SOUND FADER CONTROL CIRCUIT

GENERAL DESCRIPTION

The Sound Fader Control circuit (SOFAC) is an I^2C-bus controlled tone and volume control circuit for car radios.

Features

- Volume and balance control; control range of 86 dB in steps of 2 dB
- Bass and treble control from +15 dB (treble 12 dB) to −12 dB in steps of 3 dB
- Fader control form 0 dB to −30 dB in steps of 2 dB
- Fast muting
- Low noise suitable for Dolby* B and C NR (noise reduction)
- Signal handling suitable for compact disc
- I^2C-bus control for all functions
- ESD protected

QUICK REFERENCE DATA

parameter	symbol	min.	typ.	max.	unit
Supply voltage	V_{CC}	7,0	8,5	13,2	V
Input sensitivity for full power at the output stage	$V_{i(rms)}$	–	50	–	mV
Input signal handling	$V_{i(rms)}$	–	1,65	–	V
Frequency response	f_r	35	–	20 000	Hz
Channel separation f = 250 Hz to 10 kHz	α_{CS}	70	96	–	dB
Total harmonic distortion	THD	–	0,05	–	%
Signal plus noise-to-noise ratio	(S+N)/N	–	80	–	dB
Operating ambient temperature range	T_{amb}	−40	–	+ 85	°C

* Dolby is a registered trademark of Dolby Laboratories Licencing Corporation, San Fransisco, California (U.S.A.).

PACKAGE OUTLINE

28-lead mini-pack; plastic (SO28; SOT136A).

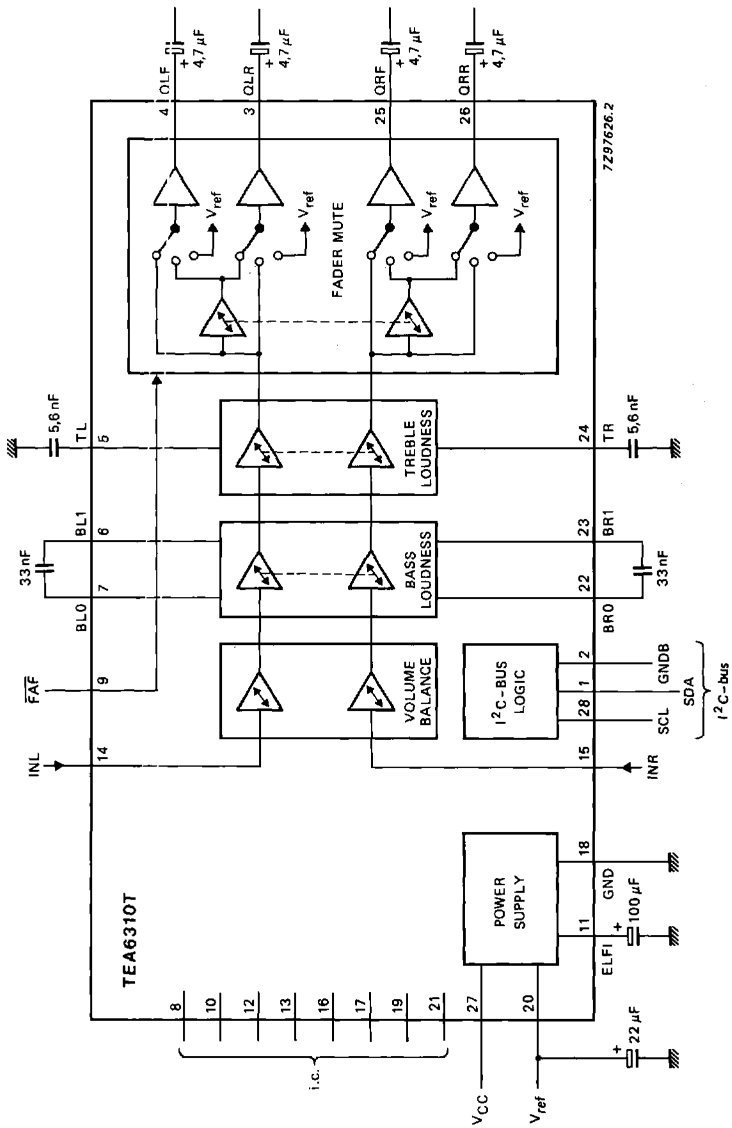


Fig. 1 Block diagram.

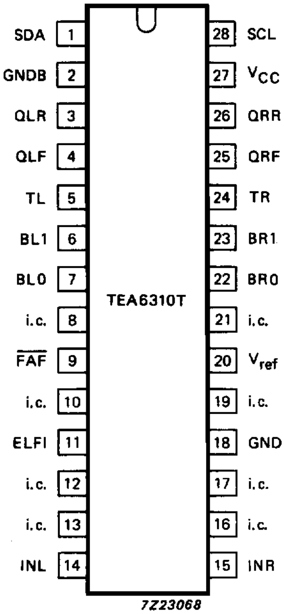


Fig. 2 Pinning diagram

PINNING

1	SDA	serial data input/output (I^2C-bus)
2	GNDB	ground for I^2C-bus terminals
3	QLR	output left rear
4	QLF	output left front
5	TL	treble control capacitor; left channel
6	BL1	bass control capacitor; left channel
7	BLO	bass control capacitor; left channel
8	i.c.	internally connected
9	$\overline{FAF}$	fader off control input
10	i.c.	internally connected
11	ELFI	electronic filtering for supply
12	i.c.	internally connected
13	i.c.	internally connected
14	INL	input left control part
15	INR	input right control part
16	i.c.	internally connected
17	i.c.	internally connected
18	GND	ground
19	i.c.	internally connected
20	V_{ref}	reference voltage (1/2 V_{CC})
21	i.c.	internally connected
22	BRO	bass control capacitor; right channel
23	BR1	bass control capacitor; right channel
24	TR	treble control capacitor; right channel
25	QRF	output right front
26	QRR	output right rear
27	V_{CC}	supply voltage
28	SCL	serial clock input (I^2C-bus)

FUNCTIONAL DESCRIPTION

The AC signal setting is performed by resistor chains in combination with multi-input operational amplifiers. The advantage of this principle is the combination of low noise, low distortion and a high dynamic range for the circuit.

The separate volume controls of the left and the right channel facilitate correct balance control. The range and balance control is software programmable.

Because the TEA6310T has four outputs a low level fader is included. The fader control is independent of the volume control and an extra mute position is built in for the front, the rear or for all channels. The last function may be used for muting during preset selection. The Fader function can be disabled by an input signal at $\overline{FAF}$ (pin 9).
An extra pop suppression circuit is built in for pop-free switching on and off. As all switching and control functions are controllable via the two-wire I^2C-bus, no external interface between the micro-computer and the TEA6310T is required.

The on-chip power-on-reset sets the TEA6310T to the general mute mode.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

parameter	symbol	min.	max.	unit
Supply voltage (pin 27-18)	V_{CC}	–	16	V
Maximum power dissipation	P_{tot}	–	1	W
Storage temperature range	T_{stg}	–55	+150	°C
Operating ambient temperature range	T_{amb}	–40	+ 85	°C

CHARACTERISTICS

V_{CC} = 8,5 V; R_S = 600 Ω; R_L = 10 kΩ; f = 1 kHz; T_{amb} = 25 °C; test circuit Fig. 10; unless otherwise specified

parameter	symbol	min.	typ.	max.	unit
Supply voltage	V_{CC}	7,0	8,5	13,2	V
Supply current	I_{CC}	–	26	–	mA
Supply current at 8,5 V	I_{CC}	–	–	30	mA
Supply current at 13,2 V	I_{CC}	–	–	44	mA
DC voltage inputs, outputs and reference	V_{DC}	0,45	0,5	0,55	V_{CC}
Internal reference voltage (pin 20) V_{ref} = 0,5 V_{CC}	V_{REF}	–	4,25	–	V
Maximum voltage gain bass and treble linear, fader off	G_V	19	20	21	dB
Output voltage level for P_{max} at the output stage for start of clipping	 $V_{o(rms)}$ $V_{o(rms)}$	 – –	 500 1000	 – –	 mV mV
Input sensitivity at V_o = 500 mV	$V_{i(rms)}$	–	50	–	mV
Frequency response bass and treble linear; roll-off frequency –1 dB	f_r	35	–	20 000	Hz
Channel separation G_V = 0 dB; bass and treble linear; frequency range 250 Hz to 10 kHz	α_{CS}	70	96	–	dB
Total harmonic distortion frequency range 20 Hz to 12,5 kHz V_i = 50 mV; G_V = 20 dB V_i = 500 mV; G_V = 0 dB V_i = 1,6 V; G_V = –10 dB	 THD THD THD	 – – –	 0,1 0,05 0,2	 0,3 0,2 0,5	 % % %
Ripple rejection $V_{r(rms)}$ <200 mV; G_V = 0 dB; bass and treble linear; at f = 100 Hz at f = 40 Hz to 12,5 kHz	 RR_{100} RR_{range}	 – –	 70 60	 – –	 dB dB

CHARACTERISTICS (continued)

parameter	symbol	min.	typ.	max.	unit
Signal-to-noise ratio; bass and treble linear; notes 1 and 2; CCIR 468-2 weighted; quasi peak;					
V_i = 50 mV; V_c = 46 mV; P_o = 50 mW	S/(S + N)	–	65	–	dB
V_i = 500 mV; V_c = 45 mV; P_o = 50 mW	S/(S + N)	–	67	–	dB
V_i = 50 mV; V_c = 200 mV; P_o = 1 W	S/(S + N)	65	72	–	dB
V_i = 500 mV; V_c = 200 mV; P_o = 1 W	S/(S + N)	65	78	–	dB
V_i = 50 mV, V_c = 500 mV; P_o = 6 W	S/(S + N)	–	72	–	dB
V_i = 500 mV; V_c = 500 mV; P_o = 6 W	S/(S + N)	–	86	–	dB
Noise output power mute position, only contribution of TEA310T, power amplifier for 25 W	P_{no}	–	–	10	nW
Crosstalk (20 log $V_{bus(p-p)}/V_{o(rms)}$) between bus inputs and signal outputs G_v = 0 dB; bass and treble linear;	α_B	–	110	–	dB
Control part					
Input impedance	Z_i	35	50	65	kΩ
Output impedance	Z_o	–	100	150	Ω
Output load resistance	R_L	5	–	–	kΩ
Output load capacity	C_L	0	–	2500	pF
Maximum input voltage; THD < 0,5%; G_v = –10 dB; bass and treble linear	$V_{i(rms)}$	–	2,0	–	V
Noise output voltage; weighted acc CCIR 468-2, quasi peak, bass and treble linear, fader off;					
G_v = 20 dB	V_{no}	–	110	220	μV
G_v = 0 dB	V_{no}	–	25	50	μV
G_v = –66 dB	V_{no}	–	19	38	μV
mute position	V_{no}	–	11	22	μV
Volume control					
Continuous control range	G_c	–	86	–	dB
Step resolution		–	2	–	dB
Attenuator set error; (G_v = + 20 to –50 dB)	ΔG_a	–	–	2	dB
Attenuator set error; (G_v = + 20 to –66 dB)	ΔG_a	–	–	3	dB
Gain tracking error; balance in mid position, bass and treble linear	ΔG_t	–	–	2	dB
Mute attenuation	α_m	76	90	–	dB

parameter	symbol	min.	typ.	max.	unit
DC step offset					
Between any adjoining step and any step to mute					
G_v = 0 to −66 dB		–	0,2	10	mV
G_v = 20 to 0 dB		–	2	15	mV
In any treble and fader position					
G_v = 0 to −66 dB		–	–	10	mV
In any bass position					
G_v = 0 to −66 dB		–	–	20	mV
Bass control					
Bass control range;					
f = 40 Hz; maximum boost	G_b	14	15	16	dB
f = 40 Hz; maximum attenuation	G_b	11	12	13	dB
Step resolution		–	3	–	dB
Step error		–	–	0,5	dB
Treble control					
Treble control range					
f = 15 kHz; maximum boost	G_t	11	12	13	dB
f = 15 kHz; maximum attenuation	G_t	11	12	13	dB
f > 15 kHz; maximum boost	G_t	–	–	15	dB
Step resolution		–	3	–	dB
Step error		–	–	0,5	dB
Fader control					
Continous attenuation fader control range	G_f	–	30	–	dB
Step resolution		–	2	–	dB
Attenuator set error		–	–	1,5	dB
Mute attenuation	α_m	74	84	–	dB
Fader enable/disable control (pin 9)					
Fader enabled					
Input voltage HIGH	$V_{9\text{-}18}$	3	–	12	V
Fader disabled					
Input voltage LOW	$V_{9\text{-}18}$	−0,3	–	1,5	V
Input current					
HIGH	I_9	−10	–	+10	μA
LOW	I_9	−10	–	+10	μA

CHARACTERISTICS (continued)

parameter	symbol	min.	typ.	max.	unit
Digital part					
Bus terminals					
Input voltage					
HIGH	V_{IH}	3	–	12	V
LOW	V_{IL}	–0,3	–	1,5	V
Input current					
HIGH	I_{IH}	–10	–	+10	μA
LOW	I_{IL}	–10	–	+10	μA
Output voltage LOW I_L = 3 mA	V_{OL}	–	–	0,4	V
AC characteristics					
in accordance with the I^2C-bus specification					
Power-on-Reset					
When RESET is active the GMU (general mute) bit is set and the I^2C-bus receiver is in RESET position					
Increasing supply voltage					
start of reset	V_{CC}	–	–	2,5	V
end of reset	V_{CC}	5,2	6,0	6,8	V
Decreasing supply voltage start of reset	V_{CC}	4,2	5,0	5,8	V

Notes to the characteristics

1. The indicated values for output power assume a 6 W power amplifier with 20 dB gain, connected to the output of the circuit. Signal-to-noise ratios exclude noise contribution of the power amplifier.
2. Signal-to-noise ratios on a CCIR 468-2 average meter reading are 4,5 dB better than on CCIR 468-2 quasi peak.

I^2C-BUS FORMAT

S	SLAVE ADDRESS	A	SUBADDRESS	A	DATA	A	P

S = start condition
SLAVE ADDRESS = 10000 0000
A = acknowledge, generated by the slave
SUBADDRESS = see Table 1
DATA = see Table 1
P = STOP condition

If more than 1 byte DATA are transmitted, then auto-increment of the subaddress is performed.

Table 1 I^2C-bus; subaddress/data

function	subaddress	DATA							
		D7	D6	D5	D4	D3	D2	D1	D0
volume left	0 0 0 0 0 0 0 0	X	X	VL5	VL4	VL3	VL2	VL1	VL0
volume right	0 0 0 0 0 0 0 1	X	X	VR5	VR4	VR3	VR2	VR1	VR0
bass	0 0 0 0 0 0 1 0	X	X	X	X	BA3	BA2	BA1	BA0
treble	0 0 0 0 0 0 1 1	X	X	X	X	TR3	TR2	TR1	TR0
fader	0 0 0 0 0 1 0 0	X	X	MFN	FCH	FA3	FA2	FA1	FA0
switch	0 0 0 0 0 1 0 1	GMU	X	X	X	X	X	X	X

Function of the bits:

VL0 to VL5 volume control left
VR0 to VR5 volume control right
BA0 to BA3 bass control
TR0 to TR3 treble control
FA0 to FA3 fader control
FCH select fader channel (front or rear)
MFN mute control of the selected fader channel (front or rear)
GMU mute control (general mute) for the outputs QLF, QLR, QRF and QRR
X don't care bits (logic 1 during testing)

Table 2 Bass setting

G_V dB	DATA			
	BA3	BA2	BA1	BA0
+ 15	1	1	1	1
+ 15	1	1	1	0
+ 15	1	1	0	1
+ 15	1	1	0	0
+ 12	1	0	1	1
+ 9	1	0	1	0
+ 6	1	0	0	1
+ 3	1	0	0	0
0	0	1	1	1
− 3	0	1	1	0
− 6	0	1	0	1
− 9	0	1	0	0
−12	0	0	1	1
−12	0	0	1	0
−12	0	0	0	1
−12	0	0	0	0

Table 3 Treble setting

G_V dB	DATA			
	TR3	TR2	TR1	TR0
+ 12	1	1	1	1
+ 12	1	1	1	0
+ 12	1	1	0	1
+ 12	1	1	0	0
+ 12	1	0	1	1
+ 9	1	0	1	0
+ 6	1	0	0	1
+ 3	1	0	0	0
0	0	1	1	1
− 3	0	1	1	0
− 6	0	1	0	1
− 9	0	1	0	0
−12	0	0	1	1
−12	0	0	1	0
−12	0	0	0	1
−12	0	0	0	0

Table 4 Volume setting LEFT

G_V dB	DATA					
	VL5	VL4	VL3	VL2	VL1	VL0
20	1	1	1	1	1	1
18	1	1	1	1	1	0
16	1	1	1	1	0	1
14	1	1	1	1	0	0
12	1	1	1	0	1	1
10	1	1	1	0	1	0
8	1	1	1	0	0	1
6	1	1	1	0	0	0
4	1	1	0	1	1	1
2	1	1	0	1	1	0
0	1	1	0	1	0	1
− 2	1	1	0	1	0	0
− 4	1	1	0	0	1	1
− 6	1	1	0	0	1	0
− 8	1	1	0	0	0	1
−10	1	1	0	0	0	0
−12	1	0	1	1	1	1
−14	1	0	1	1	1	0
−16	1	0	1	1	0	1
−18	1	0	1	1	0	0
−20	1	0	1	0	1	1
−22	1	0	1	0	1	0
−24	1	0	1	0	0	1
−26	1	0	1	0	0	0
−28	1	0	0	1	1	1
−30	1	0	0	1	1	0
−32	1	0	0	1	0	1
−34	1	0	0	1	0	0
−36	1	0	0	0	1	1
−38	1	0	0	0	1	0
−40	1	0	0	0	0	1
−42	1	0	0	0	0	0
−44	0	1	1	1	1	1
−46	0	1	1	1	1	0
−48	0	1	1	1	0	1
−50	0	1	1	1	0	0
−52	0	1	1	0	1	1
−54	0	1	1	0	1	0
−56	0	1	1	0	0	1
−58	0	1	1	0	0	0
−60	0	1	0	1	1	1
−62	0	1	0	1	1	0
−64	0	1	0	1	0	1
−66	0	1	0	1	0	0
mute left	0	1	0	0	1	1
mute left	0	1	0	0	1	0
.			.			
.			.			
.			.			
mute left	0	0	0	0	0	0

Table 5 Volume setting RIGHT

G_V dB	DATA					
	VR5	VR4	VR3	VR2	VR1	VR0
20	1	1	1	1	1	1
18	1	1	1	1	1	0
16	1	1	1	1	0	1
14	1	1	1	1	0	0
12	1	1	1	0	1	1
10	1	1	1	0	1	0
8	1	1	1	0	0	1
6	1	1	1	0	0	0
4	1	1	0	1	1	1
2	1	1	0	1	1	0
0	1	1	0	1	0	1
− 2	1	1	0	1	0	0
− 4	1	1	0	0	1	1
− 6	1	1	0	0	1	0
− 8	1	1	0	0	0	1
−10	1	1	0	0	0	0
−12	1	0	1	1	1	1
−14	1	0	1	1	1	0
−16	1	0	1	1	0	1
−18	1	0	1	1	0	0
−20	1	0	1	0	1	1
−22	1	0	1	0	1	0
−24	1	0	1	0	0	1
−26	1	0	1	0	0	0
−28	1	0	0	1	1	1
−30	1	0	0	1	1	0
−32	1	0	0	1	0	1
−34	1	0	0	1	0	0
−36	1	0	0	0	1	1
−38	1	0	0	0	1	0
−40	1	0	0	0	0	1
−42	1	0	0	0	0	0
−44	0	1	1	1	1	1
−46	0	1	1	1	1	0
−48	0	1	1	1	0	1
−50	0	1	1	1	0	0
−52	0	1	1	0	1	1
−54	0	1	1	0	1	0
−56	0	1	1	0	0	1
−58	0	1	1	0	0	0
−60	0	1	0	1	1	1
−62	0	1	0	1	1	0
−64	0	1	0	1	0	1
−66	0	1	0	1	0	0
mute right	0	1	0	0	1	1
mute right	0	1	0	0	1	0
.			.			
.			.			
.			.			
mute right	0	0	0	0	0	0

Table 6 Fader function

setting front dB	setting rear dB	MFN	FCH	FA3	FA2	FA1	FA0
		fader off					
0	0	1	1	1	1	1	1
0	0	0	1	1	1	1	1
		fader front					
– 2	0	1	1	1	1	1	0
– 4	0	1	1	1	1	0	1
– 6	0	1	1	1	1	0	0
– 8	0	1	1	1	0	1	1
–10	0	1	1	1	0	1	0
–12	0	1	1	1	0	0	1
–14	0	1	1	1	0	0	0
–16	0	1	1	0	1	1	1
–18	0	1	1	0	1	1	0
–20	0	1	1	0	1	0	1
–22	0	1	1	0	1	0	0
–24	0	1	1	0	0	1	1
–26	0	1	1	0	0	1	0
–28	0	1	1	0	0	0	1
–30	0	1	1	0	0	0	0
		mute front					
–80	0	0	1	1	1	1	0
.	.			.			
.	.			.			
.	.			.			
–80	0	0	1	0	0	0	0

setting front dB	setting rear dB	MFN	FCH	FA3	FA2	FA1	FA0
		fader off					
0	0	1	0	1	1	1	1
0	0	0	0	1	1	1	1
		fader rear					
0	– 2	1	0	1	1	1	0
0	– 4	1	0	1	1	0	1
0	– 6	1	0	1	1	0	0
0	– 8	1	0	1	0	1	1
0	–10	1	0	1	0	1	0
0	–12	1	0	1	0	0	1
0	–14	1	0	1	0	0	0
0	–16	1	0	0	1	1	1
0	–18	1	0	0	1	1	0
0	–20	1	0	0	1	0	1
0	–22	1	0	0	1	0	0
0	–24	1	0	0	0	1	1
0	–26	1	0	0	0	1	0
0	–28	1	0	0	0	0	1
0	–30	1	0	0	0	0	0
		mute rear					
0	–80	0	0	1	1	1	0
.	.			.			
.	.			.			
.	.			.			
0	–80	0	0	0	0	0	0

Table 7 Mute control

MUTE control	DATA GMU	remarks
active	1	outputs QLF, QLR QRF and QRR are muted
passive	0	no general mute

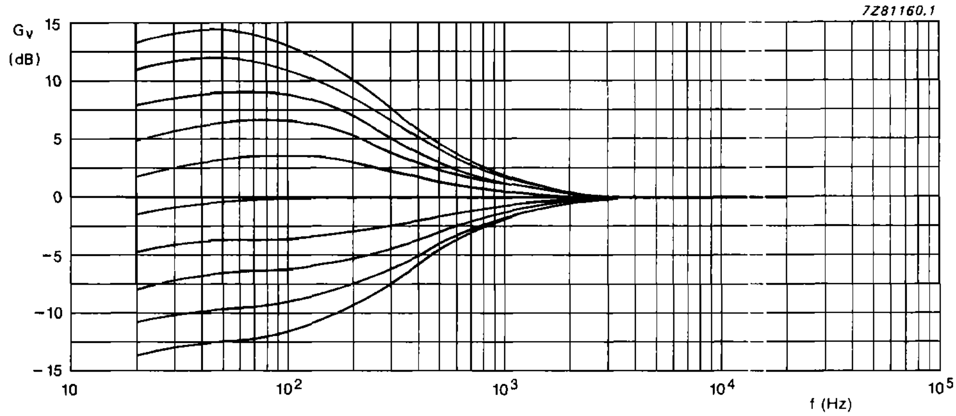


Fig. 3 Bass control without T-pass filter.

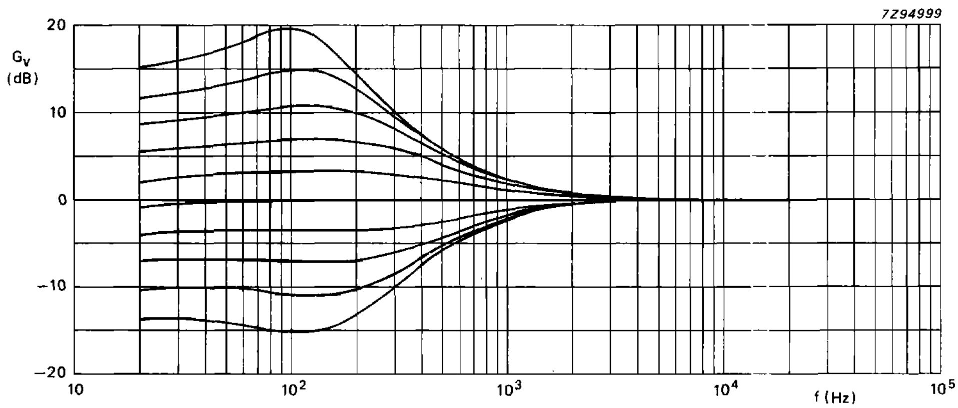
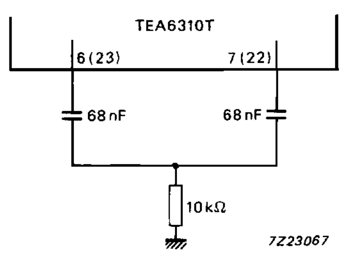


Fig. 4 Bass control with T-pass filter.



Pin numbers in parentheses refer to the bass control, right channel.

Fig. 5 T-pass filer.

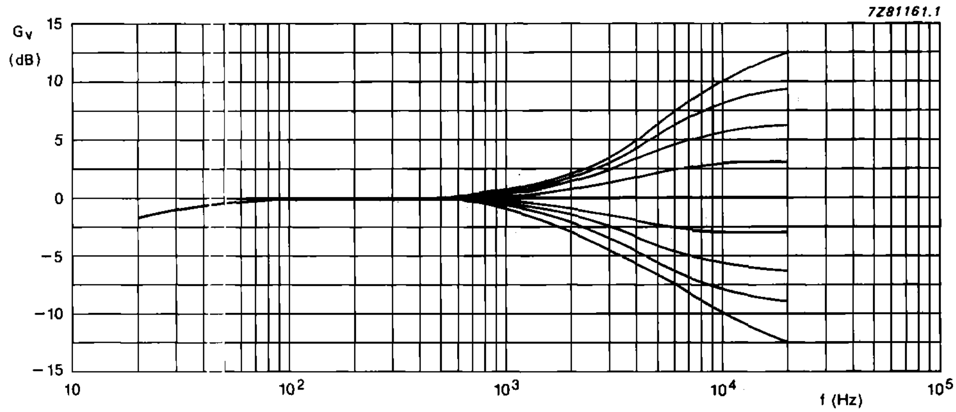


Fig. 6 Treble control.

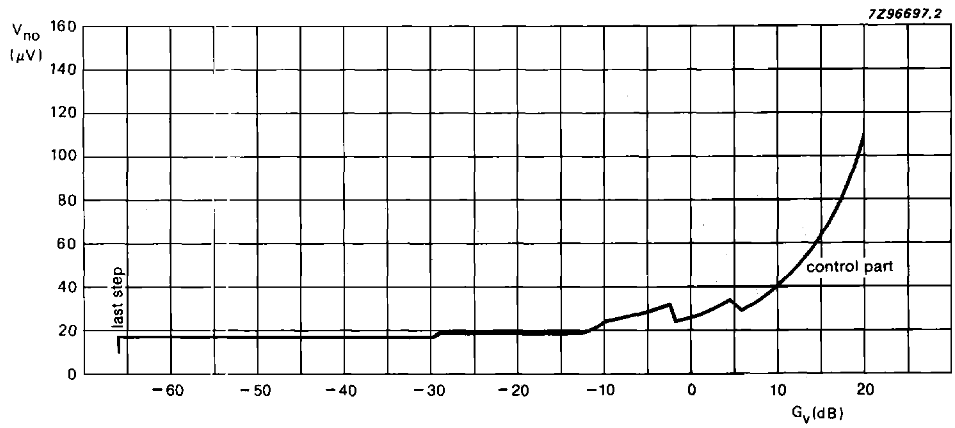


Fig. 7 Output noise voltage (CCIR 468-2 weighted: quasi peak).

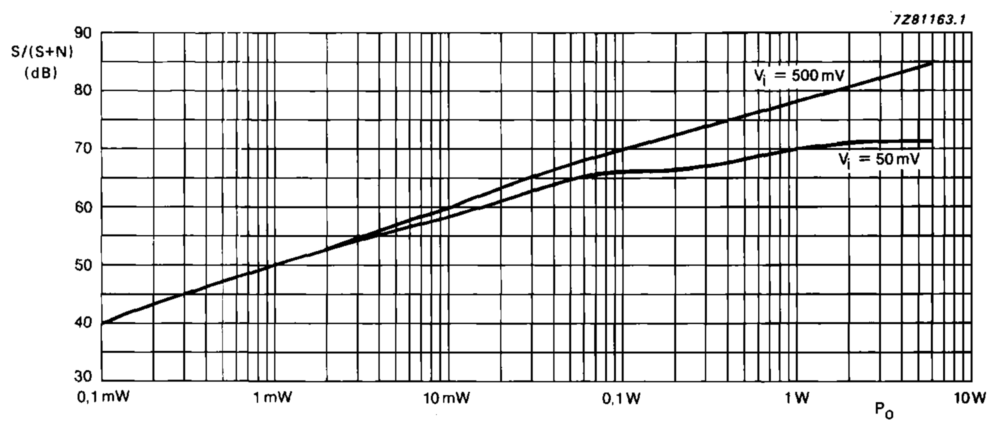


Fig. 8 Signal-to-noise ratio (CCIT 468-2 weighted; quasi peak) with a 6 W power amplifier (gain 20 dB) without noise contribution of the power amplifier (see Fig. 9).

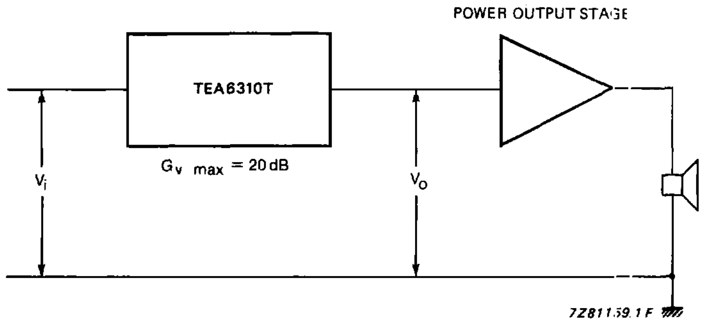


Fig. 9 Recommended level diagram; $V_{i\ min}$ = 50 mV, V_o = 500 mV for P_{max}.

APPLICATION INFORMATION

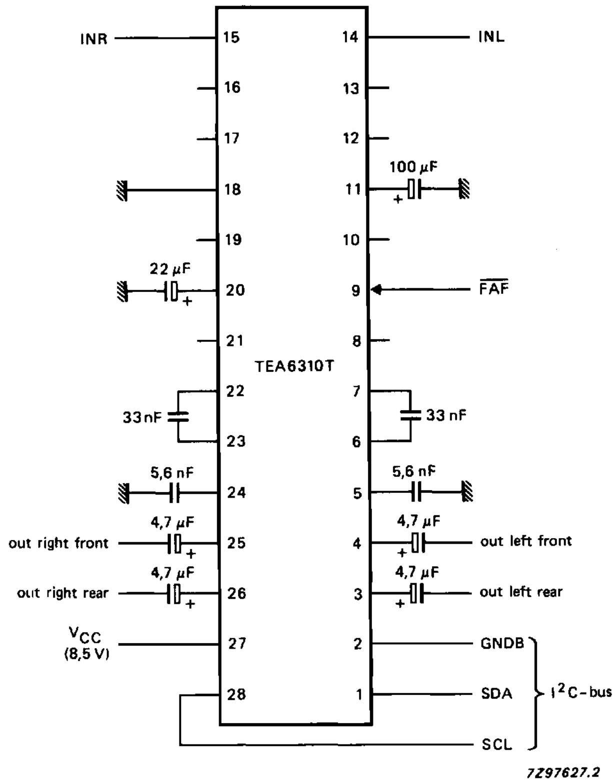


Fig. 10 Test and application circuit.

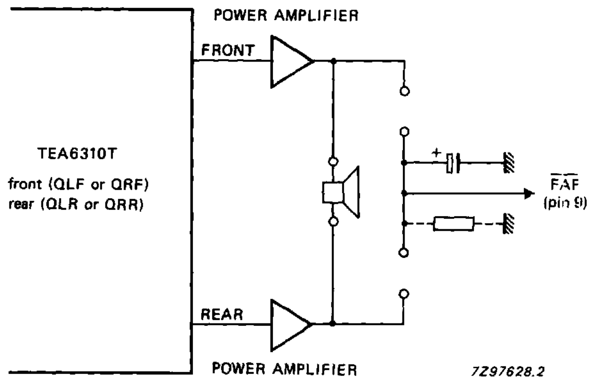


Fig. 11 Automatic FADER control; P_o = 24 W, $V_{9\text{-}18}$ = 0 V (FADER disabled).

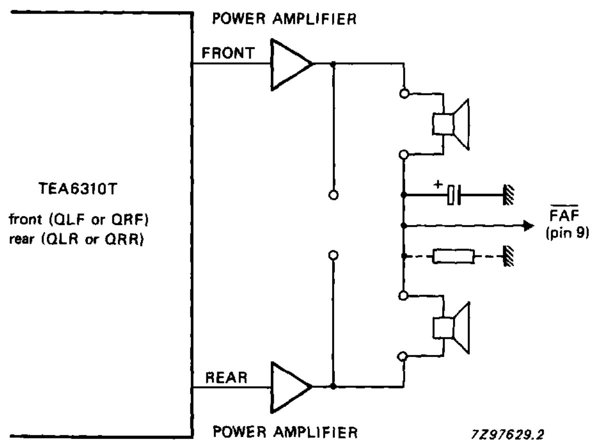


Fig. 12 Automatic FADER control; P_o = 2 x 6 W, $V_{9\text{-}18}$ = 7 V (FADER enabled).