

APPLICATION NOTE

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Applying the oscillator of the SA602 in
low-power mixer applications

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INTRODUCTION

For the designer of low power RF systems, the Philips Semiconductors SA602 mixer/oscillator provides mixer operation beyond 500MHz, a versatile oscillator capable of operation to 200MHz, and conversion gain, with only 2.5mA total current consumption. With a proper understanding of the oscillator design considerations, the SA602 can be put to work quickly in many applications.

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.

While the oscillator is simple, oscillator design isn't. 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 SA602 is fabricated with a 6GHz process, but the emitter resistor from Pin 7 to ground is nominally 20k. With 0.25mA typical bias current, 200MHz 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.

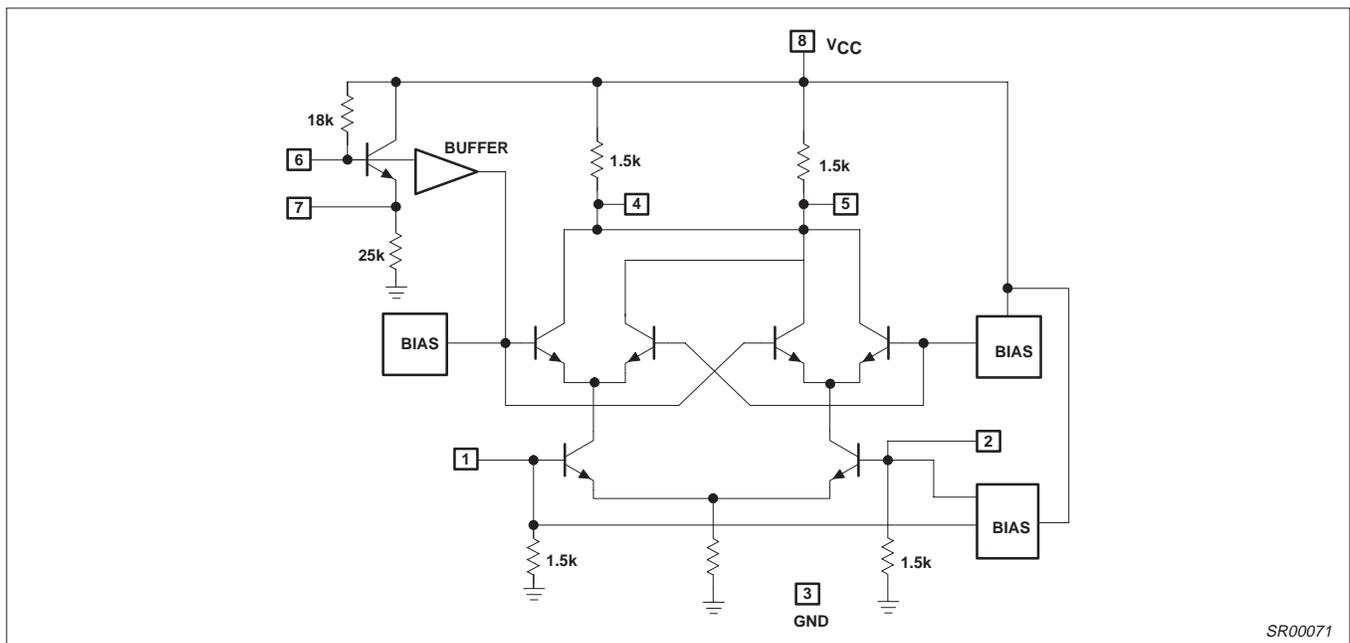


Figure 1. Equivalent Circuit

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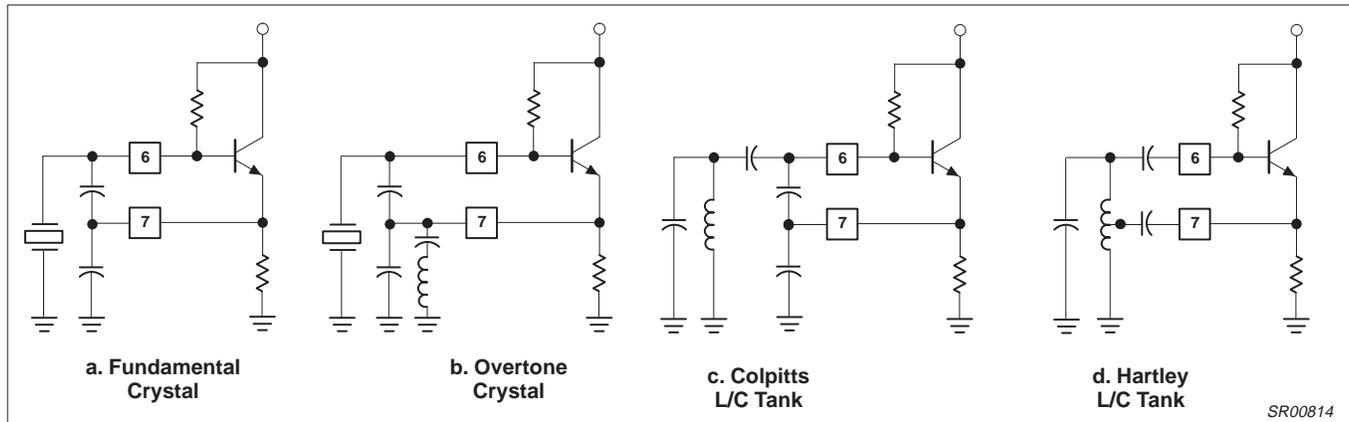


Figure 2.

Crystal Circuit Considerations

Crystal oscillators are relatively easy to implement since crystals exhibit higher Q's than LC tanks. Figure 3 shows a complete implementation of the SA602 (extended temperature version) for cellular radio with a 45MHz first IF and 455kHz second IF.

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

LC Tank Circuits

LC tanks present a little greater challenge for the designer. If the Q is too low, the oscillator won't start. A trick which will help if all else fails is to shunt Pin 7 to ground with a 22k resistor. In actual applications this has been effective to 200MHz with high Q ceramic capacitors and a tank inductor of 0.08mH 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 VCC 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. Please 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.

Synthesized Frequency Control

The SA602 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 (108–118MHz) with 10.7MHz IF.

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 SA602 and 3SK126 is typically 3mA. 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 2pF coupling capacitor adds slightly to the feedback capacitance ratio. Use of the 22k 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.

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

Injected LO

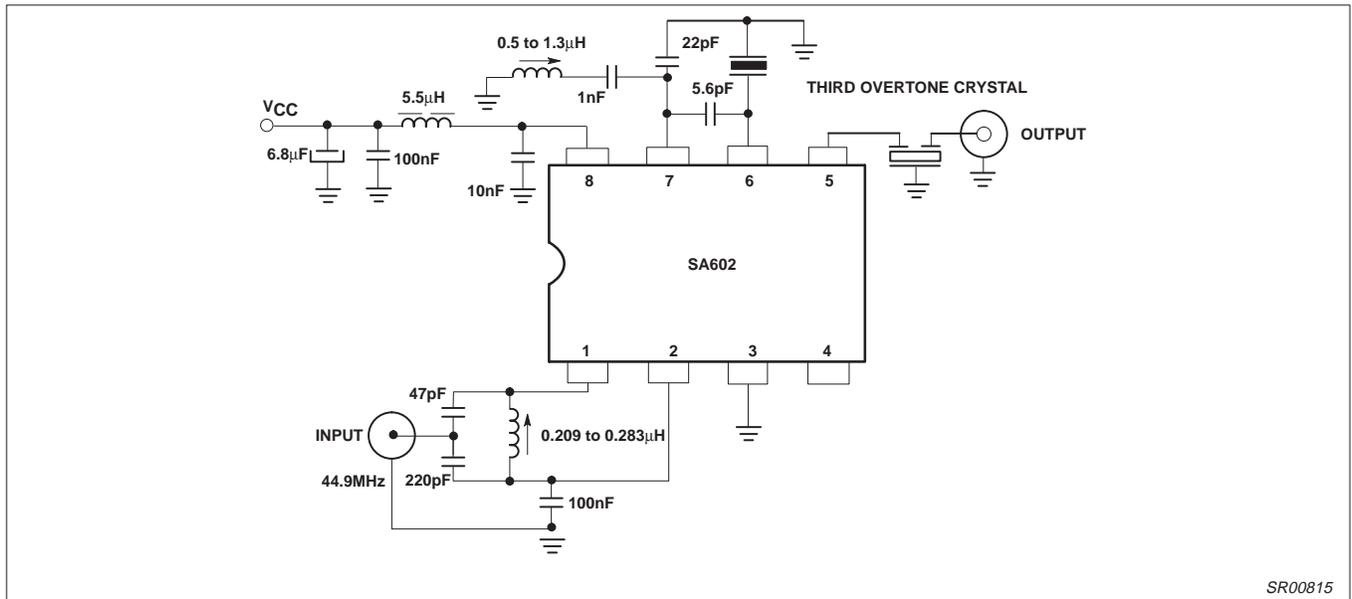
If the application calls for a separate local oscillator, it is acceptable to capacitively-couple 200 to 300mV at Pin 6.

Summary

The SA602 can be an effective low power mixer at frequencies to 500MHz with oscillator operation to 200MHz. 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.

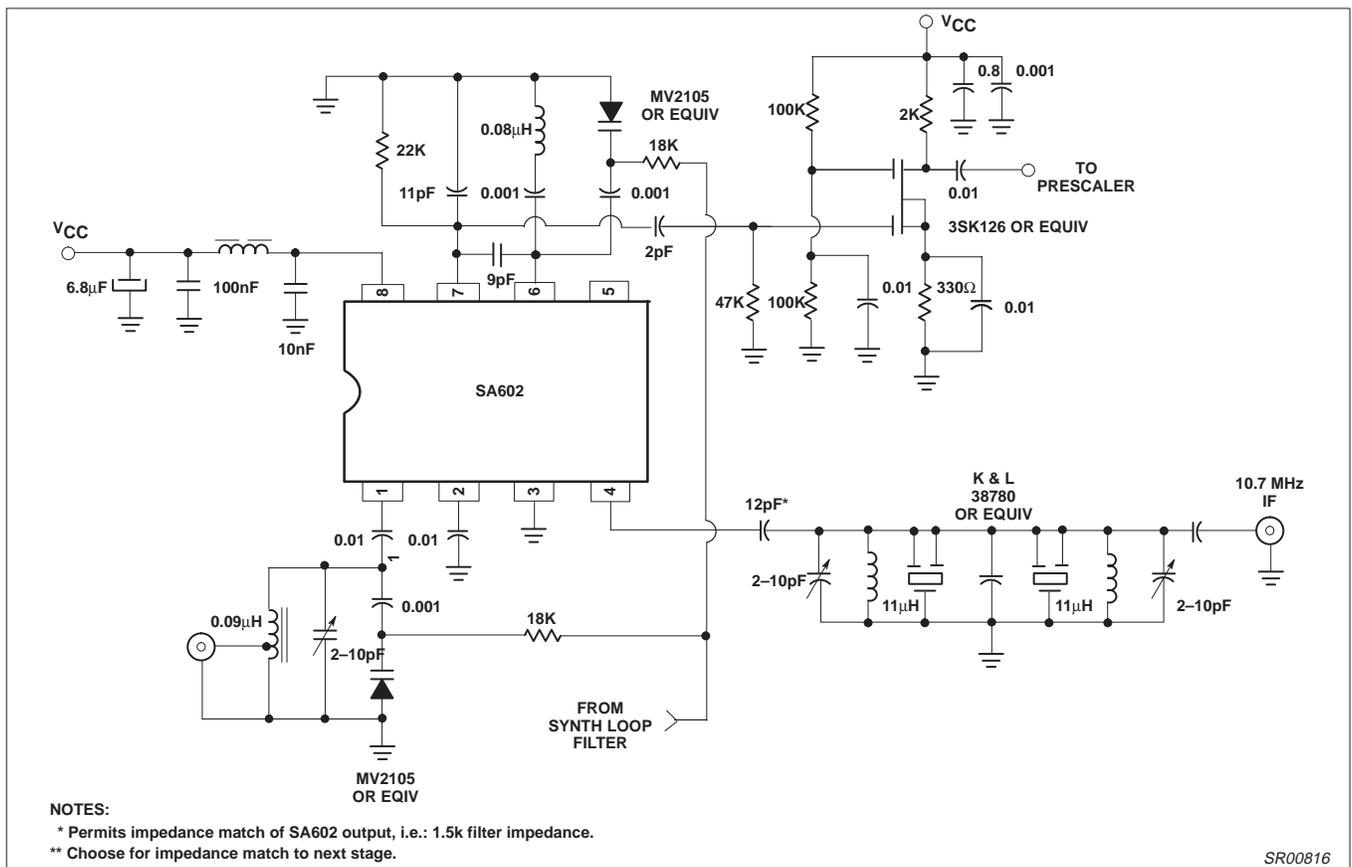
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Figure 3. Cellular Radio Application



NOTES:
 * Permits impedance match of SA602 output, i.e.: 1.5k filter impedance.
 ** Choose for impedance match to next stage.

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Figure 4.

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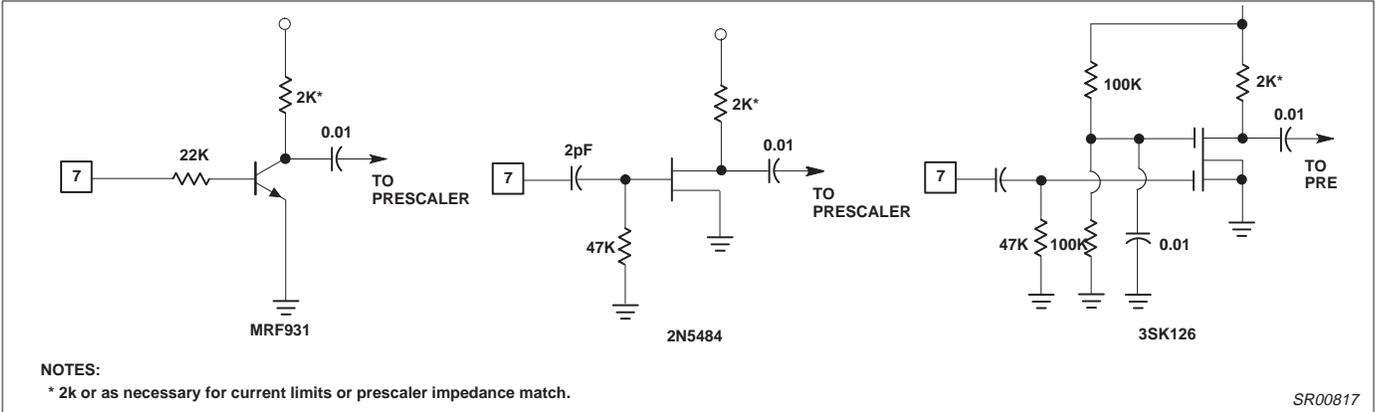


Figure 5.