DC FAN MOTOR CONTROLLER

The KA3902 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

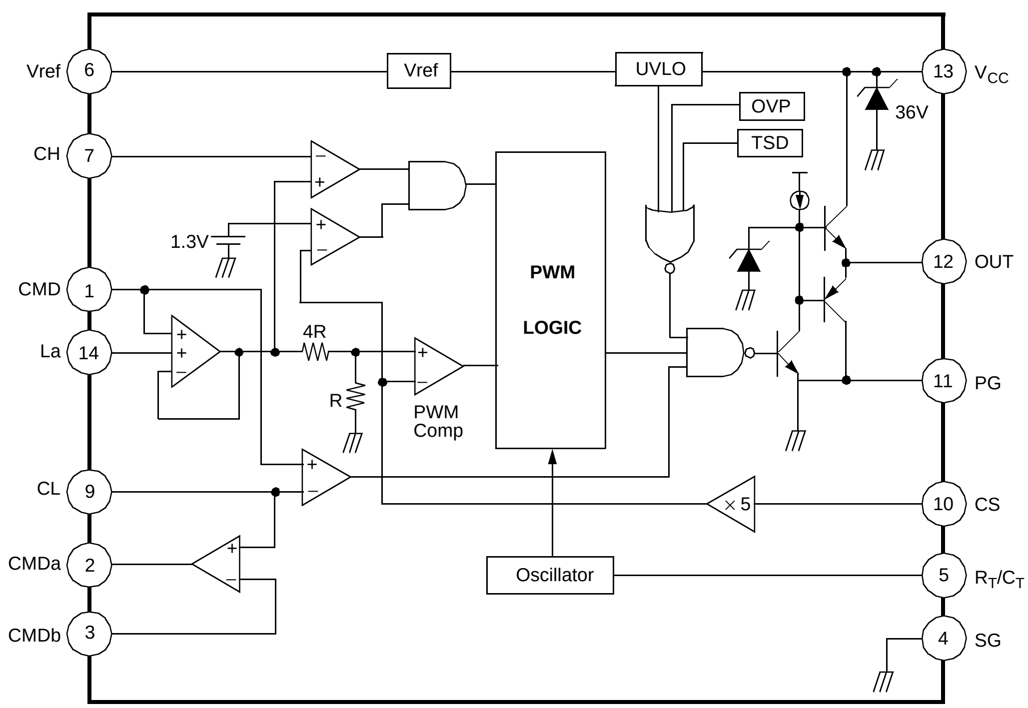
FEATURES

- 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

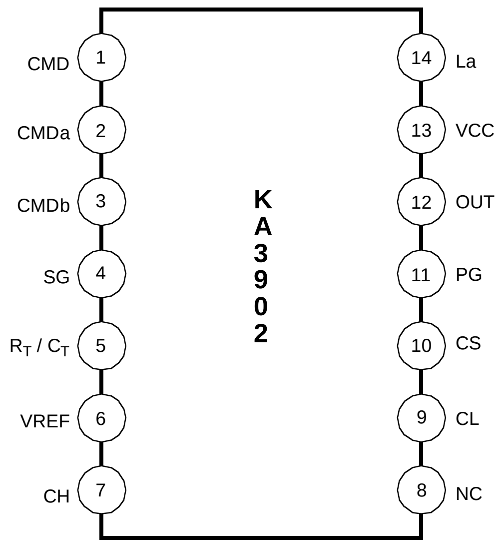
ORDERING INFORMATION

Device	Package	Operating Temperature
KA3902	14-DIP-300	–40°C ~ +90°C

BLOCK DIAGRAM



PIN CONNECTION



PIN DESCRIPTION

Pin No.	Symbol	Function
1	CMD	Motor current command input
2	CMDa	Optional OP amplifier output
3	CMDb	Optional OP amplifier (–) input
4	SG	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	PG	Power GND
12	OUT	Drive output
13	V_{CC}	V_{CC}
14	La	Motor current maximum reference input

ABSOLUTE MAXIMUM RATING (Ta=25°C)

Characteristics	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 (Ta=25°C)

Characteristics	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage	V_{CC}	9.0	12.0	32.0	V

TEMPERATURE CHARACTERISTICS

Characteristics	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

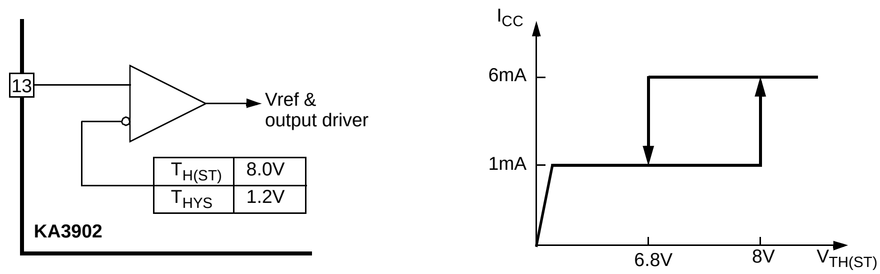
ELECTRICAL CHARACTERISTICS

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

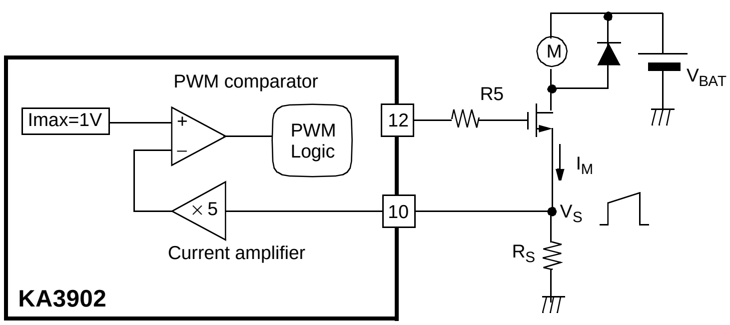
Characteristics	Symbol	Test conditions	Min.	Typ.	Max.	Unit
REFERENCE						
Reference voltage	Vref	Iref=1mA	4.75	5.0	5.25	V
Line regulation	∆Vref1	V_{CC}=9V ~ 32V	–	50	150	mV
Load regulation	∆Vref2	Iref=1mA ~ 10mA	–	10	50	mV
UNDER VOLTAGE LOCKOUT (UVLO)						
Start threshold voltage	$V_{TH(ST)}$	–	7.5	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

APPLICATION INFORMATION

1. UNDER VOLTAGE LOCKOUT (UVLO)



2. CURRENT SENSING CIRCUIT



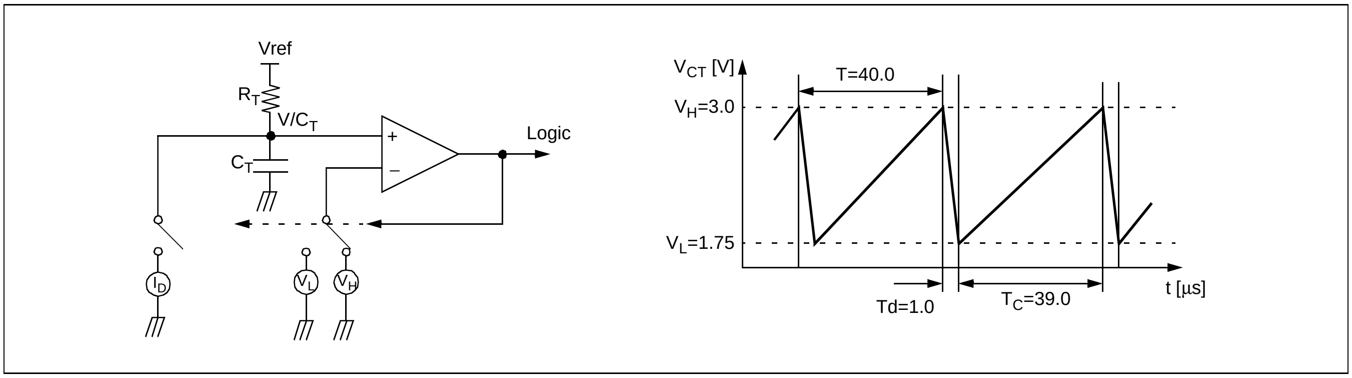
The peak current, $I_{M(MAX)}=V_S/R_S$
For example, if a required maximum current, $I_{M(MAX)}=20[A]$

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

3. THERMAL SHUTDOWN (TSD)

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

4. OSCILLATOR COMPONENT SELECTION



The oscillator timing components can be calculated as follows:

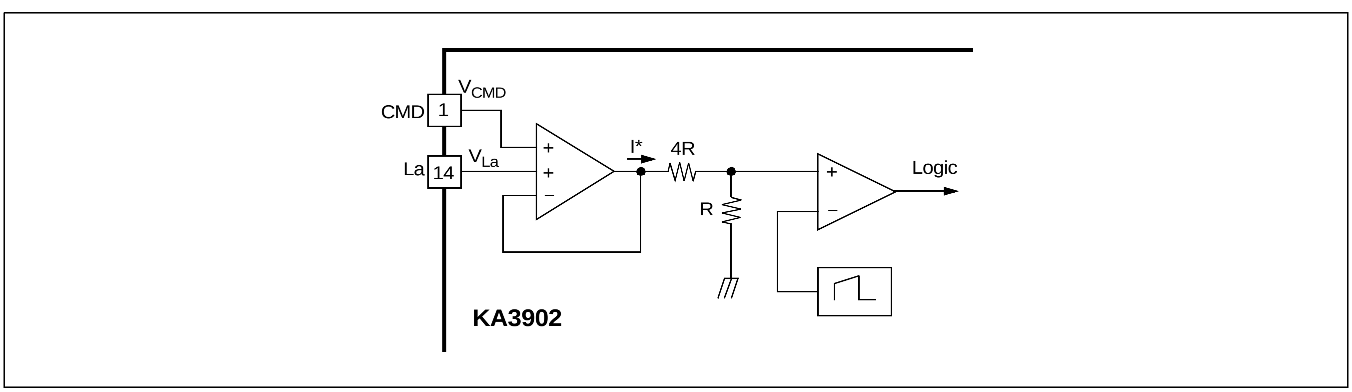
$$T_C = R_T \times C_T \times In[(Vref - V_L)/(Vref - V_H)]$$
$$T_D = C_T \times [(V_H - V_L)/I_D]$$
$$fosc = 1/(T_C + T_D)$$
$$= 1.875/(R_T \times C_T)$$
$$Duty = T_C \times fosc \times 100$$

For example, if fosc = 25kHz and duty = 95%

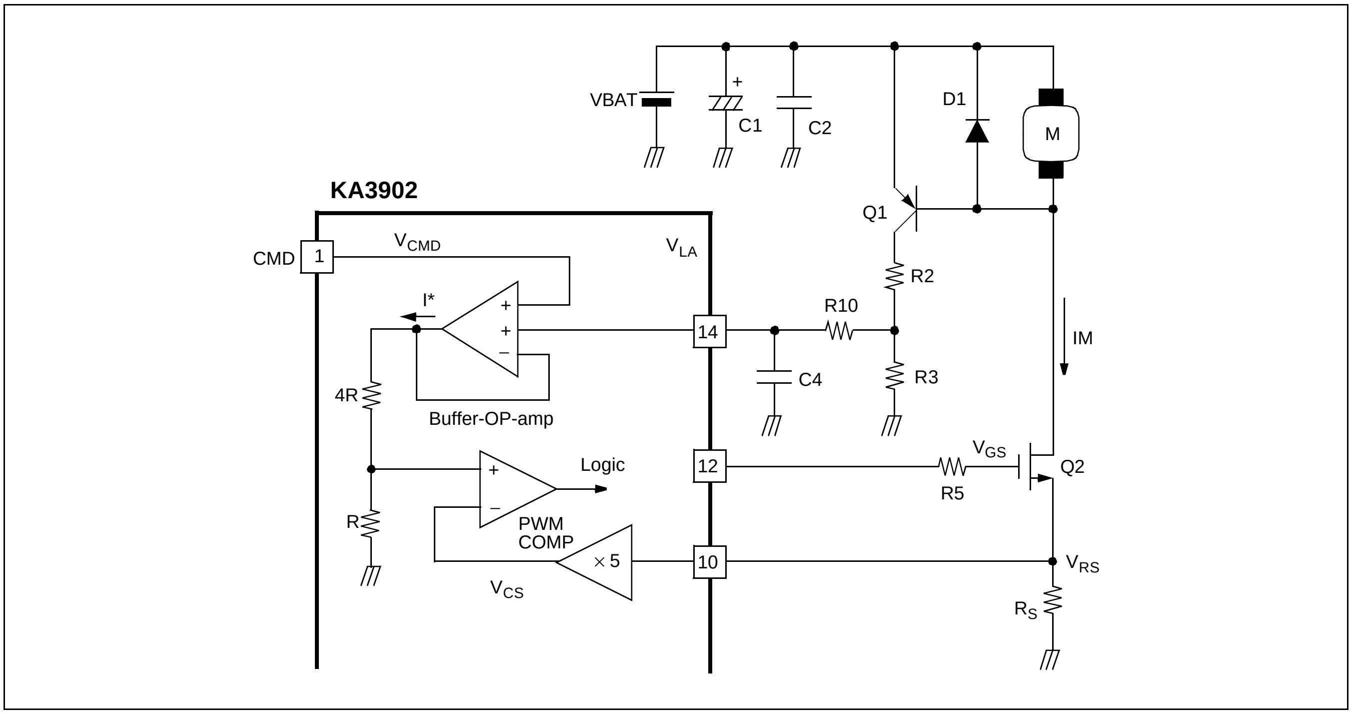
$$C_T = (T_D \times I_D)/(V_H - V_L)$$
$$= 1000[pF]$$
$$R_T = 1.875/(fosc \times C_T)$$
$$= 1.875/(25kHz \times 1000pF)$$
$$= 75[k\Omega]$$

5. CURRENT COMMAND INPUT SECTION

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



6. MOTOR STALL CURRENT LIMITATION



At 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:

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

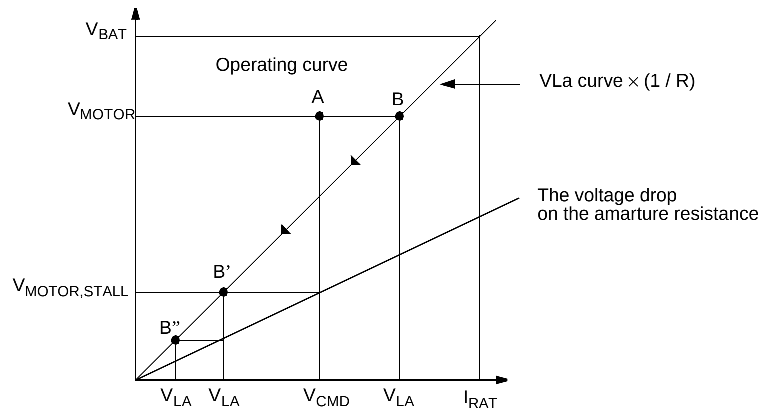
Assumed the saturation voltage of Q1 is zero.

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

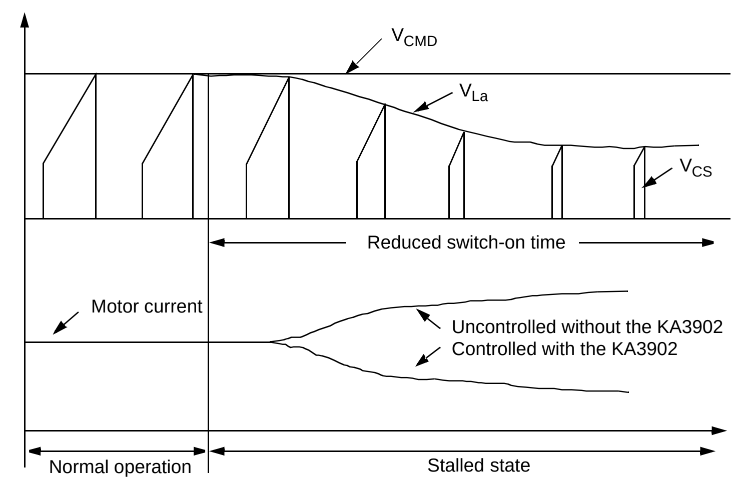
— Applied the rated voltage on motor, and then measured the current IRAT

— 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 $R_S = 100m\Omega$ and $I_{RAT} = 20[A]$ at $V_{BAT} = 13[V]$,
$V_{CMD,MAX} = V_{La,MAX} = 10m\Omega \times 20 \times 25 = 5V$

— $V_{La,MAX} = 5V = V_{BAT} \times 1 \times R3 / (R2 + R3)$
$R = R3 / (R2 + R3) = V_{CMD,MAX} / V_{BAT} = 5 / 13$
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.



7. MODE SELECTION

The KA3902 has three operation regions as follows:

— STOP: Turned-off the power MOSFET

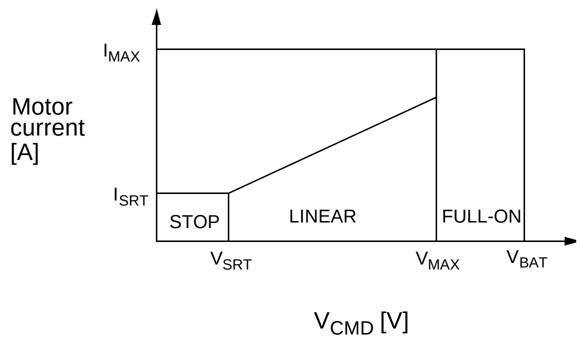
— LINEAR: Linearly controlled the power MOSFET

— 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:

— $V_{SRT\ (PIN\ \#9)} = Vref \times R9 / (R7 + R8 + R9)$

— $V_{MAX\ (PIN\ \#7)} = Vref \times (R8 + R9) / (R7 + R8 + R9)$



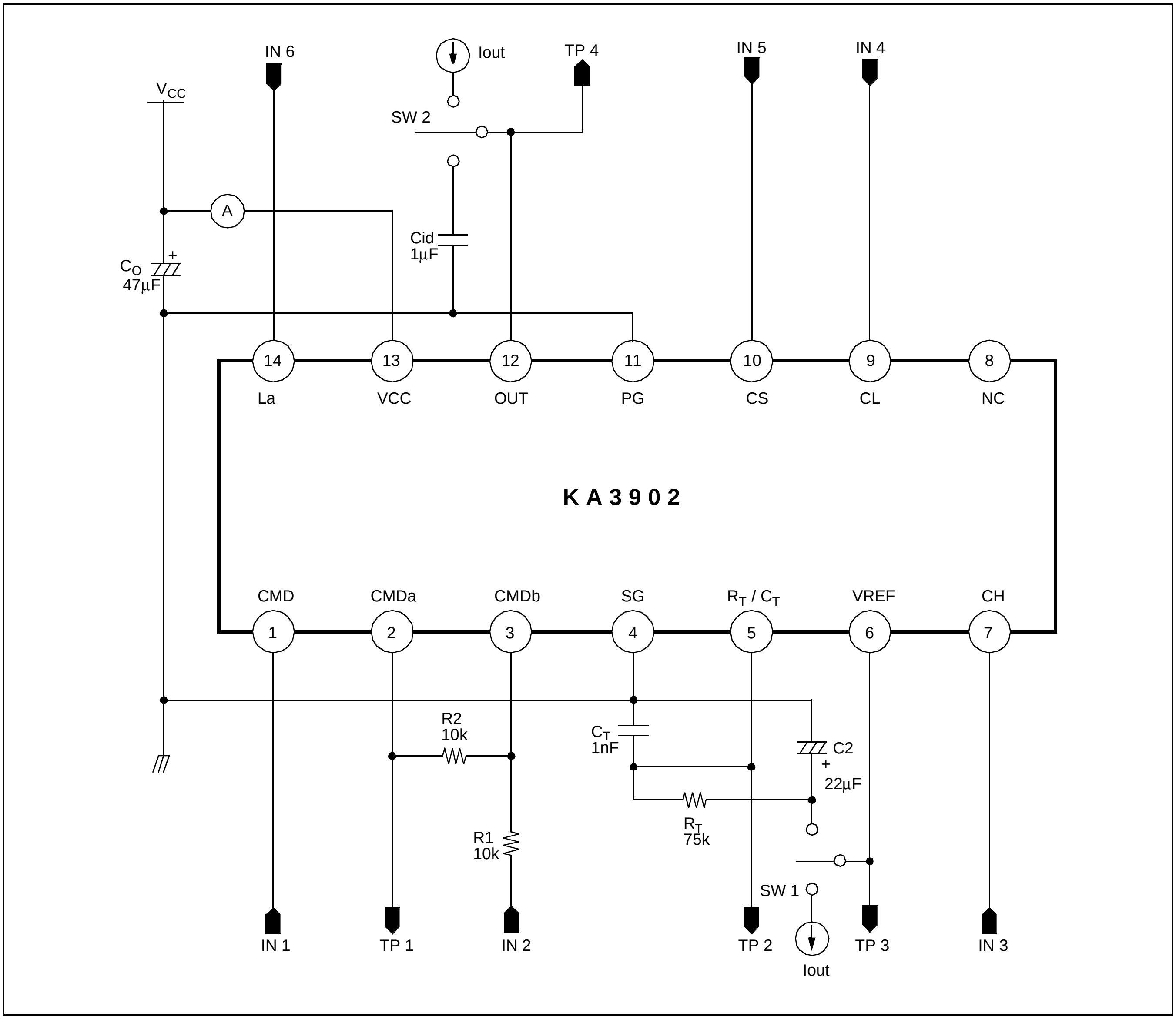
8. OVER VOLTAGE PROTECTOR (OVP)

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.

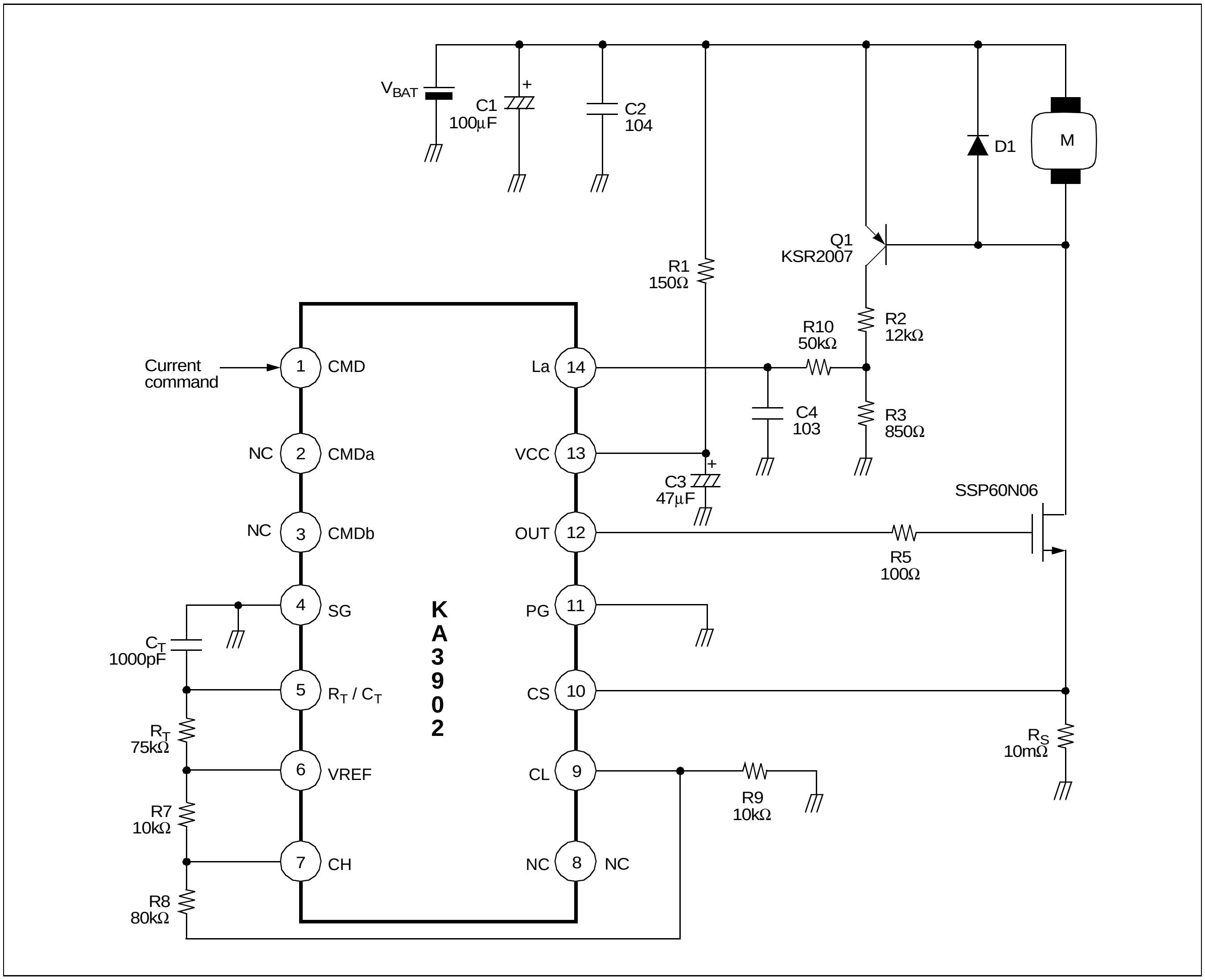
9. TOTEM-POLE OUTPUT

The KA3902 has a single totem-pole output driver which can be drive current to peak ±0.8[A].

TEST CIRCUIT

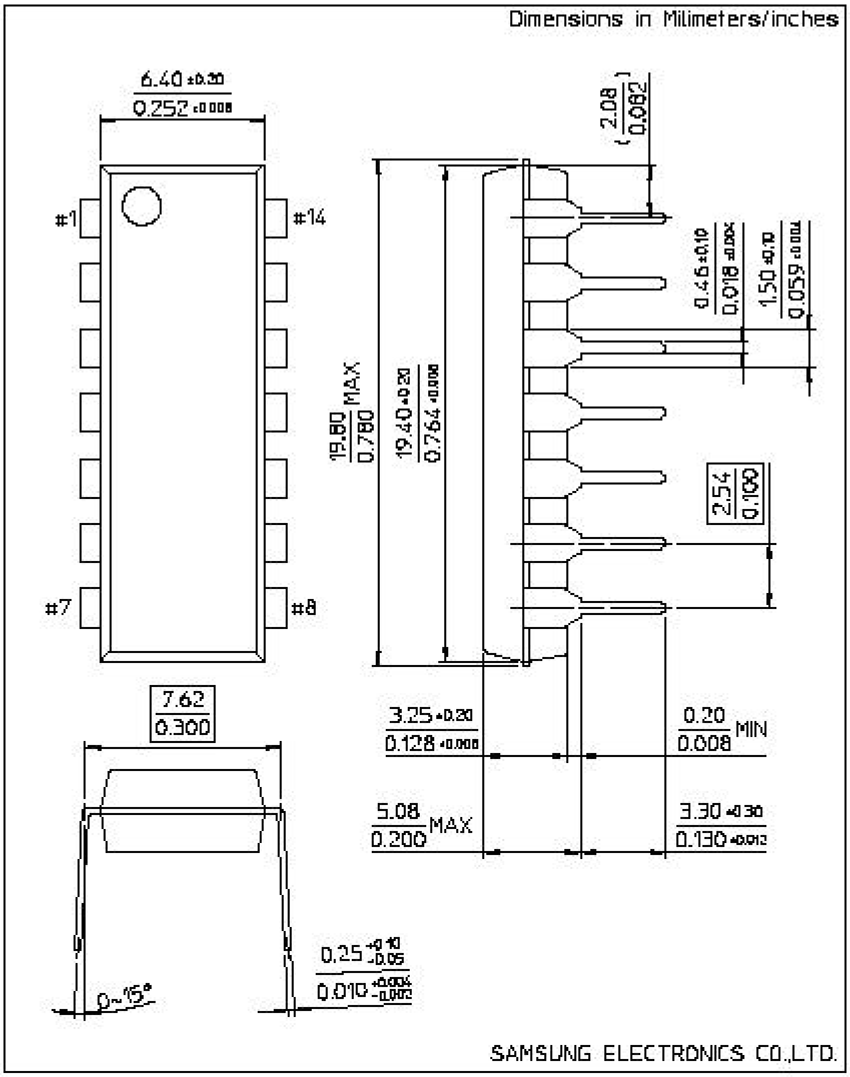


TYPICAL APPLICATION



PACKAGE DIMENSION

14–DIP–300



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