15-MEMORY TONE/PULSE SWITCHABLE DIALER

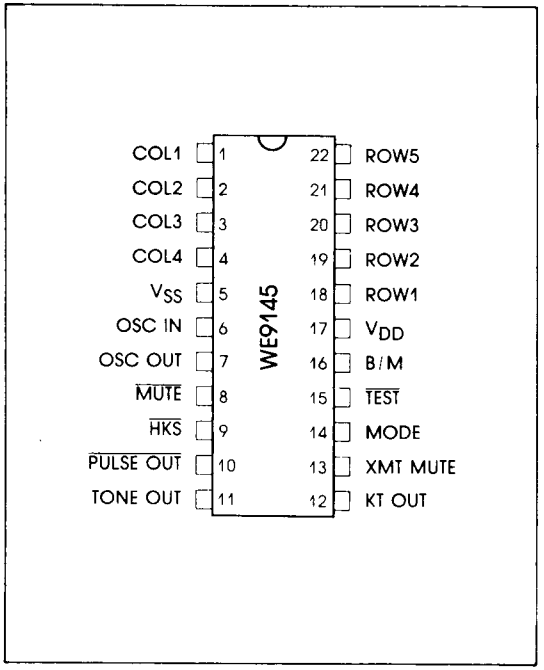
GENERAL DESCRIPTION

The WE9145 is a monolithic integrated circuit which performs 15-Memory Tone/Pulse switchable dialing functions for modern telephone set design. It is fabricated in CMOS technology thus has good performance in low voltage, low power operations. Four 16-digits direct dialing memories are added for convenient emergency calls (such as fire, police, doctor) and Long Distance Service Company (such as MCI, SPRINT) access codes operations. Wide operating voltage range and low memory retention current facilitate this chip excellent for battery-free direct line powered operation.

FEATURES

- DTMF/Pulse Switchable Dialer
- Stores Ten 16-Digits Numbers for Repertory Diaing
- Additional Four 16-Digits Numbers for Emergency Calling and Long Distance Service Company Access code Memory
- One 31-Digits for Redial Memory
- Dialing length is unlimited, if the dialing length of normal-dialing over 31 digits then redial is inhibited.
- Auto Pause Access for PBX and Toll Service Operations; 3.1 second per pause.
- Easy Operation with Redial, Store, Auto & Pause Keypads
- Key-Tone Output for valid keypad Entry recognition
- Memory Retention Current 0.2μA at V = 1.0V, ON-HOOK
- Wide operation voltage range: 2.0V~5.5V
- Automatic switching from Pulse mode to TONE mode in Long Distance memory
- 22-pin Dual-in-Line Package
- Uses Form A Keyboard or the Standard 2-of-9 Matrix Keyboard
- Electronic Keypad Input is Available; Low Active
- Uses Inexpensive 3.57954MHz Television Color-Burst Crystal
- Pin Selectable for Break/Make Ratio
- Power on reset is internally generated

PIN CONFIGURATION



KEYBOARD FUNCTION

COL1	COL2	COL3	COL4	
1	2	3	EM1	ROW1
4	5	6	EM2	ROW2
7	8	9	EM3	ROW3
*	0	#	LDC	ROW4
R	S	A	P	ROW5

R: Redial
S: Store
A: Auto Dialing
P: Pause
EM1-EM3: Emergency 1-3
LDC: Long Distance Company

ABSOLUTE MAXIMUM RATING

PARAMETER	SYM	RATING	UNIT
DC Supply Voltage	V_{DD}	6.0	V
Input Voltage Range	V_{IN}	-0.5 to $V_{DD}+0.5$	V
Power Dissipation Per Package	P_O	500 (for $T_A=-25$ to $+60°C$)	W
Operating Temperature	T_A	-25 to $+85$	°C
Storage Temperature	T_{STG}	-65 to $+150$	°C

D.C. ELECTRICAL CHARACTERISTICS

A. [$V_{DD}=2.5V$, $T_A=25°C$, unless otherwise noted]

PARAMETER	SYM	TEST CKT.	TEST CONDITION	LIMIT MIN	LIMIT TYP	LIMIT MAX	UNIT
Operating Voltage	V_{DD}		Tone	2.0	-	5.5	V
			Pulse	2.0	-	5.5	
			memory	1.0	-	5.5	
Operating Current	I_{OP}	A	Tone Note 1,4,6	-	0.6	2	mA
			Pulse	-	0.2	0.5	
Memory Retenton Current	I_{MR}	B	$\overline{HKS}=1, T_A=25°C, V_{DD}=1.0V$	-	0.1	0.2	μA
Standby Current	I_S	A	Note 1,2,3,5,6	-	0.1	5	μA
Tone Output	V_{TO}	C	Row Group, $R_L=10K\Omega$	130	150	170	mVrms
Pre-Emphasis		D	Column Group/Row Group, $V_{DD}=2.0-5.5V$	1	2	3	dB
DTMF Distortion	THD	D	$R_L=10K$, Note 7,8	-	-30	-23	dB

PARAMETER	SYM	TEST CKT	TEST CONDITION	LIMITED			UNIT
				MIN	TYP	MAX	
Tone Output External Load Impedance	R_L		THD< −23dB	10	—	—	KΩ
Tone Output DC Level	V_{DC}	D	V_{DD}=2.0−5.5V	0.5V_{DD}	—	0.6V_{DD}	—
Tone Output Sink Current	I_{TL}	E	V_{TO}=0.5V	0.2	—	—	mA
Pulse Output Drive Current	I_{PH}	E	V_{PO}=2.0V	−0.2	—	—	mA
Sink Current	I_{PL}	F	V_{PO}=0.5V	0.2	—	—	
Mute Output Drive Current	I_{MH}	E	V_{MO}=2.0V	−0.2	—	—	mA
Sink Current	I_{ML}		V_{MO}=0.5V	2	—	—	
Key Tone Output Drive Current	I_{KH}	H	V_{KO}=2.0V	−0.5	—	—	mA
Sink Current	I_{KL}	E	V_{KO}=0.5V	0.5	—	—	
XMT Mute Drive Current	I_{LH}	E	V_{LO}=2.0V	−0.2	—	—	mA
Sink Current	I_{IL}		V_{LO}=0.5V	0.2	—	—	
Input Voltage Low	V_{IL}		Pins, 1-4, 9, 14, 15	GND	—	0.3V_{DD}	
Input Voltage High	V_{IH}		16 & 18-22	0.7V_{DD}	—	V_{DD}	
Keypad Input Drive Current	I_{KD}	F	V_I=0V	4	10	30	μA
Sink Current	I_{KS}	E,G	V_I=2.5V	200	400		
Control Pin Input		I_{IN}	Pins 9,14,15,16	—	±10[5]	±0.1	μA

A.C. ELECTRICAL CHARACTERISTICS

PARAMETER	SYM	TEST CKT	TEST CONDITION	LIMIT			UNIT
				MIN	TYP	MAX	
Key-in Debounce	T_{KID}		TEST=1, Note8,9,10	—	20	—	mS
Key-released Debounce	T_{KRO}		TEST=1, Note8,9,10	—	20	—	mS
Key-Tone Delay	T_{KD}		TEST=1, Note2,4,10	—	20	—	mS

PARAMETER	SYM	TEST CKT	TEST CONDITION	LIMIT MIN	LIMIT TYP	LIMIT MAX	UNIT
Pulse Mute Delay	T_{MD}		TEST=1, B/M=1	—	40	—	mS
			Note 8, 9 B/M=0	—	33.3	—	
Pre-Digit Pause	T_{PDP}		TEST=1, B/M=1	—	40	—	mS
			Note 8,9 B/M=0	—	33.3	—	
Pulse Rate	F_{PR}		TEST=1 Note 8	—	10	—	PPS
			TEST=0	—	600	—	
Inter Digit Pause	T_{TD}		TEST=1 Note 8	—	800	—	mS
			TEST=0	—	13.3	—	
Break/Make Ratio	B:M		B/M=1 Note 8	—	60:40	—	%
			B/M=0	—	33.3	—	
Tone Duration	T_{TD}		Auto Dialing Note 8	—	100	—	mS
Inter Tone Pause	T_{TD}		Auto Dialing Note 8	—	105	—	mS
Row Group Frequency	f1	C	ROW1, NOTE 8	—	699	—	Hz
	f2		ROW2, NOTE 8	—	766	—	
	f3		ROW3, NOTE 8	—	848	—	
	f4		ROW4, NOTE 8	—	948	—	
Column Group Frequency	f5	C	COL1, NOTE 8	—	1216	—	Hz
	f6		COL2, NOTE 8	—	1332	—	
	f7		COL3, NOTE 8	—	1472	—	
Key Tone Frequency	f8		Note 8	—	1.2	—	KHz

Note 1 : $\overline{HKS}=0$
Note 2 : In DTMF Mode
Note 3 : In Pulse Mode
Note 4 : Keyboard Entry, including Auto Dialing
Note 5 : No Keyboard Entry
Note 6 : All Output Unloaded
Note 7 : Dual Tone Multi-Frequency Distortion is measured in terms of total out-of band power related to sum of row & column fundamental power
Note 8 : Crystal parameters defined as Rs< 100Ω , Lm=96mH Cm=0.25PF Ch=5PF, F=3.579545MHz & CL=18PF F < ±200PPM
Note 9 : Referred to Pulse Mode Time Diagram
Note 10 : Referred to DTMF Mode Time Diagram

FUNCTIONAL DESCRIPTION

A. ROW-COLUMN INPUT (PIN 1 ~ 4 & 18 ~ 22)

The keypads input is compatible with the standard 2-of-9 keyboard. In normal operation, any single button is pushed to produce dual tone, pulses or function. Activation of two or more buttons will result in no response, except for single tone. TABLE 1 illustrates the address keypads function, in detail.

OUTPUT		ACTIVE LOW INPUTS		OUTPUT TONE (Pin 11) PULSE (Pin 10)
		ROW (Pin 18-21)	COLUMN (Pin 1-3)	
TONE(Pin 14=0)	Normal (Pin 15=1)	One	One	Dual Tone
		Two or More	One	Pin 11=0
		One	Two or More	
		Two or More	Two or More	
	Single Tone (Pin 15=0)	One	One	Dual Tone
		Two or More	One	Column Tone
		One	Two or More	Row Tone
		Two or More	Two or More	Pin 11=0
PULSE(Pin 14=1)	10 pps (Pin 15=1)	One	One	10pps
		Two or More	One	Pin 10=1
		One	Two or More	
		Two or More	Two or More	
	600 pps (Pin 15=0)	One	One	600 pps
		Two or More	One	Pin 10=1
		One	Two or More	
		Two or More	Two or More	

Note 1: In pulse mode, Pin 10=1 for * & # buttons.

Note 2: In pulse mode, always Pin 11=0, in DTMF mode, always Pin 10=1.

Note 3: Pin 10=1, Pin 11=0 for any button in Row 5 & Column 4, regardless of mode.

B. OSC IN, OSC OUT

An built-in inverter provides oscillation with an inexpensive 3.579545MHz television color-burst crystal. The oscillator ceases when a keypad input is not sensed. Most crystals do not vary more than ±0.02%.

C. $\overline{\text{MUTE}}$

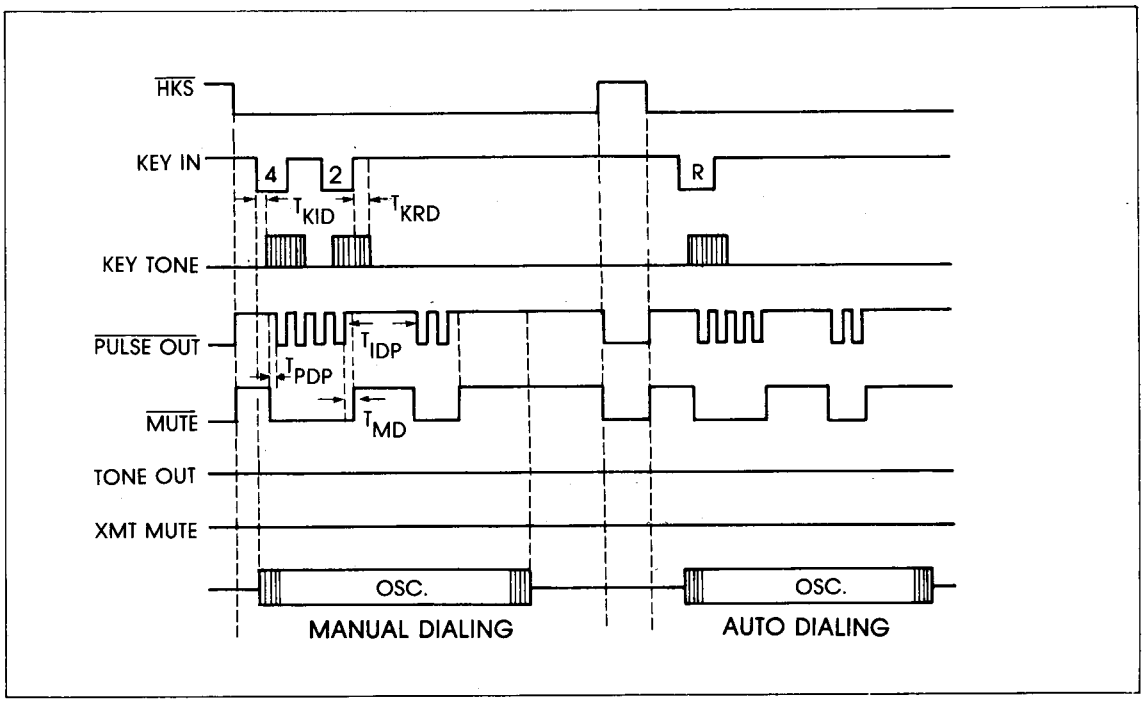
The mute output is a conventional CMOS inverter that pulls to V_{DD} with no keyboard input and pulls to V_{SS} when an address keypads entry is sensed (excluding the * & # keypads, in pulse mode), that is, any keypad in row 5 and column 4 is pushed, then mute out keeps high level still.

D. $\overline{\text{HKS}}$

The HKS(Hook Switch) input is used to detect the handset in ON-HOOK or OFF-HOOK. In ON-HOOK state, $\overline{\text{HKS}}=1$, the keyboard input is disabled. In OFF-HOOK state, $\overline{\text{HKS}}=0$.

E. $\overline{\text{PULSE OUT}}$

In DTMF mode, the pulse out keeps high level regardless of keyboard entry. In pulse mode, this output sends a chain of pulses to correspond the address keypad input, but keeps high level for * and # entry.



F. **TONE OUT**

In normal dialing, the tone duration depends on key-in lasting. When keypad is pressed less than 100ms, the tone duration will be fixed to 100ms. In opposite, the tone duration will last as long as key-in continuance. The inter-tone-pause will be different under following condtion: when key-released duration continues less than 105ms, it will be fixed to 105ms, otherwise it will be equal the duration of key-released. When redialing and memory dialing, the tone duration and inter-tone-pause are internally set to be 100ms and 105ms respectively. During pulse dialing, it always keeps at low state regardless of keypad input.(See Figure 2)

G. **KEY TONE OUT**

The key tone output is a conventional CMOS inverter. A NPN transistor is needed to drive a piezo. The output frequency is 1.2KHz. The key tone actuates, after valid key entry has been detected, and ceases at the time of button released.

H. **XMT MUTE**

The XMT MUTE is a conventional CMOS inverter. In DTMF mode, the output actuates in the duration of DTMF signal is sending. But, the output always keeps low in pulse mode. It can be used for muting operation in Tone mode or control LED for indicating(See Application Circuit).

I. **MODE**

Pulls pin 14 to V_{DD}, the dialer is in pulse mode for 10 pps dial rate, pull to V_{SS} it is in DTMF mode.

J. **$\overline{\text{TEST}}$**

In normal operation, ties the $\overline{\text{TEST}}$ Pin to V_{DD}, the single tone is inhibited and pulse rate is 10 pps. In testing operation, ties the $\overline{\text{TEST}}$ pin to V_{SS} , single tone can be created with the method shown in TABLE 1, and all of the time parameter in pulse dialing is faste by 60 times.

K. **B/M**

The Break/Make ratio is 60:40, if B/M=1, and is 66.6:33.3 if B/M=0. This pin influences nothing in DTMF mode.

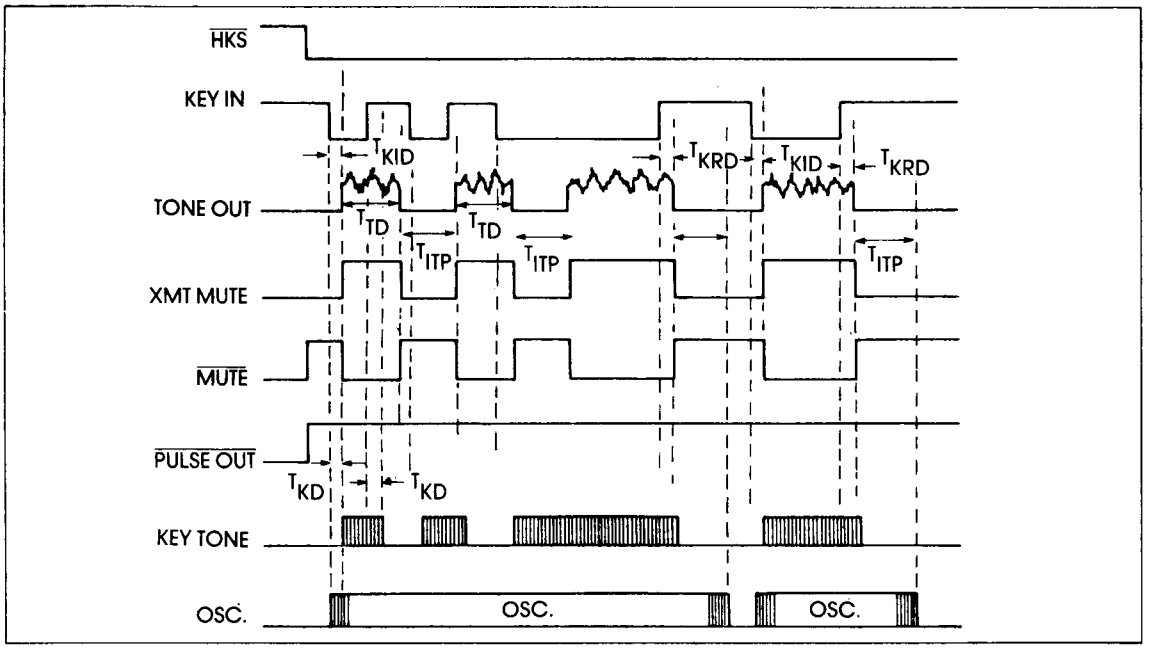


Figure 2[a] Tone Mode Normal Dialing Tim-ing Diagram

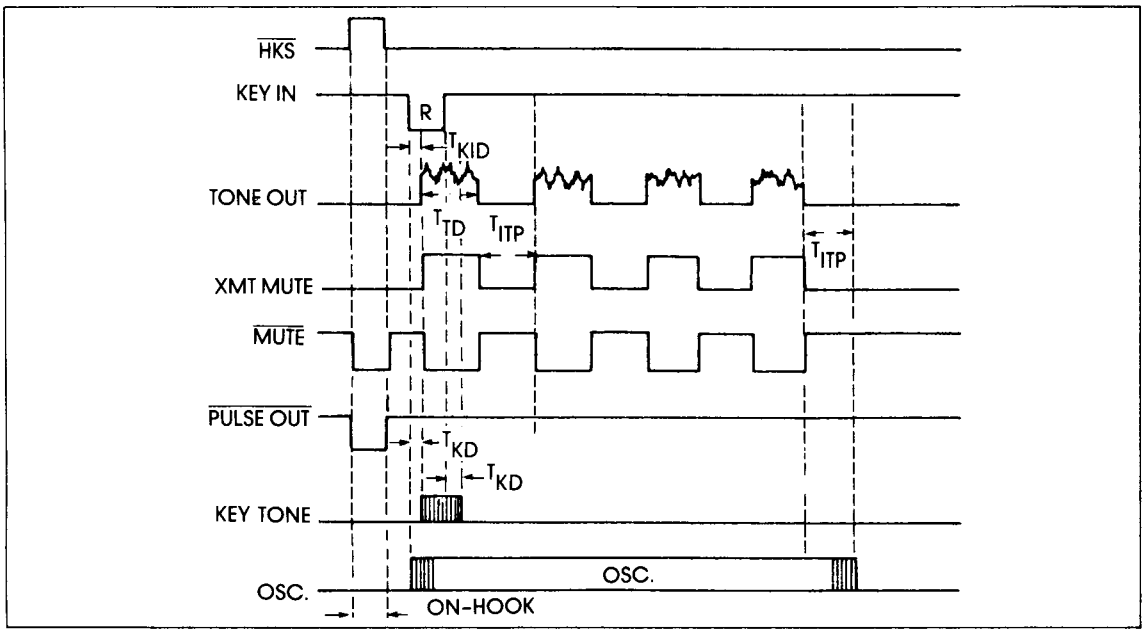


Figure 2[b] Tone Mode Redialing Timing Diagram

KEYBOARD OPERATIONS

Note: 1. All the keyboard operations should be under OFF-HOOK condition.
2. D1 ~ Dn: 0-9, *, #

A. NORMAL DIALING

[D1], [D2] ,..., [Dn]

B. REDIALING

Push [D1], [D2] ..., [Dn], busy, ON-HOOK. then OFF-HOOK, push REDIAL , the last number D1D2....Dn will be dialed out automatically.

C. NUMBER STORING

Don't care Pulse or Tone mode. Push [S] [D1], [D2] ... [Dn] [S], [Ln] Ln:0-9 then the number D1D2 .... Dn will be stored in location [Ln]

D. MEMORY DIALING

Select Pulse or Tone mode. Push keypad [A], [Ln] then the number stored in location [Ln] will be automatically dialed out in Pulse or Tone mode as selected.

E. PAUSE KEY OPERATION

In some cases, such as PABX or long distance service, pause should be inserted in dialing sequence. The WE9145 provides stackable pause function (3.1 sec/Pause) which facillitates flexible applications.

1. [D1] [P] [D2] ,..., [DN]
   Then the number will be dialed out as following sequence; D1 , D2 , ... Dn; without pause.
2. Redialing with Pause Key
   OFF-HOOK [R], then the signal will be dialed out automatically D1, pause 3.1 sec., D2 , ...Dn.

1. [S], [D1], [P], [D2] ,... [Dn] [S] [Ln] then the number D1, P, D2, ... Dn will be stored in [Ln]
2. Memory Dialing with Pause Key
   [A] [Ln], then the output signal will be dialed as: D1 , pause 3.1 Sec., D2 , ... Dn.

Note: Every Pause will occupy one digit of memory size.

F. EMERGENCY DIALING

WE9145 provides three memories for storing emergency numbers such as fire, police and doctor.

[S] [D1] [D2]... [Dn] [S] [EMn] EMn:EM1-EM3
Then the number D1, D2, ... Dn will be stored in EMn.

Push EMn, then EMn will be dialed out in Pulse or Tone mode as selected.

G. LONG DISTANCE SERVICE MEMORY DIALING

The WE9145 provides one special memory location for storing the long distance service company access code, it also provides automatic switching function from Pulse mode to Tone mode after the pause duration.

a. Storing the Long Distance Service Company Code to [LDC] memory.
Keypad [S] [D1], [D2] ... [Dn] [P] [D1], [D2] .. [Dn] [S] [LDC]

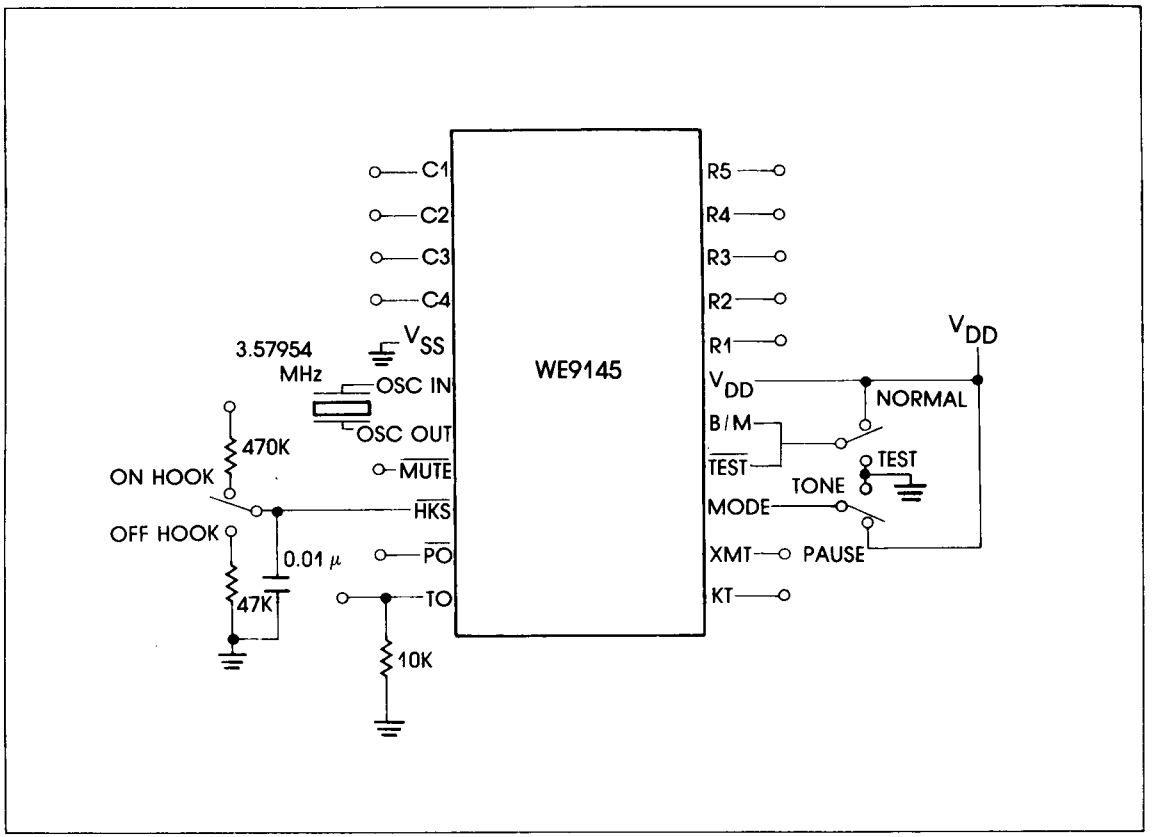
b. LDC Memory Auto Dialing
When a LDC number and access code were stored as above described procedure, the number can be automatically dialed as following sequence: Select pulse mode: press [LDC] D1D2.....Dn, pause for 3.1 seconds, D1', D2'.....Dn'

Note: 1. The chip will be automatically switched to Tone mode after the pause duration until an ON-HOOK state is detected.
2. If the mode switch was set in Tone mode then the output still keeps in tone mode.

H. Mixed Dialing

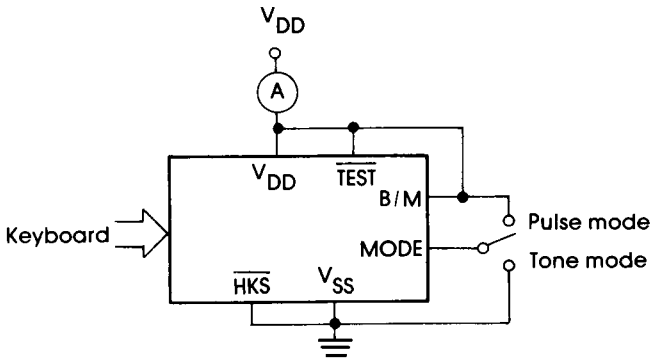
The WE9145 provides remote control function such as computer or appliance electric after the call has been put through. Mix-dialing is acceptable and has no limit on the digits of above-listed items operation.

GENERAL TEST CIRCUIT

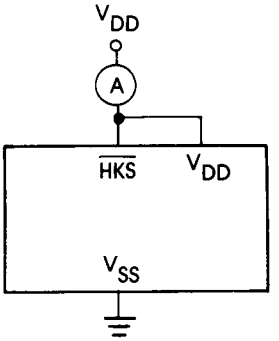


TEST CIRCUIT

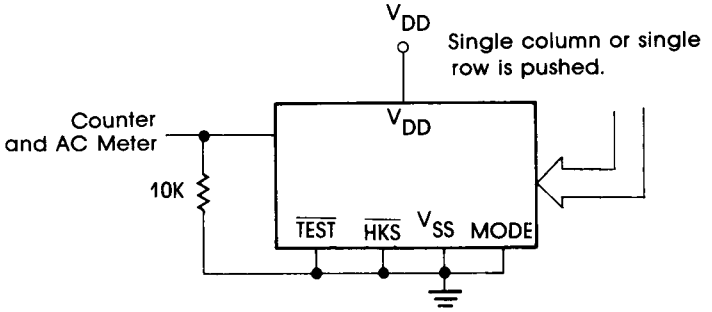
A.



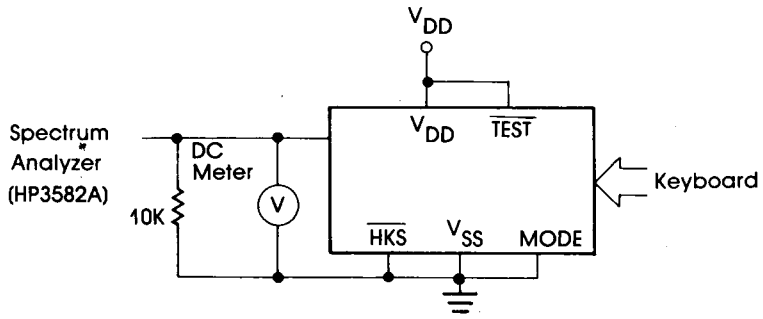
B.



C.



D.

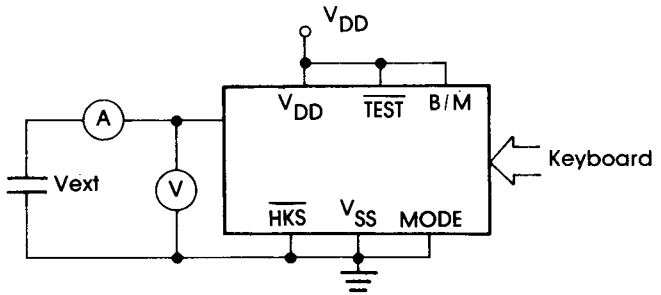


$$DIST_{db} = 20 \log \frac{\sqrt{[V_1]^2+[V_2]^2+....+[Vn]^2}}{\sqrt{[V_L]^2+[V_H]^2}}$$

* V1, ..., Vn are extraneous frequency (ie in termodulation and harmonic) components in the 500 Hz to 3400 Hz band.
* V_L, V_H, are the individual frequency components of the DTMF signal.

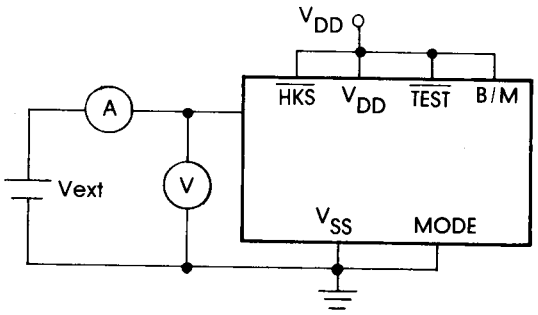
Note: Whether keyboard is pushed refer to the DTMF mode timing diagram.

E.

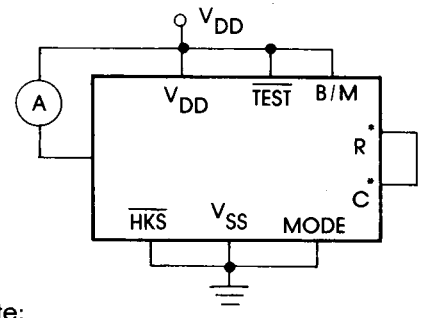


Note: Whether keyboard is pushed refer to the DTMF mode timing diagram.

F.

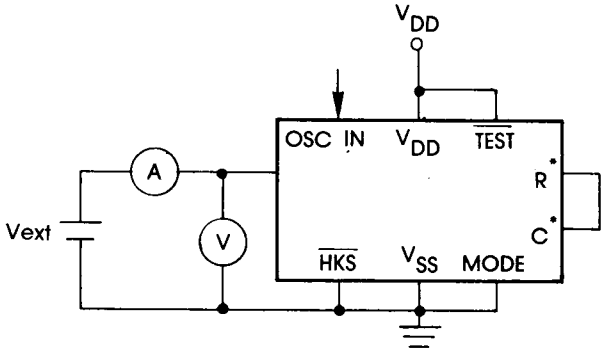


G.



Note:

H.

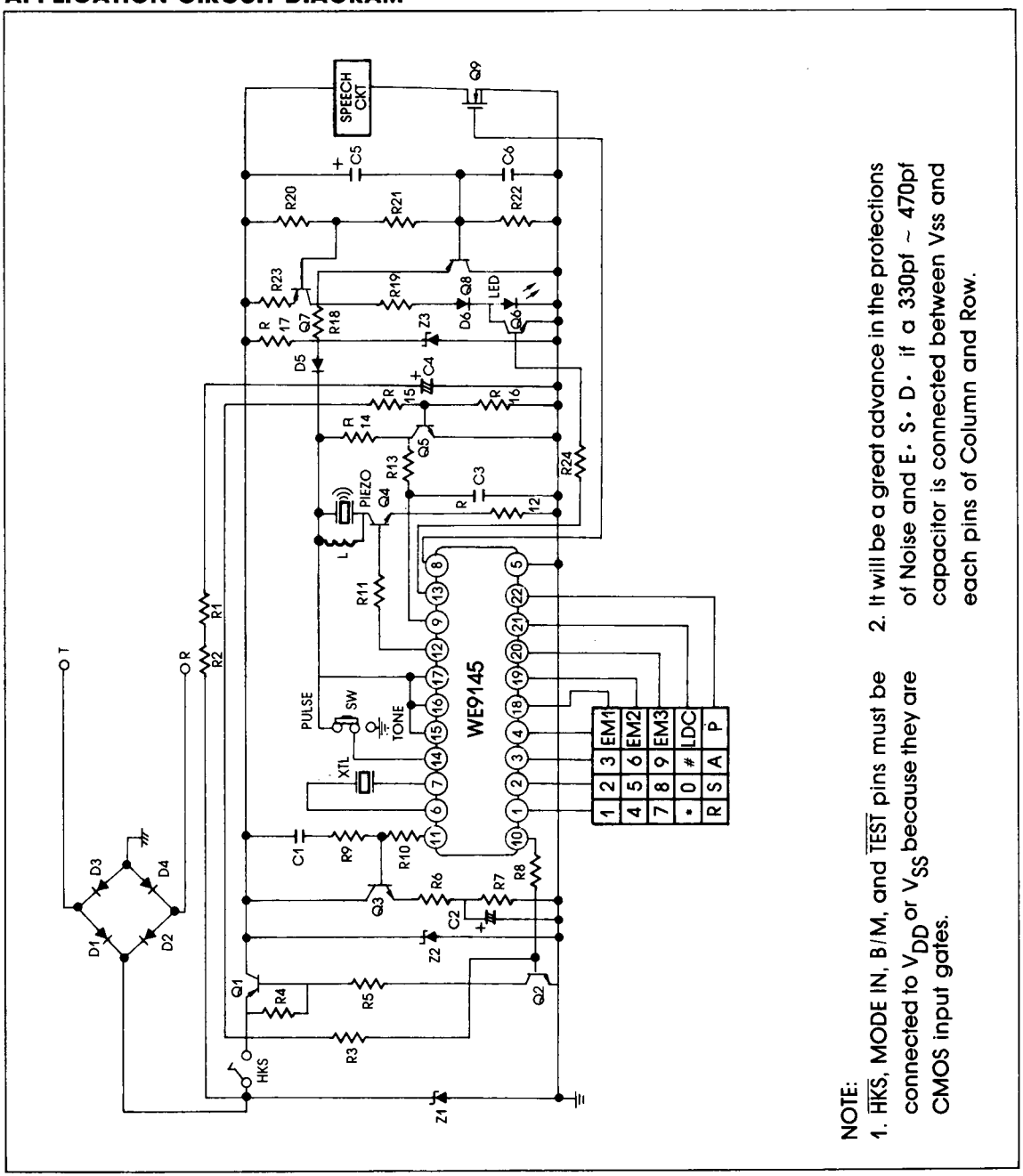


R *: anyone row of R1-R5
C *: anyone column of C1 – C4
Isink = I/(1-Duty Cycle)
I is the net DC current measured from ampere meter.

Procedure: 1. Provide clocks until output changes to high.
2. Test its current.

Note: $\overline{TEST}$ pin can be combined with V_{SS} in order to speed up testing.

APPLICATION CIRCUIT DIAGRAM



NOTE:

1. $\overline{HKS}$, MODE IN, B/M, and $\overline{TEST}$ pins must be connected to V_{DD} or V_{SS} because they are CMOS input gates.
2. It will be a great advance in the protections of Noise and E·S·D· if a 330pf ~ 470pf capacitor is connected between Vss and each pins of Column and Row.

CIRCUIT DESCRIPTION

A. The circuit is line powered through a diode bridge for rectifying and regulated by a regulation circuit which consists of Q7, Q8, R18-R23, D5 and C5, C6, Q7, Q8 are always in active region. C5 ensures a high regulator impedance for AC signals. This capacitor value should not be too large in order to have short response time of system. C6 is a compensatory capacitor. C4 must be a low leakage capacitor and D5 blocks up the path from C4 to Q8 for holding the voltage in C4.

B. In ON-HOOK state, R1, R2 provide the flow path for memory data retention current and make the circuit to satisfy the requirement of EIA-RS470 which require DC input impedance to be higher than 10MΩ . R1 and R2 are 22MΩ separately when used in parallel with other three same telephone sets. The memory data retention current of dialer is furnished through R1, R2, and C1, all other circuits are floated to decrease the need of data retention current in ON-HOOK state.

C. Dialing pulses are sent by controlling the states of Q1 and Q2. In DTMF mode, Q1 and Q2 are always saturated, and dialing tone is sent through the amplifier which consists of R6, R7, R9, R10, C1, C2 and Q3, R9, C1 is a RC feedback circuit, it keeps the tone output unaffected by different transistor.

D. Z1 and Z2 prodect the whole circuit from surge voltage and over-large signal on telephone line when off hook. Z3 limits the eoltage supplied to WE9145

E. L, Q4 and piezo make a tuning circuit and generate a key tone when the keypad is pushed. R12 is a current-limited resistor.

F. Q9 provides the muting for receiver and transmitter when dialing. R19, R24, D6, Q6 and LED implement the dialing indication.

G. R13-R16, C3 and Q5 make a detecting circuit of hook-switch. When ON-HOOK, Q5 is turned off, R13 is pulled high in a short time. In OFF-HOOK state, C3 protects HKS from spikes effect and R13 is pulled low while Q5 is turned on.

H. SW furnishs the selection of dialing mode for user.

R1	22M	R18	110Ω	D5-D6	IN4148
R2	22M	R19	330Ω	Z1	IN5379
R3	910KΩ	R20	1.6Ω	Z2	IN4743
R4	33KΩ	R21	1.2KΩ	Z3	RD4.3EB3
R5	4.7KΩ	R22	5.1Ω	Q1	2SA640
R6	36Ω	R23	10Ω	Q2	2N5551
R7	62Ω	R24	33KΩ	Q3	FC8050
R8	10KΩ	C1	0.02μF	Q4 ~ Q6	2N9014
R9	100KΩ	C2	4.7μF/16V	Q7 ~ Q8	2N4403
R10	5.1KΩ	C3	0.5μF	Q9	AVN1106
R11	33KΩ	C4	100μF/16V	XTL	3.79545MHz
R12	1.2KΩ	C5	2.2μF/25V	ICI	WE9145
R13	10KΩ	C6	0.01μF		
R14	330KΩ	D1	1N4004		
R15	330KΩ	D2	1N4004		
R16	82KΩ	D3	1N4004		
R17	10KΩ	D4	1N4004		