

**SELF-OSCILLATING HALF-BRIDGE DRIVER IC**

**Features**

- Integrated 600V Half-Bridge Gate Driver
- CT, RT programmable oscillator
- 15.4V Zener Clamp on VCC
- Micropower Startup
- Non-latched shutdown on CT pin (1/6th VCC)
- Internal bootstrap FET
- Excellent Latch Immunity on All Inputs & Outputs
- +/- 50V/ns dV/dt immunity
- ESD Protection on All Pins
- 8-lead SOIC or PDIP package
- 1.1 usec (typ.) internal deadtime

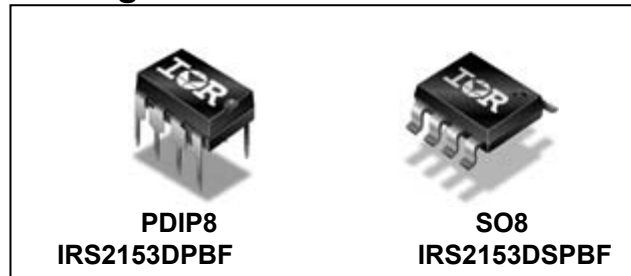
**Product Summary**

|                                   |                       |
|-----------------------------------|-----------------------|
| <b>VOFFSET</b>                    | <b>600V Max</b>       |
| <b>Duty Cycle</b>                 | <b>50%</b>            |
| <b>Driver source/sink current</b> | <b>180/260mA typ.</b> |
| <b>Vclamp</b>                     | <b>15.4V typ.</b>     |
| <b>Deadtime</b>                   | <b>1.1us typ.</b>     |

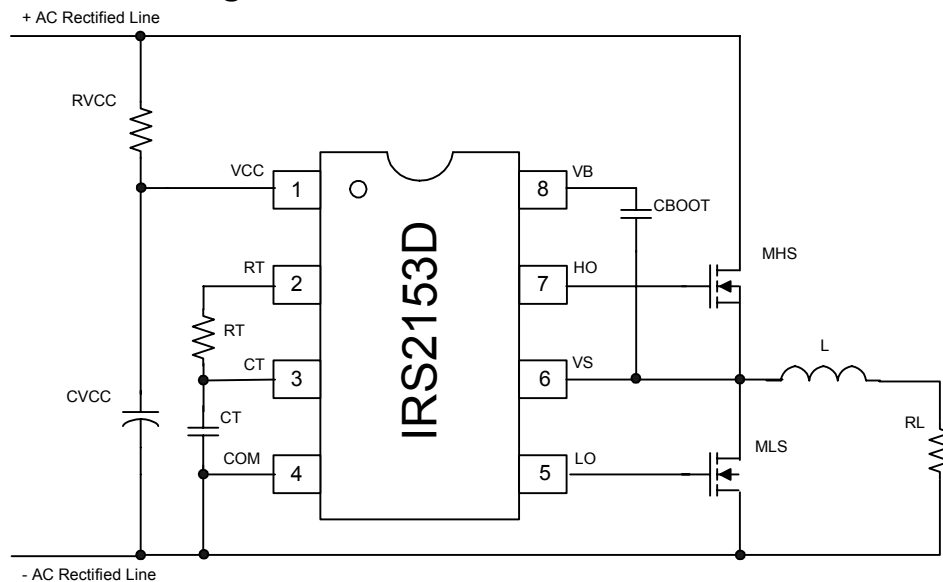
**Description**

The IRS2153D is based on the popular IR2153 self-oscillating half-bridge gate driver IC using a more advanced silicon platform, and incorporates a high voltage half-bridge gate driver with a front end oscillator similar to the industry standard CMOS 555 timer. HVIC and latch immune CMOS technologies enable rugged 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.

**Package**



**Typical Connection Diagram**



## 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.

| Parameter       |  | Min.        | Max.           | Units              |
|-----------------|--|-------------|----------------|--------------------|
| Symbol          | Definition   |             |                |                    |
| $V_B$           | High Side Floating Supply Voltage  | -0.3        | 625            | V                  |
| $V_S$           | High Side Floating Supply Offset Voltage   | $V_B - 25$  | $V_B + 0.3$    | V                  |
| $V_{HO}$        | High-Side Floating Output Voltage  | $V_S - 0.3$ | $V_B + 0.3$    | V                  |
| $V_{LO}$        | Low-Side Output Voltage  | -0.3        | $V_{CC} + 0.3$ | V                  |
| $I_{RT}$        | $R_T$ Pin Current  | -5          | 5              | mA                 |
| $V_{RT}$        | $R_T$ Pin Voltage  | -0.3        | $V_{CC} + 0.3$ | V                  |
| $V_{CT}$        | $C_T$ Pin Voltage  | -0.3        | $V_{CC} + 0.3$ | V                  |
| $I_{CC}$        | Supply Current (Note 1)  | ---         | 20             | mA                 |
| IOMAX           | Maximum allowable current at LO and HO due to external power transistor Miller effect. | -500        | 500            |                    |
| $dV_S/dt$       | Allowable Offset Voltage Slew Rate   | -50         | 50             | V/ns               |
| $P_D$           | Maximum Power Dissipation @ $T_A \leq +25^\circ\text{C}$ , 8-Pin DIP                   | ---         | 1.0            | W                  |
| $P_D$           | Maximum Power Dissipation @ $T_A \leq +25^\circ\text{C}$ , 8-Pin SOIC                  | ---         | 0.625          | W                  |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, 8-Pin DIP                                     | ---         | 85             | $^\circ\text{C/W}$ |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, 8-Pin SOIC                                    | ---         | 128            | $^\circ\text{C/W}$ |
| $T_J$           | Junction Temperature   | -55         | 150            | $^\circ\text{C}$   |
| $T_S$           | Storage Temperature  | -55         | 150            |                    |
| $T_L$           | Lead Temperature (Soldering, 10 seconds)   | ---         | 300            |                    |

**Note 1:** This IC contains a zener clamp structure between the chip  $V_{CC}$  and COM which has a nominal breakdown voltage of 15.4V. 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.

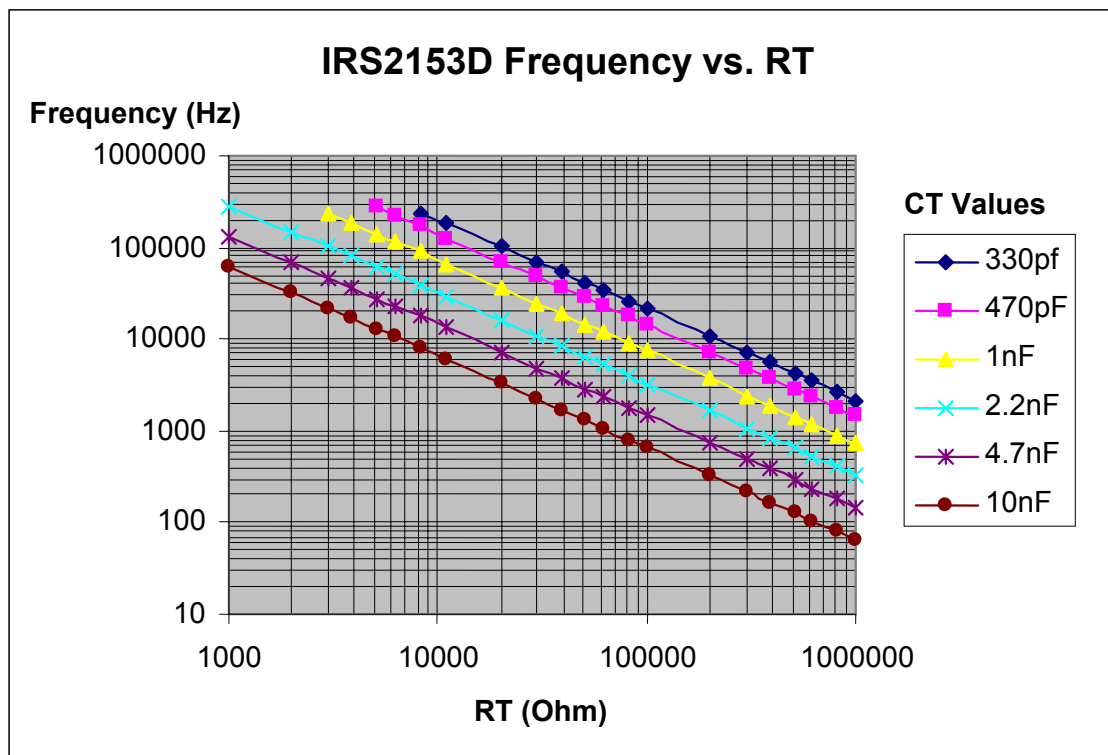
| Parameter |   | Min.               | Max.           | Units |
|-----------|---|--------------------|----------------|-------|
| Symbol    | Definition  |                    |                |       |
| $V_{BS}$  | High Side Floating Supply Voltage                     | $V_{CC} - 0.7$     | $V_{CLAMP}$    | V     |
| $V_S$     | Steady State High Side Floating Supply Offset Voltage | -3.0 (Note 2)      | 600            | V     |
| $V_{CC}$  | Supply Voltage  | $V_{CCUV+} + 0.1V$ | $V_{CC CLAMP}$ | V     |
| $I_{CC}$  | Supply Current  | (Note 3)           | 5              | mA    |
| $T_J$     | Junction Temperature                                  | -40                | 125            | °C    |

**Note 2:** Care should be taken to avoid output switching conditions where the  $V_S$  node flies inductively below ground by more than 5V.

**Note 3:** Enough current should be supplied to the  $V_{CC}$  pin of the IC to keep the internal 15.6V zener diode clamping the voltage at this pin.

## Recommended Component Values

| Parameter |                           | Min. | Max. | Units      |
|-----------|---------------------------|------|------|------------|
| Symbol    | Component                 |      |      |            |
| $R_T$     | Timing Resistor Value     | 1    | ---  | k $\Omega$ |
| $C_T$     | $C_T$ Pin Capacitor Value | 330  | ---  | pF         |



## Electrical Characteristics

VBIAS (V<sub>CC</sub>, V<sub>BS</sub>) = 14V, C<sub>T</sub> = 1 nF, V<sub>S</sub>=0V and T<sub>A</sub> = 25°C unless otherwise specified. The output voltage and current (V<sub>O</sub> and I<sub>O</sub>) parameters are referenced to COM and are applicable to the respective output leads: HO or LO.

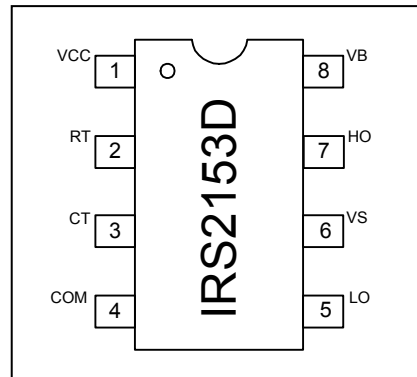
| Symbol                                    | Definition  | Min  | Typ  | Max  | Units | Test Conditions                                   |
|---|---|------|------|------|-------|---|
| <b>Low Voltage Supply Characteristics</b> |   |      |      |      |       |   |
| V <sub>CCUV+</sub>                        | Rising V <sub>CC</sub> Undervoltage Lockout Threshold                       | 10.2 | 10.8 | 11.5 | V     |   |
| V <sub>CCUV-</sub>                        | Falling V <sub>CC</sub> Undervoltage Lockout Threshold                      | 8.3  | 8.8  | 9.4  |       |   |
| V <sub>CCUVHYS</sub>                      | V <sub>CC</sub> Undervoltage Lockout Hysteresis                             | 1.6  | 2.0  | 2.4  |       |   |
| I <sub>QCCUV</sub>                        | Micropower Startup V <sub>CC</sub> Supply Current                           | ---  | 130  | 170  | μA    | V <sub>CC</sub> ≤ V <sub>CCUV-</sub>              |
| I <sub>QCC</sub>                          | Quiescent V <sub>CC</sub> Supply Current                                    | ---  | 800  | 1000 | μA    |   |
| I <sub>CC</sub>                           | V <sub>CC</sub> Supply Current  | ---  | 1.8  | ---  | mA    | R <sub>T</sub> = 36.9kΩ                           |
| V <sub>CCCLAMP</sub>                      | V <sub>CC</sub> Zener Clamp Voltage   | 14.4 | 15.4 | 16.8 | V     | I <sub>CC</sub> = 5mA                             |
| <b>Floating Supply Characteristics</b>    |   |      |      |      |       |   |
| I <sub>QBS</sub>                          | Quiescent V <sub>BS</sub> Supply Current                                    | ---  | 60   | 80   | μA    |   |
| V <sub>BSUV+</sub>                        | V <sub>BS</sub> Supply Undervoltage Positive Going Threshold                | 8.0  | 9.0  | 9.5  | V     |   |
| V <sub>BSUV-</sub>                        | V <sub>BS</sub> Supply Undervoltage negative Going Threshold                | 7.0  | 8.0  | 9.0  |       |   |
| I <sub>LK</sub>                           | Offset Supply Leakage Current   | ---  | ---  | 50   | μA    | V <sub>B</sub> = V <sub>S</sub> = 600V            |
| <b>Oscillator I/O Characteristics</b>     |   |      |      |      |       |   |
| f <sub>OSC</sub>                          | Oscillator Frequency  | 18.4 | 19.0 | 19.6 | kHz   | R <sub>T</sub> = 36.5kΩ                           |
|   |   | 88   | 93   | 100  |       | R <sub>T</sub> = 7.15kΩ                           |
| d   | R <sub>T</sub> Pin Duty Cycle   | ---  | 50   | ---  | %     | f <sub>o</sub> < 100kHz                           |
| I <sub>CT</sub>                           | C <sub>T</sub> Pin Current  | ---  | 0.02 | 1.0  | μA    |   |
| I <sub>CTUV</sub>                         | UV-Mode C <sub>T</sub> Pin Pulldown Current                                 | 0.20 | 0.30 | 0.6  | mA    | V <sub>CC</sub> = 7V                              |
| V <sub>CT+</sub>                          | Upper C <sub>T</sub> Ramp Voltage Threshold                                 | ---  | 9.32 | ---  | V     |   |
| V <sub>CT-</sub>                          | Lower C <sub>T</sub> Ramp Voltage Threshold                                 | ---  | 4.66 | ---  |       |   |
| V <sub>CTSD</sub>                         | C <sub>T</sub> Voltage Shutdown Threshold                                   | 2.2  | 2.3  | 2.4  |       |   |
| V <sub>RT+</sub>                          | High-Level R <sub>T</sub> Output Voltage, V <sub>CC</sub> - V <sub>RT</sub> | ---  | 10   | 50   | mV    | I <sub>RT</sub> = -100μA                          |
|   |   | ---  | 100  | 300  | mV    | I <sub>RT</sub> = -1mA                            |
| V <sub>RT-</sub>                          | Low-Level R <sub>T</sub> Output Voltage                                     | ---  | 10   | 50   | mV    | I <sub>RT</sub> = 100μA                           |
|   |   | ---  | 100  | 300  | mV    | I <sub>RT</sub> = 1mA                             |
| V <sub>RTUV</sub>                         | UV-Mode R <sub>T</sub> Output Voltage                                       | ---  | 0    | 100  | mV    | V <sub>CC</sub> ≤ V <sub>CCUV-</sub>              |
| V <sub>RTSD</sub>                         | SD-Mode R <sub>T</sub> Output Voltage, V <sub>CC</sub> - V <sub>RT</sub>    | ---  | 10   | 50   | mV    | I <sub>RT</sub> = -100μA,<br>V <sub>CT</sub> = 0V |
|   |   | ---  | 100  | 300  | mV    | I <sub>RT</sub> = -1mA,<br>V <sub>CT</sub> = 0V   |

## Electrical Characteristics

VBIAS (VCC, VBS) = 14V, CT = 1 nF, VS=0V and TA = 25°C unless otherwise specified. The output voltage and current (VO and IO) parameters are referenced to COM and are applicable to the respective output leads: HO or LO.

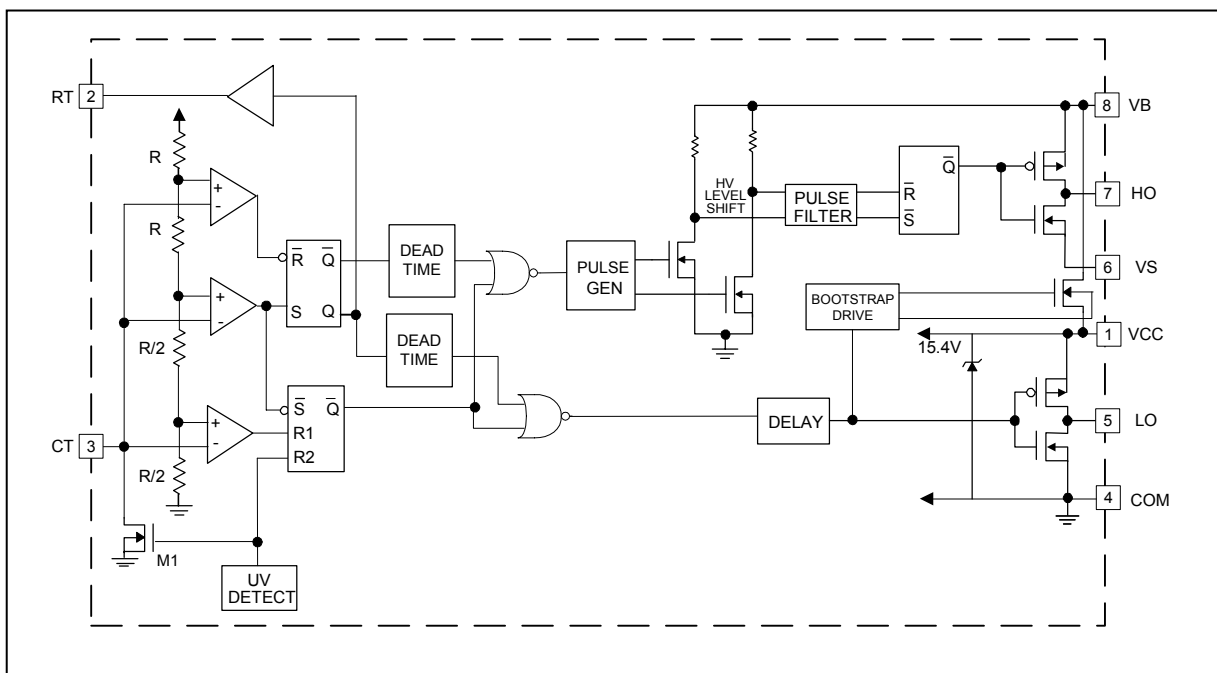
| Symbol                                    | Definition                       | Min  | Typ  | Max  | Units | Test Conditions   |
|---|----------------------------------|------|------|------|-------|---|
| <b>Gate Driver Output Characteristics</b> |                                  |      |      |      |       |   |
| V <sub>OH</sub>                           | High-Level Output Voltage        | ---  | VCC  | ---  |       | I <sub>O</sub> = 0A   |
| V <sub>OL</sub>                           | Low-Level Output Voltage         | ---  | COM  | ---  |       | I <sub>O</sub> = 0A   |
| V <sub>OL_UV</sub>                        | UV-Mode Output Voltage           | ---  | COM  | ---  |       | I <sub>O</sub> = 0A,<br>V <sub>CC</sub> ≤ V <sub>CCUV</sub> |
| t <sub>r</sub>                            | Output Rise Time                 | ---  | 120  | 220  | nsec  |   |
| t <sub>f</sub>                            | Output Fall Time                 | ---  | 50   | 80   |       |   |
| t <sub>sd</sub>                           | Shutdown Propagation Delay       | ---  | 350  | ---  |       |   |
| t <sub>d</sub>                            | Output Deadtime (HO or LO)       | 0.65 | 1.1  | 1.75 | μsec  |   |
| IO+                                       | Output source current            | ---  | 180  | ---  | mA    |   |
| IO-                                       | Output sink current              | ---  | 260  | ---  |       |   |
| <b>Bootstrap FET Characteristics</b>      |                                  |      |      |      |       |   |
| VB_ON                                     | VB when the bootstrap FET is on  | ---  | 13.7 | ---  | V     |   |
| IB_CAP                                    | VB source current when FET is on | 40   | 55   | ---  | mA    | CBS=0.1uF   |
| IB_10V                                    | VB source current when FET is on | 10   | 12   | ---  |       | VB=10V  |

## Lead Definitions



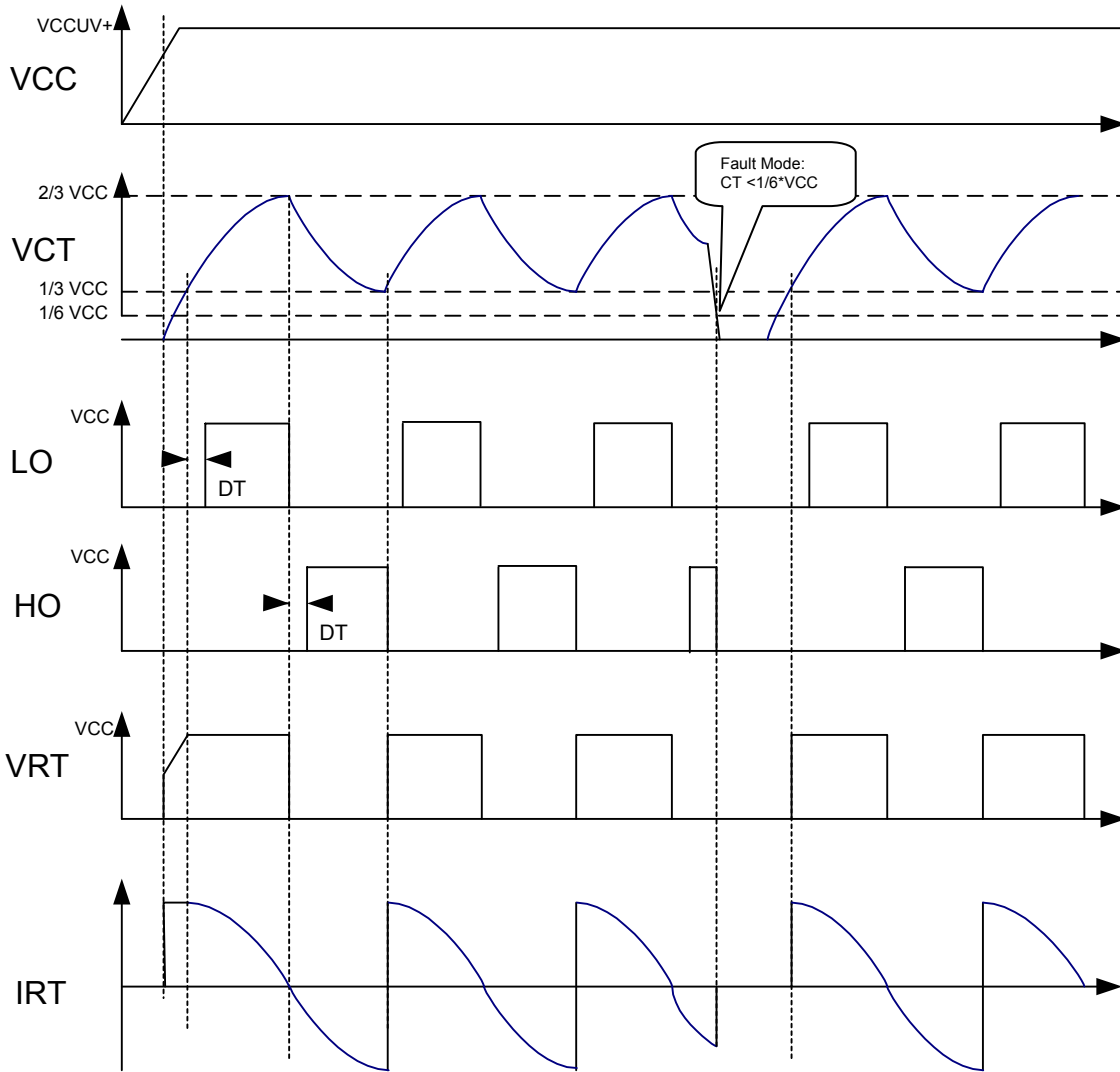
| Lead            |  |
|-----------------|--|
| Symbol          | Description                                  |
| V <sub>CC</sub> | Logic and internal gate drive supply voltage |
| R <sub>T</sub>  | Oscillator timing resistor input             |
| C <sub>T</sub>  | Oscillator timing capacitor input            |
| COM             | IC power and signal ground                   |
| LO              | Low-side gate driver output                  |
| V <sub>S</sub>  | High voltage floating supply return          |
| HO              | High-side gate driver output                 |
| V <sub>B</sub>  | High side gate driver floating supply        |

## Functional Block Diagram

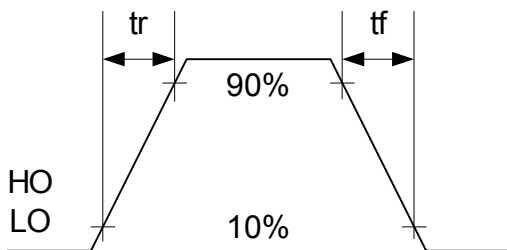


**Timing Diagram**

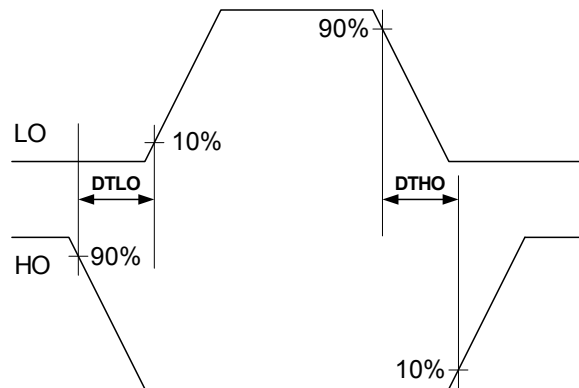
**Operating Mode**



**Switching Time Waveform**



**Deadtime Waverform**



## Functional Description

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

The under-voltage lockout mode (UVLO) is defined as the state the IC is in when VCC is below the turn-on threshold of the IC. The IRS2153D under voltage lock-out is designed to maintain an ultra low supply current of less than 155uA, 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 HO and LO are both low.

### Supply voltage

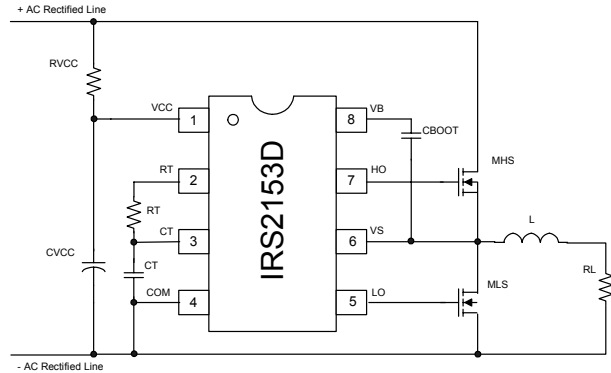


Fig. 1 Typical Connection Diagram

Fig. 1 shows an example of supply voltage. The start-up capacitor ( $C_{VCC}$ ) is charged by current through supply resistor ( $R_{VCC}$ ) minus the start-up current drawn by the IC. This resistor is chosen to provide sufficient current to supply the IRS2153D from the DC bus.  $C_{VCC}$  should be large enough to hold the voltage at Vcc above the UVLO threshold for one half cycle of the line voltage as it will only be charged at the peak, typically 0.1uF. It will be necessary for  $R_{VCC}$  to dissipate around 1W.

The use of a two diode charge pump made of DC1, DC2 and CVS (Fig. 2) from the half bridge (VS) is also possible however the above approach is simplest and the dissipation in  $R_{VCC}$  should not be unacceptably high.

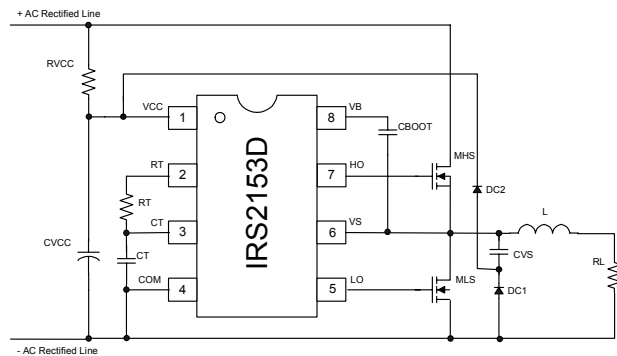


Fig. 2 Charge pump circuit

The supply resistor ( $R_{VCC}$ ) must be selected such that enough supply current is available over all operating conditions.

Once the capacitor voltage on VCC reaches the start-up threshold  $V_{CCUV+}$ , the IC turns on and HO and LO begin to oscillate.

### 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 LO is high. To guarantee that the high-side supply is charged up before the first pulse on pin HO, the first pulse from the output drivers comes from the LO pin.

### Normal operating mode

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

The following equation provides the oscillator frequency:

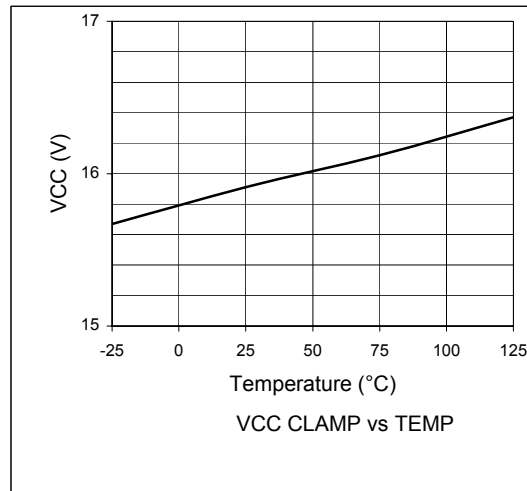
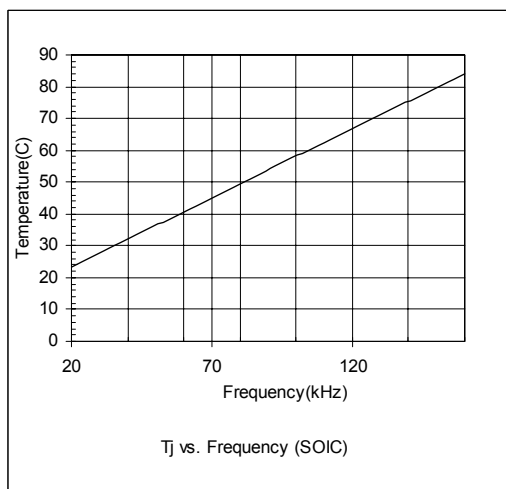
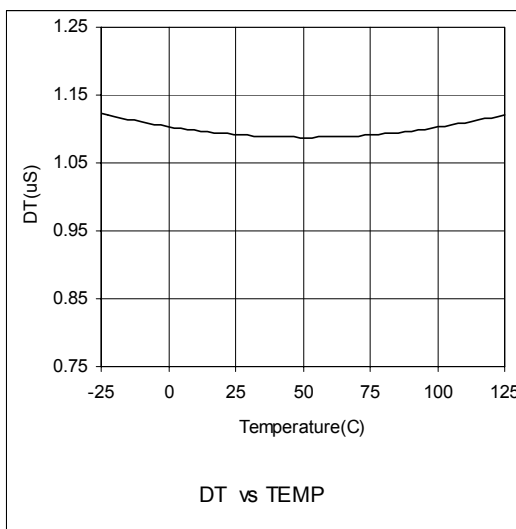
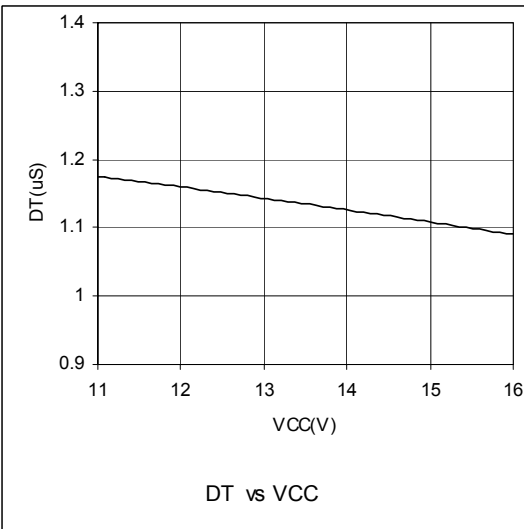
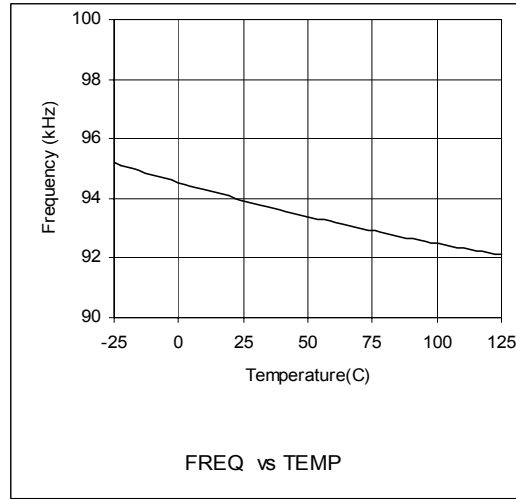
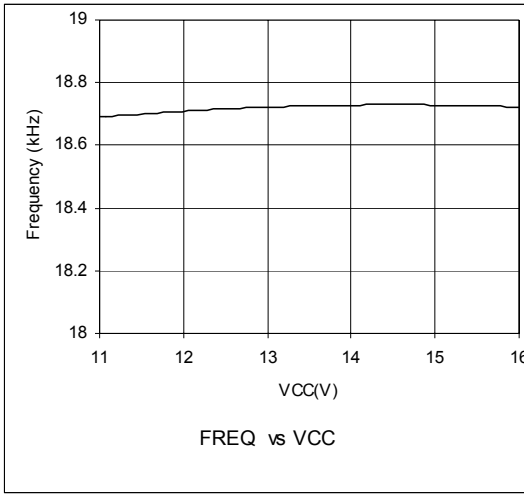
$$f \sim \frac{1}{1.453 \times RT \times CT}$$

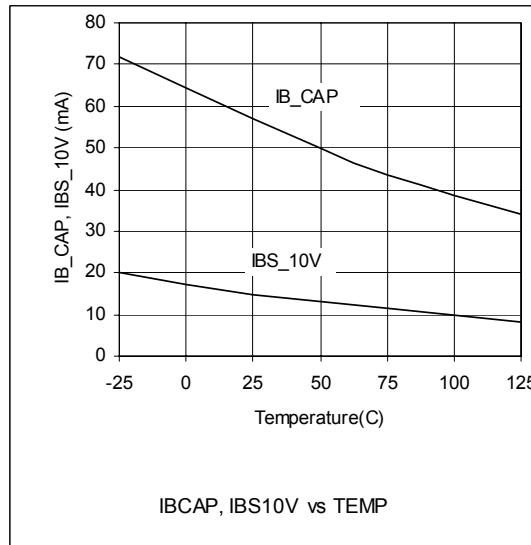
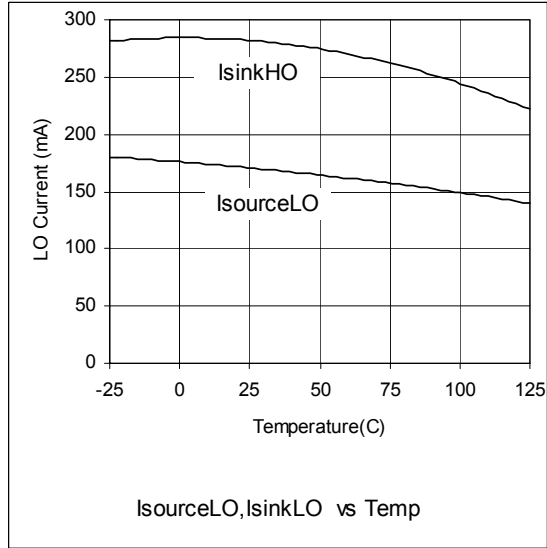
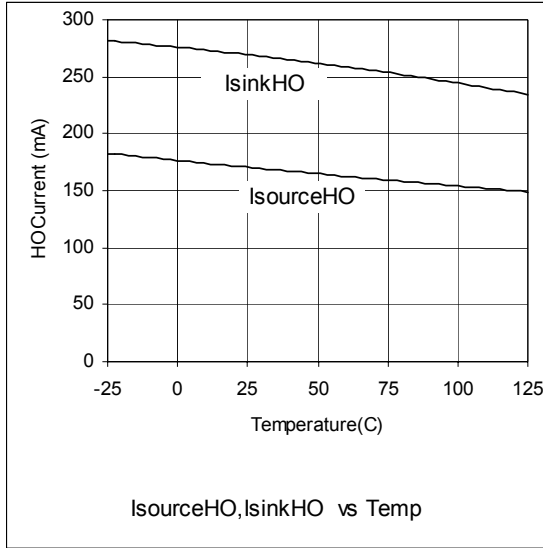
This equation can vary slightly from actual measurements due to internal comparator over- and under-shoot delays. For a more accurate determination of the output frequency, the frequency characteristic curves should be used (RT vs. Frequency, Page 3).

### Shut-down

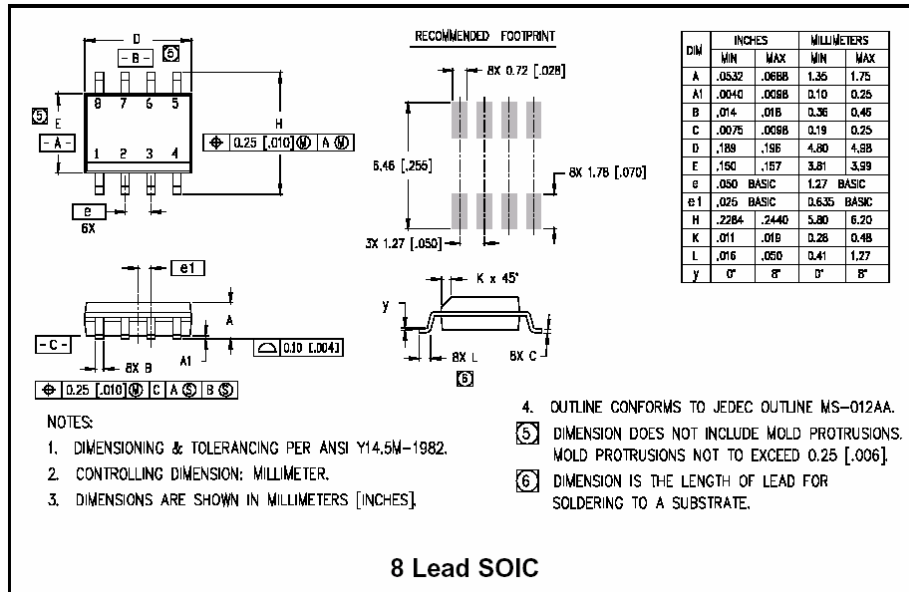
If CT is pulled down below  $V_{CTSD}$  (approximately 1/6 of VCC) by an external circuit, CT doesn't charge up and oscillation stops. LO is held low and the bootstrap FET is off. Oscillation will resume once CT is able to charge up again to  $V_{CT-}$ .



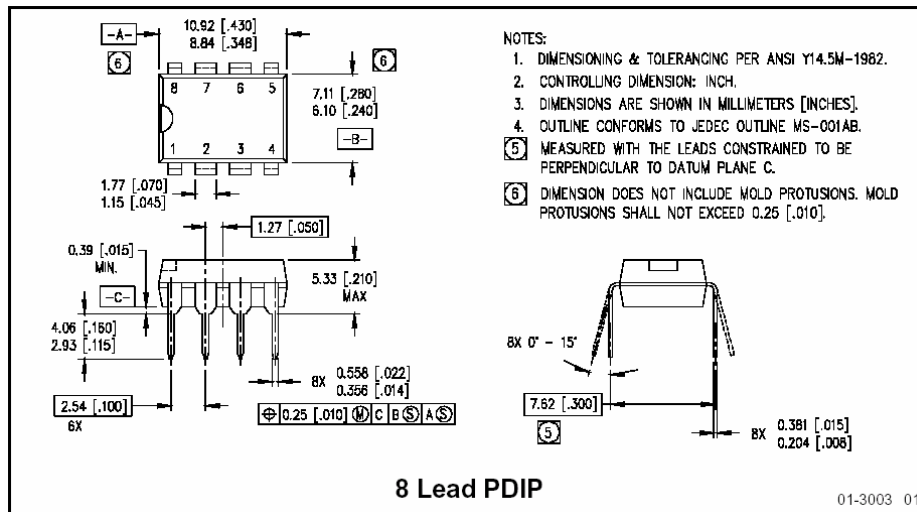




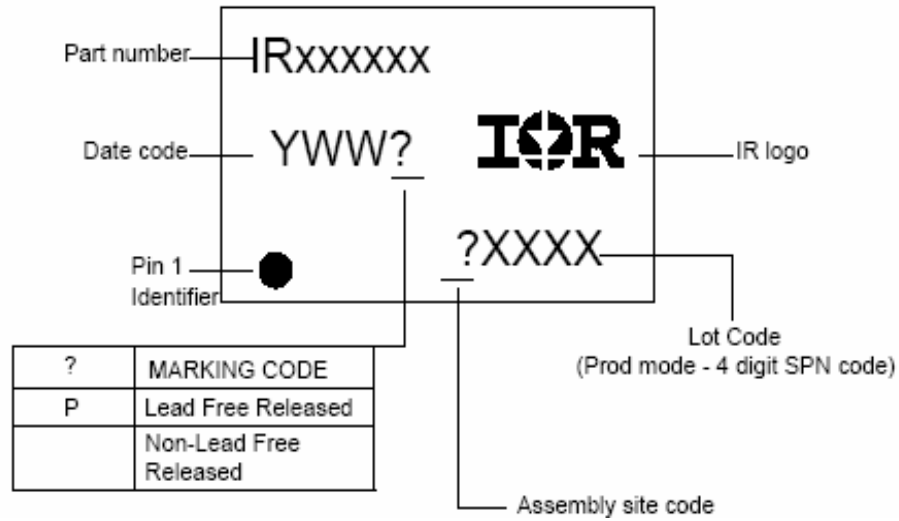
## IRS2153DSPbF



## IRS2153DPbF



**LEADFREE PART MARKING INFORMATION**



**ORDER INFORMATION**

**Leadfree Part**

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8-Lead SOIC IRS2153DS order IRS2153DSPbF

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