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LD/DTMF SWITCHABLE DIALLERS
WITH DEDICATED KEYS FOR 20 MEMORIES

FEATURES

- Selectable Loop-Disconnect or DTMF Modes

- Keypad Switchable LD to DTMF

- 20 x 24-Digit Memories, (each with Dedicated Key)

- 24 Digit Last Number Redial

- Selectable Make/Break Ratios 2:1 and 3:2

- Uses Inexpensive 560kHz Ceramic Resonator

- Batteryless operation - Low Power CMOS

- Mask Programmable Options to suit application

- Timed Break Recall (Flash) and Earth Recall

DESCRIPTION

The SA589 family are keypad switchable LD/ DTMF dialler devices with a last number redial facility and twenty 24-digit memories each with its own dedicated dialling key.

Three operating modes are available: LD only mode, DTMF only mode and LD mode with the ability to switch temporarily to DTMF mode from the keypad during a call. This last mode enables subscribers to access such services as home banking. Mixed LD and DTMF numbers can also be stored in memory.

The SA589 devices are pin compatible with the SAMES switchable dialler families SA541, SA545, SA585, SA587 and SA588 - providing a complete range of telephone features within a single PCB and circuit design. Metal mask and pin selectable options are available to service specific requirements of particular countries and customers.
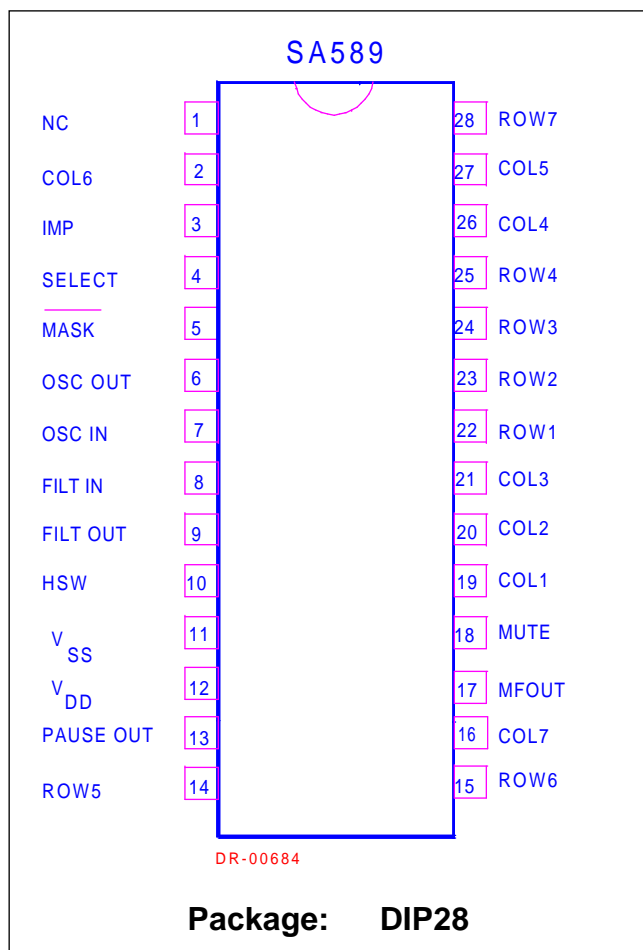
FIG. 1 PIN CONNECTIONS

SA589

NC	1	28 ROW7
COL6	2	27 COL5
IMP	3	26 COL4
SELECT	4	25 ROW4
MASK	5	24 ROW3
OSC OUT	6	23 ROW2
OSC IN	7	22 ROW1
FILT IN	8	21 COL3
FILT OUT	9	20 COL2
HSW	10	19 COL1
V_{SS}	11	18 MUTE
V_{DD}	12	17 MFOUT
PAUSE OUT	13	16 COL7
ROW5	14	15 ROW6

DR-00684

Package: DIP28

TABLE 1: PIN FUNCTIONS

Pin number	Pin name	Function
1	NC	Not connected
3	IMP	'Loop disconnect' dialling output
4	SELECT	LD/DTMF selection, IDP and B/M ratio programming
5	MASK	Output to disable speech circuit during pulse dialling and recall (see note 1)
6	OSC OUT	Connections for 560kHz ceramic resonator
7	OSC IN	
8	FILT IN	Unity gain amplifier input and output for DTMF tone filtering
9	FILT OUT	
10	HSW Hook'	Hookswitch input - a logic 1 at this pin is used to indicate 'Off-Hook'
11	V_{SS}	Negative supply
12	V_{DD}	Positive supply
13	PAUSE OUT	Active high indicating a pause when dialling from memory
17	MF OUT	Unfiltered DTMF output
18	MUTE	Output active during keying and tone transmission (see note 2)
19	COL1	
20	COL2	
21	COL3	
26	COL4	
27	COL5	
2	COL6	
16	COL7	
22	ROW1	Connections for 38 key single contact keypad
23	ROW2	
24	ROW3	
25	ROW4	
14	ROW 5	
15	ROW 6	
28	ROW 7	

1. MASK may be used to disconnect the whole speech circuit in order to maintain the break condition whilst on-hook and during a TBR (Timed Flash) operation.

2. MUTE is provided to disable the microphone while maintaining the loop during DTMF transmission.

OPERATION
Power-on
When power is applied to the chip, a power-on reset circuit operates and ensures that the Memories are cleared and all logic is reset. The power-on reset circuit is designed such that if the chip supply voltage drops to a level at which the memories may be corrupted, it will always, under all conditions, clear the memory, so that corrupt data is not retained.

Hookswitch Operation

The HSW input is used to inform the SA589 of whether the telephone is on or off hook. Logic '0' is recognised as on-hook. Logic '1' is recognised as off-hook. When the HSW input rises from '0' to '1' the off-hook state is recognised immediately and keypad inputs are accepted. However, when the HSW input falls from '1' to '0' the on-hook state is not recognised for 200 - 300ms. This is so that short line breaks of less than 200ms, such as the line reversals applied by the exchange, are ignored. In this case the IMP and $\overline{MASK}$ outputs will go low immediately the HSW input goes low in order to preserve current, but will resume normal operation immediately HSW goes high.

On-hook state

In the on-hook state all chip outputs are set low, the oscillator circuit is inhibited and no key inputs are accepted. This conserves supply current so that the MEMORY contents may be retained.

Off-hook state

When the HSW input goes high, the $\overline{MASK}$ output immediately goes to the logic '1' level and remains there until going on-hook or signalling a TBR, (see timing diagram). COLUMN outputs also go high until a key is pressed and are normally off whenever timing functions are not required.

Keypad Operation

A Single Contact, Normally Open keypad is required. When off-hook the COLUMN outputs are normally held high and the ROW inputs are low. When a key is pressed this connects a COLUMN output to a ROW input and the ROW input is pulled high.

This action initiates keyboard scanning. During keyboard scanning, the COLUMN outputs are normally low but generate scanning pulses at 7ms intervals on each output in sequence. A key is accepted as valid when two successive scanning pulses from the same COLUMN are seen on a ROW input. Hence, the minimum bounce-free key closure period which is necessary to guarantee detection is about 14ms (plus the oscillator start-up time if it was not already running).

Simultaneous key depressions

If two keys are pressed simultaneously (i.e. a second key is pressed before the first has been verified) neither key will be accepted until both keys are released and the correct key is pressed again.

Dialling Mode Selection

The dialling mode may be selected via the SELECT pin (Pin 4) as detailed in Table 2. Four 'Loop-Disconnect' + DTMF options, two 'Loop-disconnect only' options and three DTMF modes are available. Each mode offers a different combination of LD and/or MF timing. If one of the 'LD only' or DTMF only modes is selected then dialling will remain fixed in LD mode or DTMF mode respectively.

	COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7
ROW 1	1	2	3	TBR	S01	S02	S03
ROW2	4	5	6	REDIAL	S04	S05	S06
ROW3	7	8	9	STORE	S07	S08	S09
ROW4	*	0	#	PAUSE/ CONT	SHIFT	S00	LNR
ROW5					S11	S12	S13
ROW6				S10	S14	S15	S16
ROW7					S17	S18	S19

Fig. 2a Versions without TONE key

* or */# are used to change from LD to DTMF dialling and are available as digits when in DTMF mode.

TBR: Timed Break Recall (Flash).

STORE: Memory Programming key. Use in conjunction with dedicated memory keys or a two-digit code representing the number of the memory to be programmed

S00-S19: 'Single touch' dedicated memory dialling keys

LNR: Last Number Redial

REDIAL and **SHIFT:** These keys are clearly unnecessary where keypad positions are provided for all the dedicated memory keys but may be useful to access memories in applications where the telephone provides insufficient keys for all these functions. For a description of the function of the REDIALand SHIFT keys, see the SA585 and SA587 data sheets, respectively. Do not fir keys in these positions if not required.

PAUSE/CONT: Insert pause in memory/continue dialling

TONE: Change dialling mode from LD to DTMF

	COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7
ROW 1	1	2	3	TBR	S01	S02	S03
ROW2	4	5	6	REDIAL	S04	S05	S06
ROW3	7	8	9	STORE	S07	S08	S09
ROW4	*	0	#	TONE	SHIFT	S00	LNR
ROW5					S11	S12	S13
ROW6				S10	S14	S15	S16
ROW7					S17	S18	S19

Fig. 2b Versions with TONE key

Fig. 2 Keypad layout and connections

TABLE 2: Dialling mode selection

Select Pin to	Dialling Mode	B:M Ratio	TBR (msec)
V_{SS}	LD + DTMF	2:1	100
COL1	LD + DTMF	2:1	270
COL2	LD + DTMF	3:2	270
COL3	LD + DTMF	3:2	100
COL4	LD only	2:1	-
COL5	DTMF only	-	270
COL6	DTMF only	-	270
COL7	LD only	3:2	-
V_{DD}	DTMF only	-	100

However, if one of the 'LD + DTMF' modes is selected the chip will be in LD mode initially in the off-hook condition but may be switched to DTMF by pressing either *, */# or TONE key (depending on the mask variant - see Fig. 2 and page 11), provided that dialling is not in progress. If any of these keys are pressed during LD dialling, they will be ignored.

Only if * or # are pressed subsequent to switching to DTMF, will * or # be dialled. Only digits entered prior to a switch to DTMF will subsequently be available for redialling (see Last Number Redial operation), unless specified otherwise.

Once switched to DTMF, dialling will remain in this mode until either a Recall (Flash) operation or until the chip returns to the on-hook state.

Last Number Redial (LNR)
The function of the on-chip LNR store is to retain automatically a manually dialled number for redialling later. The capacity of the memory is 24 digits. If a number is dialled which is longer than this, dialling will continue, but redialling will not be allowed with this number. To redial a number in the LNR store, the LNR key may be pressed once, or the Redial key can be pressed twice.

The last number redial store has several features designed to assist the user:

Moving cursor facility
This facility is provided to aid use in PABX applications, where the user must first dial an access digit, or digits, and then wait for a second dial tone before continuing dialling.

This allows a user to enter the first digit or digits of the number in the last number redial store manually before pressing the LNR key; the remainder of the number will be dialled when the LNR key is pressed.

If the digit(s) dialled manually do not match those in the LNR memory, then redialling will be inhibited for the remainder of the call, and the numbers entered will be saved in the LNR memory for redialling in a subsequent call.

If the user manually dials the first digit(s) in the LNR memory, and then goes on-hook, the whole contents of the memory will be retained.

Mixed Mode Calls

In the case of a call which starts in LD mode and is switched by the user (via the *, */#, or TONE key) to DTMF mode, only the digits dialled in LD mode will be retained. This feature is provided to ensure security of PIN (Personal Identification Number) codes. Provided that the number of digits dialled in LD mode does not exceed 24, they will be retained regardless of the number of DTMF digits entered subsequently.

Memory Dialling

The SA589 provides 20 memories, each of which has a capacity of 24 digits and each of which has its own dedicated key . The memories can save digits for dialling in LD, DTMF and Mixed Modes and can include pauses if desired.

Programming Memories

The SA589 must be 'off-hook' and idle:

1.   Press the STORE key.

2.   Press the key (S00 - S19) of the memory to be programmed.

3.   Enter digits to be stored (no digits will be dialled whilst programming).

4.   To finish programming the memory either press the STORE key again or go 'on-hook'.

5.   Repeat to programme other memories.

If more than 24 digits are entered while programming a memory, then the memory will be cleared until reprogrammed.   If any non-valid keys are pressed during programming (e.g.LNR, TBR) they will be ignored.

Mixed mode numbers and Pauses in memory

Mixed mode (i.e. LD + DTMF) numbers are easily programmed into memory. The SELECT pin should be set to one of the 'LD + DTMF' modes (as it would be when dialling a mixed mode number), then the number entered using the same procedure as if dialling normally. The first press of *, */# or TONE (according to the mask variant) will be stored as a 'change to DTMF' and this will cause all subsequent digits to be sent in DTMF when redialling from memory.

Similarly, pauses can be stored in memory by pressing the PAUSE key in the appropriate position when programming.

When redialling from memory, both Pauses and LD to DTMF changeovers will cause dialling to halt temporarily until the user presses the PAUSE/CONT key. The exception to this rule is when an LD to DTMF changeover, is stored in the first memory location; in this case, DTMF dialling will occur immediately when memory dialling is invoked - this allows DTMF codes to be easily stored and sent even in a telephone where the normal dialling mode is LD.

It should be noted that a Pause or an LD to DTMF changeover each require one memory location.

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Dialling from memories

The SA589 must be 'off-hook' and idle:

1.   Press the appropriate memory key (S00 - S19). Dialling will now start.

2.   If dialling halts due to a Pause or an LD to DTMF changeover in the memory, the PAUSE OUT pin will go high (logic '1'). Further dialling can be resumed by pressing the PAUSE/ CONT key or alternatively, by pulling the Column 4 pin low (for a minimum of 14 ms) to achieve the same result thus allowing an external timer circuit to be used. The PAUSE OUT output is reset when dialling resumes.

All keypad positions are disabled whilst memory dialling is in progress.

Timed Break & Earth Loop Recall

The SA589 supports both TBR and ELR and offers a common operating protocol in both cases.

After a recall (Flash) operation, the dialling mode selected via the SELECT pin will be restored. Also, only the digits dialled after the ELR/TBR operation will be retained in the LNR store [1].

A TBR (Flash) of 100ms or 270ms[2] is generated when the TBR key is pressed. The MASK output goes low in order to produce the line break. When in DTMF mode, the MF OUT output also goes low for the duration of the break.

ELR is supported via the column 3 pin. If this pin is connected to ground for a minimum of 20ms during an ELR operation, the chip will offer the same operating protocol as for TBR.

This may be achieved by use of the circuit shown below in Fig. 3, or by use of a double contact switch.

(1)   *Other options are available.*

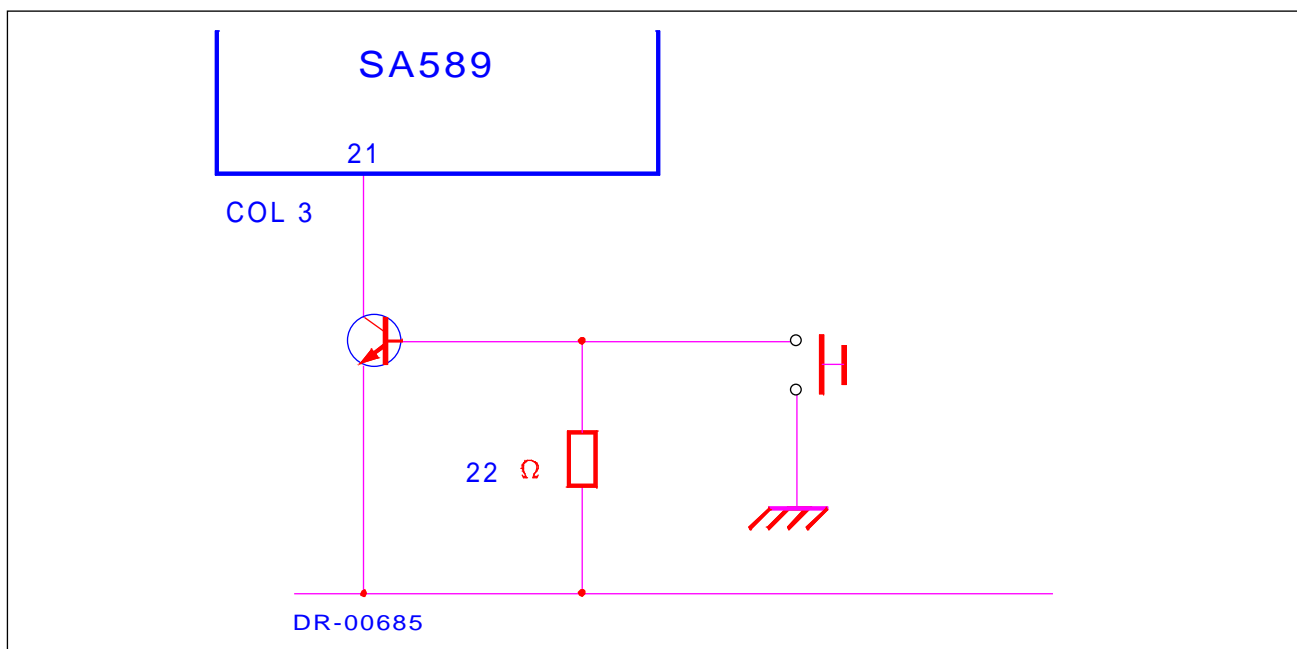*(2)*   *Other TBR (Flash) periods are available as mask options*

Fig. 3 Earth loop recall

Oscillator Circuit

This requires an external 560kHz ceramic resonator connected between OSC IN and OSC OUT to provide a timing reference for all chip functions. No other components are required or should be used.

The oscillator circuit is of the 'single pin' type. Internally, the OSC IN pin is connected to V_{SS} and therefore the resonator may alternatively be connected externally between OSC OUT and V_{SS} if desired.

Please consult your resonator supplier who will recommend a suitable resonator type.

Tone Filtering

The spectral purity of the DTMF output is sufficient for most applications. However, where lower distortion DTMF tones are required, an on-chip darlington pair is provided (accessible via pins 7 & 8) for use in a low pass active filter.

Fig. 4 shows how a 2-pole Sallen and Key filter can be implemented. The typical component values have been chosen to give a second order Butterworth response with a cut-off frequency of about 3,5kHz and a nominal pass-band insertion loss of 0.5dB.

DTMF DIALLING

During DTMF dialling the MUTE output goes to logic '1' and remains there for the duration of the tone transmission.

The IMP output remains low during tone transmission. The MF OUT output rises to its DC level of 0.9 V_{DD} at the start of the tone transmission and is kept there between tone bursts. This is to avoid transients at the beginning and end of tone bursts.

The maximum rate at which tones are sent to line is 100ms on, followed by 100ms off (unless specified otherwise). If keys are activated faster than this they are placed in a temporary store and then sent to line at the maximum rate. Dialling from the LNR memory occurs at the maximum rate.

If a key is held down for longer than the minimum Tone Burst period, the tone output will continue until the key is released.
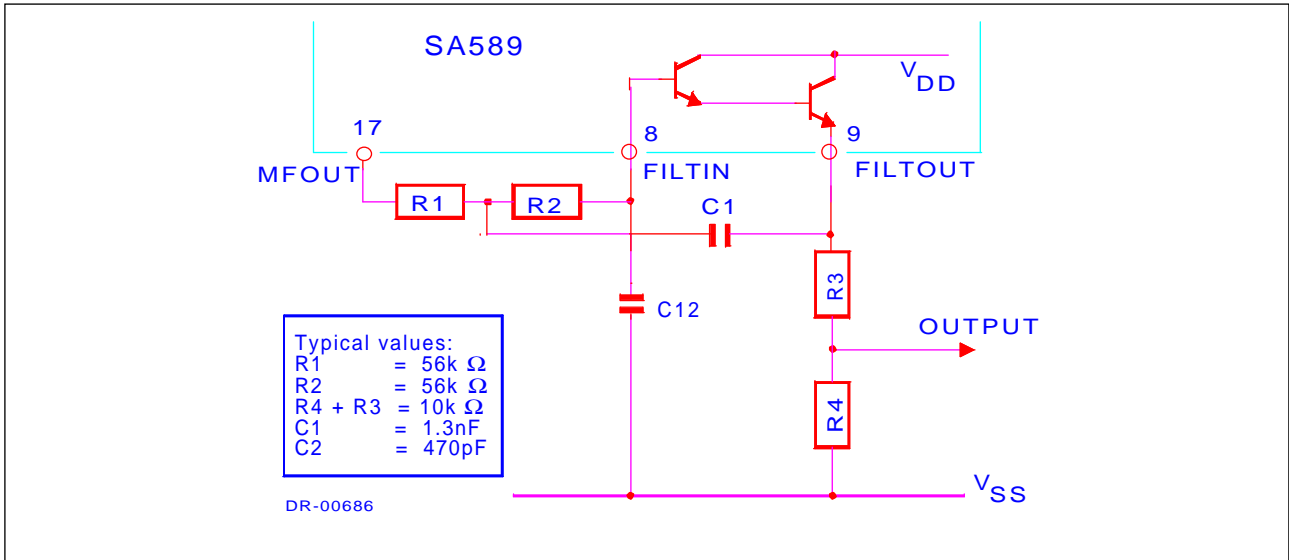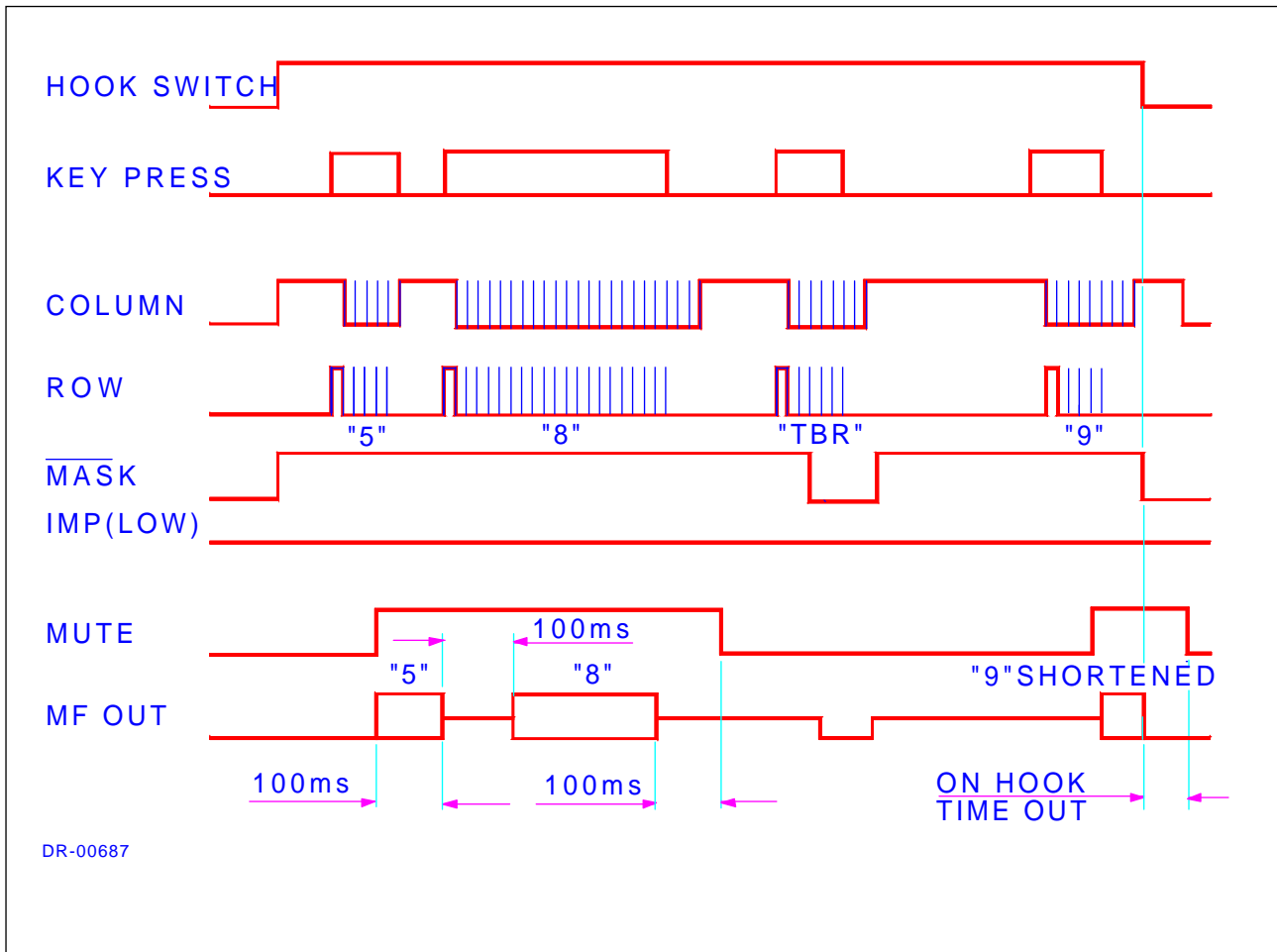
Fig. 4 DTMF tone filtering

Fig. 5 DTMF mode timing diagram

TABLE 3: Tone Frequencies

Keypad	R1	R2	R3	R4	C1	C2	C3	C4
Nominal frequency (Hz)	697	770	852	941	1209	1336	1477	1633
Deviation from nominal (%)	-0.07	-0.10	+0.19	-0.15	-0.17	-0.20	-0.22	-0.31

NOTE: There will be an additional frequency error caused by any deviation of the resonator
frequency from the nominal 560kHz.

LOOP DISCONNECT DIALLING

The $\overline{\text{MASK}}$ output is provided in order to disable the speech circuit during LD dialling. Consequently the $\overline{\text{MASK}}$ output is normally at logic '1' in the off-hook condition, but changes to logic '0' during LD dialling. $\overline{\text{MASK}}$ also changes to logic '0' in order to signal a Timed Break Recall (Flash) to the line.

Both MUTE and MF OUT remain low during LD dialling. LD dialling is signalled on the IMP output. A break is signalled by a logic '0'. Make periods and IDP times are signalled by a logic '1'. When not dialling, the IMP output sits at logic '0'.
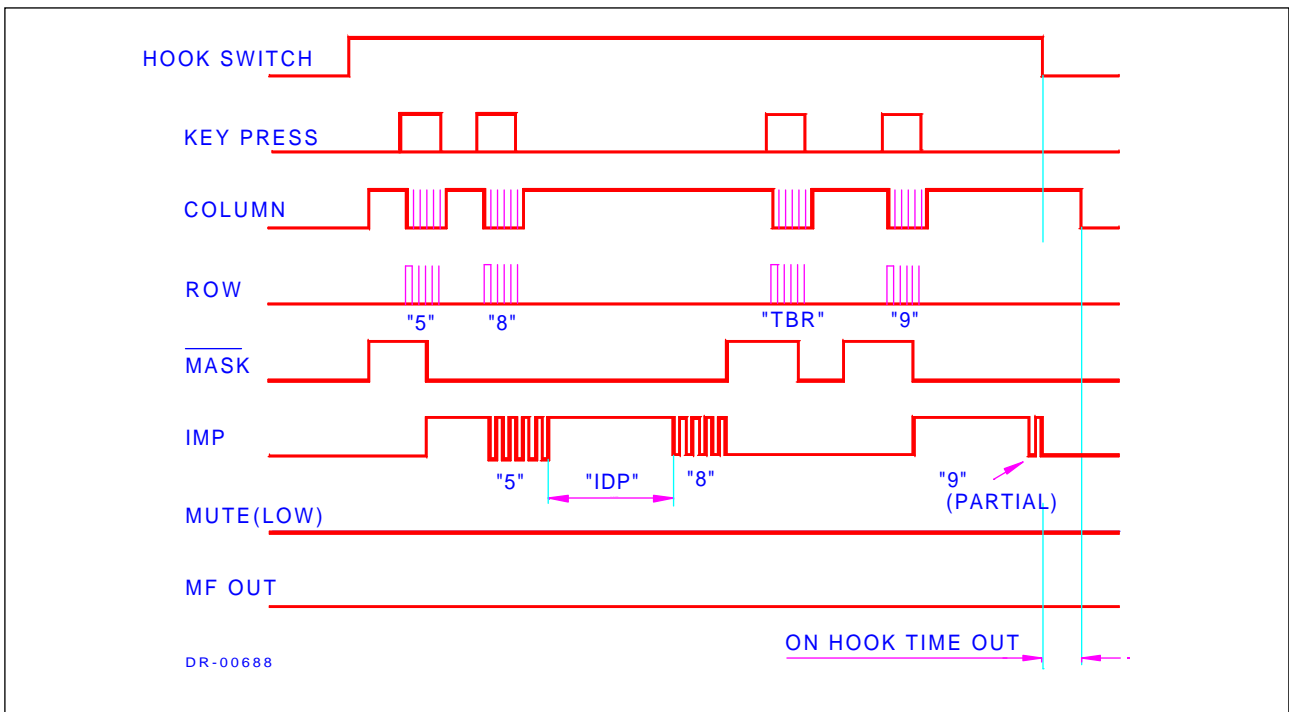
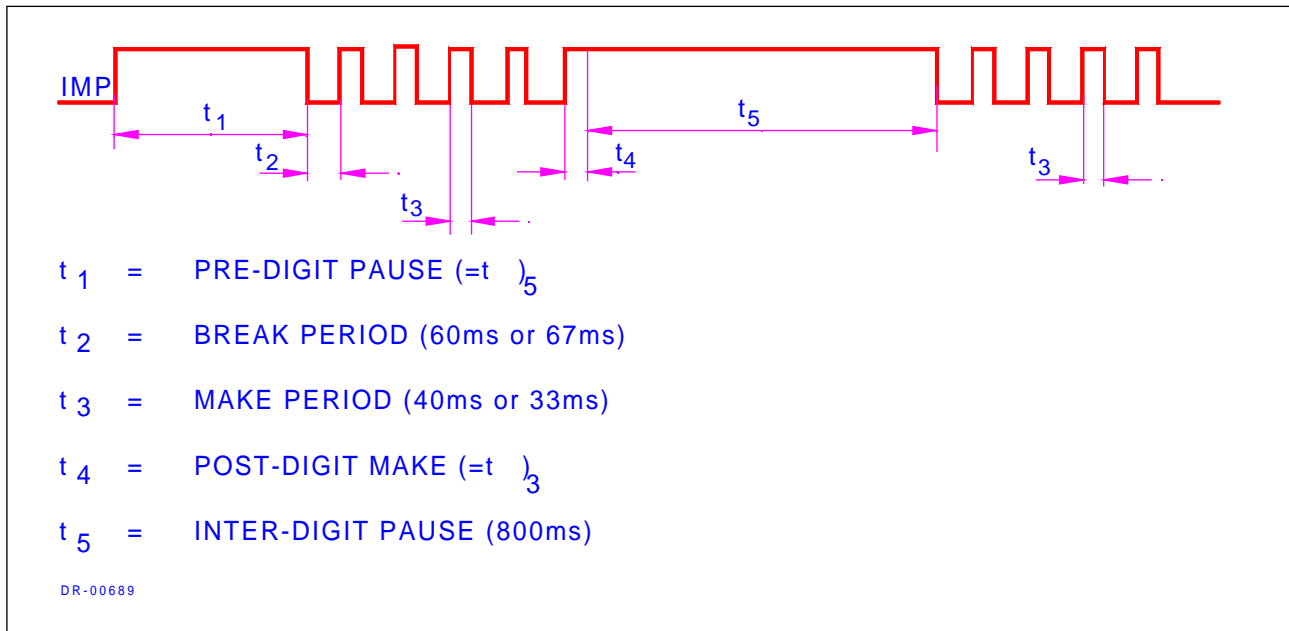

Fig. 6 LD mode timing diagram

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t $_1$ = PRE-DIGIT PAUSE (=t)$_5$

t $_2$ = BREAK PERIOD (60ms or 67ms)

t $_3$ = MAKE PERIOD (40ms or 33ms)

t $_4$ = POST-DIGIT MAKE (=t)$_3$

t $_5$ = INTER-DIGIT PAUSE (800ms)

DR-00689

Fig.7 Timing data

MASK OPTIONS

The SA589 has been designed so that many features can be altered quickly and inexpensively at the final stage of manufacture. These options allow the telephone manufacturer to cater for different market requirements throughout the world without changing the telephone circuit.

The options, listed below, are possible in any combination. Standard options are listed first in bold italics at 'a'. Other options may be produced by arrangement. Please consult your nearest SAMES Representative for advice on availability.

A.   'Long' TBR (Flash) Period
   a.   270ms
   b.   600ms
B.   LD to DTMF Keypad Switching
   a.   * and # keys
   b.   TONE key
   c.   * key

C.   Retention of Post-*/#Digits in LNR Store (DTMF Mode)
   a.   All digits retained
   b.   Digits before * or # retained

D.   Short/Long TBR Selection
   a.   As specified
   b.   Short and Long TBR reversed

E.   Recall (Flash)/LNR protocol
   a.   Digits dialled after Recall retained
   b.   Digits dialled before Recall retained

F. **DTMF Minimum Timings**
   a. *100ms on, 100ms off*
   b.   85ms on, 85ms off
   c.   85ms on, 170ms off

G. **Pin 5**
   a. *MASK̄*
   b.   MASK

H. **Pin 3**
   a. *IMP̄*
   b.   IMP̄
   c.   [IMP + MASK]̄
   d.   [IMP + MASK̄]̄

I. **Pin 18**
   a. *MŪTĒ*
   b.   MŪTE

J. **Pin 13 Function**
   a. *PAUSE OUT*
   b.   SECRECY

ABSOLUTE MAXIMUM RATINGS *

Parameter	Min	Typ	Max	Unit	Notes
Supply Voltage V_{DD} - V_{SS}	-0,3		6,5	V	
Voltage on any pin (except HSW)	V_{SS} -0,3		V_{DD} +0,3	V	
Voltage on pin HSW	V_{SS} -0,3			V	See Note 1
Current at any pin (except HSW, FILTOUT and FILTIN)	-1		1	mA	
Current at pin FILTOUT	0		0,1	mA	
Current at pin FILTIN	-5		0	mA	
Operating Temperature	-25		70	°C	
Storage Temperature	-55		125	°C	

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

Note 1: A diode is internally connected between this pin and V_{DD}. Provided current is externally limited to 300µA max, no damage will occur.

DC ELECTRICAL CHARACTERISTICS

(V_{DD} = 2,5V at 25°C, unless otherwise specified)

Condition		Min	Typ	Max	Unit	Notes
Supply voltage:	on-hook	1,8		5,7	V	For memory retention
	off-hook	2,4	5,7		V	
Hookswitch input:	on-hook			0,2 V_{DD}		
	off-hook	0,8 V_{DD}				
Supply Current:	on-hook		<0.2	5	µA	V_{DD} = 2.5V (See note 1)
	off-hook		1,5		µA	See note 1
	MF tone sending			1,0	mA	If MF OUT is low
	LD impulsing			200	µA	
Output High Voltage (MASK, MUTE and IMP Outputs)		2,2			V	I = -1mA
Output Low Voltage (MASK, MUTE and IMP Outputs)				0,3	V	I = +1mA
MF OUT d.c. Level During Tone Sending			0,9V_{DD}		V	
MF OUT Output Resistance			3		KΩ	
'Key Pressed' Resistance				2	KΩ	2,5V<V_{DD}<5,7V
'Key Not Pressed' Resistance		500			KΩ	2,5V<V_{DD}<5,7V
Darlington Pair Current Gain		600	50,000			I_e=100µA,V_{ce}=2V

NOTE 1: Specially tested versions with guaranteed lower on-hook supply current are available

AC ELECTRICAL CHARACTERISTICS

(V_{DD} = 2,5V at 25°C, unless otherwise specified)

Condition		Min	Typ	Max	Unit	Notes
Oscillating Frequency			560		kHz	
Tone Output:	Low Group	68	77		mVrms	No Load
	High Group		97	109	mVrms	No Load
High-to-Low Group Amplitude Ratio		1,5	2	2,5	dB	at MF OUT
Total harmonic Distortion:	0-4KHz		1,5		%	
	0-10KHz		2,5		%	
	0-50KHz		5,0		%	
	0-200KHz		6,5	10	%	

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