DS3154-1.0
Supersedes C800D 1 1

MA552

BILINGUAL (LOOP-DISCONNECT AND DTMF) DIALLER WITH REDIAL

The MA552 is a CMOS Bilingual (ie Loop Disconnect and Multi-frequency) dialler chip with a 21 digit Last Number Redial facility. The chip can be operated in either LD mode, MF mode or a third mode in which dialling can be switched from LD to DTMF from the keypad during a call. This third mode is intended for users connected to an exchange accepting only LD signalling but may require access to facilities such as home banking and databases accepting DTMF signalling.

Low power CMOS design allows the LNR store contents to be maintained by a minimal current whilst the telephone is on-hook. A selectable facility allows access pauses to be recognised during manual dialling and to regenerate these pauses automatically when using the LNR facility.

In order to cater for the telephone specifications of many countries and different circuit configurations, the MA552 offers a variety of pin selectable and metal mask programmable options.

Other features include a temperature compensated voltage reference for accurate DTMF levels independent of supply voltage and a 'single pin' oscillator circuit requiring only an inexpensive external 560kHz ceramic resonator. Both Timed Break Recall (Flash) and Earth Loop Recall are supported and offer identical operating protocols.

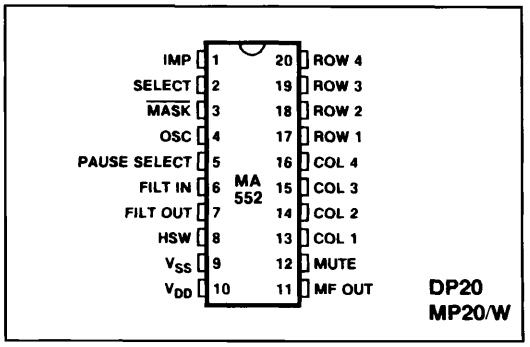

Fig.1 Pin connections - top view (not to scale)

FEATURES

- Selectable Loop-Disconnect or DTMF Modes
- Keypad Switchable LD to DTMF
- DTMF output Levels Independent of Temperature and Voltage
- 21 Digit Last Number Redial
- Automatic Pause Detection for LNR
- 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
- PIN (Personal Identification Number) Confidentiality
- Timed Break Recall (Flash) and Earth Recall

PIN FUNCTIONS

Pin number	Pin name	Function
17	ROW1	Connections for 16-key, single contact keyboard
18	ROW1	
19	ROW1	
20	ROW1	
13	COL1	
14	COL1	
15	COL1	
16	COL1	
10	V_{DD}	Positive supply
9	V_{SS}	Negative supply
2	MODE SELECT	LD/MF selection, and B/M ratio programming
5	PAUSE SELECT	Pause and Pause Duration Selection
4	OSC	Oscillator connection. Connect 560kHz resonator from this pin to V_{SS}.
8	HSW	Hookswitch. A logic '1' voltage at this pin is used to indicate 'off-hook'
3	$\overline{\text{MASK}}$	Output to disable speech circuit during LD dialling and Recall (Flash): Note 1
1	IMP	'Loop-Disconnect' dialling output
11	MF OUT	Unfiltered, dual tone output
7	FILT OUT	Unity gain amplifier output for 2-pole filter
6	FILT IN	Unity gain amplifier input for 2-pole filter
12	MUTE	Output active during keying and tone transmission: Note 2

1. $\overline{\text{MASK}}$ 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

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 MA552 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 by 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).

	COL 1	COL 2	COL 3	COL 4
ROW 1	1	2	3	TONE *
ROW 2	4	5	6	TBR
ROW 3	7	8	9	
ROW 4	*	0	#	LNR

TONE :Change dialling mode from LD to DTMF
** This key is only available as a mask variant.*
TBR: Timed Break Recall (Flash).
LNR: Last Number Redial.

Fig.2 Keypad layout and connections

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.

Two key rollover

If one key is pressed and verified and then a second key pressed whilst the first is still held down, the second key will be accepted only when both keys are released or the second key pressed again.

Dialling Mode Selection

The dialling mode may be selected via the MODE SELECT pin (pin 2) as detailed in Table 2. If one of the 'LD only' modes or 'DTMF only' mode is selected then dialling will remain fixed in the mode selected. 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 the *, */# or TONE key (dependent on the mask variant – see page 1-72), 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.

MODE SELECT pin to	Dialling mode	Keypad switchable	B/Mratio
V_{SS}	LD	NO	2:1
COL 1	LD	YES	2:1
COL 2	LD	NO	3:2
COL 3	LD	YES	3:2
V_{DD}	DTMF	–	–

Table 2 Dialling mode selection

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 REDIAL key must be pressed twice.

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

Automatic pause feature

PAUSE SELECT pin to	Pause option
V_{SS}	No pause
COL 1	3s pause
COL 2	6s pause
V_{DD}	Manual pause

Table 3 Pause option selection

This feature may be selected as detailed in Table 3. When selected, the MA552 will detect up to two pauses during dialling and insert these into the LNR store.

A pause is defined as follows:

1. In LD mode - if the user waits until the digit(s) already entered have been dialled before entering further digits
2. In DTMF mode - if the user waits for 1 second[1] after the 1st, 2nd or 3rd digit(s)[2] have been dialled before entering further digits.

On redialling, a pause of either 3s, 6s or until the user presses the LNR key again (as selected) will occur whenever a pause was recognised. A timed pause may also be interrupted by pressing the LNR key again.

Notes: (1) Mask options for 2 & 3 seconds are available.
(2) A Mask option is available to allow up to 2 pauses to be detected at any time in DTMF mode

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 REDIAL key; the remainder of the number will be dialled when the REDIAL 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. Providing that the number of digits dialled in LD mode does not exceed 21, they will be retained regardless of the number of DTMF digits entered subsequently. This feature is provided to ensure security of PIN (Personal Identification Number) codes.

DTMF calls

If a call contains the digits * or # only those digits dialled prior to the first press of either * or # will be retained in the LNR store.This feature also ensures security for PIN codes.

The exception to this is if * or # is the first digit dialled whilst in the off-hook state. In this case the * or # and all subsequent digits (including further * or #) will be retained.

Timed Break & Earth Loop Recall (Flash)

The MA552 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 MODE SELECT pin will be restored. Also, only the digits dialled after the ELR/TBR operation will be retained in the LNR store.

A TBR (Flash) of 100ms 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 column 3 pin (pin 16). 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.

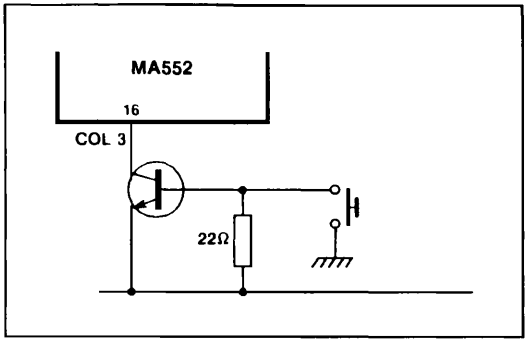

Fig.3 Earth loop recall

Oscillator Circuit

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

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.

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.

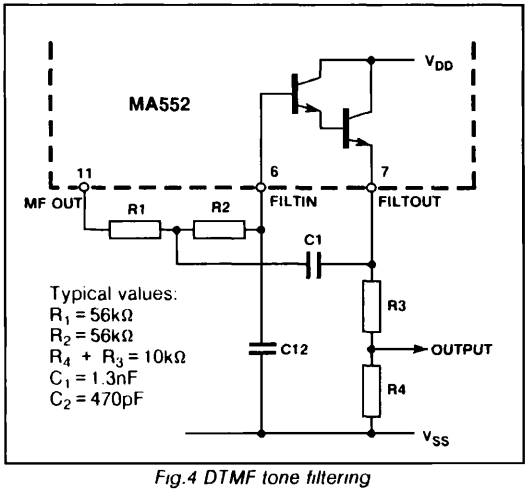

Fig.4 DTMF tone filtering

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 V_{DD} – 0.3V 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.

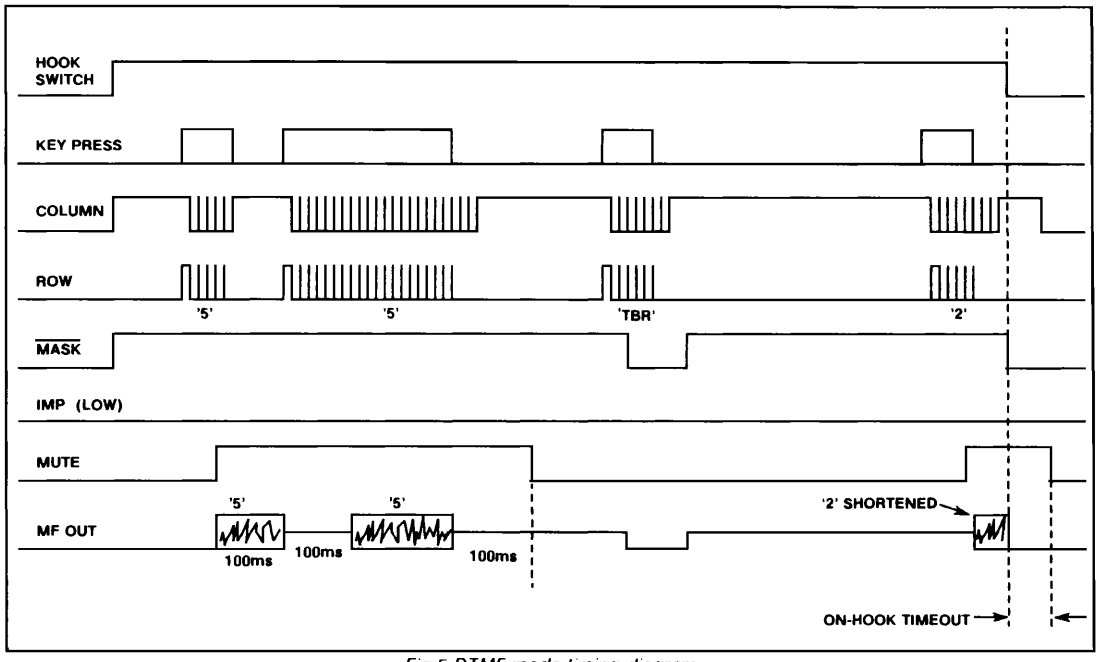

Fig.5 DTMF mode timing diagram

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

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

Table 4 Tone frequencies

LOOP-DISCONNECT DIALLING

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 sits at logic '0'.

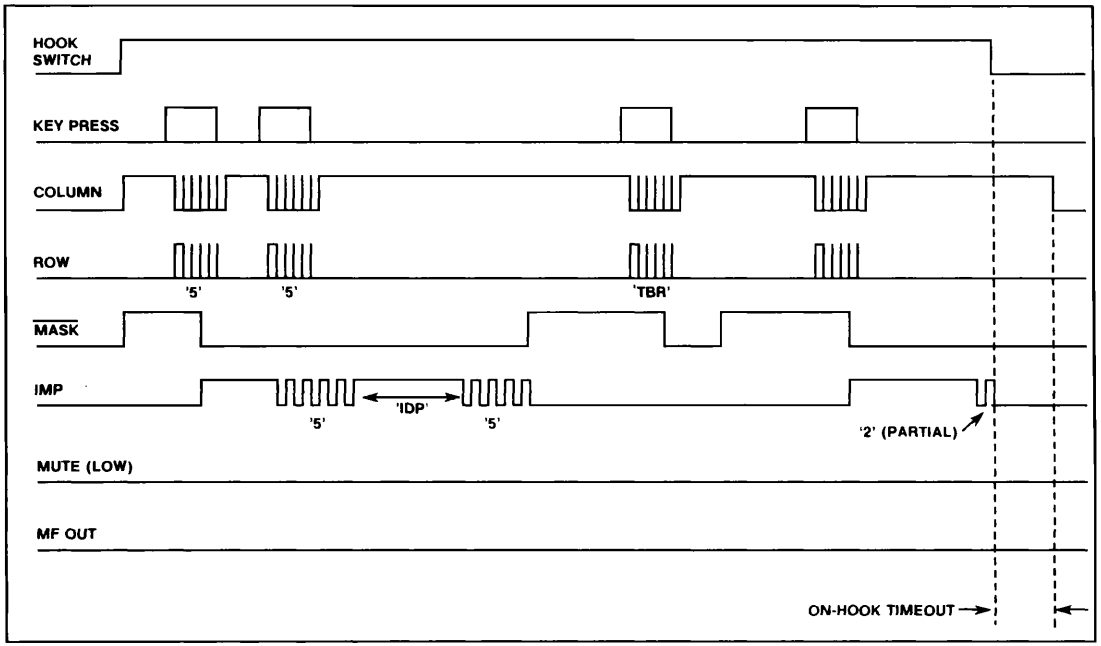

Fig.6 LD mode timing diagram

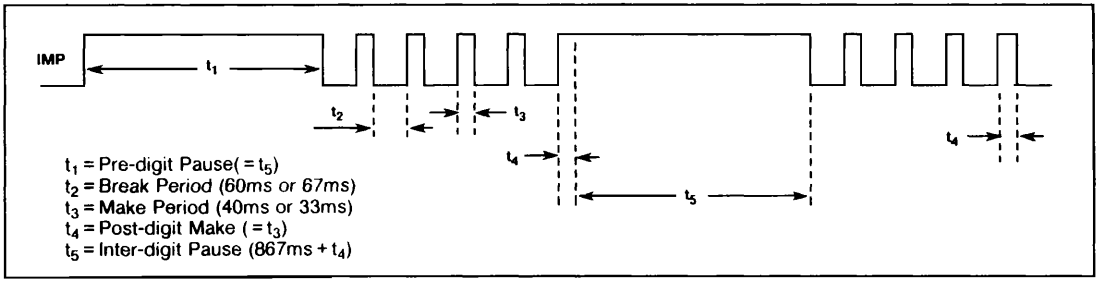

Fig.7 Timing data

MASK OPTIONS

The MA552 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.

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. * key***
- b. * and # keys
- c. TONE key

3. Inter-Digit Pause Options
- ***a. 867ms (not incluning PDM)***
- b.520ms (not including PDM)

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

5. Pin 3
- ***a. $\overline{MASK}$***
- b. MASK

6. Pin 1
- ***a. IMP***
- b. $\overline{IMP}$
- c. [IMP + $\overline{MASK}$]
- d. $\overline{[IMP + \overline{MASK}]}$

7. Pin 12
- ***a. MUTE***
- b. $\overline{MUTE}$

8. Pause Recognition Period (in DTMF Mode)
- ***a. 1 second***
- b. 2 seconds
- c. 3 seconds

9. Pause Recognition Position (in DTMF Mode)
- ***a. After 1st, 2nd and 3rd digits only***
- b. At any time during number

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 Off-hook MF tone sending LD impulsing		<1 1.5	2 1.0 200	µA µA mA µA	V_{DD} = 2.0V MF OUT low
Output high voltage ($\overline{MASK}$, MUTE and IMP outputs)	2.2			V	I = -1mA
Output low voltage ($\overline{MASK}$, MUTE and IMP outputs)			0.3	V	I = +1mA
MF OUT DC level during tone sending		V_{DD}-0.3		V	
MF OUT output resistance		5		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

AC CHARACTERISTICS

Characteristic	Min.	Typ.	Max.	Units	Condition
Tone output: low group high group	68	77 97	 109	mV rms mV rms	No load No load
High-to-Low group amplitude ratio (pre-emphasis)	1.5	2	2.5	dB	See note 1.
Total harmonic distortion: 0-4 kHz 0-10 kHz 0-50 kHz 0-200 kHz		1.5 2.5 5.0 6.5	 10	% % % %	
Oscillator start-up time		<0.1	1	ms	

NOTE 1. 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 retntion
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)	± 1mA
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	–25°C to + 70°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 Rating conditions for extended periods may affect device reliability.

TYPICAL CHARACTERISTICS

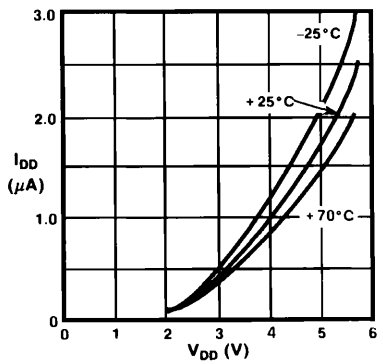

Fig.8 On-hook supply current as a function of supply voltage

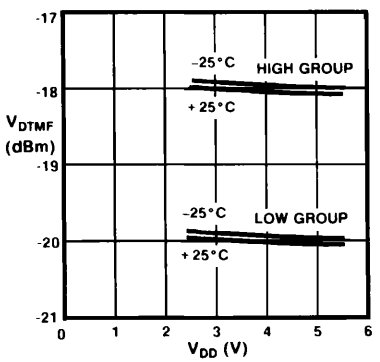

Fig.9 DTMF output voltage levels as a function of supply voltage

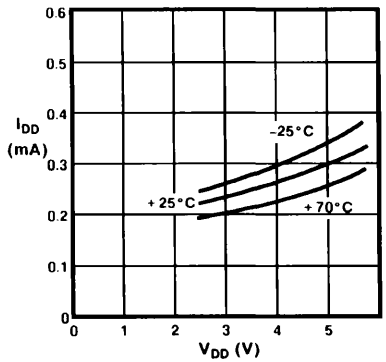

Fig.10 Operating supply current (DTMF output active) as a function of supply voltage

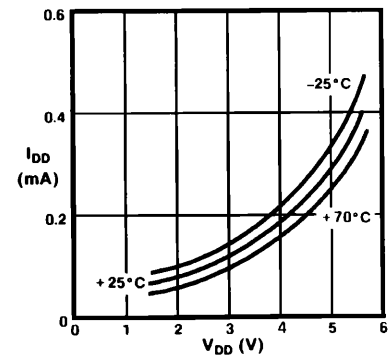

Fig.11 Operating supply current (LD outpulsing) as a function of supply voltage

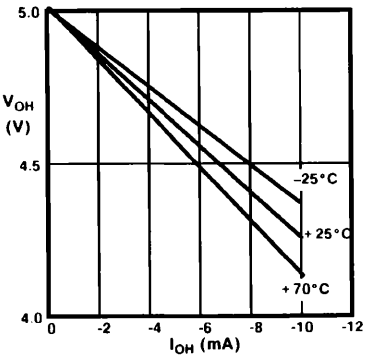

Fig.12 DC Output High levels as a function of output source current (V_{DD} = 5V)

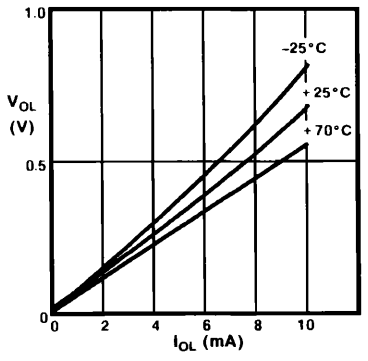

Fig.13 DC Output Low levels as function of output sink current (V_{DD} = 5V)

APPLICATION CIRCUITS

Figs. 14 and 15 are simplified examples of how the MA552 may be used in a telephone circuit suitable for Loop-Disconnect and DTMF signalling. For clarity, none of the components required for DTMF tone filtering are shown.

In Fig.14, a 4MΩ resistor is used to leak current from the line when the telephone is on-hook in order to maintain the contents of the LNR Store.

Fig. 15 demonstrates how a large, low leakage capacitor can be used to maintain the contents of the LNR store for a finite period in applications where complete line isolation is required whilst on-hook.

In both circuits a 47μF capacitor is used to maintain and smooth the supply to the chip and the 130V Zener diode protects the chip from overvoltage.

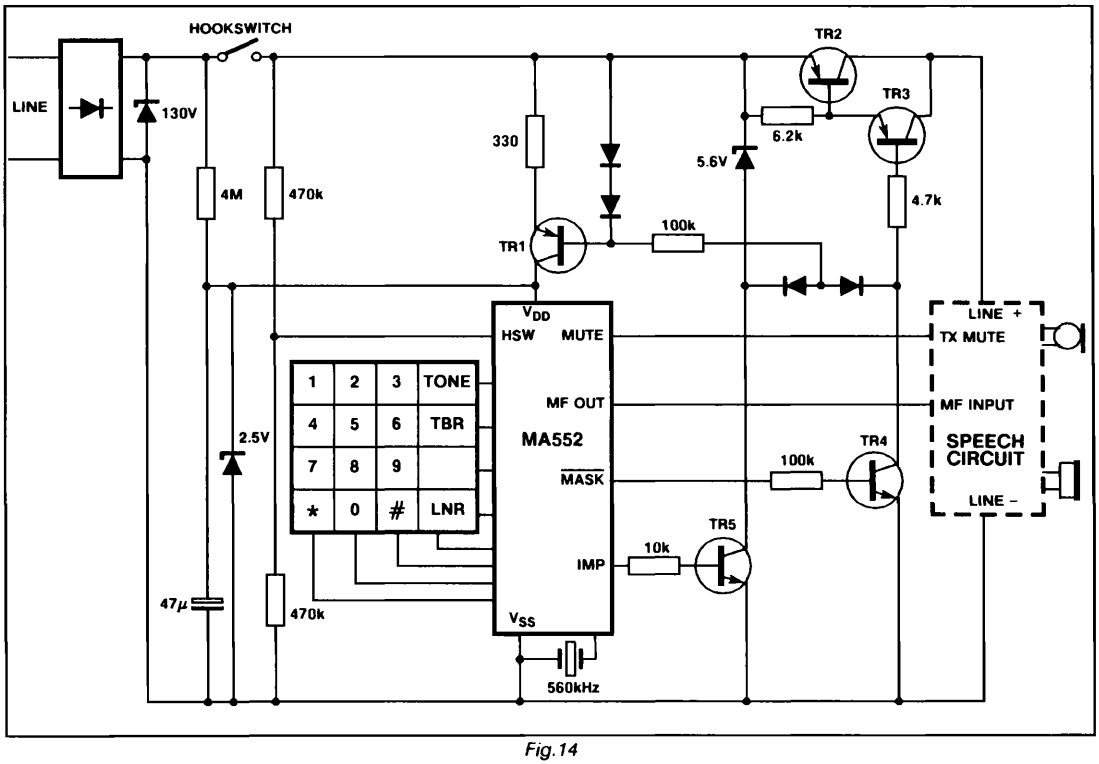

Fig.14

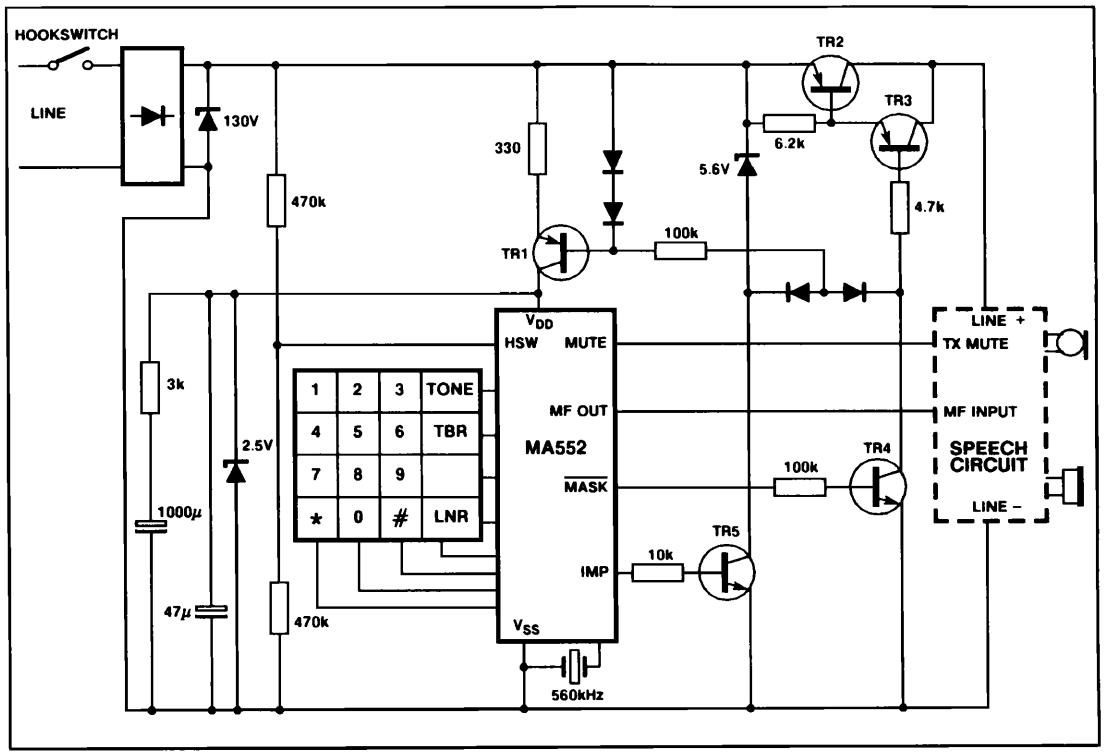
HOOKSWITCH
LINE
130V
470k
330
TR1
100k
TR2
6.2k
5.6V
TR3
4.7k
V_{DD}
HSW
MUTE
MF OUT
MA552
MASK
IMP
V_{SS}
560kHz
LINE +
TX MUTE
MF INPUT
SPEECH CIRCUIT
LINE –
TR4
100k
TR5
10k
3k
2.5V
1000μ
47μ
470k
1 2 3 TONE
4 5 6 TBR
7 8 9
* 0 # LNR

Fig.15