SSL Interface Controller for Analog (0-10V), PWM, and Resistor Dimming with Optocoupler Delay Elimination

1 Description

The iW350 is a PWM signal generator that works with three different types of dimming inputs, 0-10V PWM dimming, 0-10V linear dimming or simple dimming using a single resistor to ground from the DIM pin. The iW350 auto detects the dimmer type connected. A PWM dimming type is directly used, while the 0-10V linear dimming and resistor dimming signals are converted into a 0%-100% PWM duty cycle that can then be used to provide a dimming signal to a primary-side LED driver such as the iW3636, removing the need for transformers or other driver circuitry. The output of the iW350 is optimized in such a way as to remove the impact of the non-linear delay typical of optocouplers.

The iW350 offers a high level of flexibility by offering programmability for the maximum dimming voltage, minimum output duty cycle and the turn-off threshold voltage through external resistors. The output PWM frequency is also programmable from 100Hz to 5kHz through a single capacitor to ground. The input to the iW350 integrates the necessary current source to interface with both active and passive 0-10V dimmers without additional circuitry, while the output can drive an optocoupler to provide isolated dimming control from the secondary to the primary.

2 Features

- 15V to 60V operating voltage
- 3-in-1 dimmer interface
  - » 0-10V PWM dimming
  - » 0-10V linear dimming
  - » Single resistor dimming
- Dimmer type - auto detect
  - » PWM or DC input dimming signal
- 0% to 100% PWM output
  - » 1% PWM duty cycle tolerance
  - » Selectable frequency range via external capacitor
  - » Unique duty cycle drive to account for non-linear optocoupler delay
- SOIC-8 package
- External resistor configuration
  - » Programmable max dimming voltage: 8.5V, 9V, 9.5V and 10V
  - » Programmable minimum duty cycle: 1%, 3%, 5% and 10%
  - » Programmable turn-off threshold: 0.5V, 0.6V, 0.7V and 0.8V
- Programmable PWM output frequency range: 100Hz-5kHz
- Integrated current source for driving 0-10V dimmer
- Low power shutdown mode
- Integrated optocoupler driver for isolated applications

3 Applications

- 0-10V LED dimming application
- 3-in-1 LED driver interface chip (0-10V linear, 0-10V PWM and R dimming) dimming LED driver application

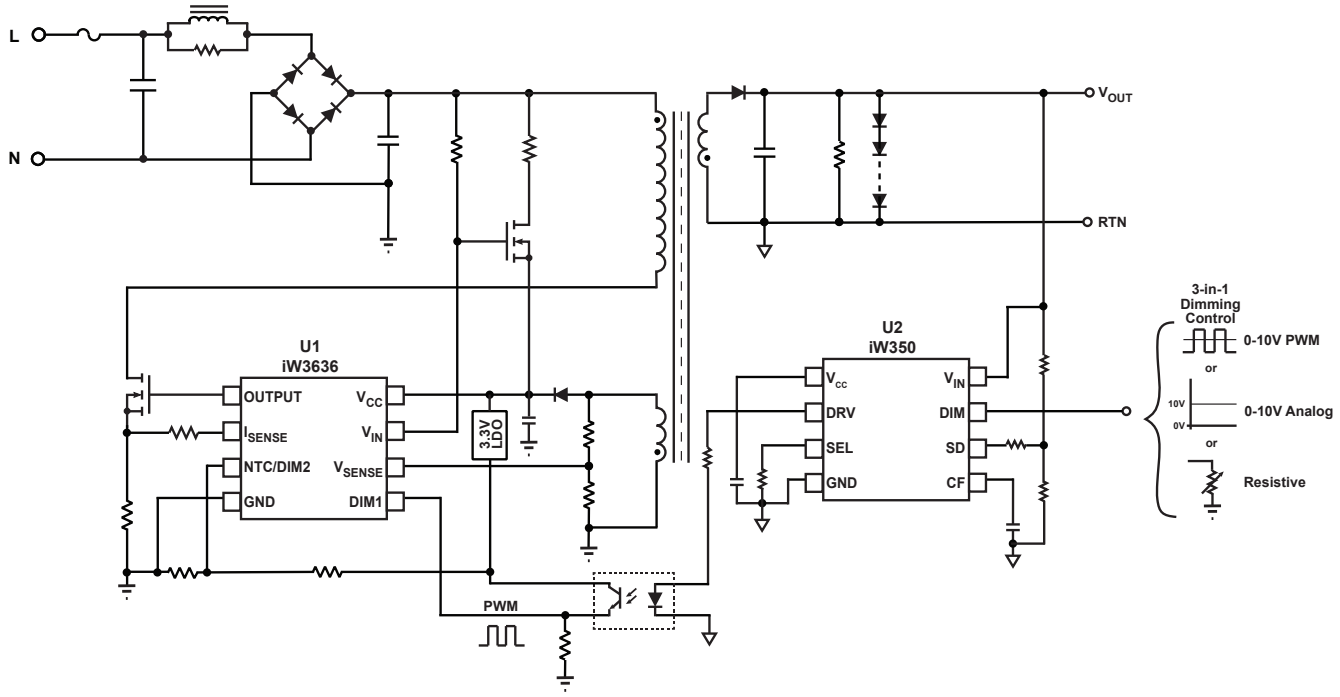


Figure 3.1 : iW350 Typical Application Circuit

4 Pinout Description

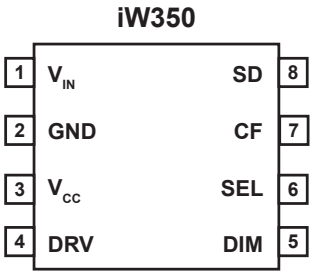


Figure 4.1 : 8-Lead SOIC Package

Pin Number	Pin Name	Type	Pin Description
1	V_{IN}	Power	Power supply up to 60V.
2	GND	Ground	Ground.
3	V_{CC}	Power	5V power supply for internal circuit, connect a 4.7uF capacitor to GND.
4	DRV	Digital Output	PWM driver.
5	DIM	Analog Input/Output	Dimming interface connection.
6	SEL	Analog Input/Output	Connect an external resistor to set max dimming voltage and turn-off threshold voltage.
7	CF	Analog Input/Output	Sets the PWM output frequency: 100Hz to 5kHz.
8	SD	Analog Input/Output	Shuts down the IC if voltage is over 0.5V, and programs the minimum duty cycle with a resistor to ground.

5 Absolute Maximum Ratings

Absolute maximum ratings are the parameter values or ranges which can cause permanent damage if exceeded.

Parameter	Symbol	Value	Units
V_{IN} to GND	V_{IN}	-0.3 to 65	V
V_{CC} to GND (IC internal power supply)	V_{CC}	-0.3 to 6.5	V
DIM to GND	V_{DIM}	-0.3 to 65	V
DRV, CF, SD and SEL to GND		-0.3 to 6.5	V
ESD rating (HBM)		±2	kV
Storage temperature range	T_{STRG}	150	°C
Maximum junction temperature	T_{JMAX}	150	°C

6 Electrical Characteristics

V_{IN} = 15V. All values are at T_A = +25°C, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply						
V_{IN} Input Voltage	V_{IN}		15		60	V
V_{IN} POR Threshold	V_{IN_POR}	V_{IN} increasing		7.5		V
V_{IN} UVLO Threshold	V_{IN_UVLO}	V_{IN} decreasing		6.5		V
V_{IN} Operating Current	I_{IN}	V_{IN} = 60V, No Dimming resistor, No driving		500		µA
V_{IN} Shut-Down Current	I_{IN_SD}	V_{IN} = 5V				µA
V_{CC} Output Voltage	V_{CC}			5.2		V
DIM (PWM Input)						
Input PWM Frequency	V_{PWM_IN}		0.1		5	kHz
Input PWM Amplitude	A_{PWM_IN}					V
Input PWM Detected Duty	$D_{PWM\_IN\_DET}$					%
Input PWM Voltage Detected Threshold	$V_{PWM\_DET\_TH}$			1.2		V
Input PWM Voltage Detected Hysteresis	$V_{PWM\_DET\_HYS}$	iW350-xx Options		50		mV
		iW350-xxB/iW350-xxAB Options		200		
DRV						
DRV Tolerance Voltage	V_{DRV}			5		V
High Output Voltage	V_{OH}	I_{SINK} = 50µA		V_{CC} - 0.1		V
		I_{SINK} = 8mA		V_{CC} - 0.5		V
Low Output Voltage	V_{OL}	I_{SOURCE} = 50µA		0.1		V
		I_{SOURCE} = 8mA		0.5		V
PWM Frequency Tolerance						%
PWM Duty Tolerance						%
PWM Output Frequency Range	f_{PWM}		0.1		5	kHz

6 Electrical Characteristics (Cont'd)

V_{IN} = 15V. All values are at T_A = +25°C, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
DIM (DC Input)						
Internal Current Source for 0-10V Dimmer/R_{DIM}	I_{DIM}	iW350-xxB		100		µA
		iW350-xxAB		150		µA
Floating Voltage	V_{DIM_FLT}	V_{IN} = 60V				V
Turn Off Threshold	$V_{TURN-OFF}$	Can be set to 0.5V, 0.6V or 0.8V by external resistor (-30 Option)		0.7		V
		(-32 Option)		0.3		V
Turn Off Hysteresis	$V_{TURN\_OFF\_HYS}$	(-30 Option)		0.15		V
		(-32 Option)		0.2		V
Max. Dimming Voltage	V_{MAX_DIM}	Can be set to 8.5V, 9.5V or 10V by external resistor (-00/-30 Options)		9		V
		(-02/-32 Options)		10		V
Minimum Duty Limitation (-00/-30 Options)	D_{MIN}	V_{DIM} ≤1V, can be set to 3%, 5% or 10% by external resistor		1		%
Minimum Duty Limitation (-02/-32 Options)	D_{MIN}	V_{DIM} ≤0.5V, can be set to 5% by external resistor		1		%
		V_{DIM} =1V, can be set by external resistor		0		%
CF						
CF Pin Current	I_{CF}	(-00/-30 Options)		69		µA
		(-02/-32 Options)		78		µA
SD						
V_{SD} Threshold Voltage	V_{SD_TH}			0.5		V
V_{SD} Threshold Hysteresis	$V_{SD\_TH\_HYS}$	V_{IN} decreasing		50		mV

7 Typical Performance Characteristics

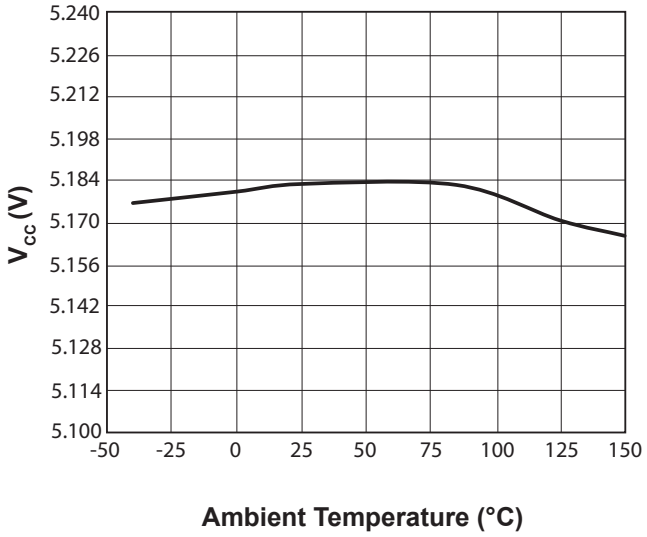


Figure 7.1 : V_{CC} vs. Temperature

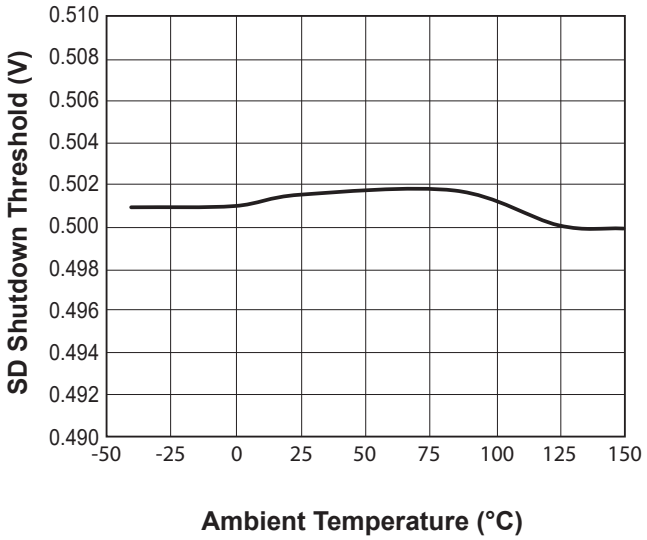


Figure 7.2 : SD Shutdown Threshold vs. Temperature

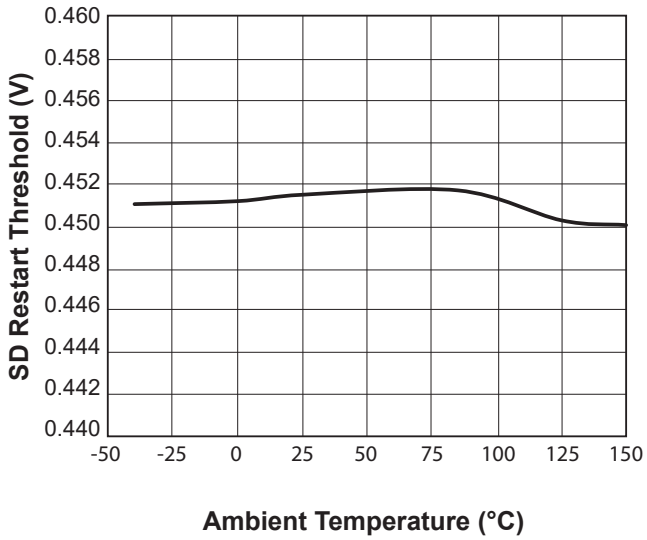


Figure 7.3 : SD Restart Threshold vs. Temperature

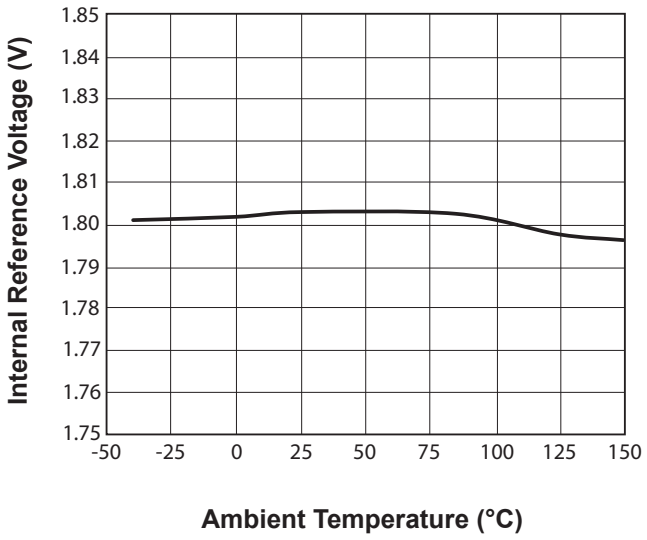


Figure 7.4 : Reference Voltage vs. Temperature

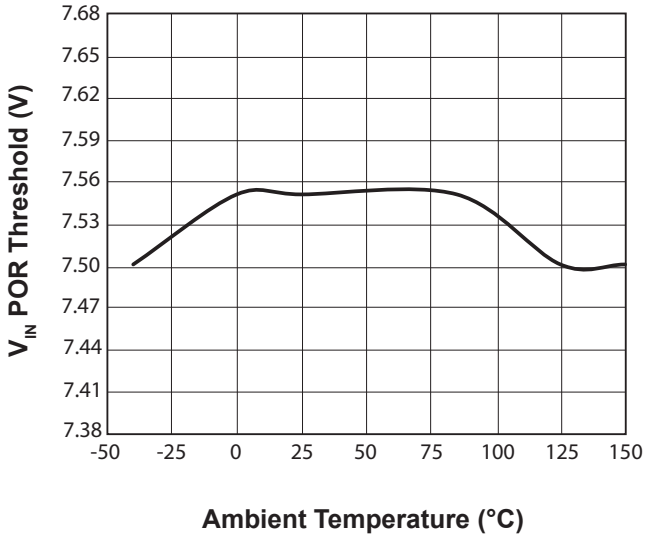


Figure 7.5 : V_{IN} POR Threshold vs. Temperature

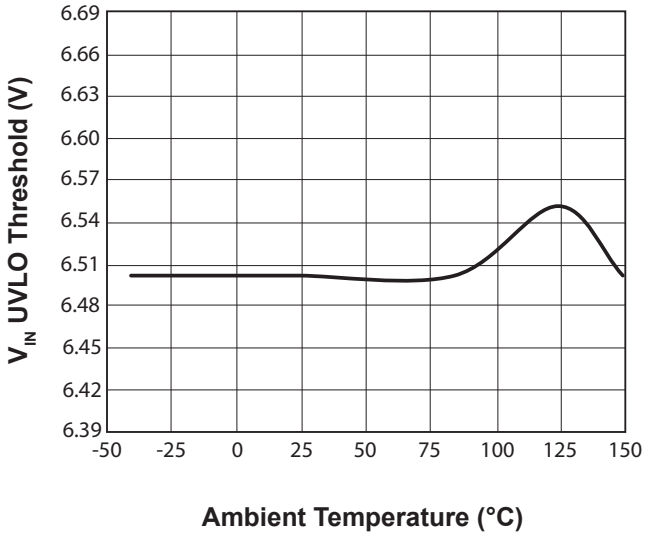


Figure 7.6 : V_{IN} UVLO Threshold vs. Temperature

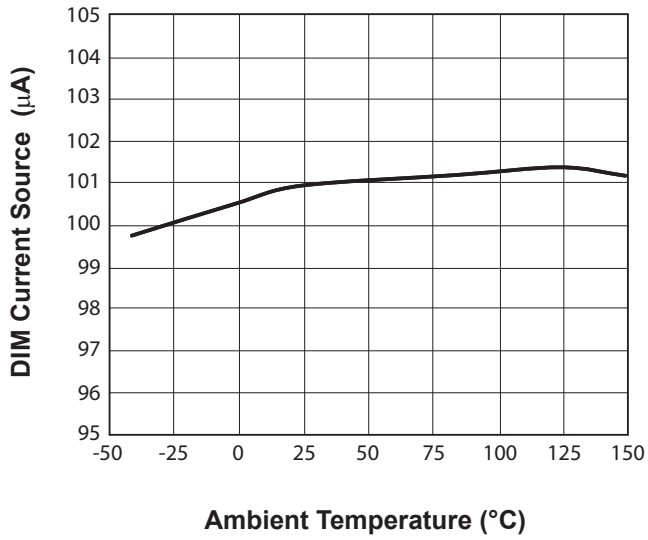


Figure 7.7 : DIM Current Source vs. Temperature

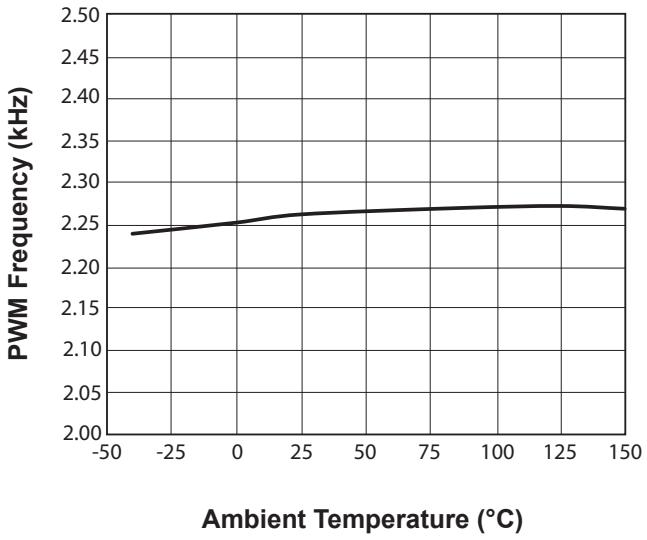


Figure 7.8 : PWM Frequency vs. Temperature[1]

(1) PWM frequency is set externally via CCF and will vary by application. See section 9.3

8 Functional Block Diagram

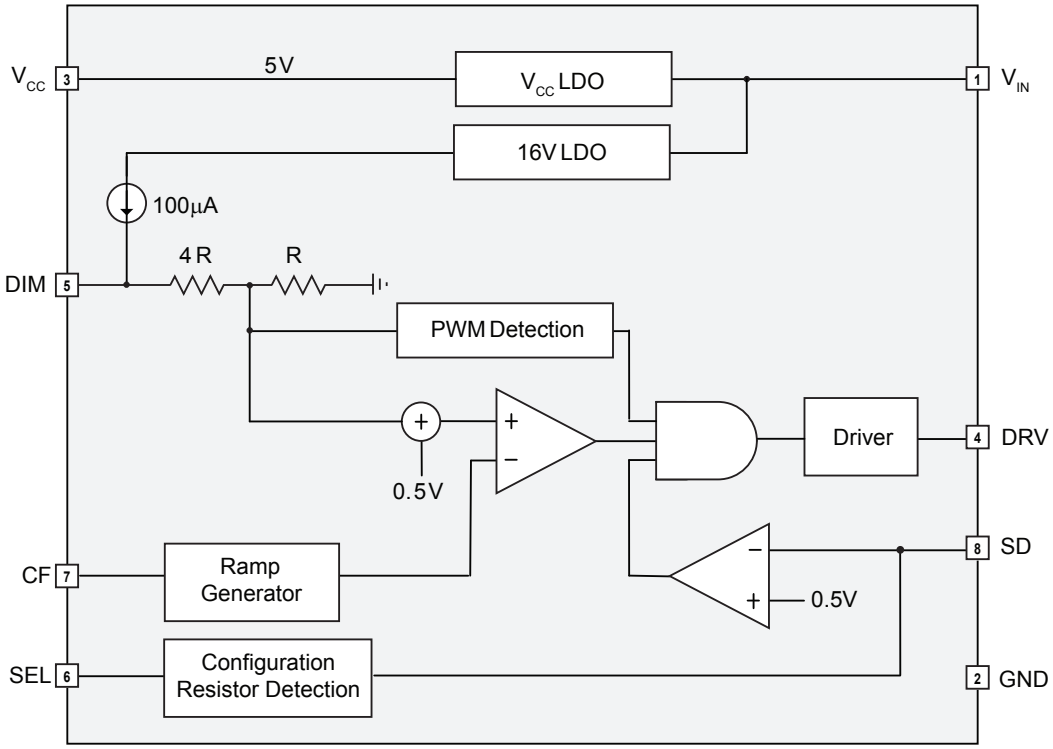


Figure 8.1 : iW350 Functional Block Diagram

9 Theory of Operation

9.1 Overview

The iW350 converts an analog or PWM dimming signal into a PWM signal used to provide a dimming signal to an LED driver. The output of the iW350 can drive an optocoupler or a MOSFET at a configurable frequency determined by an externally set capacitor value. The input analog signal is 0-10V typical. The input duty cycle signal can be auto detected when its amplitude is between 1.8V-10V. The dimming interface can also source a 100µA current to the dimmer, which allows the controller to be compatible with both active and passive dimmers. The iW350 can also set different maximum dimming voltages, minimum output duty cycle values and turn-off threshold voltages through external setting resistors. When driving an optocoupler, the dimming signal can be transferred across the isolation barrier. The iW350 also has a built-in 5V LDO which allows it to work with high input voltages up to 60V.

9.2 Power-on Sequence

The iW350 is powered from the V_{IN} pin. When the V_{IN} voltage is above 7.5V, the iW350 is activated. After an approximately 100ms (max) delay, the iW350 starts to drive the output based on the dimming signal. V_{CC} is regulated to 5.2V through an internal LDO. The operating voltage range of V_{IN} is from 15V to 60V.

9.3 Ramp Generation (-00/-30 Options)

A capacitor C_{CF} is connected to the CF pin to generate the ramp. The CF pin sources 69µA of current to the external capacitor. The voltage across the capacitor increases until it reaches the high threshold of 2.2V. The sourcing current is then disabled. The CF pin starts to sink 69µA current from the capacitor until the CF pin voltage reaches the low limit 0.685V. The PWM frequency can be determined by the following equation:

$$f_{PWM} = \frac{175\mu A}{(V_{MAX} - V_{DIM0}) \times C_{CF}} \quad (9.1)$$

Where V_{MAX} is the maxmum dimming voltage, C_{CF} is CF pin capacitance value, D_{MIN} is the minimum duty cycle output and V_{DIM0} is defined by equation 9.2.

$$V_{DIM0} = 1 - \left[D_{MIN} \times \frac{(V_{MAX} - 1)}{(1 - D_{MIN})} \right] \quad (9.2)$$

9.4 Ramp Generation (-02/-32 Options)

A capacitor C_{CF} is connected to the CF pin to generate the ramp. The CF pin sources 78µA of current to the external capacitor. The voltage across the capacitor increases until it reaches the high threshold of 2.5V. The sourcing current is then disabled. The CF pin starts to sink 78µA current from the capacitor until the CF pin voltage reaches the low limit 0.58V. The PWM frequency can be determined by the following equation:

$$f_{PWM} = \frac{190\mu A}{(10 - V_{DIM0}) \times C_{CF}} \quad (9.3)$$

Where V_{MAX} is the maxmum dimming voltage, C_{CF} is CF pin capacitance value, D_{MIN} is the minimum duty cycle output and V_{DIM0} is defined by equation 9.2.

$$V_{DIM0} = 0.5 - \left[D_{MIN} \times \frac{(9.5)}{(1 - D_{MIN})} \right] \quad (9.4)$$

9.5 Dimming Signal Processing

If an analog dimming signal is applied to the DIM pin, the voltage is first divided to 1/5th of the input amplitude. The result is added to a 0.5V offset voltage and then compared with ramp voltage to generate the PWM signal.

When the DIM pin voltage is above the maximum dimming voltage, the PWM duty cycle is 100%. When the DIM pin voltage is below the minimum dimming voltage, the PWM duty cycle output is the minimum output duty. The maximum and minimum dimming voltages that set the maximum and minimum duty cycles are either fixed or programmable, depending upon the product option.

The iW350-00 and iW350-30 offer the ability to program the maximum dimming voltage between 8.5V and 10V, while the iW350-02 and iW350-32 have a fixed maximum dimming voltage,10V. The minimum duty cycle for the iW350-00 and iW350-30 corresponds to a dimming voltage of 1.0V and can be programmed to 1%, 3%, 5% or 10% duty cycle output. For the iW350-02 and iW350-32, the minimum duty cycle can be set at 0.5V (1% or 5%) or it 0% at 0.1V. Figures 9.1 through 9.4 show the dimming characteristics for the four product options.

If a PWM signal is applied to DIM pin, when its amplitude is from 1.8V to 10V, this signal will be detected and directly output through a driver.

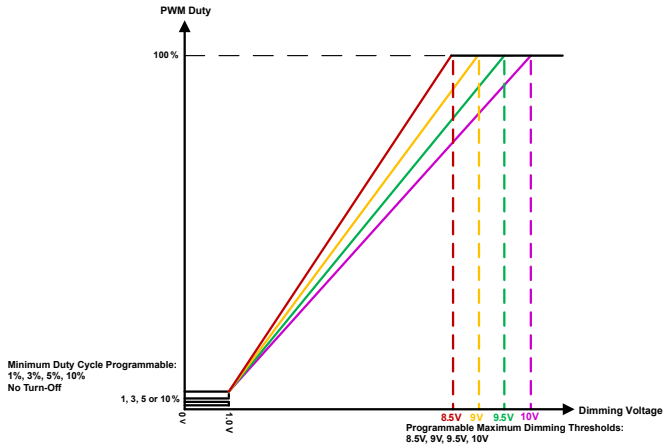


Figure 9.1 : iW350-00 Dimming Characteristics

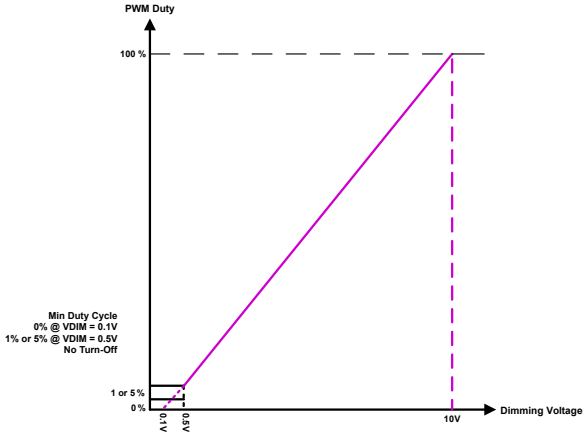


Figure 9.2 : iW350-02 Dimming Characteristics

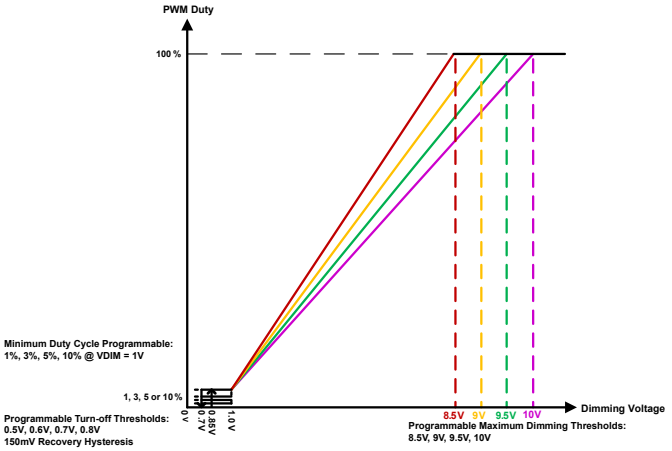


Figure 9.3 : iW350-30 Dimming Characteristics

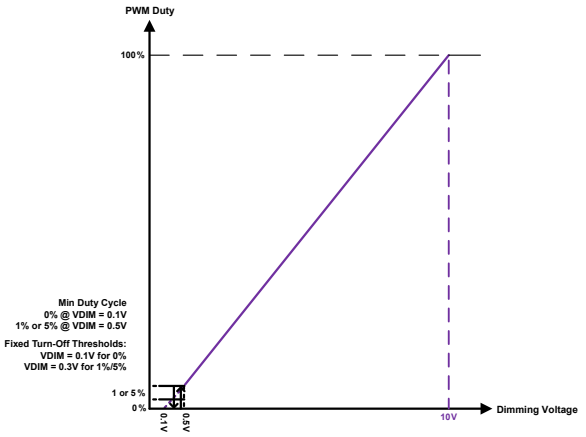


Figure 9.4 : iW350-32 Dimming Characteristics

9.6 Shut Down Protection

The iW350 has a SD pin used for external shut-down function. If the voltage applied to the SD pin is higher than 0.5V, the iW350 output is turned off and enters low power mode.

9.7 Turn-off Function

If the voltage applied to DIM pin is lower than the turn-off threshold voltage, the output of the DRV pin is held “Low” until the voltage is 0.15V higher than the turn-off threshold voltage, and during this time the PWM output of the DRV pin is at the minimum duty cycle output. The turn-off threshold voltage can be set by an external resistor.

The turn-off function is an option, the iW350-30 and iW350-32 have this enabled and the iW350-00 and iW350-02 have this disabled.

9.8 External Resistor Configuration Function (-00/-30 Options)

When the iW350 is powered on, it detects the external resistance values between the SEL pin and ground and between the SD pin and the V_{IN} resistor divider, which has a total resistance value of 25kΩ. Different resistance values can set 4 maximum dimming voltage levels, 4 minimum output duty cycle levels and 4 turn-off threshold voltage levels.

SEL Pin Resistor to Ground	Maximum Dimming Voltage	Turn-off Threshold Voltage
0K	10V	0.5V
1.4kΩ		0.6V
2.32kΩ		0.8V
3.48kΩ		0.7V
4.99kΩ	9.5V	0.5V
6.81kΩ		0.6V
9.09kΩ		0.8V
11.8kΩ		0.7V
15kΩ	8.5V	0.5V
19.6kΩ		0.6V
24.9kΩ		0.8V
36.5kΩ		0.7V
51.1kΩ	9V	0.5V
69.8kΩ		0.6V
93.1kΩ		0.8V
Floating		0.7V

Table 9.1: iW350 Configuration Resistors for Maximum Dimming Voltage and Turn-off Threshold Voltage (-00/-30 Options)

SD Pin Series Resistor	Minimum Output Duty Cycle when V_{DIM} = 1V
0Ω	1%
56.2kΩ	3%
133kΩ	5%
243kΩ	10%

Table 9.2: iW350 Configuration Resistors for Minimum Output Duty Cycle when V_{DIM} = 1V (-00/-30 Options)

Note 1: All resistor is 1% accuracy.

Note 2: For SD pin, please connect an external 24.9kΩ set resistor to ground.

9.9 External Configuration Resistors (-02/-32 Options)

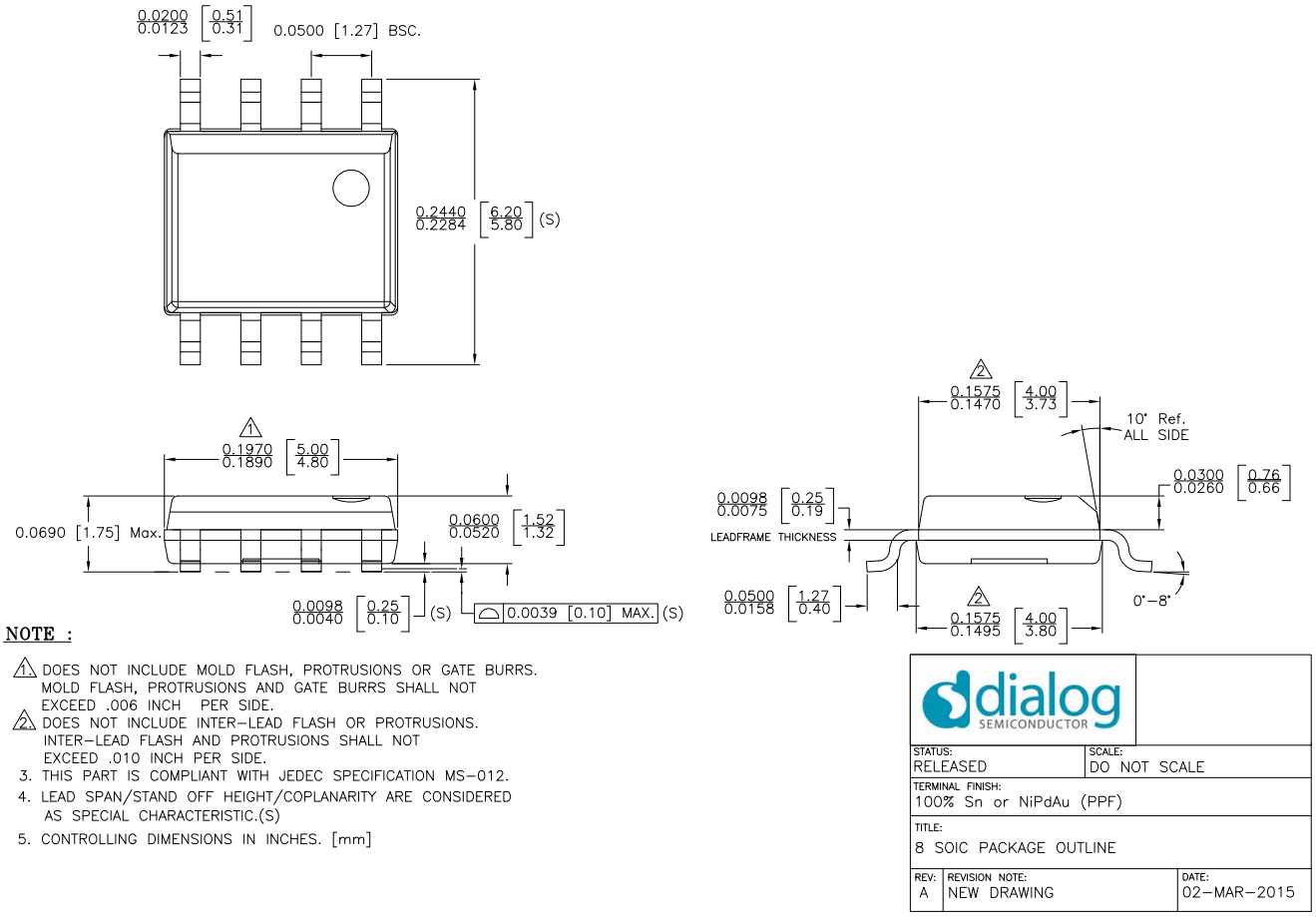
For the iW350-02 and iW350-32, different SEL resistance values can set 2 levels of minimum output duty cycle. Table 9.3 shows the resistor configuration options for the SEL pin for the iW350-02 and iW350-32.

The iW350-02 does not have the turn-off function that the iW350-32 offers, but when the device is configured for 0% duty cycle at 0.1V, the output duty cycle will stay low when the DIM pin voltage is lower than 0.1V and stays low until the voltage on the DIM pin reaches 0.25V or higher.

SEL Pin Series Resistor	Minimum Output Duty Cycle when V_{DIM} = 0.5V
Floating	1%
20kΩ	5%
0Ω	No Minimum Output Duty Cycle Limitation

Table 9.3: iW350 Configuration Resistors for Minimum Output Duty Cycle when V_{DIM} = 0.5V (-02/-32 Options)

10 Physical Dimensions



NOTE :

1. DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .006 INCH PER SIDE.
2. DOES NOT INCLUDE INTER–LEAD FLASH OR PROTRUSIONS. INTER–LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .010 INCH PER SIDE.
3. THIS PART IS COMPLIANT WITH JEDEC SPECIFICATION MS–012.
4. LEAD SPAN/STAND OFF HEIGHT/COPLANARITY ARE CONSIDERED AS SPECIAL CHARACTERISTIC.(S)
5. CONTROLLING DIMENSIONS IN INCHES. [mm]

STATUS: RELEASED	SCALE: DO NOT SCALE
TERMINAL FINISH: 100% Sn or NiPdAu (PPF)	
TITLE: 8 SOIC PACKAGE OUTLINE	
REV: A	REVISION NOTE: NEW DRAWING — DATE: 02–MAR–2015

Figure 10.1 : Physical Dimensions of 8-Pin SOIC Package

11 Ordering Information

Part Number	Options	Package	Description
iW350-00[1] iW350-00B iW350-00AB	Standard PWM Output; Dimming Curve Figure 9.1; Turn-off Function Disabled	SOIC-8	Tape & Reel[2]
iW350-02[1] iW350-02B	Standard PWM Output; Dimming Curve Figure 9.2; Turn-off Function Disabled	SOIC-8	Tape & Reel[2]
iW350-30[1] iW350-30B iW350-30AB	Standard PWM Output; Dimming Curve Figure 9.3; Turn-off Function Enabled	SOIC-8	Tape & Reel[2]
iW350-32[1] iW350-32B	Standard PWM Output; Dimming Curve Figure 9.4; Turn-off Function Enabled	SOIC-8	Tape & Reel[2]

Note 1. Not recommended for new designs, please use the -xxB version.

Note 2. Tape and reel packing quantity is 2,500/reel. Minimum packing quantity is 2,500.

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