

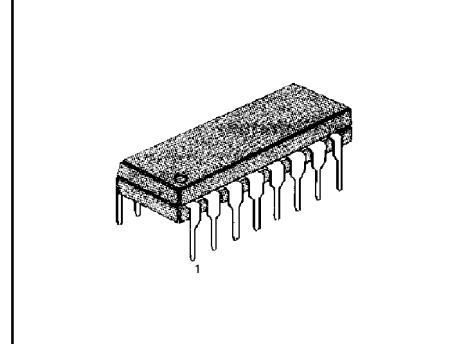
## POWER WINDOW MOTOR CONTROL IC

The KA3903 is a monolithic integrated circuit, and suitable for a window motor control and a sun roof motor control in automotive systems.

## FEATURES

- Protections
  - Human body protection with a simple switch
  - Over current protection with an integrator
  - Over voltage protection
  - Load dump protection
  - Reverse battery voltage protection
- Low off-state quiescent current ( $150\text{ }\mu\text{A}$ )
- Adjustable output control time after car-key turn-off
- Four selectable operating modes
- Thermal shutdown (TSD)
- Under voltage lockout (UVLO)

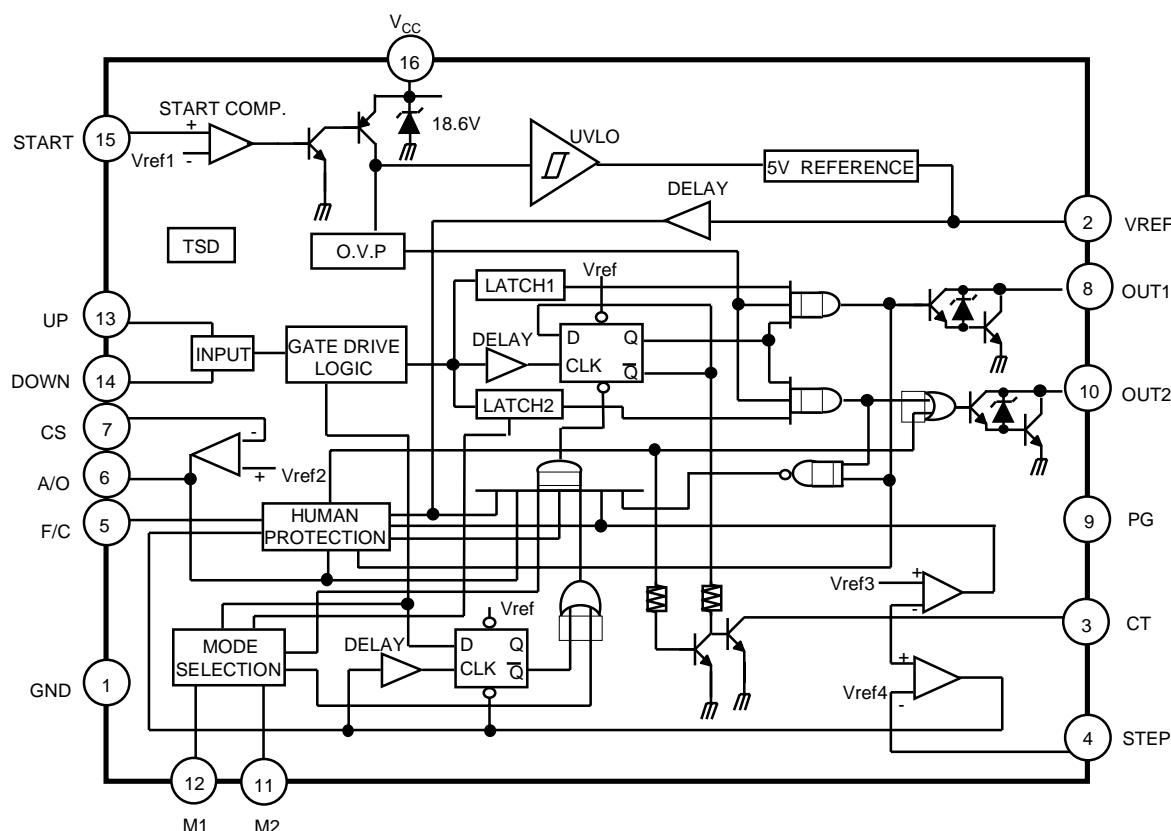
16-DIP-300A



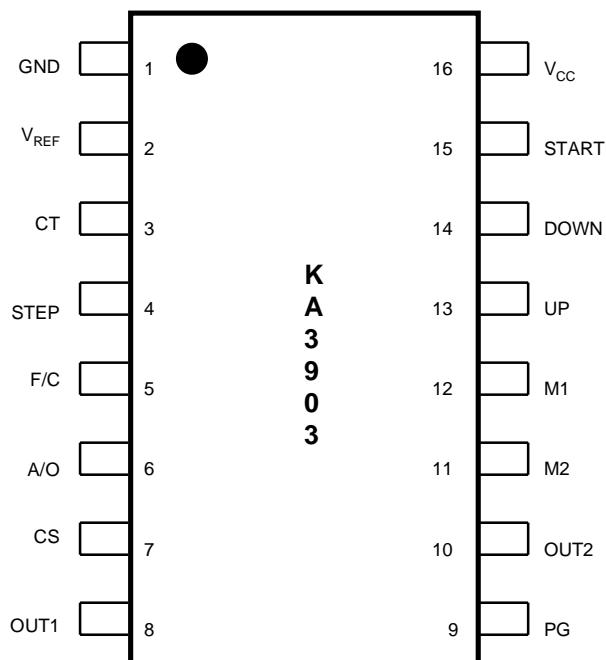
## ORDERING INFORMATION

| Device | Package     | Operating Temperature |
|--------|-------------|-----------------------|
| KA3903 | 16-DIP-300A | - 40 ~ + 90 °C        |

## BLOCK DIAGRAM



## PIN CONFIGURATION



## PIN DESCRIPTION

| Pin No. | Symbol          | Description                         |
|---------|-----------------|-------------------------------------|
| 1       | GND             | Signal ground                       |
| 2       | Vref            | Voltage reference output (typ=5.0V) |
| 3       | CT              | Step/Auto pulse generator output    |
| 4       | STEP            | Step bias signal input              |
| 5       | F/C             | Full close signal input             |
| 6       | A/O             | OP AMP output                       |
| 7       | CS              | Current sense signal input          |
| 8       | OUT1            | Up signal output                    |
| 9       | PG              | Power ground                        |
| 10      | OUT2            | Down signal output                  |
| 11      | M2              | Selectable mode signal input 2      |
| 12      | M1              | Selectable mode signal input 1      |
| 13      | UP              | Up signal input                     |
| 14      | DOWN            | Down signal input                   |
| 15      | START           | Start up signal input               |
| 16      | V <sub>CC</sub> | Supply voltage                      |

**ABSOLUTE MAXIMUM RATING** ( $T_a = 25^\circ\text{C}$ , unless otherwise specified)

| Characteristics                   | Symbol           | Value      | Unit |
|-----------------------------------|------------------|------------|------|
| Supply Voltage (1)                | V <sub>CC1</sub> | 17         | V    |
| Supply Voltage (2) : reverse bias | V <sub>CC2</sub> | -0.7       | V    |
| Output Current                    | I <sub>O</sub>   | 400        | mA   |
| Power Dissipation                 | P <sub>D</sub>   | 1.0        | W    |
| Operating Ambient Temperature     | T <sub>OPR</sub> | -40 ~ +90  | °C   |
| Storage Temperature               | T <sub>STG</sub> | -60 ~ +150 | °C   |

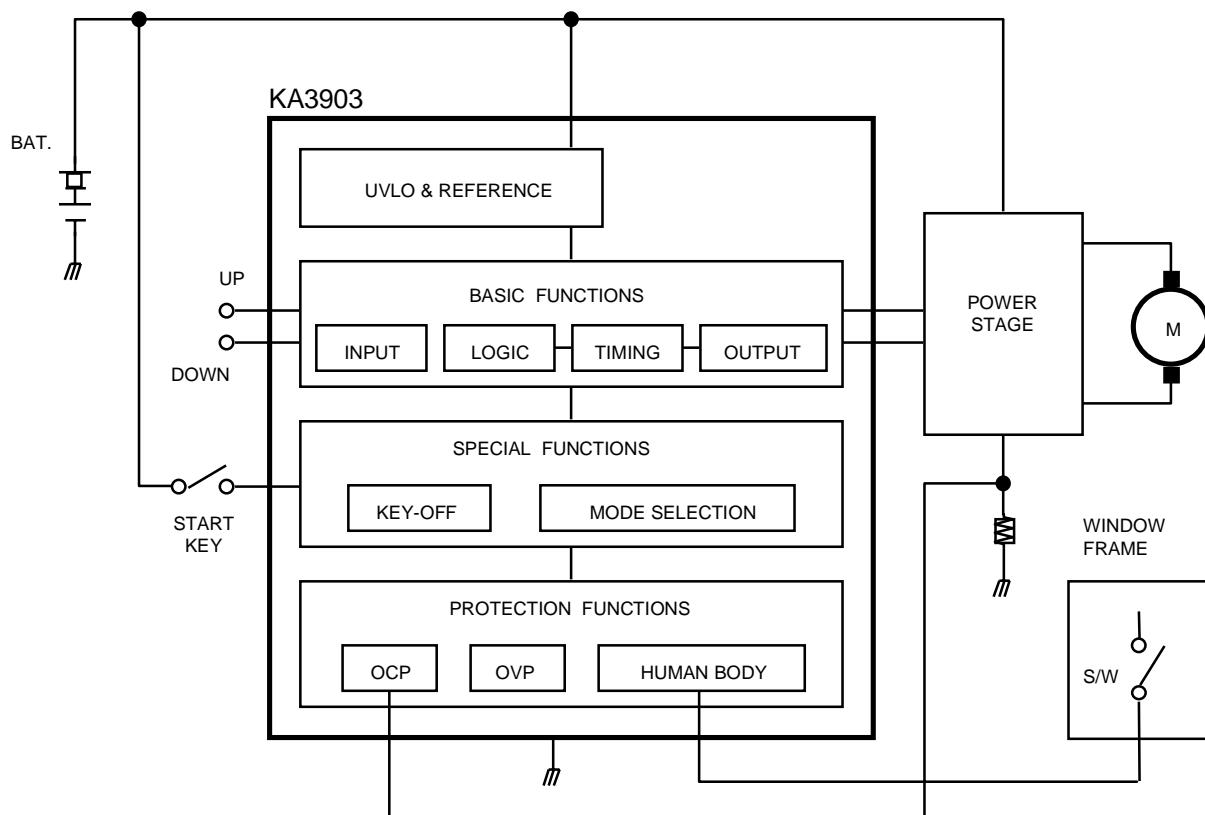
**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=12V$ ,  $T_a=25^\circ\text{C}$ , unless otherwise specified)

| Characteristics                              | Symbol                           | Test Conditions   | Min  | Typ  | Max  | Unit  |
|--|----------------------------------|---|------|------|------|-------|
| <b>Under Voltage Lock Out Section</b>        |                                  |   |      |      |      |       |
| Start - up Threshold Voltage                 | V <sub>ST</sub>                  |   | 8.3  | 8.8  | 9.3  | V     |
| UVLO Hysteresis                              | V <sub>HYS</sub>                 |   | 1.1  | 1.25 | 1.6  | V     |
| Supply Zener Voltage                         | V <sub>Z</sub>                   | I <sub>CC</sub> =20mA                                     | 17.2 | 18.6 | 20.0 | V     |
| <b>Operating Range Section</b>               |                                  |   |      |      |      |       |
| Operating Supply Voltage                     | V <sub>CC</sub>                  | V <sub>REF</sub> =5V                                      | 8.0  | -    | 17.0 | V     |
| Operating Supply Current (Off)               | I <sub>CC1</sub>                 | V <sub>START</sub> =Open                                  | -    | 150  | 200  | uA    |
| Operating Supply Current (On)                | I <sub>CC2</sub>                 | V <sub>START</sub> =12V                                   | -    | 5.0  | 6.0  | mA    |
| <b>Reference Section</b>                     |                                  |   |      |      |      |       |
| Reference Voltage                            | V <sub>REF</sub>                 |   | 4.8  | 5.0  | 5.2  | V     |
| Line Regulation                              | R <sub>EG</sub> , I <sub>I</sub> | 8V < V <sub>CC</sub> < 17V                                | -    | 1    | 2    | mV/V  |
| Load Regulation                              | R <sub>EG</sub> , I <sub>O</sub> | 0mA < I <sub>REF</sub> < 2mA                              | -    | 1    | 4    | mV/mA |
| <b>Comparator Section (UP/DOWN/FC Block)</b> |                                  |   |      |      |      |       |
| Input Resistance                             | R <sub>IN</sub>                  | V <sub>UP</sub> , V <sub>DOWN</sub> , V <sub>FC</sub> =0V | 20   | 28   | 36   | kΩ    |
| Comparing Reference Voltage (1)              | V <sub>TH1</sub>                 | Vout ON/OFF S/W Vtg                                       | 3.0  | 3.2  | 3.4  | V     |
| <b>Comparator Section (CT Block)</b>         |                                  |   |      |      |      |       |
| Comparing Reference Voltage (2)              | V <sub>TH2</sub>                 | 4.2V < V <sub>CT</sub> < 4.6V                             | 4.2  | 4.4  | 4.6  | V     |

**ELECTRICAL CHARACTERISTICS** ( $V_{CC}=12V$ ,  $T_a=25^\circ C$ , unless otherwise specified)

| Characteristics           | Symbol     | Test Conditions   | Min  | Typ  | Max  | Unit |
|---------------------------|------------|-------------------|------|------|------|------|
| <b>Output Section</b>     |            |                   |      |      |      |      |
| Output Saturation Voltage | $V_{SAT}$  | $I_O=0.2A$        | -    | 1.0  | 1.2  | V    |
| Sustain Voltage           | $V_{SUS}$  | $I_O=20mA$        | 17.2 | 18.6 | 20.0 | V    |
| <b>OP AMP Section</b>     |            |                   |      |      |      |      |
| AMP Reference Voltage     | $V_{AMP}$  | $V_{CS}=V_{outa}$ | 0.23 | 0.25 | 0.27 | V    |
| Output Voltage Range      | $V_{OUTH}$ | $I_O=-10\mu A$    | 4.0  | 4.2  | -    | V    |
|                           | $V_{OUT1}$ | $I_O=+10\mu A$    | -    | 0.05 | 0.1  | V    |

## APPLICATION INFORMATION



&lt; POWER WINDOW SYSTEM &gt;

If a battery is mounted on a car, the power window system will be in stand-by as power is supplied into the power stage and the control IC(KA3903).

When the START-KEY is turned ON by operator, the KA3903 will wait the command UP or DOWN of the window.

Upon the command UP, the power stage composed of relays will be activated by basic function circuit which consists of INPUT, LOGIC, TIMING and OUTPUT circuit.

So the motor starts to rotate in the right direction to lift the window, while rotate in the counter direction with the command DOWN to down the window.

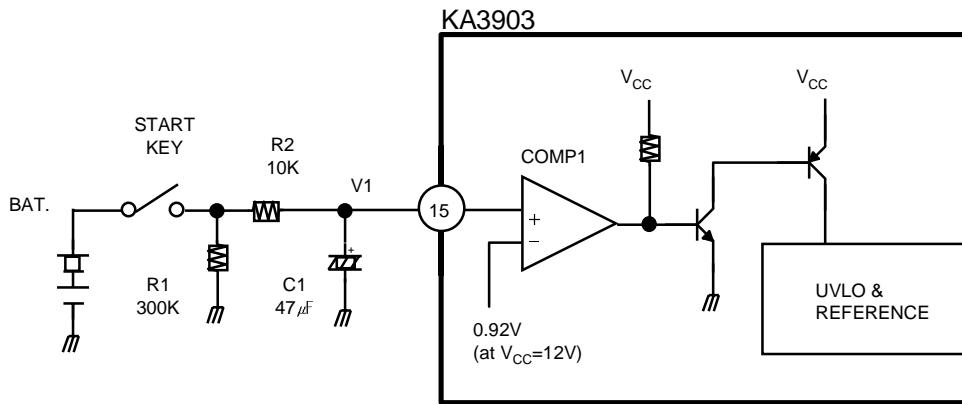
The OCP(overcurrent protector) is made up to protect the current overflowed on a motor in an abnormal condition of the system during the rotation of motor according to the command UP or DOWN.

The OCP time technique is used to detect overcurrent not sensitive to a start peak current or a current slightly larger than the reference current.

The KA3903 is based on the safety by consisting of the human body protection circuit with a simple switch attached to the window frame for cost-effective method but hard to the European specification. It also is possible to use photo sensor to meet the specification.

Moreover the KA3903 has the car-key turn-off function and the MODE SELECTION function.

## 1. START STAGE

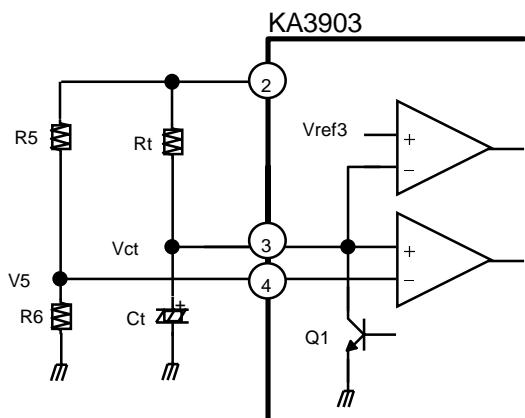


In the state of the START-KEY turned OFF, all the blocks in the KA3903 are kept to be OFF because the power is not supplied into UVLO block.

When the START-KEY is turned ON, the power is supplied into UVLO block to activate REFERENCE block in normal condition. So the blocks in KA3903 are kept to be ON.

It is minimized the stand-by current of the KA3903, as it performs ON or OFF by using the START STAGE.

## 2. STEP AND AUTO TIME



If the UP/DOWN switch is pushed less than a set time(T<sub>s</sub>), TR(Q1) will be turned off and capacitor(C<sub>t</sub>) is charged exponentially until V<sub>ct</sub> equals to V<sub>5</sub>. At that time TR(Q1) is turned on and stops the operation.

But if longer than T<sub>s</sub>, capacitor(C<sub>t</sub>) continues its charge until V<sub>ct</sub> equals to V<sub>ref3</sub>. Then Q1 is turned on and the auto function terminates its operation.

The T<sub>s</sub> and T<sub>a</sub> are determinated by components(R<sub>t</sub> & C<sub>t</sub>), external divider and V<sub>ref3</sub>.

$$T_s = 0.05 \times (R_t \times C_t), \text{ where } V_5 = 0.25V$$

$$T_a = 2.10 \times (R_t \times C_t), \text{ where } V_{ref3} = 4.4V$$

In the manual mode, the window goes UP or DOWN just while a switch is pushed. In the step mode and the auto mode, even after releasing the switch, the window continues its movements except for pushing the switch again(the topple) or happening to the stall condition.

### 3. CAR-KEY TURN-OFF FUNCTION

The window can be operated for a certain period even in the state of the START-KEY to be OFF. If the START-KEY is turned OFF, the discharge time for the voltage V1 to pin #15 will be determined by the following time constant.

$$\tau = (R_1 + R_2)C_1$$

User can get a time he wants as the discharge time for the voltage V1 by changing the capacity of the cap (C1) and the values of the resistances(R1 or R2).

Therefore, the user can run the window for a limited time(about 30 sec) produced from the above expression, even if the START-KEY is turn OFF on the window not closed.

### 4. MODE SELECTION

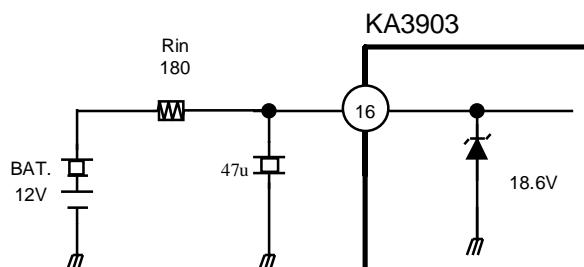
| Mode      | Pin Name |    | Operation           |                     |
|-----------|----------|----|---------------------|---------------------|
|           | M1       | M2 | UP                  | DOWN                |
| LL - MODE | L        | L  | NORMAL              | NORMAL              |
| LH - MODE | L        | H  | NORMAL              | TOGGLE & AUTO       |
| HL - MODE | H        | L  | NORMAL              | TOGGLE, STEP & AUTO |
| HH - MODE | H        | H  | TOGGLE, STEP & AUTO | TOGGLE, STEP & AUTO |

※ L : M1 or M2 = Ground, H : M1 or M2 = Open

- 1) NORMAL : The window is working as long as the UP or DOWN switch is pressed.
- 2) TOGGLE : When the window works by pressing the UP or DOWN switch, the window is stopped if the UP or DOWN switch is pressed once more.
- 3) STEP & AUTO : If the UP or DOWN switch is pressed for a certain period(0.3 seconds), the window works for 0.3 seconds, while 6 seconds if pressed for more than a certain period(0.3 seconds).

### 5. OVP(Over Voltage Protection)

It is designed to stop the control of the KA3903 if battery voltage is sensed as about 18.6V or more.



## 6. OCP(Overcurrent Protection)

### 6-1. Simple Applications

The voltage( $V_{rs}$ ) proportional to the motor current is generated across the resistor( $R_s$ ). If the  $V_{rs}$  exceeds the reference voltage( $V_{ref}$ ), over current part-time integration carried out through  $R_3$ ,  $C_2$  and OP-AMP.

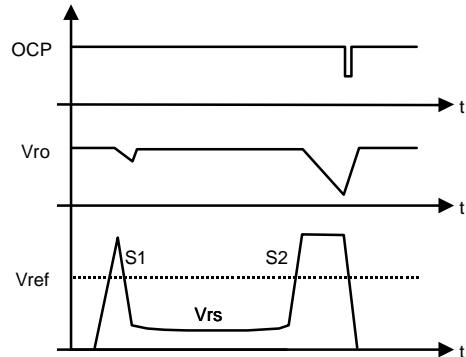
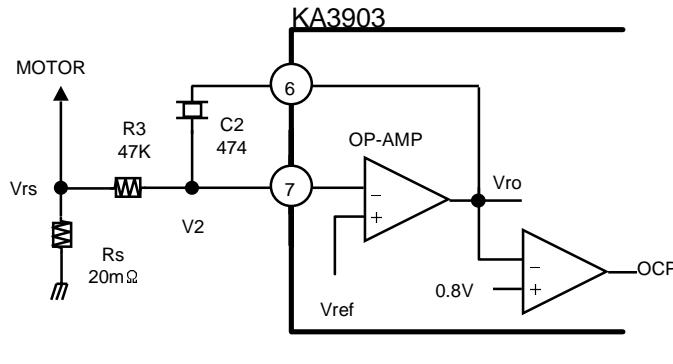
When the amount of over current integration is larger than  $S_2$ , the over current signal issued.

The cancel time( $T_c$ ) between motor stall and motor switch-off is determined by following equations ;

$$T_c = (C_3 \times dV) / I_c, \quad \text{where, } I_c = (V_{rs} - V_{ref}) / R_3$$

$$dV = V_{outh} - 0.8$$

You can adjust both the value of the sensing resistor( $R_s$ ) according to motor type and the cancel time by changing  $R_3$  and  $C_2$ . Additionally the over current detection of the KA3903 is immune to any sudden peak current or a current slightly larger than the reference current.



### 6-2. Temperature Compensation Applications

Generally speaking, the less ambient temperature, the more motor current. In the previous applications, there are some difficulty to decide the reference current level.

In case of low ambient temperature, the difference between the operating motor current and the reference current is very small. When the reference current level is high, the margin is large. But at a high ambient temperature, the difference between the motor current and the stall current is small.

Moreover, the stall current is depended on a battery voltage as well. It is hard to decide what the optimal reference level is.

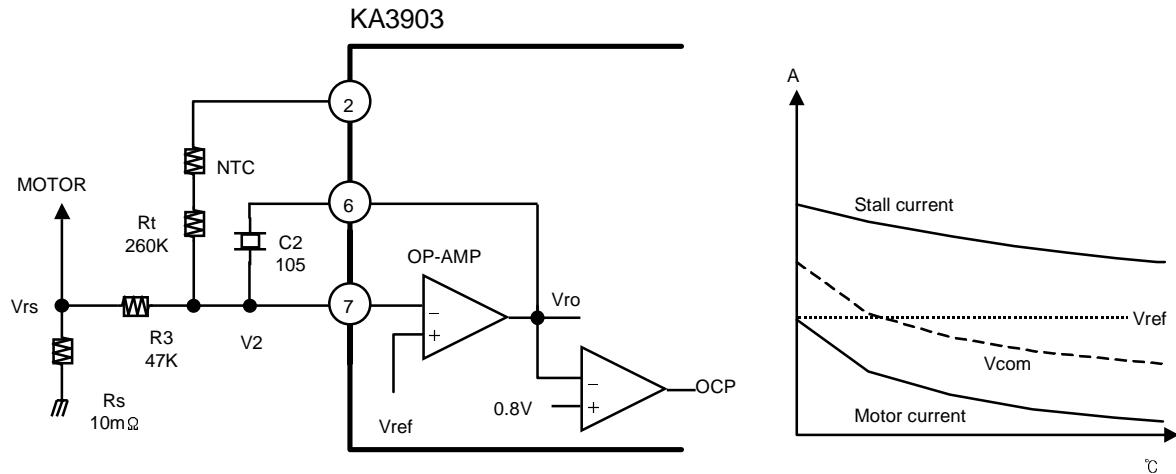
In the following figure, In the room temperature, the inverting voltage( $V_2$ ) and the reference current are calculated as follows ;

$$V_2 = V_{com} \times R_3 / (R_{ntc} + R_t + R_3)$$

$$V_{com} = V_{ref} - V_2$$

The resistance of the NTC decreases according to rising of the ambient temperature. So the reference level,  $V_{com}$  is changed on the temperature change as shown in the following figure.

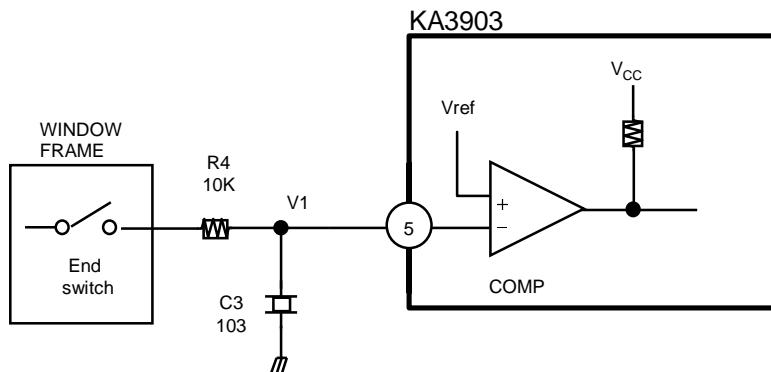
To ensure precision of the reference level,  $R_t$  can be adjusted.



## 7. HUMAN BODY PROTECTION (HBP)

### 7-1. Using an End Switch

The human body protection is to be carried out when the overcurrent protection signal is issued just while the window glass is up going and the end switch is closed, in the AUTO MODE. The controller stop the window glass, and then reverses the rotating direction of motor to move down the window plan at the bottom. There are some cases in the window glass to be locked ; its upper limit, bottom, and obstacle like human body, neck, and hand etc. The OCP function would work in any cases. So it is necessary for the controller to discriminate whether something is squeezed between the window glass and the window frame or not. The end switch is opened only when the window glass reaches almost its upper limit. Leave the F/C pin open unless you want this function.



### 7-2. Using Photo Devices (no touch sensor)

In case of using an end switch, the HBP function works on the condition that the overcurrent signal is issued. So it could have some sensitivity problem. It is very hard to decide what the optimal reference current and cancel time are.

We have tested new principle and as a result, developed one light based HBP function. The below figure explain the principle of the operation.

As sender and receiver are arranged together, it is possible for the receiver to detect the sent diode light.

The position of the sensor must be set adequately upper part of the window. When the obstacle between the window glass and the upper limit are inserted, the light sensor TR is turned off. The sensor have a two function :

1) End position switch, 2) issuing the OCP signal.

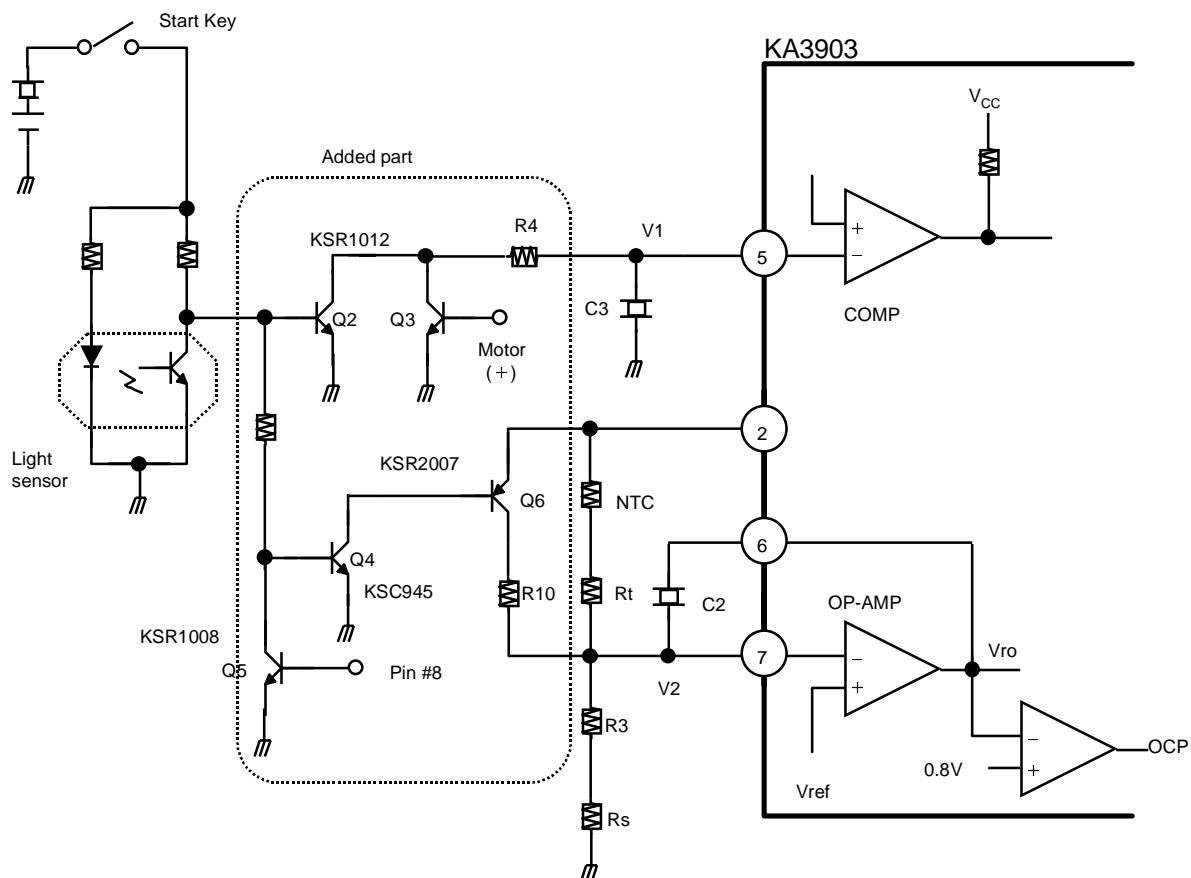
Q2 is used to make the F/C pin low, and Q4 enables to turn-on Q6 to issue the OCP signal.

As soon as Q2 is turned on, V2 changes from the equation mentioned in 6.2 paragraph to the below equation.

$$V2 = V_{com} \times [ R10 // (R_{ntc} + R_t) ] / [ R10 // (R_{ntc} + R_t) + R5 ]$$

and OP-AMP output become low level. Therefore the HBP logic stops the motor and reverses the direction of the motor.

You can adjust the delay time by changing the value of the resistor, R10. The added part works only when Q5 is on-state. In other words, when the window glass is moving upward, the added part operates. Q3 is also turned on and holds the F/C pin low level.



**8. OUTPUT STAGE**

The output stage is a darlington TR with an integrated zener diode, and designed at a pulse current of a approx. 0.4A. The zener diode limits the inductive switch-off voltage. The relay coil has a typical resistances of  $200\Omega$ , and the zener diode voltage is 18.6V.

With the circuitry of this type, the KA3903 can sustain 24V for one minute (or continuously) and load dump (70V, 0.2 sec) condition without a damage.

**9. POWER SUPPLY**

For the reasons of interference protection and surge immunity, all circuit should be provided with a RC circuit for a current limitation in the event of overvoltage and for buffering in the event of voltage dips at Vref.

Suggested dimensioning ;  $R_{in}=180\Omega$ ,  $C_{in}=47\mu F$ , as shown in the typical applications.

There ia a 18.6V zener diode between Vcc and GND.

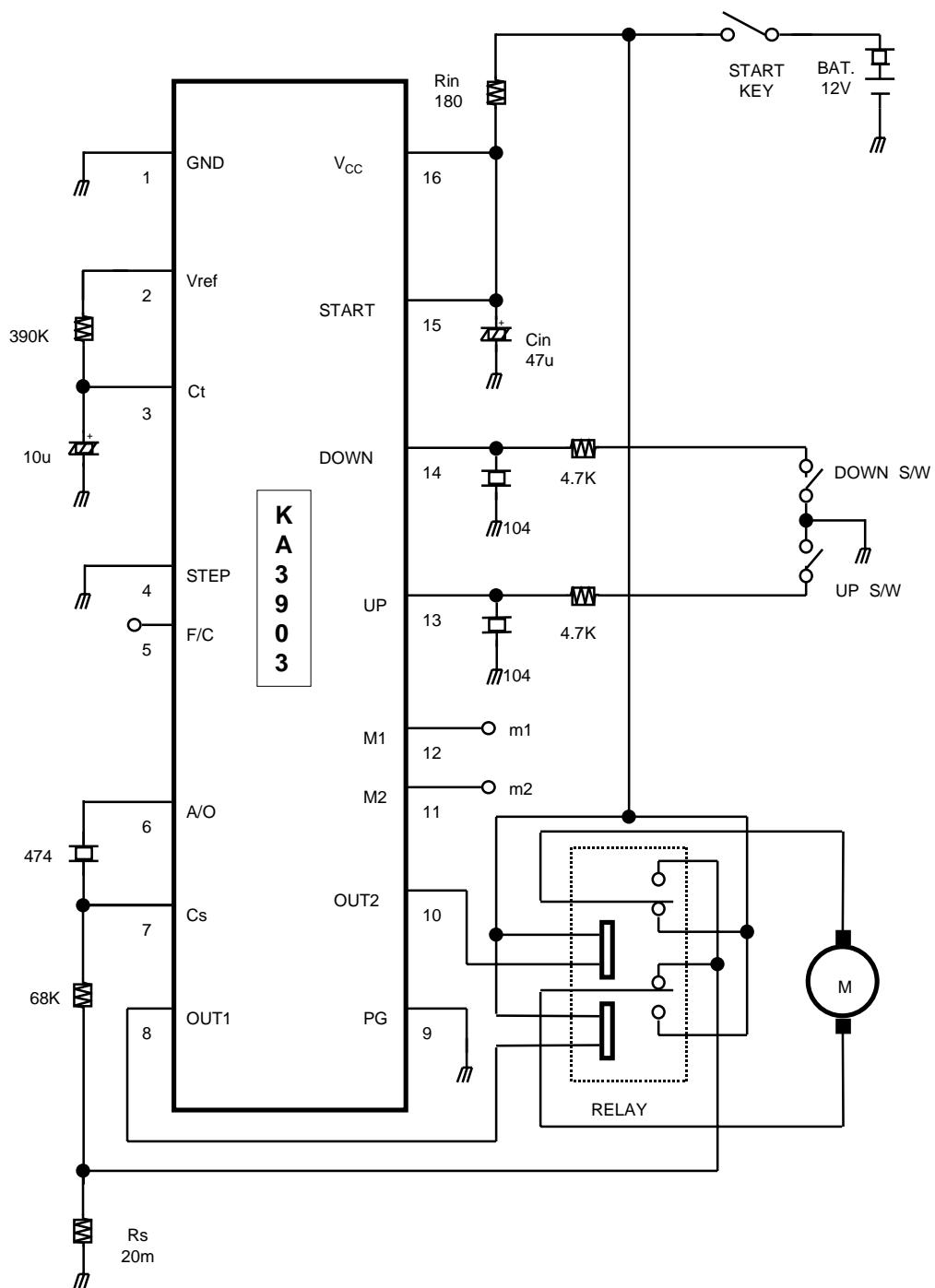
**10. LOAD DUMP PROTECTION**

The load dump protection withstands up to 70V(refer to the typical application-I) with a decay time. In this case, the power dissipation of the KA3903 takes place at three parts ; Vcc, OUT1 and OUT2. But in the typical application-II, the supply voltage of the relay is limited the internal zener diode voltage. The power dissipation of the output stage is not on count. So the KA3903 can withstand up to 100V load dump with  $\tau= 200$  ms.

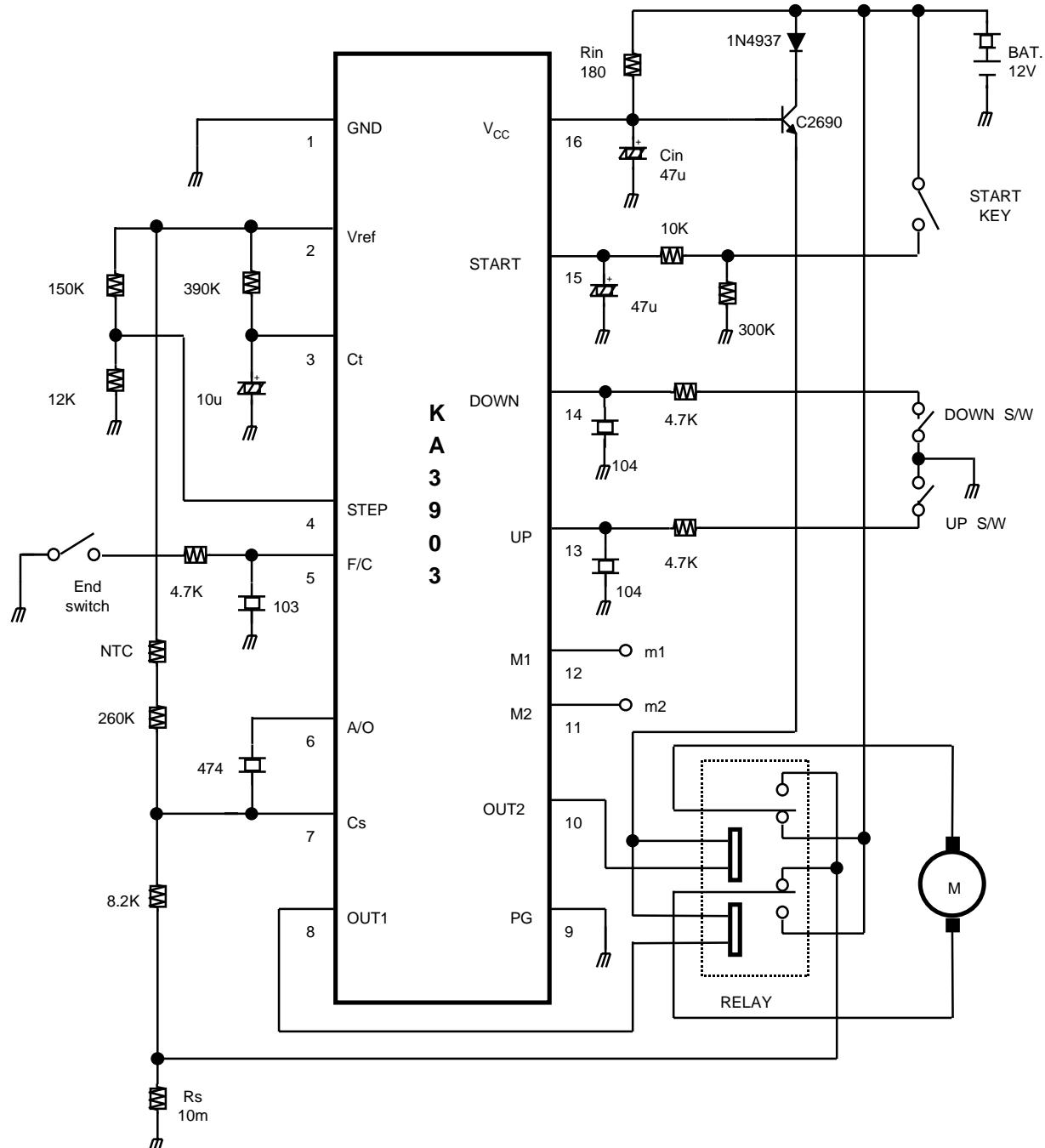
**11. REVERSE BATTERY VOLTAGE PROTECTION**

In case of the reverse battery, the KA3903 is modeled with a diode. Due to the external impedance at pin #16, the KA3903 is protected against reverse battery voltage for one minute (or continuously).

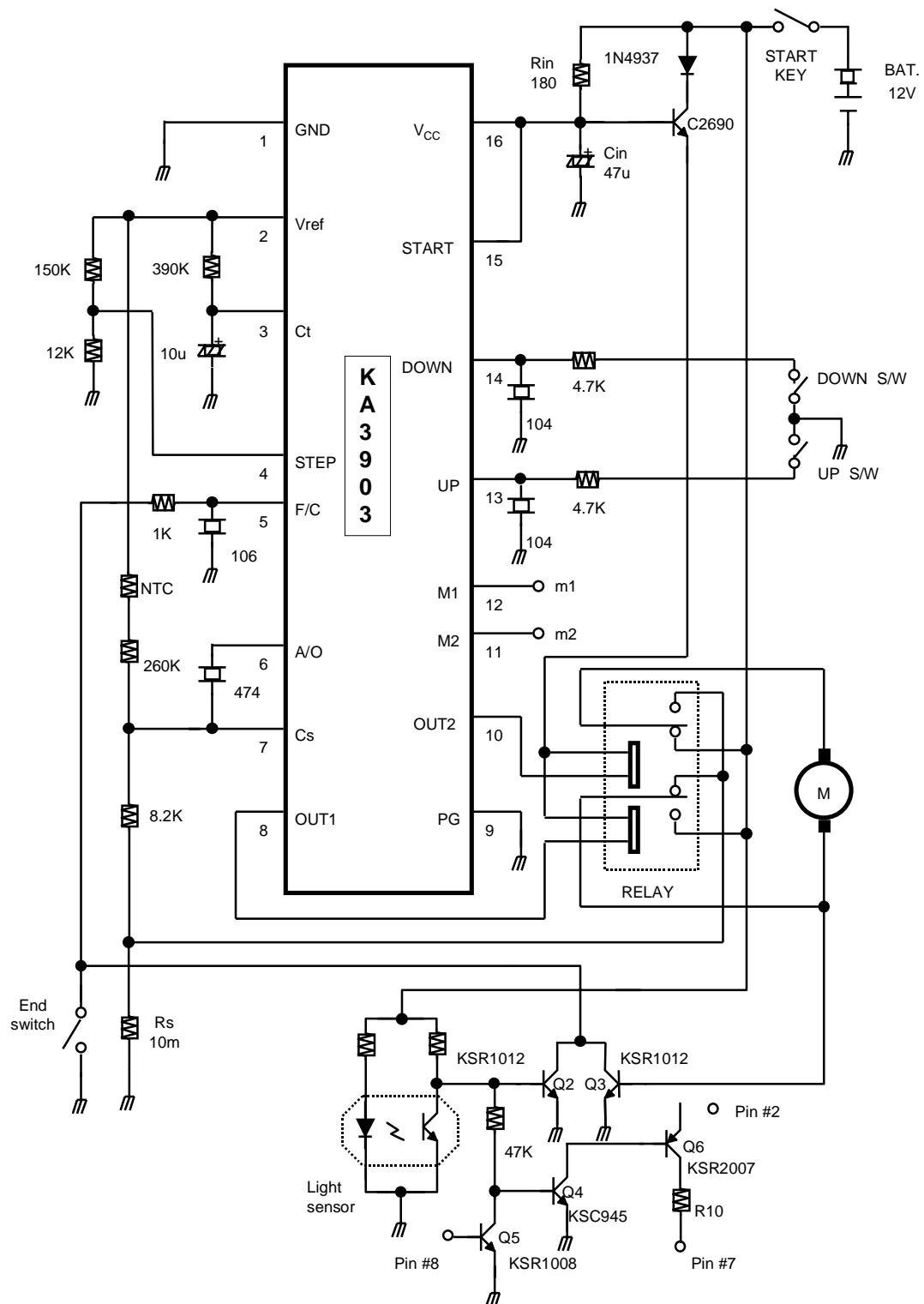
## APPLICATION CIRCUIT - I



## APPLICATION CIRCUIT - II



## APPLICATION CIRCUIT - III



## PACKAGE DIMENSIONS (Unit : mm)

16-DIP-300A

