

# IRS2304(S)PbF HALF-BRIDGE DRIVER

## Features

- Floating channel designed for bootstrap operation to +600 V
- Tolerant to negative transient voltage, dV/dt immune
- Gate drive supply range from 10 V to 20 V
- Undervoltage lockout for both channels
- 3.3 V, 5 V, and 15 V input logic input compatible
- Cross-conduction prevention logic
- Matched propagation delay for both channels
- Lower di/dt gate driver for better noise immunity
- Internal 100 ns deadtime
- Output in phase with input
- RoHS compliant

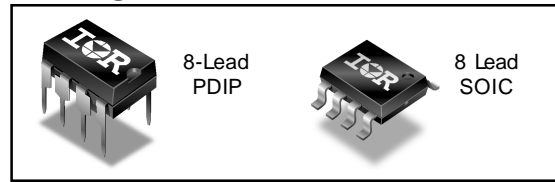
## Description

The IRS2304 is a high voltage, high speed power MOSFET and IGBT driver with independent high-side and low-side referenced output channels. Proprietary HVIC and latch immune CMOS technologies enable ruggedized monolithic construction. The logic input is compatible with standard CMOS or LSTTL output, down to 3.3 V logic. The output driver features a high pulse current buffer stage designed for minimum driver cross-conduction. The floating channel can be used to drive an N-channel power MOSFET or IGBT in the high-side configuration which operates up to 600 V.

## Product Summary

|                         |               |
|-------------------------|---------------|
| V <sub>OFFSET</sub>     | 600 V max.    |
| I <sub>O+/-</sub> (min) | 60 mA/130 mA  |
| V <sub>OUT</sub>        | 10 V - 20 V   |
| Delay Matching          | 50 ns         |
| Internal deadtime       | 100 ns        |
| ton/off (typ.)          | 150 ns/150 ns |

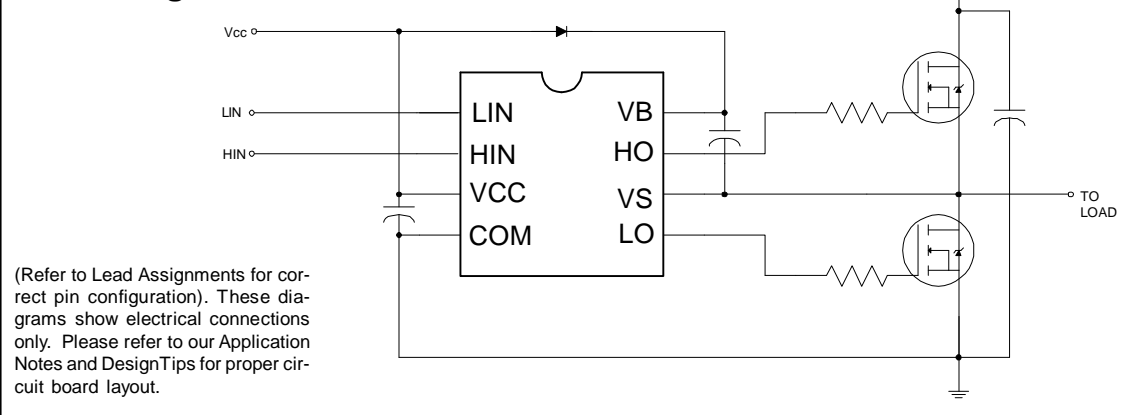
## Package



## Feature Comparison

| Part      | Input logic                  | Cross-conduction prevention logic | Deadtime (ns) | Ground Pins             | ton/toff (ns) |
|-----------|------------------------------|-----------------------------------|---------------|-------------------------|---------------|
| 2106/2301 | HIN/LIN                      | no                                | none          | COM                     | 220/200       |
| 21064     |                              |                                   |               | Vss/COM                 |               |
| 2108      | HIN/ $\overline{\text{LIN}}$ | yes                               | Internal 540  | COM                     | 220/200       |
| 21084     |                              |                                   |               | Vss/COM                 |               |
| 2109/2302 |                              |                                   |               | Programmable 540 - 5000 |               |
| 21094     | IN/ $\overline{\text{SD}}$   | yes                               | Internal 540  | COM                     | 750/200       |
| 21094     |                              |                                   |               | Programmable 540 - 5000 |               |
| 2304      | HIN/LIN                      | yes                               | Internal 100  | COM                     | 160/140       |

## Block 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.

| Symbol              | Definition                                | Min.                 | Max.                  | Units |      |
|---------------------|---|----------------------|-----------------------|-------|------|
| V <sub>S</sub>      | High-side offset voltage                  | V <sub>B</sub> - 25  | V <sub>B</sub> + 0.3  | V     |      |
| V <sub>B</sub>      | High-side floating supply voltage         | -0.3                 | 625                   |       |      |
| V <sub>HO</sub>     | High-side floating output voltage HO      | V <sub>S</sub> - 0.3 | V <sub>B</sub> + 0.3  |       |      |
| V <sub>CC</sub>     | Low-side and logic fixed supply voltage   | -0.3                 | 25                    |       |      |
| V <sub>LO</sub>     | Low-side output voltage LO                | -0.3                 | V <sub>CC</sub> + 0.3 |       |      |
| V <sub>IN</sub>     | Logic input voltage (HIN, LIN)            | -0.3                 | V <sub>CC</sub> + 0.3 |       |      |
| Com                 | Logic ground                              | V <sub>CC</sub> -25  | V <sub>CC</sub> + 0.3 |       |      |
| dV <sub>S</sub> /dt | Allowable offset supply voltage transient | —                    | 50                    | V/ns  |      |
| P <sub>D</sub>      | Package power dissipation @ TA ≤ +25 °C   | 8-Lead SOIC          | —                     | 0.625 | W    |
|                     |   | 8-Lead PDIP          | —                     | 1.0   |      |
| R <sub>thJA</sub>   | Thermal resistance, junction to ambient   | 8-Lead SOIC          | —                     | 200   | °C/W |
|                     |   | 8-Lead PDIP          | —                     | 125   |      |
| T <sub>J</sub>      | Junction temperature                      | —                    | 150                   | °C    |      |
| T <sub>S</sub>      | Storage temperature                       | -50                  | 150                   |       |      |
| T <sub>L</sub>      | Lead temperature (soldering, 10 seconds)  | —                    | 300                   |       |      |

## Recommended Operating Conditions

The input/output logic timing diagram is shown in Fig. 1. For proper operation the device should be used within the recommended conditions. The V<sub>S</sub> offset rating is tested with all supplies biased at 15 V differential.

| Symbol          | Definition                               | Min.                | Max.                | Units |
|-----------------|--|---------------------|---------------------|-------|
| V <sub>B</sub>  | High-side floating supply voltage        | V <sub>S</sub> + 10 | V <sub>S</sub> + 20 | V     |
| V <sub>S</sub>  | High-side floating supply offset voltage | Note 1              | 600                 |       |
| V <sub>HO</sub> | High-side (HO) output voltage            | V <sub>S</sub>      | V <sub>B</sub>      |       |
| V <sub>LO</sub> | Low-side (LO) output voltage             | COM                 | V <sub>CC</sub>     |       |
| V <sub>IN</sub> | Logic input voltage (HIN, LIN)           | COM                 | V <sub>CC</sub>     |       |
| V <sub>CC</sub> | Low-side supply voltage                  | 10                  | 20                  |       |
| T <sub>A</sub>  | Ambient temperature                      | -40                 | 125                 | °C    |

**Note 1:** Logic operational for V<sub>S</sub> of COM -5 V to COM +600 V. Logic state held for V<sub>S</sub> of COM -5 V to COM -V<sub>BS</sub>.

### Static Electrical Characteristics

$V_{BIAS}$  ( $V_{CC}$ ,  $V_{BS}$ ) = 15 V and  $T_A$  = 25 °C unless otherwise specified. The  $V_{IN}$ ,  $V_{TH}$ , and  $I_{IN}$  parameters are referenced to COM. The  $V_O$  and  $I_O$  parameters are referenced to COM and  $V_S$  is applicable to HO and LO.

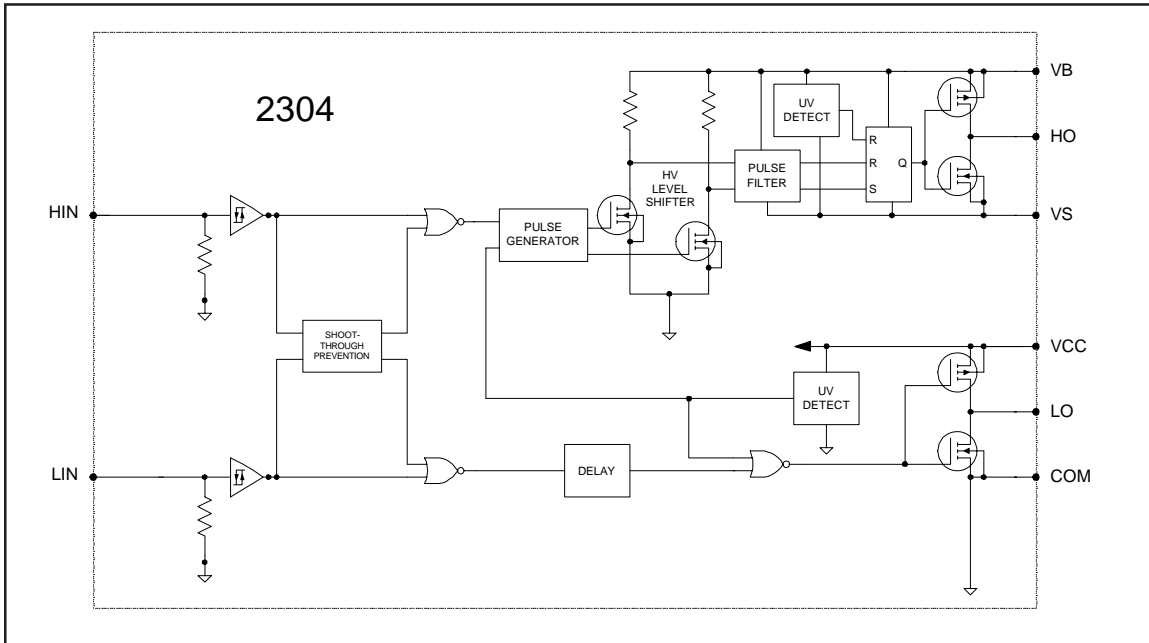
| Symbol                     | Definition   | Min. | Typ. | Max. | Units   | Test Conditions                   |
|----------------------------|--|------|------|------|---------|-----------------------------------|
| $V_{CCUV+}$<br>$V_{BSUV+}$ | $V_{CC}$ and $V_{BS}$ supply undervoltage positive going threshold | 8    | 8.9  | 9.8  | V       |                                   |
| $V_{CCUV-}$<br>$V_{BSUV-}$ | $V_{CC}$ and $V_{BS}$ supply undervoltage negative going threshold | 7.4  | 8.2  | 9    |         |                                   |
| $V_{CCUVH}$<br>$V_{BSUVH}$ | $V_{CC}$ supply undervoltage lockout hysteresis                    | 0.3  | 0.7  | —    |         |                                   |
| $I_{LK}$                   | Offset supply leakage current                                      | —    | —    | 50   | $\mu A$ | $V_B = V_S = 600 V$               |
| $I_{QBS}$                  | Quiescent $V_{BS}$ supply current                                  | 20   | 60   | 150  |         | $V_{IN} = 0 V$ or 5 V             |
| $I_{QCC}$                  | Quiescent $V_{CC}$ supply current                                  | 50   | 120  | 240  |         |                                   |
| $V_{IH}$                   | Logic "1" input voltage  | 2.3  | —    | —    | V       | $I_O = 2 mA$                      |
| $V_{IL}$                   | Logic "0" input voltage  | —    | —    | 0.7  |         |                                   |
| $V_{OH}$                   | High level output voltage, $V_{BIAS} - V_O$                        | —    | 0.05 | 0.2  |         |                                   |
| $V_{OL}$                   | Low level output voltage, $V_O$                                    | —    | 0.02 | 0.1  |         |                                   |
| $I_{IN+}$                  | Logic "1" input bias current                                       | —    | 5    | 40   | $\mu A$ | $V_{IN} = 5 V$                    |
| $I_{IN-}$                  | Logic "0" input bias current                                       | —    | 1.0  | 5.0  |         | $V_{IN} = 0 V$                    |
| $I_{O+}$                   | Output high short circuit pulse current                            | 60   | 290  | —    | mA      | $V_O = 0 V$<br>$PW \leq 10 \mu s$ |
| $I_{O-}$                   | Output low short circuit pulsed current                            | 130  | 600  | —    |         |                                   |

### Dynamic Electrical Characteristics

$V_{BIAS}$  ( $V_{CC}$ ,  $V_{BS}$ ) = 15 V,  $V_S = COM$ ,  $C_L = 1000 pF$  and  $T_A = 25 °C$  unless otherwise specified.

| Symbol    | Definition                          | Min. | Typ. | Max. | Units | Test Conditions      |
|-----------|-------------------------------------|------|------|------|-------|----------------------|
| $t_{on}$  | Turn-on propagation delay           | 90   | 150  | 210  | ns    | $V_S = 0 V$          |
| $t_{off}$ | Turn-off propagation delay          | 90   | 150  | 210  |       | $V_S = 0 V$ or 600 V |
| $t_r$     | Turn-on rise time                   | —    | 70   | 120  |       |                      |
| $t_f$     | Turn-off fall time                  | —    | 35   | 60   |       |                      |
| DT        | Deadtime                            | 80   | 100  | 190  |       |                      |
| MT        | Delay matching, HS & LS turn-on/off | —    | —    | 50   |       |                      |

## Functional Block Diagram



## Lead Definitions

| Symbol | Description                                  |
|--------|--|
| VCC    | Low-side supply voltage                      |
| COM    | Logic ground and low-side driver return      |
| HIN    | Logic input for high-side gate driver output |
| LIN    | Logic input for low-side gate driver output  |
| VB     | High-side floating supply                    |
| HO     | High-side driver output                      |
| VS     | High voltage floating supply return          |
| LO     | Low-side driver output                       |

## Lead Assignments

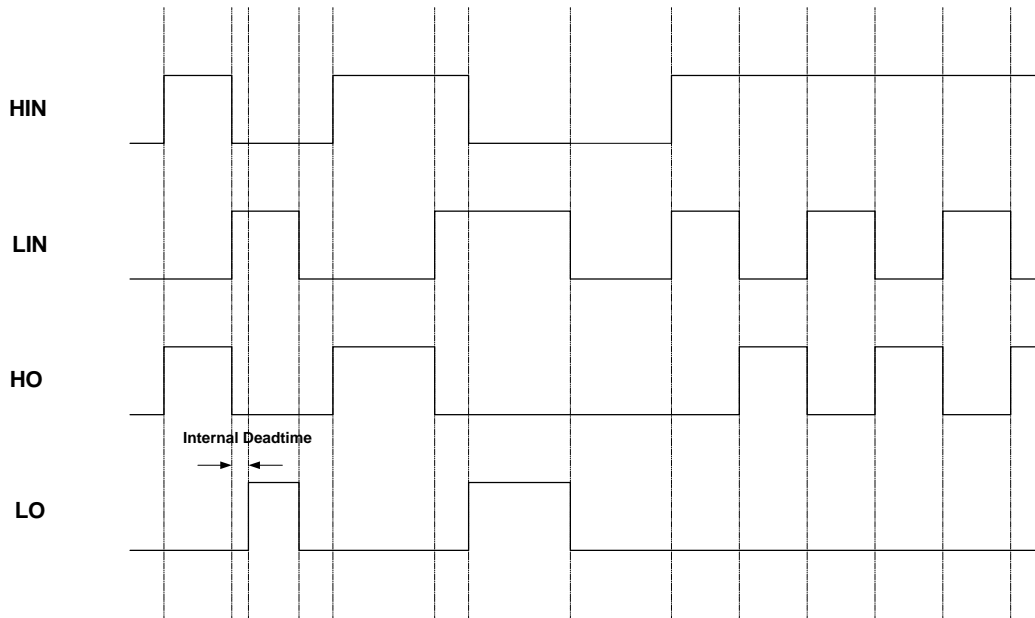
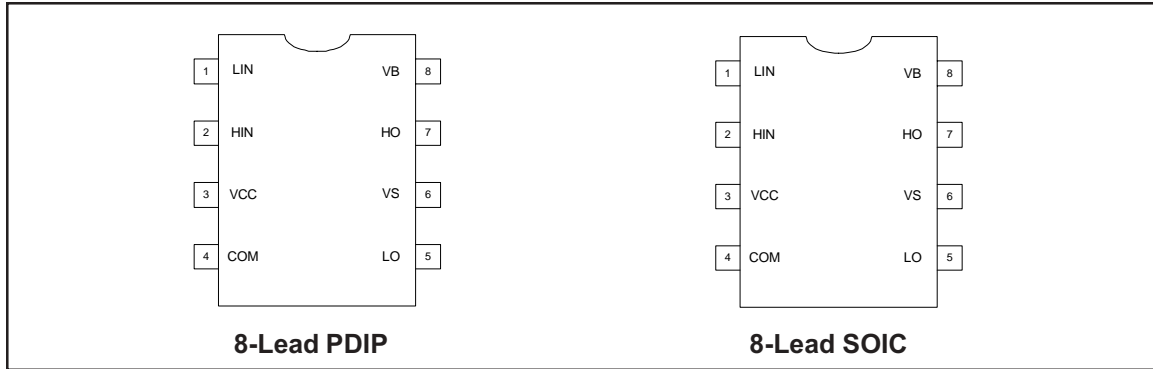


Figure 1. Input/Output Functionality Diagram

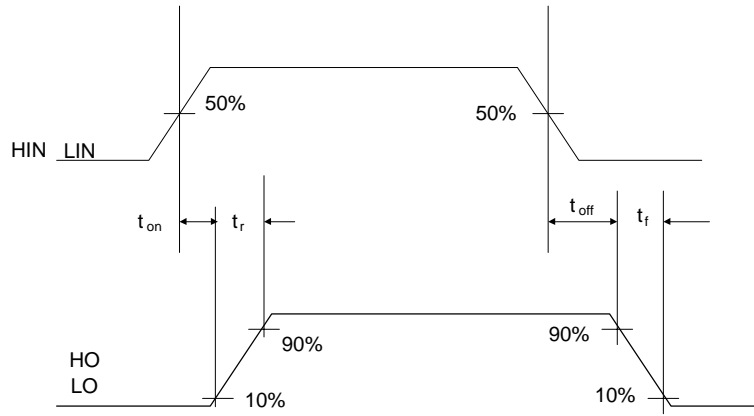


Figure 2. Switching Time Waveforms

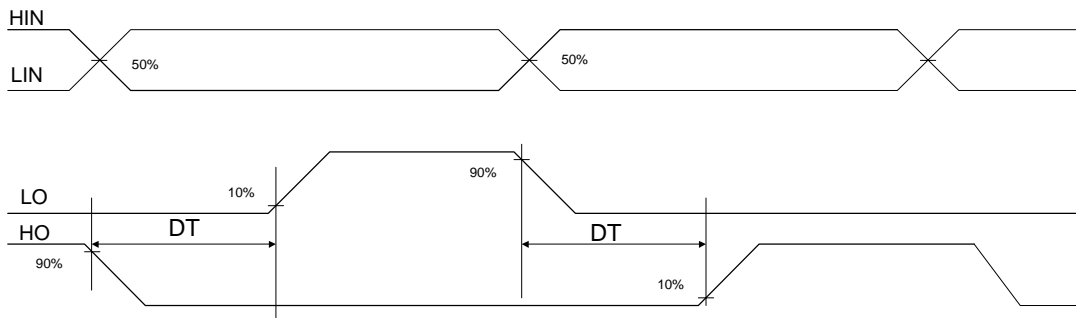
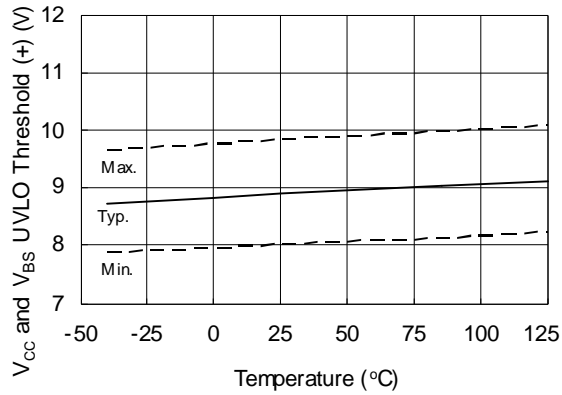
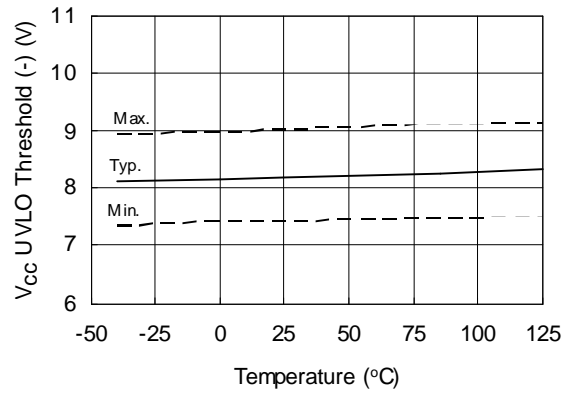


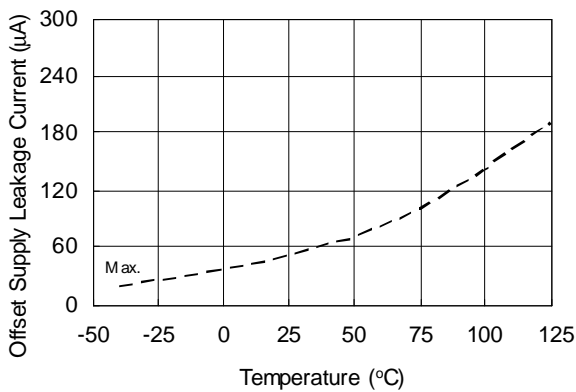
Figure 3. Internal Deadtime Timing



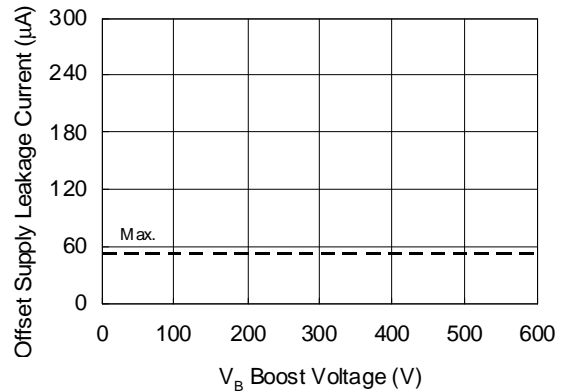
**Figure 4.  $V_{CC}$  and  $V_{BS}$  Undervoltage Threshold (+) vs. Temperature**



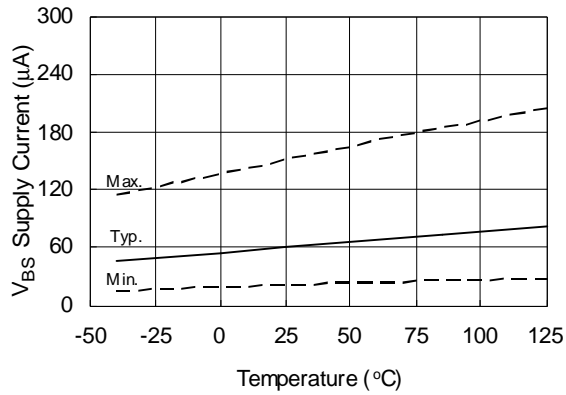
**Figure 5.  $V_{CC} / V_{DD}$  Undervoltage Threshold (-) vs. Temperature**



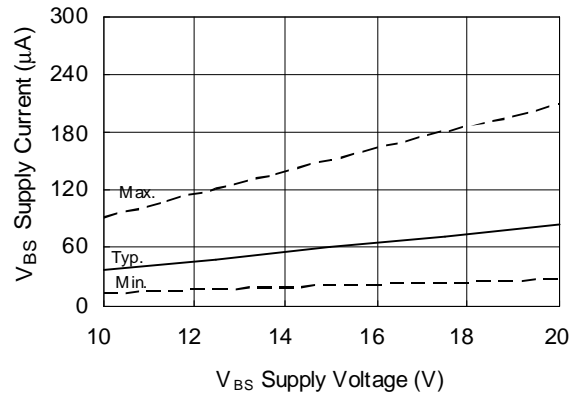
**Figure 6A. Offset Supply Leakage Current vs. Temperature**



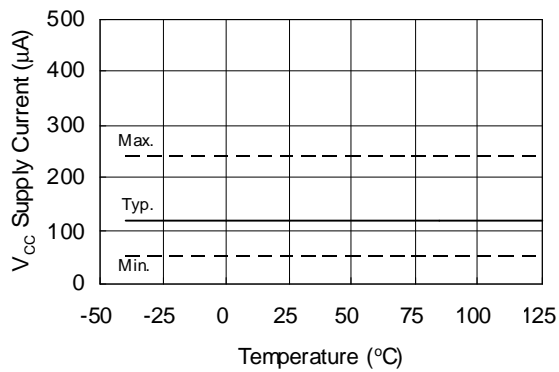
**Figure 6B. Offset Supply Leakage Current vs. Supply Voltage**



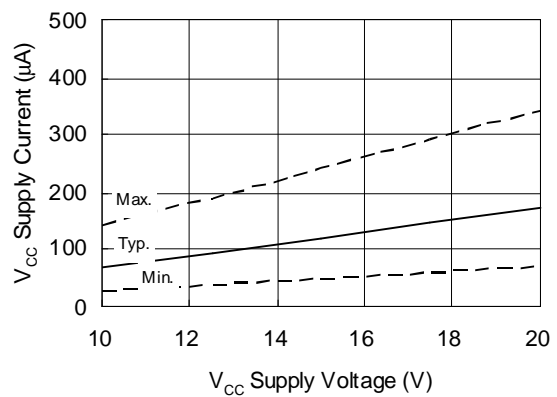
**Figure 7A.  $V_{BS}$  Supply Current vs. Temperature**



**Figure 7B.  $V_{BS}$  Supply Current vs. Supply Voltage**

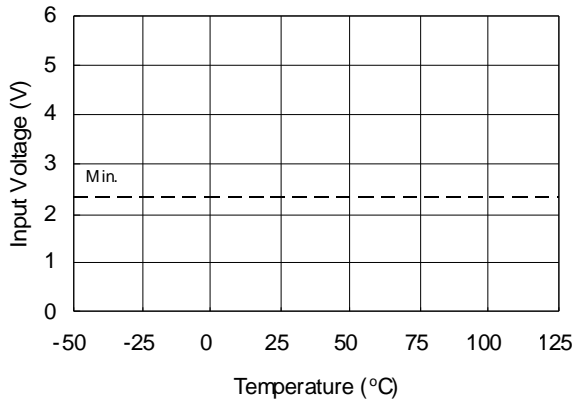


**Figure 8A. Quiescent  $V_{CC}$  Supply Current vs. Temperature**

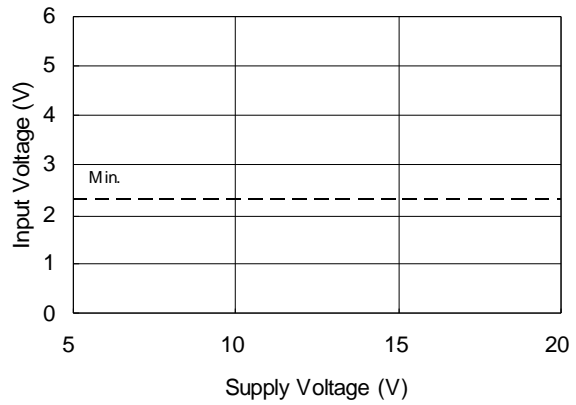


**Figure 8B. Quiescent  $V_{CC}$  Supply Current vs. Supply Voltage**

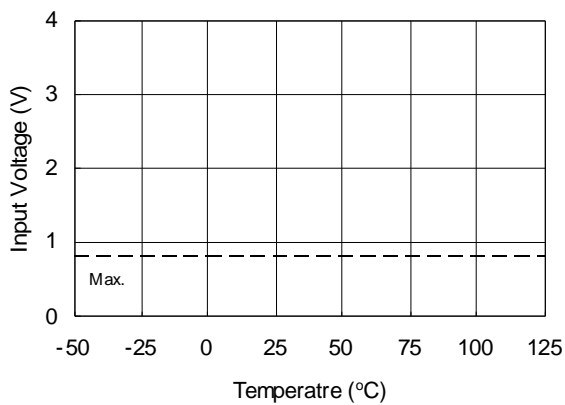




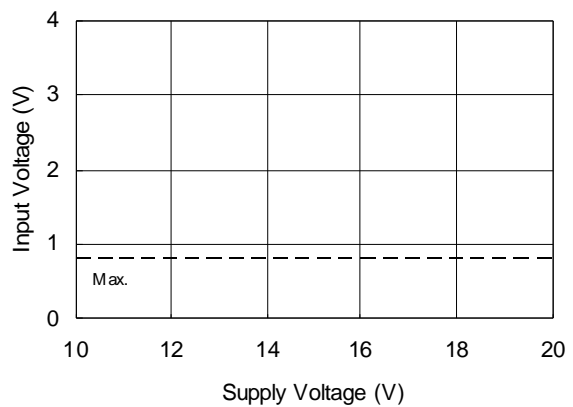
**Figure 9A. Logic "1" Input Voltage vs. Temperature**



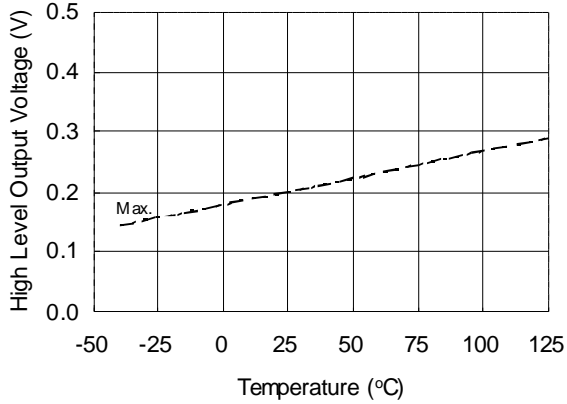
**Figure 9B. Logic "1" Input Voltage vs. Supply Voltage**



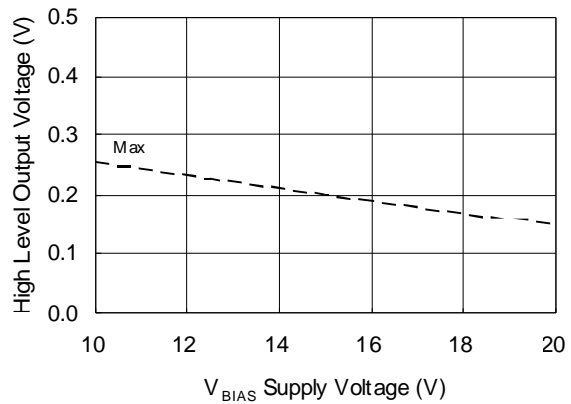
**Figure 10A. Logic "0" Input Voltage vs. Temperature**



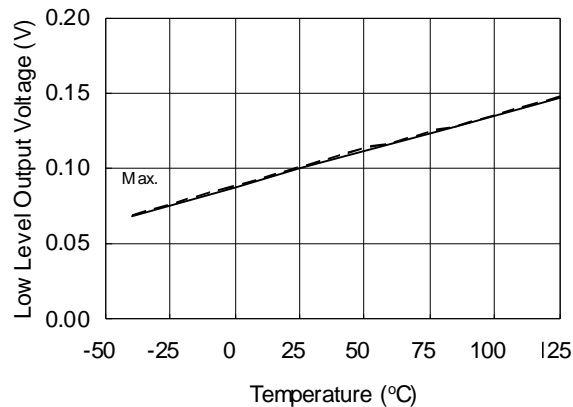
**Figure 10B. Logic "0" Input Voltage vs. Supply Voltage**



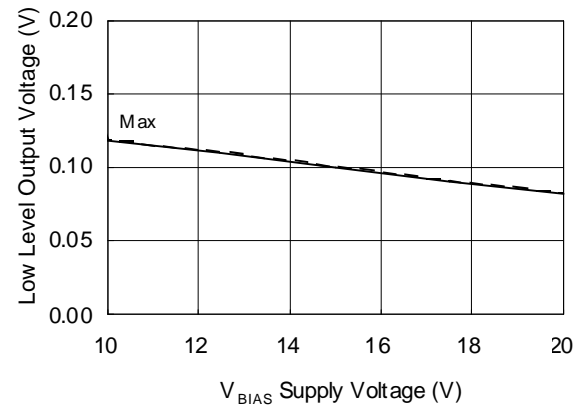
**Figure 11A. High Level Output Voltage vs. Temperature ( $I_O = 2\text{ mA}$ )**



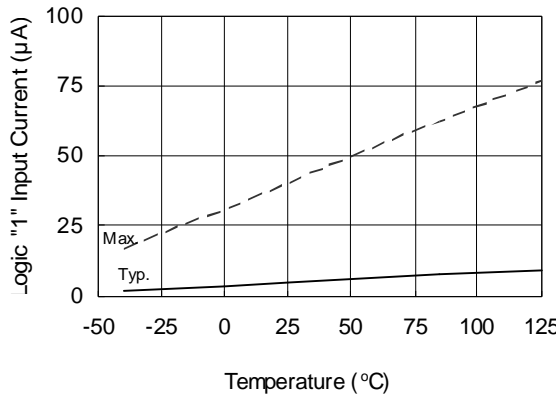
**Figure 11B. High Level Output Voltage vs. Supply Voltage ( $I_O = 2\text{ mA}$ )**



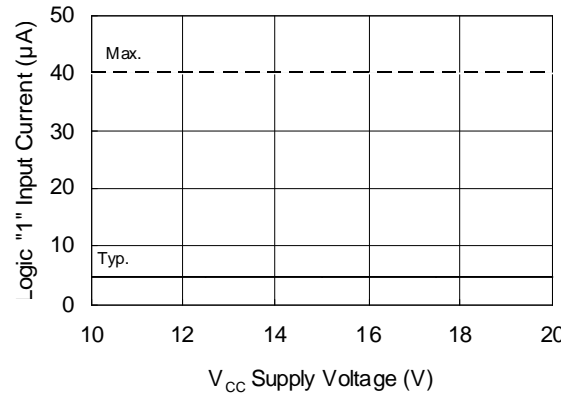
**Figure 12A. Low Level Output Voltage vs. Temperature ( $I_O = 2\text{ mA}$ )**



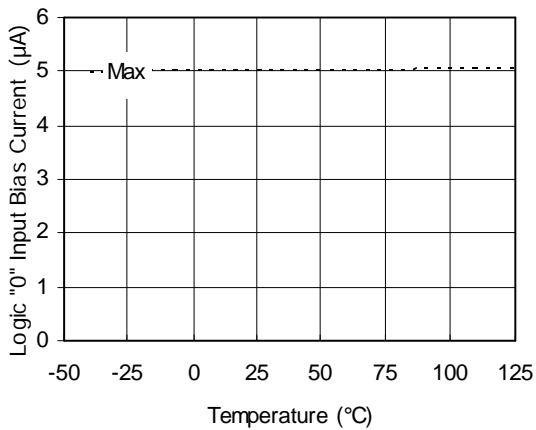
**Figure 12B. Low Level Output vs. Supply Voltage ( $I_O = 2\text{ mA}$ )**



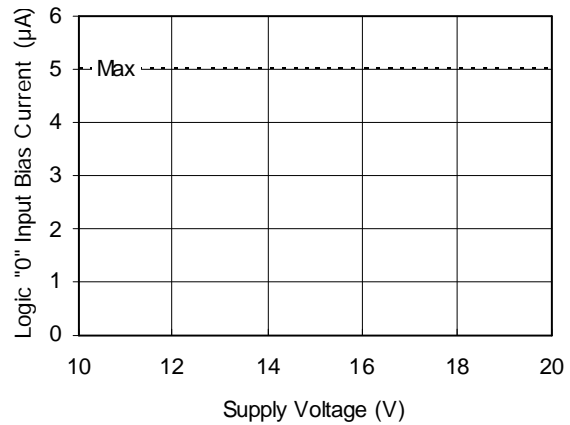
**Figure 13A. Logic "1" Input Current vs. Temperature**



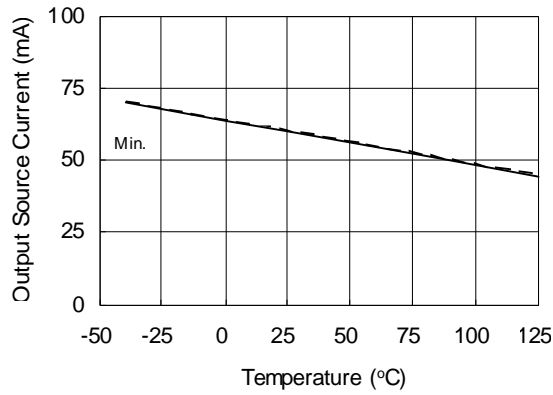
**Figure 13B. Logic "1" Input Current vs. Supply Voltage**



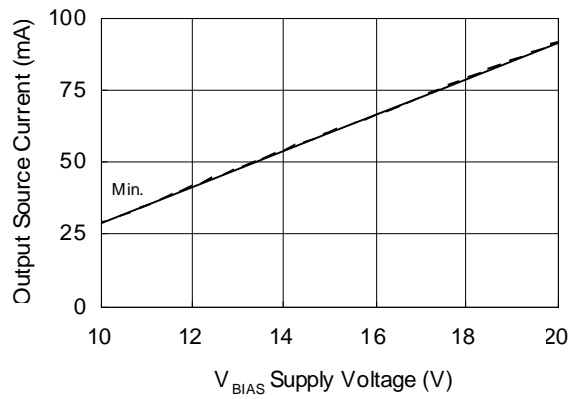
**Figure 14A. Logic "0" Input Bias Current vs. Temperature**



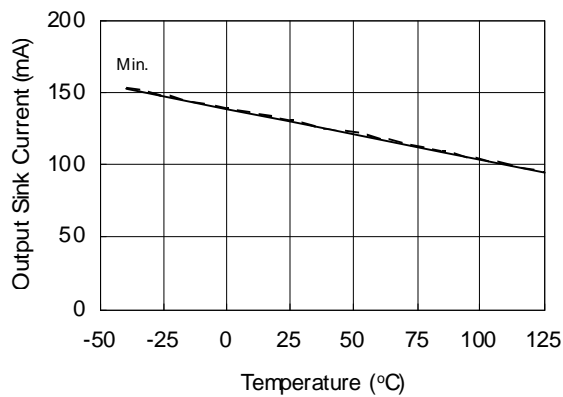
**Figure 14B. Logic "0" Input Bias Current vs. Voltage**



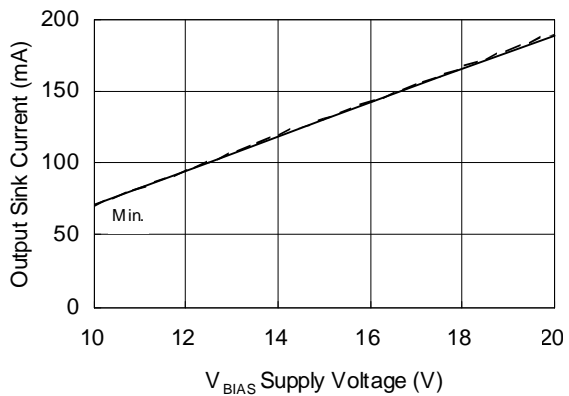
**Figure 15A. Output Source Current vs. Temperature**



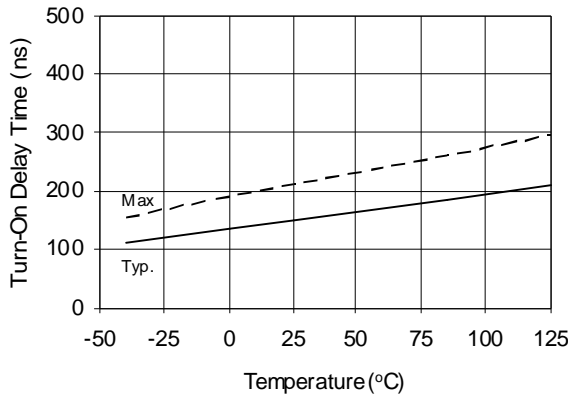
**Figure 15B. Output Source Current vs. Supply Voltage**



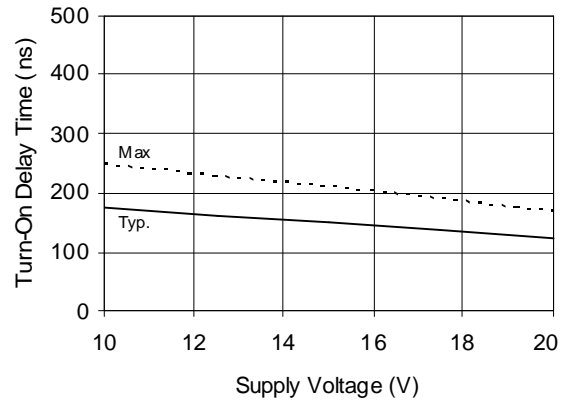
**Figure 16A. Output Sink Current vs. Temperature**



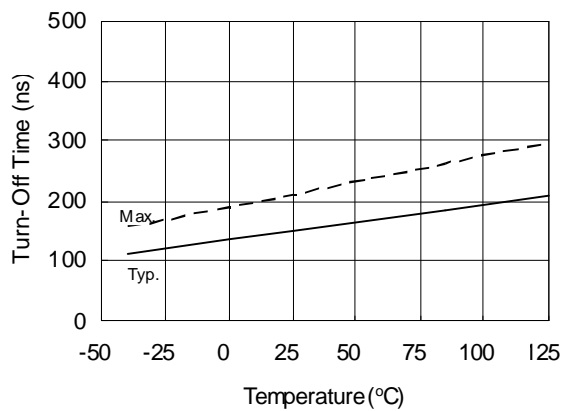
**Figure 16B. Output Sink Current vs. Supply Voltage**



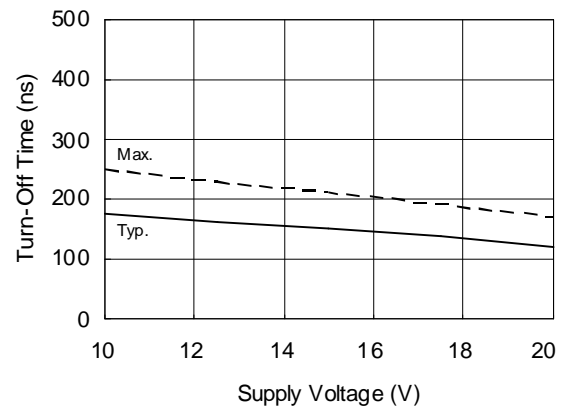
**Figure 17A. Turn-On Propagation Delay vs. Temperature**



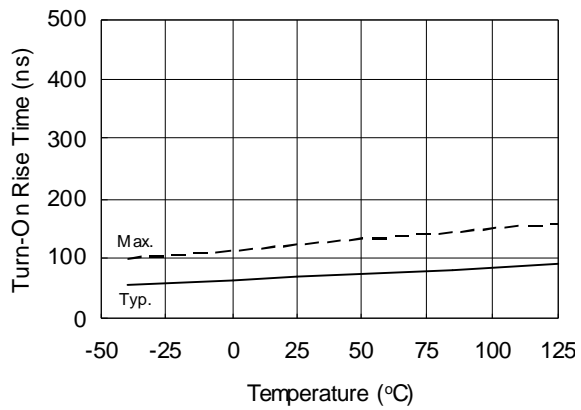
**Figure 17B. Turn-On Propagation Delay vs. Supply Voltage**



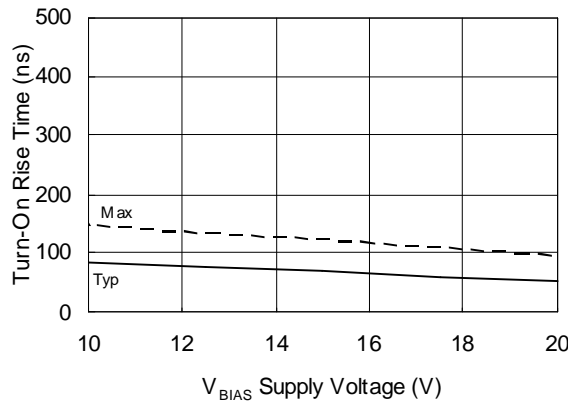
**Figure 18A. Turn-Off Propagation Delay vs. Temperature**



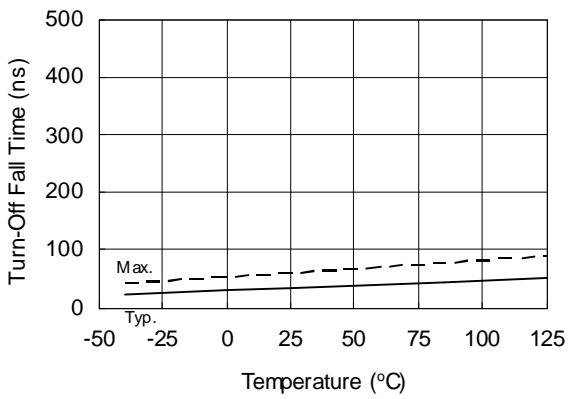
**Figure 18B. Turn-Off Propagation Delay vs. Supply Voltage**



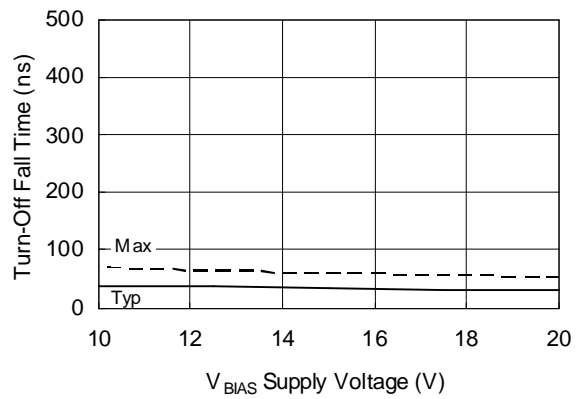
**Figure 19A. Turn-On Rise Time vs. Temperature**



**Figure 19B. Turn-On Rise Time vs. Supply Voltage**



**Figure 20A. Turn-Off Fall Time vs. Temperature**



**Figure 20B. Turn-Off Fall Time vs. Supply voltage**

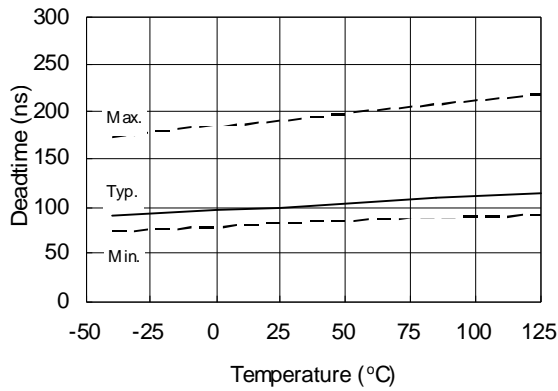


Figure 21A. Deadtime vs. Temperature

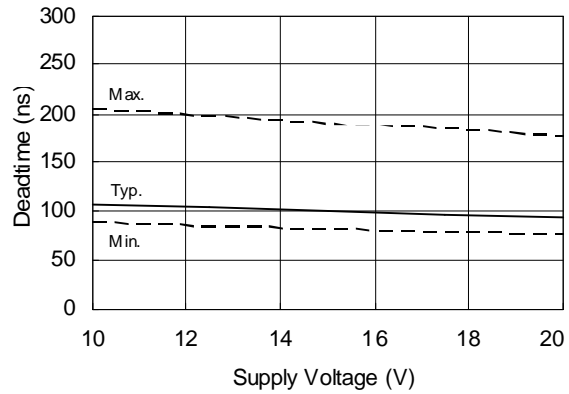


Figure 21B. Deadtime vs. Supply Voltage

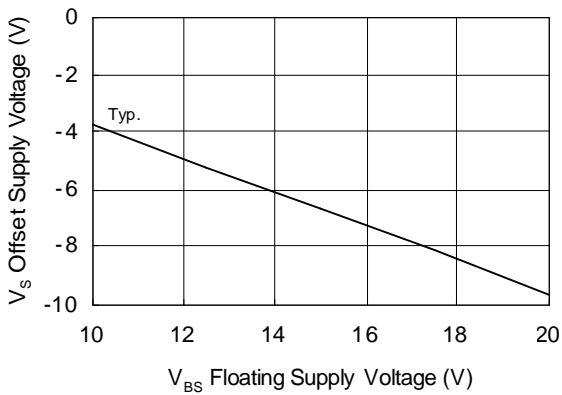


Figure 22. Maximum V<sub>s</sub> Negative Offset vs. Supply Voltage

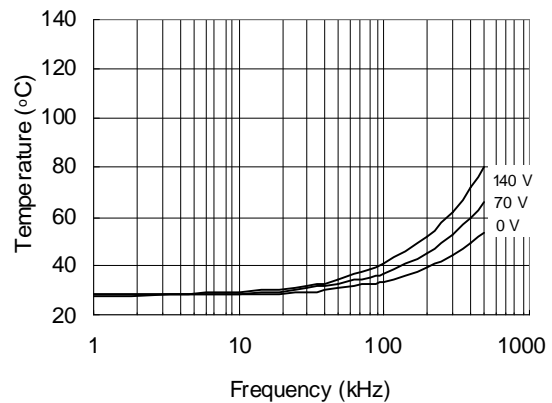
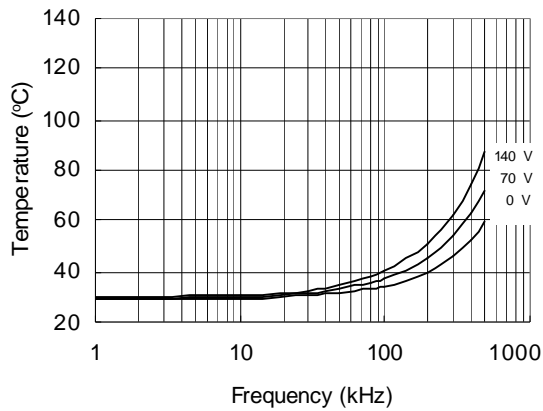
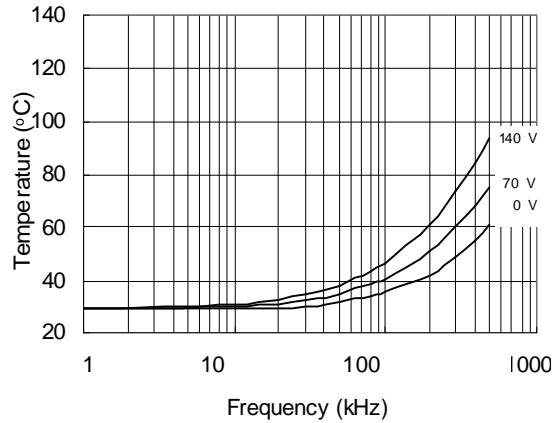


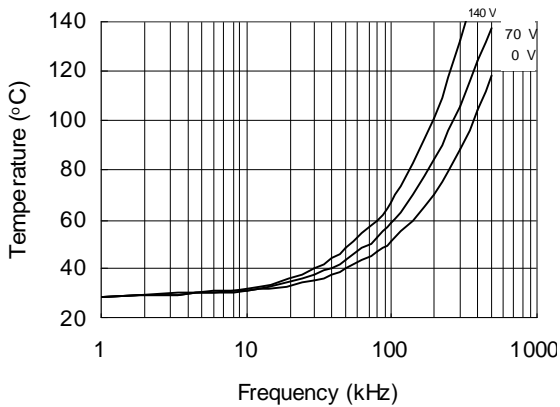
Figure 23. IRS2304 vs. Frequency (IRFBC20),  
R<sub>gate</sub>=33 Ω , V<sub>CC</sub>=15 V



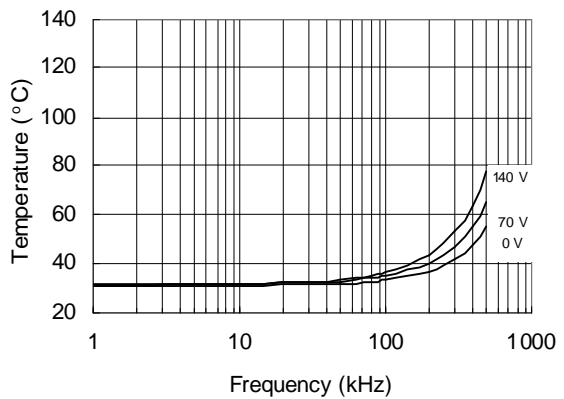
**Figure 24. IRS2304 vs. Frequency (IRFBC30)**  
 $R_{gate} = 22 \Omega, V_{cc} = 15 V$



**Figure 25. IRS2304 vs. Frequency (IRFBC40),**  
 $R_{gate} = 15 \Omega, V_{cc} = 15 V$



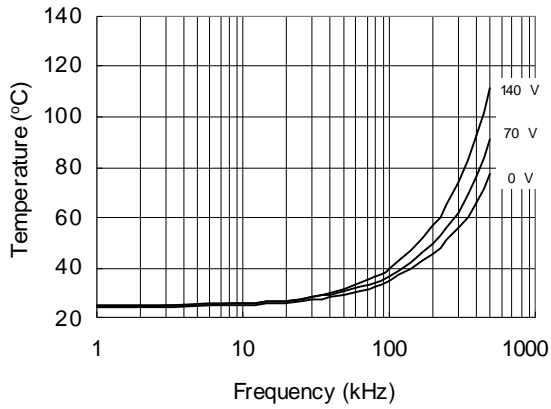
**Figure 26. IRS2304 vs. Frequency (IRFPE50),**  
 $R_{gate} = 10 \Omega, V_{cc} = 15 V$



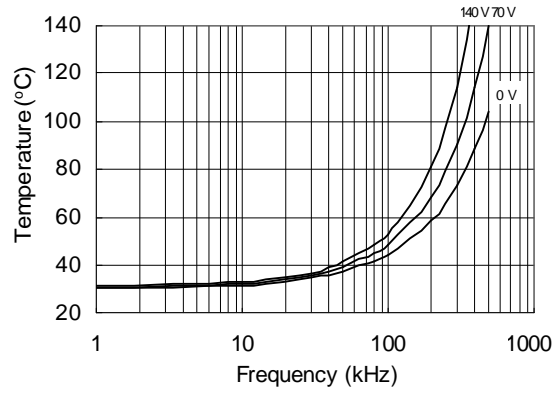
**Figure 27. IRS2304S vs. Frequency (IRFBC20)**  
 $R_{gate} = 33 \Omega, V_{cc} = 15 V$



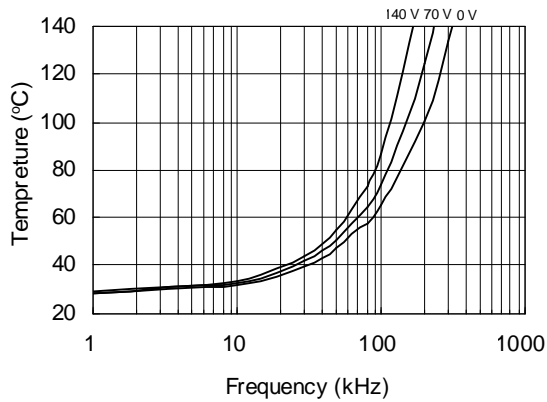
# IRS2304(S)PbF



**Figure 28. IRS2304S vs. Frequency (IRFBC30),  
 $R_{gate} = 22 \Omega$ ,  $V_{CC} = 15 V$**

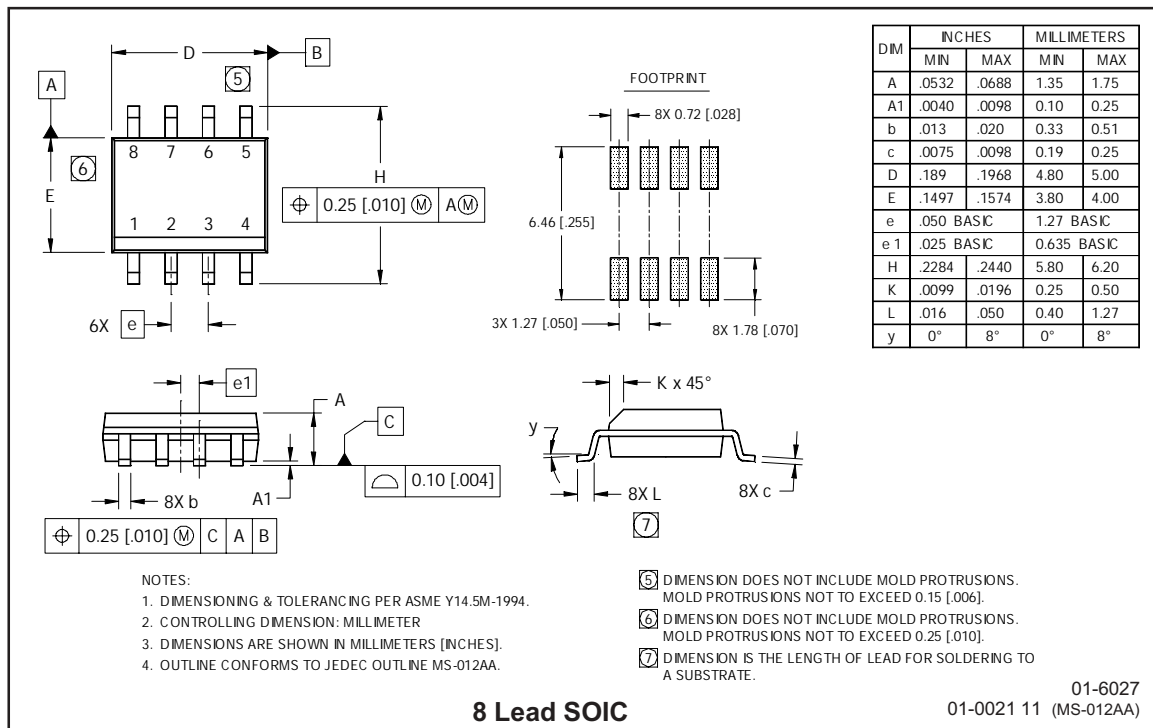
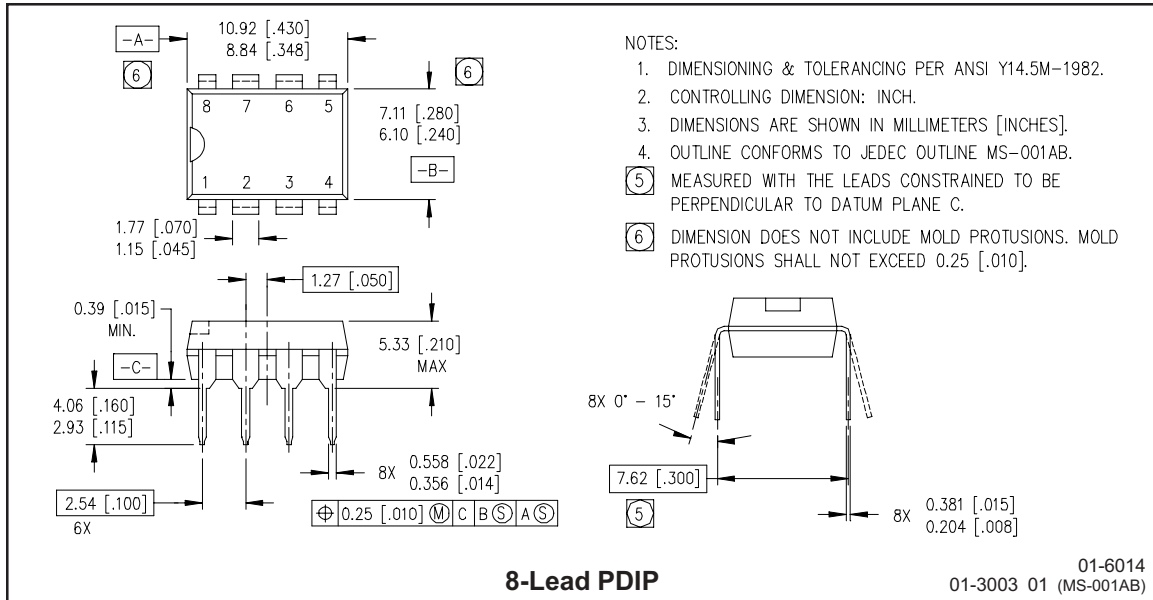


**Figure 29. IRS2304S vs. Frequency (IRFBC40),  
 $R_{gate} = 15 \Omega$ ,  $V_{CC} = 15 V$**

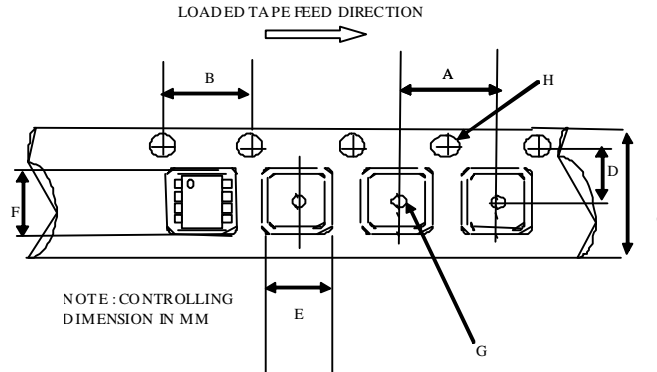


**Figure 30. IR2304s vs. Frequency (IRFPB50),  
 $R_{gate} = 10 \Omega$ ,  $V_{CC} = 15 V$**

## Case outlines

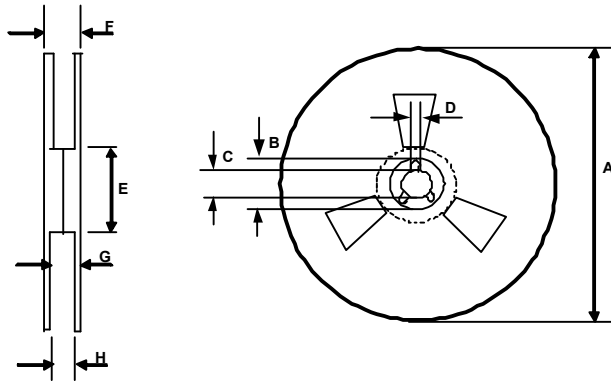


## Tape & Reel 8-lead SOIC



CARRIER TAPE DIMENSION FOR 8SOICN

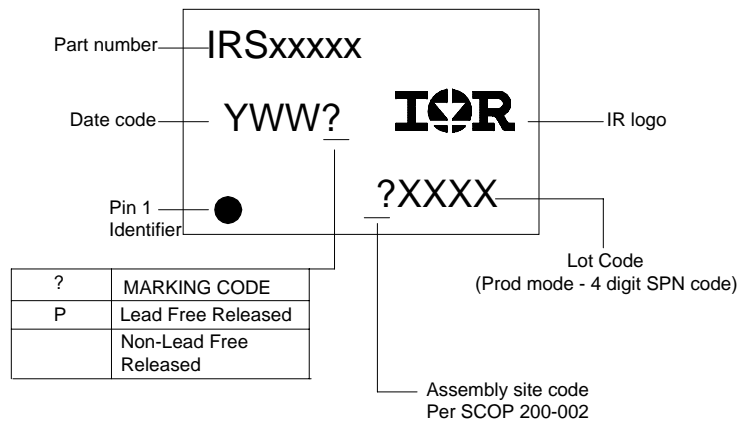
| Code | Metric |       | Imperial |       |
|------|--------|-------|----------|-------|
|      | Min    | Max   | Min      | Max   |
| A    | 7.90   | 8.10  | 0.311    | 0.318 |
| B    | 3.90   | 4.10  | 0.153    | 0.161 |
| C    | 11.70  | 12.30 | 0.46     | 0.484 |
| D    | 5.45   | 5.55  | 0.214    | 0.218 |
| E    | 6.30   | 6.50  | 0.248    | 0.255 |
| F    | 5.10   | 5.30  | 0.200    | 0.208 |
| G    | 1.50   | n/a   | 0.059    | n/a   |
| H    | 1.50   | 1.60  | 0.059    | 0.062 |



REEL DIMENSIONS FOR 8SOICN

| 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    | 18.40  | n/a      | 0.724  |
| G    | 14.50  | 17.10  | 0.570    | 0.673  |
| H    | 12.40  | 14.40  | 0.488    | 0.566  |

## LEADFREE PART MARKING INFORMATION



## ORDER INFORMATION

8-Lead PDIP IRS2304PbF  
 8-Lead SOIC IRS2304SPbF  
 8-Lead SOIC Tape & Reel IRS2304STRPbF