HV9901

Universal Relay Driver

Features

- 10V to 450V Input Voltage Range
- Energy-saving Hold Current Mode
- Adjustable Microcontroller Supply
- Low Supply Current <1 mA
- Constant-current Coil Drive
- Programmable Pull-in Current, Pull-in Time and Hold Current

Applications

- Industrial Controls
- Relay Timers
- Solenoid Drivers
- Home Automation

General Description

The HV9901 universal relay driver provides high-efficiency driving for low-voltage relays with supply voltages as high as 450V. For example, a relay with a 5V coil can be driven directly from the rectified 120 VAC or 230 VAC line.

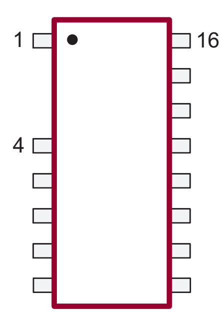
The IC includes two high-voltage linear regulators. The first one is for providing power to internal control circuitry. The second one has an adjustable output voltage and a 1 mA output current capability to support external circuitry, such as a microcontroller control circuit.

The pull-in current, pull-in time and hold current for the relay are individually programmable through two resistors and a capacitor. PWM switching can be synchronized with an external clock or with another HV9901 operating at a higher frequency.

The relay is operated through the enable input ENI. Logic polarity is under control of the polarity input POL. Audible noise coming from the relay can be suppressed by operating at a PWM frequency exceeding 20 kHz.

Package Type

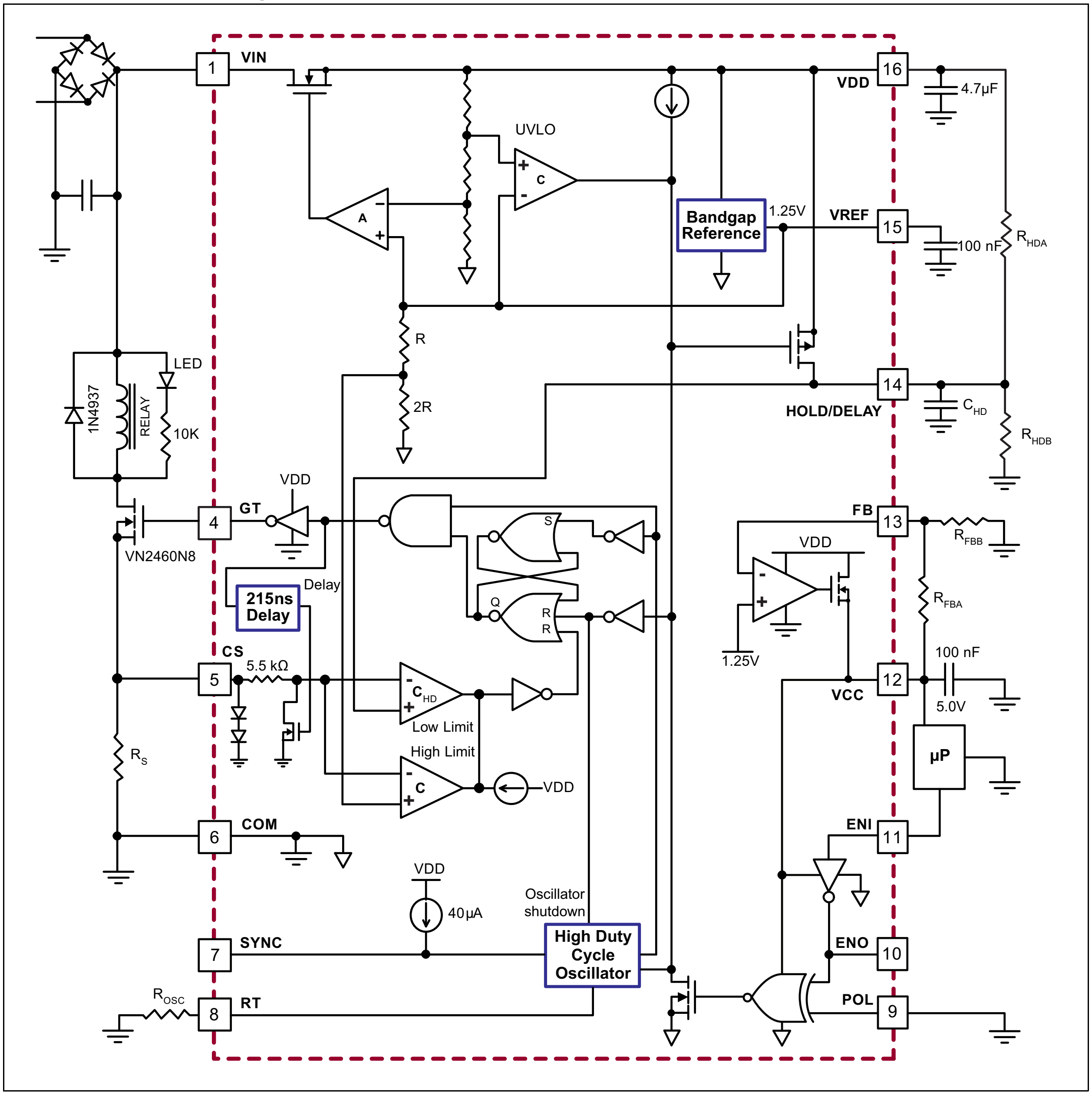
16-lead SOIC



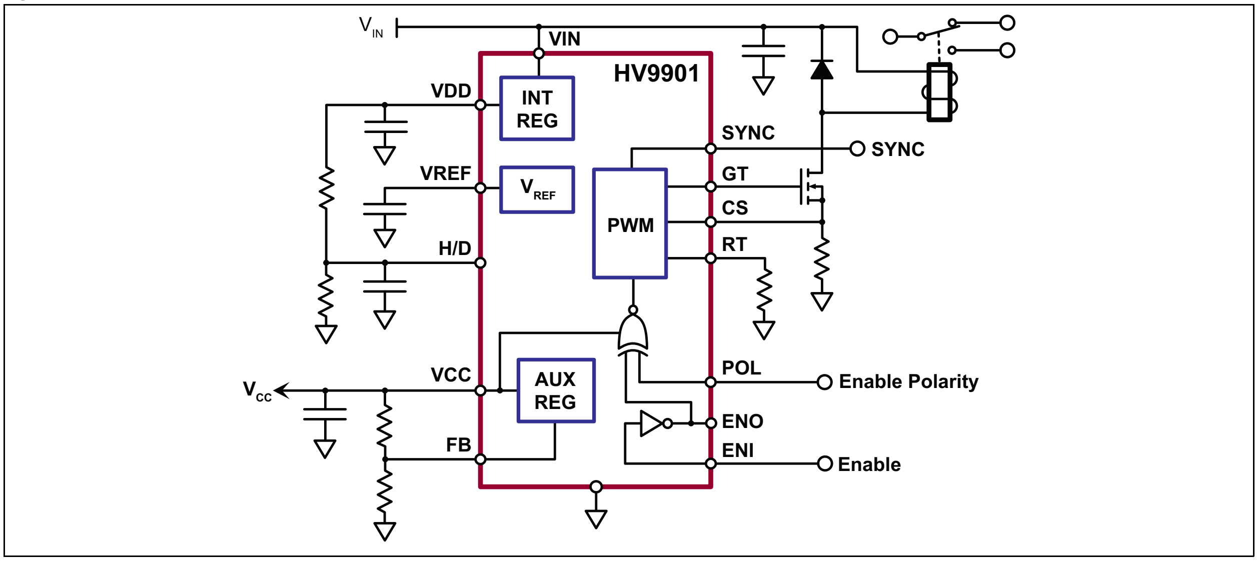
See Table 2-1 for pin information.

WARNING
The HV9901 is suited for relay driving applications operating at hazardous voltage. Ensure that adequate safeguards are provided to protect the end user from electrical shock.

Functional Block Diagram



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

Input Voltage, V_{IN}[1] .... –0.5V to 470V
Input Voltage to any other Pin[1] .... –0.3V to V_{DD} + 0.3V
Operating Junction Temperature Range .... –40°C to +125°C
Continuous Power Dissipation (T_A = +25°C)[2] .... 750 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.

Note 1: All voltages are referenced to GND.
2: For operation above +25°C ambient, derate linearly at 7.5 mW/°C.

ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Electrical Specifications: T_A = +25°C unless otherwise noted.						
High-Voltage Regulator						
Input Voltage	V_{IN}	10	—	450	V	I_{CC} = 0 mA to 1 mA load
Supply Current	I_{IN}	—	—	2	mA	No load at V_{DD} (**Note 1**) Load at I_{CC} = 1 mA, C_{GT} = 500 pF, f_{OSC} = 25 kHz
Internal Supply Voltage	V_{DD}	8.5	9	9.5	V	No load at V_{DD} (**Note 1**) C_{GT} = 500 pF, f_{OSC} = 25 kHz
V_{DD} UVLO, On	$UVLO_{(ON)}$	7.8	8.2	8.5	V	
V_{DD} UVLO, Hysteresis	$UVLO_{(HYST)}$	—	0.5	—	V	
Adjustable Regulator						
Regulator Output Voltage Range	V_{CC}	2	—	5.5	V	I_{CC} = 1 mA load
Regulator Output Current	I_{CC}	0	—	1	mA	No load at V_{DD} (**Note 1**)
Feedback Voltage	V_{FB}	0	V_{REF}	V_{DD}–1V	V	
Input Bias Current	I_{FB}	—	25	100	nA	V_{FB} = V_{REF}
Reference						
Bandgap Reference Voltage	V_{REF}	1.2	1.25	1.3	V	T_A = –40°C to +85°C
Load Regulation		—	—	7	mV	0 mA < I_{REF} < 0.3 mA
Line Regulation		—	10	15	mV	8.5V < V_{DD} < 9.5V
Short Circuit Current	$I_{REF(SHORT)}$	—	—	1	mA	
Reference Voltage Sink Current	$I_{REF(SINK)}$	—	—	20	µA	

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: T_A = +25°C unless otherwise noted.						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
Oscillator						
PWM Oscillator Frequency	f_{OSC}	20	25	35	kHz	R_T = 1 MΩ
		80	100	140	kHz	R_T = 226 kΩ
Temperature Coefficient	—	—	170	—	ppm/°C	T_A = –40°C to +85°C
Oscillator SYNC Frequency	f_{SYNC}	—	—	150	kHz	
SYNC Sourcing Current	I_{SYNC}	20	—	55	µA	
SYNC Sinking Current	I_{SYNC}	1	—	—	mA	V_{SYNC} = 0.1V
SYNC Input Logic Low Voltage	V_{SYNC}	—	—	1	V	
PWM						
Maximum Duty Cycle	D_{MAX}	96.5	—	99.5	%	R_T = 1 MΩ
		86.5	—	97.5	%	R_T = 226 kΩ
Blanking Time	t_{BLNK}	150	215	280	ns	
MOSFET Driver						
Gate Drive Output High	V_{GTH}	V_{DD}–0.3	—	—	V	I_{OUT} = 10 mA
Gate Drive Output Low	V_{GTL}	—	—	0.3	V	I_{OUT} = –10 mA
Rise Time	t_R	—	30	50	ns	C_{GT} = 500 pF
Fall Time	t_F	—	30	50	ns	
Current Sense						
Current Sense Voltage, High Limit	$V_{CS(HL)}$	0.775	0.833	0.891	V	
Current Limit Delay to GT, High Limit	$t_{DELAY(HL)}$	—	200	250	ns	50 mV overdrive
Input Bias Current	I_{CS}	—	25	1000	nA	POL = Low, ENI = Low
Low-Limit Comparator Input Offset Voltage	V_{OS}	—	—	±60	mV	
Current Limit Delay to GT, Low Limit	$t_{DELAY(LL)}$	—	200	250	ns	50 mV overdrive
Hold/Delay Output Voltage	$V_{HOLD/DEL}$	V_{DD}–0.4	—	—	V	$I_{HOLD/DEL}$(sourcing)–100 µA POL = Low, ENI = Low
Hold/Delay Input Bias Current	$I_{HOLD/DEL}$	—	25	500	nA	POL = Low, ENI = Low
Shutdown Delay	t_{ENI}	—	50	100	ns	2V < V_{CC} < 5.5V
Enable Input Voltage - High	V_{ENI}	0.7 V_{CC}	—	V_{CC}	V	
Enable Input Voltage - Low		0	—	0.3 V_{CC}	V	
Enable Input Current - High	I_{ENI}	—	1	5	µA	
Enable Input Current - Low		–5	–1	—	µA	
Polarity Voltage - High	V_{POL}	0.7 V_{CC}	—	V_{CC}	V	
Polarity Voltage - Low		0	—	0.3 V_{CC}	V	
Polarity Current - High	I_{POL}	—	1	5	µA	
Polarity Current - Low		–5	–1	—	µA	
Enable Output Voltage - High	V_{ENO}	0.9 V_{CC}	—	V_{CC}	V	
Enable Output Voltage - Low		0	—	0.1 V_{CC}	V	

Note 1: Maximum allowable load current limited by power dissipation and operating ambient temperature.

TEMPERATURE SPECIFICATIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Temperature Range						
Operating Junction Temperature	T_J	–40	—	+125	°C	
Package Thermal Resistance						
16-lead SOIC	θ_{JA}	—	83	—	°C/W	

1.1 Truth Table

ENABLE OUTPUT LOGIC TRUTH TABLE

POL	ENI	ENO	Gate Drive Output
Low	Low	High	V_{GT} = Oscillating output, duty cycle depends on inductive load
Low	High	Low	V_{GT} = Low, SYNC = High, oscillator shutdown
High	High	Low	V_{GT} = Oscillating output, duty cycle depends on inductive load
High	Low	High	V_{GT} = Low, SYNC = High, oscillator shutdown

2.0 PIN DESCRIPTIONS

The pin details of HV9901 are listed on Table 2-1. See **Section "Package Type"** for the location of the pins.

TABLE 2-1: PIN TABLE

Pin Number	Symbol	Description
1	V_{IN}	Input Supply
2	—	Pin not present
3	—	Pin not present
4	GT	Gate Driver Output for driving the external switching MOSFET
5	CS	Current Sense Input
6	GND	Ground
7	SYNC	Open-Drain Input/Output for synchronizing the internal PWM oscillator to other HV9901s or to an external clock
8	RT	A resistor from this pin to ground sets the PWM switching frequency.
9	POL	Input that determines the polarity of the ENI input. See **Section 1.1 "Truth Table"**.
10	ENO	Enable Output. It is the logical inversion of the ENI signal.
11	ENI	Enable Input. Whether ENI is active-low or active-high is determined by the POL input.
12	V_{CC}	Output of the auxiliary regulator. The output voltage is determined by the resistive divider connected to the FB pin.
13	FB	Feedback input for the auxiliary regulator.
14	H/D	HOLD/DELAY input. An RC network connected to this pin controls the pull-in time and the holding current. See Equation 3-8.
15	V_{REF}	Reference Voltage. Bypass locally with a 10 nF capacitor.
16	V_{DD}	Output of the internal supply regulator. Bypass locally with a 10 nF capacitor.

3.0 APPLICATION INFORMATION

To calculate external component values, use the equations shown in Equation 3-1 to Equation 3-8 as well as Figure 3-1 and Figure 3-2.

EQUATION 3-1:

$$V_{CS(HL)} = 833\ mV_{NOM}$$

EQUATION 3-2:

$$V_{DD} = 9V_{NOM}$$

EQUATION 3-3:

$$I_{PULL-IN} = \frac{V_{CS(HL)}}{R_{SENSE}}$$

EQUATION 3-4:

$$V_{CS(LL)} = \frac{V_{DD}}{1 + \frac{R_{HDA}}{R_{HDB}}}$$

EQUATION 3-5:

$$I_{HOLD} = \frac{V_{CS(LL)}}{R_{SENSE}}$$

EQUATION 3-6:

$$f_{PWM} \approx 3.23kHz + \frac{21.8GHz \bullet \Omega}{R_{OSC}}$$

Valid for f_{PWM} > 23 kHz

EQUATION 3-7:

$$V_{CC} = 1.25V \bullet \left(1 + \frac{R_{FBA}}{R_{FBB}}\right)$$

EQUATION 3-8:

$$t_{PULL-IN} = -(R_{HDA} // R_{HDB}) \bullet C_{HD} \bullet ln\left(1 - \frac{V_{CS(HL)} - V_{DD}}{V_{CS(LL)} - V_{DD}}\right)$$

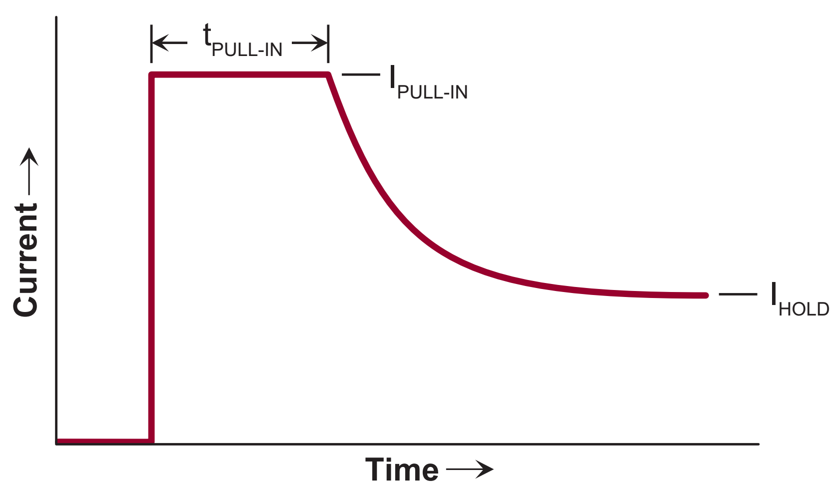


FIGURE 3-1: *Current vs. Time.*

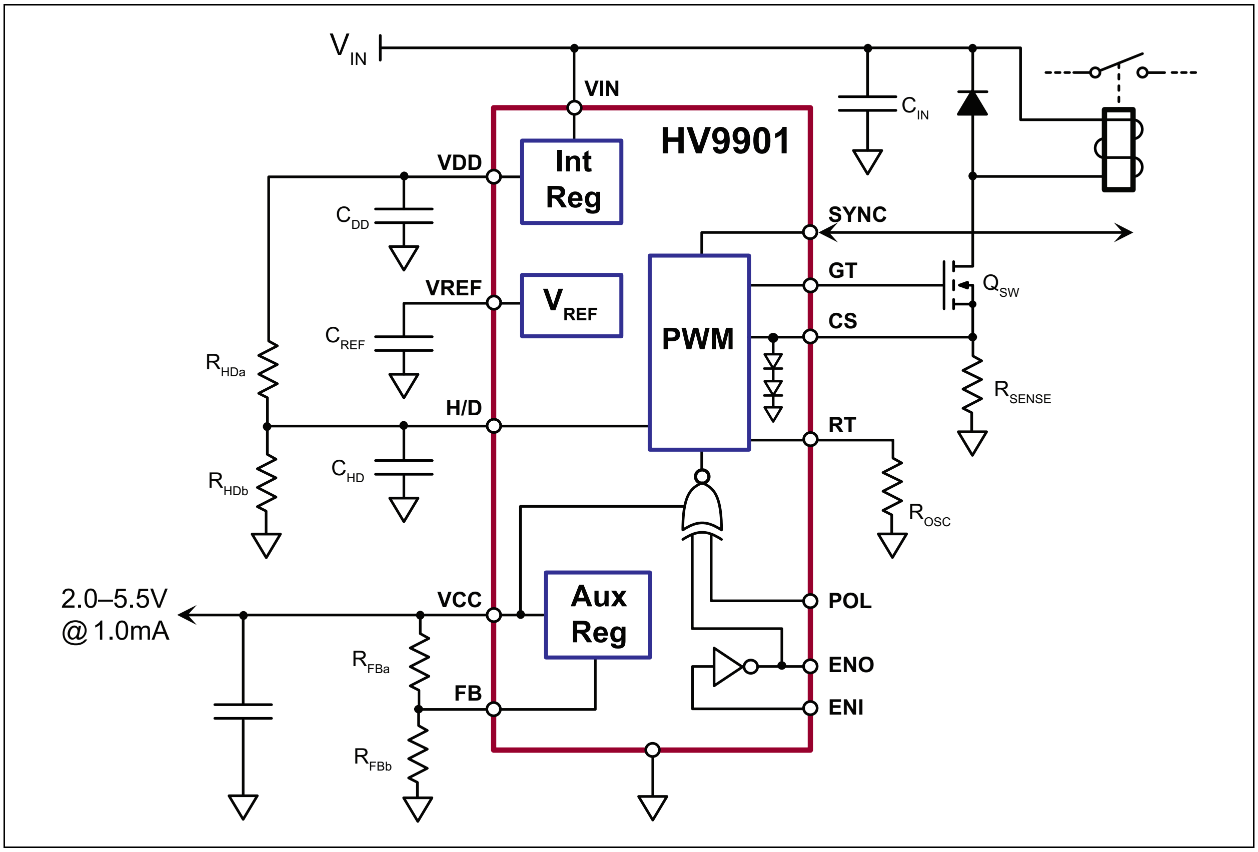
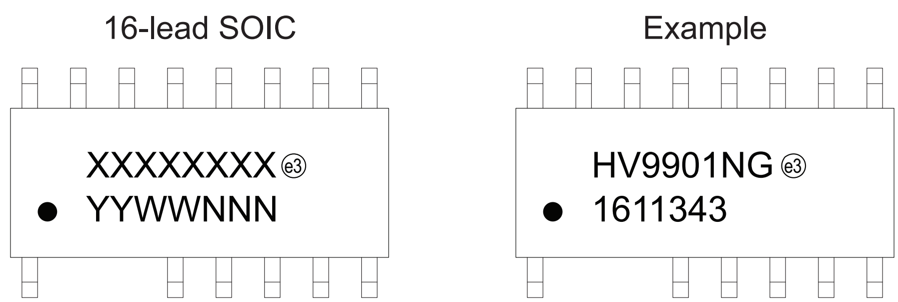


FIGURE 3-2: *Typical Application Circuit.*

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

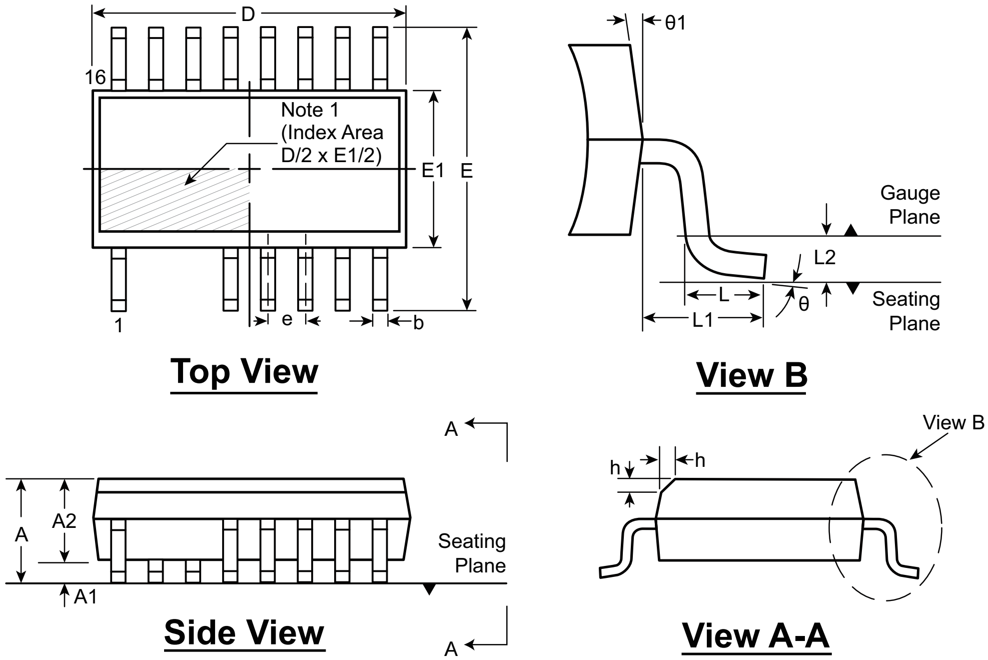


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	e3	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is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

16-Lead SOIC (Narrow Body) Package Outline (NG) Pins #2 and #3 Trimmed

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.

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	θ	θ1
Dimension (mm)	MIN	1.35*	0.10	1.25	0.31	9.80*	5.80*	3.80*	1.27 BSC	0.25	0.40	1.04 REF	0.25 BSC	0^{O}	5^{O}
	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^{O}	15^{O}

JEDEC Registration MS-012, Variation AC, Issue E, Sept. 2005.
** This dimension is not specified in the JEDEC drawing.*
Drawings are not to scale.

NOTES:

APPENDIX A: REVISION HISTORY

Revision B (September 2019)

- Updated the **Absolute Maximum Ratings†**.
- Updated the **Temperature Specifications**.
- Corrected equations in **Section 3.0, Application Information**.
- Various typographical edits.

Revision A (August 2016)

- Updated file to Microchip format.
- Converted Supertex Doc # DSFP-HV9901 to Microchip DS20005550B.
- Minor text changes throughout.

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:	HV9901	= Universal Relay Driver
Package:	NG	= 16-lead SOIC
Environmental:	G	= Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	= 45/Tube for an NG Package
	M901	= 2600/Reel for an NG Package
	M934	= 2600/Reel for an NG Package

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

Examples:

a) HV9901NG-G: Universal Relay Driver, 16-lead SOIC Package, 45/Tube

b) HV9901NG-G-M901: Universal Relay Driver, 16-lead SOIC Package, 2600/Reel

c) HV9901NG-G-M934: Universal Relay Driver, 16-lead SOIC Package, 2600/Reel

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