

DATA SHEET

SA5209

Wideband variable gain amplifier

Product specification
Replaces data of 1990 Aug 20
IC17 Data Handbook

1997 Nov 07

Philips Semiconductors



PHILIPS

Wideband variable gain amplifier

SA5209

DESCRIPTION

The SA5209 represents a breakthrough in monolithic amplifier design featuring several innovations. This unique design has combined the advantages of a high speed bipolar process with the proven Gilbert architecture.

The SA5209 is a linear broadband RF amplifier whose gain is controlled by a single DC voltage. The amplifier runs off a single 5 volt supply and consumes only 40mA. The amplifier has high impedance (1k Ω) differential inputs. The output is 50 Ω differential. Therefore, the 5209 can simultaneously perform AGC, impedance transformation, and the balun functions.

The dynamic range is excellent over a wide range of gain setting. Furthermore, the noise performance degrades at a comparatively slow rate as the gain is reduced. This is an important feature when building linear AGC systems.

FEATURES

- Gain to 1.5GHz
- 850MHz bandwidth
- High impedance differential input
- 50 Ω differential output
- Single 5V power supply
- 0 - 1V gain control pin
- >60dB gain control range at 200MHz
- 26dB maximum gain differential
- Exceptional $V_{CONTROL} / V_{GAIN}$ linearity
- 7dB noise figure minimum
- Full ESD protection
- Easily cascadable

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
16-Pin Plastic Small Outline (SO) package	-40 to +85°C	SA5209D	SOT109-1
16-Pin Plastic Dual In-Line Package (DIP)	-40 to +85°C	SA5209N	SOT38-4

PIN CONFIGURATION

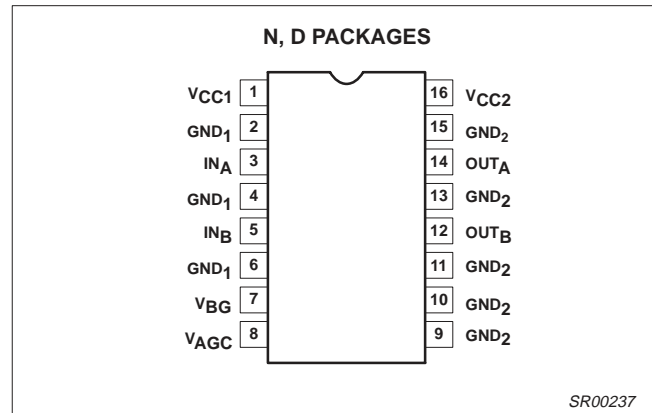


Figure 1. Pin Configuration

APPLICATIONS

- Linear AGC systems
- Very linear AM modulator
- RF balun
- Cable TV multi-purpose amplifier
- Fiber optic AGC
- RADAR
- User programmable fixed gain block
- Video
- Satellite receivers
- Cellular communications

Wideband variable gain amplifier

SA5209

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNITS
V_{CC}	Supply voltage	-0.5 to +8.0	V
P_D	Power dissipation, $T_A = 25^\circ\text{C}$ (still air) ¹ 16-Pin Plastic DIP 16-Pin Plastic SO	1450 1100	mW mW
T_{JMAX}	Maximum operating junction temperature	150	$^\circ\text{C}$
T_{STG}	Storage temperature range	-65 to +150	$^\circ\text{C}$

NOTES:

- Maximum dissipation is determined by the operating ambient temperature and the thermal resistance, θ_{JA} :
16-Pin DIP: $\theta_{JA} = 85^\circ\text{C/W}$
16-Pin SO: $\theta_{JA} = 110^\circ\text{C/W}$

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	RATING	UNITS
V_{CC}	Supply voltage	$V_{CC1} = V_{CC2} = 4.5$ to 7.0V	V
T_A	Operating ambient temperature range SA Grade	-40 to +85	$^\circ\text{C}$
T_J	Operating junction temperature range SA Grade	-40 to +105	$^\circ\text{C}$

DC ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_{CC1} = V_{CC2} = +5\text{V}$, $V_{AGC} = 1.0\text{V}$, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
I_{CC}	Supply current	DC tested	38	43	48	mA
		Over temperature ¹	30		55	
A_V	Voltage gain (single-ended in/single-ended out)	DC tested, $R_L = 10\text{k}\Omega$	17	19	21	dB
		Over temperature ¹	16		22	
A_V	Voltage gain (single-ended in/differential out)	DC tested, $R_L = 10\text{k}\Omega$	23	25	27	dB
		Over temperature ¹	22		28	
R_{IN}	Input resistance (single-ended)	DC tested at $\pm 50\mu\text{A}$	0.9	1.2	1.5	$\text{k}\Omega$
		Over temperature ¹	0.8		1.7	
R_{OUT}	Output resistance (single-ended)	DC tested at $\pm 1\text{mA}$	40	60	75	Ω
		Over temperature ¹	35		90	
V_{OS}	Output offset voltage (output referred)			± 20	± 100	mV
		Over temperature ¹			± 250	
V_{IN}	DC level on inputs		1.6	2.0	2.4	V
		Over temperature ¹	1.4		2.6	
V_{OUT}	DC level on outputs		1.9	2.4	2.9	V
		Over temperature ¹	1.7		3.1	
PSRR	Output offset supply rejection ratio (output referred)		20	45		dB
		Over temperature ¹	15			
V_{BG}	Bandgap reference voltage	$4.5\text{V} < V_{CC} < 7\text{V}$ $R_{BG} = 10\text{k}\Omega$	1.2	1.32	1.45	V
		Over temperature ¹	1.1		1.55	

Wideband variable gain amplifier

SA5209

DC ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_{CC1} = V_{CC2} = +5.0\text{V}$, $V_{AGC} = 1.0\text{V}$, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
R_{BG}	Bandgap loading	Over temperature ¹	2	10		$k\Omega$
V_{AGC}	AGC DC control voltage range	Over temperature ¹		0-1.3		V
I_{BAGC}	AGC pin DC bias current	$0\text{V} < V_{AGC} < 1.3\text{V}$		-0.7	-6	μA
		Over temperature ¹			-10	

NOTES:

1. "Over Temperature Range" testing is as follows:
SA is -40 to $+85^\circ\text{C}$

At the time of this data sheet release, the D package over-temperature data sheet limits are guaranteed via guardbanded room temperature testing only.

AC ELECTRICAL CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $V_{CC1} = V_{CC2} = +5.0\text{V}$, $V_{AGC} = 1.0\text{V}$, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
BW	-3dB bandwidth		600	850		MHz
		Over temperature ¹	500			
GF	Gain flatness	DC - 500MHz		± 0.4		dB
		Over temperature ¹		± 0.6		
V_{IMAX}	Maximum input voltage swing (single-ended) for linear operation ²			200		mV _{P-P}
V_{OMAX}	Maximum output voltage swing (single-ended) for linear operation ²	$R_L = 50\Omega$		400		mV _{P-P}
		$R_L = 1k\Omega$		1.9		V _{P-P}
NF	Noise figure (unmatched configuration)	$R_S = 50\Omega$, $f = 50\text{MHz}$		9.3		dB
V_{IN-EQ}	Equivalent input noise voltage spectral density	$f = 100\text{MHz}$		2.5		$nV/\sqrt{\text{Hz}}$
S12	Reverse isolation	$f = 100\text{MHz}$		-60		dB
$\Delta G/\Delta V_{CC}$	Gain supply sensitivity (single-ended)			0.3		dB/V
$\Delta G/\Delta T$	Gain temperature sensitivity	$R_L = 50\Omega$		0.013		dB/ $^\circ\text{C}$
C_{IN}	Input capacitance (single-ended)			2		pF
BW_{AGC}	-3dB bandwidth of gain control function			20		MHz
P_{O-1dB}	1dB gain compression point at output	$f = 100\text{MHz}$		-3		dBm
P_{I-1dB}	1dB gain compression point at input	$f = 100\text{MHz}$, $V_{AGC} = 0.1\text{V}$		-10		dBm
$IP3_{OUT}$	Third-order intercept point at output	$f = 100\text{MHz}$, $V_{AGC} > 0.5\text{V}$		+13		dBm
$IP3_{IN}$	Third-order intercept point at input	$f = 100\text{MHz}$, $V_{AGC} < 0.5\text{V}$		+5		dBm
ΔG_{AB}	Gain match output A to output B	$f = 100\text{MHz}$, $V_{AGC} = 1\text{V}$		0.1		dB

NOTE:

1. "Over Temperature Range" testing is as follows:
SA is -40 to $+85^\circ\text{C}$

At the time of this data sheet release, the D package over-temperature data sheet limits are guaranteed via guardbanded room temperature testing only.

2. With $R_L > 1k\Omega$, overload occurs at input for single-ended gain $< 13\text{dB}$ and at output for single-ended gain $> 13\text{dB}$. With $R_L = 50\Omega$, overload occurs at input for single-ended gain $< 6\text{dB}$ and at output for single-ended gain $> 6\text{dB}$.

Wideband variable gain amplifier

SA5209

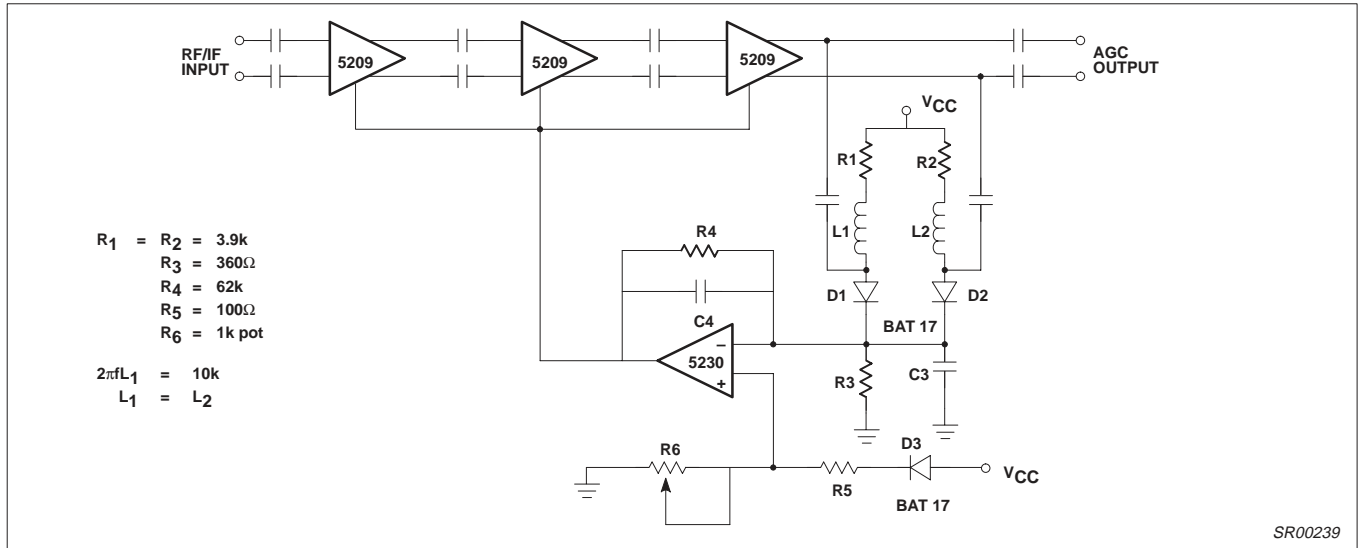


Figure 3. AGC Configuration Using Cascaded SA5209s

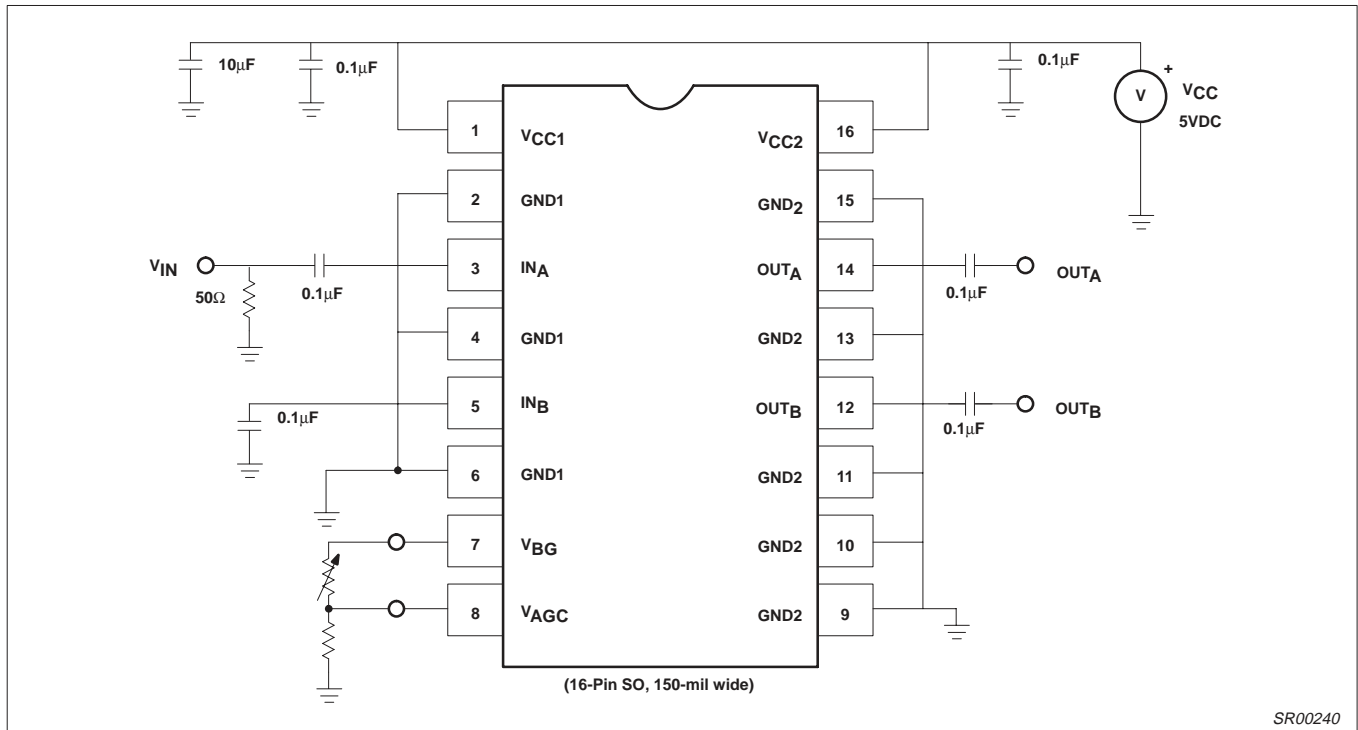


Figure 4. VGA AC Evaluation Board

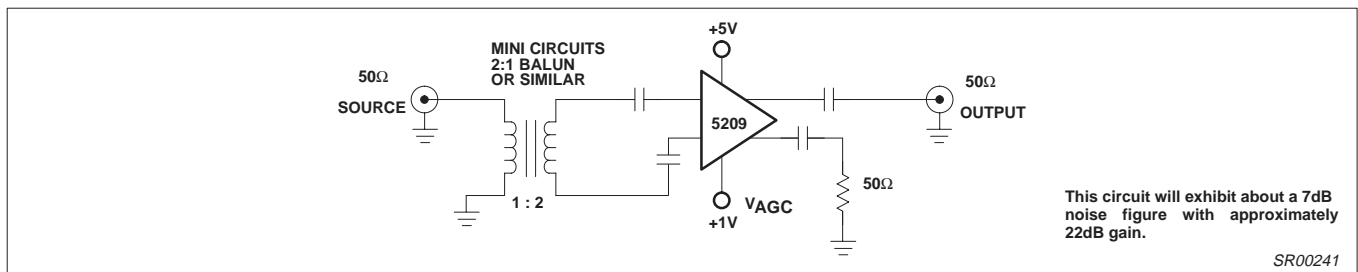


Figure 5. Broadband Noise Optimization

Wideband variable gain amplifier

SA5209

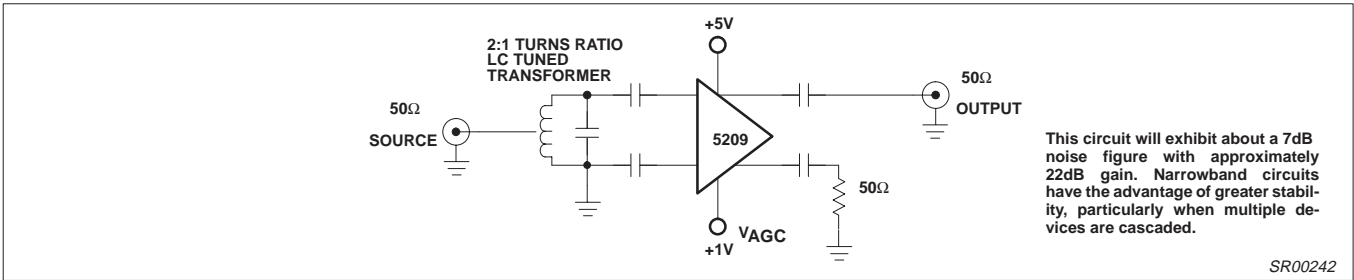


Figure 6. Narrowband Noise Optimization

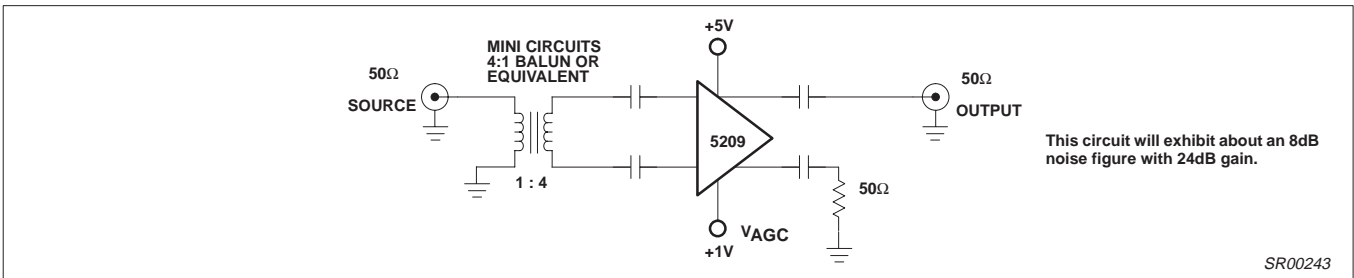


Figure 7. Broadband Gain Optimization

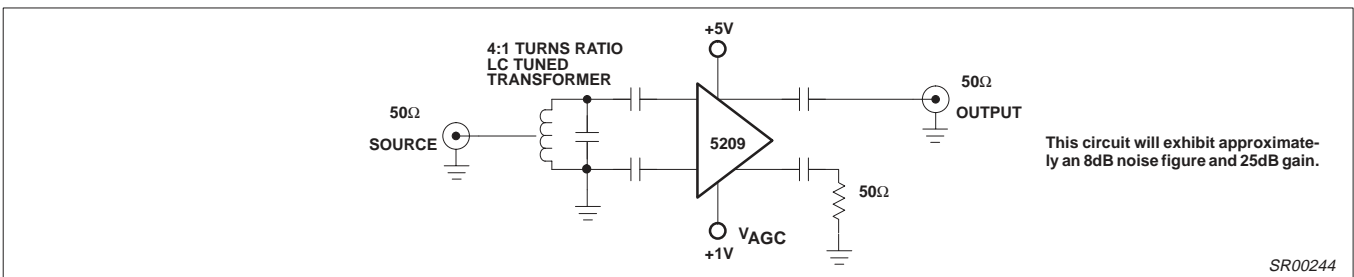


Figure 8. Narrowband Gain Optimization

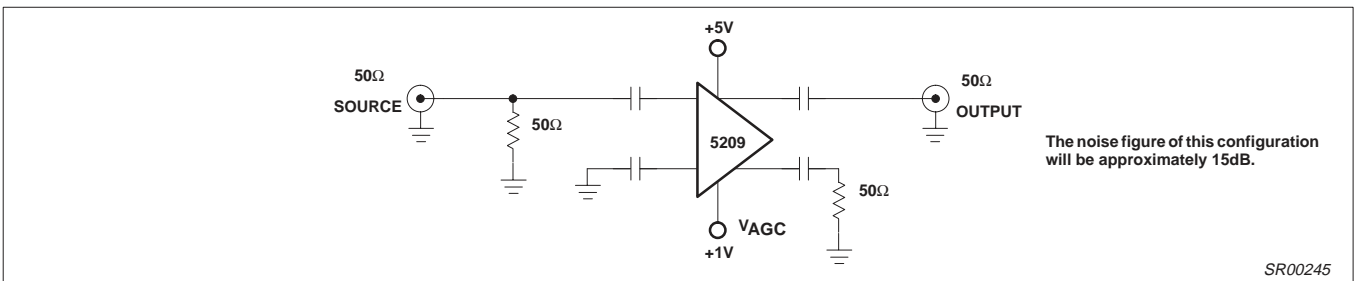


Figure 9. Simple Amplifier Configuration

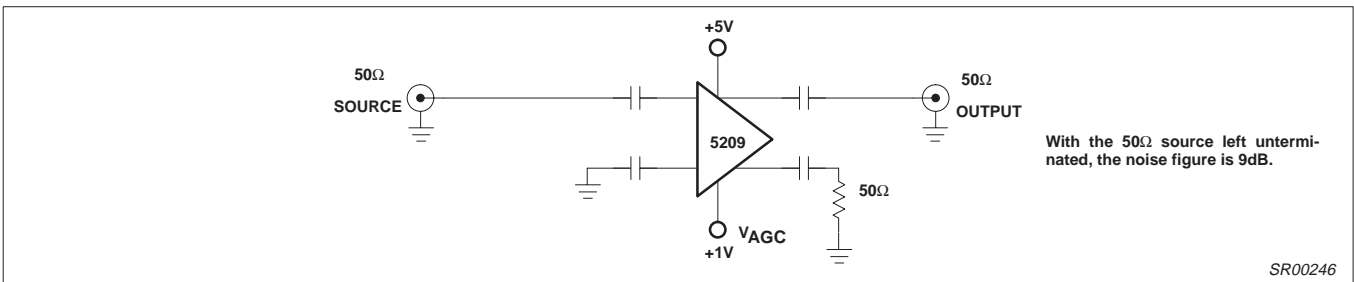


Figure 10. Underterminated Configuration

Wideband variable gain amplifier

SA5209

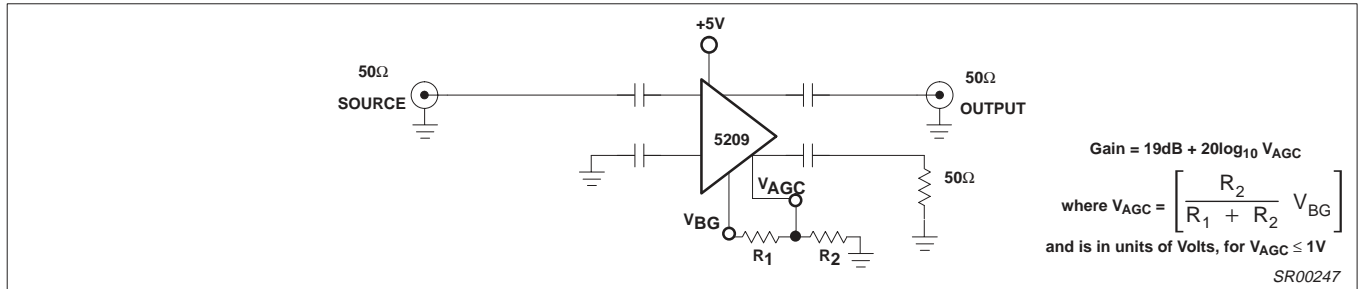


Figure 11. User-Programmable Fixed Gain Block

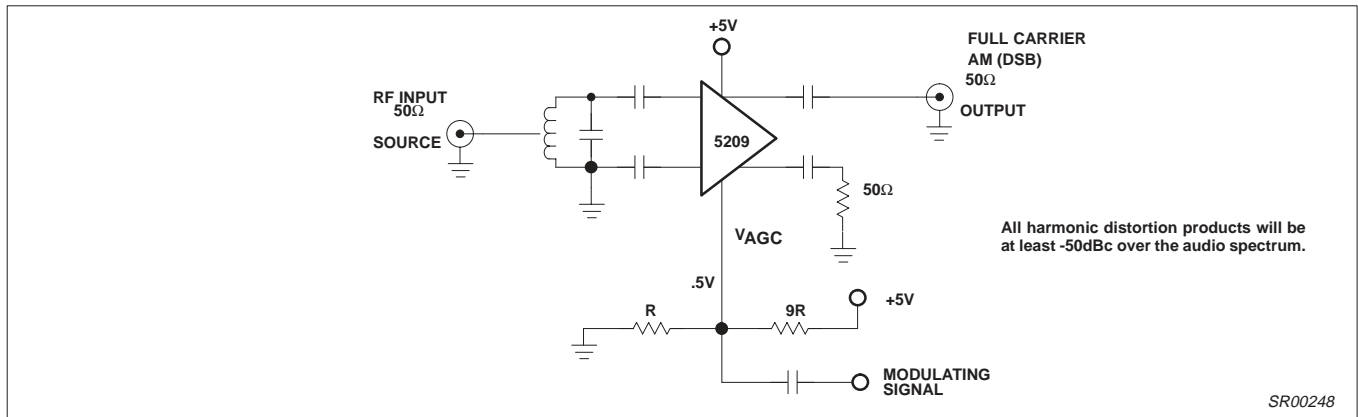


Figure 12. AM Modulator

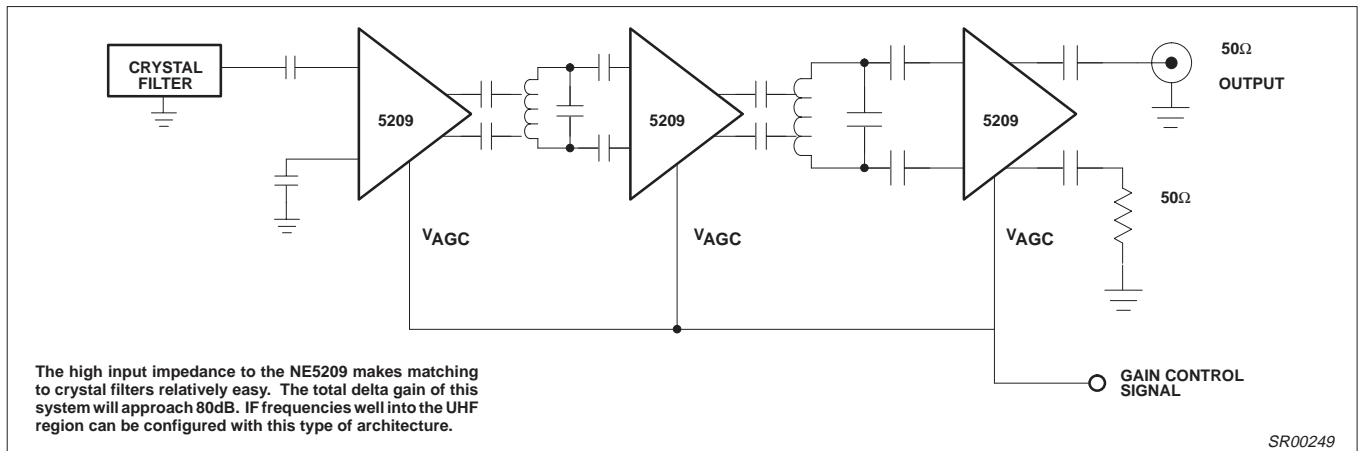


Figure 13. Receiver AGC IF Gain

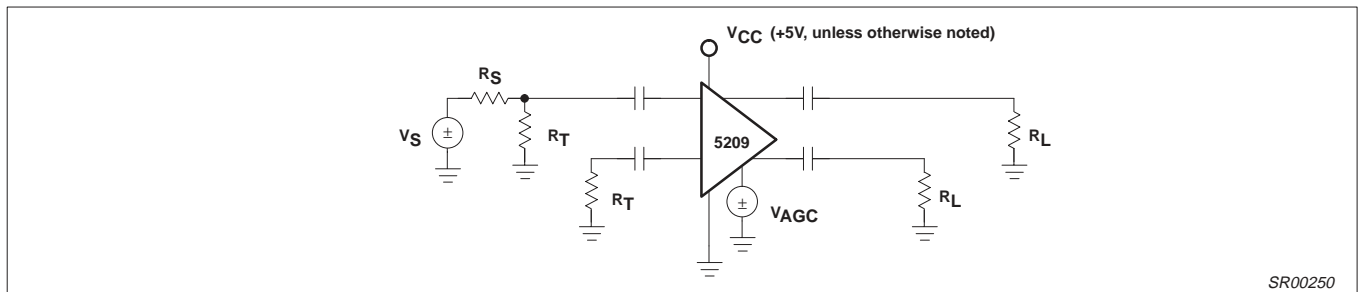


Figure 14. Test Set-up 1 (Used for all Graphs)

Wideband variable gain amplifier

SA5209

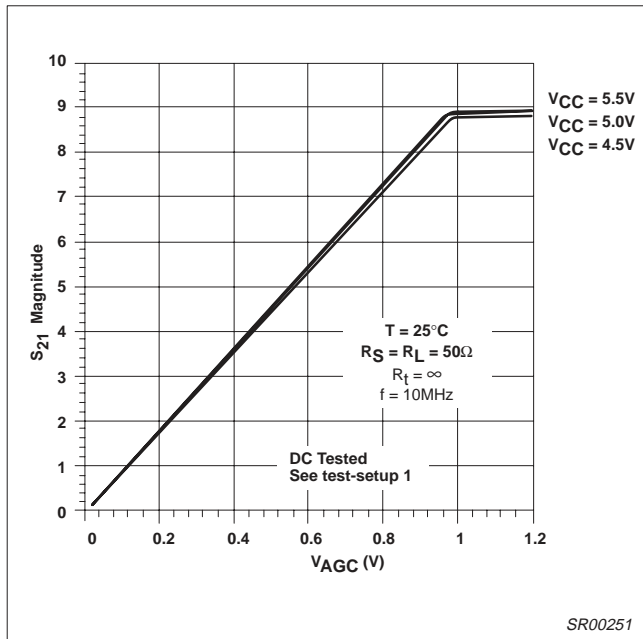


Figure 15. Gain vs V_{AGC} and V_{CC}

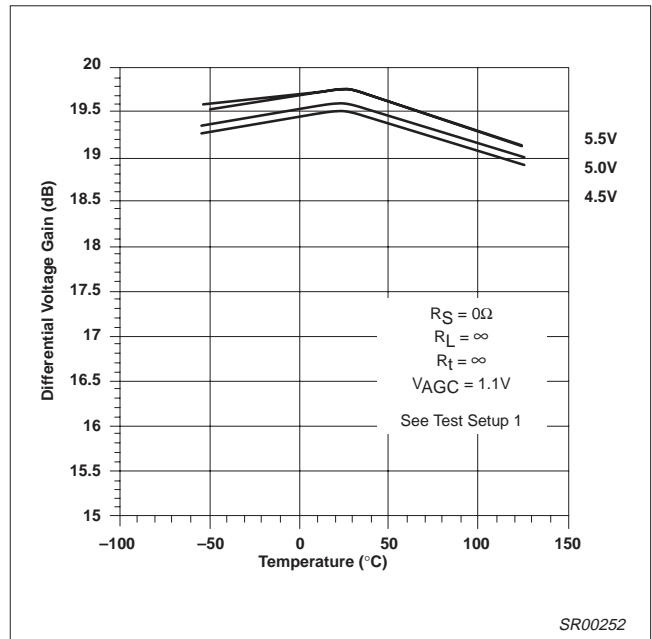


Figure 17. Voltage Gain vs Temperature and V_{CC}

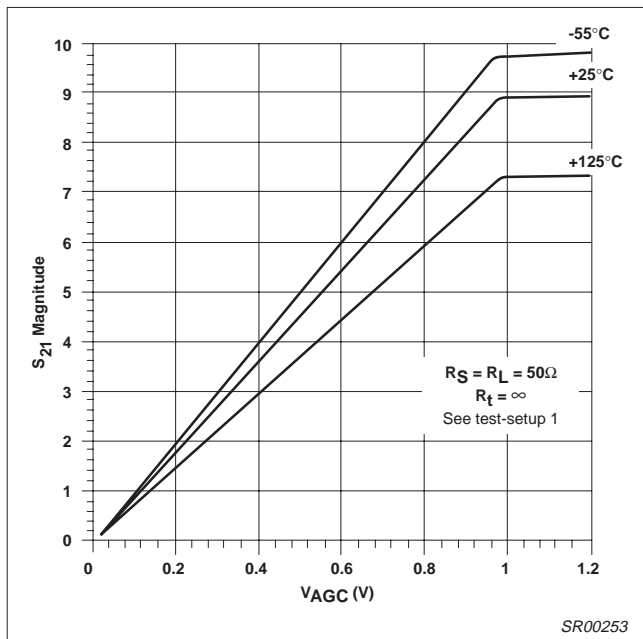


Figure 16. Insertion Gain vs V_{AGC} and Temperature

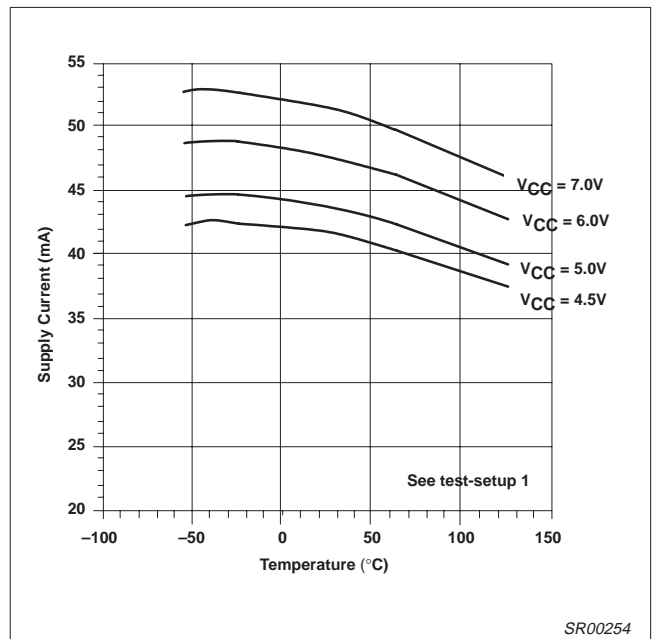


Figure 18. Supply Current vs Temperature and V_{CC}

Wideband variable gain amplifier

SA5209

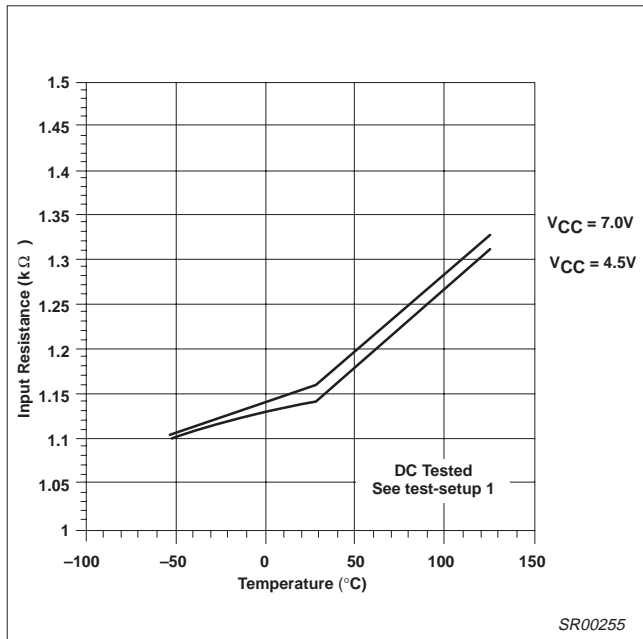


Figure 19. Input Resistance vs Temperature

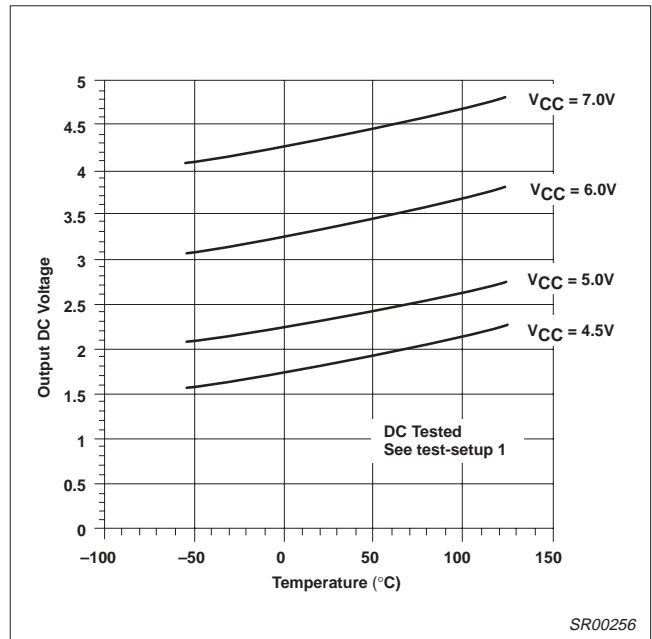


Figure 21. Output Bias Voltage vs Temperature and V_{CC}

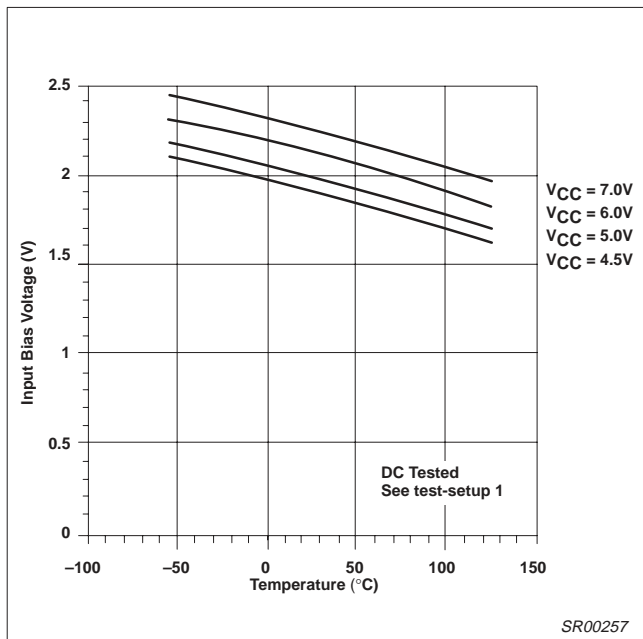


Figure 20. Input Bias Voltage vs Temperature

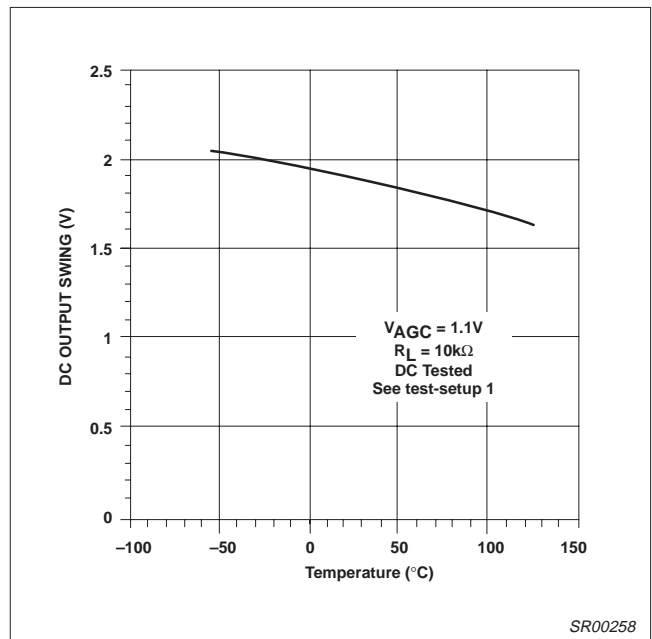


Figure 22. DC Output Swing vs Temperature

Wideband variable gain amplifier

SA5209

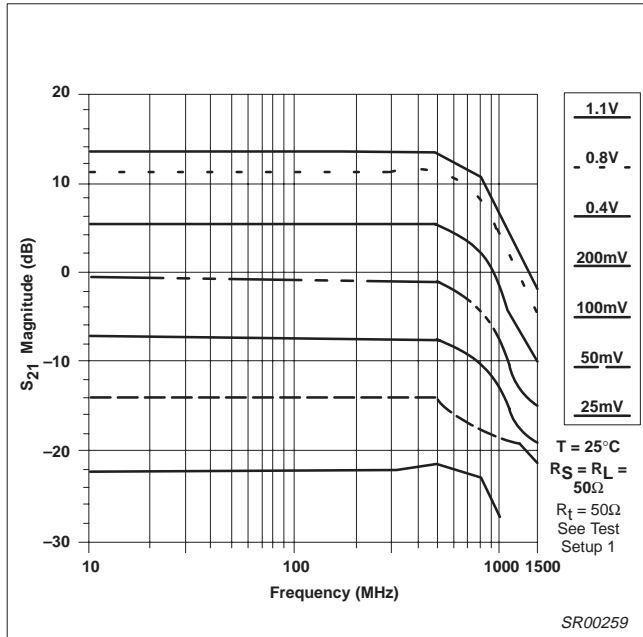


Figure 23. Insertion Gain vs Frequency and V_{AGC}

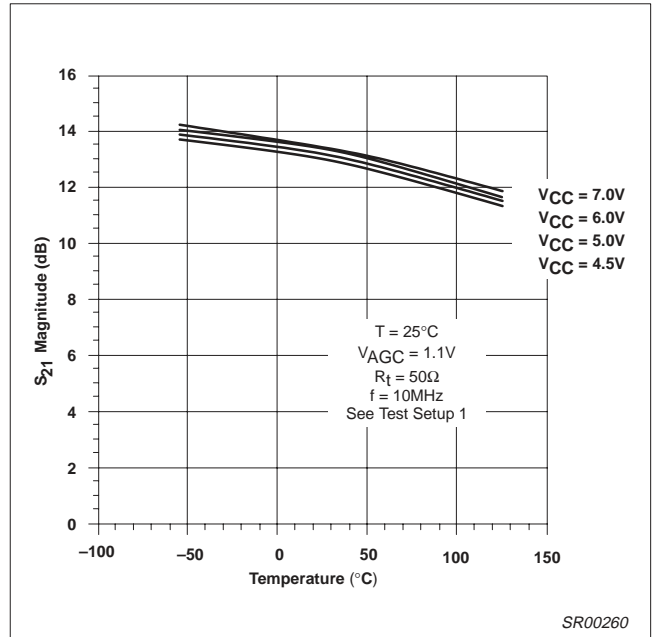


Figure 25. Insertion Gain vs Temperature and V_{CC}

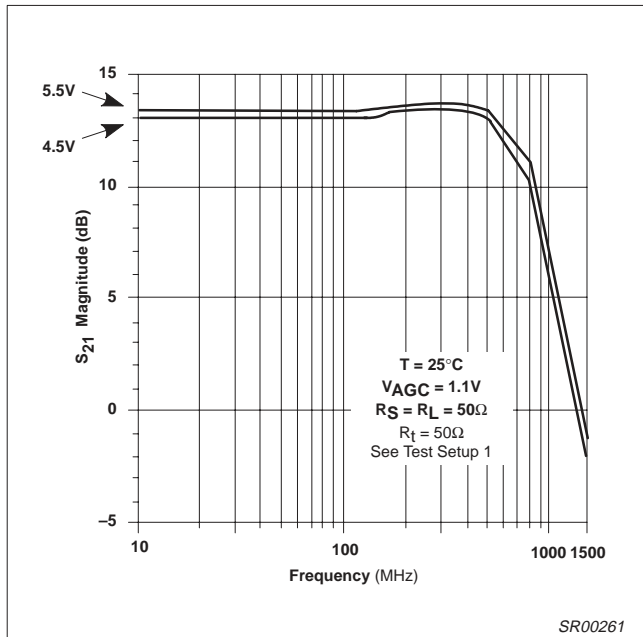


Figure 24. Insertion Gain vs Frequency and V_{CC}

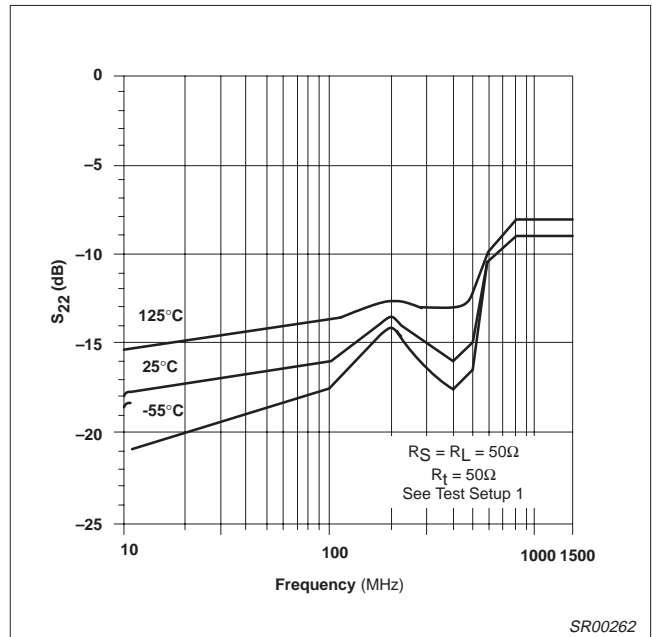


Figure 26. Output Return Loss vs Frequency

Wideband variable gain amplifier

SA5209

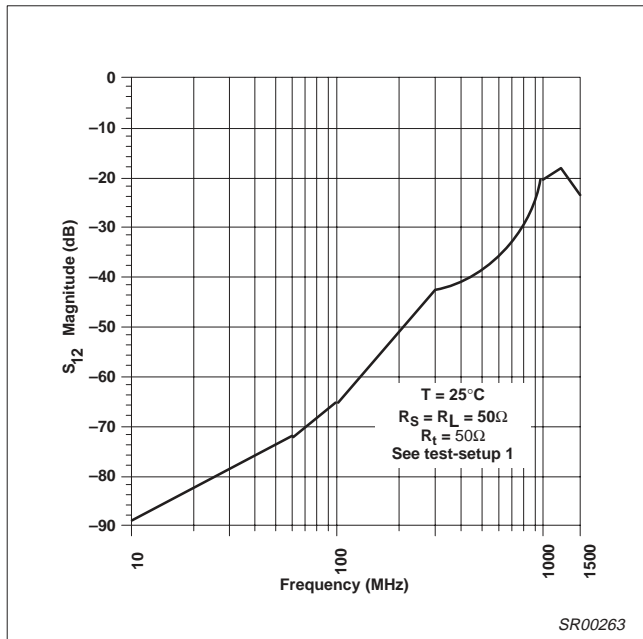


Figure 27. Reverse Isolation vs Frequency

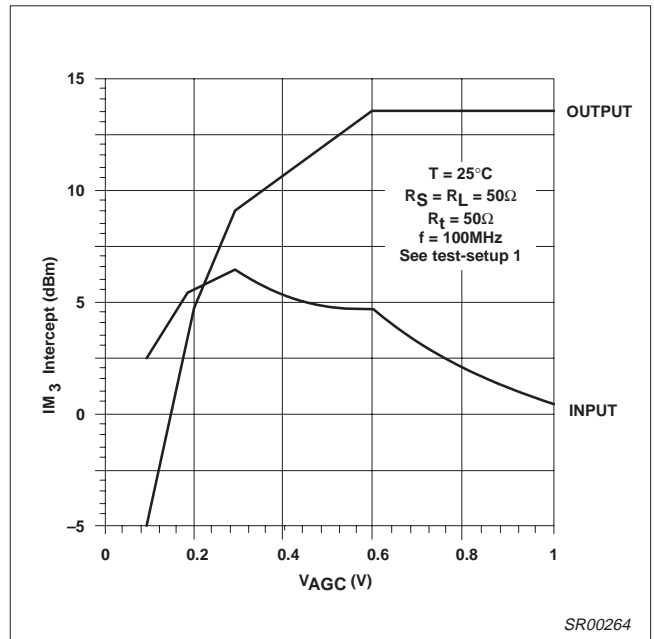


Figure 29. Third-Order Intermodulation Intercept vs V_{AGC}

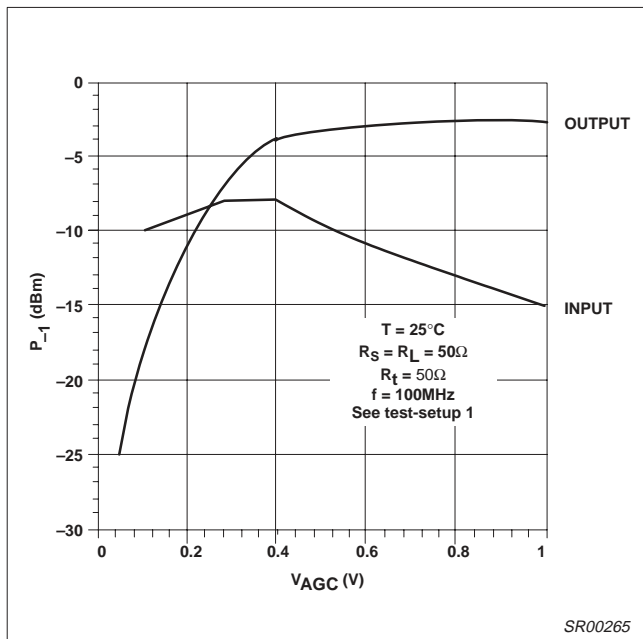


Figure 28. 1dB Gain Compression vs V_{AGC}

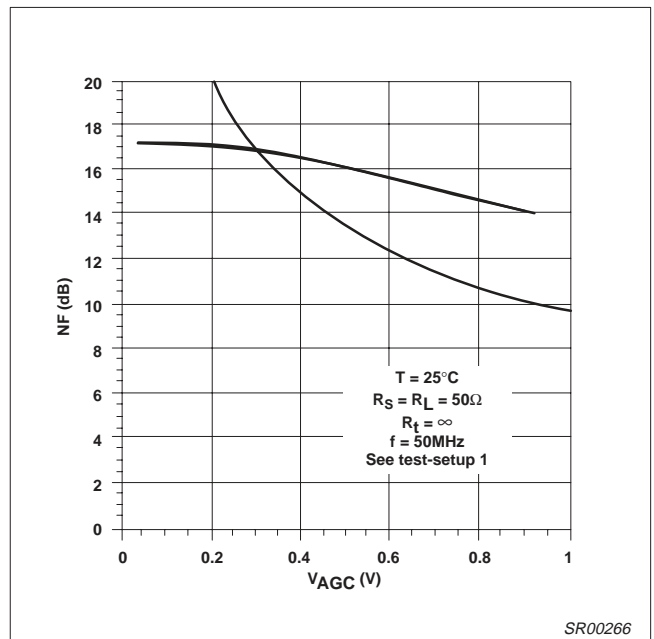


Figure 30. Noise Figure vs V_{AGC}

Wideband variable gain amplifier

SA5209

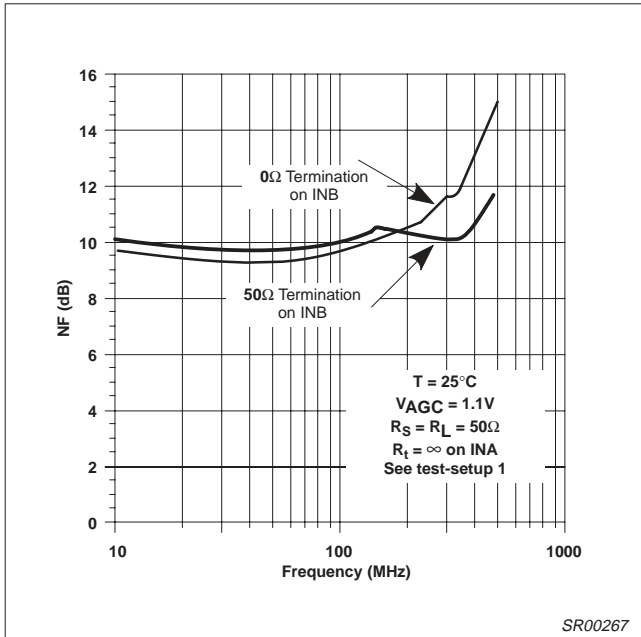


Figure 31. Noise Figure vs Frequency

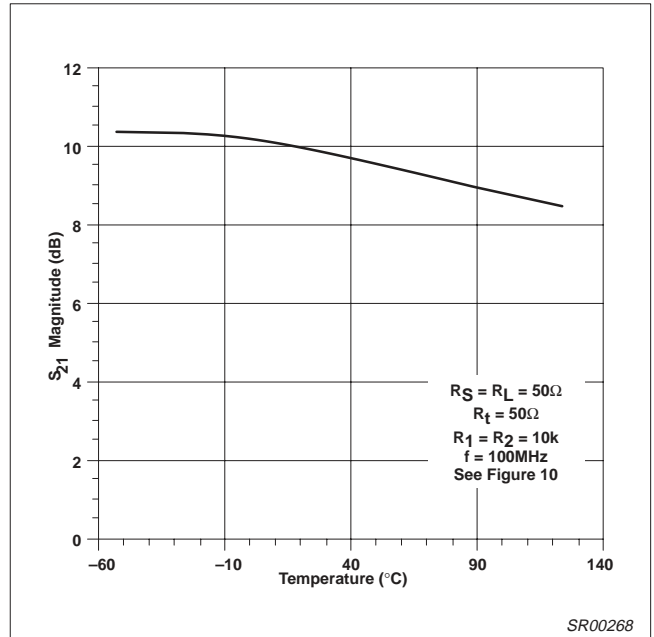


Figure 33. Fixed Gain vs Temperature

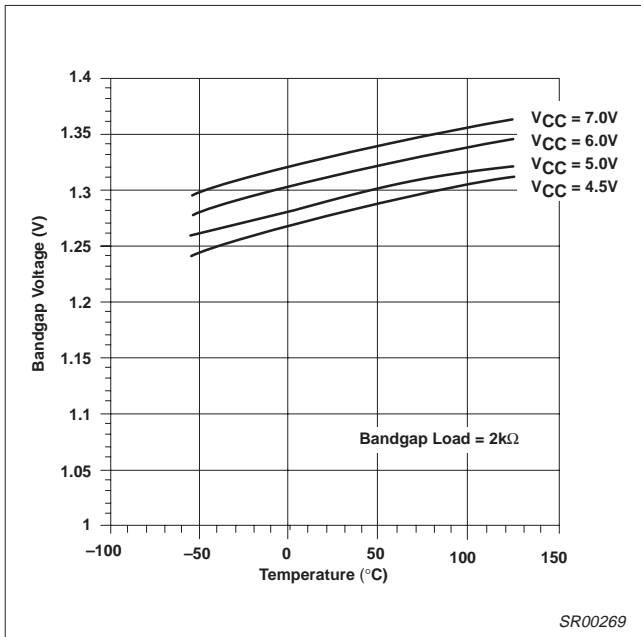


Figure 32. Bandgap Voltage vs Temperature and VCC

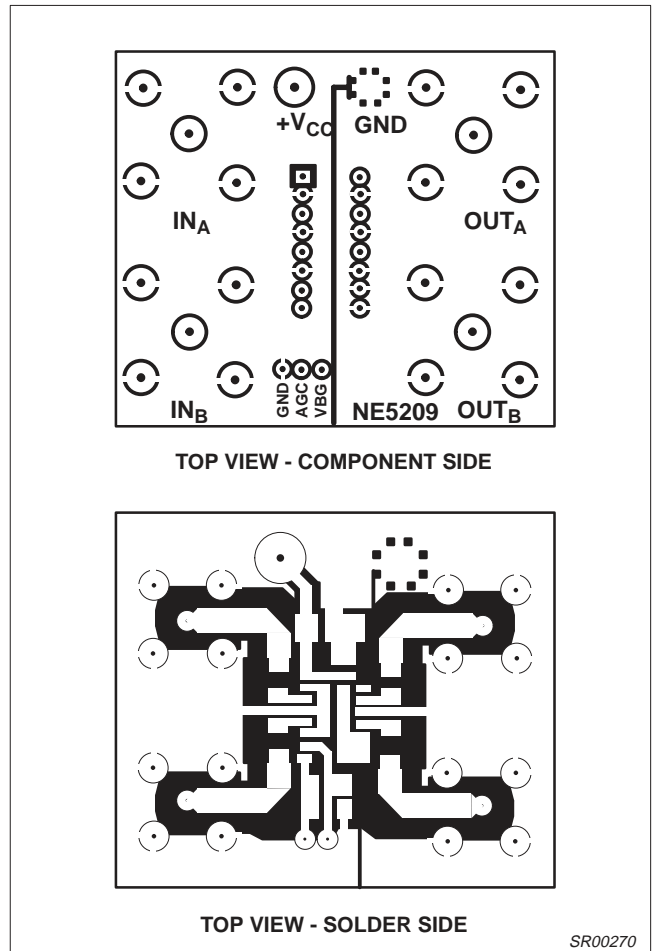


Figure 34. VGA AC Evaluation Board Layout

Wideband variable gain amplifier

SA5209

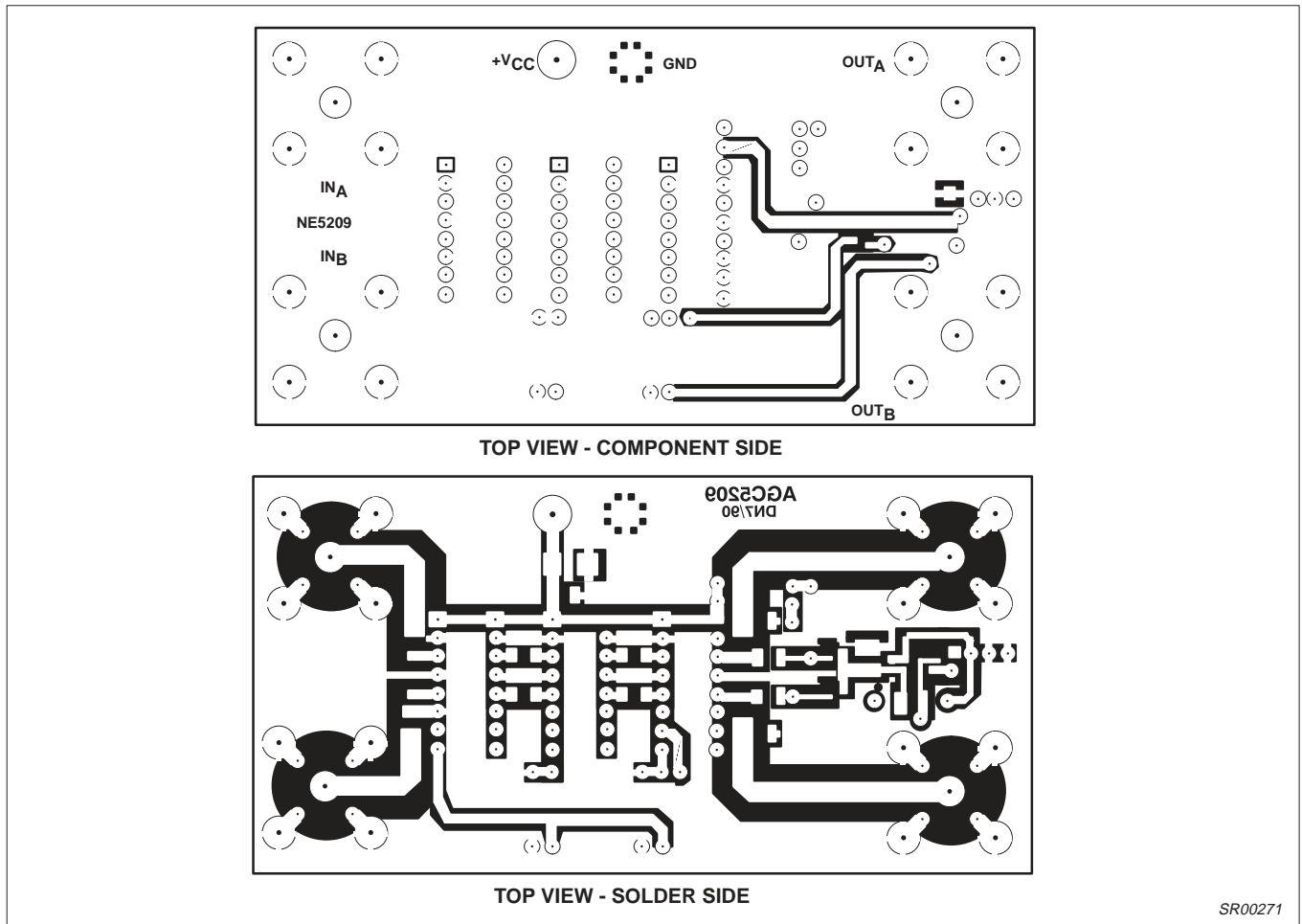


Figure 35. AGC Configuration Using Cascaded SA5209s - Layout

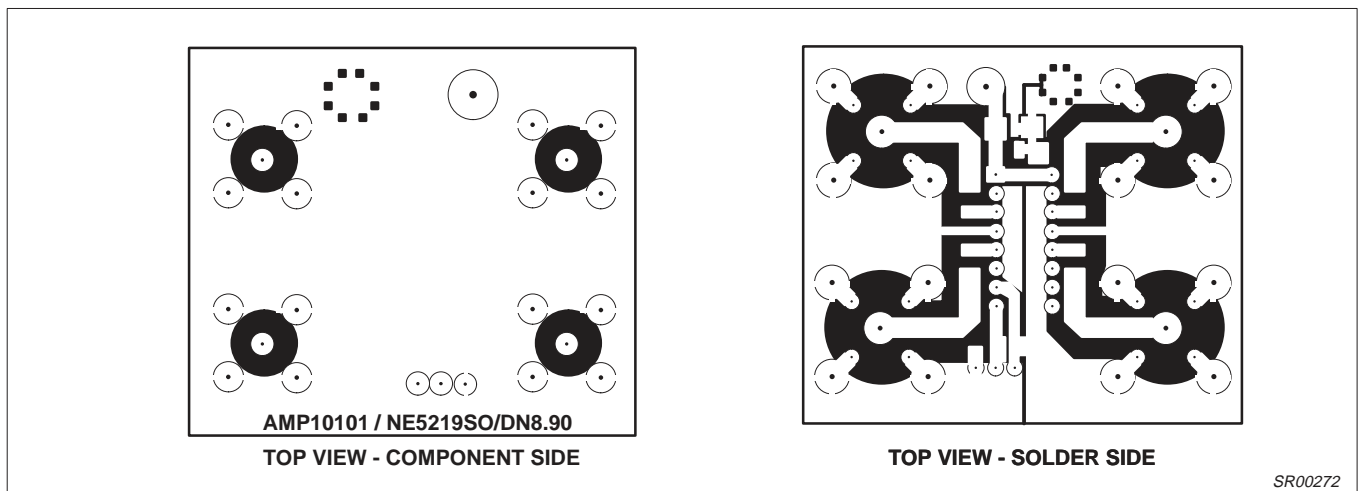


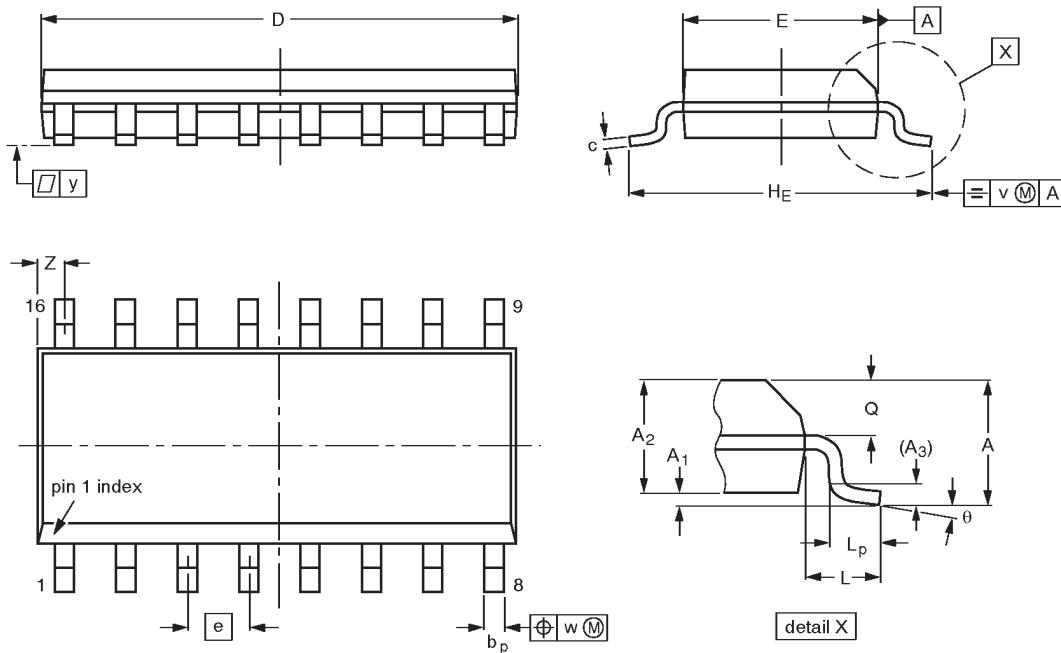
Figure 36. VGA AC Evaluation Board Layout (DIP Package)

Wideband variable gain amplifier

SA5209

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1



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 ⁽¹⁾	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	10.0 9.8	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	0.0098 0.0039	0.057 0.049	0.01	0.019 0.014	0.0098 0.0075	0.39 0.38	0.16 0.15	0.050	0.24 0.23	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

Note

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

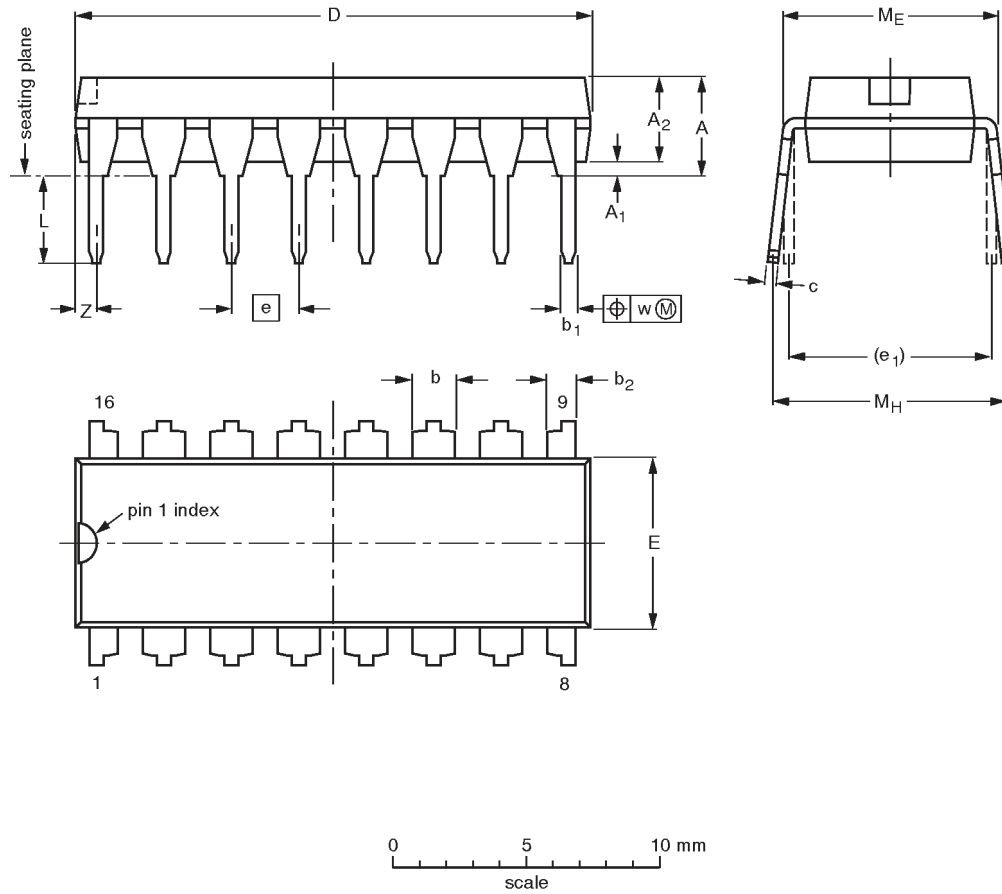
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT109-1	076E07S	MS-012AC				91-08-13 95-01-23

Wideband variable gain amplifier

SA5209

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4



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

UNIT	A max.	A ₁ min.	A ₂ max.	b	b ₁	b ₂	c	D ⁽¹⁾	E ⁽¹⁾	e	e ₁	L	M _E	M _H	w	Z ⁽¹⁾ max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	1.25 0.85	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	0.76
inches	0.17	0.020	0.13	0.068 0.051	0.021 0.015	0.049 0.033	0.014 0.009	0.77 0.73	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.030

Note

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

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT38-4						92-11-17 95-01-14

Wideband variable gain amplifier

SA5209

DEFINITIONS

Data Sheet Identification	Product Status	Definition
<i>Objective Specification</i>	Formative or in Design	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
<i>Preliminary Specification</i>	Preproduction Product	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
<i>Product Specification</i>	Full Production	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

Philips Semiconductors and Philips Electronics North America Corporation reserve the right to make changes, without notice, in the products, including circuits, standard cells, and/or software, described or contained herein in order to improve design and/or performance. Philips Semiconductors assumes no responsibility or liability for the use of any of these products, conveys no license or title under any patent, copyright, or mask work right to these products, and makes no representations or warranties that these products are free from patent, copyright, or mask work right infringement, unless otherwise specified. Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

LIFE SUPPORT APPLICATIONS

Philips Semiconductors and Philips Electronics North America Corporation Products are not designed for use in life support appliances, devices, or systems where malfunction of a Philips Semiconductors and Philips Electronics North America Corporation Product can reasonably be expected to result in a personal injury. Philips Semiconductors and Philips Electronics North America Corporation customers using or selling Philips Semiconductors and Philips Electronics North America Corporation Products for use in such applications do so at their own risk and agree to fully indemnify Philips Semiconductors and Philips Electronics North America Corporation for any damages resulting from such improper use or sale.

Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088-3409
Telephone 800-234-7381

© Copyright Philips Electronics North America Corporation 1997
 All rights reserved. Printed in U.S.A.

Let's make things better.