



TK10651

LOW VOLTAGE COMPANDOR

FEATURES

- Data and Voice Inputs
- Data and Voice Outputs
- Low Supply Current
- Regulated Output
- Wide Operating Voltage Range
- Low Standby Current
- Microphone Amplifier
- IDC Circuit (Instantaneous Deviation Control)

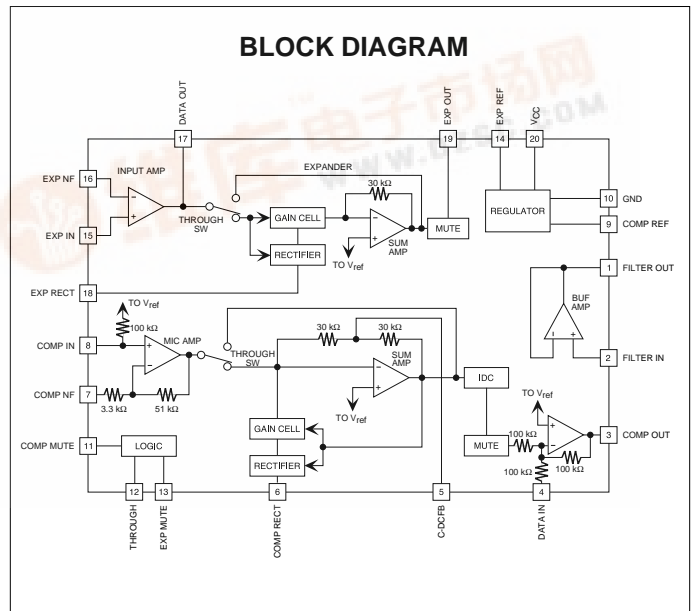
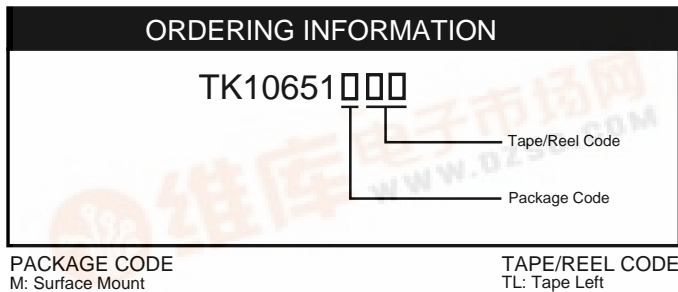
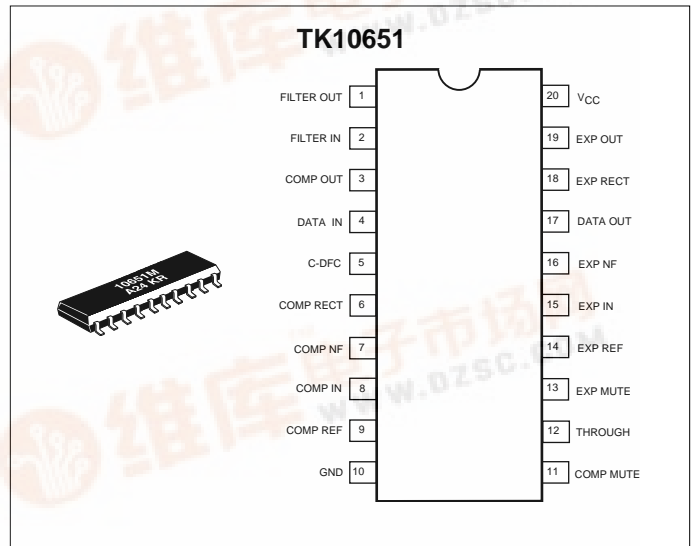
APPLICATIONS

- Portable Instrumentation
- Cordless Telephones
- Handy Talkies
- Interphones
- Amateur Radio Transceivers

DESCRIPTION

TK10651 is a noise reduction IC developed mainly for cordless phones. It is also used for voice and data communications. It has a built-in compressor circuit to increase the average modulation level and an expander circuit to reduce the noise level. The expander restores the original dynamics of the input signal. The result is a high quality signal transmission with low noise. Among the many functions included, analog switching of the input and output signal is particularly useful in cordless telephones. Separate data input and output are provided. The audio signal path can be muted during data transmission. The signal path used for data transmission bypasses the compressor and expander circuits.

The TK10651 is available in the SSOP-20 (MFP20) surface mount package.



# TK10651

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage .....	10 V	Input Frequency .....	100 kHz
Power Dissipation (Note 1) .....	410 mW	Storage Temperature Range .....	-55 to +150 °C
Junction Temperature .....	150 °C	Operating Temperature Range .....	-20 to +70 °C
Operating Voltage Range .....	2.4 to 7.0 V	Lead Soldering Temp. (10 sec.) .....	235 °C

## TK10651 ELECTRICAL CHARACTERISTICS

Test conditions:  $V_{CC} = 3.0\text{ V}$ ,  $f = 1.0\text{ kHz}$ ,  $R_L = 10\text{ k}\Omega$ ,  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
$I_{CC}$	Supply Current	No signal		4.00	6.50	mA
$V_{TH}$	Threshold Voltage	Pins 11,12,13	1.15	1.30	1.45	V
<b>Compressor</b>						
$Z_{INC}$	Input Impedance		90	120		k $\Omega$
$V_{INC}$	Standard Input Voltage	$V_{OC} = 300\text{ mV}_{rms}$ $V_{IN} = 0\text{ dB}$ , (Note 2)	8	12.5	17	$\text{mV}_{rms}$
$\Delta G_C$	Gain Error	$V_{IN} = -20\text{ dB}$ , (Note 2)	-0.5	0	+0.5	dB
		$V_{IN} = -40\text{ dB}$ , (Note 2)	-1.0	0	+1.0	dB
$\Delta G_{TC}$	Through On/Off Difference	$V_{IN} = 0\text{ dB}$ , Pin 12 grounded, (Note 2)	-1.5	0	+1.5	dB
$THD_C$	Total Harmonic Distortion	$V_{IN} = 0\text{ dB}$		0.5	1.0	%
$V_{NOC}$	Output Noise Voltage	$R_g = 620\ \Omega$ , (Note 2)		3.0	5.5	$\text{mV}_{rms}$
$ATT_C$	Mute Attenuation	$V_{IN} = 0\text{ dB}$ , Pin 11 grounded, (Note 2)	60	80		dB
$V_{LIMC}$	Limiting Voltage		1.15	1.35	1.50	$V_{P-P}$
GVD	Voltage Gain for DATA Terminal	Pin 4 voltage = $300\text{ mV}_{rms}$	-0.5	0	+0.5	dB
$V_{OUT(MAX)D}$	Maximum Output Voltage for DATA Terminal	THD = 10% Point	800	900		$\text{mV}_{rms}$
$CT_C$	Cross Talk	Exp $V_{IN} = 30\text{ mV}_{rms}$ , $R_g = 620\ \Omega$ , (Note 2)		-35	-30	dB

Note 1: Power dissipation is 410 mW in free air. Derate at 3.3 mW/°C for operation above 25 °C.

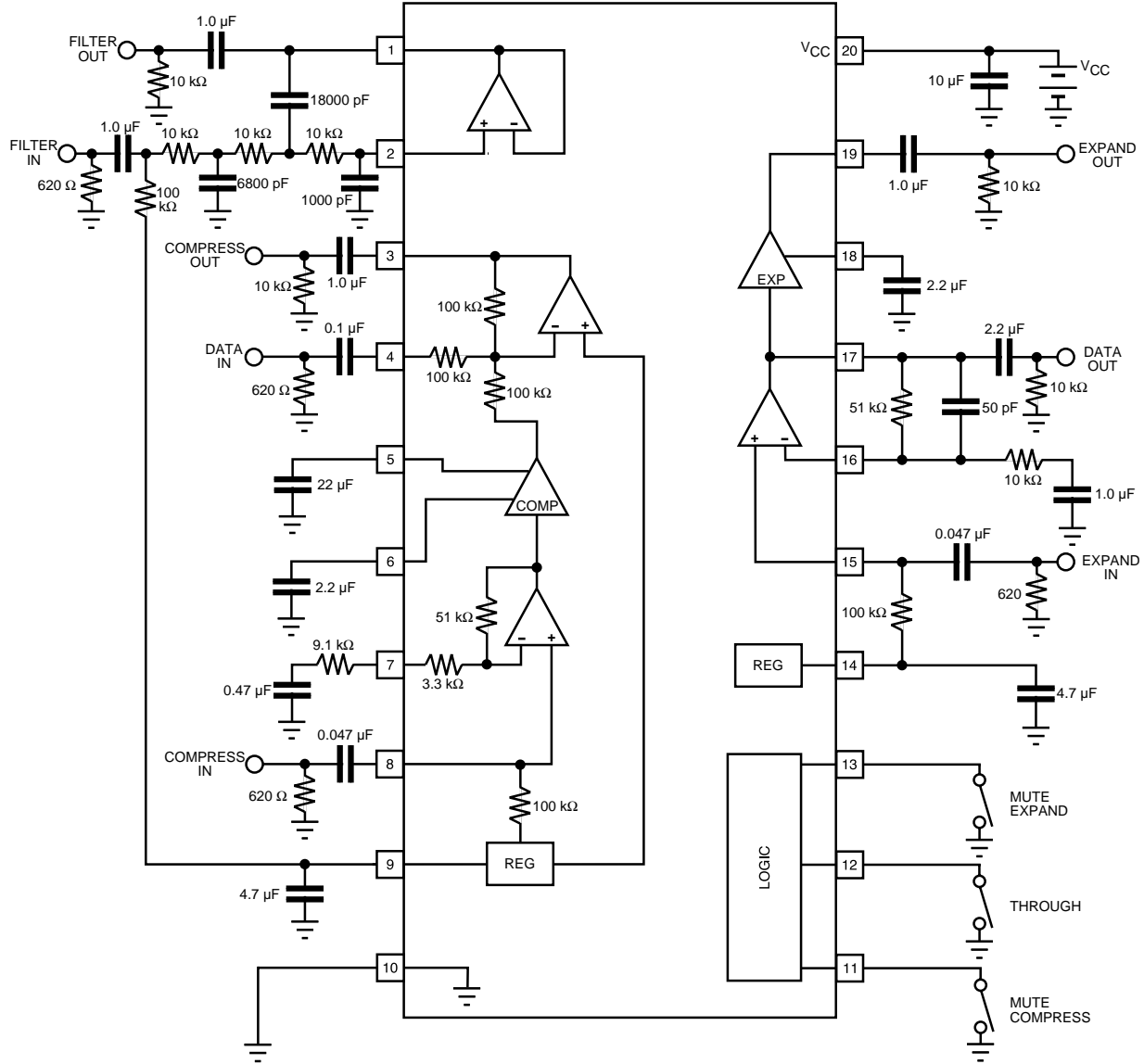
Note 2: Evaluated by CCITT standard P.53 noise filter.

**TK10651 ELECTRICAL CHARACTERISTICS (CONT.)**Test conditions:  $V_{CC} = 3.0\text{ V}$ ,  $f = 1.0\text{ kHz}$ ,  $R_L = 10\text{ k}\Omega$ ,  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>Buffer Amplifier</b>						
GVB	Voltage Gain	$V_{IN} = 300\text{ mV}_{rms}$	-0.5	0	+0.5	dB
$\Delta f$	Frequency Characteristics	$V_{IN} = 300\text{ mV}_{rms}$ , $f = 3\text{ kHz}$		-3		dB
		$V_{IN} = 300\text{ mV}_{rms}$ , $f = 30\text{ kHz}$		-60		dB
THD <sub>B</sub>	Total Harmonic Distortion	$V_{IN} = 300\text{ mV}_{rms}$		0.02	0.1	%
$V_{OUT(MAX)B}$	Maximum Output Voltage	THD = 10% Point	550	700		$\text{mV}_{rms}$
<b>Expander</b>						
$V_{OUTE}$	Standard Output Voltage	$V_{IN} = 30\text{ mV}_{rms} = 0\text{ dB}$ , (Note 2)	110	130	160	$\text{mV}_{rms}$
$\Delta G_E$	Gain Error	$V_{IN} = -10\text{ dB}$ , (Note 2)	-0.5	0	+0.5	dB
		$V_{IN} = -20\text{ dB}$ , (Note 2)	-1.0	0	+1.0	dB
		$V_{IN} = -30\text{ dB}$ , (Note 2)	-1.5	0	+2.0	dB
$\Delta G_{TE}$	Through On/Off Difference	$V_{IN} = 0\text{ dB}$ , Pin 12 grounded, (Note 2)	-2.5	-1.0	+0.5	dB
THD <sub>E</sub>	Total Harmonic Distortion	$V_{IN} = 0\text{ dB}$		0.5	1.5	%
$V_{NOE}$	Output Noise Voltage	$R_g = 620\ \Omega$ , (Note 2)		10	30	$\mu\text{V}_{rms}$
ATT <sub>E</sub>	Attenuation	$V_{IN} = 0\text{ dB}$ , Pin 13 grounded, (Note 2)	60	80		dB
$V_{OUT(MAX)E}$	Maximum Output Voltage	THD = 10% Point	700	800		$\text{mV}_{rms}$
GVI	Voltage Gain for Input Amp.	$V_{IN} = 0\text{ dB}$	14.5	15.5	16.5	dB
$V_{OUT(MAX)I}$	Maximum Output Voltage	THD = 10% Point	450	500		$\text{mV}_{rms}$
CT <sub>E</sub>	Cross Talk	Comp $V_{IN} = V_{INC}$ , $R_g = 620\ \Omega$ , (Note 2)		-70	-60	dB

Note 2: Evaluated by CCITT standard P.53 noise filter.

### TEST CIRCUIT

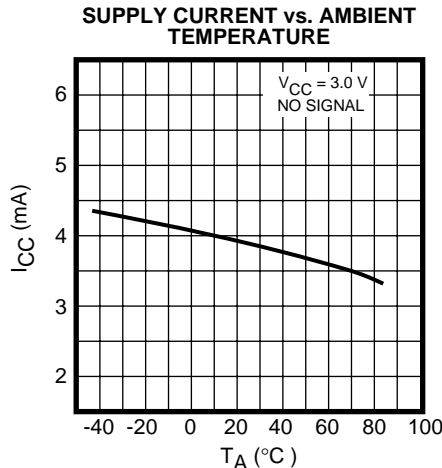
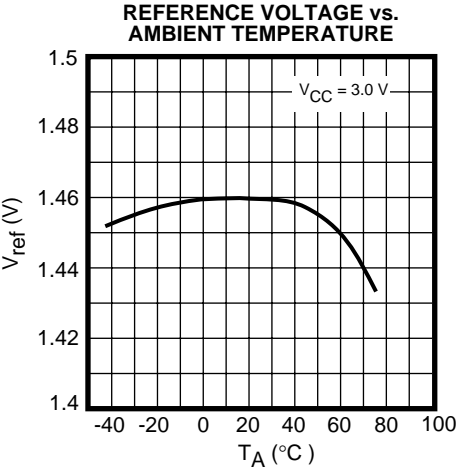
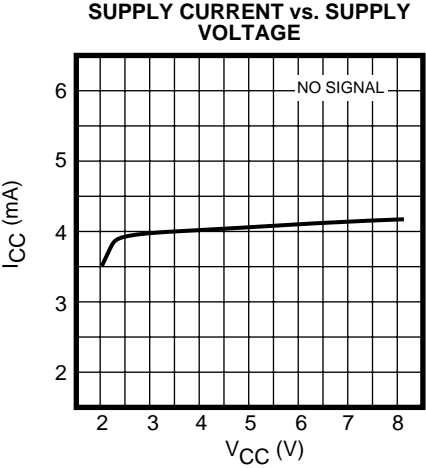
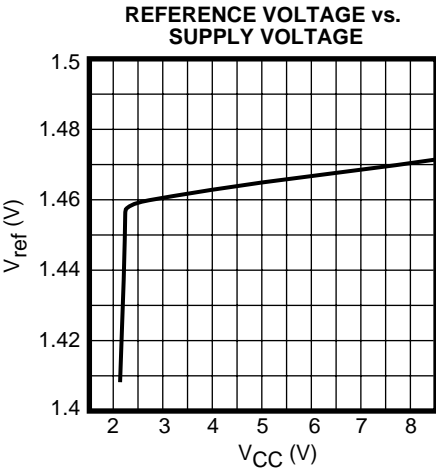


SWITCH PIN	HIGH (OPEN OR V <sub>CC</sub> )	LOW (GND)
Pin 11	Comp Mute OFF	Comp Mute ON
Pin 12	Compandor	Through
Pin 13	Exp Mute OFF	Exp Mute ON

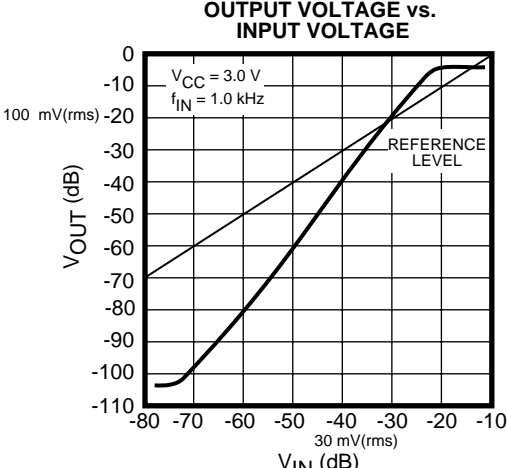
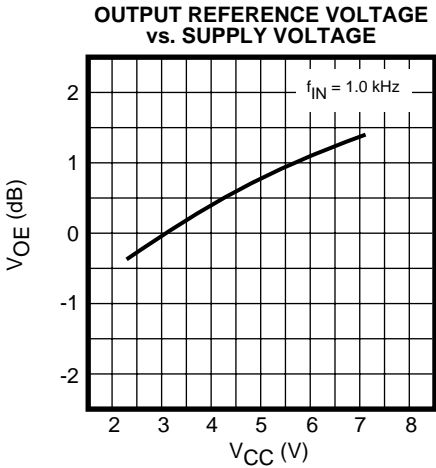
Switch pins priority order:  
High > pins 11 and 13 > pin 12 > low.

TYPICAL PERFORMANCE CHARACTERISTICS

DC CHARACTERISTICS

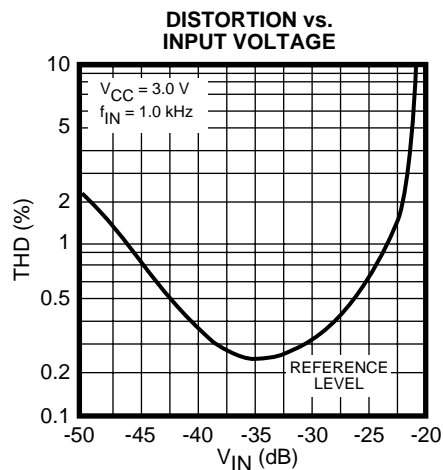
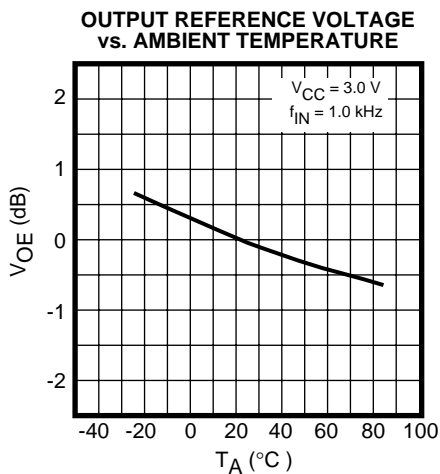


EXPANDER AC CHARACTERISTICS

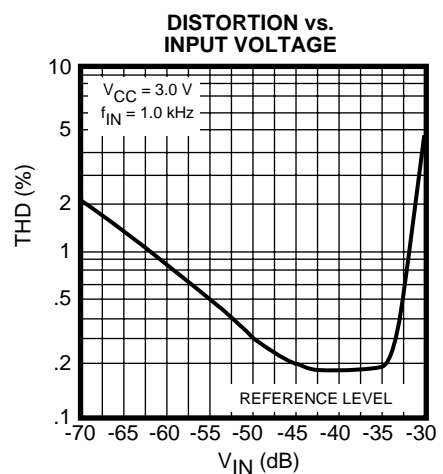
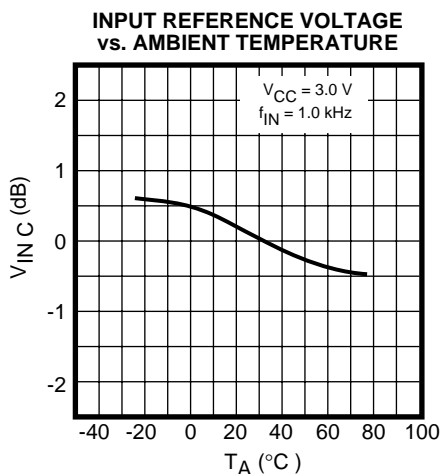
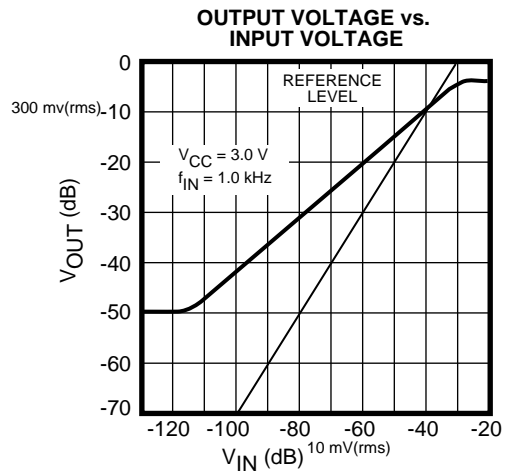
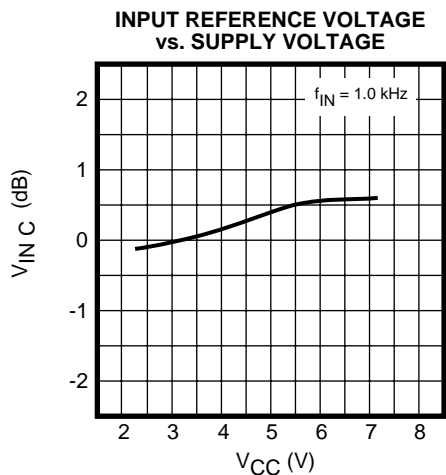


TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

EXPANDER AC CHARACTERISTICS (CONT.)

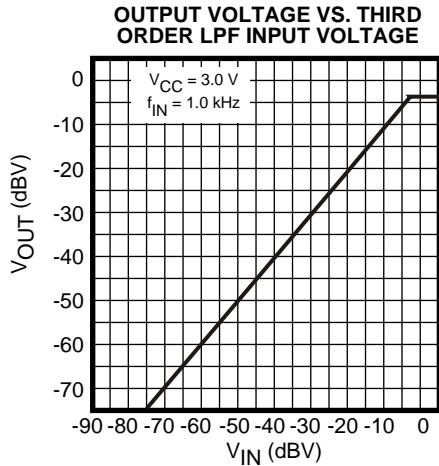
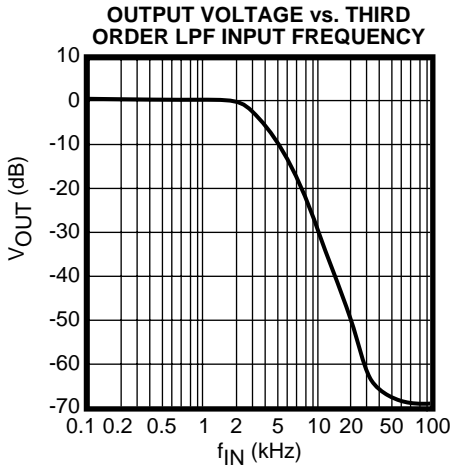


COMPRESSOR AC CHARACTERISTICS



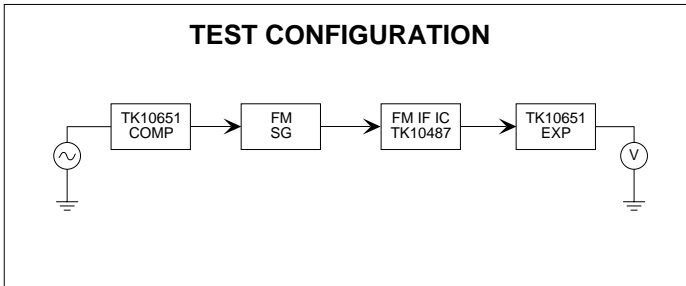
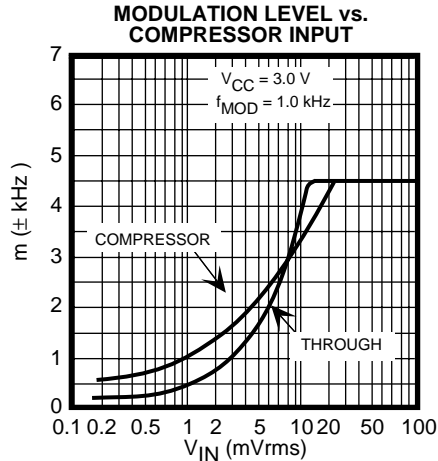
TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)

THIRD ORDER LPF CHARACTERISTICS



USING THE COMPANDOR TO IMPROVE S/N

This section provides an example of using the compandor to improve S/N in a narrow band FM communication system. In the test configuration below, the compressor modulation level was measured as a function of the input voltage to demonstrate the improvement resulting from the use of the compressor. An audio signal is connected into the compressor and the output is measured with the modulation meter connected to the external modulation input of the FM signal generator. The compressor's reference input level was set to produce  $\pm 3.0$  kHz frequency deviation. As shown in the graph on the right, the peak deviation remains the same when the compressor is used, but a wider input range is obtained. The built-in characteristics of the IDC circuit limit the maximum frequency deviation to  $\pm 4.5$  kHz.

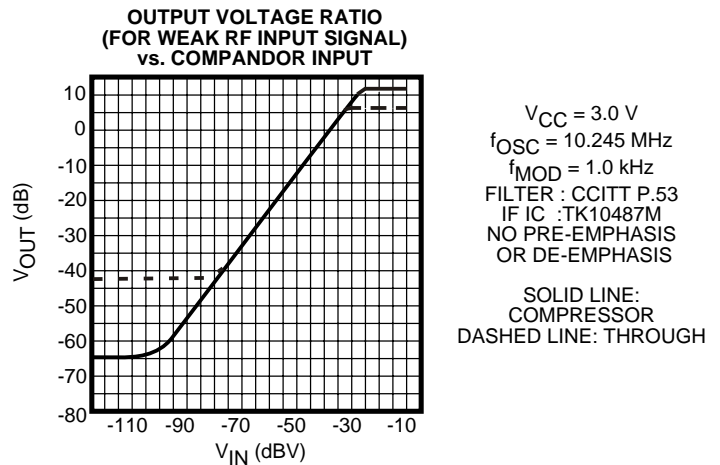
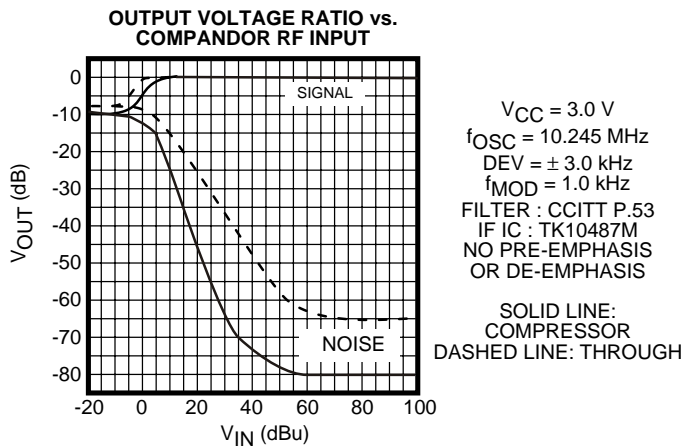


**TYPICAL PERFORMANCE CHARACTERISTICS (CONT.)**

**USING THE COMPANDOR TO IMPROVE S/N (CONT.)**

The improvement resulting from the expander is expressed by measuring the overall characteristics of the FM IF System (TK10487M). The signal generator was switched to internal modulation and the output is defined as 0 dB when the RF input = 80 dBμ. As the graph below indicates, the noise is reduced when the expander is used, and good S/N ratio is maintained even when the RF signal input is weak.

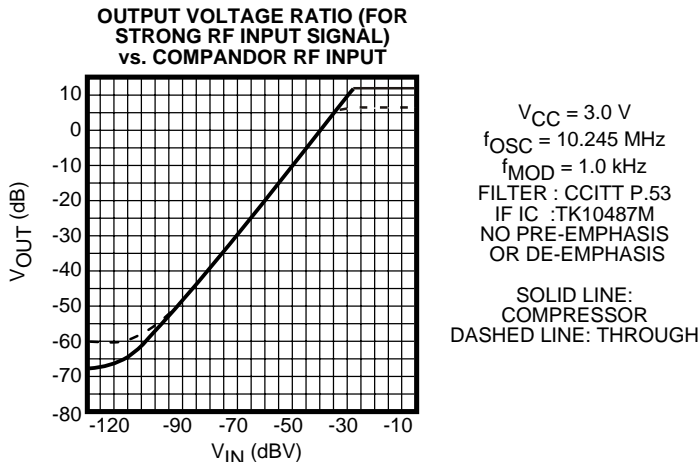
The following graph shows the characteristics when the RF input is weak (RF IN = 30 dBμ). There is a great difference when the compandor is used with a weak RF input. When the through function is used (noise reduction off), the output is lost in noise as the compressor input drops below -80 dBV; but when the compandor function is used, it remains level below -100 dBV. With a weak RF input, dynamic range is extended by 30 dB.



Finally, the overall characteristics are measured using both the compressor and the expander. The output is measured when the compressor's input is at -40 dBμV and the frequency deviation is ±3.0 kHz.

The effects of the compandor within a narrow band FM communications system was demonstrated while a coaxial cable was used in place of transmission through free space. The signal source was an FM signal generator although there are some differences when actual transmission is through free space. However, the test configuration used in this experiment is useful in understanding the effects of the compandor.

The graph below shows the characteristics when the RF input is strong (RF IN = 80 dBμ). The dynamic range is increased by more than 12 dB when the compandor is used.





## APPLICATION INFORMATION

### COMPRESSOR

By placing the data input pin following the compressor circuit, a data signal can be transmitted without being compressed. Audio from the microphone can be connected directly to the IC, because it passes through the built-in microphone amplifier (the gain is adjustable). Since there is a built-in limiter to prevent overmodulation, it is not necessary to add an external Instantaneous Deviation Control (IDC) circuit; furthermore, a Low Pass Filter (LPF) up to the third order can be constructed using the buffer amplifier. When a data signal is being transmitted, the unneeded audio can be cut by engaging the mute switch.

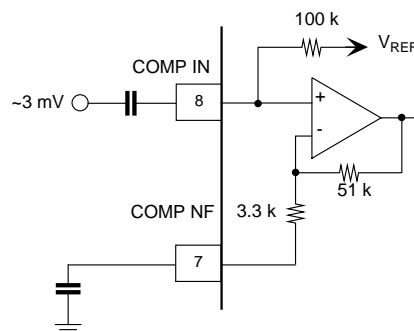
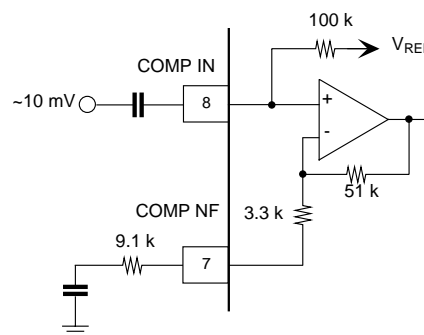
### EXPANDER

A wide range of applications are made possible because all of the input amplifier pins are accessible. A LPF of up to the third order can be constructed at the input, and with an external resistor, it can be used as an amplifier. If the data out pin is used for the output, a data signal can be extracted without passing through the expander. During data transmission, the audio signal system can be inhibited by using the mute switch.

### COMPRESSOR MICROPHONE AMPLIFIER

The input pin connects to the reference voltage through a  $100\text{ k}\Omega$  bias resistor, therefore external bias is not necessary. The microphone amplifier gain can be adjusted by connecting an external resistor to NF pin 7. The gain is highest when no resistor is added, and the standard input level is  $3\text{ mV}$ . When an external resistor of  $9.1\text{ k}\Omega$  is added, the standard input level is about a  $10\text{ mV}$ ; when the external resistor value is  $68\text{ k}\Omega$ , the standard input level is  $30\text{ mV}$ . The input can accommodate a variety of microphones by adjusting the gain to match the microphone's output voltage.

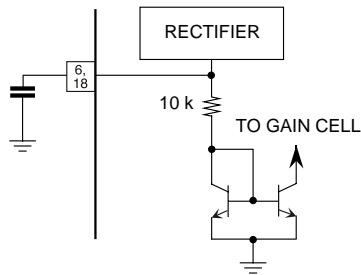
The user should set the gain and input level so that the output level at pin 3 is normally  $300\text{ mV}$  (standard level).



APPLICATION INFORMATION (CONT.)

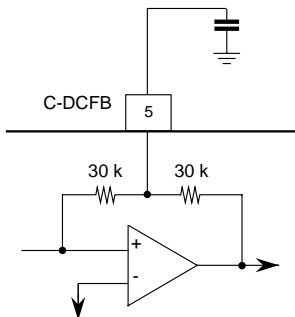
RECTIFIER

The rectifier's smoothing capacitor pins (6 & 18), determine the smoothing characteristics and the time constants of the compressor and the expander. The time constant is determined by the external capacitor value and the internal 10 kΩ resistance.



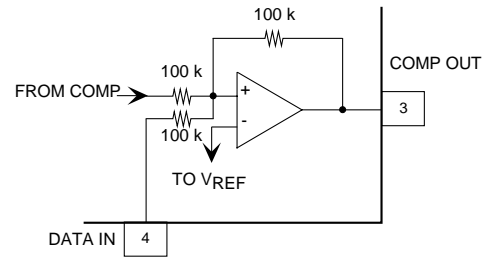
COMPRESSOR SUMMING AMPLIFIER

The compressor summing amplifier (SUM AMP) must have unity DC gain and the AC open loop gain is high. Since the feedback resistors are internal to the device, only one external capacitor is needed between pin 5 and GND. The cutoff frequency is determined by the external capacitor and the internal resistors.



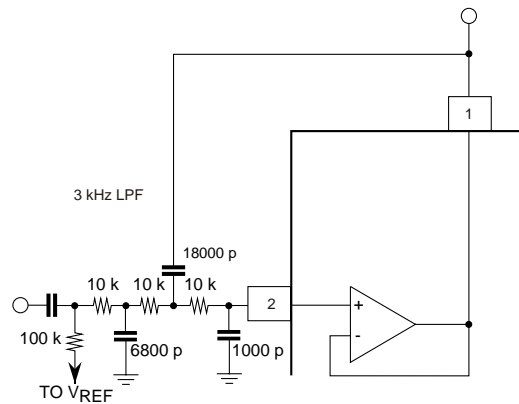
COMPRESSOR DATA INPUT

An inverting amplifier is used at the DATA input. The internal input resistors are 100 kΩ, and the DC bias ( $V_{REF}$ ) is about 1.5 V. The maximum load at the output pin is 10 kΩ.



BUFFER AMPLIFIER

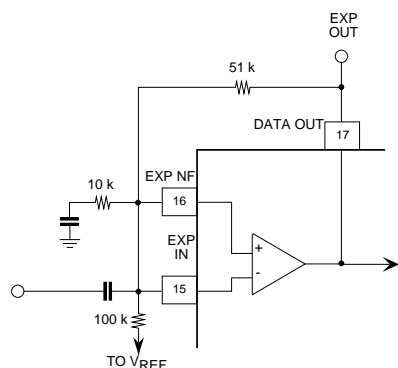
Up to a third order LPF (for example, a splatter filter) can be constructed using this amplifier. The maximum load at the output pin is 10 kΩ. The non-inverting input of the amplifier is not biased internally, therefore an external bias is needed (for example Pin 3  $V_{ref}$ ) whenever this pin is not direct-coupled from the compressor output pin (pin 3).



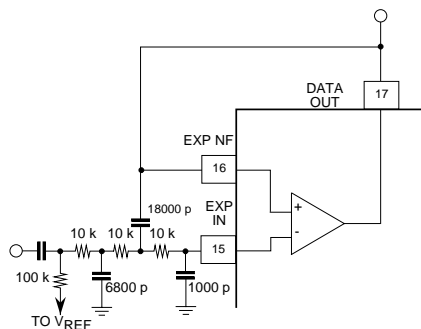
## APPLICATION INFORMATION (CONT.)

### EXPANDER INPUT AMPLIFIER

The non-inverting and inverting input pins as well as the output pins are available, and can be used as a buffer amp or filter amp. A data signal can be obtained from the output pin, without passing through the expander. The input level and amplifier gain should be set to provide 180 mV(rms) standard level at the data output pin (pin 17). The expander input amplifier is not DC biased internally, therefore a bias voltage from the expander's  $V_{REF}$  pin (pin 14) should be used. The maximum allowable load at the output pin is 10 k $\Omega$ .



AMPLIFIER (GAIN = 6)



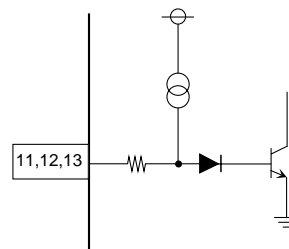
3 kHz LPF

### REFERENCE VOLTAGE SOURCE (PINS 9 AND 14)

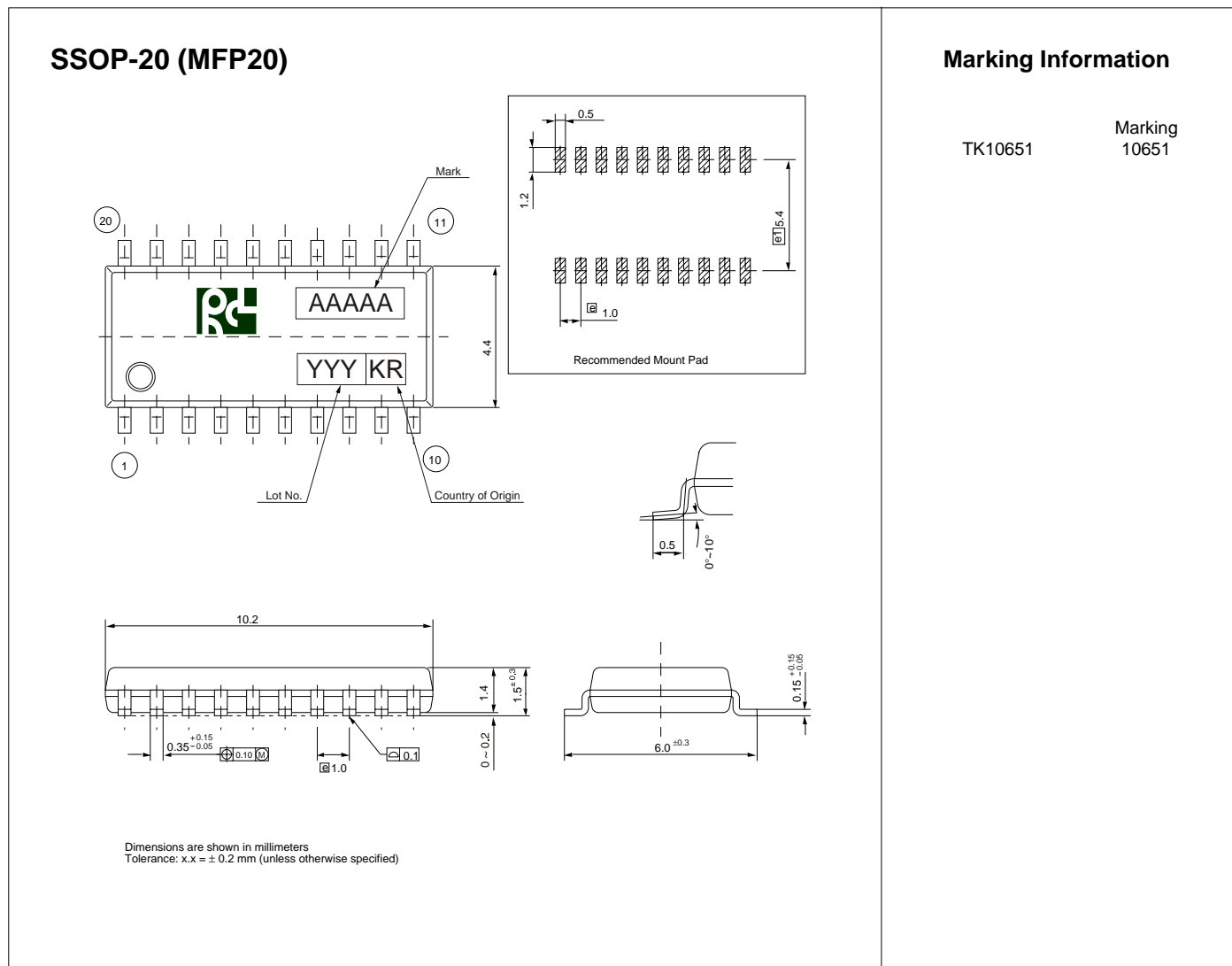
Pin 9 is the reference voltage pin for the compressor and pin 14 is the reference voltage pin for the expander. The reference voltages are obtained from an internal band gap reference and used as the bias source for each section.

### SWITCH CIRCUIT (PINS 11, 12, and 13)

The compressor's and expander's mute pins and the through pin (noise reduction is off) are pulled up by internal current sources, therefore they do not need an external pull up. Concerning the switching logic, refer to the table in the Test Circuit section.



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