40 W car radio high power amplifier — TDA1560Q

FEATURES

- Very high output power
- Low power dissipation when used for music signals
- Switches to low output power in the event of excessive heatsink temperatures
- Output power and power dissipation limited in the event of small load resistances
- Requires few external components
- Fixed gain
- Low cross-over distortion
- No switch-on/switch-off plops
- Mode select switch
- Low offset voltage at the output
- Load dump protection
- Short-circuit safe to ground or V_P and across the load
- Protected against electrostatic discharge
- Thermally protected
- Diagnostic facility
- Flexible leads.

GENERAL DESCRIPTION

The TDA1560Q is an integrated BTL class-H high power amplifier. In a load of 8 Ω, the output power is 40 W typical at a THD of 10%. The encapsulation is a 17-lead single-in-line (SIL) plastic power package. The device is primarily developed for car radio applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_P	supply voltage					
	operating		8	14.4	18	V
	non-operating		–	–	30	V
	load dump		–	–	45	V
I_{ORM}	repetitive peak output current		–	–	4	A
I_P	total quiescent current		–	100	160	mA
I_{sb}	standby current		–	5	50	μA
G_v	voltage gain		29	30	31	dB
P_o	output power					
		THD = 10%; 8 Ω	–	40	–	W
		THD = 0.5%; 8 Ω	–	30	–	W
		THD = 10%; 4 Ω	–	17	–	W
SVRR	supply voltage ripple rejection	R_S = 0 Ω; f = 100 Hz to 10 kHz	48	55	–	dB
V_{no}	noise output voltage		–	100	300	μV
$\|Z_i\|$	input impedance		180	300	–	kΩ
$\|\Delta V_o\|$	DC output offset voltage		–	–	150	mV

ORDERING INFORMATION

EXTENDED TYPE NUMBER	PACKAGE			
	PINS	PIN POSITION	MATERIAL	CODE
TDA1560Q	17	DBS	plastic	SOT243R

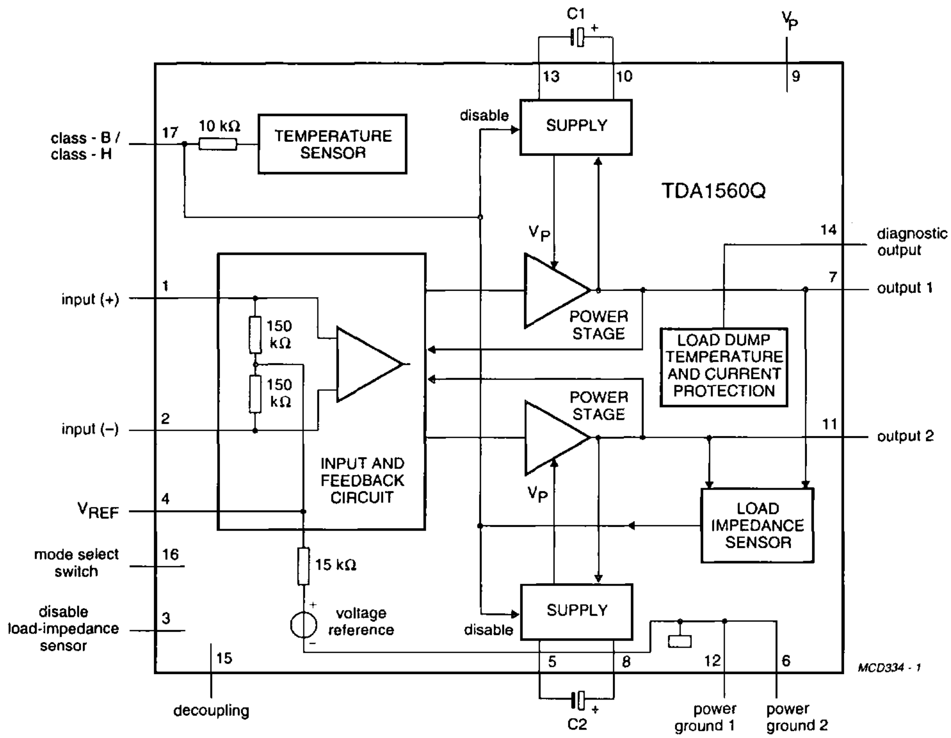


Fig.1 Block diagram.

PINNING

SYMBOL	PIN	DESCRIPTION
+INP	1	positive input
−INP	2	negative input
DLS	3	disable load-impedance sensor
V_{REF}	4	reference voltage
C2−	5	capacitor C2 negative terminal
GND2	6	power ground 2
OUT1	7	output 1
C2+	8	capacitor C2 positive terminal
V_P	9	supply voltage
C1+	10	capacitor C1 positive terminal
OUT2	11	output 2
GND1	12	power ground 1
C1−	13	capacitor C1 negative terminal
V_{DIAG}	14	diagnostic voltage output
C_{DEC}	15	decoupling
MSS	16	mode select switch
S1	17	class-B/class-H

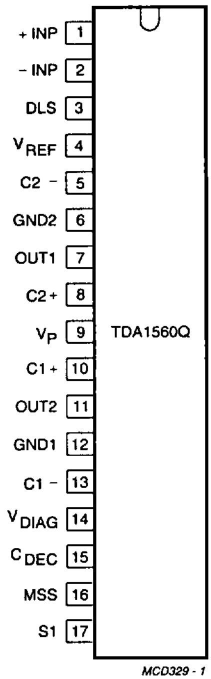


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

The TDA1560Q contains a mono class-H BTL output power amplifier. At low output power, up to 10 W, the device operates as a normal BTL amplifier. When a larger output voltage swing is required, the internal supply voltage is lifted to approximately twice the external supply voltage. This extra supply voltage is obtained from the charge in the external electrolytic capacitors. Due to this momentarily higher supply voltage, the maximum output power is 40 W typical at a THD of 10%.

In normal use, when the output is driven with music-like signals, the high output power is only required for a small percentage of the time. Assuming a music signal has a normal (Gaussian) amplitude distribution, the reduction in dissipation is approximately 50% when compared to a class-B output amplifier with the same output power. The heatsink should be designed for use with music signals. If the device is **continuous sinewave** driven, instead of driven with music signals and at a high output power (class-H operation), the case temperature can rise above 120 °C with such a practical heatsink. In this event, the thermal protection disables the high power supply voltage and limits the output power to 10 W and the maximum dissipation to 5 W.

The gain of the amplifier is internally fixed at 30 dB. With the mode select switch pin, the device can be switched to the following modes:

- low standby current (< 50 μA)
- mute condition, DC adjusted
- on, operation in class-B, limited output power
- on, operation in class-H, high output power.

The mode select switch pin can be directly switched from standby to class-H without plops or clicks. A delay in mute condition is not necessary. (This is valid only if in the application capacitor C5 at pin 4 is connected and the load-impedance sensor is enabled, see Fig.6.

The device can be used as a normal BTL class-AB amplifier if the electrolytic capacitors C1 and C2 are omitted; see Fig.6. If the case temperature exceeds 120 °C, the device will switch back from class-H to class-B operation. The high power supply voltage is then disabled and the output power is limited to 10 W. By measuring the voltage on the class-B/class-H pin, the actual crystal temperature can be detected. The open voltage on the class-B/class-H pin is related to the global temperature of the crystal. By measuring this voltage, external actions can be taken to reduce an excessive temperature (e.g. by cutting off low frequencies or externally switching to class-B). For the relationship between the crystal temperature and the voltage on this pin, see Fig.3.

By forcing a high voltage level on the class-B/class-H pin, thereby simulating a high temperature, the device can be externally switched to class-B operation. Similarly, by forcing a low voltage level on the class-B/class-H pin, thereby simulating a low temperature, the device can be forced into class-H operation, even if the case temperature exceeds 120 °C.

The device is fully protected against short-circuiting the outputs to ground or V_P and across the load, high crystal temperature and electrostatic discharge at all input and output pins. In the event of a continuing short-circuit to ground or V_P, excessive dissipation is prevented because the output stages will be switched off. The output stages will be switched on again within 20 ms after the short-circuit is removed.

Furthermore a load-impedance sensor is available. When a 4 Ω loudspeaker is connected instead of the normal 8 Ω, the power in the loudspeaker is limited, to prevent damage to it.

Each time the device is switched from standby condition to mute condition, the DC resistance between the output terminals is measured. If this load is less then 4.6 Ω (DC), the high voltage supply is disabled and only class-B operation is possible. If the DC load is more than 6.2 Ω, class-H operation is possible. If the load is less than 1.5 Ω (a short-circuited load), the output stages remain disabled and high dissipation is prevented.

The load-impedance sensor can be disabled by connecting pin 3 to ground. In that event the class-H operation is always possible (up to case temperature of 120 °C) and a short-circuited load is not detected before switching on. The load-impedance sensor is active if pin 3 is floating.
The load-impedance sensor can only operate reliably if any interference voltage at the moment of switching from standby to mute, due to external causes, is less than 1 mV between the output pins 7 and 11.

A diagnostic facility is available at pin 14. In normal conditions the voltage at this pin will be the supply voltage (V_P). In the event of the following conditions:

- junction temperature exceeds 150 °C
- short-circuit of one of the outputs to ground or to V_P
- load dump; $V_P > 20$ V

The voltage level at pin 14 will be at a constant level of approximately $V_P/2$ during the fault condition. At a short-circuit over the load, pin 14 will be at $V_P/2$ for approximately 20 ms and V_P for approximately 50 µs.

Heatsink design

There are two parameters that determine the size of the heatsink. The first is the rating for the case temperature, the second the ambient temperature at which the amplifier must still deliver its full power in the class-H mode.

Example 1.

With an 8 Ω load and driven with a **music signal**, the maximum power dissipation is approximately 6.5 W. If the amplifier is to deliver its full power at ambient temperatures up to 50 °C the case temperature should not be higher than 120 °C for class-H operation.
The $R_{th\ case\_hs} = 1$ K/W, thus the external heatsink should be:

$$\frac{(120-50)}{6.5} - 1 = 10 \text{ K/W.}$$

In this example and with an 8 Ω load, the size of the heatsink is determined by the rating for the maximum full power ambient temperature. If the case temperature of the device exceeds 120 °C then the device switches back to class-B, see Example 2.

Example 2.

With disabled class-H mode, an 8 Ω load and driven with a **sinewave signal** the maximum power dissipation is approximately 5 W. At a virtual junction temperature of 150 °C and $T_{amb\_max} = 60$ °C, $R_{th\ vj\text{-}case} = 3$ K/W and $R_{th\ case\_hs} = 1$ K/W, the thermal resistance of the heatsink should be:

$$\frac{(150-60)}{5} - 3 - 1 = 14 \text{ K/W.}$$

In this example the size of the heatsink is determined by the virtual junction temperature.

Example 3.

With disabled class-H mode, a 4 Ω load and driven with a **sinewave signal** the maximum power dissipation is approximately 10 W. At a virtual junction temperature of 150 °C and $T_{amb\_max} = 60$ °C, $R_{th\ vj\text{-}case} = 3$ K/W and $R_{th\ case\_hs} = 1$ K/W, the thermal resistance of the heatsink should be:

$$\frac{(150-60)}{10} - 3 - 1 = 5 \text{ K/W.}$$

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_P	supply voltage				
	operating		–	18	V
	non-operating		–	30	V
	load dump protected	during 50 ms; t_r > 2.5 ms	–	45	V
I_{OSM}	non-repetitive peak output current		–	6	A
I_{ORM}	repetitive peak output current		–	4	A
V_{PSC}	AC and DC short-circuit safe voltage		–	18	V
	energy handling capability at outputs	$V_P = 0$	–	200	mJ
I_{17}	current in pin 17	$V_{17} < V_P - 1$	–	5	mA
P_{tot}	total power dissipation		–	60	W
T_{stg}	storage temperature		–55	+150	°C
T_{amb}	operating ambient temperature		–40	–	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	THERMAL RESISTANCE
$R_{th\ j\text{-}a}$	from junction to ambient in free air	40 K/W
$R_{th\ j\text{-}c}$	from junction to case (note 1)	3 K/W

Note

1. Measured in Fig.6.

DC CHARACTERISTICS

V_P = 14.4 V; R_L = 8 Ω; T_{amb} = 25 °C and using heatsink 4 K/W; measured in Fig.6 unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply						
V_P	supply voltage	note 1	8	14.4	18	V
I_P	quiescent current		–	100	160	mA
V_O	DC output voltage	note 2	–	6.5	–	V
$\|\Delta V_o\|$	DC output offset voltage		–	–	150	mV
V_{14}	diagnostic output voltage	note 3	6	–	8	V
Mode select switch (see Fig.4)						
V_{16}	standby condition	note 4	0	–	1.2	V
V_{16}	mute condition		2.6	–	3.5	V
V_{16}	class-B operation		4.5	–	7.0	V
V_{16}	class-H operation		8.5	–	V_P	V
I_{sw}	maximum switch current		–	–	20	µA
I_{sb}	DC current in standby condition		–	5	50	µA
$\|\Delta V_o\|$	DC output offset voltage	in mute position	–	–	150	mV

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Mode select switch (see Fig.4)						
$\|\Delta V_o\|$	DC output offset voltage mute-on step	note 5	–	–	150	mV
V_O	output signal in mute position	V_I = 1 V (max); f = 20 Hz to 15 kHz	–	–	2	mV
Class-B/class-H operation (see Fig.3 and note 6)						
V_{17}	input switch level for class-B operation		2.5	–	V_P – 1	V
V_{17}	input switch level for class-H operation		0	–	1.0	V
I_{17}	switch current	note 7	–	–	2	mA
T_{vj}	case temperature for switching to class-B		–	120	–	°C
R_L	DC load impedance for					
	class-B or class-H operation		6.2	–	–	Ω
	class-B operation		2.5	–	4.6	Ω
	disabled output stages		–	–	1.5	Ω
V_3	load impedance sensor active		–	2.1	–	V

Notes

1. The circuit is DC adjusted at V_P = 8 to 18 V and AC operating at V_P = 8.5 to 18 V.
2. The DC output voltage, or the common mode voltage on the loudspeaker terminals with respect to ground, is 6.3 V at output powers up to 8.5 W. At higher output powers, the common mode voltage will be higher.
3. V_{14} is approximately $V_P/2$ in the event of a short-circuit, load dump or temperature protection. Any circuit connected to pin 14 should have an input resistance of more than 2 MΩ and an input capacity of less than 5 nF.
4. If the load impedance sensor is active (pin 3 floating) then for a reliable start-up the steepness of the voltage at the mode select input (pin 16) should not be slower than 10 V/s and not faster than 10 V/µs.
5. The DC output offset voltage step is the difference in output offset voltage in the mute condition and the on condition. The absolute value of this voltage step is given as: $|\Delta V_{o\_mute} - \Delta V_{o\_on}| < 150$ mV.
6. Fig.3 shows the relationship between the global crystal temperature and the open voltage at the class-B/class-H pin.
7. The maximum voltage on pin 17 is V_P – 1, ($V_P \leq 18$ V).

AC CHARACTERISTICS

V_P = 14.4 V; R_L = 8 Ω; f = 1 kHz; T_{amb} = 25 °C and using 4 K/W heatsink; measured in Fig.6 unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
P_o	output power	class-H				
		THD = 0.5%	27	30	–	W
		THD = 10%; continuously driven	36	39	–	W
		THD = 10%; with burst signals; note 1	–	40	–	W

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
P_o	output power	class-B				
		THD = 10%; R_L = 4 Ω	–	17	–	W
		THD = 10%	8	10	–	W
THD	total harmonic distortion					
		P_o = 1 W	–	0.05	–	%
		P_o = 10 W	–	0.1	–	%
BW	power bandwidth	THD = 0.5%; P_o = −1 dB with respect to 30 W; note 2	–	40 to 15 000	–	Hz
f_L	low frequency roll-off	−3 dB; note 3	–	40	–	Hz
f_H	high frequency roll-off	−1 dB	20	–	–	kHz
G_v	voltage gain		29	30	31	dB
SVRR	supply voltage ripple rejection	note 4				
	on		48	55	–	dB
	mute		48	65	–	dB
	standby		80	–	–	dB
CMRR	common mode rejection ratio on	note 5	70	–	–	dB
$\|Z_i\|$	input impedance		180	300	–	kΩ
V_i	maximum input voltage	input impedance linear within 1%	–	1.5	–	V
V_{no}	noise output voltage					
	on	R_S = 0; note 6	–	100	300	μV
	on	R_S = 10 kΩ; note 6	–	150	–	μV
	mute	notes 6 and 7	–	100	–	μV

Notes

1. With a continuous sinewave input signal the output power is approximately 1 W less than driven with a bursted signal; also depending on the equivalent series resistance of the capacitors C1 and C2 (see Fig.6) and the resistance of the connections between pins 5, 8, 10 and 13 and C1, C2.
2. The power bandwidth is limited by the value of the electrolytic capacitors C1 and C2.
3. Frequency response is externally fixed by the input coupling capacitor.
4. Ripple rejection measured at the output, across R_L, with a source-impedance of 0 Ω and a frequency between 100 Hz and 10 kHz, and an amplitude of 2 V (p-p). The maximum supply voltage ripple is 2.5 V (RMS).
5. The common mode rejection ratio is measured at the output, across R_L, with a voltage source (500 mV RMS) between both short-circuited inputs and signal ground (see Fig.5). Frequencies are between 100 Hz and 10 kHz.
6. Noise output voltage measured in a bandwidth of 20 Hz to 20 kHz.
7. Noise output voltage is independent of source impedance.

40 W car radio high power amplifier | TDA1560Q

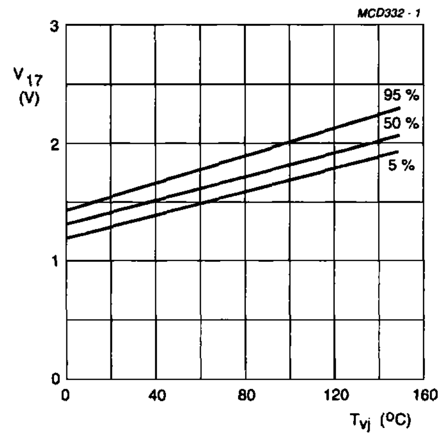


Fig.3 Class-B/class-H pin voltage level.

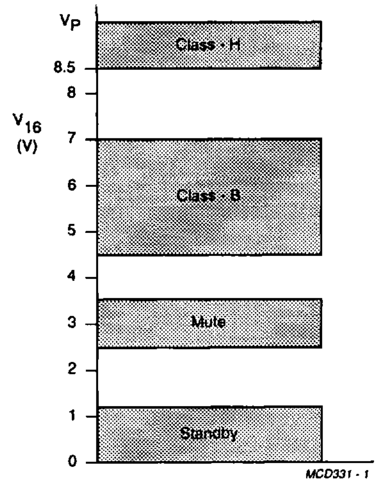


Fig.4 Standby/mute/class-B/class-H switch levels.

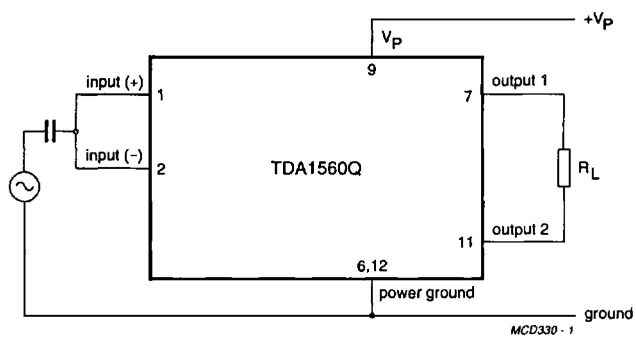


Fig.5 Common mode rejection ratio measurements.

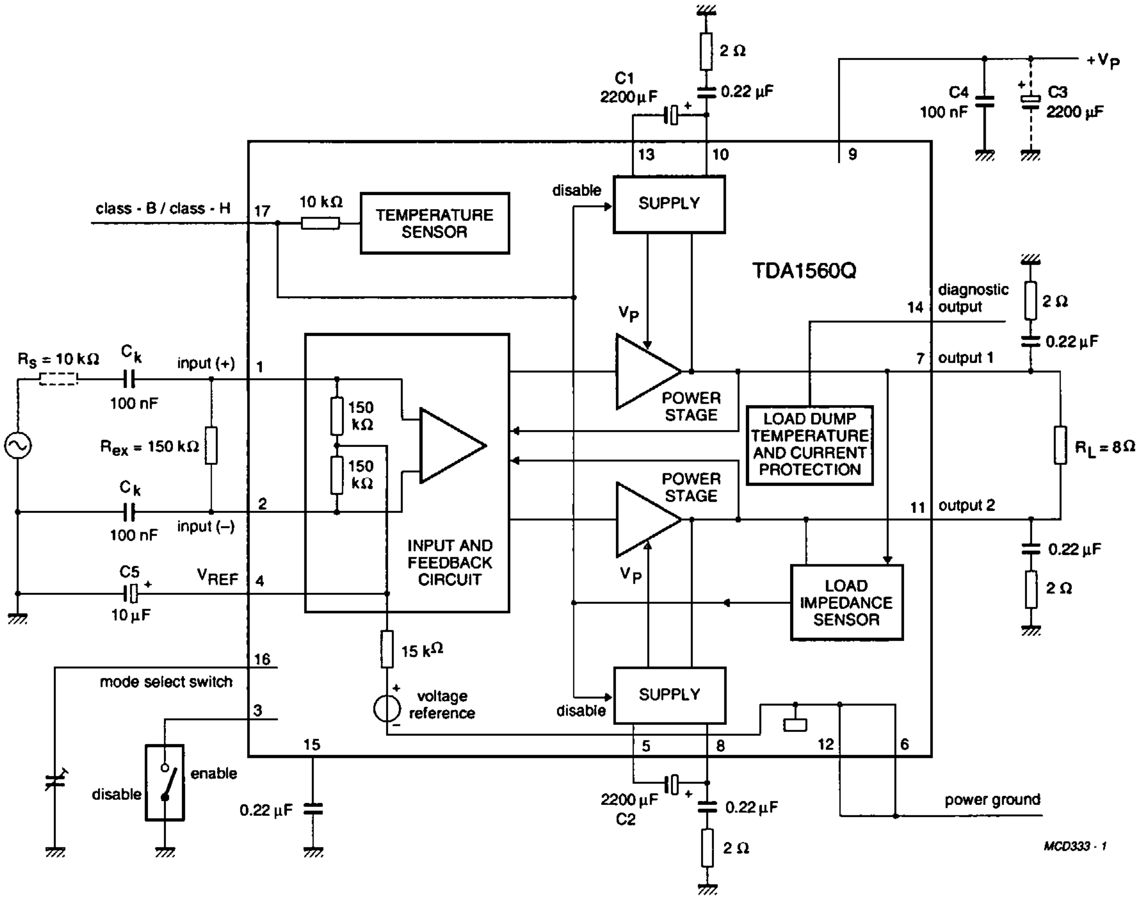
QUALITY SPECIFICATION

Quality in accordance with UZW-BO/FQ-0601, if this type is used as an audio amplifier.

TEST AND APPLICATION INFORMATION

Table 1 Values of C1, C2 and C_k as a function of frequency roll-off.

f (−3 dB) (Hz)	C1, C2 (μF)	C_k (nF)
10	4700	330
20	3300	220
30	2200	150
40	2200	100
50	1500	82
60	1500	68
70	1000	56



The values for C_k and R_{ex} are given for a low frequency roll-off (−3 dB) of 40 Hz; see also Table 1. In this application circuit the device is driven on input pin 1. If pin 2 is used the output power will be lower.

Fig.6 Test and application circuit.

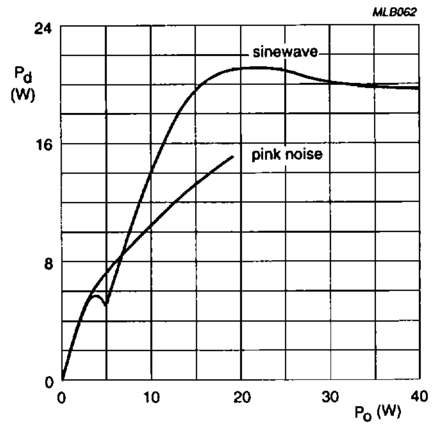


Fig.7 Dissipation as a function of output power.

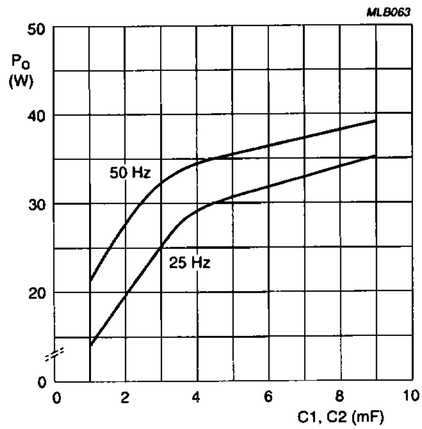


Fig.8 Output power as a function of lift capacitors (THD = 10%).

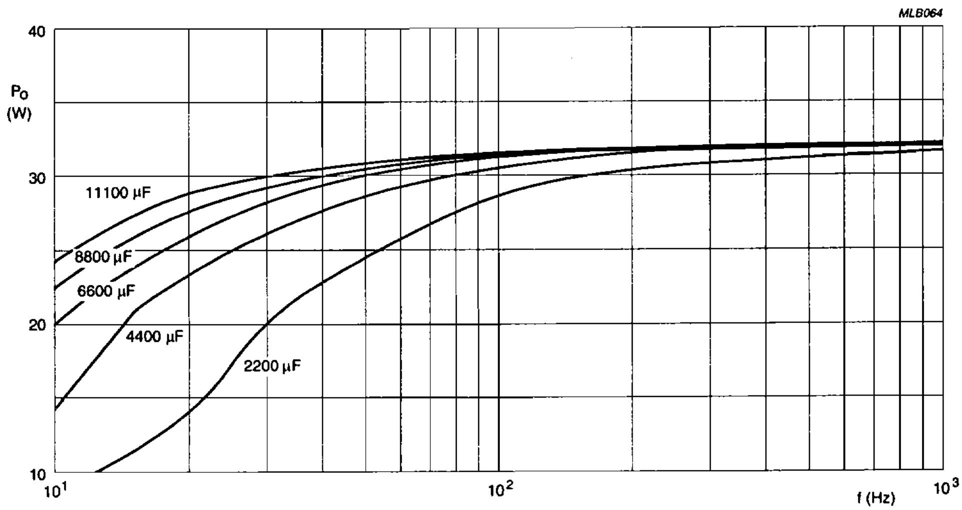


Fig.9 Output power as a function of frequency at THD = 1%.

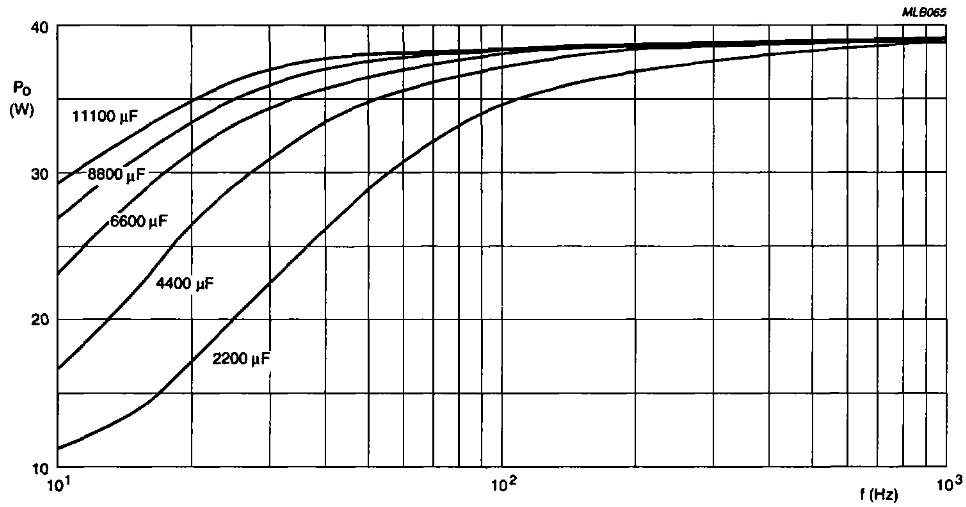


Fig.10 Output power as a function of frequency at THD = 10%.

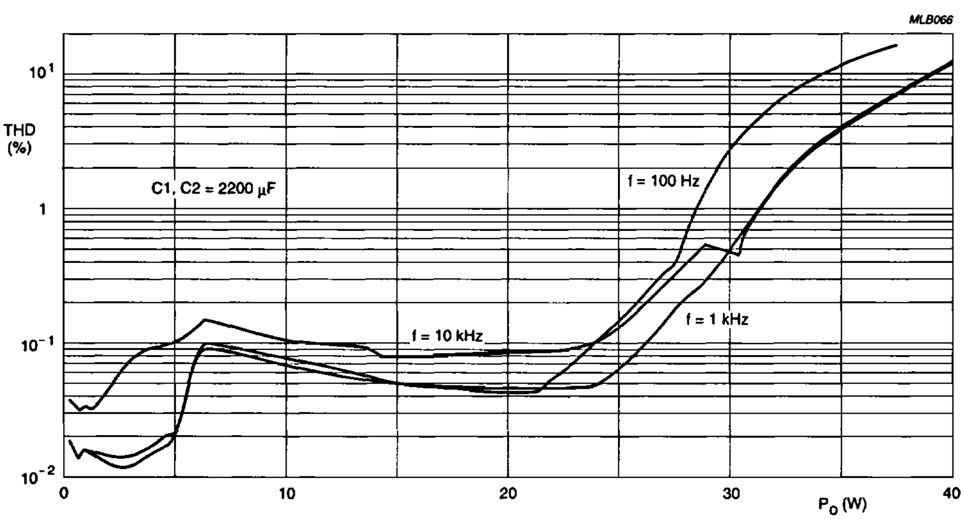


Fig.11 Total harmonic distortion as a function of output power.