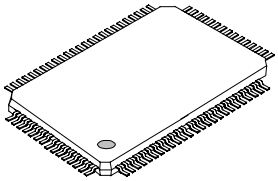
SC7001Q

3 3/4-DIGIT 3260-COUNT A/D CONVERTER



80-QFP

DESCRIPTION

The SC7001Q is a low power CMOS dual-slope A/D converter with 3 3/4-digit numeric and 33-segment bar-graph LCD display driver, auto-ranging, and single 3V battery operation.

It is ideal for high performance auto-range DMM applications with 3260 counts full-scale.

The SC7001Q provides many user function: Manual Range Hold/Data Hold/Auto Power-off/Voltage/Current/Resistance measurement/Diode Test/Continuity Check(Beeper). The built-in high temperature-stable CMOS bandgap reference and a CMOS Op Amp for ac-to-dc conversion are economical of saving external components. In addition, the voltage doubler enables a high performance digital multimer to be built with single 3V power supply operation.

FEATURES

* Auto range function
  --Voltage (DC/AC):326.0mV(NA for AC), 3.260V, 326.0V, 3260V
  --Resistance: 326.0Ω,3.260kΩ, 32.60kΩ, 326.0kΩ, 3.260MΩ, 32.60 MΩ
  -- Current (DC/AC): 326.0μA, 3260μA, 32.60mA, 326.0mA, 10A
* Triplex LCD driver including decimal points, bargraph, and annunciators
* Low power consumption: less than 1.8mW.
* 3V battery operation.
* Internal voltage doubler, ac-to-dc conversion Op Amp.
* Range Selection/Display Hold/Auto Power-off/Diode Test/Continuity Check(Beeper) function
* Built-in CMOS bandgap reference.

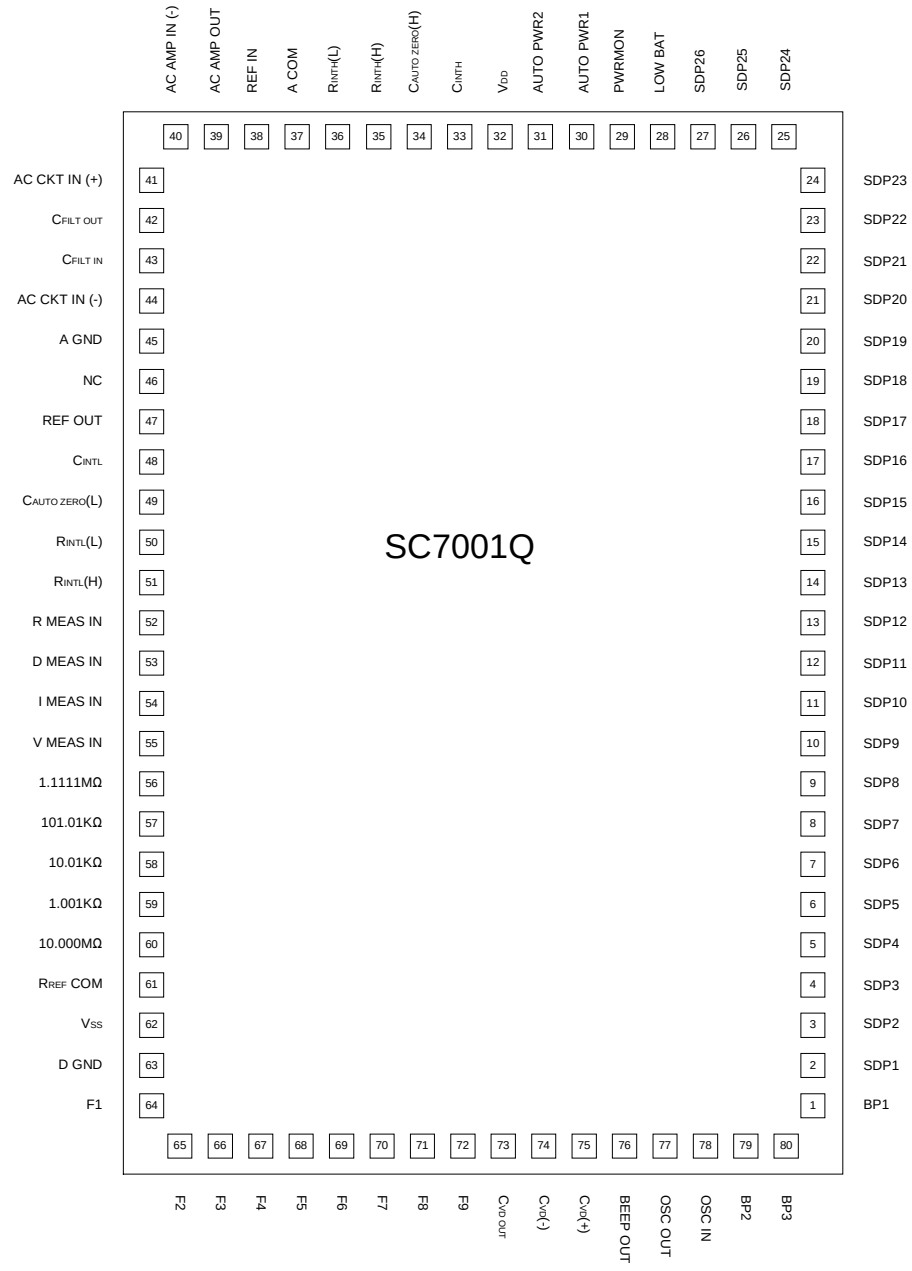
ORDERING INFORMATION

Part number	Package
SC7001Q	80QFP

APPLICATIONS

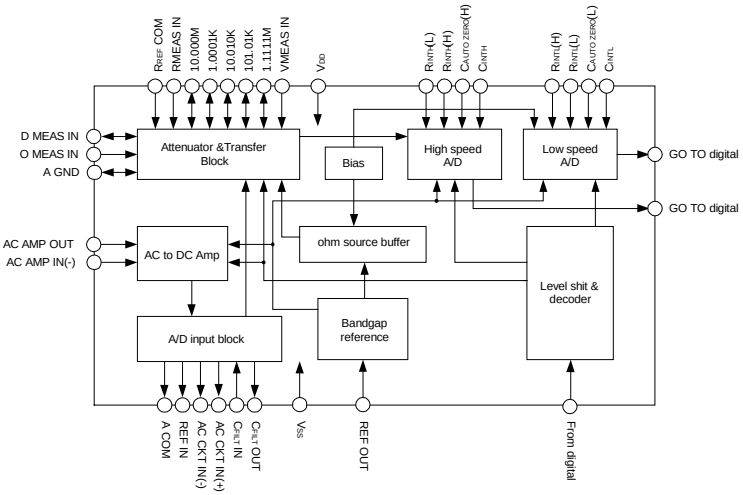
* Hand-held DMM
* Pocket DMM
* Pen-type DMM

PIN CONFIGURATION

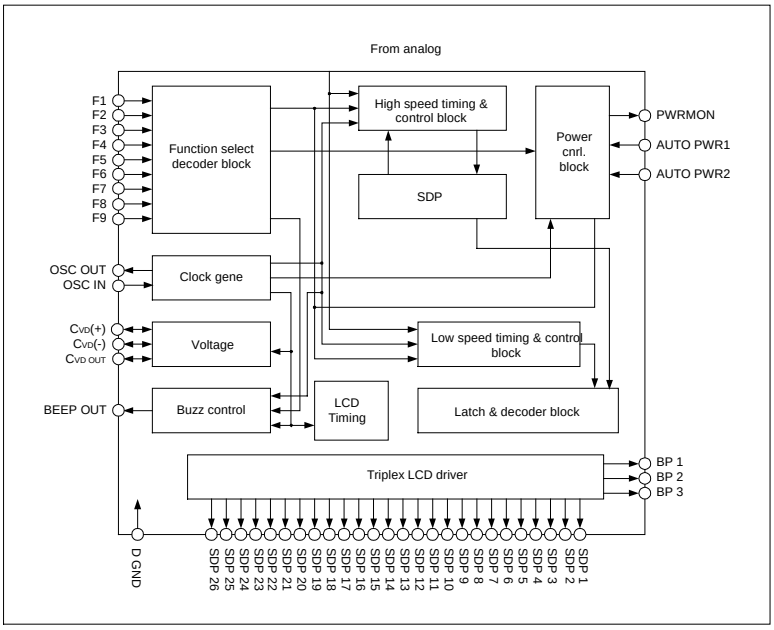


BLOCK DIAGRAM

1.Analog block



2.Digital block



ABSOLUTE MAXIMUM RATING (note1)

Characteristic	Symbol	Value	Unit
Supply voltage (V_{DD} to A COM)	V_{DD}	4	V
Supply voltage (V_{SS} to A COM)	V_{SS}	-4	V
Digital input Voltage	DV_{IN}	-0.3~V_{DD}+0.3	V
Analog input voltage	AV_{IN}	V_{SS}-0.3~V_{DD}+0.3	V
Digital output current	DI_{OUT}	-1~+1	mA
Analog output current	AI_{OUT}	-3~+3	mA
Beep output current	I_{BEEP}	-1~+1	mA
LCD output current	I_{LCD}	-0.1~+0.1	mA
Operating temperature range	T_{OPR}	0~+50	°C
Storage temperature range	T_{STG}	-40~+125	°C

Note: 1. All voltage are measure with respect to the A COM, unless otherwise noted. The separate A GND, D GND and A COM should always be wired together.

RECOMMENDED OPERATING CONDITIONS

Characteristics	Symbol	Value			Unit
		Min	Typ	Max	
Supply voltage	V_{DD}	2.4	3.0	3.6	V
Supply voltage	V_{SS}	-2.4	-3.0	-3.6	V
Digital input “L” voltage	DV_{IL}			0.5	V
Digital input “H” voltage	DV_{IH}	V_{DD}-0.5			V
Reference input voltage	REF IN		0.32768		V
LCD-ON drive voltage	V_{LCD-ON}	2.5			V
LCD-OFF drive voltage	$V_{LCD-OFF}$			1.3	V
Operating temperature range	Topr	0		50	°C
Clock frequency	f		32.768		KHz

ELECTRICAL CHARACTERISTICS

(Tamb=25°C, V_{DD}=3V, REF IN=0.32768V, f =32.768KHz,unless otherwise specified)

Parameter		Symbol	Test conditions	Min	Typ	Max	Unit
Supply current		I_{DD}	At DCV mode, V_{IN}=0mV with voltage doubler operated			600	μA
Power-off supply current		I_{PO}	At power off(down)		0	4.0	μA
Digital input “H” current		I_{IH}	V_{IH} =3V	-1.0		+1.0	μA
Digital input “L” current		I_{IL}	V_{IL}=0V	-10			μA
Measuring pin leakage		I_{LEAK}		-10		+10	pA
Digital input “H” voltage		V_{IH}		2.5			V
Digital input “L” voltage		V_{IL}				0.5	V
Built-in reference voltage output range		REF OUT		1.1	1.28	1.4	V
Built-in reference voltage output voltage coefficient		ΔREF OUT	V_{DD}=2.4~3.6V	-2000		+2000	ppm/V
Battery check internal comparator off-set voltage		V_{BATT}	On pin 47 voltage	-60		+60	mV
LCD-on drive voltage		V_{LCD-ON}		2.5			V
LCD-off drive voltage		$V_{LCD-OFF}$				1.3	V
Linearity	DCV measurement	ERR-DCV		-0.08		+0.08	%/FS
	DCA measurement	ERR-DCA		-0.15		+0.15	%/FS
	ACV measurement	ERR-ACV		-0.1		+0.1	%/FS
	ACA measurement	ERR-ACA		-0.2		+0.2	%/FS
	Resistance measurement	ERR-R	Except 32.6MΩ	-0.08		+0.08	%/FS
			32.6MΩ range	-0.5		+0.5	%/FS
	Diode test	ERR-D	Full-scale =2.0V	-0.2		+0.2	%/FS
	Option measurement	ERR-OPT		-0.08		+0.08	%/FS
Beep out frequency		f_{BEEP}		4095	4096	4097	Hz
Continuity check value		R_{CC}		18.3		20.7	Ω
AC-to-DC conversion Amp gain		A_V	Input range = -1~1v	70			dB
O.L display count		D O.L		3240		3290	count

PIN DESCRIPTION

PIN No.	Symbol	I/O	Description
1	BP1	O	Backplane 1 of LCD display
2~27	SDP1~SDP26	O	Segment display
28	LOWBAT	I	Low battery check voltage input
29	PWRMON	O	Power monitor output
30	AUTO PWR1	I	Auto power ON/OFF selection 1
31	AUTO PWR2	I	Auto power ON/OFF selection 2
32	V_{DD}	--	Supply voltage
33	C_{INTH}	I/O	High-speed A/D integrating capacitor connection
34	$C_{AUTO\ ZERO}$(H)	I/O	High-speed A/D auto zero capacitor connection
35	R_{INTH}(H)	I/O	High-speed A/D integrating resistor connection(H)
36	R_{INTH}(L)	I/O	High-speed A/D integrating resistor connection(L)
37	A COM	I	Analog circuit reference voltage
38	REF IN	I	Reference voltage input
39	AC AMP OUT	O	Built-in AC Amp output
40	AC AMP IN(-)	I	Built-in AC Amp negative input
41	AC CKT IN (+)	I	AC measurement position input
42	$C_{FILT\ OUT}$	O	Output pin for external filter
43	$C_{FILT\ IN}$	I	Input pin for external filter
44	AC CKT IN(-)	I	AC measurement negative input
45	A GND	--	Analog ground
46	NC		No connection. This pin should be open in normal operation
47	REF OUT	O	Built –in bandgap reference voltage output
48	C_{INTL}	I/O	Low-speed A/D integrating capacitor connection
49	$C_{AUTO\ ZERO}$(L)	I/O	Low-speed A/D auto zero capacitor connection
50	R_{INTL}(L)	I/O	Low-speed A/D integrating resistor connection (L)
51	R_{INTL}(H)	I/O	Low-speed A/D integrating resistor connection (H)
52	R MEAS IN	I	Resistor and current measurement input
53	D MEAS IN	I/O	Diode and current of high range measurement pin
54	I MEAS IN	I	Input for current measurement
55	V MEAS IN	I	Input for voltage measurement
56	1.1111MΩ	I/O	Voltage measurement ÷ 10 attenuator(326.0kΩ range)
57	101.01KΩ	I/O	Voltage measurement ÷ 100 attenuator(32.60kΩ range)
58	10.010 KΩ	I/O	Voltage measurement ÷ 1000 attenuator(3.260kΩ range)

(Continued)

(To be continued)

PIN No.	Symbol	I/O	Description
59	1.0001KΩ	I/O	Voltage measurement ÷ 1000 attenuator(326.0Ω range)
60	10.000MΩ	I/O	Resistance measurement 3.260MΩ range
61	R_{REF} COM	I	Attenuator resistor common connection
62	V_{SS}	--	Negative supply voltage connection of analog circuit
63	D GND	--	Digital ground
64~72	F1~F9	I	Function input pin 1~9
73	$C_{VD\ OUT}$	I/O	Voltage double output
74	C_{VD}(-)	I/O	Voltage double capacitor connection (-)
75	C_{VD}(+)	I/O	Voltage double capacitor connection(+)
76	OUT	O	Beep frequency output (4096Hz)
77	OSC OUT	O	X-tal connection (32.768KHz)
78	OSC IN	I	X-tal connection
79	BP2	O	Backplane 2 of LCD display
80	BP3	O	Backplane 3 of LCD display

FUNCTIONAL DESCRIPTION

1.SC7001Q INTEGRATING DUAL-SLOPE A/D CONVERTER

The SC7001Q consists of a low-speed A/D and a high-speed A/D conversion circuit.

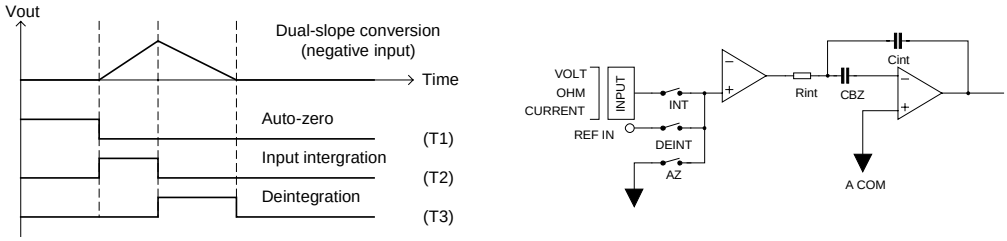
Low-speed A/D conversion circuit

When an analog DC input signal under 320mV is applied, the low-speed conversion proceeds like a sequence of AUTO ZERO (A.Z)→INTEGRATION (INT) →DEINTEGRATION (DEINT) → AUTO ZERO. One conversion takes 519.7ms is the voltage measurement mode.

The counter data of DEINTEGRATION interval is transferred to the LCD and the output value is determined.

High-speed A/D conversion circuit

Range selection and barograph display operate by the high-speed conversion which is like that of low-speed A/D conversion. One conversion takes 80ms in the voltage measurement mode.



Waveform and block diagram of dual-slope A/D converter (Negative input)

Conversion time

Tim / Speed	T1	T2	T3	Conversion time T1+T2+T3
Low-speed A/D	100ms	200ms	219.7ms(109.8ms)*	519.7ms(409.8ms)
High-speed A/D	40ms	20ms	20ms(10ms)	80ms(70ms)

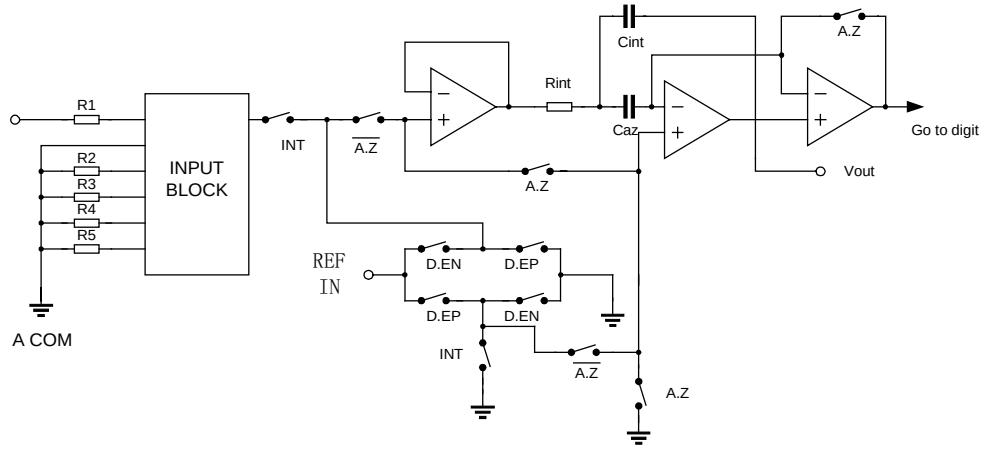
* : The value of parenthesis is for current measurement mode.

2.VOLTAGE MEASUREMENT

In the voltage measurement mode, input impedance is very high because input signal is applied to the integrator through a internal buffer amplifier.

Ranges are automatically changed by internal switch select a proper route and attenuate an unknown voltage input to the ratio of 1/1, 1/10, 1/100, 1/1000, 1/10000. 1.1111MΩ, 101.10KΩ, and 1.0001KΩ of attenuator resistors are connected to 10MΩ resistor tandemly.

Range	Attenuator (in tandem)	Attenuation ratio	Resolution
326.0(R1)	10	1	0.1mV
3.260(R2)	10M&1.1111MΩ	1/10	1 mV
32.60(R3)	10M&101.01KΩ	1/100	10 mV
326.0(R4)	10M&10.01KΩ	1/1000	100 mV
3260(R15)	10M&1.0001KΩ	1/10000	1V

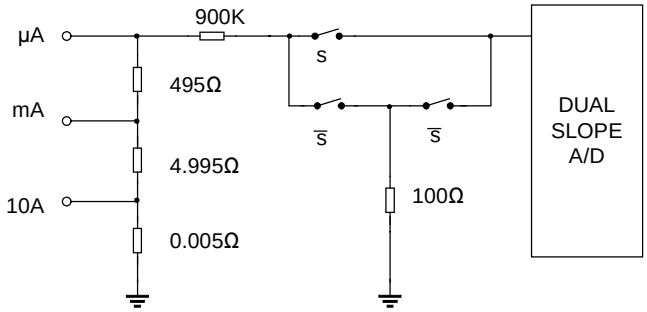


	Counter	Timer	Rint	Vout
INT	3277	200.0ms	327kΩ	(Vin • Tint)/(R • Cint)
DEINT	3800	219.7ms	327 kΩ	VOUT-(Vref •Tdeint)/(R• Cint)

3.CURRENT MEASUREMENT

Input terminals consist of μA, mA, and 10A ranges consist of two auto ranges according to the level of the input.

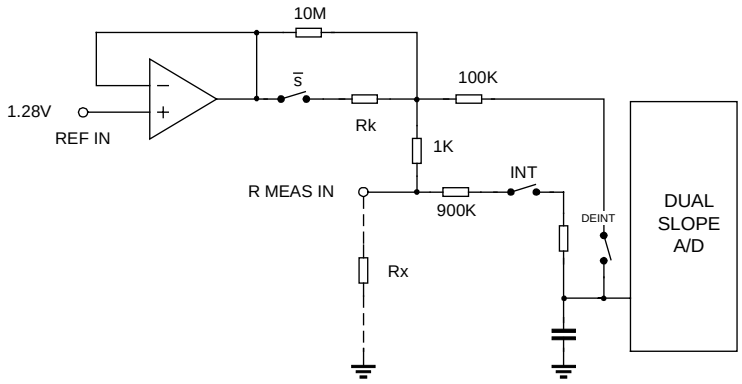
Input terminal	Range	Internal switch	Attenuation ratio	Resolution
μA	326.0μA	S	1	0.1μA
	3260μA	$\overline{S}$	1/10	1μA
mA	32.60 mA	S	1	10μA
	326.0 mA	$\overline{S}$	1/10	1μA
10A	10A	S		



	Counter	Timer	Rint	Vout
INT	3277	200.0ms	327kΩ	
DEINT	3600	109.8ms	327kΩ	VOUT-(Vref •Tdeint/2)/(R• Cint)

4.RESISTANCE CONTINUITY MEASUREMENT

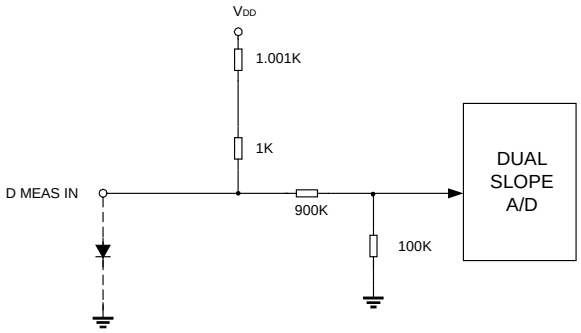
In the resistance measurement mode, each attenuation resistor is connected to a 10MΩ resistor parallelly.



Range			Counter	Time	Rint
Resistance	Except 32.60MΩ	INT	3277	200.0ms	327 kΩ
		DEINT	3600	129.7ms	1 MΩ
	32.60 MΩ	INT	3050	186.0ms	1 MΩ
		DEINT	3600	219.7ms	327 kΩ
Continuity		Same as 326.0Ω range			

5.DIODE TEST

In the diode test mode, if an input voltage is over 2.01V(201counts) then "O.L" is displayed in the LCD and any more measurement is impossible.



FUNCTION AND RANGE TABLE

1.when F5=0

No	F2	F1	F4	F3	F9=1/ F9=0	R1, DP1	R2, DP3	R3, DP2	R4, DP1	R5, DP3	R32M, DP2	Remark
1	0	0	0	0	DC/AC VOLT	•	•	•	•	•	×	TPD
2	0	0	0	1	DC/AC VOLT	•	•	•	•	•	×	
3	0	0	1	0	DC/AC VOLT	•	•	•	•	•	×	
4	0	0	1	1	OHM/Contiuity	•	•	×	×	×	×	F8=0,F9:T
5	0	1	0	0	OPTION only	×	×	×	×	×	×	326m VOLT
6	0	1	0	1	DC VOLT	•	•	•	•	•	×	
7	0	1	1	0	DC VOLT	•	•	•	•	•	×	
8	0	1	1	1	Contiuity /Diode	•))	▶|					
9	1	0	0	0	LCD test	×	×	×	×	×	×	Display 1999
10	1	0	1	0	CD/AC VOLT	•	•	•	•	•	×	
11	1	0	1	1	OHM	•	•	•	•	•	•	F6=1
						•	•	•	•	•	×	F6=0
12	1	1	0	0	OPTION	×	×	×	×	×	×	326m VOLT
13	1	1	0	1	DC/AC mA	×	×	•	•	×	×	
14	1	1	1	0	DC/AC μA	×	×	×	•	•	×	
15	1	1	1	1	DC/AC VOLT	•	•	•	•	•	×	

* R1~R5: Range 1~Range 5.

* R32M: R32M is 32MΩ range of resistance measurement.

* DP1~DP3: Dot point 1, 2, 3 on the LCD.
* F7: Manual Range Hold (to release 'RH', F7=0 during over 1sec).
* F8: Data Hold (by toggling).
* F5: Mode can be changed by a toggle switch with F9 (F9=1→0) when F5=0.
  Mode can be changed by a touch switch with F9 (F9=1→0→1).
* TPD: Auto power off time (10 minutes).
* F1~F9: Initial state using internal pull up (DC 326.0mV Range) . So every function pin (F1~F9) is "1" state unless certain input is given.
* T: Toggle.

2. When F5=1

No	F2	F1	F4	F3	F9=1/ F9=0	R1, DP1	R2, DP3	R3, DP2	R4, DP1	R5, DP3	R32M, DP2	Remark
16	0	0	0	0	DC/AC VOLT	•	•	•	•	•	×	TPD
17	0	0	0	1	DC/AC VOLT	•	•	•	•	•	×	
18	0	0	1	0	DC/AC VOLT	•	•	•	•	•	×	
19	0	0	1	1	OHM	•	•	•	•	•	•	
					CONTINUITY	•	×	×	×	×	×	F9:T
					DIODE	×	•	×	×	×	×	F9:T
20	0	1	1	1	CONTINUITY	•	×	×	×	×	×	
					DIODE	×	•	×	×	×	×	F9:T

3. Auto power off function

Power turned off by 10 minutes unless input value changed within a defined time.

* This function selected as follows.

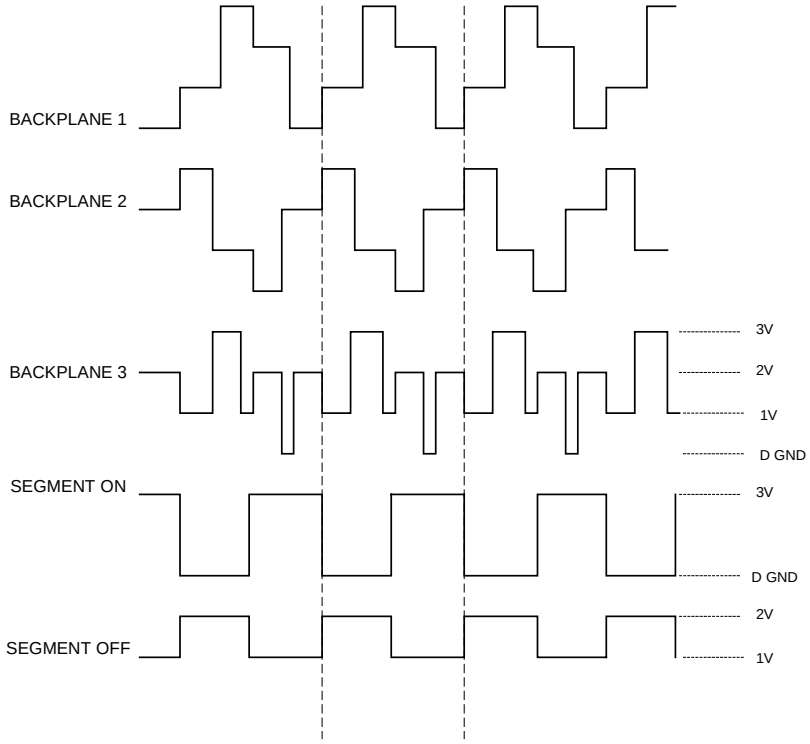
Auto PWR1(Pin30) + Auto PWR2(PIN31)	0+0	1+0	0+1	1+1
POWER	Power on	Auto power off	Off	Off

4.Full display value according to mode

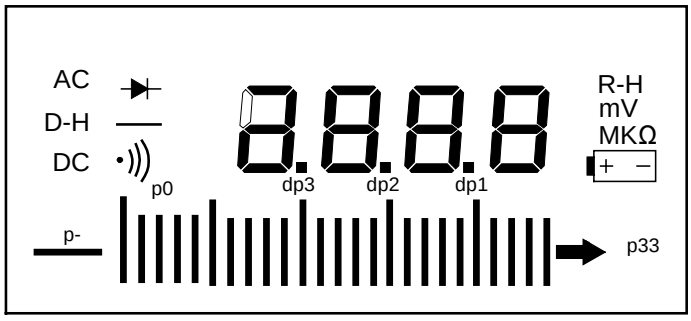
Mode		R1	R2	R3	R4	R5	R32M
Voltage	DC	326.0mV	3.260V	32.60V	3260V		
	AC		3.260V	326.0V	3260V		
Current (AC/CD)	mA		32.60mA	326.0mA			
	μA			326.0μA	3260μA		
Resistance(ohm)		326.0	3.260K	326.0K	3.260M	32.60M	32.60M

DP3 of R4 is not displayed under voltage, current mode.

LCD DRIVE WAVEFORM



LCD DISPLAY

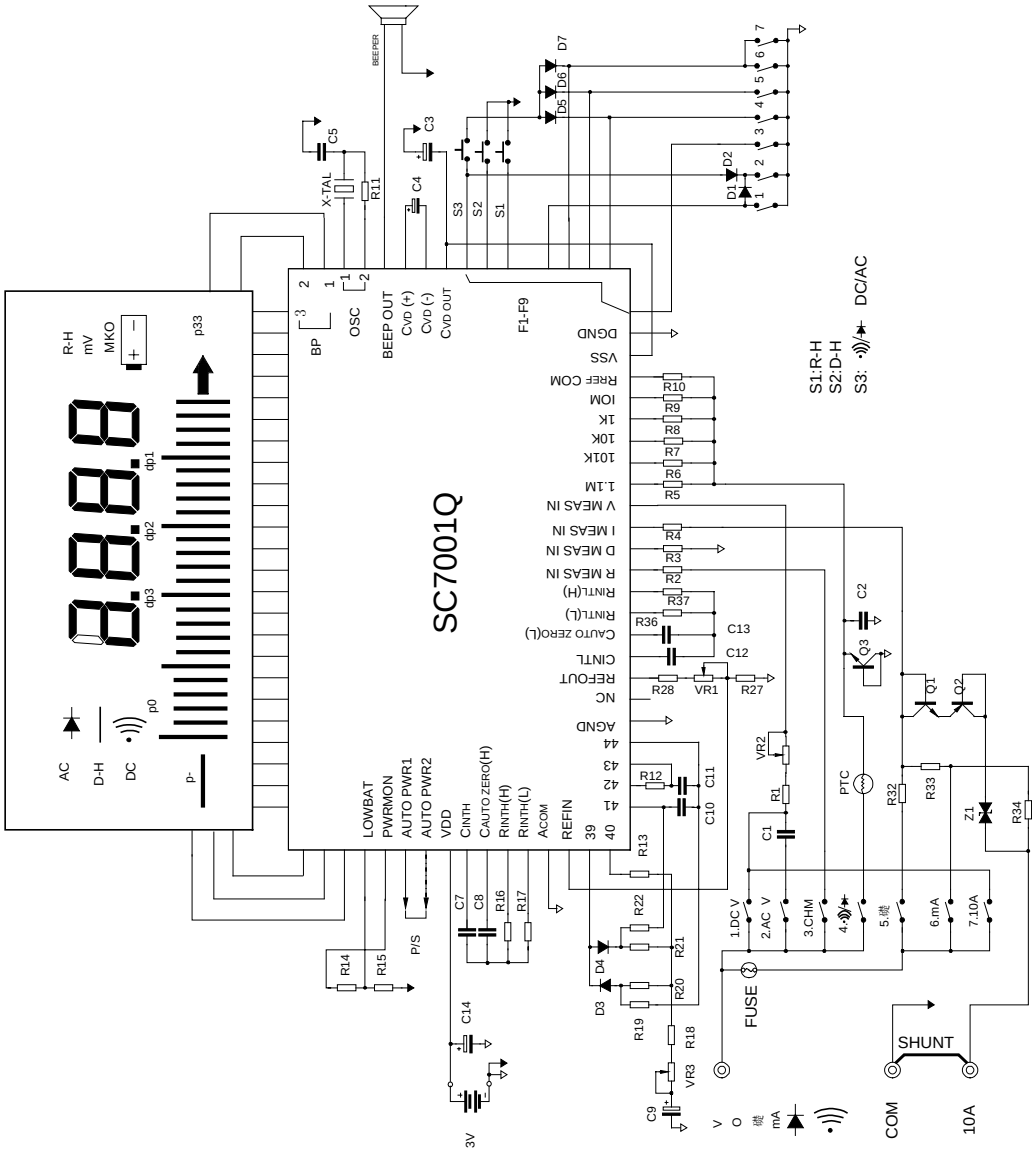


TRIPLEXED LCD DISPLAY FORMAT

BP NO \ IC PIN NO	2	3	4	5	6	7	8	9	10	11	12	13	14
BP2	79	p31	Ω	K	+ −	d0	p30	dp1	d1	p29	dp2	d2	p28	dp3
BP3	80	p32	V	M	c0	g0	e0	c1	g1	e1	c2	g2	e2	c3
BP1	1	p33	R-H	m	b0	a0	f0	b1	a1	f1	b2	a2	f2	b3

BP NO \ IC PIN NO	15	16	17	18	19	20	21	22	23	24	25	26	27
BP2	79	d3	⊣▶⊢	AC	p27	p22	p21	p16	p15	p10	p9	p4	p3	p-
BP3	80	e3	—	D-H	p26	p23	p20	p17	p14	p11	p8	p5	p2	p0
BP1	1	a3,g3	•)))	DC	p25	p24	p19	p18	p13	p12	p7	p6	p1	

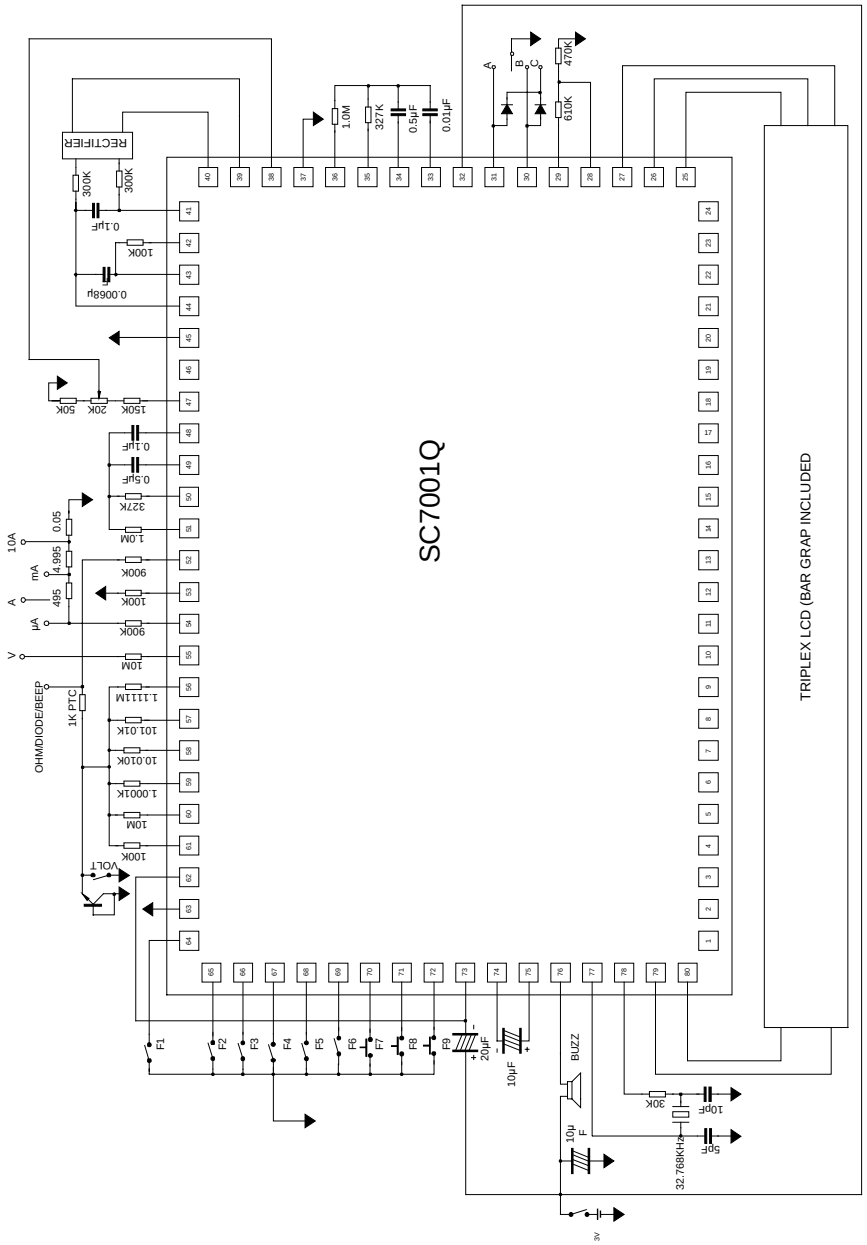
TYPICAL APPLICATION CIRCUIT



COMPONENT VALUE

No	Value	Unit	No	Value	Unit
R1	9900	KΩ	C1	0.022	μF
R2	909	KΩ	C2	0.022	μF
R3	100	KΩ	C3	10	μF
R4	900	KΩ	C4	10	μF
R5	101.01	KΩ	C5	10	pF
R6	101.01	KΩ	C7	0.015	μF
R7	10.01	KΩ	C8	0.22	μF
R8	1.001	KΩ	C9	10	μF
			C10	0.1	μF
R9	10	MΩ	C11	0.0068	μF
R10	100	KΩ	C12	0.15	μF
R11	470	KΩ	C13	1	μF
R12	0.1	MΩ	C14	10	μF
R13	100	KΩ			
			VR1	20	KΩ
R14	160	KΩ	VR2	200	KΩ
R15	150	KΩ	VR3	500	Ω
R16	324	KΩ			
R17	1	MΩ	D1	1N4148	
R18	8.2	KΩ	D2	1N4148	
R19	100	KΩ	D3	1N4148	
R20	10	KΩ	D4	1N4148	
R21	10	KΩ	D5	1N4148	
R22	100	KΩ	D6	1N4148	
			D7	1N4148	
R27	50	KΩ			
R28	150	KΩ	Q1	C2500	
R32	39	Ω	Q2	C2500	
R33	495	Ω	Q3	C945	
R34	4.995	Ω	X-Tal	32768	Hz
R36	324	KΩ			
R37	990	KΩ	Z1	ZENAMIC 220	

TEST CIRCUIT



PACKAGE OUTLINE