Ordering number: EN 1866G

SANYO

No.1866G

LA4470,4471

Monolithic Linear ICs

BTL-OCL 20W Power Amp for Car Stereo Use

Features

- High output: 20W/THD=10%, 15W/THD=1%
- Low distortion: 0.06%
- Excellent ripple rejection: 65dB
- Low residual noise (Rg=0): 0.09mV
- Low pop noise at the power ON/OFF mode
- By using the LA4470 and LA4471 (pin assignment reversed version of LA4470) in a pair, the stereo printed circuit pattern may be designed with ease.
- Even if inserted invertedly, no breakdown will occur.

Functions

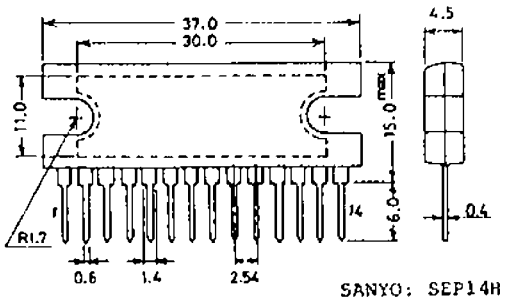
- Starting time (on-chip pop noise suppressor): 0.6 to 0.8sec.
- On-chip audio muting
  (DC+4V, active-high method) --- no external parts required, LED display capability, fast attack time
- On-chip thermal detector/protector (Tj≒170 to 180°C)
- On-chip overvoltage/surge protector (V_{CCX}≒24V)
- On-chip output pin-to-GND short protector (DC short between output and GND) --- with speaker protection
- On-chip output pin-to-V_{CC} short protector (DC short between output and V_{CC}) --- with speaker protection
- On-chip load short protector.

Maximum Ratings at Ta=25°C

				unit
Maximum Supply Voltage	V_{CC}max1	Quiescent, t=30sec	26	V
	V_{CC}max2	Quiescent	18	V
	V_{CC}max3	Operating	16	V
Surge Supply Voltage	V_{CC}surge	t≦0.2sec, single giant pulse, rise time 1msec	50	V
Output Current	I_O peak		4	A
Thermal Resistance	θjc		3	°C/W
Allowable Power Dissipation	Pdmax	See Pdmax-Ta graph.	15	W
Junction Temperature	Tjmax		150	°C
Operating Temperature	Topg		-20 to +75	°C
Storage Temperature	Tstg		-40 to +150	°C

(Note) V_{CC}max2, V_{CC}max1: Guaranteed at quiescent mode, t=30sec.

Case Outline 3023A-S14HIC
(unit:mm)



SANYO: SEP14H

Specifications and information herein are subject to change without notice.

SANYO Electric Co.,Ltd. Semiconductor Business Headquarters
TOKYO OFFICE Tokyo Bldg., 1-10,1 Chome, Ueno, Taito-ku, TOKYO, 110 JAPAN

Recommended Operating Conditions at Ta=25°C

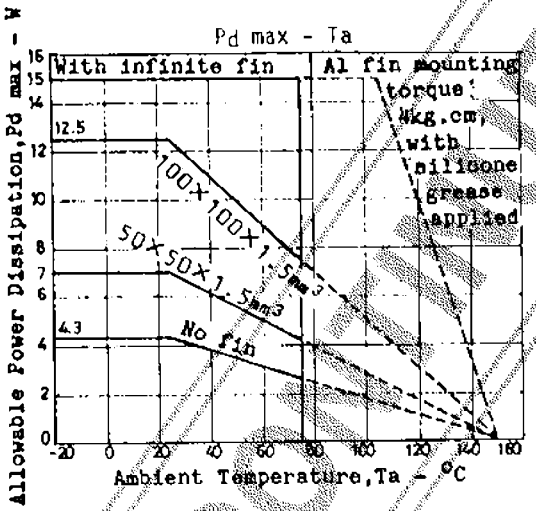
			unit
Recommended Supply Voltage	V_{CC}	13.2	V
Recommended Load Resistance	R_L	4	ohm
Operating Voltage Range	$V_{CC}op$	9 to 16	V
Operating Load Resistance Range	$R_L op$	4 to 8	ohm

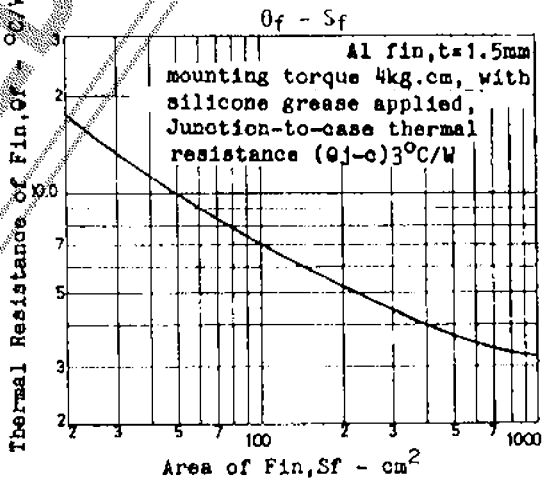
Operating Characteristics at Ta=25°C, V_{CC}=13.2V, R_L=4ohms, f=1kHz, Rg=600ohms, with 100x100x1.5mm^3 Al radiator fin, See Test Circuit (DC-B switch ON).

			min	typ	max	unit
Quiescent Current	Icco		40	80	160	mA
Voltage Gain	VG		38	40	42	dB
Output Power	Po1	THD=10%	16	20		W
Output Power	Po2	THD=1%		15		W
Total Harmonic Distortion	THD	Po=1W		0.06	0.3	%
Input Resistance	ri		20	30	40	kohm
Output Noise Voltage	V_{NO1}	Rg=0, BPF=20Hz to 20kHz		0.09	0.18	mV
	V_{NO2}	Rg=10kohms "		0.16	0.32	mV
Output Offset Voltage	V_{off}	Rg=open	-300		+300	mV
Ripple Rejection	R_r	Rg=0, V_R=0dBm, f_R=100Hz, with DC-B, BPF=20Hz to 20kHz	50	65		dB
Muting Attenuation	Att	Vo=0dBm, V_M=+4V(with LED)		80		dB

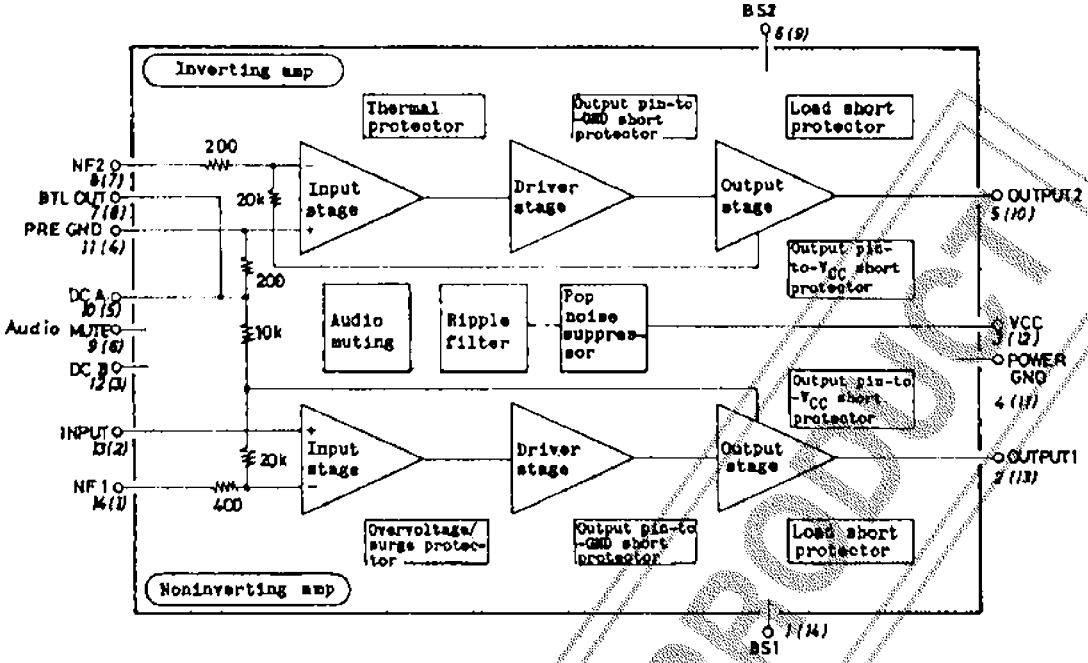
(Note) . Po at V_{CC}=14.4V, R_L=4ohms, THD=10% is approximately 23W/typ.

. $Rr=20\cdot\log\frac{V_R}{V_{NOR}-V_{NO1}}$



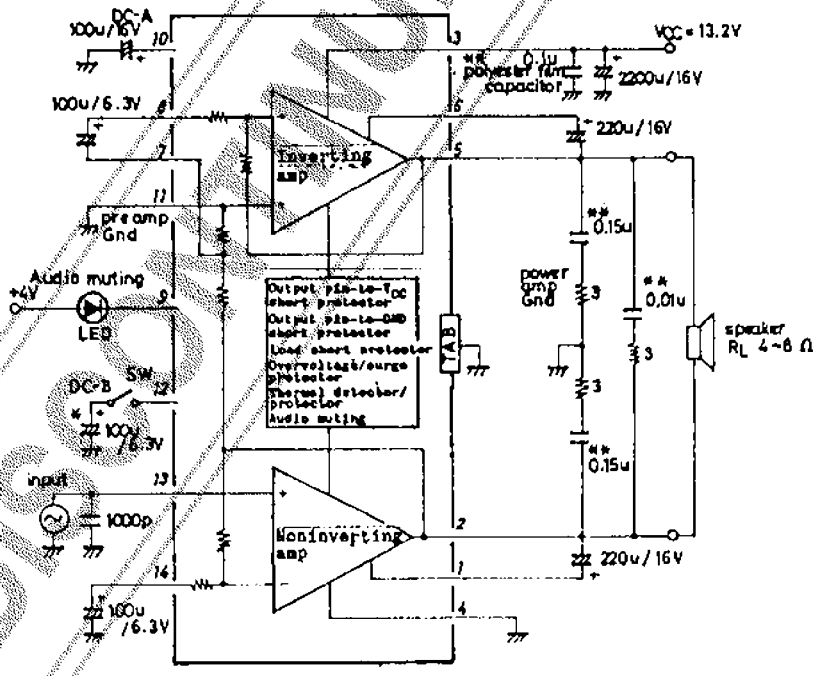


Equivalent Circuit Block Diagram: ( ) is for the LA4471.



LA4470 No.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭
LA4471 No.	(14)	(13)	(12)	(11)	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)
Pin Name	BS 1	OUT 1	V_{CC}	PWR G	OUT 2	BS 2	BTL OUT	NF 2	Audio MUT	DC A	PRE G	DC B	I N	NF 1
Pin Voltage(V)	11.5	6.7	13.2	0	6.7	11.5	0.135	1.2	0	13.1	0	0.98	0.02	1.2

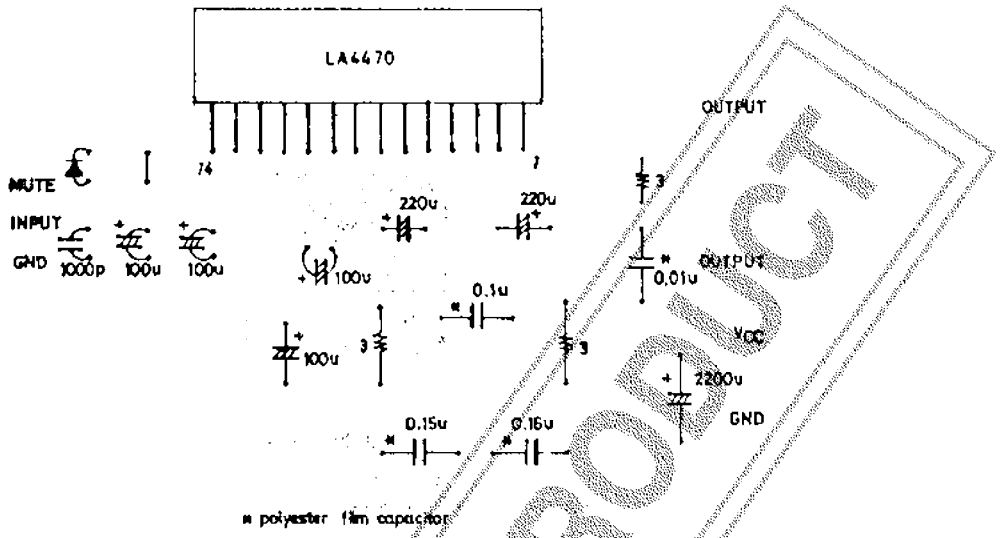
Sample Application Circuit



*: When power supply ripple $V_R \geq 500mV(rms)$, $f_R = 100Hz$, capacitors of 100uF take effect.

(Note) . The LA4471 is the pin assignment reversed version of the LA4470.
. Connect the tab (heat sink) to large-signal GND.

Sample Printed Circuit Pattern of LA4470

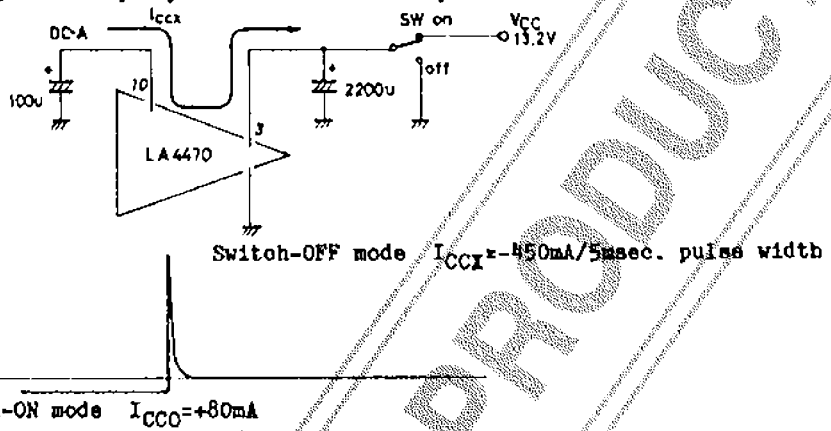


1. Functions of external parts and proper cares to be taken (explained using pin No. of LA4470)
   External parts of the LA4470, 4471 are as shown in the Sample Application Circuit. For these external parts, the recommended constants must be used. The functions of individual external parts, the possibility of reducing them, and the proper cares to be taken in using them are described below.
   a) Feedback capacitors
      The capacitor of 100uF connected across pin ⑭ of the noninverting amp and GND and the capacitor of 100uF connected across pin ⑧ and pin ⑦ of the inverting amp are feedback capacitors. It should be noted that it is impossible to remove them and the capacitance value affects the following characteristics.
      . Low roll-off frequency f_L
      . Pop noise and starting time at the time of application of power
      In particular, the effect of the capacitance value on pop noise should be considered. If the capacitance value is decreased,
      . Pop noise will strike your ears and the starting time will shorten.
      If the capacitance value is increased,
      . the starting time will lengthen.
      The feedback capacitor value must be in the range of 47uF to 100uF. The feedback capacitors used in the noninverting amp and inverting amp must be the same in the capacitance value and it is best that there is less variation in the capacitance value. This is because transient offset attributable to the imbalance of charging speed is liable to occur at the output terminal.
   b) Filter capacitors
      Used mainly for suppressing ripple components on the power line. Two stages - DC_A=100uF externally connected across pin ⑩ and GND and DC_B=100uF externally connected across pin ⑫ and GND - are used to prevent ripple components from mixing in (one stage of filter using a Zener diode is contained in the LA4470, 4471). The former DC_A=100uF, which is also used for preventing pop noise from occurring, cannot be removed. The latter DC_B=100uF may be removed. Whether or not to remove it should be decided considering the following ripple rejection.
      . DC_A=100uF, DC_B=100uF ------- Rr=65dB/typ.
      . DC_A=100uF only ----------Rr=50dB/typ.

When the capacitance value of the DC_A, DC_B is decreased, the ripple rejection will worsen, but even when the capacitance value is further increased, the ripple rejection is not expected to be better than shown above.

Next, the following should be noted. When the two conditions shown below are set in a car stereo set system:

- The capacitance value of DC_A is increased. (Example: The starting time is made longer.)
- The capacitor of 2200uF connected to pin ③ on the power line is discharged abruptly at the time of power OFF.



When the potential on pin ③ is decreased abruptly by turning the power switch OFF as shown above, potential reversal between pin ⑩ and pin ③ will occur, causing reverse current I_{CCX} to flow into the IC system. This loads the IC heavily.

- When the DC_A is increased, the pulse width of reverse current I_{CCX} will widen.
- When the supply voltage is raised, reverse current I_{CCX} will increase.

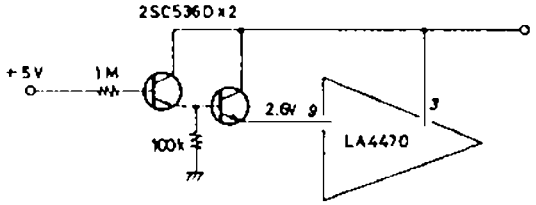
If this switch-OFF mode is present in the car stereo set system,

- IC handling capability ---------- Contact us.
- Measure to be taken externally --- Connect bypass diode DS446 across pin ③ and pin ⑩ (⑩ → ③).

c) Audio muting

Audio muting is accomplished by applying an active-high signal to pin ⑨. For data on threshold voltage ($+V_M$), drive current ($+I_M$), attenuation (Att) when LED (red) display is present or absent, see graphs shown later. Since the DC cutoff method is used, signal attenuation up to ∞ (infinity) is basically possible. However, signal attenuation is at 80dB level (Vo=0dBm, f=1kHz) because residual noise components are present.

- The LED is used as display only and may be removed.
- The active-high signal applied to pin ⑨ must be free from CR time constant.
- When no muting is used, pin ⑨ must be connected to GND externally.
- Turning the main switch OFF at the muting-ON mode is considered.
- Audio muting driven by a CMOS microcomputer, etc. may be accomplished by the following external parts which supply an adequate drive current.



d) External disturbance preventing capacitor
Capacitor of 1000pF connected across input pin (13) of the noninverting amp and GND. Whether or not to use this capacitor depends on the design conditions of a car stereo set system. The IC itself does not require this capacitor.

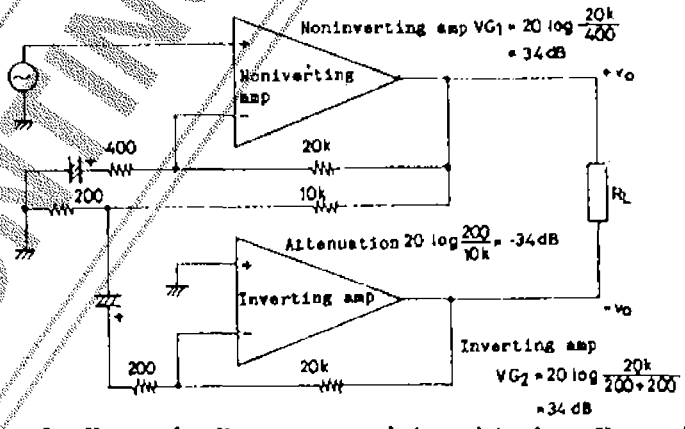
e) Bootstrap capacitors
Bootstrap capacitors of 220uF are used to provide a full dynamic range at the output terminals. It is impossible to remove these capacitors. An adequate value of these capacitors is 100 to 220uF.
- The bootstrap capacitors affect the drive capability at low frequencies.
- The bootstrap capacitors, which are in the pop noise suppressor channel, affect the starting time.

f) Oscillation compensation parts
CR filters (oscillation compensation parts) are applied at the output terminals so that feedthrough capacitors (1000 to 2000pF) may be inserted in a car stereo set. If no feedthrough capacitors are required, these CR filters may be simplified (example: all CR filters are removed and a polyester film capacitor of 0.15uF is connected only across pin ② and pin ⑤).

g) Power capacitor
The capacitance value of 2200uF may be changed according to the design conditions of a car stereo set. The IC itself does not require the polyester film capacitor of 0.1uF. This polyester film capacitor should be inserted when the power line is routed around in a car stereo set and the power impedance viewed from pin ③ rises.

2. Features of IC system and proper cares to be taken

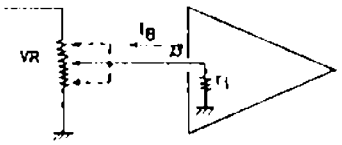
a) Voltage gain VG
The voltage gain inside the IC is designed to be VG=40dB/typ. This voltage gain may be decreased by external parts, but should be fixed normally to 40dB.



Two output signals of +Vo and -Vo are used to obtain +Vo - (-Vo)=2Vo at the load terminal.
where +Vo: Output signal amplified by the noninverting amp (VG=34dB)
-Vo: Inverted output signal obtained by suppressing output signal +Vo of the noninverting 34dB and applying it to the NF terminal of the inverting amp (VG=34dB)
Therefore, 34dB + 6dB=40dB is obtained as the VG of a BTL power IC.
This BTL system has the following advantage and disadvantage.
- More advantageous in suppressing noise as compared with an IC containing a phase inverter at the input stage
- The inverting amp is hard to overdrive and the BTL output efficiency is low.

Continued from preceding page.

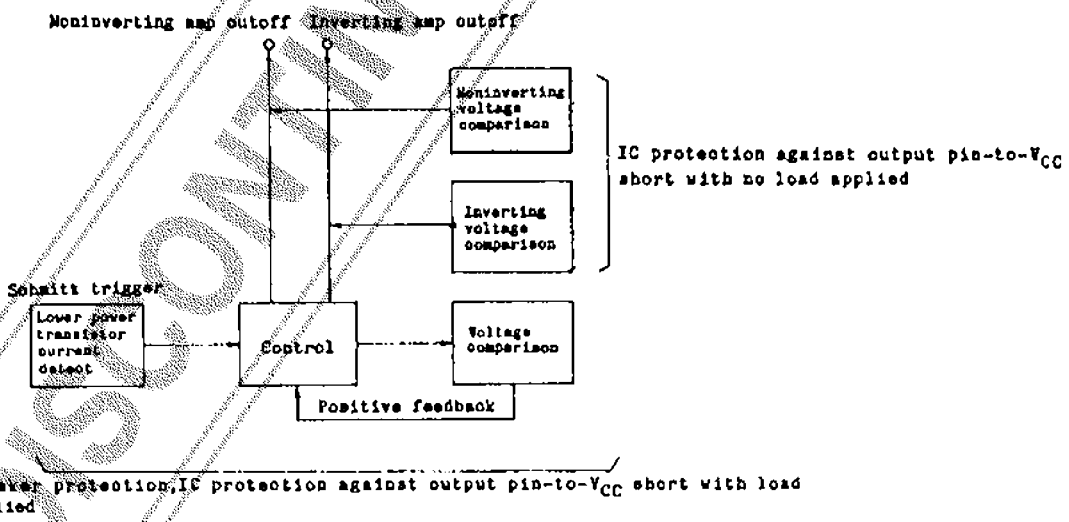
b) Input zero-bias circuit and slider contact noise of variable resistor
Since the input circuit uses PNP transistors and the bias voltage is set nearly equal to 0, no input coupling capacitor is required, thereby enabling direct connection to the variable resistor.



Here, attention should be paid to slider contact noise of the variable resistor. In general, slider contact noise, which also depends on the performance of the variable resistor, becomes higher with increasing input flow-out current I_B shown above. To prevent slider contact noise from becoming higher, we control the V_{13} voltage of $I_B \times r_i$ with pin (13) open (V_{13max}=60mV). If slider contact noise is still offensive to your ears, insert an input coupling capacitor.

c) Device saturation at the input stage and fold-back waveform
When THD≦20%, a part of the clip waveform at the output terminal will be folded back. The reason why this phenomenon occurs is that the dynamic range of the zero-bias circuit at the input stage is narrow and the device is saturated. The level diagram of the car stereo set must be considered and a measure must be taken to prevent a high input level from being applied to the input terminal (if the input level is made high and the output fold-back waveform becomes sharp, blocking symptoms may be developed). In this case, it is better to connect the tab (heat sink) to large-signal GND (it is also better to insert an input coupling capacitor).

d) Output pin-to-V_{CC} short protector



In general, if output pin-to-V_{CC} short occurs in an IC with no protector provided, DC feedback provided inside the IC may cause lower power transistors in both of noninverting amp, inverting amp to be subjected to ASO breakdown in a moment and may also cause the speaker to be damaged. Therefore, it is absolutely necessary for BTCL high-power ICs to contain an output pin-to-V_{CC} short protector. The LA4470, 4471 contain the output pin-to-V_{CC} short protector of the above-mentioned block diagram that provides IC protection, speaker protection. Output pin-to-V_{CC} short

Continued on next page.

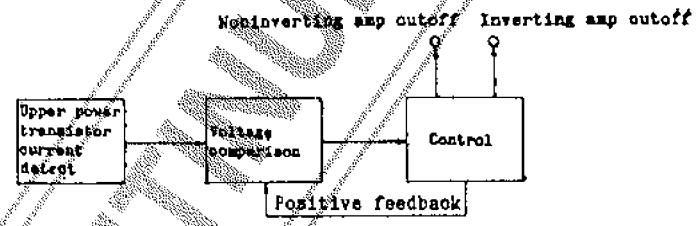
is classified into two cases - after output pin-to-V_{CC} short→application of power and after application of power→output pin-to-V_{CC} short. It is assumed that the former is the trouble caused by the end user and the latter is the trouble caused by the manufacturing process (we have developed the LA4470, 4471 with the former in mind). When we designed the protector that should operate normally in these two cases, it was difficult for us to suppress the side effect - especially pop noise, but we succeeded in solving this problem. The following are the points that we considered in designing the output pin-to-V_{CC} short protector and the problem that is yet to be solved.

. The output pin of the noninverting amp and the output pin of the inverting amp are shorted to V_{CC} separately.
. The output pin of the noninverting amp and the output pin of the inverting amp are shorted to V_{CC} simultaneously.
. Output pin-to-V_{CC} short with load/with no load
  Output pin-to-V_{CC} short with signal/with no signal
. Application of power after output pin-to-V_{CC} short
  Output pin-to-V_{CC} short after application of power
. Impedance of output pin-to-V_{CC} short: 0.3ohm is obtained.
. Protection of both IC and speaker

Problem to be solved

. If next output pin-to-V_{CC} short occurs before the IC returns to the normal bias state (within 200msec.) after output pin-to-V_{CC} short is opened, nonoperation of the IC is liable to occur (repetition test of
. output pin-to-V_{CC} short). However, repetition of power ON/OFF at the output pin-to-V_{CC} short mode presents no problem.

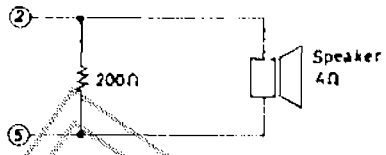
e) Output pin-to-GND short protector



The LA4470, 4471 contain the output pin-to-GND short protector of the above-mentioned block diagram that provids IC protection, speaker protection. Output pin-to-GND short is also classified into two cases - after output pin-to-GND short ⟶ application of power and after application of power ⟶ output pin-to-GND short. It is assumed that the former is the trouble caused by the end user and the latter is the trouble caused by the manufacturing process (as with output pin-to-V_{CC} short, we have developed the LA4470, 4471 with the former in mind). When we designed the protector that should operate normally in these two cases, it was difficult for us to suppress the side effect - especially pop noise, but we succeeded in solving this problem. The following are the points that we considered in designing the output pin-to-GND short protector and the problems that are yet to be solved.

. The output pin of the noninverting amp and the output pin of the inverting amp are shorted to GND separately.
. The output pin of the noniverting amp and the output pin of the inverting amp are shorted to GND simultaneously.

. Output pin-to-GND short with load/with no load
Output pin-to-GND short with signal/with no signal
. Application of power after output pin-to-GND short
Output pin-to-GND short after application of power
. Impedance of output pin-to-GND short: 0.3ohm is obtained.
. Protection of both IC and speaker



Problems to be solved

. When power is applied after output pin-to-GND short with no load, nonoperation of the IC is liable to occur. A resistor of approximately 200ohms must be connected across output pins.
. If next output pin-to-GND short occurs before the IC returns to the normal bias state (within 200msec.) after output pin-to-GND short is opened, nonoperation of the IC is liable to occur (repetition test of output pin-to-GND short). However, repetition of power ON/OFF at the output pin-to-GND short mode presents no problem if the resistor of 200ohms is connected as shown above.
. The supply voltage range of a car stereo set is 10.5 to 15.6V. If 10V or less at the output pin-to-GND short mode after application of power, nonoperation of the IC will be liable to occur.

f) R_L short

When the load is shorted, current detection of the upper/lower power transistors in the output pin-to-V_{CC} short protector and output pin-to-GND short protector occurs alternately, the voltage across pins ②, ⑤ and GND and the current at pins ②, ⑤, which depend on the signal level, will fluctuate. The protection function works within the ASO of the device. When performing the load short test, a heat sink must be attached and a choke must be connected to the power line. The main purpose of the thermal shutdown protection is to suppress Tj rise which may be caused by improper thermal design. Tj is set to 170°C. The thermal shutdown protection is not intended to suppress transient temperature rise caused by current pulse as shown in the above-mentioned load short case.

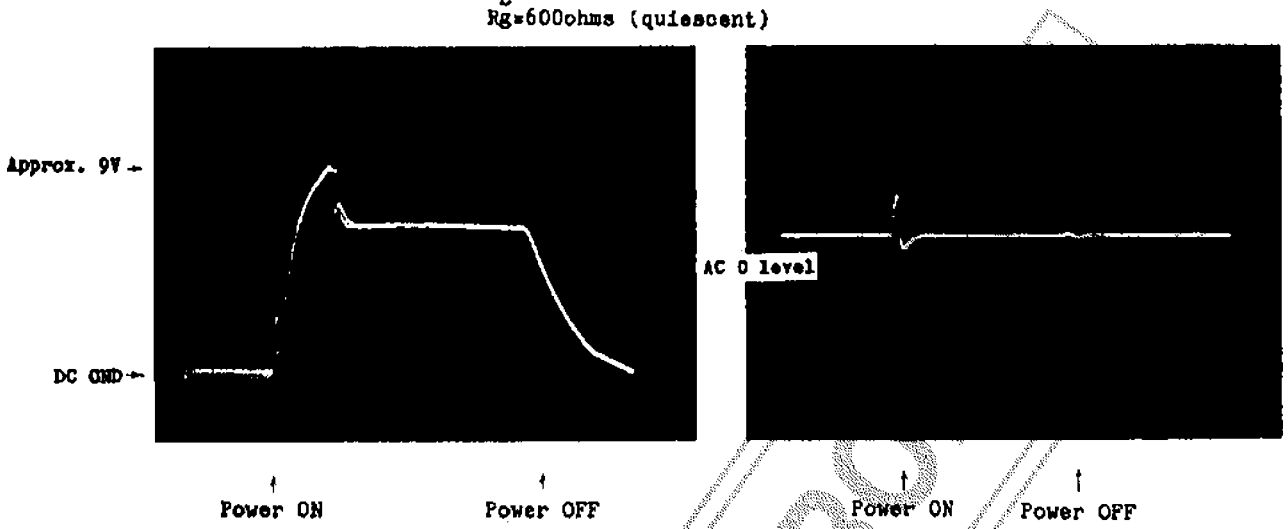
g) Proper cares to be taken

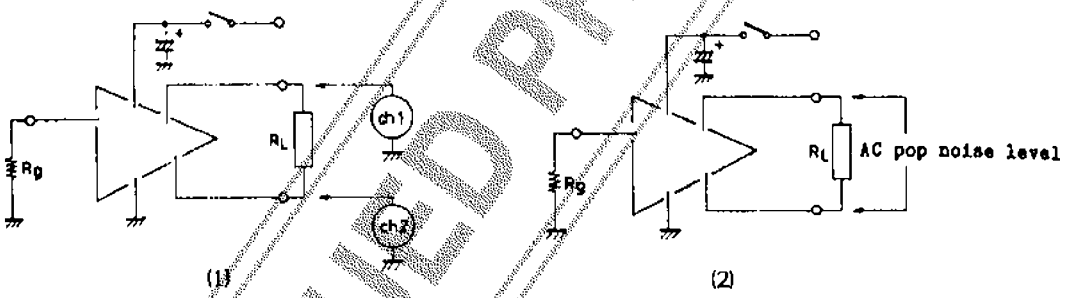
. If the IC is operated at $Tj \geq 150°C$, the clip waveform is liable to be distorted, which may lower the tone quality. Be careful of thermal design.
. When $Tj \geq 150°C$, the ASO of the power transistor device becomes narrower and the protection function does not work well. When subjecting the IC to the following tests under this thermal condition, the IC is once locked and returns to normal automatically when $Tj \leq 150°C$ (output pin-to-V_{CC} short, output pin-to-GND short, R_L short, audio muting).
. If output pin-to-V_{CC} short and output pin-to-GND short occur simultaneously, the IC will be broken down. This case occurs when the noninverting amp output pin is connected to V_{CC} and the inverting amp output pin is connected to GND simultaneously.
. 3-wire common connection
Wrong connection where one of Lch output terminals and one of Rch output terminals are connected as common. If a choke is connected to the power line, no instantaneous breakdown will occur and sound will not continue to be produced unlike ICs heretofore in use and blocking symptoms will be developed. This phenomenon makes the wrong connection known to the end user
. Inverted insertion of IC
Since the LA4471 is the pin assignment reversed version of the LA4470, appropriate provisions are made so that no breakdown will occur even if inserted invertedly.
. Connection of V_{CC} pin to GND and connection of GND pin to V_{CC}
Instantaneous breakdown may occur.

Power ON/OFF Characteristic of Typical Circuit

(1) V_{CC}=13.2V
R_L=4ohms
Rg=600ohms (quiescent)

(2)



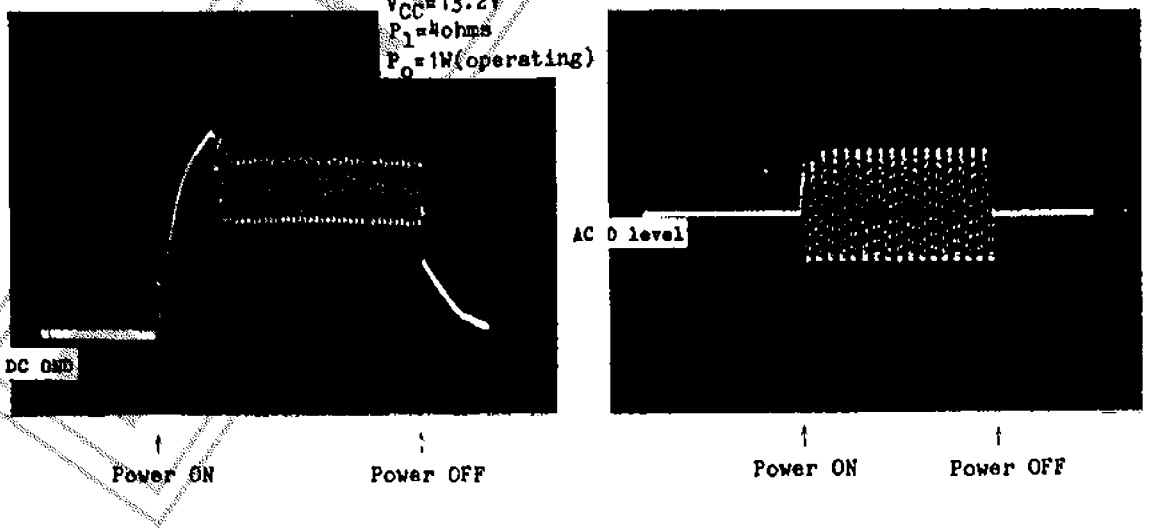


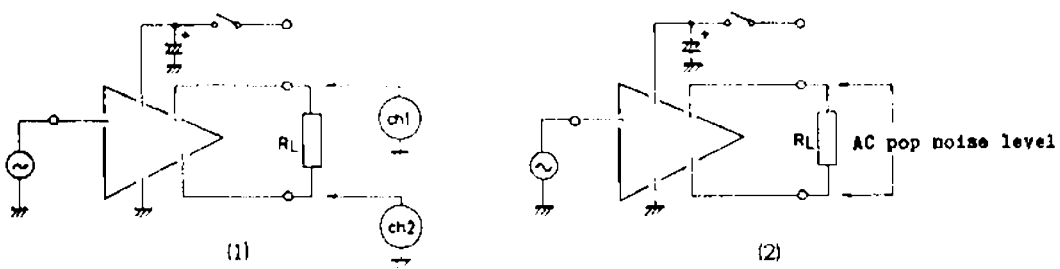
(1) (2)

Pop noise of approximately 2Vp-p is generated at the starting point(ts=0.6sec.) after power is turned ON. However, the tone quality is not affected very much because the pulse width is 200msec to 300msec. There arises no problem when power is turned OFF.

(1) V_{CC}=13.2V
P_L=4ohms
P_O=1W(operating)

(2)

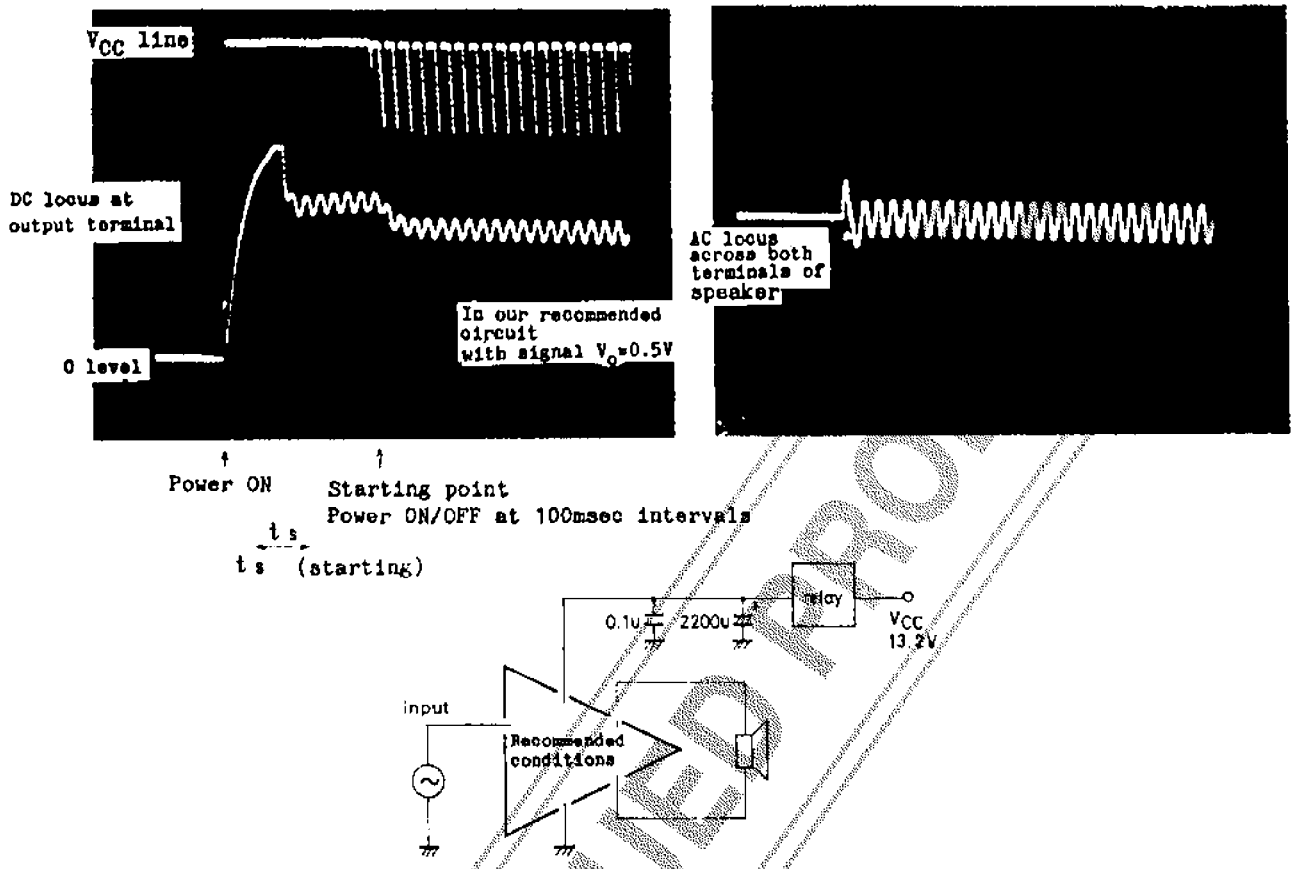




(1) (2)

ON/OFF Repetition Test

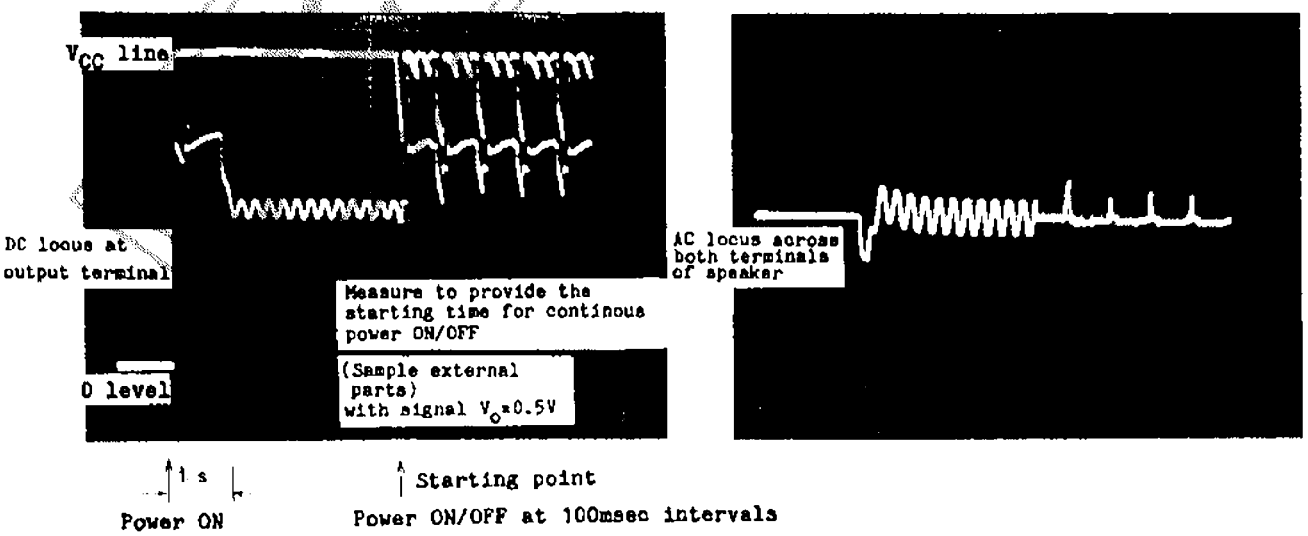
(1)

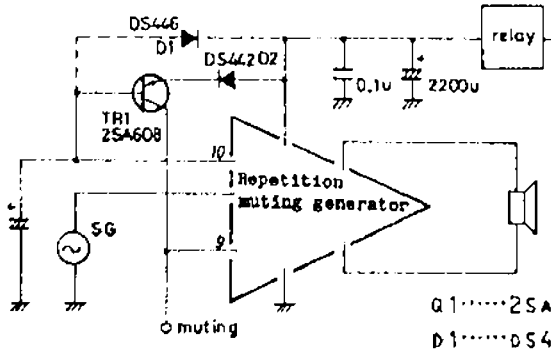


Note) If the loads (display unit, etc.) connected to the power supply of a car stereo set or the ignition switch repetition timing causes pop noise to be generated, connect a resistor of 330ohms in parallel with C_{BS}=220uF.

As shown above, the power IC itself has provisions so that no pop noise is generated during power-ON/OFF repetition. However, if an IC placed before the power IC in a car stereo set is affected by power-ON/OFF repetition and generates pop noise, this pop noise enters the power IC as the input signal and passes through to the speaker terminal and may be emitted as noise. The following is a measure to prevent this case.

(2)





Prevention of pop noise which enters through the variable resistor from the pre-circuit channel by providing the initial starting time(ts) for continuous power ON/OFF

Q1·····2SA608D
D1·····DS446(bypass diode for abrupt discharge of power)
D2·····DS442(for ON/OFF sensitivity setting)

Operates when power rises abruptly in the steady state.
For example, the use of a Zener diode of 3V decreases the sensitivity.

Proper Cares in Using IC

·Maximum ratings

It should be noted that if the IC is used in the vicinity of the maximum ratings, even a slight variation in conditions may cause the maximum ratings to be exceeded, thereby leading to breakdown.

·Use of R_L=2ohms

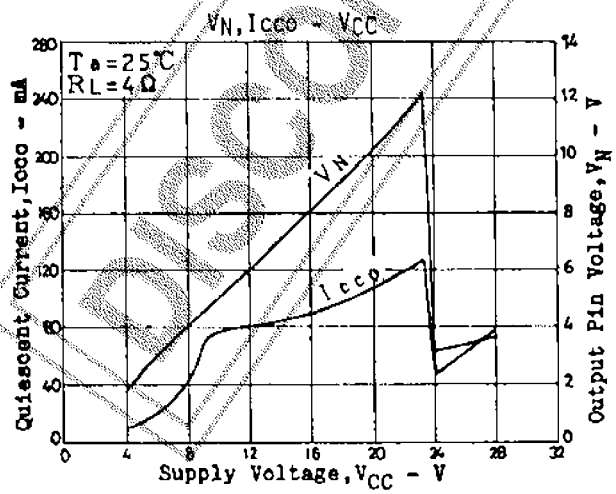
Power dissipation at V_{CC}=13.2V is Pdmax≒20W and power dissipation at V_{CC}=16V is Pdmax≒28W. It is practically impossible to make thermal design for Sg continuous signal at Ta=25°C. If we are informed of the heat sink and aging test conditions specified by you, we will perform the test to check for the presence or absence of breakdown.

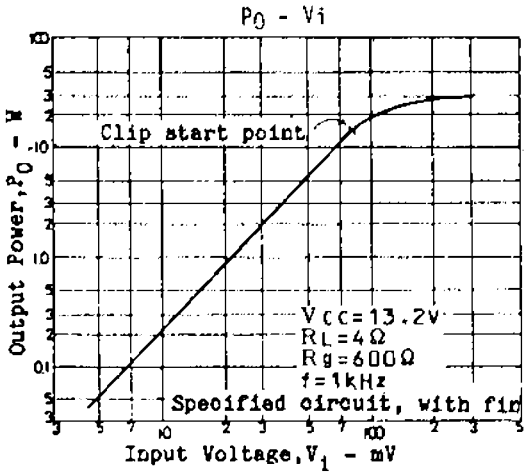
·Printed circuit board

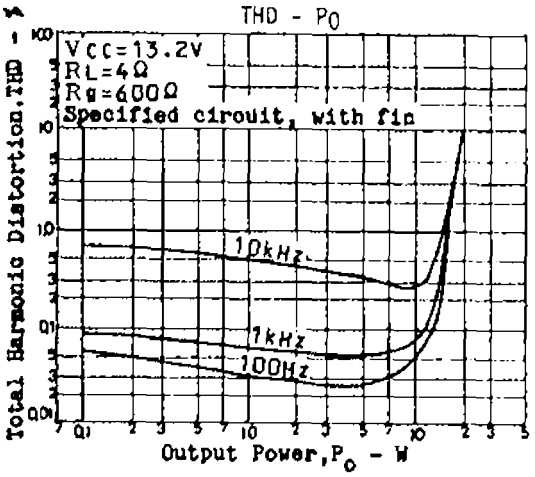
When making the board, refer to the sample printed circuit patten and be careful that no feedback loop is formed between input and output.

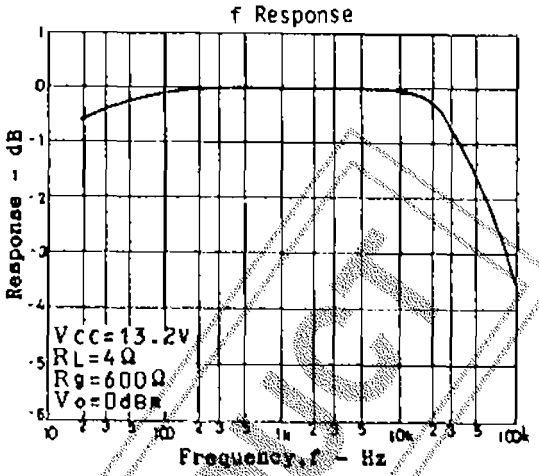
·Other

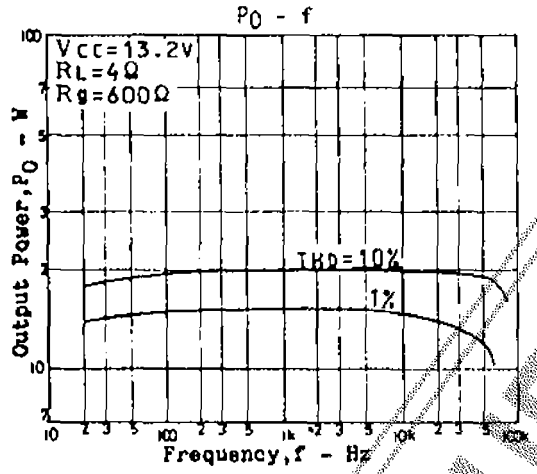
OCL power IC having BTL connection internally. Be careful that the GND line of the measuring instruments (valve voltmeter, distortion meter, oscilloscope) connected to the output terminals is not shared with the GND line of the measuring instruments connected to the input terminals.

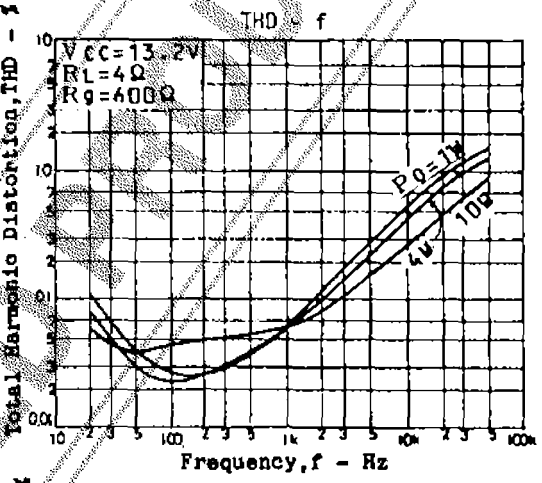


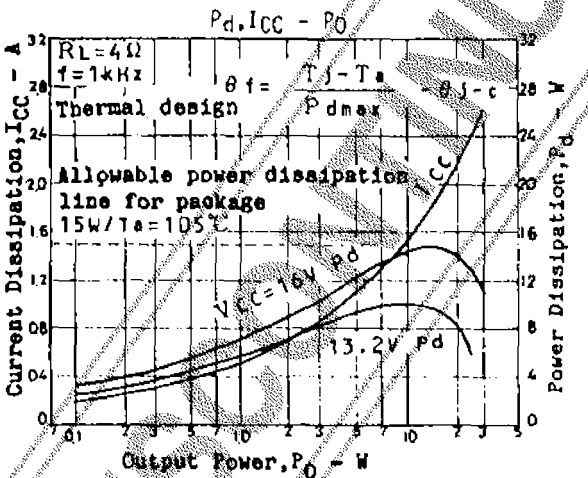


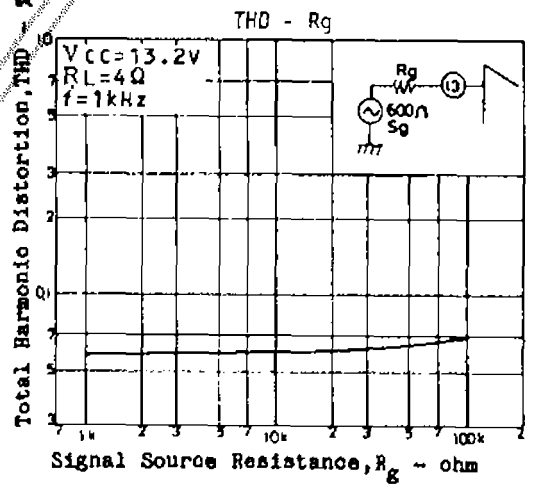


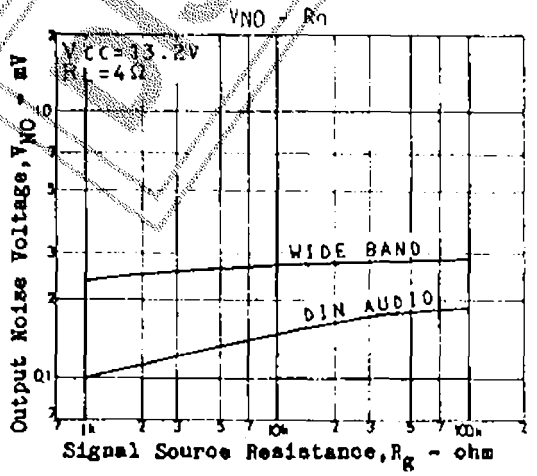


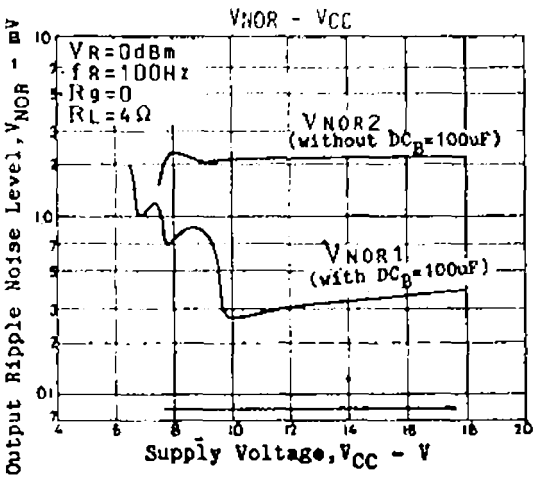




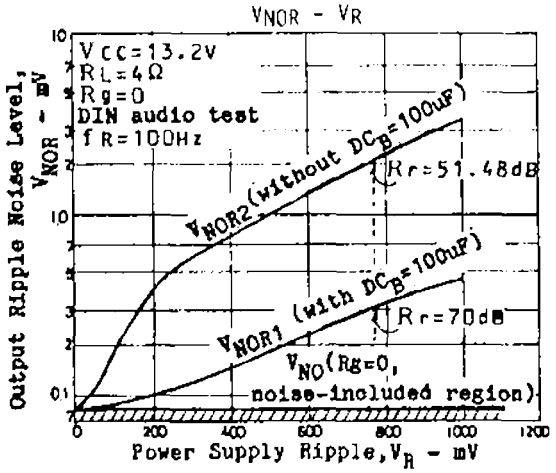




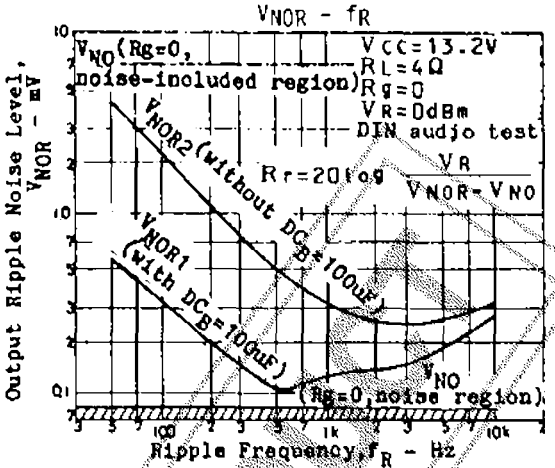




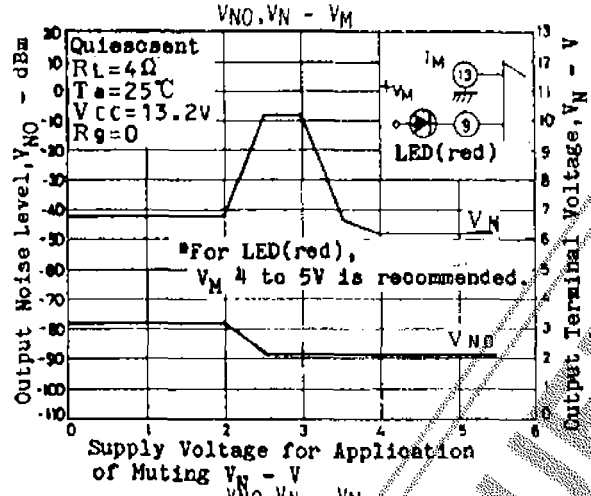
V_{NOR} - V_R



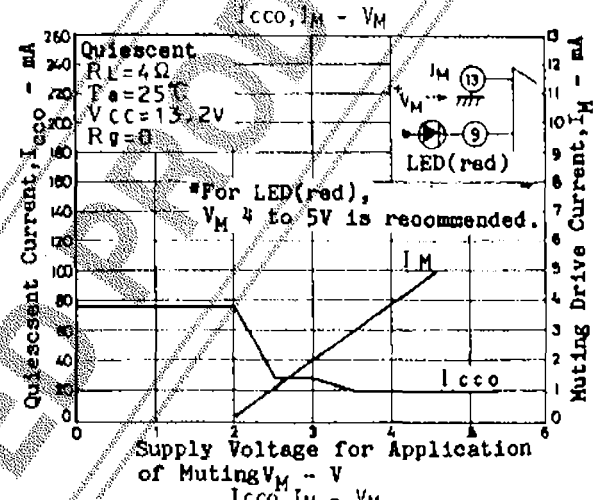
V_{NOR} - f_R



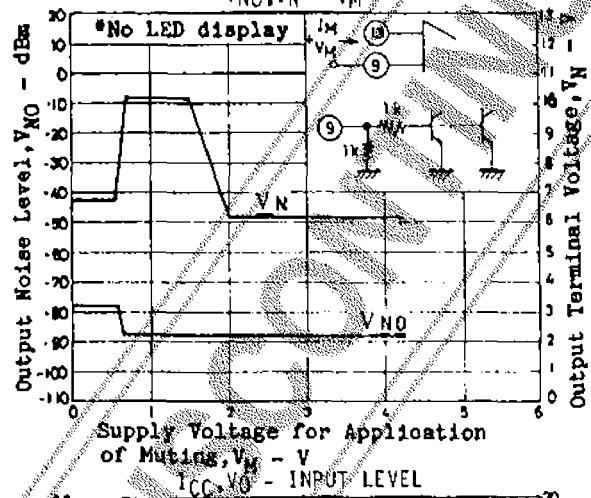
V_{NO}, V_N - V_M



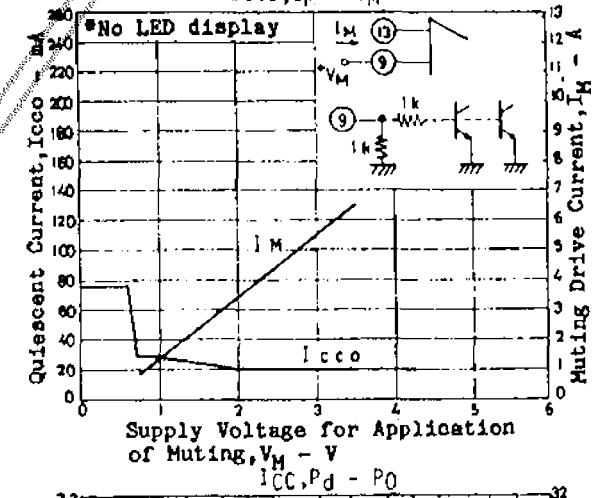
I_{CCO}, I_M - V_M



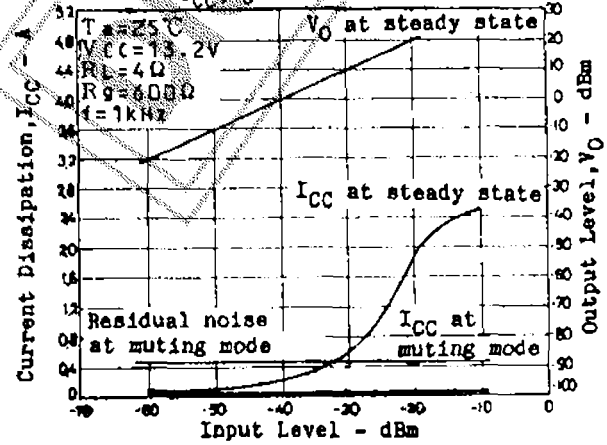
V_{NO}, V_N - V_M



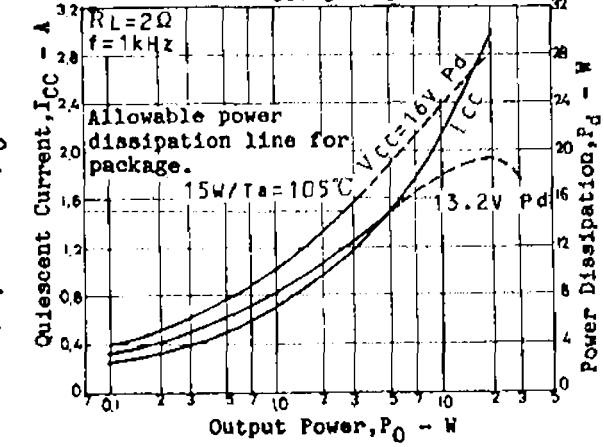
I_{CCO}, I_M - V_M



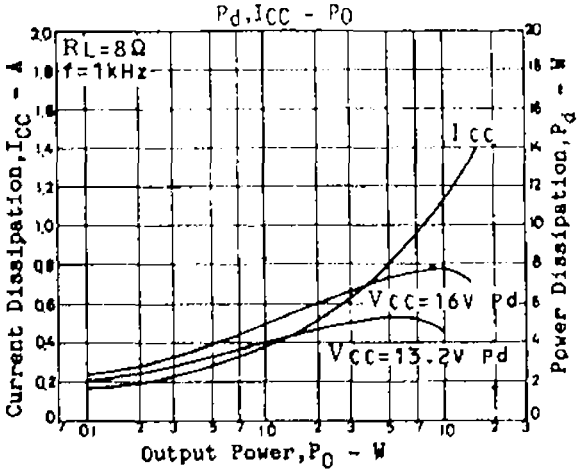
I_{CC}, V_O - INPUT LEVEL



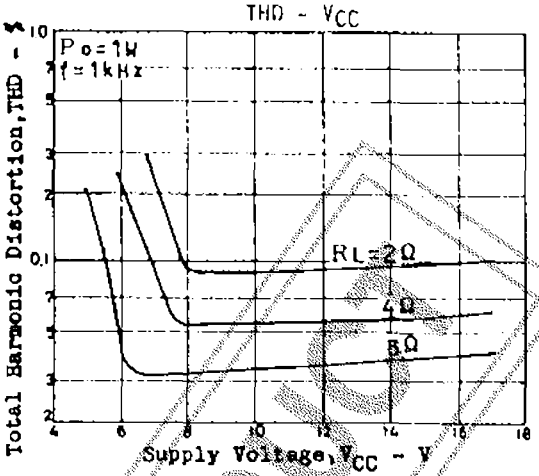
I_{CC}, P_d - P_O



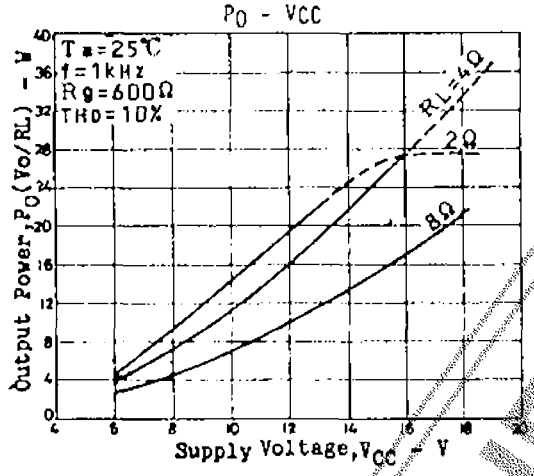
P_d, I_{CC} - P_O



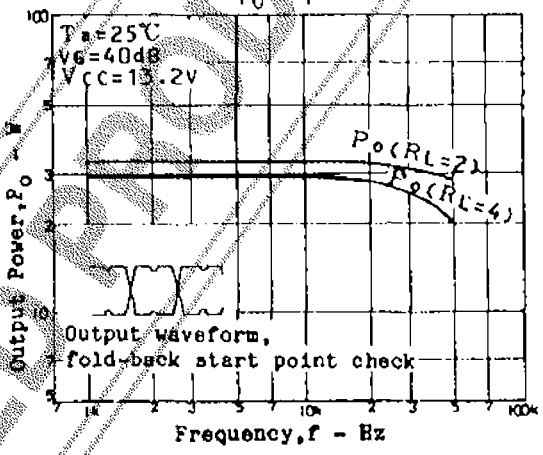
THD - V_{CC}



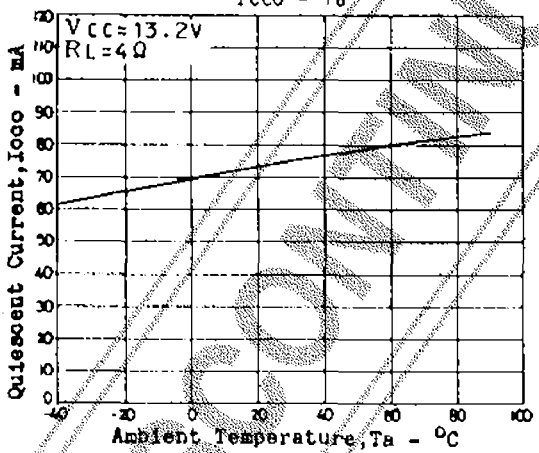
P_O - V_{CC}



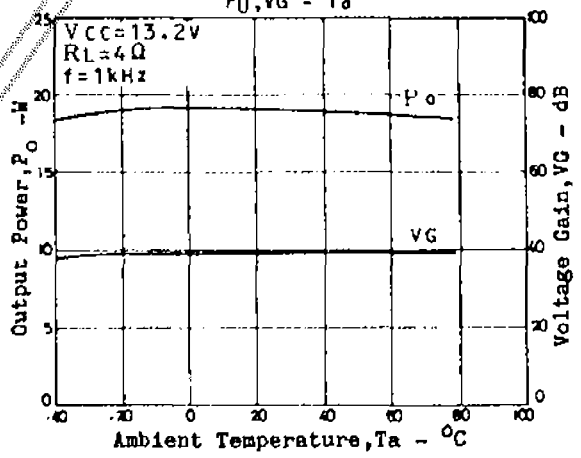
P_O - f



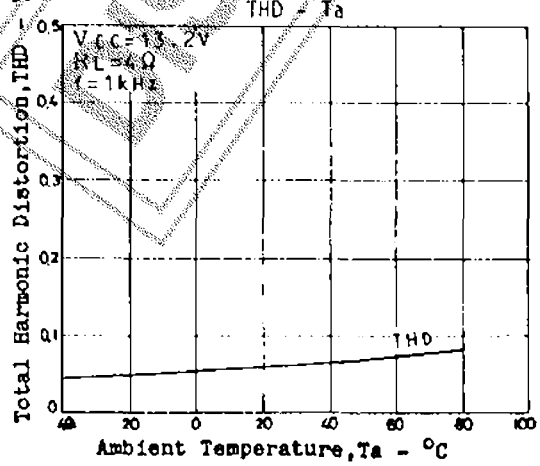
Icco - Ta



P_O, VG - Ta

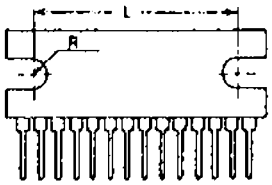


THD - Ta



Proper Cares in Mounting Radiator Fin

1. The mounting torque is in the range of 4 to 6kg.cm
2. The distance between screw holes of the radiator fin must coincide with the distance between screw holes of the IC. With case outline dimensions L and R referred to, the screws must be tightened with the distance between them as close to each other as possible.



3. The screw to be used must have a head equivalent to the one of truss machine screw or binder machine screw defined by JIS. Washers must be also used to protect the IC case.
4. No foreign matter such as cutting particles shall exist between heat sink and radiator fin. When applying greass on the junction surface, it must be applied uniformly on the whole surface.
5. IC lead pins are soldered to the printed circuit board after the radiator fin is mounted on the IC.