Monolithic Compandor

GENERAL DESCRIPTION

The XR-2216 is a monolithic audio frequency compandor designed to compress or expand the dynamic range of speech or other analog signals transmitted through telecommunication systems. The monolithic circuit can be connected as either a compressor or an expander, the choice being determined by the external circuitry.

FEATURES

- Functions as either a Compressor or an Expander
- Wide Dynamic Range: 60 dB
- Wide Supply Range: 6 to 20 Volts
- Excellent Transfer Function Tracking
- Low Power Supply Drain
- Controlled Attack and Release Times
- Low Noise and Low Distortion

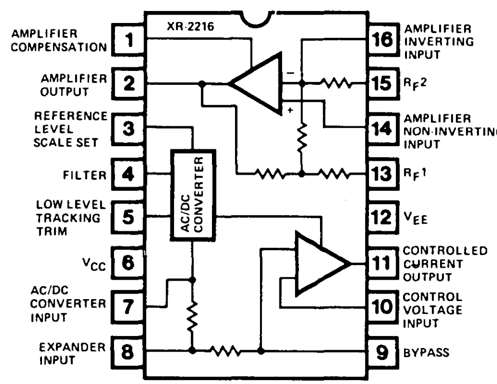
APPLICATIONS

- Telephone Trunk—Line Compandor
- Speech/Data Compression and Expansion
- Telecommunication Systems
- Mobile Communications
- Model Data Processing

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	20V
Power Dissipation	
Ceramic Package	750 mW
Derate above +25°C	6 mW/°C
Plastic Package	625 mW
Derate above +25°C	5 mW/°C
Storage Temperature	−60°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

Part Number	Package (16 Pin DIP)	Operating Temperature
XR-2216CN	Ceramic	−40°C to +60°C
XR-2216CP	Plastic	−40°C to +60°C

SYSTEM DESCRIPTION

The XR-2216 is comprised of four basic blocks: (1) an internal voltage reference; (2) an AC/DC converter which converts AC signal input to a DC current level; (3) an impedance converter whose impedance level is a function of a DC control signal; and (4) a high gain operational amplifier.

The XR-2216 is designed to accommodate a wide range of system configurations. It can be operated with positive or negative single supply systems, or dual power supplies over a power supply range of 6 volts to 20 volts.

XR-2216

ELECTRICAL CHARACTERISTICS

Test Conditions: $V_C = +12V$, $T_A = 25°C$

COMPANDOR

PARAMETERS	MIN	TYP	MAX	UNITS	CONDITIONS
Power Supply Voltage	6		20	VDC	
Nominal Power Supply Voltage	12		18	VDC	
Power Supply Current, No Signal Input			3	mA	
Gain Change Over Frequency Tolerance	−1		+1	dB	300 ~ 3500 Hz
Distortion Measured at −4 dB* Input Level at 1 KHz		3		% THD	
Attack Time Measured at −10 dB Input Level			5	ms	To 90% of Final Value
Decay Time Measured at −10 dB Input Level			5	ms	To 10% of Final Value
Transfer Characteristics**					
Compandor Output With Input Levels of:					
−4 dBm	3.5	+6	7.5	dBm	
−8 dBm	−0.5	+2	3.5	dBm	
−10 dBm	−1.5	0	+1.5	dBm	
−14 dBm (reference)		−4		dBm	
−24 dBm	−15.5	−14	−12.5	dBm	
−34 dBm	−25.5	−24	−22.5	dBm	
−44 dBm	−36.5	−34	−32.5	dBm	
−54 dBm	−49	−44	−42.5	dBm	
−64 dBm	−59	−54	−52.5	dBm	

COMPRESSOR

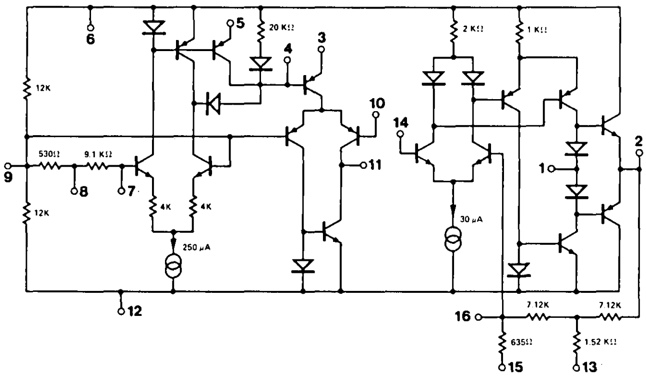
PARAMETERS	MIN	TYP	MAX	UNITS	CONDITIONS
Input Impedance	50			k ohm	
Output Impedance			50	ohm	
Output Signal Level for −10 dBm Input at 1 KHz		−10		dBm	
Output Voltage Swing	0			dB	
Output Noise, Input AC Grounded			30	dBrnc	
Compressor Transfer Characteristics**					
Compressor Output With Input Levels of:					
−4 dBm		−7		dBm	
−8 dBm		−9		dBm	
−10 dBm		−10		dBm	
−14 dBm (reference)		−12		dBm	
−24 dBm		−17		dBm	
−34 dBm		−22		dBm	
−44 dBm		−27		dBm	
−54 dBm		−32		dBm	
−64 dBm		−37		dBm	

EXPANDER

PARAMETERS	MIN	TYP	MAX	UNITS	CONDITIONS
Input Impedance	50			k ohm	
Output Impedance			50	ohm	
Output Signal Level for −10 dBm		0		dBm	
Output Voltage Swing	+8			dB	
Output Noise Input AC Grounded			+5	dBrnc	
Expander Transfer Characteristics**					
Expander Input Levels Required for Output of:					
+6 dBm		−7		dBm	
+2 dBm		−9		dBm	
0 dBm		−10		dBm	
−4 dBm (reference)		−12		dBm	
−14 dBm		−17		dBm	
−24 dBm		−22		dBm	
−34 dBm		−27		dBm	
−44 dBm		−32		dBm	
−55 dBm		−37		dBm	

Notes: *0 dBm = 0.775 Vrms (1 mW across 600 ohm load) **Recommended transfer characteristics.

EQUIVALENT SCHEMATIC DIAGRAM



CIRCUIT DESCRIPTION

The analog signal compressor/expander or "compandor" circuits are among the most fundamental building blocks in telecommunication systems. These circuits are intended to compress or expand the dynamic range of speech or other analog signals transmitted through telecommunication systems.

Figure 1 shows the simplified block diagram of a typical speech transmission system, using the compression/expansion or "companding" technique. The dynamic range of the input signal is first compressed at the transmitting end; then transmitted through the system, and finally expanded back to the original amplitude at the receiving end. Thus, the "compressor" and the "expander" sections of a compandor system perform reciprocal functions. In a bi-directional transmission system, there is a compandor at each end of the line which compresses the out-going signal, or expands the incoming signal by an equal amount.

Figure 2 shows the typical transfer characteristics of compressor and expander circuits commonly used in telecommunication systems. In the compressor, the output amplitude varies 1 dB for every 2 dB change of input amplitude; the reverse is true for the expander.

The functional block diagram of XR-2216 compandor is shown on Page 1, in terms of the monolithic circuit package. The XR-2216 is designed to be connected as *either* a compressor or an expander, the choice being determined by the external circuitry. The monolithic system is comprised of four basic blocks: (1) an internal voltage reference; (2) an ac/dc converter which converts ac signal input to a dc current level; (3) an impedance converter whose impedance level is a function of a dc control signal; and (4) a high gain operational amplifier.

The XR-2216 is designed to accommodate a wide range of system configurations It can be operated with positive, or negative, single-supply systems, or with balanced power supplies, over a power supply range of 6 volts to 20 volts.

Some of its key features are: low external component count, excellent transfer function, tracking, low power supply drain, controlled attack and release times, low noise and low distortion.

EXPANDER (Figure 3)

Figure 3 shows the external circuit connections and components necessary to operate XR-2216 as an expander. An input signal is applied to Pin 7 which is the

AC/DC converter input. The AC/DC converter converts the AC signal input to a dc current level which in turn controls the transconductance of the impedance converter. Part of the input signal is applied to the impedance converter by connecting Pins 8 and 10. Thus the signal current at Pin 11 is proportional to the product of the input signal and its average value.

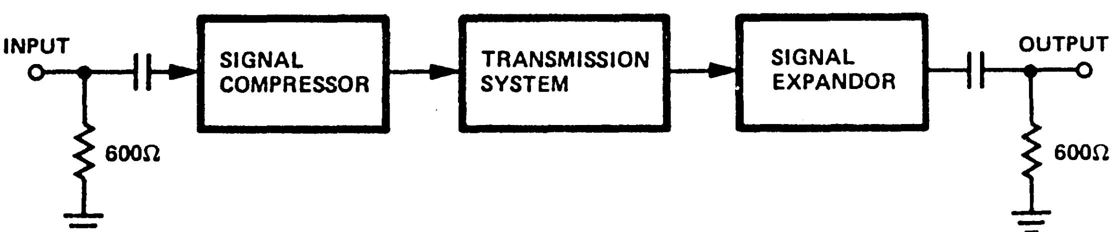


Figure 1. Simplified Block Diagram of a Speech Transmission System Using Companding Technique

XR-2216

The output signal current is then fed to the operational amplifier by connecting Pins 11 and 16, and the output signal voltage is directly proportional to the signal current flowing into Pin 16. The output signal of the expander is available at Pin 2. In this operation, the reference level is set by the trim pot R1, and the trim pot R2 provides a means for trimming low level tracking.

In the connection of Figure 3, the input signals of −37 dBm to −7 dBm are expanded to 60 dB output range with up to 0 dBm power matched output to 600Ω load.

COMPRESSOR (Figure 4)

Figure 4 shows the typical circuit connection for compressor operation. It is just a non-inverting voltage amplifier whose input level is proportional to the product of the incoming signal and the impedance of the impedance converter which is inversely proportional to the amplifier output. Consequently, the output signal at Pin 2 is proportional to square root of the input signal.

In this operation, just like expander operation, the reference level is set by the trim pot R1 and low level tracking is adjusted by the trim pot R2. In the connection of Figure 4, the output change is 1 dB for 2 dB input change. The output range can be adjusted to −37 dBm to −7 dBm for input signals of 60 dB dynamic range.

Note: Attack and Decay Times:

The speed with which gain changes to follow changes in input signal levels is determined by the capacitor C1 and the resistor R1. A small capacitor will yield rapid response but will not fully filter low frequency signals. Any ripple on the gain control signal will modulate the signal passing through the impedance converter. In an expander and compressor application, this would lead to a 3rd harmonic distortion, so there is a tradeoff to be made between fast attack and decay times, and distortion.

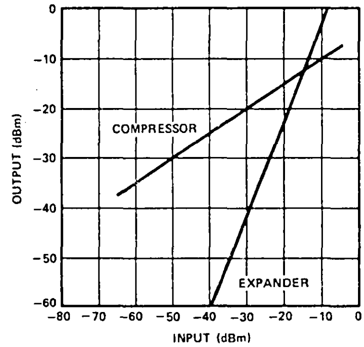


Figure 2. Transfer Characteristics of Compressor a Expander Circuits

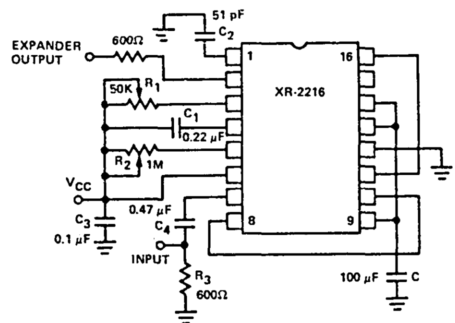


Figure 3. External Connections for Operation Expander

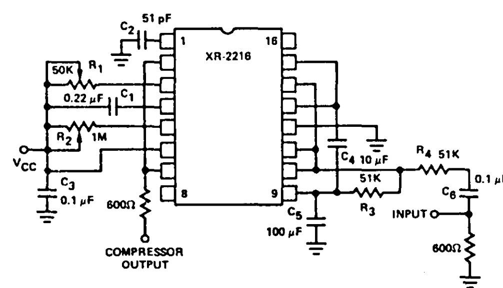


Figure 4. External Connections for Compressor Operation

TYPICAL PERFORMANCE CURVES

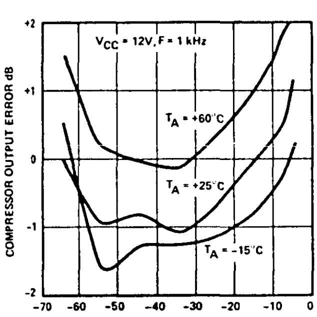


Figure 5. XR-2216 Compressor Output Error vs. Input Signal Amplitude

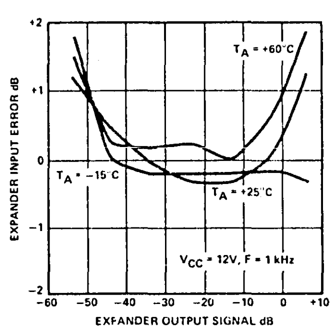


Figure 6. XR-2216 Expander Input Error vs. Output Signal Amplitude

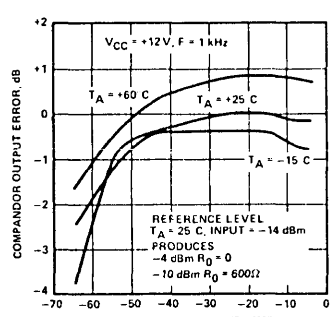


Figure 7. XR-2216 Compandor Tracking Error vs. Input Signal