

T-75-07-15

KA2420

LINEAR INTEGRATED CIRCUIT

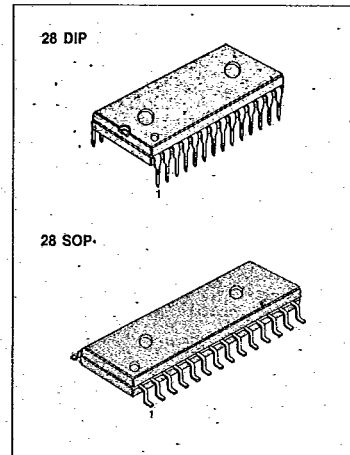
VOICE SWITCHED SPEAKER-PHONE

The KA2420 speaker phone chip includes amplifiers, attenuators, and control functions necessary to design a high quality speaker phone system. It also includes a microphone amplifier and audio power amplifier for speaker, background sound level monitoring system, attenuation control system, and the necessary regulated voltages for internal and the external circuits. This will permit operation from the mains with no additional power supply required.

The chip select pin will facilitate power down when the chip is not selected. The volume control may be implemented by using an external potentiometer. The KA2420 can be used in a wide variety of applications such as; intecom systems, business, automotive or household telephones.

FEATURES

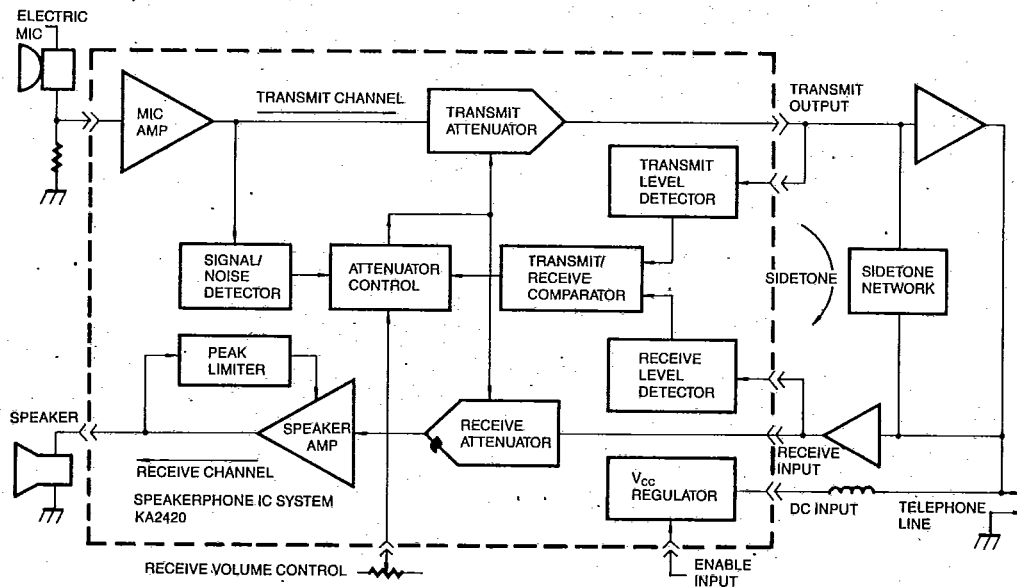
- Level detection and attenuation controls on single chip
- Monitoring for background noise level with large time constant
- On-chip regulation for supply and reference voltages
- Wide range of operation due to signal compression
- Very low output power (10mW typ.) with peak limiting for minimizing distortion
- Chip Select allowing standby mode of operation
- Volume can be controlled linearly
- 28 pin plastic DIP & SOP package



ORDERING INFORMATION

Device	Package	Operating Temperature
KA2420N	28 DIP	- 20 ~ + 60°C
KA2420D	28 SOP	

BLOCK DIAGRAM



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PIN DESCRIPTION

Pin	Name	Description
1	RR	A resistor to ground provides a reference current for the transmit and receive attenuators.
2	RTX	A resistor to ground determines the nominal gain of the transmit attenuator. The transmit channel gain is inversely proportional to the RTX resistance.
3	TXI	Input to the transmit attenuator. Input resistance is nominally 50K Ω .
4	TXO	Output of the transmit attenuator. The TXO output signal drives the input of the transmit level detector, as well as the external circuit which drives the telephone line.
5	TLI	Input of the transmit level detector. An external resistor ac coupled to the TLI pin sets the detection level. Decreasing this resistor increases the sensitivity to transmit channel signals.
6	TLO	Output of the transmit level detector. The external resistor and capacitor set the time the comparator will hold the system in the transmit mode after speech ceases.
7	RLI	Input of the receive level detector. An external resistor ac coupled to the RLI pin sets the detection level. Decreasing this resistor increases the sensitivity to receive channel signals.
8	RLO	Output of the receive level detector. The external resistor and capacitor set the time the comparator will hold the system in the receive mode after the receive signal ceases.
9	MCI	Microphone amplifier input. Input impedance is nominally 10K Ω and the dc bias voltage is approximately equal to V _B .
10	MCO	Microphone amplifier output. The mic amp gain is internally set at 34dB (50 V/V)
11	CP1	A parallel resistor and capacitor connected between this pin and V _{CC} holds a voltage corresponding to the background noise level. The transmit detector compares the CP1 voltage with the speech signal from CP2.
12	CP2	A capacitor at this pin peak detects the speech signals for comparison with the background noise level held at CP1.
13	XDI	Input to the transmit detector system. The microphone amplifier output is ac coupled to the XDI pin through an external resistor.
14	SKG	High current ground pin for the speaker amp output stage. The SKG voltage should be within 10mV of the ground voltage at pin 22.
15	SKO	Speaker amplifier output. The SKO pin will source and sink up to 100mA when ac coupled to the speaker. The speaker amp gain is internally set at 34dB (50 V/V)
16	V+	Input DC supply voltage. V+ can be powered from Tip and Ring if an ac-decoupling inductor is used to prevent loading ac line signals. The required V+ voltage is 6.0 to 11V (7.5V nominal) at 70mA.
17	AGC	A capacitor from this pin to V _B stabilizes the speaker amp gain control loop, and additionally controls the attack and decay time of this circuit. The gain control loop limits the speaker amp input to prevent clipping at SKO. The internal resistance at the AGC pin is nominally 110K Ω .
18	$\overline{\text{CS}}$	Digital chip select input. When at a logic "0" (<0.7V) the V _{CC} regulator is enabled. When at a logic "1" (>1.6V), the chip is in the standby mode drawing 0.5mA. An open $\overline{\text{CS}}$ pin is a logic "0". Input impedance is nominally 140K Ω . The input voltage should not exceed 11V.
19	SKI	Input to the speaker amplifier. Input impedance is nominally 20K Ω .
20	V _{CC}	A 5.4V regulated output which powers all circuits except the speaker amplifier output stage. V _{CC} can be used to power external circuitry such as a microprocessor (30mA max.). A filter capacitor is required. The KA2420 can be powered by a separate regulated supply by connecting V+ and V _{CC} to a voltage between 4.5V and 6.5V while maintaining $\overline{\text{CS}}$ at a logic "1".

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PIN DESCRIPTION (Continued)

Pin	Name	Description
21	V _B	An output voltage equal to approximately V _{CC} /2 which serves as an analog ground for the speakerphone system. Up to 1.5mA of external load current may be sourced from V _B . Output impedance is 250Ω. A filter capacitor is required.
22	Gnd	Ground pin for the IC (except the speaker amplifier)
23	XDC	Transmit detector output. A resistor and capacitor at this pin hold the system in the transmit mode during pauses between words or phrases. When the XDC pin voltage decays to ground, the attenuators switch from the transmit mode to the idle mode. The internal resistor at XDC is nominally 2.6KΩ (see Fig. 1)
24	VLC	Volume control input. Connecting this pin to the slider of a variable resistor provides receive mode volume control. The VLC pin voltage should be less than or equal to V _B .
25	ACF	Attenuator control filter. A capacitor connected to this pin reduces noise transients as the attenuator control switches levels of attenuation.
26	RXO	Output of the receive attenuator. Normally this pin is ac coupled to the input of the speaker amplifier.
27	RXI	Input of the receive attenuator. Input resistance is nominally 5.0KΩ.
28	RRX	A resistor to ground determines the nominal gain of the receive attenuator. The receive channel gain is directly proportional to the RRX resistance.

ABSOLUTE MAXIMUM RATINGS (Voltages referred to Pin 22, T_a = 25°C)

Characteristic	Value	Unit
Speaker Amp Ground (Pin 14)	+3.0, -1.0	V
V+ Terminal Voltage (Pin 16)	+12, -1.0	V
CS (Pin 18)	+12, -1.0	V
VLC (Pin 24)	V _{CC} , -1.0	V
Storage Temperature	-65 ~ 150	°C

"Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The "Electrical Characteristics" tables provide conditions for actual device operation.

RECOMMENDED OPERATING CONDITIONS

Characteristic	Value	Unit
Microphone Signal (Pin 9)	0 ~ 5.0	mVrms
Speaker Amp Ground (Pin 14)	-10 ~ 10	mV
V+ Terminal Voltage (Pin 16)	+6.0 ~ 11	V
CS (Pin 18)	0 ~ 11	V
I _{CC} (Pin 20)	0 ~ 3.0	mA
VLC (Pin 24)	0.55V _B ~ V _B	V
Receive Signal (Pin 27)	0 ~ 250	mVrms
Ambient Temperature	-20 ~ 60	°C

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ELECTRICAL CHARACTERISTICS (Refer to Fig. 1)

Characteristic	Symbol	Test Condition	Min	Typ	Max	Unit
SUPPLY VOLTAGE						
V ₊ Supply Current	I _{v+}	V ₊ =11V, Pin 18=0.7V			9.0	mA
		V ₊ =11V, Pin 18=1.6V			800	μA
V _{CC} Voltage	V _{CC}	V ₊ =7.5V	4.9	5.4	5.9	V
V _{CC} Line Regulation	ΔV _{CC}	6.5V < V ₊ < 11V		65	150	mV
V _{CC} Output Resistance	R _o	I _{CC} =30mA		6.0	20	Ω
V _{CC} Drop Voltage	V _{CCD}	V ₊ =5.0V		80	300	mV
V _B Voltage	V _B	V ₊ =7.5V	2.5	2.9	3.3	V
V _B Output Resistance	R _o	I _B =1.7mA		250		Ω
ATTENUATORS						
Receive Attenuator Gain Rx Mode Range Idle Mode	Ar _x	1.0KHz Pin 24=V _B , Pin 27=250mVrms	2.0	6.0	10	dB
	ΔAr _x	Rx to Tx Mode	40	44	48	dB
	Ar _{xi}	Pin 27=250mVrms	-20	-16	-12	dB
R _{xo} Voltage	V _{rxo}	Rx Mode	1.8	2.3	3.2	V
R _{xo} Voltage Change	ΔV _{rxo}	From Rx to Tx Mode			100	mV
R _{xo} Sink Current	I _{RSINK}	Rx Mode	75			μA
R _{xo} Source Current	I _{RSOURCE}	Rx Mode	1.0		3.0	mA
R _{xi} Input Resistance	R _{rx}		3.5	5.0	8.0	KΩ
Volume Control Range	V _{con}	Rx Attenuator Gain, Rx Mode, 0.6V _B < Pin 24 < V _B	24.5		32.5	dB
Transmit Attenuator Gain Tx Mode Range Idle Mode	At _x	1KHz Pin 3=250mVrms	4.0	6.0	8.0	dB
	ΔAt _x	Tx to Rx Mode	40	44	48	dB
	At _{xi}	Pin 3=250mVrms	-16.5	-13	-8.5	dB
T _{xo} Voltage	V _{txo}	Tx Mode	1.8	2.3	3.2	V
T _{xo} Voltage Change	ΔV _{txo}	From Tx to Rx Mode			100	mV
T _{xo} Sink Current	I _{TSINK}	Tx Mode	75			μA
T _{xo} Source Current	I _{TSOURCE}	Tx Mode	1.0		3.0	mA
T _{xi} Input Resistance	R _{tx}		3.5	5.0	8.0	KΩ
ACF Voltage	V _{acf}	V _{CC} -Pin 25 Voltage				
		Rx Mode		150		mV
		Tx Mode		6.0		mV
		Idle Mode		75		mV
SPEAKER AMPLIFIER						
Speaker Amp Gain	As _{pk}	Pin 19=20mVrms	33	34	35	dB
SKI Input Resistance	R _{ski}		15	22	37	KΩ
SKO Voltage	V _{sko}	Capacitor Tied to GND	2.4	3.0	3.6	V
SKO High Voltage	V _{scoh}	Pin 19=0.1V, -100mA Load at Pin 15	5.5			V

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ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	Test Condition	Min	Typ	Max	Unit
SKO Low Voltage	Vskol	Pin 19 = -0.1V, +100mA Load at Pin 15			600	mV
MICROPHONE AMPLIFIER						
Mike Amp Gain	Amci	Pin 9 = 10mVrms 1KHz	32.5	34	35	dB
Mike Amp Input Resistance	Rmci		6.5	10	16	K Ω
LOG AMPLIFIER						
RLO Leakage Current	Ilkrl0	Pin 8 = V _B + 1.0V			2.0	μ A
TLO Leakage Current	Ilklt0	Pin 6 = V _B + 1.0V			2.0	μ A
Tx-Rx Switching Threshold	S, Th.	Ratio of I _{TLL} to I _{RLL} at 20 μ A to Switch Tx-Rx Comparator	0.8		1.2	
TRANSMIT DETECTOR						
XDC Voltage	Vxdc	Idle Mode		0		V
		Tx Mode		4.0		V
CP2 Current Source	Icp2		5.0	10	13	μ A
DISTORTION						
Rx Mode-RXI to SKO	Rxd	Pin 27 = 10mVrms, 1KHz		1.5		%
Tx Mode-MCI to TXO	Txd	Pin 9 = 5.0mVrms, 1KHz		2.0		%

- Note: 1. V₊ = 7.5V, \overline{CS} = 0.7V except where noted.
 2. Rx Mode: Pin 7 = -100 μ A, Pin 5 = +100 μ A except where noted.
 Tx Mode: Pin 5, 13 = -100 μ A, Pin 7 = +100 μ A, Pin 11 = 0V
 Idle Mode: Pin 5 = -100 μ A, Pin 7, 13 = +100 μ A
 3. Current into a pin designated as +: current out of a pin designated as -
 4. Voltage referred to Pin 22, T_a = +25°C.

TEMPERATURE CHARACTERISTICS (-20 to +60°C)

Characteristic	Pin	Typical Change	Unit
V ₊ Supply Current (V ₊ = 11V, Pin 18 = 0.7V)	16	-0.2	%/°C
V ₊ Supply Current (V ₊ = 11V, Pin 18 = 1.6V)	16	-0.4	%/°C
V _{CC} Voltage (V ₊ = 7.5V)	20	+0.1	%/°C
Attenuator Gain (Max and Min Settings)		±0.003	dB/°C
Delta RXO, TXO voltage	4, 26	±0.24	%/°C
Speaker Amp Gain	15, 19	±0.003	dB/°C
Microphone Amp Gain	9, 10	±0.001	dB/°C
Microphone Amp Input Resistance	9	+0.4	%/°C
Tx-Rx Switching Threshold (@20 μ A)	5, 7	±0.2	nA/°C

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TRANSMIT ATTENUATOR VS RTX

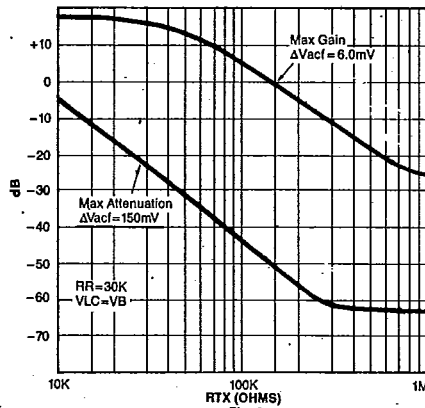


Fig. 2

RECEIVE ATTENUATOR VS RRX

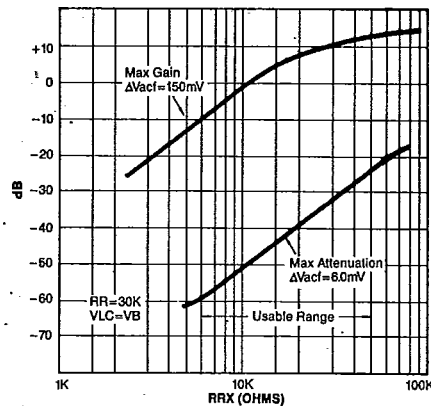


Fig. 3

GAIN AND ATTENUATION VS RESISTOR RATIOS

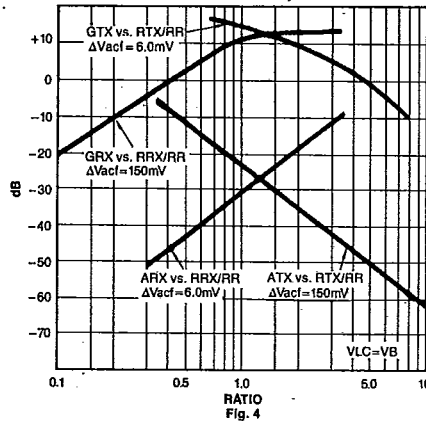


Fig. 4

ATTENUATOR GAIN VS VLC

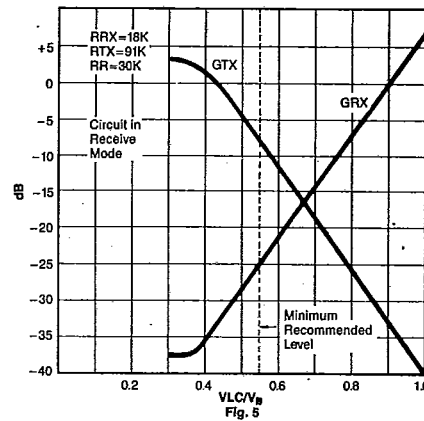


Fig. 5

ATTENUATOR GAIN VS ΔVacf

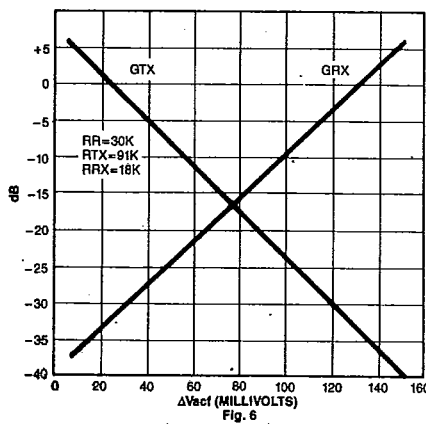


Fig. 6

LOG AMP TRANSFER CHARACTERISTICS

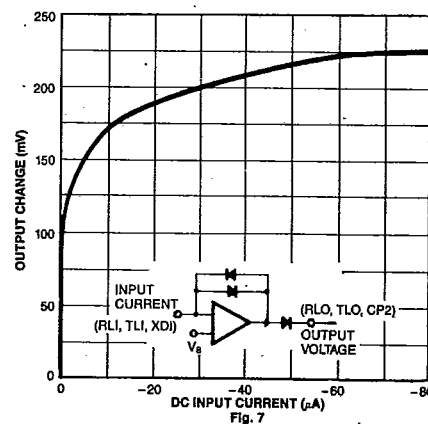
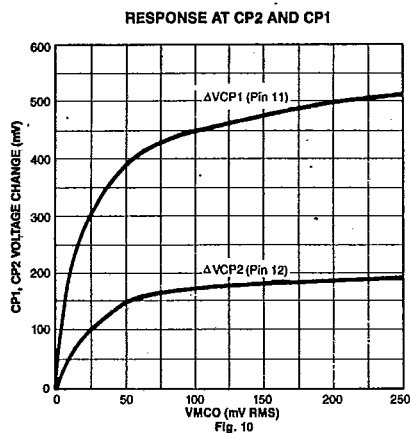
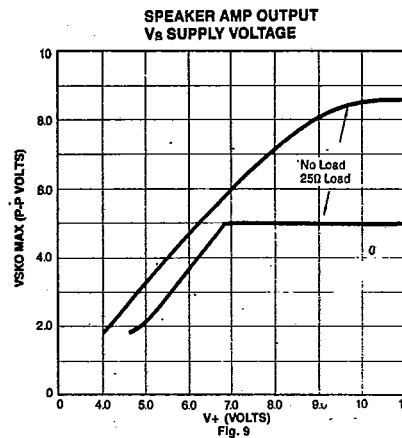
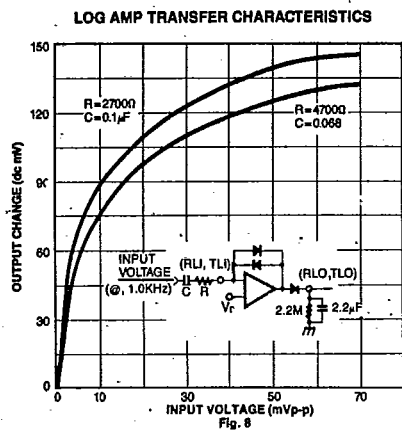


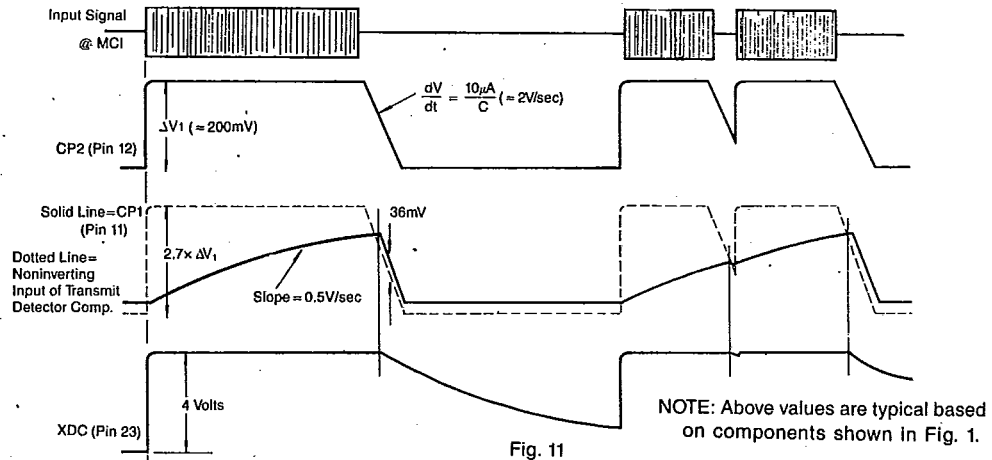
Fig. 7

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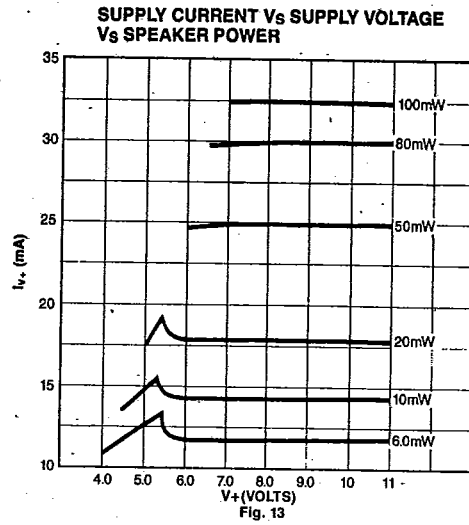
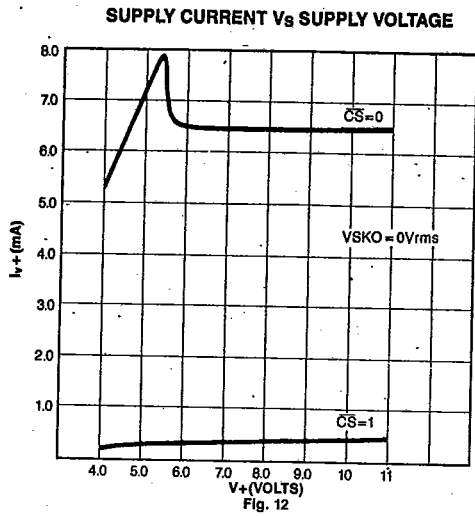


TRANSMIT DETECTOR OPERATION

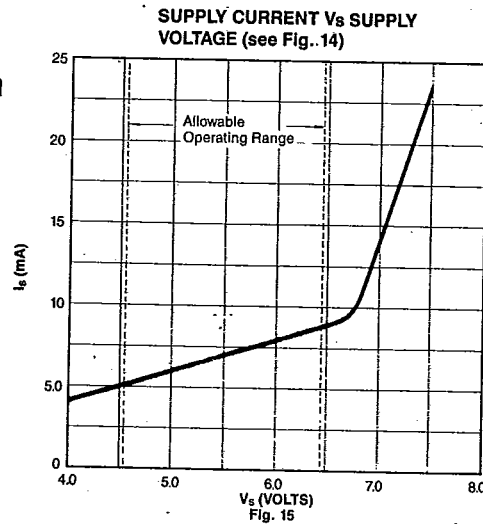
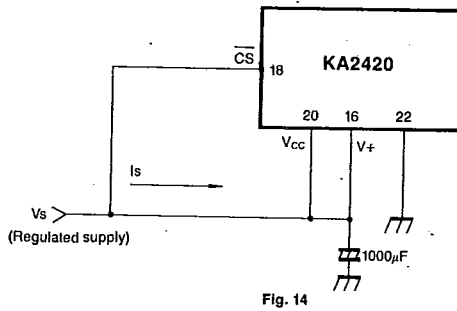


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LINEAR INTEGRATED CIRCUIT



ALTERNATE POWER SUPPLY CONFIGURATION



SWITCHING TIME

The switching times of the speakerphone depends on the external components and the instantaneous operating conditions at the time when a change takes place. For example, the switching time for changing between transmit and receive modes is much longer than that from idle to transmit.

The components connected at pin 5 "transmit turn-on", pin 6 "transmit-turn-off", pin 7 "receive-turn-on" and pin 8 "receive-turn-off" have major influence on the timing between the transmit and receive modes. The Tx-Rx comparator compares the relative and not the absolute values so the above referenced four timing functions interact with each other. The timing from transmit to idle is affected by the components at pins 11, 12, 13 and 23. The timing from idle to transmit is faster and hence the components have no major influence on it.

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The table below indicates the degree of influence of various components on the switching time, including the volume control;

Additionally, the following should be noted:

- 1) The RCs at Pin 5 and Pin 7 affect the sensitivity of the respective log amplifiers, or how loud the speech must be for gain control of the speakerphone circuit.
- 2) The RC at Pin 13 controls the sensitivity of the transmit detector circuit.
- 3) The switching speed and the relative response to transmit signal are affected by the volume control, in manner as follows: When the volume control reduces, the signal at TXO increases, and consequently the signal to the TL1 pin in the receive mode circuit.

Components	Rx to Tx	Tx to Rx	Tx to Idle
RC at Pin 5	high	medium	no influence
RC at Pin 6	medium	high	no influence
RC at Pin 7	medium	high	no influence
RC at Pin 8	high	medium	no influence
RC at Pin 11	low	no influence	medium
C at Pin 12	low	no influence	high
RC at Pin 13	low	no influence	low
RC at Pin 23	low	no influence	high
V at Pin 24	medium	no influence	no influence
C at Pin 25	medium	medium	low

Switching response times for the circuit of Fig. 1 are shown in the photographs of Fig. 16 and Fig. 17.

In Fig. 16, the circuit is supplied a continuous receive signal of $1.1\text{mV}_{\text{P-P}}$ at RXI as shown Trace #3. MCI as shown Trace #1 operates a repetitive signal of $7.2\text{mV}_{\text{P-P}}$ for 120msec, and repeated every 1sec. Trace #2 is the TXO output being about $650\text{mV}_{\text{P-P}}$ at its maximum. Trace #4 is the RXO output being about $2.2\text{mV}_{\text{P-P}}$ at its maximum.

The switching time from the receive mode to transmit mode is about 40msec required for TXO to turn on, and for RXO to turn off. After the signal at MCI is turned off, the switching time back to the receive mode is about 210msec.

In Fig. 17 a continuous signal of $7.6\text{mV}_{\text{P-P}}$ is supplied to MCI as shown Trace #1, and a repetitive burst signal of $100\text{mV}_{\text{P-P}}$ is supplied to RXI as shown Trace #3 for 120msec, and repeated every 1sec. Trace #2 is the TXO output and is about $90\text{mV}_{\text{P-P}}$ at its maximum, and Trace #4 shows the RXO output being about $150\text{mV}_{\text{P-P}}$ at its maximum. In this sequence, the circuit switches between the idle mode and the receive mode. The required switching time from idle to receive modes is about 70msec as shown in the first part of Trace #2 and Trace #4. After the receive signal is turned off, the switching time back to the idle mode is about 100msec.

All of above mentioned switching times can change significantly not only by varying the external components but also by varying the amplitude of input signals.

TRANSMIT-RECEIVE SWITCHING

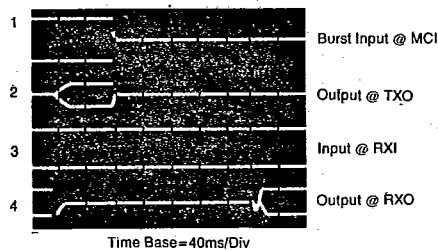


Fig. 16

IDLE-RECEIVE SWITCHING

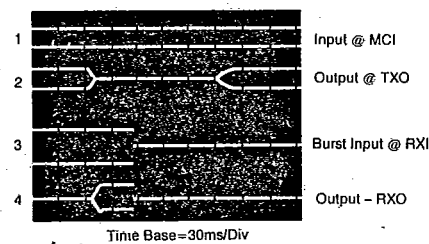
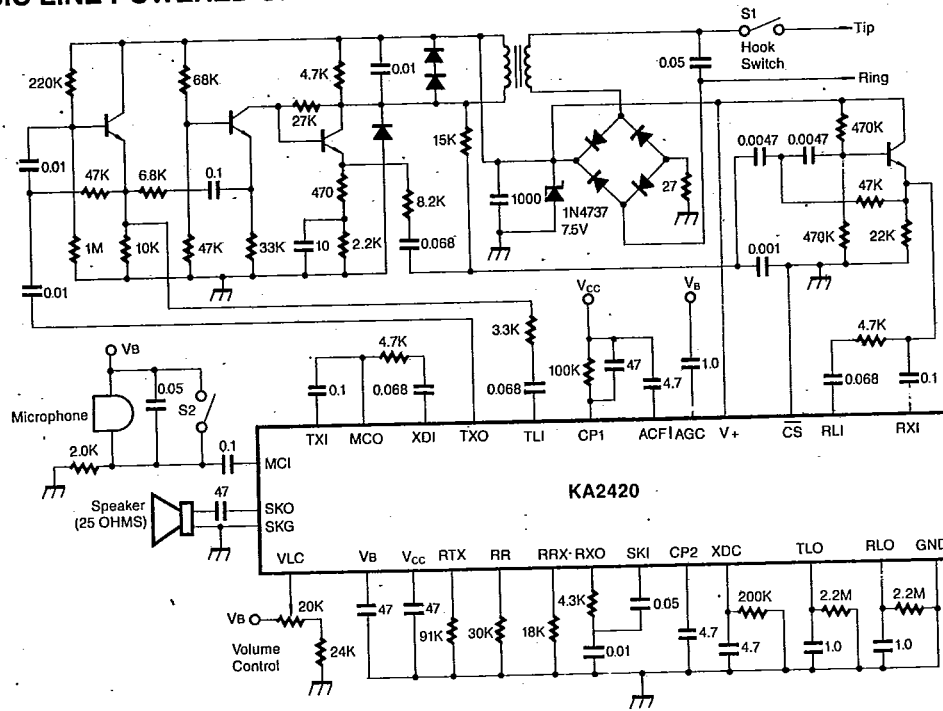


Fig. 17

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LINEAR INTEGRATED CIRCUIT

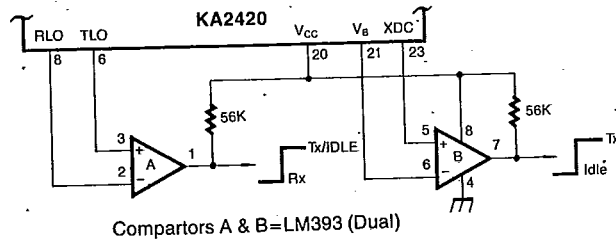
BASIC LINE POWERED SPEAKERPHONE



1. Diodes are 1N4001 unless otherwise noted.
2. 4 Transistors are KSC945-Y
3. Recommended Transformer: Seoul Jupa SJ-019-2040

Fig. 18

DIGITAL TRANSMIT/IDLE/RECEIVE INDICATION



Comparators A & B=LM393 (Dual)

Fig. 19