SGS-THOMSON MICROELECTRONICS

MK5375

TEN-NUMBER REPERTORY TONE/PULSE DIALER

- CMOS TECHNOLOGY PROVIDES LOW-VOLTAGE OPERATION
- CONVERTS PUSH-BUTTON INPUTS TO BOTH DTMF AND LOOP-DISCONNECT SIGNALS
- STORES TEN 16-DIGIT TELEPHONE NUMBERS, INCLUDING LAST NUMBER DIALED
- PACIFIER TONE AND PBX PAUSE
- LAST-NUMBER-DIALED (LND) PRIVACY
- MANUAL AND AUTO-DIALED DIGITS MAY BE CASCADED
- ABILITY TO STORE AND DIAL BOTH "*" AND "#" DTMF SIGNALS
- VARIABLE DIALING RATE
- ON-CHIP POWER-UP-CLEAR GUARANTEES DATA INTEGRITY

DESCRIPTION

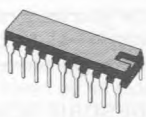
The MK5375 is a monolithic, integrated circuit manufactured using Silicon Gate CMOS process. This circuit provides the necessary signals for either DTMF or loop disconnect dialing. It also allows for the storage of ten telephone numbers, including as many as 16 digits each, in on-chip memory.

The MK5375 accepts rapid keypad inputs (up to 25 key entries per second) and buffers these inputs in the FIFO (First-In-First-Out) LND (Last-Number-Dialed) register. Each digit entry is accompanied by a pacifer tone. Which is activated after the digit has been debounced, decoded, and properly stored. Signaling occurs at a rate determined by externally connected components, allowing the dialing rate to be adjusted for any system.

The flexibility of the dialer makes possible a variety of applications, such as "scratchpad" number storage. In "scratchpad" applications, the MK5375 inhibits signaling during entry, without interrupting a conversation.

Privacy is also an important feature. The MK5375 allows the LND (Last-Number-Dialed) buffer to be cleared following a call, without affecting data stored in other permanent memory locations. The memory in the permanent locations may be easily protected from inadvertent key entries with the addition of a simple "memory lock" switch to the application.

All of these options plus additional features are discussed in more detail in the following sections. the first section contains a brief detailed description of each pin function. The second section describes the device operation. This is followed by the DC and AC Electrical Specifications, and a few application suggestions.



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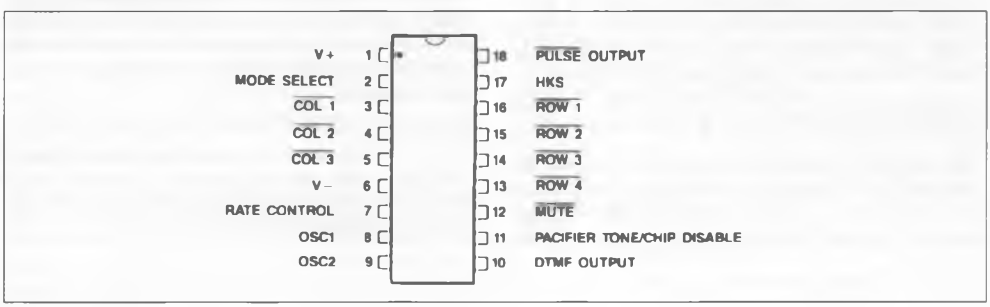
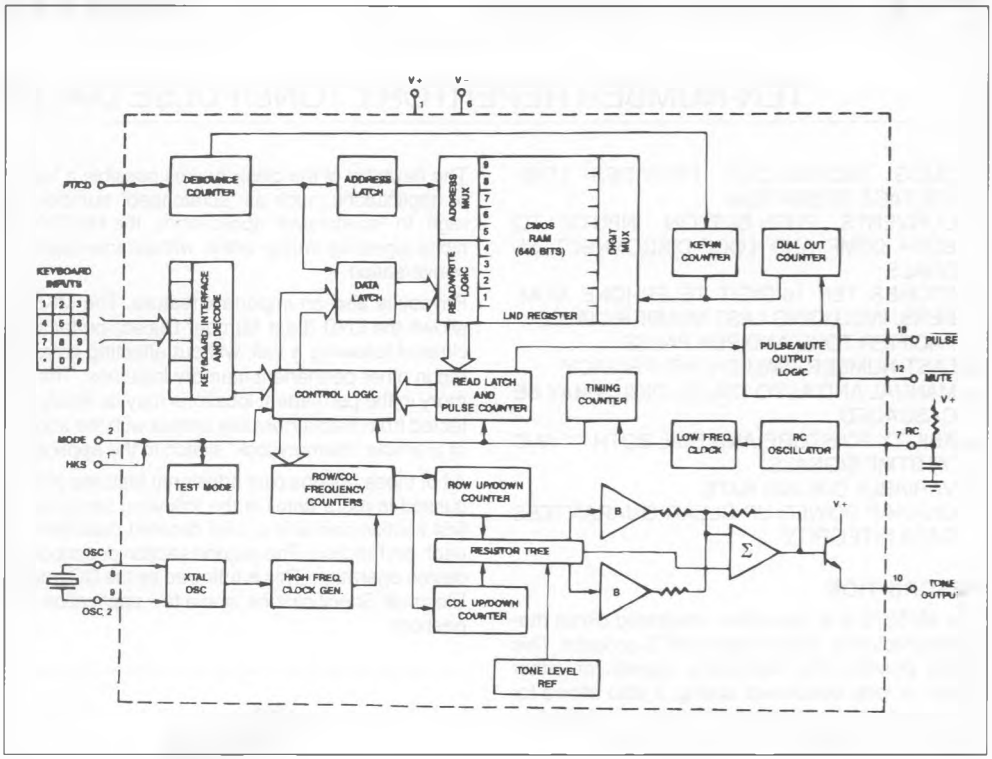
ORDER CODE : MK5375N00

PIN CONNECTION



BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

V+ (pin 1)

Pin 1 is the positive supply for the circuit and must meet the maximum and minimum voltage requirements as stated in the electrical specifications.

MODE SELECT (pin 2)

In normal operations. Pin 2 determines the signaling mode used : a logic level 1 (V+) selects Tone Mode operation. While a logic level 0 (V–) selects Pulse Mode operation. This input must be tied to one of the supplies to guarantee proper dialing.

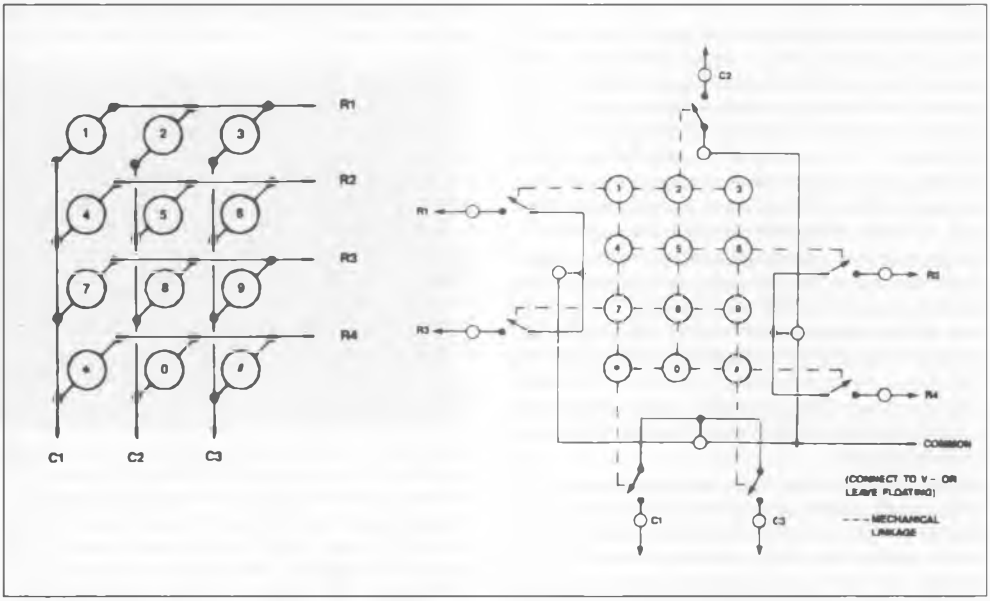
KEYBOARD INPUT : $\overline{COL1}$, $\overline{COL2}$, $\overline{COL3}$, $\overline{ROW4}$, $\overline{ROW3}$, $\overline{ROW2}$, $\overline{ROW1}$ (pins 3, 4, 5, 13, 14, 15, 16)

The MK5375 keypad interface allows either the standard 2-of-7 keyboard with negative common or the in-expensive single-contact (FORM–A) keyboard to be used (Figure 1). A valid key entry is defined by either a single Row being connected to a single Column or by V™ being presented to both a single Row and Column. In standby mode either all the rows will be a logic 1 (V+) and all the columns will be a logic 0 (V–) or vice versa.

The keyboard interface logic detects when an input is pulled low and enables the RC (Rate Control) oscillator and keypad scan. Scanning consists of alternately strobing the rows and columns high through on-chip pullups. After both valid row and column key closures have been detected, the debounce counter is enabled.

Breaks in contact continuity (bouncing contacts, etc.) are ignored for a debounce period (T_{db}) of 32 ms. At this time the keypad is sampled, and if both row and column information is valid, this information is buffered into the LND location.

Figure 1 : Keypad Schematics.



RATE CONTROL (pin 7)

The Rate Control input is a single-pin RC oscillator. An external resistor and capacitor determine the rate at which signaling occurs is both Tone and Pulse modes. An 8 kHz oscillation provides the nominal signaling rates of 10 PPS (Pulses per second) in Pulse Mode and 50 TPS (Tones per second) in Tone Mode ; the Tone duty cycle is 98 ms on, 102 ms off. The RC values on this input can be adjusted to a maximum oscillation frequency of 16 kHz resulting in an effective Pulse rate of 20 PPS an a Tone rate or 10 TPS.

The frequency of oscillation is approximated by the following equation :

$$Fosc = 1/ (1.49RC) \qquad (1.0)$$

The value suggested for the capacitor (C) should be a maximum of 410 pF to guarantee the accuray of the oscillator. The resistor is then selected for the desired signaling rate. Nominal frequency (8 kHz) is achieved with component values of 390 pF and 220 kohms. Parasitics must be taken into account.

OSCIN, OSCOUT (pins 8, 9)

Pins 8 and 9 are the input and output, respectively, of an on-chip inverter with sufficient loop gain to oscillate when used in conjunction with a low-cost television color-burst crystal. The nominal crystal frequency is 3.579545 MHz, and any deviation from this standard is directly reflected in the Tone Output frequencies.

This oscillator is under direct control of the repertory dialer and is enabled only when a tone signal is to be transmitted. During all other times it remains off, and the input has high impedance. The input OSCIN may be driven by an external source.

DTMF OUTPUT (pin 10)

The DTMF Output pin is connected internally to the emitter of an NPN transistor, which has its collector tied to V+, as shown on the functional block diagram.

The base of this transistor is the output of an on-chip operational amplifier that mixes the Row and Column Tones together.

The level of the DTMF Output is the sum of a single row frequency and a single column frequency. A typical single-tone sine wave is shown in Figure 2. This waveform is synthesized using a resistor tree with sinusoidally weighted taps.

The tone level of the MK5375 is a function of the supply voltage. The voltage to the device may be regulated to achieve the desired tone level, which is related to the supply by either of the following equations :

$$T_{(0)} = 20 \text{ LOG } [(0.078V +)/0.775] \text{ dBm} \qquad (2.0)$$

$$T_{(0)} = 0.078(V+) \text{ VRMS. (row tones)} \qquad (2.1)$$

PACIFIER TONE OUTPUT / CHIP DISABLE (pin 11)

This pin normally has high impedance. Upon acceptance of a valid key input, and after the 32 ms debounce time, a 500 Hz square-wave will be output on this pin. The square-wave terminates after a maximum of 30 ms or when the valid key is no longer present. The purpose of this pacifier tone is to provide to the user audible feedback taht a valid key has been entered. This feature is useful particularly for on-hook storage and pulse-mode signaling.

The pacifier tone is not enabled when manually dialing in tone mode. this eliminates any confusion between the audible DTMF feedback and the pacifier tone, and prevents distortion of the DTMF signal by any of the pacifier tone frequency components. In both cases, the tone confirms that the key has been properly entered and accepted : whereas without the tone the user will not know if the keys have been properly entered.

IMPORTANT : This pin also serves as a chip-disable pin. pulling this input high through a resistor will disable the keypad (high impedance) and initialize all counters and flip-flops (memory remains undisturbed). Pulling the input low through the same resistor enables the circuit. For the device to function properly, the resistor to V- (pin) is required.

This feature is useful in several applications, as described in the application notes section.

MUTE OUTPUT (pin 12)

This pin is the Mute output for both Tone and Pulse modes of operation. The timing is dependent upon which mode is being used. The output consists of an open-frain, N-channel device. During stanby, the output has high impedance and generally requires an external pullup resistor to the positive supply.
In Tone Mode, the Mute output is used to remove the transmitter and the receiver from the network during DTMF signaling. The output will mute continuously while auto-dialing and during manual DTMF signaling until each digit entered has been signaled. In Pulse Mode of operation, the Mute output is used to remove the receiver or even the entire network from the line. These timing relation ships are shown in Figure 4.

HKS INPUT (pin 17)

This pin is a high-impedance input and must be switched high for on-hook operation or low for off-hook operation. A transition on this input will cause the on-chip logic to initialize, terminating any operation in progress at the time. Signaling is inhibited while on-hook, but key inputs will be accepted and stored in the LND register. The information stored in the LND register may be copied into an alternate location only whil on-hook. A logic level may be presented to this input, independent of the position of the hook-switch, allowing on-hook operations, such as storage, to be performed off-hook.

Figure 2A : Typical Sine Wave Output - Single Tone.

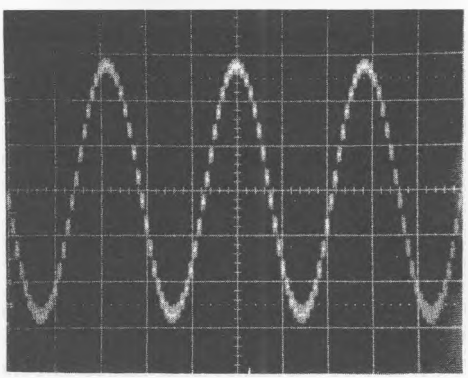


Figure 2B : Typical Dual-tone Waveform (Row 1, Col 1).

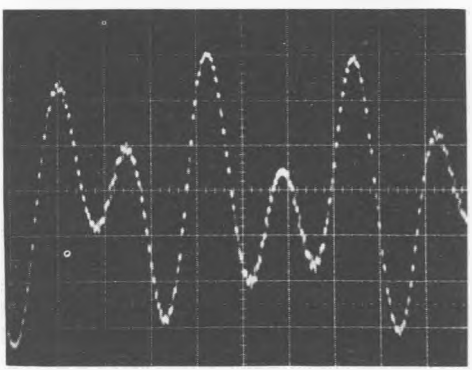


Figure 2C : Spectral Analysis of Waveform in Fig.5 (Vert.10 dB/div. Horizontal - 600 Hz/div.).

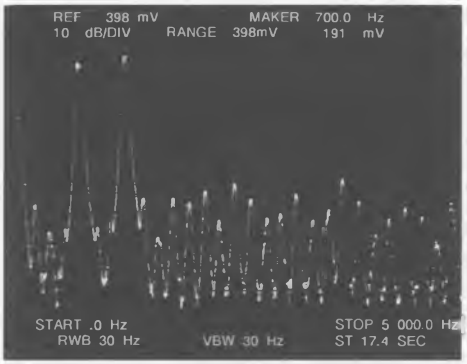


Table 1 : Output Frequency.

Key Input	Standard Frequency	Actual Frequency	% Deviation
ROW 1	697	699.1	+ 0.31
2	770	766.2	– 0.49
3	852	847.4	– 0.54
4	941	948.0	+ 0.74
COL 1	1209	1215.9	+ 0.57
2	1336	1331.7	– 0.32
3	1477	1471.9	– 0.35

PULSE (pin 18)

This is an output driven by an open-drain, N-channel device. In Pulse Mode operation, the timing at this output meets Bell Telephone and EIA specifications for loop-disconnect signaling. The Make/Brake ratio is set to 40/60 on the standard MK5375. The pulse rate is determined By the RC values selected for the Rate Control, Pin 7. Note : The standard make/break ratio may not be suitable if the Pulse dialing rate is accelerated.

DEVICE OPERATION

The Mk5375 can be used in low-priced phones with basic 3x4 matrix keypads. the block diagram shows the data and control signal flow between the various functional blocks. The keypad entries are decoded, debounced, and if valid, they are stored into the LND (Last-Number-Dialed) buffer, which acts much like a FIFO (First-In-First-Out) register. Each subsequent entry is stacked in the buffer. Typically, the dialing sequence begins 172 ms after the first digit is accepted in Pulse Mode operation and 132 ms in Tone Mode operation. Each digit buffered into the RAM is dialed out with a 98 ms burst of DTMF and an inter-signal time of 102 ms.

Buffering the data into the RAM prior to signaling is an important feature of the repertory dialer. It allows for the use of less expensive keypads, since the user cannot enter the digits too quickly for the system, and the pacifier tone can be used to provide audible feedback following each key entry not generating a DTMF signal. It also guarantees that the data stored in the RAM matches exactly the digits actually dialed.

Manual dialing and auto-dialing can be executed in any order, consecutively or cascaded. The dialer must complete auto-dialing the previous entry before another key is entered. Digits should not be entered while the device is auto-dialing. Most digits would be ignored unless preceded by a control key : in which case, an error in dialing may occur.

Figure 3 : Keypad Configuration.

NORMAL DIALING

The "*" (STAR) key is used as the modifier to control repertory functions. All numeric keys will signal normally unless preceded by a modifier. To signal either a "*" or "#", these keys must be entered twice in succession. The first entry is not signaled or stored.

LND PRIVACY

D	D	D	*	ON HOOK

A single "*" input prior to going on-hook or prior to coming off-hook will erase the information stored in the LND buffer.

AUTO DIALING (off-hook)

D	D	D	*	N
opt	opt	opt		

The key sequence "*" followed by any digit, will auto-dial the number sequence stored in the designated address location while off-hook.

STORAGE (on-hook)

D	D	D	*	N

D is any data (telephone numbers) being entered or dialed. N is the address (memory location) in which numbers are stored. The number sequence stored in the LND buffer can be transfered to one the other nine permanent locations whith the simple sequence "*" followed by the address. New digits may be written into the LND buffer while on-hook. To enter either a "*" or "#" signal the digit must be entered twice in succession.

PABX PAUSE (off-hook and on-hook)

D	D	*	#	D

An indefinite pause is stored in a number sequence by entering the "*" key modifier, followed by a "#" key input. When the number sequence is redialed, the dialer will pause when it encounters the "#" entry. A key input will cause it to continue.

PULSE DIALING

Most of the Pulse key operations are the same as they were in Tone Mode ; PABX Pause is the only exception. In Pulse Mode, the pause may be stored as in tone mode, "* #", or with a single "#" inputs will store two pauses.

The "*" key exercises the control function ; two "*" inputs will be the same as a single input (multiple inputs are not accepted).

Figure 4A : MK5375 Timing Diagram – Pulse Mode Off-hook Operation.

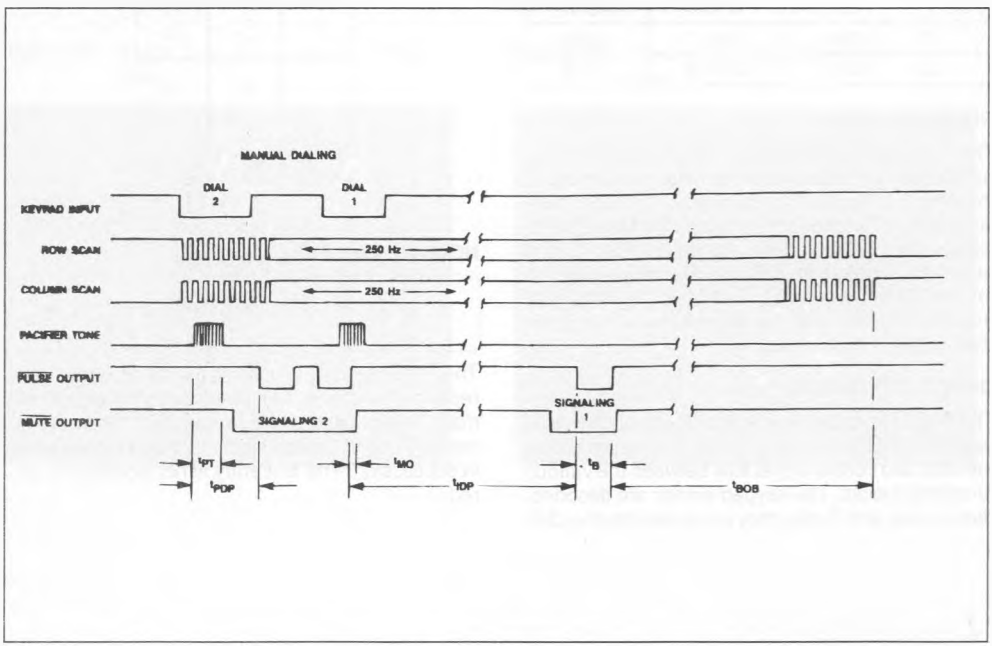
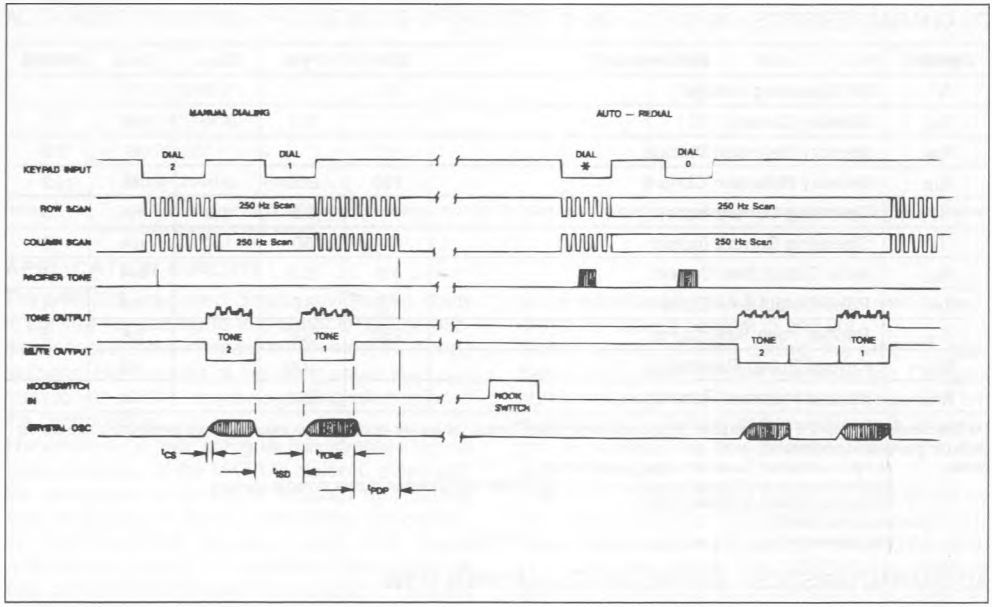


Figure 4B : MK5375 Timing Diagram – Tone Mode.



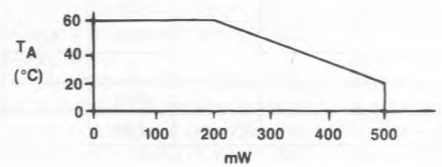
ABSOLUTE MAXIMUM RATINGS*

Parameter	Value	Unit
DC Supply Voltage V^+	6.5	V
Operating Temperature	– 30 to + 60	°C
Storage Temperature	– 55 to + 85	°C
Maximum Voltage Dissipation (25 °C)	500	mW
Maximum Voltage on any Pin	$(V^+) + 0.3$, $(V^-) - 0.3$	V

* Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

RECOMMANDED OPERATING CONDITIONS

POWER DISSIPATION DERATING CURVE



DERATE AT 9 mW/°C WHEN SOLDERED INTO PC BOARD.

ELECTRICAL OPERATING CHARACTERISTICS

DC CHARACTERISTICS – 30 °C ≤ T_A ≤ 60 °C

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
V^+	DC Operating Voltage	2.5		6.0	V	
I_{SB}	Standby Current		0.3	0.75	µA	1
V_{MR}	Memory Retention Voltage	1.5			V	2
I_{MR}	Memory Retention Current	750	200		nA	2
I_T	Operating Current (tone)		0.5	1.0	mA	3
I_P	Operating Current (pulse)		50	150	µA	3
I_{ML}	Mute Output Sink Current	1.0	3.0		mA	4
I_{PL}	Pulse Output Sink Current	1.0	3.0		mA	4
I_{PC}	Pacifier Tone Sink/Source	250	500		µA	5
K_{RU}	Keypad Pullup Resistance		100		kΩ	
K_{RD}	Keypad Pulldown Resistance		500		Ω	

(All specifications are for 2.5 Volt operation, unless otherwise stated Typical values are representative values at room temperature and are not tested or guaranteed parameters).

Notes : 1. All inputs unloaded. Quescient Mode (Oscillator off).
2. Meeting these minimum supply requirements will guarantee the rentention of data stored in memory.
3. All outputs unloaded single key input.
4. V_{OUT} = 0.5 Volts.
5. Sink current for V_{OUT} = 0.5, source current for V_{OUT} = 2.0 Volts.

AC CHARACTERISTICS – KEYPAD INPUTS, PACIFIER TONE

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T_{KD}	Keypad Debounce Time		32		ms	1
F_{KS}	Keypad Scan Frequency		250		Hz	1
T_{RL}	Two Key Rollover Time		4		ms	1
F_{PT}	Frequency Pacifier Tone		500		Hz	1
T_{PT}	Pacifier Tone		30		ms	1
F_{RC}	Frequency RC Oscillator	– 7.0	± 2.5	+ 7.0	%	2

Notes : 1. Times based upon 8 kHz RC input for Rate Control.
2. Deviation of oscillator frequency takes into account all voltage (2.5 to + 60 Volts), temperature (30° to .60°C) and unit-to-unit variations. The tolerance of the external RC components or parasitic capacitance is not included.

AC CHARACTERISTICS – TONE MODE

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T_{NK}	Tone Output no Key down			– 80	dBm	1
T_O	Tone Output (row tones)	– 13 173	– 12 194	– 11 218	dBm mV (RMS)	1
PE	Pre-emphasis, High Band	2.2	2.7	3.2	dB	1
V_{DC}	Average DC Bias Tone Out		1.7		V	
DIS	Output Distortion		5.0	8.0	%	1
TR	Tone Signaling Rate		5	10	1/SEC	2
PSD	Pre-signal Delay		132		mSEC	2
ISD	Inter-signal Delay		100		mSEC	

Notes : 1. Load 10 kΩ.
2. These values are directly related to the RC input to Pin 7 nominally 8 kHz.

ELECTRICAL OPERATING CHARACTERISTICS (continued)

AC CHARACTERISTICS – PULSE MODE OPERATION

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
P_R	Pulse Rate		10		PPS	1
PDP	Predigital Pause		172		ms	1
IDP	Interdigital Pause		940		ms	1
T_{MO}	Mute Overlap Time		2		ms	1

Notes : 1. Typical time assume nominal RC input frequency of 8 kHz. An increase in frequency results in an equal decrease in time values and an equal increase in rate values.

APPLICATION CIRCUIT

The MK5375 integrated circuit provides the ability to convert keypad inputs into either DTMF or loop-disconnect signals compatible with most telephone systems. Both modes of signaling utilise loop currents to transmit the desired signaling information to the central office.

The circuit schematic in Figure 5 illustrates a typical implementation of the MK5375 dialer IC along with the necessary components required to interface with the telephone line in a tone/pulse application.

In loop-disconnect signaling, each digit dialed consists of a series of momentary interruptions of loop current called "breaks" (i.e., a digit "1" consists of a single break, a digit "2" consists of two breaks, and so on. The Pulse output is dedicated to loop-disconnect signaling and controls the flow of loop current through the speech network switching transistors, Q4 and Q5. The Mute output, through transistors Q2 and Q3, removes the receiver and transmitter to eliminate loud pops in the receiver caused by switching current through the network. The Pulse and Mute output signals, as shown in Figure 4A, consist of make, break, and interdigital time intervals.

DTMF signaling requires that the loop current be modulated, producing an analog signal on the telephone line. Transistor Q1 modulates the loop current by amplifying the DTMF signal coupled to its base from the Tone Output. The Mute output removes the receiver and transmitter by switching transistors Q2 and Q3. This eliminates any interference with the DTMF signal from the transmitter and cuts down on the amplitude of the DTMF tone heard at the receiver. The timing diagram in Figure 4B illustrates the time relationship between key entries, Tone Output, and Mute Output.

The voltage regulator circuit comprising resistor R2, zener diode Z2, and transistor Q6 serves several purposes. In tone mode operation, it provides the regulated supply voltage to the MK5375 which determines the DTMF signal amplitude at the Tone Output. Varying the supply voltage will vary the DTMF output signal. In pulse mode, it helps provide some isolation from the transients caused by switching the speech network in and out.

During normal off-hook dialing, the MK5375 operates using current from the telephone line. On-hook number storage and memory retention current are supplied by the battery shown in Figure 5. Transistor Q6 prevents the flow of battery current to the speech network.

The rate at which dialing occurs is determined by the values chosen for resistor R1 and capacitor C1. These values can be predetermined using equation (1.0) described above. The 3.5795 MHz crystal is used as a reference for systhesizing the DTMF signals and is activated only for the short periods during which these tones are being generated.

The application circuit schematic in Figure 6 gives an example of the various features which can be utilized with the addition of several switches. the example also shows that multiple devices may be used to increase the effective storage capability of the telephone design.

Much of the circuity used to modulate and pulse the line, mute the speech network, and regulate the supply voltage is unchanged from the basic tone/pulse switchable telephone described above.

The two devices in Figure 6 are hooked up in parallel with on another except for their oscillator pins and the Chip Disable inputs. A DPDT switch is used to select between the two dialers through the Chip Disable pin ; one device is activated while the other is put on standby.

Some applications may include a memory lock switch to prevent any of the data stored to be changed inadvertently. This memory lock switch can take the form of a locking key switch, which would allow only the person with the key to alter data stored in memory.

A scratchpad feature may be implemented to allow off-hook programmming of the memory while inhibiting dialing. A switch is added in series with the telephone hook-switch to allow the dialer to be forced into its on)hook key entry mode while the telephone set is off-hook.

Figure 5 : MK5375 Circuit Schematic.

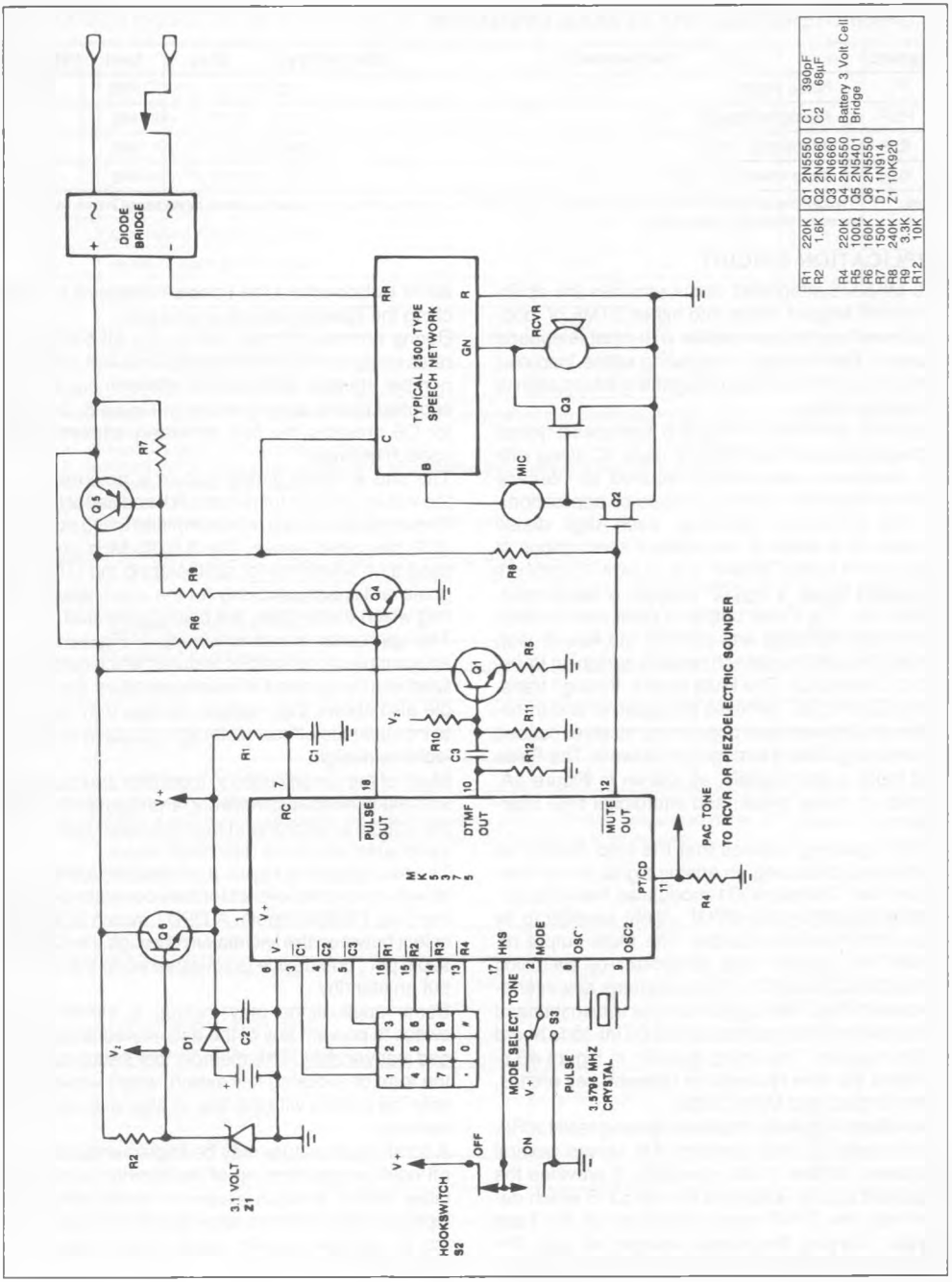


Figure 6 : MK5375 Application Circuit Schematic.