshold is surpassed.

TYPICAL APPLICATIONS

APPLICATION INFORMATION

INPUT CAPACITOR

The input capacitor is used to minimize the input voltage transient that may cause instability when the load transient current is high. Typically a 4.7 μF X5R ceramic capacitor is sufficient for most applications.

OUTPUT CAPACITOR

For stable operation and low output voltage ripple, an X5R ceramic capacitor of 4.7 μF minimum value is needed. Depending on the load transient current, a larger capacitance may be required.

INDUCTOR SELECTION

A 4.7 μH low DC resistance inductor is typically used for the 34726 to guarantee the system stable operation.

TYPICAL APPLICATIONS

1.2 V OUTPUT DC/DC CONVERTOR

Figure 16 shows a typical application using 34726A. CIN and COUT are typically 4.7 μF/X5R ceramic capacitors. L1 is typically a 4.7 μH low DC resistance inductor. The FB connects to the output directly for monitoring the output voltage. Normally, the EN pin connects to the input supply directly to enable the regulator.

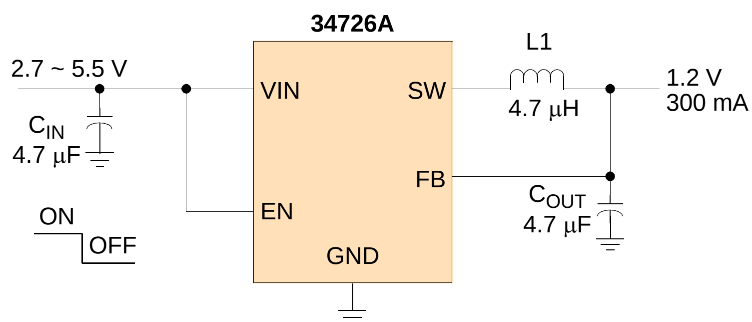
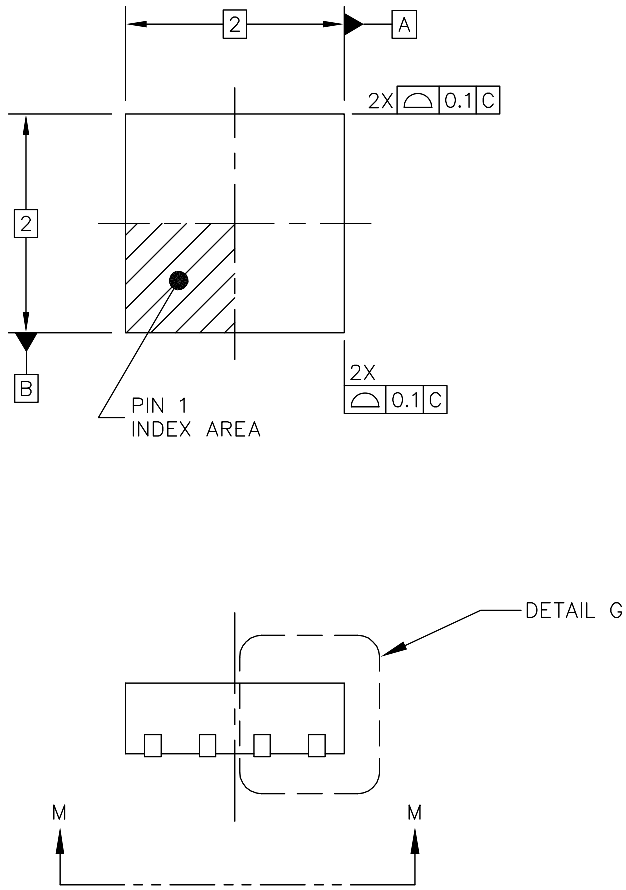


Figure 16. 1.2 V/300 mA DC/DC Convertor

PACKAGE DIMENSIONS

For the most current package revision, visit **www.freescale.com** and perform a keyword search using the “98A” listed below.



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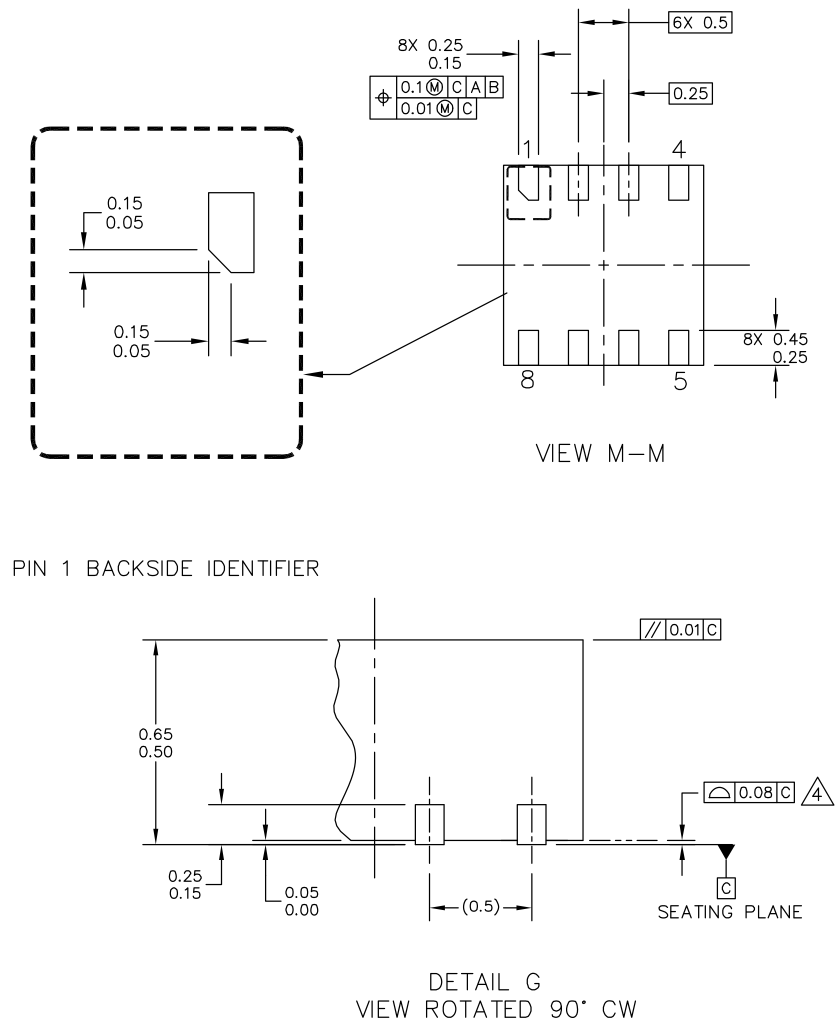
	STANDARD: NON−JEDEC	

FC SUFFIX
12-PIN
98ASA10787D
REVISION A



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	CASE NUMBER: 1944–02	10 DEC 2007
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FC SUFFIX
12-PIN
98ASA10787D
REVISION A

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
3. THE COMPLETE JEDEC DESIGNATOR FOR THIS PACKAGE IS UF–PSON.
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	STANDARD: NON–JEDEC	

FC SUFFIX
12-PIN
98ASA10787D
REVISION A

REVISION HISTORY

REVISION	DATE	DESCRIPTION OF CHANGES
1.0	5/2008	• Initial Release
2.0	9/2009	• Minor adjustments to the Ordering information and Device Variations • Updated to match the current Freescale format and style.
	1/2014	• Added archive information

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