AK4161

6-channel Capacitive Touch Sensor IC

GENERAL DESCRIPTION

The AK4161 is a low operating voltage and low power consumption 6-channel capacitive touch sensor. Maximum 6 input channels can be configured to LED drive or GPIO. 2 channels out of 6-channel can also be configured to interrupt output. The AK4161 has a channel independent automatic correct function of environmental drifts for each sense input. It reduces false detection by continuous calibration of the internal reference value in the situation when the input capacitance of the touch switch is changed by the external factors such as hydrothermal conditions. The automatic initial setting function sets the charge current and charge time according to the size and the shape of a touch switch. Even more, a noise filter and a false protection filter are integrated. The AK4161 can be configured via serial interfaces, it is suitable for mobile phones, PCs and home electric applications.

FEATURE

- **Up to 6 capacitive sensor inputs**
- **Up to 6 general purpose inputs/outputs with PWM control for LED**
- **Selectable 2 interrupt outputs**
- **Automatic initial setting function for the charge current and time**
- **Independent automatic environmental drifts correct function for each sense terminal**
- **Independent threshold configuration for each sense terminal**
- **Selectable multi touch feature**
- **Integrated Median Averaging Filter**
- **Data Update Stop Function for Noisy Environment**
- **Reset Input pin**
- **I^2C Serial Interface**
- **10 bit SAR A/D Converter with S/H circuit**
- **Integrated Regulator**
- **Low Power Consumption:**
    Typ. 4.1uA (Sampling rate=512ms, 6ch Sensor input, VDD=3.3V, N1S=20)
    Typ. 177uA (Sampling rate=1ms, 6ch Sensor input, VDD=3.3V, N1S=6)
- **Power Down Current: Typ. 1.2uA**
- **Low Power Operation: VDD = 1.6V ~ 3.6V**
- **Operating Temperature: Ta = -40 ~ 85 °C**
- **Package: 16pin QFN (3mm x 3mm, pitch 0.5mm)**

I^2C-bus is a trademark of NXP B.V.

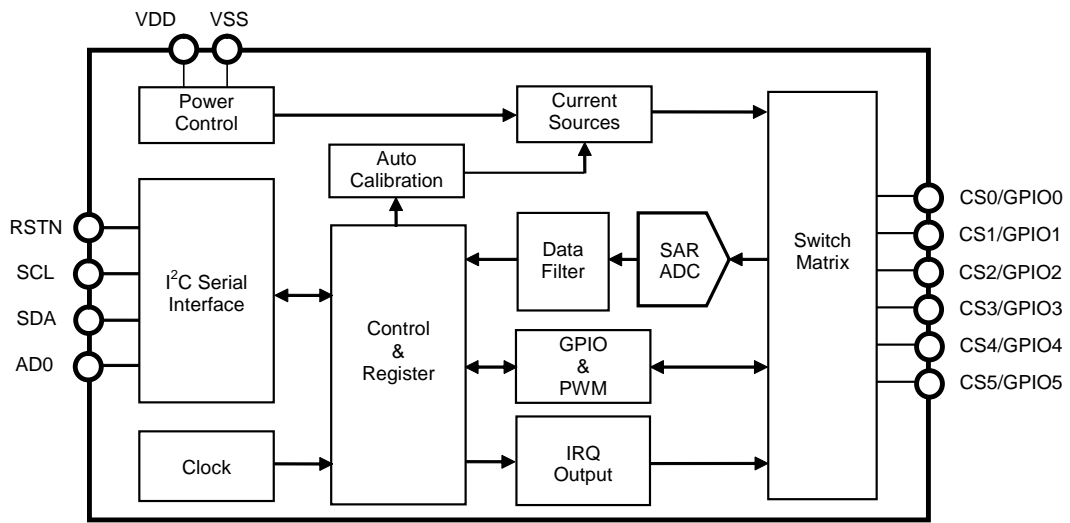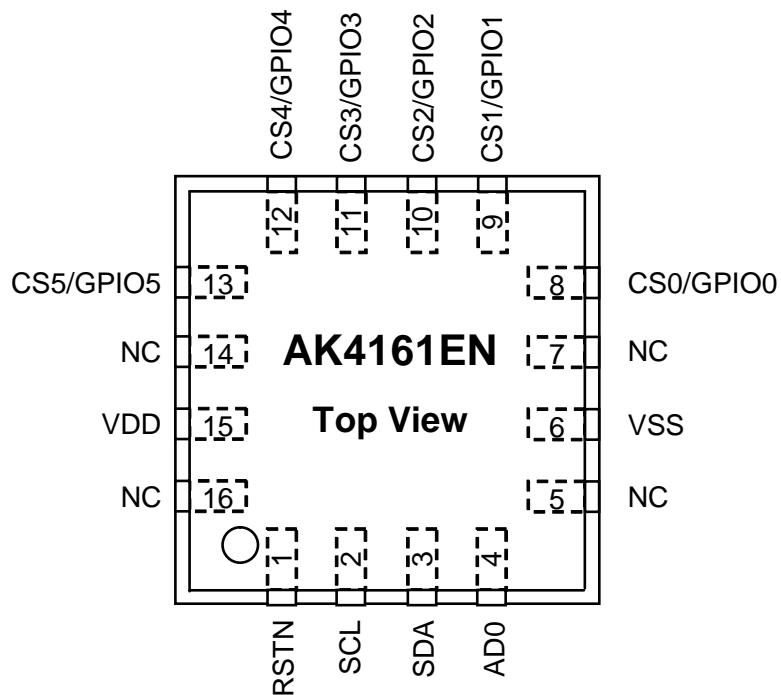Figure 1. Block Diagram

■ Ordering Guide

AK4161EN   −40 ~ +85℃   16pin QFN (3mm x 3mm, 0.5mm pitch)
AKD4161   AK4161EN Evaluation Board

■ Pin Layout

PIN/FUNCTION

Pin No.	Pin Name	Type (Note 1)	I/O (Note 2)	Function	Reset State RSTN = "L"
1	RSTN	D	I	Reset Pin (Active Low)	-
2	SCL	D	I	I²C Serial Clock Input	-
3	SDA	D	I/O	I²C Serial Data Input/ Output	Hi-z
4	AD0	D	I	I²C Slave Address Bit 0	-
6	VSS	GND	-	Ground	-
8	CS0 / GPIO0	A/D	I/O	Cap Sense / GPIO Pin0	Hi-z
9	CS1 / GPIO1	A/D	I/O	Cap Sense / GPIO Pin1	Hi-z
10	CS2 / GPIO2	A/D	I/O	Cap Sense / GPIO Pin2	Hi-z
11	CS3 / GPIO3	A/D	I/O	Cap Sense / GPIO Pin3	Hi-z
12	CS4 / GPIO4	A/D	I/O	Cap Sense / GPIO Pin4 with IRQN	Hi-z
13	CS5 / GPIO5	A/D	I/O	Cap Sense / GPIO Pin5 with IRQN	Hi-z
15	VDD	PWR	-	Power Supply : 1.6V ~ 3.6V	-
5 7 14 16	NC	-	-	No Connection No internal bonding. This pin must be connected to VSS.	-

Note 1. A (Analog terminal), D (Digital terminal), GND (Ground), PWR (Power)
Note 2. I (Input terminal), O (Output terminal)
Note 3. All digital input pins (SCL, SDA, AD0, RSTN) must not be allowed to float.

■ Handling of Unused Pins

The unused I/O pins must be connected appropriately.

Classification	Pin Name	Setting
Analog/Digital	CS0 / GPIO0 ~ CS5/ GPIO5	Pin Connection: Connect to VSS. Register Setting: FUNC (Addr: 0x1F-0x20) = "00"

ABSOLUTE MAXIMUM RATINGS

(VSS = 0V (Note 4))

Parameter	Symbol	min	max	Unit
Power Supply	VDD	-0.3	4.3	V
Input Current Any Pins except for supply	IIN	-	±10	mA
GPIO Source Current per Pin	Isource	-	12	mA
GPIO Sink Current per Pin	Isink	-	1.2	mA
Input Voltage (Note 5)	VIN	-0.3	VDD+0.3 or 4.3	V
Ambient Temperature (power applied)	Ta	-40	85	°C
Storage Temperature	Tstg	-65	150	°C

Note 4. All voltages with respect to ground.
Note 5. For SDA, SCL, AD0, RSTN, CS0/GPIO0 ~ CS5/GPIO5 pins. The maximum value is smaller value between
(VDD+0.3)V and 4.3V.

WARNING: Operation at or beyond these limits may result in permanent damage to the device.
Normal operation is not guaranteed at these extremes.

RECOMMEND OPERATING CONDITIONS

(VSS = 0V (Note 4))

Parameter	Symbol	min	typ	max	Unit
Power Supply	VDD	1.6	3.3	3.6	V

Note 4. All voltages with respect to ground.

WARNING: AKM assumes no responsibility for the usage beyond the conditions in this datasheet.

ANALOG CHARACTERISTICS

(Ta = -40°C ~ 85°C, VDD = 3.3V; unless otherwise specified)

Parameter	Symbol	min	typ	max	Unit
A/D Converter					
Resolution	RESO	-	10	-	Bits
Touch Sensor					
Charge Current Variation Against Nominal Value (Note 6)	ICHG	-30	-	30	%
Power Supply Current					
Measurement Current (All function in active)	IMEAS	-	0.765	-	mA
Idle Current	IIDLE	-	3.15	-	uA
Average Supply Current (Note 7)	IDD				
TSR= 0.25ms		-	687	-	uA
TSR= 0.5ms		-	351	-	uA
TSR= 1ms		-	177	-	uA
TSR= 2ms		-	90	-	uA
TSR= 4ms		-	47	-	uA
TSR=8ms		-	25	-	uA
TSR=16ms		-	14	-	uA
TSR=32ms		-	9	-	uA
TSR=1ms, 20 samplings at 1st order Filter		-	489	-	uA
TSR=32ms, 20 samplings at 1st order Filter		-	18	-	uA
TSR=512ms, 20 samplings at 1st order Filter		-	4.1	-	uA
Shutdown Current (After External Reset)	ISHUT	-	1.2	8.0	uA

Note 6. Sense terminal voltage condition: The AD conversion value should be less or equal to VDD-0.2[V]. (It should be less or equal to VDD-0.3[V] when CC2Xn bit= "1") The charge current is dependent on the operating voltage, and is configured by register settings in the range of "0.556 x VDD [uA]" to "70.056 x VDD [uA]".

Note 7. Measurement Condition: 6 active sense terminals, 2us charge period, 6 samplings at 1st order filter for noise cancelling, using sense terminal with 22pF capacitance.

DC CHARACTERISTICS (Logic I/O)

(Ta = -40°C ~ 85°C, VDD = 1.6V ~ 3.6V; unless otherwise specified)

Parameter	Symbol	min	typ	max	Unit
Input Leakage Current (Note 8)	IILH	-5	-	5	uA
Tri-state Leakage Current (Note 9)	IOLK	-5	-	5	uA
Input High Voltage (Note 10)	VIH	0.7×VDD	-	-	V
Input Low Voltage (Note 10)	VIL	-	-	0.3×VDD	V
Output High Voltage (Note 11) (Note 12) Io=-10mA	VOHF	VDD-0.5	-	-	V
Output High Voltage (Note 11) (Note 13) Io=-1mA	VOH	VDD-0.3	-	-	V
Output Low Voltage (Note 10) (Note 13) Io=1mA	VOL	-	-	0.3	V
Output Low Voltage (Note 14) Io=3mA	VOLI2C	-	-	0.3	V

Note 8. RSTN pin
Note 9. AD0, SCL, SDA, GPIO0~GPIO5 pins
Note 10. GPIO0 ~ GPIO5 pins (FUNCn 1-0 bits = "01", GPIO input setting)
Note 11. GPIO0 ~ GPIO5 pins (FUNCn 1-0 bits = "10", GPIO output setting)
Note 12. Full Drive Operation (Output Driver Setting: DRVn1-0 bits = "11")
Note 13. Normal Drive Operation (Output Driver Setting: DRVn1-0 bits = "00", "01", "10")
Note 14. SDA pin

SWITCHING CHARACTERISTICS

(Ta = -40°C ~ 85°C, VDD = 1.6V ~ 3.6V; unless otherwise specified)

Parameter	Symbol	min	typ	max	Unit
Internal Oscillator					
Fast Oscillator Period	FPRD	75	125	175	ns
Slow Oscillator Period	SPRD	21	32	43	us
Reset Timing					
Reset Pulse Width (Note 15)	tRW	10	-	-	us
Reset Pin Pulse Width of Spike Noise Suppressed by Input Filter (Note 16)	tRS	0.5	-	-	us
I2C					
SCL clock frequency	f_{SCL}	-	-	400	kHz
Bus Free Time Between Transmissions	tBUF	1.3	-	-	us
Start Condition Hold Time (prior to first Clock pulse)	tHD:STA	0.6	-	-	us
Clock Low Time	tLOW	1.3	-	-	us
Clock High Time	tHIGH	0.6	-	-	us
Setup Time for Repeated Start Condition	tSU:STA	0.6	-	-	us
SDA Hold Time from SCL Falling (Note 17)	tHD:DAT	0	-	-	us
SDA Setup Time from SCL Rising	tSU:DAT	0.1	-	-	us
Rise Time of Both SDA and SCL Lines	tR	-	-	0.3	us
Fall Time of Both SDA and SCL Lines	tF	-	-	0.3	us
Setup Time for Stop Condition	tSU:STO	0.6	-	-	us
Pulse Width of Spike Noise Suppressed By Input Filter	tSP	50	-	-	ns
Capacitive load on bus	Cb	-	-	400	pF

Note 15. The AK4161 can be reset by the RSTN pin = "L". Keep "L" period for 10us or more for a certain reset.
Note 16. Pulse width of spike noise suppressed by input filter of the RSTN pin.
Note 17. Data must be held for sufficient time to bridge the 300ns transition time of SCL.
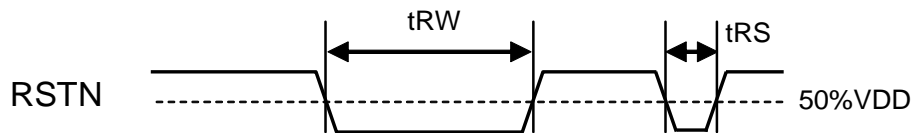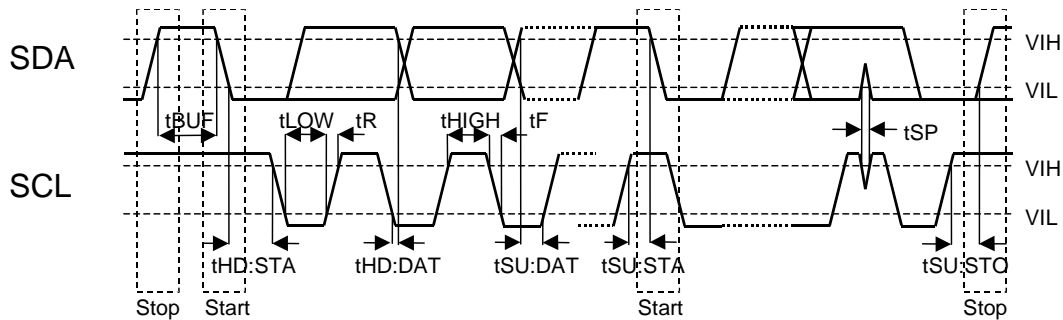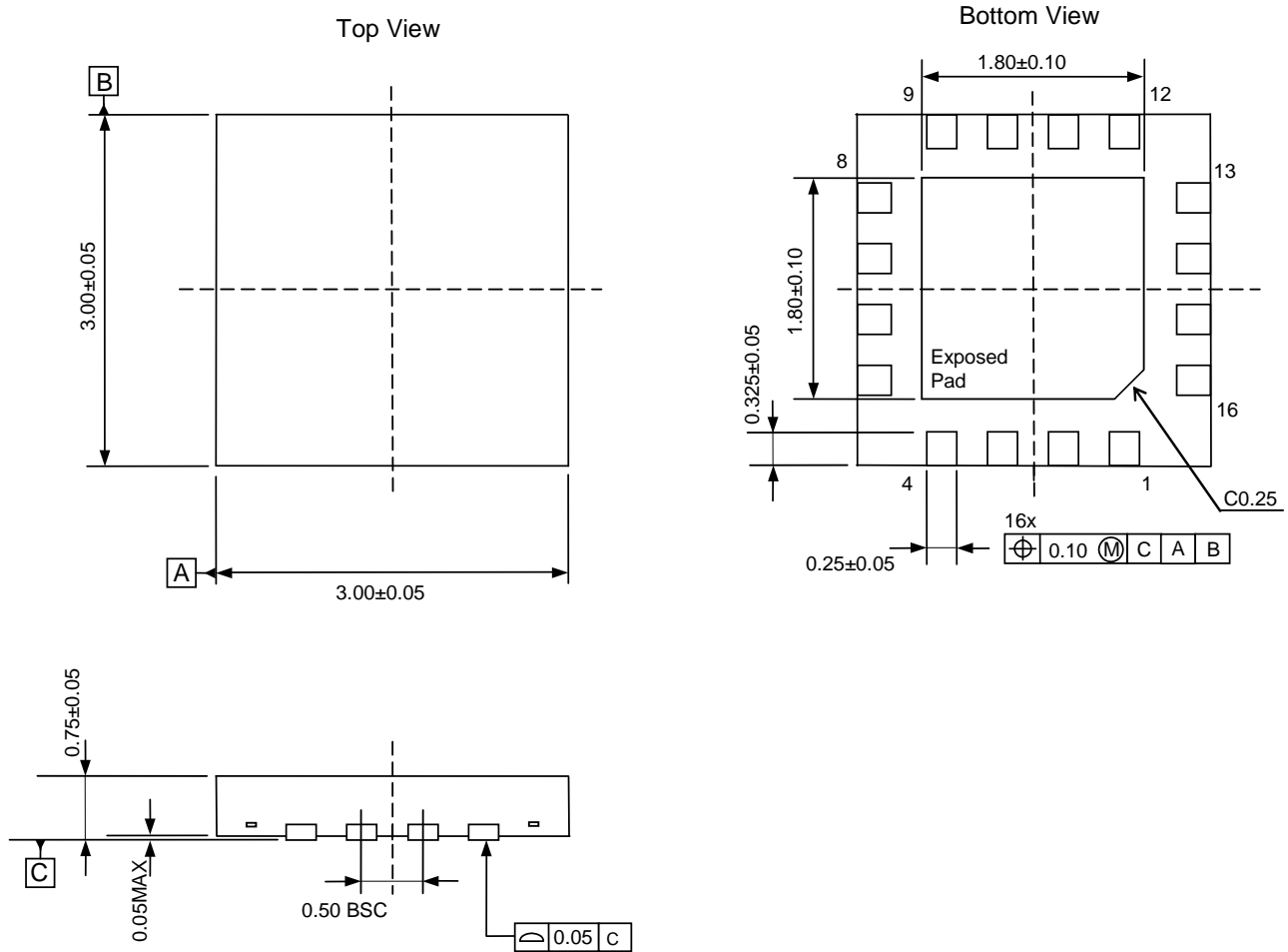
Figure 2. Reset Timing Diagram

Figure 3. I^{2}C Interface Timing Diagram

PACKAGE

16pin QFN (Unit: mm)

Top View

Bottom View

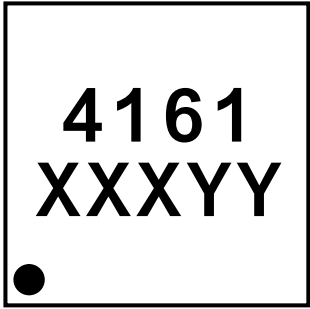Note: The thermal die pad must be connected to open node.

■ Package & Lead frame material

Package molding compound: Epoxy Resin, Halogen (Br, Cl) Free
Lead frame material: Cu Alloy
Lead frame surface treatment: Solder (Pb free) Plate

MARKING

```
┌─────────────────┐
│                 │
│   4161          │
│   XXXYY         │
│                 │
│  ●              │
└─────────────────┘
```

Contents of XXXYY
XXX: Date Code
YY: Internal Control Code
Pin #1 indication

Thank you for your access to AKM product information.
More detail product information is available, please contact our
sales office or authorized distributors.

┌─ **IMPORTANT NOTICE** ─┐

0. Asahi Kasei Microdevices Corporation ("AKM") reserves the right to make changes to the information contained in this document without notice. When you consider any use or application of AKM product stipulated in this document ("Product"), please make inquiries the sales office of AKM or authorized distributors as to current status of the Products.

1. All information included in this document are provided only to illustrate the operation and application examples of AKM Products. AKM neither makes warranties or representations with respect to the accuracy or completeness of the information contained in this document nor grants any license to any intellectual property rights or any other rights of AKM or any third party with respect to the information in this document. You are fully responsible for use of such information contained in this document in your product design or applications. AKM ASSUMES NO LIABILITY FOR ANY LOSSES INCURRED BY YOU OR THIRD PARTIES ARISING FROM THE USE OF SUCH INFORMATION IN YOUR PRODUCT DESIGN OR APPLICATIONS.

2. The Product is neither intended nor warranted for use in equipment or systems that require extraordinarily high levels of quality and/or reliability and/or a malfunction or failure of which may cause loss of human life, bodily injury, serious property damage or serious public impact, including but not limited to, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. Do not use Product for the above use unless specifically agreed by AKM in writing.

3. Though AKM works continually to improve the Product's quality and reliability, you are responsible for complying with safety standards and for providing adequate designs and safeguards for your hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of the Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption.

4. Do not use or otherwise make available the Product or related technology or any information contained in this document for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). When exporting the Products or related technology or any information contained in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. The Products and related technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.

5. Please contact AKM sales representative for details as to environmental matters such as the RoHS compatibility of the Product. Please use the Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. AKM assumes no liability for damages or losses occurring as a result of noncompliance with applicable laws and regulations.

6. Resale of the Product with provisions different from the statement and/or technical features set forth in this document shall immediately void any warranty granted by AKM for the Product and shall not create or extend in any manner whatsoever, any liability of AKM.

7. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of AKM.

└─────────┘