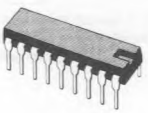
SGS-THOMSON MICROELECTRONICS

MK5371

SINGLE NUMBER PULSE TONE SWITCHABLE DIALER

- STAND-ALONE DTMF AND PULSE SIGNALING
- SOFTSWITCH AUTOMATICALLY SWITCHES SIGNALING MODE
- RECALL OF LAST NUMBER DIALED (UP TO 28 DIGITS LONG)
- FLASH KEY INPUT INITIATES TIMED HOOK FLASH
- MICROPROCESSOR INTERFACE (BDC INPUTS) FOR SMART TELEPHONES
- TIMED PABX PAUSE
- FORM-A AND 2-OF-8 KEYBOARD INTERFACE
- PACIFIER TONE
- POWERED FROM TELEPHONE LINE, LOW OPERATING VOLTAGE FOR LONG LOOP APPLICATIONS



DIP18

ORDER CODE : MK5371N00

DESCRIPTION

The MK5371 is a monolithic, integrated circuit manufactured using Silicon Gate CMOS process. These circuits provide necessary signals for either DTMF or loop disconnect (Pulse) dialing. The MK5371 buffers up to 28 digits into memory that can be later redialed with a single key input. This memory capacity is sufficient for local, long distance, overseas, and even computerized long-haul networks. Users can store all 12 signaling keys and access several unique special functions with single key entries. These functions include : Last Number Dialed (LND), Softswitch (Mode), Flash, and Pause.

A LND key input automatically redials the last number dialed. Keys entered during auto-dialing sequence will not be stored or dialed. However, auto-dialing is momentarily interrupted (during interdigital pause period or intersignal period) while manual keys are depressed.

The mode key simplifies the process of alternating dialing modes. This input automatically toggles the immediate dialing mode. The function is also stored in memory. During auto-redial, the signaling mode is toggled each time the Mode code appears in the digit sequence. The signaling mode always defaults to the mode selected (hardwire or switch) at Pin 2 (MODE) after a Power-Up-Clear initialization or a transition from on-hook to off-hook (HKS input switched from a high to low logic level). Switching modes through Pin 2 toggles the immediate dialing mode and changes the default, but it is not stored in memory.

KEYPAD CONFIGURATION

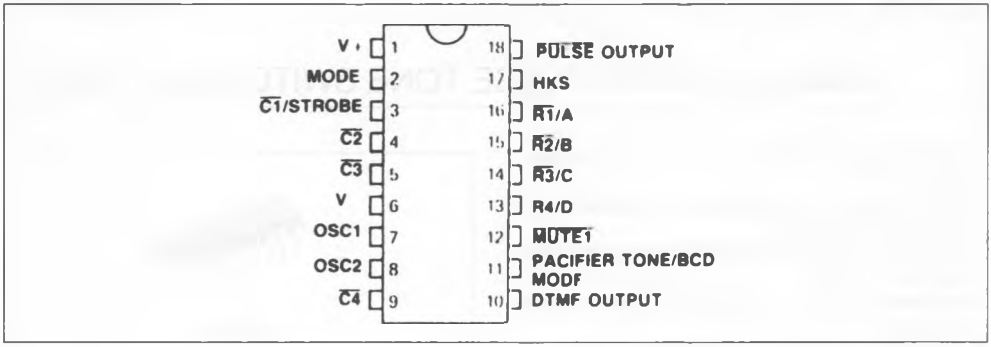
1	2	3	FLASH
4	5	6	MODE
7	8	9	PAUSE
*	0	#	LND

M88MK5371-01

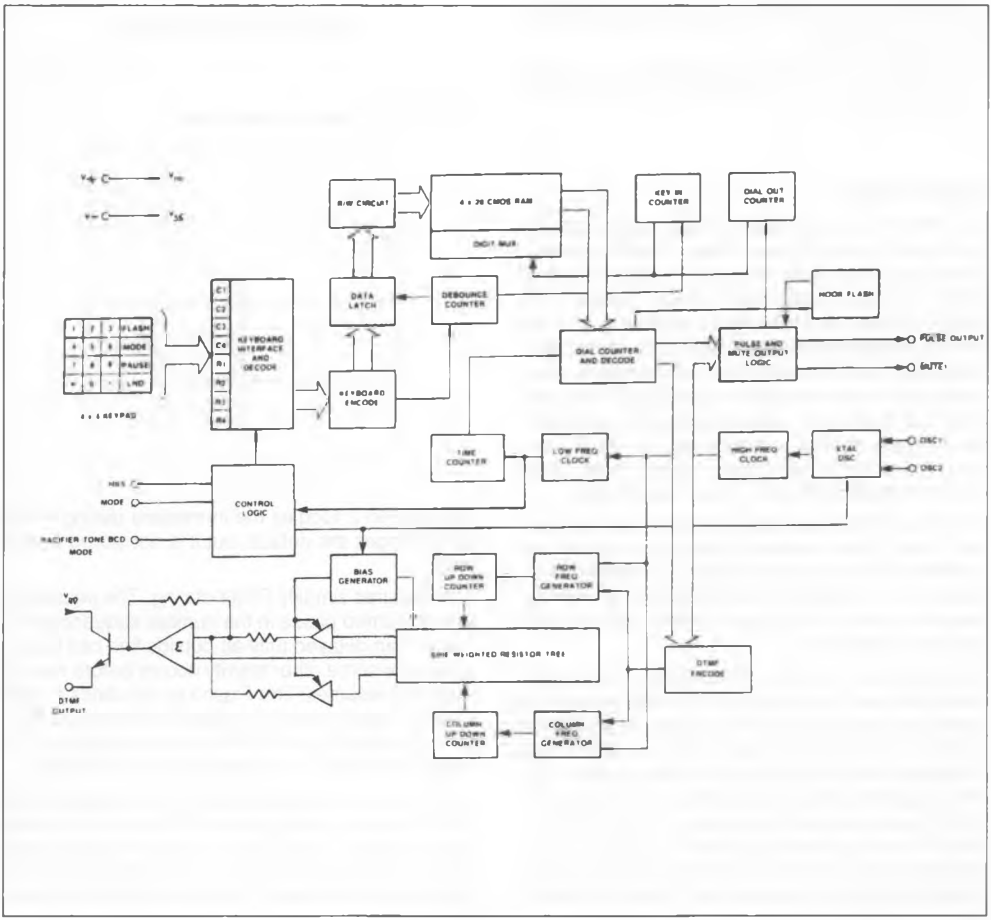
Two features simplify PABX dialing. The pause key stores a timed pause in the number sequence. Redial is then delayed until an outside line can be accessed or some other activity occurs before normal signaling resumes. The Flash key simulates a hook flash to transfer calls or to activate other special features provided by the PABX or a central office. The MK5371 ensures exact timing for the hook flash.

In addition to interfacing with standard keypads, the MK5371 also accepts parallel BCD inputs. This feature simplifies interfacing a microprocessor-based design to the telephone line. The MK5371 buffers 28 bytes of information, including special functions.

PIN CONNECTION



BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Parameter	Value	Unit
DC Supply Voltage	6.5	V
Operating Temperature	– 30 to + 60	°C
Storage Temperature	– 55 to + 125	°C
Maximum Power Dissipation (25 °C)	500	mW
Maximum Voltage on Any Pin	(V+) + 0.3, (V–) – 0.3	V

* Stresses greater than 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 conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device rehability.

ELECTRICAL OPERATING CHARACTERISTICS

(all specifications are for 2.5 Volt operation and full operating temperature range unless otherwise stated)

DC CHARACTERISTICS

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
V_+	DC Operating Voltage	2.5		6.0	V	
V_{MR}	Memory Retention Voltage	1.5			V	1, 6
I_s	Standby Current		0.2	0.750	µA	1
I_{MR}	Memory Retention Current		0,10	0.75	µA	5, 6
I_T	Operating Current (tone)		300	600	µA	2
I_P	Operating Current (pulse)		225	350	µA	2
I_{ML}	Mute Output Sink Current	1.0	2.0		mA	3
I_{PL}	Pulse Output Sink Current	1.0	2.0		mA	3
I_{PC}	Pacifier Tone Sink/Source	250	500		µA	4
K_{RU}	Keypad Pullup Resistance		100		kΩ	
K_{RD}	keypad Pulldown Resistance		750		Ω	
V_{IL}	BCD/Keypad Input Level-low	0		0.2 V+	V	
V_{IH}	BCD/Keypad Input Level-high	0.7 V+		V+	V	

Notes : 1. All inputs unloaded. Quiescent Mode (oscillator off). V+ 2.5 V.
2. All outputs unloaded. Single key input.
3. V_{OUT} 0.5 Volts. V- 2.5 V.
4. Sink Current for V_{OUT} 0.5. Source Current for V_{OUT} 2.0 Volts.
5. Memory Retention Voltage is the point where memory is guaranteed but circuit operation is not.
6. Proper memory retention is guaranteed if either the minimum I_{MR} is provided or the minimum V_{MR}. The design does not have to provide both the minimum current or voltage simultaneously.

AC CHARACTERISTICS - PULSE MODE OPERATION

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
P_R	Pulse Rate		10		PPS	
T_{PDP}	Predigital Pause		140		ms	1
T_{IDP}	Interdigital Pause		940		ms	1
T_{MO}	Mute Overlap Time		4		ms	1
T_B	Break Time		60		ms	1

Note : 1. Figure 6 illustrates this relationship.

ELECTRICAL OPERATING CHARACTERISTICS (continued)

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 Opacifier Tone		500		Hz	1
T_{PT}	Pacifier Tone Duration		30		ms	1
T_{HFP}	Hookflash Timing		600		ms	1
F_{SR}	BCD Strobe Rate			124	1/sec	1
T_{DS}	Data Set up	2			µs	1
T_{DH}	Data Hold	1			µs	1
T_{ST}	Strobe Width	2		96000	µs	1
T_{SS}	Strobe Separation	9			ms	

Notes : 1. Crystal oscillator accuracy directly affects these times.
2. Figure 1 illustrates this timing relationship.

AC CHARACTERISTICS - TONE MODE

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T_{NK}	Tone Output No Key Down			– 80	dBm	1
T_{Od}	Tone Output (dependent)	– 13 173	– 12 194	– 11 218	dBm mV_{rms}	1, 2 5
PE_d	Pre-Emphasis, High Band	2.3	2.7	3.1	dB	
DC_d	Tone Output DC Bias	1.0	1.2		V	4
R_E	Tone Output Load		10		KΩ	5
T_{RIS}	Tone Output Rise Time		0.1	1.0	ms	6
DIS	Output Distortion		5.0	8.0	%	3
TR	Tone Signaling Rate		5.0		1/sec	
T_{PSD}	Pre-signal Delay		100		ms	7
T_{ISD}	Inter-signal Delay		100		ms	

Notes : 1. O dBm equals 1 mW power into 600 ohms (775 mVolts). Important Note : The MK5371 is designed to drive a 10 kohm load. The 600 ohm load is only for reference.
2. Single tone (low group).
3. Supply voltage = 2.5 to 6 Volts. R_E = 10 kohms.
4. R_E = 10 k ohms. V+ = 2.5 Volts.
5. Supply voltage = 2.5 Volts. These specifications are supply-dependent.
6. Time from beginning of tone output waveform to 90 % of final magnitude of either frequency. Crystal parameters suggested for proper operation are R_S < 100 Ω. L_m = 96 mH. C_m = 0.02 pF. C_h = 5 pF. f = 3.579545 MHz and C_L = 18 pF
7. Time from Mute active to beginning of signaling.

FUNCTIONAL DESCRIPTION

The following pin descriptions are numbered according to the 24-pin package. Pin numbers for the 18-pin version are listed in parenthesis under each pin name.

V+

Pin 1. V+ is the positive supply for the circuit and must meet the maximum and minimum voltage requirements. (see Electrical Specifications).

MODE

Input. Pin 2. MODE determines the dialer's default operating mode. When the device is powered up or the hookswitch input is switched from on-hook, (V+), to off-hook, (V–), the default determines the signaling mode. A V+ connection defaults to Tone Mode operation and a V– connection defaults to Pulse Mode operation.

A Softswitch (Mode) code entered in a number sequence can temporarily modify the signaling mode. After encountering a first Softswitch code in a number sequence, the Signaling Mode toggles and is opposite the default determined by Pin 2. A second Softswitch toggles the Signaling Mode a second time, returning the mode back to the default condition. Note that the Softswitch code performs a toggle function on the default state ; switching the state of Pin 2 while dialing changes the default state as well as the immediate signaling mode.

$\overline{C1}$/STROBE, $\overline{C2}$, $\overline{C3}$, $\overline{C4}$, $\overline{R4}$, $\overline{R3}$, $\overline{R2}$, $\overline{R1}$

Keyboard input. Pins 3, 4, 5, 9, 13, 14, 15, 16. The MK5371 interfaces with standard keypads as well as a microprocessor-driven 4-bit bus.

A valid keypad entry is either a single Row connected to a single Column or V– simultaneously presented to both a single Row and Column. In its quiescent or standby state, during normal off-hook operation, either the Rows or the Columns are at a logic level 1 (V+). Pulling one input low enables the on-chip oscillator. Keyboard scanning then begins. Scanning consists of Rows and Columns alternately switching high through on-chip pullups. After both a Row and Column key have been detected, the debounce counter is enabled and any noise (boucing contacts, etc.) is ignored for a debounce period (Tdb) of 32 ms. At this time, the keyboard is sampled and if both Row and Column information is valid, the information is buffered into the LND location. If switched on-hook, the keyboard inputs all pull high through on-chip pull-up resistors. Information may still be entered into memory but it is not signaled and the keyboard scan is disabled. If users desire to enter data while on-hook, a 2-of-8 keypad with negative common is required.

A key entry during LND interrupts the sequence when it reaches the redial period until the key is released. Dialing then resumes. The key entered is not stored or dialed.

The keyboard inputs become high impedance when the Binary Input Mode is selected. As shown in Table 1, Row pins become inputs for the Binary codes from a microprocessor in this mode. Table 1 equates the Binary Codes to the keyboard digits and special functions. The $\overline{C1}$ input pin now provides an input for a strobe strobe used to clock the valid codes into the LND buffer. Dialing proceeds at the specified rates. The strobe duration must be active for at least 2 µs to ensure proper acceptance of the information. If the strobe remains high for longer than 96 ms false dialing may occur. A minimum of 8 ms must separate each strobe. Figure 1 illustrates the required strobe/data timing. Valid encoded signaling information must be present until the strobe goes low. Information entered during an on-hook operation is stored but signaling is inhibited. Changing between BCD and keyboard mode can only occur when the HKS input is high, or upon power-up. Caution, a power supply transient may be interpreted as a power-up condition, and the logic level on pin 11 at that time will be interpreted as a valid BCD/Keyboard selection.

V–

Input. Pin 6. Pin 6 is the negative supply input to the device. This is the voltage reference for all specifications.

OSC1, OSC2

Input/Output. Pins 7, 8. OSC1 and OSC2 are inputs to an on-chip inverter used as the timing reference for the circuit. It has sufficient loop gain to oscillate when used 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. The crystal oscillator provides the time reference for all circuit functions.

Table 1 : Binary Input Codes.

D	C	B	A	KEYBOARD FUNCTION	D	C	B	A	KEYBOARD FUNCTION
0	0	0	0	0	0	0	0	0	8
0	0	0	1	1	0	0	0	1	9
0	0	1	0	2	0	0	1	0	*
0	0	1	1	3	0	0	1	1	#
0	1	0	0	4	0	1	0	0	MODE
0	1	0	1	5	0	1	0	1	PAUSE
0	1	1	0	6	0	1	1	0	FLASH
0	1	1	1	7	0	1	1	1	LND

Figure 1 : BCD Mode Strobe Interface Timing.

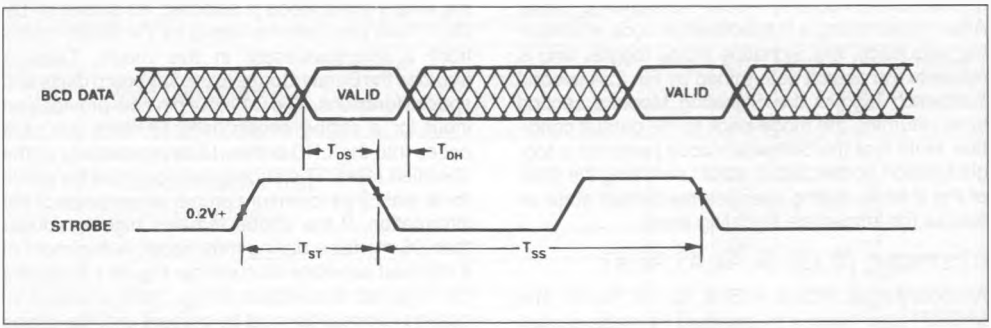


Table 2 : DTMF Output Frequency.

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

DTMF OUTPUT

Output. Pin 10. An NPN transistor emitter with a collector tied to V+ drives the DTMF OUTPUT pin. The transistor base is connected to an on-chip operational amplifier that mixes the Row and Column Tones together. Figure 4 shows the timing at this pin.

PACIFIER TONE OUTPUT/BCD MODE

Input/Output. Pin 11. A 500 Hz square wave is activated at this pin upon acceptance of a valid key input, after the 32 ms debounce time. The square wave terminates after a maximum of 30 ms or when the valid key is no longer present. In the Pulse mode the PACIFIER TONE is activated for all key entries. The PACIFIER TONE provides audible feedback, confirming that the key has been properly entered and accepted. In Tone mode, only the LND key activates the PACIFIER TONE.

This pin is normally high impedance until a key is entered. Connecting this pin high through a resistor causes the circuit to accept BCD inputs through the

Figure 2 : Single Tone.

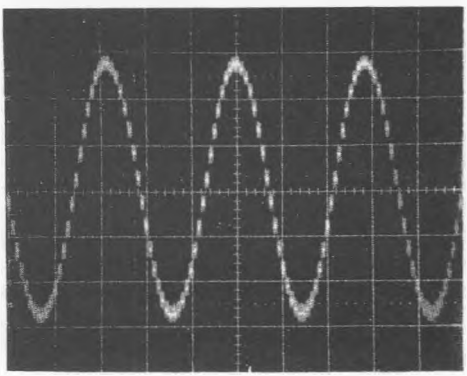


Figure 3 : Dual Tone.

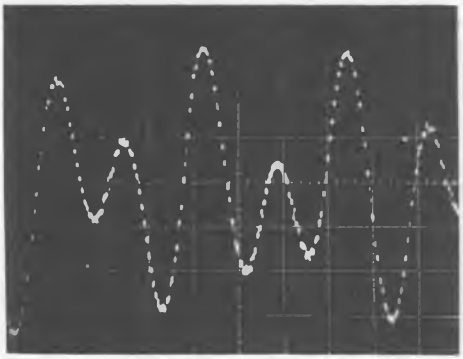


Figure 4 : Spectral Reponse.

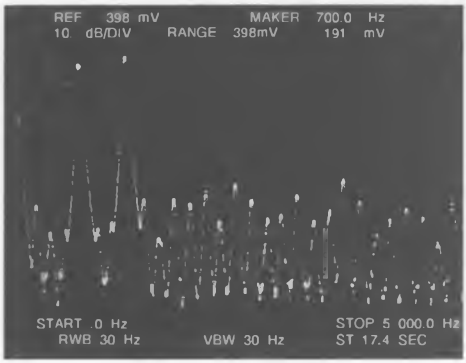
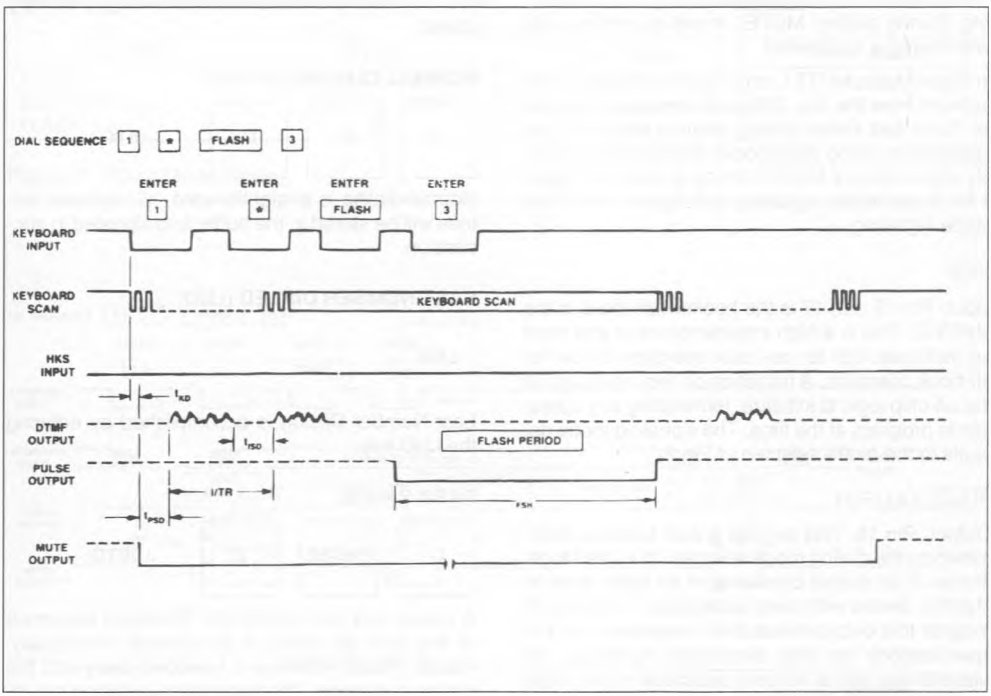


Figure 5 : Tone Mode Timing.



ROW pins. In Binary Mode, as mentioned in the keyboard interface description, the keyboard inputs are all high impedance. Keypad inputs in this mode are not recognized. Connecting this pin low enables the keyboard scan circuitry, which allows entries. The mode of operation is selected upon power-up, and thereafter may only occur when HKS pin 17 is high.

MUTE1

Output. Pin 12. This pin is the Mute Output for both Tone and Pulse Modes. Timing is dependent upon mode.

The output consists of an open drain N-channel device. During standby, the output is high impedance and generally has an external pullup resistor to the positive supply.

In Tone Mode, $\overline{\text{MUTE1}}$ removes the transmitter and the receiver from the network during DTMF signaling. During dialing, $\overline{\text{MUTE1}}$ is active continuously until dialing is completed.

In Pulse Mode, $\overline{\text{MUTE1}}$ removes the receiver or the network from the line. Different circuitry is required for Tone and Pulse muting external to the IC and applications using both modes would not necessarily share circuitry. $\overline{\text{MUTE1}}$ timing is shown in Figure 6 for Pulse Mode signaling and Figure 5 for Tone Mode signaling.

HKS

Input. Pin 17. Pin 17 is the hookswitch input to the MK5372. This 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 causes the on-chip logic to initialize, terminating any operation in progress at the time. The signaling mode defaults to the mode selected at Pin 2.

$\overline{\text{PULSE}}$ OUTPUT

Output. Pin 18. This pin has a dual function determined by the dialing mode selected. In Pulse Mode, the pin is an output consisting of an open drain N-channel device with zener protection. The break timing at this output meets Bell Telephone and EIA specifications for loop disconnect signaling. The Make/Break ratio is not user selectable in the 18-pin version. $\overline{\text{PULSE}}$ OUTPUT also provides the break timing for the hook flash function. Figure 6 shows this timing.

DEVICE OPERATION (Tone Mode)

When the MK5371 is not actively dialing, it consumes very little current. While on-hook, all keypad input pins are pulled high. Key entries are not recognized unless they utilize a keypad common connection to force the respective Row and Column inputs low. These inputs assume opposite states off-hook. The circuit verifies that a valid key has been entered by alternately scanning the Row and Column inputs. If the input is still valid following 32 ms of debounce, the digit is stored into memory, the Mute Output is activated, and dialing begins after a pre-signal delay of 100 ms. Each digit buffered into the RAM is dialed out with a 98 ms burst of DTMF and an intersignal time of 102 ms.

One important feature of the dialer is its ability to buffer data into the RAM before signaling. This feature allows less expensive keyboards to be used because signal distortion and double digit entry caused by bouncing and bounding of the keypad are eliminated. This design also ensures that data stored in the buffer exactly matches the digits actually dialed.

NORMAL DIALING (off-hoof)

Normal dialing is straightforward, all keyboard entries will be stored in the buffer and signaled in succession.

LAST NUMBER DIALED (LND)

Last Number Dialing is accomplished by entering the LND key.

PABX PAUSE

A pause may be entered into the dialed sequence at any point by keying in the special function key, Pause. Pause inserts a 1.1-second delay into the dialing sequence. The total delay, including pre-digital and post-digital pauses is shown in Table 3.

HOOK FLASH

D	FLASH	D	....ETC

HOOK FLASH may be entered into the dialed sequence at any point by keying in the function key, Flash. The flash function is stored in the LND buffer just like any other digit, but it will not be redialed, and acts much like Pause. The MK5371 has a HOOK FLASH time of 600 ms.

SOFTSWITCH

D	MODE	D	....ETC

Softswitch allows the user to easily switch from Pulse to Tone Mode while dialing a number sequence. For example, the first digits may be entered in Pulse Mode. Signaling will proceed in Pulse Mode until a Softswitch (Mode) entry is encountered. Any subsequent digits are dialed using DTMF signals. A hookswitch transition or a second Softswitch entry returns dialing to the original Default Mode.

Each special function provides a built-in delay before auto-dialing resumes. The fixed delay introduced by the function is 1.1 seconds. In addition, the fixed delay is preceded and followed by the standard interdigital pause period that depends on the selected signaling mode. Table 3 lists the actual delays produced by each function.

Table 3 : Special Function Delay Periods.

Function	Delay	Pulse Mode	Tone Mode
PAUSE	IDP + 1.1 + IDP	+ IDP	1.5 sec
SOFTSWITCH	IDP + 1.1 + IDP	2.9 sec	1.3 sec
FLASH	.6	2.1 sec	2.1 sec

Figure 6 : Pulse Mode Timing.

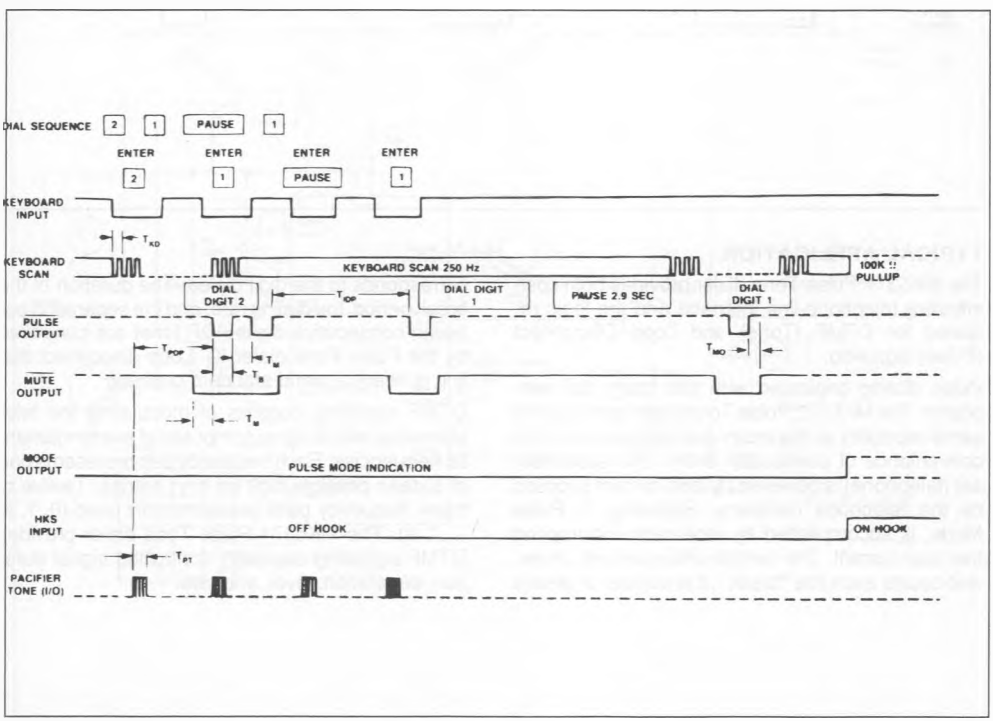
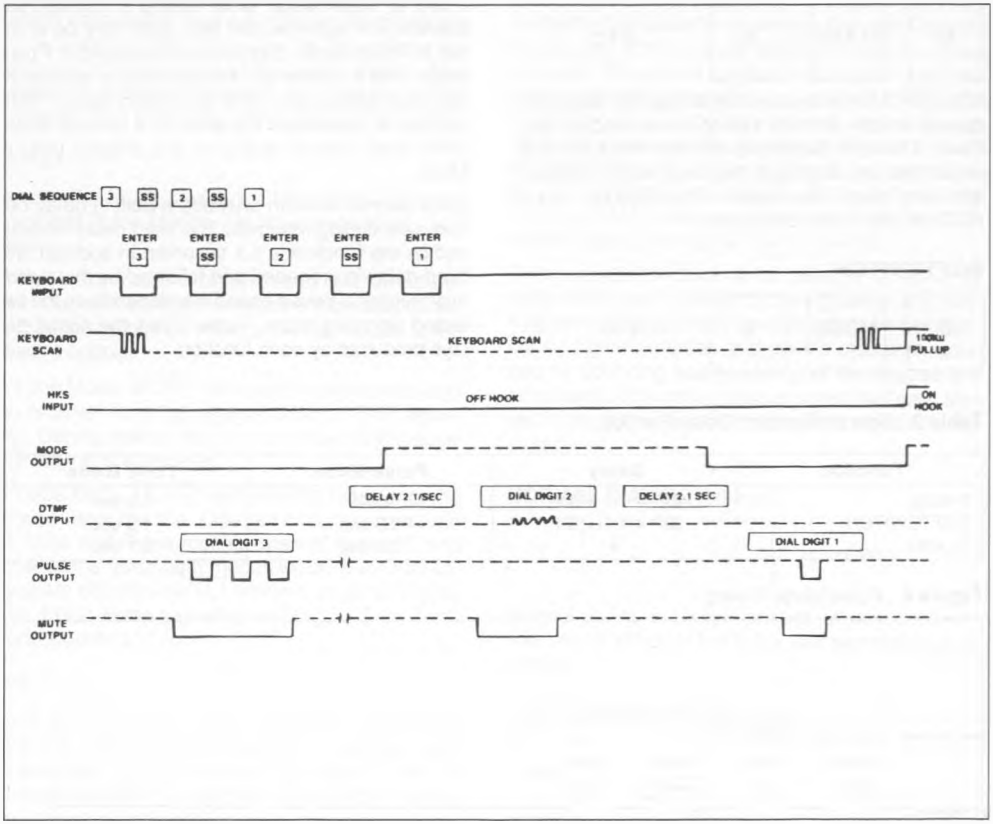


Figure 7 : Pulse And Tone Mode Timing.



TYPICAL APPLICATION

The MK5371 Pulse Tone dialer provides both cost-effective telephone-line interface and the logic required for DTMF (Tone) and Loop Disconnect (Pulse) signaling.

Pulse dialing originated with the rotary dial telephone. The MK5371 Pulse Tone dialer provides the same capability as the rotary dial telephone and the convenience of pushbutton entry. The subscriber set (telephone) is powered by loop current supplied by the telephone company. Signaling, in Pulse Mode, is accomplished by repeatedly interrupting the loop current. The central office senses, times, and counts each line "break" ; the number of breaks corresponds to the digit dialed. The duration of the break period, the dialing rate, and the separation between consecutive digits (IDP time) are controlled by the Pulse Tone dialer IC. Loop disconnect dialing is nearly a world-standard concept.

DTMF signalling consists of modulating the telephone line with a signal comprised of two fundamental frequencies. Each frequency pair represents one of sixteen possible digit (or key) entries. Twelve of these frequency pairs are commonly used (0, 1, 2, ...,*, #). The MK5371 Pulse Tone dialer provides DTMF signalling capability controlling signal duration, separation, level, and rate.

The typical application circuit in Figure 8 illustrates one way the Pulse Tone dialer can be used. The pulse output provides the signal to break the line to transistor Q3. Q3 switches off, eliminating the base current to Q4, which also switches off. The majority of the loop current is then eliminated, resulting in a break condition. The IC dialer must be protected from large voltage fluctuations, such as that caused by interrupting the loop current. Transistor Q1 along with R2, C1, and Z1 regulate the voltage to the dialer. The Mute Output signal is active while signalling each digit to mute popping noises at the receiver (earpiece or speaker).

The DTMF tone output drives the base of Q8, which modulates the line. The tone level at tip and ring is determined by the effective impedance of the telephone line and the speech network.

Mode of operation is controlled by switch S1 (which sets the default dialing mode) and the keypad. A change of dialing mode with a Mode (Softswitch) key input is stored in memory and will be repeated when the LND (last number dialed) feature is activated.

Resistor R1 provides a small memory-retention bias current to prevent the device from powering down while on hook. The current required for long term memory retention is less than 1 µA.

A ceramic sounder can also be interfaced to pin 11 (BCD/PACIFIER TONE) of the device. A pacifier tone signal is activated for each key entry. This feature provides an audible indication for each valid key entry. Keys may be entered faster than the maximum signalling rate allows. Audible feedback confirms proper key entry.

Figure 8 : MK5371 Typical Application.