

International IR Rectifier

IRS2109/IRS21094(S)PbF

HALF-BRIDGE DRIVER

Features

- Floating channel designed for bootstrap operation
- Fully operational 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 compatible
- Cross-conduction prevention logic
- Matched propagation delay for both channels
- High-side output in phase with IN input
- Logic and power ground +/- 5 V offset.
- Internal 540 ns deadtime, and programmable up to 5 μ s with one external R_{DT} resistor (IRS21094)
- Lower di/dt gate driver for better noise immunity
- Shutdown input turns off both channels.
- RoHS compliant

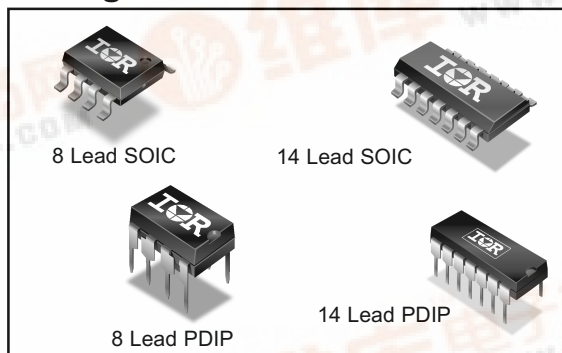
Description

The IRS2109/IRS21094 are high voltage, high speed power MOSFET and IGBT drivers with dependent high- 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 drivers feature 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.

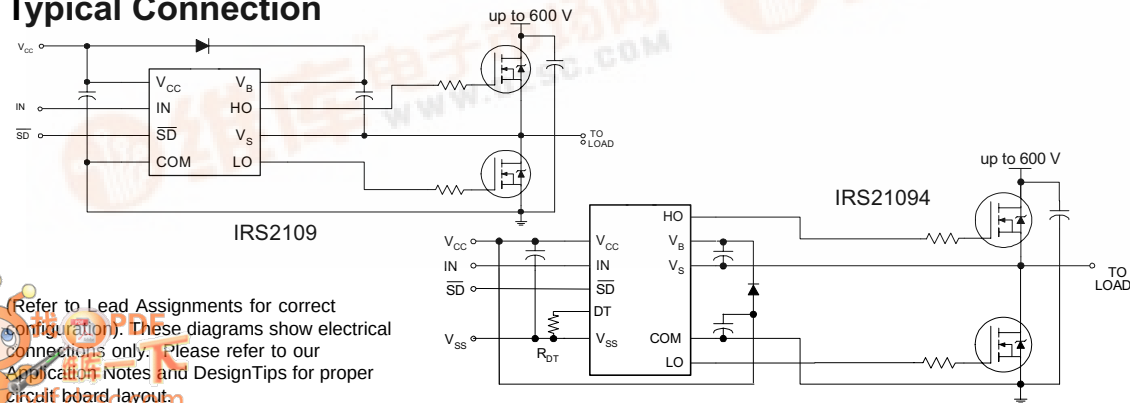
Product Summary

V_{OFFSET}	600 V max.
$I_{O+/-}$	120 mA / 250 mA
V_{OUT}	10 V - 20 V
$t_{on/off}$ (typ.)	750 ns & 200 ns
Deadtime	540 ns (programmable up to 5 μ s for IRS21094)

Packages



Typical Connection



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. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions.

Symbol	Definition		Min.	Max.	Unit
V_B	High-side floating absolute 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_{CC}	Low-side and logic fixed supply voltage		-0.3	25	V
V_{LO}	Low-side output voltage		-0.3	$V_{CC} + 0.3$	V
DT	Programmable deadtime pin voltage (IRS21094 only)		$V_{SS} - 0.3$	$V_{CC} + 0.3$	V
V_{IN}	Logic input voltage (IN & $\overline{SD}$)		$V_{SS} - 0.3$	$V_{CC} + 0.3$	V
V_{SS}	Logic ground (IRS21094/IRS21894 only)		$V_{CC} - 25$	$V_{CC} + 0.3$	V
dV_S/dt	Allowable offset supply voltage transient		—	50	V/r
PD	Package power dissipation @ $T_A \leq +25^\circ\text{C}$	(8 Lead PDIP)	—	1.0	W
		(8 Lead SOIC)	—	0.625	
		(14 lead PDIP)	—	1.6	
		(14 lead SOIC)	—	1.0	
R_{thJA}	Thermal resistance, junction to ambient	(8 Lead PDIP)	—	125	$^\circ\text{C/W}$
		(8 Lead SOIC)	—	200	
		(14 lead PDIP)	—	75	
		(14 lead SOIC)	—	120	
T_J	Junction temperature		—	150	$^\circ\text{C}$
T_S	Storage temperature		-50	150	
T_L	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_S and V_{SS} offset rating are tested with all supplies biased at a 15 V differential.

Symbol	Definition	Min.	Max.	Units
V_B	High-side floating supply absolute voltage	$V_S + 10$	$V_S + 20$	V
V_S	High-side floating supply offset voltage	(Note 1)	600	V
V_{HO}	High-side floating output voltage	V_S	V_B	V
V_{CC}	Low-side and logic fixed supply voltage	10	20	V
V_{LO}	Low-side output voltage	0	V_{CC}	V
V_{IN}	Logic input voltage (IN & $\overline{SD}$)	V_{SS}	V_{CC}	V
DT	Programmable deadtime pin voltage (IRS21094 only)	V_{SS}	V_{CC}	V
V_{SS}	Logic ground (IRS21094 only)	-5	5	V
T_A	Ambient temperature	-40	125	°C

Note 1: Logic operational for V_S of -5 V to +600 V. Logic state held for V_S of -5 V to $-V_{BS}$. (Please refer to the Design Note DT97-3 for more details).

Dynamic Electrical Characteristics

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

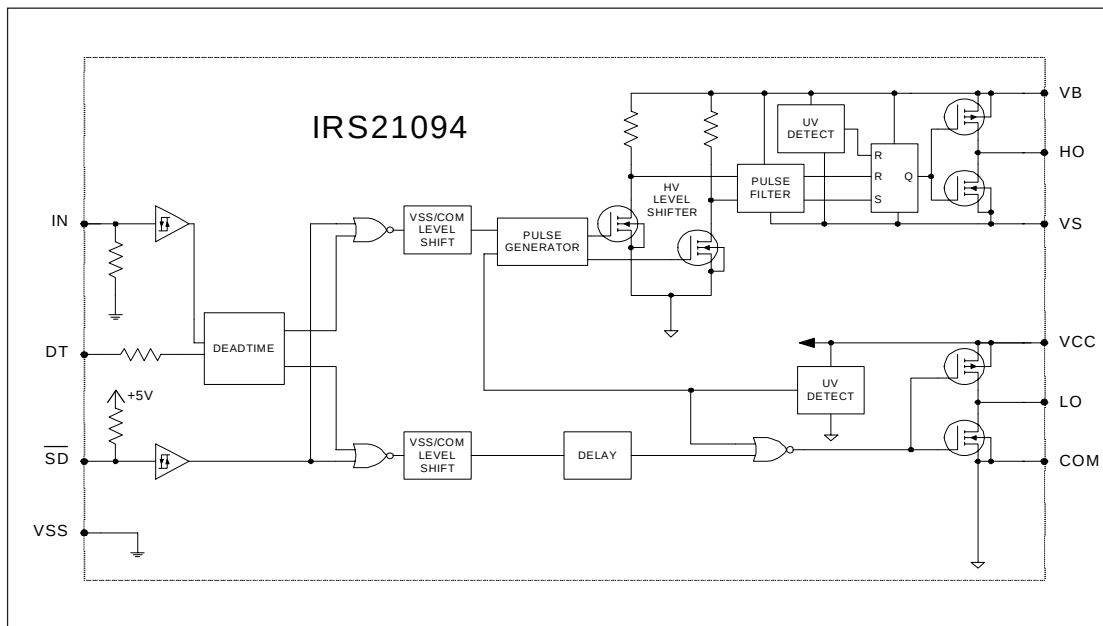
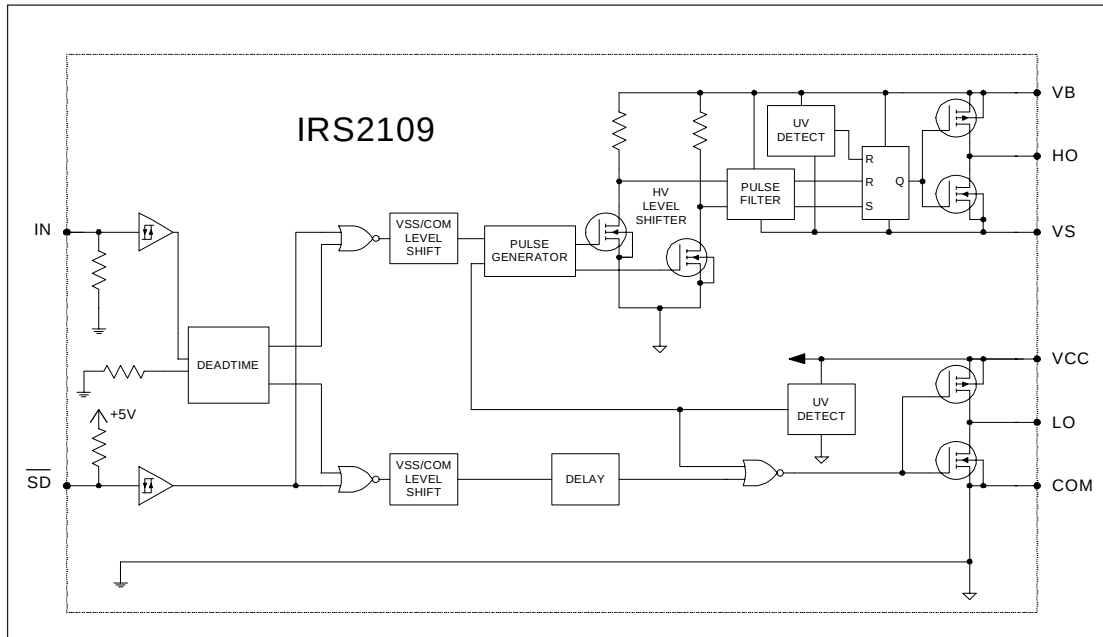
Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
t_{on}	Turn-on propagation delay	—	750	950	ns	$V_S = 0$ V
t_{off}	Turn-off propagation delay	—	200	280		$V_S = 0$ V or 60 V
t_{sd}	Shutdown propagation delay	—	2 00	280		
MT	Delay matching, HS & LS turn-on/off	—	0	70		
t_r	Turn-on rise time	—	100	220		$V_S = 0$ V
t_f	Turn-off fall time	—	35	80		
DT	Deadtime: LO turn-off to HO turn-on (DT _{LO-HO}) & HO turn-off to LO turn-on (DT _{HO-LO})	400	540	680	μs	$R_{DT} = 0 \Omega$
		4	5	6		$R_{DT} = 200 \text{ k}\Omega$ (IRS2109)
MDT	Deadtime matching = DT _{LO} - HO - DT _{HO-LO}	—	0	60	ns	$R_{DT} = 0 \Omega$
		—	0	600		$R_{DT} = 200 \text{ k}\Omega$ (IRS2109)

Static Electrical Characteristics

V_{BIAS} (V_{CC} , V_{BS}) = 15 V, V_{SS} = COM, $DT = V_{SS}$ and $T_A = 25^\circ\text{C}$ unless otherwise specified. The V_{IL} , V_{IH} , and I_{IN} parameters are referenced to V_{SS} /COM and are applicable to the respective input leads: IN and $\overline{SD}$. The V_O , I_O , and I_{LH} parameters are referenced to COM and are applicable to the respective output leads: HO and LO.

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions		
V _{IH}	Logic “1” input voltage for HO & logic “0” for LO	2.5	—	—	V	V _{CC} = 10 V to 20 V I _O = 2 mA		
V _{IL}	Logic “0” input voltage for HO & logic “1” for LO	—	—	0.8				
V _{SD,TH+}	$\overline{SD}$ input positive going threshold	2.5	—	—				
V _{SD,TH-}	$\overline{SD}$ input negative going threshold	—	—	0.8				
V _{OH}	High level output voltage, V _{BIAS} - V _O	—	0.05	0.2		μA	V _B = V _S = 60 V V _{IN} = 0 V or 5 V R _{DT} = 0 Ω	
V _{OL}	Low level output voltage, V _O	—	0.02	0.1				
I _{LK}	Offset supply leakage current	—	—	50				
I _{QBS}	Quiescent V _{BS} supply current	20	75	130				
I _{QCC}	Quiescent V _{CC} supply current	0.4	1.0	1.6	mA			V _{IN} = 0 V or 5 V R _{DT} = 0 Ω
I _{IN+}	Logic “1” input bias current	—	5	20		μA	IN = 5 V, $\overline{SD}$ = 0 V IN = 0 V, $\overline{SD}$ = 5 V	
I _{IN-}	Logic “0” input bias current	—	—	2				
V _{CCUV+} V _{BSUV+}	V _{CC} and V _{BS} supply undervoltage positive going threshold	8.0	8.9	9.8	V			
V _{CCUV-} V _{BSUV-}	V _{CC} and V _{BS} supply undervoltage negative going threshold	7.4	8.2	9.0				
V _{CCUVH} V _{BSUVH}	Hysteresis	0.3	0.7	—				
I _{O+}	Output high short circuit pulsed current	120	290	—	mA	V _O = 0 V, PW ≤ 10 μs V _O = 15 V, PW ≤ 10 μs		
I _{O-}	Output low short circuit pulsed current	250	600	—				

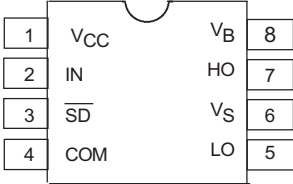
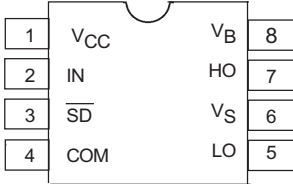
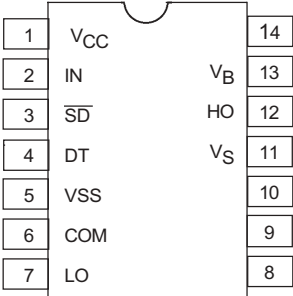
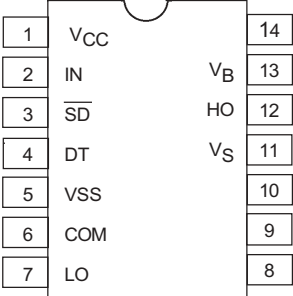
Functional Block Diagrams



Lead Definitions

Symbol	Description
IN	Logic input for high-side and low-side gate driver outputs (HO and LO), in phase with HO (referenced to COM for IRS2109 and VSS for IRS21094)
$\overline{\text{SD}}$	Logic input for shutdown (referenced to COM for IRS2109 and VSS for IRS21094)
DT	Programmable deadtime lead, referenced to VSS. (IRS21094 only)
VSS	Logic ground (IRS21094 only)
V _B	High-side floating supply
HO	High-side gate drive output
V _S	High-side floating supply return
V _{CC}	Low-side and logic fixed supply
LO	Low-side gate drive output
COM	Low-side return

Lead Assignments

 8 Lead PDIP IRS2109PbF	 8 Lead SOIC IRS2109SPbF
 14 Lead PDIP IRS21094PbF	 14 Lead SOIC IRS21094SPbF

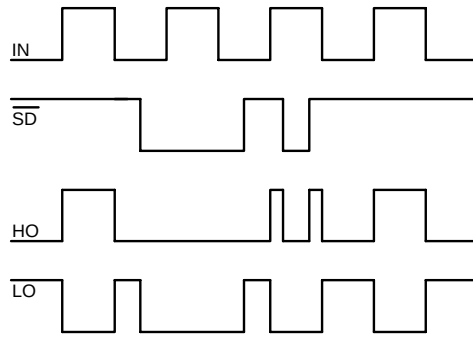


Figure 1. Input/Output Timing Diagram

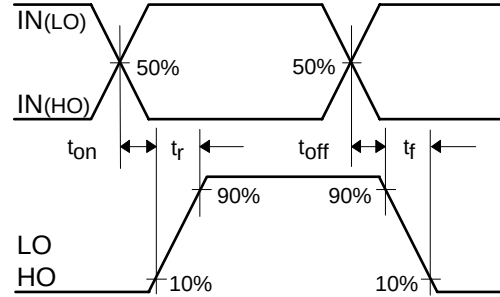


Figure 2. Switching Time Waveform Definitions

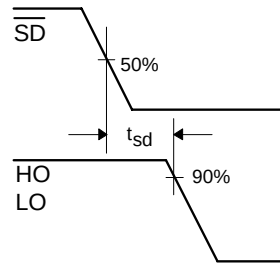


Figure 3. Shutdown Waveform Definitions

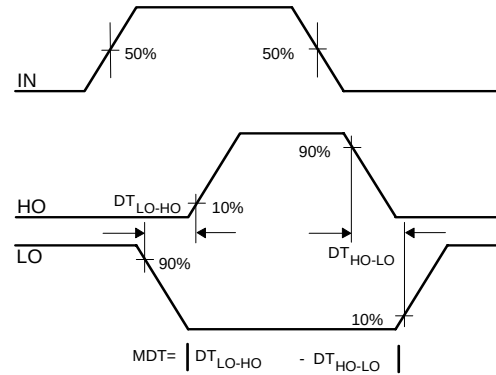


Figure 4. Deadtime Waveform Definitions

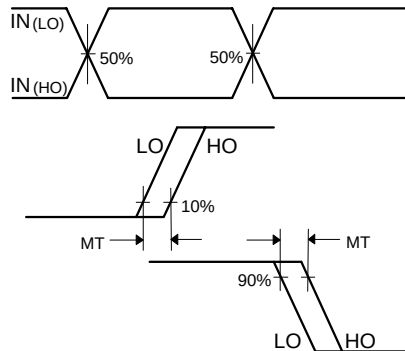


Figure 5. Delay Matching Waveform Definitions

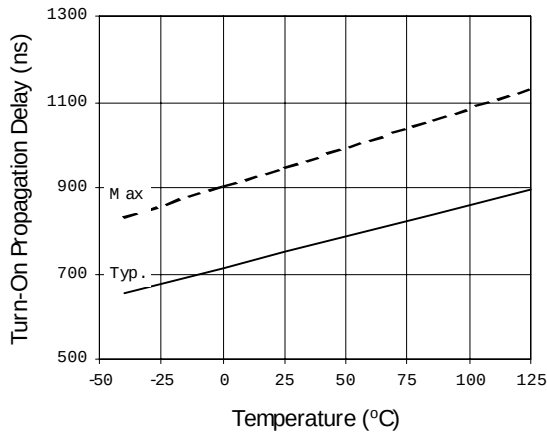


Figure 6A. Turn-On Propagation Delay vs. Temperature

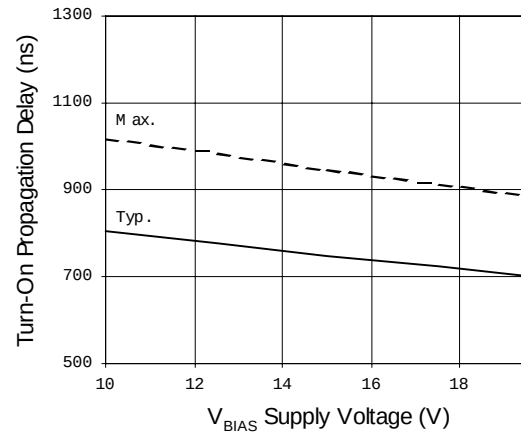


Figure 6B. Turn-On Propagation Delay vs. Supply Voltage

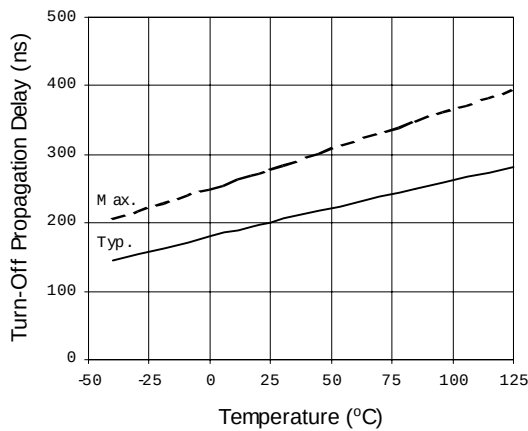


Figure 7A. Turn-Off Propagation Delay vs. Temperature

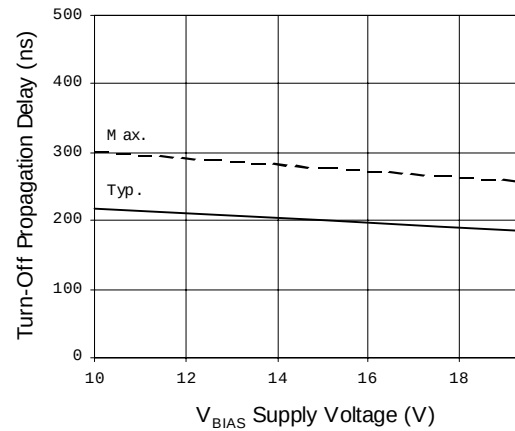


Figure 7B. Turn-Off Propagation Delay vs. Supply Voltage

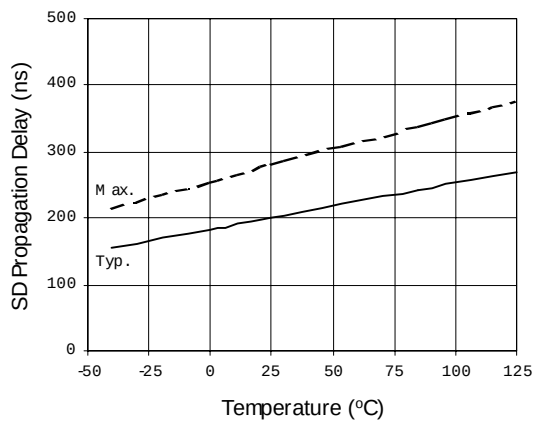


Figure 8A. SD Propagation Delay vs. Temperature

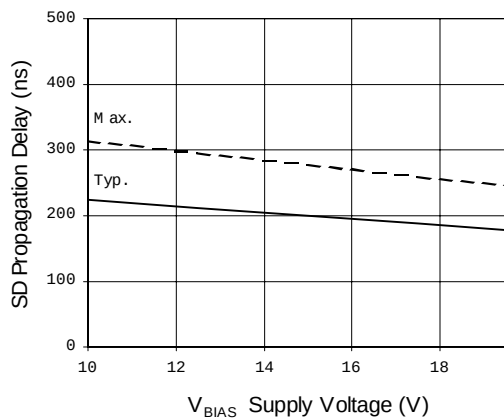


Figure 8B. SD Propagation Delay vs. Supply Voltage

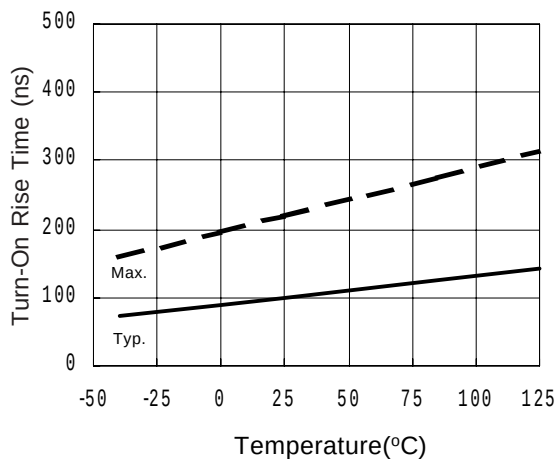


Figure 9A. Turn-On Rise Time vs. Temperature

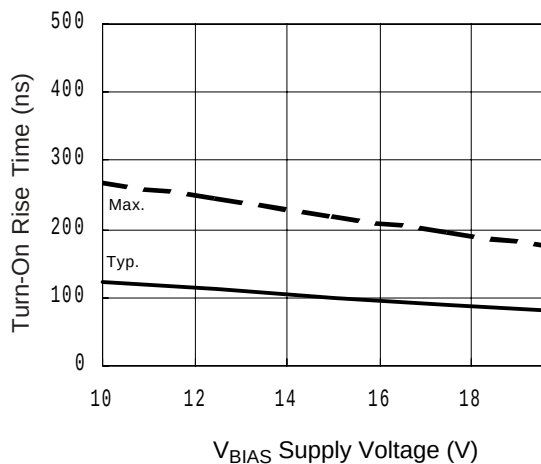


Figure 9B. Turn-On Rise Time vs. Supply Voltage

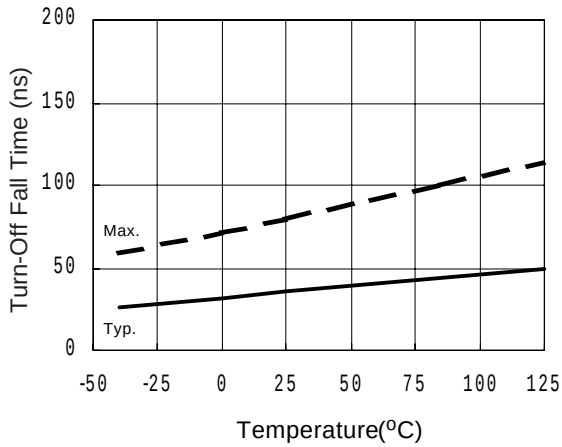


Figure 10A. Turn-Off Fall Time vs. Temperature

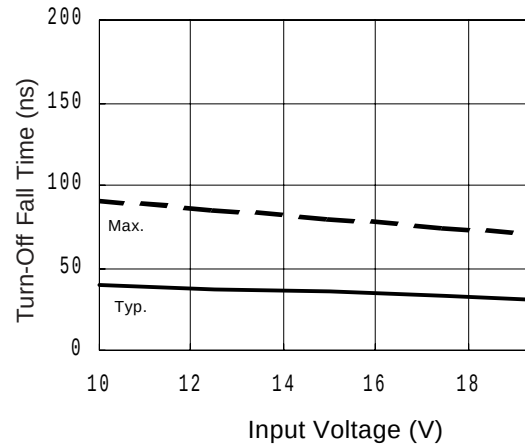


Figure 10B. Turn-Off Fall Time vs. Supply Voltage

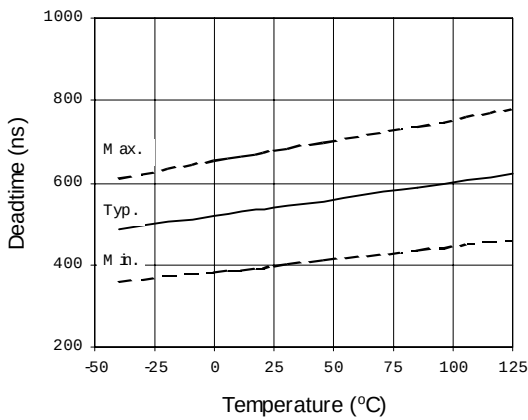


Figure 11A. Deadtime vs. Temperature

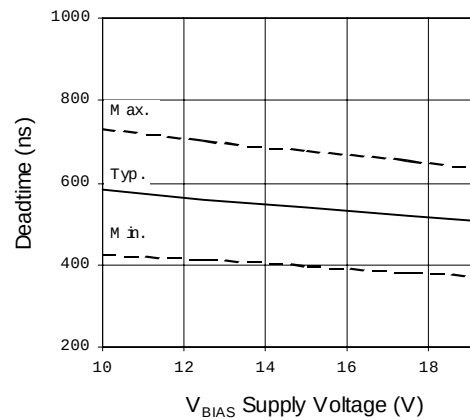
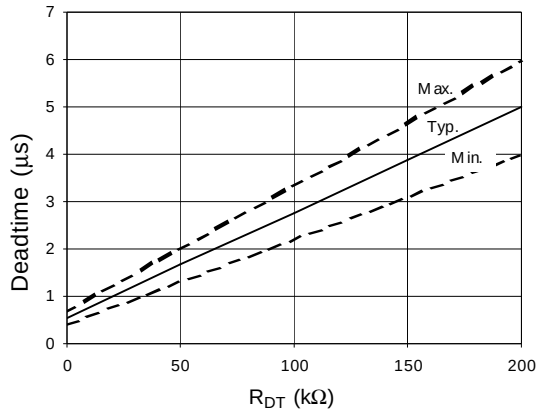
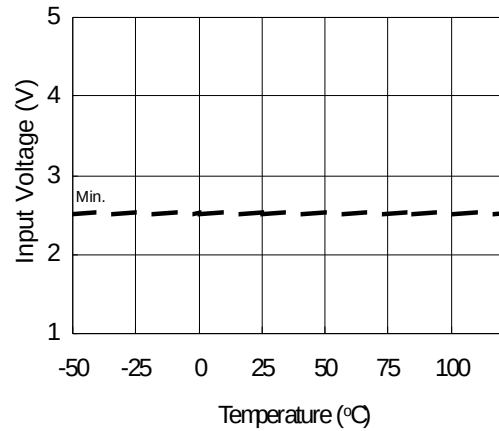


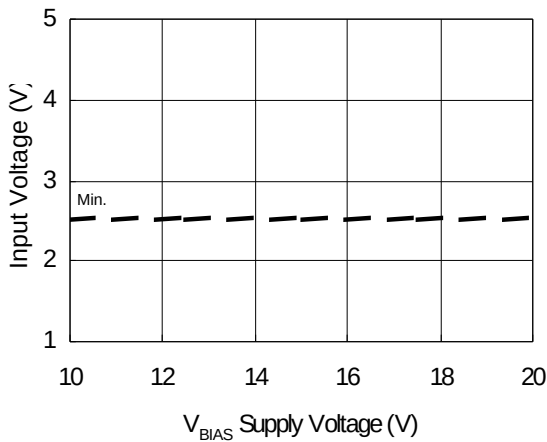
Figure 11B. Deadtime vs. Supply Voltage



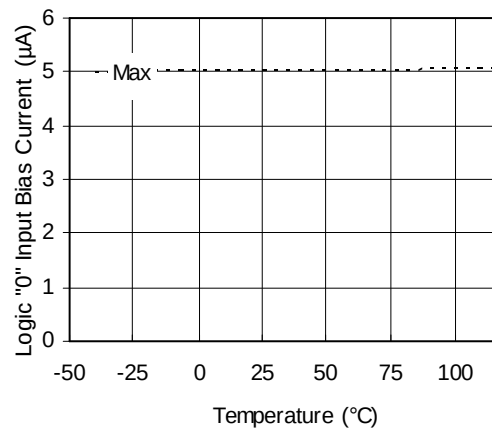
**Figure 11C. Deadtime vs. R_{DT}
(IR21094 only)**



**Figure 12A. Logic "1" Input Voltage
vs. Temperature**



**Figure 12B. Logic "1" Input Voltage
vs. Supply Voltage**



**Figure 13A. Logic "0" Input Bias Current
vs. Temperature**

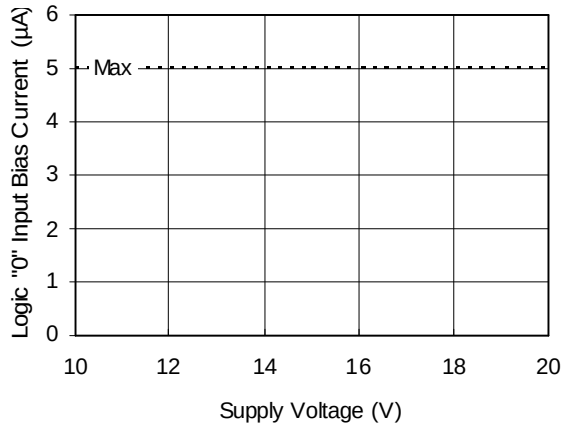


Figure 13B. Logic "0" Input Bias Current vs. Voltage

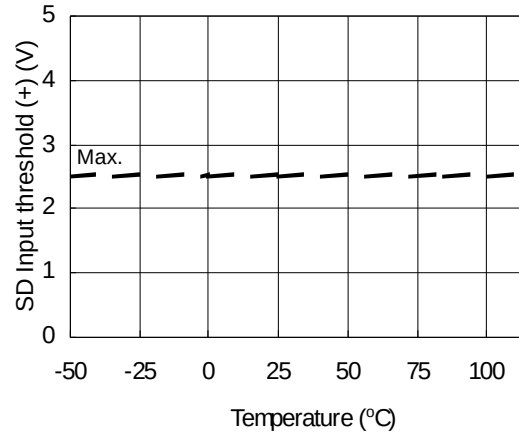


Figure 14A. SD Input Positive Going Threshold (+) vs. Temperature

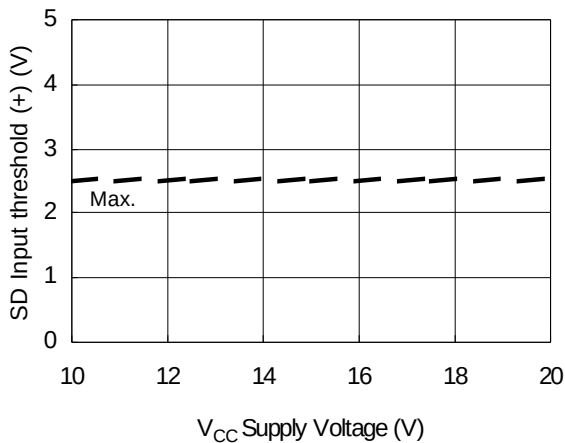


Figure 14B. SD Input Positive Going Threshold (+) vs. Supply Voltage

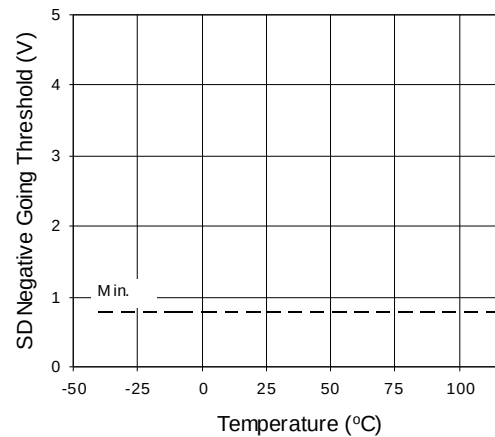


Figure 15A. SD Negative Going Threshold vs. Temperature

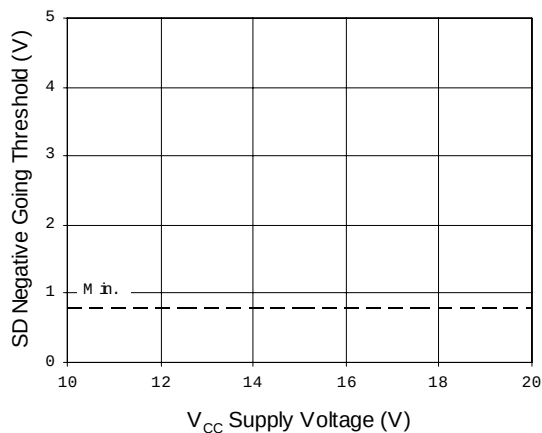


Figure 15B. SD Negative Going Threshold vs. Supply Voltage

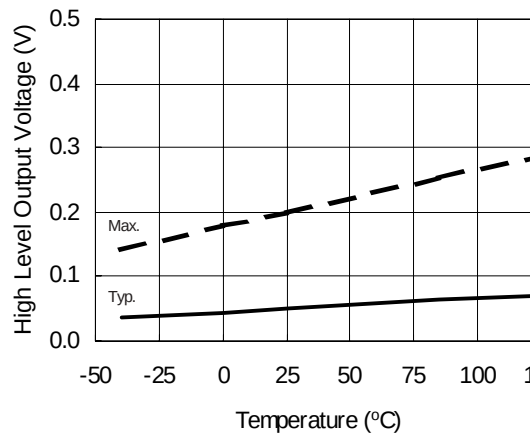


Figure 16A. High Level Output Voltage vs. Temperature

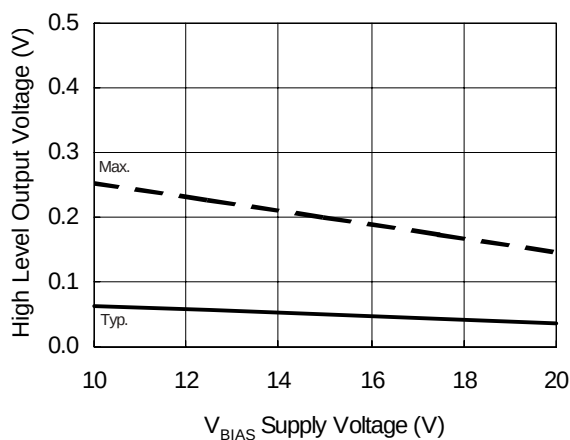


Figure 16B. High Level Output Voltage vs. Supply Voltage

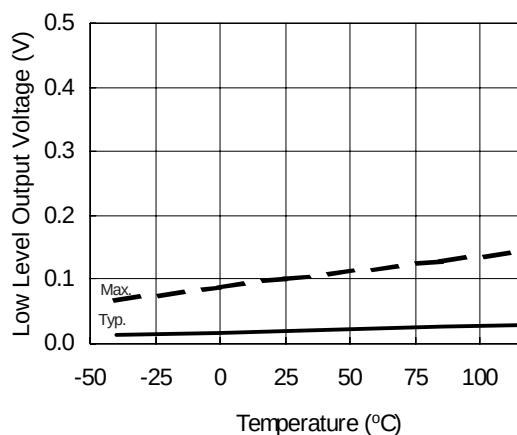


Figure 17A. Low Level Output Voltage vs. Temperature

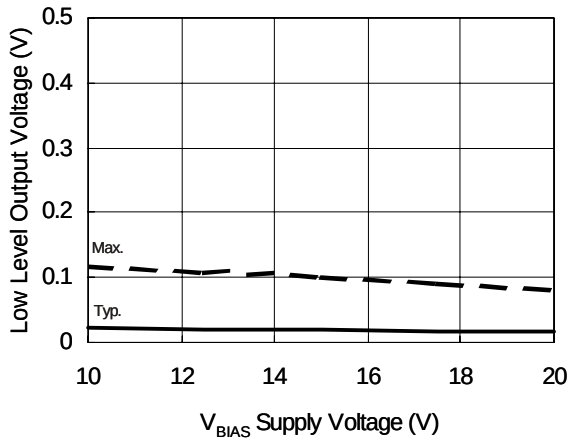


Figure 17B. Low Level Output Voltage vs. Supply Voltage

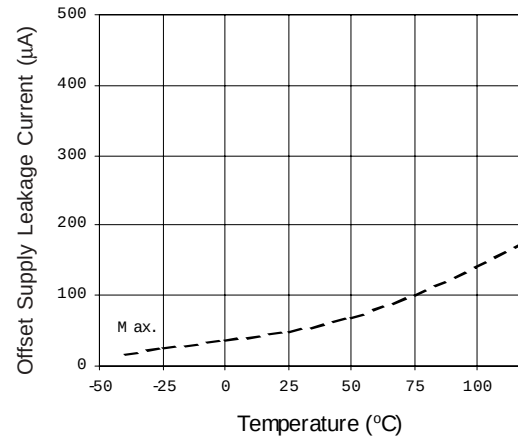


Figure 18A. Offset Supply Leakage Current vs. Temperature

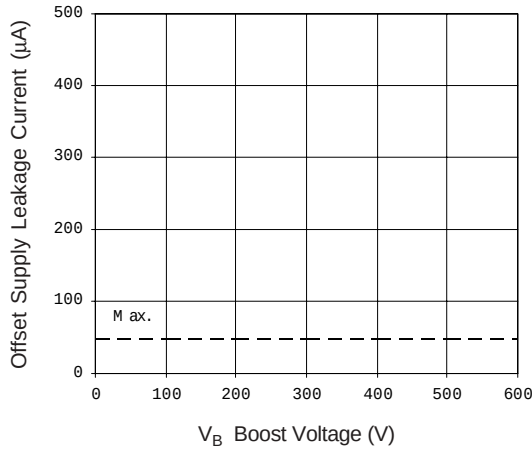


Figure 18B. Offset Supply Leakage Current vs. Boost Voltage

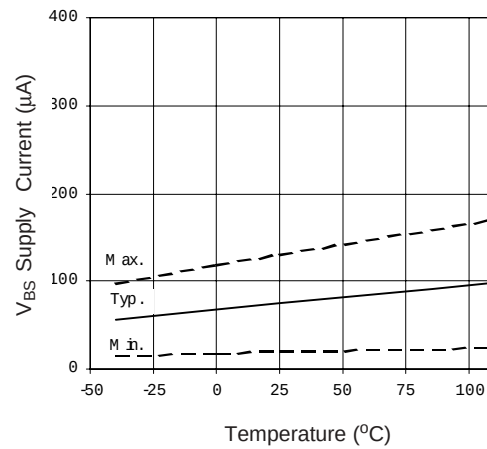


Figure 19A. VBS Supply Current vs. Temperature

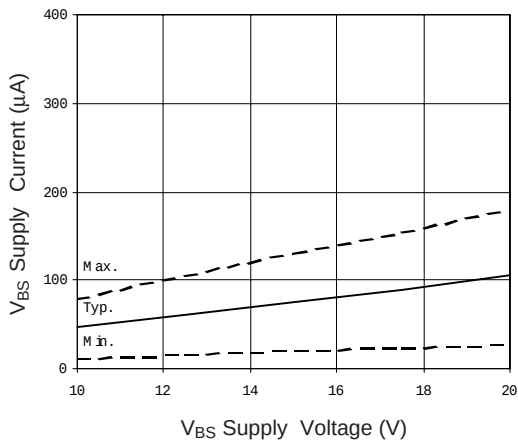


Figure 19B. V_{BS} Supply Current vs. Supply Voltage

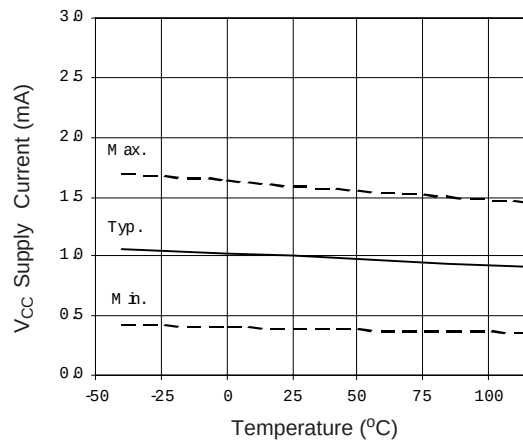


Figure 20A. V_{CC} Supply Current vs. Temperature

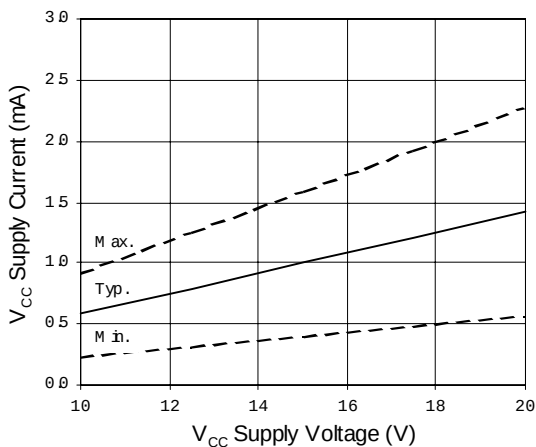


Figure 20B. V_{CC} Supply Current vs. V_{CC} Supply Voltage

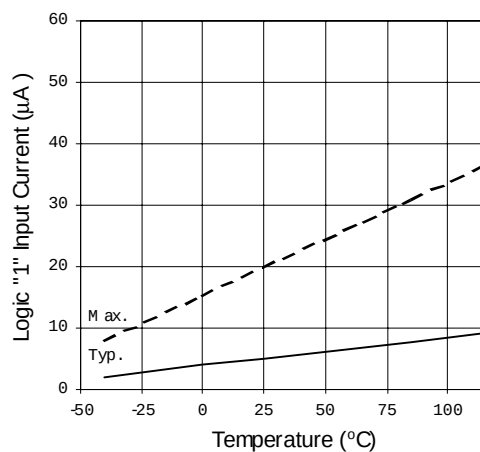


Figure 21A. Logic "1" Input Current vs. Temperature

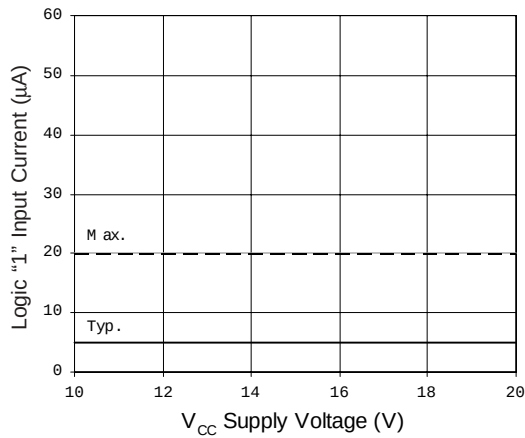


Figure 21B. Logic "1" Input Current vs. Supply Voltage

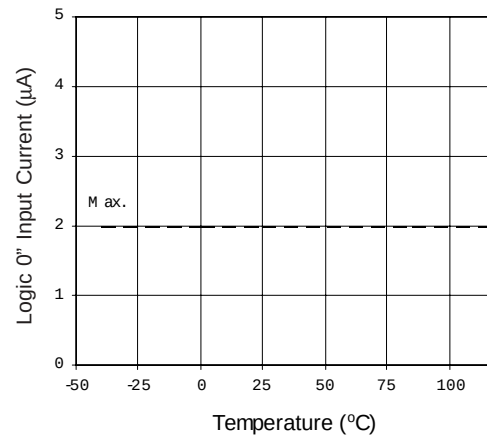


Figure 22A. Logic "0" Input Current vs. Temperature

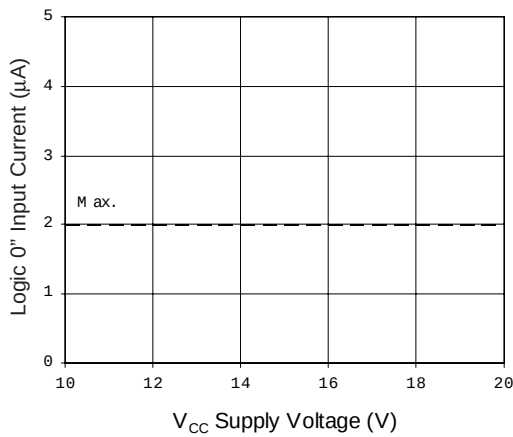


Figure 22B. Logic "0" Input Current vs. Supply Voltage

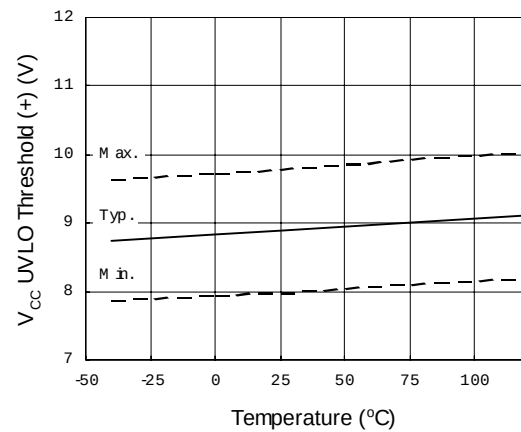


Figure 23. V_{CC} Undervoltage Threshold (+) vs. Temperature

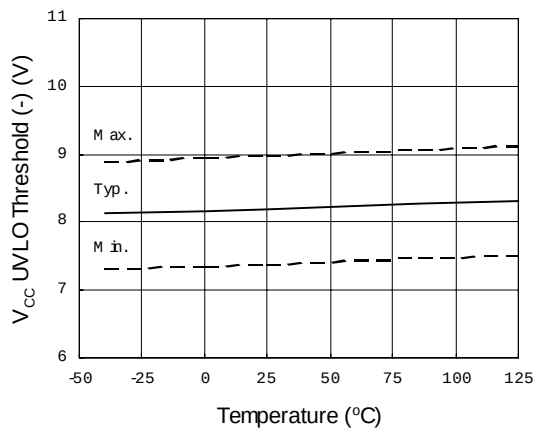


Figure 24. V_{CC} Undervoltage Threshold (-) vs. Temperature

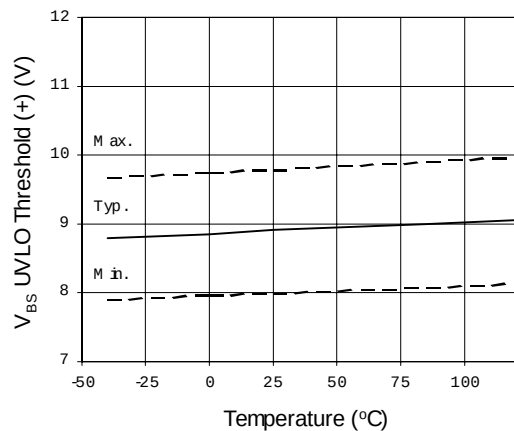


Figure 25. V_{BS} Undervoltage Threshold (+) vs. Temperature

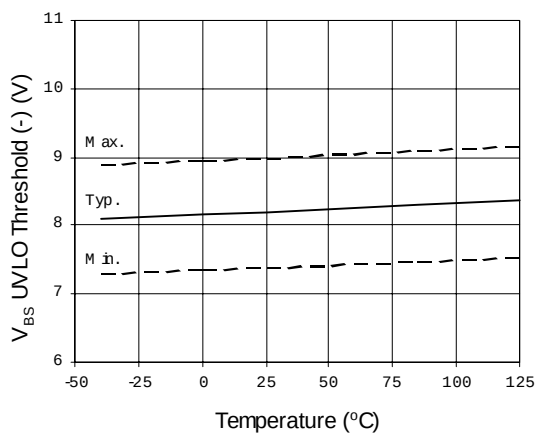


Figure 26. V_{BS} Undervoltage Threshold (-) vs. Temperature

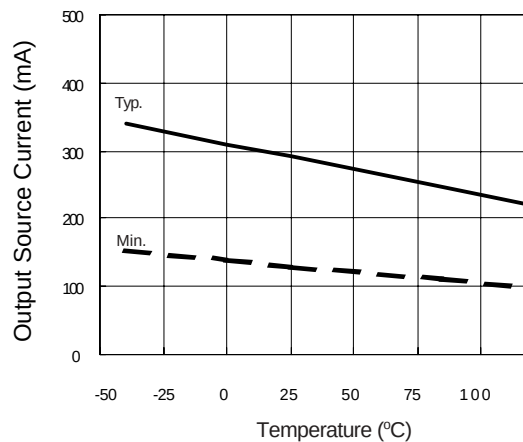


Figure 27A. Output Source Current vs. Temperature

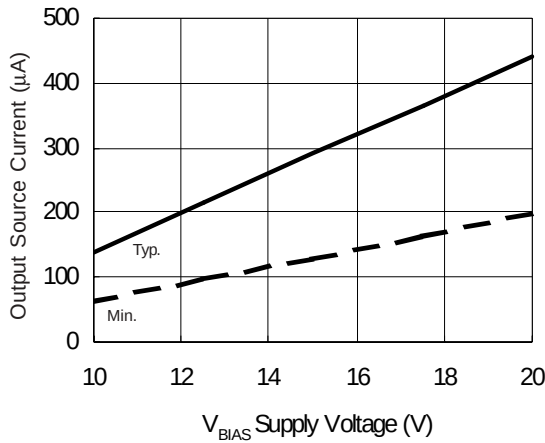


Figure 27B. Output Source Current vs. Supply Voltage

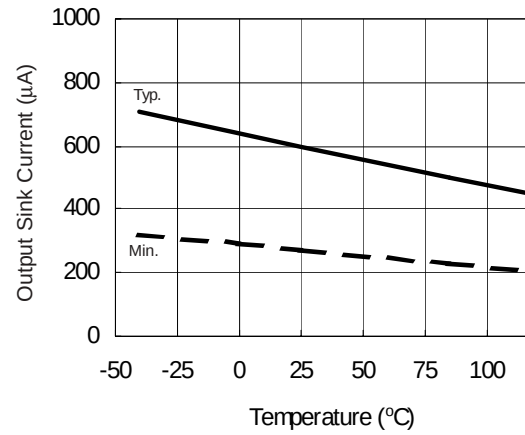


Figure 28A. Output Sink Current vs. Temperature

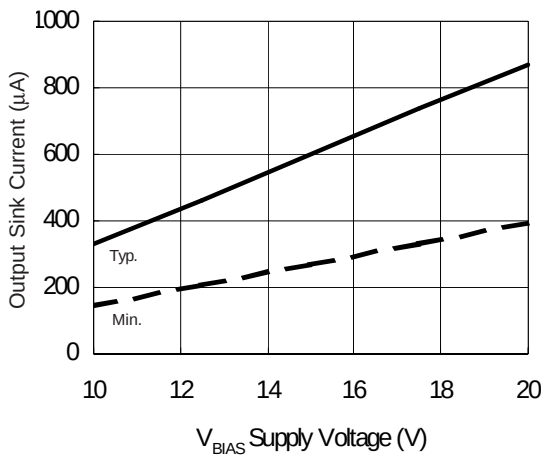


Figure 28B. Output Sink Current vs. Supply Voltage

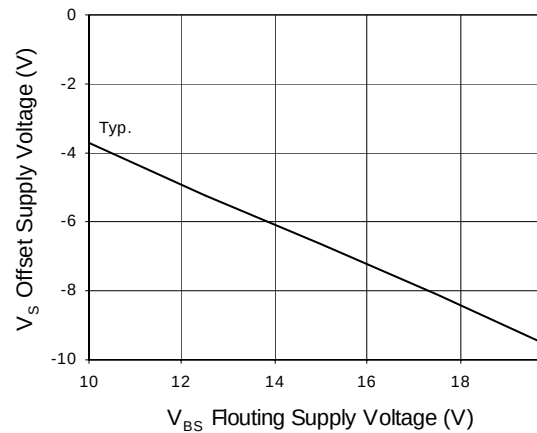


Figure 29. Maximum V_S Negative Offset vs. Supply Voltage

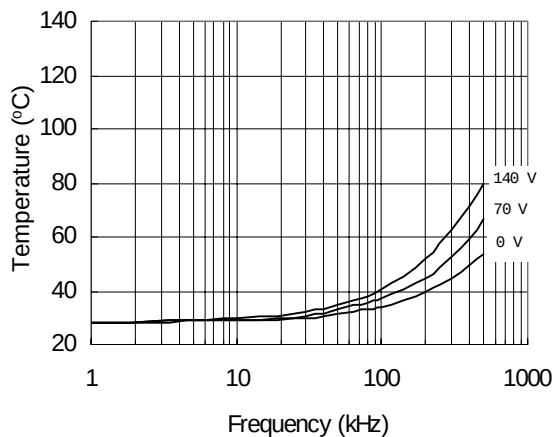


Figure 30. IRS2109 vs Frequency (IRFBC20)
 $R_{gate} = 33 \Omega$, $V_{CC} = 15 V$

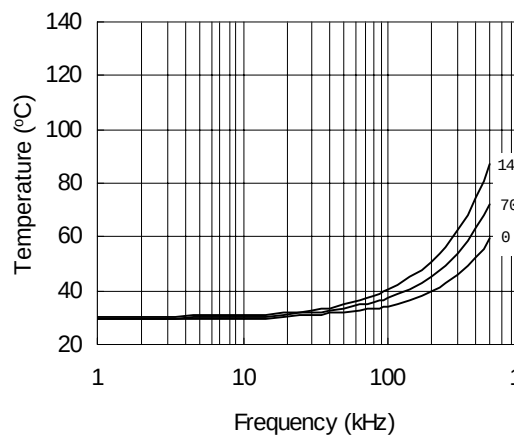


Figure 31. IRS2109 vs Frequency (IRFBC30)
 $R_{gate} = 22 \Omega$, $V_{CC} = 15 V$

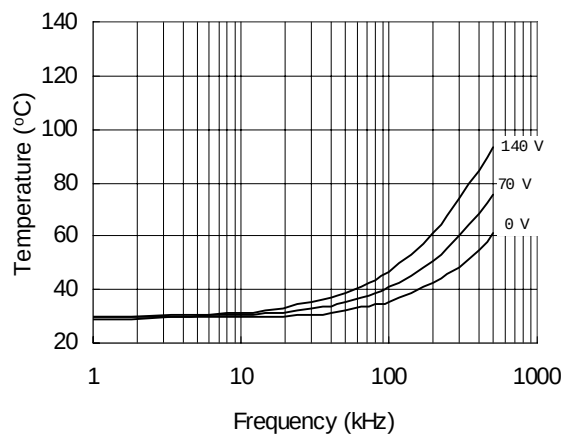


Figure 32. IRS2109 vs Frequency (IRFBC40)
 $R_{gate} = 15 \Omega$, $V_{CC} = 15 V$

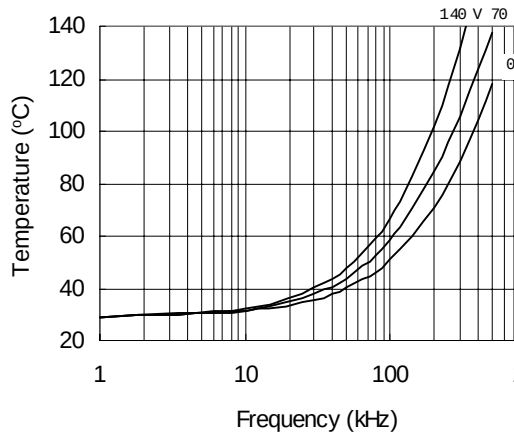


Figure 33. IRS2109 vs Frequency (IRFPE50)
 $R_{gate} = 10 \Omega$, $V_{CC} = 15 V$

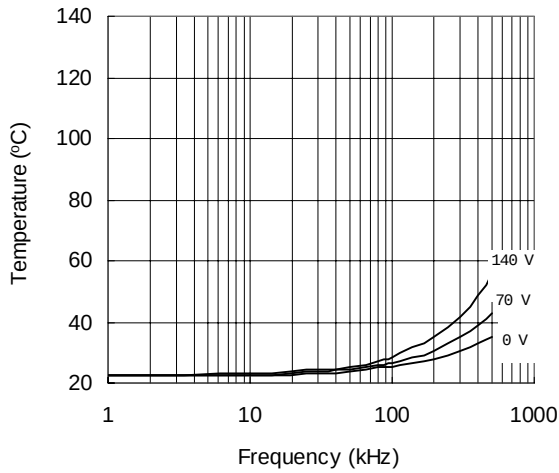


Figure 34. IRS21094 vs. Frequency (IRFBC20),
 $R_{gate}=33\ \Omega$, $V_{CC}=15\ V$

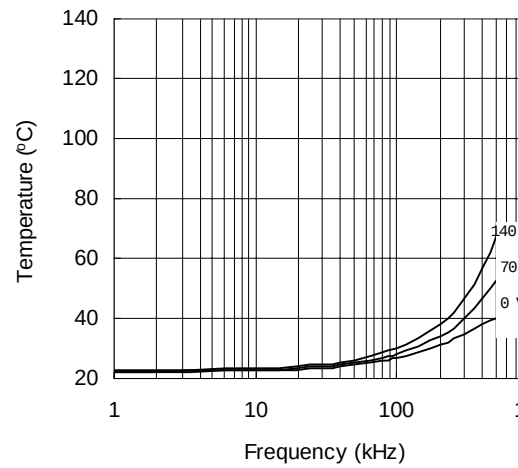


Figure 35. IRS21094 vs. Frequency (IRFBC30),
 $R_{gate}=22\ \Omega$, $V_{CC}=15\ V$

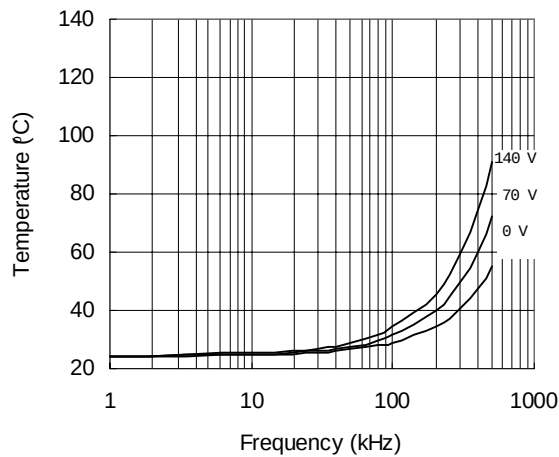


Figure 36. IRS21094 vs. Frequency (IRFBC40),
 $R_{gate}=15\ \Omega$, $V_{CC}=15\ V$

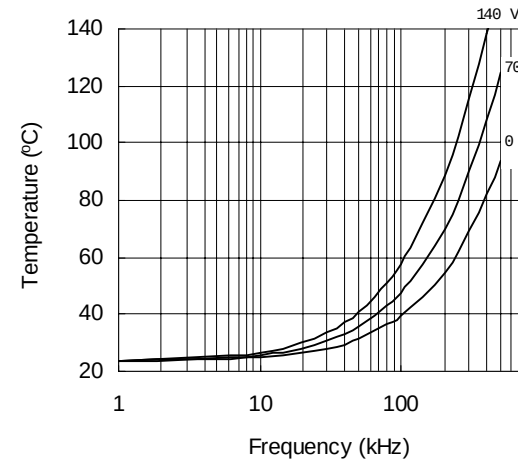
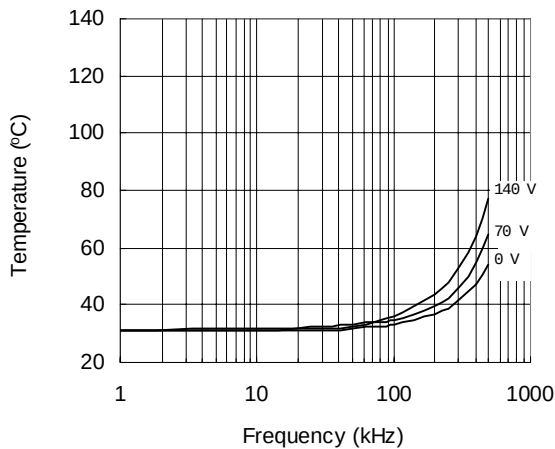
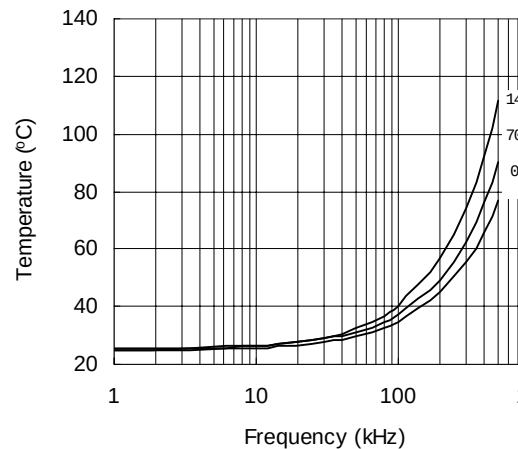


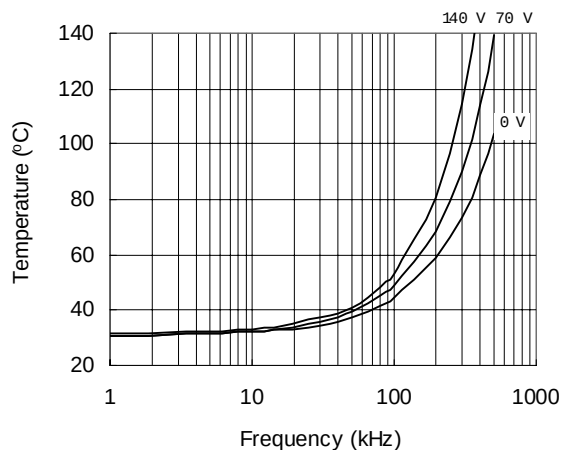
Figure 37. IRS21094 vs. Frequency (IRFBC10),
 $R_{gate}=10\ \Omega$, $V_{CC}=15\ V$



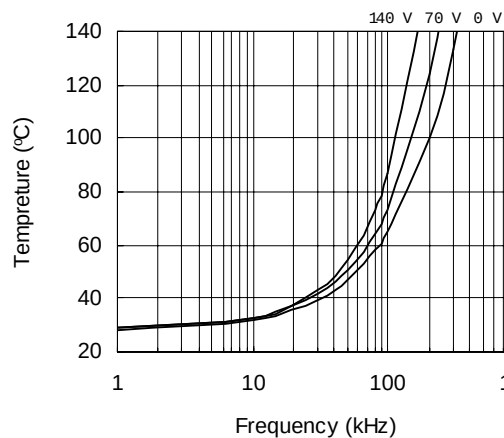
**Figure 38. IRS2109S vs. Frequency (IRFBC20),
 $R_{gate}=33\ \Omega$, $V_{CC}=15\ V$**



**Figure 39. IRS2109S vs. Frequency (IRFBC3)
 $R_{gate}=22\ \Omega$, $V_{CC}=15\ V$**



**Figure 40. IRS2109S vs. Frequency (IRFBC40),
 $R_{gate}=15\ \Omega$, $V_{CC}=15\ V$**



**Figure 41. IRS2109S vs. Frequency (IRFPE5)
 $R_{gate}=10\ \Omega$, $V_{CC}=15\ V$**

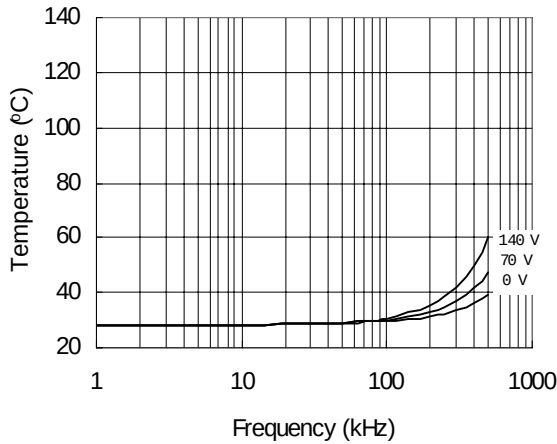


Figure 42. IRS21094S vs. Frequency (IRFBC20),
 $R_{gate}=33\ \Omega$, $V_{cc}=15\ V$

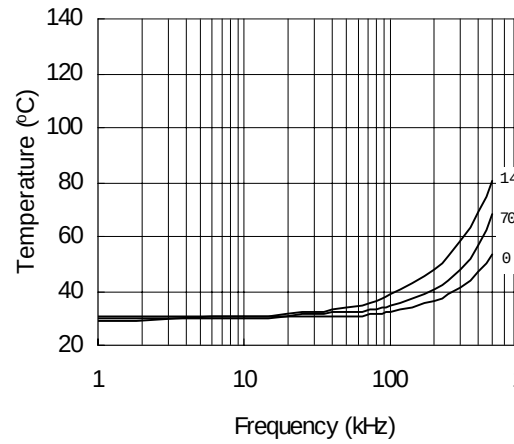


Figure 43. IRS21094S vs. Frequency (IRFBC20),
 $R_{gate}=22\ \Omega$, $V_{cc}=15\ V$

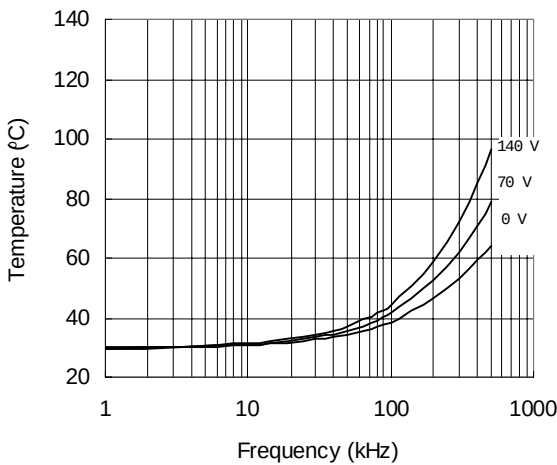


Figure 44. IRS21094S vs. Frequency (IRFBC40),
 $R_{gate}=15\ \Omega$, $V_{cc}=15\ V$

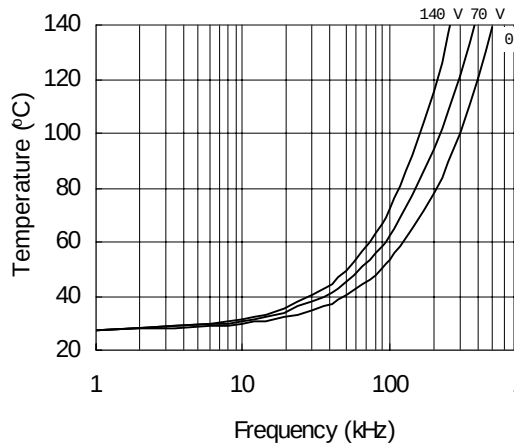
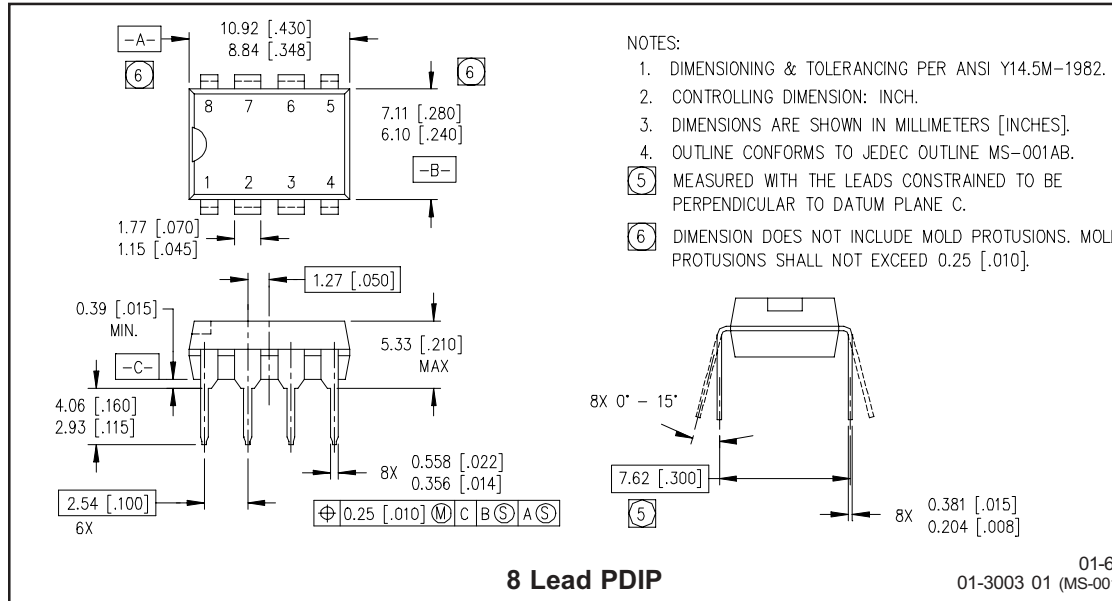
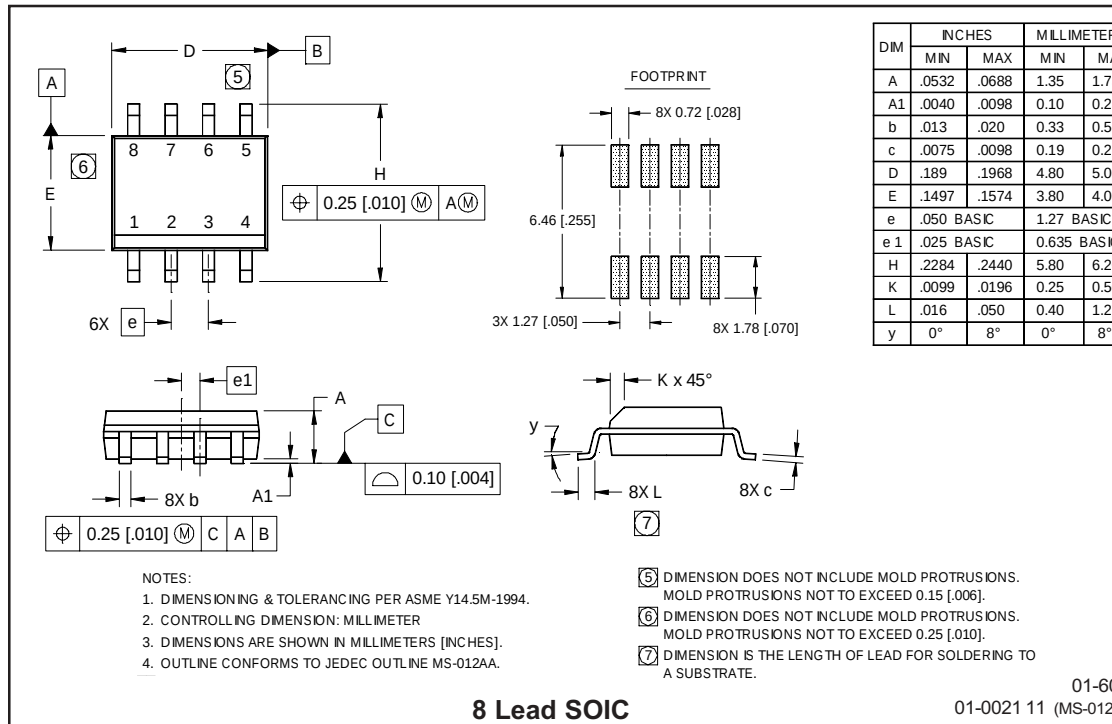


Figure 45. IRS21094S vs. Frequency (IRFPE10),
 $R_{gate}=10\ \Omega$, $V_{cc}=15\ V$

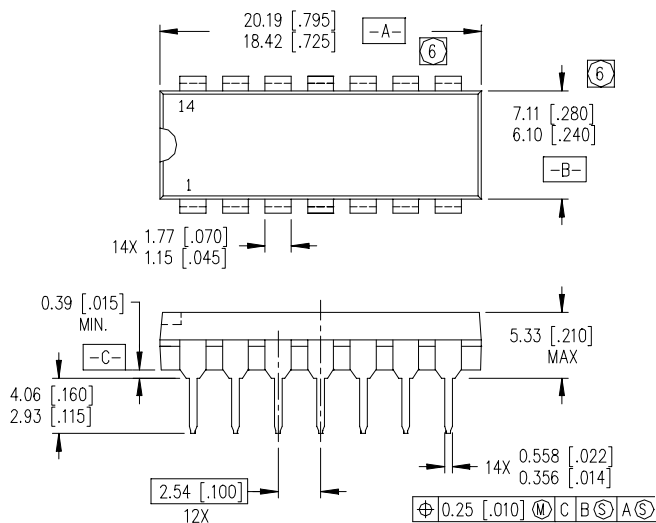
Case Outlines



01-6
01-3003 01 (MS-00



01-6
01-0021 11 (MS-012

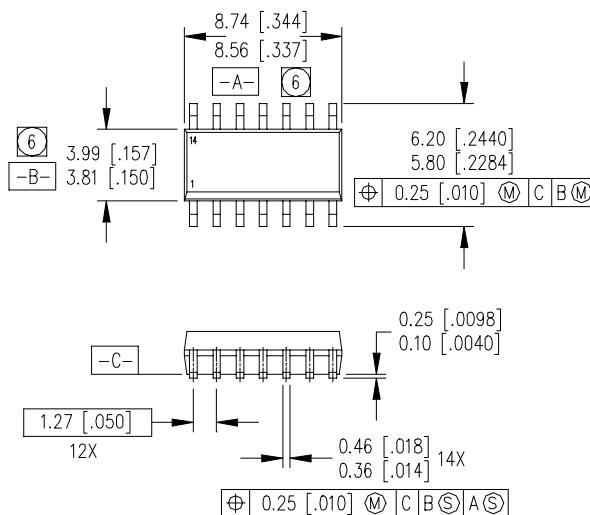
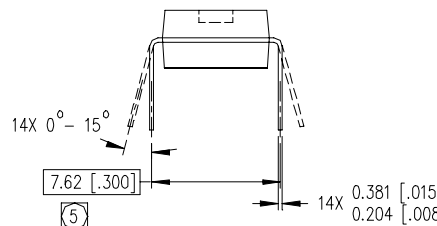


14 Lead PDIP

01-6
01-3002 03 (MS-00

NOTES:

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1994
2. CONTROLLING DIMENSION: INCH.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-001AC.
5. MEASURED WITH THE LEADS CONSTRAINED TO BE PERPENDICULAR TO DATUM PLANE C.
6. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS SHALL NOT EXCEED 0.25 [0.010].

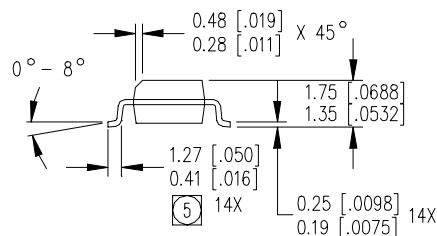


14 Lead SOIC (narrow body)

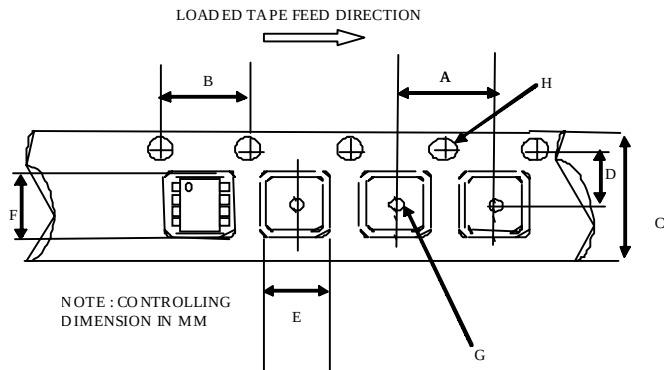
01-3063 00 (MS-01

NOTES:

- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1994
2 CONTROLLING DIMENSION: MILLIMETER
3 DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4 OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AB.
5 DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO
A SUBSTRATE.
6 DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. IF
PROTRUSIONS SHALL NOT EXCEED 0.15 [.006] INCHES.

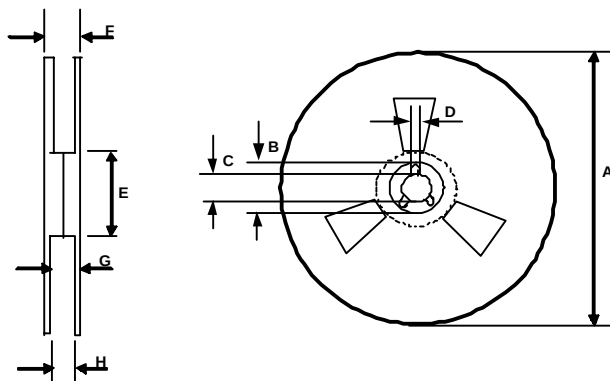


Tape & Reel 8-lead SOIC



CARRIER TAPE DIMENSION FOR 8SOICN

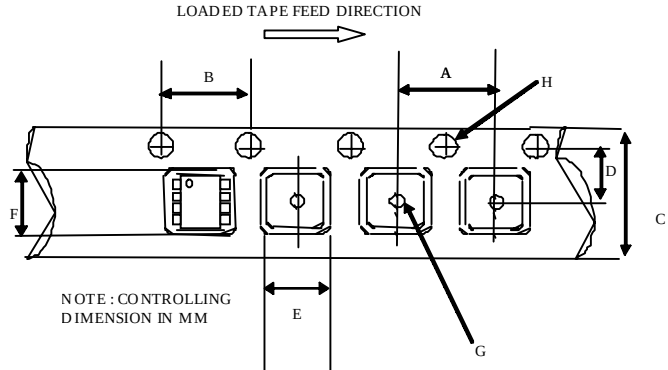
Code	Metric		Imperial	
	Min	Max	Min	Max
A	7.90	8.10	0.311	0.318
B	3.90	4.10	0.153	0.161
C	11.70	12.30	0.46	0.484
D	5.45	5.55	0.214	0.218
E	6.30	6.50	0.248	0.255
F	5.10	5.30	0.200	0.208
G	1.50	n/a	0.059	n/a
H	1.50	1.60	0.059	0.062



REEL DIMENSIONS FOR 8SOICN

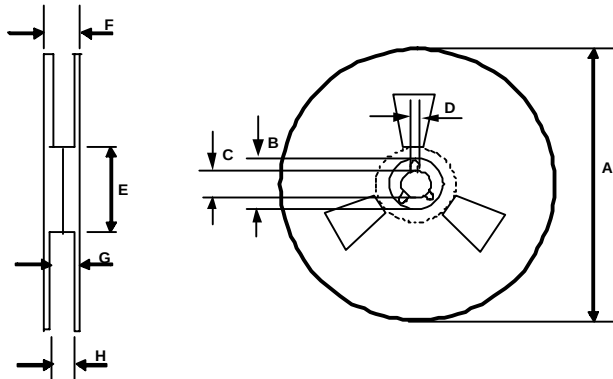
Code	Metric		Imperial	
	Min	Max	Min	Max
A	329.60	330.25	12.976	13.001
B	20.95	21.45	0.824	0.844
C	12.80	13.20	0.503	0.519
D	1.95	2.45	0.767	0.096
E	98.00	102.00	3.858	4.015
F	n/a	18.40	n/a	0.724
G	14.50	17.10	0.570	0.673
H	12.40	14.40	0.488	0.566

Tape & Reel 14-lead SOIC



CARRIER TAPE DIMENSION FOR 14SOICN

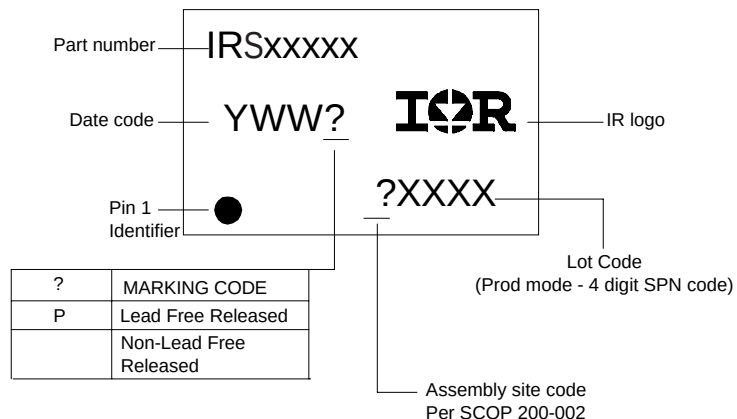
Code	Metric		Imperial	
	Min	Max	Min	Max
A	7.90	8.10	0.311	0.318
B	3.90	4.10	0.153	0.161
C	15.70	16.30	0.618	0.641
D	7.40	7.60	0.291	0.299
E	6.40	6.60	0.252	0.260
F	9.40	9.60	0.370	0.378
G	1.50	n/a	0.059	n/a
H	1.50	1.60	0.059	0.062



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

LEADFREE PART MARKING INFORMATION



ORDER INFORMATION

8-Lead PDIP IRS2109PbF
8-Lead SOIC IRS2109SPbF
8-Lead SOIC Tape & Reel IRS2109STRPbF

14-Lead PDIP IRS21094PbF
14-Lead SOIC IRS21094SPbF
14-Lead SOIC Tape & Reel IRS21094STRPbF