AUR9716

1.0MHZ TO 1.4MHZ 2A STEP-DOWN DC-DC CONVERTER

Description

The AUR9716 is a high efficiency step-down DC-DC voltage converter. The chip operation is optimized by peak-current mode architecture with built-in synchronous power MOS switchers. It is automatically switching between the normal PWM mode and LDO mode to offer improved system power efficiency covering a wide range of loading conditions.

Switching frequency during 1.0MHz to 1.4MHz is set by an external resistor and integrated Soft-Start (SS), Under-Voltage-Lock-Out (UVLO), Thermal Shutdown Detection (TSD) and short circuit protection are designed to provide reliable product applications.

The device is available in adjustable output voltage versions ranging from 0.8V to V_{IN} when input voltage range is from 2.5V to 5.5V , and is able to deliver up to 2A.

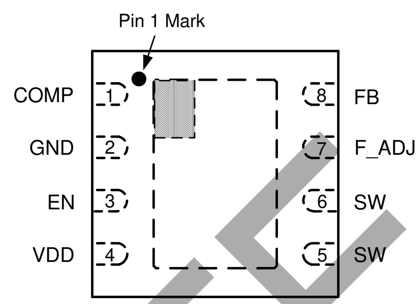
The AUR9716 is available in DFN-3×3-8 package.

Features

- High Efficiency Buck Power Converter
- Low Quiescent Current
- 2A Output Current
- Low $R_{DS(ON)}$ Internal Switches: 110mΩ
- Adjustable Output Voltage from 0.8V to V_{IN}
- Wide Operating Voltage Range: 2.5V to 5.5V
- Built-In Power Switches for Synchronous Rectification with High Efficiency
- 800mV Feedback Voltage Allows Output
- Programmable Frequency: 1.0MHz to 1.4MHz
- Thermal Shutdown Protection
- Low Drop-Out Operation at 100% Duty Cycle
- No Schottky Diode Required

Pin Assignments

(Top View)

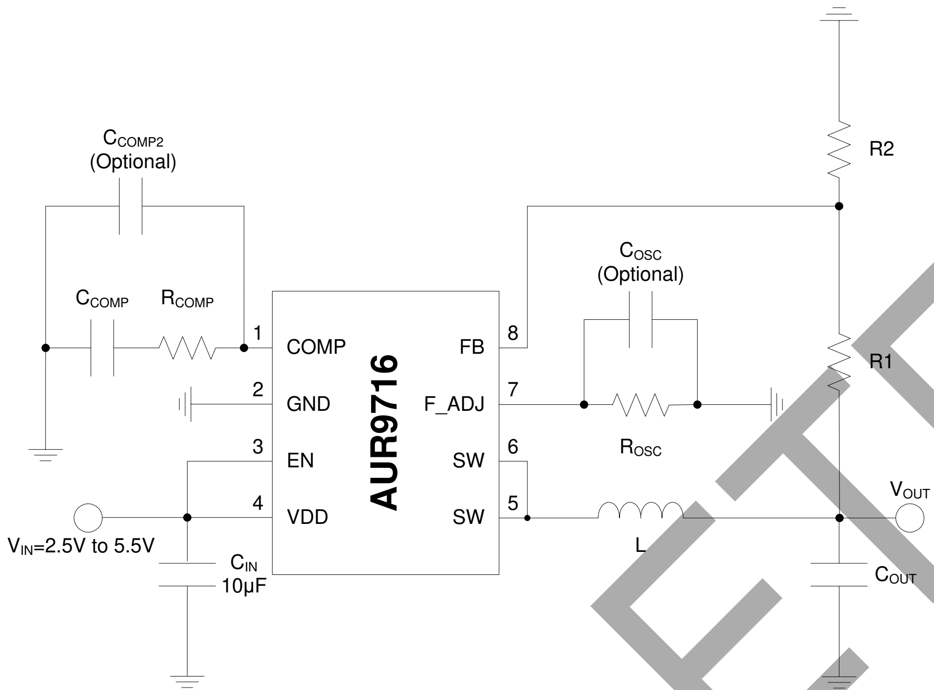


DFN-3×3-8

Applications

- LCD TV
- Post DC-DC Voltage Regulation
- PDA and Notebook Computers

Typical Applications Circuit



V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
3.3	6.25	2
2.5	4.25	2
1.8	2.5	2
1.1	0.75	2

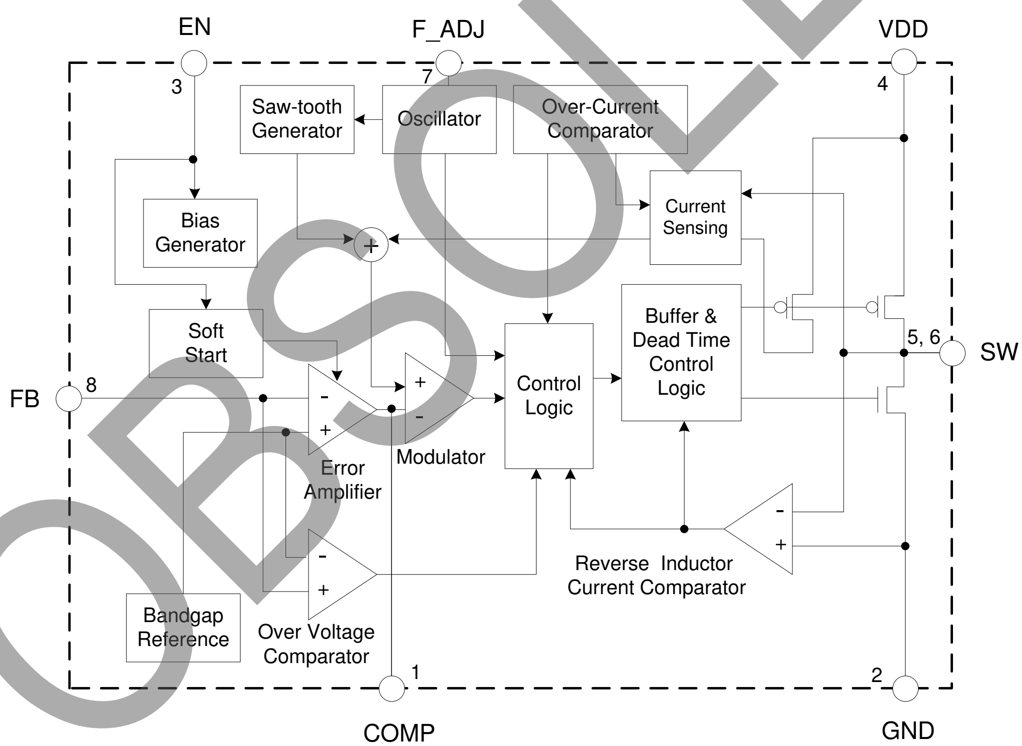
Switching Frequency (MHz)	R_{OSC} (kΩ)	R_{COMP} (kΩ)	C_{COMP} (nF)	L (μH)	C_{OUT} (μF)
1.0	536	3.6	1.5	2.2	10
1.2	976	4.3	1.0	1.5	10
1.4	5100	4.3	1.0	1.5	10

Table 1. Component Guide

Pin Descriptions

Pin Number	Pin Name	Function
1	COMP	Compensation Point. COMP is used to compensate the regulation control loop. Connect R and C from COMP and GND to compensate the regulation control loop
2	GND	Ground. The exposed pad is soldered to PCB and connected to GND plant for good power dissipation
3	EN	Enable Input. EN is an input when the regulator on or off. When left unconnected, EN pin is pulled to VDD by the internal pull up resistor
4	VDD	Power input V_{IN} provides the input power to the regulator. Connecting a ceramic bypass capacitor between VDD and GND to eliminate input noise and ripple voltage
5	SW	Switch Output. SW is the switching point which supplies voltage and current to output
6		
7	F_ADJ	Oscillator Resistor Input. Connecting a resistor to ground from this pin sets the switching frequency
8	FB	Feedback Input. Receives the feedback voltage from a resistive divider connected across the output. The feedback reference voltage is 0.8V typically

Functional Block Diagram



Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Value	Unit
V_{IN}	Supply Input Voltage	-0.3 to 6.0	V
V_{SW}	SW Pin Switch Voltage	-0.3 to V_{IN}+0.3	V
V_{EN}	Output Voltage	-0.3 to V_{IN} +0.3	V
I_{SW-P}	P-MOSFET Switch Source Current	3.5	A
I_{SW-N}	N-MOSFET Switch Sink Current	3.5	A
P_D	Power Dissipation (on PCB, T_A=+25°C)	2.56	W
$θ_{JA}$	Package Thermal Resistance (Junction to Ambient)	39.13	°C/W
$θ_{JC}$	Package Thermal Resistance (Junction to Case)	3.39	°C/W
T_{LEAD}	Lead Temperature (Soldering, 5sec)	+260	°C
T_J	Junction Temperature	+150	°C
T_{OP}	Operating Temperature Range	-40 to +85	°C
T_{STG}	Storage Temperature Range	-55 to +150	°C
V_{HBM}	ESD (Human Body Model)	2000	V
V_{MM}	ESD (Machine Model)	200	V

Note 1: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

Recommended Operating Conditions

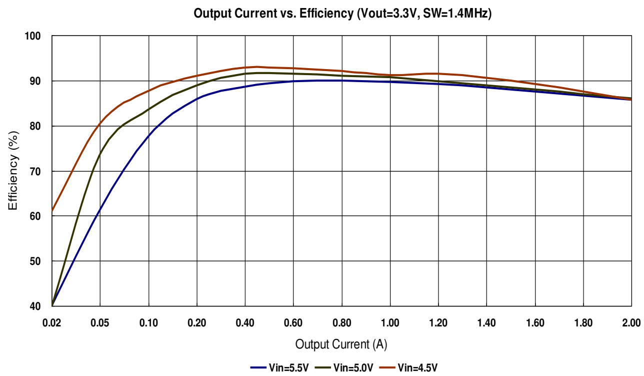
Symbol	Parameter	Min	Max	Unit
V_{IN}	Supply Input Voltage	2.5	5.5	V
T_J	Junction Temperature Range	-20	+125	°C
T_A	Operating Temperature Range	-40	+80	°C

Electrical Characteristics (V_{IN}=5V, V_{FB}=0.8V, f_{OSC}=1.4MHz, L=1.5μH, C_{IN}=10μF, C_{OUT}=10μF, T_A=+25°C, unless otherwise specified.)

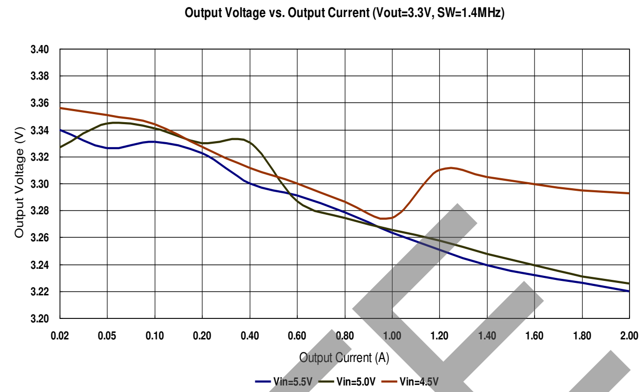
Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range	–	2.5	–	5.5	V
I_{OFF}	Shutdown Current	V_{EN}=0V	–	0.1	1	μA
I_{ON}	Active Current	V_{FB}=0.95V	–	460	–	μA
V_{FB}	Regulated Feedback Voltage	For adjustable output voltage	0.784	0.8	0.816	V
$\Delta V_{OUT}/V_{OUT}$	Regulated Output Voltage	V_{IN}=2.5V to 5.5V, I_{OUT}=0A to 2A	-3	–	3	%
I_{PK}	Peak Inductor Current	V_{FB}=0.7V	2.2	3.2	3.7	A
f_{OSC}	Oscillator Frequency	R_{OSC}=5.1MΩ	1.12	1.4	1.68	MHz
		Adjustable switching frequency	1.0	–	1.4	
$R_{DSON(P)}$	P_MOSFET R_{ON}	I_{SW}=0.5A	90	110	130	mΩ
$R_{DSON(N)}$	N_MOSFET R_{ON}	I_{SW}=0.5A	90	110	130	mΩ
V_{ENH}	EN Input High-Threshold Voltage	Enable Threshold	1.5	–	–	V
V_{ENL}	EN Input Low-Threshold Voltage	Shutdown Threshold	–	–	0.4	V
I_{EN}	EN Input Current	–	–	2	–	μA
t_{SS}	Soft-start Time	–	–	800	–	μs
D_{MAX}	Maximum Duty Cycle	–	100	–	–	%
V_{UVLO}	Under Voltage Lock Out Threshold	V_{IN} Rising	–	2.4	–	V
		V_{IN} Falling	–	2.3	–	
		Hysteresis	–	0.1	–	
T_{SD}	Thermal Shutdown	Hysteresis=30°C	–	+150	–	°C
g_m	Error Amplifier Trans Conductance	–	–	3000	–	μs
R_T	Current Sense Trans Resistance	–	–	5	–	Ω

Performance Characteristics

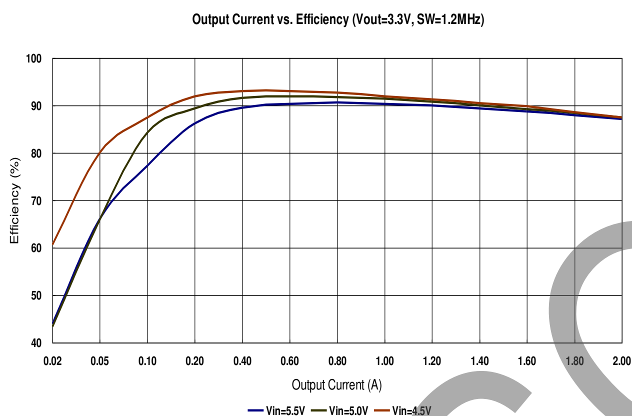
Output Current vs. Efficiency



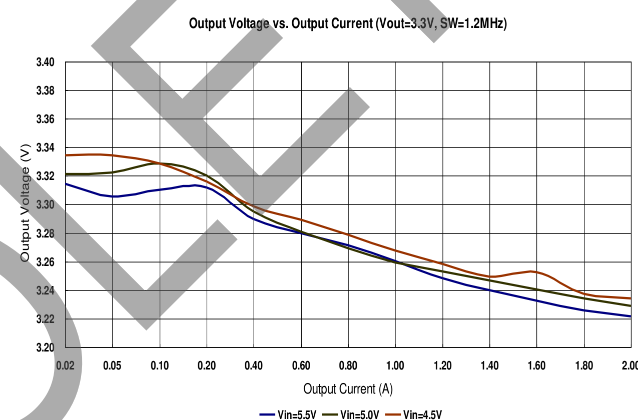
Output Voltage vs. Output Current



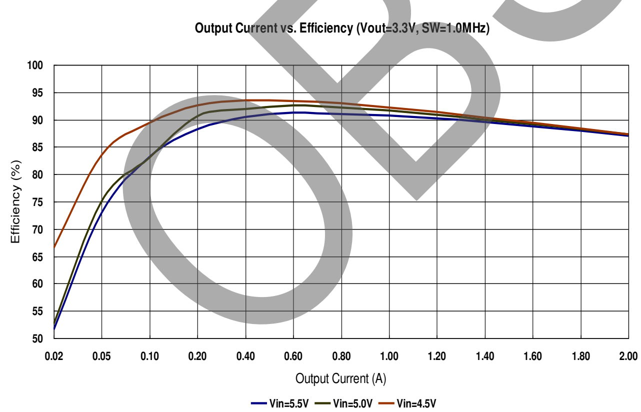
Output Current vs. Efficiency



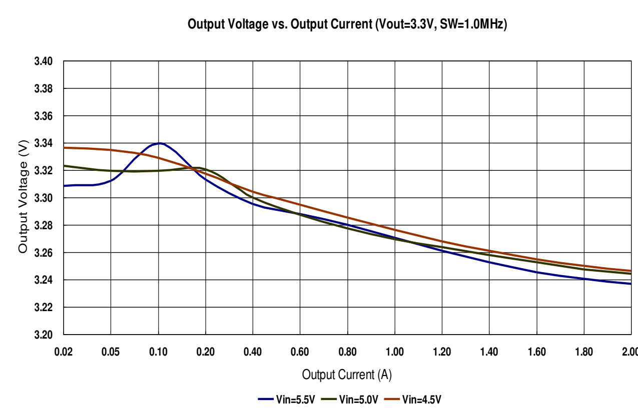
Output Voltage vs. Output Current



Output Current vs. Efficiency

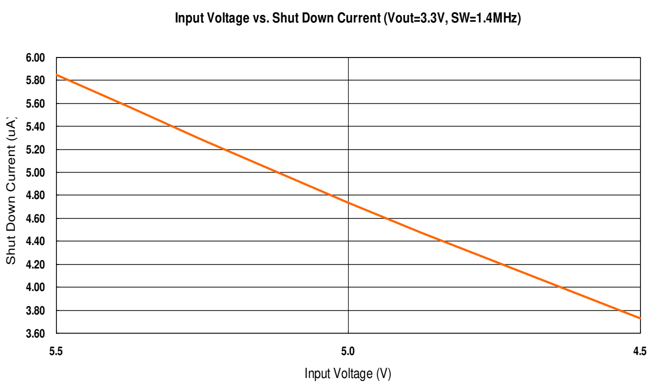


Output Voltage vs. Output Current

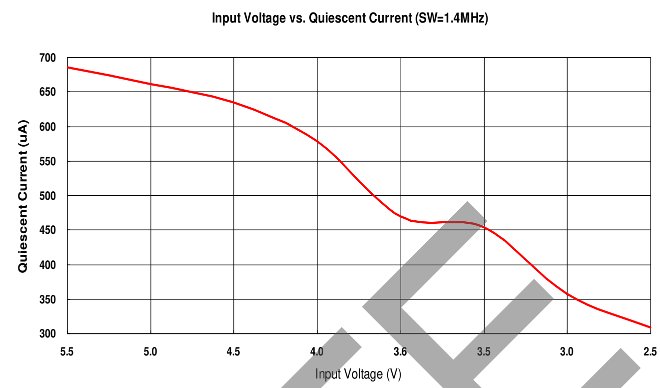


Performance Characteristics (continued)

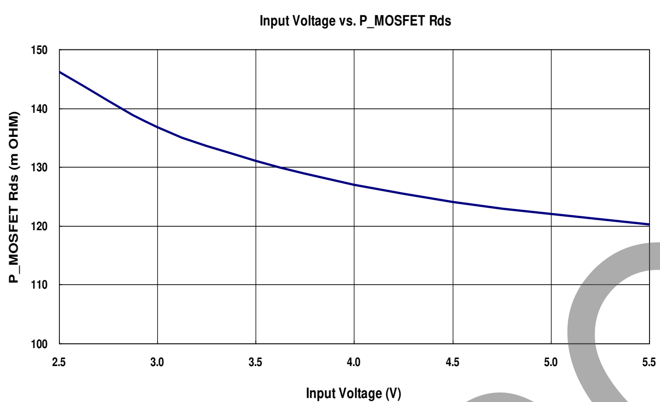
Input Voltage vs. Shutdown Current



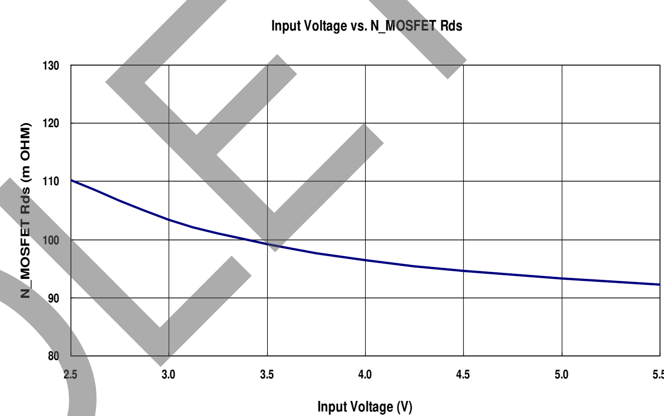
Input Voltage vs. Quiescent Current



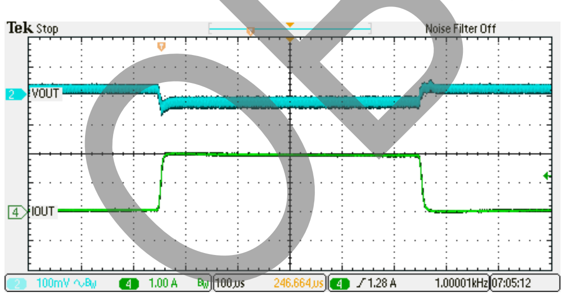
Input Voltage vs. P_MOSFET R_{DS}



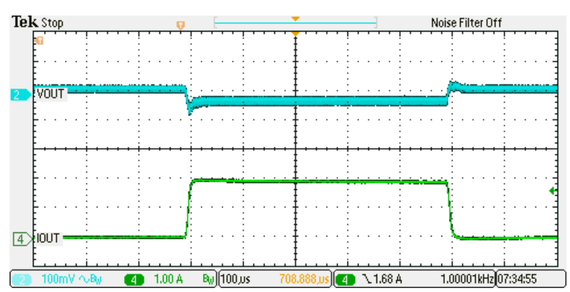
Input Voltage vs. N_MOSFET R_{DS}



Load Regulation (V_{IN}=5V, V_{OUT}=1.1V, f_{OSC}=1.4MHz, I_{OUT}=0.1A to 2A)

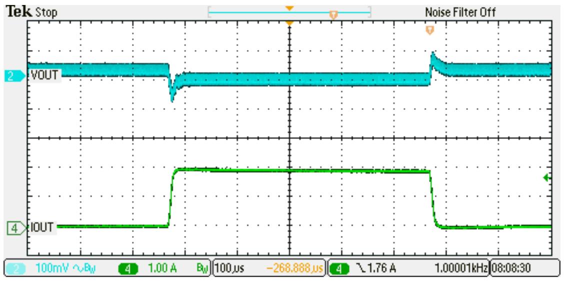


Load Regulation (V_{IN}=5V, V_{OUT}=1.1V, f_{OSC}=1.2MHz, I_{OUT}=0.1A to 2A)

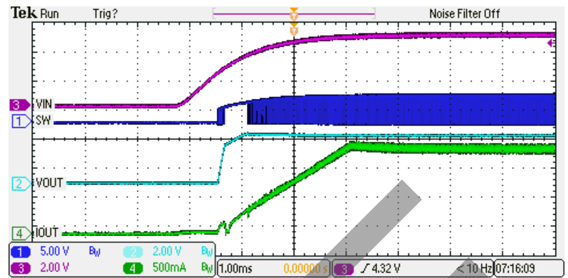


Performance Characteristics (continued)

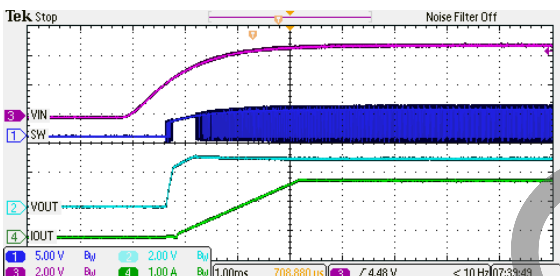
Load Regulation (V_{IN}=5V, V_{OUT}=1.1V, f_{OSC}=1.0MHz, I_{OUT}=0.1A to 2A)



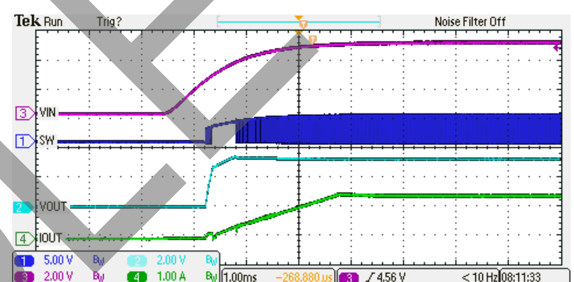
Power Start-up (V_{IN}=0V to 5V, V_{OUT}=3.3V, f_{OSC}=1.4MHz, I_{OUT}=2A)



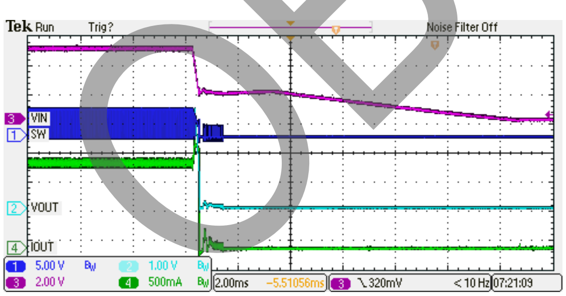
Power Start-up (V_{IN}=0V to 5V, V_{OUT}=3.3V, f_{OSC}=1.2MHz, I_{OUT}=2A)



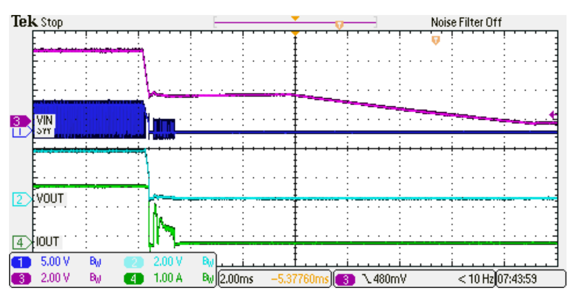
Power Start-up (V_{IN}=0V to 5V, V_{OUT}=3.3V, f_{OSC}=1.0MHz, I_{OUT}=2A)



Power Turn-off (V_{IN}=5V to 0V, V_{OUT}=3.3V, f_{OSC}=1.4MHz, I_{OUT}=2A)

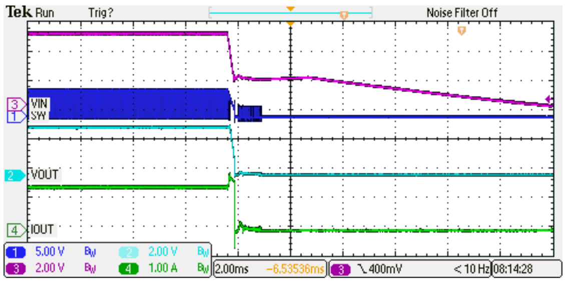


Power Turn-off (V_{IN}=5V to 0V, V_{OUT}=3.3V, f_{OSC}=1.2MHz, I_{OUT}=2A)



Performance Characteristics (continued)

Power Turn-off (V_{IN}=5V to 0V, V_{OUT}=3.3V, f_{OSC}=1.0MHz, I_{OUT}=2A)



Application Information

The AUR9716 is a synchronous buck converter which can support switching frequency range from 1.0MHz to 1.4MHz and the output current can be up to 2A. The basic AUR9716 application circuits are shown as Typical Applications Circuit, external components selection is determined by the load current and is critical with the selection of inductor and capacitor values.

1. Inductor Selection

For most applications, the value of inductor is chosen based on the required ripple current with the range of 1.5µH to 4.7µH.

$$\Delta I_L = \frac{1}{f \times L} V_{OUT} (1 - \frac{V_{OUT}}{V_{IN}})$$

The largest ripple current occurs at the highest input voltage. Having a small ripple current reduces the ESR loss in the output capacitor and improves the efficiency. The highest efficiency is realized at low operating frequency with small ripple current. However, the larger value inductors will be required. A reasonable starting point for ripple current setting is $\Delta I_L = 40\% I_{MAX}$. For a maximum ripple current stays below a specified value, the inductor should be chosen according to the following equation:

$$L = [\frac{V_{OUT}}{f \times \Delta I_L (MAX)}][1 - \frac{V_{OUT}}{V_{IN}(MAX)}]$$

The DC current rating of the inductor should be at least equal to the maximum output current plus half of the highest ripple current to prevent inductor core saturation. For better efficiency, the lower DC-resistance inductor should be selected.

2. Capacitor Selection

The input capacitance, C_{IN}, is needed to filer the trapezoidal current at the source of the top MOSFET. To prevent the large ripple voltage, a low ESR input capacitor sized for the maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$I_{RMS} = I_{OMAX} \times \frac{[V_{OUT}(V_{IN} - V_{OUT})]^{\frac{1}{2}}}{V_{IN}}$$

It indicates a maximum value at $V_{IN} = 2V_{OUT}$, where $I_{RMS} = \frac{I_{OUT}}{2}$. This simple worse-case condition is commonly used for design because even significant deviations do not much relief. The selection of C_{OUT} is determined by the equivalent series resistance (ESR) that is required to minimize output voltage ripple and load step transients, as well as the amount of bulk capacitor that is necessary to ensure the control loop is stable. Loop stability can be also checked by viewing the load step transient response as described in a latter section. The output ripple, ΔV_{OUT}, is determined by:

$$\Delta V_{OUT} \le \Delta I_L [ESR + \frac{1}{8 \times f \times C_{OUT}}]$$

The output ripple is the highest at the maximum input voltage since ΔI_L increases with input voltage.

Application Information (continued)

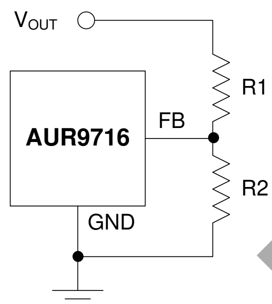
3. Load Transient

A switching regulator typically takes several cycles to respond to the load current step. When a load step occurs, V_{OUT} immediately shifts by an amount equal to $(\Delta I_{LOAD} \times ESR)$, where ESR is the equivalent series resistance of output capacitor. ΔI_{LOAD} also begins to charge or discharge C_{OUT} generating a feedback error signal used by the regulator to return V_{OUT} to its steady-state value. During the recovery time, V_{OUT} can be monitored for overshoot or ringing that would indicate a stability problem.

4. Output Voltage Setting

The output voltage of AUR9716 can be adjusted by a resistive divider according to the following formula: $V_{OUT} = V_{FB} \times (1 + \frac{R_1}{R_2}) = 0.8V \times (1 + \frac{R_1}{R_2})$

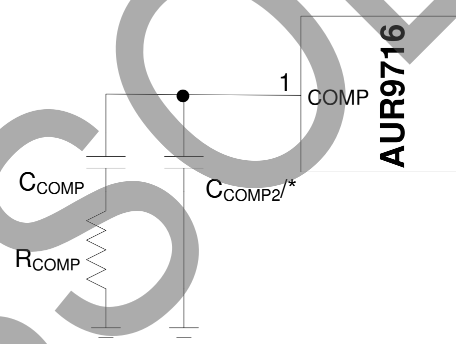
When V_{FB} is the 0.8V feedback reference voltage, the resistive divider senses the fraction of the output voltage as shown in Figure of Setting the Output Voltage.



Setting the Output Voltage

5. Slope Compensation

The slope compensation of AUR9716 provides stability in constant frequency construction by preventing oscillations at duty cycle more than 50%. It's accomplished externally by adding a series of capacitor and resistor, as shown in Figure of. Stability Compensation Components



Stability Compensation Components

The DC loop gain of the system is determined by the following equation:

$$A_{VDC} = \frac{V_{FB}}{I_{OUT}} A_V G_{CS},$$

Where A_V is error amplifier voltage gain and G_{CS} is current sense transconductance.

The dominant pole P1 is due to C_{COMP}:

$$f_{P1} = \frac{G_{EA}}{2\pi A_V C_{COMP}},$$

Where G_{EA} is error amplifier transconductance.

The output pole P2 is due to C_{OUT}:

Application Information (continued)

$$f_{P2} = \frac{I_{OUT}}{2\pi V_{OUT} C_{OUT}}$$

The zero Z1 is due to C_{COMP} and R_{COMP}:

$$f_{Z1} = \frac{1}{2\pi R_{COMP} C_{COMP}}$$

If C_{COMP2} is used, the third pole is due to R_{COMP} and C_{COMP2}:

$$f_{P3} = \frac{1}{2\pi R_{COMP} C_{COMP2}}$$

Then the cross over frequency often sets at 1/5 to 1/10 of the switching frequency.

Table 1 shows some calculated results based on stability compensation equations above.

Switching Frequency (MHz)	1.4	1.2	1.0
R_{COMP} (kΩ)	4.3	4.3	3.6
C_{COMP} (nF)	1	1	1.5
L (µH)	1.5	1.5	2.2
C_{OUT} (µF)	10	10	10

Table 1. Stability Compensation Components

To optimize the components for stability compensation listed in Table 1, we will introduce the selection value of R_{COMP} and C_{COMP} as detail as possible.

1. R_{COMP}: determine this resistor value according to the desired crossover frequency is f_C, default as 1.4MHz.

$$R_{COMP} = \frac{2\pi C_{OUT} f_C}{G_{EA} G_{CS}} \frac{V_{OUT}}{V_{FB}}$$

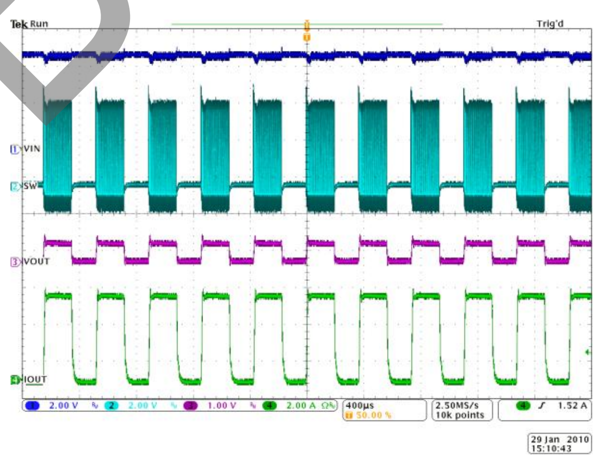
2. C_{COMP}: determine this capacitor value according to the desired phase margin. We often choose this compensation.

Zero point below one fourth of the crossover frequency to ensure the loop stability.

$$C_{COMP} > \frac{4}{2\pi R_{COMP} f_C}$$

6. Short-Circuit Protection

When AUR9716 output node is shorted to GND, as V_{FB} drops under 0.4V, chip will enter soft-start to protect itself, when short circuit is removed, and V_{FB} rises over 0.4V, the AUR9716 enters normal operation again. If AUR9716 reaches OCP threshold while short circuit, it will enter soft-start cycle until the current under OCP threshold. When AUR9716 is used to transfer V_{IN}=5V to V_{OUT}=2.5V, shorting V_{OUT} to GND makes big current which enables SCP protection. The waveform is shown in Figure of SCP Protection.



SCP Protection

Application Information (continued)

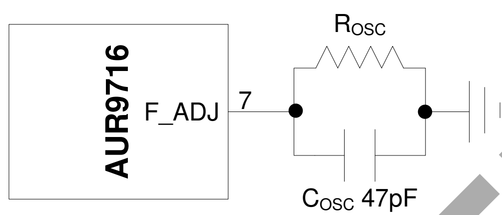
7. F_ADJ : R_{OSC} Selection

The AUR9716 can change switching frequency by choose different R_{OSC}, please refer to Table 2.

Switching Frequency (MHz)	1.4	1.2	1.0
R_{OSC} (kΩ)	5100	976	536

Table 2. R_{OSC} Setting

Due to get the better performance of AUR9716, F_ADJ pin (Pin 7) could parallel 47pF capacitor with R_{OSC}, shown in Figure of F_ADJ Components.



F_ADJ Components

8. Thermal Characteristics

The max power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of temperature between junction to ambient. The max power dissipation can be calculated by following formula:

$$P_{D(MAX)} = \left(\frac{T_{J(MAX)} - T_A}{\theta_{JA}} \right)$$

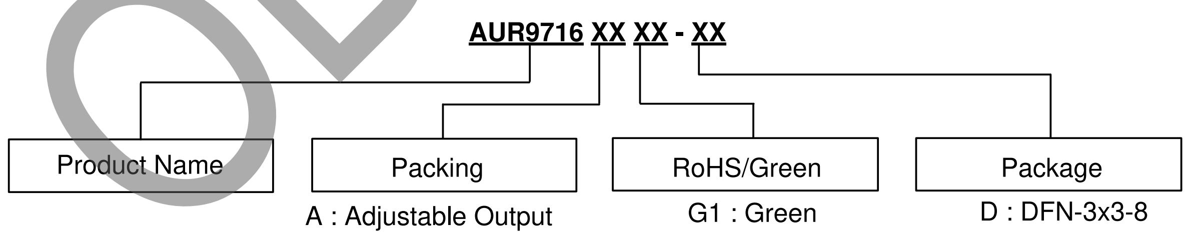
Where $T_{J(MAX)}$ is the maximum operation junction temperature, T_A is the ambient temperature and θ_{JA} is the junction to ambient thermal resistance.

9. PC Board Layout Considerations

When laying out the printed circuit board, the following checklist should be used to optimize the performance of AUR9716.

1. The power traces, including the GND trace, the SW trace and the VDD trace should be kept direct, short and wide.
2. To put the input capacitor as close as possible to the VDD and GND pins.
3. The FB pin should be connected directly to the feedback resistor divider.
4. Keep the switching node, SW, away from the sensitive FB pin and the node should be kept small area.

Ordering Information

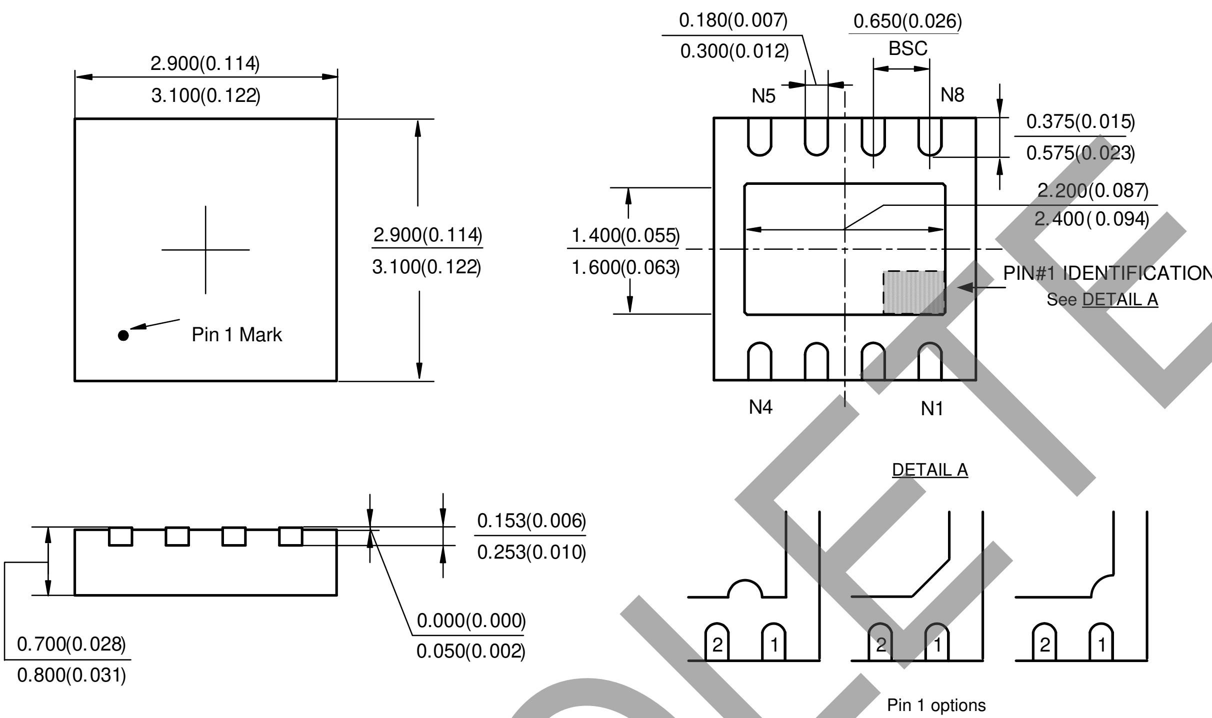


Package	Temperature Range	Part Number	Marking ID	Packing
DFN-3×3-8	-40 to +80°C	AUR9716AGD	9716A	Tape & Reel

Package Outline Dimensions (All dimensions in mm(inch).)

Please see http://www.diodes.com/package-outlines.html for the latest version.

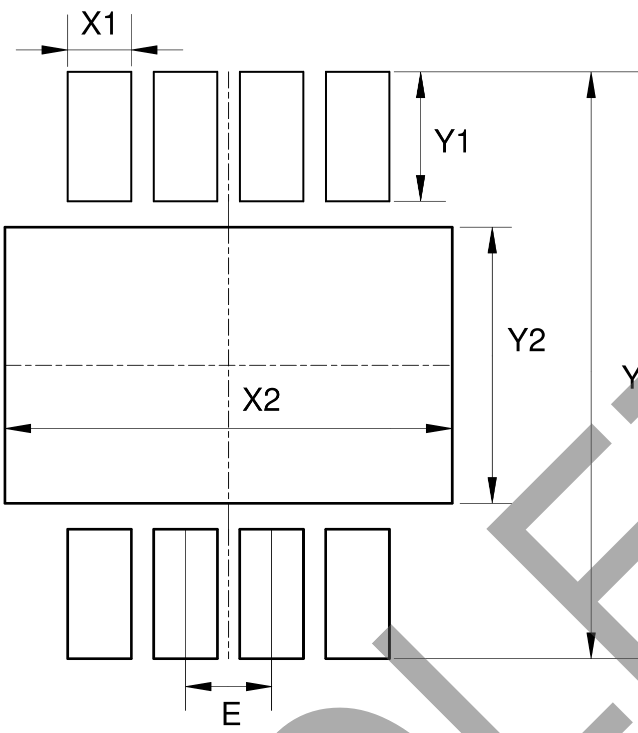
(1) Package Type: DFN-3×3-8



Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: DFN-3×3-8



Dimensions	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	X2 (mm)/(inch)	Y2 (mm)/(inch)	E (mm)/(inch)
Value	3.400/0.134	0.370/0.015	0.750/0.030	2.600/0.102	1.600/0.063	0.500/0.020