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## High-Voltage, Current-Mode, PWM Controller

### Features

- 10 to 450V input voltage range
- <1.3 mA supply current
- >1 MHz clock
- 49% maximum duty version

### Applications

- Off-line high frequency power supplies
- Universal input power supplies
- High density power supplies
- Very high efficiency power supplies
- Extra wide load range power supplies

### Description

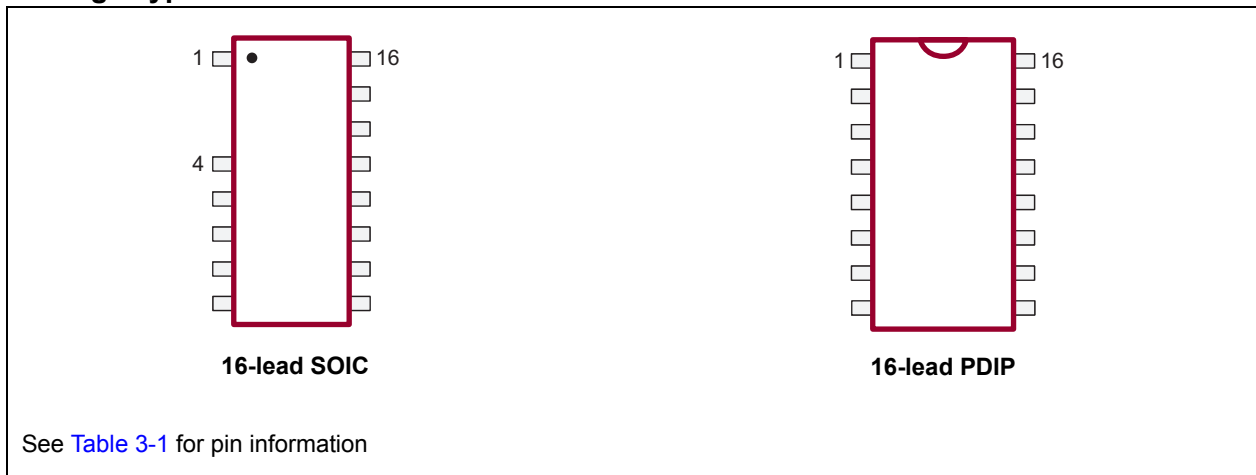
HV9120 and HV9123 are Switch-Mode Power Supply (SMPS) controllers suitable for the control of a variety of converter topologies, including flyback and forward converter.

Using an internal, high-voltage regulator, HV9120 and HV9123 can derive a bias supply for starting-up and powering a converter from a variety of power sources, such as a 12V battery or the rectified AC (230 VAC) line.

HV9120/HV9123 controllers include all essentials for a power-converter design, such as a bandgap reference, an error amplifier, a ramp generator, a high-speed PWM comparator, and a gate driver. A shutdown latch provides on/off control. Device power consumption is less than 6 mW when shutdown.

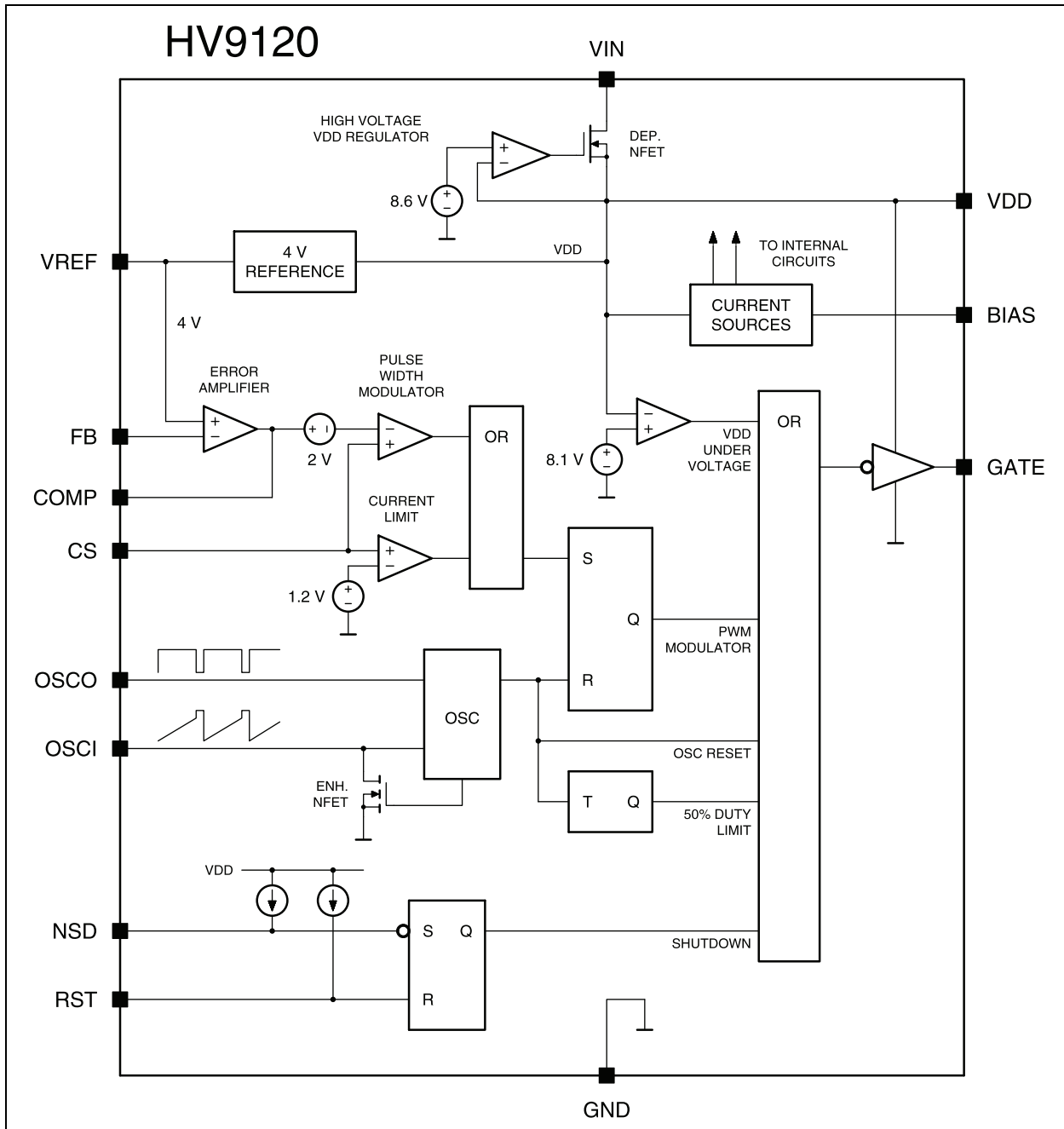
HV9120 offers 50% maximum duty and HV9123 offers nearly 100% duty.

### Package Types

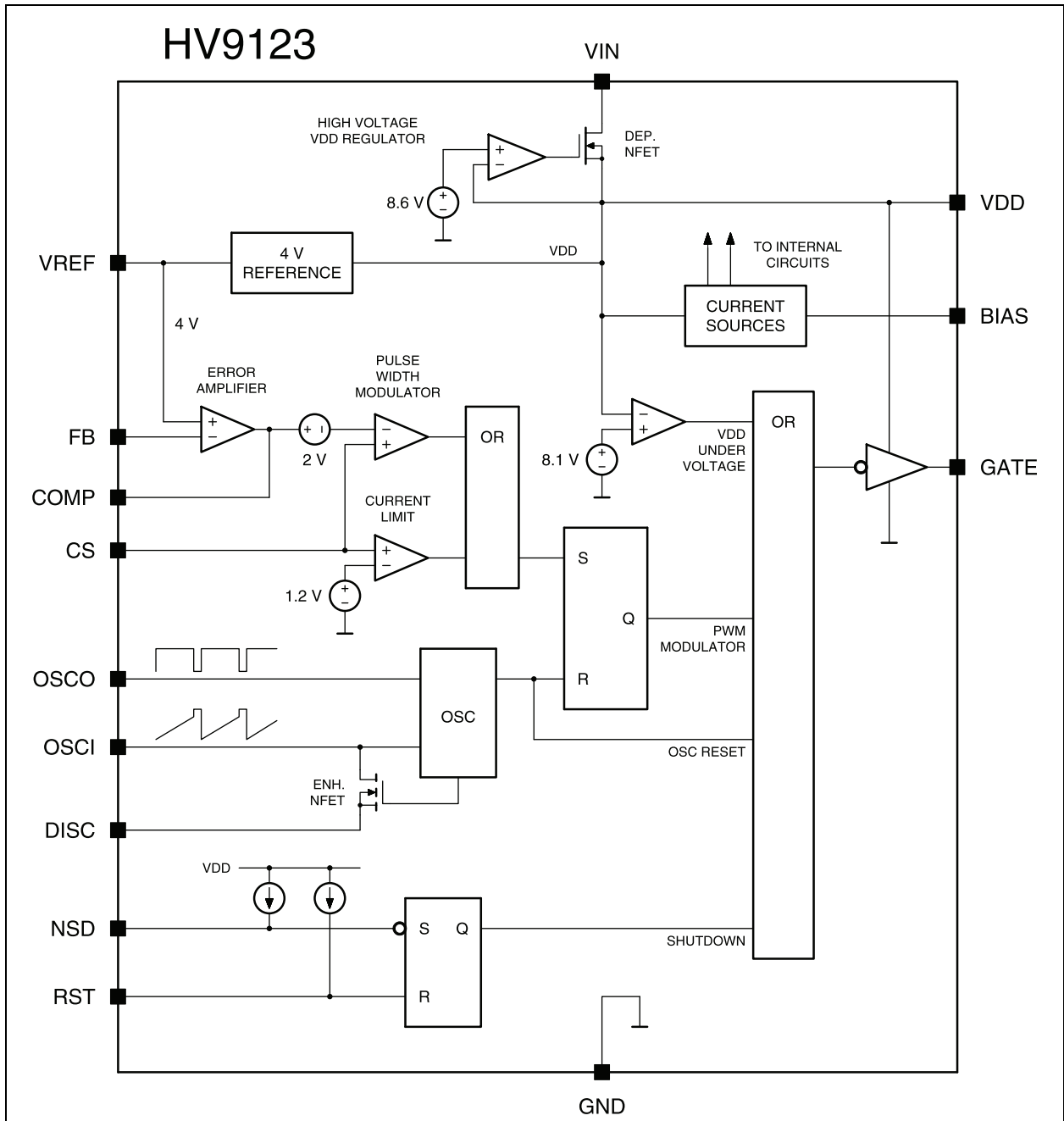


# HV9120/HV9123

## Block Diagram HV9120



## Block Diagram HV9123



# HV9120/HV9123

## 1.0 ELECTRICAL CHARACTERISTICS

### ABSOLUTE MAXIMUM RATINGS†

Input voltage, $V_{IN}$ .....	450V
Device supply voltage, $V_{DD}$ .....	15.5V
Logic input voltage .....	-0.3V to $V_{DD} + 0.3V$
Linear input voltage .....	-0.3V to $V_{DD} + 0.3V$
High-voltage regulator input current (continuous), $I_{IN}$ .....	2.5 mA
Operating temperature range .....	-40°C to +125°C
Storage temperature range .....	-65°C to +150°C
Power dissipation: 16-Lead SOIC .....	900 mW
16-Lead PDIP .....	1000 mW

† **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.

### ELECTRICAL CHARACTERISTICS

**Electrical Specifications:**  $V_{DD} = 10V$ ,  $V_{IN} = 48V$ ,  $V_{DISC} = 0V$ ,  $R_{BIAS} = 390\text{ k}\Omega$ ,  $R_{OSC} = 330\text{ k}\Omega$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise noted.

Parameter	Symbol	Min	Typ	Max	Units	Conditions	
<b>Reference</b>							
Output voltage	$V_{REF}$	3.92	4.00	4.08	V	$R_L = 10\text{ M}\Omega$	
		3.84	4.00	4.16		$R_L = 10\text{ M}\Omega$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	
Output impedance	$Z_{OUT}$	15	30	45	k $\Omega$	(Note 1)	
Short circuit current	$I_{SHORT}$	-	125	250	$\mu\text{A}$	$V_{REF} = \text{GND}$	
Change in $V_{REF}$ with temperature	$\Delta V_{REF}$	-	0.25	-	mV/ $^\circ\text{C}$	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$ (Note 1)	
<b>Oscillator</b>							
Oscillator frequency	$f_{MAX}$	1.0	3.0	-	MHz	$R_{OSC} = 0\Omega$	
Initial accuracy	$f_{OSC}$	80	100	120	kHz	$R_{OSC} = 330\text{ k}\Omega$ (Note 2)	
		160	200	240		$R_{OSC} = 150\text{ k}\Omega$ (Note 2)	
VDD regulation	-	-	-	15	%	$9.5V < V_{DD} < 13.5V$	
Temperature coefficient	-	-	170	-	ppm/ $^\circ\text{C}$	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$ (Note 1)	
<b>PWM</b>							
Maximum duty cycle	HV9120	$D_{MAX}$	49.0	49.4	49.6	%	(Note 1)
	HV9123		95	97	99		
Dead time	HV9123	$D_{MIN}$	-	225	-	ns	HV9123 only (Note 1)
Minimum duty cycle			-	-	0	%	-
Pulse width where pulse drops out			-	80	125	ns	(Note 1)
<b>Current Limit</b>							
Maximum input signal	$V_{LIM}$	1.0	1.2	1.4	V	$V_{FB} = 0V$	
Delay to output	$t_D$	-	80	120	ns	$V_{CS} = 1.5V$ , $V_{COMP} \leq 2.0V$ (Note 1)	



## ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: $V_{DD} = 10V$ , $V_{IN} = 48V$ , $V_{DISC} = 0V$ , $R_{BIAS} = 390\text{ k}\Omega$ , $R_{OSC} = 330\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.							
Parameter	Symbol	Min	Typ	Max	Units	Conditions	
<b>Error Amplifier</b>							
Feedback voltage	$V_{FB}$	3.92	4.00	4.08	V	FB shorted to COMP	
Input bias current	$I_{IN}$	-	25	500	nA	$V_{FB} = 4.0V$	
Input offset voltage	$V_{OS}$	nulled during trim			-	-	
Open loop voltage gain	$A_{VOL}$	60	80	-	dB	(Note 1)	
Unity gain bandwidth	GB	1.0	1.3	-	MHz	(Note 1)	
Output source current	$I_{SOURCE}$	-1.4	-2.0	-	mA	$V_{FB} = 3.4V$	
Output sink current	$I_{SINK}$	0.12	0.15	-	mA	$V_{FB} = 4.5V$	
<b>High-voltage Regulator and Start-up</b>							
Input voltage	$V_{IN}$	10	-	450	V	$I_{IN} < 10\text{ }\mu\text{A}$ ; $V_{CC} > 9.4V$	
Input leakage current	$I_{IN}$	-	-	10	$\mu\text{A}$	$V_{DD} > 9.4V$	
Regulator turn-off threshold voltage	$V_{TH}$	8.0	8.7	9.4	V	$I_{IN} = 10\text{ }\mu\text{A}$	
Undervoltage lockout	$V_{LOCK}$	7.0	8.1	8.9	V	-	
<b>Supply</b>							
Supply current	$I_{DD}$	-	0.75	1.3	mA	$C_L < 75\text{ pF}$	
Quiescent supply current	$I_Q$	-	0.55	-	mA	$V_{NSD} = 0V$	
Nominal bias current	$I_{BIAS}$	-	20	-	$\mu\text{A}$	-	
Operating range	$V_{DD}$	9.0	-	13.5	V	-	
<b>Shutdown Logic</b>							
Shutdown delay	$t_{SD}$	-	50	100	ns	$C_L = 500\text{ pF}$ , $V_{CS} = 0V$ (Note 1)	
NSD pulse width	$t_{SW}$	50	-	-	ns	(Note 1)	
RST pulse width	$t_{RW}$	50	-	-	ns	(Note 1)	
Latching pulse width	$t_{LW}$	25	-	-	ns	$V_{NSD}$ , $V_{RST} = 0V$ (Note 1)	
Input low voltage	$V_{IL}$	-	-	2.0	V	-	
Input high voltage	$V_{IH}$	7.0	-	-	V	-	
Input current, input high voltage	$I_{IH}$	-	1.0	5.0	$\mu\text{A}$	$V_{IN} = V_{DD}$	
Input current, input low voltage	$I_{IL}$	-	-25	-35	$\mu\text{A}$	$V_{IN} = 0V$	
<b>Output</b>							
Output high voltage	$V_{OH}$	$V_{DD} - 0.25$	-	-	V	$I_{OUT} = 10\text{ mA}$	
		$V_{DD} - 0.3$	-	-		$I_{OUT} = 10\text{ mA}$ , $T_A = -40^\circ\text{C}$ to $125^\circ\text{C}$	
Output low voltage	$V_{OL}$	-	-	0.2	V	$I_{OUT} = -10\text{ mA}$	
		-	-	0.3		$I_{OUT} = -10\text{ mA}$ , $T_A = -40^\circ\text{C}$ to $125^\circ\text{C}$	
Output resistance	Pull up	$R_{OUT}$	-	15	25	$\Omega$	$I_{OUT} = \pm 10\text{ mA}$
	Pull down		-	8.0	20		
	Pull up		-	20	30	$\Omega$	$I_{OUT} = \pm 10\text{ mA}$ , $T_A = -40^\circ\text{C}$ to $125^\circ\text{C}$
	Pull down		-	10	30		
Rise time	$t_R$	-	30	75	ns	$C_L = 500\text{ pF}$ (Note 1)	
Fall time	$t_F$	-	20	75	ns	$C_L = 500\text{ pF}$ (Note 1)	

**Note 1:** Design guidance only; Not 100% tested in production.

**2:** Stray capacitance on OSC in pin must be  $\leq 5\text{ pF}$ .

# HV9120/HV9123

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## TEMPERATURE SPECIFICATIONS

Parameter	Symbol	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Operating Temperature		-40		125	°C	
Storage Temperature		-65	–	150	°C	
<b>Package Thermal Resistances</b>						
Thermal Resistance, SOIC	$\theta_{ja}$	–	83	–	°C/W	
Thermal Resistance, PDIP	$\theta_{ja}$	–	51	–	°C/W	

### 1.1 Truth Table

#### TRUTH TABLE

SHUTDOWN	RESET	OUTPUT
H	H	Normal operation
H	H → L	Normal operation, no change
L	H	Off, not latched
L	L	Off, latched
L → H	L	Off, latched, no change

## 2.0 TYPICAL PERFORMANCE CURVES

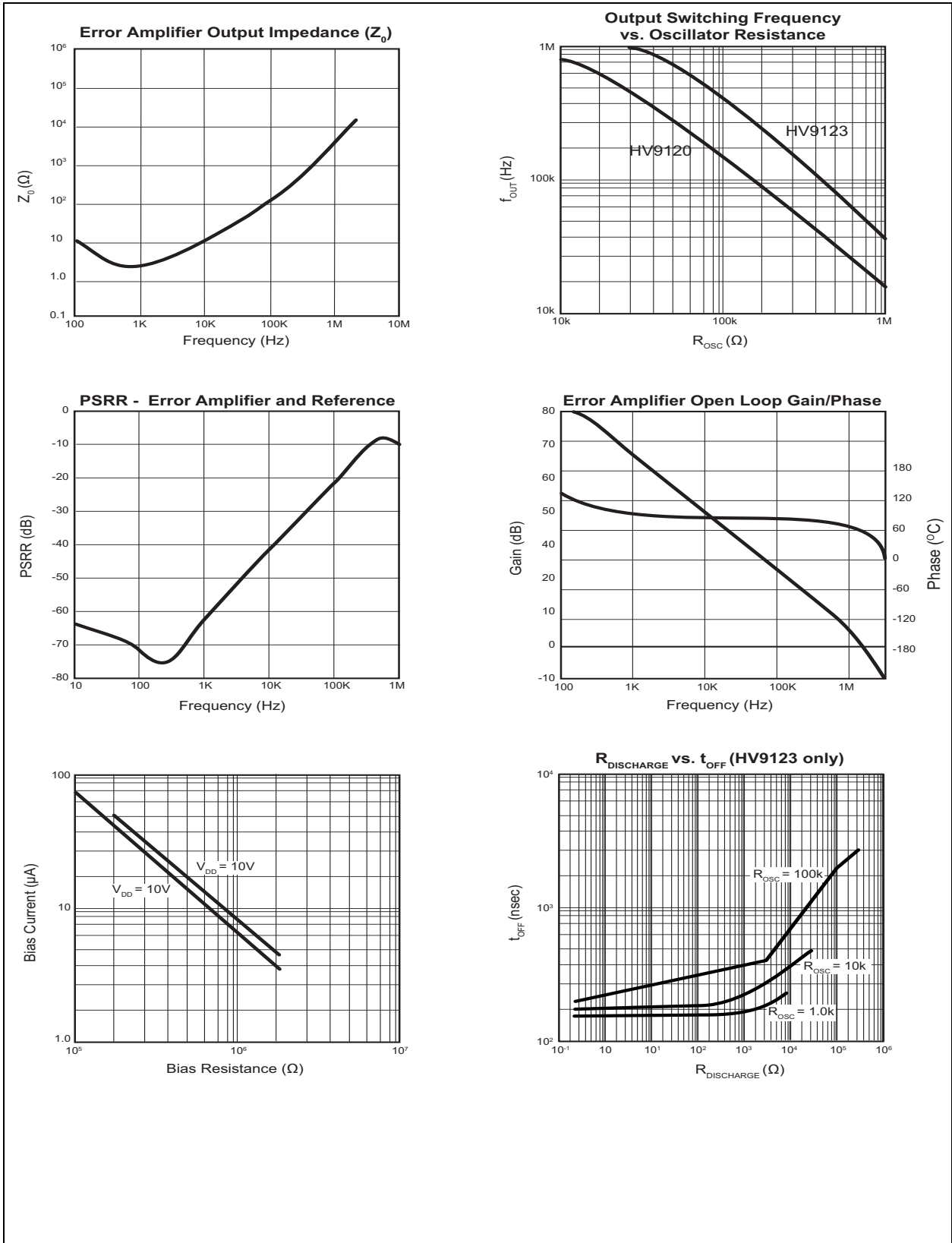


FIGURE 2-1: Typical Performance Curves



# HV9120/HV9123

## 3.0 PIN DESCRIPTION

The locations of the pins are listed in [Features](#).

**TABLE 3-1: PIN DESCRIPTION**

Pin #	Symbol HV9120	Symbol HV9123	Description
1	V <sub>IN</sub>	V <sub>IN</sub>	High-voltage, V <sub>DD</sub> regulator input
2	NC	NC	No connect
3	NC	NC	No connect
4	CS	CS	Current-sense input
5	GATE	GATE	Gate-drive output
6	GND	GND	Ground
7	VDD	VDD	High-voltage, V <sub>DD</sub> regulator output
8	OSCO	OSCO	Oscillator output
9	OSCI	OSCI	Oscillator Input
10	NC	DISC	Oscillator discharge, current set
11	VREF	VREF	4V Reference output Reference voltage level can be overridden by an externally-applied voltage source.
12	NSD	NSD	Active low input to set shutdown latch
13	RST	RST	Active high input to reset shutdown latch
14	COMP	COMP	Error-amplified output
15	FB	FB	Feedback-voltage input
16	BIAS	BIAS	Internal bias, current set

## 4.0 TEST CIRCUITS

The test circuits for characterizing error-amplifier output impedance,  $Z_{OUT}$ , and error-amplifier, power-supply rejection ratio, PSRR, are shown in Figure 4-1.

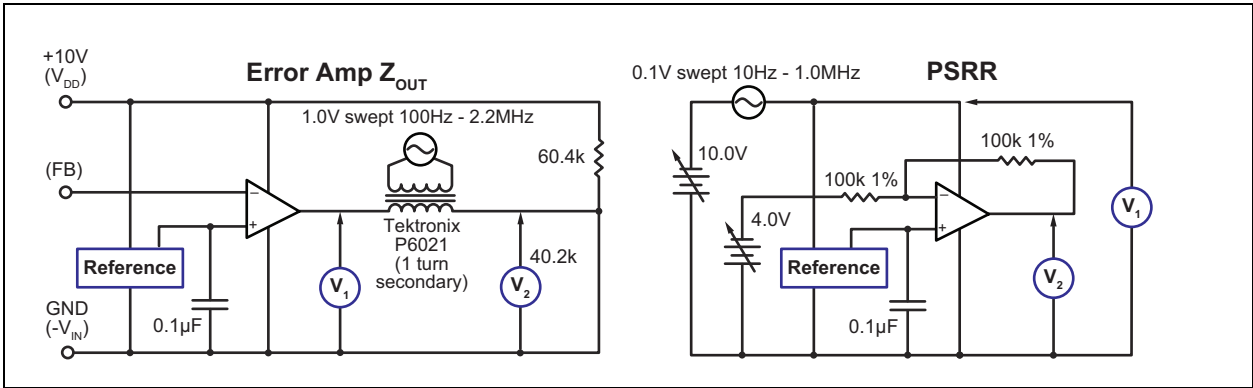


FIGURE 4-1: Test Circuits

# HV9120/HV9123

## 5.0 DETAILED DESCRIPTION

### 5.1 High-Voltage Regulator

The high-voltage regulator included in HV9120 and HV9123 consists of a high-voltage, n-channel, depletion-mode DMOS transistor, driven by an error amplifier, providing a current path between the  $V_{IN}$  terminal and the  $V_{DD}$  terminal. The maximum current, about 20 mA, occurs when  $V_{DD} = 0$ , with current reducing as  $V_{DD}$  rises. This path shuts off when  $V_{DD}$  rises to somewhere between 7.8 and 9.4V. So, if  $V_{DD}$  is held at 10 or 12V by an external source, no current other than leakage is drawn through the high voltage transistor. This minimizes dissipation.

Use an external capacitor between  $V_{DD}$  and GND to store energy used by the chip in the time between shut-off of the high voltage path and the  $V_{DD}$  supply's output rising enough to take over powering the chip. This capacitor should have a value of 100X or more the effective gate capacitance of the MOSFET being driven, as well as very good high-frequency characteristics. See the equation below. Ceramic caps work well. Electrolytic capacitors are generally not suitable.

$$C_{V_{DD}} \geq 100 \times (\text{gate charge of FET at } 10V)$$

The device uses a resistor divider string to monitor  $V_{DD}$  for both the under voltage lockout circuit and the shutoff circuit of the high voltage FET. Setting the under voltage sense point about 0.6V lower on the string than the FET shutoff point guarantees that the under voltage lockout releases before the FET shuts off.

### 5.2 Bias Circuit

HV9120 and HV9123 require an external bias resistor, connected between the BIAS pin and GND, to set currents in a series of current mirrors used by the analog sections of the chip. The nominal external bias current requirement is 15 to 20  $\mu\text{A}$ , which can be set by a 390 k $\Omega$  to 510 k $\Omega$  resistor if  $V_{DD} = 10\text{V}$ , or a 510 k $\Omega$  to 680 k $\Omega$  resistor if  $V_{DD} = 12\text{V}$ . A precision resistor is not required,  $\pm 5\%$  meets the device requirements.

### 5.3 Clock Oscillator

The clock oscillator of the HV9120 and HV9123 consists of a ring of CMOS inverters, timing capacitors, and a capacitor-discharge FET. A single external resistor between the OSC1 and OSC0 sets the oscillator frequency (see [Figure 2-1](#), Output Switching Frequency vs Oscillator Resistance).

HV9120 includes a frequency-dividing flip-flop that allows the part to operate with a 50% duty limit. Accordingly, the effective switching frequency of the power

converter is half the oscillator frequency (see [Figure 2-1](#), Output Switching Frequency vs Oscillator Resistance).

An internal, discharge FET resets the oscillator ramp at the end of the oscillator cycle. The FET is internally connected to GND in HV9120 (50% max duty version). Whereas, the FET is externally connected to GND, by way of a resistor, in the HV9123 (100% duty version). The resistor programs the oscillator dead time at the end of the oscillator period in HV9123 applications.

The oscillator turns off during shutdown to reduce supply current by about 150  $\mu\text{A}$ .

### 5.4 Reference

The reference of the HV9120 and HV9123 consists of a band-gap reference, followed by a buffer amplifier, which scales the voltage up to 4.0V. The scaling resistors of the buffer amplifier are trimmed during manufacture so that the output of the error amplifier, when connected in a gain of -1 configuration, is as close to 4.0V as possible. This nulls out the input offset of the error amplifier. As a consequence, even though the observed reference voltage of a specific part may not be exactly 4.0V, the feedback voltage required for proper regulation will be 4.0V.

An approximately 50 k $\Omega$  resistor is located internally between the output of the reference buffer amplifier and the circuitry it feeds—reference output pin and non-inverting input to the error amplifier. This allows overriding the internal reference with a low impedance voltage source  $\leq 6.0\text{V}$ . Using an external reference reinstates the input offset voltage of the error amplifier. Overriding the reference should seldom be necessary.

The reference of the HV9120 and HV9123 is a high impedance node, and usually there will be significant electrical noise nearby. Therefore, a bypass capacitor between the reference pin and GND is strongly recommended. The reference buffer amplifier is compensated to be stable with a capacitive load of 0.01 to 0.1  $\mu\text{F}$ .

### 5.5 Error Amplifier

The error amplifier in HV9120 and HV9123 is a low-power, differential-input, operational amplifier. A PMOS input stage is used, so the common mode range includes ground and the input impedance is high.

### 5.6 Current Sense Comparators

HV9120 and HV9123 use a dual-comparator system with independent comparators for modulation and current limiting. This allows the designer greater latitude in compensation design, as there are no clamps, except ESD protection, on the compensation pin.

## 5.7 Remote Shutdown

The NSD and RST pins control the shutdown latch. These pins have internal, current-source pull-ups so they can be driven from open drain logic. When not used they should be left open, or connected to  $V_{DD}$ .

## 5.8 Output Buffer

The output buffer of HV9120 and HV9123 is of standard CMOS construction—P-channel pull-up and N-channel pull-down. Thus, the body-drain diodes of the output stage can be used for spike clipping. External Schottky diode clamping of the output is not required.

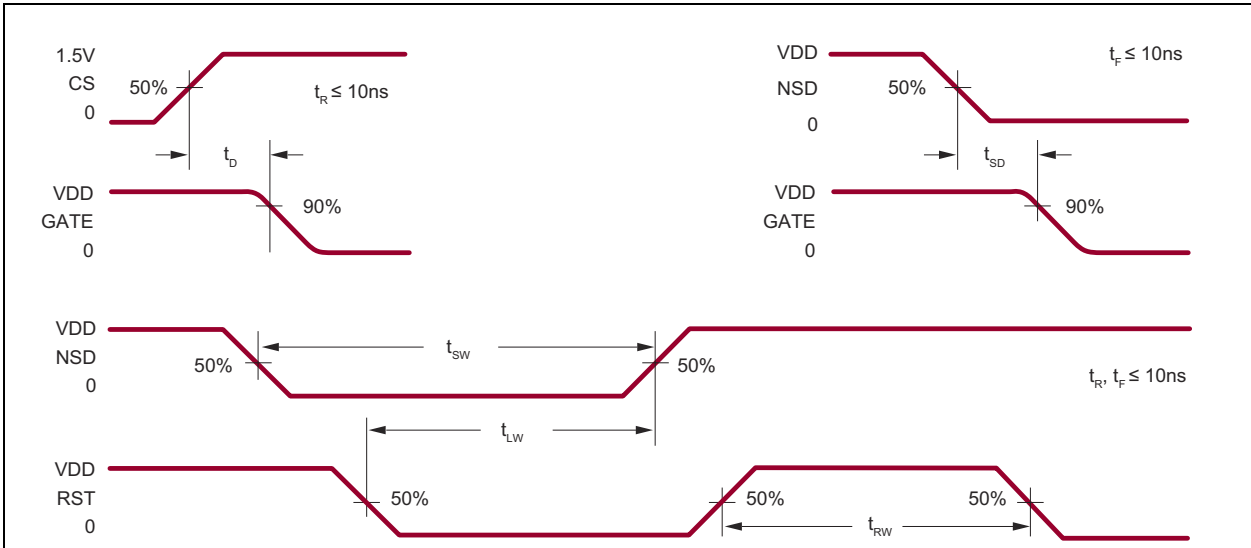


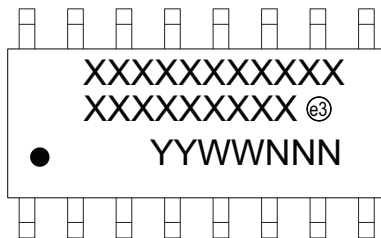
FIGURE 5-1: Shutdown Timing Waveforms

# HV9120/HV9123

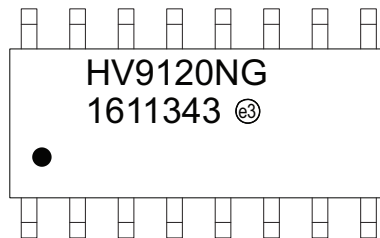
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

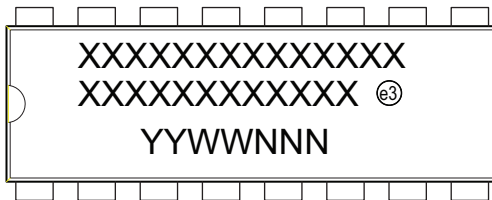
16-lead SOIC



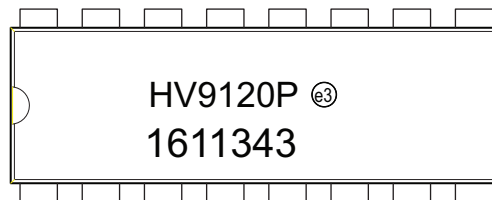
Example



16-lead PDIP



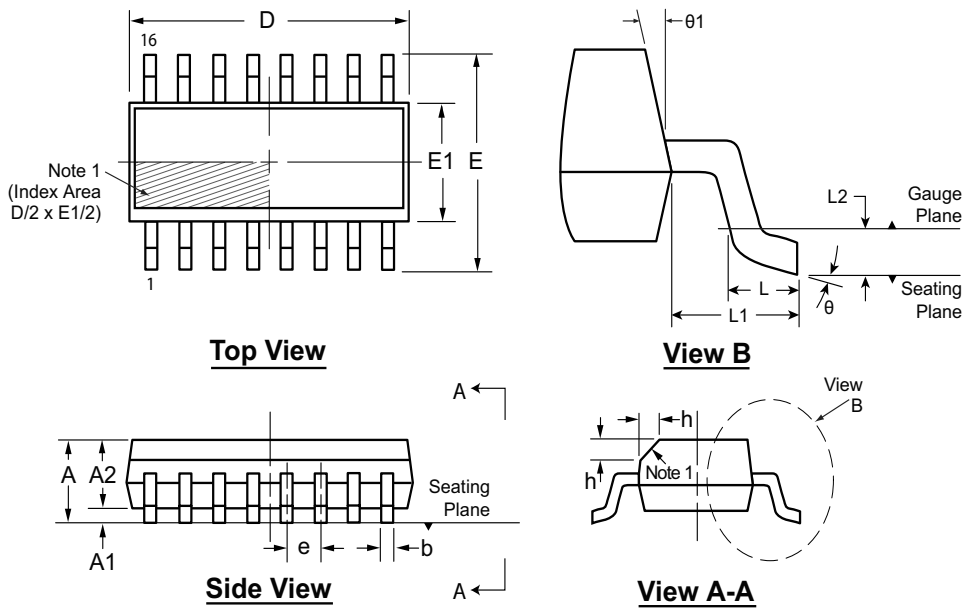
Example



<b>Legend:</b>	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.

## 16-Lead SOIC (Narrow Body) Package Outline (NG) 9.90x3.90mm body, 1.75mm height (max), 1.27mm pitch



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

**Note:**

1. This chamfer feature is optional. If it is not present, then 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.

Symbol	A	A1	A2	b	D	E	E1	e	h	L	L1	L2	$\theta$	$\theta 1$
Dimension (mm)	MIN	1.35*	0.10	1.25	0.31	9.80*	5.80*	3.80*	0.25	0.40	1.04 REF	0.25 BSC	0°	5°
	NOM	-	-	-	-	9.90	6.00	3.90	-	-			-	-
	MAX	1.75	0.25	1.65*	0.51	10.00*	6.20*	4.00*	0.50	1.27			8°	15°

JEDEC Registration MS-012, Variation AC, Issue E, Sept. 2005.

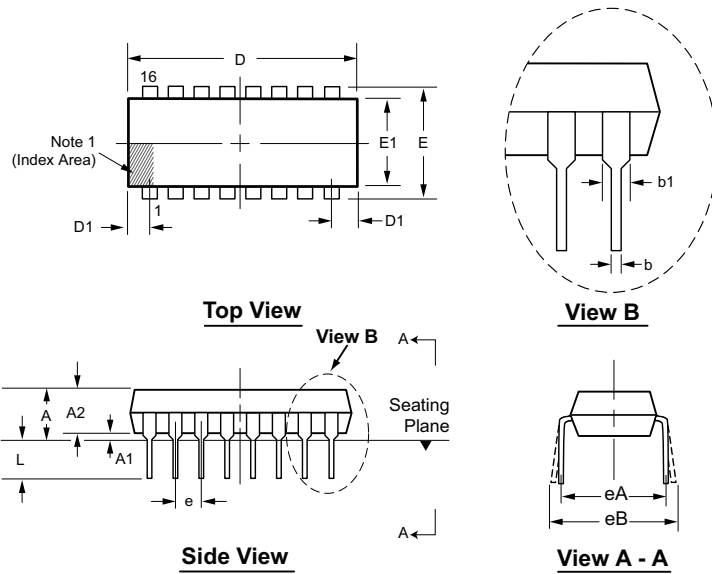
\* This dimension is not specified in the JEDEC drawing.

Drawings are not to scale.



# HV9120/HV9123

## 16-Lead PDIP (.300in Row Spacing) Package Outline (P) .790x.250in body, .210in height (max), .100in pitch



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

**Note:**

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.

Symbol	A	A1	A2	b	b1	D	D1	E	E1	e	eA	eB	L	
Dimension (inches)	MIN	.130*	.015	.115	.014	.045	.745 <sup>†</sup>	.005	.290 <sup>†</sup>	.240	.100 BSC	.300 BSC	.300*	.115
	NOM	-	-	.130	.018	.060	.790	-	.310	.250			-	.130
	MAX	.210	.035*	.195	.023 <sup>†</sup>	.070	.810 <sup>†</sup>	.050*	.325	.280			.430	.150

JEDEC Registration MS-001, Variation AB, Issue D, June, 1993.

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

† This dimension differs from the JEDEC drawing.

Drawings not to scale.

## APPENDIX A: REVISION HISTORY

### Revision A (May 2016)

- Updated file to Microchip format.
- Merged Supertex Doc #s DSFP-HV9120 and DSFP-HV9123 to Microchip DS20005519A.
- Revised [Electrical Characteristics](#) to accommodate the merged products.
- Updated Pin names to reflect new naming convention.
- Significant text changes to [Detailed Description](#)
- Minor text changes throughout.

# HV9120/HV9123

## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>XX</u>	-	<u>X</u>	-	<u>X</u>
Device	Package Options		Environmental		Media Type
Device:	HV9120	=	High Voltage Current-Mode PWM Controller, 10 to 450V input voltage range, 49% duty cycle		
	HV9123	=	High Voltage Current-Mode PWM Controller, 9 to 80V input voltage range, 99% duty cycle		
Package:	NG	=	16-lead SOIC		
	P	=	16-lead PDIP		
Environmental	G	=	Lead (Pb)-free/ROHS-compliant package		
Media Type:	(blank)	=	45/Tube for NG package 24/Tube for P package		
	M901	=	2600/Reel for NG package		
	M934	=	2600/Reel for NG package		

**Examples:**

a) HV9120NG-G      14-Lead SOIC package, 53/Tube

b) HV9123NG-G      14-Lead SOIC package, 53/Tube

c) HV9123NG-G-M901      14-Lead SOIC package, 2600/Reel

**Note:** For media types M901 and M934, the base quantity for tap and reel was standardized at 2600/reel. Both options will result in delivery of the same number of parts/reel.

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**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

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