

## IRS2453(1)D(S) SELF-OSCILLATING FULL BRIDGE DRIVER IC

### Features

- Integrated 600 V full-bridge gate driver
- CT, RT programmable oscillator
- 15.6V Zener clamp on V<sub>CC</sub>
- Micropower startup
- Logic level latched shutdown pin
- Non-latched shutdown on CT pin (1/6th V<sub>CC</sub>)
- Internal bootstrap FETs
- Excellent latch immunity on all inputs & outputs
- ESD protection on all pins
- 14-lead SOIC or PDIP package
- 0.5 or 1.0 μs (typ.) internal deadtime
- RoHS compliant

### Product Summary

|   |   |
|---|---|
| Topology                                    | Full-bridge                             |
| V <sub>OFFSET</sub>                         | 600 V                                   |
| I <sub>o+</sub> & I <sub>o-</sub> (typical) | 180 mA & 260 mA                         |
| Deadtime (typical)                          | 1.0 μs (IRS2453D)<br>0.5 μs (IRS24531D) |

### Package Options

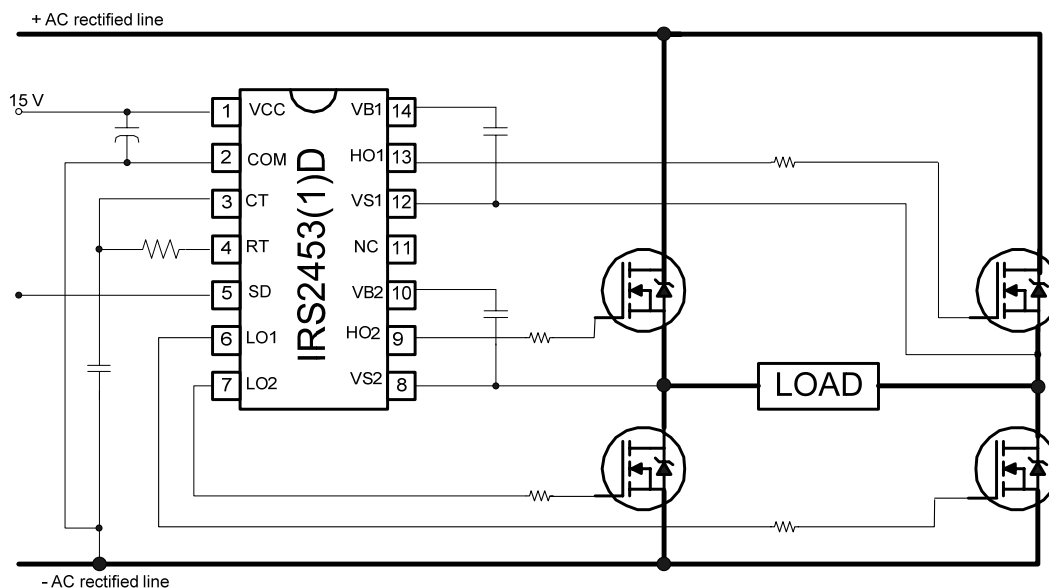


14 Lead PDIP  
IRS2453DPbF



14 Lead SOIC  
(Narrow Body)  
IRS2453(1)DSPbF

### Typical Connection Diagram



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## Description

The IRS2453(1)D is based on the popular IR2153 self-oscillating half-bridge gate driver IC, and incorporates a high voltage full-bridge gate driver with a front end oscillator similar to the industry standard CMOS 555 timer. HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. The output driver features a high pulse current buffer stage designed for minimum driver cross-conduction. Noise immunity is achieved with low di/dt peak of the gate drivers, and with an undervoltage lockout hysteresis greater than 1.5 V. The IRS2453(1)D also includes latched and non-latched shutdown pins.

**Qualification Information<sup>†</sup>**

|                                   |                  |   |  |
|-----------------------------------|------------------|---|--|
| <b>Qualification Level</b>        |                  | Industrial <sup>††</sup>  |  |
|                                   |                  | Comments: This family of ICs has passed JEDEC's Industrial qualification. IR's Consumer qualification level is granted by extension of the higher Industrial level. |  |
| <b>Moisture Sensitivity Level</b> |                  | SOIC14  | MSL2 <sup>†††</sup> 260°C<br>(per IPC/JEDEC J-STD-020) |
|                                   |                  | PDIP14  | Not applicable<br>(non-surface mount package style)    |
| <b>ESD</b>                        | Machine Model    | Class C<br>(per JEDEC standard JESD22-A115)   |  |
|                                   | Human Body Model | Class 2<br>(per EIA/JEDEC standard EIA/JESD22-A114)   |  |
| <b>IC Latch-Up Test</b>           |                  | Class I, Level A<br>(per JESD78)  |  |
| <b>RoHS Compliant</b>             |                  | Yes   |  |

- † Qualification standards can be found at International Rectifier's web site <http://www.irf.com/>
- †† Higher qualification ratings may be available should the user have such requirements. Please contact your International Rectifier sales representative for further information.
- ††† Higher MSL ratings may be available for the specific package types listed here. Please contact your International Rectifier sales representative for further information.

**Absolute Maximum Ratings**

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to COM, all currents are defined positive into any lead. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions.

| Symbol             | Definition  | Min.        | Max.           | Units              |
|--------------------|---|-------------|----------------|--------------------|
| $V_{B1}, V_{B2}$   | High side floating supply voltage   | -0.3        | 625            | V                  |
| $V_{S1}, V_{S2}$   | High side floating supply offset voltage                                      | $V_B - 25$  | $V_B + 0.3$    |                    |
| $V_{HO1}, V_{HO2}$ | High side floating output voltage   | $V_S - 0.3$ | $V_B + 0.3$    |                    |
| $V_{LO1}, V_{LO2}$ | Low side output voltage   | -0.3        | $V_{CC} + 0.3$ |                    |
| $V_{RT}$           | $R_T$ pin voltage   | -0.3        | $V_{CC} + 0.3$ |                    |
| $V_{CT}$           | $C_T$ pin voltage   | -0.3        | $V_{CC} + 0.3$ |                    |
| $V_{SD}$           | SD pin voltage  | -0.3        | $V_{CC} + 0.3$ |                    |
| $I_{RT}$           | $R_T$ pin current   | -5          | 5              | mA                 |
| $I_{CC}$           | Supply current (†)  | ---         | 25             |                    |
| $dV_S/dt$          | Allowable offset voltage slew rate  | -50         | 50             | V/ns               |
| $P_D$              | Maximum power dissipation @ $T_A \leq +25\text{ }^\circ\text{C}$ , 8-Pin DIP  | ---         | 1.0            | W                  |
| $P_D$              | Maximum power dissipation @ $T_A \leq +25\text{ }^\circ\text{C}$ , 8-Pin SOIC | ---         | 0.625          |                    |
| $R_{\theta JA}$    | Thermal resistance, junction to ambient, 8-Pin DIP                            | ---         | 125            | $^\circ\text{C/W}$ |
| $R_{\theta JA}$    | Thermal resistance, junction to ambient, 8-Pin SOIC                           | ---         | 200            |                    |
| $T_J$              | Junction temperature  | -55         | 150            | $^\circ\text{C}$   |
| $T_S$              | Storage temperature   | -55         | 150            |                    |
| $T_L$              | Lead temperature (soldering, 10 seconds)                                      | ---         | 300            |                    |

† This IC contains a zener clamp structure between the chip  $V_{CC}$  and COM which has a nominal breakdown voltage of 15.6 V. Please note that this supply pin should not be driven by a DC, low impedance power source greater than the  $V_{CLAMP}$  specified in the Electrical Characteristics section.

**Recommended Operating Conditions**

For proper operation the device should be used within the recommended conditions.

| Symbol             | Definition  | Min.           | Max.        | Units |
|--------------------|---|----------------|-------------|-------|
| $V_{BS1}, V_{BS2}$ | High side floating supply voltage                     | $V_{CC} - 0.7$ | $V_{CLAMP}$ | V     |
| $V_{S1}, V_{S2}$   | Steady state high side floating supply offset voltage | -3.0 (†)       | 600         |       |
| $V_{CC}$           | Supply voltage  | $V_{CCUV+}$    | $V_{CLAMP}$ |       |
| $I_{CC}$           | Supply current  | (††)           | 5           | mA    |
| $T_J$              | Junction temperature                                  | -25            | 125         | °C    |

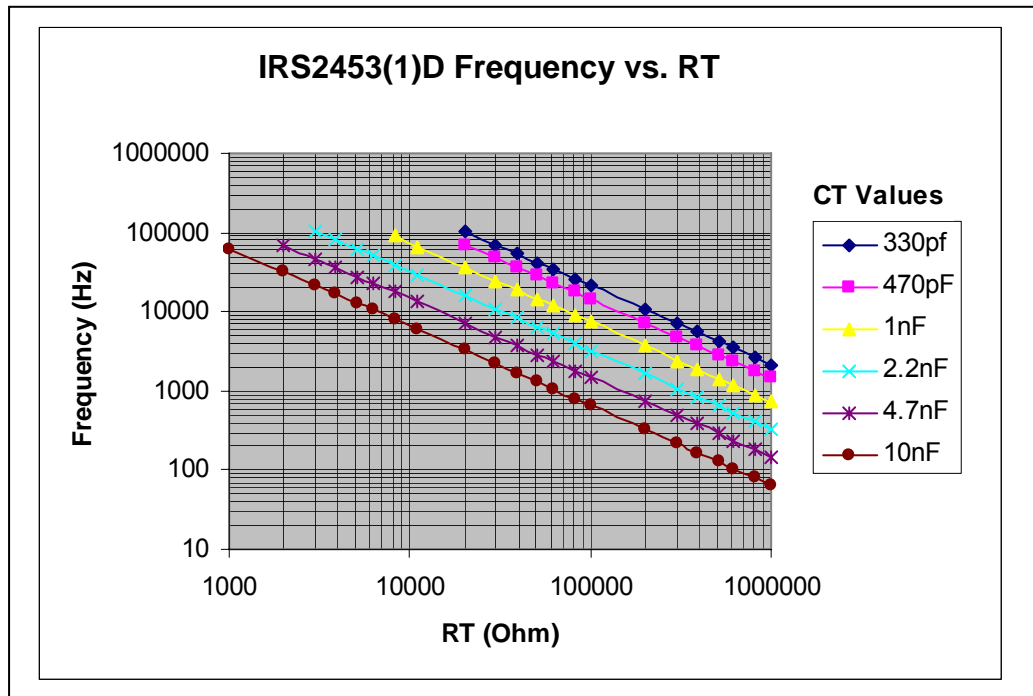
† It is recommended to avoid output switching conditions where negative-going spikes at the  $V_S$  node would decrease  $V_S$  below ground by more than -5V.

†† Enough current should be supplied to the  $V_{CC}$  pin of the IC to keep the internal 15.6 V zener diode clamping the voltage at this pin.

**Recommended Component Values**

| Symbol | Component                 | Min. | Max. | Units |
|--------|---------------------------|------|------|-------|
| $R_T$  | Timing resistor value     | 1    | ---  | kΩ    |
| $C_T$  | $C_T$ pin capacitor value | 330  | ---  | pF    |

VBIAS ( $V_{CC}, V_{BS}$ ) = 14 V,  $V_S=0$  V and  $T_A = 25$  °C,  $C_{LO1}=C_{LO2} = C_{HO1}=C_{HO2} = 1$  nF.



### Electrical Characteristics

$V_{BIAS}$  ( $V_{CC}$ ,  $V_{BS}$ ) = 14 V,  $C_T$  = 1 nF and  $T_A$  = 25 °C unless otherwise specified. The  $V_O$  and  $I_O$  parameters are referenced to COM and are applicable to the respective output leads: HO or LO. CLO1=CLO2=CHO1=CHO2=1 nF.

| Symbol                                    | Definition   | Min  | Typ  | Max  | Units   | Test Conditions                                  |
|---|--|------|------|------|---------|--|
| <b>Low Voltage Supply Characteristics</b> |  |      |      |      |         |  |
| $V_{CCUV+}$                               | Rising $V_{CC}$ undervoltage lockout threshold                   | 10.0 | 11.0 | 12.0 | V       |  |
| $V_{CCUV-}$                               | Falling $V_{CC}$ undervoltage lockout threshold                  | 8.0  | 9.0  | 10.0 |         |  |
| $V_{CCUVHYS}$                             | $V_{CC}$ undervoltage lockout hysteresis                         | 1.5  | 2.0  | 2.4  |         |  |
| $I_{QCCUV}$                               | Micropower startup $V_{CC}$ supply current                       | ---  | 140  | 200  | $\mu$ A | $V_{CC} \leq V_{CCUV-}$                          |
| $I_{QCC}$                                 | Quiescent $V_{CC}$ supply current                                | ---  | 1.3  | 2.0  | mA      |  |
| $I_{CC,20K}$                              | $V_{CC}$ supply current at $f_{osc}$ ( $R_T = 36.5$ k $\Omega$ ) | ---  | 3.0  | 3.5  |         |  |
| $I_{CCFLT}$                               | $V_{CC}$ supply current when $SD > V_{SD}$                       | ---  | 360  | 500  | $\mu$ A |  |
| $V_{CLAMP}$                               | $V_{CC}$ Zener clamp voltage                                     | 14.6 | 15.6 | 16.6 | V       | $I_{CC} = 5$ mA                                  |
| <b>Floating Supply Characteristics</b>    |  |      |      |      |         |  |
| $I_{QBS1UV},$<br>$I_{QBS2UV}$             | Micropower startup $V_{BS}$ supply current                       | ---  | 3    | 10   | $\mu$ A | $V_{CC} \leq V_{CCUV-},$<br>$V_{CC} = V_{BS}$    |
| $I_{QBS1},$<br>$I_{QBS2}$                 | Quiescent $V_{BS}$ supply current                                | ---  | 30   | 100  |         |  |
| $V_{BS1UV+},$<br>$V_{BS2UV+}$             | $V_{BS}$ supply undervoltage positive going threshold            | 8.0  | 9.0  | 10.0 | V       |  |
| $V_{BS1UV-},$<br>$V_{BS2UV-}$             | $V_{BS}$ supply undervoltage negative going threshold            | 7.0  | 8.0  | 9.0  |         |  |
| $I_{LK1}, I_{LK2}$                        | Offset supply leakage current                                    | ---  | ---  | 50   | $\mu$ A | $V_B = V_S = 600$<br>V                           |
| <b>Oscillator I/O Characteristics</b>     |  |      |      |      |         |  |
| $f_{OSC}$                                 | Oscillator frequency   | 19.6 | 20.2 | 20.8 | kHz     | $R_T = 36.5$ k $\Omega$                          |
|   |  | 88   | 94   | 100  |         | $R_T = 7.15$ k $\Omega$                          |
| $d$                                       | $R_T$ pin duty cycle   | 48   | 50   | 52   | %       | $f_o < 100$ kHz                                  |
| $I_{CT}$                                  | $C_T$ pin current  | ---  | 0.05 | 1.0  | $\mu$ A |  |
| $I_{CTUV}$                                | UV-mode $C_T$ pin pulldown current                               | 1    | 5    | ---  | mA      | $V_{CC} = 7$ V                                   |
| $V_{CT+}$                                 | Upper $C_T$ ramp voltage threshold                               | ---  | 9.3  | ---  | V       |  |
| $V_{CT-}$                                 | Lower $C_T$ ramp voltage threshold                               | ---  | 4.7  | ---  |         |  |
| $V_{RT+}$                                 | High level $R_T$ output voltage, $V_{CC} - V_{RT}$               | ---  | 10   | 50   | mV      | $I_{RT} = 100$ $\mu$ A<br>$R_T = 140$ k $\Omega$ |
|   |  | ---  | 100  | 300  |         | $I_{RT} = 1$ mA<br>$R_T = 14$ k $\Omega$         |
| $V_{RT-}$                                 | Low level $R_T$ output voltage                                   | ---  | 10   | 50   |         | $I_{RT} = 100$ $\mu$ A<br>$R_T = 140$ k $\Omega$ |
|   |  | ---  | 100  | 300  |         | $I_{RT} = 1$ mA<br>$R_T = 14$ k $\Omega$         |
| $V_{RTUV}$                                | UV-mode $R_T$ output voltage                                     | ---  | 0    | 100  |         | $V_{CC} \leq V_{CCUV-}$                          |

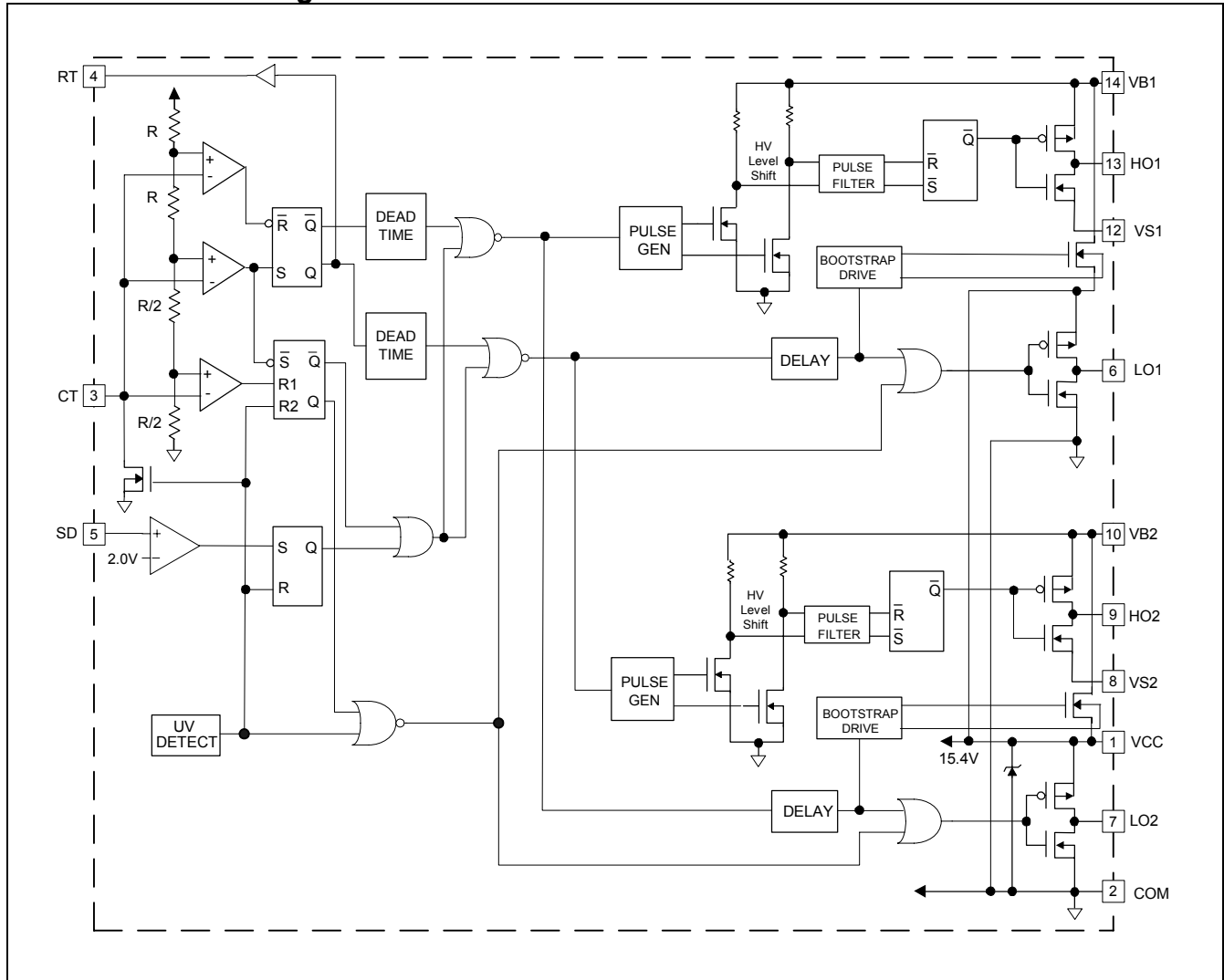
**Electrical Characteristics**

$V_{BIAS} (V_{CC}, V_{BS}) = 14 \text{ V}$ ,  $C_T = 1 \text{ nF}$  and  $T_A = 25 \text{ }^\circ\text{C}$ , unless otherwise specified. The  $V_O$  and  $I_O$  parameters are referenced to COM and are applicable to the respective output leads: HO or LO.  $CLO1=CLO2=CHO1=CHO2=1 \text{ nF}$ .

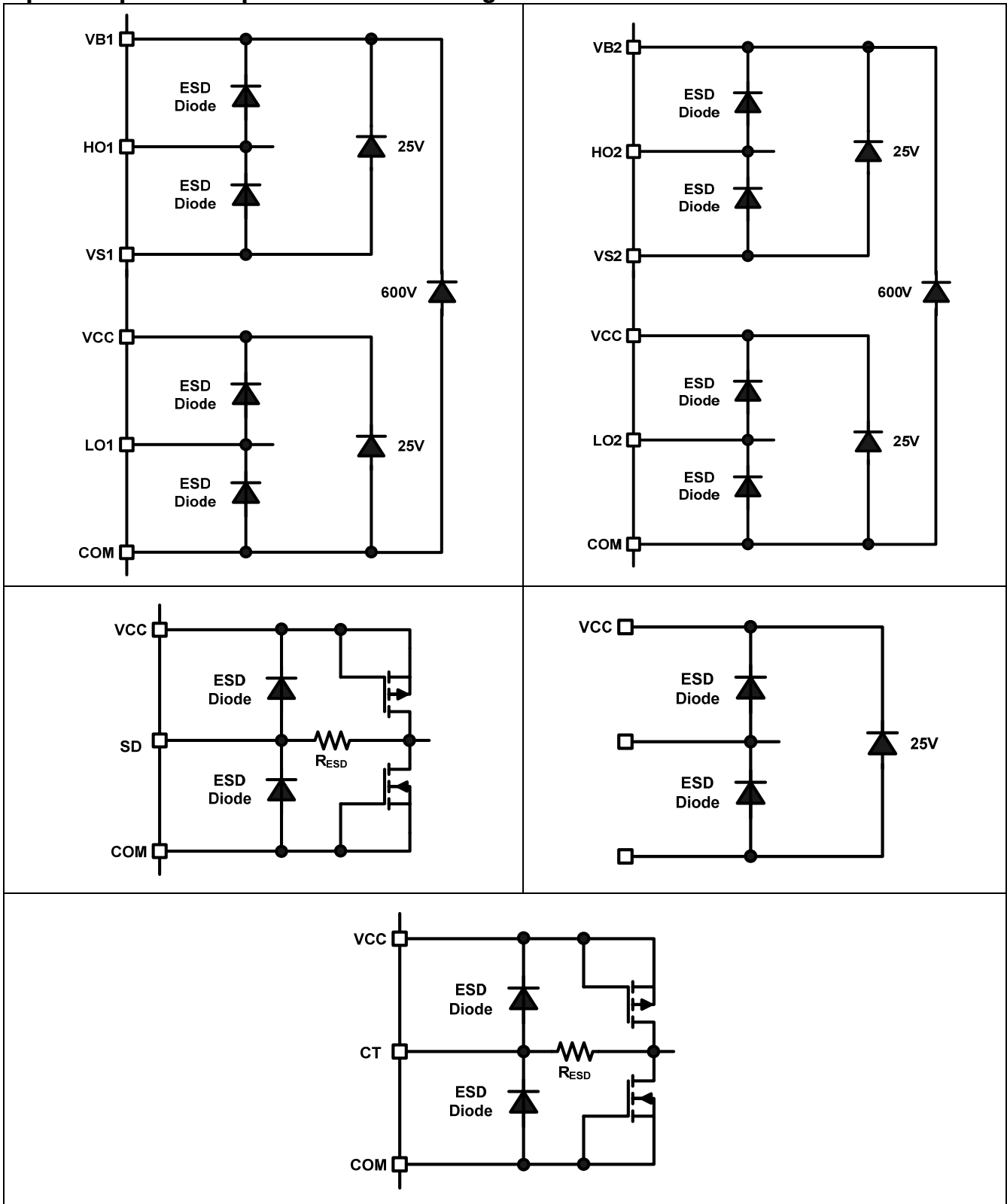
| Symbol                                    | Definition                                   | Min       | Typ      | Max | Units | Test Conditions                                       |
|---|--|-----------|----------|-----|-------|---|
| <b>Gate Driver Output Characteristics</b> |  |           |          |     |       |   |
| VOH                                       | High level output voltage, VBIAS - VO        | ---       | $V_{CC}$ | --- | V     | IO = 0 A  |
| VOL                                       | Low level output voltage, VO                 | ---       | COM      | --- |       |   |
| VOL_UV                                    | UV-mode output voltage, VO                   | ---       | COM      | --- |       | IO = 0 A,<br>VCC ≤ VCC(UV)-                           |
| t <sub>r</sub>                            | Output rise time                             | ---       | 120      | 200 | ns    |   |
| t <sub>f</sub>                            | Output fall time                             | ---       | 50       | 100 |       |   |
| t <sub>sd</sub>                           | Shutdown propagation delay                   | ---       | 250      | --- |       |   |
| t <sub>d</sub>                            | Output deadtime (HO or LO)                   | IRS2453D  | 0.8      | 1.0 | 1.40  | μs  |
|   |  | IRS24531D | 0.4      | 0.5 | 0.7   |   |
| I <sub>O+</sub>                           | Output source current                        | ---       | 180      | --- | mA    |   |
| I <sub>O-</sub>                           | Output sink current                          | ---       | 260      | --- |       |   |
| <b>Shutdown</b>                           |  |           |          |     |       |   |
| V <sub>SD</sub>                           | Shutdown threshold at SD pin (latched)       | 1.8       | 2.0      | 2.3 | V     |   |
| V <sub>CTSD</sub>                         | CT voltage shutdown threshold (non latched)  | 2.2       | 2.3      | 2.5 |       |   |
| V <sub>RTSD</sub>                         | SD mode RT output voltage, VCC - VRT         | ---       | 10       | 50  | mV    | IRT = 100 μA,<br>RT = 140 kΩ<br>V <sub>CT</sub> = 0 V |
|   |  | ---       | 100      | 300 |       | IRT = 1 mA,<br>RT = 14 kΩ<br>V <sub>CT</sub> = 0 V    |
| <b>Bootstrap FET Characteristics</b>      |  |           |          |     |       |   |
| $\frac{V_{B1\_ON}}{V_{B2\_ON}}$           | V <sub>B</sub> when the bootstrap FET is on  | 13.7      | 14.0     | --- | V     |   |
| $\frac{I_{B1\_CAP}}{I_{B2\_CAP}}$         | V <sub>B</sub> source current when FET is on | 40        | 55       | --- | mA    | C <sub>BS</sub> =0.1 μF                               |
| $\frac{I_{B1\_10V}}{I_{B2\_10V}}$         | V <sub>B</sub> source current when FET is on | 10        | 12       | --- |       | V <sub>B</sub> =10 V                                  |



**Functional Block Diagram**



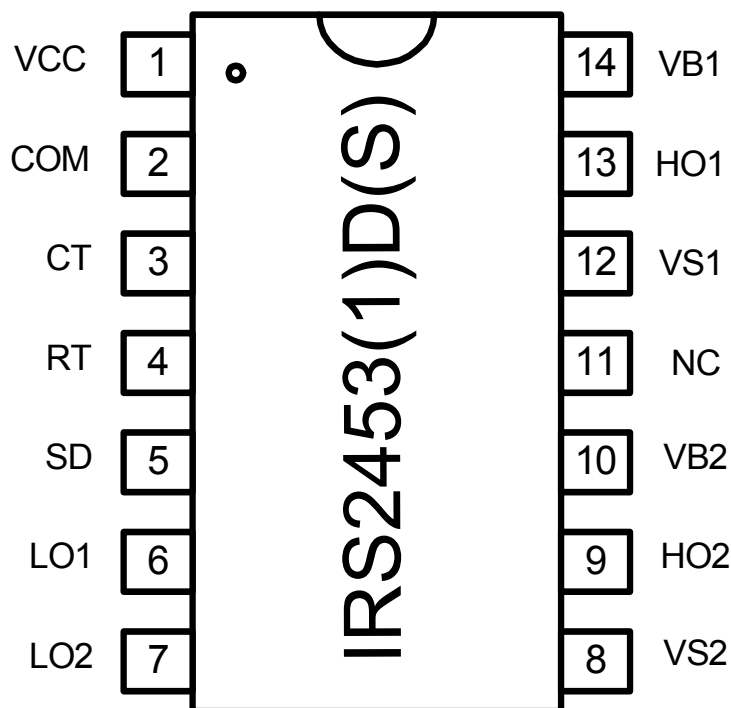
**Input/Output Pin Equivalent Circuit Diagrams:**



**Lead Definitions**

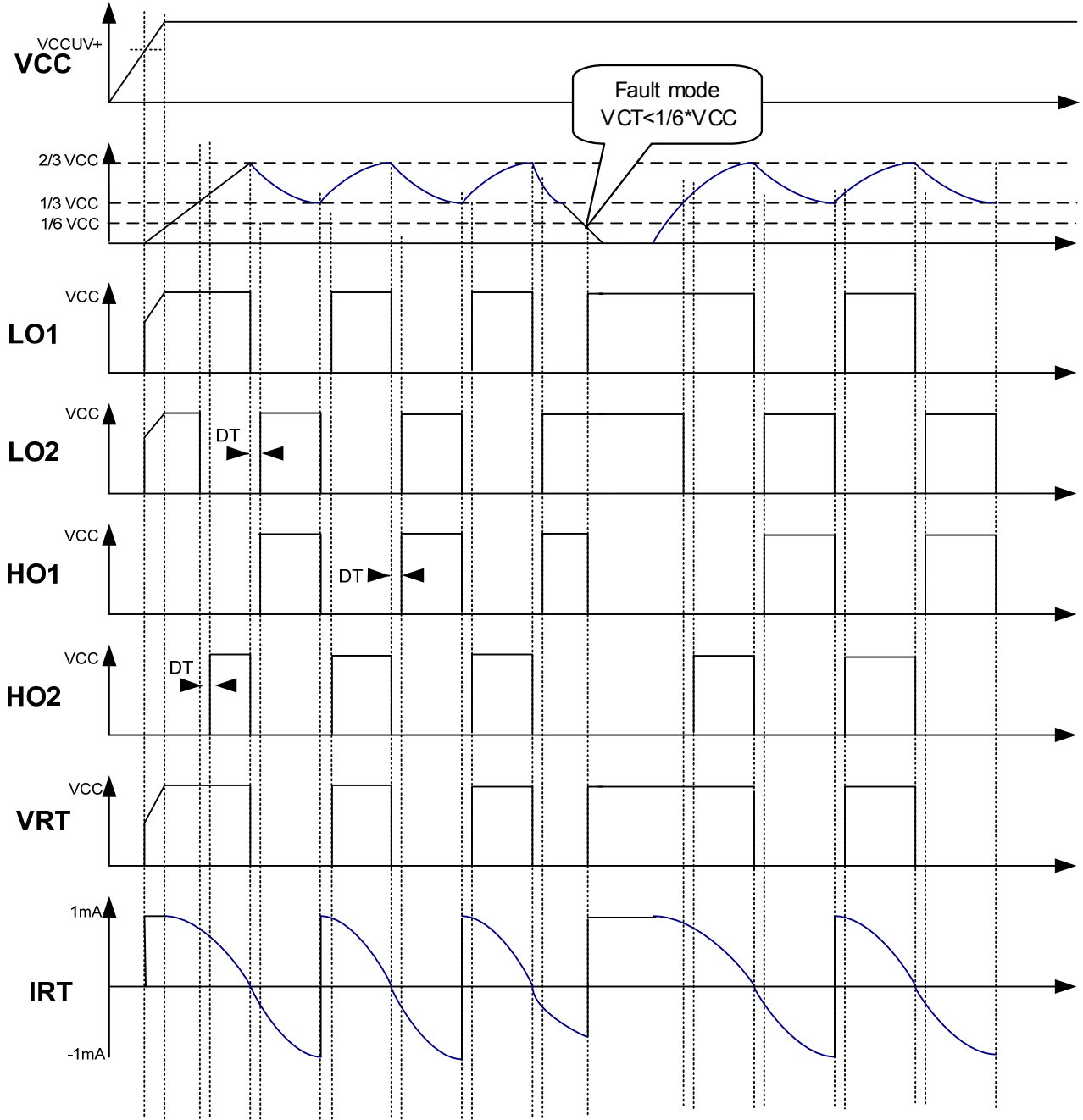
| Pin | Symbol | Description                                  |
|-----|--------|--|
| 1   | VCC    | Logic and internal gate drive supply voltage |
| 2   | COM    | IC power and signal ground                   |
| 3   | CT     | Oscillator timing capacitor input            |
| 4   | RT     | Oscillator timing resistor input             |
| 5   | SD     | Shutdown input                               |
| 6   | LO1    | Low side gate driver output                  |
| 7   | LO2    | Low side gate driver output                  |
| 8   | VS2    | High voltage floating supply return          |
| 9   | HO2    | High side gate driver output                 |
| 10  | VB2    | High side gate driver floating supply        |
| 11  | NC     | No connect                                   |
| 12  | VS1    | High voltage floating supply return          |
| 13  | HO1    | High side gate driver output                 |
| 14  | VB1    | High side gate driver floating supply        |

**Lead Assignment**



**Application Information and Additional Details**

**Timing Diagram**



## Functional Description

### Under-Voltage Lock-Out Mode (UVLO)

The under-voltage lockout mode (UVLO) is defined as the state the IC is in when  $V_{CC}$  is below the turn-on threshold of the IC. The IRS2453(1)D under-voltage lock-out is designed to maintain an ultra low supply current of less than 150  $\mu$ A, and to guarantee the IC is fully functional before the high and low side output drivers are activated. During under-voltage lock-out mode, the high and low side driver outputs LO1, LO2, HO1, HO2 are all low. With  $V_{CC}$  above the  $V_{CCUV+}$  threshold, the IC turns on and the output begin to oscillate.

### Normal Operating Mode

Once  $V_{CC}$  reaches the start-up threshold  $V_{CCUV+}$ , the MOSFET M1 opens, RT increases to approximately  $V_{CC}$  ( $V_{CC}-V_{RT+}$ ) and the external CT capacitor starts charging. Once the CT voltage reaches  $V_{CT-}$  (about 1/3 of  $V_{CC}$ ), established by an internal resistor ladder, LO1 and HO2 turn on with a delay equivalent to the deadtime ( $t_d$ ). Once the CT voltage reaches  $V_{CT+}$  (approximately 2/3 of  $V_{CC}$ ), LO1 and HO2 go low, RT goes down to approximately ground ( $V_{RT-}$ ), the CT capacitor starts discharging and the deadtime circuit is activated. At the end of the deadtime, LO2 and HO1 go high. Once the CT voltage reaches  $V_{CT-}$ , LO2 and HO1 go low, RT goes to high again, the deadtime is activated. At the end of the deadtime, LO1 and HO2 go high and the cycle starts over again.

The frequency is best determined by the graph, Frequency vs. RT, page 3, for different values of CT. A first order approximate of the oscillator frequency can also be calculated by the following formula::

$$f \approx \frac{1}{1.453 \times RT \times CT}$$

This equation can vary slightly from actual measurements due to internal comparator over- and under-shoot delays.

### Bootstrap MOSFET

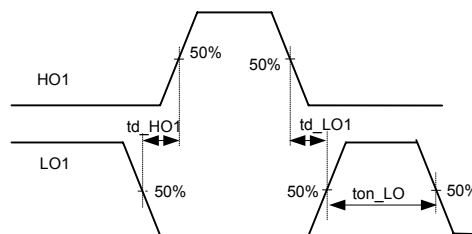
The internal bootstrap FET and supply capacitor ( $C_{BOOT}$ ) comprise the supply voltage for the high side driver circuitry. The internal bootstrap FET only turns on when the corresponding LO is high. To guarantee that the high-side supply is charged up before the first pulse on HO1 and HO2, LO1 and LO2 are both on when CT ramps between zero and 1/3\* $V_{CC}$ . LO1 and LO2 are also on when CT is grounded below 1/6\* $V_{CC}$  to ensure that the bootstrap capacitor is charged when CT is brought back over 1/3\* $V_{CC}$ .

### Non-Latched Shutdown

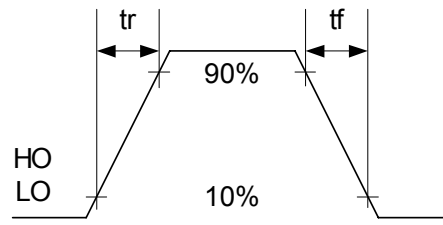
If CT is pulled down below  $V_{CTSD}$  (approximately 1/6 of  $V_{CC}$ ) by an external circuit, CT doesn't charge up and oscillation stops. All outputs are held low and the bootstrap FETs are off. Oscillation will resume once CT is able to charge up again to  $V_{CT-}$ .

### Latched Shutdown

When the SD pin is brought above 2 V, the IC goes into fault mode and all outputs are low.  $V_{CC}$  has to be recycled below  $V_{CCUV-}$  to restart the IC. The SD pin can be used for over-current or over-voltage protection using appropriate external circuitry.

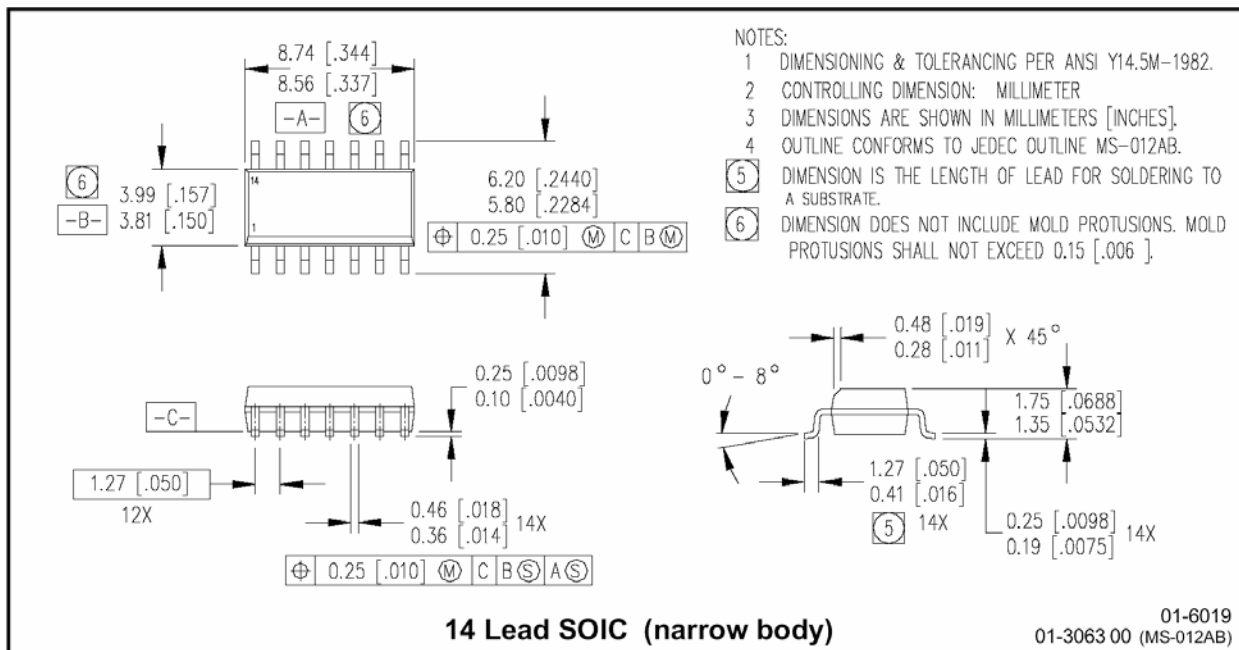
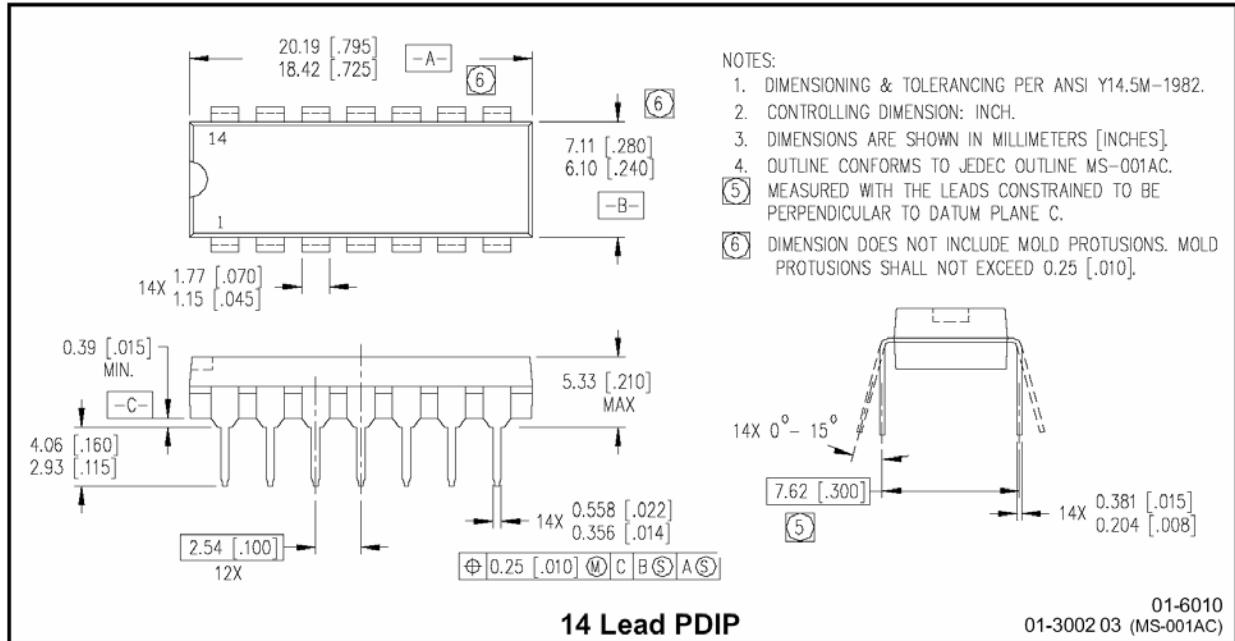


**Deadtime Waveform**

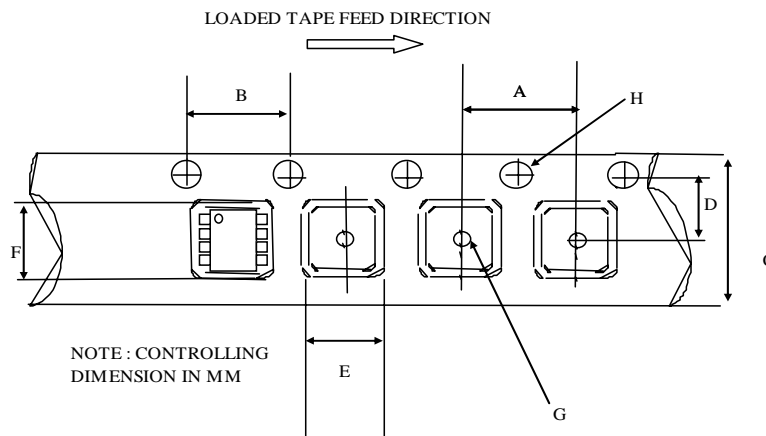


**Rise and Fall Time Waveform**

**Package Details**

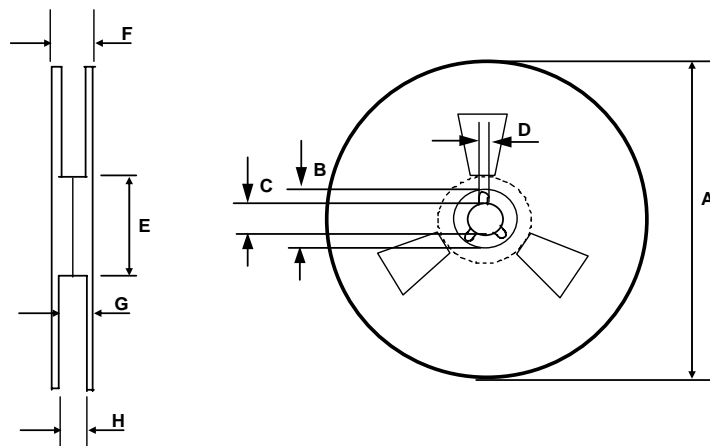


**Tape and Reel Details**



CARRIER TAPE DIMENSION FOR 14SOICN

| Code | Metric |       | Imperial |       |
|------|--------|-------|----------|-------|
|      | Min    | Max   | Min      | Max   |
| A    | 7.90   | 8.10  | 0.311    | 0.318 |
| B    | 3.90   | 4.10  | 0.153    | 0.161 |
| C    | 15.70  | 16.30 | 0.618    | 0.641 |
| D    | 7.40   | 7.60  | 0.291    | 0.299 |
| E    | 6.40   | 6.60  | 0.252    | 0.260 |
| F    | 9.40   | 9.60  | 0.370    | 0.378 |
| G    | 1.50   | n/a   | 0.059    | n/a   |
| H    | 1.50   | 1.60  | 0.059    | 0.062 |

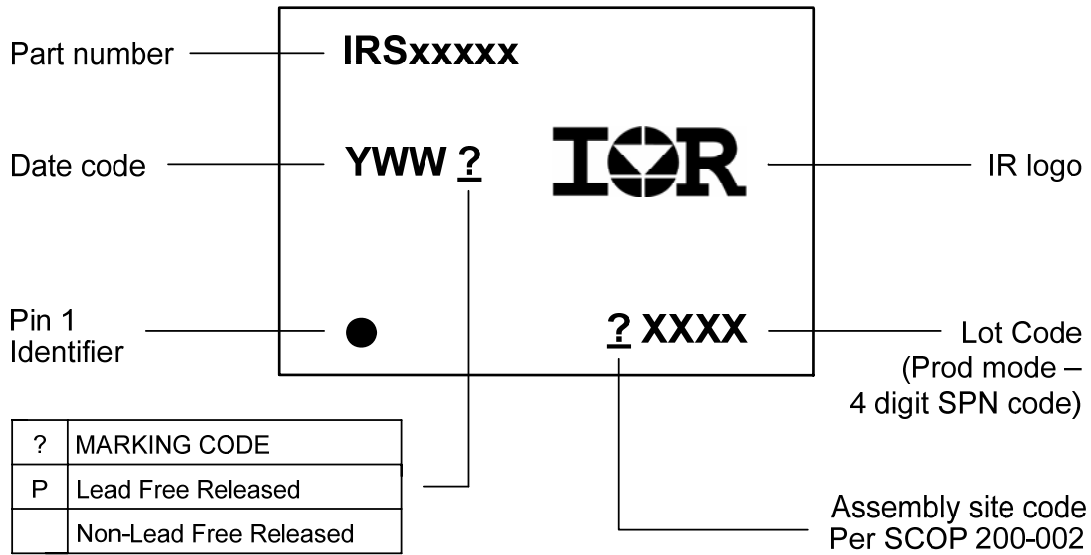


REEL DIMENSIONS FOR 14SOICN

| Code | Metric |        | Imperial |        |
|------|--------|--------|----------|--------|
|      | Min    | Max    | Min      | Max    |
| A    | 329.60 | 330.25 | 12.976   | 13.001 |
| B    | 20.95  | 21.45  | 0.824    | 0.844  |
| C    | 12.80  | 13.20  | 0.503    | 0.519  |
| D    | 1.95   | 2.45   | 0.767    | 0.096  |
| E    | 98.00  | 102.00 | 3.858    | 4.015  |
| F    | n/a    | 22.40  | n/a      | 0.881  |
| G    | 18.50  | 21.10  | 0.728    | 0.830  |
| H    | 16.40  | 18.40  | 0.645    | 0.724  |



**Part Marking Information**



**Ordering Information**

| Base Part Number | Package Type | Standard Pack |          | Complete Part Number |
|------------------|--------------|---------------|----------|----------------------|
|                  |              | Form          | Quantity |                      |
| IRS2453D(S)      | PDIP14       | Tube/Bulk     | 25       | IRS2453DPBF          |
|                  | SOIC14N      | Tube/Bulk     | 55       | IRS2453DSPBF         |
|                  |              | Tape and Reel | 2500     | IRS2453DSTRPBF       |
| IRS24531DS       | SOIC14N      | Tube/Bulk     | 55       | IRS24531DSPBF        |
|                  |              | Tape and Reel | 2500     | IRS24531DSTRPBF      |

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