## DC Motor Driver for Servo Driver Applications

## FEATURES

- Low positional error
- Low noise sensitivity due to hysteresis
- Low supply current
- Wide input voltage range ( $0.05 \mathrm{Vp} \div 0.95 \mathrm{Vp}$ )
- Over temperature protection
- Over- and under voltage lockout
- Broken wire and short-circuit indication on SET input
- Stall function via temperature
- Stall function with external stall current control
- Full output protection
- No crossover current
- Hysteresis level set externally
- Internal clamp diodes
- Enhanced power packages
- 8-pin ESOP 8-pin DIP and 14-pin PDSOP power packages
- AEC Q100 Qualified



## DESCRIPTION

IK8508 is a fully protected H-bridge driver designed especially for automotive headlight beam control and industrial servo control applications. The device is built using the high voltage BCDMOS process. IK8508 is a light position controller intended to be used in passenger cars. This circuit adapts the elevation of the light beam of the head light of the car to a state defined by the car driver using a potentiometer on the dashboard. An internal window-comparator controls the input line. In the case of a fault condition, like short circuit to ground, short circuit to supply-voltage, and broken wire, the IK8508 stops the motor immediately. Also the device is protected against temperatures above $160^{\circ} \mathrm{C}$ and electrical transients. Furthermore the built in features like under and over voltage protections, short circuit and broken wire detection, and over temperature protection will open a wide range of automotive and industrial applications.

## PIN DESCRIPTION IK8508



8-ESOP /8-DIP


14-PDSOP

Pin Configuration
8-ESOP / 8-DIP

| Pin Name | I/O | Description | Pin № |
| :---: | :---: | :---: | :---: |
| GND | - | Ground | 1 |
| OUT1 | O | Output 1 | 2 |
| Stall | I | Stall input | 3 |
| FB | I | Feedback input | 4 |
| SET | I | Set input | 5 |
| SETD | I | Set input (over range control) | 6 |
| Vp | - | Supply voltage | 7 |
| OUT2 | O | Output 2 | 8 |

## 14-PDSOP

| Pin Name | I/O | Description | Pin № |
| :---: | :---: | :---: | :---: |
| OUT1 | O | Output 1 | 1 |
| N/C | - | Not connected | 2 |
| Stall | I | Stall input | 6 |
| FB | I | Feedback input | 7 |
| SET | I | Set input | 8 |
| SETD | I | Set input (over range control) | 9 |
| Vp | - | Supply voltage | 13 |
| OUT2 | O | Output 2 | 14 |
| GND | - | Ground | $3,4,5,10,11,12$ |

## BLOCK DIAGRAM



## TIMING DIAGRAMM



The timing diagram of IK8508 can be divided into several parts starting from a steady state. In this case (until t1) a large Iref is active, indicated by the dotted lines. When the setting potentiometer is rotated and the input current Iset becomes higher than Iref (at time t 2 ), the motor will start and the motor current will decrease. At the same time the Iref is switched to a low level. During rotation of the motor the Iset will decrease until it becomes lower than this low reference current ( t 3 ). At this time the motor will stop and the Iref is set to the higher value. The polarity of the feedback potentiometer should be such that the voltage at the slider of the feedback potentiometer increases when OUT1 is high and OUT2 is low.

## ABSOLUTE MAXIMUM RATINGS

All voltages are defined with respect to ground. Positive currents flow into the device.

| Symbol | Parameter | Conditions | Min. | Max. | Unit |
| :--- | :--- | :---: | :---: | :---: | :---: |
| $\mathrm{V}_{\mathrm{P}}$ | Supply Voltage | operating | 8 | 18 | V |
|  |  | non-operating | -0.3 | 50 | V |
| Vn | Voltage on any input pin |  | -0.3 | $\mathrm{~V}_{\mathrm{P}}+0.3$ | V |
| Ves | Electrostatic Handing | note 1 | -3 | 3 | kV |
| Tstg | Storage Temperature |  | -55 | 150 | ${ }^{\circ} \mathrm{C}$ |
| Tj | Junction Temperature |  | -40 | 150 | ${ }^{\circ} \mathrm{C}$ |
| Tamb | Ambient Temperature |  | -40 | 105 | ${ }^{\circ} \mathrm{C}$ |
| $\mathrm{R}_{\mathrm{L}}$ | Load Resistance | note 2 | 10 | - | $\Omega$ |
| $\mathrm{I}_{\mathrm{L}}$ | Load Current | note 2 | 2 | - | A |

## Notes

1. Human body model: equivalent to discharging a 100 pF capacitor through a $1.5 \mathrm{k} \Omega$ resistor.
2. $\mathrm{Vb}=13 \mathrm{~V}, \mathrm{Tamb}=25^{\circ} \mathrm{C}$; duration 50 ms maximum; non repetitive.

## THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | VALUE | UNIT |
| :--- | :--- | :---: | :---: |
| Rth (j-a). | Thermal resistance from junction to ambient in <br> free air <br> $-\quad$ for 8-pin ESOP package <br> for 14-pin PDSOP package | 125 <br> 77 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| PDmax | Power Dissipation at TA <br> "THERMAL ASPECTS" <br> $-\quad$ for 8-pin ESOP package <br> $-\quad$ for 14-pin PDSOP package | 1 | W |

## ELECTRICAL CHARACTERISTICS

$\mathrm{Vp}=12 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=14 \Omega$, Rset $=\mathrm{Rfb}=20 \mathrm{k} \Omega$. All voltages are defined with respect to ground. Positive currents flow into the device. Unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |


| Supply |  |
| :---: | :---: |
| $\operatorname{Vp}(\min )$ | under voltag |
| $\operatorname{Vp}(\max )$ | over voltage |
| $\operatorname{lp}(\mathrm{ss})$ | supply <br> steady |
| $\operatorname{lp}-\|I m\|$ | supply <br> motor |
| Setting input (SET) |  |


| Vset | operating voltage |  | 0.05 Vp | - | 0.95 Vp | V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Iset | input current | Rset>20k | -50 | - | 50 | uA |
| Vset(sc) | wire short-circuited to ground threshold | output stages switched off | - |  | 0.4 | V |
|  | wire short-circuited to battery threshold | output stages switched off | Vp | - | - |  |
| $\Delta \mathrm{V}$ set | broken ground set pull-up | note 3 | - | - | 160 | mV |

## Feedback input (FB)

| Vfb | operating voltage |  | 0.05Vp | - | 0.95Vp | V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Ifb(max) | maximum input current | Rfb>20k | -0.1 | - | 0.1 | uA |
| Motor outputs |  |  |  |  |  |  |
| \|Vm| | output voltage | \| $1 \mathrm{~m} \mid<700 \mathrm{~mA}$, Tamb $=25^{\circ} \mathrm{C}$, note 2 | Vp-2.5 | - | - | V |
|  |  | $\begin{gathered} \|\operatorname{lm}\|<700 \mathrm{~mA}, \\ \text { Tamb }=-40 \text { to } 105^{\circ} \mathrm{C} \\ \text { note } 2 \end{gathered}$ | Vp-2.9 | - | - |  |
| \|Im| | output current | $\begin{gathered} \mathrm{Vp} \geq 12.3 \mathrm{~V}, \\ \text { Tamb }=25^{\circ} \mathrm{C}, \text { note } 2 \end{gathered}$ | 700 | - | - | mA |
|  |  | $\begin{gathered} \mathrm{Vp} \geq 12.3 \mathrm{~V} \\ \text { Tamb }=-40 \text { to } 105^{\circ} \mathrm{C} \\ \text { note } 2 \end{gathered}$ | 670 | - | - |  |
| Reference current |  |  |  |  |  |  |
| \| 1 set| | motor switch-on level | $\mathrm{V} p=12 \mathrm{~V}$ | 6 | 9 | 12 | uA |
|  |  | $\mathrm{V} p=18 \mathrm{~V}$ | 9 | 13.5 | 18 |  |
|  | motor switch-off level |  | - | 2.5 | - | uA |

## Thermal protection

| $\mathrm{Tj}(\mathrm{sd})$ | Thermal shutdown <br> junction temperature | T increasing | - | 160 | - | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{Tj}($ so $)$ | Thermal switch-on <br> junction temperature | T decreasing | - | 135 | - | ${ }^{\circ} \mathrm{C}$ |

## Notes:

1. Steady state implies that the motor is not running $(\mathrm{Im}=0) \mathrm{Vset}=\mathrm{Vfb}=0.5 \mathrm{Vp}$.
2. This is only valid when the temperature protection is not active.
3. $\Delta$ Vset is the difference in voltage on the set potentiometer between the situation when the ground ware is interrupted (Vset,br) and voltage on the set potentiometer during normal operation (Vset $=0.17 \mathrm{Vb}=2.72 \mathrm{~V}$ ). The conditions for this test are: Rset $=20 \mathrm{k} \Omega, \mathrm{Vb}=16 \mathrm{~V}$, $\Delta$ Vset $=$ Vset,br-2.72.


## APPLICATION CIRCUIT


for 8-pin ESOP package

The resistor in the input line Rsetd is present to limit the current during the transients and should have a value near $2 \mathrm{~K} \Omega$.

The resistor in the feedback input line Rfb is present to limit the current during the transients and should have a value lager than $2 \mathrm{~K} \Omega$.

The resistor in the set input line Rset is present to set the voltage hysteresis and must be larger than $2 \mathrm{~K} \Omega$.

A diode is placed in series with the supply line to protect the device from reverse polarity switching.
$R s t \cong 17000 \times(\mathrm{Vb}-0.7) /$ Ist,
where:
Vb - battery voltage;
Ist - motor stall current.


## for 14-pin PDSOP package

The resistor in the input line Rsetd is present to limit the current during the transients and should have a value near $2 \mathrm{~K} \Omega$.

The resistor in the feedback input line Rfb is present to limit the current during the transients and should have a value lager than $2 \mathrm{~K} \Omega$.

The resistor in the set input line Rset is present to set the voltage hysteresis and must be larger than $2 \mathrm{~K} \Omega$.

A diode is placed in series with the supply line to protect the device from reverse polarity switching.

Rst $\cong 17000 \times(\mathrm{Vb}-0.7) /$ Ist, where:

Vb - battery voltage;
Ist - motor stall current.

## STALL COUNTER

The stall counter can start from two events - over temperature ( $\mathrm{T} \geq 160^{\circ}$ ) or over load current (stall current). The resistor for setting the current threshold is:

$$
\text { Rst } \cong 17000 \times(\mathrm{Vb}-0.7) / \mathrm{Ist},
$$

where:
Vb - battery voltage;
Ist - motor stall current.

## Example:

By the formula
Rst $\cong 17000 \times(\mathrm{Vb}-0.7) /$ Ist, components of the Demo board are:
Rst=2M
Cst=2.7uF

## THERMAL ASPECTS

The maximum power dissipation is
$\mathrm{PD}(\max )=(\mathrm{Tj}, \max -\mathrm{Ta}) / \operatorname{Rth}(\mathrm{j}-\mathrm{a})$,
decreases as the ambient temperature increases.


The actual power dissipation of the device is the sum of two sources: the supply current (IP - |Im|) times the supply voltage $\left(V_{P}\right)$ plus the motor current $(|I m|)$ times the output saturation voltage ( $\mathrm{V}_{\mathrm{P}}$ $-|V m|)$. In formula:
$P D=V p \times(\mathrm{Ip}-|\mathrm{Im}|)+|\mathrm{Im}| \times(\mathrm{Vp}-|\mathrm{Vm}|)$
$(\mathrm{Vp}-|\mathrm{Vm}|)=2.5 \mathrm{~V}$ can not be allowed at $\mathrm{Ta}=105^{\circ} \mathrm{C}$. But it is also improbable that the motor is continuously driven, therefore the following assumptions have been made.
It is assumed that the device must be capable of moving the motor from one end to the other in four equal steps and that the total time needed for this excursion is 16 seconds. After this excursion a pause is allowed before the same pulses are used to return to the original position. This operation is illustrated in the below Figure.


The duration of the pause depends on the ambient temperature, see below Table.
Figure. Thermal transient test.

| Tamb( ${ }^{\circ} \mathbf{C}$ ) | PAUSE (s) |
| :---: | :---: |
| 95 | 180 |
| 135 | 257 |
| 150 | 294 |
| 155 | 308 |

Table. Duration of the pauses
The maximum allowable dissipated power $P$ is then 1 W during the motor active periods in the event of a 8-ESOP package being used. Dissipation pulses due to starting and stopping the motor can be ignored because of their short duration. This maximum allowable dissipated power implies that the maximum continuous motor current ( $|\mathrm{lm}|$ ) is approximately 300 mA during the motor active periods when the supply voltage $V_{P}$ is 13 V .
For increase maximum continuous motor current ( $|\operatorname{lm}|$ ) need increase allowable power dissipation. It can be reach by use heatsink. 8-pin ESOP \& 14-pin PDSOP allow the using heatsink. To accomplish heat sinking, the tab on PSOP package may be soldered to the copper plane of a PCB for heatsinking. In this case heat is transferred directly from the die through the paddle rather than through the small diameter bonding wires.
A cupper plane of appropriate size may be placed directly beneath the tab or on the other side of the board.

## Determining Copper Aria

One can determine the required copper area by following a few basic guidelines:

1. Determine the actual value of the circuit's power dissipation, PD by expression (2).
2. Specify a maximum operating ambient temperature $\mathrm{Ta}(\mathrm{MAX})$. Note that when specified this parameter, it must be kept in mind that, because of internal temperature rise due to power dissipation, the die temperature, Tj , will be higher than Ta by an amount that is depend on the thermal resistance from junction to ambient, Rth(j-a). Therefore, Ta must be specified such that Tj does not exceed to absolute maximum die temperature of $150^{\circ} \mathrm{C}$.
3. Specify a maximum allowable junction temperature $\mathrm{Tj}(\mathrm{MAX})$, which is the temperature of the chip at maximum operation current.
4. Calculate the value of junction to ambient thermal resistance, $\operatorname{Rth}(j-a)$ by expression (1).
5. Choose a copper area that will guarantee the specified $\operatorname{TJ}(\mathrm{MAX})$ for the calculated Rth(j-a). Rth $(j-a)$ as function of copper area in square inches is shown in Table 1.

A selection of thermal data for ESOP package is shown in Table 1.
Table 1. Thermal Resistance of ESOP Package.

| Copper | Area | $0.5 \mathrm{in}^{2}$ <br> $($ each side) | $1.0 \mathrm{in}^{2}$ <br> (each side) | $2 \mathrm{in}^{2}$ <br> $($ each side) |
| :---: | :---: | :---: | :---: | :---: |
| 0.5 oz | Top Layer Only | 115 | 105 | 102 |
| 1.0 oz |  | 91 | 79 | 72 |
| 2.0 oz |  | 74 | 60 | 52 |
| 0.5 oz | Bottom Layer Only | 102 | 88 | 81 |
| 1.0 oz |  | 92 | 75 | 65 |
| 2.0 oz |  | 85 | 66 | 54 |
| 0.5 oz | Top and Bottom | 83 | 70 | 63 |
| 1.0 oz | Layer | 71 | 57 | 47 |
| 2.0 oz |  | 63 | 48 | 37 |

## Procedure.

1. First determine the maximum power dissipated the IK8508, PDmax by formula:
$P D(\max )=V p x(\operatorname{lp}-||m|)+|I m| \times(V p-|V m|)$.
2. Determine maximum allowable die temperature rise, $\mathrm{TR}(\max )=\mathrm{Tj}(\max )-\mathrm{Ta}(\max )$
3. Using the calculated value $\operatorname{PD}(\max )$ and $\operatorname{TR}(\max )$ the required value for junction to ambient thermal resistance can be found:

$$
\operatorname{Rth}(j-a)=\operatorname{TR}(\max ) / \operatorname{PD}(\max )
$$

4. Finally, using this value $\operatorname{Rth}(\mathrm{j}-\mathrm{a})$ choose the minimum value of copper aria from Table 1.

## Package Dimensions

## 8-ESOP (Exp PAD)



|  | Dimensions In Millimeters |  | Dimensions In Inches |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Min | Max | Min | Max |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.050 | 0.150 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.006 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.200 |
| D1 | 3.202 | 3.402 | 0.126 | 0.134 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.200 | 0.228 | 0.244 |
| E2 | 2.313 | 2.513 | 0.091 | 0.099 |
| e | $1.270($ BSC) |  | 0.050 (BSC) |  |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| $\theta$ | $0^{\circ}$ | $8^{\circ}$ | 0 | $0^{\circ}$ |

## 14-PDSOP

## D SUFFIX SOIC

(MS - 012AB)


| $\oplus$ | $0.25(0.010)(M)$ | T | $\mathrm{C}(\mathrm{M}$ |
| :--- | :--- | :--- | :--- |

## NOTES:

1. Dimensions A and B do not include mold flash or protrusion.
2. Maximum mold flash or protrusion $0.15 \mathrm{~mm}(0.006)$ per side for A ; for $\mathrm{B}-0.25 \mathrm{~mm}(0.010)$ per side.


|  | Dimension, mm |  |
| :---: | :---: | :---: |
| Symbol | MIN | MAX |
| $\mathbf{A}$ | 8.55 | 8.75 |
| $\mathbf{B}$ | 3.8 | 4 |
| $\mathbf{C}$ | 1.35 | 1.75 |
| $\mathbf{D}$ | 0.33 | 0.51 |
| $\mathbf{F}$ | 0.4 | 1.27 |
| $\mathbf{G}$ | 1.27 |  |
| $\mathbf{H}$ | 5.27 |  |
| $\mathbf{J}$ | $0^{\circ}$ | $8^{\circ}$ |
| $\mathbf{K}$ | 0.1 | 0.25 |
| $\mathbf{M}$ | 0.19 | 0.25 |
| $\mathbf{P}$ | 5.8 | 6.2 |
| $\mathbf{R}$ | 0.25 | 0.5 |

