VB2000 DIGITAL IQ SIGNAL GENERATOR

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We have developed a W-CDMA Baseband Generator for the next generation of mobile communication systems, featuring a 16.384 M chip rate, -70 dBc adjacent channel power ratio, and less than 2% error vector magnitude. Thanks to the VB2000's flexible design it meets system test, ARIB (Association of Radio Industries and Businesses), and 3GPP (3rd Generation Partnership Project) specifications. It can generate up- and down-link signals and allows direct coupling to an LSI through an offset voltage additional function and differential outputs. To meet future demands regular software improvements will be performed.

INTRODUCTION

Over the last few years, cellular phones have become extremely popular as a way of personal two-way communication free from the restrictions of time and space and there are now 50 million users in Japan alone. However, as the number of users increases, the shortage of frequencies has become an issue. At the same time, there is the need to find immediate solutions to more advanced technical problems, including reliability of communication channels, sound quality, demand for international roaming to allow worldwide use of mobile communication devices, and even faster data communication to realize multimedia mobile communication. To solve these problems, Code Division Multiple Access (CDMA) system, which uses spread spectrum, has been adopted as the mainstream of new mobile communication systems and is already being used in some countries for narrow band communication. Furthermore, to develop a universal common system for digital cellular phones for the next generation, International Telecommunications Union (ITU) is now in the finishing stages of setting up the IMT-2000 standard, which is scheduled for implementation by the beginning of year 2001.

The leading candidate is a fusion of the Wideband CDMA (W-CDMA) air interface system, whose development of basic technology was led by Japan, and GSM core network for mobile communication, which was developed in Europe and is now practically a world standard. The final draft of its specifications is now being completed by 3rd Generation Partnership Project (3GPP). While CDMA2000, an advanced narrow band CDMA system that was put to immediate practical use is now scheduled to be an official standard. Therefore, the final standard of IMT-2000 is most likely to be a coexistence of these two systems. On the other hand, as IMT-2000 is likely to become a world standard and due to its accompanying concept of openness to all organizations and enterprises, there has been a lot of turns and twists along the way. In fact, the specifications have been repeatedly modified in both a basic and peripheral way. Yokogawa Electric Corporation quickly developed a W-CDMA evaluation system based on the VXI bus during the system experiment[*2] phase of W-CDMA, which contributed to the related research and development of other manufacturers.

Figure 1 VB2000 Digital IQ Signal Generator

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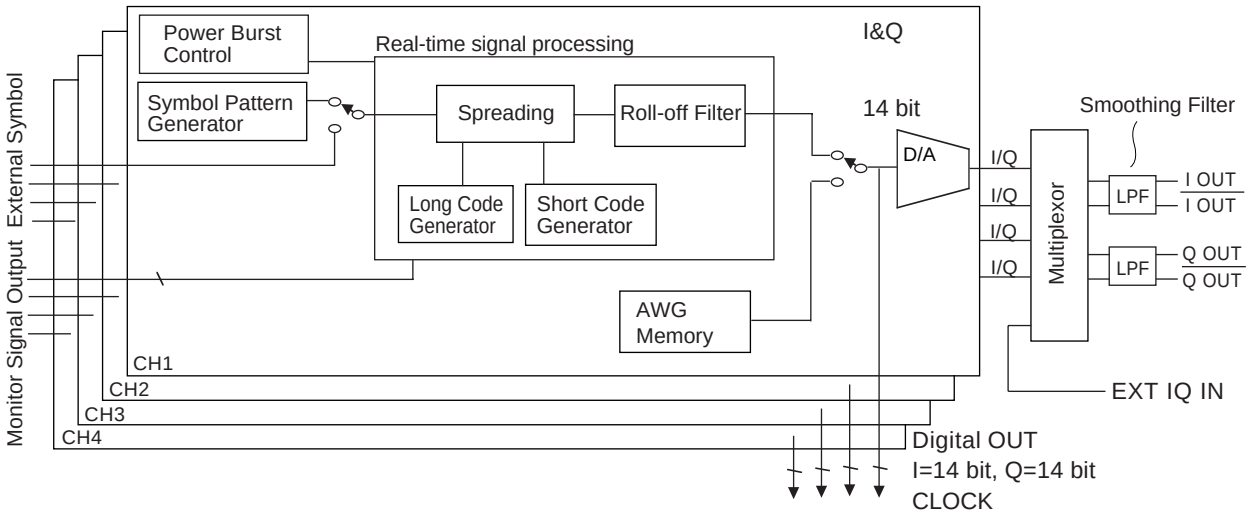

Figure 2 A Block Diagram of the Signal Generator

With the VB2000, we adopted the basic design from the W-CDMA evaluation system and succeeded in separating the baseband signal generator from the RF signal generator to make it smaller and create a stand-alone generator as well as reduce costs, to allow us to offer it at a low price. In addition, while inheriting the evaluation system's flexibility in making settings to cope with changes in the standard, we added new functions in line with product development. This flexibility in coping with standard modifications and other new standards was our most important design concept. And due to this concept, when unexpected drastic changes were made to the standard immediately before 3GPP's planned final proposal to ITU, we were able to compensate for changes by just releasing software updates such as firmware. Figure 1 shows an external view of the VB2000.

FEATURES

The VB2000 offers the following advantages:

- Real-time processing: Code multiplexing of a maximum of 4 channels
- Software processing: Code multiplexing of a maximum 512 channels
- Maximum chip rate of 16.384 M (20 MHz spread)
- Programmable spreading code generator
- Programmable roll-off filter
- Standardized encoding
- Mapping frame generator
- Output resolution of 14 bits
- Adjacent channel power ratio: About –70 dBc
- Error vector magnitude: 2% or less
- Variable differential offset voltage output for I (Inphase component) and Q (Quadrature component)

HARDWARE CONFIGURATION

Figure 2 shows a block diagram of the signal generator.

One VB2000 can incorporate up to four baseband signal generator modules, and users can select the number of modules as necessary. Parameters can be set for each module independently and this allows for more complicated signal simulation.

(1) Symbol Pattern Generator

The symbol pattern generator consists of a 16-M symbol length pattern generator. Various standardized encoding of layer 1, addition of the control bit, and mapping to physical channels are all handled by the W-CDMA Frame Data Generation Utility software running on a Windows 95/98/NT[*3] personal computer and this creates internal frame data. Loading this data in memory generates the frame data.

(2) Long Code Generator

The VB2000 has four maximum-length sequence generators with up to 45 register steps and can generate PN and Gold codes for I and Q independently. Moreover, the number of steps and tap location of the maximum-length sequence generator can be freely changed with switches to cope with changes in code standards.

(3) Short Code Generator

The short code generator consists of pattern generator memory with 1 to 2048-bit variable length. As it is a memory type generator, it can flexibly cope with code changes and allows users to define arbitrary codes.

(4) Spreading

The VB2000 computes symbol data, long codes, and short codes in real-time and performs spread processing. Its circuit configuration can deal with normal spreading, complex

spreading, and orthogonal complex spreading alternatively and even Hybrid Phase Shift Keying (H-PSK) modulation which was adopted by the latest up link standard.

(5) Roll-off Filter
The roll-off filter is a Finite Impulse Response (FIR) filter that has binary inputs allows for fast operation and fully supports future 16.384-Mcps (chip per second) standards. Its characteristics are applicable to Nyquist- and Root Nyquist-filtering and the roll-off factor can be set from 0.00 to 1.00 in 0.01 increments to allow for the evaluation of effects from filtering characteristics. The window function can be selected from five types.

(6) D/A Converter
The VB2000 employs a sophisticated D/A converter with 14-bit resolution and 100 MHz clock frequency to achieve superior performance in the adjacent channel power ratio. Code-domain power is created by making the reference voltage of the converter variable, which allows for resolution to be maintained even if code-domain power is changed.

(7) Arbitrary Waveform Generator
The VB2000 features memory for arbitrary waveform generation with a length of 256 Kword that operates at 90 MHz for I and Q. Users can select from real-time processing for each channel or use of the arbitrary waveform generator.

(8) Code Multiplexer
The code multiplexer consists of analog adders. They add the output signals from the baseband signal generators, external input signals, and preset differential offset voltage.

(9) Smoothing Filter
The smoothing filter can be switched between a 7th-order Butterworth low path filter and through path. The cut-off frequency is switched to 1.375, 5.5, 11, or 22 MHz to allow for optimal elimination of aliasing noise depending on the chip rate setting.

(10) Differential Output Amplifier
The differential output amplifier converts the single-end signals from filters to differential signals and outputs them. It can also impress the common-mode offset voltage of -1.0 V to 3.0 V to allow the single-end signals to be directly input to an A/D converter or a device under a single-power differential input test such as a modulator. Also, the differential offset voltage of -100 mV to 100 mV with 0.2 mV resolution can be set to finely adjust the carrier leakage of the device under test or modulator.

(11) Auto Calibration
The VB2000 has a calibration function to give the high level of DC and amplitude accuracy essential for a baseband signal generator. With this function, the VB2000 creates a model of error occurrence beforehand, and then reads the output voltages for each setting of the main unit through an A/D converter to calculate a model's factor. It compensates for internal settings by using this factor to generate accurate signals.

(12) Firmware
The hardware's extremely flexible design ensures that VB2000 requires only a firmware update to compensate for any changes in standards. VB2000's firmware can be easily updated by overwriting built-in flash ROM with a new version contained on floppy disks.

USER INTERFACE

VB2000's user interface consists of the key panel with numeric keys and rotary encoder, and a hierarchical-structured menu that can be operated with a combination of buttons on the right side of the monitor. The user interface facilitates the setting of a variety of complex parameters. When in the parameter setting mode for each channel, detailed parameters for the corresponding channel are listed on the main display to allow for easy identification. When in the setting mode for parameters common to all channels, basic parameters for all channels and common parameters are listed to allow for the easy confirmation of settings for each code channel. Figure 3 shows an example of the common parameter screen.

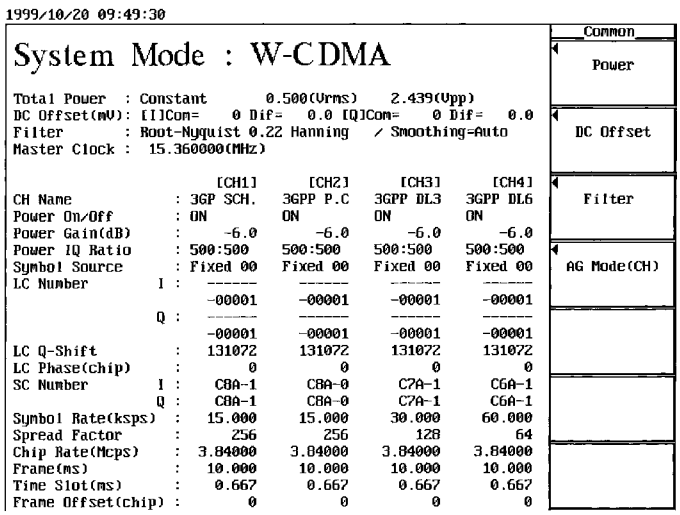

Figure 3 Common Parameter Screen

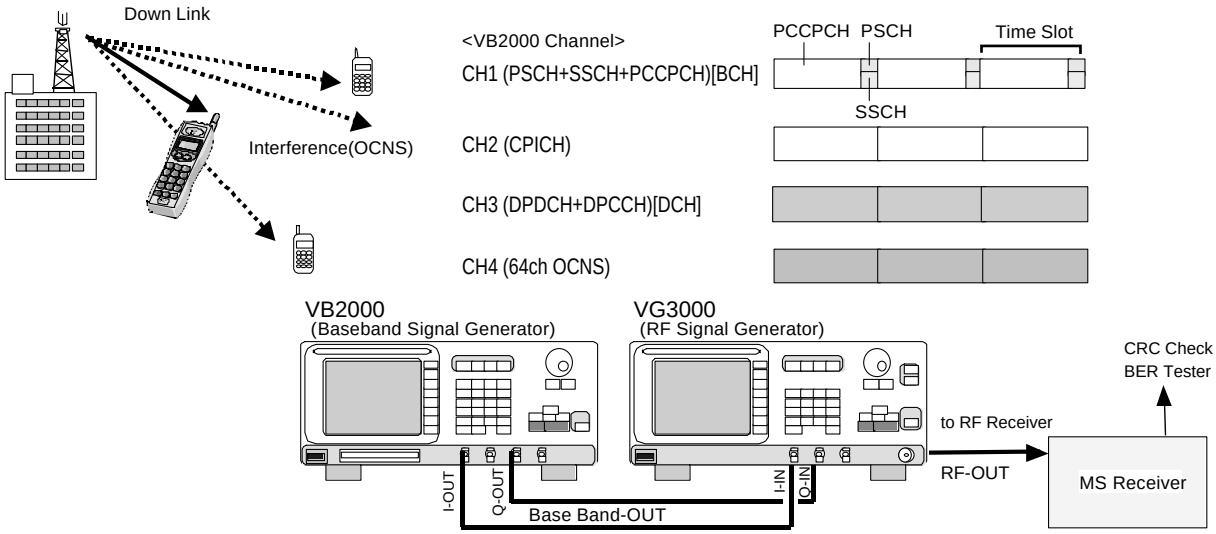

Figure 4 Application Example

Although there are many complicated settings for the VB2000, in fact, few parameters need to be changed because most parameters are preset to the type of physical channel on a one-to-one basis. To enhance operability, the Physical Channel Settings file is provided in a floppy disk for each code standard. Just inserting the floppy into the drive and specifying the physical channel to be set for each channel on the menu, allows parameters to be automatically set.

APPLICATIONS

Figure 4 shows a receiver circuit of a W-CDMA mobile station where the VB2000 is used as an example application.

In this example, the VB2000 generates the following signals from each channel.

CH1: Primary-SCH, Secondary-SCH, Primary-CCPCH
(Transport channel: BCH)
CH2: CPICH
CH3: DPDCH/DPCCH 60 ksps
(Transport channel: DCH 60 ksps)
CH4: Interference (OCNS 64channel multiplexed by software)

Connecting the channels as above allows for the verification and debugging of the following basic sequences in demodulation and decoding functions of a prototype receiver circuit of the W-CDMA mobile station.

(a) Orthogonal demodulation
(b) Slot synchronization by correlation detection of the Primary-SCH
(c) Identification of a scrambling code group and frame synchronization by correlation detection of the Secondary-SCH
(d) Separation of cells by identification of scrambling code
(e) Separation of channels and symbol synchronization by identification of channelization code (de-spreading)
(f) De-interleaving, Viterbi-decoding, and the CRC check of DCH
(g) Measurement of a Bit Error Rate (BER)

CONCLUSION

In this report we have introduced the benefits, configuration, and application of the newly developed VB2000 digital IQ signal generator.

We believe that the configuration flexibility of VB2000 will allow any changes in standards to be compensated for by just performing a software update and that this product will be very useful as a standard baseband signal source in the mobile communication field where standards change frequently. ◆

REFERENCE

(1) Matsuzaki M, Sugaya T, et al., “W-CDMA Evaluation System”, Yokogawa Technical Report, Vol. 42, No. 3, pp. 25-28 (1998) in Japanese.

*2 W-CDMA system experiment were performed with and led by NTT DoCoMo, Inc.
*3 Windows 95/98/NT are registered trademarks of Microsoft Corporation.