Ordering number : EN5652

Monolithic Linear IC

LA2650

Bass Boost IC

Overview

The LA2650 is a bass boost IC developed for use in mini-component stereo systems, TV sets, and radio/cassette player products. The cutoff frequency is determined by external capacitors, and the boost gain, addition level, and boost on/off state can be controlled by a microcontroller.

Features

- The bass boost gain is variable over a maximum range of 20 to 35 dB in 5-dB steps, and the addition level into the left and right channels can be controlled over a 0 to –35 dB range in 3-dB and 5-dB steps. This allows an optimal boost for the source and volume to be acquired using microprocessor control.
- Includes two AGC circuits on chip: a level limiter (2 V rms) for the maximum input in low-frequency boost mode and a non-clipping limiter (i.e. clip prevention) circuit.
- Can be switched between 2D and 3D systems.

Functions

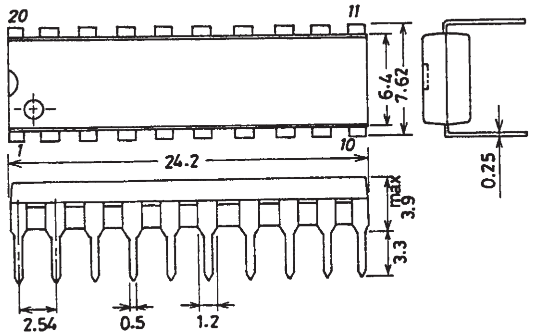
- Variable boost gain (20, 25, 30, and 35 dB)
- Boost level limiter, non-clipping limiter
- Variable boost addition level (0, –3, –6, –9, –15, –20, –25, and –35 dB)
- Left and right channel boost addition on/off
- Bass output pin for use in 3D systems
- Boost on/off
- LED on/off
- 8-bit serial microprocessor interface

Package Dimension

unit: mm

3021B-DIP20

[LA2650]



SANYO: DIP20

Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max		12	V
Allowable power dissipation	Pd max	Ta ≤ 70°C	450	mW
Operating temperature	Topr		–25 to +70	°C
Storage temperature	Tstg		–40 to +150	°C

Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Recommended supply voltage	V_{CC}		9	V
Operating voltage range	V_{CC} op		5 to 10	V

Control Data Input Voltage Levels

Parameter	Symbol	Conditions	Ratings	Unit
Low-level voltage	V_{IL}		0 to 1.5	V
High-level voltage	V_{IH}		3.5 to *5.5	V

Note: When V_{CC} is under 5.7 V, the maximum value shall be V_{CC} – 0.2 V.

Electrical Characteristics at Ta = 25°C, V_{CC} = 9 V, f_i = 1 kHz, R_L = 10 kΩ, BST = 35 dB, ADD = 0 dB, BST:ADD = ON

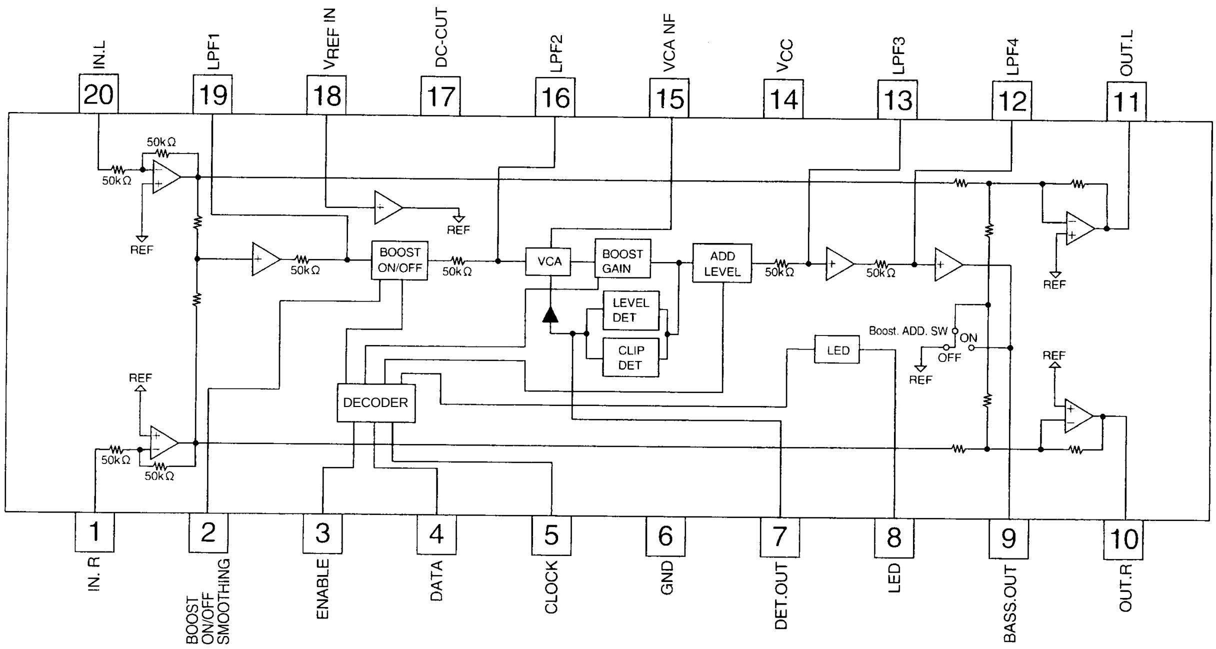
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Quiescent current	$I_{CCO}T$	Boost: off	5	8	13	mA
	$I_{CCO}B$	Boost: on	6	9	14	mA
Voltage gain	VGT	V_{IN} = 0 dBm, Boost: off	–2	0	+2	dB
	VGB	V_{IN} = 0 dBm, Boost: on	–2	0	+2	dB
Boost level: high	BST1	Boost: on, f_i = 50 Hz, BST = 35 dB, ADD = 0 dB, V_{IN} = –30 dBm	25.5	28.5	31.5	dB
	BST2	Boost: on, f_i = 50 Hz, BST = 35 dB, ADD = 0 dB, V_{IN} = –20 dBm	21	24	27	dB
	BST3	Boost: on, f_i = 50 Hz, BST = 35 dB, ADD = 0 dB, V_{IN} = –10 dBm	13	15	17	dB
	BST4	Boost: on, f_i = 50 Hz, BST = 35 dB, ADD = 0 dB, V_{IN} = 0 dBm	5	7	9	dB
Boost level: low	BST1	Boost: on, f_i = 50 Hz, BST = 30 dB, ADD = –6 dB, V_{IN} = –20 dBm	15	18	21	dB
	BST2	Boost: on, f_i = 50 Hz, BST = 30 dB, ADD = –6 dB, V_{IN} = –10 dBm	8	10	12	dB
	BST3	Boost: on, f_i = 50 Hz, BST = 30 dB, ADD = –6 dB, V_{IN} = 0 dBm	1.5	3.5	5.5	dB
Maximum output voltage	V_O maxT	THD = 1%, Boost: off	2.00	2.55		V
	V_O maxB	THD = 1%, Boost: on	2.00	2.55		V
Total harmonic distortion	THD T	V_{IN} = –10 dBm, Boost: off, BPF = 400 Hz to 30 kHz		0.008	0.03	%
	THD B	V_{IN} = –10 dBm, Boost: on, f_i = 50 Hz, LPF = 30 kHz		0.3	0.9	%
Crosstalk	CT T	V_O = 0 dB, Rg = 10 kΩ, DIN AUDIO, Boost: off	80	88		dB
	CT B	V_O = 0 dB, Rg = 10 kΩ, DIN AUDIO, Boost: on	50	59		dB
Output noise voltage	V_{NO} T	Rg = 10 kΩ, JIS A, Boost: off, Boost ADD = off		–97	–90	dBm
	V_{NO} B	Rg = 10 kΩ, JIS A, Boost: on		–91	–84	dBm
LED current	I_{LED}	RED LED	11	15	19	mA

Control Data for the Parameters in the Electrical Characteristics

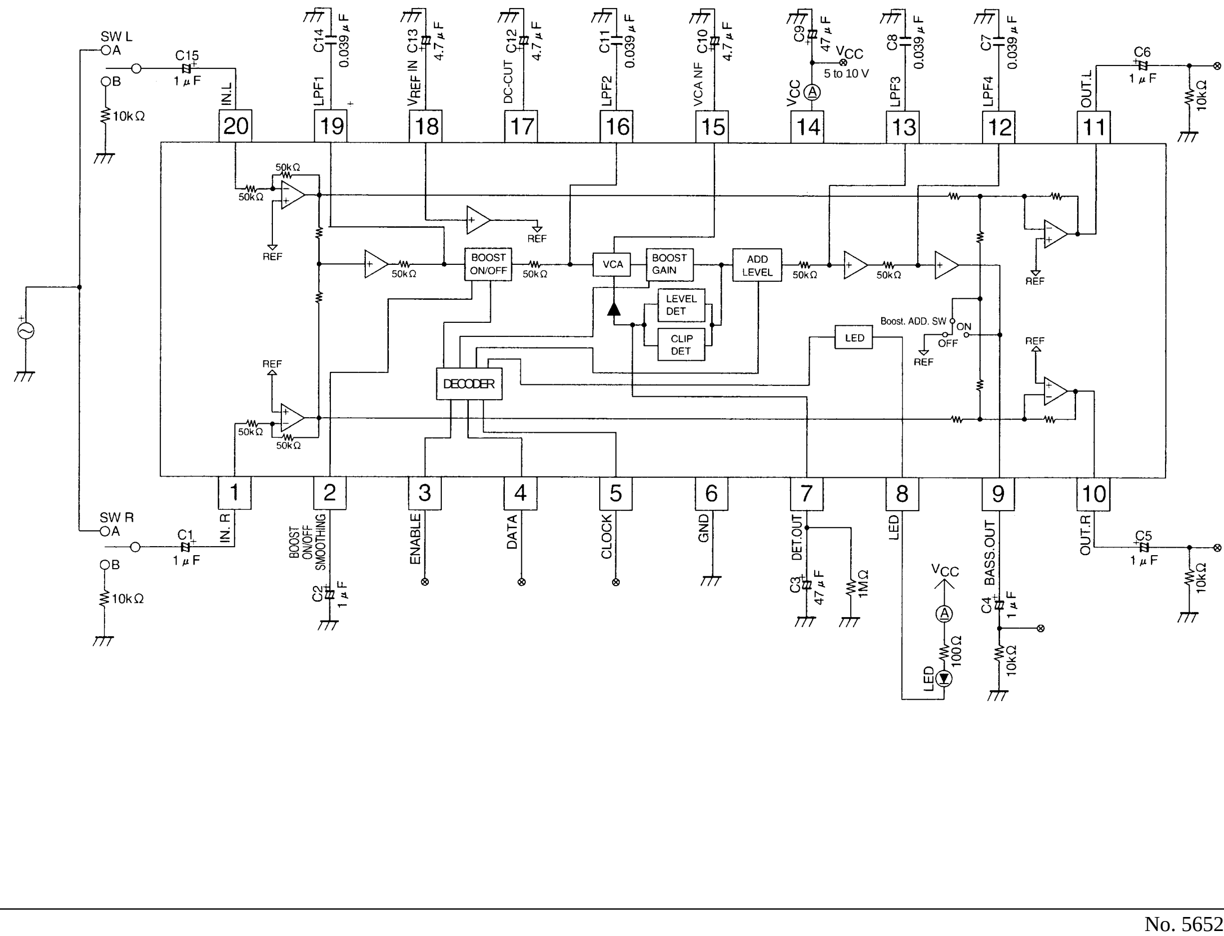
Parameter		Conditions	D1	D2	D3	D4	D5	D6	D7	D8
Quiescent current										
	$I_{CCO}T$	Boost: on	L	L	L	L	L	L	L	L
	$I_{CCO}B$	Boost: off	H	H	H	H	H	H	L	H
Voltage gain		V_{IN} = 0 dBm								
	VG T	Boost: off	L	L	L	L	L	L	L	L
	VG B	Boost: on	H	H	H	H	H	H	L	H
Boost level: high		Boost: on, f_i = 50 Hz, BST = 35 dB, ADD = 0 dB	H	H	H	H	H	H	L	H
Boost level: low		Boost: on, f_i = 50 Hz, BST = 30 dB, ADD = –6 dB	H	L	H	L	H	H	L	H
Maximum output voltage		THD = 1%								
	V_O maxT	Boost: off	L	L	L	L	L	L	L	L
	V_O maxB	Boost: on	H	H	H	H	H	H	L	H
Total harmonic distortion		V_{IN} = –10 dBm								
	THD T	Boost: off, BPF = 400 Hz to 30 kHz	L	L	L	L	L	L	L	L
	THD B	Boost: on, f_i = 50 Hz, LPF = 30 kHz	H	H	H	H	H	H	L	H
Crosstalk		V_O = 0 dBm, Rg = 10 kΩ, DIN AUDIO								
	CT T	Boost: off	L	L	L	L	L	L	L	L
	CT B	Boost: on	H	H	H	H	H	H	L	H
Output noise voltage		Rg = 10 kΩ, JIS A								
	V_{NO} T	Boost: off, Boost ADD = off	L	L	L	L	L	L	L	L
	V_{NO} B	Boost: on	H	H	H	H	H	H	L	H
LED current										
	I_{LED}	RED LED	*	*	*	*	*	*	H	*

*=don’t care

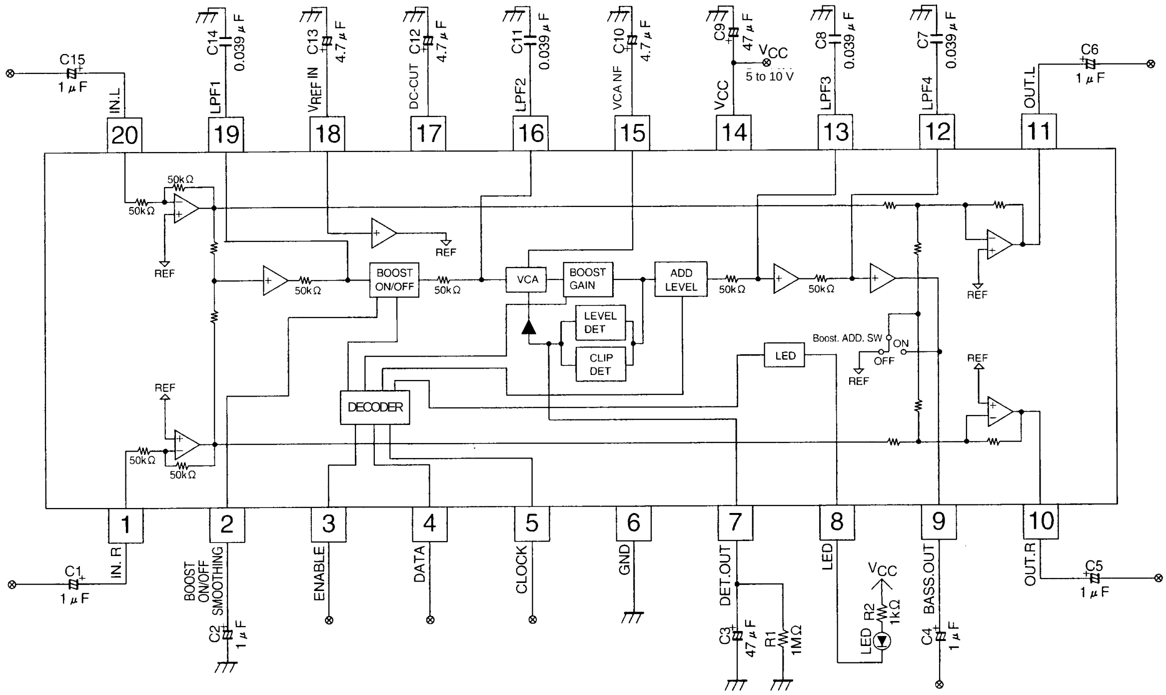
Block Diagram



Test Circuit



Sample Application Circuit



Notes on LA2650 Operation

LPF cutoff frequency

Use the following formula to calculate the cutoff frequency:

· $fc = 1/(2\pi CR)$ Hz

However: R = 50 kΩ, since the resistor is on chip.

Thus the cutoff frequency can be set by the external capacitor.

Example: C = 0.039 µF (As in the sample application circuit)

fc = 81.6 Hz

Maximum boost gain

Use the following formula to calculate the maximum boost gain.

· BASS OUT total gain (G_B) = $\alpha + 4 \times 20 \log_{10} (1 + 4\pi^2 f^2 C^2 R^2)^{-1/2} + \beta$

Here,

α = Boost gain (20, 25, 30, or 35 dB)

β = Addition level (0, –3, –6, –9, –15, –20, –25, or –35 dB)

f: Frequency

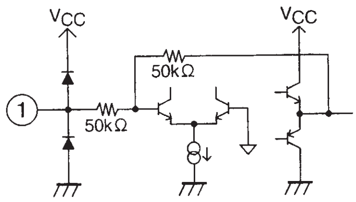
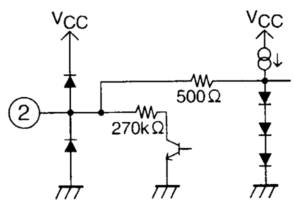
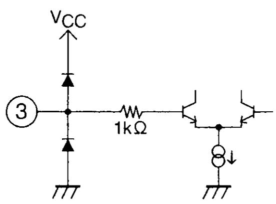
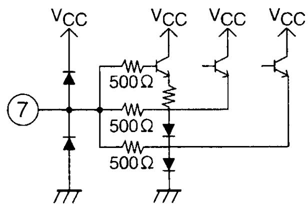
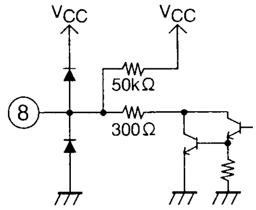
C: The LPF external capacitor

R = 50 kΩ (built in)

Example: When α = 35 dB, β = 0 dB, f = 50 Hz, C = 0.039 µF (As in the application circuit)

G_B = 29.46 dB

Pin Functions

Pin No.	Pin	Pin voltage (V)	Pin function	Equivalent circuit
1 20	IN-L IN-R	1/2 V_{CC}	Signal input pin The input impedance is 50 kΩ	
2	BOOST ON/OFF SMOOTHING	0.7 to 2	Smoothing pin for boost on/off switching	
3 4 5	ENABLE DATA CLOCK	Apply either 0 or 5 V.	Serial control data input pins	
7	DET-OUT	1.7 to 3.5	The detection attack and recovery times are set by the external resistor and capacitor connected to this pin.	
8	LED	V_{CC} max.	LED cathode Influx current: 20 mA (maximum)	

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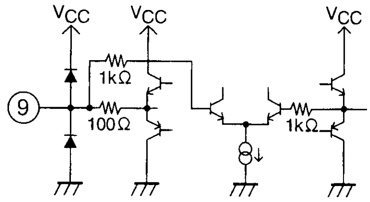
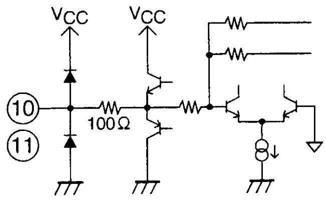
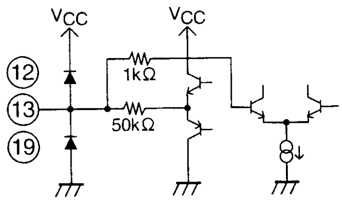
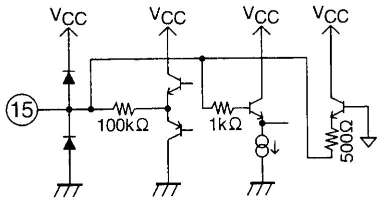
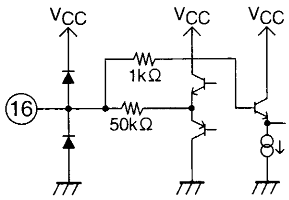
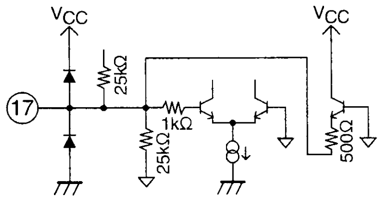
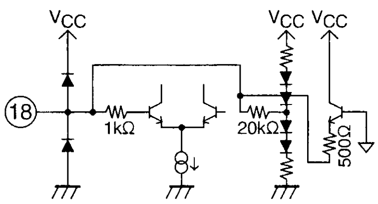
Pin No.	Pin	Pin voltage (V)	Pin function	Equivalent circuit
9	BASS-OUT	1/2 V_{CC}	Low boost output for 3D systems	
10 11	OUT-R OUT-L	1/2 V_{CC}	Signal outputs	
12 13 19	LPF4 LPF3 LPF1	1/2 V_{CC}	LPF connection for the low-boost circuit Internal resistor: 50 kΩ	
15	VCA NF	1/2 V_{CC}	VCA feedback	
16	LPF2	1/2 V_{CC}	LPF connection for the low-boost circuit Internal resistor: 50 kΩ	
17	DC-CUT	1/2 V_{CC}	Connection for DC-cut capacitor	
18	V_{REF}IN	1/2 V_{CC}	V_{REF} amplifier reference	

Note: Pin voltage values are typical values.

External Components

• C_1, C_{15} (0.22 to 10 μF)
Input coupling capacitor.
Note that the low-frequency gain is reduced at lower capacitances.
The value of these capacitors determines the extreme low-frequency cutoff.

• C_2 (0.22 to 2.2 μF)
Boost on/of switching circuit smoothing capacitor.
The on/off switching time can be adjusted by changing the value of this capacitor. However, note that if the value is lowered excessively, switching noise (spikes) may appear.

• C_3 (10 to 220 μF)
Detection capacitor.
The attack and recover times can be adjusted by changing the value of this capacitor.

• C_4, C_5, C_6 (0.22 to 10 μF)
Output coupling capacitors.

• C_7, C_8, C_{11}, C_{14}
Low boost LPF capacitors.
The low boost curve can be adjusted by changing the values of these capacitors. These capacitors may be omitted or, inversely, secondary or tertiary structures may be used.

• C_9 (22 to 220 μF)
Power supply capacitor.

• C_{10} (1.0 to 22 μF)
VCA NF capacitor.
Note that lowering the value of this capacitor will lower the low-frequency boost.
This capacitor determines the extreme low-frequency cutoff.

• C_{12} (1.0 to 22 μF)
DC cut capacitor
Note that lowering the value of this capacitor will lower the low-frequency boost.
This capacitor determines the extreme low-frequency cutoff.

• C_{13} (1.0 to 22 μF)
RF reference LPF capacitor.
The RF SVRR can be modified by changing the value of this capacitor.

• R_1 (200 kΩ to 3.9 MΩ)
Detection recovery time adjustment (discharge resistor)
Note that the total harmonic distortion is increased as the value of this resistor is reduced.

• R_2 (0 to 1 kΩ)
LED current adjustment.
LED current ≈ $(V_{CC} - V_{LED} - 0.9)/(R_2 + 300)$
The maximum LED current is 20 mA.

Control Format

Add Level Select

D1, D2, D3	Add level	Notes
H, H, H	0 dB	
H, H, L	–3 dB	
H, L, H	–6 dB	
H, L, L	–9 dB	
L, H, H	–15 dB	
L, H, L	–20 dB	
L, L, H	–25 dB	
L, L, L	–35 dB	Initial setting for the V_{CC} on time

Boost Gain Select

D4, D5	Boost gain	Notes
H, H	35 dB	
H, L	30 dB	
L, H	25 dB	
L, L	20 dB	Initial setting for the V_{CC} on time

Left and right channel boost add on/off

	L	H
D6	off	on

LED on/off

	L	H
D7	off	on

Boost on/off

	L	H
D8	off	on

Note: The V_{CC} on time and all other data is initialized to low.

Mode Switching

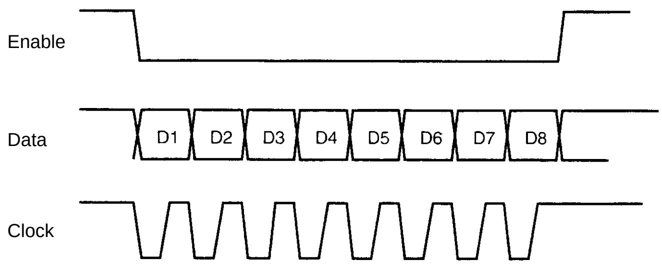
- Add level select
  — Selects the addition level at the output mixing amplifier for the low-frequency signals from the boost amplifier.
- Boost gain select
  — Selects the amplification applied to low-frequency signals by the boost amplifier.
- Left and right channel boost add on/off
  — Turns addition of the low-frequency boosted signal to the left and right channels on or off.
- LED on/off
  — Turns the LED on or off.
- Boost on/off
  — Turns the amplification of low-frequency signals on or off.

Recommended Data Transfer Procedure

The boost gain select and the left and right channel boost add on/off settings should only be set at power on. During normal operation, control the device by setting the add level select and boost on/off settings. Using the add level select and boost on/off settings for control is superior from the standpoint of minimizing switching noise (spikes).

Limiter (ALC) Operation

- The level limiter operates when the boost gain amplifier output level reaches about 2 V rms, and suppress further level increases above that point.
- The non-clipping limiter operates to prevent boost gain amplifier output clipping at power-supply voltages (about 8.5 V and lower) at which the output cannot be amplified to the operating level of the level limiter.
- Notes on Control Data



— Data is read in on the rising edge of the clock signal.

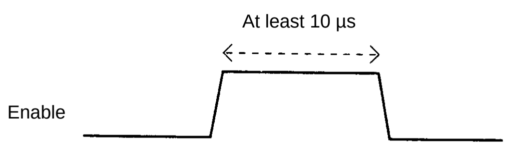
— Data consists of 8 bits, D1 through D8.

— The input data is latched on the rising edge of the enable signal.

— When the LA2650 is not being controlled, the clock and the enable signal must be held high.

— Intervals between commands

The timing of the intervals on the enable signal must meet the conditions shown in the figure below.



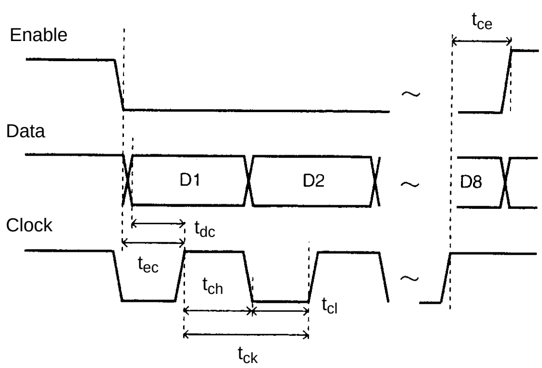
- Initial Settings at Power on

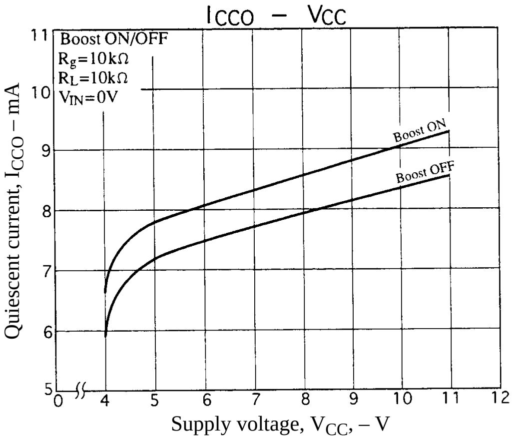
— All data is reset to low when power is first applied.

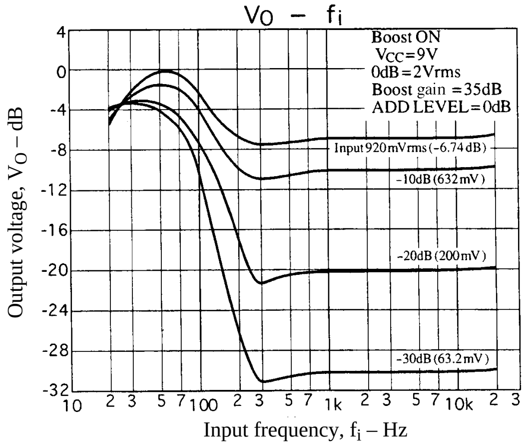
— Applications should send their initial data settings once the IC is fully operational after power is applied, i.e. about 0.5 second after power is applied.

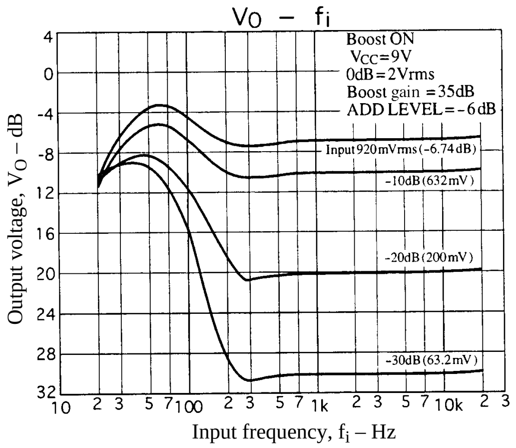
- Data Timing

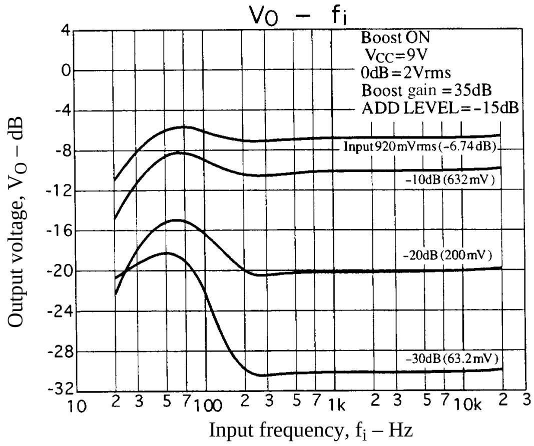
Timing characteristics		min	typ	max	unit
Enable clock delay time	t_{ec}	5			µs
Data clock delay time	t_{dc}	5			µs
Clock high-level hold time	t_{ch}	5			µs
Clock low-level hold time	t_{cl}	5			µs
Clock enable delay time	t_{ce}	5			µs
Clock cycle time	t_{ck}	10			µs

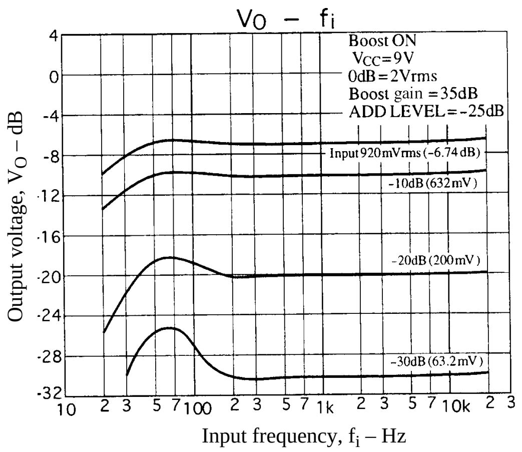


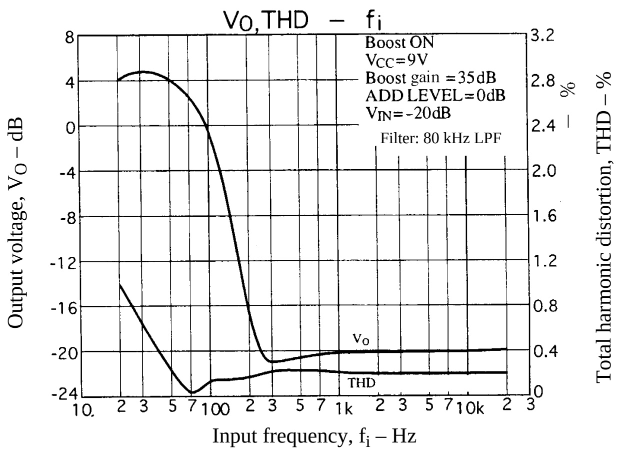

ICCO – VCC
Boost ON/OFF
Rg=10kΩ
RL=10kΩ
VIN=0V
Boost ON
Boost OFF
Quiescent current, ICCO – mA
Supply voltage, VCC, – V

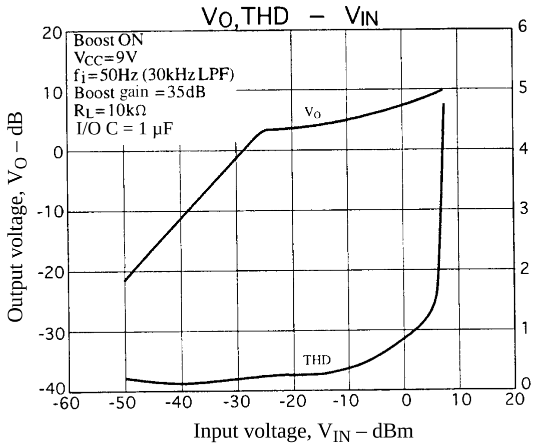

VO – fi
Boost ON
VCC=9V
0dB=2Vrms
Boost gain =35dB
ADD LEVEL=0dB
Input920mVrms(-6.74dB)
-10dB(632mV)
-20dB(200mV)
-30dB(63.2mV)
Output voltage, VO – dB
Input frequency, fi – Hz

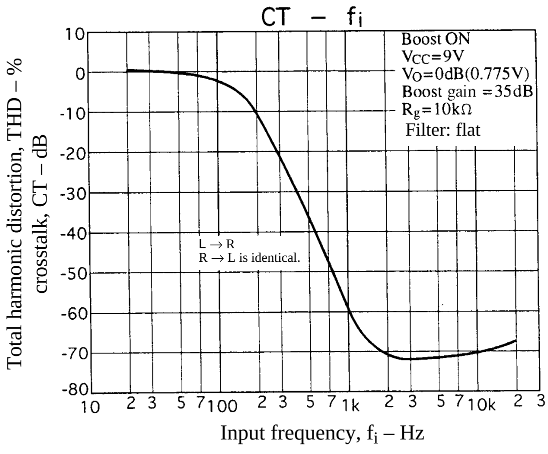

VO – fi
Boost ON
VCC=9V
0dB=2Vrms
Boost gain =35dB
ADD LEVEL=-6dB
Input920mVrms(-6.74dB)
-10dB(632mV)
-20dB(200mV)
-30dB(63.2mV)
Output voltage, VO – dB
Input frequency, fi – Hz

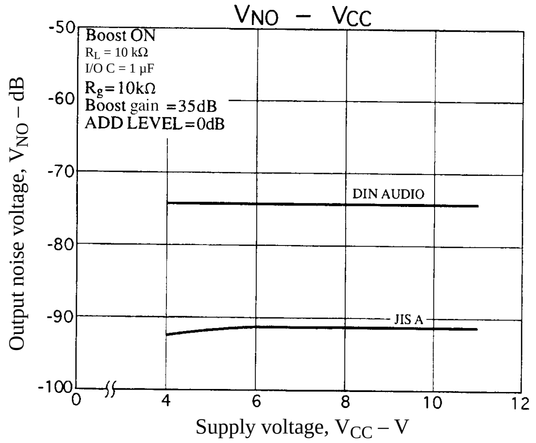

VO – fi
Boost ON
VCC=9V
0dB=2Vrms
Boost gain =35dB
ADD LEVEL=-15dB
Input920mVrms(-6.74dB)
-10dB(632mV)
-20dB(200mV)
-30dB(63.2mV)
Output voltage, VO – dB
Input frequency, fi – Hz

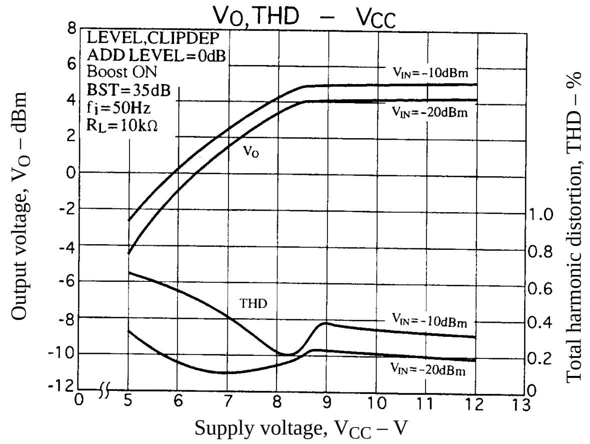

VO – fi
Boost ON
VCC=9V
0dB=2Vrms
Boost gain =35dB
ADD LEVEL=-25dB
Input920mVrms(-6.74dB)
-10dB(632mV)
-20dB(200mV)
-30dB(63.2mV)
Output voltage, VO – dB
Input frequency, fi – Hz

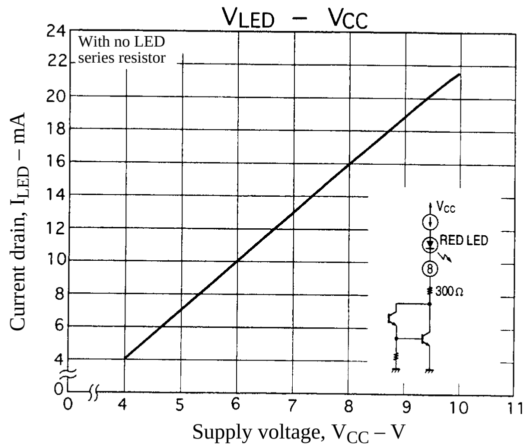

VO,THD – fi
Boost ON
VCC=9V
Boost gain =35dB
ADD LEVEL=0dB
VIN=-20dB
Filter: 80 kHz LPF
VO
THD
Output voltage, VO – dB
Total harmonic distortion, THD – %
Input frequency, fi – Hz

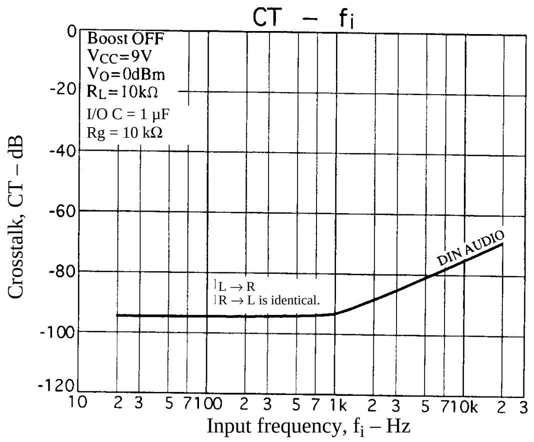

VO,THD – VIN
Boost ON
VCC=9V
fi=50Hz (30kHz LPF)
Boost gain =35dB
RL=10kΩ
I/O C = 1 μF
VO
THD
Output voltage, VO – dB
Input voltage, VIN – dBm

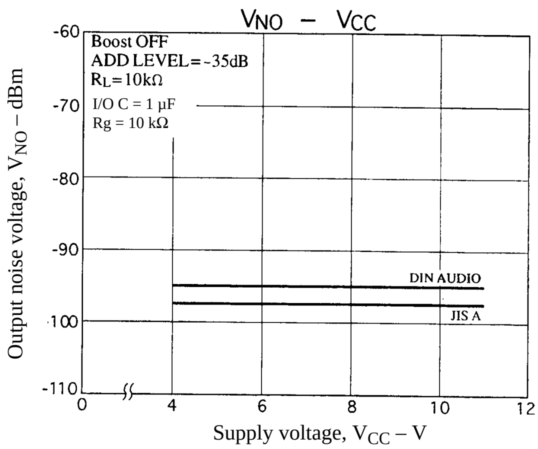

CT – fi
Boost ON
VCC=9V
VO=0dB(0.775V)
Boost gain =35dB
Rg=10kΩ
Filter: flat
L → R
R → L is identical.
Total harmonic distortion, THD – %
crosstalk, CT – dB
Input frequency, fi – Hz

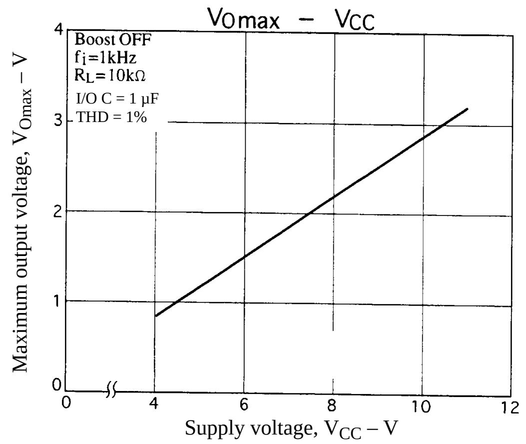

VNO – VCC
Boost ON
RL = 10 kΩ
I/O C = 1 µF
Rg = 10kΩ
Boost gain = 35dB
ADD LEVEL = 0dB
DIN AUDIO
JIS A
Output noise voltage, VNO – dB
Supply voltage, VCC – V
-50
-60
-70
-80
-90
-100
0
4
6
8
10
12

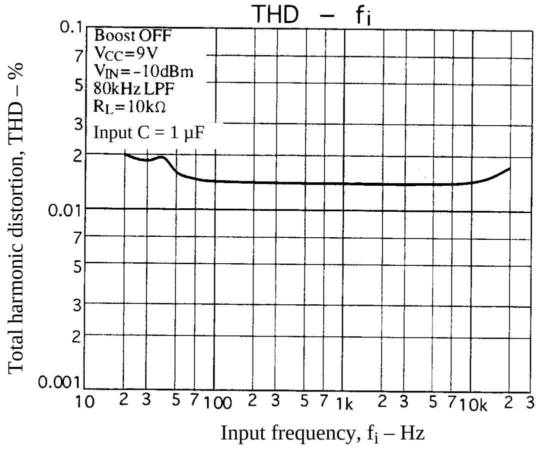

VO,THD – VCC
LEVEL,CLIPDEP
ADD LEVEL = 0dB
Boost ON
BST = 35dB
fi = 50Hz
RL = 10kΩ
VIN = -10dBm
VIN = -20dBm
VO
THD
VIN = -10dBm
VIN = -20dBm
Output voltage, VO – dBm
Total harmonic distortion, THD – %
Supply voltage, VCC – V
8
6
4
2
0
-2
-4
-6
-8
-10
-12
1.0
0.8
0.6
0.4
0.2
0
0
5
6
7
8
9
10
11
12
13

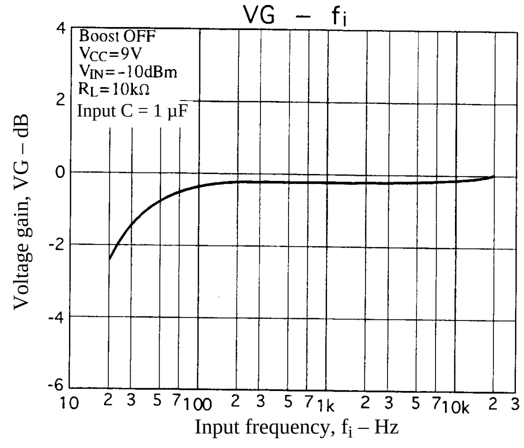

VLED – VCC
With no LED
series resistor
VCC
RED LED
300Ω
Current drain, ILED – mA
Supply voltage, VCC – V
24
22
20
18
16
14
12
10
8
6
4
0
0
4
5
6
7
8
9
10
11

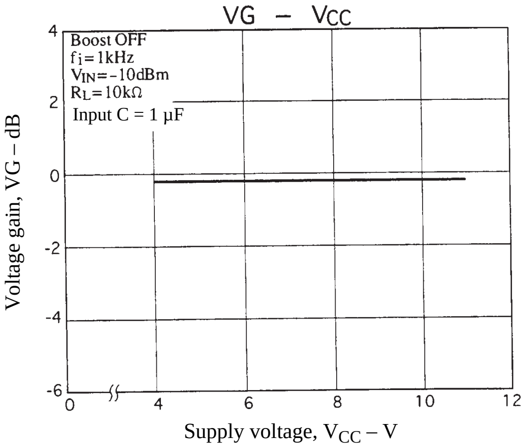

CT – fi
Boost OFF
VCC = 9V
VO = 0dBm
RL = 10kΩ
I/O C = 1 µF
Rg = 10 kΩ
DIN AUDIO
L → R
R → L is identical.
Crosstalk, CT – dB
Input frequency, fi – Hz
0
-20
-40
-60
-80
-100
-120
10
2
3
5
7
100
2
3
5
7
1k
2
3
5
7
10k
2
3

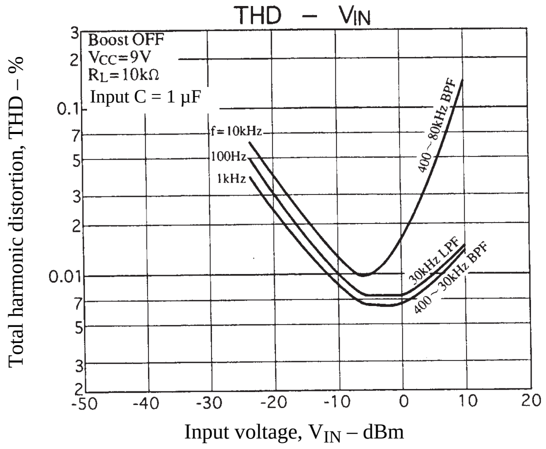

VNO – VCC
Boost OFF
ADD LEVEL = -35dB
RL = 10kΩ
I/O C = 1 µF
Rg = 10 kΩ
DIN AUDIO
JIS A
Output noise voltage, VNO – dBm
Supply voltage, VCC – V
-60
-70
-80
-90
-100
-110
0
4
6
8
10
12


VOmax – VCC
Boost OFF
fi = 1kHz
RL = 10kΩ
I/O C = 1 µF
THD = 1%
Maximum output voltage, VOmax – V
Supply voltage, VCC – V
4
3
2
1
0
0
4
6
8
10
12


THD – fi
Boost OFF
VCC = 9V
VIN = -10dBm
80kHz LPF
RL = 10kΩ
Input C = 1 µF
Total harmonic distortion, THD – %
Input frequency, fi – Hz
0.1
7
5
3
2
0.01
7
5
3
2
0.001
10
2
3
5
7
100
2
3
5
7
1k
2
3
5
7
10k
2
3


VG – fi
Boost OFF
VCC = 9V
VIN = -10dBm
RL = 10kΩ
Input C = 1 µF
Voltage gain, VG – dB
Input frequency, fi – Hz
4
2
0
-2
-4
-6
10
2
3
5
7
100
2
3
5
7
1k
2
3
5
7
10k
2
3


VG – VCC
Boost OFF
fi=1kHz
VIN=–10dBm
RL=10kΩ
Input C = 1 µF
Voltage gain, VG – dB
Supply voltage, VCC – V


THD – VIN
Boost OFF
VCC=9V
RL=10kΩ
Input C = 1 µF
f=10kHz
100Hz
1kHz
400~80kHz BPF
30kHz LPF
400~30kHz BPF
Total harmonic distortion, THD – %
Input voltage, VIN – dBm