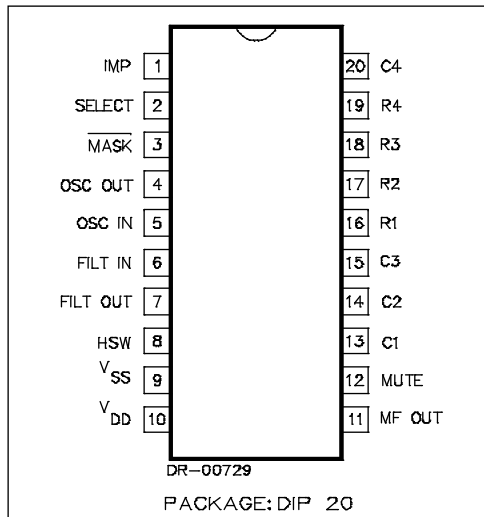


## PULSE/DTMF SWITCHABLE DIALLERS

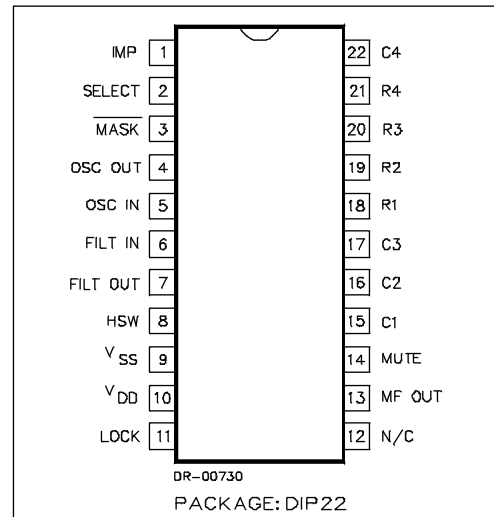
### FEATURES

- Selectable Loop-Disconnect (Pulse) or DTMF (Tone) dialling modes
- 32 Digit Last Number Redial (LNR)
- Selectable Interdigit Pause (IDP) 500ms or 800ms
- Operates with inexpensive single contact keypad
- On-chip Darlington transistor pair for DTMF tone filtering
- Low power CMOS technology enables direct operation from Telephone line
- Optional use of external capacitor for oscillator
- Keypad switchable Loop-Disconnect to DTMF during a call
- Selectable Break:Make Ratios 2:1 or 3:2
- Uses inexpensive 560KHz ceramic resonator
- Earth Loop Recall and Timed Break Recall (Timed Flash)
- Low on-hook Supply Current options  
SA5413 - 5 $\mu$ A @ 2.5V  
SA5416 - 1 $\mu$ A @ 2.5V  
SA5419 - 1 $\mu$ A @ 3.0V
- Call, barring/locking feature available on the SA54L1

### PIN CONNECTIONS: SA541



### PIN CONNECTIONS: SA54L1



## 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<br>(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 is 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 300 $\mu$ A 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<br>off-hook  | 1,8<br>2,4   |                             | 5,7<br>5,7                | V<br>V   | For memory retention  |
| Hookswitch input: on-hook<br>off-hook  | 0,8 $V_{DD}$ |                             | 0,2 $V_{DD}$              |  |   |
| Supply Current: on-hook<br>SA5413<br>SA5416<br>Sa5419<br>off-hook<br>MF tone sending<br>LD impulsing |              | <0.2<br><0.2<br><0.2<br>1,5 | 5<br>1<br>1<br>1,0<br>200 | $\mu$ A<br>$\mu$ A<br>$\mu$ A<br>mA<br>$\mu$ A | $V_{DD} = 2.5V$<br>$V_{DD} = 2.5V$<br>$V_{DD} = 3.0V$<br>If MF OUT is low |
| Output High Voltage<br>(MASK, MUTE and IMP Outputs)  | 2,2          |                             |                           | V  | $I = -1mA$  |
| Output Low Voltage<br>(MASK, MUTE and IMP Outputs)   |              |                             | 0,3                       | V  | $I = +1mA$  |
| MF OUT d.c. Level During Tone Sending  |              | 0,9 $V_{DD}$                |                           | V  |   |
| MF OUT Output Resistance   |              | 3                           |                           | k $\Omega$                                     |   |
| 'Key Pressed' Resistance   |              |                             | 2                         | k $\Omega$                                     | $2,5V < V_{DD} < 5,7V$  |
| 'Key Not Pressed' Resistance   | 500          |                             |                           | k $\Omega$                                     | $2,5V < V_{DD} < 5,7V$  |
| Darlington Pair Current Gain   | 600          | 50,000                      |                           |  | $I_e = 100\mu A, V_{ce} = 2V$   |

**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<br>High Group                                | 68  | 77<br>97                 | 109 | mVrms<br>mVrms   | No Load<br>No Load |
| High-to-Low Group Amplitude Ratio                                   | 1,5 | 2                        | 2,5 | dB               | At MF Out          |
| Total harmonic Distortion: 0-4KHz<br>0-10KHz<br>0-50KHz<br>0-200KHz |     | 1,5<br>2,5<br>5,0<br>6,5 |     | %<br>%<br>%<br>% |                    |

# SA541

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| Keypad                     | R1  | R2   | R3   | R4   | C1   | C2   | C3   |
|----------------------------|-----|------|------|------|------|------|------|
| Nominal frequency (Hz)     | 697 | 770  | 852  | 941  | 1209 | 1336 | 1477 |
| Deviation from nominal (%) |     | -,07 | -,10 | +,19 | -,15 | -,17 | -,20 |

There will be an additional error due to a deviation in the oscillator frequency from 560 kHz.

## FUNCTIONAL OVERVIEW

The SAMES SA54X1 is a family of keypad switchable Loop Disconnect (LD)/Dual Tone multi-Frequency (DTMF) dialler devices for use in low-cost, dual dialling mode telephone instruments.

The devices feature automatic storage of a single telephone number of up to 32 digits for Last Number Redial (LNR) purposes. The low current consumption of the SA54X1 ensures memory retention while powered from the line.

Two modes of operation are available. The first is a LD/DTMF mode which operates normally in LD mode, but can be switched temporarily via the keypad to DTMF mode during a call. This mode is intended for applications such as home banking, credit-card verification and other applications requiring low speed data communications. The second mode allows DTMF dialling only.

The Lock function will be described in the Functional Description.  
The SA54X1 is pin compatible with SAMES' SA54X5 family of diallers.

## Ordering Information

**S A 5 4 X 1 X**

Lock Option    L:     with (22 pin package) \_\_\_\_\_  
                   Blank: without (20 pin package)

On-Hook Current Option

|   |                                      |       |
|---|--------------------------------------|-------|
| 3 | 5µA @ 2.5V                           | _____ |
| 6 | 1µA @ 2.5V                           |       |
| 9 | 1µA @ 3V                             |       |
| 4 | 1µA @ 3V (and TBR Period = 300 mSec) |       |

### Block Diagram

Figure 1 depicts the SA54X1 block diagram, while Table 1 lists the respective pin functions.

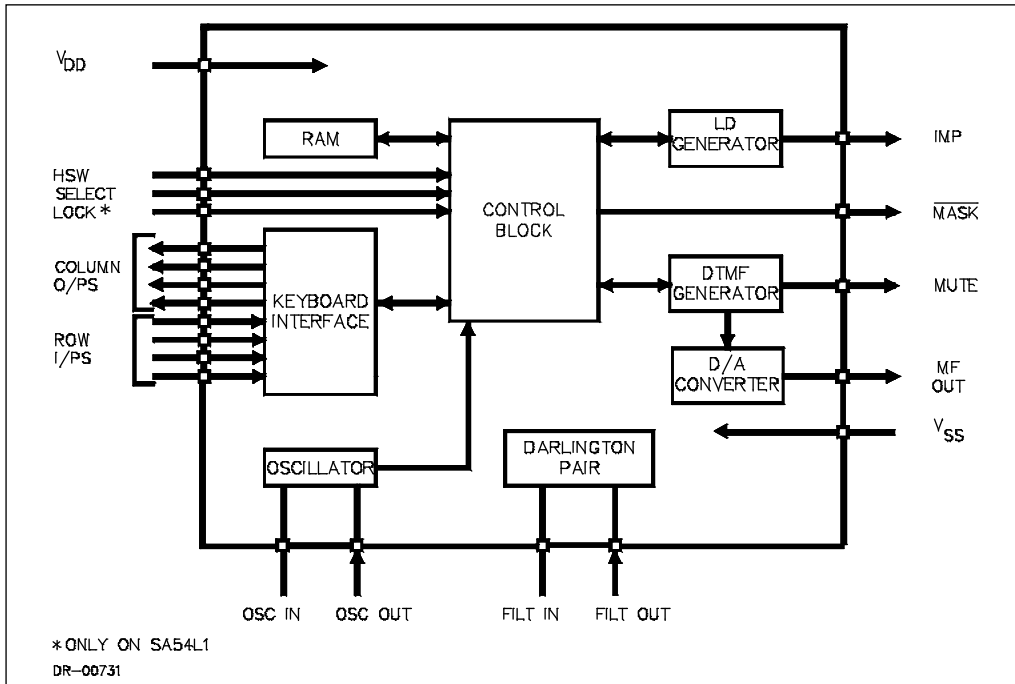


Figure 1: SA54X1 Block Diagram

| SA541  | SA54L1               | Designation          | Description   |   |
|--|----------------------|----------------------|---|---|
| 10   | 10                   | V <sub>DD</sub>      | Positive Supply input   |   |
| 9  | 9                    | V <sub>SS</sub>      | Negative Supply input   |   |
| 4  | 4                    | OSC OUT              | Connections for 560KHz ceramic resonator  |   |
| 5  | 5                    | OSC IN               |   |   |
| 12   | 14                   | MUTE                 | Active high output during keying, tone transmission and MUTE key depression. (See Note 1) |   |
| 3<br>and   | 3                    | MASK                 | Output to disable speech circuit during pulse dialling recall. (See Note 2)               |   |
| 6<br>7   | 6<br>7               | FILT IN<br>FILT OUT  | Unity gain amplifier input and output for DTMF tone filtering                             |   |
| 11   | 13                   | MF OUT               | DTMF output   |   |
| 1  | 1                    | IMP                  | 'Loop disconnect' dialling output.  |   |
| 2  | 2                    | SELECT               | LD/DTMF selection, IDP and B:M ratio programming  |   |
| 13<br>14<br>15<br>20   | 15<br>16<br>17<br>22 | C1<br>C2<br>C<br>C4  | Column output connections for 16 button single contact keypad                             |   |
| 16<br>17<br>18<br>19   | 18<br>19<br>20<br>21 | R1<br>R2<br>R3<br>R4 |   |   |
| 8  | 8                    | HSW                  |   | Hookswitch input. A logic 1 (High) indicates an "off-hook" condition  |
| -  | 11                   | LOCK                 |   | Lock Input must be tied to V <sub>SS</sub> to disable all keypad keys (except TBR, LNR and MUTE). Normal operation is enabled by connecting LOCK to V <sub>DD</sub> . |
| -  | 12                   | N/C                  | No connection   |   |
| <p>Note 1: The MUTE output is provided to disable the microphone while maintaining the loop condition during DTMF transmission.</p> <p>Note 2: The MASK output may be used to disconnect the whole speech circuit in order to maintain the break condition whilst on-hook, during a Timed Break Recall (TBR) operation or LD dialling.</p> |                      |                      |   |   |

**Table 1: Pin Description**

## FUNCTIONAL DESCRIPTION

**Note:** All timing data assumes the use of a 560 kHz ceramic resonator as time base.

### 1. Power On

When power is applied to the chip, a power-on reset circuit operates and ensures that the Last Number Redial (LNR) store is 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 LNR store may be corrupted, it will always, under all conditions, clear the store when power is restored, so that corrupt data is not retained.

### 2. Hookswitch Operation

The HSW input is used to inform the SA54X1 of whether the telephone is on-hook 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 ensures that short line breaks of less than 200ms, such as line reversals applied by the exchange, are ignored. In this case, the  $\overline{\text{MASK}}$  and IMP 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 LNR store contents may be retained.

**Off-hook state:** When the HSW input goes high, the  $\overline{\text{MASK}}$  output immediately goes to the logic '1' level and remains there until dialling starts (see Figure 5). COLUMN outputs also go high until a key is pressed. The oscillator circuit remains inactive until a key is pressed, and is normally off whenever timing functions are not required, hence reducing operating current.

### 3. 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 (via internal pull-down resistors). When a key is pressed, a COLUMN output is connected to a ROW input, pulling the latter 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 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.

Table 2 indicates the keypad layout for the SA54X1 family.

|      |                            |    |    |     |
|------|----------------------------|----|----|-----|
|      | C1                         | C2 | C3 | C4  |
| R1   | 1                          | 2  | 3  | TBR |
| R2   | 4                          | 5  | 6  | LNR |
| R3   | 7                          | 8  | 9  |     |
| R4   | *                          | 0  | #  |     |
| TBR: | Timed Break Recall (Flash) |    |    |     |
| LNR: | Last Number Redial         |    |    |     |

**Table 2: Keypad Layout**

**4. Dialling Mode Selection**

The dialling mode may be selected via the SELECT pin (pin 2) as detailed in Table 3. Four Loop-Disconnect options are available with different Interdigit pauses (IDP) and Break:Make ratios. If the DTMF mode is selected, dialling will remain fixed in the DTMF mode. However, if one of the LD modes is selected, the chip will be in LD mode in the initial off-hook condition, but may be switched to DTMF by pressing either the \* or # keys, provided that dialling is not in progress. If the \* or # keys are pressed during LD dialling, they will be ignored.

Once in DTMF mode, depression of either the \* or # keys will cause the relevant tone-pair to be output. Only digits entered prior to a DTMF switchover will be stored and available for redialling (see Last Number Redial operation).

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

| Select (Pin 2) Connected to: | Dialling Mode | IDP(ms) | B:M Ratio |
|------------------------------|---------------|---------|-----------|
| V <sub>SS</sub>              | LD            | 800     | 2:1       |
| C1                           | LD            | 500     | 2:1       |
| C2                           | LD            | 500     | 3:2       |
| C3                           | LD            | 800     | 3:2       |
| V <sub>DD</sub>              | DTMF          |         |           |

**Table3: Dialling Mode Selection**



## 5. Last Number Redial (LNR)

The function of the on-chip LNR store is to automatically retain a manually dialled number for redialling later. The capacity of the store is 32 digits. If a number longer than 32 digits is dialled, redialling will be inhibited.

The LNR store has two features designed to assist the user, viz: Moving Cursor Facility and Mixed Mode Dialling.

**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.

If the first digits of a new number dialled match the contents of the LNR store, then pressing LNR button will dial out the remaining digits.

If there is a mismatch in the numbers then redial is inhibited until the next on-hook and the LNR store will contain the new number.

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

**Mixed Mode Dialling:** In the case of a call which starts in LD mode and is switched by the user (via the \* or # keys) to DTMF mode, only the digits dialled in LD mode will be retained. Provided that the number of digits dialled in LD mode does not exceed 32, the digits will be retained regardless of the number of DTMF digits entered subsequently.

## 6. Earth Loop Recall (ELR) / Timed Break Recall (TBR) (Timed Flash)

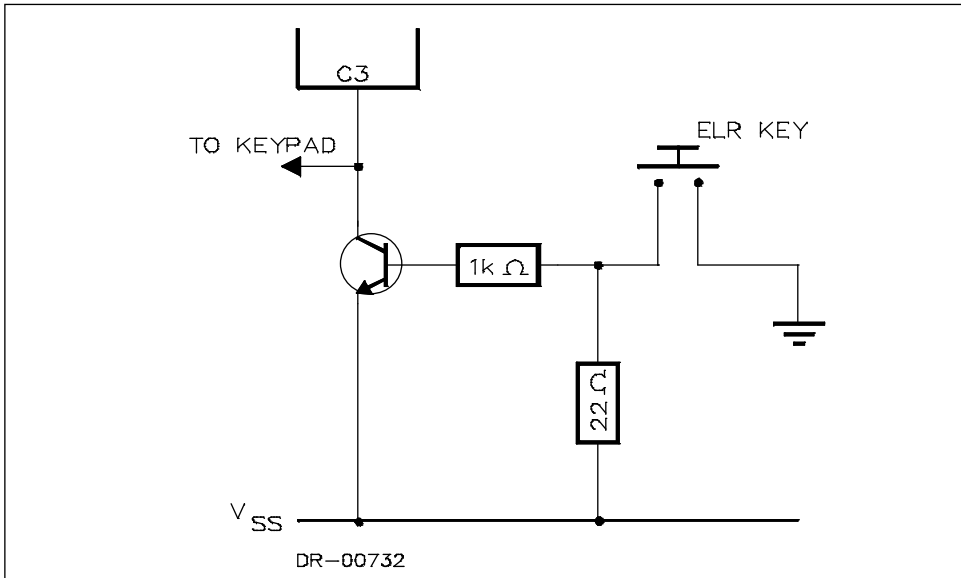
The SA54X1 supports both TBR and ELR and offers a common operating protocol in both cases.

After a Recall (Flash) operation, the dialling mode selected via the SELECT pin will be restored. Only the digits dialled after the ELR/TBR operation will be retained in the LNR store.

A TBR of 100ms (300ms on SA54X14) is generated when the TBR key is pressed. The  $\overline{\text{MASK}}$  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 C3 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.

The ELR function may be achieved by use of the circuit shown in Figure 2, or by use of a double contact switch.



**Figure 2: Earth Loop Recall Application**

### 7. Oscillator Circuit

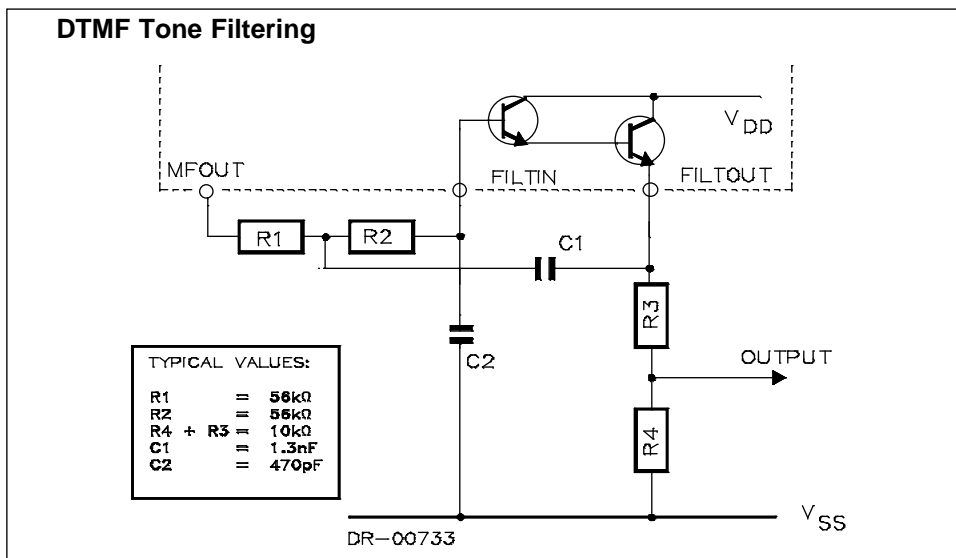
This requires an external 560KHz ceramic resonator connected between OSC IN and OSC OUT, providing a timing reference for all chip functions.

Consult your resonator supplier for recommendation of a suitable resonator type.

### 8. 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 6 & 7) for use in a low pass active filter.

Figure 3 shows how a 2-pole Sallen and Key filter may 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. The relative values of R3 and R4 may be adjusted to achieve the desired DTMF amplitude which varies with supply voltage.



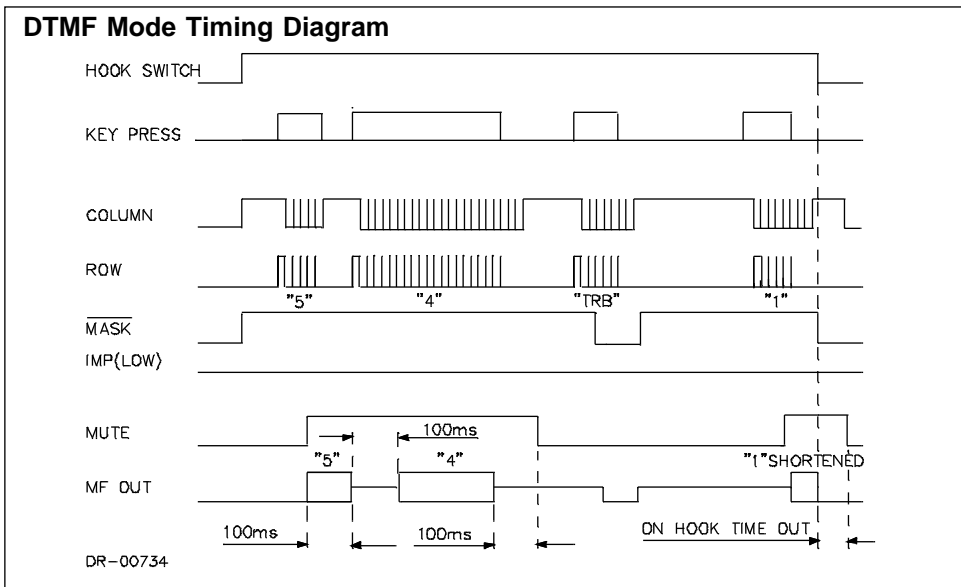
**Figure 3: 2-Pole Sallen and Key Filter Circuit**

## 9. DTMF Dialling (Figure 4)

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 d.c. 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. 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 store occurs at the maximum rate.

If a key is held down for longer than 100ms, the tone output will continue until the key is released.



**Figure 4: DTMF Mode Timing Diagram**

### 10. Loop Disconnect Dialling (Figures 5 and 6)

The MASK output is provided in order to disable the speech circuit during LD dialling. Consequently, the MASK output is normally at logic '1' in the off-hook condition, but changes to logic '0' during LD dialling. 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 remains at logic '0'.

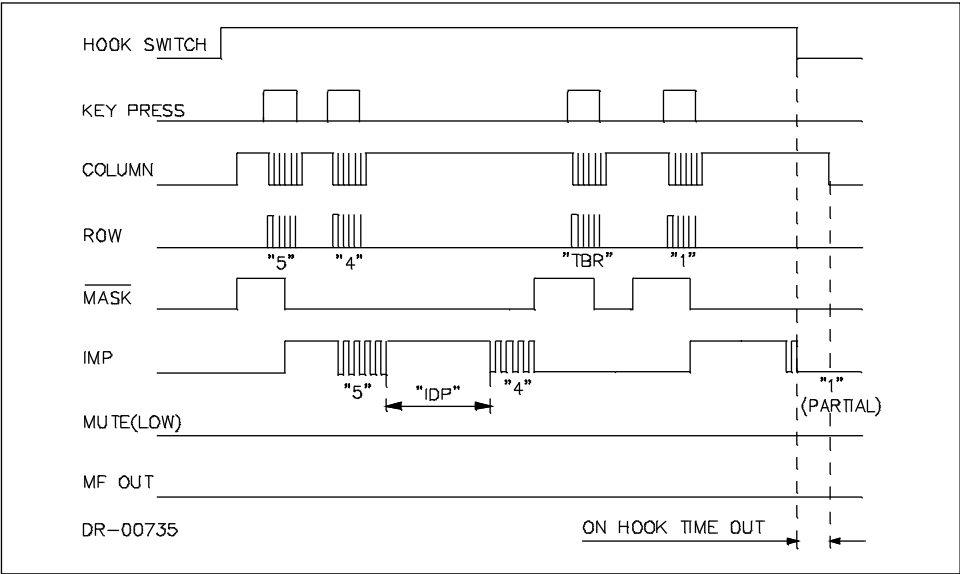


Figure 5: LD Mode Timing Diagram

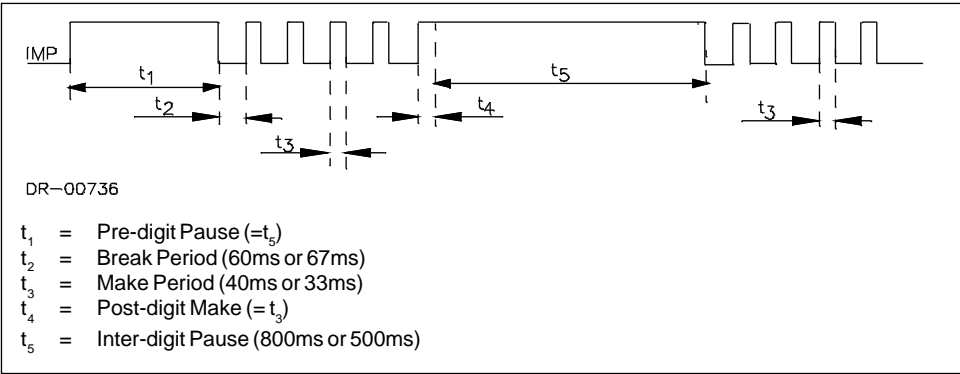


Figure 6: Detailed Timing for IMP Output

## 11. LOCKING FACILITY

This feature is available on the SA54L1. Pin 11 (LOCK) should be connected to  $V_{SS}$  if the device is to be locked and to  $V_{DD}$  if the device is to be unlocked. This feature can be controlled by an inexpensive low voltage SPDT switch. When locked, columns 1,2 and 3 on the keypad are disabled making it impossible to dial out any digits. However column 4 is not disabled, thus allowing the user to redial the contents of the LNR store. The user would therefore typically store an emergency number in the LNR memory before locking the keypad.

## TYPICAL APPLICATIONS

The circuit in Figure 7 uses a constant current supply to draw current from the telephone line which is used to power the SA54X1. The 2,5V reference diode produces a stabilised supply voltage which determines the DTMF tone level of the SA54X1.

In Figure 8, a stabilising voltage from the speech circuit is used to supply the SA54X1 during DTMF dialling to give accurate tone levels.

The SA54X1 is powered via the 150K $\Omega$  resistor during TBR operations and LD dialling breaks, and via T1 during dialling makes. This configuration minimises the component count, at the expense of allowing a leakage current of about 450 $\mu$ A during dialling breaks. The 47 $\mu$ F reservoir capacitor maintains and smoothes the supply to the chip.

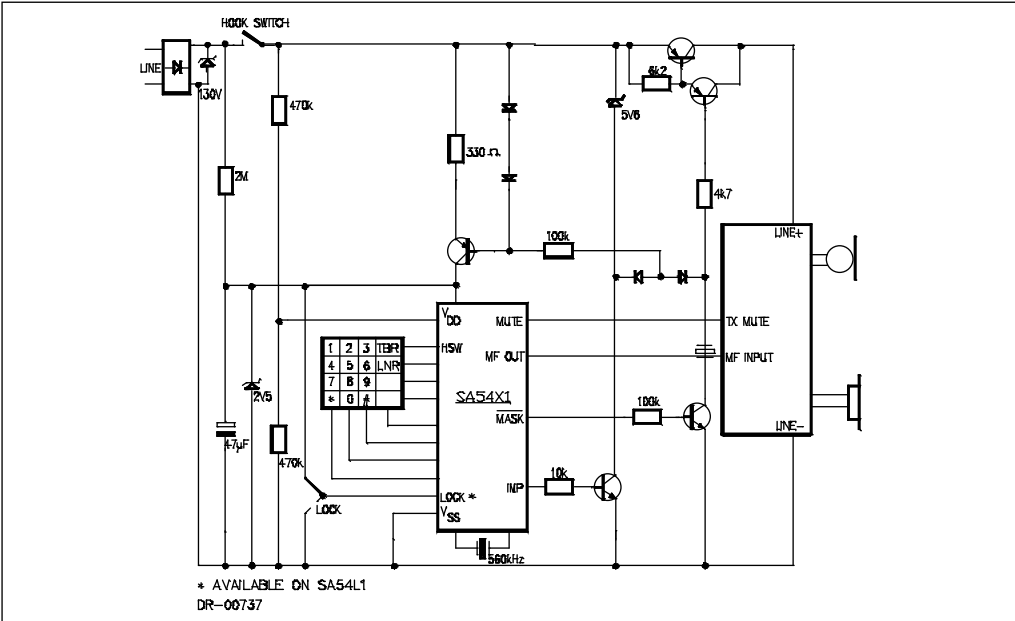


Figure 7: Typical Application Circuit: Powered via Reference Diode

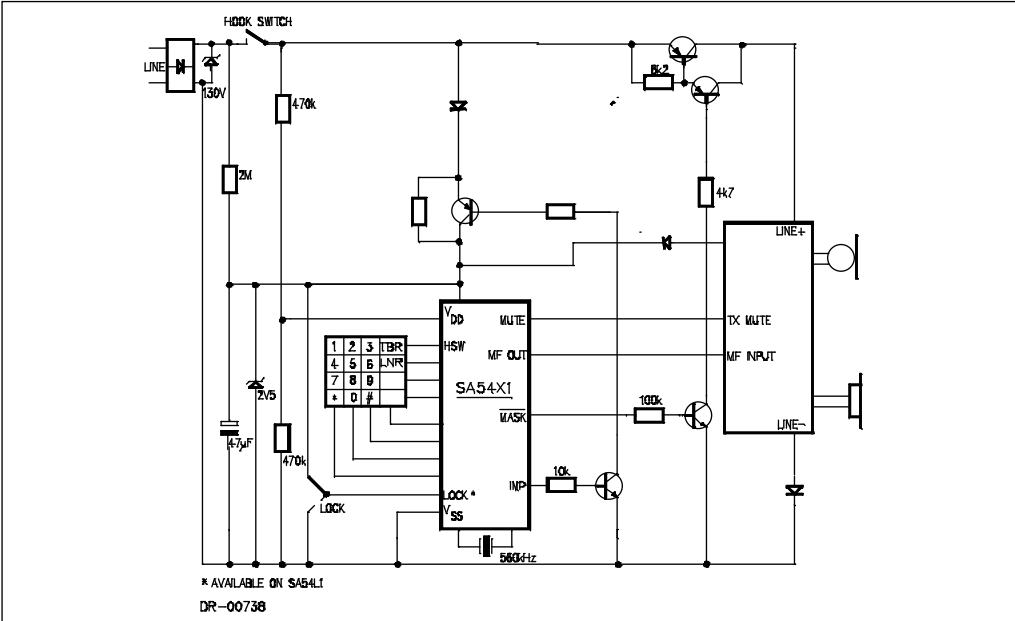


Figure 8: Typical Application Circuit: Powered via Speech Circuit

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**South African Micro-Electronic Systems (Pty) Ltd**

P O Box 15888,  
Lynn East,  
0039  
Republic of South Africa,

21 Eland Street,  
Koedoespoort Industrial Area,  
Pretoria,  
Republic of South Africa

Tel: 012 333-6021  
Fax: 012 333-8071

Tel: Int +27 12 333-6021  
Fax: Int +27 12 333-8071