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# Rubidium™ Signal Generators Redefine Industry Standards for Spectral Purity and Stability

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*Anritsu's new Rubidium signal generators address today's market demands for high performance microwave signal sources through 20 to 43.5 GHz. With innovation and quality as their driving principles, the Rubidium signal generators challenge traditional performance expectations with atomic-grade frequency stability and super clean phase noise of –140 dBc/Hz at 10 kHz offset from the 10 GHz carrier.*

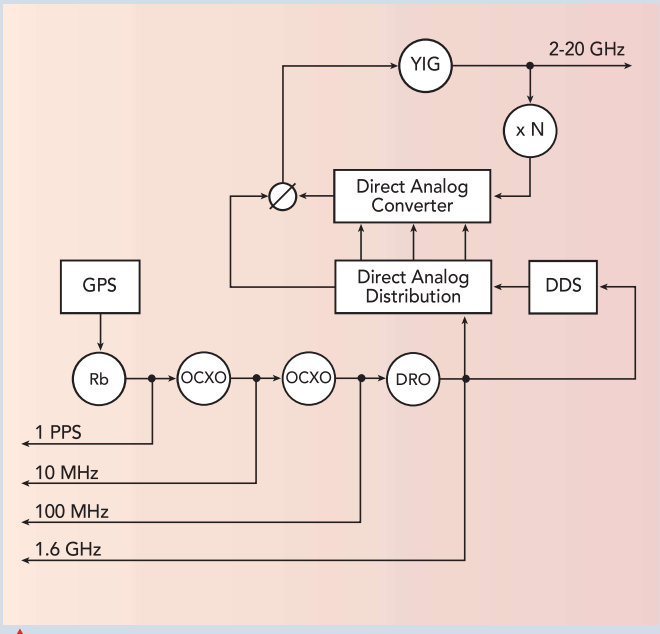


Fig. 1 A simplified block diagram of Rubidium™ synthesizer core.

Signal generators are the salt of the earth; modern technologies could not exist without them.[1,2] To address today's market requirements, Anritsu Company has introduced the Rubidium series, a new generation of microwave signal generators based on an innovative technology[3] that provides a combination of wide frequency coverage, fine resolution and high output power coupled with low phase noise and atomic-grade stability. The synthesizer core is based on a proprietary 2 to 20 GHz YIG oscillator that is locked to an internal reference extracted and distributed by direct analog means as illustrated in ***Figure 1***. The YIG native frequency coverage is further extended with a frequency multiplier and frequency divider (followed by a high-power amplifier, amplitude control and harmonic filtering) to achieve 9 kHz to 20 GHz or 43.5 GHz coverage. The YIG output signal is down-converted by a direct analog converter that eliminates any frequency divider and, therefore, phase noise degradation within the phase lock loop. A switched frequency multiplier is inserted into the loop that (a) reduces the number of frequencies generated by the direct analog distributer and (b) also provides additional residual PLL noise suppression at low frequencies.

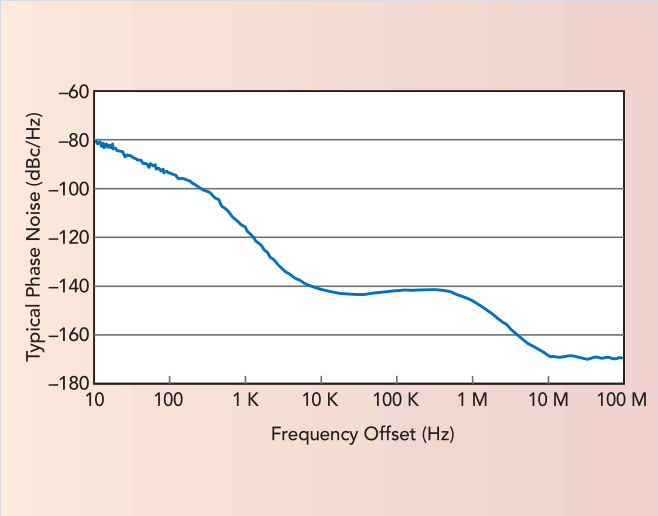


Fig. 2 Rubidium Typical Phase Noise at 10 GHz.

Fig. 3 In-field power calibration with a USB power sensor.

As a result, the presented architecture provides essentially a noiseless PLL mechanism, meaning it translates synthesizer's reference noise with no added phase noise degradation over 20logN fundamentals. A three-source combined reference is utilized to provide the lowest possible phase noise at any given frequency offset. Furthermore, the combined reference is disciplined by a rubidium atomic clock that introduces a much higher degree of stability compared to a conventional OCXO-based reference. The rubidium clock operation is based on fundamental constants rather than physical dimensions and, hence, is extremely stable. Various reference frequencies are available for instrument synchronization including a high frequency 1.6 GHz output for the highest fidelity.

The architecture of Rubidium signal generators delivers high performance in respect to spectral purity and stability. Phase noise is always a key specification for signal generators. The Rubidium signal generators offer four noise grades exhibiting exceptional -140 dBc/Hz at 10 GHz and 10 kHz offset with the premium noise option as depicted in ***Figure 2***. Another important aspect is frequency stability. Conventional signal generators normally rely on 10 MHz ovenized crystal oscillators (OCXO) showing relatively stable performance. Nonetheless, an OCXO oscillation frequency depends on the crystal mechanical resonance or—in other words—on crystal dimensions. Obviously, with a temperature change, the crystal dimensions change too, resulting in slight frequency variations. Furthermore, the crystal material itself evaporates with time, eventually leading to frequency aging. Hence, introducing an atomic standard radically improves the internal time base stability—not in multiples, but by several orders of magnitude.

## IN-FIELD CALIBRATION

Precise and stable frequency and output levels are essential in a microwave signal generator. Hence, traditional signal generators require periodic calibration. This represents a certain challenge. Whether the calibration lab is across the street or across the country, sending an instrument out for calibration during a critical time is an expensive and time-consuming proposition. To reduce the total cost-of-ownership, the Rubidium signal generators offer a built-in calibration routine to adjust its internal time base as well as output power on the spot. One of the primary tasks when calibrating a signal source is to set its time base that ultimately defines the instrument's frequency accuracy. Fortunately, the Rubidium signal generators come with a rubidium time base that is considered to be a frequency standard itself. Thus, in most practical scenarios, no frequency calibration is required at all. This is very important in some sensitive applications such as aerospace and defense.

The Rubidium signal generators include a built-in global navigation system receiver that receives a signal extracted from an on-board satellite high precision atomic source circling the earth. The output of the receiver is a 1 pps pulse stream that can be used to adjust the instrument's internal time base to synchronize it with any worldwide frequency standard offered by global navigation systems. This adjustment is performed with just a mouse click, thus, eliminating a need for sending the signal generator for a factory calibration. Another valuable feature of this signal generator is that it allows connecting a USB power sensor (see ***Figure 3***). The power sensor enables measuring the power directly at the device-under-test plane, therefore, taking into account any loss introduced by external cables or other devices. Furthermore, the precision power sensor allows calibrating the instrument output power (in certain limits) as needed without sending to the factory.

Overall, the new Rubidium technology offers superior performance in comparison with traditional instruments. With excellent spectral purity and signal stability, the Rubidium series is an ideal signal source for design and manufacturing test of components and systems for a wide variety of applications—including wireless communications, aerospace and defense and consumer electronics.

## References

1. A. Chenakin, "Frequency Synthesis: Current Status and Future Projections," *Microwave Journal*, Vol. 60, Ed. 4, April 2017, pp. 22–36.
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3. A. Chenakin, "Fractional-N Frequency Synthesizer with Reduced Spurious and Low Phase Noise," *US Patent Office*, patent pending.