TEA1075
DTMF Generator for Telephone Dialing

Product Specification

DESCRIPTION

This integrated circuit is a dual-tone multi-frequency (DTMF) generator with line interface for use in pushbutton telephone sets containing an electronic speech circuit or a conventional hybrid transformer. The IC contains a mute switch handling the full line current, which allows two-wire connection between dial and speech parts. The logic inputs can be operated with a single contact keyboard or via a direct interface with a microcomputer. I^2L technology allows digital and analog functions to be implemented on the same chip. The line interface incorporates a filter amplifier, an output stage and a voltage stabilizer all of which are switched off when the speech circuit is connected to the line. The tone generator is supplied by a temperature compensated current stabilizer and is to be driven by a 3.58MHz crystal.

The logic inputs contain an interface circuit to guarantee well-defined states of the keyboard.

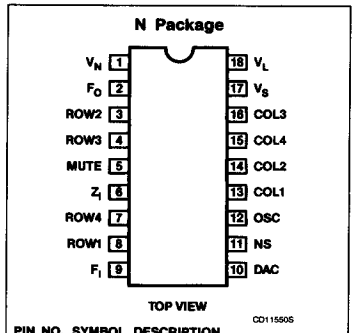
FEATURES

- **Two-wire connection between dial and speech parts allowed**
- **Wide operating line current and temperature range**
- **Operating voltage down to 1.7V**
- **No individual tone level adjustment required**
- **Few external components required**
- **All mute functions on-chip**
- **Common inputs for keyboard and microcomputer**
- **Temperature and line current independent signal levels**
- **All pins protected against electrostatic discharges**
- **On-chip output stage and line regulator**
- **Single tone generation possibility**

APPLICATIONS

- **Push button telephone set**
- **Hybrid telephone set**

PIN CONFIGURATION



PIN NO.	SYMBOL	DESCRIPTION
1	V_N	Negative line voltage
2	F_O	Filter output
3	ROW2	Row input 770 Hz/BCD input
4	ROW3	Row input 852 Hz/BCD input
5	MUTE	Mute switch
6	Z_I	Impedance setting terminal
7	ROW4	Row input 941 Hz/BCD input
8	ROW1	Row input 697 Hz/BCD input
9	F_I	Filter input
10	DAC	DTMF level setting
11	NS	Noise suppression input
12	OSC	Oscillator input
13	COL1	Column input 1209Hz/mute input
14	COL2	Column input 1336Hz/mute input
15	COL4	Column input 1633Hz/mute input
16	COL3	Column input 1477Hz/enable input
17	V_S	Voltage stabilizer filter
18	V_L	Positive line voltage

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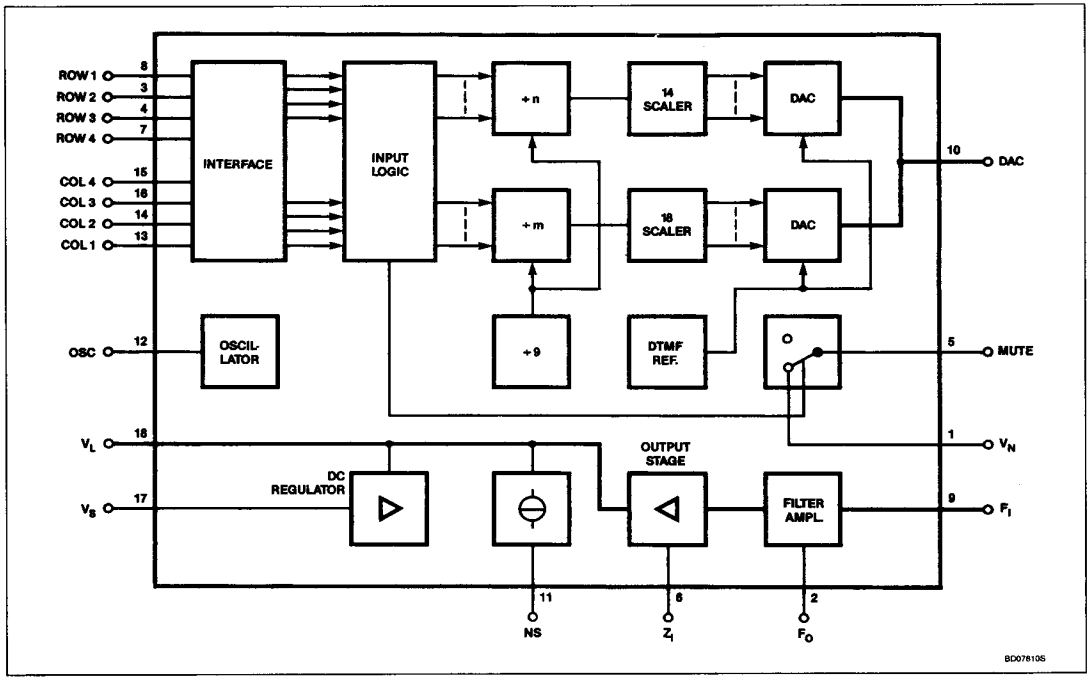
ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE
18-Pin Plastic DIP (SOT-102HE)	−25°C to +70°C	TEA1075PN

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
I_{CC}	Supply current	150	mA
I_S	Surge current ($t_p < 250\mu s$)	1000	mA
T_A	Operating ambient temperature range	−25 to +70	°C
T_{STG}	Storage temperature range	−65 to +150	°C
V_I	Voltage on any pin	$(V_N - 0.3)$ to $(V_L + 0.3)$	V
V_{L-N}	Line voltage	10	V
P_D	Power dissipation	750	mW

BLOCK DIAGRAM



DC AND AC ELECTRICAL CHARACTERISTICS $T_A = 25°C$; $I_L = 15mA$; $f = 1kHz$, unless otherwise specified. See also Figure 12.

SYMBOL	DESCRIPTION	LIMITS			UNIT
		Min	Typ	Max	
Supply					
	Line voltage DC (operating mode)				
V_L	I_L = 15mA		3.3		V
V_L	I_L = 50mA		3.7		V
V_L	I_L = 120mA		4.5		V
V_L	Line voltage DC (standby mode)			−6.5	V
T_C	Temperature coefficient		−8		mV/°C
I_L	Line current range	10		120	mA
Transmitter output stage					
	Dynamic resistance setting range				
R_I	Pin 6 open		900		Ω
R_I	Pin 6 connected to V_N		600		Ω
ΔZ_O	Variation over line current $R_I = 600\Omega$		100		Ω
A_{TL}	Gain		TBD		dB
	Balance return loss from 300 up to 3400Hz				
BRL	at 600Ω	20			dB
BRL	at 900Ω (C_L = 30nF)	20			dB
d_{TOT}	Total harmonic distortion with respect to total output level (second-order filter)		−40	−25	dB
DTMF generator					
Δf_D	Dividing error crystal frequency = 3.579545MHz	−0.31		−0.1	%
	Tone output level (adjustable)				
	$I_L > 10mA$				
V_{LG}	Lower tones	−11		−8	dBm
V_{HG}	Higher tones	−9		−6	dBm
	$I_L > 12mA$				
V_{LG}	Lower tones	−11		−6	dBm
V_{HG}	Higher tones	−9		−4	dBm
ΔV_O	Tolerance on output level over temp. and current range	−2		2	dB
ΔV_{HG}	Pre-emphasis higher tones/lower tones over temp. and current range	1	2	3	dB
t_d	Tone delay after key actuation			5	ms
t_{sb}	Switch bounce elimination		2		ms
Mute					
I_{MSS}	Mute output sink current (no key pressed)			120	mA
$V_{MT(sat)}$	Saturation voltage (I_{MS} = 75mA)		150	500	mV
V_{MT}	Maximum voltage (voltage set by speech part)			10	V
I_{STB}	Standby current (V_L = 4.5V)		2	2.5	mA
t_D	Switch delay after key release			10	μs
R_M	Resistance		10		kΩ

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DC AND AC ELECTRICAL CHARACTERISTICS (Continued) $T_A = 25°C$; $I_L = 15mA$; $f = 1kHz$, unless otherwise specified. See also Figure 12.

SYMBOL	DESCRIPTION	LIMITS			UNIT
		Min	Typ	Max	
Keyboard inputs (microcomputer inputs)					
R_{KOFF}	Contact off resistance	300			kΩ
R_{KON}	Contact on resistance			10	kΩ
	Lower frequency inputs (ROW1, 2, 3, 4)				
V_{IL}	voltage LOW			1.1	V
V_{IH}	voltage HIGH	1.5			V
I_{ILD}	current (DC) at V_{IL} dial mode		30		μA
	Higher frequency inputs (COL1, 2, 3, 4)				
V_{IL}	voltage LOW			0.5	V
V_{IH}	voltage HIGH	0.9			V
I_{IHD}	current (DC) at V_{IH} dial mode		30		μA

FUNCTIONAL DESCRIPTION

Voltage Regulator

The voltage regulator switches on as a keyboard button is pressed. It regulates the voltage drop across the IC to a nominal level of 3.3V, shunting excess line current to maintain a working current of 8mA within the chip. The voltage regulator switches off voltage level when the keyboard switch is released.

The capacitor connected to input V_S provides a low-pass filter function to avoid influence of audio signals on the line. For a short period during switch-on time the capacitor is directly connected to the line to reduce overshoot voltages to only 1V above the voltage set by the regulator.

In order to adapt the nominal DC level to the level as set by the speech circuit, a resistor can be connected either between V_L and V_S or between V_N and V_S. This will decrease or increase the level respectively. During the time the device is in the stand-by mode the voltage stabilizer circuit will conduct again as the DC line voltage set by the speech part achieves 6.0V. Part of the line current then will flow through this stabilizer.

Active Output Stage

The transmitter amplifier consists of a voltage to current converter with a class-A output stage. The circuit acts as a dynamic resistance (R_a) because of the feedback from the line to the input. This impedance can be set by output Z_I at Pin 6:
$R_a = 900Ω$ if Pin 6 is left open
$R_a = 600Ω$ if Pin 6 is connected to V_N (Pin 1).
The impedance is extremely high as long as no key is depressed (standby mode).

Speech Muting

Figure 1 shows the connection of the dial circuit with a speech circuit TEA1060/61. All mute functions are performed by internal switches. Pressing any keyboard pushbutton switches the TEA1075 to operating mode and isolates the speech circuit from the line.

The line adaption then is taken over by the dial circuit which causes:

- line voltage to be set by the voltage regulator TEA1075
- impedance to be set by the active output stage TEA1075
- audio output stage to be connected to the line for DTMF tone transmission.

During the standby mode (no key pressed) the voltage on the line is set by the speech circuit. The minimum DC operating voltage of the dial circuit for guaranteed detection of push button operation on the keyboard is 2.5V. The impedance is approximately 10kΩ and the current consumption 2mA. The standby current is used for the logic part as well as driving current for the internal mute switch which can switch the full line current available.

OSC and DTMF Generator

The crystal oscillator frequency (3.579 545MHz) is divided by a factor of nine to give the clock frequency. A maximum division error of 0.31% is achieved in the TEA1075; CCITT recommendations are that tones should be within 1.5% of the specified frequencies.

A bias resistor of 1 to 4.7MΩ must be connected between the oscillator input and V_{CC}. An external frequency generator can be connected instead of a crystal (Figure 3).

The output from the dividers for the higher and the lower frequency tones are symmetrical square wave pulses which contain consid-

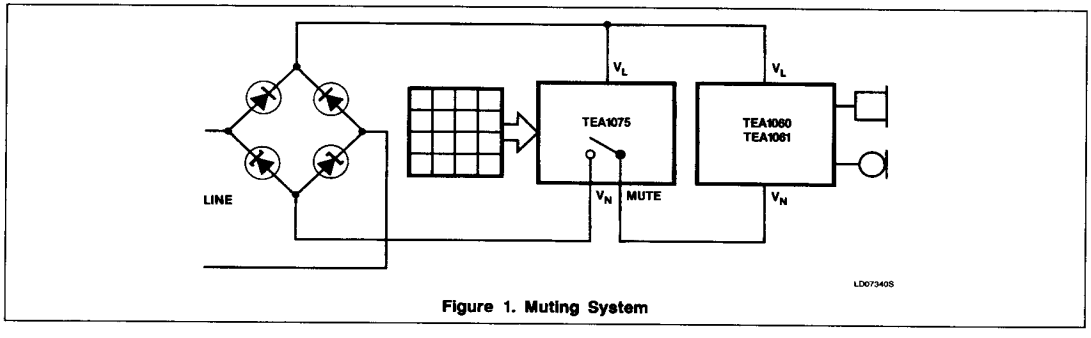


Figure 1. Muting System

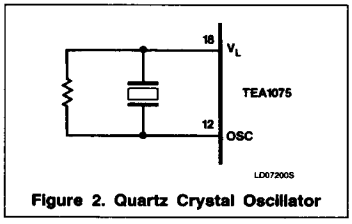


Figure 2. Quartz Crystal Oscillator

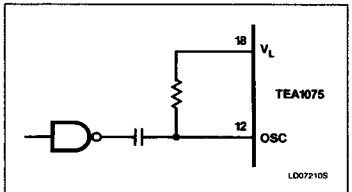


Figure 3. External Frequency Generator

Deviation of ROW and COLUMN Frequencies

	FREQ. (Hz)	DEVIATION (%)	REAL (Hz)
ROW1	697	−0.24	695.33
ROW2	770	−0.28	767.81
ROW3	852	−0.25	849.84
ROW4	941	−0.31	938.04

	FREQ. (Hz)	DEVIATION (%)	REAL (Hz)
COL1	1209	−0.31	1205.23
COL2	1337	−0.10	1334.66
COL3	1477	−0.27	1473.06
COL4	1633	−0.18	1630.03

erable odd-numbered harmonics. The lower-order odd-numbered harmonics (11th and less) are eliminated by synthesizing the tone frequencies as crude stepped sine wave approximations. Each half-cycle of the tone waveform comprises seven discrete amplitudes for the lower frequency tone and nine for the higher frequency tone. Each amplitude increment is generated by switching on and off an individual current source for the duration of each step of the sine wave. The frequency of the tones is varied by changing the duration of each step. This circuit allows the connection of a first-or second-order filter, depending on the distortion requirements (see filter and DTFM level).

Filter and DTMF Level

The output current from the DAC causes a voltage drop across R_{TLS} at Pin 10. At this point the signal path is broken to allow insertion of filter components in series with the amplifier input at Pin 9. The output of this amplifier is brought out to Pin 2 to allow connection of filter components in the feedback path to provide additional attenuation of the higher-order odd harmonics of the tone frequencies.

The output amplitude of the tones is directly proportional to the value of R_{TLS} and can therefore be adjusted to meet specific requirements. Figure 4 shows the output level as a function of R_{TLS} and $R_a = 600\Omega$. If $R_a = 900\Omega$, R_{TLS} must be divided by 1.25.

When R_{TLS} is selected for the required tone level (C_{FI} can be calculated to avoid too much influence of the filter characteristic on the pre-emphasis parameter), the time constant for a single pole filter is:

$R_{TLS} \cdot C_{FI} = 26\mu s$ (see Figure 14).

If higher attenuation is required, a second-order filter can be applied. The time constant for such is:

$R_{TLS} \cdot C_{FO} = R_{FS} \cdot C_{FI} = 46\mu s$ (see Figure 13).

Keyboard Inputs

Inputs for the logic control are compatible with different types of keyboards. Using a keyboard, tone combinations are generated:

- by connecting one of the row inputs to one of the column inputs by means of a single switch of the matrix, or
- by applying a dual contact keyboard having its common row contact tied to V_N and the common column contact via $68k\mu$ to V_L.

Single tones can be generated by connecting a row input to V_N (Pin 1) or one of the column inputs to V_L (Pin 18) through a $68k\Omega$ resistor.

An anti-bounce circuit eliminates switch bounce.

Microcomputer Mode

The inputs for the keyboard connections can be used for direct connection to a microcomputer. If the column inputs are interconnected and made 'HIGH' (> 1V or $I_{CD} = 30\mu A$) the row inputs are changed to another mode, allowing the circuit to be driven by 4-bit data plus an enable signal. In this mode, it is possible to connect a separate mute enable signal on inputs COL1, 2 and 4 and a tone enable input on COL3.

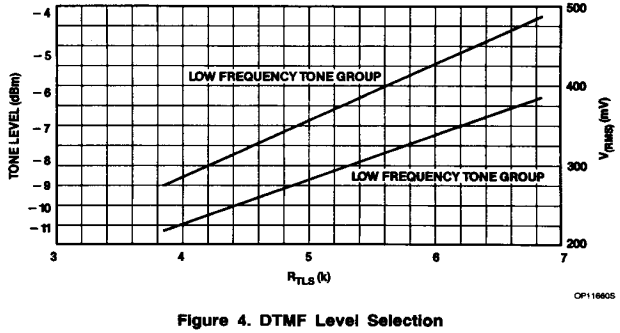


Figure 4. DTMF Level Selection

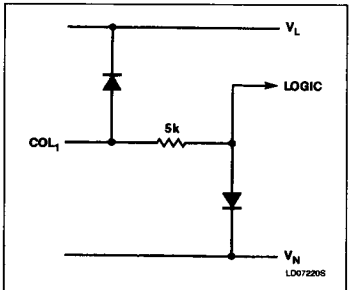


Figure 5. Configuration of Column Inputs

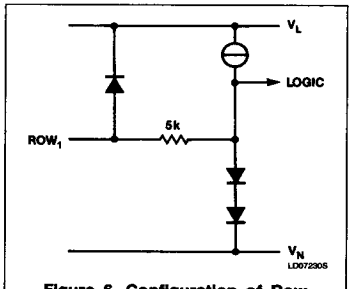


Figure 6. Configuration of Row Inputs

TRUTH TABLE MICROCOMPUTER MODE

ROW				COLUMN		TONES (Hz)	SYMBOL	MUTE[1]
1	2	3	4	1, 2, 4	3			
H	H	H	H	L	L			off
X	X	X	X	H	L			on
H	H	H	H	H	H	697/1209	1	on
H	H	H	L	H	H	697/1336	2	on
H	H	L	H	H	H	697/1477	3	on
H	H	L	L	H	H	697/1633	A	on
H	L	H	H	H	H	770/1209	4	on
H	L	H	L	H	H	770/1336	5	on
H	L	L	H	H	H	770/1477	6	on
H	L	L	L	H	H	770/1633	B	on
L	H	H	H	H	H	852/1209	7	on
L	H	H	L	H	H	852/1336	8	on
L	H	L	H	H	H	852/1477	9	on
L	H	L	L	H	H	852/1633	C	on
L	L	H	H	H	H	941/1209	*	on
L	L	H	L	H	H	941/1336	0	on
L	L	L	H	H	H	941/1477	#	on
L	L	L	L	H	H	941/1633	D	on

NOTE:
1. Mute "on" = switch open.

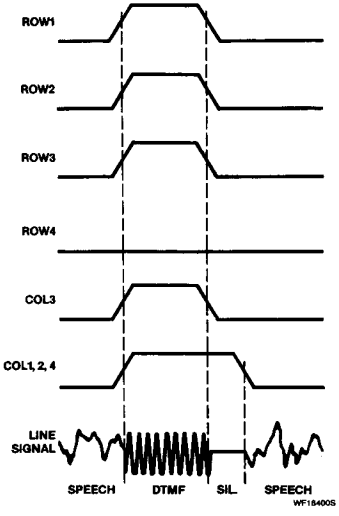


Figure 7. Waveform Tones 697/1336Hz (Dialing Number 2)

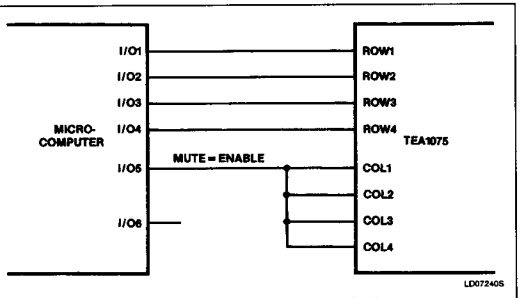


Figure 8. Microcomputer Mode; All Column Inputs Interconnected

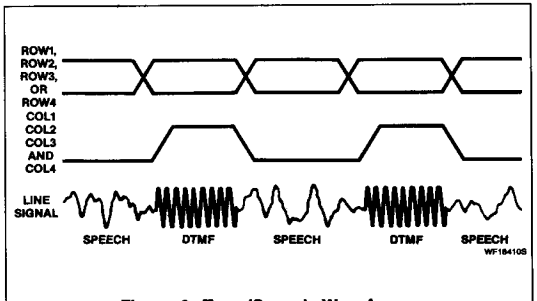


Figure 9. Tone/Speech Waveform in Circuit Diagram (Figure 8)

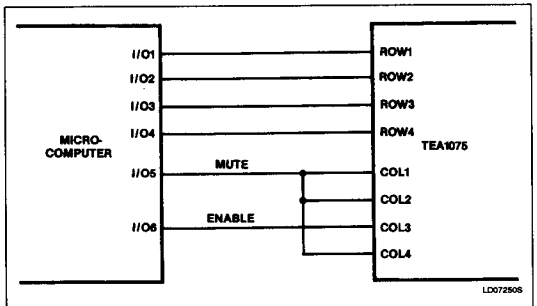


Figure 10. Microcomputer Mode; Column Inputs COL1, 2 and 4 Interconnected

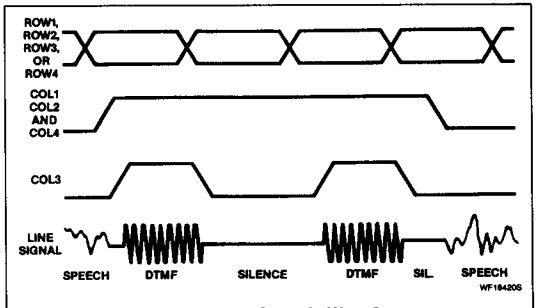
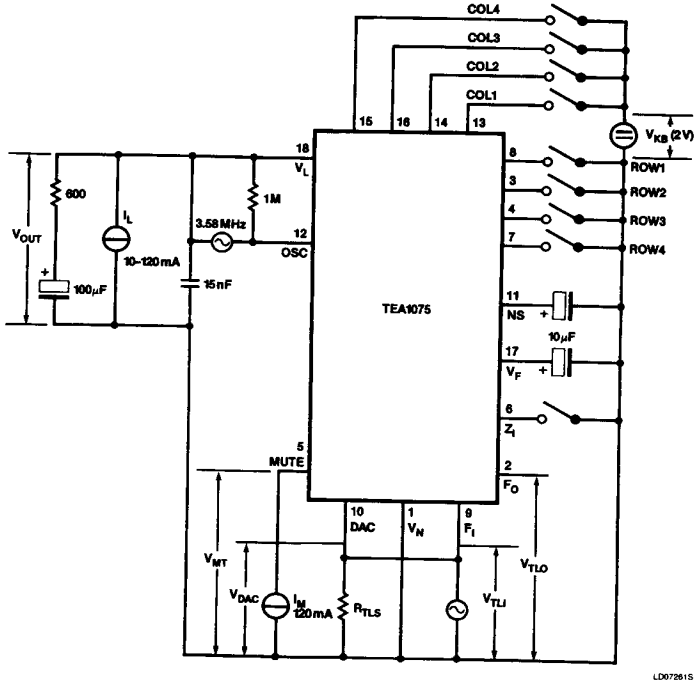


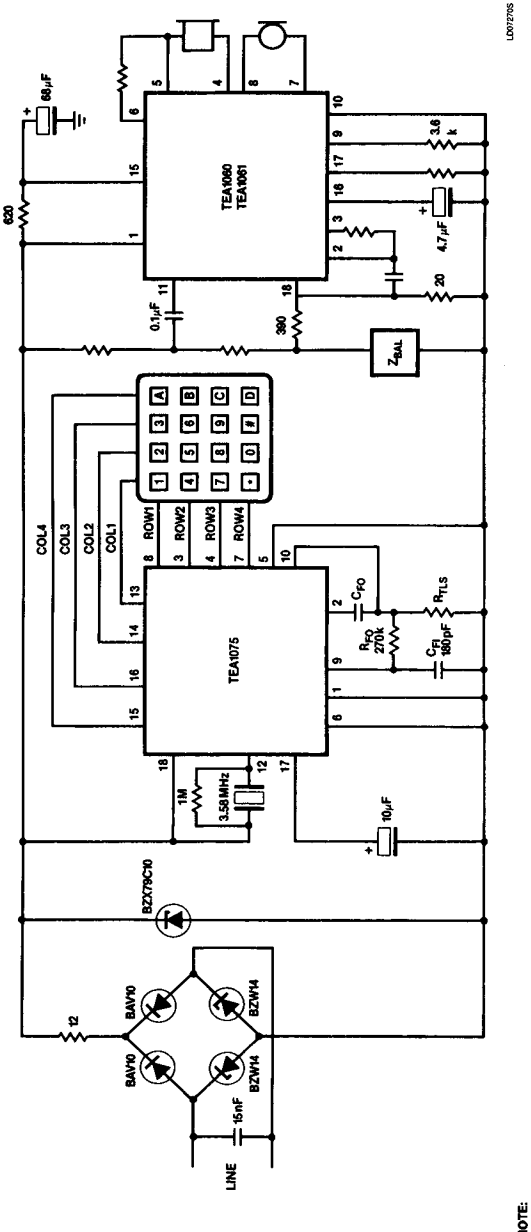
Figure 11. Tone/Speech Waveform in Circuit Diagram (Figure 10)



NOTE:

$A_{TL} = \left| \frac{V_{TLO}}{V_{TLI}} \right|$

Figure 12. Test Circuit Measuring Amplifier Voltage Gain (A_{TL}) Frequencies and Tone Output Levels of the Generator



NOTE:
Dial and speech functions are completely separated so line interface is done either by TEA1075 or TEA1060. The diagram shows a complete DTMF telephone set including protection.
Both circuits are set to an impedance of 600Ω.

Figure 13. Application Diagram TEA1075 Using a Second-Order Filter for Low Harmonic Distortion (CEPT T/CS 34-08)

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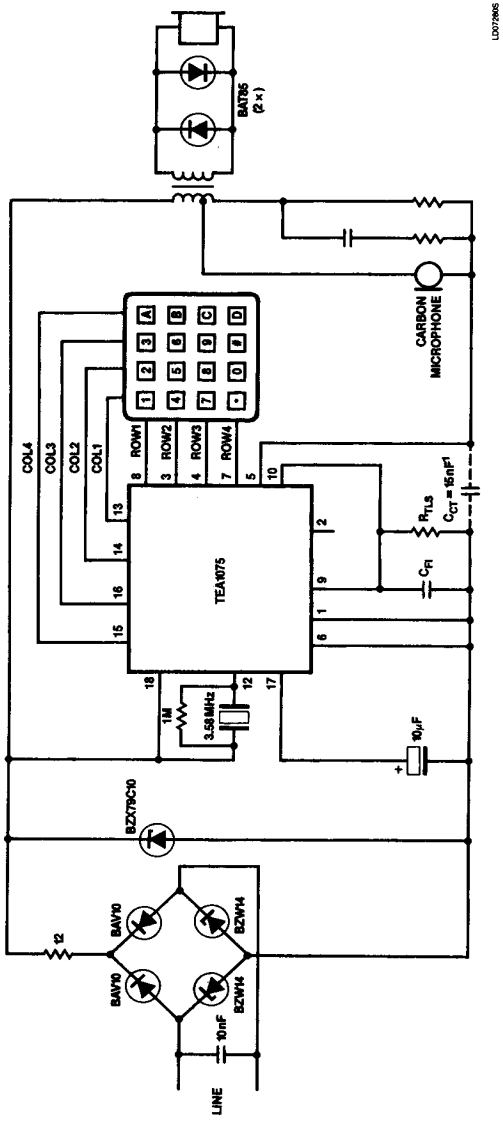

NOTES:
1. C_{CT} connected only if confidence tone is desired.
2. The diagram shows a complete DTMF set including protection.

Figure 14. Application Diagram TEA1075 Using a Single Pole Filter