MICROCHIP

HV9919B

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

Features

- Hysteretic control with high-side current sensing
- Wide input-voltage range: 4.5 to 40V
- >90% Efficiency
- Typical ±5% LED current accuracy
- Up to 2.0MHz switching frequency
- Adjustable constant LED current
- Analog or PWM control signal for PWM dimming
- Over-temperature protection
- -40ºC to +125ºC operating temperature range

Applications

- Low-voltage industrial and architectural lighting
- General purpose constant current source
- Signage and decorative LED lighting
- Indicator and emergency lighting

Description

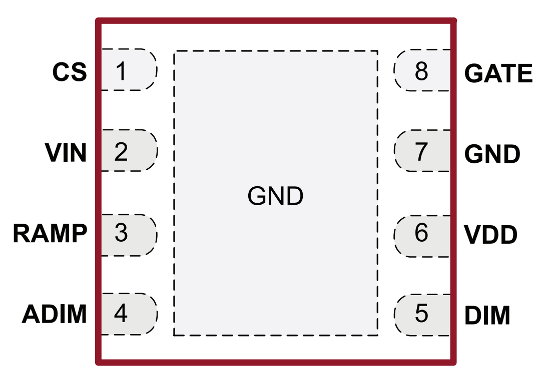
HV9919B is a Pulse-Width Modulation (PWM) controller IC designed to drive high-brightness LEDs using a buck topology. It operates from an input voltage of 4.5 to 40VDC and employs hysteretic control, with a high-side current sense resistor, to set the constant output current.

Set the operating frequency range by selecting the proper inductor. Operation at high switching frequency is possible since the hysteretic control maintains accuracy even at high frequencies. This permits the use of small inductors and capacitors, minimizing space and cost in the overall system.

LED brightness control is achieved with PWM dimming from an analog or PWM input signal. Unique PWM circuitry allows true constant color with a high dimming range. The dimming frequency is programmed using a single external capacitor.

HV9919B comes in a small, 8-Lead DFN package and is ideal for industrial and general lighting applications.

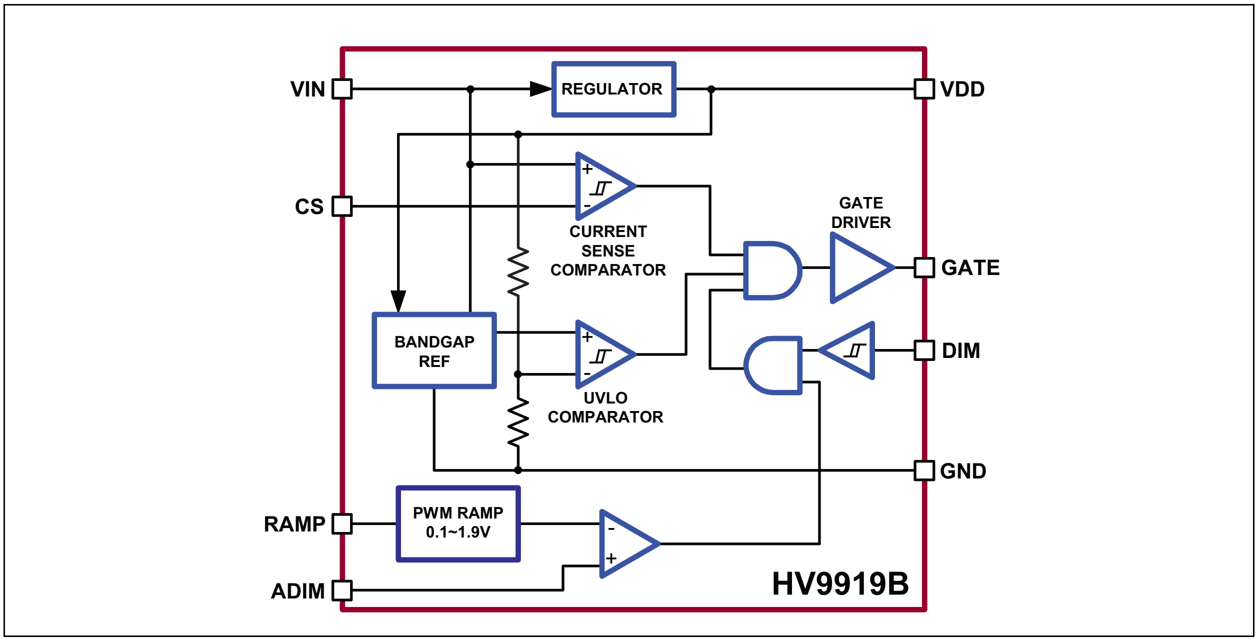
Package Type



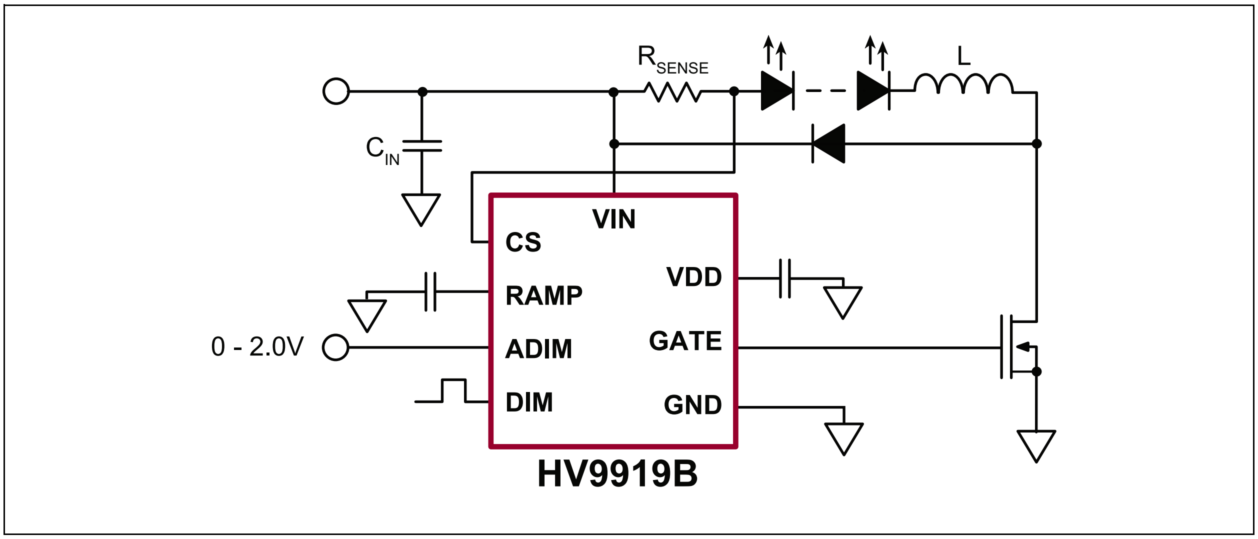
8-Lead DFN

See Table 2-1 for pin information

Block Diagram



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS†

V_{IN} to GND .... -0.3V to +45V
V_{DD} to GND .... -0.3V to +6.0V
GATE, RAMP, DIM, ADIM to GND .... -0.3V to $+V_{DD}$
CS to V_{IN} .... -1.0V to +0.3V
Continuous total power dissipation (T_A = 25.°C) 1.6W
Operating temperature range .... -40°C to +125°C
Junction temperature .... +150°C
Storage temperature range .... -65°C to +150°C

† Notice: Stresses above those listed under “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 listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 1-1: ELECTRICAL CHARACTERISTICS (SHEET 1 OF 2)

Electrical Specifications: V_{IN}=12V, V_{DIM} = V_{DD}, V_{RAMP} = GND, C_{VDD} = 1.0 µF, R_{CS} = 0.5Ω, T_A= T_J= -40°C to +125°C, unless otherwise noted. (**Note 1**)

Parameter	Symbol	Min	Typ	Max	Units	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}= 6.0 to 40V
Supply current	I_{IN}	-	-	1.5	mA	GATE open
Shutdown supply current	$I_{IN, SDN}$	-	-	900	µA	DIM< 0.7V
Current limit	$I_{IN, LIM}$	-	11	-	mA	V_{IN}= 4.5V, V_{DD}= 0V
		-	5.5	-		V_{IN}= 4.5V, V_{DD}= 4.0V
Switching frequency	f_{SW}	-	-	2.0	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	$V_{CS(HI)}$	-	230	-	mV	(V_{IN}- V_{CS}) rising
Sense voltage threshold low	$V_{CS(LO)}$	-	170	-	mV	(V_{IN}- V_{CS}) falling
Average sense voltage	$V_{CS(AVG)}$	186	200	214	mV	$V_{CS(AVG)}$ = 0.5($V_{CS(HI)}$ + $V_{CS(LO)}$)
Propagation delay to output high	t_{DPDH}	-	70	-	ns	Falling edge of (V_{IN}- V_{CS}) = $V_{RS(LO)}$- 70mV
Propagation delay to output low	t_{DPDL}	-	70	-	ns	Rising edge of (V_{IN}- V_{CS}) = $V_{RS(HI)}$+ 70mV
Current-sense input current	I_{CS}	-	-	1.0	µA	(V_{IN}- V_{CS}) = 200mV
Current-sense threshold hysteresis	$V_{CS(HYS)}$	15	56	98	mV	$V_{CS(HYS)}$ = $V_{CS(HI)}$ - $V_{CS(LO)}$
DIM Input						
Pin DIM input high voltage	V_{IH}	2.2	-	-	V	–
Pin DIM input low voltage	V_{IL}	-	-	0.7	V	–
Turn-on time	t_{ON}	-	100	-	ns	DIM rising edge to V_{GATE}= 0.5 x V_{DD}, C_{GATE}= 2.0nF
Turn-off time	t_{OFF}	-	100	-	ns	DIM falling edge to V_{GATE}= 0.5 x V_{DD}, C_{GATE}=2.0nF

TABLE 1-1: ELECTRICAL CHARACTERISTICS (SHEET 2 OF 2)

Electrical Specifications: V_{IN}=12V, V_{DIM} = V_{DD}, V_{RAMP} = GND, C_{VDD} = 1.0 µF, R_{CS} = 0.5Ω, T_A= T_J= -40°C to +125°C, unless otherwise noted. (Note 1)

Parameter	Symbol	Min	Typ	Max	Units	Conditions
GATE Driver						
GATE current, source	I_{GATE}	0.3	0.5	-	A	V_{GATE}= GND, (Note 2)
GATE current, sink		0.7	1.0	-	A	V_{GATE}= V_{DD}, (Note 2)
GATE output rise time	T_{RISE}	-	40	55	ns	C_{GATE}= 2.0nF
GATE output fall time	T_{FALL}	-	17	25	ns	C_{GATE}= 2.0nF
GATE high output voltage	$V_{GATE(HI)}$	V_{DD}-0.5	-	-	V	I_{GATE}= 10mA
GATE low output voltage	$V_{GATE(LO)}$	-	-	0.5	V	I_{GATE}= -10mA
Over-Temperature Protection						
Over temperature trip limit	T_{OT}	128	140	-	ºC	(Note 2)
Temperature hysteresis	ΔT_{HYST}	-	60	-	ºC	(Note 2)
Analog Control of PWM Dimming						
Dimming frequency	f_{RAMP}	114	-	308	Hz	C_{RAMP}= 47nF
		529	-	1380		C_{RAMP}= 10nF
RAMP threshold, Low	V_{LOW}	-	0.1	-	V	–
RAMP threshold, High	V_{HIGH}	1.8	-	2.1	V	–
ADIM offset voltage	V_{OS}	-35	-	+35	mV	–

Note 1: Specification is obtained by characterization and is 100% tested at T_A = 25°C.

2: Specification is obtained by characterization and not 100% tested

TEMPERATURE SPECIFICATIONS

Electrical Specifications: Unless otherwise specified, for all specifications T_A =T_J = +25°C

Parameter	Symbol	Min	Typ	Max	Units	Conditions
Temperature Ranges						
Operating Temperature		-40		125	°C	
Storage Temperature		-65	–	150	°C	
Package Thermal Resistances						
Thermal Resistance, DFN	θ_{ja}	–	60	–	°C/W	Mounted on FR-4 board, 25 mm x 25 mm x 1.57 mm

2.0 PIN DESCRIPTION

The locations of the pins are listed in Features.

TABLE 2-1: PIN DESCRIPTION

Pin #	Symbol	Description
1	CS	Current sense input. Senses LED string current.
2	VIN	Input voltage 4.5 to 40V DC.
3	RAMP	Analog PWM dimming ramp output.
4	ADIM	Analog 0~2.0V signal input for analog control of PWM dimming.
5	DIM	PWM signal input.
6	VDD	Internally regulated supply voltage. Connect a capacitor from V_{DD} to ground.
7	GND	Device ground.
8	GATE	Drives gate of external MOSFET.
TAB	GND	Must be wired to pin 7 on PCB.

3.0 APPLICATION INFORMATION

HV9919B is a step-down, constant current, High-Brightness LED (HB LED) driver. The device operates from a 4.5 to 40V input voltage range and provides the gate drive output to an external 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. The PWM dimming could also be achieved by applying a DC voltage between 0 and 2.0V 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 a ±8% accuracy, using a 1% sense resistor.

3.1 Undervoltage Lockout (UVLO)

HV9919B includes a 3.7V Under-Voltage lockout (UVLO) with 500mV hysteresis. When V_{DD} falls below 3.7V, GATE goes low, turning off the external N-channel MOSFET. GATE goes high once V_{DD} is 4.5V or higher.

3.2 5.0V Regulator

V_{DD} is the output of a 5.0V regulator capable of sourcing 5.0 mA. Bypass V_{DD} to GND with a 1.0µF capacitor.

3.3 DIM Input

HV9919B allows dimming with a PWM signal at the DIM input. A logic level below 0.7V at DIM forces the GATE output low, turning off the LED current. To turn the LED current on, the logic level at DIM must be at least 2.2V.

3.4 ADIM and RAMP Inputs

The PWM dimming scheme can be also implemented by applying an analog control signal to ADIM pin. If an analog control signal of 0 – 2.0V 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 to RAMP programs the PWM dimming ramp frequency.

$$f_{PWM} = \frac{1}{C_{RAMP} \bullet 120K\Omega}$$

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

When the analog control of 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 of HV9919B may include protection of the LED load from over-temperature by connecting an NTC thermistor at ADIM, as shown in Figure 3-1

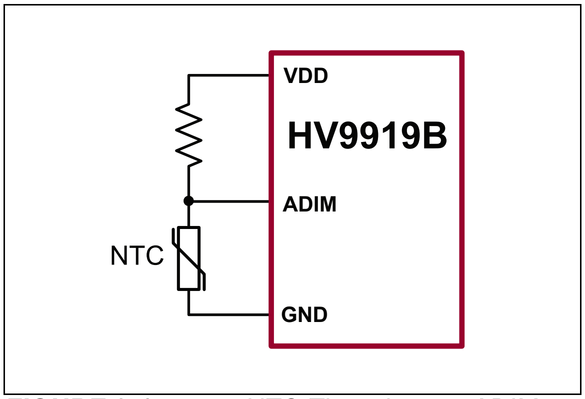


FIGURE 3-1: *NTC Thermistor at ADIM*

3.5 Setting LED Current with 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:

$$R_{SENSE} \approx \frac{1}{2} \bullet \frac{(V_{CS(HI)} + V_{CS(LO)})}{I_{LED}} = \frac{200mV}{I_{LED}}$$

3.6 Selecting Buck Inductor L

HV9919B regulates the LED output current using a 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 voltage at GATE goes low, turning off the external MOSFET. The MOSFET turns on again when the inductor current ramps down through the freewheeling diode, until the voltage across the sense resistor equals the lower threshold. Use the following equation to determine the inductor value for a desired value of operating frequency f_S:

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

Where:

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

and t_{DPDL}, t_{DPDH} are the propagation delays. The current ripple ΔI in the inductor L is greater than ΔI_O.

This ripple can be calculated from the following equation:

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

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

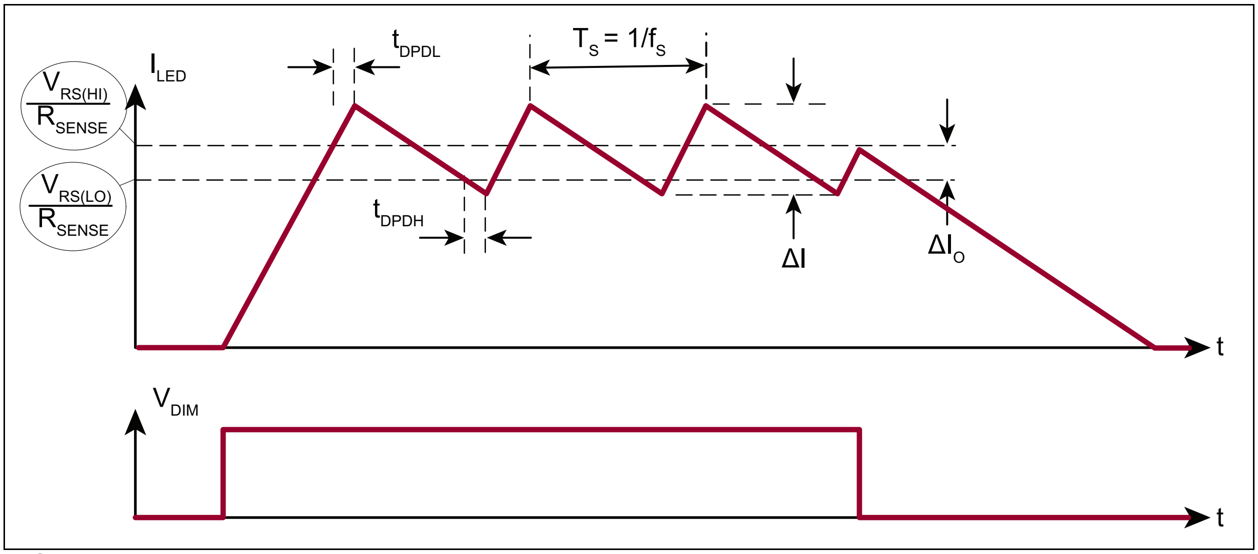


FIGURE 3-2: *Regulating LED output*

3.7 MOSFET Selection

MOSFET selection is based on the maximum input operating voltage V_{IN}, output current I_{LED}, and operating switching frequency. Choose a logic-level MOSFET that has a higher breakdown voltage than the maximum operation voltage, low $R_{DS(ON)}$, and low total gate charge for better efficiency.

3.8 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.

3.9 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.

3.10 PCB Layout Guidelines

Careful PCB layout is critical to achieve 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 free-wheeling diode and the MOSFET. To minimize noise interaction, this loop area should be as small as possible. Place R_{SENSE} as close as possible 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 tab of the IC to a large-area ground plane for improved power dissipation.

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

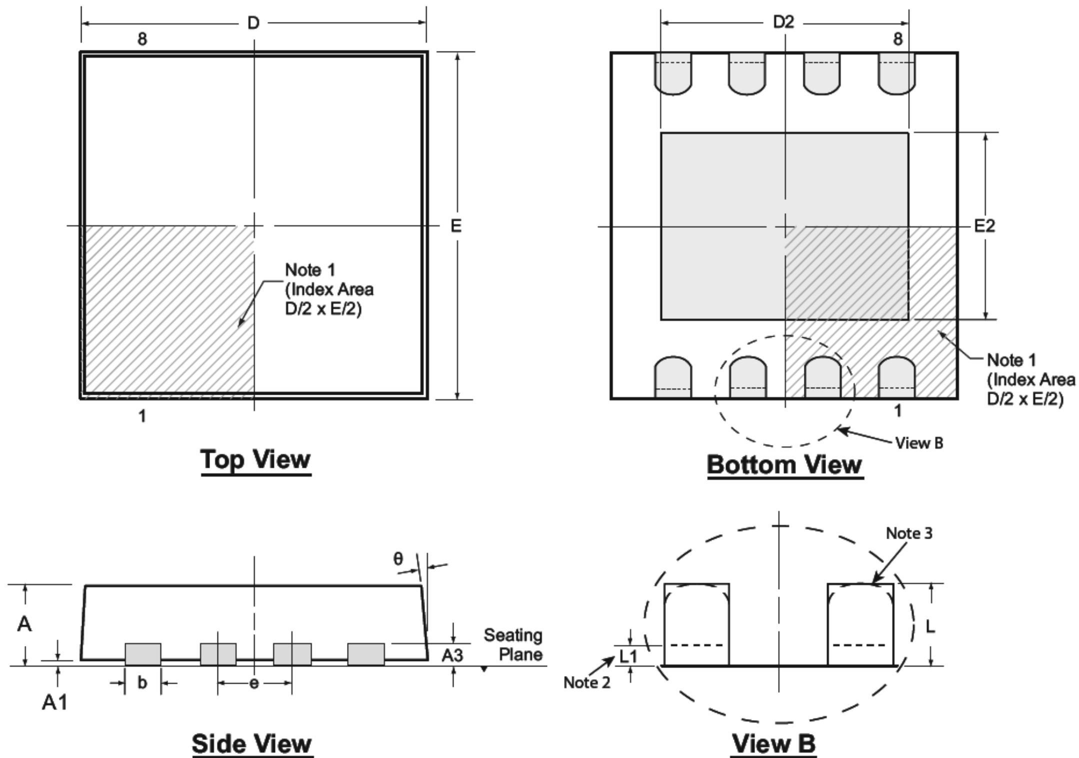
8-lead DFN	Example
XXXX YYWW ○NNN	9919 1542 ○343

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
Dimension (mm)	MIN	0.70	0.00	0.20 REF	0.25	2.85*	1.60	2.85*	1.35	0.65 BSC	0.30	0.00*	0°
	NOM	0.75	0.02		0.30	3.00	-	3.00	-		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.

APPENDIX A: REVISION HISTORY

Revision A (November 2015)

- Updated file to Microchip format.
- Revised **Absolute Maximum Ratings†**.
- Modified values and notes in **Table 1-1**.
- Added condition to **Temperature Specifications**.
- Changed value in **Section 3.2 "5.0V Regulator"**.
- Wording change in **Section 3.7 "MOSFET Selection"**.
- Minor text changes throughout.

Revision B (December 2015)

- Updated Revision History.

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

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

Device:	HV9919B	= Hysteretic, Buck, High Brightness LED Driver with High-Side Current Sensing
Package:	K7	= 48-lead DFN
Environmental	G	= Lead (Pb)-free/ROHS-compliant package
Media Type:	(blank)	= 3000/Reel

Examples:

a) HV9919BK7-G 8-Lead DFN package, 3000/Reel

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