

## 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.

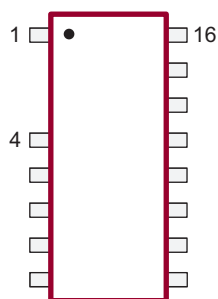
The IC includes two high-voltage linear regulators. The first one is for providing power to internal control circuitry. The second one has an adjustable output voltage and a 1 mA output current capability to support external circuitry, such as a microcontroller control circuit.

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

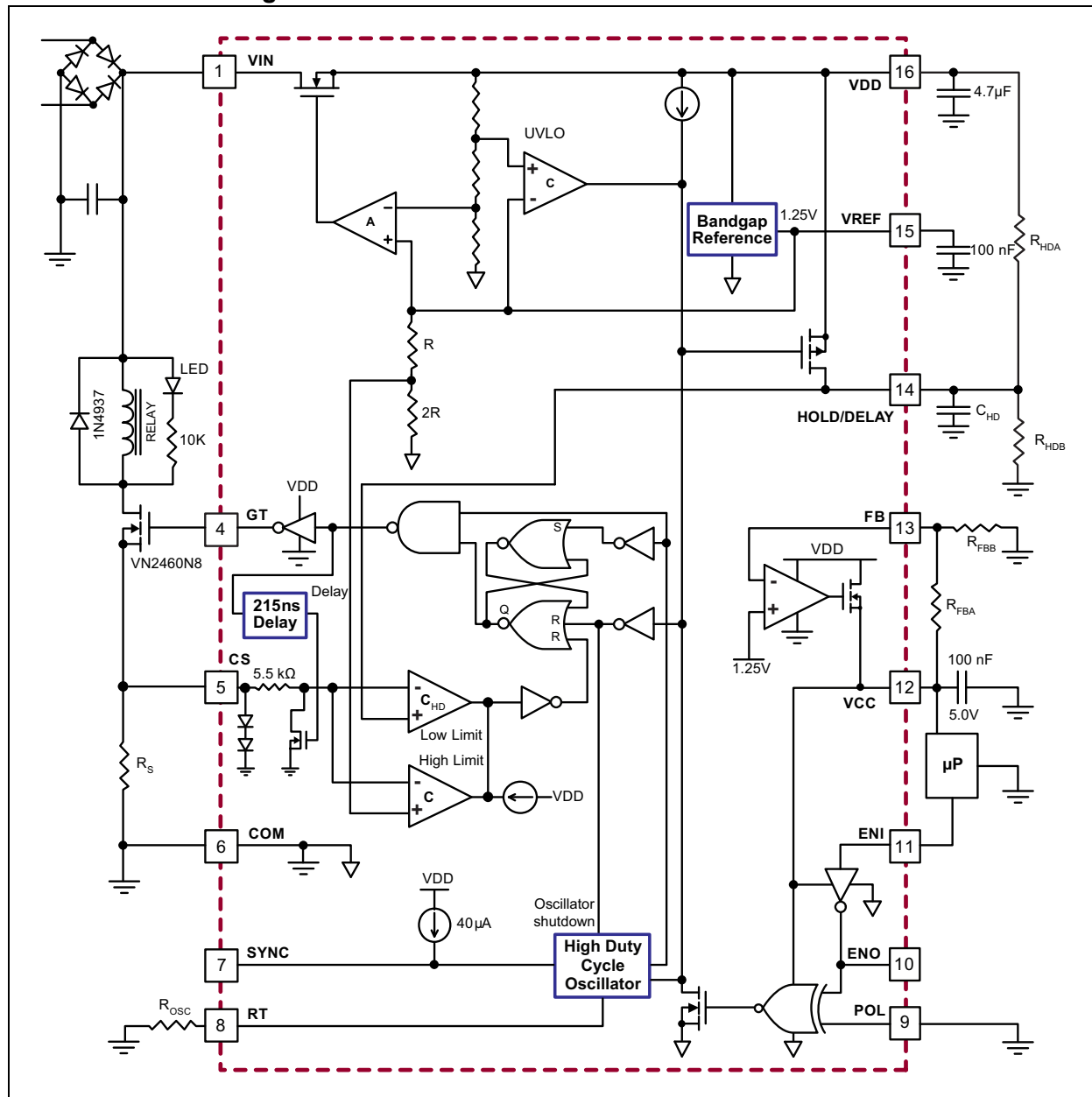


See [Table 2-1](#) for pin information.

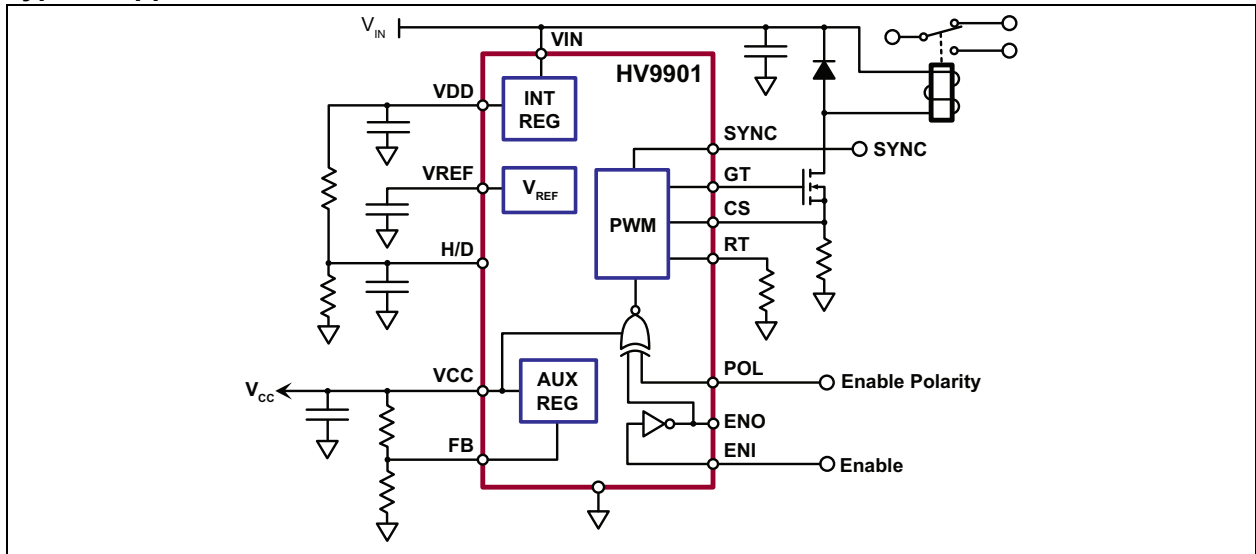
### WARNING

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, $V_{IN}$ <sup>1</sup>                              | –0.5V to 470V            |
| Input Voltage to any other Pin <sup>1</sup>                       | –0.3V to $V_{DD} + 0.3V$ |
| Operating Junction Temperature Range                              | –40°C to +85°C           |
| Continuous Power Dissipation ( $T_A = +25^\circ C$ ) <sup>2</sup> | 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:**  $T_A = 25^\circ C$  unless otherwise noted.

| Parameter                      | Symbol           | Min. | Typ.      | Max.        | Unit | Conditions                                                                                                 |
|--------------------------------|------------------|------|-----------|-------------|------|------------------------------------------------------------------------------------------------------------|
| <b>HIGH-VOLTAGE REGULATOR</b>  |                  |      |           |             |      |                                                                                                            |
| Input Voltage                  | $V_{IN}$         | 10   | —         | 450         | V    | $I_{CC} = 0$ mA to 1 mA load                                                                               |
| Supply Current                 | $I_{IN}$         | —    | —         | 2           | mA   | No load at $V_{DD}$ ( <b>Note 1</b> )<br>load at $I_{CC} = 1$ mA,<br>$C_{GT} = 500$ pF, $f_{OSC} = 25$ kHz |
| Internal Supply Voltage        | $V_{DD}$         | 8.5  | 9         | 9.5         | V    | No load at $V_{DD}$ ( <b>Note 1</b> )<br>$C_{GT} = 500$ 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    |                                                                                                            |
| <b>ADJUSTABLE REGULATOR</b>    |                  |      |           |             |      |                                                                                                            |
| 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 $V_{DD}$ ( <b>Note 1</b> )                                                                      |
| Feedback Voltage               | $V_{FB}$         | 0    | $V_{REF}$ | $V_{DD}-1V$ | V    |                                                                                                            |
| Input Bias Current             | $I_{FB}$         | —    | 25        | 100         | nA   | $V_{FB} = V_{REF}$                                                                                         |
| <b>REFERENCE</b>               |                  |      |           |             |      |                                                                                                            |
| Bandgap Reference Voltage      | $V_{REF}$        | 1.2  | 1.25      | 1.3         | V    | $T_A = -40^\circ C$ to $+85^\circ C$                                                                       |
| 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: $T_A = 25^\circ\text{C}$ unless otherwise noted. |                        |                       |       |                     |                       |                                                                                  |
|-----------------------------------------------------------------------------|------------------------|-----------------------|-------|---------------------|-----------------------|----------------------------------------------------------------------------------|
| Parameter                                                                   | Symbol                 | Min.                  | Typ.  | Max.                | Unit                  | Conditions                                                                       |
| <b>OSCILLATOR</b>                                                           |                        |                       |       |                     |                       |                                                                                  |
| PWM Oscillator Frequency                                                    | $f_{\text{OSC}}$       | 20                    | 25    | 35                  | kHz                   | $R_T = 1\text{ M}\Omega$                                                         |
|                                                                             |                        | 80                    | 100   | 140                 | kHz                   | $R_T = 226\text{ k}\Omega$                                                       |
| Temperature Coefficient                                                     | —                      | —                     | 170   | —                   | ppm/ $^\circ\text{C}$ | $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$                                 |
| Oscillator SYNC Frequency                                                   | $f_{\text{SYNC}}$      | —                     | —     | 150                 | kHz                   |                                                                                  |
| SYNC Sourcing Current                                                       | $I_{\text{SYNC}}$      | 20                    | —     | 55                  | $\mu\text{A}$         |                                                                                  |
| SYNC Sinking Current                                                        | $I_{\text{SYNC}}$      | 1                     | —     | —                   | mA                    | $V_{\text{SYNC}} = 0.1\text{V}$                                                  |
| SYNC Input Logic Low Voltage                                                | $V_{\text{SYNC}}$      | —                     | —     | 1                   | V                     |                                                                                  |
| <b>PWM</b>                                                                  |                        |                       |       |                     |                       |                                                                                  |
| Maximum Duty Cycle                                                          | $D_{\text{MAX}}$       | 96.5                  | —     | 99.5                | %                     | $R_T = 1\text{ M}\Omega$                                                         |
|                                                                             |                        | 86.5                  | —     | 97.5                | %                     | $R_T = 226\text{ k}\Omega$                                                       |
| Blanking Time                                                               | $t_{\text{BLNK}}$      | 150                   | 215   | 280                 | ns                    |                                                                                  |
| <b>MOSFET DRIVER</b>                                                        |                        |                       |       |                     |                       |                                                                                  |
| Gate Drive Output High                                                      | $V_{\text{GTH}}$       | $V_{\text{DD}} - 0.3$ | —     | —                   | V                     | $I_{\text{OUT}} = 10\text{ mA}$                                                  |
| Gate Drive Output Low                                                       | $V_{\text{GTL}}$       | —                     | —     | 0.3                 | V                     | $I_{\text{OUT}} = -10\text{ mA}$                                                 |
| Rise Time                                                                   | $t_R$                  | —                     | 30    | 50                  | ns                    | $C_{\text{GT}} = 500\text{ pF}$                                                  |
| Fall Time                                                                   | $t_F$                  | —                     | 30    | 50                  | ns                    |                                                                                  |
| <b>CURRENT SENSE</b>                                                        |                        |                       |       |                     |                       |                                                                                  |
| Current Sense Voltage, High Limit                                           | $V_{\text{CS(HL)}}$    | 0.775                 | 0.833 | 0.891               | V                     |                                                                                  |
| Current Limit Delay to GT, High Limit                                       | $t_{\text{DELAY(HL)}}$ | —                     | 200   | 250                 | ns                    | 50 mV overdrive                                                                  |
| Input Bias Current                                                          | $I_{\text{CS}}$        | —                     | 25    | 1000                | nA                    | POL = Low, ENI = Low                                                             |
| Low Limit Comparator Input Offset Voltage                                   | $V_{\text{OS}}$        | —                     | —     | $\pm 60$            | mV                    |                                                                                  |
| Current Limit Delay to GT, Low Limit                                        | $t_{\text{DELAY(LL)}}$ | —                     | 200   | 250                 | ns                    | 50 mV overdrive                                                                  |
| Hold/Delay Output Voltage                                                   | $V_{\text{HOLD/DEL}}$  | $V_{\text{DD}} - 0.4$ | —     | —                   | V                     | $I_{\text{HOLD/DEL(sourcing)}} - 100\text{ }\mu\text{A}$<br>POL = Low, ENI = Low |
| Hold/Delay Input Bias Current                                               | $I_{\text{HOLD/DEL}}$  | —                     | 25    | 500                 | nA                    | POL = Low, ENI = Low                                                             |
| Shutdown Delay                                                              | $t_{\text{ENI}}$       | —                     | 50    | 100                 | ns                    | $2\text{V} < V_{\text{CC}} < 5.5\text{V}$                                        |
| Enable Input Voltage - High                                                 | $V_{\text{ENI}}$       | $0.7 V_{\text{CC}}$   | —     | $V_{\text{CC}}$     | V                     |                                                                                  |
| Enable Input Voltage - Low                                                  |                        | 0                     | —     | $0.3 V_{\text{CC}}$ | V                     |                                                                                  |
| Enable Input Current - High                                                 | $I_{\text{ENI}}$       | —                     | 1     | 5                   | $\mu\text{A}$         |                                                                                  |
| Enable Input Current - Low                                                  |                        | -5                    | -1    | —                   | $\mu\text{A}$         |                                                                                  |
| Polarity Voltage - High                                                     | $V_{\text{POL}}$       | $0.7 V_{\text{CC}}$   | —     | $V_{\text{CC}}$     | V                     |                                                                                  |
| Polarity Voltage - Low                                                      |                        | 0                     | —     | $0.3 V_{\text{CC}}$ | V                     |                                                                                  |
| Polarity Current - High                                                     | $I_{\text{POL}}$       | —                     | 1     | 5                   | $\mu\text{A}$         |                                                                                  |
| Polarity Current - Low                                                      |                        | -5                    | -1    | —                   | $\mu\text{A}$         |                                                                                  |
| Enable Output Voltage - High                                                | $V_{\text{ENO}}$       | $0.9 V_{\text{CC}}$   | —     | $V_{\text{CC}}$     | V                     |                                                                                  |
| Enable Output Voltage - Low                                                 |                        | 0                     | —     | $0.1 V_{\text{CC}}$ | V                     |                                                                                  |

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

## TEMPERATURE SPECIFICATIONS

| Parameter                         | Symbol        | Min. | Typ. | Max. | Unit | Conditions |
|-----------------------------------|---------------|------|------|------|------|------------|
| <b>TEMPERATURE RANGE</b>          |               |      |      |      |      |            |
| Operating Junction Temperature    | $T_J$         | -40  | —    | 85   | °C   |            |
| <b>PACKAGE THERMAL RESISTANCE</b> |               |      |      |      |      |            |
| 16-lead SOIC                      | $\theta_{JA}$ | —    | 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 DESCRIPTION

The pin details of HV9901 are listed on [Table 2-1](#). See [Package Type](#) for the location of the pins.

**TABLE 2-1: PIN TABLE**

| Pin Number | Pin Name | Description                                                                                                                       |
|------------|----------|-----------------------------------------------------------------------------------------------------------------------------------|
| 1          | VIN      | 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 <a href="#">Truth Table</a> .                                            |
| 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         | VCC      | Output of the auxiliary regulator. 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 equations on page 4. |
| 15         | VREF     | Reference voltage. Bypass locally with a 10 nF capacitor.                                                                         |
| 16         | VDD      | 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:

$$I_{CS(HI)} = 833mV_{NOM}$$

### EQUATION 3-2:

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

### EQUATION 3-3:

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

### 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:

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

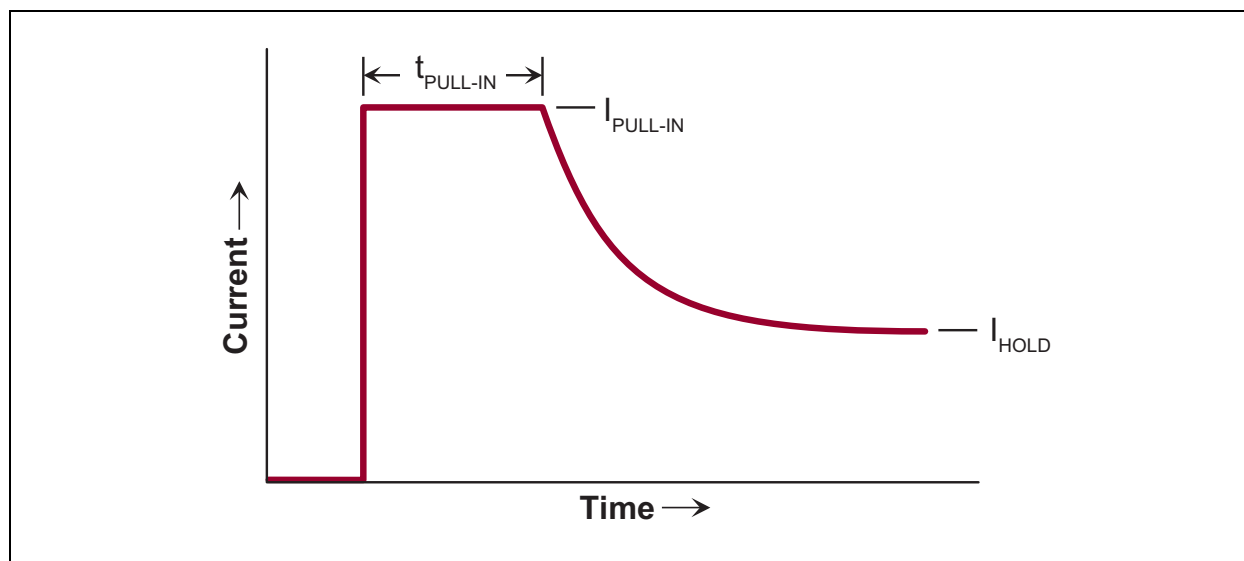
valid for  $f_{PWM} > 23kHz$

### EQUATION 3-7:

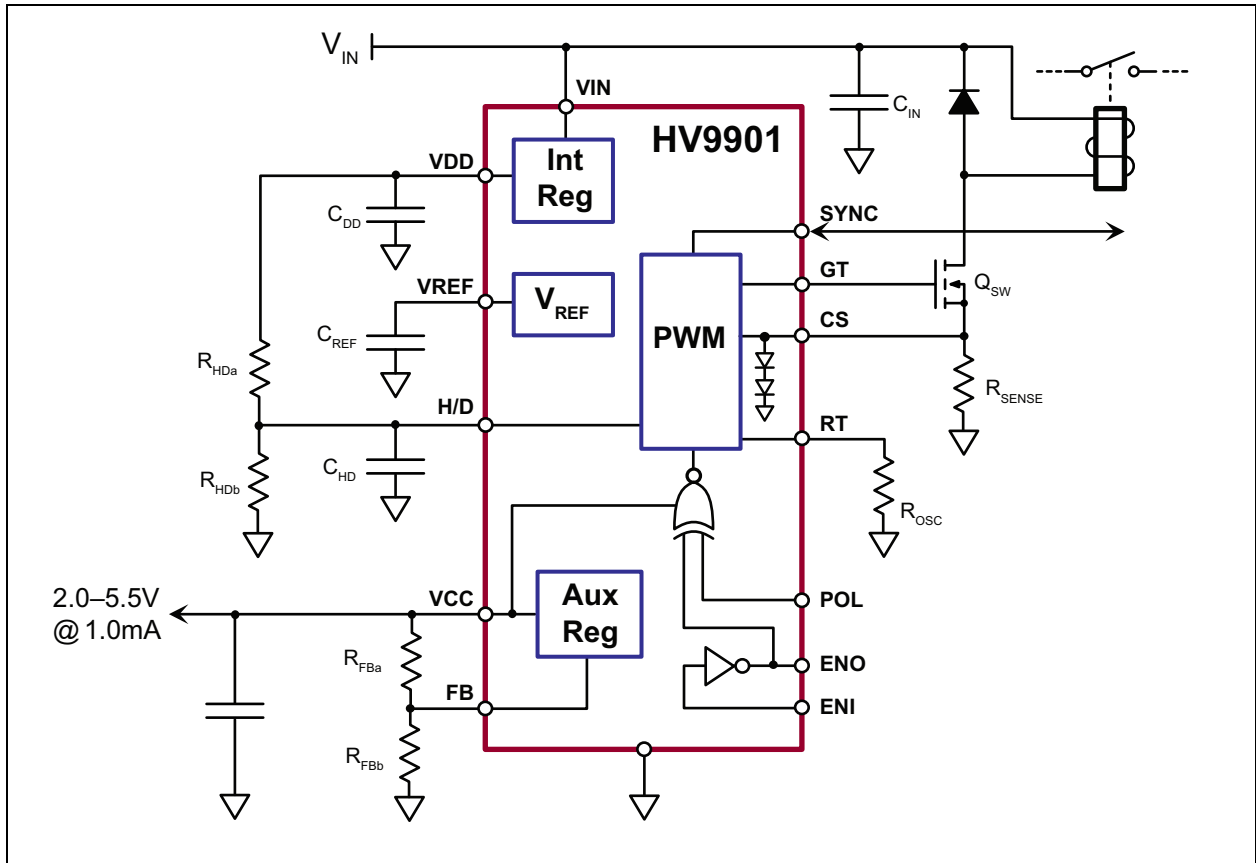
$$V_{CC} = 1.25V \cdot \left(1 + \frac{R_{FBA}}{R_{FBB}}\right)$$

### EQUATION 3-8:

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



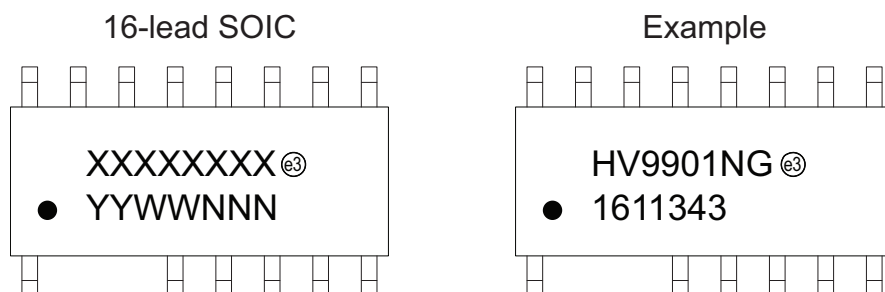
**FIGURE 3-1:** Current vs. Time.



**FIGURE 3-2:** Typical Application Circuit.

## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information



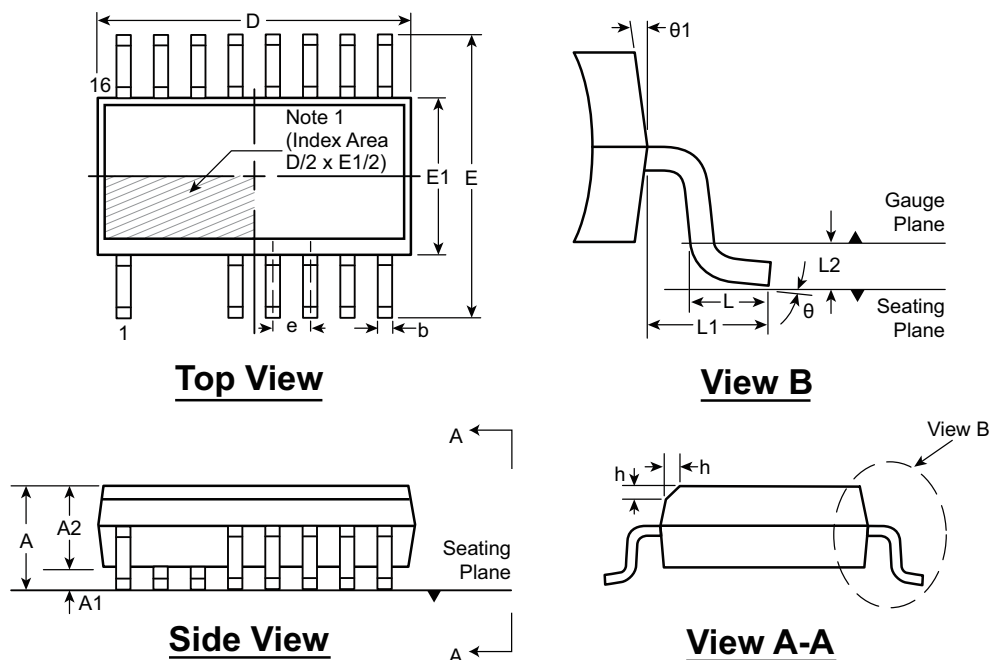
|                |        |                                                                                                                  |
|----------------|--------|------------------------------------------------------------------------------------------------------------------|
| <b>Legend:</b> | 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 <sup>®</sup> 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](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          | θ  | θ1  |
|-------------------|-----|-------|------|-------|------|--------|-------|-------|-------------|------|------|-------------|-------------|----|-----|
| Dimension<br>(mm) | MIN | 1.35* | 0.10 | 1.25  | 0.31 | 9.80*  | 5.80* | 3.80* | 1.27<br>BSC | 0.25 | 0.40 | 1.04<br>REF | 0.25<br>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 A (August 2016)

- Updated file to Microchip format.
- Converted Supertex Doc # DSFP-HV9901 to Microchip DS20005550A.
- 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. |                  |   |                                                         |   |            |
| <b>Examples:</b>                                                                                                                                                               |                  |   |                                                         |   |            |
| 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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