PRODUCT FEATURE

Miniature Ultra-High Speed Synthesizer Covers 2.25 to 18 GHz for Broad Applications Flexibility

by Wide Band Systems, Inc.

A new miniature wide band frequency synthesizer that operates from 2.25 GHz to 18 GHz, permits 3µS tuning, exhibits volume of 334.3 cc (20.4in^3), consumes just 25W DC power, and provides a clean RF output spectrum with an absolute accuracy better than 10 KHz has been introduced by Wide Band Systems, Inc., Receiver Systems Division. The ultra-high switching speed of this new synthesizer (typically 1000 times faster than similar devices), its ability to seamlessly cover an extremely broad bandwidth range, low power draw, and low phase noise characteristics make it ideal for a variety of applications for test equipment, simulator systems, and as local oscillators in advanced receiver systems.

The new synthesizer (patent pending) represents a new class of microwave frequency synthesizers, according to the company. Its design is based upon wide band frequency locking a voltage controlled oscillator (VCO) to a clock reference. In this configuration, a pair of sub-octave VCOs are doubled and then redoubled to provide single band 2.25 GHz to 18 GHz frequency coverage, substantially enhancing its versatility and usefulness.

The new synthesizer's small size (only 12.7 x 195 x 135 mm) and low power requirement opens a variety of new applications possibilities, especially when combined with its fast acquisition times and enhanced accuracy. Ultra-high speed switching capabilities permit faster receiver tuner acquisition of emitter signals. The capabilities make the new Wide Band synthesizer ideal for use as a local oscillator (LO) in fast tuning superheterodyne receivers. For this application, the synthesizer provides substantial improvement in tuning times and spurious signal generation, with acceptable phase noise and frequency accuracy.

The new Wide Band frequency synthesizer is being produced in three different physical configurations, all of which incorporate a basic circuit design (See **Figure 1**): The 2U rack chassis illustrated by **Figure 2**; the replacement synthesizer package shown in **Figure 3**; and, the integrated package of **Figure 4**. All three designs share the same circuits; the 2U rack chassis was configured to meet a specific installation requirement; the replacement synthesizer package was physically designed to replace a prior phase lock synthesizer design; and the integrated synthesizer configuration is a component of an airborne Radar Warning Receiver (RWR) system.

All three designs share the following basic performance characteristics:

RF output frequency range:	**2.25-18 GHz**
RF output frequency resolution:	**1 MHz**
	(Available frequency resolution is down to 3.9 KHz)

Output frequency accuracy:	**10 KHz (Figure 5)**
Harmonic and spurious outputs:	**-60dBc**

Phase Noise:

Output Frequency	**@10 KHz Offset**	**@1 MHz Offset**	**Figure**
2674.5 MHz:	**-86 dBc/Hz**	**-96 dBc/Hz**	**6A**
3801.0 MHz:	**-76 dBc/Hz**	**-95 dBc/Hz**	**7A**
10698 MHz:	**-73 dBc/Hz**	**-88 dBc/Hz**	**8A**
15204 MHz:	**-65 dBc/Hz**	**-82 dBc/Hz**	**9A**

(Each phase noise graph is provided with the corresponding output power spectral density graph, as **Figures 6B**, **7B**, **8B**, and **9B**.)

Tuning time (Figure 10):	**Typical 3µS, maximum 7µs**

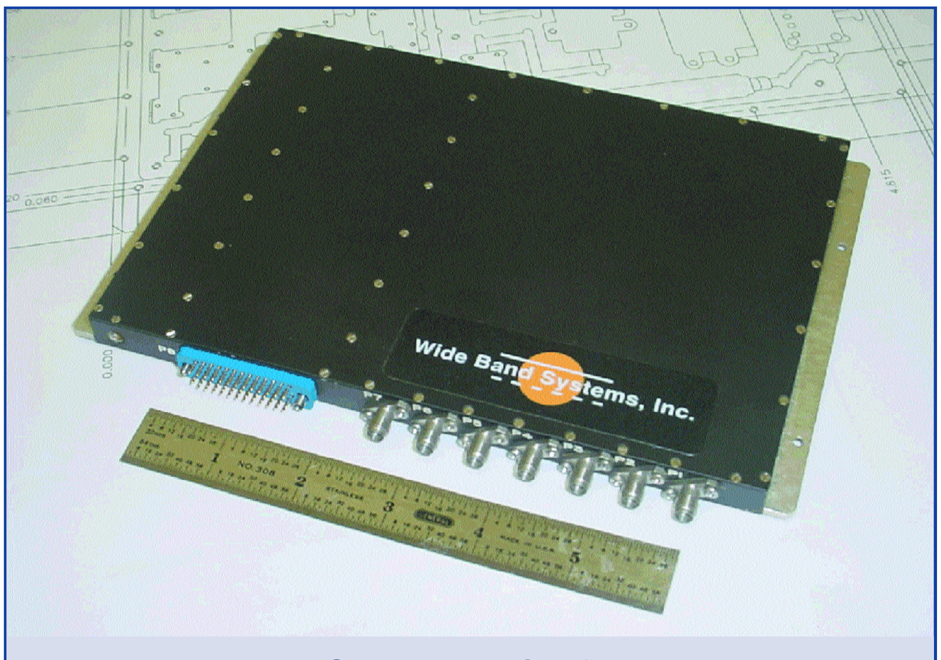

Figure 4: Integrated Synthesizer Configuration

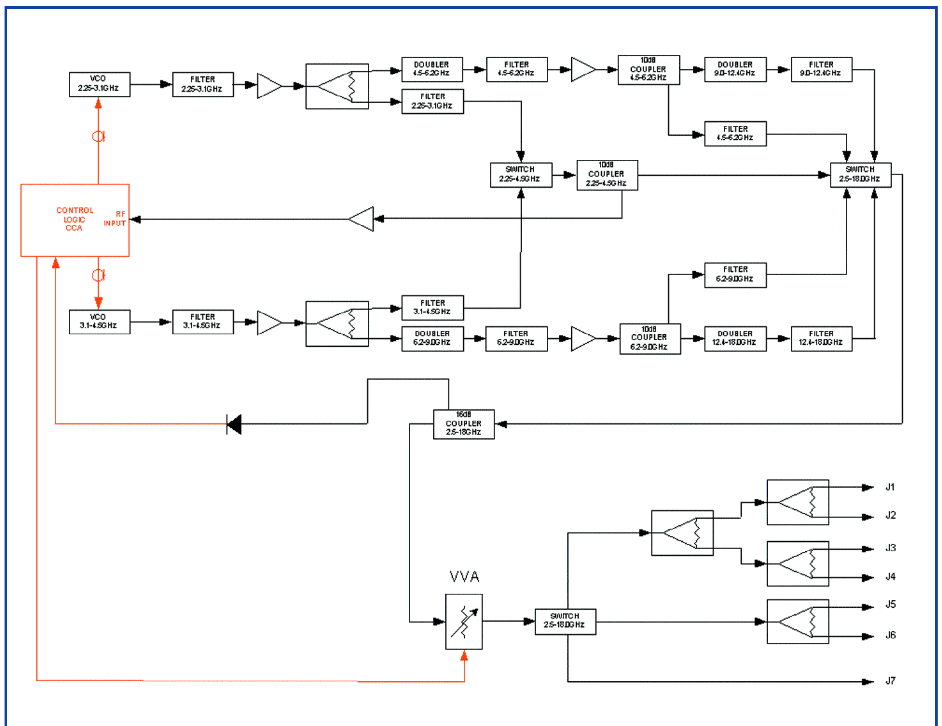

Figure 1: Synthesizer RF Circuits

Dimensions:

2U Rack synthesizer chassis	**RETMA 2U rack chassis**
Replacement synthesizer chassis:	**120.90 x 222.25 x 120.65 mm**
	4.76 x 8.75 x 4.75 in.
Integrated synthesizer chassis*:	**135 x 195 x 12.7 mm**
	5.315 x 7.677 x 0.500 in.
DC Power:	**22 W**

*Dimensions for the integrated synthesizer chassis do not include the cooling fins.

With respect to tuning time, as illustrated in **Figure 10**, the synthesizer blanks the RF output during an output frequency transition. When a synthesizer is employed as a Local Oscillator (LO) in a narrow IF bandwidth tuner, failure to blank the LO when changing the LO frequency may produce an uncontrolled spurious frequency to appear in the IF filter. The tuner would then have to wait until this spurious filter response dies out; a narrow band IF filter can waste substantial receiver time. Since the synthesizer operates by comparing the current VCO frequency to the input selected RF frequency, the digital processing automatically blanks the synthesizer RF output as soon as a strobe is

Wide Band, Continued on pg X

Figure 2: Synthesizer 2U Rack Configuration

Figure 3: Synthesizer Replacement Configuration

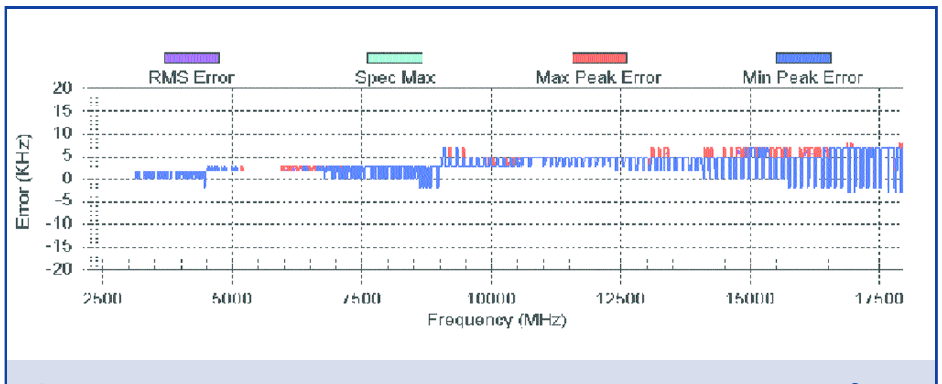

Figure 5: Measured RF Frequency Accuracy, 2.25 - 18 GHz.

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received loading new frequency data. Blanking is released when the processor determines that the synthesizer output frequency is within a preset margin with respect to the programmed frequency. For the data shown in **Figure 10**, this margin was set at 1MHz. If a fault should occur in the synthesizer (where the output frequency is not measured to be within this preset margin), the synthesizer will remain blanked and an output error flag will be set.

Since the processing and control of the VCO is accomplished digitally using high speed programmable gate arrays, the synthesizer is capable of not only providing the selected output RF frequency, but can also provide output of programmed patterns of output frequencies. These patterns can be a sequence of RF frequencies, a sequence of RF pulses, a sequence of RF amplitudes, or any combination of RF frequency, time, and amplitude desired.

A popular application for a wide band Digital Frequency Discriminator (DFD) takes advantage of its frequency accuracy and fast digital throughput capability to set-on the RF output frequency of a wide band Voltage Controlled Oscillator (VCO). **Figure 12** illustrates such an application, where an RF input signal is initially provided to the DFD; the DFD then makes a digital frequency measurement on the RF input signal and the resultant digital frequency data is provided to control the VCO output frequency. The DFD RF input is then switched from the RF input signal to the VCO RF output. The resultant measured VCO frequency data is then compared to the previously measured RF input signal frequency stored data, with the VCO frequency corrected to minimize the error. Experimental results with this

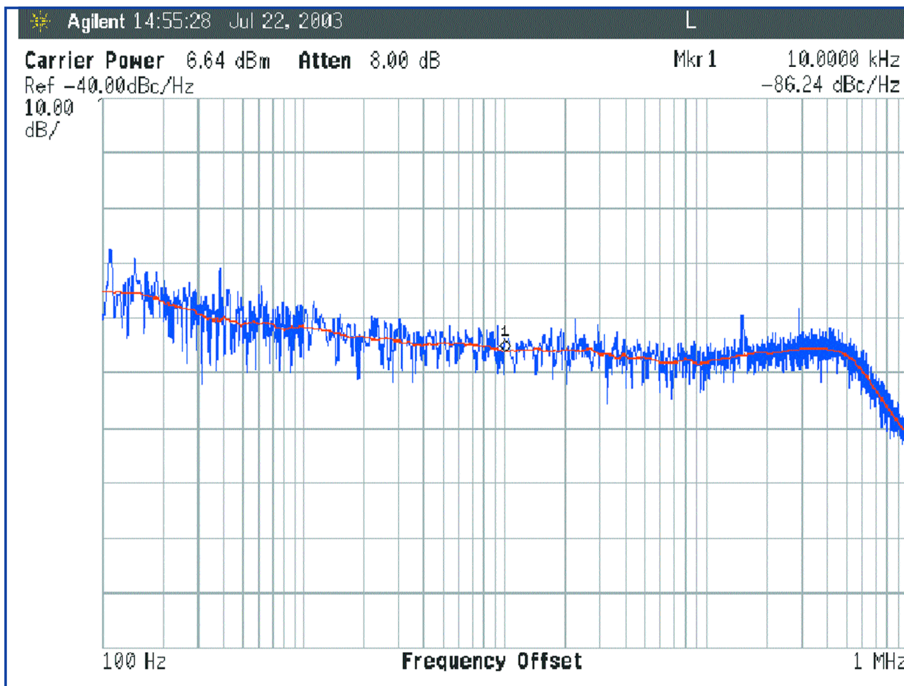

Figure 6A: Typical Phase Noise, Measured at 2674.5 MHz.

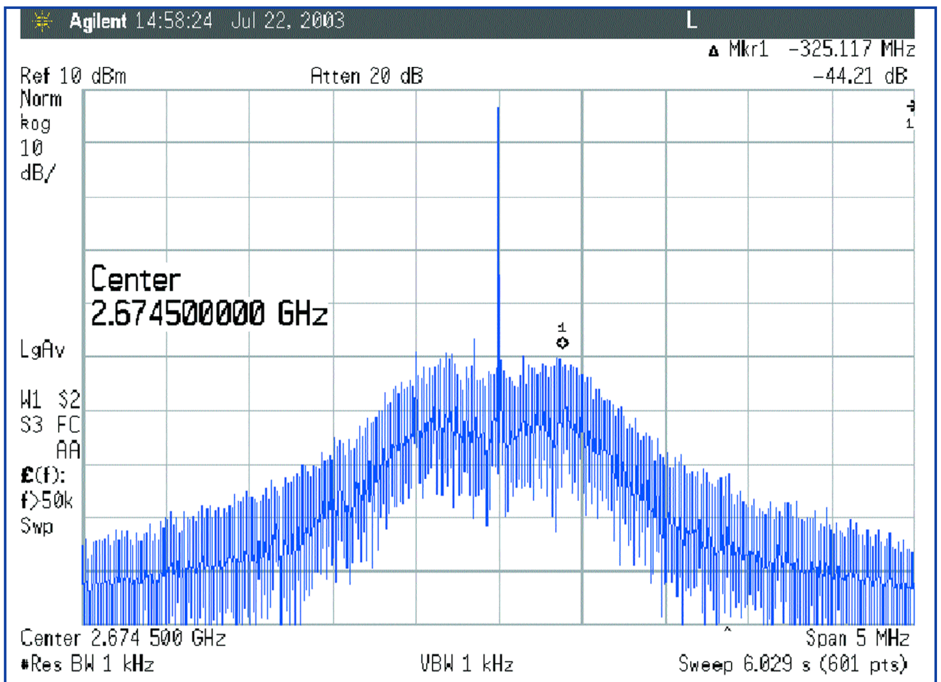

Figure 6B: Typical Power Spectral Density, Measured at 2674.5 MHz.

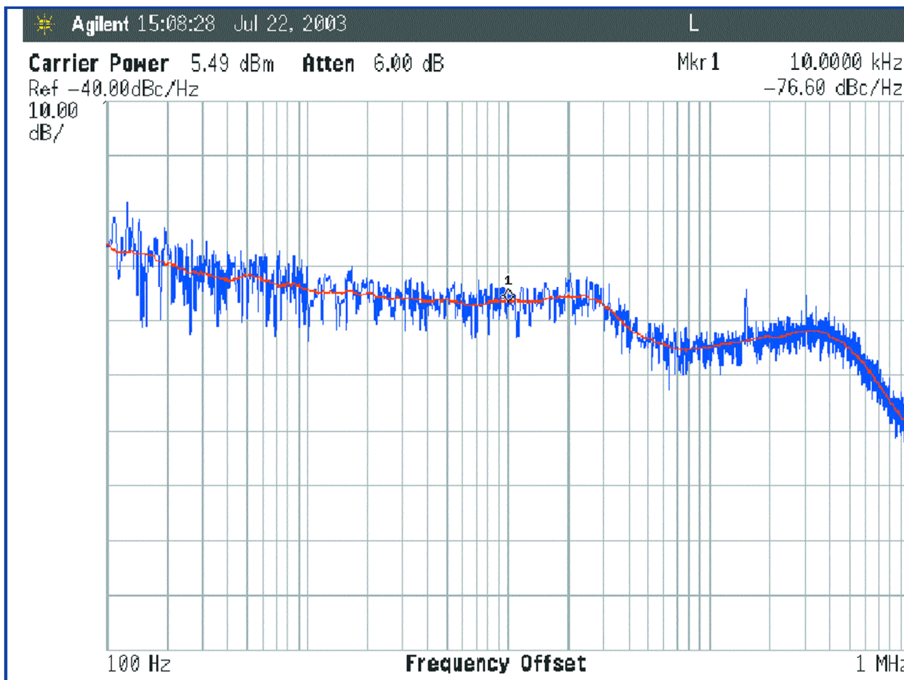

Figure 7A: Typical Phase Noise, Measured at 3801 MHz.

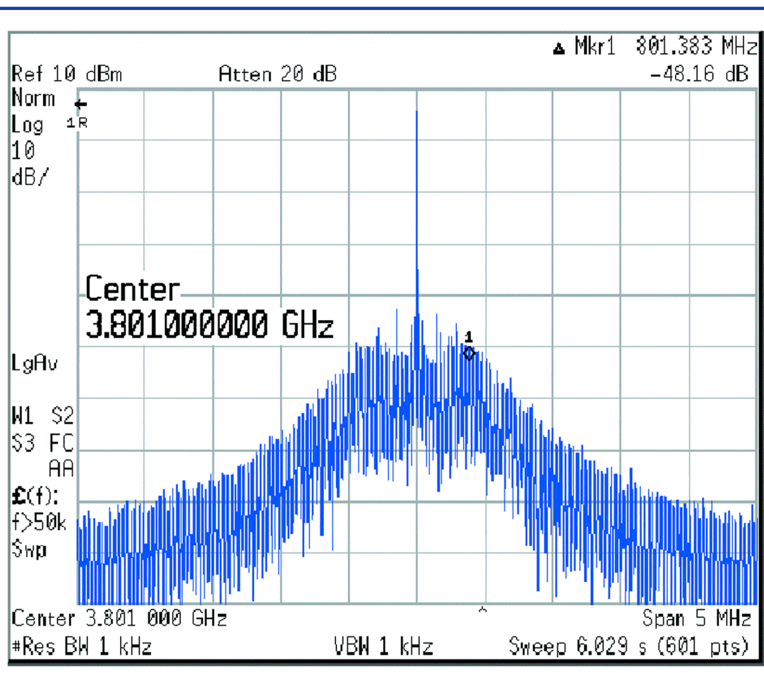

Figure 7B: Typical Power Spectral Density, Measured at 3801 MHz.

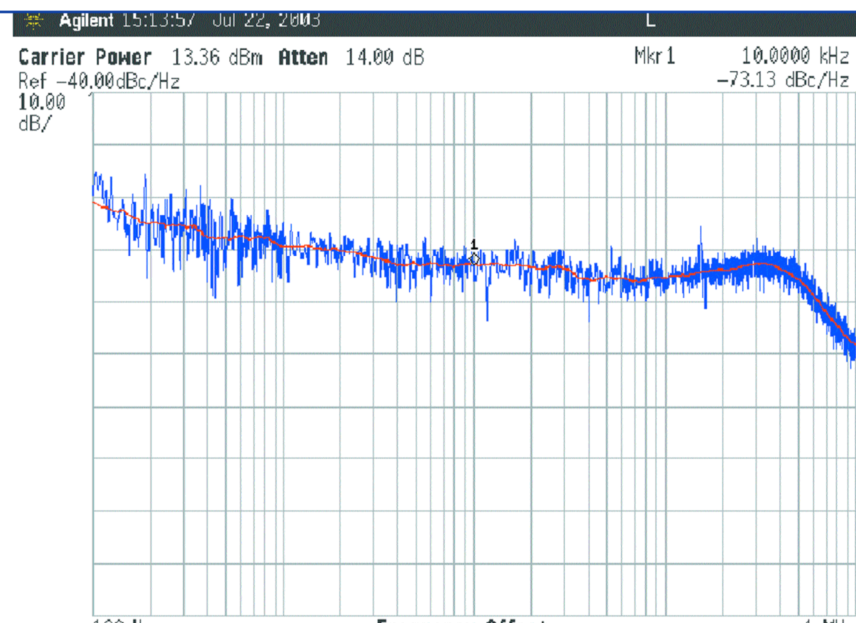

Figure 8A: Typical Phase Noise, Measured at 10.698 MHz.

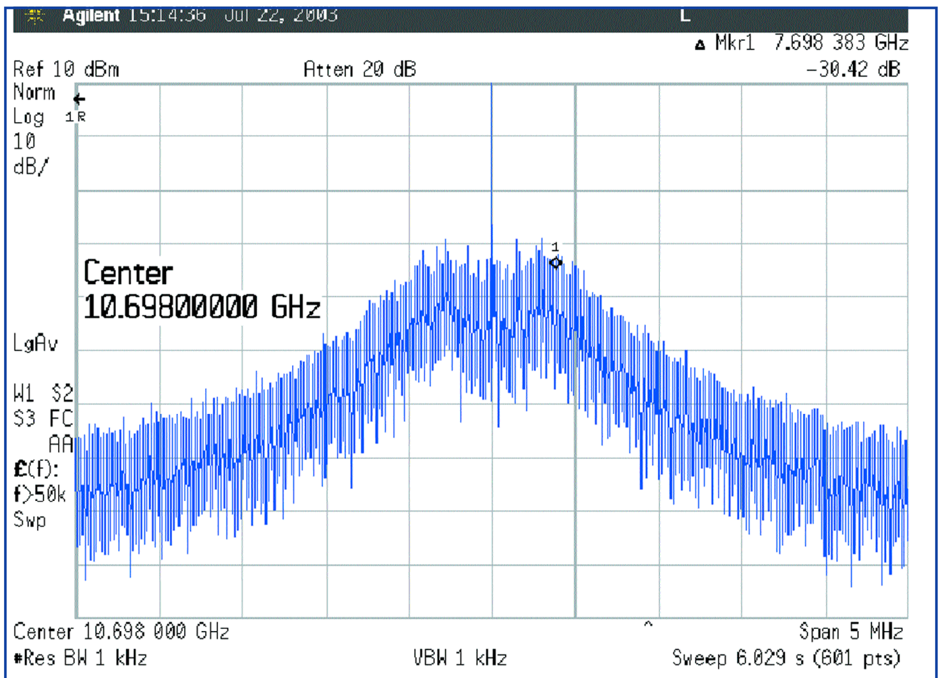

Figure 8B: Typical Power Spectral Density, Measured at 10698 MHz.

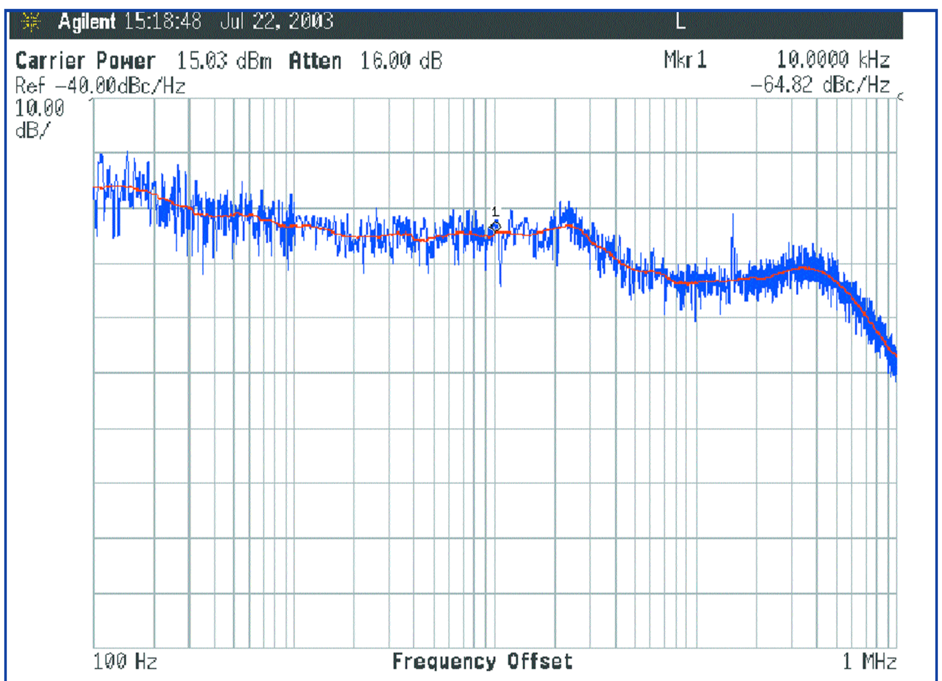

Figure 10A: Typical Phase Noise, Measured at 15 MHz.

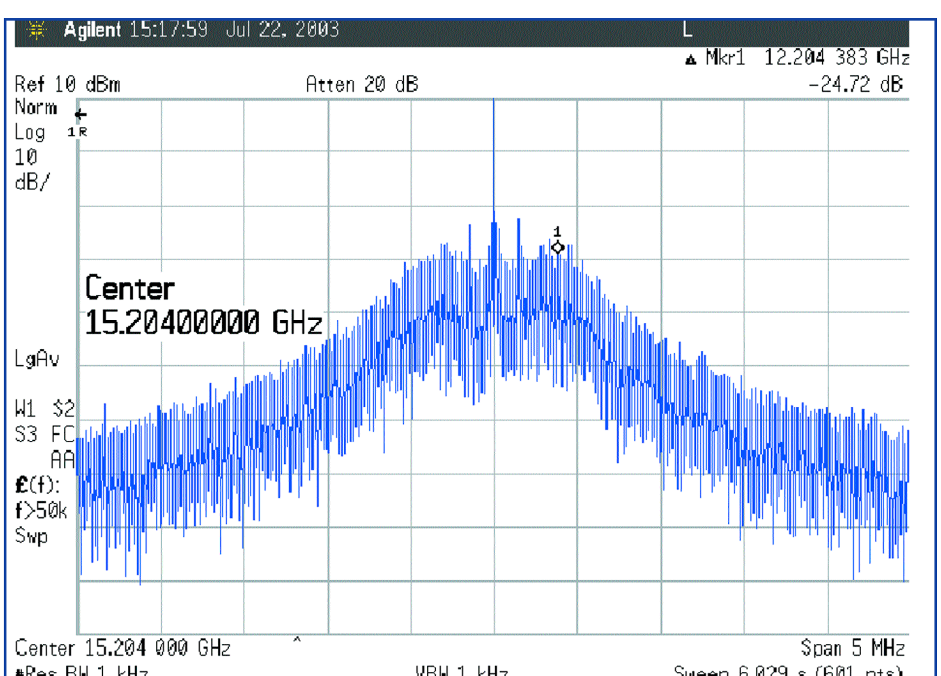

Figure 10B: Typical Power Spectral Density, Measured at 15 MHz.

configuration indicate a set-on frequency accuracy of 500 KHz, RMS, over the 2 GHz to 6 GHz band, set-on timing of approximately 10µS, and freedom from VCO long-term drift. The offsetting disadvantages included size, cost, and a poor VCO RF output spectrum.

Subsequently, a single, ambiguous, wide band microwave correlator replaced the multi-correlator DFD design. This development was referred to as the Correlator Stabilized Digitally Tuned Oscillator (CS/DTO). While this reduced the size and cost of the design, it did little to improve the VCO output spectrum. The problems with the VCO output spectrum include high FM noise, due largely to the very high tuning sensitivity (MHz/Volt) of the VCO, and the RF harmonic levels present at the output of a multi-octave VCO. The high harmonic levels at the output of a VCO tuning over greater than an octave preclude the use of simple frequency multipliers to extend the bandwidth, as these harmonics will produce in-band fifth order spurious outputs at the output of the non-linear frequency multipliers.

The RF and digital circuit design was then revised to improve the VCO output noise spectrum, including spurious outputs and harmonics, while simultaneously improving the set-on timing, using the RF circuit design of **Figure 1**. Two sub-octave VCO's are used in parallel, avoiding the problem of VCO harmonics and reducing the tuning sensitivity required of each VCO. The selected baseband VCO output is provided to a digital implementation of an ambiguous frequency correlator, measuring the rate of change of phase of the selected VCO output and comparing this measurement to that of the desired RF output frequency. The difference between the measured and predicted rate of change of phase is used to correct the VCO frequency. Switches then select the desired multiple of the corrected VCO frequency. The output RF power level is detected and used to control the Voltage Variable Attenuator (VVA), providing RF output leveling. In this particular implementation, multiple parallel RF outputs are used to tune and calibrate a wide band receiver system; other applications replace the output switch and power divider array with a programmable RF amplitude modulator.

Another application for this synthesizer design is the replacement of Digitally Tuned Oscillators (DTOs) in EW systems and system simulators. The DTO consists of an oven stabilized VCO using open loop control. The open loop control corrects the VCO input digital control data, using a memorized digital calibration. The DTO problems include the power required by the oven stabilization, post tuning frequency drift, and a long-term requirement for re-calibration. This synthesizer design does not employ oven stabilization, does not exhibit post tuning output frequency drift, and does not require re-calibration. With a total power requirement of 22 W, a volume of 20in^3, and the ability to quickly tune, in any frequency sequence, over the 2.25 GHz to 18 GHz RF band, a single synthesizer may now replace multiple DTOs for significant cost savings and performance advantages.

WIDE BAND SYSTEMS INC.

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