

compander

The dynamic range of an audio signal is the ratio, expressed in decibels (dB), between the largest and smallest usable signal levels, i.e. between the loudest and softest sounds. 'Live' sound, from the softest whisper to the clatter of a pneumatic drill, can have a dynamic range in excess of 100 dB. However, it is not possible to capture such a large dynamic range in a recording, since the largest signal that can be recorded is limited by saturation of the recording medium, and the smallest usable signal is limited by the recording medium's own inherent noise, e.g. tape noise or record surface noise. The ratio between these two, i.e. the dynamic range, is only about 60 dB for the best disc recordings, and considerably less (around 45 dB) for cassette recordings.

One way round the problem is to compress the dynamic range of the original programme material before recording it, i.e. to pass the signal through a system whose gain reduces progressively as the signal level increases. Thus a 2 dB change in signal level at the input could be compressed, for example, into a 1 dB change in level at the compressor output. To recreate the original dynamic range the compressed recording is 'expanded' by replaying it through a system having the reciprocal transfer characteristic of the compressor, e.g. a circuit which gives a 2 dB change in output for a 1 dB change in input level.

Disc to cassette

The dynamic range of material recorded on disc is compressed into the 60 dB dynamic range of this recording medium, but discs are normally played back without expansion since a dynamic range of 60 dB is considered adequate for domestic listening. Quite recently, DBX have introduced a disc compression/expansion system, but any expander system will, of course, add to the cost of disc reproduction equipment.

Transcribing discs onto cassette tape using a deck already equipped with a noise reduction system (Dolby, ANRS) is no problem. However, there are many inexpensive cassette decks on the market that are not equipped with a noise

'Compander' is a portmanteau word derived from 'compressor' and 'expander' and describes a device designed to increase the dynamic range and/or improve the signal-to-noise ratio of an audio transmission, or recording and reproduction chain. Until recently, companders were fairly complicated circuits. Now, however, they are available in the form of integrated circuits, one of which, the Exar XR 2216, is discussed in this article. This IC can be used in a variety of applications such as amateur radio, PA systems, transcription of recorded material from disc to tape etc.

reduction system, and the results obtained when discs are recorded using such a machine are likely to be disappointing, since the dynamic range is inadequate. Recordings made taking care not to overload the tape will have excessive background noise on quiet passages, while recordings made to give a reasonable noise level on quiet passages will exhibit distortion due to overloading on loud passages.

Normally, the only way to improve matters is to control the dynamic range of the programme material manually during recording, by 'riding' the recording level control. This can be very tedious if long passages are to be recorded, so a simple compander would be a useful addition to an inexpensive cassette machine.

The XR 2216

Until recently companders were fairly complex circuits, but fortunately a complete compander system is now available in the form of an integrated circuit from Exar — the XR 2216.

The equivalent circuit and functional block diagram of this IC are shown in figure 1. The device contains an AC/DC converter which converts the AC signal fed to it into a proportional DC control voltage, a voltage-controlled impedance converter (which functions as a voltage-controlled attenuator) and a high-gain operational amplifier.

Figure 2 shows the external components and circuit connections necessary to make the XR 2216 function as an expander. The input signal (from the tape deck, for example) is applied to pin 7, the input of the AC/DC converter, the output of which controls the transconductance of the impedance converter. The input signal is also fed to the impedance converter, the output of which is thus proportional to the product of the input signal and its average value from the AC/DC converter, i.e. the transfer function of the expander is a square law. The impedance converter output is fed to the operational amplifier by linking pins 11 and 16, and the expanded output signal is taken from pin 2.

By re-arranging the circuit slightly it can

Table 1. Electrical specification of the XR 2216.

Table 1

ELECTRICAL CHARACTERISTICS: $V_C = +12\text{ V}$, $T_A = 25^\circ\text{C}$

COMPANDER

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** Compunder Output With Input Levels of:					
- 4 dB	3.5	+6	7.5	dB	
- 8 dB	-0.5	+2	3.5	dB	
-10 dB	-1.5	0	+1.5	dB	
-14 dB (reference)		-4		dB	
-24 dB	-15.5	-14	-12.5	dB	
-34 dB	-25.5	-24	-22.5	dB	
-44 dB	-36.5	-34	-32.5	dB	
-54 dB	-49	-44	-42.5	dB	
-64 dB	-59	-54	-52.5	dB	

COMPRESSOR

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

EXPANDER

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

Notes: * 0 dB = 0.775 Vrms (1 mW across 600 ohm load)

** Recommended transfer characteristics.

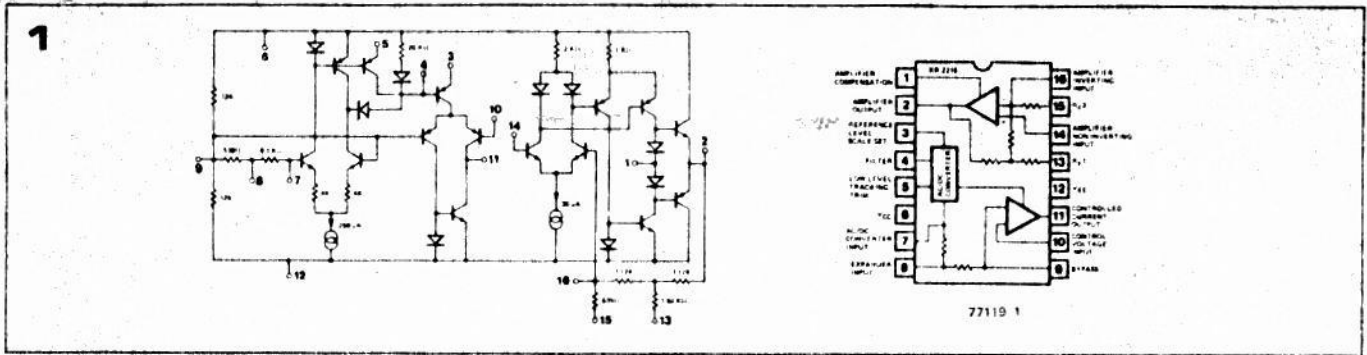


Figure 1. Internal circuit and functional block diagram of the XR 2216 compander IC.

Figure 2. Connections and external components required for operation of the IC as an expander.

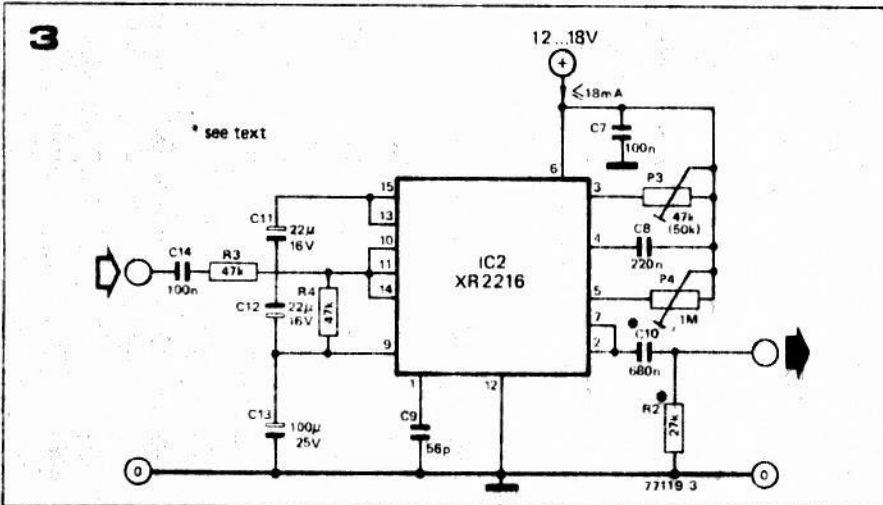
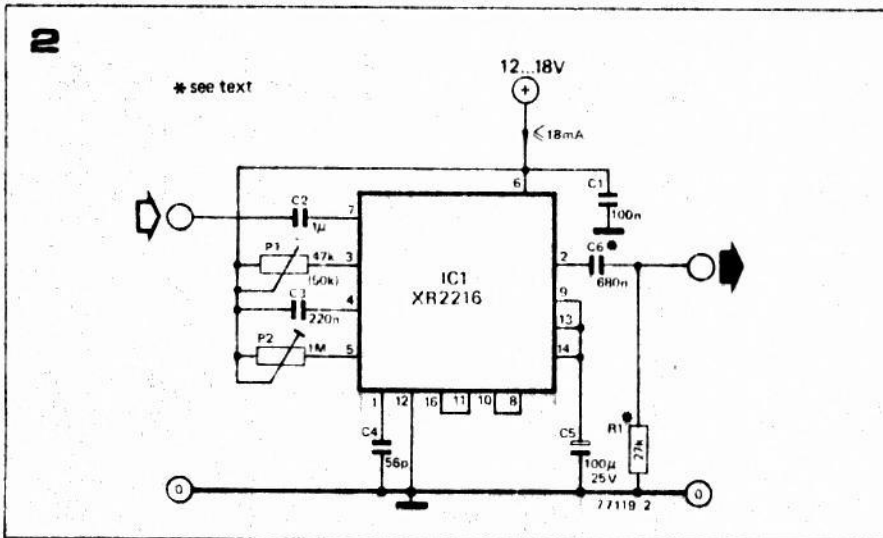
Figure 3. Connection of the XR 2216 as a compressor.

Figure 4. Typical performance curves of the XR 2216:

4a. Compressor output error versus signal amplitude.

4b. Expander input error versus output signal amplitude.

4c. Comander tracking error versus input signal amplitude.



be made to function as a compressor, the circuit of which is shown in figure 3. In this case the input signal is fed to the input of the impedance converter (pin 10) and from the output of this stage to the input of the operational amplifier, the output (to the tape deck) again being taken from pin 2. A portion of the output signal is fed to the input of the AC/DC converter, (by linking pins 2 and 7), the output of which again controls the transconductance of the impedance converter. In this case the output is thus proportional to the square root of the input signal, i.e. the transfer function is the reciprocal of the expander circuit's.

The attack and decay times of the circuit are equal and are determined by a filter consisting of an external resistor and capacitor (P1/C3 or P3/C8). It is

important that the attack time should not be too long, otherwise the response of the circuits to transients may be too slow to prevent overload.

On the other hand, if the decay time is too short then ripple may appear on the output of the AC/DC converter at low input frequencies, thus leading to modulation of the output signal and third-harmonic distortion. This is not a problem in a compander system, since the distortions produced in the compression and expansion processes tend to cancel out. However, if the circuit is used simply as a compressor or as an expander then distortion at low frequencies is a major problem.

Two preset adjustments are provided in the circuits of figures 2 and 3. P1 and P3 set the reference level of the circuit, which determines the actual input volt-

age range over which the compression/expansion takes place. P2 and P4 set the low level tracking, which ensures that the compression and expansion characteristics match, thus ensuring (amongst other things) minimum distortion.

Performance data

The specifications of the XR 2216 are given in table 1, and typical performance curves in figure 4. It can be seen that, in the compressor mode the circuit provides a 2 : 1 compression ratio, e.g. a 60 dB dynamic range can be compressed into 30 dB. In the expansion mode, not surprisingly, an expansion ratio of 1 : 2 is obtained, thus restoring the original dynamic range. From table 1 it can be seen that distor-