International
IOR Rectifier

IR2238Q

3-PHASE AC Motor Controller IC

Features

- Floating channel up to +1200V
- "soft" over-current shutdown turns off output
- Integrated desaturation circuit
- Two stage turn on output for di/dt control
- Integrated brake IGBT driver with protection
- Voltage feedback sensing function
- Separate pull-up/pull-down output drive pins
- Matched delay outputs
- Under voltage lockout with hysteresis band
- Programmable deadtime
- Hard shutdown function

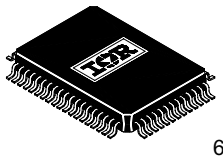
Description

The IR2238Q is a high voltage, 3-phase IGBT driver best suited for AC motor drive applications. Integrated desaturation logic provides all mode of overcurrent protection, including ground fault protection. Soft shutdown is predominantly initiated in the event of overcurrent followed by turn-off of all six outputsf. A shutdown input is provided for a customized shutdown function. The DT pin allows external resistor to program the deadtime. Output drivers have separate turn on/off pins with two stage turn-on output to achieve the desired di/dt switching level of IGBT. Voltage feedback provides accurate volts *seconds measurement.

Product Summary

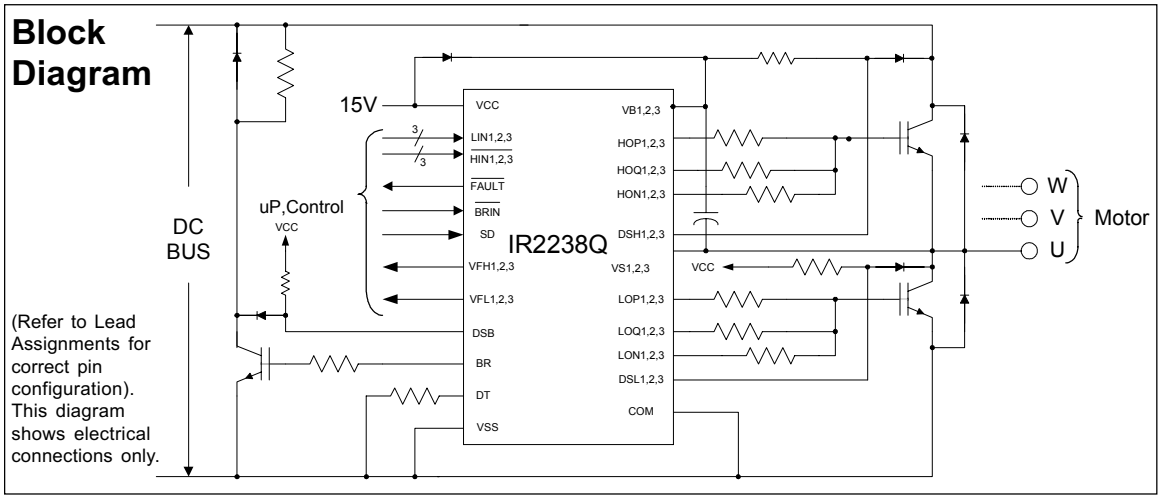
V_{OFFSET}	1200V max.
I_O+/- (min.)	220mA/460mA
V_{OUT}	12.5V - 20V
Brake (Io+/- min)	40mA/80mA
Deadtime Asymmetry Skew (max.)	145nsec
Deadtime (typ. with RDT=39kΩ)	1µsec
DESAT Blanking time (typ.)	3.0µsec
DSH, DSL input voltage threshold (typ.)	8.0V
Soft shutdown duration time (typ.)	6.0µsec
Voltage feedback matching delay time (max.)	125nsec

Package



64-Lead MQFP

Block Diagram



Absolute Maximum Ratings (tentative)

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_S	High side offset voltage	$V_{B1,2,3}$ -25	$V_{B1,2,3}$ +0.3	V
V_B	High side floating supply voltage	-0.3	1225	
V_{HO}	High side floating output voltage (HOP, HON, HOQ)	$V_{S1,2,3}$ - 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} - 25	V_{CC} + 0.3	
V_{LO}	Low side output voltage (LOP, LON, LOQ)	-0.3	V_{CC} + 0.3	
V_{IN}	Logic input voltage (HIN/N,LIN, BRIN/N, SD)	V_{SS} - 0.3	V_{CC} + 0.3 or V_{SS} + 15 which ever is lower	
V_{FLT}	FAULT output voltage	V_{SS} - 0.3	V_{CC} + 0.3	
V_F	Feedback output voltage	V_{SS} - 0.3	V_{CC} + 0.3	
V_{DSH}	High side desat/feedback input voltage	$V_{S1,2,3}$ - 0.3	$V_{B1,2,3}$ + 0.3	
V_{DSL}	Low side desat/feedback input voltage	- 0.3	V_{CC} + 0.3	
V_{BR}	Brake output voltage	-0.3	V_{CC} + 0.3	
dVs/dt	Allowable offset voltage slew rate	—	50	V/ns
P_D	Package power dissipation @ $T_A \leq +25°C$	—	2.0	W
Rth_{JA}	Thermal resistance, junction to ambient	—	60	°C/W
T_J	Junction temperature	—	125	°C
T_S	Storage temperature	-55	150	
T_L	Lead temperature (soldering, 10 seconds)	—	300	

Recommended Operating Conditions

For proper operation the device should be used within the recommended conditions. All voltage parameters are absolute voltages referenced to COM. The V_S offset rating is tested with all supplies biased at 15V differential.

Symbol	Definition	Min.	Max.	Units
$V_{B1,2,3}$	High side floating supply voltage	$V_{S1,2,3}$ + 13	$V_{S1,2,3}$ + 20	V
$V_{S1,2,3}$	High side floating supply offset voltage	Note 1	1200	
$V_{HO1,2,3}$	High side (HOP/HOQ/HON) output voltage	$V_{S1,2,3}$	$V_{B1,2,3}$	
$V_{LO1,2,3}$	Low side (LOP/LOQ/LON) output voltage	V_{COM}	V_{CC}	
V_{IN}	Logic input voltage (HIN/N,LIN,BRIN/N SD)	V_{SS}	V_{SS} + 5	
V_{CC}	Low side supply voltage	12.5	20	
V_{SS}	Logic ground	-5	+5	
V_{FLT}	FAULT output voltage	V_{SS}	V_{CC}	
V_F	Feedback output voltage	V_{SS}	V_{CC}	
V_{DSH}	High side desat/feedback input voltage	$V_{S1,2,3}$ - 0.3	$V_{B1,2,3}$	
V_{DSL}	Low side desat/feedback input voltage	- 0.3	V_{CC}	
V_{BR}	BRAKE output voltage	V_{COM}	V_{CC}	
T_A	Ambient temperature	-20	115	°C

Note 1: Logic operational for Vs of COM-5V to COM+1200V. Logic state held for Vs of COM-5V to COM-V_{BS}.

Static Electrical Characteristics

V_{BIAS} (V_{CC}, V_{BS}1,2,3) = 15V 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 channels (HOP/HOQ/HON1,2,3 and LOP/LOQ/LON1,2,3). The V_O and I_O parameters are referenced to COM and V_S1,2,3 and are applicable to the respective output leads: $H_{O1,2,3}$ and $L_{O1,2,3}$. V_{DESAT} and I_{DESAT} parameters are referenced to COM and $V_{S1,2,3}$

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
V_{CCUV+}	V_{CC1} supply undervoltage positive going threshold	10.3	11.2	12.5	V	
V_{CCUV-}	V_{CC1} supply undervoltage negative going threshold	9.5	10.2	11.3		
V_{CCUVH}	V_{CC1} supply undervoltage lockout hysteresis	—	1.0	—		
V_{BSUV+}	V_{BS} supply undervoltage positive going threshold	10.3	11.2	12.5		
V_{BSUV-}	V_{BS} supply undervoltage negative going threshold	9.5	10.2	11.3		
V_{BSUVH}	V_{BS} supply undervoltage lockout hysteresis	—	1.0	—		
I_{LK}	Offset supply leakage current	—	—	50	µA	$V_{B1,2,3}$ = $V_{S1,2,3}$ = 1200V
I_{QBS}	Quiescent V_{BS} supply current	—	150	250		V_{LIN}=0V, V_{HIN}=5V
I_{QCC}	Quiescent V_{CC} supply current	—	3	6	mA	V_{LIN}=0V, V_{HIN}=5V DT = 1µsec
V_{IH}	Logic "0" input voltage (HIN/N, BRIN/N) (OUT=LO)	2.0	—	—	V	V_{CC} = 12.5 to 20V
V_{IL}	Logic "1" input voltage (HIN/N, BRIN/N) (OUT=HI)	—	—	0.8		
V_{t+}	Logic input positive going threshold (HIN/N, LIN, BRIN/N, SD)	1.2	1.6	2.0		
V_{t-}	Logic input negative going threshold (HIN/N, LIN, BRIN/N, SD)	0.8	1.2	1.6		
ΔV_T	Logic input hysteresis (HIN, LIN, BRIN, SD)	—	0.4	—		
V_{OH}	High level output voltage, V_{BIAS} - V_O (normal switching) HOP, HOQ, LOP, LOQ	—	—	100	mV	Io = 1mA
V_{OL}	Low level output voltage, V_O (normal switching) HON, LON	—	—	100		
I_{IN+}	Logic "1" input bias current (HIN/N, BRIN/N)	—	5	—	µA	V_{IN} = 0V
	Logic "1" input bias current (LIN, SD)	—	70	—		V_{IN} = 5V
I_{IN-}	Logic "0" input bias current (HIN/N, BRIN/N)	—	70	—		V_{IN} = 5V
	Logic "0" input bias current (LIN, SD)	—	5	—		V_{IN} = 0V
I_{DS+}	High DSH, DSL, DSB input bias current	—	15	—		V_{DESAT} = 15V
I_{DS-}	Low DSH, DSL, DSB input bias current	—	0.1	—		V_{DESAT} = 0V
$I_{O}1+$	Output high first stage short circuit pulsed current	220	350	—	mA	V_O = 0V, V_{IN} = 0V PW ≤ 200 ns
$I_{O}2+$	Output high second stage short circuit pulsed current	120	200	—		V_O = 0V, V_{IN} = 0V PW ≤ 10 µs
I_{O-}	Output low short circuit pulsed current	460	540	—		V_O = 15V, V_{IN} = 5V PW ≤ 10 µs

Static Electrical Characteristics cont.

V_{BIAS} (V_{CC}, V_{BS}1,2,3) = 15V 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 channels (HOP/HOQ/HON1,2,3 and LOP/LOQ/LON1,2,3). The V_O and I_O parameters are referenced to COM and V_S1,2,3 and are applicable to the respective output leads: $H_{O1,2,3}$ and $L_{O1,2,3}$. V_{DESAT} and I_{DESAT} parameters are referenced to COM and $V_{S1,2,3}$

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
I_{OBR+}	BR output high short circuit pulsed current	40	70	—	mA	V_{BR}=0V, V_{BRIN}=0V PW ≤ 10 µs
I_{OBR-}	BR output low short circuit pulsed current	80	125	—		V_{BR}=15V,V_{BRIN}=5V PW ≤ 10 µs
V_{OHB}	BR high level output voltage, V_{CC}-V_{BR}	—	—	300	mV	I_{BR} = 1mA
V_{OLB}	BR low level output voltage, V_{BR}	—	—	150		
V_{OLVF}	VFH or VFL low level output voltage	—	—	0.8	V	I_{VF} = 10mA
$R_{ON,VF}$	VFH or VFL output on resistance	—	60	—	Ω	
$R_{ON,SS}$	Soft shutdown on resistance	—	500	—		
$R_{ON,FLT}$	FAULT low on resistance	—	60	—		
V_{DESAT+}	High DSH1,2,3 and DSL1,2,3 and DSB input threshold voltage	—	8.0	—	V	
V_{DESAT-}	Low DSH1,2,3 and DSL1,2,3 or DSB input threshold voltage	—	7.0	—		
V_{DSTH}	DS input voltage hysteresis	—	1.0	—		

AC Electrical Characteristics

V_{BIAS} (V_{CC}, V_{BS}) = 15V, $V_{S1,2,3}$ = V_{SS}, T_A = 25°C and C_L = 1000 pF unless otherwise specified.

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
Propagation Delay Characteristics						
T_{on1}	Turn-on first stage duration time	—	200	—	ns	V_{IN} = 0 & 5V RL(HOQ/LOQ) = 10Ω
t_{on}	Turn-on propagation delay	250	550	750		V_{IN} = 0 & 5V $V_{S1,2,3}$ = 0 to1200V HOP=HON,LOP=LON Figure 5
t_{off}	Turn-off propagation delay	250	550	750		
t_r	Turn-on rise time	—	80	—		
t_f	Turn-off fall time	—	25	—		
t_{DESAT1}	DSH to HO soft shutdown propogation delay at HO turn-on	—	3000	—		V_{HIN} = 0V, V_{DESAT} = 15V, Figure 7
t_{DESAT2}	DSH to HO soft shutdown propogation delay after blanking	1000	—	—		
t_{DESAT3}	DSL to LO soft shutdown propogation delay at LO turn-on	—	3000	—		V_{LIN} = 5V, V_{DESAT} =15V, Fig.7

AC Electrical Characteristics cont.

V_{BIAS} (V_{CC}, V_{BS}) = 15V, $V_{S1,2,3}$ = V_{SS}, T_A = 25°C and C_L = 1000 pF unless otherwise specified.

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
Propagation Delay Characteristics						
t_{DESAT4}	DSL to LO soft shutdown propogation delay after blanking	1000	—	—	ns	V_{LIN} = 5V, V_{DESAT} =15V, Fig. 7
t_{DESAT5}	DSB to HO hard shutdown propogation delay	—	1300	—		V_{HIN} = 0V, V_{DESAT} =15V, Fig. 7
t_{DESAT6}	DSB to LO hard shutdown propogation delay	—	1300	—		V_{LIN} = 5V, V_{DESAT} =15V, Fig. 7
t_{DESAT7}	DSB to BR hard shutdown propogation delay	900	—	—		V_{VBRIN} = 0V, V_{DSB} =15V, Fig. 7
$t_{VFHL1,2,3}$	VFH high to low propagation delay	—	550	—		V_{DESAT}=15V to 0V Figure 8
$t_{VFHHL1,2,3}$	VFH low to high propagation delay	—	550	—		V_{DESAT}=0V to 15V Figure 8
$t_{VFLH1,2,3}$	VFL low to high propagation delay	—	550	—		V_{DESAT}=0V to 15V Figure 8
$t_{VFLL1,2,3}$	VFL high to low propagation delay	—	550	—		V_{DESAT}=15V to 0V Figure 8
t_{PWVF}	Minimum pulse width of VFH and VFL	—	400	—		V_{DESAT}=15V to 0V or 0v to 15V fig. 8
t_{DS}	Soft shutdown minimum pulse width of DSx	1000	—	—		C_L=1000pF, V_{DS}=15V Figure 6
t_{SS}	Soft shutdown duration period	—	6000	—		
$t_{FLT,DESAT1}$	DSH to FAULT propagation delay at HO turn-on	—	3300	—		V_{HIN} = 0V, V_{DS} =15V, Fig. 7
$t_{FLT,DESAT2}$	DSH to FAULT propagation delay after blanking	—	1300	—		
$t_{FLT,DESAT3}$	DSL to FAULT propagation delay at LO turn-on	—	3300	—		V_{LIN} = 5V, V_{DS} =15V, Fig. 7
$t_{FLT,DESAT4}$	DSL to FAULT propagation delay after blanking	—	1000	—		
t_{FLTDSB}	DSB to FAULT propagation delay	—	1000	—		B_{RIN} = 0V, V_{DESAT} =15V, Fig. 7
t_{FLTCLR}	LIN1 =LIN2 =LIN3 =0 to FAULT	9.0	—	—	µs	V_{DESAT} =15V, Fig. 7
t_{fault}	Minimum FAULT duration period	9.0	15.0	21.0		V_{DESAT} =15V, Fig. 11 FLTCLR pending
t_{BL}	DS blanking time at turn-on	—	3000	—		V_{IN} = on, V_{DESAT} =15V, Fig. 7
t_{SD}	SD to output shutdown propagation delay	—	600	900		V_{IN} = on, V_{DESAT} =0V, Fig. 10

AC Electrical Characteristics cont.

V_{BIAS} (V_{CC}, V_{BS}) = 15V, $V_{S1,2,3}$ = V_{SS}, T_A = 25°C and C_L = 1000 pF unless otherwise specified.

Symbol	Definition	Min.	Typ.	Max.	Units	Test Conditions
Propagation Delay Characteristics						
t_{EN}	SD negation to output enable propagation delay	—	600	900		V_{IN} =on V_{DESAT}=0V, Fig.10
t_{onBR}	BR output turn-on propagation	—	110	200	ns	Figure 5
t_{offBR}	BR output turn-off propagation	—	80	150		
t_{rBR}	BR output turn-on rise time	—	235	400		
t_{fBR}	BR output turn-off fall time	—	130	200		
Deadtime/Delay Matching Characteristics						
DT	Deadtime	900	1050	1200		Figure 8 external resistor=39kΩ
		76	100	124		Figure 8 external resistor=0kΩ
		4500	5000	5500		Figure 8 external resistor=220kΩ
MDT	Deadtime asymmetry skew, any of DTLoff1,2,3-DTHoff1,2,3	—	—	145		DT=1000nsec. Fig.8
PM	PWM propagation delay matching max {ton/toff} - min {ton/toff}, (ton/toff are applicable to all six channels)	—	—	125		DT=1000nsec. Fig.5
VM	Voltage feedback delay matching, I any of $t_{VFHL1,2,3}$, $t_{VFHH1,2,3}$, $t_{VFLL1,2,3}$, $t_{VFLH1,2,3}$ - any of $t_{VFHL1,2,3}$, $t_{VFHH1,2,3}$, $t_{VFLL1,2,3}$, $t_{VFLH1,2,3}$ I	—	—	125		Input pulse width >400 nsec Figure 9

Functional Block Diagram

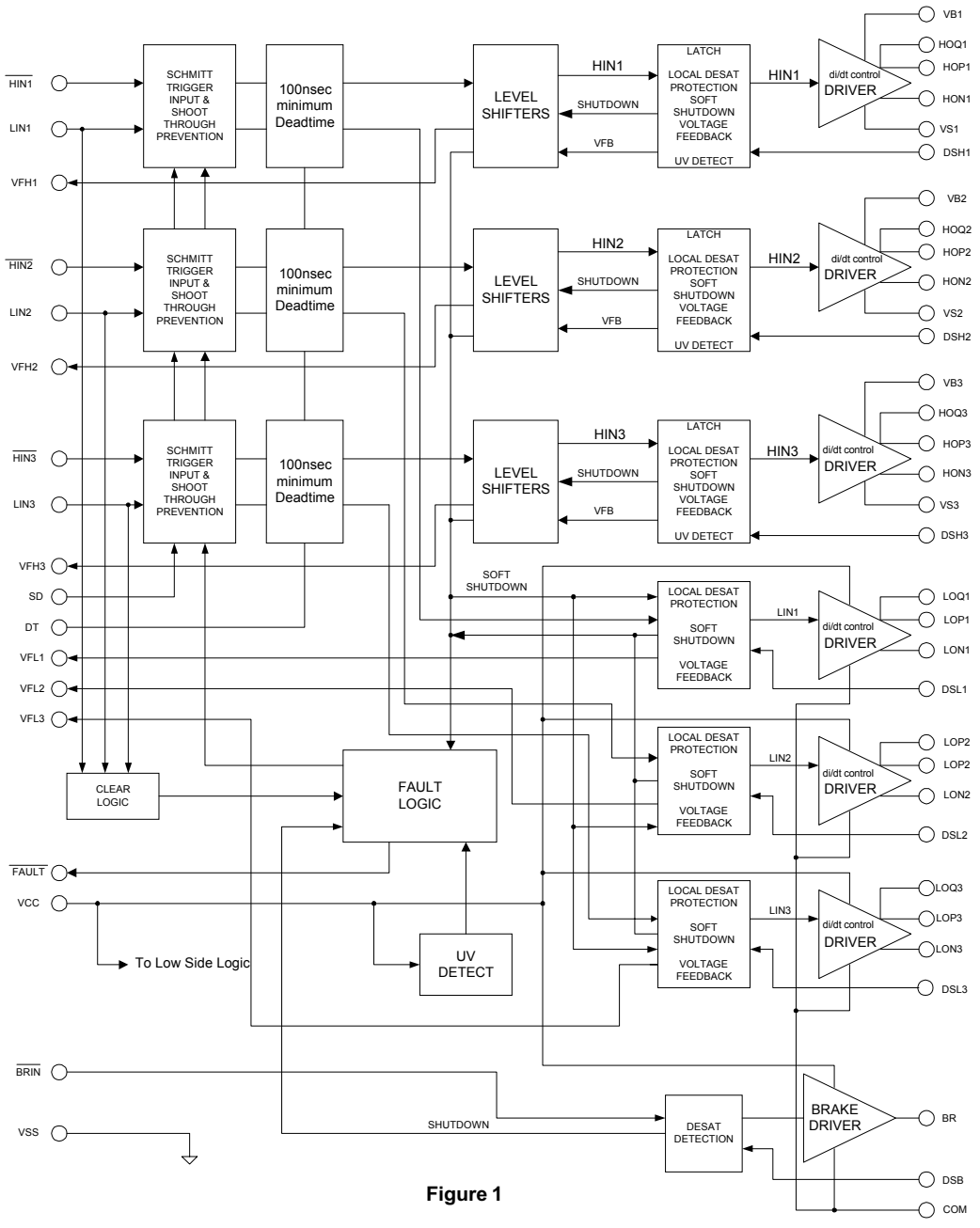


Figure 1

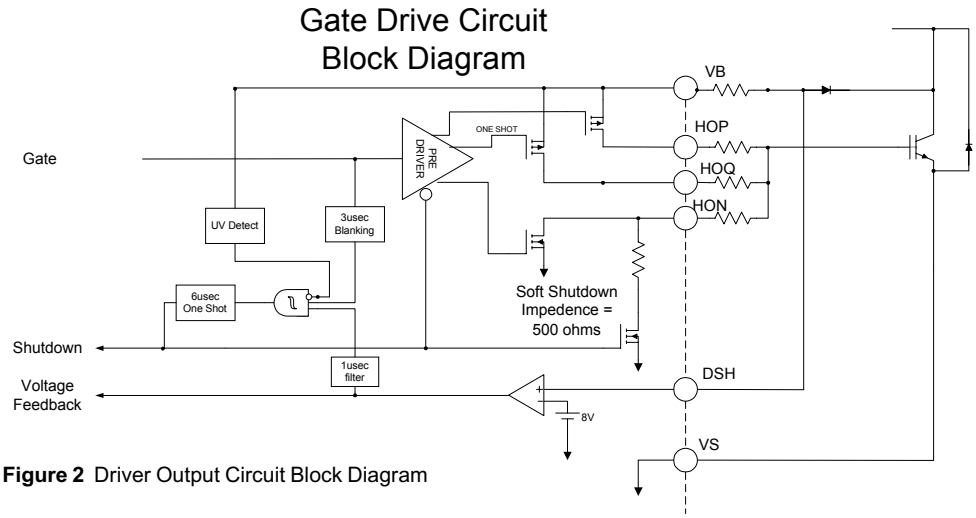


Figure 2 Driver Output Circuit Block Diagram

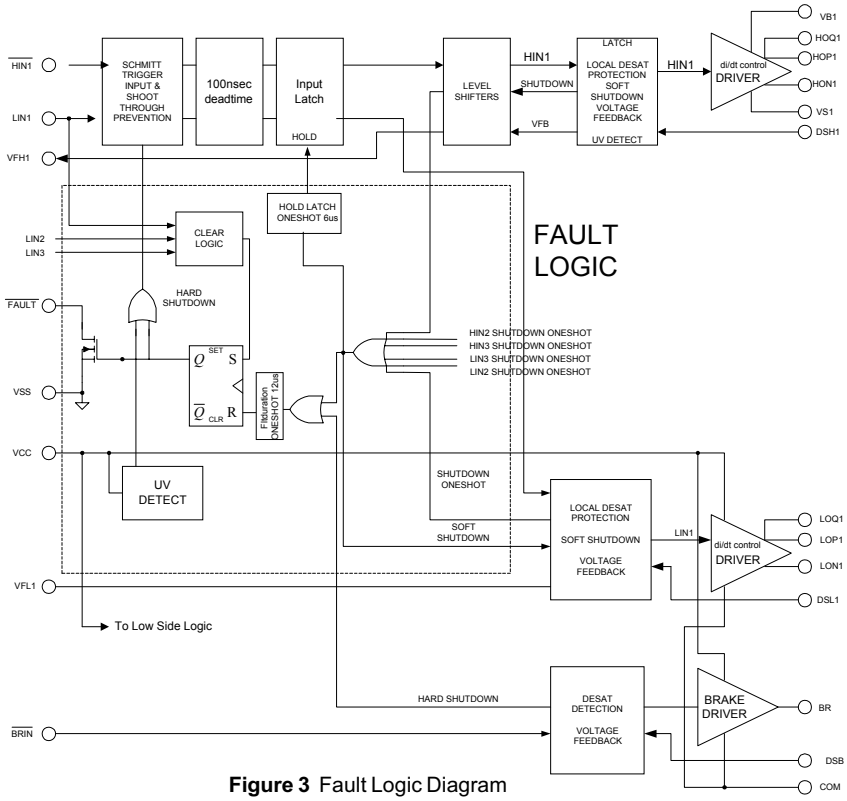


Figure 3 Fault Logic Diagram

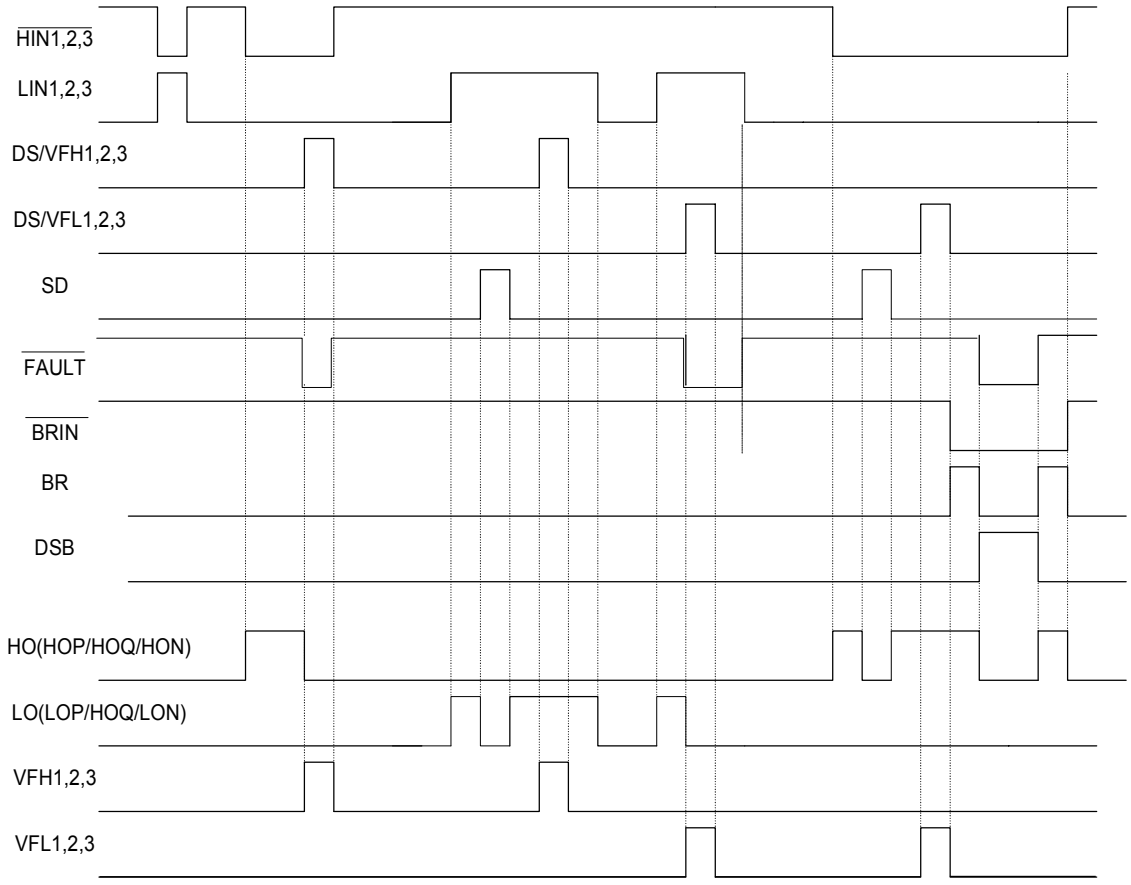


Figure 4 Input/Output Timing Diagram

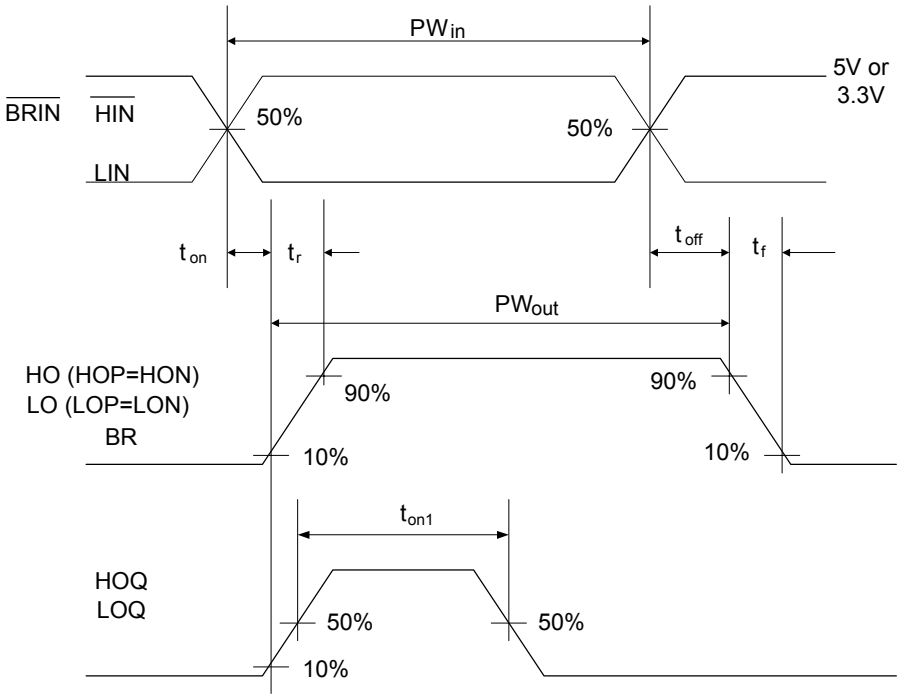


Figure 5 Switching Time Waveforms

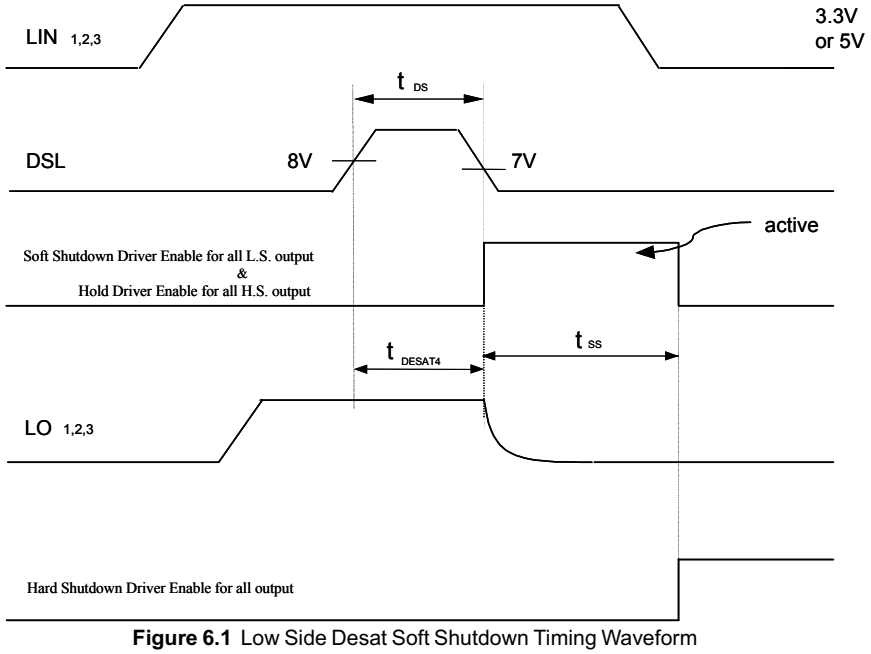


Figure 6.1 Low Side Desat Soft Shutdown Timing Waveform

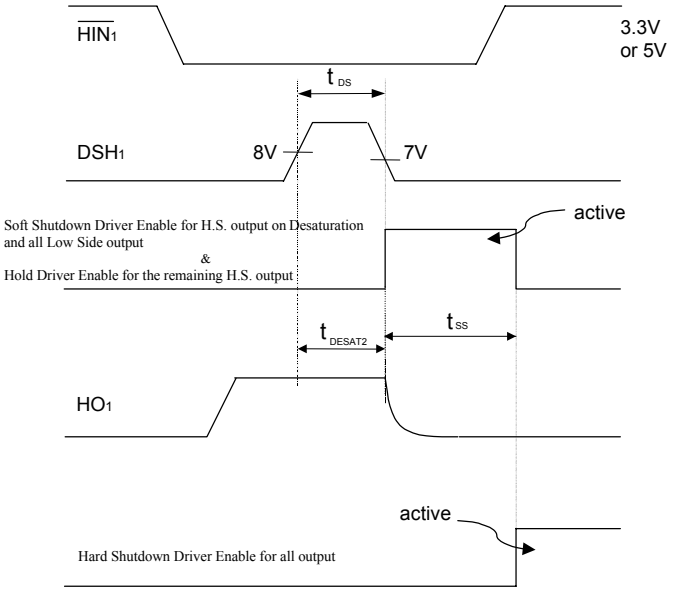


Figure 6.2 High Side Desat Soft Shutdown Timing Waveform

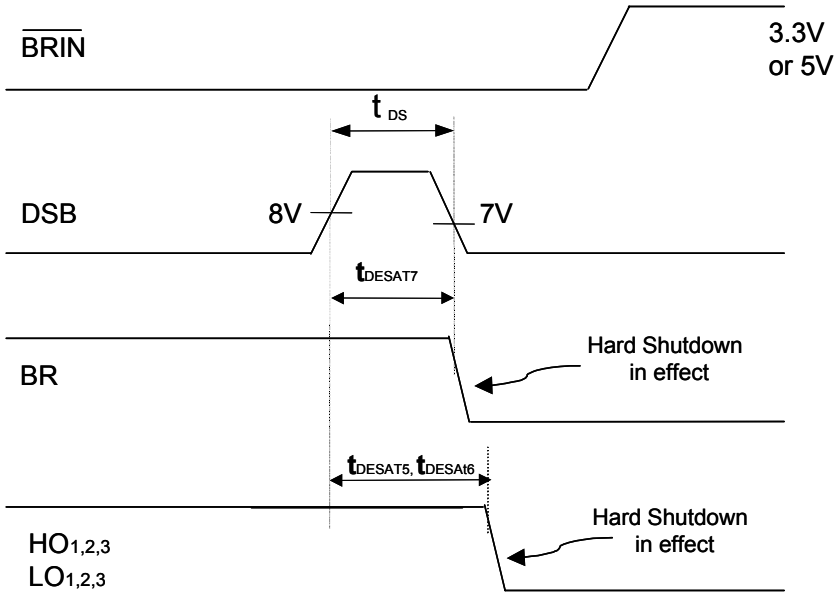


Figure 6.3 Brake Desat Timing Waveform

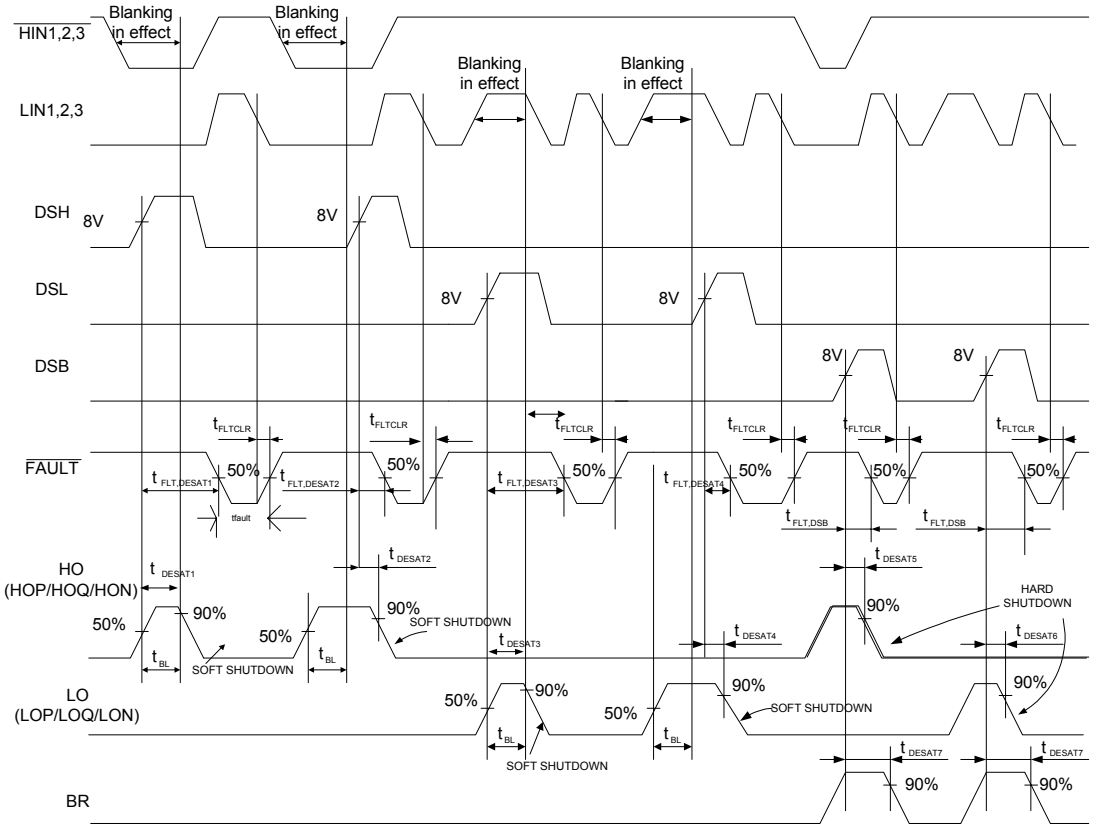


Figure 7 Desat Timing Diagram

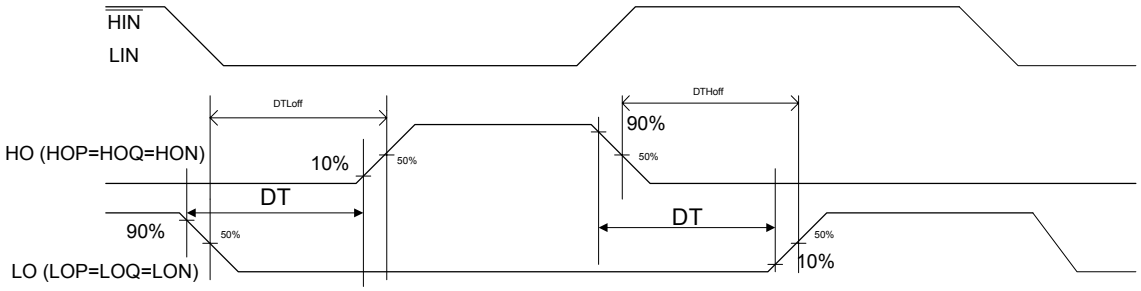


Figure 8 Internal Deadtime Timing

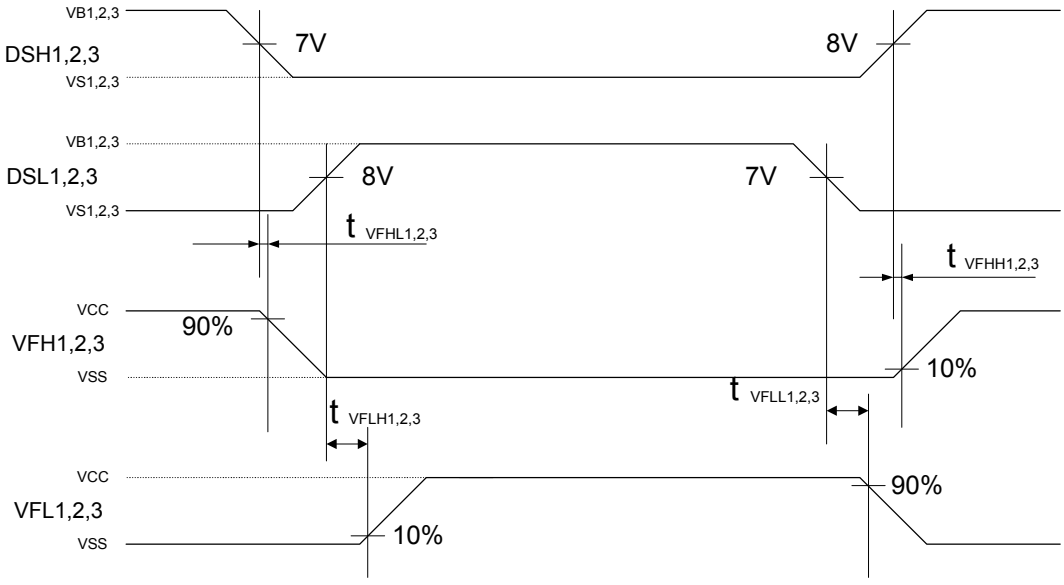


Figure 9 Voltage Feedback Timing

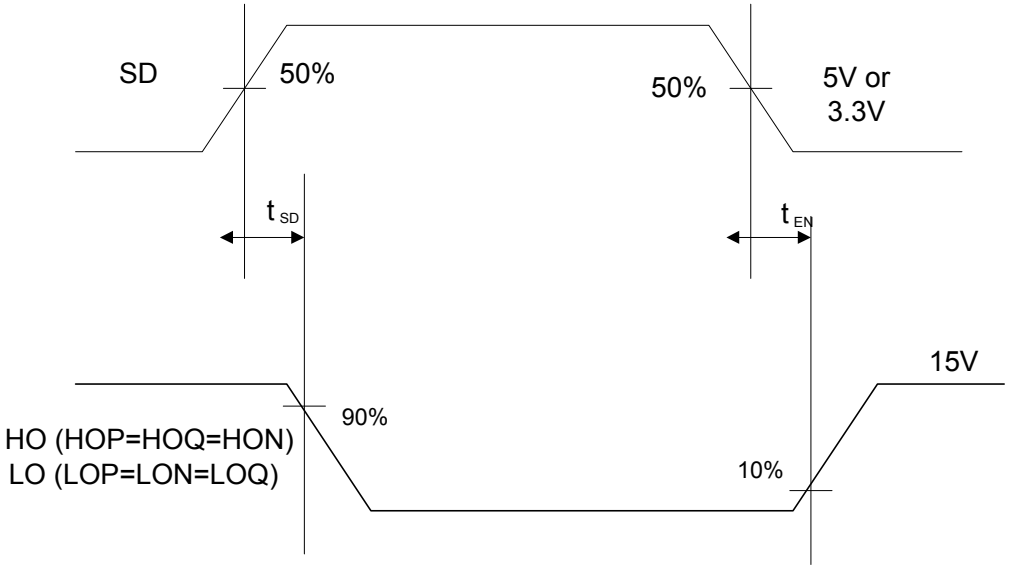


Figure 10 Shutdown Timing

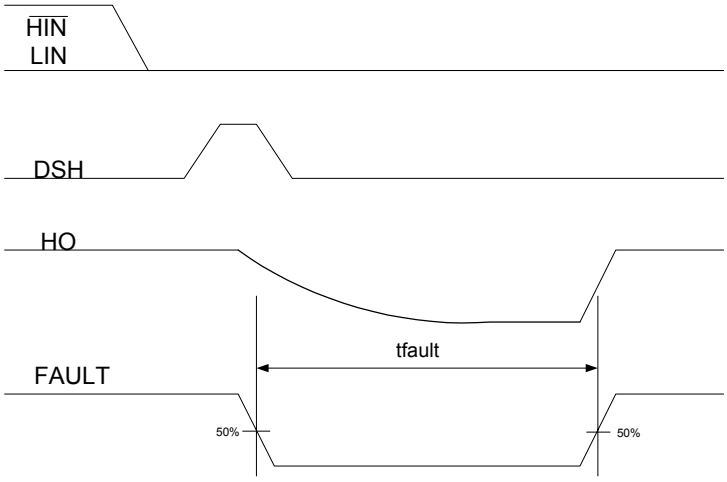


Figure 11 Fault Duration with Pending Faultclear Waveform (refer to Note LD2 under the lead definition table)

Lead Definitions

Symbol	Description
V_{CC}	Low side supply voltage
VSS	Logic Ground
$\overline{HIN1,2,3}$	Logic inputs for high side gate driver outputs (HOP1,2,3/HON1,2,3, out of phase)
LIN1,2,3	Logic inputs for low side gate driver outputs (LOP1,2,3/LON1,2,3, out of phase)
$\overline{FAULT}$	Fault output (latched and open drain)
SD	Shutdown input
DT	Deadtime programmable resistor pin
DSB	Brake IGBT desaturation protection input and voltage feedback input
$\overline{BRIN}$	Logic input for brake driver
BR	Brake driver output
COM	Low side drivers return
V_B1,2,3	High side gate drive floating supply
HOP1,2,3	High side driver sourcing output
HOQ1,2,3	High side driver boost sourcing output
HON1,2,3	High side driver sinking output
DSH1,2,3	IGBT desaturation protection input and high side voltage feedback input
$V_{S1,2,3}$	High voltage floating supply return
LOP1,2,3	Low side driver sourcing output
LON1,2,3	Low side driver sinking output
DSL1,2,3	IGBT desaturation protection input and low side voltage feedback input
VFH1,2,3	High side voltage feedback logic output
VFL1,2,3	Low side voltage feedback logic output

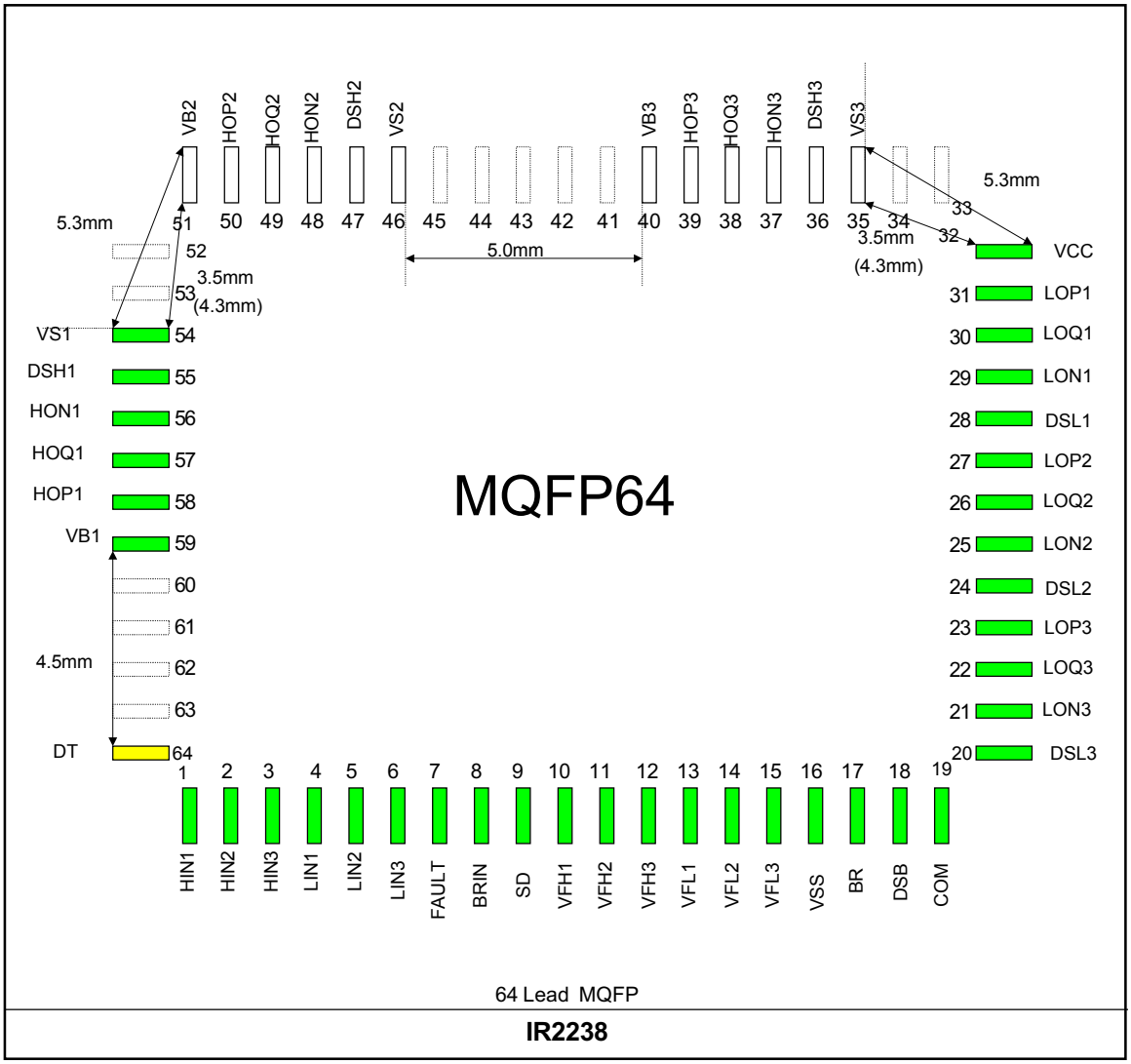
NOTE:

LD1- Low side soft shutdown is initiated locally in an event over current, which is sensed by the DSL pin. It is followed by the synchronized soft shutdown of the rest of the low side outputs; meanwhile it will hold all input information for a period of tss until the soft shutdown finishes. Then the hard shutdown will be initiated to complete the shut down cycle. (Figure 6.1)

High side soft shutdown is initiated locally in an event over current, which is sensed by the DSH pin. It is followed by the synchronized soft shutdown of all the low side outputs; meanwhile it will hold all input information for a period of tss until the soft shutdown finishes. Then the hard shutdown will be initiated to complete the shut down cycle. (Figure 6.2)

LD2- Soft shutdown is initiated in an event of overcurrent, which is followed by turn-off all six outputs. The fault condition will remain in a fixed period(tfault) even though the faultclear condition is in effect (Fig11). In the case that faultclear is not in effect, fault duration = tfault + tfltclr.

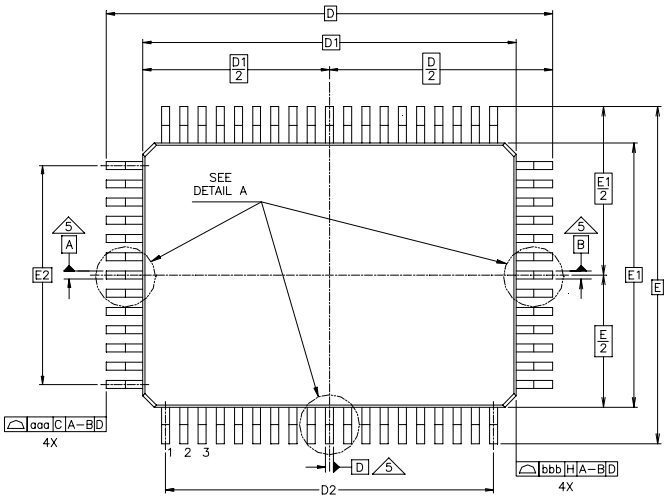
Lead Assignments



64 Lead MQFP

IR2238

Case outline



SYMBOL	DIMENSIONS					
	MILLIMETERS			INCHES		
	MS–022GA–2			*MS–022GA–2*		
	MIN	NOM	MAX	MIN	NOM	MAX
A	2.50	2.83	3.15	.098	.111	.124
A1	0.00	0.13	0.25	.000	.005	.010
A2	2.50	2.70	2.90	.098	.106	.114
b	0.35	---	0.50	.014	---	.020
b1	0.35	0.40	0.45	.014	.016	.018
c	0.09	---	0.20	.004	---	.007
c1	0.09	---	0.16	.004	---	.006
D	23.20 BSC			.913 BSC		
D1	20.00 BSC			.787 BSC		
D2	18.00 REF			.709 REF		
E	17.20 BSC			.677 BSC		
E1	14.00 BSC			.551 BSC		
E2	12.00 REF			.472 REF		
e	1.00 BSC			.039 BSC		
L	0.73	0.88	1.03	.029	.035	.040
L1	0.25 BSC			.010 BSC		
α	0°	---	7°	0°	---	7°
aaa	0.25			.010		
bbb	0.20			.008		
ccc	0.20			.008		
ddd	0.10			.004		

NOTES

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
2. DIMENSIONS ARE SHOWN IN MILLIMETERS AND INCHES.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DATUM PLANE H IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.

5 DATUM A – B AND D TO BE DETERMINED AT DATUM PLANE H.

6. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSIONS, ALLOWABLE PROTRUSION IS 0.25mm PER SIDE, D1 AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
7. OUTLINE CONFORMS TO JEDEC OUTLINE MS–022GB1.

64-Lead MQFP

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