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Applying the oscillator of the SA602A in low-power mixer applications

Rev. 2 — 29 August 2014 **Application note**

Document information

Info	Content
Keywords	Gilbert cell mixer, LC tank circuit, dual gate MOSFET, Colpitts oscillator.
Abstract	This application note discusses applying the oscillator of the SA602A in low power mixer applications. The SA602A consists of a Gilbert cell mixer, a buffered emitter follower oscillator, and RF current and voltage regulator. The simplicity of the oscillator affords many configurations which may be easily implemented to achieve good performance at frequencies to 500 MHz.

Revision history

Rev	Date	Description
2	20140829	Application note; second release Modifications: • SA602 replaced with SA602A
1.0	19971023	Application note; initial release

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1. Introduction

For the designer of low power RF systems, the NXP Semiconductors SA602A mixer/oscillator provides mixer operation beyond 500 MHz, a versatile oscillator capable of operation to 200 MHz, and conversion gain, with only 2.5 mA total current consumption. With a proper understanding of the oscillator design considerations, the SA602A can be put to work quickly in many applications.

2. Description

Figure 1 shows the equivalent circuit of the device. The chip is actually three subsystems: A Gilbert cell mixer (which provides differential input gain), a buffered emitter follower oscillator, and RF current and voltage regulation. Complete integration of the DC bias permits simple and compact application. The simplicity of the oscillator permits many configurations.

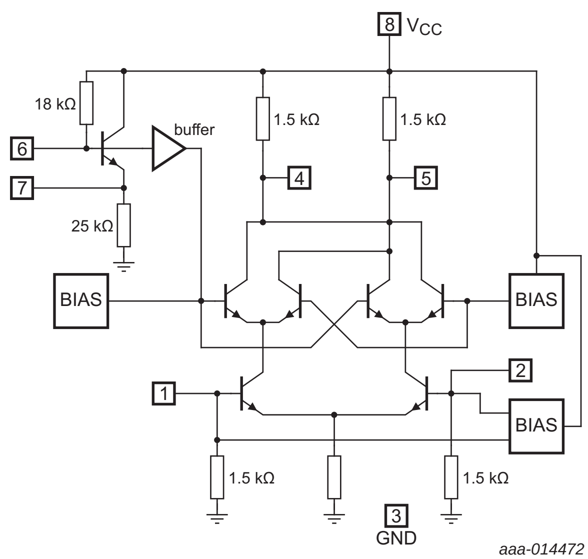


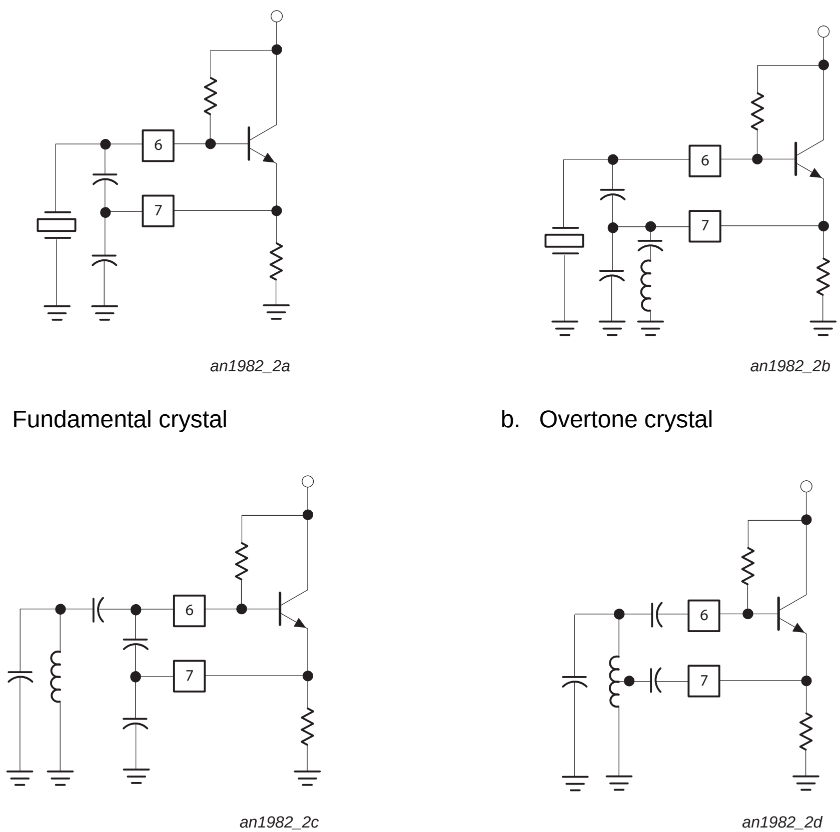
Fig 1. Equivalent circuit

While the oscillator is simple, oscillator design is not. This article will not address the rigors of oscillator design, but some practical guidelines will permit the designer to accomplish good performance with minimum difficulty.

Either crystal or LC tank circuitry can be employed effectively. Figure 2 shows the four most commonly used configurations in their most basic form.

In each case, the Q of the tank will affect the upper frequency limits of oscillation: the higher the Q the higher the frequency. The SA602A is fabricated with a 6 GHz process, but the emitter resistor from Pin 7 to ground is nominally 20 kΩ. With 0.25 mA typical bias current, 200 MHz oscillation can be achieved with high Q and appropriate feedback.

The feedback, of course, depends on the Q of the tank. It is generally accepted that a minimum amount of feedback should be used, so even if the choice is entirely empirical, a good trade-off between starting characteristics, distortion, and frequency stability can be quickly determined.



a. Fundamental crystal

b. Overtone crystal

c. Colpitts L/C tank

d. Hartley L/C tank

Fig 2. Oscillator configurations

2.1 Crystal circuit considerations

Crystal oscillators are relatively easy to implement since crystals exhibit higher Qs than LC tanks. Figure 3 shows a complete implementation of the SA602A (extended temperature version) for cellular radio with a 45 MHz first IF and 455 kHz second IF.

The crystal is a third-overtone parallel mode with 5 pF of shunt capacitance and a trap to suppress the fundamental.

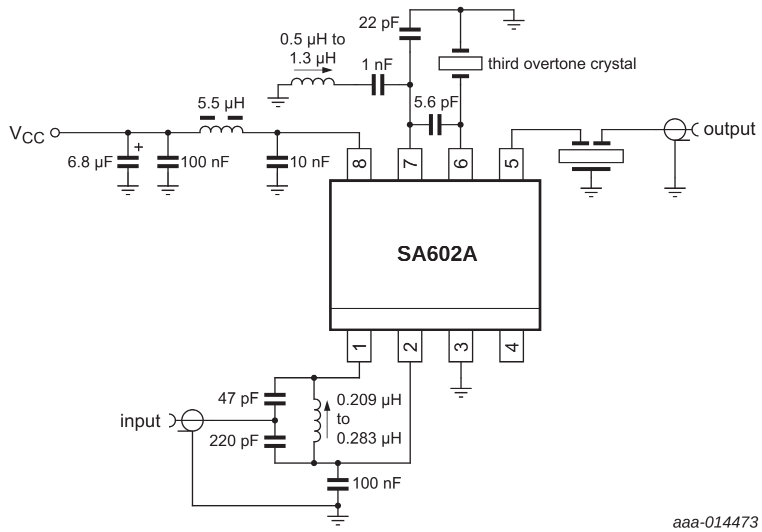


Fig 3. Cellular radio application

2.2 LC tank circuits

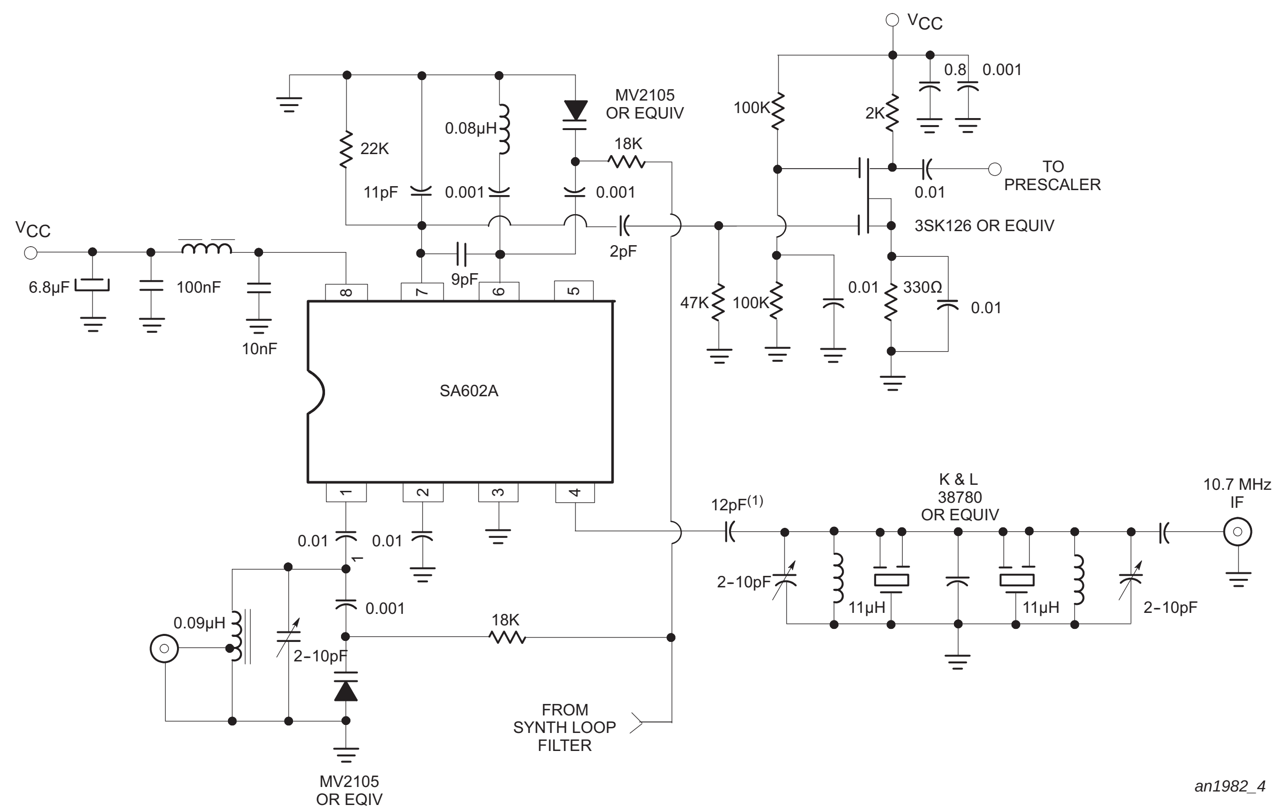
LC tanks present a little greater challenge for the designer. If the Q is too low, the oscillator will not start. A trick which will help if all else fails is to shunt Pin 7 to ground with a 22 kΩ resistor. In actual applications this has been effective to 200 MHz with high Q ceramic capacitors and a tank inductor of 0.08 μH and a Q of 90. Smaller resistor value will upset DC bias because of inadequate base bias at the input of the oscillator. An external bias resistor could be added from V_{CC} to Pin 6, but this will introduce power supply noise to the frequency spectrum.

The Hartley configuration (Figure 2d) offers simplicity. With a variable capacitor tuning the tank, the Hartley will tune a very large range since all of the capacitance is variable. Note that the inductor must be coupled to Pin 7 with a low-impedance capacitor.

The Colpitts oscillator will exhibit a smaller tuning range since the fixed-feedback capacitors limit variable capacitance range; however, the Colpitts has good frequency stability with proper components.

2.3 Synthesized frequency control

The SA602A can be very effective with a synthesizer if proper precautions are taken to minimize loading of the tank and the introduction of digital switching transients into the spectrum. Figure 4 shows a circuit suitable for aircraft navigation frequencies (108 MHz to 118 MHz) with 10.7 MHz IF.

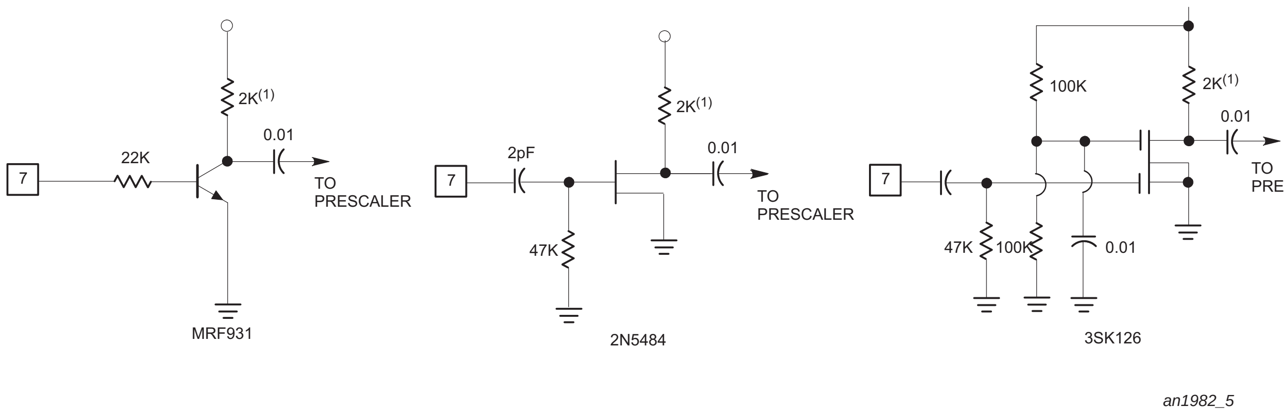


(1) Permits impedance match of SA602A output, i.e.: 1.5k filter impedance

Fig 4. Application circuit

The dual-gate MOSFET provides a high degree of isolation from prescaler switching spikes. As shown in Figure 4, the total current consumption of the SA602A and 3SK126 is typically 3 mA. The MOSFET input is from the emitter of the oscillator transistor to avoid loading the tank. The Gate 1 capacitance of the MOSFET in series with the 2 pF coupling capacitor adds slightly to the feedback capacitance ratio. Use of the 22 kΩ resistor at Pin 7 helps assure oscillation without upsetting DC bias.

For applications where optimum buffering of the tank, or minimum current are not mandatory, or where circuit complexity must be minimized, the buffers shown in Figure 5 can be considered.



(1) 2k or as necessary for current limits or prescaler impedance match.

Fig 5. Buffer options

The effectiveness of the MRF931 (or other VHF bipolar transistors) will depend on frequency and required input level to the prescaler. A bipolar transistor will generally provide the least isolation. At low frequencies the transistor can be used as an emitter-follower, but by VHF the base emitter junction will start to become a bidirectional capacitor and the buffer is lost.

The 2N5484 has an IDSS of 5 mA (max) and the 3SK126 has IDSS of 6 mA (max), making them suitable for low parts count, modest current buffers. The isolation is good.

2.4 Injected LO

If the application calls for a separate local oscillator, it is acceptable to capacitively-couple 200 mV to 300 mV at Pin 6.

3. Summary

The SA602A can be an effective low power mixer at frequencies to 500 MHz with oscillator operation to 200 MHz. All DC bias is provided internal to the device, so very compact designs are possible. The internal bias sets the oscillator DC current at a relatively low level, so the designer must choose frequency selective components which will not load the transistor. If the guidelines mentioned are followed, excellent results will be achieved.

4. Abbreviations

Table 1. Abbreviations

Acronym	Description
RF	Radio Frequency
LC	inductor-capacitor network
IF	Intermediate Frequency

Table 1. Abbreviations *…continued*

Acronym	Description
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
VHF	Very High Frequency
IDSS	drain-source saturation current (VGS = 0 V)

5. References

[1] **SA602A —** Product data sheet; NXP Semiconductors; www.nxp.com/documents/data_sheet/SA602A.pdf

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7. Contents

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