1 Amp/1.5 Amp/2 Amp Synchronous, Step-Down DC-to-DC Converters

ADP2105/ADP2106/ADP2107

FEATURES

- Extremely high 97% efficiency
- Ultralow quiescent current: 20 µA
- 1.2 MHz switching frequency
- 0.1 µA shutdown supply current
- Maximum load current:
  - ADP2105: 1 A
  - ADP2106: 1.5 A
  - ADP2107: 2 A
- Input voltage: 2.7 V to 5.5 V
- Output voltage: 0.8 V to V_{IN}
- Maximum duty cycle: 100%
- Smoothly transitions into low dropout (LDO) mode
- Internal synchronous rectifier
- Small 16-lead 4 mm × 4 mm LFCSP_VQ package
- Optimized for small ceramic output capacitors
- Enable/Shutdown logic input
- Undervoltage lockout
- Soft start

APPLICATIONS

- Mobile handsets
- PDAs and palmtop computers
- Telecommunication/Networking equipment
- Set top boxes
- Audio/Video consumer electronics

GENERAL DESCRIPTION

The ADP2105/ADP2106/ADP2107 are low quiescent current, synchronous, step-down dc-to-dc converters in a compact 4 mm × 4 mm LFCSP_VQ package. At medium-to-high load currents, these devices use a current-mode, constant-frequency pulse width modulation (PWM) control scheme for excellent stability and transient response. To ensure the longest battery life in portable applications, the ADP2105/ADP2106/ADP2107 use a pulse frequency modulation (PFM) control scheme under light load conditions that reduces switching frequency to save power.

The ADP2105/ADP2106/ADP2107 run from input voltages of 2.7 V to 5.5 V, allowing single Li+/Li− polymer cell, multiple alkaline/NiMH cells, PCMCIA, and other standard power sources. The output voltage of ADP2105/ADP2106/ADP2107-ADJ is adjustable from 0.8 V to the input voltage, while the ADP2105/ADP2106/ADP2107-xx are available in preset output voltage options of 3.3 V, 1.8 V, 1.5 V, and 1.2 V. Each of these variations is available in three maximum current levels, 1 A (ADP2105), 1.5 A (ADP2106), and 2 A (ADP2107). The power switch and synchronous rectifier are integrated for minimal external part count and high efficiency. During logic-controlled shutdown, the input is disconnected from the output, and it draws less than 0.1 µA from the input source. Other key features include undervoltage lockout to prevent deep-battery discharge and programmable soft start to limit inrush current at startup.

TYPICAL PERFORMANCE CHARACTERISTICS

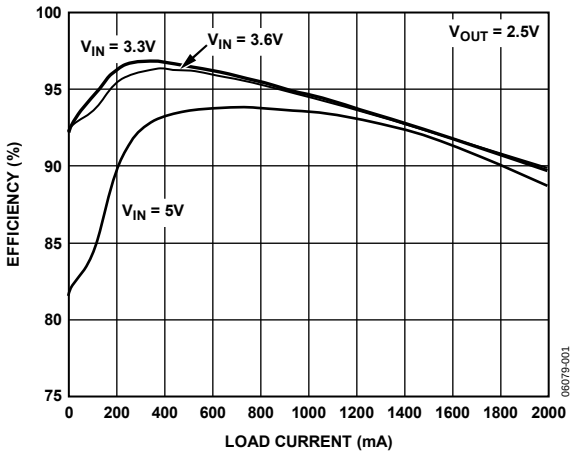

Figure 1. Efficiency vs. Load Current for the ADP2107 with V_{OUT} = 2.5 V

TYPICAL OPERATING CIRCUIT

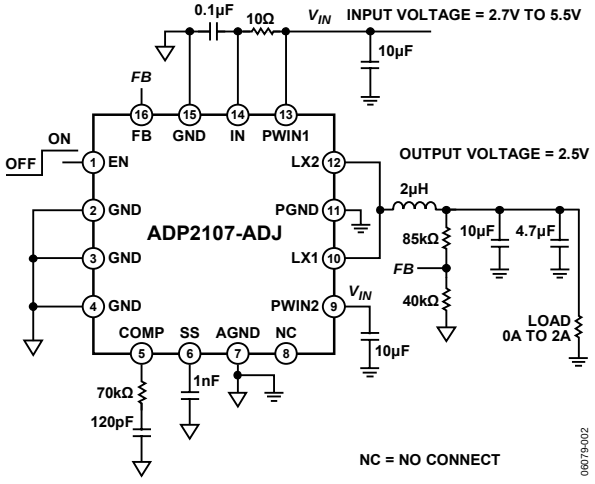

Figure 2. Circuit Configuration of ADP2107 with V_{OUT} = 2.5 V

Rev. 0

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
Fax: 781.461.3113

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REVISION HISTORY

7/06—Revision 0: Initial Version

SPECIFICATIONS

V_{IN} = 3.6 V @ T_A = 25°C, unless otherwise noted.[1] Bold values indicate −40°C ≤ T_J ≤ +125°C.

Table 1.

Parameter	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS					
Input Voltage Range		**2.7**		**5.5**	V
Undervoltage Lockout Threshold	V_{IN} rising	**2.2**	2.4	**2.6**	V
	V_{IN} falling	**2.0**	2.2	**2.5**	V
Undervoltage Lockout Hysteresis[2]			200		mV
OUTPUT CHARACTERISTICS					
Output Regulation Voltage	ADP210x-3.3, load = 10 mA	3.267	3.3	3.333	V
	ADP210x-3.3, V_{IN} = 3.5 V to 5.5 V, no load to full load	**3.201**	3.3	**3.399**	V
	ADP210x-1.8, load = 10 mA	1.782	1.8	1.818	V
	ADP210x-1.8, V_{IN} = 2.7 V to 5.5 V, no load to full load	**1.746**	1.8	**1.854**	V
	ADP210x-1.5, load = 10 mA	1.485	1.5	1.515	V
	ADP210x-1.5, V_{IN} = 2.7 V to 5.5 V, no load to full load	**1.455**	1.5	**1.545**	V
	ADP210x-1.2, load = 10 mA	1.188	1.2	1.212	V
	ADP210x-1.2, V_{IN} = 2.7 V to 5.5 V, no load to full load	**1.164**	1.2	**1.236**	V
Load Regulation	ADP2105		0.4		%/A
	ADP2106		0.5		%/A
	ADP2107		0.6		%/A
Line Regulation[3]	Measured in servo loop		0.1	0.3	%/V
Output Voltage Range	ADP210x-ADJ	0.8		V_{IN}	V
FEEDBACK CHARACTERISTICS					
OUT_SENSE Bias Current	ADP210x-1.2		3	**6**	µA
	ADP210x-1.5		4	**8**	µA
	ADP210x-1.8		5	**10**	µA
	ADP210x-3.3		10	**20**	µA
FB Regulation Voltage	ADP210x-ADJ	**0.784**	0.8	**0.816**	V
FB Bias Current	ADP210x-ADJ	**−0.1**		**+0.1**	µA
INPUT CURRENT CHARACTERISTICS					
IN Operating Current	ADP210x-ADJ, V_{FB} = 0.9 V		20	**30**	µA
	ADP210x-xx, output voltage 10% above regulation voltage		20	**30**	µA
IN Shutdown Current	V_{EN} = 0 V		0.1	1[5]	µA
LX (SWITCH NODE) CHARACTERISTICS					
LX On Resistance[4]	P-channel switch		100	**165**	mΩ
	N-channel synchronous rectifier		90	**140**	mΩ
LX Leakage Current[4]	V_{IN} = 5.5 V, V_{LX} = 0 V, 5.5 V		0.1	1[5]	µA
LX Peak Current Limit[4]	P-channel switch, ADP2107	**2.6**	2.9	**3.3**	A
	P-channel switch, ADP2106	**2.0**	2.25	**2.6**	A
	P-channel switch, ADP2105	**1.3**	1.5	**1.8**	A
LX Minimum On-Time[4]	In PWM mode of operation, V_{IN} = 5.5 V			**100**	ns
ENABLE CHARACTERISTICS					
EN Input High Voltage	V_{IN} = 2.7 V to 5.5 V	**2**			V
EN Input Low Voltage	V_{IN} = 2.7 V to 5.5 V			**0.4**	V
EN Input Leakage Current	V_{IN} = 5.5 V, V_{EN} = 0 V, 5.5 V	**−1**	−0.1	**+1**	µA
OSCILLATOR FREQUENCY	V_{IN} = 2.7 V to 5.5 V	**1**	1.2	**1.4**	MHz
SOFT START PERIOD	C_{SS} = 1 nF	750	1000	1200	µs

Parameter	Conditions	Min	Typ	Max	Unit
THERMAL CHARACTERISTICS					
Thermal Shutdown Threshold			140		°C
Thermal Shutdown Hysteresis			40		°C
COMPENSATOR TRANSCONDUCTANCE (G_m)			50		µA/V
CURRENT SENSE AMPLIFIER GAIN (G_{CS})[2]	ADP2105		1.875		A/V
	ADP2106		2.8125		A/V
	ADP2107		3.625		A/V

[1] All limits at temperature extremes are guaranteed via correlation using standard statistical quality control (SQC). Typical values are at T_A = 25°C.
[2] Guaranteed by design.
[3] The ADP2015/ADP2106/ADP2107 line regulation was measured in a servo loop on the ATE that adjusts the feedback voltage to achieve a specific comp voltage.
[4] All LX (switch node) characteristics are guaranteed only when the LX1 and LX2 pins are tied together.
[5] These specifications are guaranteed from −40°C to +85°C.

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Rating
IN, EN, SS, COMP, OUT_SENSE/FB to AGND	−0.3 V to +6 V
LX1, LX2 to PGND	−0.3 V to (V_{IN} + 0.3 V)
PWIN1, PWIN2 to PGND	−0.3 V to +6 V
PGND to AGND	−0.3 V to +0.3 V
GND to AGND	−0.3 V to +0.3 V
PWIN1, PWIN2 to IN	−0.3 V to +0.3 V
Operating Junction Temperature Range	−40°C to +125°C
Storage Temperature Range	−65°C to +150°C
Soldering Conditions	JEDEC J-STD-020

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Table 3. Thermal Resistance

Package Type	θ_{JA}[1]	Unit
16-Lead LFCSP_VQ/QFN	40	°C/W
Maximum Power Dissipation	1	W

[1] θ_{JA} is specified for the worst-case conditions; that is, θ_{JA} is specified for device soldered in circuit board for surface mount packages.

BOUNDARY CONDITION

Natural convection, 4-layer board, exposed pad soldered to the PCB.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

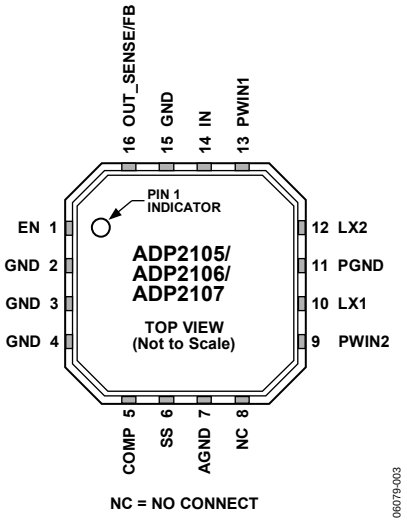


Figure 3. Pin Configuration

Table 4. Pin Function Descriptions

	Mnemonic		
Pin No.	**ADP210x-xx**	**ADP210x-ADJ**	**Description**
1	EN	EN	Enable Input. Drive EN high to turn on the ADP2105/ADP2106/ADP2107. Drive EN low to turn it off and reduce the input current to 0.1 μA.
2, 3, 4, 15	GND	GND	Test Pins. These pins are used by Analog Devices, Inc. for internal testing and are not ground return pins. Tie these pins to the AGND plane as close to the ADP2105/ADP2106/ADP2107 as possible.
5	COMP	COMP	Feedback Loop Compensation Node. COMP is the output of the internal transconductance error amplifier. Place a series RC network from COMP to AGND to compensate the converter. See the Loop Compensation section.
6	SS	SS	Soft Start Input. Place a capacitor from SS to AGND to set the soft start period. A 1 nF capacitor sets a 1 ms soft start period.
7	AGND	AGND	Analog Ground. Connect the ground of the compensation components, soft start capacitor, and the voltage divider on the FB pin to the AGND pin as close as possible to the ADP2105/ADP2106/ADP2107. Also connect AGND to the exposed pad of ADP2105/ADP2106/ADP2107.
8	NC	NC	No Connect. Not internally connected. Can be connected to other pins or left unconnected.
9, 13	PWIN2, PWIN1	PWIN2, PWIN1	Power Source Inputs. The source of the PFET high-side switch. Bypass each PWIN pin to the nearest PGND plane with a 4.7 μF or greater capacitor as close as possible to the ADP2105/ADP2106/ADP2107. See the Input Capacitor Selection section.
10, 12	LX1, LX2	LX1, LX2	Switch Outputs. The drain of the P-channel power switch and N-channel synchronous rectifier. Tie the two LX pins together and connect the output LC filter between LX and the output voltage.
11	PGND	PGND	Power Ground. Connect the ground return of all input and output capacitors to PGND pin, using a power ground plane as close as possible to the ADP2105/ADP2106/ADP2107. Also connect PGND to the exposed pad of the ADP2105/ADP2106/ADP2107.
14	IN	IN	ADP2105/ADP2106/ADP2107 Power Input. The power source for the ADP2105/ADP2106/ADP2107 internal circuitry. Connect IN and PWIN1 with a 10 Ω resistor as close as possible to the ADP2105/ADP2106/ADP2107. Bypass IN to AGND with a 0.1 μF or greater capacitor. See the Input Filter section.
16	OUT_SENSE	FB	Output Voltage Sense or Feedback Input. For fixed output versions, connect OUT_SENSE to the output voltage. For adjustable versions, FB is the input to the error amplifier. Drive FB through a resistive voltage divider to set the output voltage. The FB regulation voltage is 0.8 V.

TYPICAL PERFORMANCE CHARACTERISTICS

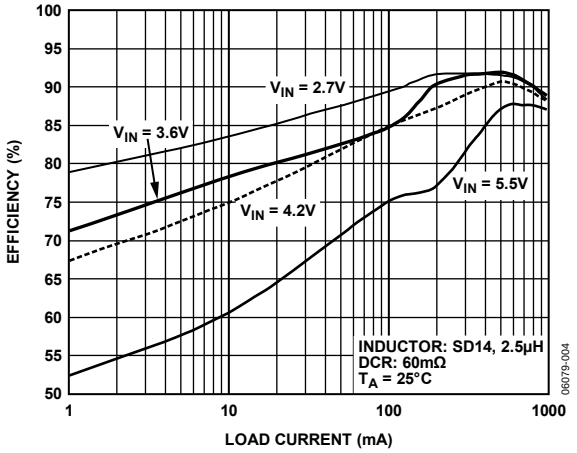


Figure 4. Efficiency—ADP2105 (1.2 V Output)

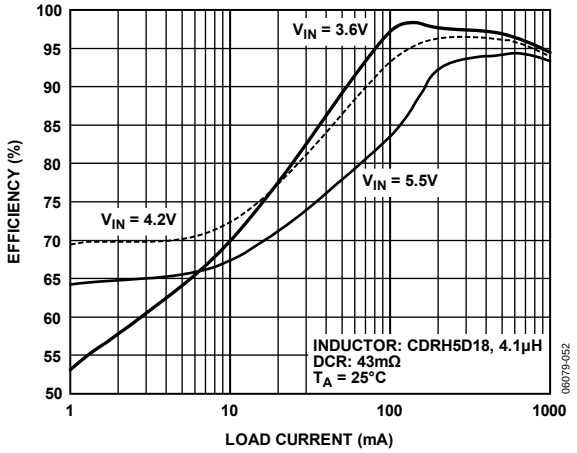


Figure 5. Efficiency—ADP2105 (3.3 V Output)

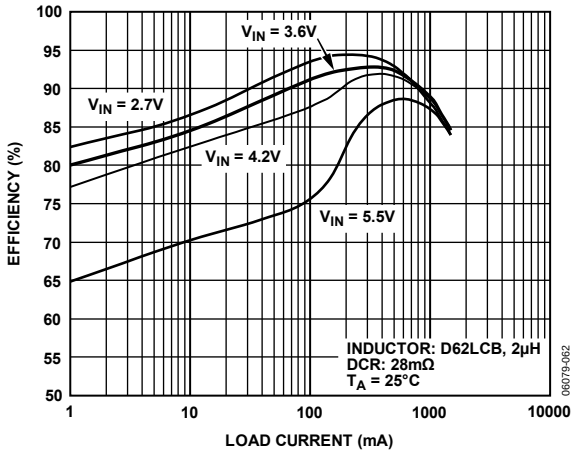


Figure 6. Efficiency—ADP2106 (1.8 V Output)

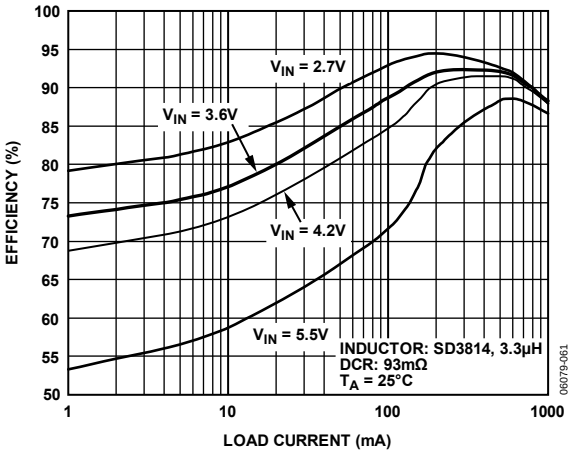


Figure 7. Efficiency—ADP2105 (1.8 V Output)

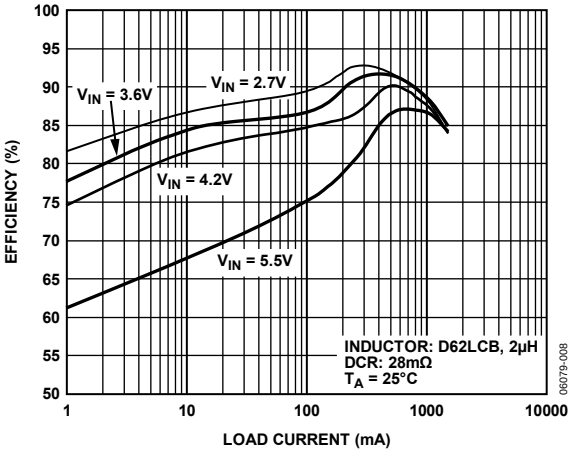


Figure 8. Efficiency—ADP2106 (1.2 V Output)

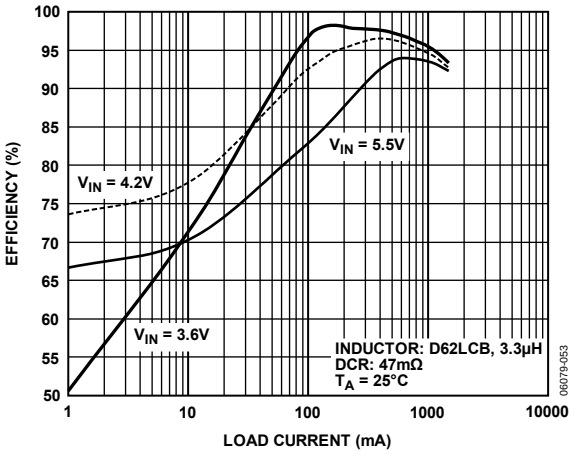


Figure 9. Efficiency—ADP2106 (3.3 V Output)

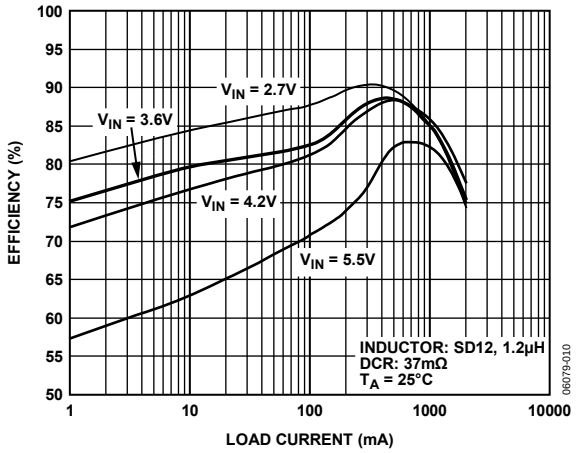


Figure 10. Efficiency—ADP2107 (1.2 V)

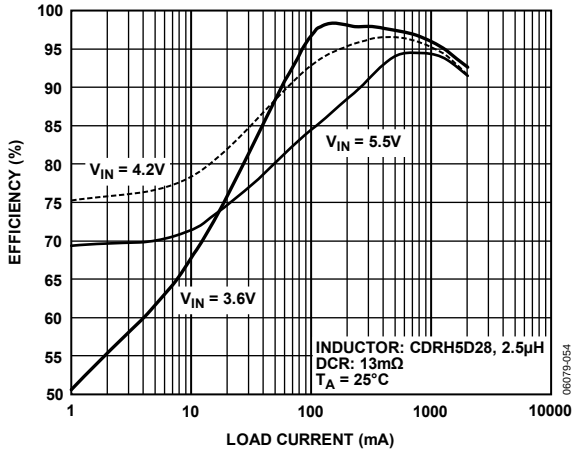


Figure 11. Efficiency—ADP2107 (3.3 V)

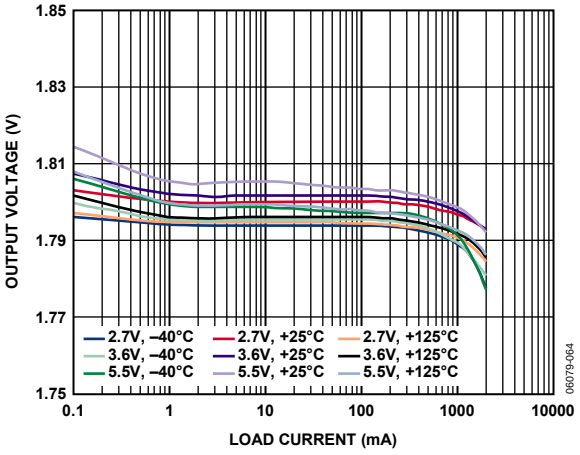


Figure 12. Output Voltage Accuracy—ADP2107 (1.8 V)

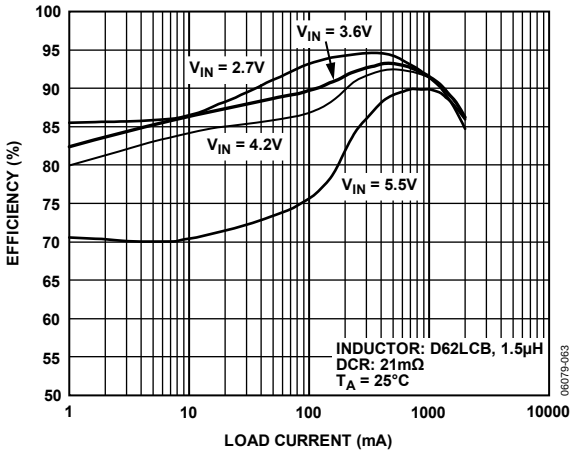


Figure 13. Efficiency—ADP2107 (1.8 V)

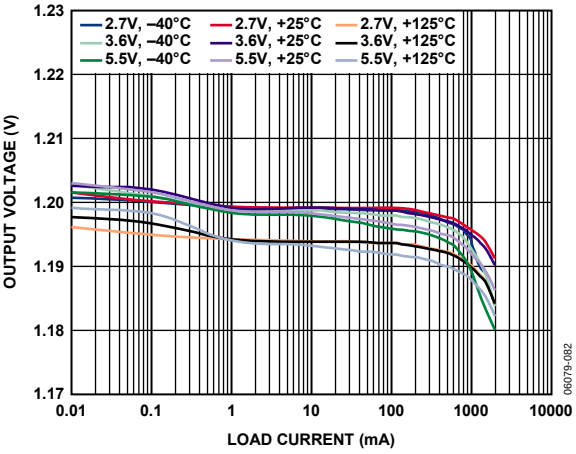


Figure 14. Output Voltage Accuracy—ADP2107 (1.2 V)

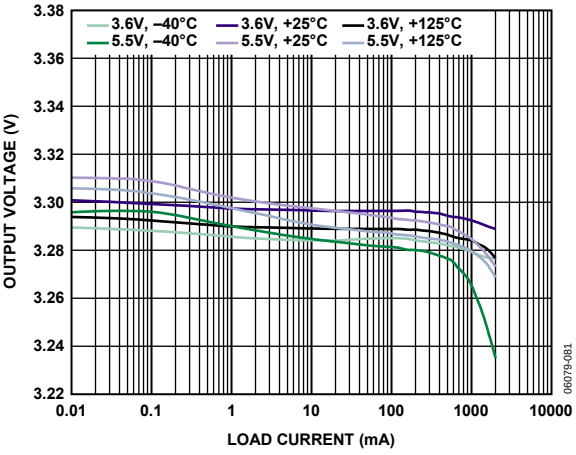


Figure 15. Output Voltage Accuracy—ADP2107 (3.3 V)

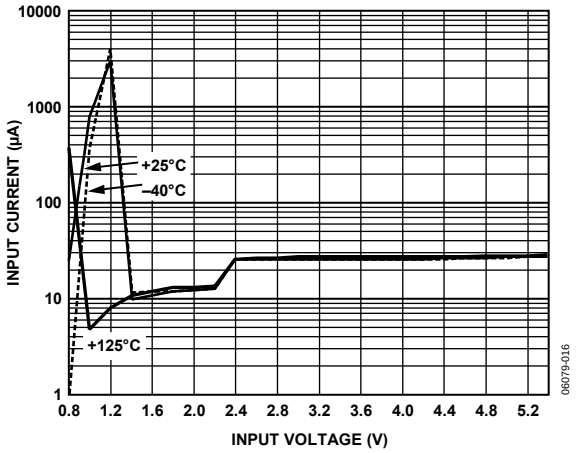


Figure 16. Quiescent Current vs. Input Voltage

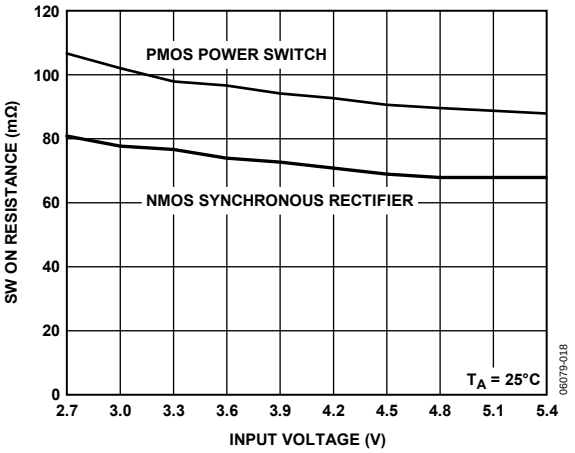


Figure 19. Switch On Resistance vs. Input Voltage

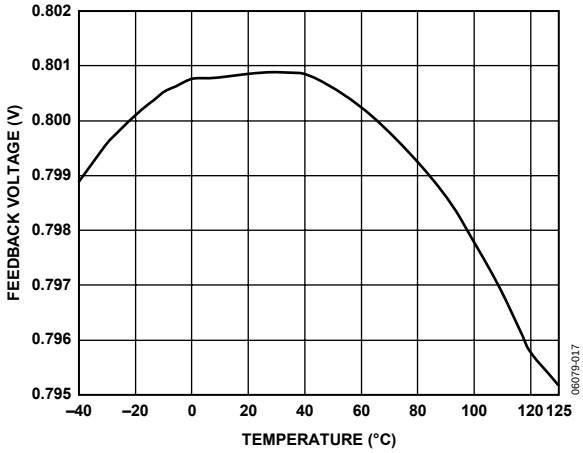


Figure 17. Feedback Voltage vs. Temperature

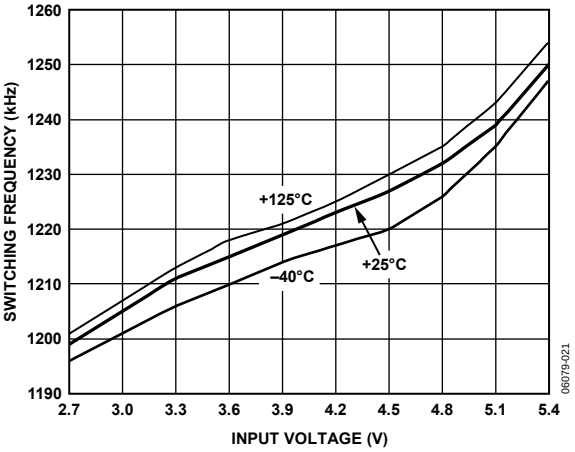


Figure 20. Switching Frequency vs. Input Voltage

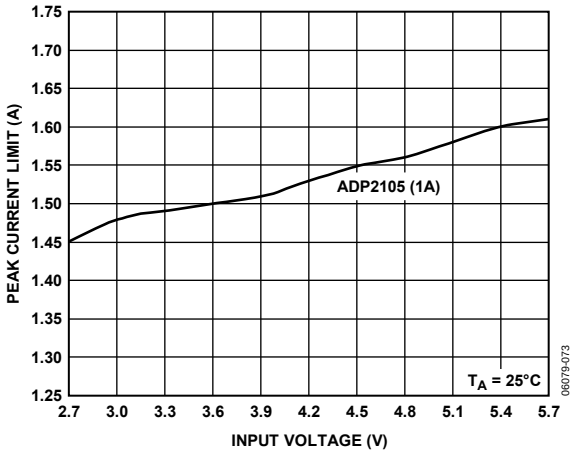


Figure 18. Peak Current Limit of ADP2105

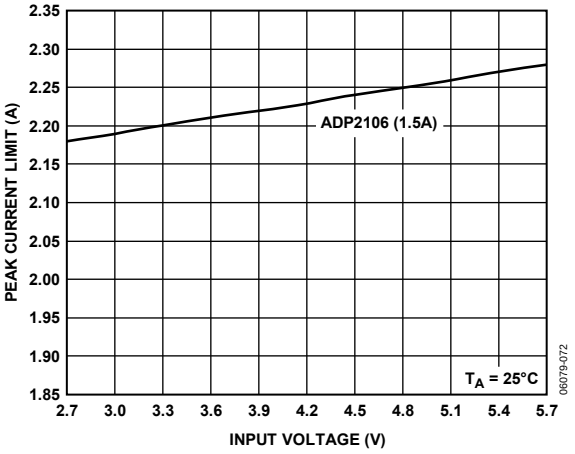


Figure 21. Peak Current Limit of ADP2106

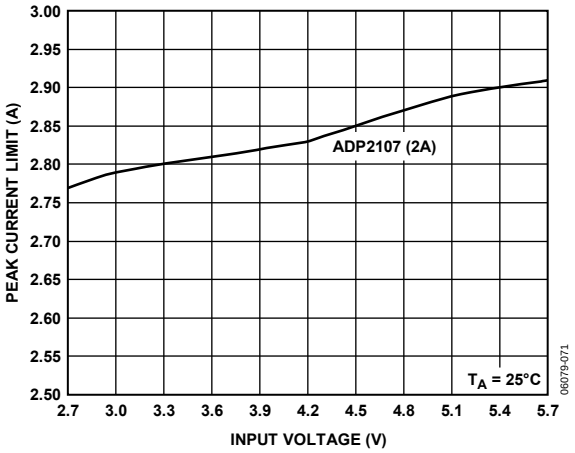


Figure 22. Peak Current Limit of ADP2107

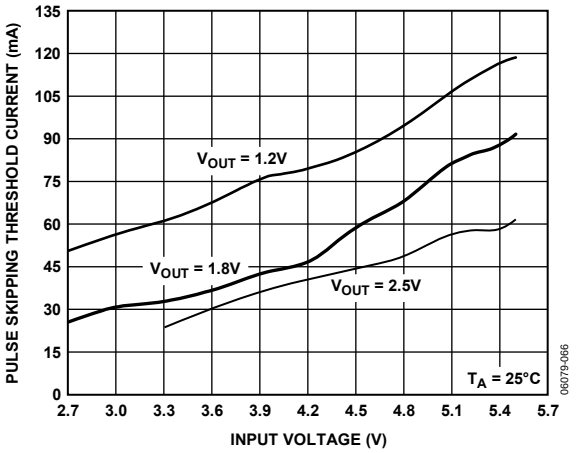


Figure 25. Pulse Skipping Threshold vs. Input Voltage for ADP2105

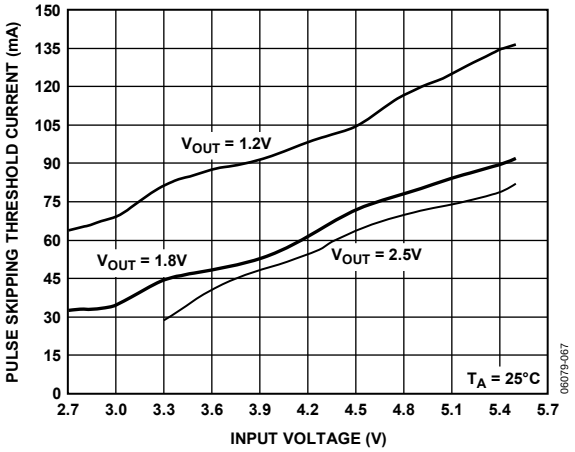


Figure 23. Pulse Skipping Threshold vs. Input Voltage for ADP2106

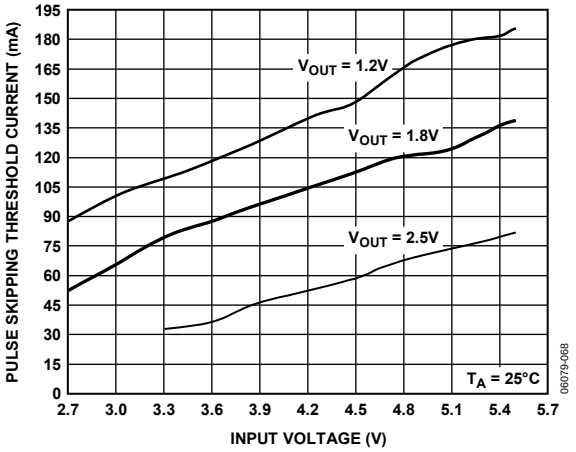


Figure 26. Pulse Skipping Threshold vs. Input Voltage for ADP2107

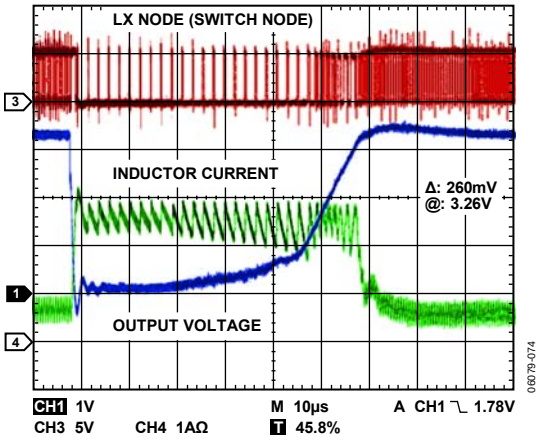


Figure 24. Short Circuit Response at Output

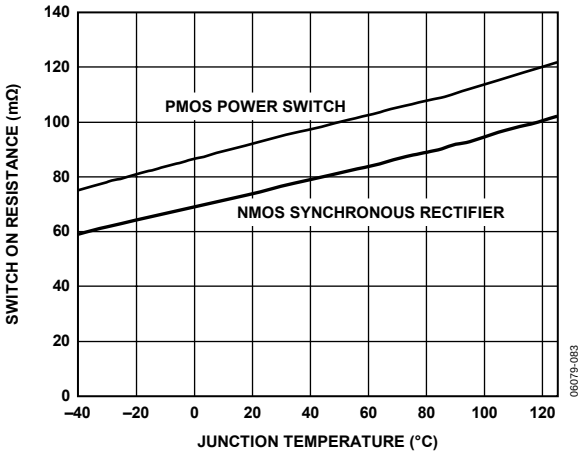


Figure 27. Switch On Resistance vs. Temperature

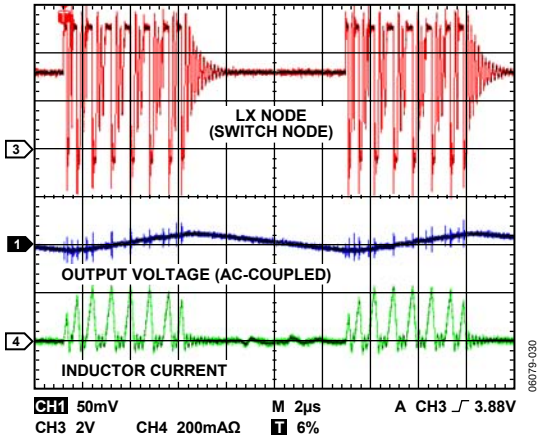


Figure 28. PFM Mode of Operation at Very Light Load (10 mA)

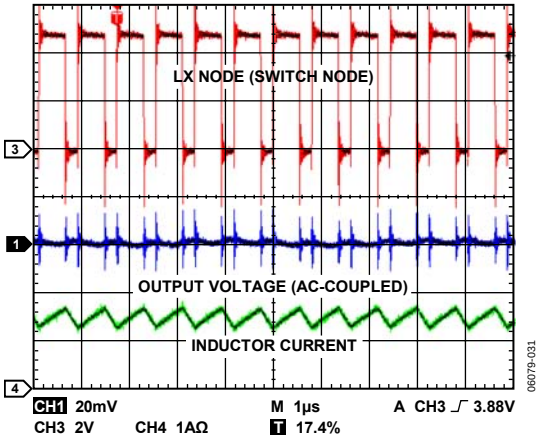


Figure 31. PWM Mode of Operation at Medium/Heavy Load (1.5 A)

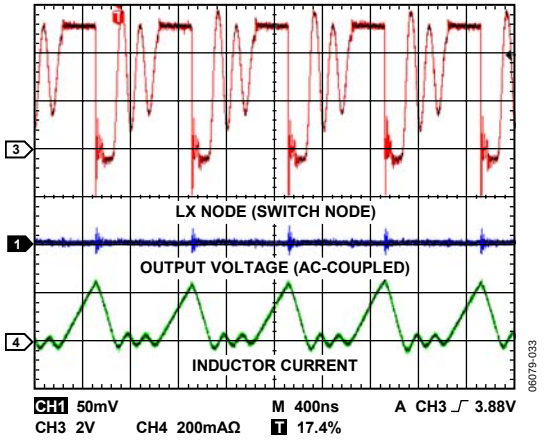


Figure 29. DCM Mode of Operation at Light Load (100 mA)

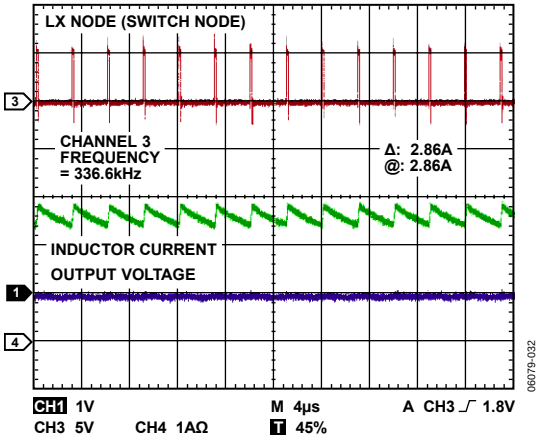


Figure 32. Current Limit Behavior of ADP2107 (Frequency Foldback)

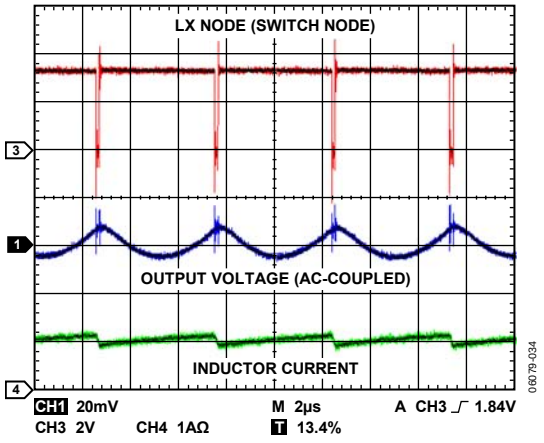


Figure 30. Minimum Off Time Control at Dropout

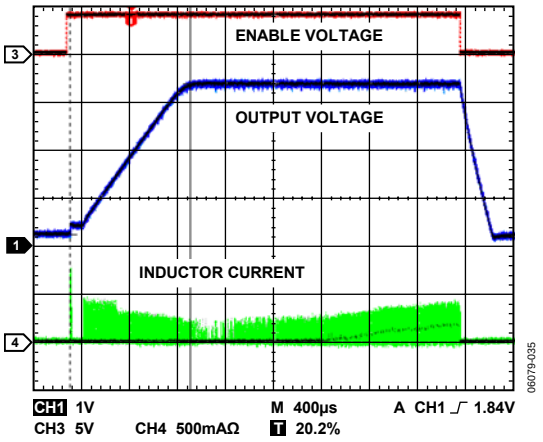


Figure 33. Startup and Shutdown Waveform (C_{SS} = 1 nF → SS Time = 1 ms)

THEORY OF OPERATION

The ADP2105/ADP2106/ADP2107 are step-down, dc-to-dc converters that use a fixed frequency, peak current-mode architecture with an integrated high-side switch and low-side synchronous rectifier. The high 1.2 MHz switching frequency and tiny 16-lead, 4 mm × 4 mm LFCSP_VQ package allow for a small step-down dc-to-dc converter solution. The integrated high-side switch (P-channel MOSFET) and synchronous rectifier (N-channel MOSFET) yield high efficiency at medium-to-heavy loads. Light load efficiency is improved by smoothly transitioning to variable frequency PFM mode.

The ADP2105/ADP2106/ADP2107-ADJ operate with an input voltage from 2.7 V to 5.5 V and regulate an output voltage down to 0.8 V. The ADP2105/ADP2106/ADP2107 are also available with preset output voltage options of 3.3 V, 1.8 V, 1.5 V, and 1.2 V.

CONTROL SCHEME

The ADP2105/ADP2106/ADP2107 operate with a fixed frequency, peak current-mode PWM control architecture at medium-to-high loads for high efficiency, but shift to a variable frequency PFM control scheme at light loads for lower quiescent current. When operating in fixed frequency PWM mode, the duty cycle of the integrated switches is adjusted to regulate the output voltage, but when operating in PFM mode at light loads, the switching frequency is adjusted to regulate the output voltage.

The ADP2105/ADP2106/ADP2107 operate in the PWM mode only when the load current is greater than the pulse-skipping threshold current. At load currents below this value, the converter smoothly transitions to the PFM mode of operation.

PWM MODE OPERATION

In PWM mode, the ADP2105/ADP2106/ADP2107 operate at a fixed frequency of 1.2 MHz set by an internal oscillator. At the start of each oscillator cycle, the P-channel MOSFET switch is turned on, putting a positive voltage across the inductor. Current in the inductor increases until the current sense signal crosses the peak inductor current level that turns off the P-channel MOSFET switch and turns on the N-channel MOSFET synchronous rectifier. This puts a negative voltage across the inductor, causing the inductor current to decrease. The synchronous rectifier stays on for the rest of the cycle, unless the inductor current reaches zero, which causes the zero-crossing comparator to turn off the N-channel MOSFET, as well. The peak inductor current is set by the voltage on the COMP pin. The COMP pin is the output of a transconductance error amplifier that compares the feedback voltage with an internal 0.8 V reference.

PFM MODE OPERATION

The ADP2105/ADP2106/ADP2107 smoothly transition to the variable frequency PFM mode of operation when the load current decreases below the pulse-skipping threshold current, switching only as necessary to maintain the output voltage within regulation. When the output voltage dips below regulation, the ADP2105/ADP2106/ADP2107 enter PWM mode for a few oscillator cycles to increase the output voltage back to regulation. During the wait time between bursts, both power switches are off, and the output capacitor supplies all the load current. Because the output voltage dips and recovers occasionally, the output voltage ripple in this mode is larger than the ripple in the PWM mode of operation.

PULSE-SKIPPING THRESHOLD

The output current at which the ADP2105/ADP2106/ADP2107 transition from variable frequency PFM control to fixed frequency PWM control is called the pulse-skipping threshold. The pulse-skipping threshold has been optimized for excellent efficiency over all load currents. The variation of pulse-skipping threshold with input voltage and output voltage is shown in Figure 23, Figure 25, and Figure 26.

100% DUTY CYCLE OPERATION (LDO MODE)

As the input voltage drops, approaching the output voltage, the ADP2105/ADP2106/ADP2107 smoothly transition to 100% duty cycle, maintaining the P-channel MOSFET switch on continuously. This allows the ADP2105/ADP2106/ADP2107 to regulate the output voltage until the drop in input voltage forces the P-channel MOSFET switch to enter dropout, as shown in the following equation:

$$V_{IN(MIN)} = I_{OUT} \times (R_{DS(ON)-P} + DCR_{IND}) + V_{OUT(NOM)}$$

The ADP2105/ADP2106/ADP2107 achieve 100% duty cycle operation by stretching the P-channel MOSFET switch on-time if the inductor current does not reach the peak inductor current level by the end of the clock cycle. Once this happens, the oscillator remains off until the inductor current reaches the peak inductor current level, at which time the switch is turned off and the synchronous rectifier is turned on for a fixed off-time. At the end of the fixed off-time, another cycle is initiated. As the ADP2105/ADP2106/ADP2107 approach dropout, the switching frequency decreases gradually to smoothly transition to 100% duty cycle operation.

SLOPE COMPENSATION

Slope compensation stabilizes the internal current control loop of the ADP2105/ADP2106/ADP2107 when operating beyond 50% duty cycle to prevent sub-harmonic oscillations. It is implemented by summing a fixed scaled voltage ramp to the current sense signal during the on-time of the P-channel MOSFET switch.

The slope compensation ramp value determines the minimum inductor that can be used to prevent sub-harmonic oscillations at a given output voltage. The slope compensation ramp values for ADP2105/ADP2106/ADP2107 follow. For more information, see the Inductor Selection section.

For the ADP2105:

Slope Compensation Ramp Value = 0.72 A/µs

For the ADP2106:

Slope Compensation Ramp Value = 1.07 A/µs

For the ADP2107:

Slope Compensation Ramp Value = 1.38 A/µs

FEATURES

Enable/Shutdown

Drive EN high to turn on the ADP2105/ADP2106/ADP2107. Drive EN low to turn off the ADP2105/ADP2106/ADP2107, reducing input current below 0.1 µA. To force the ADP2105/ADP2106/ADP2107 to automatically start when input power is applied, connect EN to IN. When shut down, the ADP2105/ADP2106/ADP2107 discharge the soft start capacitor, causing a new soft start cycle every time they are re-enabled.

Synchronous Rectification

In addition to the P-channel MOSFET switch, the ADP2105/ADP2106/ADP2107 include an integrated N-channel MOSFET synchronous rectifier. The synchronous rectifier improves efficiency, especially at low output voltage, and reduces cost and board space by eliminating the need for an external rectifier.

Current Limit

The ADP2105/ADP2106/ADP2107 have protection circuitry to limit the direction and amount of current flowing through the power switch and synchronous rectifier. The positive current limit on the power switch limits the amount of current that can flow from the input to the output, while the negative current limit on the synchronous rectifier prevents the inductor current from reversing direction and flowing out of the load.

Short Circuit Protection

The ADP2105/ADP2106/ADP2107 include frequency foldback to prevent output current run-away on a hard short. When the voltage at the feedback pin falls below 0.3 V, indicating the possibility of a hard short at the output, the switching frequency is reduced to 1/4 of the internal oscillator frequency. The reduction in the switching frequency gives more time for the inductor to discharge, preventing a runaway of output current.

Undervoltage Lockout (UVLO)

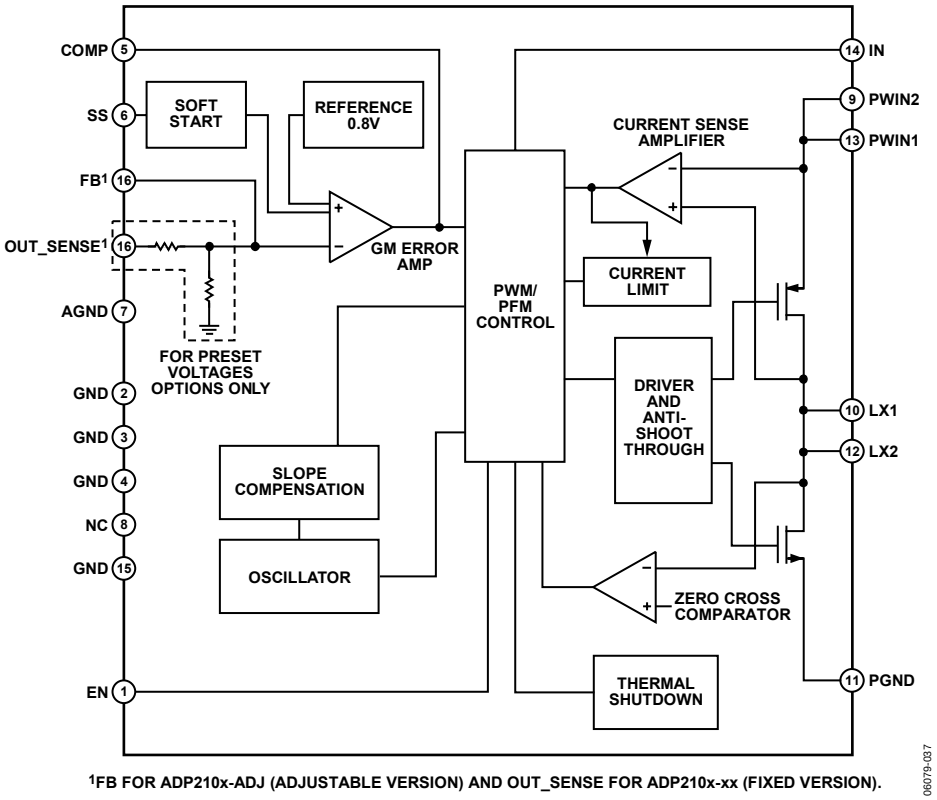
To protect against deep battery discharge, undervoltage lockout circuitry is integrated on the ADP2105/ADP2106/ADP2107. If the input voltage drops below the 2.2 V UVLO threshold, the ADP2105/ADP2106/ADP2107 shut down, and both the power switch and synchronous rectifier turn off. Once the voltage rises again above the UVLO threshold, the soft start period is initiated, and the part is enabled.

Thermal Protection

In the event that the ADP2105/ADP2106/ADP2107 junction temperatures rise above 140°C, the thermal shutdown circuit turns off the converter. Extreme junction temperatures can be the result of high current operation, poor circuit board design, and/or high ambient temperature. A 40°C hysteresis is included so that when thermal shutdown occurs, the ADP2105/ADP2106/ADP2107 do not return to operation until the on-chip temperature drops below 100°C. When coming out of thermal shutdown, soft start is initiated.

Soft Start

The ADP2105/ADP2106/ADP2107 include soft start circuitry to limit the output voltage rise time to reduce inrush current at startup. To set the soft start period, connect the soft start capacitor (C_{SS}) from SS to AGND. When the ADP2105/ADP2106/ADP2107 are disabled, or if the input voltage is below the undervoltage lockout threshold, C_{SS} is internally discharged. When the ADP2105/ADP2106/ADP2107 are enabled, C_{SS} is charged through an internal 0.8 µA current source, causing the voltage at SS to rise linearly. The output voltage rises linearly with the voltage at SS.



1FB FOR ADP210x-ADJ (ADJUSTABLE VERSION) AND OUT_SENSE FOR ADP210x-xx (FIXED VERSION).

Figure 34. Block Diagram of the ADP2105/ADP2106/ADP2107

APPLICATIONS INFORMATION

EXTERNAL COMPONENT SELECTION

The external component selection for the ADP2105/ADP2106/ADP2107 application circuits shown in Figure 35 and Figure 36 depend on input voltage, output voltage, and load current requirements. Additionally, tradeoffs between performance parameters like efficiency and transient response can be made by varying the choice of external components.

SETTING THE OUTPUT VOLTAGE

The output voltage of ADP2105/ADP2106/ADP2107-ADJ is externally set by a resistive voltage divider from the output voltage to FB. The ratio of the resistive voltage divider sets the output voltage, while the absolute value of those resistors sets the divider string current. For lower divider string currents, the small 10 nA (0.1 μA maximum) FB bias current should be taken into account when calculating resistor values. The FB bias current can be ignored for a higher divider string current, but this degrades efficiency at very light loads.

To limit output voltage accuracy degradation due to FB bias current to less than 0.05% (0.5% maximum), ensure that the divider string current is greater than 20 μA. To calculate the desired resistor values, first determine the value of the bottom divider string resistor, R_{BOT}, by

$$R_{BOT} = \frac{V_{FB}}{I_{STRING}}$$

where:

V_{FB} = 0.8 V, the internal reference.
I_{STRING} is the resistor divider string current.

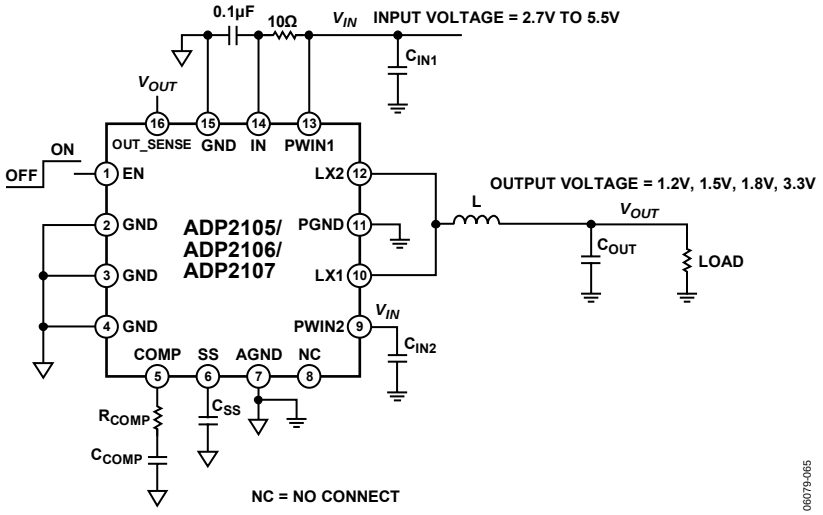


Figure 35. Typical Applications Circuit for Fixed Output Voltage Options (ADP2105/ADP2106/ADP2107-xx)

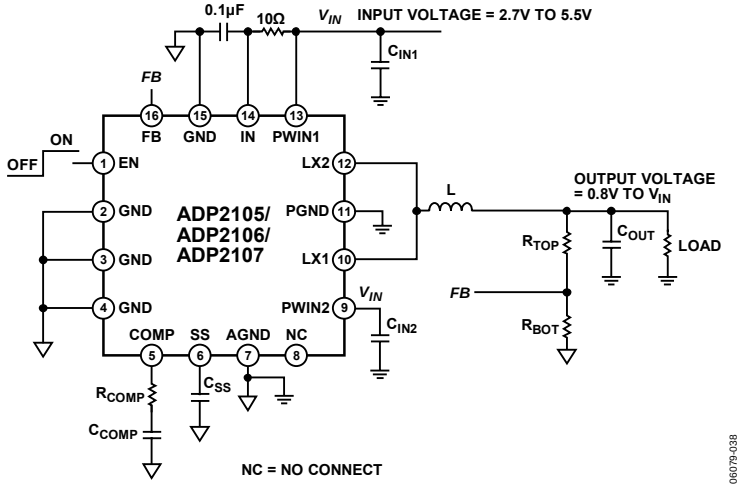


Figure 36. Typical Applications Circuit for Adjustable Output Voltage Option (ADP2105/ADP2106/ADP2107-ADJ)

Once R_{BOT} is determined, calculate the value of the top resistor, R_{TOP}, by

$$R_{TOP} = R_{BOT}\left[\frac{V_{OUT} - V_{FB}}{V_{FB}}\right]$$

The ADP2105/ADP2106/ADP2107-xx (where xx represents the fixed output voltage) include the resistive voltage divider internally, reducing the external circuitry required. Connect the OUT_SENSE to the output voltage as close as possible to the load for improved load regulation.

INDUCTOR SELECTION

The high switching frequency of ADP2105/ADP2106/ADP2107 allows for minimal output voltage ripple even with small inductors. The sizing of the inductor is a trade-off between efficiency and transient response. A small inductor leads to larger inductor current ripple that provides excellent transient response but degrades efficiency. Due to the high switching frequency of ADP2105/ADP2106/ADP2107, shielded ferrite core inductors are recommended for their low core losses and low EMI.

As a guideline, the inductor peak-to-peak current ripple, ΔI_L, is typically set to 1/3 of the maximum load current for optimal transient response and efficiency.

$$\Delta I_L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{SW} \times L} \approx \frac{I_{LOAD(MAX)}}{3}$$

$$\Rightarrow L_{IDEAL} = \frac{2.5 \times V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times I_{LOAD(MAX)}} \mu H$$

where f_{SW} is the switching frequency (1.2 MHz).

The ADP2105/ADP2106/ADP2107 use slope compensation in the current control loop to prevent subharmonic oscillations when operating beyond 50% duty cycle. The fixed slope compensation limits the minimum inductor value as a function of output voltage.

For the ADP2105:

$$L > (1.12\ \mu H/V) \times V_{OUT}$$

For the ADP2106:

$$L > (0.83\ \mu H/V) \times V_{OUT}$$

For the ADP2107:

$$L > (0.66\ \mu H/V) \times V_{OUT}$$

Also, 4.7 µH or larger inductors are not recommended because they may cause instability in discontinuous conduction mode under light load conditions.

Finally, it is important that the inductor be capable of handling the maximum peak inductor current, I_{PK}, determined by the following equation:

$$I_{PK} = I_{LOAD(MAX)} + \left(\frac{\Delta I_L}{2}\right)$$

Ensure that the maximum rms current of the inductor is greater than the maximum load current, and the saturation current of the inductor is greater than the peak current limit of the converter used in the application.

Table 5. Minimum Inductor Value for Common Output Voltage Options for the ADP2105 (1 A)

	V_{IN}			
V_{OUT}	2.7 V	3.6 V	4.2 V	5.5 V
1.2 V	1.67 µH	2.00 µH	2.14 µH	2.35 µH
1.5 V	1.68 µH	2.19 µH	2.41 µH	2.73 µH
1.8 V	2.02 µH	2.25 µH	2.57 µH	3.03 µH
2.5 V	2.80 µH	2.80 µH	2.80 µH	3.41 µH
3.3 V	3.70 µH	3.70 µH	3.70 µH	3.70 µH

Table 6. Minimum Inductor Value for Common Output Voltage Options for the ADP2106 (1.5 A)

	V_{IN}			
V_{OUT}	2.7 V	3.6 V	4.2 V	5.5 V
1.2 V	1.11 µH	2.33 µH	2.43 µH	1.56 µH
1.5 V	1.25 µH	1.46 µH	1.61 µH	1.82 µH
1.8 V	1.49 µH	1.50 µH	1.71 µH	2.02 µH
2.5 V	2.08 µH	2.08 µH	2.08 µH	2.27 µH
3.3 V	2.74 µH	2.74 µH	2.74 µH	2.74 µH

Table 7. Minimum Inductor Value for Common Output Voltage Options for the ADP2107 (2 A)

	V_{IN}			
V_{OUT}	2.7 V	3.6 V	4.2 V	5.5 V
1.2 V	0.83 µH	1.00 µH	1.07 µH	1.17 µH
1.5 V	0.99 µH	1.09 µH	1.21 µH	1.36 µH
1.8 V	1.19 µH	1.19 µH	1.29 µH	1.51 µH
2.5 V	1.65 µH	1.65 µH	1.65 µH	1.70 µH
3.3 V	2.18 µH	2.18 µH	2.18 µH	2.18 µH

Table 8. Inductor Recommendations for the ADP2105/ ADP2106/ADP2107

Vendor	Small-Sized Inductors (< 5 mm × 5 mm)	Large-Sized Inductors (> 5 mm × 5 mm)
Sumida	CDRH2D14, 3D16, 3D28	CDRH4D18, 4D22, 4D28, 5D18, 6D12
Toko	1069AS-DB3018, 1098AS-DE2812, 1070AS-DB3020	D52LC, D518LC, D62LCB
Coilcraft	LPS3015, LPS4012, DO3314	DO1605T
Cooper Bussmann	SD3110, SD3112, SD3114, SD3118, SD3812, SD3814	SD10, SD12, SD14, SD52

OUTPUT CAPACITOR SELECTION

The output capacitor selection affects both the output voltage ripple and the loop dynamics of the converter. For a given loop crossover frequency (the frequency at which the loop gain drops to 0 dB), the maximum voltage transient excursion (overshoot) is inversely proportional to the value of the output capacitor. Therefore, larger output capacitors result in improved load transient response. To minimize the effects of the dc-to-dc converter switching, the crossover frequency of the compensation loop should be less than 1/10 of the switching frequency. Higher crossover frequency leads to faster settling time for a load transient response, but it can also cause ringing due to poor phase margin. Lower crossover frequency helps to provide stable operation but needs large output capacitors to achieve competitive overshoot specifications. Therefore, the optimal crossover frequency for the control loop of ADP2105/ADP2106/ADP2107 is 80 kHz, 1/15 of the switching frequency. For a crossover frequency of 80 kHz, Figure 37 shows the maximum output voltage excursion during a 1A load transient, as the product of the output voltage and the output capacitor is varied. Choose the output capacitor based on the desired load transient response and target output voltage.

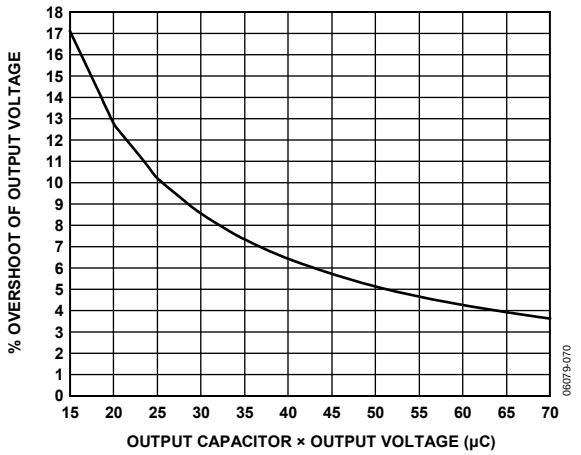


Figure 37. % Overshoot for a 1 A Load Transient Response vs. Output Capacitor × Output Voltage

For example, if the desired 1A load transient response (overshoot) is 5% for an output voltage of 2.5 V, then from Figure 37

$$Output\ Capacitor \times Output\ Voltage = 50\ \mu C$$

$$\Rightarrow Output\ Capacitor = \frac{50\ \mu C}{2.5} \approx 20\ \mu F$$

The ADP2105/ADP2106/ADP2107 have been designed for operation with small ceramic output capacitors that have low ESR and ESL, thus comfortably able to meet tight output voltage ripple specifications. X5R or X7R dialectrics are recommended with a voltage rating of 6.3 V or 10 V. Y5V and Z5U dialectrics are not recommended, due to their poor temperature and dc bias characteristics. Table 9 shows a list of recommended MLCC capacitors from Murata and Taiyo Yuden.

It is also important, while choosing output capacitors, to account for the loss of capacitance due to output voltage dc bias. Figure 38 shows the loss of capacitance due to output voltage dc bias for a few X5R MLCC capacitors from Murata.

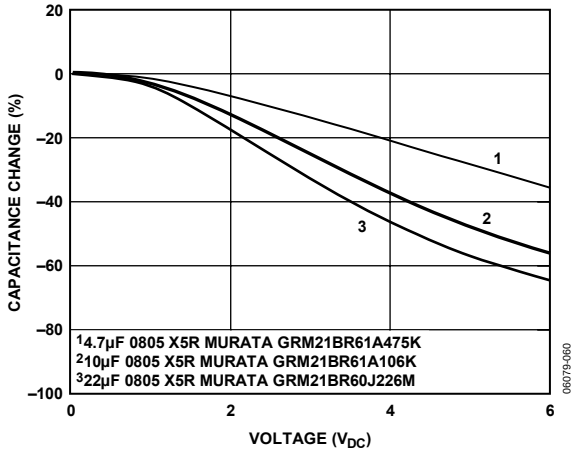


Figure 38. % Drop-In Capacitance vs. DC Bias for Ceramic Capacitors (Information Provided by Murata Corporation)

For example, to get 20 µF output capacitance at an output voltage of 2.5 V, based on Figure 38, as well as giving some margin for temperature variance, it is suggested that a 22 µF and a 10 µF capacitor be used in parallel to ensure that the output capacitance is sufficient under all conditions for stable behavior.

Table 9. Recommended Input and Output Capacitor Selection for the ADP2105/ADP2106/ADP2107

	Vendor	
Capacitor	**Murata**	**Taiyo Yuden**
4.7 µF 10 V X5R 0805	GRM21BR61A475K	LMK212BJ475KG
10 µF 10 V X5R 0805	GRM21BR61A106K	LMK212BJ106KG
22 µF 6.3 V X5R 0805	GRM21BR60J226M	JMK212BJ226MG

INPUT CAPACITOR SELECTION

The input capacitor reduces input voltage ripple caused by the switch currents on the PWIN pins. Place the input capacitors as close as possible to the PWIN pins. Select an input capacitor capable of withstanding the rms input current for the maximum load current in your application.

For the ADP2105, it is recommended that each PWIN pin be bypassed with a 4.7 µF or larger input capacitor. For the ADP2106, bypass the PWIN pins with a 10 µF and a 4.7 µF capacitor, and for the ADP2107, bypass each PWIN pin with a 10 µF capacitor.

As with the output capacitor, a low ESR ceramic capacitor is recommended to minimize input voltage ripple. X5R or X7R dialectrics are recommended, with a voltage rating of 6.3 V or 10 V. Y5V and Z5U dialectrics are not recommended, due to their poor temperature and dc bias characteristics. Refer to Table 9 for input capacitor recommendations.

INPUT FILTER

The IN pin is the power source for the ADP2105/ADP2106/ADP2107 internal circuitry, including the voltage reference and current sense amplifier that are sensitive to power supply noise. To prevent high frequency switching noise on the PWIN pins from corrupting the internal circuitry of the ADP2105/ADP2106/ADP2107, a low-pass RC filter should be placed between the IN pin and the PWIN1 pin. The suggested input filter consists of a small 0.1 µF ceramic capacitor placed between IN and AGND and a 10 Ω resistor placed between IN and PWIN1. This forms a 150 kHz low-pass filter between PWIN1 and IN that prevents any high frequency noise on PWIN1 from coupling into the IN pin.

SOFT START

The ADP2105/ADP2106/ADP2107 include soft start circuitry to limit the output voltage rise time to reduce inrush current at startup. To set the soft start period, connect a soft start capacitor (C_{SS}) from SS to AGND. The soft start period varies linearly with the size of the soft start capacitor, as shown in the following equation:

$$T_{SS} = C_{SS} \times 10^9 \text{ ms}$$

To get a soft start period of 1 ms, a 1 nF capacitor must be connected between SS and AGND.

LOOP COMPENSATION

The ADP2105/ADP2106/ADP2107 utilize a transconductance error amplifier to compensate the external voltage loop. The open loop transfer function at angular frequency, s, is given by

$$H(s) = G_m G_{CS}\left(\frac{Z_{COMP}(s)}{sC_{OUT}}\right)\left(\frac{V_{REF}}{V_{OUT}}\right)$$

where:

V_{REF} is the internal reference voltage (0.8 V).
V_{OUT} is the nominal output voltage.
$Z_{COMP}(s)$ is the impedance of the compensation network at the angular frequency, s.
C_{OUT} is the output capacitor.
G_m is the transconductance of the error amplifier (50 µA/V nominal).
G_{CS} is the effective transconductance of the current loop.

G_{CS} = 1.875 A/V for the ADP2105.
G_{CS} = 2.8125 A/V for the ADP2106.
G_{CS} = 3.625 A/V for the ADP2107.

The transconductance error amplifier drives the compensation network that consists of a resistor (R_{COMP}) and capacitor (C_{COMP}) connected in series to form a pole and a zero, as shown in the following equation:

$$Z_{COMP}(s) = \left(R_{COMP} + \frac{1}{sC_{COMP}}\right) = \left(\frac{1 + sR_{COMP}C_{COMP}}{sC_{COMP}}\right)$$

At the crossover frequency, the gain of the open loop transfer function is unity. This yields the following equation for the compensation network impedance at the crossover frequency:

$$Z_{COMP}(F_{CROSS}) = \left(\frac{(2\pi)F_{CROSS}}{G_m G_{CS}}\right)\left(\frac{C_{OUT}V_{OUT}}{V_{REF}}\right)$$

where:

F_{CROSS} = 80 kHz, the crossover frequency of the loop.
$C_{OUT}V_{OUT}$ is determined from the Output Capacitor Selection section.

To ensure that there is sufficient phase margin at the crossover frequency, place the Compensator Zero at 1/4 of the crossover frequency, as shown in the following equation:

$$(2\pi)\left(\frac{F_{CROSS}}{4}\right)R_{COMP}C_{COMP} = 1$$

Solving the above two simultaneous equations yields the value for the compensation resistor and compensation capacitor, as shown in the following equation:

$$R_{COMP} = 0.8\left(\frac{(2\pi)F_{CROSS}}{G_m G_{CS}}\right)\left(\frac{C_{OUT}V_{OUT}}{V_{REF}}\right)$$

$$C_{COMP} = \frac{2}{\pi F_{CROSS}R_{COMP}}$$

BODE PLOTS

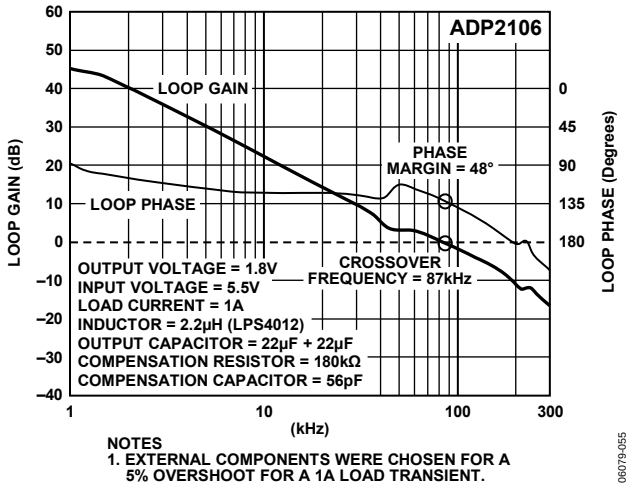


Figure 39. ADP2106 Bode Plot at V_{IN} = 5.5 V, V_{OUT} = 1.8 V and Load = 1 A

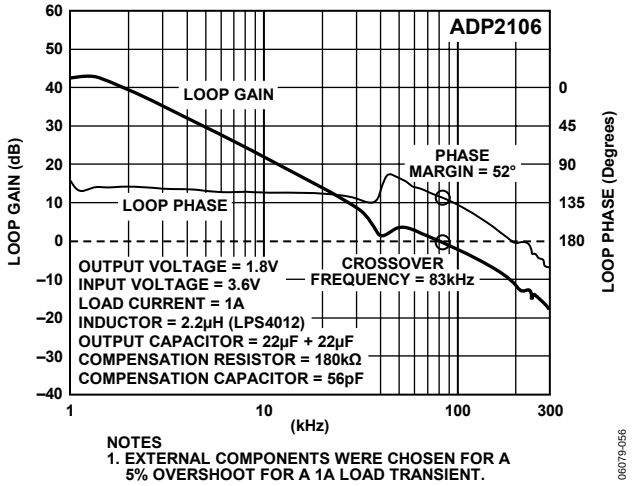


Figure 40. ADP2106 Bode Plot at V_{IN} = 3.6 V, V_{OUT} = 1.8 V, and Load = 1 A

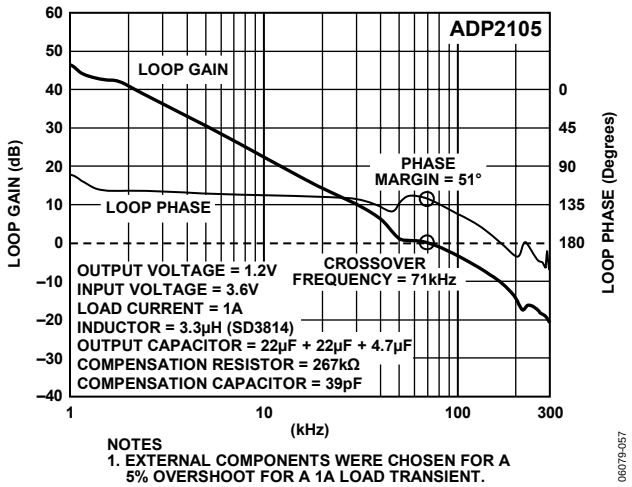


Figure 41. ADP2105 Bode Plot at V_{IN} = 3.6 V, V_{OUT} = 1.2 V, and Load = 1 A

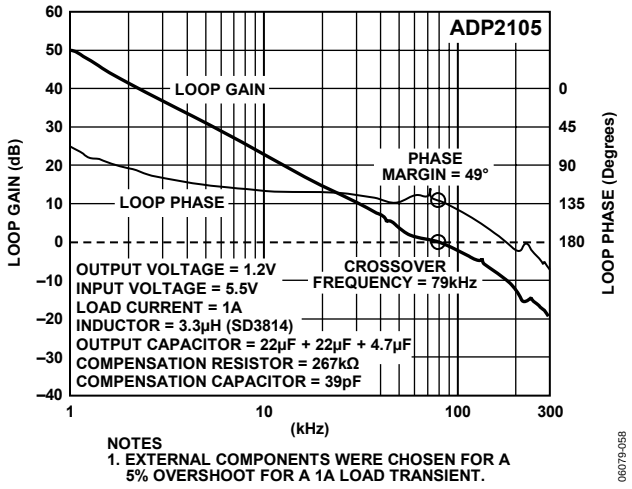


Figure 42. ADP2105 Bode Plot at V_{IN} = 5.5 V, V_{OUT} = 1.2 V and Load = 1 A

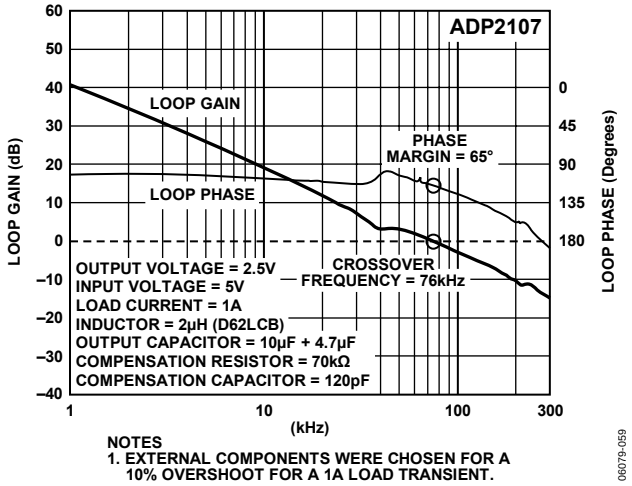


Figure 43. ADP2107 Bode Plot at V_{IN} = 5 V, V_{OUT} = 2.5 V and Load = 1 A

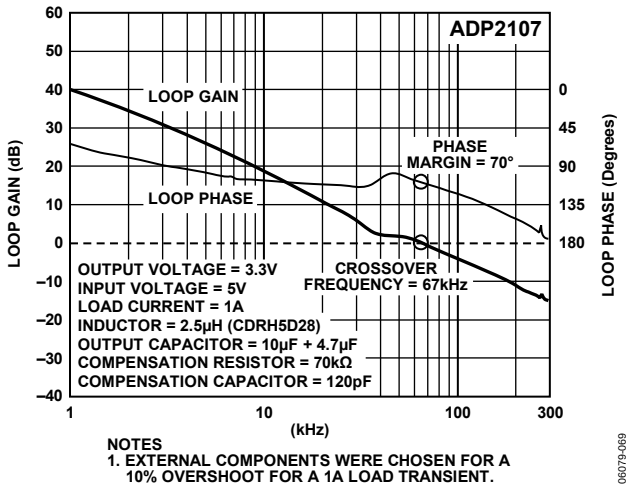
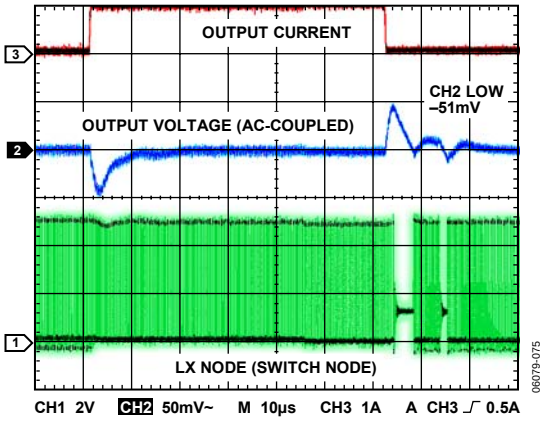


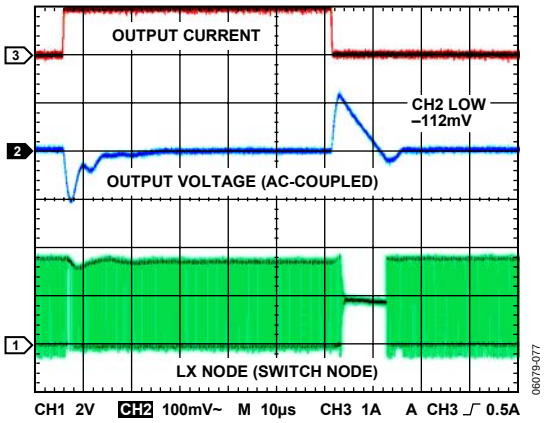
Figure 44. ADP2107 Bode Plot at V_{IN} = 5 V, V_{OUT} = 3.3 V, and Load = 1 A

LOAD TRANSIENT RESPONSE



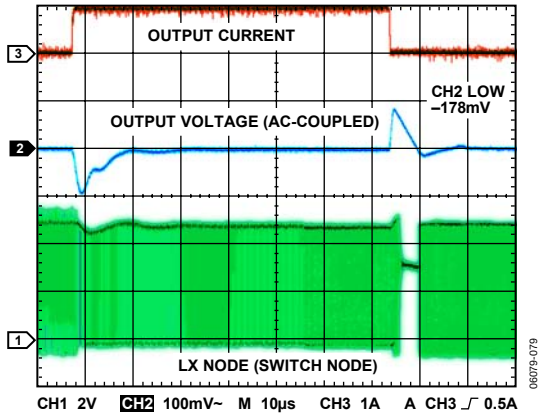
OUTPUT CAPACITOR: 22µF + 22µF + 4.7µF
INDUCTOR: SD14, 2.5µH
COMPENSATION RESISTOR: 270kΩ
COMPENSATION CAPACITOR: 39pF

Figure 45. 1 A Load Transient Response for ADP2105-1.2 with External Components Chosen for 5% Overshoot



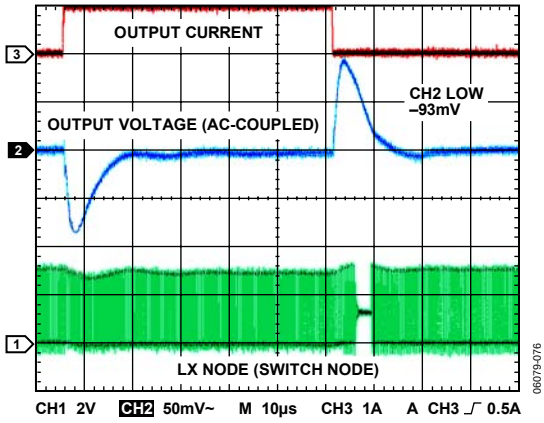
OUTPUT CAPACITOR: 22µF + 22µF
INDUCTOR: SD3814, 3.3µH
COMPENSATION RESISTOR: 270kΩ
COMPENSATION CAPACITOR: 39pF

Figure 46. 1 A Load Transient Response for ADP2105-1.8 with External Components Chosen for 5% Overshoot



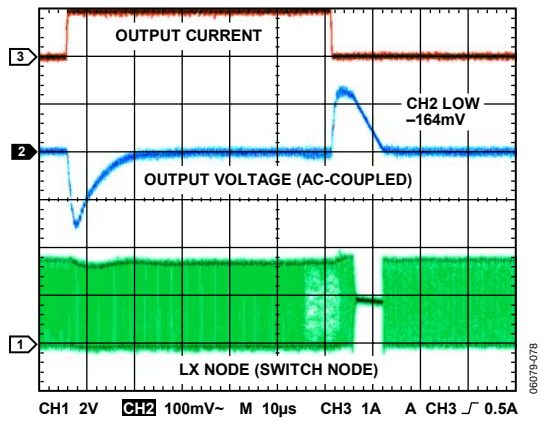
OUTPUT CAPACITOR: 22µF + 4.7µF
INDUCTOR: CDRH5D18, 4.1µH
COMPENSATION RESISTOR: 270kΩ
COMPENSATION CAPACITOR: 39pF

Figure 47. 1 A Load Transient Response for ADP2105-3.3 with External Components Chosen for 5% Overshoot



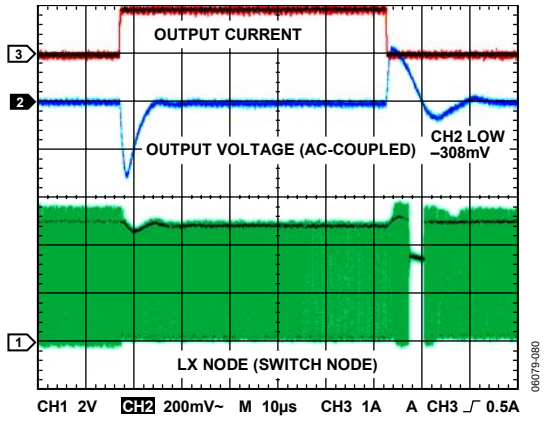
OUTPUT CAPACITOR: 22µF + 4.7µF
INDUCTOR: SD14, 2.5µH
COMPENSATION RESISTOR: 135kΩ
COMPENSATION CAPACITOR: 82pF

Figure 48. 1 A Load Transient Response for ADP2105-1.2 with External Components Chosen for 10% Overshoot



OUTPUT CAPACITOR: 10µF + 10µF
INDUCTOR: SD3814, 3.3µH
COMPENSATION RESISTOR: 135kΩ
COMPENSATION CAPACITOR: 82pF

Figure 49. 1 A Load Transient Response for ADP2105-1.8 with External Components Chosen for 10% Overshoot



OUTPUT CAPACITOR: 10µF + 4.7µF
INDUCTOR: CDRH5D18, 4.1µH
COMPENSATION RESISTOR: 135kΩ
COMPENSATION CAPACITOR: 82pF

Figure 50. 1 A Load Transient Response for ADP2105-3.3 with External Components Chosen for 10% Overshoot

EFFICIENCY CONSIDERATIONS

Efficiency is defined as the ratio of output power to input power. The high efficiency of the ADP2105/ADP2106/ADP2107 has two distinct advantages. First, only a small amount of power is lost in the dc-to-dc converter package that reduces thermal constraints. In addition, high efficiency delivers the maximum output power for the given input power, extending battery life in portable applications.

There are four major sources of power loss in dc-to-dc converters like the ADP2105/ADP2106/ADP2107.

- Power switch conduction losses
- Inductor losses
- Switching losses
- Transition losses

Power Switch Conduction Losses

Power switch conduction losses are caused by the flow of output current through the P-channel power switch and the N-channel synchronous rectifier, which have internal resistances ($R_{DS(ON)}$) associated with them. The amount of power loss can be approximated by

$$P_{SW-COND} = [R_{DS(ON)-P} \times D + R_{DS(ON)-N} \times (1 - D)] \times I_{OUT}^2$$

where $D = V_{OUT}/V_{IN}$.

The internal resistance of the power switches increases with temperature but decreases with higher input voltage. Figure 19 in the Typical Performance Characteristics section shows the change in $R_{DS(ON)}$ vs. input voltage, while Figure 27 in the Typical Performance Characteristics section shows the change in $R_{DS(ON)}$ vs. temperature for both power devices.

Inductor Losses

Inductor conduction losses are caused by the flow of current through the inductor, which has an internal resistance (DCR) associated with it. Larger sized inductors have smaller DCR, which can improve inductor conduction losses.

Inductor core losses are related to the magnetic permeability of the core material. Because the ADP2105/ADP2106/ADP2107 are high switching frequency dc-to-dc converters, shielded ferrite core material is recommended for its low core losses and low EMI.

The total amount of inductor power loss can be calculated by

$$P_L = DCR \times I_{OUT}^2 + Core\ Losses$$

Switching Losses

Switching losses are associated with the current drawn by the driver to turn on and turn off the power devices at the switching frequency. Each time a power device gate is turned on and turned off, the driver transfers a charge ΔQ from the input supply to the gate and then from the gate to ground.

The amount of power loss can by calculated by

$$P_{SW} = (C_{GATE-P} + C_{GATE-N}) \times V_{IN}^2 \times f_{SW}$$

where:

$(C_{GATE-P} + C_{GATE-N})$ ~ 600 pF.
f_{SW} = 1.2 MHz, the switching frequency.

Transition Losses

Transition losses occur because the P-channel MOSFET power switch cannot turn on or turn off instantaneously. At the middle of a LX node transition, the power switch is providing all the inductor current, while the source to drain voltage of the power switch is half the input voltage, resulting in power loss. Transition losses increase with load current and input voltage and occur twice for each switching cycle.

The amount of power loss can be calculated by

$$P_{TRAN} = \frac{V_{IN}}{2} \times I_{OUT} \times (t_{ON} + t_{OFF}) \times f_{SW}$$

where t_{ON} and t_{OFF} are the rise time and fall time of the LX node, which are approximately 3 ns.

THERMAL CONSIDERATIONS

In most applications, the ADP2105/ADP2106/ADP2107 do not dissipate a lot of heat due to their high efficiency. However, in applications with high ambient temperature, low supply voltage, and high duty cycle, the heat dissipated in the package is large enough that it can cause the junction temperature of the die to exceed the maximum junction temperature of 125°C. Once the junction temperature exceeds 140°C, the converter goes into thermal shutdown. It recovers only after the junction temperature has decreased below 100°C to prevent any permanent damage. Therefore, thermal analysis for the chosen application solution is very important to guarantee reliable performance over all conditions.

The junction temperature of the die is the sum of the ambient temperature of the environment and the temperature rise of the package due to the power dissipation, as shown in the following equation:

$$T_J = T_A + T_R$$

where:

T_J is the junction temperature.
T_A is the ambient temperature.
T_R is the rise in temperature of the package due to power dissipation in it.

The rise in temperature of the package is directly proportional to the power dissipation in the package. The proportionality constant for this relationship is defined as the thermal resistance from the junction of the die to the ambient temperature, as shown in the following equation:

$$T_R = \theta_{JA} \times P_D$$

where:

T_R is the rise in temperature of the package.
P_D is the power dissipation in the package.
θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature of the package.

For example, consider an application where the ADP2107-1.8 is used with an input voltage of 3.6 V and a load current of 2 A. Also, assume that the maximum ambient temperature is 85°C. At a load current of 2 A, the most significant contributor of power dissipation in the dc-to-dc converter package is the conduction loss of the power switches. Using the graph of switch resistance vs. temperature (see Figure 27), as well as the equation of power loss given in the Power Switch Conduction Losses section, the power dissipation in the package can be calculated by

$$P_{SW-COND} = [R_{DS(ON)-P} \times D + R_{DS(ON)-N} \times (1 - D)] \times I_{OUT}^2 =$$

$$[109\ \text{m}\Omega \times 0.5 + 90\ \text{m}\Omega \times 0.5] \times (2\ \text{A})^2 \sim 400\ \text{mW}$$

The θ_{JA} for the LFCSP_VQ package is 40°C/W, as shown in Table 3. Thus, the rise in temperature of the package due to power dissipation is

$$T_R = \theta_{JA} \times P_D = 40°\text{C/W} \times 0.40\ \text{W} = 16°\text{C}$$

The junction temperature of the converter is

$$T_J = T_A + T_R = 85°\text{C} + 16°\text{C} = 101°\text{C}$$

which is below the maximum junction temperature of 125°C. Thus, this application operates reliably from a thermal point of view.

DESIGN EXAMPLE

Consider an application with the following specifications:

Input Voltage = 3.6 V to 4.2 V.
Output Voltage = 2 V.
Typical Output Current = 600 mA.
Maximum Output Current = 1.2 A.
Soft Start Time = 2 ms.
Overshoot ≤ 100 mV under all load transient conditions.

1. Choose the dc-to-dc converter that satisfies the maximum output current requirement. Because the maximum output current for this application is 1.2 A, the ADP2106 with a maximum output current of 1.5 A is ideal for this application.

2. See whether the output voltage desired is available as a fixed output voltage option. Because 2 V is not one of the fixed output voltage options available, choose the adjustable version of ADP2106.

3. The first step in external component selection for an adjustable version converter is to calculate the resistance of the resistive voltage divider that sets the output voltage.

$$R_{BOT} = \frac{V_{FB}}{I_{STRING}} = \frac{0.8\ \text{V}}{20\ \mu A} = 40\ \text{k}\Omega$$

$$R_{TOP} = R_{BOT}\left[\frac{V_{OUT} - V_{FB}}{V_{FB}}\right] = 40\ \text{k}\Omega \times \left[\frac{2\ \text{V} - 0.8\ \text{V}}{0.8\ \text{V}}\right] = 60\ \text{k}\Omega$$

4. Calculate the minimum inductor value as follows:

   For the ADP2106:

   $L > (0.83\ \mu\text{H/V}) \times V_{OUT}$

   ⇨ $L > 0.83\ \mu\text{H/V} \times 2\ \text{V}$

   ⇨ $L > 1.66\ \mu\text{H}$

   Next, calculate the ideal inductor value that sets the inductor peak-to-peak current ripple, ΔI_L, to1/3 of the maximum load current at the maximum input voltage.

$$L_{IDEAL} = \frac{2.5 \times V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times I_{LOAD(MAX)}}\mu\text{H} =$$

$$\frac{2.5 \times 2 \times (4.2 - 2)}{4.2 \times 1.2}\mu\text{H} = 2.18\ \mu\text{H}$$

   The closest standard inductor value is 2.2 µH. The maximum rms current of the inductor should be greater than 1.2 A, and the saturation current of the inductor should be greater than 2 A. One inductor that meets these criteria is the LPS4012-2.2 µH from Coilcraft.

5. Choose the output capacitor based on the transient response requirements. The worst-case load transient is 1.2 A, for which the overshoot must be less than 100 mV, which is 5% of the output voltage. Therefore, for a 1 A load transient, the overshoot must be less than 4% of the output voltage. For these conditions, Figure 37 gives

   $Output\ Capacitor \times Output\ Voltage = 60\ \mu\text{C}$

$$\Rightarrow Output\ Capacitor = \frac{60\ \mu\text{C}}{2.0\ \text{V}} \approx 30\ \mu\text{F}$$

   Next, taking into account the loss of capacitance due to dc bias, as shown in Figure 38, two 22 µF X5R MLCC capacitors from Murata (GRM21BR60J226M) are sufficient for this application.

6. Because the ADP2106 is being used in this application, the input capacitors are 10 µF and 4.7 µF X5R Murata capacitors (GRM21BR61A106K and GRM21BR61A475K).
7. The input filter consists of a small 0.1 µF ceramic capacitor placed between IN and AGND and a 10 Ω resistor placed between IN and PWIN1.
8. Choose a soft start capacitor of 2 nF to achieve a soft start time of 2 ms.
9. Finally, the compensation resistor and capacitor can be calculated as

$$R_{COMP} = 0.8\left(\frac{(2\pi)F_{CROSS}}{G_m G_{CS}}\right)\left(\frac{C_{OUT}V_{OUT}}{V_{REF}}\right)$$

$$= 0.8\left(\frac{(2\pi)\times 80\text{ kHz}}{50\text{ µA/V}\times 2.8125\text{ A/V}}\right)\left(\frac{30\text{ µF}\times 2\text{ V}}{0.8\text{ V}}\right) = 215\text{ kΩ}$$

$$C_{COMP} = \frac{2}{\pi F_{CROSS} R_{COMP}} = \frac{2}{\pi\times 80\text{ kHz}\times 215\text{ kΩ}} = 39\text{ pF}$$

EXTERNAL COMPONENT RECOMMENDATIONS

Table 10. Recommended External Components for Popular Output Voltage Options at 80 kHz Crossover Frequency with 10% Overshoot for a 1 A Load Transient (Refer to Figure 35 and Figure 36)

Part	V_{OUT} (V)	C_{IN1}[1] (µF)	C_{IN2}[2] (µF)	C_{OUT}[3] (µF)	L (µH)	R_{COMP} (kΩ)	C_{COMP} (pF)	R_{TOP}[4] (kΩ)	R_{BOT}[5] (kΩ)
ADP2105-ADJ	0.9	4.7	4.7	22 + 10	2.0	135	82	5	40
ADP2105-ADJ	1.2	4.7	4.7	22 + 4.7	2.5	135	82	20	40
ADP2105-ADJ	1.5	4.7	4.7	10 + 10	3.0	135	82	35	40
ADP2105-ADJ	1.8	4.7	4.7	10 + 10	3.3	135	82	50	40
ADP2105-ADJ	2.5	4.7	4.7	10 + 4.7	3.6	135	82	85	40
ADP2105-ADJ	3.3	4.7	4.7	10 + 4.7	4.1	135	82	125	40
ADP2106-ADJ	0.9	4.7	10	22 + 10	1.5	90	100	5	40
ADP2106-ADJ	1.2	4.7	10	22 + 4.7	1.8	90	100	20	40
ADP2106-ADJ	1.5	4.7	10	10 + 10	2.0	90	100	35	40
ADP2106-ADJ	1.8	4.7	10	10 + 10	2.2	90	100	50	40
ADP2106-ADJ	2.5	4.7	10	10 + 4.7	2.5	90	100	85	40
ADP2106-ADJ	3.3	4.7	10	10 + 4.7	3.0	90	100	125	40
ADP2107-ADJ	0.9	10	10	22 + 10	1.2	70	120	5	40
ADP2107-ADJ	1.2	10	10	22 + 4.7	1.5	70	120	20	40
ADP2107-ADJ	1.5	10	10	10 + 10	1.5	70	120	35	40
ADP2107-ADJ	1.8	10	10	10 + 10	1.8	70	120	50	40
ADP2107-ADJ	2.5	10	10	10 + 4.7	1.8	70	120	85	40
ADP2107-ADJ	3.3	10	10	10 + 4.7	2.5	70	120	125	40
ADP2105-1.2	1.2	4.7	4.7	22 + 4.7	2.5	135	82	-	-
ADP2105-1.5	1.5	4.7	4.7	10 + 10	3.0	135	82	-	-
ADP2105-1.8	1.8	4.7	4.7	10 + 10	3.3	135	82	-	-
ADP2105-3.3	3.3	4.7	4.7	10 + 4.7	4.1	135	82	-	-
ADP2106-1.2	1.2	4.7	10	22 + 4.7	1.8	90	100	-	-
ADP2106-1.5	1.5	4.7	10	10 + 10	2.0	90	100	-	-
ADP2106-1.8	1.8	4.7	10	10 + 10	2.2	90	100	-	-
ADP2106-3.3	3.3	4.7	10	10 + 4.7	3.0	90	100	-	-
ADP2107-1.2	1.2	10	10	22 + 4.7	1.5	70	120	-	-
ADP2107-1.5	1.5	10	10	10 + 10	1.5	70	120	-	-
ADP2107-1.8	1.8	10	10	10 + 10	1.8	70	120	-	-
ADP2107-3.3	3.3	10	10	10 + 4.7	2.5	70	120	-	-

[1] 4.7 µF 0805 X5R 10 V Murata–GRM21BR61A475KA73L.
10 µF 0805 X5R 10 V Murata–GRM21BR61A106KE19L.
[2] 4.7 µF 0805 X5R 10 V Murata–GRM21BR61A475KA73L.
10 µF 0805 X5R 10 V Murata–GRM21BR61A106KE19L.
[3] 4.7 µF 0805 X5R 10 V Murata–GRM21BR61A475KA73L.
10 µF 0805 X5R 10 V Murata–GRM21BR61A106KE19L.
22 µF 0805 X5R 6.3 V Murata–GRM21BR60J226ME39L.
[4] 0.5% accuracy resistor.
[5] 0.5% accuracy resistor.

Table 11. Recommended External Components for Popular Output Voltage Options at 80 kHz Crossover Frequency with 5% Overshoot for a 1 A Load Transient (Refer to Figure 35 and Figure 36)

Part	V_{OUT} (V)	C_{IN1} [1] (µF)	C_{IN2} [2] (µF)	C_{OUT} [3] (µF)	L (µH)	R_{COMP} (kΩ)	C_{COMP} (pF)	R_{TOP} [4] (kΩ)	R_{BOT} [5] (kΩ)
ADP2105-ADJ	0.9	4.7	4.7	22 + 22 + 22	2.0	270	39	5	40
ADP2105-ADJ	1.2	4.7	4.7	22 + 22 + 4.7	2.5	270	39	20	40
ADP2105-ADJ	1.5	4.7	4.7	22 + 22	3.0	270	39	35	40
ADP2105-ADJ	1.8	4.7	4.7	22 + 22	3.3	270	39	50	40
ADP2105-ADJ	2.5	4.7	4.7	22 + 10	3.6	270	39	85	40
ADP2105-ADJ	3.3	4.7	4.7	22 + 4.7	4.1	270	39	125	40
ADP2106-ADJ	0.9	4.7	10	22 + 22 + 22	1.5	180	56	5	40
ADP2106-ADJ	1.2	4.7	10	22 + 22 + 4.7	1.8	180	56	20	40
ADP2106-ADJ	1.5	4.7	10	22 + 22	2.0	180	56	35	40
ADP2106-ADJ	1.8	4.7	10	22 + 22	2.2	180	56	50	40
ADP2106-ADJ	2.5	4.7	10	22 + 10	2.5	180	56	85	40
ADP2106-ADJ	3.3	4.7	10	22 + 4.7	3.0	180	56	125	40
ADP2107-ADJ	0.9	10	10	22 + 22 + 22	1.2	140	68	5	40
ADP2107-ADJ	1.2	10	10	22 + 22 + 4.7	1.5	140	68	20	40
ADP2107-ADJ	1.5	10	10	22 + 22	1.5	140	68	35	40
ADP2107-ADJ	1.8	10	10	22 + 22	1.8	140	68	50	40
ADP2107-ADJ	2.5	10	10	22 + 10	1.8	140	68	85	40
ADP2107-ADJ	3.3	10	10	22 + 4.7	2.5	140	68	125	40
ADP2105-1.2	1.2	4.7	4.7	22 + 22 + 4.7	2.5	270	39	-	-
ADP2105-1.5	1.5	4.7	4.7	22 + 22	3.0	270	39	-	-
ADP2105-1.8	1.8	4.7	4.7	22 + 22	3.3	270	39	-	-
ADP2105-3.3	3.3	4.7	4.7	22 + 4.7	4.1	270	39	-	-
ADP2106-1.2	1.2	4.7	10	22 + 22 + 4.7	1.8	180	56	-	-
ADP2106-1.5	1.5	4.7	10	22 + 22	2.0	180	56	-	-
ADP2106-1.8	1.8	4.7	10	22 + 22	2.2	180	56	-	-
ADP2106-3.3	3.3	4.7	10	22 + 4.7	3.0	180	56	-	-
ADP2107-1.2	1.2	10	10	22 + 22 + 4.7	1.5	140	68	-	-
ADP2107-1.5	1.5	10	10	22 + 22	1.5	140	68	-	-
ADP2107-1.8	1.8	10	10	22 + 22	1.8	140	68	-	-
ADP2107-3.3	3.3	10	10	22 + 4.7	2.5	140	68	-	-

[1] 4.7µF 0805 X5R 10V Murata – GRM21BR61A475KA73L
10µF 0805 X5R 10V Murata – GRM21BR61A106KE19L
[2] 4.7µF 0805 X5R 10V Murata – GRM21BR61A475KA73L
10µF 0805 X5R 10V Murata – GRM21BR61A106KE19L
[3] 4.7µF 0805 X5R 10V Murata – GRM21BR61A475KA73L
10µF 0805 X5R 10V Murata – GRM21BR61A106KE19L
22µF 0805 X5R 6.3V Murata – GRM21BR60J226ME39L
[4] 0.5% Accuracy Resistor
[5] 0.5% Accuracy Resistor

CIRCUIT BOARD LAYOUT RECOMMENDATIONS

Good circuit board layout is essential in obtaining the best performance from the ADP2105/ADP2106/ADP2107. Poor circuit layout degrades the output ripple, as well as the electromagnetic interference (EMI) and electromagnetic compatibility (EMC) performance.

Figure 52 and Figure 53 show the ideal circuit board layout for the ADP2105/ADP2106/ADP2107. Use this layout to achieve the highest performance. Refer to the following guidelines if adjustments to the suggested layout are needed.

- Use separate analog and power ground planes. Connect the ground reference of sensitive analog circuitry (such as compensation and output voltage divider components) to analog ground; connect the ground reference of power components (such as input and output capacitors) to power ground. In addition, connect both the ground planes to the exposed pad of the ADP2105/ADP2106/ADP2107.
- For each PWIN pin, place an input capacitor as close to the PWIN pin as possible and connect the other end to the closest power ground plane.
- Place the 0.1 µF, 10 Ω low-pass input filter between the IN pin and the PWIN1 pin, as close to the IN pin as possible.
- Ensure that the high current loops are as short and as wide as possible. Make the high current path from C_{IN} through L, C_{OUT}, and the PGND plane back to C_{IN} as short as possible. To accomplish this, ensure that the input and output capacitors share a common PGND plane.

  Also, make the high current path from PGND pin of the ADP2105/ADP2106/ADP2107 through L and C_{OUT} back to the PGND plane as short as possible. To do this, ensure that the PGND pin of the ADP2105/ADP2106/ADP2107 is tied to the PGND plane as close as possible to the input and output capacitors.
- Place the feedback resistor divider network as close as possible to the FB pin to prevent noise pickup. Try to minimize the length of trace connecting the top of the feedback resistor divider to the output while keeping away from the high current traces and the switch node (LX) that can lead to noise pickup. To reduce noise pickup, place an analog ground plane on either side of the FB trace. For the low fixed voltage options (1.2 V and 1.5 V), poor routing of the OUT_SENSE trace can lead to noise pickup, adversely affecting load regulation. This can be fixed by placing a 1 nF bypass capacitor close to the OUT_SENSE pin.
- The placement and routing of the compensation components are critical for proper behavior of the ADP2105/ADP2106/ADP2107. The compensation components should be placed as close to the COMP pin as possible. It is advisable to use 0402-sized compensation components for closer placement, leading to smaller parasitics. Surround the compensation components with analog ground plane to prevent noise pickup. Also, ensure that the metal layer under the compensation components is the analog ground plane.

EVALUATION BOARD

EVALUATION BOARD SCHEMATIC (ADP2107-1.8)

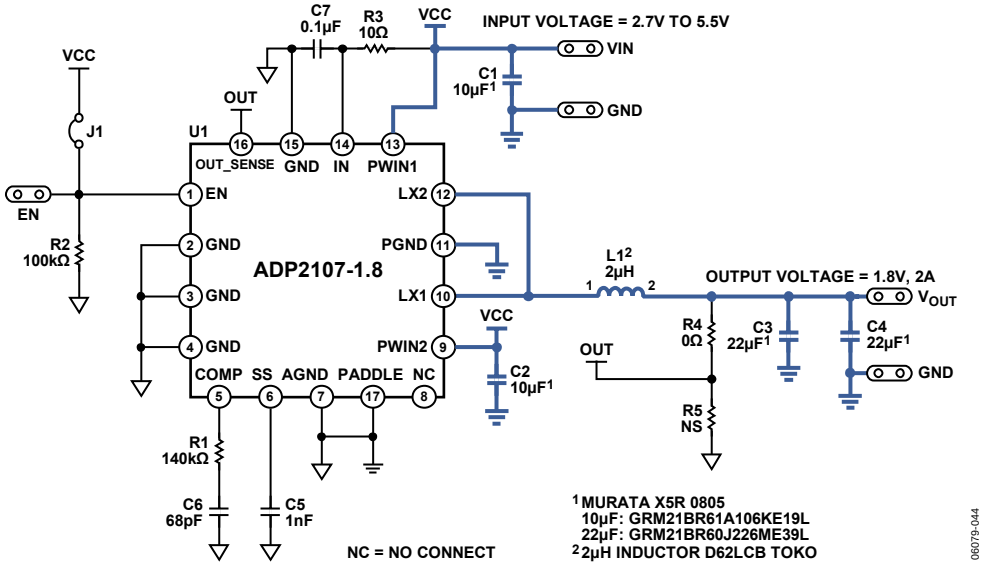


Figure 51. Evaluation Board Schematic of the ADP2107-1.8 (Bold Traces Are High Current Paths)

RECOMMENDED PCB BOARD LAYOUT (EVALUATION BOARD LAYOUT)

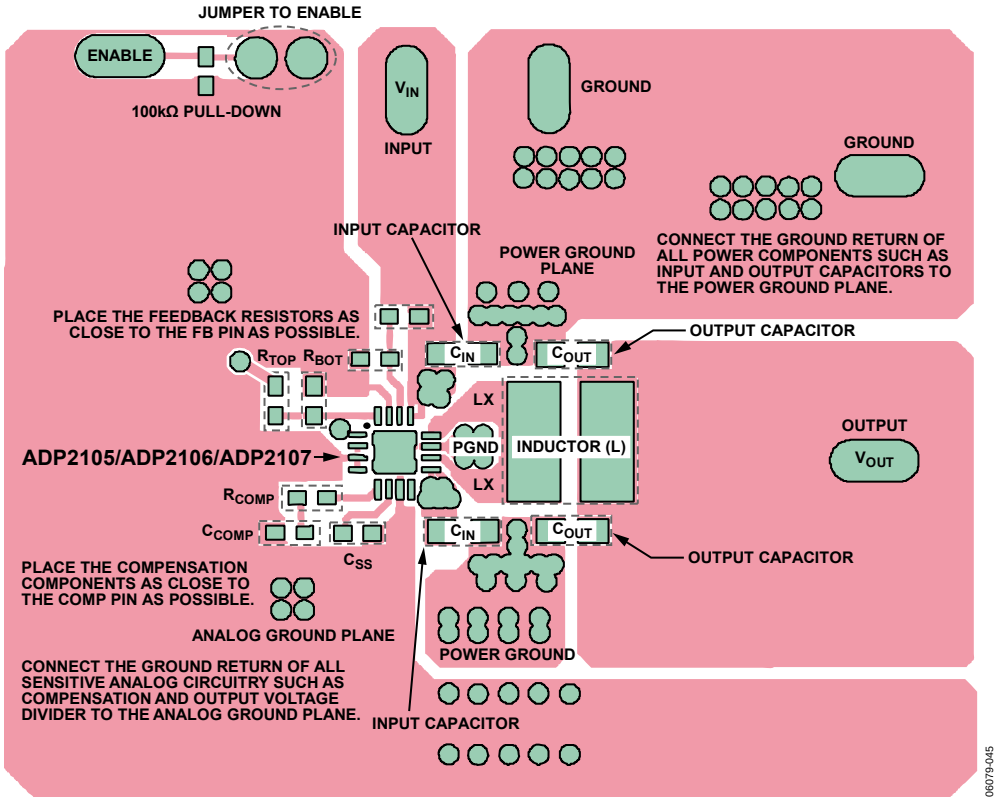


Figure 52. Recommended Layout of Top Layer of ADP2105/ADP2106/ADP2107

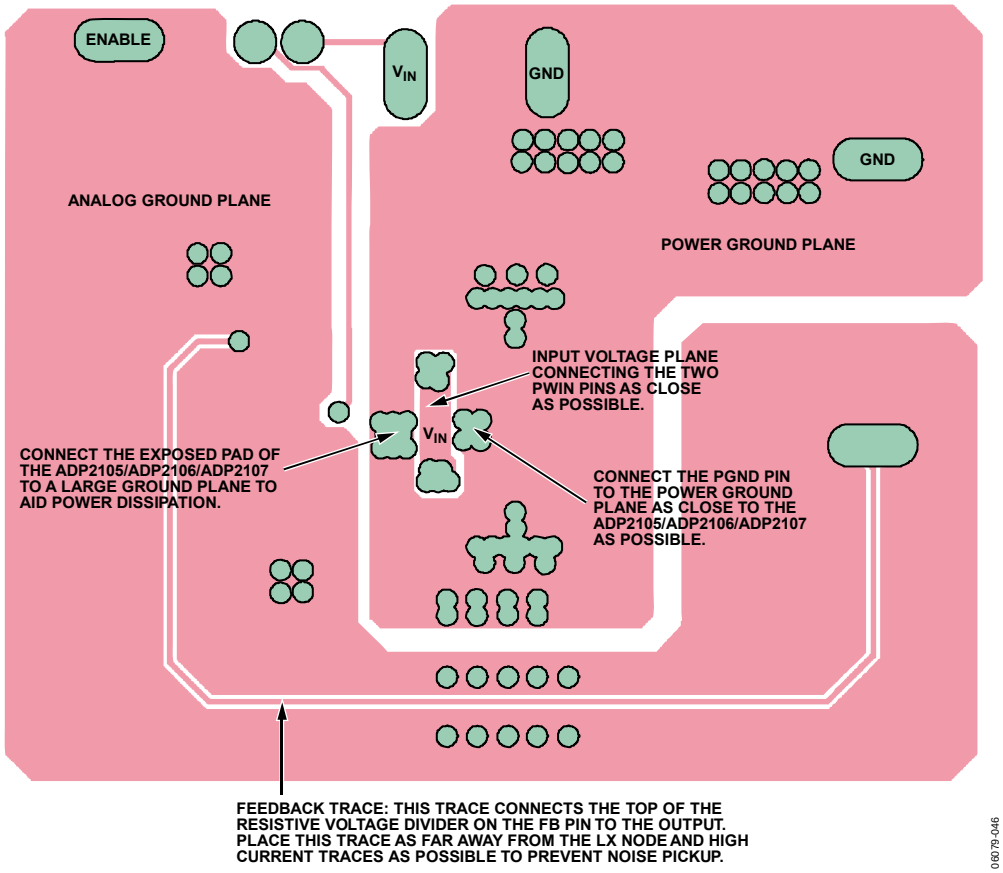


Figure 53. Recommended Layout of Bottom Layer of ADP2105/ADP2106/ADP2107

APPLICATION CIRCUITS

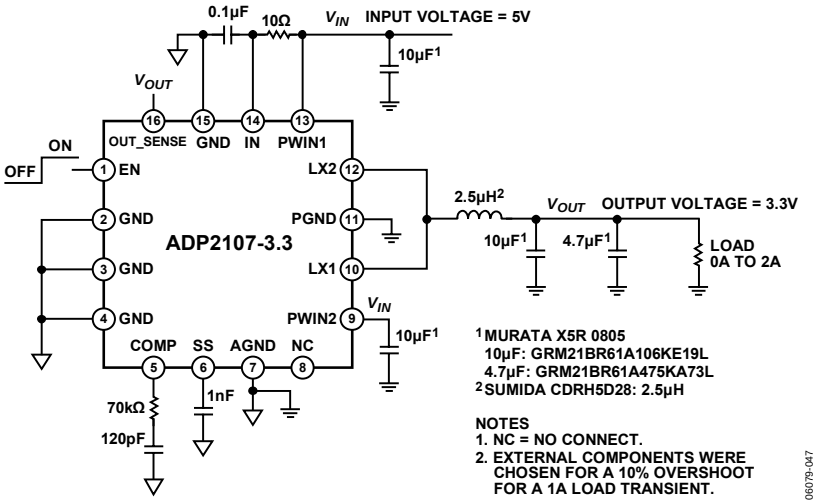


Figure 54. Application Circuit—V_{IN} = 5 V, V_{OUT} = 3.3 V, LOAD = 0 A to 2 A

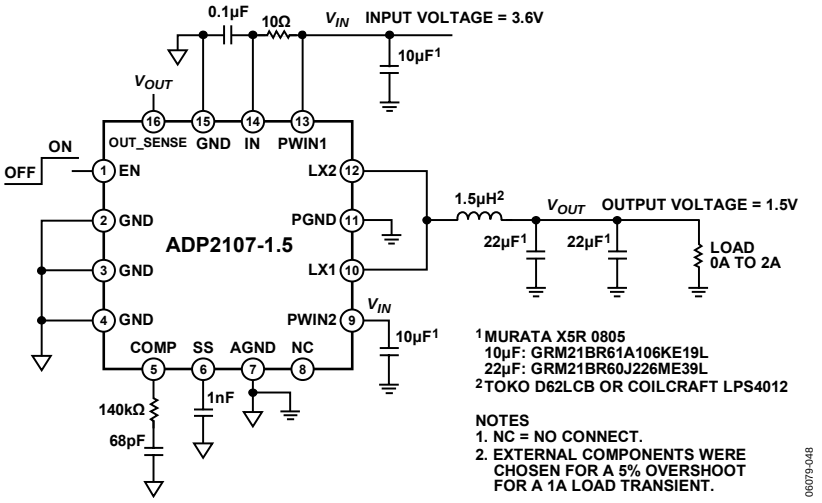


Figure 55. Application Circuit—V_{IN} = 3.6 V, V_{OUT} = 1.5 V, LOAD = 0 A to 2 A

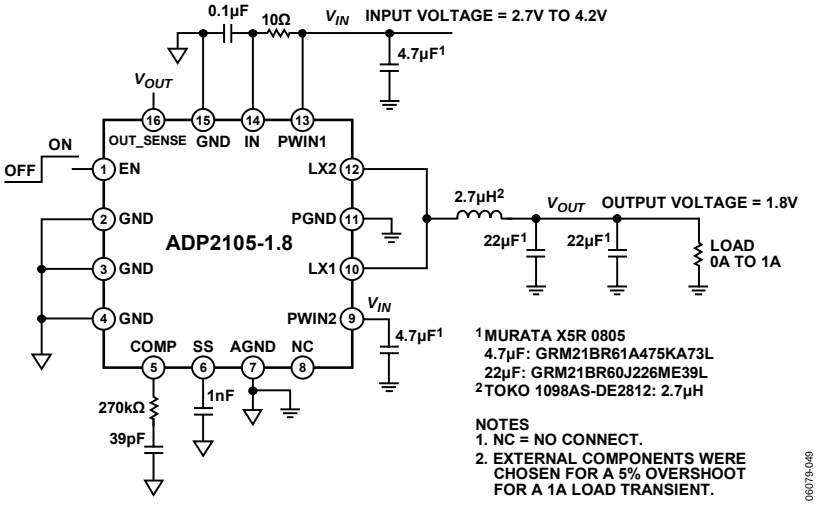


Figure 56. Application Circuit—V_{IN} = Li-Ion Battery, V_{OUT} = 1.8 V, LOAD = 0 A to 1 A

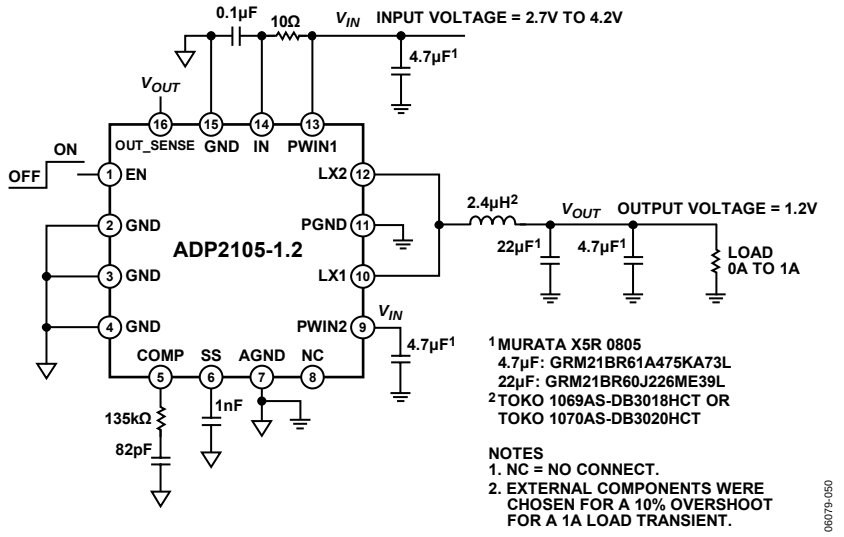


Figure 57. Application Circuit—V_{IN} = Li-Ion Battery, V_{OUT} = 1.2 V, LOAD = 0 A to 1 A

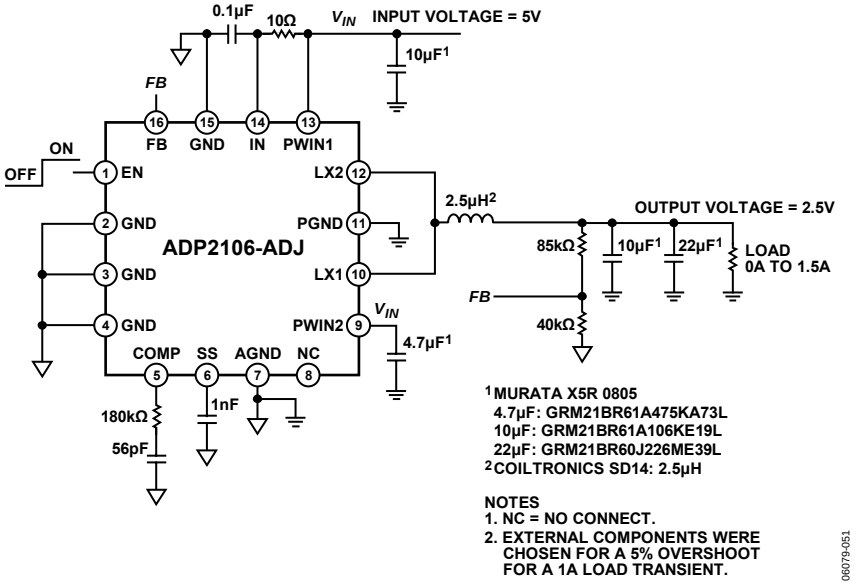


Figure 58. Application Circuit—V_{IN} = 5 V, V_{OUT} = 2.5 V, LOAD = 0 A to 1.5 A

OUTLINE DIMENSIONS

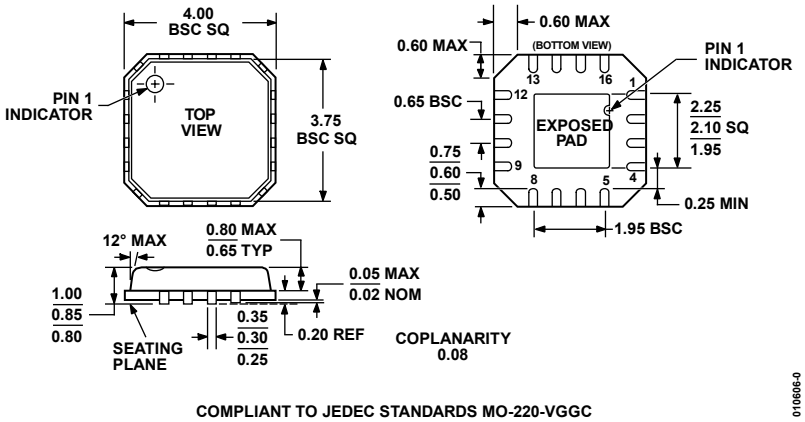


Figure 59. 16-Lead Lead Frame Chip Scale Package [LFCSP_VQ]
4 mm × 4 mm Body, Very Thin Quad
(CP-16-4)
Dimensions shown in millimeters

ORDERING GUIDE

Model	Output Current	Junction Temperature Range	Output Voltage	Package Description	Package Option
ADP2105ACPZ-1.2-R7[1]	1 A	−40°C to +125°C	1.2 V	16-Lead LFCSP_VQ	CP-16-4
ADP2105ACPZ-1.5-R7[1]	1 A	−40°C to +125°C	1.5 V	16-Lead LFCSP_VQ	CP-16-4
ADP2105ACPZ-1.8-R7[1]	1 A	−40°C to +125°C	1.8 V	16-Lead LFCSP_VQ	CP-16-4
ADP2105ACPZ-3.3-R7[1]	1 A	−40°C to +125°C	3.3 V	16-Lead LFCSP_VQ	CP-16-4
ADP2105ACPZ-R7[1]	1 A	−40°C to +125°C	ADJ	16-Lead LFCSP_VQ	CP-16-4
ADP2106ACPZ-1.2-R7[1]	1.5 A	−40°C to +125°C	1.2 V	16-Lead LFCSP_VQ	CP-16-4
ADP2106ACPZ-1.5-R7[1]	1.5 A	−40°C to +125°C	1.5 V	16-Lead LFCSP_VQ	CP-16-4
ADP2106ACPZ-1.8-R7[1]	1.5 A	−40°C to +125°C	1.8 V	16-Lead LFCSP_VQ	CP-16-4
ADP2106ACPZ-3.3-R7[1]	1.5 A	−40°C to +125°C	3.3 V	16-Lead LFCSP_VQ	CP-16-4
ADP2106ACPZ-R7[1]	1.5 A	−40°C to +125°C	ADJ	16-Lead LFCSP_VQ	CP-16-4
ADP2107ACPZ-1.2-R7[1]	2 A	−40°C to +125°C	1.2 V	16-Lead LFCSP_VQ	CP-16-4
ADP2107ACPZ-1.5-R7[1]	2 A	−40°C to +125°C	1.5 V	16-Lead LFCSP_VQ	CP-16-4
ADP2107ACPZ-1.8-R7[1]	2 A	−40°C to +125°C	1.8 V	16-Lead LFCSP_VQ	CP-16-4
ADP2107ACPZ-3.3-R7[1]	2 A	−40°C to +125°C	3.3 V	16-Lead LFCSP_VQ	CP-16-4
ADP2107ACPZ-R7[1]	2 A	−40°C to +125°C	ADJ	16-Lead LFCSP_VQ	CP-16-4
ADP2105-1.8-EVAL			1.8 V	Evaluation Board	
ADP2105-EVAL			Adjustable, but set to 2.5 V	Evaluation Board	
ADP2106-1.8-EVAL			1.8 V	Evaluation Board	
ADP2106-EVAL			Adjustable, but set to 2.5 V	Evaluation Board	
ADP2107-1.8-EVAL			1.8 V	Evaluation Board	
ADP2107-EVAL			Adjustable, but set to 2.5 V	Evaluation Board	

[1] Z = Pb-free part.

NOTES

D06079-0-7/06(0)