APPLICATION NOTE

UAA3220TS with SAW-stabilised local oscillator

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Abstract

This report describes the application of the UAA3220TS operating at 433.92 MHz with a surface acoustic wave (SAW) stabilised local oscillator taking advantage of the internal oscillator. The given circuit proposal supersedes the one given in chapter 2.2 of the application note AN99044, “UAA3220TS with SAW-stabilised local oscillator”. The necessary changes are presented to adapt the application circuits as given in the data sheet and the application note AN98104, “UAA3220TS”.

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APPLICATION NOTE

UAA3220TS with SAW-stabilised local oscillator

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Summary

The application of the UAA3220TS with a surface acoustic wave (SAW) based local oscillator (LO) has been described in the application note AN99044 (see [3]). The LO circuit has been given either using an external transistor especially at higher frequencies (e.g. 868.35 MHz) or taking advantage of the internal oscillator transistors for lower frequencies (e.g. 433.92 MHz). Following evaluations of the lower frequency LO circuit yielded a solution being more reliable against component and supply voltage variations.

This report describes the application of the UAA3220TS with a SAW stabilised local oscillator operating at 423.22 MHz which supersedes the circuit given in chapter 2.2 of [3]. The necessary changes are presented to adapt the application circuits as given in the data sheet ([1]) and the application not AN98104 ([2]).

The first section describes the possible problems of the application circuit given in chapter 2.2 of [3]. Section 2 describes a new application proposal for a SAW stabilised LO circuit operating at 423.22 MHz. Section 3 focuses on hints for PCB layout to achieve optimum receiver performance. A receiver schematic for a receive frequency of 433.92 MHz is given in section 4 together with the corresponding PCB layout and measurement results respectively.

Please note that all figures and measurement results presented in this paper are typical values only and may vary as a result of device spreads, component tolerances or temperature changes. For a detailed description of the IC characteristic please refer to [1]. Detailed application support is given in [2].

Contents

1. INTRODUCTION

The integrated circuit UAA3220TS is a single–chip superheterodyne receiver. The high frequency carrier (e.g. 315, 433.92 or 868.35 MHz) is down-converted to the intermediate frequency of typical 10.7 MHz by means of the local oscillator (LO) signal. Generation of the LO signal can be done in two different ways:

The UAA3220TS has been designed to employ a crystal oscillator and frequency multiplication to generate the local oscillator signal. Among other things this method of frequency synthesis is described in the application note AN98104 (see [2]).

The second possibility of generating the local oscillator frequency is to employ a SAW resonator based oscillator. This solution has been described in the application note AN99044 (see [3]) for two carrier frequencies. The solution operating at a receive frequency of 868.35 MHz has to use an external oscillator whereas the 433.92 MHz solution takes advantage of the internal oscillator transistors.

Later evaluations of the 433.92 MHz SAW-resonator based solution showed that this circuit (please refer to figure 3 in [3]) is sensitive against component and supply voltage variations. These limitations are mainly due to the following effects:

- The local oscillator of the UAA3220TS is connected to the multiplier via an internal 8.2 pF capacitor (see figure 10 in [2]). On account of the bipolar process this capacitor offers a parasitic diode referred to ground. This diode is biased in reverse direction and hence it has a supply voltage dependant parasitic capacitance. Since this capacitance is in parallel to capacitors C13 and C14 it directly influences the local oscillator and may violate the oscillation condition.
- The given LO circuit uses the SAW resonator to AC couple the base of the internal oscillator transistor to ground. In this configuration the input capacitance of pin 3/OSB is in parallel to the parasitic capacitance of the PCB and to the static capacitance of the SAW resonator. In case the overall parasitic input capacitance yields an impedance value lower than that of the SAW resonator, the local oscillator frequency may not be determined by the resonator any more.

This report describes a circuit proposal for a SAW-based local oscillator using the internal oscillator transistor. The given example supersedes the application proposal given in chapter 2.2 in [3].

An application description for a receive frequency of 868.35 MHz can be found in [3].

2. GENERAL DESCRIPTION

The SAW resonator stabilised local oscillator takes advantage of the UAA3220TS on-chip building blocks. The differences to the application circuits as given in [1] and [2] are described in the following.

2.1 SAW oscillator

The on-chip oscillator of the UAA3220TS is coupled to the multiplier via an internal 8.2 pF capacitor. Especially at lower frequencies, e.g. 423.22 MHz, this capacitor offers sufficient impedance to the local oscillator. For this reason the internal transistors can be used to build up the local oscillator. This approach takes advantage of the temperature compensated biasing of the internal circuitry. A Colpitts configuration is used to build up the LO (see Figure 1).

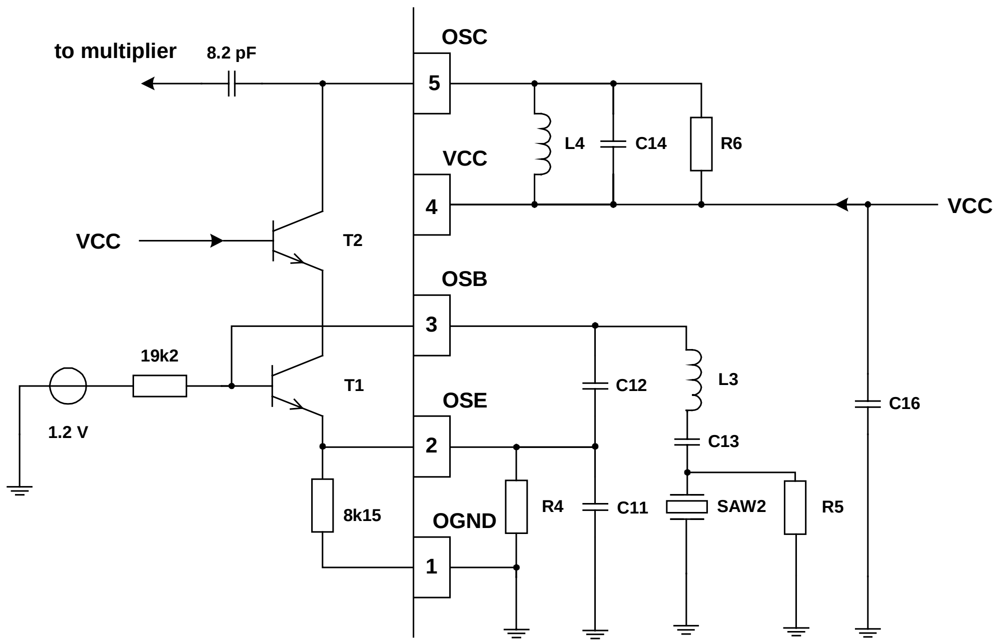

Figure 1: SAW based local oscillator using the internal transistor of the UAA3220TS

The on-chip transistor T1 operates in common-collector configuration by means of a following cascode stage. The resonant load consists of the SAW and its matching inductance L3 in parallel with the capacitors C11 and C12, which provide the oscillator feedback. The SAW resonator is a one-port device and can be used bi-directional. At resonance its low inherent series resistance is transformed to a higher value and presented to the base of transistor T1.

The oscillator offers best frequency stability when the SAW resonator is operated close to its serial resonance frequency where it provides almost the maximum loaded Q-factor. To ascertain optimum component values for C11 and C12, the SAW resonator has to be replaced by its equivalent circuit at resonance (parallel combination of motional resistance and static capacitance as given in the respective SAW data sheet). The resulting free LC oscillator frequency should be located at the SAW resonator frequency or up to 5 MHz above.

Biasing of the transistor T1 is controlled by R4. It allows to control the collector current and thus the LO output signal. Its value has to be chosen so that the specified mixer conversion gain is reached (see [1]). Please note that the current through resistor R4 shall not exceed about 1mA permanently.

The tank circuit (L4, C14 and R6) at the output of the cascode stage is tuned to the SAW's series resonant frequency and suppresses unwanted harmonics of the LO. R6 is used to dampen the input signal of the frequency multiplier.

R5 has to be used to avoid parasitic oscillation of the LO due the SAW's static capacitance. The capacitance C13 decouples the SAW resonator and resistor R5 from DC to maintain proper transistor biasing.

2.2 Frequency multiplier

The multiplier stage is used as a buffer stage generating a balanced drive for the mixer stage as well as suppressing unwanted harmonics of the LO frequency (see Figure 2).

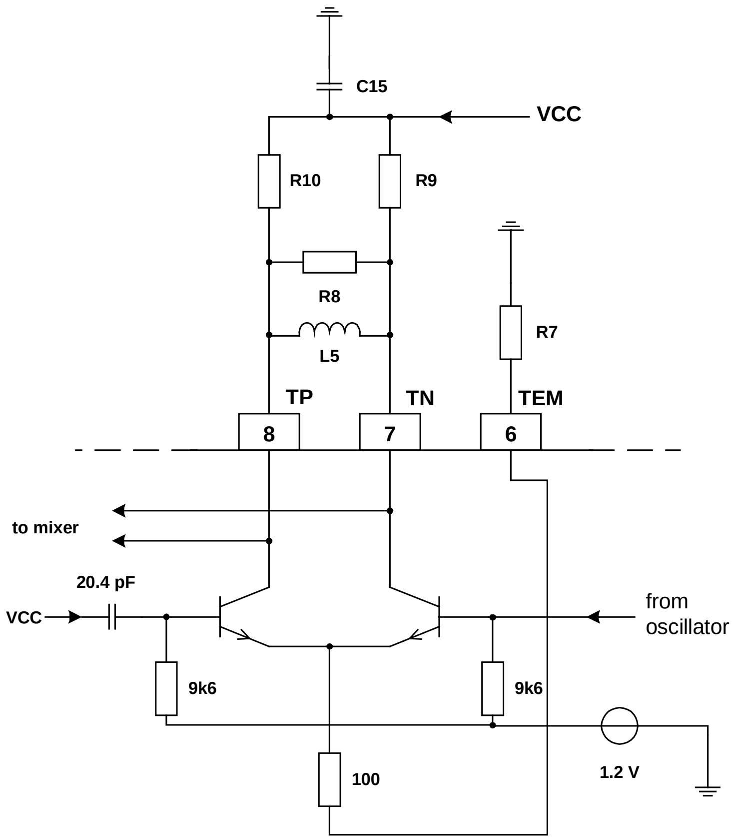

Figure 2: Usage of the frequency multiplier as a buffer stage

The collector load consists of resistor R9 and R10. The value of R7, R9 and R10 are chosen so that the DC-values as given in [1] are reached.

The SAW oscillator signal is an unbalanced signal injected into one side of the multiplier's differential amplifier. For this reason a DC-offset between the two collectors outputs exists during operation. Inductance L5 provides a DC short and thus a more balanced signal at the mixer input. Choosing the value of L5 such that it resonates with the IC input as well as the parasitic PCB capacitance provides additional frequency selectivity. Resistor R8 is used to dampen the multiplier output signal and hence to control the conversion gain of the mixer.

3. PCB LAYOUT GUIDELINES

The design of the PCB should be started with the layout of the **local oscillator** section, as this area is most important regarding spurious radiation and receiver sensitivity:

The Colpitts oscillator comprising the SAW resonator, the capacitors C11, C12 and C13 and the inductance L3 respectively draw a large RF current from the supply line. In order to minimise the RF current path –and thus spurious radiation from the LO-, the capacitor C16 bypasses the supply line to ground. Hence, the ground points of the SAW resonator, the capacitors C11 and C16 should be placed physically close together. The ground points of these components should be connected to a solid ground plane below the oscillator section at least with two vias each. Furthermore, capacitor C16 should be placed close to the oscillator tank circuit (L4, C14 and R6).

The requirement to minimise all RF paths brings about to place all components of the LO (SAW oscillator and multiplier) as close together as possible. Please note, that every millimetre of additional PCB line between the components adds about 1 nH inductance and thus acts as an additional source of radiation. The above described design goals can be reached easily using SMD capacitors and inductances of style 0603.

A solid ground plane should be provided below and around the local oscillator. This measure further minimises spurious radiation and coupling to the receiver front-end section respectively. Furthermore, stable oscillation conditions are provided.

The design should be continued with the **frequency multiplier** section, which should be symmetric and compact. The application note AN98104 (see chapter 7 in [2]) gives further detailed layout guidelines for the frequency multiplier and the remaining circuitry.

Special PCB layout design hints for the SAW front-end filter can be found in several application notes from SAW device manufacturers (see also chapter 5).

4. APPLICATION EXAMPLES

Figure 3 gives an application example for a carrier frequency of 433.92 MHz at a data rate of 1 kbps. The example allows the use of either ASK or FSK demodulation.

For FSK mode (with a frequency deviation of 10 kHz), jumper J1 has to be removed. The board offers the possibility to employ either a discrete parallel resonant circuit at pin 10 (DEMO1) and pin 11 (DEMO2) or an SMD style ceramic discriminator (see chapter 5, available for a temperature range from –10° to +50°C only).

Please note that the given component values have been adapted to the board layout (see chapter 4.2). Other PCB designs may require different component values.

4.1 Receiver schematic

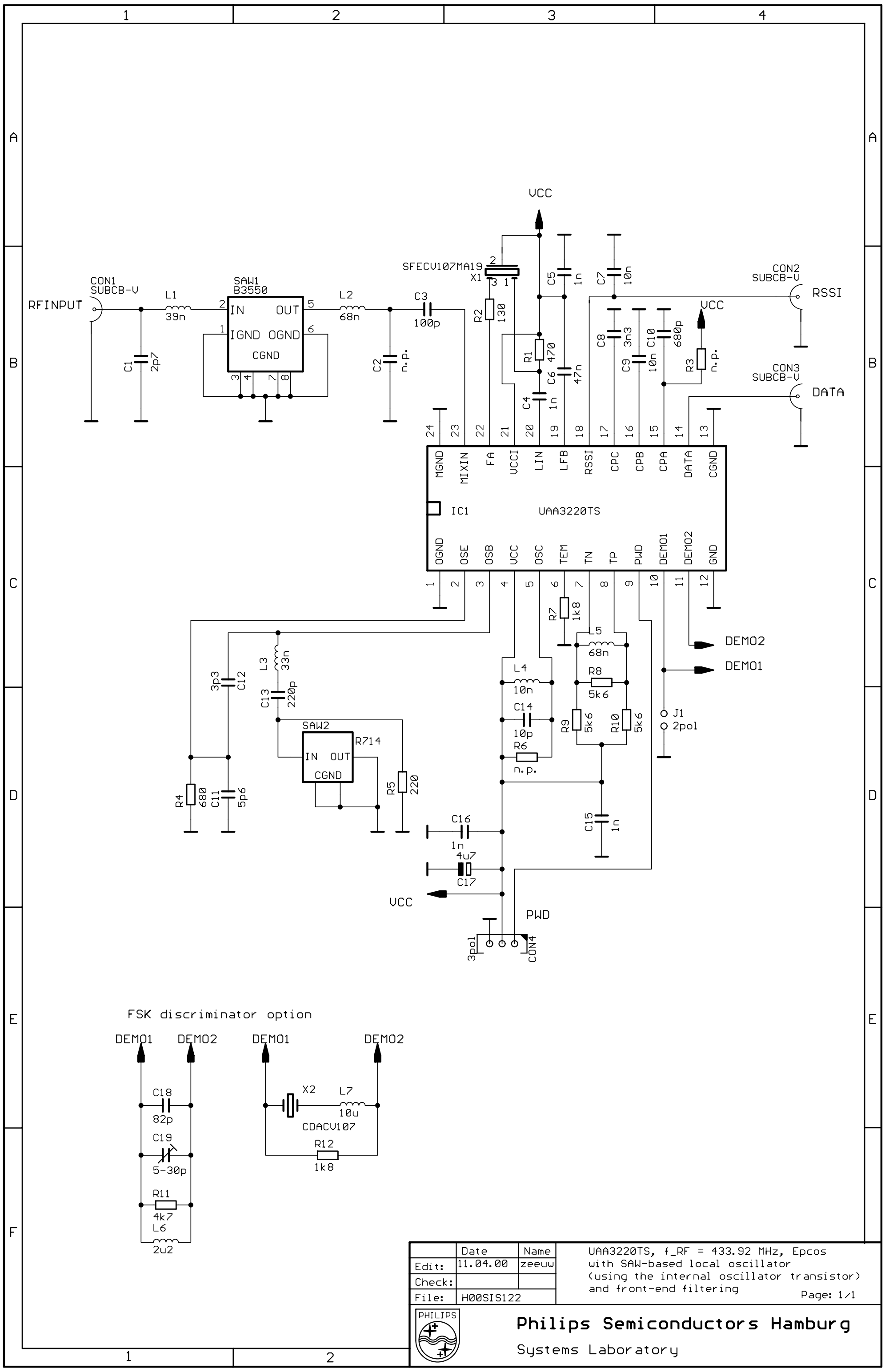

Figure 3: Typical application for f_{RF} = 433.92 MHz

4.2 PCB layout

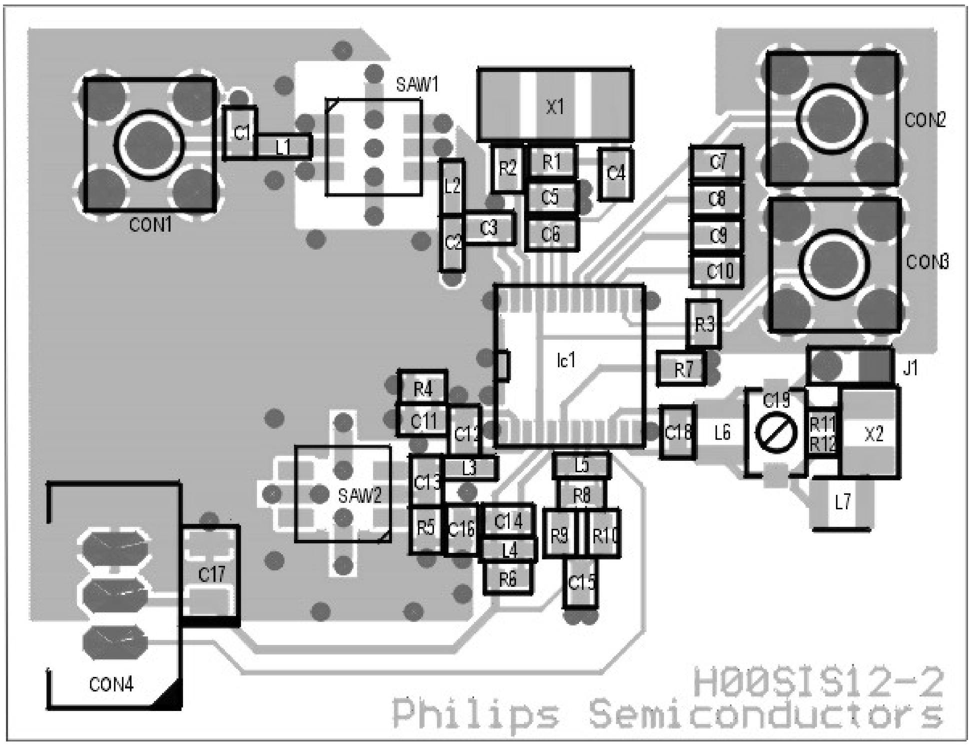

Figure 4: H00SIS12-2 layout and components placement

4.3 Typical electrical characteristics

Sensitivity performance

The LeCroy LC584AXL oscilloscope -including the "Jitter and Timing Analysis (JTA)" software option- has been used to measure the sensitivity. The sensitivity limit was defined as follows: 99,9% of the data output signal had to have a duty cycle deviation of smaller than 5%. Typical sensitivity performance at a data rate f_{Data} = 1kbps (square shaped, duty cycle 50%), f_{RF} = 433.92 MHz and at room temperature:

- ASK modulation : **-110 dBm**
- FSK modulation : **- 99 dBm**

Spurious radiation

Spurious radiation was measured at the RF-input connector and was smaller than –90 dBm for the local oscillator frequency and smaller than –110 dBm for the second harmonic of the LO.

Current consumption

The current consumption at room temperature was measured to:

- ASK modulation : **3.9 mA**
- FSK modulation : **4.5 mA**

5. LIST OF MANUFACTURERS

The following list gives an overview over selected components and their manufacturers used for the described application circuits. The given internet addresses offer links to specifications, application notes and the corresponding sales representatives/distributors.

Manufacturer	Selected components
Murata Manufacturing Co., Ltd 26 10, Tenjin 2-chome, Nagaokakyo-shi Kyoto 617-8555, Japan Phone (075) 951-9111 http://www.iijnet.or.jp/murata/index.html	ceramic filters and discriminators: SFECV 10.7MS3A10, SFECV10.7MA2, SFECV10.7MA19…. chip coils: Series LQP11A and LQG11A
Epcos AG Geschäftsbereich Oberflächenwellenkomponenten Anzinger Str. 13 München Phone +49-89-636-233 59 http://www.epcos.com	SAW resonators: R714, R712 ... SAW filters: B3550, B3551…

6. REFERENCES

[1] Data Sheet UAA3220TS, Frequency Shift Keying (FSK)/Amplitude Shift Keying (ASK) receiver; 1998 Nov 26

[2] Application Note: UAA3220TS, AN98104; 1998 November 18

[3] Application Note: UAA3220TS with SAW-stabilised local oscillator , AN99044; 1999 August 31