

# Double Hex Driver

## NCV7708F

The NCV7708F is a fully protected Hex Half Bridge Driver designed specifically for automotive and industrial motion control applications. The six low and high side drivers are freely configurable and can be controlled separately. This allows for high side, low side, and H-Bridge control. H-Bridge control provides forward, reverse, brake, and high impedance states. The drivers are controlled via a standard SPI interface.

### Features

- Ultra Low Quiescent Current Sleep Mode
- Six Independent High-Side and Six independent Low-Side Drivers
- Integrated Freewheeling Protection (LS and HS)
- Internal Upper and Lower Clamp Diodes
- Configurable as H-Bridge Drivers
- $R_{DS(on)} = 0.6 \Omega$  (typ)
- 5 MHz SPI Control
- SPI Valid Frame Detection
- Compliance with 5 V and 3.3 V Systems
- Overvoltage Lockout
- Undervoltage Lockout
- Fault Reporting
- Current Limit
- Overtemperature Protection
- Internally Fused Lead in SOIC-28
- SSOP-24 NB EPAD
- These are Pb-Free Devices

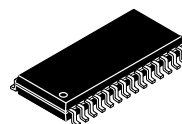
### Typical Applications

- Automotive
- Industrial
- DC Motor Management



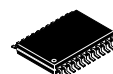
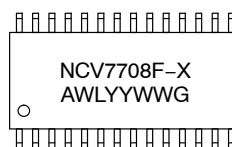
**ON Semiconductor®**

[www.onsemi.com](http://www.onsemi.com)



**SOIC-28  
DW SUFFIX  
CASE 751F**

### MARKING DIAGRAMS



**SSOP-24 NB EP  
DQ SUFFIX  
CASE 940AK**



X = Optional Wafer Fab Indicator  
A = Assembly Location  
WL = Wafer Lot  
YY = Year  
WW = Work Week  
G = Pb-Free Package

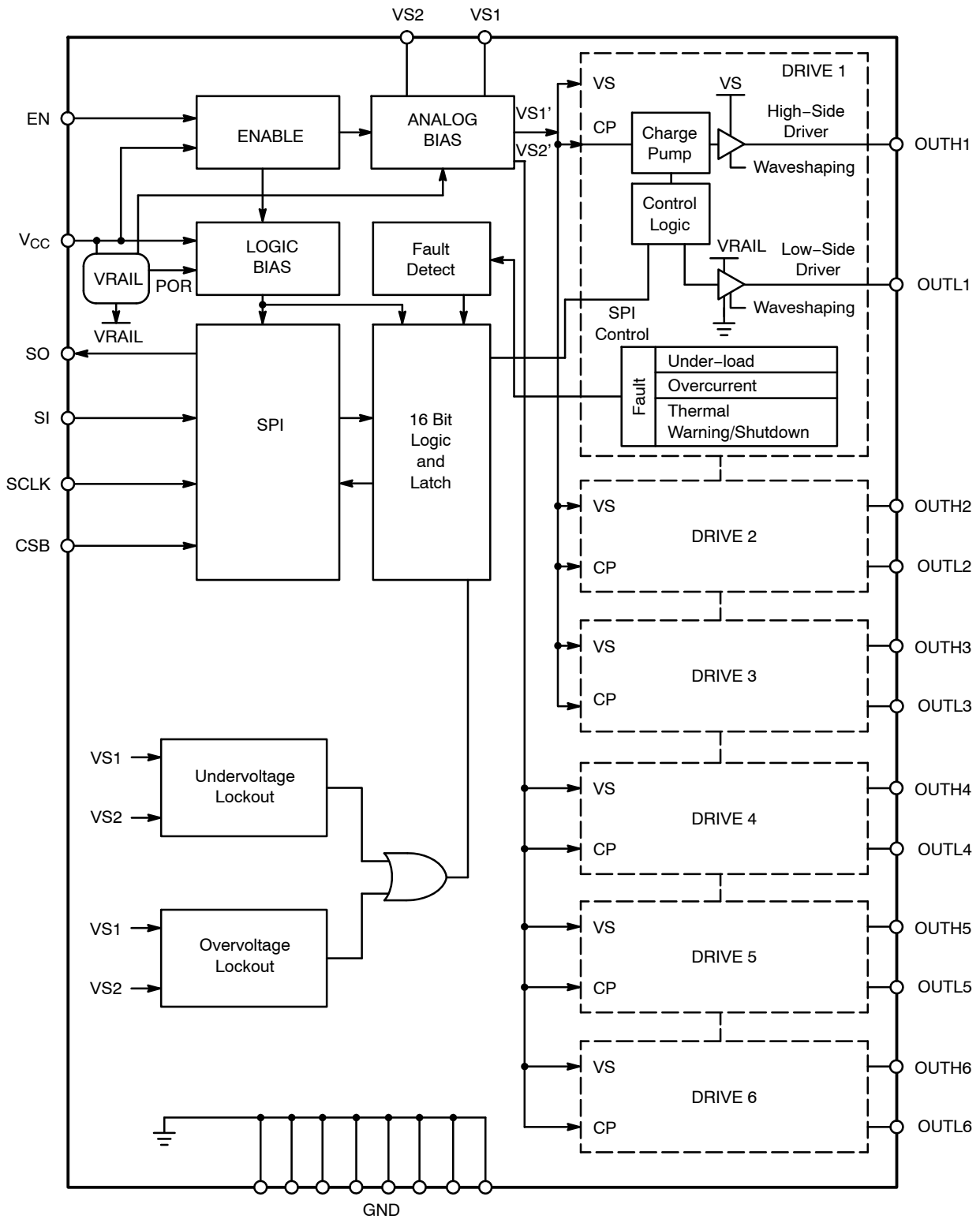
### ORDERING INFORMATION

| Device         | Package               | Shipping†             |
|----------------|-----------------------|-----------------------|
| NCV7708FDWR2G* | SOIC-28W<br>(Pb-Free) | 1000 /<br>Tape & Reel |
| NCV7708FDQR2G  | SSOP-24N<br>(Pb-Free) | 1000 /<br>Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*Contact your local sales representative for the NCV7708F device availability in SOIC-28 package.

**NCV7708F**



### Figure 1. Block Diagram

# NCV7708F

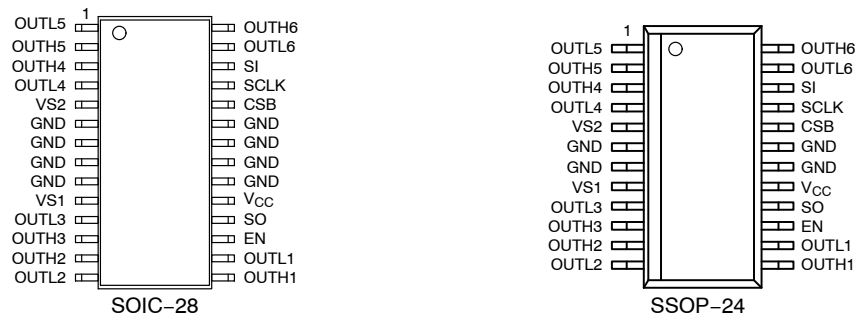


Figure 2. Pin Connection

## PIN DESCRIPTION

| Pin No. |         | Symbol          | Description                                                                                         |
|---------|---------|-----------------|-----------------------------------------------------------------------------------------------------|
| SSOP-24 | SOIC-28 |                 |                                                                                                     |
| 1       | 1       | OUTL5           | Output Low Side 5. Open drain output driver with internal reverse diode.                            |
| 2       | 2       | OUTH5           | Output High Side 5. Open source output driver with internal reverse diode. Drain connected to VS2'. |
| 3       | 3       | OUTH4           | Output High Side 4. Open source output driver with internal reverse diode. Drain connected to VS2'. |
| 4       | 4       | OUTL4           | Output Low Side 4. Open drain output driver with internal reverse diode.                            |
| 5       | 5       | VS2             | Power Supply input for the High-Side Output Drivers 4, 5, and 6.                                    |
| 6       | 6       | GND             | Ground                                                                                              |
| 7       | 7       | GND             | Ground                                                                                              |
| –       | 8       | GND             | Ground                                                                                              |
| –       | 9       | GND             | Ground                                                                                              |
| 8       | 10      | VS1             | Power Supply input for the High-Side Output Drivers 1, 2, and 3                                     |
| 9       | 11      | OUTL3           | Output Low Side 3. Open drain output driver with internal reverse diode.                            |
| 10      | 12      | OUTH3           | Output High Side 3. Open source output driver with internal reverse diode. Drain connected to VS1'. |
| 11      | 13      | OUTH2           | Output High Side 2. Open source output driver with internal reverse diode. Drain connected to VS1'. |
| 12      | 14      | OUTL2           | Output Low Side 2. Open drain output driver with internal reverse diode.                            |
| 13      | 15      | OUTH1           | Output High Side 1. Open source output driver with internal reverse diode. Drain connected to VS1'. |
| 14      | 16      | OUTL1           | Output Low Side 1. Open drain output driver with internal reverse diode.                            |
| 15      | 17      | EN              | Enable. Input high wakes the IC up from sleep mode.                                                 |
| 16      | 18      | SO              | Serial Output. 16 bit serial communications output.                                                 |
| 17      | 19      | V <sub>CC</sub> | Power supply input for Logic.                                                                       |
| 18      | 20      | GND             | Ground                                                                                              |
| 19      | 21      | GND             | Ground                                                                                              |
| –       | 22      | GND             | Ground                                                                                              |
| –       | 23      | GND             | Ground                                                                                              |
| 20      | 24      | CSB             | Chip Select Bar. Active low serial port operation.                                                  |
| 21      | 25      | SCLK            | Serial Clock. Clock input for use with SPI communication.                                           |
| 22      | 26      | SI              | Serial Input. 16 bit serial communications input.                                                   |
| 23      | 27      | OUTL6           | Output Low Side 6. Open drain output driver with internal reverse diode.                            |
| 24      | 28      | OUTH6           | Output High Side 6. Open source output driver with internal reverse diode. Drain connected to VS2'. |
| EPAD    | –       | EPAD            | Connect to Ground for best thermal performance or leave unconnected.                                |

# MAXIMUM RATINGS

| Rating                                                                                                                                                                                                                                                                                                                                                                         | Value                                                                                    | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|
| Power Supply Voltage (VS1, VS2)<br>(DC)<br>(AC), $t < 500$ ms, $I_{VSX} > -2$ A                                                                                                                                                                                                                                                                                                | -0.3 to 40<br>-1.0                                                                       | V    |
| Output Pin OUTHx<br>(DC)<br>(AC – inductive clamping)                                                                                                                                                                                                                                                                                                                          | -0.3 to 40<br>-8.0                                                                       | V    |
| Output Pin OUTLx<br>(DC)<br>(AC), $t < 500$ ms, $I_{OUTLX} > -2$ A<br>(AC Inductive Clamping)                                                                                                                                                                                                                                                                                  | -0.3 to 36<br>-1.0<br>45                                                                 | V    |
| Pin Voltage (Logic Input pins, SI, SCLK, CSB, SO, EN, V <sub>CC</sub> )                                                                                                                                                                                                                                                                                                        | -0.3 to 5.5                                                                              | V    |
| Output Current (OUTL1, OUTL2, OUTL3, OUTL4, OUTL5, OUTL6, OUTH1, OUTH2, OUTH3, OUTH4, OUTH5, OUTH6)<br>(DC) V <sub>ds</sub> = 12 V<br>(DC) V <sub>ds</sub> = 20 V<br>(DC) V <sub>ds</sub> = 40 V<br>(AC) V <sub>ds</sub> = 12 V, (50 ms pulse, 1 s period)<br>(AC) V <sub>ds</sub> = 20 V, (50 ms pulse, 1 s period)<br>(AC) V <sub>ds</sub> = 40 V, (50 ms pulse, 1 s period) | -1.5 to 1.5<br>-0.7 to 0.7<br>-0.25 to 0.25<br>-2.0 to 2.0<br>-0.9 to 0.9<br>-0.3 to 0.3 | A    |
| Electrostatic Discharge, Human Body Model, VS1, VS2, OUTx (Note 1)                                                                                                                                                                                                                                                                                                             | 4.0                                                                                      | kV   |
| Electrostatic Discharge, Human Body Model, all other pins                                                                                                                                                                                                                                                                                                                      | 2.0                                                                                      | kV   |
| Electrostatic Discharge, Machine Model                                                                                                                                                                                                                                                                                                                                         | 200                                                                                      | V    |
| Electrostatic Discharge, Charged Device Model                                                                                                                                                                                                                                                                                                                                  | 1.0                                                                                      | kV   |
| Short Circuit Reliability Characterization (AEC-Q10x)                                                                                                                                                                                                                                                                                                                          | GRADE A                                                                                  | –    |
| Operating Junction Temperature                                                                                                                                                                                                                                                                                                                                                 | -40 to 150                                                                               | °C   |
| Storage Temperature Range                                                                                                                                                                                                                                                                                                                                                      | -55 to 150                                                                               | °C   |
| Moisture Sensitivity Level<br>SOIC-28<br>SSOP-24 EPAD                                                                                                                                                                                                                                                                                                                          | MSL 3<br>MSL 2                                                                           | –    |
| Peak Reflow Soldering Temperature: Pb-Free, 60 to 150 seconds at 217°C (Note 2)                                                                                                                                                                                                                                                                                                | 260                                                                                      | °C   |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

- Tested with a VS1/VS2 power supply common point.
- For additional information, please see or download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM/D.

# THERMAL CONDITIONS

| Thermal Parameters                                  | Test Conditions, Typical Value |                        | Unit |
|-----------------------------------------------------|--------------------------------|------------------------|------|
|                                                     | Board Details (Note 3)         | Board Details (Note 4) |      |
| SOIC-28                                             |                                |                        |      |
| Junction-to-Lead (psi-JL8, ΨJL8) or Pins 6-9, 20-23 | 10                             | 11                     | °C/W |
| Junction-to-Ambient (RθJA, θJA)                     | 78                             | 63                     | °C/W |
| SSOP-24 EPAD                                        |                                |                        |      |
| Junction-to-Board (RΨB)                             | –                              | 2                      | °C/W |
| Junction-to-Ambient (RθJA)                          | –                              | 54                     | °C/W |
| Junction-to-Lead (RΨJL)                             | –                              | 7                      | °C/W |

- 1-oz copper, 240 mm<sup>2</sup> copper area, 0.062" thick FR4. This is the minimum pad board size.
- 1-oz copper, 986 mm<sup>2</sup> copper area, 0.062" thick FR4.

## RECOMMENDED OPERATING CONDITIONS

| Rating                                        | Symbol      | Value |      | Unit |
|-----------------------------------------------|-------------|-------|------|------|
|                                               |             | Min   | Max  |      |
| Digital Supply Input Voltage ( $V_{CC}$ )     | $V_{CCmax}$ | 3.15  | 5.25 | V    |
| Battery Supply Input Voltage ( $V_S$ )        | $V_{Smax}$  | 5.5   | 28   | V    |
| DC Output Current ( $I(OUTLx)$ , $I(OUTHx)$ ) | $DC_{max}$  | –     | 0.5  | A    |
| Junction Temperature                          | $T_J$       | –40   | 150  | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(–40°C <  $T_J$  < 150°C, 5.5 V <  $V_{Sx}$  < 40 V, 3.15 V <  $V_{CC}$  < 5.25 V, EN =  $V_{CC}$ , unless otherwise specified)

| Characteristic | Symbol | Test Conditions | Min | Typ | Max | Unit |
|----------------|--------|-----------------|-----|-----|-----|------|
|----------------|--------|-----------------|-----|-----|-----|------|

## GENERAL

|                                                             |                  |                                                                                                 |      |      |      |    |
|-------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------|------|------|------|----|
| Supply Current ( $V_{S1} + V_{S2}$ )<br>Sleep Mode (Note 5) | $I_{vs\_sleep}$  | $V_{S1} = V_{S2} = 13.2$ V,<br>$V_{CC} = CSB = 5$ V,<br>EN = SI = SCLK = 0 V<br>(–40°C to 85°C) | –    | 1.0  | 2.5  | μA |
| Supply Current ( $V_{S1}$ )<br>Active Mode                  | $I_{vs1\_act}$   | EN = $V_{CC}$ ,<br>5.5 V < $V_{Sx}$ < 35 V<br>No Load                                           | –    | 1.25 | 2.5  | mA |
| Supply Current ( $V_{CC}$ ) – Sleep Mode (Note 5)           | $I_{vcc\_sleep}$ | $CSB = V_{CC}$ ,<br>EN = SI = SCLK = 0 V<br>(–40°C to 85°C)                                     | –    | 1.0  | 2.5  | μA |
| Supply Current ( $V_{CC}$ ) – Active Mode                   | $I_{vcc\_act}$   | EN = $CSB = V_{CC}$ ,<br>SI = SCLK = 0 V                                                        | –    | 1.5  | 3.0  | mA |
| Supply Current ( $V_{S2}$ )<br>Active Mode                  | $I_{vs2\_act}$   | EN = $V_{CC}$ ,<br>5.5 V < $V_{Sx}$ < 35 V<br>No Load                                           | –    | 1.25 | 2.5  | mA |
| $V_{CC}$ Power-On-Reset Threshold                           | $V_{CCpor}$      |                                                                                                 | –    | 2.55 | 2.9  | V  |
| $V_{Sx}$ Undervoltage Detection Threshold                   | $V_{Suv}$        | $V_{Sx}$ decreasing                                                                             | 3.7  | 4.1  | 4.5  | V  |
| $V_{Sx}$ Undervoltage Detection Hysteresis                  | $V_{Suv\_hys}$   |                                                                                                 | 100  | 365  | 450  | mV |
| $V_{Sx}$ Overvoltage Detection Threshold                    | $V_{Sov}$        | $V_{Sx}$ increasing                                                                             | 33   | 36.5 | 40.0 | V  |
| $V_{Sx}$ Overvoltage Detection Hysteresis                   | $V_{Sov\_hys}$   |                                                                                                 | 1    | 2.5  | 4.0  | V  |
| Thermal Warning (Note 6)                                    | $T_{tw}$         |                                                                                                 | 120  | 140  | 170  | °C |
| Thermal Warning Hysteresis (Note 6)                         | $T_{tw\_hys}$    |                                                                                                 | –    | 20   | –    | °C |
| Thermal Shutdown (Note 6)                                   | $T_{tsd}$        |                                                                                                 | 155  | 175  | 195  | °C |
| Ratio of Thermal Shutdown to Thermal Warning (Note 6)       | $T_{tsd}/T_{tw}$ |                                                                                                 | 1.05 | 1.20 | –    | –  |

## OUTPUTS

|                                            |                                    |                                                                                                              |              |          |            |    |
|--------------------------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------|----------|------------|----|
| Output High $R_{DS(on)}$ (source and sink) | $R_{DSon\_src}$<br>$R_{DSon\_snk}$ | $I_{out} = -500$ mA<br>25°C<br>–40°C < $T_J$ < 150°C                                                         | –<br>–       | 0.6<br>– | 1.3<br>1.7 | Ω  |
| Source Leakage Current                     | $I_{src}$                          | OUTH(1–6) = 0 V,<br>$V_{sx} = 40$ V, $V_{CC} = 5$ V<br>OUTH(1–6) = 0 V,<br>$V_{sx} = 13.2$ V, $V_{CC} = 5$ V | –5.0<br>–1.0 | –<br>–   | –<br>–     | μA |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

5. For temperatures above 85°C, refer to graphs for  $V_{Sx}$  and  $V_{CC}$  Sleep Current vs. Temperature on page 17.

6. Thermal characteristics are not subject to production test.

7. Refer to “Typical High-Side Negative Clamp Voltage” graph on page 17.

8. Current limit is active with and without overcurrent detection.

9. Not production tested.

# NCV7708F

## ELECTRICAL CHARACTERISTICS

( $-40^{\circ}\text{C} < T_J < 150^{\circ}\text{C}$ ,  $5.5\text{ V} < V_{Sx} < 40\text{ V}$ ,  $3.15\text{ V} < V_{CC} < 5.25\text{ V}$ ,  $EN = V_{CC}$ , unless otherwise specified)

| Characteristic | Symbol | Test Conditions | Min | Typ | Max | Unit |
|----------------|--------|-----------------|-----|-----|-----|------|
|----------------|--------|-----------------|-----|-----|-----|------|

### OUTPUTS

|                                             |               |                                                                                                                     |    |     |      |               |
|---------------------------------------------|---------------|---------------------------------------------------------------------------------------------------------------------|----|-----|------|---------------|
| Sink Leakage Current                        | $I_{snk}$     | OUTL(1-6) = 34 V,<br>$V_{CC} = 5\text{ V}$<br>OUTL(1-6) = 34 V,<br>$V_{CC} = 5\text{ V}$ , $T = 25^{\circ}\text{C}$ | –  | –   | 5.0  | $\mu\text{A}$ |
| Power Transistor Body Diode Forward Voltage | $V_{bd\_fwd}$ | $I_F = 500\text{ mA}$                                                                                               | –  | 0.9 | 1.3  | V             |
| High-Side Clamping Voltage (Note 7)         | $V_{clp\_hs}$ | $I_{(OUTHx)} = -50\text{ mA}$                                                                                       | –  | –   | -0.7 | V             |
| Low-Side Clamping Voltage                   | $V_{clp\_ls}$ | $I_{(OUTLx)} = 50\text{ mA}$                                                                                        | 36 | –   | 45   | V             |

### UNDER LOAD

|                                        |               |                                                  |     |      |      |               |
|----------------------------------------|---------------|--------------------------------------------------|-----|------|------|---------------|
| Under Load Detection Threshold (OUTLx) | $I_{ul\_ls}$  | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ | 2.0 | 8.0  | 16   | mA            |
| Under Load Detection Threshold (OUTHx) | $I_{ul\_hs}$  | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ | -16 | -8.0 | -2.0 | mA            |
| Under Load Detection Delay Time        | $t_{ul\_del}$ | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ | 200 | 350  | 600  | $\mu\text{s}$ |

### OVERCURRENT

|                                        |                                |                                                                              |          |           |           |                                |
|----------------------------------------|--------------------------------|------------------------------------------------------------------------------|----------|-----------|-----------|--------------------------------|
| Overcurrent Shutdown Threshold (OUTHx) | $I_{ocsd\_hs}$                 | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ ,<br>Bit13 = 1              | -2.0     | -1.45     | -1.1      | A                              |
| Overcurrent Shutdown Threshold (OUTLx) | $I_{ocsd\_ls}$                 | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ ,<br>Bit13 = 1              | 1.1      | 1.45      | 2.0       | A                              |
| Overcurrent Shutdown Delay Time        | $t_{ocsd\_0}$<br>$t_{ocsd\_1}$ | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ ,<br>Bit13 = 0<br>Bit13 = 1 | 80<br>10 | 200<br>25 | 400<br>50 | $\mu\text{s}$<br>$\mu\text{s}$ |

### CURRENT LIMIT (Note 8)

|                       |               |                                                  |      |      |      |   |
|-----------------------|---------------|--------------------------------------------------|------|------|------|---|
| Current Limit (OUTHx) | $I_{lim\_hs}$ | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ | -5.0 | -3.0 | -2.0 | A |
| Current Limit (OUTLx) | $I_{lim\_ls}$ | $V_{CC} = 5\text{ V}$ , $V_{Sx} = 13.2\text{ V}$ | 2.0  | 3.0  | 5.0  | A |

### LOGIC INPUTS (EN, SI, SCLK, CSB)

|                                     |                  |                           |          |        |          |           |
|-------------------------------------|------------------|---------------------------|----------|--------|----------|-----------|
| Input Threshold – High<br>– Low     | $V_{inlh}$       |                           | 2.0<br>– | –<br>– | –<br>0.8 | V         |
| Input Hysteresis (SI, SCLK, CSB)    | $V_{inhys\_spi}$ |                           | 100      | 300    | 600      | mV        |
| Input Hysteresis (EN)               | $V_{inhys\_en}$  |                           | 100      | 400    | 800      | mV        |
| Pull-down Resistance (EN, SI, SCLK) | $R_{pd}$         | $EN = SI = SCLK = V_{CC}$ | 50       | 125    | 250      | $k\Omega$ |
| Pull-up Resistance (CSB)            | $R_{pu}$         | $CSB = 0\text{ V}$        | 50       | 125    | 250      | $k\Omega$ |
| Input Capacitance (Note 9)          | $C_{IN}$         |                           | –        | 10     | 15       | pF        |

### LOGIC OUTPUT (SO)

|                                      |           |                                                           |                |                |     |               |
|--------------------------------------|-----------|-----------------------------------------------------------|----------------|----------------|-----|---------------|
| Output High                          | $V_{soh}$ | $I_{out} = 1\text{ mA}$                                   | $V_{CC} - 1.0$ | $V_{CC} - 0.7$ | –   | V             |
| Output Low                           | $V_{sol}$ | $I_{out} = -1.6\text{ mA}$                                | –              | 0.2            | 0.4 | V             |
| Tri-state Leakage                    | $I_{so}$  | $CSB = V_{CC}$ ,<br>$0\text{ V} < SO < V_{CC}$            | -10            | –              | 10  | $\mu\text{A}$ |
| Tri-state Input Capacitance (Note 9) | $C_{so}$  | $CSB = V_{CC}$ ,<br>$0\text{ V} < V_{CC} < 5.25\text{ V}$ | –              | 10             | 15  | pF            |

### TIMING SPECIFICATIONS

|                         |             |                                                 |   |     |     |               |
|-------------------------|-------------|-------------------------------------------------|---|-----|-----|---------------|
| High Side Turn On Time  | $t_{hson}$  | $V_S = 13.2\text{ V}$ , $R_{load} = 25\ \Omega$ | – | 7.5 | 13  | $\mu\text{s}$ |
| High Side Turn Off Time | $t_{hsoff}$ | $V_S = 13.2\text{ V}$ , $R_{load} = 25\ \Omega$ | – | 3.0 | 6.0 | $\mu\text{s}$ |
| Low Side Turn On Time   | $t_{lson}$  | $V_S = 13.2\text{ V}$ , $R_{load} = 25\ \Omega$ | – | 6.5 | 13  | $\mu\text{s}$ |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

5. For temperatures above  $85^{\circ}\text{C}$ , refer to graphs for  $V_{Sx}$  and  $V_{CC}$  Sleep Current vs. Temperature on page 17.

6. Thermal characteristics are not subject to production test.

7. Refer to "Typical High-Side Negative Clamp Voltage" graph on page 17.

8. Current limit is active with and without overcurrent detection.

9. Not production tested.

# ELECTRICAL CHARACTERISTICS

(-40°C < T<sub>J</sub> < 150°C, 5.5 V < V<sub>Sx</sub> < 40 V, 3.15 V < V<sub>CC</sub> < 5.25 V, EN = V<sub>CC</sub>, unless otherwise specified)

| Characteristic | Symbol | Test Conditions | Min | Typ | Max | Unit |
|----------------|--------|-----------------|-----|-----|-----|------|
|----------------|--------|-----------------|-----|-----|-----|------|

## TIMING SPECIFICATIONS

|                        |                        |                                                   |     |     |     |    |
|------------------------|------------------------|---------------------------------------------------|-----|-----|-----|----|
| Low Side Turn Off Time | t <sub>lsoff</sub>     | V <sub>s</sub> = 13.2 V, R <sub>load</sub> = 25 Ω | –   | 2.0 | 5.0 | μs |
| High Side Rise Time    | t <sub>hsr</sub>       | V <sub>s</sub> = 13.2 V, R <sub>load</sub> = 25 Ω | –   | 4.0 | 8.0 | μs |
| High Side Fall Time    | t <sub>hsf</sub>       | V <sub>s</sub> = 13.2 V, R <sub>load</sub> = 25 Ω | –   | 2.0 | 3.0 | μs |
| Low Side Rise Time     | t <sub>lsr</sub>       | V <sub>s</sub> = 13.2 V, R <sub>load</sub> = 25 Ω | –   | 1.0 | 2.0 | μs |
| Low Side Fall Time     | t <sub>lsf</sub>       | V <sub>s</sub> = 13.2 V, R <sub>load</sub> = 25 Ω | –   | 1.0 | 3.0 | μs |
| Non-Overlap Time       | t <sub>hsOfflsOn</sub> | High Side Turn Off To Low Side Turn On            | 1.5 | –   | –   | μs |
| Non-Overlap Time       | t <sub>lsOffhsOn</sub> | Low Side Turn Off To High Side Turn On            | 1.5 | –   | –   | μs |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

5. For temperatures above 85°C, refer to graphs for V<sub>Sx</sub> and V<sub>CC</sub> Sleep Current vs. Temperature on page 17.
6. Thermal characteristics are not subject to production test.
7. Refer to "Typical High-Side Negative Clamp Voltage" graph on page 17.
8. Current limit is active with and without overcurrent detection.
9. Not production tested.

# ELECTRICAL CHARACTERISTICS

(-40°C < T<sub>J</sub> < 150°C, 5.5 V < V<sub>Sx</sub> < 40 V, EN = V<sub>CC</sub> = 5 V, unless otherwise specified)

| Characteristic | Conditions | Symbol | Min | Typ | Max | Unit |
|----------------|------------|--------|-----|-----|-----|------|
|----------------|------------|--------|-----|-----|-----|------|

## SERIAL PERIPHERAL INTERFACE (V<sub>CC</sub> = 5 V)

|                                  |                                                  |                                            |            |        |        |     |
|----------------------------------|--------------------------------------------------|--------------------------------------------|------------|--------|--------|-----|
| SCLK Frequency                   |                                                  | f <sub>SCLK</sub>                          | –          | –      | 5.0    | MHz |
| SCLK Clock Period                | V <sub>CC</sub> = 5 V<br>V <sub>CC</sub> = 3.3 V | t <sub>SCLK</sub>                          | 200<br>500 | –<br>– | –<br>– | ns  |
| SCLK High Time                   |                                                  | t <sub>CLKH</sub>                          | 85         | –      | –      | ns  |
| SCLK Low Time                    |                                                  | t <sub>CLKL</sub>                          | 85         | –      | –      | ns  |
| SCLK Setup Time                  |                                                  | t <sub>CLKSU1</sub><br>t <sub>CLKSU2</sub> | 85<br>85   | –<br>– | –<br>– | ns  |
| SI Setup Time                    |                                                  | t <sub>SISU</sub>                          | 50         | –      | –      | ns  |
| SI Hold Time                     |                                                  | t <sub>SIHT</sub>                          | 50         | –      | –      | ns  |
| CSB Setup Time                   |                                                  | t <sub>CSBSU1</sub><br>t <sub>CSBSU2</sub> | 100<br>100 | –<br>– | –<br>– | ns  |
| CSB High Time (Note 10)          |                                                  | t <sub>CSBHT</sub>                         | 5.0        | –      | –      | μs  |
| SO enable after CSB falling edge |                                                  | t <sub>SOCSEF</sub>                        | –          | –      | 200    | ns  |
| SO disable after CSB rising edge |                                                  | t <sub>SOCSEB</sub>                        | –          | –      | 200    | ns  |
| SO Rise Time (10% to 90%)        | C <sub>load</sub> = 40 pF                        | t <sub>SORISE</sub>                        | –          | 10     | 25     | ns  |
| SO Fall Time (90% to 10%)        | C <sub>load</sub> = 40 pF                        | t <sub>SOFALL</sub>                        | –          | 10     | 25     | ns  |
| SO Valid Time (Note 11)          | SCLK High to SO 50%                              | t <sub>SOV</sub>                           | –          | 50     | 100    | ns  |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

10. This is the minimum time the user must wait between SPI commands.
11. Not tested in production

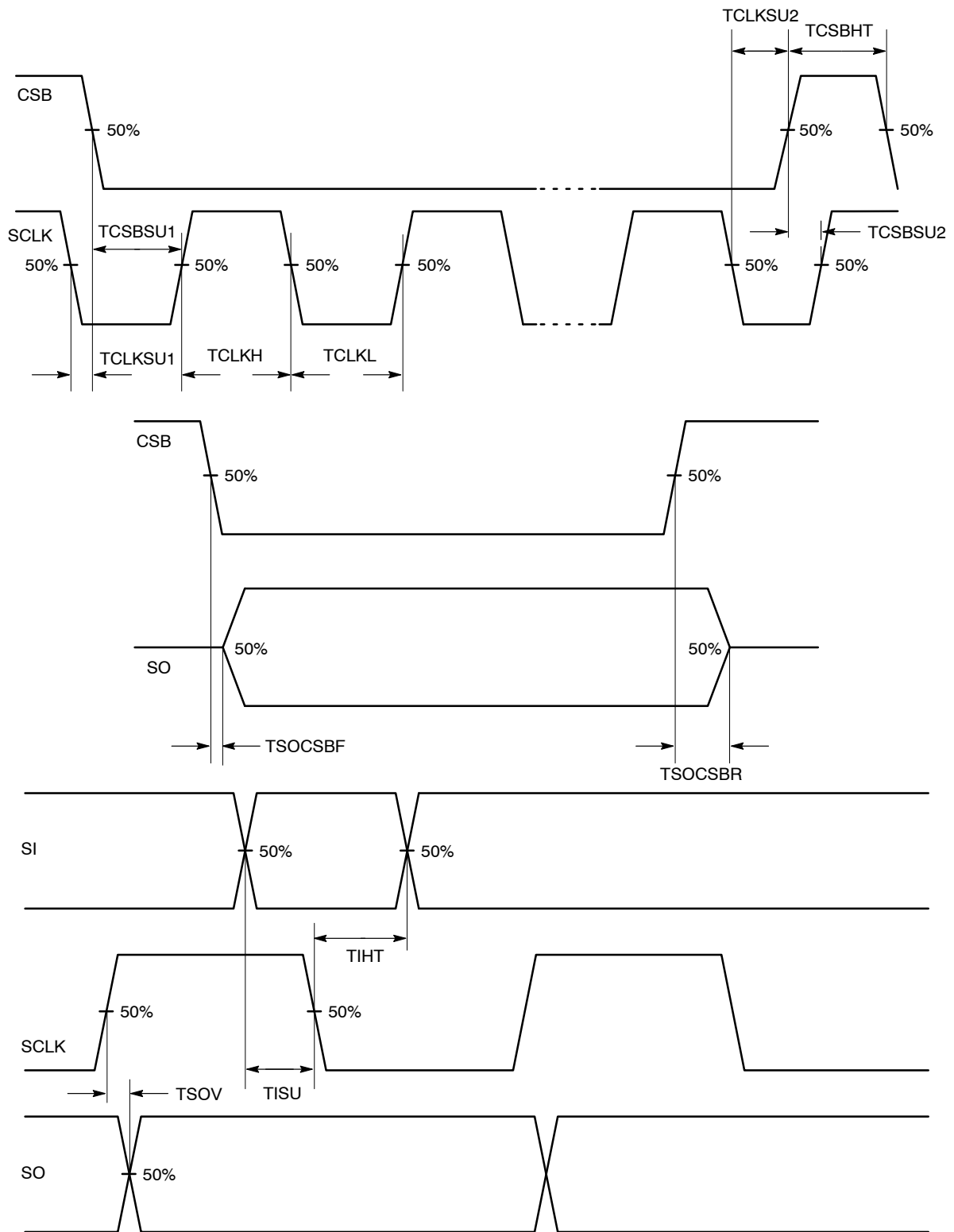


Figure 3. SPI Timing Diagram

### SPI Communication

Standard 16-bit communication has been implemented for the communication of this IC to turn drivers on and off, and to report faults. (Reference the SPI Communication Frame Format Diagram). The LSB (Least Significant Bit) is clocked in first.

For SPI communication, the device must first be enabled (EN = high). The SPI inputs are TTL compatible and the SO output high level is defined by the applied VCC. The active-low CSB input has a pull-up resistor. SPI communication is active when CSB is low. Providing a pull-up resistor insures the communication bus is not active should the communication link between the microcontroller and NCV7708F become open. SCLK and SI have pull-down resistors. This provides known states when the SPI is not active.

Communication is implemented as follows:

1. CSB goes low to allow serial data transfer.
2. A 16 bit word is clocked (SCLK) into the SI (serial input) pin. The SI input signal is latched on the falling edge of SCLK.
3. Current SO data is simultaneously shifted out on every rising edge of SCLK starting with the LSB (TW).
4. CSB goes high to transfer the clocked in information to the data registers.  
(Note: SO is tristate when CSB is high.)
5. The SI data will be accepted when a valid SPI frame is detected. A valid SPI frame consists of the above conditions and a complete set of multiples of 16 bit words. Invalid frames are ignored with previous input data intact.

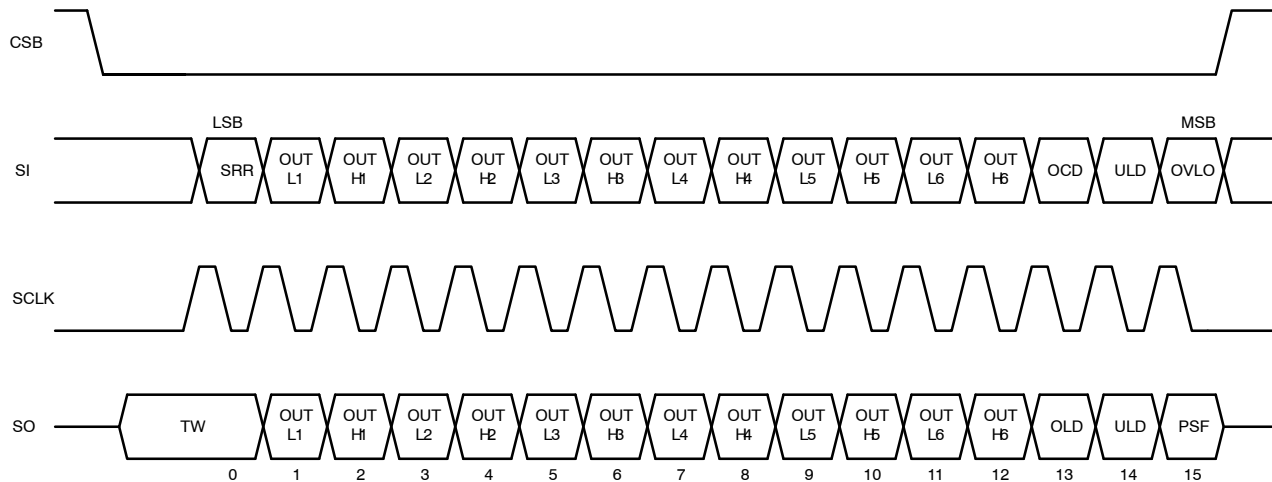


Figure 4. SPI Communication Frame Format

## NCV7708F

The table below defines the programming bits and diagnostic bits. Fault information is sequentially clocked out the SO pin of the NCV7708F as programming information is clocked into the SI pin of the device. Daisy chain

communication between SPI compatible IC's is possible by connection of the serial output pin (SO) to the input of the sequential IC (SI).

| Input Data |                                               |                   |
|------------|-----------------------------------------------|-------------------|
| Bit #      | Bit Description                               | Bit Status        |
| 15         | Overvoltage Lock Out Control (OVLO)           | 0 = Disable       |
|            |                                               | 1 = Enable        |
| 14         | Under Load Detection Shut Down Control (ULD)  | 0 = Disable       |
|            |                                               | 1 = Enable        |
| 13         | Overcurrent Detection Shut Down Control (OCD) | 0 = 200 $\mu$ sec |
|            |                                               | 1 = 25 $\mu$ sec  |
| 12         | OUTH6                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 11         | OUTL6                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 10         | OUTH5                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 9          | OUTL5                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 8          | OUTH4                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 7          | OUTL4                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 6          | OUTH3                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 5          | OUTL3                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 4          | OUTH2                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 3          | OUTL2                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 2          | OUTH1                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 1          | OUTL1                                         | 0 = Off           |
|            |                                               | 1 = On            |
| 0          | Status Register Reset (SRR)                   | 0 = No Reset      |
|            |                                               | 1 = Reset         |

\*Output Bits [1:12] represent the state of the designated outputs.

### Status Register Reset – SRR

Sending SRR = 1 clears status memory and reactivates faulted output. The previous SI data pattern must be sent with SRR to preserve device configuration and output states. SRR takes effect at the rising edge of CSB. If a fault is still

| Output Data |                                               |               |
|-------------|-----------------------------------------------|---------------|
| Bit #       | Bit Description                               | Bit Status    |
| 15          | Power Supply Fail Signal (OVLO or UVLO = PSF) | 0 = No Fault  |
|             |                                               | 1 = Fault     |
| 14          | Under Load Detect Signal (ULD)                | 0 = No Fault  |
|             |                                               | 1 = Fault     |
| 13          | Over Load Detect Signal (OLD)                 | 0 = No Fault  |
|             |                                               | 1 = Fault     |
| 12          | OUTH6*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 11          | OUTL6*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 10          | OUTH5*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 9           | OUTL5*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 8           | OUTH4*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 7           | OUTL4*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 6           | OUTH3*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 5           | OUTL3*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 4           | OUTH2*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 3           | OUTL2*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 2           | OUTH1*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 1           | OUTL1*                                        | 0 = Off       |
|             |                                               | 1 = On        |
| 0           | Thermal Warning (TW)                          | 0 = Not in TW |
|             |                                               | 1 = In TW     |

present when SRR is sent, protection can be re-engaged and shutdown can recur. The device can also be reset by toggling the EN pin or by VCC power-on reset.

When asserted, all latched faults are cleared (TW, OLD, ULD, and PSF).

CHARACTERISTIC TIMING DIAGRAMS

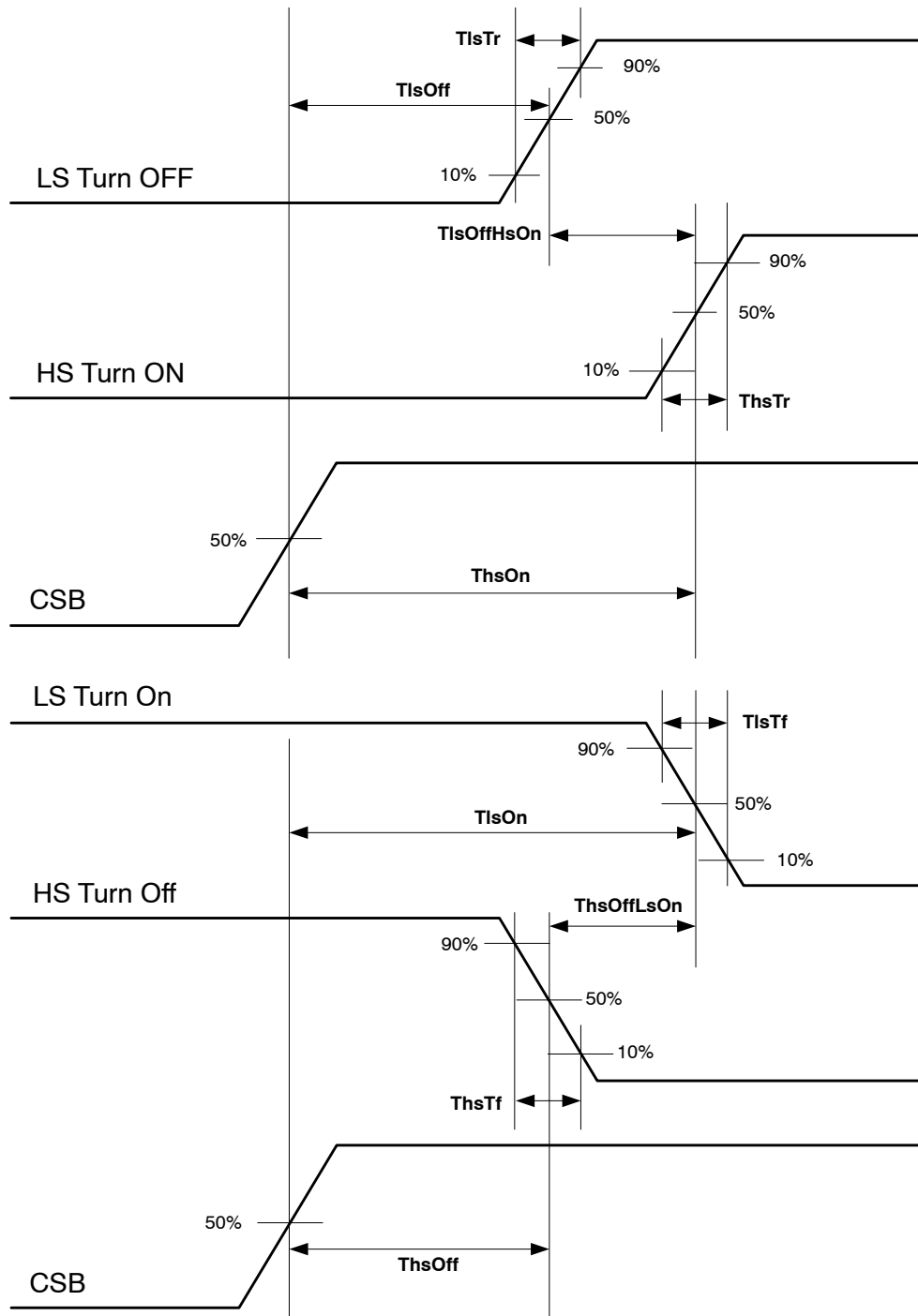


Figure 5. Detailed Driver Timing

## DETAILED OPERATING DESCRIPTION

**General**

The NCV7708F Double Hex Driver provides drive capability for three independent H-Bridge configurations, or 6 High Side configurations with 6 Low Side configurations, or any combination of arrangements. Each output drive is characterized for a 500 mA load and has a typical 1.0 A surge capability (at 13.2 V). Strict adherence to integrated circuit die temperature is necessary. Maximum die temperature is 150°C. This may limit the number of drivers enabled at one time. Output drive control and fault reporting is handled via the SPI (Serial Peripheral Interface) port.

**Sleep Mode**

An Enable function (EN = Low) provides a low quiescent sleep current mode when the device is not being utilized. No data is stored when the device is in sleep mode.

**Input Impedance**

A pull down resistor is provided on the EN input to ensure the device is off if the input signal is lost. Pull down resistors are also provided on the SI and SCLK inputs. A pull up resistor is provided for the CSB input for the same reason. A loss of signal pulls the CSB input high to stop any spurious signals into the SPI port.

**Power Up/Down Control**

An undervoltage lockout circuit prevents the output drivers from turning on unintentionally. This control is provided by monitoring the voltages on the VS1, VS2, and V<sub>CC</sub> pins. Each analog power pin (VS1 or VS2) powers their respective high-side output drivers and supporting charge pump. VS1 powers OUTH1, OUTH2, and OUTH3. VS2 powers OUTH4, OUTH5, and OUTH6.

All low-side drivers are powered by V<sub>RAIL</sub> via V<sub>CC</sub>.

All drivers are initialized in the off (high impedance) condition. Power up sequencing of V<sub>CC</sub>, VS1, and VS2 is up to the user. The voltage on VS1 and VS2 should be operated at the same potential. If the VSx supply moves into either of the VS under voltage or overvoltage regions (with (OVLO = 1), the output drivers are switched to high Z, but command and status data is preserved.

Internal power-up circuitry on the logic supply pin supports a smooth turn on transition. V<sub>CC</sub> power up resets the internal logic such that all output drivers will be off as power is applied. Exceeding the under voltage lockout threshold on V<sub>CC</sub> allows information to be input through the SPI port for turn on control. Logic information remains intact over the entire VS1 and VS2 voltage range.

**Current Limit**

OUTx current is limited per the Current Limit electrical parameter for each driver. The magnitude of the current has a minimum specification of 2 A at V<sub>CC</sub> = 5 V and Vs<sub>x</sub> = 13.2 V. The output is protected for high power conditions during Current Limit by thermal shutdown and the Overcurrent Detection shutdown function. Overcurrent Detection shutdown protects the device during current limit because the Overcurrent threshold is below the Current Limit threshold. The Overcurrent Detection Shutdown Control Timer is initiated at the Overcurrent Shutdown Threshold which starts before the Current Limit is reached.

Note: High currents will cause a rise in die temperature. Devices will not be allowed to turn on if the die temperature exceeds the thermal shutdown temperature.

**Overcurrent Shutdown (BIT13 = 1)**

Effected outputs will turn off when the Overcurrent Shutdown Threshold has been breached for the Overcurrent Shutdown Delay Time. The respective OLD status bit will be set to a “1” and the driver will latch off. The driver can only be turned back on via the SPI port with a SPI command that includes an SRR = 1.

Note: High currents will cause a rise in die temperature. Devices will not be allowed to turn on if the die temperature exceeds the thermal shutdown temperature.

**OVERCURRENT DETECTION SHUT DOWN**

| OCD Input Bit 13 | OUTx OCD Condition | Output Data Bit 13 Over Load Detect (OLD) Status | OUTx Status                                                   | Current Limit of all Drivers |
|------------------|--------------------|--------------------------------------------------|---------------------------------------------------------------|------------------------------|
| 0                | 0                  | 0                                                | Unchanged                                                     | 3 A (typ.)                   |
| 0                | 1                  | 1 (Need SRR to reset)                            | OUTx Latches off after 200 $\mu$ s (typ.) (Need SRR to reset) | 3 A (typ.)                   |
| 1                | 0                  | 0                                                | Unchanged                                                     | 3 A (typ.)                   |
| 1                | 1                  | 1 (Need SRR to reset)                            | OUTx Latches Off After 25 $\mu$ s (typ.) (Need SRR to reset)  | 3 A (typ.)                   |

### Overcurrent Detection Shut Down Control Timer

There are two protection mechanisms for output current, overcurrent and current limit.

1. Current limit – Always active with a typical threshold of 3 A.
2. Overcurrent Detection – Selectable shutdown time via Bit 13 with a typical threshold of 1.45 A.

Figure 6 shows the typical performance of a part which has exceeded the 1.45 A Overcurrent Detection threshold and started the shutdown control timer. When Bit 13 = 1, the shutdown time is 25  $\mu$ sec. When Bit 13 = 0, the shutdown time is 200  $\mu$ sec.

Once an Overcurrent Shutdown Delay Time event has been detected by the NCV7708F, the timer setting cannot be interrupted by an attempted change via a SPI command of Bit 13.

| Input Bit 13 | Overcurrent Shutdown Delay Time |
|--------------|---------------------------------|
| 0            | 200 $\mu$ sec                   |
| 1            | 25 $\mu$ sec                    |

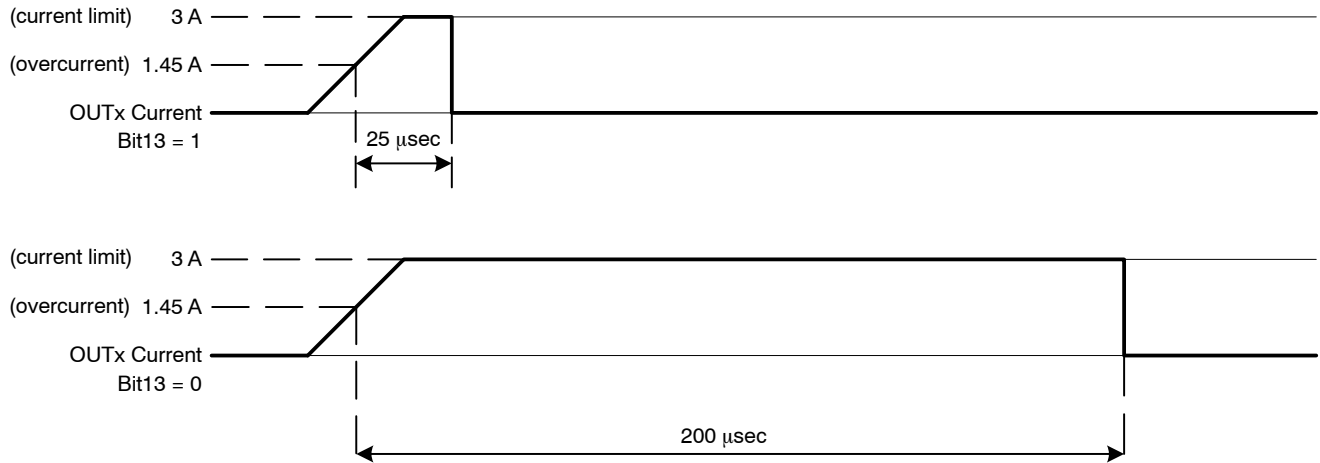


Figure 6. Output Current Shutdown Control

### Under Load Detection

The under-load detection is accomplished by monitoring the current from each output driver. A minimum load current (this is the maximum detection threshold) is required when the drivers are turned on. If the under-load circuit detection threshold has been crossed for more than the under-load delay time, the bit indicator (output bit #14) will be set to a 1. In addition, the offending driver will be turned off only if input bit 14 (ULD) is set to 1 (true).

The NCV7708F uses a global under load timer. An under load condition starts the global under load delay timer. If under load occurs in another channel after the global timer has been started, the delay for any subsequent under load will be the remainder of the initially started timer. The timer runs continuously with any persistent under load condition. The under load detect bit is reset by setting input data bit 0, SRR = 1.

### UNDER LOAD DETECTION SHUT DOWN

| ULD Input Bit 14 | OUTx ULD Condition | Output Data Bit 14 Under Load Detect (ULD) Status | OUTx Status                          |
|------------------|--------------------|---------------------------------------------------|--------------------------------------|
| 0                | 0                  | 0                                                 | Unchanged                            |
| 0                | 1                  | 1 (Need SRR to reset)                             | Unchanged                            |
| 1                | 0                  | 0                                                 | Unchanged                            |
| 1                | 1                  | 1 (Need SRR to reset)                             | OUTx Latches Off (Need SRR to reset) |

### Undervoltage Lockout (PSF)

Undervoltage shutdown circuitry monitors the voltage on the VS1 and VS2 pins. When the Undervoltage Threshold level has been breached on both or either one of the VSx supply inputs, output bit 15 (PSF) will be set and all outputs will turn off.

Turn on/off status is maintained in the logic circuitry. When proper input voltage levels are re-established, the programmed outputs will return to programmed operation.

The Power Supply Fail bit is reset by setting input data bit 0, SRR = 1.

### UNDERVOLTAGE LOCK OUT (UVLO) SHUT DOWN

| VSx UVLO Condition | Output Data Bit 15 Power Supply Fail (PSF) Status | OUTx Status                                           |
|--------------------|---------------------------------------------------|-------------------------------------------------------|
| 0                  | 0                                                 | Unchanged                                             |
| 1                  | 1 (Need SRR to reset)                             | All Outputs Off (Remain off until VSx is out of UVLO) |

### Overvoltage Shutdown (PSF)

Overvoltage shutdown circuitry monitors the voltage on the VS1 and VS2 pins. When the Overvoltage Threshold voltage level has been breached on both or either one of the VSx supply inputs, output bit 15 will be set and, if input bit 15 (OVLO) is set to 1, all drivers will turn off. Turn on/off

status is maintained in the logic circuitry. When proper input voltage levels are re-established, the programmed outputs will turn back on. Overvoltage shutdown can be disabled by using the SPI input bit 15 (OVLO = 0). The Power Supply Fail bit is reset by setting input data bit 0, SRR = 1.

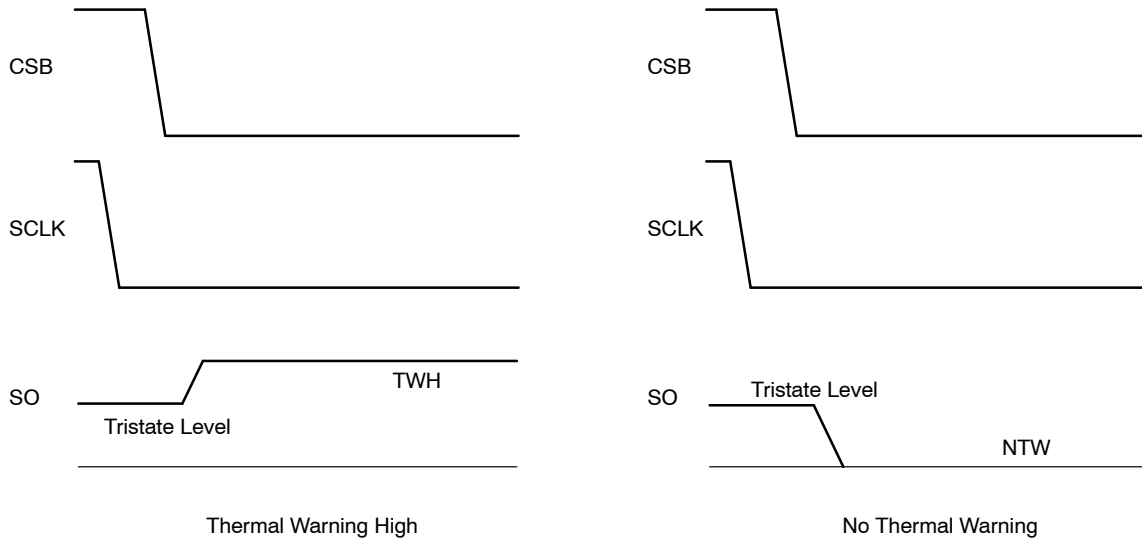
### OVERVOLTAGE LOCK OUT (OVLO) SHUT DOWN

| OVLO Input Bit 15 | VSx OVLO Condition | Output Data Bit 15 Power Supply Fail (PSF) Status | OUTx Status                                                                   |
|-------------------|--------------------|---------------------------------------------------|-------------------------------------------------------------------------------|
| 0                 | 0                  | 0                                                 | Unchanged                                                                     |
| 0                 | 1                  | 1 (Need SRR to reset)                             | Unchanged                                                                     |
| 1                 | 0                  | 0                                                 | Unchanged                                                                     |
| 1                 | 1                  | 1 (Need SRR to reset)                             | All Outputs Latch Off while in OVLO<br>Return to programmed state out of OVLO |

### Thermal Shutdown

Six independent thermal shutdown circuits are featured (one common sensor for each HS and LS transistor pair). Each sensor has two levels, one to give a Thermal Warning (TW) and a higher one, Thermal Shutdown, which will shut the drivers off. When the part reaches the temperature point of Thermal Warning, the output data bit 0 (TW) will be set to a 1, and the outputs will remain on. With one or more sensors detecting the thermal shutdown level, all channels will be turned off simultaneously. All outputs will return to normal operation when the part thermally recovers (Thermal toggling), because the thermal shutdown does not change the channel selection. The output data bit 0, Thermal Warning, will latch and remain set, even after cooling, and is reset by using a software command to input bit 0 (SRR = 1). Since thermal warning precedes a thermal shutdown, software polling of this bit will allow for load control and possible prevention of thermal shutdown conditions.

Thermal warning information can be retrieved immediately without performing a complete SPI access cycle. Figure 7 displays how this is accomplished. Bringing the CSB pin from a 1 to a 0 with SI = 0 immediately displays the information on output data bit 0, thermal warning. As the temperature of the NCV7708F changes from a condition from below the thermal warning threshold to above the thermal warning threshold, the state of the SO pin changes and this level is available immediately when the CSB goes to 0. A 0 on SO indicates there is no thermal warning, while a 1 indicates the IC is above the thermal warning threshold. This warning bit is reset by setting input data bit 0, SRR = 1.



**Figure 7. Access to Temperature warning information shows the thermal information is available immediately with activation of the CSB signal without having to toggle the SCLK line.**

### Applications Drawing

The applications drawing below displays the range with which this part can drive a multitude of loads.

1. H-Bridge Driver configuration
2. Low Side Driver
3. High Side Driver

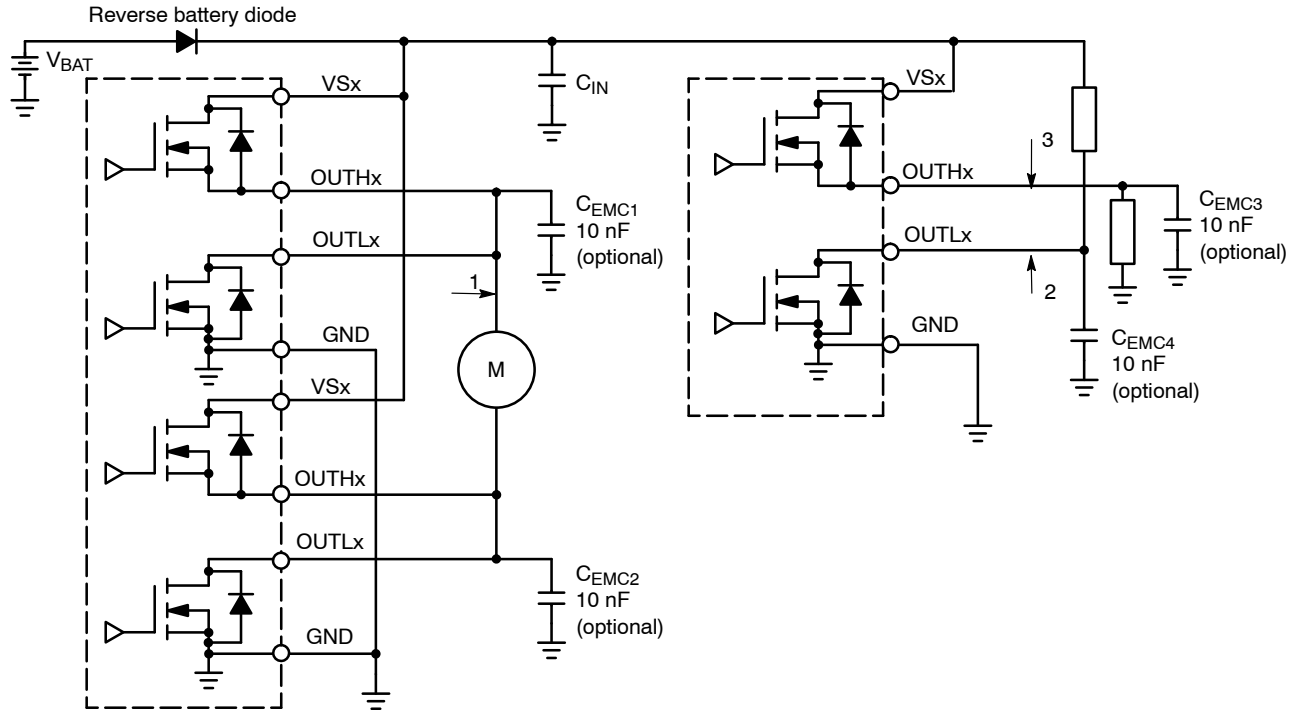


Figure 8. Application Drawing

Any combination of H-Bridge, high-side, or low-side drivers can be designed in. This allows for flexibility in many systems.

### H-Bridge Driver Configuration

The NCV7708F has the flexibility of controlling each driver independently. When the device is set up in an H-Bridge configuration, the software design has to take care of avoiding simultaneous activation of connected HS and LS transistors. Resulting high shoot through currents could cause irreversible damage to the device.

### Overvoltage Clamping – Driving Inductive Loads

To avoid excessive voltages when driving inductive loads in a single-side-mode (LS or HS switch, no freewheeling path), the NCV7708F provides internal clamping diodes. Thus any load type can be driven without the requirement of external freewheeling diodes. Due to high power dissipation during clamping, the maximum energy capability of the driver transistor has to be considered.

TYPICAL OPERATING CHARACTERISTICS

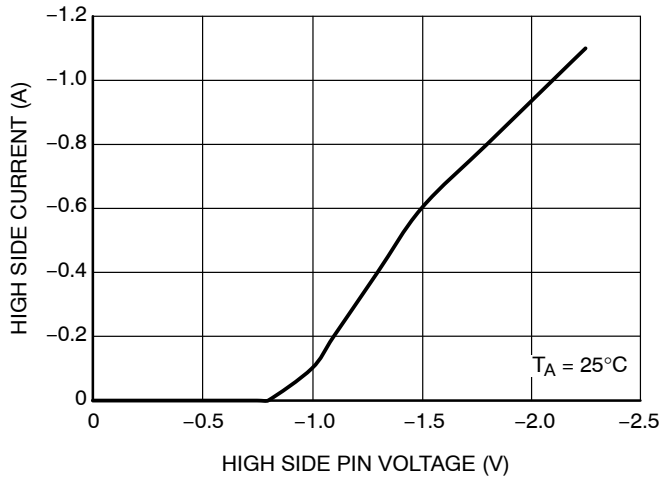


Figure 9. High-Side Negative Clamp Voltage vs. Reverse Current

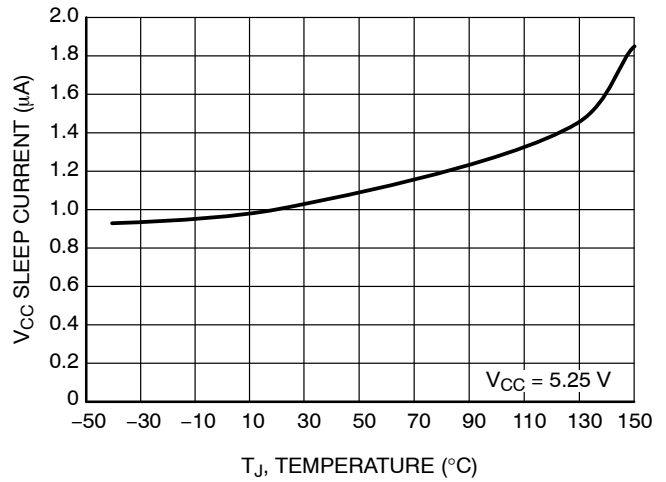


Figure 10.  $V_{CC}$  Sleep Supply Current vs. Temperature

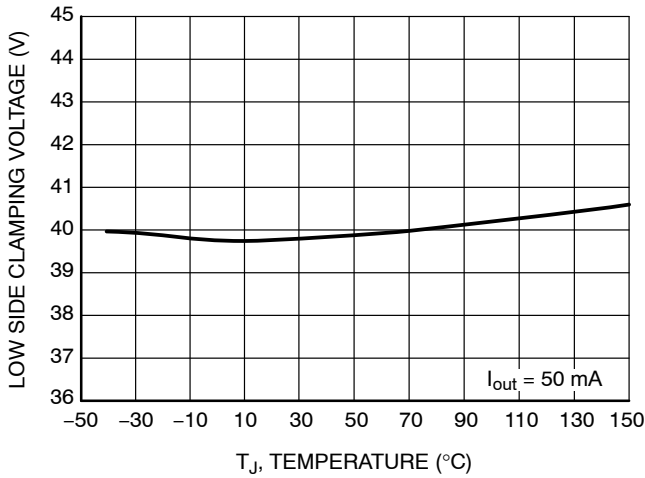


Figure 11. Low-Side Clamping Voltage vs. Temperature

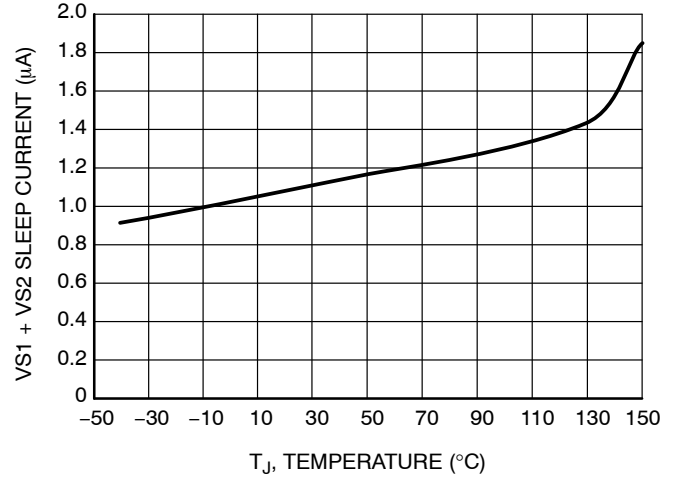


Figure 12.  $VS1 + VS2$  Sleep Current vs. Temperature

Table 1. FAULT HANDLING

| Fault                                                        | Fault Memory Serial Output Bit | Driver Condition During Fault                                                 | Driver Condition after Parameters Within Specified Limits       | Output Register Clear Requirement                                                     |
|--------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Current Limit<br>$\pm 3\text{ A}$<br>(Input OCD Bit 13 = 0)* | Latched                        | Offending Driver is latched off after 200 $\mu\text{sec}$                     | Offending Driver is latched off                                 | Valid SPI frame with SRR set to 1                                                     |
| Over Load<br>$\pm 1.45\text{ A}$<br>(Input OCD Bit 13 = 1)*  | Latched                        | Offending Driver is latched off by overcurrent timer after 25 $\mu\text{sec}$ | Offending Driver is latched off                                 | Valid SPI frame with SRR set to 1                                                     |
| Under Load<br>(Input ULD Bit 14 = 0)                         | Latched                        | Unchanged                                                                     | Unchanged                                                       | Valid SPI frame with SRR set to 1                                                     |
| Under Load<br>(Input ULD Bit 14 = 1)                         | Latched                        | Offending Driver is latched off after 350 $\mu\text{sec}$                     | Offending Driver is latched off                                 | Valid SPI frame with SRR set to 1 falls below                                         |
| Power Supply Fail (OVLO)                                     | Latched                        | Output Driver on                                                              | Bit 15 = 0<br>Outputs return to their previous programmed state | PSF bit is cleared when VSx falls below the hysteresis voltage level and SRR set to 1 |
|                                                              |                                | Output Driver switched to high Z                                              | Bit 15 = 1<br>Outputs return to their previous programmed state | PSF bit is cleared when VSx falls below the hysteresis voltage level and SRR set to 1 |
| Power Supply Fail (UVLO)                                     | Latched                        | Output Driver switched to high Z                                              | Return to programmed state                                      | Valid SPI frame with SRR set to 1                                                     |
| Thermal Warning (TW)                                         | Latched                        | Output Driver on                                                              | Drivers in Normal Operation                                     | Valid SPI frame with SRR set to 1                                                     |
| Thermal Shutdown                                             | No Thermal Shutdown Bit        | All Drivers turns off                                                         | Return to programmed state                                      | No Thermal Shutdown Bit                                                               |

All specified currents and times refer to typical numbers.

\*Current Limit performance is independent of Overcurrent (Bit13). The output will always limit to current limit independent of bit 13.

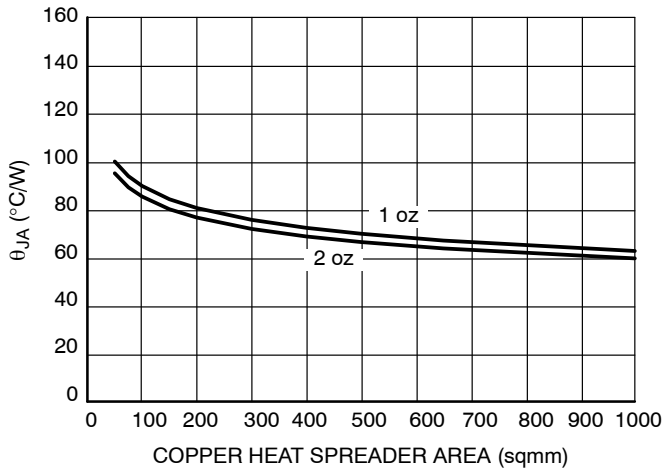


Figure 13. SOIC-28  $\theta_{JA}$  vs. Copper Spreader Area

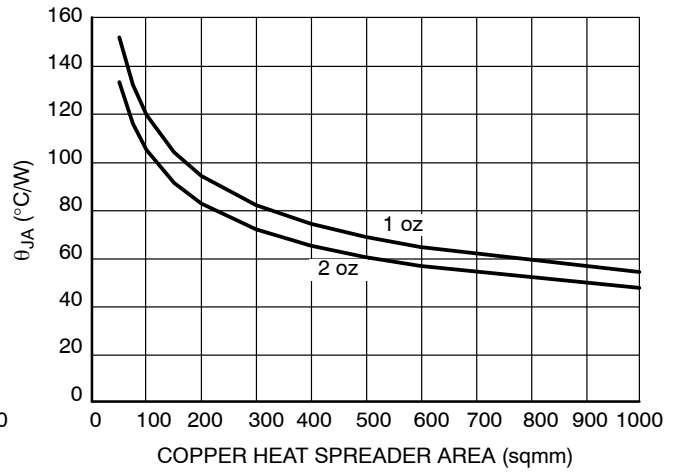


Figure 14. SSOP24 Narrow Body Exposed Pad  $\theta_{JA}$  vs. Copper Spreader Area

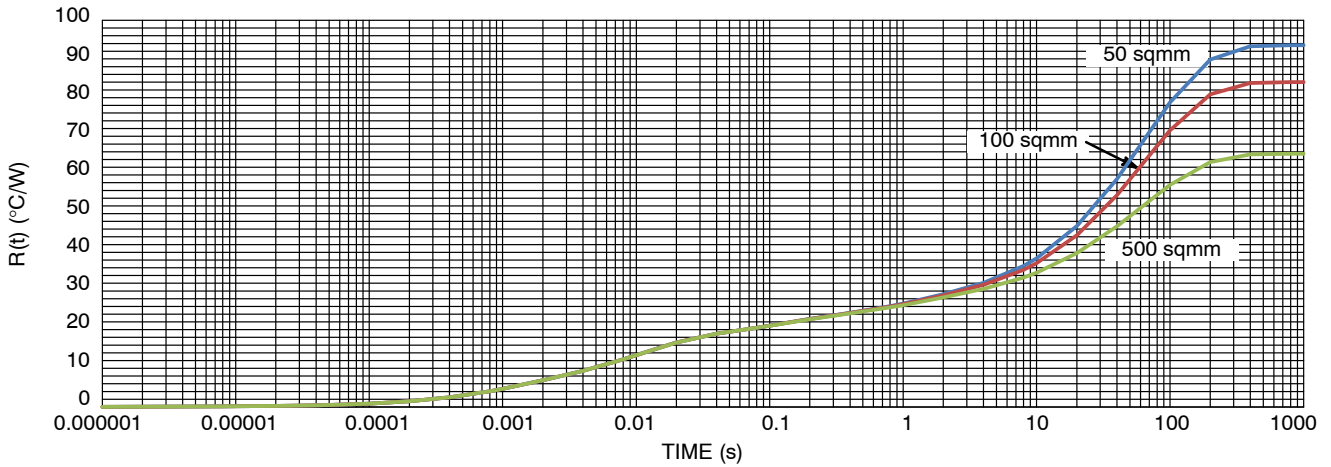


Figure 15. SOIC 28-Lead Single Pulse Heating Curve

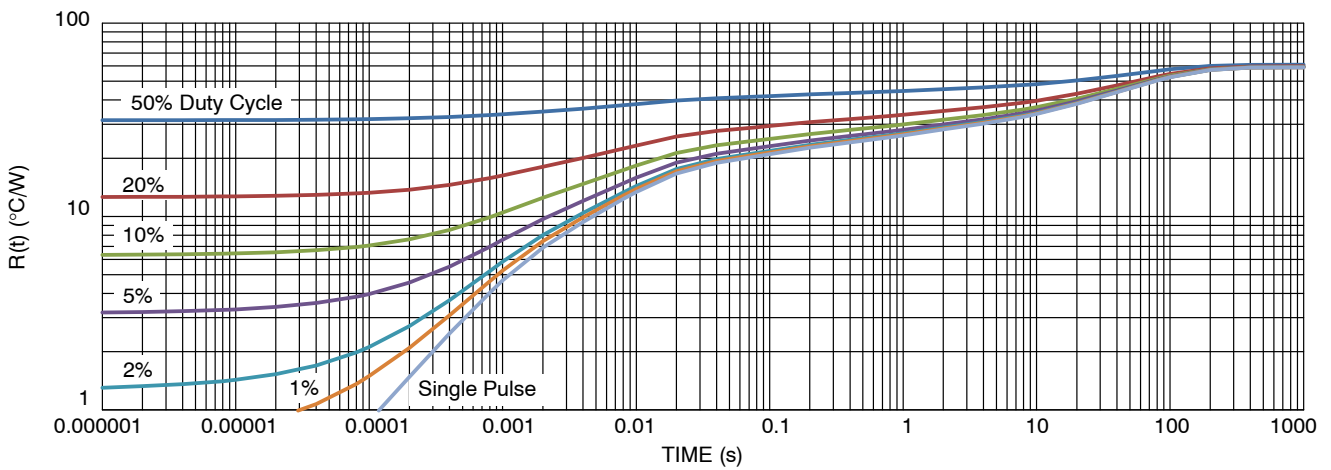


Figure 16. SOIC 28-Lead Thermal Duty Cycle Curve on 986 mm<sup>2</sup> Spreader Test Board

# NCV7708F

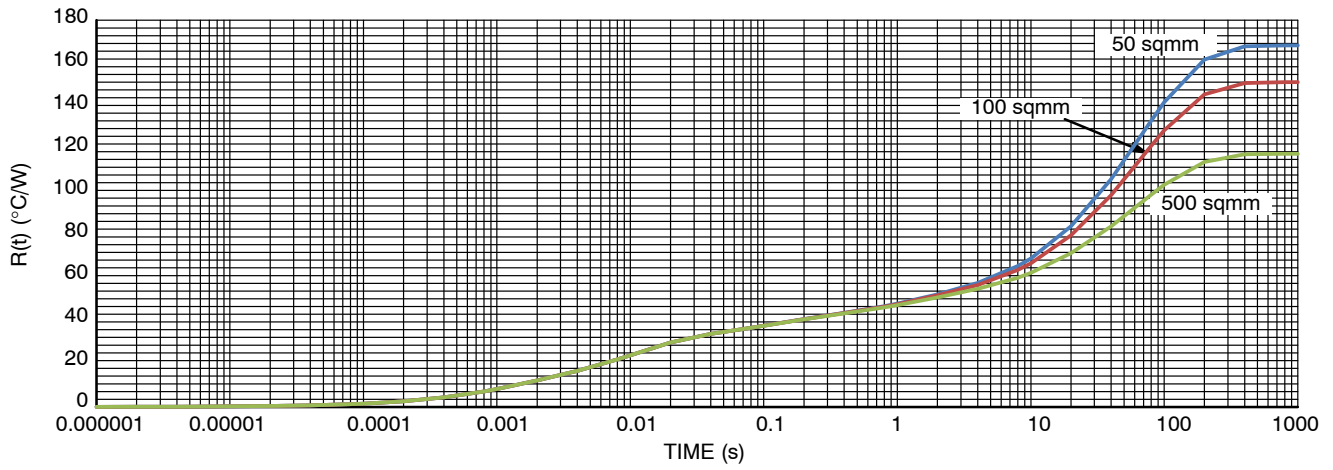


Figure 17. SSOP24 Narrow Body Exposed Pad Single Pulse Heating Curve

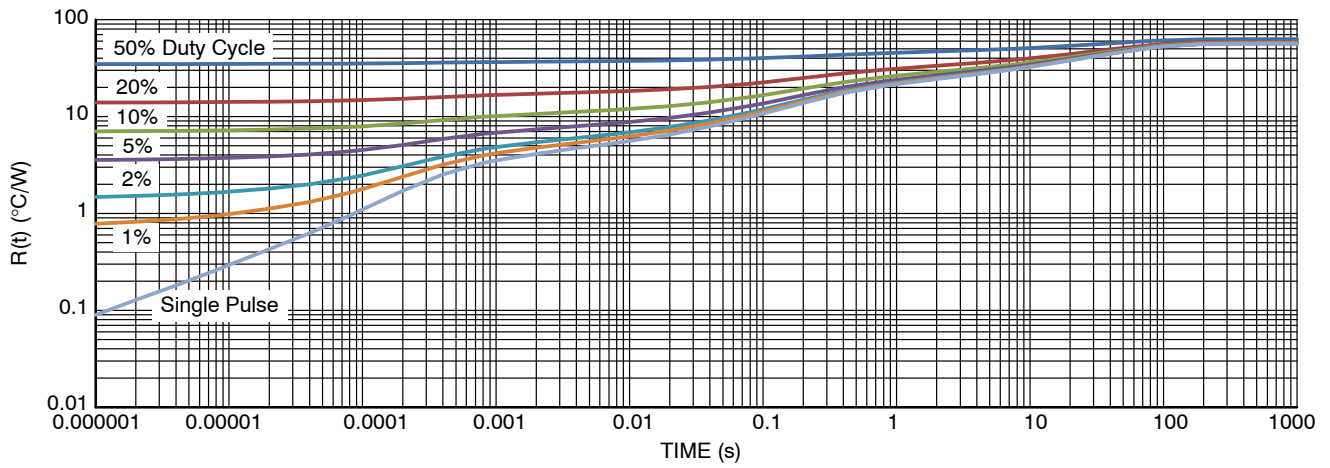
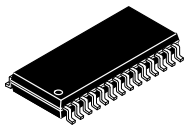


Figure 18. SSOP24 Lead Single Pulse Heating Curve

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

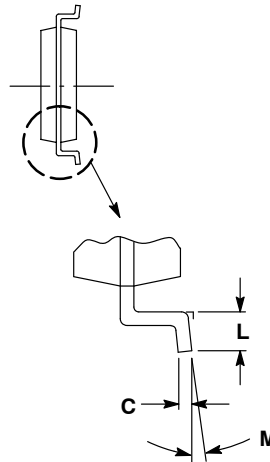
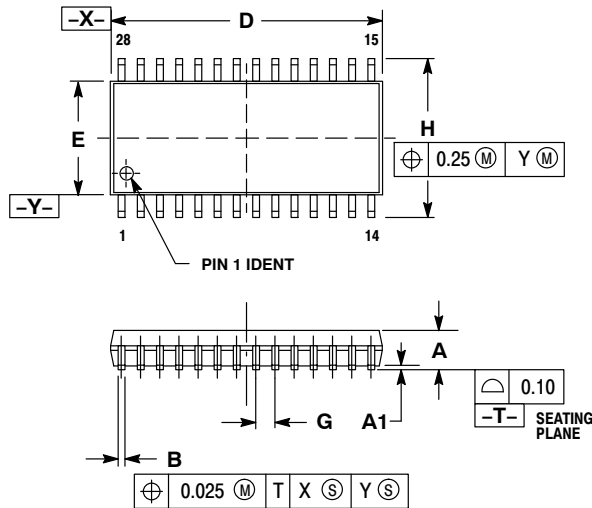
ON Semiconductor®



SCALE 1:1

SOIC-28 WB  
CASE 751F  
ISSUE J

DATE 23 SEP 2015

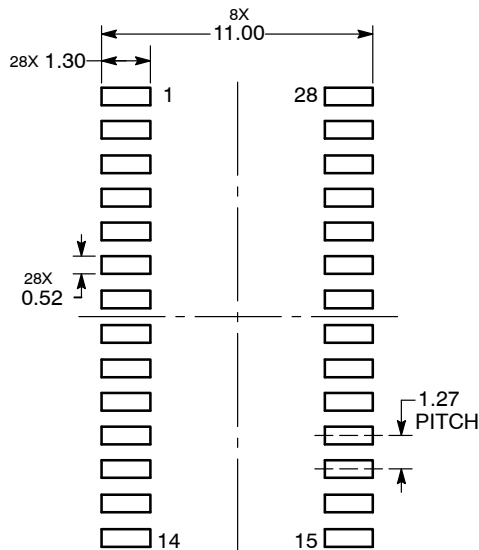


## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL NOT BE 0.13 TOTAL IN EXCESS OF B DIMENSION AT MAXIMUM MATERIAL CONDITION.

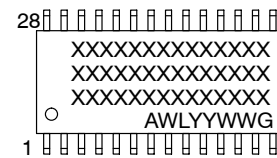
| DIM | MILLIMETERS |       |
|-----|-------------|-------|
|     | MIN         | MAX   |
| A   | 2.35        | 2.65  |
| A1  | 0.13        | 0.29  |
| B   | 0.35        | 0.49  |
| C   | 0.23        | 0.32  |
| D   | 17.80       | 18.05 |
| E   | 7.40        | 7.60  |
| G   | 1.27 BSC    |       |
| H   | 10.05       | 10.55 |
| L   | 0.41        | 0.90  |
| M   | 0°          | 8°    |

## SOLDERING FOOTPRINT



DIMENSIONS: MILLIMETERS

## GENERIC MARKING DIAGRAM\*



XXXXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present.

|                  |                   |                                                                                                                                                                                  |
|------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DOCUMENT NUMBER: | 98ASB42345B       | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| DESCRIPTION:     | SOIC-28 WIDE BODY | PAGE 1 OF 1                                                                                                                                                                      |

ON Semiconductor and are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. ON Semiconductor does not convey any license under its patent rights nor the rights of others.

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS

ON Semiconductor®

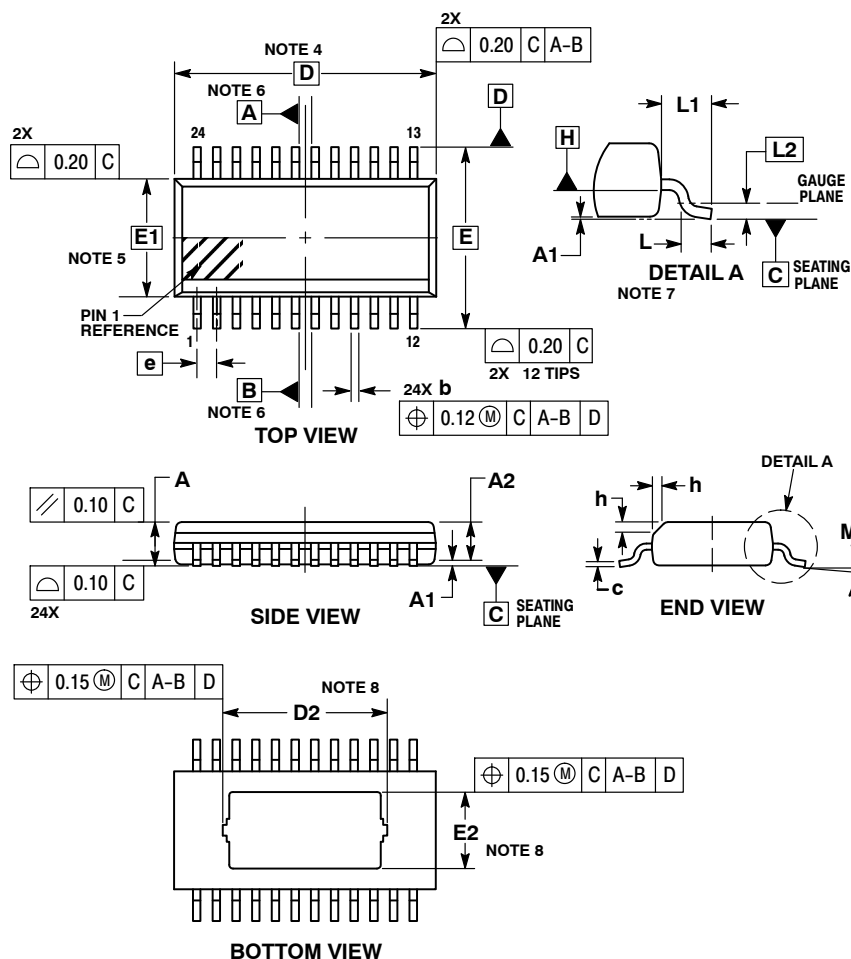
ON



SCALE 1:1

SSOP24 NB EP  
CASE 940AK  
ISSUE O

DATE 24 APR 2012



## NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
- CONTROLLING DIMENSION: MILLIMETERS.
- DIMENSION  $b$  DOES NOT INCLUDE DAMBAR PROTRUSION. DAMBAR PROTRUSION SHALL BE 0.10 MAX. AT MMC. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT. DIMENSION  $b$  APPLIES TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10 TO 0.25 FROM THE LEAD TIP.
- DIMENSION  $D$  DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION  $D$  IS DETERMINED AT DATUM PLANE  $H$ .
- DIMENSION  $E1$  DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE. DIMENSION  $E1$  IS DETERMINED AT DATUM PLANE  $H$ .
- DATUMS  $A$  AND  $B$  ARE DETERMINED AT DATUM PLANE  $H$ .
- $A1$  IS DEFINED AS THE VERTICAL DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT ON THE PACKAGE BODY.
- CONTOURS OF THE THERMAL PAD ARE UNCONTROLLED WITHIN THE REGION DEFINED BY DIMENSIONS  $D2$  AND  $E2$ .

| MILLIMETERS |          |      |
|-------------|----------|------|
| DIM         | MIN      | MAX  |
| A           | ---      | 1.70 |
| A1          | 0.00     | 0.10 |
| A2          | 1.10     | 1.65 |
| b           | 0.19     | 0.30 |
| c           | 0.09     | 0.20 |
| D           | 8.64 BSC |      |
| D2          | 5.28     | 5.58 |
| E           | 6.00 BSC |      |
| E1          | 3.90 BSC |      |
| E2          | 2.44     | 2.64 |
| e           | 0.65 BSC |      |
| h           | 0.25     | 0.50 |
| L           | 0.40     | 0.85 |
| L1          | 1.00 REF |      |
| L2          | 0.25 BSC |      |
| M           | 0°       | 8°   |

## GENERIC MARKING DIAGRAM\*

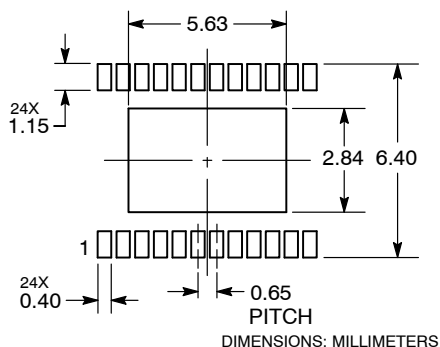


XXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
YY = Year  
WW = Work Week  
G = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

## RECOMMENDED SOLDERING FOOTPRINT



DOCUMENT NUMBER: 98AON79998E

DESCRIPTION: SSOP24 NB EP

Electronic versions are uncontrolled except when accessed directly from the Document Repository.  
Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.

PAGE 1 OF 1

ON Semiconductor and ON are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. ON Semiconductor does not convey any license under its patent rights nor the rights of others.

**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

## ADDITIONAL INFORMATION

### TECHNICAL PUBLICATIONS:

Technical Library: [www.onsemi.com/design/resources/technical-documentation](http://www.onsemi.com/design/resources/technical-documentation)  
onsemi Website: [www.onsemi.com](http://www.onsemi.com)

### ONLINE SUPPORT: [www.onsemi.com/support](http://www.onsemi.com/support)

For additional information, please contact your local Sales Representative at  
[www.onsemi.com/support/sales](http://www.onsemi.com/support/sales)