Description

The AL1665 is a high performance single stage flyback and buck-boost controller, targeting dimmable LED lighting application. It is a Primary Side Regulation (PSR) controller which can provide accurate Constant Current (CC) regulation without opto-coupler and secondary control circuitry. It can be operated at BCM mode which results in low EMI and high efficiency, and keeps high Power Factor (PF) and low Total Harmonic Distortion (THD) under universal input voltage.

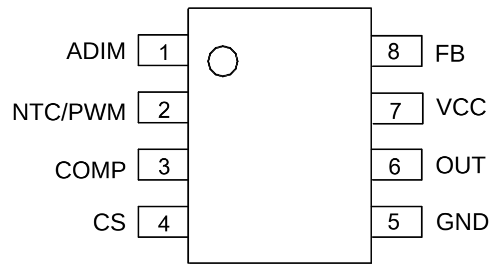
The AL1665 can support analog/PWM dimming modes. When a 50mV to 2.5V DC signal is applied on ADIM pin, the device will be operated in analog dimming mode. The analog dimming range is 5% to 100%. When a PWM signal is applied to NTC/PWM pin, the device will be operated at PWM dimming mode. The PWM dimming range is 0.5% to 100% (1k PWM dimming frequency).

The AL1665 features low operation current. It integrates multiple protections including over voltage, short circuit, over current and over temperature.

The AL1665 is available in SO-8 (Standard) package.

Pin Assignments

(Top View)



SO-8 (Standard)

Applications

- General LED Lighting Driver with Dimming Function
- General Purpose Constant Current Source
- LED Backlighting Driver
- Smart LED Lighting

Features

- Primary Side Regulation without Opto-Coupler
- Valley Switching for Low Switching Loss
- Low Start-Up Current
- Support Analog and PWM Dimming
  - Analog Dimming Range: 5% to 100%
  - PWM Dimming Range: 0.5% to 100% (1k PWM Frequency)
- Internal Protections
  - Under Voltage Lock Out (UVLO)
  - Output Over Voltage Protection (OVP)
  - Output Short Protection (OSP)
  - Over Current Protection (OCP)
  - CS Short Protection
  - Winding Short Circuit Protection
  - Secondary Diode Short Protection
  - Shorted Current Sense Protection
  - User Programmable NTC Based Thermal Foldback
  - Internal Thermal Fold-Back Protection (TFP)
  - Over Temperature Protection (OTP)
- Low System Cost
- High PF>0.9 and Low THD<20%
- High Efficiency
- Tight LED Current Variation Range
  - LED Current Line Regulation: ±2%
  - LED Current Load Regulation: ±2% Full Load to Half Load
- Tight Output Open Voltage Variation Range
- Package: SO-8 (Standard)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.

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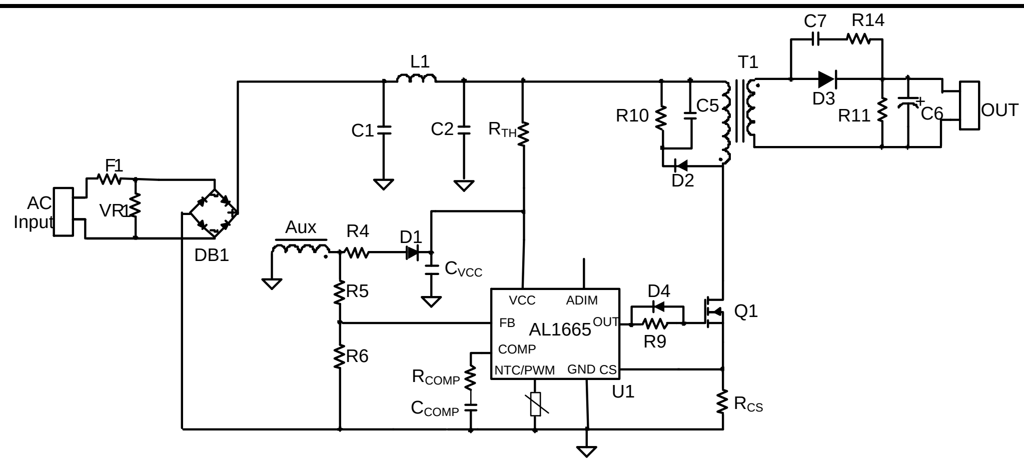
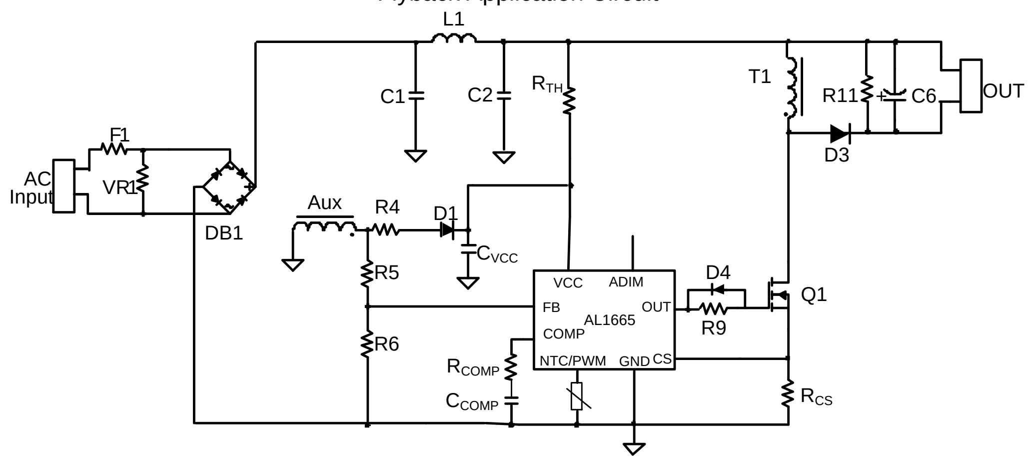
Typical Applications Circuit



Flyback Application Circuit



Buck-Boost Application Circuit

Pin Descriptions

Pin Number	Pin Name	Function
1	ADIM	Analog Dimming Input Pin
2	NTC/PWM	NTC Input Pin for Thermal Foldback/PWM Dimming Input Pin
3	COMP	Loop Compensation Pin
4	CS	Current Sense Pin, Connect This Pin to the Source of the Primary Switch
5	GND	Ground
6	OUT	Gate Driver Output
7	VCC	Supply Voltage of Gate Driver and Control Circuits of the IC
8	FB	The Feedback Voltage Sensing from the Auxiliary Winding

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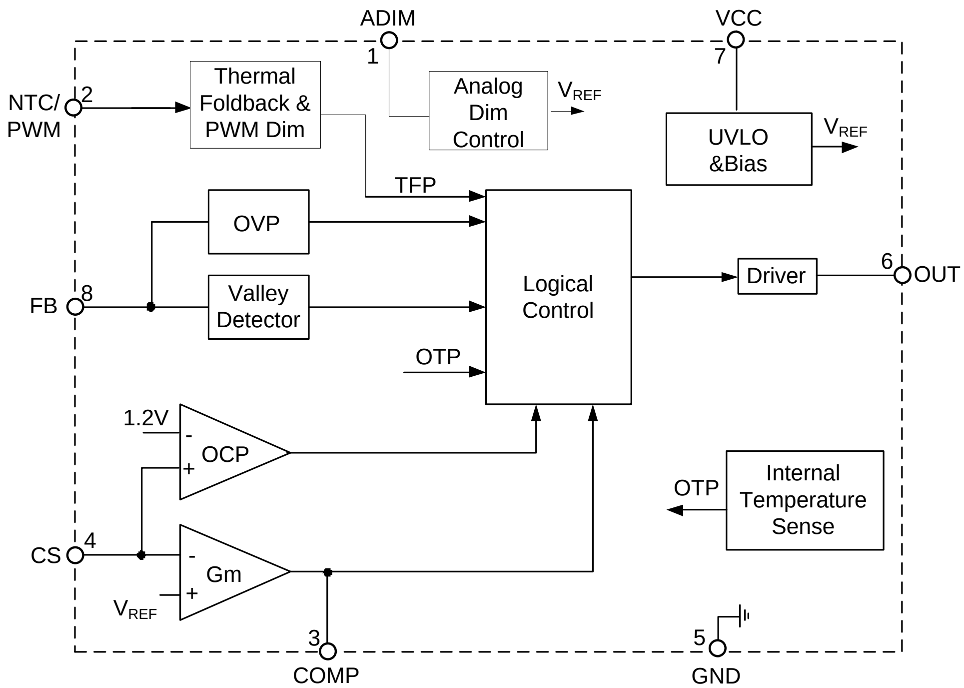
Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter	Rating	Unit
V_{CC}	Power Supply Voltage	-0.3 to 30	V
V_{CS}	Voltage at CS to GND	-0.3 to 7	V
V_{FB}	FB Input Voltage	-0.3 to 7	V
V_{COMP}	Voltage at Loop Compensation Pin	-0.3 to 7	V
V_{OUT}	Driver Output Voltage	-0.3 to 20	V
$V_{NTC/PWM}$	Voltage at NTC/PWM to GND	-0.3 to 7	V
V_{ADIM}	Voltage at ADIM to GND	-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, 10s)	+300	°C
P_D	Power Dissipation at T_A = +50°C	0.65	W
θ_{JA}	Thermal Resistance (Junction to Ambient)	136	°C /W
θ_{JC}	Thermal Resistance (Junction to Case)	30	°C/W
–	ESD (Human Body Model)	2000	V
	ESD (Charged-Device Model)	1000	V

Note: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can 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 can affect device reliability. All voltages unless otherwise stated are measured with respect to GND.

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Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
T_A	Ambient Temperature (Note 5)	-40	+105	°C
V_{CC}	Operating VCC Voltage (Note 6)	8.5	V_{CC_OVP} (Min)	V

Notes: 5. The device may operate normally at +125°C ambient temperature under the condition not triggers temperature protection.
6. I_{CC} should be limited less than 5mA.

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
UVLO Section						
V_{CC_TH}	Startup Threshold Voltage	–	15.8	18.5	19.5	V
V_{OPR_MIN}	Minimal Operating Voltage	After Turn On	5.8	7.8	9	V
V_{CC_OVP}	V_{CC} OVP Voltage	–	21.8	25	29.5	V
Standby Current Section						
I_{ST}	Startup Current	V_{CC} = V_{CC_TH} -0.5V, Before Start Up	–	120	300	µA
I_{CC}	Operating Current	FB, CS Connect to GND, C_{GATE} = 100pF	–	2	4	mA
I_{CC_OVP}	Shunt Current in OVP Mode	$V_{CC} > V_{CC\_OVP}$	3.1	–	–	mA
Drive Output Section						
t_R	Output Voltage Rise Time (Note 7)	C_L = 1nF	–	100	–	ns
t_F	Output Voltage Fall Time (Note 7)	C_L = 1nF	–	100	–	ns
V_{OUT_CLAMP}	Output Clamp Voltage	V_{CC} = 20V	9.8	12	15.5	V
t_{ON_MIN}	Minimum On Time (Note 7)	–	–	1000	2010	ns
t_{ON_MAX}	Maximum On Time	–	–	20	31	µs
t_{OFF_MAX}	Maximum Off Time	–	–	290	405	µs
f_{MAX}	Maximum Frequency	–	–	150	–	kHz
Internal CS Reference						
V_{REF}	Internal Reference Voltage	–	0.394	0.4	0.406	V
V_{CS_CLAMP}	Primary Current Clamp Voltage	–	1.8	2	2.5	V
V_{CS_OCP}	Primary Over Current Voltage	–	–	3	–	V
Error Amplifier						
Gm	Trans-Conductance	–	–	27	–	µA/V
I_{SOURCE}	Amplifier Source Current	–	–	7.2	–	µA
Feedback Input Section						
V_{FB_CV}	FB CV Threshold	–	2.5	3.0	3.5	V
ADIM Section						
–	Analog Dimming Range on ADIM	–	0.05	–	2.5	V
–	Analog Dimming High Level	–	2.45	2.5	2.55	V
–	Analog Dimming Range Ratio	–	5%	–	100%	–

Note: 7. These parameters, although guaranteed by design, are not 100% tested in production.

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
NTC/PWM Section						
$V_{NTC/PWM(PULL-UP)}$	Pull-Up Voltage when NTC/PWM Open	NTC/PWM Pin Open	–	2.5	–	V
$I_{OTP(REF)}$	Reference Current for Direct Connection of NTC/PWM (Note 9)	–	70.5	85	91	µA
$V_{OTP(OFF)}$	Fault Detection Level for OTP (Note 8)	$V_{NTC/PWM}$ Falling	–	0.50	–	V
$V_{OTP(ON)}$	NTC/PWM Pin Level for Operation Recovery after an OTP Detection	$V_{NTC/PWM}$ Rising	–	0.70	–	V
$t_{OTP(START)}$	OTP Blanking Time when Circuit Starts Operating (Note 9)	–	250	–	370	µs
$V_{TF(START)}$	NTC/PWM Pin Voltage at which Thermal Fold−Back Starts (V_{REF} is Decreased)	–	0.94	1.00	1.06	V
$V_{TF(STOP)}$	NTC/PWM Pin Voltage at which Thermal Fold−Back Stops (V_{REF} is Clamped to V_{REF50})	–	0.64	0.69	0.74	V
$V_{REF(50)}$	V_{REF} @ $V_{NTC/PWM}$ = 600mV (Percent of V_{REF})	–	40	50	60	%
Thermal Fold-Back Section						
T_{REG}	Overheating Temperature Regulation (Note 7)	–	–	+150	–	°C
Over Temperature Protection Section						
–	Shutdown Temperature (Notes 7, 8)	–	–	+180	–	°C

Notes:
7. These parameters, although guaranteed by design, are not 100% tested in production.
8. The device will latch when OTP happens and won't be operated constantly at this temperature.
9. At startup, when V_{CC} reaches $V_{CC(ON)}$, the controller blanks OTP for more than 250µs to avoid detecting an OTP fault by allowing the NTC/PWM pin voltage to reach its nominal value if a filtering capacitor is connected to the NTC/PWM pin.

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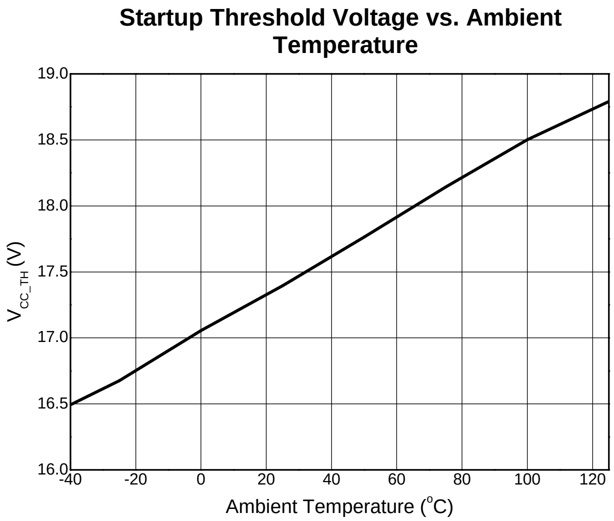
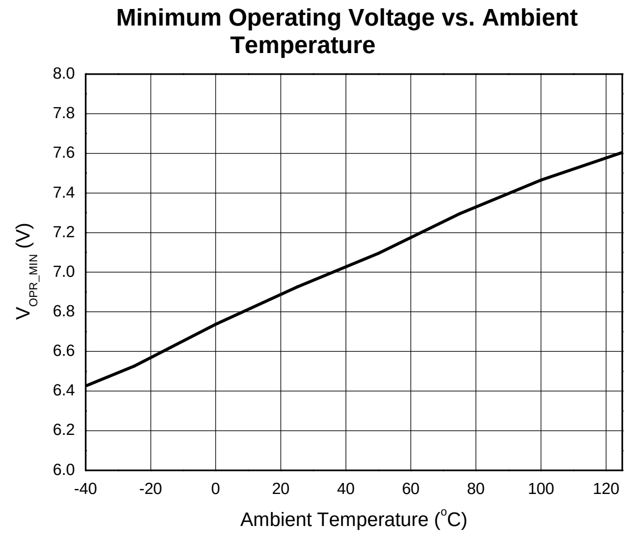
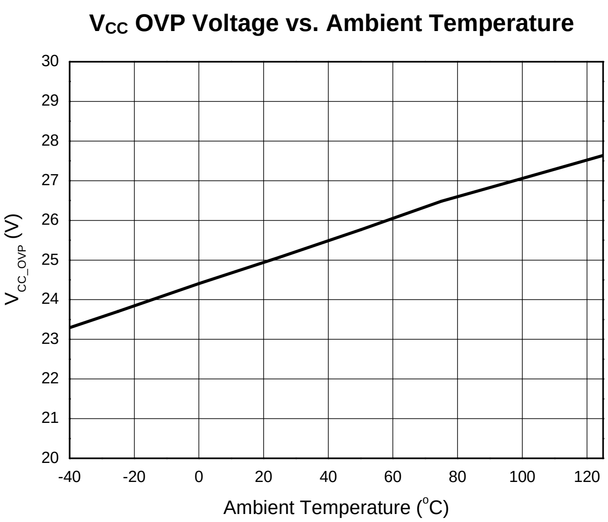
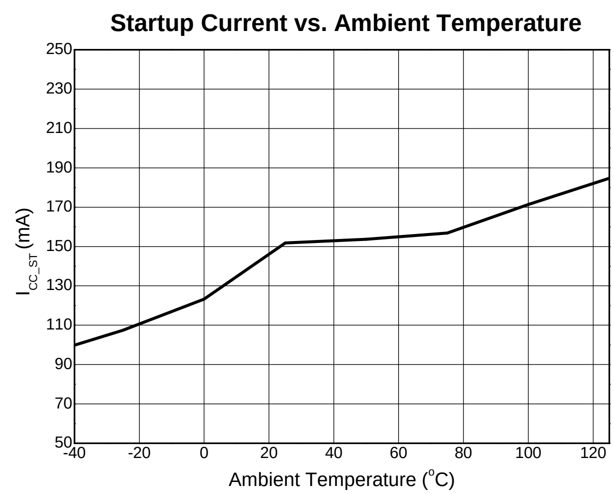
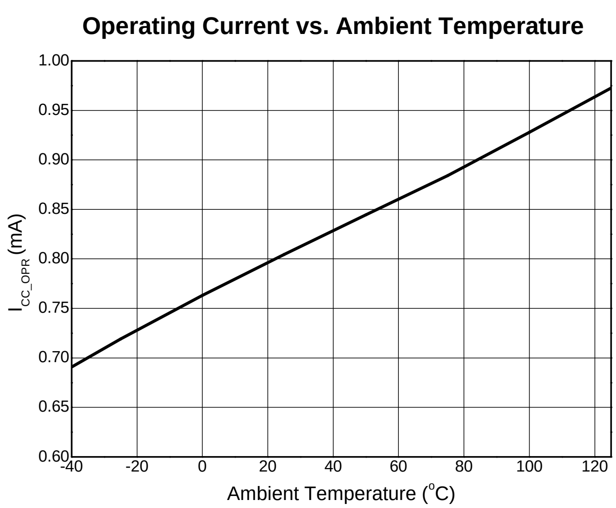
Performance Characteristics (Note 10)

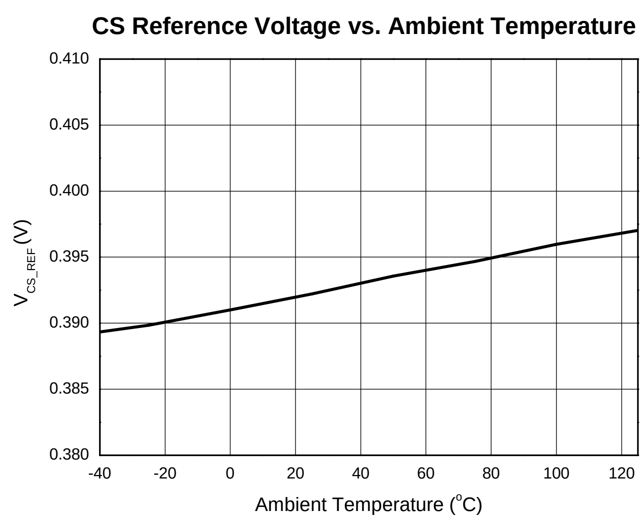












Note: 10. These electrical characteristics are tested under DC condition. The ambient temperature is equal to the junction temperature of the device.

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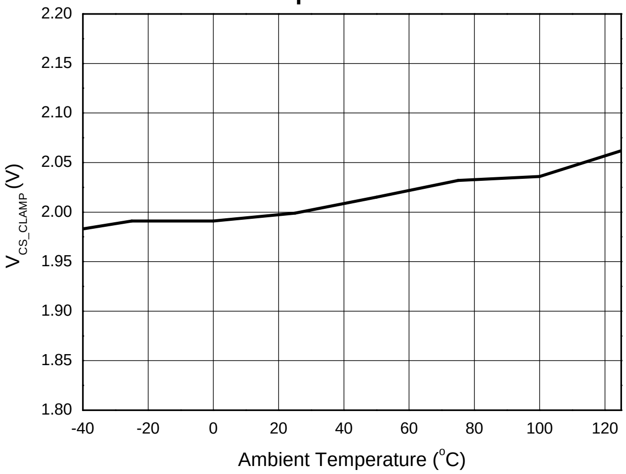
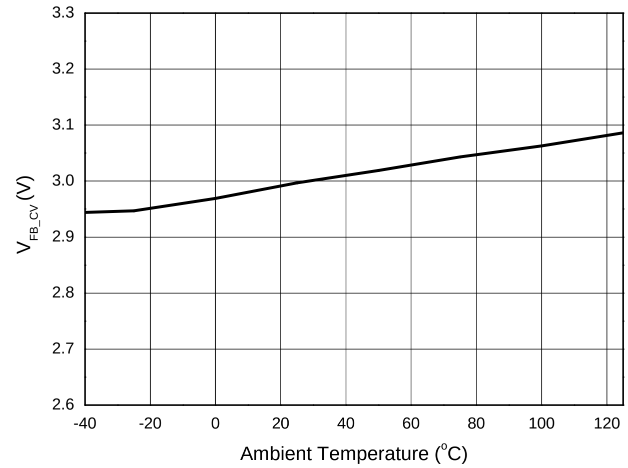
Performance Characteristics (continued)

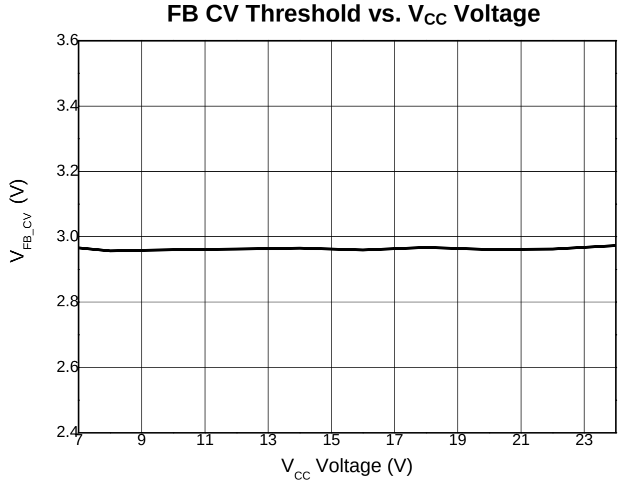
CS Clamp Reference Voltage vs. Ambient Temperature



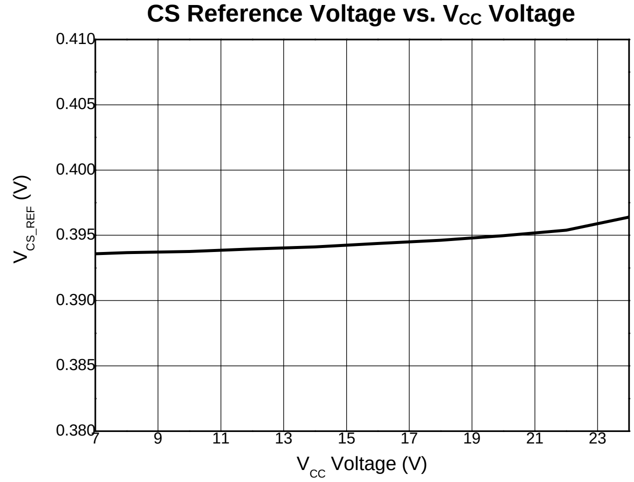
FB CV Threshold vs. Ambient Temperature



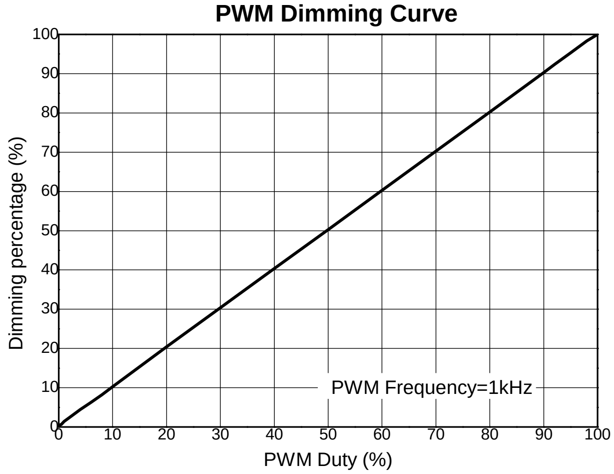
FB CV Threshold vs. V_{CC} Voltage



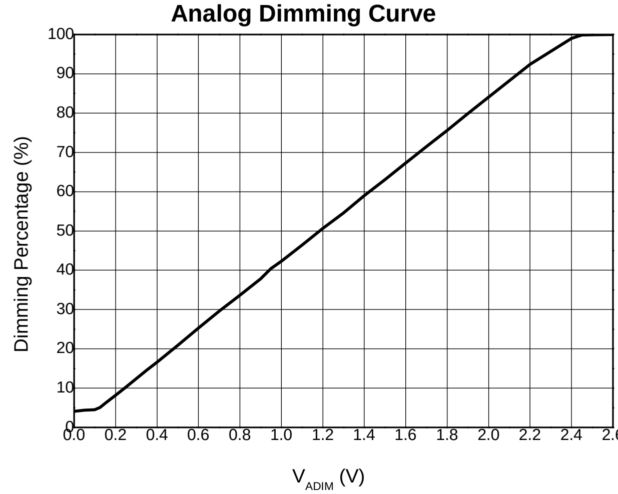
CS Reference Voltage vs. V_{CC} Voltage



PWM Dimming Curve



Analog Dimming Curve



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Application Information

The AL1665 is a constant current high PF flyback and buck-boost controller with Primary Side Regulation (PSR), targeting LED lighting applications. The device eliminates the opto-couplers or the secondary feedback circuits, which is helpful to cost down the whole system. High power factor is achieved by constant on-time operation. In order to reduce the switching losses and improve EMI performance, quasi-resonant switching mode is applied. The AL1665 integrates multiple protections including UVLO protection, V_{CC} over voltage protection, output open voltage protection, over current protection, thermal fold-back protection and over temperature protection. The AL1665 can support analog and PWM dimming modes.

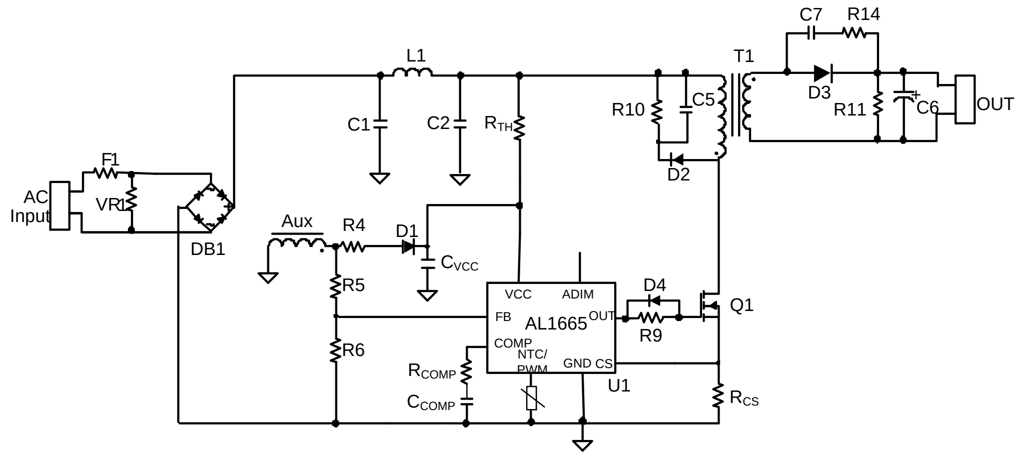

Figure 1. Flyback Application Circuit

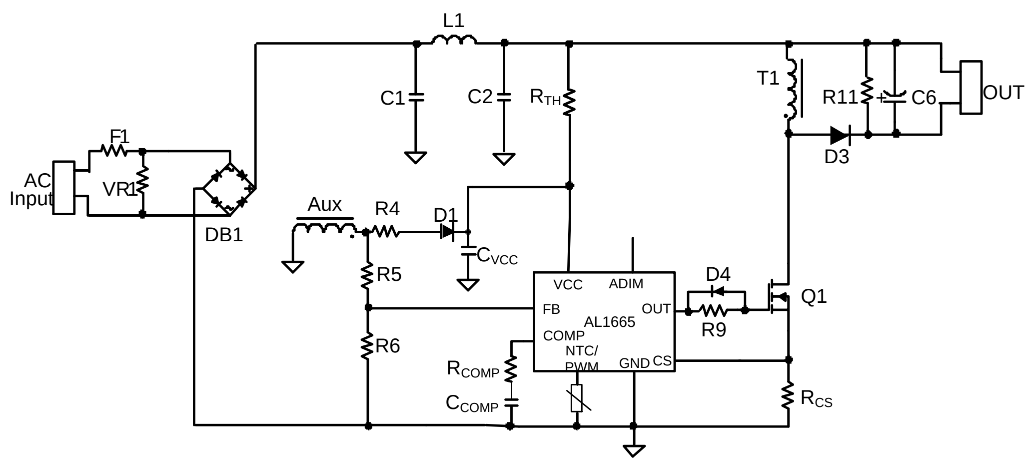

Figure 2. Buck-Boost Application Circuit

Start-Up

After AC supply is powered on, the capacitor C_{VCC} across VCC and GND pin will be charged up by BUS voltage through a start-up resistor R_{TH}. Once V_{CC} reaches V_{CC_TH}, the internal blocks start to work. V_{CC} will be supplied by V_{BUS} until the auxiliary winding of flyback transformer could supply enough energy to maintain V_{CC} above V_{OPR_MIN}. If V_{CC} voltage is lower than V_{OPR_MIN}, switch will be turned off.

After V_{CC} exceeds V_{CC_TH}, the drive blocks won't start to switch on/off signals until V_{COMP} is higher than the initial voltage V_{COMP_ST}, which can be programmed by R_{COMP}. The formula is shown as below. Such design can program startup on time to reduce the startup time or the output overshoot current.

$$V_{COMP\_ST} = 1.4V - 700\mu A \cdot R_{COMP}$$

Where V_{COMP_ST} is the pre-charged voltage of COMP pin. R_{COMP} is shown as Figure 1.

Generally, a big capacitance of C_{COMP} is necessary to achieve high power factor and stabilize the system loop (1µF to 2µF is recommended). The pre-charged voltage in start-up procedure can be programmed by R_{COMP}.

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Application Information (continued)

Protections

1. Output Open Protection (OVP)

The output voltage is reflected by the voltage on transformer's auxiliary winding. Both the FB pin and the VCC pin of IC have the over voltage protection function. When there is a rapid line and load transient, the output voltage may exceed the regulated value. If V_{CC} exceeds V_{CC_OVP}, the V_{CC} over voltage protection will be triggered, the switch will be turned off and the V_{CC} will be discharged. Once V_{CC} is lower than V_{OPR_MIN}, the IC will shut down and be powered on again by BUS voltage through start up resistor. If V_{FB} exceeds V_{FB_CV}, the FB over voltage protection will be triggered, switch will be turned off and V_{CC} will be latched for 16s, then V_{CC} will be discharged. Once V_{CC} is below V_{OPR_MIN}. the IC will shut down and be powered on again by BUS voltage through start up resistor. Power dissipation is low when FB over voltage protection happens.

Thus, output over voltage depends on the minimum voltage between both OVP protections' limitation. It can be gotten by below formula.

$$V_{OVP} = Min\left(\frac{N_S}{N_{AUX}} \cdot V_{CC\_OVP}, \frac{N_S}{N_{AUX}} \cdot \frac{R5+R6}{R6} \cdot V_{FB\_CV}\right)$$

Where V_{OVP} is the output over voltage setting; R5 and R6 shown in Figure 1 are divider resistors connected from the auxiliary winding.

N_{AUX} is the turns of auxiliary wind; N_S is turns of the secondary wind. V_{CC_OVP} is the OVP Voltage of V_{CC}.

2. Output Short Protection (OSP)

When the output is shorted, the output voltage would drop down to zero. The output voltage of the auxiliary winding, which is proportional to the output winding, will drop down too. If the V_{FB} drops below 0.4V, the output short protection will be triggered, switch will be turned off and V_{CC} will be latched for 16s, then V_{CC} will be discharged. Once V_{CC} is below the V_{OPR_MIN}, the IC will be shut down and powered on again by the BUS voltage through the startup resistor. Power dissipation is low when output short protection happens.

3. Over Current Protection (OCP)

The AL1665 has a built-in cycle by cycle over current protection of primary inductor current. When CS pin voltage reaches the voltage V_{CS_CLAMP}, the switch will be turned off until next switch period. The maximum peak current ($I_{PEAK\ (MAX)}$) of the inductor can be calculated as below:

$$I_{PEAK\_MAX} = \frac{V_{CS\_CLAMP}}{R_{CS}}$$

Where V_{CS_CLAMP} means primary current clamp voltage that is 2V.

R_{CS} is current sense resister which is shown as Figure 1.

4. CS Short Protection

When CS pin is shorted to GND, CS voltage is latched to zero. If CS is detected lower than 0.3V for 7 pulses, the CS short protection will be triggered, switch will be turned off and V_{CC} will be latched for 16s, then V_{CC} will be discharged. Once V_{CC} is below V_{OPR_MIN}, the IC will be shut down and powered on again by the BUS voltage through the startup resistor. High rush current appears when CS is shorted to GND, and it may damage the components.

5. Secondary Diodes/Primary Windings/Secondary Windings Short Protection

The CS voltage will be high when secondary diodes/primary windings/secondary windings are shorted. If the CS voltage is higher than V_{CS_OCP}, the protection will be triggered, switch will be turned off and V_{CC} will be latched for 16s, then V_{CC} will be discharged. Once V_{CC} is below V_{OPR_MIN}, the IC will be shut down and powered on again by the BUS voltage through the startup resistor. Power dissipation is low when output short protection happens.

6. Thermal Fold-back Protection (TFP)

Connect a NTC between the NTC/PWM pin and ground to detect an over temperature condition. In response to a high temperature (detected if $V_{NTC/PWM}$ drops below $V_{TF(START)}$), the circuit gradually reduces the LED current down 50% of its nominal value when $V_{NTC/PWM}$ reaches $V_{TF(STOP)}$, in accordance with the characteristic of Figure 3. If this thermal fold-back cannot prevent the temperature from rising (testified by $V_{NTC/PWM}$ droping below V_{OTP}), the circuit would be latched off or enter the auto−recovery mode, and cannot be re-operated until $V_{NTC/PWM}$ exceeds $V_{OTP(ON)}$ to provide some temperature hysteresis (around +10°C typically). The OTP thresholds nearly correspond to the following resistances of the NTC:

Thermal fold-back starts when R_{NTC} <=$R_{TF(START)}$(11.7kΩ typically); Thermal fold-back stops when R_{NTC} <=$R_{TF(STOP)}$ (8.0kΩ typically); OTP triggers when R_{NTC} <= $R_{OTP(OFF)}$ (5.9kΩ typically); OTP is removed when R_{NTC} >= $R_{OTP(ON)}$ (8.0kΩ typically). At startup, when V_{CC} reaches $V_{CC(ON)}$, the OTP comparator is blanked for at least 250µs in order to allow the NTC/PWM pin voltage to reach its nominal value if a filtering capacitor is connected to the NTC/PWM pin. This would avoid flickering of the LED light during turn-on.

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Application Information (continued)

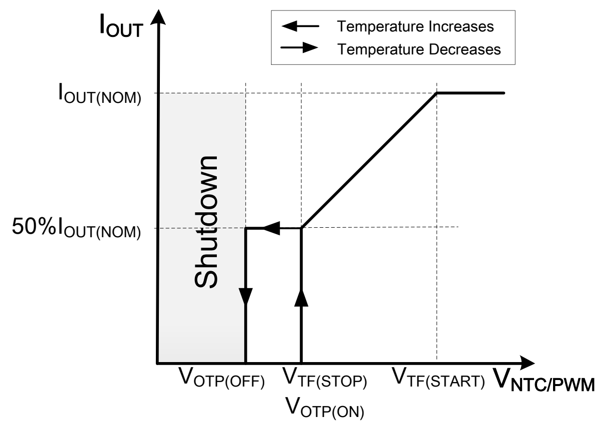

Figure 3. Output Current Reduction versus NTC/PWM Pin Voltage

7. Over Temperature Protection (OTP)

The AL1665 has built-in Over Temperature Protection (OTP) function. When the temperature goes up to +165°C, the over temperature protection will be triggered, which leads to a latch mode protection. When OTP happens, the system needs to be powered off and restart.

Output Constant Current Control

According to the definition of mean output current, the mean output current can be obtained as below:

$$I_{O\_MEAN} = \frac{1}{\pi} \cdot \int_0^{\pi} \frac{1}{2} \cdot I_{SP} \cdot \frac{t_{ONS}}{t_{SW}} dt$$

Where I_{O_MEAN} is the mean output current; I_{SP} is the secondary peak current of transformer;
t_{ONS} is the discharge time of secondary side of transformer; t_{SW} is the switch period.

According to the principle of AL1665 closed loop control, the voltage of R_{CS} will be sampled when switch is turned off and the value will be held until discharge time t_{ONS} is over. It can be described by following formula:

$$V_{REF} = \frac{1}{\pi} \int_0^{\pi} I_P \cdot R_{CS} \cdot \frac{t_{ONS}}{t_{SW}} dt$$

Where I_P is the primary peak current of transformer; R_{CS} is the current sense resister which is shown as Figure 1.

t_{ONS} is the discharge time of secondary side of transformer; t_{SW} is the switch period. V_{REF} is internal reference voltage that is equal to 0.4V.

The peak current at secondary side has the following relationship with primary side peak current, if the effect of the leakage inductor is neglected.

$$I_{SP} = N_{PS} \cdot I_P$$

Where N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost); I_P is the primary peak current of the transformer.

According to these above formulas, the mean output current can be induced finally by the expression below:

$$I_{O\_MEAN} = \frac{N_{PS} \cdot V_{REF}}{2 \cdot R_{CS}}$$

Where I_{O_MEAN} is the mean output current; R_{CS} is the current sense resister which is shown as Figure 1 and Figure 2;

V_{REF} is the internal reference voltage that is equal to 0.4V; N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost);
Therefore, the constant output current control can be realized with appropriate parameter design.

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Application Information (continued)

PF and THD Compensation Circuit

In typical application, AL1665 can provide PF>0.9 and THD <40%. It can improve PF>0.95 and THD<20% by adding the compensation circuit as below. The V_{BUS} is connected to bus line which is after the rectifier bridge. The COMP pin voltage will increase an offset that is almost followed with bus line voltage in the circuit. Due to the COMP voltage controls the switch-on time, the phase difference between input voltage and input current will be reduced, which can optimize the PF and THD. In the circuit, the range of resister value R12 is from 800kΩ to 1.5MΩ, and the range of resistor value R13 is from 500Ω to 5.1kΩ. The Range of capacitance C11 is 1μF to 2μF. The PF and THD circuit can be improved by fine-tuning these components.

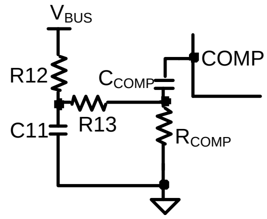

Figure 4. PF and THD Compensation Circuit

Line Regulation Compensation Function

The AL1665 can achieve good line regulation by adjusting FB pull-up resistor R_{FB1} and CS external horizontal resistor R_{CS1}. The circuit is shown as Figure 5. I_{FB3} is the current that flows from GND to the internal FB pull-down resistor. I_{FB3} will be detected during t_{ONP} time, and flows into CS to compensate V_{REF}.

$$V_{CS\_OFFSET}=\frac{K\cdot V_{IN}\cdot N_{AP}\cdot\frac{R_{FB2}}{R_{FB2}+R_{FB3}}}{R_{FB1}+\frac{R_{FB2}\cdot R_{FB3}}{R_{FB2}+R_{FB3}}}\cdot(R_{CS1}+R_{CS2})$$

V_{REF} is the internal reference voltage that is equal to 0.4V; K is conversion coefficient of I_{FB3} that is equal to 4; V_{IN} is the input Voltage;
N_{AP} is the turns' ratio of auxiliary winding and primary winding;
R_{FB2} is the external FB pull-down resistor; R_{FB3} is the internal FB pull-down resistor that is connected to the system during t_{ONP} time, and equals to 207Ω;
R_{CS2} is the internal horizontal resistor that is 6kΩ.

As R_{FB1} and R_{FB2} are far larger than R_{FB3}, the output current can be calculated approximately as following:

$$I_{O\_MEAN}=\frac{N_{PS}}{2\cdot R_{CS}}\cdot(V_{REF}-V_{CS\_offset})=\frac{N_{PS}}{2\cdot R_{CS}}\cdot(V_{REF}-\frac{K\cdot V_{IN}\cdot N_{AP}\cdot(R_{CS1}+R_{CS2})}{R_{FB1}})$$

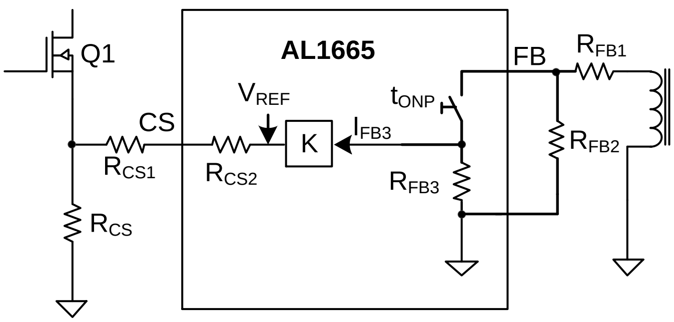

Figure 5. Line Regulation Compensation Circuit

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Application Information (continued)

Dimming Mode

The AL1665 can support two dimming modes: analog dimming and PWM dimming.

1. Analog Dimming Mode

In analog dimming mode, the dimming signal is added to ADIM pin directly to realize dimming function. The setting circuit is shown as Figure 6. When V_{APWM} is higher than 2.5V, the driver will output 100% of rated current; when the voltage V_{ADIM} is in the range from 50mV to 2.5V, the output current will be changed linearly with the voltage V_{APWM}. The dimming curve is shown as Figure 7 and the dimming range is from 2% to 100%.

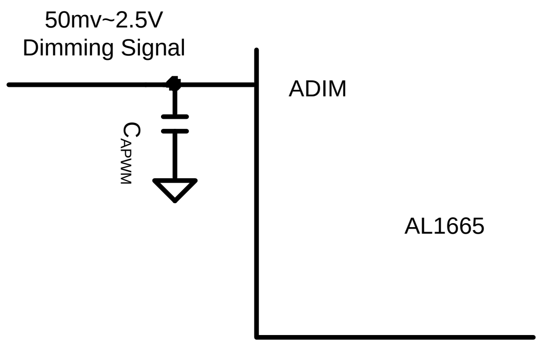

Figure 6. Analog Dimming Setting Circuit

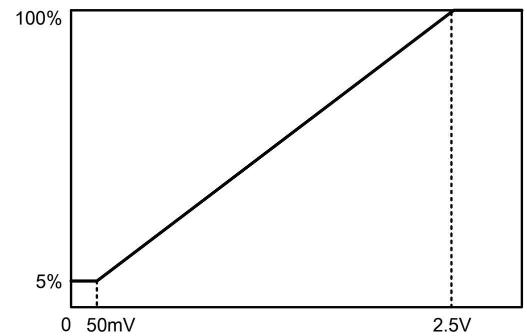

Figure 7. Analog Dimming Curve

2. PWM Dimming Mode

In PWM dimming mode, dimming signal will be added to NTC/PWM pin .The setting circuit is shown as Figure 8. The output current is chopped by the dimming signal directly. The logic high level of the dimming signal needs to be higher than 1V while the logic low level is lower than 0.5V. The switch is turned off at logic low level. The dimming curve is shown as Figure 9. The dimming range can be 100% to 0.5% with 1kHz frequency of PWM signal.

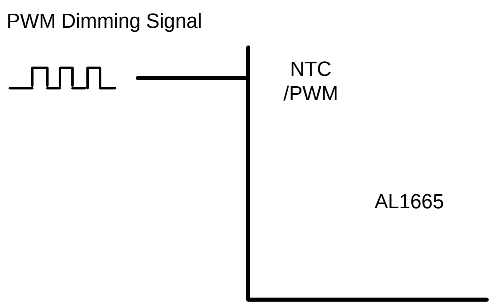

Figure 8. PWM Dimming Setting Circuit

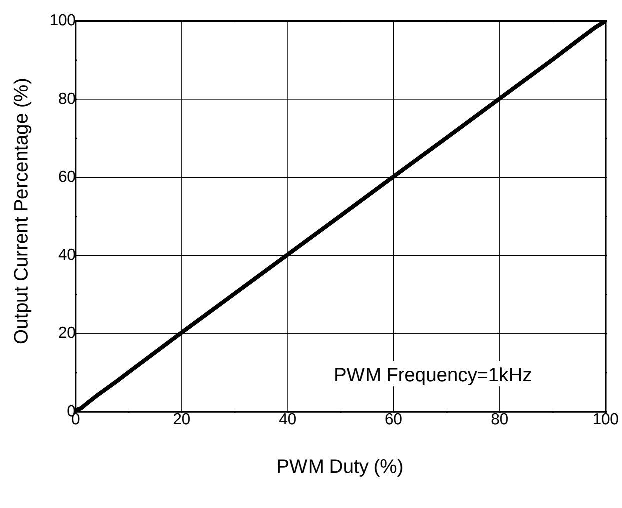

Figure 9. PWM Dimming Curve

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Application Information (continued)

Operation Parameters Design

1. Setting the Current Sense Resistor R_{CS}

The current sense resistance can be calculated as following:

$$R_{CS}=\frac{N_{PS}\cdot V_{REF}}{2\cdot I_{O\_MEAN}}$$

Where I_{O_MEAN} is the mean output current; R_{CS} is the current sense resister which is shown as Figure 1;
V_{REF} is the internal reference voltage that is equal to 0.4V; N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost).

2. Setting Transformer Selection (T1)

N_{PS} is limited by the electrical stress of the switch MOSFET, can be calculated by below formula.

$$N_{PS}\le\frac{V_{MOS\_(BR)DS}\cdot 90\%-\sqrt{2}\cdot V_{IN\_MAX}-\Delta V_S}{V_O+V_{D\_F}}$$

Where $V_{MOS\_(BR)DS}$ is the breakdown voltage of the switch MOSFET. V_{IN_MAX} is the max rated input voltage. ΔV_S is the overshoot voltage clamped by RCD snobbier during OFF time. V_O is the output voltage. V_{D_F} is the forward voltage of secondary diode. N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost);

For boundary conduction mode and constant on time method, the peak current of primary inductance can be calculated as below.

$$I_P=\frac{2\cdot\pi\cdot I_{O\_MEAN}}{N_{PS}\cdot\int_0^{\pi}\sin(\theta)\cdot\frac{\sqrt{2}\cdot V_{IN\_RMS}\cdot\sin(\theta)}{\sqrt{2}\cdot V_{IN\_RMS}\cdot\sin(\theta)+N_{PS}\cdot Vo}d\theta}$$

Where V_{IN_RMS} is the rate input voltage; I_P is the primary inductance current. N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost); I_{O_MEAN} is the mean output current; V_O is the output voltage.

The switching frequency is not constant for AL1665 due to boundary conduction mode. To set the minimum switching frequency f_{MIN} at the crest of the minimum AC input, primary inductance can be obtained by below formula.

$$L_P=\frac{\sqrt{2}\cdot V_{IN\_RMS}\cdot N_{PS}\cdot V_O}{I_P\cdot(\sqrt{2}V_{IN\_RMS}+N_{PS}V_O)\cdot f_{MIN}}$$

Where V_{IN_RMS} is the rate input voltage; I_P is the primary inductance current. N_{PS} is the turns' ratio of flyback transformer (N_{PS}=1 for buck-boost); V_O is the output voltage; f_{MIN} is the minimum switching frequency at the crest of the minimum AC input.

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

$$N_P=\frac{L_P\cdot I_P}{A_e\cdot B_m}$$

$$N_S=\frac{N_P}{N_{PS}}$$

Where,

A_e is the core effective area.

B_m is the maximum magnetic flux density.

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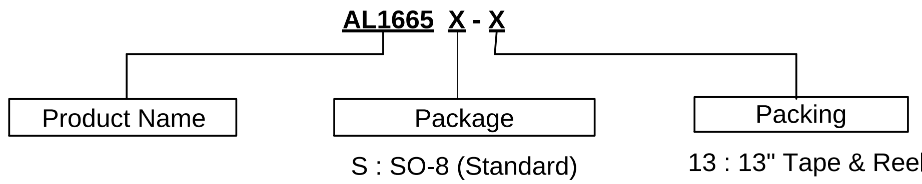
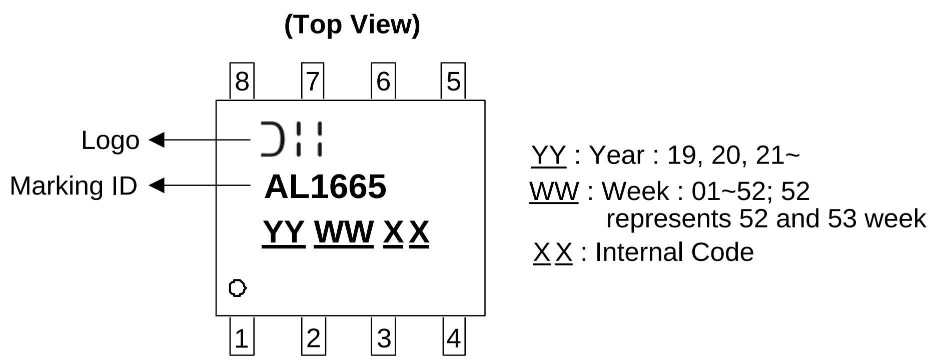
Ordering Information



Part Number	Package Code	Package	13" Tape and Reel	
			Quantity	Part Number Suffix
AL1665S-13	S	SO-8 (Standard)	4000/Tape & Reel	-13

Marking Information



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Package Outline Dimensions (All dimensions in mm.)

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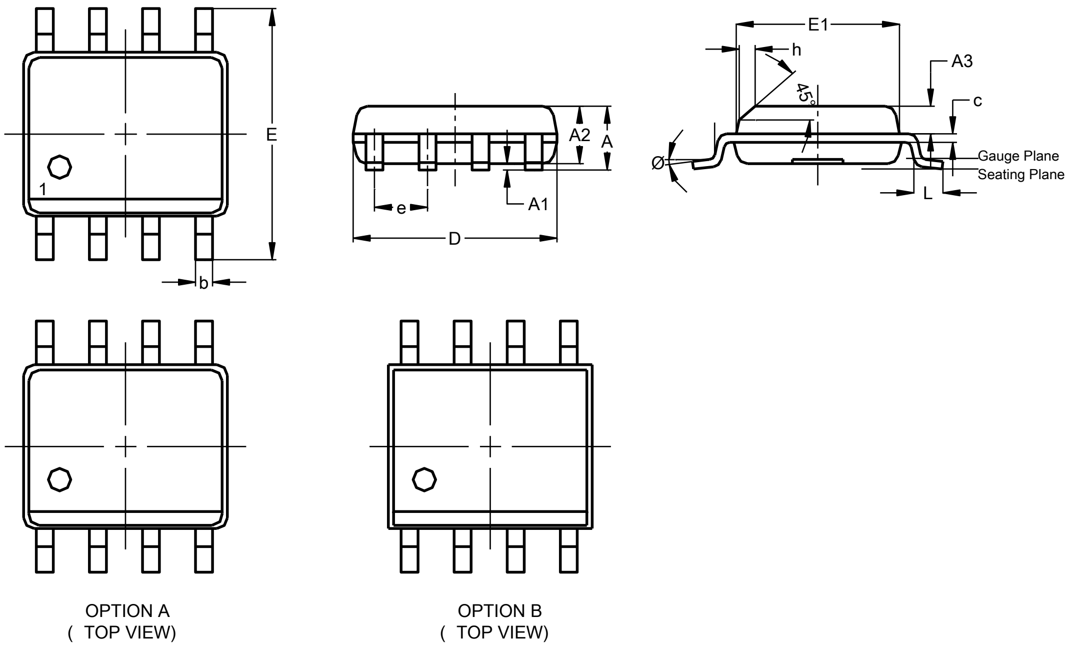
(1) Package Type: SO-8 (Standard)

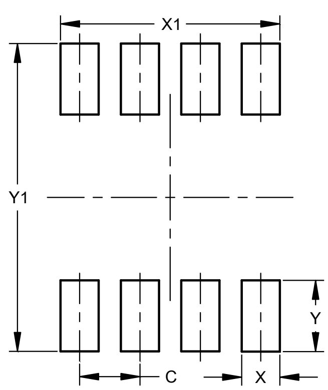


SO-8 (Standard)			
Dim	**Min**	**Max**	**Typ**
A	--	1.75	--
A1	0.10	0.25	--
A2	1.25	1.65	--
A3	0.50	0.70	--
b	0.30	0.51	--
c	0.15	0.25	--
D	4.80	5.00	--
E	5.80	6.20	6.00
E1	3.80	4.00	--
e	--	--	1.27
h	0.25	0.50	--
L	0.45	0.82	--
Ø	0°	8°	--
All Dimensions in mm			

Suggested Pad Layout

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

(1) Package Type: SO-8 (Standard)



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

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