Development of MS2830A-018 Audio Analyzer Option for MS2830A Signal Analyzer

Momoko Inadomaru, Keiichi Yoshitomi, Keisuke Nishio

[Summary] We have developed the MS2830A-018 Audio Analyzer Option for installation in the MS2830A Signal Analyzer. Previously, TRX tests of analog commercial radio equipment were supported by two MS2830A options—the MS2830A-088 Analog Signal Generator, and the MX269018A Analog Measurement Software. Installing this newly developed Audio Analyzer Option supports all key measurements of FM, AM, and ϕM analog radio using a single MS2830A. Additionally, with a built-in, high-performance spectrum analyzer, the MS2830A is an integrated platform assuring that measurements such as out-of-band spurious, adjacent channel leakage power, emission masks, etc., meet the stricter standards required as commercial radio starts using narrower frequency bands. As a result, only a single MS2830A unit is now required to support almost every test of narrow-band analog radio, including adjacent spurious that cannot be measured using conventional radio communication analyzers.

1 Introduction

1.1 Market and Requirements

The terrestrial mobile wireless market is transitioning from analog methods to digital methods typified by P25, NXDN, TETRA, etc. Additionally, the Federal Communications Commission (FCC) is proceeding with regulation to promote use of narrower bandwidths making more efficient use of the radio frequency spectrum, such as limiting bandwidths to 6.25 MHz. Moreover, in Japan, taxi and fire-fighting radio will become digital by 2016, followed by full digitalization of commercial radio using the 350 and 400-MHz bands by 2022. As a consequence of these changes, there is an increasing need for measuring instruments supporting digital methods and narrow frequency bands. On the other hand, evaluations of systems now using the 4FSK digital modulation method are being performed using conventional analog measuring instruments and radio communications analyzers with built-in analog functions, such as signal-to-noise and distortion ratio (SINAD) measurement, are being used to evaluate the RF sections of other digital methods.

Anritsu's popular MS555B and MT2605B radio communication analyzers and MS616B Modulation Analyzer are in widespread use as testers on analog wireless production lines but support is being discontinued and development of a successor instrument has been awaited. At the same time, the MS2830A Signal Analyzer already has an analog signal generator option (MS2830A-088) and analog measurement software supporting tests of RF characteristics for commercial analog radio, although lack of audio input/output requires combined use with an external audio analyzer. To overcome this weakness, we have now developed the MS2830A-018 Audio Analyzer Option for installation in the MS2830A, offering all-in-one support for TRX tests of analog commercial radio.

1.2 Development Concept

This unit was developed based on the following four concepts:

(1) Must be backwards compatible with purchased MX269018A analog measurement software to support TRX tests when installed in MS2830A.
(2) Must support TRX measurement items supported by MS555B Radio Communication Analyzer.
(3) Must support seamless operation with RF and AF measurements on one screen.
(4) Must support retrofitting to already shipped MS2830A units.

1.3 Overall Block Diagram

Figure 1 shows the overall block diagram. Installing the MX269018A Analog Measurement Software in the MS2830A supports use of the analog signal generator option and the TRX measurement mode. Adding the MS2830A-018 Audio Analyzer Option to the configuration supports audio generator, audio generator window, and audio analysis functions.

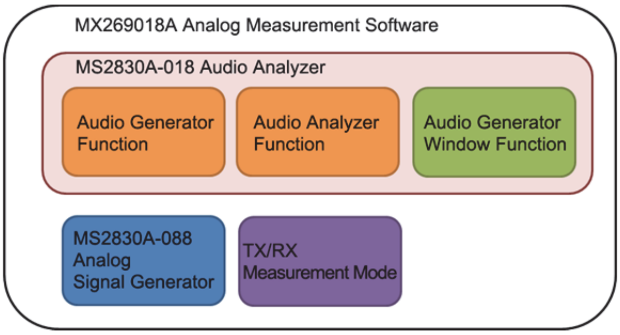


Figure 1 Overall Block Diagram

1.4 Function Outline

Figure 2 shows the measurement concept diagram when the MS2830A-018 option is installed. The MS2830A-018 mainly has audio signal output, audio signal analysis, and FM demodulation functions. The audio signal output function can output Tone signals, Digital Code Squelch (DCS) signals, pseudo voice (built-in white noise audio generator and ITU-T Rec. G.227 evaluation filters), and DTMF (Dual-Tone Multi-Frequency) signals. As well as having HPF and LPF functions for filtering tone signals, the audio signal analysis function has various built-in filters for evaluating wireless microphones. Moreover, it has a Wide Band Function for measuring FM deviation of up to 1 MHz. Additionally, the built-n speaker can be used to confirm the demodulated FM signal by ear. A wireless Push to Talk (PTT) function controls sending and receiving.

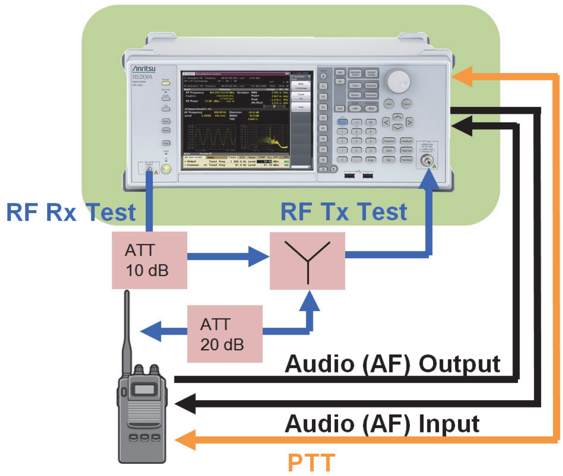


Figure 2 Measurement Concept Diagram with MS2830A-018 Installed

Figure 3 shows an external view of the MS2830A-018 with the interfaces all on the back panel. From the left, the interfaces are: audio inputs (unbalanced and balanced), noise source driver (requires Opt-*17), audio function connector, PTT connector, audio outputs (unbalanced and balanced), demodulated output, and headphones output. When the MX269018A Analog Measurement Software has been purchased previously, retrofitting the MS830A-018 supports use of the audio analyzer functions.

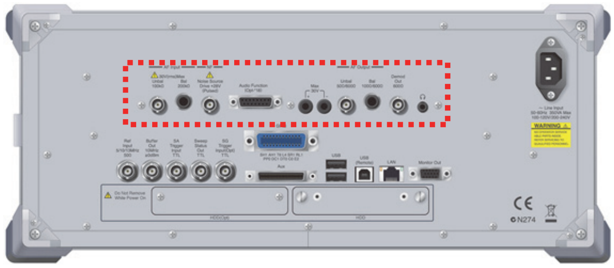


Figure 3 MS2830A-018 External Appearance

2 Key Design Points

2.1 Audio Generator Section

Figure 4 shows the block diagram of the MS2830A-018 audio generator function. The audio generator is composed of an FPGA, DAC, I/V converter, reconstruction filter, step attenuator, and current controller circuit. Either unbalanced or balanced output is achieved by switching the step attenuator backstage relay. Use of low-noise operation amplifier in the signal path greatly suppresses noise to achieve low-distortion performance. The FPGA corrects the frequency characteristics downstream of the DAC, assuring a level flatness of ±0.05 dB (actual value) at 10 Hz to 30 kHz, and ±0.25 dB (actual value) at 30 kHz to 50 kHz. The unbalanced output impedance is 600 Ω for A/V equipment and 50 Ω for broadcast equipment.

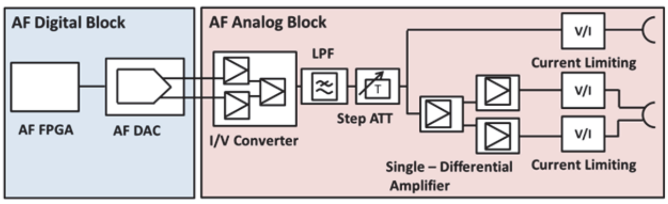


Figure 4 Audio Generator Block Diagram

Figure 5 shows the signal generator block in the FPGA. The DCS Generator block repeatedly generates a 23-bit Non Return to Zero (NRZ) signal at a speed of 134.3 bps. The PN31 Generator is a white noise generator (PN31 pseudorandom noise). The generation polynomial is $X^{31}+X^{28}+1$. In addition, the DCS and PN31 have a structure that can perform FIR FILTER processing. The DTMF Controller function sets the DTMF output time.

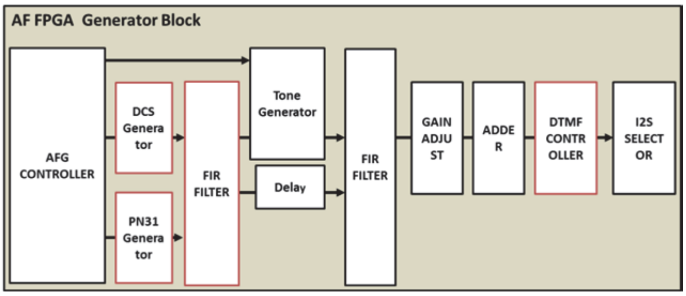


Figure 5 FPGA Signal Generator Block Diagram

2.2 Audio Analyzer Section

Figure 6 shows the MS2830A-018 audio analyzer block. The audio analyzer is composed of attenuators, gain amplifier, anti-aliasing filter, differential amplifier, ADC, and FPGA. Both the balanced and unbalanced circuits use a high-withstand-voltage attenuator to endure high-voltage input (35 Vrms) from the radio. The anti-aliasing filter signal path is structured so as to suppress loopback noise in the analysis bandwidth. Like the audio generator, a low-noise operation amplifier is used in the signal path to achieve low-noise performance.

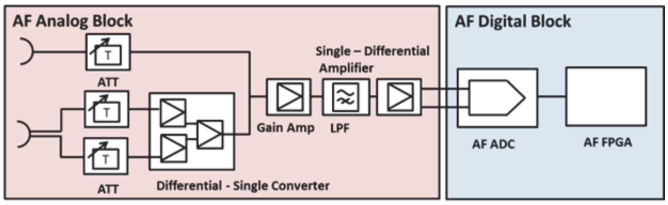


Figure 6 Audio Analyzer Block Diagram

2.3 Demodulation Section

The MS2830A-018 has an FM demodulation function using digital processing by the FPGA. This function demodulates the FM signal from the DUT using the FPGA for monitoring the demodulated audio and demodulated audio signal.

Figure 7 shows the FM demodulation function block. The FM modulation signal input to the MS2830A RF Input connector passes via the RF front end before FIR filtering by sub-sampling at the FPGA and computation of the phase data by CORDIC to convert from PM (phase data) to FM (frequency data). The IQ data is sent in real time between the Core FPGA on the Control Board and FPGA to output the demodulated signal as audible sound from either the built-in speaker or headphones connected to the Headphone connector. Additionally, the demodulated signal is output from the Demodulate Output connector for monitoring using external equipment. When the demodulated audio signal frequency deviation is 3.5 kHz, a sine wave signal of 0.7 Vp-p is output from the Demodulate Output connector.

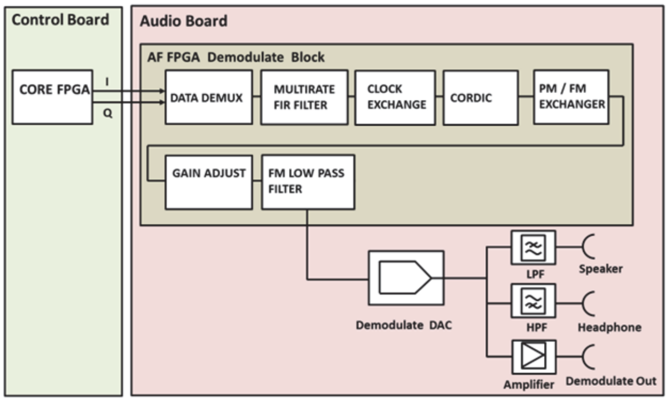


Figure 7 FM Demodulation Section

3 Functions

3.1 GUI Structure

The GUI has been re-designed to optimize measurements using the MX269018A with the MS2830A-018. The screen modes are broadly classified into three related to the Tx test screen, Rx test screen, and other applications, such as the spectrum analyzer. The Tx and Rx test screens display the analysis results at the screen top and the signal source settings at the screen bottom giving a clear understanding of the relationship between settings and results as a strong design point of the all-in-one tester. Moreover, to support linked operation with other applications such as a spectrum analyzer, there is also a mode for minimizing the MX269018A screen and displaying only audio generator settings.

3.2 Audio Generator Functions

When performing Tx tests of analog radio equipment, it is necessary to tune the audio generator while watching the DUT RF signal output. As a result, we have added a new GUI for the audio generator to the bottom edge of the previous MX269018A Tx test screen.

Figure 8 shows the analog radio Tx test screen. The radio Tx measurement settings (Tx frequency, filter, etc.) are displayed at the top row. The middle displays the measured RF Tx output power, RF Tx frequency, frequency deviation, demodulated audio waveform and frequency level computed by software, time domain graph, frequency domain graph, and various distortion levels.

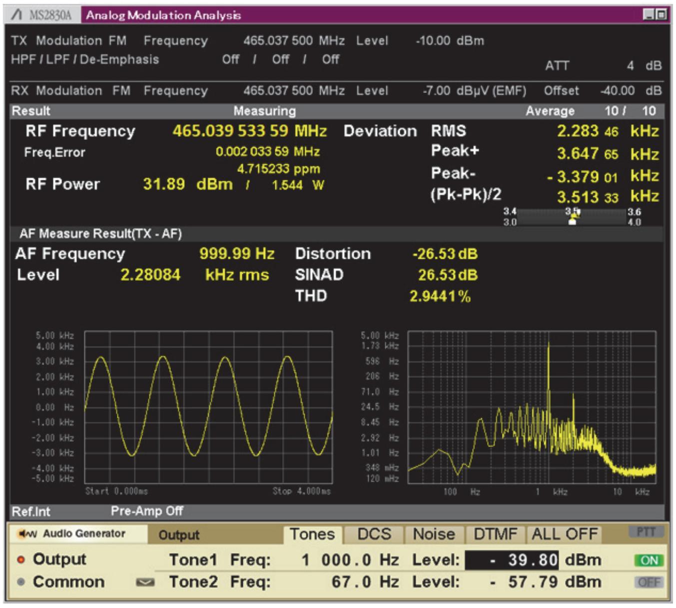


Figure 8 Tx Test Screen

When measuring the microphone input, it is possible to adjust the output of the audio generator while watching the frequency deviation at the top of the screen so that the frequency deviation becomes the reference frequency deviation. Adjustment of each parameter of the audio generator is achieved using the ten keys, arrow keys, and rotary knob, offering the optimum operation for fine adjustment. Not only can complex settings and screens be made using these but operation becomes fast, intuitive, and stress-free due to good integration with the audio generator GUI. Additionally, the audio generator has four modes optimized for each type of measurement operation: the Tones mode, the DCS mode, the DTMF mode, and the Noise mode. The Tones mode can output up to three tones simultaneously and is used when observing the response at multiple inputs. The DCS mode outputs a 2-tone + DCS signal, that is useful for debugging radios at the development stage. The DTMF mode can output 12 types of DTMF signal with a specific length and can be used for the same ten-key operation as a telephone. The Noise mode can switch between output of a tone signal or a pseudo-voice signal. Usually, the pseudo-voice signal is required when measuring occupied bandwidth, etc. First, the optimum input level is found using the tone signal, and then measurement is performed while outputting at 10-dB higher pseudo-voice signal than this level is setting[1]. Consequently, the Noise mode uses a GUI to optimize switching between the tone signal and pseudo-voice signal and to simplify setting of the 10-dB offset. The pseudo-voice signal is white noise that has been filtered with a digitally reproduced G.227 filter. As a result, only one MS2830A is required to perform the TELEC technical compliance test. Moreover, the audio generator function can be used as a modulation signal source for an RF signal generator with an external modulation function, such as the MG3740A; special signals such as the DCS signal and the DTMF required for evaluation of analog radio can also be output from the RF signal generator.

The audio generator conceptual block diagram is shown in Figure 9. The audio generator signal source and analog signal generator internal modulation signal source are mutually independent, so each can be set separately.

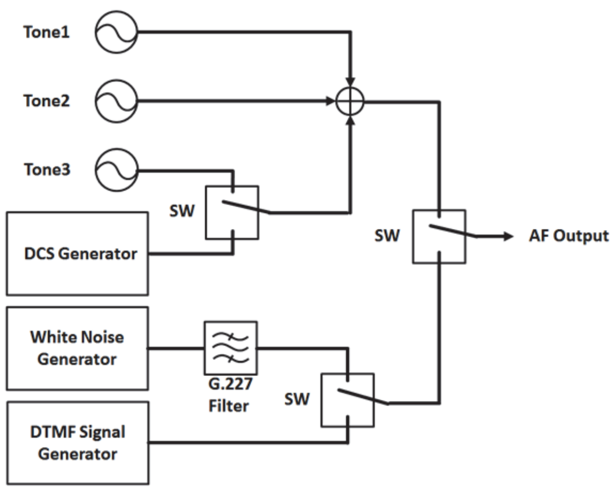


Figure 9 Audio Generator Concept Block Diagram

3.3 Audio Generator Window Function

The common measurements made using an audio generator and spectrum analyzer are spurious measurements and occupied frequency bandwidth measurements[2]. These measurements must be made while the radio is in the modulated state, requiring an audio generator as the modulation signal source. Consequently, the MX269018A has a function usable of the audio generator even when using other analysis software.

An example of the measurement screen at occupied frequency bandwidth measurement using the audio generator is shown in Figure 10. As shown in the figure, the standard spectrum analyzer function is displayed along with the audio generator operation GUI at the screen bottom (or top). The audio generator can be set and adjusted while observing the measurement results using the spectrum analyzer and other measurement software.

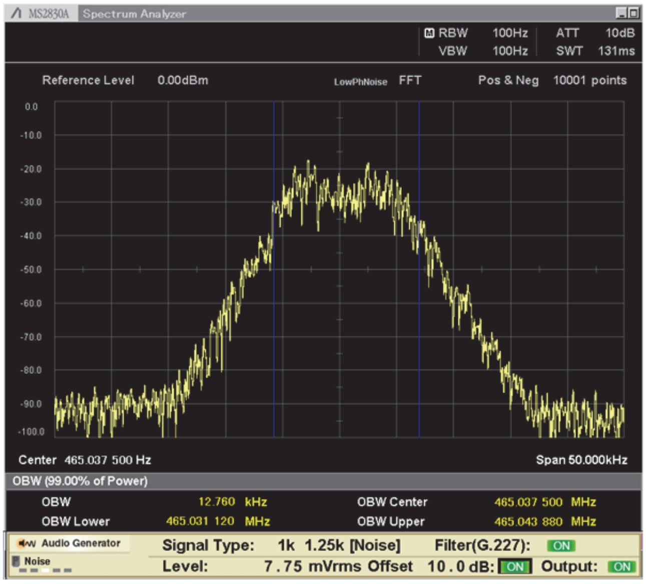


Figure 10 Occupied Frequency Bandwidth Measurement Screen

3.4 Audio Analyzer Function

The Rx test screen is shown in Figure 11. The audio analyzer settings and measurement results are displayed at the screen top and center while the analog signal generator (RF Signal Generator) setting screen is displayed at the screen bottom. The frequency versus level of the demodulated voice, the time domain graph, the frequency domain graph, and various distortion measurements are displayed as the measurement results.

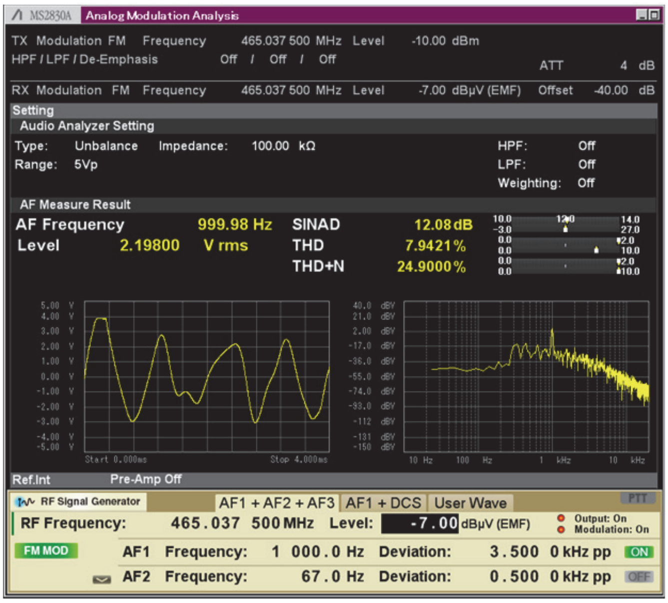


Figure 11 Rx Test Screen

The analog signal generator GUI is positioned at the screen bottom and the analog signal generator settings can be changed while observing the audio analyzer measure results at the screen top. When changing one parameter of the analog signal generator using the conventional MX269018A GUI, it was necessary to input a numeric value using the ten-key pad after searching for the parameter using complex function keys. During development of the MS2830A-018, we optimized operation by assigning the same ten keys, arrow keys, and rotary knob operations used by the audio generator function to adjust the analog signal generator parameters. Additionally, we also added modes to the analog signal generator, supporting one-touch switching between Tone Squelch and DCS to speed-up Tone Squelch tests.

3.5 Graph Display Function

The Rx test measurement result graphs are reproduced in Figure 12; the left side shows the time domain graph and the right side shows the frequency domain graph. The time domain graph can display the interval from 1 ms to 200 ms to observe the voltage response with time. The y-axis indicates the waveform amplitude; fixed and auto-range switching is supported. Testing using a conventional analog radio tester requires provision of separate oscilloscope but this is incorporated into this graph function. The frequency domain graph can display the frequency distribution over an interval from 0 Hz to 50 kHz, making it easy to observe the distortion and frequency response that are hard to understand using only the time domain graph. Additionally, the x-axis has a function for switching between a linear and logarithmic scale. The y-axis has a multiple windows function that can be switched by the user. The window function can be selected to display a rectangular, hann window, hamming window, or Blackman-Harris window.

In addition, each graph supports readout using markers. Positioning two delta markers on a graph displays the difference between the two markers. The time domain graph markers support Peak Search and Next Peak Search, making it easy to determine peak and distortion differences.

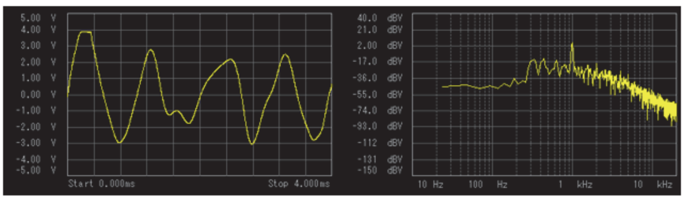


Figure 12 Graph Results Display
(Left: Time Domain; Right: Frequency Domain)

3.6 Meter Display Function

As well as displaying frequency deviation and distortion measurement results numerically, results can also be displayed by meter as shown in Figure 13. Analog radio measurement results have large dispersion and a conventional analog radio tester with both numeric and meter needle displays makes it easy for the operator to understand and intuitively evaluate results at a glance. To mimic this analog needle, we have designed a Meter function giving an intuitive understanding of measurement results with large dispersion based on the 12-dB SINAD method. This meter not only replaces the conventional analog needle but also supports the functions described below.

Figure 13 Meter Screen

As shown in Figure 13, the meter can be set with two different range widths. For example, an 8-dB width is set at the top part of the display and a 24-dB width is set at the bottom part, supporting fine adjustment following coarse adjustment for more intuitive setting.

There is also a Deflection function offering a visual representation of the most recent (X number) measurement results. The user can specify any range for the minimum and maximum values of X, indicated by the yellow line shown in Figure 13. Using this Deflection function makes it easy to visually confirm the degree by which unstable measurement results move within a fixed time period, offering an intuitive visual representation of the dispersion range and median value. Moreover, an Evaluation function judges whether or not the change within a specified range meets the required criteria. When this Evaluation function is enabled, a line indicating the threshold value is displayed above the Meter display. The yellow line becomes green when it satisfies the threshold value and red when it is outside the threshold. This offers an easy way to evaluate measurement values with dispersion.

3.7 Filters

Various Low-Pass Filter (LPF), High-Pass Filter (HPF), Band-Pass Filter (BPF), and De-Emphasis (only TX measurement mode) evaluation filters are available. Adding a new A-weighting to the BPF also supports evaluation of wireless microphones. In case of The Tx test, filtering process is executed for demodulated voice signal. On the other hand, in case of the Rx test, filtering process is executed for input signal. Each of the measurement results is calculated after filtering. The various measurement results are computed after filtering. Furthermore, the filter settings can also be changed after measurement for easy comparison of measurement results using filters.

3.8 Main Specifications

The main specifications of the MS2830A-018 option are listed in Table 1.

4 Summary

Analog measuring instruments continue to be used for evaluating RF sections even as the terrestrial mobile radio market proceeds with conversion to digital methods. Consequently, we have developed the MS2830A-018 Audio Analyzer Option for installation in the MS2830A to meet the need for TRX tests of commercial analog radio equipment. Installing this audio analyzer option in the MS2830A supports all -in-one TRX and spurious emission measurements of commercial radio equipment.

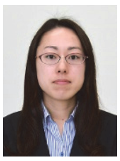
We are continuing with development of new solutions promoting future growth of the continuously expanding terrestrial mobile radio market.

References

1) Eishin Nakagawa, Kazuyuki Yasuda, Actual radio equipment measurement method, Chapter 4, Foundation of Information and Communications Promotion, Tokyo, 2011

2) TELEC-T208, F3E Etc. (Article 2, Paragraph 1, No.1-11) Characteristic test method, pp.11-20, Foundation of Telecom Engineering Center, Tokyo, 3.4 Edition

Authors



Momoko Inadomaru
R&D Division
Product Development Division
3rd Product Dept.

Keiichi Yoshitomi
R&D Division
Product Development Division
3rd Product Dept.

Keisuke Nishio
R&D Division
Product Development Division
3rd Product Dept.

Table 1 Main Specifications of MS2830A-018 Audio Analyzer Option

Audio Generator Function		All values specified for single-tone measurements
	Connection Type (Connector)	Balanced: Standard phone jack (3-pole, φ6.3 mm) Unbalanced: BNC-J
	Output Impedance	Balanced: 100 Ω/600 Ω (AC coupled) (nominal) Unbalanced: 50 Ω/600 Ω (AC coupled) (nominal)
	Output Waveform	Single tone Multi-tone (AF tone × 3, DCS, DTMF) White noise generation (built-in ITU-T Rec. G.227 evaluation filters)
	Frequency Setting Range	10 Hz to 50 kHz
	Frequency Resolution	0.01 Hz
	Output Level Range	Balanced: 0 (off), 1 mV to 7 Vrms (100 kΩ termination) Unbalanced: 0 (off), 1 mV to 3.5 Vrms (100 kΩ termination)
	Level Resolution	1 mV (350 mVrms < Output Level ≤ 3.5 Vrms) 100 μV (35 mVrms < Output Level ≤ 350 mVrms) 10 μV (Output Level ≤ 35 mVrms)
	Level Accuracy	±0.3 dB (1 kHz, 0.7 Vrms, 20 Hz to 25 kHz band, 100 kΩ termination, 18° to 28°C)
	Max. Output Current	100 mA (nominal) (no short circuit)
	THD+N	<–60 dB <–80 dB (nominal) (1 kHz, 0.7 Vrms, 20 Hz to 25 kHz band, 100 kΩ termination, 18° to 28°C)
Audio Analyzer Function		All values specified for single-tone measurements
	Connection Type (Connector)	Balanced: Standard phone jack (3-pole, φ6.3 mm) Unbalanced: BNC-J
	Input Impedance	Balanced: 200 kΩ (AC coupled) (nominal) Unbalanced: 100 kΩ (AC coupled) (nominal)
	Frequency Range	20 Hz to 50 kHz
	Input Level Setting Range	1 mVrms to 25 Vrms (30 Vrms max)
	Input Range Settings	50 mV peak, 500 mV peak, 5 V peak, 50 V peak
	Level Accuracy	±0.4 dB (20 Hz ≤ f ≤ 25 kHz) (18° to 28°C) ±3.0 dB (25 kHz ≤ f ≤ 50 kHz)
	THD+N	<–60 dB <–80 dB (nominal) (1 kHz, 1.4 Vrms, 20 Hz to 20 kHz band, 5 Vp range, 18° to 28°C)
	LPF	Off, 3, 15, 20, 30, 50 kHz
	HPF	Off, 20, 50, 100, 300, 400 Hz, 30 kHz
	Evaluation Filters	Off, CCITT, C-Message, CCIR486, CCIR-ARM, A-Weighting