a leap ahead

22 austria**micro**systems

AS1976, AS1977 Ultra-Low Current, 1.8V Comparators

1 General Description

Table 1. Standard Products

The AS1976/AS1977 are very low-current comparators that can operate beyond the rail voltages and are guaranteed to operate down to $1.8 \mbox{V}$

Low input bias current, current-limiting output circuitry, and ultra-small packaging make these comparators ideal for low-power 2-cell applications including powermanagement and power-monitoring systems.

The comparators are available as the standard products listed in Table 1.

Model	Output Type	Current
AS1976	Push/Pull	200nA
AS1977	Open-Drain	200nA

The AS1976 push/pull output can sink or source current.

The AS1977 open-drain output can be pulled beyond Vcc to a maximum of 6V > VEE. This open-drain model is ideal for use as a logic-level translator or bipolar-to-unipolar converter.

Large internal output drivers provide rail-to-rail output swings with loads up to 8mA. Both devices feature builtin battery power-management and power-monitoring circuitry.

The AS1976/AS1977 are available in a 5-pin SOT23 package.

2 Key Features

- CMOS Push/Pull Output Sinks and Sources 8mA (AS1976)
- CMOS Open-Drain Output Voltage Extends Beyond Vcc (AS1977)
- Ultra-Low Supply Current: 200nA
- Internal Hysteresis: 3mV
- 3V-to5V Logiv-Level Translation
- Guaranteed to Operate Down to +1.8V
- Input Voltage Range Operates 200mV Beyond the Rails
- Crowbar Current-Free Switching
- No Phase Reversal for Overdriven Inputs
- 5-pin SOT23 Package

3 Applications

The devices are ideal for battery monitoring/management, mobile communication devices, laptops and PDAs, ultra-low-power systems, threshold detectors/discriminators, telemetry and remote systems, medical instruments, or any other space-limited application with low power-consumption requirements.

Figure 1. Block Diagram



Downloaded from Elcodis.com electronic components distributor

Data Sheet



4 Pinout

Pin Assignments

Figure 2. Pin Assignments (Top View)



Pin Descriptions

Table 2. Pin Descriptions

Pin Number	Pin Name	Description
1	OUT	Comparator Output
2	VEE	Negative Supply Voltage
3	IN+	Comparator Non-Inverting Input
4	IN-	Comparator Inverting Input
5	Vcc	Positive Supply Voltage

5 Absolute Maximum Ratings

Stresses beyond those listed in Table 3 may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in Section 6 Electrical Characteristics on page 4 is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 3.	Absolute	Maximum	Ratings
10010 0.	7 10001010	maximan	raango

Parameter	Min	Max	Units	Comments
Supply Voltage Vcc to VEE		+7	V	
Voltage Inputs IN+, IN-	Vee - 0.3	Vcc + 0.3	V	
Output Voltage AS1976, AS1978	Vee - 0.3	Vcc + 0.3	V	
Output Current	-50	+50	mA	
Output Short-Circuit Duration		10	S	
Continuous Power Dissipation		571	mW	Derate at 7.31mW/°C above +70°C
Operating Temperature Range	-40	+85	°C	
Storage Temperature Range	-65	+150	°C	
Package Body Temperature		+260	٥C	The reflow peak soldering temperature (body temperature) specified is in accordance with <i>IPC/ JEDEC J-STD-020C "Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices".</i> The lead finish for Pb-free leaded packages is matte tin (100% Sn).

6 Electrical Characteristics

 $V_{CC} = +5V$, $V_{EE} = 0$, $V_{CM} = 0$, $T_{AMB} = -40$ to $+85^{\circ}C$ (unless otherwise specified). Typ values are at $T_{AMB} = +25^{\circ}C$. Table 4. AS1976/AS1977 Electrical Characteristics

Symbol	Parameter	Conditions		Тур	Max	Units	
Vcc	Supply Voltage Range	Inferred from the PSRR test	1.8		5.5	V	
Icc		Vcc = 1.8V		0.2			
	Supply Current	Vcc = 5V, Tamb = +25°C		0.21	0.5	μA	
		VCC = 5V, TAMB = TMIN to TMAX			0.9		
Vсм	Input Common-Mode Voltage Range	Inferred from CMRR test	Vee - 0.2		Vcc + 0.2	V	
		$-0.2V \le VCM \le (VCC + 0.2V),$		1	5		
Vos	Input Offset Voltage	$TAMB = +25^{\circ}C^{-1}$			5	mV	
		-0.2V \leq VCM \leq (VCC + 0.2V), TAMB = TMIN to TMAX			10		
Vнв	Input-Referred Hysteresis	$-0.2V \le V_{CM} \le (V_{CC} + 0.2V)^2$		3		mV	
le	Innut Dies Ourrent ³	Тамв = +25°С		0.15	1	nΑ	
ID	Input Blas Current	TAMB = TMIN tO TMAX			2		
los	Input Offset Current			10		рА	
PSRR	Power-Supply Rejection Ratio	Vcc = 1.8 to 5.5V, TAMB = +25°C		0.05	1	mV/V	
CMRR	Common-Mode Rejection Ratio	$\begin{array}{l} (VEE\mbox{ - }0.2V) \leq VCM \leq (VCC\mbox{ + }0.2V), \\ TAMB\mbox{ = }+25^{o}C \end{array}$		0.2	3	mV/V	
Vcc - Vон	Output Voltage Swing High	Тамв = +25°С, AS1976 only Vcc = 5.5V, Isink = 8mA		220	500	mV	
		Тамв = Тміл to Тмах, AS1976 only Vcc = 5.5V, Isink = 8mA			650		
		TAMB = +25°C AS1976 only Vcc = 1.8V, ISOURCE = 1mA		80	200		
		TAMB = TMIN to TMAX, AS1976 only Vcc = $1.8V$, ISOURCE = $1mA$			300		
	Output Voltage Swing Low	Тамв = +25°С, AS1976 only Vcc = 5.5V, Isink = 8mA		220	500	- mV	
Mai		Тамв = Тмін to Тмах, AS1976 only Vcc = 5.5V, Ізінк = 8mA			650		
VOL		TAMB = +25°C, VCC = 1.8V, ISOURCE = 1mA		70	200		
		TAMB = TMIN to TMAX, VCC = 1.8V, ISOURCE = 1mA			300		
ILEAK	Output Leakage Current	AS1977 only, Vout = 5.5V		0.001	1	μA	
lsc		Sourcing, VOUT = VEE, VCC = 5.5V		50			
	Output Short-Circuit Current	Sourcing, VOUT = VEE, VCC = 1.8V		6		^	
		Sinking, VOUT = VCC, VCC = 5.5V		70		IIIA	
		Sinking, VOUT = VCC, VCC = 1.8V		5			
1	High-to-Low	Vcc = 1.8V		10			
190-	Propagation Delay ⁴	Vcc = 5.5V		12		μs	

Symbol	Parameter	Parameter Conditions			Max	Units
t ^{PD+} Lo	Low-to-High	AS1976 only, Vcc = 1.8V		13		
		AS1976 only, Vcc = 5.5V		15		
	Propagation Delay ⁴	AS1977 only, Vcc = 1.8V, RPULUP = $100k\Omega$		16		μs
		AS1977 only, Vcc = 3.6V, RPULUP = $100k\Omega$		18		
trise	Rise Time	AS1976 only, CLOAD = 15pF		10		ns
tFALL	Fall Time	CLOAD = 15pF		10		ns
ton	Power-Up Time			100		ns

Table 4. A	AS1976/AS1977	Electrical	Characteristics	(Continued)
------------	---------------	------------	-----------------	-------------

1. Vos is defined as the center of the hysteresis band at the input.

2. The hysteresis-related trip points are defined as the edges of the hysteresis band, measured with respect to the center of the band (i.e., Vos) (see Figure 26 on page 11).

3. Guaranteed by design.

4. Specified with an input overdrive voltage (VOVERDRIVE) = 100mV, and load capacitance (CLOAD) = 15pF. VOVER-DRIVE is defined above and beyond the offset voltage and hysteresis of the comparator input. A reference voltage error should also be added.



7 Typical Operating Characteristics

Figure 3. Icc vs. Vcc and Temperature























Figure 9. Voh vs. Isource and Temperature

















Figure 14. tpp- vs. Capacitive Load





Data Sheet - Typical Operating Characteristics

*austriamicro*systems

Figure 15. tPD+ vs. Capacitive Load



Figure 17. tpp- 5V



















Figure 21. tPD- 1.8V



Figure 23. 1kHz Response @ 5V



Figure 22. 10kHz Response @ 1.8V



Figure 24. Powerup/Powerdown Response



8 Detailed Description

The AS1976/AS1977 are ultra low-current comparators and are guaranteed to operate with voltages as low as +1.8V. The common-mode input voltage range extends 200mV beyond the rail voltages, and internal hysteresis ensures clean output switching, even with slow input signals.

The AS1976 push/pull output stage sinks and sources-current. The AS1977 open-drain output stage can be pulled beyond Vcc to an absolute maximum of 3.6V > VEE. The AS1979/AS1977 are perfect for implementing wired-OR output logic functions.

For all comparators, large internal output drivers allow rail-to-rail output swings with loads of up to 8mA. The output stage design minimizes supply-current surges during switching, eliminating most power supply transients.

Input Stage

The input common-mode voltage range extends from (VEE - 0.2V) to (Vcc + 0.2V), and the comparators can operate at any differential input voltage within this range. The comparators have very low input bias current (\pm 0.15nA, typ) if the input voltage is within the common-mode voltage range.

Inputs are protected from over-voltage conditions by internal ESD protection diodes connected to the supply rails. As the input voltage exceeds the supply rails, these ESD protection diodes are forward biased and begin to conduct.

Output Stage

The break-before-make output stage is capable of rail-to-rail operation with loads up to 8mA. Many comparators consume orders of magnitude more current during switching than during steady-state operation.

Even at loads of up to 8mA, changes in supply-current during an output transition are extremely small (see Figure 5 on page 6). As shown in Figure 5, the minimal supply current increases as the output switching frequency approaches 1kHz. This characteristic reduces the need for power-supply filter capacitors to reduce transients created by comparator switching currents.

Because of the unique design of its output stage, the AS1976/AS1977 can dramatically increase battery life, even in high-speed applications.

9 Application Information

The AS1976/AS1977 comparators are perfect for use with all 2-cell battery-powered applications. Figure 25 shows a typical application for the AS1977.





Internal Hysteresis

The comparators were designed with 3mV of internal hysteresis to neutralize the effects of parasitic feedback, i.e., to prevent unwanted rapid changes between the two output states.

The internal hysteresis in the AS1976/AS1977 creates two trip points:

- Rising Input Voltage (VTHR) The comparator switches its output from low to high as VIN rises above this trip point.
- Falling Input Voltage (VTHF) The comparator switches its output from high to low as VIN falls below this trip point.

The area between the trip points is the hysteresis band (VHB) (see Figure 26). When the AS1976/AS1977 input voltages are equivalent, the hysteresis effectively causes one input to move quickly past the other, thus taking the input out of the region where oscillation occurs. In Figure 26 IN- has a fixed voltage applied and IN+ is varied.

Note: If the inputs are reversed the output will be inverted.

Figure 26. Threshold Hysteresis Band



Downloaded from Elcodis.com electronic components distributor

Additional Hysteresis (AS1976)

Additional hysteresis can be added to the AS1976 and AS1978 with three resistors and positive feedback (see Figure 27), however, this positive feedback method slows hysteresis response time.

Figure 27. AS1976 Additional Hysteresis



Resistor Selection Example

For the circuit shown in Figure 27, use the following steps to calculate values for R1, R2, and R3.

 First select the value for R₃. Leakage current at IN is less than 2nA, thus the current through R₃ should be at least 0.2µA to minimize errors due to leakage current. The current through R₃ at the trip point is:

Taking into consideration the two possible output states, solving for R₃ yields two formulas:

$$R_3 = V_{REF}/I_{R3}$$
(EQ 2)

$$R_3 = (VCC - VREF)/IR3$$
 (EQ 3)

Use the smaller of the two resulting values for R₃. For example, for VREF = 1.245V, VCC = 3.3V, and IR₃ = 1 μ A, the two resistor values are 1.2M Ω and 2.0M Ω , therefore choose a 1.2M Ω standard resistor for R₃.

- 2. Choose the required hysteresis band (VHB). For this example, choose 33mV.
- 3. Calculate R1 as:

$$R_1 = R_3(VHB/VCC) \tag{EQ 4}$$

Substituting the R1 and VHB example values gives:

$$R_1 = 1.2M\Omega(50mV/3.3V) = 12k\Omega$$

- 4. Choose the trip point for VIN rising (VTHR) such that VTHR > VREF(R1 + R3)/R3. For this example, choose 3V.
- 5. Calculate R2 as:

$$R_2 = 1/[V_{THR}/(V_{REF} \times R_1) - (1/R_1) - (1/R_3)]$$
(EQ 5)

Substituting the R1 and R3 example values gives:

 $R_2 = 1/[3.0V/(1.2V \times 12k\Omega) - (1/12k\Omega) - (1/1.2M\Omega)] = 8.05k\Omega$

In this example, a standard 8.2 k Ω resistor should be used for R2.

6. Verify the trip voltages and hysteresis as:

$$V_{THR} = V_{REF} \times R_1[(1/R_1) + (1/R_2) + (1/R_3)]$$
(EQ 6)

$$VTHF = VTHR - (R1 \times VCC/R3)$$
(EQ 7)

Hysteresis = VTHR - VTHF (EQ 8)

Additional Hysteresis (AS1977)

Additional hysteresis can be added to the AS1977 and AS1979 with 4 resistors and positive feedback (see Figure 28).

Figure 28. AS1977 Additional Hysteresis



Resistor Selection Example

For the circuit shown in Figure 28, use the following steps to calculate values for R1, R2, R3, and R4.

1. Select R3 according to one of these formulas:

$$R_3 = V_{REF}/1\mu A \tag{EQ 9}$$

$$R_3 = (V_{CC} - V_{REF})/1\mu A - R_4$$
 (EQ 10)

Use the smaller of the two resulting resistor values for R_3 .

- 2. Choose the hysteresis band required (VHB).
- 3. Calculate R1 as:

$$R_1 = (R_3 + R_4)(V_{HB}/VCC)$$
 (EQ 11)

- 4. Choose the trip point for VIN rising (VTHR).
- 5. Calculate R2 as:

$$R_2 = 1/[VTHR/(VREF x R_1) - (1/R_1) - 1/R_3]$$
(EQ 12)

6. Verify the trip voltages and hysteresis as:

$$V_{IN} rising: V_{THR} = V_{REF}[R_1(1/R_1 + 1/R_2 + 1/R_3)]$$
(EQ 13)

$$V_{IN} falling: V_{THF} = V_{REF}[R_1(1/R_1 + 1/R_2 + 1/(R_3 + R_4))] - [1/(R_3 + R_4)]V_{CC}$$
(EQ 14)

Zero-Crossing Detector

Figure 29 shows the AS1976 in a zero-crossing detector circuit. The inverting input (IN-) is connected to ground, and the non-inverting input (IN+) is connected to a 100mVp-p signal source. When the signal at IN- crosses 0V, the signal at OUT changes states.





Downloaded from Elcodis.com electronic components distributor

Logic-Level Translation

The AS1977 can be used as a 5V-to-3V logic translator. Figure 30 shows an application that converts 5V- to 3V-logic levels, and provides the full 5V logic-swing without creating overvoltage on the 3V logic inputs.

Note: When the comparator is powered by a 5V supply, RPULUP for the open-drain output should be connected to the +3V supply voltage.

For 3V-to-5V logic-level translations, connect the +3V supply voltage to Vcc and the +5V supply voltage to RPULUP.





Layout Considerations

The AS1976/AS1977 requires proper layout and design techniques for optimum performance.

- Power-supply bypass capacitors are not typically required, although 100nF bypass capacitors should be placed close to the AS1976/AS1977 supply pins when supply impedance is high, leads are long, or for excessive noise on the supply lines.
- Minimize signal trace lengths to reduce stray capacitance.
- A ground plane should be used.
- Surface-mount components should be used whenever practical.



10 Package Drawings and Markings

The AS1976/AS1977 are available in a 5-pin SOT23 package.

Figure 31. 5-pin SOT23 Package



Notes:

- 1. Controlling dimension is millimeters.
- 2. Foot length measured at intercept point between datum A and lead surface.
- 3. Package outline exclusive of mold flash and metal burr.
- 4. Package outline inclusive of solder plating.
- 5. Meets JEDEC MO178.

L

е

e1

α

0.30

0°

0.55

8º

0.95 REF

1.90 REF

*austriamicro*systems

11 Ordering Information

The devices are available as the standard products shown in Table 5.

Table 5. Ordering Information

Туре	Marking	Description	Output Type	Delivery Form	Package
AS1976	ASI9	Ultra-Low Current 1.8V Comparator	Push/Pull	Tube	5-pin SOT23
AS1976-T	ASI9	Ultra-Low Current 1.8V Comparator	Push/Pull	Tape and Reel	5-pin SOT23
AS1977	ASJA	Ultra-Low Current 1.8V Comparator	Open-Drain	Tube	5-pin SOT23
AS1977-T	ASJA	Ultra-Low Current 1.8V Comparator	Open-Drain	Tape and Reel	5-pin SOT23

Copyrights

Copyright © 1997-2007, austriamicrosystems AG, Schloss Premstaetten, 8141 Unterpremstaetten, Austria-Europe. Trademarks Registered ®. All rights reserved. The material herein may not be reproduced, adapted, merged, translated, stored, or used without the prior written consent of the copyright owner.

All products and companies mentioned are trademarks or registered trademarks of their respective companies.

Disclaimer

Devices sold by austriamicrosystems AG are covered by the warranty and patent indemnification provisions appearing in its Term of Sale. austriamicrosystems AG makes no warranty, express, statutory, implied, or by description regarding the information set forth herein or regarding the freedom of the described devices from patent infringement. austriamicrosystems AG reserves the right to change specifications and prices at any time and without notice. Therefore, prior to designing this product into a system, it is necessary to check with austriamicrosystems AG for current information. This product is intended for use in normal commercial applications. Applications requiring extended temperature range, unusual environmental requirements, or high reliability applications, such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional processing by austriamicrosystems AG for each application. For shipments of less than 100 parts the manufacturing flow might show deviations from the standard production flow, such as test flow or test location.

The information furnished here by austriamicrosystems AG is believed to be correct and accurate. However, austriamicrosystems AG shall not be liable to recipient or any third party for any damages, including but not limited to personal injury, property damage, loss of profits, loss of use, interruption of business or indirect, special, incidental or consequential damages, of any kind, in connection with or arising out of the furnishing, performance or use of the technical data herein. No obligation or liability to recipient or any third party shall arise or flow out of austriamicrosystems AG rendering of technical or other services.



Contact Information

Headquarters austriamicrosystems AG A-8141 Schloss Premstaetten, Austria

Tel: +43 (0) 3136 500 0 Fax: +43 (0) 3136 525 01

For Sales Offices, Distributors and Representatives, please visit:

http://www.austriamicrosystems.com/contact

Downloaded from Elcodis.com electronic components distributor