DC MOTOR DRIVER FOR POWER FOLDING

IK8509

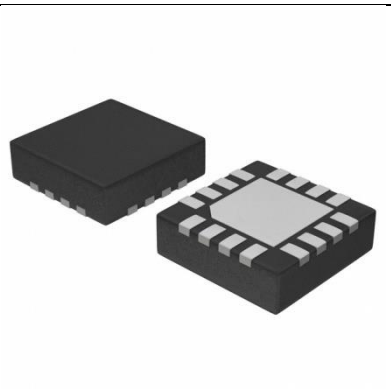
GENERAL DESCRIPTION

IK8509 is a fully protected motor driver designed especially for automotive power folding system.

The couple of devices IK8509 need to carry out driving power folding of horizontal and vertical type application.

The device is built using the high voltage BCDMOS process.

The built in features like under/over voltage protections, electrical transients suppression, over temperature protection with 165°C threshold, and max folding time control with15sec counter allows new level of reliability.



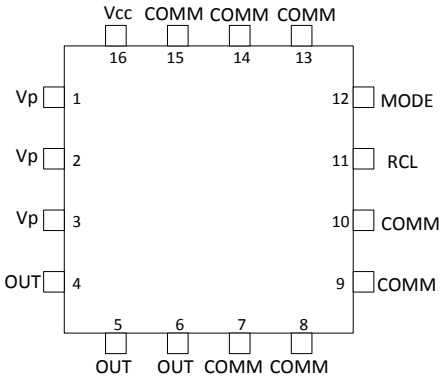
QFN16 (4x4)

The package has an exposed PAD (GND) from the bottom view.
The exposed PAD serves as radiator and must be soldered to PCB.

FEATURES

- Over-temperature protection (165˚C)
- Over- and under voltage lockout
- Supply voltage transient protection
- Low system drop voltage (2.0V@2.5A)
- Max. folding time counter (15 s)
- 16 QFN package
- Dual mode operation
- MSL Level 2
- AEC Q100 qualified

PIN ASSIGNMENT



(Top View)

Table2. ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IN}	Supply Voltage Range Note 1	Continuous	8	18	V
		Non-operating continuously	-0.3	28	V
R_L	Load Resistance	Note 1,2	5	-	Ω
I_L	Output Current	Note 1,2		2.5	A
I_{pr}	Reverse supply current	Note 1,2	0.5	2.5	A
T_{stg}	Storage Temperature		-55	150	°C
T_J	Operating Junction Temperature Range		-40	150	°C
T_A	Operating Ambient Temperature Range		-40	85	°C
V_{ESD_HBM}	ESD Capability, Human Body Model		-3	3	kV
V_{ESD_MM}	ESD Capability, Machine Model		-300	300	V
P_D	Power Dissipation at T_A = 25°C			0.8	W
$R_{th(j-a)}$	Thermal Resistance			80	ºC/W

1. Voltage applied to both COMM terminal in dual mode operation
2. V_{IN}(input voltage) =13 V, T_A=25°C; duration 50 ms maximum; non repetitive.

All voltages are defined with respect to COMM (internal GND).
Positive currents flow into the device.

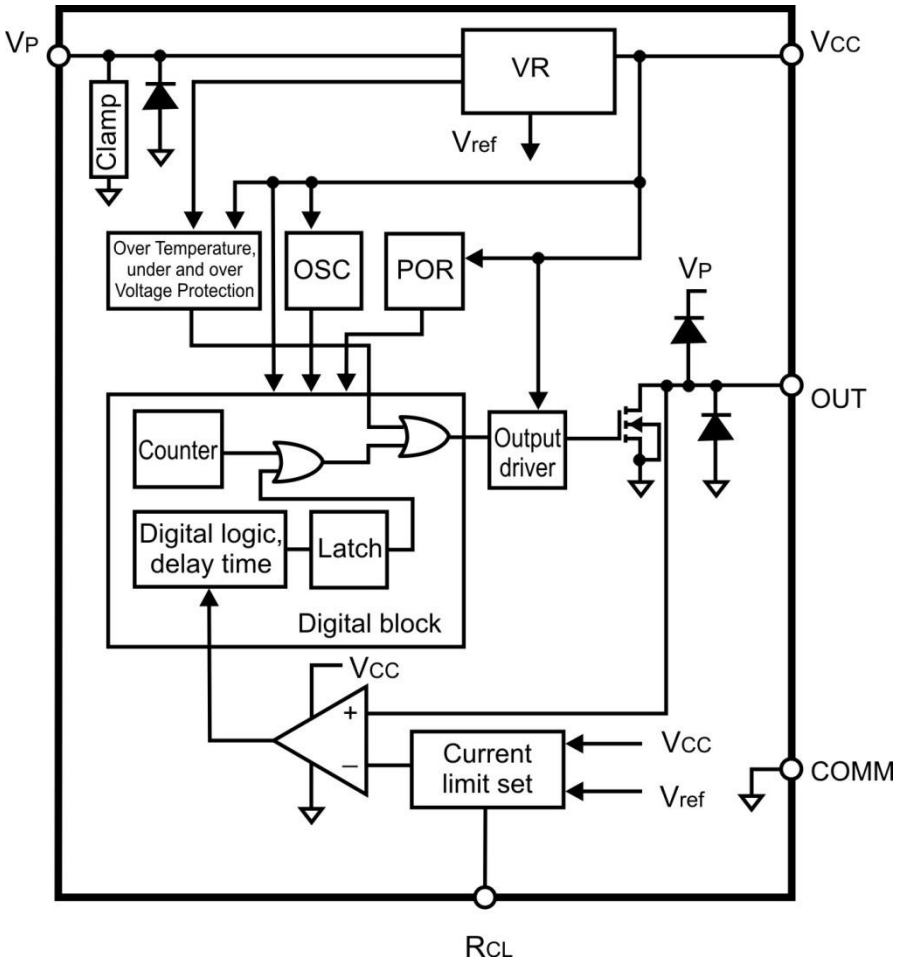


Fig.1. Block Diagram

Name	Description
V_R	Internal voltage regulator 3.6V
Over temp, under/over Voltage Protection	Over temperature protection (+ 165°C), Under / Over (<8V / >18V) voltage protection detect
Counter	Counter with counter time 15s
Current limit set	Adjust current set point by external resistor, R_{CL}connected to R_{CL}pin
Digital logic and delay time block	This block provides timing behavioral IC according Fig. 4. This is combination of several delay and logic circuits.
Latch	Latch with power on state – Output On (motor active)
Output Driver	Sink LDNMOS Output Driver
POR	Power On Reset

Table 3.ELECTRICAL CHARACTERISTICS

V_{IN}=8V to 16V; -40ºC < T_A<85ºC. All voltages are defined with respect to COMM (internal GND). Positive currents flow into the device. Unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply (V_{IN})						
V_{IN_MIN}	Under voltage threshold	V_{IN} (Dual mode)	4.8	5.8	6.8	V
V_{IN_MAX}	Over voltage threshold	V_{IN}, T_A = 25ºC	18	-	22	V
		V_{IN} T_A= -40ºC to +85ºC	17.5	-	22.8	
I_P(ss)	Dark current	T_A= 25ºC, V_{IN} =13V (Dual mode)	-	-	120	μA
I_P-$\|I_m\|$	Supply current(1)	$\|I_m\|$<2.3A	-	1.3	2	mA
V_F	Diode forward drop voltage	I_P = 2.3A, T_A= 25ºC	-	-	1.2	V
		I_P = 2.3A, T_A = -40ºC to +85ºC	-	-	1.7	
V_P	Output supply voltage drop	V_{IN}= 8V, T_A = 25ºC	7	-	-	V
Motor outputs(Pin OUT)						
V_{OUT}	Output Voltage(1)	I_{SINK}<-2.3A, T_A= 25ºC	-	0.6	0.75	V
		$\|I_m\|$<2.3A, T_A= -40ºC to +85ºC	-	-	0.90	
I_{st}	Stall Current(2) Threshold	V_{IN}=13V, T_A = 25°C R_{CL} = 5.1K	0.826	0.865	1.100	A
ΔI_{st}	Stall current set point range(3)	T_A = 25°C, V_{IN} = 8 V~16V	0.5	-	2.5	A
ΔI_{stTj}	Stall current temperature change range(3)	V_{IN} = 13V, T_A = -40°C~85°C	0.5	-	2.5	A
I_{ST_HYST}	Stall Current Hysteresis(3)	V_{IN}=12V, T_A = 25°C	3.4	3.6	3.8	%
T_{mgc}	Max. time of start current (glitch current, Fig.4)	V_{IN}= 13V,T_A = 25ºC	127	150	172	ms
T_{msc}	Max. time of stall current (Fig.4) (3)	V_{IN}= 13V, T_A = 25ºC	400	460	520	ms

ELECTRICAL CHARACTERISTICS (continue)

V_{IN}=8V to 16V; -40 ºC < T_A<85 ºC. All voltages are defined with respect to COMM (internal GND). Positive current flows into the device. Unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Max. operation time						
T_{fld}	Max-.folding time(3)	T_A = 25ºC	12	13	16	s
Clampingcircuit						
V_{CLMPTH}	Clamping circuit threshold voltage	T_A= 25ºC	34	37	40	V
Thermal protection						
T_j(sd)	Thermal shutdown junction temp. (3)	Temp. increasing	-	165	-	˚C
T_j(so)	Thermal switch-on junction temp.(3)	Temp. decreasing	-	145	-	˚C

1. This is only valid when the temperature protection is not active.
2. Stall current threshold is determined by external resistors R_{CL} =5.1kΩ. This resistor value for motor with stall current more than 1A and operating current less than 500mA. For other motor characteristics need calculate R_{CL} by formula (2).
3. This parameter, although guaranteed, is not 100% tested in production

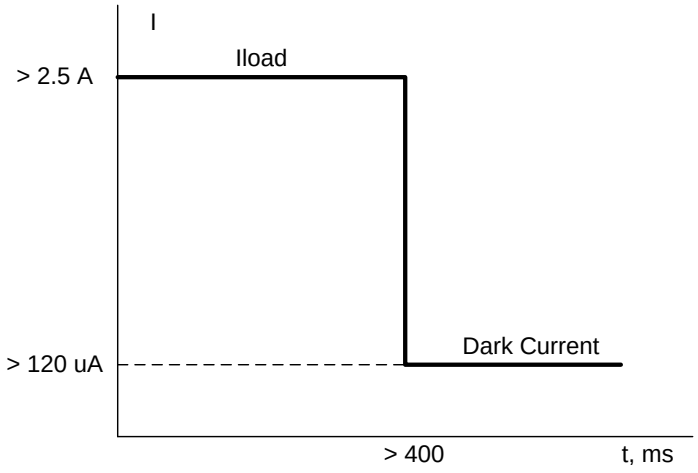


Fig. 3Dark Current Time Diagram

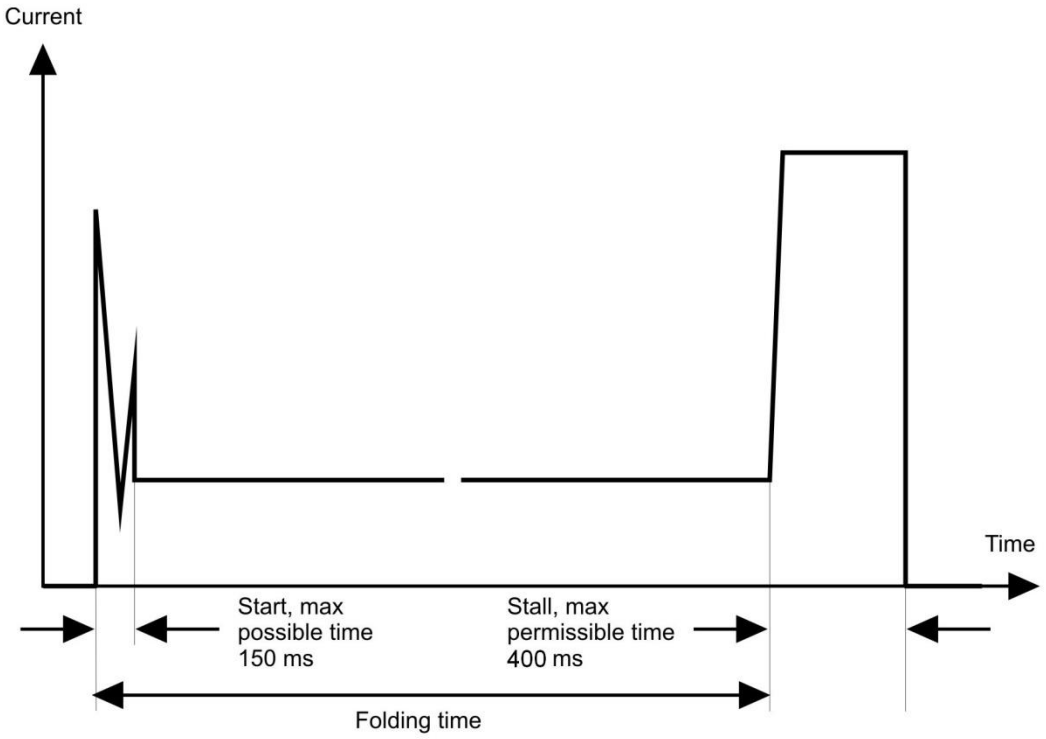


Fig. 4 Output Current Timing

Table 1. PIN LIST AND DESCRIPTIONS

Pin #	Name	I/O	Description
1,2,3	V_P	In/Out	Supply voltage for active IC through reverse IC. 10 ohm is required between active and reverse IC's
4,5,6	OUT	Out	Motor Driver Output. Low side LDNMOS of active IC and Diode of reverse IC.
7,8,9,10 13,14,15	COMM	In/Out	Power Ground of active IC and Input Voltage of reverse IC.
12	MODE	In	Mode selection. Use for IC test only. Internally pull up to VCC. MODE should be left floating in circuit board layout.
16	VCC	Out	Output of internal voltage regulator. Bypass with 100nF ceramic capacitor to COMM.
11	R_{CL}	In	Set current limit level (need connect external resistor to COMM)

FUNCTIONAL DESCRIPTION.

VR and POR blocks.

A power supply circuit is performed by applying a voltage between terminals "V_P" and "COMM". The “VR” block produces low voltage power supply for internal circuits and forms all reference voltages inside IC. The power supply voltage for the internal parts can be monitored on V_{CC} pin. An external ceramic capacitor 0.33 uF can be connected to V_{CC} pin for reducing noise issue. If voltage on V_{CC} pin is decreased more than 1 V “POR” block produces reset signal for internal blocks (initial state). If voltage on V_{CC} pin grows up bigger than 2.4 V reset signal is released and circuit goes to normal operation mode. Output transistor is opened and IC waits 150 ms as a fig.2. IC doesn’t control any protection function and current through output transistor during this time. After delay time in the 150 ms IC check over-voltage, under-voltage, over-temperature, over-current conditions. If under-voltage and over-temperature conditions are happened, output transistor is closed after 3ms. If under-voltage and over-temperature conditions are released, output transistor is opened again after 3ms. If over-voltage and over-current conditions are happened, output transistor is closed. These states are latched in digital part and can reset only by turn-off/turn-on main power supply. If over-voltage is happened, output transistor is closed after 3ms. But, if over-current is happened, output transistor is closed after 400ms as a fig.2. Over-current condition must have duration not less 400ms. Otherwise, internal over-current counter will be reset and over-current condition not detect.

If protection issues aren’t happened during 15 s, IC turn-off output transistor by timing and latches this state. It can be reset only in the next turn-off/turn-on cycle of main power supply.

Over-temperature, over-voltage protection and under-voltage lockout block.

Several comparators check input voltage on V_P pin and temperature of chip and compare them with internal reference points. A behavior is defined in description of “VR and POR blocks”.

OSC block.

Internal oscillator is built in as RC-oscillator structure. It is started by “POR” signal release and stopped by latch signal from digital part. It can be restart in the next turn-off/turn-on cycle of main power supply. Internal oscillator has frequency value around 32 KHz. All timing parameters inside IC are formed by counting numbers of the periods of the oscillator.

Counter.

Long time counter provides maximal operation time 15 seconds.

Digital Logic and Delay Time.

This block provides delay time: for over-voltage, under-voltage and over-temperature 1ms; for over-current 400ms and initial delay time 150ms. These times shown on fig.2

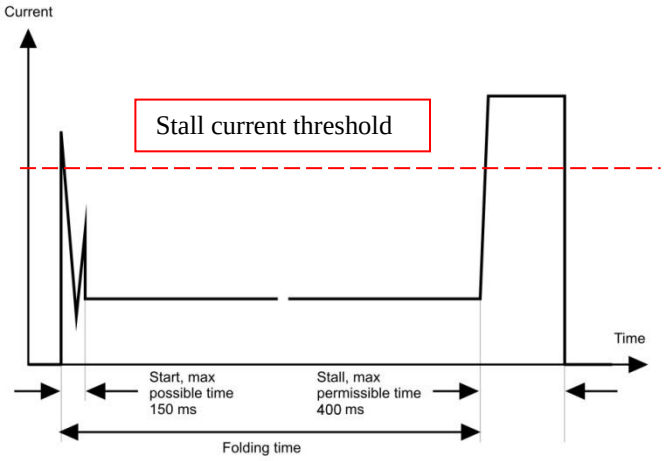


Fig. 2 Output Current Timing

Current limit set.

Current sensor and adjustable reference current source are placed inside one block. Reference current from Adjustable reference current source compared with scaled load current from Current sensor block by Current comparator. Reference current value can be set by external resistor R_{CL_EXT} connected to R_{CL} pin.

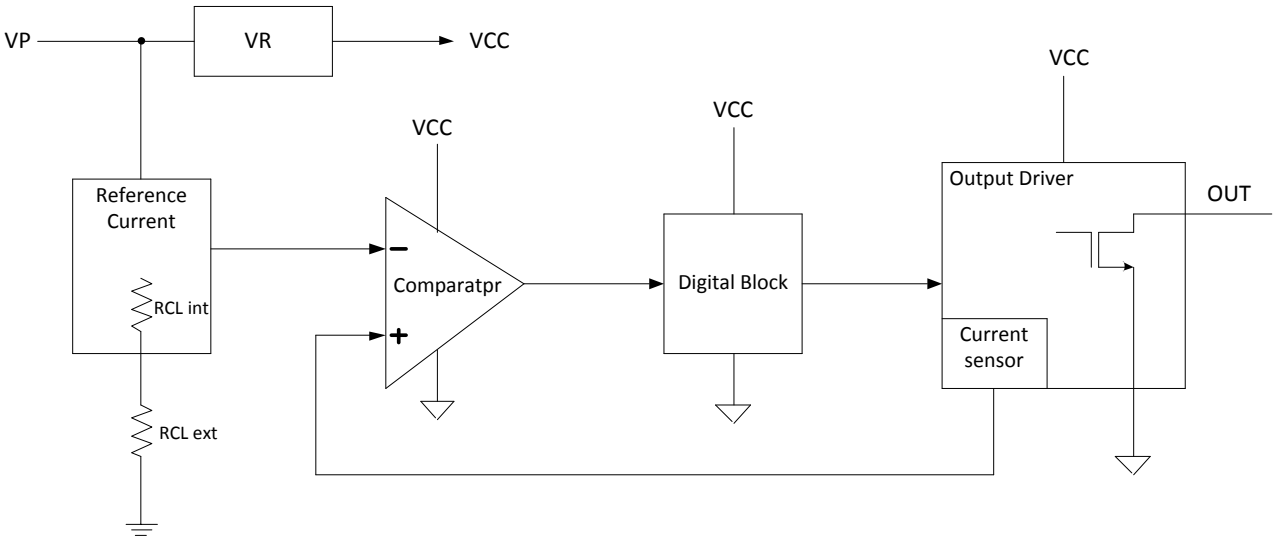


Fig.3. Current limit block.

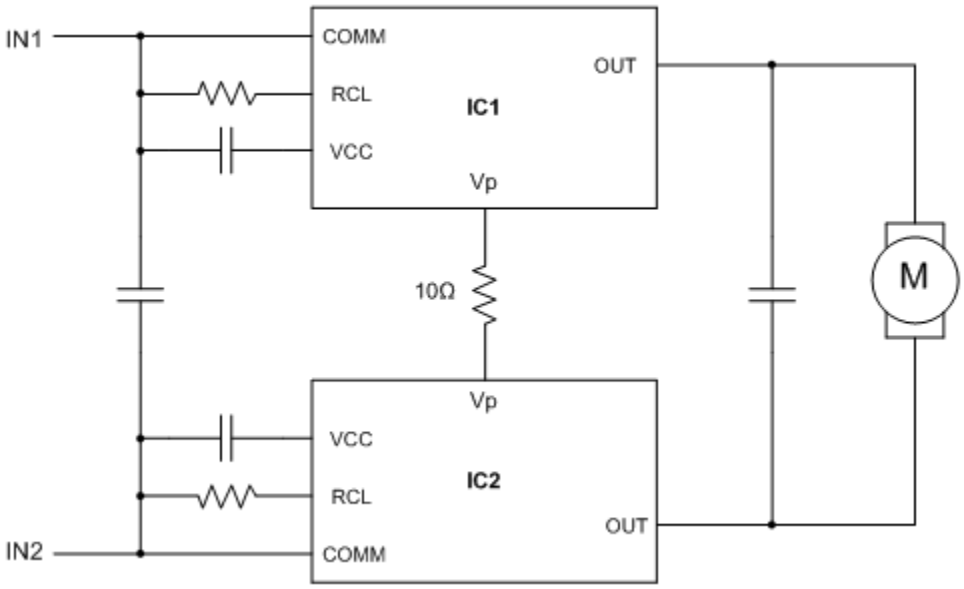
The Current threshold for room temperature is calculated as:

$$Istall = \frac{Gain * (VIN - 0.735V)}{70 * (Rclext + Rcl\,\mathrm{int})} \quad \text{at } T_A=25^\circ C \qquad (1)$$

Where

VIN – supply voltage.
Gain – scaling factor by Current Sensor Block (fig.3).
Gain = 59500
Rclext and Rclint – external and internal resistors on pin Rcl (pin11) (fig.3)
Rclint = 5K

TYPICAL APPLICATION CIRCUITS



All resistors R_{CL} are used for the current reference set input (not current sensor).

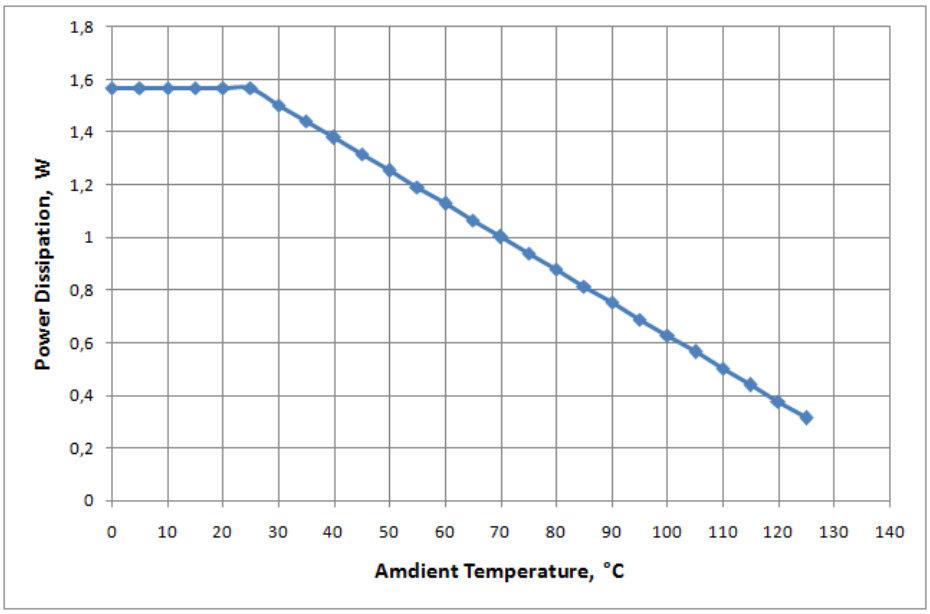
$$Rcl = \frac{Gain * (VIN - 0.735V)}{70 * (Istall - 100mA)} - Rcl\,\mathrm{int} \qquad (2)$$

Where

VIN - supply voltage which motor stall current is specify
Gain = 59500
Rclint = 5K
Istall – motor stall current.

Package Power Dissipation (PD)

The maximum power dissipation, $P_D(max) = (T_{j,max} – T_A) / R_{th(j-a)}$.



The actual package power dissipation is:

PD(reverse) = $V_F \times I_{LOAD}$ for reverse IC connection,
PD(active) = $V_{OUT} \times I_{LOAD}$ for active IC connection.

Therefore, to keep PD(actual) ≤ PD(max), the allowable maximum Load current (motor current) is:
I_{LOAD} max = $(Tj,max – T_A) / (Rth(j-a) \times V_F)$ for reverse IC or
I_{LOAD} max = $(Tj,max – T_A) / (Rth(j-a) \times V_{OUT})$ for active IC, where Tj,max = 150°C.

Heat Sink/Thermal Consideration.

In many cases, only a small heat sink is required to keep the p-n junction temperature within the allowed operating range. For each application, to determine whether or not a heat sink will be required, the following must be identified:

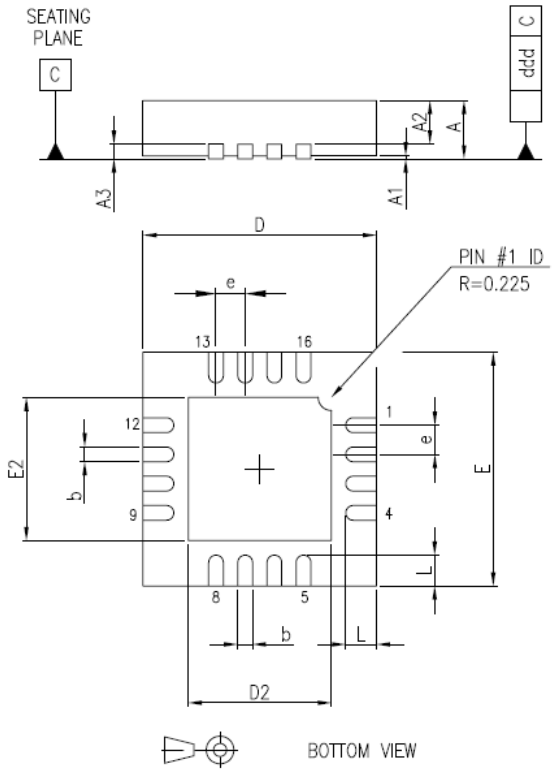
1. Maximum ambient temperature (in the application).
2. Maximum power dissipation (in application).
3. Maximum allowed junction temperature (150°C). For a safe, conservative design, a temperature approximately 15°C cooler than the maximum temperature should be selected.
4. Package thermal resistance.

Total power dissipation can be estimated as follows:
PD(reverse) = $V_F \times I_{LOAD}$ for reverse IC connection,
PD(active) = $V_{OUT} \times I_{LOAD}$ for direct IC connection.
When no heat sink is used, the junction temperature rise can be determined by the following:
$\Delta Tj = P_D * Rth(j-a)$
To arrive at the actual operating junction temperature, add the junction temperature rise to the maximum ambient temperature.
$Tj = \Delta Tj + Ta$

If the actual operating junction temperature is greater than the selected safe operating junction temperature determined in step 3, then a heat sink is required.
When using a heat sink, the junction temperature rise can be determined by the following:
$\Delta Tj = P_D * (Rth(j\text{-}c) + Rth(\text{heat sink}))$
The operating junction temperature will be:
$Tj = Ta + \Delta Tj$
If the actual operating junction temperature is greater than the selected safe operating junction temperature, then a larger heat sink is required (one that has a lower thermal resistance).

Package Outline Drawing

16 QFN with exposed pad plastic package



DIMENSIONS						
REF.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	0.80	0.90	1.00	0.031	0.035	0.039
A1		0.02	0.05		0.001	0.002
A2		0.65	1.00		0.026	0.039
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	3.85	4.00	4.15	0.152	0.157	0.163
D2	2.10		2.60	0.083		0.102
E	3.85	4.00	4.15	0.152	0.157	0.163
E2	2.10		2.60	0.083		0.102
e		0.50			0.020	
L	0.30	0.40	0.50	0.012	0.016	0.020
ddd			0.08			0.003