Development of Signal Analyzer MS2850A for 5G Mobile Communications Systems

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[Summary] There are high expectations for development of 5G wireless mobile networks and implementation of ultra-high speeds is being examined. Implementing ultra-high speeds requires use of wideband signals and both micro-wave and mm-wave bands are being investigated for this purpose. To meet demands for wider bandwidth and higher-frequency solutions, Anritsu has developed the Signal Analyzer MS2850A supporting an analysis bandwidth of 1 GHz and an upper frequency limit of 44.5 GHz. The MS2850A is a middle-price-range signal analyzer with excellent in-band flatness and dynamic range performance for high-accuracy 5G measurements. Additionally, installing 5G application software in the main unit simplifies and speeds-up measurement.

1 Introduction

Recently, there is an increasing trend in favor of commercial 5G service rollout. Various wireless communications equipment makers are moving from the demonstration stage towards development of commercial products and testing of manufacturing infrastructure. 5G deployment requires testing of various technical advances, and assuring the ultra-high-speed 5G requirement involves testing of frequency bandwidths supporting unhindered cross-border international communications. However, it is difficult to secure a wide bandwidth at frequencies below 3 GHz currently used by mobile communications systems. As a result, use of the micro and mm wavebands (28- and 39-GHz bands) is being examined as a means to achieve that.

Testing these signals requires a signal analyzer supporting high-frequency and wideband analysis. However, these features are limited to expensive high-end machines while development and manufacturing require many of these instruments. These rising equipment costs are an issue hindering commercial 5G deployment.

To solve these issues, the MS2850A was developed by Anritsu as the industry's first middle-price-range signal analyzer supporting wideband signal analysis required by 5G. The MS2850A has an analysis bandwidth of 1 GHz covering frequencies up to 44.5 GHz. As well as these specifications, it has better dynamic range performance (difference between Analog to Digital Converter (ADC) range overflow level and noise floor) and in-band flatness performance than commercial high-end instruments. When measuring a 100-MHz band single-carrier signal in the 28-GHz band expected to be used by 5G, the excellent dynamic range performance of the MS2850A yields an Error Vector Magnitude (EVM) of ≤1%. Additionally, installing the MX285051A 5G Measurement Software supporting measurement of up to 8 carriers at once makes modulation analysis of 5G signals both easy and quick. Furthermore, with 16 GB of waveform memory and high-speed interfaces for fast transfer of waveform data to an externally connected PC, the MS2850A is the perfect platform for analysis of wideband signals. Figure 1 shows the front view of the MS2850A.

Figure 1 MS2850A Front Panel

2 Development Concept

This development of a signal analyzer for 5G focused on the following concepts:

(1) ≤1% EVM at 28-GHz Center Frequency and 100-MHz Bandwidth Signal

5G seems likely to use the 28-GHz band. An EVM of ≤1% was targeted for this frequency band. Assuming a Peak to Average Power Ratio (PAPR) of 14 dB, the target dynamic range performance was a Signal to Noise Ratio (SNR) of ≥54 dB.

(2) Excellent In-band Flatness Performance

The volume of mobile traffic by the 2020s is forecast to be more than 1000 times that of the 2010s and deployment of 5G services is required to cope with these huge traffic volumes at low cost and low power consumption. R&D into Massive MIMO and Digital Pre-Distortion (DPD) technologies is progressing to meet these demands. Using these technologies, both in-band amplitude and in-band phase characteristics have an impact on performance. Consequently, 5G measuring instruments require excellent and better in-band flatness than previous instruments.

The target in-band flatness for the MS2850A at a center frequency of 28 GHz and 1-GHz analysis bandwidth is:

In-band Amplitude Characteristics: ±1.25 dB
In-band Phase Characteristics: 6°p-p

(3) 1-GHz Analysis Bandwidth and Large-Capacity Capture

Due to the expansion of the bandwidth, high-speed, next-generation communications systems like 5G must capture signals by performing ADC at a high sampling rate and the data size increases in proportion to the sampling rate.

Since the MS2850A has an analysis bandwidth of 1 GHz, the aim was to achieve a Field Programmable Gate Array (FPGA) signal processing speed matching the high-speed data. In addition, the goal was to capture sufficiently large capacity for performing failure analysis, etc. for large data sizes.

(4) 5G Measurement Software

5G measurement software is built into the MS2850A main unit for future-proof analysis of 5G signals at R&D and manufacturing. The planned 5G standards were published in June 2016 as the Verizon 5G standards at the Verizon 5G Technical Forum. It seems likely that future development and manufacturing of devices will be based on the Verizon 5G standards. On the other hand, the 3GPP organization, a separate body from the Verizon 5G Technical Forum, is also promoting plans for 5G standards. These seem likely to have different physical-layer specifications compared to the Verizon 5G standards. As a result, the 5G measurement software built into the MS2850A main unit is configured to also support any future 3GPP 5G standards.

(5) External I/F for High-Speed Data Transfer

At the R&D stage of communications systems on the standards roadmap, developers sometimes configure a unique measurement environment using their own signal analysis software. In particular, for communications systems handling wideband signals, such as 5G, data must be captured at a high sampling rate and the size of the captured data can be very large. As a result, when handling this large data with an external PC, the data transfer speed between the instrument and the PC can be an issue. To achieve high transfer speed for large data volumes, the MS2850A has two built-in high-speed interfaces—a USB3.0 interface, and an 8-lane PCIe Gen2 interface, supporting the following average data transfer speeds:

USB3.0: 300 Mbyte/s
PCIe Gen2 × 8 lanes: 2000 Mbyte/s

3 Design Requirements

3.1 MS2850A Structure

Figure 2 shows the MS2850A internal block diagram. The radio frequency (RF) signal input to the INPUT connector on the left side is adjusted to the appropriate input level by the RF Attenuator (RF ATT) before input to the Mixer where it is mixed with the Local Oscillator (LO) signal and converted to the Intermediate Frequency (IF) signal. This converted IF signal passes via the Antialiasing Filter and is input to the ADC after level adjustment by the IF Amplifier (IF AMP) and IF Attenuator (IF ATT). The IF signal sampled by the ADC is converted to a complex signal by the FPGA and signal processed for drawing as a spectrum on the display.

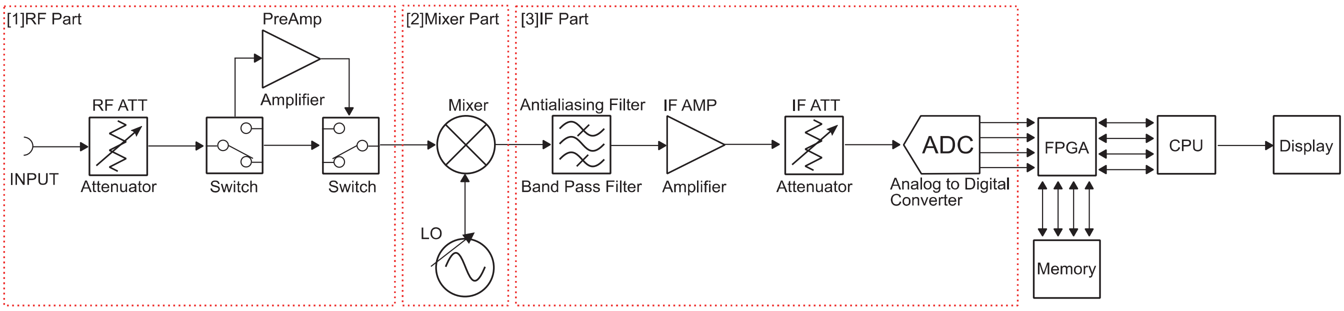


Figure 2 MS2850A Block Diagram

3.2 ≤1% EVM with 28-GHz Center Frequency and 100- MHz Bandwidth Signal

EVM is one index of the modulation accuracy of communications equipment. The modulation accuracy at measurement of an ideal signal is called the residual EVM; it determines the measurement limits at modulation analysis making it a key index of the measuring instrument's performance. Since residual EVM becomes smaller as measurement error becomes smaller, an instrument with small EVM can be said to have good performance.

The residual EVM of a measuring instrument is determined by various composite factors (SNR, distortion, phase noise, etc.). However, SNR is the main factor for wideband signals because power density drops as the signal band becomes wider and the SNR contribution to the residual EVM increases relative to other error sources. For example, in a signal analyzer with a DANL of –140 dBm/Hz, a signal with a level of –10 dBm is input at the 20-MHz band (LTE for example). The SNR at this time is 57 dB of which EVM is about 0.14%. On the other hand, when the band is 100 MHz (5G for example), the SNR is 50 dB of which EVM is about 0.3%. This shows that the impact of instrument SNR as these signals become wider band cannot be ignored, and the lower the instrument noise floor, the better.

There are a number of factors in the environment surrounding 5G systems that lower the SNR.

The first major factor is PAPR, which is the peak to average power ratio of the signal. The PAPR of an Orthogonal Frequency Division Multiplexing (OFDM) signal being examined for use by 5G systems is about 14 dB. To handle signals without deterioration, the signal input must not (or must be adjusted so as not to) cause the peak power to exceed the instrument ADC full-scale upper limit level, meaning that it is necessary to set the average power lower by the PAPR amount from the upper limit level of the instrument, but the SNR is decreased by the PAPR amount. Figure 3 shows this relationship. With a signal analyzer, the system dynamic range is determined by the sum of the signal-path Noise Figure (NF) and the SNR of the ADC itself. The maximum signal level is determined by the ADC full-scale vale but due to the existence of signal PAPR, the actual SNR is reduced by the PAPR amount as shown in the figure.

The second major factor is the small bit count for currently available wideband ADC units. The SNR of ADC is determined by this bit count. Since wideband ADC bit count is small, the wideband system SNR is low in comparison to narrowband systems used so far (from Figure 3, we can see that a wideband ADC has a higher noise level N than a narrowband ADC).

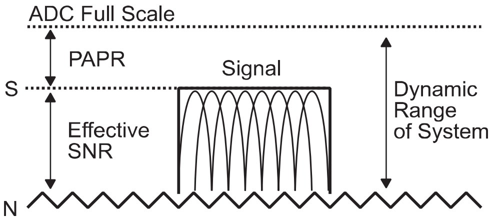


Figure 3 Actual SNR of Signal Analyzer

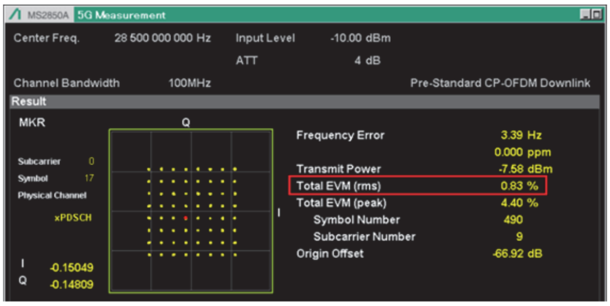
The ADC units in the MS2850A for narrowband signal analysis and wideband signal analysis are separate; the former has a count of 16 bits while the latter has a count of 12 bits.

To summarize the above, in a wideband signal analyzer, the SNR of the entire system decreases as a result of the ADC bit count, and the actual SNR is further reduced due to the PAPR and bandwidth. Consequently, optimizing the instrument internal level adjustment is important. With general-purpose signal analyzers, the level adjustment mechanism is simply an attenuator (RF ATT in Figure 2). In this case, it will be necessary to search the point with the best SNR without the ADC overflowing using only the RF ATT.

However, since there is only one variable mechanism, it is difficult to find a balance between SNR and ADC overflow. When the RF ATT value is small, the SNR of the signal path is good but on the other hand, the ADC overflows easily due to PAPR. Conversely, when the RF ATT value is large to prevent ADC overflow, the signal-path SNR becomes degraded.

In the MS2850A, a variable attenuator (IF ATT) is positioned at the IF stage to solve this problem by division into RF input level adjustment (RF ATT) and ADC input level adjustment (IF ATT). The RF ATT mechanism is used to adjust the level for the mixer is used in the linear region. Reducing the RF ATT value in the range where the mixer does not suffer distortion increases the SNR of the signal path. There is a risk of ADC overflow at this time but overflow is suppressed using the IF ATT to control the ADC input level. This mechanism maximizes the system SNR.

Based on the above, the MS2850A achieves an EVM of 0.83% (Figure 4) at input of a 100-MHz band Verizon 5G signal with a center frequency of 28 GHz.



Center Freq. 28 500 000 000 Hz
Input Level -10.00 dBm
ATT 4 dB
Channel Bandwidth 100MHz
Pre-Standard CP-OFDM Downlink

Subcarrier 0
Symbol 17
Physical Channel xPDSCH
I -0.15049
Q -0.14809

Frequency Error 3.39 Hz
0.000 ppm
Transmit Power -7.58 dBm
Total EVM (rms) 0.83 %
Total EVM (peak) 4.40 %
Symbol Number 490
Subcarrier Number 9
Origin Offset -66.92 dB

Figure 4 MS2850A EVM Analysis Results

3.3 Excellent In-band Flatness

To achieve in-band amplitude characteristics of ±1.25 dB and in-band phase characteristics of 6°p-p, the MS2850A was designed for optimum calibration corresponding to the internal circuit conditions.

The impact of each section of the MS2850A (Figure 2) on in-band flatness is explained below.

[1] RF Part

The RF section adjusts the gain using the RF ATT and PreAmp so that the signal is input at the optimum level to the mixer. The RF section is built to handle the passage of signals over a very wide frequency range; the MS2850A can pass signals from 9 kHz to 44.5 GHz.

For example, when observing a narrow frequency range of 30 or 40 MHz, the frequency characteristics of the RF section have good flatness, but at a bandwidth of 1 GHz like that used by 5G, the performance is degraded compared to a narrow frequency range.

Additionally, the RF ATT and PreAmp are switched to adjust the gain, requiring consideration of changes in frequency characteristics with switched path.

[2] Mixer Part

Changes in the LO signal frequency cause changes in the LO signal level, requiring care about the impact on the in-band flatness of the signal output from the mixer. To maintain good in-band flatness over a wide signal range, it is important to understand the impact of changes in the LO signal frequency on in-band flatness.

[3] IF Part

The IF section performs filtering using an Antialiasing Filter to remove unwanted signals. In addition, it also adjusts the IF ATT to optimize the measurement dynamic range.

The Antialiasing Filter has sharp attenuation characteristics to suppress image generation by out-of-band signals. This has a large impact on in-band flatness. In addition, changes in the IF ATT value change the impedance which has an impact on in-band flatness.

By calibrating the factors having an impact on the amplitude and phase characteristics described in items [1] through [3], the MS2850A achieves excellent flatness with in-band amplitude characteristics[*1] of ±1.2 dB and in-band phase characteristics[*2] of 5°p-p. Figures 5(a) and 5(b) show the actual measured in-band amplitude and in-band phase characteristics, respectively, before and after calibration.

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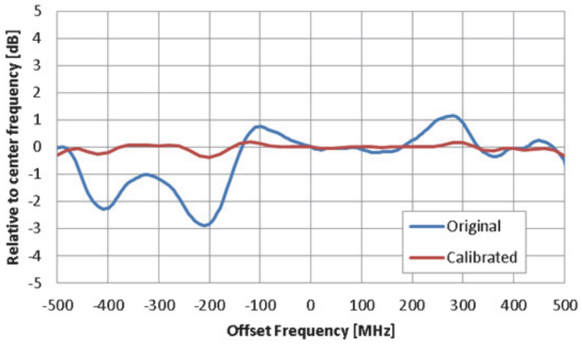
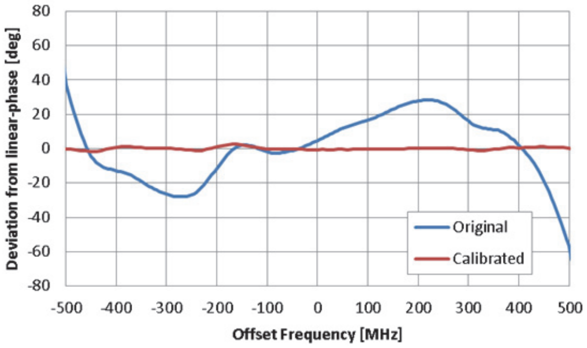
*1: Nominal value at 18° to 28°C, on the basis of a level of the Center Frequency, Bandwidth >31.25 MHz.

*2: Deviation from linear phase characteristics.
Nominal value at Offset Frequency ≤ Center Frequency ±500 MHz.
Bandwidth > 31.25 MHz, ATT 10 dB, Preamp Off,
Reference Level ≤ 0 dBm.



(a) In-Band Amplitude Characteristics



(b) In-Band Phase Characteristics

Figure 5 In-Band Flatness Before/After Calibration (Center Frequency = 28 GHz)

3.4 1-GHz Analysis Bandwidth and Large-Capacity Capture

(1) 1-GHz Analysis Bandwidth

To implement a 1-GHz analysis bandwidth, the MS2850A has a function for high-speed signal processing of the digital data sampled at high speed from the ADC using the FPGA.

As shown in Figure 6, communications between the ADC and FPGA are performed in accordance with the JESD204B standard which was developed for high-speed communications between the converter and FPGA and is a serial-data communications standard supporting a maximum speed of 12.5 Gbps/lane.

The MS2850A uses a 12-bit, 2600-Msamples/s ADC supporting the JESD204B standard to send digital data to the FPGA. However, the FPGA operation clock depends on the device grade and circuit scale and is several hundred MHz, making it unable to process 2600 MSample/s digital data as is. Consequently, the received digital data is parallel-processed to achieve analysis that can keep up with the acquisition of ADC high-speed data.

In addition, to implement the excellent in-band flatness performance recommended in item (2) of section 2, a calibration filter is built-in to calibrate the in-band amplitude and phase characteristics (refer to section 3.3 for the in-band flatness characteristics before and after calibration using the calibration filter).

Data transfer to the CPU uses PCIe2.0 x8 (Peripheral Component Interconnect Express Generation 2, 8 lane). Parallel processing is performed for the calibration filter to process at much higher speeds.

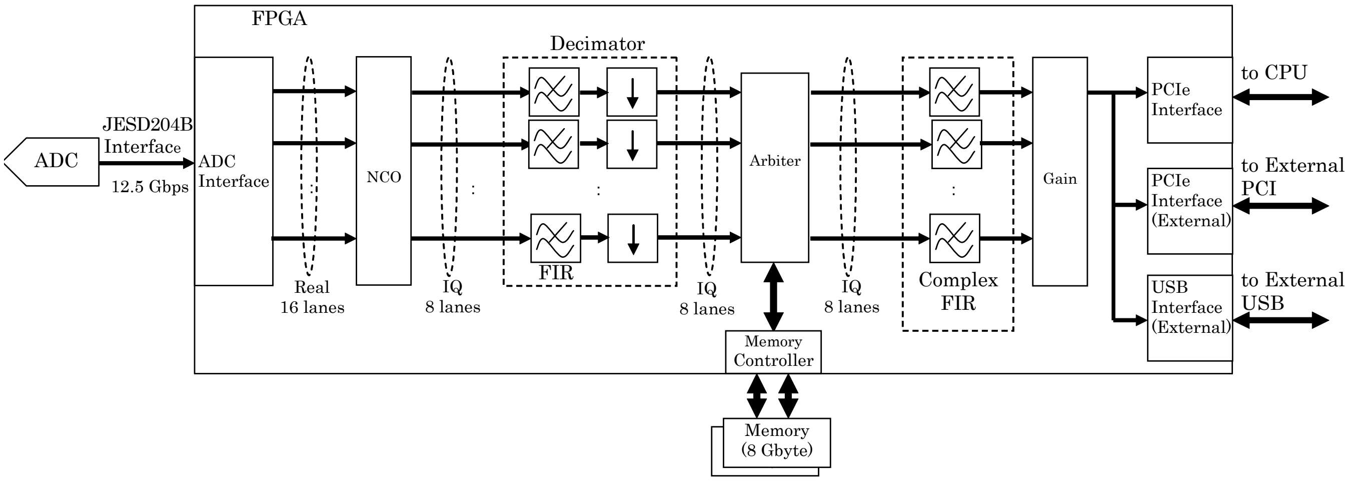


Figure 6 Parallel Processing in FPGA

(2) Large-Capacity Capture

The captured data size is proportionally larger relative to the analysis bandwidth. Table 1 shows the ratio of the LTE and 5G data sizes captured by the MS2850A.

Table 1 LTE and 5G Captured Data Size Ratio

	Each per Frame [ms]	Sampling Rate [MSample/s][*1]	Size [Mbyte]
LTE	10	50	1
5G	20[*2]	1300	104

*1: Sampling rates assume LTE bandwidth of 30.72 MHz and 5G bandwidth of 800 MHz

*2: According to 3GPP TS 38.213 V1.1.0 (2017-10)

From this table, captured 5G data is more than 100 times larger than the captured LTE data size. Moreover, data for multiple frames is required at fault analysis of this signal. Consequently, 16 GB memory was built-in the MS2850A. This signal analyzer waveform memory size is the world's largest (as of November 2017). Table 2 lists the maximum data capture time for the analysis bandwidth and sampling rate.

Table 2 Relationship between Analysis Bandwidth (Span), Sampling Rate, and Capture Time

Span [MHz]	Sampling Rate [MSample/s]	Maximum Capture Time [s]
1000	1300	3.07
510	650	6.15
255	325	12.3
125	162.5	24.6

As described, the MS2850A supports wideband signal analysis by implementing capture of large data volumes.

3.5 5G Standard Measurement Software

The 5G standard measurement software supports the physical layer standards as follows. Using selectable options offering customized functions improves the measurement environment cost-performance as well as easy support for future upgrades for 3GPP 5G standards. Table 3 lists the measurement software options that can be installed in the MS2850A at its release in November 2017.

Table 3 Measurement Software for 5G

Model	Name
MX285051A	5G Standard Measurement Software (Base License)
MX285051A-001	Pre-Standard CP-OFDM Downlink
MX285051A-051	Pre-Standard CP-OFDM Uplink

With a 1-GHz modulation analysis bandwidth and installation of modulation analysis software for the Verizon 5G standard, the MS2850A can perform all-at-once batch analysis of up to 8 carriers with a bandwidth of 800 MHz.

Moreover, using the Verizon 5G modulation analysis software simplifies the complex parameter settings required for modulation analysis. Additionally, modulation analysis software option for LTE, etc., supported by earlier instruments can also be installed in the MS2850A, enabling one unit to support both LTE and 5G analysis; the LTE analysis software can even be controlled using the same remote commands as used for previous instruments. When configuring a measurement environment for 5G, assuring interchangeability with existing remote sequences helps cut workloads when changing instruments.

3.6 High-Speed Data Transfer

Previously, data transfer to PC controllers uses the Programmed I/O (PIO) data-transfer method following the Standard Commands for Programmable Instruments (SCPI) standards. Due to limitations such as the maximum memory size allocation of the CPU used in instruments, the data-transfer time becomes longer because each data-transfer size is limited to 50 kSamples. Additionally, the transfer time becomes even longer, because data is transferred via the instrument CPU. Figure 7 shows the data-transfer flow for earlier instruments. Data is read from waveform memory (1) and is then written to the external PC I/O device (2), forming one cycle. If the large amount of data is split for transfer, processes (1) and (2) are repeated over. In the earlier method, the CPU processing load increases in proportion to the number of repetitions, resulting in slower data-transfer speed.

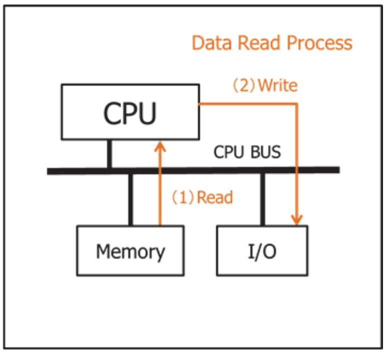


Figure 7 PIO Data Transfer Method

The high-speed data-transfer method uses a Direct Memory Access Controller (DMAC) for Direct Memory Access (DMA) without passing data via the instrument CPU. High-speed data transfer using hardware performance can be realized by the DMA transfer method without CPU load. Figure 8 shows the high-speed data-transfer flow. Data is read from memory (1) and is then written to the New I/O device of the external PC (2), forming one cycle. If the large amount of data is split for transfer, processes (1) and (2) are repeated over. Even if the large amount of data is split for transfer, the transfer speed remains constant because the data does not pass via the instrument CPU.

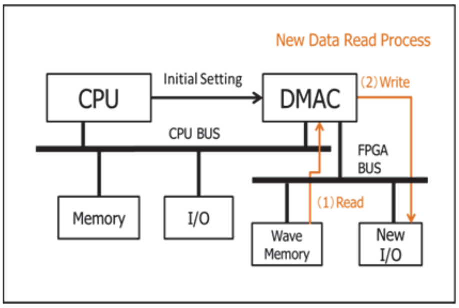


Figure 8 DMA Data Transfer Method

In summary, using the high-speed data-transfer method assures stable high-speed transfer.

4 Functions

4.1 5G Standard Measurement Software Functions

The Pre-Standard CP-OFDM Downlink and Pre-Standard CP-OFDM Uplink options installed for the 5G Standard Measurement Software has the following functions:

- All-at-once batch analysis for up to 8 carriers in 800-MHz band
- Auto-optimization of problematic input level settings at wideband-signal EVM measurements
- Easy measurement display for multicarrier signal measurements

Details of these functions are explained below.

4.1.1 All-At-Once Batch Analysis Function for up to 8 Carriers in 800-MHz Band

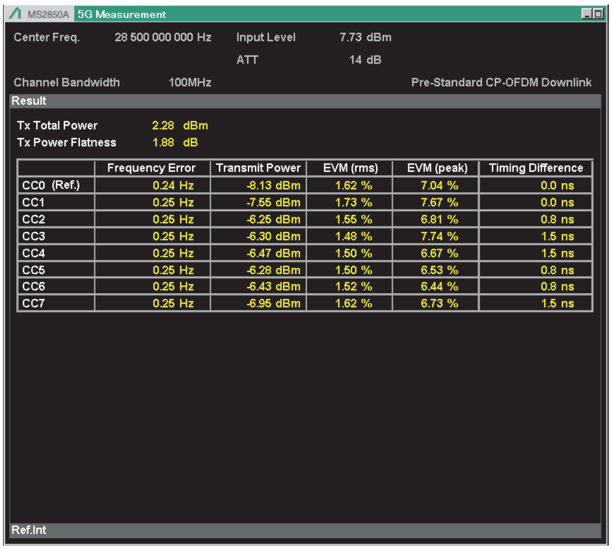
Verizon 5G compliant signals have a 100-MHz bandwidth per component carrier, supporting 800-MHz bandwidth multicarrier signals composed of up to 8 component carriers. The modulation analysis software can capture 8 carriers at once for analysis. Capturing a multicarrier signal at one time supports accurate measurement of dynamic differences between carriers as well as degraded signal quality for a specific carrier due to the effects of other carriers.

Table 4 shows results for selected traces at multicarrier signal measurement.

Table 4 Trace Name and Displayed Measurement Results

Trace Name	Displayed Measurement Results
Summary	Tx Total Power: Displays total Tx power for all carriers Tx Power Flatness: Displays difference in Tx powers between carrier with maximum Tx power and carrier with minimum Tx power out of measured carriers Frequency Error: Displays frequency error for each carrier Transmit Power: Displays Tx power for each carrier EVM (rms): Displays EVM (rms) value for each carrier EVM (peak): Displays EVM peak value for each carrier Timing Difference: Displays difference in timing for carrier specified at Reference Carrier
Power vs RB	Displays color-coded power for each Resource Block (RB)
EVM vs RB	Displays color-coded EVM for each Resource Block (RB)

Figures 9, 10, and 11 show examples for each trace.



MS2850A 5G Measurement

Center Freq. 28 500 000 000 Hz Input Level 7.73 dBm
ATT 14 dB
Channel Bandwidth 100MHz Pre-Standard CP-OFDM Downlink

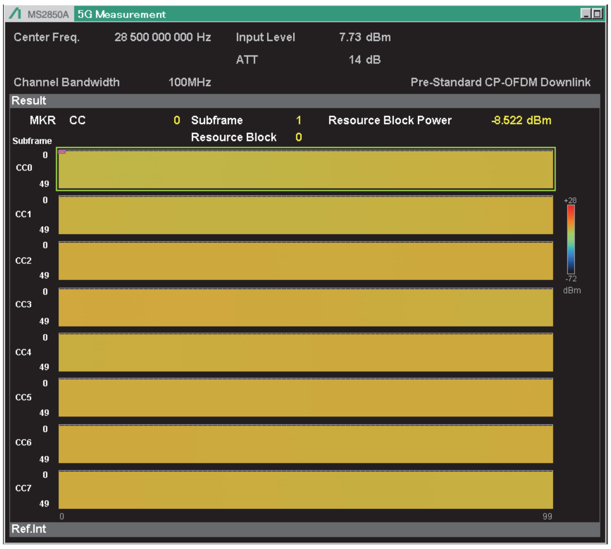
Result

Tx Total Power 2.28 dBm
Tx Power Flatness 1.88 dB

	Frequency Error	Transmit Power	EVM (rms)	EVM (peak)	Timing Difference
CC0 (Ref.)	0.24 Hz	-8.13 dBm	1.62 %	7.04 %	0.0 ns
CC1	0.25 Hz	-7.55 dBm	1.73 %	7.67 %	0.0 ns
CC2	0.25 Hz	-6.25 dBm	1.55 %	6.81 %	0.8 ns
CC3	0.25 Hz	-6.30 dBm	1.48 %	7.74 %	1.5 ns
CC4	0.25 Hz	-6.47 dBm	1.50 %	6.67 %	1.5 ns
CC5	0.25 Hz	-6.28 dBm	1.50 %	6.53 %	0.8 ns
CC6	0.25 Hz	-6.43 dBm	1.52 %	6.44 %	0.8 ns
CC7	0.25 Hz	-6.95 dBm	1.62 %	6.73 %	1.5 ns

Ref.Int

Figure 9 Summary



MS2850A 5G Measurement

Center Freq. 28 500 000 000 Hz Input Level 7.73 dBm

ATT 14 dB

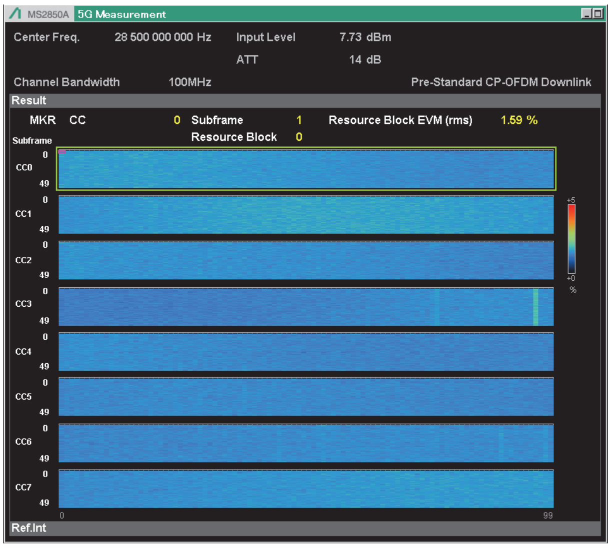
Channel Bandwidth 100MHz Pre-Standard CP-OFDM Downlink

Result

MKR CC 0 Subframe 1 Resource Block Power -8.522 dBm

Resource Block 0

Figure 10 Power vs RB



MS2850A 5G Measurement

Center Freq. 28 500 000 000 Hz Input Level 7.73 dBm

ATT 14 dB

Channel Bandwidth 100MHz Pre-Standard CP-OFDM Downlink

Result

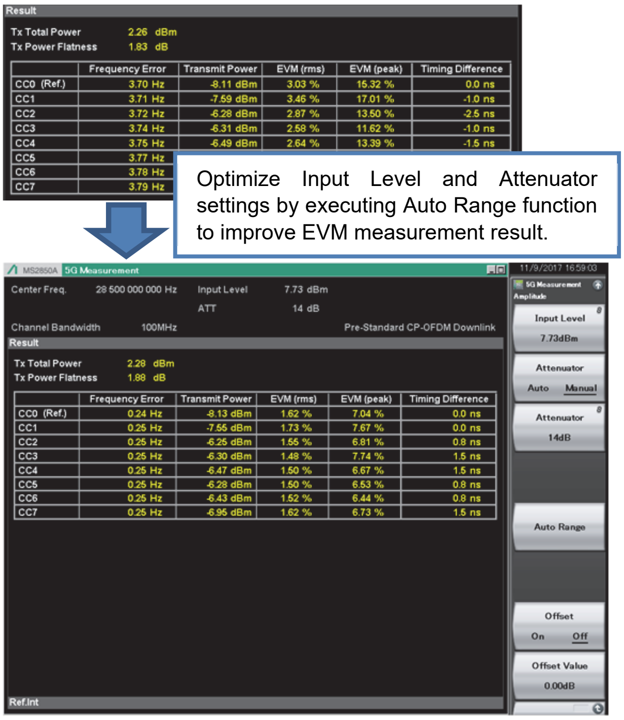
MKR CC 0 Subframe 1 Resource Block EVM (rms) 1.59 %

Resource Block 0

Figure 11 EVM vs RB

4.1.2 Input Level Auto-Setting Function

As described in section 3.2, it is best to minimize the impact of instrument SNR as much as possible at measurement of wideband signals such as 5G. The Verizon 5G measurement software has a 1-button function for setting the optimum Input Level and attenuation value matching the input signal level. This function not only cuts the time required for setting the signal analyzer but also simplifies optimized EVM measurement settings whatever the operator skill level (Figure 12).



Result

Tx Total Power 2.26 dBm

Tx Power Flatness 1.83 dB

	Frequency Error	Transmit Power	EVM (rms)	EVM (peak)	Timing Difference
CC0 (Ref.)	3.70 Hz	-8.11 dBm	3.03 %	15.32 %	0.0 ns
CC1	3.71 Hz	-7.59 dBm	3.46 %	17.01 %	-1.0 ns
CC2	3.72 Hz	-6.28 dBm	2.87 %	13.50 %	-2.5 ns
CC3	3.74 Hz	-6.31 dBm	2.58 %	11.62 %	-1.0 ns
CC4	3.75 Hz	-6.49 dBm	2.64 %	13.39 %	-1.5 ns
CC5	3.77 Hz				
CC6	3.78 Hz				
CC7	3.79 Hz				

Optimize Input Level and Attenuator settings by executing Auto Range function to improve EVM measurement result.

MS2850A 5G Measurement 11/9/2017 16:59:03

Center Freq. 28 500 000 000 Hz Input Level 7.73 dBm

ATT 14 dB

Channel Bandwidth 100MHz Pre-Standard CP-OFDM Downlink

Result

Tx Total Power 2.28 dBm

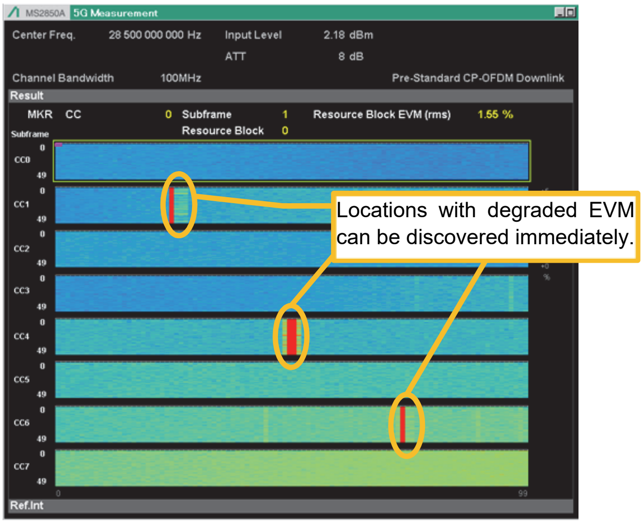
Tx Power Flatness 1.88 dB

	Frequency Error	Transmit Power	EVM (rms)	EVM (peak)	Timing Difference
CC0 (Ref.)	0.24 Hz	-8.13 dBm	1.62 %	7.04 %	0.0 ns
CC1	0.25 Hz	-7.55 dBm	1.73 %	7.67 %	0.0 ns
CC2	0.25 Hz	-6.25 dBm	1.55 %	6.81 %	0.8 ns
CC3	0.25 Hz	-6.30 dBm	1.48 %	7.74 %	1.5 ns
CC4	0.25 Hz	-6.47 dBm	1.50 %	6.67 %	1.5 ns
CC5	0.25 Hz	-6.28 dBm	1.50 %	6.53 %	0.8 ns
CC6	0.25 Hz	-6.43 dBm	1.52 %	6.44 %	0.8 ns
CC7	0.25 Hz	-6.95 dBm	1.62 %	6.73 %	1.5 ns

Figure 12 Auto Range Example

4.1.3 Easy Measurement Display for Multicarrier Signal Measurements

When displaying measurement results for a single carrier at multicarrier signal measurement, it can be very difficult to find the required results because more results are obtained in proportion to the number of carriers. The Verizon 5G measurement software can display color-coded EVM and power values for each RB during multicarrier signal measurement for confirming the outline results on one screen. In addition, when an abnormal carrier is discovered in the measurement results, that carrier alone can be analyzed to confirm detailed results and track-down the causes of the abnormality.



MS2850A 5G Measurement

Center Freq. 28 500 000 000 Hz Input Level 2.18 dBm

ATT 8 dB

Channel Bandwidth 100MHz Pre-Standard CP-OFDM Downlink

Result

MKR CC 0 Subframe 1 Resource Block EVM (rms) 1.55 %

Resource Block 0

Locations with degraded EVM can be discovered immediately.

Figure 13 EVM vs RB Example

4.2 External I/F for High-Speed Data Transfer

As shown in Figure 6, the MS2850A has two built-in high-speed data-transfer USB3.0 and PCIe2.0 x8 interfaces supporting both general purpose and high-speed requirements (Table 5).

Table 5 External I/Fs for High-Speed Data Transfer

Model	Name
MS2850A-053/153	External Interface for High Speed Data Transfer PCIe
MS2850A-054/154	External Interface for High Speed Data Transfer USB3.0

As shown in Table 6, transferring 160 ms of data for up to 8 carriers in the 800-MHz band (1-GHz analysis bandwidth) using the previous PIO data-transfer method over 1000Base-T requires a long time of about 90 s, whereas using the DMA data transfer method with the high-speed data-transfer external interface is about 100 times faster than even PCIe.

Table 6 Data Transfer Speed Comparison
(1-GHz Analysis Bandwidth, 160-ms Data Length)

MS2850A (Measured Value)	PCIe (x8/Gen2)	USB (3.0)	1000Base-T (VISA)
Avg. Transfer Speed [Mbyte/s]	2233.8	360.0	18.6
Transfer Time [s]	0.745	4.62	89.46

However, the data-transfer speed depends on the external PC specifications.

Table 7 lists the specifications for the external PC used when evaluating the above-described data-transfer speeds.

Table 7 External PC Specifications

OS	Windows 10 Pro (64-bit)
CPU	Intel® Xeon® Processor E5-1630v4 3.7 to 4.0
Chipset	Intel® C612
Memory	16 GB (8 GB × 2)

5 Conclusions

Anritsu has developed the MS2850A to support future deployment of 5G mobile systems. Although it is a middle-price-range signal analyzer, in addition to having a 1-GHz analysis bandwidth, it also has excellent in-band flatness and dynamic range performance required for measuring wideband signals, helping cut equipment costs at development and commercial production of 5G devices.

Anritsu expects the MS2850A will play a key role in development of future wireless technologies and devices.

References

1) Verizon 5G TF; Air Interface Working Group; Verizon 5th Generation Radio Access; Physical channels and modulation (Release 1) TS V5G.211 V1.7 (2016-10)

2) T. Otani, K. Tomisaki, N. Miyauchi, K. Kuramitsu, Y. Kondo, J. Kimura, H. Oyama, "Development of Signal Analyzer MS2840A with Built-in Low Phase-Noise Synthesizer", Anritsu Technical Review No.25 (2017-9)

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Yuki Kondo
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Table 8 MS2850A Signal Analyzer Main Specifications

<table>
<tr><td rowspan="2">Frequency</td><td>Frequency Range</td><td>MS2850A-047: 9 kHz to 32 GHz
MS2850A-046: 9 kHz to 44.5 GHz
Signal Analyzer mode (at Analysis Bandwidth of >31.25 MHz)
MS2850A-047: 800 MHz to 32 GHz
MS2850A-046: 800 MHz to 44.5 GHz</td></tr>
<tr><td>SSB Phase Noise</td><td>18° to 28°C, 1000 MHz, Spectrum Analyzer mode
<table>
<tr><th>Offset Frequency</th><th>Specification</th></tr>
<tr><td>10 Hz</td><td>–80 dBc/Hz (nom.)</td></tr>
<tr><td>10 MHz</td><td>–148 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></td></tr>
<tr><td>Amplitude</td><td>Display Average Noise Level (DANL)</td><td>At 18° to 28°C, Detector: Sample, VBW: 1 Hz (Video Average), Input Attenuator: 0 dB,
Spectrum Analyzer Mode, MS2850A-046 installed, MS2850A-076 not installed,
Frequency Band Mode: Normal, Preselector Bypass: Off
<table>
<tr><th>Frequency</th><th>MS2850A-068 Not Installed</th><th>MS2850A-068 Installed and PreAmp Off</th></tr>
<tr><td>9 kHz ≤ Frequency < 100 kHz</td><td>–120 dBm/Hz</td><td>–120 dBm/Hz</td></tr>
<tr><td>100 kHz ≤ Frequency < 1 MHz</td><td>–134 dBm/Hz</td><td>–134 dBm/Hz</td></tr>
<tr><td>1 MHz ≤ Frequency < 10 MHz</td><td>–144 dBm/Hz</td><td>–144 dBm/Hz</td></tr>
<tr><td>10 MHz ≤ Frequency < 30 MHz</td><td>–150 dBm/Hz</td><td>–150 dBm/Hz</td></tr>
<tr><td>30 MHz ≤ Frequency < 1 GHz</td><td>–153 dBm/Hz</td><td>–153 dBm/Hz</td></tr>
<tr><td>1 GHz ≤ Frequency < 2.4 GHz</td><td>–150 dBm/Hz</td><td>–150 dBm/Hz</td></tr>
<tr><td>2.4 GHz ≤ Frequency ≤ 3.5 GHz</td><td>–147 dBm/Hz</td><td>–147 dBm/Hz</td></tr>
<tr><td>3.5 GHz < Frequency ≤ 6 GHz</td><td>–144 dBm/Hz</td><td>–144 dBm/Hz</td></tr>
<tr><td>6 GHz < Frequency ≤ 13 GHz</td><td>–146 dBm/Hz</td><td>–142 dBm/Hz</td></tr>
<tr><td>13 GHz < Frequency ≤ 18.3 GHz</td><td>–144 dBm/Hz</td><td>–140 dBm/Hz</td></tr>
<tr><td>18.3 GHz < Frequency ≤ 26.5 GHz</td><td>–140 dBm/Hz</td><td>–136 dBm/Hz</td></tr>
<tr><td>26.5 GHz < Frequency ≤ 34 GHz</td><td>–140 dBm/Hz</td><td>–135 dBm/Hz</td></tr>
<tr><td>34 GHz < Frequency ≤ 40 GHz</td><td>–136 dBm/Hz</td><td>–131 dBm/Hz</td></tr>
<tr><td>40 GHz < Frequency ≤ 44.5 GHz</td><td>–130 dBm/Hz (nom.)</td><td>–125 dBm/Hz (nom.)</td></tr>
</table>
<table>
<tr><th>Frequency</th><th>MS2840A-068/069 Installed and PreAmp On</th></tr>
<tr><td>100 kHz</td><td>–147 dBm/Hz (nom.)</td></tr>
<tr><td>1 MHz</td><td>–156 dBm/Hz</td></tr>
<tr><td>30 MHz ≤ Frequency < 1 GHz</td><td>–166 dBm/Hz</td></tr>
<tr><td>1 GHz ≤ Frequency < 2 GHz</td><td>–164 dBm/Hz</td></tr>
<tr><td>2 GHz ≤ Frequency ≤ 3.5 GHz</td><td>–163 dBm/Hz</td></tr>
<tr><td>3.5 GHz < Frequency ≤ 6 GHz</td><td>–160 dBm/Hz</td></tr>
<tr><td>6 GHz < Frequency ≤ 13 GHz</td><td>–163 dBm/Hz</td></tr>
<tr><td>13 GHz < Frequency ≤ 18.3 GHz</td><td>–162 dBm/Hz</td></tr>
<tr><td>18.3 GHz < Frequency ≤ 26.5 GHz</td><td>–159 dBm/Hz</td></tr>
<tr><td>26.5 GHz < Frequency ≤ 34 GHz</td><td>–156 dBm/Hz</td></tr>
<tr><td>34 GHz < Frequency ≤ 40 GHz</td><td>–153 dBm/Hz</td></tr>
<tr><td>40 GHz < Frequency ≤ 44.5 GHz</td><td>–145 dBm/Hz (nom.)</td></tr>
</table></td></tr>
</table>

<table>
<tr><td rowspan="2">Flatness</td><td>In-band Frequency Characteristics</td><td>At 18°~28°C, on the basis of a level of the Center Frequency,
Bandwidth >31.25 MHz
At Center Frequency ±50 MHz
<table>
<tr><th>Center Frequency</th><th>Specification</th></tr>
<tr><td>4.2 GHz ≤ Frequency < 5 GHz</td><td>±0.3 dB (nom.)</td></tr>
<tr><td>5 GHz ≤ Frequency ≤ 18.5 GHz</td><td>±0.3 dB (nom.)</td></tr>
<tr><td>18.5 GHz < Frequency ≤ 26.5 GHz</td><td>±0.3 dB (nom.)</td></tr>
<tr><td>26.5 GHz < Frequency ≤ 32 GHz</td><td>±0.3 dB (nom.)</td></tr>
<tr><td>32 GHz < Frequency ≤ 44.5 GHz</td><td>±0.3 dB (nom.)</td></tr>
</table>
At Center Frequency ±255 MHz
<table>
<tr><th>Center Frequency</th><th>Specification</th></tr>
<tr><td>4.2 GHz ≤ Frequency < 5 GHz</td><td>±0.7 dB (nom.)</td></tr>
</table>
At Center Frequency ±500 MHz
<table>
<tr><th>Center Frequency</th><th>Specification</th></tr>
<tr><td>5 GHz < Frequency ≤ 18.5 GHz</td><td>±0.7 dB (nom.)</td></tr>
<tr><td>18.5 GHz < Frequency ≤ 26.5 GHz</td><td>±1.0 dB (nom.)</td></tr>
<tr><td>26.5 GHz < Frequency ≤ 32 GHz</td><td>±1.2 dB (nom.)</td></tr>
<tr><td>32 GHz < Frequency ≤ 44.5 GHz</td><td>±1.25 dB (nom.)</td></tr>
</table>
</td></tr>
<tr><td>In-band Phase Characteristics</td><td>Deviation form the linear phase characteristics
At Bandwidth > 31.25 MHz, ATT 10 dB
At Offset Frequency ≤ Center Frequency ±500 MHz
At PreAmp Off, Reference Level ≤ 0 dBm
<table>
<tr><th>Center Frequency</th><th>Specification</th></tr>
<tr><td>4.2 GHz ≤ Frequency ≤ 5.14 GHz</td><td>5°p-p (nom.)</td></tr>
<tr><td>5.14 GHz < Frequency ≤ 42.1 GHz</td><td>5°p-p (nom.)</td></tr>
<tr><td>42.1 GHz < Frequency ≤ 44.5 GHz</td><td>6°p-p (nom.)</td></tr>
</table>
At PreAmp On, Reference Level ≤ –20 dBm
<table>
<tr><th>Center Frequency</th><th>Specification</th></tr>
<tr><td>4.2 GHz ≤ Frequency ≤ 5.14 GHz</td><td>7°p-p (nom.)</td></tr>
<tr><td>5.14 GHz < Frequency ≤ 42.1 GHz</td><td>6°p-p (nom.)</td></tr>
<tr><td>42.1 GHz < Frequency ≤ 44.5 GHz</td><td>6°p-p (nom.)</td></tr>
</table>
</td></tr>
<tr><td>Capture</td><td>Span</td><td>Signal Analyzer Mode
<table>
<tr><th>Span</th><th>Sampling Rate</th><th>Max. Capture Time</th><th>Target Option</th></tr>
<tr><td>1 kHz</td><td>2 kHz</td><td>2000 s</td><td>MS2850A-032/033/133/034/134</td></tr>
<tr><td>2.5 kHz</td><td>5 kHz</td><td>2000 s</td><td></td></tr>
<tr><td>5 kHz</td><td>10 kHz</td><td>2000 s</td><td></td></tr>
<tr><td>10 kHz</td><td>20 kHz</td><td>2000 s</td><td></td></tr>
<tr><td>50 kHz</td><td>100 kHz</td><td>2000 s</td><td></td></tr>
<tr><td>100 kHz</td><td>200 kHz</td><td>500 s</td><td></td></tr>
<tr><td>250 kHz</td><td>500 kHz</td><td>200 s</td><td></td></tr>
<tr><td>500 kHz</td><td>1 MHz</td><td>100 s</td><td></td></tr>
<tr><td>1 MHz</td><td>2 MHz</td><td>50 s</td><td></td></tr>
<tr><td>2.5 MHz</td><td>5 MHz</td><td>20 s</td><td></td></tr>
<tr><td>5 MHz</td><td>10 MHz</td><td>10 s</td><td></td></tr>
<tr><td>10 MHz</td><td>20 MHz</td><td>5 s</td><td></td></tr>
<tr><td>25 MHz</td><td>50 MHz</td><td>2 s</td><td></td></tr>
<tr><td>31.25 MHz</td><td>50 MHz</td><td>2 s</td><td></td></tr>
<tr><td>50 MHz</td><td>81.25 MHz</td><td>48 s</td><td></td></tr>
<tr><td>62.5 MHz</td><td>81.25 MHz</td><td>48 s</td><td></td></tr>
<tr><td>100 MHz</td><td>162.5 MHz</td><td>24 s</td><td></td></tr>
<tr><td>125 MHz</td><td>162.5 MHz</td><td>24 s</td><td></td></tr>
<tr><td>255 MHz</td><td>325 MHz</td><td>12 s</td><td></td></tr>
<tr><td>510 MHz</td><td>650 MHz</td><td>6 s</td><td>MS2850A-033/133/034/134</td></tr>
<tr><td>1000 MHz</td><td>1300 MHz</td><td>3 s</td><td>MS2850A-034/134</td></tr>
</table>
</td></tr>
<tr><td rowspan="5">External Controls</td><td>Ethernet (10/100/1000Base-T)</td><td>Rear panel, RJ-45</td></tr>
<tr><td>GPIB</td><td>IEEE488.2 compatible
Rear panel, IEEE488 bus connector
Interface function: SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, C0, E2</td></tr>
<tr><td>USB (B)</td><td>USB2.0 compatible
Rear panel, USB-B connector</td></tr>
<tr><td>USB (B)</td><td>USB3.0 compatible
Rear panel, USB-B connector</td></tr>
<tr><td>PCIe</td><td>PCIe Gen2 × 8 compatible
Rear panel, PCIe connector</td></tr>
</table>

Publicly available