# FAN8902(KA3902)

## DC FAN Motor Controller

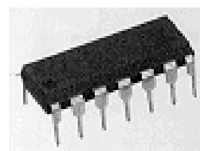
### Features

- 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

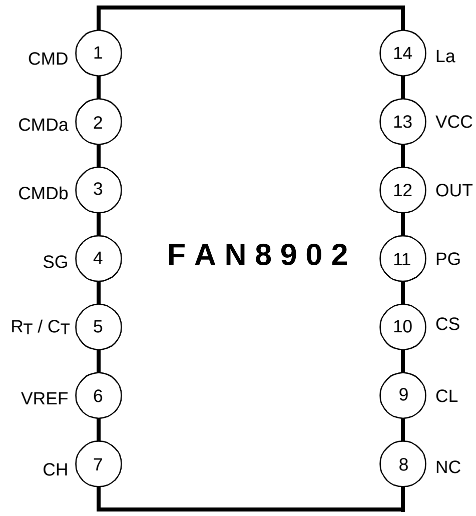
- DC for Motor Control for Automotive

### Ordering Information

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

Rev. 1.0.3

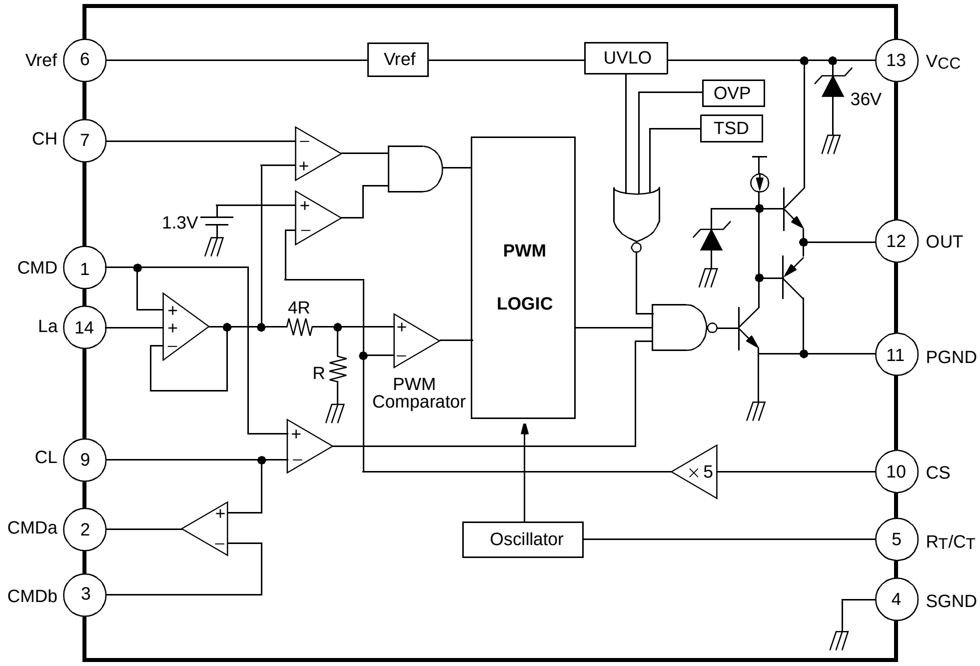
## Pin Assignments




## 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 | $R_T$ / $C_T$ | 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



## 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 |

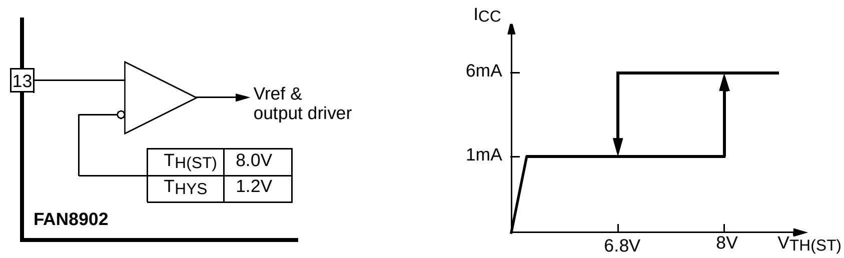
# Electrical Characteristics

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

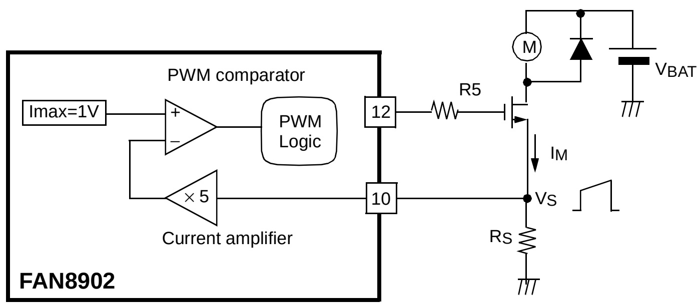
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **REFERENCE** | | | | | | |
| Reference Voltage | Vref | Iref=1mA | 4.75 | 5.0 | 5.25 | V |
| Line Regulation | ΔVref1 | $V_{CC}$=9V ~ 32V | - | 50 | 150 | mV |
| Load Regulation | ΔVref2 | Iref=1mA ~ 10mA | - | 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 |

# Application Information

## 1. Under Voltage Lockout (UVLO)




## 2. Current Sensing Circuit



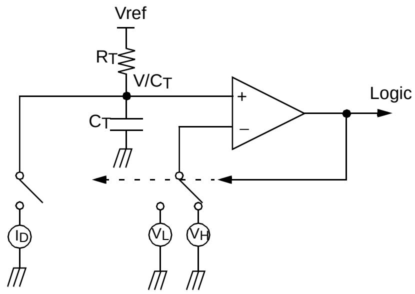

The peak current, $I_{M(MAX)}=V_S/R_S$
For example, if a required maximum current, $I_{M(MAX)}=20[A]$

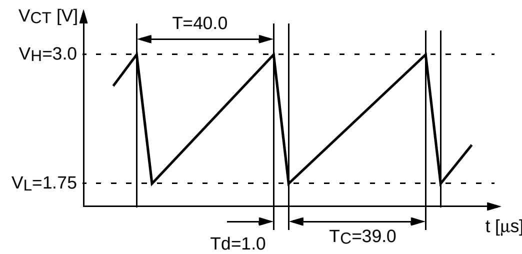
$$R_S = \frac{1V/5}{20A} = 10[m\Omega]$$

## 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:

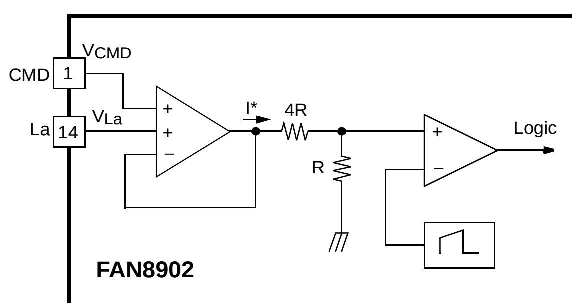
$$T_C = R_T \times C_T \times \ln[(Vref - V_L)/(Vref - V_H)]$$
$$T_D = C_T \times [(V_H - V_L)/I_D]$$
$$fosc = 1/(T_C + T_D)$$
$$= 1.875/(R_T \times C_T)$$
$$Duty = T_C \times fosc \times 100$$

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

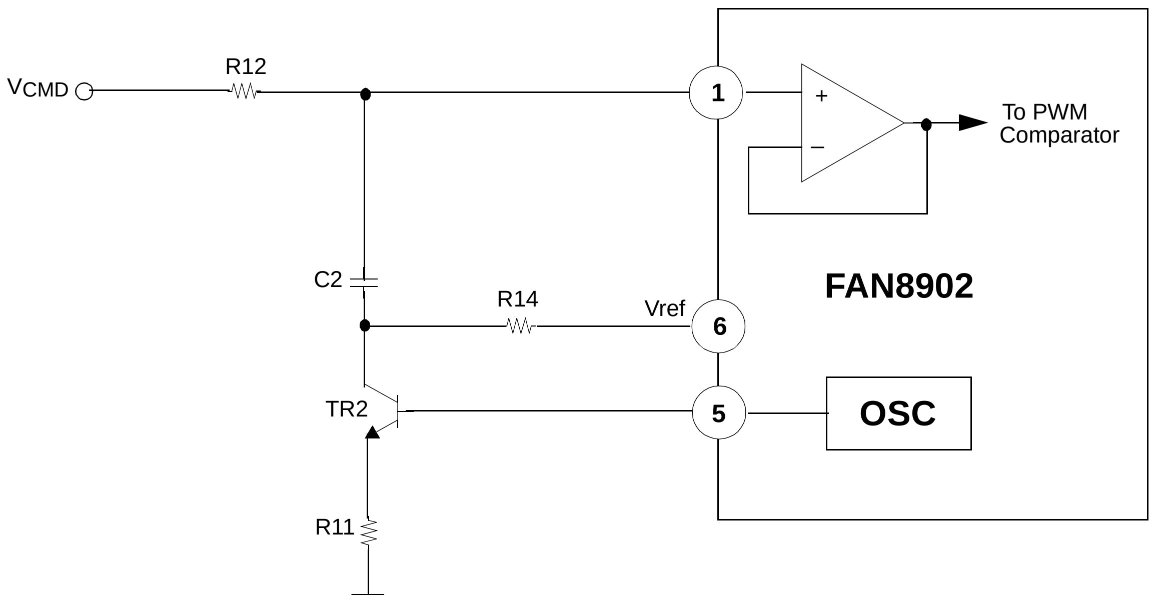
The current command I* selects the lower value between $V_{CMD}$ and $V_{La}$.



## 6. Slope Compensation

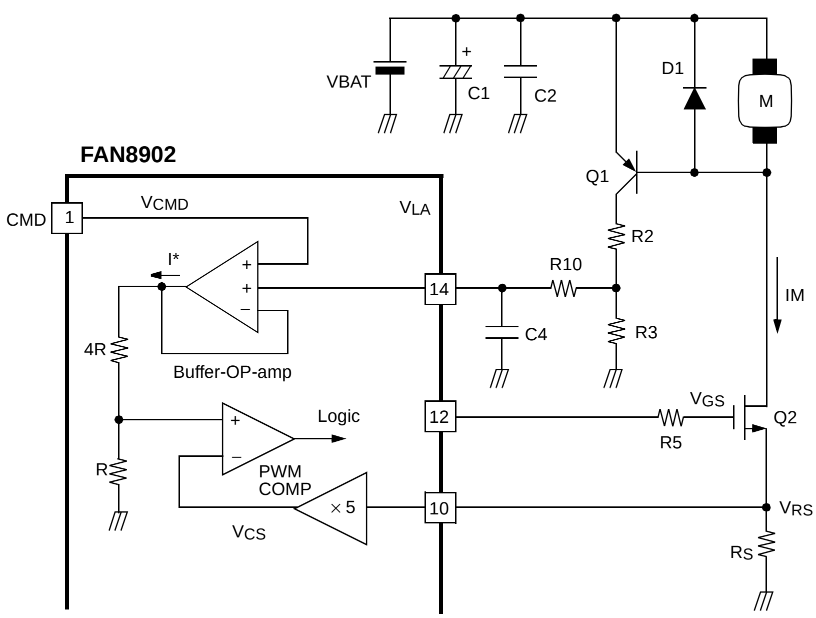
An unconditional instability of the inner current loop exists for any fixed frequency current-mode converter operating above 50% duty cycle. Therefore, to guarantee current loop stability, the slope of the compensation ramp must be greater than one-half of the down slope of the current waveform. The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

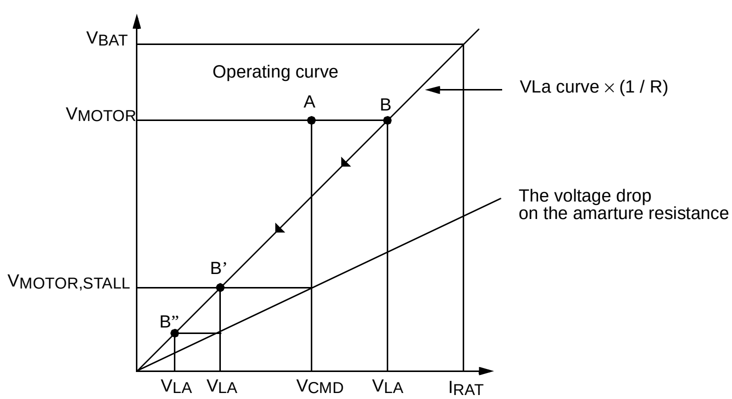
The voltage on pin #14 ($V_{La}$) ia calculated as follows:

$$V_{La} = V_{BAT} \times D \times \frac{R3}{R2 + R3}$$

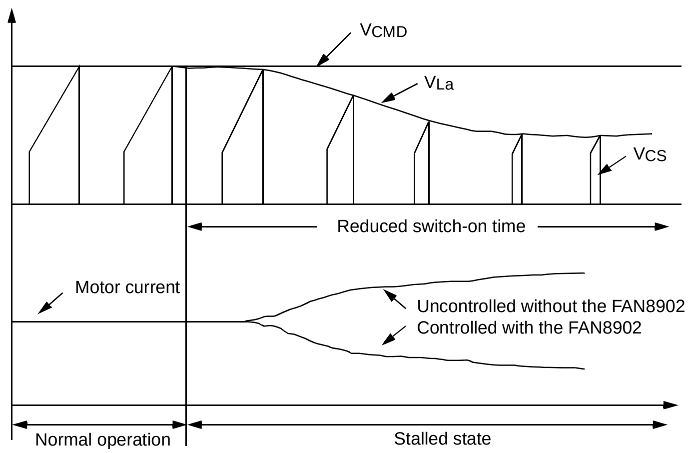
Assumed the saturation voltage of Q1 is zero.

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 $V_{BAT} = 13[V]$,
  $V_{CMD,MAX} = V_{La,MAX} = 10m\Omega \times 20 \times 25 = 5V$
- $V_{La,MAX} = 5V = V_{BAT} \times 1 \times R3 / (R2 + R3)$
  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.



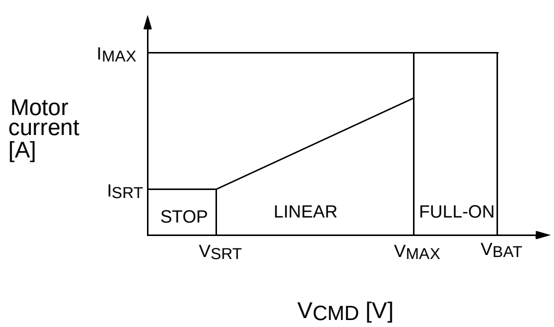

## 8. Operational Mode Selection

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



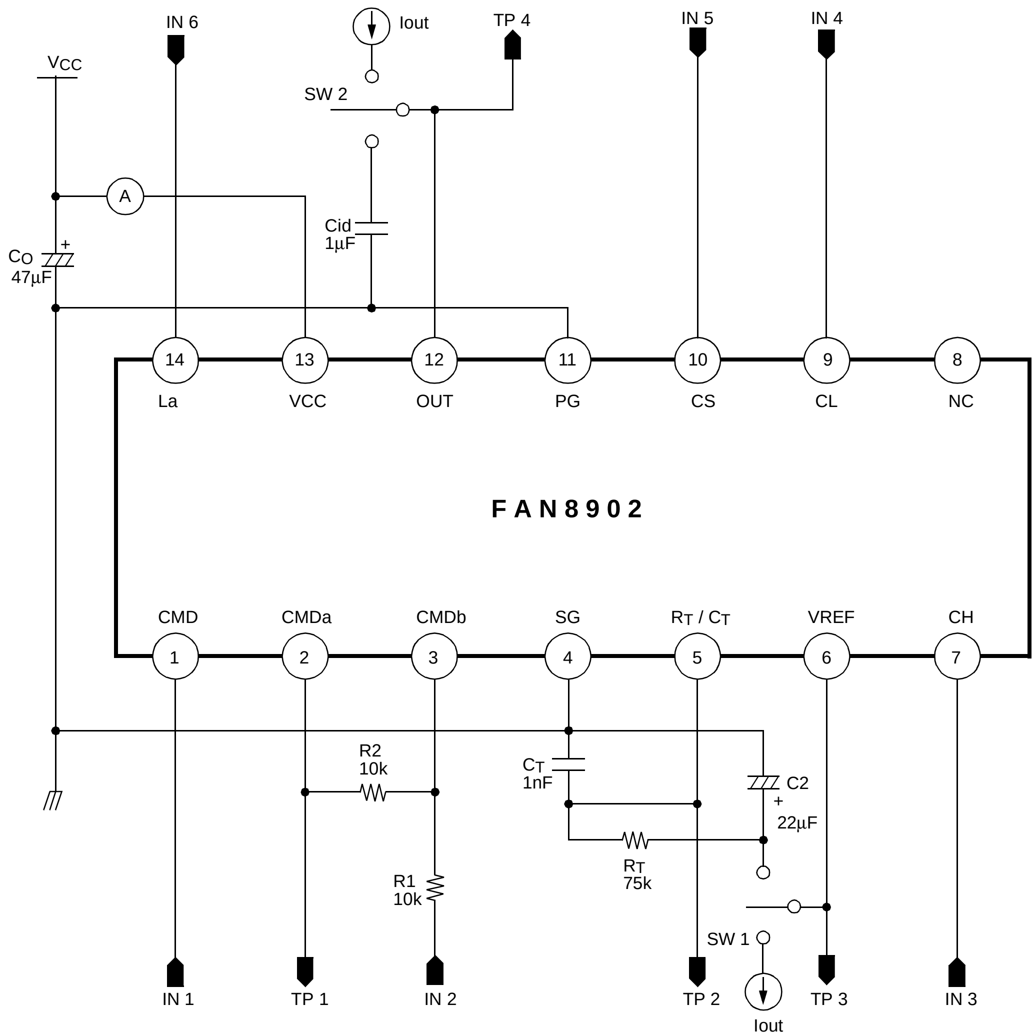

## 9. Over Voltage Protector (Ovp)

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, $V_{BAT} \rightarrow 36[V]$, the switching device is turned-on again, and the motor is operated.

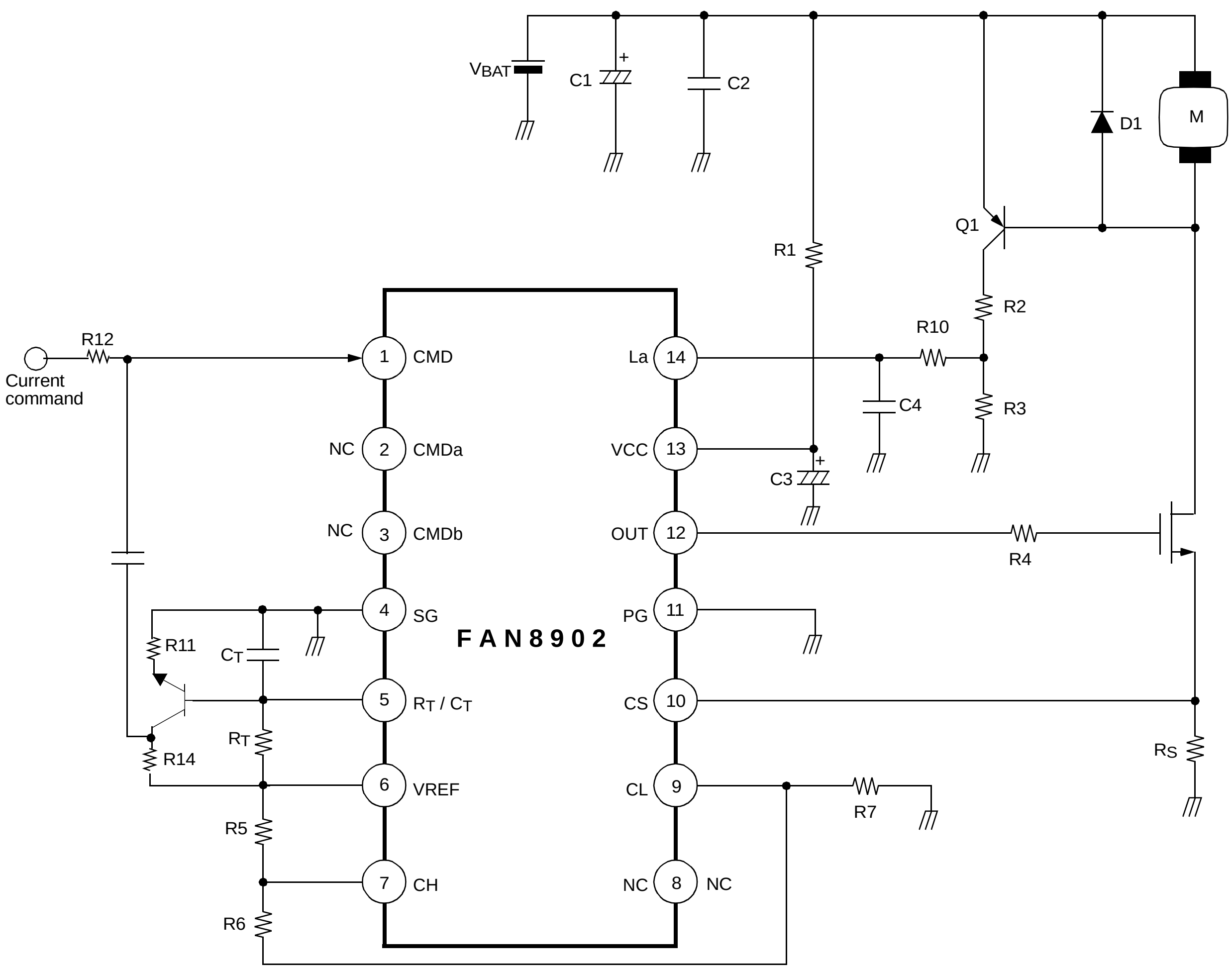
## 10. Totem-pole Output

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

# Test Circuit



# Typical Application



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