

# FAN8902(KA3902)

## DC FAN Motor Controller

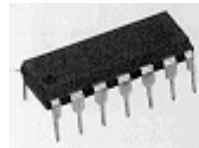
### Features

- Built-in PWM Current Control Circuit
- Built-in 5V Regulator
- Low Supply Current
- Stalled Motor Current Limitation
- Built-in Over Voltage Protection (OVP)
- Built-in Over Current Protection (OCP)
- Built-in Load Dump Protection
- Built-in Thermal Shutdown (TSD) Circuit
- Built-in Under Voltage Lockout (UVLO) Circuit

### Description

The FAN8902 is a monolithic integrated circuit, designed for the PWM control of a DC fan motor current in an automotive systems. It allows the fan motor speed to be controlled linearly and efficiently.

14-DIP-300



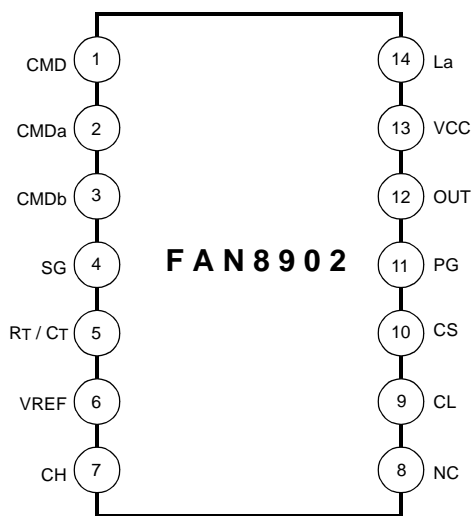
### Typical Application

- DC for Motor Control for Automotive

### Ordering Information

Device	Package	Operating Temperature
FAN8902	14-DIP-300	-40°C ~ +90°C

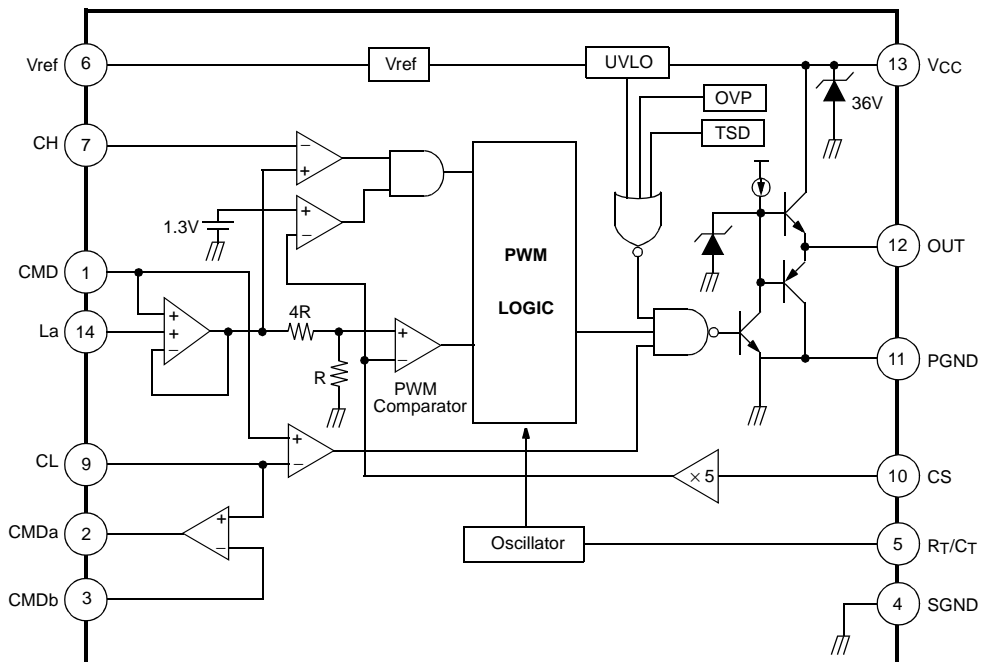
## Pin Assignments



## Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	CMD	Motor Current Command Input
2	CMDa	Optional OP Amplifier Output
3	CMDb	Optional OP Amplifier (-) Input
4	SGND	Signal GND
5	R <sub>T</sub> / C <sub>T</sub>	Oscillator Time Constant
6	VREF	Voltage Reference (5V)
7	CH	Maximum Current Reference Input
8	NC	No Connection
9	CL	Minimum Current Reference Input
10	CS	Motor Current Sense Voltage Input
11	PGND	Power GND
12	OUT	Drive Output
13	VCC	VCC
14	La	Motor Current Maximum Reference Input

# Internal Block Diagram



## Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V <sub>CC</sub>	32	V
CMD Input Voltage	V <sub>CMD</sub>	6	V
Peak Output Current	I <sub>OPK</sub>	±0.8	A
Power Dissipation	P <sub>D</sub>	1	W

## Operating Voltage

Parameter	Symbol	Min.	Typ.	Max	Unit
Power Supply Voltage	V <sub>CC</sub>	9.0	12.0	32.0	V

## Temperature Characteristics

Parameter	Symbol	Temp	Value	Unit
V <sub>ref</sub> Temperature Stability	V <sub>ST</sub>	-40 ~ +90°C	200	°C
Frequency Stability	F <sub>ST</sub>	-40 ~ +90°C	20 ~ 30	°C
Operating Temperature	T <sub>OPR</sub>	-	-40 ~ +90	°C
Storage Temperature	T <sub>STG</sub>	-	-60 ~ +150	°C

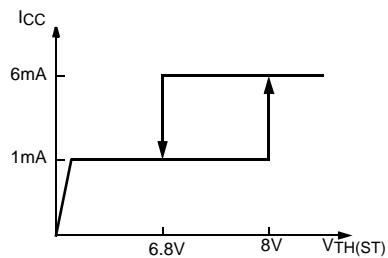
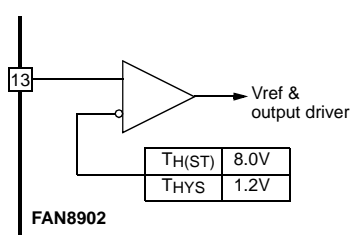
## Electrical Characteristics

(Unless otherwise,  $T_a=25^{\circ}\text{C}$ ,  $V_{CC}=5\text{V}$ ,  $V_M=12\text{V}$ )

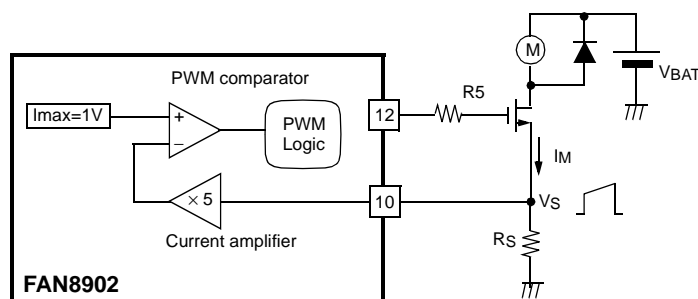
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
<b>REFERENCE</b>						
Reference Voltage	Vref	Iref=1mA	4.75	5.0	5.25	V
Line Regulation	$\Delta V_{ref1}$	$V_{CC}=9\text{V} \sim 32\text{V}$	-	50	150	mV
Load Regulation	$\Delta V_{ref2}$	Iref=1mA ~ 10mA	-	10	50	mV
<b>UNDER VOLTAGE LOCKOUT (UVLO)</b>						
Start Threshold Voltage	$V_{TH(ST)}$	-	7.5	8.0	8.5	V
Threshold Hysteresis	$V_{HYS}$	-	1.0	1.2	1.4	V
<b>PROTECTION</b>						
Over Voltage	OVP	-	33	36	-	V
<b>OSCILLATOR (<math>R_T=75\text{k}\Omega</math>, <math>C_T=1\text{nF}</math>)</b>						
Frequency	fosc	-	20	25	30	kHz
Duty Cycle	Duty	-	90	95	-	%
<b>CURRENT SENSING INPUT</b>						
Threshold Voltage	$V_{TH(ST)}$	$V_{CMD} = 5\text{V}$	0.19	0.20	0.21	V
<b>OUTPUT DRIVER</b>						
Output Voltage Switching Limit	VOLIM	$V_{CC} = 18\text{V}$ , $C_{ld} = 1\text{nF}$	-	15	-	V
Low Output Voltage	VOL1	Iout = 20mA	-	-	0.4	V
	VOL2	Iout = 200mA	-	-	2.2	V
High Output Voltage	VOH1	Iout = -20mA	10.0	-	-	V
	VOH2	Iout = -200mA	9.0	-	-	V
Rising Time	Tr	$C_{ld} = 1\text{nF}$	-	100	200	ns
Falling Time	Tf	$C_{ld} = 1\text{nF}$	-	100	200	ns
<b>TOTAL STANDBY CURRENT</b>						
Start-up Current	IST	$V_{CC} = 7\text{V}$	-	1.0	1.5	mA
Operating Supply Current	ICC	$V_{CC} = 9\text{V}$	-	6.0	8.0	mA

## Application Information

### 1. Under Voltage Lockout (UVLO)



### 2. Current Sensing Circuit



The peak current,  $I_{M(MAX)} = V_S / R_S$

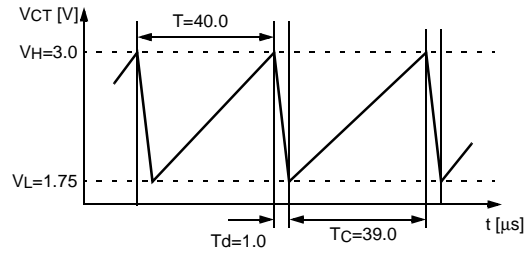
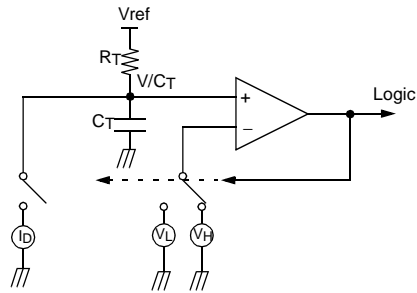
For example, if a required maximum current,  $I_{M(MAX)} = 20[A]$

$$R_S = \frac{1V/5}{20A} = 10[m\Omega]$$

### 3. Thermal Shutdown (Tsd)

When the chip, temperature rises up to 150°C, the thermal shutdown (TSD) circuit is activated and the output driver turn off, and then turn on again at 125°C.

### 4. Oscillator Component Selection



The oscillator timing components can be calculated as follows:

$$T_C = R_T \times C_T \times \ln[(V_{ref} - V_L)/(V_{ref} - V_H)]$$

$$T_D = C_T \times [(V_H - V_L)/I_D]$$

$$f_{osc} = 1/(T_C + T_D)$$

$$= 1.875/(R_T \times C_T)$$

$$Duty = T_C \times f_{osc} \times 100$$

For example, if  $f_{osc} = 25\text{kHz}$  and  $duty = 95\%$

$$C_T = (T_D \times I_D)/(V_H - V_L)$$

$$= 1000[\text{pF}]$$

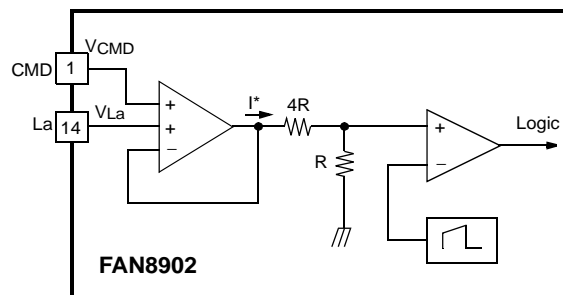
$$R_T = 1.875/(f_{osc} \times C_T)$$

$$= 1.875/(25\text{kHz} \times 1000\text{pF})$$

$$= 75[\text{k}\Omega]$$

### 5. Current Command Input Section

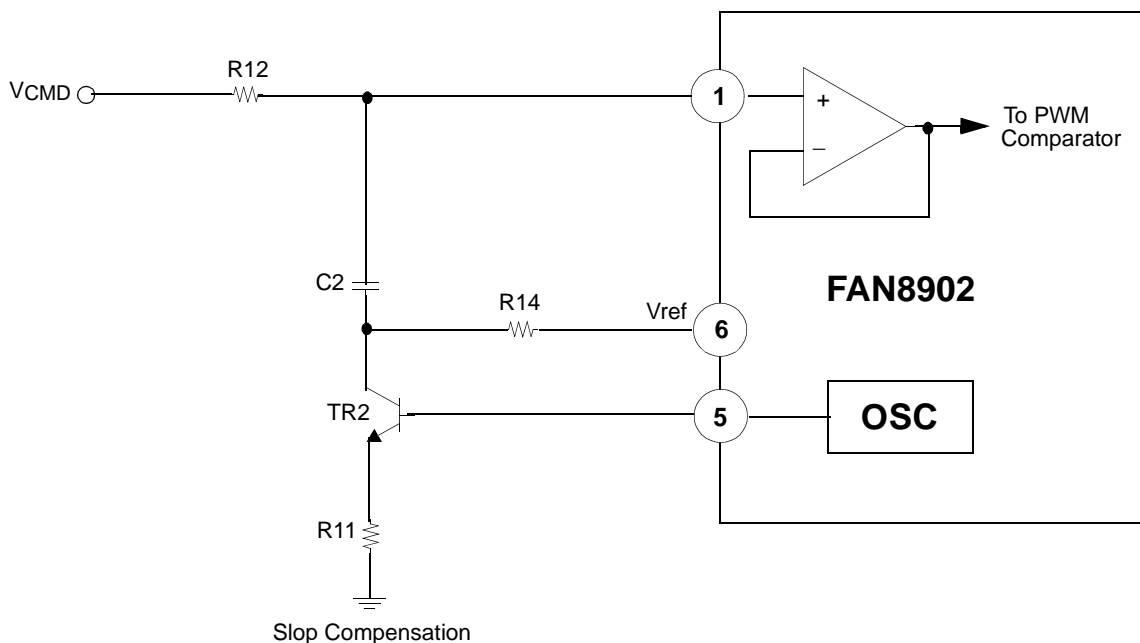
The current command  $I^*$  selects the lower value between  $V_{CMD}$  and  $V_{La}$ .



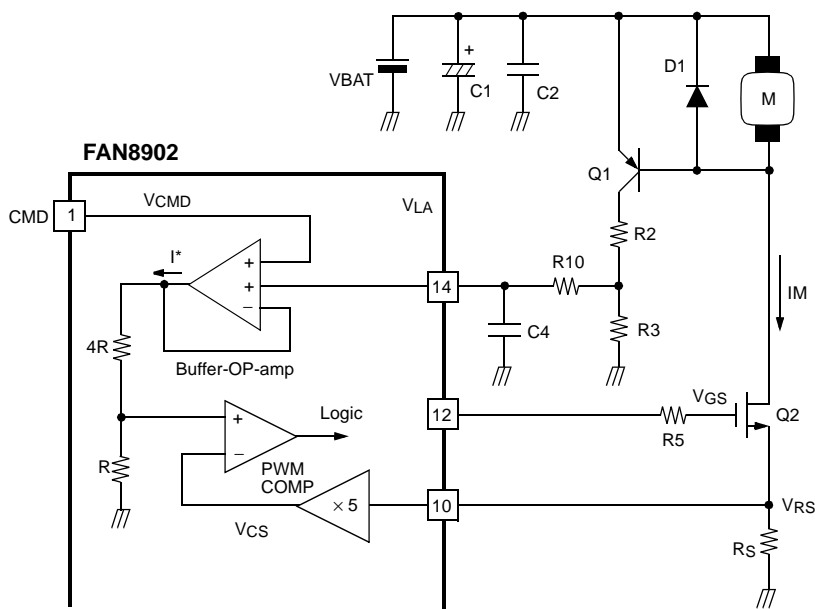
### 6. Slope Compensation

An unconditional instability of the inner current loop exists for any fixed frequency current-mode converter operating above 50% duty cycle. Therefore, to guarantee current loop stability, the slope of the compensation ramp must be greater than one-half of the down slope of the current waveform. The ramp voltage for slope compensation is as follow,

$$V_{RAMP} = \frac{R14}{R11} \times \Delta V_{OSC}$$



### 7. Motor Stall Current Limitation





In the steady state, the terminal voltage on a motor is consisted of a back EMF and the voltage drop on the armature resistors. When the motor happens to be stalled, the back EMF becomes zero, and the motor current ( $I_M$ ) is quickly increased until a maximum values.

Therefore the duty of the pin #12 output becomes lower because of the increase of the sense voltage ( $V_{RS}$ ). Also it makes the voltage ( $V_{La}$ ) be lowered, then it makes the duty become lower again.

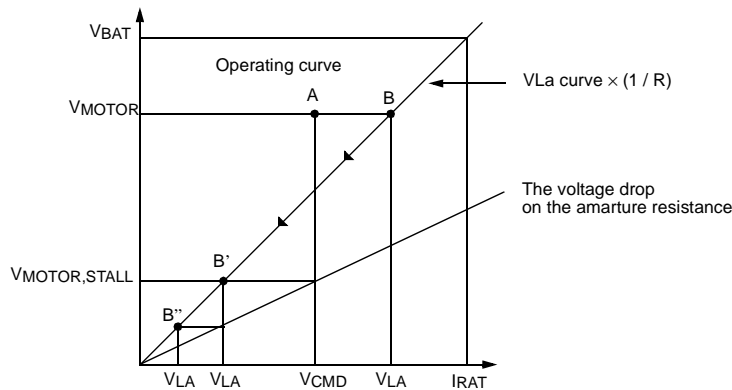
This mechanism makes the motor current hold very low value in the stalled motor state.

The voltage on pin #14 ( $V_{La}$ ) is calculated as follows:

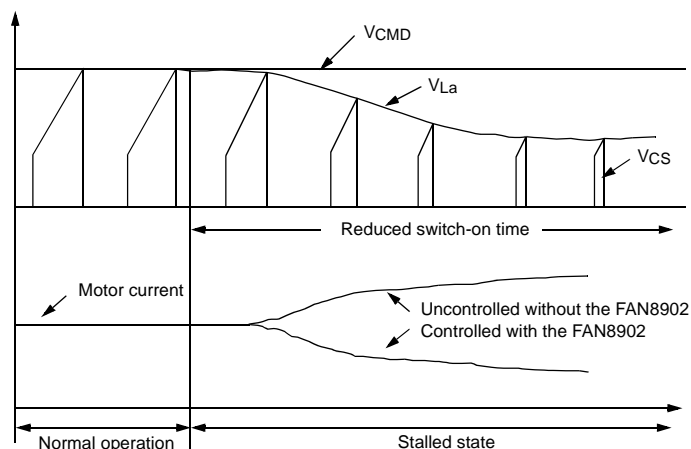
$$V_{La} = V_{BAT} \times D \times \frac{R3}{R2 + R3} \quad \text{Assumed the saturation voltage of Q1 is zero.}$$

We can choose the ratio of the resistors,  $R2$  and  $R3$ , as follows:

- Applied the rated voltage on motor, and then measured the current  $I_{RAT}$
- Matched the maximum command current,  $V_{CMD,MAX}$  to  $I_{RAT}$ .  
 $V_{CMD,MAX} = V_{La,MAX} = R_S \times I_{RAT} \times 5 \times 5$   
 for example, if  $R_S = 10m\Omega$  and  $I_{RAT} = 20[A]$  at  $V_{BAT} = 13[V]$ ,  
 $V_{CMD,MAX} = V_{La,MAX} = 10m\Omega \times 20 \times 25 = 5V$
- $V_{La,MAX} = 5V = V_{BAT} \times 1 \times R3 / (R2 + R3)$   
 $Ratio = R3 / (R2 + R3) = V_{CMD,MAX} / V_{BAT} = 5 / 13$   
 Therefore,  $R2 : R3 = 8 : 5$



The buffer OP-amp selects the lower command between  $V_{CMD}$  and  $V_{La}$  so as to limit the stalled motor current to very low in the above figure. Because of much larger  $V_{La}$  than  $V_{CMD}$ , the motor operating point stays at A. But the point gradually moves toward B' and then B'' through the curve from the instance of stall as the below figure.



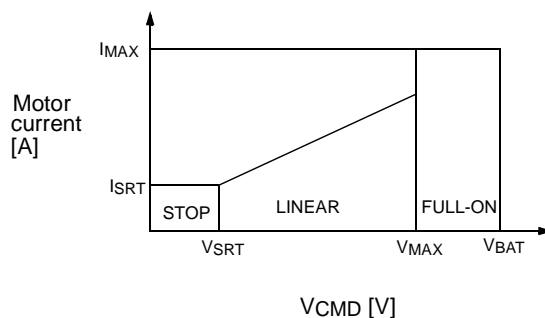
## 8. Operational Mode Selection

The FAN8902 has three operation modes as follows:

- STOP: Turned-off the power MOSFET
- LINEAR: Linearly controlled the power MOSFET
- FULL-ON: Fully turned-on the power MOSFET

The voltage,  $V_{SRT}$  (PIN #9) and  $V_{MAX}$  (PIN #7), in the application circuit are as follows:

- $V_{SRT}$  (PIN #9) =  $V_{ref} \times R7 / (R5 + R6 + R7)$
- $V_{MAX}$  (PIN #7) =  $V_{ref} \times (R6 + R7) / (R5 + R6 + R7)$



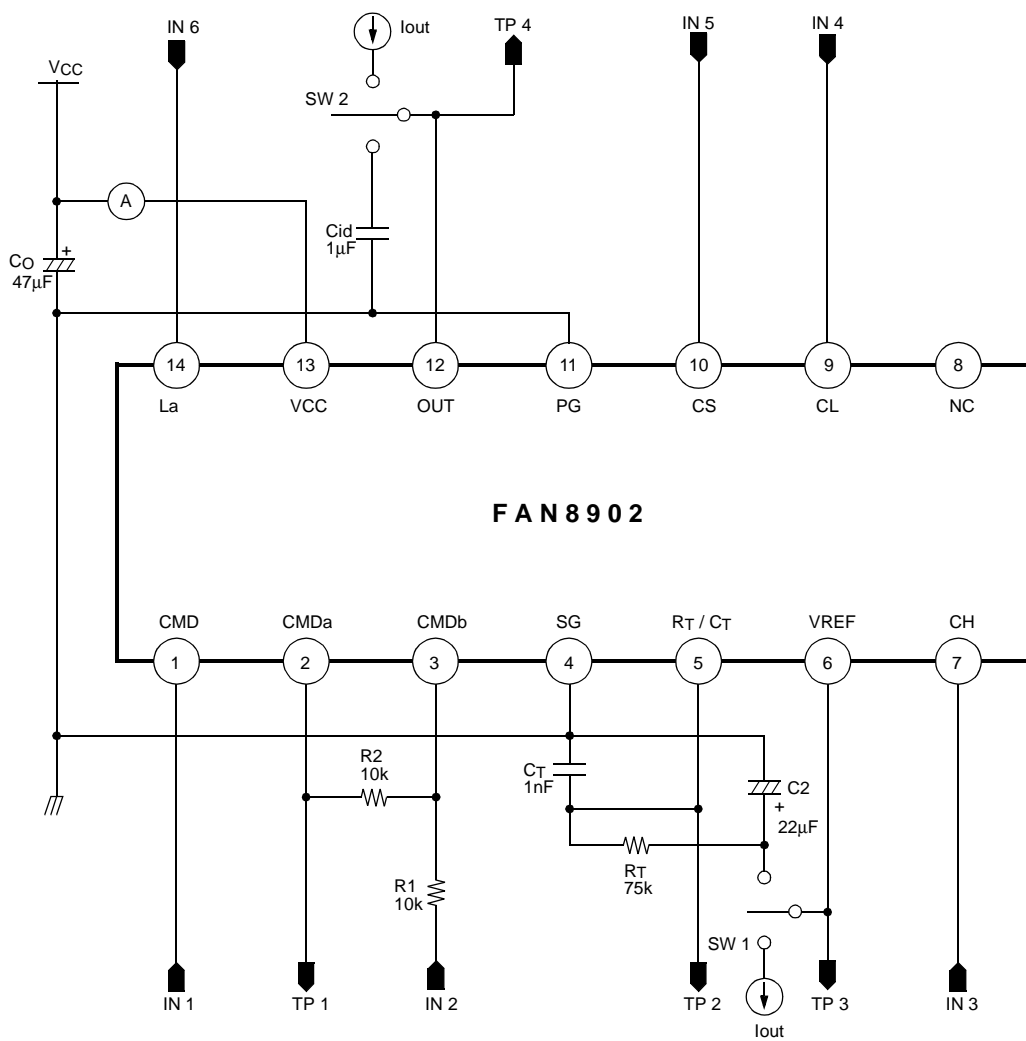
## 9. Over Voltage Protector (Ovp)

If the voltage,  $V_{BAT} \geq 36[V]$ , the output (pin #12) is grounded, and the switching device (power MOSFET) is turned-off, and the motor is stopped. Then if the voltage,  $V_{BAT} \rightarrow 36[V]$ , the switching device is turned-on again, and the motor is operated.

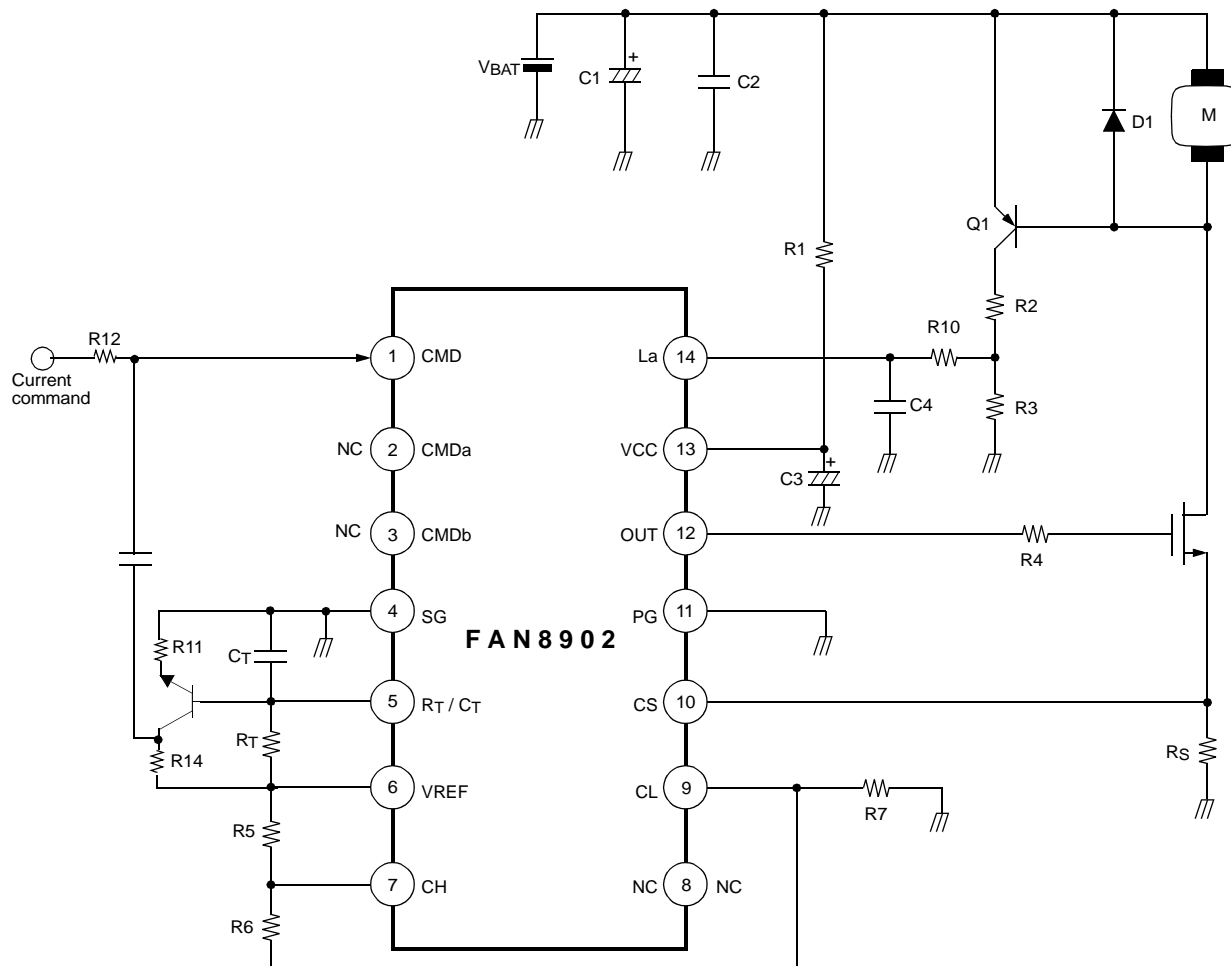
## 10. Totem-pole Output

The FAN8902 has a single totem-pole output driver which can be drive current to peak  $\pm 0.8[A]$ .

# Test Circuit



# Typical Application





**DISCLAIMER**

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

**LIFE SUPPORT POLICY**

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.