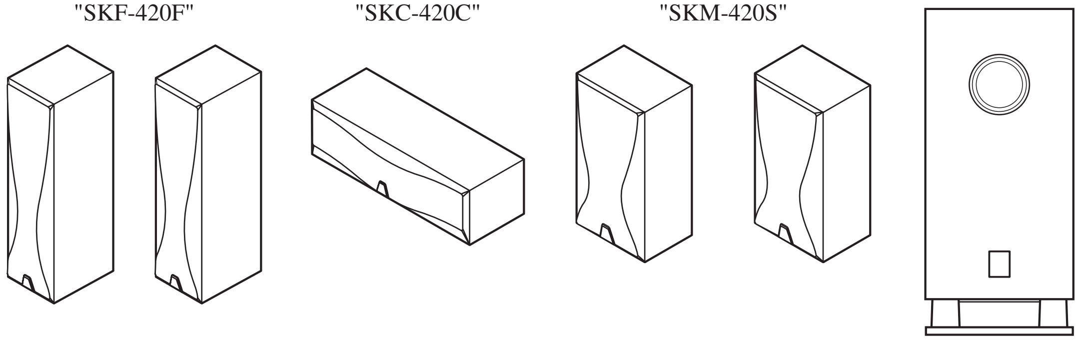
Ref. No. 3808
042004

ONKYO SERVICE MANUAL

5.1-CH HOME THEATER SPEAKER PACKAGE
MODEL HTP-420(B)/(S)



Black and Silver models

BMDD	120V AC, 60Hz
BMDC	120V AC, 60Hz
---	---
BMPA	230-240V AC, 50Hz
---	---
---	---

SMDD	120V AC, 60Hz
SMDC	120V AC, 60Hz
SMDT	120V AC, 60Hz
SMPA	230-240V AC, 50Hz
SMGT	220-230V AC, 50/60Hz
SMPT	230-240V AC, 50Hz

SAFETY-RELATED COMPONENT WARNING!!

COMPONENTS IDENTIFIED BY MARK ⚠ ON THE SCHEMATIC DIAGRAM AND IN THE PARTS LIST ARE CRITICAL FOR RISK OF FIRE AND ELECTRIC SHOCK. REPLACE THESE COMPONENTS WITH ONKYO PARTS WHOSE PART NUMBERS APPEAR AS SHOWN IN THIS MANUAL.
MAKE LEAKAGE-CURRENT OR RESISTANCE MEASUREMENTS TO DETERMINE THAT EXPOSED PARTS ARE ACCEPTABLY INSULATED FROM THE SUPPLY CIRCUIT BEFORE RETURNING THE APPLIANCE TO THE CUSTOMER.

ONKYO®
IMAGINATIVE SIGHT & SOUND

SPECIFICATIONS

Powered Subwoofer (SKW-420)

Type :	Bass-reflex with built-in power amplifier
Input sensitivity/impedance :	220 mV / 15 k ohm
Maximum output power :	150 W (Dynamic Power)
Frequency response :	30 Hz - 150 Hz
Cabinet capacity :	1.15 cubic feet (32.5 L)
Dimensions (W x H x D) :	9-1/4" x 20-3/8" x 16-3/16" (235 x 518 x 411 mm)
Weight :	28.2 lbs. (12.8 kg)
Driver unit :	8 inch Cone Woofer
Power supply :	
America :	AC 120 V, 60 Hz
Others :	AC 230-240 V, 50 Hz AC 220-230 V, 50/60 Hz
Power consumption :	
America :	75 W
Australia :	77 W
Others :	77 W
Other :	Auto Standby function

Center Speaker (SKC-420C)

Type :	2 Way Bass-reflex
Impedance :	8 ohm
Maximum input power :	100 W
Output sound pressure level :	84 dB/W/m
Frequency response :	60 Hz - 50 kHz
Crossover frequency :	5 kHz
Cabinet capacity :	0.2 cubic feet (5.6 L)
Dimensions (W x H x D) :	17-1/8" x 5-1/8" x 7-1/16" (435 x 130 x 179 mm)
Weight :	7.5 lbs. (3.4 kg)
Drivers unit :	4 inch Cone Woofer x 2 1 inch Balanced Dome tweeter
Terminal :	Color-coded push type
Other :	Magnetic shielding

Front Speaker (SKF-420F)

Type :	2-way Bass-reflex
Impedance :	8 ohm
Maximum input power :	100 W
Output sound pressure level :	84 dB/W/m
Frequency response :	60 Hz - 50 kHz
Crossover frequency :	5 kHz
Cabinet capacity :	0.2 cubic feet (5.6L)
Dimensions (W x H x D) :	4-7/8" x 18-5/16" x 7-1/16" (124 x 465 x 179 mm)
Weight :	7.5 lbs. (3.4 kg)
Drivers unit :	4 inch Cone Woofer x 2 1 inch Balanced Dome tweeter
Terminal :	Color-coded push type
Other :	Magnetic shielding

Surround Speaker (SKM-420S)

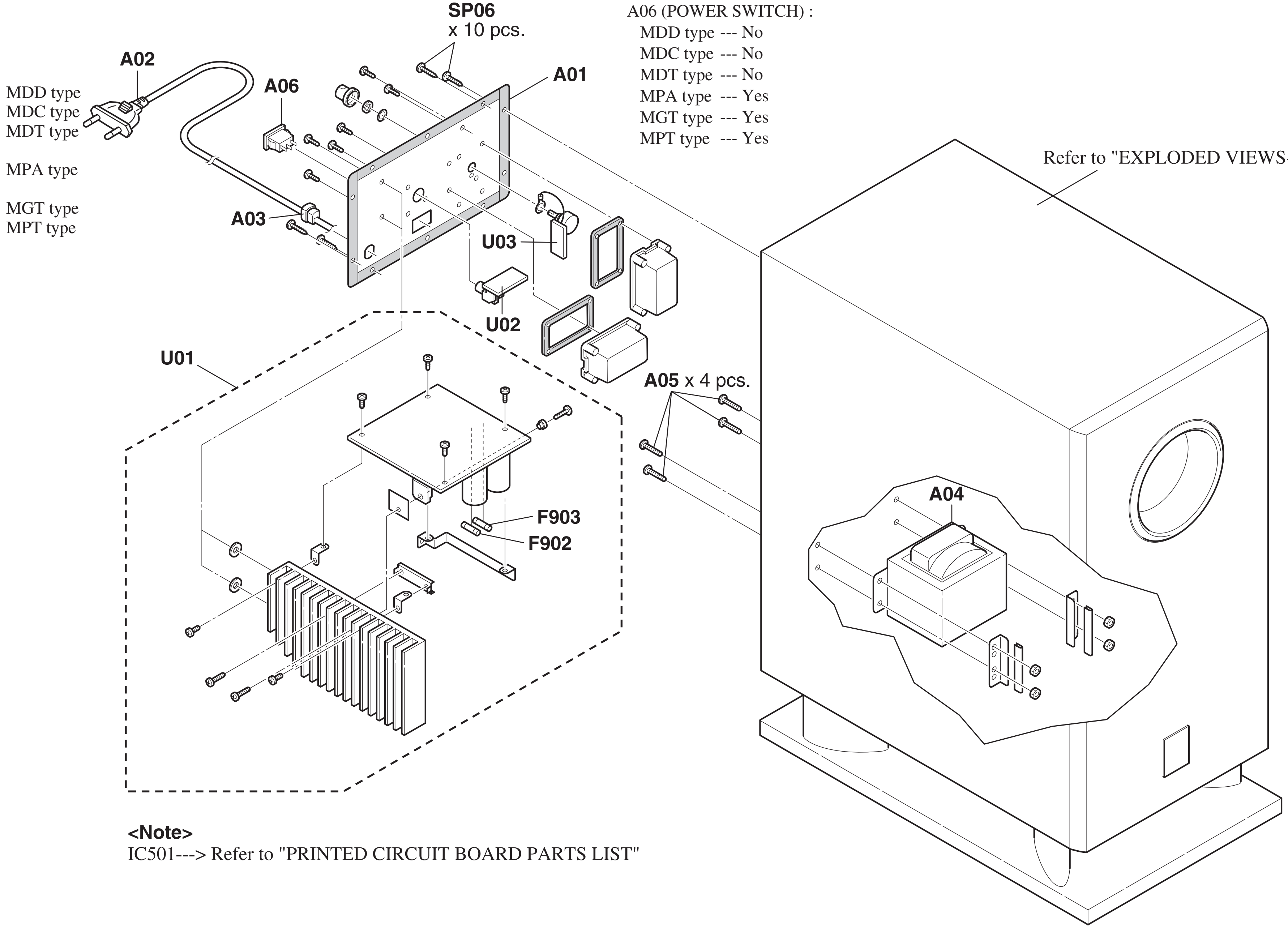
Type :	2-way Bass-reflex
Impedance :	8 ohm
Maximum input power :	100 W
Output sound pressure level :	82 dB/W/m
Frequency response :	60 Hz - 50 kHz
Crossover frequency :	5 kHz
Cabinet capacity :	0.08 cubic feet (2.3 L)
Dimensions (W x H x D) :	5-13/16" x 11" x 4-7/8" (147 x 280 x 124 mm)
Weight :	3.7 lbs. (1.7 kg)
Drivers unit :	4 inch Cone Woofer 1 inch Balanced Dome tweeter
Terminal :	Color-coded push type

Specifications and appearance are subject to change without prior notice.

EXPLODED VIEWS-1

SKW-420 : POWERED SUBWOOFER

<Notes>
A06 (POWER SWITCH) :
MDD type --- No
MDC type --- No
MDT type --- No
MPA type --- Yes
MGT type --- Yes
MPT type --- Yes

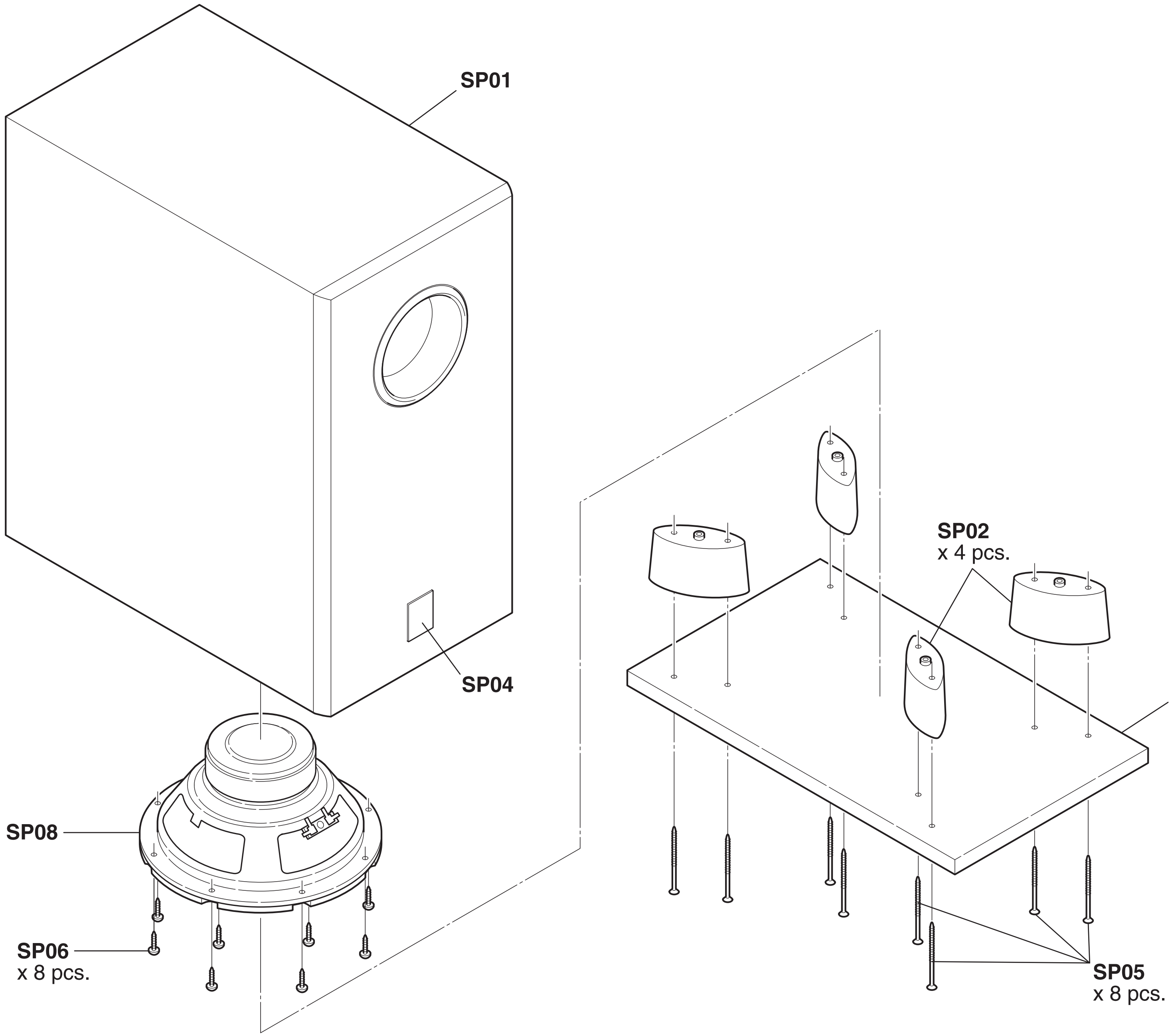


<Note>
IC501---> Refer to "PRINTED CIRCUIT BOARD PARTS LIST"

HTP-420

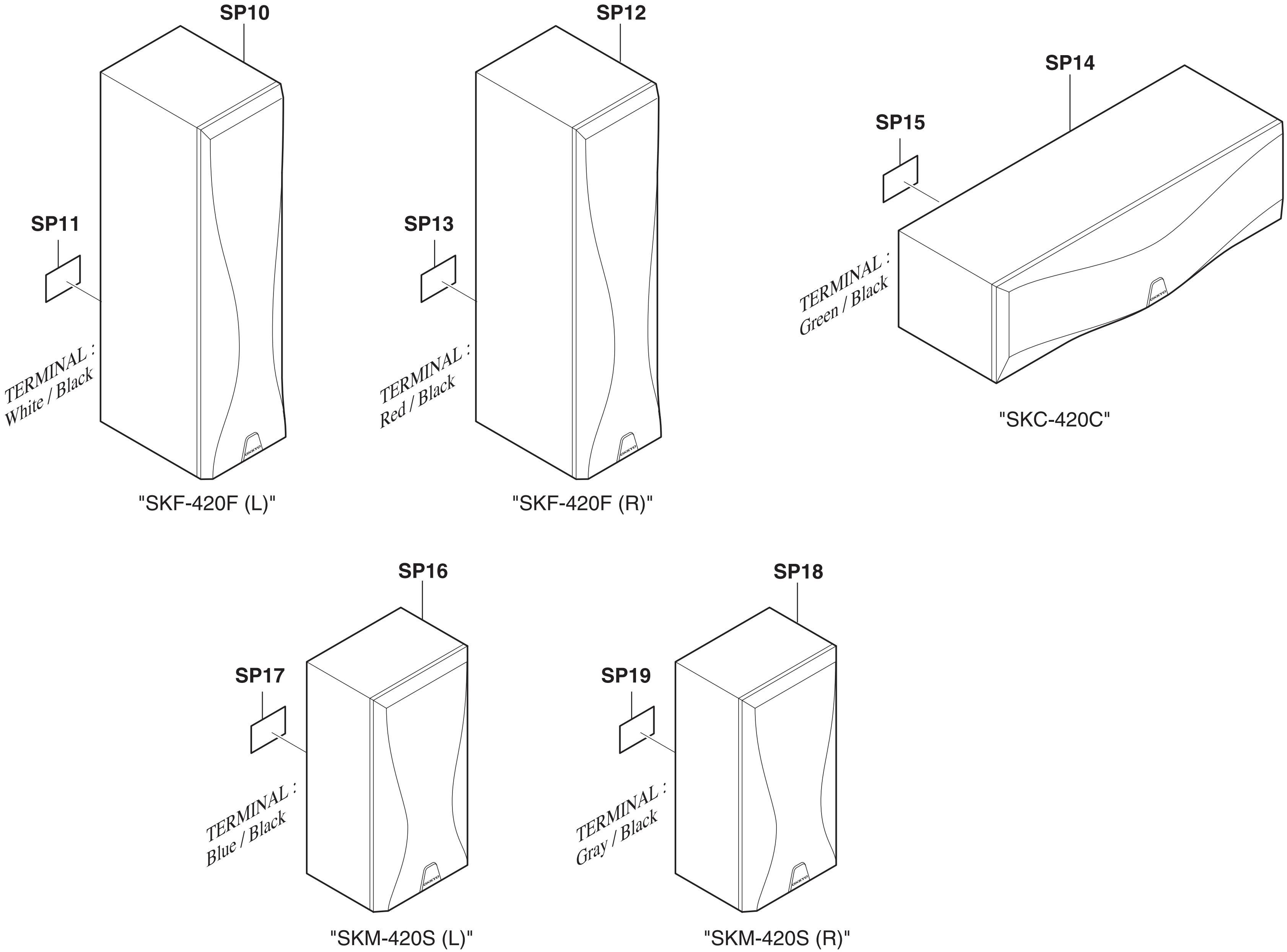
EXPLODED VIEWS-2

SKW-420 : POWERED SUBWOOFER



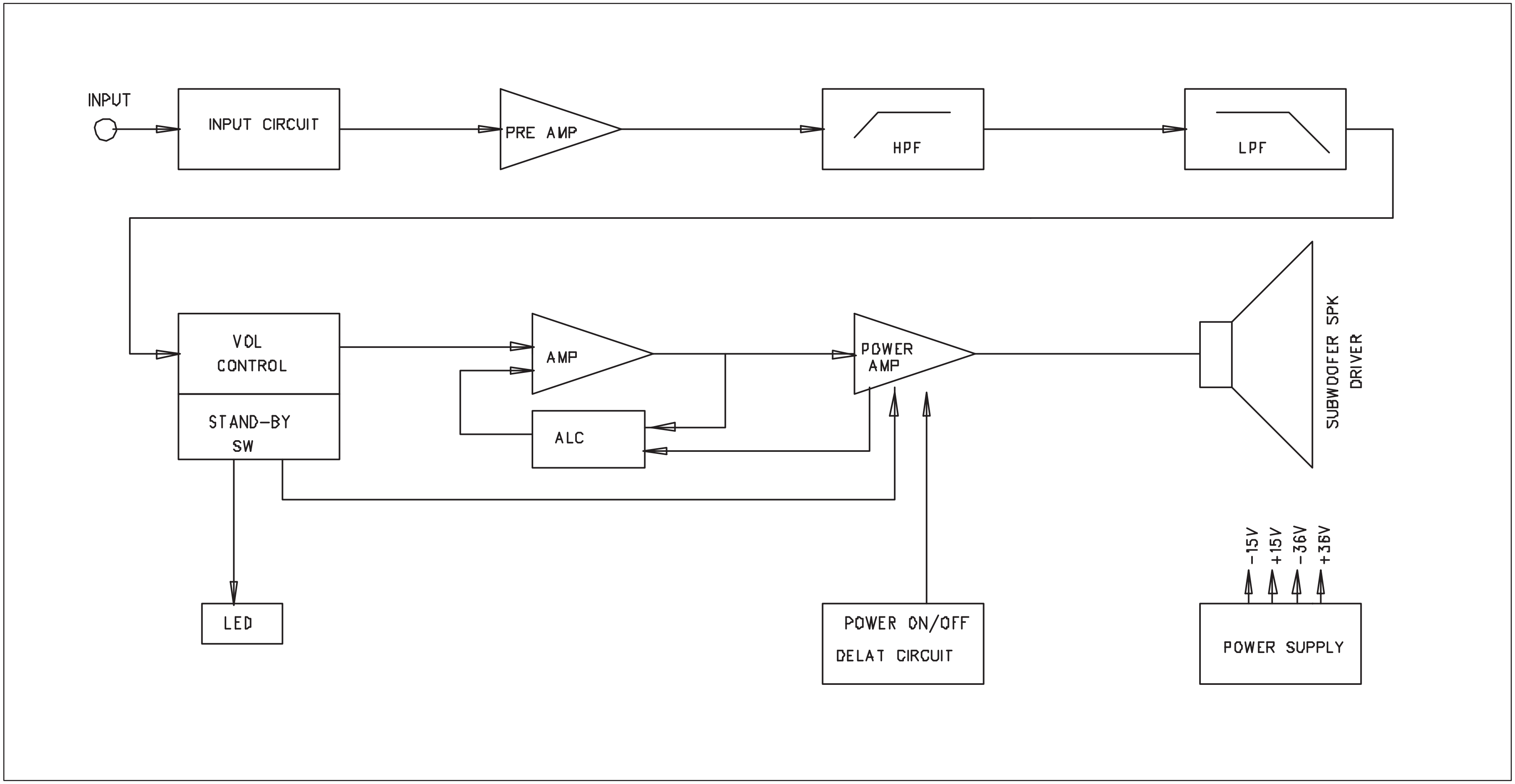
EXPLODED VIEWS-3

SKF-420F / SKC-420C / SKM-420S



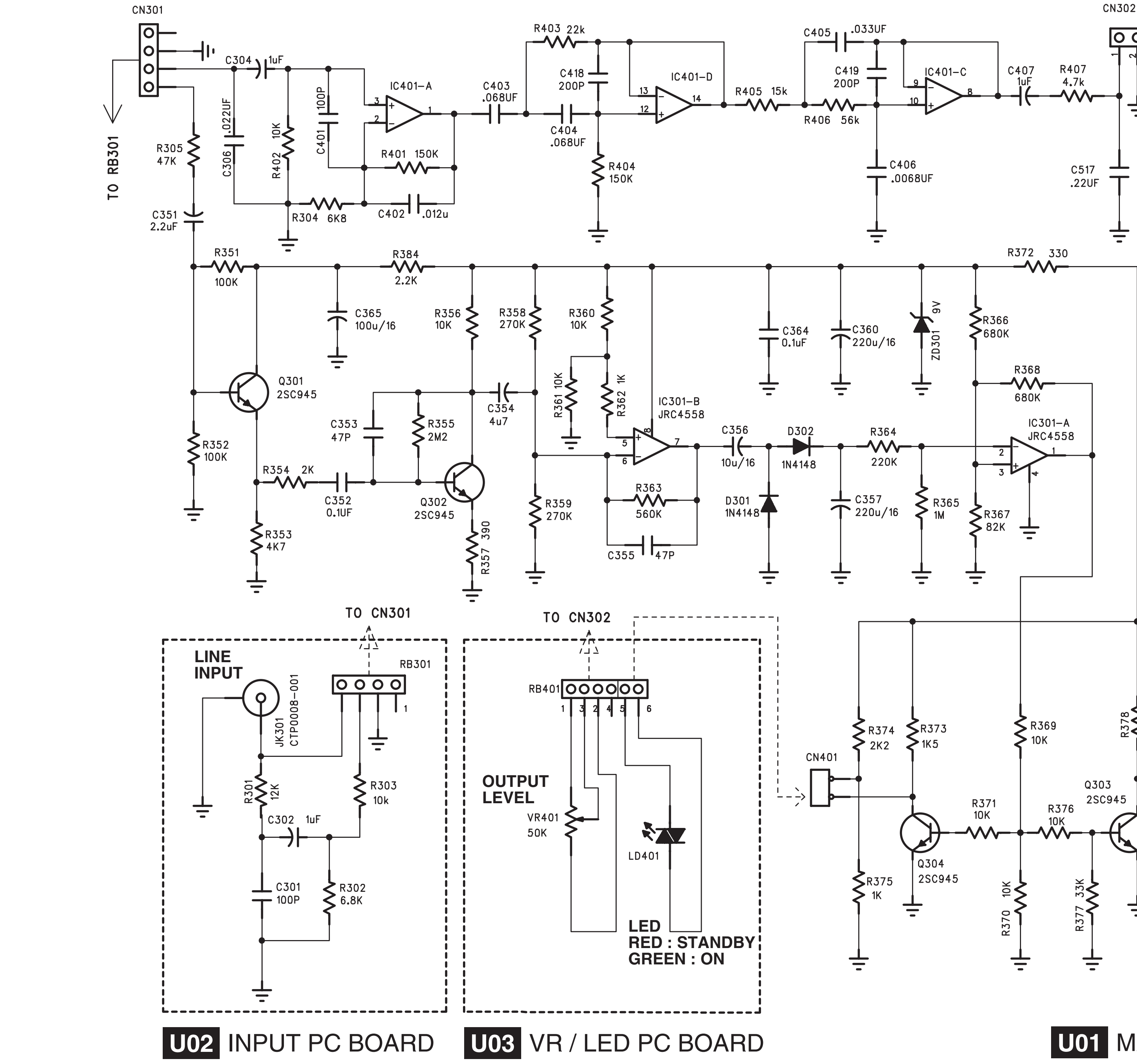
HTP-420

BLOCK DIAGRAM
SKW-420 : POWERED SUBWOOFER



A B C D

SCHEMATIC DIAGRAM
SKW-420 : POWERED SUBWOOFER



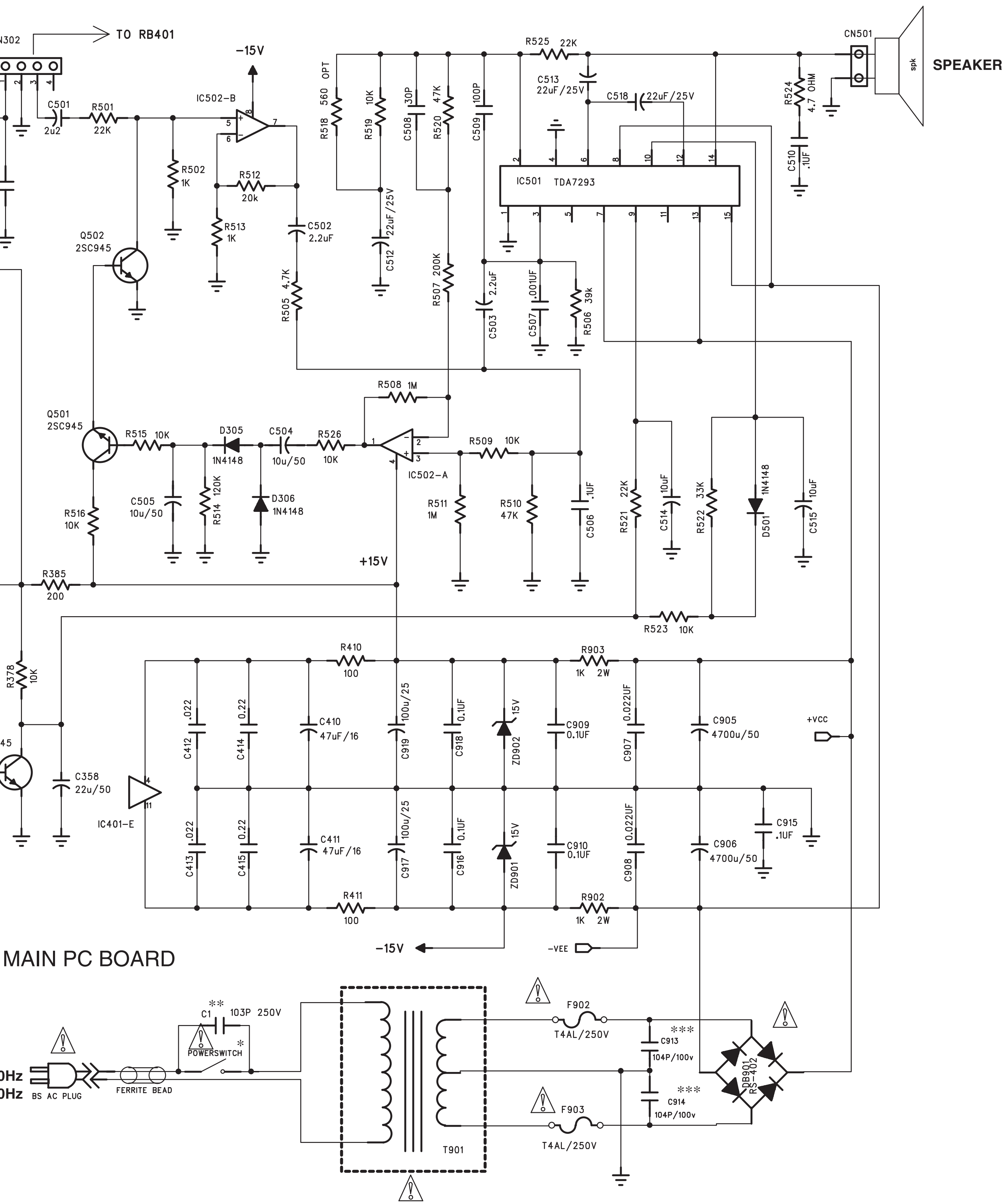
5

<Note>
POWER SWITCH* / C1**
MDD type --- No
MDC type --- No
MDT type --- No
MPA type --- Yes
MGT type --- Yes
MPT type --- Yes

<Note>
C913*** / C914***
MDD type --- Yes
MDC type --- Yes
MDT type --- Yes
MPA type --- No
MGT type --- No
MPT type --- No

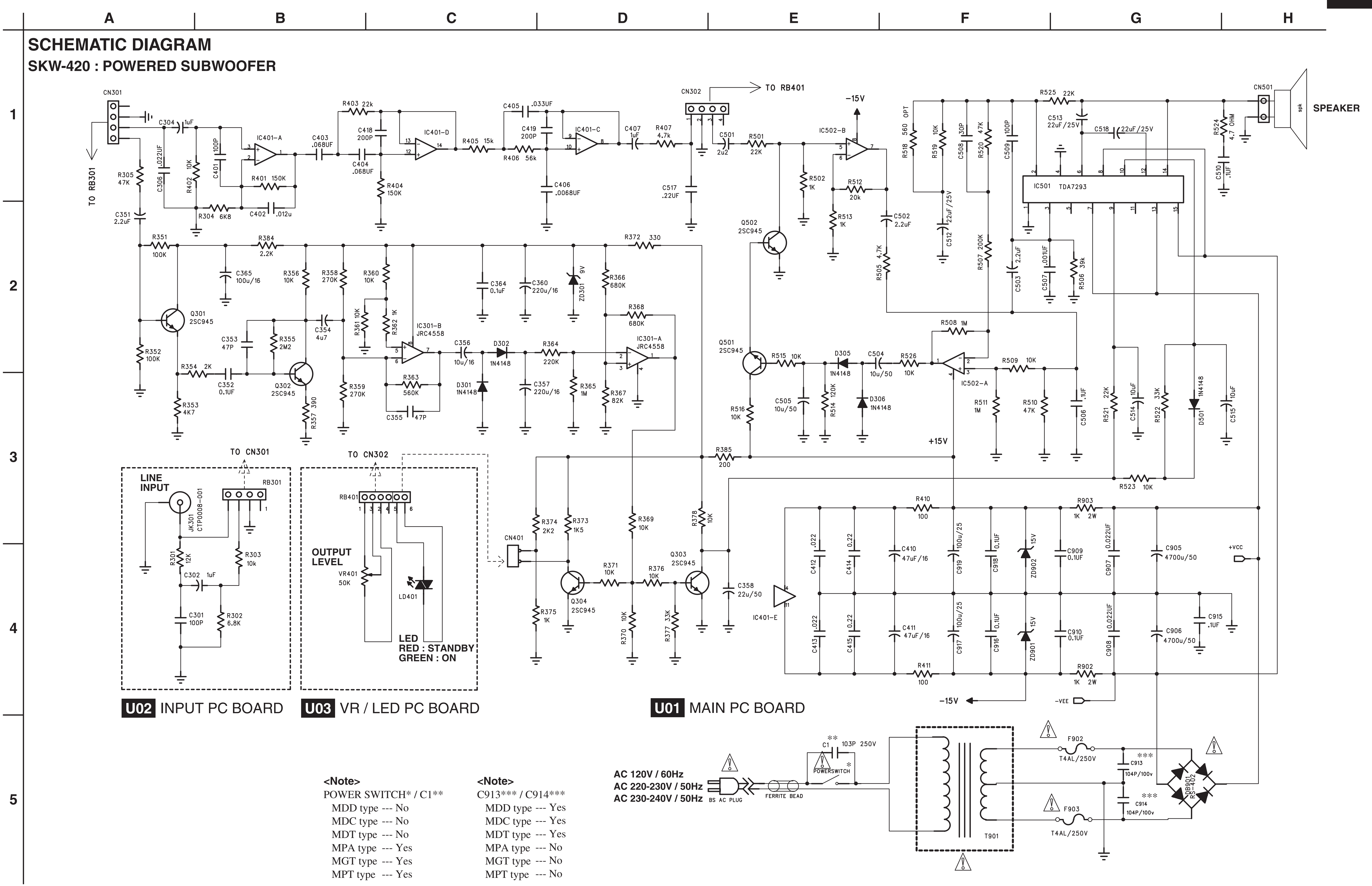
AC 120V / 60Hz
AC 220-230V / 50Hz
AC 230-240V / 50Hz

E	F	G	H



MAIN PC BOARD

SCHEMATIC DIAGRAM
SKW-420 : POWERED SUBWOOFER



U02 INPUT PC BOARD

U03 VR / LED PC BOARD

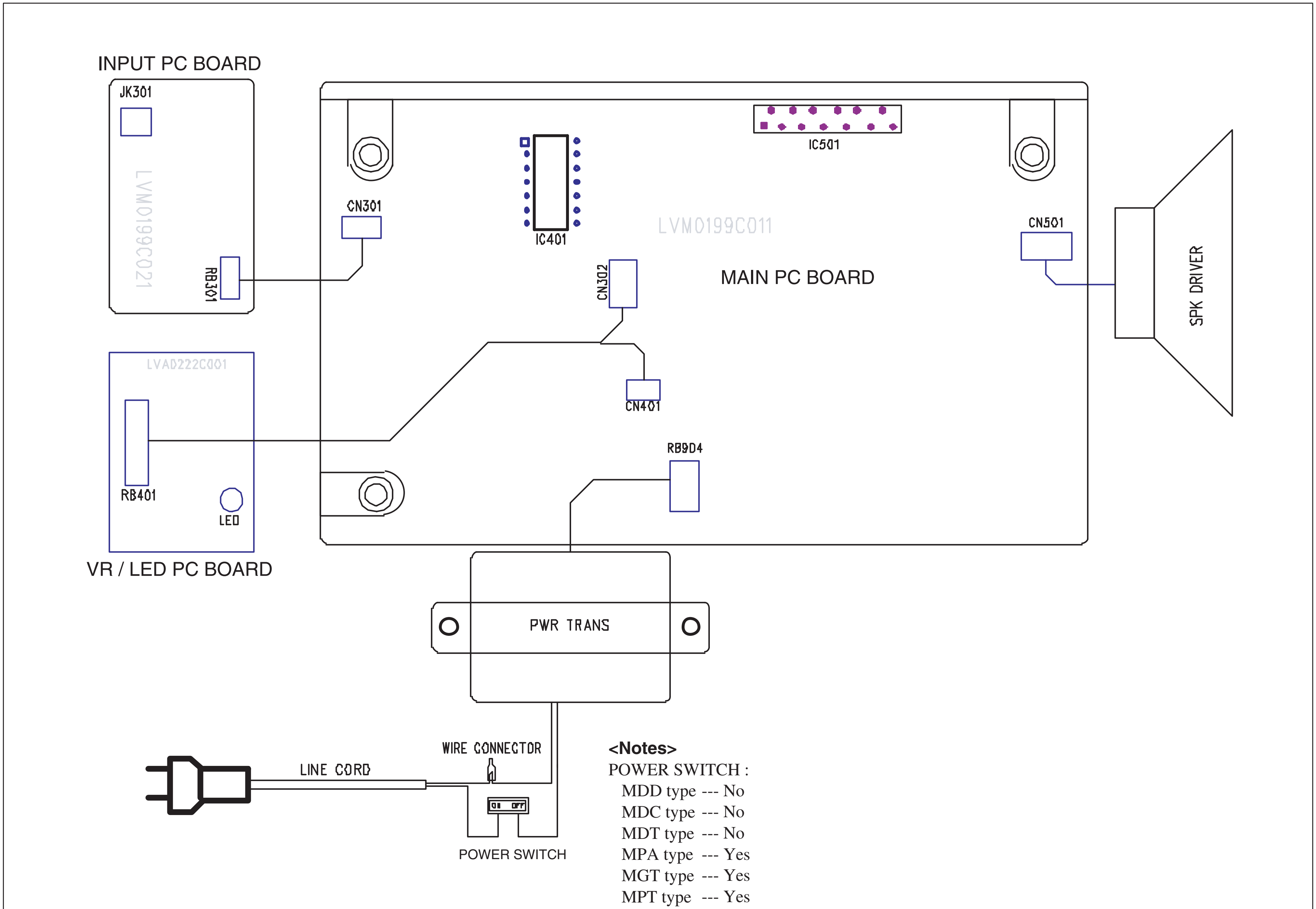
U01 MAIN PC BOARD

<Note>
POWER SWITCH* / C1**
- MDD type --- No
- MDC type --- No
- MDT type --- No
- MPA type --- Yes
- MGT type --- Yes
- MPT type --- Yes

<Note>
C913*** / C914***
- MDD type --- Yes
- MDC type --- Yes
- MDT type --- Yes
- MPA type --- No
- MGT type --- No
- MPT type --- No

PC BOARD CONNECTION DIAGRAM

SKW-420 : POWERED SUBWOOFER



<Notes>
POWER SWITCH :
MDD type --- No
MDC type --- No
MDT type --- No
MPA type --- Yes
MGT type --- Yes
MPT type --- Yes

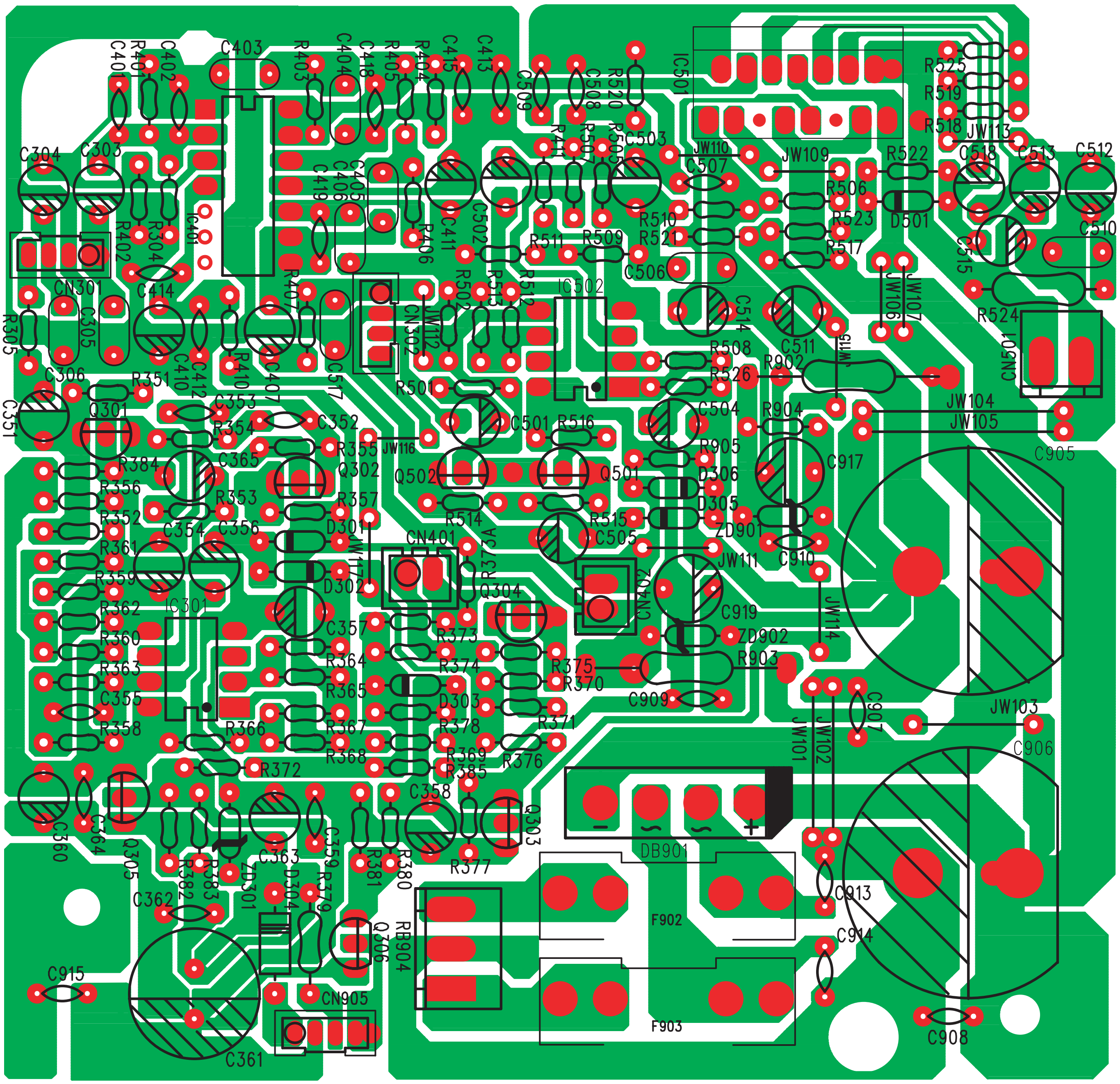
A B C D

PRINTED CIRCUIT BOARD VIEW

SKW-420 : POWERED SUBWOOFER

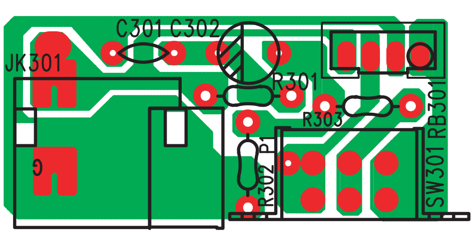
1

U01 MAIN PC BOARD



4

U02 INPUT PC BOARD



5

U03 VR / LED PC BOARD

No PC board view

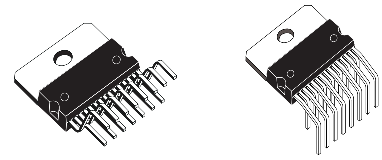
Look over the actual PC board on hand

TDA7293

120V - 100W DMOS AUDIO AMPLIFIER WITH MUTE/ST-BY

- VERY HIGH OPERATING VOLTAGE RANGE (±50V)
- DMOS POWER STAGE
- HIGH OUTPUT POWER (100W @ THD = 10%, R_L = 8Ω, V_S = ±40V)
- MUTING/STAND-BY FUNCTIONS
- NO SWITCH ON/OFF NOISE
- VERY LOW DISTORTION
- VERY LOW NOISE
- SHORT CIRCUIT PROTECTED (WITH NO INPUT SIGNAL APPLIED)
- THERMAL SHUTDOWN
- CLIP DETECTOR
- MODULARITY (MORE DEVICES CAN BE EASILY CONNECTED IN PARALLEL TO DRIVE VERY LOW IMPEDANCES)

MULTIPOWER BCD TECHNOLOGY



Multiwatt15V	Multiwatt15H
ORDERING NUMBERS:	
TDA7293V	TDA7293HS

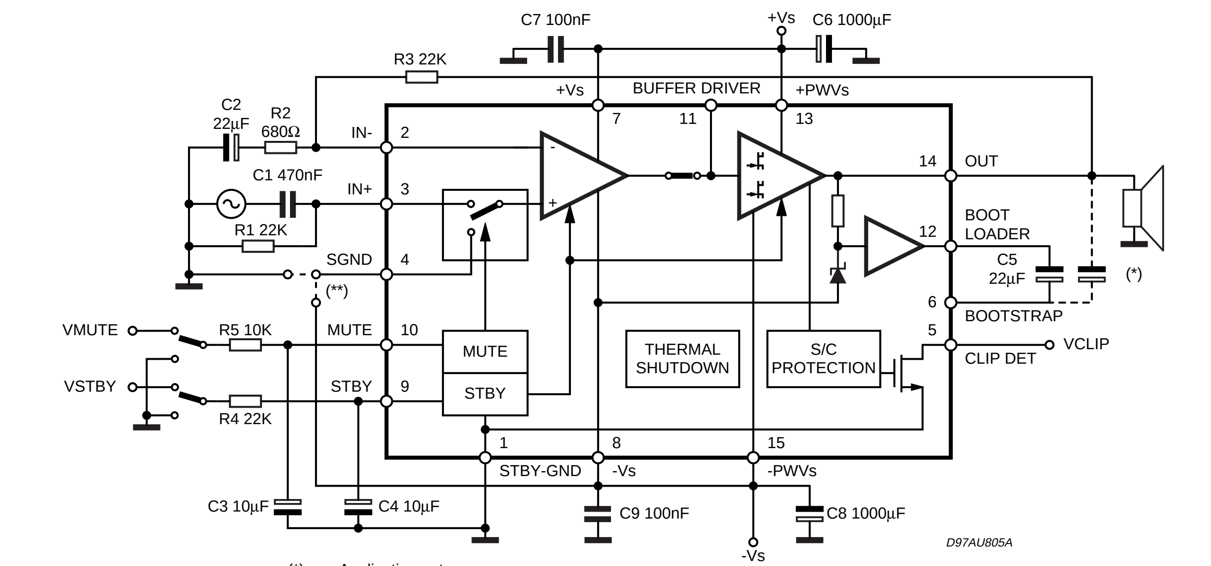
DESCRIPTION

The TDA7293 is a monolithic integrated circuit in Multiwatt15 package, intended for use as audio class AB amplifier in Hi-Fi field applications (Home Stereo, self powered loudspeakers, Top-class TV). Thanks to the wide voltage range and to the high out current capability it is able to supply the highest power into both 4Ω and 8Ω loads.

The built in muting function with turn on delay simplifies the remote operation avoiding switching on-off noises.

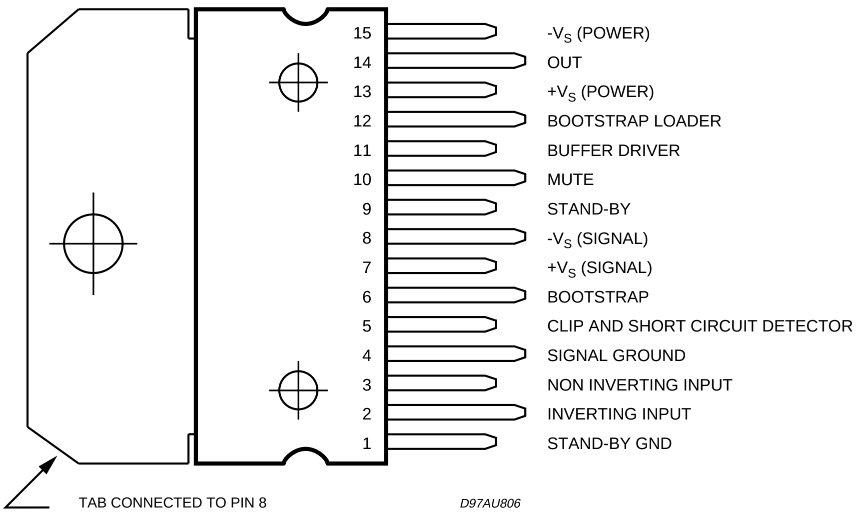
Parallel mode is made possible by connecting more device through of pin11. High output power can be delivered to very low impedance loads, so optimizing the thermal dissipation of the system.

Figure 1: Typical Application and Test Circuit



(*) see Application note
(**) for SLAVE function

PIN CONNECTION (Top view)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply Voltage (No Signal)	±60	V
V_1	$V_{STAND-BY}$ GND Voltage Referred to $-V_S$ (pin 8)	90	V
V_2	Input Voltage (inverting) Referred to $-V_S$	90	V
$V_2 - V_3$	Maximum Differential Inputs	±30	V
V_3	Input Voltage (non inverting) Referred to $-V_S$	90	V
V_4	Signal GND Voltage Referred to $-V_S$	90	V
V_5	Clip Detector Voltage Referred to $-V_S$	120	V
V_6	Bootstrap Voltage Referred to $-V_S$	120	V
V_9	Stand-by Voltage Referred to $-V_S$	120	V
V_{10}	Mute Voltage Referred to $-V_S$	120	V
V_{11}	Buffer Voltage Referred to $-V_S$	120	V
V_{12}	Bootstrap Loader Voltage Referred to $-V_S$	100	V
I_O	Output Peak Current	10	A
P_{tot}	Power Dissipation T_{case} = 70°C	50	W
T_{op}	Operating Ambient Temperature Range	0 to 70	°C
T_{stg}, T_j	Storage and Junction Temperature	150	°C

THERMAL DATA

Symbol	Description	Typ	Max	Unit
$R_{th\ j-case}$	Thermal Resistance Junction-case	1	1.5	°C/W

ELECTRICAL CHARACTERISTICS (Refer to the Test Circuit V_S = ±40V, R_L = 8Ω, R_g = 50 Ω; T_{amb} = 25°C, f = 1 kHz; unless otherwise specified).

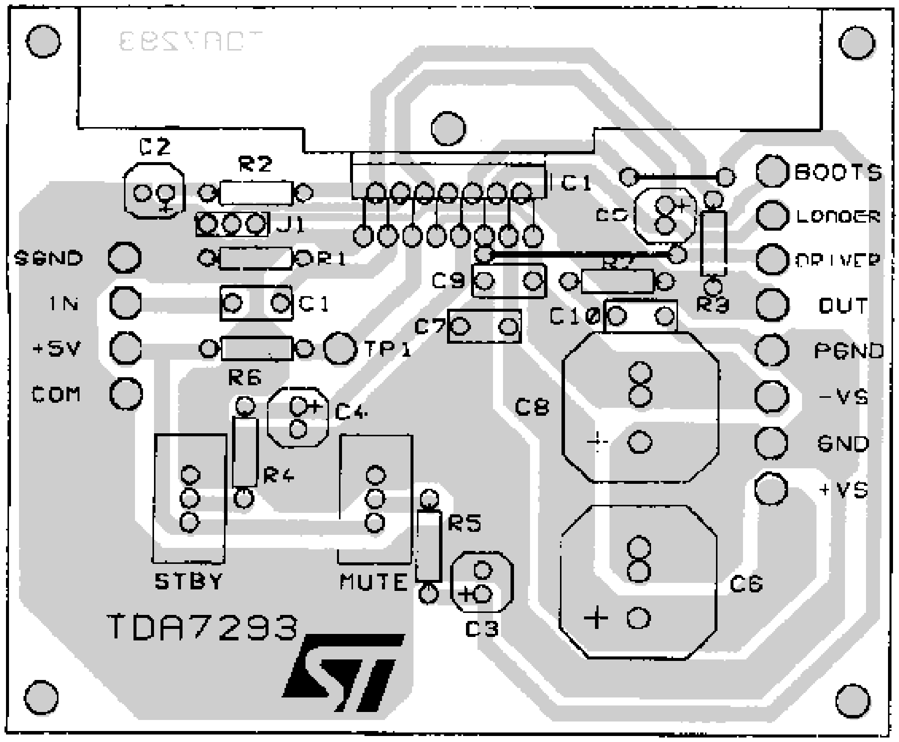
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_S	Supply Range		±12		±50	V
I_q	Quiescent Current			50	100	mA
I_b	Input Bias Current			0.3	1	µA
V_{OS}	Input Offset Voltage		-10		10	mV
I_{OS}	Input Offset Current				0.2	µA
P_O	RMS Continuous Output Power	d = 1%: R_L = 4Ω; V_S = ± 29V,	75	80 80		W
		d = 10% R_L = 4Ω ; V_S = ±29V	90	100 100		W
d	Total Harmonic Distortion (**)	P_O = 5W; f = 1kHz P_O = 0.1 to 50W; f = 20Hz to 15kHz		0.005	 0.1	% %
I_{SC}	Current Limiter Threshold	$V_S \leq \pm$ 40V		6.5		A
SR	Slew Rate		5	10		V/µs
G_V	Open Loop Voltage Gain			80		dB
G_V	Closed Loop Voltage Gain (1)		29	30	31	dB
e_N	Total Input Noise	A = curve f = 20Hz to 20kHz		1 3	 10	µV µV
R_i	Input Resistance		100			kΩ
SVR	Supply Voltage Rejection	f = 100Hz; V_{ripple} = 0.5Vrms		75		dB
T_S	Thermal Protection	DEVICE MUTED		150		°C
		DEVICE SHUT DOWN		160		°C
STAND-BY FUNCTION (Ref: to pin 1)						
$V_{ST\ on}$	Stand-by on Threshold				1.5	V
$V_{ST\ off}$	Stand-by off Threshold		3.5			V
$ATT_{st\text{-}by}$	Stand-by Attenuation		70	90		dB
$I_{q\ st\text{-}by}$	Quiescent Current @ Stand-by			0.5	1	mA
MUTE FUNCTION (Ref: to pin 1)						
V_{Mon}	Mute on Threshold				1.5	V
V_{Moff}	Mute off Threshold		3.5			V
ATT_{mute}	Mute AttenuatIon		60	80		dB
CLIP DETECTOR						
Duty	Duty Cycle (pin 5)	THD = 1% ; RL = 10KΩ to 5V		10		%
		THD = 10% ; RL = 10KΩ to 5V	30	40	50	%
I_{CLEAK}		PO = 50W			3	µA
SLAVE FUNCTION pin 4 (Ref: to pin 8 -Vs)						
V_{Slave}	SlaveThreshold				1	V
V_{Master}	Master Threshold		3			V

Note (1): $G_{Vmin} \geq$ 26dB

Note: Pin 11 only for modular connection. Max external load 1MΩ/10 pF, only for test purpose

Note (**): Tested with optimized Application Board (see fig. 2)

Figure 2: Typical Application P.C. Board and Component Layout (scale 1:1)



APPLICATION SUGGESTIONS (see Test and Application Circuits of the Fig. 1)

The recommended values of the external components are those shown on the application circuit of Figure 1. Different values can be used; the following table can help the designer.

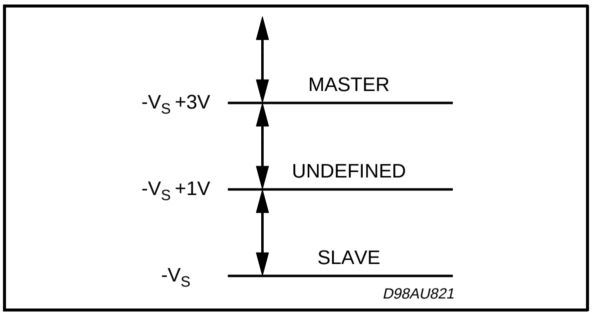
COMPONENTS	SUGGESTED VALUE	PURPOSE	LARGER THAN SUGGESTED	SMALLER THAN SUGGESTED
R1 (*)	22k	INPUT RESISTANCE	INCREASE INPUT IMPEDANCE	DECREASE INPUT IMPEDANCE
R2	680Ω	CLOSED LOOP GAIN SET TO 30dB (**)	DECREASE OF GAIN	INCREASE OF GAIN
R3 (*)	22k		INCREASE OF GAIN	DECREASE OF GAIN
R4	22k	ST-BY TIME CONSTANT	LARGER ST-BY ON/OFF TIME	SMALLER ST-BY ON/OFF TIME; POP NOISE
R5	10k	MUTE TIME CONSTANT	LARGER MUTE ON/OFF TIME	SMALLER MUTE ON/OFF TIME
C1	0.47µF	INPUT DC DECOUPLING		HIGHER LOW FREQUENCY CUTOFF
C2	22µF	FEEDBACK DC DECOUPLING		HIGHER LOW FREQUENCY CUTOFF
C3	10µF	MUTE TIME CONSTANT	LARGER MUTE ON/OFF TIME	SMALLER MUTE ON/OFF TIME
C4	10µF	ST-BY TIME CONSTANT	LARGER ST-BY ON/OFF TIME	SMALLER ST-BY ON/OFF TIME; POP NOISE
C5	22µFXN (***)	BOOTSTRAPPING		SIGNAL DEGRADATION AT LOW FREQUENCY
C6, C8	1000µF	SUPPLY VOLTAGE BYPASS		
C7, C9	0.1µF	SUPPLY VOLTAGE BYPASS		DANGER OF OSCILLATION

(*) R1 = R3 for pop optimization

(**) Closed Loop Gain has to be ≥ 26dB

(***) Multiplay this value for the number of modular part connected

Slave function: pin 4 (Ref to pin 8 -VS)



Note:

If in the application, the speakers are connected via long wires, it is a good rule to add between the output and GND, a Boucherot Cell, in order to avoid dangerous spurious oscillations when the speakers terminal are shorted.

The suggested Boucherot Resistor is 3.9Ω/2W and the capacitor is 1µF.

INTRODUCTION

In consumer electronics, an increasing demand has arisen for very high power monolithic audio amplifiers able to match, with a low cost, the performance obtained from the best discrete designs.

The task of realizing this linear integrated circuit in conventional bipolar technology is made extremely difficult by the occurence of 2nd breakdown phoenomenon. It limits the safe operating area (SOA) of the power devices, and, as a consequence, the maximum attainable output power, especially in presence of highly reactive loads.

Moreover, full exploitation of the SOA translates into a substantial increase in circuit and layout complexity due to the need of sophisticated protection circuits.

To overcome these substantial drawbacks, the use of power MOS devices, which are immune from secondary breakdown is highly desirable.

The device described has therefore been developed in a mixed bipolar-MOS high voltage technology called BCDII 100/120.

1) Output Stage

The main design task in developping a power operational amplifier, independently of the technology used, is that of realization of the output stage.

The solution shown as a principle shematic by Fig3 represents the DMOS unity - gain output buffer of the TDA7293.

This large-signal, high-power buffer must be capable of handling extremely high current and voltage levels while maintaining acceptably low harmonic distortion and good behaviour over frequency response; moreover, an accurate control of quiescent current is required.

A local linearizing feedback, provided by differential amplifier A, is used to fullfil the above requirements, allowing a simple and effective quiescent current setting.

Proper biasing of the power output transistors alone is however not enough to guarantee the absence of crossover distortion.

While a linearization of the DC transfer characteristic of the stage is obtained, the dynamic behaviour of the system must be taken into account.

A significant aid in keeping the distortion contributed by the final stage as low as possible is provided by the compensation scheme, which exploits the direct connection of the Miller capacitor at the amplifier's output to introduce a local AC feedback path enclosing the output stage itself.

2) Protections

In designing a power IC, particular attention must be reserved to the circuits devoted to protection of the device from short circuit or overload conditions.

Due to the absence of the 2nd breakdown phenomenon, the SOA of the power DMOS transistors is delimited only by a maximum dissipation curve dependent on the duration of the applied stimulus.

In order to fully exploit the capabilities of the power transistors, the protection scheme implemented in this device combines a conventional SOA protection circuit with a novel local temperature sensing technique which " dynamically" controls the maximum dissipation.

Figure 3: Principle Schematic of a DMOS unity-gain buffer.

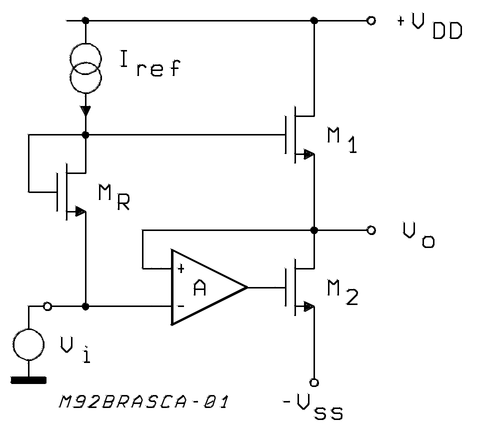
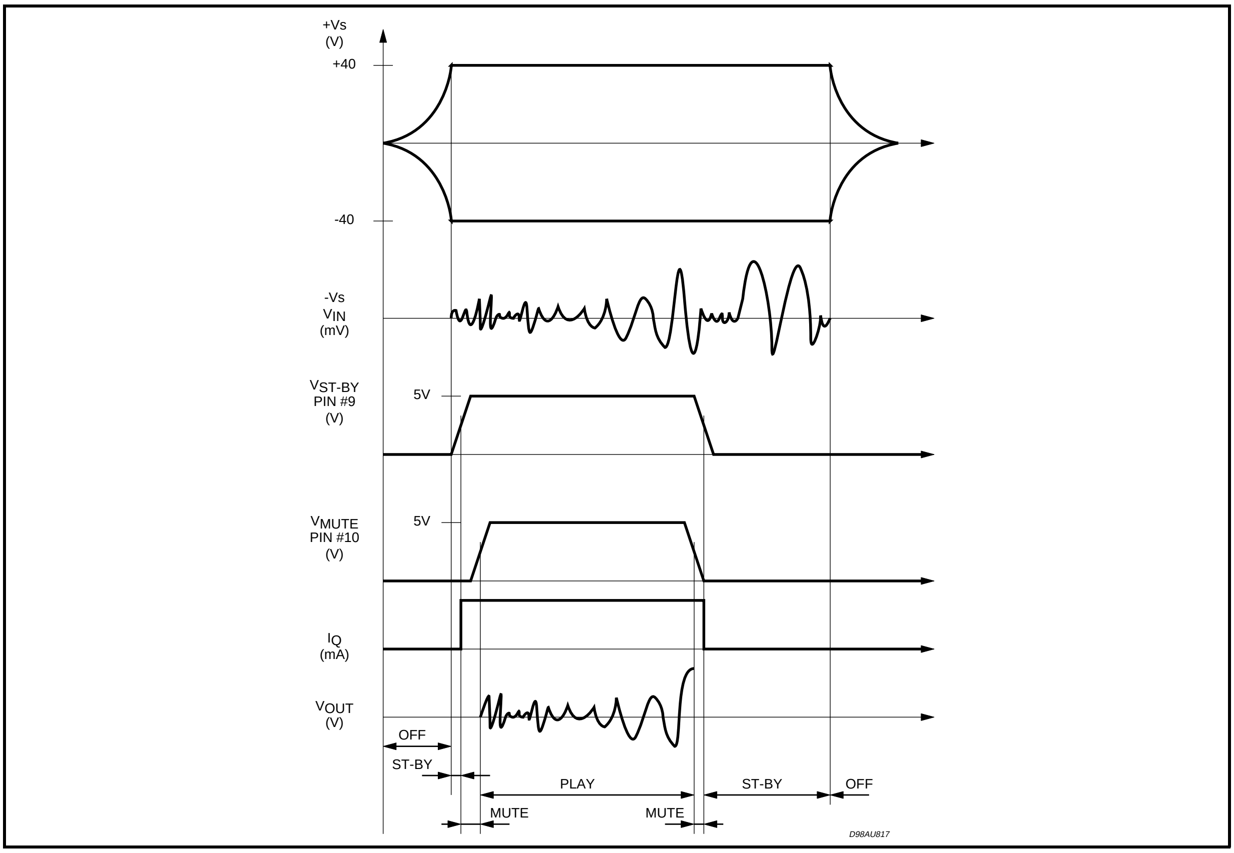


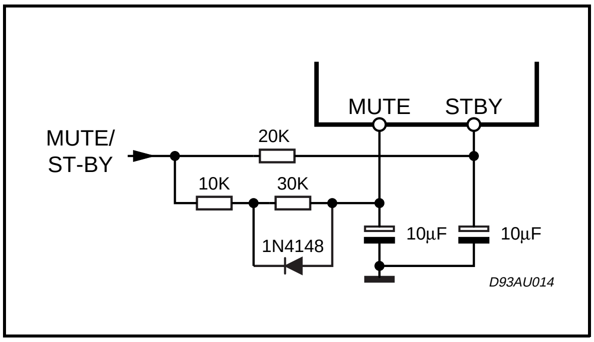
Figure 4: Turn ON/OFF Suggested Sequence



In addition to the overload protection described above, the device features a thermal shutdown circuit which initially puts the device into a muting state (@ Tj = 150 ^oC) and then into stand-by (@ Tj = 160 ^oC).

Full protection against electrostatic discharges on every pin is included.

Figure 5: Single Signal ST-BY/MUTE Control Circuit



3) Other Features

The device is provided with both stand-by and mute functions, independently driven by two CMOS logic compatible input pins.

The circuits dedicated to the switching on and off of the amplifier have been carefully optimized to avoid any kind of uncontrolled audible transient at the output.

The sequence that we recommend during the ON/OFF transients is shown by Figure 4.

The application of figure 5 shows the possibility of using only one command for both st-by and mute functions. On both the pins, the maximum applicable range corresponds to the operating supply voltage.

APPLICATION INFORMATION

HIGH-EFFICIENCY

Constraints of implementing high power solutions are the power dissipation and the size of the power supply. These are both due to the low efficiency of conventional AB class amplifier approaches.

Here below (figure 6) is described a circuit proposal for a high efficiency amplifier which can be adopted for both HI-FI and CAR-RADIO applications.

The TDA7293 is a monolithic MOS power amplifier which can be operated at 100V supply voltage (120V with no signal applied) while delivering output currents up to ±6.5 A.
This allows the use of this device as a very high power amplifier (up to 180W as peak power with T.H.D.=10 % and Rl = 4 Ohm); the only drawback is the power dissipation, hardly manageable in the above power range.
The typical junction-to-case thermal resistance of the TDA7293 is 1 $^oC/W$ (max= 1.5 $^oC/W$). To avoid that, in worst case conditions, the chip temperature exceedes 150 ^oC, the thermal resistance of the heatsink must be 0.038 $^oC/W$ (@ max ambient temperature of 50 ^oC).
As the above value is pratically unreachable; a high efficiency system is needed in those cases where the continuous RMS output power is higher than 50-60 W.
The TDA7293 was designed to work also in higher efficiency way.
For this reason there are four power supply pins: two intended for the signal part and two for the power part.
T1 and T2 are two power transistors that only operate when the output power reaches a certain threshold (e.g. 20 W). If the output power increases, these transistors are switched on during the portion of the signal where more output voltage swing is needed, thus "bootstrapping" the power supply pins (#13 and #15).

The current generators formed by T4, T7, zener diodes Z1, Z2 and resistors R7,R8 define the minimum drop across the power MOS transistors of the TDA7293. L1, L2, L3 and the snubbers C9, R1 and C10, R2 stabilize the loops formed by the "bootstrap" circuits and the output stage of the TDA7293.

By considering again a maximum average output power (music signal) of 20W, in case of the high efficiency application, the thermal resistance value needed from the heatsink is 2.2$^oC/W$ (Vs =±50 V and Rl= 8 Ohm).
All components (TDA7293 and power transistors T1 and T2) can be placed on a 1.5$^oC/W$ heatsink, with the power darlingtons electrically insulated from the heatsink.
Since the total power dissipation is less than that of a usual class AB amplifier, additional cost savings can be obtained while optimizing the power supply, even with a high heatsink .

BRIDGE APPLICATION

Another application suggestion is the BRIDGE configuration, where two TDA7293 are used.
In this application, the value of the load must not be lower than 8 Ohm for dissipation and current capability reasons.
A suitable field of application includes HI-FI/TV subwoofers realizations.

The main advantages offered by this solution are:

- High power performances with limited supply voltage level.
- Considerably high output power even with high load values (i.e. 16 Ohm).

With Rl= 8 Ohm, Vs = ±25V the maximum output power obtainable is 150 W, while with Rl=16 Ohm, Vs = ±40V the maximum Pout is 200 W.

APPLICATION NOTE: (ref. fig. 7)

Modular Application (more Devices in Parallel)

The use of the modular application lets very high power be delivered to very low impedance loads.
The modular application implies one device to act as a master and the others as slaves.

The slave power stages are driven by the master device and work in parallel all together, while the input and the gain stages of the slave device are disabled, the figure below shows the connections required to configure two devices to work together.

- The master chip connections are the same as the normal single ones.
- The outputs can be connected together **without the need of any ballast resistance.**
- The slave SGND pin must be tied to the negative supply.
- The slave ST-BY and MUTE pins must be connected to the master ST-BY and MUTE pins.
- The bootstrap lines must be connected together and the bootstrap capacitor must be increased: for N devices the boostrap capacitor must be 22µF times N.
- The slave IN-pin must be connected to the negative supply.

THE BOOTSTRAP CAPACITOR

For compatibility purpose with the previous devices of the family, the boostrap capacitor can be connected both between the bootstrap pin (6) and the output pin (14) or between the boostrap pin (6) and the bootstrap loader pin (12).
When the bootcap is connected between pin 6 and 14, the maximum supply voltage in presence of output signal is limited to 100V, due the bootstrap capacitor overvoltage.
When the bootcap is connected between pins 6 and 12 the maximum supply voltage extend to the full voltage that the technology can stand: 120V.

This is accomplished by the clamp introduced at the bootstrap loader pin (12): this pin follows the output voltage up to 100V and remains clamped at 100V for higher output voltages. This feature lets the output voltage swing up to a gate-source voltage from the positive supply (Vs -3 to 6V).

Figure 6: High Efficiency Application Circuit

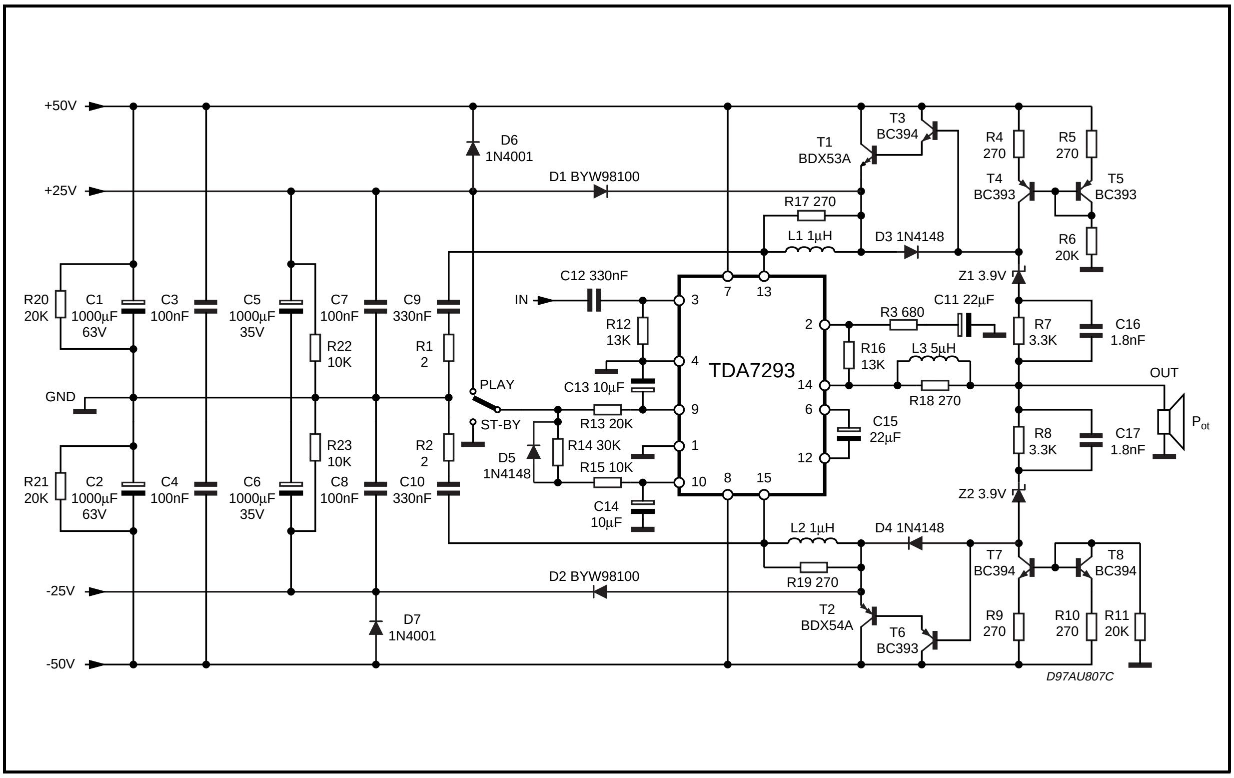


Figure 6a: PCB and Component Layout of the fig. 6

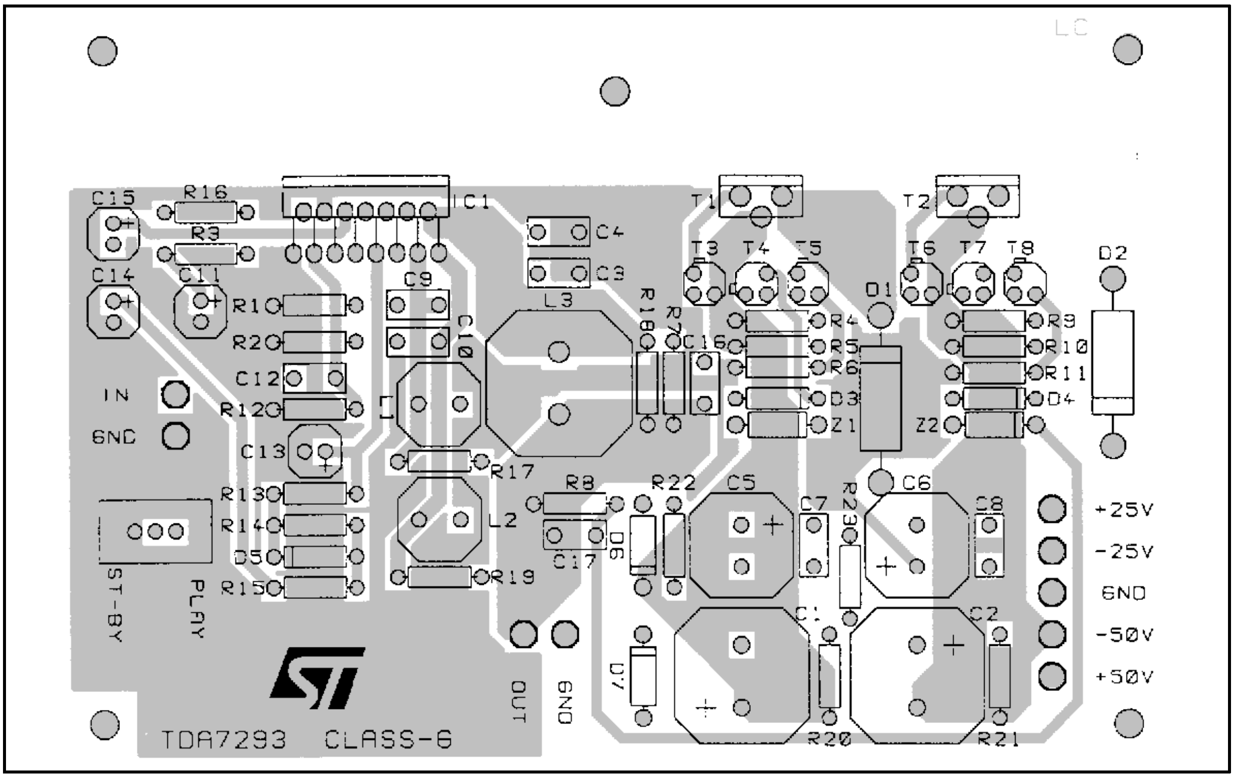


Figure 6b: PCB - Solder Side of the fig. 6.

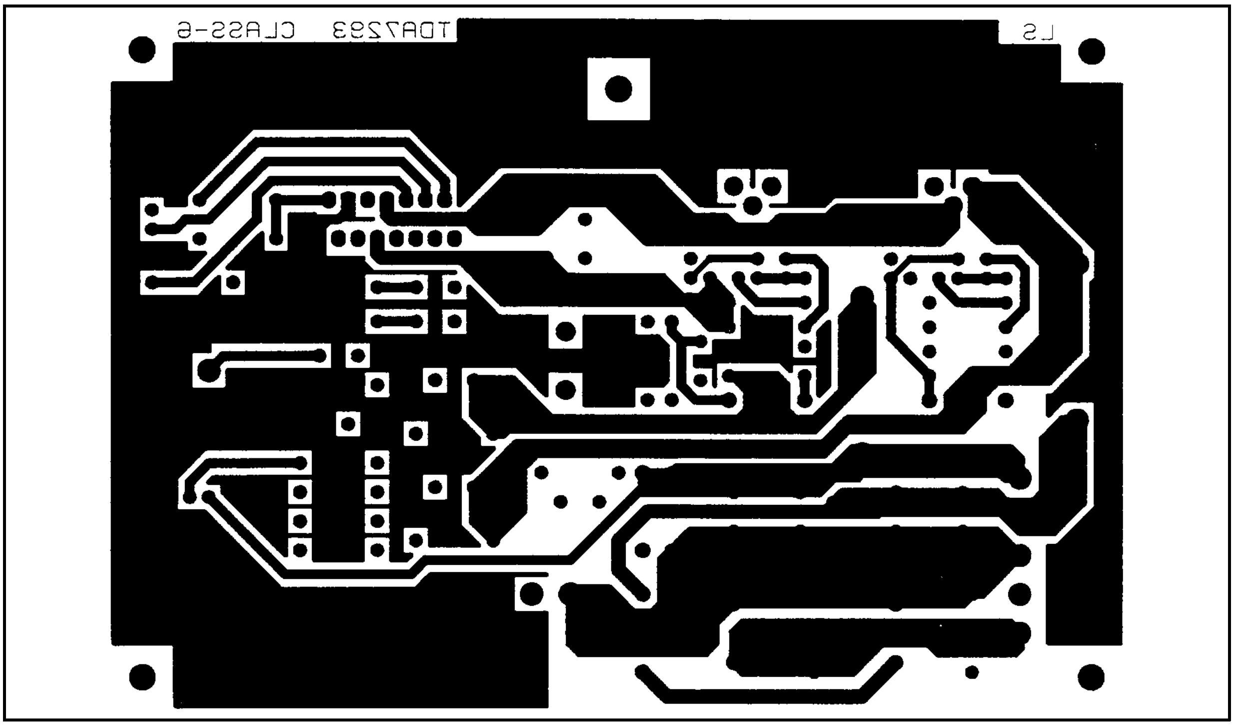


Figure 7: Modular Application Circuit

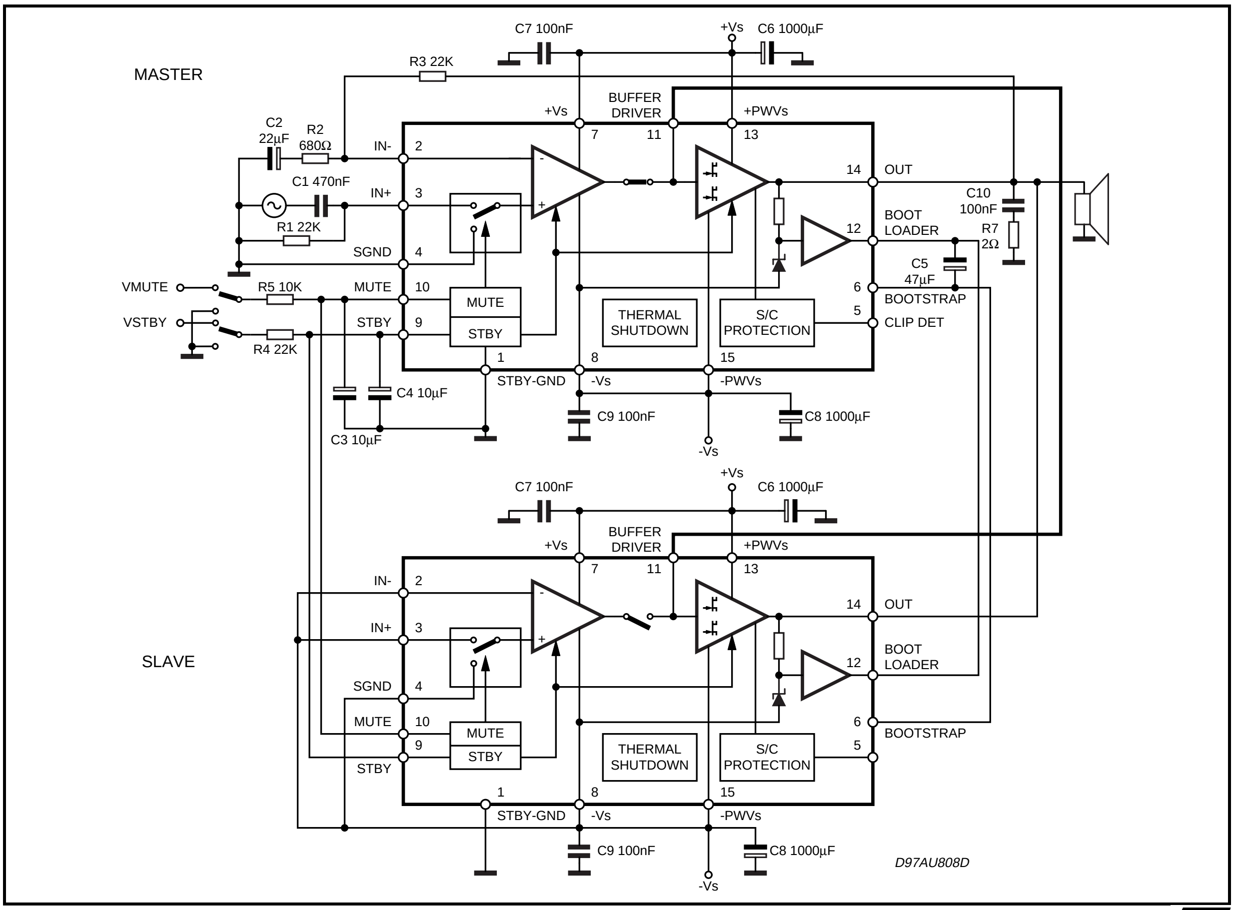


Figure 8a: Modular Application P.C. Board and Component Layout (scale 1:1) (Component SIDE)

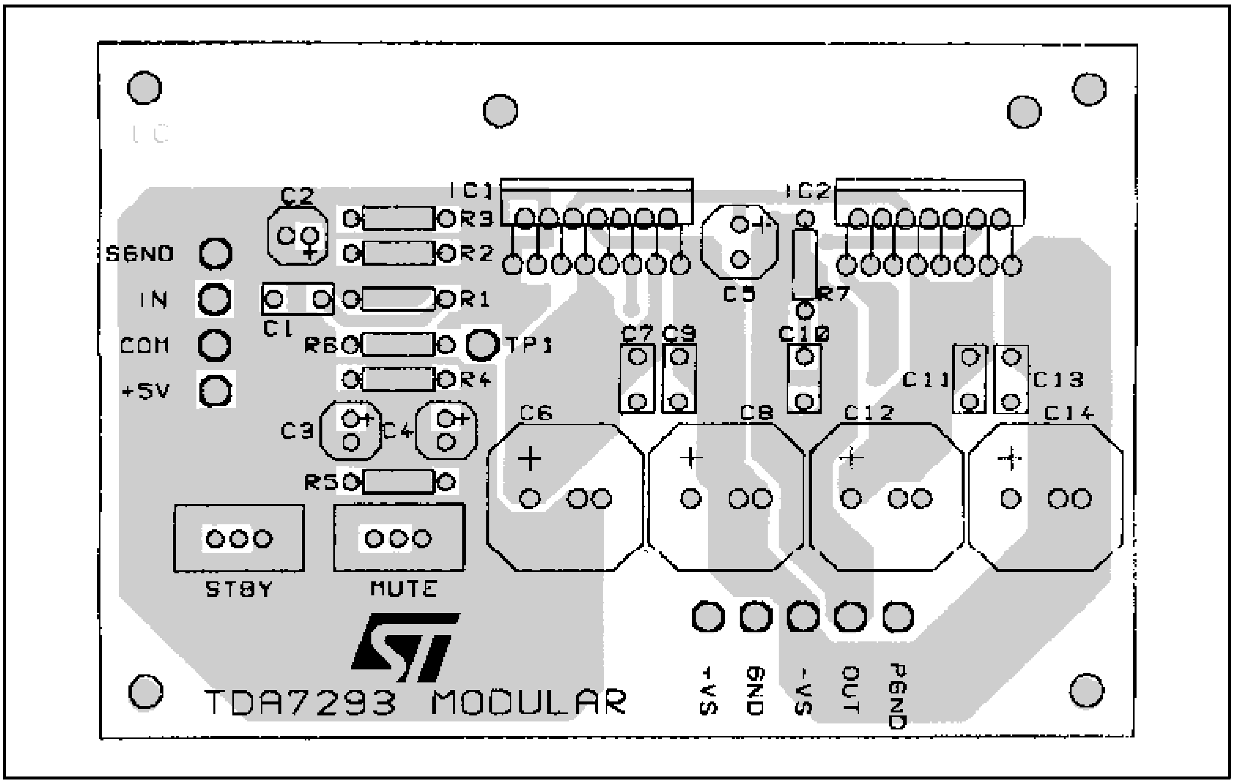


Figure 8b: Modular Application P.C. Board and Component Layout (scale 1:1) (Solder SIDE)

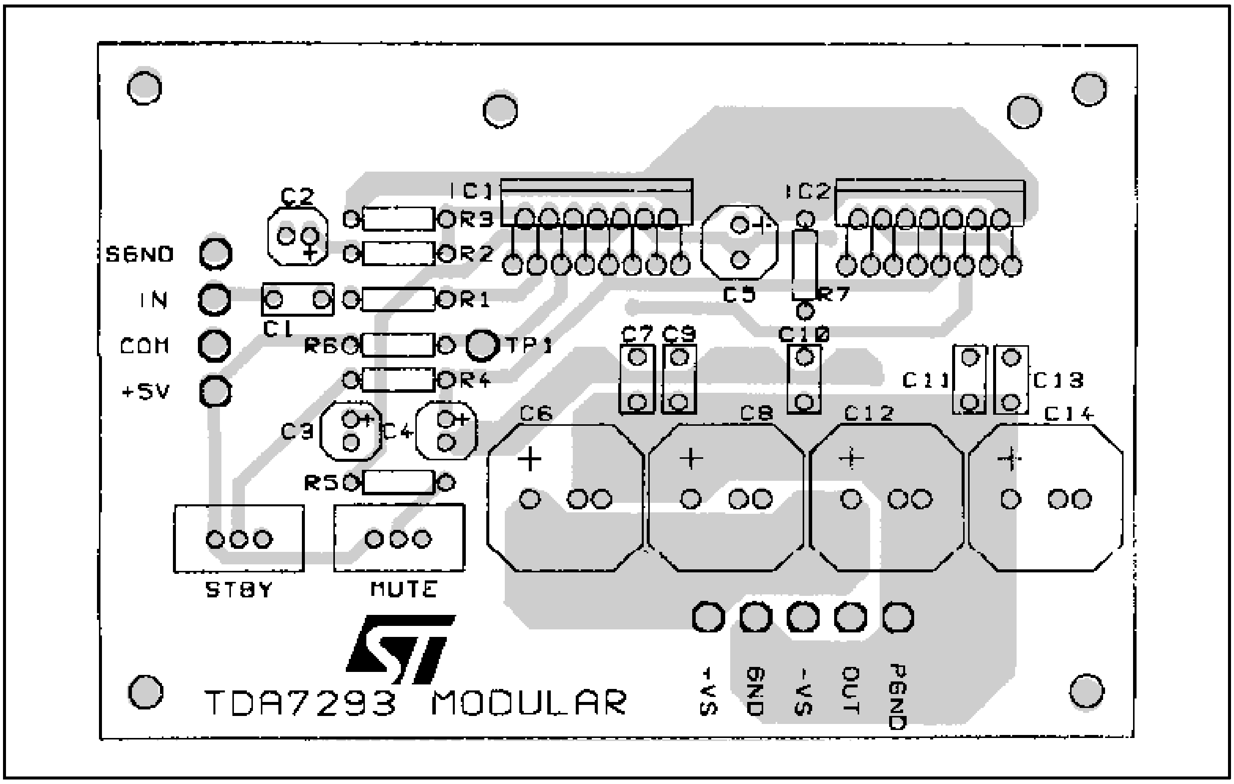


Figure 9: Distortion vs Output Power

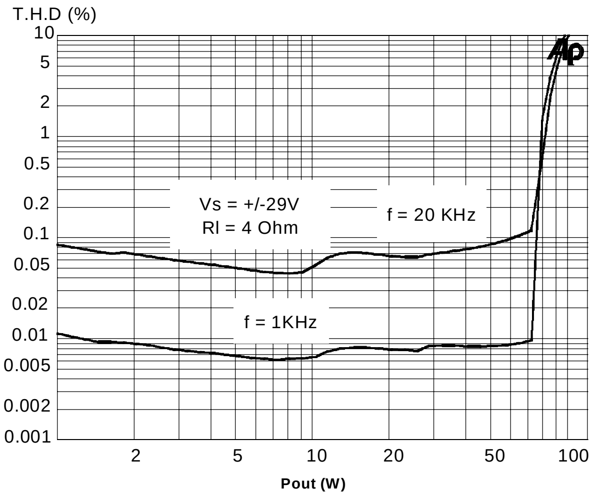


Figure 10: Distortion vs Output Power

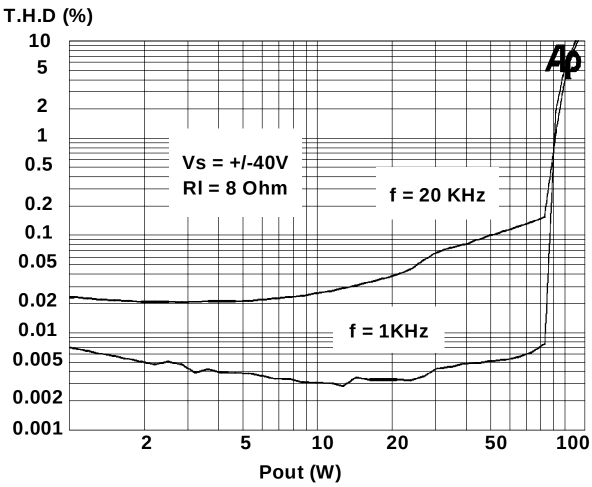


Figure 11: Distortion vs Frequency

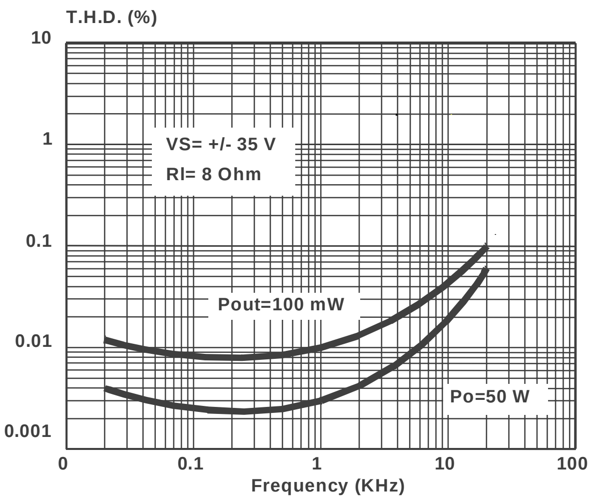


Figure 12: Modular Application Derating Rload vs Vsupply (ref. fig. 7)

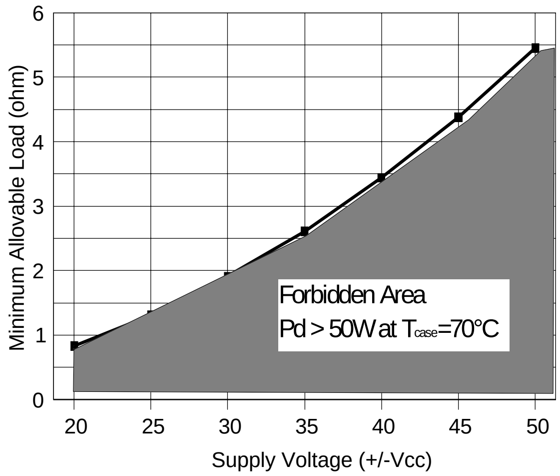


Figure 13: Modular Application Pd vs Vsupply (ref. fig. 7)

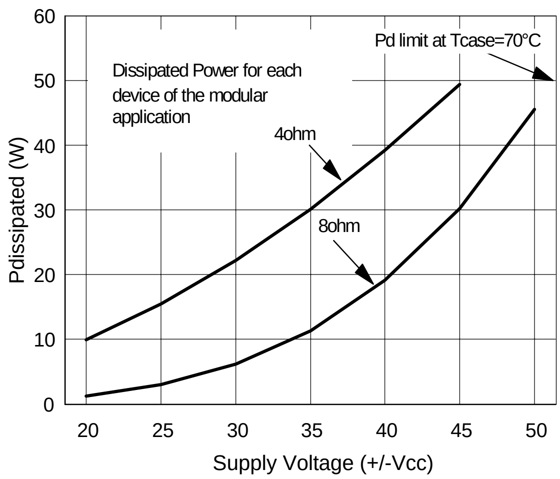
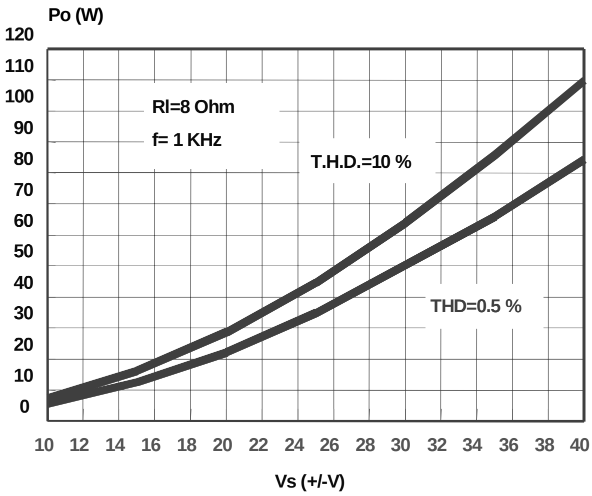
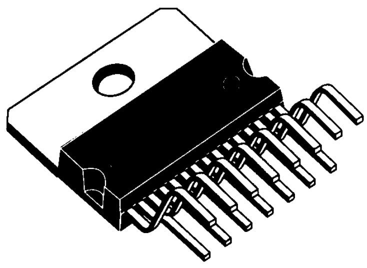


Figure 14: Output Power vs. Supply Voltage

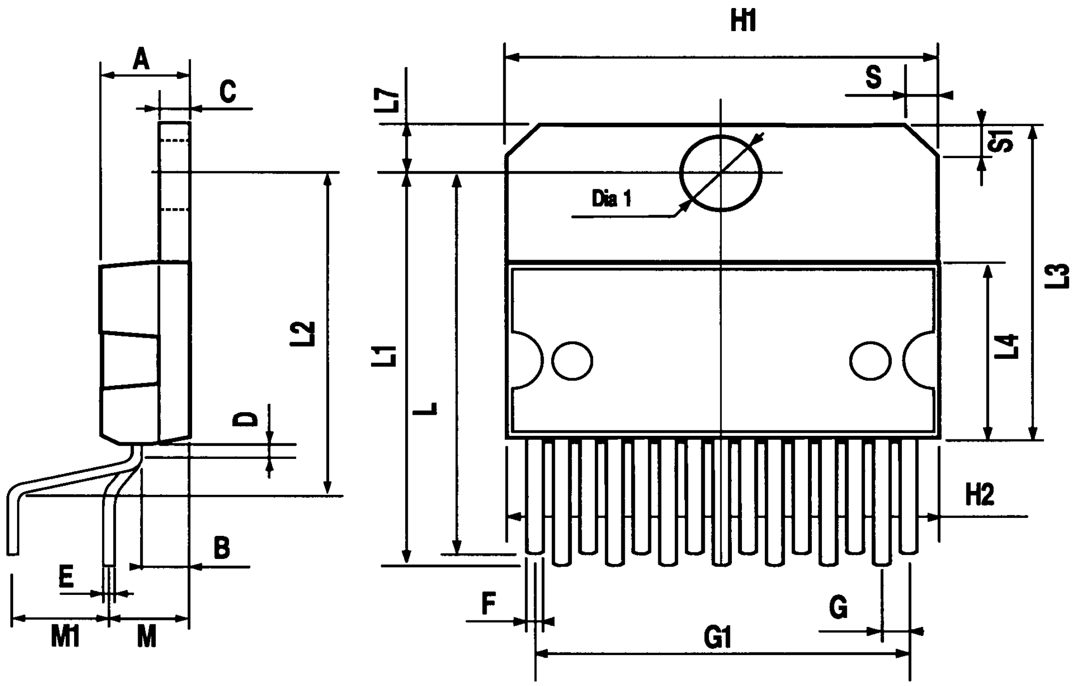


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
D		1			0.039	
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.02	1.27	1.52	0.040	0.050	0.060
G1	17.53	17.78	18.03	0.690	0.700	0.710
H1	19.6			0.772		
H2			20.2			0.795
L	21.9	22.2	22.5	0.862	0.874	0.886
L1	21.7	22.1	22.5	0.854	0.870	0.886
L2	17.65		18.1	0.695		0.713
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L7	2.65		2.9	0.104		0.114
M	4.25	4.55	4.85	0.167	0.179	0.191
M1	4.63	5.08	5.53	0.182	0.200	0.218
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA

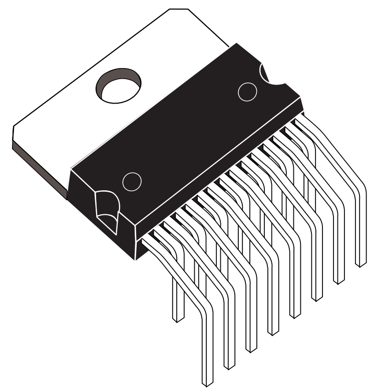


Multiwatt15 V

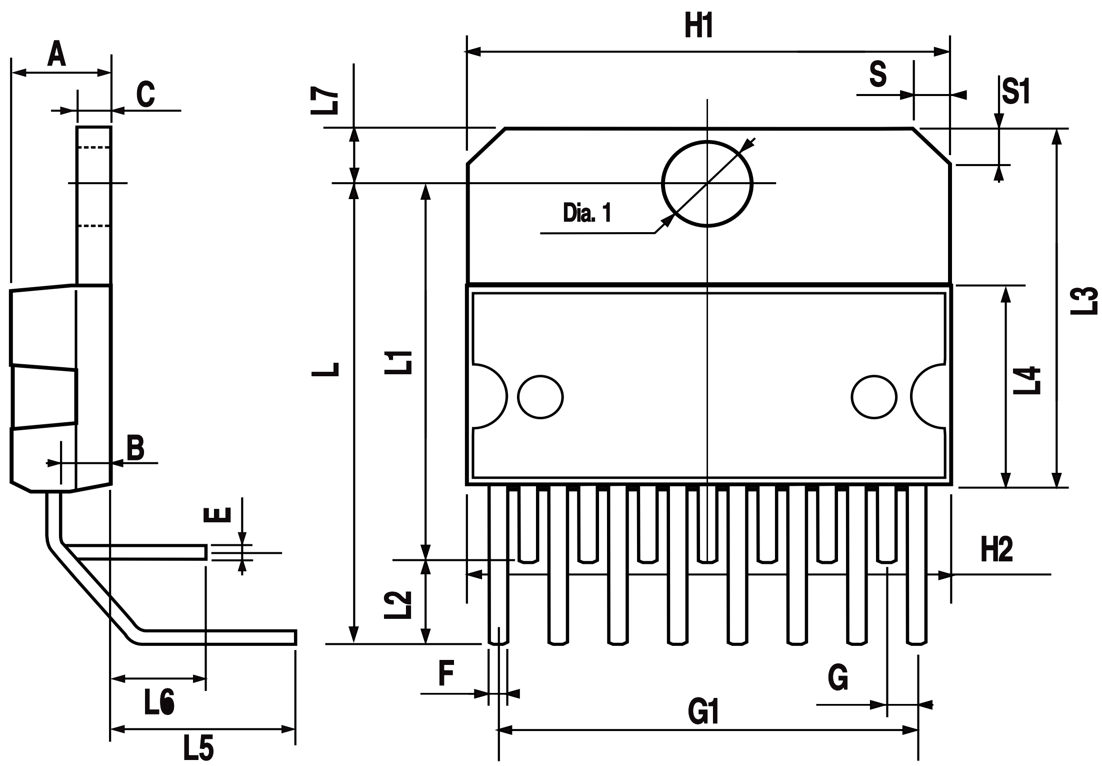


DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			5			0.197
B			2.65			0.104
C			1.6			0.063
E	0.49		0.55	0.019		0.022
F	0.66		0.75	0.026		0.030
G	1.14	1.27	1.4	0.045	0.050	0.055
G1	17.57	17.78	17.91	0.692	0.700	0.705
H1	19.6			0.772		
H2			20.2			0.795
L		20.57			0.810	
L1		18.03			0.710	
L2		2.54			0.100	
L3	17.25	17.5	17.75	0.679	0.689	0.699
L4	10.3	10.7	10.9	0.406	0.421	0.429
L5		5.28			0.208	
L6		2.38			0.094	
L7	2.65		2.9	0.104		0.114
S	1.9		2.6	0.075		0.102
S1	1.9		2.6	0.075		0.102
Dia1	3.65		3.85	0.144		0.152

OUTLINE AND MECHANICAL DATA



Multiwatt15 H



National Semiconductor

August 2000

LM124/LM224/LM324/LM2902 Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage
- The unity gain cross frequency is temperature compensated
- The input bias current is also temperature compensated

Advantages

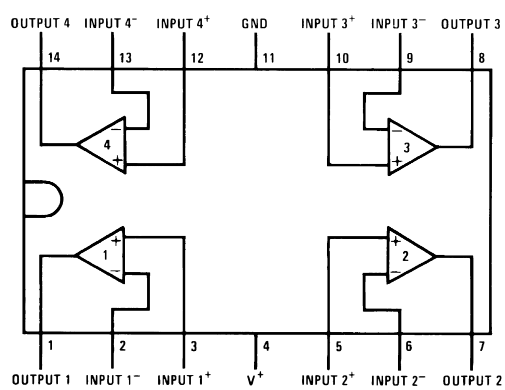
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and V_{OUT} also goes to GND
- Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  Single supply 3V to 32V
  or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 µA)—essentially independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV
  and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to $V^+ - 1.5V$

Connection Diagram

Dual-In-Line Package



DS009299-1

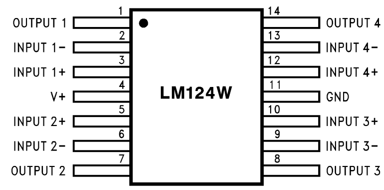
Top View
Order Number LM124J, LM124AJ, LM124J/883 (Note 2)**, LM124AJ/883** (Note 1)**, LM224J, LM224AJ, LM324J, LM324M, LM324MX, LM324AM, LM324AMX, LM2902M, LM2902MX, LM324N, LM324AN, LM324MT, LM324MTX or LM2902N LM124AJRQML and LM124AJRQMLV**(Note 3)
See NS Package Number J14A, M14A or N14A

Note 1: LM124A available per JM38510/11006

Note 2: LM124 available per JM38510/11005

Connection Diagram (Continued)

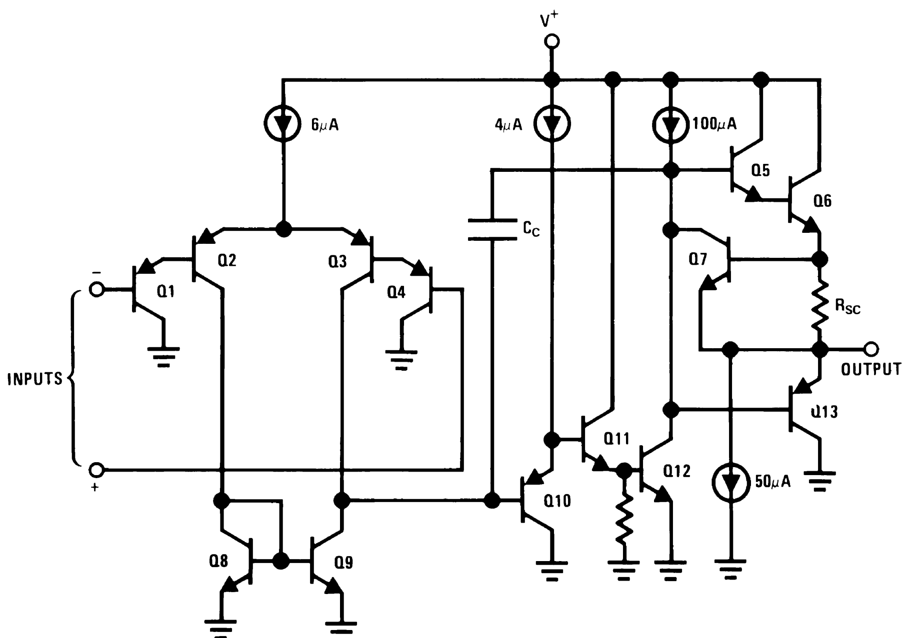
Note 3: See STD Mil DWG 5962R99504 for Radiation Tolerant Device



DS009299-33

Order Number LM124AW/883, LM124AWG/883, LM124W/883 or LM124WG/883
LM124AWRQML and LM124AWRQMLV(Note 3)
See NS Package Number W14B
LM124AWGRQML and LM124AWGRQMLV(Note 3)
See NS Package Number WG14A

Schematic Diagram (Each Amplifier)



DS009299-2

Absolute Maximum Ratings (Note 12)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902
Supply Voltage, V^+	32V	26V
Differential Input Voltage	32V	26V
Input Voltage	−0.3V to +32V	−0.3V to +26V
Input Current		
(V_{IN} < −0.3V) (Note 6)	50 mA	50 mA
Power Dissipation (Note 4)		
Molded DIP	1130 mW	1130 mW
Cavity DIP	1260 mW	1260 mW
Small Outline Package	800 mW	800 mW
Output Short-Circuit to GND		
(One Amplifier) (Note 5)		
$V^+ \leq 15V$ and $T_A = 25˚C$	Continuous	Continuous
Operating Temperature Range		−40˚C to +85˚C
LM324/LM324A	0˚C to +70˚C	
LM224/LM224A	−25˚C to +85˚C	
LM124/LM124A	−55˚C to +125˚C	
Storage Temperature Range	−65˚C to +150˚C	−65˚C to +150˚C
Lead Temperature (Soldering, 10 seconds)	260˚C	260˚C
Soldering Information		
Dual-In-Line Package		
Soldering (10 seconds)	260˚C	260˚C
Small Outline Package		
Vapor Phase (60 seconds)	215˚C	215˚C
Infrared (15 seconds)	220˚C	220˚C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

ESD Tolerance (Note 13)	250V	250V

Electrical Characteristics

$V^+ = +5.0V$, (Note 7), unless otherwise stated

Parameter	Conditions	LM124A			LM224A			LM324A			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) $T_A = 25˚C$		1	2		1	3		2	3	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25˚C$		20	50		40	80		45	100	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25˚C$		2	10		2	15		5	30	nA
Input Common-Mode Voltage Range (Note 10)	$V^+ = 30V$, (LM2902, $V^+ = 26V$), $T_A = 25˚C$	0		$V^+−1.5$	0		$V^+−1.5$	0		$V^+−1.5$	V
Supply Current	Over Full Temperature Range $R_L = \infty$ On All Op Amps										mA
	$V^+ = 30V$ (LM2902 $V^+ = 26V$)		1.5	3		1.5	3		1.5	3	
	$V^+ = 5V$		0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain	$V^+ = 15V$, $R_L \geq 2k\Omega$, (V_O = 1V to 11V), $T_A = 25˚C$	50	100		50	100		25	100		V/mV
Common-Mode Rejection Ratio	DC, V_{CM} = 0V to $V^+ − 1.5V$, $T_A = 25˚C$	70	85		70	85		65	85		dB

Electrical Characteristics (Continued)

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter		Conditions		LM124A			LM224A			LM324A			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Supply Rejection Ratio		V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V), T_A = 25˚C		65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, T_A = 25˚C (Input Referred)			−120			−120			−120		dB
Output Current	Source	V_{IN}^+ = 1V, V_{IN}^- = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		20	40		20	40		20	40		mA
	Sink	V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 2V, T_A = 25˚C		10	20		10	20		10	20		
		V_{IN}^- = 1V, V_{IN}^+ = 0V, V^+ = 15V, V_O = 200 mV, T_A = 25˚C		12	50		12	50		12	50		µA
Short Circuit to Ground		(Note 5) V^+ = 15V, T_A = 25˚C			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				4			4			5	mV
V_{OS} Drift		R_S = 0Ω			7	20		7	20		7	30	µV/˚C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, V_{CM} = 0V				30			30			75	nA
I_{OS} Drift		R_S = 0Ω			10	200		10	200		10	300	pA/˚C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	100		40	100		40	200	nA
Input Common-Mode Voltage Range (Note 10)		V^+ = +30V (LM2902, V^+ = 26V)		0		V^+−2	0		V^+−2	0		V^+−2	V
Large Signal Voltage Gain		V^+ = +15V (V_OSwing = 1V to 11V) $R_L \geq$ 2 kΩ		25			25			15			V/mV
Output Voltage Swing	V_{OH}	V^+ = 30V (LM2902, V^+ = 26V)	R_L = 2 kΩ	26			26			26			V
			R_L = 10 kΩ	27	28		27	28		27	28		
	V_{OL}	V^+ = 5V, R_L = 10 kΩ			5	20		5	20		5	20	mV
Output Current	Source	V_O = 2V	V_{IN}^+ = +1V, V_{IN}^- = 0V, V^+ = 15V	10	20		10	20		10	20		mA
	Sink		V_{IN}^- = +1V, V_{IN}^+ = 0V, V^+ = 15V	10	15		5	8		5	8		

Electrical Characteristics

V^+ = +5.0V, (Note 7), unless otherwise stated

Parameter	Conditions	LM124/LM224			LM324			LM2902			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) T_A = 25˚C		2	5		2	7		2	7	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25˚C		45	150		45	250		45	250	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, V_{CM} = 0V, T_A = 25˚C		3	30		5	50		5	50	nA
Input Common-Mode Voltage Range (Note 10)	V^+ = 30V, (LM2902, V^+ = 26V), T_A = 25˚C	0		V^+−1.5	0		V^+−1.5	0		V^+−1.5	V
Supply Current	Over Full Temperature Range R_L = ∞ On All Op Amps										mA
	V^+ = 30V (LM2902 V^+ = 26V)		1.5	3		1.5	3		1.5	3	
	V^+ = 5V		0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain	V^+ = 15V, $R_L \geq$ 2kΩ, (V_O = 1V to 11V), T_A = 25˚C	50	100		25	100		25	100		V/mV
Common-Mode Rejection Ratio	DC, V_{CM} = 0V to V^+ − 1.5V, T_A = 25˚C	70	85		65	85		50	70		dB
Power Supply Rejection Ratio	V^+ = 5V to 30V (LM2902, V^+ = 5V to 26V),	65	100		65	100		50	100		dB

Electrical Characteristics (Continued)

$V^+ = +5.0V$, (Note 7), unless otherwise stated

Parameter		Conditions		LM124/LM224			LM324			LM2902			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
		$T_A = 25°C$											
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, $T_A = 25°C$ (Input Referred)			−120			−120			−120		dB
Output Current	Source	$V_{IN}^+ = 1V$, $V_{IN}^- = 0V$, $V^+ = 15V$, $V_O = 2V$, $T_A = 25°C$		20	40		20	40		20	40		mA
	Sink	$V_{IN}^- = 1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$, $V_O = 2V$, $T_A = 25°C$		10	20		10	20		10	20		mA
		$V_{IN}^- = 1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$, $V_O = 200$ mV, $T_A = 25°C$		12	50		12	50		12	50		µA
Short Circuit to Ground		(Note 5) $V^+ = 15V$, $T_A = 25°C$			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				7			9			10	mV
V_{OS} Drift		$R_S = 0\Omega$			7			7			7		µV/°C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, $V_{CM} = 0V$				100			150		45	200	nA
I_{OS} Drift		$R_S = 0\Omega$			10			10			10		pA/°C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	300		40	500		40	500	nA
Input Common-Mode Voltage Range (Note 10)		$V^+ = +30V$ (LM2902, $V^+ = 26V$)		0		V^+-2	0		V^+-2	0		V^+-2	V
Large Signal Voltage Gain		$V^+ = +15V$ (V_OSwing = 1V to 11V) $R_L \geq 2$ kΩ		25			15			15			V/mV
Output Voltage Swing	V_{OH}	$V^+ = 30V$ (LM2902, $V^+ = 26V$)	$R_L = 2$ kΩ	26			26			22			V
			$R_L = 10$ kΩ	27	28		27	28		23	24		V
	V_{OL}	$V^+ = 5V$, $R_L = 10$ kΩ			5	20		5	20		5	100	mV
Output Current	Source	$V_O = 2V$	$V_{IN}^+ = +1V$, $V_{IN}^- = 0V$, $V^+ = 15V$	10	20		10	20		10	20		mA
	Sink		$V_{IN}^- = +1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$	5	8		5	8		5	8		mA

Note 4: For operating at high temperatures, the LM324/LM324A/LM2902 must be derated based on a +125˚C maximum junction temperature and a thermal resistance of 88˚C/W which applies for the device soldered in a printed circuit board, operating in a still air ambient. The LM224/LM224A and LM124/LM124A can be derated based on a +150˚C maximum junction temperature. The dissipation is the total of all four amplifiers — use external resistors, where possible, to allow the amplifier to saturate of to reduce the power which is dissipated in the integrated circuit.

Note 5: Short circuits from the output to V^+ can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA independent of the magnitude of V^+. At values of supply voltage in excess of +15V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Note 6: This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the V^+voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than −0.3V (at 25˚C).

Note 7: These specifications are limited to $-55°C \leq T_A \leq +125°C$ for the LM124/LM124A. With the LM224/LM224A, all temperature specifications are limited to $-25°C \leq T_A \leq +85°C$, the LM324/LM324A temperature specifications are limited to $0°C \leq T_A \leq +70°C$, and the LM2902 specifications are limited to $-40°C \leq T_A \leq +85°C$.

Note 8: $V_O \simeq 1.4V$, $R_S = 0\Omega$ with V^+ from 5V to 30V; and over the full input common-mode range (0V to $V^+ - 1.5V$) for LM2902, V^+ from 5V to 26V.

Note 9: The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

Note 10: The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V (at 25˚C). The upper end of the common-mode voltage range is $V^+ - 1.5V$ (at 25˚C), but either or both inputs can go to +32V without damage (+26V for LM2902), independent of the magnitude of V^+.

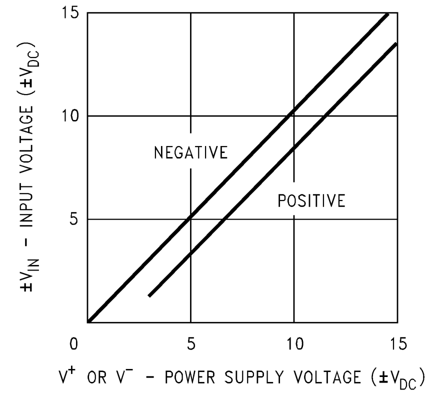
Note 11: Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

Note 12: Refer to RETS124AX for LM124A military specifications and refer to RETS124X for LM124 military specifications.

Note 13: Human body model, 1.5 kΩ in series with 100 pF.

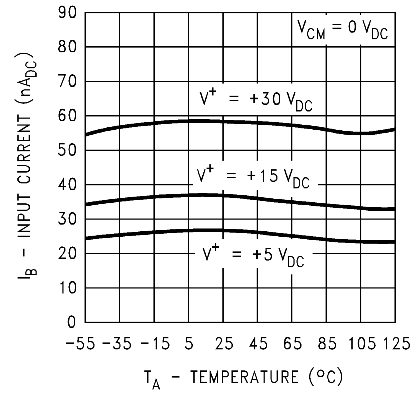
Typical Performance Characteristics

Input Voltage Range



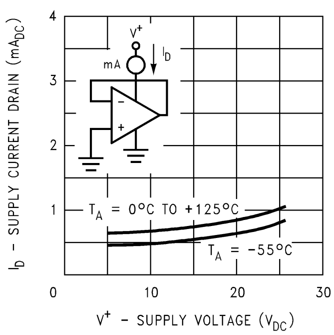
DS009299-34

Input Current



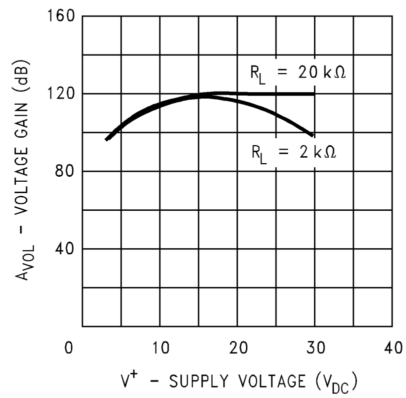
DS009299-35

Supply Current



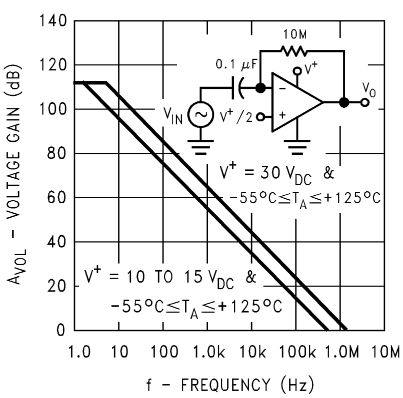
DS009299-36

Voltage Gain



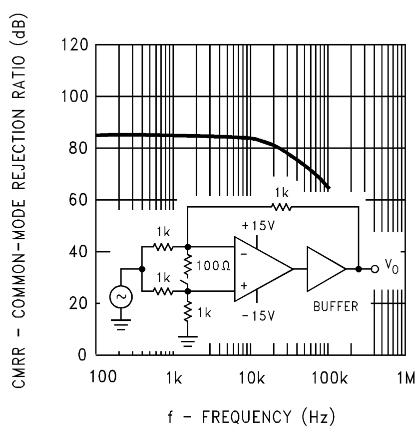
DS009299-37

Open Loop Frequency Response



DS009299-38

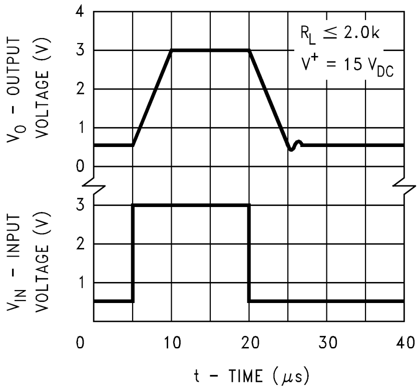
Common Mode Rejection Ratio



DS009299-39

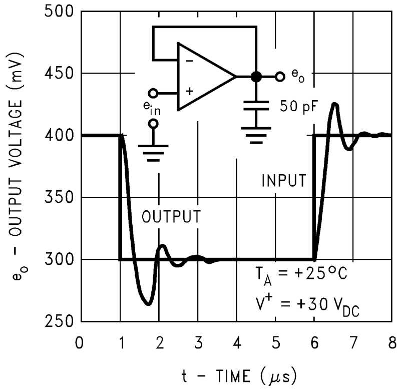
Typical Performance Characteristics (Continued)

Voltage Follower Pulse Response



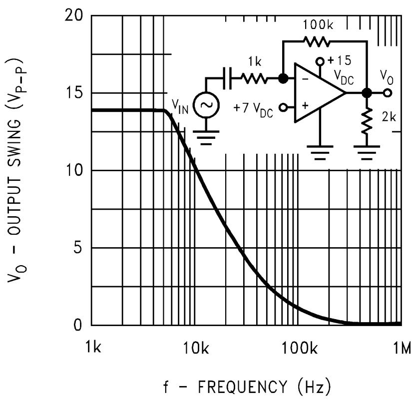
DS009299-40

Voltage Follower Pulse Response (Small Signal)



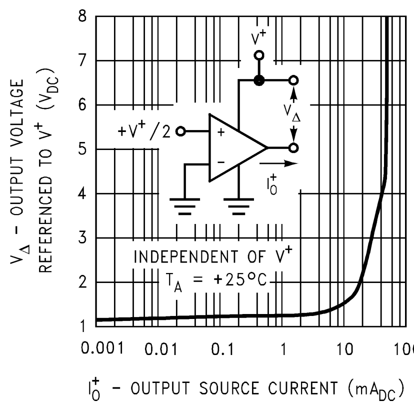
DS009299-41

Large Signal Frequency Response



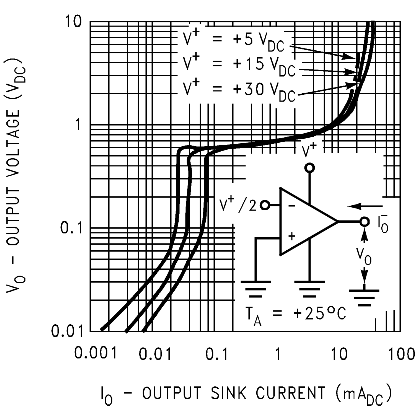
DS009299-42

Output Characteristics Current Sourcing



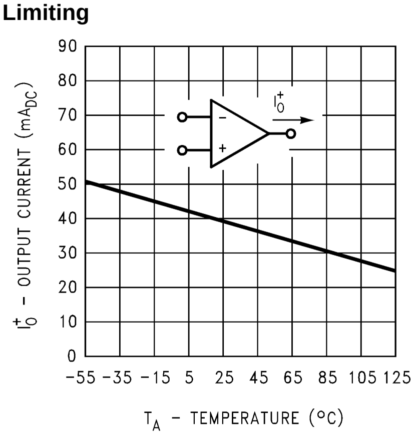
DS009299-43

Output Characteristics Current Sinking



DS009299-44

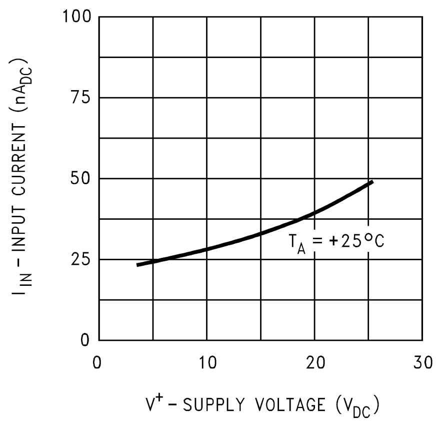
Current Limiting



DS009299-45

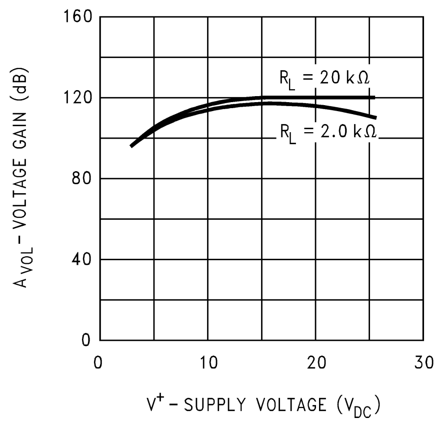
Typical Performance Characteristics (Continued)

Input Current (LM2902 only)



DS009299-46

Voltage Gain (LM2902 only)



DS009299-47

Application Hints

The LM124 series are op amps which operate with only a single power supply voltage, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of 0 V_{DC}. These amplifiers operate over a wide range of power supply voltage with little change in performance characteristics. At 25˚C amplifier operation is possible down to a minimum supply voltage of 2.3 V_{DC}.

The pinouts of the package have been designed to simplify PC board layouts. Inverting inputs are adjacent to outputs for all of the amplifiers and the outputs have also been placed at the corners of the package (pins 1, 7, 8, and 14).

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than −0.3 V_{DC} (at 25˚C). An input clamp diode with a resistor to the IC input terminal can be used.

To reduce the power supply drain, the amplifiers have a class A output stage for small signal levels which converts to class B in a large signal mode. This allows the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications.

For ac applications, where the load is capacitively coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the class A bias current and prevent crossover distortion.

Where the load is directly coupled, as in dc applications, there is no crossover distortion.

Capacitive loads which are applied directly to the output of the amplifier reduce the loop stability margin. Values of 50 pF can be accommodated using the worst-case non-inverting unity gain connection. Large closed loop gains or resistive isolation should be used if larger load capacitance must be driven by the amplifier.

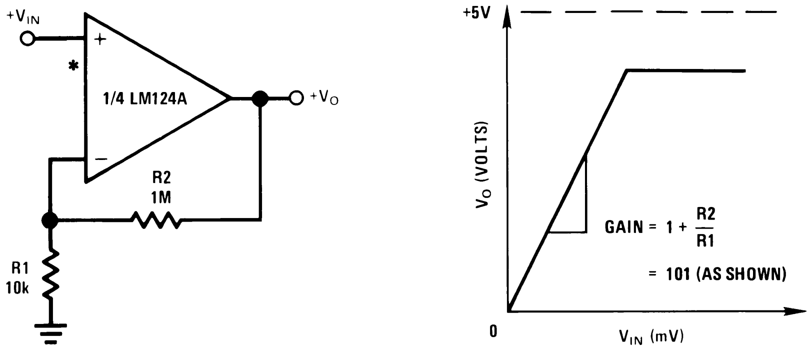
The bias network of the LM124 establishes a drain current which is independent of the magnitude of the power supply voltage over the range of from 3 V_{DC} to 30 V_{DC}.

Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. Putting direct short-circuits on more than one amplifier at a time will increase the total IC power dissipation to destructive levels, if not properly protected with external dissipation limiting resistors in series with the output leads of the amplifiers. The larger value of output source current which is available at 25˚C provides a larger output current capability at elevated temperatures (see typical performance characteristics) than a standard IC op amp.

The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference of $V^+/2$) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

Typical Single-Supply Applications $(V^+ = 5.0\ V_{DC})$

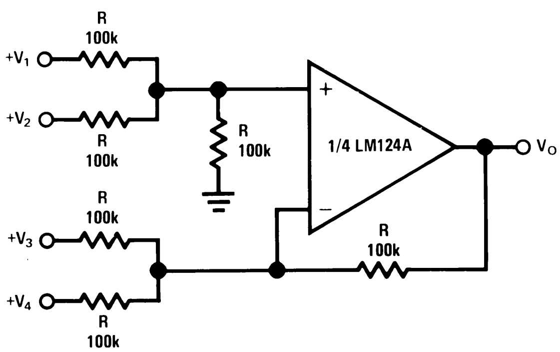
Non-Inverting DC Gain (0V Input = 0V Output)



DS009299-5

*R not needed due to temperature independent I_{IN}

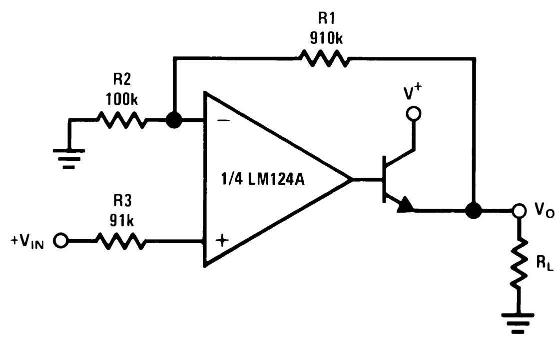
DC Summing Amplifier $(V_{IN'S} \geq 0\ V_{DC}$ and $V_O \geq V_{DC})$



DS009299-6

Where: $V_0 = V_1 + V_2 - V_3 - V_4$
$(V_1 + V_2) \geq (V_3 + V_4)$ to keep $V_O > 0\ V_{DC}$

Power Amplifier

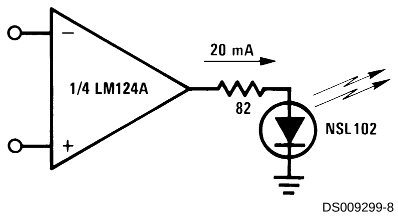


DS009299-7

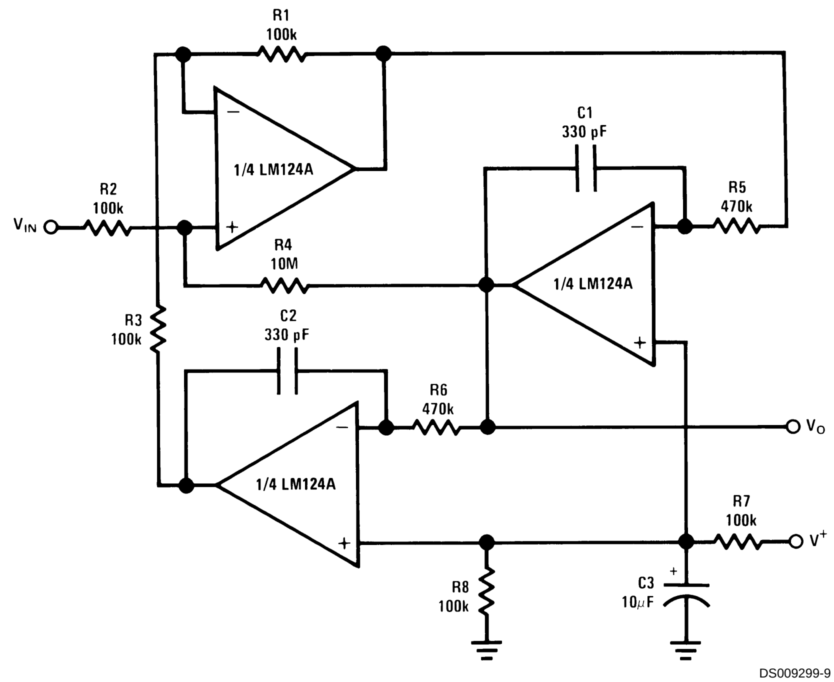
$V_0 = 0\ V_{DC}$ for $V_{IN} = 0\ V_{DC}$
$A_V = 10$

Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

LED Driver

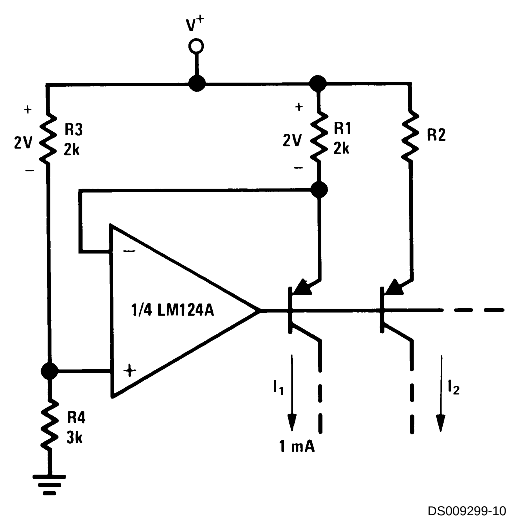


"BI-QUAD" RC Active Bandpass Filter



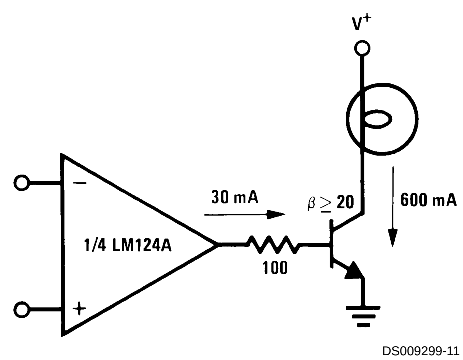
$f_o = 1\ kHz$
$Q = 50$
$A_V = 100\ (40\ dB)$

Fixed Current Sources



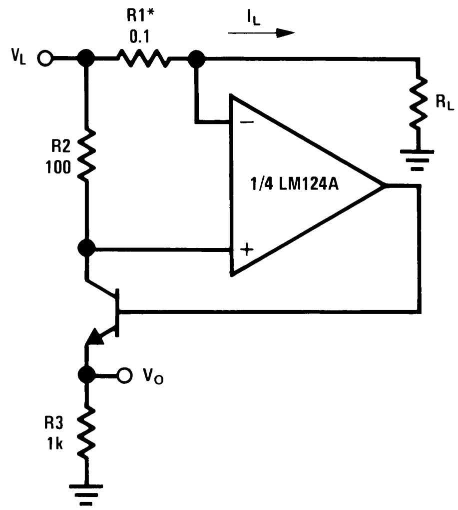
$$I_2 = \left(\frac{R1}{R2}\right) I_1$$

Lamp Driver



Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

Current Monitor



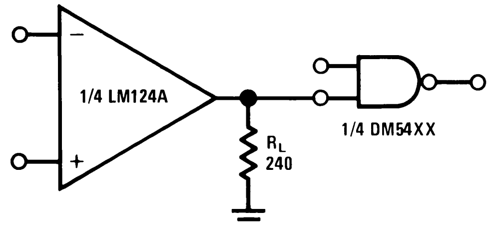
DS009299-12

$$V_O = \frac{1V(I_L)}{1A}$$

$$V_L \leq V^+ - 2V$$

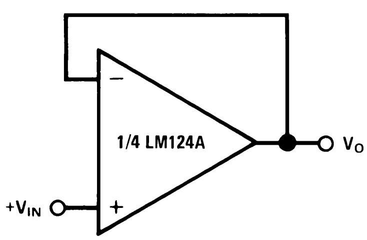
*(Increase R1 for I_L small)

Driving TTL



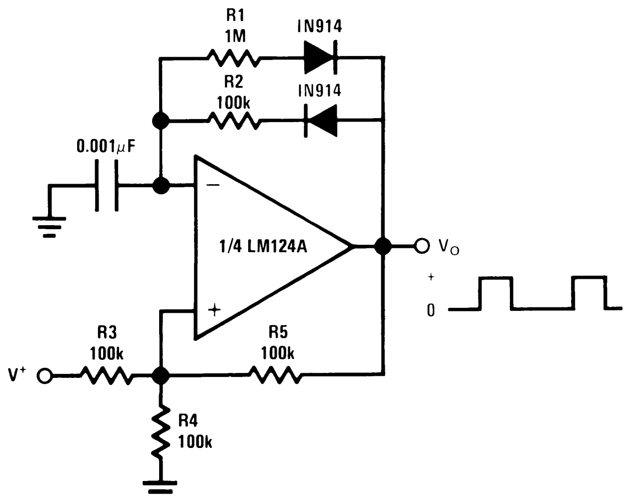
DS009299-13

Voltage Follower



DS009299-14

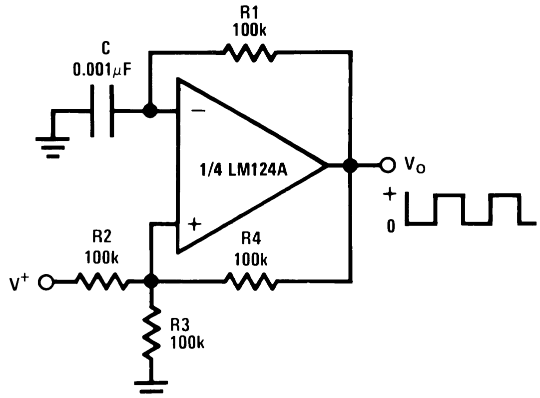
Pulse Generator



DS009299-15

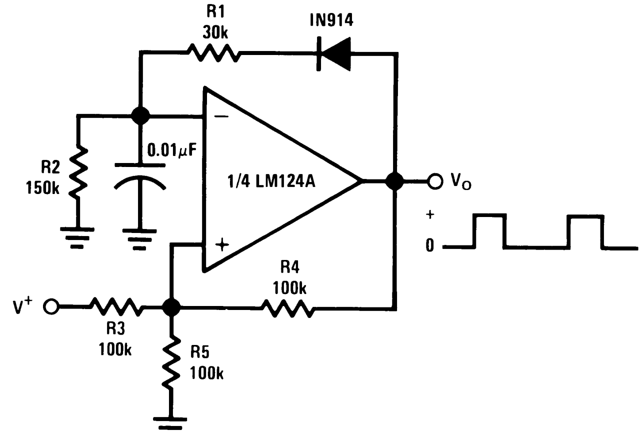
Typical Single-Supply Applications ($V^{+} = 5.0\ V_{DC}$) (Continued)

Squarewave Oscillator



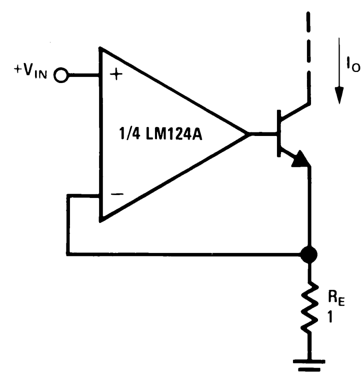
DS009299-16

Pulse Generator



DS009299-17

High Compliance Current Sink

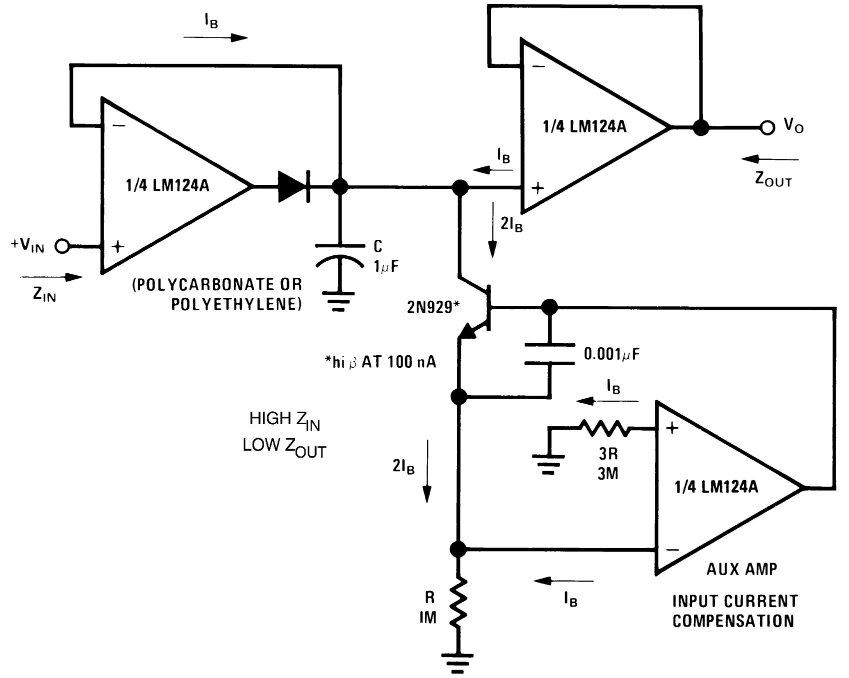


DS009299-18

I_O = 1 amp/volt V_{IN}
(Increase R_E for I_o small)

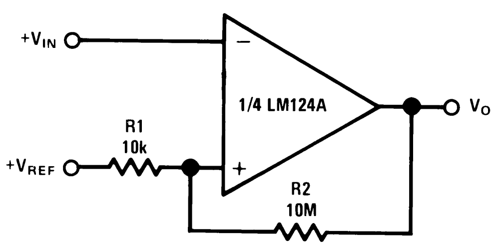
Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

Low Drift Peak Detector



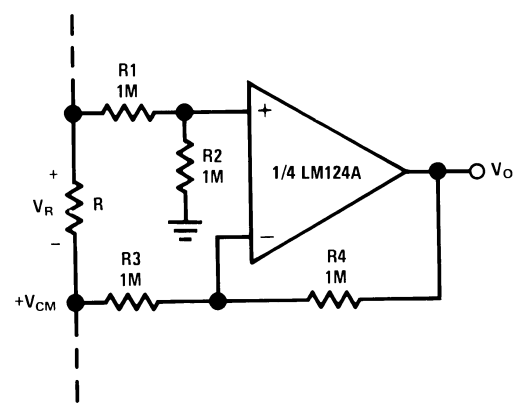
DS009299-19

Comparator with Hysteresis



DS009299-20

Ground Referencing a Differential Input Signal

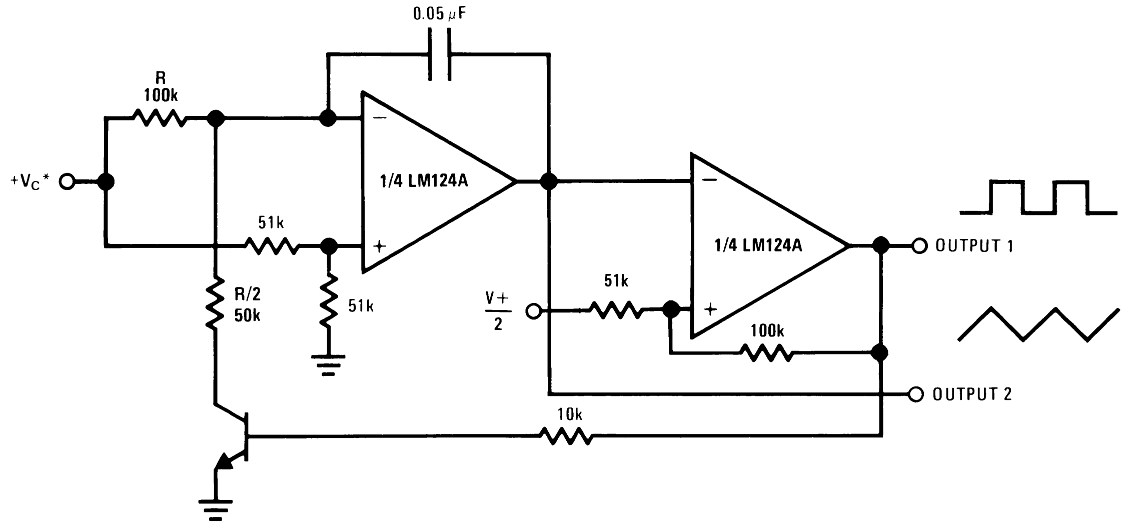


DS009299-21

$V_O = V_R$

Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

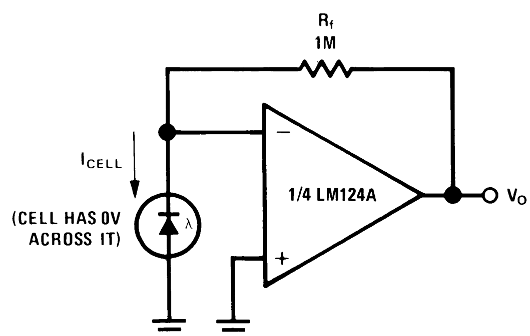
Voltage Controlled Oscillator Circuit



DS009299-22

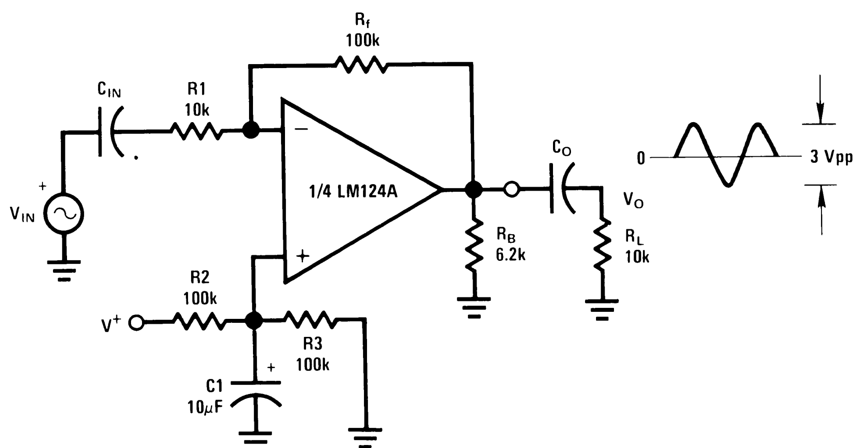
*Wide control voltage range: $0\ V_{DC} \leq V_C \leq 2\ (V^+ - 1.5\ V_{DC})$

Photo Voltaic-Cell Amplifier



DS009299-23

AC Coupled Inverting Amplifier

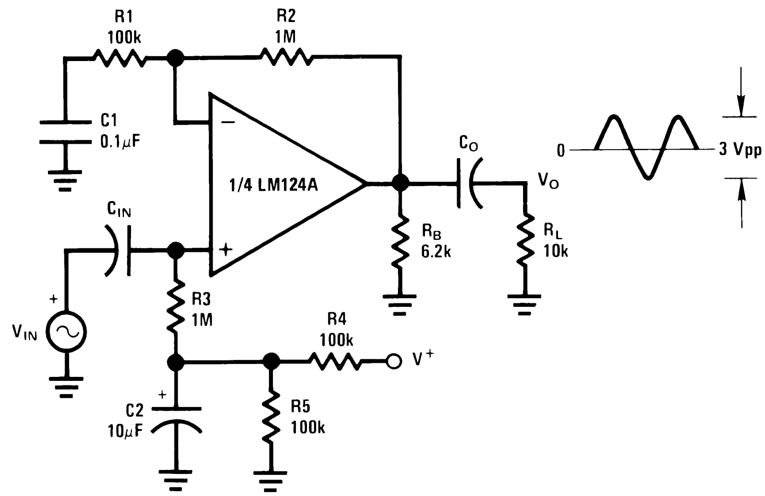


DS009299-24

$A_V = \frac{R_f}{R1}$ (As shown, $A_V = 10$)

Typical Single-Supply Applications (V+ = 5.0 V_{DC}) (Continued)

AC Coupled Non-Inverting Amplifier

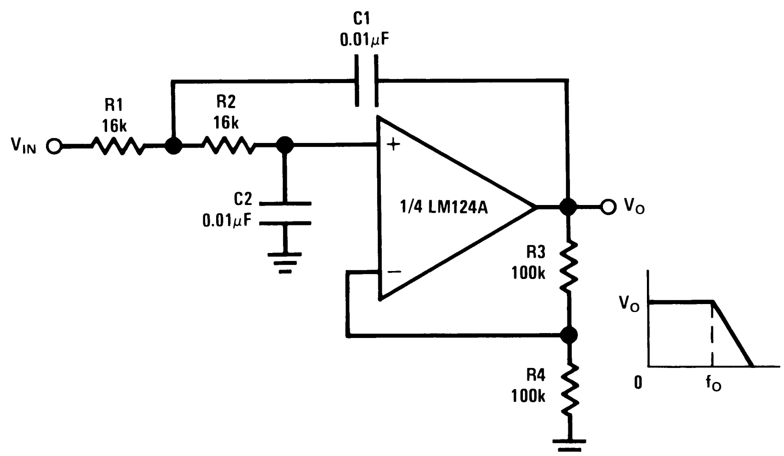


DS009299-25

$A_V = 1 + \frac{R2}{R1}$

A_V = 11 (As shown)

DC Coupled Low-Pass RC Active Filter

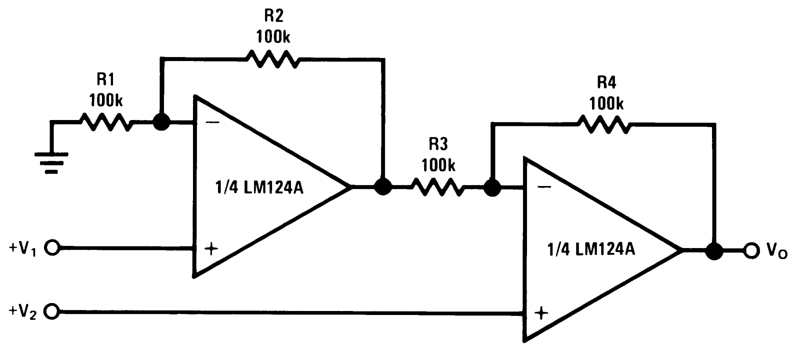


DS009299-26

f_O = 1 kHz
Q = 1
A_V = 2

Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

High Input Z, DC Differential Amplifier



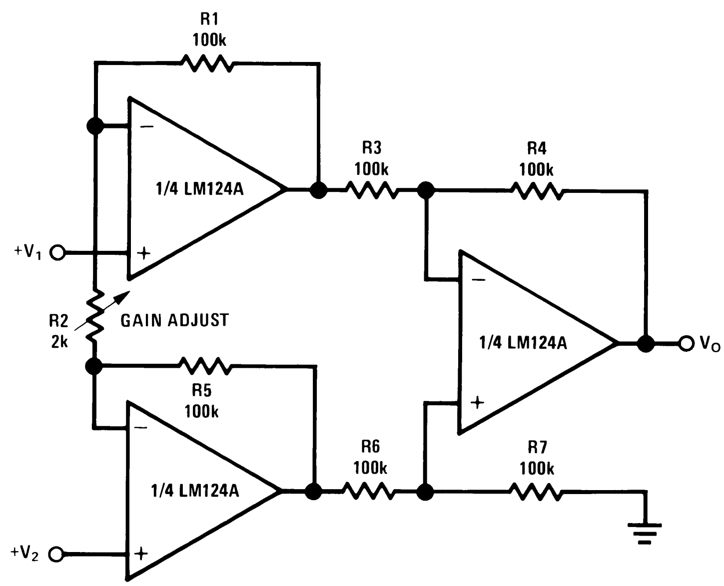
DS009299-27

For $\frac{R1}{R2} = \frac{R4}{R3}$ (CMRR depends on this resistor ratio match)

$V_O = 1 + \frac{R4}{R3}(V_2 - V_1)$

As shown: $V_O = 2(V_2 - V_1)$

High Input Z Adjustable-Gain DC Instrumentation Amplifier



DS009299-28

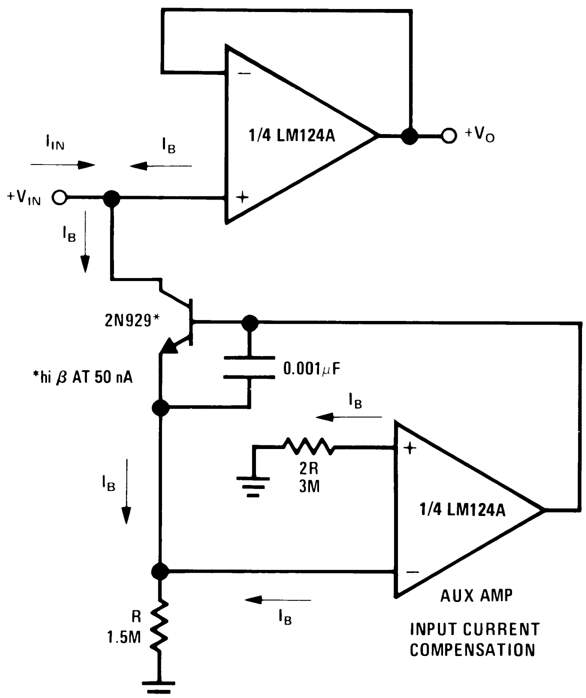
If R1 = R5 & R3 = R4 = R6 = R7 (CMRR depends on match)

$V_O = 1 + \frac{2R1}{R2}(V_2 - V_1)$

As shown $V_O = 101\ (V_2 - V_1)$

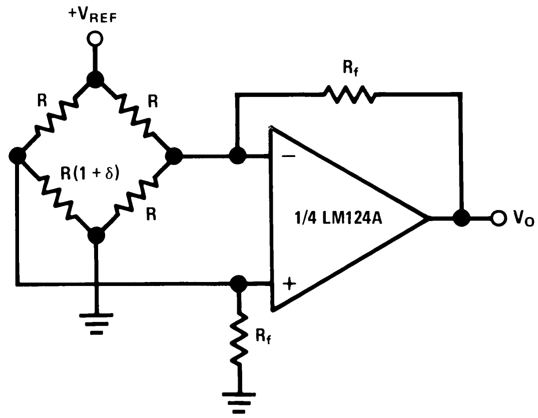
Typical Single-Supply Applications ($V^+ = 5.0\ V_{DC}$) (Continued)

Using Symmetrical Amplifiers to Reduce Input Current (General Concept)



DS009299-29

Bridge Current Amplifier

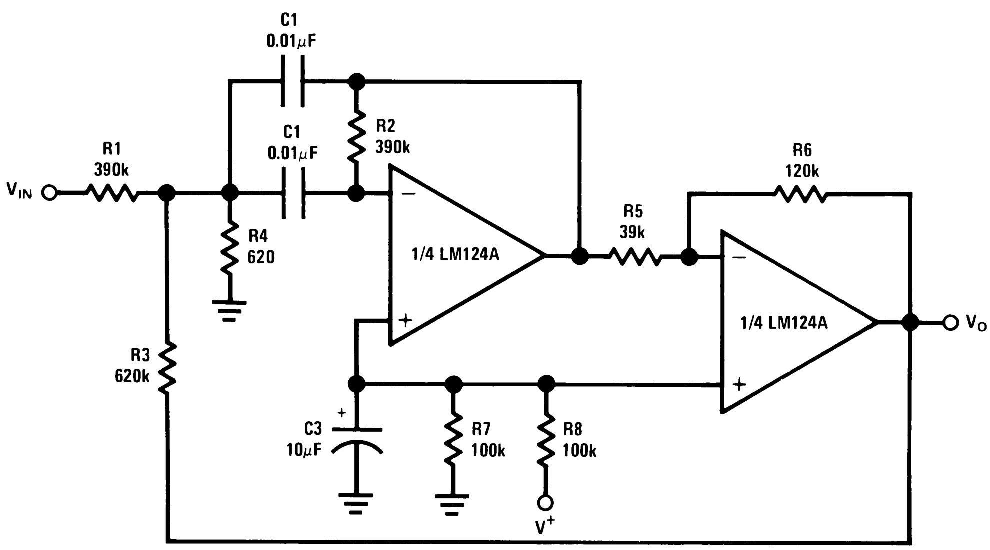


DS009299-30

For $\delta << 1$ and $R_f >> R$

$$V_O \cong V_{REF} \left(\frac{\delta}{2}\right) \frac{R_f}{R}$$

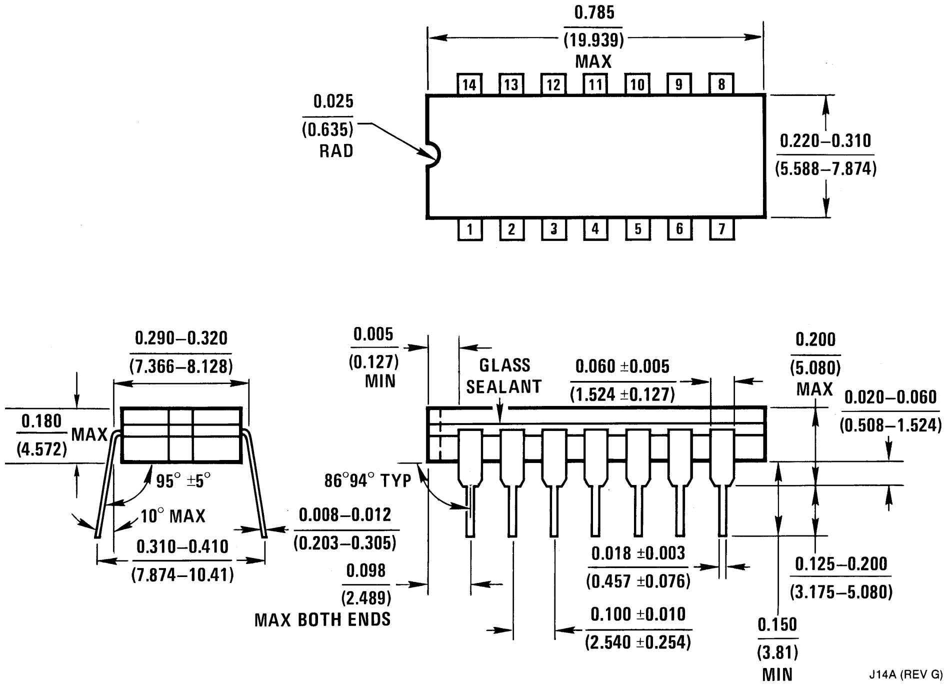
Bandpass Active Filter



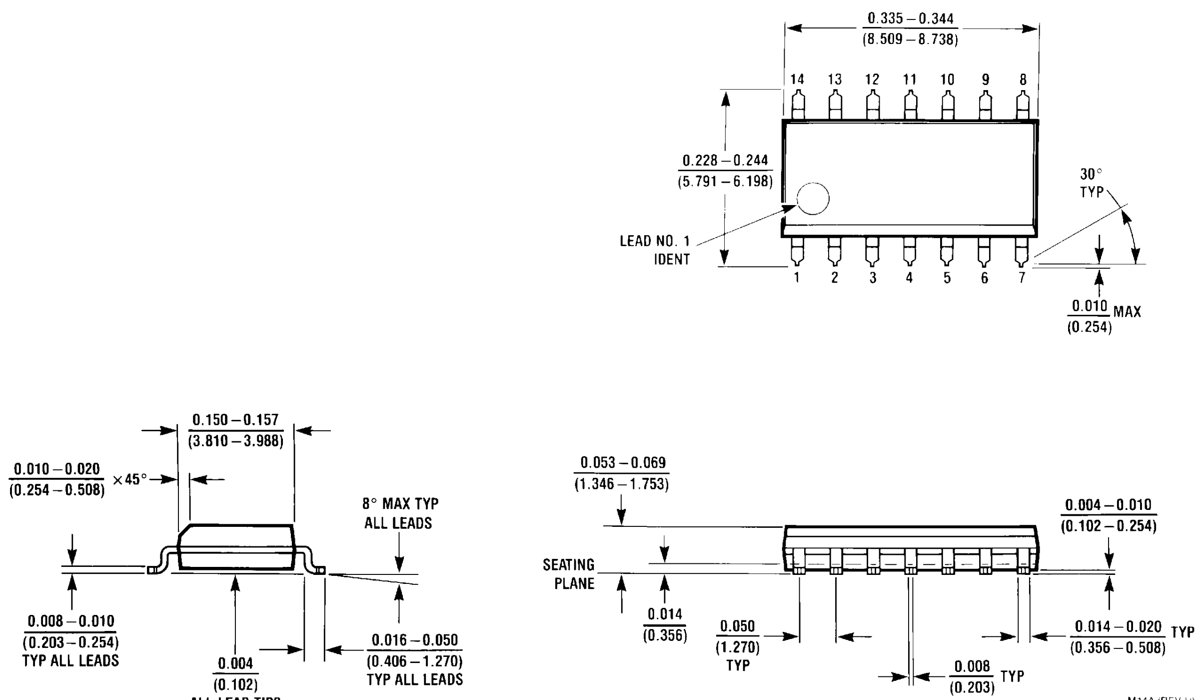
DS009299-31

$f_O = 1$ kHz
Q = 25

Physical Dimensions inches (millimeters) unless otherwise noted

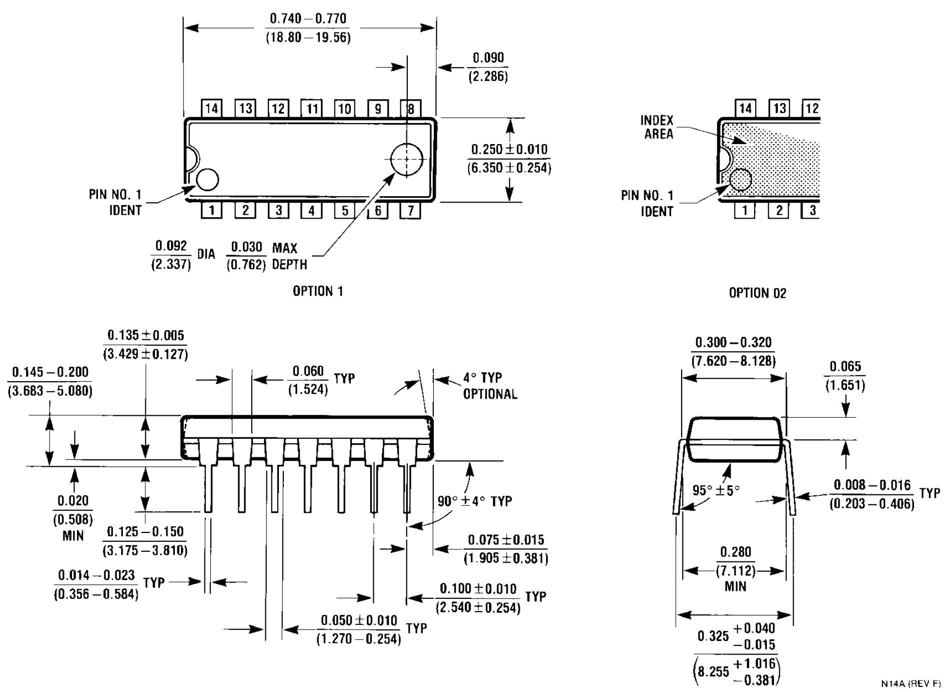


Ceramic Dual-In-Line Package (J)
Order Number JL124ABCA, JL124BCA, JL124ASCA, JL124SCA, LM124J, LM124AJ, LM124AJ/883, LM124J/883, LM224J, LM224AJ or LM324J
NS Package Number J14A

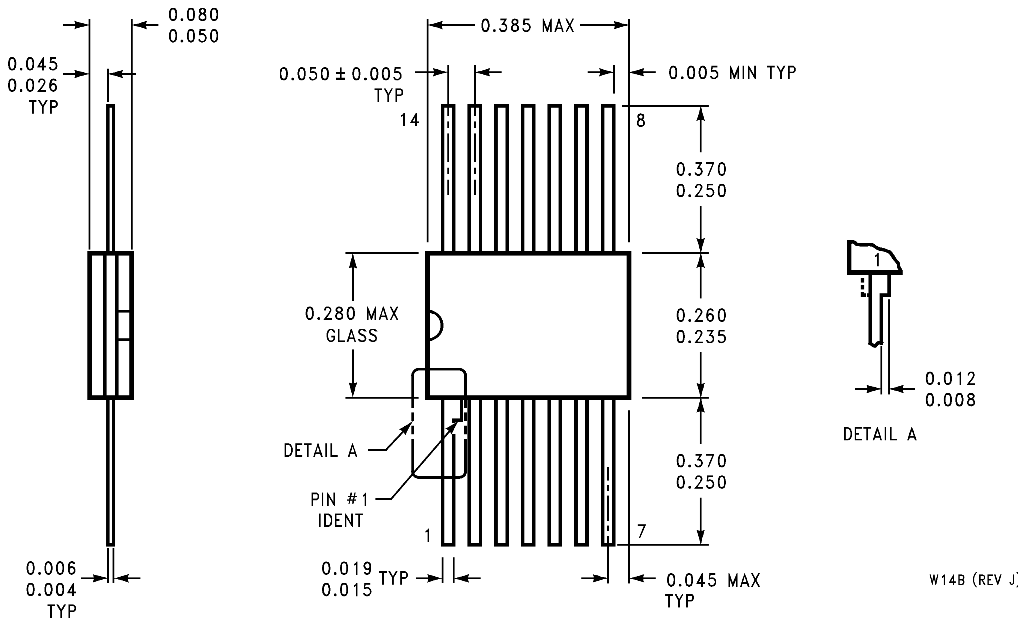


MX S.O. Package (M)
Order Number LM324M, LM324MX, LM324AM, LM324AMX, LM2902M or LM2902MX
NS Package Number M14A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)

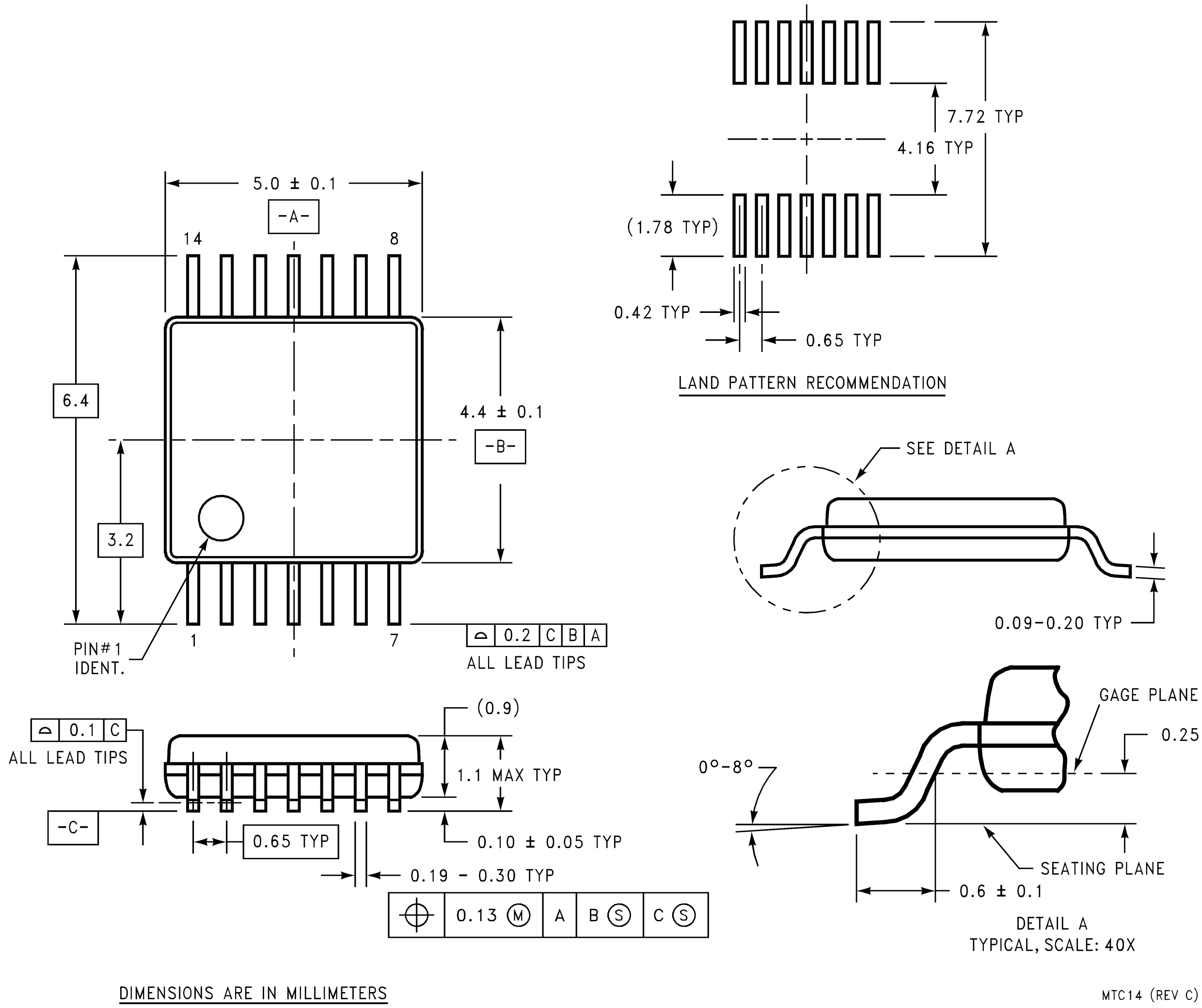


Molded Dual-In-Line Package (N)
Order Number LM324N, LM324AN or LM2902N
NS Package Number N14A



Ceramic Flatpak Package
Order Number JL124ABDA, JL124ABZA, JL124ASDA, JL124BDA, JL124BZA, JL124SDA, LM124AW/883, LM124AWG/883, LM124W/883 or LM124WG/883
NS Package Number W14B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



14-Pin TSSOP
Order NumberLM324MT or LM324MTX
NS Package Number MTC14

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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HTP-420

EXPLODED VIEW PARTS LIST

<Notes>
(B) : Black model
(S) : Silver model
<MDD> : American model
<MDC> : Canadian model
<MDT> : Asian model (120V)
<MPA> : Australian model
<MGT> : Asian model (220-230V)
<MPT> : Asian model (230-240V)

NOTE : THE COMPONENTS IDENTIFIED BY THE MARK ! ARE CRITICAL FOR RISK OF FIRE AND ELECTRIC SHOCK. REPLACE ONLY WITH PART NUMBER SPECIFIED.

	REF. NO.	PART NAME	DESCRIPTION	Q'TY	PART NO. (SN)	MARK
EXPLODED	**SKW-420 (B) / (S) : POWERED SUBWOOFER**					
EXPLODED	SP01	CABINET ASS'Y (B)	Black	1	ANW8W670BBM10	<MDD>
EXPLODED	SP01	CABINET ASS'Y (B)	Black	1	ANW8W670BBM10	<MDC>
EXPLODED	SP01	CABINET ASS'Y (B)	Black	1	ANW8W670BBM30	<MPA>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM10	<MDD>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM10	<MDC>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM10	<MDT>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM30	<MPA>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM40	<MGT>
EXPLODED	SP01	CABINET ASS'Y (S)	Silver	1	ANW8W670SBM60	<MPT>
EXPLODED	SP02	FOOT	D87.5 x D37.5 x H50 HIPS BLK	4	BPE8000040001	
EXPLODED	SP03	BOTTOM BOARD	F2905-GW	1	ANF860002BM10	(B)
EXPLODED	SP03	BOTTOM BOARD	F2905-GW	1	ANF860003BM10	(S)
EXPLODED	SP04	FRONT PLATE	SKW-420 / ONKYO NAME PLATE	1	BPL8001470001	
EXPLODED	SP05	WOOD SCREW	8 x 4 x L75 (FOR FOOT)	8	NST8550514750	
EXPLODED	SP06	WOOD SCREW	4STT+20A (FOR AMPLIFIER / SP)	18	837440204	
EXPLODED	SP08	WOOFER SPEAKER	20cm 4ohm 50W	1	W20178A	
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750001	<MDD>
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750001	<MDC>
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750001	<MDT>
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750004	<MPA>
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750003	<MGT>
EXPLODED	A01	REAR PANEL	"SKW-420" SPCC 190 x 120 x T2.0mm	1	GSE4001750004	<MPT>
EXPLODED	A02	AC CORD	LINE CORD 2P 1800mm BLK POLARIZE	1	VPA0040120010	! <MDD>
EXPLODED	A02	AC CORD	LINE CORD 2P 1800mm BLK POLARIZE	1	VPA0040120010	! <MDC>
EXPLODED	A02	AC CORD	LINE CORD 2P 1800mm BLK POLARIZE	1	VPA0040120010	! <MDT>
EXPLODED	A02	AC CORD	LINE CORD 2P 1980mm BLK SAA	1	VPE0010140010	! <MPA>
EXPLODED	A02	AC CORD	LINE CORD 2P 1980mm BLK VDE	1	VPE003012-0020	! <MGT>
EXPLODED	A02	AC CORD	LINE CORD 2P 1980mm BLK VDE	1	VPE003012-0020	! <MPT>
EXPLODED	A03	BUSHING	AC LINE BUSHING	1	DBU001002-0011	!
EXPLODED	A04	POWER TRANSFORMER	AC120V / 60Hz 100W	1	TTI1120010120	! <MDD>
EXPLODED	A04	POWER TRANSFORMER	AC120V / 60Hz 100W	1	TTI1120010120	! <MDC>
EXPLODED	A04	POWER TRANSFORMER	AC120V / 60Hz 100W	1	TTI1120010120	! <MDT>
EXPLODED	A04	POWER TRANSFORMER	AC230 / 240V / 50Hz 100W	1	TTI4234100010	! <MPA>
EXPLODED	A04	POWER TRANSFORMER	AC220 / 230V / 50Hz 100W	1	TTI4223100010	! <MGT>
EXPLODED	A04	POWER TRANSFORMER	AC230 / 240V / 50Hz 100W	1	TTI4234100010	! <MPT>
EXPLODED	A05	SCREW	M4.0 x P0.7 x L25mm (FOR TRANS)	4	HSD1431033250	
EXPLODED	A06	POWER SWITCH	ROCKER 5A AC 250V TV-5	1	MSW0080040010	! <MPA>

EXPLODED	A06	POWER SWITCH	ROCKER 5A AC 250V TV-5	1	MSW0080040010	! <MGT>
EXPLODED	A06	POWER SWITCH	ROCKER 5A AC 250V TV-5	1	MSW0080040010	! <MPT>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW WALT	2	KSA0204000011	! <MDD>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW WALT	2	KSA0204000011	! <MDC>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW WALT	2	KSA0204000011	! <MDT>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW 5ST	2	KSA0204000020	! <MPA>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW 5ST	2	KSA0204000020	! <MGT>
EXPLODED	F902, F903	FUSE	4A / 250V SLOW 5ST	2	KSA0204000020	! <MPT>
EXPLODED	U01	MAIN PC BOARD ASS'Y	MAIN PC BOARD ASS'Y	1	APE4012115001	
EXPLODED	<Note>					
EXPLODED	U01 : MAIN PC BOARD ASS'Y = PCB BRACKET + HEAT SINK + ALL PARTS FOR MAIN PC BOARD					
EXPLODED	U02	INPUT PC BOARD ASS'Y	INPUT PC BOARD ASS'Y	1	APE4012125001	
EXPLODED	<Note>					
EXPLODED	U02 : INPUT PC BOARD ASS'Y = INPUT PC BOARD with RCA JACK + CORD ASS'Y					
EXPLODED	U03	VR / LED PC BOARD ASS'Y	VR / LED PC BOARD ASS'Y	1	APE4012135001	
EXPLODED	<Note>					
EXPLODED	U03 : VR/ LED PC BOARD ASS'Y = VR / LED PC BOARD with VR / LED / CORD ASS'Y etc.					
EXPLODED	**SKF-420F (B) : FRONT SPEAKERS L / R**					
EXPLODED	SP10	COMPLETE UNIT	"SKF-420F (B) L"	1	ANM8S670BBM10	(B)
EXPLODED	SP11	BACK LABEL (L)	---	1	YLB810004FL10	(B)
EXPLODED	SP12	COMPLETE UNIT	"SKF-420F (B) R"	1	ANM8S670BBM11	(B)
EXPLODED	SP13	BACK LABEL (R)	---	1	YLB810004FR10	(B)
EXPLODED	**SKF-420F (S) : FRONT SPEAKERS L / R**					
EXPLODED	SP10	COMPLETE UNIT	"SKF-420F (S) L"	1	ANM8S670SBM10	(S)
EXPLODED	SP11	BACK LABEL (L)	---	1	YLB810004FL10	(S)
EXPLODED	SP12	COMPLETE UNIT	"SKF-420F (S) R"	1	ANM8S670SBM11	(S)
EXPLODED	SP13	BACK LABEL (R)	---	1	YLB810004FR10	(S)
EXPLODED	**SKC-420C (B) : CENTER SPEAKER**					
EXPLODED	SP14	COMPLETE UNIT	"SKC-420C (B)"	1	ANC8S670BBM10	(B)
EXPLODED	SP15	BACK LABEL	---	1	YLB810004C010	(B)
EXPLODED	**SKC-420C (S) : CENTER SPEAKER**					
EXPLODED	SP14	COMPLETE UNIT	"SKC-420C (S)"	1	ANC8S670SBM10	(S)
EXPLODED	SP15	BACK LABEL	---	1	YLB810004C010	(S)
EXPLODED	**SKM-420S (B) : SURROUND SPEAKERS L / R**					
EXPLODED	SP16	COMPLETE UNIT	"SKM-420S (B) L"	1	ANU8S670BBM10	(B)
EXPLODED	SP17	BACK LABEL (L)	---	1	YLB810004SL10	(B)
EXPLODED	SP18	COMPLETE UNIT	"SKM-420S (B) R"	1	ANU8S670BBM11	(B)
EXPLODED	SP19	BACK LABEL (R)	---	1	YLB810004SR10	(B)
EXPLODED	**SKM-420S (S) : SURROUND SPEAKERS L / R**					
EXPLODED	SP16	COMPLETE UNIT	"SKM-420S (S) L"	1	ANU8S670SBM10	(S)
EXPLODED	SP17	BACK LABEL (L)	---	1	YLB810004SL10	(S)
EXPLODED	SP18	COMPLETE UNIT	"SKM-420S (S) R"	1	ANU8S670SBM11	(S)
EXPLODED	SP19	BACK LABEL (R)	---	1	YLB810004SR10	(S)

HTP-420

PRINTED CIRCUIT BOARD PARTS LIST

	CIRCUIT NO.	PART NAME	DESCRIPTION	Q'TY	PART NO. (SN)	MARK
PWB	IC501	POWER IC	15PIN TDA7293	1	RHI007293-0001	
PWB	DB901	DIODE	RS402L 4A 100V	1	RHD2040100011	!

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