

## TELEPHONE ANALOG FRONT END

### SPEECH

- DC LINE CURRENT RANGE FROM 6 TO 120mA
- EXTERNALLY ADJUSTABLE :
  - Tx AND Rx GAIN
  - MAXIMUM TRANSMIT LEVEL
  - RETURN LOSS
  - SIDETONE NETWORKS
  - Tx AND Rx AGC (LINE CURRENT START UP VALUE AND SLOPE)
- SOFTCLIPPING ON Tx CHANNEL
- SQUELCH ON Tx CHANNEL TO REDUCE NOISE ENVIRONMENT AND TO IMPROVE HOWLING IMMUNITY IN LOUDHEARING MODE
- RECEIVING AMPLIFIER FOR PIEZO AND ELECTRODYNAMIC TRANSDUCERS
- FREQUENCY GENERATOR FOR WAITING MELODY
- ERROR BEEP GENERATOR
- HOLD LINE CURRENT DETECTOR FOR TRANSFER/AUTO RELEASE FEATURE
- PROGRAMMABLE BY MICROCONTROLLER SERIAL BUS :
  - -6dB ON Tx CHANNEL
  - +6dB ON Rx CHANNEL
  - AGC INHIBITION ON Tx AND Rx CHANNELS FOR PABX USE
  - SQUELCH INHIBITION

### GROUP LISTENING / ON HOOK DIALING

- ANTI-HOWLING WITH ACOUSTIC FEED-BACK SYSTEM COUPLED TO SQUELCH
- RING MELODY CONTROL AND ERROR BEEP GENERATORS
- PROGRAMMABLE BY MICROCONTROLLER SERIAL BUS :
  - DIGITAL VOLUME CONTROL (7 STEPS OF 4dB EACH) AND OFF MODE

### HANDFREE INTERFACE

- PINS AND SOFTWARE FACILITY FOR EASY INTERCONNECTION WITH HANDSFREE CONTROLLER I.C. LIKE TEA7540

### RING ON LOUDSPEAKER

- EMBEDDED SWITCH MODE POWER SUPPLY DRIVER TO FEED THE LOUDSPEAKER AMPLIFIER DURING RING MODE

- PROGRAMMABLE BY MICROCONTROLLER SERIAL BUS :
  - DIGITAL VOLUME CONTROL (15 STEPS OF 4dB EACH) AND OFF MODE
  - RING FREQUENCY GENERATOR (MORE THAN 200 FREQUENCIES AVAILABLE)

### DIALING

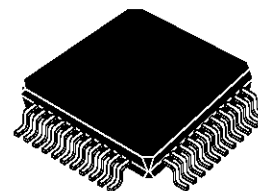
- PROGRAMMABLE BY MICROCONTROLLER SERIAL BUS :
  - DTMF GENERATOR
  - 2V DC LINE VOLTAGE DURING THE MAKE PERIOD IN PULSE MODE

### MICROCONTROLLER INTERFACE

- 3.5V STABILIZED SUPPLY
- TWO WIRES SERIAL BUS INTERFACE
- RING INDICATOR
- PON LINE CURRENT INDICATOR
- RESET SIGNAL
- LINE CURRENT VARIATION INDICATOR (FOR TRANSFER FEATURE)
- OSCILLATOR WITH STAND BY MODE

### CORDLESS AND ANSWERING MACHINE INTERFACE

- SELF BIASED LOUDSPEAKER AMPLIFIER AND MICROCONTROLLER INTERFACE FOR ANSWERING MACHINE
- SIGNAL INPUT AND OUTPUT INTERFACE FOR CORDLESS
- $V_{RMC}$  SUPPLY CAN BE EXTERNALLY FORCED TO 5V FOR EASY INTERFACE WITH A MAIN POWERED MICROCONTROLLER



**TQFP44**  
(Plastic Quad Flat Package)

**ORDER CODES : TEA7092TQ - TEA7092TQT**

# TEA7092

## DESCRIPTION

The TEA7092 is a Telephone set Analog Front End (TAFE) interface intended for use in conjunction with a microcontroller.

In this configuration the TEA7092 provides a worldwide telephone set with loudhearing and melody ringer on loudspeaker. An handsfree telephone set can be built by adding the TEA7540 handsfree controller.

The simple interface with a +5V main supply allows to use the TEA7092 in terminal like Answering machine, FAX and cordless base station.

Repertory dialer (memory on MCU) and various features (HOLD, Tone/Pulse, Flash, Mute, adjustable Ringer and Loudspeaker levels...) are programmable by the MCU through the serial bus interface.

The MCU through the serial bus interface.

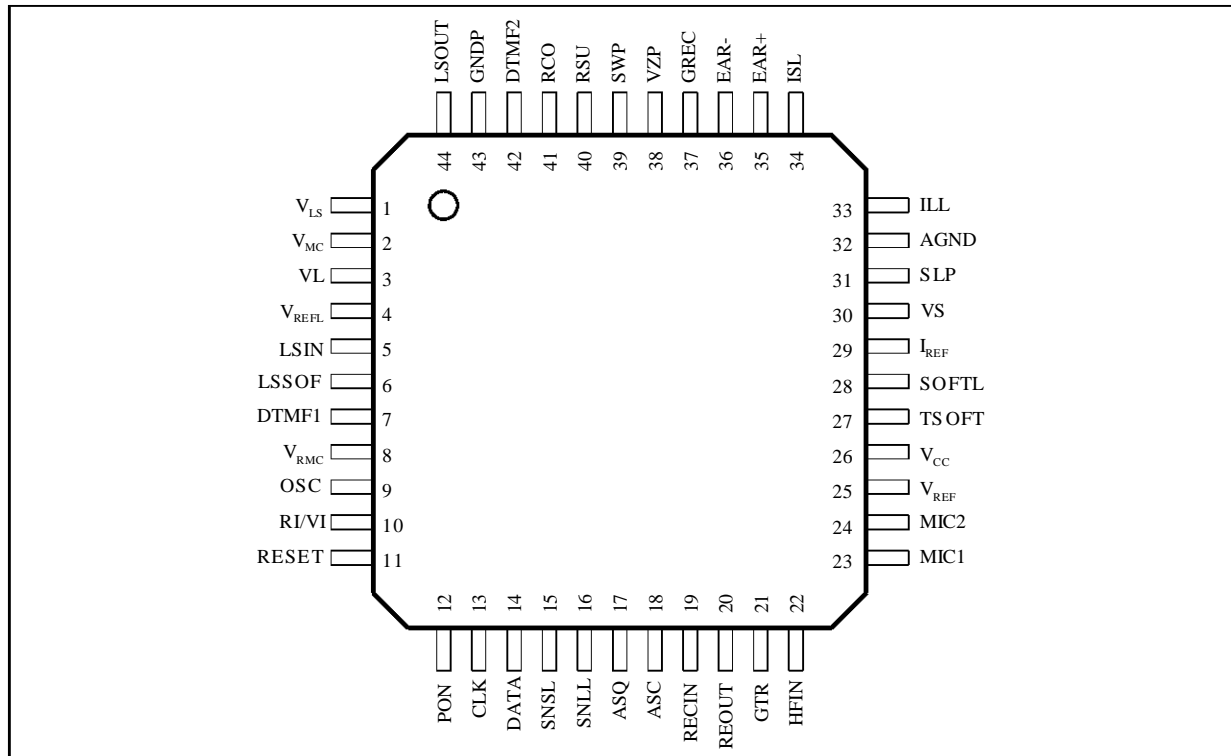
The concept using TAFE and Microcontroller is called BICHIP approach.

## BENEFITS

The benefits of this concept are :

- Saving of external components.
- Easy upgrade of the features (memories, LCD driver, Answering machine, FAX, Cordless ...).
- Replacement of configuration switches (PABX/Public, Tone/Pulse) and potentiometers for loudspeaker and ringer control, by EEPROM settings.
- Reliability and cost improvements.

## PIN CONNECTIONS

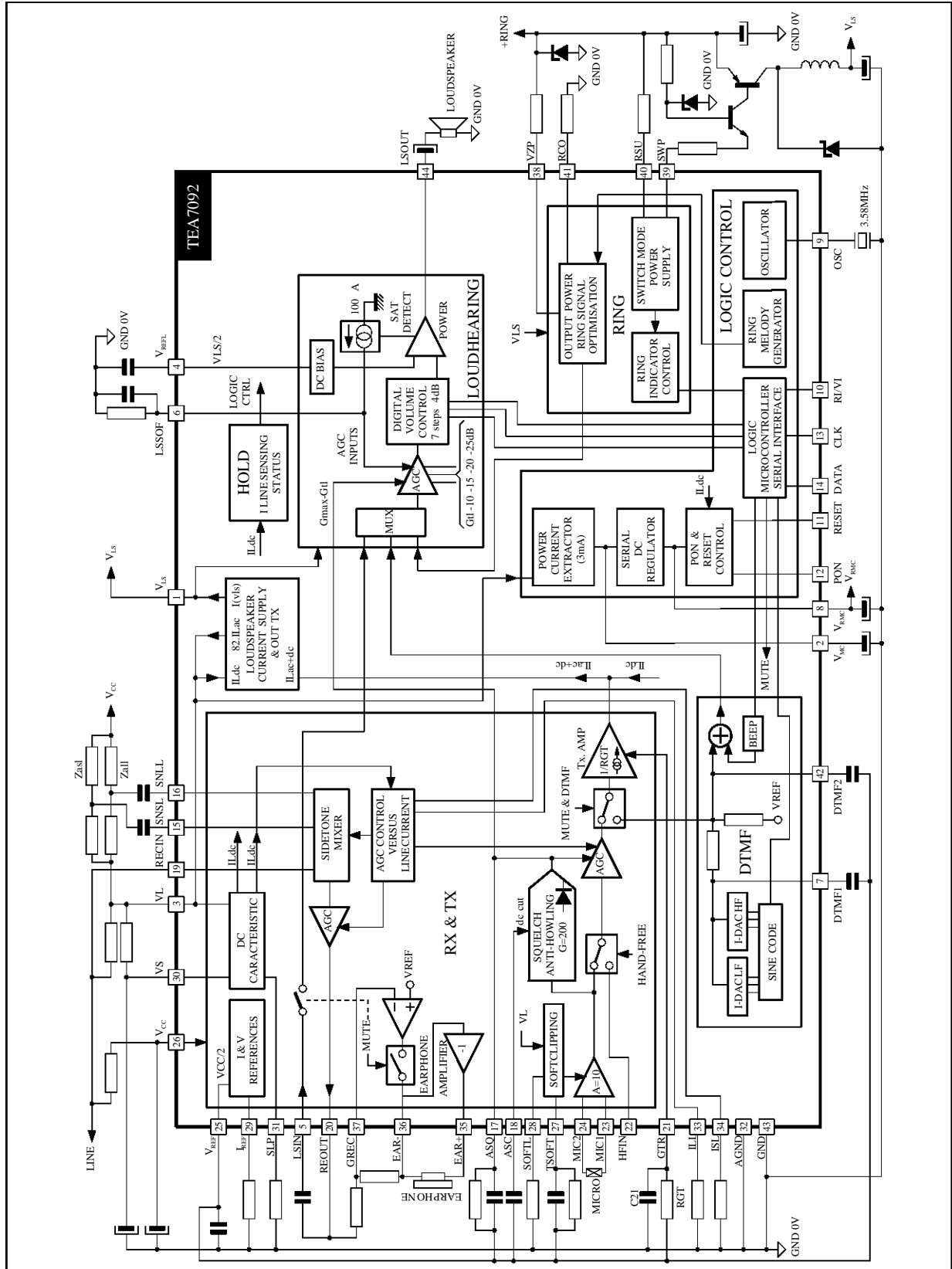


## PIN DESCRIPTION

Pin Number	Name	Description
1	V <sub>LS</sub>	Loudspeaker Power Supply
2	V <sub>MC</sub>	Unregulated Input of Microcontroller Power Supply
3	VL	Transmit Output
4	V <sub>REFL</sub>	Loudspeaker Reference Voltage (V <sub>LS</sub> /2)
5	LSIN	Loudspeaker Amplifier Input
6	LSSOF	Loudspeaker Softclipping Time Constant
7	DTMF1	DTMF Filter 1
8	V <sub>RMC</sub>	Stabilized Microcontroller Power Supply
9	OSC	Oscillator Input
10	RI/VI	Ring Indicator / Line Current Variation Indicator
11	RESET	Microcontroller Reset Output
12	PON	Line Current Indicator Output
13	CLK	Serial Bus Clock Input
14	DATA	Serial Bus Data Input
15	SNSL	Short Line Sidetone Network Input
16	SNLL	Long Line Sidetone Network Input
17	ASQ	Antiacoustic & Squelch Time Constant
18	ASC	DC Offset Cancellation of Squelch Amplifier
19	RECIN	Receive Input
20	REOUT	Receive Output for Handsfree Interface & Loudspeaker Input
21	GTR	Transmit Gain Adjustment
22	HFIN	Handsfree Microphone Input Referenced to V <sub>REF</sub>
23	MIC1	Microphone Input 1 Referenced to V <sub>REF</sub>
24	MIC2	Microphone Input 2 Referenced to V <sub>REF</sub>
25	V <sub>REF</sub>	Speech Reference Voltage (V <sub>CC</sub> /2)
26	V <sub>CC</sub>	Speech Power Supply
27	TSOFT	Transmit Softclipping Time Constant
28	SOFTL	Softclipping Adjustment
29	I <sub>REF</sub>	Resistor to Set Reference Current
30	VS	Active Self Inductor & DC Characteristic Adjustment
31	SLP	DC Mask Slope Adjustment
32	AGND	Analog Ground & Negative Line Voltage
33	ILL	Long Line Speech Control Adjustment (GMAX)
34	ISL	Short Line Speech Control Adjustment (GMAX-6dB)
35	EAR+	Earphone Output
36	EAR-	Earphone Output
37	GREC	Receive Gain Adjustment
38	VZP	Switch Mode Power Supply Internal Zener
39	SWP	Switch Mode Power Supply Output Switch
40	RSU	Ring Start-up Level
41	RCO	Ring Power Output Control
42	DTMF2	DTMF Filter 2
43	GND	Power Ground & Negative Line Voltage
44	LSOUT	Loudspeaker Output

7092-01.TBL

BLOCK DIAGRAM



7092-02.EPS

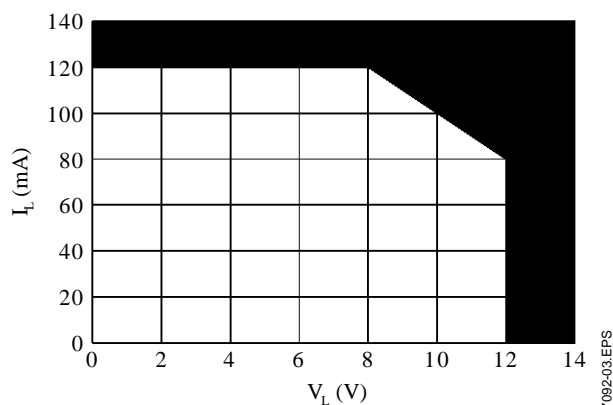
## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V <sub>RECIN</sub>	Supply Voltage	13	V
V <sub>L</sub>	Line Voltage	13	V
I <sub>L</sub>	Line Current	0.15	A
V <sub>RSU</sub>	Ring Input Voltage	22	V
V <sub>SWP</sub>	Output Switch Voltage	7	V
V <sub>VLS</sub>	Loudspeaker Part Supply	5.5	V
V <sub>VCC</sub>	Speech Part Supply Voltage	10	V
V <sub>VM</sub>	Unregulated Microprocessor Supply Voltage	5.5	V
V <sub>VPMC</sub>	Regulated Microprocessor Supply Voltage	5.5	V
V <sub>PON</sub>	Power-On Out Voltage	V <sub>PMC</sub> +0.3V, GND-0.3V	V
V <sub>CLOCK</sub>	Clock In Voltage	V <sub>PMC</sub> +0.3V, GND-0.3V	V
V <sub>DATA</sub>	Data In Voltage	V <sub>PMC</sub> +0.3V, GND-0.3V	V
V <sub>RI/VI</sub>	RI/VI Out Voltage	V <sub>PMC</sub> +0.3V, GND-0.3V	V
T <sub>oper</sub>	Operating Temperature	-20, +70	°C
T <sub>j</sub>	Junction Temperature	-20, +150	°C
T <sub>stg</sub>	Storage Temperature	-55, +150	°C

7092-02.TBL

Note: Typical Thermal resistance TQFP44 Copper lead frame 70° K/W @ 1W.

Figure 1 : Safe Area



7092-03.EPS

**DC CHARACTERISTICS** (T<sub>amb</sub> = 25°C, see Test 1)

Between I<sub>L</sub> = 8mA and I<sub>L</sub> = 20mA the DC slope is fixed by RS and RSLP :

$$V_L(I_L) = RS \times (40E^{-6} + 0.5E^{-3} \times I_L) + RSLP/55 \times (I_L - 5.6E^{-3}).$$

For line current higher than 20mA the slope is fixed by RSLP :  $V_L(I_L) = V_L(20E^{-3}) + RSLP/55 \times (I_L - 20E^{-3})$ .

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V <sub>L1</sub>	Line Voltage in Speech Mode	I <sub>L</sub> = 20mA I <sub>L</sub> = 90mA	4.1 6.6	4.7 7.5	5.25 8.4	V V
V <sub>L2</sub>	Line Voltage after Having Sent 0010101 Mask Code	I <sub>L</sub> = 20mA		1.6	2.5	V
I <sub>LSQ</sub>	Loudspeaker Amplifier Quiescent Bias Current	V <sub>LS</sub> = 4.5V		1.1	2.2	mA
I(V <sub>MC</sub> )1 I(V <sub>MC</sub> )2	Unstabilized Supply : - Start up Current - Unregulated Input Current	I <sub>L</sub> = 20 mA, V <sub>LS</sub> no connect, V <sub>MC</sub> = 2.4V V <sub>RMC</sub> = 2.4V V <sub>RMC</sub> = 3.75V	10 2	15 2.7	3.6	mA mA
V <sub>RMC</sub>	Stabilized Microprocessor Supply	I <sub>L</sub> = 20mA, I(V <sub>RMC</sub> ) = -1.8 or 0mA	3.2	3.5	3.75	V
(V <sub>L</sub> -V <sub>LS</sub> )1 (V <sub>L</sub> -V <sub>LS</sub> )2	I <sub>LS</sub> Drop Voltage	V <sub>L AC</sub> = 0V <sub>RMS</sub> I <sub>L</sub> = 20mA I <sub>L</sub> = 90mA		1.1 1.8	1.3 2.3	V V
I <sub>LS1</sub>	Loudspeaker Current Supply	V <sub>LS</sub> = 2V I <sub>L</sub> = 20mA I <sub>L</sub> = 90mA	11 70	13 77		mA mA

7092-03.TBL

**RETURN LOSS** (T<sub>amb</sub> = 25°C, see Test 2)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
R <sub>Loss</sub>	Return Loss	I <sub>L</sub> = 20mA, f = 1000Hz	20	23		dB

7092-04.TBL

**TRANSMIT CHARACTERISTICS**

The maximum gain G<sub>tl</sub> is adjustable between 44 and 56dB versus RGT value

$$G_{tl} = 20 \times \log \left( 820 \times \frac{(RZ // RL + R3) // Z_{IN}}{RGT // 50k\Omega} \right)$$

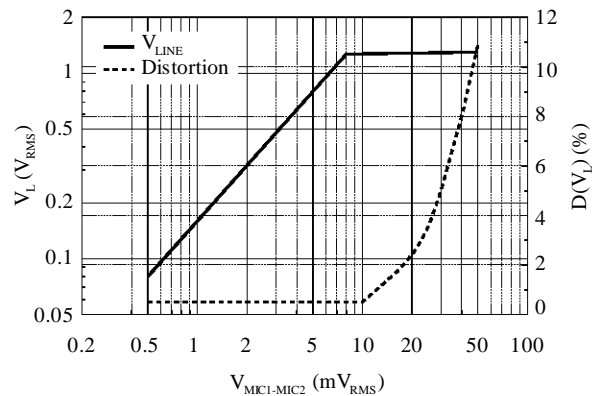
Z<sub>IN</sub> = internal impedance at Pin V<sub>L</sub> # 8kΩ.

The AGC variation is programmable through two external resistors connected on Pins ILL and ISL. ILL is the line current at which the gain is at the maximum value and ISL is the line current at which the gain is at the maximum value minus 6dB. For line current lower than ILL or higher than ISL, the transmit and receive gains have a constant value. The following formulas give RLL and RSL values versus ILL and ISL.

$$RSL = \frac{310}{ISL - 5.6mA} \text{ and } RLL = \frac{310}{ILL - 5.6mA}$$

**Tx Softclipping** (see Figure 2)

**Figure 2 :** Tx Softclipping and Distortion at I<sub>L</sub> = 20mA



7092-04.EFS

**TRANSMIT CHARACTERISTICS** (continued)

**Maximum Level on Line in Tx** (see Figure 3)

The minimum operating voltage of the TEA7092 is 2.5V. At low line current value, when the voltage over the TEA7092 is low, the softclipping function automatically limits the AC dynamic to avoid to reach the 2.5V limit on the TEA7092.

When the DC voltage over the TEA7092 is high enough, the AC dynamic is limited at a value fixed by the external resistor RSOFT connected on Pin SOFTL.

The Value of RSOFT is performed by :  $RSOFT = (RS \times 50E^{-6} - 0.8 - VacPeak) / 40E^{-6}$

**Tx Characteristics** ( $T_{amb} = 25^{\circ}C$ ,  $f = 1kHz$ , see Test 3)

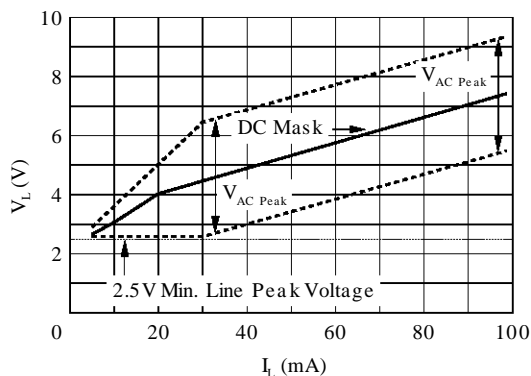
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Gtl Gtsm	Transmit gain in Handset Mode	$V_{em} = -48dBV$ $I_L = 20mA$ $I_L = 90mA$	44 37	45 39	46 41	dB dB
Ghl Ghfm	Transmit gain in Handsfree Mode	$V_{hfin} = -28dBV$ , Code 0110010 $I_L = 20mA$ $I_L = 90mA$	24 17	25 19	26 21	dB dB
Gt-6dB	Transmit Gain (-6dB in transmit path)	$V_{em} = -48dBV$ , $I_L = 20mA$ Code 0110110	5	6	7	dB
Zmic Zhfm	Handset Mic Input Impedance Handsfree Mic Input Impedance	Between Pins MIC1, MIC2 Between HFIN and $V_{REF}$	30 15	40 20	50 25	k $\Omega$ k $\Omega$
Ntx Nhf	Transmit Noise in Handset Mode Transmit Noise in Handsfree Mode	$I_L = 20mA$ , Code 0110010 2k $\Omega$ between MIC1 & MIC2 2k $\Omega$ between HFIN & $V_{REF}$		-75 -75		dBmp dBmp
Mmic	Microphone Mute	$V_{em} = -48dBV$ , $I_L = 20mA$	60			dB
$V_{Lpeak}$	Transmit Softclipping Level	See Figure 2, $V_{em} = -42dBV$ , $I_L = 20mA$	1.0	1.4	1.8	Vpeak
Dtx1 Dtx2	Transmit Distortion	$I_L = 20mA$ , see Figure 2 $V_{em} = -48dBV$ $V_{em} = -36dBV$			1 5	% %

**Squelch on Transmit Channel** ( $T_{amb} = 25^{\circ}C$ ,  $f = 1kHz$ ,  $I_L = 20mA$ , see Test3)

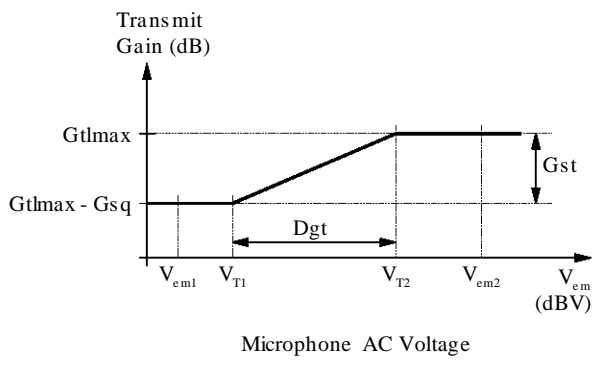
The principle of the squelch is to reduce the transmit gain as soon as the amplitude of the signal on the microphone is lower than a fixed threshold voltage,  $V_{T2}$ .

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Gtlmax Gtlmax-Gsq	Transmit Gain	$V_{em1} = -75dBV$ $V_{em2} = -65dBV$		36 45		dB dB
Gsq	Gain Variation	See Figure 4 /		9		dB

**Figure 3 :** Line Peak Voltage versus DC Line Current



**Figure 4 :** Transmit Gain versus Microphone AC Input Signal



**RECEIVE CHARACTERISTICS** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $f = 1\text{kHz}$ )

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Eff	Sidetone Efficiency	Test 3, $V_{em} = -48\text{dBV}$ , $I_L = 20\text{mA}$			26	dB
Grl Grs Grs+6	Gain  +6dB Code [0010110]	Test 2 $I_L = 20\text{mA}$ $I_L = 90\text{mA}$ $I_L = 90\text{mA}$	5 -1.2 5	6 0.8 6	7 2.8 7	dB dB dB
Drx1 Drx2	Distortion	Test 2, $I_L = 20\text{mA}$ $V_{ear} = -3\text{dBV}$ $V_{ear} = 0\text{dBV}$			3 5	% %
Nrx	Noise	Test 2, $I_L = 20\text{mA}$		-76		dBmp
Mrx	Mute	Test 2, $I_L = 20\text{mA}$ , $V_L = -9\text{dBV}$	60			dB
Z <sub>IN</sub>	Input Impedance	Between Pins SNSL & SNLL		120	150	k $\Omega$
Z <sub>OUT</sub>	Output Impedance			5		$\Omega$

The sidetone of the TEA7092 uses two networks, these two networks are internally mixed between long line length and short line length.

The following equation gives the sidetone impedance versus line current :  $ZAL = K \times ZALL + (1 - K) \times ZASL$   
 $K = 1$  for  $I_L = ILL$  ;  $K = 0$  for  $I_L = ISL$ , and  $K$  varies linearly between 1 and 0 when  $I_L$  varies between  $ILL$  and  $ISL$ .

It is possible to use only the standard one sidetone concept by short-circuited Pins SNSL and SNLL.

**Gain Control Inhibition Facility For PABX Application**

( $T_{amb} = 25^{\circ}\text{C}$ ,  $I_L = 20\text{mA}$ ,  $f = 1\text{kHz}$  / No AGC mode selected 0010100)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Gtp	Transmit Gain	Test 2	Gtl - 3	Gtl - 2	Gtl - 1	dB
Grp	Receive Gain	Test 3	Grl - 3	Grl - 1.4	Grl - 0.5	dB

**LOUDSPEAKER AMPLIFIER PART**

**Loudspeaker Amplifier Channel** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $f = 1\text{kHz}$ ,  $R_{LS} = 50\Omega$ ,  $V_{em} = 0$ )

The Loudspeaker amplifier channel has a maximum gain of 35dB between Pin LSIN and Pin LSOUT. This gain is programmable through the serial bus interface, 7 steps of 4dB each.

To avoid distortion, the output level on the loudspeaker is controlled by a softclipping function, the time constant of this feature is connected to LSSOF pin.

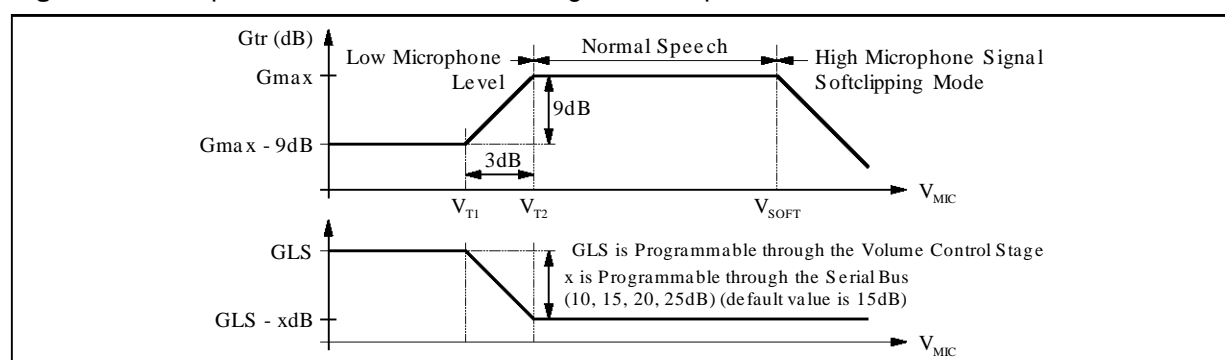
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
	GAIN VHP/Vac	Test 4 $I_L = 20\text{mA}$				
GLS0	GMAX	Code: (0 1 0 0 1 1 1)	33.5	35	36.5	dB
GLS1	GMAX-4dB	Code: (0 1 0 0 1 1 0)	29.5	31	32.5	dB
GLS2	GMAX-8dB	Code: (0 1 0 0 1 0 1)	25.5	27	28.5	dB
GLS3	GMAX-12dB	Code: (0 1 0 0 1 0 0)	21.5	23	24.5	dB
GLS4	GMAX-16dB	Code: (0 1 0 0 0 1 1)	17.5	19	20.5	dB
GLS5	GMAX-20db	Code: (0 1 0 0 0 1 0)	13.5	15	16.5	dB
GLS6	GMAX-24dB	Code: (0 1 0 0 0 0 1)	9.5	11	12.5	dB
GLS7	GMAX-28dB	Code: (0 1 0 0 0 0 0)	5.5	7	8.5	dB
Mls	Mute Loudspeaker	Test 4			-30	dB
Isin	Input Impedance		30	40	50	k $\Omega$
PLS1 PLS2	Output Power	Test 4, Gain = GLS0, $V_{IN} = 0.15V_{RMS}$ $I_L = 20\text{mA}$ , $D \leq 2\%$ $I_L = 90\text{mA}$ , $D \leq 2\%$	13 40	18 55		mW mW



**LOUDSPEAKER AMPLIFIER PART (continued)****Antiacoustic Feedback** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $I_L = 20\text{mA}$ , see Test 4)

The antiacoustic feedback system is coupled to the microphone squelch. As soon as the level on the handset microphone is higher than  $V_{T2}$ , the transmit gain increases and the loudspeaker gain decreases. So the transmit and loudspeaker gains are never simultaneously at maximum gain, which reduces larsen effect.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Dgls(0)	Antiacoustic Feedback Efficiency	Code 0111100	-12	-9.5	-7	dB
Dgls(1)		Code 0111101	-17	-14.5	-12	dB
Dgls(2)		Code 0111110	-21.5	-18.5	-15.5	dB
Dgls(3)		Code 0111111	-26.5	-22.5	-18.5	dB

**Figure 5** : Loudspeaker Gain GLS versus Voltage on Microphone**RING MODE****Loudspeaker Power Supply in Ring Mode** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $R_{LS} = 50\Omega$ , see Test 5)

In ring mode, it is necessary to convert the high voltage / low current power input to a low voltage / high current power, output to be able to drive a  $50\Omega$  loudspeaker, the external switch mode power supply driven by the TEA7092 realizes this feature.

The switch mode power supply, through external component values, fixes the impedance and the start up threshold level.

The volume control in ring mode is the same than the one used in loudspeaking mode for the highest steps, 8 steps of 4dB, and 5 more steps of 4dB each have been added, by using the code 0111011, for the lowest one, by this way the maximum depth in ring mode for the volume control is 48dB.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I <sub>LEAK1</sub>	Leakage Current	$V_{RING} = 16\text{V}$ , $I(VZP) = 0$		40	150	$\mu\text{A}$
I <sub>LEAK2</sub>		$V_{RING} = V_{RSU} = 22\text{V}$ , $I(VZP) = 20\mu\text{A}$		130	400	$\mu\text{A}$
I <sub>RON1</sub>	Input Current	$V_{RING} = 22\text{V}$ $I(VZP) = 140\mu\text{A}$ , $I(VLS) = 40\text{mA}$ No code sent, no signal on the loudspeaker output		10	12	mA
I <sub>VRSU</sub>	Start up Current			60	150	$\mu\text{A}$
V <sub>LS1</sub>	LS Supply		2.8	3.05	3.5	V
V <sub>RMC1</sub>	Stabilized Microprocessor Supply		2.75	3		V
V <sub>RI1</sub>	Ring Indicator Output		2.7	2.95		V
V <sub>RES1</sub>	Reset Output		2.7	2.95		V
V <sub>LS2</sub>	LS Supply	$V_{RING} = 22\text{V}$ , $I(VZP) = 250\mu\text{A}$ , Gain = Gain Max., Codes sent : - Group listening - FI = 26321Hz & n = 60 - Ring start	5	5.4		V
V <sub>RMC2</sub>	Stabilized Microprocessor Supply		3	3.4	3.75	V
V <sub>RI2</sub>	Ring Indicator Output		2.9	3.3		V
V <sub>RES2</sub>	Reset Output		2.9	3.3		V
V <sub>OUT</sub>	LS Output Level		5	5.4		$V_{PP}$

**Ring Frequency**

The frequencies of the ring are given by :  $F_{ring} = \frac{F_i}{n}$ .

$F_i$  can take one of the following values : 19455Hz, 21308Hz, 23551Hz or 26321Hz, and n varies between 1 and 63.  $F_i$  and n correspond to 2 codes sent on the serial bus.

**DTMF GENERATOR** ( $T_{amb} = 25^{\circ}\text{C}$ , see Test 3)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Amf	Tone Frequency Accuracy	$f = 3.58\text{MHz}$ , $I_L = 90\text{mA}$	-0.4		0.4	%
Llf	Low Frequency Group Line Level	$I_L = 20\text{mA} \ \& \ 90\text{mA}$	-9.5	-8	-6.5	dBm
Lhf	High Frequency Group Line Level	$I_L = 20\text{mA} \ \& \ 90\text{mA}$	-7.5	-6	-4.5	dBm
Pmf	Preemphasis HF/LF	$I_L = 20\text{mA} \ \& \ 90\text{mA}$	1	2	3	dB
$t_R$	Rise Time	$I_L = 20\text{mA} \ \& \ 90\text{mA}$			5	ms
$t_{diff}$	Decay Time	$I_L = 20\text{mA} \ \& \ 90\text{mA}$			5	ms
Velf	Confidence Tone Level :	$I_L = 20\text{mA} \ \& \ 90\text{mA}$				
Vehf	- Earphone Level (Low Frequency)		-35	-32	-29	dBm
Vlhf	- Earphone Level (High Frequency)		-33	-30	-27	dBm
Vlhf	- Loudspeaker Level (Low Frequency)	Code Level (0100111)	-10	-7	-4	dBm
Vhlf	- Loudspeaker Level (High Frequency)		-8	-5	-2	dBm

Unwanted frequencies comply with CEPT 46-03.

**SINE WAVE GENERATOR** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $I_L = 20 \ \& \ 90\text{mA}$ , see Test 3)

The sine wave generator uses the same path than the DTMF generator. Sinus wave frequencies are the half of the DTMF frequencies.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Sfl	Line Level	Low Frequency Group 348 / 385 / 426 / 470Hz	-18	-14	-10	dBm
Sfh	Line Level	High Frequency Group 604 / 668 / 738 / 816 Hz	-16	-12	-8	dBm

**ERROR BEEP GENERATOR**

The frequencies of the error beep generator are given by :  $F_{EB} = \frac{F_i}{n}$ .

$F_i$  can take one the following values : 19455Hz, 21308Hz, 23551Hz or 26321Hz, and  $n$  varies between 1 and 63.

Error beep generator code generates square wave signal in the earphone.

Error beep generator code following by group listening code generate square wave signal in the earphone and in the loudspeaker.

**MICROCONTROLLER INTERFACE**

**Microcontroller Power Supply**

The microcontroller power supply consists in a serial regulator which generates a 3.5V regulated supply on  $V_{RMC}$  Pin, from an unregulated voltage applied on  $V_{MC}$  or  $V_{LS}$  Pin.

The  $V_{MC}$  Pin can be supplied either by the line, a battery or any DC generator. The use of  $V_{MC}$  input allows to regulate the output  $V_{RMC}$  voltage for an LCD display. With no load, the quiescent current, is 60 $\mu$ A. For an output current of 1.8mA, the typical drop voltage between  $V_{MC}$  and  $V_{RMC}$  Pins is 150mV.

**Microcontroller Control Signals**

**RESET** : This output is setting to "1" when  $V_{RMC}$  reaches the 2.6V threshold level. This output goes back to "0" :

- If  $V_{RMC}$  goes below 2.5V or
- If the Reset code (0010111) is sent on the serial bus interface and if PON output is at level "0".

When the Reset code has been previously sent, Pin RESET goes back to an high level, if  $V_{RMC}$  is

higher than the rise threshold, only on a rise edge of PON signal. If this PON rise edge does not appear, the RESET Pin remains at low logic level even if  $V_{RMC}$  goes upper 2.6V.

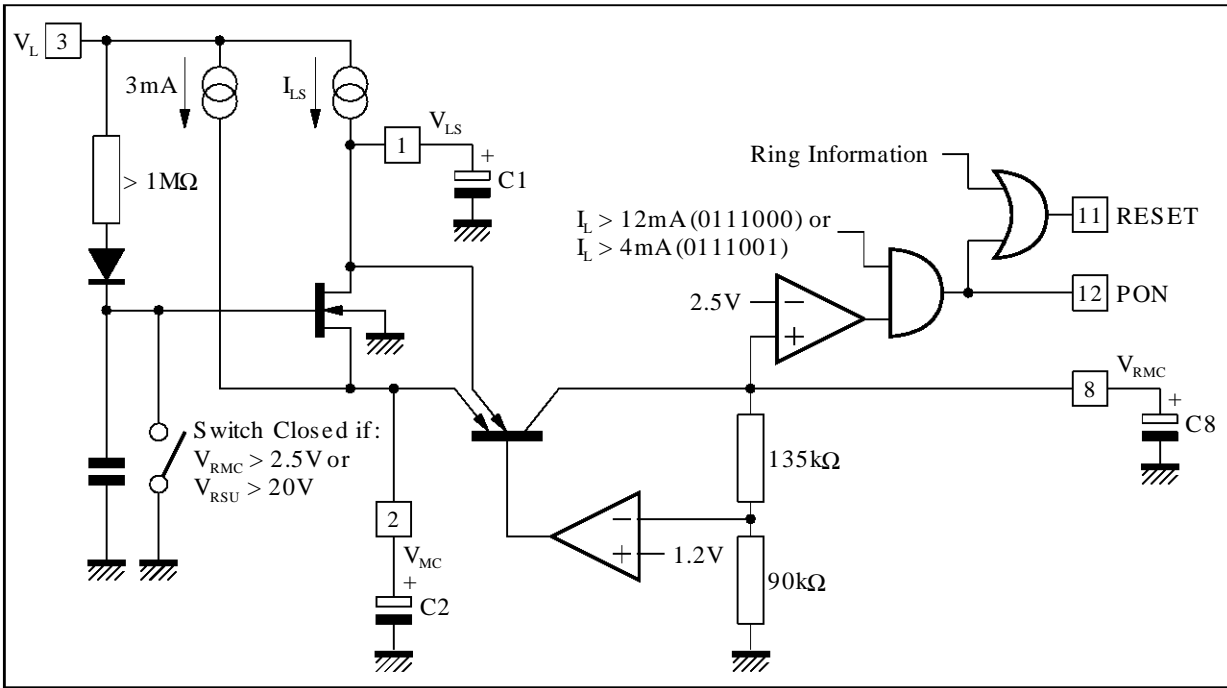
When PON output is at level "1", the Reset code is inhibited.

**PON** : This output goes high when  $V_{RMC}$  reaches the 2.6V threshold level and the line current value is upper than 12mA. As soon as the Reset output is at level "1", the 4mA line current threshold detector can be sent through the serial bus interface (0111001) to check if the line current value is between 4 and 12mA.

**R/VI :**

- In Ring mode : This output goes to level "1" if :
  - Pin  $RSU > 19V$
  - Pin  $V_{RMC} > 2.6V$
- In Off-Hook mode : This output manages the line current variation indicator for transfer function and this information is used by the microcontroller to manage the transfer from one telephone set to another one connected in parallel on the same line.

**Figure 6 : Microprocessor Power Supply Block Diagram**

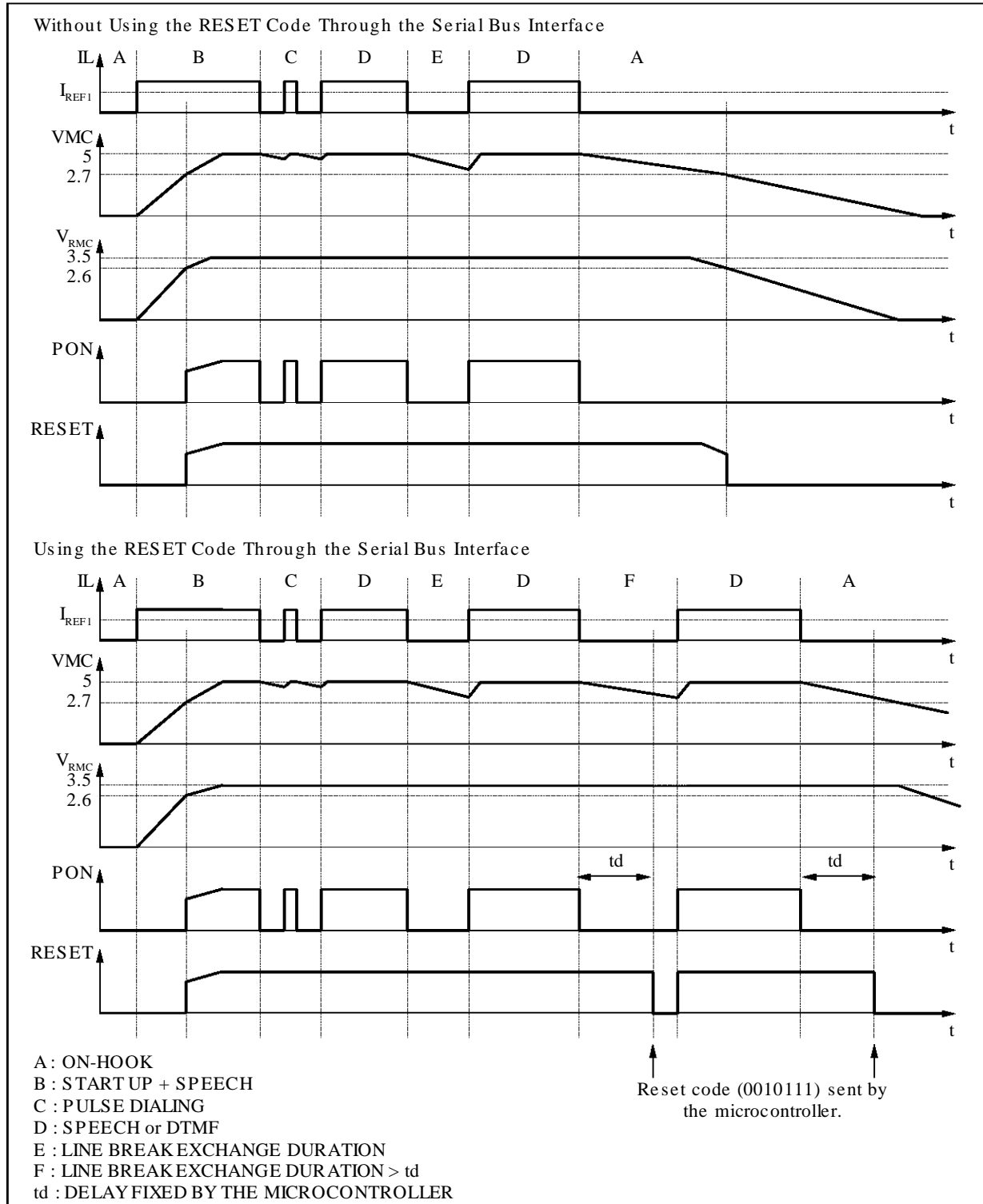


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MICROCONTROLLER INTERFACE (continued)

Reset and Power On

Figure 7 : Telephone Set Powered from the Line,  $I_L > I_{REF1}$ , without Batteries



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**MICROCONTROLLER INTERFACE** (continued)**Microcontroller Stabilized Supply** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $I_L = 0\text{mA}$ )

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{RMC1}$ $V_{RMC2}$	Output Voltage	$I(V_{RMC}) = -1.8\text{mA}$ , $V_{MC} = 4\text{V}$ , $V_{LS} = 0\text{V}$ $I(V_{RMC}) = 0$ , $V_{MC} = 0\text{V}$ , $V_{LS} = 4\text{V}$	3.2 3.2	3.5 3.5	3.75 3.75	V V
$I_{vmcq1}$	Quiescent Current $I(V_{MC}) - I(V_{RMC})$	$V_{MC} = V_{RMC} + 0.3\text{V}$ Oscillator ON, $I(V_{RMC}) = 0$		250	400	$\mu\text{A}$
$I_{vmcq2}$ $I_{vmcq3}$		Code 0111010 $I(V_{RMC}) = -1.8\text{mA}$ $I(V_{RMC}) = 0$		95 50	200 120	$\mu\text{A}$ $\mu\text{A}$

**RESET** ( $T_{amb} = 25^{\circ}\text{C}$ ,  $I_L = 0\text{mA}$ )

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{RESL}$ $V_{RESH}$	Low Threshold High Threshold	$I_{RESET} = 1\text{mA}$ , $V_{MC} = 4\text{V}$ $V_{RMC} = 0.66 \times V_{RMC1}$ $V_{RMC} = 0.8 \times V_{RMC1}$	$V_{RMC} - 0.4$		0.4	V V

**PON** ( $T_{amb} = 25^{\circ}\text{C}$ )

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{PONL}$ $V_{PONH1}$ $V_{PONH2}$	Low Threshold High Threshold High Threshold	$I_{PON} = -1\text{mA}$ Code (0111000), $I_L = 8\text{mA}$ Code (0111000), $I_L = 20\text{mA}$ Code (0111001), $I_L = 8\text{mA}$	$V_{RMC} - 0.4$ $V_{RMC} - 0.4$		0.4	V V V

**RI/VI , Hold Function** ( $T_{amb} = 25^{\circ}\text{C}$ )

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{RIVIL}$ $V_{RIVIH}$	Low Threshold High Threshold	$I_L = 90\text{mA}$ , Code (0011010) $I_L = 70\text{mA}$	$V_{RMC} - 0.4$		0.4	V V

**MICROCONTROLLER INTERFACE (continued)**

**Serial Bus Interface (data and clock)**

The serial bus uses 7 bits, a standard 8 bit word can be sent, the TEA7092 take care only of the seven first bits.

The different codes are :

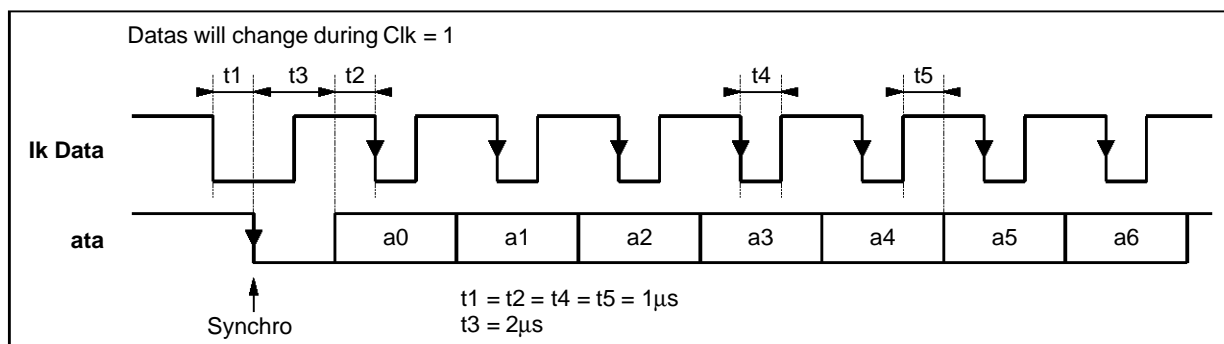
- The ring start up code
- The ring frequency control code
- The mode codes :
  - Handset mode
  - Group listening mode
  - Handsfree mode
- The operating codes (these codes are used under each code mode) :
  - Speech
  - Dialing
  - Microphone mute
  - Earphone/Microphonemute
  - Error beep
  - Sine wave high frequency
  - Sine wave low frequency
- The data codes (DTMF, sinus wave, ring frequency, error beep frequency codes) :  
 These data codes are stored inside the TEA7092 and are used as soon as an operating code is sent, dialing, error beep, sine wave or ring melody control or ring start up code.
- The configuration codes (those codes are "flip-flop" codes) :
  - AGC/no AGC
  - No mask / mask

- Normal gain/normal gain +6dB, on receive channel
- Two sidetone network/one sidetone network
- Squelch/No squelch
- Line current variation initialization (No transfer/Transfer)
- Minus 21dB in Ring Mode
- Minus 6dB in Sending Mode
- Oscillator Stand-by

For instance : The first time that the +6dB code is sent, the receive gain increases of +6dB. If it is sent again, the receive gain goes back to normal value.

- The loudspeaker level control codes
- The reset code to initialize the TEA7092 and to set the reset output to "0" low logic level
- The Init code to initialize the TEA7092, software initialization to set the TEA7092 in the start up condition.
- The start up condition of the TEA7092 is :
  - Handset mode.
  - Speech.
  - No mask.
  - AGC in transmit and receive channels.
  - Normal gain on receive channel.
  - Squelch on transmit channel.
  - Two sidetone networks.
  - No transfer.
  - Oscillator ON.
  - PON line threshold current : 12mA.
  - Anti-acoustic feed-back attenuation : 15dB.

**Figure 8 : 7 Bit Codes Data and Clock Input Timing**



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**MICROCONTROLLER INTERFACE** (continued)

**Note** : In the tables in the following pages, the default codes are in **Bold**.

**The Mode Codes**

Codes							Remarks
a6	a5	a4	a3	a2	a1	a0	
<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Handset Mode</b>
0	1	1	0	0	0	1	Group Listening Mode
0	1	1	0	0	1	0	Handsfree Mode

**The Operating Codes Related to Mode Codes**

Codes							Remarks
a6	a5	a4	a3	a2	a1	a0	
<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Speech</b>
0	0	1	0	0	0	1	Dialing
0	0	1	0	0	1	0	Mute Tx & Rx
0	0	1	0	0	1	1	Mute Tx
0	0	1	1	1	0	0	Error Beep
0	0	1	1	1	0	1	Sine Wave High Frequencies
0	0	1	1	1	1	0	Sine Wave Low Frequencies

**The Configuration Codes (toggle codes)**

Codes							Remarks
a6	a5	a4	a3	a2	a1	a0	
0	0	1	0	1	0	0	<b>AGC</b> / no AGC
0	0	1	0	1	0	1	<b>No Mask</b> / Mask
0	0	1	0	1	1	0	<b>Normal Receive Gain</b> / +6dB
0	0	1	1	0	0	0	<b>Two Sidetones</b> / Fixed Up (3/4 x ZALL +1/4 x ZASL)
0	0	1	1	0	0	1	<b>Squelch</b> / No Squelch
0	0	1	1	0	1	0	<b>No Transfer</b> / Transfer Request
0	0	1	1	0	1	1	<b>Two Sidetones</b> / One Sidetone (ZASL)

**The Other Codes**

Codes							Remarks
a6	a5	a4	a3	a2	a1	a0	
0	0	1	0	0	0	1	Ring Start
0	0	1	0	1	1	1	Reset Control
0	1	0	1	0	0	0	Initialization Code
<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Line Threshold Current 12mA</b>
0	1	1	1	0	0	1	Line Threshold Current 4mA
0	1	1	1	1	0	0	Dgls(1) 10dB
<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>Dgls(2) 15dB</b>
0	1	1	1	1	1	0	Dgls(3) 20dB
0	1	1	1	1	1	1	Dgls(4) 25dB
0	1	1	0	1	1	0	Transmit Gain -6dB
0	1	1	1	0	1	1	-21dB Attenuation in Ring Mode
0	1	1	1	0	1	0	Oscillator Stand-by
0	1	1	0	0	1	1	Ring Melody Control

**MICROCONTROLLER INTERFACE (continued)**

**HFIN Input Selection**

For answering machine or cordless connection it can be requested to select HFIN input without enabling the loudspeaker. For this the following procedure should be sent :

- Handsfree code 0110010.
- Tx & Rx mutes 0010010.
- HFIN input select 0110111.

To go back to handsfree mode, send :

- Speech code 0010000.

To go back to handset mode, send :

- Speech code 0010000.
- Handset code 0110000.

**The Loudspeaker Control Code**

Codes							Remarks
a6	a5	a4	a3	a2	a1	a0	
0	1	0	0	0	0	0	Gmax -28dB
0	1	0	0	0	0	1	Gmax -24dB
0	1	0	0	0	1	0	Gmax -20dB
0	1	0	0	0	1	1	Gmax -16dB
0	1	0	0	1	0	0	Gmax -12dB
0	1	0	0	1	0	1	Gmax -8dB
0	1	0	0	1	1	0	Gmax -4dB
0	1	0	0	1	1	1	Gmax

Loudspeaker Level Control

**The Data Codes**

These codes are used in three different ways, depending of the operating code sent after the data codes :

- In DTMF dialing : Data code+Dialing code
- In Single sine wave : Data code+Sine wave high frequencies (or Sine wave low frequencies)
- In Ring mode, to program the Fi parameter, the Data code is following by the divider code n. Fi and n codes fix the ring output frequency.

Codes							DTMF Dialing Mode		Sine Wave Generator	Fi
a6	a5	a4	a3	a2	a1	a0	Key	DTMF Frequencies		
0	0	0	0	0	0	0	"2"	1336Hz + 697Hz	348 or 604Hz	19455Hz
0	0	0	0	0	0	1	"1"	1209Hz + 697Hz		
0	0	0	0	0	1	0	"A"	1633Hz + 697Hz		
0	0	0	0	0	1	1	"3"	1477Hz + 697Hz		
0	0	0	0	1	0	0	"8"	1336Hz + 852Hz		
0	0	0	0	1	0	1	"7"	1209Hz + 852Hz		
0	0	0	0	1	1	0	"C"	1633Hz + 852Hz		
0	0	0	0	1	1	1	"9"	1477Hz + 852Hz	426 or 738Hz 385 or 668Hz	23551Hz 21308Hz
0	0	0	1	0	0	0	"5"	1336Hz + 770Hz		
0	0	0	1	0	0	1	"4"	1209Hz + 770Hz		
0	0	0	1	0	1	0	"B"	1633Hz + 770Hz		
0	0	0	1	0	1	1	"6"	1477Hz + 770Hz	470 or 816Hz	26321Hz
0	0	0	1	1	0	0	"0"	1336Hz + 941Hz		
0	0	0	1	1	0	1	"*"	1209Hz + 941Hz		
0	0	0	1	1	1	0	"D"	1633Hz + 941Hz		
0	0	0	1	1	1	1	"#"	1477Hz + 941Hz		



## MICROCONTROLLER INTERFACE (continued)

## Programmable Divider for Ring Frequencies

		Ring Frequencies						Ring Frequencies			
		Fi codes (Hz) / * Notes (Hz)						Fi codes (Hz) / * Notes (Hz)			
Divider Codes	n	26321 000XX10	23551 000XX11	21308 000XX00	19455 000XX01	Divider Codes	n	26321 000XX10	23551 000XX11	21308 000XX00	19455 000XX01
1010000	16	1645	1471.9	1331.7	1215.9	1101000	40	* 658	* 588.8	532.7	486.4
1010001	17	1548.3	1385.3	1253.4	1144.4	1101001	41	642	574.4	519.7	474.5
1010010	18	1462.3	1308.4	1183.8	1080.8	1101010	42	626.7	560.7	507.3	463.2
1010011	19	1385.3	1239.5	1121.5	1023.9	1101011	43	612.1	547.7	* 495.5	452.4
1010100	20	1316	1177.5	1065.4	972.7	1101100	44	598.2	535.2	484.3	442.2
1010101	21	1253.4	1121.5	1014.7	926.4	1101101	45	584.9	* 523.4	473.5	432.3
1010110	22	1196.4	1070.5	968.5	884.3	1101110	46	572.2	512	* 463.2	422.9
1010111	23	1144.4	1024	926.4	845.9	1101111	47	560	501.1	453.4	* 413.9
1011000	24	1096.7	981.3	887.8	810.6	1110000	48	548.3	490.6	443.9	405.3
1011001	25	1052.8	942	852.3	778.2	1110001	49	537.2	480.6	434.9	397
1011010	26	1012.3	905.8	819.5	748.3	1110010	50	526.4	471	426.2	389.1
1011011	27	974.8	872.3	789.2	720.6	1110011	51	516.1	461.8	417.8	381.5
1011100	28	940	841.1	761	* 694.8	1110100	52	506.2	452.9	409.8	374.1
1011101	29	907.6	812.1	734.8	670.9	1110101	53	496.6	444.4	402	367.1
1011110	30	* 877.4	* 785	710.3	648.5	1110110	54	487.4	436.1	394.6	360.3
1011111	31	849.1	759.7	687.3	627.6	1110111	55	478.6	428.2	387.4	353.7
1100000	32	822.5	* 736	665.9	608	1111000	56	470	420.5	380.5	347.4
1100001	33	797.6	713.7	645.7	589.5	1111001	57	461.8	413.2	373.8	341.3
1100010	34	774.1	692.7	626.7	572.2	1111010	58	453.8	406	* 367.4	335.4
1100011	35	752	672.9	608.8	* 555.9	1111011	59	446.1	399.2	361.1	* 329.7
1100100	36	731.1	654.2	591.9	540.4	1111100	60	* 438.7	* 392.5	355.1	324.2
1100101	37	711.4	636.5	575.9	525.8	1111101	61	431.5	386.1	* 349.3	318.9
1100110	38	692.7	* 619.8	560.7	512	1111110	62	424.5	379.8	343.7	313.8
1100111	39	674.9	603.9	546.4	498.8	1111111	63	417.8	373.8	338.2	308.8

If requested, the high frequencies corresponding to n varied between 1 to 15 or Divider codes 100XXXX are accessible.

**Operating Modes**

The TEA7092 can work in 1 of the 3 modes :

- Handset,
- Group listening,
- Handsfree.

In each mode the operating codes determine the operations held by the circuit as soon as this code is received :

For instance DTMF dialing begins as soon as the dialing code is received.

The configuration codes operate in each mode of operation : for instance if the No AGC code is sent, the AGC inhibition will work in the 3 modes : Handset, Group listening and Handsfree.

**DTMF Dialing**

To dial in DTMF the following code sequence is sent :

- DTMF : 000XXXX.
- Dialing code : 0010001.
- Mute or SPEECH code : 0010010 or 0010000 (to end DTMF mode).

The duration of the DTMF signal is fixed by the

duration between DIALING code and MUTE or SPEECH code

**Note** : DTMF code automatically mutes the microphone.

**Sine Wave Codes**

To generate a melody the following sequence of codes is sent :

- Frequency code : 000XXXX.
- SINE WAVE code : 0011101 or 0011110 (low or high frequency).
- SPEECH code : 0010000 (to end SINE WAVE mode).

The duration of the melody is being set by the duration between SINE WAVE code and SPEECH code.

**Note** : SINE WAVE code automatically mutes the microphone.

**PULSE Dialing**

The pulse dialing function is performed by the microcontroller through the high voltage stage.

The voltage over the TEA7092 during dialing can be reduced by sending the MASK code 0010101.

To recover the normal speech voltage at the end of dialing the mask code must be sent again.

**MICROCONTROLLER INTERFACE (continued)**

**RING Mode**

- Ring frequency generator :  
In ring mode, to generate the ring melody in the loudspeaker, the following sequence is sent :
  - LOUDSPEAKER LEVEL : 0100XXX.
  - Fi DATA : 000XXXX.
  - DIVIDER DATA : 1XXXXXX.
  - GROUP LISTENING CODE : 0110001.
  - RING START : 0010001.
  - SPEECH : 0010000 (To stop the ring mode when off-hook is detected, PON = 1).

To change the ring frequency only Fi data and divider data are sent again.

- Ring indicator input (RI/VI) :  
In ring mode the TEA7092 generates a high logic level on pin RI/VI, as soon as the voltage on pin RSU is higher than 19V, and the voltage on pin VRMC is higher than 2.6V. When the voltage on pin VRMC is higher than 2.6V, the RESET output goes high.

**Ring Melody Control**

The melody can be checked in off-hook by sending the following sequence of codes :

- LOUDSPEAKER LEVEL : 0100XXX.
- Fi data : 000XXXX.
- DIVIDER data : 1XXXXXX.
- RING MELODY CONTROL : 0110011.

To change the melody or the level, only loudspeaker level, Fi data and n divider data have to be sent. To stop the ring melody, a speech code 0010000 is sent.

**Error Beep**

Error beep could be used to signalize wrong operations (memory empty, re-dial empty, store too many digits in a memory...) or for other procedures, like melody. To generate the error beep, the following sequence of codes is sent :

- Fi data : 000XXXX.
- DIVIDER data : 1XXXXXX.
- ERROR BEEP code : 0011100.

To stop the error beep a speech code 0010000 is sent. The error beep is a square wave sent on the earphone, if it is requested to send it also in the loudspeaker, the Group listening code should also be sent.

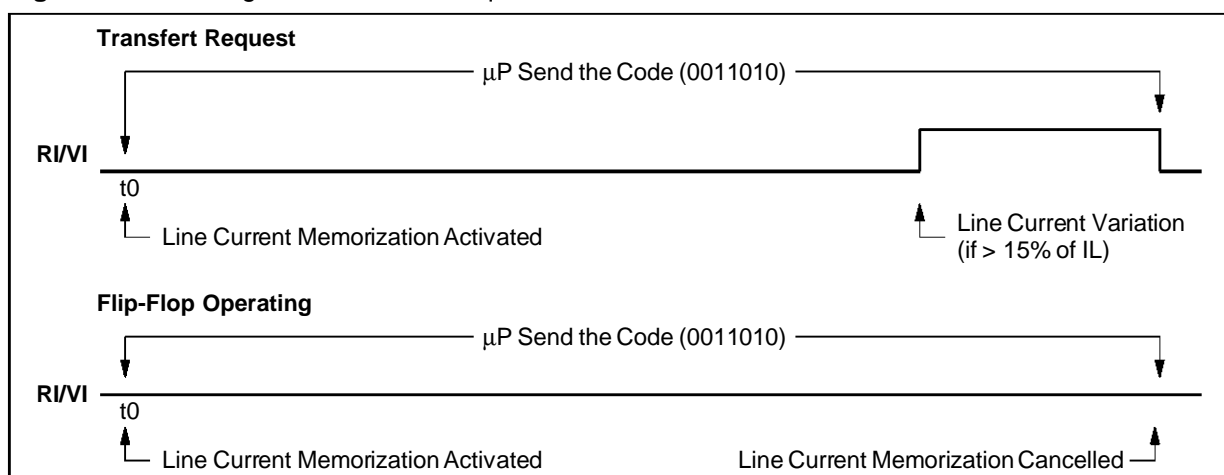
**Line Current Variation Detection**

The TEA7092 has a line current variation detector. This feature memorizes the line current value. When the transfer request code is sent, and if a the current inside the TEA7092 decreases of 15% or more of the line current value, due for example to a telephone set off-hooked in parallel on the same line, the output RI/VI goes HIGH to prevent the associated microcontroller. Oscillator should be ON, and it is preferable to mute the transmit and receive paths to avoid current variation due to ac signals.

- TRANSFER REQUEST : 0011010.

If the Transfer request code is sent again, the current memorization is disabled.

**Figure 9 : Time Diagram of Transfer Request**



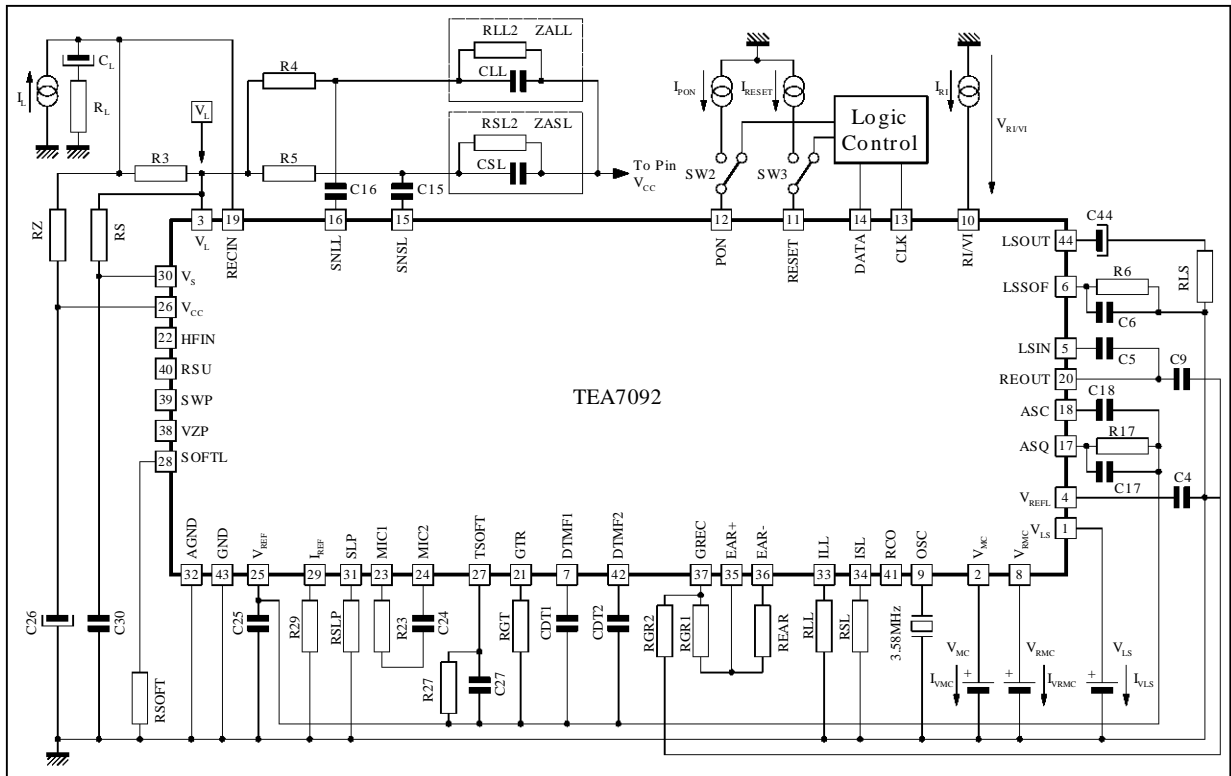
7092-11.EPS

## COMPONENT LIST

Reference	Part	Reference	Part	Reference	Part	Reference	Part
DC Mask		CLL, CSL	33pF	Rring	47Ω	C26	100μF/16V
RS	82kΩ	Resistors		RLS	50Ω	C27	150nF
RSLP	2.2kΩ	R1	220kΩ	Rear	300Ω	C30	1μF
Return Loss		R3	30Ω	Capacitors		C38	22nF
RZ	620Ω	R4	3kΩ	C1	68μF/16V	C41	470pF
Tx Path		R5	3kΩ	C2	470μF/6V	C44	47μF/6V
RGT	1540Ω	R6	220kΩ	C3	10μF/63V	Others	
RSOFT	51kΩ	R7	100kΩ	C4	47nF	D1, D2, D3, D4	1N4004
Rx path		R8	1.5MΩ	C5	47nF	DS1	BYW10-60
RGR1	39kΩ	R9	1.5MΩ	C6	470nF	DS2	BAT43
RGR2	39kΩ	R10	10kΩ	C7	1nF	Z1	BZX55C 47V
DTMF Path		R11	12kΩ	C8	10μF/6V	Z2	BZX55C 8.2V
CDT	47nF/1%	R17	220kΩ	C9	47nF	Z3	BZX55C 12V
CDT2	3.3nF	R23	2kΩ	C15	220nF	Q1	BC556B
A.G.C.		R25	2kΩ	C16	220nF	Q2	BC546B
RLL	15kΩ	R27	910kΩ	C17	470nF	Q4	BF393
RSL	4.7kΩ	R29	30kΩ	C18	1μF	M1	BSS 92
Sidetone Networks		R39	1.5kΩ	C22	47nF	L1	1mH (R < 4Ω/Imax = 400mA)
RLL1, RSL1	0	R40	47kΩ	C24	47nF		
RLL2, RSL2	30kΩ	R41	30kΩ	C25	47nF	Quartz	3.58MHz (Ri < 100Ω)

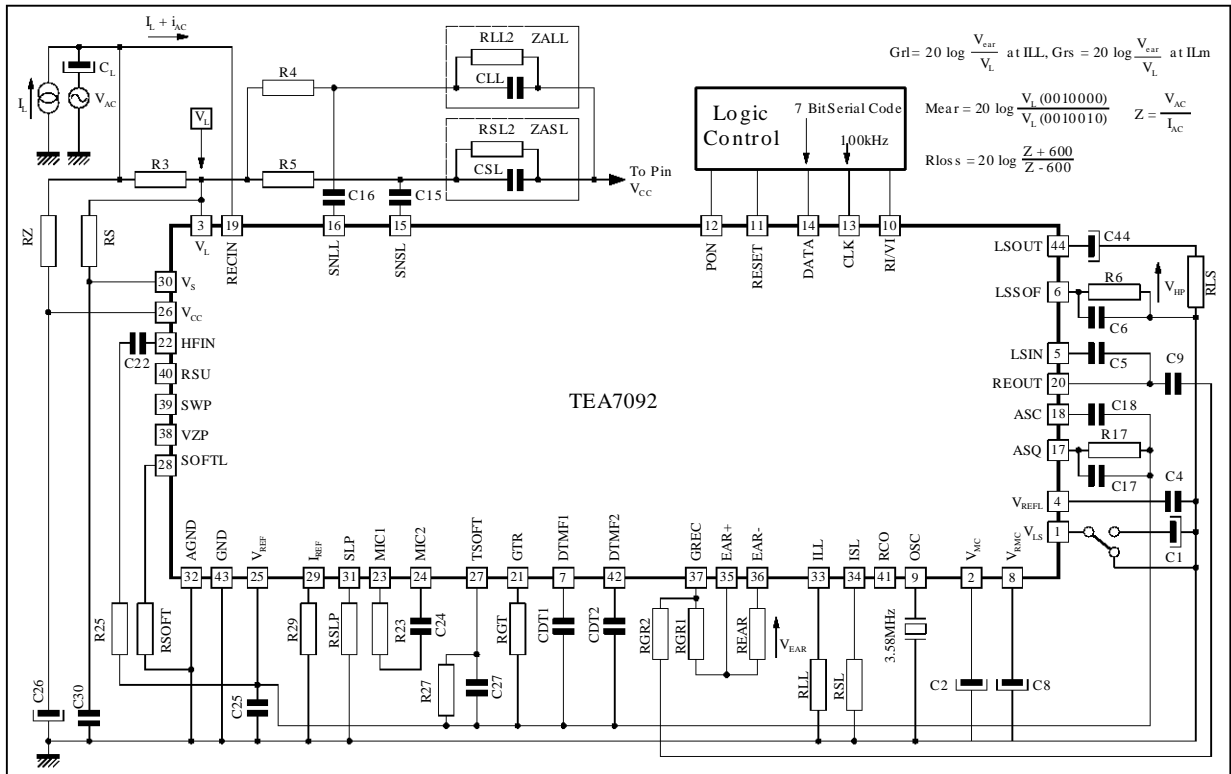
7092-05.TEL

Test 1



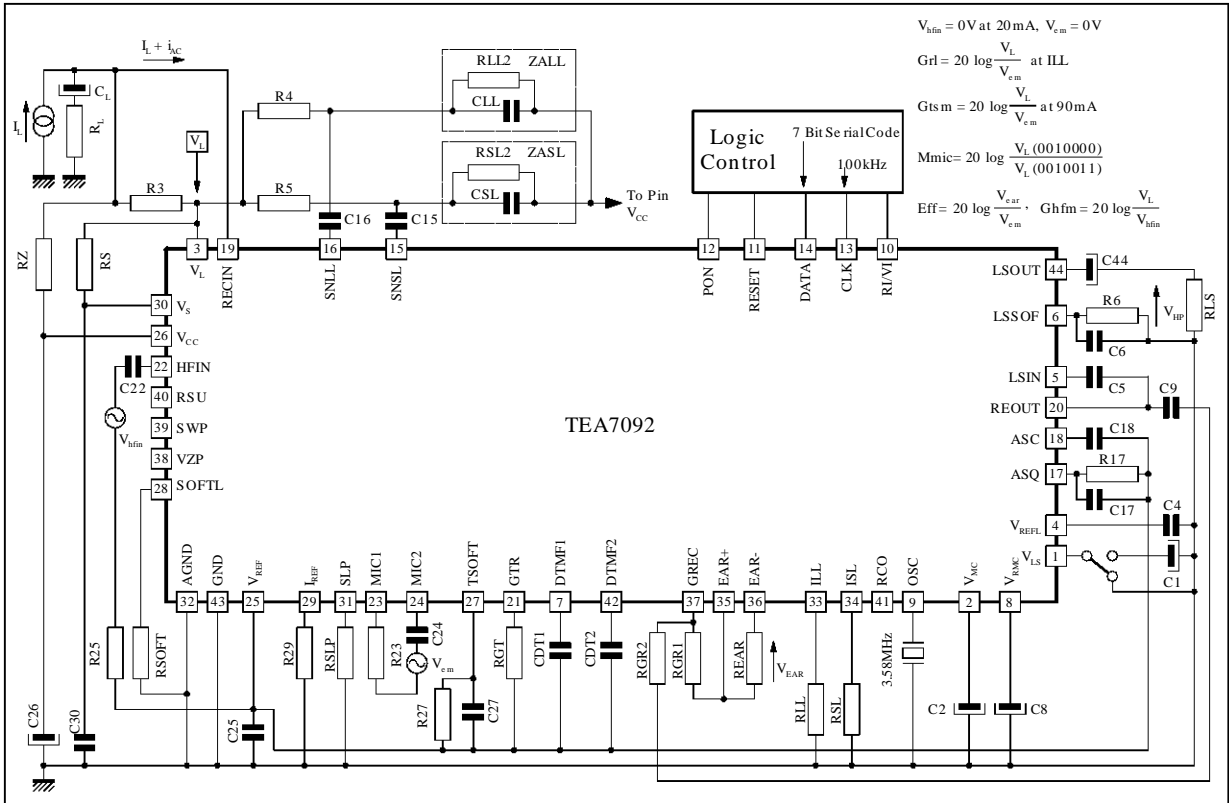
7092-12.EPS

Test 2



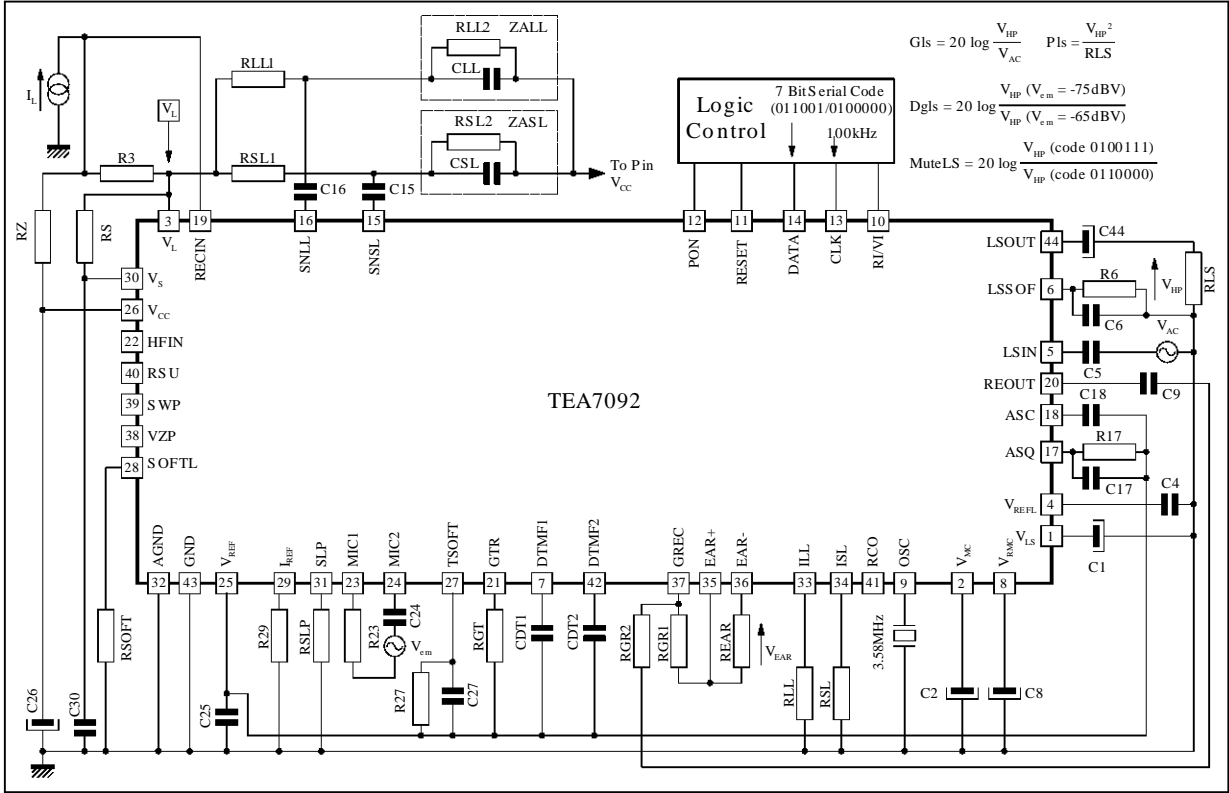
7092-13.EPS

Test 3



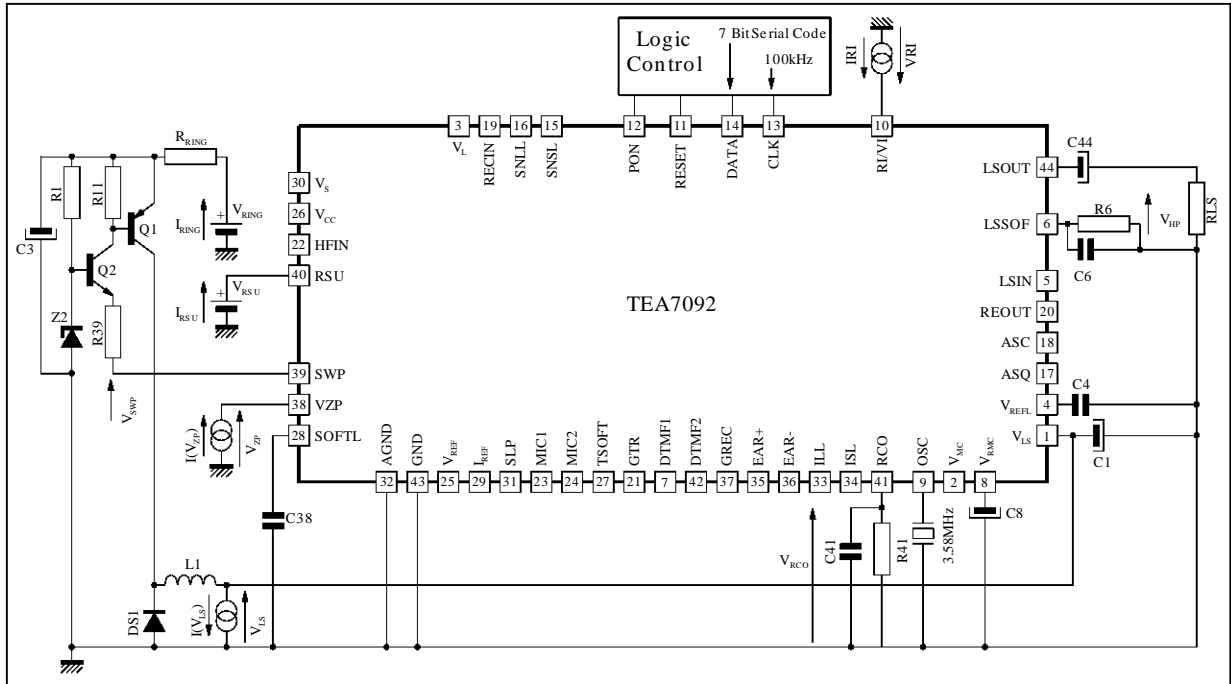
7092-14.EPS

Test 4



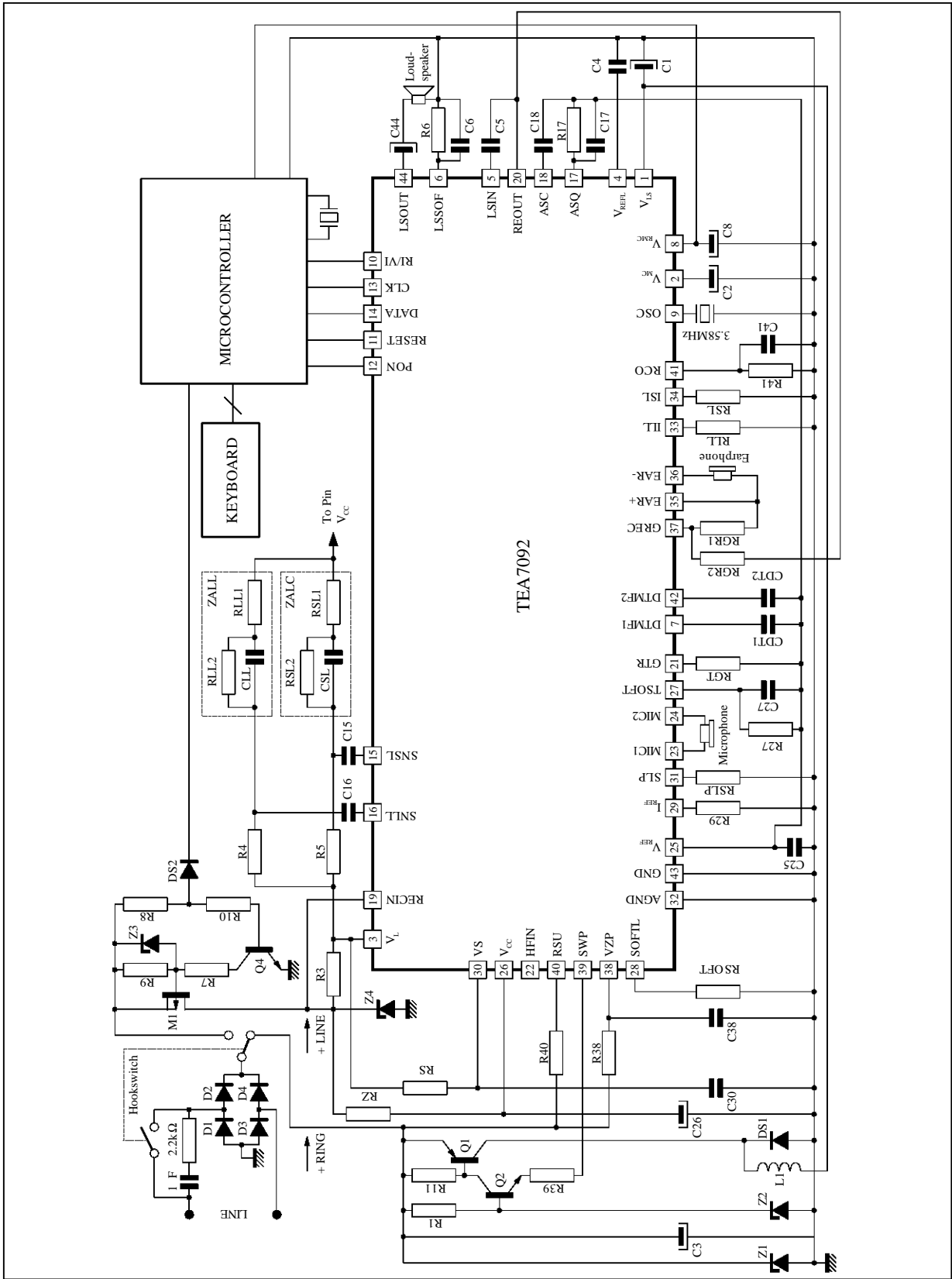
7092-15.EPS

Test 5



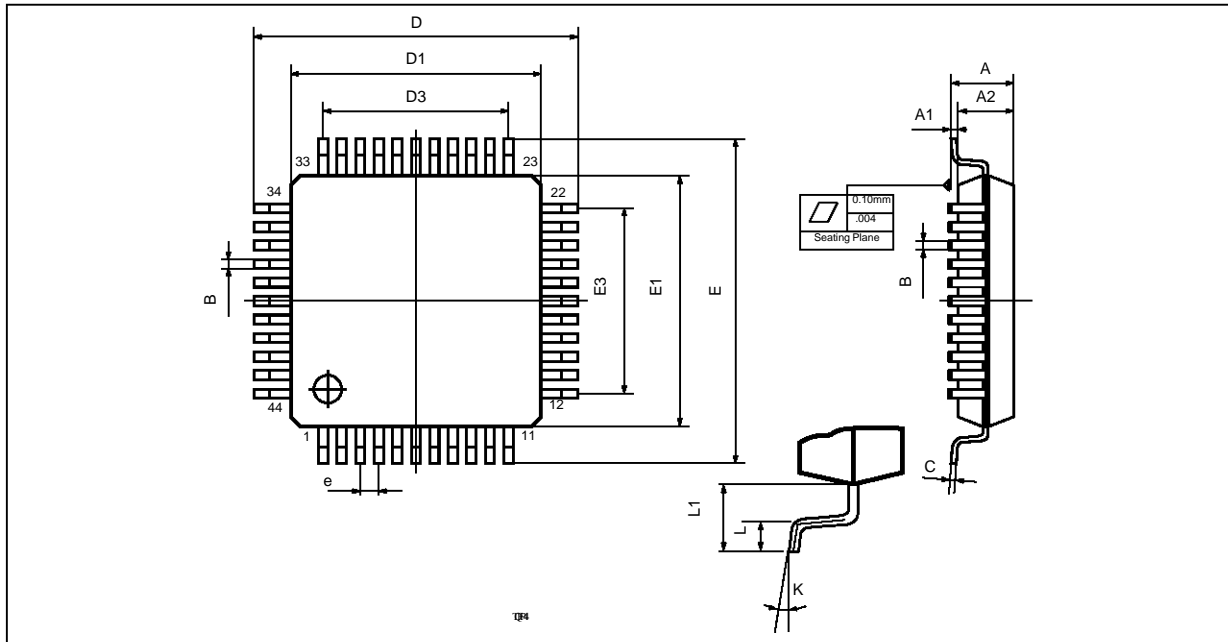
7092-16.EPS

TYPICAL APPLICATION



7092-17.EPS

**PACKAGE MECHANICAL DATA**  
**44 PINS - PLASTIC QUAD FLAT PACK (THIN)**



PMTQFP44.EPS

Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.60			0.063
A1	0.05		0.15	0.002		0.006
A2	1.35	1.40	1.45	0.053	0.055	0.057
B	0.30	0.35	0.40	0.012	0.014	0.016
C	0.09		0.20	0.004		0.008
D		12.00			0.472	
D1		10.00			0.394	
D3		8.00			0.315	
e		0.80			0.031	
E		12.00			0.472	
E1		10.00			0.394	
E3		8.00			0.315	
K	0° (Min.), 7° (Max.)					
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	

TOFP44A.TBL

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