Ordering number : ENN2824A

Monolithic Linear IC

LA4165M

Recording/Playback IC for Micro-Cassette Tape Recorder

Overview

The LA4165M Recording-Playback IC combines the functions required to design the recording and playback systems and motor control circuits for micro- or standard-cassette tape recorders into a single chip.
Functions provided include automatic audio input sensing during recording with stepless setting of the on-off threshold using the playback volume control, and LED indication that recording is in progress.
Recording and playback modes can be toggled using a single control pin.
The LA4165M also has an on-chip preamp, power amp and ALC circuits, and has been designed to operate with a 3V power supply. The device is available in 24-pin plastic MFPs.

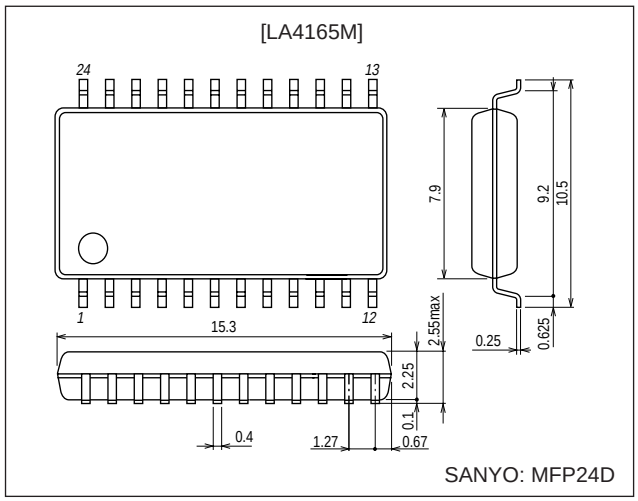
Features

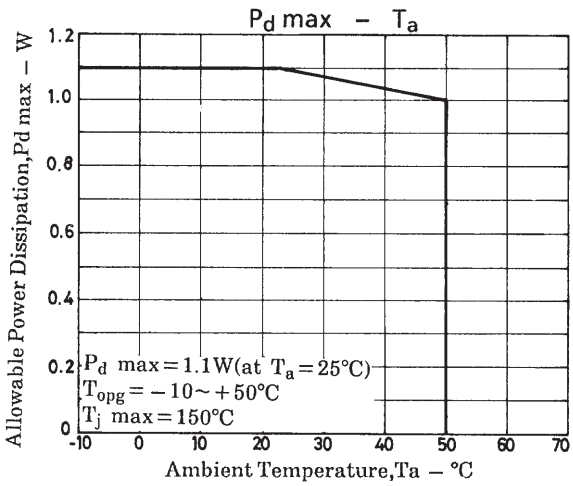
- Audio input sensor circuit
- LED driver circuit
- Motor control circuit
- ALC circuit
- Preamp and power amp circuits

Package Dimensions

unit: mm

3108-MFP24D





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TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN
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Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum Supply Voltage	V_{CC} max		4.5	V
Allowable Power Dissipation	Pd max	G_{VN} + Power	1100	mW
Operating Temperature	Topr		–10 to +50	°C
Storage Temperature	Tstg		–55 to +150	°C

Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Recommended Supply Voltage	V_{CC}		3.0	V
Operating Voltage Range	V_{CC} op		1.8 to 3.6	V
Power Amp Load Resistance	$R_{L\ PWR}$	PLAY	4	Ω
		REC	10	kΩ
Preamp Load Resistance	$R_{L\ PRE}$		10	kΩ

Operating Characteristics at Ta = 25°C, V_{CC} = 3.0 V, R_L = 4 Ω (Play Power), R_L = 10 kΩ (Rec Power), R_L = 10 kΩ (Pre), f = 1 kHz, 0 dBm = 0.775 V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Pre + Power]						
Quiescent Current	$I_{CC\text{-}R}$	REC mode, Vi = 0 V	12	25	38	mA
Quiescent Current	$I_{CC\text{-}P}$	PLAY mode, Vi = 0 V	13	26	39	mA
Voltage Gain (Closed Loop) REC	VG_{TR}	REC mode, V_O = –5 dBm	62	64.5	67	dB
Voltage Gain (Closed Loop) PLAY	VG_{TP}	PLAY mode, V_O = –5 dBm	71	73.5	76	dB
[Pre Amp]						
Voltage Gain (Closed Loop) REC	VG1 R	REC mode, V_O = –10 dBm, R_{NF} = 100 Ω	32.5	35	37.5	dB
Voltage Gain (Closed Loop) PLAY	VG1 P	PLAY mode, V_O = –10 dBm, R_{NF} = 100 Ω	42.5	45	47.5	dB
Maximum Output Voltage	V_O max	THD=1%, PLAY mode	0.3	0.6	1.0	V
Equivalent Input Noise Voltage	V_{NI}	PLAY mode, BPF = 20 Hz to 20 kHz	0.5	1.1	2.0	μV
Input Resistance	RI		22.5	32.2	42	kΩ
Total Harmonic Distortion	THD1	PLAY mode, V_O = 0.4 V	0.01	0.11	1.0	%
[POWER AMP]						
Voltage Gain	VG2	V_O = –5 dBm, R_L = 4 Ω	26.0	28.5	31.0	dB
Output Power	P_O	THD = 10 %, R_L = 4 Ω	180	215	350	mW
Total Harmonic Distortion	THD2	P_O = 30 mW, R_L = 4 Ω	0.05	0.5	1.5	%
Output Noise Voltage	V_{NO}	RV = 0, RL = 4 Ω, BPF = 20 Hz to 20 kHz	5	25	100	μV
[ALC]						
ALC Width	ALC W	Input voltage above ALC cut-in voltage for ALC output to rise by 2.5 dB	30	38	45	dB
ALC Distortion	ALC THD	Pre: Vi = –40 dBm	0.1	0.67	1.5	%
ALC Output	ALC V_O	Pre: Vi = –40 dBm	0.35	0.46	0.55	V
ALC Start Input Level	ALC V_{IN}		–66.5	–69	–71.5	dBm
[Voice Sensor]						
Minimum Activation Input Voltage	V_{OP} min	VR (10 kΩ) max	–84.5	–81.5	–78.5	dBm
Maximum Activation Input Voltage	V_{OP} max	VR (10 kΩ) max	–62.5	–59.5	–56.5	dBm
Input Hysteresis	$V_{O\ HL}$		3	6	9	dB
[LED Drive]						
LED Drive Current	I_{LED}	Red LED	1.0	2.5	4.5	mA

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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
[Moter Control]						
Reference voltage	V_{ref}	I_m = 100 mA	1.1	1.25	1.4	V
Quiescent Current	I_d	I_m = 100 mA	2.0	3.0	6.0	mA
Shunt Ratio	K	I_m = 50–100 mA	45	50	55	
Residual Voltage	V_{sat}	I_m = 200 mA, $V_{ref} = V_{cont}$	0.1	0.3	0.5	V
Voltage Characteristic of Reference Voltage	$\frac{\Delta Vref}{Vref}/\Delta V_{CC}$	V_{CC} = 1.8 to 4.5 V, I_m = 100 mA	0	0.1	0.5	%/V
Voltage Characteristic of Shunt Ratio	$\frac{\Delta K}{K}/\Delta V_{CC}$	V_{CC} =2.0 to 4.5 V, I_m = 50–100 mA	0	0.1	0.5	%/V
Current Characteristic of Reference Voltage	$\frac{\Delta Vref}{Vref}/\Delta I_m$	I_m = 50 to 200 mA	0	0.007	0.03	%/mA
Current Characteristic of Shunt Ratio	$\frac{\Delta K}{K}/\Delta I_m$	I_m = 50–100 mA to 150–200 mA	–0.05	+0.005	+0.05	%/mA

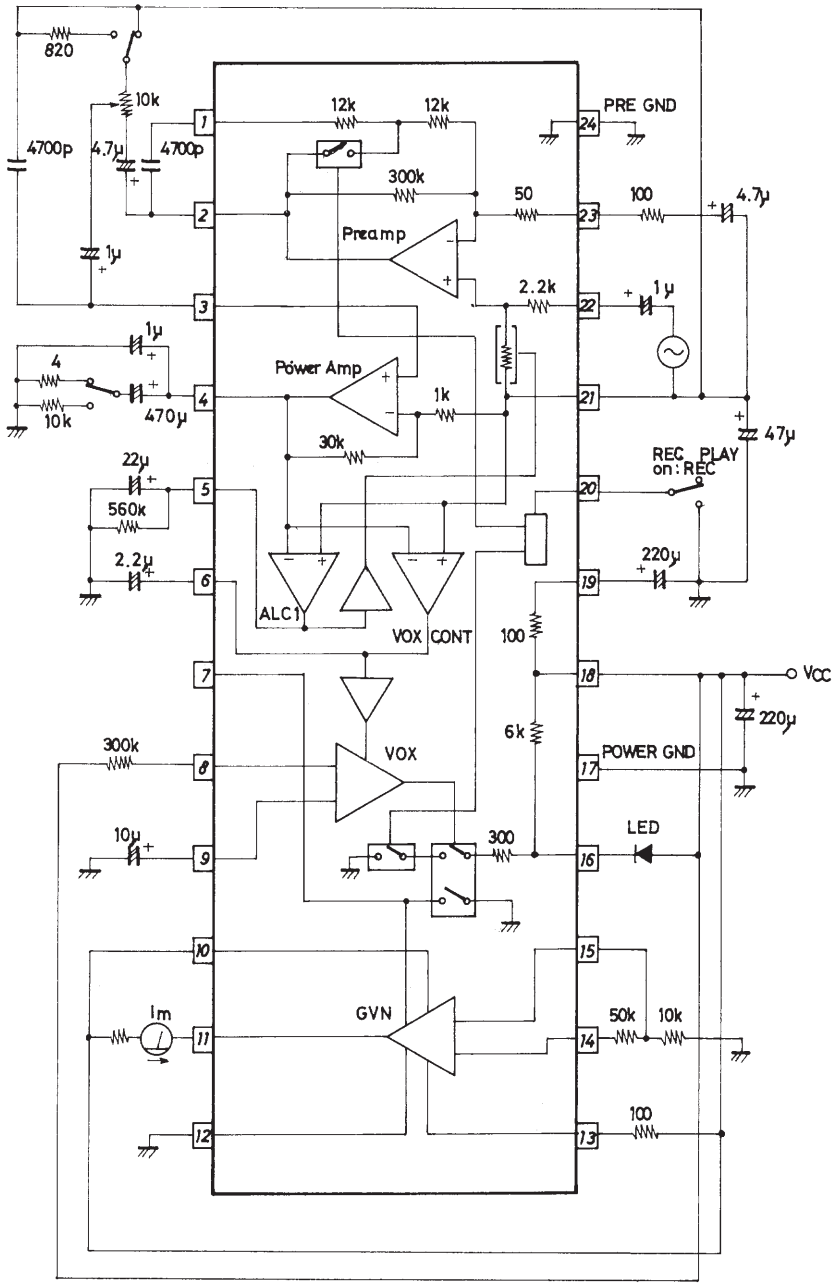
Recording/Playback Mode Functions

○ : ON ×: OFF

Circuit	Preamp	ALC Circuit	LED Drive	Voice Sensor Circuit	Power Amp	Motor Control
Recording Mode	(MIC Amp) ○	○	※ ○	※ ○	○	※ ○
Playback Mode	(EQ Amp) ○	×	×	×	○	○

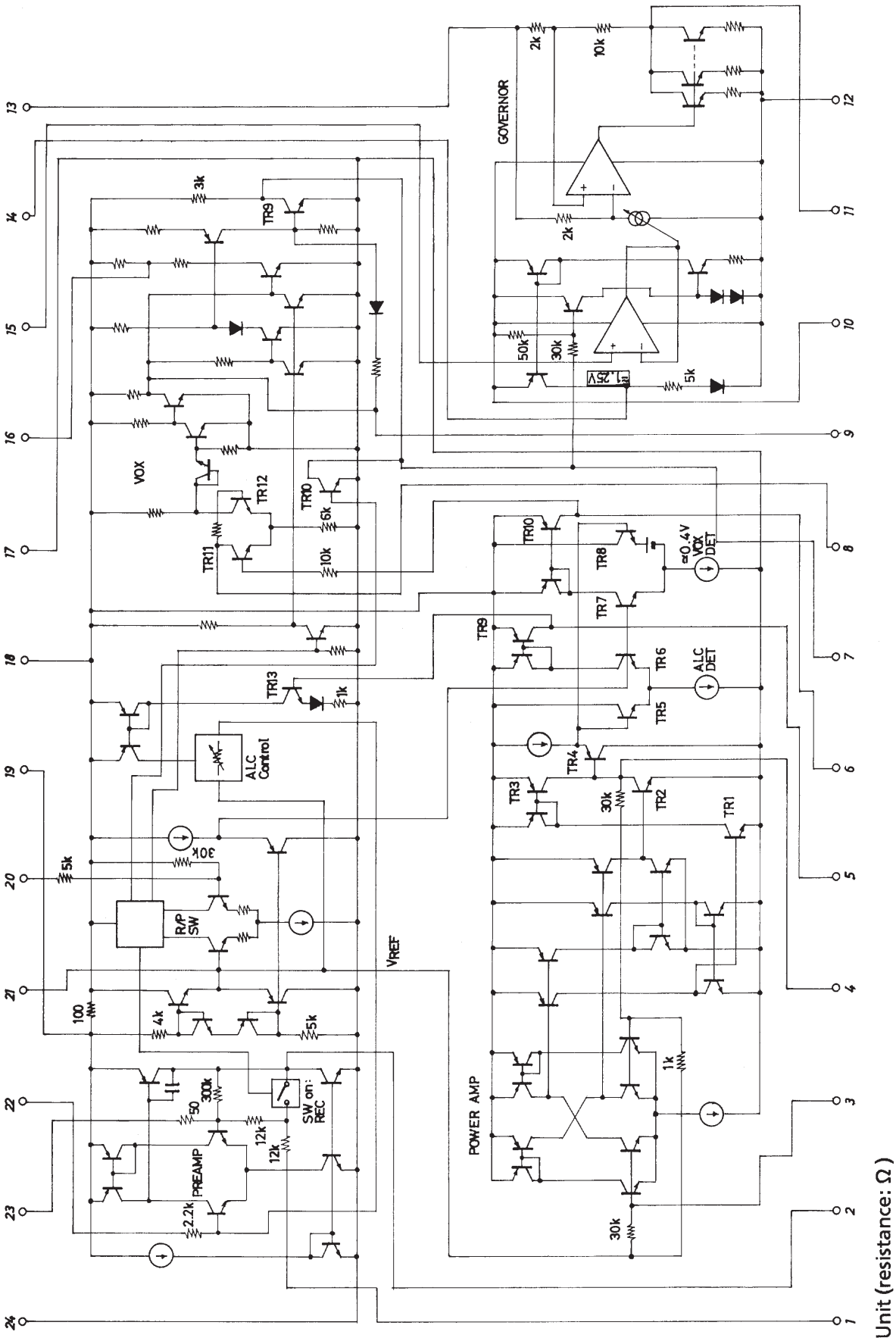
※ : Block is on when MIC input voltage exceeds the threshold level.

Test Circuit



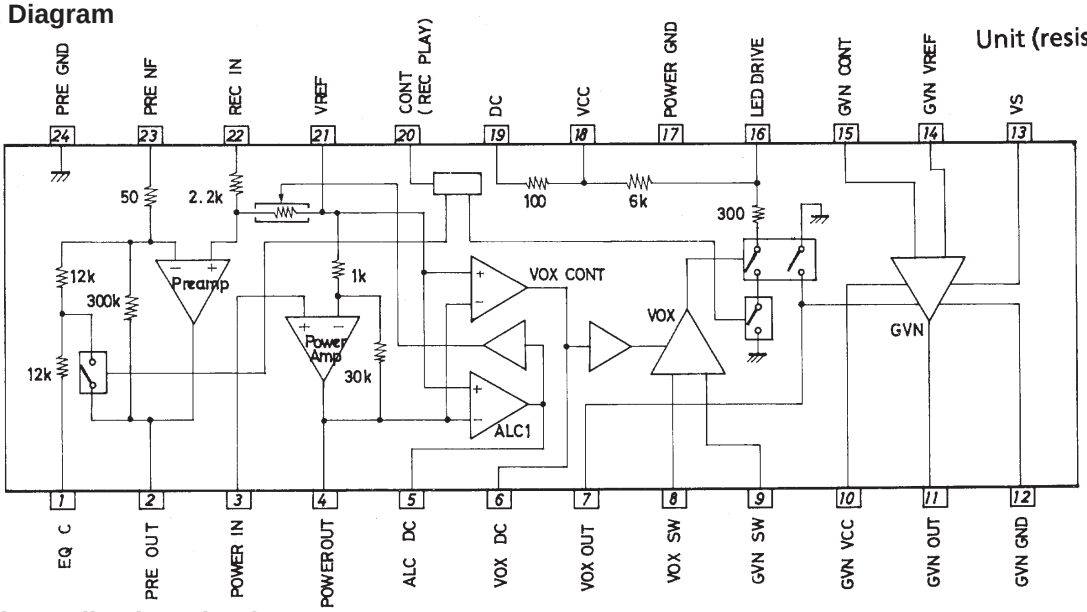
Unit (resistance: Ω, capacitance: F)

Equivalent Circuit



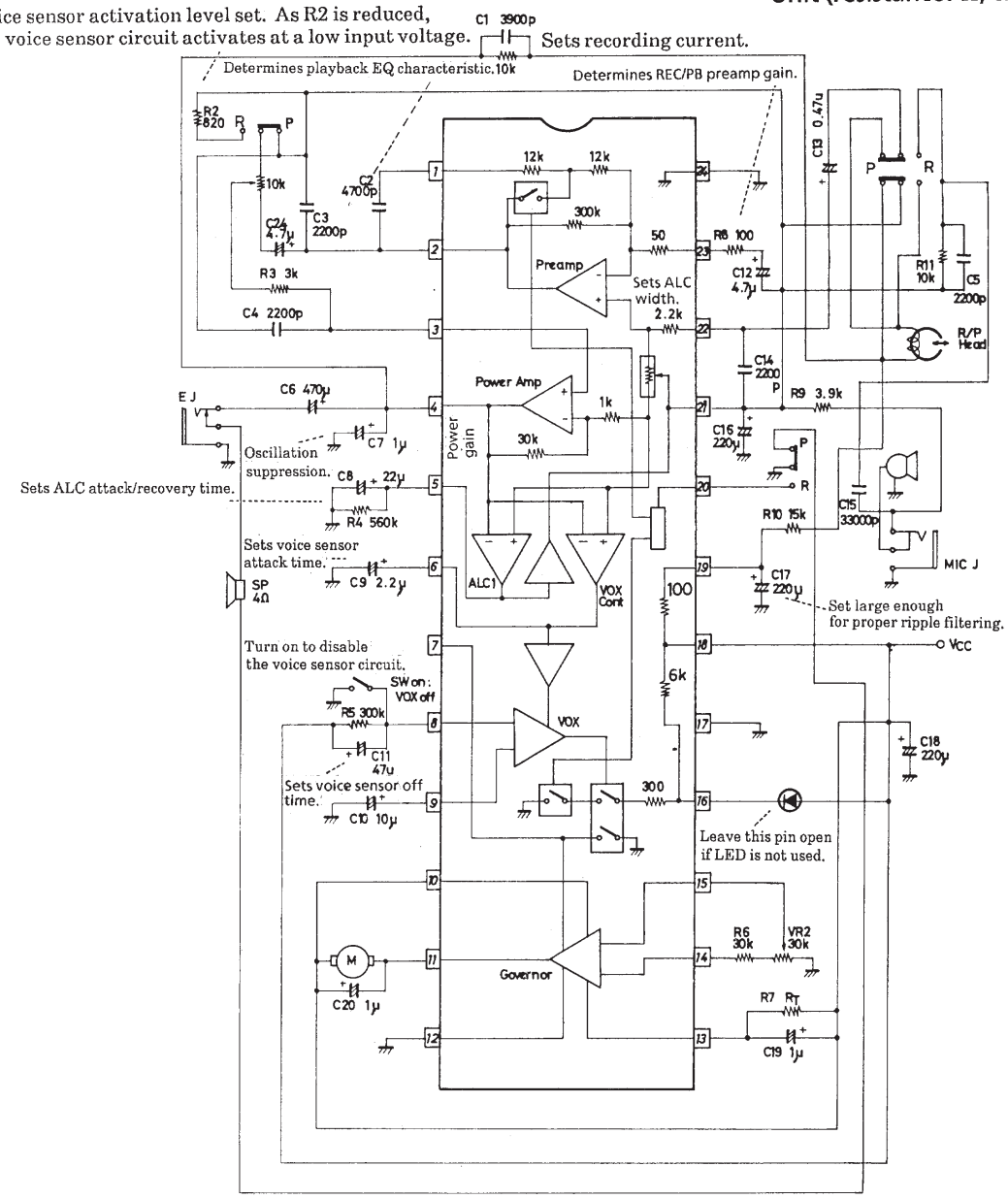
Block Diagram

Unit (resistance: Ω)



Sample Application Circuit

Unit (resistance: Ω, capacitance: F)



Functional Description

[Preamp]

- The frequency response characteristic of the low noise preamplifier is selected by the record/playback select pin CONT (pin 20). If CONT is taken to ground to select record mode, the frequency response is flat. If CONT is left open, playback mode is selected and the preamp has the NAM response curve.

[Power Amp]

- The power amplifier is suited to driving 4 Ω speakers and earphones.

[ALC]

- The ALC (Automatic Level Control) circuit is active in recording mode. It detects the power amp output level, and controls the preamplifier input gain so that the power amp output level is constant.

[VOX CONT VOX]

- This circuit monitors the power amp output level, and turns the motor drive on or off. When the VOX CONT circuit is operating, the LED drive output on pin 16 is active. The LED is extinguished if the supply voltage drops to 1.8V.

[GVN]

- Motor control circuit. The external constants are determined according to the motor characteristics to keep the motor speed constant.

Circuit Components

The function of each component, together with recommended values in parentheses, are listed below.

- C1: (2200 to 4700 pF)
  Determines the frequency response of the signal voltage to the record/replay head during recording. Its value should be selected according to the characteristics of the head.
- C2 : (4700 pF)
  Determines the playback equalization frequency response.
- C3 : (2200 pF)
  Suppresses high-frequency oscillation.
- C4 : (2200 to 4700 pF)
  Controls high-frequency characteristics. C4 will interact with R3 to reduce the power amp input level if it is too large.
- C5 : (2200 to 4700 pF)
  Microphone input high-frequency filter. This should be selected according to the high-frequency cut-off and the value of C21.
- C6 : (470 µF)
  Couples the power amp output to the speaker or headphones. A value of 220 µF is adequate when using an 8 Ω speaker or headphones.
- C7 : (1 µF)
  Suppresses oscillation. For low-temperature operation (down to -10°C), a 0.47 µF tantalum electrolytic capacitor should be used.
- C8 : (22 µF)
  ALC control smoothing filter. C8 should not be too large, since this will also increase attack time.
- C9 : (0.1 to 2.2 µF)
  Voice sensor (VOX) control smoothing filter. C8 should not be too large, since this will also increase turn-on delay (the time for the motor drive circuit to turn on after the microphone input voltage reaches the set level).

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- C10 : (10 µF)
  Voice sensor transient suppression. This prevents the motor drive from being turned on by large transient pulses.
- C11 : (47 µF)
  Determines the time constant for motor drive hold after the voice sensor circuit turns off. The motor drive remains on for approximately 4 to 5 seconds if the resistor in parallel with R5 is 300 kΩ.
- C12 : (4.7 µF)
  Together with series resistor R8, determines the preamp low-frequency cut-off. For C12 =4.7 µF and R8=100 Ω, the cut-off is approximately 200 Hz. The cut-off can be set to approximately 100 or 300 Hz by giving C12 a value of 10 µF or 2.2 µF, respectively.
- C13 : (0.47 µF)
  Preamp input coupling capacitor.
- C14 : (2200 µpF)
  EMI suppression capacitor. Select this according to the characteristics of the record/play head.
- C15 : (3300 pF)
  Microphone input high-frequency filter.
- C16 : (220 µF)
  Reference voltage decoupling capacitor.
- C17 : (220 µF)
  Head DC supply ripple filter.
- C18 : (220 µF)
  Supply decoupling capacitor.
- C19 : (1 to 10 µF)
  Reference resistor (R7) bypass capacitor. Setting should be performed according to motor characteristics.
- C20 : (1 µF)
  Load (motor) bypass capacitor. Setting should be performed according to motor characteristics.
- R1 : (5 to 15 kΩ)
  Determines the flow of AC current through the head. Select this according to the head characteristics and ALC level.
- R2 : (820 Ω)
  Determines the microphone input level at which the voice sensor starts operating when VR1 is at minimum. Larger values for R2 give voice sensor operation at lower microphone input signal levels.
- R3 : (3 kΩ)
  Improves high-frequency response and reduces high-frequency distortion. Distortion above 5 kHz increases as R3 decreases.
- R4 : (100 kΩ to 3 MΩ)
  Determines ALC recovery time.
- R5 : (300 kΩ)
  Voice sensor circuit control current resistor. R5 and C11 form the motor drive hold-time constant.
- R6 : (20 to 70 kΩ)
  Determines motor speed. Select this according to the motor characteristics and the value of variable resistor VR2.

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- R7 : (100 to 300 Ω)

  Select this according to the motor characteristics.

- R8 : (0 to 200 Ω)

  Preamp negative feedback resistor.

- R9 : (3.9 kΩ)

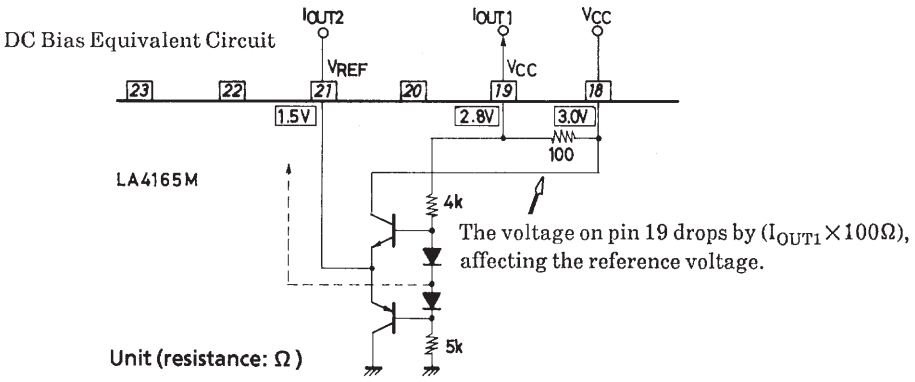
  Bias set resistor for electrostatic microphones.

  The current into or out of the reference voltage pin (pin 21) should not be greater than ±1mA, or the biase of other circuits will be affected. In particular, the power amplifier output power will be reduced.

- R10 : (15 kΩ)

  Recording head bias set resistor. Since the bias reference voltage is the filtered DC voltage on pin 19, excessive current should not be drawn by R10, or the reference voltage on pin 21 will be affected.

  The following diagram shows the internal circuit of the reference voltage generator.



- R11 : (5 to 20 kΩ)

  Select this to match the electrostatic microphone output characteristics.

- VR1 : (10 to 30 kΩ)

  Adjusts the output level in playback mode, and the voice sensor sensitivity in record mode.

- VR2 : (5 to 30 kΩ)

  Motor speed fine adjustment.

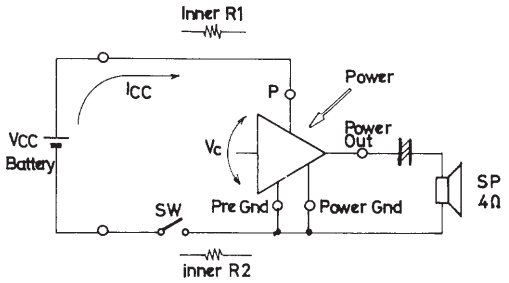
- LED : (Red LED)

  Illuminated while recording. The LED starts to go out when V_{CC} drops to 2.2 V, and is completely extinguished when V_{CC} drops to 1.8 V.

Pin No.	Symbol	Pin Name	Voltage [V]
1	$V_{EQ\,C}$	Equalizer C	1.5
2	$V_{PRE\,OUT}$	Pre out	1.5
3	$V_{PWR\,IN}$	Power in	1.5
4	V_{OUT}	Power out	1.5
5	ALC	Auto Level Cont	0
6	VOX CONT	Voice Ope Cont	0
7	VOX SW	Voice Ope Switch	3.0
8	VOX RECOV	Voice Ope Recorder	0
9	VOX C	Voice Ope C	0
10	V_{CC}	GVN V_{CC}	3.0
11	V_{OUT} GVN	GVN out	
12	GND GVN	GVN GND	0
13	VS GVN	VS GVN	
14	V_{REF} GVN	GVN V_{REF}	1.2
15	GVN CONT	GVN Cont	
16	LED	LED Drive	
17	GND	Power GND	0
18	V_{CC}	V_{CC}	3.0
19	R.F	Ripple Filter	2.8
20	R/P CONT	REC/PLAY Cont	3.0
21	V_{REF}	V_{REF}	1.5
22	IN	Pre in	1.5
23	NF	Pre NF	1.5
24	GND	Pre GND	0

Design Notes

1. Locate the LC4165M as close as possible to the power source, to prevent voltage and power loss due to supply line resistance.



Change "Inner R_1" to "Wiring resistance R_1"

Change "Inner R_2" to "Wiring resistance R_2"

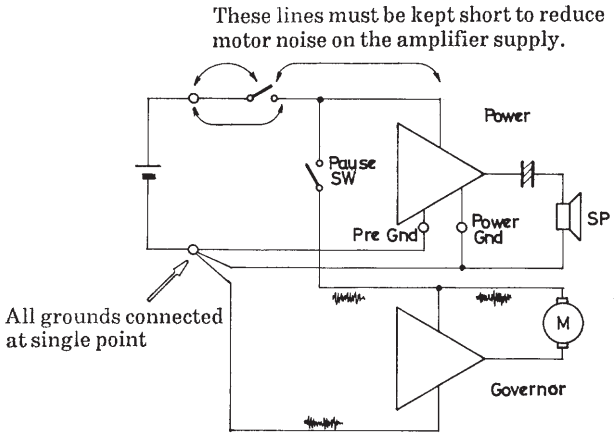
The total wiring resistance $R_T = R_1 + R_2$ causes the voltage V_C at the IC supply pins to drop from the source voltage V_{CC} to

$$V_C = V_{CC} - I_{CC}\,(R_1 + R_2)$$

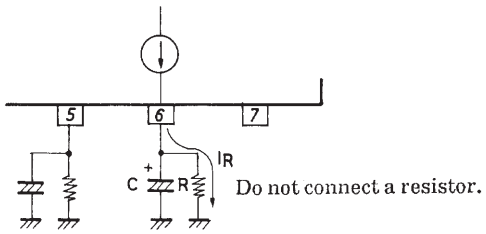
The power output from the amplifier is equal to

$$P0 \propto (V_C)^2$$

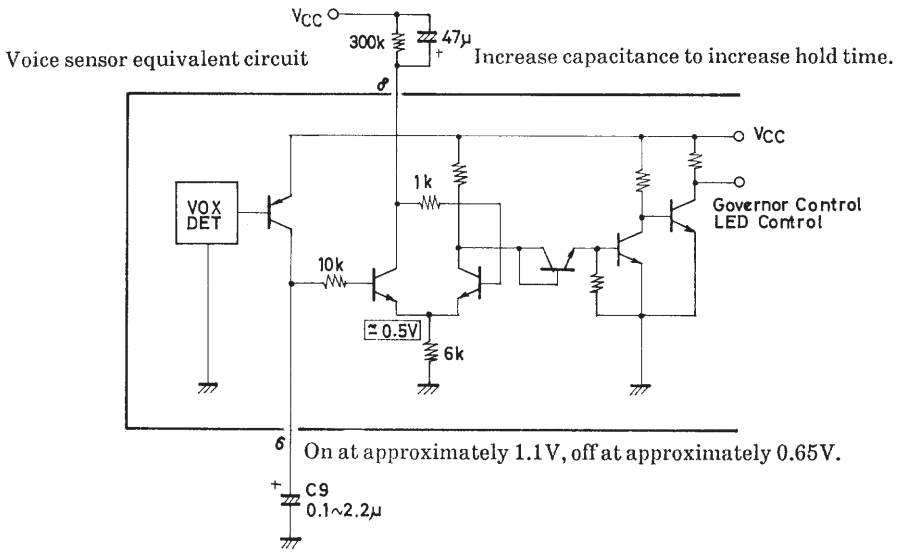
2. Keep the supply lines for the amplifier circuits separate from those for the motor drive circuit. This will reduce the effect of motor noise on the amplifiers and help prevent voltage drop due to motor load from affecting the amplifier supply voltage.
   The recommended supply layout for the LA4165M power supply lines is shown below.



3. Do not connect a resistor to pin 6. The capacitor on this pin is being charged by a small current to determine the voice sensor attack time. Bypassing this capacitor with a resistor will increase attack time, and possibly prevent the voice sensor circuit from turning on.

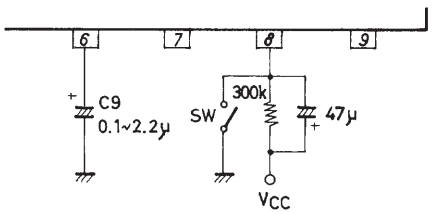


4. The voice sensor circuit has approximately 6 dB hysteresis. It turns on at a voltage on pin 6 of approximately 1.1 V and turns off at approximately 0.65 V. Biasing pin 6 higher than 0.65 V will cause it to remain on. The voice sensor equivalent circuit is shown below.



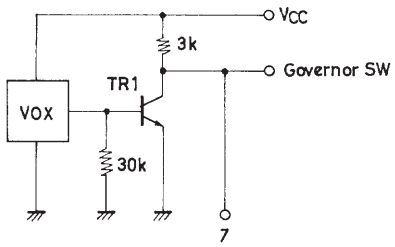
Unit (resistance: Ω, capacitance: F)

5. In record mode, grounding pin 8 will turn off the voice sensor circuit and keep the motor drive circuit operating continuously.



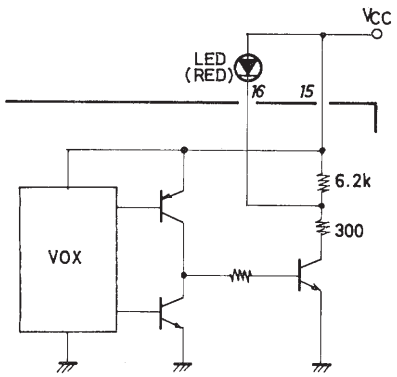
Unit (resistance: Ω, capacitance: F)

6. Pin 7 is close to 0 V when the governor circuit is on, and close to V_{CC} when it is off. The voice sensor output stage equivalent circuit is shown below.

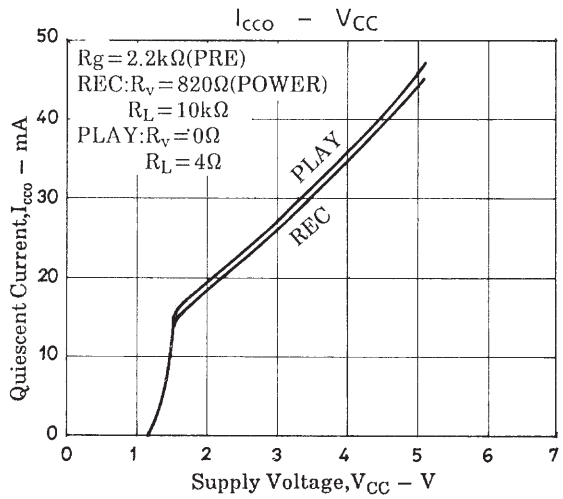


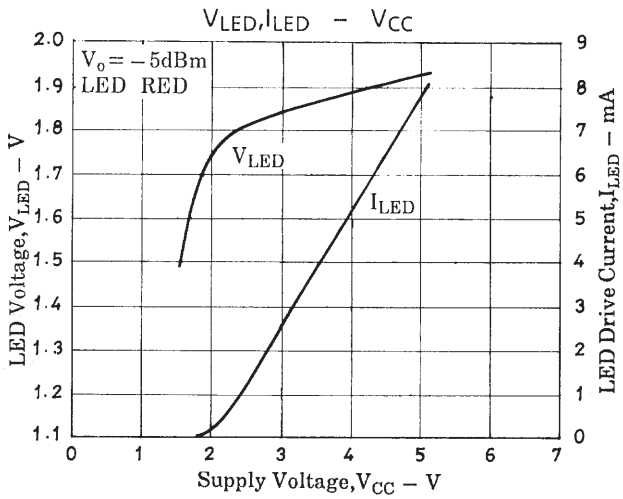
Unit (resistance: Ω)

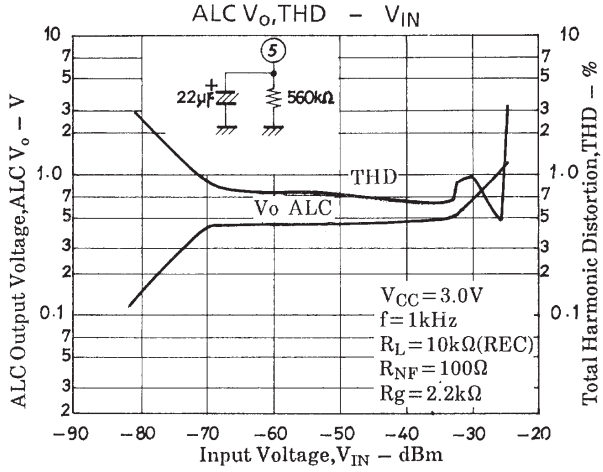
7. Pin 16 is used solely for driving an external LED, and should be left open when an LED is not used. It is active only during record mode while the motor drive is on. The LED drive circuit is shown below.

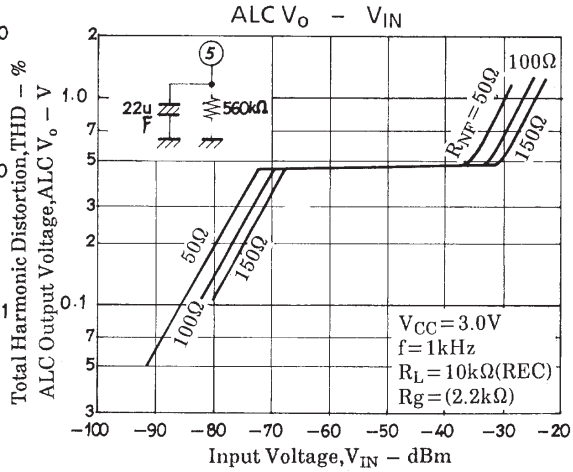


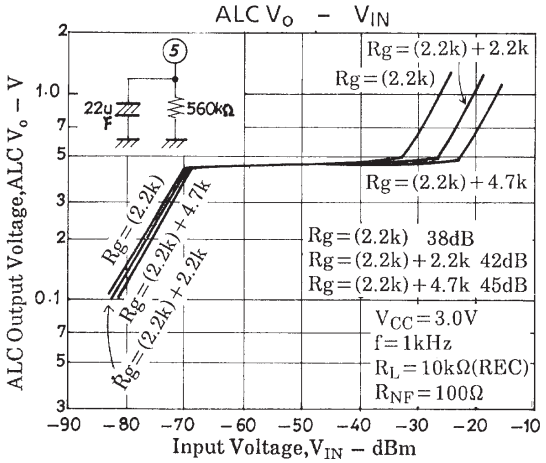
Unit (resistance: Ω)

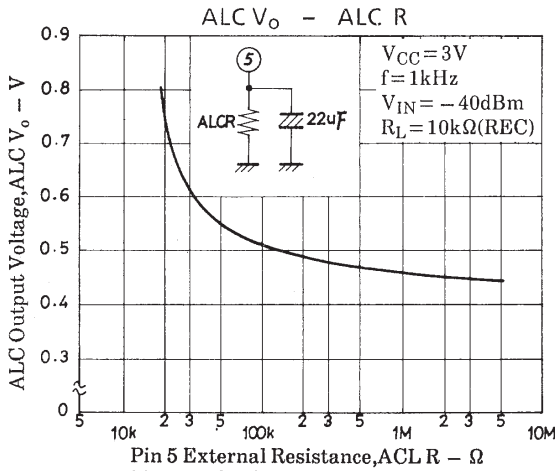


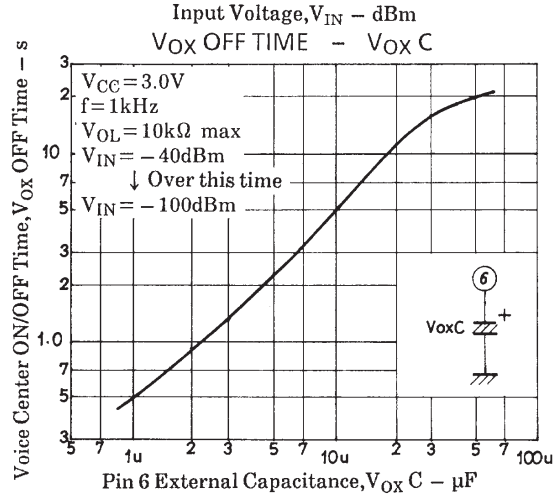


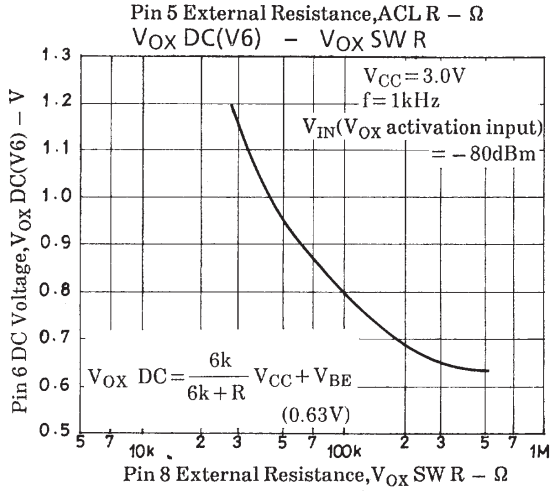

ALC Vo,THD – VIN
ALC Output Voltage,ALC Vo – V
Input Voltage,VIN – dBm
THD
Vo ALC
22μF
560kΩ
VCC=3.0V
f=1kHz
RL=10kΩ(REC)
RNF=100Ω
Rg=2.2kΩ

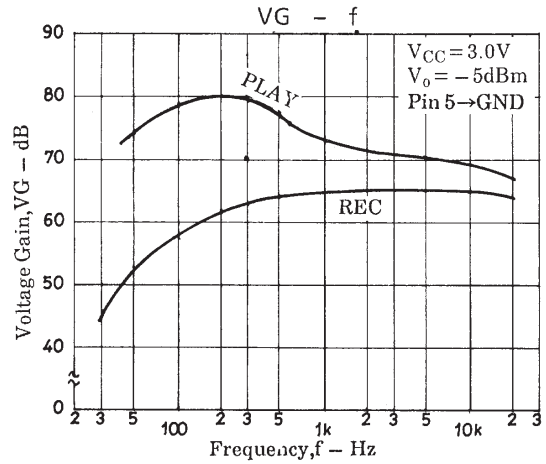

ALC Vo – VIN
Total Harmonic Distortion,THD – %
ALC Output Voltage,ALC Vo – V
Input Voltage,VIN – dBm
22u F
560kΩ
RNF=50Ω
100Ω
150Ω
VCC=3.0V
f=1kHz
RL=10kΩ(REC)
Rg=(2.2kΩ)

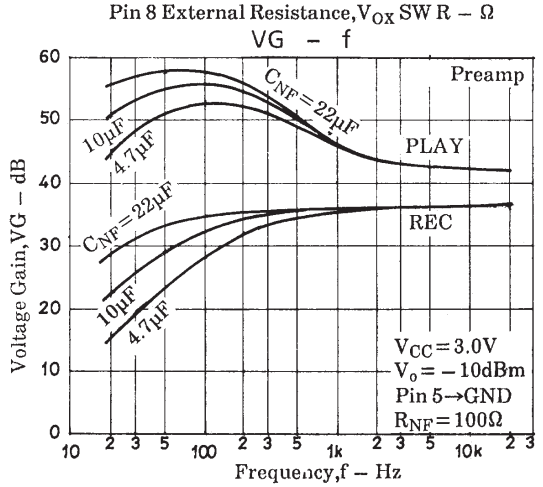

ALC Vo – VIN
ALC Output Voltage,ALC Vo – V
Input Voltage,VIN – dBm
Rg=(2.2k)+2.2k
Rg=(2.2k)
Rg=(2.2k)+4.7k
Rg=(2.2k) 38dB
Rg=(2.2k)+2.2k 42dB
Rg=(2.2k)+4.7k 45dB
VCC=3.0V
f=1kHz
RL=10kΩ(REC)
RNF=100Ω


ALC Vo – ALC R
ALC Output Voltage,ALC Vo – V
Pin 5 External Resistance,ACL R – Ω
ALCR
22uF
VCC=3V
f=1kHz
VIN=–40dBm
RL=10kΩ(REC)

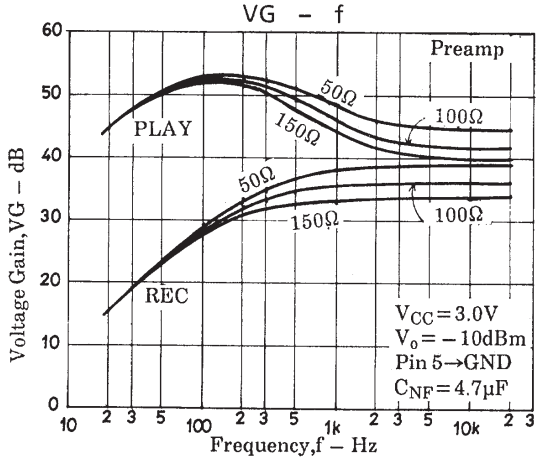

VOX OFF TIME – VOX C
Voice Center ON/OFF Time,VOX OFF Time – s
Pin 6 External Capacitance,VOX C – μF
VCC=3.0V
f=1kHz
VOL=10kΩ max
VIN=–40dBm
↓ Over this time
VIN=–100dBm
VoxC


VOX DC(V6) – VOX SW R
Pin 6 DC Voltage,VOX DC(V6) – V
Pin 8 External Resistance,VOX SW R – Ω
VCC=3.0V
f=1kHz
VIN(VOX activation input)
=–80dBm
VOX DC=6k/(6k+R) VCC+VBE
(0.63V)

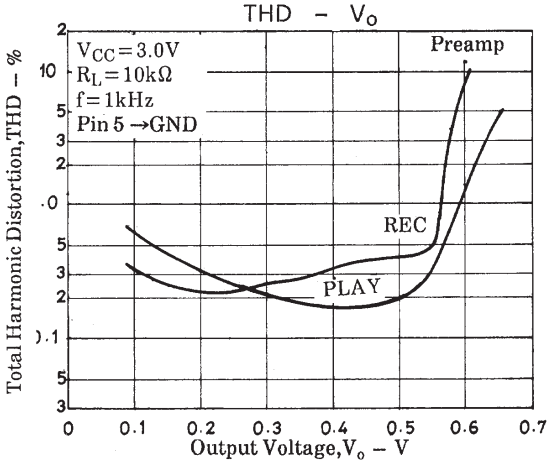

VG – f
Voltage Gain,VG – dB
Frequency,f – Hz
PLAY
REC
VCC=3.0V
Vo=–5dBm
Pin 5→GND


VG – f
Voltage Gain,VG – dB
Frequency,f – Hz
Preamp
PLAY
REC
CNF=22μF
10μF
4.7μF
VCC=3.0V
Vo=–10dBm
Pin 5→GND
RNF=100Ω

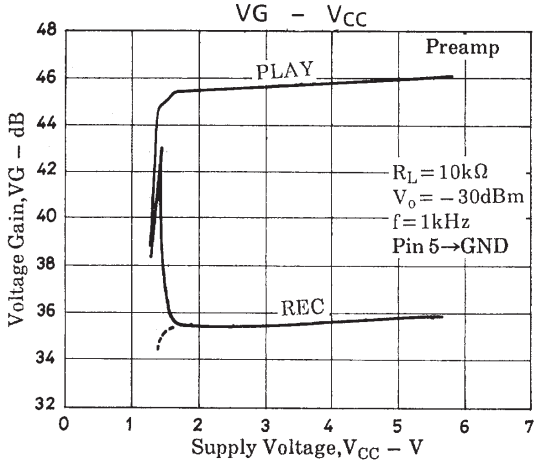
VG – f



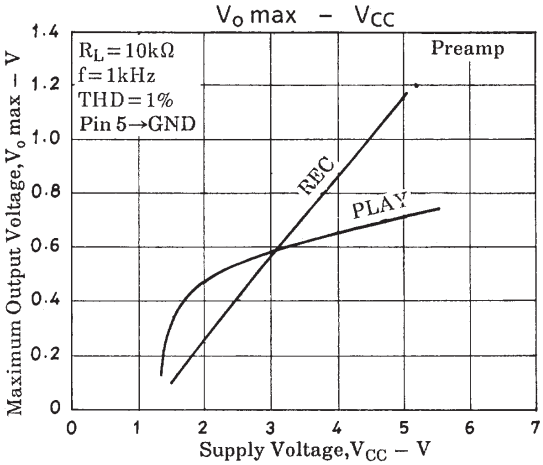
THD – V_o



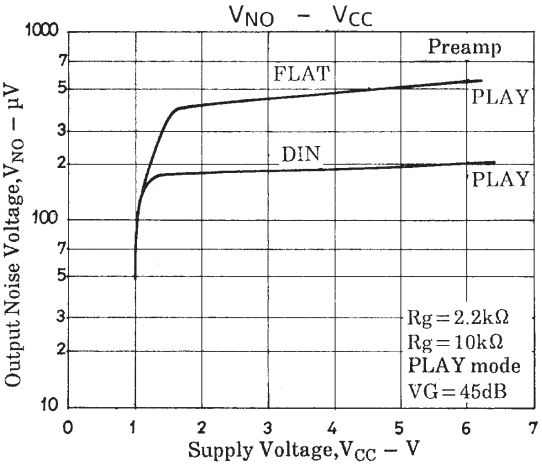
VG – V_{CC}



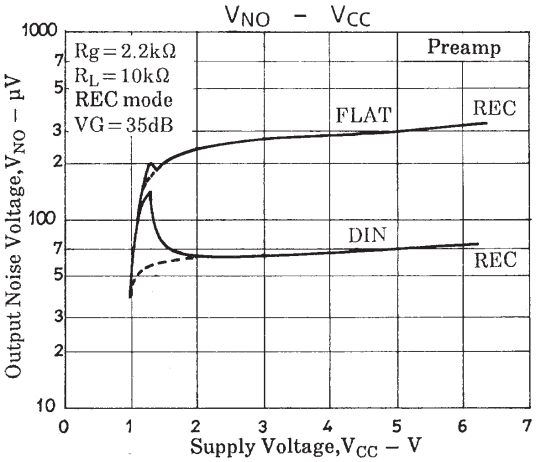
V_o max – V_{CC}



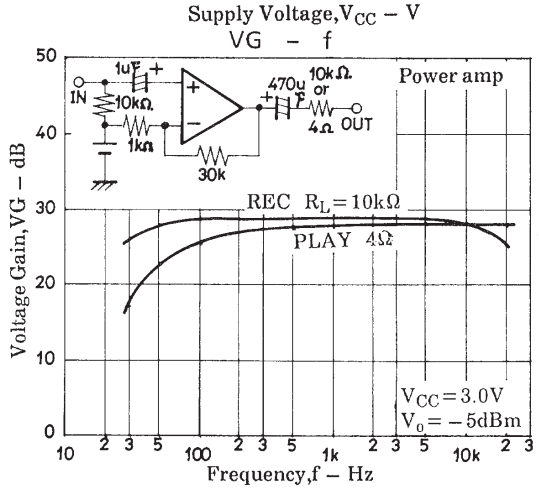
V_{NO} – V_{CC}



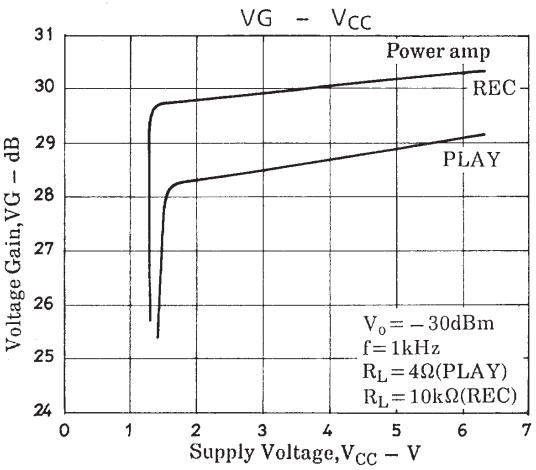
V_{NO} – V_{CC}

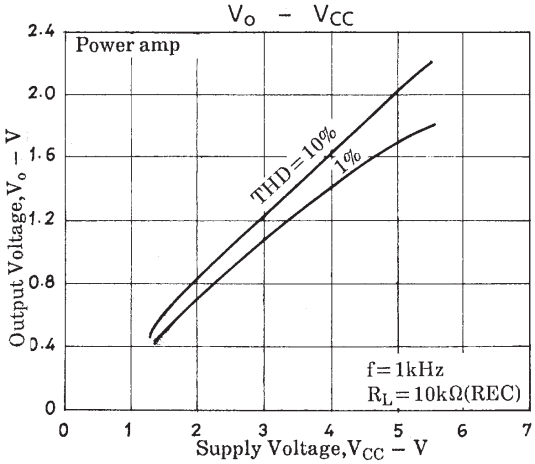


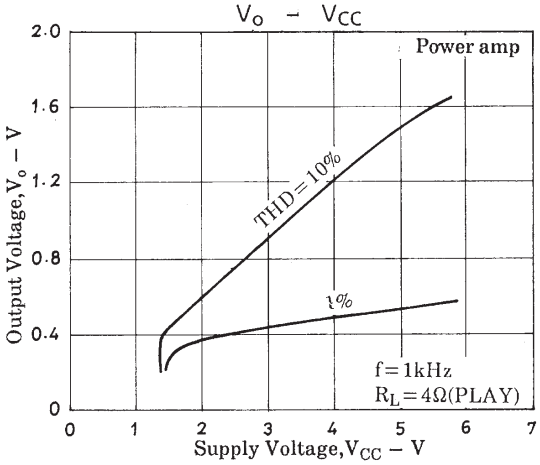
VG – f

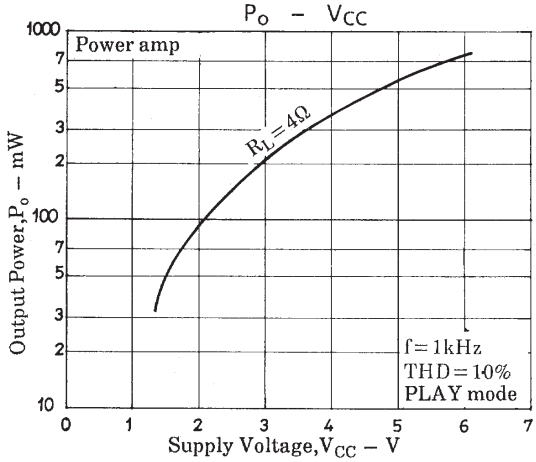


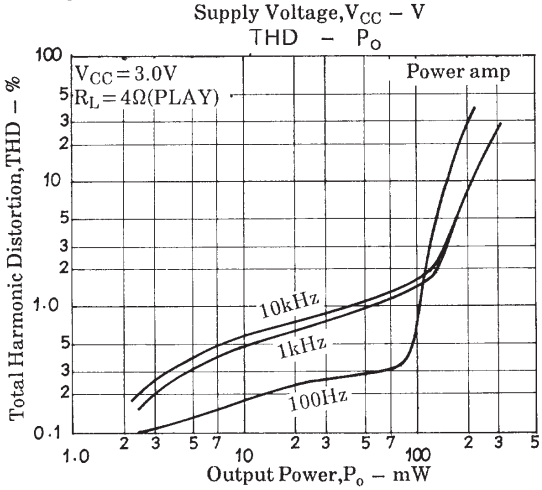
VG – V_{CC}

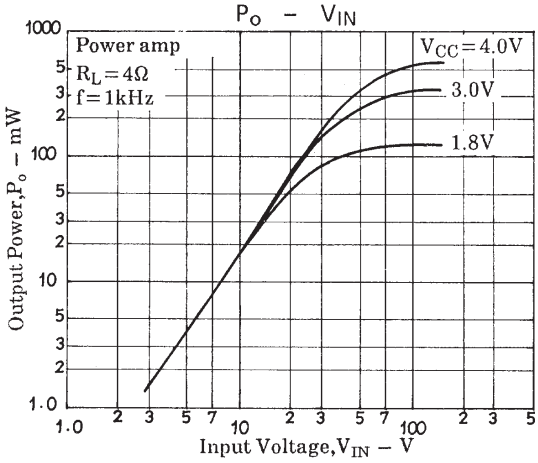


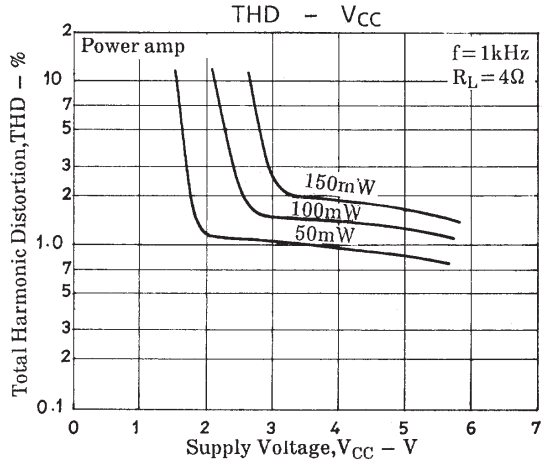

Vo – VCC
Power amp
THD=10%
1%
f=1kHz
RL=10kΩ(REC)
Output Voltage, Vo – V
Supply Voltage, VCC – V

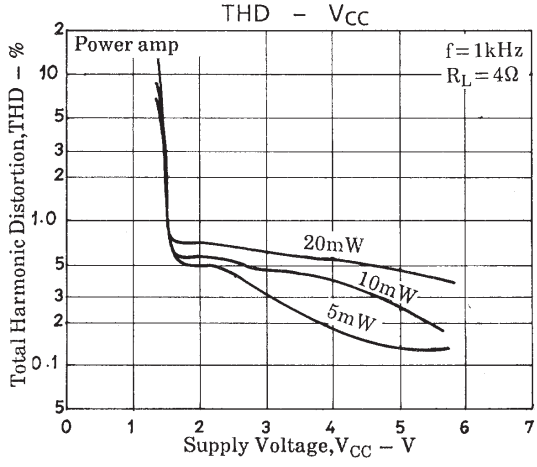

Vo – VCC
Power amp
THD=10%
1%
f=1kHz
RL=4Ω(PLAY)
Output Voltage, Vo – V
Supply Voltage, VCC – V

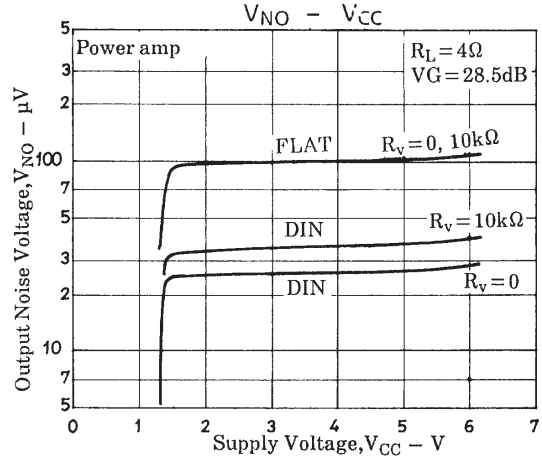

Po – VCC
Power amp
RL=4Ω
f=1kHz
THD=10%
PLAY mode
Output Power, Po – mW
Supply Voltage, VCC – V

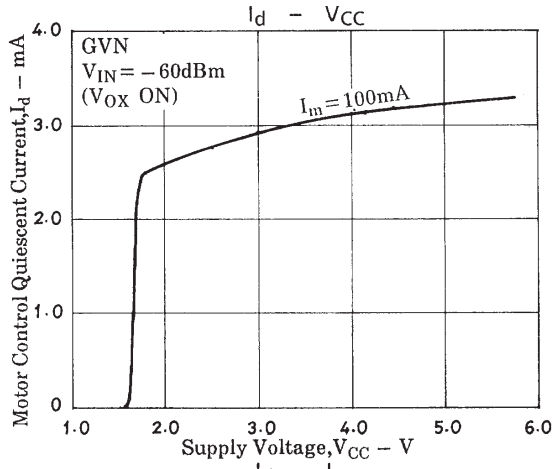

THD – Po
VCC=3.0V
RL=4Ω(PLAY)
Power amp
10kHz
1kHz
100Hz
Total Harmonic Distortion, THD – %
Output Power, Po – mW

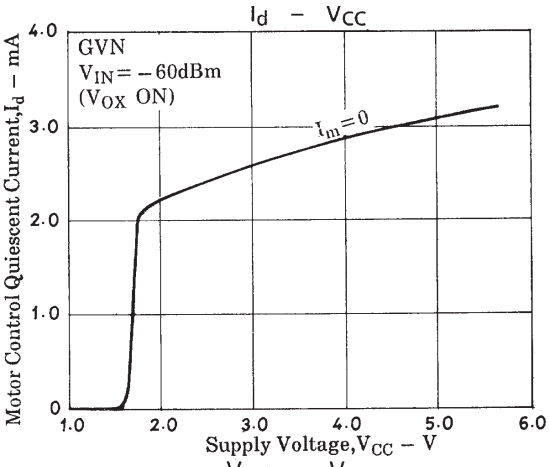

Po – VIN
Power amp
RL=4Ω
f=1kHz
VCC=4.0V
3.0V
1.8V
Output Power, Po – mW
Input Voltage, VIN – V

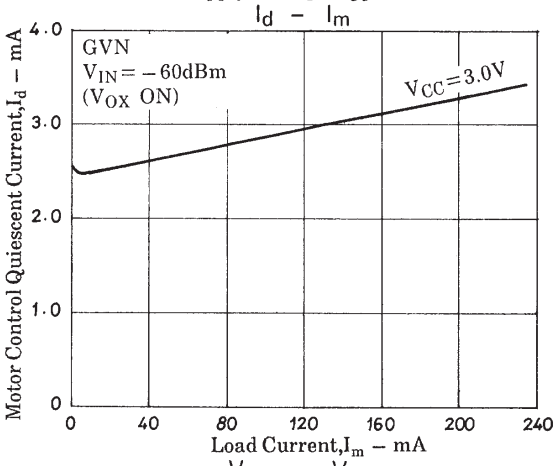

THD – VCC
Power amp
f=1kHz
RL=4Ω
150mW
100mW
50mW
Total Harmonic Distortion, THD – %
Supply Voltage, VCC – V

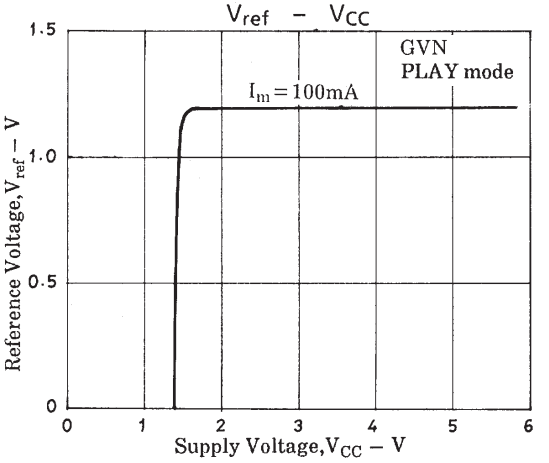

THD – VCC
Power amp
f=1kHz
RL=4Ω
20mW
10mW
5mW
Total Harmonic Distortion, THD – %
Supply Voltage, VCC – V

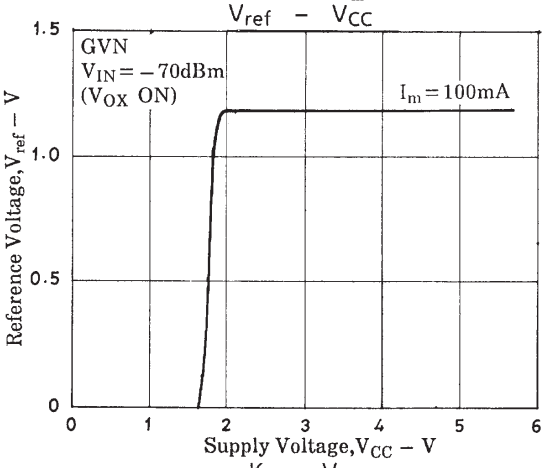

VNO – VCC
Power amp
RL=4Ω
VG=28.5dB
FLAT
Rv=0, 10kΩ
DIN
Rv=10kΩ
DIN
Rv=0
Output Noise Voltage, VNO – μV
Supply Voltage, VCC – V

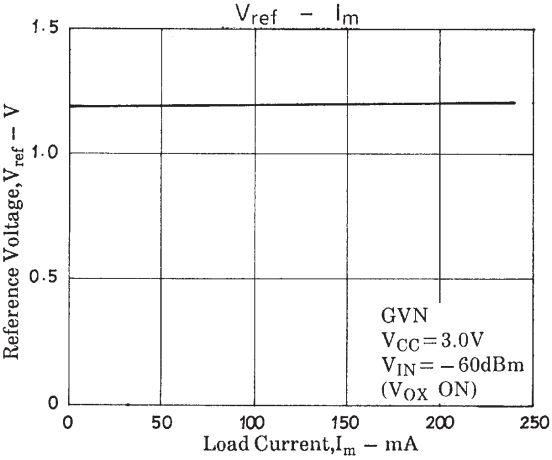

I_d – V_{CC}
GVN
V_{IN} = –60dBm
(V_{OX} ON)
I_m = 100mA
Motor Control Quiescent Current, I_d – mA
Supply Voltage, V_{CC} – V

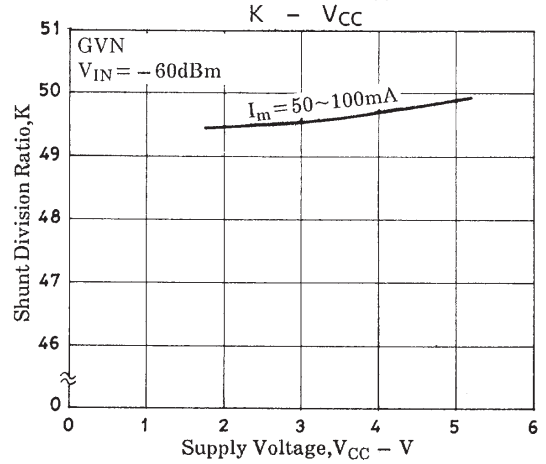

I_d – V_{CC}
GVN
V_{IN} = –60dBm
(V_{OX} ON)
I_m = 0
Motor Control Quiescent Current, I_d – mA
Supply Voltage, V_{CC} – V

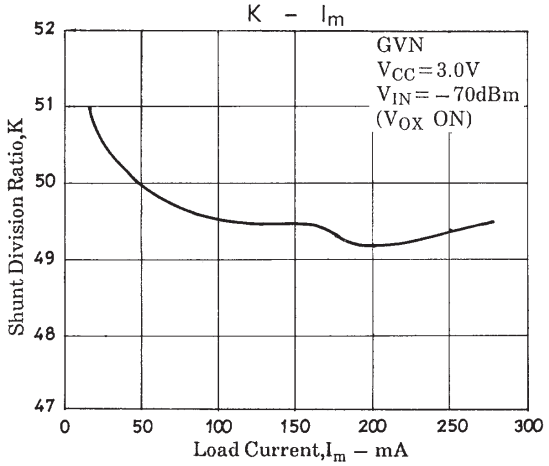

I_d – I_m
GVN
V_{IN} = –60dBm
(V_{OX} ON)
V_{CC} = 3.0V
Motor Control Quiescent Current, I_d – mA
Load Current, I_m – mA


V_{ref} – V_{CC}
GVN
PLAY mode
I_m = 100mA
Reference Voltage, V_{ref} – V
Supply Voltage, V_{CC} – V


V_{ref} – V_{CC}
GVN
V_{IN} = –70dBm
(V_{OX} ON)
I_m = 100mA
Reference Voltage, V_{ref} – V
Supply Voltage, V_{CC} – V


V_{ref} – I_m
GVN
V_{CC} = 3.0V
V_{IN} = –60dBm
(V_{OX} ON)
Reference Voltage, V_{ref} – V
Load Current, I_m – mA


K – V_{CC}
GVN
V_{IN} = –60dBm
I_m = 50~100mA
Shunt Division Ratio, K
Supply Voltage, V_{CC} – V


K – I_m
GVN
V_{CC} = 3.0V
V_{IN} = –70dBm
(V_{OX} ON)
Shunt Division Ratio, K
Load Current, I_m – mA