

1	Document history	2
2	Description	3
3	Features	3
4	Applications	3
5	Typical Circuit	3
6	Block Diagram	4
7	Functional Description	4
7.1	Sensitivity adjustment.....	4
7.2	Output mode(By TOG, OD, AHLB pad option)	4
7.3	Key operating mode(By SM pad option).....	5
7.4	Maximum key on duration time (By MOT0, MOT1 pad option).....	6
7.5	Fast and Low power mode selection (By LPMB pad option).....	6
7.6	Internal regulator enable/disable	7
8	Pinning / Pad Coordinates	7
9	Operating Conditions	8
9.1	Absolute Maximum Ratings	8
9.2	DC/AC Characteristics	8
10	Application Circuit	9
11	Package Outline	10

1 Document history

Revision	Date	Name	Changes
A	2009/07/27		INITIAL
B	2009/10/02		Modify Output Response Time. Fast Mode : 100ms -> 60ms Low Power Mode : 200ms -> 160ms

2 Description

The ap3004OS is capacitive sensing design specifically for touch pad controls. The device built in regulator for touch sensor. Stable sensing method can cover diversity conditions. Human interfaces control panel links through non-conductive dielectric material. The main application is focused at replacing of the mechanical switch or button. The ASSP can independently handle the 4 touch pads with 4 direct output pins.

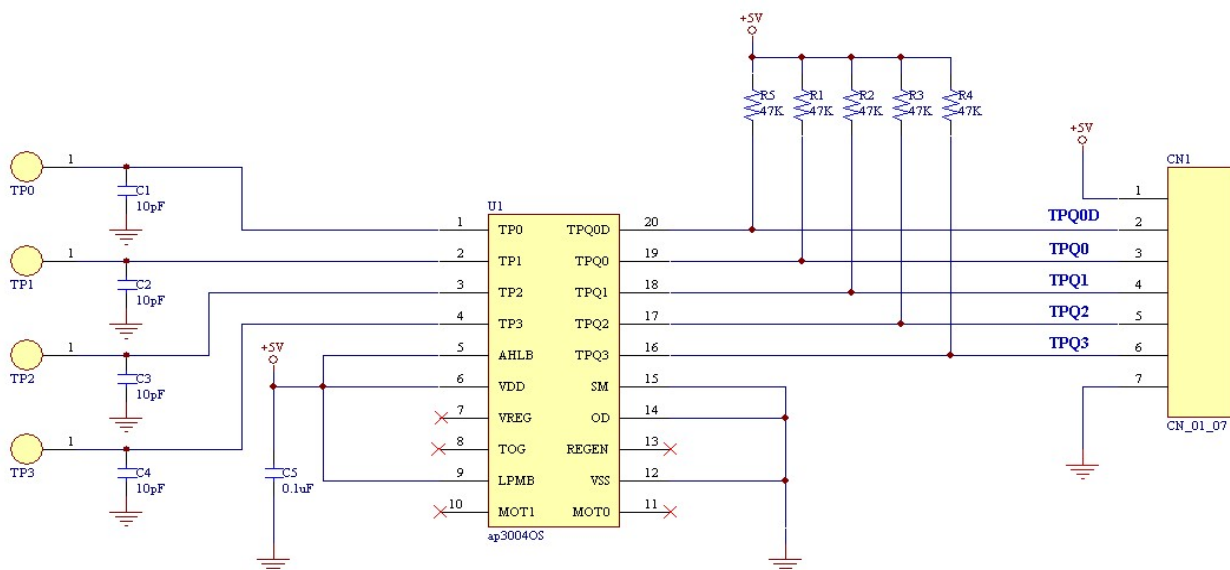
3 Features

- ❑ Operating voltage 2.4V~5.5V
- ❑ Built-in regulator with external enable/disable option
- ❑ Operating current, @VDD=3V no load
 - At low power mode typical 2.5uA
 - At fast mode typical 9.0uA
- ❑ @VDD=3V The response time about 60mS at fast mode, 160mS at low power mode
- ❑ Sensitivity can adjust by the capacitance(0~50pF) outside for each touch pad
- ❑ Provides Fast mode and Low Power mode selection by pad option(LPMB pin)
- ❑ Provides direct mode or toggle mode、CMOS output or open drain output、active high or active low by pad option(TOG/AHLB/OD pin).
- ❑ Have the maximum on time 120sec / 64sec / 16sec/infinite by pad option(MOT1, MOT0 pin)
- ❑ After power-on have about 0.5sec stable-time, during the time do not touch the key pad, and the function is disabled
- ❑ Auto calibration for life, and the re-calibration period is about 4.0sec, when key has not be touched.
- ❑ Package : SSOP-20

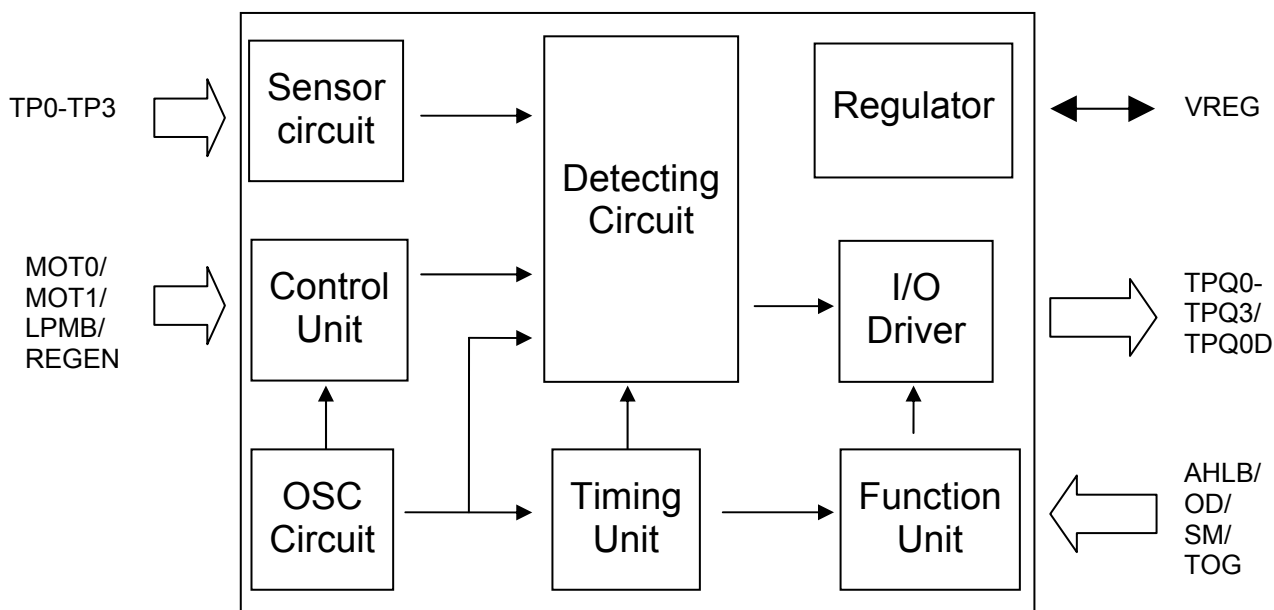
4 Applications

- ❑ Wide consumer products
- ❑ Button key replacement Alternator Controller

5 Typical Circuit



6 Block Diagram



7 Functional Description

7.1 Sensitivity adjustment

The total loading of electrode size and capacitance of connecting line on PCB can affect the sensitivity. So the sensitivity adjustment must according to the practical application on PCB. The ap3004OS offers some methods for adjusting the sensitivity outside.

1-1 by the electrode size

Under other conditions are fixed. Using a larger electrode size can increase sensitivity. Otherwise it can decrease sensitivity. But the electrode size must use in the effective scope.

1-2 by the panel thickness

Under other conditions are fixed. Using a thinner panel can increase sensitivity. Otherwise it can decrease sensitivity. But the panel thickness must be below the maximum value.

1-3 by the value of C1~C4 (please see the down figure)

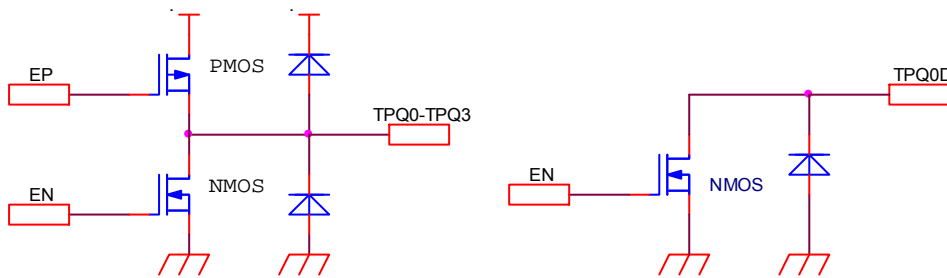
Under other conditions are fixed. Add the capacitors C1~C4 can fine tune the sensitivity for single key, that lets all key's sensitivity identical. When do not use any capacitor to VSS, the sensitivity is most sensitive. When adding the values of C1~C4 will reduce sensitivity in the useful range ($0 \leq C1 \sim C4 \leq 50\text{pF}$).

7.2 Output mode(By TOG, OD, AHLB pad option)

The ap3004OS outputs(TPQ0~TPQ3) has direct mode active high or low by AHLB pad option, has toggle mode by TOG pad option and has open drain(have diode protective circuit) mode by OD pad option. Another TPQ0D is open drain active low output pin has no diode protective circuit.

TOG	OD	AHLB	Pad TPQ0-TPQ3 option feature	Note
0	1	0	Direct mode, CMOS active high output	Default
0	1	1	Direct mode, CMOS active low output	
0	0	0	Direct mode, open drain active high output	
0	0	1	Direct mode, open drain active low output	
1	1	0	Toggle mode, CMOS output, Power on state=0	
1	1	1	Toggle mode, CMOS output, Power on state=1	
1	0	0	Toggle mode, Power on state high-Z, active high	
1	0	1	Toggle mode, Power on state high-Z, active low	

TOG	Pad TPQ0D option features	Note
0	Direct mode, open drain active low output, power on state high-Z	Default
1	Toggle mode, open drain active low output, power on state high-Z	



7.3 Key operating mode(By SM pad option)

SM	Option features	Note
0	Multi-key mode	Default
1	Single key mode	

The ap3004OS has the Single-key and Multi-key functions by SM pad option.

- a. Multi-key mode : the TP0-TP3 can be detected 2 keys or above 2 keys at the same time.
- b. Single-key mode : the TP0-TP3 can be detected 1 key only at the same time, when any key be detected, the other 3 keys can not be detected.

7.4 Maximum key on duration time (By MOT0, MOT1 pad option)

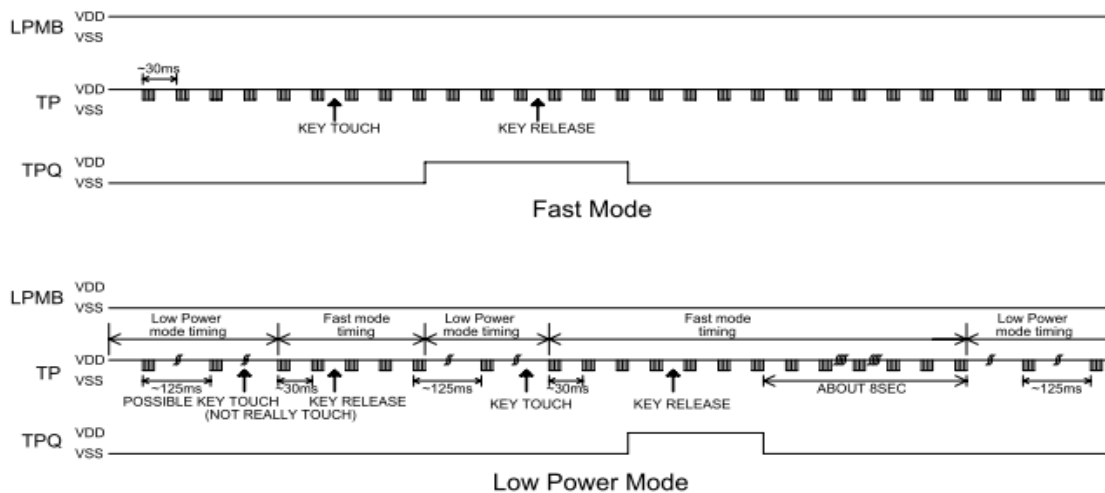
If some objects cover in the sense pad, and causing the change quantity enough to be detected. To prevent this, the ap3004OS sets a timer to monitor the detection. The timer is the maximum on duration time. When the detection is over the timer, the system will return to the power-on initial state, and the output becomes inactive until the next detection.

MOT1	MOT0	Option features	Note
0	0	Maximum on time 120sec	Default
0	1	Maximum on time 64sec	
1	0	Maximum on time 16sec	
1	1	Infinite(Disable maximum on time)	

7.5 Fast and Low power mode selection (By LPMB pad option)

The ap3004OS has Fast mode and Low Power mode to be selected. It depends on the state of LPMB pad. When the LPMB pin is connected to VDD, the ap3004OS runs in Fast mode. When the LPMB pin is opened or connected to VSS, the ap3004OS runs in Low Power mode. In the Fast mode response time is faster, but the current consumption will be increased. In the Low Power mode it will be saving power, but will be slowing response time for first touch. When it awaked in fast mode, the response time is the same the fast mode. In this mode when detecting key touch, it will switch to Fast mode. Until the key touch is released and will keep a time about 8sec. Then it returns to Low Power mode.

The states and timing of two modes please see below figure.



LPMB	Option features	Note
0	Fast Mode	Default
1	Low Power mode	

7.6 Internal regulator enable/disable

The ap3004OS built in regulator in the chip. The regulator can be set enable or disable by the REGEN pin. The REGEN pin is opened or connected to VDD, the regulator is enabled. The REGEN pin is connected to VSS, the regulator is disabled. When the internal regulator is disabled, the VREG pin must be connected to external VDD.

REGEN	Option features	Note
0	Enable internal regulator	Default
1	Disable internal regulator	

8 Pinning / Pad Coordinates

Name	Type ¹⁾	Pin No.	Function
TP0	I	1	Touch pad input pin
TP1	I	2	Touch pad input pin
TP2	I	3	Touch pad input pin
TP3	I	4	Touch pad input pin
AHLB	IPL	5	Output active high or low option, default : low
VDD	P	6	Positive power supply
VREG	P	7	Internal regulator output pin
TOG	IPL	8	Output type option, default : low
LPMB	IPL	9	Low power/fast mode option, default : low
MOT1	IPH	10	Key maximum on time option, default : low
MOT0	IPH	11	
VSS	P	12	Negative power supply, ground
REGEN	I	13	Internal regulator enable/disable function option, default : high
OD	I	14	Output open-drain option, default : high
SM	I	15	Single/multi key option, default : high
TPQ3	O	16	Direct output
TPQ2	O	17	Direct output
TPQ1	O	18	Direct output
TPQ0	O	19	Direct output
TPQ0D	OD	20	Open drain open (have no diode protective circuit), default : low

Notes:

1. I=CMOS Input, IPL=CMOS Input and pull-low resistor, IPH=CMOS Input and pull-high resistor,
O=CMOS Output, OD=Open drain output, P=Power/Ground, I=Input,

9 Operating Conditions

9.1 Absolute Maximum Ratings

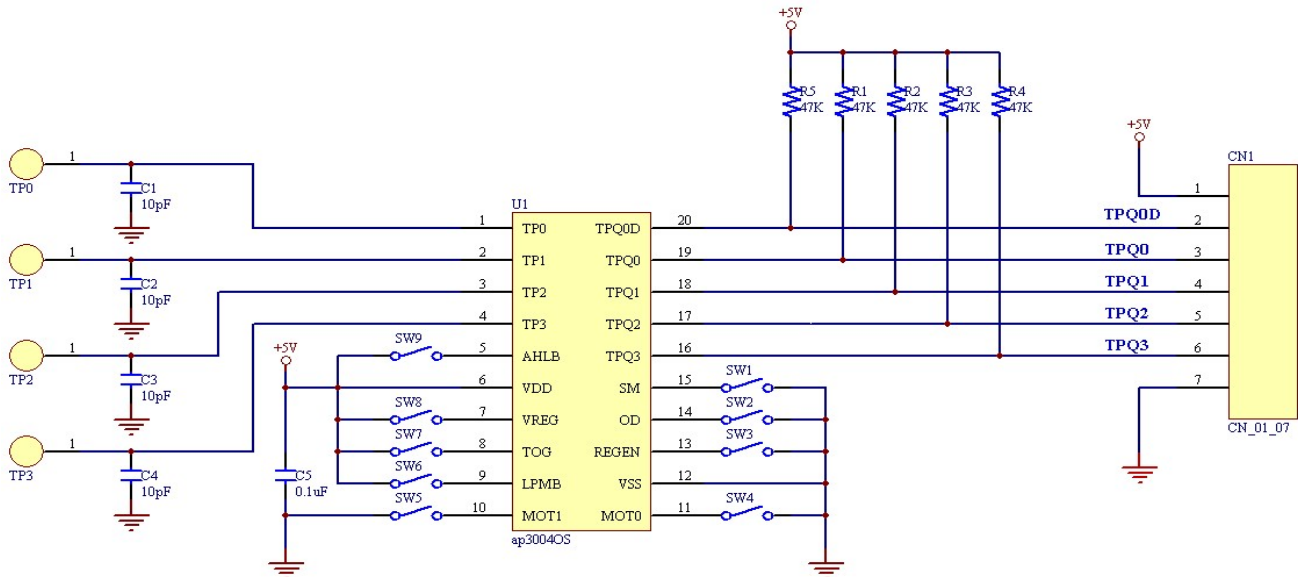
Parameter	Condition	Symbol	Min.	Max.	Unit
Operating Temperature		TA_MAX	-40	+85	°C
Storage Temperature		TST_MAX	-50	+125	°C
Supply Voltage	Ta=25°C	VDD	VSS-0.3	VSS+6.0	V
Input Voltage	Ta=25°C		VSS-0.3	VDD+0.3	V
Human Body Mode				5	KV

Note : VSS symbolizes for system ground

9.2 DC/AC Characteristics

No	Parameter	Condition	Symbol	Min.	Typ	Max.	Unit
1	Operating Voltage	Regulator disable	VDD	2.0		5.5	V
2	Operating Voltage	Regulator enable	VDD	2.4	14	5.5	V
3	Internal Regulator Output		Vreg	2.2	2.3	2.4	V
4	Operating Current	VDD=3V (Regulator enable) @low power mode	Ioc		2.5		uA
		VDD=3V (Regulator enable) @fast mode			9		uA
5	Input Ports	Input low voltage	V _{IL}	0		0.2	VDD
6	Input Ports	Input high voltage	V _{IH}	0.8		1.0	VDD
7	Output Port Sink Current	VDD=3V, VOL=0.6V	I _{OL}		8		mA
8	Output Port Source Current	VDD=3V, VOH=2.4V	I _{OH}		-4		mA
9	Input Pin Pull-high Resistor	VDD=3V	R _{PH}		30K		ohm
10	Input Pin Pull-low Resistor	VDD=3V	R _{PL}		25K		ohm
11	Output Response Time	VDD=3V, @fast mode	T _R		60		ms
		VDD=3V, @low power mode			160		ms

10 Application Circuit



Option Table:

TOG	OD	AHLB	Pad TPQ0-TPQ3 option feature
Open	Open	Open	Direct mode, CMOS active high output
Open	Open	VDD	Direct mode, CMOS active low output
Open	VSS	open	Direct mode, open drain active high output
Open	VSS	VDD	Direct mode, open drain active low output
VDD	Open	Open	Toggle mode, CMOS output, Power on state=0
VDD	Open	VDD	Toggle mode, CMOS output, Power on state=1
VDD	VSS	Open	Toggle mode, Power on state high-Z, active high
VDD	VSS	VDD	Toggle mode, Power on state high-Z, active low

TOG	Pad TPQ0D option features
Open	Direct mode, open drain active low output, power on state high-Z
VDD	Toggle mode, open drain active low output, power on state high-Z

Key operation mode:

SM	Option features
Open	Multi-key mode
VSS	Single key mode

Maximum key on duration time:

MOT1	MOT0	Option features
VSS	VSS	Maximum on time 120sec
VSS	Open	Maximum on time 64sec
Open	VSS	Maximum on time 16sec
Open	open	Infinite(Disable maximum on time)

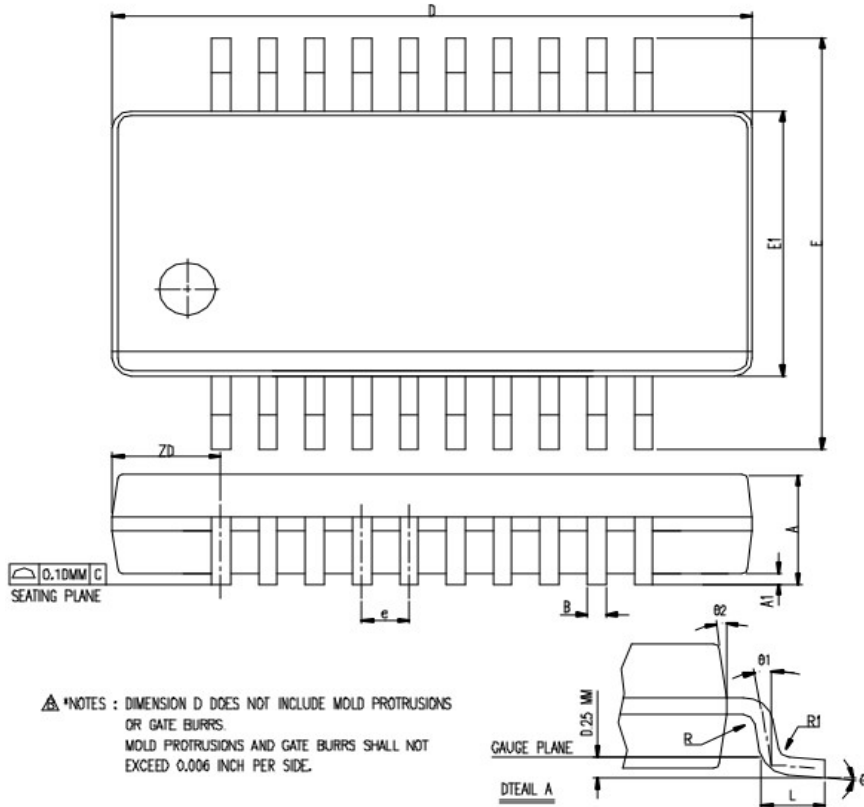
Fast and low power mode:

LPMB	Option features
VDD	Fast Mode
open	Low Power mode

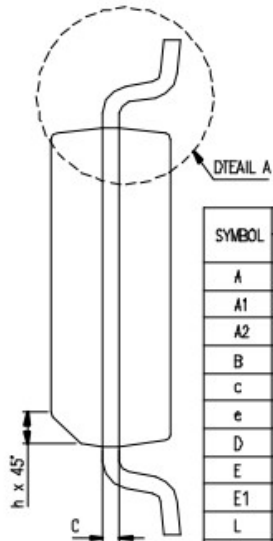
PS:

- On PCB, the length of lines from touch pad to IC pin shorter is better. And the lines do not parallel and cross with other lines.
- The power supply must be stable. If the supply voltage drift or shift quickly, maybe causing sensitivity anomalies or false detections.
- The material of panel covering on the PCB can not include the metal or the electric element. The paints on the surfaces are the same.
- The C5 capacitor must be used between VDD and VSS; and should be routed with very short tracks to the device's VDD and VSS pins (ap3004OS).
- The capacitance C1~C4 can be used to adjust the sensitivity. The value of C1~C4 use smaller, then the sensitivity will be better. The sensitivity adjustment must according to the practical application on PCB. The range of C1~C4 value are 0~50pF.
- The sensitivity adjustment capacitors (C1~C4) must use smaller temperature coefficient and more stable capacitors. Such are X7R, NPO for example. So for touch application, recommend to use NPO capacitor, for reducing that the temperature varies to affect sensitivity.

11 Package Outline



*NOTES : DIMENSION D DOES NOT INCLUDE MOLD PROTRUSIONS OR GATE BURRS.
MOLD PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED 0.006 INCH PER SIDE.



SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	1.63	1.75	0.053	0.064	0.069
A1	0.10	0.15	0.25	0.004	0.006	0.010
A2			1.50			0.059
B	0.20		0.30	0.008		0.012
c	0.18		0.25	0.007		0.010
e	0.635 BASIC			0.025 BASIC		
D	8.56	8.66	8.74	0.337	0.341	0.344
E	5.79	5.99	6.20	0.228	0.236	0.244
E1	3.81	3.91	3.99	0.150	0.154	0.157
L	0.41	0.635	1.27	0.016	0.025	0.050
h	0.25		0.50	0.010		0.020
ZD	1.4732REF			0.058 REF.		
R1	0.20		0.33	0.008		0.013
R	0.20			0.008		
theta	0°		8°	0°		8°
theta1	0°			0°		
theta2	5°	10°	15°	5°	10°	15°
JEDEC	MO-137 (AD)					

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