International
IOR Rectifier

PRELIMINARY

Data Sheet No. PD60274 revA

IRS2130/IRS21303/IRS2132 (J&S)PbF

3-PHASE 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 all channels
- Over-current shutdown turns off all six drivers
- Three Independent half-bridge drivers
- Matched propagation delay for all channels
- 2.5 V logic compatible
- Outputs out of phase with inputs
- Cross-conduction prevention logic
- All parts are LEAD-FREE

Product Summary

V_{OFFSET}	600 V max.
I_O+/- (min.)	200 mA / 420 mA
V_{OUT}	10 V – 20 V (IRS213(0,2)) 13 V – 20 V (IRS21303)
$t_{on/off}$ (typ.)	500 ns
Deadtime (typ.)	2.0 µs (IRS2130) 0.7 µs (IRS213(2,03))

Applications:

*Motor Control
*Air Conditioners/ Washing Machines
*General Purpose Inverters
*Micro/Mini Inverter Drives

Description

The IRS213(0, 03, 2) are high voltage, high speed power MOSFET and IGBT drivers with three independent high and low side referenced output channels. Proprietary HVIC technology enables ruggedized monolithic construction. Logic inputs are compatible with CMOS or LSTTL outputs, down to 2.5 V logic. A ground-referenced operational amplifier provides analog feedback of bridge current via an external current sense resistor. A current trip function which terminates all six outputs is also derived from this resistor. An open drain FAULT signal indicates if an over-current or undervoltage shutdown has occurred. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to simplify use at high frequencies. The floating channels can be used to drive N-channel power MOSFETs or IGBTs in the high side configuration which operates up to 600 V.

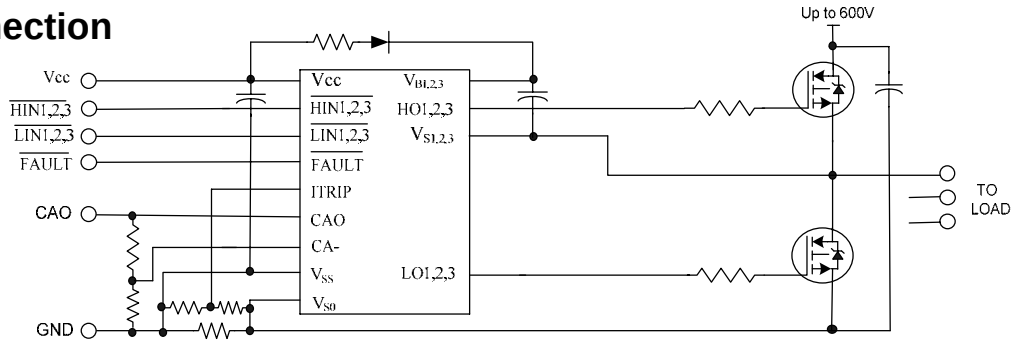
Packages

28-Lead SOIC

28-Lead PDIP

44-Lead PLCC w/o 12 Leads

Typical Connection



(Refer to Lead Assignments for correct pin configuration). This diagram shows electrical connections only. Please refer to our Application Notes and Design Tips for proper circuit board layout.

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 V_{SO}. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Zener clamps are included between V_{CC} & V_{SO} (25 V), V_{CC} & V_{SS} (20V), and V_{Bx} & V_{Sx} (20 V).

Symbol	Definition		Min.	Max.	Units
$V_{B1,2,3}$	High side floating supply voltage		-0.3	625	V
$V_{S1,2,3}$	High side floating offset voltage		$V_{B1,2,3}$ - 20	$V_{B1,2,3}$ + 0.3	
$V_{HO1,2,3}$	High side floating output voltage		$V_{S1,2,3}$ - 0.3	$V_{B1,2,3}$ + 0.3	
V_{CC}	Low side and logic fixed supply voltage		-0.3	25	
V_{SS}	Logic ground		V_{CC} - 20	V_{CC} + 0.3	
$V_{LO1,2,3}$	Low side output voltage		-0.3	V_{CC} + 0.3	
V_{IN}	Logic input voltage ($\overline{HIN1,2,3}$, $\overline{LIN1,2,3}$ & ITRIP)		V_{SS} -0.3	(V_{SS} + 15) or (V_{CC} + 0.3), whichever is lower	
V_{FLT}	$\overline{FAULT}$ output voltage		V_{SS} -0.3	V_{CC} +0.3	
V_{CAO}	Operational amplifier output voltage		V_{SS} -0.3	V_{CC} +0.3	
V_{CA-}	Operational amplifier inverting input voltage		V_{SS} -0.3	V_{CC} +0.3	
dV_S/dt	Allowable offset supply voltage transient		—	50	V/ns
P_D	Package power dissipation @ $T_A \leq +25$ °C	(28 lead PDIP)	—	1.5	W
		(28 lead SOIC)	—	1.6	
		(44 lead PLCC)	—	2.0	
$R_{th,JA}$	Thermal resistance, junction to ambient	(28 lead PDIP)	—	83	°C/W
		(28 lead SOIC)	—	78	
		(44 lead PLCC)	—	63	
T_J	Junction temperature		—	150	°C
T_S	Storage temperature		-55	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. All voltage parameters are absolute voltage referenced to V_{SO}. The V_S offset rating is tested with all supplies biased at a 15 V differential.

Symbol	Definition		Min.	Max.	Units
$V_{B1,2,3}$	High side floating supply voltage	IRS213(0,2)	$V_{S1,2,3}$ +10	$V_{S1,2,3}$ +20	V
		IRS21303	$V_{S1,2,3}$ +13		
$V_{S1,2,3}$	High side floating offset voltage		Note 1	600	
$V_{HO1,2,3}$	High side floating output voltage		$V_{S1,2,3}$	$V_{B1,2,3}$	
V_{CC}	Low side and logic fixed supply voltage	IRS213(0,2)	10	20	
		IRS21303	13		
V_{SS}	Logic ground		-5	5	
$V_{LO1,2,3}$	Low side output voltage		0	V_{CC}	
V_{IN}	Logic input voltage ($\overline{HIN1,2,3}$, $\overline{LIN1,2,3}$ & ITRIP)		V_{SS}	V_{SS} + 5	
V_{FLT}	$\overline{FAULT}$ output voltage		V_{SS}	V_{CC}	
V_{CAO}	Operational amplifier output voltage		V_{SS}	V_{SS} + 5	
V_{CA-}	Operational amplifier inverting input voltage		V_{SS}	V_{SS} + 5	
T_A	Ambient temperature		-40	125	°C

Note 1: Logic operational for V_S of (V_{SO} - 8 V) to (V_{SO} + 600 V). Logic state held for V_S of (V_{SO} - 8 V) to (V_{SO} – V_{BS}). (Please refer to the Design Tip DT97-3 for more details).

Note 2: The CAO pin and all input pins (except CA-) are internally clamped with a 5.2 V zener diode.

Static Electrical Characteristics

V_{BIAS} (V_{CC}, $V_{BS1,2,3}$) = 15 V, $V_{SO1,2,3}$ = V_{SS} and T_A = 25 °C unless otherwise specified. The V_{IN}, V_{TH}, and I_{IN} parameters are referenced to V_{SS} and are applicable to all six logic input leads: $\overline{HIN1,2,3}$ & $\overline{LIN1,2,3}$. The V_O and I_O parameters are referenced to $V_{SO1,2,3}$ and are applicable to the respective output leads: HO1,2,3 or LO1,2,3.

Symbol	Definition		Min.	Typ.	Max.	Units	Test Conditions
V_{IH}	Logic "0" input voltage (OUT = LO)		2.2	—	—	V	
V_{IL}	Logic "1" input voltage (OUT = HI)		—	—	0.8		
$V_{IT,TH+}$	ITRIP input positive going threshold		400	490	580	mV	
V_{OH}	High level output voltage, V_{BIAS} - V_O		—	—	1	V	V_{IN} = 0 V, Io= 20 mA
V_{OL}	Low level output voltage, V_O		—	—	400	mV	V_{IN} = 5 V, Io= 20 mA
I_{LK}	Offset supply leakage current		—	—	50	µA	V_B = V_S = 600 V
I_{QBS}	Quiescent V_{BS} supply current		—	30	70		V_{IN} = 0 V
I_{QCC}	Quiescent V_{CC} supply current		—	3	5	mA	
I_{IN+}	Logic "1" input bias current (OUT = HI)		—	300	400	µA	
I_{IN-}	Logic "0" input bias current (OUT = LO)		—	220	300		V_{IN} = 5 V
I_{ITRIP+}	"High" ITRIP bias current		—	5	10		ITRIP = 5 V
I_{ITRIP-}	"Low" ITRIP bias current		—	—	100	nA	ITRIP = 0 V
V_{BSUV+}	V_{BS} supply undervoltage positive going threshold	IRS213(0,2)	7.5	8.35	9.2	V	
		IRS21303	11	—	13		
V_{BSUV-}	V_{BS} supply undervoltage negative going threshold	IRS213(0,2)	7.1	7.95	8.8		
		IRS21303	9	—	11		
V_{CCUV+}	V_{CC} supply undervoltage positive going threshold	IRS213(0,2)	8.3	9	9.7		
		IRS21303	11	—	13		
V_{CCUV-}	V_{CC} supply undervoltage negative going threshold	IRS213(0,2)	8	8.7	9.4		
		IRS21303	9	—	11		
V_{CCUVH}	Hysteresis	IRS213(0,2)	—	0.3	—		
		IRS21303	—	2	—		
V_{BSUVH}	Hysteresis	IRS213(0,2)	—	0.4	—		
		IRS21303		2			
$R_{on,\ FLT}$	$\overline{FAULT}$ low on-resistance		—	55	75	Ω	
I_{O+}	Output high short circuit pulsed current		200	250	—	mA	V_O = 0 V, V_{IN} = 0 V PW ≤ 10 µs
I_{O-}	Output low short circuit pulsed current		420	500	—		V_O = 15 V, V_{IN} = 5 V PW ≤ 10 µs
V_{OS}	Operational amplifier input offset voltage		—	—	10	mV	V_{SO} = V_{CA-} = 0.2 V
I_{CA-}	CA- input bias current		—	—	50	nA	V_{CA-} = 2.5 V
CMRR	Operational amplifier common mode rejection ratio		TBD	80	—	dB	V_{SO} = V_{CA-} = 0.1 V & 1.1 V
PSRR	Operational amplifier power supply rejection ratio		TBD	75	—		V_{SO} = V_{CA-} = 0.2 V V_{CC} = 10 V & 20 V
$V_{OH,AMP}$	Operational amplifier high level output voltage		4.9	5.2	5.4	V	V_{CA-} = 0 V, V_{SO} =1 V
$V_{OL,AMP}$	Operational amplifier low level output voltage		—	—	30	mV	V_{CA-} = 1 V, V_{SO} =0 V

Static Electrical Characteristics - (Continued)

V_{BIAS} (V_{CC}, $V_{BS1,2,3}$) = 15 V, $V_{SO1,2,3}$ = V_{SS} and T_A = 25 °C unless otherwise specified. The $V_{IN,}$ V_{TH}, and I_{IN} parameters are referenced to V_{SS} and are applicable to all six logic input leads: $\overline{HIN1,2,3}$ & $\overline{LIN1,2,3}$. The V_O and I_O parameters are referenced to $V_{SO1,2,3}$ and are applicable to the respective output leads: HO1,2,3 or LO1,2,3.

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
$I_{SRC,AMP}$	Operational amplifier output source current	4	7	—	mA	V_{CA-} = 0 V, V_{SO} =1 V V_{CAO} = 4 V
$I_{SNK,AMP}$	Operational amplifier output sink current	1	2.1	—		V_{CA-} = 1 V, V_{SO} =0 V V_{CAO} = 2 V
$I_{O+,AMP}$	Operational amplifier output high short circuit current	—	10	—		V_{CA-} = 0 V, V_{SO} =5 V V_{CAO} = 0 V
$I_{O-,AMP}$	Operational amplifier output low short circuit current	—	4	—		V_{CA-} = 5 V, V_{SO} =0 V V_{CAO} = 5 V

Dynamic Electrical Characteristics

V_{BIAS} (V_{CC}, $V_{BS1,2,3}$) = 15 V, $V_{SO1,2,3}$ = V_{SS} , C_L = 1000 pF, T_A = 25 °C unless otherwise specified.

Symbol	Definition		Min.	Typ.	Max.	Units	Test Conditions
t_{on}	Turn-on propagation delay		400	500	700	ns	
t_{off}	Turn-off propagation delay		400	500	700		
t_r	Turn-on rise time		—	80	125		$V_{S1,2,3}$ = 0 V to 600 V
t_f	Turn-off fall time		—	35	55		
t_{itrip}	ITRIP to output shutdown propagation delay		400	660	920		
t_{bl}	ITRIP blanking time		—	400	—		
t_{flt}	ITRIP to $\overline{FAULT}$ indication delay		350	550	870		
$t_{flt,\ in}$	Input filter time (all six inputs)		—	325	—		
t_{fltclr}	$\overline{LIN1,2,3}$ to $\overline{FAULT}$ clear time IRS213(0,2) $\overline{LIN1,2,3}$ & $\overline{HIN1,2,3}$ to $\overline{FAULT}$ clear time IRS21303		5300	8500	13700		
DT	Deadtime	IRS2130	1300	2000	3100		
		IRS213(2,03)	500	700	1100		
SR+	Operational amplifier slew rate (+)		5	10	—	V/µs	1 V input step
SR-	Operational amplifier slew rate (-)		2.4	3.2	—		

NOTE: For high side PWM, HIN pulse width must be ≥ 1.5 µs.

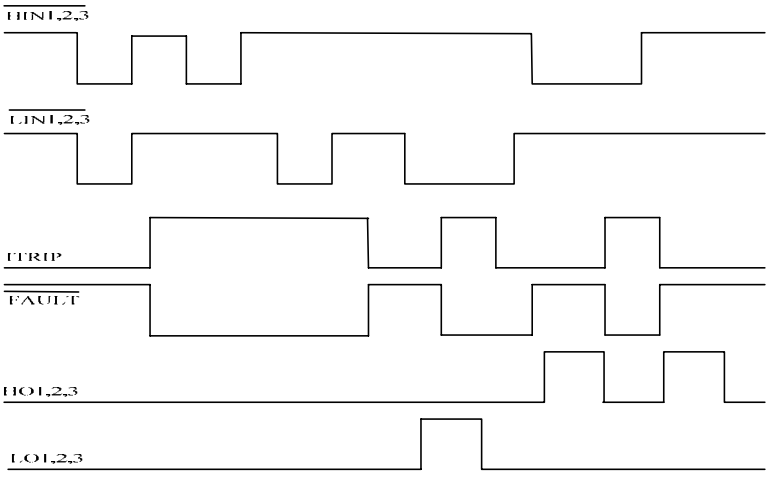


Fig. 1. Input/Output Timing Diagram

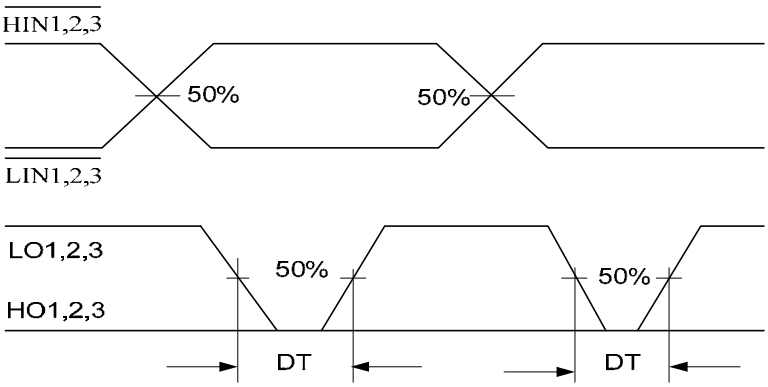


Fig. 2. Deadtime Waveform Definitions

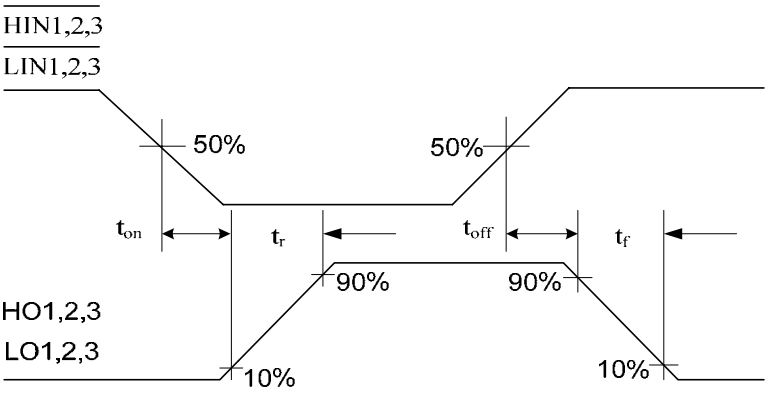


Fig. 3. Input/Output Switching Time Waveform Definitions

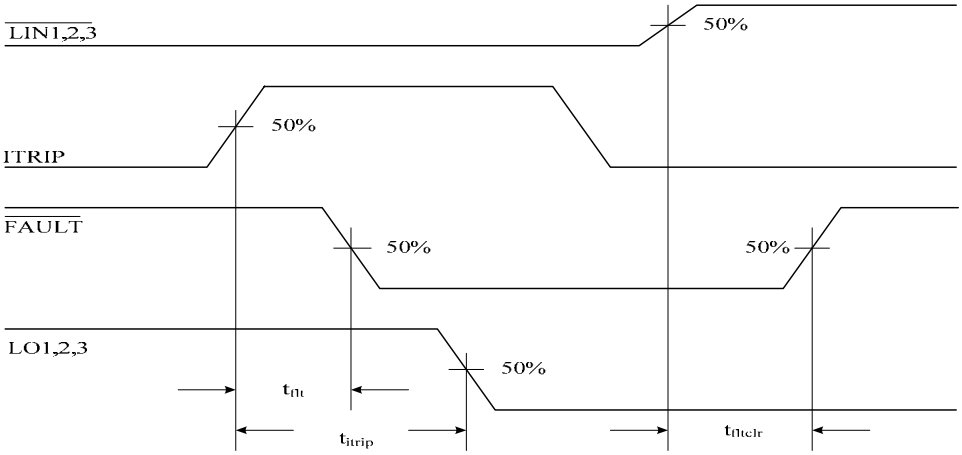


Fig. 4. Overcurrent Shutdown Switching Time Waveform Definitions

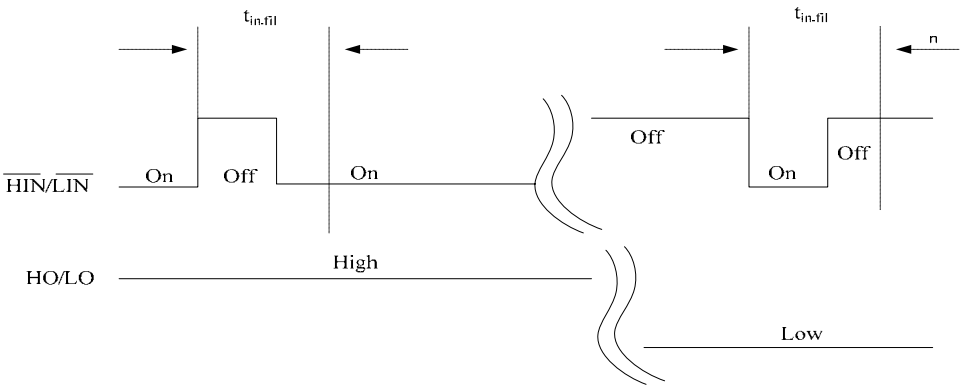


Fig. 5. Input Filter Function

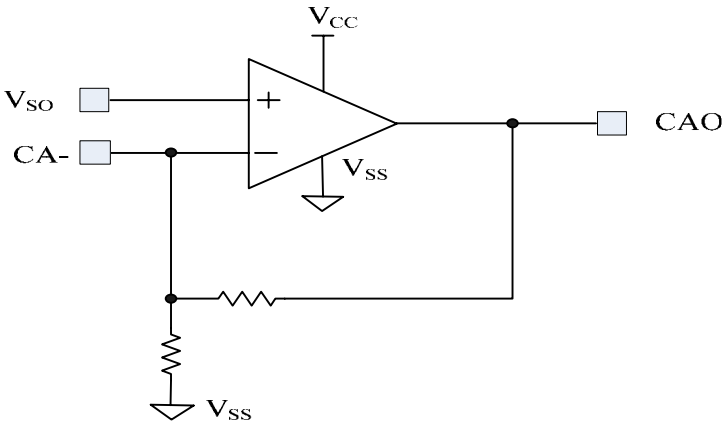
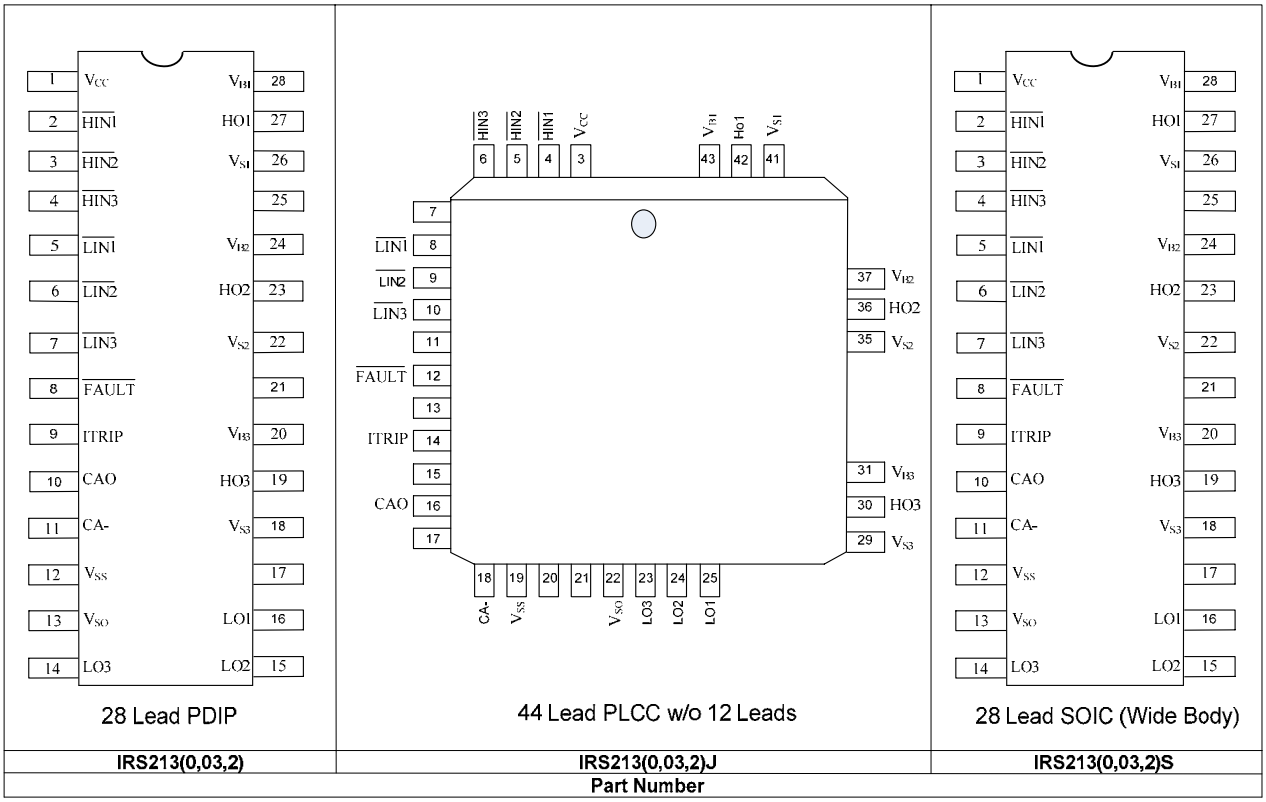


Fig. 6. Diagnostic Feedback Operational Amplifier Circuit

Lead Definitions

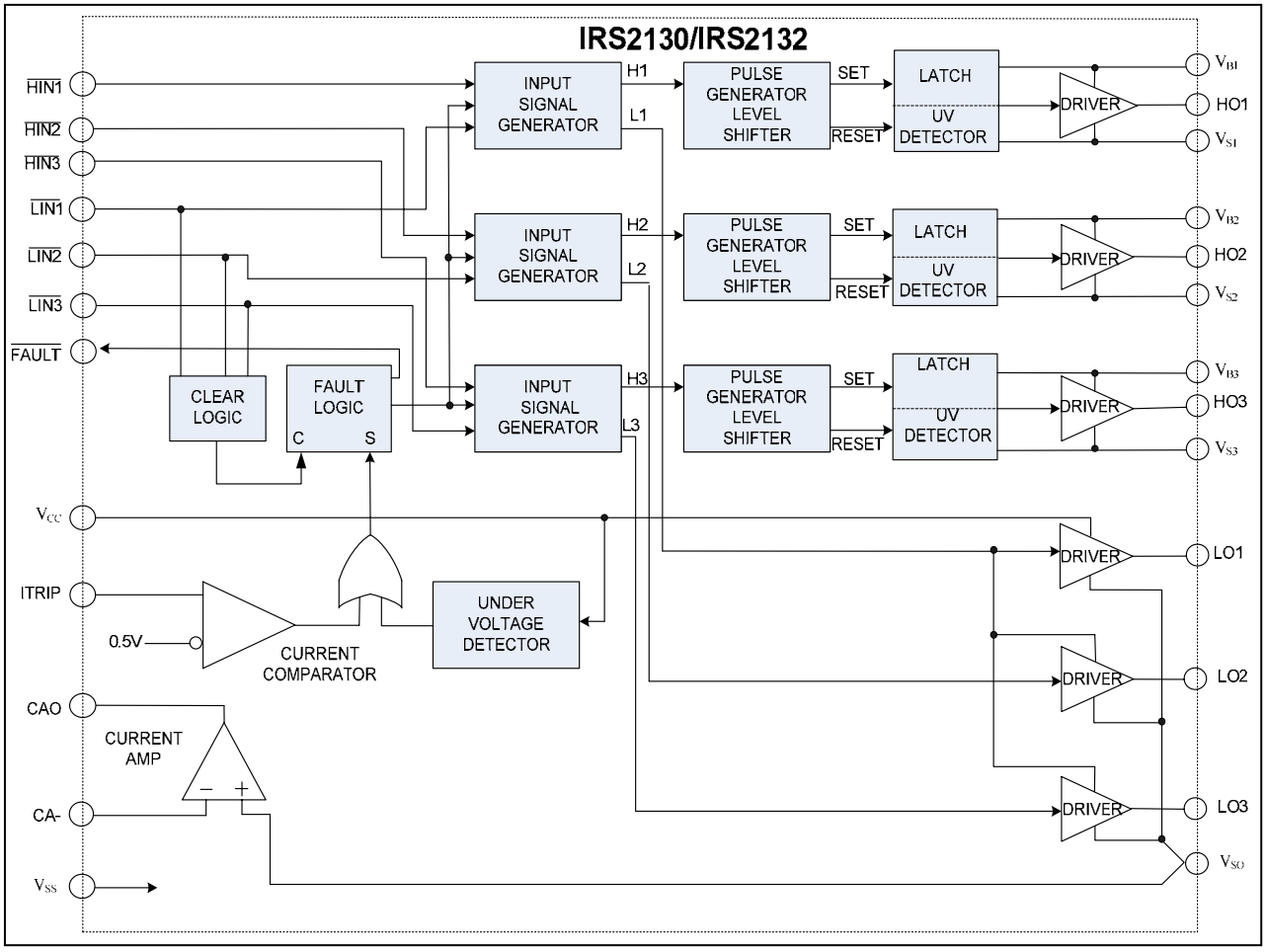
Symbol	Description
$\overline{HIN1,2,3}$	Logic input for high side gate driver outputs (HO1,2,3), out of phase
$\overline{LIN1,2,3}$	Logic input for low side gate driver output (LO1,2,3), out of phase
$\overline{FAULT}$	Indicates over-current or undervoltage lockout (low side) has occurred, negative logic
V_{CC}	Low side and logic fixed supply
ITRIP	Input for over-current shutdown
CAO	Output of current amplifier
CA-	Negative input of current amplifier
V_{SS}	Logic ground
$V_{B1,2,3}$	High side floating supply
HO1,2,3	High side gate drive output
$V_{S1,2,3}$	High side floating supply return
LO1,2,3	Low side gate drive output
V_{SO}	Low side return and positive input of current amplifier

Lead Assignments

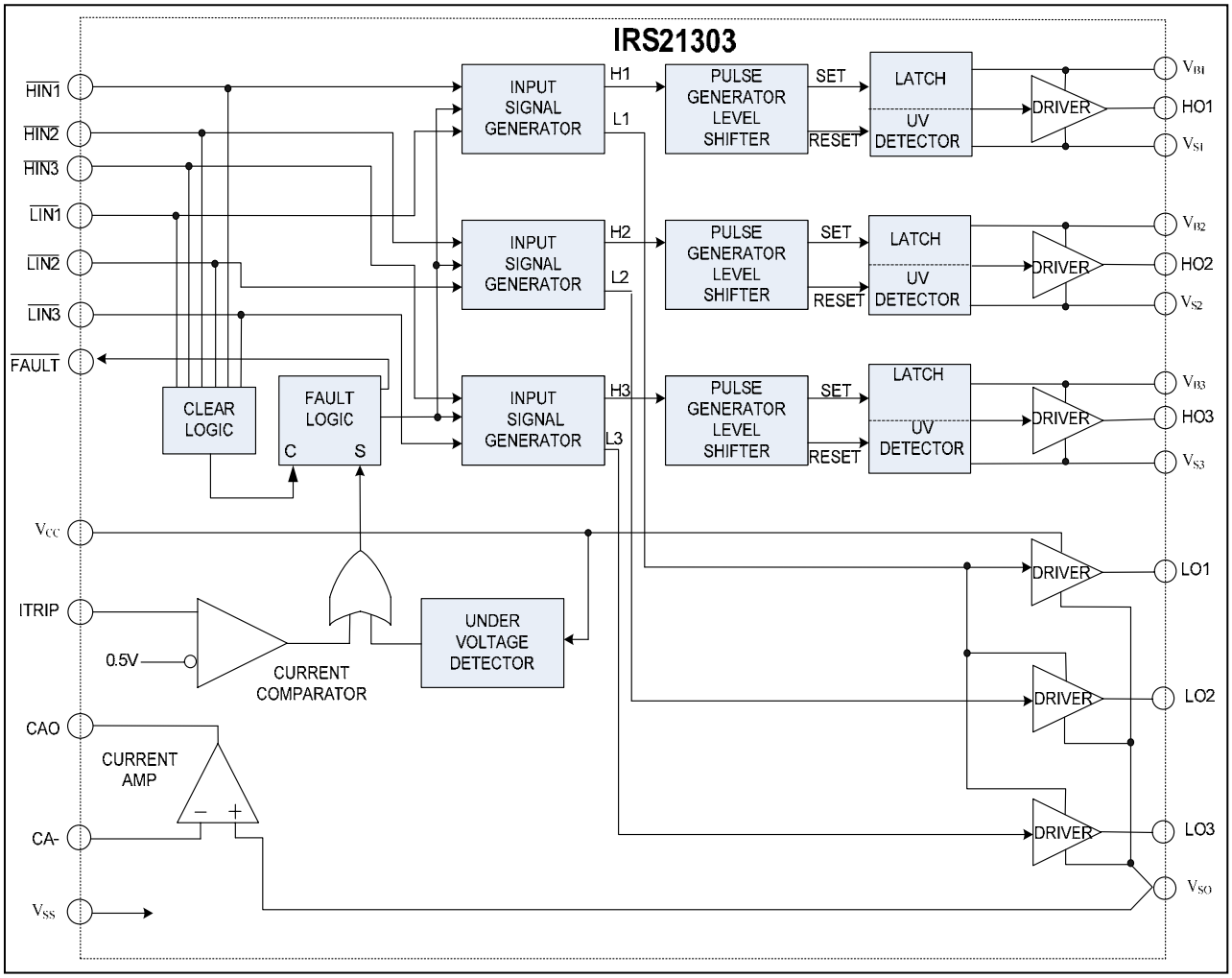


IRS213(0,03,2)	IRS213(0,03,2)J	IRS213(0,03,2)S
Part Number		

Functional Block Diagram



Functional Block Diagram



1 PCB Layout Tips

1.1 Distance from H to L Voltage

The IRS213(0,03,2)J package lacks some pins (see page 8) in order to maximizing the distance between the high voltage and low voltage pins. It's strongly recommended to place the components tied to the floating voltage in the respective high voltage portions of the device ($V_{B1,2,3}$, $V_{S1,2,3}$) side.

1.2 Ground Plane

To minimize noise coupling the ground plane must not be placed under or near the high voltage floating side.

1.3 Gate Drive Loops

Current loops behave like an antenna able to receive and transmit EM noise (see Fig. 7). In order to reduce EM coupling and improve the power switch turn on/off performances, gate drive loops must be reduced as much as possible. Moreover, current can be injected inside the gate drive loop via the IGBT collector-to-gate parasitic capacitance. The parasitic auto-inductance of the gate loop contributes to develop a voltage across the gate-emitter increasing the possibility of self turn-on effect.

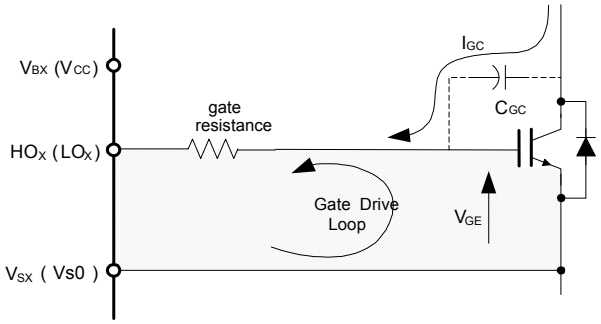


Fig. 7. Antenna Loops

1.4 Supply Capacitors

Supply capacitors must be placed as close as possible to the device pins (V_{CC} and V_{SS} for the ground tied supply, V_B and V_S for the floating supply) in order to minimize parasitic inductance/resistance.

1.5 Routing and Placement

Power stage PCB parasitic may generate dangerous voltage transients for the gate driver and the control logic. In particular it's recommended to limit phase voltage negative transients.

In order to avoid such undervoltage it is highly recommended to minimize high side emitter to low side collector distance and low side emitter to negative bus rail stray inductance. See DT04-4 at www.irf.com for more detailed information.

Figures 8-38 provide information on the experimental performance of the IRS2130S HVIC. The line plotted in each figure is generated from actual lab data. A large number of individual samples were tested at three temperatures (-40 ºC, 25 ºC, and 125 ºC) in order to generate the experimental (Exp.) curve. The line labeled Exp. consist of three data points (one data point at each of the tested temperatures) that have been connected together to illustrate the understood trend. The individual data points on the curve were determined by calculating the averaged experimental value of the parameter (for a given temperature).

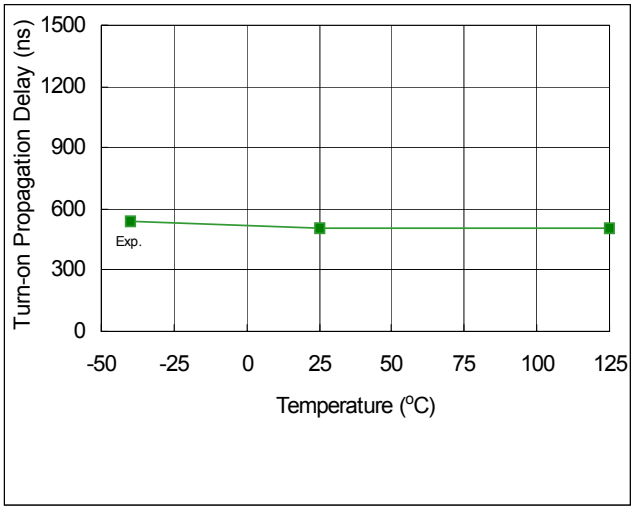


Fig. 8. Turn-On Propagation Delay vs. Temperature

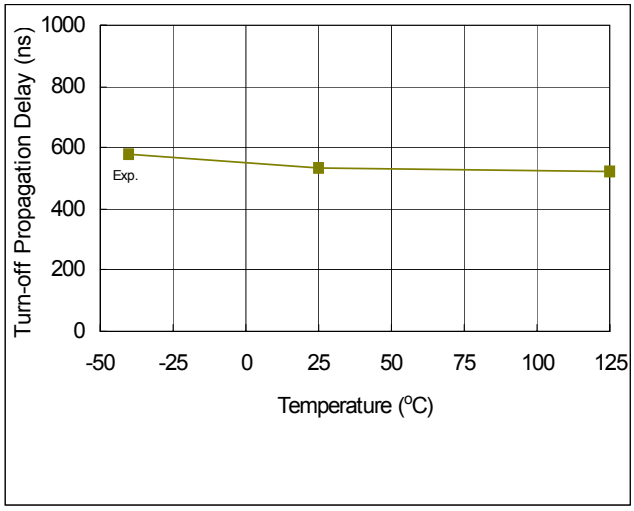


Fig. 9. Turn-Off Propagation Delay vs. Temperature

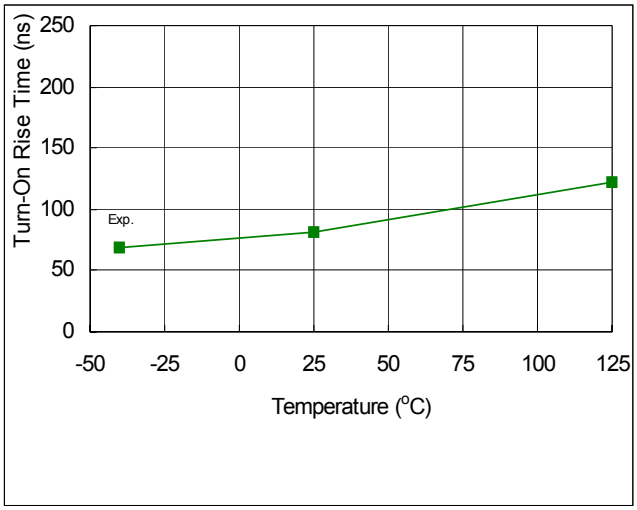


Fig. 10. Turn-On Rise Time vs. Temperature

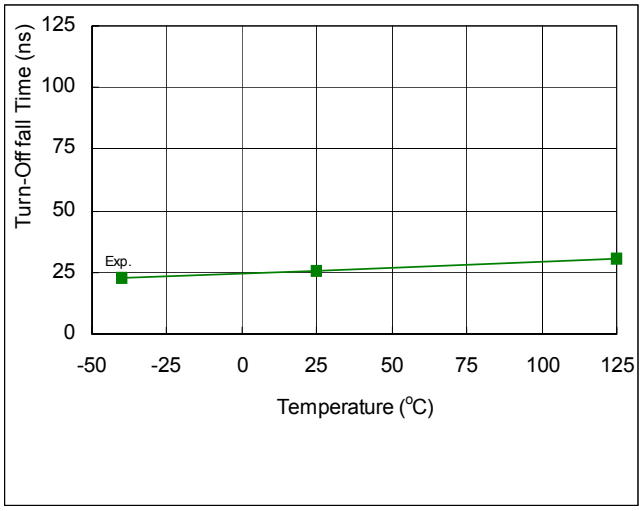


Fig. 11. Turn-Off Fall Time vs. Temperature

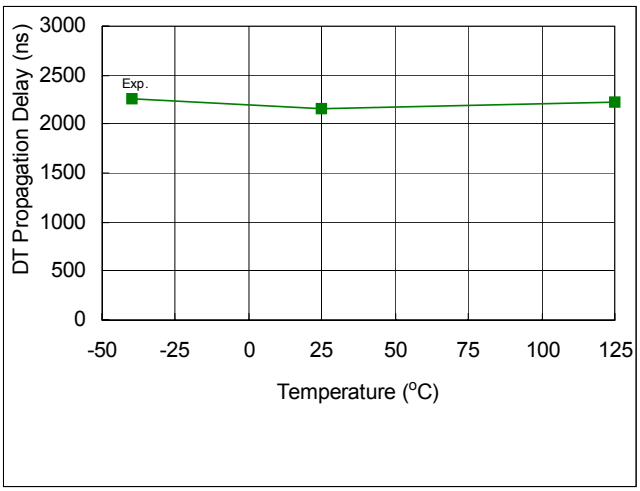


Fig. 12. DT Propagation Delay vs. Temperature

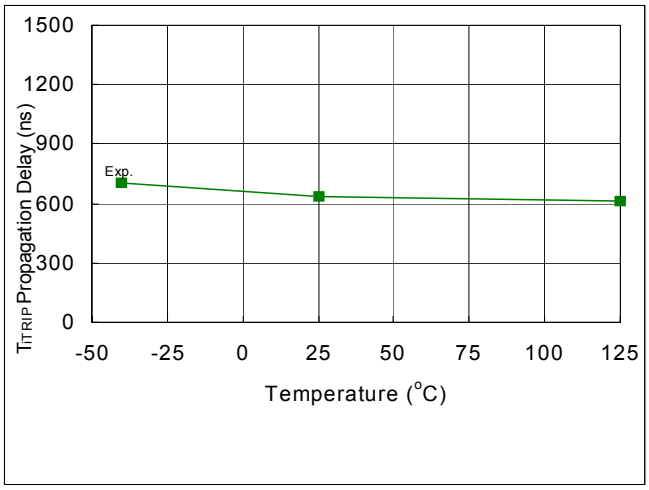


Fig. 13. T_{ITRIP} Propagation Delay vs. Temperature

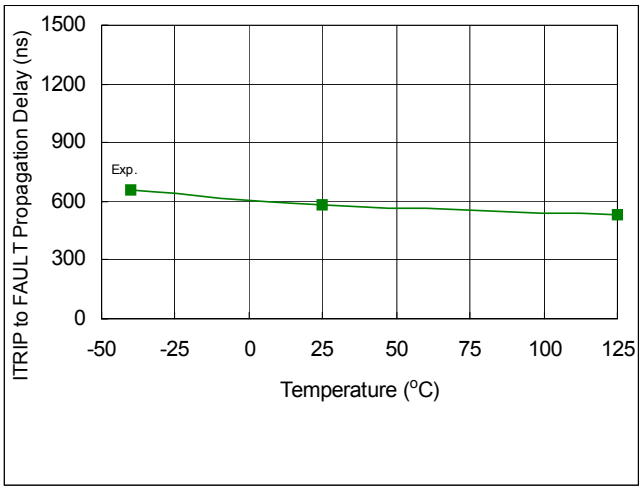


Fig. 14. ITRIP to $\overline{FAULT}$ Propagation Delay vs. Temperature

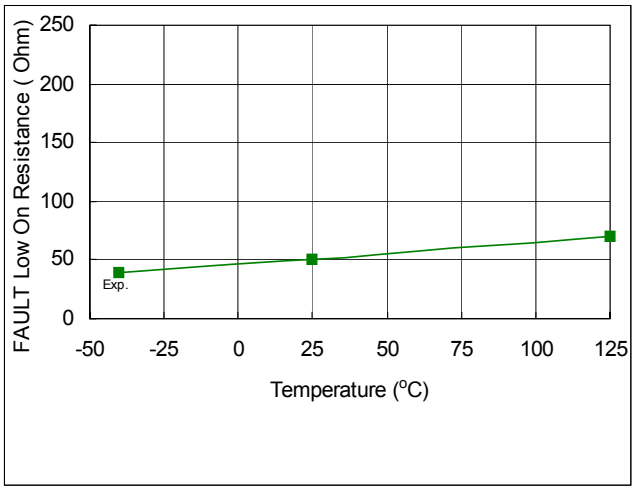


Fig.15. $\overline{FAULT}$ Low On Resistance vs. Temperature

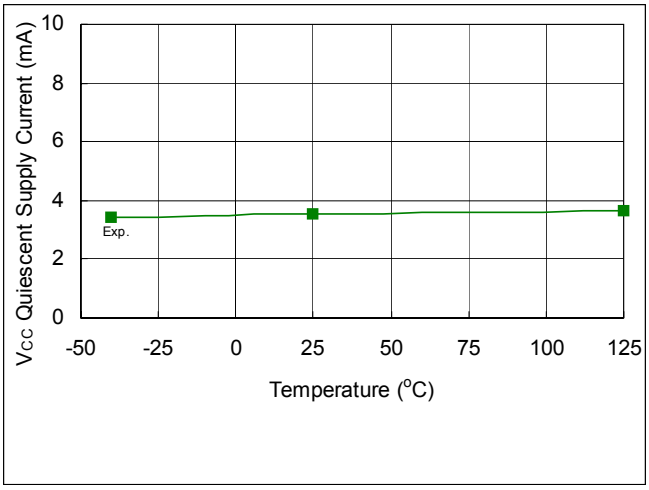


Fig. 16. V_{CC} Quiescent Current vs. Temperature

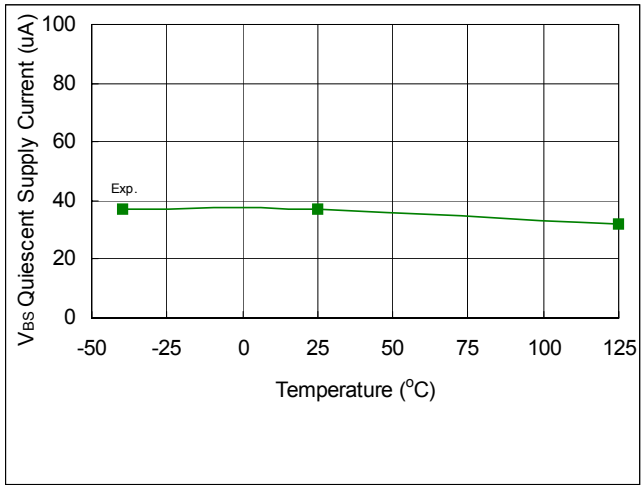


Fig. 17. V_{BS} Quiescent Current vs. Temperature

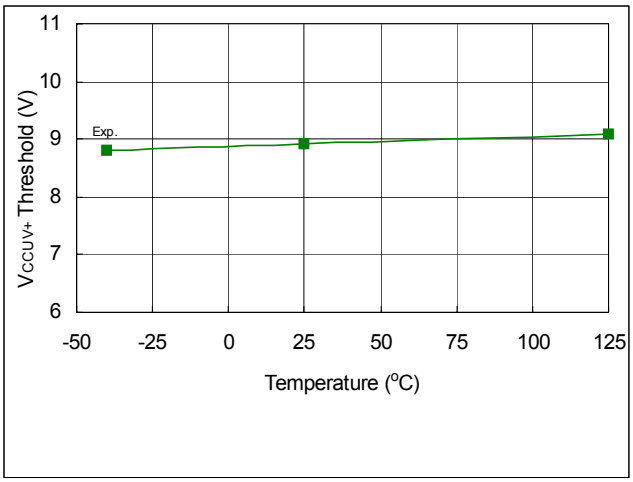


Fig. 18. V_{CCUV+} Threshold vs. Temperature

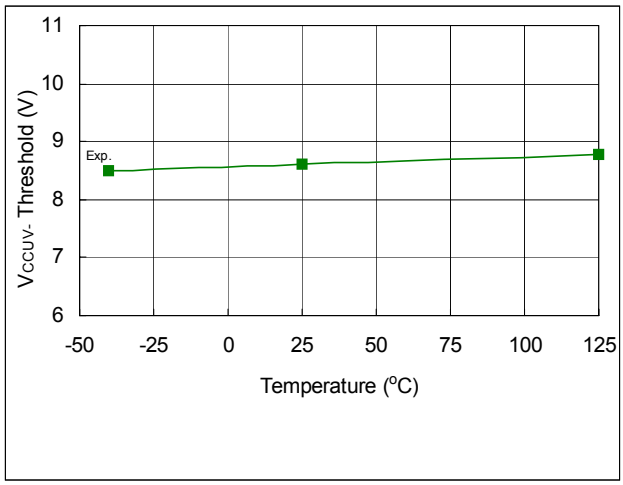


Fig. 19. V_{CCUV-} Threshold vs. Temperature

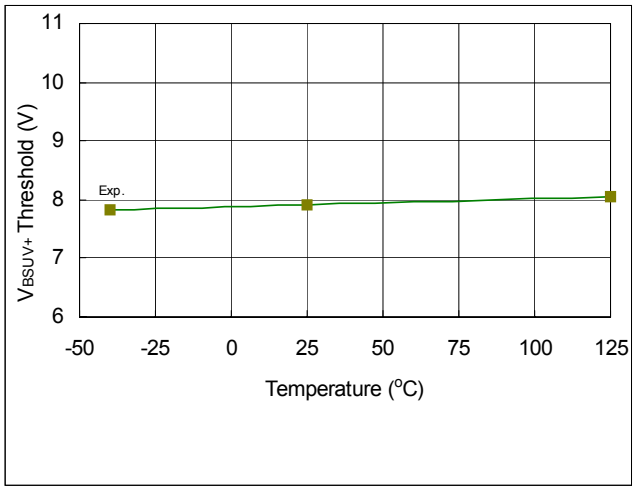


Fig. 20. V_{BSUV+} Threshold vs. Temperature

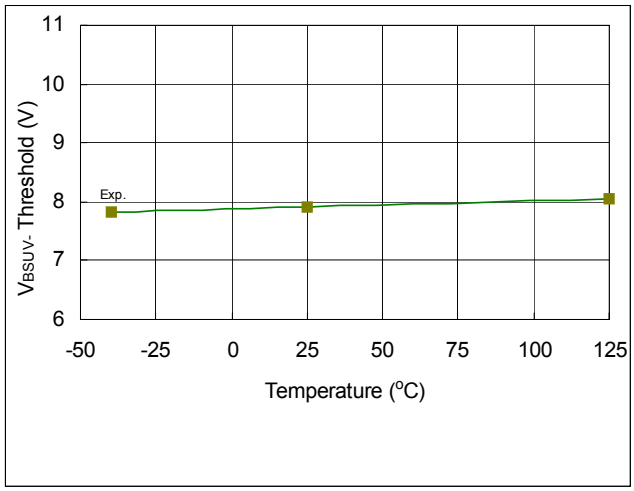


Fig. 21. V_{BSUV-} Threshold vs. Temperature

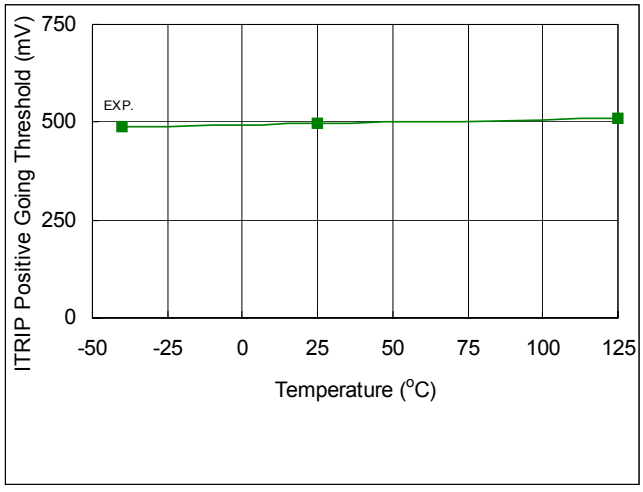


Fig. 22. ITRIP Positive Going Threshold vs. Temperature

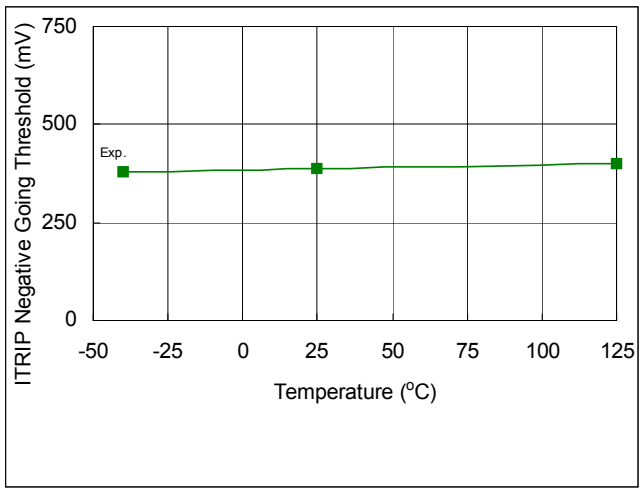


Fig. 23. ITRIP Negative Going Threshold vs. Temperature

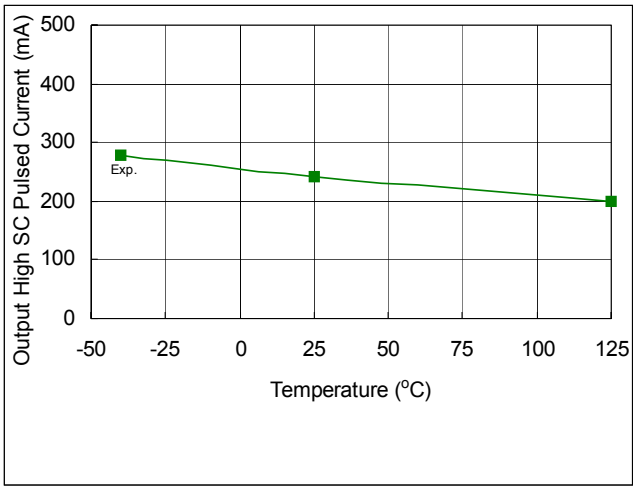


Fig. 24. Output High Short Circuit Pulsed Current vs. Temperature

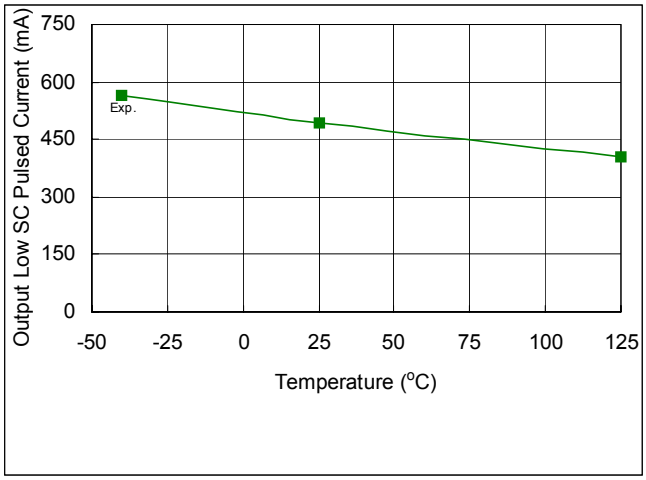


Fig. 25. Output Low Short Circuit Current vs. Temperature

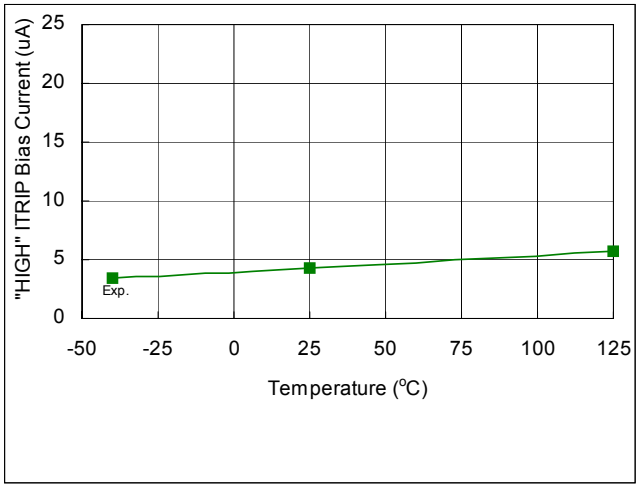


Fig. 26. "High" ITRIP Bias Current vs. Temperature

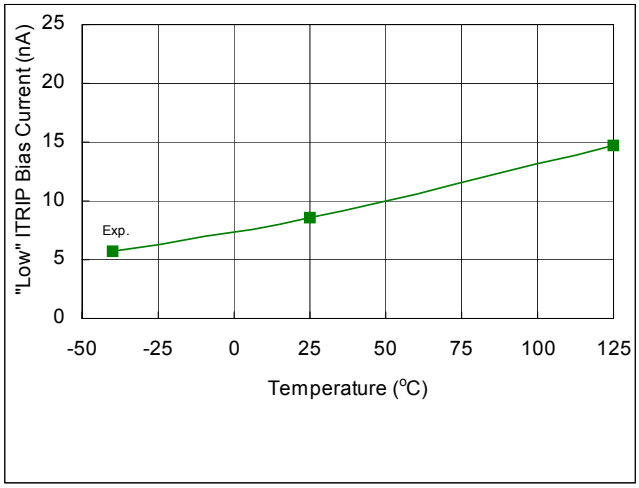


Fig. 27. "Low" ITRIP Bias Current vs. Temperature

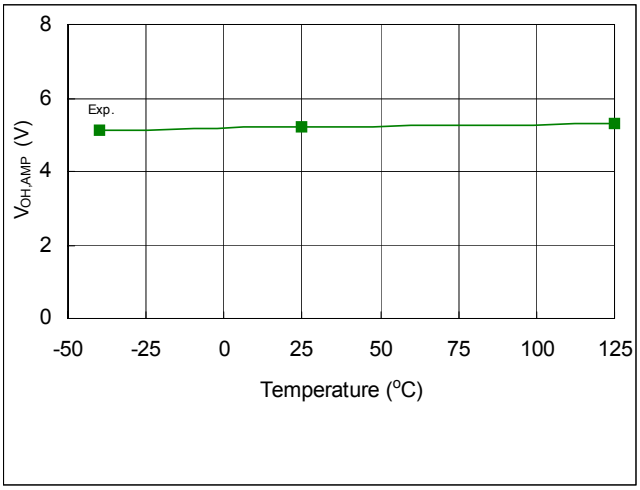


Fig. 28. $V_{OH,AMP}$ vs. Temperature

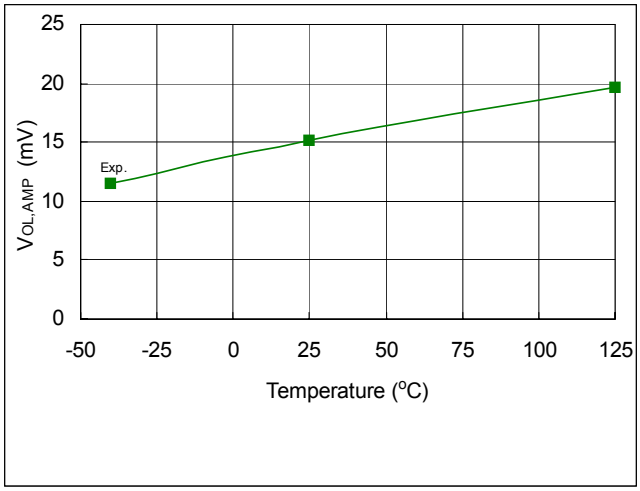


Fig. 29. $V_{OL,AMP}$ vs. Temperature

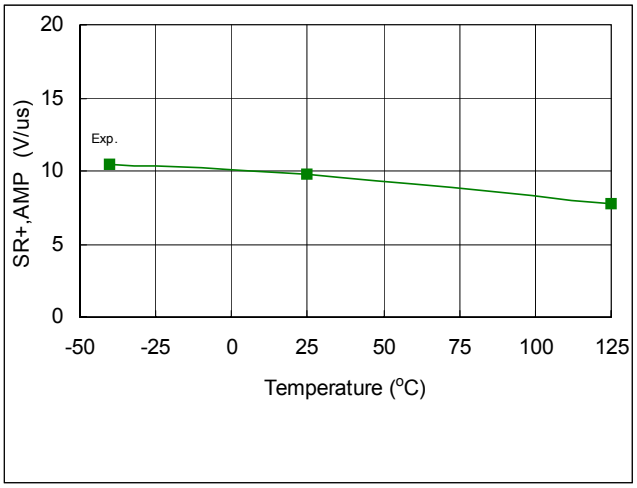


Fig. 30. SR+,AMP vs. Temperature

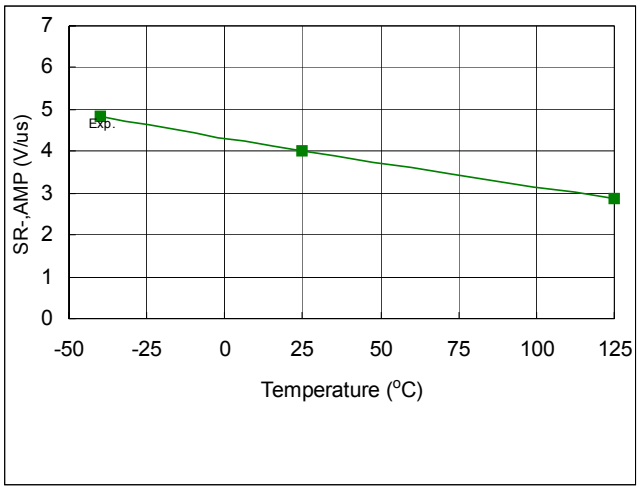


Fig. 31. SR-,AMP vs. Temperature

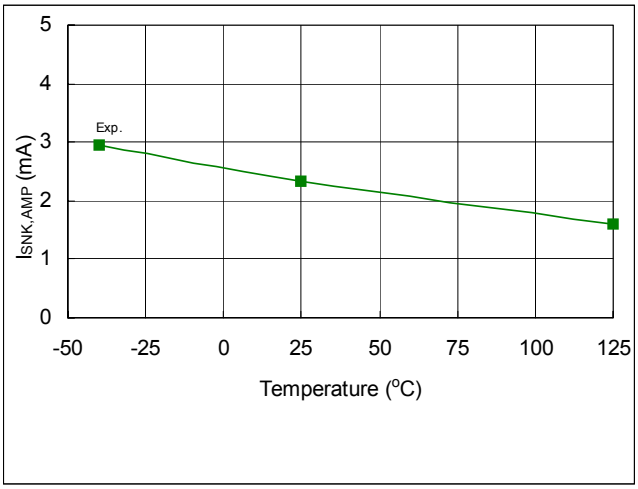


Fig. 32. $I_{SNK,AMP}$ vs. Temperature

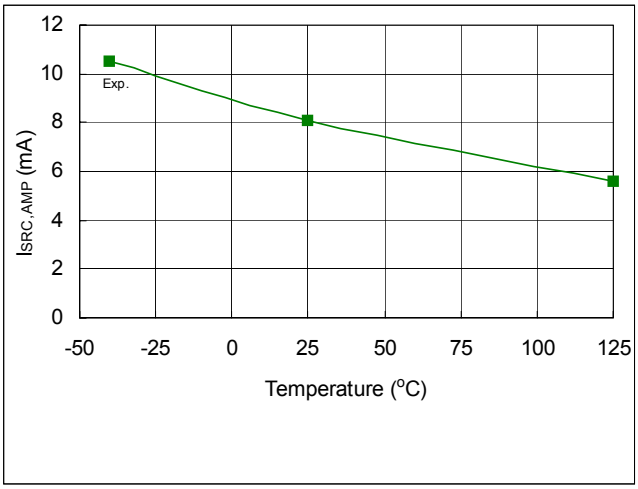


Fig. 33. $I_{SRC,AMP}$ vs. Temperature

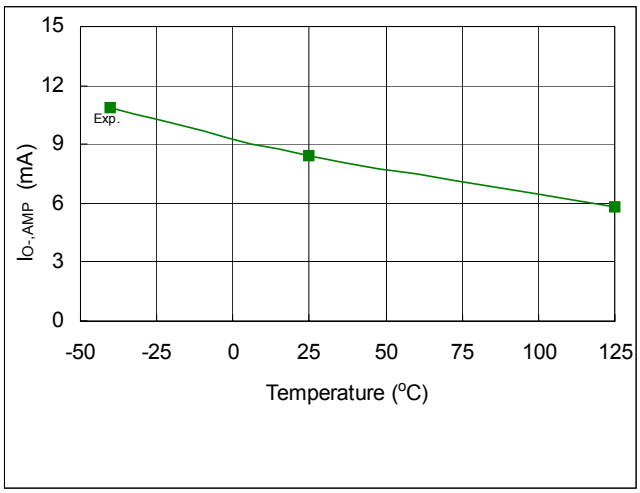


Fig. 34. $I_{O-,AMP}$ vs. Temperature

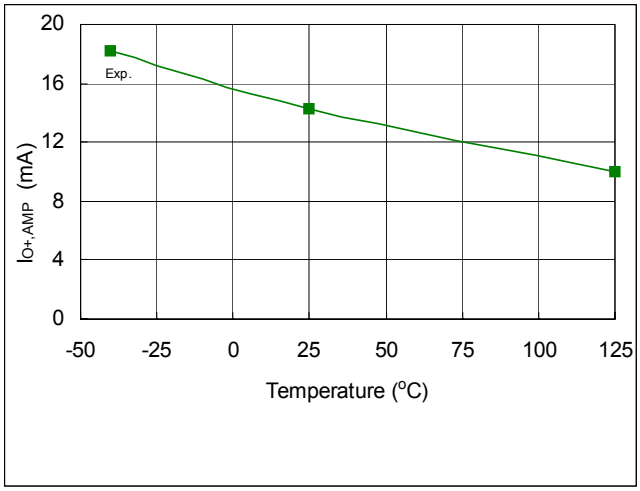


Fig. 35. $I_{O+,AMP}$ vs. Temperature

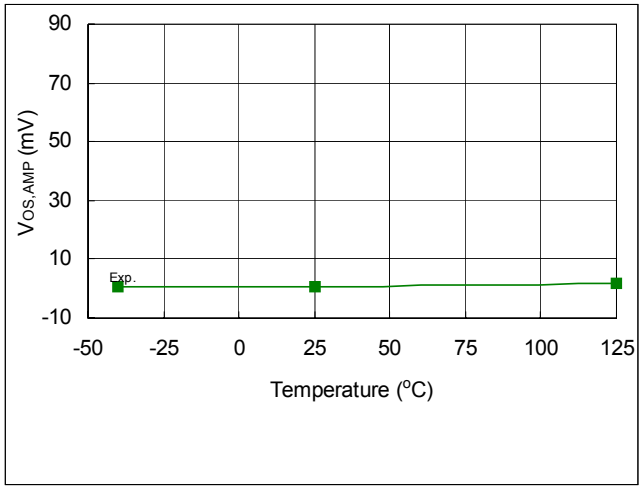


Fig. 36. $V_{OS,AMP}$ vs. Temperature

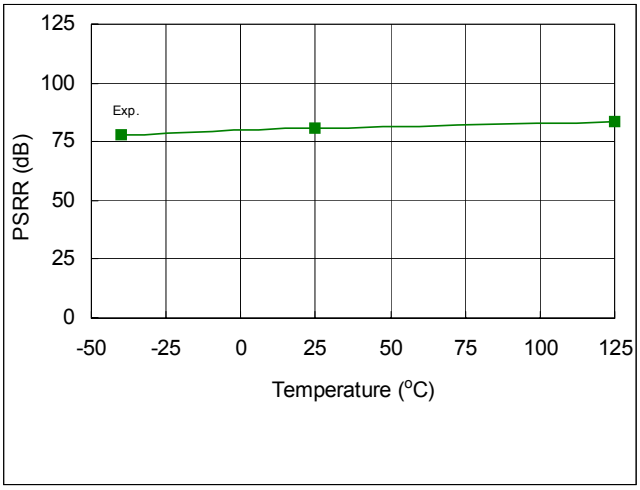


Fig. 37. PSRR vs. Temperature

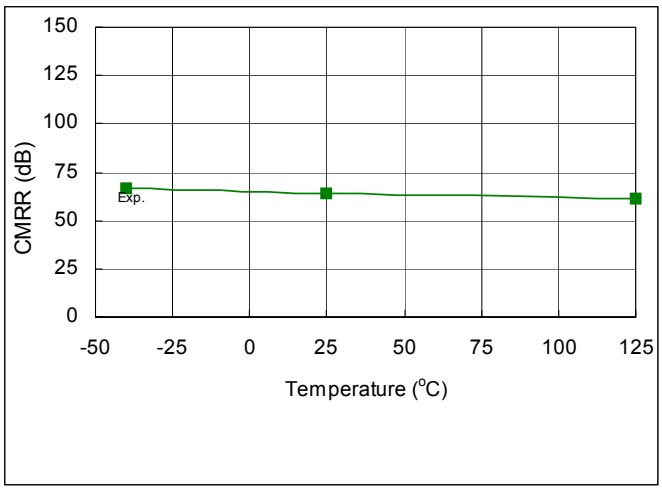
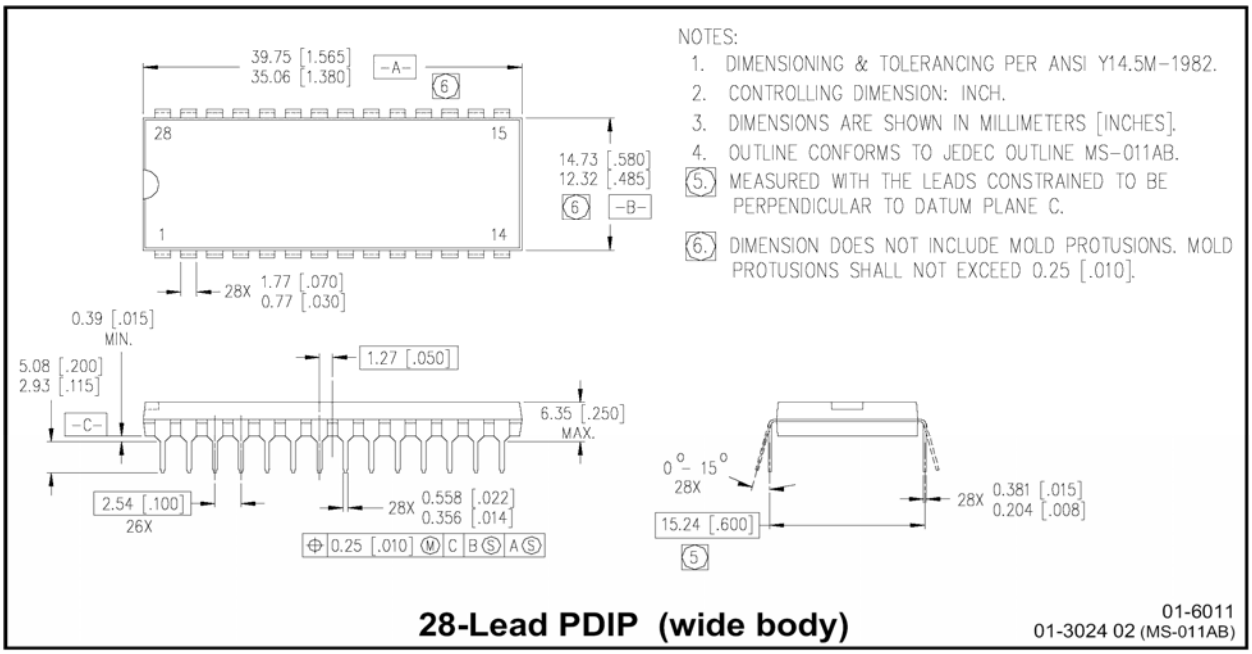
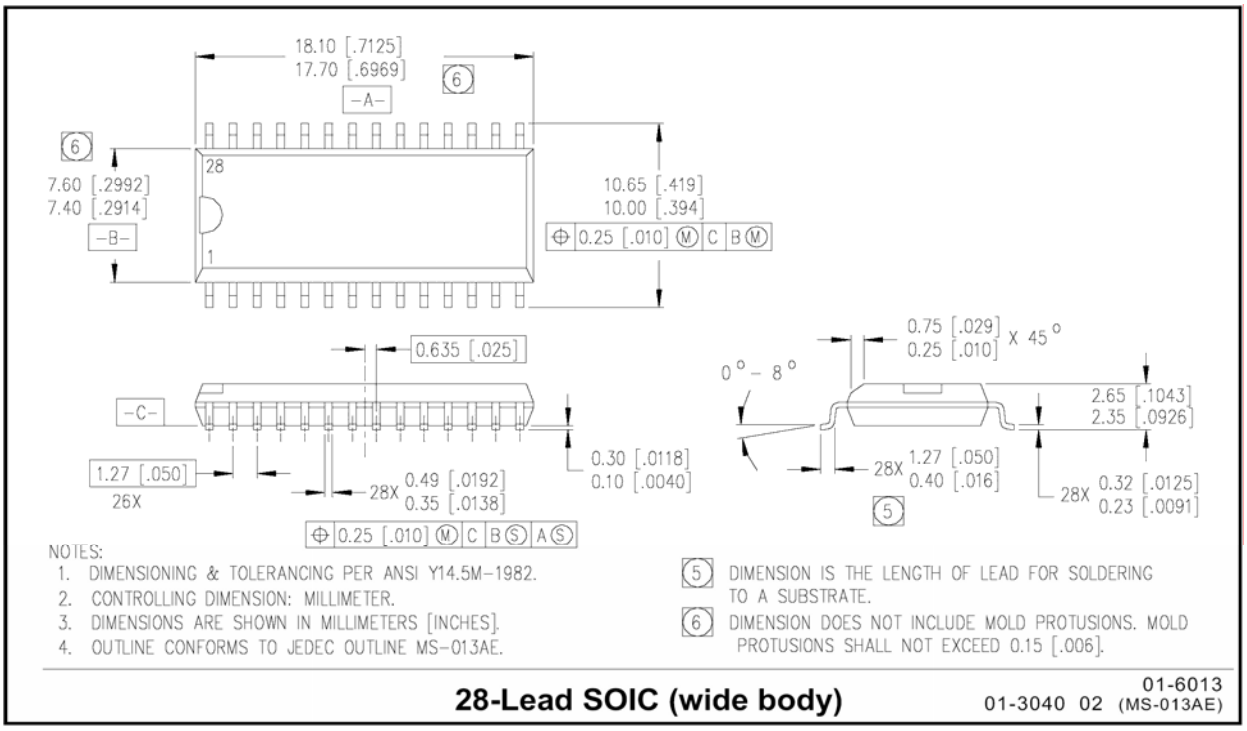


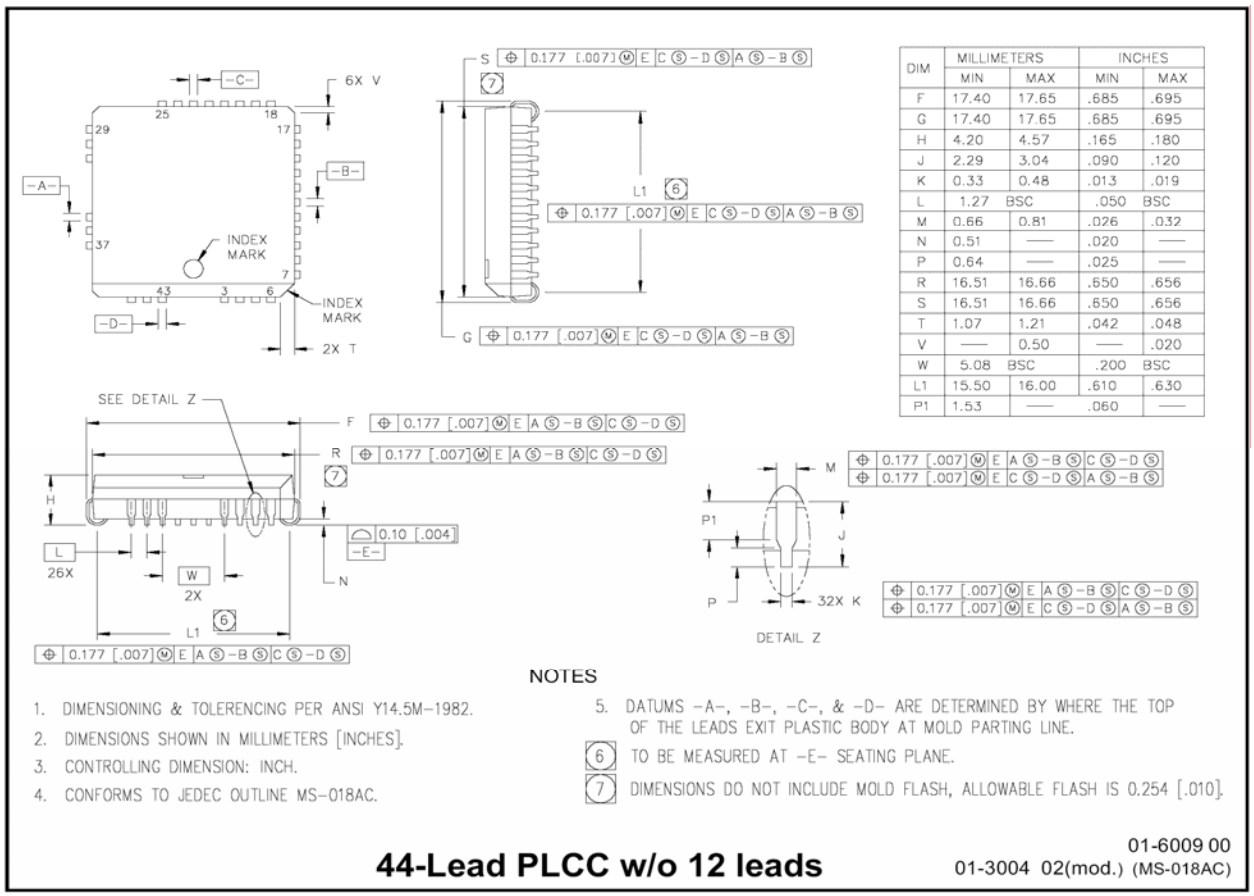
Fig. 38. CMRR vs. Temperature

Case Outlines





Case Outlines



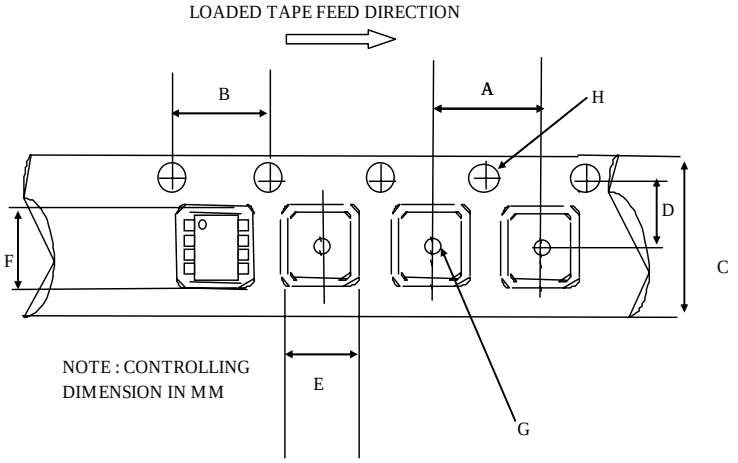
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
F	17.40	17.65	.685	.695
G	17.40	17.65	.685	.695
H	4.20	4.57	.165	.180
J	2.29	3.04	.090	.120
K	0.33	0.48	.013	.019
L	1.27 BSC		.050 BSC	
M	0.66	0.81	.026	.032
N	0.51	—	.020	—
P	0.64	—	.025	—
R	16.51	16.66	.650	.656
S	16.51	16.66	.650	.656
T	1.07	1.21	.042	.048
V	—	0.50	—	.020
W	5.08 BSC		.200 BSC	
L1	15.50	16.00	.610	.630
P1	1.53	—	.060	—

NOTES

1. DIMENSIONING & TOLERENCING PER ANSI Y14.5M-1982.
2. DIMENSIONS SHOWN IN MILLIMETERS [INCHES].
3. CONTROLLING DIMENSION: INCH.
4. CONFORMS TO JEDEC OUTLINE MS-018AC.
5. DATUMS -A-, -B-, -C-, & -D- ARE DETERMINED BY WHERE THE TOP OF THE LEADS EXIT PLASTIC BODY AT MOLD PARTING LINE.
6. TO BE MEASURED AT -E- SEATING PLANE.
7. DIMENSIONS DO NOT INCLUDE MOLD FLASH, ALLOWABLE FLASH IS 0.254 [.010].

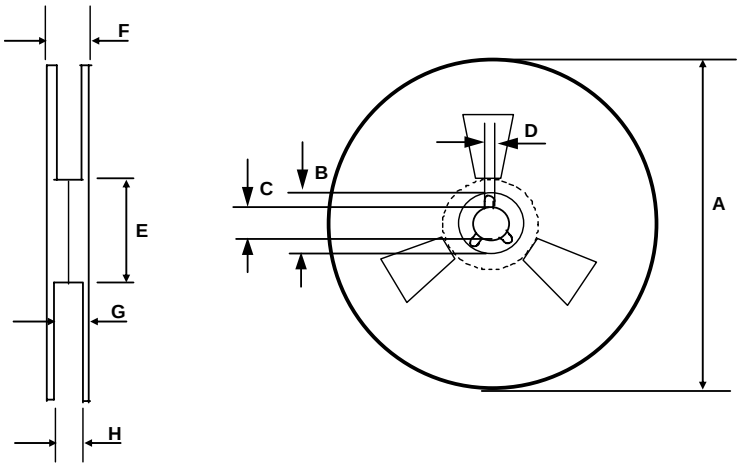
44-Lead PLCC w/o 12 leads

01-6009 00
01-3004 02(mod.) (MS-018AC)



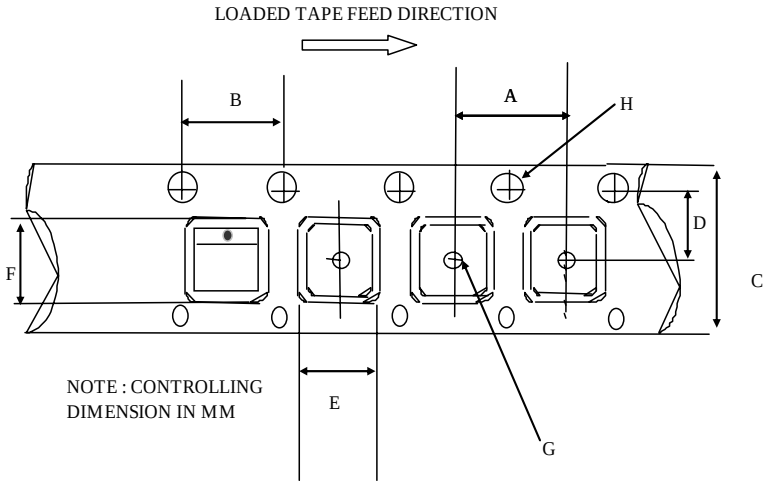
CARRIER TAPE DIMENSION FOR 28SOICW

Code	Metric		Imperial	
	Min	Max	Min	Max
A	11.90	12.10	0.468	0.476
B	3.90	4.10	0.153	0.161
C	23.70	24.30	0.933	0.956
D	11.40	11.60	0.448	0.456
E	10.80	11.00	0.425	0.433
F	18.20	18.40	0.716	0.724
G	1.50	n/a	0.059	n/a
H	1.50	1.60	0.059	0.062



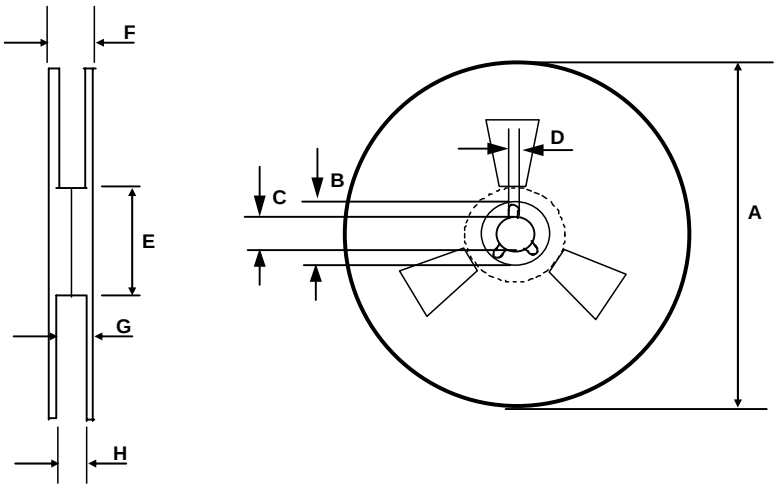
REEL DIMENSIONS FOR 28SOICW

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	30.40	n/a	1.196
G	26.50	29.10	1.04	1.145
H	24.40	26.40	0.96	1.039



CARRIER TAPE DIMENSION FOR 44PLCC

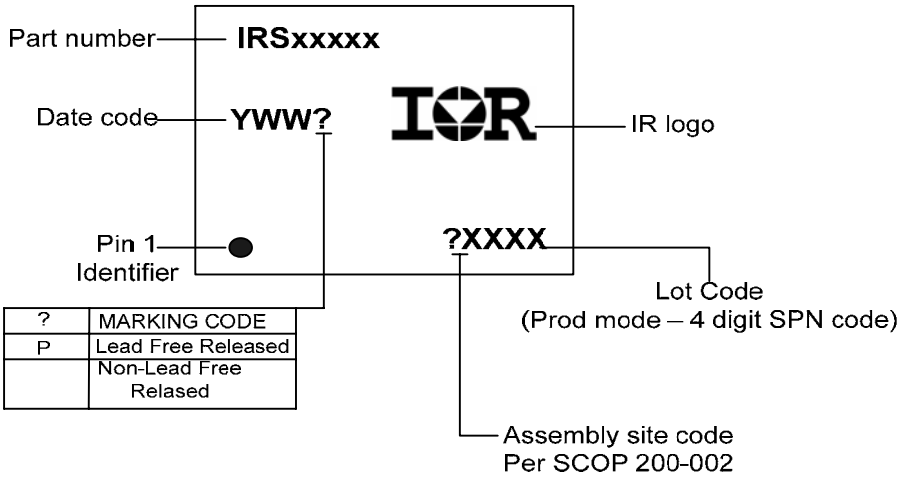
Code	Metric		Imperial	
	Min	Max	Min	Max
A	23.90	24.10	0.94	0.948
B	3.90	4.10	0.153	0.161
C	31.70	32.30	1.248	1.271
D	14.10	14.30	0.555	0.562
E	17.90	18.10	0.704	0.712
F	17.90	18.10	0.704	0.712
G	2.00	n/a	0.078	n/a
H	1.50	1.60	0.059	0.062



REEL DIMENSIONS FOR 44PLCC

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	38.4	n/a	1.511
G	34.7	35.8	1.366	1.409
H	32.6	33.1	1.283	1.303

LEAD-FREE PART MARKING INFORMATION



?	MARKING CODE
P	Lead Free Released
	Non-Lead Free Relased

ORDER INFORMATION

28-Lead PDIP IRS2130PbF
28-Lead PDIP IRS21303PbF
28-Lead PDIP IRS2132PbF
28-Lead SOIC IRS2130SPbF
28-Lead SOIC IRS21303SPbF
28-Lead SOIC IRS2132SPbF
44-Lead PLCC IRS2132JPbF
44-Lead PLCC IRS21303JPbF
44-Lead PLCC IRS2132JPbF

28-Lead SOIC Tape & Reel IRS2130STRPbF
28-Lead SOIC Tape & Reel IRS21303STRPbF
28-Lead SOIC Tape & Reel IRS2132STRPbF
44-Lead PLCC Tape & Reel IRS2130JTRPbF
44-Lead PLCC Tape & Reel IRS21303JTRPbF
44-Lead PLCC Tape & Reel IRS2132JTRPbF