# 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.
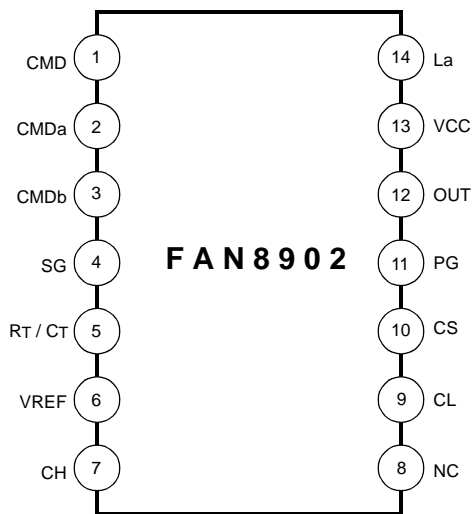
14-DIP-300
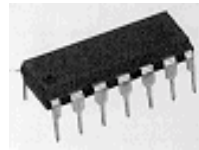
Typical Application

- DC for Motor Control for Automotive

Ordering Information

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

Rev. 1.0.3

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Pin Assignments

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         CMD ( 1 )              ( 14 ) La

        CMDa ( 2 )              ( 13 ) VCC

        CMDb ( 3 )              ( 12 ) OUT

          SG ( 4 )   F A N 8 9 0 2   ( 11 ) PG

       RT / CT ( 5 )             ( 10 ) CS

        VREF ( 6 )              ( 9 ) CL

          CH ( 7 )              ( 8 ) NC
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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_T / C_T	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	V_{CC}	V_{CC}
14	La	Motor Current Maximum Reference Input

Internal Block Diagram

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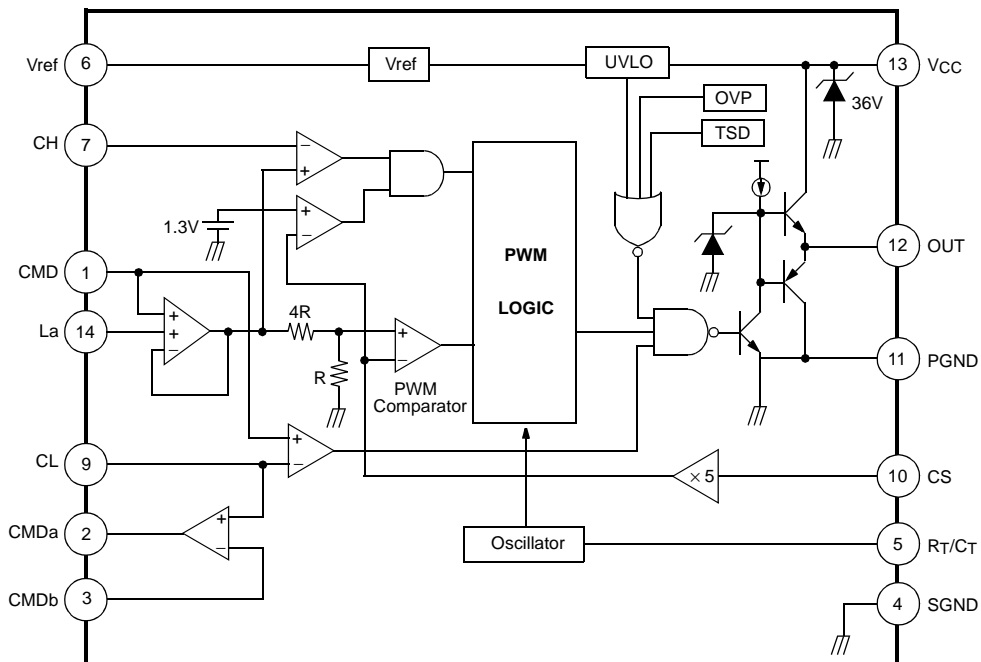
Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	32	V
CMD Input Voltage	V_{CMD}	6	V
Peak Output Current	I_{OPK}	±0.8	A
Power Dissipation	P_D	1	W

Operating Voltage

Parameter	Symbol	Min.	Typ.	Max	Unit
Power Supply Voltage	V_{CC}	9.0	12.0	32.0	V

Temperature Characteristics

Parameter	Symbol	Temp	Value	Unit
Vref Temperature Stability	V_{ST}	-40 ~ +90°C	200	°C
Frequency Stability	F_{ST}	-40 ~ +90°C	20 ~ 30	°C
Operating Temperature	T_{OPR}	-	-40 ~ +90	°C
Storage Temperature	T_{STG}	-	-60 ~ +150	°C

Electrical Characteristics

(Unless otherwise, Ta=25°C, V_{CC}=5V, V_M=12V)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
REFERENCE						
Reference Voltage	Vref	Iref=1mA	4.75	5.0	5.25	V
Line Regulation	∆Vref1	V_{CC}=9V ~ 32V	-	50	150	mV
Load Regulation	∆Vref2	Iref=1mA ~ 10mA	-	10	50	mV
UNDER VOLTAGE LOCKOUT (UVLO)						
Start Threshold Voltage	$V_{TH(ST)}$	-	7.5	8.0	8.5	V
Threshold Hysteresis	V_{HYS}	-	1.0	1.2	1.4	V
PROTECTION						
Over Voltage	O_{VP}	-	33	36	-	V
OSCILLATOR (R_T=75kΩ, C_T=1nF)						
Frequency	fosc	-	20	25	30	kHz
Duty Cycle	Duty	-	90	95	-	%
CURRENT SENSING INPUT						
Threshold Voltage	$V_{TH(ST)}$	V_{CMD} = 5V	0.19	0.20	0.21	V
OUTPUT DRIVER						
Output Voltage Switching Limit	V_{OLIM}	V_{CC} = 18V, Cld =1nF	-	15	-	V
Low Output Voltage	V_{OL1}	Iout = 20mA	-	-	0.4	V
	V_{OL2}	Iout = 200mA	-	-	2.2	V
High Output Voltage	V_{OH1}	Iout = -20mA	10.0	-	-	V
	V_{OH2}	Iout = -200mA	9.0	-	-	V
Rising Time	Tr	Cld = 1nF	-	100	200	ns
Falling Time	Tf	Cld = 1nF	-	100	200	ns
TOTAL STANDBY CURRENT						
Start-up Current	I_{ST}	V_{CC} = 7V	-	1.0	1.5	mA
Operating Supply Current	I_{CC}	V_{CC} = 9V	-	6.0	8.0	mA

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Application Information

1. Under Voltage Lockout (UVLO)
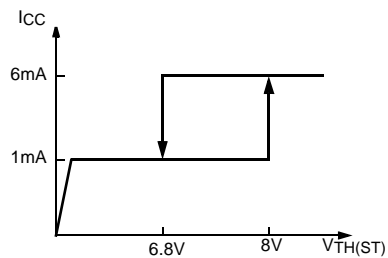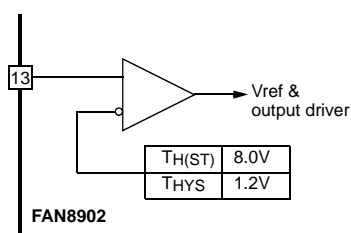
2. Current Sensing Circuit
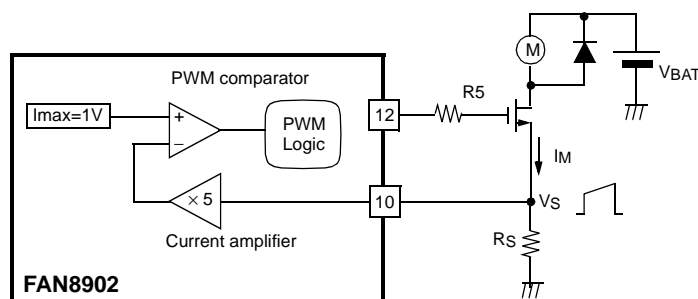
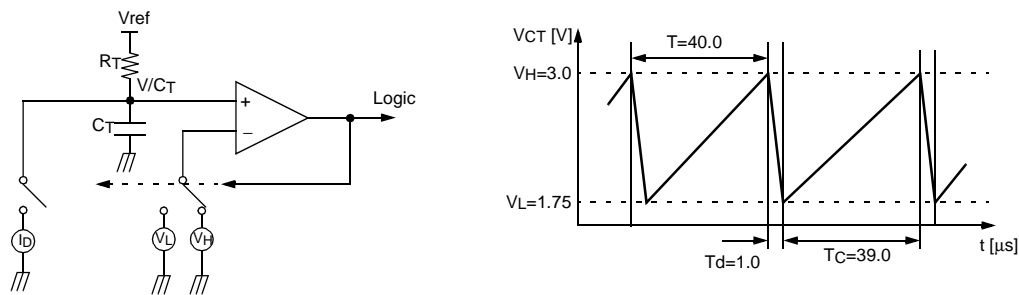The peak current, $I_{M(MAX)} = V_S / R_S$

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:

$$T_C = R_T \times C_T \times \ln[(Vref - V_L)/(Vref - V_H)]$$
$$T_D = C_T \times [(V_H - V_L)/I_D]$$
$$fosc = 1/(T_C + T_D)$$
$$= 1.875/(R_T \times C_T)$$
$$Duty = T_C \times fosc \times 100$$

For example, if fosc = 25kHz and duty = 95%
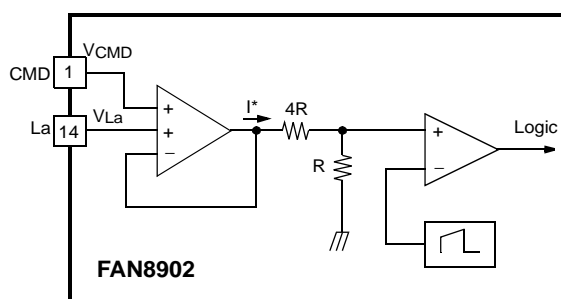
$$C_T = (T_D \times I_D)/(V_H - V_L)$$
$$= 1000[pF]$$
$$R_T = 1.875/(fosc \times C_T)$$
$$= 1.875/(25kHz \times 1000pF)$$
$$= 75[k\Omega]$$

5. Current Command Input Section

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

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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,

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

Slop Compensation
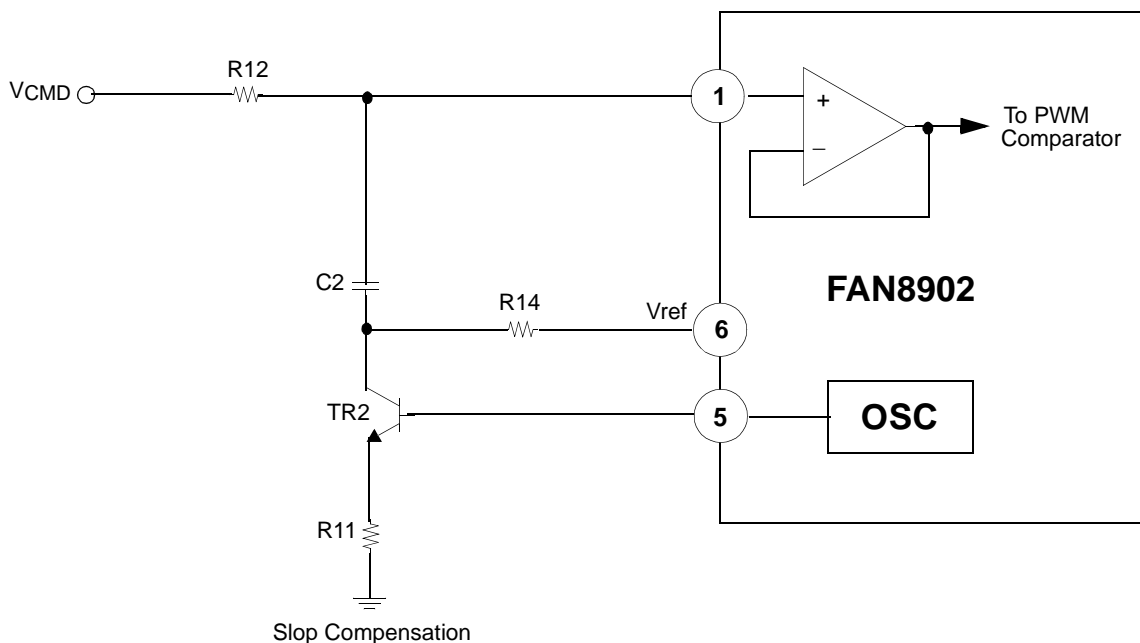
7. Motor Stall Current Limitation
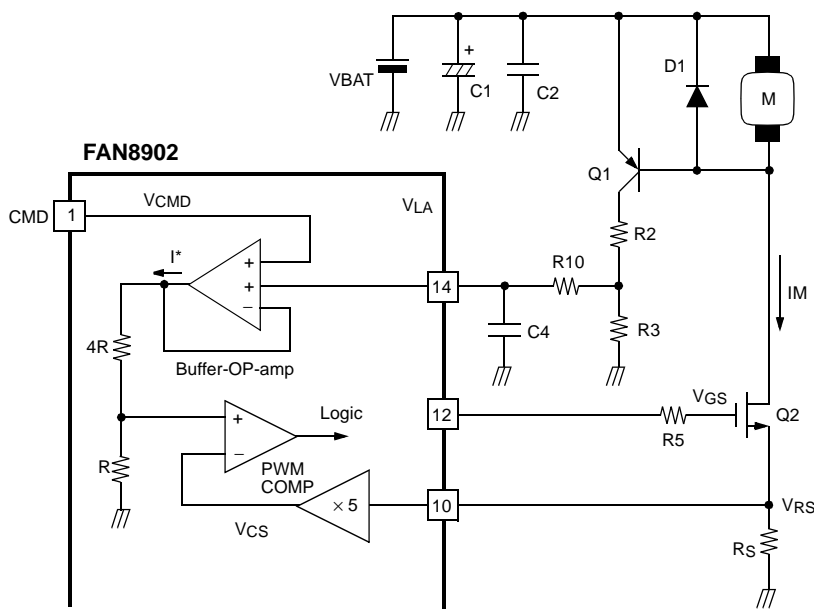
In the steady state, the terminal voltage on a motor is consisted of a back EMF and the voltage drop on the armarture resistors. When the motor happens to be stalled, the back EMF becomes zero, and the motor current (I_M) is quickly increased until a maximum values.

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}) ia calculated as follows:

$$V_{La} = V_{BAT} \times D \times \frac{R3}{R2 + R3}$$ 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 IRAT
- 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 $V_{BAT} = 13[V]$,
  $\qquad V_{CMD,MAX} = V_{La,MAX} = 10m\Omega \times 20 \times 25 = 5V$
- $V_{La,MAX} = 5V = V_{BAT} \times 1 \times R3 / (R2 + R3)$
  Ratio $= R3 / (R2 + R3) = V_{CMD,MAX} / V_{BAT} = 5 / 13$
  Therefore, $R2 : R3 = 8 : 5$
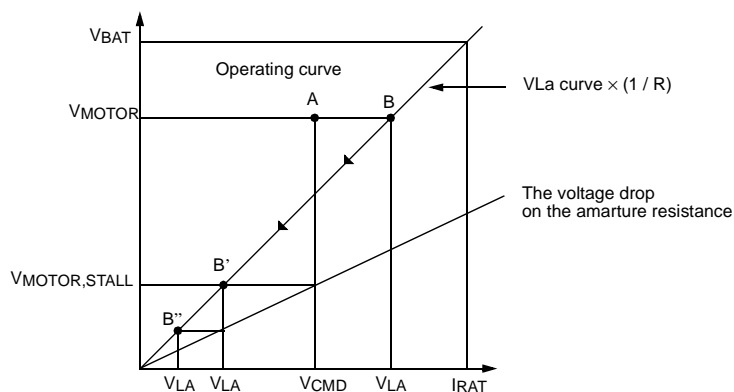
The buffer OP-amp selects the lower command between V_{CMD} and V_{La} so as to limit the stalled motor current to very low in the above figure. Because of much larger V_{La} than V_{CMD}, the motor operating point stays at A. But the point gradually moves toward B' and then B'' through the curve from the instance of stall as the below figure.
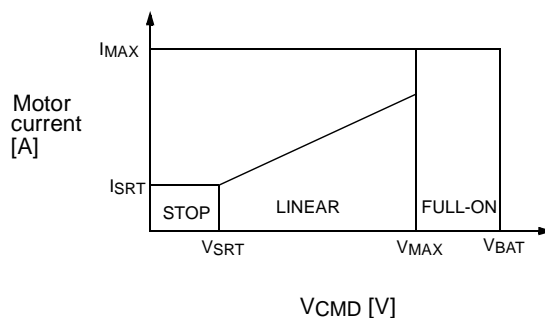
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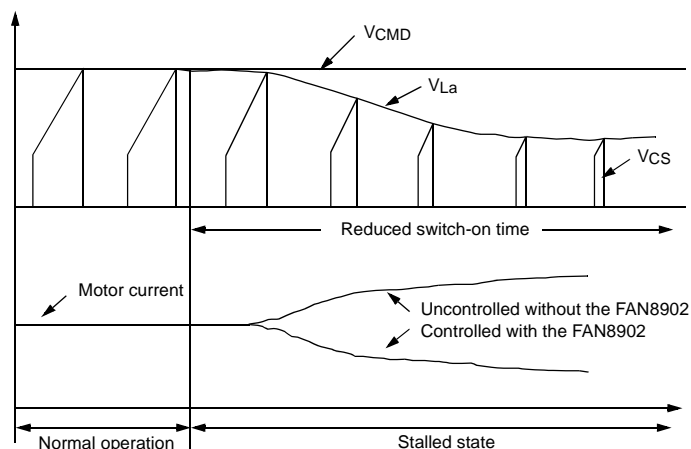
8. Operational Mode Selection

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:

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

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, $V_{BAT} \to 36[V]$, the switching device is turned-on again, and the motor is operated.
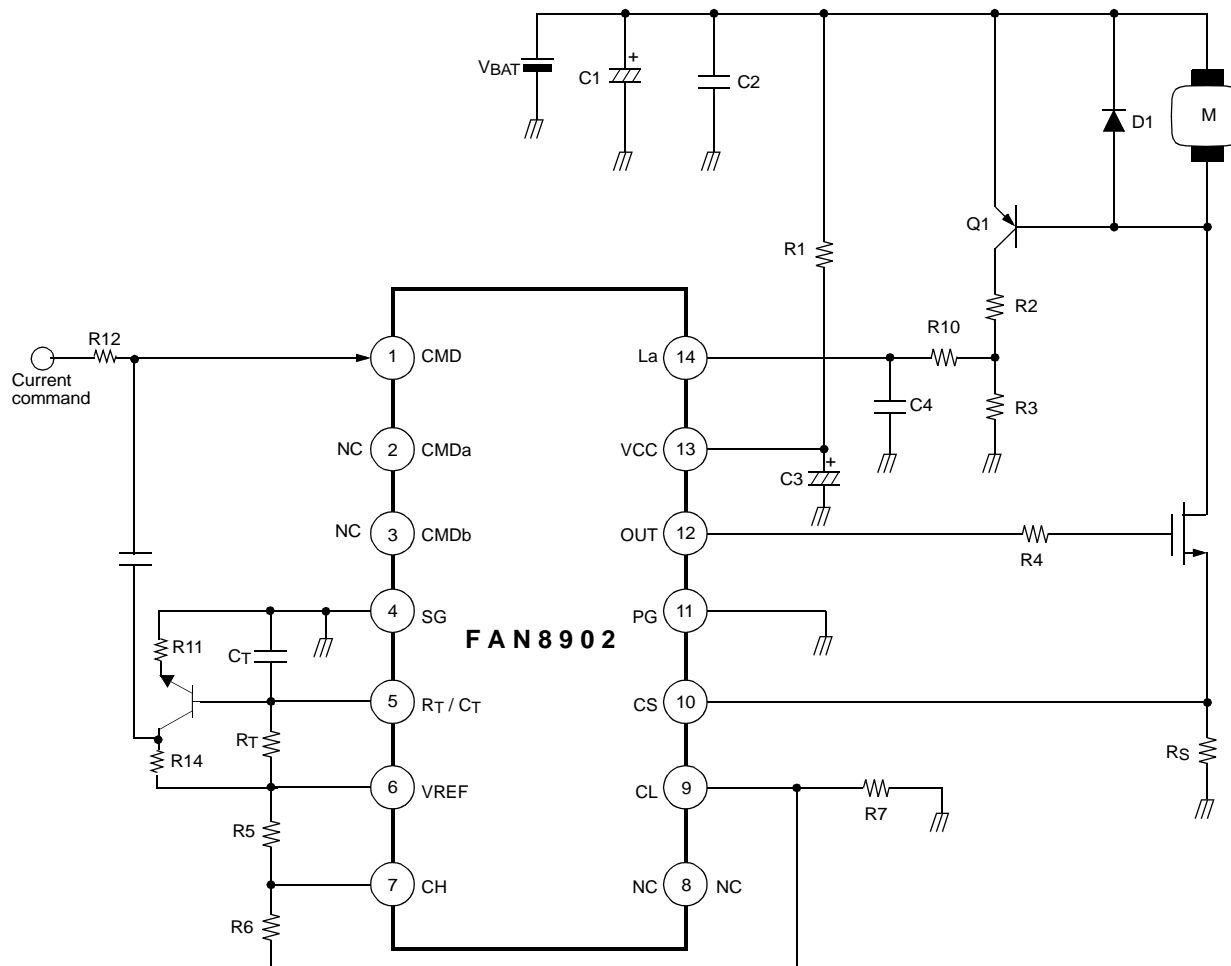
10. Totem-pole Output

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

Test Circuit
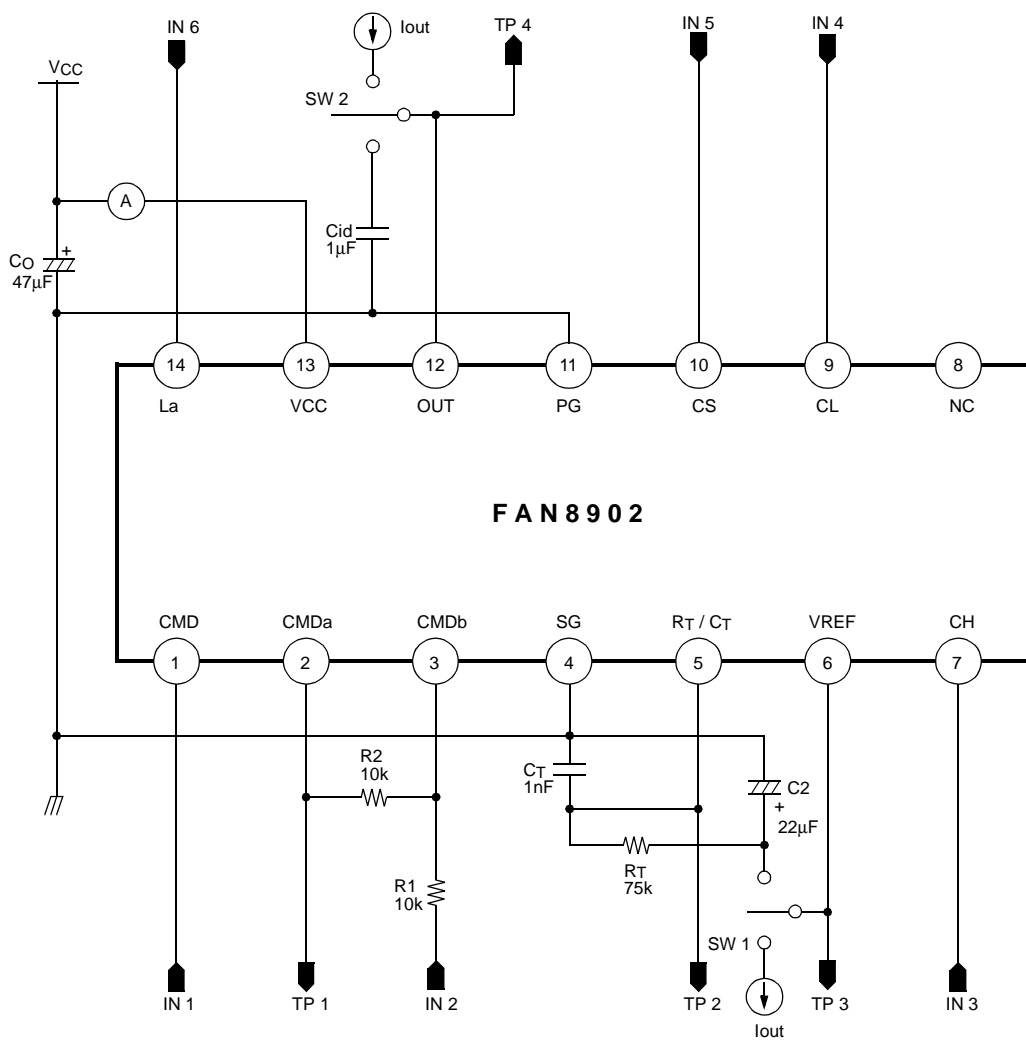
Typical Application

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