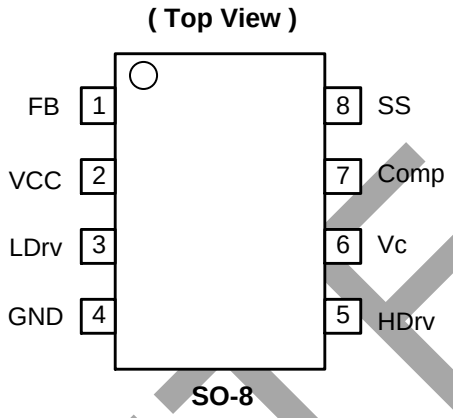
Description

The AP2014/A controller IC is designed to provide a low cost synchronous Buck regulator for on-board DC to DC converter applications. With today's ASIC products requiring supply voltages at 1.8V and lower, when the output current is as much as 3A and the input voltage is at either 3.3V or 5V, traditional linear regulator simply incurs too much loss within itself. The AP2014/A together with dual N-channel MOSFETs provide a low cost solution for such applications. This device features an internal 200kHz oscillator (400kHz for "A" version), under-voltage lockout for both V_{CC} and V_C supplies, an external programmable soft-start function as well as output under-voltage detection that latches off the device when an output short is detected.

Pin Assignments



Features

- Synchronous Controller in 8-Pin Package
- Operating with Single 5V or 12V Supply Voltage
- Internal 200kHz Oscillator (400kHz for AP2014A)
- Soft-Start Function
- Fixed Frequency Voltage Mode
- 500mA Peak Output Drive Capability
- Protects the Output when Control FET is Shorted
- SO-8 Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

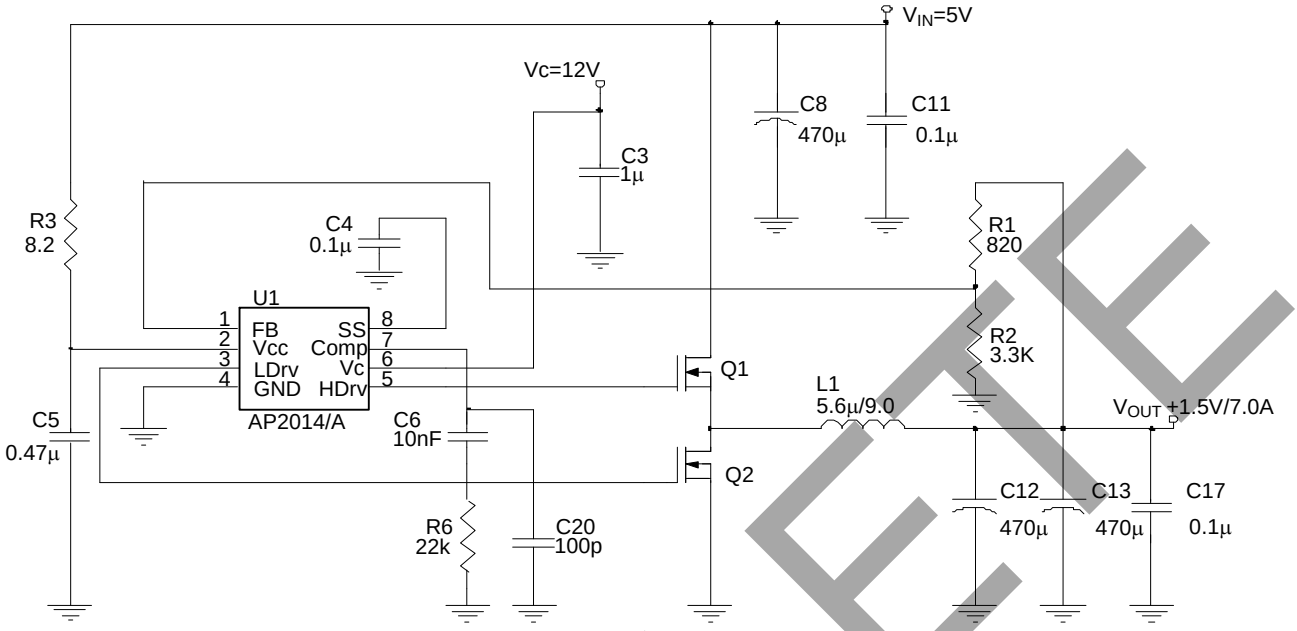
Applications

- Graphic Card
- Hard Disk Drive
- DDR Memory Source Sink Vtt Application
- Low Cost On-Board DC to DC such as 5V to 3.3V, 2.5V or 1.8V

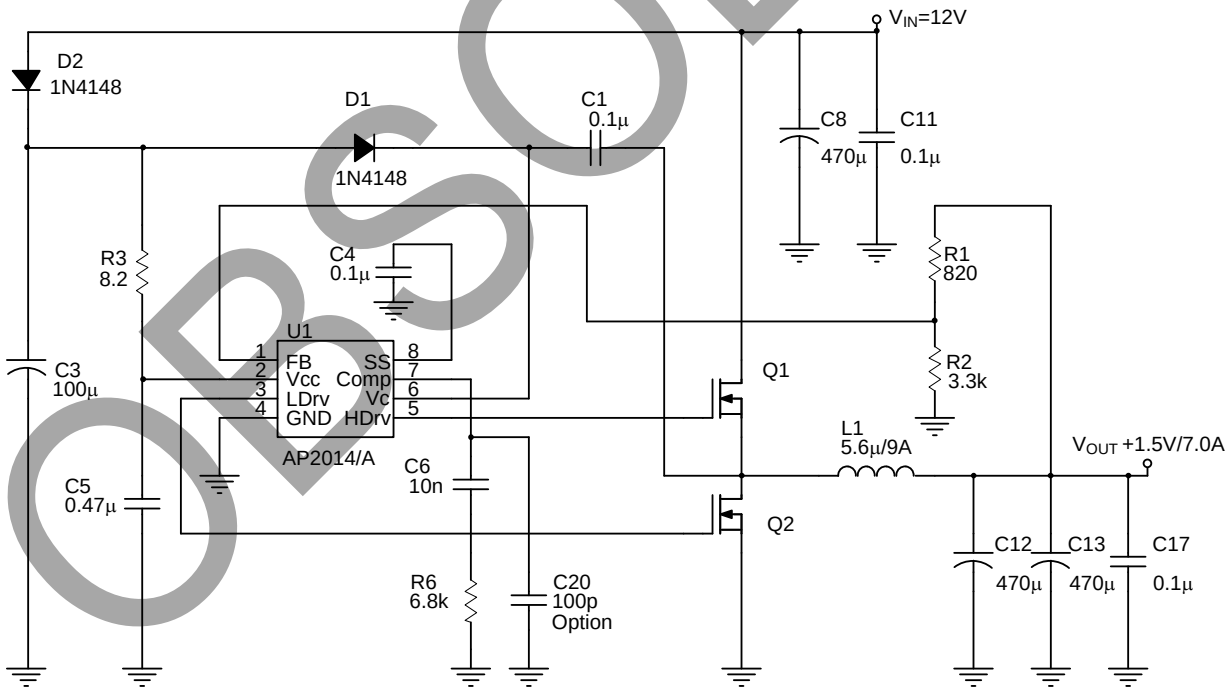
Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free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

Typical Applications Circuit

(1)



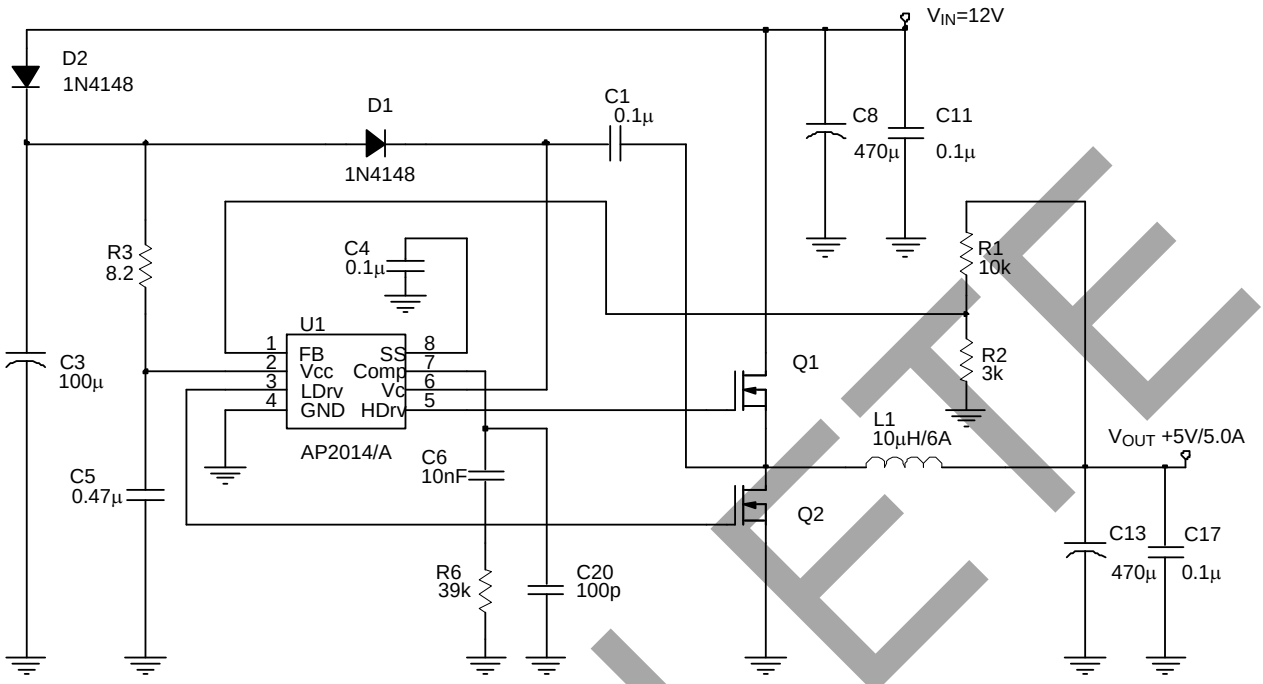
(2)



Single Supply 12V Input

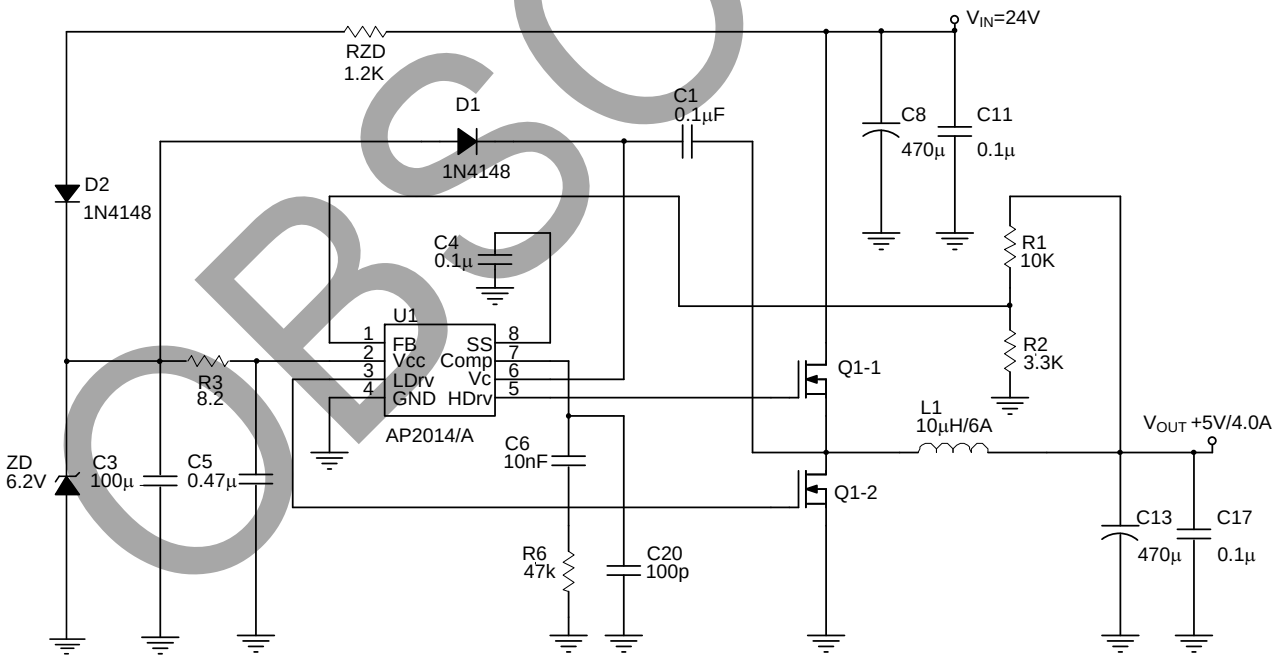
Typical Applications Circuit (Cont.)

(3)



Single Supply 12V Input

(4)

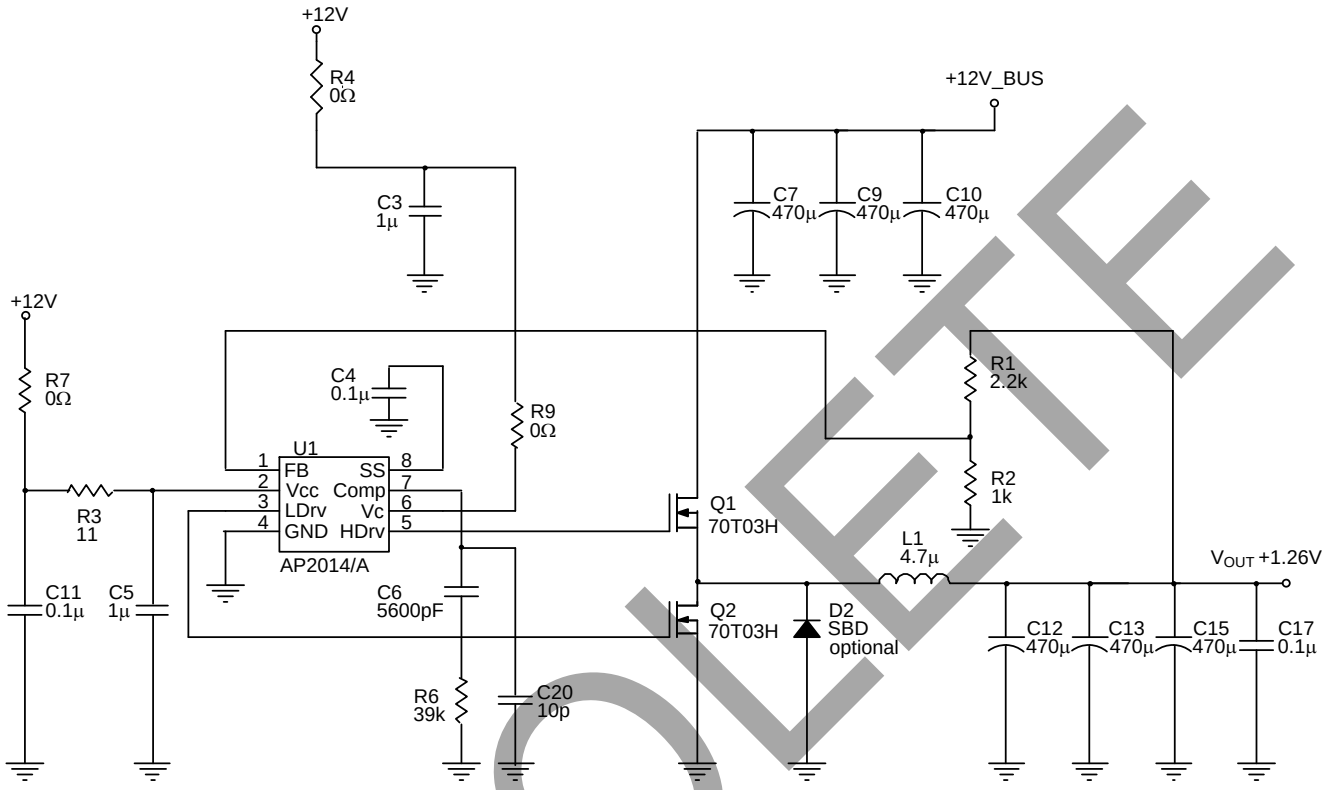


$I_{ZD}(\geqq 15mA)=(V_{IN}-V_{D2}-V_{ZD})/RZD$

Single Supply 24V Input

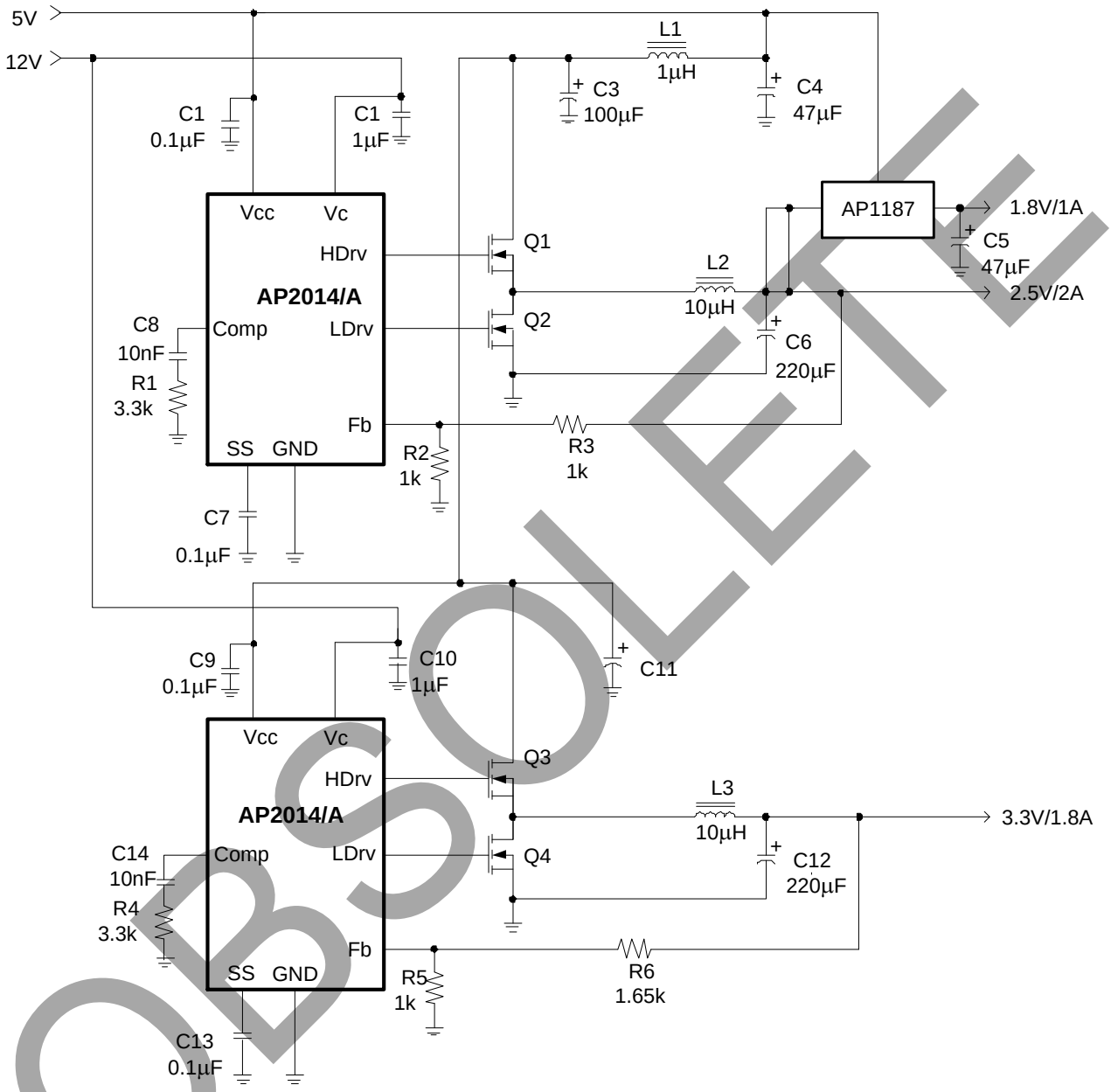
Typical Applications Circuit (Cont.)

(5)



Typical Applications Circuit (Cont.)

(6) Dual Supply, 5V Bus and 12V Bias Input

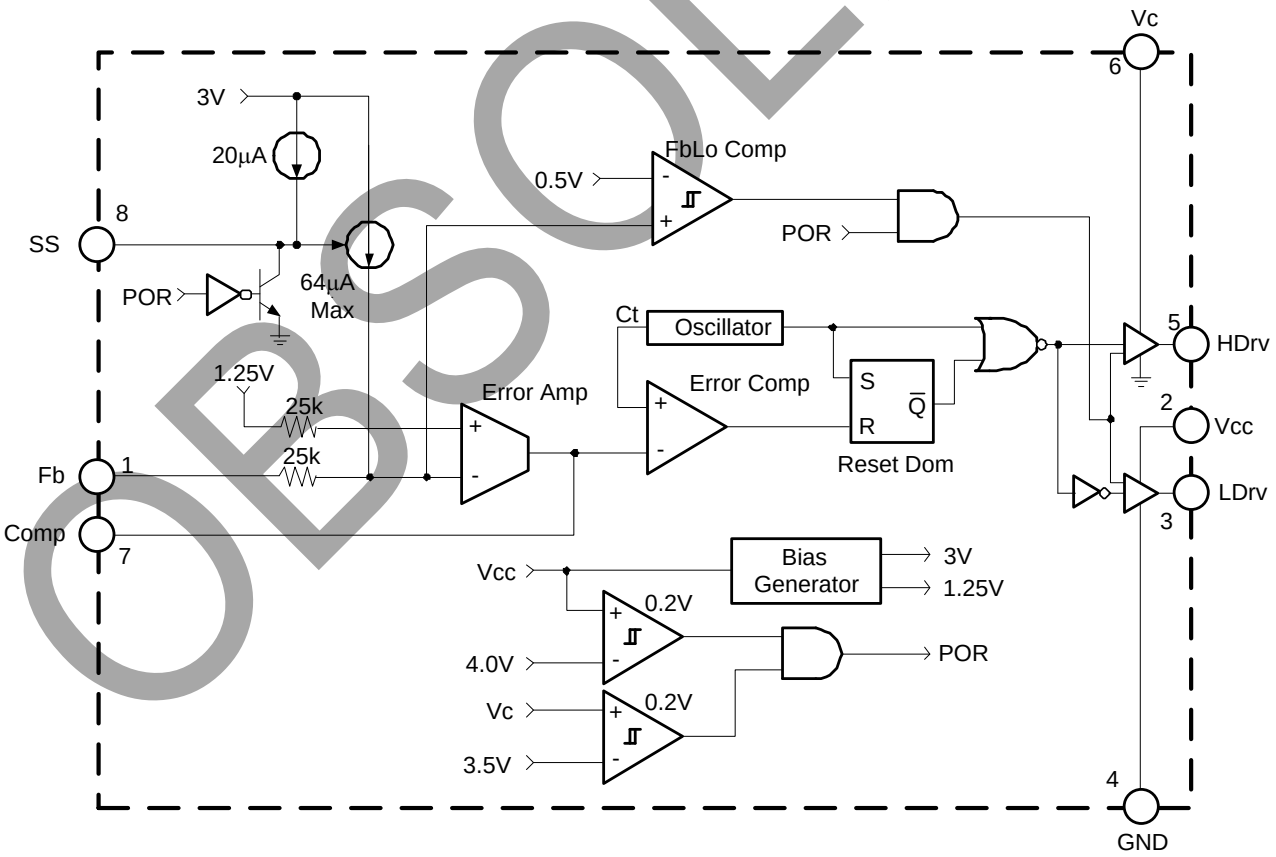


Dual Supply, 5V Bus and 12V Bias Input

Pin Descriptions

Pin Name	Pin No.	Description
FB	1	This pin is connected directly to the output of the switching regulator via resistor divider to provide feedback to the Error amplifier.
Vcc	2	This pin provides biasing for the internal blocks of the IC as well as power for the low side driver. A minimum of 1uF, high frequency capacitor must be connected from this pin to ground to provide peak drive current capability.
LDrv	3	Output driver for the synchronous power MOSFET.
GND	4	This pin serves as the ground pin and must be connected directly to the ground plane. A high frequency capacitor (0.1 to 1uF) must be connected from V5 and V12 pins to this pin for noise free operation.
HDrv	5	Output driver for the high side power MOSFET.
Vc	6	This pin is connected to a voltage that must be at least 4V higher than the bus voltage of the switcher (assuming 5V threshold MOSFET) and powers the high side output driver. A minimum of 1uF, high frequency capacitor must be connected from this pin to ground to provide peak drive current capability.
Comp	7	Compensation pin of the error amplifier. An external resistor and capacitor network is typically connected from this pin to ground to provide loop compensation.
SS	8	This pin provides soft-start for the switching regulator. An internal current source charges an external capacitor that is connected from this pin to ground which ramps up the output of the switching regulator, preventing it from overshooting as well as limiting the input current. The converter can be shutdown by pulling this pin below 0.5V.

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V_{CC}	V_{CC} Supply Voltage	20	V
V_C	V_C Supply Voltage (Not Rated for Inductive Load)	32	V
T_{ST}	Storage Temperature Range	-65 to +150	°C
T_{OP}	Operating Junction Temperature Range	0 to +125	°C
θ_{JC}	Thermal Resistance Junction to Case (Note 4)	7	°C/W
θ_{JA}	Thermal Resistance Junction to Ambient (Note 4)	160	°C/W

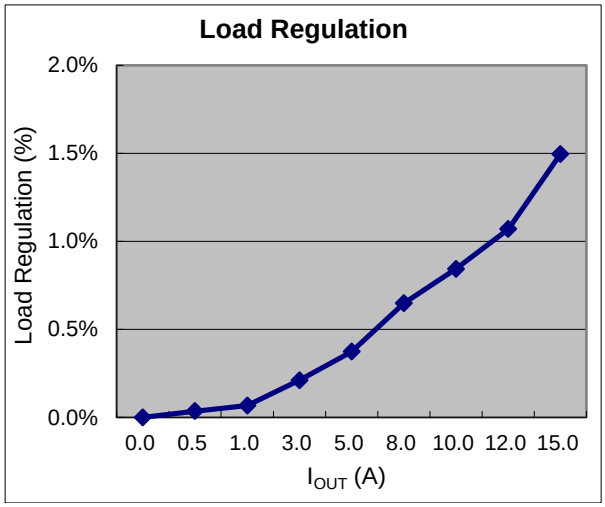
Note: 4. Test conditions for SO-8: Device mounted on 2oz copper, minimum recommended pad layout, FR-4 PCB.

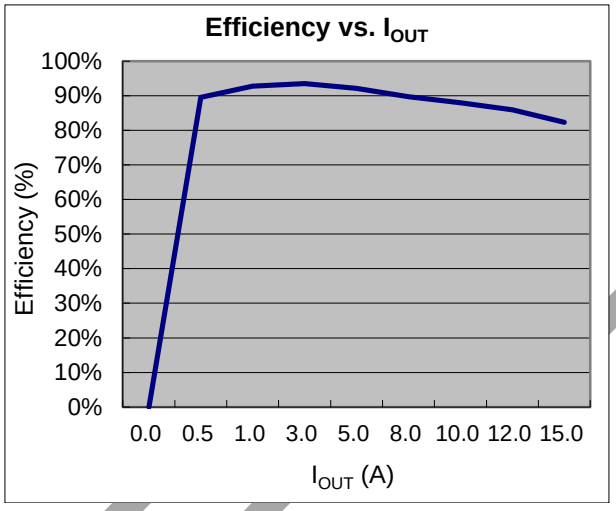
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

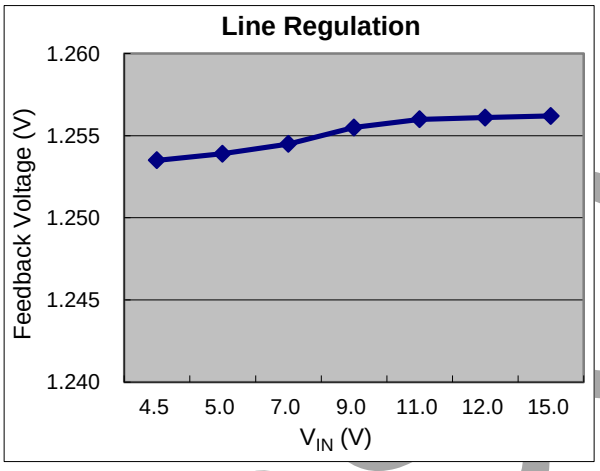
Unless otherwise specified, these specifications apply over V_{CC}=5V, V_C=12V and T_A=0 to +70°C. Typical values refer to T_A =+25°C. Low duty cycle pulse testing is used which keeps junction and case temperatures equal to the ambient temperature.

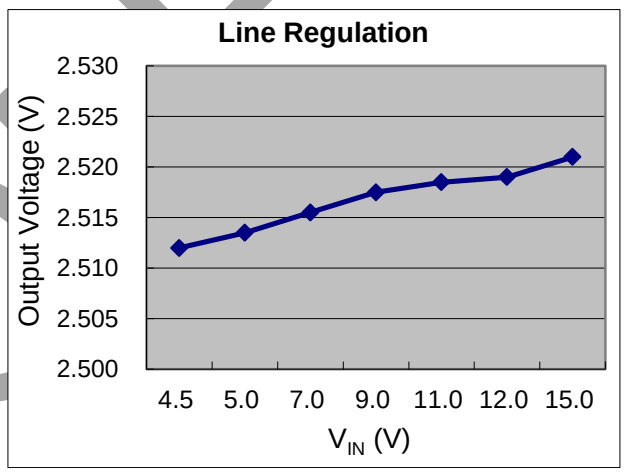
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Reference Voltage						
V_{FB}	FB Voltage	AP2014	1.225	1.25	1.275	V
		AP2014A	0.784	0.800	0.816	
L_{REG}	FB Voltage Line Regulation	5V < V_{CC} < 12V	-	0.2	0.35	%
UVLO						
UVLO V_{CC}	UVLO Threshold - V_{CC}	Supply Ramping Up	4.0	4.2	4.4	V
	UVLO Hysteresis - V_{CC}		-	0.25	-	V
UVLO V_C	UVLO Threshold - V_C	Supply Ramping Up	3.1	3.3	3.5	V
	UVLO Hysteresis - V_C		-	0.2	-	V
UVLO V_{FB}	UVLO Threshold - V_{FB}	FB Ramping Down (AP2014)	0.4	0.6	0.8	V
		FB Ramping Down (AP2014A)	0.3	0.4	0.5	V
	UVLO Hysteresis - V_{FB}	-	-	0.1	-	V
Supply Current						
Operation I_{CC}	V_{CC} Operation Supply Current	Freq=200kHz, C_L=1500pF	-	7	10	mA
Operation I_C	V_C Operation Supply Current	Freq=200kHz, C_L=1500pF	-	7	10	mA
I_{CCQ}	V_{CC} Static Supply Current	V_{SS}=0V	-	3.3	6	mA
I_{CQ}	V_C Static Supply Current	V_{SS}=0V	-	1	4.5	mA
Soft-Start Section						
SS_{IB}	Charge Current	V_{SS}=0V	10	20	30	μA
Error Amp						
I_{FB1}	FB Voltage Input Bias Current	V_{SS}=3V, V_{FB}=1V	-	-0.1	-	μA
I_{FB2}	FB Voltage Input Bias Current	V_{SS}=0V, V_{FB}=1V	-	-64	-	μA
gm	Transconductance	-	450	600	750	μmho
Oscillator						
Freq	Frequency	AP2014	170	200	230	kHz
		AP2014A	340	400	460	kHz
V_{RAMP}	Ramp-Amplitude Voltage	-	1.225	1.25	1.275	V
Output Drivers						
t_R	Rise Time	C_L =1500pF	-	50	100	ns
t_F	Fall Time	C_L =1500pF	-	50	100	ns
t_{DB}	Dead Band Time	-	50	150	250	ns
t_{ON}	Max Duty Cycle	V_{FB} =1V, Freq=200kHz	85	90	95	%
t_{OFF}	Min Duty Cycle	V_{FB}=1.5V	0	0	-	%

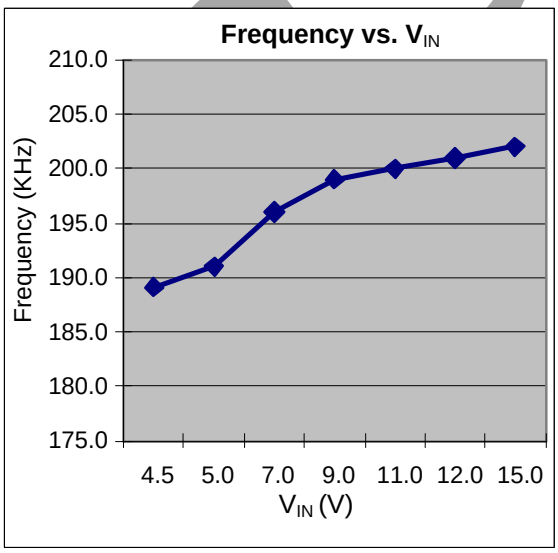
Typical Performance Characteristics

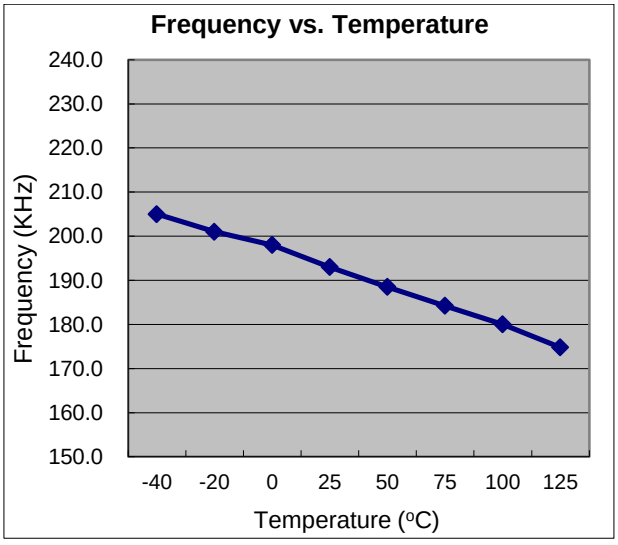




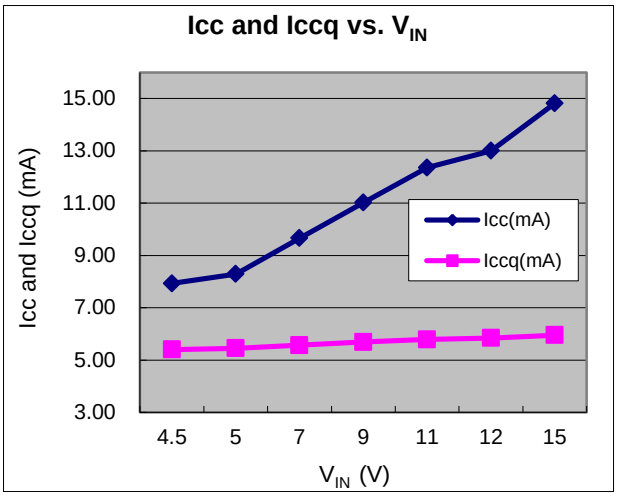


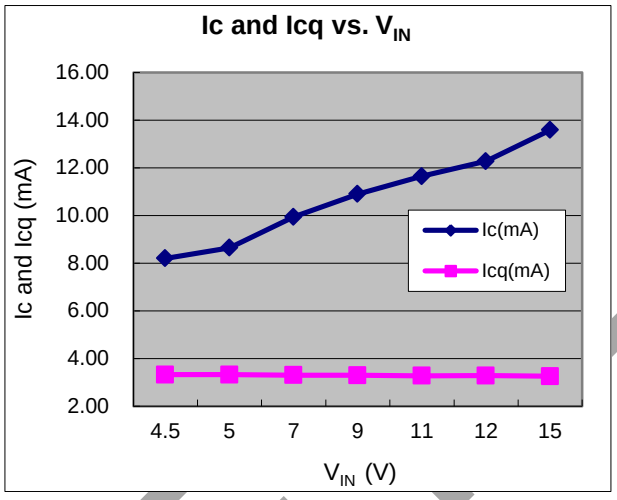


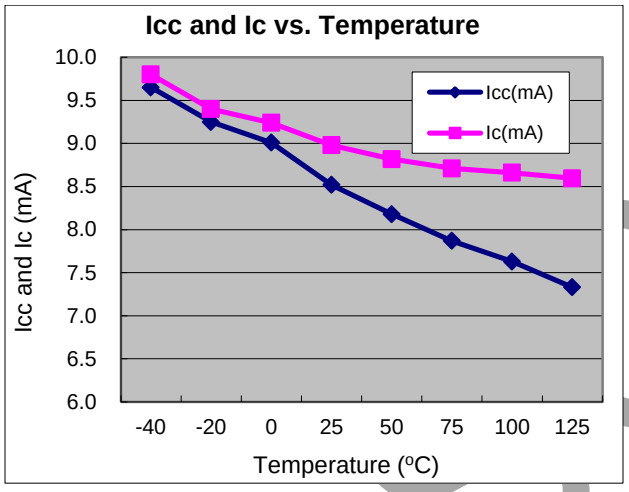


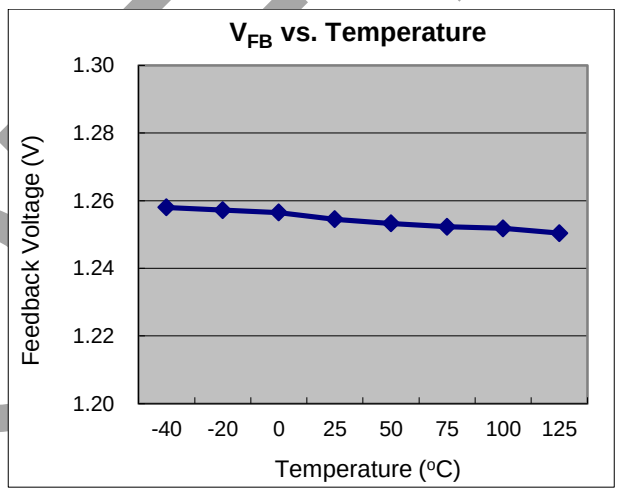


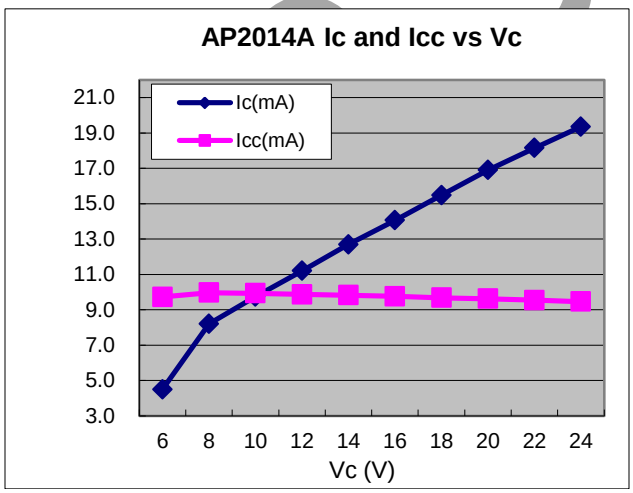
Typical Performance Characteristics (Cont.)

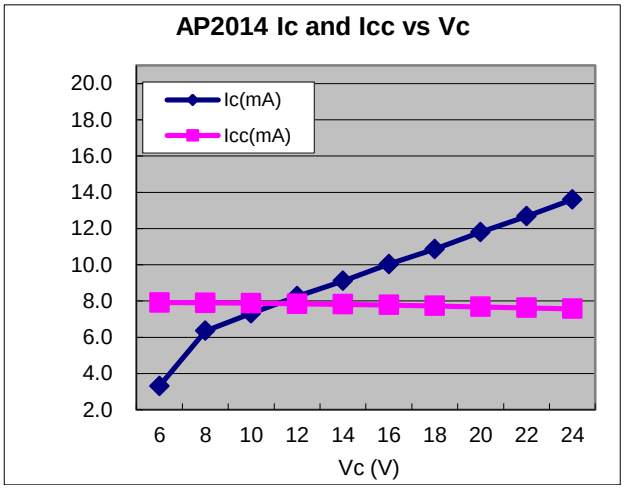






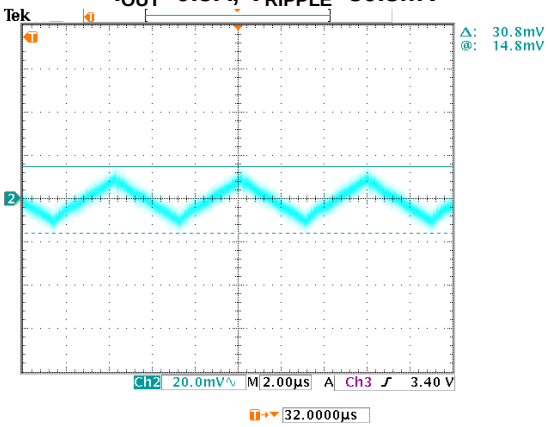




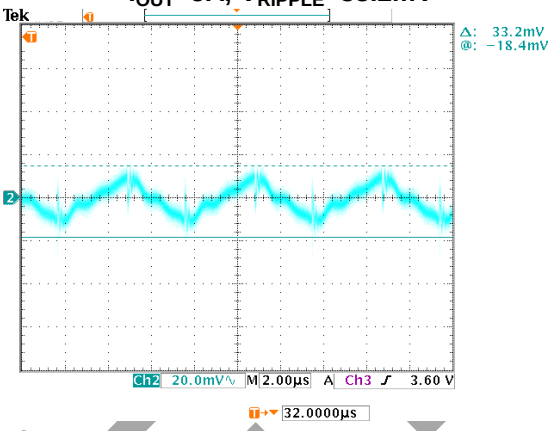


Typical Performance Characteristics (Cont.)

V_{OUT} Ripple
V_{CC}=5V; V_C=12V; V_{OUT}=2.5V
I_{OUT}=0.5A, V_{RIPPLE}=30.8mV

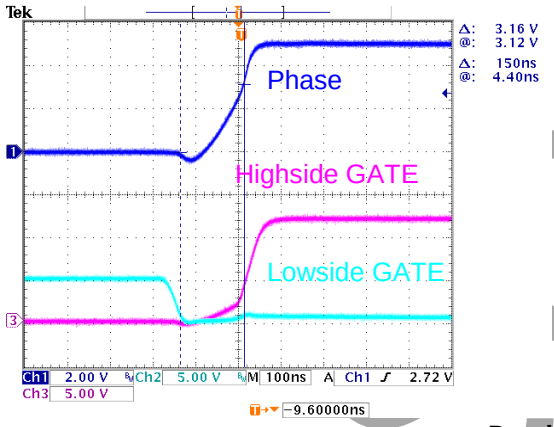


V_{OUT} Ripple
V_{CC}=5V; V_C=12V; V_{OUT}=2.5V
I_{OUT}=5A, V_{RIPPLE}=33.2mV

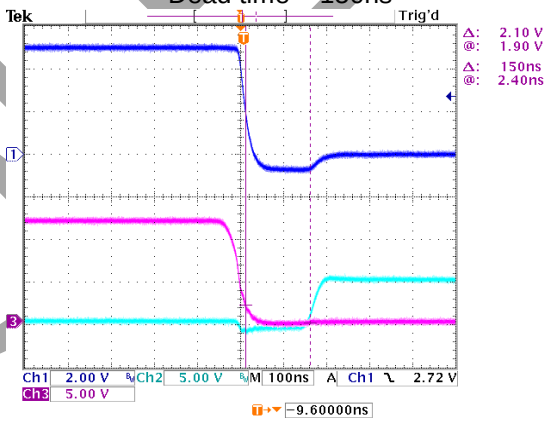


Dead time vs. I_{OUT}
V_{CC}=5V, V_C=12V, V_{OUT}=2.5V, I_{OUT}=0.5A, Temp=+28°C

Dead time = 150ns

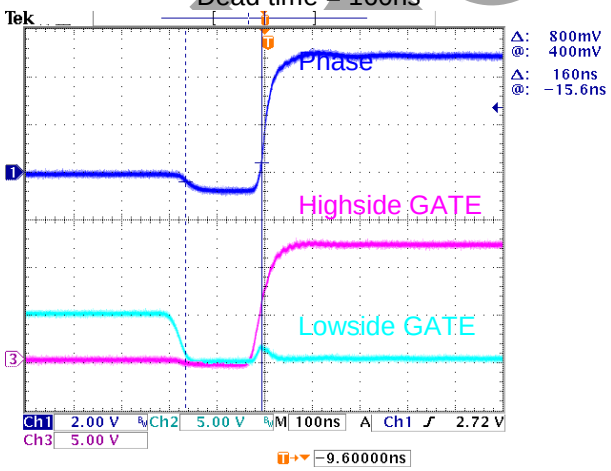


Dead time = 150ns

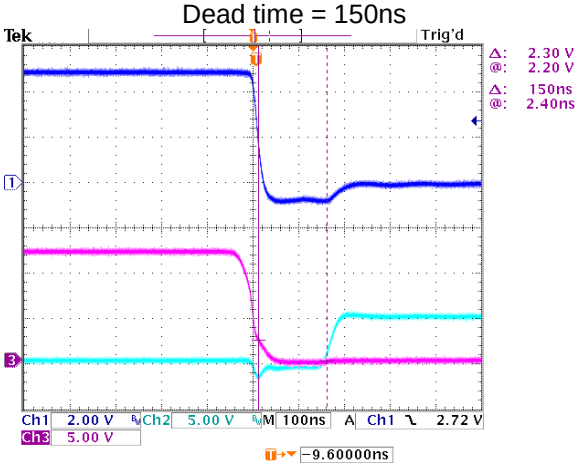


Dead time vs. I_{OUT}
V_{CC}=5V, V_C=12V, V_{OUT}=2.5V, I_{OUT}=5A , Temp=+28°C

Dead time = 160ns



Dead time = 150ns



Functional Descriptions

Introduction
The AP2014A is a fixed frequency, voltage mode synchronous controller and consists of a precision reference voltage, an error amplifier, an internal oscillator, a PWM comparator, 0.5A peak gate driver, soft-start and shutdown circuits (see Block Diagram).

The output voltage of the synchronous converter is set and controlled by the output of the error amplifier; this is the amplified error signal from the sensed output voltage and the reference voltage.

This voltage is compared to a fixed frequency linear sawtooth ramp and generates fixed frequency pulses of variable duty-cycle, which drives the two N-channel external MOSFETs. The timing of the IC is provided through an internal oscillator circuit which uses on-chip capacitor to set the oscillation frequency to 200kHz (400kHz for "A" version).

Soft-Start
The AP2014 has a programmable soft-start to control the output voltage rise and limit the current surge at the start-up. To ensure correct start-up, the soft-start sequence initiates when the V_C and V_{CC} rise above their threshold (3.3V and 4.2V respectively) and generates the Power On Reset (POR) signal. Soft-start function operates by sourcing an internal current to charge an external capacitor to about 3V. Initially, the soft-start function clamps the E/A's output of the PWM converter. As the charging voltage of the external capacitor ramps up, the PWM signals increase from zero to the point the feedback loop takes control.

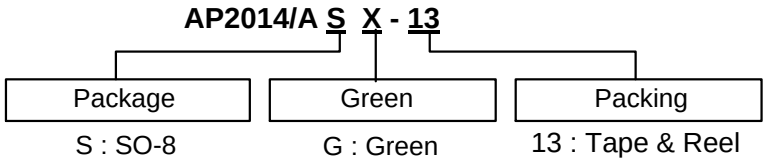
Short-Circuit Protection
The outputs are protected against the short circuit. The AP2014 protects the circuit for shorted output by sensing the output voltage (through the external resistor divider). The AP2014 shuts down the PWM signals, when the output voltage drops below 0.6V (0.4V for AP2014A).

The AP2014 also protects the output from over-voltaging when the control FET is shorted. This is done by turning on the sync FET with the maximum duty cycle.

Under-Voltage Lockout
The under-voltage lockout circuit assures that the MOSFET driver outputs remain in the off state whenever the supply voltage drops below set parameters. Lockout occurs if V_C and V_{CC} fall below 3.3V and 4.2V respectively. Normal operation resumes once V_C and V_{CC} rise above the set values.

IC Quiescent Power Dissipation
Power dissipation for IC controller is a function of applied voltage, gate driver loads and switching frequency. The IC's maximum power dissipation occurs when the IC operating with single 12V supply voltage (V_{CC}=12V and $V_C \cong$24V) at 400kHz switching frequency and maximum gate loads.
Page 8 shows voltage vs. current, when the gate drivers loaded with 1500pF capacitors. The IC's power dissipation results in an excessive temperature rise. This should be considered when using AP2014A for such application.

Ordering Information

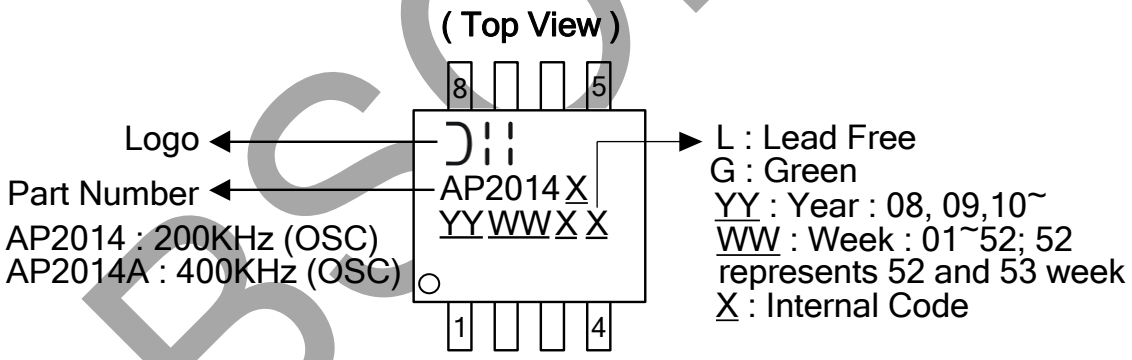


Device (Note 5)	Package Code	Package (Note 6)	Green	Quantity	Part Number Suffix		Status (Note 5)
					Tube	13"Tape and reel	
AP2014ASG-13	S	SO-8	Green	2500	NA	-13	In production

Notes: 5. All Lead-Free variants are End of Life without replacement. AP2014SG-13 is End of Life without replacement.
6. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

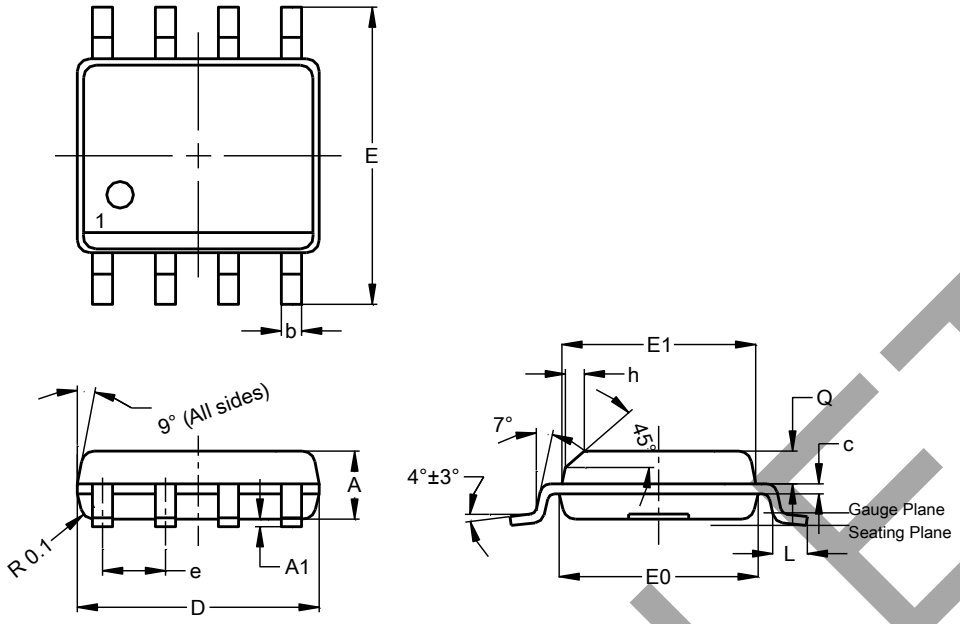
(1) SO-8



Package Outline Dimensions (All dimensions in mm.)

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

SO-8

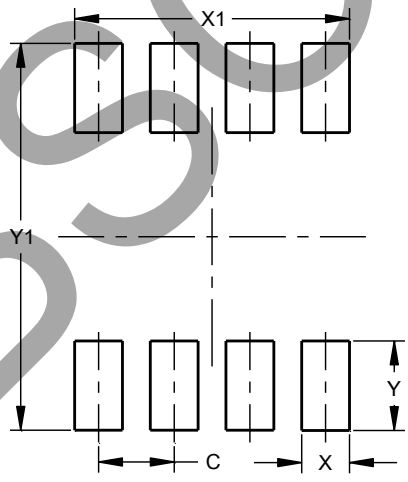


SO-8			
Dim	**Min**	**Max**	**Typ**
A	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
c	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
e	--	--	1.27
h	-	--	0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All Dimensions in mm			

Suggested Pad Layout

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

SO-8



Dimensions	Value (in mm)
C	1.27
X	0.802
X1	4.612
Y	1.505
Y1	6.50

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1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

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