

4-Channel Low-Noise Amplifier

Features

- ▶ 2.5V ± 0.125V operation
- ▶ 4 independent channels
- ▶ Fully differential inputs and outputs
- ▶ 0.74nV/ $\sqrt{\text{Hz}}$ input-referred noise at 18.5dB gain
- ▶ Ultra low current noise 0.35pA/ $\sqrt{\text{Hz}}$
- ▶ 600k Ω /17.5pF internal input impedance
- ▶ 100MHz amplifier bandwidth
- ▶ Linear-in-dB continuous variable gain control
- ▶ Four digital programmable gain settings for PGA
- ▶ 60MHz whole channel bandwidth at maximum gain
- ▶ 70dB maximum channel gain
- ▶ Variable gain scaling control
- ▶ Active input impedance matching

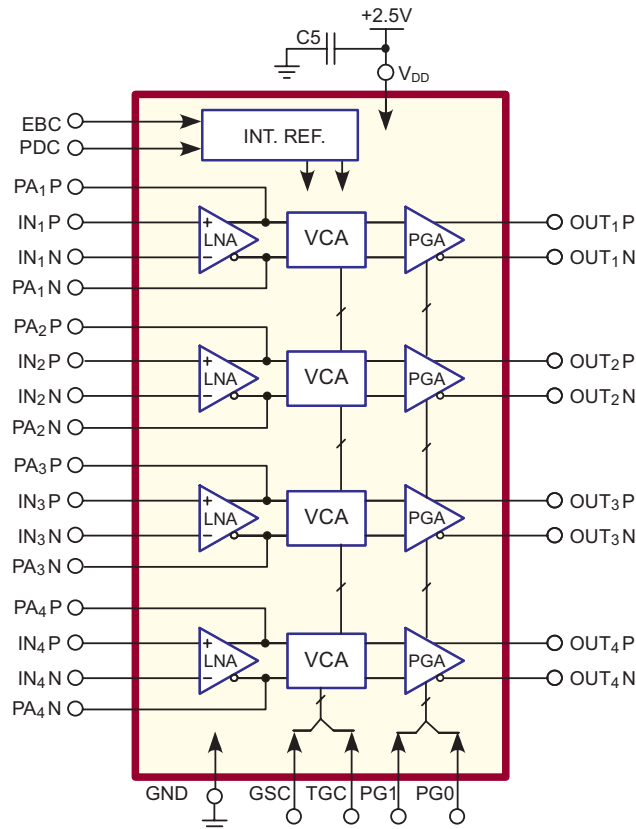
General Description

The MD3880 is a 4-channel, variable gain amplifier (VGA) paired with a low noise amplifier (LNA) that delivers fully differential input and output for ultrasound applications. The 18.5dB gain of the LNA allows the whole channel to have 0.74nV/ $\sqrt{\text{Hz}}$ of input-referred voltage noise at 5MHz. The LNA is capable of active impedance control to improve noise performance, provided that the applications can take advantage of input impedance matching. The output of the LNA is fed directly into the VGA without using an external coupling capacitor. The VGA is composed of a voltage controlled attenuator (VCA) and a programmable gain amplifier (PGA). The VCA can be continuously varied linear-in-dB by a control voltage (V_{TGC}) from 0dB to a maximum 47dB. In addition, the gain of the PGA can be varied between four discrete settings.

Applications

- ▶ Medical ultrasound receiver LNA & TGC
- ▶ Doppler signal amplification
- ▶ Transducer signal conditioning

Typical Application Circuit



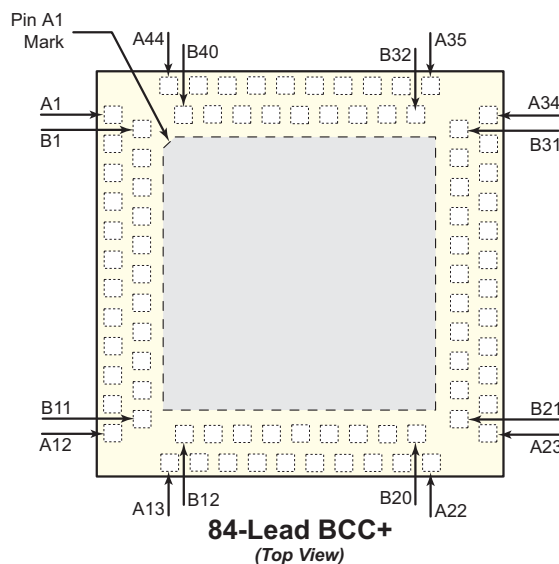
Ordering Information

Device	Package Option
	84-Lead BCC+ 7x7mm body, 0.80mm height (max.), 0.50mm pitch
MD3880	MD3880B2-G

-G indicates package is RoHS compliant ("Green")



Pin Configuration

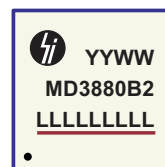


Absolute Maximum Ratings

Parameter	Value
V _{DD} , positive supply	-0.5V to +3.5V
V _{IN} , any input pin voltage range	-0.5V to V _{DD}
Operating temperature	-40°C to +85°C
Storage temperature	-65°C to +150°C
Power dissipation	2.0W

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

Product Marking



L = Lot Number
YY = Year Sealed
WW = Week Sealed
— = "Green" Packaging

84-Lead BCC+ Package

Operating Supply Voltages

(Over operating conditions unless otherwise specified, V_{DD} = +2.5V, T_A = 25°C)

Sym	Parameter	Min	Typ	Max	Units	Conditions
V _{DD}	Power supply	2.375	2.5	2.625	V	T _A = -40°C to +85°C
I _{DDQ}	V _{DD} supply current	-	-	45	mA	Power down, PDC=1, total of all channels
I _{DD}	V _{DD} supply current	-	75	-	mA	PDC = 0
PWR	Power dissipation	-	700	-	mW	Total of all channels
		-	175	-	mW	Per channel
PSRR	PSRR	-	-60	-	dB	f = 100kHz

Logic Data and Clock Inputs Characteristics

(Over operating conditions unless otherwise specified, V_{DD} = +2.5V, T_A = 25°C)

Sym	Parameter	Min	Typ	Max	Units	Conditions
V _{IH}	Input logic high voltage	0.8V _{DD}	-	V _{DD}	V	---
V _{IL}	Input logic low voltage	0	-	0.2V _{DD}	V	---
I _{IH}	Input logic high current	-	-	1.0	μA	---
I _{IL}	Input logic low current	-1.0	-	-	μA	---
C _{IN}	Input logic pin capacitance	-	10	-	pF	---

Electrical Characteristics

(All typical values are under the condition of $T_a = +25^\circ\text{C}$, $V_{DD} = 2.5\text{V}$, Load resistance = $1\text{k}\Omega$ across the differential outputs, $C_{LOAD} = 1\text{pF}$, $f_{IN} = 10\text{MHz}$, $PG0 = 0$, $PG1 = 0$, $V_{GSC} = 2.5\text{V}$, $V_{CM} = 1.25\text{V}$, $GAIN_{LNA} = 18.5\text{dB}$, Single-ended input: $R_S = R_{IN} = 50\Omega$. R_{IN} is formed by active termination with $R_{FB} = 237\Omega$ and C_{FB} , Differential signal output, unless otherwise noted.)

Low Noise Amplifier

Sym	Parameter	Min	Typ	Max	Units	Conditions
G_{LNA}	Amplifier gain	-	18.5	-	dB	---
R_{IN}	Input resistance	-	600	-	$\text{k}\Omega$	Without active termination
C_{IN}	Input capacitance	-	17.5	-	pF	Without active termination
I_{BIAS}	Input bias current	-	1	-	nA	From ESD leakage
CMRR	Common mode rejection ratio	-	-65	-	dB	$PG0 = PG1 = V_{DD}$, $V_{TGC} = 2.0\text{V}$, $f = 1\text{MHz}$
V_{IN}	Input voltage range	-	± 210	-	mV	AC-coupled
$V_{IN-NOISE}$	Input voltage noise, 5MHz	-	0.74	-	$\text{nV}/\sqrt{\text{Hz}}$	Without active termination
$I_{IN-NOISE}$	Input current noise	-	0.35	-	$\text{pA}/\sqrt{\text{Hz}}$	Without active termination
NF	Noise figure	-	2.3	-	dB	$f = 5\text{MHz}$, without active termination
		-	3.7	-	dB	$R_S = R_{IN} = 50\Omega$, $f = 5\text{MHz}$ with active termination
BW	Bandwidth	-	100	-	MHz	Small signal bandwidth

Overall Channel

Sym	Parameter	Min	Typ	Max	Units	Conditions
Gain	Whole channel gain	-	70	-	dB	Without active termination, max. gain
BW_{VGA}	-3dB bandwidth	-	60	-	MHz	Small signal bandwidth at max. gain
SR_{VGA}	Slew rate	-	500	-	$\text{V}/\mu\text{s}$	---
VO_{VGA}	Output signal range	-	4	-	V_{PP}	$RL > 1\text{k}\Omega$ differentially
R_{OUT}	Output Impedance	-	3	-	Ω	$f = 5\text{MHz}$, single ended
I_{OUTS}	Output short-circuit current	-	± 40	-	mA	---
$V_{IN-NOISE}$	Input voltage noise	-	0.8	-	$\text{nV}/\sqrt{\text{Hz}}$	At max. gain and 5MHz
IMD	Intermodulation distortion, two-tone	-	-76	-	dBc	1MHz, $V_{OUT} = 1V_{PP}$, 30dB gain
		-	-70	-		10MHz, $V_{OUT} = 1V_{PP}$, 30dB gain
HD3	Third harmonic distortion	-	-73	-	dBc	$V_{OUT} = 1V_{PP}$, 1MHz, 30dB gain
		-	-69	-		$V_{OUT} = 1V_{PP}$, 10MHz, 30dB gain
		-	-55	-		$V_{OUT} = 1V_{PP}$, 1MHz, 10dB gain
		-	-47	-		$V_{OUT} = 1V_{PP}$, 10MHz, 10dB gain
HD2	Second harmonic distortion	-	-87	-	dBc	$V_{OUT} = 1V_{PP}$, 1MHz, 30dB gain
		-	-70	-		$V_{OUT} = 1V_{PP}$, 10MHz, 30dB gain
		-	-53	-		$V_{OUT} = 1V_{PP}$, 1MHz, 10dB gain
		-	-51	-		$V_{OUT} = 1V_{PP}$, 10MHz, 10dB gain
A_{OUT1dB}	1dB compression point	-	-1.3	-	dBm	$V_{OUT} = 1V_{PP}$, $f = 10\text{MHz}$, 8dB gain

Overall Channel

Sym	Parameter	Min	Typ	Max	Units	Conditions
CSTK	Crosstalk	-	-78	-	dB	PG0 and PG1 = 1, 30dB gain, 1MHz, 1V _{PP} at adjacent channel
Δt_{gd}	Group delay variation	-	± 2	-	ns	2 MHz < f < 50 MHz, Full Gain Range
t_{OLR}	Overload recovery time	-	5	-	ns	8dB Gain, V _{IN} = 50mV _{PP} to 1V _{PP} change, f = 10MHz
V _{DC-OUT}	DC output level, V _{IN} = 0	-	1.25	-	V	---

Note: V_{IN} is the voltage at the non-inverting node of the amplifier.

Accuracy

Sym	Parameter	Min	Typ	Max	Units	Conditions
G _{SLOPE}	Gain slope	31	33	35	dB/V	V _{GSC} = 2.5V
G _{MAT}	Ch. to ch. gain matching	-	± 0.1	-	dB	V _{TGC} = 0V or 2.0V
E _{GAIN}	Gain error	-	± 0.8	-	dB	Referenced to best fit dB-linear curve, 0.5V < V _{TGC} < 1.7V
V _{OS-OUT}	Output offset voltage	-	± 20	-	mV	Reference to 1.25V

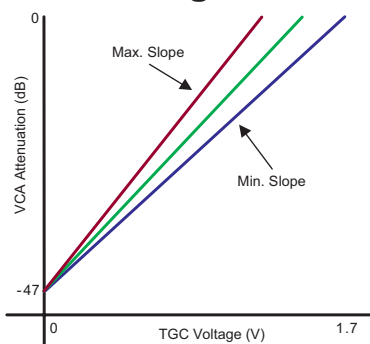
Gain Control Interface

Sym	Parameter	Min	Typ	Max	Units	Conditions
V _{TGC}	Gain control voltage	0	-	2	V	Linear in dB, See gain scaling diagram
V _{GSC}	Gain slope voltage	2.0	-	2.5	V	About 41dB/V at 2.0V and 33dB/V at 2.5V
R _{GSC}	Input resistance of GSC	-	120	-	k Ω	---
R _{TGC}	Input resistance of TGC	-	1.5	-	M Ω	Connected to $\frac{3}{4}$ V _{GSC}
td _{TGC}	Response time	-	0.2	-	μ s	95% full gain change

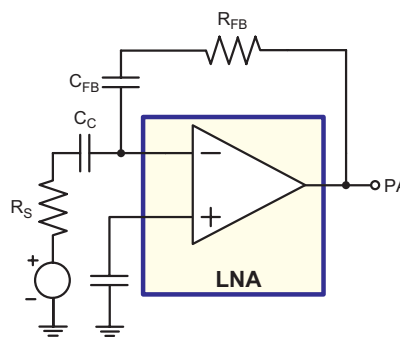
PGA Gain Control Table

PG1, PG0	PGA Gain (dB)
0,0	35
0,1	40.5
1,0	46
1,1	51.5

TGC and GSC Voltage for Gain Scaling



Configurations for Active Feedback



Pin Configuration

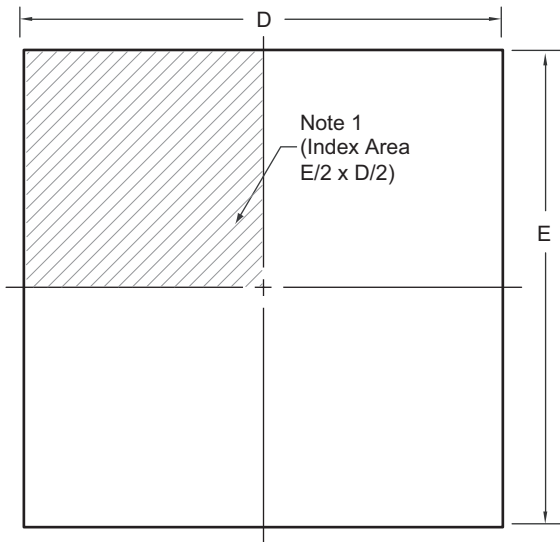
Pin #	Pin Name	Pin #	Pin Name	Pin #	Pin Name	Pin #	Pin Name
A1	IN ₁ P	A22	AGND	A43	GND	B20	NC
A2	IN ₁ N	A23	AV _{DD}	A44	AGND	B21	OUT ₄ P
A3	PA ₁ P	A24	AV _{DD}	B1	PA ₁ N	B22	CM4
A4	PA ₂ N	A25	AGND	B2	AV _{DD}	B23	OUT ₄ N
A5	AV _{DD}	A26	OUT ₃ P	B3	AGND	B24	AV _{DD}
A6	PA ₂ P	A27	CM3	B4	IN ₂ P	B25	AV _{DD}
A7	PA ₃ N	A28	OUT ₃ N	B5	IN ₂ N	B26	AGND
A8	AV _{DD}	A29	OUT ₂ P	B6	AGND	B27	AV _{DD}
A9	PA ₃ P	A30	CM2	B7	IN ₃ P	B28	AV _{DD}
A10	AGND	A31	OUT ₂ N	B8	IN ₃ N	B29	AGND
A11	IN ₄ P	A32	OUT ₁ P	B9	PA ₄ N	B30	CM1
A12	IN ₄ N	A33	AV _{DD}	B10	AV _{DD}	B31	OUT ₁ N
A13	AGND	A34	AV _{DD}	B11	PA ₄ P	B32	NC
A14	AGND	A35	AGND	B12	NC	B33	NC
A15	EBC	A36	GND	B13	GND	B34	NC
A16	AGND	A37	V _{DD}	B14	PDC	B35	NC
A17	GSC	A38	V _{DD}	B15	AV _{DD}	B36	NC
A18	CM0	A39	GND	B16	NC	B37	NC
A19	A0	A40	GND	B17	A1	B38	NC
A20	PG1	A41	V _{DD}	B18	PG0	B39	NC
A21	GND	A42	V _{DD}	B19	TGC	B40	NC

Pin Description

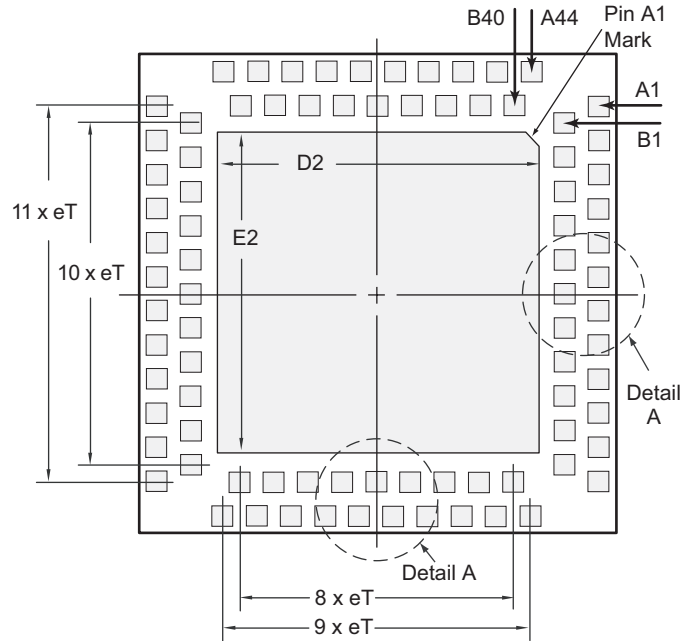
Pin Name	Description
V _{DD}	V _{DD} voltage supply
GND	Ground
AVDD	Analog supply
AGND	Analog ground
IN _{1~4} P	Positive polarity LNA input of channel 1~4
IN _{1~4} N	Negative polarity LNA input of channel 1~4
PA _{1~4} P	Channel 1~4 LNA positive output
PA _{1~4} N	Channel 1~4 LNA negative output
OUT _{1~4} P	Positive polarity PGA output of channel 1~4
OUT _{1~4} N	Negative polarity PGA output of channel 1~4
PDC	PDC = 1, power down and enable external biasing, 450kΩ internal pull down
EBC	External current biasing
GSC	Input of gain scaling control for all channels
A0, A1	Reserved, should connect to AV _{DD}
PG0, PG1	PGA Gain select inputs (PG0 = LSB, PG1 = MSB)
TGC	Attenuator control input
CM0~4	0.1μF bypass capacitors to ground

84-Lead BCC+ Package Outline (B2)

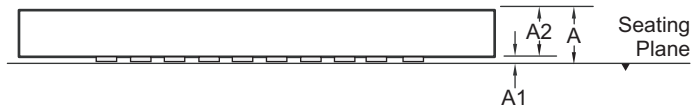
7x7mm body, 0.80mm height (max.), 0.50mm pitch



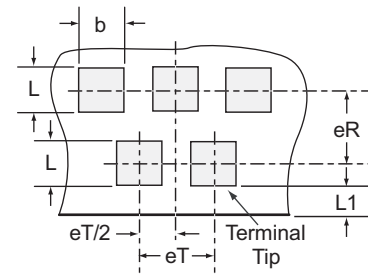
Top View



Bottom View



Side View



Detail A

Notes:

1. Details of Pin 1 identifier are optional, but must be located within the indicated area. The Pin 1 identifier may be either a mold, or an embedded metal or marked feature.

Symbol		A	A1	A2	b	D	D2	E	E2	eR	eT	L	L1
Dimension (mm)	MIN	0.65	0.05	0.60	0.20	6.85	4.55	6.85	4.55	0.50 BSC	0.50 BSC	0.20	0.10 REF
	NOM	-	-	0.65	0.30	7.00	4.70	7.00	4.70			0.30	
	MAX	0.80	0.10	0.70	0.40	7.15	4.85	7.15	4.85			0.40	

Drawings not to scale.

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to <http://www.supertex.com/packaging.html>.)

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