



## Features

- RPM measurement
- VAHZ mode measures frequency in voltage or current mode
- 34MHz Frequency counter
- ADP mode
- Full automatic measurement
  - \* Voltage measurement
  - \* Current measurement
  - \* Resistor measurement
- 3400 count display
- Range change function
- Data hold function
- Diode measurement
- Continuity check
- External reference voltage
- Serial data output (RS232 format)
- Auto power off and re-power on
- Low battery detect (3V and 9V)
- 3V DC power supply
- 100 pin flat package

## Description

ES51972 is an integrated analog-to-digital converter (ADC) with 3400 counts and bar graph LCD display, automatic range selection, and 3V DC power supply. Automatic range selection is provided for voltage (AC/DC) measurement, resistor measurement, current measurement, frequency counter under V/A measurement, frequency counter and RPM measurement. Expensive and bulky mechanical range switches are not required. Other features include data holding, diode measurement, temperature measurement, continuity checking, low battery detection, auto power off, re-power on, and RS232 data output.

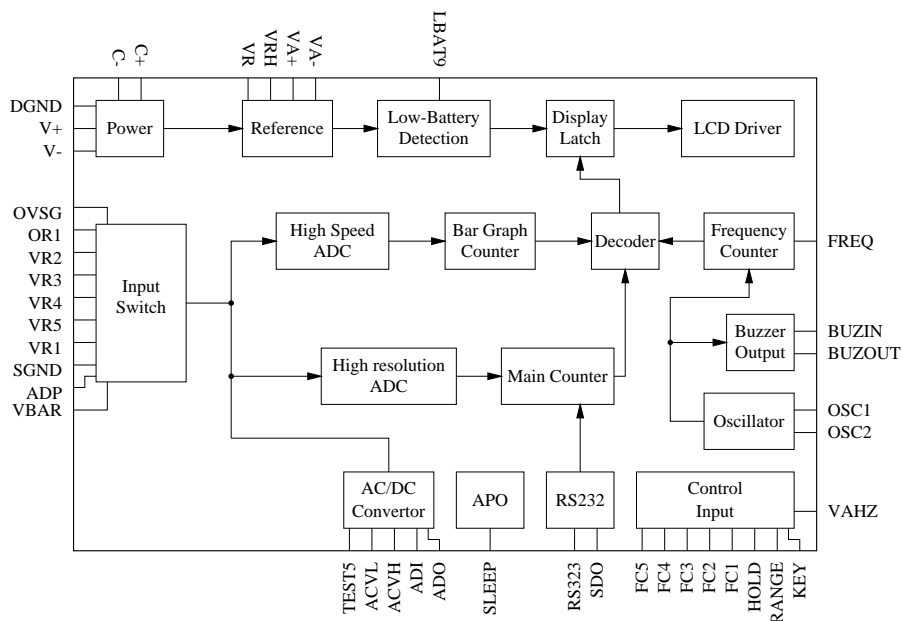
## Application

Digital Multimeter.

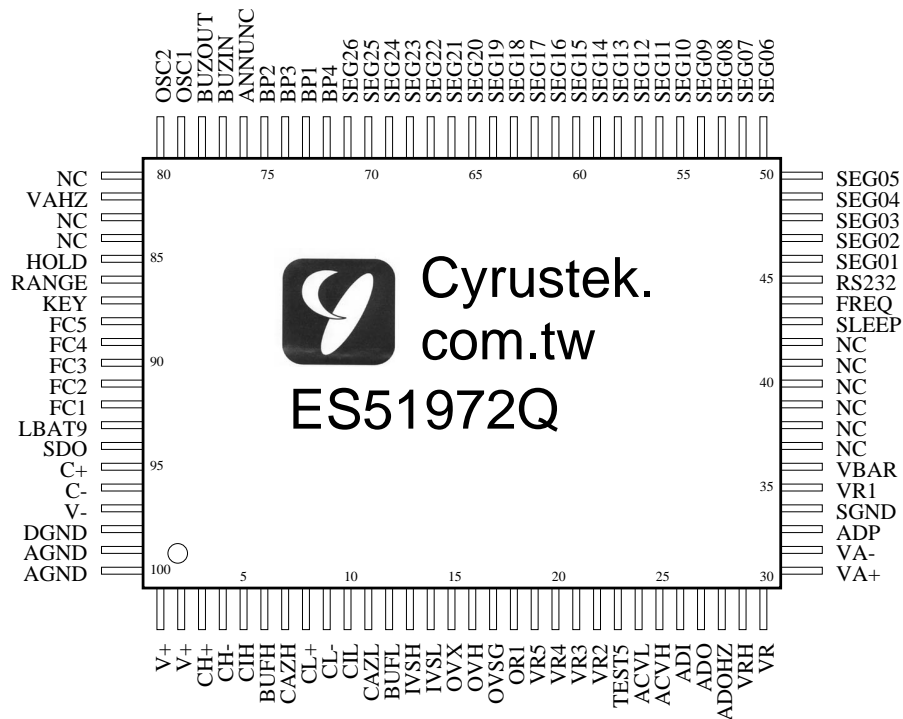
**Taiwan patent: 510,502**



## Block Diagram



## Pin Assignment



## Pin Description



| Pin No. | Symbol | Type | Description  |
|---------|--------|------|--|
| 1       | V+     | P    | Positive supply voltage, output of on-chip DC-DC converter.                          |
| 2       | V+     | P    | Positive supply voltage, output of on-chip DC-DC converter                           |
| 3       | CH+    | IO   | High speed positive connection for reference capacitor.                              |
| 4       | CH-    | IO   | High speed negative connection for reference capacitor.                              |
| 5       | CIH    | O    | High speed integrator output. Connected to integral capacitor.                       |
| 6       | BUFH   | O    | Integration resistor connection for high speed buffer output.                        |
| 7       | CAZH   | O    | High speed auto-zero capacitor connection.   |
| 8       | CL+    | IO   | High resolution positive connection for reference capacitor.                         |
| 9       | CL-    | IO   | High resolution negative connection for reference capacitor.                         |
| 10      | CIL    | O    | High resolution integrator output. Connected to integral capacitor.                  |
| 11      | CAZL   | O    | High resolution auto-zero capacitor connection.                                      |
| 12      | BUFL   | O    | Integral resistor connection for high resolution buffer output.                      |
| 13      | IVSH   | I    | High current measurement input.  |
| 14      | IVSL   | I    | Low current measurement input.   |
| 15      | OVX    | I    | Input high voltage for resistance measurement.                                       |
| 16      | OVH    | I    | Output connection for resistance measurement.  |
| 17      | OVSG   | I    | Sense low voltage for resistance measurement.  |
| 18      | OR1    | O    | Reference resistor connection for 399.9 $\Omega$ range.                              |
| 19      | VR5    | O    | Voltage measurement $\div 10000$ attenuator (3400V.)                                 |
| 20      | VR4    | O    | Voltage measurement $\div 1000$ attenuator (340.0V.)                                 |
| 21      | VR3    | O    | Voltage measurement $\div 100$ attenuator (34.00V.)                                  |
| 22      | VR2    | O    | Voltage measurement $\div 10$ attenuator (3.400V.)                                   |
| 23      | TEST5  | IO   | Testing pin.   |
| 24      | ACVL   | O    | Negative output of AC to DC converter.   |
| 25      | ACVH   | O    | Positive output of AC to DC converter.   |
| 26      | ADI    | I    | Negative input of internal AC to DC OpAmp .  |
| 27      | ADO    | O    | Output of internal AC to DC OpAmp.   |
| 28      | ADOHZ  | I    | Frequency input under voltage/current mode, offset to AGND.                          |
| 29      | VRH    | O    | Output of band-gap voltage reference. Typically -1.2V.                               |
| 30      | VR     | I    | Reference input voltage connection. Typically -100mV.                                |
| 31      | VA+    | I    | For ADP. De-integrating voltage positive input. The input should be higher than VA-. |
| 32      | VA-    | I    | For ADP. De-integrating voltage negative input. The input should be lower than VA+.  |
| 33      | ADP    | I    | ADP Input.   |
| 34      | SGND   | G    | Signal Ground.   |
| 35      | VR1    | I    | Measurement input.   |
| 36      | VBAR   | I    | In ADP mode, if this pin connect to V-, the bar graph will not display.              |
| 37      | NC     | -    | No connection.   |
| 38      | NC     | -    | No connection.   |
| 39      | NC     | -    | No connection.   |
| 40      | NC     | -    | No connection.   |
| 41      | NC     | -    | No connection.   |
| 42      | NC     | -    | No connection.   |
| 43      | SLEEP  | O    | Asserts low in the sleep mode.   |
| 44      | FREQ   | I    | Frequency counter input, offset to $\frac{V-}{2}$ internally by the chip.            |
| 45      | RS232  | I    | Pulse low to enable serial data output.  |

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|---------------------------------|---------------|------|--|
| Pin No.                         | Symbol        | Type | Description  |
| 46 – 71                         | SEG01 – SEG26 | O    | LCD segment line 01 – 26.  |
| 72                              | BP4           | O    | LCD backplane 4.   |
| 73                              | BP1           | O    | LCD backplane 1.   |
| 74                              | BP3           | O    | LCD backplane 3.   |
| 75                              | BP2           | O    | LCD backplane 2.   |
| 76                              | ANNUNC        | O    | Square wave output at the backplane frequency, synchronized to BP1. ANNUNC can be used to control display annunciator. Connect an LCD segment to ANNUNC to turn it on; connect an LCD segment to its backplane to turn it off.                   |
| 77                              | BUZIN         | I    | Enables the buzzer. Low active.  |
| 78                              | BUZOUT        | O    | Outputs an 2KHz audio frequency signal for driving piezoelectric buzzer when BUZIN is low.   |
| 79                              | OSC1          | I    | Crystal oscillator input connection.   |
| 80                              | OSC2          | O    | Crystal oscillator output connection.  |
| 81                              | NC            | –    | No connection.   |
| 82                              | VAHZ          | I    | Pulse low to show the frequency of input signal in V(DC/AC),I(DC/AC.)  |
| 83                              | NC            | –    | No connection.   |
| 84                              | NC            | –    | No connection.   |
| 85                              | HOLD          | I    | Pulse low to enable HOLD mode.   |
| 86                              | RANGE         | I    | Pulse low to enable manual mode and manual range selection.  |
| 87                              | KEY           | I    | Pulse low to change mode. In ADP mode, if this pin is connected to V–, the buzzer output will be off when the ADP input overflows.   |
| 88                              | FC5           | I    | Switch 5 for function selection.   |
| 89                              | FC4           | I    | Switch 4 for function selection.   |
| 90                              | FC3           | I    | Switch 3 for function selection.   |
| 91                              | FC2           | I    | Switch 2 for function selection.   |
| 92                              | FC1           | I    | Switch 1 for function selection.   |
| 93                              | LBAT9         | I    | Low battery configuration. If 3V battery is used, connect it to AGND. The default low-battery threshold voltage is –2.3V. If 9V battery is used, the low battery annunciator is displayed when the voltage of this pin is less than VRH (–1.2V). |
| 94                              | SDO           | O    | RS232 compliant serial data output.  |
| 95                              | C+            | O    | Positive capacitor connection for on-chip DC-DC converter.   |
| 96                              | C–            | O    | Negative capacitor connection for on-chip DC-DC converter.   |
| 97                              | V–            | P    | Negative supply voltage. Connecting to battery negative terminal.  |
| 98                              | DGND          | G    | Digital ground, connected to battery positive terminal.  |
| 99                              | AGND          | G    | Analog ground.   |
| 100                             | AGND          | G    | Analog ground.   |



## Absolute Maximum Ratings

| Characteristic                  | Rating                       |
|---------------------------------|------------------------------|
| Supply Voltage (V- to AGND)     | -4V                          |
| Analog Input Voltage            | V- - 0.6 to V+ + 0.6         |
| V+                              | V+ $\geq$ (AGND/DGND + 0.5V) |
| AGND/DGND                       | AGND/DGND $\geq$ (V- - 0.5V) |
| Digital Input                   | V- - 0.6 to DGND + 0.6       |
| Power Dissipation, Flat Package | 500mW                        |
| Operating Temperature           | 0°C to 70°C                  |
| Storage Temperature             | -40°C to 125°C               |

## Electrical Characteristics

$T_A = 25^\circ\text{C}, V_- = -3\text{V}$

| Parameter   | Symbol    | Test Condition  | Min.  | Typ.      | Max.      | Units                 |
|---|-----------|---|-------|-----------|-----------|-----------------------|
| Power supply  | V-        |   | -3.5  | -3.0      | -2.2      | V                     |
| Operating supply current in DCV mode                                    | $I_{DD}$  | Normal operation  | -     | 1.2       | 1.7       | mA                    |
|   | $I_{SS}$  | In sleep mode   | -     | 0.1       | 5         | $\mu\text{A}$         |
| Voltage roll-over error   | REV       | 10M $\Omega$ input resistor   | -     | -         | $\pm 0.1$ | %F.S. <sup>1</sup>    |
| Bar graph roll-over error   | REB       |   | -     | -         | $\pm 0.5$ | %F.S.                 |
| Voltage nonlinearity  | NLV       | Best case straight line   | -     | -         | $\pm 0.1$ | %F.S.                 |
| Bar graph nonlinearity  | NLB       |   | -     | -         | $\pm 0.5$ | %F.S.                 |
| Input leakage   |           |   | -10   | 1         | 10        | pA                    |
| Low battery flag voltage  |           | V- to AGND  | -2.5  | -2.3      | -2.1      | V                     |
| Zero input reading  |           | 10M $\Omega$ input resistor   | -000  | 000       | +000      | counts                |
| Reference voltage and open circuit voltage for 400 $\Omega$ measurement | $V_{REF}$ | 100K $\Omega$ resistor between VRH and AGND   | -1.3  | -1.2      | -1.1      | V                     |
| Peak to peak backplane drive voltage                                    |           | $-3.5 \leq V_- \leq -2.2$   | 3.00  | 3.2       | 3.40      | V                     |
| Counter time base period  |           | $f_{osc} = 4\text{MHz}$   | -     | 1         | -         | sec.                  |
| Open circuit voltage for $\Omega$ measurement (except 400 $\Omega$ )    |           | $\Omega$ and Continuity mode  | -0.54 | -0.47     | -0.4      | V                     |
| Internal pull-high to 0V current  |           | Between V-pin and HOLD, RANGE, KEY, FC1, FC2, FC3, FC4, FC5, VAHZ                             | -     | 1.2       | -         | $\mu\text{A}$         |
|   |           | Between V-pin and RS232   | -     | 11        | -         |                       |
| AC frequency response at 4.000V range                                   |           | $\pm 1\%$ error   | -     | 40 - 650  | -         | Hz                    |
|   |           | $\pm 5\%$ error   | -     | 40 - 2700 | -         |                       |
| Reference voltage temperature coefficient                               | $TC_{RF}$ | 100K $\Omega$ resistor Between VRH and AGND, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ | -     | 50        | -         | ppm/ $^\circ\text{C}$ |
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|---------------------------------|--------|----------------|------|------|------|--------|
| Parameter                       | Symbol | Test Condition | Min. | Typ. | Max. | Units  |
| RPM Measurement                 |        |                | –    | ±3   | –    | counts |

**Note:**

1. Full Scale

## Functional Description

### 1 Operating Modes

#### 1.1 Voltage Measurement

A reconfigurable voltage divider automatically provides a suitable full scale range in voltage measurement mode. The following table summarizes the full scale ranges in each configuration.

| Configuration    | Full Scale Range | Divider Ratio     | Resistor Connection   |
|------------------|------------------|-------------------|-----------------------|
| VR1 <sup>1</sup> | 340.0mV          | 1                 | –                     |
| VR2              | 3.400V           | $\frac{1}{10}$    | $\frac{R_2}{R_1+R_2}$ |
| VR3              | 34.00V           | $\frac{1}{100}$   | $\frac{R_3}{R_1+R_3}$ |
| VR4              | 340.0V           | $\frac{1}{1000}$  | $\frac{R_4}{R_1+R_4}$ |
| VR5              | 3400V            | $\frac{1}{10000}$ | $\frac{R_5}{R_1+R_5}$ |

**Note:** For DC measurement only.

#### 1.2 Resistance Measurement

A reconfigurable voltage divider automatically provides a suitable full scale range in resistance measurement mode. The following table summarizes the full scale ranges and the reference resistors in each configuration.

| Configuration | Full Scale Range | Reference Resistor  | Recommended Value |
|---------------|------------------|---------------------|-------------------|
| OR1           | 340.0Ω           | $R_6$               | 100Ω              |
| OR2           | 3.400KΩ          | $R_5$               | 1KΩ               |
| OR3           | 34.00KΩ          | $R_4$               | 10KΩ              |
| OR4           | 340.0KΩ          | $R_1 \parallel R_3$ | 100KΩ             |
| OR5           | 3.400MΩ          | $R_1 \parallel R_2$ | 1MΩ               |
| OR6           | 34.00MΩ          | $R_1$               | 10MΩ              |

#### 1.3 Current Measurement

Current measurement has three modes. The following table summarizes the full scale range of each mode.

| Mode             | Range Selection | Full Scale      |
|------------------|-----------------|-----------------|
| Automatic Mode 1 | μA              | 340.0μA 3400μA  |
| Automatic Mode 2 | mA              | 34.00mA 340.0mA |
| Manual Mode      | A               | 34.00A          |

#### 1.4 Continuity Check

Continuity check mode shares the same configuration with 340.0Ω manual resistance measurement mode, but with buzzer output to indicate continuity. The buzzer generates a 2KHz sound whenever the test is less than 35Ω.



## 1.5 Diode Measurement

Diode measurement mode shares the same configuration with 3.400V manual voltage measurement mode. If the test circuit is open or the voltage drop between the two ports of the device (diode) under test is larger than 2 V, the LCD panel will show "OL". If the test is less than 0.25V, the chip generates a 2KHz beep.

## 1.6 Frequency Counter

The time base of the frequency counter is derived from an external crystal oscillator by

$$T_{counter} = \frac{4,000,000}{f_{osc}},$$

where  $f_{osc}$  is the frequency of the crystal oscillator. Thus, the counter will operate with a 1 second time base when a 4 MHz oscillator is used. The frequency counter can select the proper range automatically or manually. Auto-range operation extends over five decades, from 3.400KHz to 34.00MHz. The following table summarizes the full scale range of the frequency counter.

| Range | Full Scale |
|-------|------------|
| FR1   | 3.400KHz   |
| FR2   | 34.00KHz   |
| FR3   | 340.0KHz   |
| FR4   | 3.400MHz   |
| FR5   | 34.00MHz   |

## 1.7 RPM Measurement

Like the frequency measurement mode, the counter will operate with a 1-second time base. The following table summarizes the full scale range of RPM measurement mode.

| Range | Full Scale |
|-------|------------|
| RP1   | 34.00KRPM  |
| RP2   | 340.0KRPM  |
| RP3   | 3.400MRPM  |
| RP4   | 34.00MRPM  |
| RP5   | 340.0MRPM  |

## 1.8 Auto Power Off

ES51972 has a default auto power off function. If the meter idles for more than 10 minutes, the chip automatically turns the power off. When this happens, the state of the meter is saved. In order to disable auto power off function, power on the meter when any of the push function, except for HOLD, is pressed down. IN addition, when RS232 output is activated, the auto power off function is also disabled. The APO sign on the LCD panel indicates whether the auto power-off function is enabled or not.

**Note:** Powering on the meter while pressing HOLD turns on all LCD segment until HOLD is pressed again.

## 1.9 Sleep

The meter enters sleep mode after auto power off. The SLEEP pin asserts low (-3V) in the sleep mode, and asserts high (+3V, not 0V) after re-power on.



### 1.10 Re-power On

Pushing any of the push function or changing the rotary mode after auto power off can turn on the meter again. If the meter is re-powered on by changing the rotary mode, or if the meter is in the logic measurement mode, the saved state is cleared. If the meter is re-powered on by push functions, the chip restores the saved state and enters HOLD mode. The LCD displays the saved value.

## 2 Measurement Mode Switching

Measurement mode depends on the logic level of FC1, FC2, FC3, FC4, FC5, and KEY. When FC5 is HIGH, the measurement modes are listed in the following table.

| FC1 | FC2 | FC3 | FC4 | Mode                           | Function of KEY   |
|-----|-----|-----|-----|--------------------------------|---|
| 1   | 0   | 1   | 1   | Voltage Measurement            | DCV $\longleftrightarrow$ ACV   |
| 1   | 1   | 0   | 1   | Current Measurement ( $\mu$ A) | DCA $\longleftrightarrow$ ACA   |
| 1   | 0   | 0   | 1   | Current Measurement (mA)       | DCA $\longleftrightarrow$ ACA   |
| 1   | 1   | 1   | 1   | Current Measurement (A)        | DCA $\longleftrightarrow$ ACA   |
| 0   | 0   | 1   | 1   | Resistance Measurement         | $\Omega$ $\longleftrightarrow$ Continuity                             |
| 0   | 1   | 0   | 1   | Resistance Measurement         | $\Omega$ $\longleftrightarrow$ Diode                                  |
| 0   | 1   | 1   | 1   | Continuity Check               | Continuity $\longleftrightarrow$ Diode                                |
| 0   | 0   | 0   | 1   | Resistance Measurement         | $\Omega$ $\longleftrightarrow$ Continuity $\longleftrightarrow$ Diode |
| 0   | 0   | 1   | 0   | Frequency Measurement          | Frequency $\longleftrightarrow$ RPM                                   |
| 0   | 1   | 0   | 0   | Temperature ( $^{\circ}$ C)    | —   |

When FC5 is LOW, KEY is disable. The corresponding measurement modes are listed below.

| FC1 | FC2 | FC3 | FC4 | Mode                                      |
|-----|-----|-----|-----|---|
| 1   | 0   | 1   | 1   | AC Voltage Measurement                    |
| 1   | 1   | 0   | 1   | AC Current Measurement ( $\mu$ A)         |
| 1   | 0   | 0   | 1   | AC Current Measurement (mA)               |
| 1   | 1   | 1   | 1   | AC Current Measurement (A)                |
| 0   | 0   | 1   | 1   | Resistance Measurement                    |
| 0   | 1   | 0   | 1   | Resistance Measurement + Continuity Check |
| 0   | 1   | 1   | 1   | Continuity Check                          |
| 0   | 0   | 0   | 1   | Diode Measurement                         |
| 0   | 0   | 1   | 0   | RPM                                       |
| 0   | 1   | 0   | 0   | Temperature ( $^{\circ}$ F)               |

The other combinations of FC1, FC2, FC3, and FC4 are for ADP modes. In ADP modes, if FC5 is LOW, the minus sign on the LCD panel will not be displayed. VBAR controls the bar graph in ADP mode. If VBAR is LOW, the bar graph is not displayed. And if RANGE pin is floating, the buzzer beeps when the input signal is overflow. The ADP mode function is summarized below.

| FC1 | FC2 | FC3 | FC4 | VBAR     | Mode                   |
|-----|-----|-----|-----|----------|------------------------|
| 1   | 1   | 1   | 0   | floating | ADP0                   |
| 1   | 1   | 0   | 0   | floating | ADP1                   |
| 1   | 0   | 0   | 0   | floating | ADP2                   |
| 1   | 0   | 1   | 0   | floating | ADP3                   |
| 1   | 1   | 1   | 0   | LOW      | ADP0 without bar graph |
| 1   | 1   | 0   | 0   | LOW      | ADP1 without bar graph |
| 1   | 0   | 0   | 0   | LOW      | ADP2 without bar graph |
| 1   | 0   | 1   | 0   | LOW      | ADP3 without bar graph |





**Note:** Temperature measurement mode takes input signal from ADP pin. In temperature measurement mode, VBAR pin is used to control the right most digit point on the LCD panel. When VBAR is LOW, this digit point is displayed.

### 3 Push Functions

#### 3.1 HOLD

HOLD mode makes the meter stop updating the LCD panel. This mode can be nested in most of the special modes. Enabling HOLD function in automatic mode makes the meter switch to manual mode, but the full scale range remains the same. HOLD function can be cancelled by changing the measurement mode, pressing RANGE, or push HOLD again.

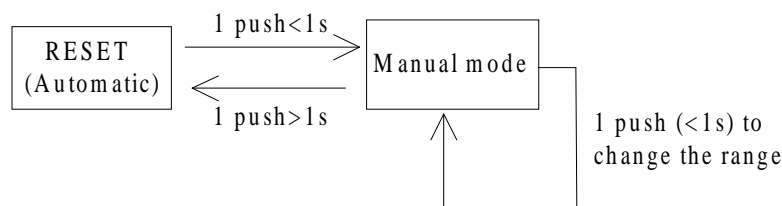
#### 3.2 VAHZ

If VAHZ is pushed in voltage or current measurement mode, the meter enters frequency counter mode with automatic range selection. Therefore, pressing RANGE in VAHZ mode does not change the frequency range. However, RANGE changes the sensitivity of frequency detection. If the input signal has a small amplitude, the user shall increase the sensitivity.

**Note:** Since VAHZ mode is treated as a temporary frequency measurement in voltage or current mode, pressing RANGE in VAHZ mode also changes the full scale range of the original voltage or current mode after VAHZ mode is cancelled.

#### 3.3 RANGE

RANGE pin switches to and from automatic and manual mode, and while in manual mode, changes the full scale range. In VAHZ mode, RANGE is not use to change the full scale frequency range, but change the sensitivity of frequency measurement. The following figure shows the state transition.



| Measurement Mode | Auto      | Manual   | Control Range     | Initial Range |
|------------------|-----------|--|-------------------|---------------|
| DCV              | VR1 – VR5 | VR <sub>i</sub> →<br>VR <sub>i</sub> + 1,<br>VR5 → VR1 | 340.0mV – 3400V   | 340.0mV       |
| ACV              | VR2 – VR5 | VR <sub>i</sub> →<br>VR <sub>i</sub> + 1,<br>VR5 → VR2 | 3.400V – 3400V    | 3.400V        |
| μA (DC/AC)       | R1 – R2   | R1 → R2, R2<br>→ R1                                    | 340.0μA – 3400μA  | 340.0μA       |
| mA (DC/AC)       | R1 – R2   | R1 → R2, R2<br>→ R1                                    | 34.00mA – 340.0mA | 34.00mA       |
| A (DC/AC)        | fixed     | fixed  | 34.00A            | 34.00A        |
| Ω                | OR1 – OR6 | OR <sub>i</sub> →<br>OR <sub>i</sub> + 1,<br>OR6 → OR1 | 340.0Ω – 34.00MΩ  | 340.0Ω        |



| Measurement Mode | Auto      | Manual   | Control Range         | Initial Range |
|------------------|-----------|--|-----------------------|---------------|
| Continuity       | fixed     | fixed  | 340.0Ω                | 340.0Ω        |
| Diode            | fixed     | fixed  | 3.400V                | 3.400V        |
| Frequency        | FR1 – FR5 | FR <sub>i</sub> → FR <sub>i</sub> + 1, FR5 → FR1 | 3.400KHz – 34.00MHz   | 3.400KHz      |
| RPM              | RP1 – RP5 | RP <sub>i</sub> → RP <sub>i</sub> + 1, RP5 → RP1 | 34.00KRPM – 340.0MRPM | 34.00KRPM     |

**Note:** Pushing RANGE resets all existing special modes except for VAHZ mode.

### 3.4 KEY

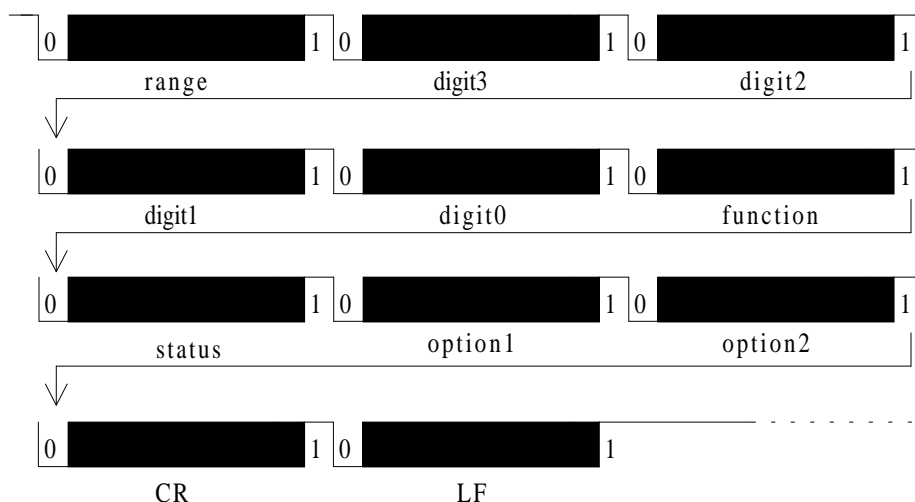
See Section “Measurement Mode Switching” for the function of this pin.

## 4 Serial Data Output

The serial data is sent to SDO pin twice every A/D conversion cycle. The data format complies with JIS 7BIT transmission code with a baud rate of 2400. The host can use RS-232 interface to read the data. A single data packet includes a start bit (always 0), 7 data bits, an odd parity check bit, and a stop bit (always 1). The high and low voltage levels correspond to DGND and V- respectively. SDO remains at 1 (high) when it is inactive. Hence the start bit (0) could be used as the triggering signal to begin the reading process. The following figure shows the data format of a single packet. The LSB is sent first and the MSB is sent last.



One data block consists of 11 packets, or 110 bits. The following figure shows the format of a data block. The range packet indicates the full scale range of the meter. Digit 3 through digit 0 is just the digits on the LCD panel. The function packet indicates the measurement mode of the meter. Status, option 1 and option 2 gives the status of the meter. CR and LF are delimiters used to separate the blocks.



The meter always outputs the current input value to the serial port in spite of HOLD mode. Each block is repeated twice in one conversion cycle. The detailed data format of each packet is listed below.



#### 4.1 FUNCTION

This packet indicates the measurement mode of the meter. The following table summarizes the transmitted code for each mode. Note that the encoding of this packet is different from the encoding of FC1–FC4 switch.

| Code    | Measurement Mode             |
|---------|------------------------------|
| 0111011 | Voltage                      |
| 0111101 | $\mu$ A Current              |
| 0111001 | mA Current                   |
| 0111111 | A Current                    |
| 0110011 | $\Omega$                     |
| 0110101 | Continuity                   |
| 0110001 | Diode                        |
| 0110010 | Frequency / RPM <sup>1</sup> |
| 0110100 | Temperature <sup>2</sup>     |
| 0111110 | ADP0                         |
| 0111100 | ADP1                         |
| 0111000 | ADP2                         |
| 0111010 | ADP3                         |

**Note:**

1. The Judge bit in the Status packet determines whether it is frequency mode or RPM mode.
2. The Judge bit in the Status packet determines whether the unit is Celcius or Fahrenheit.

#### 4.2 RANGE

This packet indicates the full scale range of the meter. When the meter operates in continuity mode, diode mode, or current (A) mode, this packet is always 0110000 since the full scale range in these modes are fixed. The following table lists the code for each range in each measurement mode.

| Code    | V       | mA      | $\mu$ A       | $\Omega$        | Frequency | RPM       |
|---------|---------|---------|---------------|-----------------|-----------|-----------|
| 0110000 | 340.0mV | 34.00mA | 340.0 $\mu$ A | 340.0 $\Omega$  | 3.400KHz  | 34.00KRPM |
| 0110001 | 3.400V  | 340.0mA | 3400 $\mu$ A  | 3.400K $\Omega$ | 34.00KHz  | 340.0KRPM |
| 0110010 | 34.00V  |         |               | 34.00K $\Omega$ | 340.0KHz  | 3.400MRPM |
| 0110011 | 340.0V  |         |               | 340.0K $\Omega$ | 3.400MHz  | 34.00MRPM |
| 0110100 | 3400V   |         |               | 3.400M $\Omega$ | 34.00MHz  | 340.0MRPM |
| 0110101 |         |         |               | 34.00M $\Omega$ |           |           |

#### 4.3 DIGIT 3 – DIGIT 0

Digit 3 is the most significant digit on the LCD panel, and digit 0 is the least significant digit. When the LCD panel shows OL, the serial port outputs 3400.



| Digit | Code    |
|-------|---------|
| 0     | 0110000 |
| 1     | 0110001 |
| 2     | 0110010 |
| 3     | 0110011 |
| 4     | 0110100 |
| 5     | 0110101 |
| 6     | 0110110 |
| 7     | 0110111 |
| 8     | 0111000 |
| 9     | 0111001 |

#### 4.4 STATUS

The format of this packet is shown below. The Judge field is meaningful only when the Function packet indicates Frequency/RPM mode or Temperature mode. In Temperature mode, judge is 1 if the unit is  $^{\circ}C$  and is 0 if the unit is  $^{\circ}F$ . In Frequency/RPM mode, judge is 1 if the meter operates in RPM mode; otherwise, it is 0. Sign field indicates whether the minus sign on the LCD panel is on or off. BATT field is one if battery low condition is true. OL indicates input overflow.

|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 0     | 1     | 1     | Judge | Sign  | BATT  | OL    |
| Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |

#### 4.5 OPTION 1

This packet contains information on VAHZ measurement modes. The least significant bit indicates whether the VAHZ mode is enabled or not.

|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 0     | 1     | 1     | 0     | 0     | 0     | VAHZ  |
| Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |

#### 4.6 OPTION 2

This packet contains information on the operation mode of the meter. The format is shown below. The DC field indicates that the meter operates in DC measurement mode, either voltage or current. The AC field indicates that the meter operates in AC measurement mode. The AUTO field is set to one if the meter operates in automatic mode, and is set to zero when the meter operates in manual mode. The APO field indicates whether auto power off function is enabled or not.

|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 0     | 1     | 1     | DC    | AC    | AUTO  | APO   |
| Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |

#### 4.7 CR

Carrage return. The transmitted code is 0001101.

#### 4.8 LF

Line feed. The transmitted code is 0001010.

### 5 Miscellaneous

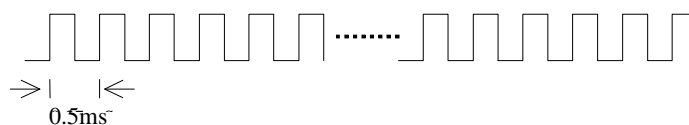
#### 5.1 The Buzzer

The conditions which the meter turns on the buzzer include:

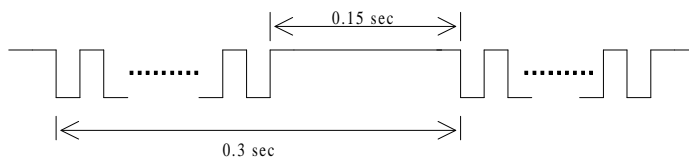


- (1) Changing measurement mode generates one beep.
- (2) Pressing any of the push functions generates one beep, if the function is valid.
- (3) Power on and re-power on generate one beep.
- (4) Input over flow in voltage and current measurement mode generates one beep every 0.3 seconds (or 3.33 beeps per second.)
- (5) Continuity check and diode measurement generate a continuous 2KHz beep whenever the bar graph count is less than 3.
- (6) Auto power off generates a 2KHz beep which lasts for 1.5 seconds.

The following figures shows the output waveform from the BUZOUT pin.



(a) Continuous 2KHz beep



(b) 3.33 beep/sec

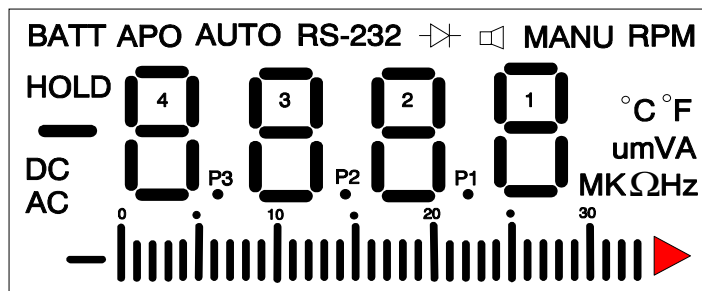


## 5.2 LCD Pin Assignment

|     | SEG1  | SEG2 | SEG3 | SEG4           | SEG5           | SEG6           | SEG7           | SEG8           | SEG9           | SEG10          |
|-----|-------|------|------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| BP1 | bar33 | MANU | m    | 1 <sub>b</sub> | 1 <sub>a</sub> | 1 <sub>f</sub> | 2 <sub>b</sub> | 2 <sub>a</sub> | 2 <sub>f</sub> | 3 <sub>b</sub> |
| BP2 | bar31 | Ω    | K    | BATT           | 1 <sub>d</sub> | bar30          | P1             | 2 <sub>d</sub> | bar29          | P2             |
| BP3 | bar32 | V    | M    | 1 <sub>c</sub> | 1 <sub>g</sub> | 1 <sub>e</sub> | 2 <sub>c</sub> | 2 <sub>g</sub> | 2 <sub>e</sub> | 3 <sub>c</sub> |
| BP4 | bar34 | A    | μ    | Hz             | °F             | °C             |                | RS232          |                |                |

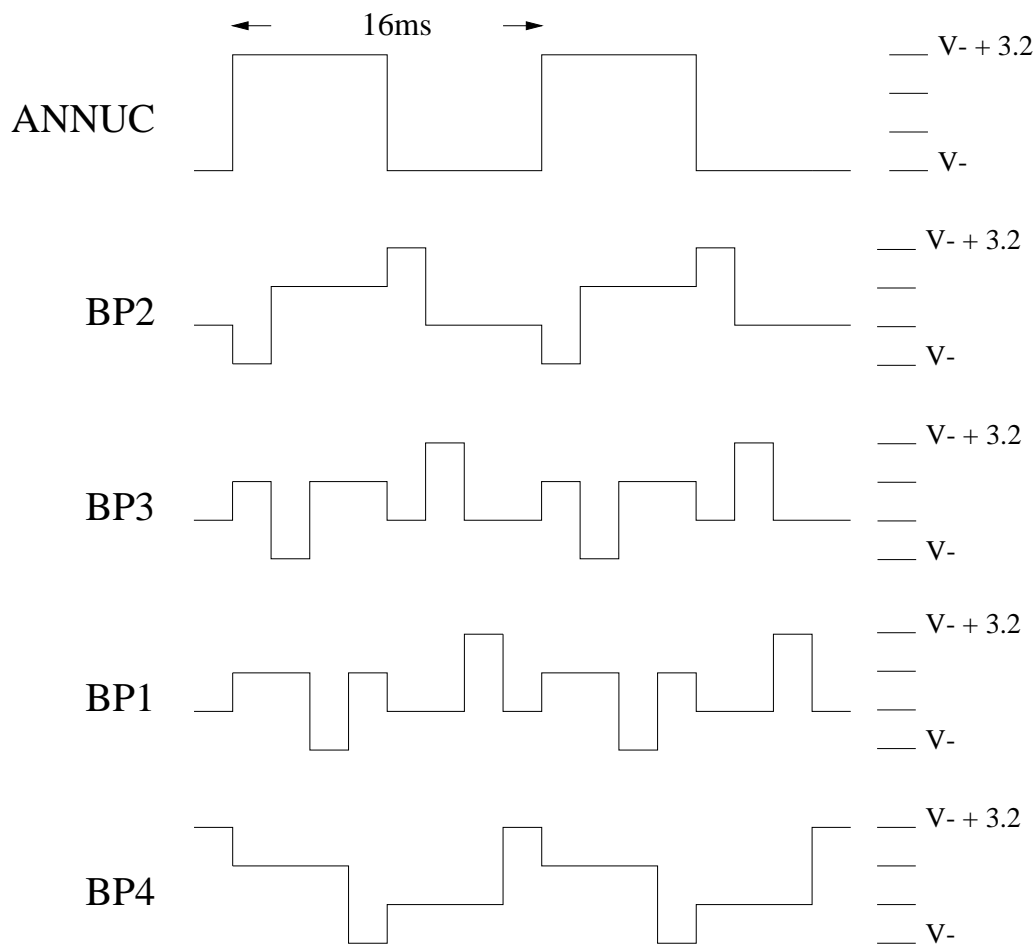
|     | SEG11          | SEG12          | SEG13          | SEG14                         | SEG15 | SEG16 | SEG17 | SEG18 |
|-----|----------------|----------------|----------------|-------------------------------|-------|-------|-------|-------|
| BP1 | 3 <sub>a</sub> | 3 <sub>f</sub> | 4 <sub>b</sub> | 4 <sub>a</sub> 4 <sub>g</sub> |       | DC    | bar25 | bar24 |
| BP2 | 3 <sub>d</sub> | bar28          | P3             | 4 <sub>d</sub>                |       | AC    | bar27 | bar22 |
| BP3 | 3 <sub>g</sub> | 3 <sub>e</sub> | 4 <sub>c</sub> | 4 <sub>e</sub>                | —     | HOLD  | bar26 | bar23 |
| BP4 | AUTO           |                | APO            |                               | RPM   |       |       |       |

|     | SEG19 | SEG20 | SEG21 | SEG22 | SEG23 | SEG24 | SEG25 | SEG26 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| BP1 | bar19 | bar18 | bar13 | bar12 | bar7  | bar6  | bar1  |       |
| BP2 | bar21 | bar16 | bar15 | bar10 | bar9  | bar4  | bar3  | bar-  |
| BP3 | bar20 | bar17 | bar14 | bar11 | bar8  | bar5  | bar2  | bar0  |
| BP4 |       |       |       |       |       |       |       |       |





### 5.3 LCD Backplane Waveform



### 5.4 LCD Display On Condition

| LCD Annunciator | Condition  |
|-----------------|--|
| V               | In voltage measurement mode and diode measurement mode.  |
| A               | In current measurement mode.   |
| $\Omega$        | In resistance measurement mode and continuity check mode.                                      |
|                 | In continuity check mode.  |
|                 | In diode mode.   |
| Hz              | In frequency mode, VAHZ mode.  |
| DC              | In DC voltage or DC current mode.  |
| AC              | In AC voltage or AC current mode.  |
| AUTO            | When automatic full scale range selection is enabled.  |
| MANU            | In manual mode.  |
| HOLD            | When HOLD function is enabled.   |
| m               | In voltage or current measurement mode and the full scale range is in the order of $10^{-3}$ . |
| $\mu$           | In current measurement mode and the full scale range is in the order of $\mu A$ .              |



| LCD Annunciator | Condition  |
|-----------------|--|
| M               | In resistance or frequency measurement mode and the full scale range is in the order of M $\Omega$ or MHz. |
| K               | In resistance or frequency measurement mode and the full scale range is in the order of K $\Omega$ or KHz. |
| RPM             | In RPM measurement mode.   |
| $^{\circ}C$     | In temperature measurement mode and when the unit is $^{\circ}C$ .   |
| $^{\circ}F$     | In temperature measurement mode and when the unit is $^{\circ}F$ .   |
| APO             | When auto power off function is enabled.   |
| –               | In voltage or current measurement mode and when the input is negative.                                     |
| bar graph       | Always indicates the current input value.  |

### 5.5 Operation Timing

ES51972 incorporates a dual slope ADC with four phases: ZI, AZ, INT, and DINT. The ADC consists of a high resolution part for digital display and a high speed part for bar graph display. The timing of each phase of the two parts are listed below.

- Voltage measurement:

| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI    | 100ms           | 10ms       |
| AZ    | 150ms           | 15ms       |
| INT   | 100ms           | 10ms       |
| DINT  | 400ms           | 40ms       |

- Current measurement:

| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI    | 100ms           | 10ms       |
| AZ    | 150ms           | 15ms       |
| INT   | 100ms           | 10ms       |
| DINT  | 200ms           | 20ms       |

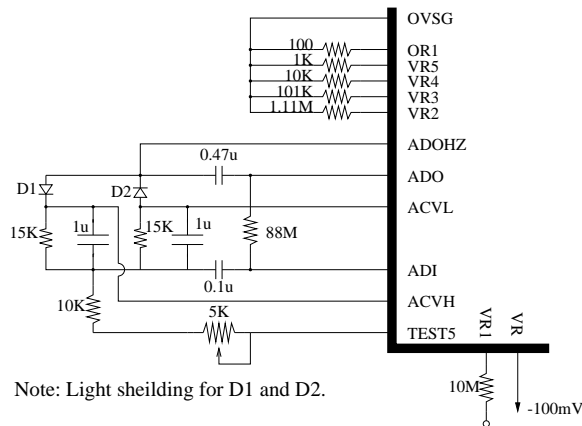
- Continuity check:

| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI    | 100ms           | 5ms        |
| AZ    | 150ms           | 7.5ms      |
| INT   | 100ms           | 5ms        |
| DINT  | 400ms           | 20ms       |

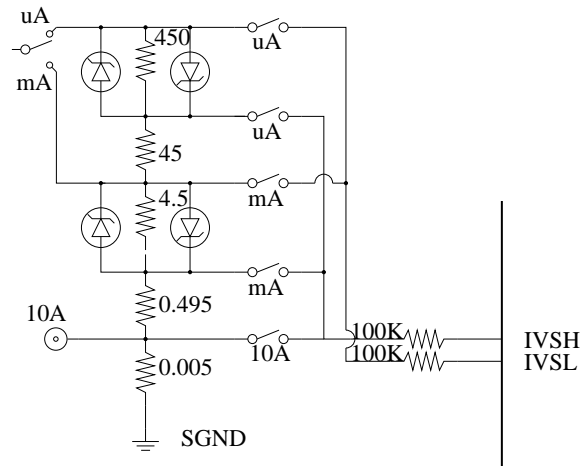




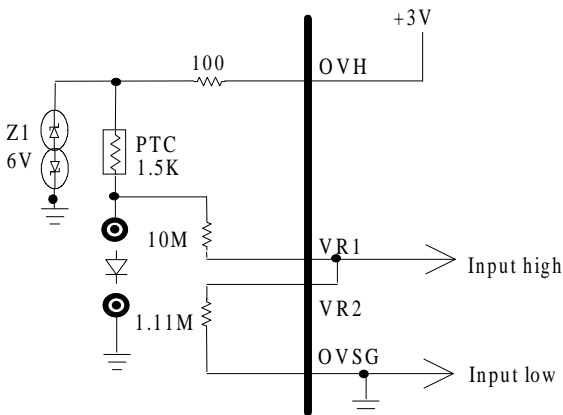
## Test Circuit



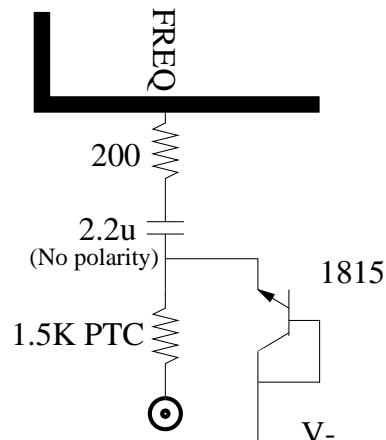
(a) Testing voltage measurement.



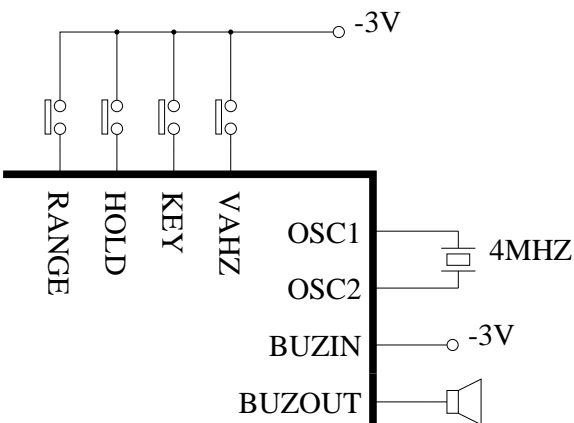
(b) Testing current measurement.



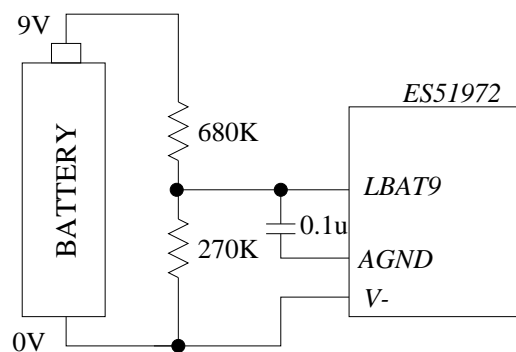
(c) Testing diode mode.



(d) Testing frequency mode.



(e) Testing function switch.



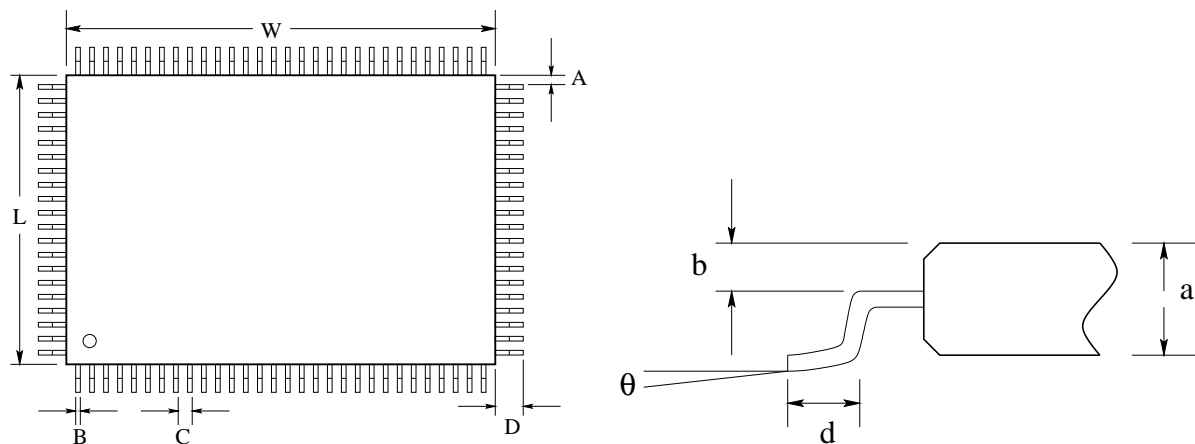
(e) Testing battery-low function.





## Packaging

### 1 100 Pin QFP Package



### 2 Dimension Parameters

| Symbol   | Milimeter |       |       | Mill  |       |       |
|----------|-----------|-------|-------|-------|-------|-------|
|          | Min.      | Typ.  | Max.  | Min.  | Typ.  | Max.  |
| W        | 19.90     | 20.00 | 20.10 | 783.5 | 787.4 | 791.3 |
| L        | 13.90     | 14.00 | 14.10 | 547.2 | 551.2 | 555.1 |
| A        |           | 0.425 |       |       | 16.7  |       |
| B        | 0.20      | 0.30  | 0.40  | 7.9   | 11.8  | 15.7  |
| C        |           | 0.65  |       |       | 25.6  |       |
| d        | 1.05      | 1.20  | 1.35  | 41.3  | 47.2  | 53.1  |
| a        | 2.57      | 2.72  | 2.87  | 101.2 | 107.1 | 113.0 |
| D        |           | 2.50  |       |       | 98.4  |       |
| $\theta$ | 0°        |       | 10°   |       |       |       |