

Features

- 22,000 counts LCD driver with 46-segment bargraph display
- Conversion rate : 2 times/s
- Full automatic measurement
 - *Voltage measurement:
Manual 220.00mV / Auto 2.2000V – 1000.0V /
Auto 220.00 – 1000.0V
 - *Current measurement: $\mu\text{A}/\text{mA}/\text{A}$
 - *Resistance measurement:
220.00 Ω – 220.00M Ω
 - *Capacitance measurement:
22.000nF – 220.00mF(25sec)
(Taiwan patent no.: 323347,453443)
 - *Frequency counter
22.00Hz – 220.00MHz
- Current modes for clamp meter
- Duty cycle measurement (5.0% ~ 94.9%)
- Diode measurement & continuity check
- ADP mode with independent reference voltage
- Temperature mode with internal scale translation circuit from $^{\circ}\text{C}$ to $^{\circ}\text{F}$
- Push functions
 - *Range change function
 - *VAHZ function
 - *Peak Hold with automatic calibration
(Taiwan patent no.: 476418)
 - *Relative function
 - *Zero function in manual DCA mode
 - *Data hold function with delay hold feature
 - *MAX/MIN function
 - *Back-light function

*KEY function

- Programmable LCD segment display
- Support a low pass filter* for AC voltage & Clamp ACA measurement
- SHIFT function
- High-crest-factor signal detection
(Taiwan patent no.: 234661)
- Band-gap reference voltage output
- CE selection (610V, 1010V or 1500V)
- Serial data output (RS232 format)
- LCD segment check when power on
- Auto power off with idle time selection
- Sleep output
- Re-power on
- On-chip buzzer driver
- 3V DC power supply
- Low battery detection for 3V or 9V battery

Description

ES51922 is an integrated analog-to-digital converter (ADC) with 22,000 counts LCD display, automatic range selection, and 3V DC power supply. Automatic range selection is provided for voltage (AC/DC) measurement, resistance measurement, current measurement, capacitance measurement, and frequency counter. Expensive and bulky mechanical range switches are not required. Other features include peak detection with calibration mode, relative value display, Zero function, data holding, maximum and minimum holding, diode measurement, temperature measurement, continuity checking, low battery detection, auto power off, re-power on, and RS232 data output.



Application

- Digital multimeter
- Clamp meter
- Thermometer

Pin Assignment

| | | | |
|-----|--------|-----|----------|
| 103 | VAHZ | 102 | BKLT |
| 104 | BUZOUT | 101 | PEAK |
| 105 | BKOUT | 100 | MAX/MIN |
| 106 | OSC2 | 99 | KEY |
| 107 | OSC1 | 98 | REL_ZERO |
| 108 | SCLK | 97 | RANGE |
| 109 | SDATA | 96 | HOLD |
| 110 | uPLCD | 95 | ANNUNC |
| 111 | RS232 | 94 | BP1 |
| 112 | APOSEL | 93 | BP2 |
| 113 | BKSEL | 92 | BP3 |
| 114 | VST | 91 | BP4 |
| 115 | SHIFT | 90 | SEG01 |
| 116 | CESEL | 89 | SEG02 |
| 117 | SLACDC | 88 | SEG03 |
| 118 | FC5 | 87 | SEG04 |
| 119 | FC4 | 86 | SEG05 |
| 120 | FC3 | 85 | SEG06 |
| 121 | FC2 | 84 | SEG07 |
| 122 | FC1 | 83 | SEG08 |
| 123 | SDO | 82 | SEG09 |
| 124 | C+ | 81 | SEG10 |
| 125 | C- | 80 | SEG11 |
| 126 | V- | 79 | SEG12 |
| 127 | V+ | 78 | SEG13 |
| 128 | LBAT9 | 77 | SEG14 |
| | | 76 | SEG15 |
| | | 75 | SEG16 |
| | | 74 | SEG17 |
| | | 73 | SEG18 |
| | | 72 | SEG19 |
| | | 71 | SEG20 |
| | | 70 | SEG21 |
| | | 69 | SEG22 |
| | | 68 | SEG23 |
| | | 67 | SEG24 |
| | | 66 | SEG25 |
| | | 65 | SEG26 |
| | | | SEG27 |
| | | | SEG28 |
| | | | SEG29 |
| | | | SEG30 |
| | | | SEG31 |
| | | | FREQ |
| | | | SLEEP |
| | | | BUZIN |
| | | | LPFC3 |
| | | | LPFON |
| | | | LPFOUT |
| | | | LPFC2 |
| | | | LPFC1 |
| | | | PMAX |
| | | | PMIN |
| | | | R1K |
| | | | R9K |
| | | | CA+ |
| | | | CA- |
| | | | VBAR |
| | | | VR1 |
| | | | V220m |
| | | | VA- |
| | | | VA+ |
| | | | ADP |
| | | | SGND |
| | | | VR |
| | | | NC |
| | | | OHM1C1 |
| | | | OHM1C2 |
| | | | OHM1C3 |
| | | | OHM1C4 |
| | | | ACVH |
| | | | ACVL |
| | | | TEST5 |
| | | | VR2 |
| | | | VR3 |
| | | | VR4 |
| | | | VR5 |
| | | | OR1 |
| | | | OVSF |
| | | | OVB |
| | | | OVS |
| | | | IVSL |
| | | | IVSH |
| | | | RAZ |
| | | | BUFL |
| | | | CAZL |
| | | | CTL |
| | | | CL- |
| | | | CL+ |
| | | | CAZH |
| | | | CAZH |
| | | | BUFFFH |
| | | | CIH |
| | | | CH- |
| | | | CH+ |
| | | | AGND |
| | | | AGND |
| | | | DGND |
| | | | V+ |
| | | | V+ |



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ES51922



Pin Description

| Pin No | Symbol | Type | Description |
|--------|--------|------|---|
| 1 | V+ | O | Output of on-chip DC-DC converter. |
| 2 | V+ | O | Output of on-chip DC-DC converter. |
| 3 | DGND | P/G | Digital ground. Connecting to 3V battery positive terminal. |
| 4 | AGND | P/G | Analog ground. |
| 5 | AGND | P/G | Analog ground. |
| 6 | CH+ | IO | Positive connection for reference capacitor of high-speed A/D. |
| 7 | CH- | IO | Negative connection for reference capacitor of high-speed A/D. |
| 8 | CIH | O | High-speed integrator output. Connect to integral capacitor. |
| 9 | BUFFH | O | High-speed buffer output pin. Connect to integral resistor. |
| 10 | CAZH | O | High-speed auto-zero capacitor connection. |
| 11 | CL+ | IO | Positive connection for reference capacitor of high-resolution A/D. |
| 12 | CL- | IO | Negative connection for reference capacitor of high-resolution A/D. |
| 13 | CIL | O | High-resolution integrator output. Connect to integral capacitor. |
| 14 | CAZL | O | High-resolution auto-zero capacitor connection. |
| 15 | BUFFL | O | High-resolution Buffer output pin. Connect to integral resistor |
| 16 | RAZ | O | Buffer output pin in AZ and ZI phase. |
| 17 | IVSH | I | Current measurement input for 2200 μ A, 220mA and 22A modes. |
| 18 | IVSL | I | Current measurement input for 220 μ A, 22mA. |
| 19 | OVX | I | Input high voltage for resistance measurement |
| 20 | OVH | I | Output connection for resistance measurement |
| 21 | OVSG | O | Sense low voltage for resistance measurement |
| 22 | OR1 | O | Reference resistor connection for 220.00 Ω range |
| 23 | VR5 | O | Voltage measurement \div 10000 attenuator(1000.0V) |
| 24 | VR4 | O | Voltage measurement \div 1000 attenuator(220.00V) |
| 25 | VR3 | O | Voltage measurement \div 100 attenuator(22.000V) |
| 26 | VR2 | O | Voltage measurement \div 10 attenuator(2.2000V) |
| 27 | TEST5 | IO | Test pin |
| 28 | ACVL | O | DC signal low input in ACV/ACA mode. Connect to negative output of external AC to DC converter. |
| 29 | ACVH | O | DC signal high input in ACV/ACA mode. Connect to positive output of external AC to DC converter. |
| 30 | ADI | I | Negative input of internal AC to DC OP Amp. |
| 31 | ADO | O | Output of internal AC to DC OP Amp. |
| 32 | OHMC1 | O | Filter capacitor connection for resistance mode. |
| 33 | OHMC2 | O | Filter capacitor connection for resistance mode. |
| 34 | OHMC3 | O | Filter capacitor connection for resistance mode. |
| 35 | OHMC4 | O | Filter capacitor connection for resistance mode. |
| 36 | NC | - | |
| 37 | VRH | O | Output of band-gap voltage reference. Typically -1.23 V |
| 38 | VR | I | Reference input voltage connection. Typically -100 mV |
| 39 | SGND | G | Signal Ground. |
| 40 | ADP | I | Measurement input in ADP mode. Connect to AGND if no used. |
| 41 | VA+ | I | For ADP mode. De-integrating voltage positive input. The input should be higher than VA-. |
| 42 | VA- | I | For ADP mode. De-integrating voltage negative input. The input should be lower than VA+. |
| 43 | V220m | I | Independent input terminal for AC/DC 220.00mV mode. |
| 44 | VR1 | I | Measurement Input. |
| 45 | VBAR | I | In temperature mode, it is used to control decimal point. In μ A or mA modes, it is used to control the ' μ ' or 'm' sign. |
| 46 | CA- | IO | Negative auto-zero capacitor connection for capacitor measurement |



| | | | |
|---------|---------------|----|---|
| 47 | CA+ | IO | Positive auto-zero capacitor connection for capacitor measurement |
| 48 | R9K | O | Connect to a precise 9KΩ resistor for capacitor measurement. |
| 49 | R1K | O | Connect to a precise 1KΩ resistor for capacitor measurement. |
| 50 | PMIN | O | Minimum peak hold output |
| 51 | PMAX | O | Maximum peak hold output. |
| 52 | LPFC1 | O | Capacitor C1 connection for internal low-pass filter |
| 53 | LPFC2 | O | Capacitor C2 connection for internal low-pass filter |
| 54 | LPFOUT | O | Capacitor C1 connection for internal low-pass filter |
| 55 | LPFON | I | Pull to V- to enable low-pass filter |
| 56 | LPFC3 | I | Capacitor C3 connection for internal low-pass filter |
| 57 | BUZIN | I | Pull to V- to enable the BUZOUT. |
| 58 | SLEEP | O | Sleep mode indicator, asserts low in SLEEP mode. |
| 59 | FREQ | I | Frequency counter input, offset V-/2 internally by the chip. |
| 60 - 90 | SEG31 – SEG01 | O | LCD segment line 01 – 31 |
| 91 | BP4 | O | LCD backplane 4 |
| 92 | BP3 | O | LCD backplane 3 |
| 93 | BP2 | O | LCD backplane 2 |
| 94 | BP1 | O | LCD backplane 1 |
| 95 | ANNUNC | O | Square wave output at the backplane frequency, synchronized to BP1. ANNUNC can be used to control display annunciator. Connect a LCD segment to ANNUNC to turn it on; connect an LCD segment to its backplane to turn it off. |
| 96 | HOLD | I | Pulse to V- to enable HOLD function. |
| 97 | RANGE | I | Pulse to V- to enable manual mode and manual range selection. |
| 98 | REL_ZERO | I | Pulse to V- to enable Relative function or Zero function. |
| 99 | KEY | I | Pulse to V- to change mode. In ADP mode, if this pin is connected to V-, the buzzer output will be off when the ADP input overflows. |
| 100 | MAX/MIN | I | Pulse to V- to enable MAX/MIN function. |
| 101 | PEAK | I | Pulse to V- to enable Peak Hold mode. |
| 102 | BKLIT | I | Back light function. Pulse low to set BKOUT pin output. |
| 103 | VAHZ | I | Pulse to V- to enable VAHZ mode. |
| 104 | BUZOUT | O | Outputs a 2KHz audio frequency signal for driving piezoelectric buzzer when BUZIN is low. |
| 105 | BKOUT | O | If BKLIT function is enabled, this pin will change from -3V to +3V For 60 sec, once press BKLIT pin again within 60 sec, this pin will Change back to -3V. |
| 106 | OSC2 | O | Crystal oscillator output connection |
| 107 | OSC1 | I | Crystal oscillator input connection |
| 108 | SCLK | I | Clock signal input for programmable LCD segment display. |
| 109 | SDATA | I | Serial data input pin for programmable LCD segment display. |
| 110 | μPLCD | I | Enable pin for programmable LCD segment display and SDO output enable |
| 111 | RS232 | I | Assert low to enable serial data output. |
| 112 | APOSEL | I | Idle time selection for auto power off feature. |
| 113 | BKSEL | I | Set to V- to change the backlight idle time from 60 sec. to 180 sec. |
| 114 | VST | I | Set to V- to enable the auto range voltage mode to start from 220.00V range. |
| 115 | SHIFT | I | Assert low to enable LCD SHIFT feature, only works in 220MΩ, and all capacitor measurement ranges |
| 116 | CESEL | I | CE selection feature control pin. |
| 117 | SLACDC | I | Select initial state. |
| 118 | FC5 | I | Switch 5 for function selection. |
| 119 | FC4 | I | Switch 4 for function selection. |
| 120 | FC3 | I | Switch 3 for function selection. |
| 121 | FC2 | I | Switch 2 for function selection. |



| | | | |
|-----|-------|---|---|
| 122 | FC1 | I | Switch 1 for function selection. |
| 123 | SDO | O | RS232 compliant serial data output. |
| 124 | C+ | O | Positive capacitor connection for on-chip DC-DC converter. |
| 125 | C- | O | Negative capacitor connection for on-chip DC-DC converter. |
| 126 | V- | P | Negative supply voltage. Connecting to 3V battery negative terminal. |
| 127 | V- | P | Negative supply voltage. Connecting to 3V battery negative terminal. |
| 128 | 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) |

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 | -25°C to 125°C |

Electrical Characteristics

TA=25°C, V- = -3V

| Parameter | Symbol | Test Condition | Min. | Typ. | Max | Units |
|---|------------------|---|------|------|-------|-------------------|
| Power supply | V- | | -3.5 | -3.0 | -2.5 | V |
| Operating supply current | I _{DD} | Normal operation | — | 2.0 | 2.5 | mA |
| In DCV mode | I _{SS} | In sleep mode | — | 2.5 | 5 | μA |
| Voltage roll-over error | REV | 10MΩ input resistor | — | — | ±0.03 | %F.S ¹ |
| Voltage nonlinearity | NLV | Best case straight line | — | — | ±0.03 | %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 | | 10MΩ input resistor | -000 | 000 | +000 | counts |
| Band-gap reference voltage | V _{REF} | 100KΩ resistor between VRH and AGND | -1.3 | -1.2 | -1.1 | V |
| Peak to peak backplane drive voltage | | -3.5V ≤ V ≤ -2.2V | 3.0 | 3.1 | 3.2 | V |
| Counter time base period | | f _{OSC} = 4MHZ | — | 1 | — | sec |
| Internal pull-high to 0V current | | Between V- pin and HOLD, RANGE, KEY, FC1, FC2, FC3, FC4, FC5, BKLIT, MAXMIN | — | 1.2 | — | μA |
| | | Between V- pin and RS232 | — | 11 | — | |
| Open circuit voltage for 220Ω measurement | | 220Ω mode | — | -3.0 | — | V |



| | | | | | | |
|--|-----------|--|-------|----------|-------|-------------------|
| Open circuit voltage for Ω measurement (except 220 Ω) | | Ω and Continuity Mode | -0.58 | -0.53 | -0.48 | V |
| Internal pull-low to V-current | | Between GND Pin and SLACDC | | 1.5 | | μ A |
| AC frequency response at 2.2000V range | | $\pm 1\%$ | — | 40-400 | — | HZ |
| | | $\pm 5\%$ | — | 400-2000 | — | |
| 3dB frequency for LPF mode | | 3 rd order LPF | 800 | 1000 | 1200 | Hz |
| Reference voltage temperature coefficient | T_{CRF} | 100K Ω resistor Between VRH 0 $^{\circ}$ C < TA < 70 $^{\circ}$ C | — | 75 | — | ppm/ $^{\circ}$ C |
| Minimum pulse width for Peak Hold feature | T_{PW} | 4MHz crystal oscillator | 100 | | | μ s |
| Capacitance measurement accuracy ² | | 22nF – 220nF | -1.0 | — | 1.0 | % |
| | | | -10 | — | 10 | counts |
| | | 2.2 μ F | -1.0 | — | 1.0 | % |
| | | | -10 | — | 10 | counts |
| | | 22 μ F~220mF | -2.0 | | 2.0 | % |
| | | | 20 | | 20 | counts |

Note:

1.Full Scale

2.Above specification from 22nF to 2.2uF ranges are specified under REL mode. The reading is calibrated to zero by relative function, when input is floating.

Function Description

1. Operating Modes

1.1 Voltage Measurement

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

| Configuration | Full Scale Range | Divider Ratio | Resistor Connection | Input Pin |
|---------------|-----------------------|---------------|---------------------|-----------------|
| VR1 | 220.00mV ¹ | 1 | - | V220m V.S. SGND |
| VR2 | 2.2000V | 1/10 | R2 / (R1+R2) | VR1 V.S. SGND |
| VR3 | 22.000V | 1/100 | R3 / (R1+R3) | VR1 V.S. SGND |
| VR4 | 220.00V ² | 1/1000 | R4 / (R1+R4) | VR1 V.S. SGND |
| VR5 | 2200.0V | 1/10000 | R5 / (R1+R5) | VR1 V.S. SGND |

Note:

- 220.00mV range is independent and manual mode. The input pin is different from other voltage ranges.
- If VST is set to V- level, the auto range mode will start from 220.00V range. 2.2000V – 22.000V ranges only exist in manual mode.



1.1.2 CE selection

ES51922 has a CE selection feature archived by configuring a CESEL pin. If pin CESEL is connected to V-, ES51922 will have a 610.0V overflow level in DCV and ACV ranges. If pin CESEL is connected to DGND, the overflow level will be set to 1010V. When it is floating, the overflow level is set to 1500V in DCV mode and 1010V in ACV mode. The meter will show OL when the measuring signal reaches the overflow level. The configuration of CESEL is listed below.

| CESEL | DCV | ACV |
|----------|---------|---------|
| V- | 610.0 | 610.0V |
| DGND | 1010.0V | 1010.0V |
| Floating | 1500.0V | 1010.0V |

1.1.3 HCF signal detection

ES51922 provides detection of high-crest-factor (HCF) signal in ACV mode. When this function is enabled, ES51922 senses the signal and determines it as HCF if the Vpp is large enough. Once the signal is determined as HCF, ES51922 will jump up one measuring range regardless of current measurement value. It takes 60ms to jump one range up. The jumping up process will continue until the maximum range is reached. With HCF detection, a more accurate result could be obtained. For example, when a input signal with Vpeak=240V, Vrms=40V(CF=6) was applied, traditional DMMs might stay at 22.000V range but shows counts with the amount of error up to 10% or even bigger. The error rises from limited input/output swing at internal ADC. With HCF detection, DMM will stay at 220.00V and exhibits more accurate results.

In addition to accuracy improvement, HCF will speed up the measuring process for high voltage signals. For example, a 500Vrms is applied, ES51922 will take about 180ms (3 HCF jumps) to enter 1000.0 V range. And it takes 1 or 2 measuring processes to obtain the stable result. Thus a stable LCD reading could be obtained within 1 sec.



1.1.4 The true RMS-to-DC conversion with ES636

If ES636 is used for true RMS-to-DC measurement, the test circuit is shown in Figure 1. Make ADO and ADI pin short, and TEST5 pin keeps float. Connect OVSG pin to AGND through a switch in ACV measurement mode. If the DCV and ACV measurement modes are in the same rotary switch, please also add this switch in the rotary switch. The configuration of this switch will not influence the precision of DCV measurement.

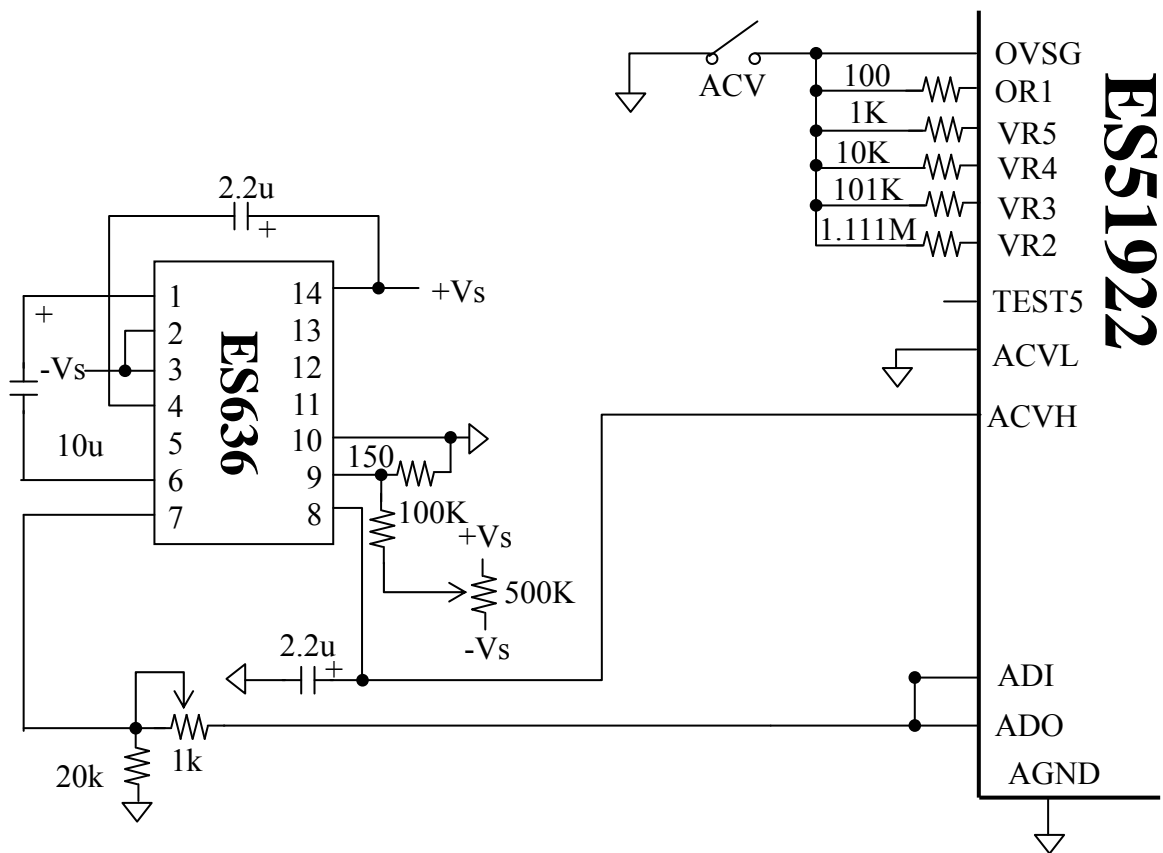


Figure 1. The true RMS-to-DC conversion with ES636

1.1.5 Low-pass filter feature

ES51922 provides a 3-order low-pass filter to reduce the influence of high frequency noise above 1KHz(3dB). This LPF feature is available in all ACV or clamp_meter ACA modes. Set FC5 to low in these mode, the KEY bottom is use to activate the LPF feature. Press KEY bottom for less than 1 second force meter enter LPF mode, and the AC sign on LCD panel will blink until the LPF mode is canceled. When LPF is activated, most of noise above 1KHz will decay greatly. So we can obtain more stable and accurate readings on low frequency response.

1.2 Resistance Measurement

A re-configurable 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. In 220.00MΩ, if SHIFT pin connects to V-, the least digit will not be displayed and the other digits and decimal point will shift right away. So the full scale becomes 220.0MΩ instead of 220.00MΩ.

| Configuration | Full Scale Range | Divider Ratio | Resister Connection |
|---------------|------------------|---------------|---------------------|
| OR1 | 220.00Ω | R6 | 100Ω |
| OR2 | 2.2000KΩ | R5 | 1KΩ |
| OR3 | 22.000KΩ | R1 // R4 | 10KΩ |
| OR4 | 220.00KΩ | R1 // R3 | 100KΩ |
| OR5 | 2.2000MΩ | R1 // R2 | 1MΩ |
| OR6 | 22.000MΩ | R1 | 10MΩ |
| OR7 | 220.00MΩ | R1 | 10MΩ |

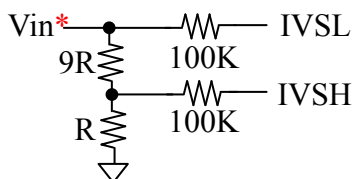
1.3 Current measurement for multimeter

ES51922 has 2 automatic and 1 manual current measurement modes for multimeter. The following table summarizes the full-scale range of each mode. When ES51922 operates in the current measurement modes for multimeter, It takes high input from pin IVSH or IVSL, low input from pin SGND and reference voltage from pin VR.

| Mode | FC1~4 | VBAR | Full Scale | Input Terminal |
|------------|---------|------|---------------------|---------------------|
| Automatic1 | 1,1,0,1 | 1 | 220.00μA / 2200.0μA | IVSL/IVSH V.S. SGND |
| Automatic2 | 1,1,1,1 | 1 | 22.000mA / 220.00mA | IVSL/IVSH V.S. SGND |
| Manual | 0,0,0,0 | X | 22.000A | IVSH V.S. SGND |

Note:

1. The typical connection of input terminal is as the schematic below:





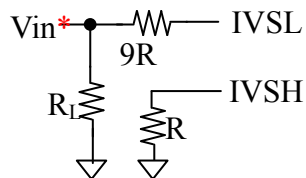
1.4 Current measurement for clampmeter

ES51922 has 2 automatic and 4 manual current measurement modes for clampmeter. The following table summarizes the full-scale range of each mode. When ES51922 operate in the automatic mode1&2, it takes high input from IVSH/IVSL (higher range/lower range), low input from SGND and reference voltage from VR. When ES51922 operates in the manual mode1~4, It takes high input from ADP, low input from SGND and reference voltage from VA+ and VA-.

| Mode | FC1~4 | VBAR | Full Scale | Input Terminal |
|------------|---------|------|-------------------|---------------------|
| Automatic1 | 1,1,0,1 | 0 | 220.00A / 2200.0A | IVSL/IVSH V.S. SGND |
| Automatic2 | 1,1,1,1 | 0 | 22.000A / 220.00A | IVSL/IVSH V.S. SGND |
| Manual1 | 1,1,0,0 | X | 22.000A | ADP V.S. SGND |
| Manual2 | 1,0,0,0 | X | 220.00A | ADP V.S. SGND |
| Manual3 | 1,0,1,0 | X | 2200.0A | ADP V.S. SGND |
| Manual4 | 1,0,0,1 | X | 22000A | ADP V.S. SGND |

Note:

1. Connect VBAR to V- will disable the “ μ_2 ” / ”m₂” symbol on LCD panel.
2. In DC current modes for clampmeter, ES51922 provides **Zero function** for offset removing.
3. The typical connection of input terminal for automatic1&2 is as the schematic below:





1.5 Capacitance Measurement

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

| Configuration | Full Scale Range | Resistance Ratio |
|-----------------|------------------|------------------|
| C1 | 22.000nF | - |
| C2 | 220.00nF | VR ⁴ |
| C3 | 2.2000uF | 10kΩ |
| C4 | 22.000uF | R9k/R1k |
| C5 | 220.00uF | R9k/R1k |
| C6 | 2.2000mF | R9k/R1k |
| C7 ³ | 22.000mF | R9k/R1k |
| C8 ³ | 220.00mF | R9k/R1k |

Note:

1. 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 **dIS.C**
2. Discharging through the chip is quite slow. We recommend the user to discharge the capacitor with some other apparatus.
3. In C7~C8 ranges, the bargraph is used to show the measured time in counting down.
4. The C2 range is calibrated by VR near the **OVX** pin.
5. In ranges of C1~C8, the SHIFT feature is also available to move the digits and decimal points rightward to prevent the least digit from jumping.

1.6 Continuity Check

Continuity check shares the same configuration with 220.00Ω manual resistance measurement mode, but with buzzer output to indicate continuity. The buzzer generates a 2KHz sound whenever the digit number is less than 30Ω.

1.7 Diode Measurement

Diode measurement mode shares the same configuration with 2.2000V manual voltage measurement mode.. The buzzer generates a 2KHz sound whenever the digit number is less than 30mV.



1.8 Frequency counter

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

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

where F_{osc} is the frequency of the crystal oscillator. Thus, the counter has a 1-second time base when a 4MHz oscillator is used. The frequency counter can select the proper range automatically or manually. Auto-range operation extends over seven decades, from 22.00Hz to 220.00MHz. The following table summarizes the full-scale range of the frequency counter. In frequency mode, press VAHz button switches the mode to/from duty cycle mode.

| Range | Full Scale |
|------------------|----------------------|
| ² FR1 | 22.00Hz ¹ |
| ³ FR2 | 220.0Hz ¹ |
| FR3 | 22.000KHz |
| FR4 | 220.00KHz |
| FR5 | 2.2000MHz |
| FR6 | 22.000MHz |
| FR7 | 220.00MHz |

NOTE:

¹In the range FR1~FR2, the maximum counting number is 2200 counts.

²In the Range FR1, ES51922 will show 0.00Hz if the input frequency is less than 2.00Hz.

³In the Range FR2 (manual mode), ES51922 will show 0.0Hz if the input frequency is less than 20.0Hz..

1.8.1Duty Cycle measurement

The duty cycle measurement is available in frequency mode with VAHz operation. Press VAHz key when frequency mode is in operation, the ES51922 will switch to duty cycle measurement mode. Press VAHz key again to switch to frequency measurement mode also. The duty cycle mode range is within 5.0% to 94.9%. The minimum resolution is 0.1%. If the source frequency duty cycle is smaller than 5.0%, the **UL** will be shown on the LCD display. If the duty cycle is larger than 94.9%, the **OL** will be shown on the LCD display.



1.9 Temperature measurement mode

Temperature measurement mode takes input signal from ADP pin and reference voltage from (VA+ - VA-). ES51922 has a built-in °C-to-°F scale translation circuit, and only needs an external °C scale application circuit. The application circuit for °F scale is not required. In temperature measurement mode, the default range is 2200.0 °C or °F. The VBAR pin is used to control the second decimal point (DP2) on the LCD panel. When VBAR is LOW, DP2 is turned on and the first decimal point (DP1) is turned off. And the range becomes 220.00°C and °F.

1.10 Auto power off and Idle Time selection

ES51922 has a default auto power off function. If the meter is idle for more than the given idle time, the chip automatically turns the power off. The idle time to trigger the auto power off function is determined by pin 'APOSEL'. If pin APOSEL is connected to V-, the idle time will be set to 30 minutes. If pin APOSEL is connected to DGND or floating, the idle time will be set to 15 minutes. When APO happens, the state of the meter is saved. The APO symbol on the LCD panel indicates whether the auto power off is enabled or not. In some cases, user might want to disable Auto power off. There are two ways to disable this feature as following:

1. Power on the meter when any of the push functions, except for HOLD is pressed down.
2. In addition, when RS232 output is active, the auto power off function is also disabled.

Note:

Powering on the meter while pressing HOLD and lasts 2 seconds turns on all LCD segments until HOLD is pressed again.

1.11 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.

1.12 Re-power on

After auto power-off, pushing any of the push function or changing the rotary mode can turn on the meter again. If the meter is re-powered on by changing the rotary 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 SLACDC, FC1, FC2, FC3, FC4, FC5, and KEY. When FC5 is high, the measurement mode list is below.

| SLACDC | FC1 | FC2 | FC3 | FC4 | Mode | Function of KEY |
|--------|-----|-----|-----|-----|--|------------------------|
| 0 | 1 | 0 | 1 | 1 | Voltage Measurement | DCV ↔ ACV |
| 0 | 1 | 1 | 0 | 1 | Auto DC Current Measurement(μA) | DCA ↔ ACA |
| 0 | 1 | 1 | 1 | 1 | Auto DC Current Measurement(mA) | DCA ↔ ACA |
| 0 | 0 | 0 | 0 | 0 | ³ 22A DC Current Measurement(A) | DCA ↔ ACA |
| 0 | 1 | 1 | 1 | 0 | DCmV 220.00mV | DCmV ↔ ACmV |
| 0 | 1 | 1 | 0 | 0 | ² Manual DC 22.000A | DCA ↔ ACA |
| 0 | 1 | 0 | 0 | 0 | Manual DC 220.00A | DCA ↔ ACA |
| 0 | 1 | 0 | 1 | 0 | Manual DC 2200.0A | DCA ↔ ACA |
| 0 | 1 | 0 | 0 | 1 | Manual DC 22000A | DCA ↔ ACA |
| 0 | 0 | 0 | 1 | 1 | Resistance Measurement | Ω ↔ Continuity |
| 0 | 0 | 0 | 0 | 1 | Continuity Check | Continuity ↔ Diode |
| 0 | 0 | 1 | 1 | 1 | Resistance Measurement | Ω ↔ Continuity ↔ Diode |
| 0 | 0 | 0 | 1 | 0 | Frequency Measurement | — |
| 0 | 0 | 1 | 1 | 0 | Capacitance Measurement | — |
| 0 | 0 | 1 | 0 | 0 | Temperature Measurement | °C ↔ °F |
| 0 | 0 | 1 | 0 | 1 | Resistance Measurement | Ω ↔ Diode |
| 1 | 1 | 0 | 1 | 1 | Voltage Measurement | ACV ↔ DCV |
| 1 | 1 | 1 | 0 | 1 | Auto AC Current Measurement(μA) | ACμA ↔ DCμA |
| 1 | 1 | 1 | 1 | 1 | Auto AC Current Measurement(mA) | ACmA ↔ DCmA |
| 1 | 0 | 0 | 0 | 0 | ³ 22A AC Current Measurement(A) | ACA ↔ DCA |
| 1 | 1 | 1 | 1 | 0 | ACmV 220.00mV | ACmV ↔ DCmV |
| 1 | 1 | 1 | 0 | 0 | ² Manual AC 22.000A | ACA ↔ DCA |
| 1 | 1 | 0 | 0 | 0 | Manual AC 220.00A | ACA ↔ DCA |
| 1 | 1 | 0 | 1 | 0 | Manual AC 2200.0A | ACA ↔ DCA |
| 1 | 1 | 0 | 0 | 1 | Manual AC 22000A | ACA ↔ DCA |
| 1 | 0 | 0 | 1 | 1 | ¹ ADP0(22000) | — |
| 1 | 0 | 0 | 0 | 1 | ADP1(2200.0) | — |
| 1 | 0 | 1 | 1 | 1 | ADP2(220.00) | — |
| 1 | 0 | 0 | 1 | 0 | ADP3(22.000) | — |
| 1 | 0 | 1 | 1 | 0 | ADP4(2.2000) | — |
| 1 | 0 | 1 | 0 | 0 | Temperature Measurement | °F ↔ °C |
| 1 | 0 | 1 | 0 | 1 | Capacitance Measurement (Clamp) ⁴ | — |

X means “don’t care”.

Note1: When FC5 is high, the ADP0, ADP1, ADP2, ADP3 and ADP4 modes can display minus sign.

Note2: The manual DC/AC 22A, 220A, 2200A and 22000A modes are designed for clampmeter.

Note3: DC 22A and AC 22A current measurement modes, (FC1~4) = (0, 0, 0, 0), are designed for multimeter.

Note4: It provides the ranges from 2.2uF to 220mF in this mode.



When FC5=low, **KEY** is disabled and the measurement mode list is below.

| SLACDC | FC1 | FC2 | FC3 | FC4 | Mode | Push KEY to enable LPF mode |
|--------|-----|-----|-----|-----|--|-----------------------------|
| 0 | 1 | 0 | 1 | 1 | DC Voltage Measurement | |
| 0 | 1 | 1 | 0 | 1 | Auto DC Current Measurement(μ A) | |
| 0 | 1 | 1 | 1 | 1 | Auto DC Current Measurement(mA) | |
| 0 | 0 | 0 | 0 | 0 | ³ 22A DC Current Measurement(A) | |
| 0 | 1 | 1 | 1 | 0 | DC 220.00mV | |
| 0 | 1 | 1 | 0 | 0 | ² Manual DC 22.000A | |
| 0 | 1 | 0 | 0 | 0 | Manual DC 220.00A | |
| 0 | 1 | 0 | 1 | 0 | Manual DC 2200.0A | |
| 0 | 1 | 0 | 0 | 1 | Manual DC 22000A | |
| 0 | 0 | 0 | 1 | 1 | Resistance Measurement | |
| 0 | 0 | 0 | 0 | 1 | Continuity Check | |
| 0 | 0 | 1 | 1 | 1 | Diode Measurement | |
| 0 | 0 | 0 | 1 | 0 | Frequency Measurement | |
| 0 | 0 | 1 | 1 | 0 | Capacitance Measurement | |
| 0 | 0 | 1 | 0 | 0 | Temperature Measurement ($^{\circ}$ C) | |
| 0 | 0 | 1 | 0 | 1 | Resistance Measurement | |
| 1 | 1 | 0 | 1 | 1 | AC Voltage Measurement | O |
| 1 | 1 | 1 | 0 | 1 | Auto AC Current Measurement(μ A) | O(VBAR to V-) |
| 1 | 1 | 1 | 1 | 1 | Auto AC Current Measurement(mA) | O(VBAR to V-) |
| 1 | 0 | 0 | 0 | 0 | ³ 22A AC Current Measurement(A) | |
| 1 | 1 | 1 | 1 | 0 | AC 220.00mV | O |
| 1 | 1 | 1 | 0 | 0 | ² Manual AC 22.000A | O |
| 1 | 1 | 0 | 0 | 0 | Manual AC 220.00A | O |
| 1 | 1 | 0 | 1 | 0 | Manual AC 2200.0A | O |
| 1 | 1 | 0 | 0 | 1 | Manual AC 22000A | O |
| 1 | 0 | 0 | 1 | 1 | ¹ ADP0(22000) | |
| 1 | 0 | 0 | 0 | 1 | ADP1(2200.0) | |
| 1 | 0 | 1 | 1 | 1 | ADP2(220.00) | |
| 1 | 0 | 0 | 1 | 0 | ADP3(22.000) | |
| 1 | 0 | 1 | 1 | 0 | ADP4(2.2000) | |
| 1 | 0 | 1 | 0 | 0 | Temperature Measurement ($^{\circ}$ F) | |
| 1 | 0 | 1 | 0 | 1 | Capacitance Measurement (Clamp) ⁴ | |

X means "don't care".

Note1: When FC5 is low, the ADP0-ADP4 modes can not display minus sign.

Note2: The manual DC/AC 22A/220A/2200A/22000A modes are designed for clampmeter.

Note3: DC 22A and AC 22A Current Measurement mode, (FC1~4) = (0, 0, 0, 0), is designed for multimeter.

Note4: It provides the ranges from 2.2uF to 220mF in this mode.



3. Push function

All the enabled push functions will be reset when the measurement mode is changed by rotary switch. Change measurement mode by KEY function will reset enabled Range, Hold, Max/Min, REL, Zero and Peak functions. The following table lists the available function versus every measurement mode.

| Function Mode | Range | Hold | Max/Min | REL | Zero | Peak | VAHz |
|---------------|-------|------|---------|-----|------|------|------|
| Voltage | O | O | O | O | X | O | O |
| Current1 | O | O | O | O | X | O | O |
| Current2 | X | O | O | AC | DC | O | O |
| Resistance | O | O | O | O | X | X | X |
| Capacitance | O | O | O | O | X | X | X |
| Frequency | O | O | X | X | X | X | O |
| Duty cycle | X | O | X | X | X | X | X |
| Continuity | X | O | O | O | X | X | X |
| Diode | X | O | O | O | X | X | X |
| Temperature | X | O | O | O | X | X | X |
| ADP | X | O | O | O | X | O | X |

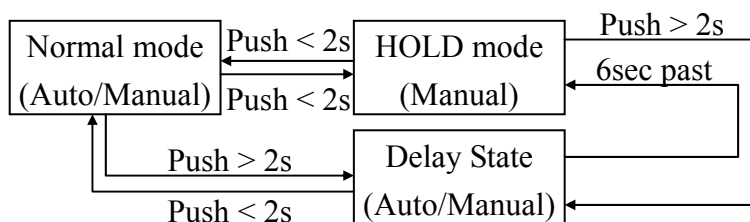
Note:

Current1 includes Auto μ A, Auto mA and 22A modes.

Current2 includes Manual 2.2A, 22A, 220A, 2200A and 22000A modes.

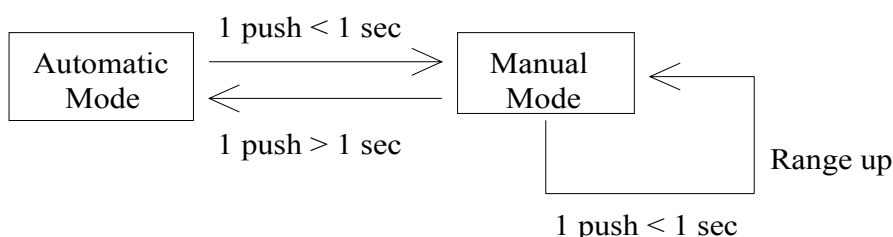
3.1 HOLD and Delay HOLD

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. ES51922 provides a Delay HOLD feature. To activate Delay HOLD feature, press down the HOLD bottom and last for 2 seconds. The meter will delay for 6 seconds, than enters HOLD mode. In the 6-second delayed time, the HOLD symbol on LCD panel will blink. To cancel the delayed state, push the HOLD bottom again.



3.2 Range

RANGE pin switches to and from automatic and manual mode, and while in manual mode, changes the full-scale range. The following figure shows the state transition.



| Measurement Mode | Auto | Manual | Control Range | Initial Range |
|-------------------------------------|-----------|-----------------------------|---------------------|---------------|
| 220.00mV(DC/AC) | VR1 | VR1 | 220.00mV | 220.00mV |
| V(DC/AC) | VR2 – VR5 | VRi → VRi + 1, VR5 → VR2 | 2.2000V – 1010.0V | 2.2000V |
| Auto 220V/1010V (Set VST to low) | VR4-VR5 | VRi → VRi + 1, VR5 → VR2 | 2.2000V – 1010.0V | 220.00V |
| Auto μA(DC/AC) | R1 – R2 | R1 → R2, R2 → R1 | 220.00μA – 2200.0μA | 220.00μA |
| Auto mA(AC/DC) | R1 – R2 | R1 → R2 R2 → R1 | 22.000mA – 220.00mA | 22.000mA |
| 22 A(DC/AC) | Fixed | Fixed | 22.000A | 22.000A |
| Auto 22A/220A (DC/AC) | R1 – R2 | R1 → R2, R2 → R1 | 22.000A – 220.00A | 22.000A |
| Auto 220A/2200A (DC/AC) | R1 – R2 | R1 → R2 R2 → R1 | 220.00A – 2200.0A | 220.00A |
| Ω | OR1 - OR7 | ORi → ORi + 1, OR7 → OR1 | 220.00Ω – 220.00MΩ | 220.00Ω |
| Capacitance | C1 – C8 | Ci → Ci + 1, C8 → C1 | 22.000nF – 220.00mF | 22.000nF |
| Capacitance (Clamp mode) | C3 – C8 | Ci → Ci + 1, C8 → C3 | 2.2000μF – 220.00mF | 2.2000μF |
| Continuity | fixed | fixed | 220.00Ω | 220.00Ω |
| Diode | fixed | fixed | 2.2000V | 2.2000V |
| Frequency | FR1 – FR7 | FRi → FRi + 1 FR7 → FR1 | 22.00Hz – 220.00MHz | 22.00Hz |

Note: Pushing RANGE resets all existing special modes.

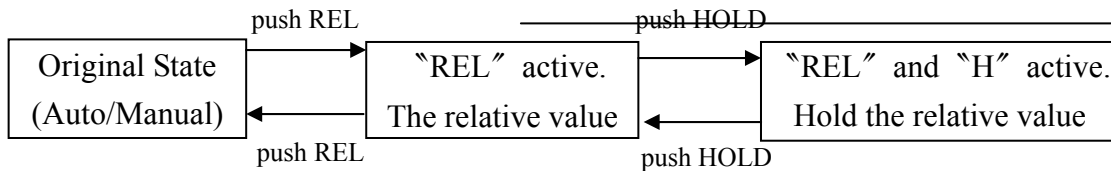


3.3 KEY

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

3.4 REL + HOLD

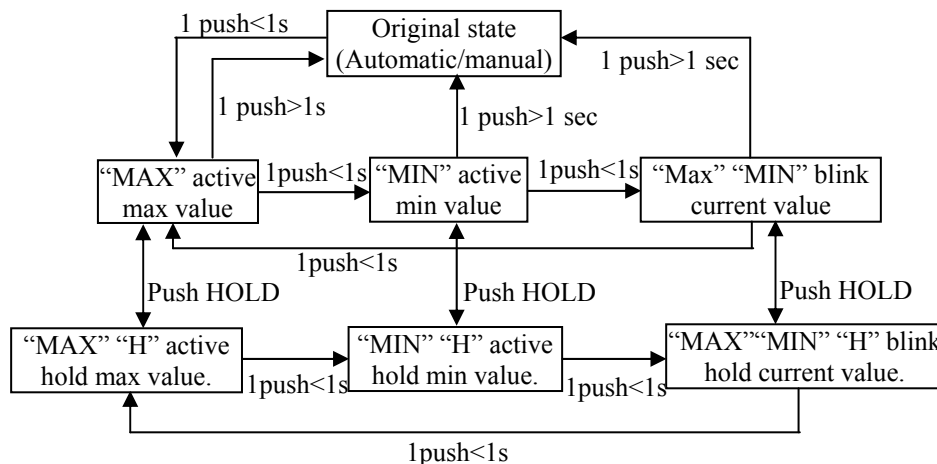
In REL mode, the LCD panel displays $D_{N+K} - D_N$, where $D_N = 1, 2, 3, \dots$, D_N is the last value before REL is pushed, and D_{N+K} is the current value. If REL is pushed again in REL mode, the meter displays the reference value. The meter returns to normal operation if REL is pressed and held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



Note: It's possible that the relative value exceeds 22,000 or -22,000 counts. Such relative values are displayed. The LCD panel shows OL in REL mode only if D_N or D_{N+K} is more than 22,580 counts.

3.5 Max/Min + HOLD

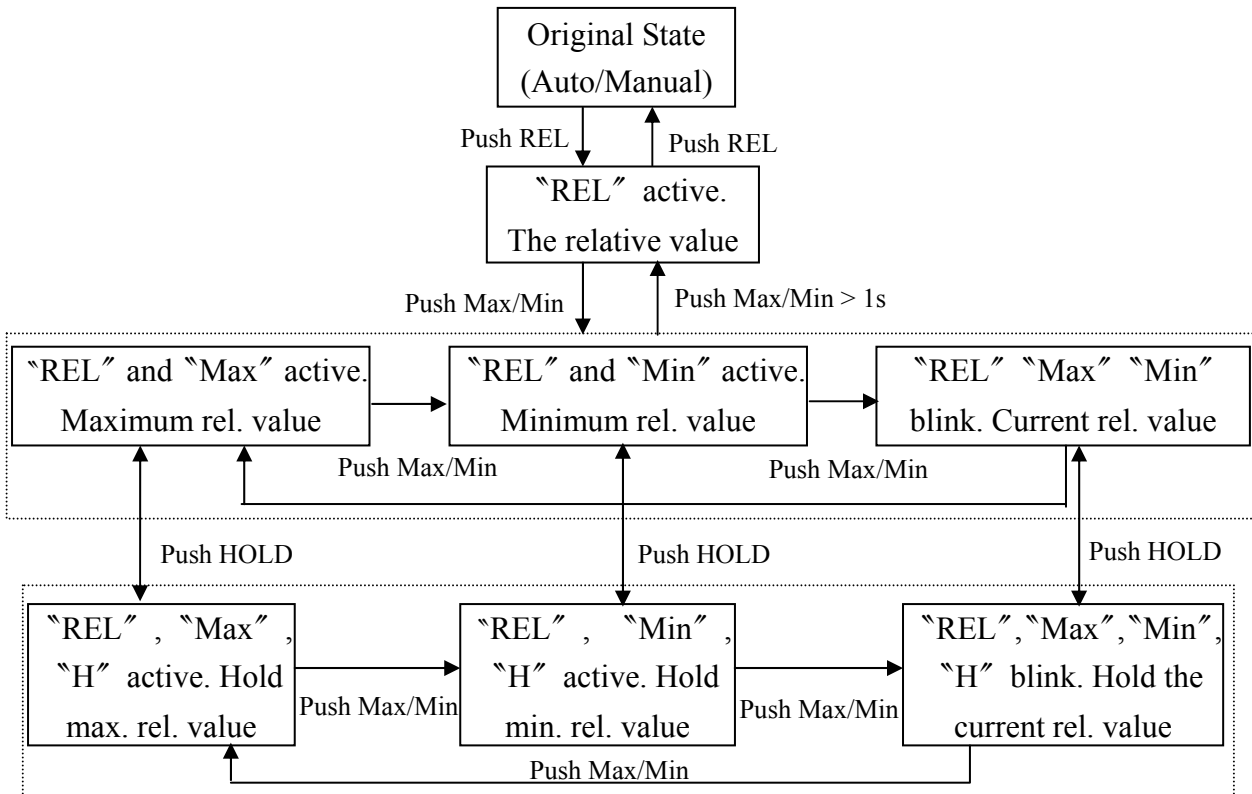
The meter displays the maximum or minimum value of the input in Max/Min mode. When Max/Min is pressed for the first time, the meter displays the maximum value. When Max/Min is pressed again, the meter displays the minimum value. When Max/Min is pressed for the third time, the meter displays current value with Max/Min blinking. 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.





3.6 Relative + Max/Min + HOLD

Max/Min mode can be nested in REL mode. The meter displays the maximum or minimum value relative to the reference when Max/Min is pressed in REL mode. Pressing HOLD under REL + Max/Min makes the meter stop updating the LCD panel.

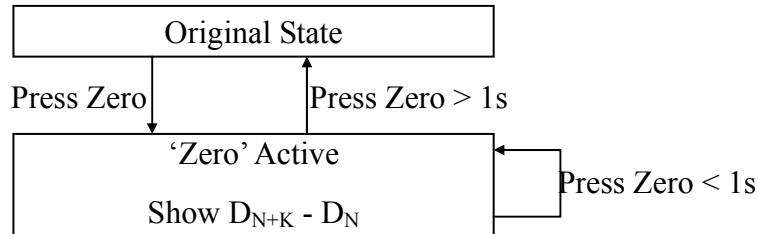


3.7 Zero : In manual DC 22.000A, 220.00A, 2200.0A and 22000A measurement modes, the REL pin changes to control Zero function instead of relative function. In Zero mode, the LCD panel displays $D_{N+K} - D_N$, where $D_N = 1, 2, 3, \dots$, D_N is the last conversion value before Zero is pushed, and D_{N+K} is the current conversion value. If Zero is pushed again in Zero mode, the meter will refresh the D_N value and displays the $D_{N+K} - D_N$ again. The meter returns to normal operation if Zero is pressed and held for longer than one second. Pressing HOLD in Zero mode makes the meter stop updating the LCD panel. In Zero mode, LCD **will not** show any symbol to remind users of Zero mode is active. In 2-range auto DCA modes for clampmeter (220.00A/2200.0A or 22.000A/220.00A), the system will stay in automatic mode, even if the Zero function is activated. In other words, it could achieve real automatic operation. In automatic mode, Zero function could not be entered from higher range, but it could be still activated if current range is lower one. This is because most residual current value is so small that

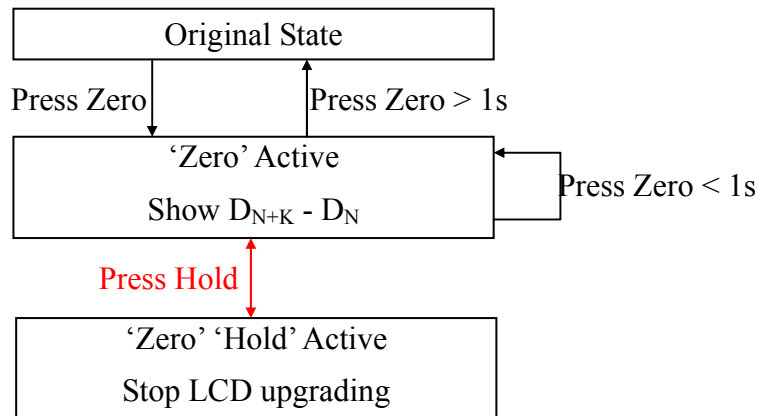


the range could not be higher one in automatic mode. When enter Zero mode from lower range, the system will store the nonzero counts (residual current value). If the range goes up to higher one automatically, the nonzero counts will be divided by ten. So this function will still work well in automatic modes.

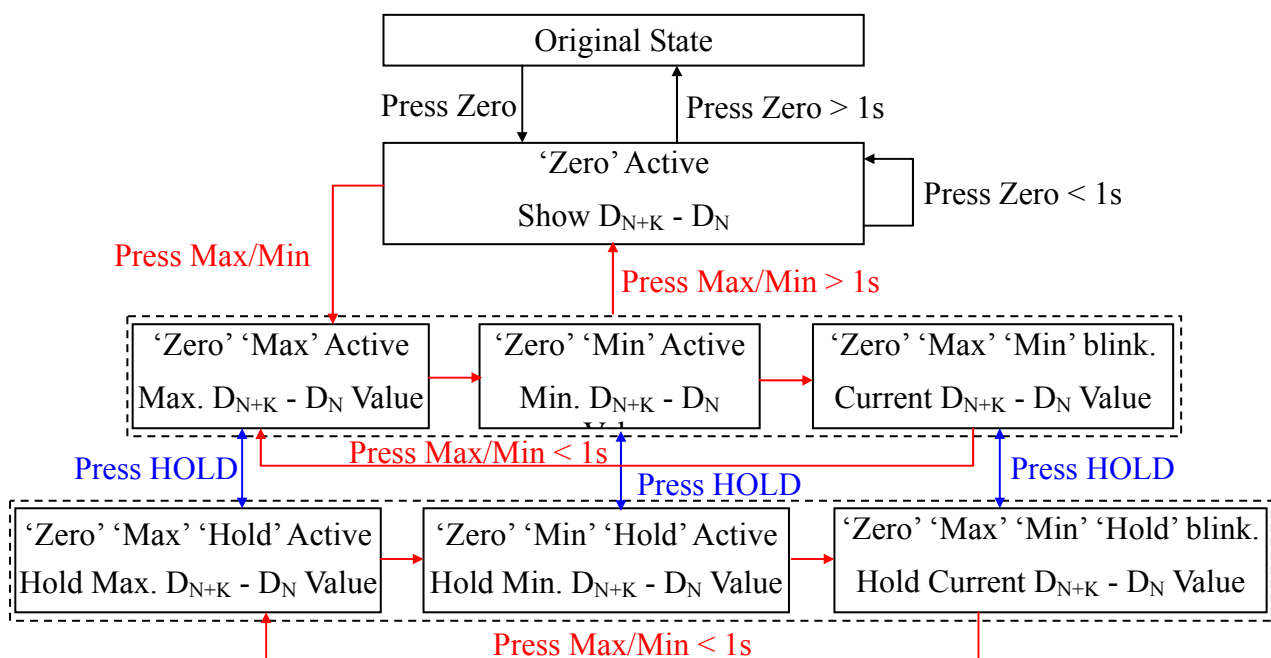
State diagram for Zero mode:



State diagram for Zero + HOLD mode:



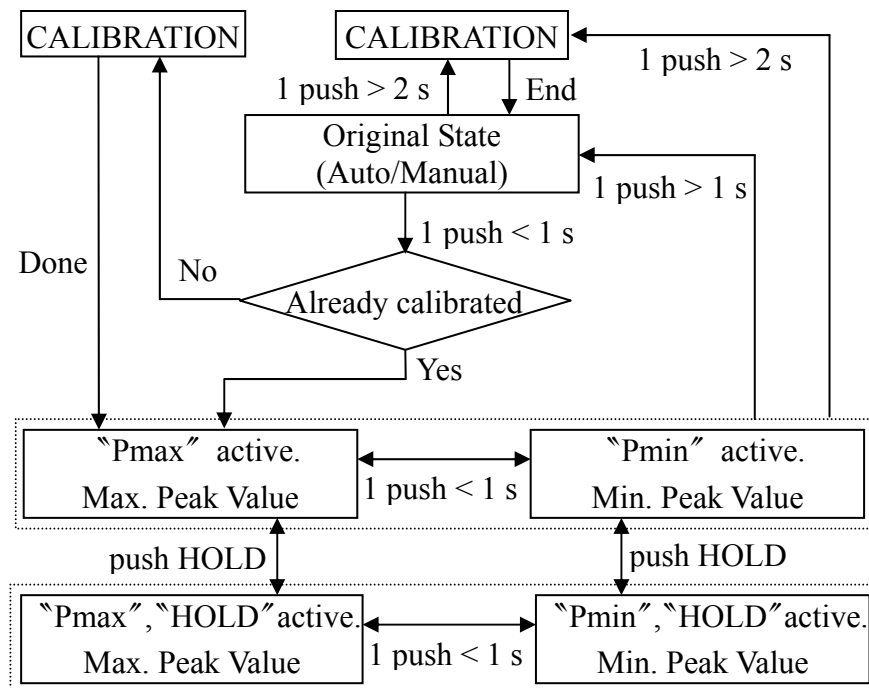
State diagram for Zero + Max/Min + HOLD mode:





3.8 Peak + HOLD

Peak mode takes input from Pmax or Pmin pin. The peak values are stored in external capacitors. Polyester mylar capacitors are recommended. The precision of Peak mode measurement can be enhanced by calibration. Calibration for Peak mode is invoked by pressing Peak bottom for more than 2 seconds. Entering Peak mode will automatically execute peak calibration, if peak calibration was never done before. The Calibration process measures and stores the offset voltage of internal operation amplifiers. High precision is achieved by subtracting this offset from reading. When power off the ES51922 or switch the measurement mode to °F temperature mode, the calibrated offset value will be cleared. ES51922 will automatically execute peak calibration, if peak mode was activated again after the calibrated offset value was cleared.

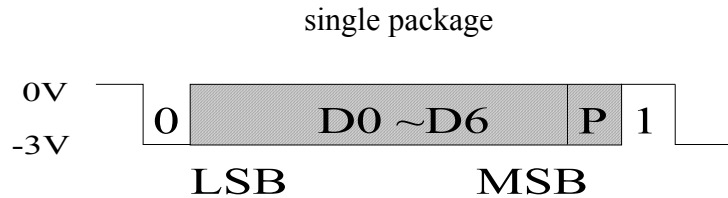


4. Serial Data Output

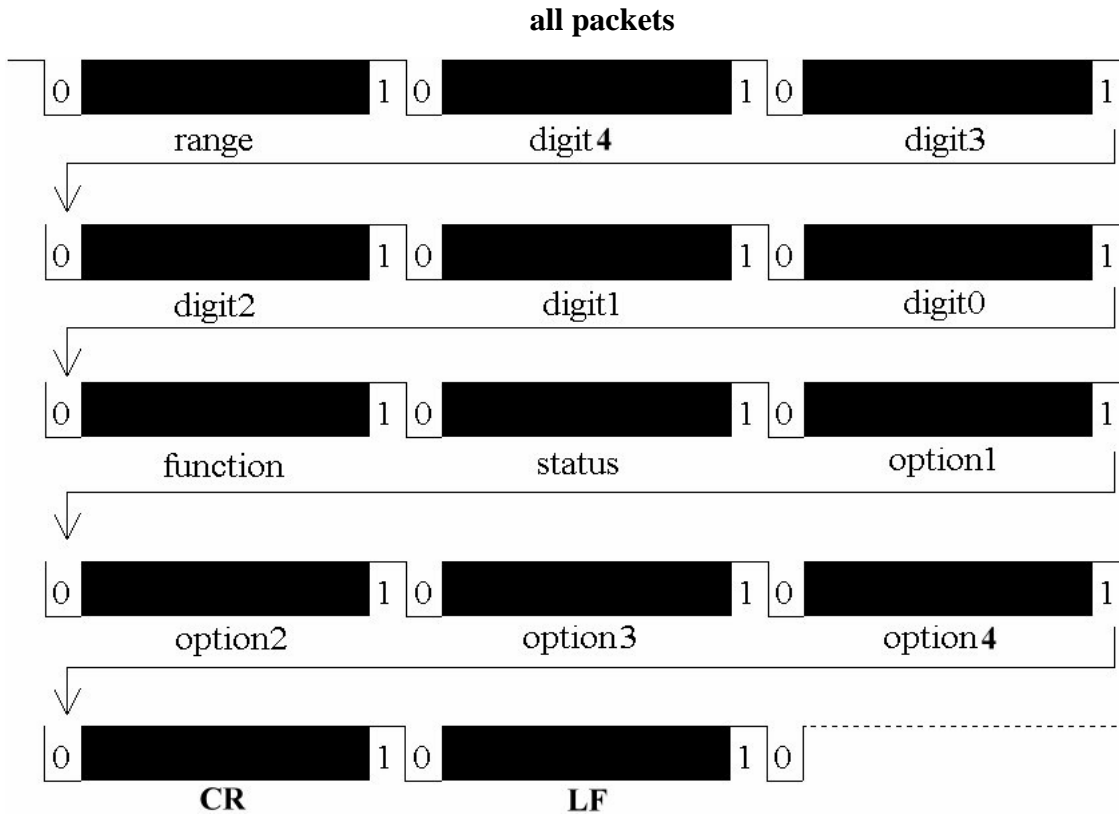
The RS232 function will be activated if the RS232 pin is pulled to and asserts at V-. The serial data sent to SDO pin once every A/D conversion cycle. The data format complies with JIS 7Bits-transmission code with a baud rate of 19230. The host can use RS232 interface to read the data. A single data 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 14 packets, or 140 bits. The following figure shows the format of a data block. The range packet indicates the full scale range of the meter. Digit4 through digit0 are just the digits on the LCD panel. The function packet indicates the measurement mode of the meter. Status, option1~4 give 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. The detailed data format of each packet is listed at next page.



4.1 FUNCTUON

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-FC5 switch.

| Code | Measurement Mode | VBAR=0 | VBAR=1 |
|---------|--------------------------|----------------------|----------------------|
| 0111011 | Voltage | Don't care | |
| 0111101 | Auto μ A Current | Auto μ A Current | Auto 220.00A/2200.0A |
| 0111111 | Auto mA Current | Auto mA Current | Auto 22.000A/220.00A |
| 0110000 | 22 A current | Don't care | |
| 0111001 | Manual A Current | | |
| 0110011 | Ω | | |
| 0110101 | Continuity | | |
| 0110001 | Diode | | |
| 0110010 | ¹ Frequency | | |
| 0110110 | Capacitance | | |
| 0110100 | ² Temperature | | |
| 0111110 | ADP | | |

1. When the function code = 0110010, the measurement mode is determined by judge bit of Status packet. If judge bit is 1, it means frequency mode. If judge bit is 0, it means duty cycle mode.
2. When the function code = 0110100, the judge bit in the Status packet determines whether the unit is Celsius or Fahrenheit. **And the digit4~0 only presents Celsius value whatever the mode is °C or °F.**
3. When the function code = 0111101 or 0111111, the measurement mode is determined by VBAR bit.

4.2 RANGE

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

| Code | V | *2-range auto A | 22 A | Manual A | ADP | Ω | Frequency | Capacitor |
|---------|----------|--------------------|----------|----------|------|------------------|-----------|----------------|
| 0110000 | 2.2000V | Lower Range(IVSL) | 22.000 A | 2.2000A | ADP4 | 220.00 Ω | 22.00Hz | 22.000nF |
| 0110001 | 22.000V | Higher Range(IVSH) | | 22.000A | ADP3 | 2.2000K Ω | 220.0Hz | 220.00nF |
| 0110010 | 220.00V | | | 220.00A | ADP2 | 22.000K Ω | | 2.2000 μ F |
| 0110011 | 2200.0V | | | 2200.0A | ADP1 | 220.00K Ω | 22.000KHz | 22.000 μ F |
| 0110100 | 220.00mV | | | 22000A | ADP0 | 2.2000M Ω | 220.00KHz | 220.00 μ F |
| 0110101 | | | | | | 22.000M Ω | 2.2000MHz | 2.2000mF |
| 0110110 | | | | | | 220.00M Ω | 22.000MHz | 22.000mF |
| 0110111 | | | | | | | 220.00MHz | 220.00mF |

*It includes auto μ A, mA, 22.000A/220.00A, 220.00A/2200.0A.



4.3 DIGIT 4 – DIGIT 0

Digit 4 is the first significant digit on the LCD panel, and digit 0 is the least significant digit.

| 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 package shown below. The Judge field is meaningful only when the Function packet indicates Temperature mode. In Temperature mode, judge is 1 if the unit is °C and is 0 if the unit is °F. Sign field indicates whether the minus sign on the LCD panel is on or off. BATT field is one when 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 the push function of the meter. The format is shown below. MAX, MIN or RMR bit will be high if the meter enters Max/Min function and stays at state of maximum, minimum or current value respectively. REL bit will be high if meter enters REL/Zero mode.

| | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|
| 0 | 1 | 1 | MAX | MIN | REL | RMR |
| BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |



4.6 OPTION 2

| | | | | | | |
|-------|-------|-------|-------|------------------|------------------|-------|
| 0 | 1 | 1 | UL | P _{MAX} | P _{MIN} | 0 |
| BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |

Under the following conditions, the UL bit will be set to 1.

1. In 22.00Hz range, the input frequency is less than 2.00Hz.
2. In 220.0Hz range, the input frequency is less than 20.0Hz.
3. In duty cycle mode, the reading is less than 10.0%.

If P_{MAX} field is 1, P_{MAX} is active and LCD panel display maximum peak value.

If P_{MIN} field is 1, P_{MIN} is active and LCD panel display minimum peak value.

4.7 OPTION 3

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, either voltage or current. 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.

| | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|
| 0 | 1 | 1 | DC | AC | AUTO | VAHZ |
| BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |

4.8 OPTION4

This packet contains information on the operation mode of the meter. The format is shown below. VBAR will be set to high, only when the VBAR pin is connected to V-. Hold bit is set to high when meter enters hold mode. LPF bit is set to high when the low-pass-filter feature is activated.

| | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|
| 0 | 1 | 1 | 0 | VBAR | Hold | LPF |
| BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 |

4.9 CR

Carriage returns. The transmitted code is 0001101.

4.10 LF

Line feed. The transmitted code is 0001010.

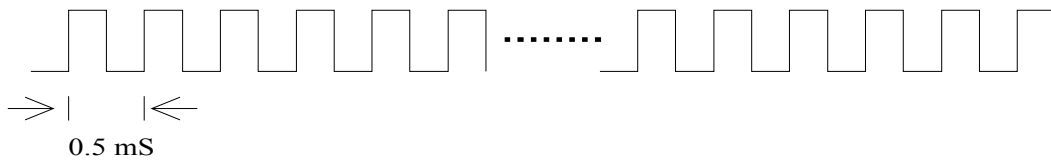


5. Miscellaneous

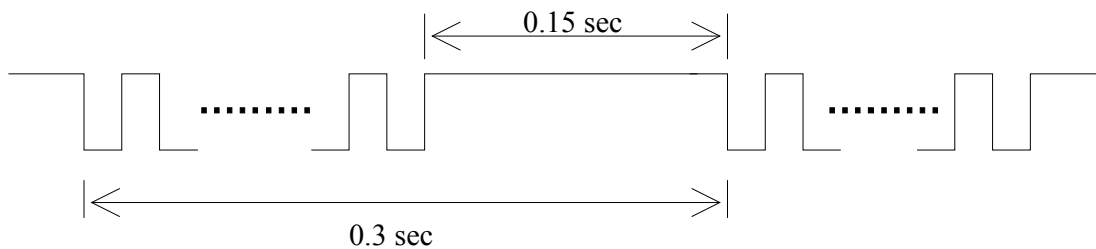
The conditions on which the meter turns on the buzzer include:

- (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 (220mV range not included) and current mode generates one beep every 0.3 seconds (or 3.33 beeps per second.)
- (5) Continuity(diode) check generates a continuous 2KHz beep whenever the measurement is less then $30\Omega(30mV)$
- (6) Auto power off generates a 2KHz beep that lasts for 1.5 seconds.

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



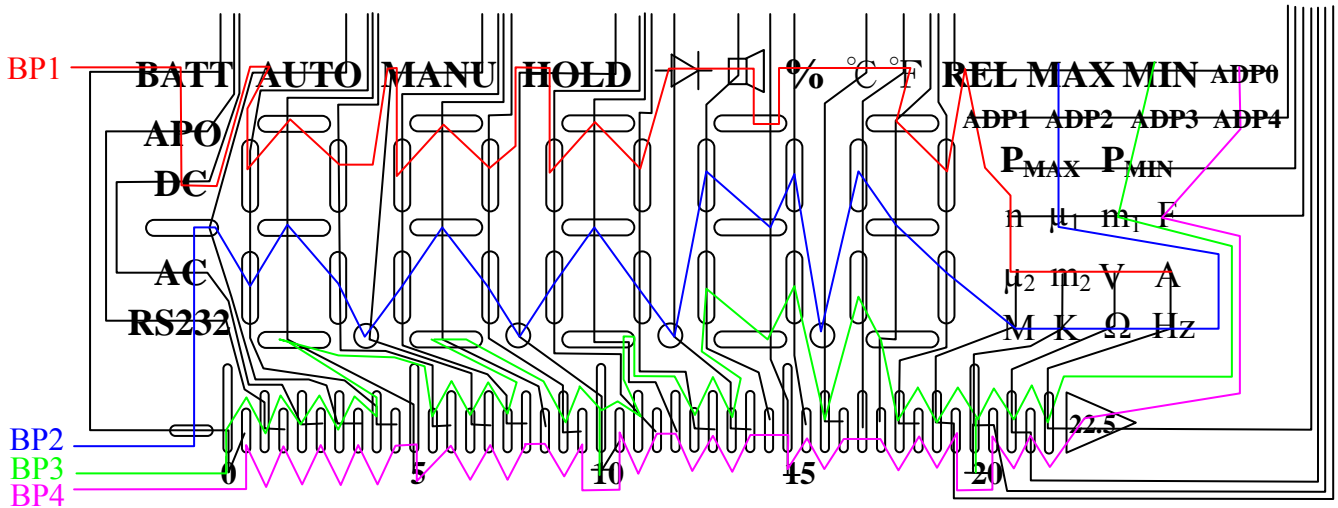
(a) Continuous 2KHz beep



(b) 3.33 beep/sec



5.1 LCD Panel Configuration



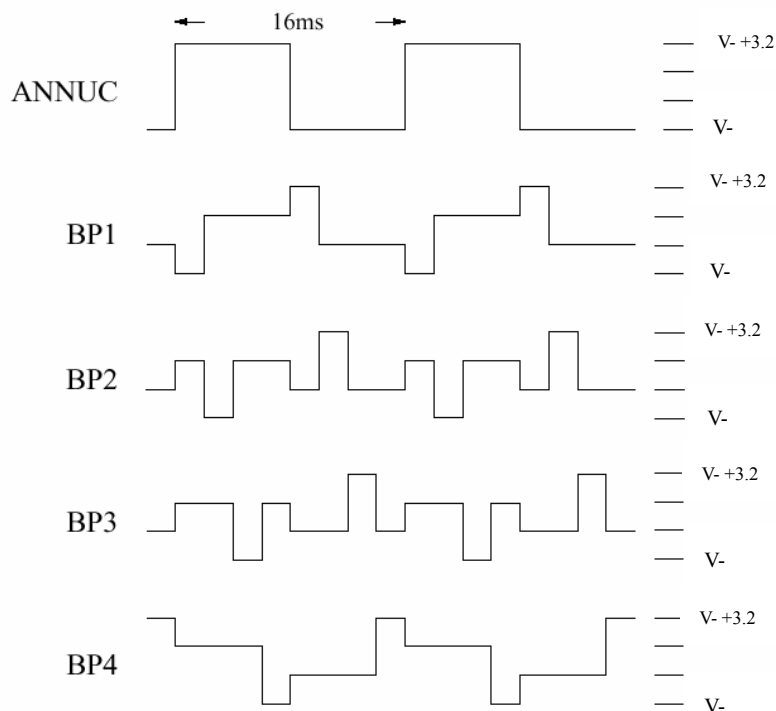
| | SEG01 | SEG02 | SEG03 | SEG04 | SEG05 | SEG06 | SEG07 | SEG08 | SEG09 | SEG10 | SEG11 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| BP1 | BATT | APO | DC | AUTO | 5F | 5A | 5B | MANU | 4F | 4A | 4B |
| BP2 | bar- | RS232 | AC | - | 5E | 5G | 5C | DP4 | 4E | 4G | 4C |
| BP3 | bar0 | bar2 | bar4 | bar6 | bar8 | 5D | bar11 | bar13 | bar15 | 4D | bar18 |
| BP4 | bar1 | bar3 | bar5 | bar7 | bar9 | bar10 | bar12 | bar14 | bar16 | bar17 | bar19 |

| | SEG12 | SEG13 | SEG14 | SEG15 | SEG16 | SEG17 | SEG18 | SEG19 | SEG20 | SEG21 | SEG22 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| BP1 | HOLD | 3F | 3A | 3B | ▷ | ◻ | 2A | % | °C | °F | 1A |
| BP2 | DP3 | 3E | 3G | 3C | DP2 | 2F | 2G | 2B | DP1 | 1F | 1G |
| BP3 | bar20 | bar22 | 3D | bar25 | bar27 | 2E | 2D | 2C | bar32 | 1E | 1D |
| BP4 | bar21 | bar23 | bar24 | bar26 | bar28 | bar29 | bar30 | bar31 | bar33 | bar34 | bar35 |

| | SEG23 | SEG24 | SEG25 | SEG26 | SEG27 | SEG28 | SEG29 | SEG30 | SEG31 |
|-----|-------|----------------|----------------|-------|-------|-------|-------|----------------|------------------|
| BP1 | 1B | μ ₂ | m ₂ | V | A | REL | ADP1 | n | ⊗ |
| BP2 | 1C | M | K | Ω | Hz | MAX | ADP2 | μ ₁ | P _{MAX} |
| BP3 | bar36 | bar38 | bar40 | bar42 | bar44 | MIN | ADP3 | m ₁ | P _{MIN} |
| BP4 | bar37 | bar39 | bar41 | bar43 | bar45 | ADP0 | ADP4 | F | ⊗ |



LCD Backplane Waveform



5.2 LCD display on condition

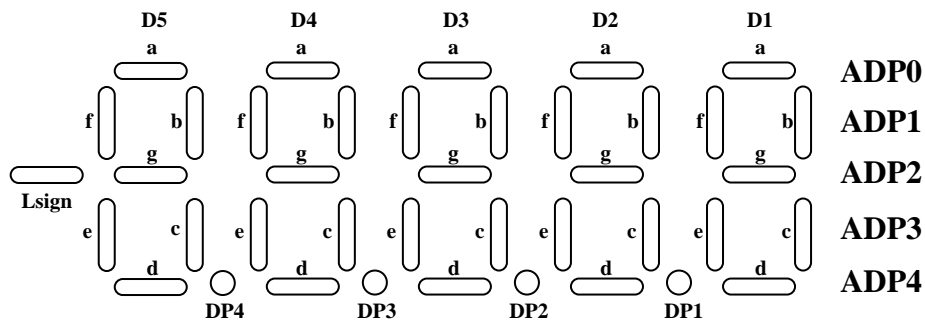
| LCD Annunciator | Condition |
|---------------------|--|
| V | In voltage measurement mode, and diode measurement mode. |
| A | In current measurement mode. |
| Ω | In resistance measurement mode, and continuity mode. |
| F | In capacitance measurement mode. |
| | In continuity check mode. |
| | In diode mode. |
| Hz | In frequency mode. |
| % | In duty cycle 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 Relative function is enabled. |
| MAX / MIN | When Maximum or Minimum function is enabled. |
| P_{MAX} / P_{MIN} | When P_{MAX} or P_{MIN} function is enabled. |
| m_1 | In capacitor measurement mode and the full scale range is in the order of mF. |
| μ_1 | In capacitor measurement mode and the full scale range is in the order of uF. |
| n | In capacitor 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} . |
| μ_2 | In current measurement mode and the full scale range is in the order of uA. |
| 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 |
| $^{\circ}C$ | 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. |
| RS232 | When RS232 output is enabled. |



5.3 Programmable LCD Segment Display

ES51922 supports a “Programmable LCD Segment Display”(PLSD) feature. Except peak hold measurement, capacitor measurement mode & duty cycle measurement, all modes could support PLSD. PLSD allows the meter designer to process or modify the conversion results by external microprocessor and displayed on LCD panel. The more accurate and stable reading would be possible. ES51922 provides uPLCD, SCLK and SDATA pins to archive the PLSD feature. Connect uPLCD to V- to enable PLSD feature and received the serial data from SDO pin. After the data processing, transfer the display data through the SDATA and give a clock signal to SCLK. ES51922 will receive the display data through SDATA at the falling edge of clock signal, then display the data on LCD panel. Only the segments shown below could be modified, other segments are still controlled by ES51922. When peak hold, capacitor or duty mode is selected, the LCD display is determined by ES51922.

About the details of serial data format, please refer to page 21-25.



PLSD Data format:

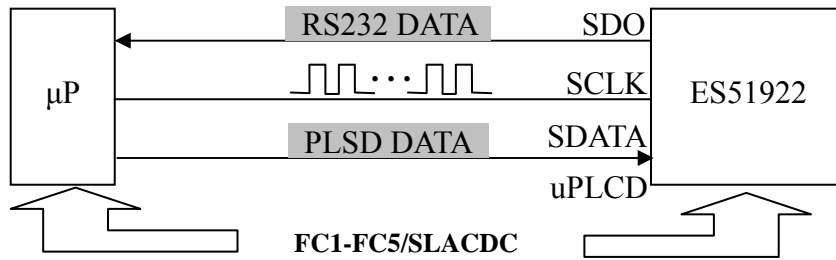
| | | | | | | | | | | | |
|------------|-------------|-------------|-------------|-------------|-------------|------------|------------|------------|--------------|------------|------------|
| B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 |
| OL | ADP0 | ADP1 | ADP2 | ADP3 | ADP4 | D1a | D1b | D1c | D1d | D1e | D1f |
| B13 | B14 | B15 | B16 | B17 | B18 | B19 | B20 | B21 | B22 | B23 | B24 |
| D1g | DP1 | D2a | D2b | D2c | D2d | D2e | D2f | D2g | DP2 | D3a | D3b |
| B25 | B26 | B27 | B28 | B29 | B30 | B31 | B32 | B33 | B34 | B35 | B36 |
| D3c | D3d | D3e | D3f | D3g | DP3 | D4a | D4b | D4c | D4d | D4e | D4f |
| B37 | B38 | B39 | B40 | B41 | B42 | B43 | B44 | B45 | B46 | | |
| D4g | DP4 | D5a | D5b | D5c | D5d | D5e | D5f | D5g | Lsign | | |

Note: The B1 should be sent first and the last is B46.

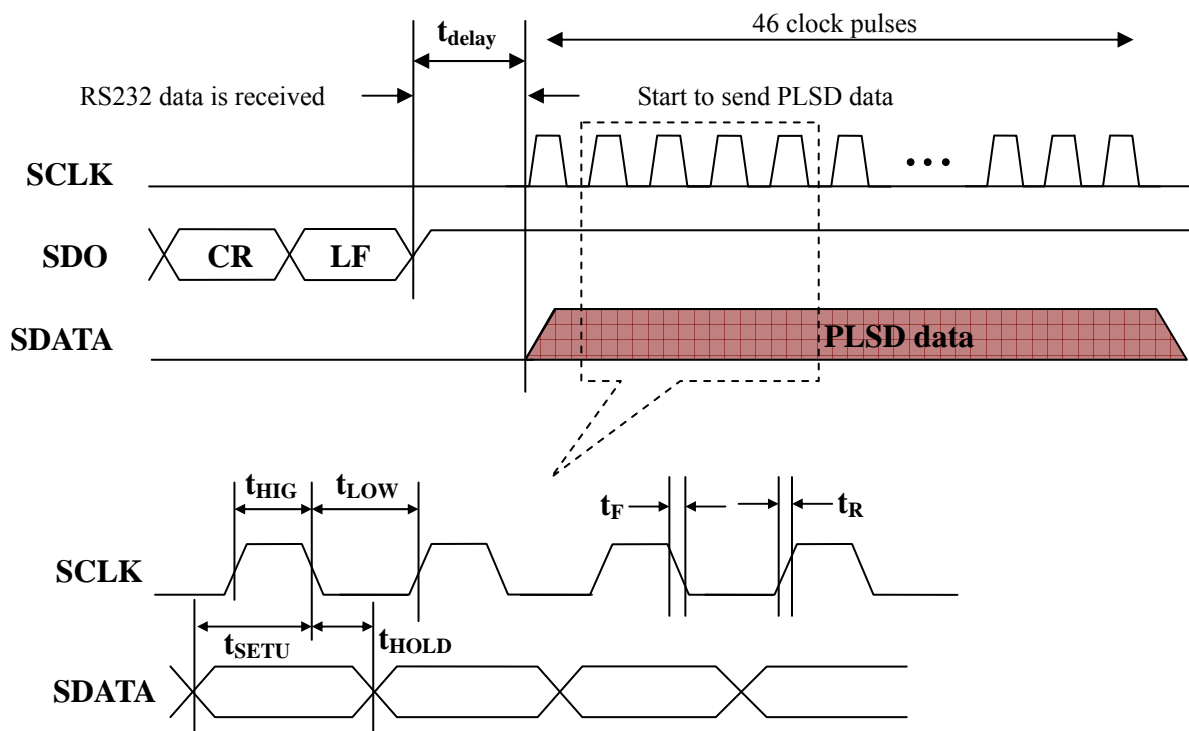
Set the OL bit = 1, the buzzer output will be active for 3.3beep/sec in voltage & current mode (or peak mode). And if auto range is available, it will change to higher range if LCD bar44 is active also.



Block diagram:



Operation timing diagram for PLSD feature is shown as below:



| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---------------------------------------|-------------|------|------|------|------|
| SCLK clock frequency | f_{SCLK} | 10 | - | 100 | KHz |
| SCLK clock time "L" | t_{LOW} | 4.7 | - | - | us |
| SCLK clock time "H" | t_{HIGH} | 4.0 | - | - | |
| Data input setup time | t_{SETUP} | 200 | | | ns |
| Data input hold time | t_{HOLD} | 100 | | | |
| SCLK/SDATA rising time | t_R | | | 1.0 | us |
| SCLK/SDATA falling time | t_F | | | 0.3 | |
| SCLK delay time after receiving RS232 | t_{delay} | 0.1 | | 100 | ms |



5.4 Operating Timing

ES51922 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 the bar-graph display. The time of each phase is shown below:

*Voltage /Current /Ohm/Cont./Diode/ADP measurement:

| Phase | High resolution | High speed |
|-------|-----------------|------------|
| ZI | 100ms | 10ms |
| AZ | 74ms | 7.4ms |
| INT | 100ms | 10ms |
| DINT | 226ms | 22.6ms |

*Peak mode voltage measurement:

| Phase | High resolution | High speed |
|-------|-----------------|------------|
| ZI | 100ms | 10ms |
| AZ | 74ms | 7.4ms |
| INT | 100ms | 10ms |
| DINT | 326ms | 32.6ms |

*Capacitance measurement:

| Range | Maximum measurement period |
|----------|----------------------------|
| 22.000nF | 0.5sec |
| 220.00nF | 0.5sec |
| 2.2000uF | 0.5sec |
| 22.000uF | 0.5sec |
| 220.00uF | 0.5sec |
| 2.2000mF | 1sec |
| 22.000mF | 5sec |
| 220.00mF | 25sec |

*Frequency measurement

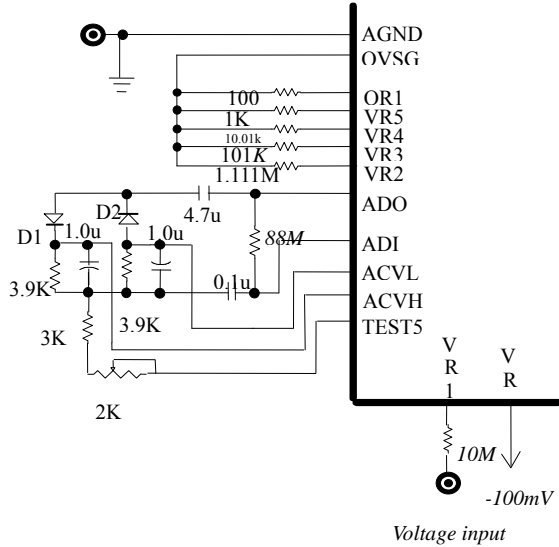
The measurement cycle = 1.05 sec

P.S. In the frequency measurement with auto mode, if the range is changed, the internal clock rate will increase five times and the new measurement cycle becomes 0.21 sec until the range is stable.

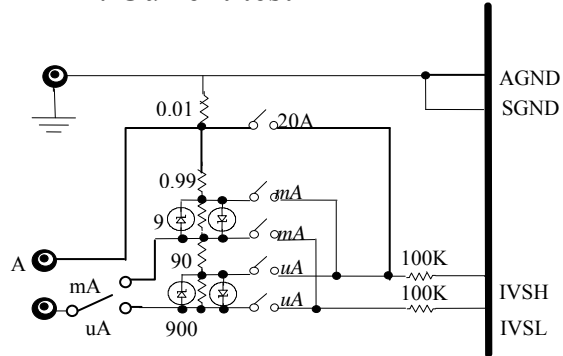


6. Test Circuit

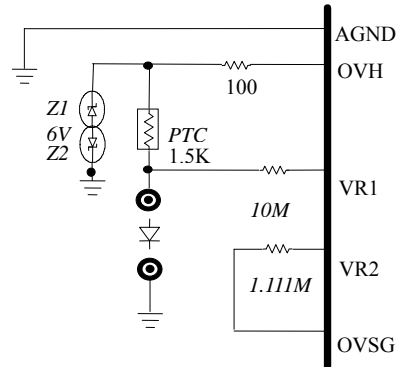
1. Voltage test



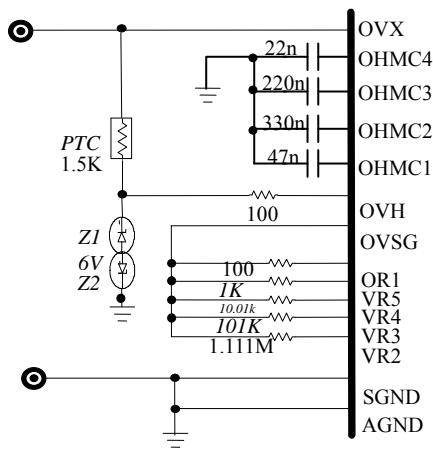
4. Current test



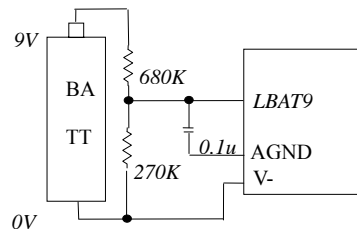
5. Diode test



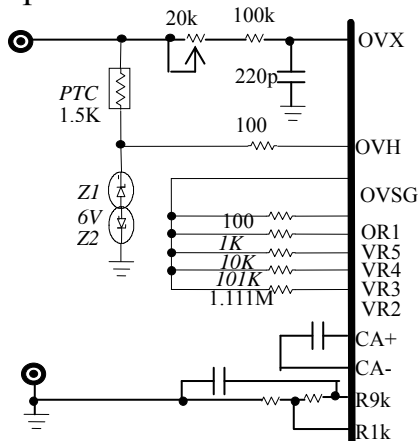
2. Resistor test



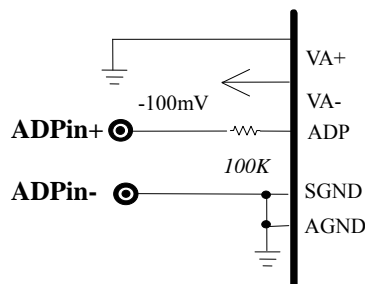
6. Low battery



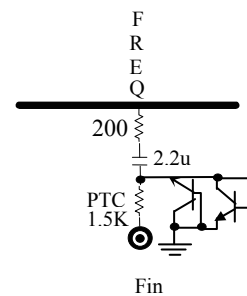
3. Capacitor test



7. ADP test

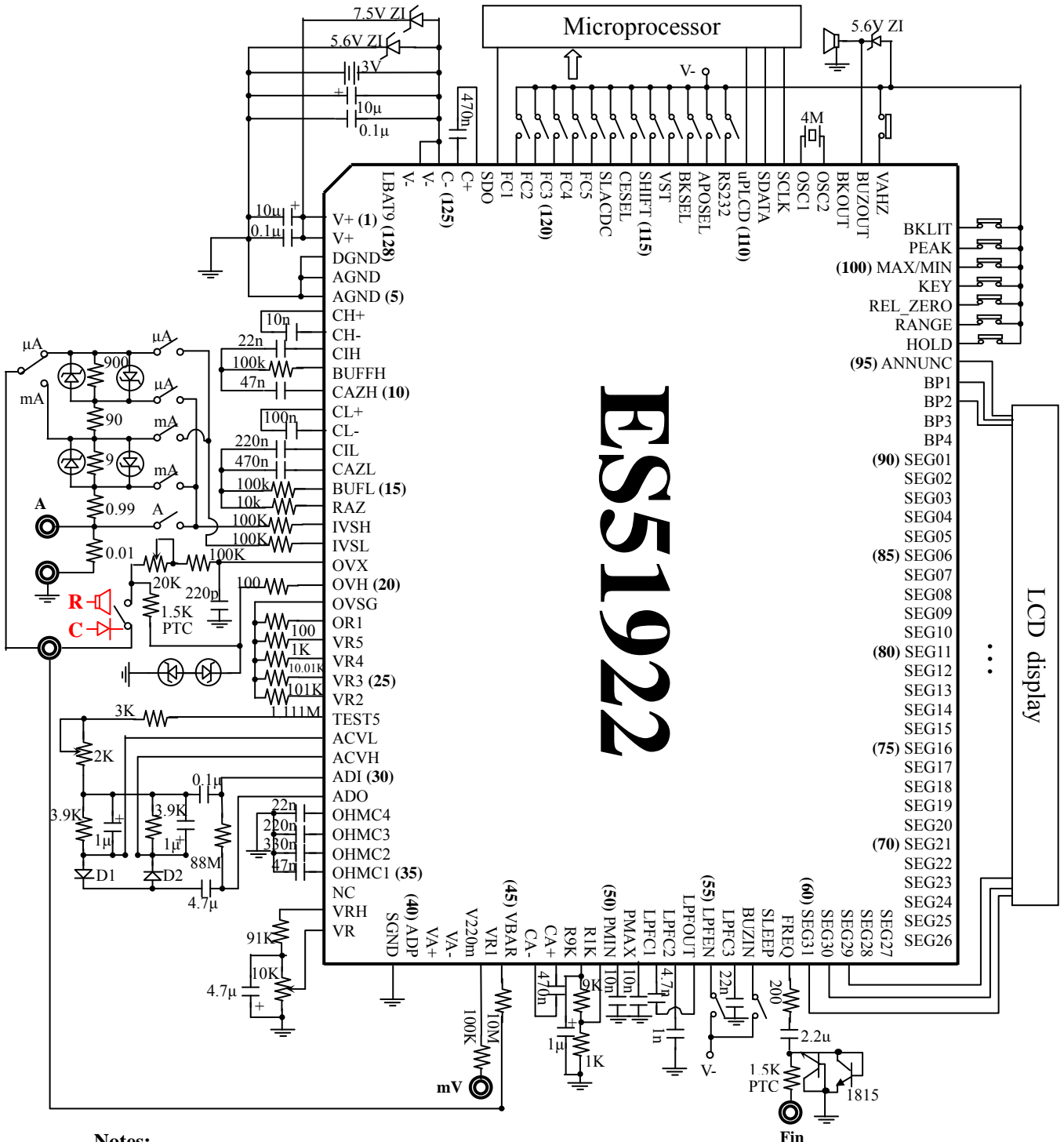


8. Frequency test





7. Application Circuit

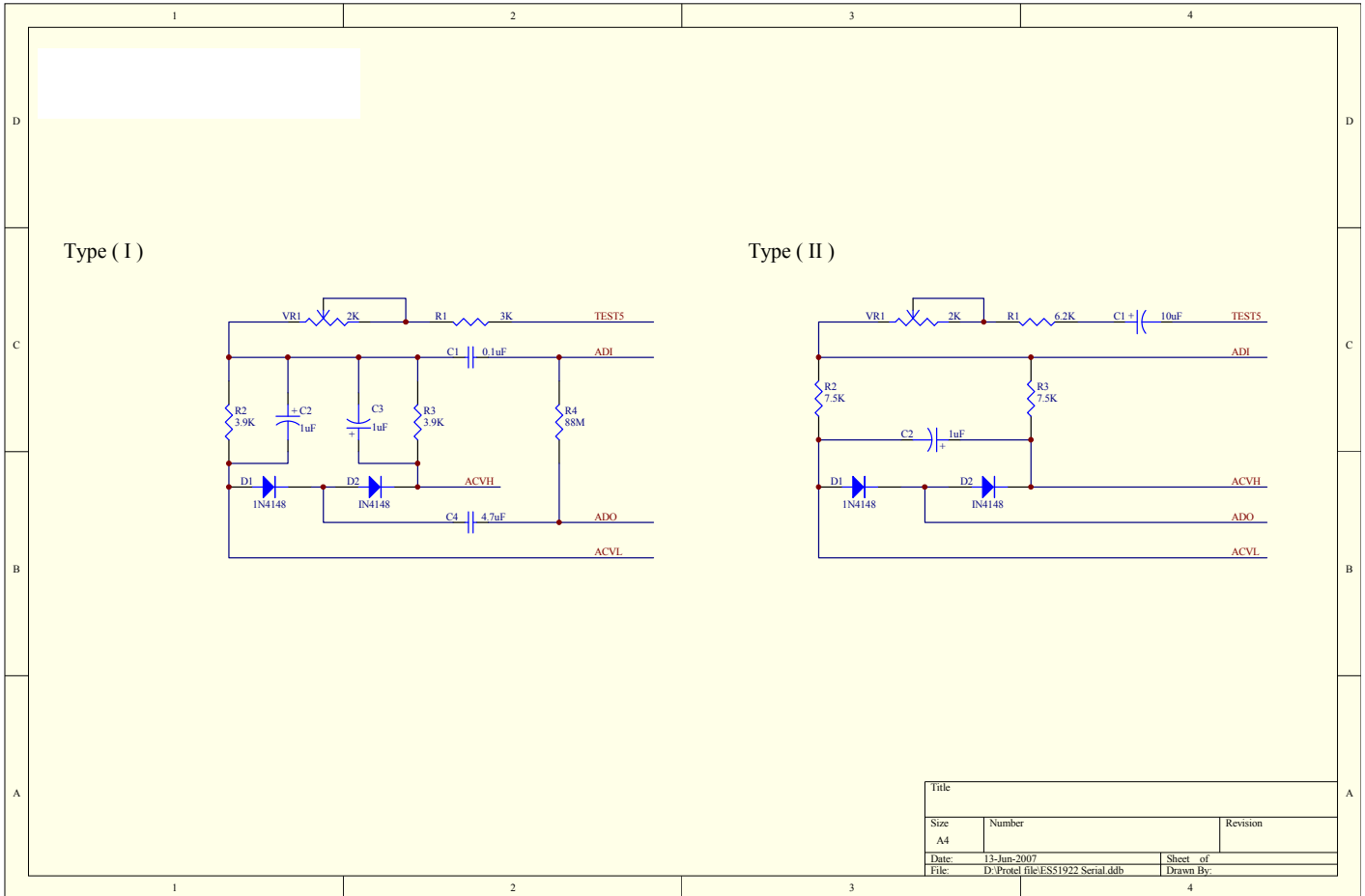


Notes:

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 decrease. 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. Cp is the compensation capacitor for measuring capacitance. Its value depends on the parasitic capacitor on the PCB board.
3. Light shielding for the diodes and Zeners.



7.1 Appendix: Average rectified circuit

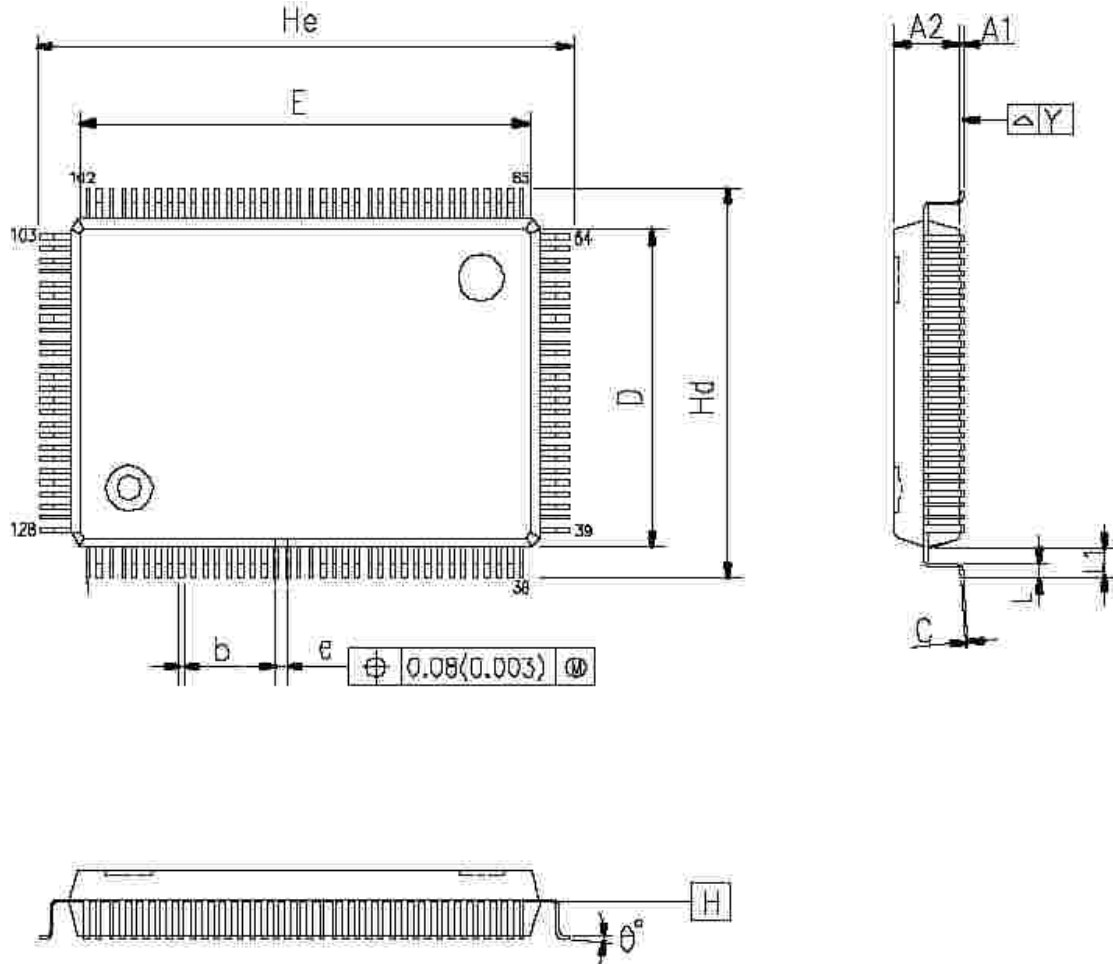


Note: 88MΩ resistors could be omitted at Type(II) circuit



8. Package

1. 128L QFP Topview



2. Dimension Parameters

| SYMBOLS | MIN. | NOM. | MAX. |
|---------|-------|-------|-------|
| A1 | 0.25 | 0.35 | 0.45 |
| A2 | 2.57 | 2.72 | 2.87 |
| b | 0.10 | 0.20 | 0.30 |
| C | 0.10 | 0.15 | 0.20 |
| D | 13.90 | 14.00 | 14.10 |
| E | 19.90 | 20.00 | 20.10 |
| e | - | 0.50 | - |
| Hd | 17.00 | 17.20 | 17.40 |
| He | 23.00 | 23.20 | 23.40 |
| L | 0.65 | 0.80 | 0.95 |
| L1 | - | 1.60 | - |
| Y | - | - | 0.08 |
| theta | 0 | - | 12 |

UNIT : mm

NOTES:

1. JEDEC OUTLINE: N/A
2. DATUM PLANE [H] IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.
3. DIMENSIONS E AND D DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25 mm PER SIDE. DIMENSIONS E AND E DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE [H].
4. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION.