HV9918

Hysteretic Buck High-Brightness LED Driver with High-Side Current Sensing

Features

- Hysteretic Control with High-Side Current Sensing
- Integrated 40V1Ω MOSFET
- >90% Efficiency
- 4.5V to 40V Wide Input Voltage Range
- ±5% LED Current Accuracy
- Up to 2 MHz Switching Frequency
- Adjustable Constant LED Current
- Analog or Pulse-With Modulation (PWM) Control Signal for PWM Dimming
- Overtemperature Protection
- –40ºC to +125ºC Operating Ambient Temperature Range

Applications

- Low-Voltage Industrial and Architectural Lighting
- General Purpose Constant Current Source
- Signage and Decorative LED Lighting
- Indicator and Emergency Lighting

General Description

The HV9918 is a PWM controller IC designed to drive high-brightness LEDs using a buck topology. It operates from an input voltage of 4.5 VDC to 40 VDC and employs hysteretic control with a high-side current sense resistor to set the constant output current up to 700 mA. The device is well suited for applications requiring a wide input voltage range. The high-side current sensing and an integrated current-setting circuitry minimize the number of external components while delivering an accurate average output.

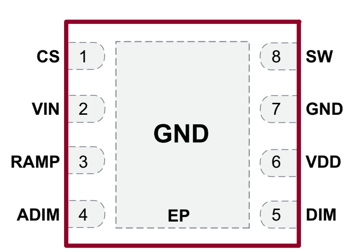
A dedicated PWM input enables pulsed LED dimming over a wide range of brightness levels. A hysteretic control method ensures excellent input supply rejection and fast response during load transients and PWM dimming.

The HV9918 offers an analog-controlled PWM dimming feature that reduces the output current by applying an external DC voltage below the internal 2V threshold voltage from ADIM to GND. ADIM can also accept input from a resistor divider including a negative temperature coefficient (NTC) thermistor connected between ADIM and GND or a positive temperature coefficient (PTC) thermistor connected between ADIM and V_{DD}. This provides a PWM thermal foldback feature that reduces the LED current when the temperature of the LED string exceeds a specified temperature point. Additional features include thermal-shutdown protection.

The high-switching frequency up to 2 MHz permits the use of small inductors and capacitors, minimizing space and cost in the overall system.

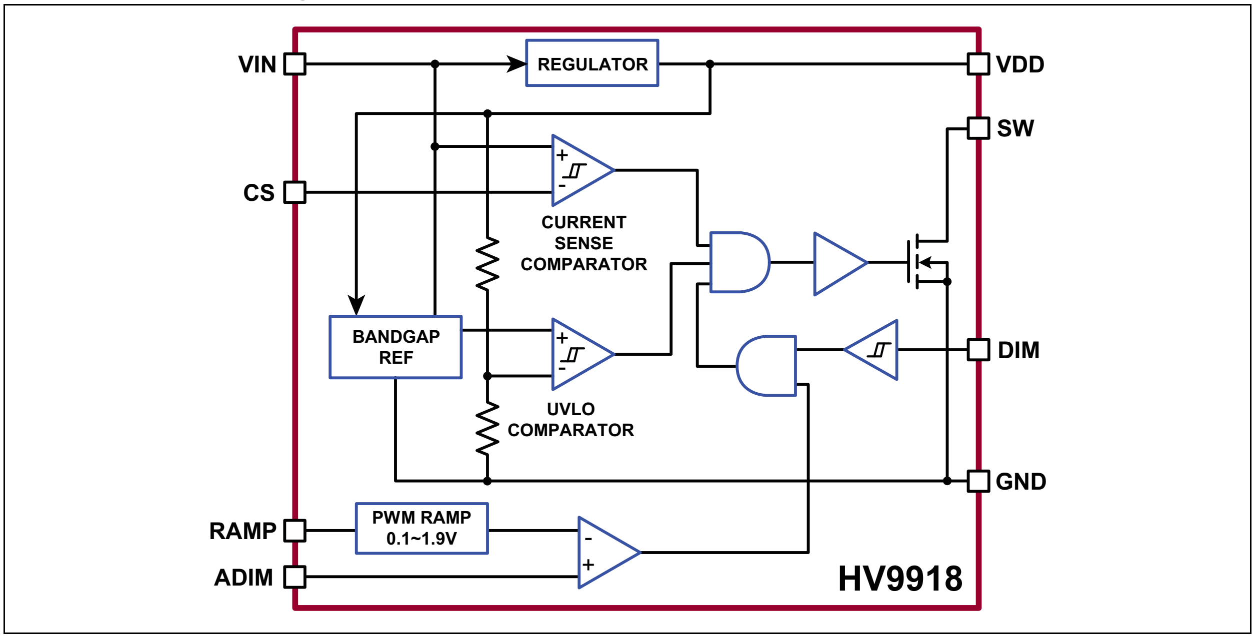
Package Type

8-lead DFN
(Top View)

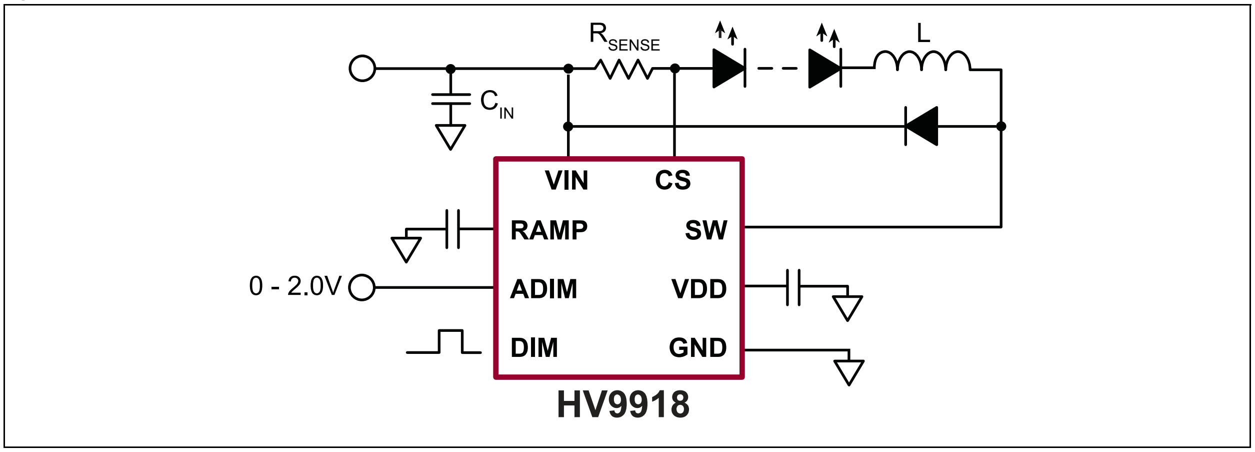


See Table 2-1 for pin information.

Functional Block Diagram



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

V_{IN}, CS and SW to GND .... –0.3V to +45V
V_{DD}, GATE, RAMP, DIM, ADIM to GND .... –0.3V to +6V
CS to V_{IN} .... –1V to +0.3V
Junction Temperature, T_J .... –40°C +150°C
Storage Temperature Range, T_S .... –65°C to +150°C
Continuous Power Dissipation (T_A = +25°C):
8-lead DFN 1.6W

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

Electrical Specifications: V_{IN} = 12V, V_{DIM} = V_{DD}, V_{RAMP} = GND, C_{VDD} = 1 µF, R_{SENSE} = 0.5Ω, T_A = T_J = –40ºC to +125ºC (**Note 1**) unless otherwise noted.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Input DC Supply Voltage Range	V_{IN}	4.5	—	40	V	DC input voltage
Internally Regulated Voltage	V_{DD}	4.5	—	5.5	V	V_{IN} = 6V to 40V
Supply Current	I_{IN}	—	—	1.5	mA	SW = GND
Shutdown Supply Current	$I_{IN, SDN}$	—	—	900	µA	V_{DIM} < 0.7V
Internal Regulator Current Limit	$I_{IN, LIM}$	—	30	—	mA	V_{IN} = 4.5V, V_{DD} = 0V
		—	8	—		V_{IN} = 4.5V, V_{DD} = 4V
Switching Frequency	f_{SW}	—	—	2	MHz	
V_{DD} Undervoltage Lockout Threshold	UVLO	—	—	4.5	V	V_{DD} rising
V_{DD} Undervoltage Lockout Hysteresis	ΔUVLO	—	500	—	mV	V_{DD} falling
SENSE COMPARATOR						
Sense Voltage Threshold High	$V_{RS(HI)}$	213	—	246	mV	(V_{IN} – V_{CS}) rising
Sense Voltage Threshold Low	$V_{RS(LO)}$	158	—	182	mV	(V_{IN} – V_{CS}) falling
Propagation Delay to SW Off	t_{DPDL}	—	70	—	ns	Rising edge of V_{IN} – V_{CS} = $V_{RS(HI)}$ + 70 mV to V_{SW} = 0.1 x V_{IN}
Propagation Delay to SW On	t_{DPDH}	—	70	—	ns	Falling edge of V_{IN} – V_{CS} = $V_{RS(LO)}$ – 70 mV to V_{SW} = 0.9 x V_{IN}
Current Sense Input Current	I_{CS}	—	—	1	µA	V_{IN} – V_{CS} = 200 mV
Current Sense Voltage Threshold Hysteresis	$V_{RS(HYS)}$	—	56	70	mV	
DIM INPUT						
DIM Input High Voltage	$V_{DIM(H)}$	2.2	—	—	V	
DIM Input Low Voltage	$V_{DIM(L)}$	—	—	0.7	V	
Turn-On Time	t_{ON}	—	100	—	ns	V_{DIM} rising edge to V_{SW} = 0.9 x V_{IN}
Turn-Off Time	t_{OFF}	—	100	—	ns	V_{DIM} falling edge to V_{SW} = 0.1 x V_{IN}

Note 1: Limits obtained by design and characterization. Typical values are given at T_A = 25°C.
2: For design guidance only

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: V_{IN} = 12V, V_{DIM} = V_{DD}, V_{RAMP} = GND, C_{VDD} = 1 µF, R_{SENSE} = 0.5Ω, T_A = T_J = –40ºC to +125ºC (**Note 1**) unless otherwise noted.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
OUTPUT SWITCH						
SW Continuous Current	$I_{SW(DC)}$	—	—	0.7	A	
SW On Resistance	$R_{SW(ON)}$	—	1	2	Ω	
SW Leakage Current	$I_{SW(LK)}$	—	10	—	µA	V_{IN} = 40V
OVERTEMPERATURE PROTECTION						
Overtemperature Trip Limit	T_{OT}	128	140	—	ºC	**Note 2**
Overtemperature Hysteresis	ΔT_{HYST}	—	60	—	ºC	**Note 2**
ANALOG CONTROL OF PWM DIMMING						
Dimming Frequency	f_{RAMP}	130	—	300	Hz	C_{RAMP} = 47 nF
		550	—	1250		C_{RAMP} = 10 nF
RAMP Threshold, Low	$V_{TH(L)}$	—	0.1	—	V	
RAMP Threshold, High	$V_{TH(H)}$	1.8	—	2.1	V	
ADIM Offset Voltage	V_{OS}	–35	—	+35	mV	

Note 1: Limits obtained by design and characterization. Typical values are given at T_A = 25°C.

2: For design guidance only

TEMPERATURE SPECIFICATIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
TEMPERATURE RANGE						
Operating Ambient Temperature	T_A	–40	—	+125	°C	**Note 2**
Maximum Junction Temperature	$T_{J(ABSMAX)}$	—	—	+150	°C	
Storage Temperature	T_S	–65	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
8-lead 3x3 DFN	θ_{JA}	—	+60	—	°C/W	**Note 1**

Note 1: Mounted on an FR–4 board, 25 mm x 25 mm x 1.57 mm

2: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature, and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact device reliability.

2.0 PIN DESCRIPTION

The details on the pins of HV9918 8-lead DFN are listed on Table 2-1. Refer to **Package Type** for the location of pins.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	CS	Current sense input. Senses LED string current.
2	VIN	Input voltage 4.5V to 40V DC
3	RAMP	Analog PWM dimming ramp output
4	ADIM	Analog 0V–2V signal input for analog control of PWM dimming
5	DIM	PWM signal input
6	VDD	Internally regulated supply voltage. Connect a capacitor from VDD to ground.
7	GND	Device ground
8	SW	Open Drain Output of an internal 40V 1Ω MOSFET
EP	GND	Exposed backside Pad. Must be wired to pin 7 and GND plane on PCB to maximize the thermal performance of the package

3.0 APPLICATION INFORMATION

3.1 General Description

The HV9918 is a step-down, constant-current, high-brightness LED (HB LED) driver. The device operates from a 4.5V to 40V input voltage range and includes an internal 40V 1Ω N-channel MOSFET. A high-side current sense resistor sets the output current, and a dedicated PWM dimming input (DIM) allows for a wide range of dimming duty ratios. PWM dimming can also be achieved by applying a DC voltage between 0V and 2V to the analog dimming input (ADIM). In this case, the dimming frequency can be programmed using a single capacitor at the RAMP pin. The high-side current setting and sensing scheme minimizes the number of external components while delivering LED current with ±5% accuracy using a 1% sense resistor.

3.2 Undervoltage Lockout (UVLO)

The HV9918 includes a 3.7V UVLO with 500 mV hysteresis. When V_{IN} falls below 3.7V, switching of SW is disabled. Switching of SW resumes once V_{IN} is 4.5V or higher.

3.3 5V Regulator

V_{DD} is the output of a 5V internal regulator capable of sourcing 8 mA. Bypass V_{DD} to GND with a 1 µF capacitor.

3.4 DIM Input

The HV9918 allows dimming with a PWM signal at the DIM input. A logic level below 0.7V at DIM halts SW switching, turning the LED current off. To turn the LED current back on, the logic level at DIM must be at least 2.2V.

3.5 ADIM and RAMP Inputs

The PWM dimming scheme can also be implemented by applying an analog control signal to the ADIM pin. If an analog control signal of 0V–2V is applied to ADIM, the device compares this analog input to a voltage ramp to pulse-width modulate the LED current. Connecting an external capacitor across RAMP and GND programs the PWM dimming ramp frequency. See Equation 3-1.

EQUATION 3-1:

$$f_{PWM} = \frac{1}{C_{RAMP} \times 120k\Omega}$$

The DIM and ADIM inputs can be used simultaneously. In such case, a $f_{PWM(MAX)}$ lower than the frequency of the dimming signal at DIM must be selected. The smaller dimming duty cycle of ADIM and DIM will determine the SW signal.

When the analog control of the PWM dimming feature is not used, RAMP must be wired to GND and ADIM should be connected to V_{DD}.

One possible application of the ADIM feature may include protection of the LED load from overtemperature by connecting an NTC thermistor to ADIM as shown in Figure 3-1.

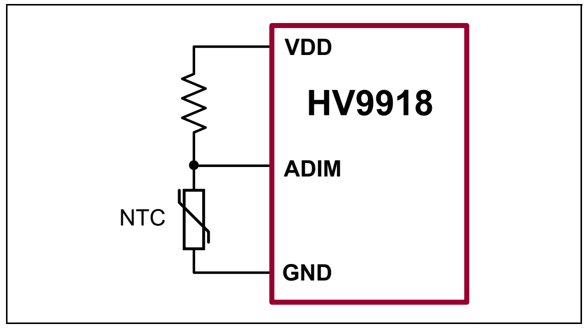


FIGURE 3-1: *Overtemperature Protection using ADIM Pin.*

3.6 Setting LED Current with the External Resistor (R_{SENSE})

The output current in the LED is determined by the external current sense resistor (R_{SENSE}) connected between V_{IN} and CS. Disregarding the effect of the propagation delays, the sense resistor can be calculated as seen in Equation 3-2.

EQUATION 3-2:

$$R_{SENSE} \approx \left(\frac{1}{2}\right) \times \left(\frac{V_{RS(HI)} + V_{RS(LO)}}{I_{LED}}\right) = \frac{200mV}{I_{LED}}$$

3.7 Selecting Buck Inductor (L)

The HV9918 regulates the LED output current using an input comparator with hysteresis. (See Figure 3-2.) As the current through the inductor ramps up and the voltage across the sense resistor reaches the upper threshold, the internal MOSFET at SW turns off. Then the inductor current ramps down through the freewheeling diode until the voltage across the sense resistor equals the lower threshold and the MOSFET turns on again.

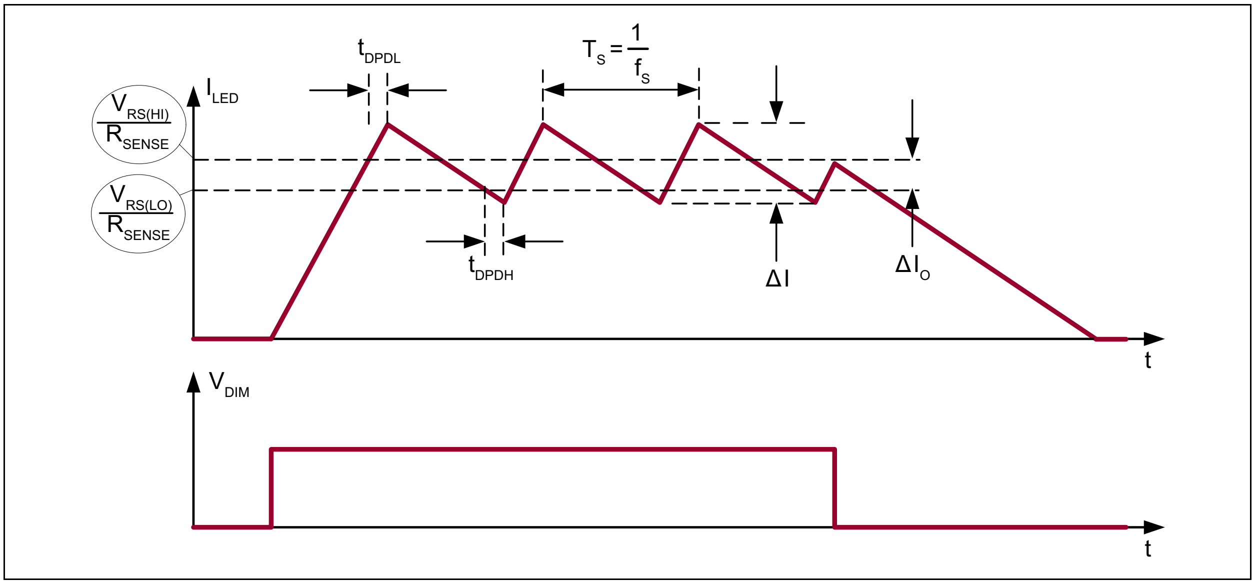


FIGURE 3-2: *Inductor Current Waveform.*

Equation 3-3 shows how to determine the inductor value for a desired operating frequency (f_S).

EQUATION 3-3:

$$L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{f_S V_{IN} \Delta I_O} - \frac{(V_{IN} - V_{OUT}) \times t_{DPDL}}{\Delta I_O} - \frac{V_{OUT} t_{DPDH}}{\Delta I_O}$$

Where:

$$\Delta I_O = \frac{V_{RS(HI)} - V_{RS(LO)}}{R_{SENSE}}$$

and t_{DPDL} and t_{DPDH} are the propagation delays.
Note that the current ripple (ΔI_L) in the inductor (L) is greater than ΔI_O.

The current ripple in the inductor (L) can be calculated with Equation 3-4.

EQUATION 3-4:

$$\Delta I_L = \Delta I_O + \frac{(V_{IN} - V_{OUT}) \times t_{DPDL}}{L} + \frac{V_{OUT} t_{DPDH}}{L}$$

For proper inductor selection, note that the maximum switching frequency occurs at the highest V_{IN} and $V_{OUT} = V_{IN} / 2$.

3.8 Thermal Shutdown

The HV9918's thermal shutdown feature turns off the SW driver when the junction temperature exceeds +140°C. The SW driver turns back on when the junction temperature drops +60°C below the shutdown temperature threshold.

3.9 Freewheeling Diode Selection

The forward voltage of the freewheeling diode should be as low as possible for better efficiency. A Schottky diode is a good choice as long as the breakdown voltage is high enough to withstand the maximum operating voltage. The forward current rating of the diode must be at least equal to the maximum LED current.

3.10 LED Current Ripple

The LED current ripple is equal to the inductor current ripple. In cases when a lower LED current ripple is needed, a capacitor can be placed across the LED terminals.

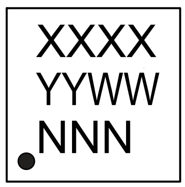
3.11 PCB Layout Guidelines

Careful PCB layout is critical to achieving low switching losses and stable operation. Use a multilayer board whenever possible for better noise immunity. Minimize ground noise by connecting high-current ground returns, the input bypass capacitor ground lead and the output filter ground lead to a single point (star ground configuration). The fast *di/dt* loop is formed by the input capacitor C_{IN}, the freewheeling diode and the HV9918 switching MOSFET. To minimize noise interaction, this loop area should be as small as possible. Place R_{SENSE} extremely close to the input filter and V_{IN}. For better noise immunity, a Kelvin connection is strongly recommended between CS and R_{SENSE}. Connect the exposed pad of the IC to a large area ground plane for improved power dissipation.

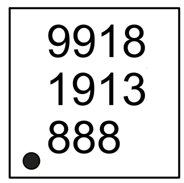
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

8-lead DFN



Example

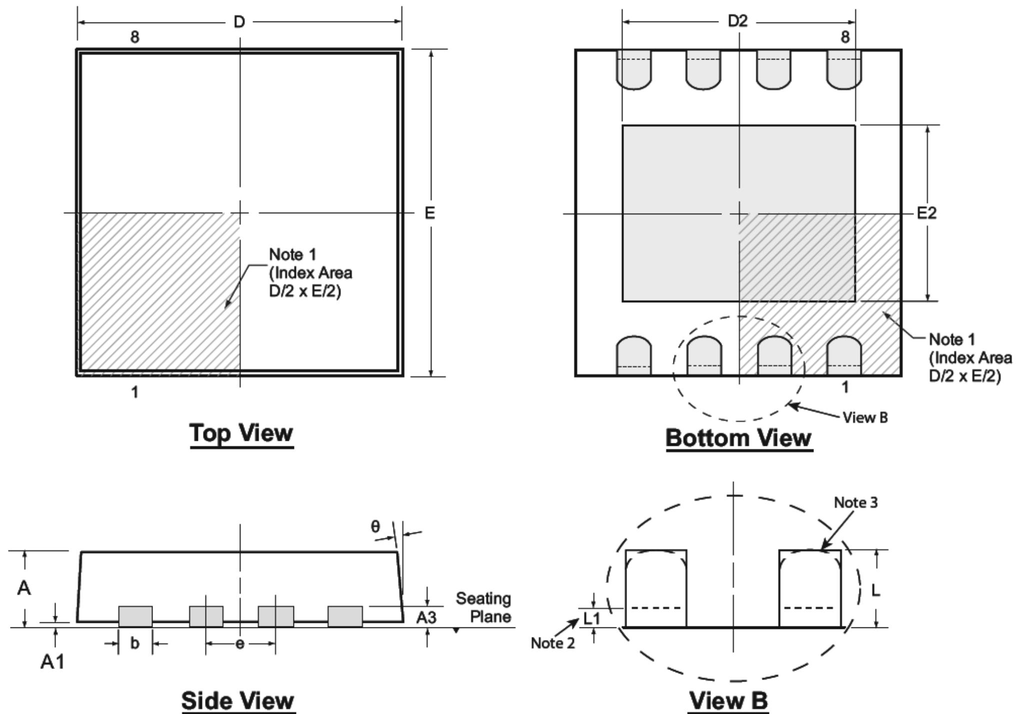


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

8-Lead DFN Package Outline (K7)

3.00x3.00mm body, 0.80mm height (max), 0.65mm pitch



Note: For the most current package drawings, see the Microchip Packaging Specification at www.microchip.com/packaging.

Notes:

1. *A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.*
2. *Depending on the method of manufacturing, a maximum of 0.15mm pullback (L1) may be present.*
3. *The inner tip of the lead may be either rounded or square.*

Symbol		A	A1	A3	b	D	D2	E	E2	e	L	L1	θ
	MIN	0.70	0.00		0.25	2.85*	1.60	2.85*	1.35		0.30	0.00*	0°
Dimension (mm)	NOM	0.75	0.02	0.20 REF	0.30	3.00	-	3.00	-	0.65 BSC	0.40	-	-
	MAX	0.80	0.05		0.35	3.15*	2.50	3.15*	1.75		0.50	0.15	14°

JEDEC Registration MO-229, Variation WEEC-2, Issue C, Aug. 2003.

***** This dimension is not specified in the JEDEC drawing.*

Drawings not to scale.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (September 2019)

- Converted Supertex Doc# DSFP-HV9918 to Microchip DS20005722A
- Changed the package marking format
- Changed the packaging quantity of 8-lead DFN from 3000/Reel to 3300/Reel
- Made minor text changes throughout the document

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Device:	HV9918	=	Hysteretic Buck High-Brightness LED Driver with High-Side Current Sensing
Package:	K7	=	8-lead WDFN
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	3300/Reel for a K7 Package

Example:

a) HV9918K7-G: Hysteretic Buck High-Brightness LED Driver with High-Side Current Sensing, 8-lead WDFN Package, 3300/Reel

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