

## VHF I / VHF II / UHF-Tuner IC

**TUA 2009X**  
**TUA 2009XS**

### Preliminary Data

**Bipolar IC**

#### Features

- Few external components
- Frequency and amplitude-stable unbalanced oscillator for the VHF I-frequency range
- Frequency and amplitude-stable balanced oscillators for the VHF II- and UHF-frequency range
- Optimum decoupling of input frequency from oscillator
- Double balanced mixer with wide dynamic range and high-impedance inputs for the VHF I-frequency range
- Double balanced mixer with wide dynamic range and low-impedance inputs for the VHF II- and UHF-frequency range
- Low-impedance SAW-filter driver output
- SAW-filter driver with high signal-handling capability
- Internal band switch
- Low-noise, internal reference voltage
- Integrated 1st IF-bandpass filter



**P-DSO-24-1**



**P-SSOP-24-1**

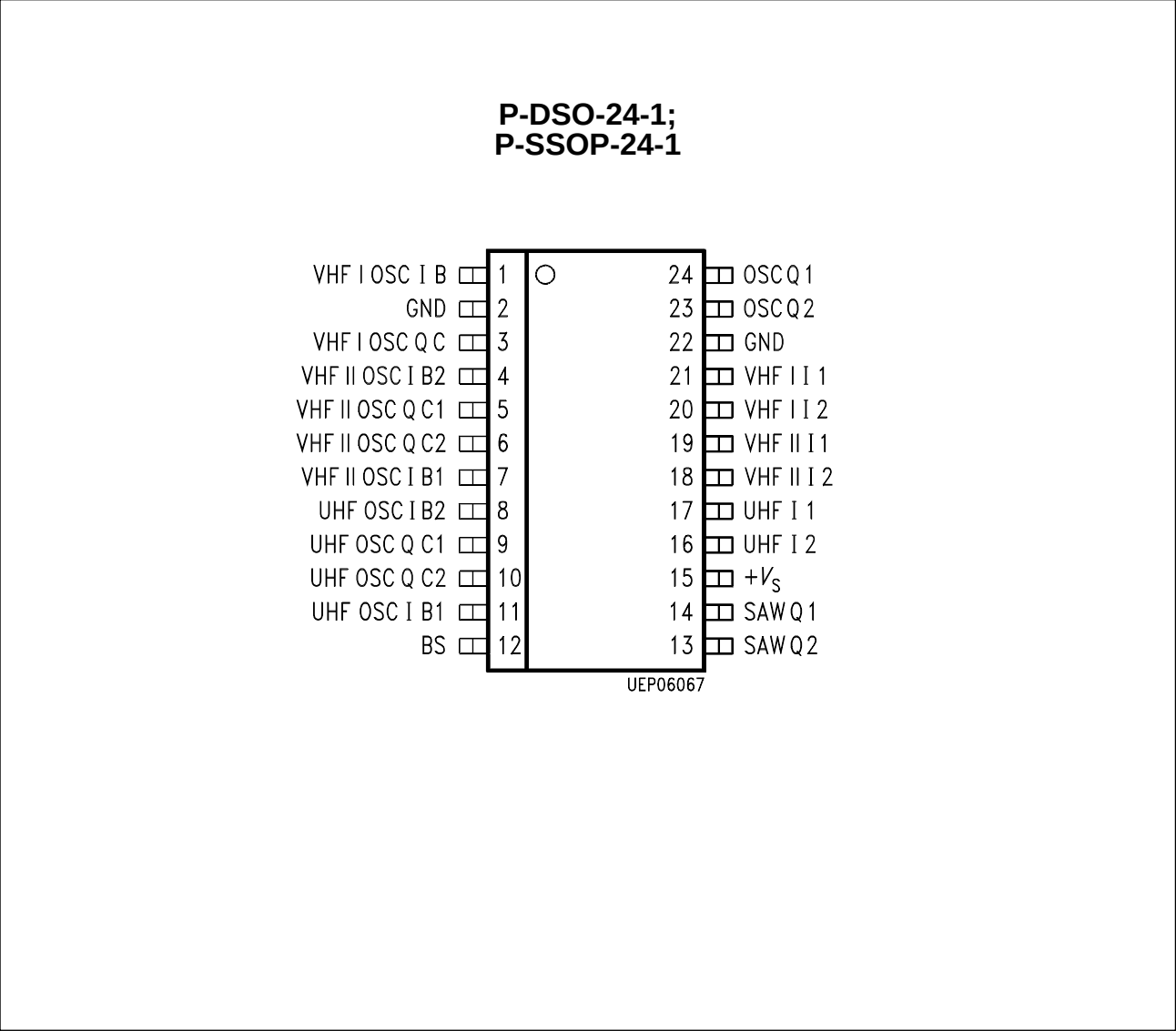
| Type       | Ordering Code | Package                 |
|------------|---------------|-------------------------|
| TUA 2009X  | Q67000-A5113  | P-DSO-24-1 (SMD)        |
| TUA 2009X  | Q67006-A5113  | P-DSO-24-1 Tape & Reel  |
| TUA 2009XS | Q67006-A5202  | P-SSOP-24-1 Tape & Reel |

#### Circuit Description

This integrated circuit permits the design of TV-tuners covering the entire frequency range from 48 ... 900 MHz split into 3 frequency bands. The application is suitable for all tuners in TV- and VCR-sets.

The integrated circuit includes 3 balanced mixers (double balanced mixer/ring mixer), one unbalanced oscillator for VHF I and two balanced oscillators for VHF II and UHF, a SAW-filter driver amplifier as well as a reference voltage source and a band switch. Filters between tuner input and IC separate the TV-frequency signal into three bands. The band switch ensures that only one band at a time is activated. In the activated band the signal passes a frontend stage with MOSFET-amplifier, a double-tuned bandpass filter and is then fed to the balanced mixer input of the IC which is a high-impedance stage for the VHF I-range and a low-impedance stage for the VHF II- and UHF-range, respectively. The input signal is mixed there with the oscillator signal from the activated oscillator section and fed into common IF-stage for all bands. The IF-signal is further amplified in a SAW-filter driver section in order to drive the SAW-filter with a low impedance.

Pin Configuration  
(top view)

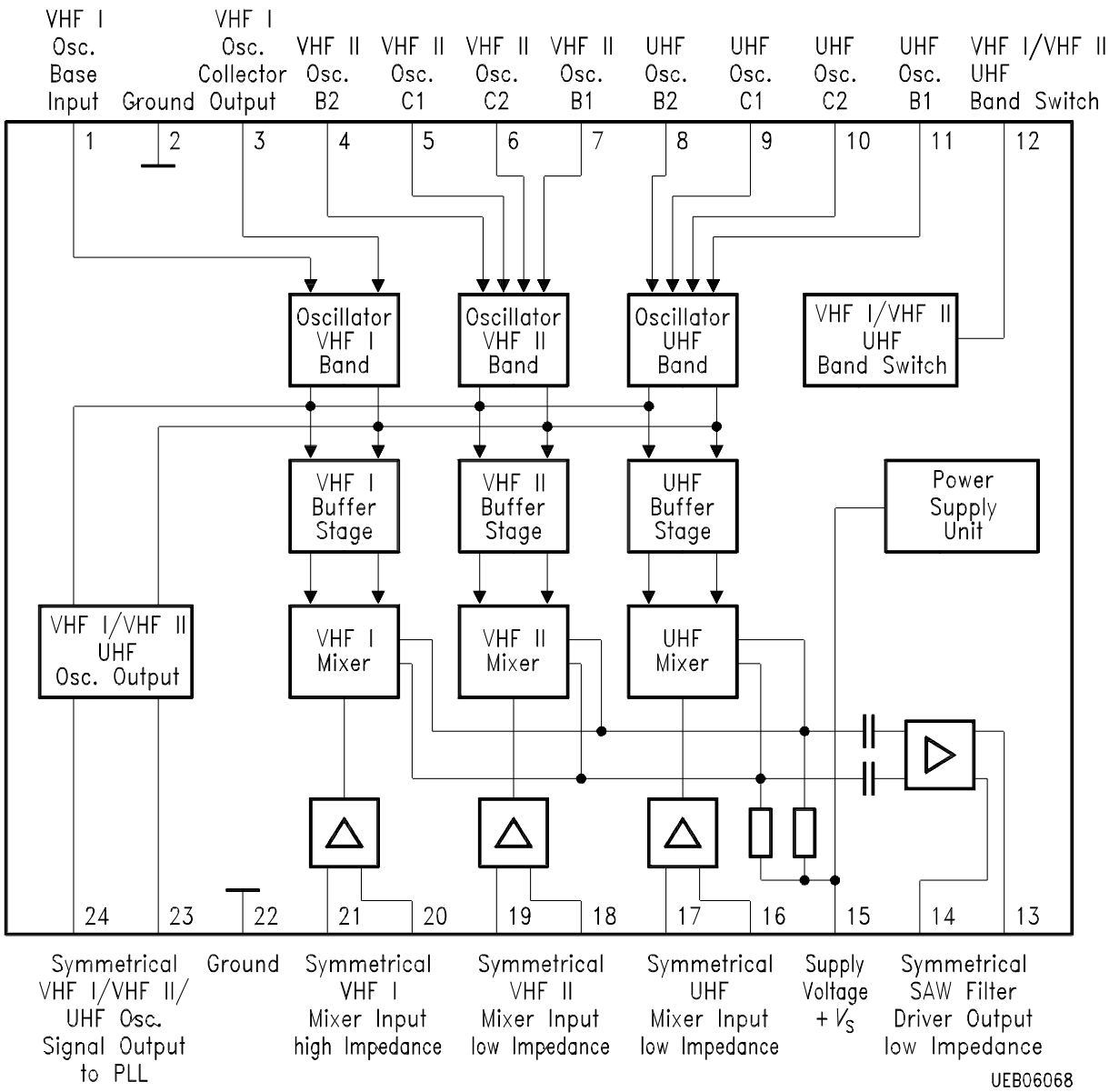


**Pin Definitions and Functions**

| Pin No. | Symbol                    | Function                                                                        |
|---------|---------------------------|---------------------------------------------------------------------------------|
| 1       | VHF I-osc.<br>coupling 2  | VHF I-osc. coupling, base input                                                 |
| 2       | GND                       | Ground                                                                          |
| 3       | VHF I-osc.<br>coupling 1  | VHF I-osc. coupling, collector output                                           |
| 4       | VHF II-osc.<br>input B2   | VHF II-osc. amplifier, high-impedance base input,<br>symmetrical to pin 7       |
| 5       | VHF II-osc.<br>output C1  | VHF II-osc. amplifier, high-impedance collector output,<br>symmetrical to pin 6 |
| 6       | VHF II-osc.<br>output C2  | VHF II-osc. amplifier, high-impedance collector output,<br>symmetrical to pin 5 |
| 7       | VHF II-osc.<br>input B1   | VHF II-osc. amplifier, high-impedance base input,<br>symmetrical to pin 4       |
| 8       | UHF-osc.<br>input B2      | UHF-osc. amplifier, high-impedance base input,<br>symmetrical to pin 11         |
| 9       | UHF-osc.<br>output C1     | UHF-osc. amplifier, high-impedance coll. output,<br>symmetrical to pin 10       |
| 10      | UHF-osc.<br>output C2     | UHF-osc. amplifier, high-impedance coll. output,<br>symmetrical to pin 9        |
| 11      | UHF-osc.<br>input B1      | UHF-osc. amplifier, high-impedance base input,<br>symmetrical to pin 8          |
| 12      | Band switch               | VHF I - / VHF II - / UHF-band switch                                            |
| 13      | SAW-filter driv.<br>out 2 | SAW-filter driver output, low-impedance,<br>symmetrical to pin 14               |
| 14      | SAW-filter driv.<br>out 1 | SAW-filter driver output, low-impedance,<br>symmetrical to pin 13               |
| 15      | + $V_s$                   | Supply voltage                                                                  |
| 16      | UHF-input 2               | UHF-mixer input low-impedance, symmetrical to pin 17                            |

**Pin Definitions and Functions (cont'd)**

| <b>Pin No.</b> | <b>Symbol</b>  | <b>Function</b>                                                              |
|----------------|----------------|------------------------------------------------------------------------------|
| 17             | UHF-input 1    | UHF-mixer input low-impedance, symmetrical to pin 16                         |
| 18             | VHF II-input 2 | VHF II-mixer input low-impedance, symmetrical to pin 19                      |
| 19             | VHF II-input 1 | VHF II-mixer input low-impedance, symmetrical to pin 18                      |
| 20             | VHF I-input 2  | VHF I-mixer input high-impedance, symmetrical to pin 21                      |
| 21             | VHF I-input 1  | VHF I-mixer input high-impedance, symmetrical to pin 20                      |
| 22             | GND            | Ground                                                                       |
| 23             | Osc. output 2  | VHF I - / VHF II - /UHF-osc. signal output to PLL,<br>symmetrical to pin 24  |
| 24             | Osc. output 1  | VHF I - / VHF II - / UHF-osc. signal output to PLL,<br>symmetrical to pin 23 |



Block Diagram

## Absolute Maximum Ratings

$T_A = 0$  to  $70\text{ }^{\circ}\text{C}$

| Parameter            | Symbol         | Limit Values |         | Unit |
|----------------------|----------------|--------------|---------|------|
|                      |                | min.         | max.    |      |
| Supply voltage $V_S$ | $V_{15/2, 23}$ | – 0.3        | 14      | V    |
| Current              | $I_{15}$       |              | 60      | mA   |
| Switching voltage    | $V_{12}$       | – 0.3        | + $V_S$ | V    |

According to application circuit 1, only the provided circuitry can be connected to pins 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 23, 24

|                                                            |                                          |      |          |                    |
|------------------------------------------------------------|------------------------------------------|------|----------|--------------------|
| Junction temperature                                       | $T_j$                                    |      | 150      | $^{\circ}\text{C}$ |
| Storage temperature                                        | $T_{\text{stg}}$                         | – 40 | 125      | $^{\circ}\text{C}$ |
| Thermal resistance P-DSO-24-1<br>P-SSOP-24-1 <sup>1)</sup> | $R_{\text{th SA}}$<br>$R_{\text{th SA}}$ |      | 75<br>83 | K/W<br>K/W         |

## Operating Range

|                                    |                      |    |      |                    |
|------------------------------------|----------------------|----|------|--------------------|
| Supply voltage                     | $V_S$                | 10 | 13.2 | V                  |
| Supply current                     | $I_{15}$             | 23 | 53   | mA                 |
| VHF I-mixer input frequency range  | $f_{\text{VHF I}}$   | 30 | 500  | MHz                |
| VHF II-mixer input frequency range | $f_{\text{VHF II}}$  | 30 | 900  | MHz                |
| UHF-mixer input frequency range    | $f_{\text{UHF}}$     | 30 | 900  | MHz                |
| VHF I-oscillator frequency range   | $f_{\text{OVHF I}}$  | 30 | 500  | MHz                |
| VHF II-oscillator frequency range  | $f_{\text{OVHF II}}$ | 30 | 900  | MHz                |
| UHF-oscillator frequency range     | $f_{\text{OUHF}}$    | 30 | 900  | MHz                |
| Ambient temperature                | $T_A$                | 0  | 70   | $^{\circ}\text{C}$ |

1) Tested with an application oriented IC substitute inside the tuner box

**Characteristics**
 $T_A = 25\text{ °C}; V_S = 12\text{ V}$ 

| Parameter           | Symbol   | Limit Values |      |      | Unit | Test Condition          | Test Circuit |
|---------------------|----------|--------------|------|------|------|-------------------------|--------------|
|                     |          | min.         | typ. | max. |      |                         |              |
| Current consumption | $I_{15}$ | 30           | 38   | 45   | mA   | $V_{12} > 1.6\text{ V}$ | 1            |
| Current consumption | $I_{15}$ | 27           | 34   | 41   | mA   | $V_{12} < 0.9\text{ V}$ | 1            |

**VHF I-Circuit Section**

|                                        |                           |     |     |     |       |                                                        |   |
|----------------------------------------|---------------------------|-----|-----|-----|-------|--------------------------------------------------------|---|
| Switching voltage                      | $V_{12}$                  | 0   |     | 1   | V     |                                                        | 1 |
| Switching current                      | $I_{12}$                  |     |     | 10  | μA    | $V_{12} = 0.5\text{ V}$                                | 1 |
| Oscillator frequency range             | $f_{\text{VHF I}}$        | 80  |     | 216 | MHz   | $V_d = 0 \dots 28\text{ V}$                            | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF I}}$ |     |     | 200 | kHz   | $V_S = 12\text{ V} \pm 10\%$                           | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF I}}$ |     |     | 400 | kHz   | $\Delta T = 25\text{ °C}$                              | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF I}}$ |     |     | 200 | kHz   | $t = 5\text{ s}$ up to 15 min. after switching on      | 1 |
| Oscillator level                       | $V_K$                     |     | 700 |     | mVrms | channel E2, at hot end                                 | 1 |
| Oscillator level                       | $V_K$                     |     | 700 |     | mVrms | channel S10, at hot end                                | 1 |
| Oscillator level                       | $a_{\text{PLL}}$          |     | -20 |     | dBm   | channel E2                                             | 1 |
| Oscillator level                       | $a_{\text{PLL}}$          |     | -20 |     | dBm   | channel S10                                            | 1 |
| Oscillator output impedance            | $R_{23, 24}$              |     | 100 |     | Ω     | parallel equivalent circuit                            | 3 |
|                                        | $C_{23, 24}$              |     | 2   |     | pF    | parallel equivalent circuit                            | 3 |
| Harmonic wave ratio interference level | $a_{23, 24}$              |     |     | -10 | dB    | $V_{\text{HF}} = 1\text{ Vrms}$                        | 1 |
| Oscillator pulling                     | $V_{20, 21}$              | 100 | 108 |     | dB/μV | $\Delta f = 10\text{ kHz}$ in channel E2               | 1 |
| Oscillator pulling                     | $V_{20, 21}$              | 100 | 108 |     | dB/μV | $\Delta f = 10\text{ kHz}$ in channel S10              | 1 |
| Oscillator pulling                     | $V_{20, 21}$              | 80  | 88  |     | dB/μV | $\Delta f_{\text{int}} = E2 + (N + 5 - 1\text{ MHz})$  | 1 |
| Oscillator pulling                     | $V_{20, 21}$              | 80  | 88  |     | dB/μV | $\Delta f_{\text{int}} = S10 + (N + 5 - 1\text{ MHz})$ | 1 |
| Gain                                   | $G_{\text{VHF I}}$        |     | 27  |     | dB    | channel E2<br>pin 20, 21 > 13, 14                      | 1 |
| Gain                                   | $G_{\text{VHF I}}$        |     | 27  |     | dB    | channel S10<br>pin 20, 21 > 13, 14                     | 1 |
| Mixer noise figure                     | $NF_{\text{VHF I}}$       |     | 7.5 | 9   | dB    | channel E2 (DSB)                                       | 2 |
| Mixer noise figure                     | $NF_{\text{VHF I}}$       |     | 7.5 | 9   | dB    | channel S10 (DSB)                                      | 2 |
| Interference voltage                   | $V_{\text{int}}$          |     | 70  |     | dB/μV | 1 % cross mod; E2 ± 2                                  | 1 |
| Interference voltage                   | $V_{\text{int}}$          |     | 70  |     | dB/μV | 1 % cross mod; S10 ± 2                                 | 1 |

**Characteristics (cont'd)**
 $T_A = 25\text{ °C}; V_S = 12\text{ V}$ 

| Parameter             | Symbol          | Limit Values |      |      | Unit       | Test Condition              | Test Circuit |
|-----------------------|-----------------|--------------|------|------|------------|-----------------------------|--------------|
|                       |                 | min.         | typ. | max. |            |                             |              |
| Mixer input impedance | $R_{20, 21}$    |              | 3    |      | k $\Omega$ | parallel equivalent circuit | 3            |
|                       | $C_{20, 21}$    |              | 0.5  |      | pF         | parallel equivalent circuit | 3            |
| IF-suppression        | $a_{\text{IF}}$ |              | 20   |      | dB         | channel E2                  | 1            |
| IF-suppression        | $a_{\text{IF}}$ |              | 20   |      | dB         | channel S10                 | 1            |

**VHF II-Circuit Section**

|                                        |                            |     |      |      |                   |                                                        |   |
|----------------------------------------|----------------------------|-----|------|------|-------------------|--------------------------------------------------------|---|
| Switching voltage                      | $V_{12}$                   | 1.6 |      | 2.3  | V                 |                                                        | 1 |
| Switching current                      | $I_{12}$                   |     | 10   | 30   | $\mu\text{A}$     | $V_{12} = 2.1\text{ V}$                                | 1 |
| Oscillator frequency range             | $f_{\text{VHF II}}$        | 190 |      | 485  | MHz               | $V_d = 0 \dots 28\text{ V}$                            | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF II}}$ |     |      | 400  | kHz               | $V_S = 12\text{ V} \pm 10\%$                           | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF II}}$ |     |      | 500  | kHz               | $\Delta T = 25\text{ °C}$                              | 1 |
| Oscillator drift                       | $\Delta f_{\text{VHF II}}$ |     |      | 200  | kHz               | $t = 5\text{ s}$ up to 15 min. after switching on      | 1 |
| Oscillator level                       | $a_{\text{PLL}}$           |     | - 20 |      | dBm               | E5 balanced tested                                     | 1 |
| Oscillator level                       | $a_{\text{PLL}}$           |     | - 20 |      | dBm               | S37 balanced tested                                    | 1 |
| Oscillator output impedance            | $R_{23, 24}$               |     | 100  |      | $\Omega$          | parallel equivalent circuit                            | 3 |
|                                        | $C_{23, 24}$               |     | 2    |      | pF                | parallel equivalent circuit                            | 3 |
| Harmonic wave ratio interference level | $a_{23, 24}$               |     |      | - 10 | dB                | $V_{\text{HF}} = 1\text{ V}_{\text{rms}}$              | 1 |
| Oscillator pulling                     | $V_{18, 19}$               | 100 | 108  |      | dB/ $\mu\text{V}$ | $\Delta f = 10\text{ kHz}$ in channel E5               | 1 |
| Oscillator pulling                     | $V_{18, 19}$               | 100 | 108  |      | dB/ $\mu\text{V}$ | $\Delta f = 10\text{ kHz}$ in channel S37              | 1 |
| Oscillator pulling                     | $V_{18, 19}$               | 80  | 88   |      | dB/ $\mu\text{V}$ | $\Delta f_{\text{int}} = K5 + (N + 5 - 1\text{ MHz})$  | 1 |
| Oscillator pulling                     | $V_{18, 19}$               | 80  | 88   |      | dB/ $\mu\text{V}$ | $\Delta f_{\text{int}} = S37 + (N + 5 - 1\text{ MHz})$ | 1 |
| Gain                                   | $G_{\text{VHF II}}$        |     | 41   |      | dB                | channel E5<br>pin 18, 19 > 13, 14                      | 1 |
| Gain                                   | $G_{\text{VHF II}}$        |     | 41   |      | dB                | channel S37<br>pin 18, 19 > 13, 14                     | 1 |
| Mixer noise figure                     | $NF_{\text{VHF II}}$       |     | 7.5  | 9    | dB                | channel E5 (DSB)                                       | 2 |
| Mixer noise figure                     | $NF_{\text{VHF II}}$       |     | 7.5  | 9    | dB                | channel S37 (DSB)                                      | 2 |



**Characteristics (cont'd)**
 $T_A = 25\text{ °C}; V_S = 12\text{ V}$ 

| Parameter             | Symbol           | Limit Values |      |      | Unit  | Test Condition            | Test Circuit |
|-----------------------|------------------|--------------|------|------|-------|---------------------------|--------------|
|                       |                  | min.         | typ. | max. |       |                           |              |
| Interference voltage  | $V_{\text{int}}$ | 97           | 100  |      | dB/μV | 1 % cross mod.; E5 ± 2    | 1            |
| Interference voltage  | $V_{\text{int}}$ | 97           | 100  |      | dB/μV | 1 % cross mod.; S37 ± 2   | 1            |
| Mixer input impedance | $R_{18, 19}$     |              | 25   |      | Ω     | serial equivalent circuit | 3            |
|                       | $L_{18, 19}$     |              | 10   |      | nH    | serial equivalent circuit | 3            |
| IF-suppression        | $a_{\text{IF}}$  |              | 20   |      | dB    | channel E5                | 1            |
| IF-suppression        | $a_{\text{IF}}$  |              | 20   |      | dB    | channel S37               | 1            |

**UHF-Circuit Section**

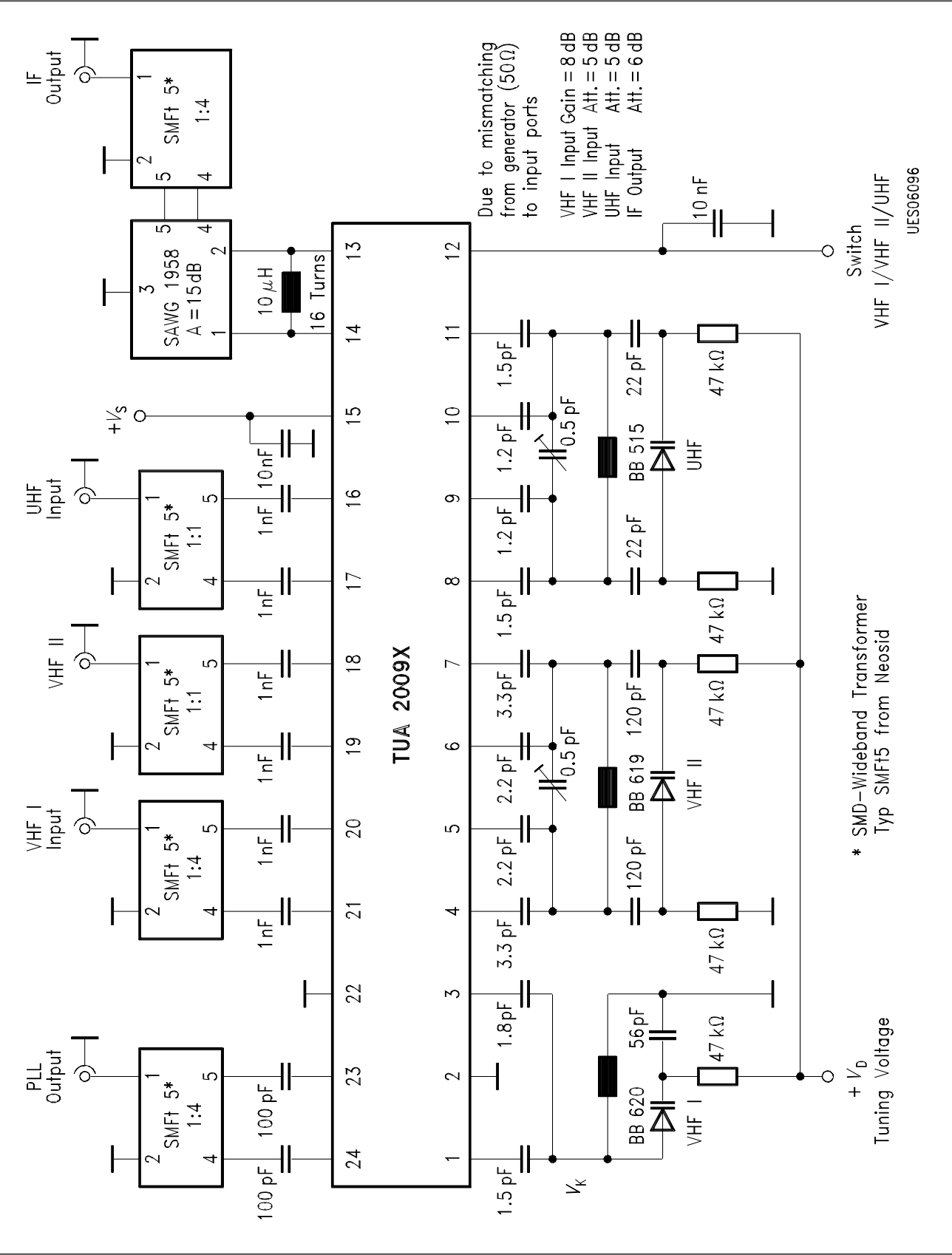
|                                        |                         |     |      |            |       |                                                               |   |
|----------------------------------------|-------------------------|-----|------|------------|-------|---------------------------------------------------------------|---|
| Switching voltage                      | $V_{12}$                | 3.2 |      | $\leq V_S$ | V     |                                                               | 1 |
| Switching current                      | $I_{12}$                |     | 60   | 300        | μA    | $V_{12} = V_S$                                                | 1 |
| Oscillator frequency range             | $f_{\text{UHF}}$        | 470 |      | 900        | MHz   | $V_d = 0 \dots 28\text{ V}$                                   | 1 |
| Oscillator drift                       | $\Delta f_{\text{UHF}}$ |     |      | 400        | kHz   | $V_S = 12\text{ V} \pm 10\%$                                  | 1 |
| Oscillator drift                       | $\Delta f_{\text{UHF}}$ |     |      | 800        | kHz   | $\Delta T = 25\text{ °C}$                                     | 1 |
| Oscillator drift                       | $\Delta f_{\text{UHF}}$ |     |      | 600        | kHz   | $t = 5\text{ s}$ up to 15 min. after switching on             | 1 |
| Oscillator level                       | $V_{23, 24}$            |     | – 20 |            | dBm   | E21 balanced tested                                           | 1 |
| Oscillator level                       | $V_{23, 24}$            |     | – 20 |            | dBm   | E68 balanced tested                                           | 1 |
| Oscillator output impedance            | $R_{23, 24}$            |     | 100  |            | Ω     | parallel equivalent circuit                                   | 3 |
|                                        | $C_{23, 24}$            |     | 2    |            | pF    | parallel equivalent circuit                                   | 3 |
| Harmonic wave ratio interference level | $a_{23, 24}$            |     |      | – 10       | dB    | $V_{\text{HF}} = 1\text{ Vrms}$                               | 1 |
| Oscillator pulling                     | $V_{16, 17}$            | 100 | 108  |            | dB/μV | $\Delta f = 10\text{ kHz}$ in channel E21                     | 1 |
| Oscillator pulling                     | $V_{16, 17}$            | 100 | 108  |            | dB/μV | $\Delta f = 10\text{ kHz}$ in channel E68                     | 1 |
| Oscillator pulling                     | $V_{16, 17}$            | 80  | 88   |            | dB/μV | $\Delta f_{\text{int}} = \text{E21} + (N + 5 - 1\text{ MHz})$ | 1 |
| Oscillator pulling                     | $V_{16, 17}$            | 80  | 88   |            | dB/μV | $\Delta f_{\text{int}} = \text{E68} + (N + 5 - 1\text{ MHz})$ | 1 |
| Gain                                   | $G_{\text{UHF}}$        |     | 41   |            | dB    | channel E21<br>pin 16, 17 > 13, 14                            | 1 |
| Gain                                   | $G_{\text{UHF}}$        |     | 41   |            | dB    | channel E68<br>pin 16, 17 > 13, 14                            | 1 |

**Characteristics (cont'd)**
 $T_A = 25\text{ °C}; V_S = 12\text{ V}$ 

| Parameter             | Symbol            | Limit Values |      |      | Unit  | Test Condition            | Test Circuit |
|-----------------------|-------------------|--------------|------|------|-------|---------------------------|--------------|
|                       |                   | min.         | typ. | max. |       |                           |              |
| Mixer noise figure    | $NF_{\text{UHF}}$ |              | 8    | 10   | dB    | channel E21 (DSB)         | 2            |
| Mixer noise figure    | $NF_{\text{UHF}}$ |              | 9    | 11   | dB    | channel E68 (DSB)         | 2            |
| Interference voltage  | $V_{\text{int}}$  | 97           | 100  |      | dB/μV | 1 % cross mod.; E21 ± 2   | 1            |
| Interference voltage  | $V_{\text{int}}$  | 97           | 100  |      | dB/μV | 1 % cross mod.; E68 ± 2   | 1            |
| Mixer input impedance | $R_{16, 17}$      |              | 25   |      | Ω     | serial equivalent circuit | 3            |
|                       | $L_{16, 17}$      |              | 10   |      | nH    | serial equivalent circuit | 3            |
| IF-suppression        | $a_{\text{IF}}$   |              | 20   |      | dB    | channel E21               | 1            |

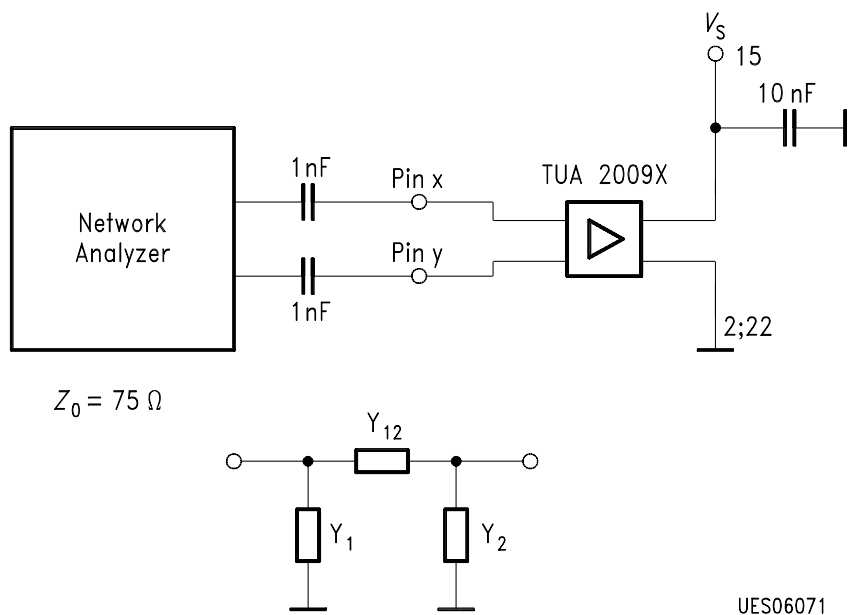
**SAW-Filter Driver Section**

|                                    |                   |  |    |  |     |                                              |   |
|------------------------------------|-------------------|--|----|--|-----|----------------------------------------------|---|
| SAW-filter driver output impedance | $R_{13, 14}$      |  | 75 |  | Ω   | serial equivalent circuit                    | 4 |
|                                    | $C_{13, 14}$      |  | 95 |  | nH  | serial equivalent circuit                    | 4 |
| Output voltage linearity           | $V_{\text{AOFW}}$ |  | 24 |  | dBm | total harmonic distortion factor $THD = 5\%$ |   |



Test Circuit 1

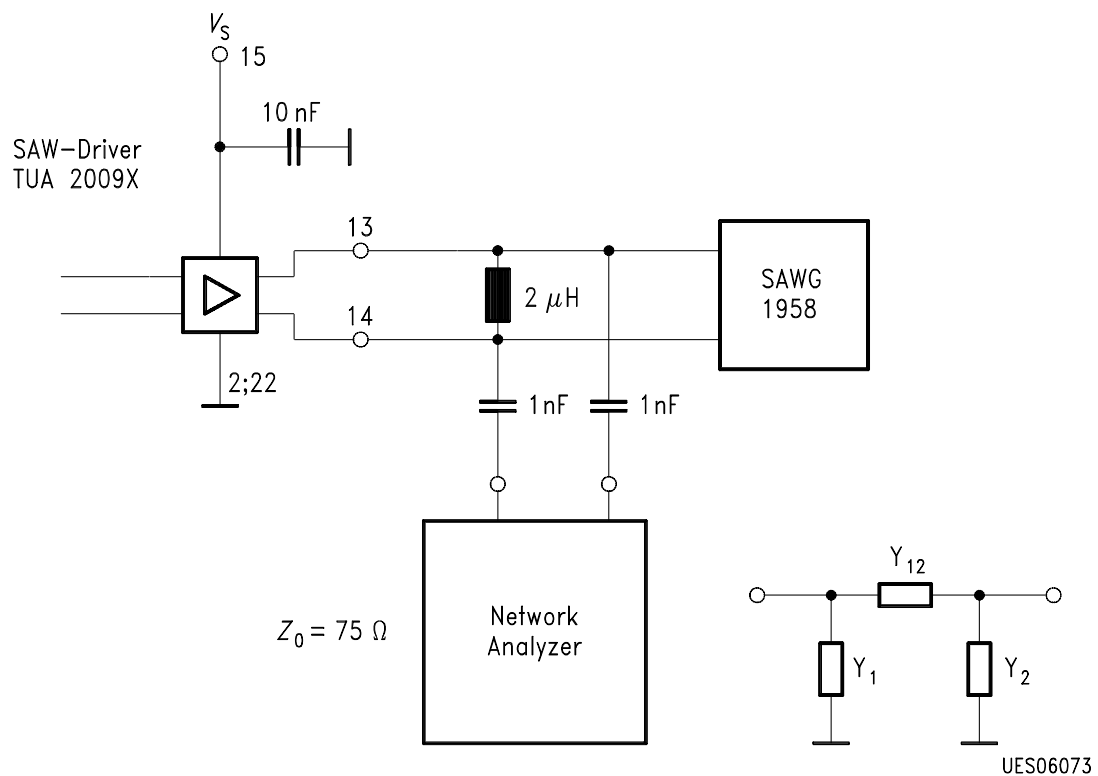




Measurement of the 4-pole matrix S11, S12, S21, S22 and calculation of the  $\pi$ -equivalent circuit, which follows from that.

Test Circuit 3

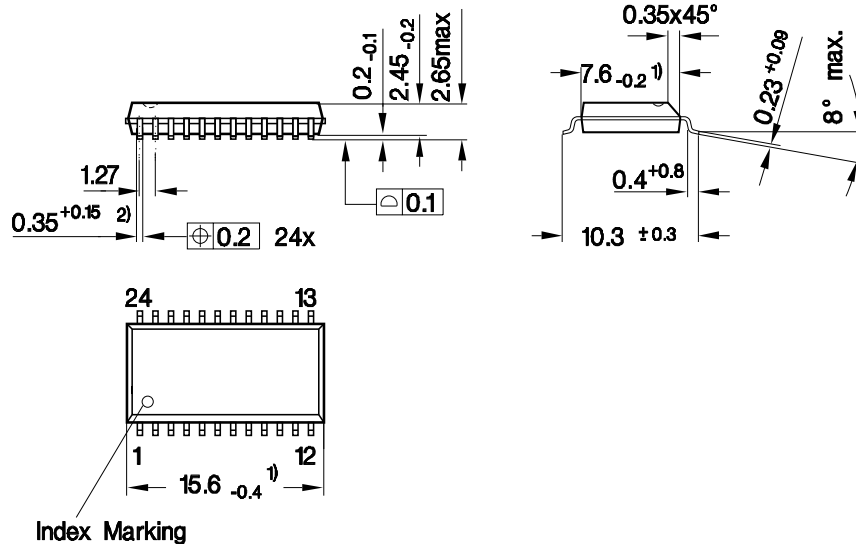
| Test Point                  | Test Frequency in MHz | Pin x | Pin y |
|-----------------------------|-----------------------|-------|-------|
| Oscillator output impedance | 100                   | 23    | 24    |
| Mixer input impedance VHF 1 | 100                   | 20    | 21    |
| Mixer input impedance VHF 2 | 300                   | 18    | 19    |
| Mixer output impedance UHF  | 600                   | 16    | 17    |



Measurement of the 4-pole matrix at 37 MHz S11, S12, S21, S22  
and calculation of the  $\pi$ -equivalent circuit, which follows from that.

## Test Circuit 4

## Plastic Package, P-DSO-24-1 (SMD) (Plastic Dual Small Outline)



- 1) Does not include plastic or metal protrusion of  $0.15$  max. per side
- 2) Does not include dambar protrusion of  $0.05$  max. per side

GPS05144

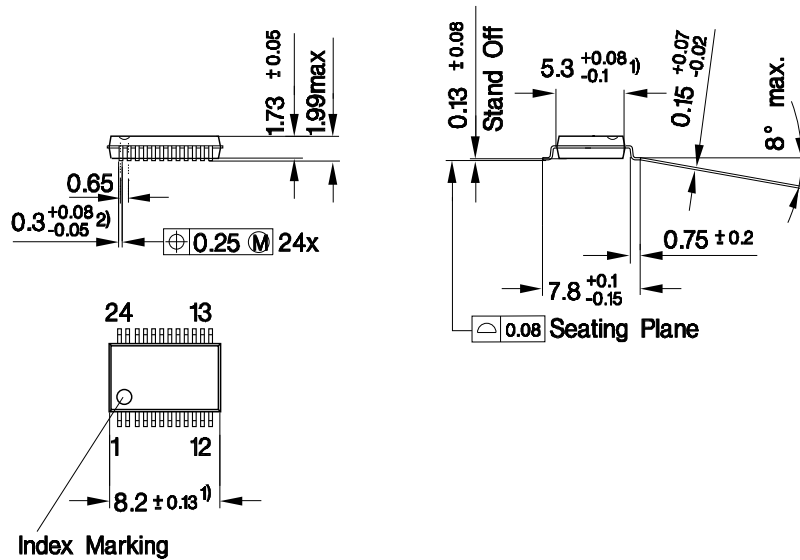
### Sorts of Packing

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information"

SMD = Surface Mounted Device

Dimensions in mm

**Plastic Package, P-SSOP-24-1 (SMD)**  
(Plastic Shrink Small Outline Package)



- 1) Does not include plastic or metal protrusion of 0.15 max. per side
- 2) Does not include dambar protrusion of 0.08 max. per side

GPS05388

**Sorts of Packing**

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information"

SMD = Surface Mounted Device

Dimensions in mm