



Features:

- Full Automatic measurement
- 3 3/4 digits display
- Frequency measurement (400M HZ)
- Rotary or push setting mode
- Auto-power-off then hold the final data
- Rotary or push re-power on function
- Data hold, MAX or MIN hold, Relative data when this function is pressed
- Low battery detect(3V & 9V)
- On chip buzzer driver
- Backlight function
- 3V DC power supply
- External reference voltage for ADP measurement
- Internal AC to DC conversion OP AMP
If non_AC mode , OP will become unit gain buffer.
- Serial Data Output (RS232 format)
- LCD segment check
- 100 Pin flat-package

Description:

The ES51960 is an integrated analog-to-digital converter (ADC)with 3 3/4 digits and 42-segment bargraph LCD display, automatic range, and 3V power supply.

Automatic range selection is provided for voltage (AC/DC) measurement, ohm measurement, current (uA and mA) measurement, and frequency counter. The ES51960 also provides serial data output function.

Expensive and bulky mechanical range switches are not required. The other functions are provided for MAX and MIN holding and current value display, data holding, Relative data and reference value display, low battery detection, auto-power-off, diode measurement, continuity checking.

Absolute Maximum Ratings

Characteristics	Ratings
Supply Voltage (V- to AGND)	-4V
Analog Input Voltage	V+ to V-
Digital Input	V- to DGND
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

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Count
V-	Power Supply		-3.5	-3.0	-2.2	Volt
I _{dd}	Operating Supply Current	Normal Power On	-	1.0	1.5	mA
I _{ss}		Auto-power-off	-	5	10	uA
REV	Rollover Error (Voltage)	10M input Resistor	-	-	± 0.1	% F.S.
REB	Rollover Error (Bargraph)		-	-	± 0.5	% F.S.
NLV	Nonlinearity (Voltage)	Best Case Straight Line	-	-	± 0.1	% F.S.
NLB	Nonlinearity (Bargraph)		-	-	± 0.5	% F.S.
	Input Leakage		-	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	Count
VREF	Reference Voltage and 400Ω measurement	100KΩ Between VRH and AGND	-1.3	-1.2	-1.1	V
	Peak to Peak Backplane Drive Voltage	-3.2 ≤ V- ≤ -2.2	2.85	3.0	3.15	V
	Counter Time Base Period	fosc=4MHz	-	1	-	Sec
	Open Circuit Voltage for Ω Measurement(except 400Ω)	Ω and Continuity Function	-0.5	-0.45	-0.4	V
	Pull High to 0V Resistance	FC1,FC2,FC3,FC4 FC5,RANGE,HOLD MAX/MIN,BKLIT REL	-	2.5	-	MΩ
	Pull High to 0V Resistance	KEY, SET, BUZIN	-	250	-	KΩ
	AC Frequency Response (4V range)	± 1% Error	-	40 to 500	-	HZ
		± 5% Error	-	40 to 2000	-	
TCRF	Reference Voltage Temperature Coefficient	100KΩ Between VRH and AGND 0°C < TA < 70°C	-	50	-	ppm/°C



Pin Description

Pin No.	Symbol	Description
1	V+	Positive supply voltage, output of on-chip DC-DC converter.
2	V+	Positive supply voltage, output of on-chip DC-DC converter.
3	CH+	High speed positive connection for reference capacitor.
4	CH-	High speed negative connection for reference capacitor.
5	CIH	High speed integrator output. Connected to integration capacitor.
6	BUFH	Integration resistor connection for high speed buffer output.
7	CAZH	High speed auto-zero capacitor connection
8	CL+	High resolution positive connection for reference capacitor.
9	CL-	High resolution negative connection for reference capacitor.
10	CIL	High resolution integrator output. Connected to integration capacitor.
11	CAZL	High resolution auto-zero capacitor connection.
12	BUFL	Integration resistor connection for high resolution buffer output.
13	IVSH	High level current measurement input.
14	IVSL	Low level current measurement input
15	OVX	Input high voltage for resistance measurement.
16	OVH	Output connection for resistance measurement.
17	OVSG	Sense low voltage for resistance measurement.
18	OR1	Reference resistor connection for 399.9Ω range.
19	VR5	Voltage measurement ÷ 10000 attenuator (3999V).
20	VR4	Voltage measurement ÷ 1000 attenuator (399.9V).
21	VR3	Voltage measurement ÷ 100 attenuator (39.99V).
22	VR2	Voltage measurement ÷ 10 attenuator (3.999V).
23	TEST5	Test pin 5.
24	ACVL	Negative output of AC to DC converter.
25	ACVH	Positive output of AC to DC converter.
26	ADI	Negative input of internal AC to DC OP AMP.
27	ADO	Output of internal AC to DC OP AMP.
28	VA+	For ADP use. Deintegrating voltage input. The pin voltage should be more positive than VA- pin.
29	VA-	For ADP use. Deintegrating voltage input.
30	ADP	Adapted input for other application measurement.
31	SGND	Signal ground.
32	VR1	Measurement input .
33	ADODC	Optional pin.
34	VR	Reference input voltage connection. Typically -100 mV.
35	VRH	Output of band-gap voltage reference. Typically -1.2 V.
36	ACVR	Optional pin. When connected to -3V, ACV without 400mV range.
37	BKLIT	Back light function. Pulse low to set BKOUT pin output.

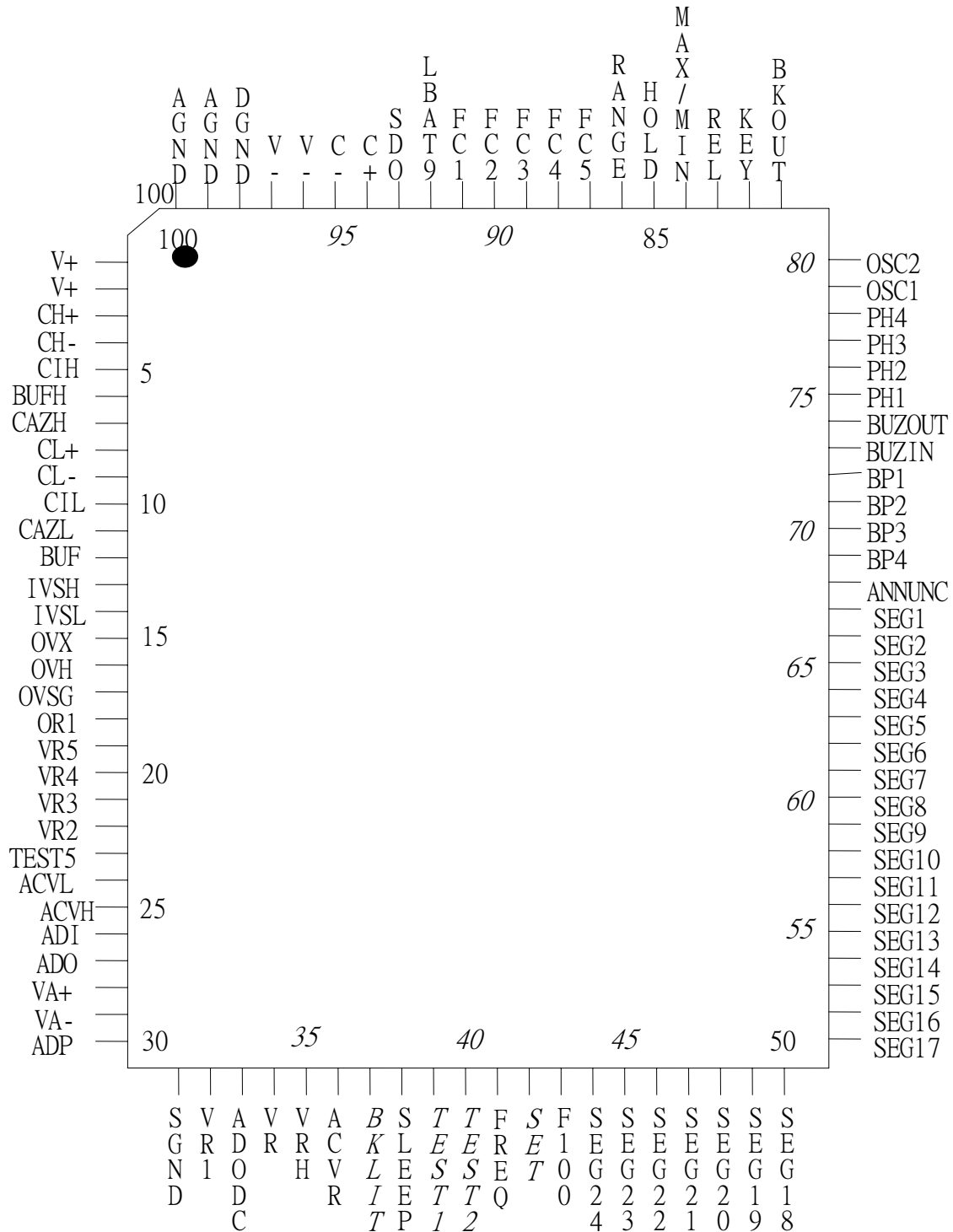


Pin. No	Symbol.	Description
38	SLEEP	When auto-power-off happen, this pin output will change from +3V to -3V. When re-power on happens, this pin output will change back to +3V.
39	TEST1	Test pin 1.
40	TEST2	Test pin 2
41	FREQ	Frequency counter input, offset to 1/2(V-).
42	SET	Input to set serial data output. Pulse low to make this function active.
43	F100	100 HZ square wave output.
44	SEG24	LCD Segment line 24.
45	SEG23	LCD Segment line 23.
46	SEG22	LCD Segment line 22.
47	SEG21	LCD Segment line 21
48	SEG20	LCD Segment line 20.
49	SEG19	LCD Segment line 19.
50	SEG18	LCD Segment line 18.
51	SEG17	LCD Segment line 17.
52	SEG16	LCD Segment line 16.
53	SEG15	LCD Segment line 15.
54	SEG14	LCD Segment line 14.
55	SEG13	LCD Segment line 13.
56	SEG12	LCD Segment line 12.
57	SEG11	LCD Segment line 11.
58	SEG10	LCD Segment line 10.
59	SEG9	LCD Segment line 9.
60	SEG8	LCD Segment line 8.
61	SEG7	LCD Segment line 7.
62	SEG6	LCD Segment line 6.
63	SEG5	LCD Segment line 5.
64	SEG4	LCD Segment line 4.
65	SEG3	LCD Segment line 3.
66	SEG2	LCD Segment line 2.
67	SEG1	LCD Segment line 1.
68	ANNUNC	Square-wave output at the backplane frequency, synchronized to BP1. ANNUNC can be used to control display annunciator. Connecting an LCD segment to ANNUNC and turns it on; connecting an LCD segment to its backplane and turns it off.
69	BP4	LCD Backplane 4.
70	BP3	LCD Backplane 3.
71	BP2	LCD Backplane 2.
72	BP1	LCD Backplane 1.

Pin. No	Symbol.	Description.
73	BUZIN	Buzzer control input. When Connected BUZIN to -3V turns the buzzer on.(2.0 KHZ continue signal)
74	BUZOUT	Buzzer output. Audio frequency (2.0KHz) output which drives a piezoelectric buzzer.
75	PH1	Phase output 1,for capacitance measurement.
76	PH2	Phase output 2,for capacitance measurement.
77	PH3	Phase output 3,for capacitance measurement.
78	PH4	Phase output 4,for capacitance measurement.
79	OSC1	Crystal oscillator (input) connection.
80	OSC2	Crystal oscillator (output) connection.
81	BKOUT	If BKLIT function is enabled , this pin output will change from -3V to +3V for 60 sec, once pressed BKLIT pin again within the 60 sec, this pin output will change back to -3V.
82	KEY	Mode change pin.
83	REL	Input to get relative display. Pulse low to make this function active.
84	MAX/MIN	Input to set MAX/MIN display. Pulse low to make this function active.
85	HOLD	Input to hold display. Pulse low to make this function active.
86	RANGE	Input to set automatic/manual mode and manual range selection. Pulse low to make this function active.
87	FC5	Switch 5 for function selection.
88	FC4	Switch 4 for function selection.
89	FC3	Switch 3 for function selection.
90	FC2	Switch 2 for function selection.
91	FC1	Switch 1 for function selection.
92	LBAT9	Low battery voltage setting. If used 3V battery, connected this pin to AGND, the default low battery voltage will be -2.3V. If used 9V battery, when the input voltage is small than VRH(-1.2V), the low battery annunciator will be display.
93	SDO	Serial data output.
94	C+	Positive capacitor connection for on-chip DC-DC converter.
95	C-	Negative capacitor connection for on-chip DC-DC converter.
96	V-	Negative supply voltage. Connecting to battery negative terminal.
97	V-	Negative supply voltage. Connecting to battery negative terminal.
98	DGND	Digital ground, connected to battery positive terminal.
99	AGND	Analog ground.
100	AGND	Analog ground.



Pin Configuration





Operation Mode

(1) Measurement Description

Voltage Measurement

Resistive divider is automatically changed to provide in range reading for 399.9mV to 3999V full scale reading. The following table shows the various full scale range.

Range	Full scale	Resistive Ratio
VR1	399.9 mV	1, 1/1
VR2	3.999 V	$R2/(R1+R2)$, 1/10
VR3	39.99 V	$R3/(R1+R3)$, 1/100
VR4	399.9 V	$R4/(R1+R4)$, 1/1000
VR5	3999 V	$R5/(R1+R5)$, 1/10000

Resistance Measurement

Resistive divider is automatically changed to provide the proper range. The following table shows the various full scale range.

Range	Full Scale	Reference Resistor
OR1	399.9 Ω	R6(100 Ω)
OR2	3.999 K Ω	R5(1K Ω)
OR3	39.99 K Ω	R4(10K Ω)
OR4	399.9 K Ω	$R1 \parallel R3 (=100K \Omega)$
OR5	3.999 M Ω	$R1 \parallel R2 (=1M \Omega)$
OR6	39.99 M Ω	R1(10M Ω)

Current Measurement

In the current measurement mode , there are three range selections :

Mode	Range Selection	Full Scale
Automatic Mode 1	uA	399.9 uA
		3999 uA
Automatic Mode 2	mA	39.99 mA
		399.9 mA
Manual Mode	A	39.99 A

When the mode changes among (uA, mA, A), the original AC/DC state will keep.



Continuity Check

The continuity check is the same as the 399.9Ω range of the resistance measurement mode (manual mode). If the bargraph number <=3 , there will 2.0 KHz signal comes out from BUZOUT pin, if the bargraph number >=4, there will be no beep exist.

Diode Measurement

Use the DCV 3.999V range of voltage measurement mode (manual mode). If the test circuit is open or the device (diode) under test is larger than 2V, the LCD display will show "OL", but the bargraph will show the real detected voltage.

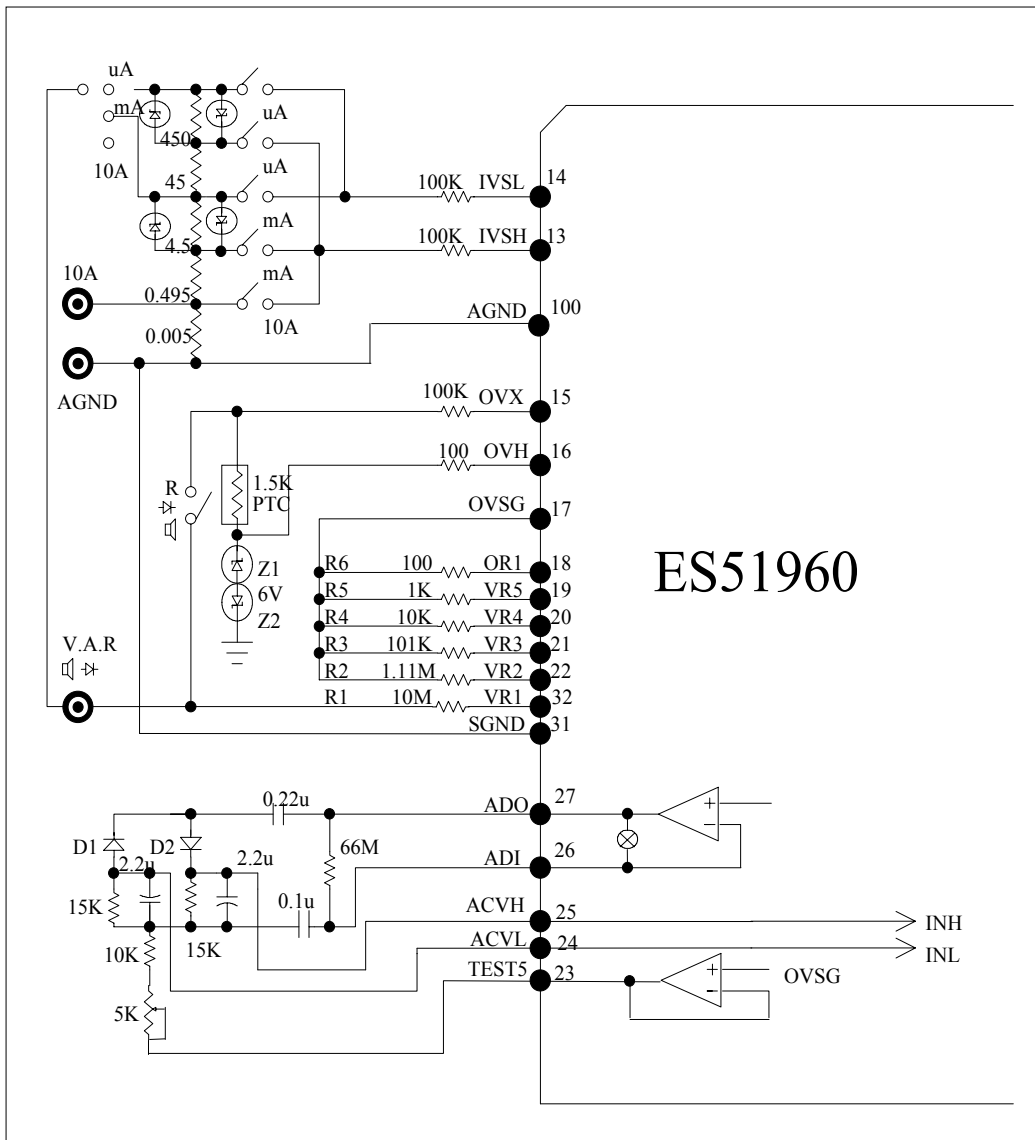
Frequency Counter

The timebase of ES51960 is derived by a clock oscillator.
The timebase of counter is :

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

Thus , the counter will operate with a 1 second timebase when a 4MHz oscillator is used. For accurate frequency measurement,a crystal oscillator is recommended. The frequency counter can automatically or manually select the proper range. Autorange operation extends over six decades from 1 Hz to 399.9MHz.

Range	Full Scale
FR1	3.999 KHZ
FR2	39.99 KHZ
FR3	399.9 KHZ
FR4	3.999 MHZ
FR5	39.99 MHZ
FR6	399.9 MHZ



Analog Switch Selection

Note : Light shielding for Z1, Z2, D1, D2.



(2) Switch Description

Rotary mode : FC1,FC2,FC3,FC4,FC5

Measurement mode depends on the logic levels of FC1,FC2,FC3,FC4
FC5 and KEY :

When FC5=1

FC1	FC2	FC3	FC4	Mode	Push mode(KEY)
1	1	0	0	DC V	DC V — AC V
1	1	1	0	DC uA	DC uA — AC uA
1	1	0	1	DC mA	DC mA — AC mA
1	1	1	1	DC A	DC A — AC A
0	1	1	1	Ω	Ω — Continuity
0	1	1	0	Continuity	Continuity — Diode
1	0	1	1	Ω	Ω — Continuity — Diode
1	0	1	0	Frequency	

When FC5=0, KEY is disabled.

FC1	FC2	FC3	FC4	Mode
1	1	0	0	ACV
1	1	1	0	AC uA
1	1	0	1	AC mA
1	1	1	1	ACA
0	1	1	1	Ω
0	1	1	0	Continuity
1	0	1	1	Diode
1	0	1	0	Frequency

Under ADP mode

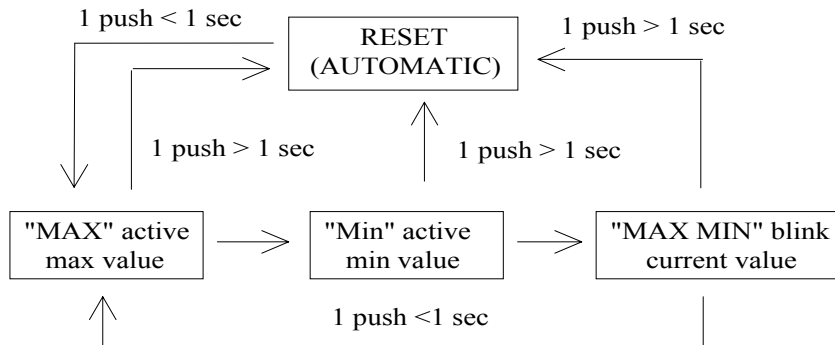
(1) FC5=1, when the input value is overflow, the buzzer will beep.

(2) FC5=0, when the input value is overflow, the buzzer will not beep.

FC1	FC2	FC3	FC4	Mode
0	1	0	1	ADP0
1	0	0	1	ADP1
0	0	1	1	ADP2
0	0	0	1	ADP3
0	1	0	0	ADP0(no bar)
1	0	0	0	ADP1(no bar)
0	0	1	0	ADP2(no bar)
0	0	0	0	ADP3(no bar)

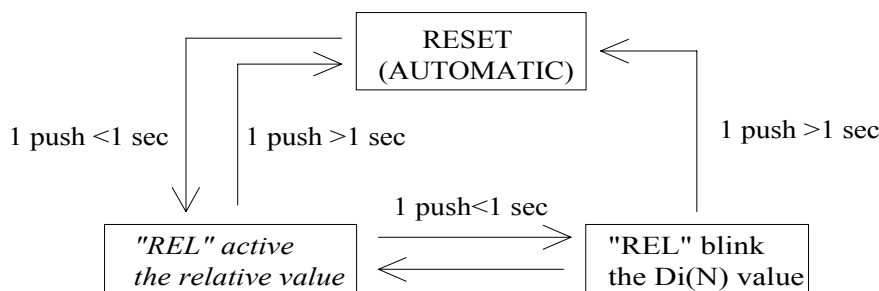
Push mode

MAX/MIN :



- (1) If MAX/MIN function is enabled, REL function is disabled, or if REL function is enabled, MAX/MIN function is disabled.
- (2) The sequence order is MAX value, MIN value, Current value.

REL :



* When REL function is enabled :

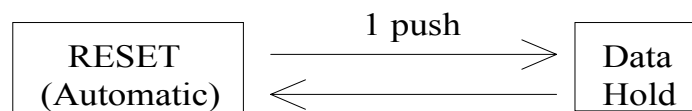
$$\text{Display} = D_i(N+K) - D_i(N), K = 0, 1, 2, 3, \dots$$

$D_i(N)$: Input reading when REL function active.

$D_i(N+K)$: Next K step input reading.

* If the input value $D_i(N)$ or $D_i(N+K) \geq (\pm 4000)$, the relative value will display "OL".

HOLD :



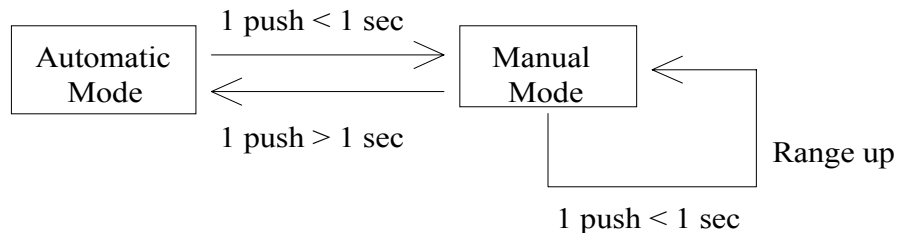
- (1) Under auto mode, press the HOLD function, the mode will change to manual mode and stay at the same scale range.
- (2) If HOLD function is enabled, MAX/MIN, REL function is disabled. but if MAX/MIN, REL function is pressed first, the HOLD function still can active.



(3) If continue to press the HOLD pin(logic low)then power on the ES51960, all the segments will blight until release the HOLD pin.

Range :

The mode selection of Auto-mode and Manual-mode is determined by RANGE pin. The following is the operating flow chart of Auto-mode and Manual-mode.



- * If HOLD, MAX/MIN, REL function is enabled , when RANGE function is pressed , the enabled function will be clear.
- * The bargraph is not affected by HOLD, MAX/MIN, REL function.

Function	Auto	Manual	Control Range	Initial Range
Voltage (AC/DC)	R1 – R5	R _i → R _{i+1} (R ₅ →R ₁)	399.9mV 3999V	399.9mV(DC) 3.999V (AC)
uA(AC/DC)	R1 – R2	R ₁ → R ₂ R ₂ → R ₁	399.9uA 3999uA	399.9uA
mA(AC/DC)	R1 – R2	R ₁ → R ₂ R ₂ → R ₁	39.99mA 399.9mA	39.99mA
A(AC/DC)	Fix	Fix	39.99A	39.99A
Ω	R1 – R6	R _i → R _{i+1} (R ₆ →R ₁)	399.9Ω 39.99MΩ	"OL" 399.9Ω
Continuity	Fix	Fix	399.9Ω	"OL" 399.9Ω
Diode	Fix	Fix	3.999V	"OL" 3.999V
Frequency	FR1 – FR6	FR _i →FR _{i+1} (FR ₆ →FR ₁)	3.999KHZ 399.9MHZ	3.999KHZ
ADP0 ADP1 ADP2 ADP3	Fix	Fix	NOTE	XXXX XXX.X XX.XX X.XXX



Auto-Power-off function

Once power on the ES51960, the auto-power-off function will be enabled and if the functions are not changed in 30 minutes, the auto-power-off condition will happen and SLEEP pin output will change from +3V to -3V. When power-off happens, the final data is saved. If continue to press anyone of the pushed function (except HOLD pin) then power on the ES51960, the auto-power -off function will be disabled , and LCD segment "APO" will be turned off.

BKLIT

When this pin BKLIT is pushed, the BKOUT pin output will change from V- to V+ for 60 sec then returned to V- again, but if this pin is pushed again within 60 sec, this function will be canceled.

SLEEP

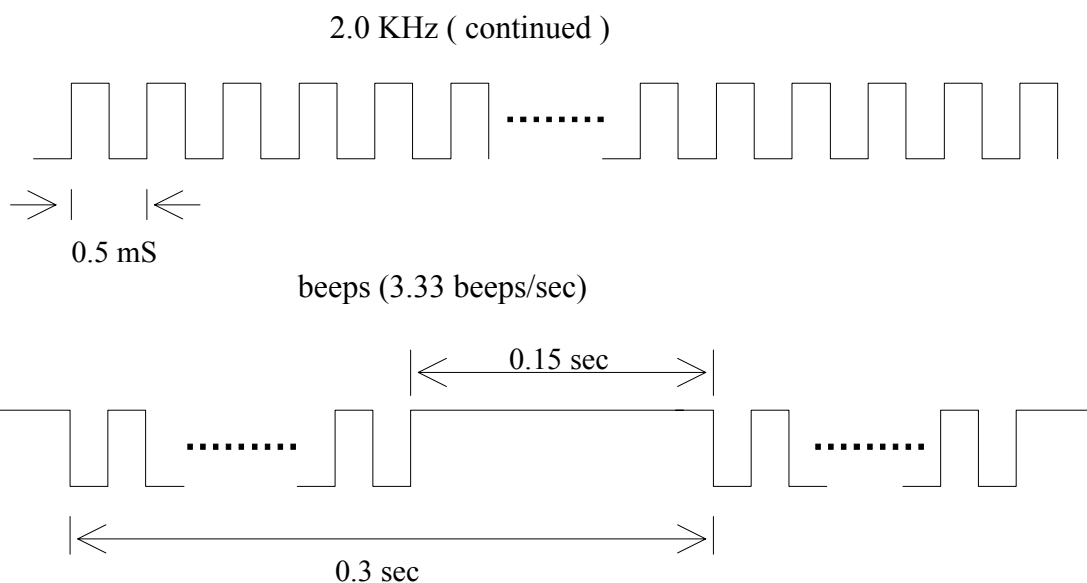
When auto-power-off happens, this pin output will change from V+ to V-, once re-power on happen, this pin output will change from V- to V+.

(3) Buzzer

The BUZZER turns on in the following condition :

- 1 beep : Measurement function changed ,power and re-power on , RANGE, HOLD, MAX/MIN, REL, SET, BKLIT or KEY are pushed.
- 3.3 beeps : Input reading overrange. (except diode, ohm, continuity, frequency function used)
- 2.0 KHZ continue: Continue check (Bargraph number<=3).
- 2.0 KHZ continue 1.5 sec : Auto-power-off.

BUZZER output waveform :





RANGE :

Range	V	mA	uA	Ohm	Frequency
0110000	400mV	40mA	400uA	400 Ohm	4K HZ
0110001	4V	400mA	4000uA	4K Ohm	40K HZ
0110010	40V			40K Ohm	400K HZ
0110011	400V			400K Ohm	4M HZ
0110100	4000V			4M Ohm	40M HZ
0110101				40M Ohm	400M HZ

Because Continuity, Diode, Current(A) and ADP measurement range are all fixed, so they are all the first code 0110000.

DIGIT0 ~ 3 :

Digit	Display data
0110000	0
0110001	1
0110010	2
0110011	3
0110100	4
0110101	5
0110110	6
0110111	7
0111000	8
0111001	9

If the input value is over-range(OL), the reading data DIGIT3=4, DIGIT2=0, DIGIT1=0, DIGIT0=0, but under the frequency mode, DIGIT0~3 output the measured value.

FUNCTION : The definition code is not the same as FC1 ~ FC5.

Function	Measurement mode
0111111	A
0111110	UA
0111101	MA
0111100	Voltage
0110111	Ω
0110110	Continuity



0111011	Diode
0111010	Frequency
0110101	ADP0
0111001	ADP1
0110011	ADP2
0110001	ADP3
0110100	ADP0*
0111000	ADP1*
0110010	ADP2*
0110000	ADP3*

Under ADP mode, the bargraph will not display

STATUS :

0	1	1	-	BATT	ACOL	OL
BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1

- : "1" is for the negative(-).

BATT : "1" is for the battery voltage is less than $2.3V \pm 0.2V$.

OL : "1" is for the input voltage over-range.

ACOL : "1" is that the offset value of input signal is too large on the AC mode.

OPTION1 :

0	1	1	0	0	0	0
BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1

OPTION2 :

0	1	1	DC/AC	AUTO	MAN	APO
BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1

DC/AC : "1" is for the DC mode and Ω , Diode, Continuity, ADP, Frequency Function, "0" is for the AC mode.

AUTO : "1" is for auto range.

MAN : "1" is for the manual range.

APO : "1" is for the auto-power-off function enabled.

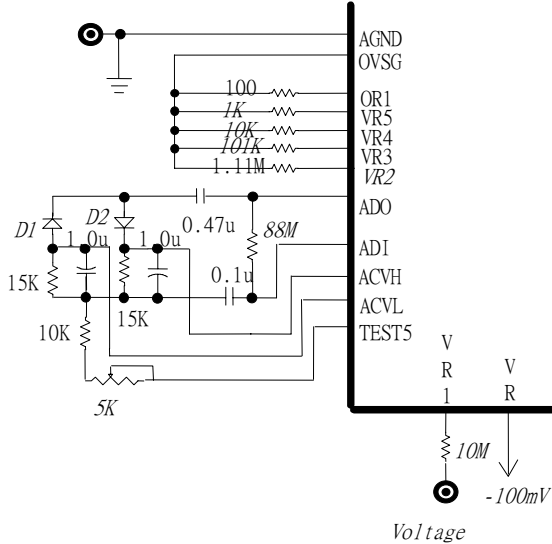
CR(BACK) : Transmission code "0001101".

LF(LINE FEED) : Transmission code "0001010".

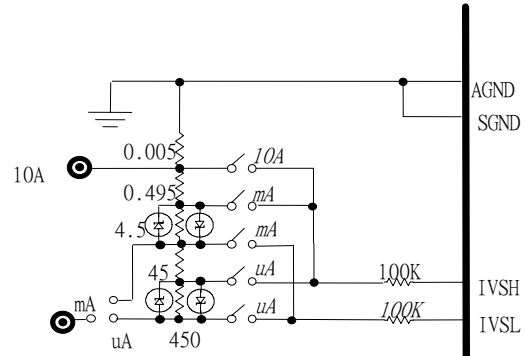


TEST CIRCUIT

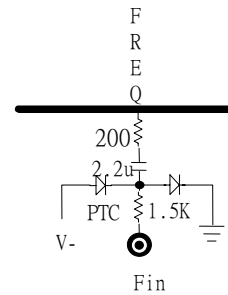
1 Voltage



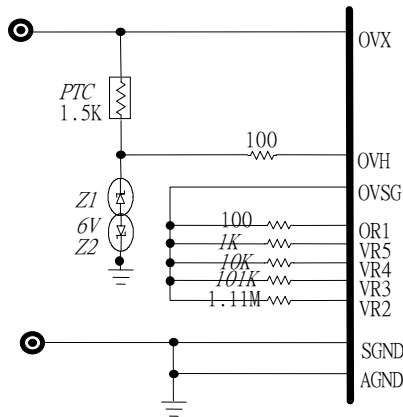
4 Current



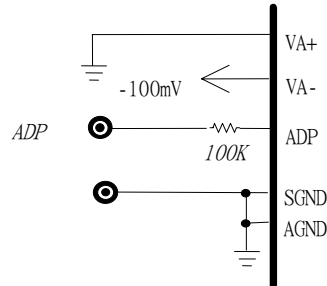
5 Frequency



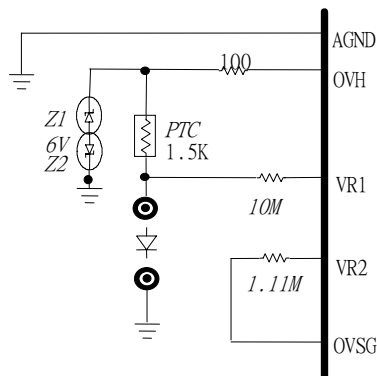
2 Resistor



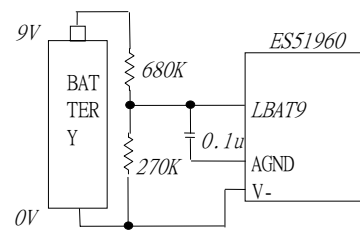
6 ADP



3 Diode

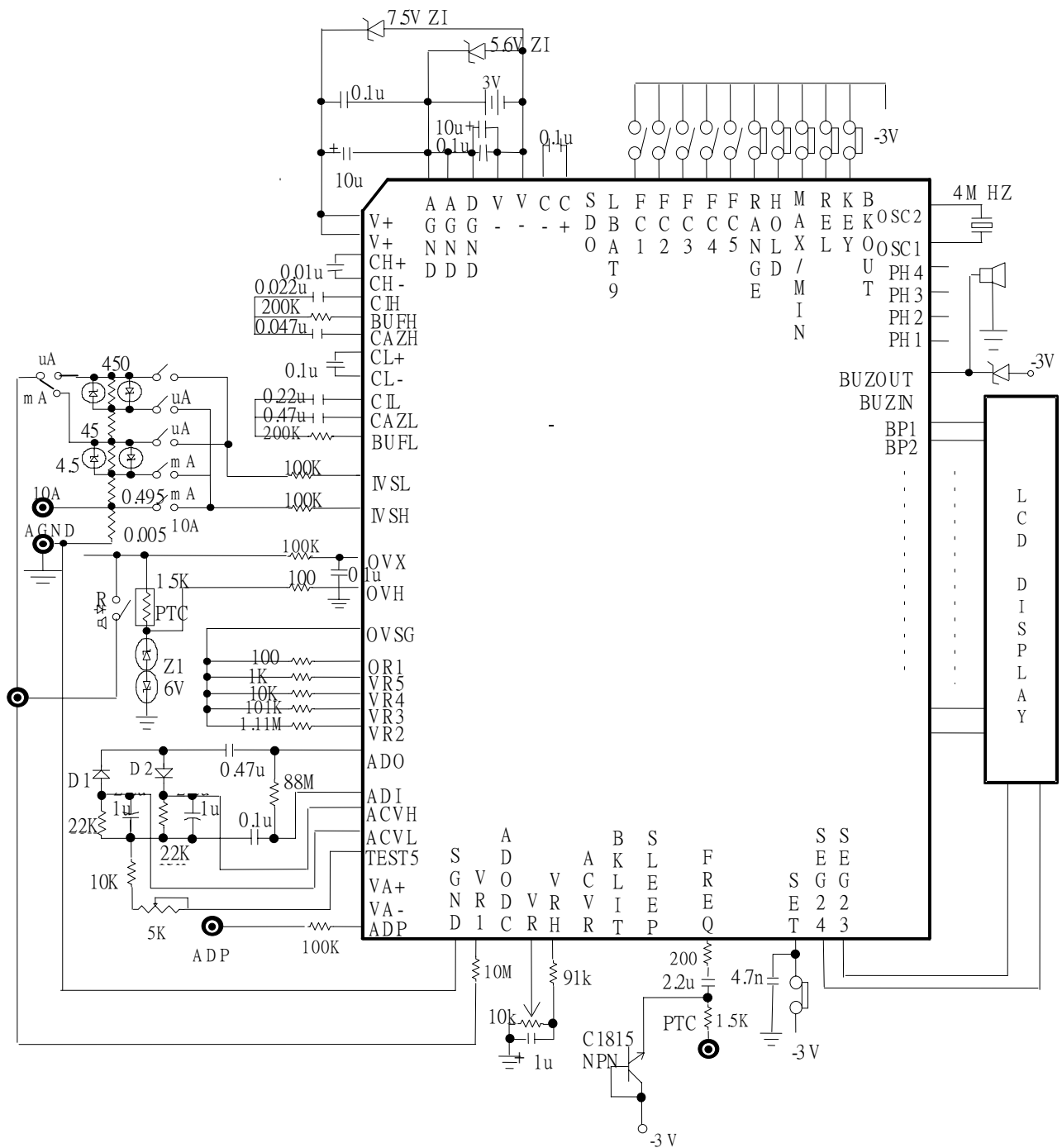


7 Low battery





APPLICATION CIRCUIT





Note: In order to prevent IC from damaging by inappropriate operation, the Zener diodes **MUST** be required as protection.

The Other
(1) LCD pin assignment

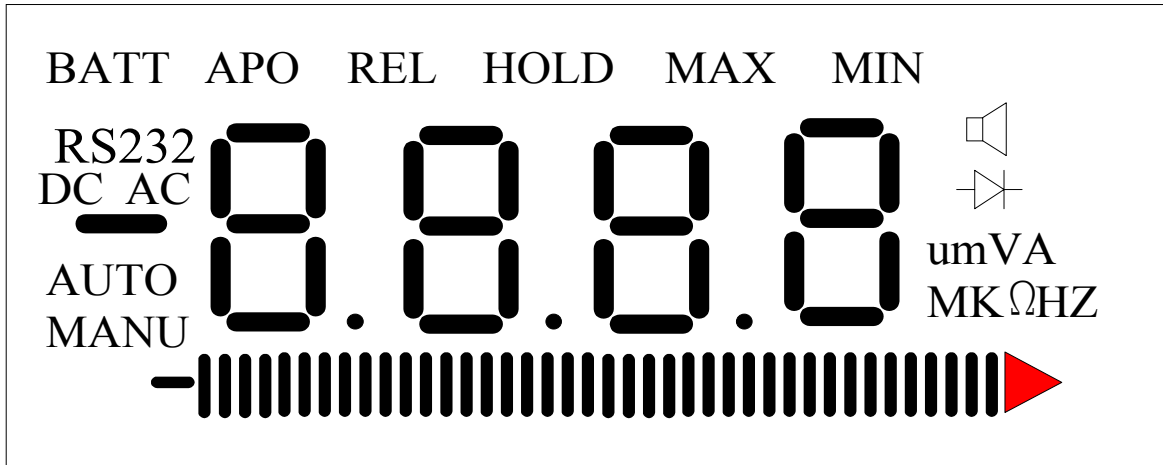
	SEG1	SEG2	SEG3	SEG4	SEG5	SEG6	SEG7
BP1	RS232	bar2	bar4	bar6	bar8	bar9	bar11
BP2	Bar0	bar1	bar3	bar5	bar7	d3	bar10
BP3	Bar-	—	AUTO	MANU	e3	g3	c3
BP4	DC	BATT	f3	AC	AP0	a3	b3

	SEG8	SEG9	SEG10	SEG11	SEG12	SEG13	SEG14
BP1	bar13	bar15	bar16	bar18	bar20	bar22	bar24
BP2	bar12	bar14	d2	bar17	bar19	bar21	bar23
BP3	p3	e2	g2	c2	px	p2	e1
BP4	REL	f2	a2	b2	HOLD	MAX	f1

	SEG15	SEG16	SEG17	SEG18	SEG19	SEG20	SEG21
BP1	bar25	bar27	bar29	bar31	bar32	bar34	bar36
BP2	d1	bar26	bar28	bar30	d0	bar33	bar35
BP3	g1	c1	p1	e0	g0	c0	M
BP4	a1	b1	MIN	f0	a0	b0	u

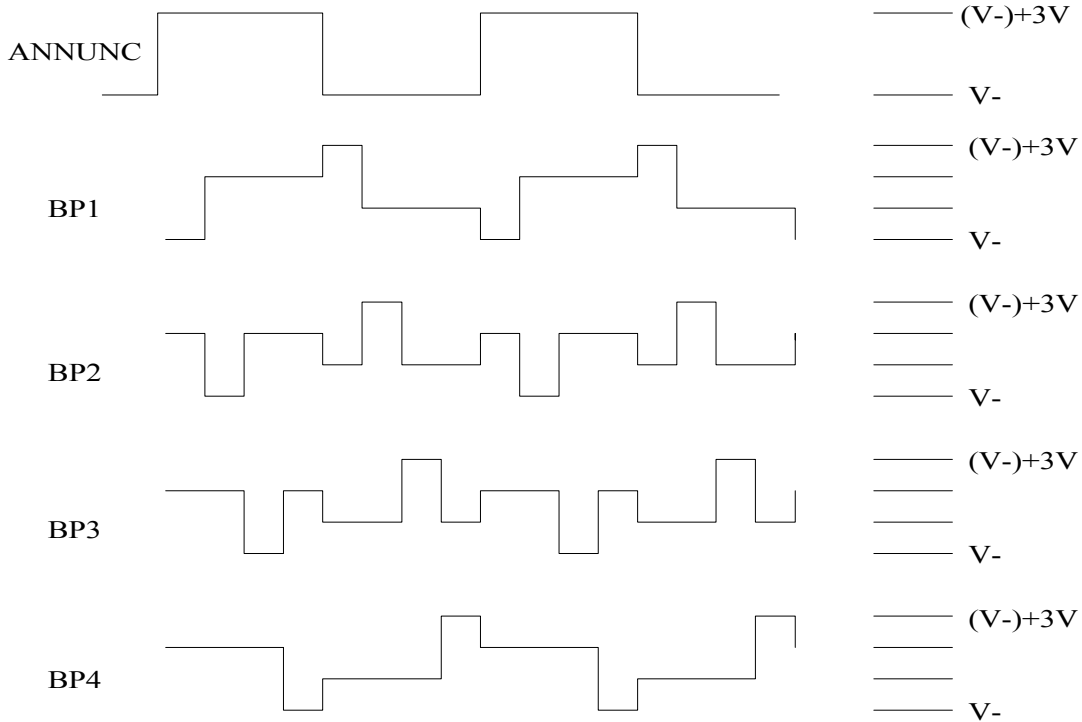
	SEG22	SEG23	SEG24
BP1	bar38	bar40	HZ
BP2	bar37	bar39	Ω
BP3	K	V	A
BP4	m		

- NOTE :**
- 1 : "bar0" is normally ON.
 - 2 : "p1" is always ON when ADP1 function is used.
 - 3 : "p2" is always ON when ADP2 function is used.
 - 4 : "p3" is always ON when ADP3 function is used.
 - 5 : "px" is always OFF(not used).
 - 6 : "RS232" is always ON when SDO function is enabled(option).





LCD Display Panel

Backplane Waveform (Frequency = 62.5 HZ)



(2) LCD Display ON Condition

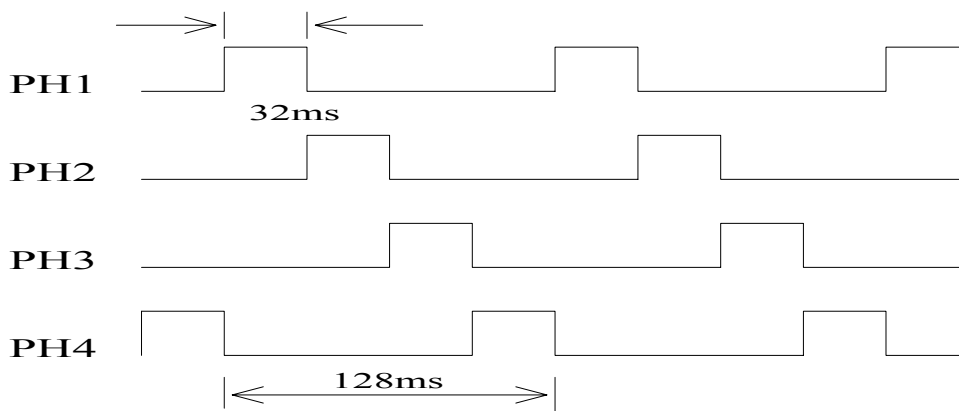
LCD Annunciator	
"BATT"	Low battery is detected.
"DC"	DC voltage and DC current functions are used.
"AC"	AC voltage and AC current functions are used.
"_."	DC voltage and current function.
"AUTO"	Automatic mode is used.
"MANU"	Manual mode is used.
"REL"	REL function is used.
"HOLD"	HOLD function is used.
"MAX"	MAX function is used.
"MIN"	MIN function is used.
"  & "Ω"	Continuity-check is used.
"  & "V"	Diode measurement is used.
"mV"	AC/DC voltage function is used.
"umA"	AC/DC current function is used.
"MK Ω"	Ω measurement function is used.
"MKHZ"	Frequency counter is used.
"APO"	Auto-power-off function is used.
"RS232"	Serial data output is used.
Bargraph	Bargraph annunciator is only depend on input reading .



(3) DC offset value at the ACV

Generally when we measure an ac voltage, it may be biased upon a dc level. Once the offset voltage is too large, the measurement data will not be true. There is one method can remind user to notice this condition. Connecting ADODC (pin 33) to -3V, when the above condition happens, the LCD symbol "dc" will blink and the data display will be "OL", then user can press RANGE pin to enter to the next range and get the correct value. If this function is enabled, user also can read this condition from the RS232 output form(status).

(4) PH1,PH2,PH3,PH4 four phase output

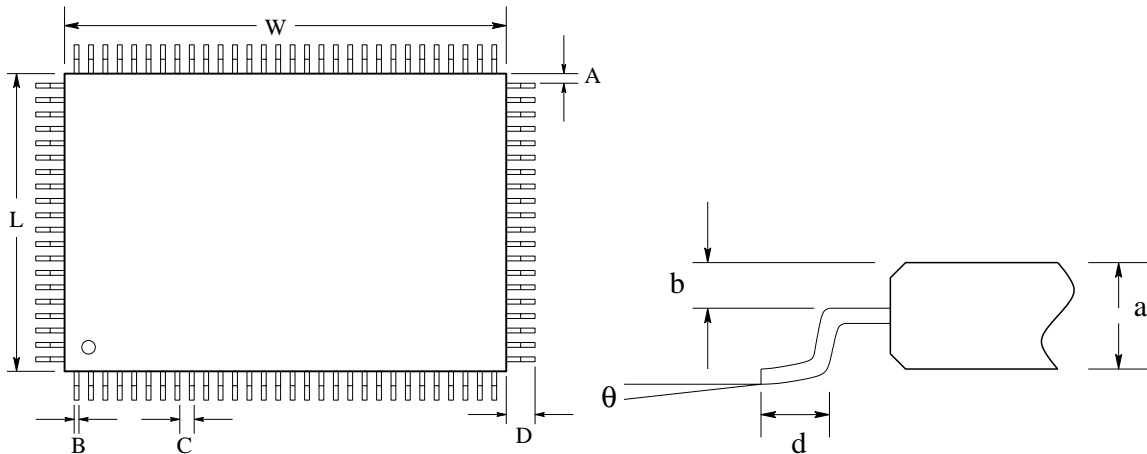


(5) High Resolution and High Speed(Bargraph) time

Mode	High Resolution		High Speed	
	Current(I) Measurement	Other Measurement (V,R)	Current(I) Measurement	Other Measurement (V,R)
ZI	100m sec	100m sec	10m sec	10m sec
AZ	150m sec	150m sec	15m sec	15m sec
INT	100m sec	100m sec	10m sec	10m sec
DEINT	200m sec	400m sec	20m sec	40m sec

Package

1 100 Pin QFP Package



2 Dimension Parameters

Symbol	Milimeter			Mill		
	Min.	Typ.	Max.	Min.	Typ.	Max.
W	19.90	20.00	20.10	783.5	787.4	791.3
L	13.90	14.00	14.10	547.2	551.2	551.2
A		0.425			16.7	
B	0.20	0.30	0.40	7.9	11.8	11.8
C		0.65			25.6	
d	1.05	1.20	1.35	41.3	47.2	47.2
a	2.57	2.72	2.87	101.2	107.1	107.1
D		2.50			98.4	
θ	0°		10°			