

T-74-05-01

**18W Hi-Fi AMPLIFIER AND 35W DRIVER**

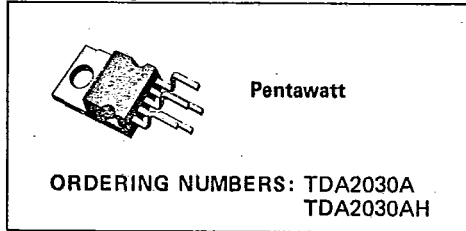
The TDA2030A is a monolithic IC in Pentawatt® package intended for use as low frequency class AB amplifier.

With  $V_{s\ max} = 44V$  it is particularly suited for more reliable applications without regulated supply and for 35W driver circuits using low-cost complementary pairs.

The TDA2030A provides high output current and has very low harmonic and cross-over distortion.

Further the device incorporates a short circuit protection system comprising an arrangement for automatically limiting the dissipated power so as to keep the working point of the output

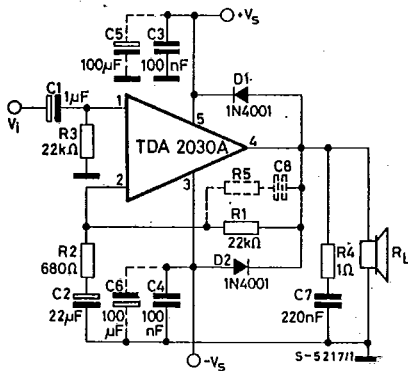
transistors within their safe operating area. A conventional thermal shut-down system is also included



**ABSOLUTE MAXIMUM RATINGS**

$V_s$	Supply voltage	$\pm 22$	V
$V_i$	Input voltage	$V_s$	
$V_d$	Differential input voltage	$\pm 15$	V
$I_o$	Peak output current (internally limited)	3.5	A
$P_{tot}$	Total power dissipation at $T_{case} = 90^\circ C$	20	W
$T_{stg}, T_j$	Storage and junction temperature	-40 to 150	$^\circ C$

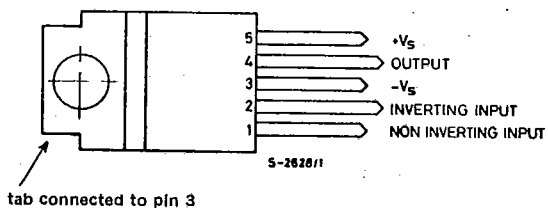
**TYPICAL APPLICATION**



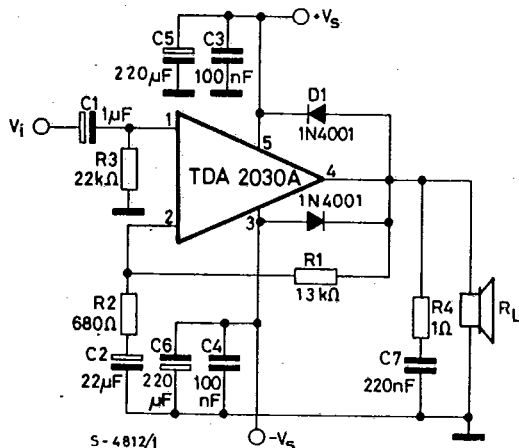
CONNECTION DIAGRAM  
(top view)

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TEST CIRCUIT



THERMAL DATA

$R_{th J-case}$	Thermal resistance junction-case	max 3 °C/W
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**ELECTRICAL CHARACTERISTICS** (Refer to the test circuit,  $V_s = \pm 16V$ ,  $T_{amb} = 25^\circ C$  unless otherwise specified)

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Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_s$ Supply voltage		$\pm 6$		$\pm 22$	V
$I_d$ Quiescent drain current			50	80	mA
$I_b$ Input bias current	$V_s = \pm 22V$		0.2	2	$\mu A$
$V_{os}$ Input offset voltage			$\pm 2$	$\pm 20$	mV
$I_{os}$ Input offset current			$\pm 20$	$\pm 200$	nA
$P_o$ Output power	$d = 0.5\%$ $G_v = 26$ dB $f = 40$ to $15000$ Hz $R_L = 4 \Omega$ $R_L = 8 \Omega$	15 10	18 12		W
	$V_s = \pm 19V$ $R_L = 8 \Omega$	13	16		
BW Power bandwidth	$P_o = 15W$ $R_L = 4 \Omega$		100		KHz
SR Slew Rate			8		V/ $\mu$ sec
$G_v$ Open loop voltage gain	$f = 1$ KHz		80		dB
$G_v$ Closed loop voltage gain		25.5	26	26.5	dB
d Total harmonic distortion	$P_o = 0.1$ to $14W$ $R_L = 4 \Omega$ $f = 40$ to $15000$ Hz $f = 1$ KHz		0.08 0.03		%
	$P_o = 0.1$ to $9W$ $R_L = 8 \Omega$ $f = 40$ to $15000$ Hz		0.05		%
$d_2$ Second order CCIF intermodulation distortion	$P_o = 4W$ $R_L = 4 \Omega$	$f_2 - f_1 = 1$ KHz	0.03		%
$d_3$ Third order CCIF Intermodulation distortion	$f_1 = 14$ KHz $f_2 = 15$ KHz	$2 f_1 - f_2 = 13$ KHz	0.08		%
$e_N$ Input noise voltage	B = curve A		2		$\mu V$
	B = 22 Hz to 22 KHz		3	10	
$I_N$ Input noise current	B = curve A		50		$\mu A$
	B = 22 Hz to 22 KHz		80	200	
S/N Signal to noise ratio	$R_L = 4 \Omega$ $R_g = 10$ K $\Omega$ B = curve A	$P_o = 15W$	106		dB
		$P_o = 1W$	94		

Parameter	Test conditions	Min.	Typ.	Max.	Unit
$R_i$ Input resistance (pin 1)	(open loop) $f = 1 \text{ KHz}$	0.5	5		$M\Omega$
SVR Supply voltage rejection	$R_L = 4 \Omega$ $G_V = 26 \text{ dB}$ $R_g = 22 \text{ K}\Omega$ $f = 100 \text{ Hz}$		54		dB
$T_j$ Thermal shut-down junction temperature			145		$^{\circ}\text{C}$

Fig. 1 - Single supply amplifier

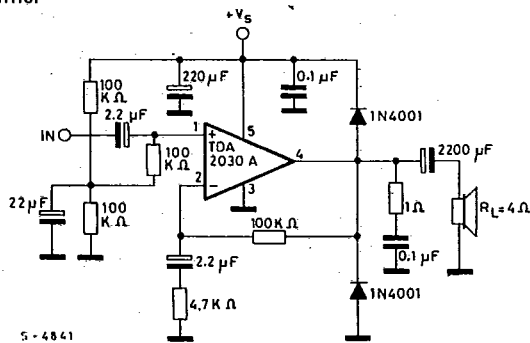


Fig. 2 - Open loop-frequency response

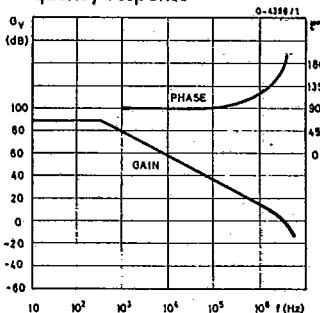


Fig. 3 - Output power vs. supply voltage

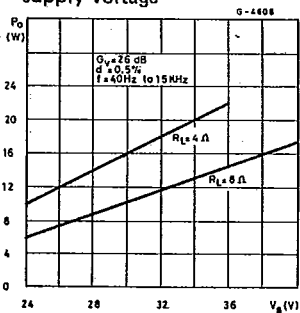
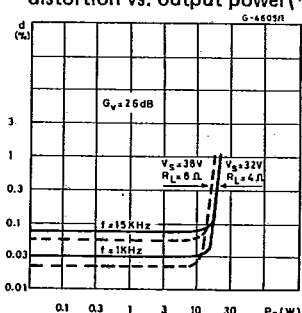


Fig. 4 - Total harmonic distortion vs. output power(\*)



\*) Test using noise filters.

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T-74-05-01

Fig. 5 - Two tone CCIF intermodulation distortion

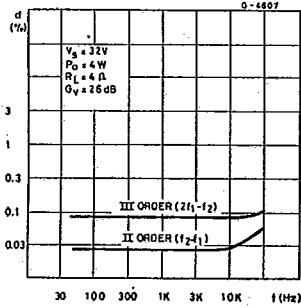


Fig. 6 - Large signal frequency response

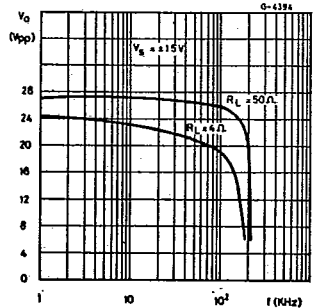


Fig. 7 - Maximum allowable power dissipation vs. ambient temperature

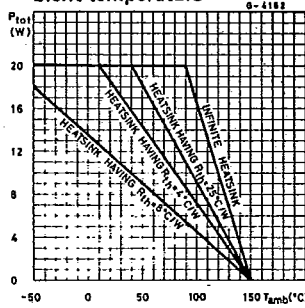


Fig. 8 - Single supply high power amplifier (TDA 2030A + BD907/BD908)

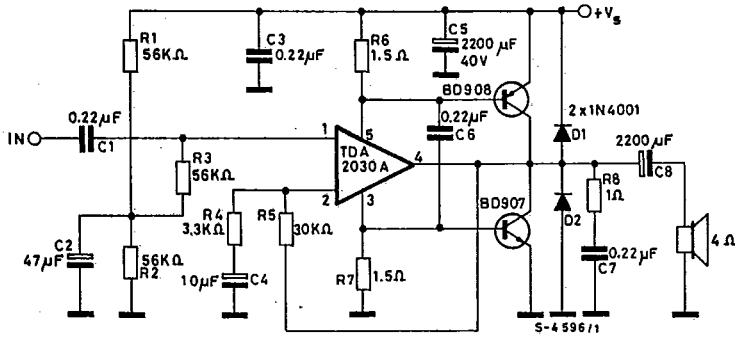
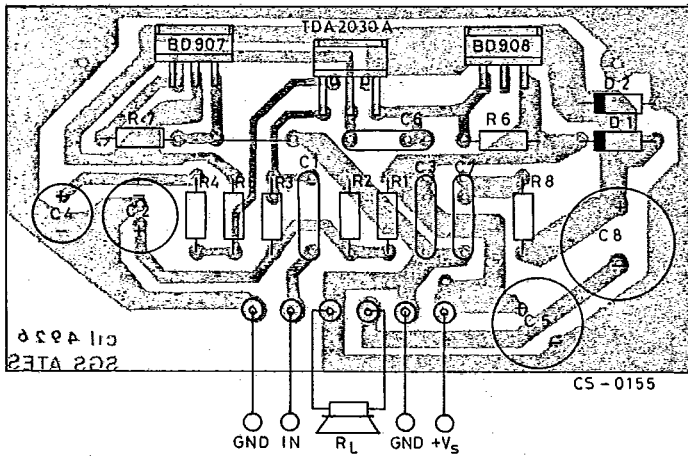


Fig. 9 - P.C. board and component layout for the circuit of fig. 8 (1:1 scale)

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Typical performance of the circuit of fig. 8

Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_s$ Supply voltage			36	44	V
$I_d$ Quiescent drain current	$V_s = 36V$		50		mA
$P_o$ Output power	$d = 0.5\%$ $R_L = 4\Omega$ $f = 40\text{Hz to } 15\text{KHz}$	$V_s = 39V$	35		W
		$V_s = 36V$	28		
	$d = 10\%$ ; $f = 1\text{KHz}$ $R_L = 4\Omega$	$V_s = 39V$		44	W
		$V_s = 36V$		35	
$G_v$ Voltage gain	$f = 1\text{ KHz}$	19.5	20	20.5	dB
SR Slew Rate			8		V/ $\mu\text{sec}$
$d$ Total harmonic distortion	$f = 1\text{KHz}$		0.02		%
	$P_o = 20W$ $f = 40\text{ Hz to } 15\text{ KHz}$		0.05		
$V_i$ Input sensitivity	$G_v = 20\text{ dB}$ $P_o = 20W$ $f = 1\text{ KHz}$ $R_L = 4\Omega$		890		mV
S/N Signal to noise ratio	$R_L = 4\Omega$ $R_g = 10\text{ K}\Omega$ B = curve A	$P_o = 25W$	108		dB
		$P_o = 4W$	100		

Fig. 10 - Output power vs. supply voltage

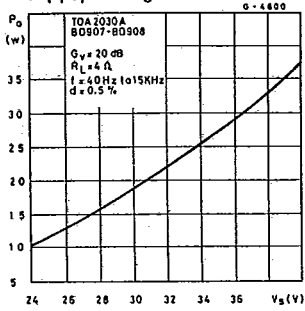


Fig. 11 - Total harmonic distortion vs. output power

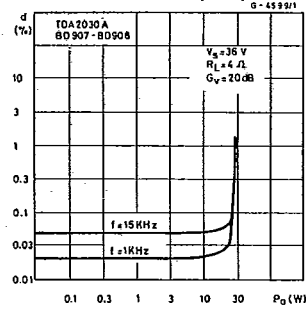
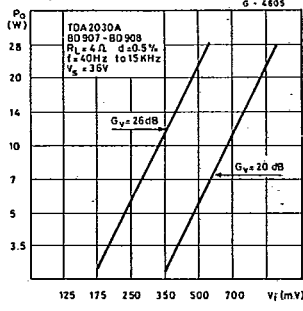


Fig. 12 - Output power vs. input level



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Fig. 13 - Power dissipation vs. output power

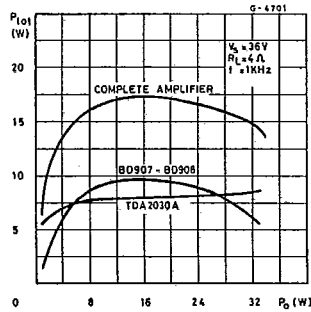


Fig. 14 - Typical amplifier with split power supply

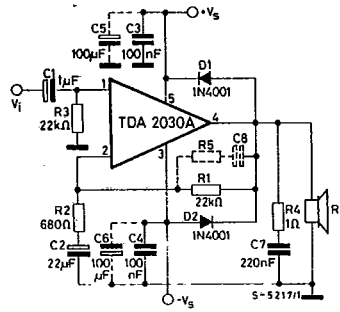


Fig. 15 - P.C. board and component layout for the circuit of fig. 14 (1 : 1 scale)

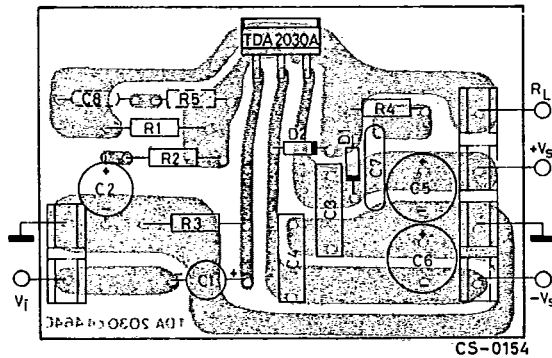


Fig. 16 - Bridge amplifier with split power supply ( $P_o = 34W$ ,  $V_s = \pm 16V$ )

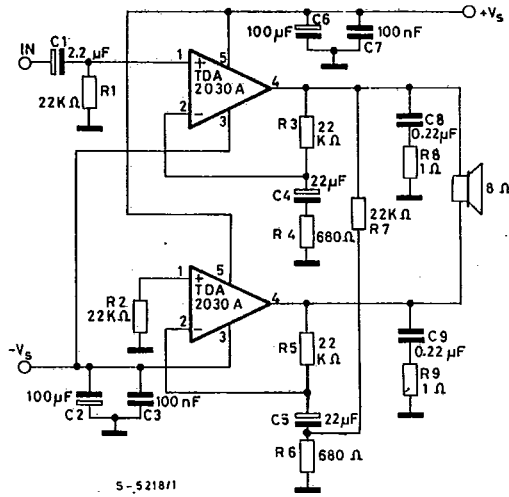
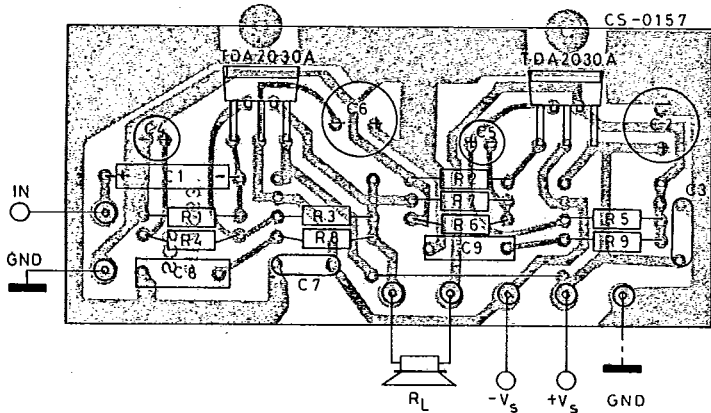


Fig. 17 - P.C. board and component layout for the circuit in fig. 16 (1:1 scale)





## Multiway speaker systems and active boxes

Multiway loudspeaker systems provide the best possible acoustic performance since each loudspeaker is specially designed and optimized to handle a limited range of frequencies. Commonly, these loudspeaker systems divide the audio spectrum into two or three bands.

To maintain a flat frequency response over the HI-FI audio range the bands covered by each loudspeaker must overlap slightly. Imbalance between the loudspeakers produces unacceptable results therefore it is important to ensure that each unit generates the correct amount of acoustic energy for its segment of the audio spectrum. In this respect it is also important to know the energy distribution of the music spectrum to determine the cutoff frequencies of the crossover filters (see Fig. 18). As an example, a 100W three-way system with crossover frequencies of 400Hz and 3KHz would require 50W for the woofer, 35W for the midrange unit and 15W for the tweeter.

Both active and passive filters can be used for crossovers but today active filters cost significantly less than a good passive filter using air-cored inductors and non-electrolytic capacitors. In addition, active filters do not suffer from the typical defects of passive filters:

- power loss;
- increased impedance seen by the loudspeaker (lower damping)

- difficulty of precise design due to variable loudspeaker impedance.

Obviously, active crossovers can only be used if a power amplifier is provided for each drive unit. This makes it particularly interesting and economically sound to use monolithic power amplifiers.

In some applications, complex filters are not really necessary and simple RC low-pass and high-pass networks (6dB/octave) can be recommended.

The result obtained are excellent because this is the best type of audio filter and the only one free from phase and transient distortion.

The rather poor out of band attenuation of single RC filters means that the loudspeaker

Fig. 19 - Active power filter

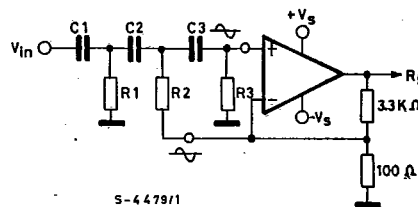
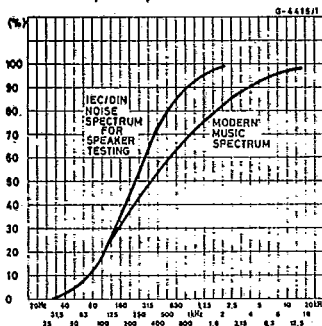


Fig. 18 - Power distribution vs. frequency



must operate linearly well beyond the crossover frequency to avoid distortion.

A more effective solution, named "Active Power Filter" by SGS is shown in Fig. 19.

The proposed circuit can realize combined power amplifiers and 12dB/octave or 18dB/octave high-pass or low-pass filters.

In practice, at the input pins of the amplifier two equal and in-phase voltages are available, as required for the active filter operation.

The impedance at the pin (-) is of the order of 100Ω, while that of the pin (+) is very high, which is also what was wanted.

The component values calculated for  $f_c = 900\text{Hz}$  using a Bessel 3rd order Sallen and Key structure are:

$C_1 = C_2 = C_3$	$R_1$	$R_2$	$R_3$
22nF	8.2K $\Omega$	5.6K $\Omega$	33K $\Omega$

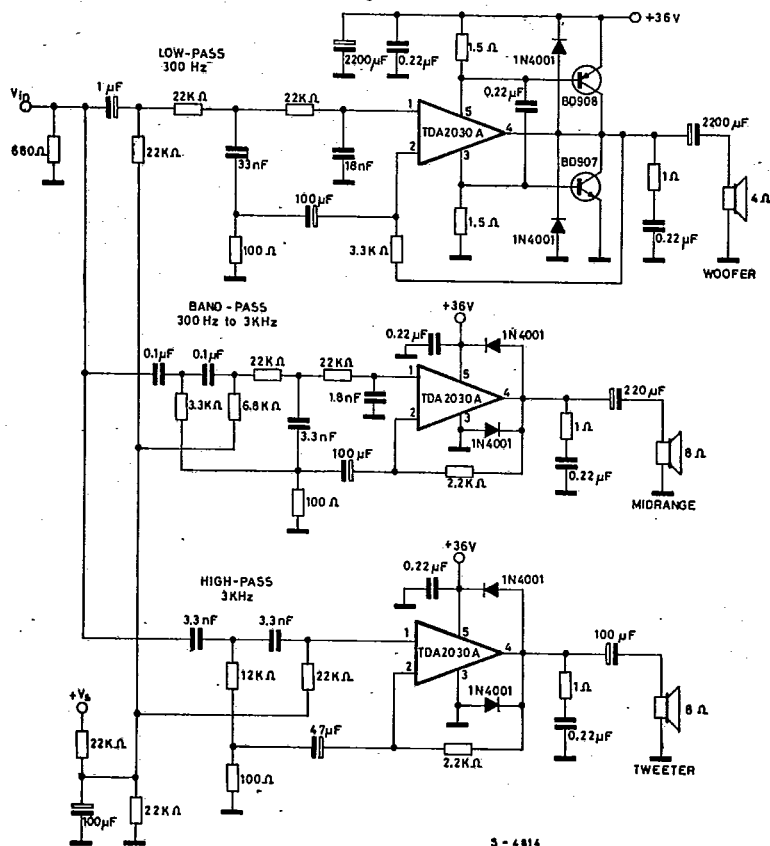
Using this type of crossover filter, a complete 3-way 60W active loudspeaker system is shown in Fig. 20.

It employs 2nd order Butterworth filters with the crossover frequencies equal to 300Hz and 3KHz.

The midrange section consists of two filters, a high pass circuit followed by a low pass network. With  $V_s = 36\text{V}$  the output power delivered to the woofer is 25W at  $d = 0.06\%$  (30W at  $d = 0.5\%$ ). The power delivered to the midrange and the tweeter can be optimized in the design phase taking in account the loudspeaker efficiency and impedance ( $R_L = 4\Omega$  to  $8\Omega$ ).

It is quite common that midrange and tweeter speakers have an efficiency 3dB higher than woofers.

Fig. 20 - 3 way 60W active loudspeaker system ( $V_s = 36\text{V}$ )

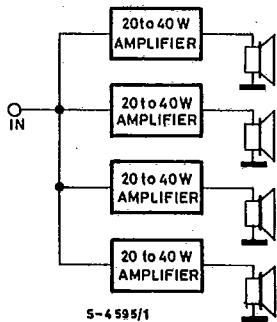


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**Musical instruments amplifiers**

Another important field of application for active systems is music. In this area the use of several medium power amplifiers is more convenient than a single high power amplifier, and it is also more reliable. A typical example (see Fig. 21) consist of four amplifiers each driving a low-cost, 12 inch loud-speaker. This application can supply 80 to 160W rms.

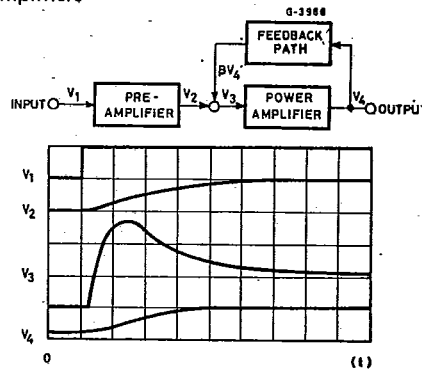
Fig. 21 - High power active box for musical instrument



**Transient intermodulation distortion (TIM)**

Transient intermodulation distortion is an unfortunate phenomenon associated with negative-feedback amplifiers. When a feedback amplifier receives an input signal which rises very steeply, i.e. contains high-frequency components, the feedback can arrive too late so that the amplifiers overloads and a burst of intermodulation distortion will be produced as in Fig. 22. Since transients occur frequently in music this obviously a problem for the designer of audio amplifiers. Unfortunately, heavy negative feedback is frequently used to reduce the total harmonic distortion of an amplifier, which tends to aggravate the transient intermodulation (TIM) situation. The best known method for the measurement of TIM consists of feeding sine waves superimposed onto square waves, into the amplifier under test. The output spectrum is then examined using a

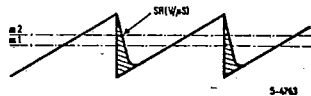
Fig. 22 - Overshoot phenomenon in feedback amplifiers



spectrum analyser and compared to the input. This method suffers from serious disadvantages: the accuracy is limited, the measurement is a rather delicate operation and an expensive spectrum analyser is essential. A new approach (see Technical Note 143) applied by SGS to monolithic amplifiers measurement is fast cheap-it requires nothing more sophisticated than an oscilloscope - and sensitive - and it can be used down to the values as low as 0.002% in high power amplifiers.

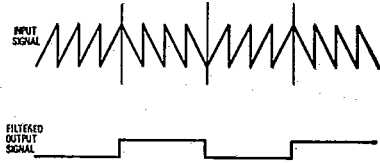
The "inverting-sawtooth" method of measurement is based on the response of an amplifier to a 20KHz sawtooth waveform. The amplifier has no difficulty following the slow ramp but it cannot follow the fast edge. The output will follow the upper line in Fig. 23 cutting off the shaded area and thus increasing the mean level. If this output signal is filtered to remove the sawtooth, direct voltage remains which indicates the amount of TIM distortion, although it is difficult to measure because it is indistinguishable from the DC offset of the amplifier. This problem is neatly avoided in the IS-TIM method

Fig. 23 - 20KHz sawtooth waveform



by periodically inverting the sawtooth waveform at a low audio frequency as shown in Fig. 24. In the case of the sawtooth in Fig. 25 the mean level was increased by the TIM distortion, for a sawtooth in the other direction the opposite is true.

Fig. 24 - Inverting sawtooth waveform

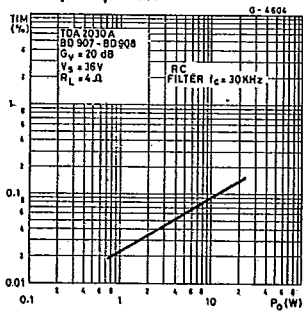


The result is an AC signal at the output whose peak-to-peak value is the TIM voltage, which can be measured easily with an oscilloscope. If the peak-to-peak value of the signal and the peak-to-peak of the inverting sawtooth are measured, the TIM can be found very simply from:

$$TIM = \frac{V_{out}}{V_{sawtooth}} \cdot 100$$

In Fig. 25 the experimental results are shown for the 30W amplifier using the TDA2030A as a driver and a low-cost complementary pair. A simple RC filter on the input of the amplifier to limit the maximum signal slope (SS) is an effective way to reduce TIM:

Fig. 25 - TIM distortion vs. output power

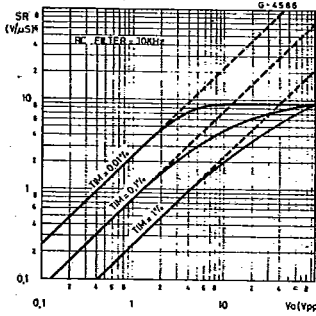


The diagram of Fig. 26 originated by SGS can be used to find the Slew-Rate (SR) required for a given output power or voltage and a TIM design target.

For example if an anti-TIM filter with a cutoff at 30KHz is used and the max. peak-to-peak output voltage is 20V then, referring to the diagram, a Slew-Rate of 6V/ $\mu$ s is necessary for 0.1% TIM.

As shown Slew-Rates of above 10V/ $\mu$ s do not contribute to a further reduction in TIM. Slew-Rates of 100/ $\mu$ s are not only useless but also a disadvantage in Hi-Fi audio amplifiers because they tend to turn the amplifier into a radio receiver.

Fig. 26 - TIM design diagram ( $f_c = 30$ KHz)



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Power supply

Using monolithic audio amplifier with non-regulated supply voltage it is important to design the power supply correctly. In any working case it must provide a supply voltage less than the maximum value fixed by the IC breakdown voltage.

It is essential to take into account all the working conditions, in particular mains fluctuations and supply voltage variations with and without load. The TDA2030A ( $V_{s,max} = 44$ V) is particularly suitable for substitution of the standard IC power amplifiers (with  $V_{s,max} = 36$ V) for more reliable applications.

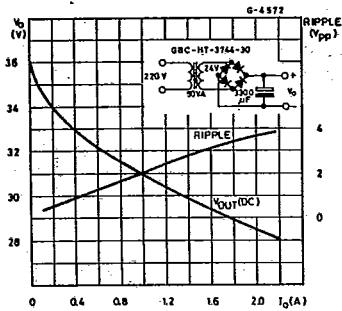
An example, using a simple full-wave rectifier followed by a capacitor filter, is shown in the table and in the diagram of Fig. 27.

A regulated supply is not usually used for the power output stages because of its dimensioning must be done taking into account the power to supply in the signal peaks. They are only a small percentage of the total music signal, with consequently large overdimensioning of the circuit.

Even if with a regulated supply higher output power can be obtained ( $V_s$  is constant in all working conditions), the additional cost and power dissipation do not usually justify its use. Using non-regulated supplies, there are fewer design restrictions. In fact, when signal peaks are present, the capacitor filter acts as a flywheel supplying the required energy.

In average conditions, the continuous power supplied is lower. The music power/continuous power ratio is greater in this case than for the case of regulated supply, with space saving and cost reduction.

Fig. 27 - DC characteristics of 50W non-regulated supply



Mains (220V)	Secondary voltage	DC output voltage ( $V_o$ )		
		$I_o = 0$	$I_o = 0.1A$	$I_o = 1A$
+20%	28.8V	43.2V	42V	37.5V
+15%	27.6V	41.4V	40.3V	35.8V
+10%	26.4V	39.6V	38.5V	34.2V
-	24V	36.2V	35V	31V
-10%	21.6V	32.4V	31.5V	27.8V
-15%	20.4V	30.6V	29.8V	26V
-20%	19.2V	28.8V	28V	24.3V

## Application suggestion

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T-74-05-01

The recommended values of the components are those shown on application circuit of Fig. 14.

Different values can be used. The following table can help the designer.

Component	Recommended value	Purpose	Larger than recommended value	Smaller than recommended value
R1	22K $\Omega$	Closed-loop gain setting.	Increase of gain.	Decrease of gain. *
R2	680 $\Omega$	Closed loop gain setting.	Decrease of gain. *	Increase of gain.
R3	22K $\Omega$	Non inverting input biasing.	Increase of input impedance.	Decrease of input impedance.
R4	1 $\Omega$	Frequency stability.	Danger of oscillation at high frequencies with inductive loads.	
R5	$\cong 3 R2$	Upper frequency cutoff.	Poor high frequencies attenuation.	Danger of oscillation.
C1	1 $\mu$ F	Input DC decoupling.		Increase of low frequencies cutoff.
C2	22 $\mu$ F	Inverting DC decoupling.		Increase of low frequencies cutoff.
C3, C4	0.1 $\mu$ F	Supply voltage bypass.		Danger of oscillation.
C5, C6	100 $\mu$ F	Supply voltage bypass.		Danger of oscillation.
C7	0.22 $\mu$ F	Frequency stability.		Larger bandwidth.
C8	$\cong \frac{1}{2\pi B R1}$	Upper frequency cutoff.	Smaller bandwidth.	Larger bandwidth.
D1, D2	1N4001	To protect the device against output voltage spikes.		

\* The value of closed loop gain must be higher than 24dB.

## SHORT CIRCUIT PROTECTION

The TDA2030A has an original circuit which limits the current of the output transistors. This function can be considered as being peak power limiting rather than simple current limiting. It reduces the possibility that the device gets damaged during an accidental short circuit from AC output to ground.

## THERMAL SHUT-DOWN

The presence of a thermal limiting circuit offers the following advantages:

1. An overload on the output (even if it is permanent), or an above limit ambient temperature can be easily supported since the  $T_j$  cannot be higher than 150°C.
2. The heatsink can have a smaller factor of safety compared with that of a conventional circuit. There is no possibility of device damage due to high junction temperature. If for any reason, the junction temperature increases up to 150°C, the thermal shut-down simply reduces the power dissipation and the current consumption.