

Datasheet

FS9168-015

FS9168 standard code for digital clinical thermometer application

FOR FORTUNE'S
Properties
For Reference Only

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1. General Description

The FS9168-015 is a digital clinical thermometer IC for body temperature measurement. It provides fever alarm and auto power off functions. LCD driver and voltage doubler are included for LCD display. The other functions are one-key on/off switch, memory function, buzzer frequency selection and embedded low battery detection.

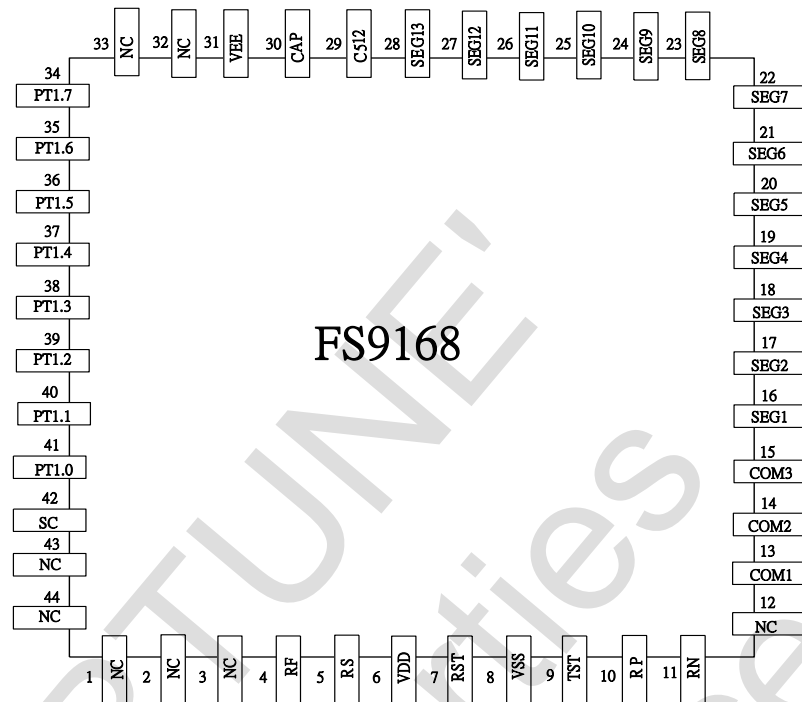
2. Features

- 1.5V battery operation; operation current is less than 100 μ A, and sleep mode current is less than 1 μ A.
- Measurement range: +32.00 ~ +43.00°C, Accuracy 0.1°C, Resolution 0.01°C.
- Centigrade/Fahrenheit measurement selection.
- Alarm warning for fever.
- Highest temperature hold.
- Auto power off after 5 min.
- Memory function for last time measurement.
- Buzzer output frequency selection.
- Embedded low battery detection, 1.35V $\pm$ 0.05 V.

3. Ordering Information

Product Number	Package Type
FS9168-015	Dice form of 36 pin, or 44 pin LQFP

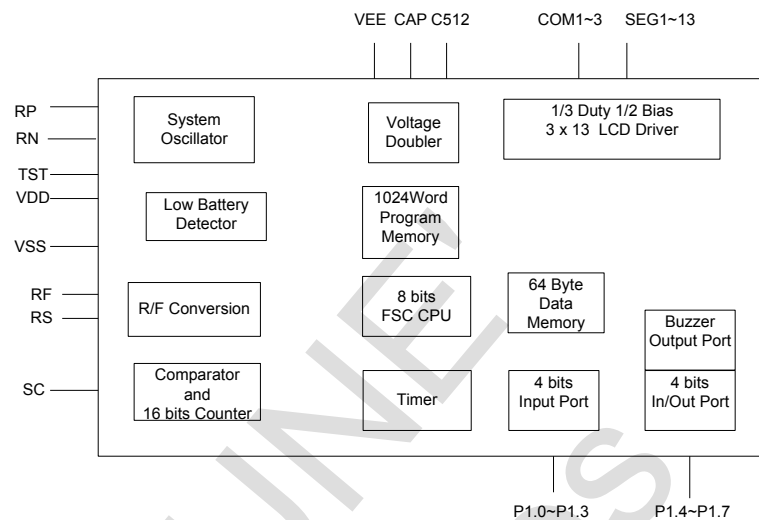
4. Pin Configuration



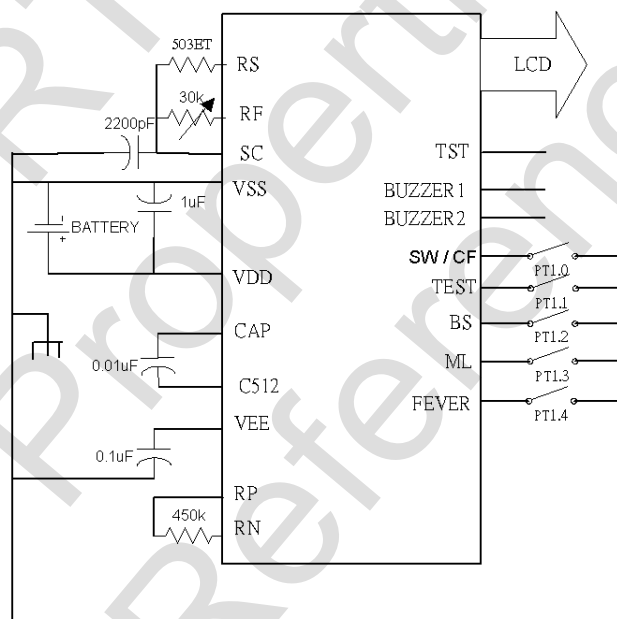
5. Pin Description

Name	In/Out	Pad NO.	Description
VDD	I	3	Positive input of power supply (1.5V)
VSS	I	5	Negative input of power supply
TST	I	6	Test pin for IC
RP	I/O	7	System oscillator external resistor connection (450k)
RN	I/O	8	System oscillator external resistor connection (450k)
VEE	I/O	27	Voltage doubler output (+3.0V)
CAP	I/O	26	Voltage doubler capacitor positive terminal
C512	I/O	25	Voltage doubler capacitor negative terminal
COM1~3	O	9~11	LCD common driver
SEG1~13	O	12~24	LCD segment driver
RF	I	1	Reference resistor connection
RS	I	2	Sensor resistor connection
SC	I	36	Comparator input
P1.0~P1.3	I	32~35	Input Ports
P1.4~P1.7	I/O	28~31	In/Out Ports
RST	I	4	CPU Reset Pin

6. Functional Block Diagram



7. Typical Application Circuit



- SW (PT1.0): Power on/off switch
- TEST (PT1.1): Resistance Reference Test. Close the switch during test
- BS (PT1.2): Buzzer frequency select (Close is 4KHz , Open is 8 KHz, When RP,RN is 450KΩ)
- ML (PT1.3): Memory function select (Close Select Memory, Open No Memory)
- FEVER (PT1.4): Fever warning function select (Close Select FEVER warning function, Open “one Beep” When Measure stable)
- C/F (PT1.0) : °C and °F unit select (When power off, press and hold power switch over 2 seconds)
- BUZZER1 and BUZZER2 (PT1.6 , PT1.7): Buzzer frequency out

8. Absolute Maximum Ratings

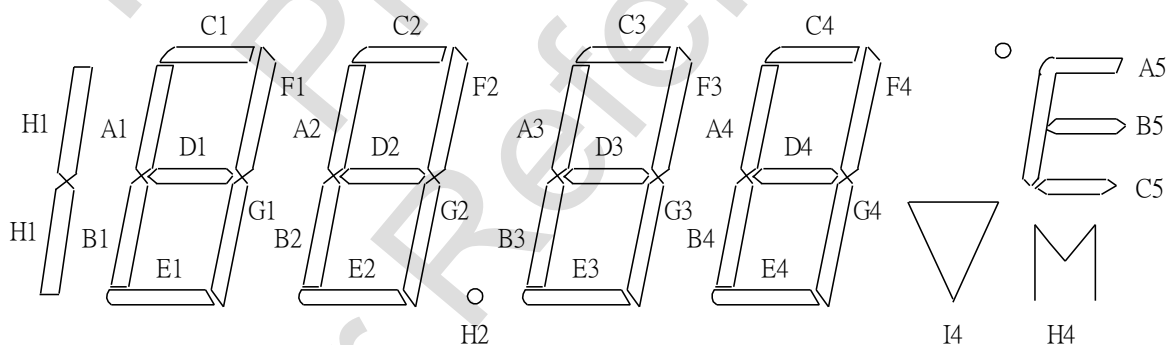
Parameter	Rating	Unit
Supply Voltage to Ground Potential	-0.3 to 1.65	V
Applied Input/Output Voltage	-0.3 to VDD+0.15	V
Ambient Operating Temperature	0 to +70	°C
Storage Temperature	-55 to +150	°C
Soldering Temperature, Time	260°C, 10 Sec	

9. Electrical Characteristics

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
VDD	Recommended Operation Voltage		1.2	1.5	1.65	V
IDD	Supply Current	CPU, R2F ADC On		40	60	μA
IPO	Power off Current	At Sleep mode	0.1	0.2	1.0	μA
FOSC	System Clock	ROSC=350k, VDD=1.5V	25.6	32	38.4	KHz
RNE	Resistance Non-Linearity Error	Rin=22k~38k			0.2	%

10. LCD Pin Assignment

LCD PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				SEG1	SEG2	SEG3	SEG4	SEG5	SEG6	SEG7	SEG8	SEG9	SEG10	SEG11	SEG12	SEG13
COM1	COM1			A1	C1	F1	A2	C2	F2	A3	C3	F3	A4	C4	F4	A5
COM2		COM2		B1	D1	G1	B2	D2	G2	B3	D3	G3	B4	D4	G4	B5
COM3			COM3	H1	E1			E2	H2		E3		I4	E4	H4	C5



11. Function Description

Power Switch

Press to turn on or turn off the power.

Operation Procedure

Turn on the power: When press the switch, the system will sound one “beep”.

- a. At first the system will display all LCD signals about 2 seconds.
- b. Following step a, if press and hold the key over 2 seconds, user can select unit status $^{\circ}\text{C}$ or $^{\circ}\text{F}$.
- c. Following step b, it depends on the memory function. If the memory function exists, then jump to step d;
if no memory function, the system will display 36.50°C instead of the memory symbol, then jump to step i.
- d. Following step c, if the memorized temperature is between $32^{\circ}\text{C} \sim 43^{\circ}\text{C}$, the system will display the last time measured temperature value about 3 seconds and the memory symbol; if it is out of the range ($<32^{\circ}\text{C}$ or $>43^{\circ}\text{C}$), the system will display 36.50°C and not display the memory symbol.
- e. Test the resistance reference to see whether it is normal or not. If it is normal, the system will display 37.00°C about 1 second, then jump to step f; if it is abnormal, the system will display Err and recycle in step e.
- f. Display the highest measured temperature value. In the meantime, $^{\circ}\text{C}$ signal will flash with frequency about 1Hz.
- g. If the temperature is lower than 32.00°C , the system displays Lo $^{\circ}\text{C}$.
- h. If the temperature is higher than 43.00°C , the system displays Hi $^{\circ}\text{C}$.
- i. If the temperature is between $32.00^{\circ}\text{C} \sim 43.00^{\circ}\text{C}$, the system will display the highest measured temperature value.
- j. If the temperature keeps unchanged over 8 seconds, the temperature has reached the desired stable reading. The measurement is over and $^{\circ}\text{C}$ signal will stop flashing.
- k. If fever warning is enabled, jump to step l; if not, the system will beep one sound and jump to step m.
- l. When the temperature is higher than 37.50°C , the beeper will sound “beep-beep-beep---beep-beep-beep---” about 4 seconds. The sound would be as follow:

Beep(0.125 seconds) — (0.125 seconds) Beep(0.125 seconds) — (0.125 seconds)
Beep(0.125 seconds) ——— (0.375 seconds) 4 times

When the temperature is lower than or equal to 37.50°C , the beeper will sound “beep-beep-beep-beep-” about 4 seconds. The sound would be as follow:

Beep(0.5 second) — (0.5 second) Beep(0.5 second) — (0.5 second) Beep(0.5 second)
—— (0.5 second) Beep(0.5 second)

- m. After measurement is over, if the temperature keeps unchanged for 5 minutes, the system will beep one sound and turn off automatically.
- n. If the temperature changes (larger than or equal to 0.05°C) within 5 minutes, $^{\circ}\text{C}$ signal will flash again (repeat step f), then start to recount 5 minutes.
- o. When beeper sounds (within 4 seconds proximately), the system will not measure temperature.

Power off

The system will enter sleep mode. The current consumption is $\leq 1\mu\text{A}$.

Buzzer frequency

The Buzzer frequency can be selected with external pin to be 4kHz or 8kHz.

Measurement Resolution

The smallest measurement resolution for $^{\circ}\text{C}$ is 0.01.

Sensor Type

The sensor type uses 503ET.

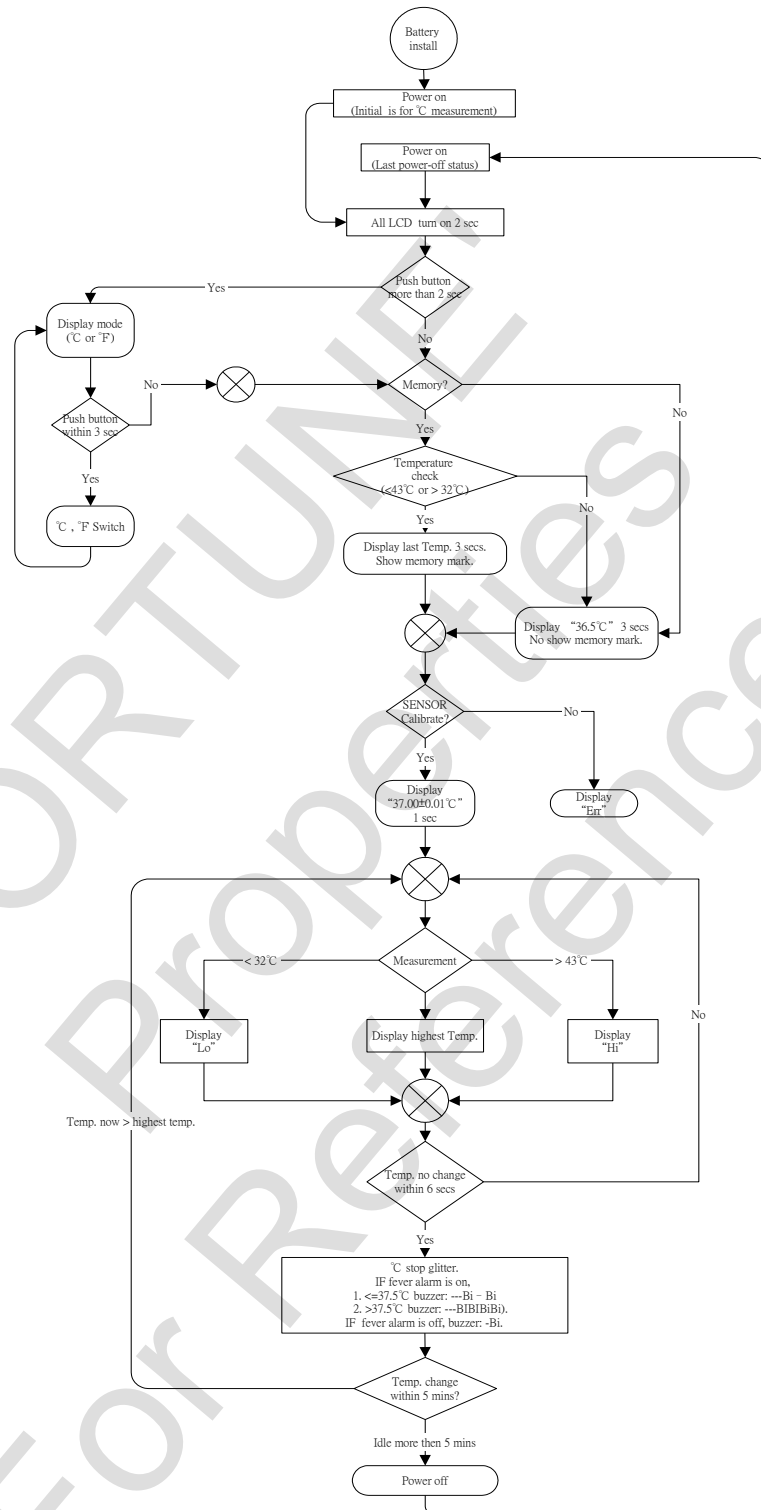
Resistance reference value

Resistance reference value is the thermistor resistance at 37.00°C .

Others

- When the temperature is not in the measuring range (Hi or Lo), the low voltage indication and “M” flag won’t display.
- When the voltage of the battery is too low, the battery symbol “ ” will flash. The frequency is about 1Hz, and the measured results are not always accurate; Detecting voltage: 1.35V 0.05V.
- During production in the factories, TEST pin is shorted for adjusting reference resistance value (R_F). In this situation, the temperature reading is the temperature of the test environment (such as the temperature tank). The display will jump up or down, and won’t keep the highest value.

12. Program Flow Chart



$$^{\circ}\text{C} = (5 / 9) \times (^{\circ}\text{F} - 32) \quad , \quad ^{\circ}\text{F} = ((9 / 5) \times ^{\circ}\text{C}) + 32$$

13. FS9168-015 R2F Converter Linearity Measured Data

Definition

Reference resistance R_f is converted to frequency value CF_{rf} . Thermistor resistance R_s is converted to frequency value CF_{rs} . $Temp = (CF_{rs} / CF_{rf}) * T_a$. R_f is the resistance value when the thermistor is at $37^\circ C$. $T_a = 37^\circ C$

Linearity Error Table

- Calculate the linearity error of resistance count readings in temperature range $32^\circ C \sim 43^\circ C$

Linearity Slope Points: Start 26300 Ω ; End 36900 Ω

Reference Resistance $R_f = 30974\Omega$

Count = (Count(R_s) / Count(R_f)) * 3700

Actual Linearity = 10000000/Count

Slope $\delta = (31918 - 23159) \div (36900 - 26300)$

Ideal Linearity Value = $23159 + \delta \times [(R_{s(N)} - R_{s(N-1)})]$

Linearity Error = Ideal Linearity Value - Actual Linearity

Error Percentage = (Linearity Error $\div$ Ideal Linearity Value) $\times$ 100%

Power Source: BATTERY

Measured Resistance Value R_s	Count	Actual Linearity		Ideal Linearity Value	Linearity Error	Error Percentage
26300	4318	23159		23159		
26400	4302	23245	86	23242	-3	-0.01%
26500	4288	23321	76	23324	3	0.01%
26600	4272	23408	87	23407	-1	0%
26700	4257	23491	83	23490	-1	0%
26800	4242	23574	83	23572	-2	-0.01%
26900	4227	23657	83	23655	-2	-0.01%
27000	4213	23736	79	23737	1	0%
27100	4198	23821	85	23820	-1	0%
27200	4184	23901	80	23903	2	0.01%
27300	4169	23987	86	23985	-2	-0.01%
27400	4154	24073	86	24068	-5	-0.02%
27500	4140	24155	82	24151	-4	-0.02%
27600	4126	24237	82	24233	-4	-0.02%
27700	4112	24319	82	24316	-3	-0.01%
27800	4098	24402	83	24398	-4	-0.02%
27900	4084	24486	84	24481	-5	-0.02%
28000	4070	24570	84	24564	-6	-0.02%
28100	4056	24655	85	24646	-9	-0.04%
28200	4043	24734	79	24729	-5	-0.02%
28300	4029	24820	86	24812	-8	-0.03%
28400	4016	24900	80	24894	-6	-0.02%
28500	4002	24988	88	24977	-11	-0.04%
28600	3989	25069	81	25060	-9	-0.04%
28700	3976	25151	82	25142	-9	-0.04%
28800	3963	25233	82	25225	-8	-0.03%
28900	3950	25316	83	25307	-9	-0.04%
29000	3937	25400	84	25390	-10	-0.04%
29100	3924	25484	84	25473	-11	-0.04%
29200	3912	25562	78	25555	-7	-0.03%
29300	3899	25648	86	25638	-10	-0.04%
29400	3887	25727	79	25721	-6	-0.02%
29500	3875	25806	79	25803	-3	-0.01%
29600	3862	25893	87	25886	-7	-0.03%
29700	3850	25974	81	25968	-6	-0.02%
29800	3837	26062	88	26051	-11	-0.04%
29900	3825	26144	82	26134	-10	-0.04%
30000	3813	26226	82	26216	-10	-0.04%
30100	3801	26309	83	26299	-10	-0.04%

30200	3789	26392	83	26382	-10	-0.04%
30300	3778	26469	77	26464	-5	-0.02%
30400	3766	26553	84	26547	-6	-0.02%
30500	3753	26645	92	26630	-15	-0.06%
30600	3742	26724	79	26712	-12	-0.04%
30700	3731	26802	78	26795	-7	-0.03%
30800	3719	26889	87	26877	-12	-0.04%
30900	3707	26976	87	26960	-16	-0.06%
31000	3696	27056	80	27043	-13	-0.05%
31100	3685	27137	81	27125	-12	-0.04%
31200	3674	27218	81	27208	-10	-0.04%
31300	3663	27300	82	27291	-9	-0.03%
31400	3651	27390	90	27373	-17	-0.06%
31500	3641	27465	75	27456	-9	-0.03%
31600	3630	27548	83	27539	-9	-0.03%
31700	3619	27632	84	27621	-11	-0.04%
31800	3608	27716	84	27704	-12	-0.04%
31900	3597	27801	85	27786	-15	-0.05%
32000	3587	27878	77	27869	-9	-0.03%
32100	3576	27964	86	27952	-12	-0.04%
32200	3565	28050	86	28034	-16	-0.06%
32300	3555	28129	79	28117	-12	-0.04%
32400	3544	28217	88	28200	-17	-0.06%
32500	3534	28297	80	28282	-15	-0.05%
32600	3524	28377	80	28365	-12	-0.04%
32700	3513	28466	89	28447	-19	-0.07%
32800	3503	28547	81	28530	-17	-0.06%
32900	3493	28629	82	28613	-16	-0.06%
33000	3484	28703	74	28695	-8	-0.03%
33100	3474	28785	82	28778	-7	-0.02%
33200	3463	28877	92	28861	-16	-0.06%
33300	3454	28952	75	28943	-9	-0.03%
33400	3443	29044	92	29026	-18	-0.06%
33500	3434	29121	77	29109	-12	-0.04%
33600	3426	29189	68	29191	2	0.01%
33700	3416	29274	85	29274	0	0%
33800	3406	29360	86	29356	-4	-0.01%
33900	3397	29438	78	29439	1	0%
34000	3387	29525	87	29522	-3	-0.01%
34100	3377	29612	87	29604	-8	-0.03%
34200	3367	29700	88	29687	-13	-0.04%
34300	3358	29780	80	29770	-10	-0.03%
34400	3348	29869	89	29852	-17	-0.06%
34500	3340	29940	71	29935	-5	-0.02%
34600	3331	30021	81	30017	-4	-0.01%
34700	3322	30102	81	30100	-2	-0.01%
34800	3312	30193	91	30183	-10	-0.03%
34900	3303	30276	83	30265	-11	-0.04%
35000	3295	30349	73	30348	-1	0%
35100	3286	30432	83	30431	-1	0%
35200	3277	30516	84	30513	-3	-0.01%
35300	3268	30600	84	30596	-4	-0.01%
35400	3259	30684	84	30679	-5	-0.02%
35500	3251	30760	76	30761	1	0%
35600	3242	30845	85	30844	-1	0%
35700	3234	30921	76	30926	5	0.02%
35800	3225	31008	87	31009	1	0%
35900	3217	31085	77	31092	7	0.02%
36000	3208	31172	87	31174	2	0.01%
36100	3199	31260	88	31257	-3	-0.01%
36200	3191	31338	78	31340	2	0.01%
36300	3182	31427	89	31422	-5	-0.02%
36400	3174	31506	79	31505	-1	0%
36500	3166	31586	80	31587	1	0%

36600	3158	31666	80	31670	4	0.01%
36700	3149	31756	90	31753	-3	-0.01%
36800	3141	31837	81	31835	-2	-0.01%
36900	3133	31918	81	31918	0	0%

- Calculate the linearity error of resistance count readings in temperature range 32°C~37°C

Linearity Slope Points: Start 26300Ω; End 30800Ω

Reference Resistance $R_F = 30974\Omega$

Count = (Count(R_S) / Count(R_F)) * 3700

Actual Linearity = 10000000/Count

Slope $\delta = (26976 - 23159) \div (30900 - 26300)$

Ideal Linearity Value = 23159 + $\delta \times [(R_{S(N)} - R_{S(N-1)})]$

Linearity Error = Ideal Linearity Value - Actual Linearity

Error Percentage = (Linearity Error $\div$ Ideal Linearity Value) $\times$ 100%

Power Source: BATTERY

Measured Resistance Value R_S	Count	Actual Linearity	Ideal Linearity Value	Linearity Error	Error Percentage
26300	4318	23159	23159		
26400	4302	23245	23242	-3	-0.01%
26500	4288	23321	23325	4	0.02%
26600	4272	23408	23408	0	0%
26700	4257	23491	23491	0	0%
26800	4242	23574	23574	0	0%
26900	4227	23657	23657	0	0%
27000	4213	23736	23740	4	0.02%
27100	4198	23821	23823	2	0.01%
27200	4184	23901	23906	5	0.02%
27300	4169	23987	23989	2	0.01%
27400	4154	24073	24072	-1	0%
27500	4140	24155	24155	0	0%
27600	4126	24237	24238	1	0%
27700	4112	24319	24321	2	0.01%
27800	4098	24402	24404	2	0.01%
27900	4084	24486	24487	1	0%
28000	4070	24570	24570	0	0%
28100	4056	24655	24653	-2	-0.01%
28200	4043	24734	24736	2	0.01%
28300	4029	24820	24819	-1	0%
28400	4016	24900	24902	2	0.01%
28500	4002	24988	24985	-3	-0.01%
28600	3989	25069	25068	-1	0%
28700	3976	25151	25150	-1	0%
28800	3963	25233	25233	0	0%
28900	3950	25316	25316	0	0%
29000	3937	25400	25399	-1	0%
29100	3924	25484	25482	-2	-0.01%
29200	3912	25562	25565	3	0.01%
29300	3899	25648	25648	0	0%
29400	3887	25727	25731	4	0.02%
29500	3875	25806	25814	8	0.03%
29600	3862	25893	25897	4	0.02%
29700	3850	25974	25980	6	0.02%
29800	3837	26062	26063	1	0%
29900	3825	26144	26146	2	0.01%
30000	3813	26226	26229	3	0.01%
30100	3801	26309	26312	3	0.01%
30200	3789	26392	26395	3	0.01%
30300	3778	26469	26478	9	0.03%
30400	3766	26553	26561	8	0.03%

30500	3753	26645	26644	-1	0%
30600	3742	26724	26727	3	0.01%
30700	3731	26802	26810	8	0.03%
30800	3719	26889	26893	4	0.01%

- Calculate the linearity error of resistance count readings in temperature range 37°C ~43°C

Linearity Slope Points: Start 30900Ω; End 36900Ω

Resistance Reference $R_F = 30974\Omega$

Count = (Count(R_S) / Count(R_F)) * 3700

Actual Linearity = 10000000/Count

Slope $\delta = (31918 - 23159) \div (36900 - 30900)$

Ideal Linearity Value = 23159 + $\delta \times [(R_{S(N)} - R_{S(N-1)})]$

Linearity Error = Ideal Linearity Value - Actual Linearity

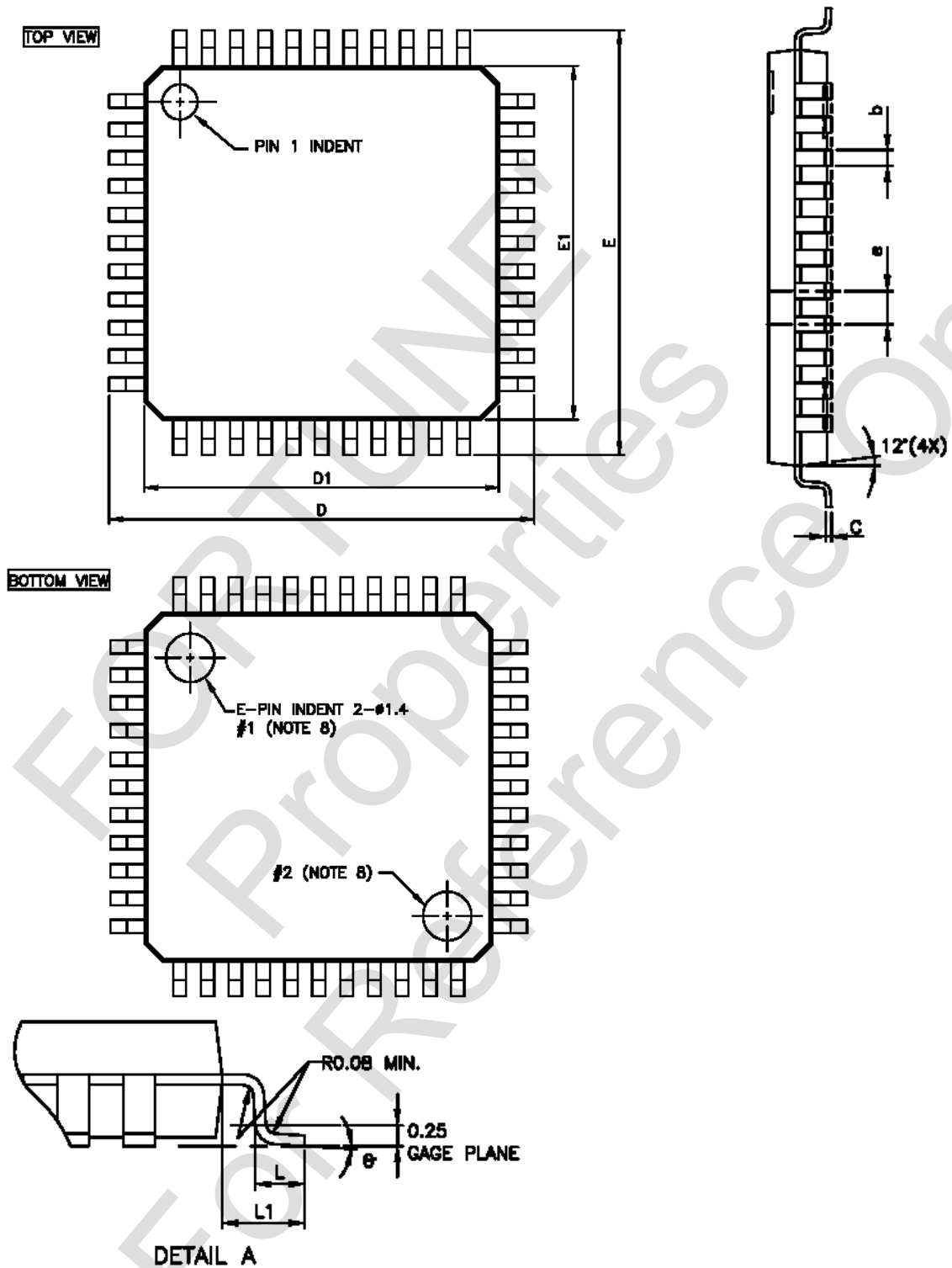
Error Percentage = (Linearity Error $\div$ Ideal Linearity Value) $\times$ 100%

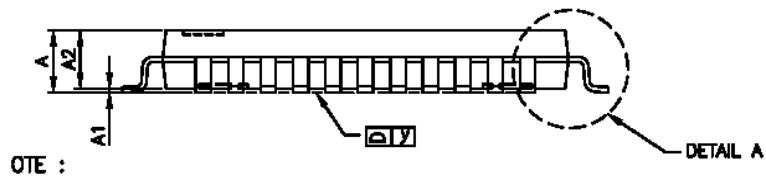
Power Source: BATTERY

Measured Resistance Value R_S	Count	Actual Linearity	Ideal Linearity Value	Linearity Error	Error Percentage
30900	3707	26976	26976	0	0%
31000	3696	27056	27058	2	0.01%
31100	3685	27137	27141	4	0.01%
31200	3674	27218	27223	5	0.02%
31300	3663	27300	27305	5	0.02%
31400	3651	27390	27388	-2	-0.01%
31500	3641	27465	27470	5	0.02%
31600	3630	27548	27553	5	0.02%
31700	3619	27632	27635	3	0.01%
31800	3608	27716	27717	1	0%
31900	3597	27801	27800	-1	0%
32000	3587	27878	27882	4	0.01%
32100	3576	27964	27964	0	0%
32200	3565	28050	28047	-3	-0.01%
32300	3555	28129	28129	0	0%
32400	3544	28217	28212	-5	-0.02%
32500	3534	28297	28294	-3	-0.01%
32600	3524	28377	28376	-1	0%
32700	3513	28466	28459	-7	-0.02%
32800	3503	28547	28541	-6	-0.02%
32900	3493	28629	28623	-6	-0.02%
33000	3484	28703	28706	3	0.01%
33100	3474	28785	28788	3	0.01%
33200	3463	28877	28870	-7	-0.02%
33300	3454	28952	28953	1	0%
33400	3443	29044	29035	-9	-0.03%
33500	3434	29121	29118	-3	-0.01%
33600	3426	29189	29200	11	0.04%
33700	3416	29274	29282	8	0.03%
33800	3406	29360	29365	5	0.02%
33900	3397	29438	29447	9	0.03%
34000	3387	29525	29529	4	0.01%
34100	3377	29612	29612	0	0%
34200	3367	29700	29694	-6	-0.02%
34300	3358	29780	29776	-4	-0.01%
34400	3348	29869	29859	-10	-0.03%
34500	3340	29940	29941	1	0%
34600	3331	30021	30024	3	0.01%
34700	3322	30102	30106	4	0.01%
34800	3312	30193	30188	-5	-0.02%

34900	3303	30276	30271	-5	-0.02%
35000	3295	30349	30353	4	0.01%
35100	3286	30432	30435	3	0.01%
35200	3277	30516	30518	2	0.01%
35300	3268	30600	30600	0	0%
35400	3259	30684	30683	-1	0%
35500	3251	30760	30765	5	0.02%
35600	3242	30845	30847	2	0.01%
35700	3234	30921	30930	9	0.03%
35800	3225	31008	31012	4	0.01%
35900	3217	31085	31094	9	0.03%
36000	3208	31172	31177	5	0.02%
36100	3199	31260	31259	-1	0%
36200	3191	31338	31341	3	0.01%
36300	3182	31427	31424	-3	-0.01%
36400	3174	31506	31506	0	0%
36500	3166	31586	31589	3	0.01%
36600	3158	31666	31671	5	0.02%
36700	3149	31756	31753	-3	-0.01%
36800	3141	31837	31836	-1	0%
36900	3133	31918	31918	0	0%

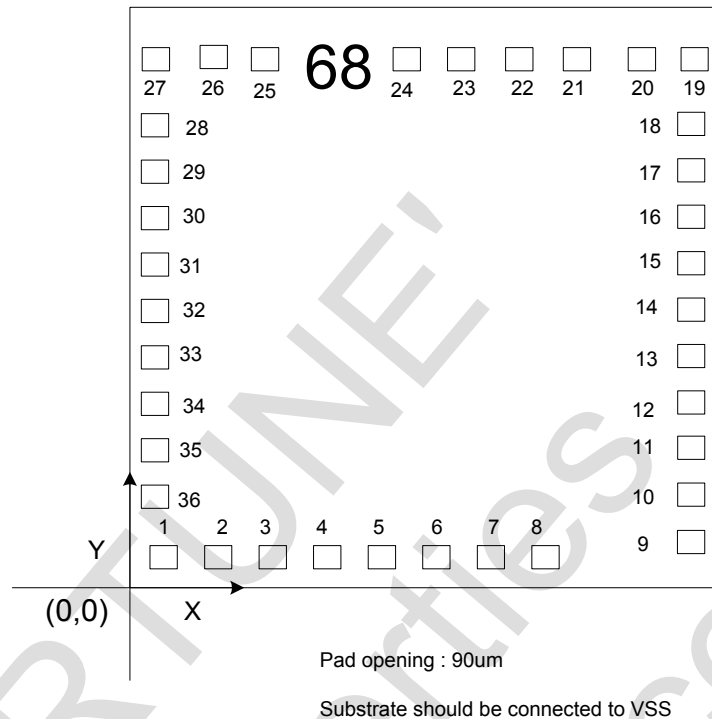
14. Package Outline





SYMBOL	DIMENSIONS IN MILLIMETERS		
	MIN.	NOM.	MAX.
A	—	—	1.60
A1	0.05	—	0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
C	0.09	—	0.20
E	11.80	12.00	12.20
E1	9.90	10.00	10.10
D	11.80	12.00	12.20
D1	9.90	10.00	10.10
e	—	0.80	—
L	0.45	0.60	0.75
L1	—	1.00	—
θ°	θ°	3.5°	7°
v	0.0	—	0.08

15. Pad Assignment



16. Pad Coordinate

※PAD NO: 36 pads

Pad No.	Name	X[um]	Y[um]	Pad No.	Name	X[um]	Y[um]
1	RF	85	74	19	SEG<8>	1335	1406
2	RS	205	74	20	SEG<9>	1205	1406
3	VDD	329	74	21	SEG<10>	1095	1406
4	RST	449	74	22	SEG<11>	975	1406
5	VSS	569	74	23	SEG<12>	855	1406
6	TST	689	74	24	SEG<13>	738	1406
7	RP	809	74	25	C512	331	1406
8	RN	929	74	26	CAP	200	1406
9	COM<1>	1346	87	27	VEE	74	1406
10	COM<2>	1346	205	28	PT1<7>	74	1262
11	COM<3>	1346	324	29	PT1<6>	74	1142
12	SEG<1>	1346	441	30	PT1<5>	74	1021
13	SEG<2>	1346	561	31	PT1<4>	74	902
14	SEG<3>	1346	681	32	PT1<3>	74	772
15	SEG<4>	1346	802	33	PT1<2>	74	650
16	SEG<5>	1346	924	34	PT1<1>	74	531
17	SEG<6>	1346	1041	35	PT1<0>	74	411
18	SEG<7>	1346	1162	36	SC	74	291