ES51928
6000 Counts Smart DMM

Features

- 6000 counts LCD display
- 3V DC power supply
- Conversion rate: 3 times/s (voltage mode)
- Full automatic measurement:
  *Voltage/Current: AC/DC auto scanning & auto range: 6.000V~1000V
  *Resistance/Diode/Capacitance(RDC scan) Auto scanning & auto range:
  Resistance: 600.0Ω~6.000MΩ
  Capacitance: 6.000nF~600.0uF
- Push functions
  Function selection by single key
  Range change function
  Hold function
  MAX/MIN function
  VAHZ function
  Back light function
- Support non-contact voltage detection
- High voltage (> 30V) indication of LCD display for voltage measurement
- Built-in HCF(high crest factor detection) function in AC mode
- OL level selection (600V/1000V/1500V)
- Band-gap reference voltage output
- Auto power off (3min. or 10min.) & re-power on
- Sleep output indication
- On-chip buzzer driver
- Low battery detection

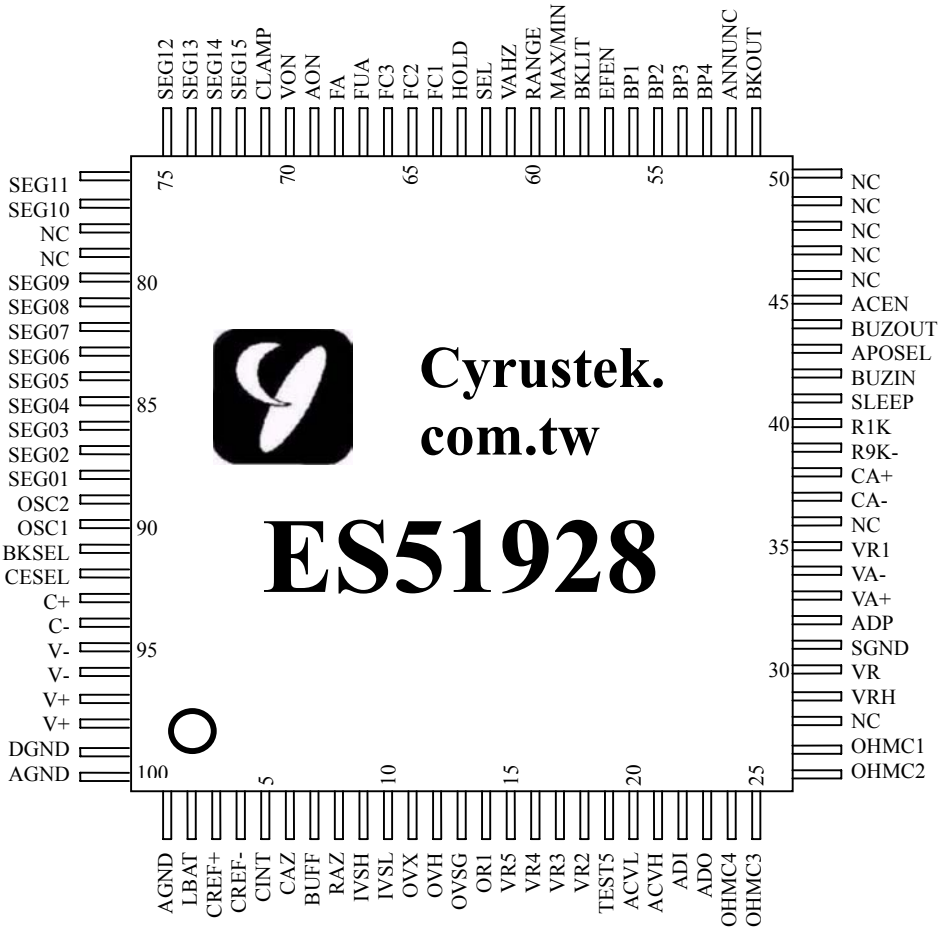
Application

- Smart digital multi-meter
- Smart clamp meter

General description

ES51928 is an integrated ADC with 6000 counts LCD display driver. It could support fully automatic DMM function measurement. In voltage or current mode, the AC or DC signals auto scanning. In R/D/C (passive component) mode, resistance (including continuity), capacitance or diode measurements are allowed by fully automatic detection. A single key and simple switch could select all measurements. Expensive and bulky mechanical range switches are not required. A non-contact electric field detector (EF mode) is built-in for ac voltage measurement also. Other features including range control, data hold, max/min hold, VAHz and back light function are available. For power saving, an auto power off & re-power on scheme are built-in. A sleep output is the indication of entering auto power off mode.

Pin Assignment



Pin Description

Pin No	Symbol	Type	Description
1	AGND	P	Analog ground.
2	LBAT	I	Low battery configuration. If 3V battery is used, connect it to DGND. The default low-battery threshold voltage is –2.3V. If 9V battery is used, the low battery enunciator is displayed when the voltage of this pin is less than VRH (-1.2V)
3	CREF+	I/O	Positive connection for reference capacitor.
4	CREF-	I/O	Negative connection for reference capacitor.
5	CINT	O	Integrator output. Connect to integral capacitor
6	CAZ	I	Auto-zero capacitor connection.
7	BUFF	O	Buffer output pin. Connect to integral resistor
8	RAZ	O	Buffer output pin in high-speed mode. Connect to high-speed integral resistor.
9	IVSH	I	High current measurement input.

10	IVSL	I	Low current measurement input
11	OVX	I	Input high voltage for resistance/capacitor measurement
12	OVH	I	Output connection for resistance/capacitor measurement
13	OVSG	I	Sense low voltage for resistance measurement
14	OR1	O	Reference resistor connection for 600.0Ω range
15	VR5	O	Voltage measurement ÷10000 attenuated (1000V)
16	VR4	O	Voltage measurement ÷1000 attenuated (600.0V)
17	VR3	O	Voltage measurement ÷100 attenuated (60.00V)
18	VR2	O	Voltage measurement ÷10 attenuated (6.000V)
19	TEST5	I/O	Test pin
20	ACVL	I	DC signal low input in ACV/ACA mode. Connect to negative output of external AC to DC converter.
21	ACVH	I	DC signal high input in ACV/ACA mode. Connect to positive output of external AC to DC converter.
22	ADI	I	Negative input of internal AC to DC OP Amp.
23	ADO	O	Output of internal AC to DC OP Amp.
24	OHMC4	O	Filter capacitor connection for resistance mode
25	OHMC3	O	Filter capacitor connection for resistance mode
26	OHMC2	O	Filter capacitor connection for resistance mode
27	OHMC1	O	Filter capacitor connection for resistance mode
28	NC	-	
29	VRH	O	Output of band-gap voltage reference. Typically –1.2V
30	VR	I	Reference input voltage connection. Typically –400mV
31	SGND	I	Signal Ground.
32	ADP	I	Measurement input in ADP mode
33	VA+	I	For ADP mode. De-integrating voltage positive input. The input should be higher than VA-.
34	VA-	I	For ADP mode. De-integrating voltage negative input. The input should be lower than VA+.
35	VR1	I	Measurement input.
36	NC	-	
37	CA-	I/O	Negative auto-zero capacitor connection for capacitor measurement
38	CA+	I/O	Positive auto-zero capacitor connection for capacitor measurement
39	R9K	O	Connect to a precise 9KΩ resister for capacitor measurement.
40	R1K	O	Connect to a precise 1KΩ resister for capacitor measurement.
41	SLEEP	O	Sleep mode indicator, asserts low in SLEEP mode. Normal V+ output.
42	BUZIN	I	Pull to V- to enable the BUZOUT.
43	APOSEL	I	Auto power off idle time selection.
44	BUZOUT	O	Outputs a 2KHz audio frequency signal for driving piezoelectric buzzer
45	ACEN	O	Output to V- when AC mode inactive and output to V+ in AC mode.
46 – 50	NC	-	
51	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.
52	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 back plane to turn it off.
53	BP4	O	LCD backplane 4
54	BP3	O	LCD backplane 3
55	BP2	O	LCD backplane 2
56	BP1	O	LCD backplane 1
57	EFEN	I	Pull-low to enable non-contact AC voltage detection
58	BKLIT	I	Back light function. Pulse low to set BKOUT pin output.
59	MAX/MIN	I	Pulse to V- to enable MAX/MIN function.
60	RANGE	I	Pulse to V- to enable manual mode and manual range selection.

61	VAHz	I	Pulse to V- to enable VAHz mode.
62	SEL	I	Pulse to V- to select target measurement
63	HOLD	I	Pulse to V- to enable HOLD function.
64	FC1	I	Switch 1 for function selection.
65	FC2	I	Switch 2 for function selection.
66	FC3	I	Switch 3 for function selection.
67	FUA	I	Switch 1 for current measurement selection.
68	FA	I	Switch 2 for current measurement selection.
69	AON	I	Pull to high to sense current measurement priority in auto scan mode
70	VON	I	Pull to high to sense voltage measurement priority in auto scan mode
71	CLAMP	I	Switch for clamp meter application function
72 – 77	SEG15 – 10	O	LCD segment line 10 – 15
78 – 79	NC	-	
80 – 88	SEG09 - 01	O	LCD segment line 01 – 09
89	OSC2	I	Crystal oscillator input connection
90	OSC1	O	Crystal oscillator output connection
91	BKSEL	I	When pulled to V-, an auto back light configuration is allowed. Configure a low level applied to BKLIT larger than 1 second, the BKOUT will be active. If BKLIT is back to high level, the BKOUT would be inactive.
92	CESEL	I	OL selection feature control pin.
93	C+	O	Positive capacitor connection for on-chip DC-DC converter.
94	C-	O	Negative capacitor connection for on-chip DC-DC converter.
95	V-	P	Negative supply voltage. Connecting to battery negative terminal.
96	V-	P	Negative supply voltage. Connecting to battery negative terminal.
97	V+	P/O	Output of on-chip DC-DC converter.
98	V+	P/O	Output of on-chip DC-DC converter.
99	DGND	G	Digital ground.
100	AGND	G	Analog ground.

Absolute Maximum Ratings

Characteristic	Rating
Supply Voltage (V- to AGND)	-4V
Analog Input Voltage	V- -0.6 to V+ +0.6
V+	V+ ≥ (AGND/DGND+0.5V)
AGND/DGND	AGND/DGND ≥ (V- -0.5V)
Digital Input	V- -0.6 to DGND +0.6
Power Dissipation. Flat Package	500mW
Operating Temperature	0℃ to 70℃
Storage Temperature	-25℃ to 125℃

Electrical Characteristics

TA=25℃, V- = -3V

Parameter	Symbol	Test Condition	Min.	Typ.	Max	Units
Power supply	V-		-3.5	-3.0	-2.5	V
Operating supply current In Scan AC/DC mode	I_{DD}	Normal operation	—	2.5	—	mA
	I_{SS}	In sleep mode	—	0.6	2.5	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
Input Leakage			-10	1	10	PA
Low battery flag voltage		V- to AGND	-2.4	-2.3	-2.2	V
Zero input reading		10MΩ input resistor	-000	000	+000	counts
Peak to peak backplane drive voltage		-3.5V≦ V ≦-2.2V	3.0	3.15	3.3	V
Counter time base period		f_{OSC} = 4MHZ	—	1	—	sec
Reference voltage and open circuit voltage for 600Ω measurement	V_{REF}	100KΩ resistor between VRH and AGND	-1.33	-1.23	-1.13	V
Open circuit voltage for Ω measurement (except 600Ω)		Ω and Continuity Mode	-0.86	-0.78	-0.70	V
Internal pull-high to 0V current		Between V- pin and HOLD, RANGE, SEL,FC1-3,FUA, FA, VON, AON, CLAMP, BKLIT, MAXMIN	—	1.2	—	µA
AC frequency response at 6.000V Range		±1%	—	40-400	—	HZ
		±5%	—	400-2000	—	
AC input response for scan mode			10	—	50000	Hz
AC/DC voltage scan mode sensitivity@1kHz		VR1(10MΩ input impedance)	300	400	500	mV
AC/DC current scan mode sensitivity@1kHz		ADP, IVSL and IVSH	8	10	12	mV
RDC scan mode RES sensitivity		Parasitic capacitance allowed in 6.000MΩ range	—	—	200	pF
RDC scan mode DIODE sensitivity		Forward voltage		0.8		V
RDC scan mode CAP sensitivity			400	—	—	pF
Reference voltage temperature coefficient	TC_{RF}	100KΩ resister Between VRH 0℃<TA<70℃	—	50	—	ppm/℃
Capacitance measurement accuracy		6nF – 6.0µF	-1.5	—	1.5	%F.S
			-5	—	5	counts
		60µF ~ 60mF	-2.0	—	2.0	%F.S
			-5	—	5	counts

Note:

1.Full Scale

Functional Description

1. Operation 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	Resister Connection
VR1	600.0mV*	1	VR1 (10MΩ)
VR2	6.000V**	1/10	VR2 (1.111MΩ)
VR3	60.00V	1/100	VR3 (101KΩ)
VR4	600.0V	1/1000	VR4 (10KΩ)
VR5	1000V***	1/10000	VR5 (1KΩ)

Note:

* Exists in manual mode only by *RANGE* key control

**This range is the default range for auto range & auto scan mode

*** Depends on *CESEL* selection

1.1.1 OL selection

ES51928 has a OL display selection feature archived by configuring a *CESEL* pin. If pin *CESEL* is connected to V-, ES51928 will have a 600.0V overflow level in DC and AC 600.0V ranges. And the 1000V range will not occur anymore. If pin CESEL is connected to DGND, the ES51928 will have a 1010V overflow level in DCV mode and have a 1010V overflow level in ACV mode also. When CE is floating, a 1500V overflow level in DCV mode but ACV is still 1010V overflow level. The meter will Show OL when the measuring signal reaches the overflow level with beeper warning. The configuration of *CESEL* is listed below.

CESEL	DCV	ACV
V-	600.0V	600.0V
DGND	1010V	1010V
Floating	1500V	1010V

1.1.2 HCF detection

ES51928 provides detection of high-crest-factor (HCF) signal in ACV auto range mode. ES51928 senses the signal and determines it as HCF if the Vpp is large enough. Once the signal is determined as HCF, ES51928 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 Vpp=350V, Vrms=70V(CF=5) was applied, traditional DMM might stay at 60V 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 600V range and exhibits more accurate results.

1.1.3 EF mode

ES51928 supports a non-contact ac voltage measurement, which is called electric field measurement also. The EF mode is selected by *SEL* key when EF_EN is active. The ADC input is configured from *ADP* pin vs. *SGND*. When no or less electric field is detected, the LCD shows “EF”. If the detector senses electric field, the strength will be showed on LCD by “-“ not digits type. Level 1(weak) is “-“ and the level 4(strong) is “----“. Additional beeper will be output from *BUZOUT* pin. The buzzer frequency depends on the strength of electric field also. The Faster beeper means the stronger electric field (ac voltage) is sensed.

1.2 Current Measurement

1.2.1 For multi-meter application

ES51928 has 2 automatic and 1 manual current measurement modes for multi-meter. The following table summarizes the full-scale range of each mode. When ES51928 operates in the current measurement modes for multi-meter, it takes high input from pin IVSH or IVSL, low input from pin SGND and reference voltage from pin VR.

Mode	Full Scale	Input Terminal	Full scale
Automatic1	600.0μA / 6000μA	IVSL/IVSH V.S. SGND	300.0mV
Automatic2	60.00mA / 600.0mA	IVSL/IVSH V.S. SGND	300.0mV
Manual	60.00A	IVSH V.S. SGND	300.0mV

1.2.2 For clamp meter application

ES51928 has 2 automatic and 4 manual current measurement modes for Clamp meter. The following table summarizes the full-scale range of each mode. When ES51928 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 ES51928 operate in the manual mode1~4, it takes high input from ADP, low input from SGND and reference voltage from VA+ & VA-.

Mode	Full Scale	Input Terminal	Full scale
Automatic1	600.0A / 6000A	IVSL/IVSH V.S. SGND	600.0mV
Automatic2	60.00A / 600.0A	IVSL/IVSH V.S. SGND	600.0mV
Manual1	6.000A	ADP V.S. SGND	600.0mV
Manual2	60.00A	ADP V.S. SGND	600.0mV
Manual3	600.0A	ADP V.S. SGND	600.0mV
Manual4	6000A	ADP V.S. SGND	600.0mV

1.3 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.

Configuration	Full Scale Range	Relative Resistor	Equivalent value
OR1	600.0Ω*	OR1	100Ω
OR2	6.000KΩ	VR5	1KΩ
OR3	60.00KΩ	VR4	10KΩ
OR4	600.0KΩ	VR3 ∥VR1	100KΩ
OR5	6.000MΩ	VR2 ∥VR1	1MΩ
OR6	60.00MΩ**	VR1	10MΩ

Note: * When auto scan mode is set, continuity check is implemented in this range
** When auto scan mode is set, the 60.00MΩ range is omitted

1.3.1 Continuity check

Continuity check shares the same configuration with 600.0Ω manual resistance measurement mode and has buzzer output to indicate continuity. The buzzer generates 2KHz beep whenever the reading is less than 30Ω.

1.4 Diode Measurement

Diode measurement mode shares the same configuration with 6.000V manual voltage measurement mode and has buzzer output to indicate continuity. The buzzer generates a 2KHz sound whenever the reading is less than 30mV. If the test circuit is open or the voltage drop between the two ports of the device (diode) under test is larger than 2V, the LCD panel will show “OL”.

1.5 Capacitance Measurement

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

Configuration	Full Scale Range	Relative Resistor
C1	6.000nF	20kΩVR+100kΩ
C2	60.00nF	20kΩVR+100kΩ
C3	600.0nF	101kΩ
C4	6.000uF	10kΩ
C5	60.00uF	R9K / R1K
C6	600.0uF	R9K / R1K
C7	6.000mF*	R9K / R1K
C8	60.00mF**	R9K / R1K

Note: * & ** The C7-C8 both range is not available for auto scan mode

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**" Discharging through the chip is quite slow. We recommend users to discharge the capacitor with some other apparatus.

1.6 Auto power off mode (APO)

1.6.1 Idle Time selection

ES51928 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 3 minutes. If pin APOSEL is connected to DGND or floating, the Idle Time will be set to 10 minutes. When APO happens, the state of the meter is saved. If the APO is necessary to be cancelled, power on the ES51928 when any of the push key, except for HOLD, is pressed down simultaneously.

1.6.2 Sleep output

The meter enters sleep mode after auto power-off or push *SEL* key to last for 2s. The SLEEP pin asserts low (-3V) in the sleep mode, and asserts high (+3V, not 0V) after re-power on.

1.6.3 Re-power on

After auto power-off is active, pushing any of the push function or changing the measurement function can turn on the meter again. If the meter is re-powered on by changing measurement function, 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 except for the auto scan mode.

2. Functional Modes Table

Measurement mode depends on the logic level of FC1, FC2, FC3, FUA, FA, VON, AON and CLAMP.

FC1	FC2	FC3	FUA	FA	VON	AON	CLAMP	Functional Mode(pushing *SEL* key)	Input
1	X	0	X	X	X	0	0	V_{AUTO}→V_{AC}→V_{DC}→EF*→V_{AUTO}→…	VR1,ADP
1	X	0	1	0	X	1	0	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(uA)	IVSH/IVSL
1	X	0	0	0	X	1	0	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(mA)	IVSH/IVSL
1	X	0	0	1	X	1	0	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(A)	IVSH
1	X	0	X	X	1	X	1	V_{AUTO}→V_{AC}→V_{DC}→V_{AUTO}→…	VR1
1	X	0	1	0	0	X	1	I_{AC}(600.0A/6000A)	IVSH/IVSL
1	X	0	0	0	0	X	1	I_{AC}(60.00A/600.0A)	IVSH/IVSL
0	1	0	X	X	X	X	X	RDC_{AUTO}→R→D→C→RDC_{AUTO}→…	VR1
0	0	1	X	X	0	X	1	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(6.000A)	ADP
0	1	1	X	X	0	X	1	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(60.00A)	ADP
1	0	1	X	X	0	X	1	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(600.0A)	ADP
1	1	1	X	X	0	X	1	I_{AUTO}→I_{AC}→I_{DC}→I_{AUTO}→…(6000A)	ADP

Note: * EF mode could be selected when EF_EN is active.

3. Push Function

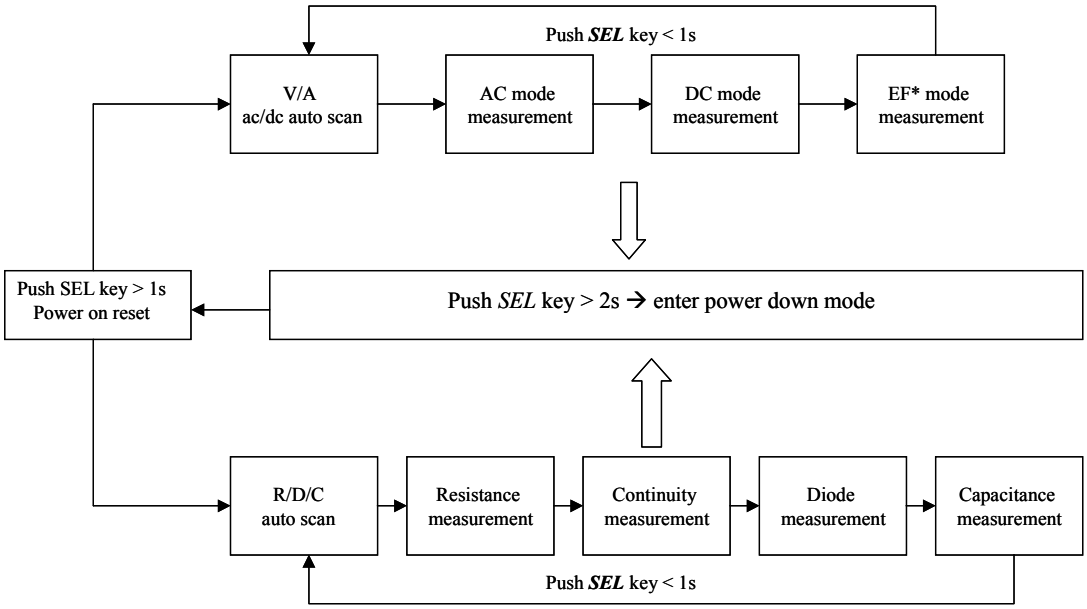
All the enabled push functions will be reset when the measurement mode is changed by external switch. Change measurement mode by *SEL* function will reset enabled *RANGE*, *HOLD*, *MAX/MIN*, and *VAHz* functions. The following table lists the available function versus every measurement mode.

	SEL	*RANGE*	*HOLD*	*MAX/MIN*	*VAHz*	*BKLIT*
V_{SCAN}	O	X	X	X	O	O
V_{AC}	O	O	O	O	O	O
V_{DC}	O	O	O	O	O	O
EF	O	X	X	X	X	O
I_{SCAN}	O	X	X	X	O	O
I_{AC}	O	O*	O	O	O	O
I_{DC}	O	O*	O	O	O	O
RDC_{SCAN}	O	X	X	X	X	O
Resistance	O	O	O	O	X	O
Continuity	O	X	O	O	X	O
Diode	O	X	O	O	X	O
Capacitance	O	O	O	O	X	O

Note: For ADP input, *RANGE* is not available

3.1 Select function

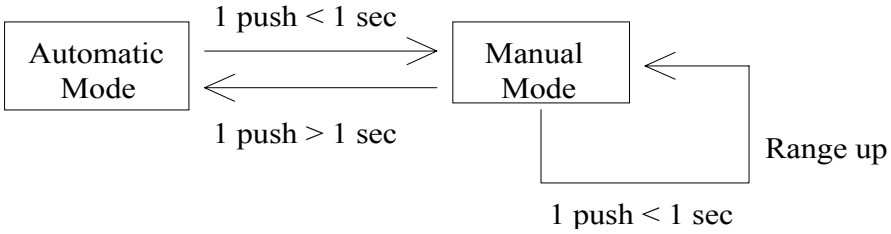
When power on or *SEL* key is pressed longer than one second, ES51928 will be power-on reset to auto scan mode, which scanning mode is determined by [FC1-FC3] function set. In auto scan mode, the ES51928 automatically selects the appropriate measurement mode and range. Pushing the *SEL* key less than one second could select the target measurement function. Pushing the key larger than two seconds, the ES51928 will enter power down mode. If power down mode is entered, only press SEL key to last for one second or apply the power to V-terminal could re-power on the ES51928. The following figure shows the state transition.



Note: * Available when *EF_EN* is active only

3.2 Range function

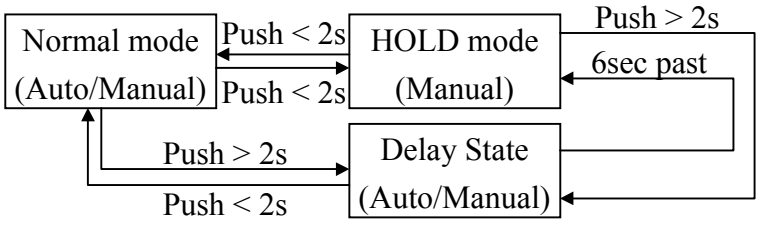
RANGE pin switches to and from automatic and manual mode, and while in manual mode, changes the full-scale range. The following figure shows the state transition.



3.3 Hold and delay-hold function

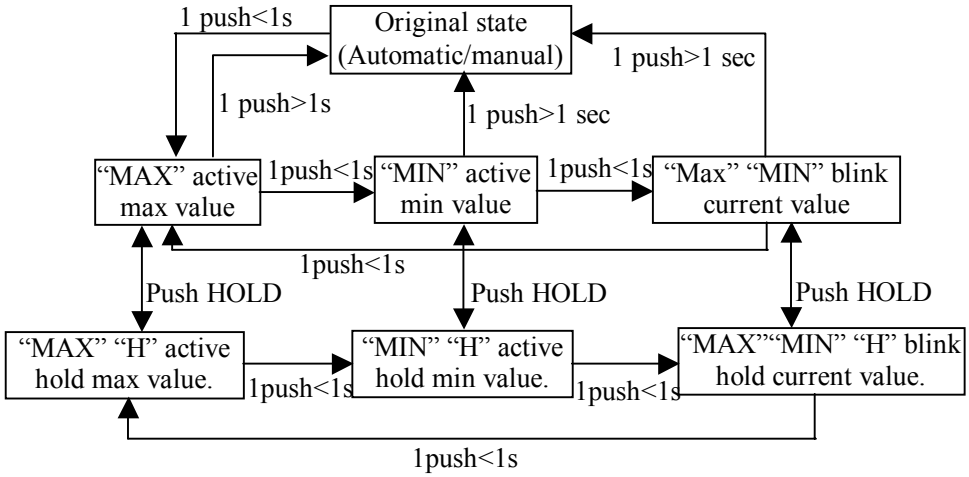
The data hold mode makes the meter stop updating the LCD panel. This mode can be nested in most of the special modes. In auto scanning mode, the *HOLD* key is not available. Enabling hold function in automatic mode makes the meter switch to manual mode. Hold function can be cancelled by changing the measurement mode, pressing *RANGE*, or push *HOLD* again.

The delay-hold function is enabled when *HOLD* key is pressed larger than 2 seconds. When delay-hold function is entered successfully, the meter will stop to update the LCD data after six seconds delayed. During the six seconds waiting, the HOLD symbol on LCD panel will be blinking.



3.4 Max/Min + Hold function

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



3.5 VAHz function

When voltage or current measurement mode is selected, the VAHz funtion is available. Push *VAHz* key to select this frequency measurement mode. The frequency is measured by auto ranging. The maximum frequency range is 100kHz. The sensitivity of signal input is 10% full scale of voltage or current mode typically.

Configuration	Range
FR1	6.000KHz
FR2	60.00KHz
FR3	100.0KHz

3.6 Back light function

When BKSEL is set to DGND or floating, push the *BKLIT* key to enable the back light output driving ON/OFF. If the auto back light configuration is active, the *BKLIT* becomes a control input for external light sensed circuit. Set to low for one second to active the back light output driving. Set to high then the driving output is inactive immediately.

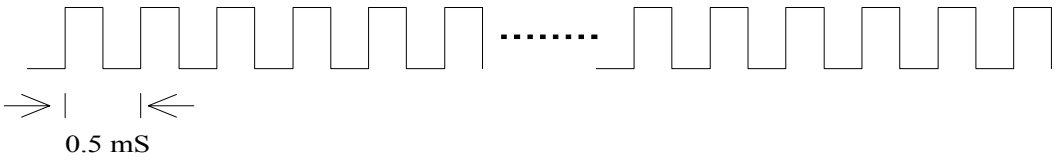
BKSEL	Configuration
DGND or floating	Normal back light function
V-	Auto back light function

4. Miscellaneous

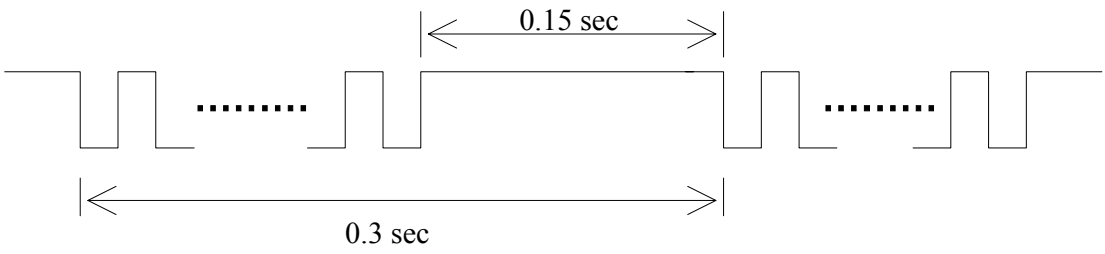
The conditions, which the meter turns on the buzzer, include:

(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 30Ω(30mV)
(6) Auto power off or power down by *SEL* key generates a 2KHz beeper that lasts for 1.5 seconds.

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

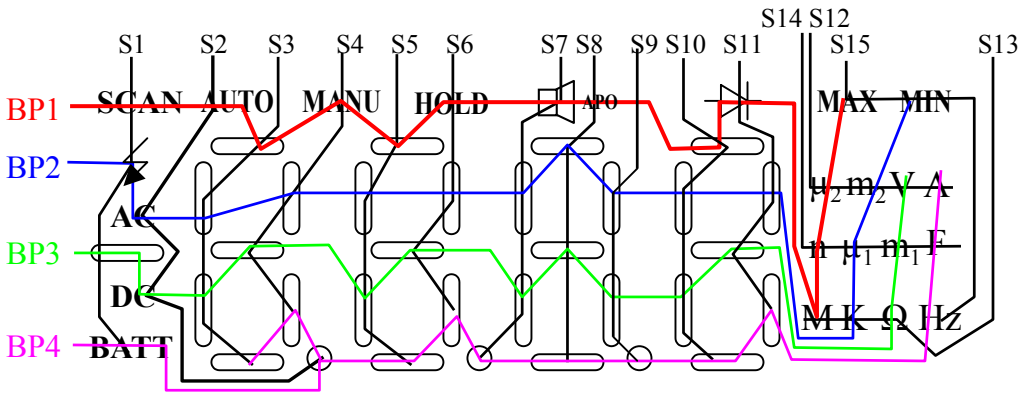


(a) Continuous 2KHz beep



(b) 3.33 beep/sec

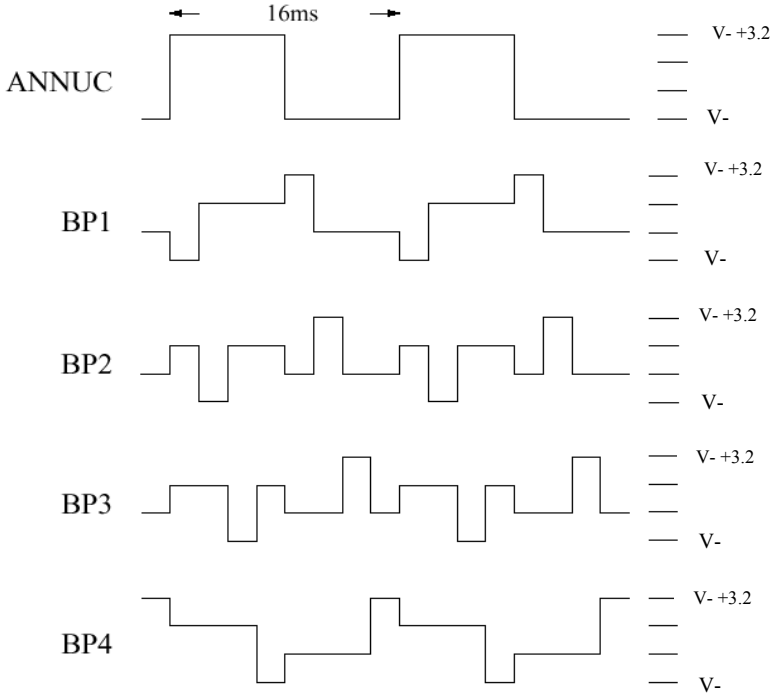
4.1 LCD configuration



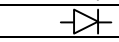
	SEG01	SEG02	SEG03	SEG04	SEG05	SEG06	SEG07	SEG08	SEG09
BP1	SCAN	AUTO	A4	MANU	A3	HOLD		APO	
BP2		AC	F4	B4	F3	B3	F2	A2	B2
BP3	-	DC	E4	G4	E3	G3	E2	G2	C2
BP4	BATT	DP3	D4	C4	D3	C3	DP2	D2	DP1

	SEG10	SEG11	SEG12	SEG13	SEG14	SEG15
BP1	A1		μ_2	M	n	MAX
BP2	F1	B1	m_2	K	μ_1	MIN
BP3	E1	G1	V	Ω	m_1	
BP4	D1	C1	A		F	Hz

LCD Backplane Waveform

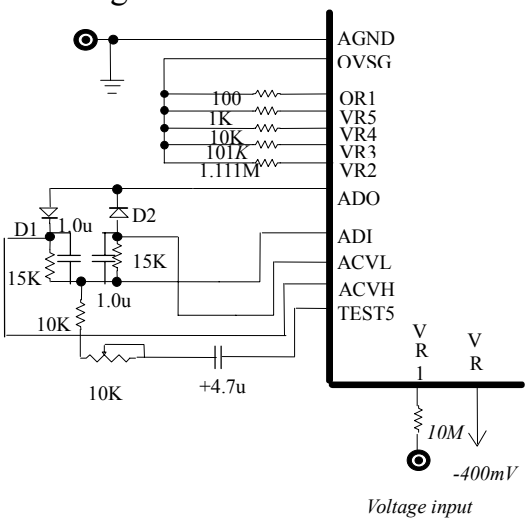


4.2 LCD display on condition

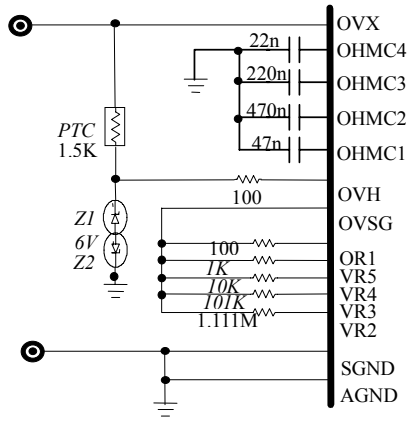
LCD annunciates	Condition
V	In voltage measurement mode, and diode measurement mode.
A	In current measurement mode.
Ω	In resistance measurement mode, and continuity mode.
F	In capacitance measurement mode.
	In continuity check mode.
	In diode mode.
Hz	In VAHZ frequency mode.
DC	In DC voltage or DC current mode.
AC	In AC voltage or AC current mode.
SCAN	When auto scan mode is selected
AUTO	When automatic full scale range selection is enabled.
MANU	In manual mode.
	When the reading is exceeding 30V in DCV or ACV, the DNAGER symbol will be displayed on
HOLD	When HOLD function is enabled. When delay-hold is selected, the HOLD symbol will be blinking for 6 seconds.
Max / Min	When Max or 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 MΩ
K	In resistance measurement mode and the full scale range is in the order of KΩ
APO	When auto power off function is enabled.

Test Circuit

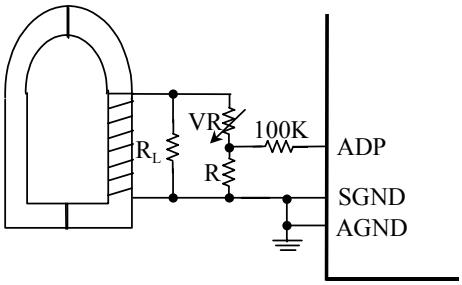
1. Voltage test



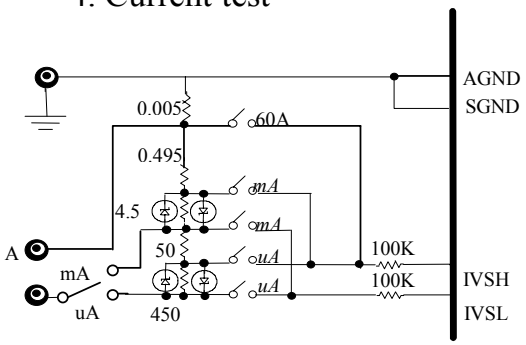
2. Resistance test



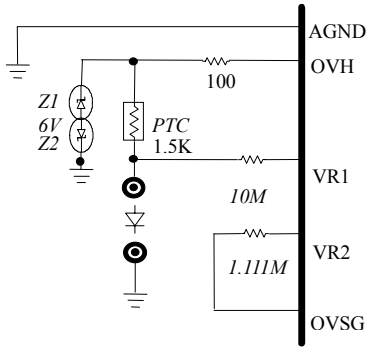
3. Current test for clampmeter



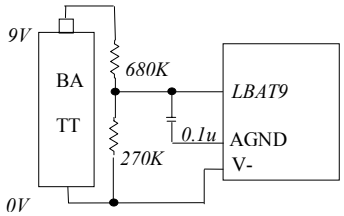
4. Current test



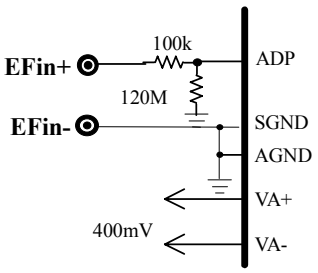
5. Diode test



6. Low battery

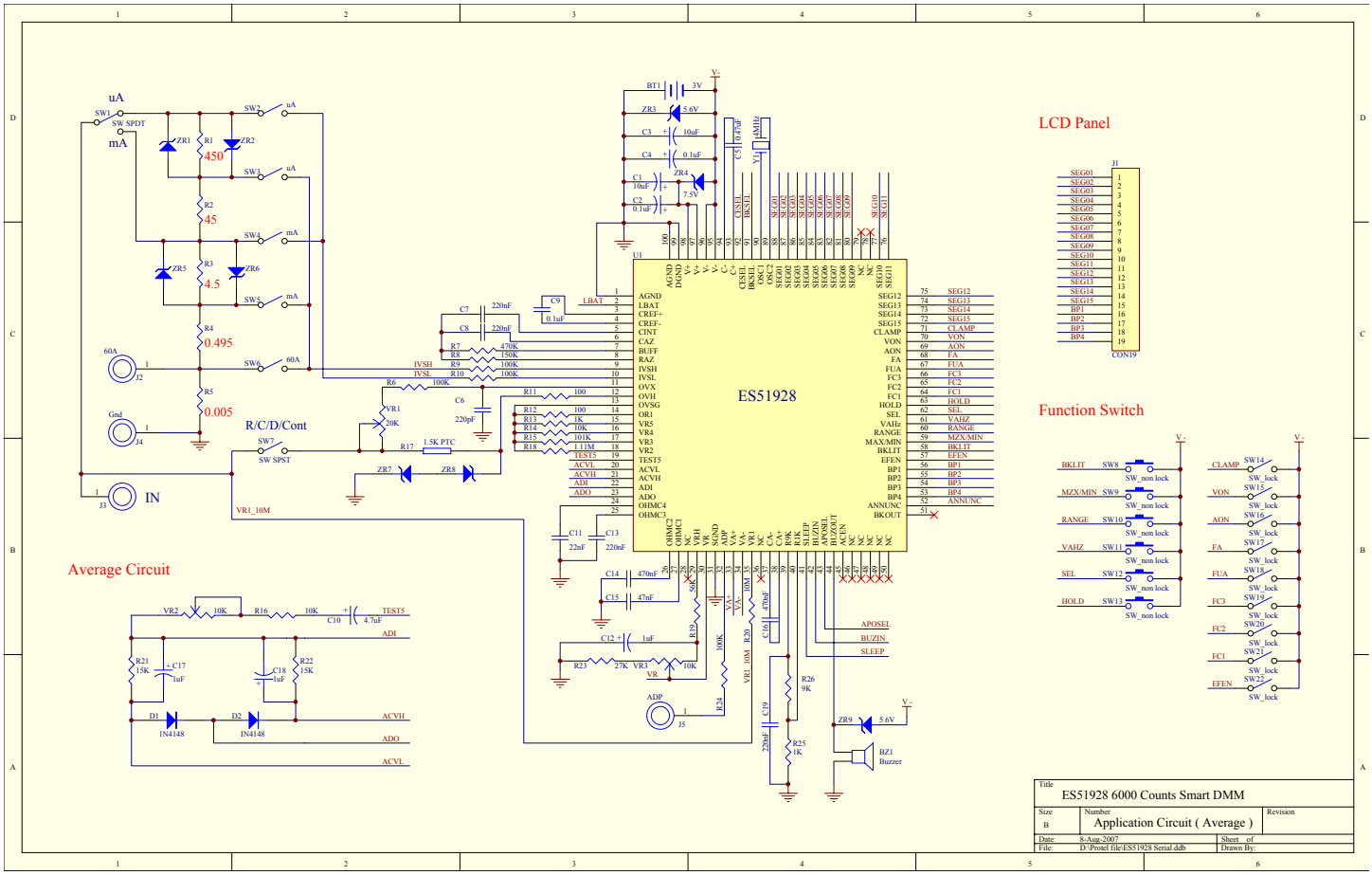


7. EF test



Application Circuit

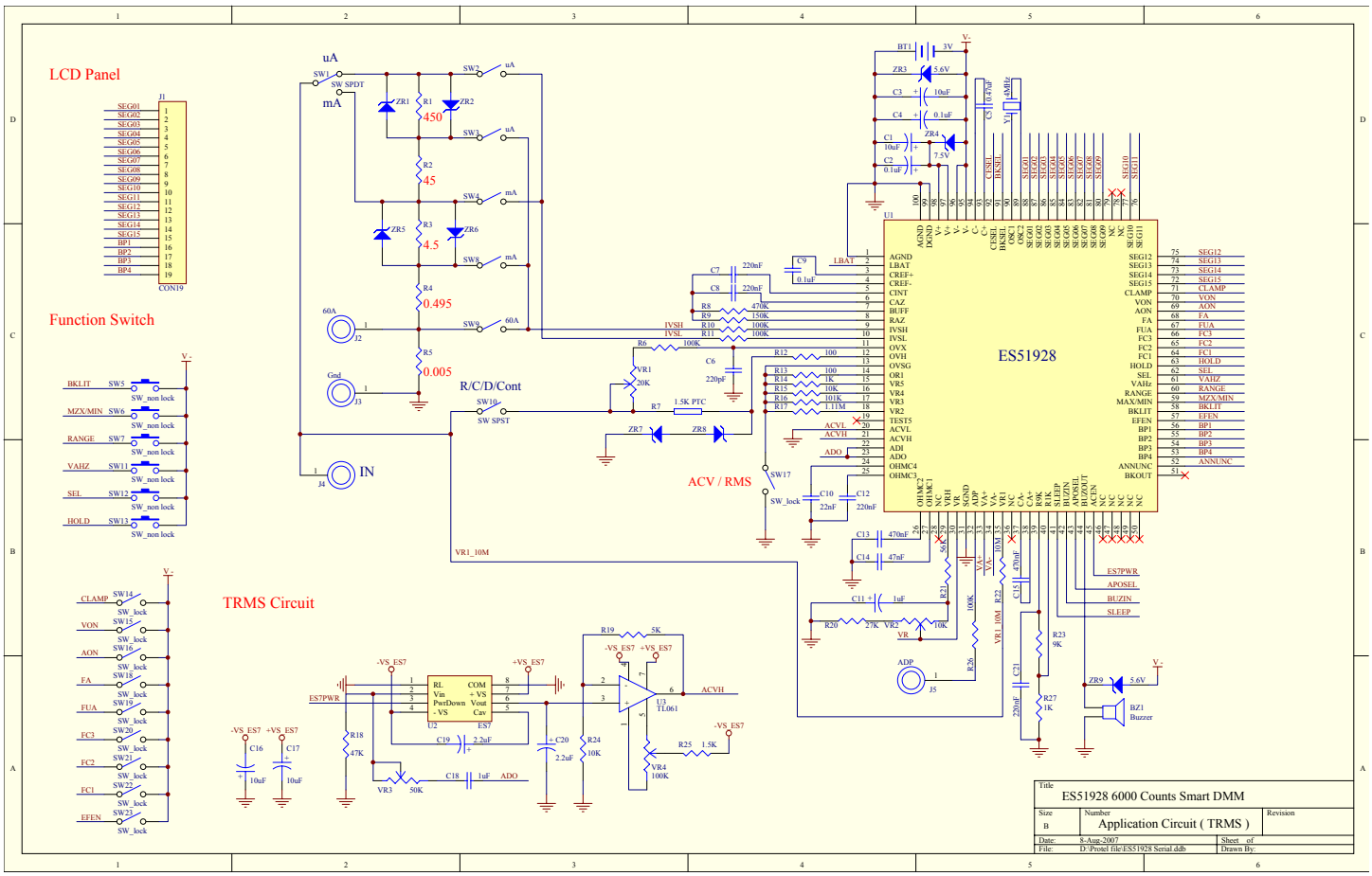
a.) AC average rectified circuit



Notes:

1. The ESD protection circuits protect most of pins. 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. All the zener diodes above are used for IC protection. These protections are needed and these zener diodes must be soldered on PCB first before soldering ES51928 on.
3. The OVX pin resistance have to be kept below 120kΩ for the capacitance mode accuracy (6/60nF range). For higher voltage protection, additional configuration of PTC protection is necessary.

b.) AC RMS circuit

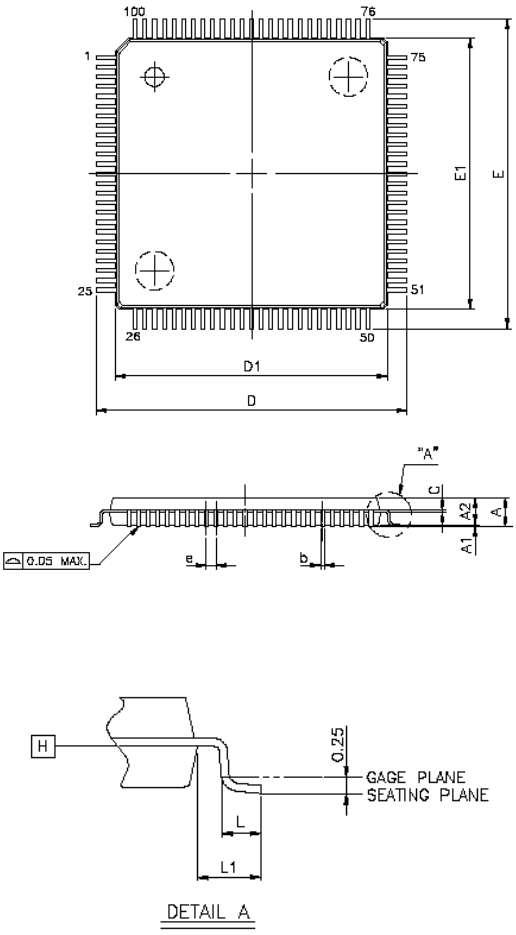


Notes:

1. The ESD protection circuits protect most of pins. 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. All the zener diodes above are used for IC protection. These protections are needed and these zener diodes must be soldered on PCB first before soldering ES51928 on.
3. The OVX pin resistance have to be kept below 120kΩ for the capacitance mode accuracy (6/60nF range). For higher voltage protection, additional configuration of PTC protection is necessary.

Package Information

7.1 100 Pin LQFP Package



7.2 Dimension Parameters

VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

SYMBOLS	MIN.	NOM.	MAX.
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.17	0.20	0.27
c	0.09	0.127	0.20
D	16.00 BSC		
D1	14.00 BSC		
E	16.00 BSC		
E1	14.00 BSC		
e	0.50 BSC		
L	0.45	0.60	0.75
L1	1.00 REF		