



Features

- 5000 counts dual LCD display
- 128L QFP package
- 3V DC power supply
- ADC Conversion rate : 3.3 times/s
- Full automatic measurement
 - *Voltage measurement: 500.0mV – 1000V
 - *Current measurement: 50.00A/500.0A, 500A/5000A
 - *Flame rod DCuA mode measurement: 500.0uA/5000uA both manual ranges
 - *Smart auto check for R/S/D/C mode
Resistance: 500.0Ω~5.000MΩ
Capacitance: 5.000nF~500.0uF
(Taiwan patent no.: 326361)
 - *Not contact AC electric field detection
 - *Frequency mode active on sub-display for ACA
500.0Hz ~ 5000Hz
 - *Resistance measurement: 500.0Ω – 50.00MΩ
 - *Capacitance measurement: 5.000nF – 50.00mF
(Taiwan patent no.: 323347, 453443)
 - *Frequency counter with duty cycle display:
500.0Hz – 50.00MHz
5% – 95% (< 10kHz)
- ZERO function for DCA mode
- Voltage high crest factor detection
(Taiwan patent no.: 234661)
- Voltage & Current measured simultaneously
ACV+ACA, DCV+DCA
- Diode measurement & continuity check
- Auto range temperature mode(500.0 °C /5000 °C)
- Temperature mode with internal scale translation circuit from °C to °F
- Push functions:
 - *Single Select key operation:
Zero for DCA
Hz for ACA
 - *Range change function

- *Inrush function: ACA clampmeter only
- *Data hold function
- *Back light function
- *Semi-auto Calibration Operation
(Taiwan patent no.: 367334)
- Low pass filter for ACA measurement
- Band-gap reference voltage output
- CE selection (DC/AC 1010V, DC/AC 610V)
- LCD segment check when power on
- Auto power off (30min/15min)
- Sleep state indicative signal output
- Re-power on
- On-chip buzzer driver
- High Voltage (HV) danger indication
- Low battery multi-level detection

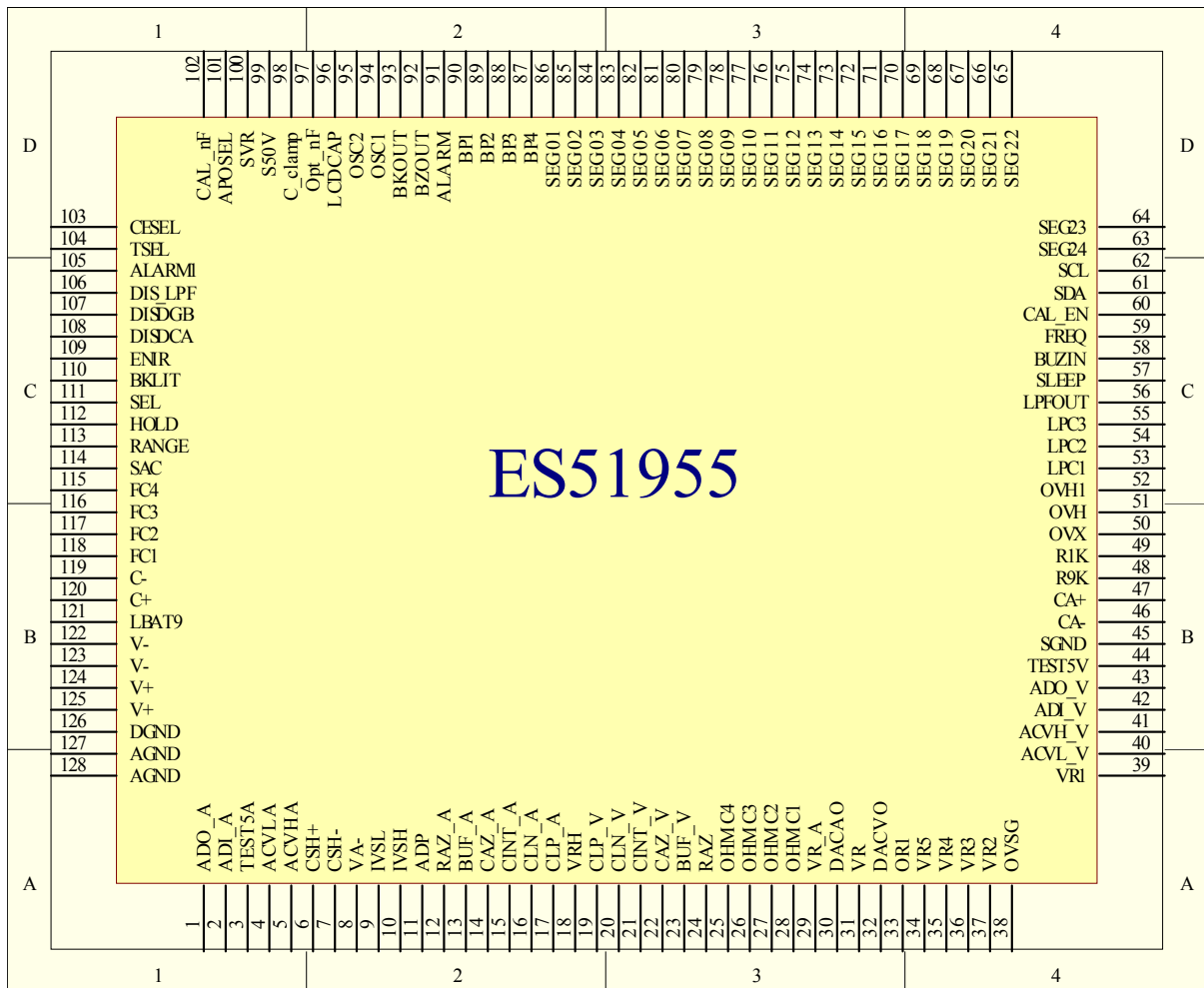
Description

ES51955 is an integrated analog-to-digital converter (ADC) with dual 5,000-count LCD display, which 4-digit main-display (AC/DC Voltage) and 4-digit sub-display (AC/DC Current), automatic range selection, and 3V DC power supply. ES51955 could be designed for a clamp-meter with V & A measurement simultaneously. Automatic range selection is provided for voltage (AC/DC) measurement, resistance measurement, current measurement, capacitance measurement, and frequency counter. Other features include inrush function, offset removing feature for DCA clampmeter, data holding, duty cycle measurement, diode measurement, temperature measurement, continuity checking, multi-level low battery detection, auto power off, re-power on, backlight driver, and buzzer output driver.



Application
Clamp meter

Pin Assignment
LQFP-128L





Pin Description

| Pin No | Symbol | Type | Description |
|--------|---------|------|--|
| 1 | ADO_A | O | Output of internal AC to DC OP Amp for ACA mode. |
| 2 | ADI_A | I | Negative input of internal AC to DC OP Amp for ACA mode. |
| 3 | TEST5_A | O | Buffer output of SGND for ACA mode |
| 4 | ACVL_A | O | DC signal low input in ACA mode. Connect to negative output of external AC to DC converter. |
| 5 | ACVH_A | O | DC signal high input in ACA mode. Connect to positive output of external AC to DC converter. |
| 6 | CSH+ | I/O | Cap for duty-cycle and inrush mode |
| 7 | CSH- | I/O | Cap for duty-cycle and inrush mode |
| 8 | VA- | I | For ADP mode. De-integrating voltage negative input |
| 9 | IVSL | I | Current measurement input for higher range. |
| 10 | IVSH | I | Current measurement input for lower range. |
| 11 | ADP | I | Measurement input in ADP mode. (Current/Temperature/NCV mode) |
| 12 | RAZ_A | O | Buffer output pin in AZ and ZI phase for ADC_A. |
| 13 | BUF_A | O | Buffer output pin for ADC_A. Connect to integral resistor |
| 14 | CAZ_A | O | Auto-zero capacitor connection for ADC_A. |
| 15 | CINT_A | O | Integrator output for ADC_A. Connect to integral capacitor. |
| 16 | CLN_A | I/O | Negative connection for reference capacitor of ADC_A. |
| 17 | CLP_A | I/O | Positive connection for reference capacitor of ADC_A. |
| 18 | VRH | O | Output of band-gap voltage reference. Typically -1.23V |
| 19 | CLP_V | I/O | Positive connection for reference capacitor of ADC_V. |
| 20 | CLN_V | I/O | Negative connection for reference capacitor of ADC_V. |
| 21 | CINT_V | O | Integrator output for ADC_V. Connect to integral capacitor. |
| 22 | CAZ_V | O | Auto-zero capacitor connection for ADC_V. |
| 23 | BUF_V | O | Buffer output pin for ADC_V. Connect to integral resistor |
| 24 | RAZ_V | O | Buffer output pin in AZ and ZI phase for ADC_V. |
| 25-28 | OHMC1-4 | O | Filter capacitor connection1-4 for resistance mode. |
| 29 | VR_A | I | Reference input voltage in current mode or ADP. Typically -400mV |
| 30 | DAC_AO | O | DAC output for current mode or ADP input mode |
| 31 | VR | I | Reference input voltage in voltage mode. Typically -400mV |
| 32 | DAC_VO | O | DAC output for voltage mode |
| 33 | OR1 | O | Reference resistor connection for 500.00Ω range |
| 34 | VR5 | O | Voltage measurement ÷10000 attenuator(1000V) |
| 35 | VR4 | O | Voltage measurement ÷1000 attenuator(500.0V) |
| 36 | VR3 | O | Voltage measurement ÷100 attenuator(50.00V) |
| 37 | VR2 | O | Voltage measurement ÷10 attenuator(5.000V) |
| 38 | OVSG | O | Sense low voltage for resistance/voltage measurement |
| 39 | VR1 | I | Measurement Input. Connect to a precise 10MΩ resistor. |
| 40 | ACVL_V | O | DC signal low input in ACV mode. Connect to negative output of external AC to DC converter. |
| 41 | ACVH_V | O | DC signal high input in ACV mode. Connect to positive output of external AC to DC converter. |
| 42 | ADI_V | I | Negative input of internal AC to DC OP Amp for ACV mode. |
| 43 | ADO_V | O | Output of internal AC to DC OP Amp for ACV mode. |
| 44 | TEST5_V | O | Buffer output of OVSG for ACV mode |
| 45 | SGND | G | Signal Ground. |
| 46 | CA- | I/O | Negative auto-zero capacitor connection for capacitor measurement |
| 47 | CA+ | I/O | 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 | OVX | I | Sense input for resistance/capacitance measurement |
| 51 | OVH | O | Output connection for resistance measurement |
| 52 | OVH1 | O | Output connection for resistance measurement (Optional) |



| | | | |
|---------|-------------|-----|---|
| 53 | LPFC1 | O | Capacitor C1 connection for internal low-pass filter |
| 54 | LPFC2 | O | Capacitor C2 connection for internal low-pass filter |
| 55 | LPFC3 | O | Capacitor C3 connection for internal low-pass filter |
| 56 | LPFOUT | O | Capacitor C1 connection for internal low-pass filter |
| 57 | SLEEP | O | Sleep mode indicator, asserts low in SLEEP mode. |
| 58 | BUZIN | I | Pull to V- to enable the BUZOUT. |
| 59 | FREQ | I | Frequency counter input, offset V-/2 internally by the chip. |
| 60 | CAL_EN | I | Pulled to V- to enable the semi-auto calibration scheme. |
| 61 | SDA | I/O | Input/Output from/to EEPROM 24C02 data |
| 62 | SCL | O | Output to EEPROM 24C02 clock |
| 63-86 | SEG24-SEG01 | O | LCD segment output driver 01-24 (SEG signals) |
| 87-90 | BP4-BP1 | O | LCD backplane 1-4 (COM signals) |
| 91 | ALARM | O | LED control output driver for HV indication and NCV detection |
| 92 | BUZOUT | O | Outputs a 2KHz audio frequency signal for driving piezoelectric buzzer when BUZIN is low or functional key is active. |
| 93 | BKOUT | O | If BKLIT function is enabled, this pin will change from V- to V+ For 60 sec, once press BKLIT pin again within 60 sec, this pin will Change back to V-. |
| 94 | OSC1 | I | Crystal oscillator input connection |
| 95 | OSC2 | O | Crystal oscillator output connection |
| 96 | LCDCAP | I | LCD bias voltage bypass capacitor connection |
| 97 | Opt_nF | I | Pull to V- to change the initial range to 50nF in Cap mode. |
| 98 | C_clamp | I | Pull to V- to change the initial range to 5uF in Cap mode. |
| 99 | S50V | I | Switch control for function selection |
| 100 | SVR | I | Switch control for function selection |
| 101 | APOSEL | I | Auto power off idle time selection |
| 102 | CAL_nF | I | Pulled to V- to enable the small capacitor calibration scheme. |
| 103 | CESEL | I | OL selection feature control pin in Voltage mode. |
| 104 | TSEL | I | Pulled to V- to cancel the 500°C auto range mode |
| 105 | ALARM1 | O | LED control output driver for short-circuit detected in Cont. mode. |
| 106 | DIS_LPF | I | Pulled to V- to disable the low-pass-filter path in ACA mode |
| 107 | DIS_DGB | I | Pulled to V- to disable the buzzer beeper when HV danger appears. |
| 108 | DIS_DCA | I | Pulled to V- to disable DCA function in DCV mode. |
| 109 | ENIR | I | Pulse to V- to enable the INRUSH function for clamp ACA mode |
| 110 | BKLIT | I | Back light function. Pulse to V- to set BKOUT pin output. |
| 111 | SEL | I | Pulse to V- to enable function selection |
| 112 | HOLD | I | Pulse to V- to enable HOLD function. |
| 113 | RANGE | I | Pulse to V- to enable manual mode and manual range selection. |
| 114 | SAC | I | Switch for AC/DC function selection. |
| 115-118 | FC4-FC1 | I | Switches for function selection. |
| 119 | C- | O | Negative capacitor connection for on-chip DC-DC converter. |
| 120 | C+ | O | Positive capacitor connection for on-chip DC-DC converter. |
| 121 | LBAT9 | I | Multi-level low battery configuration input. Simple external resistor divider is required. |
| 122 | V- | P | Negative supply voltage. |
| 123 | V- | P | Negative supply voltage. |
| 124 | V+ | O | Output of on-chip DC-DC converter and positive supply voltage. |
| 125 | V+ | O | Output of on-chip DC-DC converter and positive supply voltage. |
| 126 | DGND | P/G | Digital ground. |
| 127 | AGND | P/G | Analog ground. |
| 128 | AGND | P/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 | -25°C to 125°C |

Electrical Characteristics

TA=25°C, V- = -3.0V

| Parameter | Symbol | Test Condition | Min. | Typ. | Max | Units |
|--|----------------------|-------------------------------------|-------|----------|-------|-------------------|
| Power supply | V- | | -2.5 | -3.0 | -3.5 | V |
| Operating supply current | I _{DD} | Normal operation | — | 1.9 | 2.2 | mA |
| In DCV+DCA mode | I _{SS} | In sleep mode | — | 5 | 10 | μA |
| Voltage roll-over error | REV | 10MΩ input resistor | — | — | ±0.1 | %F.S ¹ |
| Voltage nonlinearity | NLV | Best case straight line | — | — | ±0.1 | %F.S ¹ |
| Input Leakage | | | -10 | 1 | 10 | PA |
| Zero input reading | | 10MΩ input resistor | -000 | 000 | +000 | counts |
| Band-gap reference voltage | V _{REF} | 100KΩ resistor between VRH and AGND | -1.29 | -1.23 | -1.17 | V |
| Open circuit voltage for 500Ω measurement | | | — | -3.0 | — | V |
| Open circuit voltage for other Ω measurement | | | -1.19 | -1.08 | -0.97 | V |
| Peak to peak backplane drive voltage | | -3.5V ≤ V- ≤ -2.5V | 2.9 | 3.1 | 3.3 | V |
| Internal pull-high to 0V current | I _{pull-up} | Pin97-118 inputs | — | 1.2 | — | μA |
| AC frequency response at 5.000V range | | ±1% | — | 40-400 | — | HZ |
| | | ±5% | — | 400-2000 | — | |
| Multi-level low battery detector | V _{t1} | LBAT9 vs. V- | — | 2.15 | — | V |
| | V _{t2} | | — | 1.82 | — | |
| 3dB Bandwidth for ACA mode | f _{3dB} | Low-pass-filter ON | | 4 | | kHz |



| | | | | | | |
|---|------------------|---|------|-----|-----|--------|
| RSDC smart mode RES sensitivity | | Parasitic capacitance allowed in 5.000MΩ range | — | — | 200 | pF |
| RSDC smart mode DIODE sensitivity | | Forward voltage | | 0.8 | | V |
| RSDC scan mode CAP sensitivity | | | 400 | — | — | pF |
| Reference voltage temperature coefficient | TC _{RF} | 100KΩ resister between VRH/GND 0°C < TA < 70°C | — | 100 | — | ppm/°C |
| Capacitance measurement accuracy | | 5.0nF – 50mF | -2.5 | — | 2.5 | %F.S |
| | | | -3 | — | 3 | counts |

Note:

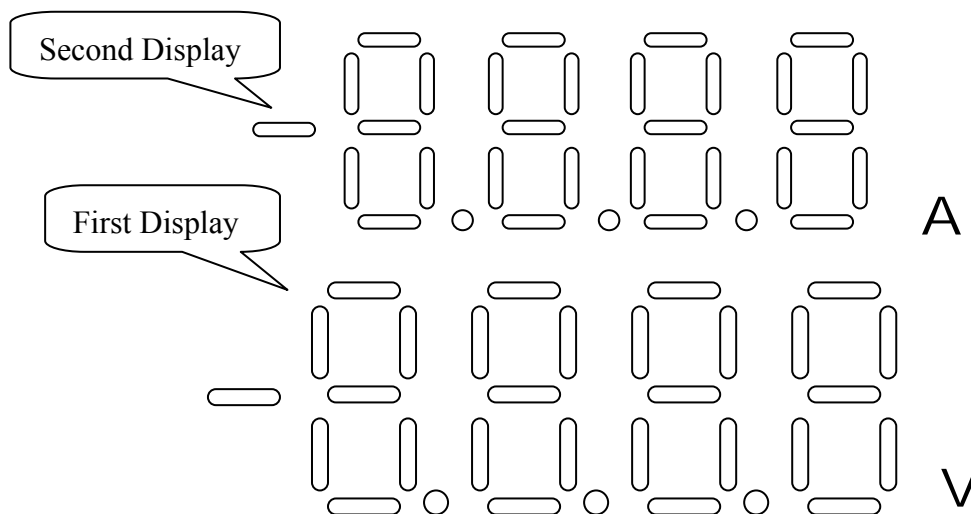
1. Full Scale

Function Description

1. Dual Display

1.1 Introduction

ES51955 configures a dual display LCD driver for DMM applications. The dual display includes first-display and second-display. Each display has 4 digits to show up to 5000 counts. The simplified representation of dual display is shown below. First-display usually shows Volts readings in ACV/DCV mode or Hz readings in Frequency mode. Second-display usually shows Amps/Hz readings in ACA/DCA mode or Duty-cycle readings in Frequency mode. By the dual display feature, ES51955 can shows Amps and Volts readings at the same time. Other features achieved by dual display will be introduced in later sections. The full LCD configuration is shown at [section 3.5](#) of [page 25](#).



1.2 Dual display V.S. measurement mode

The dual display default mode configuration is shown at the table below.

| Main measurement mode | First-display | Second-display (defaulted) |
|-----------------------|---------------|----------------------------|
| DC voltage | DC voltage | N/A |
| AC voltage | AC voltage | N/A |
| NCV mode | EF | Electrical field strength |
| Resistance mode | Resistance | N/A |
| Capacitance mode | Capacitance | N/A |
| Frequency mode | Frequency | Duty cycle |
| Continuity Check | Resistance | N/A |
| Diode mode | Voltage | N/A |
| Smart RSDC mode | R/S/D/C | N/A |
| Temperature mode | °C | °F |
| DCuA mode | N/A | DCuA |

1.3 Push key operation

With dual display, user can use single push key “SEL” to active the Volts and Amps readings simultaneously.

| Push function | First-display | Second-display |
|---|--|--|
| SEL in DCV mode (function selection) | DC Voltage | DCA ¹ → DCA/Zero ² See Fig.1 |
| SEL in ACV mode (function selection) | AC Voltage | ACA ← → ACA Hz ³ See Fig.2 |
| SEL in Smart mode (function selection) | R/S/D/C auto scan see Fig. 3 | N/A |
| Hold | Stop updating | Stop updating |
| Inrush (waiting state) | N/A | Four bars (----) |
| Inrush (done) | N/A | Inrush value |

NOTE:

1. DCA mode is not available if DIS_DCA (pin108) is pulled to V-.
2. DCA/Zero means the readings shown on LCD is offset-cancelled readings.
3. Hz mode is the frequency reading of ACA mode.



Fig.1 SEL key operation in DCV + DCA(zero) mode

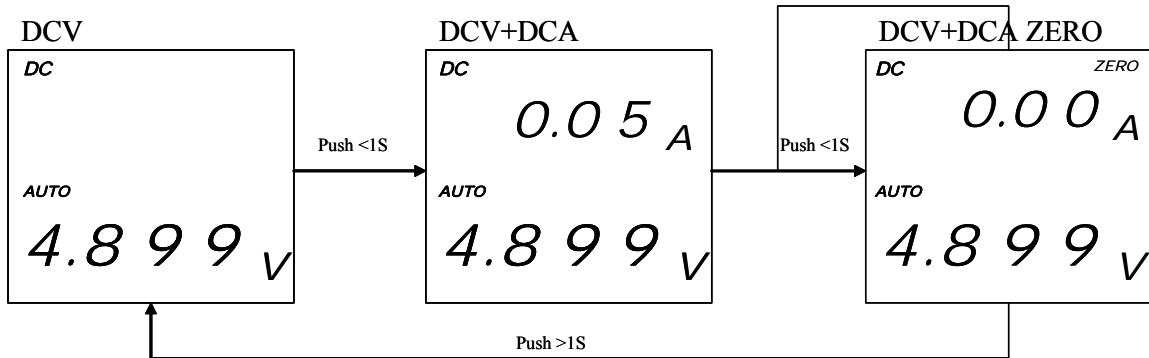


Fig. 2 SEL key operation in ACV + ACA(Hz) mode

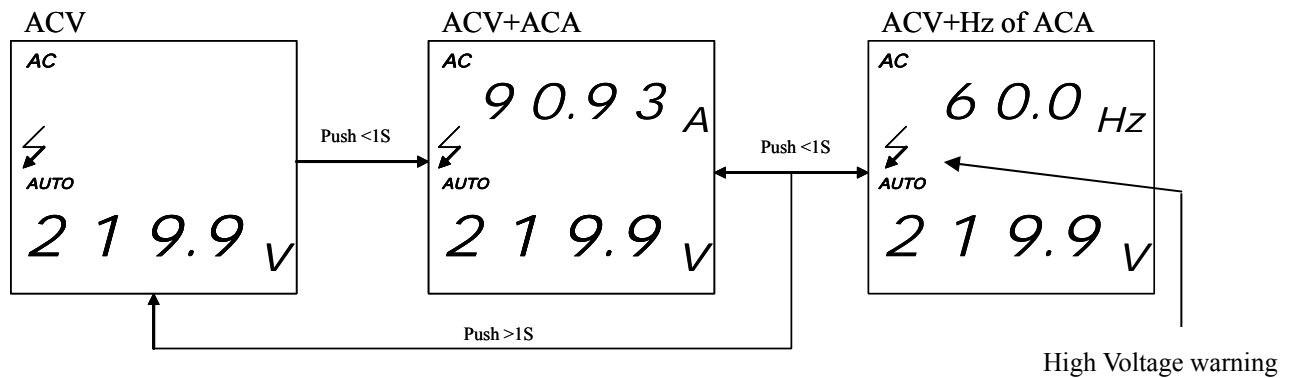
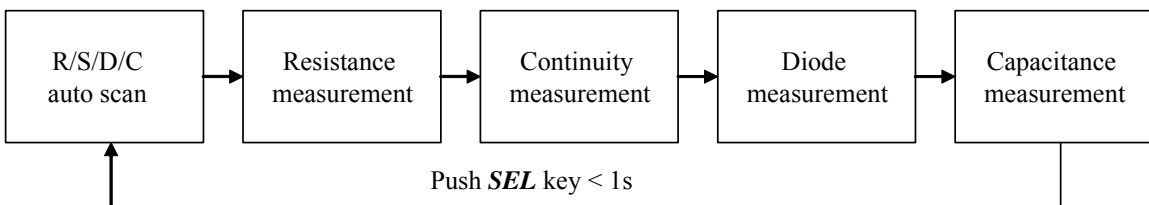


Fig. 3 SEL key operation in Smart (R/S/D/C auto scan) mode

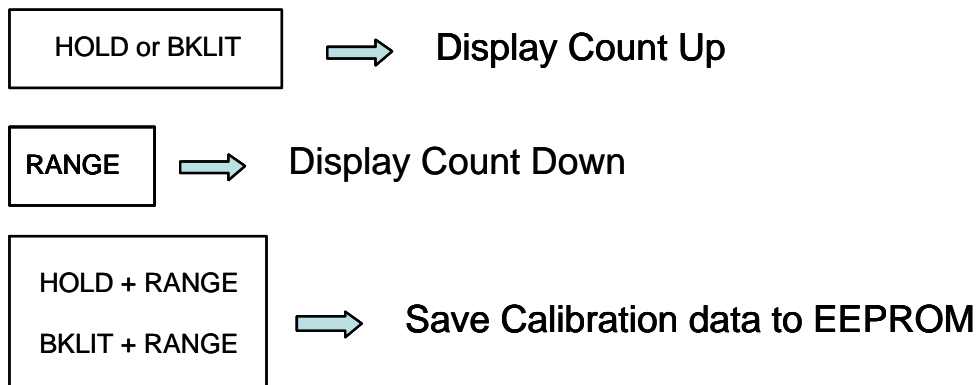




2. Operating Modes

2.1. Semi-auto calibration scheme

ES51955 includes DMM & CLAMP_ON meter features in single chip. DMM manufacturers need the calibration process in production. The traditional solution needs the variable resistors for calibration by manual adjustment. ES51955 provide another calibration scheme and the variable resistors could be ignored. When ES51955 is at OFF-state, pull *CAL_EN* (pin 60) to V- to active the calibration scheme after re-power on. A digital controlled voltage output will be active from *DAC_AO* & *DAC_VO*. When semi-auto calibration scheme is active, use **HOLD** (or **BKLIT**) key to decrease voltage and use **RANGE** key to increase the voltage. Decrease the reference voltage means the counts on display will be increased. Increase the reference voltage means the counts on display will be decreased. The adjustment step is approximate one count. If coarse adjustment is required, push **HOLD** (or **BKLIT**) and **RANGE** larger than one second to speed up to approximate 30 counts per second. After calibration process is finished, push **HOLD** (or **BKLIT**) and **RANGE** (less than one second) simultaneously to save the digital control code to external EEPROM (24C02).





The semi-auto calibration scheme supports the following seven measurement modes. When *CAL_EN* pin is active, set the proper function switches and push *SEL* key to choose the target measurement mode. When mode is selected, the LCD segment of Unit at related measurement will be blinking.

| Mode | Default range for CAL | Remark |
|-------------------------|-----------------------------|---|
| DC Voltage measurement | 5.000V | Accuracy of other ranges is guaranteed by external resistor |
| AC Voltage measurement | | |
| DC Current measurement | 50.00A or 500.0A or 5000A | Lower range in auto ACA mode |
| AC Current measurement | | |
| DC μ A measurement | 500 μ A or 5000 μ A | - |
| Capacitor measurement | 50.00nF | Set CAL_nF to V- |
| Temperature measurement | 500.0°C or 5000 °C | Lower range in Auto Temperature mode |

After calibration procedure is finished, set the ES51955 to OFF-state and set *CAL_EN* to DGND to return to normal operation after re-power on.

2.2. 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 | Resister Connection |
|------------------|------------------|---------------|------------------------|
| ¹ VR1 | 500.0mV | 1 | VR1 (10M Ω) |
| VR2 | 5.000V | 1/10 | VR2 (1.111M Ω) |
| VR3 | 50.00V | 1/100 | VR3 (101K Ω) |
| VR4 | 500.0V | 1/1000 | VR4 (10.01K Ω) |
| VR5 | 1000V | 1/10000 | VR5 (1K Ω) |

Note:

1. 500.0mV range only exists in manual mode.

2.2.1 CE selection & high voltage (HV) indication

ES51955 has a CE selection feature archived by configuring the pin CESEL. In automatic voltage mode, ES51955 will show OL when the voltage is over than the overflow level. If CESEL is connected to V- or DGND, ES51955 will have a 610.0V or 1010V overflow level in voltage mode relatively.. The configuration of CESEL is listed below.

For fully automatic voltage modes:

| CESEL | DCV | ACV |
|------------------|-------|-------|
| V- | 610V | 610V |
| DGND or floating | 1010V | 1010V |

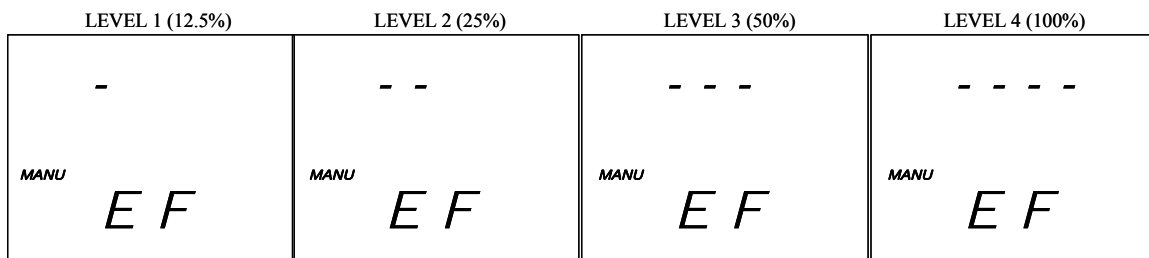


During voltage measurement is in operation (DCV or ACV), the HV indication will be active when input voltage is larger than 30V or OL in manual range. The HV indication includes:

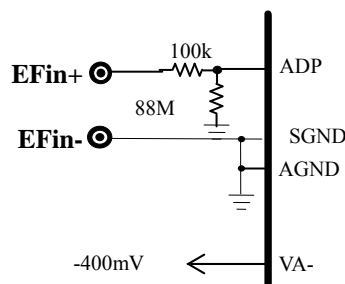
- HV warning LCD segment active
- Buzzer output active if DIS_DGB (pin107) is kept floating
- ALARM (pin91) LED output active.

2.2.2 NCV mode

ES51955 supports a non-contact AC voltage measurement, which is called electric field measurement also. The EF mode is selected by setting function control mode FC1-FC4 = [1,0,0,1]. The ADC input is configured from ADP pin vs. SGND. When no or less electric field is detected, the first-display LCD shows “EF” and the second-display LCD shows “Blank”. If the electric field is detected, the strength will be showed on the second-display LCD by “-“ not digits type. Level 1(equivalent to 12.5% full scale of ADC) is “-“ and the level 4(equivalent to 100% full scale of ADC) is “----“. Additional beeper (BUZOUT pin) and LED alarm (ALARM pin) will be output from ES51955. The frequency of buzzer and LED alarm depends on the strength of electric field also. The Faster beeper means the stronger electric field (AC voltage) is sensed.



EF test circuit





2.3 Current measurement for clampmeter

(1) ACA/DCA

ES51955 has 2 automatic and 3 manual current measurement modes for Clampmeter. The following table summarizes the full-scale range of each mode. When ES51955 operate in the automatic VA1 ~ VA2, it takes high input from IVSH/IVSL (higher range/lower range), low input from SGND and reference voltage from VR_A (pin29). When ES51955 operates in the manual VA3 ~ VA5, It takes high input from ADP, low input from SGND and reference voltage from VA- (pin8).

| Mode | FC1~4 | Full Scale | Input Terminal |
|------|---------|-----------------|-----------------------------|
| VA1 | 0,0,0,0 | 50.00A / 50.00A | IVSL/IVSH V.S. SGND (500mV) |
| VA2 | 0,0,0,1 | 500.0A / 5000A | IVSL/IVSH V.S. SGND (500mV) |
| VA3 | 0,1,0,0 | 50.00A | ADP V.S. SGND (500mV) |
| VA4 | 0,1,0,1 | 500.0A | ADP V.S. SGND (500mV) |
| VA5 | 0,1,1,0 | 5000A | ADP V.S. SGND (500mV) |

Note:

1. In DCA current modes (SAC = 0) , ES51955 provides **Zero function** (push SEL key) for offset removing.

(2) DCuA mode

ES51955 has 2 manual DCuA current measurement modes for flame rod application. The following table summarizes the full scale range of each mode.

| Mode | FC1~4 | Full Scale | Input Terminal |
|-------|---------|------------|-----------------------|
| DCuA1 | 0,0,1,0 | 500.0uA | ADP V.S. SGND (500mV) |
| DCuA2 | 0,0,1,1 | 5000uA | ADP V.S. SGND (500mV) |

(3) Low pass filter (LPF) mode for ACA mode

A 3rd order low-pass filter (3dB bandwidth = 4kHz typ.) with is built in ES51955 to reduce the influence of high frequency noise. The LPF mode is active in ACA only if DIS_LPF is connected to DGND or floating.

2.4 Resistance Measurement (R)

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.

| Configuration | Full Scale Range | Relative Resistor | Equivalent value |
|---------------|------------------|-------------------|------------------|
| OR1 | 500.0Ω | OR1 | 100Ω |
| OR2 | 5.000KΩ | VR5 | 1KΩ |
| OR3 | 50.00KΩ | VR4 VR1 | 10KΩ |
| OR4 | 500.0KΩ | VR3 VR1 | 100KΩ |
| OR5 | 5.000MΩ | VR2 VR1 | 1MΩ |
| OR6 | 50.00MΩ | VR1 | 10MΩ |

2.5 Capacitance Measurement (C)

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

| Configuration | Full Scale Range | Relative Resistor |
|---------------|------------------|-------------------|
| C1 | 5.000nF | Ratio to C2 range |
| C2 | 50.00nF | CAL |
| C3 | 500.0nF | Ratio to C2 range |
| C4 | 5.000uF | R9K / R1K |
| C5 | 50.00uF | R9K / R1K |
| C6 | 500.0uF | R9K / R1K |
| C7 | 5.500mF | R9K / R1K |
| C8 | 50.00mF | 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 main-display shows **dIS.C**
2. Discharging through the chip is quite slow. We recommend users to discharge the capacitor with some other apparatus.
3. The C2 range is calibrated by the variable resistance near to the OVX pin when CAL_nF (pin 102) is kept floating or use the semi-auto calibration scheme when CAL_nF is set to V-.
4. The C1 range zero offset could be compensated by the small capacitors near to OVH pin.
5. The C7 and C8 measurement period is depended on the capacitance of input terminals.



2.6 Continuity Check (S)

Continuity check shares the same configuration with 500.0Ω manual resistance measurement mode and has buzzer output to indicate continuity. The buzzer generates 2KHz beep and ALARM1 (pin 105) drive high output (V+ level) whenever the reading is less than 30Ω. The ES51955 built in a high speed short detection circuit and the detection could be less than 10ms.

2.7 Diode Measurement (D)

Diode measurement mode shares the same configuration with 5.000V manual voltage measurement mode and has buzzer output to indicate continuity. The buzzer generates a 2KHz sound and Alarm1 (pin 105) drive high output (V+ level) whenever the reading is less than 30mV. If the test circuit is open or the voltage drop between the two ports of the diode under test is larger than 2V, the LCD panel will show “OL”.

2.8 Frequency counter

In frequency mode, main-display shows frequency and sub-display shows duty cycle at the same time. 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 500.0Hz to 50.00MHz. The following table summarizes the full-scale range of the frequency counter.

| Configuration | Full Scale range |
|---------------|------------------|
| FR1 | 500.0Hz |
| FR2 | 5.000KHz |
| FR3 | 50.00KHz |
| FR4 | 500.0KHz |
| FR5 | 5.000MHz |
| FR6 | 50.00MHz |

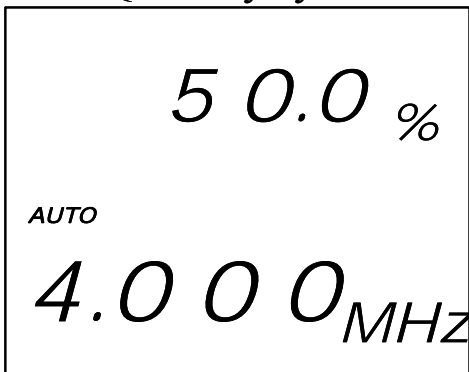
*If input frequency is less than 5.0Hz, ES51955 will show **0.0Hz**



2.9 Duty Cycle measurement

The duty cycle measurement is available in frequency mode simultaneously. The duty cycle mode range is available within 5.0% to 95.0% (< 10kHz@3Vpp). The minimum resolution is 0.1%. If the source frequency duty cycle is smaller than 1.0%, the 0.0% will be shown on the LCD display. If the duty cycle is larger than 98.9%, the **OL** will be shown on the LCD sub-display. When the frequency is zero, the duty cycle display will be 0.0%.

FREQ + Duty cycle



2.10 Temperature measurement mode

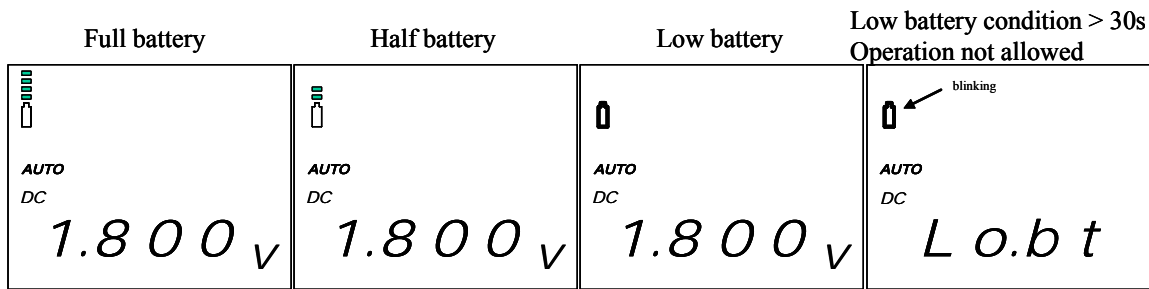
Temperature measurement mode takes input signal from ADP pin and reference voltage from VA-. ES51955 has a built-in °C-to-°F scale translation circuit, and only needs an external °C scale application circuit. The application circuit for °F scale is not required. The °C & °F readings are shown on the dual-display LCD simultaneously. In temperature2 measurement mode, the default range is 5000 °C or 9032 °F manual range. In temperature1 measurement mode, the default range is 500.0/5000 °C or 932.0/9032 °F auto range. The TSEL pin (pin104) is pulled to V-, the temperature1 measurement mode will be set to 500.0 °C manual mode.

| Range | Full scale range | Input terminal |
|-------|-----------------------|----------------------------|
| Temp1 | Auto 500.0°C / 5000°C | ADP V.S. SGND (50mV/500mV) |
| Temp2 | Manual 5000°C | ADP V.S. SGND (500mV) |

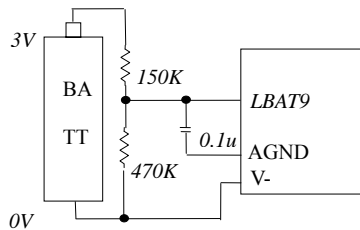


2.11 Multi-level low battery voltage detection

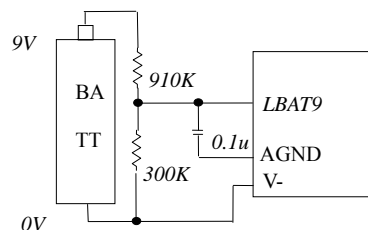
ES51955 provides a voltage detection input (pin 121: LBAT9) for multi-level low battery application. There are two internal voltage reference V_{t1} & V_{t2} for comparing with LBAT9. If LBAT9 is larger than V_{t1} , the LCD segment of SLB3 – SLB1 will active always. This status implies Full battery. When LBAT9 is less than V_{t1} but larger than V_{t2} , the LCD segment of SLB3 will disappear and this status implies Half battery. When LBAT9 is less than V_{t2} , the LCD segment of SLB2 will disappear and this status implies Low battery. When the Low battery status lasts for 10 seconds, the LCD segment of SLB1 will be blinking. When the SLB1 is blinking for 20 seconds, the operation of meter will be inhibited and LCD panel will show “Lo.bt”. In this case, it is suggested to replace a new battery immediately. After “Lo.bt” appears and lasts for 60 seconds, ES51955 will enter to auto power off mode.



Low battery test circuit (a)



Low battery test circuit (b)





2.12 Auto power off (APO) and idle time selection

ES51955 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 sign on the LCD panel indicates whether the auto power off is enabled or not. If user might want to disable Auto power off, power on the meter when any of the push functions, except for HOLD, is pressed down.

Note:

1. Powering on the meter while pressing HOLD and lasts 2 seconds turns on all LCD segments until HOLD is pressed again.
2. When low battery status happened (LCD show "Lo.b"), the APO idle time will be reset to 60 sec.

2.13 Sleep

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

2.14 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.

3. Measurement Mode Switching

Measurement mode depends on the logic level of SVR, S50V, SAC, FC1, FC2, FC3 and FC4.

| SVR | S50V | SAC | FC1 | FC2 | FC3 | FC4 | Function mode | Remark |
|-----|------|-----|-----|-----|-----|-----|---|--------|
| 0 | X | 1 | 0 | 0 | 0 | 0 | ACV (5.000V) + ACA (50.00A / 500.0A) | VA1 |
| 0 | X | 1 | 0 | 0 | 0 | 1 | ACV (5.000V) + ACA (500.0A / 5000A) | VA2 |
| 0 | X | 1 | 0 | 1 | 0 | 0 | ACV (5.000V) + ACA (50.00A) | VA3 |
| 0 | X | 1 | 0 | 1 | 0 | 1 | ACV (5.000V) + ACA (500.0A) | VA4 |
| 0 | X | 1 | 0 | 1 | 1 | 0 | ACV (5.000V) + ACA (5000A) | VA5 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 | ACV (50.00V) + ACA (50.00A / 500.0A) | VA1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | ACV (50.00V) + ACA (500.0A / 5000A) | VA2 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | ACV (50.00V) + ACA (50.00A) | VA3 |
| 1 | 0 | 1 | 0 | 1 | 0 | 1 | ACV (50.00V) + ACA (500.0A) | VA4 |
| 1 | 0 | 1 | 0 | 1 | 1 | 0 | ACV (50.00V) + ACA (5000A) | VA5 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | ACV (500.0V) + ACA (50.00A / 500.0A) | VA1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | ACV (500.0V) + ACA (500.0A / 5000A) | VA2 |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | ACV (500.0V) + ACA (50.00A) | VA3 |
| 1 | 1 | 1 | 0 | 1 | 0 | 1 | ACV (500.0V) + ACA (500.0A) | VA4 |
| 1 | 1 | 1 | 0 | 1 | 1 | 0 | ACV (500.0V) + ACA (5000A) | VA5 |
| 0 | X | 0 | 0 | 0 | 0 | 0 | DCV (5.000V) + DCA (50.00A / 500.0A) | VA1 |
| 0 | X | 0 | 0 | 0 | 0 | 1 | DCV (5.000V) + DCA (500.0A / 5000A) | VA2 |
| 0 | X | 0 | 0 | 1 | 0 | 0 | DCV (5.000V) + DCA (50.00A) | VA3 |
| 0 | X | 0 | 0 | 1 | 0 | 1 | DCV (5.000V) + DCA (500.0A) | VA4 |
| 0 | X | 0 | 0 | 1 | 1 | 0 | DCV (5.000V) + DCA (5000A) | VA5 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | DCV (50.00V) + DCA (50.00A / 500.0A) | VA1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | DCV (50.00V) + DCA (500.0A / 5000A) | VA2 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | DCV (50.00V) + DCA (50.00A) | VA3 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | DCV (50.00V) + DCA (500.0A) | VA4 |
| 1 | 0 | 0 | 0 | 1 | 1 | 0 | DCV (50.00V) + DCA (5000A) | VA5 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | DCV (500.0V) + DCA (50.00A / 500.0A) | VA1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | DCV (500.0V) + DCA (500.0A / 5000A) | VA2 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 | DCV (500.0V) + DCA (50.00A) | VA3 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | DCV (500.0V) + DCA (500.0A) | VA4 |
| 1 | 1 | 0 | 0 | 1 | 1 | 0 | DCV (500.0V) + DCA (5000A) | VA5 |
| X | X | 0 | 0 | 0 | 1 | 0 | DCuA (500.0uA) | DCuA1 |
| X | X | 0 | 0 | 0 | 1 | 1 | DCuA (5000uA) | DCuA2 |
| X | X | X | 1 | 0 | 0 | 0 | FREQ + Duty cycle | Fmode |
| X | X | X | 1 | 0 | 0 | 1 | NCV (EF) | EFmode |
| X | X | X | 1 | 0 | 1 | 0 | Temp (500.0 °C / 5000 °C) (AUTO) ¹ | Temp1 |
| X | X | X | 1 | 0 | 1 | 1 | Temp (5000 °C) | Temp2 |
| X | X | 0 | 1 | 1 | 0 | 0 | R (Resistance mode) | R |
| X | X | 0 | 1 | 1 | 0 | 1 | S (Continuity mode) | S |
| X | X | 0 | 1 | 1 | 1 | 0 | D (Diode check mode) | D |
| X | X | 0 | 1 | 1 | 1 | 1 | C (Capacitance mode) ^{2,3} | C |
| X | X | 1 | 1 | 1 | 0 | 0 | R,S | RS |
| X | X | 1 | 1 | 1 | 0 | 1 | R,S,D | RSD |
| X | X | 1 | 1 | 1 | 1 | 0 | R,S,D,C ^{2,3} | RSDC |
| X | X | 1 | 1 | 1 | 1 | 1 | Auto scan RSDC | Smart |

X means "don't care".

¹ 50mV full scale is for 500 °C range and 500mV full scale is for 5000 °C range. When TSEL (pin104) is pulled to V-, the 500 °C range is fixed

² Set the C_clamp (pin98) to V- to change initial range of C to 5.000uF. Set the Opt_nF(pin97) to V- to change initial range of C to 50.00nF.

³ Set the Opt_nF(pin97) to V- to change initial range of C to 50.00nF.

Push function

All the enabled push functions will be reset when the measurement mode is changed by rotary switch. The following table lists the available function versus every measurement mode.

| | RANGE | HOLD | SEL | BKLIT | INRUSH |
|----------------------------------|-----------------|-------------|------------|--------------|---------------|
| DCV | O | O | O | O | X |
| DCV + DCA | O (V only) | O | O | O | X |
| ACV | O | O | O | O | X |
| ACV + ACA | O (V only) | O | O | O | O |
| DCuA | X | O | X | O | X |
| Frequency | O | O | X | O | X |
| NCV (EF) | X | X | X | O | X |
| ³Temp1 | O | O | X | O | X |
| Temp2 | X | O | X | O | X |
| Resistance | O | O | X | O | X |
| Continuity | X | O | X | O | X |
| Diode | X | O | X | O | X |
| Capacitance | O | O | X | O | X |
| R , S¹ | O (R only) | O | O | O | X |
| R , S¹ , D | O (R only) | O | O | O | X |
| R , S¹ , D , C | O (R/C only) | O | O | O | X |
| Smart² | X | X | O | O | X |

Note:

¹Continuity mode

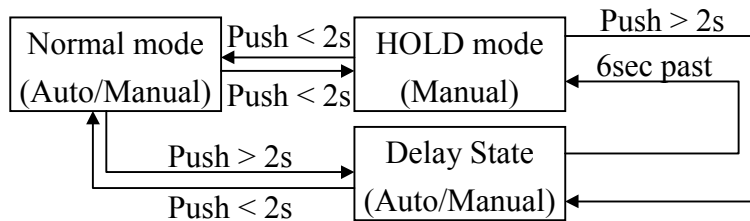
²Auto check for RSDC mode: Max range for R is 5.000MΩ and Max range for C is 500.0uF

³Auto range configuration



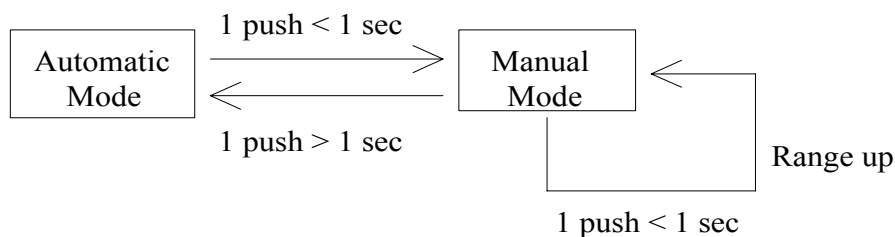
3.1. HOLD and Delay Hold feature

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. ES51955 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. HOLD function and the delayed state can be cancelled by changing the measurement mode, pressing RANGE, or push HOLD again.



3.2. Range

RANGE pin configuration is shown below. It is available for voltage, resistance, capacitance, frequency and temperature (Temp1) modes.



| Measurement Mode | Auto | Manual | Control Range | Initial Range |
|------------------|-----------|-----------------------------|----------------------------------|----------------------|
| V(DC/AC) | VR2 – VR5 | VRi → VRi + 1, VR5 → VR1 | 500.0mV – 1000V | 5.000V ¹ |
| Auto A(DC/AC) | IR1 – IR2 | N/A ³ | 500.0A – 5000A | 500.0A |
| Auto A(AC/DC) | IR1 – IR2 | N/A ³ | 50.00A – 500.0A | 50.00A |
| Manual A(AC/DC) | fixed | fixed | 50.00A | 50.00A |
| | | | 500.0A | 500.0A |
| | | | 5000A | 5000A |
| Manual DCuA | fixed | fixed | 500.0uA | 500.0uA |
| | | | 5000uA | 5000uA |
| Capacitance | C1 – C8 | Ci → Ci + 1, C8 → C1 | 5.000nF – 50.00mF | 5.000nF ² |
| Ω | OR1 – OR6 | ORi → ORi + 1, OR6 → OR1 | 500.0 Ω – 50.00M Ω | 500.0 Ω |
| Continuity | fixed | fixed | 500.0 Ω | 500.0 Ω |
| Diode | fixed | fixed | 5.000V | 5.000V |
| Temp1 | T1-T2 | T1 → T2 T2 → T1 | 500.0°C – 5000°C | 500.0°C |
| Frequency | FR1 – FR6 | FRi → FRi + 1 FR6 → FR1 | 500.0Hz – 50.00MHz | 500.0Hz |

Note: Pushing RANGE resets all existing special modes.

¹ Initial range depends on status of SVR & S50V. See Measurement Mode Switching

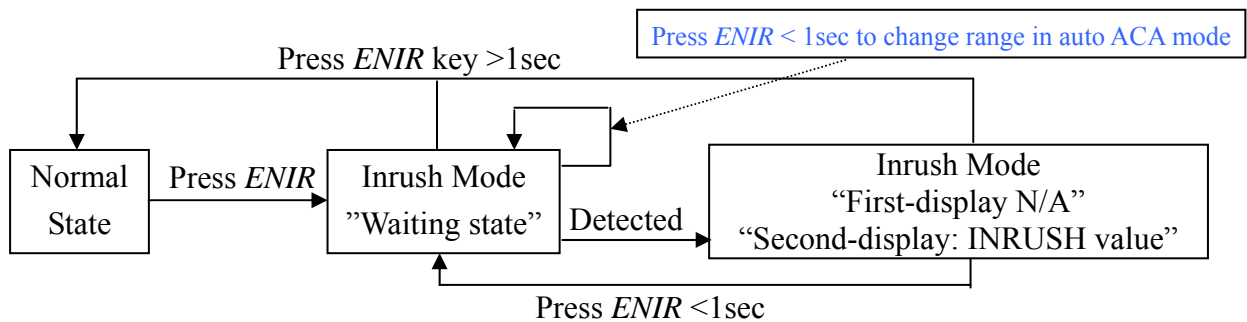
² Initial range depends on status of C_clamp & Opt_nF.

³ When inrush mode is active and waiting for signal triggered, push *ENIR* key could change the range of ACA.



3.3. INRUSH function

ES51955 provides an inrush function for AC current measurement for clampmeter to detect the starting-up current of a motor. Push **ENIR** (pin 109) key to enable the inrush function. In inrush mode, second-display shows “- - -” until the motor starting up and being detected. If the starting-up current is detected, ES51955 execute the inrush current measurement and held the inrush rms current value with 100ms integration period at second-display. When the inrush current measurement is done, press **ENIR** could enter inrush mode (waiting state) again. To exit inrush mode, press **ENIR** key more than one second. Enter inrush mode in automatic ACA modes (FC1-FC4 = [0,0,0,X]) will force the range to be locked in manual range. During the waiting state, push **ENIR** key to change the manual range of inrush mode. To have the detail application circuit, please refer to application circuit. Any change of the component value may have influence on the INRUSH characteristic. So it's not recommended to have any change on these component value. For INRUSH function, an external **true RMS-to-DC ES636 IC** must be required. The flow chart of inrush function is shown below.

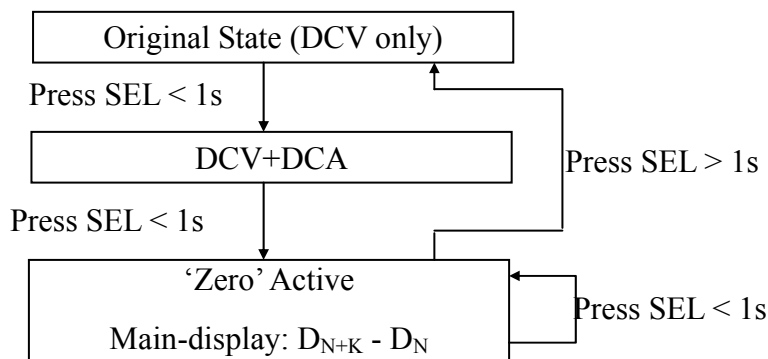




3.4. ZERO function

In manual DC 50.00A, 500.0A and 5000A, auto DC 50.00A/500.0A and auto DC 500.0A/5000A measurement modes, ES51955 provides Zero function to remove the residual current value. During DCV and DCA mode are active simultaneously, push *SEL* key less than one second to enter Zero mode. In Zero mode, second-display shows $D_{N+K} - D_N$, where $N = 1, 2, 3, \dots$, D_N is the last conversion value before *SEL* is pushed, and D_{N+K} is the current conversion value. If *SEL* is pushed again in Zero mode, second-display will update the D_N value and displays the $D_{N+K} - D_N$ again. The meter returns to DCV operation only if *SEL* is pressed and held for longer than one second. In 2-range auto DCA modes for clampmeter (500.0A/5000A or 50.00A/500.0A), 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 should stay at lower one in automatic mode. When enter Zero mode in lower range, the system will store the nonzero counts (residual current value). If the range goes up to higher one automatically, the non-zero counts will be divided by ten. So this function will still work well in automatic modes.

State diagram for Zero mode:



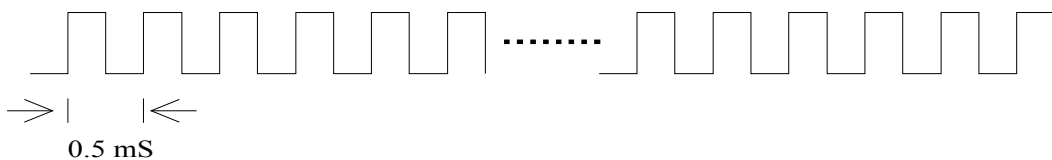


Miscellaneous

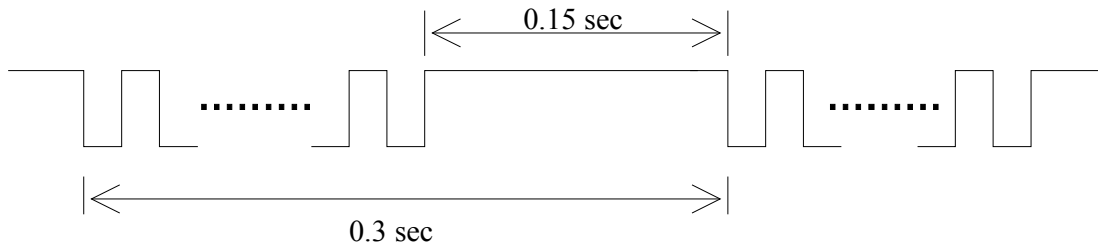
The conditions, which the meter turns on the buzzer, include:

- (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(diode) check generates a continuous 2KHz beep whenever the measurement is less then $30\Omega(30mV)$
- (6) Auto power off generates a 2KHz beep which lasts for 1.5 seconds.

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



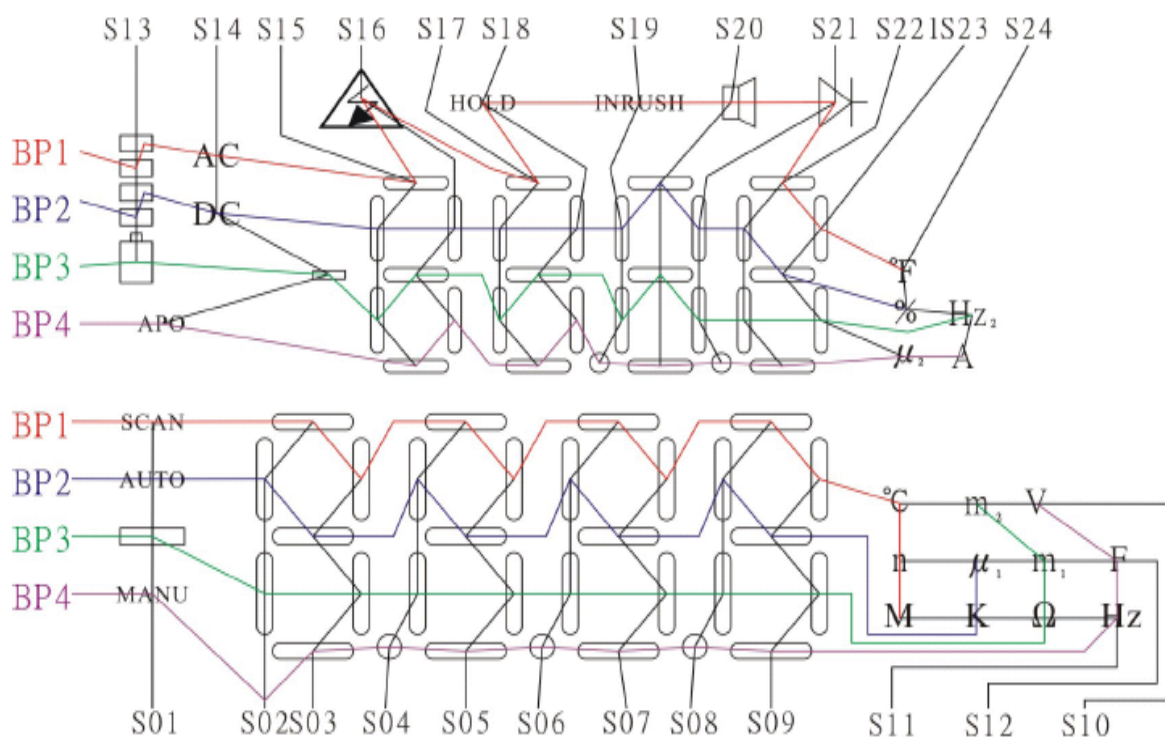
(a) Continuous 2KHz beep

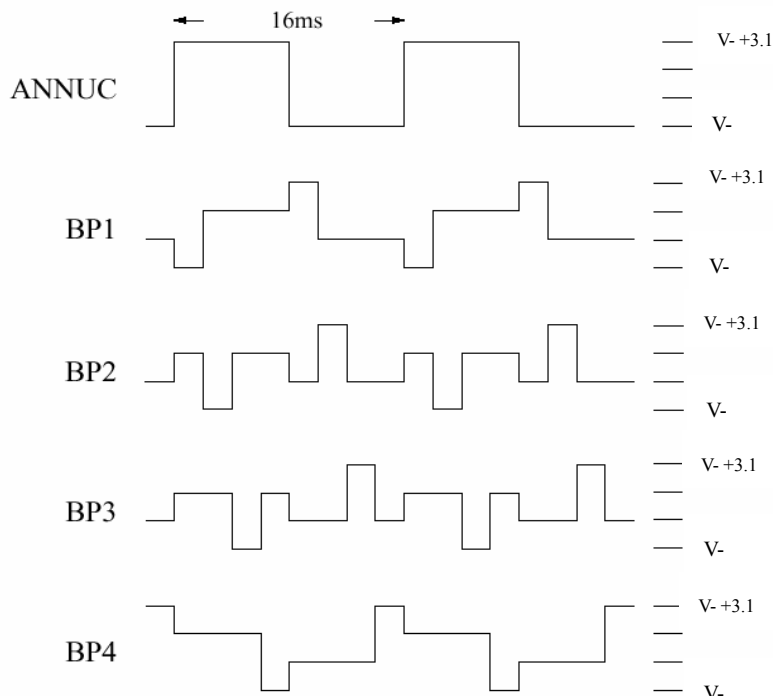





(b) 3.33 beep/sec

3.5. LCD Panel

| | | | | | | | | | | | | |
|-----|-------|--------|-----|-----|-----|------|--------|-----|------|----------------|----------------|-----------------|
| | S13 | S14 | S15 | S16 | S17 | S18 | S19 | S20 | S21 | S22 | S23 | S24 |
| BP1 | SLB3 | AC | S4A | | S3A | HOLD | INRUSH | | | S1A | S1B | °F |
| BP2 | SLB2 | DC | S4F | S4B | S3F | S3B | S2F | S2A | S2B | S1F | S1G | % |
| BP3 | SLB1 | SMINUS | S4E | S4G | S3E | S3G | S2E | S2G | S2C | S1E | S1C | Hz ₂ |
| BP4 | | APO | S4D | S4C | S3D | S3C | SDP2 | S2D | SDP1 | S1D | μ ₂ | A |
| | S01 | S02 | S03 | S04 | S05 | S06 | S07 | S08 | S09 | S10 | S11 | S12 |
| BP1 | SCAN | 4A | 4B | 3A | 3B | 2A | 2B | 1A | 1B | °C | M | n |
| BP2 | AUTO | 4F | 4G | 3F | 3G | 2F | 2G | 1F | 1G | | K | μ ₁ |
| BP3 | MINUS | 4E | 4C | 3E | 3C | 2E | 2C | 1E | 1C | m ₂ | Ω | m ₁ |
| BP4 | MANU | | 4D | DP3 | 3D | DP2 | 2D | DP1 | 1D | V | Hz | F |



LCD Backplane Waveform

3.6. 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. |
| % | In duty cycle measurement. |
| Hz | Hz for Frequency mode (voltage signal to FREQ input) |
| Hz ₂ | Hz for ACA mode (ADP/IVSH/IVSL) |
| DC | In DC voltage or current mode. |
| AC | In AC voltage or current mode. |
| AUTO | When automatic range selection is enabled. (Voltage, resistance, capacitance, frequency mode) |
| MANU | In manual mode. |
| SCAN | When smart (resistance, continuity, diode, capacitance auto check mode) is active. |
| HOLD | When HOLD function is enabled. |
| INRUSH | When INRUSH 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 μ F. |
| n | In capacitor measurement mode and the full scale range is in the order of nF. |
| m ₂ | In voltage measurement mode and the full scale range is in the order of 10^{-3} . |
| μ ₂ | In DCuA 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 |
|  | When the reading is exceeding 30V or OL in DCV or ACV, the HV warning symbol will be displayed. |



| | |
|------|---|
| °C | In temperature measurement mode and when the unit is °C |
| °F | In temperature measurement mode and when the unit is °F |
| SLB3 | When voltage (ref. to V-) of LBAT9 pin is less than Vt1, SLB3 will disappear. |
| SLB2 | When voltage (ref. to Vo) of LBAT9 pin is less than Vt2, SLB2 will disappear. |
| SLB1 | When SLB2 disappears for 8 seconds, SLB1 will be blinking. |
| APO | When auto power off function is enabled. |



3.7. Operating Timing

ES51955 incorporates a dual slope ADC with four phases: ZI, AZ, INT and DINT. The timing of each phase is listed below.

*Voltage / Current / Ohm / ADP / Temperature (High range) measurement:

| Phase | Period |
|-------|--------|
| ZI | 50ms |
| AZ | 24ms |
| INT | 100ms |
| DINT | 126ms |

* Temperature mode (Low range: 500°C mode)

| Phase | Period |
|-------|--------|
| ZI | 50ms |
| AZ | 24ms |
| INT | 1000ms |
| DINT | 126ms |

*Capacitance measurement:

| Range | Total Measurement Time |
|---------|------------------------|
| 6.600nF | 0.35 sec |
| 66.00nF | 0.35 sec |
| 660.0nF | 0.95 sec |
| 6.600μF | 0.7 sec |
| 66.00μF | 0.7 sec |
| 660.0μF | 1.4 sec |
| 6.600mF | 2.8 sec (max) |
| 66.00mF | 14.0 sec (max) |

*Frequency + Duty cycle mode measurement

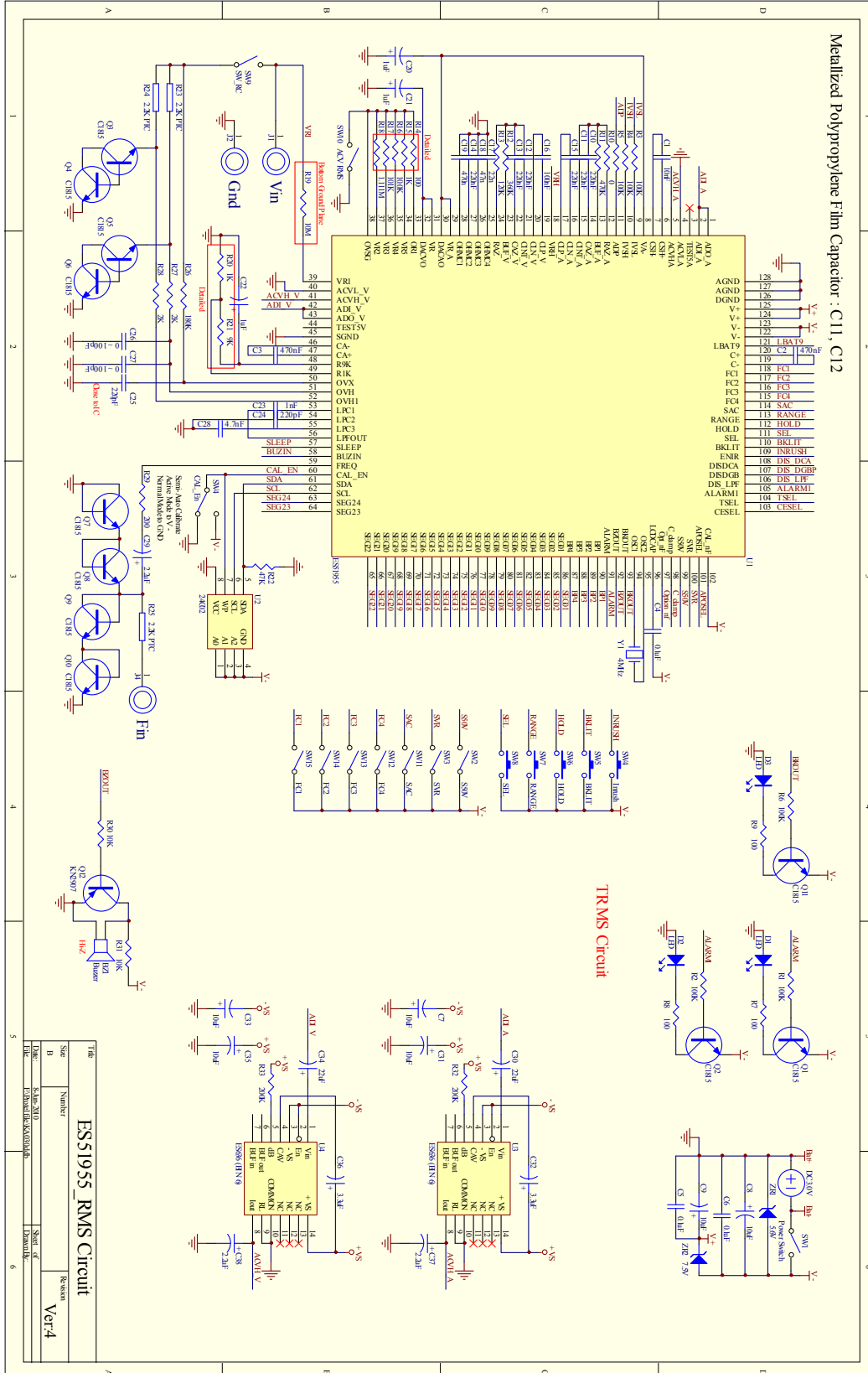
In range 500.0Hz~50MHz, the measurement cycle = 1.05 sec

P.S. In the frequency measurement with auto mode, if the range is changed, the internal clock rate will increase ten times and the new measurement cycle becomes 1/10 times of the original cycle until the range is stable.



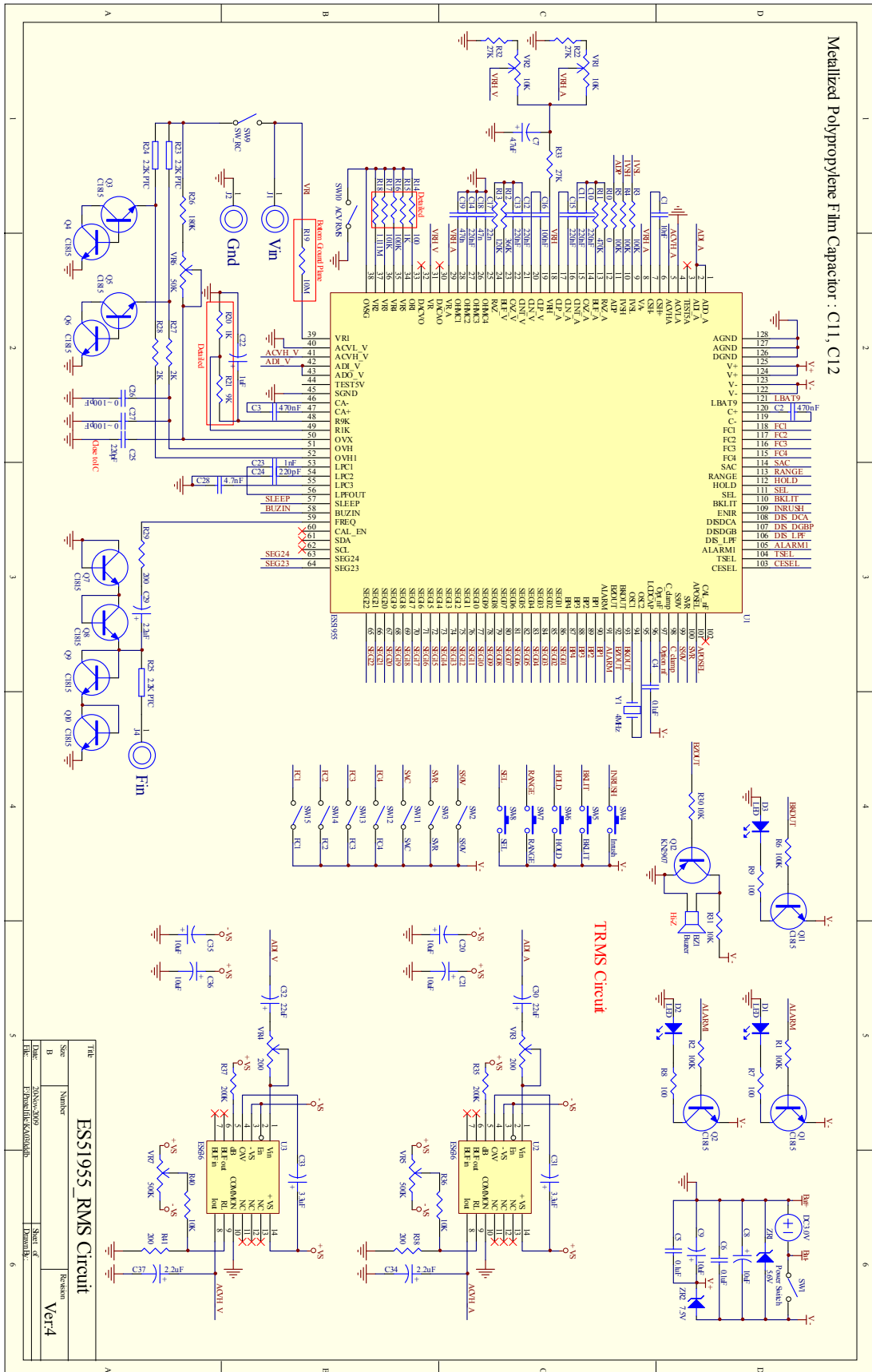
4. Application Circuit

4.1 EEPROM is used





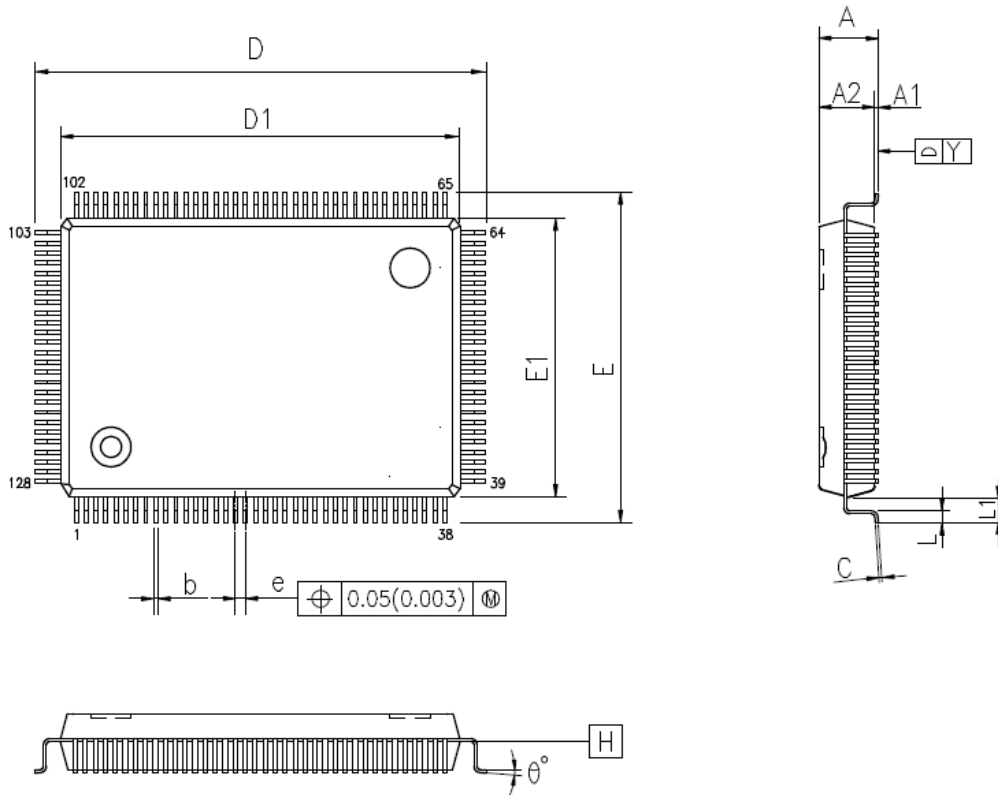
4.2 EEPROM is not used





5. Package Information

8.1 128L LQFP Outline drawing



8.2 Dimension parameters

| SYMBOLS | MIN. | NOM. | MAX. |
|---------|------|-----------|------|
| A | — | — | 1.60 |
| A1 | 0.05 | — | 0.15 |
| A2 | 1.35 | 1.40 | 1.45 |
| b | 0.17 | 0.22 | 0.27 |
| C | 0.10 | 0.15 | 0.20 |
| D1 | — | 20.00 BSC | — |
| E1 | — | 14.00 BSC | — |
| e | — | 0.50 BSC | — |
| D | — | 22.00 BSC | — |
| E | — | 16.00 BSC | — |
| L | 0.45 | 0.60 | 0.75 |
| L1 | — | 1.00 REF | — |
| Y | — | — | 0.08 |
| θ° | 0° | 3.5° | 7° |

UNIT : mm

NOTES:

1. JEDEC OUTLINE:
MS-026 BHB;
MS-026 BHB-HD(THERMALLY ENHANCED VARIATIONS ONLY).
2. DATUM PLANE [H] IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.
3. DIMENSIONS E1 AND D1 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.