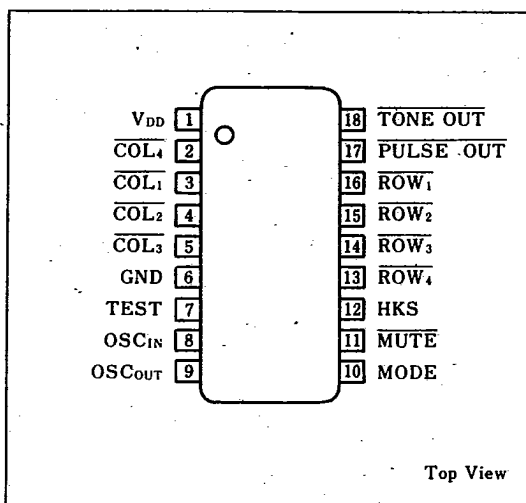T-75-07-07

LR48021 Pulse/Tone Dialer LSI

■ Description

The LR48021 is a CMOS pulse/tone dialer LSI providing 18-digit×10-channel memory including a redial memory.
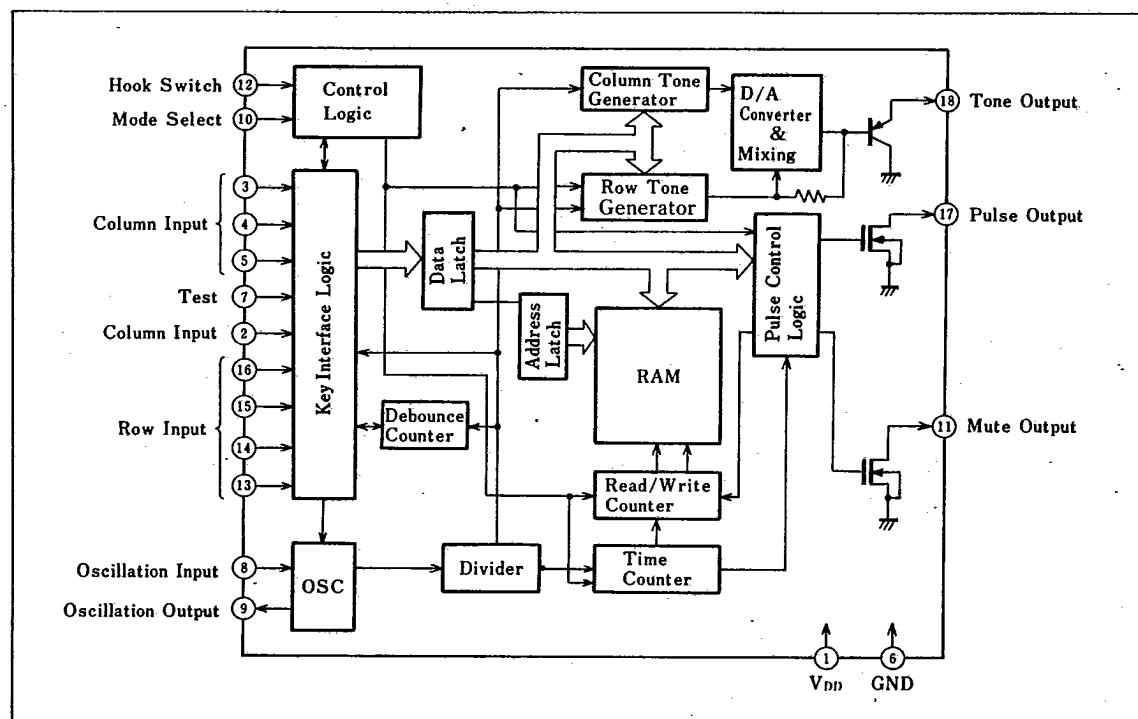
■ Features

1. 18-digit×9-channel two-touch memory and a redial memory
2. Make ratio : 32%
3. Pulse rate : 10/20pps pin-selectable
4. Keytone output
5. Switchable between DTMF tone dialing and pulse dialing modes
6. Uses a 3.579545 MHz color-burst crystal/ceramic oscillator as a frequency reference
7. PBX pause storage
8. Uses the single contact, the standard 2-of-7 or 2-of-8 matrix keyboard
9. 18-pin dual-in-line package

■ Pin Connections

V_{DD}	1		18	TONE OUT
$\overline{COL_4}$	2	○	17	PULSE OUT
$\overline{COL_1}$	3		16	$\overline{ROW_1}$
$\overline{COL_2}$	4		15	$\overline{ROW_2}$
$\overline{COL_3}$	5		14	$\overline{ROW_3}$
GND	6		13	$\overline{ROW_4}$
TEST	7		12	HKS
OSC_{IN}	8		11	$\overline{MUTE}$
OSC_{OUT}	9		10	MODE

Top View

■ Block Diagram

■ Absolute Maximum Ratings

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Parameter	Symbol	Ratings	Unit	Note
Supply voltage	V_{DD}	6.5	V	1
Maximum pin voltage	V_{IN1}	−0.3	V	2
	V_{IN2}	+0.3		3
Power dissipation	P_D	500	mW	4
Operating temperature	T_{opr}	−30 to +60	℃	
Storage temperature	T_{stg}	−55 to +150	℃	

Note 1 : Referenced to GND.
Note 2 : The maximum applicable voltage on any pin with respect to GND.
Note 3 : The maximum applicable voltage on any pin with respect to V_{DD}.
Note 4 : Ta=25℃

■ Recommended Operating Conditions
(Ta=25℃, Referenced to GND.)

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply voltage	V_{DD}	2.0		6.0	V

■ DC Characteristics
(Ta=25℃, Referenced to GND.)

Parameter		Symbol	Conditions		MIN.	TYP.	MAX.	Unit	Note
Input voltage		V_{IL}			GND		$0.2V_{DD}$	V	
		V_{IH}			$0.8V_{DD}$		V_{DD}	V	
Tone output voltage	ROW	V_{OR}	R_L=10kΩ, V_{DD}=4V		100	160	260	mV_{rms}	
	COLUMN	V_{OC}	R_L=10kΩ, V_{DD}=4V		130	200	300	mV_{rms}	
Standby current		I_{SB}	V_{DD}=3.5V			1.5	3.0	μA	1
Operating current		I_{OPP}	V_{DD}=3.5V	Pulse mode		0.7	2.0	mA	2
		I_{OPT}		Tone mode		1.0			
Mute output current		I_{OL}	V_{DD}=2V, V_{OL}=0.5V		1.0	2.0		mA	3
Pulse sink output current		I_{PL}	V_{DD}=2V, V_O=0.5V		1.0			mA	
Pulse leakage output current		$|I_{LKG}|$	V_{DD}=6V, V_O=6V				1.0	μA	
Key pull-up input resistance		R_{KP}	V_{DD}=3.5V			100		kΩ	4
Key pull-down input resistance		R_{KD}	V_{DD}=3.5V			5.0		kΩ	4
Mode pull-up input resistance		R_{MP}	V_{DD}=3.5V			100		kΩ	
Mode pull-down input resistance		R_{MD}	V_{DD}=3.5V			100		kΩ	
HKS pull-up input resistance		R_{HK}	V_{DD}=3.5			60		kΩ	
Tone output distortion			$V_{DD}\geq2.5V$, R_L=10kΩ				−20	dB	5
Pre-emphasis		PE_{HB}	$V_{DD}\geq2.5V$, R_L=10kΩ		1.0	2.0	3.0	dB	

Note 1 : All output pins in no-load condition when clock is stopped and when Off-Hook
Note 2 : All output pins in no-load condition during key input and when On/Off-Hook (upper row : during pulse mode, lower row : during tone mode)
Note 3 : Applied to the $\overline{MUTE}$ pin.
Note 4 : Resistance when a $\overline{ROW}$ pin or $\overline{COL}$ pin is scanned at 125Hz, at high or low level.
Note 5 : Unwanted frequency components relative to the total power of the fundamental tone signal of the $\overline{ROW}$ pin and $\overline{COL}$ pin.

SHARP

■ AC Characteristics   (Ta=25℃)   T-75-07-07

Parameter	Symbol	MIN.	TYP.	MAX.	Unit	Note
Oscillation start time	t_{OS}			8.0	ms	1
Key debounce time	t_{DB}	4.0		32	ms	2
Pulse rate	P_R		10		pps	3
			20			4
Break time	t_B		68		ms	5
Inter-digital pause time	t_{IDP}		1000		ms	5 6
Mute overlap time	t_{MOL}		2.0	4.0	ms	
Pre-digital pause time	t_{PDP}		32		ms	5
Tone output rate	t_{OR}		220		ms	
Tone output time	t_{OPT}	50			ms	7
Tone mute overlap time	t_{OM}	4		32	ms	

Note 1 : When a crystal oscillation element with characteristics $R_S=100\,\Omega$, $Lm=96mH$, $C_m=0.02pF$,
$C_h=5pF$, $f=3.579545MHz$ is used.
Note 2 : Key input is accepted after oscillation begins if valid after t_{DB}.
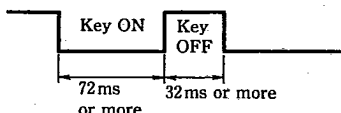Note 3 : MODE pin left open.
Note 4 : Connect the MODE pin to V_{DD}.
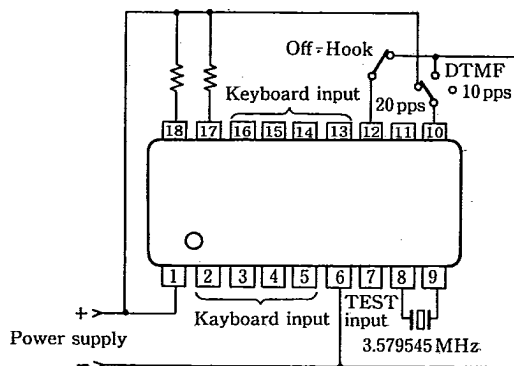Note 5 : During 10-pps pulse mode (1/2 during 20-pps mode).
Note 6 : 100ms during DTMF mode.
Note 7 : During normal dialing, the tone output time t_{OPT} depends on KEY ON time.
See Fig. right minimum KEY ON time and KEY OFF time necessary for tone output.

```
Key ON   | Key
         | OFF
 72ms      32ms or more
 or more
```

■ Test Circuit


```
              Off-Hook
         Keyboard input  20pps    DTMF
                                  o 10pps
      18 17 16 15 14 13 12 11 10

       O

       1  2  3  4  5  6  7  8  9
   +                    TEST
 Power supply  Kayboard input  input  ╢◻╟
   -                           3.579545MHz
```

■ Description of Operation

The mode select pin of the LR48021 LSI enables either DTMF tone dialing or 10pps/20pps pulse dialing mode to be selected. It is a 10 number memory repertory dialer which, depending on the mode selected, outputs either tone signals or pulse and mute signals in response to the key inputs. A low-cost 3.579545MHz color burst crystal may be used for the oscillator. The device contains 900 bits of RAM (18 digits×5 bits×10) enabling it to store up to 10 telephone numbers, including the number last dialed. Numbers up to a maximum of 18 digits can be stored. When used with a PBX system, a pause can be input. The repertory dialer will recognize this pause during auto-dial operations and will suspend output for 4 seconds. When the DTMF tone dialing mode is selected, 8 types of audio frequency are generated and an output tone conforming to DTMF dialing standards is synthesized from them. In response to ROW and COLUMN key inputs, a dual audio tone output is obtained by division of the 3.579545MHz signal. The D/A converter in this LSI consists of an on-chip R-2R ladder network and an op-amp. The output signal is a staircase approximation of a sine wave. When particularly low distortion is required, an external filtering circuit should be added. When On/Off-Hook in pulse dialing mode, or when On-Hook in DTMF mode, a 1215.9Hz tone is output when a key is depressed.

■ Pin Descriptions

V$_{DD}$ (Pin 1)

This pin is the power supply pin. It is positive with respect to GND (Pin 6). Maximum input voltage is 6.0 volts.

Key Inputs (Pins 2, 3, 4, 5, 13, 14, 15 and 16)

Using GND as a common pin, the LR48021 may be used with either a standard 2-of-7 or 2-of-8 matrix keyboard, or with a single contact (Form A) keyboard. Figure 1 shows the keyboard configurations.

In order for the key input to be valid, a single ROW input should be connected to a single COLUMN input. The single ROW and COLUMN inputs should go low simultaneously. Simultaneous multiple key depressions invalidates the key input.

If a single tone output is required as a check, multiple keys in the same ROW or COLUMN may be pressed simultaneously in DTMF mode. No tone at all is output if multiple keys in the diagonal direction are depressed simultaneously. Multiple key depressions of ROW4 and COL4 inputs are not recognized. Oscillation begins when the first key input is detected. A key search is then performed on the ROW and COLUMN inputs alternately using high and low levels.

■ Key Functions

Key	Pulse dialing mode	DTMF mode
0-9	Data key	Data key
*	Data key-pause key	Data key
#	Control key-redial (Note 1)	Data key
RED/P	Control/data key (See Note 2)	Control/data key (See Note 2)
Pause	Data key (pause key)	Data key (pause key)
Store	Control key (store)	Control key (store)
Recall	Control key (recall)	Control key (recall)

Note 1 : If the # key is used for the first key input in pulse mode, it functions as a control key. In all other cases, # key input is ignored.

Note 2 : If the RED/P is the first key used when Off-Hook, then it functions as a control key, causing redialing to occur. In other cases it functions as a pause key.

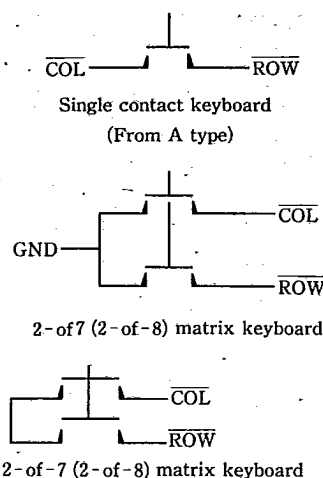Note 3 : A pause key input, in tone dialing mode, is valid when redialing or recalling.

Single contact keyboard
(From A type)

2-of7 (2-of-8) matrix keyboard

2-of-7 (2-of-8) matrix keyboard
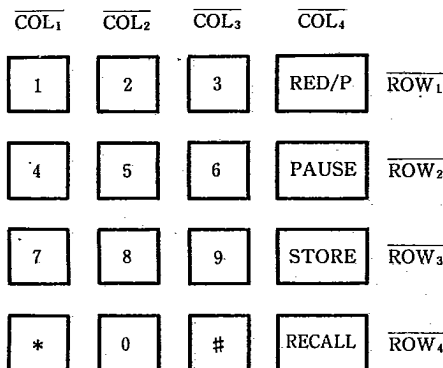
Fig. 1   Keyboard configurations

Fig. 2   Key matrix

GND (Pin 6)

Negative power supply pin.

Oscillator (Pin 8 and 9)

The LR48021 has on-chip inverters with enough loop-gain to enable an oscillator to be formed by simply connecting either a low-cost TV color burst crystal or a ceramic oscillator across the OSC$_{IN}$ and OSC$_{OUT}$ pins. Table 2 shows the frequencies of the output tones when a 3.579545MHz crystal oscillator is used.

Pulse/Tone Dialer LSI   LR48021

Table 2

	Standard DTMF [Hz]	*LR48021 Output Tone [Hz]	Deviation from Standard DTMF [%]
f1 (ROW1)	697	701.3	+0.62
f2 (ROW2)	770	771.4	+0.19
f3 (ROW3)	852	857.2	+0.61
f4 (ROW4)	941	935.1	−0.63
f5 (COL1)	1209	1215.9	+0.57
f6 (COL2)	1336	1331.7	−0.32
f7 (COL3)	1477	1471.9	−0.35

No single tone is generated on COL4.
* When using a 3.579545MHz crystal. Note that any deviations in the crystal frequency from 3.57954MHz will directly affect the frequency of output tone.

Mode Select (Pin 10)

This pin enables switching between DTMF dialing mode and the 10/20pps pulse dialing modes. Table 3 shows the relationship between the pin connections and the operating modes. If the input to the mode select pin is changed during pulse output, the mode transition occurs when t_{IDP} (max. 1 sec) has elapsed following data output in that mode or when a maximum of 3.6 sec has elapsed after the mode transition during tone output.

Table 3

Pin Connection	Operation mode
V_{DD}	20pps pulse dialing
Open	10pps pulse dialing
GND	DTMF tone dialing

Mode transition

Pulse mode | Tone model

Internal operating mode

20 pps pulse | Tone
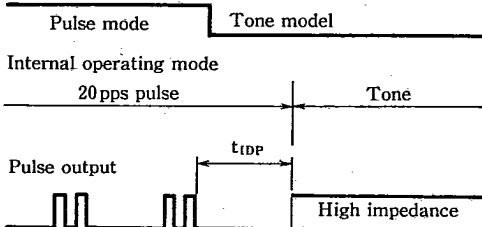
Pulse output

t_{IDP}

High impedance

Fig. 3 Mode change timing diagram

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Mute Output (Pin 11)

The Mute output pin consists of an N-channel open-drain transistor. In pulse dialing mode, the Mute Output returns to GND level upon key input or pulse output. In tone dialing mode, the output returns to GND level upon key input or tone output during auto-dialing.

Hook Switch Input (Pin 12)

This pin is the Hook Switch input. An internal pull-up resistor connects it to V_{DD}. When left open or at the V_{DD} level, the circuit is in On-Hook mode. When connected to GND, it is in Off-Hook mode (dialing mode).

Pulse Output (Pin 17)

This pin outputs pulses when in 10pps or 20pps pulse dialing mode. It is an N-channel open-drain output capable of driving an external transistor. The pulse Make/Break ratio is 32%/68%. In DTMF tone dialnig mode, it is in a high impedance state.

Tone Output (Pin 18)

The Tone Output is connected to the emitter of an on-chip bipolar transistor, the collector of which is connected to ground. The ROW and COLUMN signal inputs to this transistor are connected to an on-chip op-amp to ensure stable output levels. In DTMF tone-dialing mode, the DTMF signal is output as described below. The ROW and COLUMN outputs are digitally synthesized. Fig. 4 and 5 show the waveforms output from the on-chip D/A converters. Without filtering, the distortion of the signal is within 7% of the ideal waveform. The ROW and COLUMN signals are then combined by the on-chip op-amp to form a dual-tone output waveform.

Test Input (Pin 7)

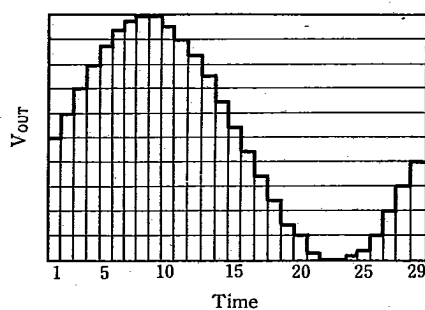This is used for LSI testing and is internally connected to V_{DD} through a pull-up resistor.

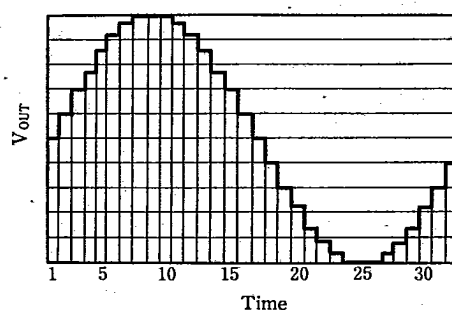**Fig. 4   Row Signal Tone Waveform**

Fig.5   Column Signal Tone Wavefom

■ Functional Description

Normal Dialing

Normal dialing involves numeric key input while the phone is Off-Hook. If the key input is valid, the data is stored at location 0 in internal RAM. The memory operations occur on a FIFO (First-In First-Out) basis and telephone numbers up to 18 digits long can be stored. Key input of more than 19 digits causes memory to be cleared and filled with new data. In tone dialing mode, the DTMF tone is output in response to the key inputs.

Memory Function

During normal dialing each key input is written to the buffer memory (RAM location 0). The dialed number stored in this temporary buffer can be transferred to and stored in another location (1-9) in the storage memory. The LR48021 automatically loads the telephone number input from the key pad into the buffer regardless of whether the phone is On-Hook or Off-Hook. When the $\boxed{\text{STORE}}$ $\boxed{\text{N}}$ (N=1-9) key sequence is input, the contents of the buffer are transferred to one of the memory locations 1-9. The existing contents of the buffer are automatically overwritten when a new number is input.

Note* Key input is accepted for 0.6 sec of transferring time and then the store operation is reset by switching the Hook Switch on and off.

If the $\boxed{\text{RED/P}}$ key is input while the Hook-Swich is off (i.e., HKS pin at GND level), then the contents of the buffer memory are read out and redialing is performed. If the $\boxed{\#}$ key is the first input after the Hook-Switch pin has been grounded, the number in buffer memory is redialed.

Recall Function

When the Hook Switch is off and a $\boxed{\text{RECALL}}$ $\boxed{\text{N}}$ (N=1-9) key input sequence occurs, dialing starts from the time the N key becomes valid.

Note* By pushing a $\boxed{\text{RECALL}}$ or $\boxed{\text{STORE}}$ key when pulse are output in Off-Hook mode, pulse output is halted and a mode transition occurs.

Pause/Auto-Dialing Function

The LR48021 allows pauses to be programmed within the 17 digits of the telephone number. A pause is recorded in memory by entering the $\boxed{\text{PAUSE}}$ key. If a pause code is detected during the execution of a redial or recall auto-dial operation, dialing is automatically suspended. After 4 seconds the rest of the number is then dialed.

During an auto-dialing operation in the DTMF mode, $\boxed{\text{PAUSE}}$ key input causes data to be written into RAM. but a pause is output only when the memory contents are dialed.
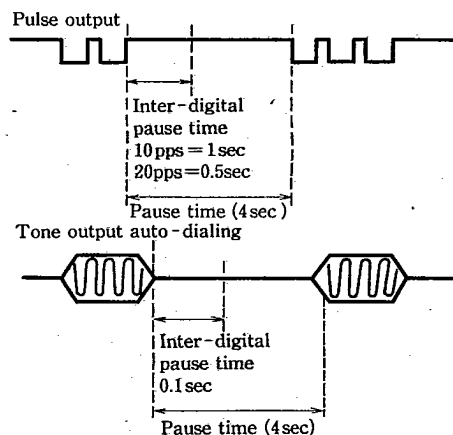
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## Sample Operations

[A] 1. ON HOOK
    2. Input "0 PAUSE 98-7654"; "0 PAUSE 98-7654" is written to the buffer memory.
    3. Input "STORE 2"   ; "0 PAUSE 98-7654" is transferred to and stored in memory location 2.
    4. OFF HOOK
    5. Input "RECALL 2"   ; "0" is transmitted and, after 4 seconds, "98-7654" is automatically trans-
   mitted.

[B] 1. OFF HOOK
    2. Input "0 PAUSE 1234" ; "0 PAUSE 1234" is transmitted and simultaneously written into the buffer
         memory.
    3. BUSY confirmation   ; (The other party is engaged.)
    4. ON HOOK
    5. OFF HOOK
    6. RED/P   ; "0" is transmitted and, after 4 seconds, "1234" is automatically transmitted.
    7. ON HOOK
    8. Input "STORE 3"   ; "0 PAUSE 1234" is transferred to and stored in memory location 3.
    9. OFF HOOK
  10. Input "RECALL 3"   ; "0" is transmitted and, after 4 seconds, "1234" is automatically
         transmitted.
  11. BUSY confirmation
  12. ON HOOK
  13. OFF HOOK
  14. Input REDIAL   ; "0" is transmitted and, after 4 seconds, "1234" is automatically transmitted.
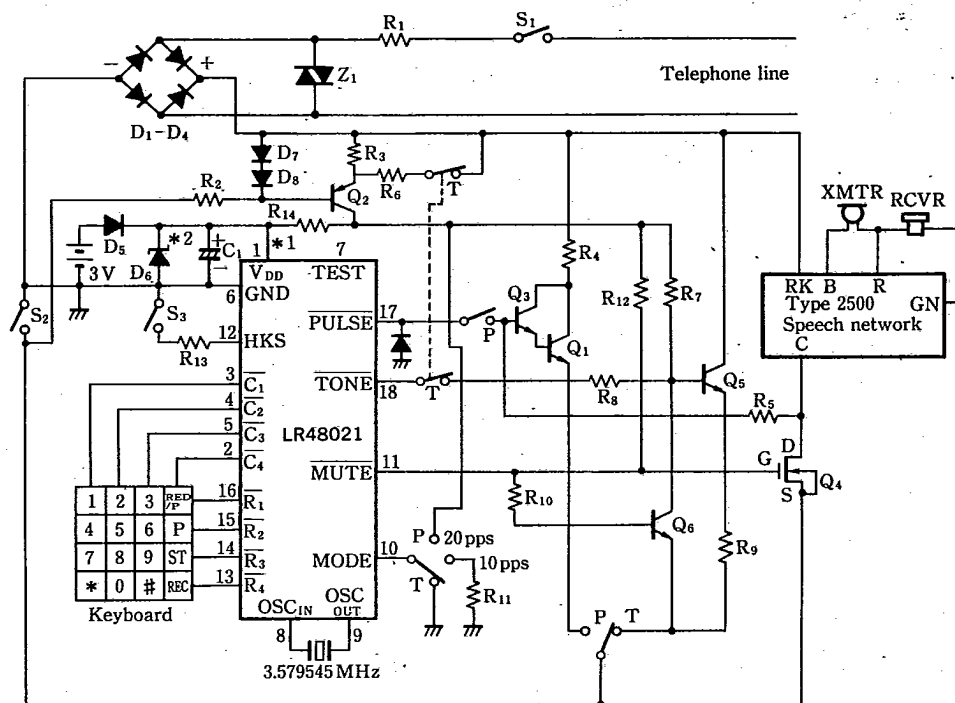
■ Timing Diagram

(1) **Pulse mode**

(2) **DTMF mode**

Pulse/Tone Dialer LSI   LR48021
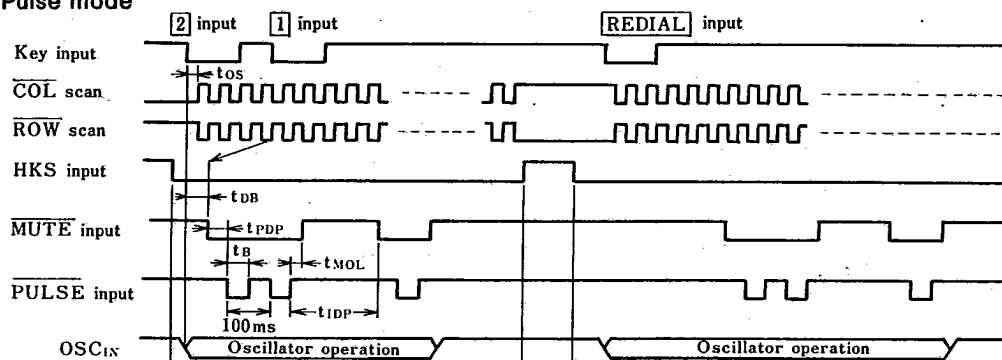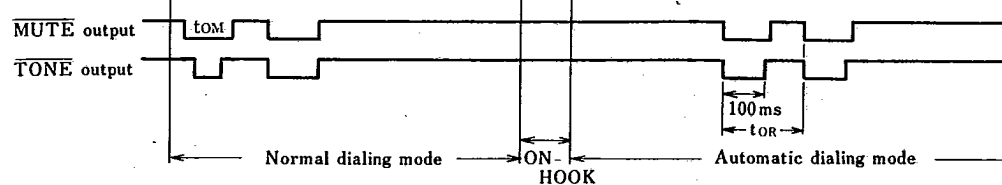
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■ **System Configuration Example**

Note : Connect the switch to "P" for pulse mode and "T" for tone mode.

Z_1 = 10DK820	Q_1 = 2N6660
R_1 = 22 Ω 1W	Q_2 = 2N5401
R_2 = 560k Ω	Q_3 = 2N5550
R_3 = 1.5k Ω	Q_4 = 2N5550
R_4 = 150 Ω	Q_5 = 2N5550
R_5 = 270k Ω	Q_6 = 2N5550
R_6 = 51 Ω	S_1, S_2, S_3 = Hook Switch
R_7 = 5k Ω	$D_1 \sim D_4$ = 1N4004
R_8 = 100 Ω	D_5 = 1N270
R_9 = 200 Ω	D_6 = 1N752 (5.6V)
R_{10} = 100k Ω	D_7 = 1N914
R_{11} = 1M Ω	D_8 = 1N914
R_{12} = 10k Ω	
R_{13} = 470 Ω	
R_{14} = 39 Ω	

C_1 = 68 μ F (Insert a capacitor to smooth the power supply and prevent latch up.)