

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.

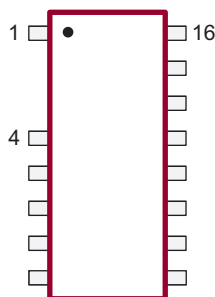
The IC includes two high-voltage linear regulators. The first one is for providing power to internal control circuitry. The second one has an adjustable output voltage and a 1 mA output current capability to support external circuitry, such as a microcontroller control circuit.

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

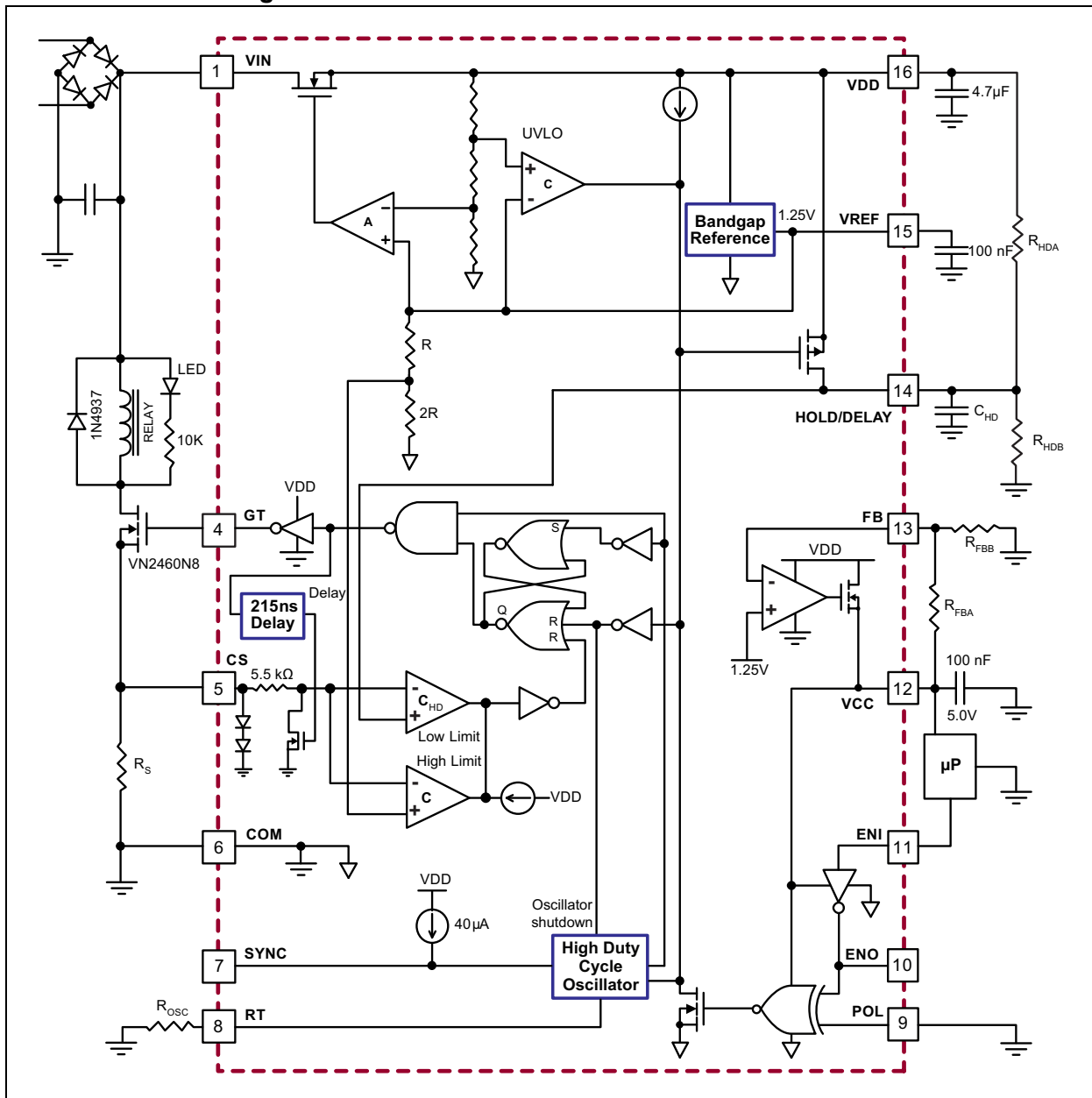


See [Table 2-1](#) for pin information.

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



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 ($T_A = +25^\circ\text{C}$) 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.

Note 2: For operation above +25°C ambient, derate linearly at 7.5 mW/°C.

ELECTRICAL CHARACTERISTICS

Electrical Specifications: $T_A = +25^\circ\text{C}$ unless otherwise noted.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
High-Voltage Regulator						
Input Voltage	V_{IN}	10	—	450	V	$I_{CC} = 0 \text{ mA to } 1 \text{ mA load}$
Supply Current	I_{IN}	—	—	2	mA	No load at V_{DD} (Note 1) Load at $I_{CC} = 1 \text{ mA}$, $C_{GT} = 500 \text{ pF}$, $f_{OSC} = 25 \text{ kHz}$
Internal Supply Voltage	V_{DD}	8.5	9	9.5	V	No load at V_{DD} (Note 1) $C_{GT} = 500 \text{ pF}$, $f_{OSC} = 25 \text{ kHz}$
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	$I_{CC} = 1 \text{ mA load}$
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	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$
Load Regulation		—	—	7	mV	$0 \text{ mA} < I_{REF} < 0.3 \text{ mA}$
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:** $T_A = +25^\circ\text{C}$ 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:

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

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 3-8:

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

EQUATION 3-5:

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

EQUATION 3-6:

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

Valid for $f_{PWM} > 23 \text{ kHz}$

EQUATION 3-7:

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

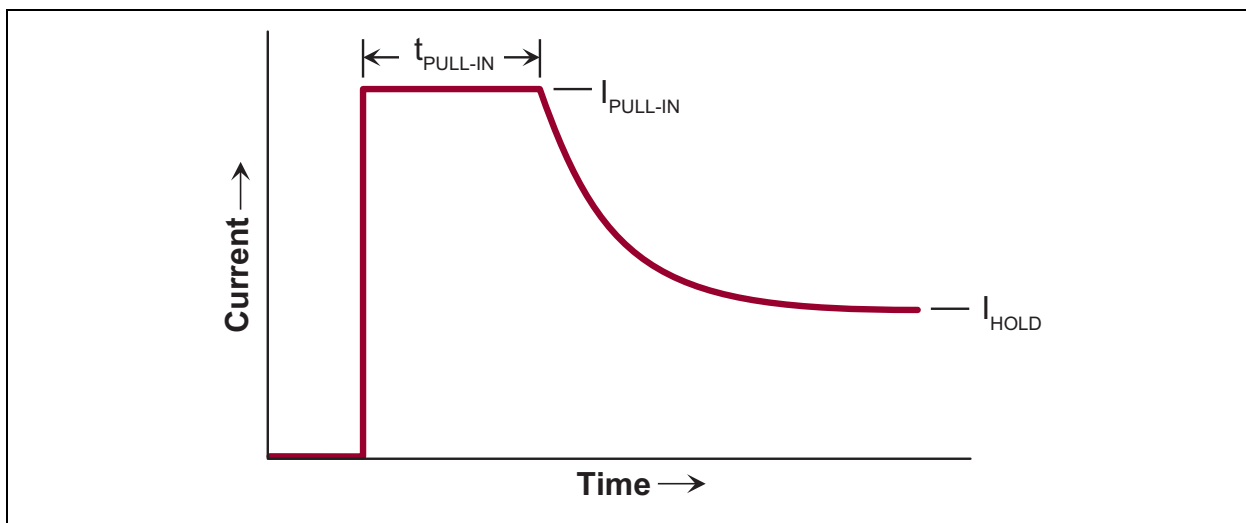


FIGURE 3-1: Current vs. Time.

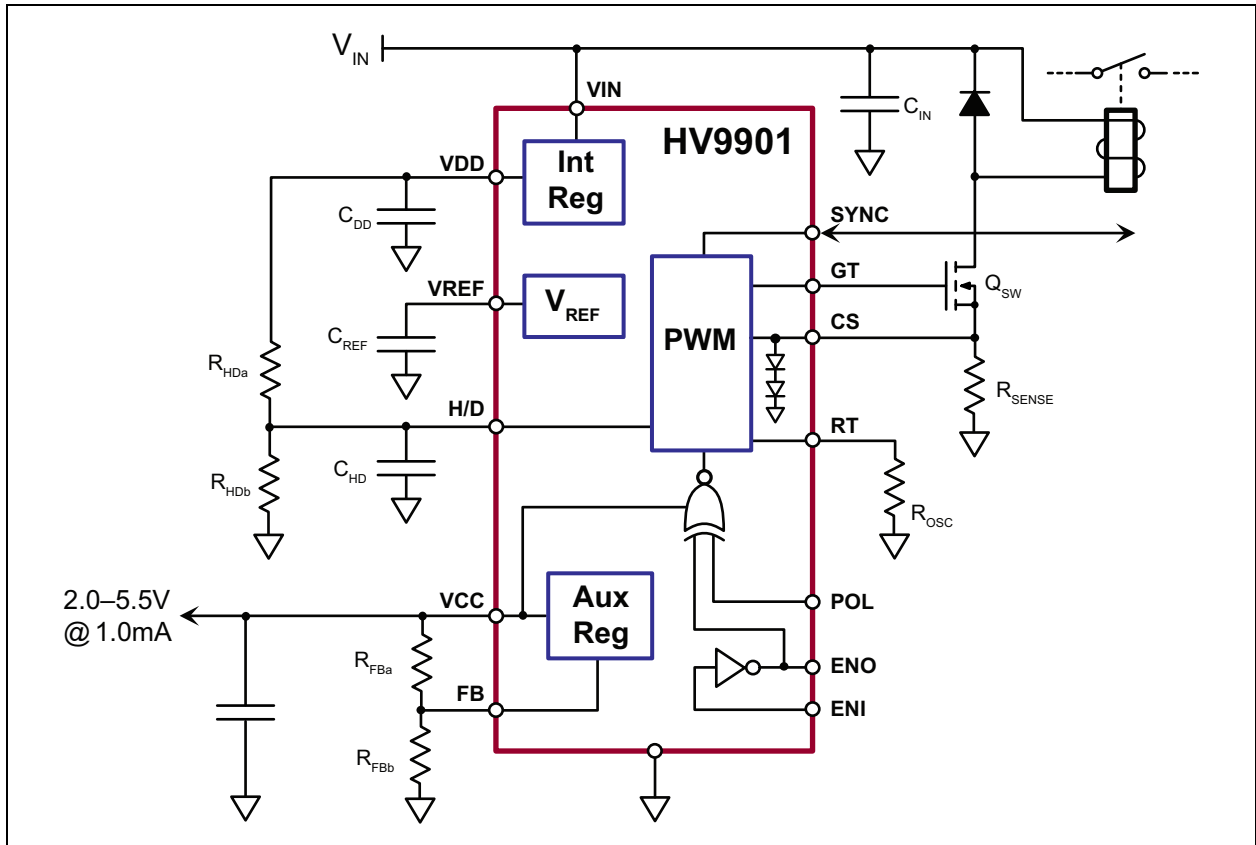
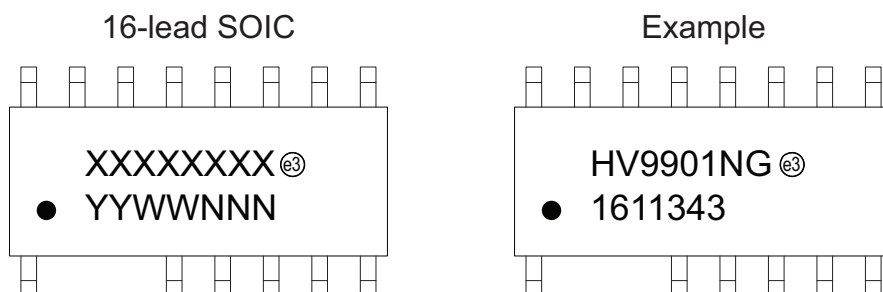


FIGURE 3-2: Typical Application Circuit.

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

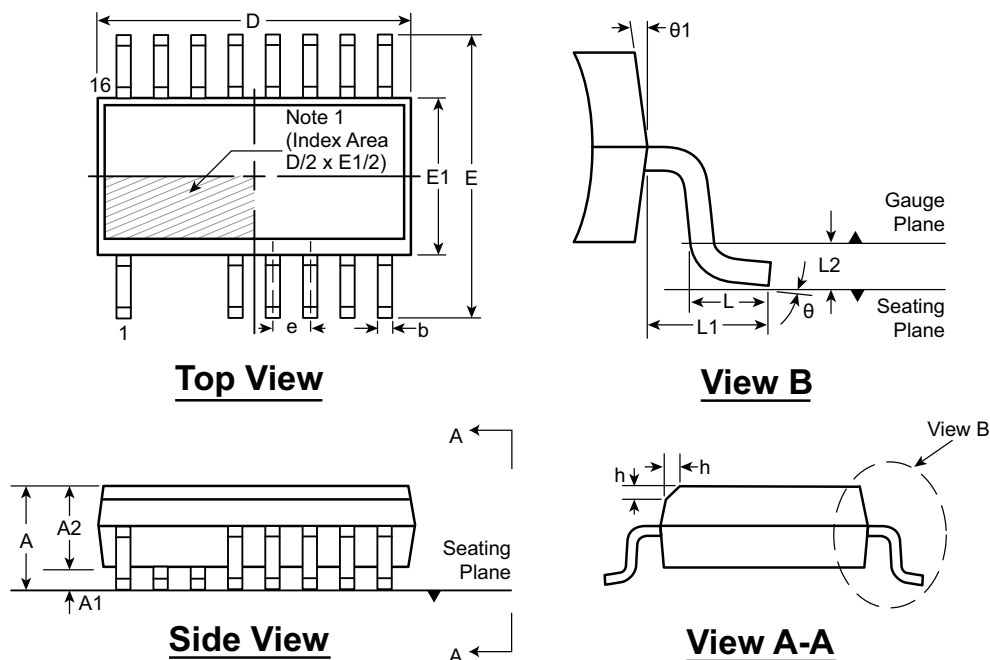


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package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

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.

<u>PART NO.</u>	<u>XX</u>	-	<u>X</u>	-	<u>X</u>
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					

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.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TempTracker, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2016-2019, Microchip Technology Incorporated, All Rights Reserved.

ISBN: 978-1-5224-5022-1

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880-3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820