



Features

- Full automatic measurement
 - * Voltage measurement
 - * Current measurement
 - * Resistor measurement
- 4000 count display
- Range change function
- Data hold function
- Relative / Maximum / Minimum modes
- Diode measurement
- Continuity check
- Capacitor measurement (Auto range: 4n to 40mF)
- Peak hold mode
- RPM measurement
- VAHZ mode measures frequency in voltage or current mode
- 400MHz Frequency counter
- ADP mode
- 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

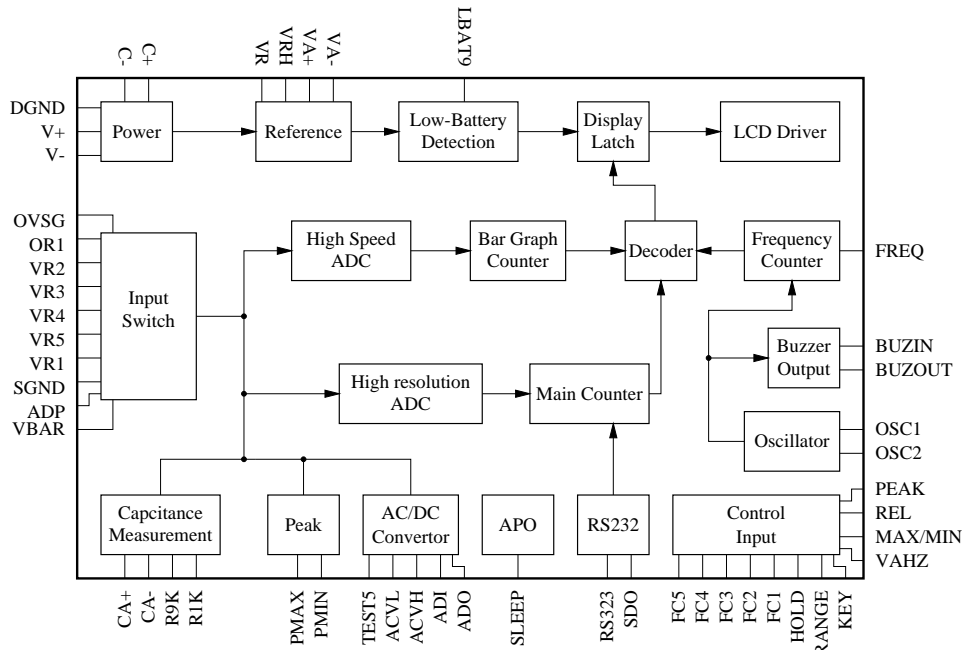
ES51962 is an integrated analog-to-digital converter (ADC) with 4000 counts and bar graph LCD display, automatic range selection, and 3V DC power supply. Automatic range selection is provided for voltage (AC/DC) measurement, resistor measurement, current measurement, capacitor measurement, frequency counter under V/A measurement, frequency counter and RPM measurement. Expensive and bulky mechanical range switches are not required. Other features include data holding, relative/maximum/minimum/peak measurement, diode measurement, temperature measurement, continuity checking, low battery detection, auto power off, re-power on, and RS232 data output.

Application

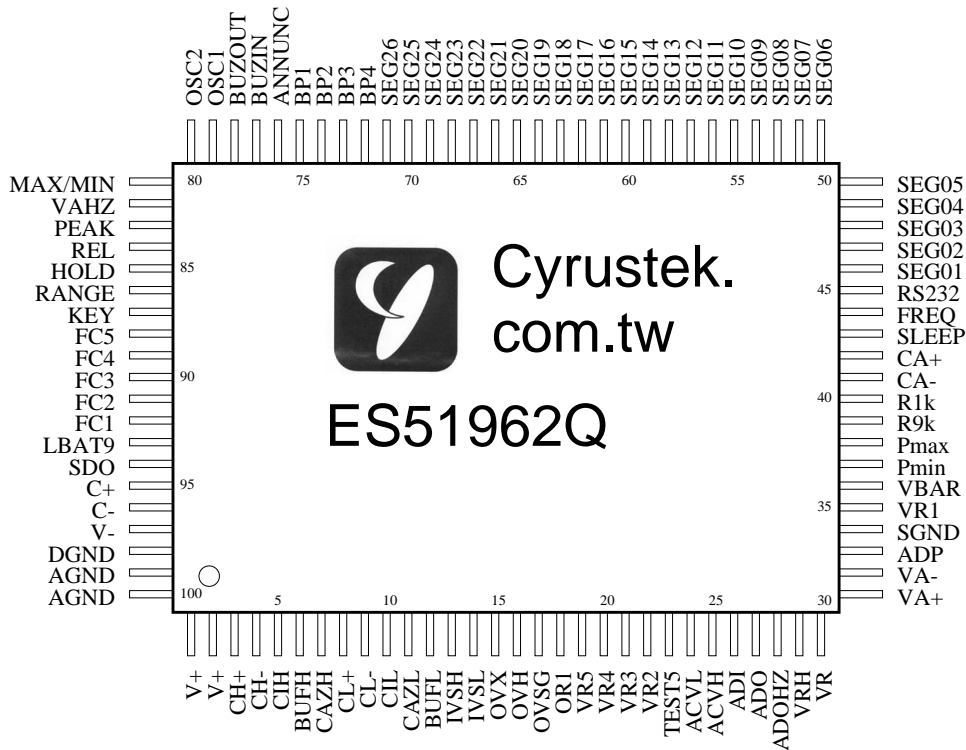
Digital Multimeter.



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 399.9Ω range. |
| 19 | VR5 | O | Voltage measurement ÷10000 attenuator (4000V.) |
| 20 | VR4 | O | Voltage measurement ÷1000 attenuator (400.0V.) |
| 21 | VR3 | O | Voltage measurement ÷100 attenuator (40.00V.) |
| 22 | VR2 | O | Voltage measurement ÷10 attenuator (4.000V.) |
| 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. In capacitance mode, a compensation capacitance is connected. |
| 37 | P _{MIN} | O | Minimum peak hold output. |
| 38 | P _{MAX} | O | Maximum peak hold output. |
| 39 | R9K | O | Connect to a 9kΩ resistor for capacitor measurement. |
| 40 | R1K | O | Connect to an 1kΩ resistor for capacitor measurement. |
| 41 | CA- | IO | Negative auto-zero capacitor connection for capacitor measurement. |

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|---------------------------------|---------------|------|--|
| Pin No. | Symbol | Type | Description |
| 42 | CA+ | IO | Positive auto-zero capacitor connection for capacitor measurement. |
| 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. |
| 46 – 71 | SEG01 – SEG26 | O | LCD segment line 01 – 26. |
| 72 | BP4 | O | LCD backplane 4. |
| 73 | BP3 | O | LCD backplane 3. |
| 74 | BP2 | O | LCD backplane 2. |
| 75 | BP1 | O | LCD backplane 1. |
| 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 | MAX/MIN | I | Pulse low to enable MAX/MIN mode. |
| 82 | VAHZ | I | Pulse low to show the frequency of input signal in V(DC/AC), I(DC/AC.) |
| 83 | PEAK | I | Pulse low to enable PEAK mode. |
| 84 | REL | I | Pulse low to enable REL mode. |
| 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 | μA |
| Voltage roll-over error | REV | 10M Ω input resistor | - | - | ± 0.1 | %F.S. ¹ |
| Bar graph roll-over error | REB | | - | - | ± 0.5 | %F.S. |
| Voltage nonlinearity | NLV | Best case straight line | - | - | ± 0.1 | %F.S. |
| Bar graph nonlinearity | NLB | | - | - | ± 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 Ω input resistor | -000 | 000 | +000 | counts |
| Reference voltage and open circuit voltage for 400 Ω measurement | V_{REF} | 100K Ω 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 Ω measurement (except 400 Ω) | | Ω and Continuity mode | -0.54 | -0.47 | -0.4 | V |
| Internal pull-high to 0V current | | Between V- pin and MAX/MIN, PEAK, REL, HOLD, RANGE, KEY, FC1, FC2, FC3, FC4, FC5, VAHZ | - | 1.2 | - | μA |
| | | Between V- pin and RS232 | - | 11 | - | |
| AC frequency response at 4.000V range | | $\pm 1\%$ error | - | 40 - 650 | - | Hz |
| | | $\pm 5\%$ error | - | 40 - 2700 | - | |
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|---|-----------|--|------|--------|------|-------------------------|
| Parameter | Symbol | Test Condition | Min. | Typ. | Max. | Units |
| Reference voltage temperature coefficient | TC_{RF} | 100K Ω resistor Between VRH and AGND, $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ | - | 50 | - | ppm/ $^{\circ}\text{C}$ |
| Maximum and minimum peak value accuracy | | Use 10nF polyester mylar capacitor, 10 μs pulse, $V_{-} = -3.0\text{V}$, ADP, 470 Ω input | -2 | - | 2 | %F.S |
| | | | -25 | - | 25 | counts |
| Capacitance measurement accuracy | | 4nF range | -1.5 | - | 1.5 | %F.S. |
| | | | -2 | - | 2 | counts |
| | | 40nF - 4 μF range | -0.8 | - | 0.8 | %F.S. |
| | | | -2 | - | 2 | counts |
| | | 4 μF ~4mF range | -1.1 | - | 1.1 | %F.S. |
| -2 | - | | 2 | counts | | |
| 40mF range | -2 | - | 2 | %F.S. | | |
| RPM Measurement | | | -3 | - | 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 | 400.0mV | 1 | - |
| VR2 | 4.000V | $\frac{1}{10}$ | $\frac{R_2}{R_1+R_2}$ |
| VR3 | 40.00V | $\frac{1}{100}$ | $\frac{R_3}{R_1+R_3}$ |
| VR4 | 400.0V | $\frac{1}{1000}$ | $\frac{R_4}{R_1+R_4}$ |
| VR5 | 4000V | $\frac{1}{10000}$ | $\frac{R_5}{R_1+R_5}$ |

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 | 400.0 Ω | R_6 | 100 Ω |
| OR2 | 4.000K Ω | R_5 | 1K Ω |
| OR3 | 40.00K Ω | R_4 | 10K Ω |
| OR4 | 400.0K Ω | $R_1 R_3$ | 100K Ω |
| OR5 | 4.000M Ω | $R_1 R_2$ | 1M Ω |
| OR6 | 40.00M Ω | R_1 | 10M Ω |



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 | 400.0 μA 4000 μA |
| Automatic Mode 2 | mA | 40.00mA 400.0mA |
| Manual Mode | A | 40.00A |

1.4 Capacitance Measurement

The following table summarizes the eight ranges of capacitance measurement mode.

| Configuration | Full Scale Range | Resistance Ratio |
|---------------|---------------------|---------------------|
| C1 | 4.000nF | R_1 |
| C2 | 40.00nF | $R_1 \parallel R_2$ |
| C3 | 400.0nF | $R_1 \parallel R_3$ |
| C4 | 4.000 μF | R_4 |
| C5 | 40.00 μF | — |
| C6 | 400.0 μF | — |
| C7 | 4.000mF | — |
| C8 | 40.00mF | — |

Note:

1. The bar graph is disabled in capacitance measurement mode. However, since the measurement time of C7 and C8 modes is quite long (3.75s and 7.5s respectively, to be precise,) the bar graph is used to display the time rest to accomplish the measurement.
2. In order to obtain an accurate reading, a capacitor must be discharged before measurement begins. The chip has a built-in discharge mode to automatically discharge the capacitor. In discharge mode, the LCD displays $\square 15.1$.
3. Discharging through the chip is quite slow. We recommend the user to discharge the capacitor with some other apparatus.

1.5 Continuity Check

Continuity check mode shares the same configuration with 400.0 Ω manual resistance measurement mode, but with buzzer output to indicate continuity. The buzzer generates a 2KHz sound whenever the bar graph is less than 35 Ω .

1.6 Diode Measurement

Diode measurement mode shares the same configuration with 4.000V 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". The buzzer generates a 2KHz sound whenever the bar graph is less than 0.25 V.

1.7 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 six decades, from 4.000KHz to 400.0MHz. The following table summarizes the full scale range of the frequency counter.

| Range | Full Scale |
|-------|------------|
| FR1 | 4.000KHz |
| FR2 | 40.00KHz |
| FR3 | 400.0KHz |
| FR4 | 4.000MHz |
| FR5 | 40.00MHz |
| FR6 | 400.0MHz |

1.8 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 | 40.00KRPM |
| RP2 | 400.0KRPM |
| RP3 | 4.000MRPM |
| RP4 | 40.00MRPM |
| RP5 | 400.0MRPM |
| RP6 | 4000MRPM |

1.9 Auto Power Off

ES51962 has a default auto power off function. If the meter idles for more than 30 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.

1.10 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.

1.11 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 \leftrightarrow ACV |
| 1 | 1 | 0 | 1 | Current Measurement (μ A) | DCA \leftrightarrow ACA |
| 1 | 0 | 0 | 1 | Current Measurement (mA) | DCA \leftrightarrow ACA |
| 1 | 1 | 1 | 1 | Current Measurement (A) | DCA \leftrightarrow ACA |
| 0 | 0 | 1 | 1 | Resistance Measurement | Ω \leftrightarrow Continuity |
| 0 | 1 | 0 | 1 | Resistance Measurement | Ω \leftrightarrow Diode |
| 0 | 1 | 1 | 1 | Continuity Check | Continuity \leftrightarrow Diode |
| 0 | 0 | 0 | 1 | Resistance Measurement | Ω \leftrightarrow Continuity \leftrightarrow Diode |
| 0 | 0 | 1 | 0 | Frequency Measurement | Frequency \leftrightarrow RPM |
| 0 | 1 | 1 | 0 | Capacitance Measurement | - |
| 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 (μ 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 | 1 | 0 | Capacitance Measurement |
| 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 KEY 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

Push functions control the special measurement modes of the meter. Some special modes can be nested in other special modes, while some push functions reset all existing special mode. The following table summarizes the available push functions in each special mode.



| Active mode | Push Functions | | | | | | |
|-------------|--------------------|------------------|------|-----|---------|------|-------------------|
| | RANGE ¹ | KEY ² | HOLD | REL | MAX/MIN | PEAK | VAHZ ³ |
| HOLD | ○ | ○ | ○ | × | × | × | × |
| REL | ○ | ○ | ○ | ○ | ○ | × | × |
| MAX/MIN | ○ | ○ | ○ | × | ○ | × | × |
| PEAK | ○ | ○ | ○ | × | × | ○ | × |
| VAHZ | ○ | × | ○ | × | × | × | ○ |

The state transition of the push functions are described below.

Note:

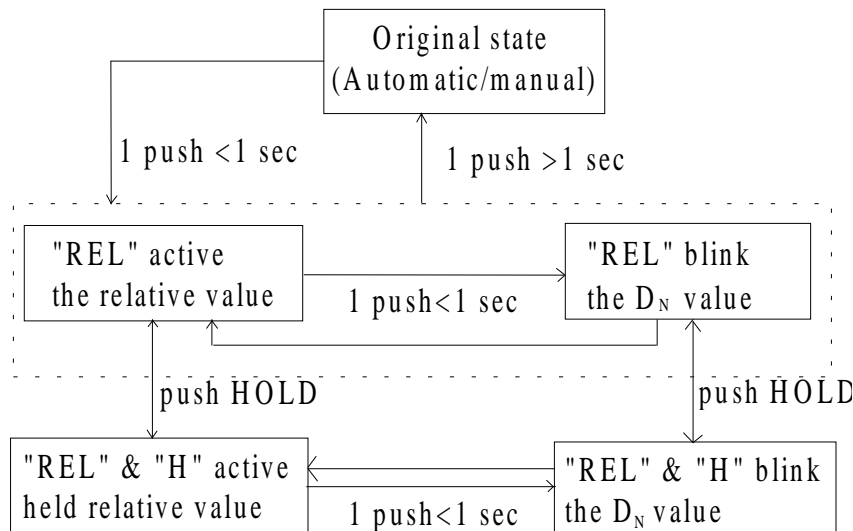
1. RANGE resets all special modes other than VAHZ mode.
2. KEY reset all special modes other than VAHZ mode.
3. VAHZ is only used to toggle between frequency measurement mode and voltage or current measurement mode, and thus can not be nested in any other special modes.
4. The bar graph always shows the current value, regardless of the special mode.

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 REL + HOLD

In REL mode, the LCD panel displays $D_{N+K} - D_N$, where $K = 1, 2, 3, \dots$, D_N is the last value before REL is pushed, and D_{N+K} is the current value. If REL is pressed again in REL mode, the meter displays the reference value. The meter returns to normal operation if REL is pressed and held for longer than one second. Pressing HOLD in REL mode makes the meter stop updating the LCD panel.



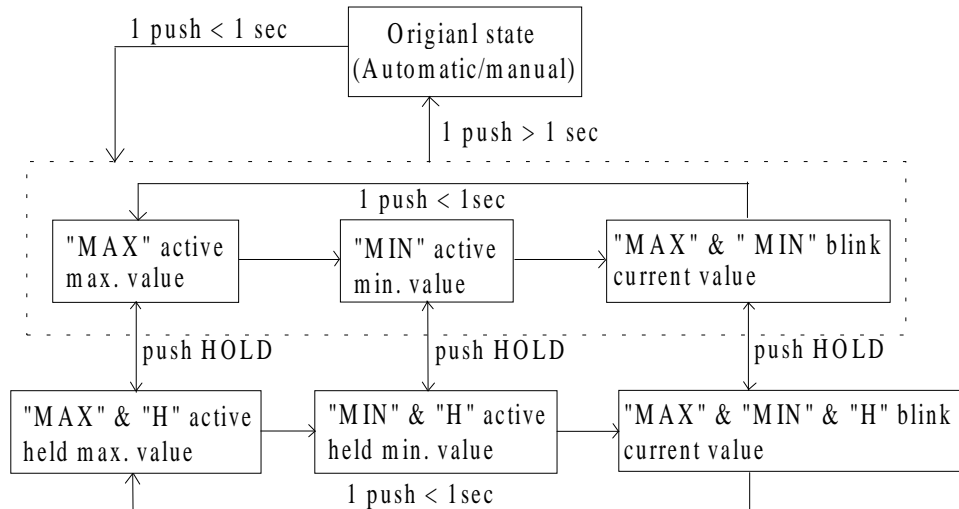
Note: It is possible for the relative value to exceed 4000 or -4000 counts. Such relative values are displayed. The LCD shows OL only if either D_N or D_{N+K} is greater than 3999 counts or less than -3999 counts.

3.3 MAX/MIN + HOLD

The meter displays the maximum or minimum value of the input in MAX/MIN mode. When MAX/MIN is pressed for the first time, the meter displays the maximum value. When MAX/MIN is pressed again, the meter

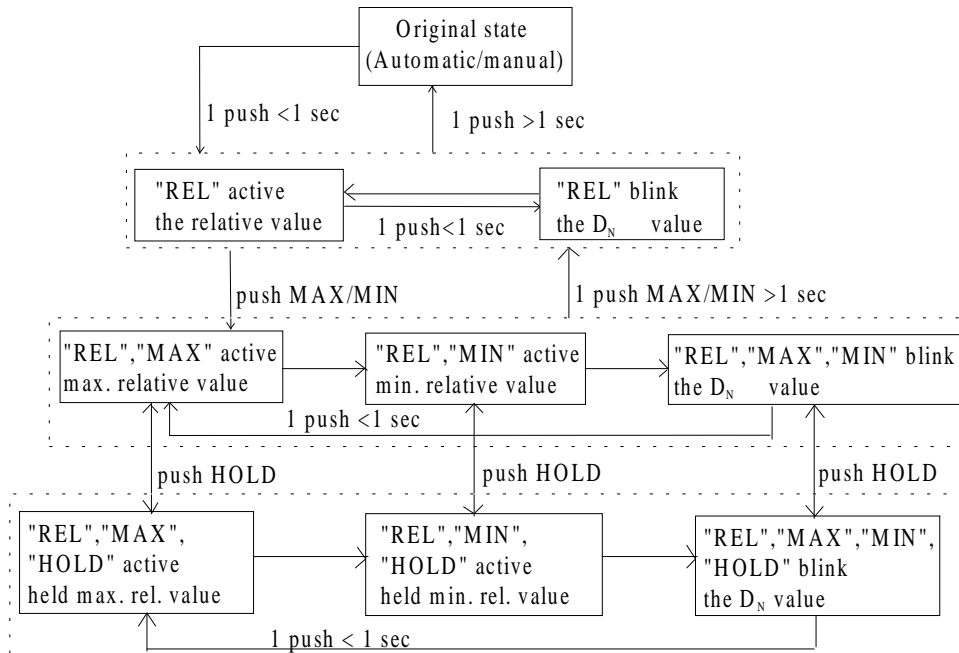


displays the minimum value. When MAX/MIN is pressed for the third time, the meter displays current input value. The meter returns to normal operation if MAX/MIN is pressed and held for longer than one second. Pressing HOLD in MAX/MIN mode makes the meter stop updating the maximum or the minimum value.



3.4 REL + MAX/MIN + HOLD

MAX/MIN mode can be nested in REL mode. The meter displays the maximum or the minimum value relative to the reference when MAX/MIN is pressed in REL mode.



3.5 PEAK + HOLD

PEAK mode takes input from P_{MAX} pin or P_{MIN} pin. The peak values are stored in external capacitors. Polyester mylor capacitors are recommended.



| Measurement Mode | Auto | Manual | Control Range | Initial Range |
|------------------|-----------|--|----------------------------------|----------------|
| mA (DC/AC) | R1 – R2 | R1 → R2, R2 → R1 | 40.00mA – 400.0mA | 40.00mA |
| A (DC/AC) | fixed | fixed | 40.00A | 40.00A |
| Ω | OR1 – OR6 | OR _i → OR _i + 1, OR6 → OR1 | 400.0 Ω – 40.00M Ω | 400.0 Ω |
| Capacitance | C1 – C8 | C _i → C _i + 1, C8 → C1 | 4.000nF – 40.00mF | 4.000nF |
| Continuity | fixed | fixed | 400.0 Ω | 400.0 Ω |
| Diode | fixed | fixed | 4.000V | 4.000V |
| Frequency | FR1 – FR6 | FR _i → FR _i + 1, FR6 → FR1 | 4.000KHz – 400.0MHz | 4.000KHz |
| RPM | RP1 – RP6 | RP _i → RP _i + 1, RP6 → RP1 | 40.00KRPM – 4000MRPM | 40.00KRPM |

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

3.8 KEY

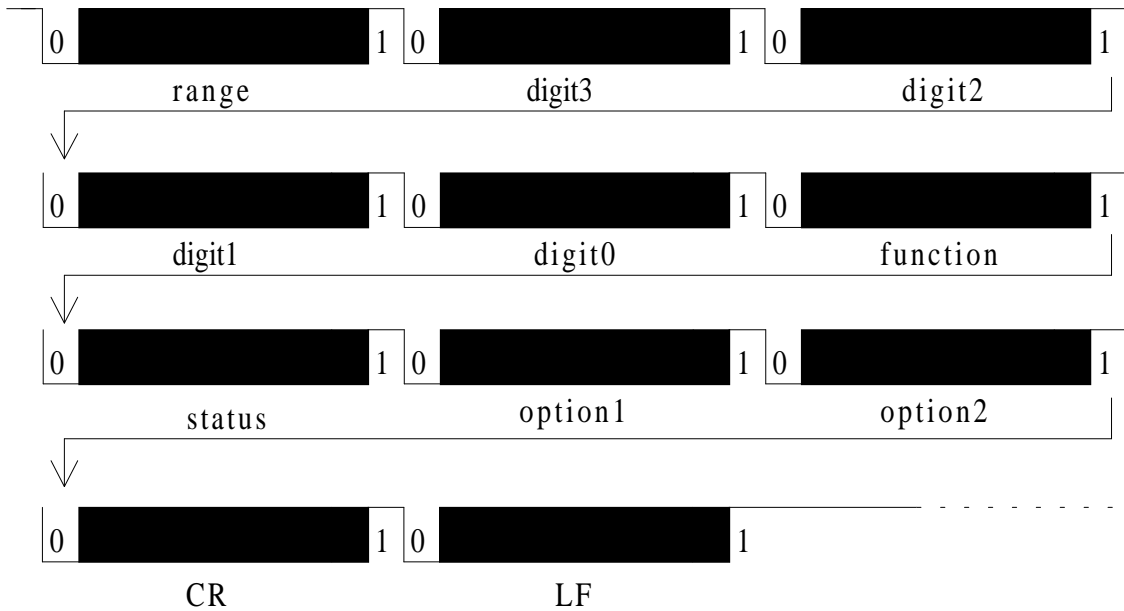
See Section “Measurement Mode Switching” for the function of this pin.

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 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. 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 | μ A Current |
| 0111001 | mA Current |
| 0111111 | A Current |
| 0110011 | Ω |
| 0110101 | Continuity |
| 0110001 | Diode |
| 0110010 | Frequency / RPM ¹ |
| 0110110 | Capacitance |
| 0110100 | Temperature ² |
| 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 | μ A | Ω | Frequency | RPM | Capacitance |
|---------|---------|---------|---------------|-----------------|-----------|-----------|---------------|
| 0110000 | 400.0mV | 40.00mA | 400.0 μ A | 400.0 Ω | 4.000KHz | 40.00KRPM | 4.000nF |
| 0110001 | 4.000V | 400.0mA | 4000 μ A | 4.000K Ω | 40.00KHz | 400.0KRPM | 40.00nF |
| 0110010 | 40.00V | | | 40.00K Ω | 400.0KHz | 4.000MRPM | 400.0nF |
| 0110011 | 400.0V | | | 400.0K Ω | 4.000MHz | 40.00MRPM | 4.000 μ F |
| 0110100 | 4000V | | | 4.000M Ω | 40.00MHz | 400.0MRPM | 40.00 μ F |
| 0110101 | | | | 40.00M Ω | 400.0MHz | 4000MRPM | 400.0 μ F |
| 0110110 | | | | | | | 4.000mF |
| 0110111 | | | | | | | 40.00mF |

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 4000.

| 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 special measurement modes. The format of this packet is shown below. The three non-constant fields is set to one when the meter operates in the corresponding special modes.

| | | | | | | |
|-------|-------|-------|-----------|-----------|-------|-------|
| 0 | 1 | 1 | P_{MAX} | P_{MIN} | 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.

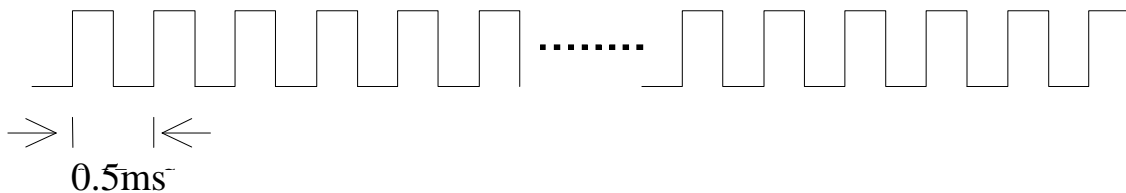
5 Miscellaneous

5.1 The Buzzer

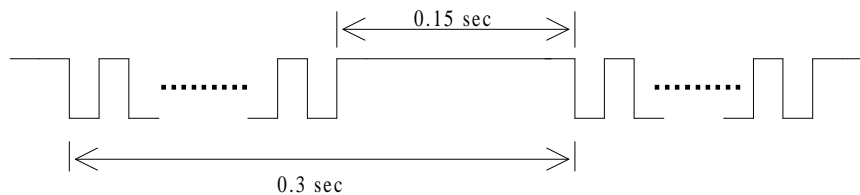
The conditions which the meter turns on the buzzer include:

- (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 overflow in voltage and current mode generates one beep every 0.3 seconds (or 3.33 beeps per second.)
- (5) Continuity check generates a continuous 2KHz beep whenever the measurement is less then 35Ω.
- (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

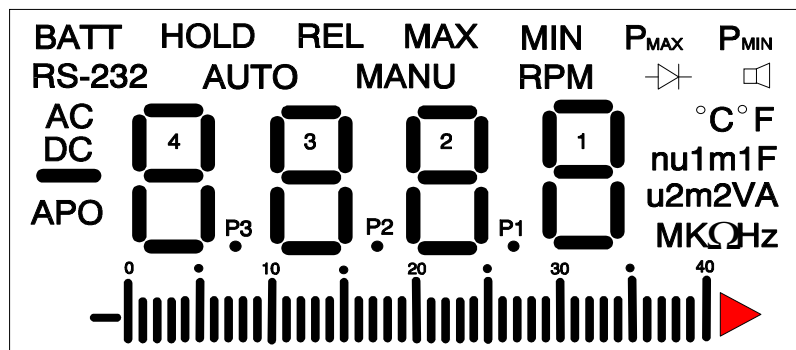


5.2 LCD Pin Assignment

| | SEG1 | SEG2 | SEG3 | SEG4 | SEG5 | SEG6 | SEG7 | SEG8 | SEG9 | SEG10 |
|-----|-------|-------|----------------|------------------|----------------|----------------|-------|------------------|----------------|----------------|
| BP1 | bar40 | bar37 | bar36 | m ₂ | bar33 | bar32 | bar29 | bar28 | bar25 | bar24 |
| BP2 | bar39 | bar38 | Hz | bar35 | bar34 | bar31 | bar30 | bar27 | bar26 | 1 _d |
| BP3 | F | °F | | °C | Ω | u ₂ | K | M | 1 _c | 1 _g |
| BP4 | A | V | m ₁ | P _{MIN} | u ₁ | n | | P _{MAX} | 1 _b | 1 _a |

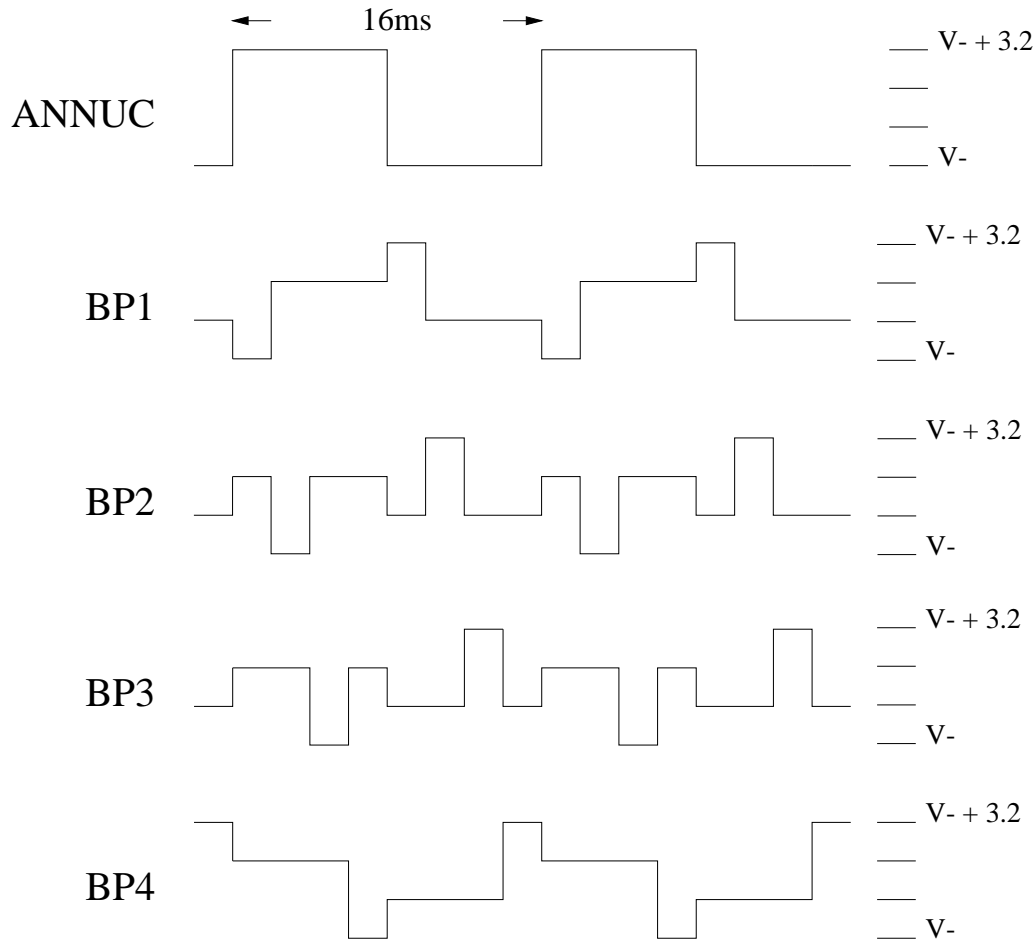
| | SEG11 | SEG12 | SEG13 | SEG14 | SEG15 | SEG16 | SEG17 | SEG18 |
|-----|----------------|-------|----------------|----------------|----------------|-------|----------------|----------------|
| BP1 | bar22 | bar21 | bar19 | bar18 | bar16 | bar15 | bar13 | bar12 |
| BP2 | bar23 | P1 | bar20 | 2 _d | bar17 | P2 | bar14 | 3 _d |
| BP3 | 1 _e | RPM | 2 _c | 2 _g | 2 _e | MANU | 3 _c | 3 _g |
| BP4 | 1 _f | MIN | 2 _b | 2 _a | 2 _f | MAX | 3 _b | 3 _a |

| | SEG19 | SEG20 | SEG21 | SEG22 | SEG23 | SEG24 | SEG25 | SEG26 |
|-----|----------------|-------|----------------|----------------|----------------|-------|-------|-------|
| BP1 | bar10 | bar9 | bar7 | bar6 | bar4 | bar3 | bar1 | bar0 |
| BP2 | bar11 | bar8 | P3 | 4 _d | bar5 | bar2 | APO | bar- |
| BP3 | 3 _e | AUTO | 4 _c | 4 _g | 4 _e | RS232 | DC | - |
| BP4 | 3 _f | REL | 4 _b | 4 _a | 4 _f | HOLD | BATT | AC |





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. |
| Ω | In resistance measurement mode and continuity check mode. |
| F | In capacitance measurement 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. |
| REL | When REL function is enabled. When the LCD displays the reference value, REL blinks. |



| LCD Annunciator | Condition |
|------------------|---|
| MAX | When the LCD displays max value in MAX/MIN mode. When the LCD displays current value, MAX blinks. |
| MIN | When the LCD displays min value in MAX/MIN mode. When the LCD displays current value, MIN blinks. |
| P _{MAX} | When the LCD displays max value in PEAK mode. |
| P _{MIN} | When the LCD displays min value in PEAK mode. |
| m ₁ | In capacitance measurement mode and the full scale range is in the order of mF. |
| u ₁ | In capacitance measurement mode and the full scale range is in the order of μ F. |
| n | In capacitance measurement mode and the full scale range is in the order of nF. |
| m ₂ | In voltage or current measurement mode and the full scale range is in the order of 10^{-3} . |
| u ₂ | In current measurement mode and the full scale range is in the order of μ A. |
| M | In resistance measurement mode and the full scale range is in the order of M Ω . |
| K | In resistance measurement mode and the full scale range is in the order of K Ω . |
| 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

ES51962 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 |

- PEAK mode voltage measurement:

| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI | 100ms | 10ms |
| AZ | 150ms | 15ms |
| INT | 100ms | 10ms |
| DINT | 500ms | 50ms |



- Current measurement:

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

- PEAK mode current measurement:

| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI | 100ms | 10ms |
| AZ | 150ms | 15ms |
| INT | 100ms | 10ms |
| DINT | 250ms | 25ms |

- Continuity check:

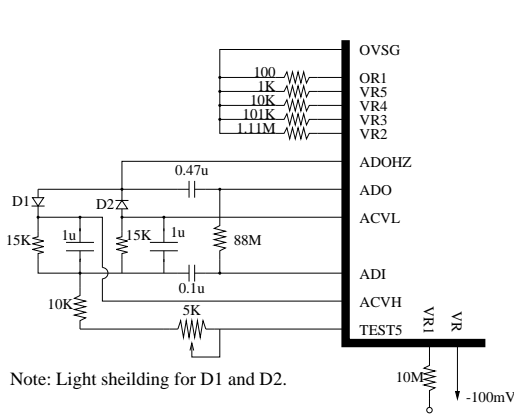
| Phase | High Resolution | High Speed |
|-------|-----------------|------------|
| ZI | 100ms | 5ms |
| AZ | 150ms | 7.5ms |
| INT | 100ms | 5ms |
| DINT | 400ms | 20ms |

- Capacitance measurement:

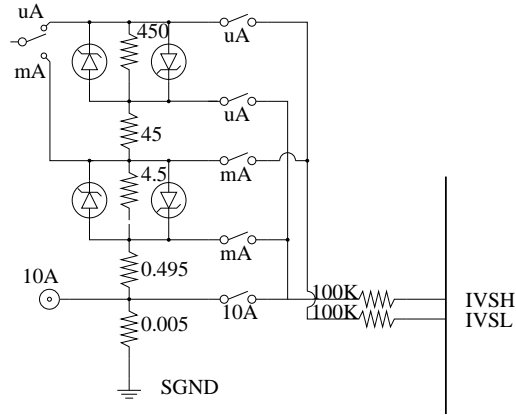
| Range | Total Measurement Time |
|---------------|------------------------|
| 4.000nF | 0.75sec. |
| 40.00nF | 0.75sec. |
| 400.0nF | 0.75sec. |
| 4.000 μ F | 0.75sec. |
| 40.00 μ F | 0.75sec. |
| 400.0 μ F | 1.5sec. |
| 4.000mF | 3.75sec. |
| 40.00mF | 7.5sec. |



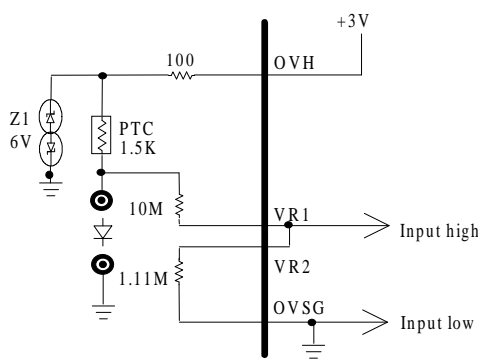
Test Circuit



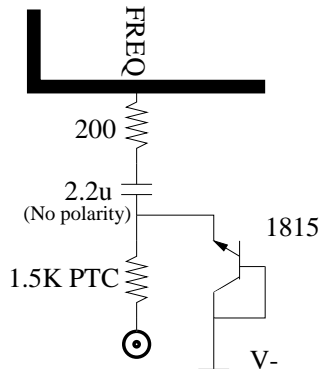
(a) Testing voltage measurement.



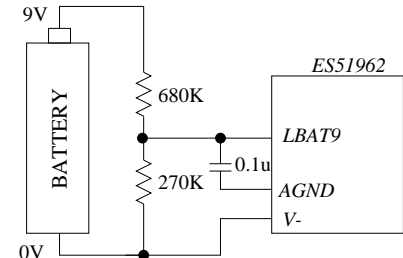
(b) Testing current measurement.



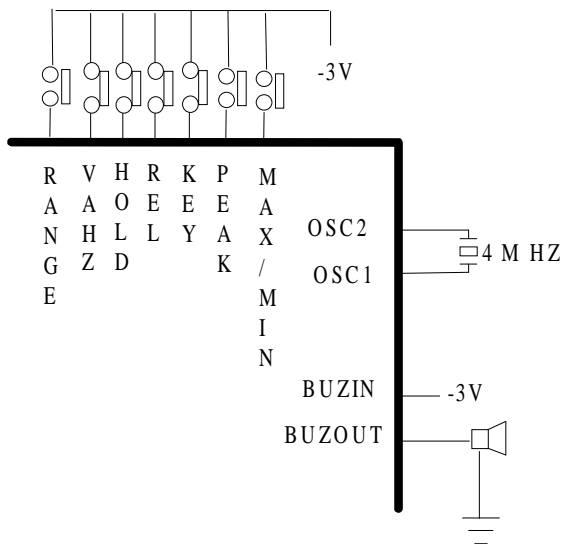
(c) Testing diode mode.



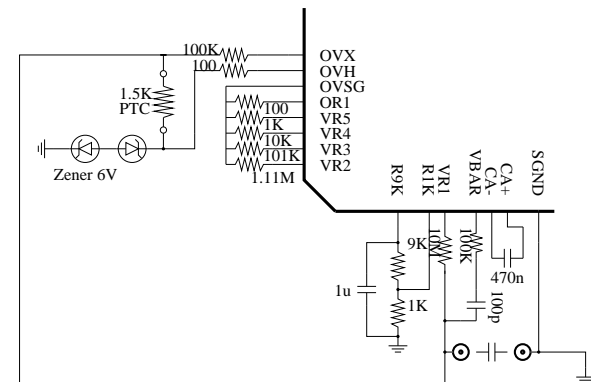
(d) Testing frequency mode.



(e) Testing battery-low function.



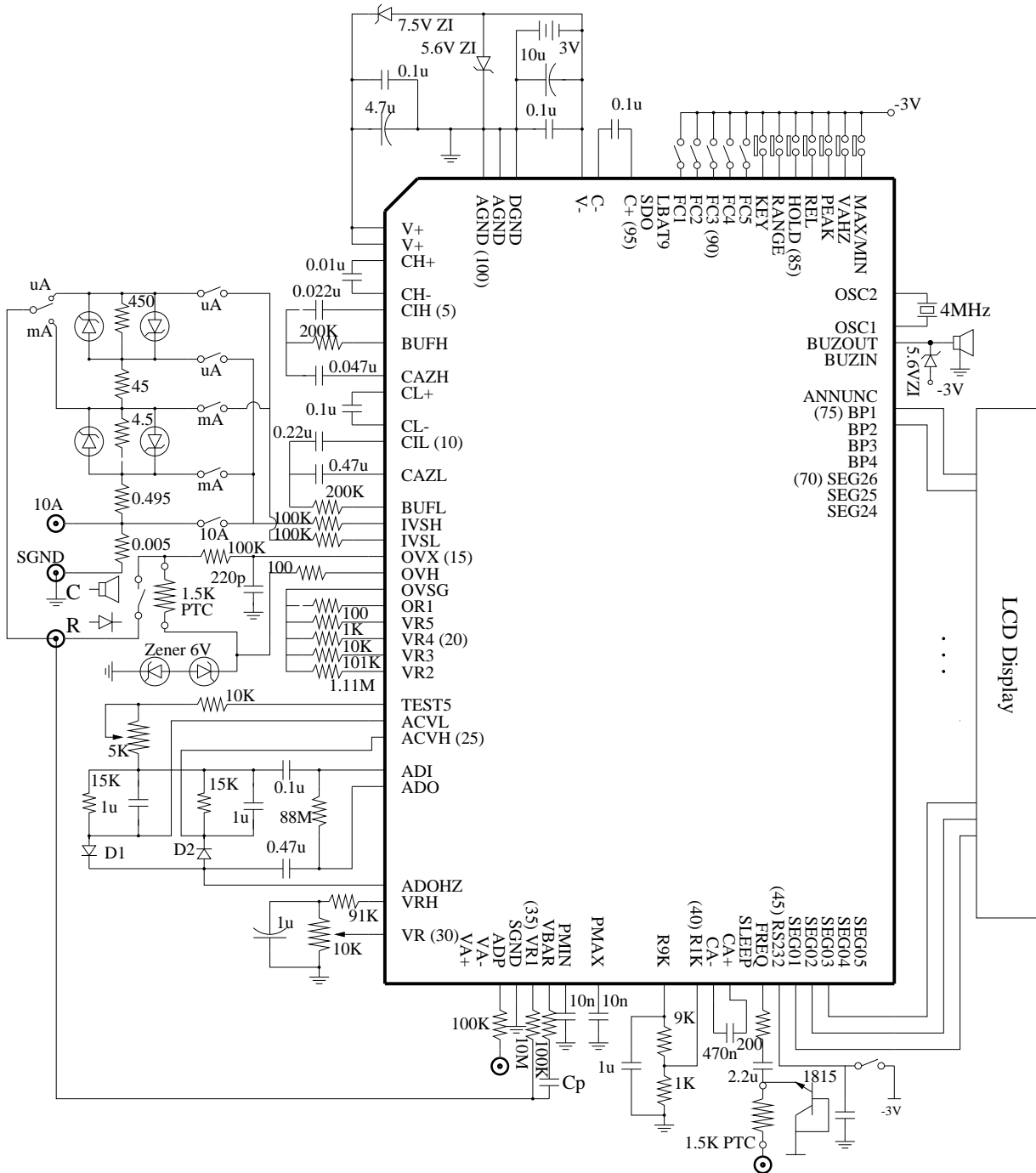
(f) Testing function switch.



(g) Testing capacitance measurement.



Application Circuit



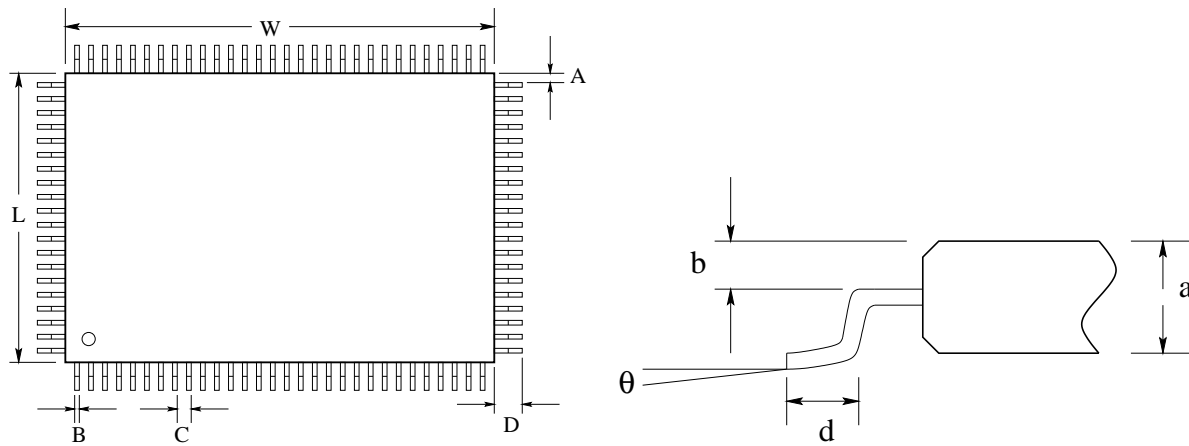
Note:

1. Most of pins are protected by the ESD protection circuits, however pins, V-, V+, AGND, DGND and VR1 are not protected enough because the parasitic effect must be decreased. Therefore enough external protection is needed for assembling, carrying and keeping. In addition, components connecting to these unprotected pins have to be soldered on board before the IC is soldered.
2. Light shielding for the diodes and Zeners
3. C_p is the compensation capacitor for measuring capacitance. Its value depends on the parasitic capacitor on the PCB board.



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 | 551.2 |
| A | | 0.425 | | | 16.7 | |
| B | 0.20 | 0.30 | 0.40 | 7.9 | 11.8 | 11.8 |
| C | | 0.65 | | | 25.6 | |
| d | 1.05 | 1.20 | 1.35 | 41.3 | 47.2 | 47.2 |
| a | 2.57 | 2.72 | 2.87 | 101.2 | 107.1 | 107.1 |
| D | | 2.50 | | | 98.4 | |
| θ | 0° | | 10° | | | |

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