

# DATA SHEET

## **TDA5731M**

Low power VHF, UHF and  
hyperband mixer/oscillator for TV  
and VCR 3-band tuners

Product specification  
File under Integrated Circuits, IC02

1995 Mar 21

**Philips Semiconductors**



**PHILIPS**

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

## TDA5731M

### FEATURES

- Balanced mixer with a common emitter input for band A (single input)
- 2-pin oscillator for bands A and B
- 3-pin oscillator for band C
- Balanced mixer with a common base input for band B and C (balanced input)
- Local oscillator buffer output for external synthesizer
- SAW filter preamplifier with a low output impedance to drive the SAW filter directly
- Electronic band switch.

### APPLICATIONS

- 3-band TV tuners
- 3-band TV front-ends
- 3-band VCR tuners
- 3-band VCR front-ends.

### GENERAL DESCRIPTION

The TDA5731M is a monolithic integrated circuit that performs the band A, band B and band C mixer/oscillator functions in TV and VCR tuners. This low power mixer/oscillator circuit requires a power supply of 5 V and is available in a very small package outline. This device gives the designer the capability to design an economical and physically small 3-band tuner. The tuner development time can be drastically reduced by using this device.

In addition, when hyperband is not required, the TDA5731M may be used in a VHF/UHF tuner with an appropriate tuned circuit for VHF1 and VHF111 in band A and the tuned circuit of band C for UHF.

### QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$V_P$	supply voltage		–	5.0	–	V
$I_P$	supply current		–	36	–	mA
$f_R$	frequency range	band A	42	–	180	MHz
		band B	160	–	470	MHz
		band C	430	–	860	MHz
N	noise figure	band A	–	7.5	–	dB
		band B	–	8.0	–	dB
		band C	–	9.0	–	dB
IP	intermodulation	band A	–	–66	–	dB
		band B	–	–66	–	dB
		band C	–	–66	–	dB
$G_V$	voltage gain	band A	–	23	–	dB
		band B	–	34	–	dB
		band C	–	33	–	dB

### ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
TDA5731M	SSOP20	plastic shrink small outline package; 20 leads; body width 4.4 mm	SOT266-1

Low power VHF, UHF and hyperband  
 mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

BLOCK DIAGRAM

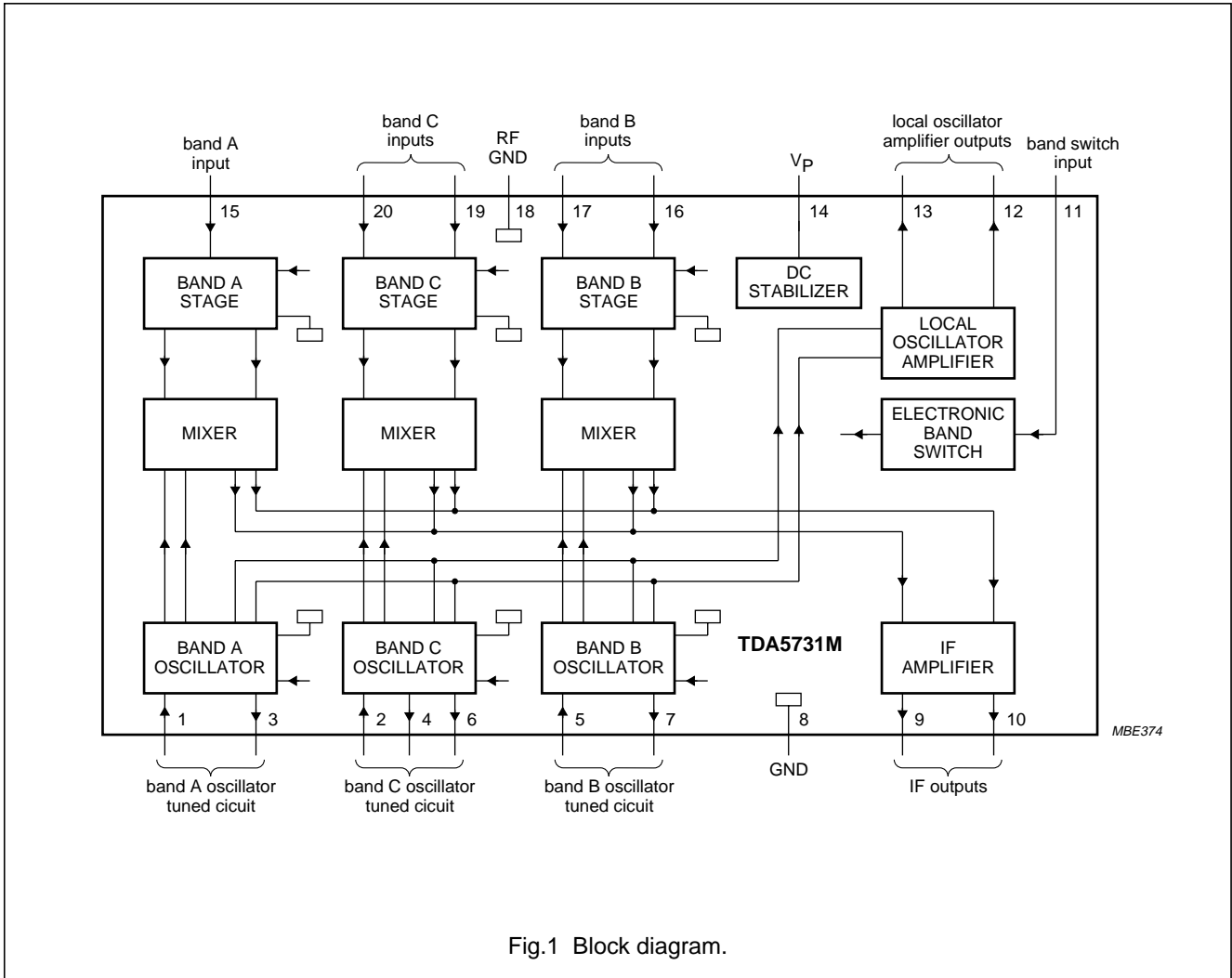


Fig.1 Block diagram.

Low power VHF, UHF and hyperband  
 mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

**PINNING**

SYMBOL	PIN	DESCRIPTION
AOSCIB	1	band A oscillator input base
COSCIB	2	band C oscillator input base
AOSCOC	3	band A oscillator output collector
COSCOC1	4	band C oscillator output collector 1
BOSCIB	5	band B oscillator input base
COSCOC2	6	band C oscillator output collector 2
BOSCOC	7	band B oscillator output collector
GND	8	ground (0 V)
IFOUT1	9	IF amplifier output 1
IFOUT2	10	IF amplifier output 2
BS	11	band switch input
LOOUT1	12	local oscillator amplifier output 1
LOOUT2	13	local oscillator amplifier output 2
V <sub>P</sub>	14	supply voltage
AIN	15	band A input
BIN1	16	band B input 1
BIN2	17	band B input 2
RFGND	18	ground for RF input
CIN1	19	band C input 1
CIN2	20	band C input 2

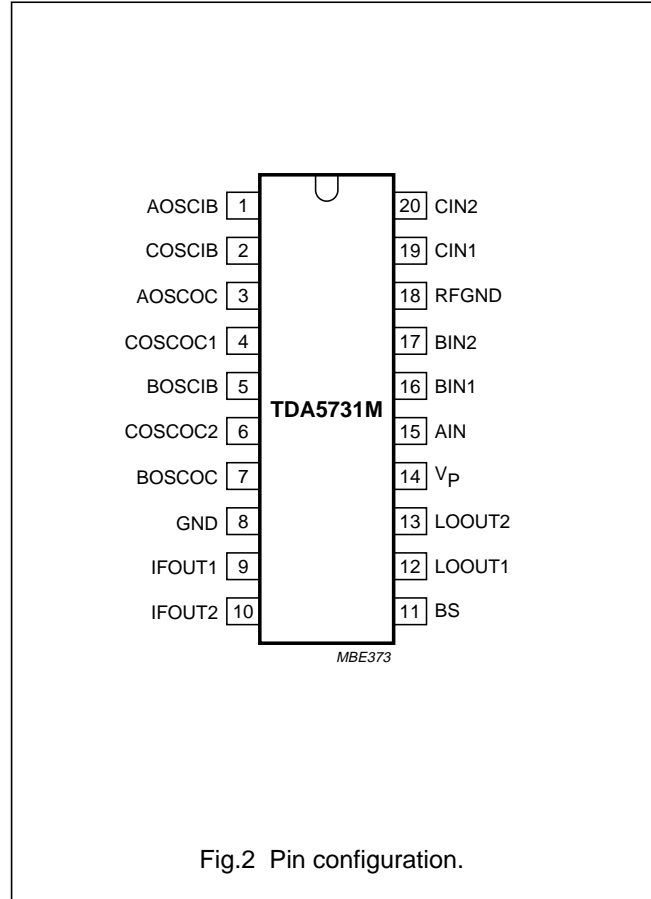


Fig.2 Pin configuration.

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

## LIMITING VALUES

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

SYMBOL	PARAMETER	MIN.	MAX/	UNIT
$V_P$	supply voltage	-0.3	+7.0	V
$V_{SW(max)}$	maximum switching voltage	-0.3	+7.5	V
$V_{P(op)}$	operating supply voltage	4.5	5.5	V
$V_{n(max)}$	maximum voltage on each pin with a 22 k $\Omega$ resistor connected in series	-	35	V
$I_O$	output current of each pin to ground	-	-10	mA
$t_{sc(max)}$	maximum short-circuit time (all pins)	-	10	s
$T_{stg}$	storage temperature	-55	+150	$^{\circ}C$
$T_{amb}$	operating ambient temperature	-10	+80	$^{\circ}C$
$T_j$	junction temperature	-	+150	$^{\circ}C$

## THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j-a}$	thermal resistance from junction to ambient in free air	120	K/W

## HANDLING

Human Body Model: GND (8), RFGND (18),  $V_P$  (14) shorted together. Pins 4, 6 and 7 withstand 500 V. All other pins withstand 2000 V.

Machine Model: GND (8), RFGND (18),  $V_P$  (14) shorted together. Pins 4, 6 and 7 withstand 50 V. All other pins withstand 200 V.

## IF AMPLIFIER CHARACTERISTICS

$V_P = 5\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}C$ ; differentially measured at 36 MHz; measured in circuit of Fig.6; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.		MAX.	UNIT
				MOD.	PHASE		
$S_{22}$	output reflection coefficient	note 1; see Fig.11	-	-14	+9	-	dB/ $^{\circ}$
$Z_o$	output impedance ( $R_s + L_s$ )	$R_s$	-	74		-	$\Omega$
		$L_s$	-	21		-	nH

### Note

- All S parameters are referenced to a 50  $\Omega$  system.

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

**CHARACTERISTICS**

$V_P = 5\text{ V}$ ;  $T_{\text{amb}} = 25\text{ °C}$ ; measured in circuit of Fig.6; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Supply (<math>T_{\text{amb}} = -10\text{ to }+80\text{ °C}</math>; <math>V_P = 4.5\text{ to }5.5\text{ V}</math>)</b>						
$V_P$	supply voltage		4.5	5.0	5.5	V
$I_P$	supply current		28	36	44	mA
$V_{\text{SW}}$	switching voltage (depending on supply voltage $V_P$ )	band A	0	–	$0.18V_P$	V
		band B	$0.26V_P$	–	$0.47V_P$	V
		band C	$0.55V_P$	–	$V_P$	V
$I_{\text{SW}}$	switching current	band A	–	–	2	$\mu\text{A}$
		band B	–	–	10	$\mu\text{A}$
		band C	–	–	25	$\mu\text{A}$
<b>Band A mixer (including IF amplifier)</b>						
$f_R$	frequency range		42	–	180	MHz
N	noise figure	$f_i = 50\text{ MHz}$ ; see Fig.3	–	7.5	9	dB
		$f_i = 180\text{ MHz}$ ; see Fig.3	–	9	10	dB
$g_{\text{os}}$	optimum source conductance for minimum noise figure	$f_i = 50\text{ MHz}$	–	0.5	–	mS
		$f_i = 180\text{ MHz}$	–	1.1	–	mS
$Y_I$	input admittance ( $G_P//C_P$ )	$f_i = 50\text{ MHz}$ ; see Fig.7	–	0.27	–	mS
		$f_i = 180\text{ MHz}$ ; see Fig.7	–	0.34	–	mS
		$f_i = 50\text{ to }180\text{ MHz}$ ; see Fig.7	–	1.9	–	pF
IP3	intermodulation using the 3 signals method	$f_N = 180\text{ MHz}$ ; note 1	–	–66	–60	dB
$V_i$	input voltage	10 kHz pulling in channel; $f_i = 180\text{ MHz}$	96	100	–	$\text{dB}\mu\text{V}$
$G_V$	voltage gain	$20\log(V_{9-10}/V_{15})$ ; $f_i = 50\text{ MHz}$ ; note 2	20.5	23	25.5	dB
		$20\log(V_{9-10}/V_{15})$ ; $f_i = 180\text{ MHz}$ ; note 2	20.5	23	25.5	dB
<b>Band A oscillator</b>						
$f_R$	frequency range	$T_{\text{amb}} = -10\text{ to }+80\text{ °C}$ ; $V_P = 4.5\text{ to }5.5\text{ V}$ ; $V_{\text{tune}} = 0.45\text{ to }28\text{ V}$	80	–	210	MHz
$f_{\text{shift}}$	frequency shift	$\Delta V_P = \pm 5\%$ ; note 3	–	–	200	kHz
$\chi_{\text{ripple(p-p)}}$	ripple susceptibility of supply voltage (peak-to-peak value)	$f_i = 80\text{ MHz}$ ; note 4	20	–	–	mV
$f_{\text{ripple(p-p)}}$	frequency ripple (peak-to-peak value)	from 20 Hz to 500 kHz; $f_i = 210\text{ MHz}$	20	–	–	mV
$f_{\text{drift}}$	frequency drift	without compensation: notes 5 and 6	–	–	600	kHz
		5 s to 15 min after switching on; without compensation: note 7	–	–	200	kHz

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Band B mixer (including IF amplifier); measurements using hybrid; note 8</b>						
$f_R$	frequency range		160	–	470	MHz
N	noise figure (not corrected for image)	$f_i = 170$ MHz	–	8.0	10	dB
		$f_i = 470$ MHz	–	8.0	10	dB
$Z_i$	input impedance ( $R_s + L_s$ )	$f_i = 160$ to 470 MHz; see Fig.8	–	23	–	$\Omega$
		$f_i = 160$ to 470 MHz; see Fig.8	–	10	–	nH
IP3	intermodulation using the 3 signal method	$f_N = 170$ MHz; note 1	–	–66	–60	dB
		$f_N = 470$ MHz; note 1	–	–66	–60	dB
$V_i$	input voltage	$f_i = 470$ MHz; 10 kHz pulling; in channel	83	87	–	dB $\mu$ V
		N + 5 – 1 MHz pulling; $f_i = 470$ MHz; note 9	–	62	–	dB $\mu$ V
$G_v$	voltage gain	$f_i = 170$ MHz; note 2	31	34	37	dB
		$f_i = 470$ MHz; note 2	31	34	37	dB
<b>Band B oscillator</b>						
$f_R$	frequency range	$T_{amb} = -10$ to $+80$ °C; $V_P = 4.5$ to $5.5$ V; $V_{tune} = 0.45$ to $28$ V	205	–	490	MHz
$f_{shift}$	frequency shift	$\Delta V_P = \pm 5\%$ ; note 3	–	–	400	kHz
$\chi_{ripple(p-p)}$	ripple susceptibility of supply voltage (peak-to-peak value)	$f_i = 205$ MHz; note 8	20	–	–	mV
$f_{ripple(p-p)}$	frequency ripple (peak-to-peak value)	from 20 Hz to 500 kHz; $f_i = 490$ MHz	10	–	–	mV
$f_{drift}$	frequency drift	without compensation; notes 5 and 6	–	–	2	MHz
		5 s to 15 min after switching on; without compensation; note 7	–	–	300	kHz
<b>Band C mixer (including IF amplifier); measurements using hybrid; note 8</b>						
$f_R$	frequency range		430	–	860	MHz
N	noise figure (not corrected for image)	$f_i = 430$ MHz	–	9	11	dB
		$f_i = 860$ MHz	–	9	11	dB
$Z_i$	input impedance ( $R_s + L_s$ )	$f_i = 430$ MHz; see Fig.9	–	34	–	$\Omega$
		$f_i = 860$ MHz; see Fig.9	–	45	–	$\Omega$
		$f_i = 430$ to 860 MHz; see Fig.9	–	9	–	nH
IP3	intermodulation using the 3 signal method	$f_N = 430$ MHz; note 1	–	–66	–60	dB
		$f_N = 860$ MHz; note 1	–	–66	–60	dB
$V_i$	input voltage	10 kHz pulling in channel; $f_i = 860$ MHz; note 2	83	87	–	dB $\mu$ V
		N + 5 – 1 MHz pulling; $f_i = 860$ MHz; note 9	–	61	–	dB $\mu$ V
$G_v$	voltage gain	$f_i = 430$ MHz; note 2	30	33	36	dB
		$f_i = 860$ MHz; note 2	30	33	36	dB

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Band C oscillator</b>						
$f_R$	frequency range	$T_{amb} = -10$ to $+80$ °C; $V_P = 4.5$ to $5.5$ V; $V_{tune} = 0.45$ to $28$ V	485	–	900	MHz
$f_{shift}$	frequency shift	$\Delta V_P = \pm 5\%$ ; note 3	–	–	400	kHz
$\chi_{ripple(p-p)}$	ripple susceptibility of supply voltage (peak-to-peak value)	$f_i = 485$ MHz; note 4	20	–	–	mV
$f_{ripple(p-p)}$	frequency ripple (peak-to-peak value)	from 20 Hz to 500 kHz; $f_i = 900$ MHz	10	–	–	mV
$f_{drift}$	frequency drift	without compensation; notes 5 and 6	–	–	2.5	MHz
		5 s to 15 min after switching on; without compensation; note 7	–	–	600	kHz
<b>LO output</b>						
$Y_O$	output admittance ( $G_P//C_P$ )	$f_i = 80$ MHz; see Fig.10	–	2.4	–	mS
		$f_i = 80$ MHz; see Fig.10	–	0.9	–	pF
		$f_i = 900$ MHz; see Fig.10	–	4.6	–	mS
		$f_i = 900$ MHz; see Fig.10	–	0.9	–	pF
$V_o$	output voltage	$R_L = 50$ $\Omega$ ; $T_{amb} = -10$ to $+80$ °C; $V_P = 4.5$ to $5.5$ V;	80	91	100	dB $\mu$ V
SRF	spurious signal on LO output with respect to LO output signal	$R_L = 50$ $\Omega$ ; $T_{amb} = -10$ to $+80$ °C; $V_P = 4.5$ to $5.5$ V; note 10	–	–	–10	dB
HLO	LO signal harmonics with respect to LO signal	$R_L = 50$ $\Omega$ ; $T_{amb} = -10$ to $+80$ °C; $V_P = 4.5$ to $5.5$ V;	–	–	–10	dB

**Notes**

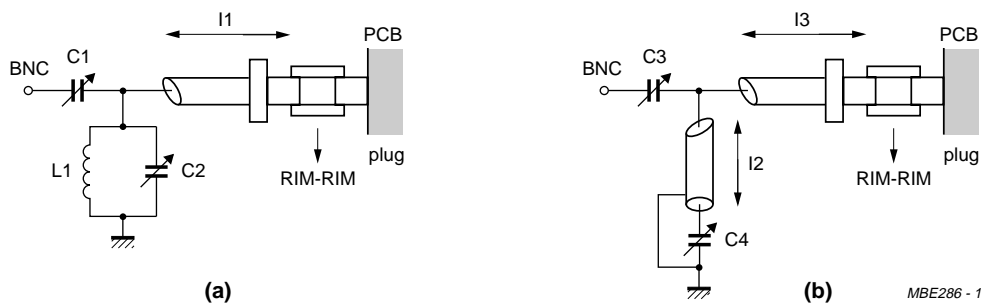
- Cross modulation measurement is achieved using the 3 equal signals method (see Fig.4).
- The gain is defined as the transducer gain (measured in Fig.8) plus the voltage transformation ratio of L7 to L8 (5 : 1, 15.4 dB).
- The frequency shift is defined as a change in oscillator frequency for a variation of supply voltage. In one instance  $V_P = 5$  to  $4.75$  V and in the other instance  $V_P = 5$  to  $5.25$  V. In both cases, the frequency shift is below the specified value.
- The frequency ripple susceptibility is measured at 500 kHz at the LO output (see Fig.5). The level of the ripple signal is increased until a difference of 53.5 dB is reached at the IF output.
- The frequency drift is defined as the change in oscillator frequency for a variation of ambient temperature, on the one hand from  $T_{amb} = 25$  °C to  $T_{amb} = 0$  °C and on the other hand from  $T_{amb} = 25$  °C to  $T_{amb} = 50$  °C.
- The capacitors in the oscillator circuits of Fig.8 are as follows:
  - Band A: C1, C5 and C7.
  - Band B: C4 and C9 and C11.
  - Band C: C2, C3, C6, C8 and C10 are NP0 types.
- Switching on drift is the change in oscillator frequency between 5 seconds and 15 minutes after switching on.
- The values have been corrected for hybrid and cable losses. The symmetrical output impedance of the circuit is 100  $\Omega$ .



## Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

### TDA5731M

9. The input level of a  $N + 5 - 1$  MHz signal which gives a signal 30 dB below the oscillator carrier at the LO output.
10. Measured at  $50 \Omega$  with the following RF input voltages;
- RF voltage level =  $120 \text{ dB}\mu\text{V}$  at  $f_i < 180 \text{ MHz}$ .
  - RF voltage level =  $107.5 \text{ dB}\mu\text{V}$  at  $f_i = 180 \text{ to } 225 \text{ MHz}$ .
  - RF voltage level =  $97 \text{ dB}\mu\text{V}$  at  $f_i = 225 \text{ to } 860 \text{ MHz}$ .



**(a) For  $f_R = 50 \text{ MHz}$ :**

mixer A frequency response measured = 57 MHz, loss = 0 dB  
 image suppression = 16 dB  
 $C1 = 9 \text{ pF}$   
 $C2 = 15 \text{ pF}$   
 $L1 = 7 \text{ turns } (\Delta 5.5 \text{ mm, wire dia.} = 0.5 \text{ mm})$   
 $I1 = \text{rigid cable (RIM): } 5 \text{ cm long}$   
 (rigid cable (RIM); 33 dB/100 m;  $50 \Omega$ , 96 pF/m).

**(b) For  $f_R = 180 \text{ MHz}$ :**

mixer A frequency response measured = 150.3 MHz, loss = 1.3 dB  
 image suppression = 13 dB  
 $C3 = 5 \text{ pF}$   
 $C4 = 25 \text{ pF}$   
 $I2 = \text{rigid cable (RIM): } 30 \text{ cm long}$   
 $I3 = \text{rigid cable (RIM): } 5 \text{ cm long}$   
 (rigid cable (RIM); 33 dB/100 m;  $50 \Omega$ ; 96 pF/m).

Fig.3 Input circuit for optimum noise figure.

Low power VHF, UHF and hyperband  
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TDA5731M

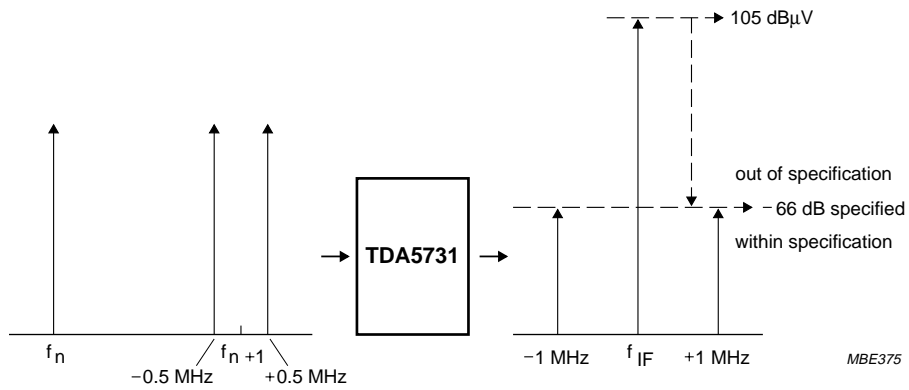


Fig.4 Cross modulation/incidental FM measurement.

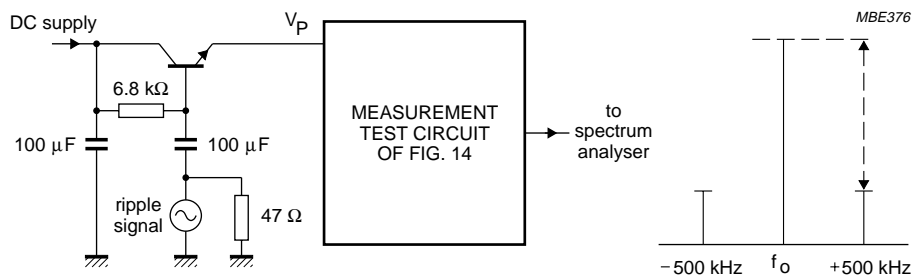
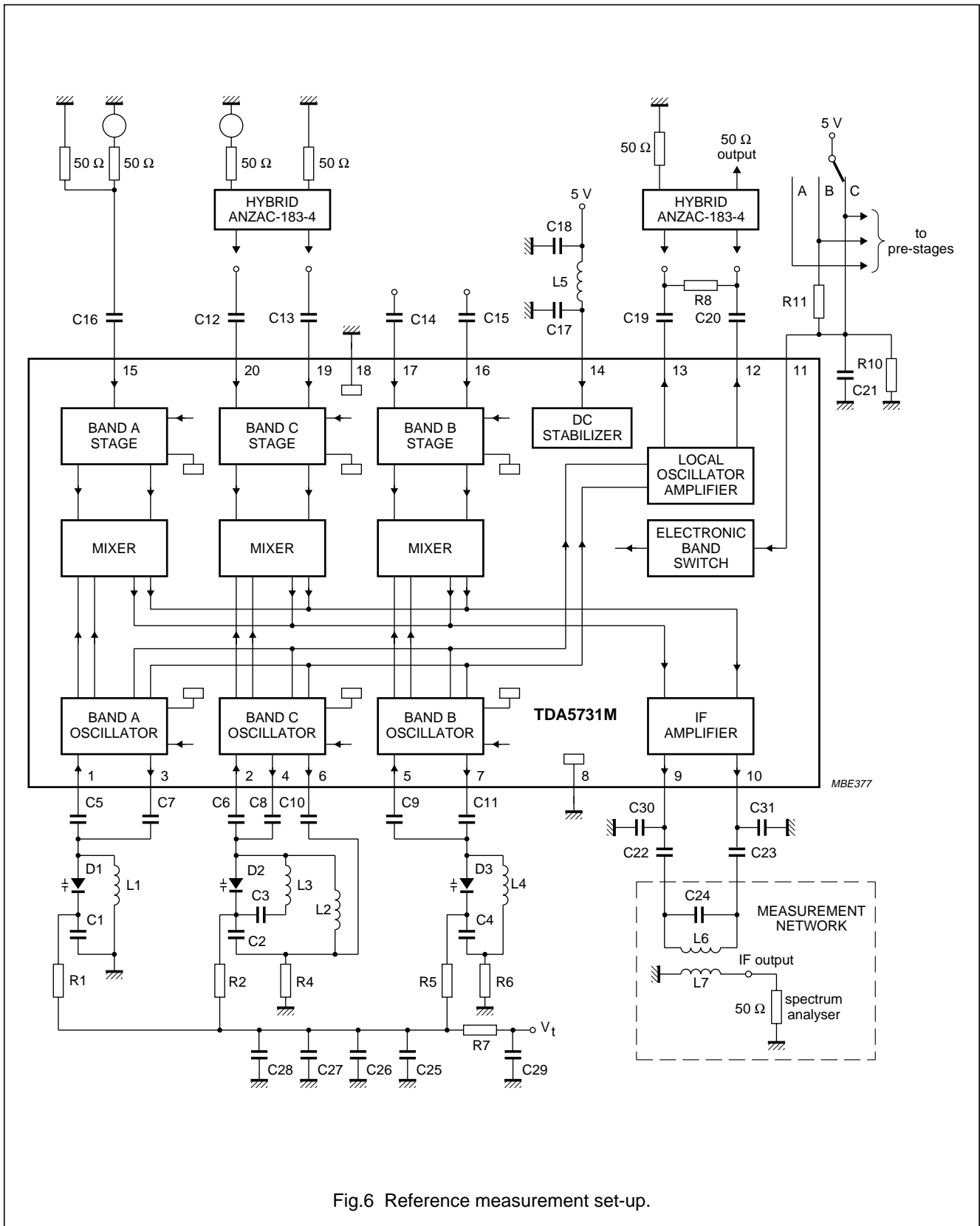


Fig.5 Ripple susceptibility measurement.

# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

## TDA5731M



# Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

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## Components values for Fig.8

**Table 1** Capacitors  
(all SMD and NP0 except C28)

NUMBER	VALUE
C1	82 pF
C2	5.6 pF
C3	100 pF
C4	100 pF
C5	2.2 pF
C6	1 pF
C7	2.2 pF
C8	1 pF
C9	2.2 pF
C10	2.2 pF
C11	2.7 pF
C12	1 nF
C13	1 nF
C14	1 nF
C15	1 nF
C16	1 nF
C17	10 nF
C18	10 nF
C19	1 nF
C20	1 nF
C21	1 nF
C22	1 nF
C23	1 nF
C24	18 pF
C25	1 nF
C26	1 nF
C27	1 nF
C28	150 nF
C29	1 nF
C30	3 pF
C31	3 pF

**Table 2** Resistors (all SMD)

NUMBER	VALUE
R1	47 kΩ
R2	24 kΩ
R4	24 kΩ
R5	47 kΩ
R6	15 Ω
R7	10 kΩ
R8	100 Ω
R10	15 kΩ
R11	27 kΩ

**Table 3** Diodes and coils

NUMBER	VALUE
<b>Diodes</b>	
D1	BB132
D2	BB134
D3	BB133
<b>Coils<sup>(1)</sup></b>	
L1	7.5 turns (3 mm)
L2	2.5 turns (3.5 mm)
L3	1.5 turns (2.5 mm)
L4	1.5 turns (4 mm)
L5	2.2 μH (choke coil)

### Note

1. Wire size for L1 to L4 is 0.4 mm

### Transformers (L6 = 2 × 5 turns and L7 = 2 turns)

Coil type: TOKO 7kN; material: 113kN, screw core (03-0093), pot core (04-0026).

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TDA5731M

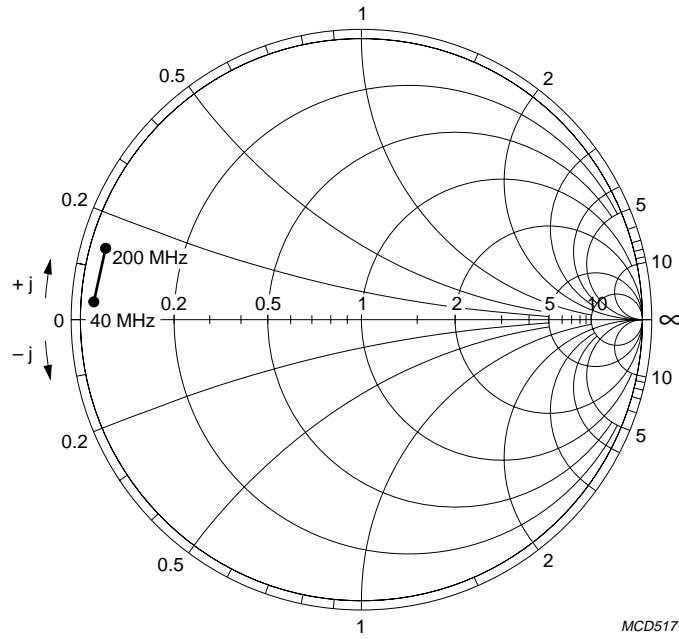


Fig.7 Input admittance ( $S_{11}$ ) of the band A mixer input (40 to 200 MHz) (Y chart).

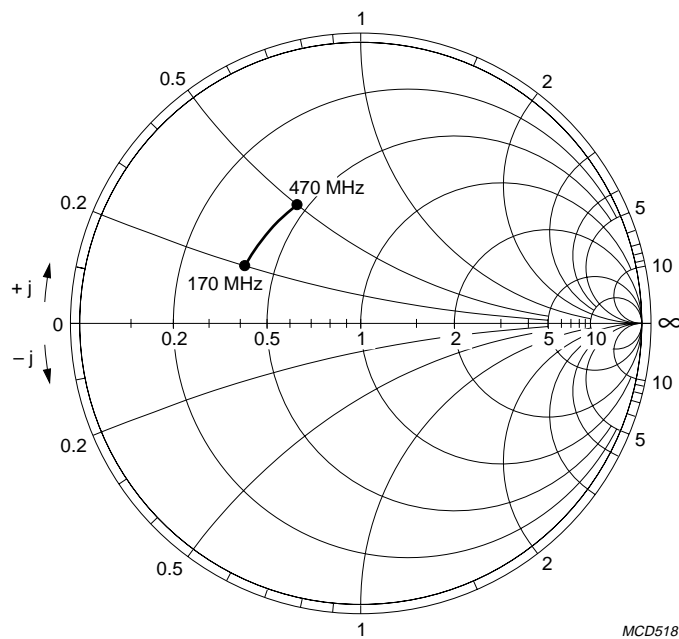


Fig.8 Input impedance ( $S_{11}$ ) of the band B mixer input (170 to 470 MHz) (Z chart).

Low power VHF, UHF and hyperband  
 mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

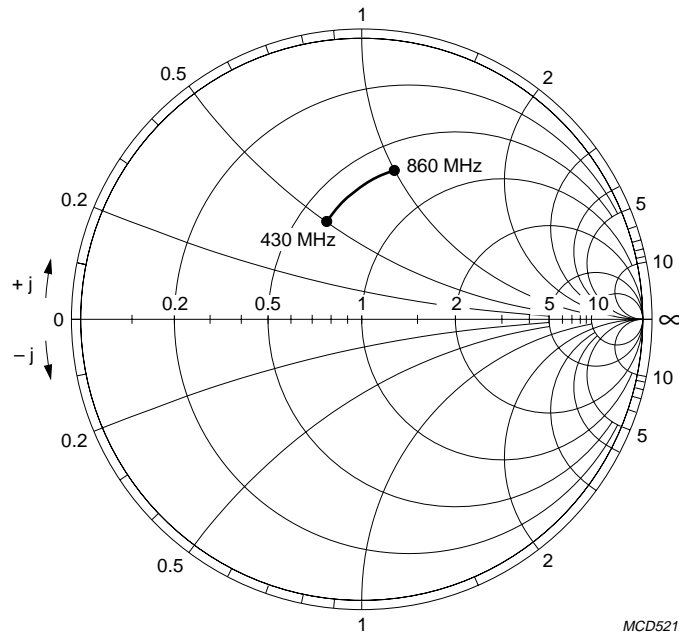


Fig.9 Input impedance ( $S_{11}$ ) of the band C mixer input (460 to 880 MHz) (Z chart).

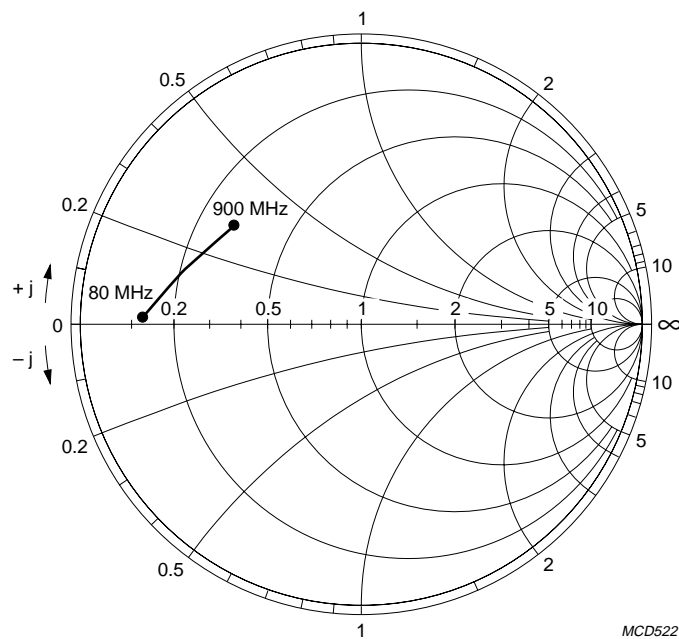


Fig.10 Output admittance ( $S_{22}$ ) of the IF amplifier (80 to 900 MHz) (Y chart).

Low power VHF, UHF and hyperband  
mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

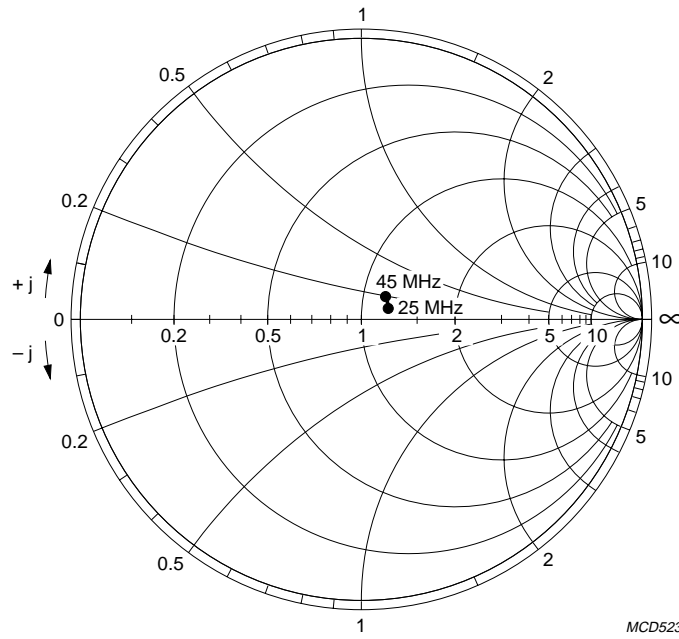


Fig.11 Output reflection coefficient ( $S_{22}$ ) of the LO amplifier (25 to 45 MHz) (Z chart).

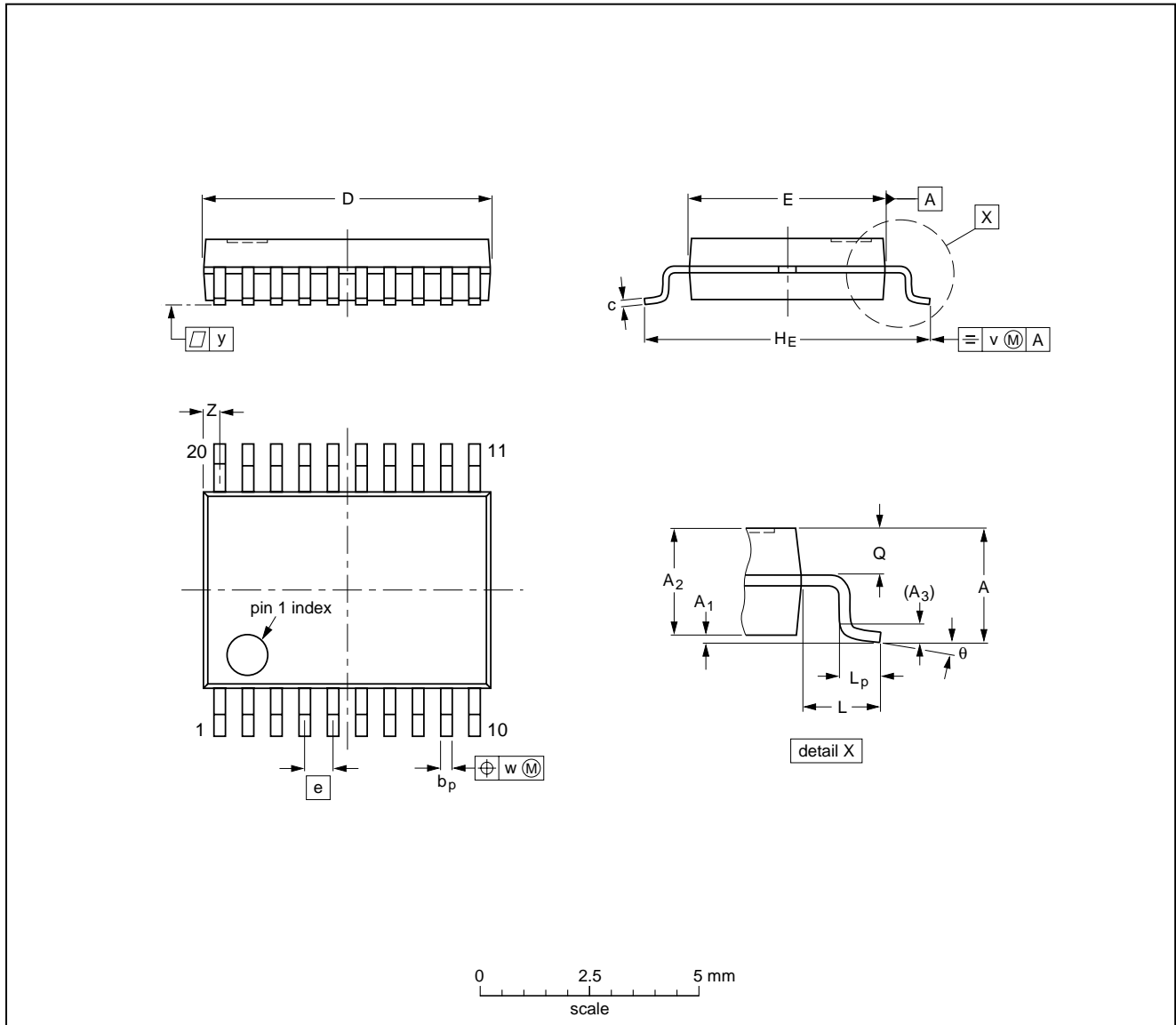
Low power VHF, UHF and hyperband  
mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

PACKAGE OUTLINE

SSOP20: plastic shrink small outline package; 20 leads; body width 4.4 mm

SOT266-1



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.5	0.15 0	1.4 1.2	0.25	0.32 0.20	0.20 0.13	6.6 6.4	4.5 4.3	0.65	6.6 6.2	1.0	0.75 0.45	0.65 0.45	0.2	0.13	0.1	0.48 0.18	10° 0°

Note

1. Plastic or metal protrusions of 0.20 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT266-1						90-04-05 95-02-25



## Low power VHF, UHF and hyperband mixer/oscillator for TV and VCR 3-band tuners

TDA5731M

### SOLDERING

#### 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.	

### LIFE SUPPORT APPLICATIONS

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