Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

Preliminary Data

**MOS IC**

T-15-27-09

Type	Ordering Code	Package
PSB 8592	Q 67100-Y956	DIP 20
PSB 8593	Q 67100-H8168	DIP 20

The DTMF generator PSB 8592/PSB 8593 is specially designed to implement a dual-tone telephone dialling system. The device can be connected directly to a standard pushbutton telephone (single-contact keyboard type X-Y matrix code) and is operated together with an integrated speech circuit. All necessary dual-tone frequencies are derived from the commonly used standard TV crystal (3.58 MHz) which features a very high degree of accuracy and stability. The required sinusoidal waveform for the individual tones is digitally synthesized on the chip. The waveform so generated has very low total harmonic distortion. The voltage reference is on the speech circuit and regulates the signal levels of the dual tones to meet the recommended specifications for telephone sets. The buffer amplifier, providing the overvoltage protection, is also located on the speech circuit.

Applications of the device include radio and mobile telephones, remote control and process control.

Plastic plug-in package 20 A 20 DIN 41866,
20 pins, DIP
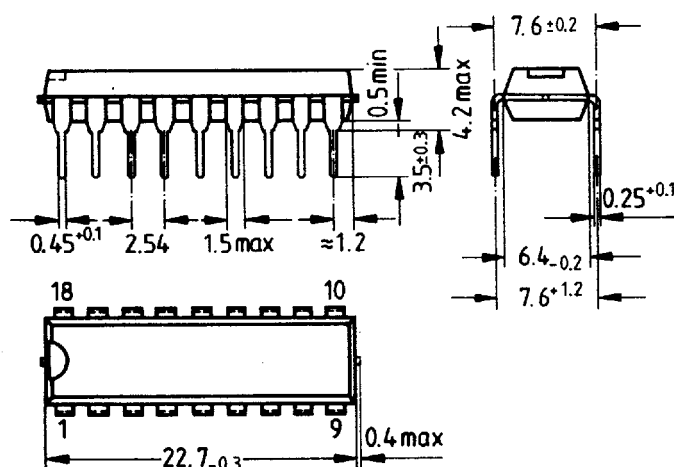
Approx. weight 1.5 g
Dimensions in mm

Dual-Tone Multi-Frequency Generator

PSB 8592
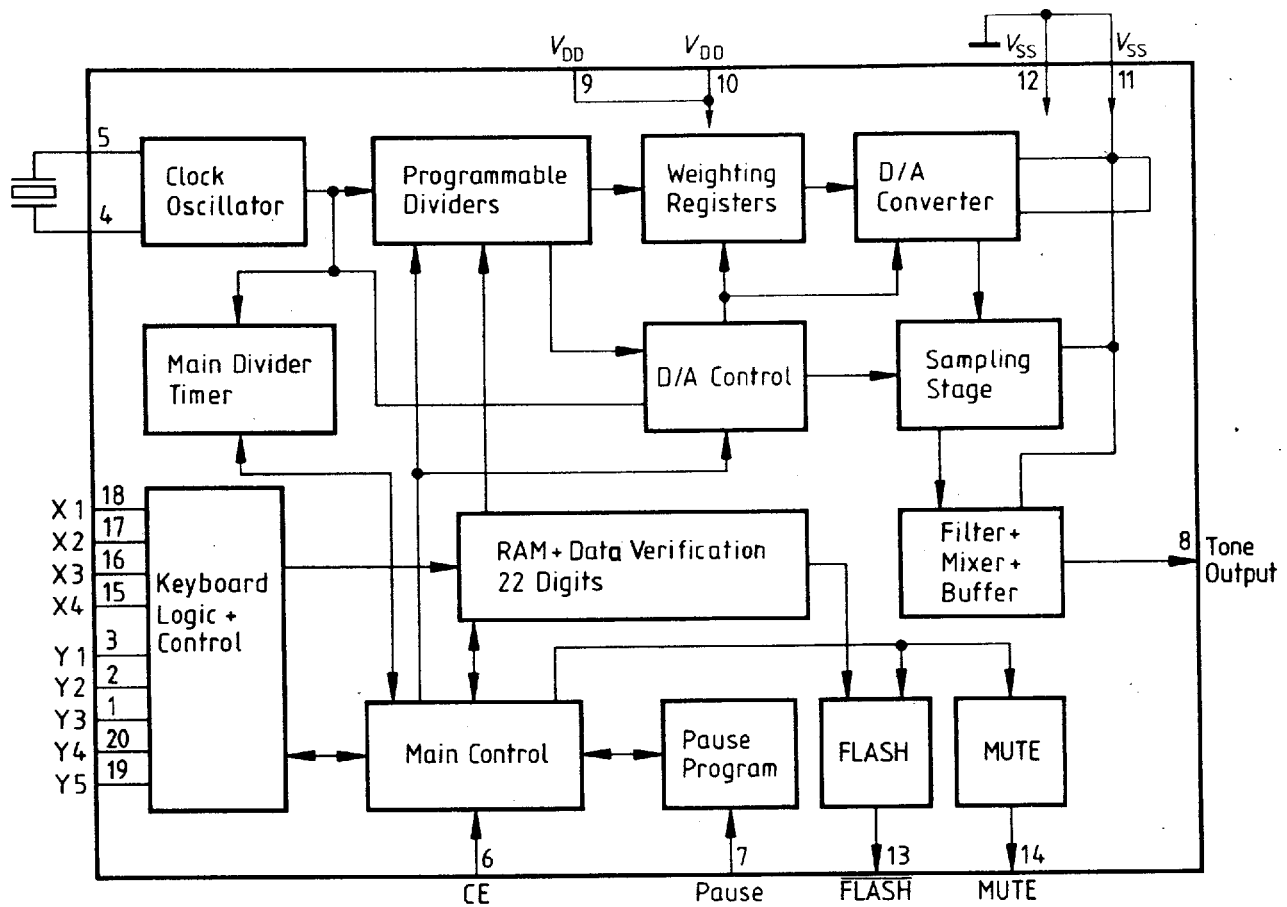**PSB 8593**

T–75–27–09

Features

- Advanced CMOS technology
- Last-number radial (up to 22 digits)
- Flash generation (register call)
- CEPT-compatible without external filtering
- Standard low-cost TV crystal (3.58 MHz)
- High frequency accuracy (better than 0.4 %)
- Operation with single-contact matrix keyboard, 20 keys
- Multi-key lockout and debouncing
- Binary data input
- Dual-tone and single-tone output
- Defined audio output time and interdigital pause
- Programmable access pause
- Low operating and standby current
- Mute output
- Chip enable input (CE)
- Internal power-on reset
- PSB 8593: Internal reference
  Supply voltage independent DTMF level

Pin Configuration
(top view)
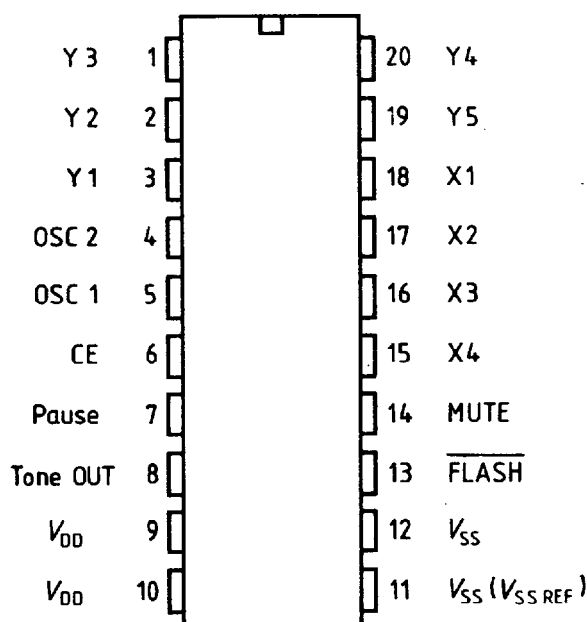
Pin Definitions

| Pin	Symbol	Function
1	Y3	⎫
2	Y 2	⎬ Keyboard interface
3	Y 1	⎭
4	OSC 2	⎫ Connection for crystal
5	OSC 1	⎭ 3.5795 MHz
6	CE	Hook switch – chip enable
7	Pause	Programmable pin for pause
8	Tone OUT	Output for dual-tone multi-frequencies
9	V_{DD}	Positive supply voltage
10	V_{DD}	(internally connected)
11	V_{SS}	Ground (PSB 8592)
11	$V_{SS\,REF}$	Reference voltage (PSB 8593)
12	V_{SS}	Ground
13	$\overline{FLASH}$	$\overline{FLASH}$ output
14	MUTE	MUTE output
15	X4	⎫
16	X3	⎪
17	X2	⎬ Keyboard interface
18	X 1	⎪
19	Y 5	⎪
20	Y 4	⎭

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T-75-27-09

Block Diagram   PSB 8592

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Block Diagram PSB 8593
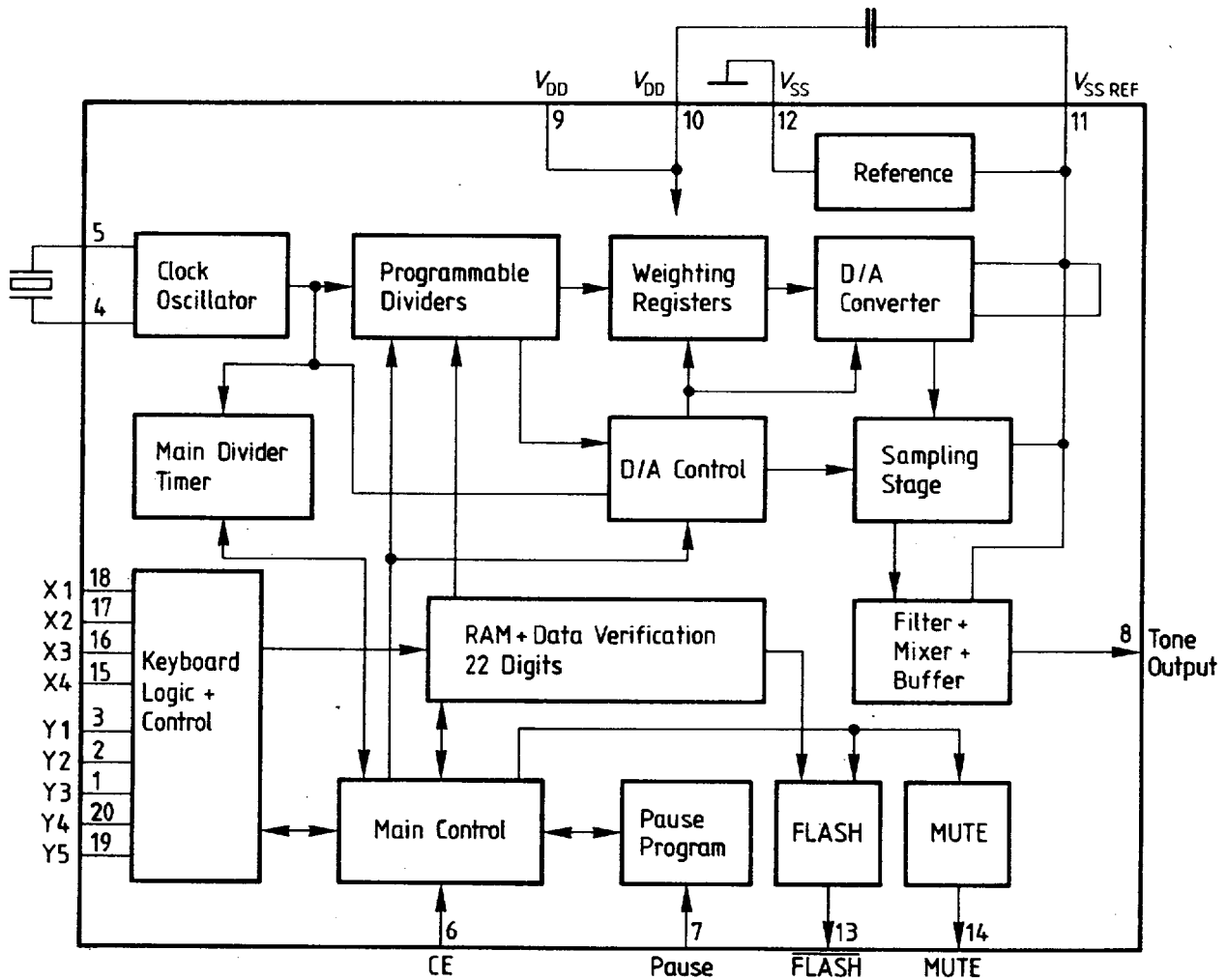
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PSB 8592
PSB 8593

T-75-27-09

Functional Description

Internal Logic Description

After recognizing a key closure, oscillator operation is started. When the oscillation is high enough to activate the first flipflop, the oscillator current is reduced and the entire logic is reset. The chip command first starts the logic comparator to suppress the switch bouncing. When the protection time has lapsed, the valid code is stored in the RAM. Next, the RAM is reset if the valid code is a newly dialled number. Then, the code is read out of the RAM, and it programs the two dividers of the sine-wave synthesizer. This is done continuously as long as the sending timer is active (80 ms), or until the key is released. In the meantime, further digits can be stored in the RAM. When the sending timer has stopped operation or the key contact is opened, a command will activate the pause timer (80 ms); the same counter is used in both cases. At this point, the command reads out the next digit from the RAM location or completes the function. The command also sets the MUTE output high when programming the dividers and low before completing the function. The MUTE output will remain low until new sinewaves are generated. If the recognized key closure is a redial function, a command will start to read out the stored number from RAM location. If the recognized key closure is a single-tone mode, the command will just program the appropriate divider during key depression. The MUTE output has the same function as in dual-tone mode without timing.

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T-75-27-09

Tone Generation

When a valid key closure is recognized or a digit is still in the RAM that is marked for access, the command programs the high and low group dividers with appropriate divider ratios. This means, the outputs of these dividers cycle at 26 times the desired high-group and low-group frequencies, respectively, for a minimum of 80 ms. The outputs of the programmable dividers drive two 6-stage up/down counters with connected sign bit. Every time, an up and down counting process has been completed, the sign bit is changed. In this way 26 equal time segments are generated within each output cycle. The 26 segments are used to digitally synthesize a stair-step waveform in order to approximate the sinewave function (see figure) in one D/A converter for the high and low-group frequency. Synthesizing the two sinewave functions in one D/A converter requires the converter's working below 600 ns, as it is to be multiplexed between the two functions. This is done by connecting a sinewave-adjusted capacitor network between the two outputs of the converter via a sign bit circuit that is applied to $V_{REF} = V_{DD}$ or V_{SS} and virtual ground. The peak-to-peak amplitude of the stair-step function is adjusted by a connected sample and hold capacitor having a different value for the high and low frequency group, respectively. The sample and hold capacitor is followed by two low-pass filters, one for the high and one for the low-frequency group. The individual tones generated with different amplitudes and filtered separately are added linearly and drive an output buffer.

Single-Tone Mode

A low-group tone can be generated by activating the appropriate row inputs connected to ground. A high-group tone can be generated by activating the appropriate column inputs with V_{DD}. In this mode no digit-frequency combination will be activated and no digit will be stored in the RAM.

The generation time depends on the duration of the input function. A stored phone number remains in the RAM.

Clock Generation

The device contains an oscillator circuit with the necessary parasitic capacitances on-chip, so it is only required to connect the standard 3.58 MHz TV crystal across the OSC I and OSC 0 terminals in order to implement the oscillator function.

Whenever a row or column input is activated the oscillator is operating until all timing functions are terminated.

6

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T–75–27–09

## Connection to Keyboard
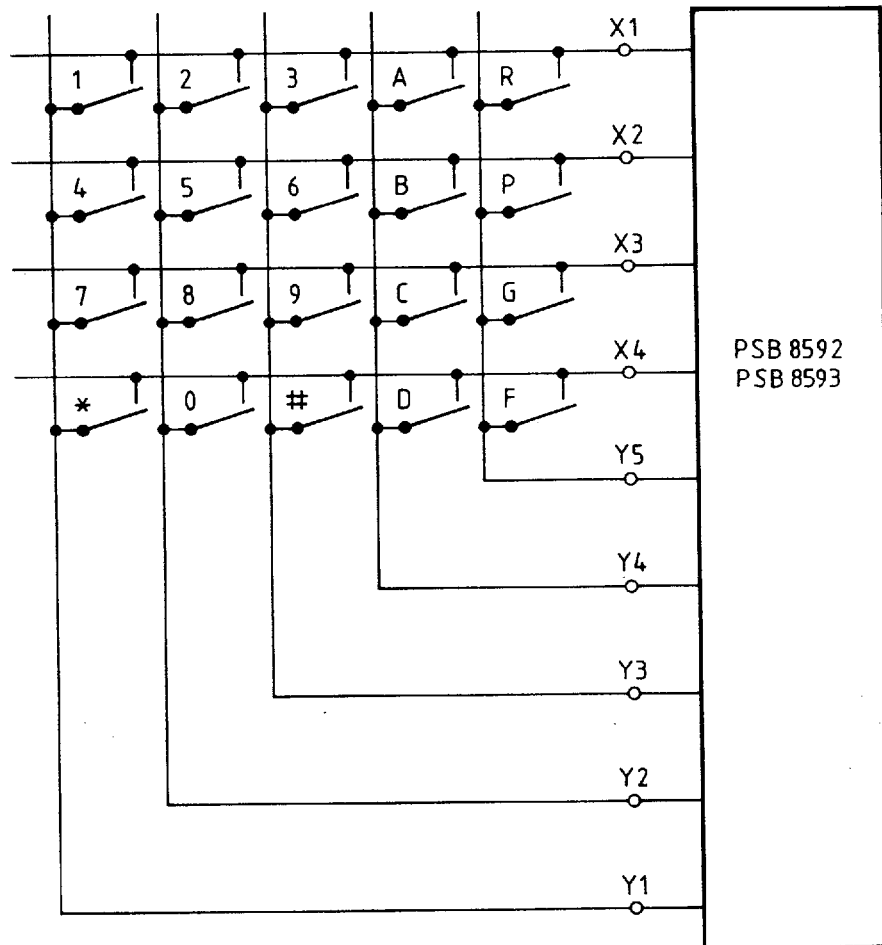
Keyboard Interface

The device can be connected directly on an X-Y matrix keyboard and requires no protection against multi-key function. An internal logic prevents the transmission of illegal tones when more than one key is pressed. Individual tones can be obtained by connecting a column input to V_{DD} or grounding a row input. After key recognition the inputs are static, i.e. there is no noise generation as it is the case with scanned or dynamic inputs.

An interrupt of longer than 4 ms on the key inputs releases the key function in the recognition circuit. After this the next digit is detected.

1

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T-75-27-09

Synthesized Output Waveforms
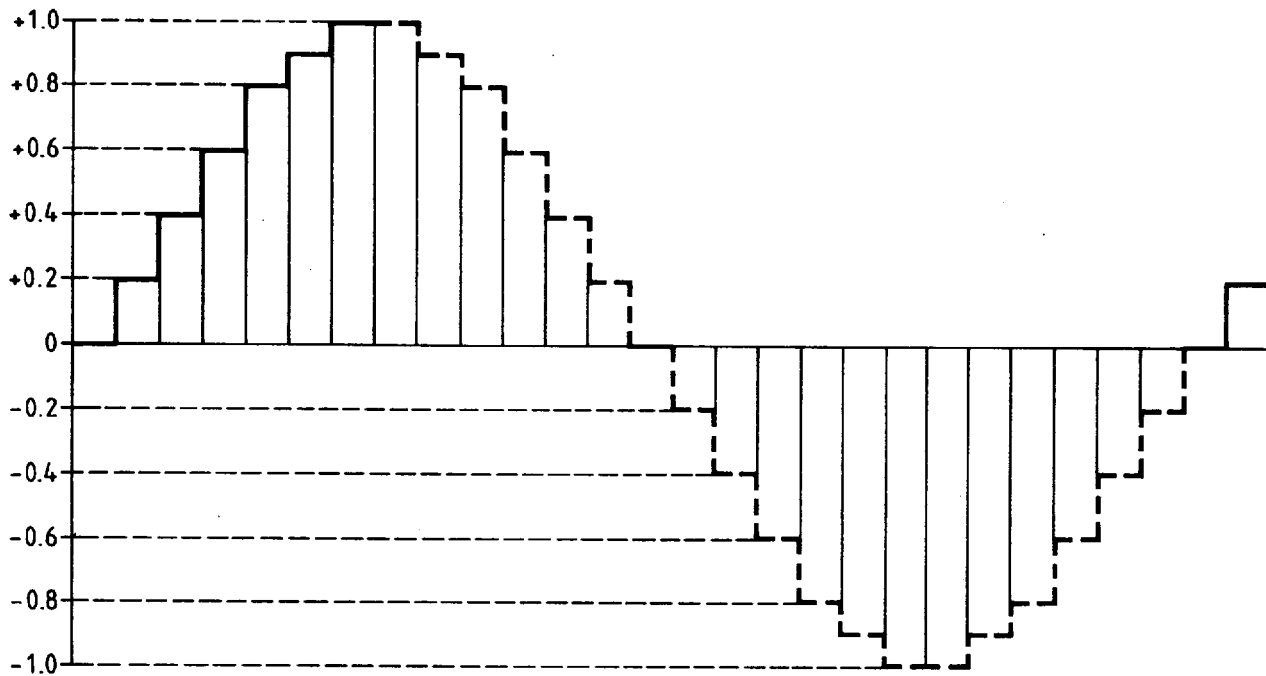
Active Input	Output Frequency (Hz)		(%)
	Specified	Actual	without Crystal Drift
X1	697	695.32731	−0.241
X2	770	773.4539	+0.448
X3	852	849.84449	−0.254
X4	941	942.97813	+0.210
Y1	1209	1207.67375	−0.110
Y2	1336	1336.64862	+0.049
Y3	1477	1480.37428	+0.228
Y4	1633	1638.98581	+0.365

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

Special Functions

Keyboard Configuration (with maximum number of keys)

The position of the 4 special keys is mask-programmable.

Redial Function

If the redial button is pressed after the handset has been picked up, all numbers stored in the RAM including pause and flash function will be sent out.

After termination and during redial function it is possible to dial also further digits which will be sent out after termination of the redial function.

Before starting the redial function a supervisory equipment checks the usefulness of the RAM contents.

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

Programming of Pause

If the telephone system needs pauses e.g. for trunk searching of dial-tone connection, the pauses must be stored in the RAM. To store such pauses, only depress the pause-button; afterwards further digits can be dialled. The number of pauses is unlimited. The timing of the pause is programmable via the pause-programming pin.

There are 3 choices:

Programming pin connected to V_{DD}:   3 s,
                       connected to ground (V_{SS}):   5 s
                       open: unlimited pause.

Go Function

The go button terminates the unlimited pause. Furthermore, it is possible to terminate even pause functions with fixed timing earlier. With a transistor connected in parallel to the go button switch the pause can be terminated by operating the transistor via a dial-tone recognition circuit.

Flash Function

The flash function is handled like the pause function, it is stored in the RAM. The number of flashes is unlimited. The flash output goes to V_{SS} for 90 ms; once the flash function is completed the DTMF signalling will continue after a pause of 900 ms.

BCD Coding

The device offers the possibility to use a BCD interface. BCD inputs are the column pins Y1 to Y5. To program the device for BCD code, row inputs X1 and X4 must be grounded upon the BCD code's appearance on the column inputs. All digits, including pause and flash, are stored in the RAM. The minimum timing is 5 to 8 ms. A quick timing for BCD code input is possible with test mode feature.

Hook Switch/Power Down

The device is in power down mode when the hook switch input is low. In this mode, the pullup resistors are disconnected at the 4 row inputs and all inputs are passive. In this case, the maximum ratings apply to the inputs. If the hook switch input is high = V_{DD}, the row and column inputs will be activated and the device started via the inputs.

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T-75-27-09

Option: Various branch exchanges show interrupts in the line-power supply during trunk searching. Therefore, it is difficult to detect the right onhook-switch function; we recommend to use our line-power fault detection featuring the following: After every interrupt of line power supply, the device starts a "wait cycle" of 240 ms, during this time power is supplied by the buffer capacitor (only DTMF and PAUSE function). If the line power supply is restored in the meantime, the device will ignore the interrupt; after 240 ms, the device will accept the interrupt as an exchange release and the stored digits are prepared for redial. During interrupt, the device accepts dialling but can not send DTMF.

Electrical Characteristics

Absolute Maximum Ratings

		min.	max.	
DC supply voltage	V_{DD}-V_{SS}	−0.3	+7	V
Input voltage at any pin	V_I	−0.3	V_{DD}+0.3	V
Power dissipation at 25°C	P		10	mW
Operating temperature	T_A	−25	70	°C
Storage temperature	T_{stg}	−55	125	°C

11

Dual-Tone Multi-Frequency Generator

PSB 8592
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T-75-27-09

DC Characteristics ($T_A = 25°C$)

		Test conditions	min.	typ.	max.	
Supply voltage =	V_{DD}	PSB 8592	3.0	3.5	4.5	V
reference voltage	V_{DD}	PSB 8593	3.0	3.5	6.0	V
Operating current	I_{DD}	One key selected tone and MUTE output unloaded $V_{DD} = 3.5$ V	1	1.5	2.0	mA
Standby current	I_{DD}	No key selected output unloaded $V_{DD} = 3.5$ V	–	1	2	μA
Standby voltage	V_{DD}	For data retention	1.2	–	–	V
MUTE output		$V_{DD} = 3.5$ V	0.5	1	2	mA
	I_{OH}	$V_{OH} = 3$ V				
	I_{OL}	$V_{OL} = 0.4$ V	1	2	3	mA
Flash output	I_{OL}	Open drain	1	2	3	mA
Inputs						
Chip enable CE	V_{IH}		3	–	V_S	V
	V_{IL}		–	–	0.5	V
Input leakage current	$+I_{IH}$	CE = H			50	nA
	$-I_{IL}$	CE = L			50	nA
Pause programming pin						
high level	V_{IH}	During scanning, load	3	–	V_S	V
low level	V_{IL}	capacitance $C_L = 50$ pF	–	–	0.5	V
Open input			600	–	–	kΩ
Matrix keyboard operation						
Keyboard current	I_{Key}	X connected to Y CE = H	100	150	200	μA
Keyboard						
ON resistance	$R_{Key ON}$	Contact ON	–	–	1	kΩ
OFF resistance	$R_{Key OFF}$	Contact OFF	100	–	–	kΩ
Input current for						
X_n ON	$-I_{IL}$	$V_I = 0...1$ V	100	150	200	μA
Y_n ON	$+I_{IH}$	$V_I = 2.5...3.5$ V	200	300	400	μA
Frequency OUT						
Output dc level		CE = H	1.70	1.75	1.8	V
Small-signal output impedance	Z_O		0.5	1.5	3	kΩ

12

Dual-Tone Multi-Frequency Generator

PSB 8592
PSB 8593

T–75–27–09

AC Characteristics ($T_A = 25°C$)

		Test conditions	min.	typ.	max.	
Minimum load, ac-coupled	R_L	For specified distortion according to CEPT	15	–	–	$k\Omega$
Frequency output						
sum level	P_S		–	496	–	mV_{rms}
low group	P_L		275	309	350	mV_{rms}
high group	P_H		346	388	435	mV_{rms}
Preemphasis	P_D		1	2	3	dB
Frequency deviation	Δf		0.254	–	+0.448	%
Timing specifications			4.5	–	–	ms
Debounce time	t_d					
Setup time	t_s	Min. debounce + oscillator start-up time	5.5	6.0	6.5	ms
(key pressed to frequency OUT)						
Binary input						
Data valid	t		7	–	–	ms
Data change	t		10	–	–	ms

Dual-Tone Multi-Frequency Generator

Timing Diagrams
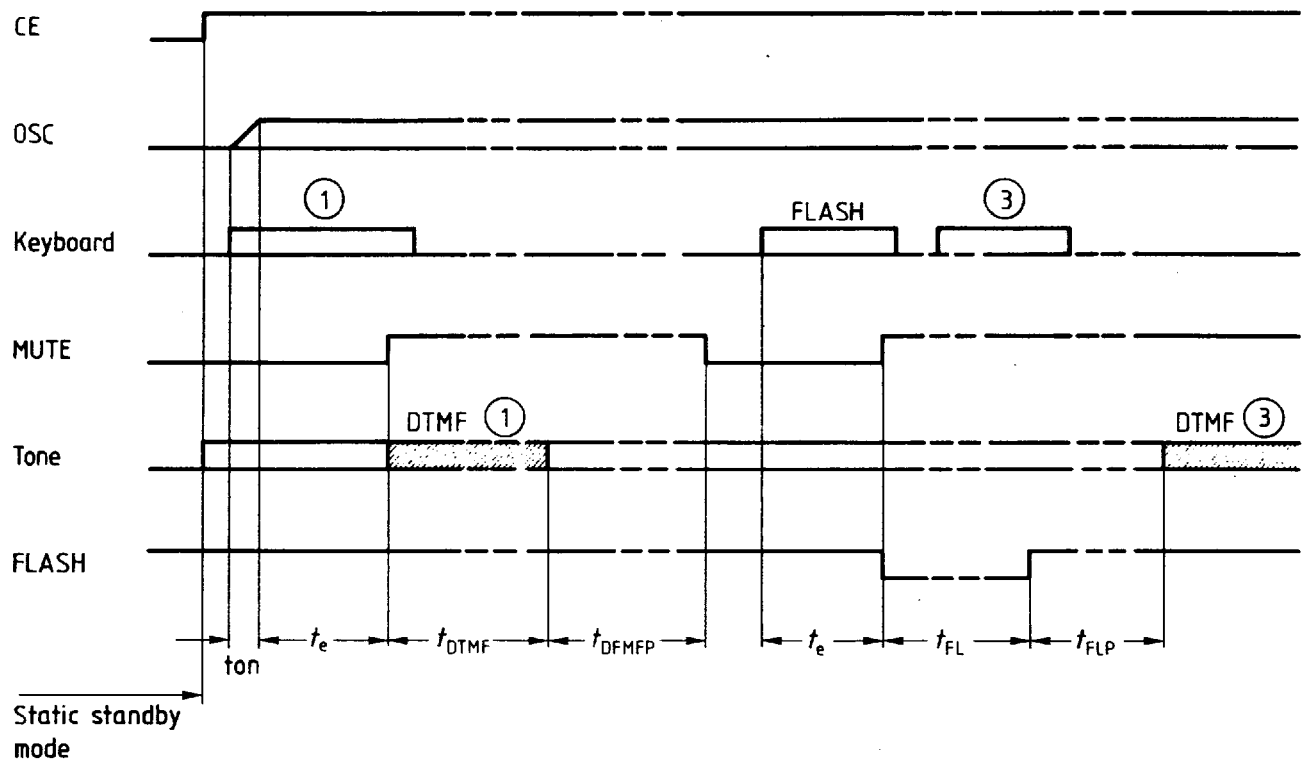
Oscillator start-up upon key depression (t_{on}), key recognition time (t_e),
DTMF (t_{DTMF}, t_{DTMFP}), and FLASH (t_{FL}, t_{FLP})

Timing specs:
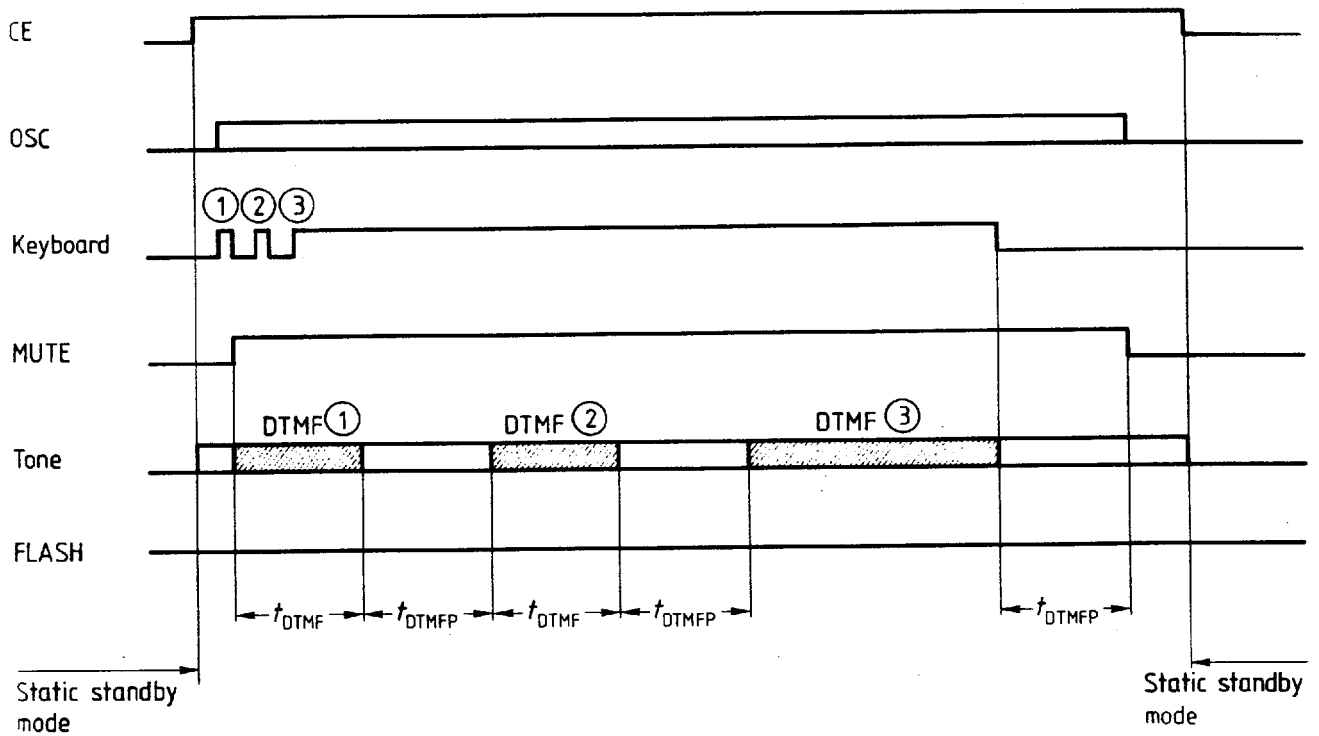
	typ.	max.	
t_{on}	–	2	ms
t_e	4.7	–	ms
t_{DTMF}	80	–	ms
t_{DTMFP}	80	–	ms
t_{FL}	90	–	ms
t_{FLP}	870	–	ms

Figure 1

14

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Signals at fast as well as slow data entry (sending time extension)
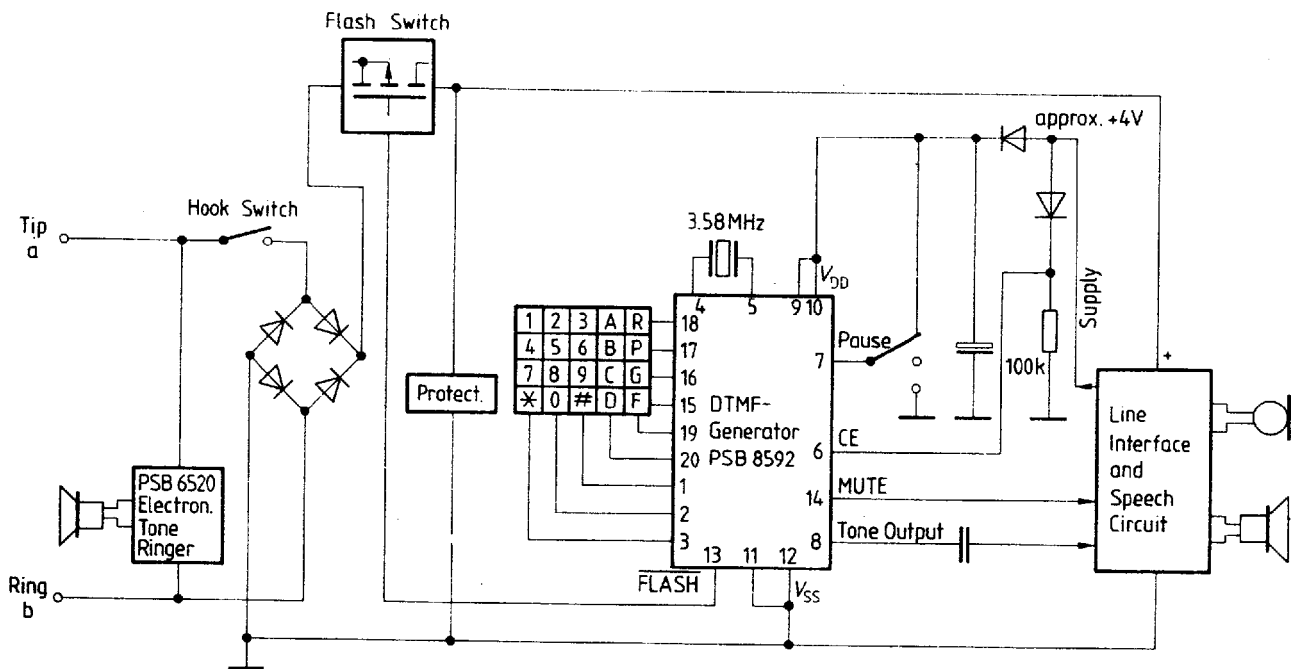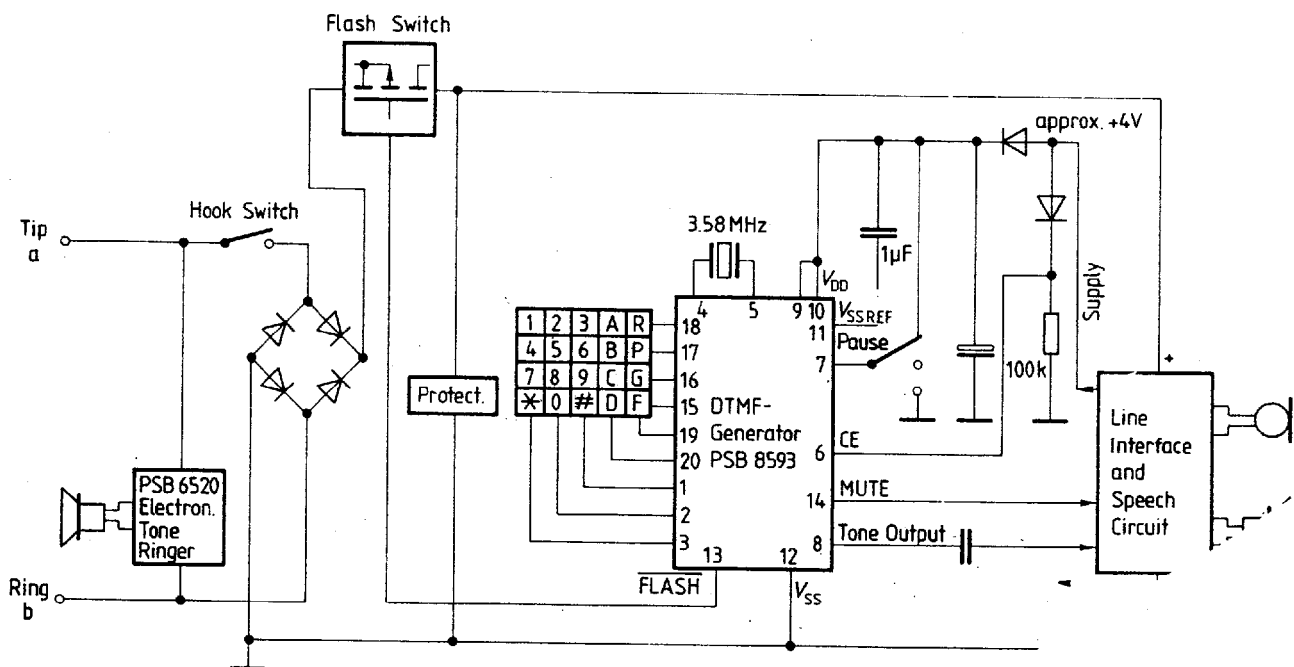
Figure 2

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Key Closure Recognition with X-Y Keyboard

Case 1

Case 2

Case 3

t_p = Time Protection (4 ms)
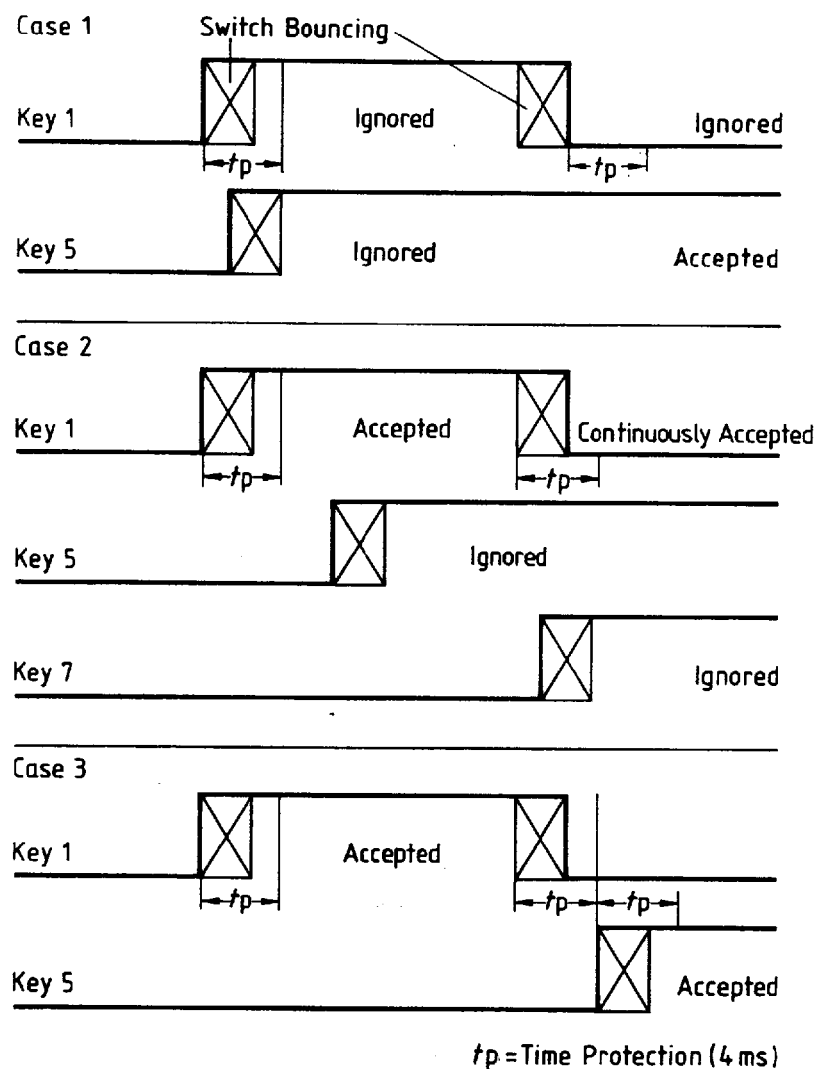
Dual-Tone Multi-Frequency Generator

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Simplified Circuit Example
Telephone Set with PSB 8592

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Telephone Set with PSB 8593

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**Auxiliary Test Circuits
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