# MA587 FAMILY

## LD/DTMF SWITCHABLE DIALLERS WITH 20 MEMORIES (10 DEDICATED MEMORY KEYS)

The MA587 family are keypad switchable LD/DTMF dialler devices with a last number redial facility and twenty 24-digit memories, accessible via 10 dedicated dialling keys. 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 MA587 devices are pin compatible with the GPS switchable dialler families MA526, MA527, MA541, MA545, MA547, MA585 and MA589.

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.

### FEATURES

- Selectable Loop-Disconnect or DTMF Modes
- Keypad Switchable LD to DTMF
- 20x24-Digit Memories, (10 Dedicated Keys)
- 24 Digit Last Number Redial
- Selectable Make/Break Ratios 2:1 and 3:2
- Uses Inexpensive 560kHz Ceramic Resonator
- Battery-less operation - Low Power CMOS
- Mask Programmable Options to suit Application
- Timed Break Recall (Flash) and Earth Recall

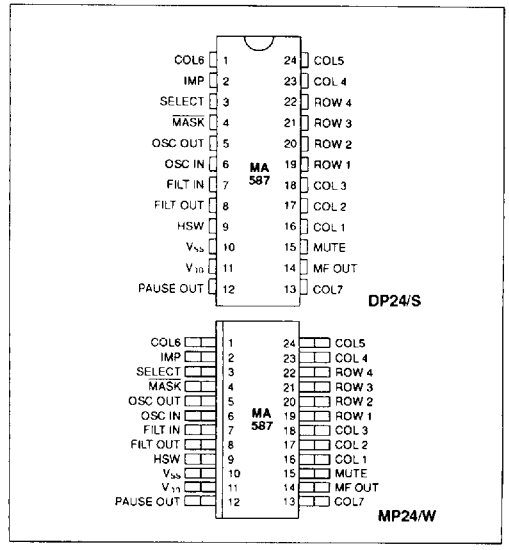


*Figure 1 Pin connections - top view. DP24/S 0.3in 'skinnydip' plastic DIL, MP24/W wide-bodied Small Outline package*

### PIN FUNCTIONS

| Pin number | Pin name | Function |
|---|---|---|
| 2 | IMP | 'Loop disconnect' dialling output |
| 3 | SELECT | LD/DTMF selection, IDP and B/M radio programming |
| 4 | MASK | Output to disable speech circuit during pulse dialling and recall (see note 1) |
| 5 | OSC OUT | Connections for 560kHz ceramic resonator |
| 6 | OSC IN | |
| 7 | FILT IN | Unity gain amplifier input and output for DTMF tone filtering |
| 8 | FILT OUT | |
| 9 | HSW | Hookswitch input - a logic 1 at this pin is used to indicate 'Off-hook' |
| 10 | $V_{ss}$ | Negative supply |
| 11 | $V_{DD}$ | Positive supply |
| 12 | PAUSE OUT | Active high output indicating a pause when dialling from memory |
| 14 | MF OUT | Unfiltered DTMF output |
| 15 | MUTE | Output active during keying and tone transmission (see note 2) |
| 16 | COL1 | Connections for 28 key single contact keypad |
| 17 | COL2 | |
| 18 | COL3 | |
| 23 | COL4 | |
| 24 | COL5 | |
| 1 | COL6 | |
| 13 | COL7 | |
| 19 | ROW1 | |
| 20 | ROW2 | |
| 21 | ROW3 | |
| 22 | ROW4 | |

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 condition during DTMF transmission

*Table 1 Pin functions*



3768522 0020360 061

## OPERATION

### Power-on

When power is applied to the chip, a power-on reset circuit operates and ensures that the last number redial 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.

### Hookswitch Operation

The HSW input is used to inform the MA587 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 line reversals applied bv the exchange, are ignored. In this case the IMP and $\overline{\text{MASK}}$ 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 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 going on-hook or signalling a TBR, (see timing diagram). 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.

### 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 beell 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 3) as detailed in Table 2. Four 'Loop-Disconnect + DTMF options and four 'Loop-Disconnect only' options with different Interdigit pauses and Break/Make ratios are available and one DTMF mode If one of the 'LD only' modes or the DTMF mode 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 | S1 | S2 | S3 |
| ROW 2 | 4 | 5 | 6 | LNR | S4 | S5 | S6 |
| ROW 3 | 7 | 8 | 9 | STORE | S7 | S8 | S9 |
| ROW 4 | * | 0 | # | PAUSE/ CONT | SHIFT | S0 | |

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

**TBR** Timed Break Recall (Flash)
**LNR** Last Number Redial
**STORE**: Memory programming
**PAUSE/CONT**. Insert pause in memory/continue dialling
**SHIFT**: Used in conjunction with the 10 dedicated memory keys, allows all 20 memories to be addressed
**S0-S9** Dedicated memory dialling keys
**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 | S1 | S2 | S3 |
| ROW 2 | 4 | 5 | 6 | LNR | S4 | S5 | S6 |
| ROW 3 | 7 | 8 | 9 | STORE | S7 | S8 | S9 |
| ROW 4 | * | 0 | # | TONE | SHIFT | S0 | PAUSE/ CONT |

*Figure 2: Keypad layout and connections*

| SELECT pin to | Dialling mode | IDP (ms) | B/M ratio |
|---|---|---|---|
| $V_{SS}$ | LD + DTMF | 800 | 2:1 |
| COL 1 | LD + DTMF | 500 | 2:1 |
| COL 2 | LD + DTMF | 500 | 3:2 |
| COL 3 | LD + DTMF | 800 | 3:2 |
| COL 4 | LD only | 800 | 2:1 |
| COL 5 | LD only | 500 | 2:1 |
| COL 6 | LD only | 500 | 3:2 |
| COL 7 | LD only | 800 | 3:2 |
| $V_{DD}$ | DTMF | - | - |

*Table 2: Dialling mode selection*

However, if one of the 'LD + DTMF' modes is selected, the chip will lie in LD mode initially in the off-hook condition but may be switched lo DTMF by pressing either the *, */# or TONE key (depending on the mask variant - see Fig. 2 and page 1-57), 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).

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.



3768522 0020361 TT8

**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 store is 24 digits. If a number is dialled which is longer than this, redialling will not be allowed with this number. To redial a number in the LNR store, the LNR key must be pressed once.

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

**Moving cursor facility**

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 store Then redialling will be inhibited for the remainder of the call, and the numbers entered will be saved in the LNR store for redialling in a subsequent call

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

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.

**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 Nurnber) 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 MA587 provides 20 memories, each of which has a capacity of 24 digits There are 10 dedicated memory keys and a SHIFT key which allows all 20 memories to be addressed by the 10 memory keys The memories can store digits to be dialled in LD, DTMF or mixed modes and also pauses.

**Programming Memories**

The MA587 must be 'off-hook' and idle:

1. Press the STORE key
2. Press key S0-S9 or SHIFT + S0-S9 indicating 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

**Dialling from memories**

The MA587 must be 'off-hook' and idle:

1 Press the appropriate memory key S0-S9 or SHIFT + S0-S9 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 either by pressing the PAUSE/CONT key or, alternatively, the Column 4 pin can be pulled 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 (Flash)**

The MA587 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 [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.

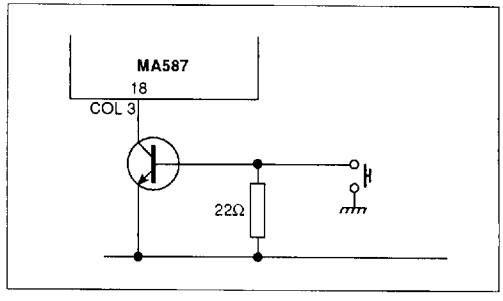


*Figure 3 Earth loop recall*



3768522 0020362 934

*(1) Other options are available including an option for Danish requirements (see page 1-57). In Denmark TBR (or ELR) is used to obtain an outside line in PABX use. Under these conditions the LNR store contents will be retained and can be redialled after a TBR or ELR. Digits manually entered after a TBR or ELR will become the new LNR store contents.*

*(2) Other TBR (Flash) periods are available as mask options (see page 1-57).*

### 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.

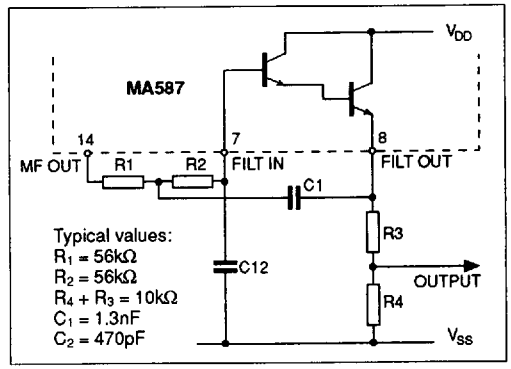


*Figure 4: DTMF tone filtering*

## 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 al 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.

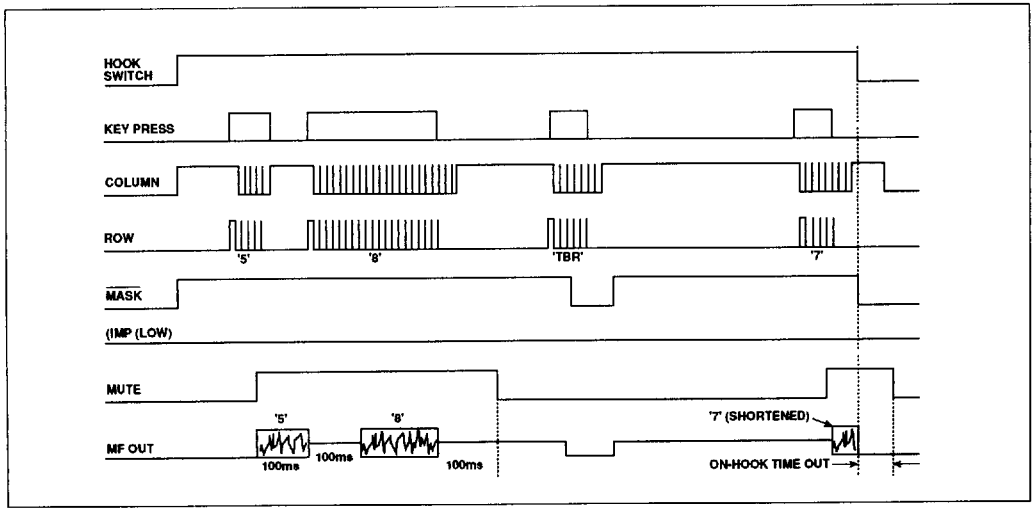


*Figure 5: DTMF mode timing diagram*



3768522 0020363 870

| 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.

*Table 3: Tone frequencies*

## 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'.

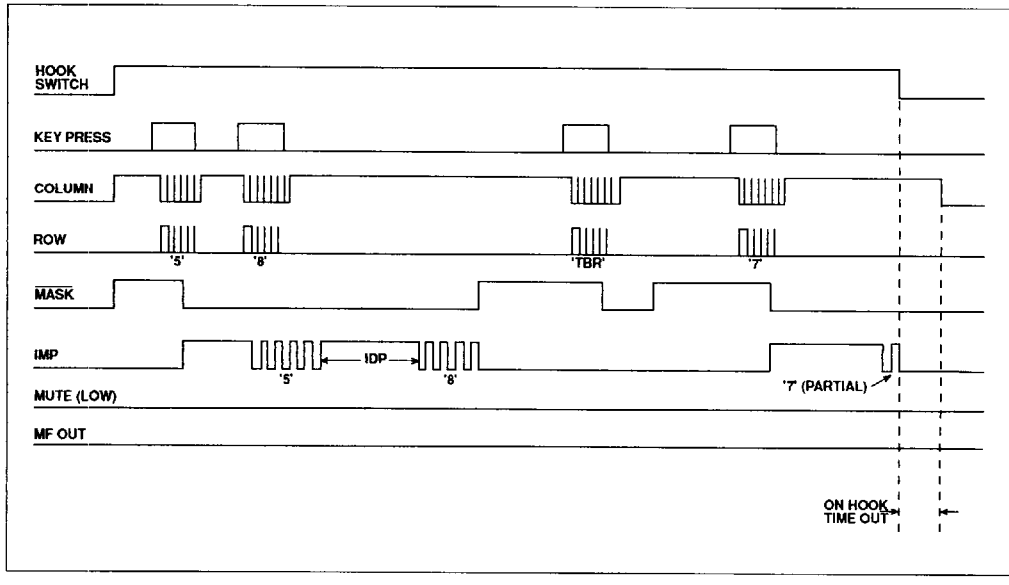


*Figure 6: LD mode timing diagram*

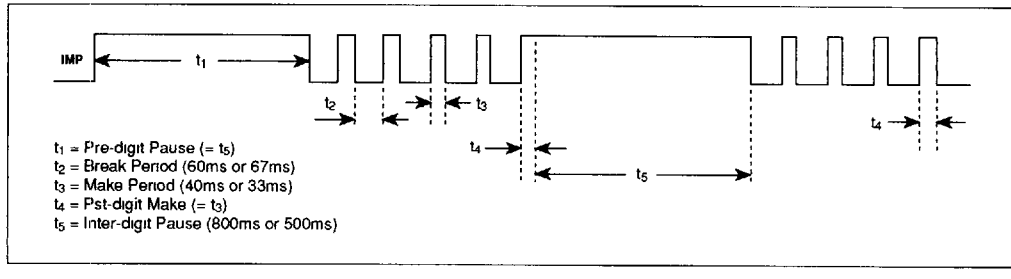


*Figure 7. Timing data*



3768522 0020364 707

## MASK OPTIONS

The MA587 has been designed so that many features can be altered quickly and inexpensively at the final stage of manufactute. 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.

**1. TBR (Flash) Period**
***a. 100 ms***
b. 200 ms
c. 300 ms
d. 400 ms
e. 500 ms
f. 600 ms

**2. LD to DTMF Keypad Switching**
***a. *and ,# keys***
b. TONE key
c, * key

**3. Retention of Post - */# Digits in LNR Store (DTMF mode)**
***a. All digits retained***
b. Digits before * or # retained
c. Digits before * and # retained (except when * or # is first digit

**4. LD dialling options**
***a. Standard (n = N pulses, except 0 = 10 pulses)***
b. Swedish (n = (n + 1) pulses)
c. Norwegian (n = (11 - n) pulses)
d. New Zealand (n = (10 - n) pulses)

**5. Recall (Flash) / LNR Protocol**
***a. Digits dialled after Recall retained***
b. Digits dialled before Recall retained
c. Recall inhibits LNR
d. For Danish PABX requirements

**6. DTMF Minimum Timings**
***a. 100ms on, 100ms off***
b. 73ms on, 73ms off
c. 73ms on, 147ms off

**7. Pin 4**
***a. $\overline{MASK}$***
b. MASK

**8. Pin 2**
***a. IMP***
b. $\overline{IMP}$
c. [IMP + $\overline{MASK}$]
d. [$\overline{IMP}$ + MASK]

**9. Pin 15**
***a. MUTE***
b. $\overline{MUTE}$

## APPLICATION CIRCUITS

Refer to the MA541 data sheet, Figs. 8 and 9, on pages 1-29 and 1-30

## ELECTRICAL CHARACTERISTICS

**Test conditions (unless otherwise stated): $V_{DD}$ = 2.5V $T_{amb}$ = 25°C**

## DC CHARACTERISTICS

| Characteristic | | Min. | Typ. | Max. | Units | Condition |
|---|---|---|---|---|---|---|
| Supply current: | On-hook | | <1 | 5.0 | µA | $V_{DD}$ = 2.0V |
| | Off-hook | | 1.5 | | µA | MF OUT low |
| | MFtone sending | | | 1.0 | mA | |
| | LD impulsing | | | | µA | |
| Output high voltage ($\overline{MASK}$ and MUTE outputs) | | 2.2 | | | V | I = -1mA |
| Output low voltage ($\overline{MASK}$ and MUTE outputs) | | | | 0.3 | V | I = +1mA |
| MF OUT DC 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 (see fig 4) | | 600 | 50,000 | | | $I_E$ = 100µA, $V_{CE}$ = 2V |

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



3768522 0020365 643

## AC CHARACTERISTICS

| Characteristic | | Min. | Typ. | Max. | Units | Condition |
|---|---|---|---|---|---|---|
| Tone output: | low group | 57 | 64 | | mV rms | No load. |
| | high group | | 81 | 91 | mV rms | No load. |
| High-to-Low group amplitude ratio (pre emphasis) | | 1.5 | 2 | 2 5 | dB | See note 2 |
| Total harmonic distortion: | 0-4 kHz | | 1 5 | | % | |
| | 0-10 kHz | | 2.5 | | % | |
| | 0-50 kHz | | 5.0 | | % | |
| | 0-200 kHz | | 6.5 | 10 | % | |
| Oscillator start-up time | | | <0.1 | 1 | ms | |

NOTE 2. Typical value varies slightly dependent upon particular tone pair.

## RECOMMENDED OPERATING CONDITIONS

| Condition | | Min. | Typ. | Max. | Units | Notes |
|---|---|---|---|---|---|---|
| Supply Voltage: | On-hook | 1.8 | | 5.7 | V | For memory retention |
| | Off-hook | 2.4 | | 5.7 | V | |
| Hookswitch input: | On-hook | | | $0.2V_{DD}$ | V | |
| | Off-hook | $0.8V_{DD}$ | | | V | |
| Oscillating frequency | | | 560 | | kHz | |

## ABSOLUTE MAXIMUM RATINGS

| | |
|---|---|
| Supply voltage, $V_{DD}$-$V_{SS}$ | - 0.3 to + 6 5V |
| Voltage on any pin (except HSW) | $V_{SS}$ - 0.3V to $V_{DD}$ + 0 3V |
| Voltage on HSW pin (See note 1) | $V_{SS}$ - 0.3V min. |
| Current at any I/O pin (except HSW, FILTOUT and FILTIN) | ±1 mA |
| Current at FILTOUT pin | 0 to 0.1mA |
| Current at FILTIN pin | -5 to 0mA |
| Storage temperature | -55°C to + 125°C |
| Operating temperature range | -10°C to + 55°C |

## NOTES

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

2. Stresses above those listed in the Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions, or at any other condition above those indicated in the Electrical Characteristics, is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods may affect device reliability.



3768522 0020366 58T