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L3914A
L3924A - L3934A

SPEECH AND 14 MEMORY DIALER WITH HOLD FUNCTION

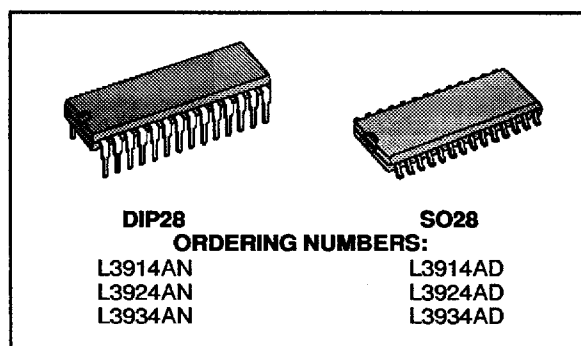**ADVANCE DATA**

SPEECH CIRCUIT
- 2 TO 4 WIRES CONVERSION
- PRESENT THE PROPER DC PATH FOR THE LINE CURRENT AND THE FLEXIBILITY TO ADJUST IT AND ALLOW PARALLEL PHONE OPERATION
- PROVIDES SUPPLY WITH LIMITED CURRENT FOR EXTERNAL CIRCUITRY
- SYMMETRICAL HIGH IMPEDANCE MICROPHONE INPUTS SUITABLE FOR DYNAMIC ELECTRET OR PIEZOELECTRIC TRANSDUCER
- ASYMMETRICAL EARPHONE OUTPUT SUITABLE FOR DYNAMIC TRANSDUCER
- LINE LOSS COMPENSATION
- INTERNAL MUTING TO DISABLE SPEECH DURING DIALING
- HOLD FUNCTION FOR PARALLEL PHONE WITH 400ms DELAY TO PREVENT FALSE RELEASE
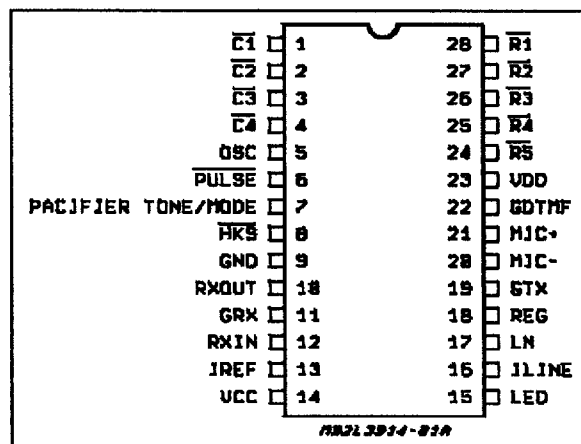
DIALER CIRCUIT
- 32 DIGITS FOR LAST NUMBER REDIAL BUFFER
- 18 DIGITS FOR 13 MEMORY REDIAL
- ALLOW MIXED MODE DIALING IN EITHER TONE OR PULSE MODE
- PACIFIER TONE PROVIDES AUDIBLE INDICATION OF VALID KEY PRESSED IN A BUZZER OR/AND IN THE EARPHONE
- TIMED PABX PAUSE
- FLASH INITIATES TIMED BREAK: MASK OPTIONS WITH 585ms,300ms,100ms
- CONTINUOUS TONE FOR EACH DIGIT UNTIL KEY RELEASE
- USES INEXPENSIVE 3.579545MHz CERAMIC RESONATOR
- POWERED FROM TELEPHONE LINE, LOW OPERATING VOLTAGE FOR LONG LOOP APPLICATION

DESCRIPTION
The device consists of the speech and the dialer. It provides the DC line interface circuit that terminates the telephone line, analog amplifier for speech transmission and necessary signals for either DTMF or loop disconnect (pulse) dialing.

DIP28	SO28
ORDERING NUMBERS:	
L3914AN	L3914AD
L3924AN	L3924AD
L3934AN	L3934AD

PIN CONNECTION (Top view)

$\overline{C1}$	1	28	$\overline{R1}$
$\overline{C2}$	2	27	$\overline{R2}$
$\overline{C3}$	3	26	$\overline{R3}$
$\overline{C4}$	4	25	$\overline{R4}$
OSC	5	24	$\overline{R5}$
$\overline{PULSE}$	6	23	VDD
PACIFIER TONE/MODE	7	22	GDTMF
$\overline{HKS}$	8	21	MIC+
GND	9	20	MIC-
RXOUT	10	19	STX
GRX	11	18	REG
RXIN	12	17	LN
IREF	13	16	ILINE
VCC	14	15	LED

L3L3914-01A

KEYPAD CONFIGURATION

1	2	3	FLASH
4	5	6	PROG
7	8	9	PAUSE /LND
* SOFT SWITCH	0	#	HOLD
E1	E2	E3	MEM

L3L3914-02A

Note: PAUSE/LND:
PAUSE and LND functions are sharing the same key with different sequence. Hereafter, PAUSE and LND keys are referring to the same key.

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BLOCK DIAGRAM
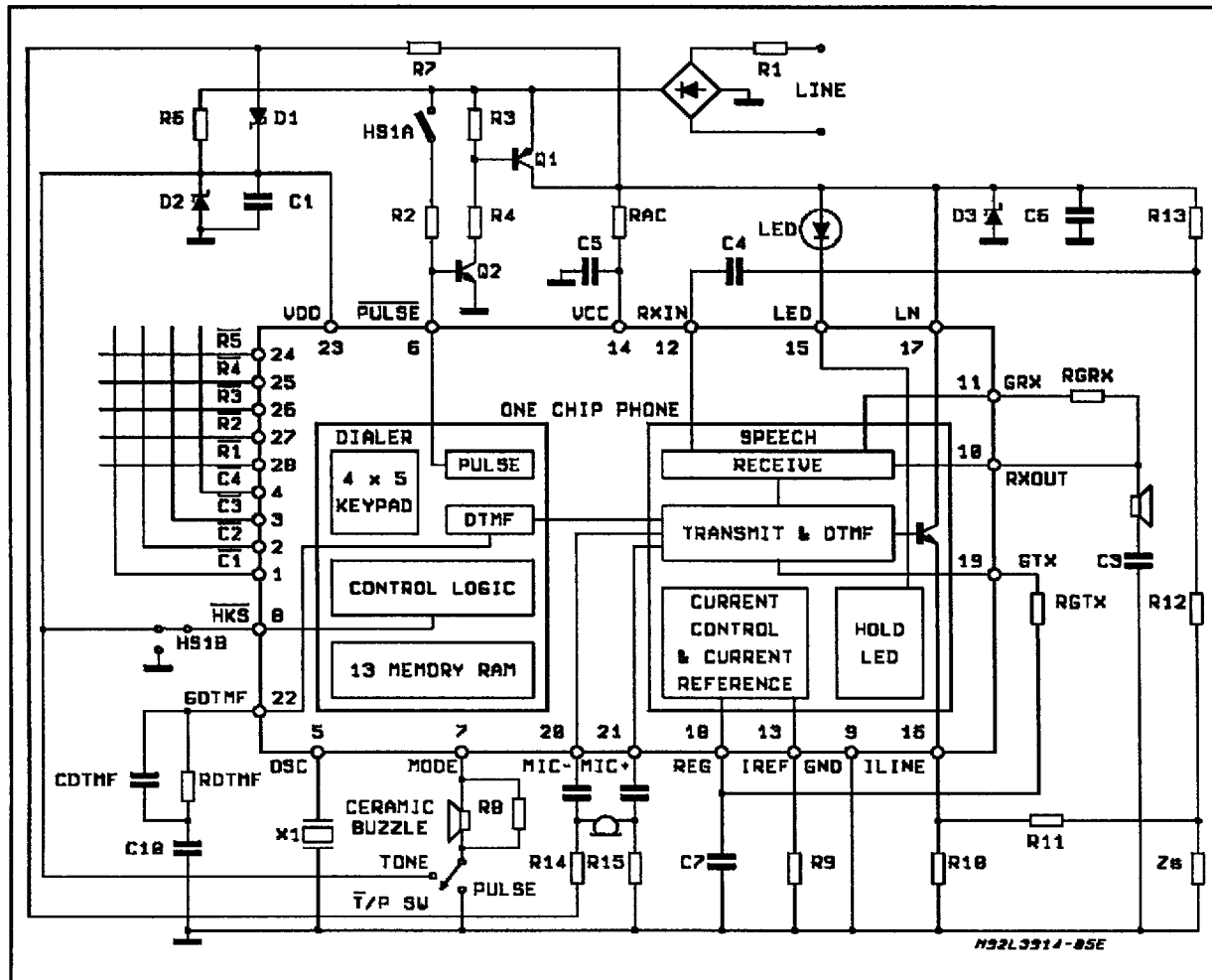
When mated with a tone ringer, a complete telephone can be produced with just two ICs.

The DC line interface circuit develops its own line voltage across the device and it is adjustable by external resistor to suit different country's specification.

The speech network provides the two to four wires interface, electronic switching between dialing and speech and automatic gain control on transmit and receive.

The dialing network buffers up to 32 digits into the LND memory that can be later redialed with a single key input. Additionally, another 13 memories (including 3 emergency memories) of 18 digits memory is available. Users can store all 13 signalling keys and access several unique functions with single key entries. These functions include: Pause/Last Number Dialed (LND), Softswitch, Flash and Hold.

The FLASH key simulates a timed hook flash to transfer calls or to activate other special features provided by the PABX or central office.

The PAUSE key stores a timed pause in the number sequence. Redial is then delayed until an outside line can be accessed or some other activity occurs before normal signaling resumes.

A LND key input automatically redials the last number dialed.

The HOLD key allows the user to suspend the conversation and resume the call on either the same phone by pressing the HOLD key again or resume the conversation at a parallel phone.

FUNCTION PIN DESCRIPTION

$\overline{C1}, \overline{C2}, \overline{C3}, \overline{C4}, \overline{R5}, \overline{R4}, \overline{R3}, \overline{R2}, \overline{R1}$

Keyboards inputs. Pins 1, 2, 3, 4, 24, 25, 26, 27, 28. The one chip phone interfaces with either the standard 2-of-9 with negative common or the single-contact (Form A) keyboard.

FUNCTION PIN DESCRIPTION (continued)

A valid keypad entry is either a single Row connected to a single Column or GND simultaneously presented to both a single Row and a single Column.

In its quiescent or standby state, during normal off-hook operation, either the Rows or the Columns are at logic level 1 (V_{DD}). Pulling one input low enables the on chip oscillator. Keyboard scanning then begins.

Scanning consists of Rows and Columns alternately switching high through on chip pullups. After both a Row and Column key have been detected, the debounce counter is enabled and any noise (bouncing contacts, etc) is ignored for a debounce period (TKD) of 32ms. At this time, the keyboard is sampled and if both the Row and Column information are valid, the information is buffered into the LND location. After scanning starts, the row and column inputs will assume opposite states.

In the tone mode, if two or more keys in the same row or if two or more keys in the same column are depressed a single tone will be output. The tone will corresponds to the row or column for which the two keys were pushed. This feature is for testing purposes, and single tone will not be redialed. Also in the tone mode, the output tone is continuous in the manual dialing as long as the key is pushed. The output tone duration follows the Table 1. When redialing in the tone mode, each DTMF output has 100ms duration, and the tone separation (inter signal delay) is 100ms.

Table 1: Output Tone Duration

Key-Push Time, T	Tone Output
T<= 32ms	No output, ignored by one chip phone.
32ms < = T < = 100ms + Tkd	100ms Duration
T > = 100ms + Tkd	Output Duration = T - Tkd

OSC

Output. Pin 5. Only one pin is needed to connect the ceramic resonator to the oscillator circuit. The other end of the resonator is connected to GND (pin 8). The nominal resonator frequency is 3.579545MHz and any deviation from this standard is directly reflected in the Tone output frequencies. The ceramic resonator provides the time reference for all circuit functions. A ceramic resonator with tolerance of ±0.25% is recommended.

PULSE

Output. Pin 6. This is an output consisting of an open drain N-Channel device. During on-hook, pulse output pin is in high impedance and once off-hooked, it will be pulled high by external resistor. The pulse out will go high when the Hold key is pressed, in this way the phone will stay connected to the line untill the parallel phone is hooked-OFF or the Hold Key is pressed again.

MODE/PACIFIER TONE

Input (MODE). Pin 7. MODE determines the dialer's default operating mode. When the device is powered up or the hookswitch input is switched from on-hook (V_{DD}) to off-hook (GND), the default determines the signalling mode. A V_{DD} connection defaults to tone mode operation and a GND connection defaults to pulse mode operation.

When dialing in the pulse mode, a softswitch feature will allow a change to the tone mode whenever the * key is depressed. Subsequent* key inputs will cause the DTMF code for an * to be dialed.. The softswitch will only switch from pulse to tone. After returning to on-hook and back to off-hook, the phone will be in pulse mode. Redial by the LND key or the MEM key will repeat the softswitch.

Output (PACIFIER TONE). Pin 7. In pulse mode, all valid key entries activate the pacifier tone. In tone mode, any non DTMF entry (FLASH, PROG, PAUSE, LND, HOLD, MEM, E1, E2 and E3), activates the pacifier tone. The pacifier tone provides audible feedback, confirming that key has been properly entered and accepted. It is a 500Hz square wave activated upon acceptance of valid key input after the 32ms debounce time. The square wave terminates after a maximum of 75ms or when the valid key is no longer present. The pacifier tone signal is simultaneously sent to earphone and the buzzer. The buzzer can be removed without affecting this function.

HKS

Input. Pin 8. This is the hookswitch input to the one chip phone. This is a high impedance input and must be switched high for on-hook operation or low for off-hook operation. A transition on this input causes the on chip logic to initialize, terminating any operation in progress at the time. The signaling mode defaults to the mode selected at pin 7. Figures 1 and 2 illustrate the timing for this pin.

GND

Pin 9 is the negative line terminal of the device. This is the voltage reference for all specifications.

RXOUT, GRX, RXIN

RXOUT (pin 10), GRX (pin 11) and RXIN (pin 12). The receive amplifier has one input RXIN and a non inverting output RXOUT. Amplification from RXIN to RXOUT is typically 31dB and it can be adjusted between 11dB and 41dB to suit the sensitivity of the earphone used. The amplification is proportional to the external resistor connected between GRX and RXOUT.

FUNCTION PIN DESCRIPTION (continued)

IREF

Pin 13. An external resistor of 3.6kOhm connected between IREF and GND will set the internal current level. Any change of this resistor value will influence the microphone gain, DTMF gain, earphone gain and sidetone.

V$_{CC}$

Pin 14, V$_{CC}$ is the positive supply of the speech network. It is stabilized by a decoupling capacitor between V$_{CC}$ and GND. The V$_{CC}$ supply voltage may also be used to supply external peripheral circuits.

LED

Pin 15. The LED connected to this pin will start to blink when the HOLD key is pressed and will turn off if the HOLD key is pressed again. Otherwise, it will continue to blink at 1Hz frequency when the phone is on-hooked and then turn off when the parallel phone goes off-hook.

I$_{LINE}$

Pin 16. A recommended external resistor of 20ohm is connected between I$_{LINE}$ and GND. Changing this resistor value will have influence on microphone gain, DTMF gain, sidetone, maximum output swing on LN and on the DC characteristics (especially in the low voltage region).

LN

Pin 17. LN is the positive line terminal of the device.

REG

Pin 18. The internal voltage regulator has to be decoupled by a capacitor from REG) to GND). The DC characteristics can be changed with an external resistor connected between LN and REG or between REG and I$_{LINE}$.

GTX, MIC-, MIC+

GTX (pin 19), MIC- (pin 20) and MIC+ (pin 21). The one chip phone has symmetrical microphone inputs. The amplification from microphone inputs to LN is 51.5dB and it can be adjusted between 43.5 and 51.5dB. The amplification is proportional to external resistor connected between GTX and REG.

GDTMF

Pin 22. When the DTMF input is enabled, the microphone inputs and the receive amplifier input will be muted and the dialing tone will be sent to the line. The voltage amplification from GDTMF to LN is 40dB. Final output level on LN can be adjusted via the external resistor connected between GDTMF and GND through a decoupling capacitor. A confidence tone is sent to the earphone during tone dialing. The attenuation of the confidence tone from LN to Vear is -32dB typically.

V$_{DD}$

Pin 23. V$_{DD}$ is the positive supply for the dialing network and must meet the maximum and minimum voltage requirements.

DEVICE OPERATION

During on-hook all keypad inputs are high impedance internally and it requires very low current for memory retention. At anytime, Row and Column inputs assume opposite states at off-hook. The circuit verifies that a valid key has been entered by alternately scanning the Row and Column inputs. If the input is still valid following 32ms of debounce, the digit is stored into memory, and dialing begins after a pre-signal delay of approximately 40ms (measured from the initial key closure). Output tone duration is shown in Table 1.

The device allows manual dialing of an indefinite number of digits, but if more than 32 digits are dialed, it will "wrap around". That is, the extra digits beyond 32 will be stored at the beginning of LND buffer, and the first 32 digits will no longer be available for redial.

Table 2: DTMF Output Frequency

Key Input	Stadard Frequency	Actual Frequency	% Deviation
ROW 1	697	699.1	+0.31
ROW 2	770	766.2	-0.49
ROW 3	852	847.4	-0.54
ROW 4	941	948.0	+0.74
COL 1	1209	1215.9	+0.57
COL 2	1336	1331.7	-0.32
COL 3	1477	1471.9	-0.35

NORMAL DIALING

D1   D2   D3   ....etc

Normal dialing is straighforward, all keyboard entries will be stored in the buffer and signaled in succession.

PROGRAMMING AND REPORTORY DIALING

To program, enter the following:

PROG   D1   D2   Dn MEM (location 0-9)
or
PROG   D1   D2   Dn E1-E3

During programming, dialing is inhibited.

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FUNCTION PIN DESCRIPTION (continued)

To dial a number from repertory memory ($\overline{\text{HKS}}$ must be low), enter the following:

MEM (Location 0-9) or E1-E3

To save the last number dialed, enter the following:

PROG MEM (location 0-9) or E1-E3

HOOK FLASH

D1 FLASH D2 ...etc

Hook flash may be entered into the dialed sequence at any point by keying in the function key, FLASH. Flash consists of a timed break of 585ms, 300ms or 100ms depending on the Mask option. When a FLASH key is pressed, no further key inputs will be accepted until the hookflash function has been dialed. The key input following a FLASH will be stored as the initial digit of the new number, overwriting the number dialed before the FLASH, unless it is another FLASH.

FLASH key pressed immediately after hookswitch or LND will not clear the LND buffer unless digits are entered following the FLASH key.

Example:

FLASH

LND not cleared

LND FLASH

LND not cleared

LND FLASH D1 D2

LND buffer will contain D1, D2

PAUSE/LAST NUMBER DIALED

If the PAUSE/LND key is pressed right after off hook or FLASH key, it is considered as LND, if it is pressed after a digit, it will be considered as PAUSE.

LAST NUMBERED DIALED

OFF-HOOK PAUSE/LND or FLASH PAUSE/LND

Last number dialing is accomplished by entering the PAUSE/LND key.

PAUSE

OFF-HOOK D1 PAUSE/LND D2 ...etc

A pause may be entered into the dialed sequence at any point by keying in the special function key, PAUSE/LND. Pause inserts a 3.1 second delay into the dialing sequence. The total delay, including pre-digit and post-digit pauses is shown in Table 3.

Table 3: Special Function Delays

Each delay shown below represents the time required after the special function key is depressed until a new digit is dialed. The time is considered "FIRST" key if all previous inputs have been completely dialed. The time is considered "AUTO" if in redial, or if previous dialling is still in progress.

Function	First/Auto	Delay (seconds)	
		Pulse	Tone
SOFTSWITCH	FIRST	0.2	
	AUTO	1.0	
PAUSE	FIRST	2.6	3.0
	AUTO	3.4	3.1

HOLD

When HOLD key is pressed during off hook, there are two options. The first option is to mute the phone (LED will blink) and the conversation can be resumed by pressing the HOLD key again. The second option is to mute the phone (LED will blink), on-hook the phone (LED will still blink at 1Hz frequency) and automatic switch off the phone when parallel phone is off-hook.

The HOLD function is disabled when the line current drops below 20mA.

SOFTSWITCH FUNCTION USING TONE/PULSE MODE SWITCH

When dialing in Pulse mode after off-hook, switching TONE/PULSE mode switch from Pulse to Tone will cause the device to change the signaling mode into tone signal and store the softswitch function in the LND memory for redial. To redial the softswitch function (mixed mode dialing) in the pulse mode after going on-hook and back to off-hook, you have to switch the TONE/PULSE mode switch back to pulse mode either before going on-hook or after off-hook or during on-hook.

Subsequent mode change from Tone to Pulse will change the signaling mode to pulse dialing sequence but this mode change will not be stored in .the LND memory.

When dialing in Tone mode after off-hook, a switching of TONE/PULSE mode Switch from Tone to Pulse will cause the device to change the signaling mode into pulse mode but this mode change will not be stored in the LND memory. When LND key is pressed in Tone mode after going off-hook, the device will output all tone signals.

A pacifier tone of 75ms is provided after 32ms debounce time when switching from Pulse to Tone mode.

Redial by the LND key will repeat the mixed dialing sequence in Pulse mode.

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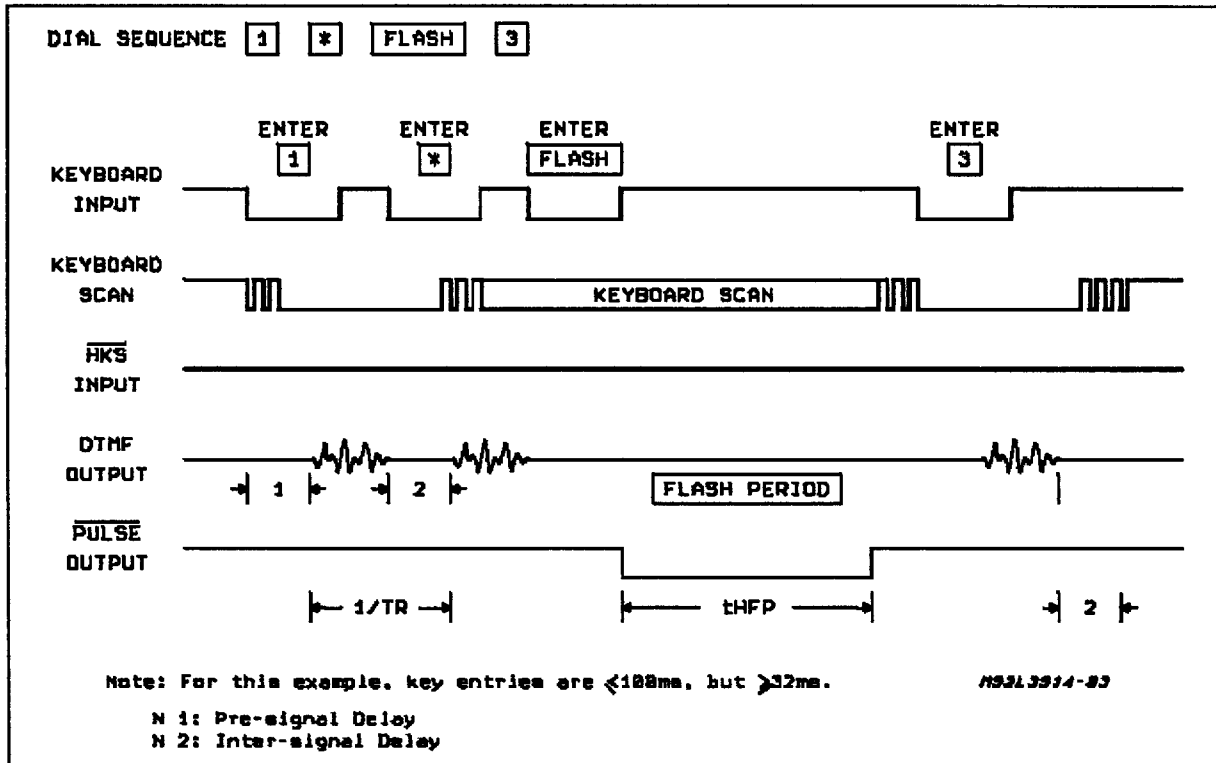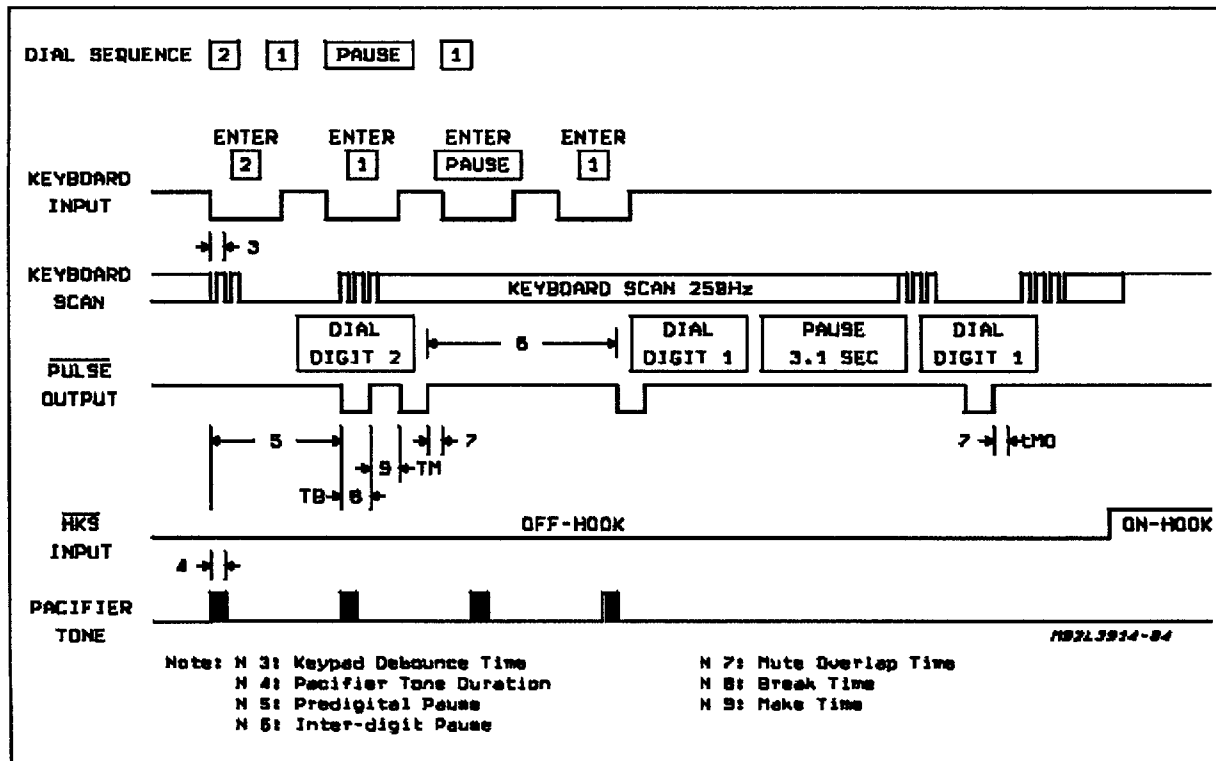**Figure 1:** Tone Mode Timing

Figure 2: Pulse Mode Timing

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ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{LN}	Positive Line Voltage Continuous	12	V
I_{LN}	Line Current	140	mA
V_{DD}	Logic Voltage	7.0	V
V_I	Maximum Voltage on Any Pin	GND(-0.3) V_{DD}(+0.3)	V
T_{amb}	Operating Temperature Range	-25 to +75	°C
T_{stg}	Storage Temperature	-40 to 125	°C
P_{tot}	Total Power Dissipation	700	mW

ELECTRICAL CHARACTERISTICS (I_L = 10 to 120mA; V_{DD} = 3V; f = 1KHz; T_{amb} = 25°C, unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit	Fig.
V_{LN}	Line Voltage	I_L = 4mA I_L = 15mA I_L = 120mA R_A = 68KΩ ; I_L = 15mA R_B = 39KΩ ; I_L = 15mA	3.15	3.50 3.2 4.1	2.50 3.85 7.0	V V V V V	3
V_{DD}	Logic Voltage)	TONE MODE PULSE MODE	2.50 2.20		6.00 6.00	V V	3
I_{DD}	Supply Current Into V_{DD}	TONE MODE PULSE MODE		600 400		μA μA	3
I_{CC}	Supply Current Into V_{CC}	I_L = 15mA		1.30		mA	3
I_{LED}	Supply Current to HOLD LED	I_L = 15mA I_L = 120mA		4 30		mA mA	3
V_{MR}	Memory Retention Voltage		1.50			V	4
I_{MR}	Memory Retention Current				1.00	μA	4
I_S	Off-Hook Stand-by Current	V_{DD} = 4.0V		150	250	μA	3
I_{PL}	Pulse Output Sink Current	V_O = 0.5V	1.00	3.00		mA	3
I_{PO}	Pacifier Tone Sink/Source Current	V_O = 0.5V (Sink) V_O = 2.5V (Source)	1 0.6	3 1		mA mA	3
V_{IL}	HKS, Mode, Keyboard Inputs Low				0.3xV_{DD}	V	-
V_{IH}	HKS, Mode, Keyboard Inputs High		0.7xV_{DD}			V	-
G_{TX}	Transmit Gain	V_{mic} = 2mVrms I_L = 15mA; R_{GTX} = 68KΩ I_L = 60mA; R_{GTX} = 68KΩ	50.0 44.5	51.5 46.5	53.0 48.5	dB dB	6
A_{GTX}	Transmit Gain Variation with R_{GTX}	I_L = 15mA V_{mic} = 2mVrms R_{GTX} = 43KΩ R_{GTX} = 27KΩ	-8	- 4 - 8	0	dB dB dB	6
D_{TX}	Transmit Distortion	I_L = 15mA; V_{LN} = 1Vrms			2	%	6
N_{TX}	Transmit Noise	I_L = 15mA; V_{mic} = 0V		-72		dBmp	6
Z_{MIC}	Microphone Input Impedance			64		KΩ	5
G_{DTMF}	DTMF Gain (Output @ LN)	I_L = 15mA ; R_{DTMF} = 2.25KΩ	38	40	42	dB	7
C_{DTMF}	Confidence Tone Level V_{ear}/V_{LN}		-34	-32	-30	dB	7

7929237 0067724 107

ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit	Fig.
V_{DTMF}	DTMF Level on the line High Frequency Group Low Frequency Group	R_{DTMF} = 2.25KΩ, C_{DTMF} = 22nF	 -8 -10	 -6 -8	 -4 -6	 dBm dBm	7
P_{EI}	Pre-emphasis		1.0	2	3.0	dB	7
DIS	DTMF Output Distortion			5	8	%	7
Z_{DTMF}	DTMF Att. pin Impedance			32		KΩ	
G_{RX}	Receive Gain	V_{inp} = 5mVrms; R_e = 300Ω R_{GRX} = 100KΩ I_L = 15mA I_L = 60mA	 29.5 24	 31.0 26	 32.5 28	 dB dB	8
A_{GRX}	Receive Gain Variation	I_L =15mA; R_e = 300Ω R_{GRX} = 10KΩ R_{GRX} = 300KΩ	-20	 -20 +10	+10	dB dB dB	8
D_{RX}	Reveive Output Distortion	I_L = 15mA; R_{GRX} = 100KΩ R_e = 150Ω; V_C = 0.25V_{rms} R_e = 300Ω; V_C = 0.45V_{rms} R_e = 450Ω; V_C = 0.55V_{rms}			 2 2 2	 % % %	8
N_{RX}	Receive Noise	I_L = 15mA; R_L = 300Ω; R_{GRX} = 100KΩ; V_{INP} = 0V		200		μV	8
Z_{OUT}	Receive Output Impedance	I_L = 15mA		35		Ω	8
V_{PT}	Pacifier Tone Level on Earphone	I_L = 15mA; R_P = ∞ R_p = 430K		60 600		mVrms mVrms	8
KEYBOARD INTERFACE							
TKD FKS KRU KRD	Keypad Debounce Time Keypad Scan Frequency Keypad Pullup Resistance Keypad Pulldown Resistance			32 250 100 500		ms Hz KΩ Ω	
PULSE MODE							
TPT FPT PR TB TM IDP PDP	Pacifier Tone Duration Pacifier Tone Frequency Pulse Rate Break Time Make Time Inter Digit Pause Predigit Pause			75 500 10 60 40 820 50		ms Hz PPS ms ms ms ms	
TONE MODE							
TRIS TR TPSD TISD TDUR	Tone Output Rise Time Tone Signalling Rate Pre Signal Delay Inter Signal Delay Tone Output Duration		 40	 5 100 100	5	ms 1/s ms ms ms	
THD	Hold Mode Delay			400		ms	
tHFP	Hook Flash Timing	L3914A L3924A L3934A		585 300 100		ms ms ms	

Notes:
1. All inputs unloaded. Quiescent mode (oscillator off).
2. Pulse output sink current for V_{OUT} = 0.5V.
3. Pacifier tone sink current for V_{OUT} = 0.5V. Source current for V_{OUT} = 2.5V.
4. Memory retention voltage is the point where memory is guaranteed but circuit operation is not. Proper memory retention is guaranteed if either the minimum IMR is provided or the minimum VMR. The design does not have to provide both the minimum current and voltage simultaneously.
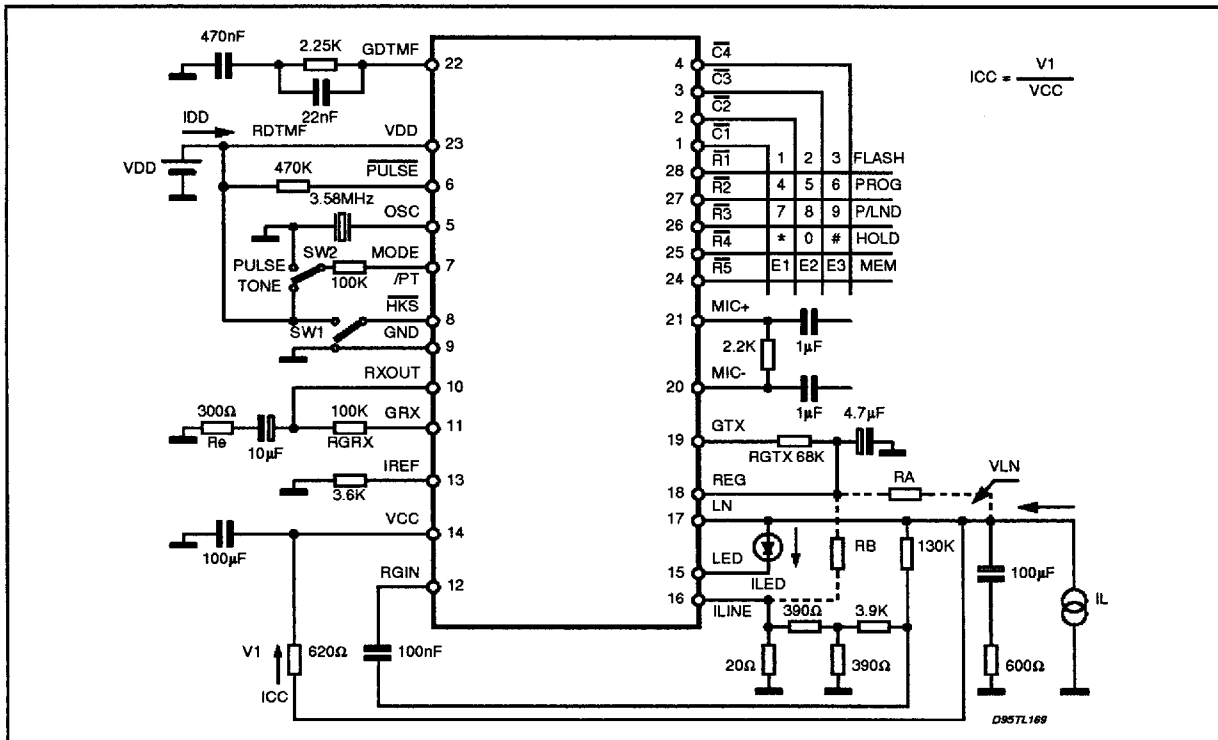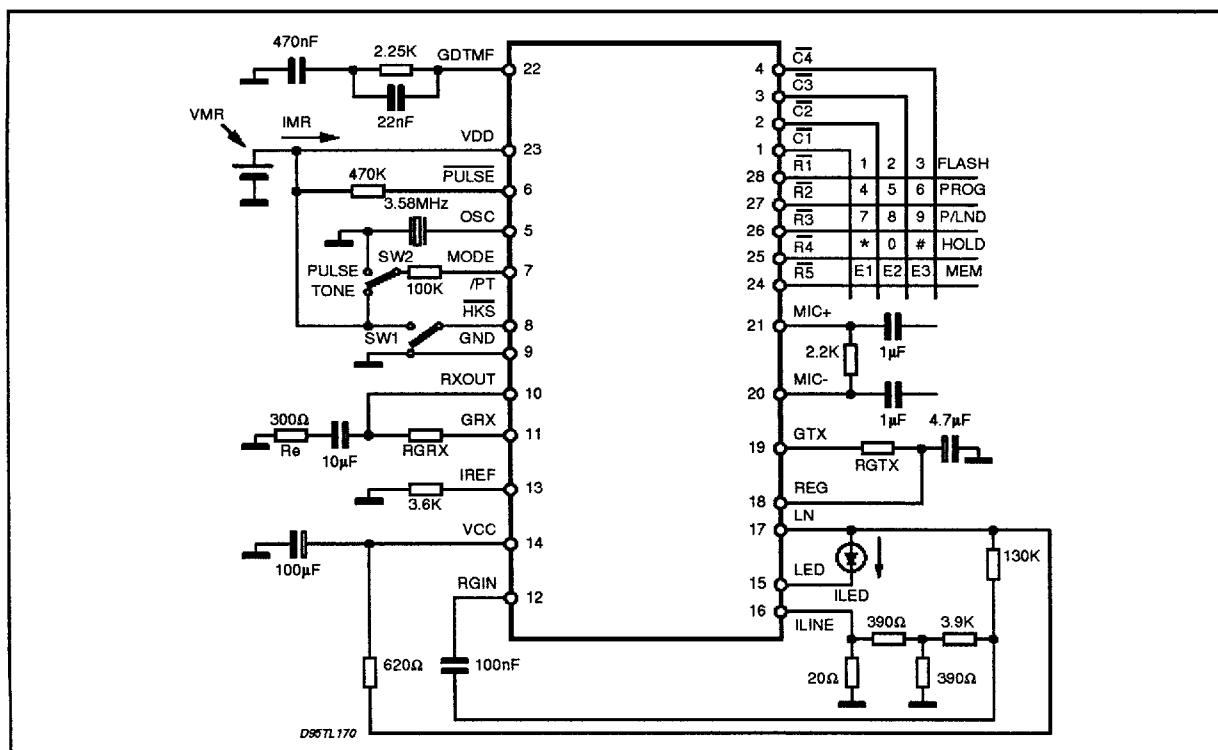
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TEST CIRCUITS
Figure 3.

Figure 4.

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TEST CIRCUITS(continued)
Figure 5.

Figure 6.

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TEST CIRCUITS(continued)
Figure 7.

$$GDTMF = 20\log\frac{VLN}{VMF}$$

$$CDTMF = 20\log\frac{Vear}{VLN}$$

Figure 8.

$$GRX = 20\log\frac{Vear}{Vinp}$$

NRX with Vin=0

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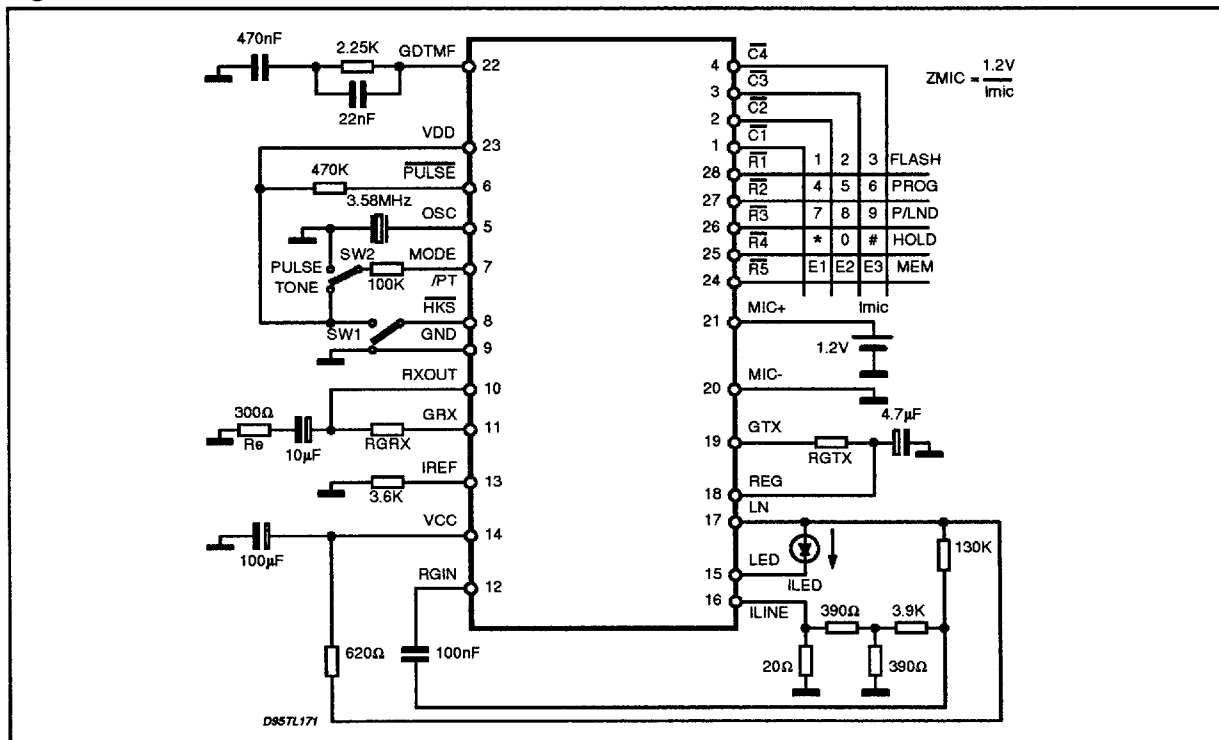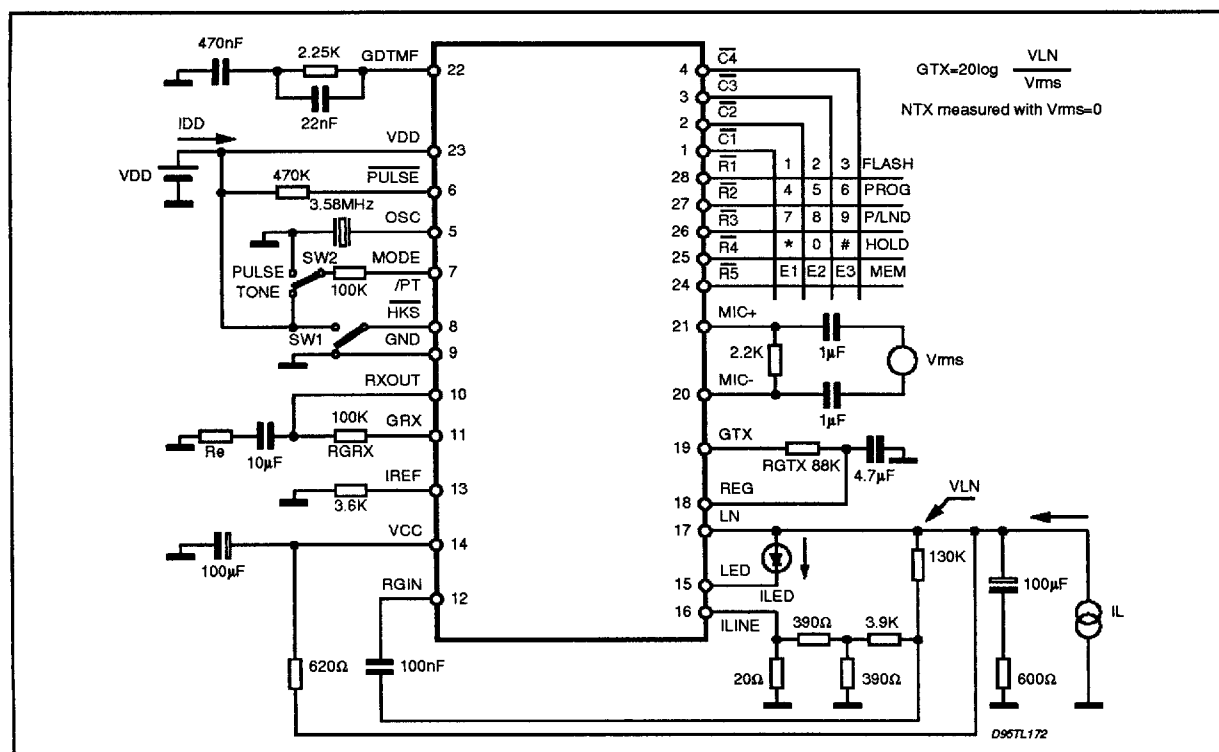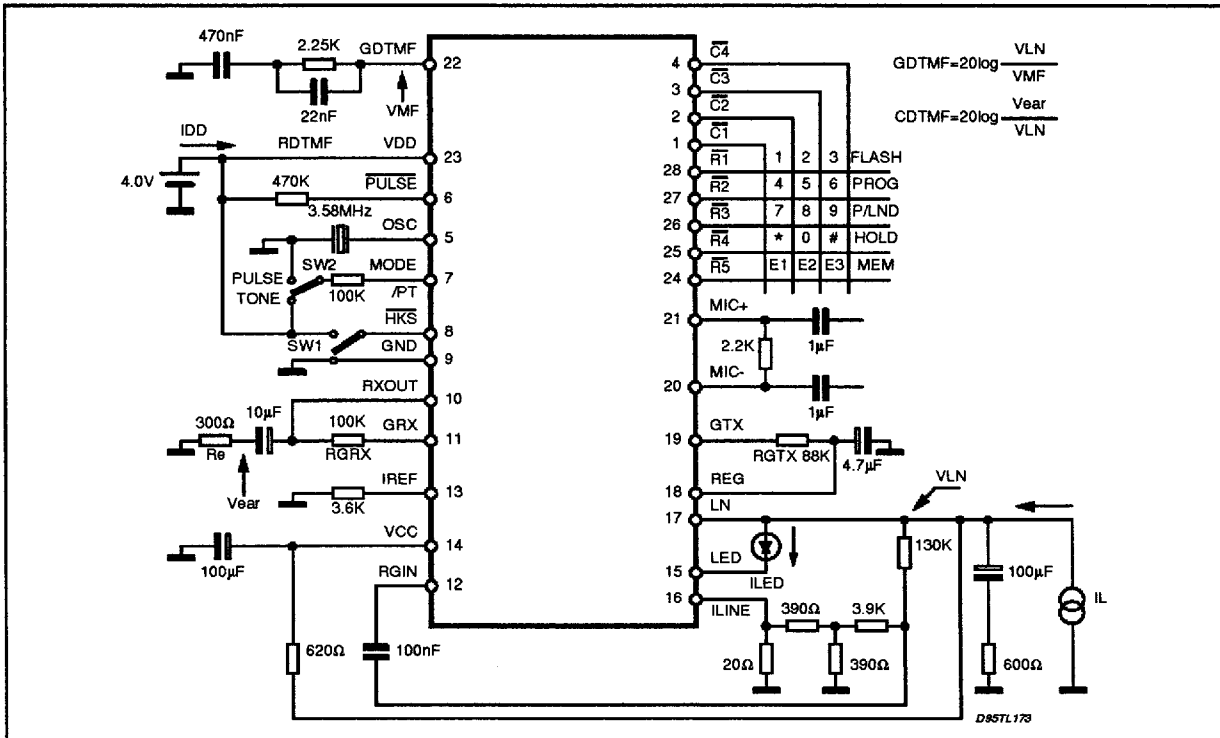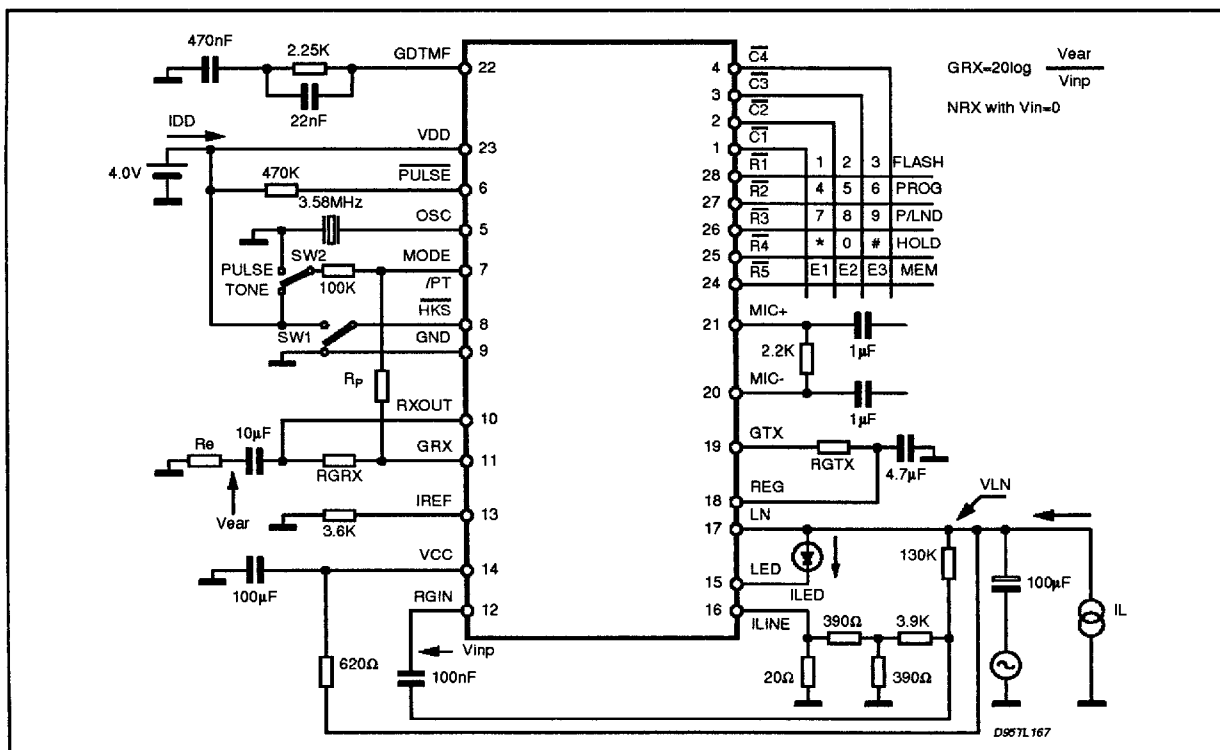
Figure 9: Typical Application Circuit.

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SO28 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.3	0.004		0.012
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.013
C		0.5			0.020	
c1	45° (typ.)					
D	17.7		18.1	0.697		0.713
E	10		10.65	0.394		0.419
e		1.27			0.050	
e3		16.51			0.65	
F	7.4		7.6	0.291		0.299
L	0.4		1.27	0.016		0.050
S	8° (max.)					

0016572

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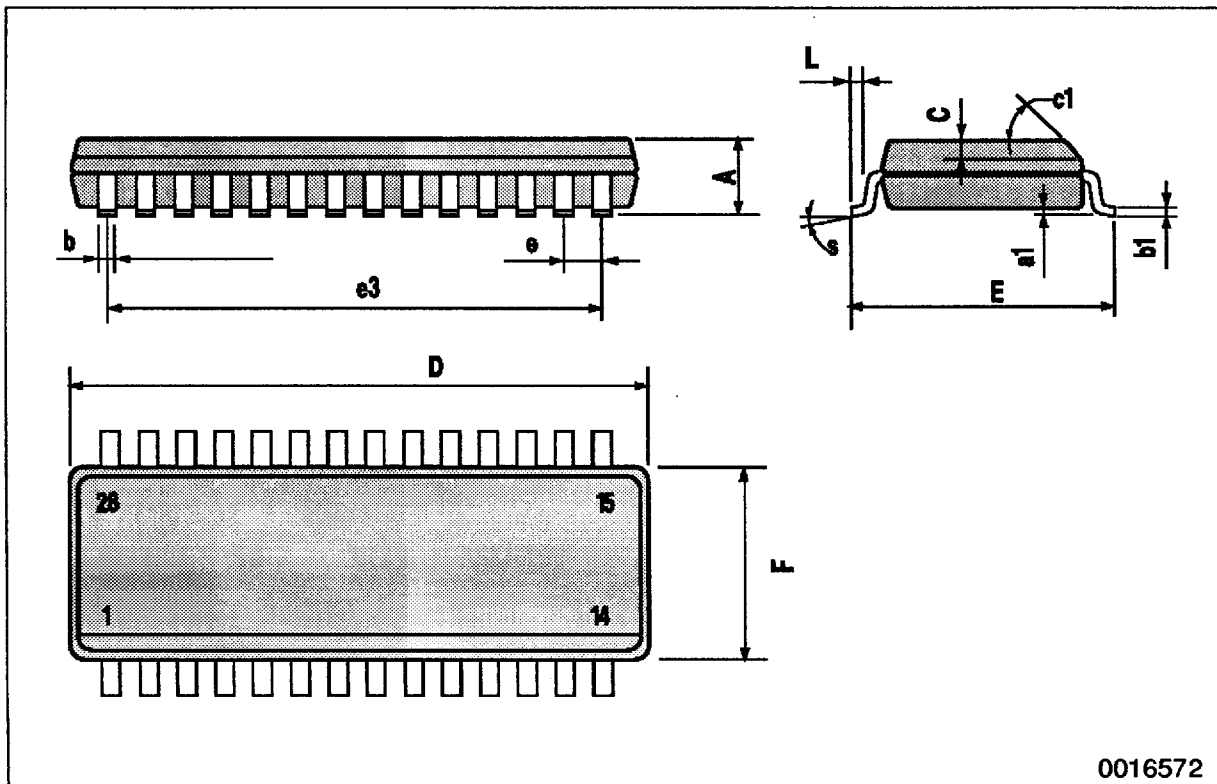
DIP28 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1		0.63			0.025	
b		0.45			0.018	
b1	0.23		0.31	0.009		0.012
b2		1.27			0.050	
D			37.34			1.470
E	15.2		16.68	0.598		0.657
e		2.54			0.100	
e3		33.02			1.300	
F			14.1			0.555
I		4.445			0.175	
L		3.3			0.130	

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