VB8300/VN7100 SIGNAL GENERATOR AND ANALYZER FOR WIDEBAND DIGITAL MODULATION

KOYANAGI Nobuo [*1] *IWAOKA Mitsuru* [*1] *YAZAWA Kenichi* [*1] *YOKOHIRA Kanji* [*1]

We have developed the VB8300 VectorCreator™ baseband signal generator and the VN7100 VectorExplorer™ wideband modulation analyzer, capable of generating or analyzing a wideband modulation signal required for the next-generation wireless communications market. The VB8300 features a maximum clock rate of 300 MS/s, a D/A resolution of 14 bits, a multichannel signal generation for up to 8 channels, an ultra long memory of up to 128 M points per channel, as well as sequence functions and noise and analog addition functions. The VN7100 features an 84-MHz to 6.2-GHz RF input frequency range, a maximum analysis bandwidth of 168 MHz, and an ultra long memory, thereby enabling various analyses including EVM analysis. This paper outlines both the VB8300 and VN7100 and their applications.

INTRODUCTION

Wireless communication technology has been changing from analog modulation systems to digital modulation systems, and from voice transmission to high-speed data communications, and the signals being used have also been undergoing speed enhancement and wideband availability. Moreover, various new modulation methods or systems are being put forward.

In mobile telephones, the widespread use of third-generation (3G) mobile phones is in full swing around the globe, and the development of fourth generation (4G) mobile phones, or next-generation units, has also been increasing. Also for wireless LAN, the IEEE is pursuing drawing up next-generation standards in which the speed enhancement of wireless LAN will be standardized using the multi-in multi-out (MIMO) technology. For 4G mobile phones, a band range of 100 MHz or more is expected to be promising. High-speed wideband generators and analyzers are required for these new wireless communication technologies, to conduct device performance evaluations, take measures against system interference (noise, multipath), etc., in development departments.

Against these backgrounds, we have developed the VB8300 baseband signal generator and VN7100 wideband modulation analyzer, capable of coping with next-generation wireless communication technologies. Figure 1 shows the appearances of the VB8300 and VN7100.

Figure 1 Appearances of VB8300 (Top) and VN7100 (Bottom)

*1 Communications and Measurement Business Headquarters

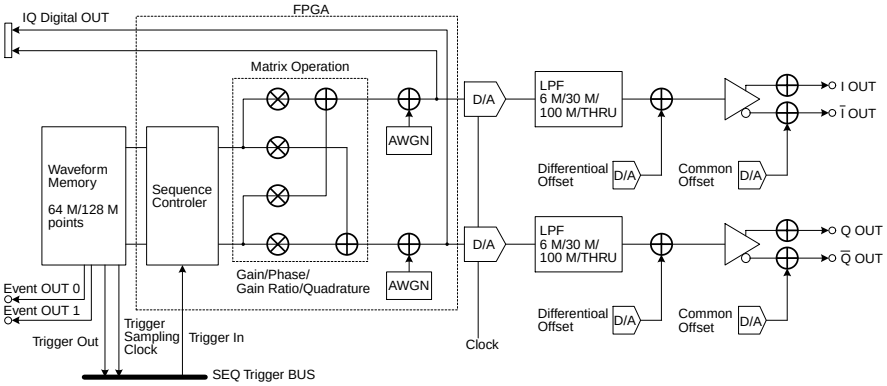

Figure 2 VB8300's Waveform Generator Board (Up to Four Boards Installable)

VB8300 BASEBAND SIGNAL GENERATOR

Features

The VB8300 is an arbitrary waveform generator optimized for baseband signal generation. It has the following features:

- Fast clock rate: 300-MS/s maximum
- High resolution: 14 bits
- Multichannel signal generation: 8 channels maximum (4 sets of I + Q)
- Ultra long memory: up to 128 M points per channel
- Sequence function (linked with a trigger as an option)
- Internal noise (additive white Gaussian noise (AWGN)) addition function
- Analog addition output (option)
- Digital output (option)

Conversion to a faster clock rate allows the instrument to cope with next-generation communications, and use of multichannel signal generation allows it to be compatible with new systems such as the MIMO.

Hardware Configuration

Figure 2 shows the waveform generator board diagram. By following the basic configuration of the conventional VB8000 model, at the same time as increasing development efficiency we have also made improvements to every part, thus making it faster and easier to use. An IQ signal generator section is implemented on a single waveform generator board and performs high-speed data processing using a D/A conversion of 300-MHz and 14-bits resolution, and a field programmable gate array (FPGA).

The VB8300 is capable of modifying a gain, phase, IQ gain ratio, and orthogonal offset in real time by matrix operation (matrix operation section) to emulate strain or errors in a communication path or device. This function was previously achieved by an analog multiplier and adder, but the VB8300 allows those parameters to be set with good linearity due to the adoption of digital computation.

To be compatible with an ultra long memory, instruments take a long time to perform data transfer. In contrast, the VB8300 has adopted the PCI bus and Linux operating system and employed interfaces such as the 100BASE-TX and CompactFlash Disk (CFD) speeding up data transfer of PC-created waveforms to the waveform memory.

New Functions

(1) Sequence Function (Linked with a Trigger as an Option)
The VB8300 has a sequence function as standard. It allows waveform elements to be output by a preset number of repetitions or in a preset sequence. Moreover, non-signal zones can be set without consuming the waveform memory. Use of the /AT option (analog addition output and sequence trigger) allows a sequence to be linked with a trigger between channels. Thus, a trigger signal from one channel can be internally linked to another channel to switch waveform elements by synchronization with a trigger. This function allows the VB8300 to be applied to simple communication protocol emulation.

(2) Internal Noise (AWGN) Addition Function
In conventional models, one dedicated channel must be provided for noise generation, but in the VB8300, noise can be internally added on a channel basis. This allows effective use of the channels.

(3) Waveform Selection and Waveform Display
For the user interface, the VB8300 has inherited excellent previous operability, but has made significant modifications for ease of use. To output created waveform, you simply choose the desired file on the basic screen. This allows the created waveform to be transferred from the HDD to the

Table 1 VN7100's Analysis Function

Category	Display Items
Time axis analysis	Waveform display Power trend
Frequency axis analysis	Spectrum Spectrogram
Modulation analysis	Eye pattern Constellation Modulation accuracy (EVM) Symbol table Symbol power
Statistical analysis	CCDF (Complementary Cumulative Distribution Function)

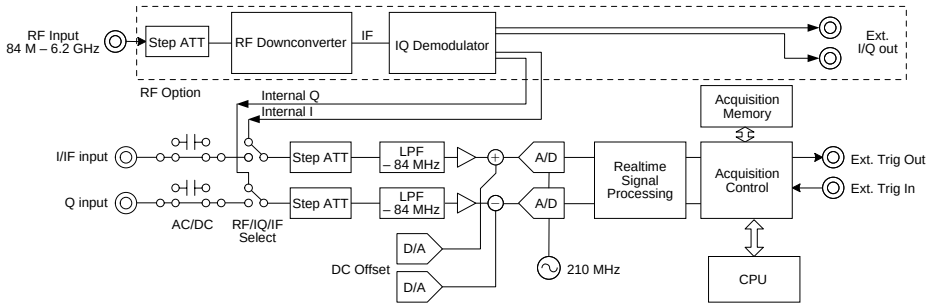

Figure 3 VN7100 Block Diagram

waveform memory.

In the past, checking the waveform to be output required observation of actual outputs. However, the VB8300 has a simple waveform analysis & display function, allowing the display of waveform, spectrum, constellation, etc. provided for noise generation, but in the VB8300, noise can be internally added on a channel basis. This allows effective use of the channels.

VN7100 WIDEBAND MODULATION ANALYZER

Overview

The VN7100 wideband modulation analyzer is an instrument for measuring and evaluating waveforms, frequency spectrum, and/or the modulation accuracy of digital modulation signals. It has a maximum analysis bandwidth of 168 MHz and is also capable of handling next-generation mobile phones.

The analysis functions available on the VN7100 are given in Table 1.

Hardware Configuration

The VN7100 block diagram is shown in Figure 3. If input is an RF signal, it is level-adjusted by the step ATT section, converted into intermediate frequency (IF) by the RF down-converter, and further converted into a baseband signal by the IQ demodulator.

The baseband signal is band-limited by the LPF for aliasing removal and then sampled by an A/D converter with the 210-MS/s clock rate and 12-bits resolution. The signal is then sampling-rate converted by the real-time signal sampling section and stored in the acquisition memory in response to a trigger signal. Data stored in the acquisition memory is read by the CPU to perform the analysis processing shown in Table 1. The analyzed results can be saved as a file in the internal HDD or read out via LAN as well as being displayed on the LCD.

The VN7100 was developed with the aim of achieving an analysis bandwidth of 168 MHz. Therefore, as well as employing A-D converters with a capacity as high as 210-MS/s, it handled RF signals by IQ demodulation before A/D conversion.

Furthermore, to have only one type of anti-aliasing filter required before A/D conversion, the A/D sampling rate is fixed to 210-MS/s and conversion to user-set sampling frequency is made by digital signal processing. Sampling frequency conversion is achieved in two steps: hardware-based real-time sampling frequency conversion and CPU-based post-processing. This real-time sampling frequency conversion uses multi-stages of thinning filters that thin out the sampling frequency to half in order to obtain 2^{-n} (n = 0 to 10) before storing data to the acquisition memory. In CPU-based sampling frequency conversion, the signal is band-limited and then interpolated by a sinc function to be converted to any frequency.

Firmware

The VN7100 must have a network function, large-capacity HDD (30 GB), advanced analysis functions, and a wide variety of graphics display capabilities, resulting in an increased firmware scale. To achieve efficient firmware development, we have adopted Linux as the operating software. The VN7100 utilizes middleware running on Linux, for applications such as file sharing with Windows-based PCs and the support of various printers.

For the graphics display capabilities, we have developed middleware running on the X-Window System to accomplish high-speed display updating and cursor functions.[2]

To integrate and use Linux in the instrument, we took the following measures this time:

① The Linux operating system is stored in a CompactFlash Disk, so that it can be started without relying on the HDD.
② Demons not required for the instrument are stopped to reduce the overheads.
③ All unnecessary communication ports are closed as a security countermeasure.
④ Multi-threads are used to improve response time.

EXAMPLES OF APPLICATION

Generation and Analysis of OFDM Signals

To realize high-speed, large-capacity transmission under the multipath/fading environment, the orthogonal frequency division multiplexing (OFDM) of multicarrier systems is starting to be used. In next-generation wireless communication such as 4G and IEEE 802.16, OFDM are used as common technologies. Thus, we have developed general-purpose software capable of freely creating and analyzing an OFDM signal conforming to various standards. This software allows not only setting of the number of subcarriers or guard interval lengths, which are the basic OFDM

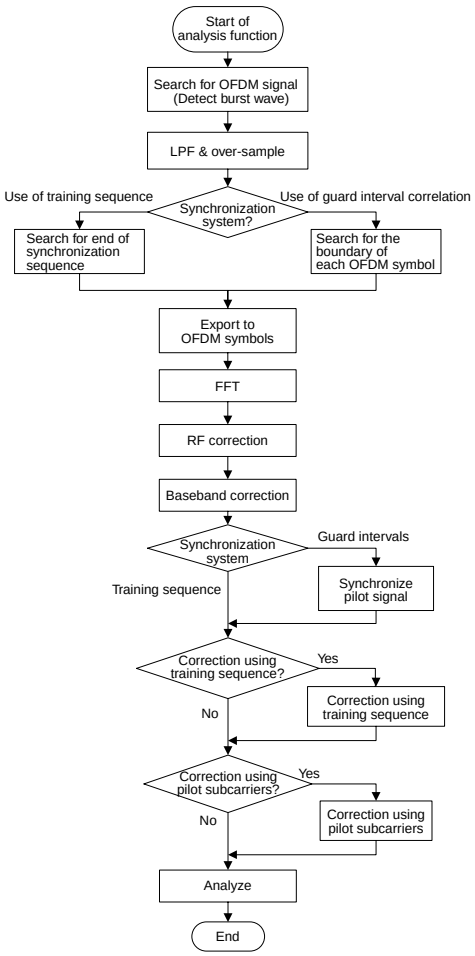

Figure 4 OFDM Analysis Flow

parameters, but also detailed parameters without restraints. Therefore, the VN7100 can be compatible with not only the defined standards such as IEEE802.16, but also undefined communication systems such as IEEE802.11n and 4G.

General-purpose OFDM Signal Creation Software

The general-purpose OFDM signal creation software is PC software for creating OFDM signal waveform data that can be used in the VB8300. This software allows you to define the number of pilot signals and their positions, phase, and training sequence waveform freely. Moreover, it allows subcarrier modulation systems to be defined for a maximum of three groups. Transferring created waveform data to the VB8300 for output allows easy obtainment of a signal for testing IEEE 802.16 or 4G system.

General-purpose OFDM Signal Analysis Software

The general-purpose OFDM signal analysis software is application software for loading VN7100-acquired data via LAN into a PC for analysis. The software's processing flow is shown in Figure 4.

(1) Synchronization System
There are two synchronization systems: the method of using guard intervals and that of using training sequences. If a training sequence is used for the synchronization system, a synchronous point is detected making use of correlation peak intervals.

(2) RF Correction
This correction calculates a frequency offset for correction by utilizing short training or long training sequences to measure changes in the phase between the symbols for each subcarrier. It also uses pilot subcarriers of data symbols to make fine adjustments.

(3) Baseband Correction
The analysis software takes advantage of pilot subcarriers of data symbols to conduct baseband corrections. It calculates the phase difference from the pilot signal of the OFDM symbol prior to the current one, to perform linear interpolation for making baseband corrections for each carrier.

This analysis software performs the following analyses to display the results in graphical form. For waveform, power trend, spectrum, and CCDF, signals are analyzed on the VN7100 and the results are read out for display.

- Waveform
- Power trend
- Spectrum
- Error vector magnitude (EVM)
- Constellation
- CCDF
- Flatness

CONCLUSION

This paper has introduced an overview of the VB8300 and VN7100 and their applications. We expect that these instruments will contribute to research and development of next-generation wireless communications. From now on, we wish to expand their application. ◆

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