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## Wireless Components

2 Band TV Tuner Mixer-Oscillator-PLL  
with unbalanced IF-Amplifier

KTS6027-2, KTS6029-2 Version 2.0

Specification July 2001

**Revision History: Current Version: Preliminary Datasheet V 1.1, July 2000**

Previous Version: Target Data Sheet

Page (in previous Version)	Page (in current Version)	Subjects (major changes since last revision)
all	all	version to 1.1, status to preliminary
4 - 2	4 - 2	circuit diagram modified
4 - 3	4 - 3	circuit diagram modified
5 - 2	5 - 2	Bus input/output SDA max changed to 6V, Bus input SCL max changed to 6V, ADC input added
5 - 3	5 - 3	new reference for ESD protection
5 - 5	5 - 5	Current consumption for LOW/MID band and HIGH band added, tbf's replaced by data Charge Pump output voltage VCP = 1.3 V min
5 - 8	5 - 8	Oscillator phsase noise -85 dBc/Hz min, -89 dBc/Hz typ
5 - 9	5 - 9	Oscillator phsase noise -85 dBc/Hz min, -89 dBc/Hz typ

**Revision History: Current Version: Datasheet, V 2.0, July 2001**

Previous Version: Preliminary Datasheet V 1.1, July 2000

Page (in previous Version)	Page (in current Version)	Subjects (major changes since last revision)
all	all	version to 2.0, preliminary deleted
5 - 2	5 - 2	definition of thermal properties changed
5 - 5	5 - 5	current consumption changed

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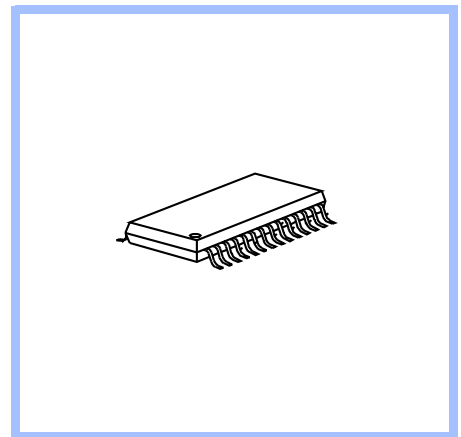
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# Product Info

**General Description** The **KTS6027-2/KTS6029-2** is a 5 V mixer/oscillator and synthesizer for analog and digital TV and VCR tuners.

## Package



## Features **General**

- Suitable for analog and digital terrestrial TV tuner
- Compatible with KTS6027-S or KTS6029-S in normal mode
- New features in extended mode
- Full ESD protection

## Mixer/Oscillator

- High impedance mixer input for LOW/MID band
- Low impedance mixer input for HIGH band
- 4 pin oscillator for LOW/MID band
- 4 pin oscillator for HIGH band

## IF-Amplifier

- single ended IF preamplifier
- 75  $\Omega$  output impedance

## PLL

- PLL with short lock-in time
- High voltage VCO tuning output
- Fast I<sup>2</sup>C bus
- 4 NPN bandswitch buffers
- Internal LOW-MID/HIGH switch
- Lock-in flag
- Power-down reset
- 4 programmable reference divider ratios: 24, 64, 80, 128
- 4 programmable charge pump currents

- Application** ■ The IC is suitable for NTSC tuners in TV- and VCR-sets or CATV set-top receivers for analog and digital (ATSC) TV.

## Ordering Information

Type	Ordering Code	Package
KTS6027-2	Q67037-A1162 ( tape and reel)	P-TSSOP-28-1
KTS6029-2	Q67037-A1163 ( tape and reel)	P-TSSOP-28-1

# 1

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# 2 Product Description

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## 2.1 General Description

The **KTS6027-2, KTS6029-2** device combines a digitally programmable phase locked loop (PLL), with a mixer-oscillator block including two balanced mixers and oscillators for use in TV and VCR tuners.

The PLL block with four selectable chip addresses forms a digitally programmable phase locked loop. With a 4 MHz quartz crystal, the PLL permits precise setting of the frequency of the tuner oscillator up to 1024 MHz in increments of 31.25, 50, 62.5 or 166.7 kHz. The tuning process is controlled by a microprocessor via an I<sup>2</sup>C bus. The device has four output ports. A flag is set when the loop is locked. It can be read by the processor via the I<sup>2</sup>C bus.

The mixer-oscillator block includes two balanced mixers (one mixer with high-impedance input and one mixer with a balanced low-impedance input), two frequency and amplitude-stable balanced oscillators for LOW/MID and HIGH, an IF amplifier, a low-noise reference voltage source, and a band switch.

## 2.2 Features

### General

- Suitable for analog and ATSC TV tuners
- Compatible with KTS6027-S or KTS6029-S in normal mode
- New features in extended mode
- Full ESD protection

### Mixer/Oscillator

- High impedance mixer input for LOW/MID band
- Low impedance mixer input for HIGH band
- 4 pin oscillator for LOW/MID band
- 4 pin oscillator for HIGH band

### IF-Amplifier

- single ended IF preamplifier
- 75 Ω output impedance

### PLL

- PLL with short lock-in time
- High voltage VCO tuning output
- Fast I<sup>2</sup>C bus
- 4 NPN bandswitch buffers
- Internal LOW-MID/HIGH switch

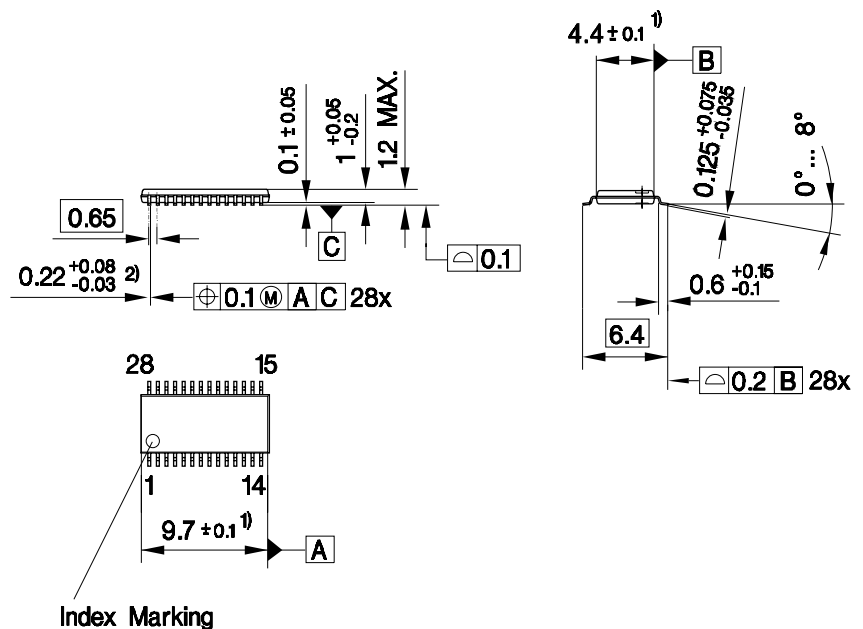
- Lock-in flag
- Power-down reset
- 4 programmable reference divider ratios: 24, 64, 80, 128
- 4 programmable charge pump currents

## 2.3 Application

- The IC is suitable for NTSC tuners in TV- and VCR-sets or CATV set-top receivers for analog and digital (ATSC) TV.

## 2.4 Package Outlines

P-TSSOP-28-1



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

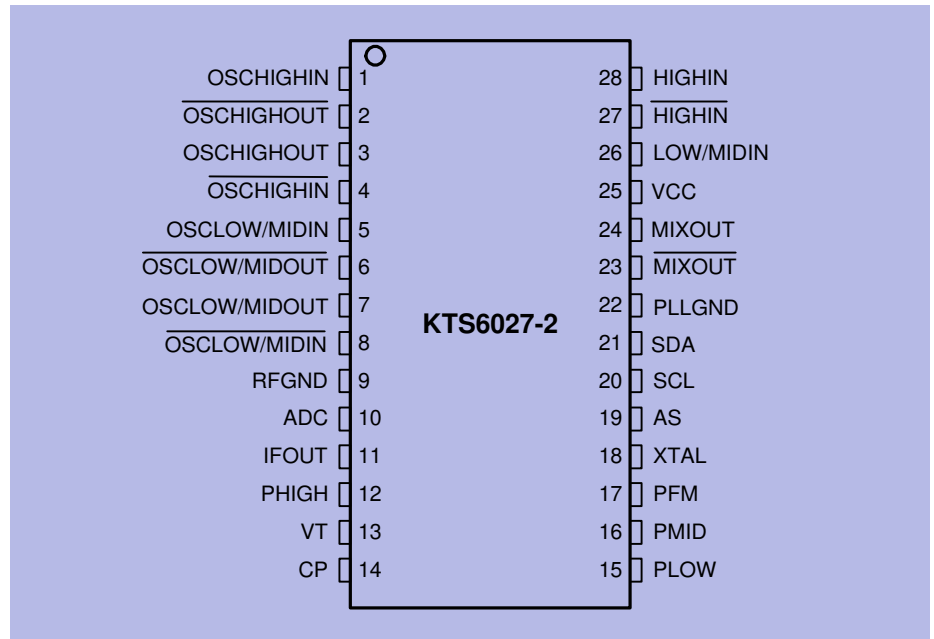


# 3 Functional Description

## Contents of this Chapter

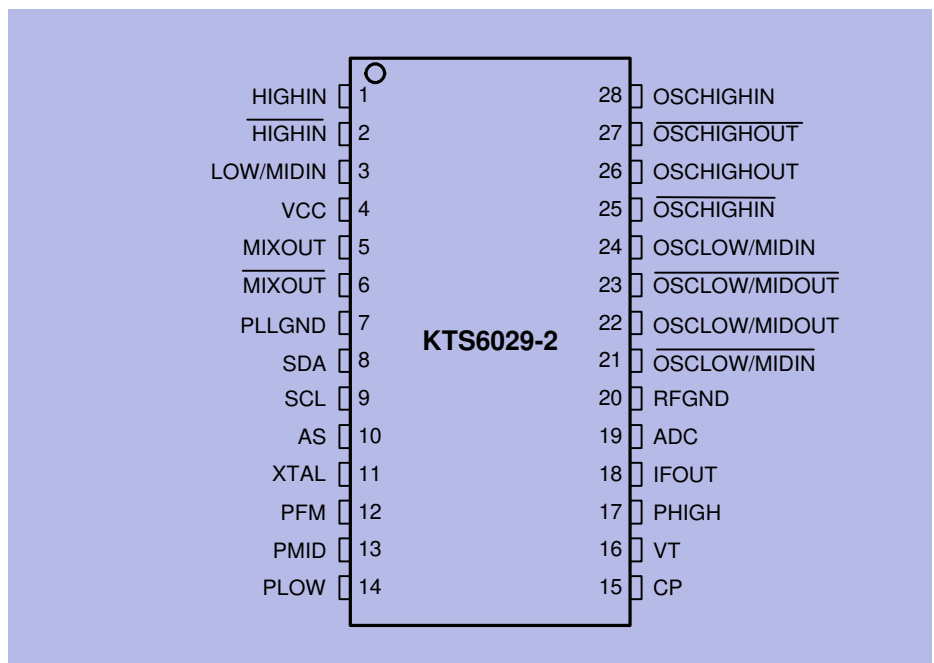
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### 3.1 Pin Configuration



KTS6027-2\_Pin\_config

Figure 3-1 KTS6027-2 Pin Configuration



KTS6029-2\_Pin\_config

Figure 3-2 KTS6029-2 Pin Configuration

### 3.2 Internal Pin Configuration

Note: Pin designation refers to KTS6027-2. KTS6029-2 has reversed pinning

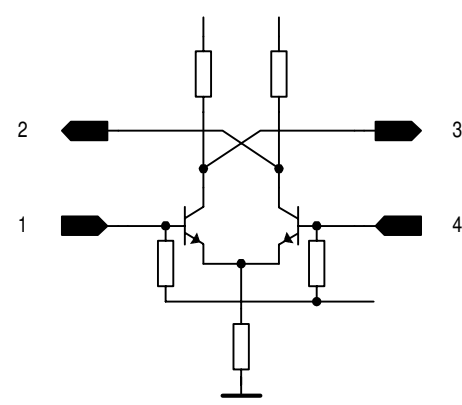
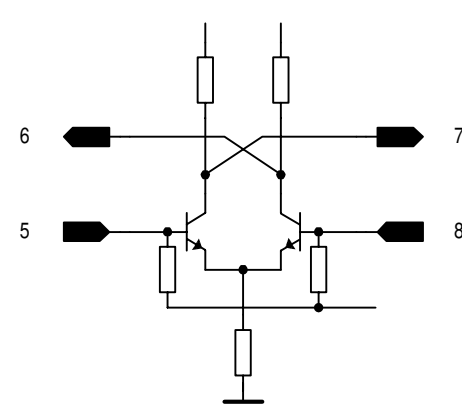
Table 3-1 Pin Definition and Function				
Pin No.	Symbol	Equivalent I/O-Schematic	Average DC voltage	
			LOW/MID	HIGH
1	OSCHIGHIN		0.0 V	1.6 V
2	$\overline{\text{OSC-HIGHOUT}}$		0.0 V	2.8 V
3	OSC-HIGHOUT		0.0 V	2.8 V
4	$\overline{\text{OSCHIGHIN}}$		0.0 V	1.6 V
5	OSCLOW/ MIDIN		1.6 V	0.0 V
6	$\overline{\text{OSCLOW/}}\overline{\text{MIDOUT}}$		2.3 V	0.0 V
7	OSCLOW/ MIDOUT		2.3 V	0.0 V
8	$\overline{\text{OSCLOW/}}\overline{\text{MIDIN}}$		1.6 V	0.0 V
9	RFGND	analog ground	0.0 V	0.0 V

Table 3-1 Pin Definition and Function (continued)

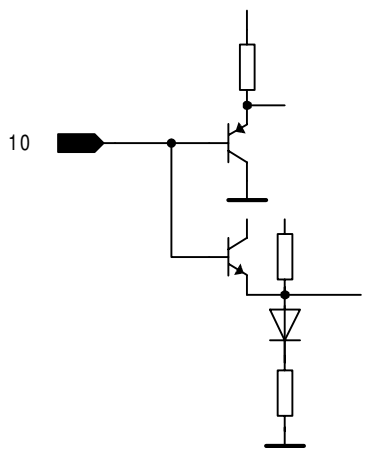
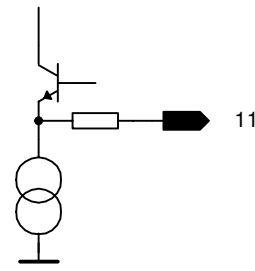
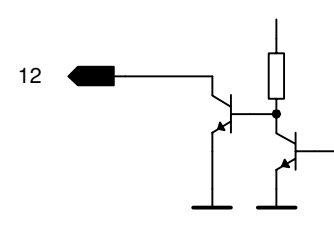
Pin No.	Symbol	Equivalent I/O-Schematic	Average DC voltage	
			LOW/MID	HIGH
10	ADC		$V_{ADC}$	$V_{ADC}$
11	IFOUT		2.3 V	2.3 V
12	PHIGH		5.0 V	$V_{CE}$

Table 3-1 Pin Definition and Function (continued)

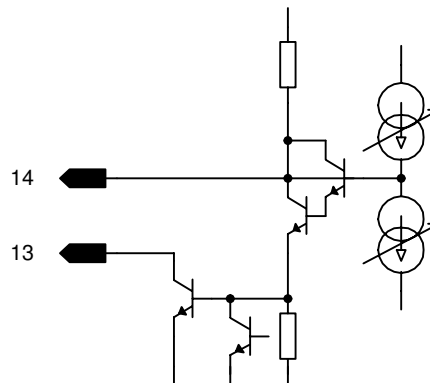
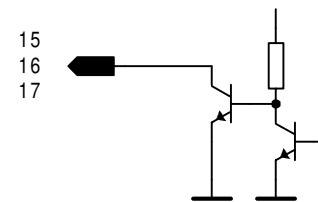
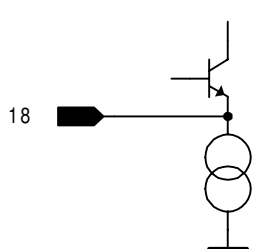
Pin No.	Symbol	Equivalent I/O-Schematic	Average DC voltage	
			LOW/MID	HIGH
13	VT		$V_T$	$V_T$
14	CP		2.1 V	2.1 V
15	PLOW		5 V or $V_{CE}$	5 V
16	PMID		5 V or $V_{CE}$	5 V
17	PFM		5 V or $V_{CE}$	5 V or $V_{CE}$
18	XTAL		3.0 V	3.0 V

Table 3-1 Pin Definition and Function (continued)

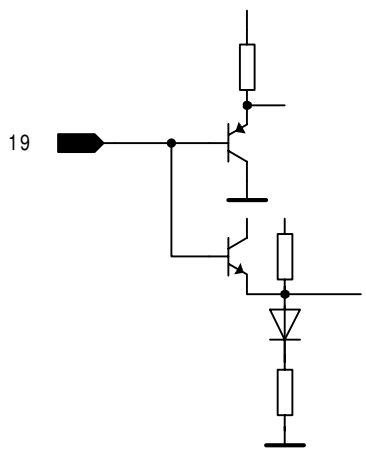
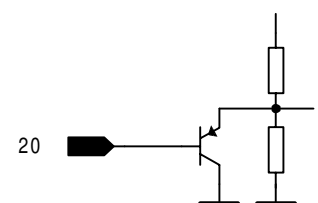
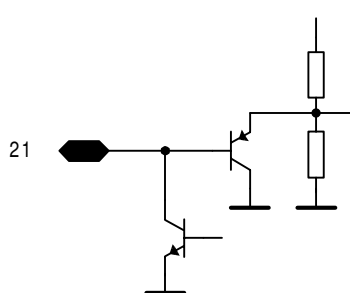
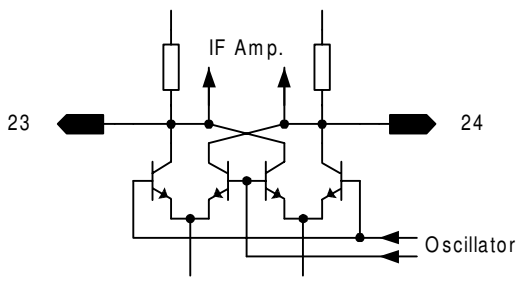
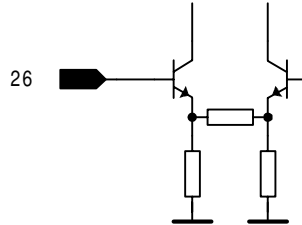
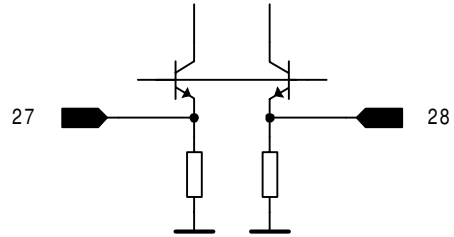
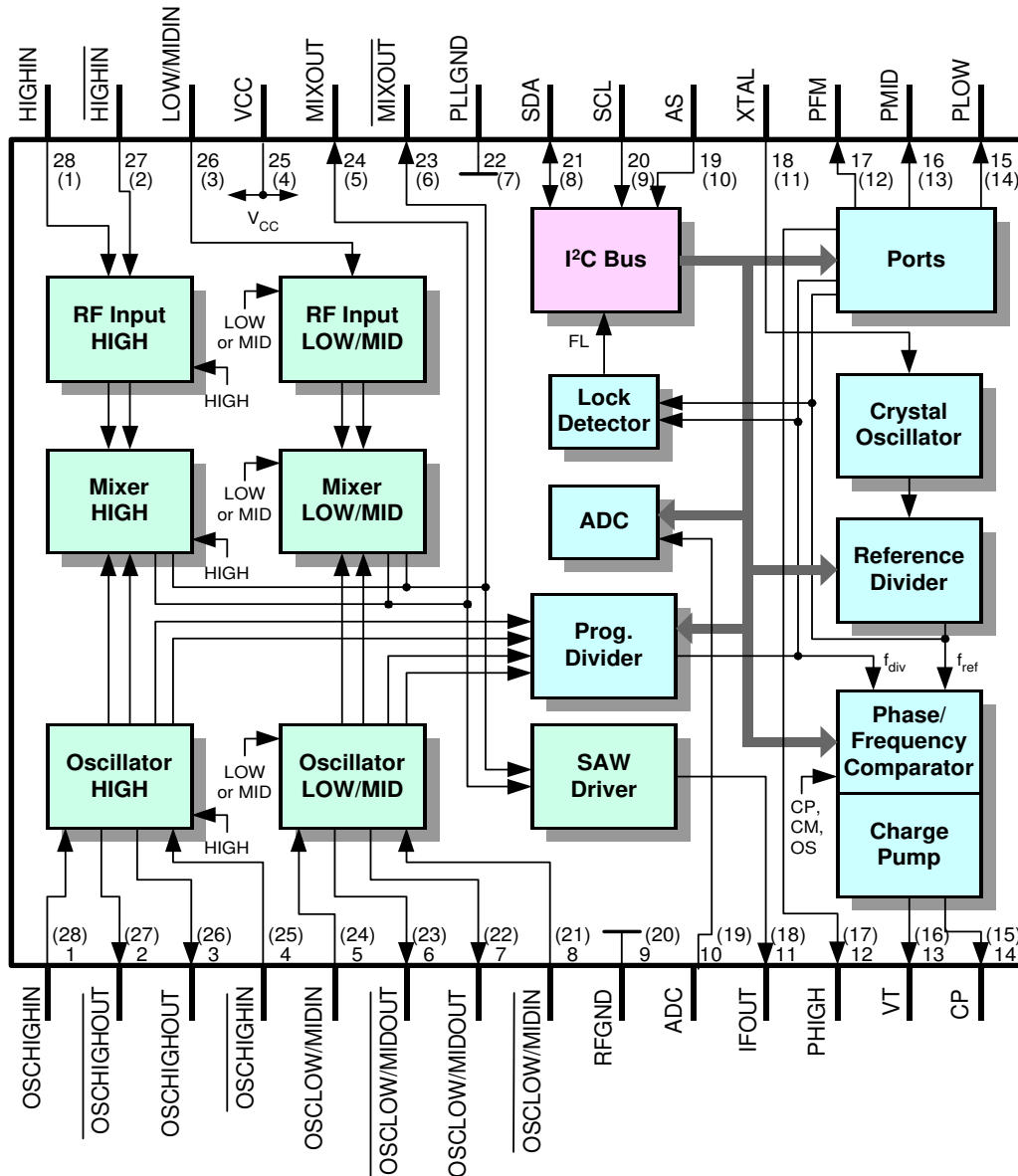
Pin No.	Symbol	Equivalent I/O-Schematic	Average DC voltage	
			LOW/MID	HIGH
19	AS		$V_{AS}$	$V_{AS}$
20	SCL		n.a.	n.a.
21	SDA		n.a.	n.a.
22	PLLGND	digital ground	0.0 V	0.0 V

Table 3-1 Pin Definition and Function (continued)

Pin No.	Symbol	Equivalent I/O-Schematic	Average DC voltage	
			LOW/MID	HIGH
23	$\overline{\text{MIXOUT}}$		3.8 V	3.8 V
24	MIXOUT		3.8 V	3.8 V
25	VCC	supply voltage	5.0 V	5.0 V
26	LOW/MIDIN		1.8 V	0.0 V
27	$\overline{\text{HIGHIN}}$		0.0 V	0.9 V
28	HIGHIN		0.0 V	0.9 V

### 3.3 Block Diagram



KTS602729\_block\_diag

Note: Pin designations in parenthesis refer to KTS6029-2

Figure 3-3 Block Diagram



## 3.4 Circuit Description

### 3.4.1 General

In the **normal** mode (see [Table 5-7 Test modes on page 32](#)) the IC is compatible with KTS6027-S / KTS6029-S. An **extended** mode makes a reference divider ratio of 24 (see [Table 5-8 Reference divider ratio on page 32](#)) and two additional charge pump currents (see [Table 5-9 Charge pump current on page 33](#)) available.

### 3.4.2 Mixer-Oscillator block

The mixer oscillator section includes two balanced mixers (double balanced mixer), two balanced oscillators for LOW and / or MID band and HIGH band, an IF amplifier, a reference voltage source and a band switch.

Filters between tuner input and IC separate the TV frequency signals into two bands. The band switching in the tuner front-end is done by using two or three port outputs. In the selected band the signal passes a tuner input stage with MOSFET amplifier, a double-tuned bandpass filter and is then fed to the balanced mixer input of the IC which has in case of LOW / MID a high-impedance input and in case of HIGH a low-impedance input. The input signal is mixed there with the signal from the activated on chip oscillator to the IF frequency which is filtered out at the balanced high-impedance output pair by means of a parallel tuned circuit. The following SAW preamplifier has a low output impedance to drive the SAW filter directly.

### 3.4.3 PLL block

The oscillator signal is internally DC-coupled as a differential signal to the programmable divider inputs. The signal subsequently passes through a programmable divider with ratio  $N = 256$  through 32767 and is then compared in a digital frequency / phase detector to a reference frequency  $f_{ref} = 31.25, 50, 62.5$  or 166.7 kHz.

This frequency is derived from an unbalanced, low-impedance 4 MHz crystal oscillator (pin XTAL) divided by  $R = 128, 80, 64$  or 24.

The phase detector has two outputs that drive two current sources of opposite polarity as charge pump. If the negative edge of the divided VCO signal appears prior to the negative edge of the reference signal, the positive current source pulses for the duration of the phase difference. In the reverse case the negative current source pulses. If the two signals are in phase, the charge pump output (CP) goes into the high-impedance state (PLL is locked). An active low-pass filter integrates the current pulses to generate the tuning voltage for the VCO

(internal amplifier, external pull-up resistor at TUNE and external RC circuitry). The charge pump output is also switched into the high-impedance state if the control bits T0 = 1 and T1 = 0. Here it should be noted, however, that the tuning voltage can alter over a long period in the high-impedance state as a result of self-discharge in the peripheral circuitry. TUNE may be switched off by the control bit OS to allow external adjustments.

If the VCO is not oscillating the PLL locks to a tuning voltage of 33 V .

By means of the control bits CP, CM, T0 and T1 the pump current can be switched between four values by software. This programmability permits alteration of the control response time of the PLL in the locked-in state. In this way different VCO gains can be compensated, for example.

The software-switched ports PLOW, PMID, PHIGH and PFM are general-purpose open-collector outputs. The test bits T0 = 0 and T1 = 1 switches the test signals  $f_{ref}$  (i.e.  $f_{XTAL} / 64$ ) and  $f_{div}$  (divided input signal) to PLOW and PMID respectively.

The lock detector resets the lock flag FL if the width of the charge pump current pulses is wider than the period of the crystal oscillator (i.e. 250 ns). Hence, if FL = 1, the maximum deviation of the input frequency from the programmed frequency is given by

$$\Delta f = \pm I_P (K_{VCO} / f_{XTAL}) (C1+C2) / (C1C2)$$

where  $I_P$  is the charge pump current,  $K_{VCO}$  the VCO gain,  $f_{XTAL}$  the crystal oscillator frequency and C1, C2 the capacitances in the loop filter (see [Figure 4-1 KTS6027-2 Evaluation Board on page 20](#)). As the charge pump pulses at i.e. 62.5 kHz (=  $f_{ref}$ ), it takes a maximum of 16  $\mu$ s for FL to be reset after the loop has lost lock state.

Once FL has been reset, it is set only if the charge pump pulse width is less than 250 ns for eight consecutive  $f_{ref}$  periods. Therefore it takes between 128 and 144  $\mu$ s for FL to be set after the loop regains lock.

### 3.4.4 I<sup>2</sup>C-Bus Interface

Data is exchanged between the processor and the PLL via the I<sup>2</sup>C bus. The clock is generated by the processor (input SCL), while pin SDA functions as an input or output depending on the direction of the data (open collector, external pull-up resistor). Both inputs have hysteresis and a low-pass characteristic, which enhance the noise immunity of the I<sup>2</sup>C bus.

The data from the processor pass through an I<sup>2</sup>C bus controller. Depending on their function the data are subsequently stored in registers. If the bus is free, both lines will be in the marking state (SDA, SCL are HIGH). Each telegram begins with the start condition and ends with the stop condition. Start condition: SDA goes LOW, while SCL remains HIGH. Stop condition: SDA goes HIGH

while SCL remains HIGH. All further information transfer takes place during SCL = LOW, and the data is forwarded to the control logic on the positive clock edge.

The table "Bit Allocation" (see [Table 5-4 Bit Allocation Read / Write on page 31](#)) should be referred to the following description. All telegrams are transmitted byte-by-byte, followed by a ninth clock pulse, during which the control logic returns the SDA line to LOW (acknowledge condition). The first byte is comprised of seven address bits. These are used by the processor to select the PLL from several peripheral components (chip select). The LSB bit (R/W) determines whether data are written into (R/W = 0) or read from (R/W = 1) the PLL.

In the data portion of the telegram during a WRITE operation, the MSB bit of the first or third data byte determines whether a divider ratio or control information is to follow. In each case the second byte of the same data type has to follow the first byte.

If the address byte indicates a READ operation, the PLL generates an acknowledge and then shifts out the status byte onto the SDA line. If the processor generates an acknowledge, a further status byte is output; otherwise the data line is released to allow the processor to generate a stop condition. The status word consists the lock flag and the power-on flag.

Four different chip addresses can be set by appropriate DC level at pin AS (see [Table 5-6 Address selection on page 32](#)).

While applying the supply voltage, a power-on reset circuit prevents the PLL from setting the SDA line to LOW, which would block the bus. The power-on reset flag POR is set at power-on and when  $V_{CC}$  falls below 3.2 V. It will be reset at the end of a READ operation.

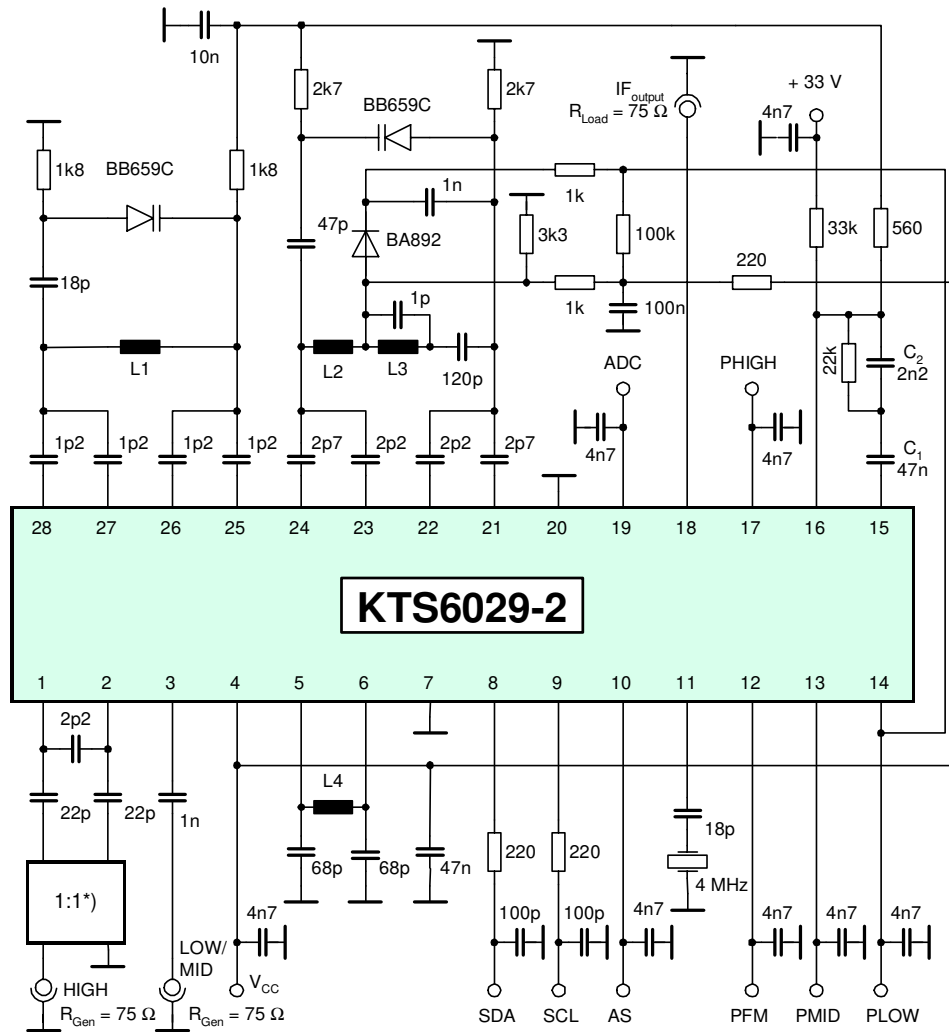
# 4 Applications

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## 4.2 KTS6029-2 Evaluation Board



KTS6029-2 Application Circuit

Figure 4-2 KTS6029-2 Evaluation Board (NTSC)

	Table 4-1 Recommended band limits in MHz			
	RF input		Oscillator	
	min	max	min	max
LOW	55.25	127.25	101	173
MID	133.25	361.25	179	407
HIGH	367.25	803.25	413	849

	Table 4-1 Coils		
	turns	E	wire E
L1	1.5	2 mm	0.4 mm
L2	3.5	2.5 mm	0.5 mm
L3	9.5	2.5 mm	0.4 mm
L4	12.5	3.5 mm	0.3 mm
*)	TOKO B4F Type 617DB-1023		

# 5 Reference

## Contents of this Chapter

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## 5.1 Electrical Data

### 5.1.1 Absolute Maximum Ratings



#### WARNING

The maximum ratings may not be exceeded under any circumstances, not even momentarily and individually, as permanent damage to the IC may result.

**Table 5-1 Absolute Maximum Ratings**

Parameter <sup>1)</sup>	Symbol	Limit Values		Unit	Remarks
		min	max		
Supply voltage	$V_{CC}$	-0.3	6	V	
Ambient temperature	$T_A$	-40	$T_{Amax}$ <sup>2)</sup>	°C	
Junction temperature	$T_J$		+125	°C	
Storage temperature	$T_{Stg}$	-40	+125	°C	
Temperature difference junction to case <sup>3)</sup>	$T_{JC}$		2	K	
<b>PLL</b>					
CP	$V_{CHGPMP}$	-0.3	3	V	
	$I_{CHGPMP}$		1	mA	
Crystal oscillator pin XTAL	$V_{XTAL}$		$V_{CC}$	V	
	$I_{XTAL}$	-5		mA	
Bus input/output SDA	$V_{SDA}$	-0.3	6	V	
Bus output current SDA	$I_{SDA(L)}$		5	mA	open collector
Bus input SCL	$V_{SCL}$	-0.3	6	V	
Chip address switch AS	$V_{AS}$	-0.3	$V_{CC}$	V	
VCO tuning output (loop filter)	$V_T$	-0.3	35	V	
ADC input	$V_{ADC}$	-0.3	$V_{CC}$	V	
Port outputs PLOW, PMID, PHIGH, PFM	$V_P$	-0.3	$V_{CC}$	V	
	$I_{P(L)}$	-1	25	mA	$t_{max} = 0.1$ sec. at 5.5 V
Total port output current	$\Sigma I_{P(L)}$		40	mA	$t_{max} = 0.1$ sec. at 5.5 V



**Table 5-1 Absolute Maximum Ratings**

Parameter <sup>1)</sup>	Symbol	Limit Values		Unit	Remarks
		min	max		
<b>Mixer-Oscillator</b>					
Mix input LOW/MID	$V_i$	-0.3	3	V	
Mix inputs HIGH	$V_i$		2	V	
	$I_i$	-5	6	mA	
VCO base voltage	$V_B$	-0.3	3	V	
VCO collector voltage	$V_C$		$V_{CC}$	V	
<b>ESD-Protection <sup>4)</sup></b>					
all pins	$V_{ESD}$		2	kV	

1). All values are referred to ground (pin), unless stated otherwise.

Currents with a positive sign flow into the pin and currents with a negative sign flow out of pin.

2). The maximum ambient temperature depends on the mounting conditions of the package. Any application mounting must guarantee not to exceed the maximum junction temperature of 125 °C. As reference the temperature difference junction to case is given.

3). Referred to top center of package

4). According to EIA/JESD22-A114-B (HBM incircuit test), as a single device incircuit contact discharge test.

### 5.1.2 Operating Range

Within the operational range the IC operates as described in the circuit description. The AC / DC characteristic limits are not guaranteed.

Table 5-2 Operating Range							
Parameter	Symbol	Limit Values		Unit	Test Conditions	L	Item
		min	max				
Supply voltage	$V_{CC}$	+4.5	+5.5	V			
Programmable divider factor	N	256	32767				
LOW/MID Mixer input frequency range	$f_i$	40	500	MHz			
HIGH Mixer input frequency range	$f_i$	350	900	MHz			
LOW/MID Oscillator frequency range	$f_O$	75	560	MHz			
HIGH Oscillator frequency range	$f_O$	380	950	MHz			
Ambient temperature	$T_A$	-20	$T_{Amax}$ 1).	°C			

1).see 5.1.1 Absolute Maximum Ratings on page 2