Phase Matrix: Unique Synthesizer Technology

February 14, 2011
Alexander Chenakin, Vice President, Phase Matrix Signal Sources

Dr. Alexander Chenakin of Phase Matrix talks about the technology behind the company's state-of-the-art frequency synthesizers and the specific market requirements addressed by these high performance products.

**Back to Archives >>**

**MJ:** What is the business outlook for the major markets for Phase Matrix and which markets do you think will see the highest growth over the next year?

**AC:** Phase Matrix develops and manufactures various RF/microwave components and instruments primarily for test-and-measurement applications. The product line ranges from frequency counters to sophisticated up/downconverters and frequency synthesizers available in different flavors including stand along modules and synthetic instruments. In addition, Phase Matrix maintains solid relationships with its OEM customers and cultivates new ones by offering turnkey solutions and new product development. In spite of the recent industry downturn, we continued to heavily invest in R&D and are seeing the fruits of that investment manifesting in new markets that we were not previously in before the downturn. For 2011 we expect more than 60% of our revenues to be derived from products introduced in 2009 and 2010. In a way we see that the downturn can actually help the small manufacturers. As customers look for more value from their limited budgets, they are forced to look beyond their traditional suppliers. From this angle, one of the most successful recent developments is the QuickSyn synthesizer that helped us to penetrate into many new market niches. This new product further confirms the technical leadership that Phase Matrix provides with its signal generation products.

**MJ:** What are the most unique features of the QuickSyn synthesizer?

**AC:** This product represents a new generation of microwave frequency synthesizers based on a patented, phase-refining technology that provides a unique combination of fast-switching speed, very low phase noise, low spurious, and low cost characteristics.

**MJ:** What synthesizer characteristics are the most important?

**AC:** Although the answer strictly depends on a particular application, frequency coverage, resolution, spectral purity, and switching speed are those characteristics that first get customers attention. The ideal synthesizer should be preferably broadband with a fine frequency resolution that allows addressing a bigger number of potential applications. On other hand, the phase noise and spurious are even more important parameters since they determine the ultimate performance of a microwave system driven by the synthesizer. However, the major technology challenge is in increasing the synthesizer tuning speed as dictated by the ongoing increase of the data rates of modern microwave systems. The time spent by the synthesizer jumping between the frequencies becomes increasingly valuable since it cannot be used for data processing.

**MJ:** What is the frequency coverage and step size of your QuickSyn synthesizers?

**AC:** The product line includes FSW-0010 and FSW-0020 models covering the 0.1-10 and 0.2-20 GHz bands respectively. The resolution is 0.001 Hz for both models.

**MJ:** Your new synthesizer tunes over a wider range now from 0.2 to 20 GHz. How were you able to accomplish this wide tuning range? Do you use frequency multiplication within your synthesizer?

**AC:** Both models utilize a broadband fundamental VCO. No multiplication is used that eliminates spectrum contamination from subharmonic products.

**MJ:** What phase noise performance does the QuickSyn exhibit?

**AC:** Phase noise is a function of the output frequency and frequency offset and is usually represented as a graph or a table. Such a representation can be found in the datasheet available on our website at http://www.phasematrix.com/pages/Synthesizers.html. Let me give you a couple of numbers as a quick reference. At a 20 GHz output and 10 kHz offset, the phase noise is typically measured at -116 dBc/Hz. At a 10 GHz output, the noise drops down on 6 dB to about -122 dBc/Hz, same offset.

**MJ:** This seems to be very respectable performance. What about switching speed?

**AC:** The switching speed in the list mode is specified at 100 microseconds for +/-50 kHz accuracy.

**MJ:** Is this number set for a specific frequency step or subband?

**AC:** No. The parameter is valid for any frequency to any frequency step within the entire operating range.

**MJ:** There are several approaches to generate clean output signals but there is typically a tradeoff between switching speed and phase noise. What method is Phase Matrix using and how does that differ from traditional VCO and YIG-based designs?

**AC:** There is an old belief (better to say, a myth?) that phase noise and switching speed don't co-exist very well. In low phase noise applications – such as test-and-measurement equipment – a typical solution is the YIG oscillator. The YIG does offer very low phase noise. However, its tuning speed is limited to milliseconds due to the presence of high-inductance tuning coil. On the other hand, VCOs tune much faster - microseconds operation is easily achieved. However, their free running noise is considerably worse. Hence, there is a common consensus that in practical (not super-expensive) designs ether low phase noise or fast switching can be provided, but not both.

Why not? Note, we don't necessarily need to rely on free running oscillator characteristics. Our job is to design a synthesizer or, in other words, to lock an oscillator (ether VCO or YIG) to a low phase noise reference. Assume that we use a VCO in conjunction with a 100 MHz reference oscillator that exhibits, let's say, -163 dBc/Hz phase noise at 10 kHz offset. It is a very typical, relatively low-cost representative, not a record number at all. Let's also assume we have an ideal, noiseless PLL that locks our VCO to this reference. What phase noise can we get? If our PLL bandwidth is greater than 10 kHz (and, obviously, it should be) we can potentially get -123 dBc/Hz at 10 GHz output and -129 dBc/Hz at a 5 GHz output, same offset of 10 kHz. Compare these numbers to free running YIG oscillator noise we normally rely on! We can state that our locked VCO supersedes the best YIG oscillator performance at the same frequency settings. And it runs much faster – we are talking not about times but orders of improvement in terms of switching speed!

**MJ:** This sounds good but there should be a very unique PLL hardware to support such "noiseless" translation.

**AC:** Unique is a relative term. Sometimes it is just a fresh view from a different angle. Let me give you an example. It is well known that a frequency divider within PLL feedback path degrades phase noise at 20logN rate. If N is big (which is normally the case for conventional designs), the degradation can be quite significant. Thus, all battles around PLL are how to decrease N to minimize phase noise degradation. But what if we take a more radical step by inserting a frequency multiplier into the loop instead of the frequency divider? By doing this, we can reduce PLL residual noise at the same 20logN rate. Now the PLL becomes our lovely friend! For example, if N equals 10 (it is just a hypothetical example), we can improve other characteristics by 20 dB, which is a big deal.

**MJ:** Is this method utilized in the QuickSyn technology? What other solutions would you recommend?

**AC:** We utilize a number of "unusual" solutions. Many interesting ideas are illustrated in my book "Frequency Synthesizers: Concept to Product," which has been recently published by Artech House. Overall, our technology provides almost ideal frequency translation of the utilized low phase noise reference source.

**MJ:** How do you address spurious signals and what are the levels you achieve?

**AC:** Interestingly, all measures that help to improve phase noise (such as the mentioned loop division minimization) also work well for spur reduction. It is basically the same mechanism since phase noise can be thought of randomly distributed spurs. As a result, the generated signal is clean and free of obvious perturbations typically to -70 or even -80 dBc levels. I am saying "typically" because it is hard to measure spurs at these levels. Keep in mind that a spectrum analyzer has it is own LO source that is not ideal either. Many detected spurs can belong to test equipment and, thus, need careful processing. Overall, the spurious levels are comparable or even better to what is provided by instrument-grade signal generators.

**MJ:** Can the QuickSyn synthesizer be used as an LO source in a modern spectrum analyzer from the spurious and phase noise characteristics point of view?

**AC:** It can certainly be the case. Furthermore, it can also help to reduce sweep time. Similarly, the QuickSyn can be used as an engine in many other test-and-measurement applications, for example, phase noise testers.

**MJ:** What output power is available?

**AC:** The FSW-0010 model provides about +20 dBm uncorrected raw output that is calibrated and leveled between -25 and +15 dBm. The FSW-0020 specified range is -10 to +13 dBm.

**MJ:** How is the performance across the entire band and over temperature?

**AC:** The synthesizer includes sophisticated temperature compensation that ensures repeatable output power characteristics within specified frequency and temperature limits.

**MJ:** What other parameters or functions are available with QuickSyn?

**AC:** Besides getting a clean and fast settling output, the QuickSyn provides multiple modulation options including AM, FM, phase and pulse modulation. It also allows sweeping the output frequency and power. Other functions include power mute, lock recovery, blanking, reference adjustment, list mode and many others. In short, the QuickSyn brings all major functions available in complex bench-top and rack-mountable signal generators just at a fraction of their size and cost.

**MJ:** What is the size of this synthesizer?

**AC:** The QuickSyn measures only 5 by 7 by 1 inches. So you can hold it in your hand!

**MJ:** How could you insert so many functions and features in such a small volume?

**AC:** Inside a synthesizer, there are always many devices that can carry multiple functions and be reused to increase the functionality without a significant cost penalty. For example, for a broadband synthesizer you will probably need a switch to select a particular subband. Note, that you can use this switch to accomplish another function, for example, pulse modulation. You can always use this switch to control your harmonics instead of using a dedicated switched filter bank. This is a just a simple example to illustrate the concept we utilize.

**MJ:** What are the major markets that are interested in this new product and how has the response been?

**AC:** The FSW-0010 model (that covers the 0.1 to 10 GHz frequency range) came about two years ago and generated a lot of interest. I can say that demand was even higher than we anticipated. The 20 GHz FSW-0020 model was introduced last summer at the IMS show in response to the need for wider frequency coverage. The product was also very well received within the industry. High performance with compact size and low cost are desirable in various applications including test-and-measurement, telecommunications, monitoring systems and many others. We have seen all kind of practical implementation scenarios from integrating the QuickSyn box into a complex subsystem to using it in an R&D lab in lieu a traditional bench-top signal generator.

**MJ:** What are your plans for major new product introductions this year?

**AC:** We typically don't like to prematurely announce products but we certainly have not pulled back on our R&D efforts. You can anticipate to see enhanced performance from our signal generation products as well as more on the value or what we refer to as performance to cost ratio. You will see the QuickSyn technology in other platforms and form factors, such as PXI where high-level performance and reduced size are simultaneously required.

**MJ:** What challenges do you see ahead over the next few years for your industry?

**AC:** One of the biggest challenges is persistent pressure to deliver higher system throughput. This drastically reduces the choice of components and solutions that may be used. I expect that many low switching speed components (such as YIG devices, electromechanical parts, etc.) will be substituted with other solutions. From this perspective, the QuickSyn synthesizer brings a good example how instrument-grade performance can be achieved without using traditional low-speed devices. Similar solutions are expected in other instruments such as broadband up and downconverters, complex receivers, spectrum analyzers and many others.

Another challenge is size and cost reduction. In the past, complex microwave subsystems were often built using individual connectorized modules connected with coaxial cables. The designer could easily isolate and refine individual blocks to make them perfect. These days, such complex assemblies have to be made on a common PCB using tiny surface-mount parts. A great effort is required to minimize interactions between individual components sitting on the same board. Furthermore, as I mentioned earlier, many parts are reused to accomplish different functions, which are distributed through the whole assembly. The net result is a significant increase in “design density” meaning both component count and functionality per square inch. All these factors drastically complicate the design process. Nevertheless, this seems to be a “must” approach these days.

**Back to Archives >>**