

Description

The AL1676 is a universal AC input (85~277 V_{AC}), high power factor (PF) and high efficiency Buck LED driver. The AL1676 topology provides accurate constant current (CC) with good line and load regulation, operating at boundary conduction mode (BCM) to ease in EMI/EMC qualification and testing to meet the latest regulatory laws.

The AL1676 single Buck stage driver works with a single winding inductor and High voltage MOSFET included, therefore, can use fewer external components and create a low bill of material (BOM) cost solution. The AL1676 has rich protection features to enhance system safety and reliability, including under voltage lock out (UVLO), LED open/short, over voltage, over current, over temperature protection and thermal fold-back function which can reduce output current when the driver's temperature is higher than the setting value.

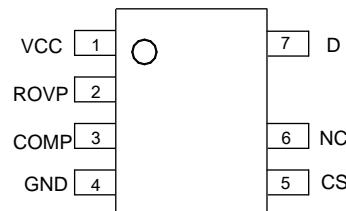
The AL1676 is available for SO-7 package.

Features

- >90% Efficiency
- Universal 85 to 277 V_{AC} Input Range
- Multiple Options for Internal MOSFET
- Tight Output Current Tolerance: $\pm 3\%$
- Low Startup Current: 100 μ A
- Low Operation Current: 170 μ A (5KHz Switching)
- Single Winding Inductor
- Internal Protections:
 - Under Voltage Lock Out (UVLO)
 - Leading-Edge Blanking (LEB)
 - Cycle-by-cycle Over Current Protection (OCP)
 - Output Open/Short Protection (OVP/OSP)
 - Thermal Fold-back Protection (TFP)
 - Over Temperature Protection (OTP)
- SO-7 Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Pin Assignments

(Top View)



SO-7

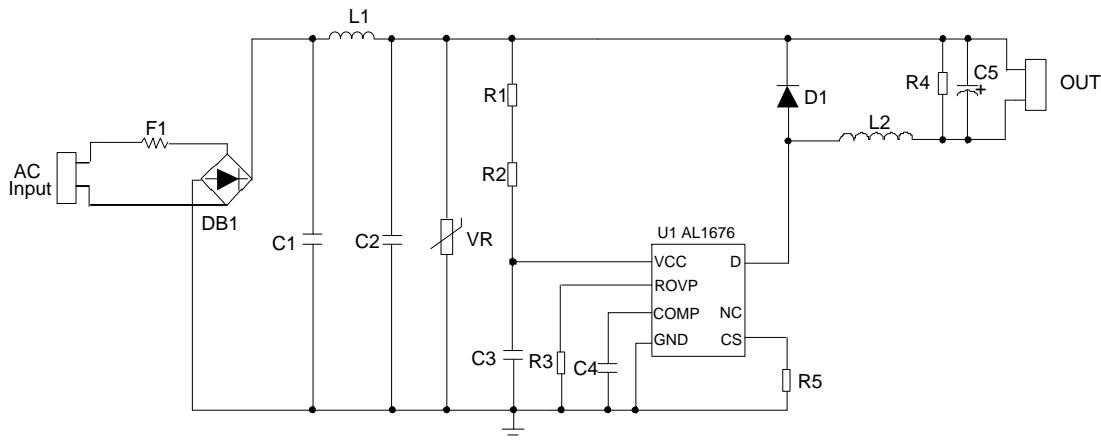
Applications

- Retrofit LED Lamps
- LED Tube
- High Voltage DC-DC LED Driver
- General Purpose Constant Current Source

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.

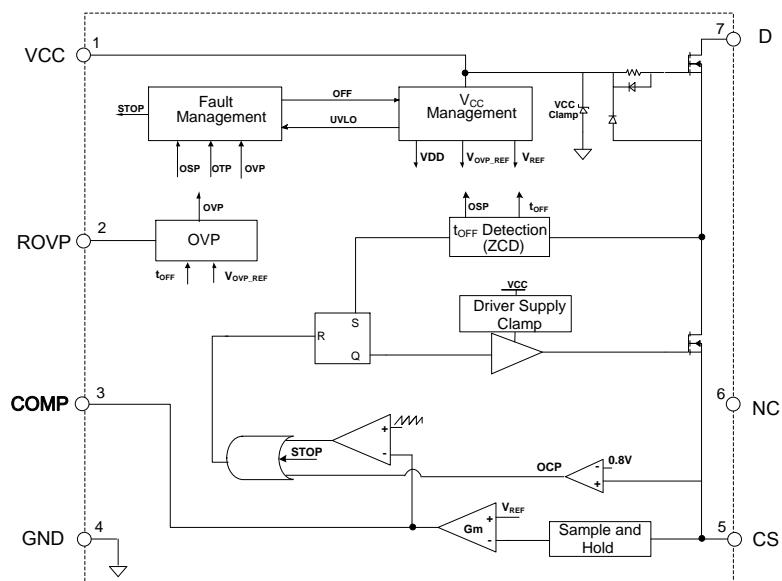
Typical Applications Circuit



Pin Descriptions

Pin Number	Pin Name	Function
1	VCC	Power supply voltage
2	ROVP	Resistor set the open voltage
3	COMP	Compensation for current control
4	GND	Ground
5	CS	Current sensing
6	NC	No connection
7	D	Drain of the internal high voltage MOSFET

Functional Block Diagram



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

Symbol	Parameter	Rating	Unit
V_{CC}	Power Supply Voltage	18	V
V_D	Voltage on D Pin (AL1676-20AS7-13)	300	V
	Voltage on D Pin (AL1676-30AS7-13)	300	V
	Voltage on D Pin (AL1676-10BS7-13)	500	V
	Voltage on D Pin (AL1676-20BS7-13)	500	V
	Voltage on D Pin (AL1676-20CS7-13)	600	V
	Voltage on D Pin (AL1676-40DCS7-13)	670	V
I_D	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-20AS7-13)	2.0	A
	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-30AS7-13)	3.0	A
	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-10BS7-13)	1.0	A
	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-20BS7-13)	2.0	A
	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-20CS7-13)	2.0	A
	Continuous Drain Current $T_C = +25^\circ\text{C}$ (AL1676-40DS7-13)	4.0	A
V_{CS}	Voltage on CS Pin	-0.3 to 7	V
V_{ROVP}	Voltage on ROVP Pin	-0.3 to 7	V
T_J	Operating Junction Temperature	-40 to +150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10 seconds)	+260	°C
P_D	Power Dissipation and Thermal Characteristics ($T_A = +50^\circ\text{C}$)	0.8	W
θ_{JA}	Thermal Resistance (Junction to Ambient) (Note 5)	123	°C/W
θ_{JC}	Thermal Resistance (Junction to Case) (Note 5)	19	°C/W
-	ESD (Human Body Model)	2000	V
	ESD (Machine Model)	200	V

Notes:

4. 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.
5. Device mounted on 1"x1" FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.

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

Symbol	Parameter	Min	Max	Unit
T_A	Ambient Temperature (Note 6)	-40	+105	°C

Note 6: The device can operate normally at $+125^\circ\text{C}$ ambient temperature under the condition that the junction temperature is less than $+150^\circ\text{C}$.

Electrical Characteristics (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
UVLO						
$V_{TH(ST)}$	Startup Voltage	—	—	14.5	—	V
$V_{OPR(\text{Min})}$	Minimal Operating Voltage	After Turn On	—	8.5	—	V
V_{CC_CLAMP}	VCC Clamp Voltage	$I_{CC} = 1\text{mA}$	—	15.5	—	V
Standby Current						
I_{ST}	Start-up Current	$V_{CC} = V_{TH(ST)} - 0.5\text{V}$, Before Start up	—	100	—	μA
$I_{CC(OPR)}$	Operating Current	Switching Frequency at 5kHz	—	170	—	μA
Internal High Voltage MOSFET						
$R_{DS(\text{ON})}$	Drain-Source On-State Resistance	AL1676-20AS7-13	—	—	6.5	Ω
		AL1676-30AS7-13	—	—	3	
		AL1676-10BS7-13	—	—	12	
		AL1676-20BS7-13	—	—	6	
		AL1676-20CS7-13	—	—	5.5	
		AL1676-40DS7-13	—	—	2.5	
I_{DS}	Continuous Drain-Source Current	AL1676-20AS7-13	—	—	2.0	A
		AL1676-30AS7-13	—	—	3.0	
		AL1676-10BS7-13	—	—	1.0	
		AL1676-20BS7-13	—	—	2.0	
		AL1676-20CS7-13	—	—	2.0	
		AL1676-40DS7-13	—	—	4.0	
V_{DS}	Drain-Source Voltage	AL1676-20AS7-13	300	—	—	V
		AL1676-30AS7-13	300	—	—	
		AL1676-10BS7-13	500	—	—	
		AL1676-20BS7-13	500	—	—	
		AL1676-20CS7-13	600	—	—	
		AL1676-40DS7-13	650	—	—	
I_{DSs}	Drain-Source Leakage Current	AL1676-20AS7-13	—	—	1	μA
		AL1676-30AS7-13	—	—	1	
		AL1676-10BS7-13	—	—	1	
		AL1676-20BS7-13	—	—	1	
		AL1676-20CS7-13	—	—	1	
		AL1676-40DS7-13	—	—	1	

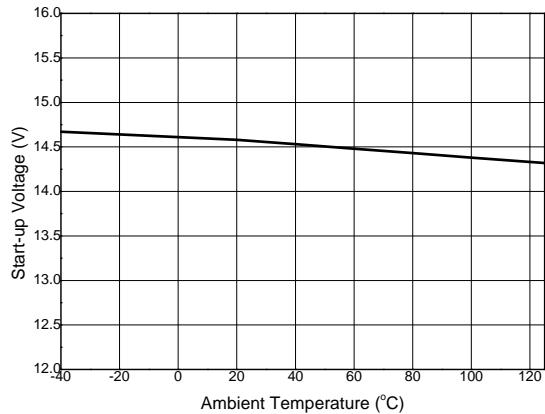
Electrical Characteristics (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.) (Cont.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ROVP						
V_{ROVP}	Reference Voltage of ROVP Pin	—	—	0.5	—	V
Current Sense						
V_{REF}	Internal Reference Voltage	—	—	0.400	—	V
V_{CS_CLAMP}	VCS Clamp Voltage	—	—	0.8	—	V
t_{ON_MIN}	Minimum t_{ON}	—	—	550	—	ns
t_{ON_MAX}	Maximum t_{ON}	—	—	29	—	μs
t_{OFF_MAX}	Maximum t_{OFF}	—	—	180	—	μs
t_{OFF_MIN}	Minimum t_{OFF} (Note 7)	—	—	6	—	μs
Error Amplifier						
G_m	G_m Trans-conductance	—	—	25	—	$\mu\text{A/V}$
I_{SOURCE}	Amplifier Source Current	—	—	10	—	μA
I_{SINK}	Amplifier Sink Current	—	—	9	—	μA
Thermal Foldback and Over Temperature Protection						
T_{REG}	Overheating Temperature Regulation (Note 7)	—	—	+150	—	$^\circ\text{C}$
—	Shutdown Temperature (Notes 7, 8)	—	—	+170	—	$^\circ\text{C}$

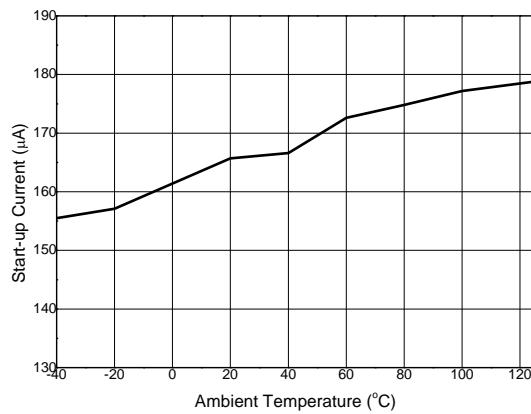
Notes: 7. These parameters, although guaranteed by design, are not 100% tested in production.
 8. The device will latch off when OTP happens, recovered after power cycle and device won't operating normally at this temperature.

Performance Characteristics (Note 9)

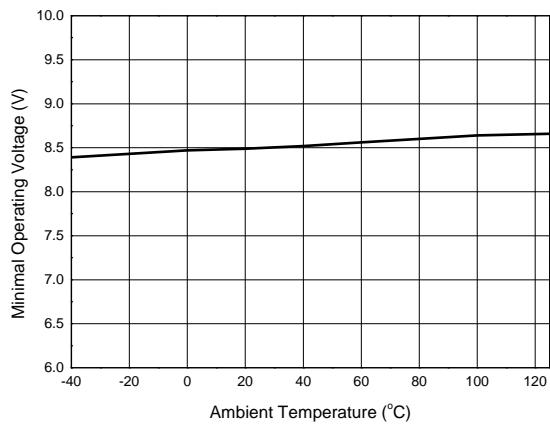
Start-up Voltage vs. Ambient Temperature



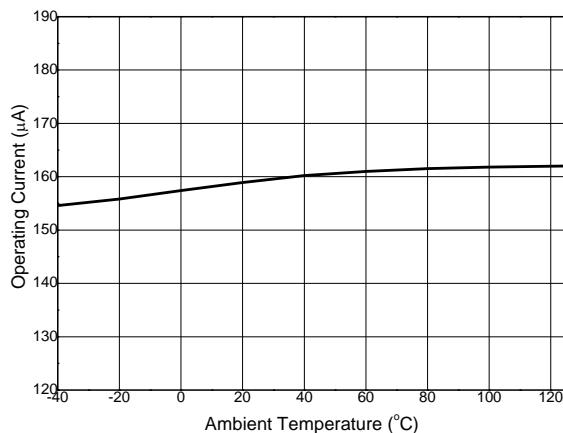
Start-up Current vs. Ambient Temperature



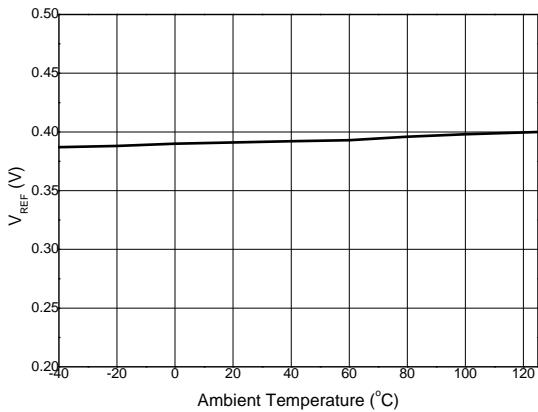
Minimal Operating Voltage vs. Ambient Temperature



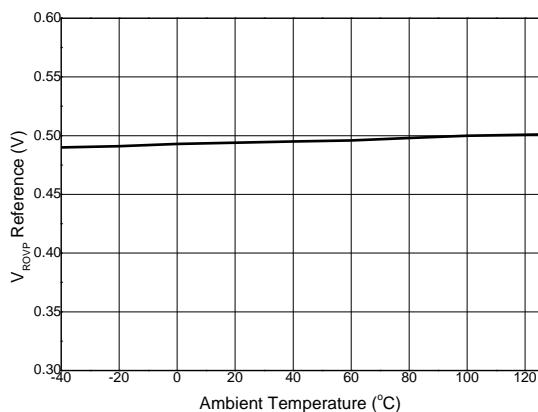
Operating Current vs. Ambient Temperature

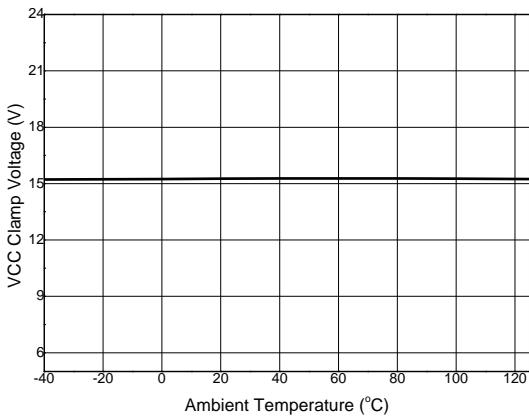
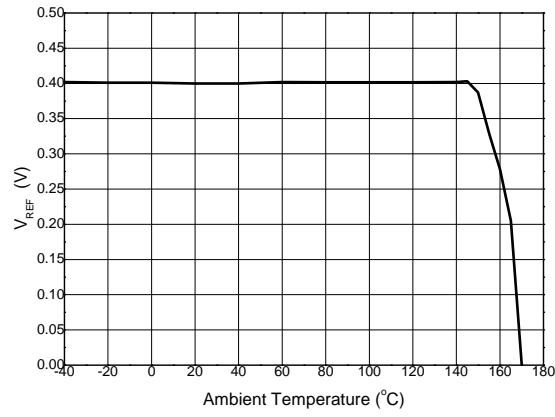


V_{REF} vs. Ambient Temperature



V_{ROVP} Reference vs. Ambient Temperature



Performance Characteristics (Cont.) (Note 9)**VCC Clamp Voltage vs. Ambient Temperature** **V_{REF} vs. Ambient Temperature**

Note 9: These electrical characteristics are tested under DC condition. The ambient temperature is equal to the junction temperature of the device.

Functional Description and Application Information

Converter Operation

The AL1676 is a high efficiency and high power factor BUCK LED driver solution for universal input application based on single winding inductor. It is available for 6 internal MOSFET options (300V/2A, 300V/3A, 500V/1A, 500V/2A, 600V/2A, 650V/4A) which can help to reduce the overall LED driver solution size of the LED lamp. This 6 MOSFET options can cover most of the 3~18W applications.

High power factor (PF) is achieved by constant on-time control. Coupled with simple closed loop of constant current control, the AL1676 can achieve good line and load regulation. The AL1676 adopts source-driver technique to decrease the system operating current. It uses a novel method to detect the t_{OFF} time which helps to get rid of an auxiliary winding for (V_{CC} supply and) detecting the t_{OFF} time, resulting in an extremely low bill material (BOM). The AL1676 operates at boundary conduction mode (BCM) which can ease EMI design.

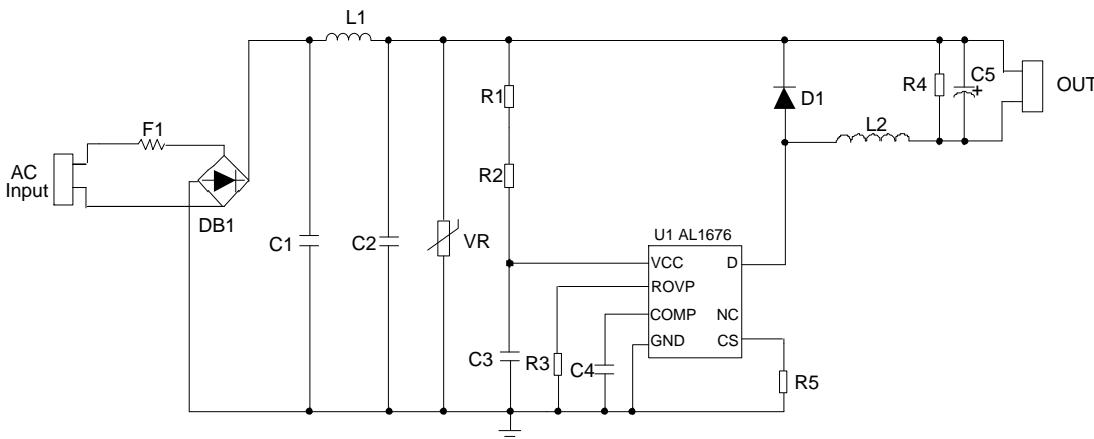


Figure 1. Typical Application Circuit

Start-up and Supply Voltage

Before start-up, the VCC capacitor C3 is charged by the startup resistors (R1, R2) from the high voltage mains. When the start-up voltage is reached, the AL1676 starts switching. During normal operation, the VCC supply is provided by start-up resistors (R1, R2) and internal source driver circuit.

The AL1676 has an internal VCC clamp voltage (typical 15.5V), which is limited by one internal active Zener diode.

When VCC voltage drops to below the under voltage lockout (UVLO), switching stops, the IC can restart when the voltage on VCC pin is exceeding the startup voltage ($V_{TH(ST)}$).

Protections

Under Voltage Lockout (UVLO)

When the voltage on the VCC pin drops to below $V_{OPR(Min)}$, the IC stops switching. The IC can restart when the voltage on VCC exceeds the startup voltage ($V_{TH(ST)}$).

Leading-Edge Blanking (LEB)

To prevent false detection of the peak current of the inductor, a blanking time following switch-on is designed. When the internal switch turns on, a short current spike can occur because of the capacitive discharge of the voltage over the drain and source. It is disregarded during the LEB time (t_{ON_MIN}).

Cycle-by-cycle Over Current Protection (OCP)

The AL1676 has a built-in peak current detector. It triggers when the voltage on CS pin reaches the peak level V_{CS_CLAMP} . The R5 is connected to the CS pin to sense the current of the inductor. The maximum peak current ($I_{PEAK(MAX)}$) of the inductor can be calculated as below:

$$I_{PEAK(MAX)} = \frac{V_{CS_CLAMP}}{R5} \quad \dots \dots \dots \quad (1)$$

Functional Description and Application Information (Cont.)

The detection circuit is activated after the LEB time. When the detection circuit sense the CS voltage is higher than 1V, the IC will turn off the switch to limit the output current. It automatically provides protection for the maximum LED current during operation. A propagation delay exists between over current detection and actual source-switch off, so the actual peak current is a little higher than the OCP level set by the R5.

Over-Voltage Protection and Output-Open Protection (OVP)

The AL1676 has output open voltage protection when the LED is open, which can prevent the output voltage from increasing to a very high value. This feature can help the system designer to select a smaller volume capacitor. The output voltage is set by the external resistor R3 shown in Figure 1.

When LED is open, the t_{OFF_OVP} time can be calculated as:

$$t_{OFF_OVP} = \frac{L1 \cdot V_{CS}}{V_{OVP} \cdot R5} \dots \dots \dots \quad (2)$$

Where,

V_{OVP} is the output open voltage.

V_{CS} is the voltage on the CS pin when OVP happens.

The output voltage is set by R3, and R3 is calculated as:

$$R3 = \frac{V_{ROVP_REF} \cdot t_{OFF_OVP}}{20 \cdot C_{REF} \cdot V_{CS}} = \frac{V_{ROVP_REF} \cdot L1}{20 \cdot C_{REF} \cdot V_{OVP} \cdot R5} \dots \dots \dots (3)$$

Where, V_{ROVP_REF} is the internal ROVP pin 0.5V's reference, C_{REF} is the internal 6pF capacitor.

Output-Short Protection (OSP)

When LED is shorted, the device cannot detect the t_{OFF} time, and the device controls the system operating at 5kHz low switching frequency.

Thermal Foldback Protection (TFP)

The AL1676 has a thermal foldback function and adopts self-adaptive control method, which can prevent the system from breaking down caused by high temperature. The overheating temperature is set at +150°C typical, when the junction temperature of the IC is higher than +150°C typical, the device will linearly decrease the internal reference voltage to decrease the output current. As a result of this feature, the device can control the system's output power at high ambient temperature, to control the quantity of heat of the system. This enhances the safety of the system at high temperature.

The thermal foldback waveform is shown below:

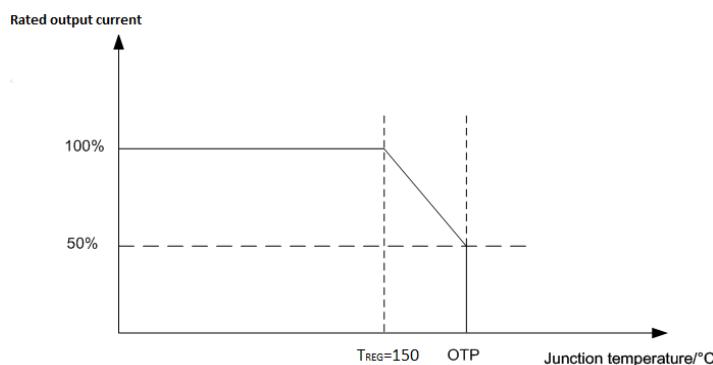


Figure 2. Thermal Foldback Waveform

Functional Description and Application Information (Cont.)

The AL1676 controls the system operating at boundary conduction mode which results in its operating frequency inconstant. To set the minimum switching frequency f_{MIN} at the crest of the minimum AC input.

$$L2 = \frac{(\sqrt{2}V_{IN_RMS} - V_o) \cdot V_o}{I_{PEAK} \cdot \sqrt{2}V_{IN_RMS} \cdot f_{MIN}} \dots \dots \dots \quad (9)$$

According to the Faraday's Law of Induction, the winding number of the inductance can be calculated by:

$$N_{L2} = \frac{L2 \cdot I_{PEAK}}{A \cdot B_{..}} \dots \dots \dots \quad (10)$$

Where,

A_e is the core effective area.

B_m is the maximum magnetic flux density.

The AL1676 has designed the minimum t_{ON} time and maximum t_{ON} time, the t_{ON_MIN} is about 700ns and the t_{ON_MAX} time is about 29μs. In buck topology there is the equation $V_{IN_RMS} - V_o = L * I_{PEAK}/t_{ON}$. If the inductance is too small, it will make t_{ON} smaller than t_{ON_MIN} , the device cannot detect the peak current of the system, resulting in incorrect output current. If the inductance is too large, make t_{ON} longer than the t_{ON_MAX} , the system's output current will decrease because of the limit of the t_{ON_MAX} .

The AL1676 has also the limitation of minimum t_{OFF} time and maximum t_{OFF} time, the t_{OFF_MIN} time is about 6 μ s and t_{OFF_MAX} time is about 180 μ s. In buck topology there is the equation $V_O = L * I_{PEAK} / t_{OFF}$. If the inductance is too small, make t_{OFF} smaller than t_{OFF_MIN} , the system will enter DCM mode, and the output current will be incorrect. If the inductance is too large, make t_{OFF} longer than t_{OFF_MAX} , the system will enter CCM mode, and the output current will also be incorrect. So a suitable value of the inductance is very important.

Consider these parameters, two examples of the typical application inductance is recommended as below:

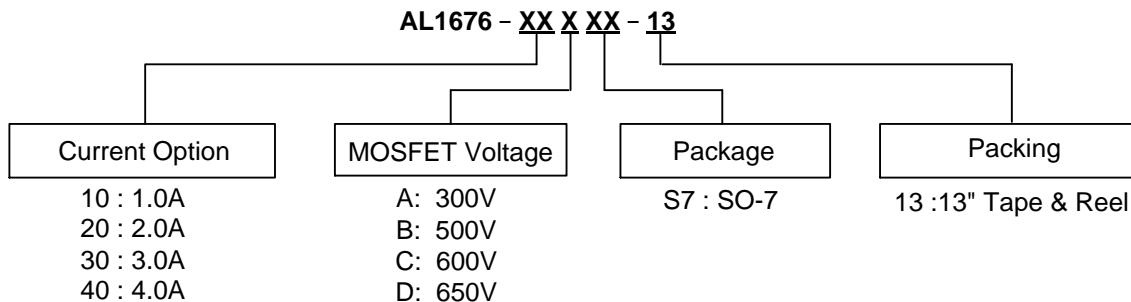
System spec	Inductance Value	System Frequency	t _{ON_MIN}	t _{OFF}
60V/100mA (85~265V _{AC})	2.2mH	64KHz(230 V _{AC})	2.4μs (265 V _{AC})	12.6μs
42V/150mA (85~265 V _{AC})	1.1mH	64KHz(230 V _{AC})	1.6μs (265 V _{AC})	13.5μs

Recommended Applications

The AL1676 integrates different MOSFET to adapt different wattage application. The output current is limited by the integrated MOSFET, and the SO-7 package's heat dissipation capability. The minimum output voltage is limited by the LEB time, and the minimum output voltage is recommended to 20V. The recommended application is given below:

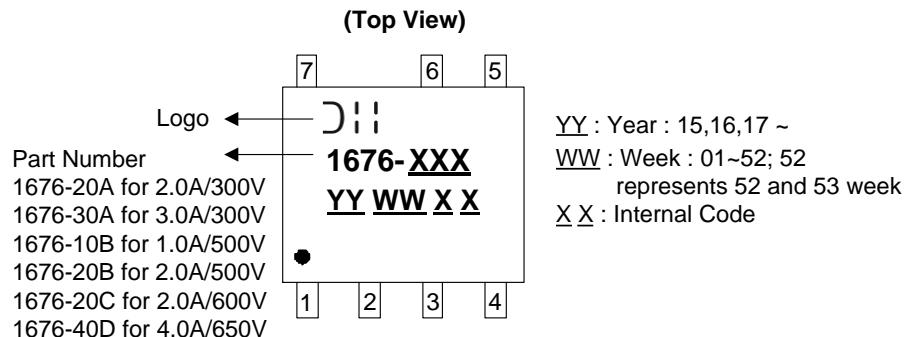
Device	Output Power Coverage	Maximum Output Current	Minimum Output Voltage
AL1676-20A	≤10W	≤200mA	20V
AL1676-30A	≤13W	≤300mA	20V
AL1676-10B	≤7W	≤120mA	20V
AL1676-20B	≤10W	≤200mA	20V
AL1676-20C	≤10W	≤200mA	20V
AL1676-40D	≤18W	≤350mA	20V

Ordering Information



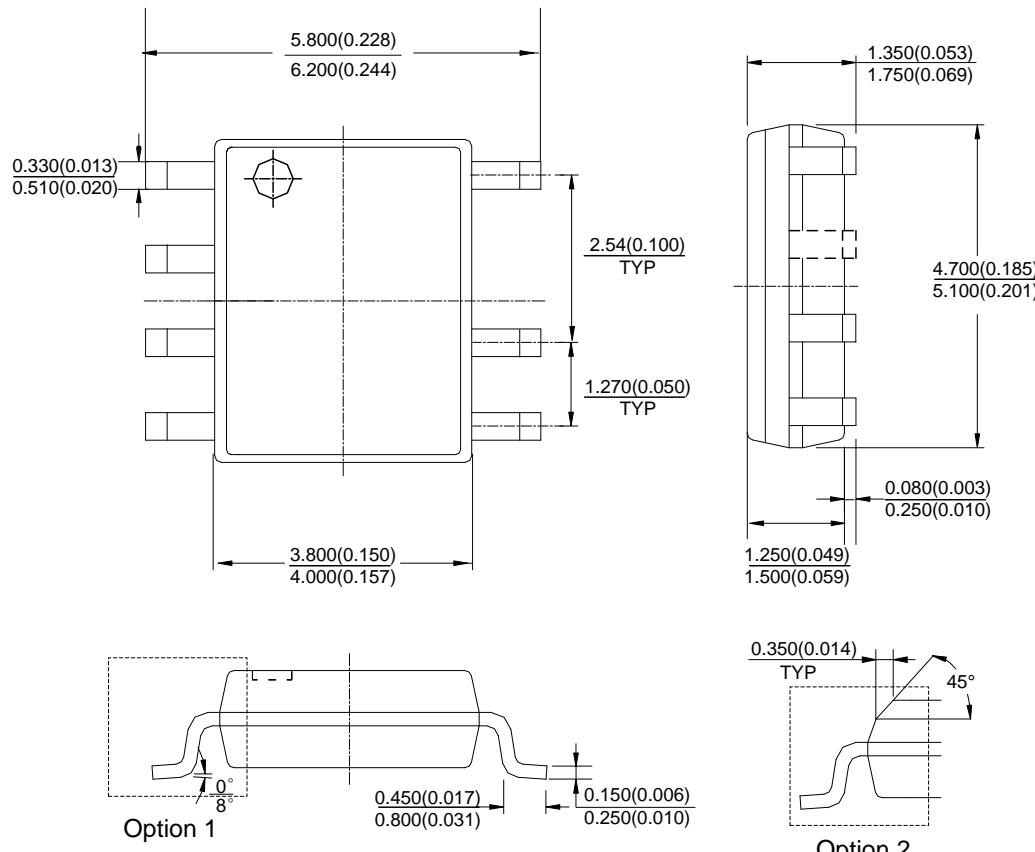
Part Number	Package code	Package	13" Tape and Reel	
			Quantity	Part Number Suffix
AL1676-20AS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1676-30AS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1676-10BS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1676-20BS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1676-20CS7-13	S7	SO-7	4000/Tape & Reel	-13
AL1676-40DS7-13	S7	SO-7	4000/Tape & Reel	-13

Marking Information



Package Outline Dimensions (All dimensions in mm.)

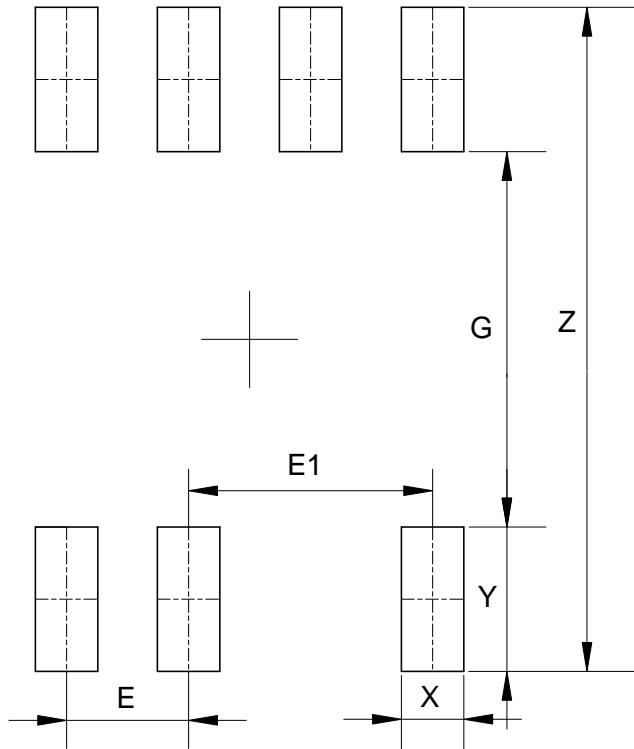
(1) Package Type: SO-7



Note: Eject hole, oriented hole and mold mark is optional.

Suggested Pad Layout

(1) Package Type: SO-7



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)	E1 (mm)/(inch)
Value	6.900/0.272	3.900/0.154	0.650/0.026	1.500/0.059	1.270/0.050	2.540/0.100

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel. Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

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.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

Copyright © 2016, Diodes Incorporated

www.diodes.com

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Diodes Incorporated](#):

[AL1676-30AS7-13](#) [AL1676-20BS7-13](#) [AL1676-20AS7-13](#) [AL1676-20CS7-13](#) [AL1676-10BS7-13](#) [AL1676-40DS7-13](#)