M51137FP

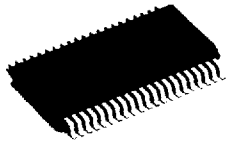
ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

DESCRIPTION

The M51137FP is a Bi-CMOS IC developed for audio-visual systems. It is suitable for multiamplifiers, being used for processing small analog signals in the stage before power amplifier. The IC uses 8-bit serial data transmitted from a microcomputer in order to perform sound control such as master volume control (VCA system), tone control (bass, mid, and treble), and bass boosting. Its applications also include use as a single output and car audio systems.

FEATURES

- Built-in VCA circuit for main volume control
- Variable volume range ····· – 96dB ~ + 9dB
- Capability of controlling VCA from external source
- Built-in bass booster enhances heavy bass
- Tone control
  - Treble ····· – 10dB ~ + 16dB (2dB/step)
  - Mid ····· – 10dB ~ + 10dB (2dB/step)
  - Bass ····· – 10dB ~ + 16dB (2dB/step)
  - Bass boost ····· – 10dB ~ + 10dB (2dB/step)
- For controlling in each mode, the IC uses built-in microcomputer interface and serial data that regulates volume (8-bit), treble, mid, bass, and bass boost (4-bit)



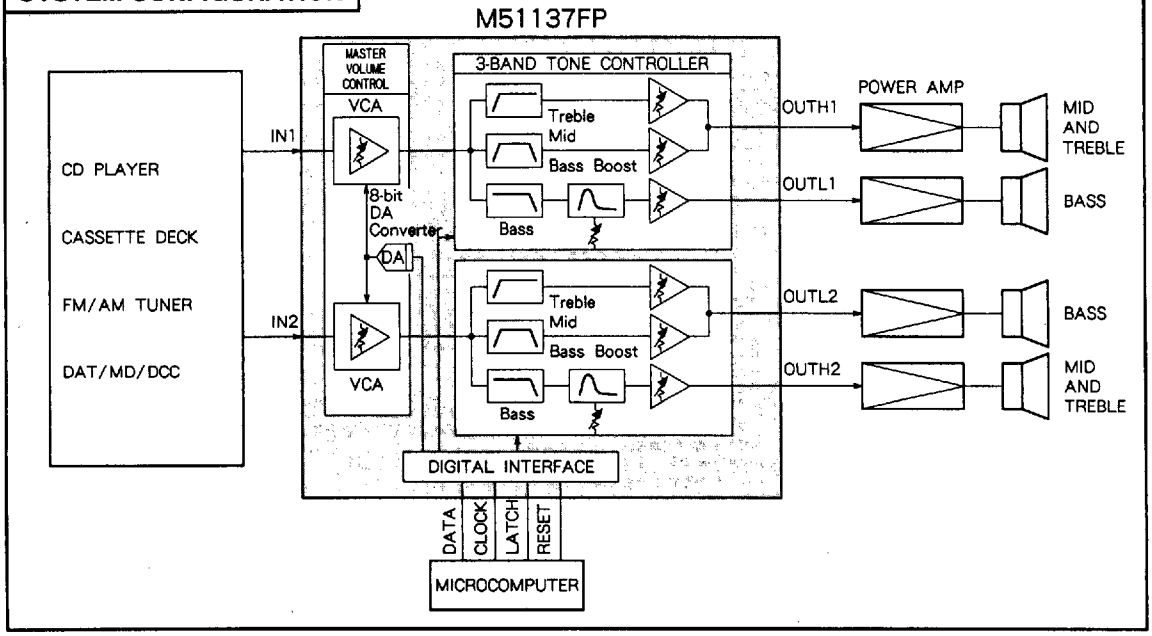
Outline 42P2R-A

0.8mm pitch 450mil SSOP
(8.4mm × 17.5mm × 2.0mm)

RECOMMENDED OPERATING CONDITIONS

Supply voltage range ····· Vcc = 7.5~12V
Rated supply voltage ····· Vcc = 9V

SYSTEM CONFIGURATION



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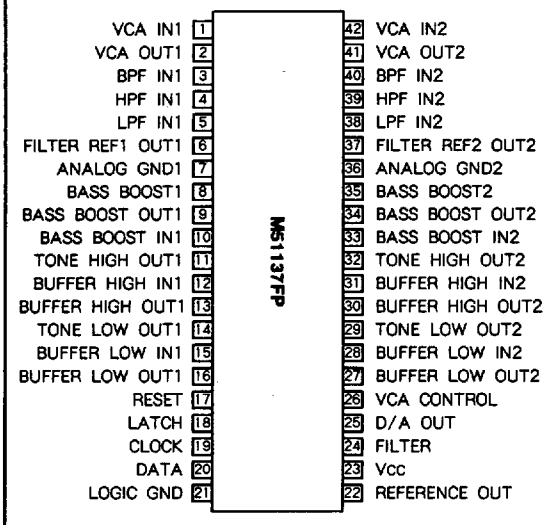
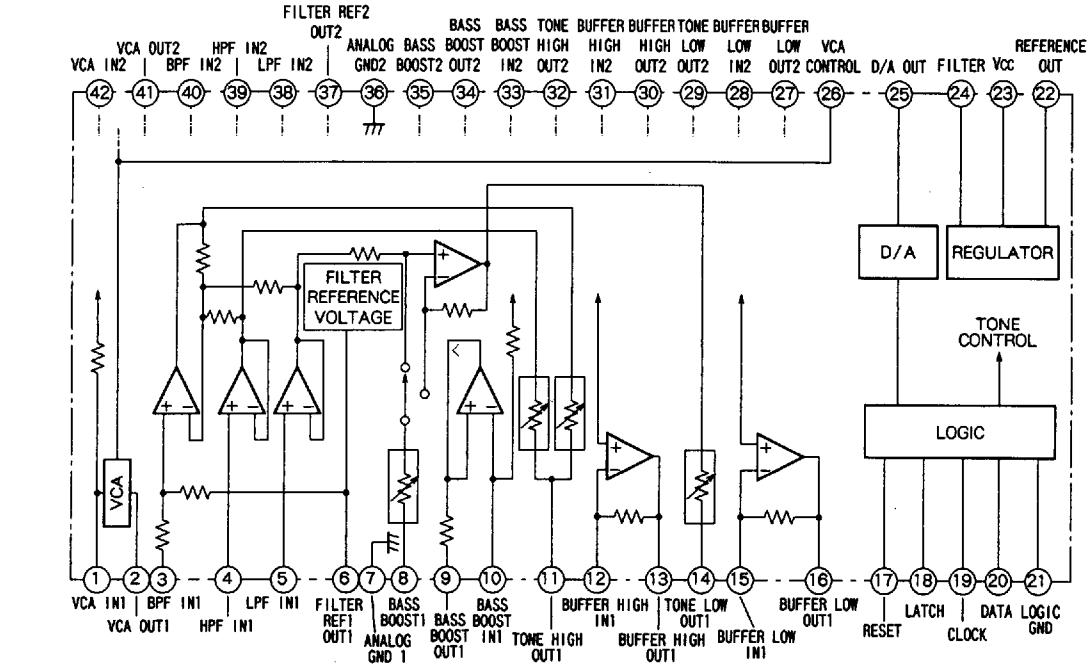
PIN CONFIGURATION



Outline 42P2R-A

IC INTERNAL BLOCK DIAGRAM



ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

PIN DESCRIPTION

Pin No.	Name	Function
① (㊷)	VCA IN 1 (2)	Signal input terminal of ch1 (2)
② (㊶)	VCA OUT 1 (2)	Signal output terminal of ch1 (2)
③ (㊵)	BPF IN 1 (2)	BPF input terminal of ch1 (2)
④ (㊴)	HPF IN 1 (2)	HPF input terminal of ch1 (2)
⑤ (㊳)	LPF IN 1 (2)	LPF input terminal of ch1 (2)
⑥ (㊲)	Filter REF 1 (2)	Filter output for analog reference voltage
⑦ (㊱)	Analog GND 1 (2)	Ground of analog circuit
⑧ (㊺)	Bass-boost 1 (2)	Bass-boost gain terminal
⑨ (㊹)	Bass-boost OUT 1 (2)	Bass-boost resonanse Amplifier output
⑩ (㊸)	Bass-boost IN 1 (2)	Bass-boost resonanse Amplifier input
⑪ (㊷)	Tone high OUT 1 (2)	Treble, mid output
⑫ (㊶)	Buffer high IN 1 (2)	Treble, mid buffer input
⑬ (㊵)	Buffer high OUT 1 (2)	Treble, mid buffer output
⑭ (㉙)	Tone low OUT 1 (2)	Bass, bass-boost out
⑮ (㉘)	Buffer low IN 1 (2)	Bass, bass-boost buffer input
⑯ (㉗)	Buffer low OUT 1 (2)	Bass, bass-boost buffer output
⑰	RESET	MUTE. Set Volume minimum and tone control minimum by high level voltage.
⑱	LATCH	Latch signal of serial data from microcomputer to the IC. Operate at rising eges of pulse.
⑲	CLOCK	Clock signal of serial data from microcomputer to the IC. Operate at rising eges of pulse.
⑳	DATA	Serial data input. (LSB first)
㉑	Logic GND	Ground of digital circuit
㉒	REFERENCE OUT	Reference output voltage source. (5.8V typ)
㉓	Vcc	Supply voltage (7.5~12V)
㉔	FILTER	Filter for ripple
㉕	D/A OUT	VCA control voltage source by D/A convertor
㉖	VCA CONTROL	VCA gain control terminal

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Ratings	Unit
V_{CC}	Supply voltage	14	V
V_I	Digital input voltage	− 0.3~7.0	V
P_d	Power dissipation	1000 * standard board	mW
K_θ	Thermal derating	10 ($T_a \geq 25$℃)	mW/℃
T_{opr}	Operating temperature	− 10~+ 70	℃
T_{stg}	Storage temperature	− 40~+ 125	℃

* Standard board
- board size 70mm × 70mm
- board thickness 1.6mm
- board material glass epoxy
- copper pattern
  copper thickness 18μm
  copper size 0.25mm(width) 30mm(length/lead)

ELECTRICAL CHARACTERISTICS

(Ta = 25℃, Vcc = 9V, Control data : FF5550 (volume max/tone flat), f = 1kHz, unless otherwise noted)

Symbol		Parameter	Test conditions: Input condition	Control data	Switch condition: SA	SB1	SB2	SC	Measurement point	Limits: Min	Typ	Max	Unit
Icc	Supply voltage	Circuit current	Quiescent	FF5550	OPEN	OPEN	BPF	a	PIN㉓	26	38	50	mA
VREF		Reference voltage	⇧	⇧	⇧	⇧	⇧	⇧	PIN㉒	5.4	5.8	6.3	V
VFIL		Filter voltage	⇧	⇧	⇧	⇧	⇧	⇧	PIN㉔	8.2	8.9	–	V
IIH	Logic	Level "H" input current	VIH = 4.5V	FF5550	OPEN	OPEN	BPF	b	PIN⑰ PIN⑱ PIN⑲ PIN⑳	0.3	1.0	3.0	μA
IIL		Level "L" input current	VIL = 0.5V	⇧	⇧	⇧	⇧	⇧	⇧	−0.3	0.0	0.3	μA
OFSTM1	Switching offset	Tre/mid switching offset voltage	Quiescent (data switching offset voltage difference)	FFD050 ↳ FFDA50	OPEN	OPEN	BPF	a	PIN⑪ PIN㉜	−20	0	+20	mV
OFSBB1		Boost switching offset voltage 1	⇧	FF5550 ↳ FF5555	⇧	⇧	⇧	⇧	PIN⑧ PIN㉕	−10	0	+10	mV
OFSBB2		Boost switching offset voltage 2	⇧	FF5550 ↳ FF555D	⇧	⇧	⇧	⇧	PIN⑧ PIN㉕	−10	0	+10	mV
CBVT	Channel balance	Total channel balance 1	(Calculation)	–	–	–	–	–	CB + CBT	−3	0	3	dB
CBVM		Total channel balance 2	(Calculation)	–	–	–	–	–	CB + CBM	−3	0	3	dB
CBVB		Total channel balance 3	(Calculation)	–	–	–	–	–	CB + CBBA	−3	0	3	dB
ATT (min)	Electronic volume	Minimum Attenuation level	Vi = −14dBV *1	FF5550	CLOSE	OPEN	BPF	a	A(1), A(2)	7.2	9.0	10.8	dB
CB		Channel balance	⇧	⇧	⇧	⇧	⇧	⇧	A(1)/ A(2)	−1.8	0	1.8	dB
THD		Total harmonic distortion	Vi=−14dBV, *1 BPF=400Hz~30kHz	⇧	⇧	⇧	⇧	⇧	A(1), A(2)	–	0.02	0.1	%
No (min)		Noise voltage	Quiescent IHF-A	⇧	OPEN	⇧	⇧	⇧	⇧	–	25.0	56.0	μVrms
THD (max)		Maximum total harmonic distortion	Vi=−3dBV, *1 BPF=400Hz~30kHz	⇧	CLOSE	⇧	⇧	⇧	⇧	–	0.1	1.0	%
ATT (−10)		Attenuation level (−10dB)	Vi = −14dBV *1	9A5550	⇧	⇧	⇧	⇧	⇧	−2.8	−1.0	0.8	dB
ATT (max)		Maximum attenuation level	Vi = −3dBV, *1 IHF-A	005550	⇧	⇧	⇧	⇧	⇧	–	−97	−77	dB
No		Maximum attenuation noise voltage	Quiescent IHF-A	⇧	OPEN	⇧	⇧	⇧	⇧	–	10.0	20.0	μVrms
CT		Cross talk	Vi = −3dBV, *1 IHF-A	FF5550	OPEN/ CLOSE CLOSE/ OPEN	⇧	⇧	⇧	⇧	–	−90	−70	dB
GVT	TREBLE	Voltage gain	Vi = −5dBV *2	FF5550	OPEN	CLOSE	HPF	a	B(1), B(2)	−19	−17	−15	dB
CBT		Channel balance	⇧	⇧	⇧	⇧	⇧	⇧	B(1)/ B(2)	−2	0	+2	dB
THDT		Total harmonic distortion	Vi = −5dBV BPF=400Hz~30kHz	⇧	⇧	⇧	⇧	⇧	B(1), B(2)	–	0.01	0.1	%
NoT		Noise voltage	Quiescent IHF-A	⇧	⇧	OPEN	⇧	⇧	⇧	–	4.0	8.0	μVrms

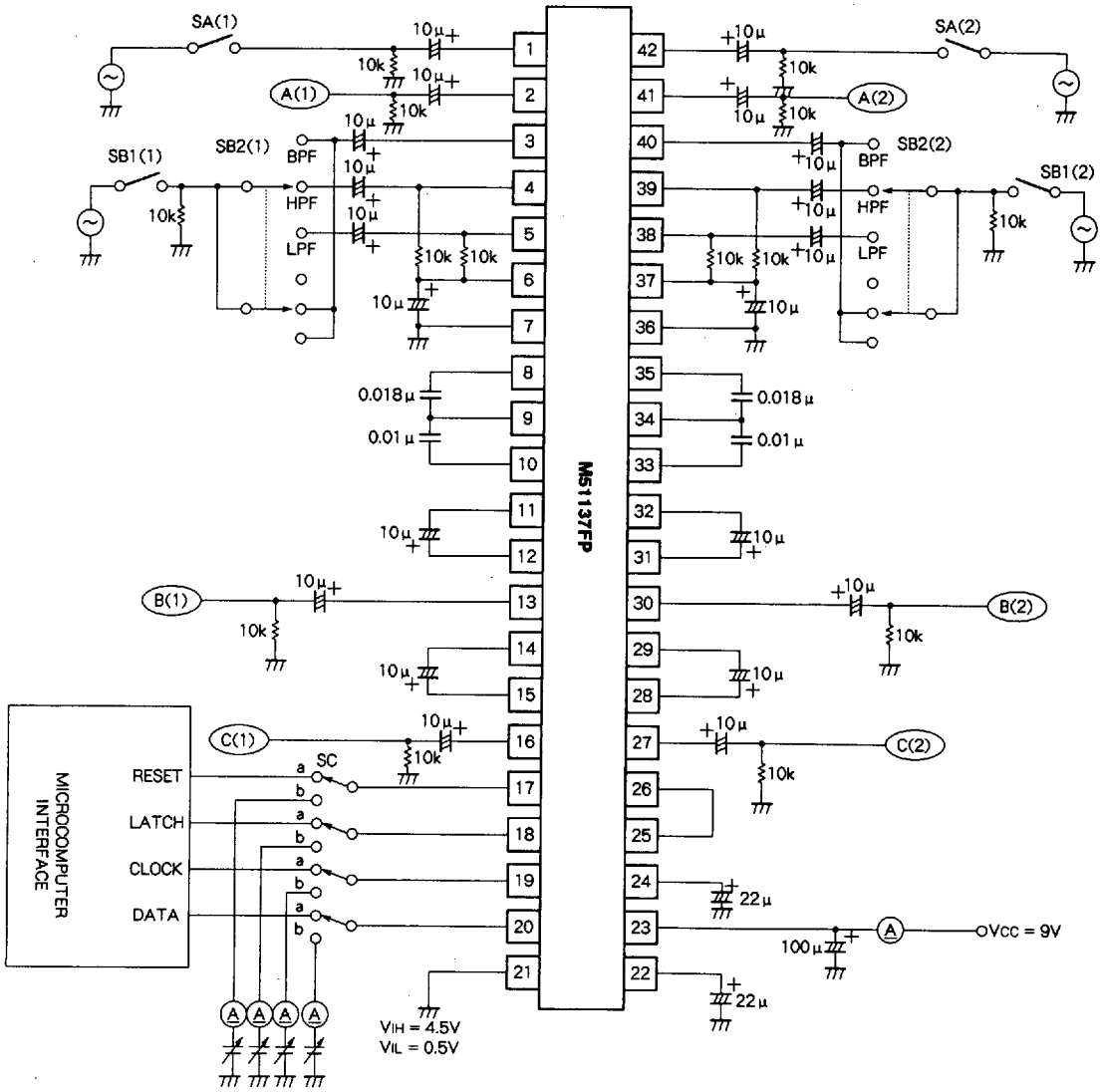
ELECTRICAL CHARACTERISTICS (cont.)
(Ta = 25℃, Vcc = 9V, Control data : FF5550 (volume max/tone flat), f = 1kHz, unless otherwise noted)

Symbol		Parameter	Test conditions: Input condition	Control data	Switch condition: SA	SB1	SB2	SC	Measurement point	Limits: Min	Typ	Max	Unit
THDT max	TREBLE	Maximum total harmonic distortion	Vi=+6dBV, *2 BPF=400Hz~30kHz	FFD550	OPEN	CLOSE	HPF	a	B(1), B(2)	–	0.1	1.0	%
GVT (max)	TREBLE	Maximum voltage gain	Vi = – 5dBV *2	⇧	⇧	⇧	⇧	⇧	⇧	– 3	– 1	+ 1	dB
GVT (min)	TREBLE	Minimum voltage gain	⇧	FF0550	⇧	⇧	⇧	⇧	⇧	– 29	– 27	– 25	dB
CTT	TREBLE	Cross talk	Vi = + 6dBV *2 IHF-A	FFD550	⇧	OPEN/ CLOSE CLOSE/ OPEN	⇧	⇧	⇧	–	– 80	– 60	dB
GVM	MID	Voltage gain	Vi = – 5dBV *3	FF5550	OPEN	CLOSE	BPF	a	B(1), B(2)	– 19	– 17	– 15	dB
CBM	MID	Channel balance	⇧	⇧	⇧	⇧	⇧	⇧	B(1)/ B(2)	– 2	0	+ 2	dB
THDM	MID	Total harmonic distortion	Vi = – 5dBV BPF=400Hz~30kHz	⇧	⇧	⇧	⇧	⇧	B(1), B(2)	–	0.01	0.1	%
NoM	MID	Noise voltage	Quiescent IHF-A	⇧	⇧	OPEN	⇧	⇧	⇧	–	4.0	8.0	μVrms
THDM max	MID	Maximum total harmonic distortion	Vi=+6dBV, *3 BPF=400Hz~30kHz	FF5A50	⇧	CLOSE	⇧	⇧	⇧	–	0.1	1.0	%
GVM (max)	MID	Maximum voltage gain	Vi = – 5dBV *3	⇧	⇧	⇧	⇧	⇧	⇧	– 9	– 7	– 5	dB
GVM (min)	MID	Minimum voltage gain	⇧	FF5050	⇧	⇧	⇧	⇧	⇧	– 29	– 27	– 25	dB
CTM	MID	Cross talk	Vi = + 6dBV, *3 IHF-A	FF5A50	⇧	OPEN/ CLOSE CLOSE/ OPEN	⇧	⇧	⇧	–	– 80	– 60	dB
GVBA	Bass	Voltage gain	Vi = – 5dBV *4	FF5550	OPEN	CLOSE	LPF	a	C(1), C(2)	– 19	– 17	– 15	dB
CBBA	Bass	Channel balance	⇧	⇧	⇧	⇧	⇧	⇧	C(1)/ C(2)	– 2	0	+ 2	dB
THDBA	Bass	Total harmonic distortion	Vi = – 5dBV BPF=400Hz~30kHz	⇧	⇧	⇧	⇧	⇧	C(1), C(2)	–	0.01	0.1	%
NoBA	Bass	Noise voltage	Quiescent IHF-A	⇧	⇧	OPEN	⇧	⇧	⇧	–	4.0	8.0	μVrms
THDBA max	Bass	Maximum total harmonic distortion	Vi=+6dBV, *4 BPF=400Hz~30kHz	FF55D0	⇧	CLOSE	⇧	⇧	⇧	–	0.1	1.0	%
GVBA (max)	Bass	Maximum voltage gain	Vi = – 5dBV *4	⇧	⇧	⇧	⇧	⇧	⇧	– 3	– 1	+ 1	dB
GVBA (min)	Bass	Minimum voltage gain	⇧	FF5500	⇧	⇧	⇧	⇧	⇧	– 29	– 27	– 25	dB
CTBA	Bass	Cross talk	Vi = + 6dBV *4 IHF-A	FF55D0	⇧	OPEN/ CLOSE CLOSE/ OPEN	⇧	⇧	⇧	–	– 80	– 60	dB
THDBB max	Bass	Boost maximum total harmonic distortion	Vi=–10dBV, *4 BPF=400Hz~30kHz	FF55D5	⇧	CLOSE	⇧	⇧	⇧	–	0.1	1.0	dB
GVBB (max)	Bass	Boost maximum voltage gain	Vi = – 10dBV *4 f = 800Hz	FF5555	⇧	⇧	⇧	⇧	⇧	10	– 7	– 5	dB
GVBB (min)	Bass	Boost minimum voltage gain	⇧	FF555D	⇧	⇧	⇧	⇧	⇧	– 29	– 27	– 24	dB

Note : * 1 ; Vi is VCA input voltage. * 2 ; Vi is HPF input voltage. * 3 ; Vi is BPF input voltage. * 4 ; Vi is LPF input voltage.

ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

TEST CIRCUIT



Units Resistance : Ω
Capacitance : F

ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

OPERATIONAL DESCRIPTION

1. CONTROL METHOD

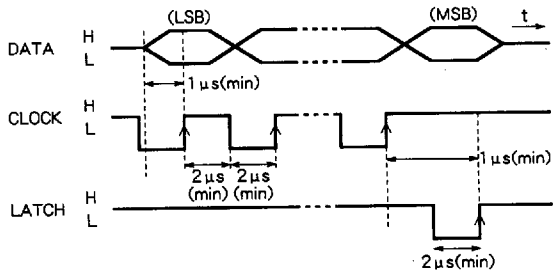
(1) DIGITAL CONTROL SPECIFICATION

Data format

	8bit	4bit	4bit	4bit	4bit	
(MSB)	Volume	Treble	Mid	Bass	Bass boost	(LSB)

Volume : 00~FF (8bit D/A data)
Treble : 0~D (14 step)
Mid : 0~A (11 step)
Bass : 0~D (14 step)
Bass-boost : 0 (11 step)
1~5
9~D

TIMING DIAGRAM (RECOMMENDED CONDITION)



Note 1. RESET (MUTE) is volume minimum and tone control minimum by "H" level.
Puls width 2µs(min)
2. CLOCK, LATCH functions operates at rising ege of pulse.
3. Recommended input level
"H" level : more than 4V
"L" level : less than 1V
the, threshold voltage (Logic input buffer) is about 2.5V.

CONTROL DATA TABLE

D/A converter for VCA		TREBLE		MID		BASS		BASS-BOOST	
DATA	OUTPUT VOLTAGE	DATA	GAIN	DATA	GAIN	DATA	GAIN	DATA	GAIN
00	V_Z	0	− 10dB	0	− 10dB	0	− 10dB	0	± 0dB
01	$\frac{255V_Z + V_F}{256}$	1	− 8dB	1	− 8dB	1	− 8dB	1	+ 2dB
		2	− 6dB	2	− 6dB	2	− 6dB	2	+ 4dB
		3	− 4dB	3	− 4dB	3	− 4dB	3	+ 6dB
		4	− 2dB	4	− 2dB	4	− 2dB	4	+ 8dB
		5	± 0dB	5	± 0dB	5	± 0dB	5	+ 10dB
		6	+ 2dB	6	+ 2dB	6	+ 2dB	6	−
		7	+ 4dB	7	+ 4dB	7	+ 4dB	7	−
		8	+ 6dB	8	+ 6dB	8	+ 6dB	8	−
		9	+ 8dB	9	+ 8dB	9	+ 8dB	9	− 2dB
		A	+ 10dB	A	+ 10dB	A	+ 10dB	A	− 4dB
		B	+ 12dB	B	−	B	+ 12dB	B	− 6dB
		C	+ 14dB	C	−	C	+ 14dB	C	− 8dB
		D	+ 16dB	D	−	D	+ 16dB	D	−10dB
FE	$\frac{2V_Z + 254V_F}{256}$	E	−	E	−	E	−	E	−
FF	$\frac{V_Z + 255V_F}{256}$	F	−	F	−	F	−	F	−

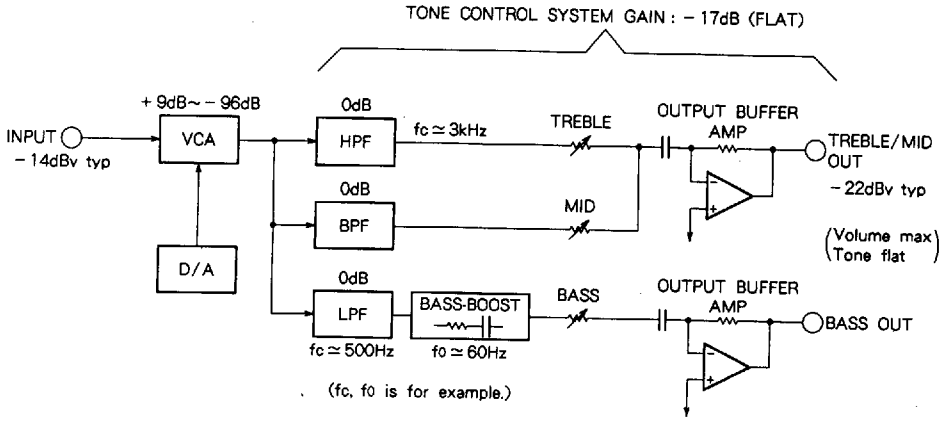
Note typical or designed value. V_Z, V_F is internal power supply voltage.
+ 12dB~ + 16dB of treble and bass are for loudness.

VCA GAIN LEVEL (EXAMPLE)

Control data (D/A converter)	VCA gain level (dB)
0F	(Maximum attenuation)
1F	− 79
2F	− 59
3F	− 44
4F	− 32
5F	− 23
6F	− 15
7F	− 9
8F	− 4
9F	0
AF	+ 3
BF	+ 5
CF	+ 6
DF	+ 7
EF	+ 8
FF	+ 9

(2) SIGNAL PROCESSING SYSTEM

[System] {Total gain : − 8dB (VCA MAX)}

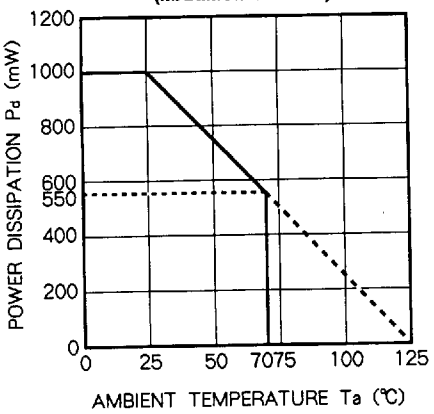


Voltage gain (designed value. Tone control system gain : − 17dB (flat))

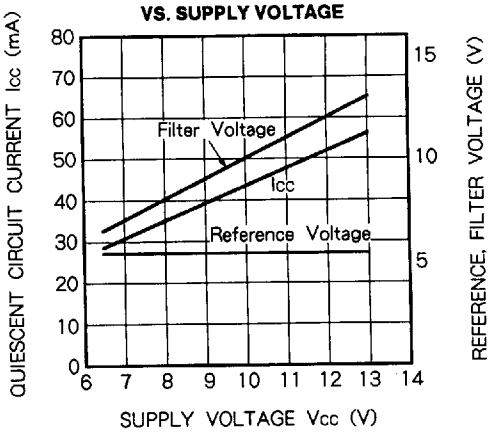
Volume (VCA) : + 9dB~ − 96dB typ.
Treble : − 10dB~0dB~ + 10dB (2dB/step)
(+ 12dB, + 14dB, + 16dB for loudness)
Mid : − 10dB~0dB~ + 10dB (2dB/step)
Bass : − 10dB~0dB~ + 10dB (2dB/step)
(+ 12dB, + 14dB, + 16dB for loudness)
Bass-boost : − 10dB~0dB~ + 10dB (2dB/step)

TYPICAL CHARACTERISTICS

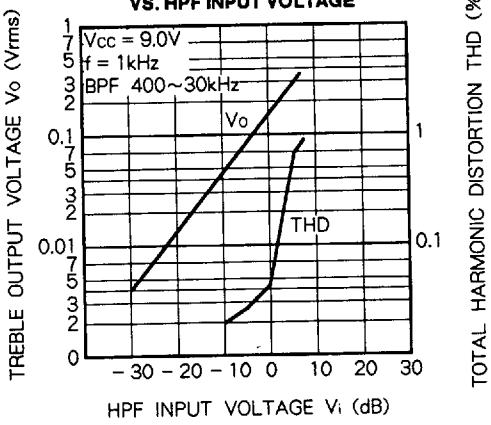
THERMAL DERATING
(MAXIMUM RATING)



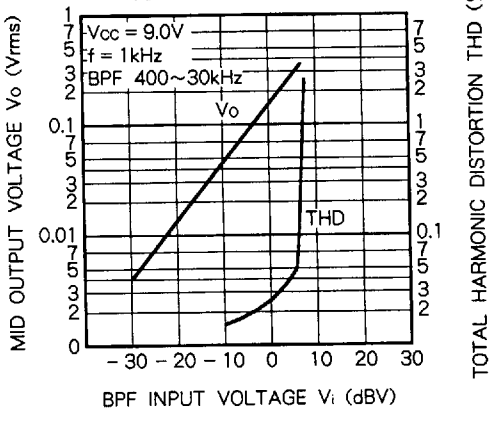
CIRCUIT CURRENT
REFERENCE, FILTER VOLTAGE
VS. SUPPLY VOLTAGE



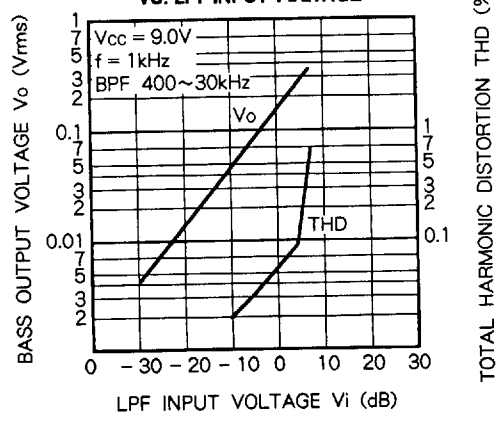
TOTAL HARMONIC DISTORTION
TREBLE OUTPUT VOLTAGE
VS. HPF INPUT VOLTAGE



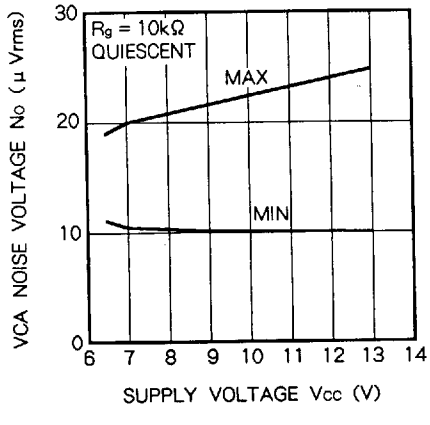
TOTAL HARMONIC DISTORTION
MID OUTPUT VOLTAGE
VS. BPF INPUT VOLTAGE



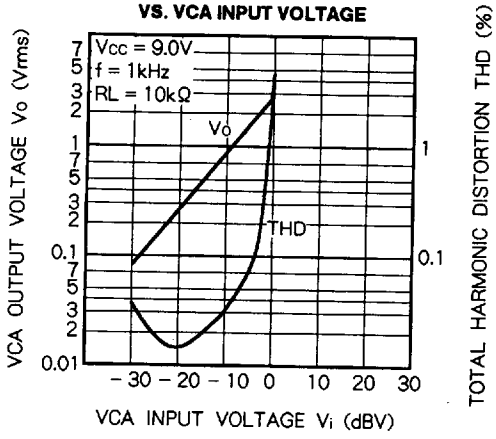
TOTAL HARMONIC DISTORTION
BASS OUTPUT VOLTAGE
VS. LPF INPUT VOLTAGE



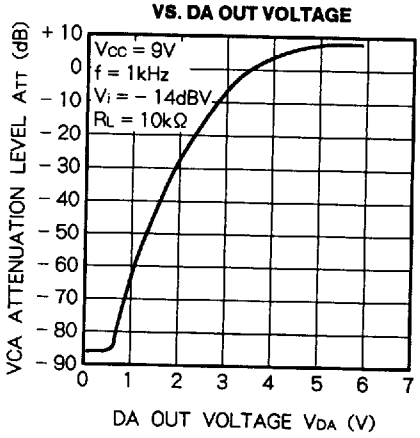
VCA NOISE VOLTAGE
VS. SUPPLY VOLTAGE



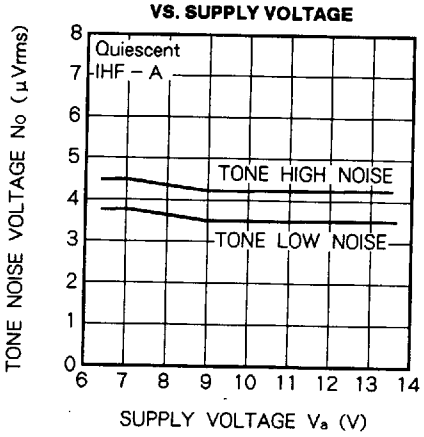
TOTAL HARMONIC DISTORTION VCA OUTPUT VOLTAGE VS. VCA INPUT VOLTAGE



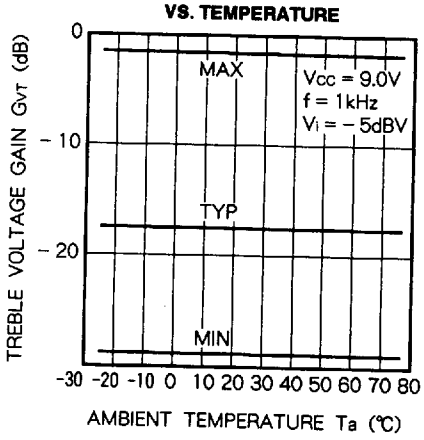
ATTENUATION LEVEL VS. DA OUT VOLTAGE



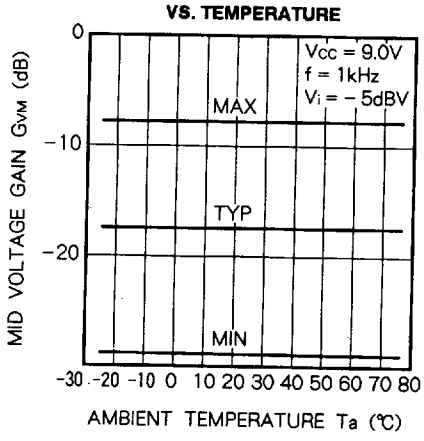
TONE NOISE VOLTAGE VS. SUPPLY VOLTAGE



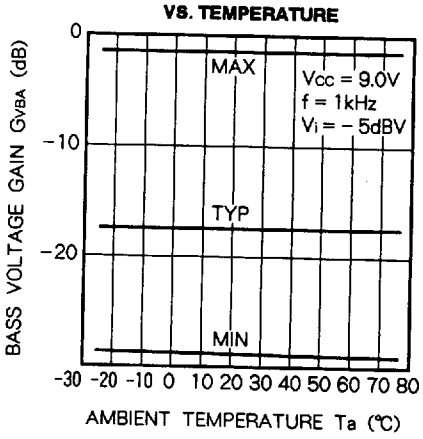
TREBLE VOLTAGE GAIN VS. TEMPERATURE



MID VOLTAGE GAIN VS. TEMPERATURE



BASS VOLTAGE GAIN VS. TEMPERATURE



ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

APPLICATION NOTES

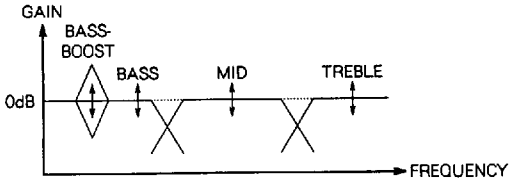
(1) Take care of the heat radiation of PCB.

(2) Take care of a PCB design about digital noise.

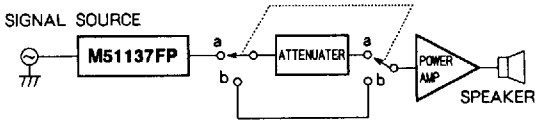
(3) The IC has three GND pins.

(4) Take care of electrostatic damage of ⑥pin and ㉗pin.

(5) Take care of gain characteristics of tone control. The loose attenuation characterestics of filters will disturb the frequency respose in another filtering region.

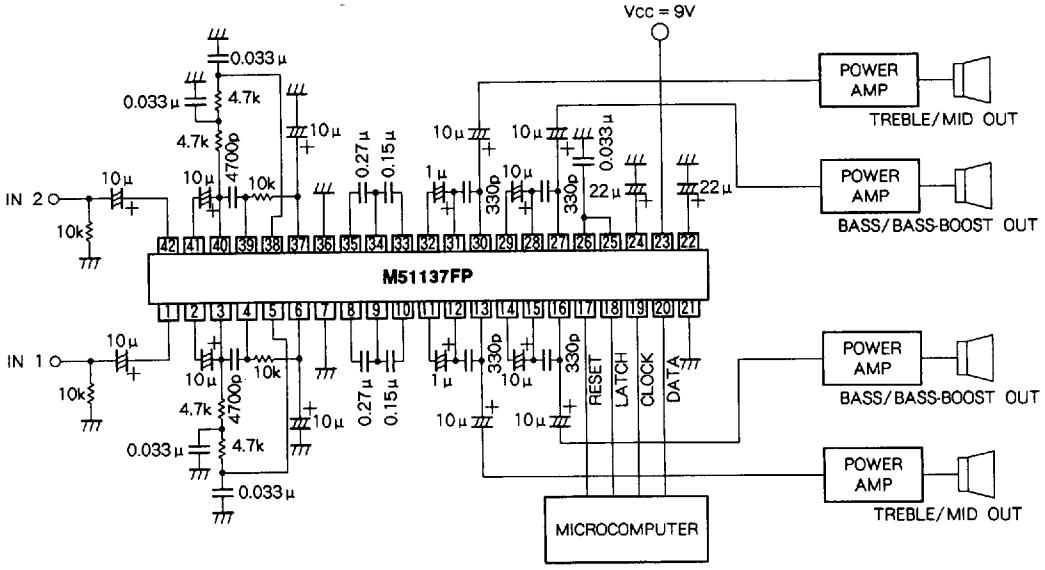


(6) NOISE IMPROVEMENT METHOD



The additional attenuater improves the noise characteristics for small signals.
Volume : Small·····a
Volume : Large·····b

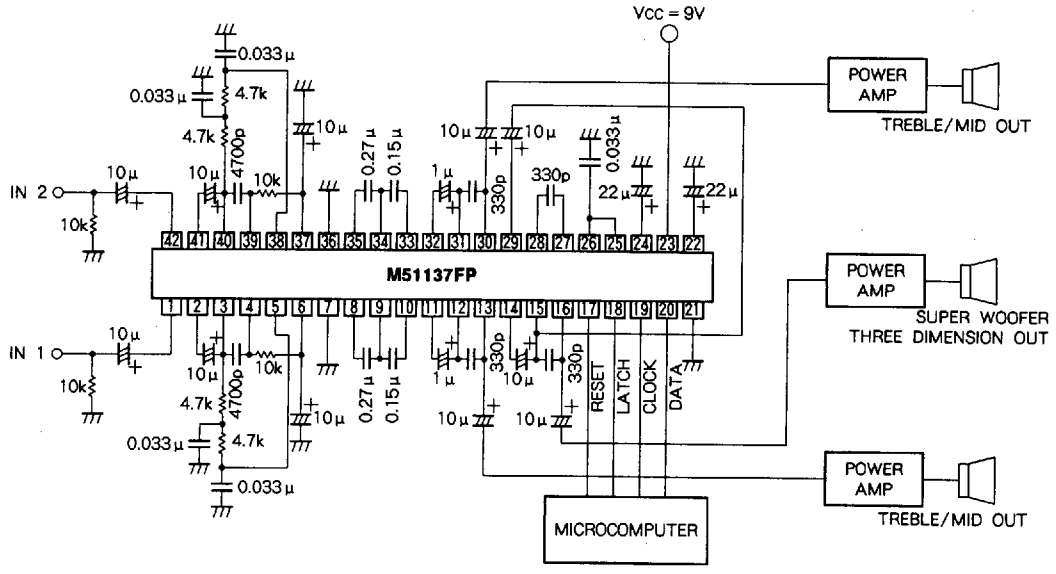
APPLICATION EXAMPLE 1 (Bi-amplifier system)



Units Resistance : Ω
Capacitance : F

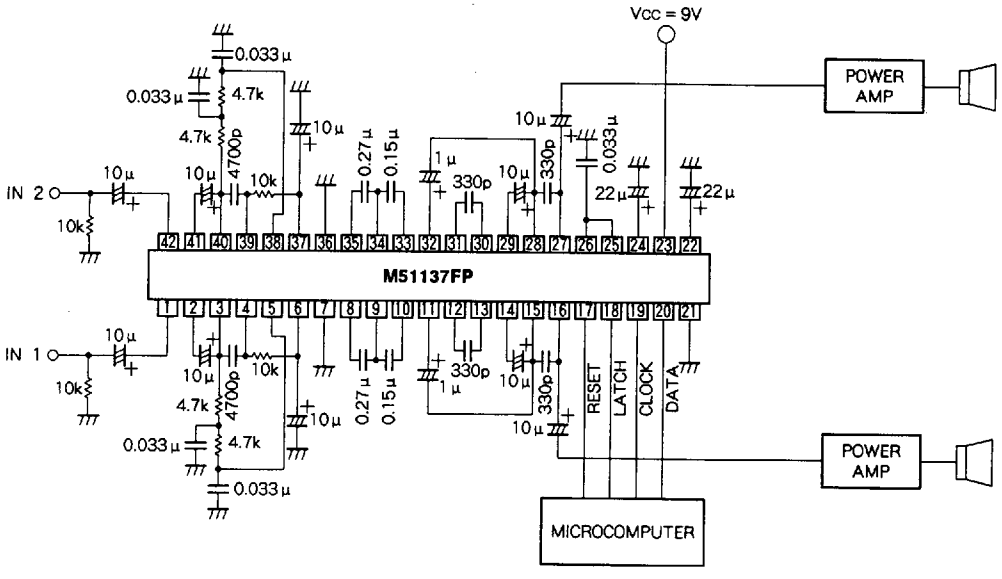
ELECTRONIC VOLUME CONTROL WITH TONE CONTROLLER FOR MULTIAMPLIFIER APPLICATIONS

APPLICATION EXAMPLE 2 (Three dimensional type)



Units Resistance : Ω
Capacitance : F

APPLICATION EXAMPLE 3 (Standard type)



Units Resistance : Ω
Capacitance : F