

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
 - *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 selectable low pass filter 3dB bandwidth for ACV & ACA measurement
(Taiwan patent no.: 362409)
(China patent no.: 1363073)
- 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

ES51931 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 REL/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.

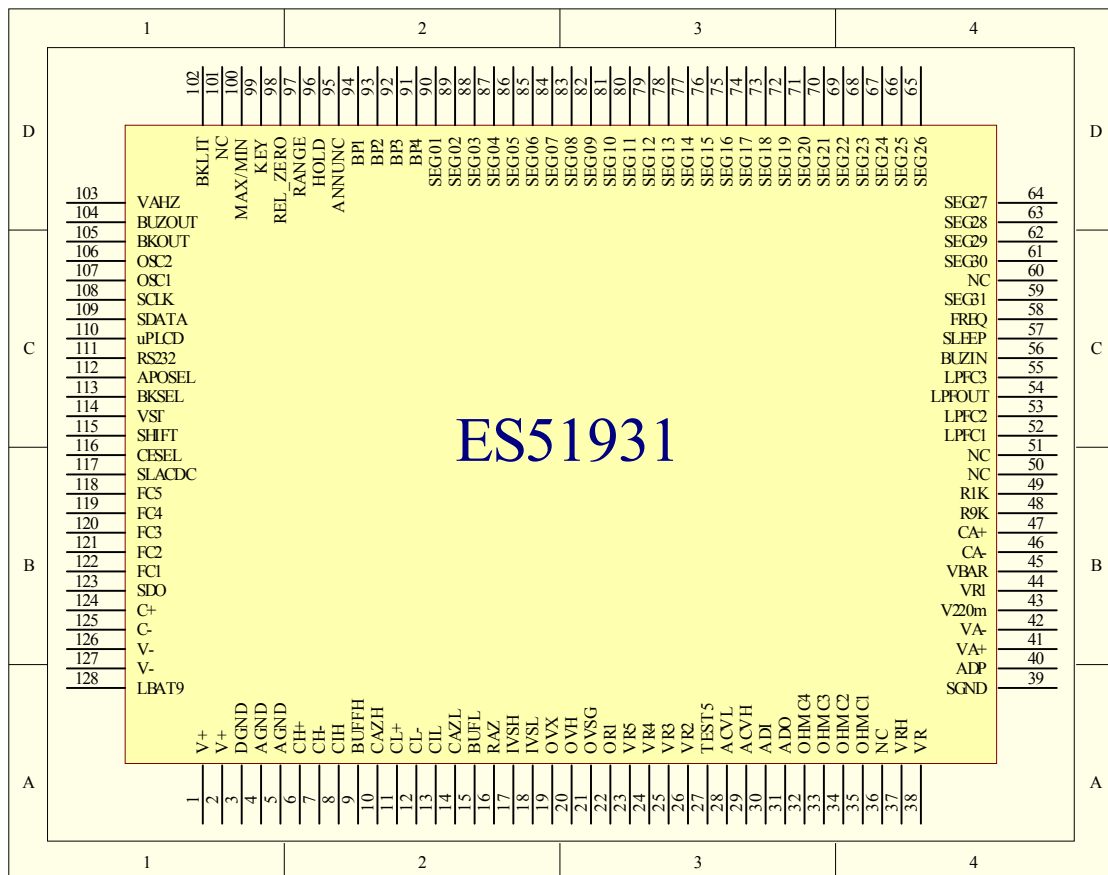


Application

- Digital multimeter
- Clamp meter
- Thermometer

Pin Assignment

LQFP-128L





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	NC	-	
51	NC	-	
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	LPFC3	I	Capacitor C3 connection for internal low-pass filter
56	BUZIN	I	Pull to V- to enable the BUZOUT.
57	SLEEP	O	Sleep mode indicator, asserts low in SLEEP mode.
58	FREQ	I	Frequency counter input, offset V-/2 internally by the chip.
59 - 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	NC	-	
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	OL selection feature control pin of voltage mode.
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 In DCV mode	I _{DD}	Normal operation	—	2.0	2.5	mA
	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	f_{3dB}	3dB=Full (ADP)	100	—	—	kHz
		3dB=10k (ADP)	—	10	—	kHz
		3dB=1k (ADP)	—	1	—	kHz
Reference voltage temperature coefficient	TC_{RF}	100K Ω resistor Between VRH 0 $^{\circ}$ C < TA < 70 $^{\circ}$ C	—	75	—	ppm/ $^{\circ}$ C
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:

1. 220.00mV range is independent and manual mode. The input pin is different from other voltage ranges.
2. 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

ES51931 has a CE selection feature archived by configuring a CESEL pin. If pin CESEL is connected to V-, ES51931 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

ES51931 provides detection of high-crest-factor (HCF) signal in ACV mode. When this function is enabled, ES51931 senses the signal and determines it as HCF if the Vpp is large enough. Once the signal is determined as HCF, ES51931 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, ES51931 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.



1.1.5 Low-pass filter feature

ES51931 provides a 3-order low-pass filter to reduce the influence of high frequency noise. This LPF feature is available in ACV or ACA modes. Set FC5 to low in these modes, the KEY button is used to activate the LPF feature. Press KEY button for less than 1 second to select the 3dB bandwidth of LPF sequentially (Full/10kHz/1kHz) and the relative LCD segment on LCD panel will be active also.

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

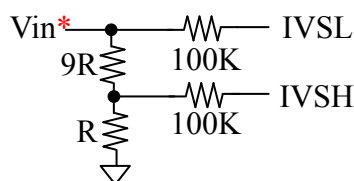
1.3 Current measurement for multimeter

ES51931 has 2 automatic and 1 manual current measurement modes for multimeter. The following table summarizes the full-scale range of each mode. When ES51931 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:

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





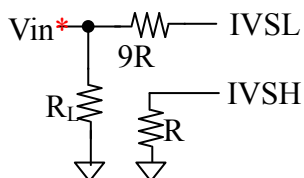
1.4 Current measurement for clampmeter

ES51931 has 2 automatic and 4 manual current measurement modes for clampmeter. The following table summarizes the full-scale range of each mode. When ES51931 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 ES51931 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, ES51931 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. When the LCD display counts are larger than 1.9000V, the OL will be shown.



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, ES51931 will show 0.00Hz if the input frequency is less than 2.00Hz.

³In the Range FR2 (manual mode), ES51931 will show 0.0Hz if the input frequency is less than 20.0Hz..

1.8.1 Duty Cycle measurement

The duty cycle measurement is available in frequency mode with VAHz operation. Press VAHz key when frequency mode is in operation, the ES51931 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-). ES51931 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

ES51931 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 kept 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:

Power on the meter while pressing HOLD and lasts 1 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 select LPF 3dB
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
1	1	1	1	1	Auto AC Current Measurement(mA)	O
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, and Zero functions. The following table lists the available function versus every measurement mode.

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

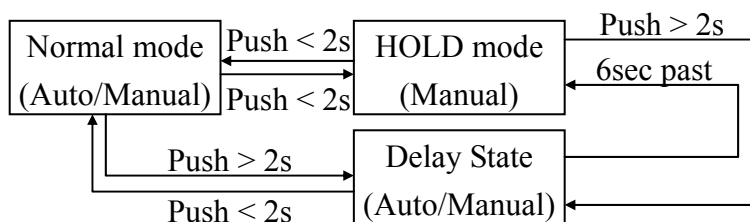
Note:

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

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

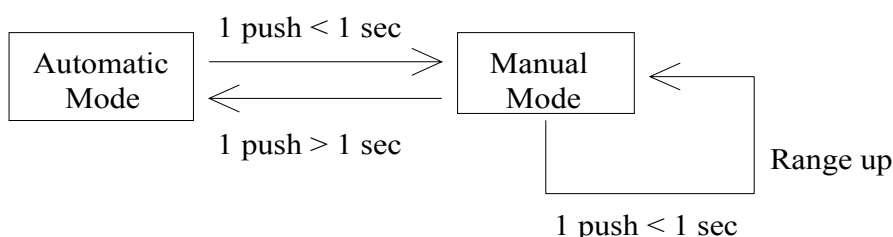
3.1 HOLD and Delay HOLD

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. ES51931 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.

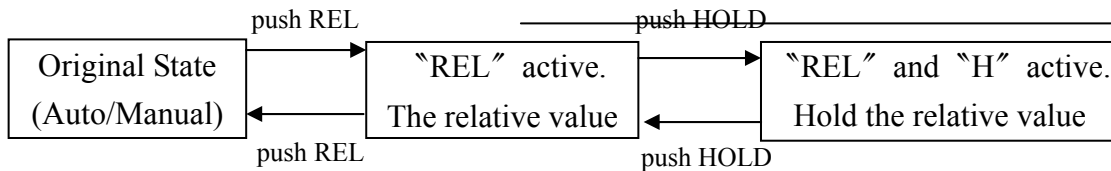


3.3 KEY

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

3.4 REL + HOLD

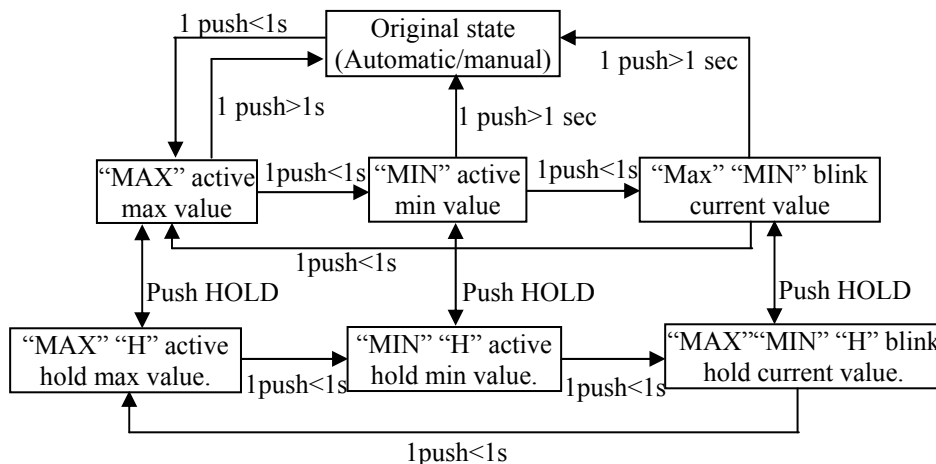
In REL mode, the LCD panel displays $D_{N+K} - D_N$, where $D_N = 1, 2, 3, \dots$, D_N is the last value before REL is pushed, and D_{N+K} is the current value. If REL is pushed again in REL mode, the meter displays the reference value. The meter returns to normal operation if REL is pressed and held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

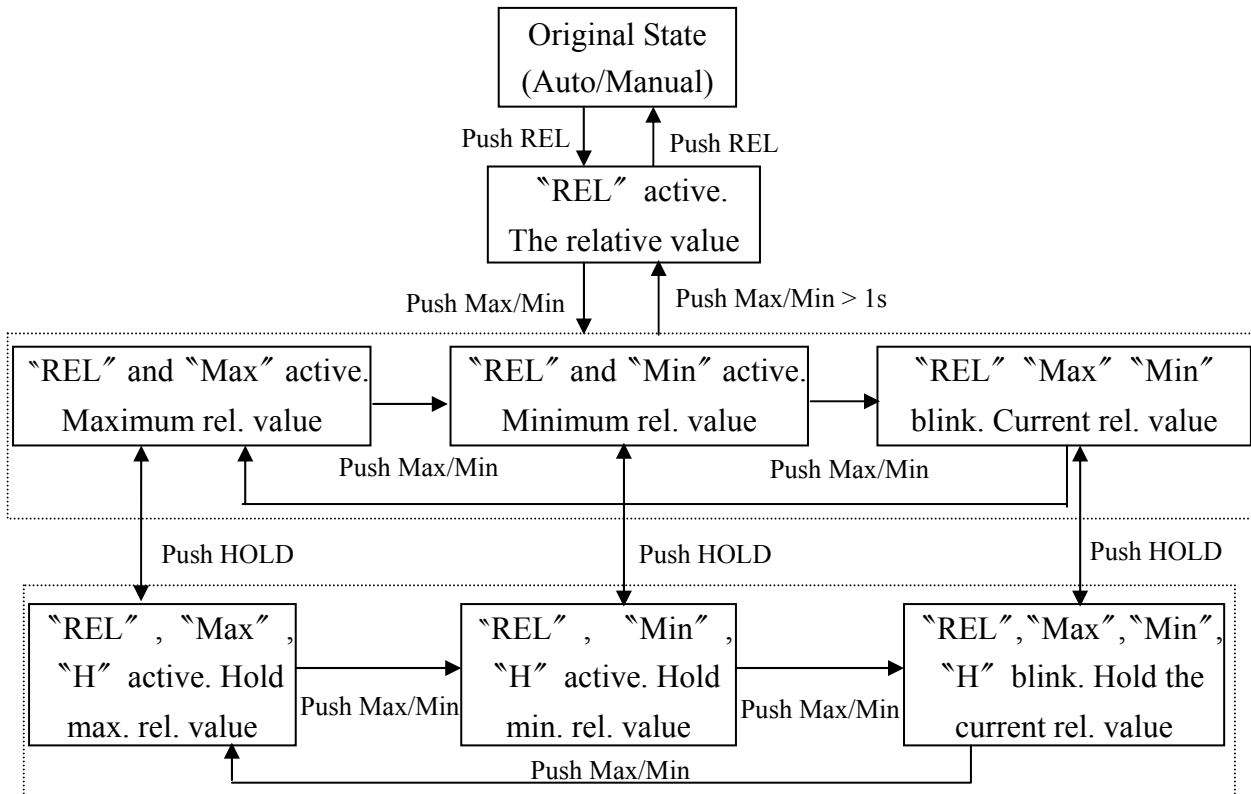
The meter displays the maximum or minimum value of the input in Max/Min mode. When Max/Min is pressed for the first time, the meter displays the maximum value. When Max/Min is pressed again, the meter displays the minimum value. When Max/Min is pressed for the third time, the meter displays current value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

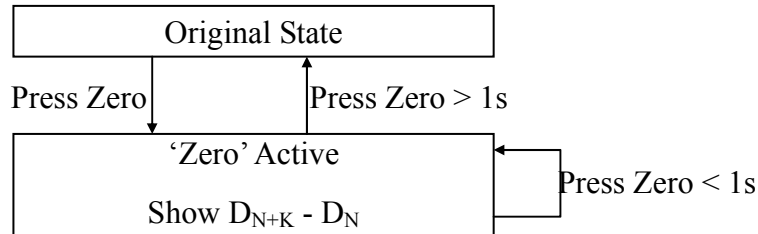


3.7 Zero : In manual DC 22.000A, 220.00A, 2200.0A and 22000A measurement modes, the REL pin changes to control Zero function instead of relative function. In Zero mode, the LCD panel displays $D_{N+K} - D_N$, where $D_N = 1, 2, 3, \dots$, D_N is the last conversion value before Zero is pushed, and D_{N+K} 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

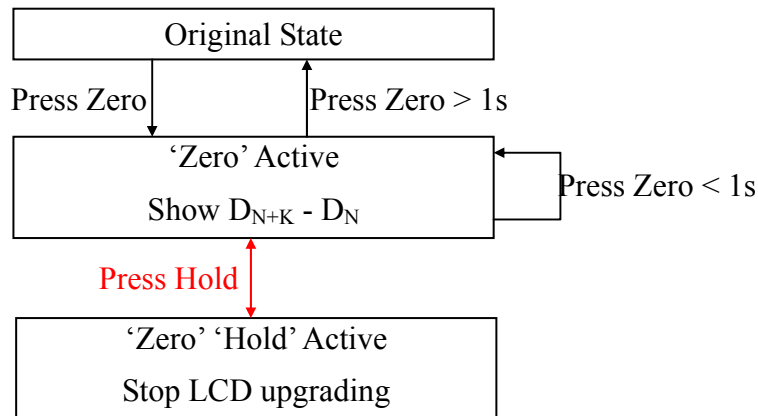


the range could not be higher one in automatic mode. When enter Zero mode from lower range, the system will store the nonzero counts (residual current value). If the range goes up to higher one automatically, the nonzero counts will be divided by ten. So this function will still work well in automatic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

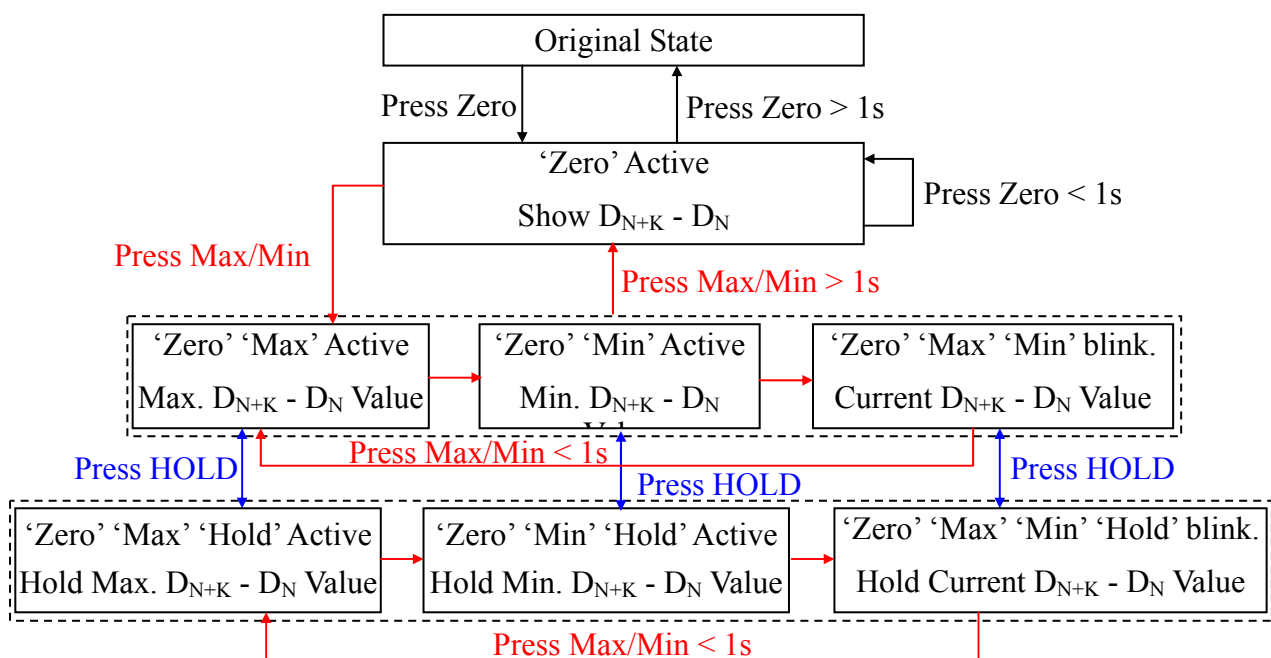
State diagram for Zero mode:



State diagram for Zero + HOLD mode:



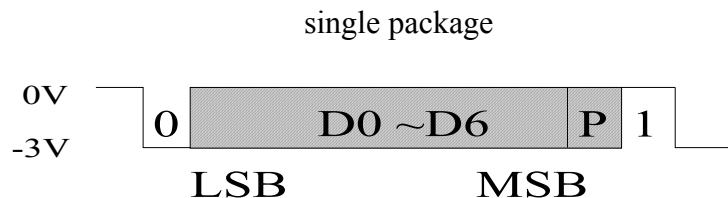
State diagram for Zero + Max/Min + HOLD mode:



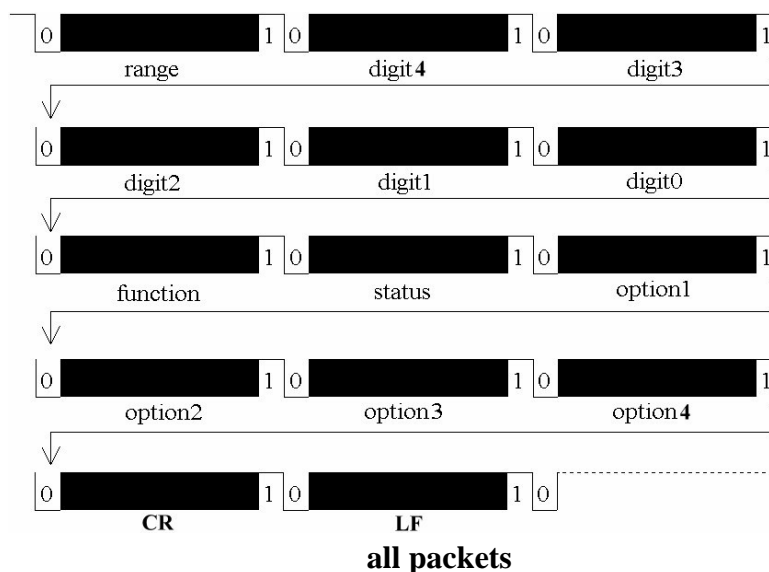


4. Serial Data Output

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		

- 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.
- 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.**
- 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	0	0	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%.

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. The default value of LPF0/LPF1 bit are all “HI”. When the low-pass-filter feature is activated, the 3dB BW status is shown in the table below.

3dB BW	LPF1	LPF0
Full	0	0
10kHz	0	1
1kHz	1	0
LPF off	1	1

0	1	1	Hold	VBAR	LPF1	LPF0
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

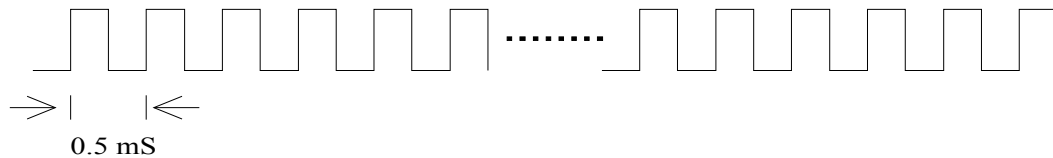
Line feed. The transmitted code is 0001010.

5. Miscellaneous

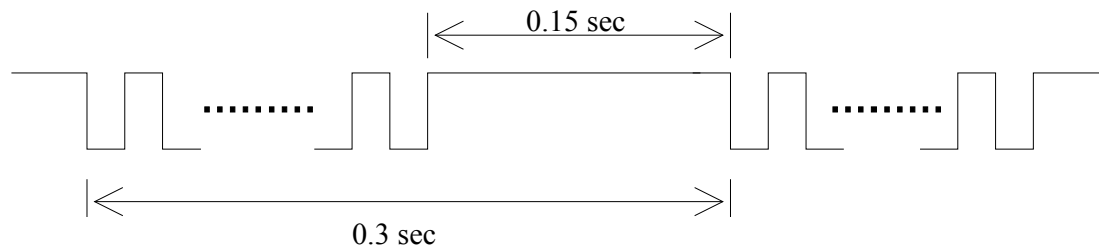
The conditions on which the meter turns on the buzzer include:

- (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

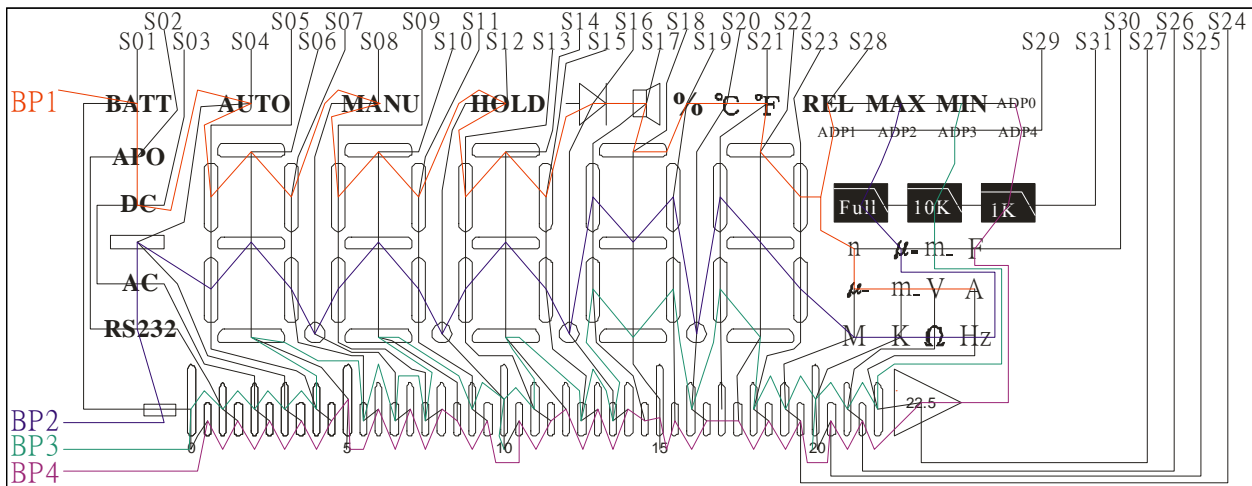


5.1 LCD Panel Configuration

	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

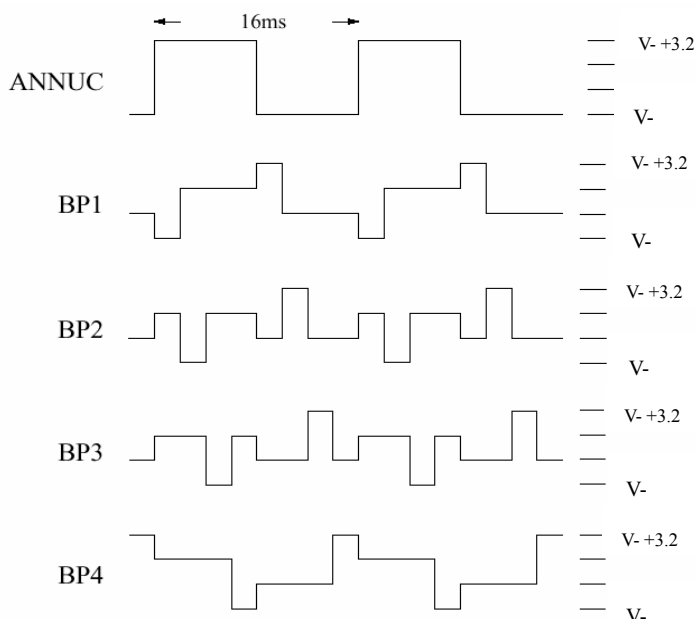
	SEG12	SEG13	SEG14	SEG15	SEG16	SEG17	SEG18	SEG19	SEG20	SEG21	SEG22
BP1	HOLD	3F	3A	3B			2A	%	°C	°F	1A
BP2	DP3	3E	3G	3C	DP2	2F	2G	2B	DP1	1F	1G
BP3	bar20	bar22	3D	bar25	bar27	2E	2D	2C	bar32	1E	1D
BP4	bar21	bar23	bar24	bar26	bar28	bar29	bar30	bar31	bar33	bar34	bar35

	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	Full
BP3	bar36	bar38	bar40	bar42	bar44	MIN	ADP3	m_1	10kHz
BP4	bar37	bar39	bar41	bar43	bar45	ADP0	ADP4	F	1kHz





LCD Backplane Waveform



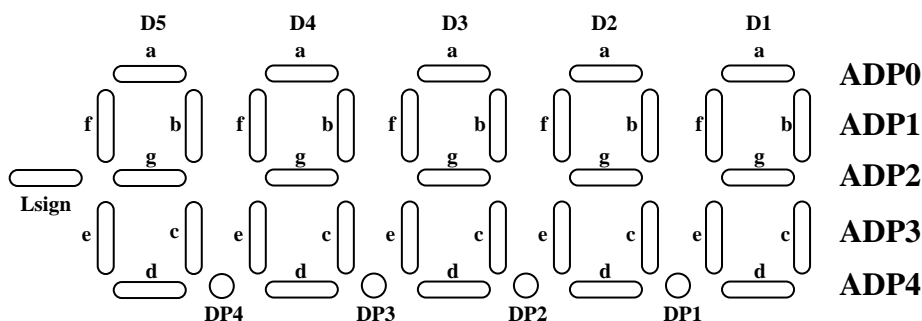
5.2 LCD display on condition

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 id 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.
Full/10k/1kHz	Low pass filter is active with 3dB = full bandwidth/10kHz/1kHz
ADP0-ADP4	When ADP mode is active, the ADP0-ADP4 segment will be active respectively.
RS232	When RS232 output is enabled.

5.3 Programmable LCD Segment Display

ES51931 supports a “Programmable LCD Segment Display”(PLSD) feature. Except 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. ES51931 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. ES51931 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 ES51931. When the capacitor or duty mode is selected, the LCD display is determined by ES51931.

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



PLSD Data format:

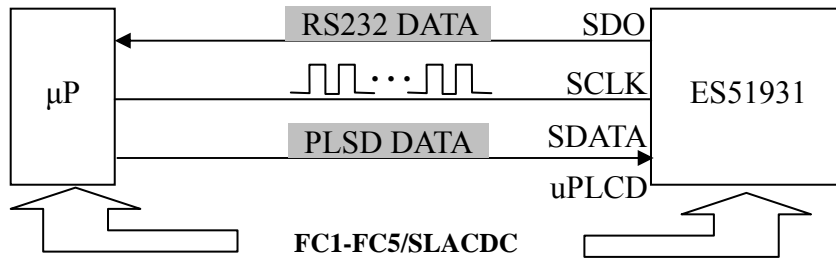
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
OL	ADP0	ADP1	ADP2	ADP3	ADP4	D1a	D1b	D1c	D1d	D1e	D1f
B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24
D1g	DP1	D2a	D2b	D2c	D2d	D2e	D2f	D2g	DP2	D3a	D3b
B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36
D3c	D3d	D3e	D3f	D3g	DP3	D4a	D4b	D4c	D4d	D4e	D4f
B37	B38	B39	B40	B41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

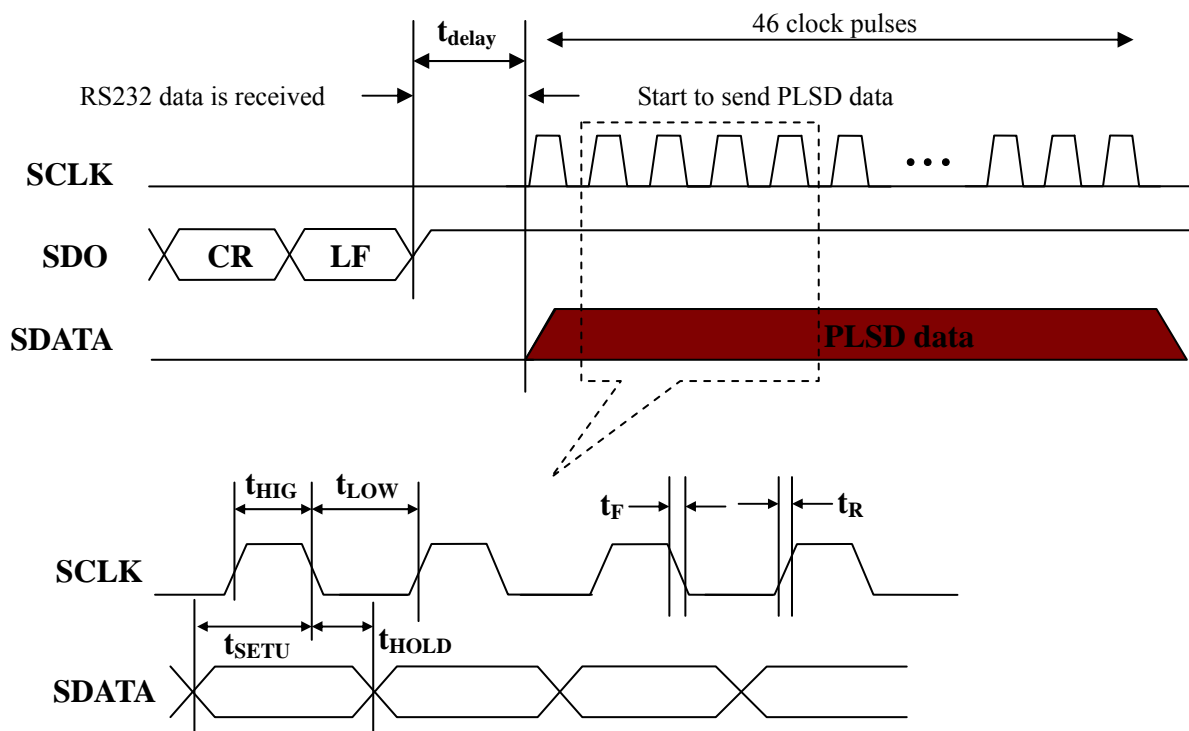
Set the OL bit = 1, the buzzer output will be active for 3.3beep/sec in voltage & current mode. And if auto range is available, it will change to higher range if LCD bar44 is active also.



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

ES51931 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

*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

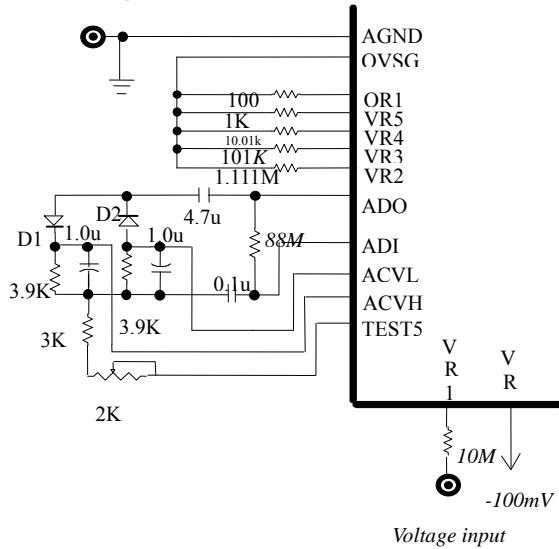
The measurement cycle = 1.05 sec

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.

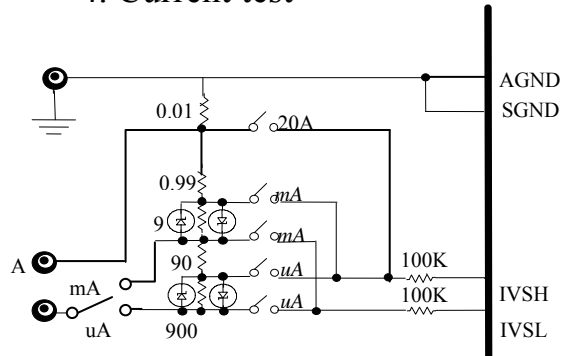


6. Test Circuit

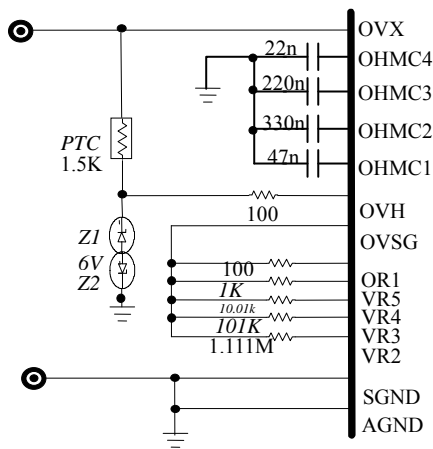
1. Voltage test



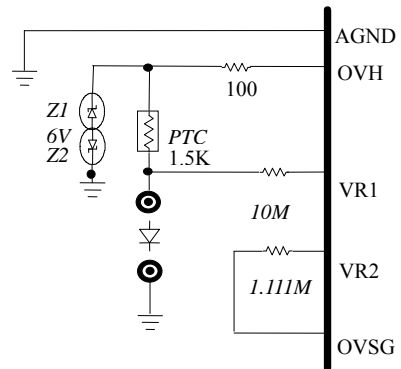
4. Current test



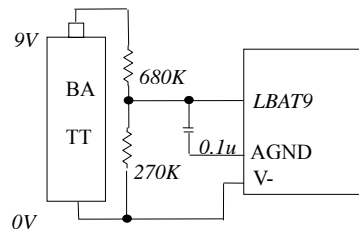
2. Resistor test



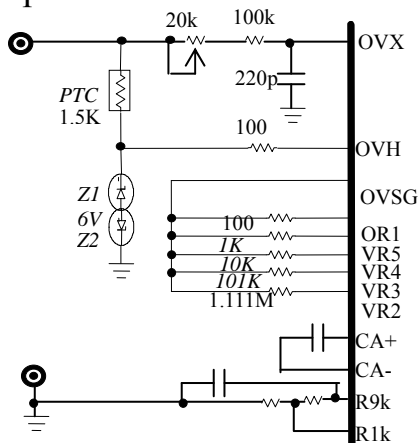
5. Diode test



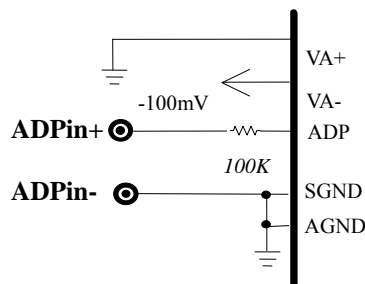
6. Low battery



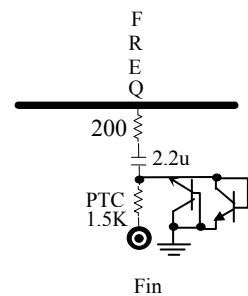
3. Capacitor test



7. ADP test



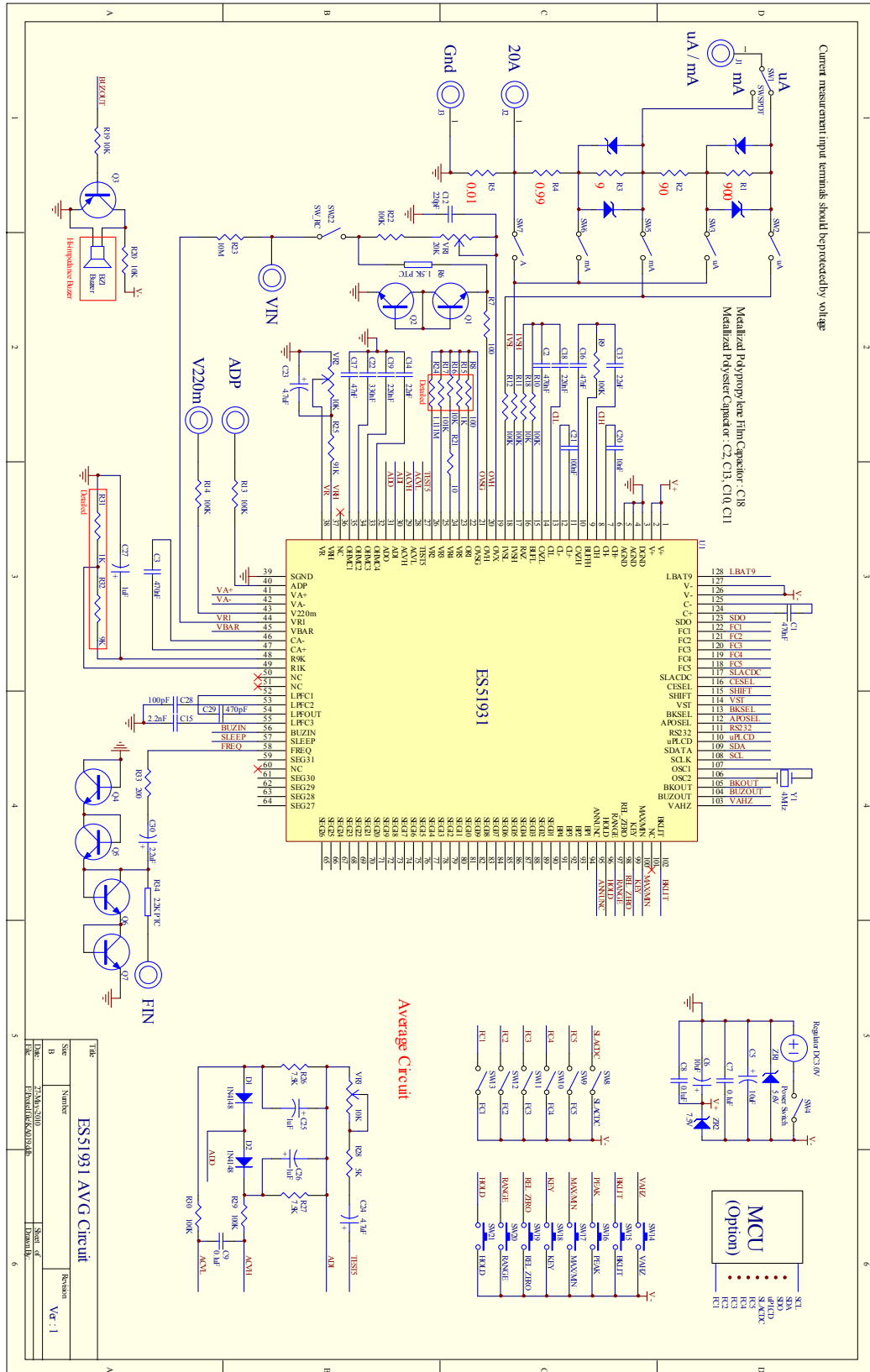
8. Frequency test





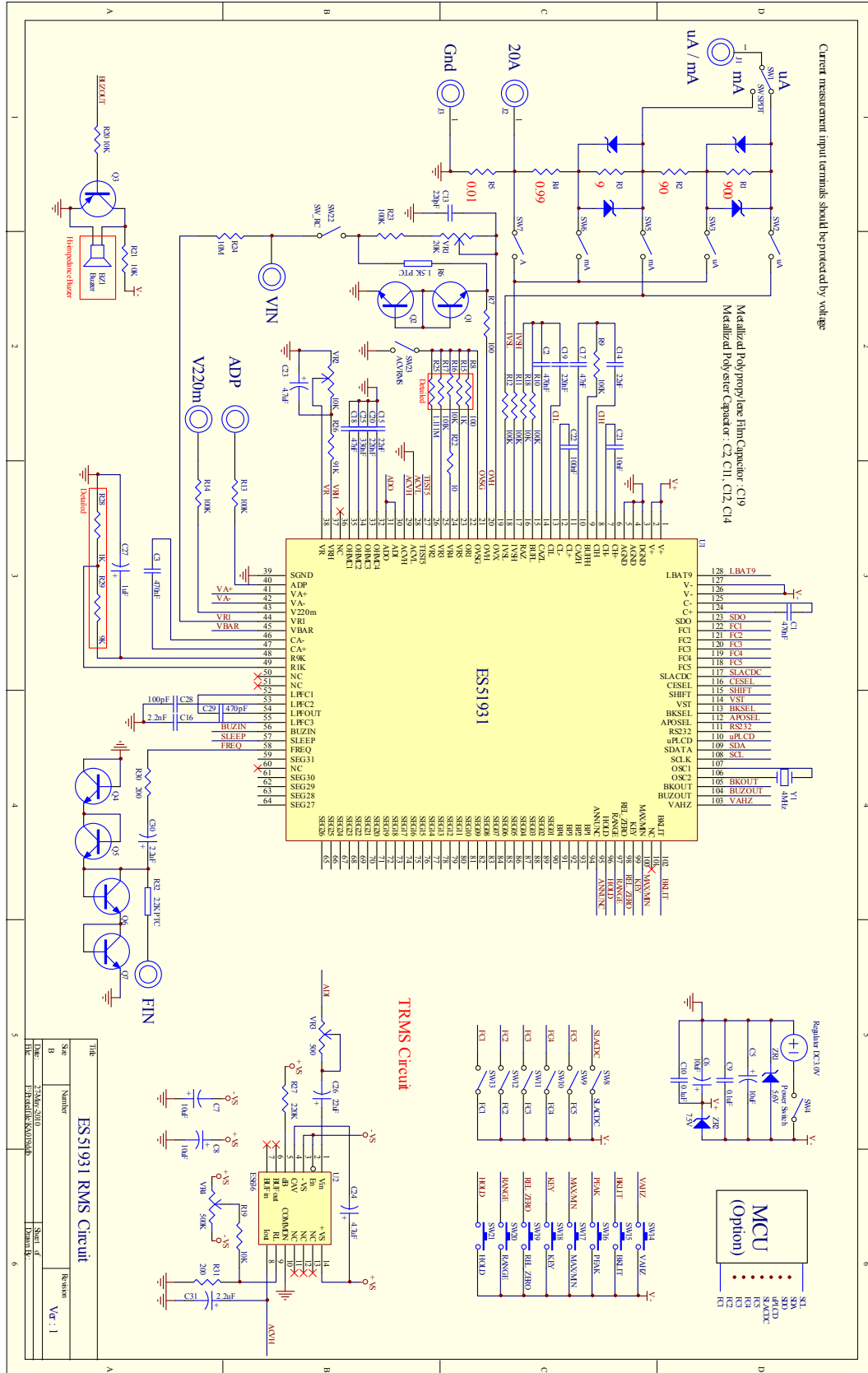
7. Application Circuit

7.1 AVG circuit





7.2 True RMS circuit





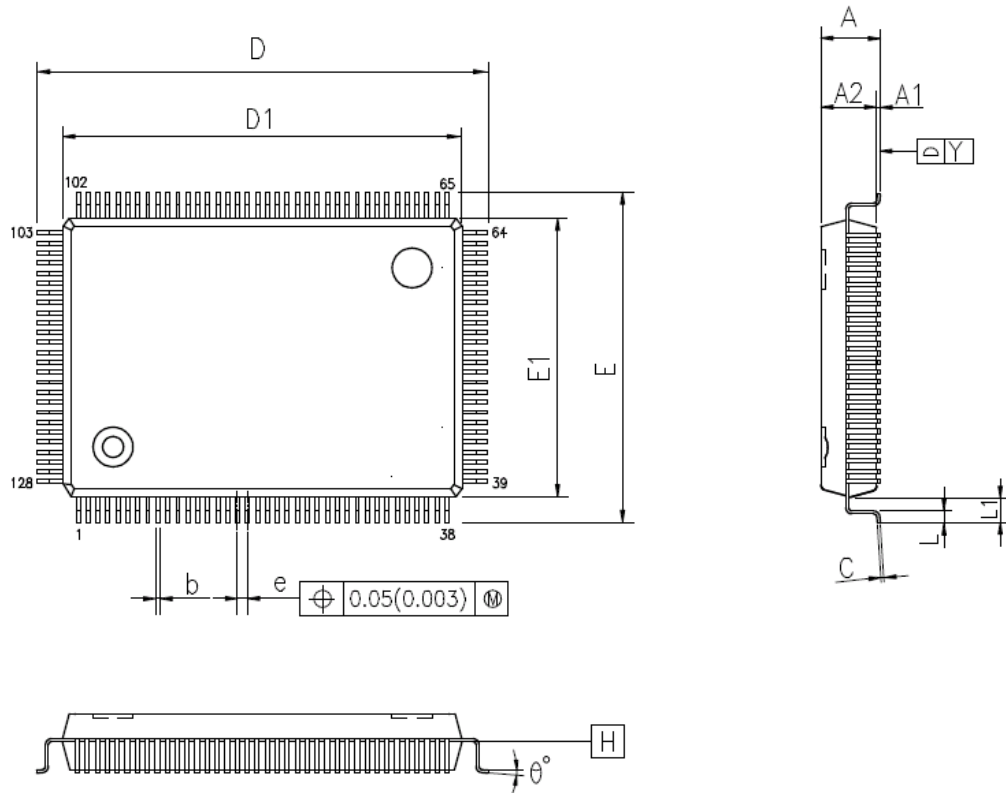
Notes:

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 Zener diodes.



8. Package

1. 128L LQFP Topview



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:

- JEDEC OUTLINE:
MS-026 BHB;
MS-026 BHB-HD(THERMALLY ENHANCED VARIATIONS ONLY).
- DATUM PLANE [Y] IS LOCATED AT THE BOTTOM OF THE MOLD PARTING LINE COINCIDENT WITH WHERE THE LEAD EXITS THE BODY.
- 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 [Y].
- DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION .