SA602A

Double-balanced mixer and oscillator

Rev. 3 — 27 May 2014 **Product data sheet**

1. General description

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high-performance, low-power communication systems. The guaranteed parameters of the SA602A make this device well-suited for cellular radio applications. The mixer is a ‘Gilbert cell’ multiplier configuration which typically provides 18 dB of gain at 45 MHz. The oscillator operates to 200 MHz. It can be configured as a crystal oscillator, a tuned tank oscillator, or a buffer for an external LO. For higher frequencies, the LO input may be externally driven. The noise figure at 45 MHz is typically less than 5 dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead SO (surface-mount miniature package).

2. Features and benefits

- Low current consumption: 2.4 mA typical
- Excellent noise figure: <4.7 dB typical at 45 MHz
- High operating frequency
- Excellent gain, intercept and sensitivity
- Low external parts count; suitable for crystal/ceramic filters
- SA602A meets cellular radio specifications

3. Applications

- Cellular radio mixer/oscillator
- Portable radio
- VHF transceivers
- RF data links
- HF/VHF frequency conversion
- Instrumentation frequency conversion
- Broadband LANs

4. Ordering information

Table 1. Ordering information

Type number	Package		
	Name	Description	Version
SA602AD/01	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1

4.1 Ordering options

Table 2. Ordering options

Type number	Orderable part number	Package	Packing method	Minimum order quantity	Temperature
SA602AD/01	SA602AD/01,112	SO8	Standard marking * IC's tube - DSC bulk pack	2000	T_{amb} = –40 °C to +85 °C
	SA602AD/01,118	SO8	Reel 13" Q1/T1 Standard mark SMD	2500	T_{amb} = –40 °C to +85 °C

5. Block diagram

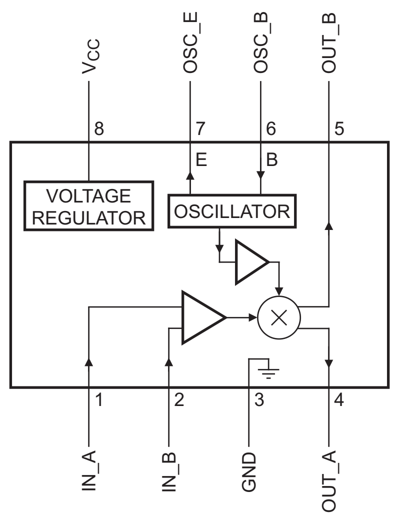


Fig 1. Block diagram

6. Pinning information

6.1 Pinning

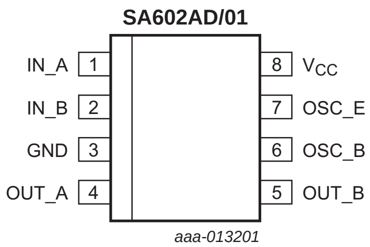


Fig 2. Pin configuration for SO8

6.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
IN_A	1	RF input A
IN_B	2	RF input B
GND	3	ground
OUT_A	4	mixer output A
OUT_B	5	mixer output B
OSC_B	6	oscillator input (base)
OSC_E	7	oscillator output (emitter)
V_{CC}	8	supply voltage

7. Functional description

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature-compensated bias network as shown in Figure 3. The Gilbert cell is a differential amplifier (IN_A and IN_B pins) that drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.

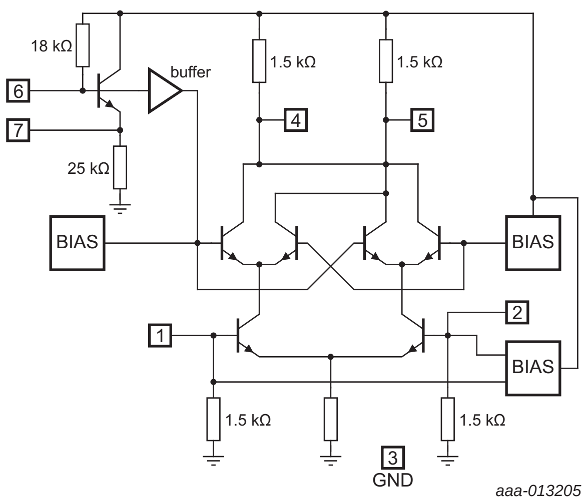
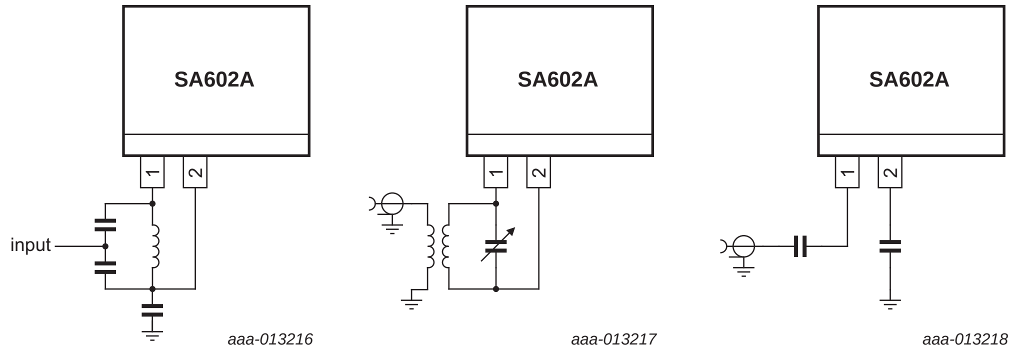


Fig 3. Equivalent circuit

The SA602A is designed for optimum low-power performance. When used with the SA604A as a 45 MHz cellular radio second IF and demodulator, the SA602A is capable of receiving –119 dBm signals with a 12 dB S/N ratio. Third-order intercept is typically –13 dBm (that is approximately +5 dBm output intercept because of the RF gain). The system designer must be cognizant of this large signal limitation. When designing LANs or other closed systems where transmission levels are high, and small-signal or signal-to-noise issues are not critical, the input to the SA602A should be appropriately scaled.

Besides excellent low-power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports support various configurations provided the designer understands certain constraints, which are explained here.

The RF inputs (IN_A and IN_B pins) are biased internally. They are symmetrical. The equivalent AC input impedance is approximately 1.5 kΩ || 3 pF through 50 MHz. IN_A and IN_B pins can be used interchangeably, but they should not be DC biased externally. Figure 4 shows three typical input configurations.



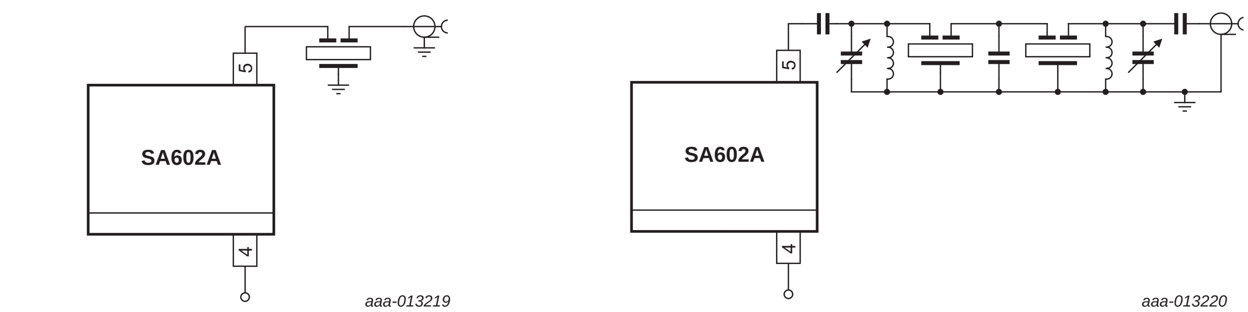
a. Single-ended tuned input

b. Balanced input (for attenuation of second-order products)

c. Single-ended untuned input

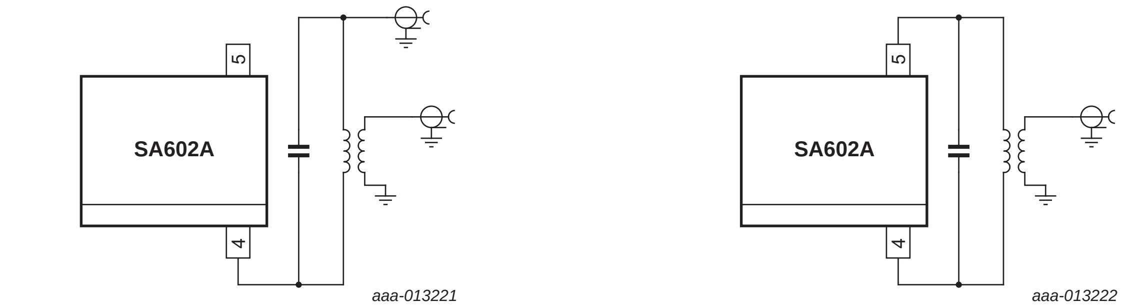
Fig 4. Input configuration

The mixer outputs (OUT_A and OUT_B pins) are also internally biased. Each output is connected to the internal positive supply by a 1.5 kΩ resistor. This permits direct output termination yet allows for balanced output as well. Figure 5 shows three single-ended output configurations and a balanced output.



a. Single-ended ceramic filter

b. Single-ended crystal filter



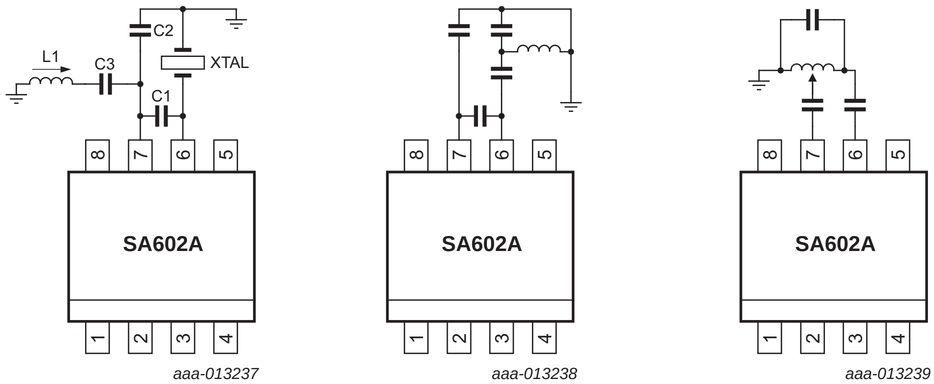
c. Single-ended IFT

d. Balanced output

Fig 5. Output configuration

The oscillator can sustain oscillation beyond 200 MHz in crystal or tuned tank configurations. The upper limit of operation is determined by tank 'Q' and required drive levels. The higher the 'Q' of the tank or the smaller the required drive, the higher the permissible oscillation frequency. If the required LO is beyond oscillation limits, or the system calls for an external LO, the external signal can be injected at OSC_B (pin 6) through a DC blocking capacitor. External LO should be at least 200 mV (peak-to-peak).

Figure 6 shows several proven oscillator circuits. Figure 6a is appropriate for cellular radio. As shown, an overtone mode of operation is utilized. Capacitor C3 and inductor L1 suppress oscillation at the crystal fundamental frequency. In the fundamental mode, the suppression network is omitted.



a. Colpitts crystal oscillator (overtone mode)

b. Colpitts L/C tank oscillator

c. Hartley L/C tank oscillator

Fig 6. Oscillator circuits

Figure 7 shows a Colpitts varactor tuned tank oscillator suitable for synthesizer-controlled applications. It is important to buffer the output of this circuit to assure that switching spikes from the first counter or prescaler do not end up in the oscillator spectrum. The dual-gate MOSFET provides optimum isolation with low current. The FET offers good isolation, simplicity, and low current, while the bipolar transistors provide the simple solution for non-critical applications. The resistive divider in the emitter-follower circuit should be chosen to provide the minimum input signal that assures correct system operation.

When operated above 100 MHz, the oscillator may not start if the Q of the tank is too low. A 22 kΩ resistor from OSC_E (pin 7) to ground increases the DC bias current of the oscillator transistor. This improves the AC operating characteristic of the transistor and should help the oscillator to start. A 22 kΩ resistor does not upset the other DC biasing internal to the device, but smaller resistance values should be avoided.

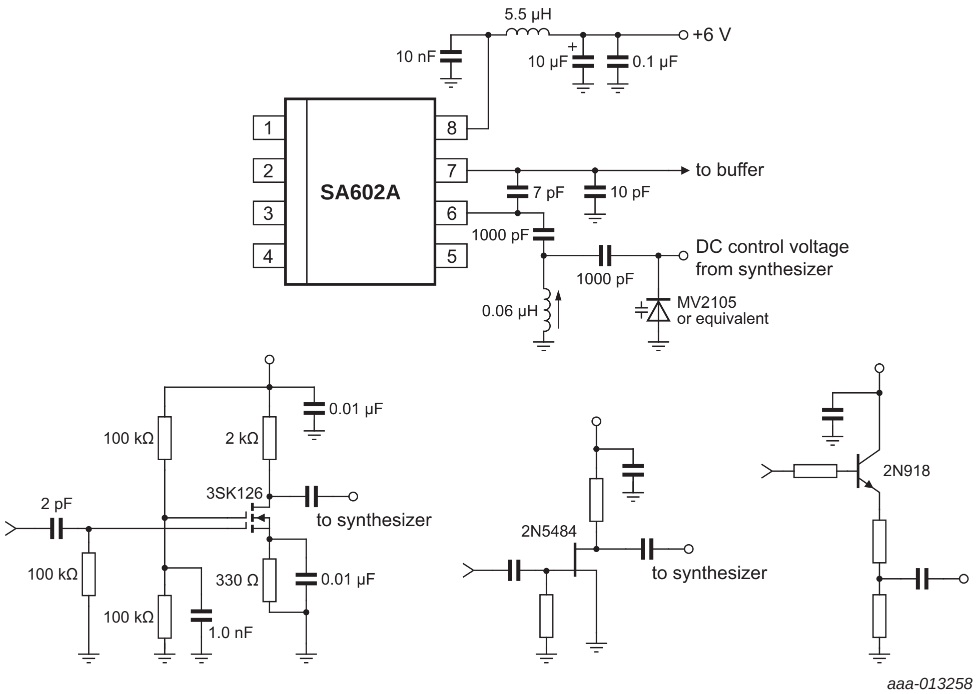


Fig 7. Colpitts oscillator suitable for synthesizer applications and typical buffers

8. Application design-in information

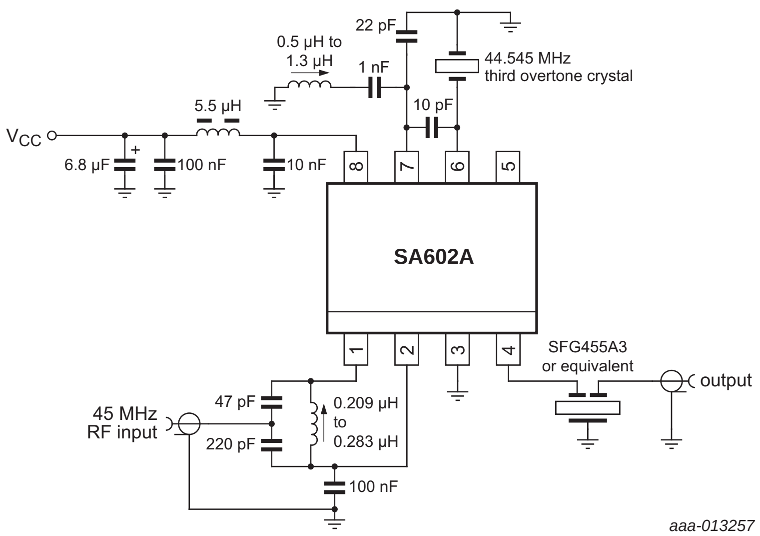


Fig 8. Typical application for cellular radio

9. Limiting values

Table 4. Limiting values
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		-	9	V
T_{stg}	storage temperature		–65	+150	°C
T_{amb}	ambient temperature	operating	–40	+85	°C

10. Thermal characteristics

Table 5. Thermal characteristics

Symbol	Parameter	Conditions	Min	Max	Unit
$Z_{th(j-a)}$	transient thermal impedance from junction to ambient		-	90	°C/W

11. Static characteristics

Table 6. Static characteristics
V_{CC} = +6 V; T_{amb} = 25 °C; unless specified otherwise.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		4.5	-	8.0	V
I_{CC}	supply current		-	2.4	2.8	mA

12. Dynamic characteristics

Table 7. Dynamic characteristics
T_{amb} = 25 °C; V_{CC} = +6 V; unless specified otherwise.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_i	input frequency		-	500	-	MHz
f_{osc}	oscillator frequency		-	200	-	MHz
NF	noise figure	at 45 MHz	-	5.0	5.5	dB
$IP3_i$	input third-order intercept point	RF input = –45 dBm; RF1 = 45.0 MHz; RF2 = 45.06 MHz	-	–13	–15	dBm
G_{conv}	conversion gain	at 45 MHz	14	17	-	dB
$R_{i(RF)}$	RF input resistance		1.5	-	-	kΩ
$C_{i(RF)}$	RF input capacitance		-	3	3.5	pF
$R_{o(mix)}$	mixer output resistance	OUT_A, OUT_B pins	-	1.5	-	kΩ

13. Performance curves

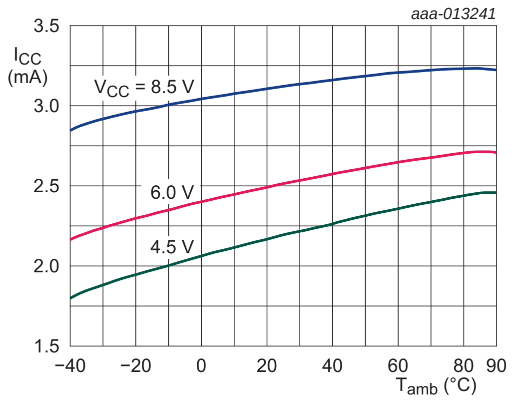


Fig 9. Supply current versus temperature

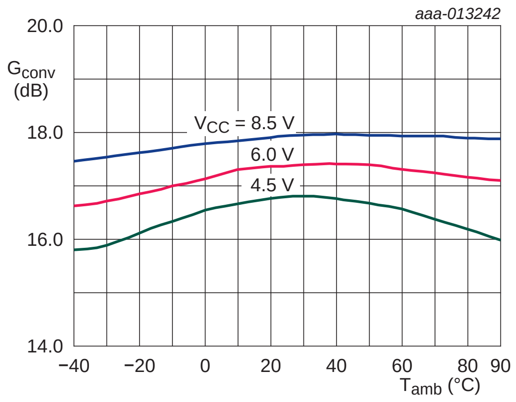


Fig 10. Conversion gain versus temperature

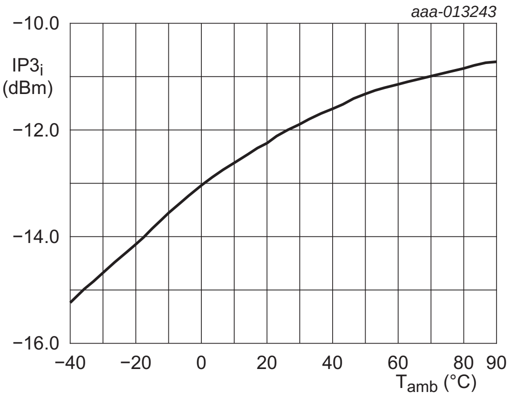


Fig 11. Third-order intercept point versus temperature

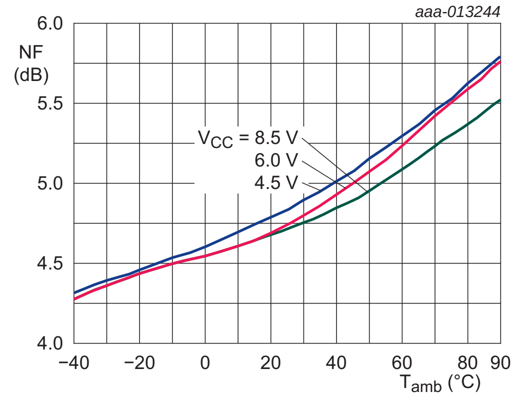
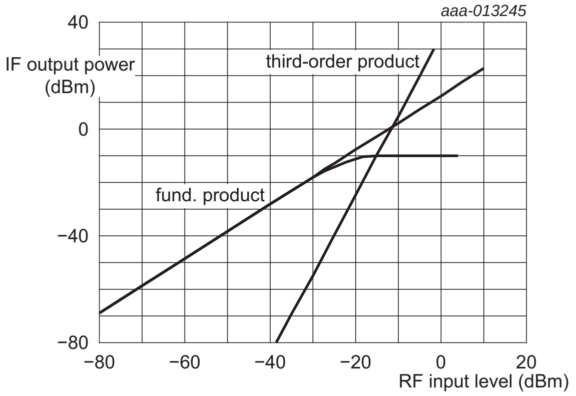


Fig 12. Noise Figure versus temperature



RF1 = 45 MHz; IF = 455 kHz; RF2 = 45.06 MHz

Fig 13. Third-order intercept and compression

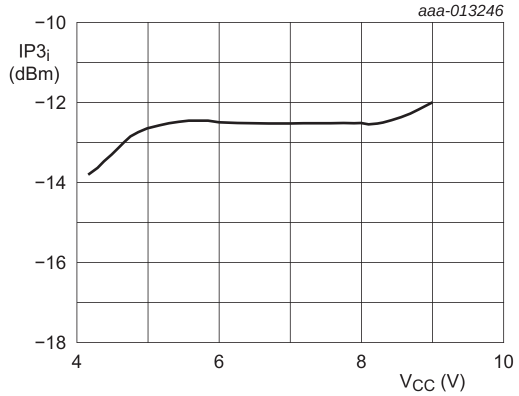


Fig 14. Input third-order intercept point versus supply voltage

14. Test information

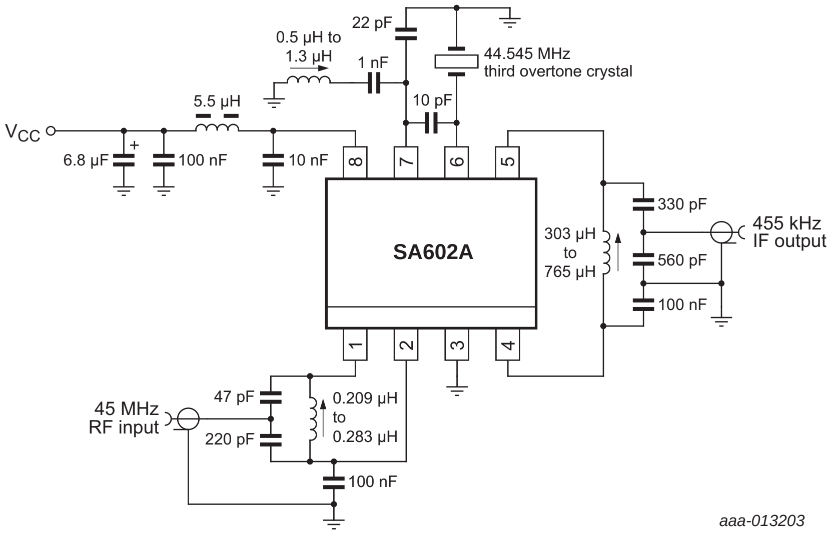
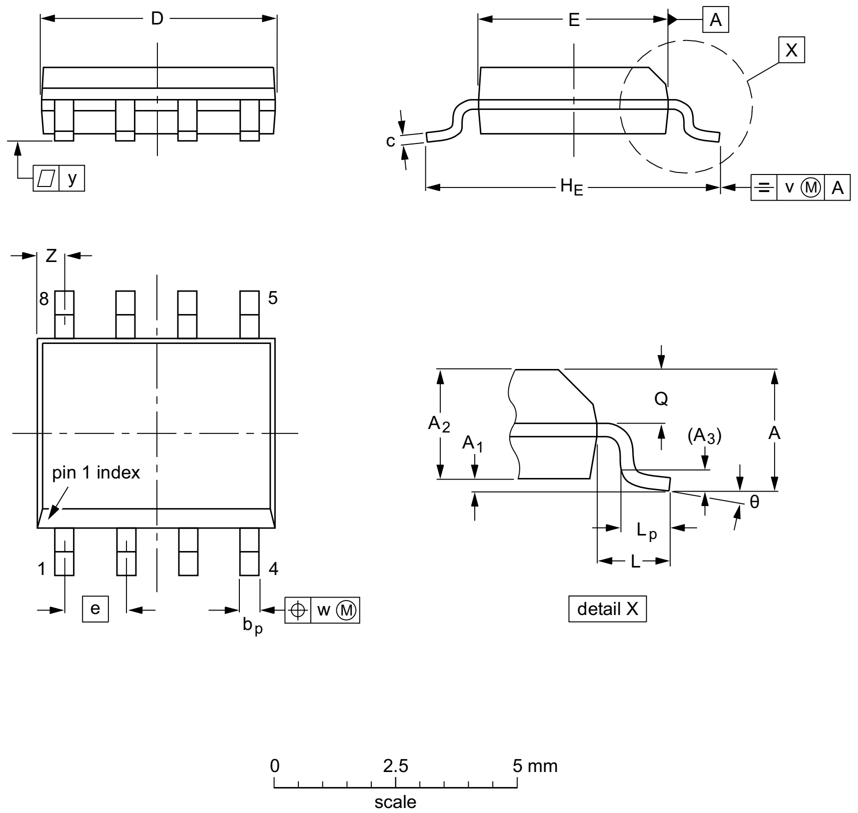


Fig 15. Test configuration

15. Package outline

SO8: plastic small outline package; 8 leads; body width 3.9 mm **SOT96-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(2)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT96-1	076E03	MS-012				~~99-12-27~~ 03-02-18

Fig 16. Package outline SOT96-1 (SO8)

16. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 “Surface mount reflow soldering description”*.

16.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

16.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

16.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

16.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 17) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 8 and 9

Table 8. SnPb eutectic process (from J-STD-020D)

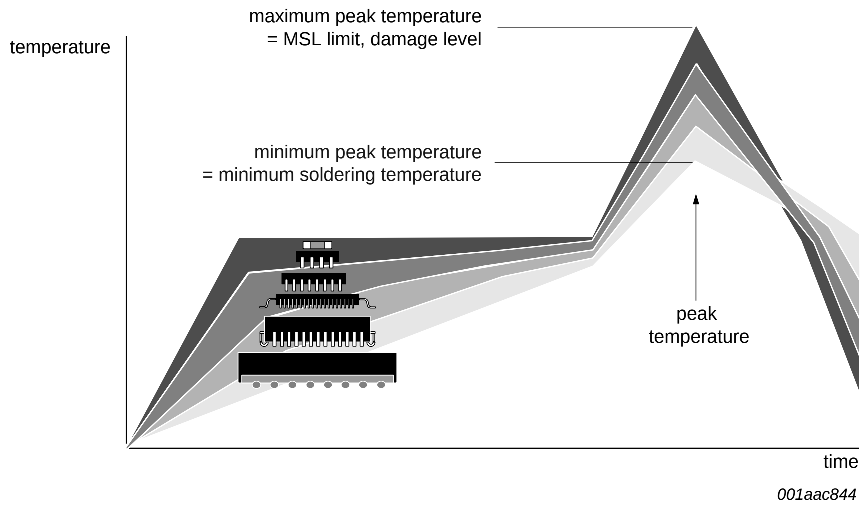
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm^3)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 9. Lead-free process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm^3)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 17.



MSL: Moisture Sensitivity Level

Fig 17. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.

17. Soldering: PCB footprints

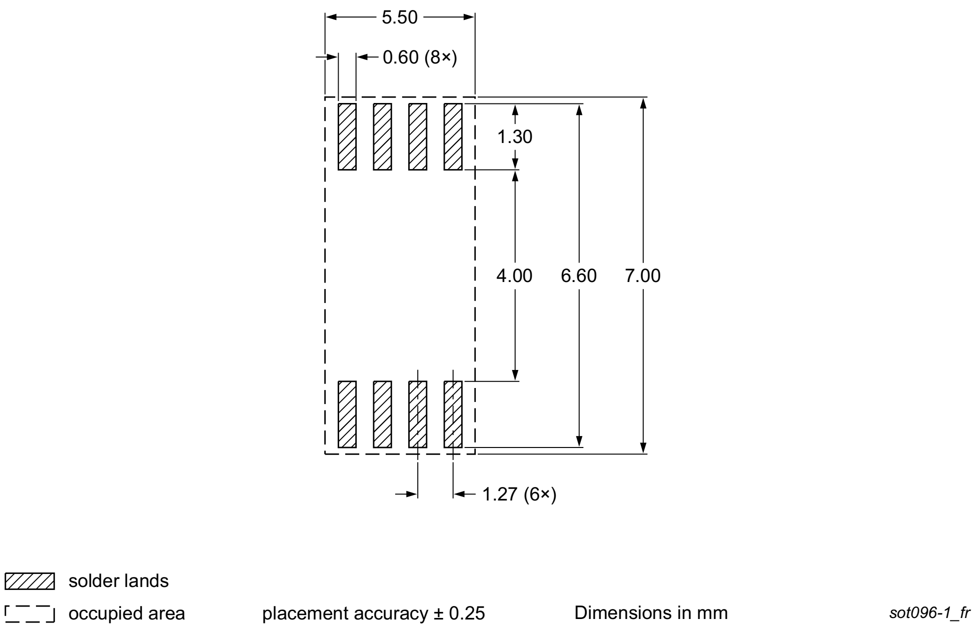


Fig 18. PCB footprint for SOT96-1 (SO8); reflow soldering

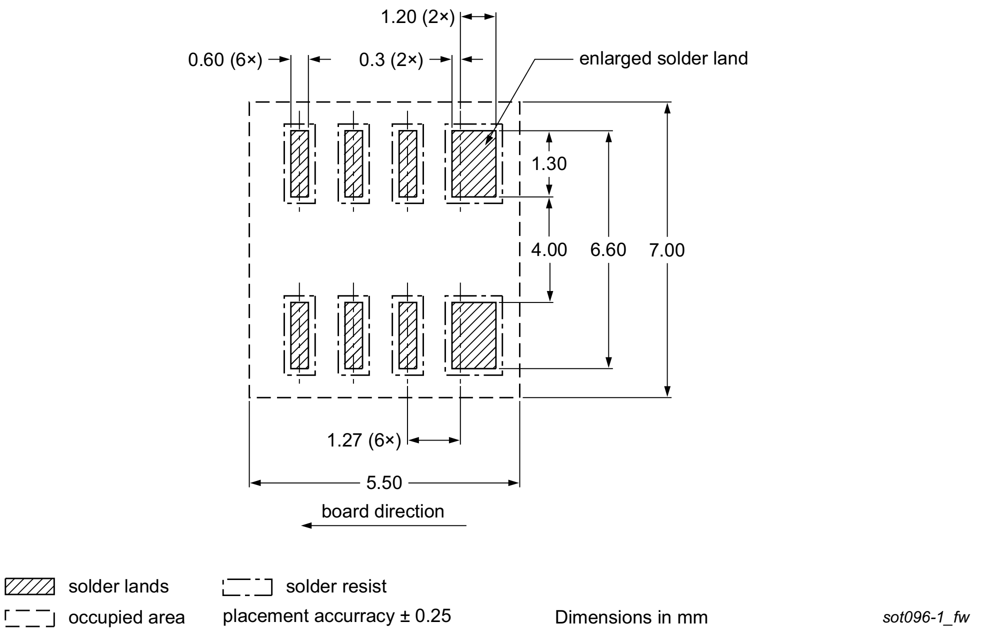


Fig 19. PCB footprint for SOT96-1 (SO8); wave soldering

18. Abbreviations

Table 10. Abbreviations

Acronym	Description
FET	Field-Effect Transistor
HF	High Frequency
IF	Intermediate Frequency
LAN	Local Area Network
LO	Local Oscillator
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
RF	Radio Frequency
VHF	Very High Frequency

19. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
SA602A v.3	20140527	Product data sheet	-	SA602A v.2
Modifications:	• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • Section 1 "General description", last sentence: deleted "8-lead dual in-line plastic package" • Table 1 "Ordering information": – Type number SA602AN (DIP8 package, SOT97-1 package outline) is discontinued and removed from this data sheet – Type number changed from "SA602AD" to "SA602AD/01" • Added Section 4.1 "Ordering options" • Added Section 6.2 "Pin description" • Figure 7 "Colpitts oscillator suitable for synthesizer applications and typical buffers": capacitor value corrected from "0.10 pF" to "10 nF" (above pin 8) • Figure 8 "Typical application for cellular radio": component value corrected from "34.545 MHz third overtone crystal" to "44.545 MHz third overtone crystal" • Table 5 "Thermal characteristics": deleted characteristic values for "N package" (SA602AN) • Old table "AC/DC electrical characteristics" split into Table 6 "Static characteristics" and Table 7 "Dynamic characteristics" • Table 7 "Dynamic characteristics", Conditions for $IP3_i$, input third-order intercept point, corrected from "f_1" to "RF1" and from "f_2" to "RF2" • Figure 15 "Test configuration": component values corrected throughout this drawing • Package outline SOT97-1 (DIP8) is deleted • Added soldering information • Added Section 17 "Soldering: PCB footprints" • Added Section 18 "Abbreviations"			
SA602A v.2	19971107	Product specification	853-1424 18662	NE/SA602A v.1
NE/SA602A v.1	19900417	Product specification	853-1424 99374	-

20. Legal information

20.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

21. Contact information

For more information, please visit: **http://www.nxp.com**

For sales office addresses, please send an email to: **salesaddresses@nxp.com**

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