



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

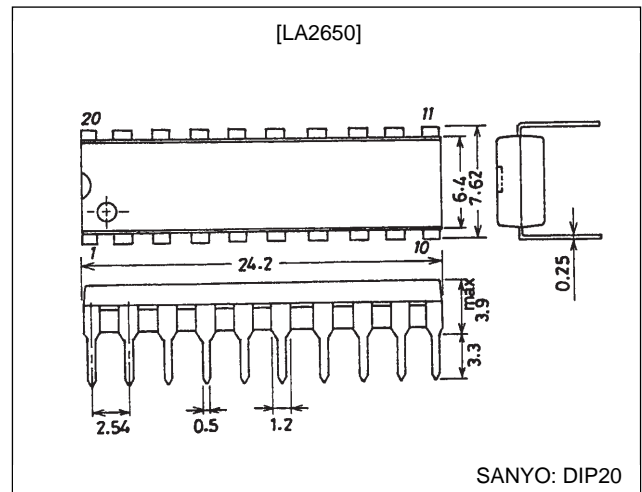
- Variable boost gain (20, 25, 30, and 35 dB)
- Boost level limiter, non-clipping limiter
- Variable boost addition level (0, -3, -6, -9, -15, -20, -25, and -35 dB)

- 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



Specifications

Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{CC \text{ max}}$		12	V
Allowable power dissipation	$P_d \text{ max}$	$T_a \leq 70^\circ\text{C}$	450	mW
Operating temperature	T_{opr}		-25 to +70	$^\circ\text{C}$
Storage temperature	T_{stg}		-40 to +150	$^\circ\text{C}$

Operating Conditions at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Recommended supply voltage	V_{CC}		9	V
Operating voltage range	$V_{CC \text{ op}}$		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.

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Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{CC} = 9\text{ V}$, $f_i = 1\text{ kHz}$, $R_L = 10\text{ k}\Omega$, $BST = 35\text{ dB}$, $ADD = 0\text{ dB}$, $BST:ADD = ON$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Quiescent current	I_{CC0T}	Boost: off	5	8	13	mA
	I_{CC0B}	Boost: on	6	9	14	mA
Voltage gain	VGT	$V_{IN} = 0\text{ dBm}$, Boost: off	-2	0	+2	dB
	VGB	$V_{IN} = 0\text{ dBm}$, Boost: on	-2	0	+2	dB
Boost level: high	BST1	Boost: on, $f_i = 50\text{ Hz}$, $BST = 35\text{ dB}$, $ADD = 0\text{ dB}$, $V_{IN} = -30\text{ dBm}$	25.5	28.5	31.5	dB
	BST2	Boost: on, $f_i = 50\text{ Hz}$, $BST = 35\text{ dB}$, $ADD = 0\text{ dB}$, $V_{IN} = -20\text{ dBm}$	21	24	27	dB
	BST3	Boost: on, $f_i = 50\text{ Hz}$, $BST = 35\text{ dB}$, $ADD = 0\text{ dB}$, $V_{IN} = -10\text{ dBm}$	13	15	17	dB
	BST4	Boost: on, $f_i = 50\text{ Hz}$, $BST = 35\text{ dB}$, $ADD = 0\text{ dB}$, $V_{IN} = 0\text{ dBm}$	5	7	9	dB
Boost level: low	BST1	Boost: on, $f_i = 50\text{ Hz}$, $BST = 30\text{ dB}$, $ADD = -6\text{ dB}$, $V_{IN} = -20\text{ dBm}$	15	18	21	dB
	BST2	Boost: on, $f_i = 50\text{ Hz}$, $BST = 30\text{ dB}$, $ADD = -6\text{ dB}$, $V_{IN} = -10\text{ dBm}$	8	10	12	dB
	BST3	Boost: on, $f_i = 50\text{ Hz}$, $BST = 30\text{ dB}$, $ADD = -6\text{ dB}$, $V_{IN} = 0\text{ dBm}$	1.5	3.5	5.5	dB
Maximum output voltage	$V_{O\text{ max}T}$	THD = 1%, Boost: off	2.00	2.55		V
	$V_{O\text{ max}B}$	THD = 1%, Boost: on	2.00	2.55		V
Total harmonic distortion	THD T	$V_{IN} = -10\text{ dBm}$, Boost: off, BPF = 400 Hz to 30 kHz		0.008	0.03	%
	THD B	$V_{IN} = -10\text{ dBm}$, Boost: on, $f_i = 50\text{ Hz}$, LPF = 30 kHz		0.3	0.9	%
Crosstalk	CT T	$V_O = 0\text{ dB}$, $R_g = 10\text{ k}\Omega$, DIN AUDIO, Boost: off	80	88		dB
	CT B	$V_O = 0\text{ dB}$, $R_g = 10\text{ k}\Omega$, DIN AUDIO, Boost: on	50	59		dB
Output noise voltage	$V_{NO\ T}$	$R_g = 10\text{ k}\Omega$, JIS A, Boost: off, Boost ADD = off		-97	-90	dBm
	$V_{NO\ B}$	$R_g = 10\text{ k}\Omega$, JIS A, Boost: on		-91	-84	dBm
LED current	I_{LED}	RED LED	11	15	19	mA

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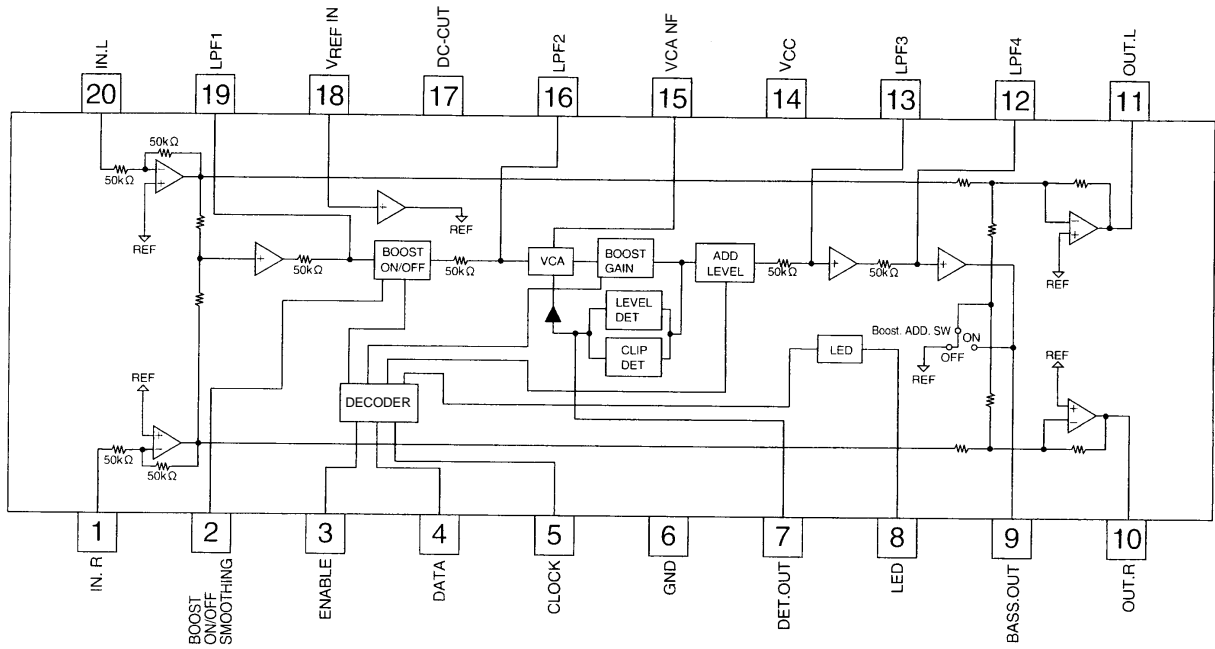
Control Data for the Parameters in the Electrical Characteristics

Parameter	Conditions	D1	D2	D3	D4	D5	D6	D7	D8
Quiescent current									
	I_{CCOT}								
I_{CCOB}	Boost: on	L	L	L	L	L	L	L	L
	Boost: off	H	H	H	H	H	H	L	H
Voltage gain	$V_{IN} = 0 \text{ dBm}$								
	V_{GT}	L	L	L	L	L	L	L	L
V_{GB}	Boost: off	L	L	L	L	L	L	L	L
	Boost: on	H	H	H	H	H	H	L	H
Boost level: high	Boost: on, $f_i = 50 \text{ Hz}$, BST = 35 dB, ADD = 0 dB	H	H	H	H	H	H	L	H
Boost level: low	Boost: on, $f_i = 50 \text{ Hz}$, BST = 30 dB, ADD = -6 dB	H	L	H	L	H	H	L	H
Maximum output voltage	THD = 1%								
	$V_{O \text{ max}T}$	L	L	L	L	L	L	L	L
$V_{O \text{ max}B}$	Boost: on	H	H	H	H	H	H	L	H
Total harmonic distortion	$V_{IN} = -10 \text{ dBm}$								
	THD T	L	L	L	L	L	L	L	L
THD B	Boost: off, BPF = 400 Hz to 30 kHz	L	L	L	L	L	L	L	L
	Boost: on, $f_i = 50 \text{ Hz}$, LPF = 30 kHz	H	H	H	H	H	H	L	H
Crosstalk	$V_O = 0 \text{ dBm}$, $R_g = 10 \text{ k}\Omega$, DIN AUDIO								
	CT T	L	L	L	L	L	L	L	L
CT B	Boost: off	L	L	L	L	L	L	L	L
	Boost: on	H	H	H	H	H	H	L	H
Output noise voltage	$R_g = 10 \text{ k}\Omega$, JIS A								
	$V_{NO T}$	L	L	L	L	L	L	L	L
$V_{NO B}$	Boost: off, Boost ADD = off	L	L	L	L	L	L	L	L
	Boost: on	H	H	H	H	H	H	L	H
LED current									
	I_{LED}	*	*	*	*	*	*	H	*

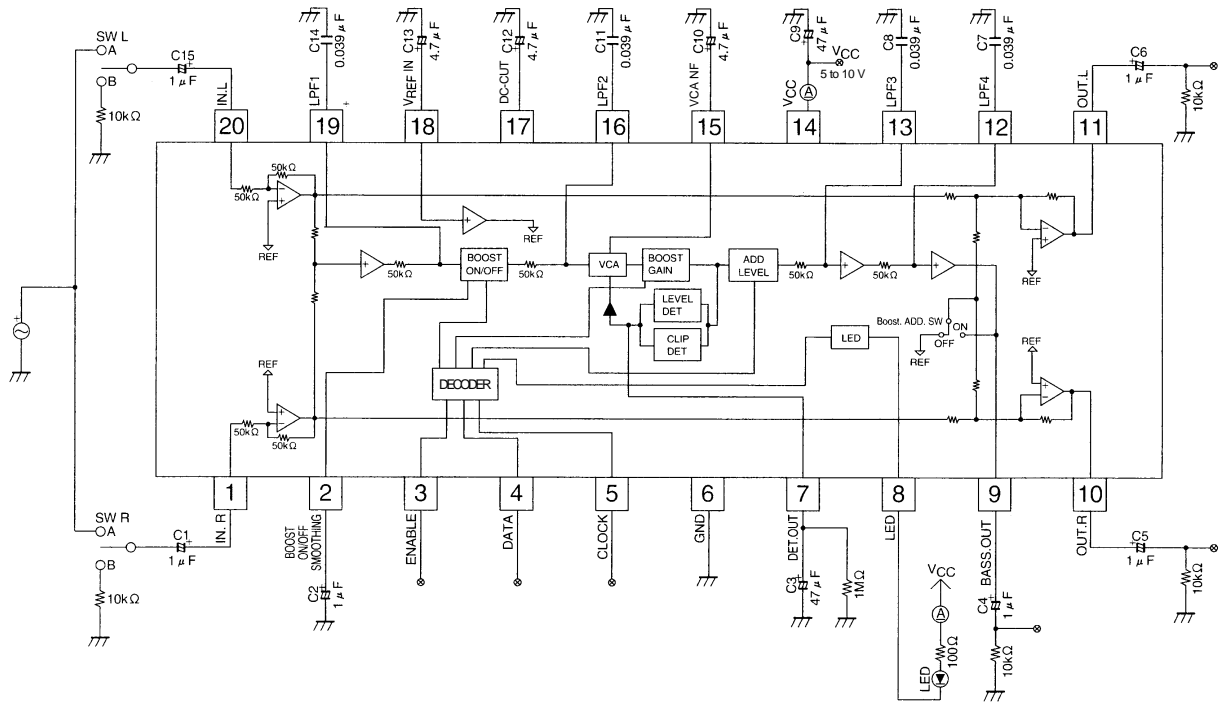
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Block Diagram

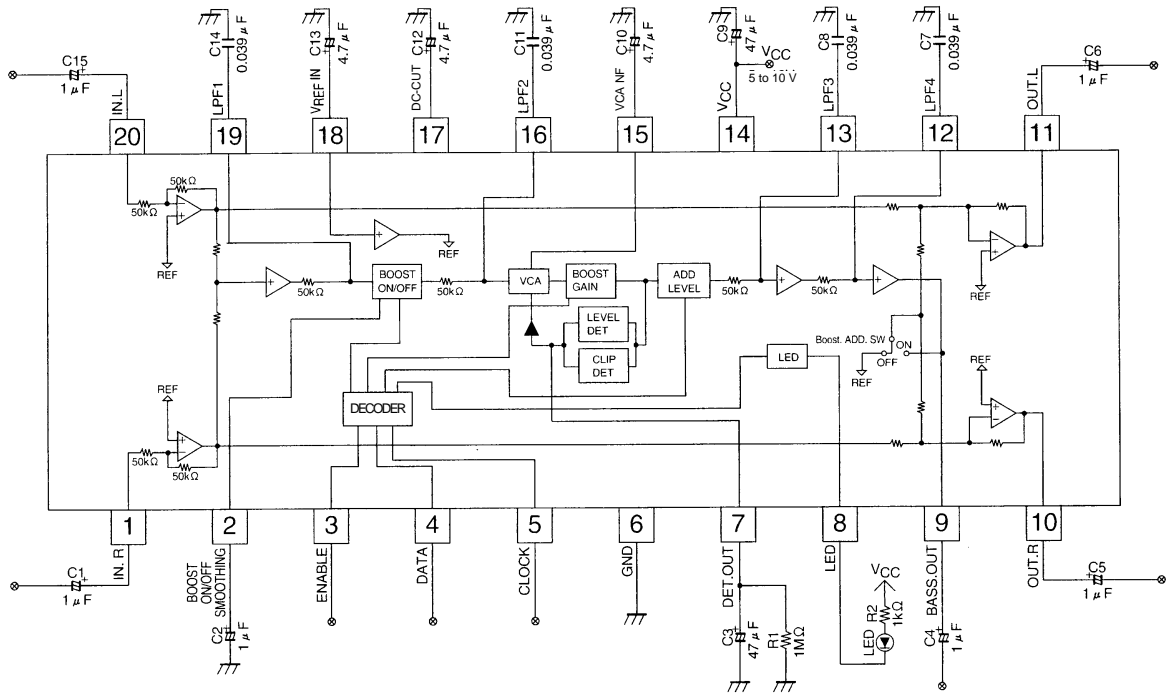


Test Circuit



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Sample Application Circuit



Notes on LA2650 Operation

LPF cutoff frequency

Use the following formula to calculate the cutoff frequency:

$$f_c = 1/(2\pi CR) \text{ Hz}$$

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)

$$f_c = 81.6 \text{ Hz}$$

Maximum boost gain

Use the following formula to calculate the maximum boost 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)

$$G_B = 29.46 \text{ dB}$$

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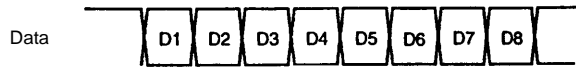
Pin No.	Pin	Pin voltage (V)	Pin function	Equivalent circuit
9	BASS-OUT	$1/2 V_{CC}$	Low boost output for 3D systems	
10 11	OUT-R OUT-L	$1/2 V_{CC}$	Signal outputs	
12 13 19	LPF4 LPF3 LPF1	$1/2 V_{CC}$	LPF connection for the low-boost circuit Internal resistor: 50 kΩ	
15	VCA NF	$1/2 V_{CC}$	VCA feedback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

Note: Pin voltage values are typical values.

External Components

- **C₁, C₁₅ (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.
- **C₂ (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.
- **C₃ (10 to 220 μF)**
Detection capacitor.
The attack and recover times can be adjusted by changing the value of this capacitor.
- **C₄, C₅, C₆ (0.22 to 10 μF)**
Output coupling capacitors.
- **C₇, C₈, C₁₁, C₁₄**
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.
- **C₉ (22 to 220 μF)**
Power supply capacitor.
- **C₁₀ (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.
- **C₁₂ (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.
- **C₁₃ (1.0 to 22 μF)**
RF reference LPF capacitor.
The RF SVRR can be modified by changing the value of this capacitor.
- **R₁ (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.
- **R₂ (0 to 1 kΩ)**
LED current adjustment.
LED current $\approx (V_{CC} - V_{LED} - 0.9)/(R_2 + 300)$
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

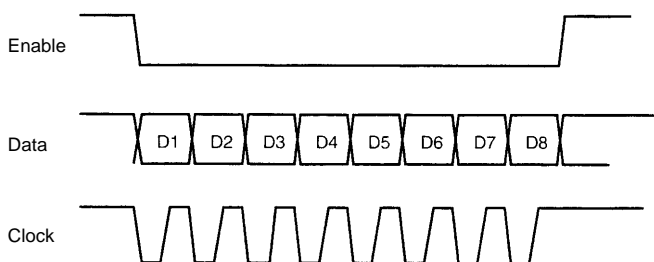
- Add level select
 - Selects the addition level at the output mixing amplifier for the low-frequency signals from the boost amplifier.
- Boost gain select
 - Selects the amplification applied to low-frequency signals by the boost amplifier.
- Left and right channel boost add on/off
 - Turns addition 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).

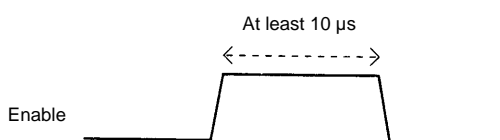
Limiter (ALC) Operation

- 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

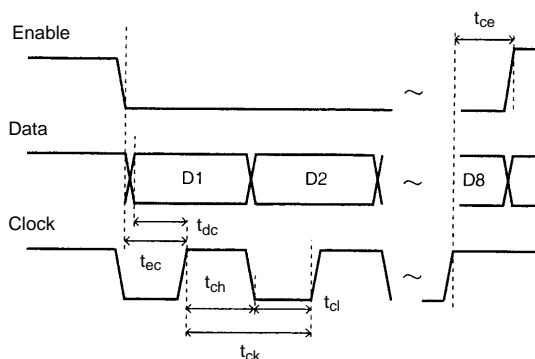
The timing of the intervals on the enable signal must meet the conditions shown in the figure below.

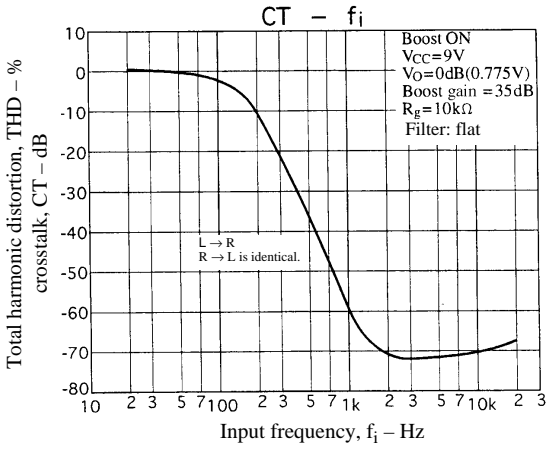
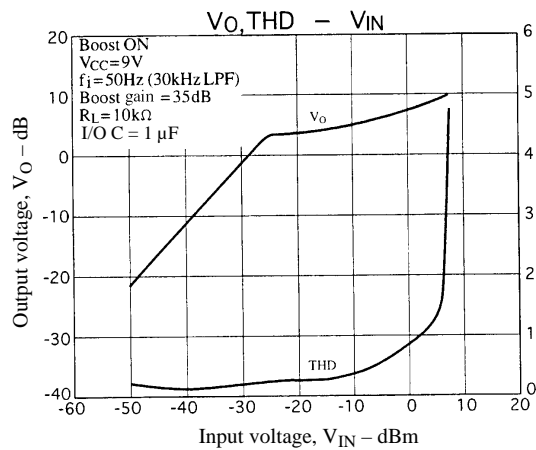
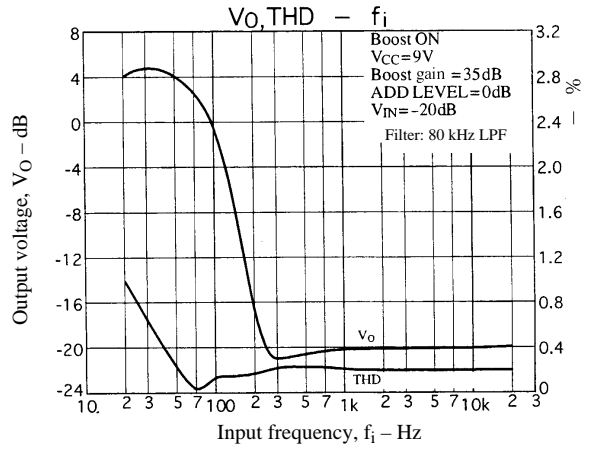
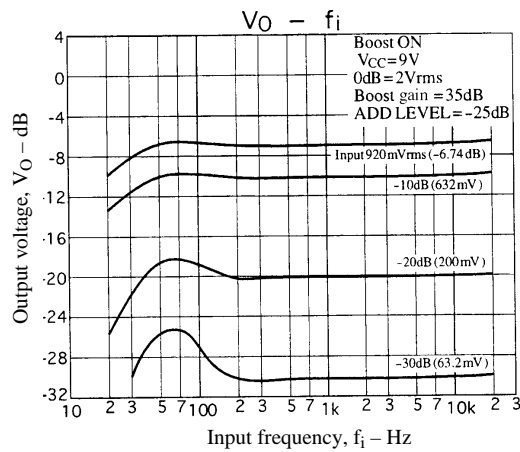
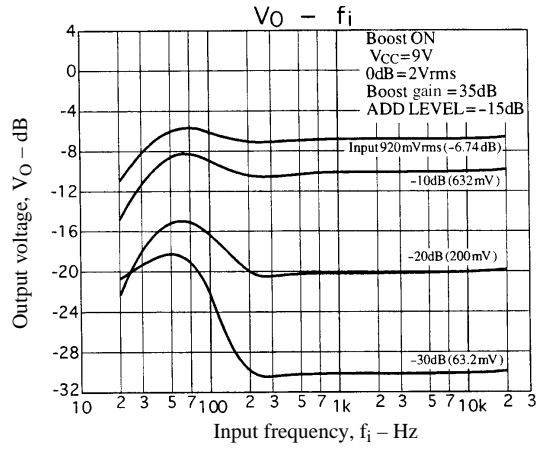
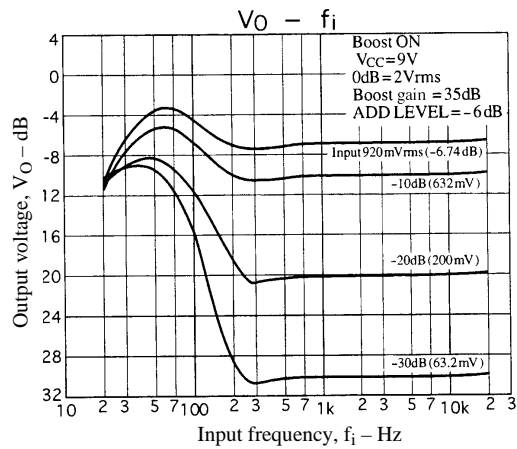
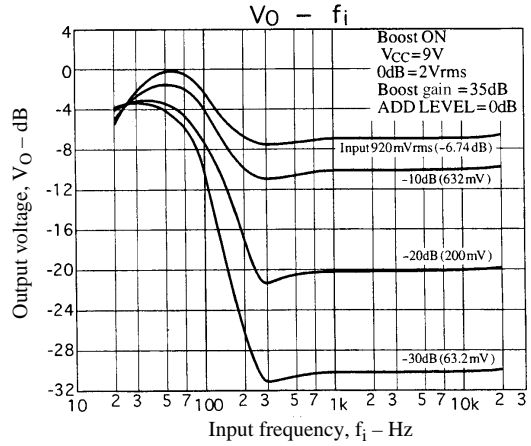
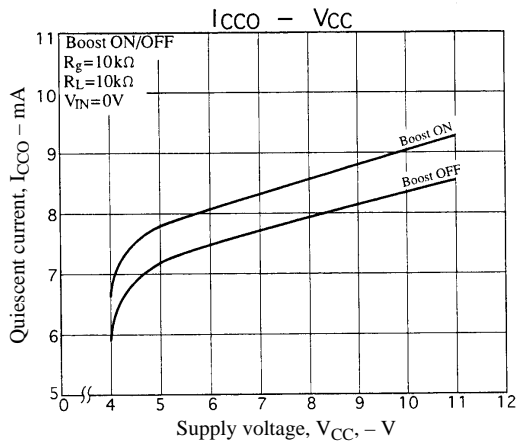


- Initial Settings at Power on
 - All data is reset to low when power is first applied.
 - Applications should send their initial data settings once the IC is fully operational after power is applied, i.e. about 0.5 second after power is applied.

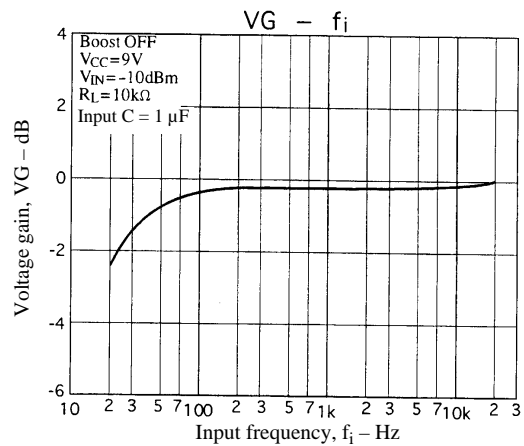
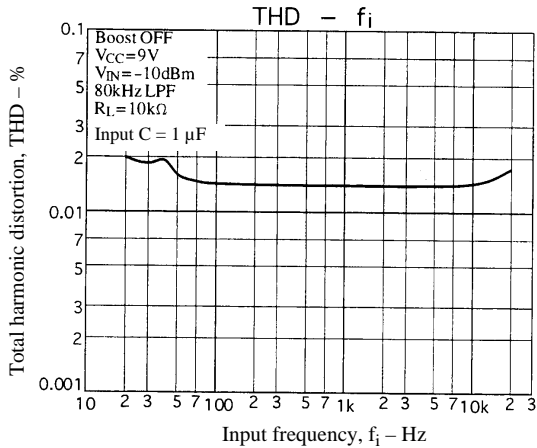
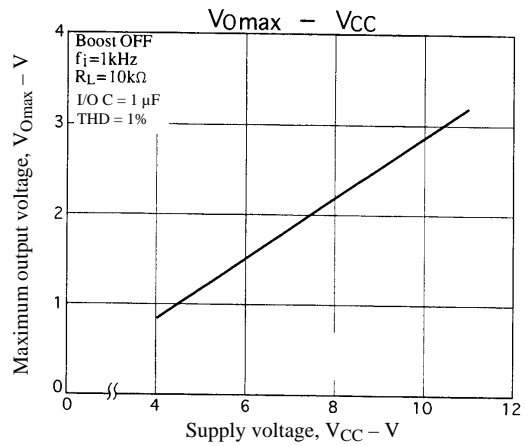
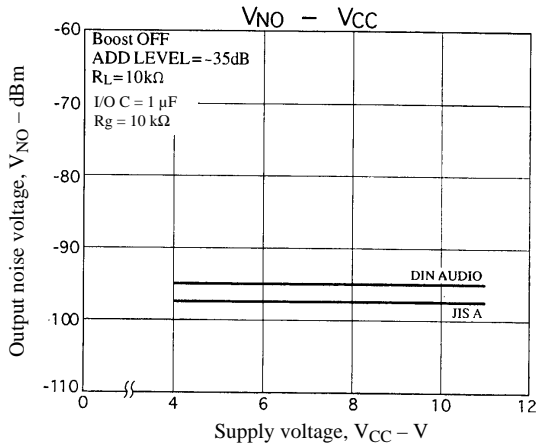
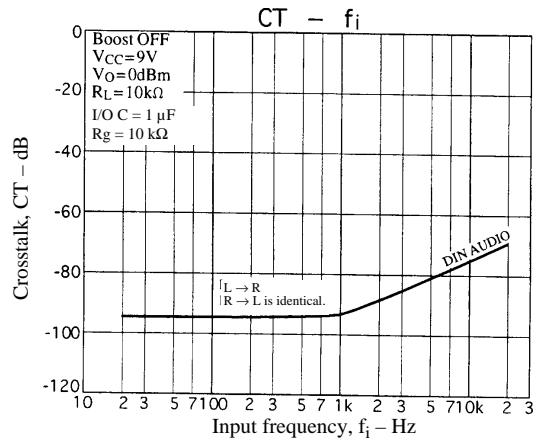
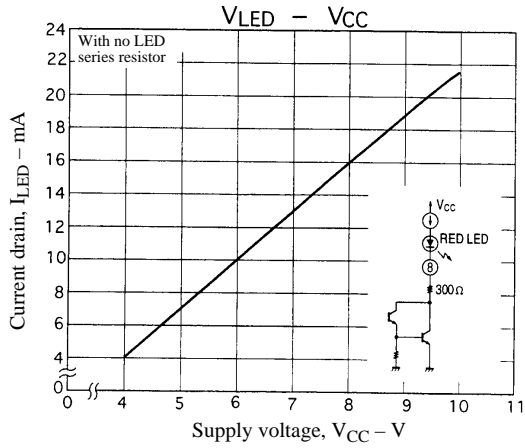
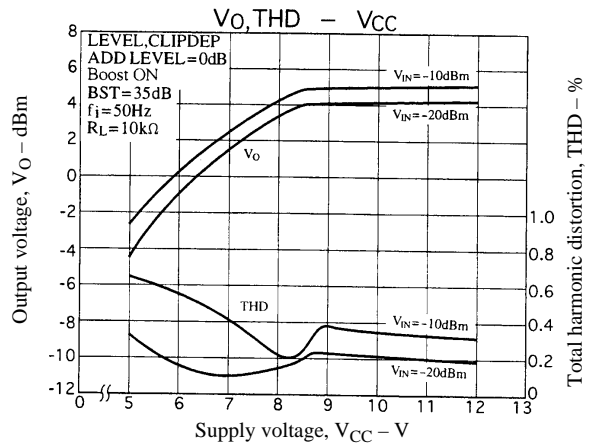
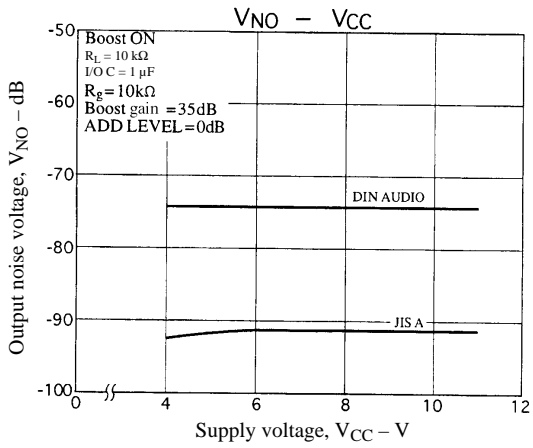
Data Timing

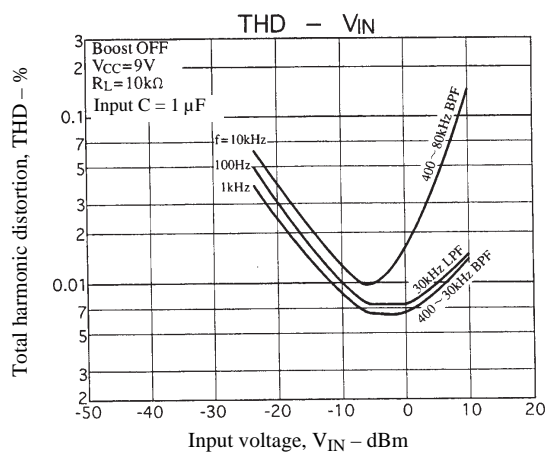
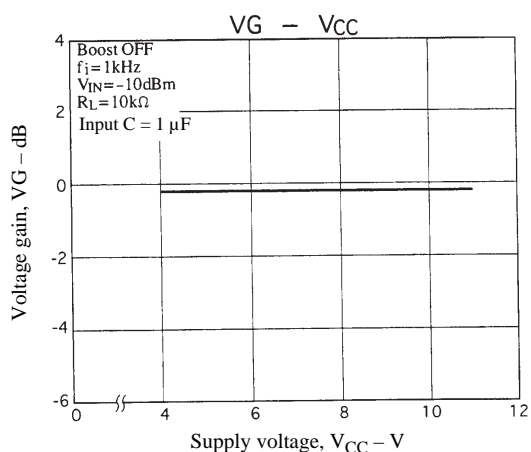
Timing characteristics		min	typ	max	unit
Enable clock delay time	t_{ec}	5			μs
Data clock delay time	t_{dc}	5			μs
Clock high-level hold time	t_{ch}	5			μs
Clock low-level hold time	t_{cl}	5			μs
Clock enable delay time	t_{ce}	5			μs
Clock cycle time	t_{ck}	10			μs





Total harmonic distortion, THD - %





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