

# HA16103PJ

## Voltage Regulator Control IC for Microcomputer Systems

The HA16103PJ monolithic voltage control is designed for microcomputer systems. In addition to voltage regulator, it includes watch dog timer function, power on reset function, and output voltage monitor function.

It is suitable for battery used microcomputer systems.

### Functions

- 5 V Regulated power supply
- Power on reset pulse generator
- Watch dog timer
- Low voltage inhibit protection

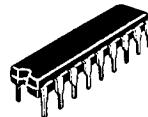
### Features

- Wide operational supply voltage range ( $V_{CC} = 6$  to 40 V)
- Various control signals are generated when microcomputer system runaway occurs. ( $\overline{NMI}$  signal and  $\overline{STBY}$  signal are generated by detecting voltage level, and  $\overline{RES}$  signal is generated by monitoring the time after  $\overline{NMI}$  signal is detected)
- Regulated voltage,  $\overline{NMI}$  detecting voltage,  $\overline{STBY}$  detecting voltage are adjustable.
- At low voltage and re-start, the delay time of  $\overline{RES}$  signal is adjustable
- Watchdog timer filtering uses the minimum clock input pulse width and maximum cycle detection method

### Ordering Information

| Type No.  | Package |
|-----------|---------|
| HA16103PJ | DP-18   |

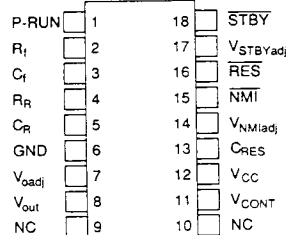
HA16103PJ



(DP-18)

### Pin Arrangement

HA16103PJ



(Top View)



## Block Diagram

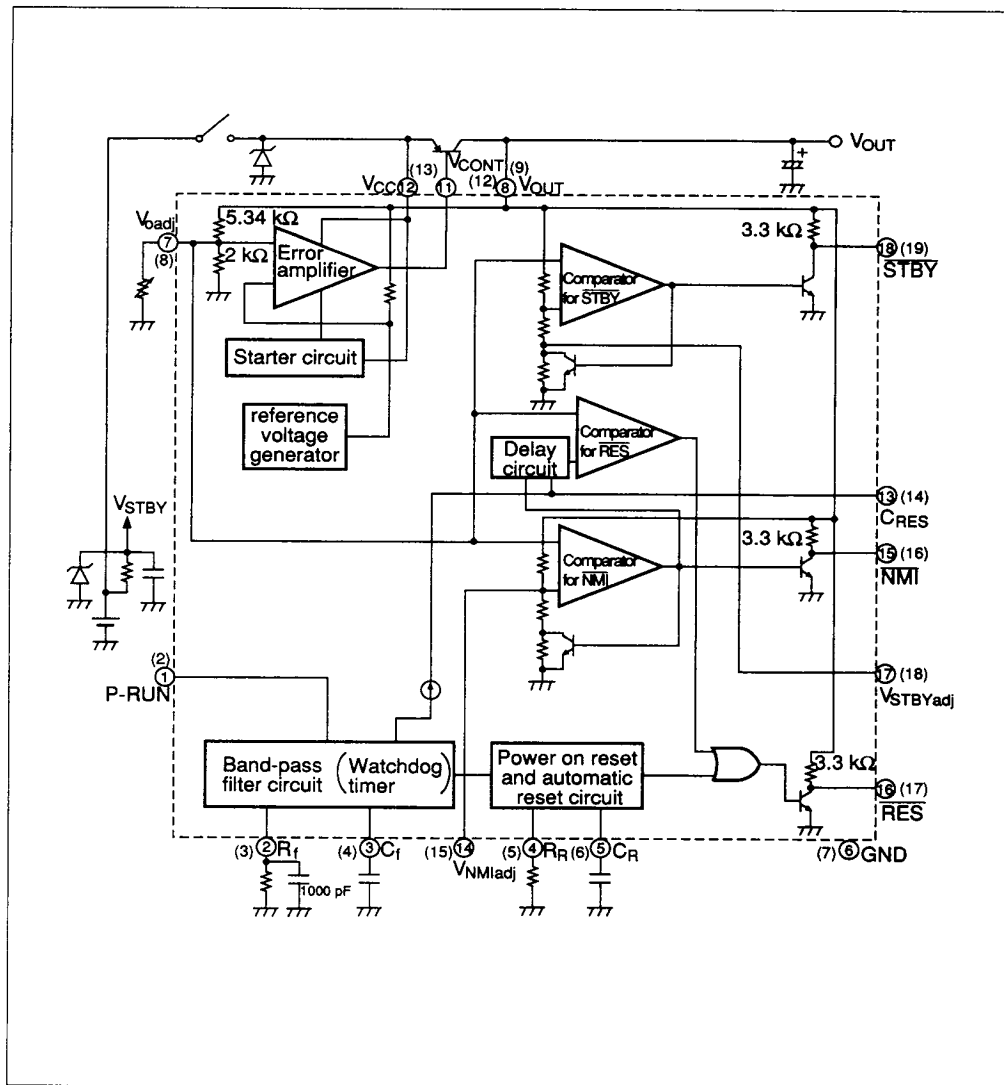


Table 1 Pin Functions

| Pin Name No. | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | P-RUN P-RUN signal input pin for watchdog timer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 2            | R <sub>f</sub> Connect resistor R <sub>f</sub> . Frequency bandwidth of the filter circuit depends on R <sub>f</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 3            | C <sub>f</sub> Connect resistor C <sub>f</sub> . Frequency bandwidth of the filter circuit depends on C <sub>f</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4            | R <sub>R</sub> Connect resistor R <sub>R</sub> . Reset-signal power-on time depends on R <sub>R</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 5            | C <sub>R</sub> Connect resistor C <sub>R</sub> . Reset-signal power-on time depends on C <sub>R</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 6            | GND Ground                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 7            | V <sub>oadj</sub> 5-V reference voltage fine-tuning pin. Connect a resistor between this pin and GND. The value of output voltage is given by<br>$V_{out} = \{1 + 5.34 / (R1 // 2.0)\} \times V_{oadj}$ Unit for R1: k $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 8            | V <sub>out</sub> Connect the collector of an external PNP-type transistor. The pin supplies 5-V regulated voltage for internal circuit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 9            | NC NC pin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 10           | NC NC pin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 11           | V <sub>CONT</sub> The external PNP-type transistor's base control pin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 12           | V <sub>CC</sub> Supply voltage pin. Operating supply voltage range is 6.0 to 40 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 13           | C <sub>RES</sub> If the voltage of V <sub>out</sub> pin declines to less than Detection voltage(1) (because of an instant power cut or other cause), $\overline{NMI}$ signals are generated. If $t_{RES} \approx 0.5 \cdot R_f \cdot C_{RES}(\text{sec})$ has passed since then, $\overline{RES}$ signals are generated. If the voltage of V <sub>out</sub> pin inclines to more than Detection voltage(1) (in case of re-start from LVI state), $\overline{NMI}$ signals are stop. $t_r \approx 0.5 \cdot R_f \cdot C_{RES}(\text{sec})$ has passed since then, $\overline{RES}$ signals are stop. Connect capacitor C <sub>RES</sub> between this pin and GND to adjust the $\overline{RES}$ signals delay time( $t_{RES}$ , $t_r$ ). If delay time is unnecessary, make this pin open ( $t_{RES} = 2 \mu\text{s}$ typ. $t_r = 10 \mu\text{s}$ typ. at open) |
| 14           | V <sub>NMIadj</sub> $\overline{NMI}$ detection voltage fine-tuning pin. Connect a resistor between this pin and V <sub>out</sub> pin or GND. The value of output voltage is given by<br>$V_{NMI} = \{1 + (R2 // 25.5) / (R3 // 10.6)\} \times V_{NMIadj}$ Unit for R2, R3: k $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 15           | $\overline{NMI}$ $\overline{NMI}$ signal output pin. Connect to pin $\overline{NMI}$ of the microcomputer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 16           | $\overline{RES}$ $\overline{RES}$ signal output pin. Connect to pin $\overline{RES}$ of the microcomputer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 17           | V <sub>STBYadj</sub> $\overline{STBY}$ detection voltage tuning pin. Connect a resistor between this pin and V <sub>out</sub> or GND. The value of output voltage is given by<br>$V_{STBY} = 1.89 \times \{1 + 21 / (7.9 + 8.85 // R4)\} \times V_{STBYadj}$ Unit for R4: k $\Omega$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 18           | $\overline{STBY}$ $\overline{STBY}$ signal output pin. Connect to pin $\overline{STBY}$ of the microcomputer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

## Functional Description

### Stabilized Power Supply Function

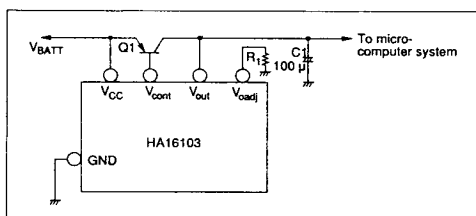
The stabilized power supply includes the following features:

- Wide range of operating input voltage from 6 V to 40 V to provide stabilized voltages
- Availability of any output current, by simply replacing the external transistor
- Fine adjustment of output voltage

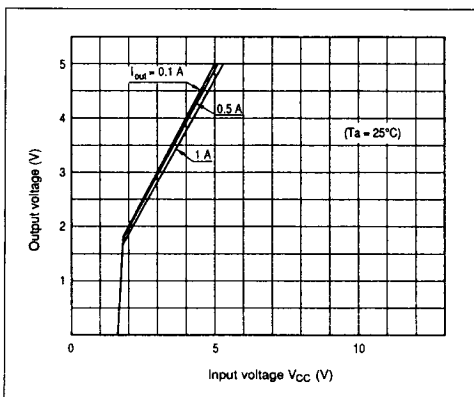
Figure 1 shows the fine adjustment circuit of the output circuit. Select the resistor R1 as shown in equation 1.

Add a resistor between GND and V<sub>oadj</sub> to increase the output voltage.

$$R1 = 1 / \{0.187(V_{out}/V_{oadj} - 1) - 0.5\} \quad \text{Equation 1}$$



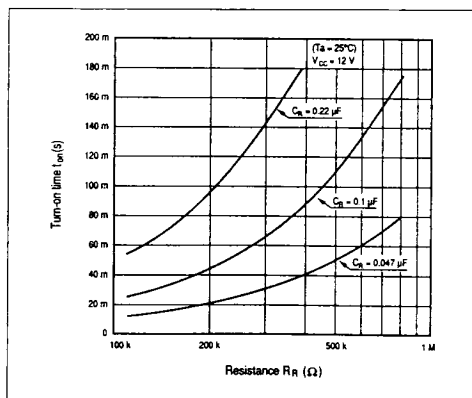
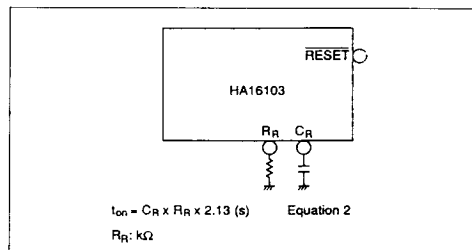
**Figure 1** Fine Adjustment Circuit of Output Voltage



**Figure 2** Output Voltage Characteristic

### Power-On Reset Function

The system contains the power-on reset function required when a microcomputer is turned on. The reset period may be set with external components R<sub>R</sub> and C<sub>R</sub>. Equation 2 specifies how to determine the reset period (ton) and figure 3 shows the characteristic of the circuit.



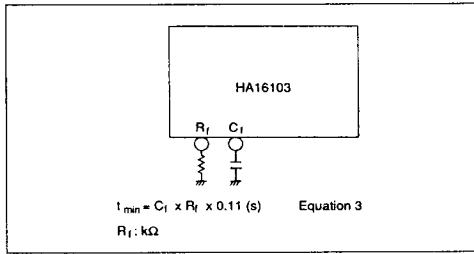
**Figure 3** Characteristic of Power-On Reset Circuit

### Watchdog Timer Function

The system contains a bandpass filter for pulse width detection, which outputs a reset pulse when input pulses are not at the preselected frequency (at either a higher or lower frequency).

The RC characteristic of the bandpass filter may be set with external components R<sub>f</sub> and C<sub>f</sub>. Equation 3 specifies how to determine the minimum pulse width (tmin) for runaway detection of the bandpass filter, (and figure 4 shows the characteristic of the filter.)





### Low Voltage Monitoring Function

The system contains a circuit to send a control signal to the microcomputer when the output voltage drops. The circuit includes the following features.

- Two-point monitoring of output voltage (Vth1 and Vth2)
- Availability of fine adjustment of Vth1 (VNM1) and Vth2 (VSTBY)
- Output of control signal in standby mode of microcomputer

Figure 5 shows the timing chart of control signals when the output voltage drops.

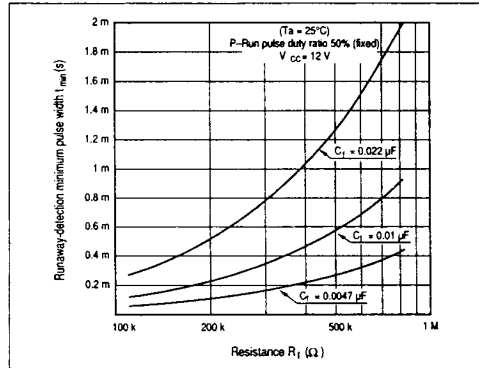


Figure 4 Characteristic of Power-On Reset Circuit

If the output voltage drops below Vth1 (4.60 V), the  $\overline{\text{NMI}}$  signal rises to request the microcomputer to issue the  $\overline{\text{NMI}}$  interrupt signal. The  $\overline{\text{RESET}}$  signal falls  $t_{\text{RES}}$  seconds after the  $\overline{\text{NMI}}$  signal rises. If the output voltage drops further to below Vth2 (3.2 V), the  $\overline{\text{STBY}}$  signal rises to enable the microcomputer to enter standby mode.

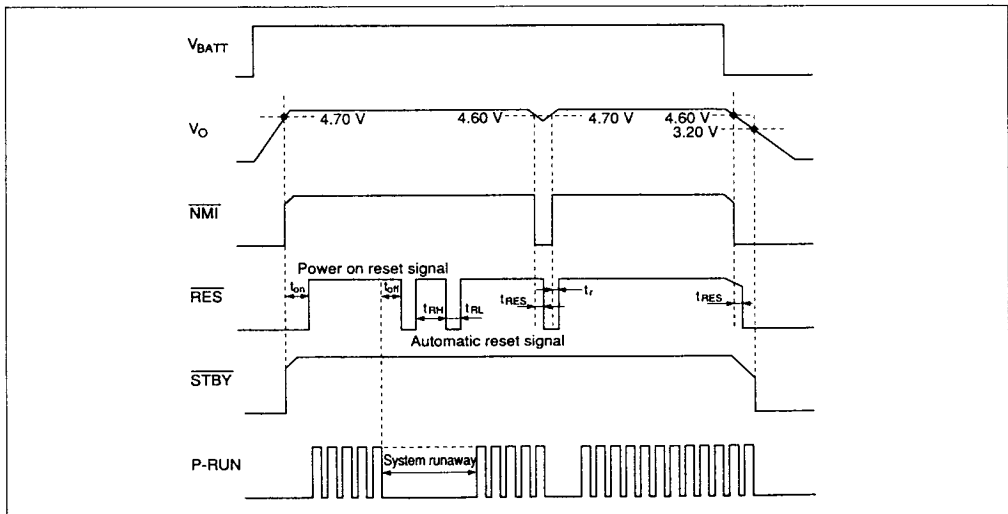


Figure 5 Timing Chart for Low Voltage Monitoring



Table 2 Absolute Maximum Ratings (Ta = 25°C)

| Item                                | Symbol            | Ratings     |       |
|-------------------------------------|-------------------|-------------|-------|
|                                     |                   | HA16103PJ   | Units |
| V <sub>CC</sub> supply voltage      | V <sub>CC</sub>   | 40          | V     |
| Control pin voltage                 | V <sub>CONT</sub> | 40          | V     |
| Control pin current                 | I <sub>CONT</sub> | 20          | mA    |
| V <sub>OUT</sub> pin voltage        | V <sub>OUT</sub>  | 12          | V     |
| Power dissipation                   | P <sub>T</sub>    | 400*        | mW    |
| Operating ambient temperature range | Topr              | −40 to +85  | °C    |
| Storage temperature range           | Tstg              | −50 to +125 | °C    |

The absolute maximum ratings are limiting values, to be applied individually, beyond which the device may be permanently damaged. Functional operation under any of these conditions is not guaranteed. Exposing a circuit to its absolute maximum rating for extended periods of time may affect the device's reliability.

- \* Value under Ta ≤ 77°C. If Ta is greater, 8.3 mW/°C derating occurs.
- \*\* Allowable temperature of IC junction part, Tj (max.), is as shown below.  
 $Tj (max.) = \theta j-a \cdot Pc (max.) + Ta$   
 (θj-a is thermal resistance value during mounting, and Pc (max.) is the maximum value of IC power dissipation.)  
 Therefore, to keep Tj (max.) ≤ 125°C, wiring density and board material must be selected according to the board thermal conductivity.  
 Be careful that the value of Pc (max.) does not exceed that P<sub>T</sub>.

**Table 3 Electrical Characteristics** ( $T_a = 25^\circ\text{C}$ ,  $V_{DD} = 12\text{ V}$ ,  $V_{out} = 5\text{ V}$ )

| Items          |                                              | Symbols               | Min  | Typ                      | Max  | Units                | Test Conditions                                                                                 |
|----------------|----------------------------------------------|-----------------------|------|--------------------------|------|----------------------|-------------------------------------------------------------------------------------------------|
| Regulator      | Supply current                               | $I_{CCL}$             | —    | 8                        | 12   | mA                   | $V_{CC} = 12\text{ V}$                                                                          |
|                | Output voltage                               | $V_{O1}$              | 4.80 | 5.00                     | 5.20 | V                    | $V_{CC} = 6\text{ to }17.5\text{ V}$<br>$I_{OUT} = 0.5\text{ A}$ ,<br>$R_1 = 30\text{ k}\Omega$ |
|                |                                              | $V_{O2}$              | 4.70 | 5.00                     | 5.30 | V                    | $V_{CC} = 6\text{ to }17.5\text{ V}$<br>$I_{OUT} = 1\text{ A}$ , $R_1 = 30\text{ k}\Omega$      |
|                | Line regulation                              | $V_{oline}$           | -50  | —                        | 50   | mV                   | $V_{CC} = 6\text{ to }17.5\text{ V}$<br>$I_{out} = 1\text{ A}$ , $R_1 = 30\text{ k}\Omega$      |
|                | Load regulation                              | $V_{oload}$           | -100 | —                        | 100  | mV                   | $I_{out} = 10\text{ mA to }1.5\text{ A}$ ,<br>$R_1 = 30\text{ k}\Omega$                         |
|                | Ripple rejection                             | $R_{REJ}$             | 45   | 75                       | —    | dB                   | $V_i = 0.5\text{ Vrms}$ ,<br>$f_i = 1\text{ kHz}$ , $R_1 = 30\text{ k}\Omega$                   |
|                | Output voltage<br>Temperature<br>coefficient | $\delta V_o/\delta T$ | —    | 0.6                      | —    | mV/ $^\circ\text{C}$ | $V_{CC} = 12\text{ V}$ , $R_1 = 30\text{ k}\Omega$                                              |
| Clock<br>input | "L"-input voltage                            | $V_{IL}$              | —    | —                        | 0.8  | V                    |                                                                                                 |
|                | "H"-input voltage                            | $V_{IH}$              | 2.0  | —                        | —    | V                    |                                                                                                 |
|                | "L"-input current                            | $I_{IL}$              | -120 | -60                      | —    | $\mu\text{A}$        | $V_{IL} = 0\text{ V}$                                                                           |
|                | "H"-input current                            | $I_{IH}$              | —    | 0.3                      | 0.5  | mA                   | $V_{IH} = 5\text{ V}$                                                                           |
| NMI<br>output  | NMI pin<br>"L"-level voltage                 | $V_{OL1}$             | —    | —                        | 0.4  | V                    | $I_{OL1} = 2\text{ mA}$                                                                         |
|                | NMI pin<br>"H"-level voltage                 | $V_{OH1}$             | —    | $V_{O1}$<br>( $V_{O2}$ ) | —    | V                    |                                                                                                 |
|                | NMI function start<br>$V_{out}$ voltage      | $V_{NMI}$             | —    | 0.7                      | 1.4  | V                    |                                                                                                 |
| STBY<br>output | STBY pin<br>"L"-level voltage                | $V_{OL2}$             | —    | —                        | 0.4  | V                    | $I_{OL2} = 2\text{ mA}$                                                                         |
|                | STBY pin<br>"H"-level voltage                | $V_{OH2}$             | —    | $V_{O1}$<br>( $V_{O2}$ ) | —    | V                    |                                                                                                 |
|                | STBY function start<br>$V_{out}$ voltage     | $V_{STBY}$            | —    | 0.7                      | 1.4  | V                    |                                                                                                 |



Table 3 Electrical Characteristics (Ta = 25°C, VDD = 12 V, Vout = 5 V) (Cont)

| Items                  |                                       | Symbols    | Min  | Typ                      | Max  | Units         | Test Conditions                                                                                                             |
|------------------------|---------------------------------------|------------|------|--------------------------|------|---------------|-----------------------------------------------------------------------------------------------------------------------------|
| RES output             | RES pin "L"-level voltage             | $V_{OL3}$  | —    | —                        | 0.4  | V             | $I_{OL3} = 2\text{ mA}$                                                                                                     |
|                        | RES pin "H"-level voltage             | $V_{OH3}$  | —    | $V_{O1}$<br>( $V_{O2}$ ) | —    | V             |                                                                                                                             |
|                        | RES function start Vout voltage       | $V_{RES}$  | —    | 0.7                      | 1.4  | V             |                                                                                                                             |
|                        | Power on time                         | $t_{ON}$   | 25   | 40                       | 60   | ms            | $R_f = 180\text{ k}\Omega$ , $R_R = 180\text{ k}\Omega$<br>$C_f = 0.01\text{ }\mu\text{F}$ , $C_R = 0.1\text{ }\mu\text{F}$ |
|                        | Clock off reset time                  | $t_{OFF}$  | 80   | 130                      | 190  | ms            |                                                                                                                             |
|                        | Reset pulse "L"-level time            | $t_{RL}$   | 15   | 20                       | 30   | ms            | $R_f = 180\text{ k}\Omega$ , $R_R = 180\text{ k}\Omega$<br>$C_f = 0.01\text{ }\mu\text{F}$ , $C_R = 0.1\text{ }\mu\text{F}$ |
|                        | Reset pulse "H"-level time            | $t_{RH}$   | 37   | 60                       | 90   | ms            | $R_f = 180\text{ k}\Omega$ , $R_R = 180\text{ k}\Omega$<br>$C_f = 0.01\text{ }\mu\text{F}$ , $C_R = 0.1\text{ }\mu\text{F}$ |
| Low Voltage Protection | Detection voltage(1)                  | $V_{H1}$   | 4.40 | 4.60                     | 4.80 | V             |                                                                                                                             |
|                        | Detection voltage(1) Hysteresis width | $V_{HYS1}$ | 50   | 100                      | 150  | mV            |                                                                                                                             |
|                        | Detection voltage(2)                  | $V_{H2}$   | 2.9  | 3.2                      | 3.5  | V             |                                                                                                                             |
|                        | Detection voltage(2) Hysteresis width | $V_{HYS2}$ | 1.35 | 1.5                      | 1.65 | V             |                                                                                                                             |
|                        | Reset pulse inhibit                   | $t_{RES}$  | —    | 200                      | —    | $\mu\text{s}$ | $C_{RES} = 2200\text{ pF}$                                                                                                  |
|                        | Delay time restart                    | $t_r$      | —    | 200                      | —    | $\mu\text{s}$ | $C_{RES} = 2200\text{ pF}$                                                                                                  |

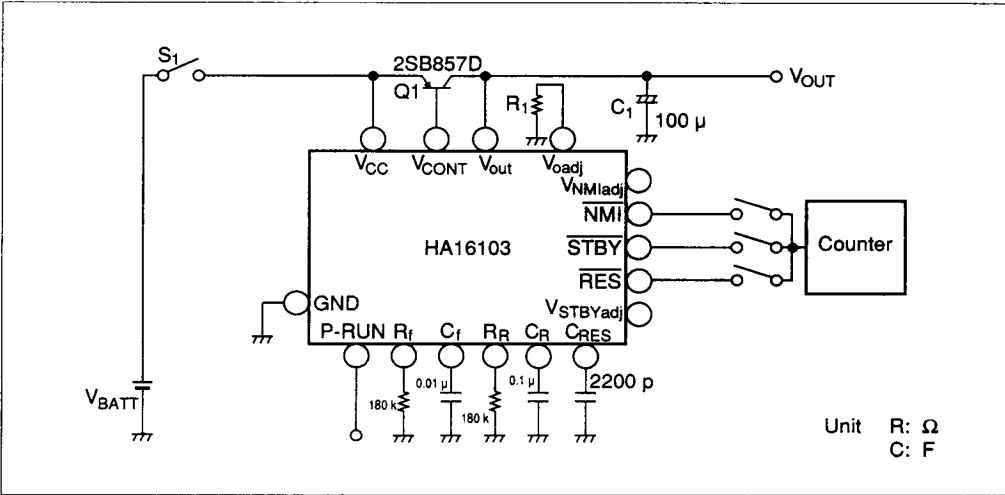


Figure 7 Test Circuit



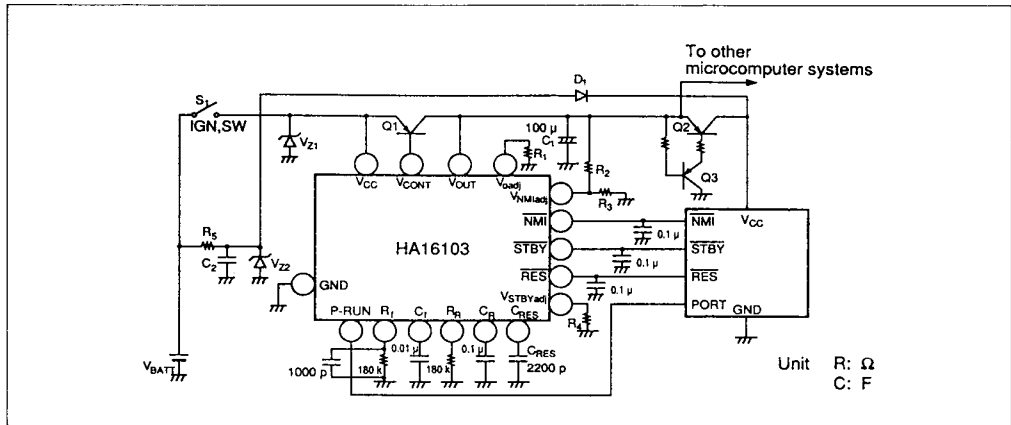


Figure 8 Sample Connection Circuit

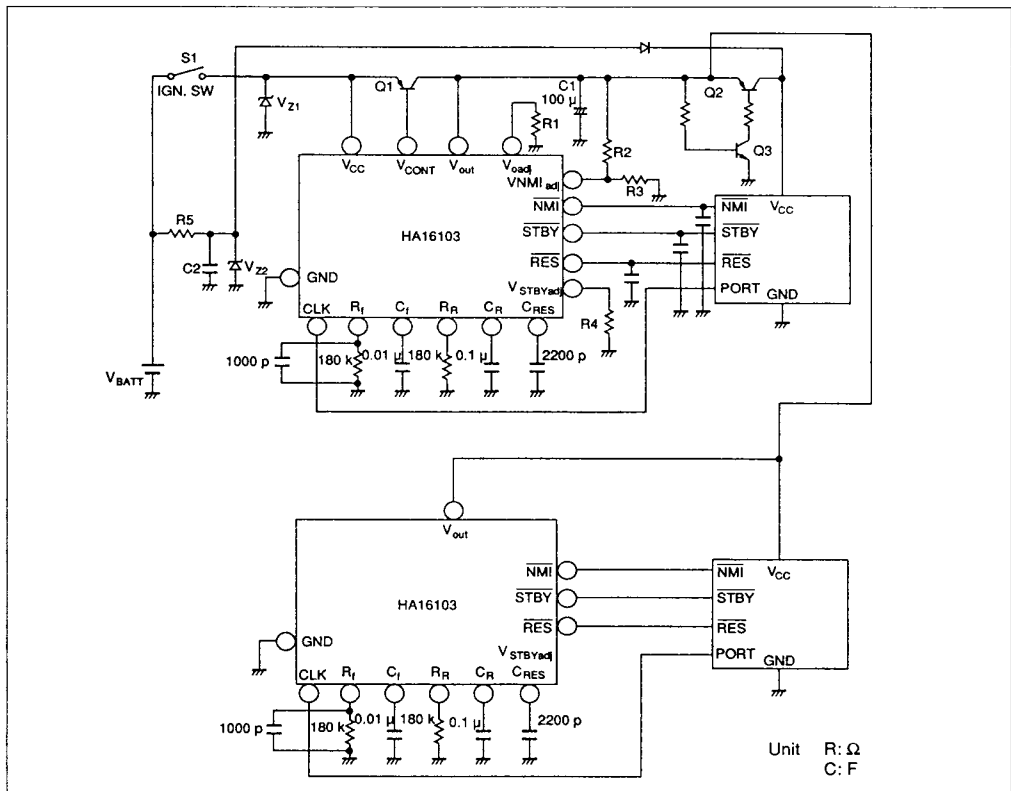


Figure 9 Sample Connection Circuit

