## INTEGRATED CIRCUITS



Product data Supersedes data of 2001 Oct 03 2002 Nov 13



Philips Semiconductors

## SA58603

### **GENERAL DESCRIPTION**

The SA58603 is comprised of a low voltage, high precision dual operational amplifier, a comparator, and a reference voltage source. The input offset voltage is typically 100  $\mu$ V with a very low temperature drift of ±1  $\mu$ V/°C. The SA58603 supply current is typically 100  $\mu$ A per amplifier and it operates from 1.8 V to 6 V single supply.

Having single power supply capability, low current consumption, low offset voltage, low input offset current and low input bias current, the SA58603 is ideal for battery-powered applications and amplification of very small signals. It is excellent for precision amplifiers in gas burners and gas pilot water heaters which use thermal couple heat sensors.

#### **FEATURES**

#### General

- Functionality to 1.8 V typical
- Low supply current: 100 μA per amplifier (typical)

### Amplifier section

- Very low input offset voltage: 100 μV (typical)
- Very low input offset drift:  $\pm 1 \ \mu V/^{\circ}C$  (typical)
- Low input offset current: 1 nA (typical)
- Input bias current: 50 nA (typical)
- Open loop gain: 100 dB (typical)
- Common mode input includes ground

#### **Comparator section**

- Input offset voltage: ±1.0 mV (typical)
- Low input offset voltage voltage drift (-40 to +85 °C): ±10 μV (typical)
- Input bias current: 25 nA (typical)
- Output sink current: 5 mA (minimum)



#### **Reference voltage section**

- Reference voltage: 1.27 V ±50 mV
- Reference voltage temperature characteristics: ±100 ppm/°C (typical)
- Output current: 0.3 mA (minimum)

### **APPLICATIONS**

- Gas burners
- Gas water heaters
- Tankless gas water heaters



Figure 1. Simplified device diagram.

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## **ORDERING INFORMATION**

	PACKAGE	TEMPERATURE	
ITPE NOWBER	NAME	DESCRIPTION	RANGE
SA58603D	SO8	plastic small outline package; 8 leads; body width 3.9 mm	–40 to +85 °C

### PIN CONFIGURATION



Figure 2. Pin configuration.

### **PIN DESCRIPTION**

PIN	SYMBOL	DESCRIPTION
1	AIN+	Non-inverting input of Op Amp. This is a PNP amplifier with the reference voltage as its supply voltage.
2	AIN-	Inverting input of Op Amp. This is a PNP amplifier with the reference voltage as its supply voltage.
3	AOUT	Output of Op Amp. This is a NPN emitter follower output with a 22 k $\Omega$ internal on-chip pull-down resistor. Its supply voltage is V <sub>CC</sub> .
4	GND	Ground.
5	COMPIN-	Inverting input of Comparator. This is a PNP amplifier with $V_{CC}$ as its positive supply voltage.
6	V <sub>S</sub>	Reference voltage output. The output reference is typically 1.27 V. The output reference is derived from the series combination of a NPN transistor (configured as a diode with the base shorted to the collector) and a 120 k $\Omega$ resistor.
7	COMPOUT	Output of Comparator. It is an open collector output stage which requires an external pull-up resistor.
8	V <sub>CC</sub>	Positive supply. Its operating range is 1.8 to 6.0 V.

## **EQUIVALENT CIRCUITS**

PIN NUMBER	PIN NAME	INTERNAL EQUIVALENT CIRCUIT	PIN NUMBER	PIN NAME	INTERNAL EQUIVALENT CIRCUIT
1	AIN+	V <sub>S</sub>	5	COMPIN-	V <sub>S</sub>
2	AIN–	V <sub>S</sub> V <sub>S</sub> V <sub>S</sub> V <sub>S</sub> V <sub>S</sub> R 25 kΩ 18 kΩ 777	6	VS	V <sub>CC</sub> R 120 kΩ
3	AOUT	R 22 kΩ	7	COMPOUT	V <sub>CC</sub>
4	GND		8	V <sub>CC</sub>	

## **MAXIMUM RATINGS**

SYMBOL	PARAMETER		MAX.	UNIT
V <sub>CC</sub>	Single supply voltage	-0.3	+10	V
V <sub>IN</sub>	Input voltage		+10	V
T <sub>stg</sub>	Storage temperature	-40	+125	°C
T <sub>amb</sub>	Operating temperature	-40	+85	°C
Р	Power dissipation	-	300	mW

## **ELECTRICAL CHARACTERISTICS**

 $V_{CC}$  = 3.0 V,  $V_{IN}$  = 0 V, and  $T_{amb}$  = 25 °C, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT	
I <sub>CC</sub>	Supply current		-	0.1	0.15	mA	
I <sub>OVS</sub>	Reference voltage output current		0.3	-	-	mA	
Vs	Reference voltage		1.22	1.27	1.32	V	
$\Delta V_S$	Reference voltage temperature drift		-	±100	-	ppm/°C	
PSRR	Power supply rejection ratio	f = 100 Hz	50	60	-	dB	
V <sub>CC</sub>	Power supply voltage operating range		1.8	3.0	6.0	V	
Amplifier s	ection (note 1)						
V <sub>INA</sub>	Input voltage range		-0.2	-	0.3	V	
V <sub>IOA</sub>	Input offset voltage		-	±0.1	±0.35	mV	
$\Delta V_{IO} / \Delta T$	Input offset voltage temperature drift	$T_{amb} = -20$ to +75 °C	-	±1	±3	μV/°C	
I <sub>IOA</sub>	Input offset current		-	1	10	nA	
I <sub>i(bias)A</sub>	Input bias current		-	50	150	nA	
G <sub>v(ol)A</sub>	Open-loop voltage gain		80	100	-	dB	
I <sub>OA</sub>	Output current	$V_{IN} = 10 \text{ mV}; V_O = 0.5 \text{ V}$	0.5	-	-	mA	
V <sub>OA</sub>	Output voltage swing	$V_{IN}$ = -5 to +25 mV; R <sub>L</sub> = 10 k $\Omega$	0.01	-	V <sub>CC</sub> – 1.0	V	
Comparato	Comparator section (note 2)						
V <sub>IOC</sub>	Input offset voltage	$V_{IN} = -5 \text{ mV}$	-	±1.0	±3.5	mV	
$\Delta V_{IOC} / \Delta T$	Input offset voltage temperature drift	V <sub>IN</sub> = -5 mV	-	±10	±30	μV/°C	
I <sub>i(bias)C</sub>	Input bias current	V <sub>IN</sub> = -5 mV	-	25	75	nA	
I <sub>O(sink)</sub>	Output sink current	$V_{IN} = 10 \text{ mV}; V_O = 0.4 \text{ V}$	5	-	-	mA	
I <sub>LO</sub>	Output leakage current	$V_{O} = V_{CC} + 1 V$	-	-	0.2	μA	
V <sub>SAT</sub>	Output saturation voltage	V <sub>IN</sub> = 10 mV; I <sub>O(sink)</sub> = 5 mA	-	200	400	mV	

NOTES:

Amplifier output is emitter follower with an on-chip 22 kΩ pull-down resistor.
 Comparator output is open collector; it requires an external pull-up resistor. See application section on how to determine this resistor.

## **TYPICAL CHARACTERIZATION CURVES**

 $T_{amb}$  = 25 °C,  $V_{CC}$  = 3 V,  $V_{IN}$  = 0 V, unless otherwise specified.



Figure 3. Supply current versus ambient temperature.



Figure 5. Amplifier input offset voltage versus ambient temperature.



Figure 7. Amplifier input bias current versus ambient temperature.



Figure 4. Reference voltage versus ambient temperature.



Figure 6. Amplifier input offset current versus ambient temperature.



Figure 8. Amplifier output current versus ambient temperature.

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### TYPICAL CHARACTERIZATION CURVES (continued)





Figure 11. Comparator input offset voltage versus ambient temperature.



Figure 13. Comparator output sink current versus ambient temperature.



Figure 10. Amplifier output voltage, HIGH versus ambient temperature.



Figure 12. Comparator bias current versus ambient temperature.



Figure 14. Comparator output saturation voltage versus ambient temperature.

**TYPICAL CHARACTERIZATION CURVES** (continued)



## Figure 15. Supply current versus supply voltage.



Figure 17. Amplifier input offset voltage versus supply voltage.



Figure 19. Amplifier input bias current versus supply voltage.



Figure 16. Reference voltage versus supply voltage.



Figure 18. Amplifier input offset current versus supply voltage.



Figure 20. Amplifier output current versus supply voltage.

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### TYPICAL CHARACTERIZATION CURVES (continued)





Figure 23. Comparator input offset voltage versus supply voltage.



Figure 25. Comparator output sink current versus supply voltage.



Figure 22. Amplifier output voltage, HIGH versus supply voltage.



Figure 24. Comparator bias current versus supply voltage.



Figure 26. Comparator output saturation voltage versus supply voltage.

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## High precision operational amplifier, comparator, and voltage reference



Figure 27. Power supply rejection ratio versus frequency.



Figure 29. Reference voltage versus output current.



Figure 28. Amplifier open loop gain versus frequency.



Figure 30. Comparator output saturation voltage versus sink current.

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### **APPLICATION INFORMATION**

#### Typical gas pilot detection circuit

Figure 31 shows a typical application of the SA58603 in which the input amplifier is driven by a thermocouple heated by the pilot flame in a water heater or gas burner. The circuit comparator may be programmed to detect when the pilot is out. The IC is operated from a single voltage supply making it capable of battery backup with loss of AC power. It may be operated from a one-cell Lithium battery or two alkaline cells. 10 nF bypass capacitors are placed from V<sub>CC</sub> and reference voltage output (pin 6) to ground to filter power supply noise and interference from external noise sources.

#### Selecting external components

#### Gain

Recommended amplifier gain is 40 dB. The gain is is set by the combination of R1, R2, and R3 as shown in the following equations:

$$Av = \frac{(R3 + R2)}{R3}$$
; Av (dB) = 20 log (Av); R3 = R1 || R2

For a gain of 40 dB, Av = 100 V/V;

if R2 = 1 k $\Omega$ , then 99\*R3 = 1 k $\Omega$ ; R3 = 10.1  $\Omega$ .

$$R3 = \frac{R1 \times R2}{(R1 + R2)}; R3 \times R1 + R3 \times R2 = R1 \times R2:$$
$$R3 \times R2 = R1 (R2 - R3)$$

Thus R1 = 
$$\frac{R3 \times R2}{(R2 - R3)} = 10.2\Omega$$

#### Comparator output pull-up resistor

The comparator output pull-up resistor is determined by the following formula:

$$R = \frac{\left(V_{CC} - V_{SAT(max)}\right)}{I_{O(sink)(min)}}$$

where  $V_{SAT(max)} = 400 \text{ mV}$ , and  $I_{O(sink)(min)} = 5 \text{ mA}$ .

#### Comparator threshold voltage

The comparator threshold voltage is determined by R4 and R5. They form a voltage divider from the reference voltage output (V<sub>S</sub>, Pin 6) to ground. In the application example, V<sub>COMP</sub>, the comparator input (COMPIN–, Pin 5) is connected to the junction of R4 and R5. The input level is calculated by following relationship:

$$V_{COMP} = 1.27V \times \frac{R5}{(R4 + R5)}$$



Figure 31. Typical flame detection circuit.

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## **PACKING METHOD**



### Figure 32. Tape and reel packing method.

õ°

0.003

## SA58603

## SO8: plastic small outline package; 8 leads; body width 3.9 mm



#### Notes

inches

0.010

0.004

0.068

0.057

0.049

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

0.189

0.195

0.013

0.020

2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE	REFERENCES				
VERSION	IEC	JEDEC	EIAJ		
SO8	076E03	MS-012			

0.0100

0.0075

0.20

0.19

0.16

0.15

0.050

0.244

0.228

0.050

0.015

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**REVISION HISTORY** 

Rev	Date	Description	
_2	20021113	Product data; second version (9397 750 10671). Supersedes SA58603_1 of 2001 Oct 03 (9397 750 08955).	
		ngineering Change Notice 853–2289 29151 (date: 20021105).	
		Modifications:	
		<ul> <li>Add "Typical characterization curves" section.</li> </ul>	
_1	20011003	Product data; initial version (9397 750 08955).	
		Engineering Change Notice 853–2289 27197 (date: 20011003).	

### Data sheet status

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I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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