Application Note No. 002

Silicon Bipolar - Dielectric Resonator Oscillator (DRO) at 10 GHz using BFP405

RF & Protection Devices

Never stop thinking

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Silicon Bipolar - Dielectric Resonator Oscillator (DRO) at 10 GHz using BFP405 Revision History: 2007-07-12, Rev. 2.1	
Previous Version: 2006-11-14	
Page	**Subjects (major changes since last revision)**
1	Correction of document title

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1 Silicon Bipolar - Dielectric Resonator Oscillator (DRO) at 10 GHz

Oscillators represent the basic microwave energy source for all microwave systems such as radar, communications and navigation. A typical oscillator essentially consists of an active device and a passive frequency-determining resonant element such as a dielectric resonator for fixed-frequency oscillators or a varactor for a tunable oscillator. The emphasis has been on high output-power, low noise, small size, low cost, high reliability and high temperature stability.

The new SIEGET®25 BFP405 (SIEMENS Grounded Emitter Transistor) offers now the extension of plastic packaged bipolar transistor oscillators up to 12 GHz (**Figure 1**)

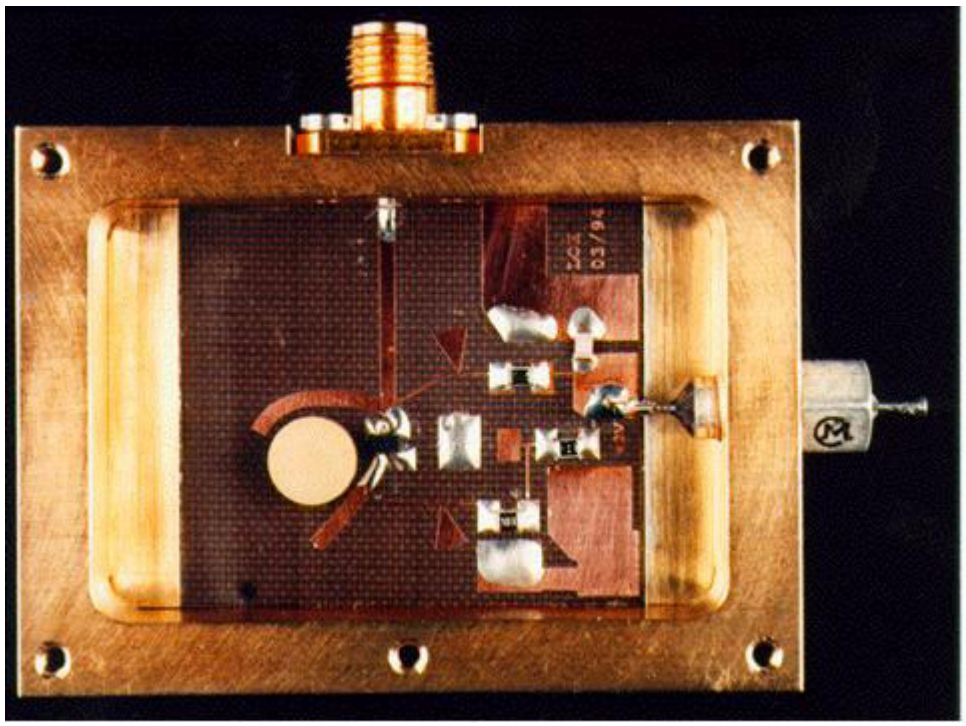

Figure 1 Lab-version of a parallel feedback stabilized oscillator at 10 GHz

This DRO is shown without top-plate, tuning screw and 1 pF blocking capacitor.

There are two categories of fixed oscillators:

- Serial feedback
- Parallel feedback

In the serial feedback case the transistor gain must be higher, because the coupling from the resonator to the microstripline is not that strong and also the emitter cannot be directly connected to the ground potential. Therefore the parallel feedback configuration is a good choice.

Highly selective positive feedback between base and collector of the transistor can be used to create stable oscillations. This is achieved by feeding back part of the output signal into the input signal. There are two conditions for oscillation:

- Open-loop phase shift at f_0 has to be $2\pi n$ n = 0, 1, 2, ...
- Open-loop small signal gain must exceed unity

At oscillator start up, the loop gain is greater than one with phase of $2\pi n$. As the signal level builds up from noise, limiting takes place and steady state condition is reached.

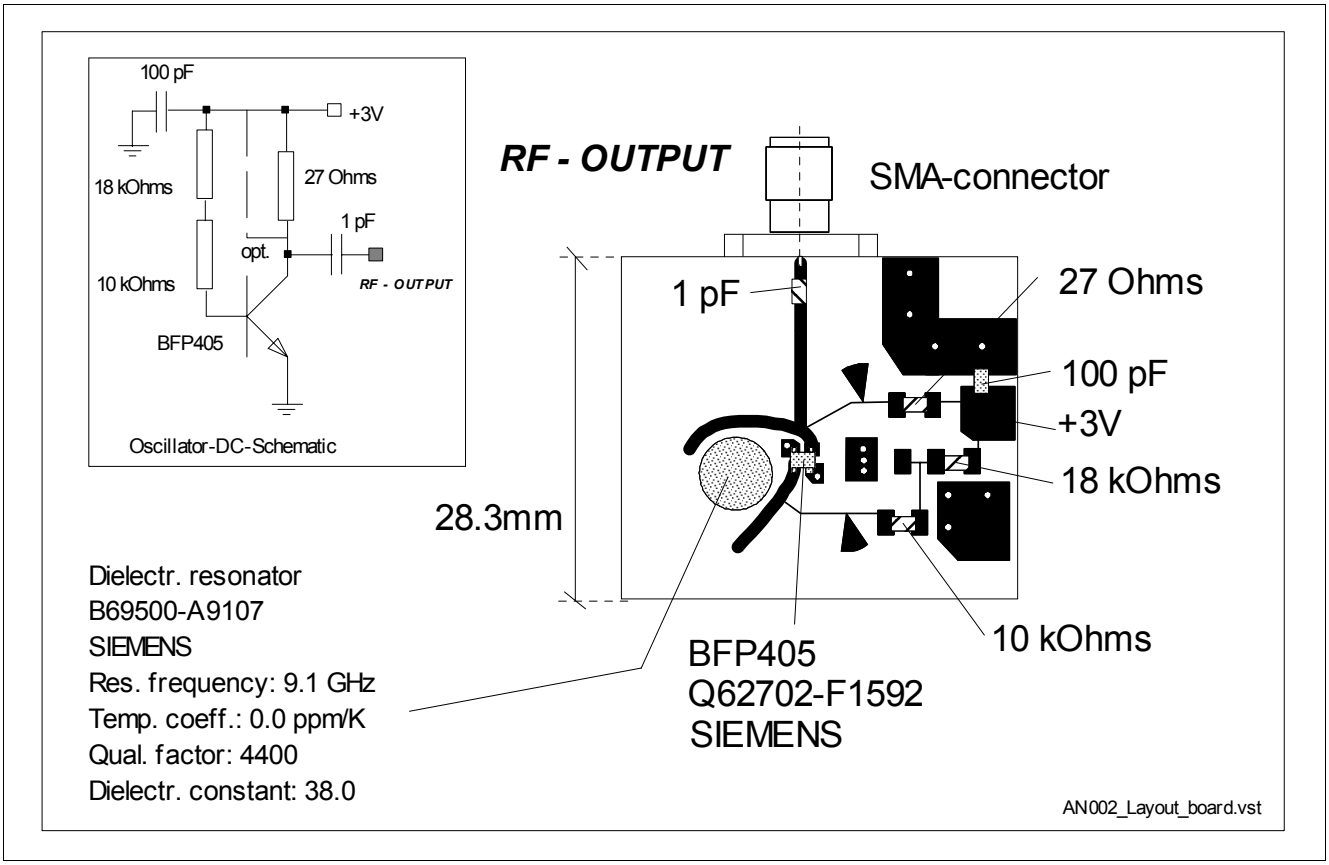

Figure 2 Layout of the silicon DRO on a PTFE-board (ε_r = 2.45, h = 0.38 mm, t = 17.5 µm copper)

The 10 GHz-oscillator in **Figure 1** / **Figure 2** exhibits an output-power of +3 dBm at 50 Ω , a phase noise of typical < -80 dbc/Hz at 10 kHz offset and a temperature stability unoptimized of ±3 MHz at -20 °C to 60 °C. The operation voltage of +3 V causes a device current of 8 mA.

The biasing circuit uses a 27 Ω collector resistor and a base resistor of 10 kΩ and 18 kΩ. Please keep in mind, that the feedback from base to the + 3 V -pad and to the collector port of the transistor has to be minimized by filtering (**Figure 2**) or by using an active biasing circuit.

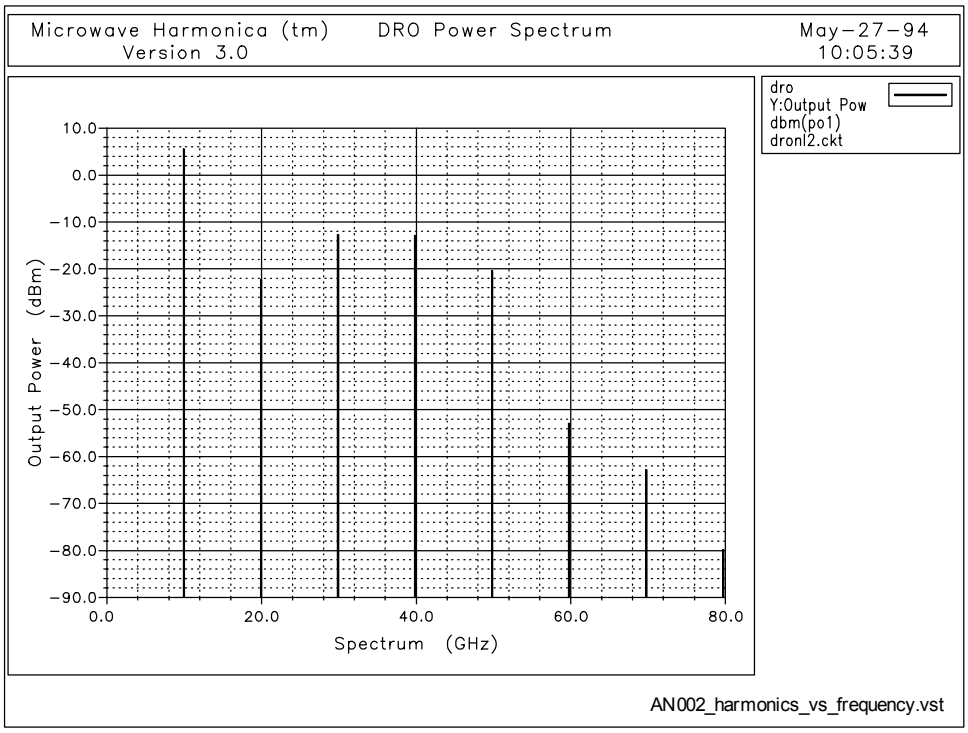

Figure 3 Simulated harmonics versus frequency of the oscillator (description above)

Figure 3: By using the nonlinear parameters of the BFP405 and a CAD-program (Microwave Harmonica) one can easily determine the harmonics of the oscillator.

A new DC-bias-circuit shows better stability (**Figure 4**).The oscillator exhibits a phase-noise of -85 dBc/Hz at 10 kHz offset (**Figure 6** / **Figure 7**). By using a spacer a 15 dB reduction of the phase noise can be achieved.

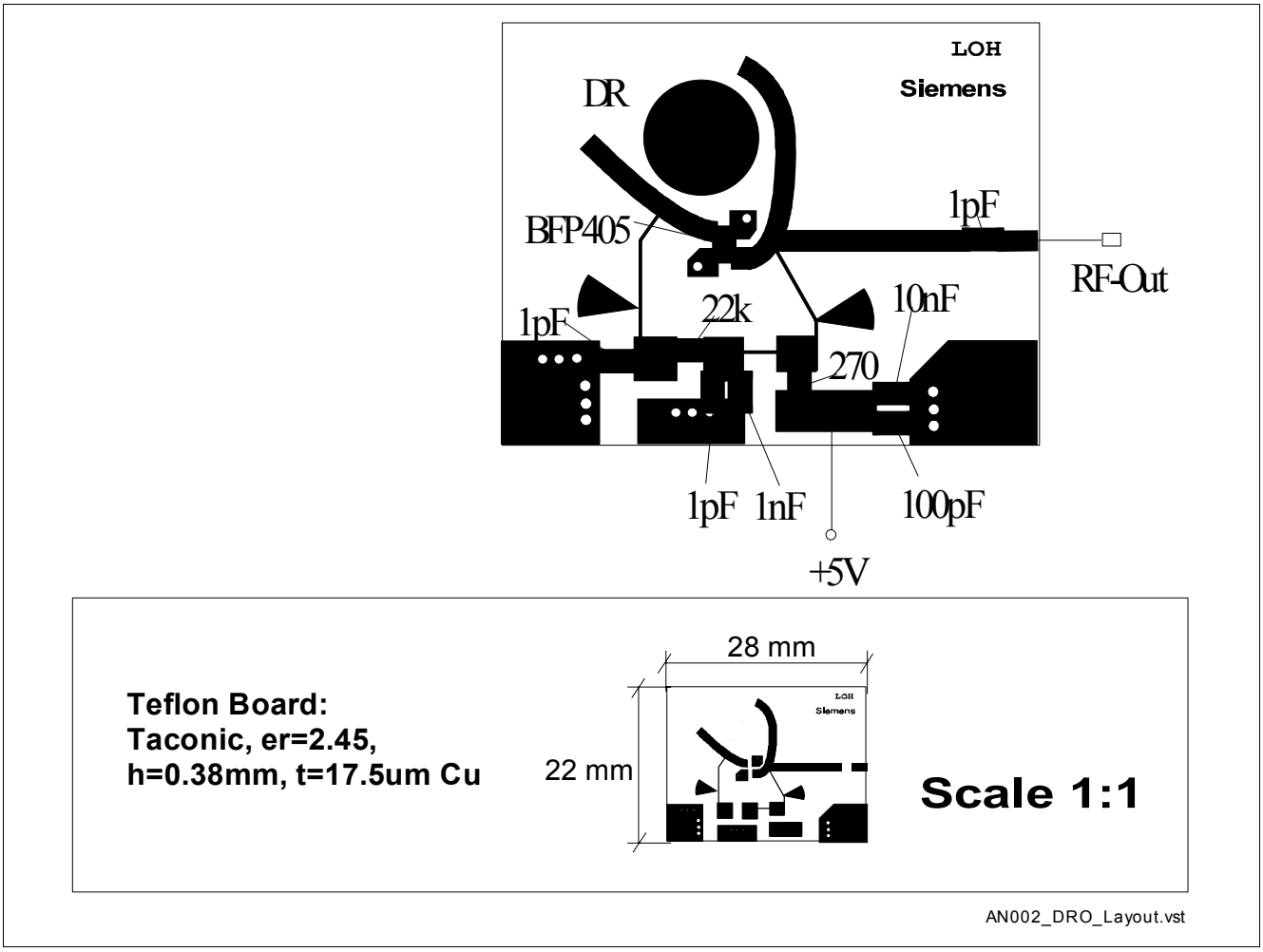

Figure 4 Layout of the DRO-Redesign

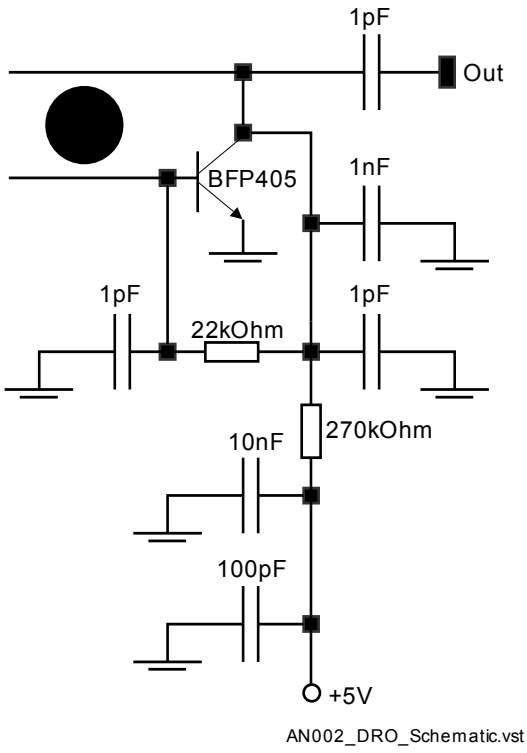

Figure 5 Schematic of the DRO-Redesign

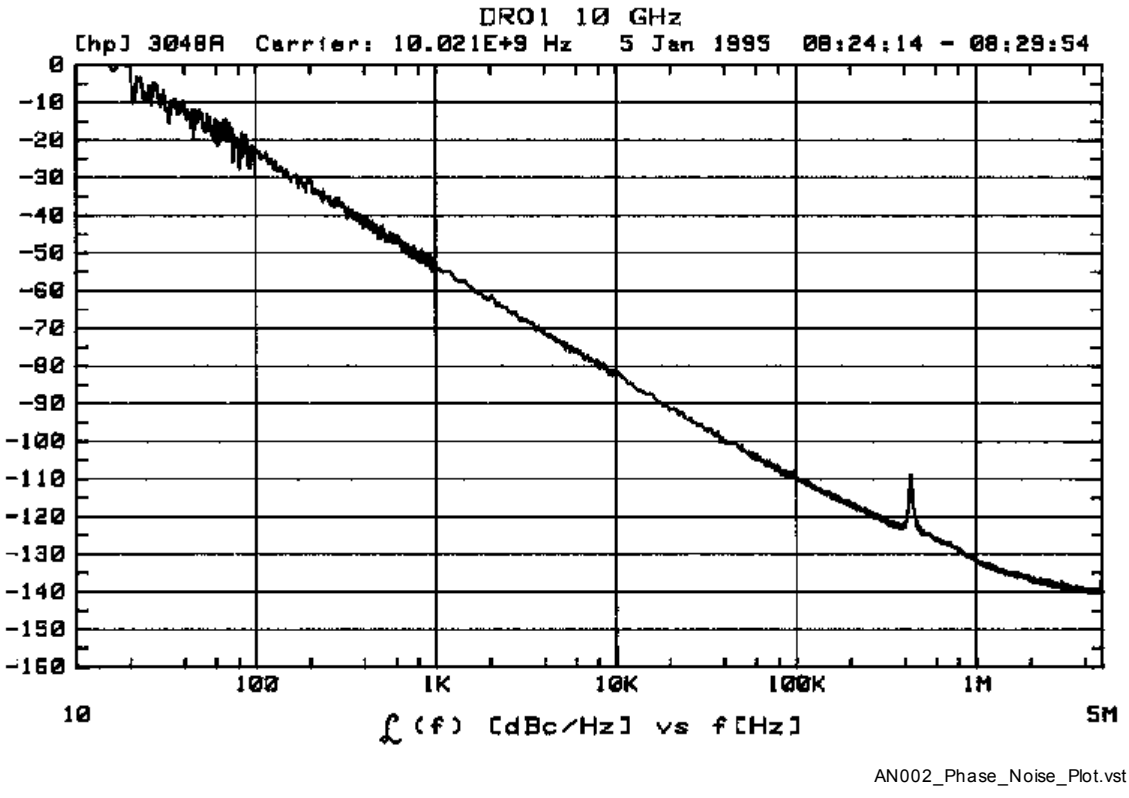

Figure 6 Phase Noise plot

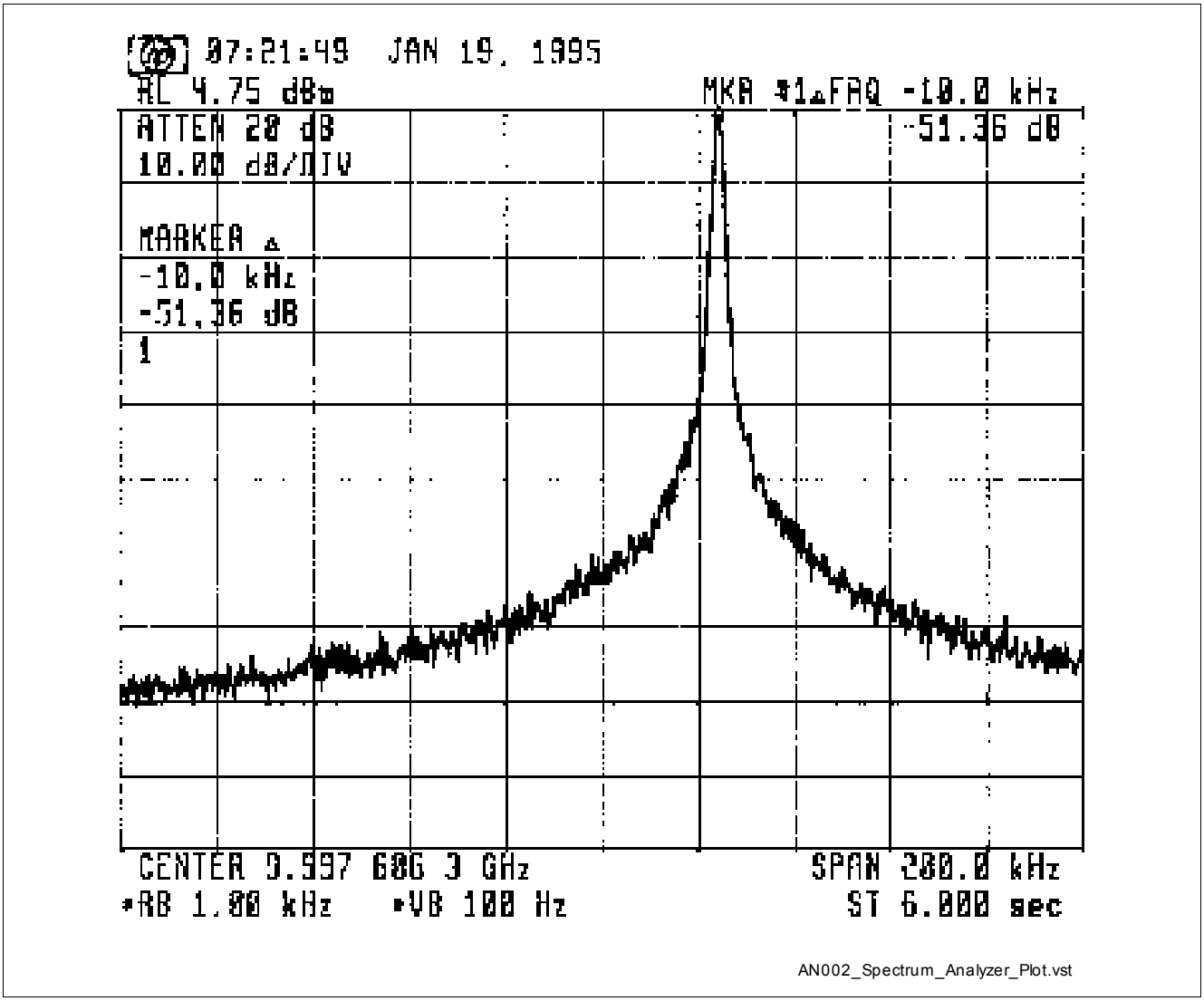

Figure 7 Spectrum-Analyzer plot GHz DRO

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