DATA SHEET

TEA1093
Hands-free IC

Product specification
Supersedes data of 1995 May 18
File under Integrated Circuits, IC03

1996 Feb 09

Philips
Semiconductors

PHILIPS

FEATURES

- Line powered supply with:
  - adjustable stabilized supply voltage
  - power down function
- Microphone channel with:
  - externally adjustable gain
  - microphone mute function
- Loudspeaker channel with:
  - externally adjustable gain
  - dynamic limiter to prevent distortion
  - rail-to-rail output stages for single-ended or bridge-tied load drive
  - logarithmic volume control via linear potentiometer
  - loudspeaker mute function
- Duplex controller consisting of:
  - signal envelope and noise envelope monitors for both channels with:

    externally adjustable sensitivity

    externally adjustable signal envelope time constant

    externally adjustable noise envelope time constant
  - decision logic with:

    externally adjustable switch-over timing

    externally adjustable idle mode timing

    externally adjustable dial tone detector in receive channel
  - voice switch control with:

    adjustable switching range

    constant sum of gain during switching

    constant sum of gain at different volume settings.

APPLICATIONS

- Line-powered telephone sets with hands-free/listening-in functions.

GENERAL DESCRIPTION

The TEA1093 is a bipolar circuit intended for use in line-powered telephone sets. In conjunction with a member of the TEA1060 family or PCA1070 transmission circuits, the device offers a hands-free function for line powered telephone sets. It incorporates a supply, a microphone channel, a loudspeaker channel and a duplex controller with signal and noise monitors on both channels.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TEA1093	DIP28	plastic dual in-line package; 28 leads (600 mil)	SOT117-1
TEA1093T	SO28	plastic small outline package; 28 leads; body width 7.5 mm	SOT136-1

QUICK REFERENCE DATA

V_{SREF} = 4.2 V; V_{GND} = 0 V; I_{SUP} = 15 mA; V_{SUP} = 0 V (RMS); f = 1 kHz; T_{amb} = 25 °C; PD = LOW; MUTET = LOW; R_L = 50 Ω; R_{VOL} = 0 Ω; measured in test circuit of Fig.15; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{SUP}	operating supply current (pin SUP)		7	–	140	mA
V_{BB}	stabilized supply voltage		3.35	3.6	3.85	V
$I_{BB(pd)}$	current consumption from pin V_{BB} in power-down condition	PD = HIGH; V_{BB} = 3.6 V	–	400	550	μA
$I_{SUP(pd)}$	current consumption from pin SUP in power-down condition	PD = HIGH; V_{sup} = 4.5 V	–	55	75	μA
G_{vtx}	voltage gain from pin MIC to pin MOUT in transmit mode	V_{MIC} = 1 mV (RMS); R_{GAT} = 30.1 kΩ	12.5	15	17.5	dB
ΔG_{vtxr}	voltage gain adjustment with R_{GAT}		–10	–	+10	dB
G_{vrx}	voltage gain in receive mode	V_{RIN} = 20 mV (RMS); R_{GAR} = 66.5 kΩ; R_L = 50 Ω				
	the difference between RIN1 and RIN2 to LSP1 or LSP2 single-ended load		15.5	18	20.5	dB
	the difference between RIN1 and RIN2 to the difference between LSP1 and LSP2 bridge-tied load		21.5	24	26.5	dB
ΔG_{vrxr}	voltage gain adjustment with R_{GAR}		–15	–	+15	dB
$V_{O(p-p)}$	bridge-tied load (peak-to-peak value)	V_{RIN} = 150 mV (RMS); R_L = 33 Ω; note 1	–	5.15	–	V
SWRA	switching range		–	40	–	dB
ΔSWRA	switching range adjustment with R_{SWR} referenced to R_{SWR} = 365 kΩ		–40	–	+12	dB
T_{amb}	operating ambient temperature		–25	–	+75	°C

Note

1. Corresponds to 100 mW output power.

BLOCK DIAGRAM

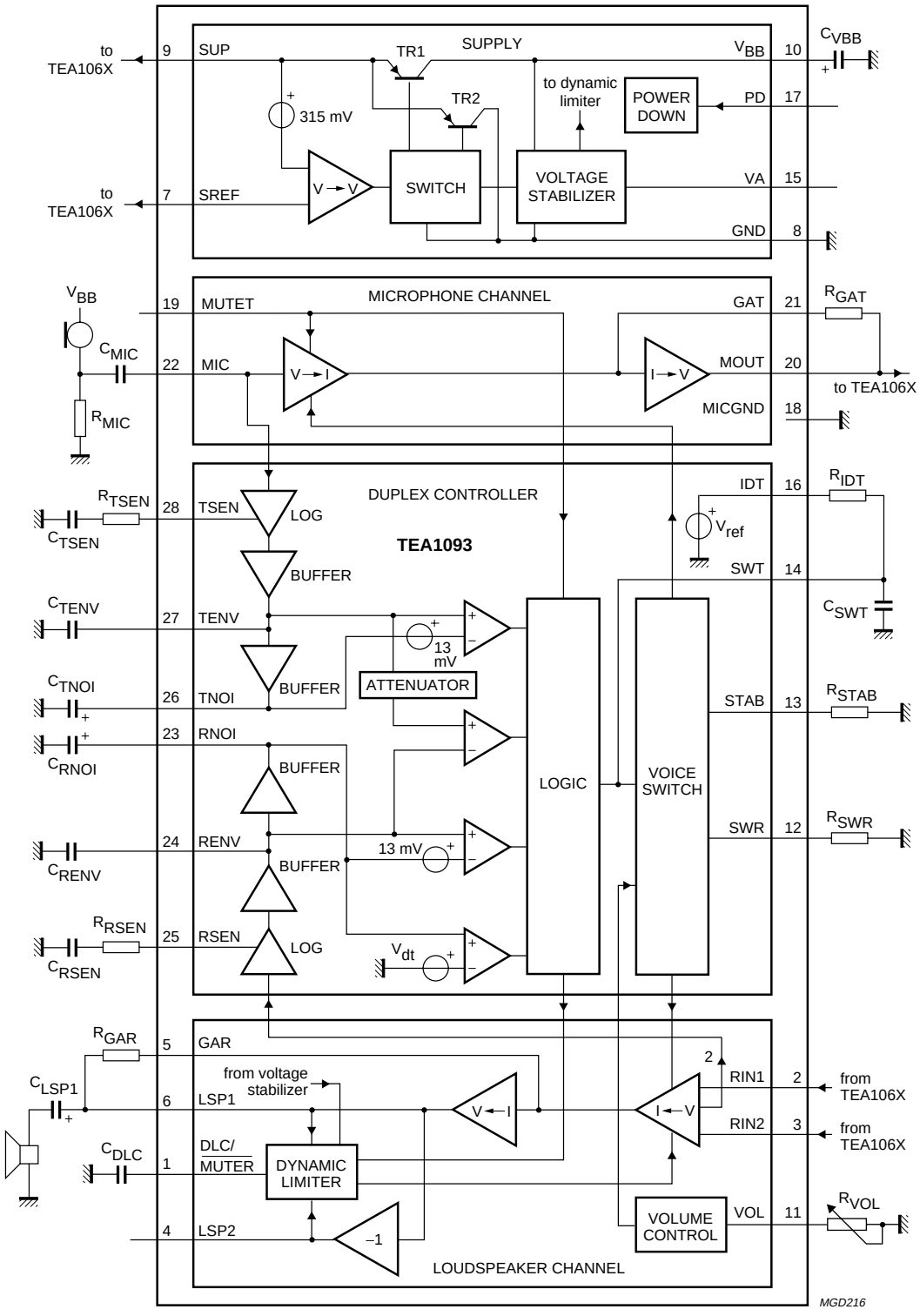


Fig.1 Block diagram.

PINNING

SYMBOL	PIN	DESCRIPTION
DLC/$\overline{\text{MUTER}}$	1	dynamic limiter timing adjustment, receiver channel mute input
RIN1	2	receiver amplifier input 1
RIN2	3	receiver amplifier input 2
LSP2	4	loudspeaker amplifier output 2
GAR	5	receiver gain adjustment
LSP1	6	loudspeaker amplifier output 1
SREF	7	supply reference input
GND	8	ground reference
SUP	9	supply input
V_{BB}	10	stabilized supply output
VOL	11	receiver volume adjustment
SWR	12	switching range adjustment
STAB	13	reference current adjustment
SWT	14	switch-over timing adjustment
VA	15	V_{BB} voltage adjustment
IDT	16	idle mode timing adjustment
PD	17	power-down input
MICGND	18	ground reference for the microphone amplifier
MUTET	19	transmit channel mute input
MOUT	20	microphone amplifier output
GAT	21	microphone gain adjustment
MIC	22	microphone input
RNOI	23	receive noise envelope timing adjustment
RENV	24	receive signal envelope timing adjustment
RSEN	25	receive signal envelope sensitivity adjustment
TNOI	26	transmit noise envelope timing adjustment
TENV	27	transmit signal envelope timing adjustment
TSEN	28	transmit signal envelope sensitivity adjustment

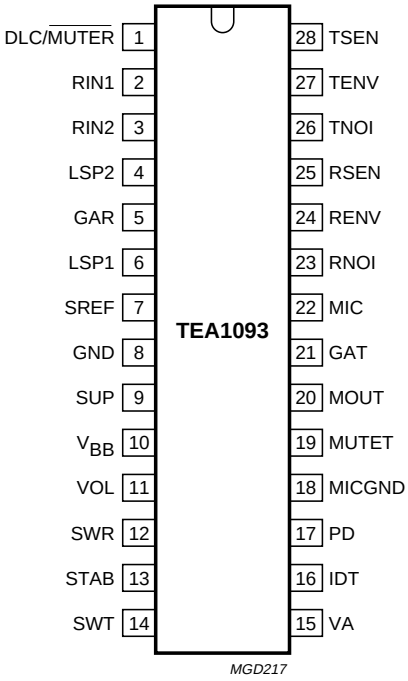


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

The values given in the functional description are typical values except when otherwise specified.

A principle diagram of the TEA106X is shown on the left side of Fig.3. The TEA106X is a transmission circuit of the TEA1060 family intended for hand-set operation. It incorporates a receiving amplifier for the earpiece, a transmit amplifier for the microphone and a hybrid. For more details on the TEA1060 family, please refer to *"Data Handbook IC03"*. The right side of Fig.3 shows a principle diagram of the TEA1093, a hands-free add-on circuit with a microphone amplifier, a loudspeaker amplifier and a duplex controller.

As can be seen from Fig.3, a loop is formed via the sidetone network in the transmission circuit and the acoustic coupling between loudspeaker and microphone of the hands-free circuit. When this loop gain is greater than 1, howling is introduced. In a full duplex application, this would be the case. The loop-gain has to be much lower than 1 and therefore has to be decreased to avoid howling. This is achieved by the duplex controller.The duplex controller of the TEA1093 detects which channel has the 'largest' signal and then controls the gain of the microphone amplifier and the loudspeaker amplifier so that the sum of the gains remains constant. As a result, the circuit can be in three stable modes:

1. Transmit mode (Tx mode): the gain of the microphone amplifier is at its maximum and the gain of the loudspeaker amplifier is at its minimum.
2. Receive mode (Rx mode): the gain of the loudspeaker amplifier is at its maximum and the gain of the microphone amplifier is at its minimum.
3. Idle mode: the gain of the amplifiers is halfway between their maximum and minimum value.

The difference between the maximum gain and minimum gain is called the switching range.

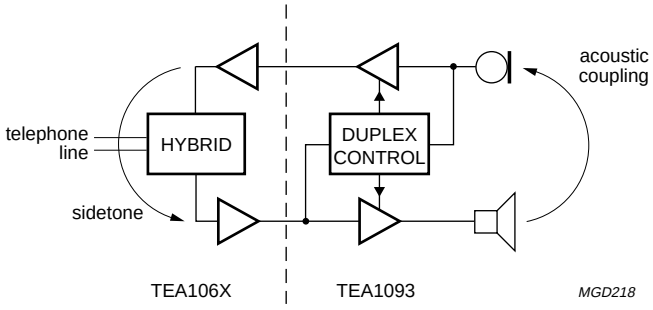


Fig.3 Hands-free telephone set principles.

Supply: pins SUP, SREF, V_{BB}, GND, VA and PD

As can be seen from Fig.4, the line current is divided between the speech-transmission circuit (I_{TR} + I_{CC}) and the TEA1093 circuit (I_{SUP}). It can be shown that:

$I_{SUP} = I_{line} - I_{TR} - I_{CC}$

Where:

$I_{TR} = V_{SUP} - V_{SREF}/R_{SREF}$

$V_{SUP} - V_{SREF}$ = 315 mV

R_{SREF} = 100 Ω

$I_{CC} \approx$ 1 mA

It follows that $I_{SUP} \approx I_{LINE}$ − 4 mA.

The TEA1093 stabilizes its own supply voltage of 3.6 V at V_{BB}. The voltage on V_{BB} can be adjusted by means of an external resistor R_{VA}.

When R_{VA} is connected between pin V_A and GND, the voltage on V_{BB} is increased, when connected between pin V_A and V_{BB}, it is decreased. This is shown in Fig.5. Two capacitors of 4.7 nF (C_{SREF} and C_{STAB}) are required to ensure stability of the supply block. When V_{SUP} is greater than V_{BB} + 0.4 V, the current I_{SUP} is supplied to V_{BB} via TR1. When V_{SUP} is less, the current is shunted to GND via TR2, which prevents distortion on the line.

To reduce current consumption during pulse dialling or register recall (flash), the TEA1093 is provided with a power-down (PD) input. When the voltage on PD is HIGH, the current consumption from SUP is 55 μA and from V_{BB} 400 μA. Therefore a capacitor of 470 μF (C_{VBB}) is sufficient to power the TEA1093 during pulse dialling.

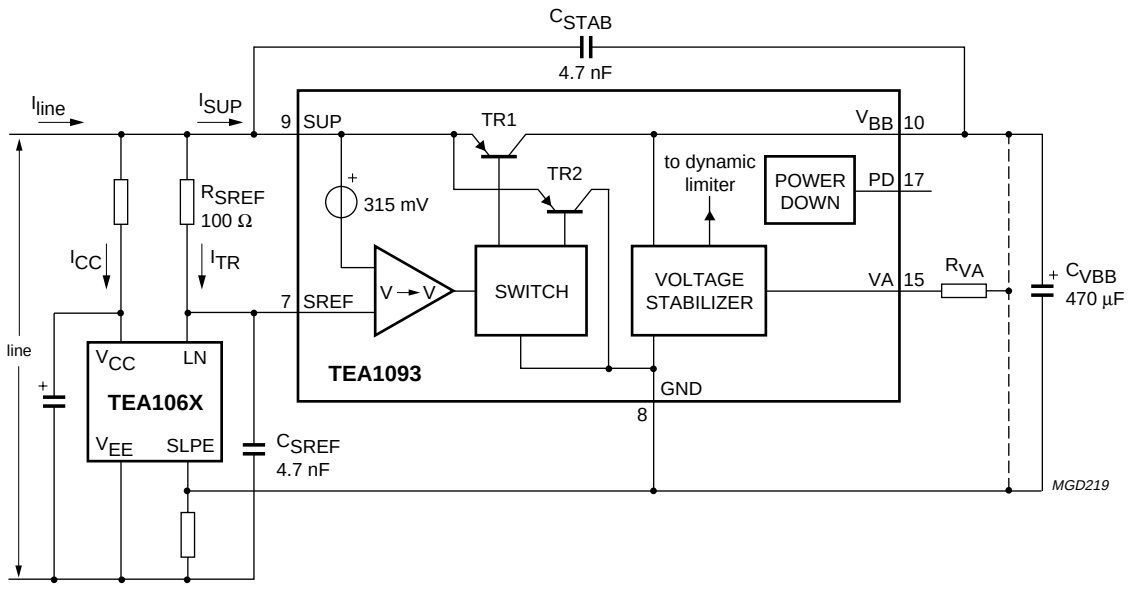


Fig.4 Supply arrangement.

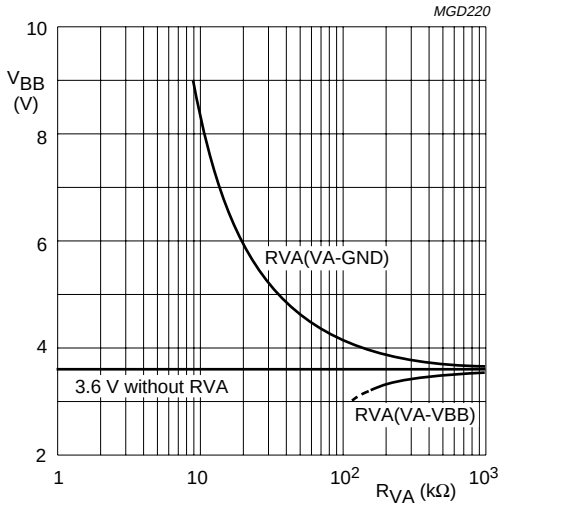


Fig.5 V_{BB} as a function of R_{VA}.

Microphone channel: pin MIC, GAT, MOUT, MICGND and MUTET

The TEA1093 has an asymmetrical microphone input MIC with an input resistance of 20 kΩ. The gain of the input stage varies according to the mode of the TEA1093. In the transmit mode, the gain is at its maximum; in the receive mode, it is at its minimum and in the idle mode, it is halfway between maximum and minimum. Switch-over from one mode to the other is smooth and click-free. The output capability at pin MOUT is 20 μA (RMS).

In the transmit mode, the overall gain of the microphone amplifier (from pin MIC to MOUT) can be adjusted from 5 dB up to 25 dB to suit specific application requirements. The gain is proportional to the value of R_{GAT} and equals 15 dB typical with R_{GAT} = 30.1 kΩ.

A capacitor must be connected in parallel with R_{GAT} to ensure stability of the microphone amplifier. Together with R_{GAT}, it also provides a first-order low-pass filter.

By applying a HIGH level on pin MUTET, the microphone amplifier is muted and the TEA1093 is automatically forced into the receive mode.

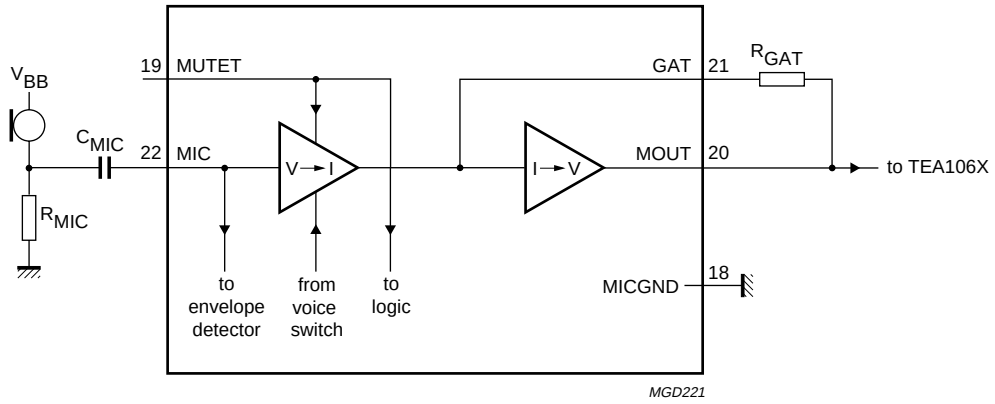


Fig.6 Microphone channel.

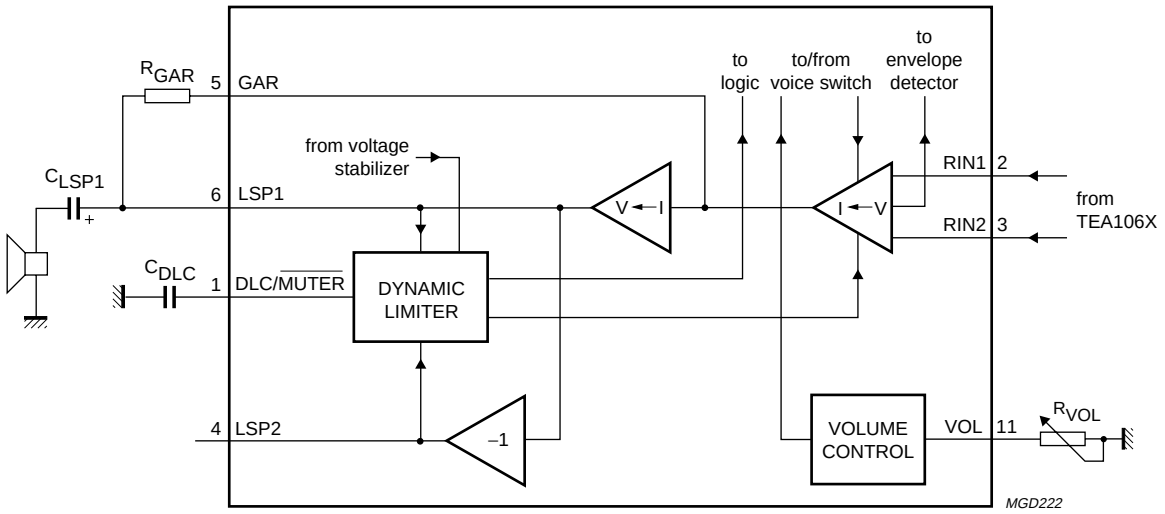


Fig.7 Loudspeaker channel.

Loudspeaker channel

LOUDSPEAKER AMPLIFIER: PINS RIN1, RIN2, GAR, LSP1 AND LSP2

The TEA1093 has symmetrical inputs for the loudspeaker amplifier with an input resistance of 40 kΩ between RIN1 and RIN2 (2×20 kΩ). The input stage can accommodate signals up to 390 mV (RMS) at room temperature for 2% of total harmonic distortion (THD). The gain of the input stage varies according to the mode of the TEA1093. In the receive mode, the gain is at its maximum; in the transmit mode, it is at its minimum and in the idle mode, it is halfway between maximum and minimum. Switch-over from one mode to the other is smooth and click-free. The rail-to-rail output stage is designed to power a loudspeaker which is connected as a single-ended load (between LSP1 and GND) or as a bridge-tied load (between LSP1 and LSP2).

In the receive mode, the overall gain of the loudspeaker amplifier can be adjusted from 3 dB up to 39 dB to suit specific application requirements. The gain from RIN1 or RIN2 to LSP1 is proportional to the value of R_{GAR} and equals 18 dB with R_{GAR} = 66.5 kΩ. The second output LSP2 is in opposite phase with LSP1. Therefore, in the basic application, the gain between RIN1-RIN2 to LSP1-LSP2 equals 24 dB typical with R_{GAR} = 66.5 kΩ. A capacitor connected in parallel with R_{GAR} can be used to provide a first-order low-pass filter.

VOLUME CONTROL: PIN VOL

The loudspeaker amplifier gain can be adjusted with the potentiometer R_{VOL}. A linear potentiometer can be used to obtain logarithmic control of the gain at the loudspeaker amplifier. Each 950 Ω increase of R_{VOL} results in a gain loss of 3 dB. The maximum gain reduction with the volume control is internally limited to the switching range.

DYNAMIC LIMITER: PIN DLC/$\overline{\text{MUTER}}$

The dynamic limiter of the TEA1093 prevents clipping of the loudspeaker output stages and protects the operation of the circuit when the supply condition falls below a certain level.

Hard clipping of the loudspeaker output stages is prevented by rapidly reducing the gain when the output stages start to saturate. The time in which gain reduction is effected (clipping attack time) is approximately a few milliseconds. The circuit stays in the reduced gain mode until the peaks of the loudspeaker signals no longer cause saturation. The gain of the loudspeaker amplifier then returns to its normal value within the clipping release time (typical 250 ms). Both attack and release times are proportional to the value of the capacitor C_{DLC}. The total harmonic distortion of the loudspeaker output stages, in reduced gain mode, stays below 5% up to 10 dB (minimum) of input voltage overdrive [providing V_{RIN} is below 390 mV (RMS)].

When the supply conditions drop below the required level, the gain of the loudspeaker amplifier is reduced in order to prevent the TEA1093 from malfunctioning. Only the gain of the loudspeaker amplifier is affected since it is considered to be the major power consuming part of the TEA1093.

When the TEA1093 experiences a loss of current, the supply voltage V_{BB} decreases. In this event, the gain of the loudspeaker amplifiers is slowly reduced (approximately a few seconds). When the supply voltage continues to decrease and drops below an internal voltage threshold of 2.75 V, the gain of the loudspeaker amplifier is rapidly reduced (approximately 1 ms). When normal supply conditions are resumed, the gain of the loudspeaker amplifier is increased again. This system ensures that in the event of large continuous signals, all current is used to power the loudspeaker while the voltage on pin V_{BB} remains at its nominal value.

By forcing a level lower than 0.2 V on pin DLC/$\overline{\text{MUTER}}$, the loudspeaker amplifier is muted and the TEA1093 is automatically forced into the transmit mode.

Duplex controller

SIGNAL AND NOISE ENVELOPE DETECTORS: PINS TSEN, TENV, TNOI, RSEN, RENV AND RNOI

The signal envelopes are used to monitor the signal level strength in both channels. The noise envelopes are used to monitor background noise in both channels. The signal and noise envelopes provide inputs for the decision logic. The signal and noise envelope detectors are shown in Fig.8.

For the transmit channel, the input signal at MIC is 40 dB, amplified to TSEN. For the receive channel, the differential signal between RIN1 and RIN2 is 0 dB amplified to RSEN. The signals from TSEN and RSEN are logarithmically compressed and buffered to TENV and RENV respectively. The sensitivity of the envelope detectors is set with R_{TSEN} and R_{RSEN}. The capacitors connected in series with the two resistors block any DC component and form a first-order high-pass filter. In the basic application, see Fig.16, it is assumed that V_{MIC} = 1 mV (RMS) and V_{RIN} = 100 mV (RMS) nominal and both R_{TSEN} and R_{RSEN} have a value of 10 kΩ. With the value of C_{TSEN} and C_{RSEN} at 100 nF, the cut-off frequency is at 160 Hz.

The buffer amplifiers leading the compressed signals to TENV and RENV have a maximum source current of 120 μA and a maximum sink current of 1 μA. Together with the capacitor C_{TENV} and C_{RENV}, the timing of the signal envelope monitors can be set. In the basic application, the value of both capacitors is 470 nF. Because of the logarithmic compression, each 6 dB signal increase means 18 mV increase of the voltage on the envelopes TENV or RENV at room temperature. Thus, timings can be expressed in dB/ms. At room temperature, the 120 μA sourced current corresponds to a maximum rise-slope of the signal envelope of 85 dB/ms. This is sufficient to track normal speech signals. The 1 μA current sunk by TENV or RENV corresponds to a maximum fall-slope of 0.7 dB/ms. This is sufficient for a smooth envelope and also eliminates the effect of echoes on switching behaviour.

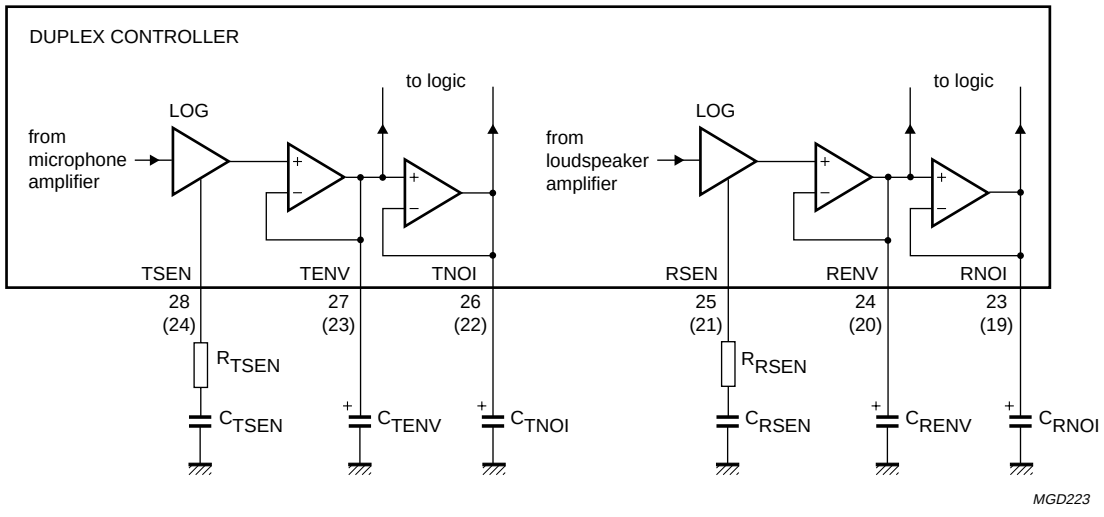


Fig.8 Signal and noise envelope detectors.

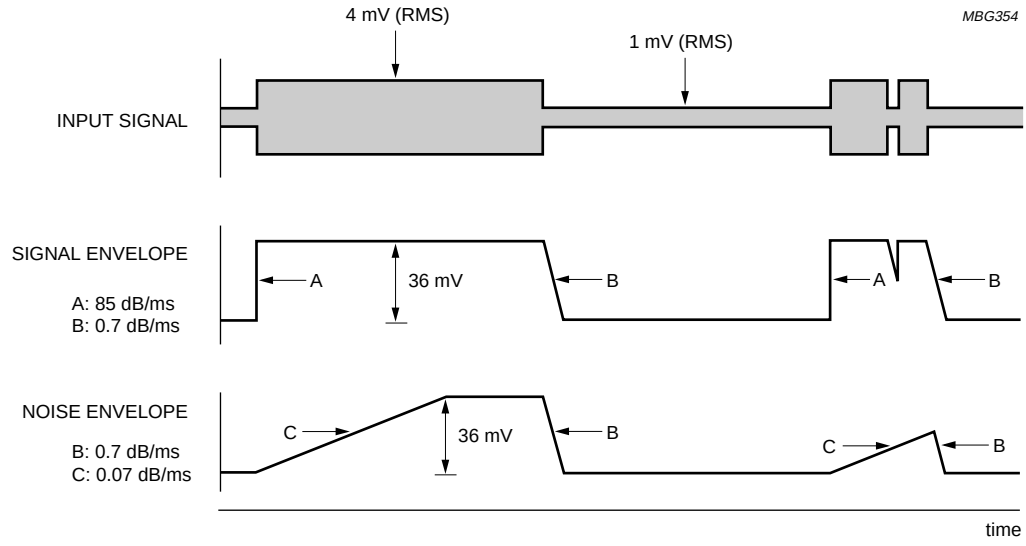
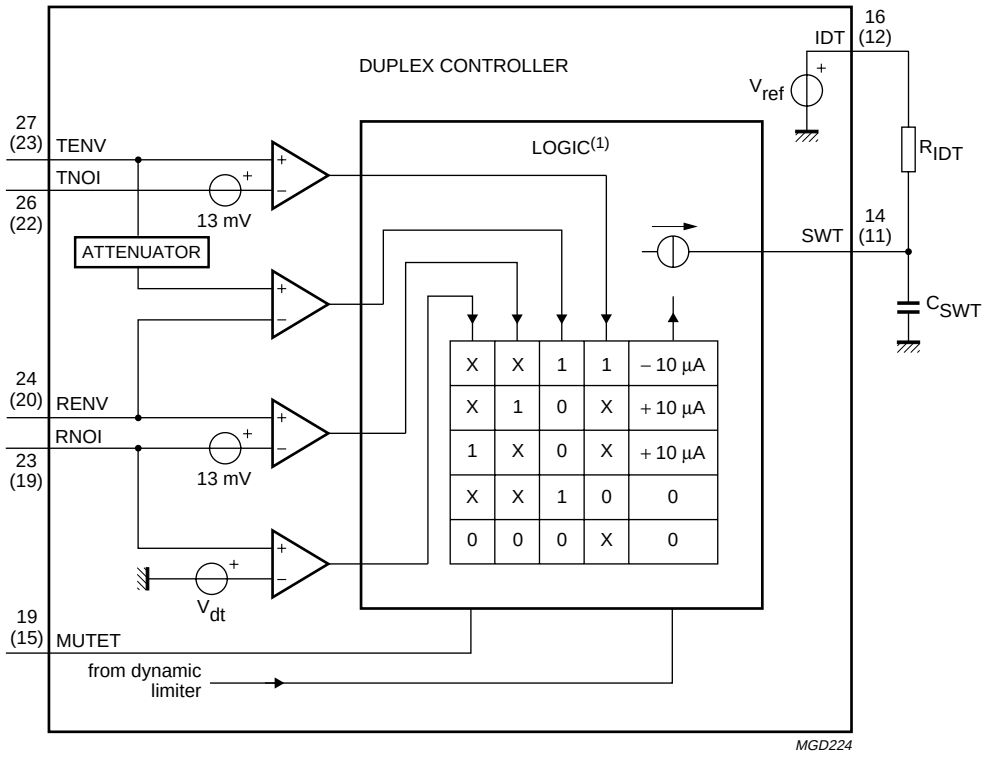


Fig.9 Signal and noise envelope waveforms.



X	X	1	1	− 10 μA
X	1	0	X	+ 10 μA
1	X	0	X	+ 10 μA
X	X	1	0	0
0	0	0	X	0

(1) When MUTET = HIGH, +10 μA is forced.
When DLC/MUTER < 0.2 V, −10 μA is forced.

Fig.10 Decision logic.

To determine the noise level, the signal on TENV and RENV are buffered to TNOI and RNOI. These buffers have a maximum source current of 1 μA and a maximum sink current of 120 μA. Together with the capacitors C_{TNOI} and C_{RNOI}, the timing can be set. In the basic application of Fig.16, the value of both capacitors is 4.7 μF. At room temperature, the 1 μA sourced current corresponds to a maximum rise-slope of the noise envelope of approximately 0.07 dB/ms. This is small enough to track background noise and not to be influenced by speech bursts. The 120 μA current that is sunk corresponds to a maximum fall-slope of approximately 8.5 dB/ms. However, during the decrease of the signal envelope, the noise envelope tracks the signal envelope so it will never fall faster than approximately 0.7 dB/ms. The behaviour of the signal envelope and noise envelope monitors is illustrated in Fig.9.

DECISION LOGIC: PINS IDT AND SWT

The TEA1093 selects its mode of operation (transmit, receive or idle mode) by comparing the signal and the noise envelopes of both channels. This is executed by the decision logic. The resulting voltage on pin SWT is the input for the voice-switch.

To facilitate the distinction between signal and noise, the signal is considered as speech when its envelope is more than 4.3 dB above the noise envelope. At room temperature, this is equal to a voltage difference $V_{ENV}-V_{NOI}$ = 13 mV. This so called speech/noise threshold is implemented in both channels.

The signal on MIC contains both speech and the signal coming from the loudspeaker (acoustic coupling). When receiving, the contribution from the loudspeaker overrules the speech. As a result, the signal envelope on TENV is formed mainly by the loudspeaker signal. To correct this, an attenuator is connected between TENV and the TENV/RENV comparator. Its attenuation equals that applied to the microphone amplifier.

When a dial tone is present on the line, without monitoring, the tone would be recognized as noise because it is a signal with a constant amplitude. This would cause the TEA1093 to go into the idle mode and the user of the set would hear the dial tone fade away. To prevent this, a dial tone detector is incorporated which, in standard applications, does not consider input signals between RIN1 and RIN2 as noise when they have a level greater than 127 mV (RMS). This level is proportional to R_{RSEN}.

As can be seen from Fig.10, the output of the decision logic is a current source. The logic table gives the relationship between the inputs and the value of the current source. It can charge or discharge the capacitor C_{SWT} with a current of 10 μA (switch-over). If the current is zero, the voltage on SWT becomes equal to the voltage on IDT via the high-ohmic resistor R_{IDT} (idling). The resulting voltage difference between SWT and IDT determines the mode of the TEA1093 and can vary between –400 mV and +400 mV.

Table 1 Modes of TEA1093

$V_{SWT} - V_{IDT}$ (mV)	MODE
<–180	transmit mode
0	idle mode
>+180	receive mode

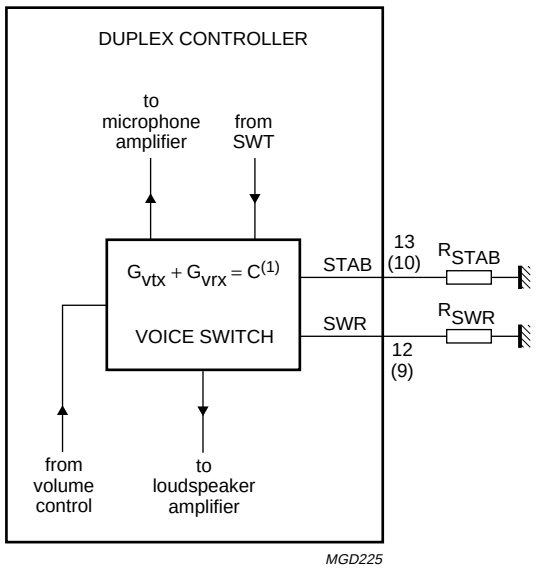
The switch-over timing can be set with C_{SWT}, the idle mode timing with C_{SWT} and R_{IDT}. In the basic application given in Fig.16, C_{SWT} is 220 nF and R_{IDT} is 2.2 MΩ. This enables a switch-over time from transmit to receive mode or vice-versa of approximately 13 ms (580 mV swing on SWT). The switch-over time from idle mode to transmit mode or receive mode is approximately 4 ms (180 mV swing on SWT).

The switch over, from receive mode or transmit mode to idle mode, is equal to $4 \times R_{IDT} \times C_{SWT}$ and is approximately 2 seconds (idle mode time).

The inputs MUTET and DLC/$\overline{\text{MUTER}}$ overrule the decision logic. When MUTET goes HIGH, the capacitor C_{SWT} is charged with 10 μA thus resulting in the receive mode. When the voltage on pin DLC/$\overline{\text{MUTER}}$ goes lower than 0.2 V, the capacitor is discharged with 10 μA thus resulting in the transmit mode.

VOICE-SWITCH: PINS STAB AND SWR

A diagram of the voice-switch is illustrated in Fig.11. With the voltage on SWT, the TEA1093 voice-switch regulates the gains of the transmit and the receive channel so that the sum of both is kept constant.



(1) c - constant.

Fig.11 Voice-switch.

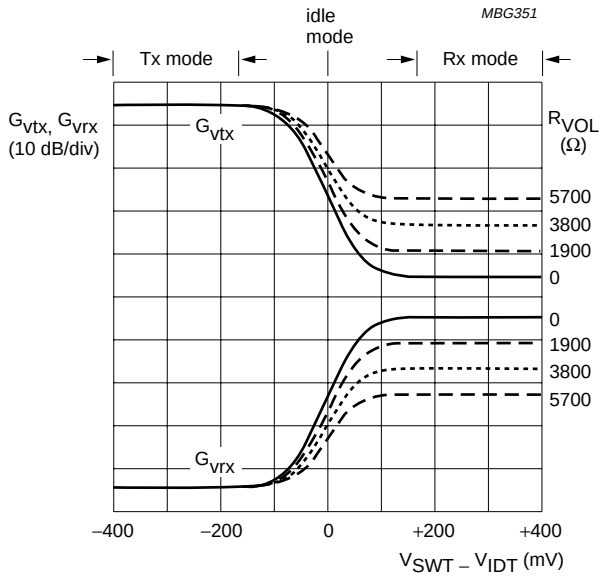


Fig.12 Switch-over behaviour.

In the transmit mode, the gain of the microphone amplifier is at its maximum and the gain of the loudspeaker amplifier is at its minimum. In the receive mode, the opposite applies. In the idle mode, both microphone and loudspeaker amplifier gains are halfway. The difference between maximum and minimum is the so called switching range. This range is determined by the ratio of R_{SWR} and R_{STAB} and is adjustable between 0 and 52 dB. R_{STAB} should be 3.65 kΩ and sets an internally used reference current. In the basic application diagram given in Fig.16, R_{SWR} is 365 kΩ which results in a switching range of 40 dB. The switch-over behaviour is illustrated in Fig.12.

In the receive mode, the gain of the loudspeaker amplifier can be reduced using the volume control. Since the voice-switch keeps the sum of the gains constant, the gain of the microphone amplifier is increased at the same time (see dashed curves in Fig.12). In the transmit mode, however, the volume control has no influence on the gain of the microphone amplifier or the gain of the loudspeaker amplifier. Consequently, the switching range is reduced when the volume is reduced. At maximum reduction of volume, the switching range becomes 0 dB.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

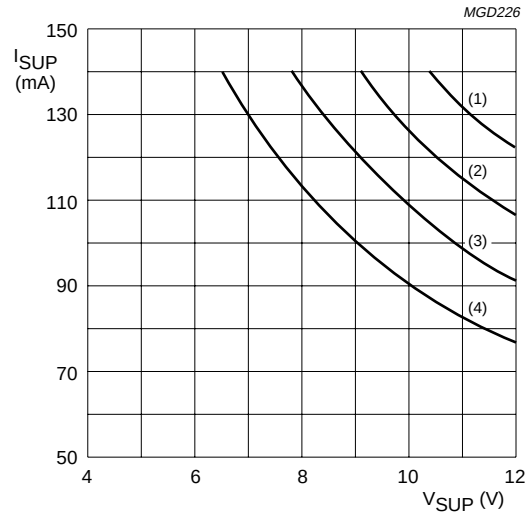
SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$V_{n(max)}$	maximum voltage on all pins; except pins SUP, SREF, V_{BB}, RIN1 and RIN2		V_{GND} − 0.4 V	V_{BB} + 0.4 V	V
V_{RINmax}	maximum voltage on pin RIN1 or RIN2		V_{GND} − 1.2 V	V_{BB} + 0.4 V	V
V_{BBmax}	maximum voltage on pin V_{BB}		V_{GND} − 0.4 V	12.0	V
$V_{SREFmax}$	maximum voltage on pin SREF		V_{GND} − 0.4 V	V_{SUP} + 0.4 V	V
V_{SUPmax}	maximum voltage on pin SUP		V_{GND} − 0.4 V	12.0	V
I_{SUPmax}	maximum current on pin SUP	see also Figs 13 and 14	–	140	mA
P_{tot}	total power dissipation	see also Figs 13 and 14; T_{amb} = 75 °C			
	TEA1093		–	910	mW
	TEA1093T		–	670	mW
T_{stg}	storage temperature		–40	+125	°C
T_{amb}	operating ambient temperature		–25	+75	°C

HANDLING

ESD in accordance with MIL STD883C; Method 3015 (HBM 1500 Ω, 100 pF); 3 pulses positive and 3 pulses negative on each pin referenced to ground. Class 2: 2000 to 3999 V.

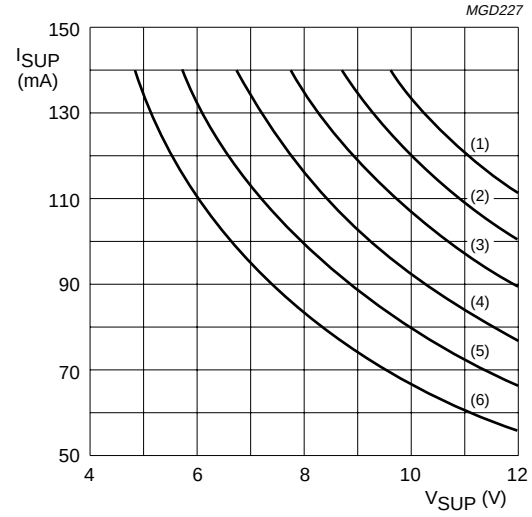
THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient in free air		
	TEA1093	55	K/W
	TEA1093T	75	K/W



(1) T_{amb} = 45 °C; P_{tot} = 1.45 W.
(2) T_{amb} = 55 °C; P_{tot} = 1.27 W.
(3) T_{amb} = 65 °C; P_{tot} = 1.09 W.
(4) T_{amb} = 75 °C; P_{tot} = 0.91 W.

Fig.13 TEA1093 safe operating area.



(1) T_{amb} = 25 °C; P_{tot} = 1.33 W.
(2) T_{amb} = 35 °C; P_{tot} = 1.20 W.
(3) T_{amb} = 45 °C; P_{tot} = 1.07 W.
(4) T_{amb} = 55 °C; P_{tot} = 0.93 W.
(5) T_{amb} = 65 °C; P_{tot} = 0.80 W.
(6) T_{amb} = 75 °C; P_{tot} = 0.67 W.

Fig.14 TEA1093T safe operating area.

CHARACTERISTICS

V_{SREF} = 4.2 V; V_{GND} = 0 V; I_{SUP} = 15 mA; V_{SUP} = 0 V (RMS); f = 1 kHz; T_{amb} = 25 °C; PD = LOW; MUTET = LOW; R_L = 50 Ω; R_{VOL} = 0 Ω; measured in test circuit of Fig.15; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply (VA, SREF, SUP, V_{BB}, GND and PD)						
V_{BB}	stabilized supply voltage		3.35	3.6	3.85	V
$\Delta V_{BB(ISUP)}$	V_{BB} variation with I_{SUP}	I_{SUP} = 15 to 140 mA	–	20	–	mV
$\Delta V_{BB(T)}$	V_{BB} variation with temperature referenced to 25 °C	T_{amb} = –25 to + 75 °C	–	±20	–	mV
$\Delta V_{BB(RVA)}$	V_{BB} adjustment with R_{VA}	between VA and V_{BB}; R_{VA} = 180 kΩ	–	3.2	–	V
		between VA and GND; V_{SREF} = 4.9 V; R_{VA} = 56 kΩ	–	4.5	–	V
$I_{SUP(min)}$	minimum operating current		–	5.5	7.0	mA
$V_{SUP} - V_{BB}$	minimum DC voltage drop between pin SUP and V_{BB}		0.4	–	–	V
$V_{SUP} - V_{SREF}$	internal reference voltage		275	315	355	mV
THD	total harmonic distortion of AC signal on SUP	V_{SUP} = 1 V (RMS)	–	0.5	–	%
Power-Down input PD						
V_{IL}	LOW level input voltage		V_{GND} – 0.4 V	–	0.3	V
V_{IH}	HIGH level input voltage		1.5	–	V_{BB} + 0.4 V	V
I_{PD}	input current in power-down condition	PD = HIGH	–	2.5	5.0	µA
$I_{SUP(PD)}$	current consumption from pin SUP in power-down condition	PD = HIGH; V_{SUP} = 4.5 V	–	55	75	µA
$I_{BB(PD)}$	current consumption from pin V_{BB} in power-down condition	PD = HIGH; V_{BB} = 3.6 V	–	400	550	µA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Microphone channel (MIC, GAT, MOUT, MUTET and MICGND)						
MICROPHONE AMPLIFIER						
$\|Z_i\|$	input impedance between pin MIC and MICGND		17	20	23	kΩ
G_{vtx}	voltage gain from pin MIC to MOUT in transmit mode	V_{MIC} = 1 mV (RMS)	12.5	15	17.5	dB
ΔG_{vtxr}	voltage gain adjustment with R_{GAT}		−10	–	+10	dB
ΔG_{vtxT}	voltage gain variation with temperature referenced to 25 °C	V_{MIC} = 1 mV (RMS); T_{amb} = −25 to +75 °C	–	±0.3	–	dB
ΔG_{vtxf}	voltage gain variation with frequency referenced to 1 kHz	V_{MIC} = 1 mV (RMS); f = 300 to 3400 Hz	–	±0.3	–	dB
V_{notx}	noise output voltage at pin MOUT	pin MIC connected to MICGND through 200 Ω in series with 10 μF; psophometrically weighted (P53 curve)	–	−100	–	dBmp
TRANSMIT MUTE INPUT MUTET						
V_{IL}	LOW level input voltage		V_{GND} − 0.4 V	–	0.3	V
V_{IH}	HIGH level input voltage		1.5	–	V_{BB} + 0.4 V	V
I_{MUTET}	input current	MUTET = HIGH	–	2.5	5	μA
ΔG_{vtxm}	voltage gain reduction with MUTET active	MUTET = HIGH	–	80	–	dB
Loudspeaker channel (RIN1, RIN2, GAR, LSP1, LSP2 and DLC/$\overline{\text{MUTER}}$)						
LOUDSPEAKER AMPLIFIER						
$\|Z_i\|$	input impedance	between pins RIN1 or RIN2 and GND	17	20	23	kΩ
		between pins RIN1 and RIN2	34	40	46	kΩ
G_{vrx}	voltage gain in receive mode	V_{RIN} = 20 mV (RMS)				
	the difference between RIN1 and RIN2 to the difference between LSP1 and LSP2, bridge-tied load		21.5	24	26.5	dB
	the difference between RIN1 and RIN2 to LSP1 or LSP2, single-ended load		15.5	18	20.5	dB
ΔG_{vrxr}	voltage gain adjustment with R_{GAR}		−15	–	+15	dB
ΔG_{vrxT}	voltage gain variation with temperature referenced to 25 °C	V_{RIN} = 20 mV (RMS); T_{amb} = -25 to +75 °C	–	±0.3	–	dB

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
ΔG_{vrxf}	voltage gain variation with frequency referenced to 1 kHz	V_{RIN} = 20 mV (RMS); f = 300 to 3400 Hz	–	±0.3	–	dB
$V_{RIN(rms)}$	maximum input voltage between RIN1 and RIN2 (RMS value)	for 2% THD in input stage; R_{GAR} = 11.8 kΩ	–	390	–	mV
$V_{norx(rms)}$	noise output voltage at pin LSP1 or LSP2 (RMS value)	inputs RIN1 and RIN2 short-circuited through 200 Ω in series with 10 μF; psophometrically weighted (P53 curve)	–	80	–	μV
CMRR	common mode rejection ratio		–	50	–	dB
ΔG_{vrxv}	voltage gain variation related to ΔR_{VOL} = 950 Ω	when total attenuation does not exceed the switching range	–	3	–	dB
OUTPUT CAPABILITY						
$V_{OSE(p-p)}$	single-ended load (peak-to-peak value)	V_{RIN} = 150 mV (RMS); I_{SUP} = 11 mA; note 1	1.2	1.45	–	V
		V_{RIN} = 150 mV (RMS); I_{SUP} = 16.5 mA; note 2	2.5	2.9	–	V
$V_{OBTL(p-p)}$	bridge-tied load (peak-to-peak value)	V_{RIN} = 150 mV (RMS); I_{SUP} = 27 mA; note 2	2.5	2.9	–	V
		V_{RIN} = 150 mV (RMS); I_{SUP} = 35 mA; note 3	3.5	4.0	–	V
		V_{RIN} = 150 mV (RMS); I_{SUP} = 62 mA; R_L = 33 Ω; note 4	–	5.15	–	V
$\lvert I_{OM(max)} \rvert$	maximum output current at LSP1 or LSP2 (peak value)		150	300	–	mA
DYNAMIC LIMITER						
t_{att}	attack time when V_{RIN} jumps from 20 mV to 20 mV + 10 dB	R_{GAR} = 374 kΩ; I_{SUP} = 20 mA	–	–	5	ms
t_{rel}	release time when V_{RIN} jumps from 20 mV + 10 dB to 20 mV	R_{GAR} = 374 kΩ; I_{SUP} = 20 mA	–	250	–	ms
THD	total harmonic distortion at V_{RIN} = 20 mV + 10 dB	R_{GAR} = 374 kΩ; I_{SUP} = 20 mA; $t > t_{att}$	–	0.9	5	%
$V_{BB(th)}$	V_{BB} limiter threshold		–	2.75	–	V
t_{att}	attack time when V_{BB} jumps below $V_{BB(th)}$		–	1	–	ms

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
MUTE RECEIVE						
$V_{DLC(th)}$	threshold voltage required on pin DLC/$\overline{\text{MUTER}}$ to obtain mute receive condition		V_{GND} – 0.4 V	–	0.2	V
$I_{DLC(th)}$	threshold current sourced by pin DLC/$\overline{\text{MUTER}}$ in mute receive condition	V_{DLC} = 0.2 V	–	80	–	µA
ΔG_{vrxm}	voltage gain reduction in mute receive condition	V_{DLC} < 0.2 V	–	80	–	dB
Envelope and noise detectors (TSEN, TENV, RSEN and RENV)						
PREAMPLIFIERS						
$G_{v(TSEN)}$	voltage gain from MIC to TSEN		38	40	42	dB
$G_{v(RSEN)}$	voltage gain between RIN1 and RIN2 to RSEN.		–2	0	+2	dB
LOGARITHMIC COMPRESSOR AND SENSITIVITY ADJUSTMENT						
$\Delta V_{det(TSEN)}$	sensitivity detection on pin TSEN; voltage change on pin TENV when doubling the current from TSEN	I_{TSEN} = 0.8 to 160 µA	–	18	–	mV
$\Delta V_{det(RSEN)}$	sensitivity detection on pin RSEN; voltage change on pin RENV when doubling the current from RSEN	I_{RSEN} = 0.8 to 160 µA	–	18	–	mV
SIGNAL ENVELOPE DETECTORS						
$I_{source(ENV)}$	maximum current sourced from pin TENV or RENV		–	120	–	µA
$I_{sink(ENV)}$	maximum current sunk by pin TENV or RENV		0.75	1	1.25	µA
ΔV_{ENV}	voltage difference between pin RENV and TENV	when 10 µA is sourced from both RSEN and TSEN; envelope detectors tracking; note 5	–	±3	–	mV
NOISE ENVELOPE DETECTORS						
$I_{source(NOI)}$	maximum current sourced from pin TNOI or RNOI		0.75	1	1.25	µA
$I_{sink(NOI)}$	maximum current sunk by pin TNOI or RNOI		–	120	–	µA
ΔV_{NOI}	voltage difference between pin RNOI and TNOI	when 5 µA is sourced from both RSEN and TSEN; noise detectors tracking; note 5	–	±3	–	mV

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
DIAL TONE DETECTOR						
$V_{RINDT(rms)}$	threshold level at pin RIN1 and RIN2 (RMS value)		–	127	–	mV
Decision logic (IDT and SWT)						
SIGNAL RECOGNITION						
$\Delta V_{Srx(th)}$	threshold voltage between pin RENV and RNOI to switch-over from receive to idle mode	$V_{RIN} < V_{RINDT}$; note 6	–	13	–	mV
$\Delta V_{Stx(th)}$	threshold voltage between pin TENV and TNOI to switch-over from transmit to idle mode	note 6	–	13	–	mV
SWITCH-OVER						
$I_{source(SWT)}$	current sourced from pin SWT when switching to receive mode		7.5	10	12.5	μA
$I_{sink(SWT)}$	current sunk by pin SWT when switching to transmit mode		7.5	10	12.5	μA
$I_{idle(SWT)}$	current sourced from pin SWT in idle mode		–	0	–	μA
Voice switch (STAB and SWR)						
SWRA	switching range		–	40	–	dB
ΔSWRA	switching range adjustment with R_{SWR} referenced to 365 kΩ		–40	–	12	dB
$\lvert\Delta G_v\rvert$	voltage gain variation from transmit mode to idle mode on both channels		–	20	–	dB
G_{tr}	gain tracking ($G_{vtx} + G_{vrx}$) during switching, referenced to idle mode		–	±0.5	–	dB

Notes

1. Corresponds to 5 mW output power.
2. Corresponds to 20 mW output power.
3. Corresponds to 40 mW output power.
4. Corresponds to 100 mW output power.
5. Corresponds to ±1 dB tracking.
6. Corresponds to 4.3 dB noise/speech recognition level.

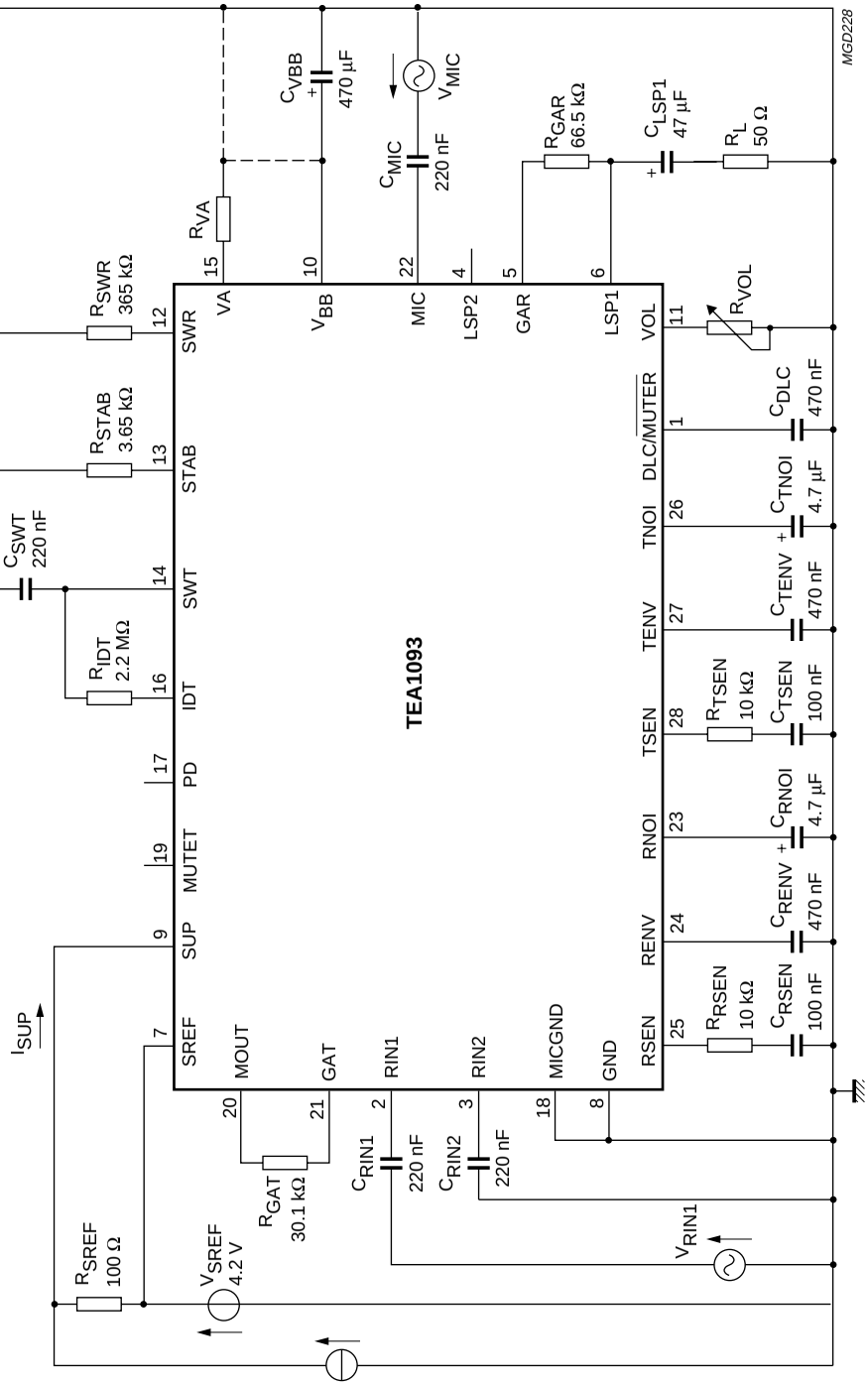


Fig.15 Test circuit.

APPLICATION INFORMATION

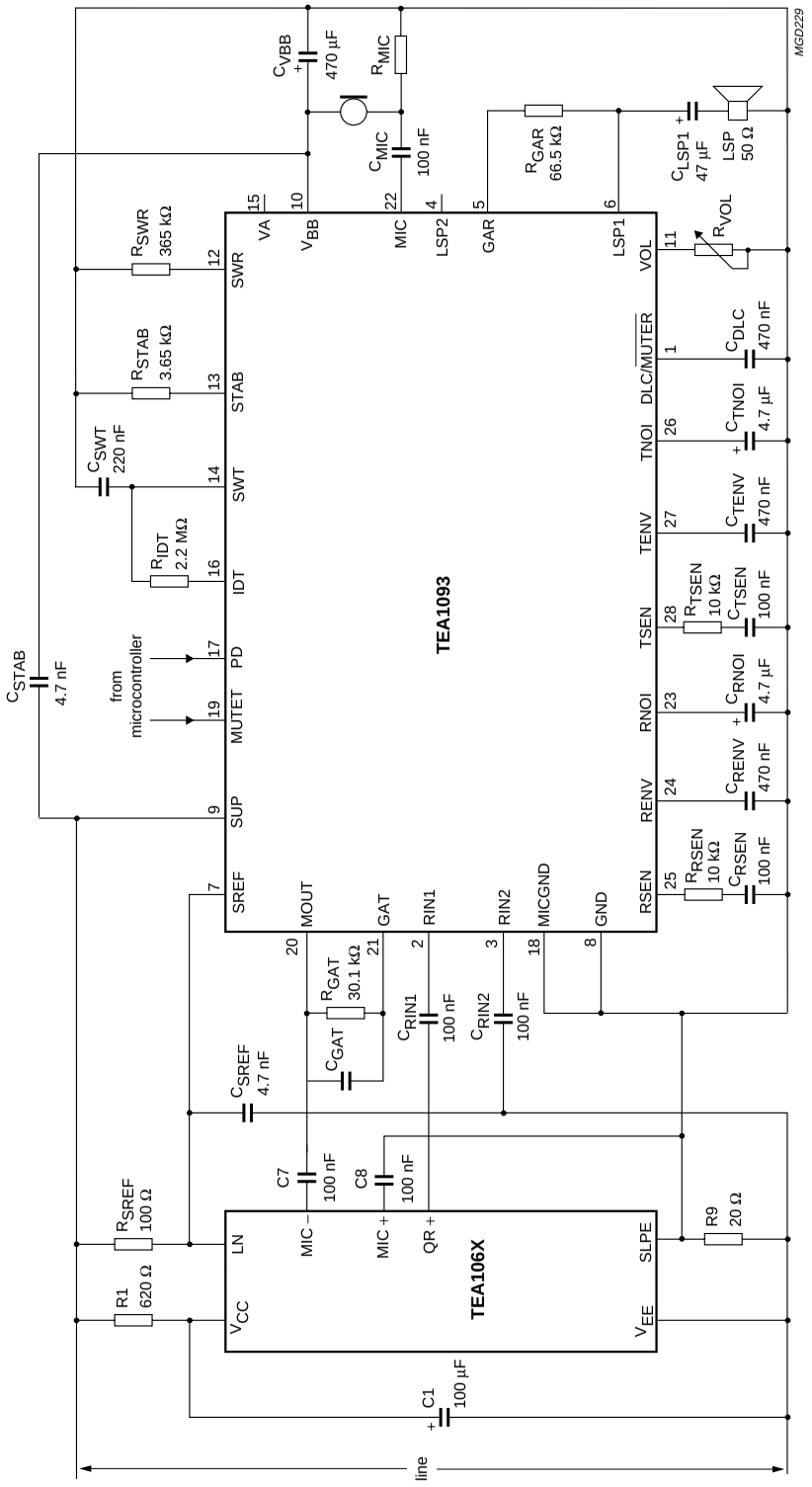


Fig.16 Basic application diagram.

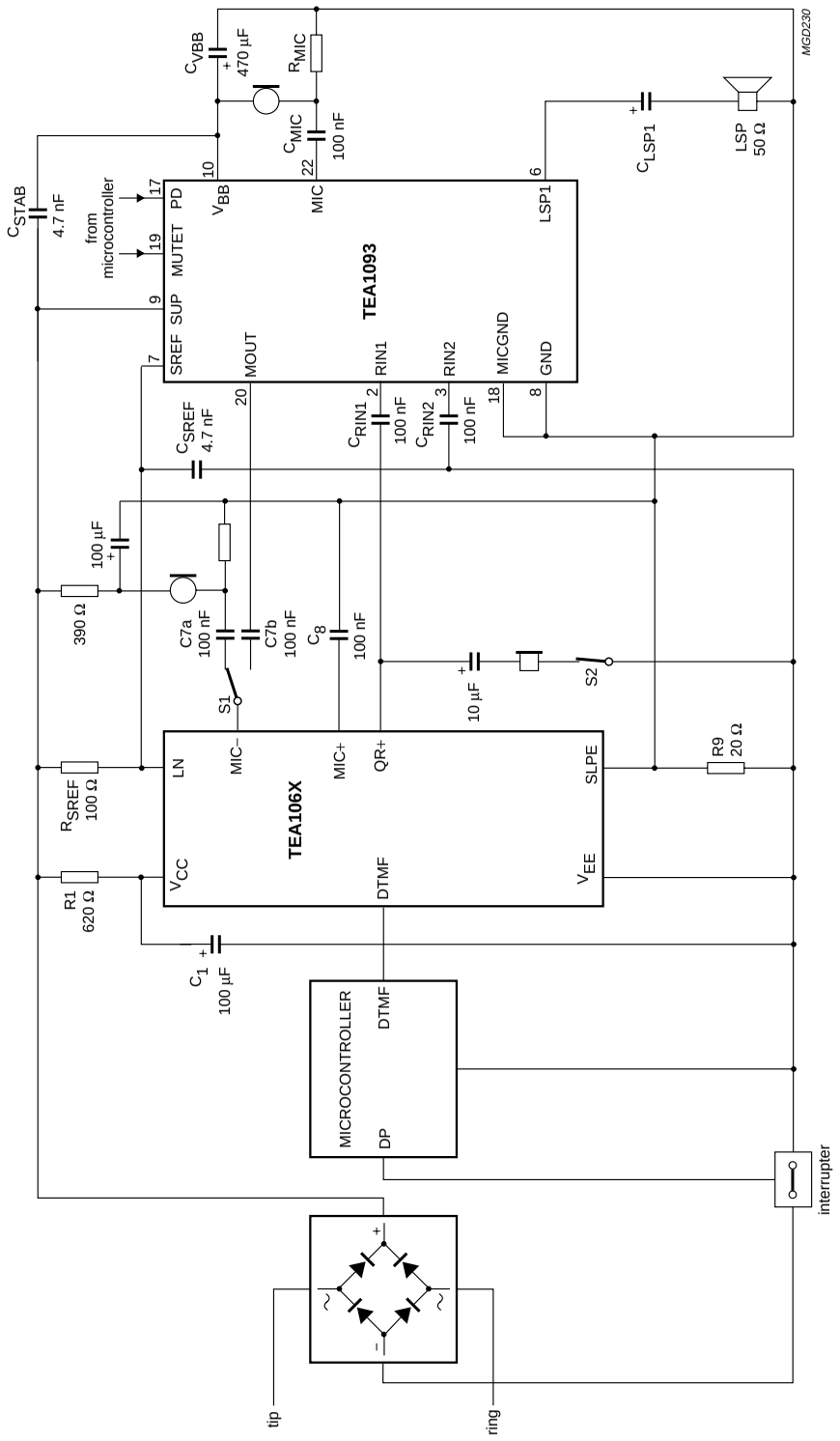
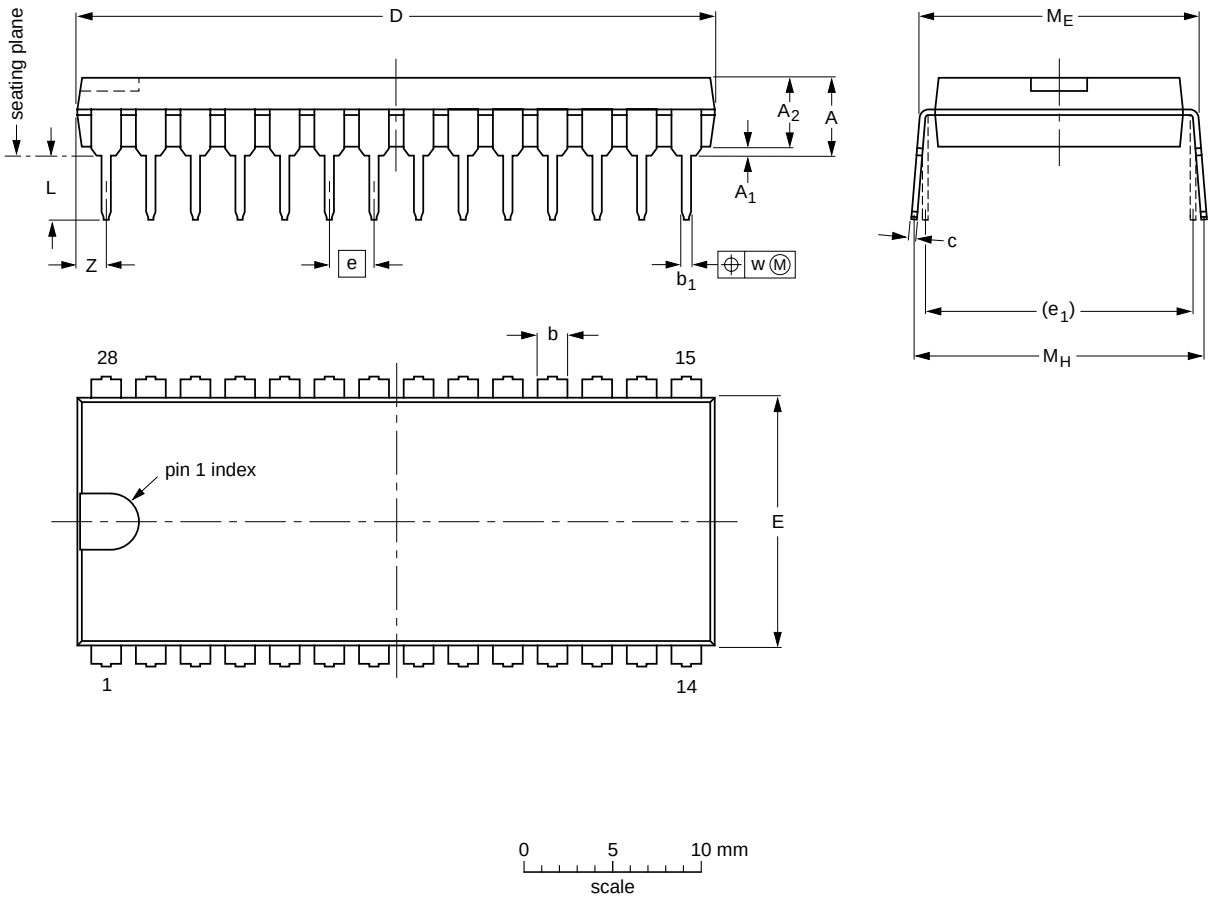


Fig.17 Application proposal.

PACKAGE OUTLINES

DIP28: plastic dual in-line package; 28 leads (600 mil) **SOT117-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

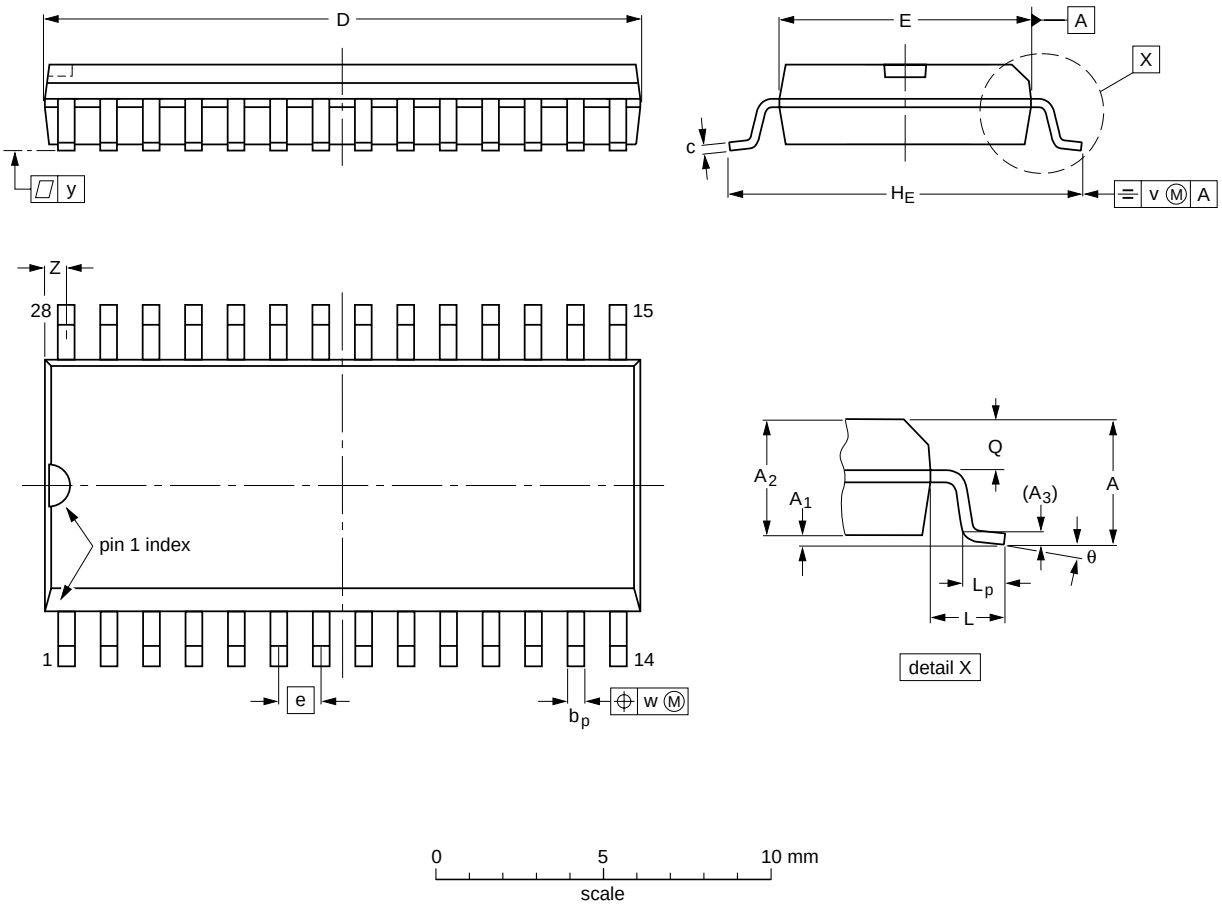
UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	5.1	0.51	4.0	1.7 1.3	0.53 0.38	0.32 0.23	36.0 35.0	14.1 13.7	2.54	15.24	3.9 3.4	15.80 15.24	17.15 15.90	0.25	1.7
inches	0.20	0.020	0.16	0.066 0.051	0.020 0.014	0.013 0.009	1.41 1.34	0.56 0.54	0.10	0.60	0.15 0.13	0.62 0.60	0.68 0.63	0.01	0.067

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT117-1	051G05	MO-015AH				~~92-11-17~~ 95-01-14

SO28: plastic small outline package; 28 leads; body width 7.5 mm **SOT136-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (1)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	18.1 17.7	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8^o 0^o
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.71 0.69	0.30 0.29	0.050	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT136-1	075E06	MS-013AE				~~95-01-24~~ 97-05-22

SOLDERING

Plastic dual in-line packages

BY DIP OR WAVE

The maximum permissible temperature of the solder is 260 °C; this temperature must not be in contact with the joint for more than 5 s. The total contact time of successive solder waves must not exceed 5 s.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified storage maximum. If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

REPAIRING SOLDERED JOINTS

Apply the soldering iron below the seating plane (or not more than 2 mm above it). If its temperature is below 300 °C, it must not be in contact for more than 10 s; if between 300 and 400 °C, for not more than 5 s.

Plastic small outline packages

BY WAVE

During placement and before soldering, the component must be fixed with a droplet of adhesive. After curing the adhesive, the component can be soldered. The adhesive can be applied by screen printing, pin transfer or syringe dispensing.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder bath is 10 s, if allowed to cool to less than 150 °C within 6 s. Typical dwell time is 4 s at 250 °C.

A modified wave soldering technique is recommended using two solder waves (dual-wave), in which a turbulent wave with high upward pressure is followed by a smooth laminar wave. Using a mildly-activated flux eliminates the need for removal of corrosive residues in most applications.

BY SOLDER PASTE REFLOW

Reflow soldering requires the solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the substrate by screen printing, stencilling or pressure-syringe dispensing before device placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt, infrared, and vapour-phase reflow. Dwell times vary between 50 and 300 s according to method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 min. at 45 °C.

REPAIRING SOLDERED JOINTS (BY HAND-HELD SOLDERING IRON OR PULSE-HEATED SOLDER TOOL)

Fix the component by first soldering two, diagonally opposite, end pins. Apply the heating tool to the flat part of the pin only. Contact time must be limited to 10 s at up to 300 °C. When using proper tools, all other pins can be soldered in one operation within 2 to 5 s at between 270 and 320 °C. (Pulse-heated soldering is not recommended for SO packages.)

For pulse-heated solder tool (resistance) soldering of VSO packages, solder is applied to the substrate by dipping or by an extra thick tin/lead plating before package placement.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

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