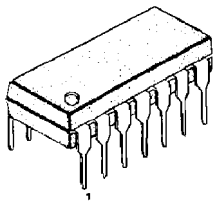
FAN MOTOR CONTROLLER

The KA3902 is a monolithic integrated circuit, designed for the PWM control of a fan motor current in an automotive systems. It allows the fan motor speed to be controlled linearly and efficiently.

14-DIP-300



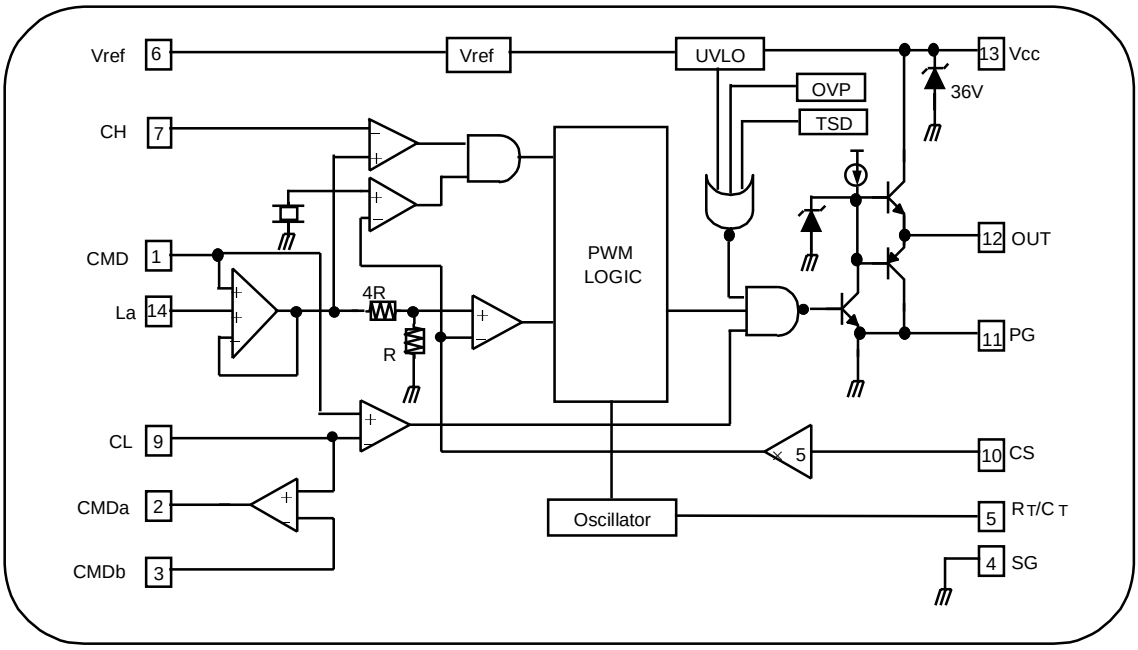
FEATURES

- Built-in PWM control circuit
- Built-in 5V regulator
- Low supply current
- Stalled motor current limitation
- Built-in overvoltage protector(OVP)
- Built-in overcurrent protector(OCP)
- Built-in load dump protector
- Built-in thermal shutdown(TSD) circuit
- Built-in undervoltage lockout(UVLO) circuit

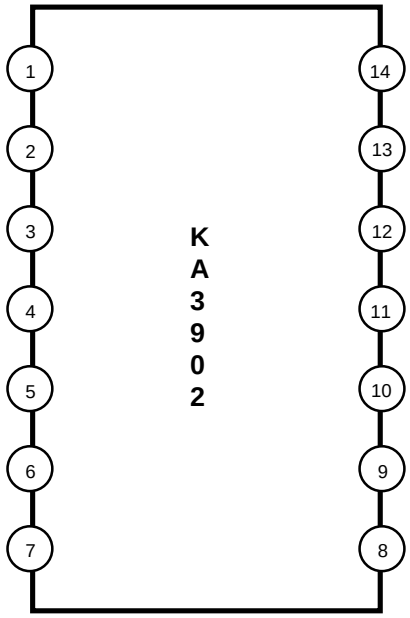
ORDERING INFORMATION

Device	Package	Operating Temperature
KA3902	14-DIP-300	-40 ~ +90℃

BLOCK DIAGRAM



PIN CONNECTIONS



PIN DISCRIPTION

Pin No.	Symbol	Function
1	CMD	Current command input
2	CMDa	OP AMP output
3	CMDb	OP AMP input (-)
4	SG	Signal GND
5	Rt/Ct	Oscillator time constant
6	VREF	Voltage reference (5V)
7	CH	Max. speed reference input
8	NC	No connection
9	CL	Min. speed reference input
10	CS	Current sense input
11	PG	Power GND
12	OUT	Drive output
13	V_{CC}	V_{CC}
14	La	Max. current reference input

ABSOLUTE MAXIMUM RATING (Ta=25℃)

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℃)

Characteristics	Symbol	Value			Unit
		Min	Typ	Max	
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℃	200	℃
Frequency Stability	F_{ST}	-40 ~ +90℃	20 ~ 30	℃
Operating Temperature	T_{OPR}	-	-40 ~ +90	℃
Storage Temperature	T_{STG}	-	-60 ~ +150	℃

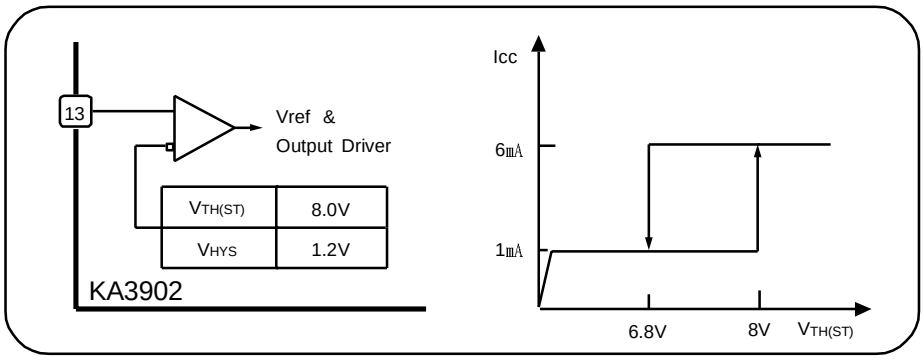
ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, T_a=25℃, V_{CC}=5V, V_M=12V)

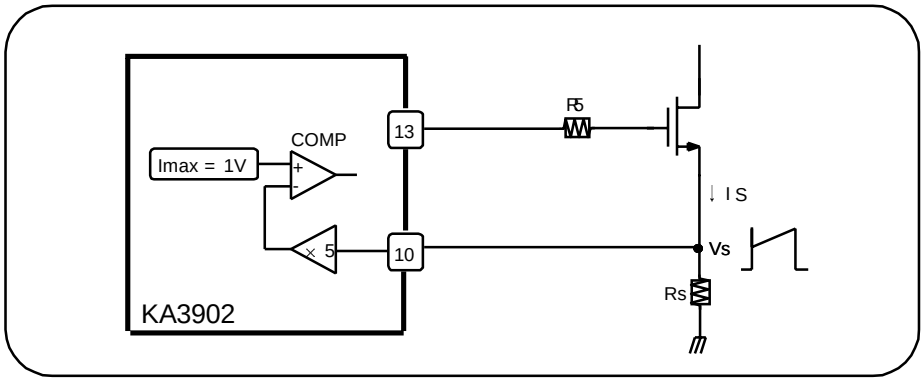
Characteristics	Symbol	Test Conditions	SPEC			Unit
			Min	Typ	Max	
REFERENCE						
Reference Voltage	Vref	Iref=1mA	4.75	5.0	5.25	V
Line Regulation	△Vref1	V_{CC}=9V~32V	-	50	150	mV
Load Regulation	△Vref2	Iref=1mA~10mA	-	10	50	mV
UNDER VOLTAGE LOCKOUT (UVLO)						
Start Threshold Voltage	Vth(st)	-	7.5	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 (Rt=75kΩ, Ct=1nF)						
Frequency	f_{OSC}	-	20	25	30	KHz
Duty Cycle	Duty	-	90	95	-	%
CURRENT SENSING INPUT						
Threshold Voltage	Vth(cs)	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}	200mA	-	-	2.2	V
High Output Voltage	V_{OH1}	Iout=-20mA	10.0	-	-	V
	V_{OH2}	-200mA	9.0	-	-	V
Rising Time	T_r	Cld=1nF	-	100	200	nS
Falling Time	T_f	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



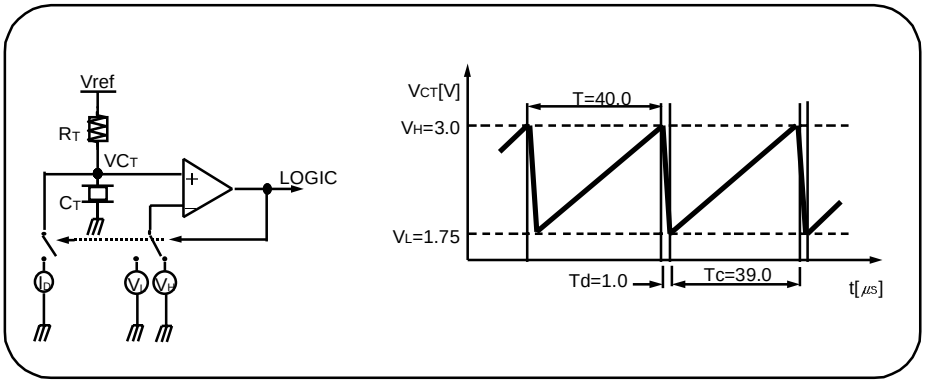
The peak current, $I_{S(MAX)} = V_S/R_S$
For example, if a required maximum current, $I_{S(MAX)} = 20[A]$,

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

3. THERMAL SHUTDOWN (TSD)

When the chip temperature rises up to 150℃, the output driver will be turned off, and then the output will be turned on again at 125℃.

4. OSCILLATOR COMPONENT SELECTION



The oscillator timing components can be calculated as follows :

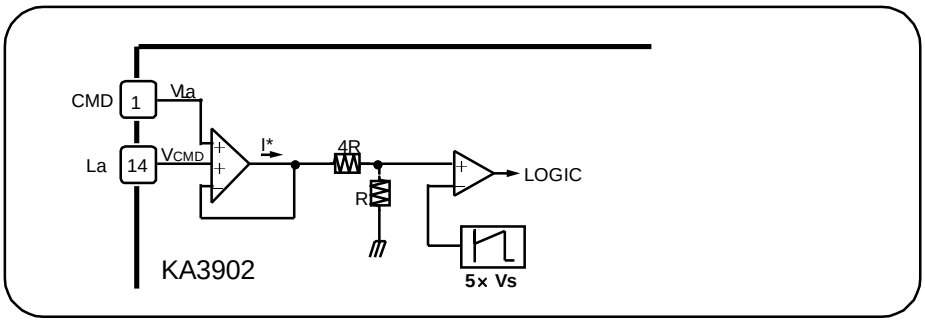
$$T_C = R_T \times C_T \times \ln[(Vref - V_L)/(Vref - V_H)]$$
$$T_D = C_T \times [(V_H - V_L)/I_D]$$
$$f_{OSC} = 1/(T_C + T_D)$$
$$= 1.875/(R_T \times C_T)$$
$$Duty = T_C \times f_{OSC} \times 100$$

For example, if f_{OSC}=25kHz and duty=95%,

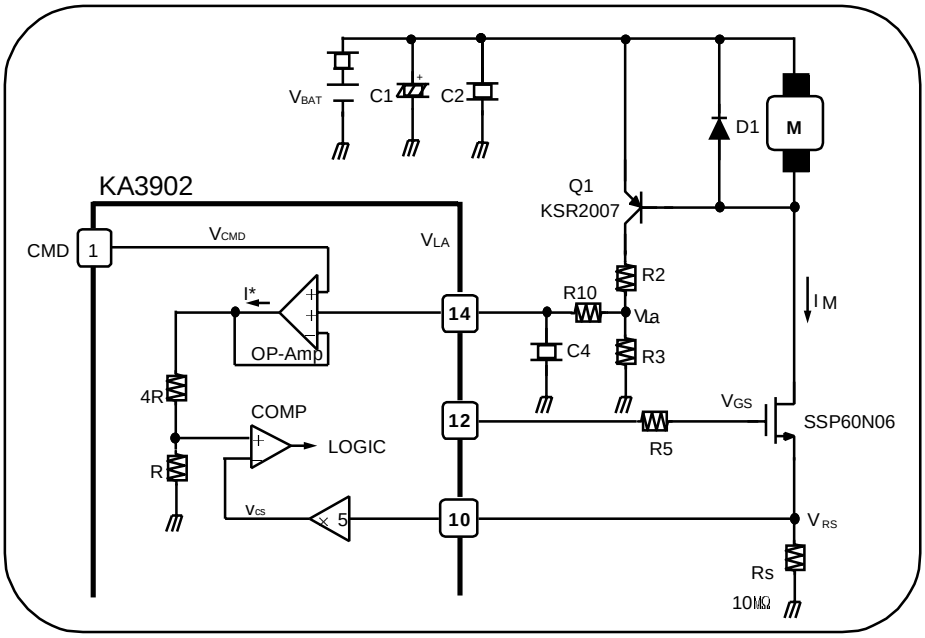
$$C_T = (T_D \times I_D)/(V_H - V_L)$$
$$= 1{,}000[pF]$$
$$R_T = 1.875/(f_{OSC} \times C_T)$$
$$= 1.875/(25kHz \times 1{,}000pF)$$
$$= 75[k\Omega]$$

5. CURRENT COMMAND INPUT SECTION

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



6. MOTOR STALL CURRENT LIMITATION

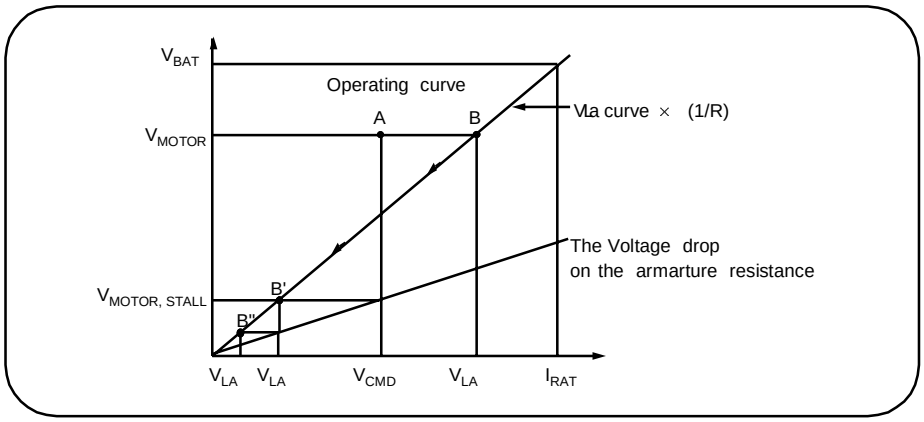


At the steady state, the terminal voltage on a motor is consisted of a back EMF and the voltage drop on the armature resistors. When the motor happens to be stalled, the back EMF becomes zero, and the motor current(I_M) is quickly increased until a maximum values.
Therefore the duty of the PIN #12 output 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 becomes 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 :

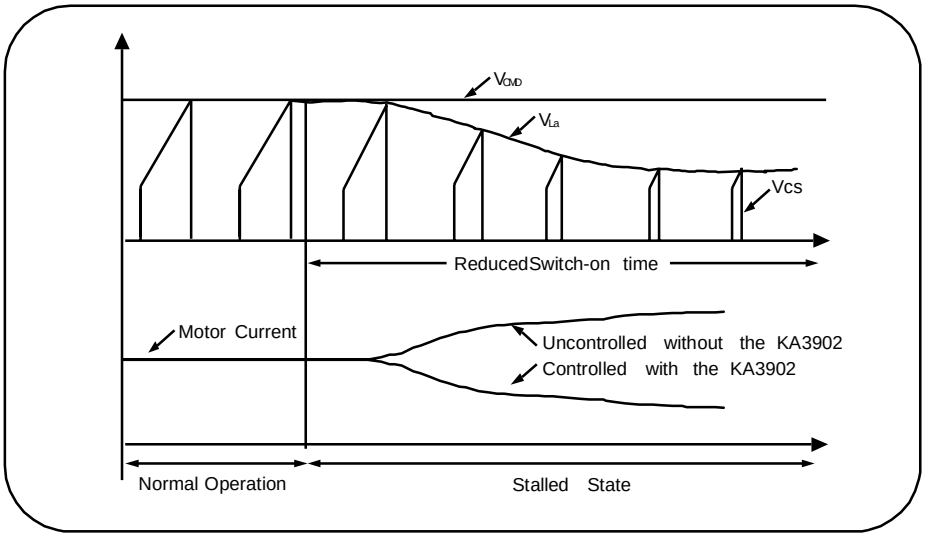
$$V_{La} = V_{BAT} \times D \times \frac{R3}{R2 + R3}$$ Assumed the saturation voltage of Q1 is zero.

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

① Applied the rated voltage on motor, and then measured the current IRAT
② Matched the maximum command current, $V_{CMD,MAX}$ to I_{RAT}.
$V_{CMD,MAX} = V_{La,MAX} = Rs \times I_{RAT} \times 5 \times 5$
for example, if Rs = 10mΩ and I_{RAT} = 20[A] at V_{BAT} = 13[V],
$V_{CMD,MAX} = V_{La,MAX} = 10m\Omega \times 20 \times 25 = 5V$
③ $V_{La,MAX} = 5V = V_{BAT} \times 1 \times R3/(R2+R3)$
$R = R3/(R2+R3) = V_{CMD,MAX}/V_{BAT} = 5/13$
Therefore, R2 : R3 = 8 : 5



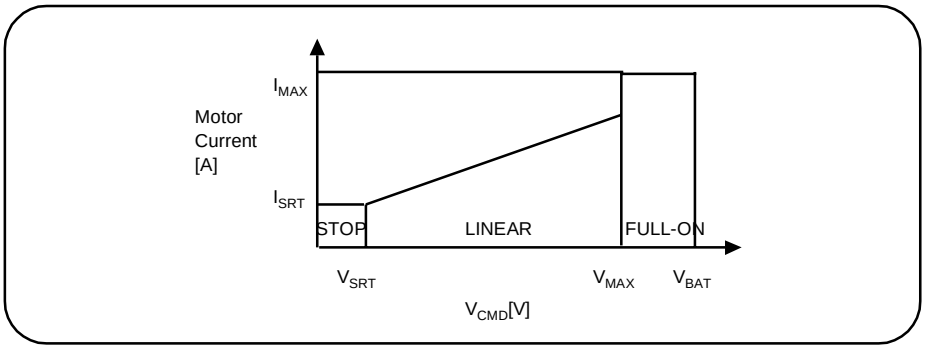
The buffer OP-Amp selects the lower command between VCMD and VLa so as to limit the stalled motor current to very low level in the above figure. Because of much larger VLa than VCMD, the motor operating point stays at A. But the point gradually moves toward B' and then B" through the curve from the instance of stall as the below figure.



7. MODE SELECTION

The KA3902 has three operation regions as follows.
① STOP : turned-off the power MOSFET
② LINEAR : linearly controlled the power MOSFET
③ FULL-ON : fully turned-on the power MOSFET

The Voltages, $V_{SRT(PIN\#\ 9)}$ and $V_{MAX(PIN\#\ 7)}$, in the application circuit are as follows.
$V_{SRT(PIN\#\ 9)} = Vref \times R9/(R7+R8+R9)$
$V_{MAX(PIN\#\ 7)} = Vref \times (R8+R9)/(R7+R8+R9)$



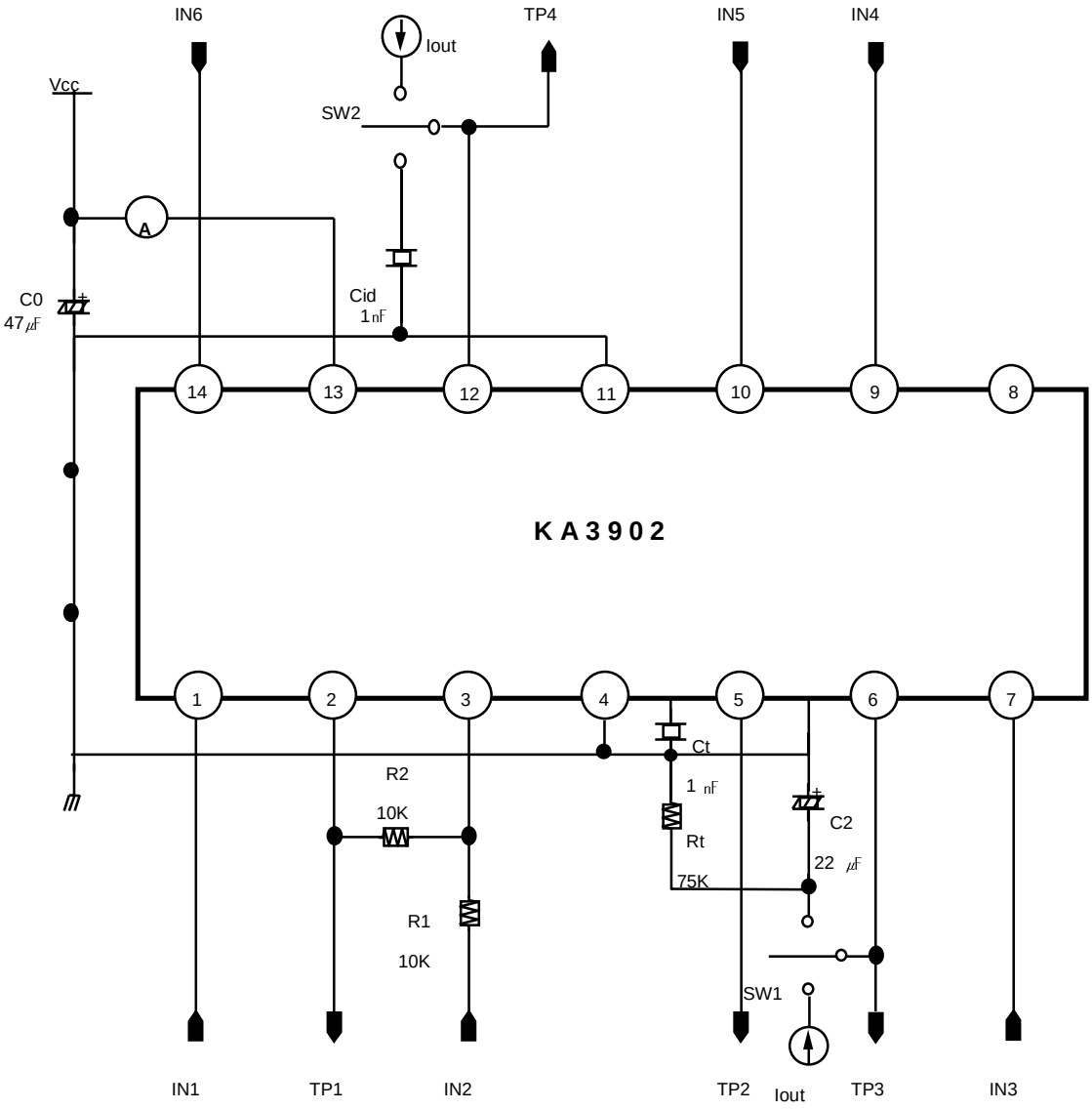
8. OVER VOLTAGE PROTECTOR (OVP)

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

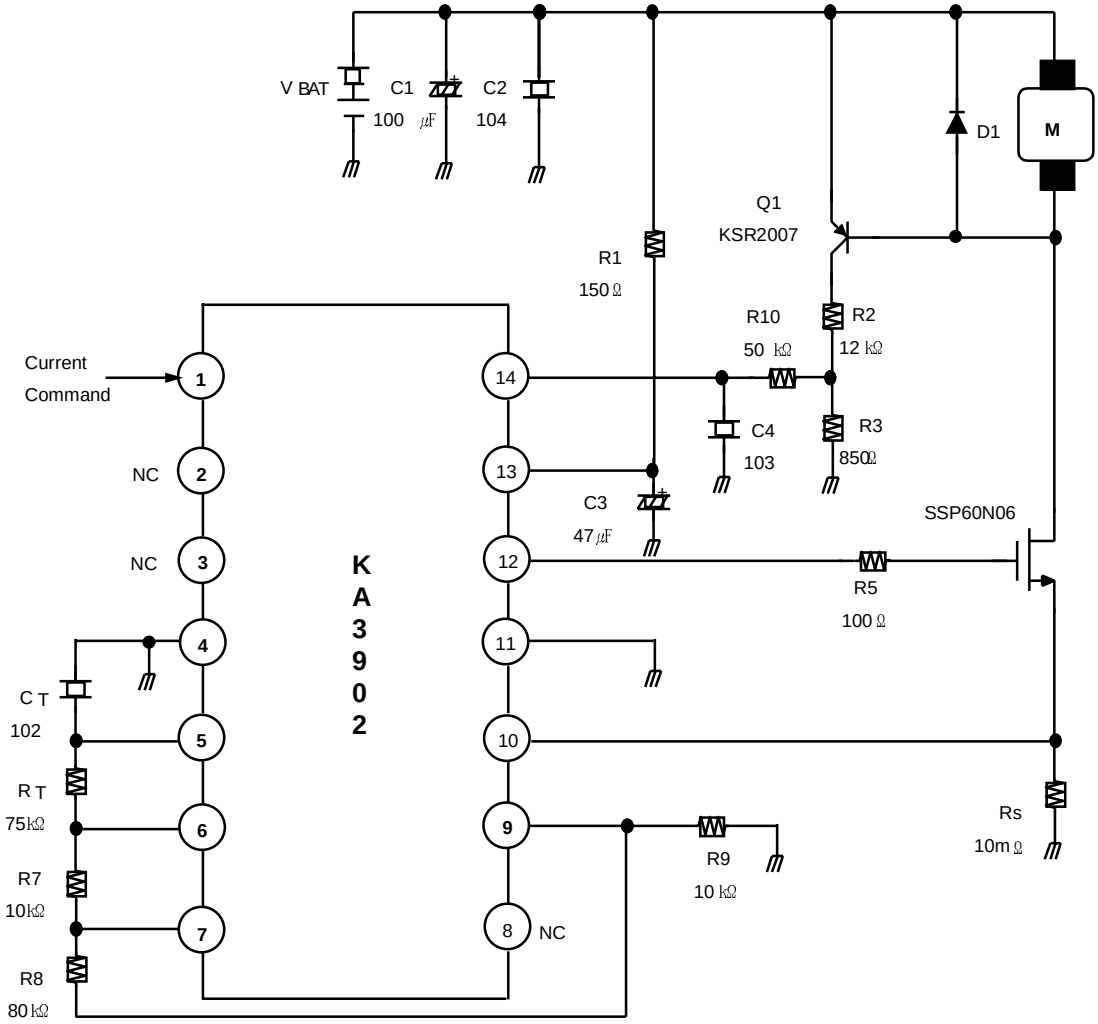
9. TOTEM-POLE OUTPUT

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

TEST CIRCUIT

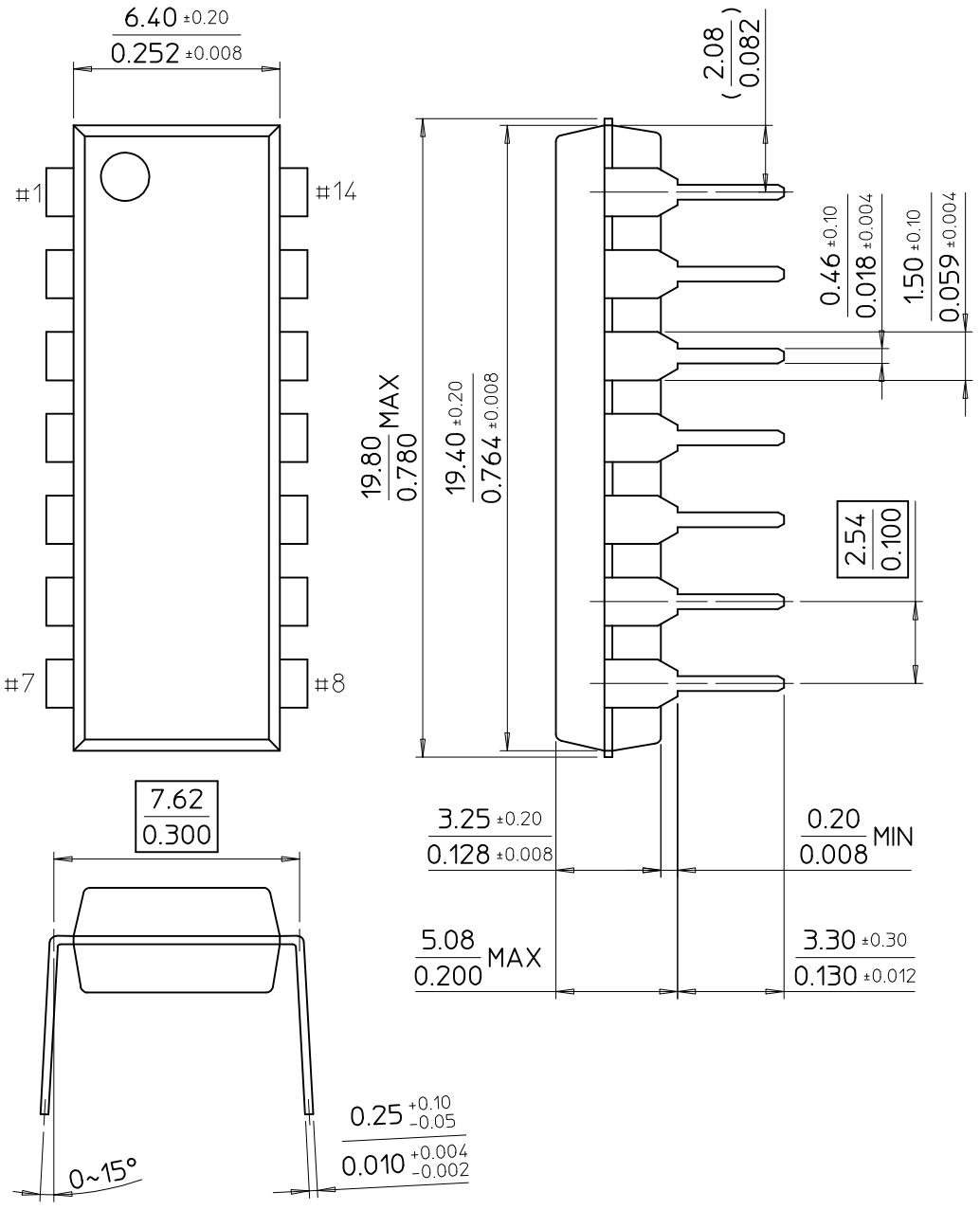


TYPICAL APPLICATION



14–DIP–300

Dimensions in Milimeters/inches



SAMSUNG ELECTRONICS CO.,LTD.