Development of Signal Analyzer MS2840A with Built-in Low Phase-Noise Synthesizer

Toru Otani, Koichiro Tomisaki, Naoto Miyauchi, Kota Kuramitsu, Yuki Kondo, Junichi Kimura, Hitoshi Oyama

[Summary] Evaluation of microwave wireless backhaul and VHF/UHH public and business radio equipment, etc., to prevent interference with other communications channels requires measurement of items such as close-in spurious, adjacent channel leakage power etc. These measurements demand the high phase-noise performance of high-end spectrum analyzer models. We developed the new MS2840A as a middle-price-range spectrum analyzer featuring the same phase-noise performance as high-end models plus extended measurement functions for evaluating narrowband communications equipment. It has the same carrier close-in phase noise performance (–123 dB at 10-kHz offset and 1-GHz measurement frequency) as high-end models, and installing the low phase-noise option (MS2840A-066) achieves better performance (–133 dBc/Hz at 10-kHz offset and 500-MHz measurement frequency) than high-end models.

1 Introduction

Recently, spectrum analyzer designs are focused on models for measuring broadband signals, such as for Long Term Evolution (LTE) mobile and W-LAN networks. However, R&D for microwave wireless backhaul applications and for oscillators built into commercial VHF/UHF radio and other wireless equipment places heavy emphasis on close-in SSB (SSB) phase-noise performance and spurious characteristics. Consequently, many commercially available middle-range spectrum analyzer models are unsatisfactory based on these performance aspects.

To solve this issue, we have developed the Signal Analyzer MS2840A with greatly improved SSB phase-noise performance using a newly developed Local Oscillator (LO) synthesizer with excellent low-phase-noise performance. As a result of this development, we can now support SSB phase-noise performance and close-in spurious evaluations, which were previously impossible without expensive dedicated phase noise measuring instruments and a high-end spectrum analyzer, using a middle-price-range spectrum analyzer.

Moreover, the new MS2840A includes built-in signal analyzer functions as standard for various measurements including instantaneous spectrum observation, frequency changes over time, phase changes over time, spectrogram displays, etc. Additionally, optional functions such as the Phase Noise Measurement Function (MS2840A-010), Vector Modulation Analysis Software (MX269017A), Analog Measurement Software (MX269018A), Noise Figure (NF) Measurement Function (MS2840A-017), etc., can be added, enabling one MS2840A unit to support all Tx tests required by narrowband communications systems.

2 Development Concept

This development was based on the following concepts to successfully support the functions and performance required for evaluating microwave wireless backhaul and narrowband VHF/UHF communications equipment.

(1) Develop a new LO synthesizer with low phase noise frequency characteristics of –123 dBc/Hz at a 10-kHz offset from a center frequency of 1 GHz for measuring narrowband communications equipment using a middle-price-range analyzer.

(2) Aim to increase measurement speed by up to 8 times compared to existing equipment to cut manufacturing tact times, etc.

(3) Aim to upgrade input attenuator resolution, preamplifier NF low sensitivity (improve preamp DANL), and extend high frequency limit to create a usage environment for microwave-band wireless backhaul measurements, etc.

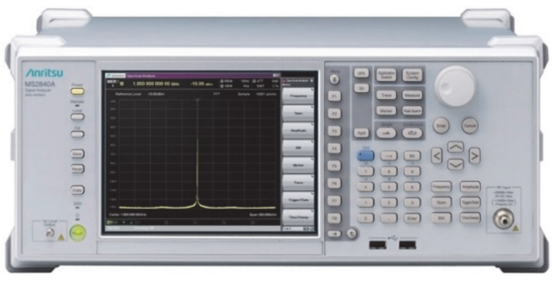

Figure 1 MS2840A Front Panel

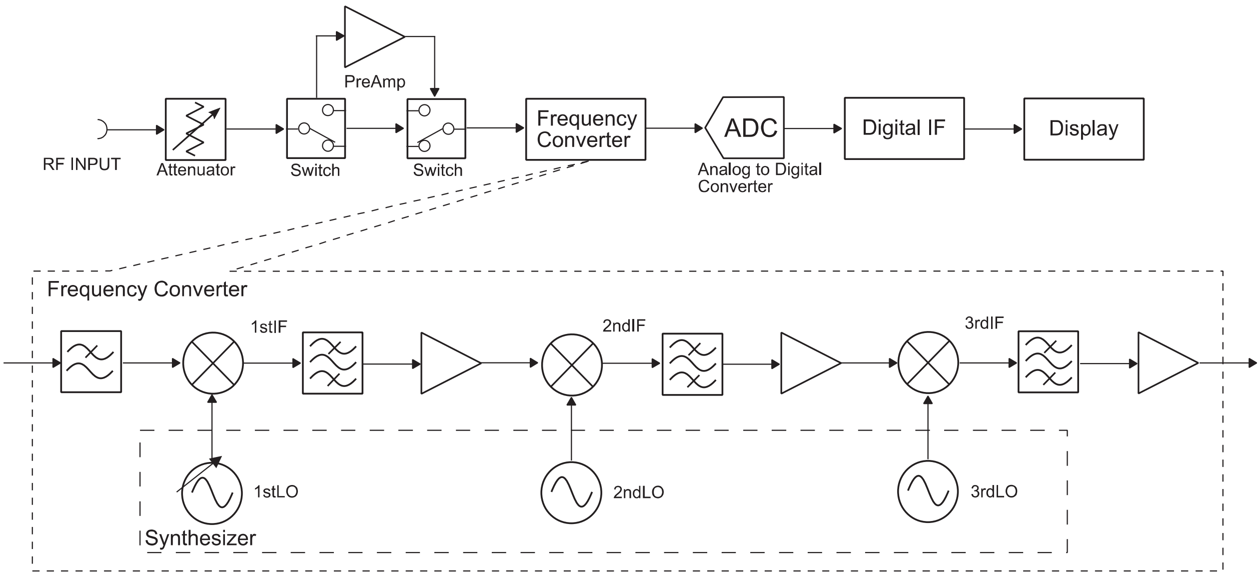

Figure 2 MS2840A Block Diagram

3 Design Points

3.1 MS2840A Basic Structure

Figure 2 shows the basic structure of the MS2840A. It is a superheterodyne LO sweep-type spectrum analyzer. The input Radio Frequency (RF) signal is adjusted to the appropriate level by an input attenuator and frequency-converted to an Intermediate Frequency (IF) signal by multiple mixers before input to an Analog-to-Digital Converter (ADC). The ADC-converted signal is digitally signal processed for display on the screen.

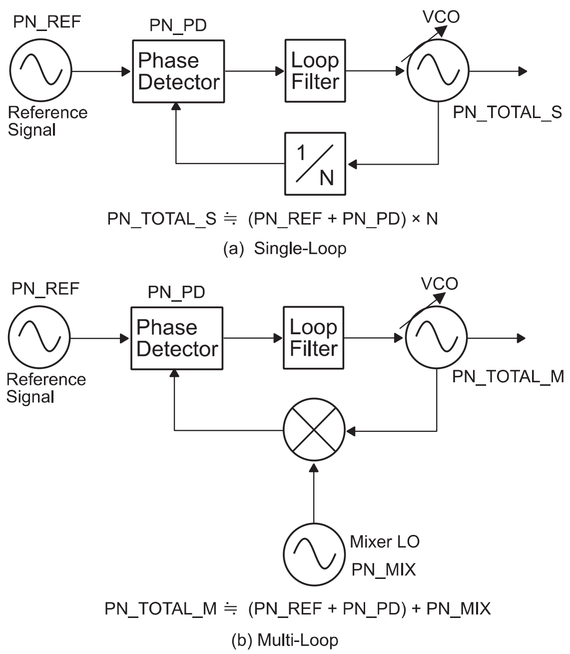

Figure 3 Comparison of Synthesizer Methods

Additionally, either the common low-cost single-loop method, or the multi-loop method with excellent phase-noise performance can be used at the LO synthesizer section (1stLO) supplying the LO signal to the mixer. The MS2840A uses the multi-loop method; Figures 3(a) and 3(b) compare the single and multi-loop methods.

The spectrum analyzer IF, LO and RF frequencies are related as IF = |LO − RF|. To obtain a constant IF, the LO signal must have the same variable frequency range as the RF signal. Consequently, the spectrum analyzer LO signal usually requires a variable frequency range of 1 octave.

The single-loop phase noise PN_TOTAL_S in Figure 3(a) is expressed by the following equation:

$$PN\_TOTAL\_S \fallingdotseq (PN\_REF + PN\_PD) \times N$$

where, PN_REF is the Reference Signal phase noise, PN_PD is the Phase Detector phase noise, and N is a multiplier.

From this equation, the phase noise of the overall system is an N multiple of the sum of the Reference Signal and Phase Detector phase noise. Therefore, although a wide frequency range can be implemented just by changing the multiplier N with the single-loop method, the phase noise increases as frequency increases because the multiplier N becomes larger.

On the other hand, the phase noise PN_TOTAL_M of the multi-loop method in Figure 3(b) is expressed by the following equation:

$$PN\_TOTAL\_M \fallingdotseq (PN\_REF + PN\_PD) + PN\_MIX$$

where, PN_REF is the Reference Signal, PN_PD is the Phase Detector phase noise, and PN_MIX is the mixer LO phase noise.

From this equation, the phase noise of the overall system is the sum of the phase noises of the Reference Signal, Phase Detector and mixer LO signal. Since there is no multiplier N as in the single-loop method, it is possible to achieve low phase noise. However, this method has the disadvantage of being expensive because it requires generation of a mixer LO covering the wide frequency range.

In this reported work, we developed a new multi-loop type LO synthesizer with the dual advantages of excellent phase-noise performance and low cost.

3.2 Low Phase Noise Performance LO Synthesizer

As previously described, spectrum analyzers with a built-in low phase-noise synthesizer are limited to costly high-end models. In this reported development, we considered a new multi-loop type synthesizer offering both good low phase-noise performance and low cost to support inclusion in a middle-price-range spectrum analyzer model. Additionally, this synthesizer required not only low spurious and the same 4000 GHz/second high-speed sweeping as the MS2830A by implementing the following required technologies:

[Low Phase Noise]

Supports both low cost and low phase noise by using new multi-loop method

[High-Speed Sweep]

Implements high sweep speed using Voltage Controlled Oscillator (VCO) for multi-loop method

[Low Spurious]

Implements reduced spurious using low-spurious Direct Digital Synthesizer (DDS) function and spurious suppression algorithm

3.2.1 Both Low Cost and Low Phase Noise using New Multi-Loop Method

Generally, low phase-noise synthesizers use a multi-loop method incorporating multiple PLL circuits. This type of PLL circuit down-converts an oscillator feedback signal to perform phase comparison, and achieving the same phase deviation for the oscillator and phase comparator makes it possible to output a low phase-noise signal close to the phase noise of the phase comparator. Figure 4 shows an example of a block diagram for a conventional multi-loop type circuit.

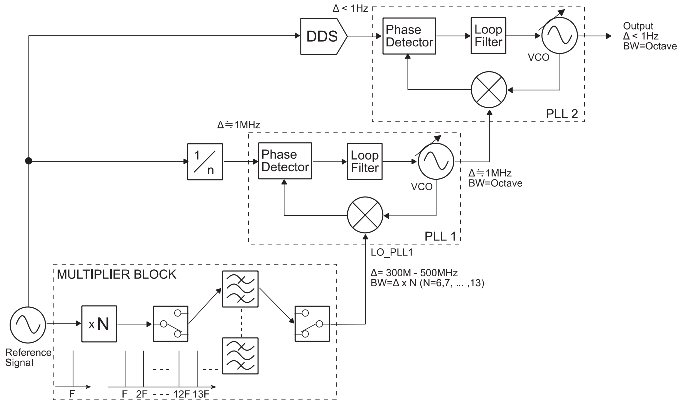

Figure 4 Example of Multi-Loop Method

The conventional multi-loop method is expensive because a frequency bandwidth that is equal to the synthesizer output (Figure 4 PLL_2 output) is required by the PLL_1 mixer LO signal (Figure 4 LO_PLL1) and the PLL_1 output signal.

For example, conventionally, this requires a frequency multiplier circuit (Figure 4 MULTIPLIER_BLOCK) capable of outputting a 6 to 13-order harmonic with low phase noise as the PLL_1 mixer LO signal, plus a PLL_1 oscillator with a variable frequency width of 1 octave.

The frequency setting for the above-described conventional multi-loop method can be written as the equation:

$$f_{SUM} = [\{(f_{ref} \times N) + f_{tune\_coarse}\} + f_{tune\_fine}]$$

(N=6, 7, …, 13)

where, f_{SUM} is the synthesizer output frequency, f_{ref} is the reference signal source frequency, N is the reference signal source multiplier factor, f_{tune_coarse} is the coarse tuning frequency and f_{tune_fine} is the fine-tuning frequency.

$\{(f_{ref} \times N) + f_{tune\_coarse}\}$ expresses the output of PLL_1 and f_{SUM} expresses the output of PLL_2. From these equations, approximately same frequency bandwidth as f_{SUM} is required for the output frequency bandwidth of $(f_{ref} \times N)$ and PLL1. This is one reason explaining the high cost of the conventional multi-loop method.

With the new multi-loop method, the cost is lowered by using narrow bandwidths for signals other than PLL_2. Figure 5 outlines the MS2840A LO synthesizer block diagram.

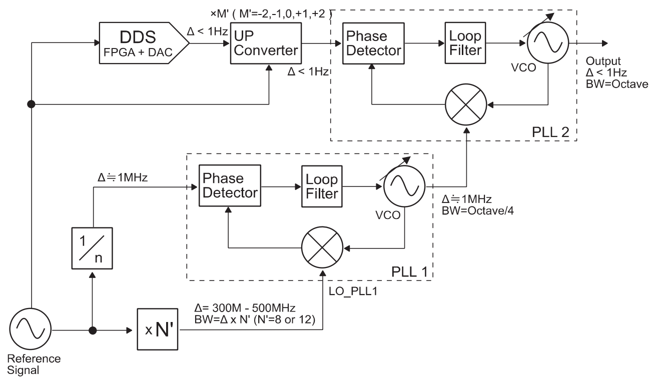

Figure 5 Block Diagram of New Multi-Loop Method

The new multi-loop method frequency settings can be written as the equation:

$f_{SUM} = [\{(f_{ref} \times N') + f_{tune\_coarse}\} + \{(f_{ref} \times M') + f_{tune\_fine}\}]$

$(N' = 8 \text{ or } 12,\ M' = -2, -1, 0, 1, 2)$

where, N' and M' are the multiplier factor for the respective multiplier circuits.

In the conventional method, f_{ref} is multiplied by N = 6, 7, …13. In comparison to this, with the new method, the multiplier is split into N' = 8, and 12, and M' = –2, –1, 0, 1, 2; the multiplier M' component is added at the final-stage PLL. As a result, the ($f_{ref} \times$ N) circuit replaces the high-cost multiplier circuit having many multiplier degrees with a multiplier circuit having only two switched paths. Moreover, $\{(f_{ref} \times N') + f_{tune\_coarse}\}$ expresses the output of PLL_1, and, unlike the conventional method requiring a variable band with the same frequency as the synthesizer output frequency f_{SUM}, the new method is reduced to one-quarter of the conventional bands, resulting in both cost and space savings. $\{(f_{ref} \times M') + f_{tune\_fine}\}$ is a circuit for up-converting the Fine Adjust signal with ($f_{ref} \times$ M'), but it can be implemented at low cost, because it is a low-frequency circuit.

We were able to implement a middle-price-range spectrum analyzer with low phase noise by cutting the cost of this new multi-loop synthesizer. Figure 6 shows an MS2840A phase noise measurement example.

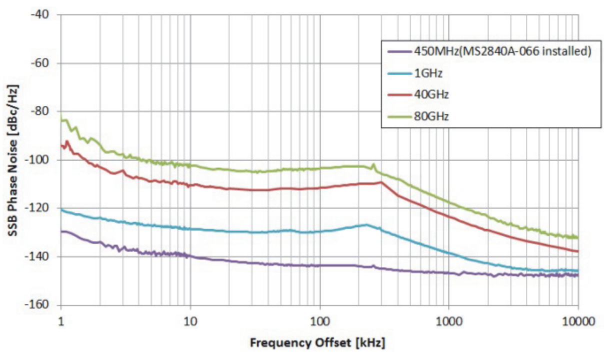

Figure 6 MS2840A Phase Noise Measurement Example

As shown in Figure 6, the new design achieves a measured phase noise of –128 dBc/Hz at a center frequency of 1 GHz and 10-kHz offset. At measurement in combination with the High-Performance Waveguide Mixer (MA2808A) on the 80-GHz band likely to be used for future mobile backhaul and automobile radar, the measured phase-noise performance was –102 dBc/Hz at a 10-kHz offset.

3.2.2 High Sweep Speed using VCO for Multi-Loop Method

The spectrum analyzer LO synthesizer requires a variable frequency band of one octave. Consequently, either a VCO or a YIG-Tuned Oscillator (YTO) is used as a wideband oscillator for the synthesizer. The oscillator-related performance is compared in the following table.

Table 1 Comparison of VCO and YTO

Oscillator-Related Performance Item	VCO	YTO
Sweep speed	Good	Not Good
Cost	Good	Not Good
Frequency linearity	Not Good	Good
Oscillator phase noise	Not Good	OK

To achieve low phase noise, high-speed measurement and low cost, the MS2840A uses a VCO with excellent sweep speed and cost performance, which maintains the 4000 GHz/second sweep speed of the predecessor MS2830A. However, a VCO has never been used with the multi-loop method until now because the high sensitivity of the VCO coupled with its non-linear frequency/voltage (F-V) characteristics (frequency linearity) make it difficult to achieve the required accuracy at frequency switching. If the VCO is at a different frequency to the set frequency, it can result in a reversed PLL polarity at the PLL_2 mixer shown in Figure 5. Reversal of the VCO oscillation frequency control voltage polarity at frequency switching causes problems, such as loss of frequency lock. For example, as shown in Figure 3(b), assuming the VCO output is 3050 MHz and the PLL_2 mixer LO signal is 3000 MHz and the PLL phase comparison frequency is frequency locked at 50 MHz, when the VCO output drops lower than 2950 MHz at frequency switching, the PLL_2 polarity becomes reversed and the VCO oscillator frequency control voltage becomes reverse polarity, preventing frequency locking.

With the conventional multi-loop method, it is possible to use a YTO due to the good frequency linearity and PLL narrow variable frequency width. Consequently, the above-described problem is never observed. However, when switching to a VCO, the poor frequency linearity and wider PLL variable frequency make very accurate frequency switching control essential for frequency locking with the multi-loop method.

In this reported development, we ameliorated the required accuracy for multi-loop frequency switching control by using a new frequency lock stabilizing algorithm and a new calibration method to obtain the VCO frequency linearity individually. As understood from the previous clarification of the lost frequency lock, the permissible error at frequency switching becomes wider as the phase comparison frequency becomes higher. With the multi-loop method, the frequency can be locked easily using a VCO by setting a high phase comparison frequency. As a result, since setting a low phase comparison frequency suppresses the previously described PLL_2 polarity reversal, frequency switching is controlled using a so-called two-stage frequency lock sequence by first obtaining a frequency lock with correct polarity by setting a high phase comparison frequency, followed by switching by setting a low phase comparison frequency. Introducing this two-stage locking sequence with the multi-loop method ameliorates the required accuracy for frequency switching control and supports use of a VCO with the multi-loop method by individually obtaining the VCO frequency linearity.

3.2.3 Spurious Reduction

In this development, to achieve both low spurious and low cost, in addition to configuring the frequency fine-tuning block using a low-spurious DDS, we introduced a spurious suppression algorithm.

(1) Low-cost, low-spurious DDS configuration

The spectrum analyzer frequency setting resolution is 1 Hz. Consequently, the LO synthesizer requires a frequency resolution smaller than 1 Hz. To implement this with the MS2840A, a DDS was selected based on cost and space aspects. However, there is no commercial product on the market that meets the required spurious performance, so we configured a frequency fine-tuning block with functions equivalent to a DDS by incorporating a Numerical Controlled Oscillator (NCO) in a Field Programmable Gate Array (FPGA) controlling hardware, and combining it with a Digital to Analog Converter (DAC), resulting in a low-spurious, low-cost circuit. Spurious caused by quantization errors was reduced by using a 16-bit DAC and spurious caused by phase discontinuity was reduced by interpolation.

(2) Spurious suppression algorithm

In addition to spurious generated by a DDS described above in the synthesizer, there is also spurious unique to the new multi-loop method. This spurious is caused by setting a high phase comparison frequency at the multi-loop method. It is possible to calculate the frequency at which this spurious occurs and we introduced an algorithm to optimize the synthesizer internal frequency so as to minimize the spurious level based on the conditions at which these two types of spurious occur. As a result, not only is DDS spurious reduced but also the spurious that is unique to the new multi-loop method is fundamentally avoided.

3.3 Accelerating Software Processing

As explained in sections 3.2.1 and 3.4.1, the MS2840A has achieved both high sweep speed and low phase noise. Additionally, to implement faster measurement including signal analysis, screen drawing, etc., it also featured a high-performance, multi-core CPU optimized for faster processing. Table 2 lists speed increases over the existing MS2830A using the same settings, demonstrating the greatly shortened measurement times.

Table 2 Comparison with Predecessor MS2830A using Single Core CPU

	Measurement	Speed Increase
Spectrum Analyzer Functions	Sweep (Display Off)	393%
	Sweep (Display On)	450%
Signal Analyzer Functions	Spectrum (Display Off)	168%
	Spectrum (Display On)	291%
	Spectrogram (Display Off)	593%
	Spectrogram (Display On)	815%

3.4 Other Extended Functions

The MS2840A has the following extended functions in addition to the functions of the existing MS269xA/MS2830A spectrum/signal analyzers.

3.4.1 Improved Phase Noise Measurement Function

Phase-noise performance is evaluated easily using the phase-noise performance measurement function (MS2840A-010). This phase-noise measurement function has three selectable loop filters: Best Close-in optimized for close-in measurements; Best Wide-offset optimized for far end measurements; and Balance with characteristics between each of the previous two. In addition, the Auto setting combines with multiple loop filters to optimize and display the measurement results. Using these additional functions users can set any loop filter easily to obtain measurement results at the optimum settings. Figure 7 shows an example of measurement results at the phase-noise measurement function Auto setting.

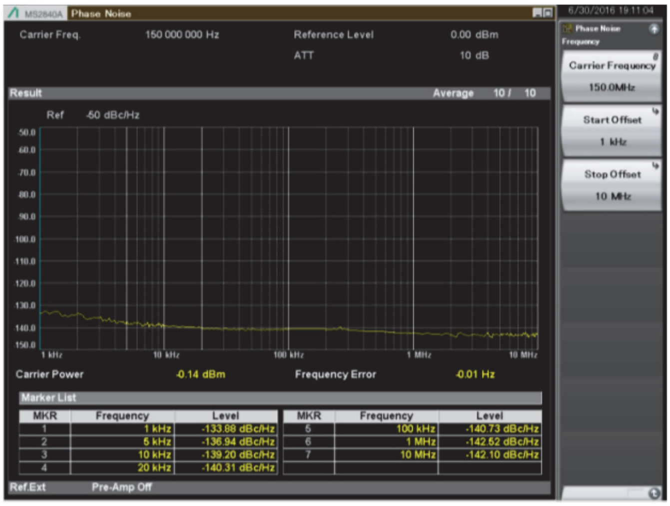

Figure 7 Phase Noise Function (MS2840A-010)

3.4.2 Improved Input Step Attenuator Resolution

We have also developed an optional 2-dB step attenuator (MS2840A-019) to make best use of the MS2840A excellent low DANL performance in the millimeter waveband. Combined use with Opt-19 supports a 2-dB step setting resolution up to the upper frequency limit of 44.5 GHz.

To achieve a 2-dB setting resolution over an attenuation range of 0 to 60 dB, the design facilitates connection of the developed 2-dB step attenuator in addition to the standard built-in 10-dB step attenuator. Achieving a 2-dB setting resolution supports adjustment of the input level close to the optimum mixer input level for obtaining the maximum dynamic range to improve measurement ability for adjacent channel leakage power, etc.

3.4.3 Preamp NF Reduction

We designed the preamp circuit with a low NF so the preamp (MS2840A-008/068/069) can measure low-level signals with high sensitivity. This new preamp circuit has a first-stage amplifier featuring low noise characteristics, a second-stage amplifier for supplementing the amplification of the first-stage amplifier, and an equalizer for flattening the amplification frequency characteristics. Choosing this configuration achieved a NF of 2.6 dB (at 1 GHz) at the preamp block as well as a DANL of −169 dBm/Hz (at 1 GHz) for the entire system. Figure 8 shows the typical DANL with the preamp enabled. This improved DANL supports precision measurements of low-level noise, spurious, etc.

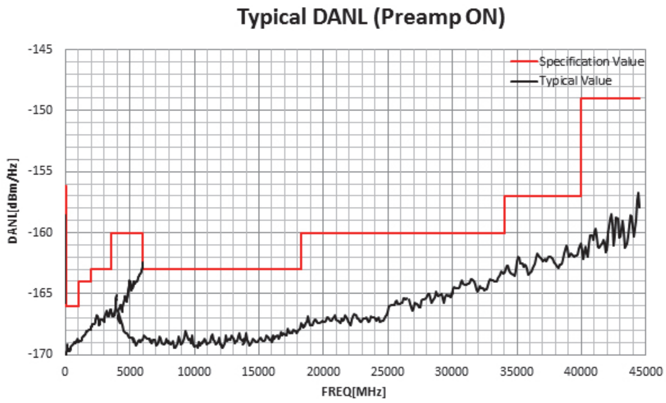

Figure 8 DANL Measurement Example (Preamp ON)

3.4.4 Extended Upper Frequency Limit

The upper frequency limit of the Ka Band used for microwave wireless backhaul is 43.5 GHz. Spectrum emission mask and spurious, etc., tests requires measurements in a frequency band exceeding the system upper limit, so we extended the MS2840A upper frequency limit to 44.5 GHz.

3.4.5 Installed Measurement Software

Both Vector Modulation Analysis Software (MX269017A) and Analog Measurement Software (MX201918A) are installed in the MS2840A to support modulation accuracy tests of digital wireless equipment and Tx performance tests of analog wireless equipment. Moreover, installing the optional Noise Measurement Function (MS2840A-017) enables NF measurement, which is a key item in evaluating the Rx block of communications equipment.

4 Conclusion

We developed a new LO synthesizer with both excellent phase-noise performance and low cost for the MS2840A. As a result, the MS2840 is a middle-price-range spectrum analyzer featuring the same SSB phase-noise and close-in spurious evaluation performance for narrowband communications as other high-end expensive models. In addition, it has better measurement speed and extended basic performance for evaluating narrowband wireless communications equipment, such as microwave wireless backhaul and VHF/UHF business radio. Anritsu expects its new MS2840A solution to play a key role in future development of wireless equipment and communications technologies.

References

1) Fixed Radio Systems;Characteristics and requirements for point-to-point equipment and antennas;Part 2-2: Digital systems operating in frequency bands where frequency co-ordination is applied; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive". ETSI EN 302 217-2-2 V2.2.1 (2014.4)
2) Yuji Kishi, Shuichi Matsuda, Koichiro Tomisaki, Kozo Yokoyama, Yoshiaki Yasuda, Tsukasa Yasui, Kota Kuramitsu, "Development of high cost performance signal analyzer MS2830A -044/045", Anritsu Technical Review No.20 (2013.3)

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Table 3 Signal Analyzer MS2840A Main Specifications

<table>
<tr><td rowspan="2">Frequency</td><td>Frequency Range</td><td>MS2840A-040: 9 kHz to 3.6 GHz
MS2840A-041: 9 kHz to 6 GHz
MS2840A-044: 9 kHz to 26.5GHz
MS2840A-046: 9 kHz to 44.5 GHz</td></tr>
<tr><td>SSB Phase Noise</td><td>At 18° to 28°C, 1000 MHz, Spectrum Analyzer function
<table>
<tr><th>Offset Frequency</th><th>Specification</th></tr>
<tr><td>10 Hz</td><td>–80 dBc/Hz (nom.)*</td></tr>
<tr><td>100 Hz</td><td>–92 dBc/Hz (nom.)*</td></tr>
<tr><td>1 kHz</td><td>–117 dBc/Hz (nom.)*</td></tr>
<tr><td>10 kHz</td><td>–123 dBc/Hz</td></tr>
<tr><td>100 kHz</td><td>–123 dBc/Hz</td></tr>
<tr><td>1 MHz</td><td>–135 dBc/Hz</td></tr>
<tr><td>10 MHz</td><td>–148 dBc/Hz (nom.)</td></tr>
</table>
*Without MS2840A-001 but with MS2840A-002

At 18° to 28°C, With MS2840A-066 operating
<table>
<tr><th>Offset Frequency</th><th>Specification</th></tr>
<tr><td>100 Hz</td><td>–98 dBc/Hz (nom.)</td></tr>
<tr><td>1 kHz</td><td>–122 dBc/Hz (nom.)</td></tr>
<tr><td>10 kHz</td><td>–133 dBc/Hz</td></tr>
<tr><td>100 kHz</td><td>–133 dBc/Hz</td></tr>
<tr><td>1 MHz</td><td>–148 dBc/Hz (nom.)</td></tr>
</table></td></tr>
<tr><td>Frequency</td><td>LO Spurious</td><td>At 10 MHz < Frequency ≤ 1 GHz
<table>
<tr><td>3 kHz ≤ Offset Frequency < 100 kHz</td><td>−70 dBc (nom.)</td></tr>
<tr><td>100 kHz ≤ Offset Frequency < 10 MHz</td><td>−75 dBc (nom.)</td></tr>
</table>
At Frequency > 1 GHz
<table>
<tr><td>3 kHz ≤ Offset Frequency < 100 kHz</td><td>−70 + 20 × log(f)dBc (nom.)</td></tr>
<tr><td>100 kHz ≤ Offset Frequency < 10 MHz</td><td>−75 + 20 × log(N)dBc (nom.)</td></tr>
</table>
f: Rx Frequency (GHz), N: Mixing Degree</td></tr>
</table>

Amplitude	DANL	At 18° to 28°C, Detector: Sample, VBW: 1 Hz (Video Average), Input attenuator : 0 dB, Spectrum Analyzer Mode, MS2840A-046 installed

Frequency	Without MS2840A-067 at Frequency Band Mode: Normal	
	Without MS2840A-068	With MS2840A-068 and Preamp: Off
9 kHz ≤ Frequency < 100 kHz	–120 dBm/Hz	–120 dBm/Hz
100 kHz ≤ Frequency < 1 MHz	–134 dBm/Hz	–134 dBm/Hz
1 MHz ≤ Frequency < 10 MHz	–144 dBm/Hz	–144 dBm/Hz
10 MHz ≤ Frequency < 30 MHz	–150 dBm/Hz	–150 dBm/Hz
30 MHz ≤ Frequency < 1 GHz	–153 dBm/Hz	–153 dBm/Hz
1 GHz ≤ Frequency < 2.4 GHz	–150 dBm/Hz	–150 dBm/Hz
2.4 GHz ≤ Frequency ≤ 3.5 GHz	–147 dBm/Hz	–147 dBm/Hz
3.5 GHz < Frequency ≤ 6 GHz	–144 dBm/Hz	–144 dBm/Hz
6 GHz < Frequency ≤ 13.5 GHz	–151 dBm/Hz	–147 dBm/Hz
13.5 GHz < Frequency ≤ 18.3 GHz	–149 dBm/Hz	–145 dBm/Hz
18.3 GHz < Frequency ≤ 34 GHz	–146 dBm/Hz	–141 dBm/Hz
34 GHz < Frequency ≤ 40 GHz	–144 dBm/Hz	–135 dBm/Hz
40 GHz < Frequency ≤ 44.5 GHz	–140 dBm/Hz	–132 dBm/Hz

Frequency	Without MS2840A-067 at Frequency Band Mode: Normal and MS2840A-068/069 installed and Preamp: On
100 kHz	–147 dBm/Hz (nom.)
1 MHz	–156 dBm/Hz
30 MHz ≤ Frequency < 1 GHz	–166 dBm/Hz
1 GHz ≤ Frequency < 2 GHz	–164 dBm/Hz
2 GHz ≤ Frequency < 3.5 GHz	–163 dBm/Hz
3.5 GHz < Frequency ≤ 6 GHz	–160 dBm/Hz
6 GHz < Frequency ≤ 18.3 GHz	–163 dBm/Hz
18.3 GHz < Frequency ≤ 34 GHz	–160 dBm/Hz
34 GHz < Frequency ≤ 40 GHz	–157 dBm/Hz
40 GHz < Frequency ≤ 44.5 GHz	–149 dBm/Hz

Table 4 High-Performance Waveguide Mixer MA2806A/MA2808AMain Specifications

Model		MA2806A	MA2808A
Frequency Range		50 GHz to 75 GHz	60 GHz to 90 GHz
Multiplier Coefficient		8	12
Conversion Loss*		<15 dB (nom.)	
1 dB Gain Compression (P1 dB)*		>0 dBm (nom.)	
RF Input VSWR		≤1.5 (nom.)	
IF/LO Port VSWR	1.875 GHz (IF)	≤2.0 (nom.)	
	5 GHz to 10 GHz (LO)	≤2.4 (nom.)	≤2.0 (nom.)
Max Input Level (CW)		+10 dBm	

*At recommended temperature range (+18° to +28°C)

Publicly available