Speakerphone Audio Circuit

GENERAL DESCRIPTION

The XR-T6420-1 is a monolithic integrated circuit for use in high performance speakerphone systems. It is designed to be used with the XR-T6421 Speakerphone Control Circuit.

The XR-T6420-1 contains the audio paths comprising the following: Two variable gain cells, a microphone amplifier, a transmitting amplifier, a receive amplifier, and a speaker amplifier.

FEATURES

Two Matched Variable Gain Cells
Internal Microphone Amplifier
Independent Control of Transmitting and Receiving Levels
External Control of Gains and Frequency Response

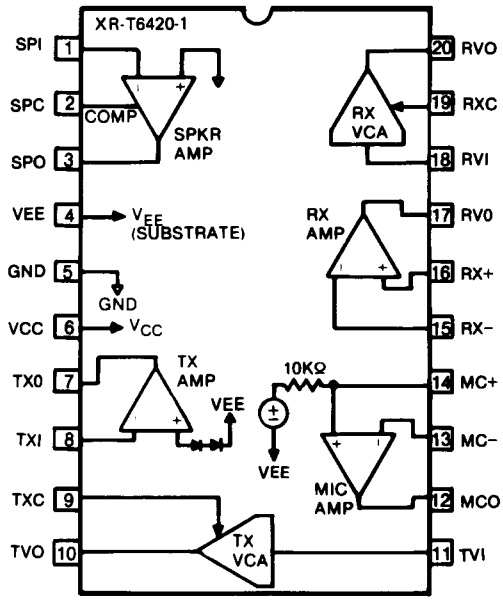
APPLICATIONS

Speakerphones
Intercoms
Voltage Controlled Amplifiers

ABSOLUTE MAXIMUM RATINGS

Power Supply ($V_{CC} - V_{EE}$)	+20 V
Power Dissipation	1 W
Derate Above +25°C	7 mW/°C
Operating Temperature	0°C to 70°C
Any Input Voltage	V_{CC} – 0.5 V to V_{EE} + 0.5 V
Storage Temperature	-55°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-T6420-1CN	Ceramic	0°C to 70°C
XR-T6420-1CP	Plastic	0°C to 70°C

SYSTEM DESCRIPTION

The speakerphone concept essentially requires that only one direcction of sound transmission be permitted at any time. This restraint is brought about by the large gains required to provide loudspeaker volume and high microphone sensitivity. Owing to the inevitable acoustic coupling between loudspeaker and microphone, plus imperfections in the hybrid 2 to 4 wire conversion, it is necessary to lower the gain in either the transmitting or receiving path at any one time to avoid regeneration.

The XR-T6420-1 and XR-T6421 chip set enables the system designer to make a highly adaptive, high performance speakerphone. The XR-T6421 provides for all sensing and control functions, while the XR-T6420-1 contains all audio paths needed to switch the gain in either path and provide interfacing between the system and line.

ELECTRICAL CHARACTERISTICS

Test Conditions: $T_A = 25°C$, $V_{CC} = +6$ V, $V_{EE} = -6$ V, unless specified otherwise.

PARAMETERS	MIN	TYP	MAX	UNIT	CONDITIONS
V_{CC} Minimum	+4.5			V	
V_{EE} Minimum	-6			V	
I_{CC}	15	22	30	mA	
I_{GND}	-1	−.1	1	mA	
MICROPHONE AMPLIFIER					
V_{IN}	1.7	2	2.25	V	Referenced to V_{EE}
V_{OFFSET}		2	5	mV	
I_{bias}		1	5	μA	
A_{OL}	40	50		dB	
R_{IN}		10		kΩ	Typical Input Impedance to GND
SPEAKER AMPLIFIER					
V_{OFFSET}		4	10	mV	
I_{bias}		-3	-10	μA	
A_{OL}	60	70		dB	
Swing	−4.9		4.8		
TRANSMIT AMPLIFIER					
Vpin 8	.8	1.3	1.5	V	Referenced to V_{EE}
I_{source} (Pin 7)	1			mA	
I_{sink} (Pin 7)	−1			mA	
RECEIVE AMPLIFIER					
Differential Mode Gain	−4	-1	0	dB	
Common Mode Gain		-30	−28	dB	
V_{OUT} (Pin 17)		-2.7		V	
TRANSMIT VCA					
V_{OUT} (Pin 10)	−2.1	-1.9	−1.5	V_{DC}	
Gain Maximum	6	8	13	dB	
V_{OUT} Maximum		1		Vp-p	
RECEIVE VCA					
V_{OUT} (Pin 20)	1.2	1.5	1.7	V_{DC}	
Gain Maximum	2	4	7	dB	
V_{OUT} Maximum		1		Vp-p	

PRINCIPLES OF OPERATION

Power Supply – Normal operation is with two supplies. V_{CC} is the highest potential and V_{EE} is the lowest, with the ground pin in between. The circuit can be operated from a single supply if the ground pin is connected to a low impedance source of approximately half the supply voltage.

Microphone Amplifier – The microphone amplifier is an operational amplifier with the noninverting input internally biased to approximately V_{EE} + 2 Volts. The noninverting input impedance is nominally 10.3 Kohms. Gain and frequency response can be set by external components using the noninverting configuration for the op amp. The amplifier has an emitter follower output, therefore, needs an external pull down resistor to V_{EE}. This resistor is selected low in value in order to prevent slewing of the output waveform due to capacitance.

Transmit VCA – This VCA provides a voltage dependent gain, given in Figure 2. The input, referred to V_{EE}, has a nominal impedance of 14.8 Kohms. The output is also referred to V_{EE} and is buffered by an emitter follower.

Transmit Amplifier – This amplifier is a Darlington Common Emitter Amplifier with a Class A output stage. Pin 8 is approximately 1.1 Volt above V_{EE}. Gain is set by the input and feedback resistor. To increase the output swing, the output DC level is determined using a resistor from Pin 8 to V_{EE}.

Receive Amplifier – This amplifier has a high impedance differential input and a fixed gain of one. The inputs must be referred to a voltage greater than V_{EE} + 1.5 V. The output is at a fixed DC level with a Class A output stage.

Receive VCA – This VCA provides a voltage dependent gain, given in Figure 3. The input is referenced to V_{EE} and has a nominal impedance of 14Kohms. The output is referred to ground and is buffered by an emitter follower.

Speaker Amplifier – This is an operational amplifier with the noninverting input referred to ground through a 1.8 Kohm resistor. The gain is externally set using the input and feedback resistor. The amplifier can be compensated by a capacitor from the output to Pin 2 or from Pin 2 to ground. The output is capable of sourcing or sinking 4 mA.

CIRCUIT DESCRIPTION

Pin 1 - SPI – Inverting input to speaker amplifier.

Pin 2 - SPC – Speaker amplifier compensation

Pin 3 - SPO – Speaker amplifier output.

Pin 4 - V_{EE} – Negative DC supply pin (usually -5 to -10 V).

Pin 5 - GND – Ground pin reference for circuit. Can be used with ($V_{CC} - V_{EE}$)/2 external reference.

Pin 6 - V_{CC} – Positive DC supply voltage, usually +5 to +10 V.

Pin 7 - T_{XO} – Output of transmit amplifier.

Pin 8 - T_{XI} – Input of transmit amplifier.

Pin 9 - T_{XC} – Control voltage of transmit VCA. Transfer function of VCA is:

$$\frac{T_{VO}}{T_{VI}} = 2\,(1 + \exp\,(T_{XD} - V\text{pin } 5/VT))^{-1}$$

where $V_T = \dfrac{KT}{q} \cong 26$ mV at +25°C

Pin 10 - T_{VO} – Output of transmit VCA. Output is an emitter follower.

Pin 11 - T_{VI} – Input of transmit VCA. Input impedance is nominally 14.9 Kohms.

Pin 12 - MCO – Output of microphone amplifier.

Pin 13 - MC- – Inverting input of microphone amplifier.

Pin 14 - MC+ – Noninverting input of microphone amplifier. Input impedance is nominally 10.3 K ohms.

Pin 15 - R_{X-} – Inverting input to receive amplifier. Input is high impedance.

Pin 16 - R_{X+} – Noninverting input to receive amplifier. Input is high impedance.

Pin 17 - R_{XO} – Output of receive amplifier. Output DC level is nominally 0 volts.

Pin 18 - R_{VI} – Input to receive VCA. Input impedance is nominally 14 K ohms.

Pin 19 - R_{XC} – Control voltage of receive VCA. Transfer function of VCA is:

$$\frac{R_{VO}}{R_{VI}} = (1 + \exp\,((V\text{pin } 5 - R_{XC})/VT))^{-1}$$

where $V_T = \dfrac{KT}{q} \cong 26$ mV at 25°C

Pin 20 - R_{VO} – Output of receive VCA. Output is an emitter follower.

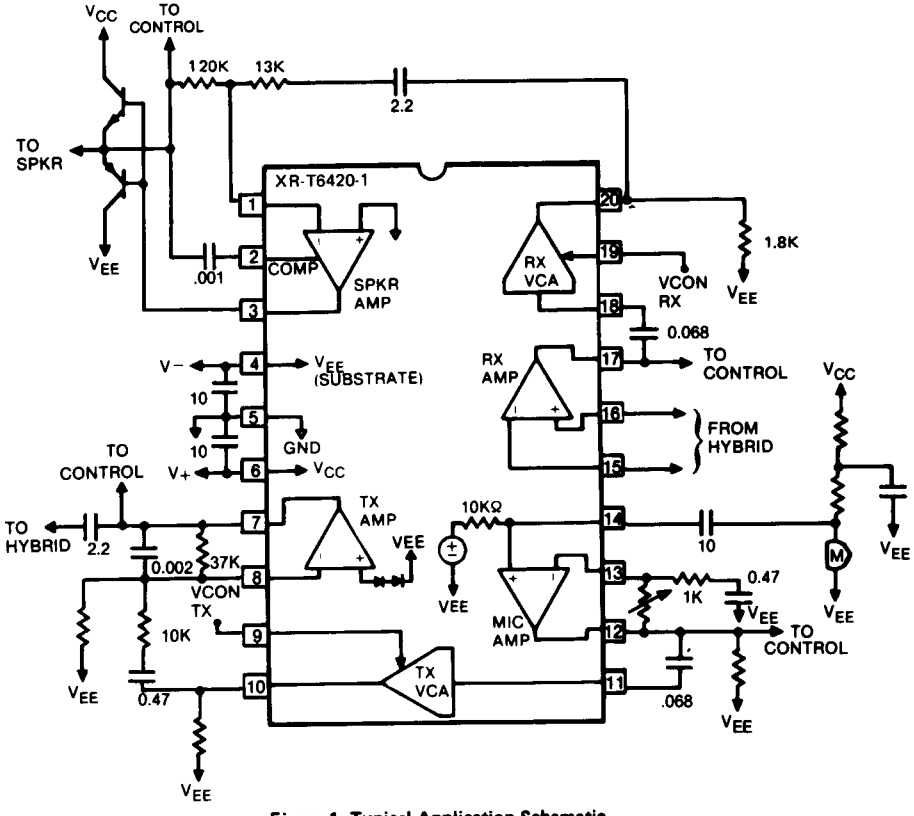


Figure 1. Typical Application Schematic

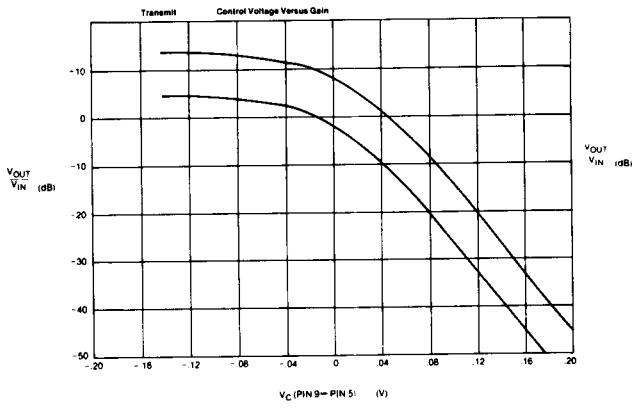


Figure 2. Transmit Control Voltage vs. Gain

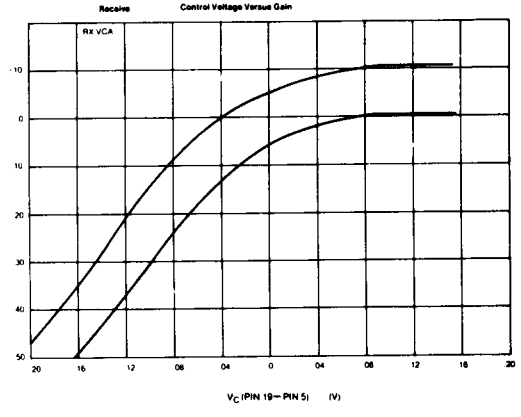


Figure 3. Receive Control Voltage vs. Gain