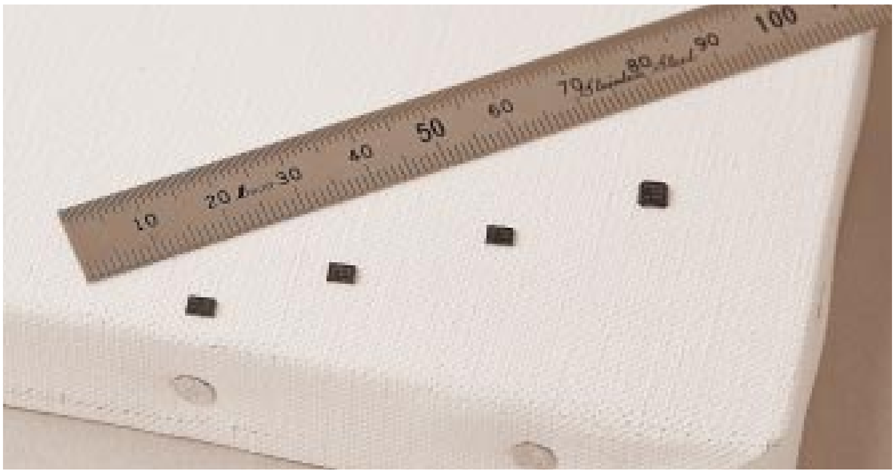
Key Components for the Broadband Age

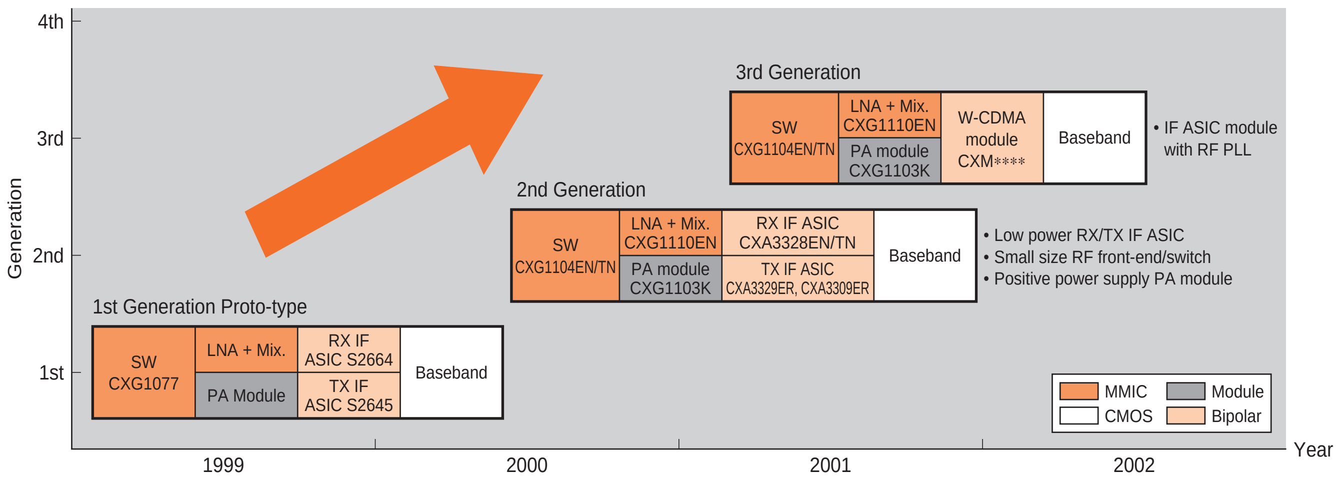
Ultrasmall High-performance W-CDMA RF Chip Sets

- **Systems implemented with only 2 synthesizers: one for IF and one for RF**
- **Low power consumption**
- **Low noise**
- **Low distortion**
- **Ultrasmall leadless package**

In May 2001, IMT-2000 standard W-CDMA cellular phone service, which represents the start of the broadband age, will finally begin. This system is the next-generation cellular phone communication system developed and promoted as a global standard by NTT DoCoMo. It provides communication at 384 kbps, which is much faster than the current maximum cellular phone maximum data transfer rate of 64 kbps. This will make internet access extremely pleasant and make services such as music distribution more popular. Sony is moving forward with the development of RF chip sets that take full advantage of the Sony technology developed during Sony's cdmaOne efforts started in 1997 at the very first stages of the development of W-CDMA cellular phones. Sony completed the first test product in this area in April 1998, and has accumulated continual improvements leading to the creation of RF chip set products that are optimal for current W-CDMA systems. (See figures 1 and 2.)



■ **Photo 1 Ultrasmall W-CDMA RF Chip Set**



■ **Figure 1 W-CDMA RF Chip Set Development Trends**

Reception IF (CXA3328EN/TN) and Transmission IF (CXA3309ER/3329ER)

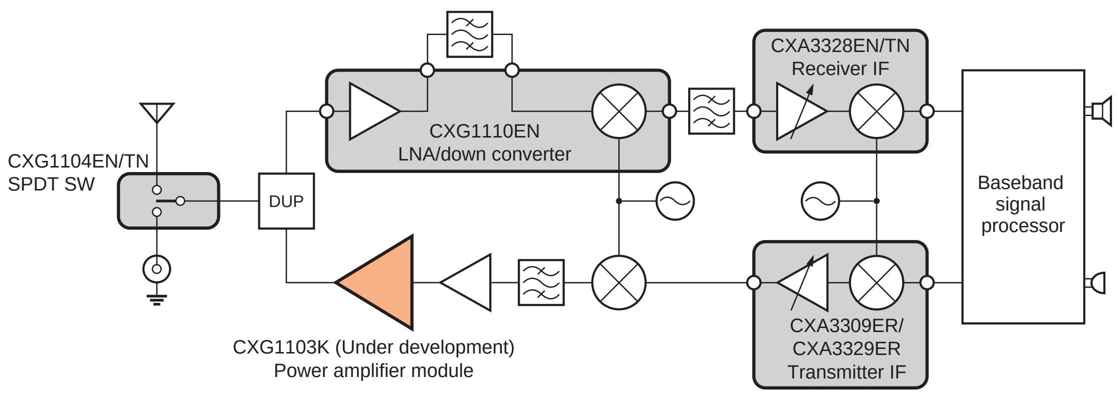
1) Two-synthesizer system using one IF and one RF synthesizer

In the IMT-2000 standard, the ITU (International Telecommunication Union) allocated the frequency bands for transmission (mobile station → base station) and reception (base station → mobile station) so that the transmission and reception frequencies are separated by 190 MHz as shown in figure 3. Most cellular phones adopt a superheterodyne system in which transmission and reception signals are first converted to IF (intermediate frequency) and then the IF signal is converted to either an RF (the transmission/reception frequency) or a baseband signal. In this system, the transmission and reception IF frequencies must be designed to have the same separation as that between the transmission and reception RF frequencies. As a result, separate synthesizers must be provided for the synthesizer (local oscillator) used to convert the transmission IF frequency to the transmission RF frequency and the synthesizer used to convert the reception IF to baseband. These synthesizers each consist of a VCO (voltage controlled oscillator) and a PLL (phase locked loop) circuit. In these W-CDMA IF chip sets, the skillful use of divider circuits allows a single synthesizer to be shared as the transmission and reception local oscillator. A two-synthesizer system can then be constructed by adding an RF synthesizer. As compared to the normal three-synthesizer structure, this has the advantages of reduced power consumption and reduced mounting area requirements.

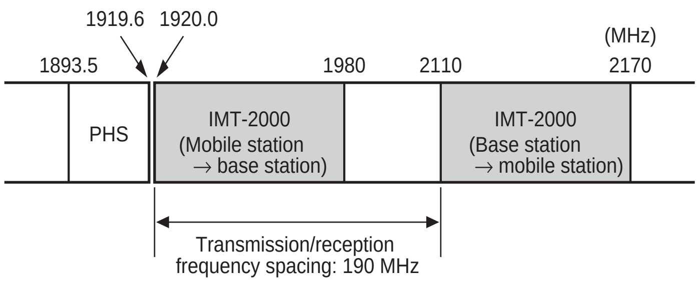
In the Japanese domestic market, combinations of 570 and 380 MHz, and of 380 and 190 MHz are the most common for the respective transmission and reception frequencies. Sony products support the former combination by using division factors of 3/4 and 1/2 with a 760 MHz synthesizer (CXA3309ER and CXA3328EN/TN) and division factors of 1/2 and 1/4 with a 760 MHz synthesizer (CXA3329ER and CXA3328EN/TN). (See figure 4.)

2) Power-saving Gain Control Circuit

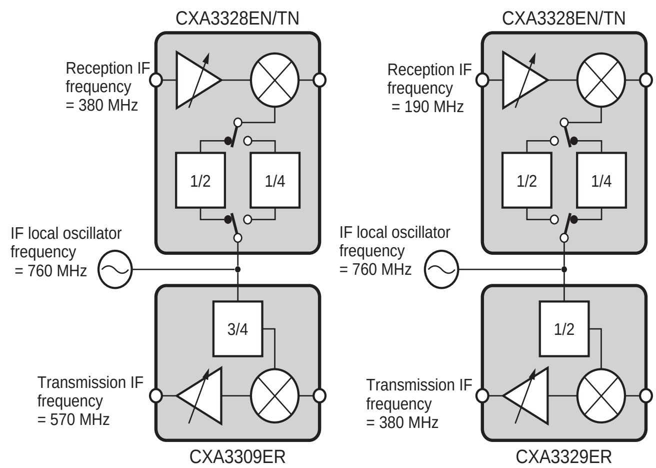
About 1/2 to 3/4 of the current consumption in an IF IC occurs in the gain control circuit. The following techniques are used in these W-CDMA chip sets to significantly reduce the current



■ **Figure 2 W-CDMA Cellular Phone System**



■ **Figure 3 Relationship Between IMT-2000 Transmission and Reception Frequency Bands**



■ **Figure 4 Use of a Divider Circuit Allows a Single IF Local Oscillator to Perform the Functions of both Transmission and Reception Local Oscillators** consumption in the gain control circuit. A gain control range of over 80 dB is required in CDMA system gain control circuits. To meet this requirement, multiple gain control circuits are connected in series. In these W-CDMA chip sets, Sony has reduced the current consumption by reducing number of these stages connected in series. However, reducing the number of stages degrades the gain control circuit linearity and temperature characteristics. To prevent this problem, Sony has added a control characteristics compensation circuit to the gain control circuit, thus achieving excellent control characteristics. (See figures 5 and 6.)

Furthermore, the system average current consumption was reduced even further by designing the transmission IF IC circuit structure so that only the required amount of current for the state of the gain flows in the circuit. These efforts resulted in reductions in current consumption over the first generation ICs of from 18 to 11 mA in the reception IC and from 59 to 25 mA in the transmission IC. (See figure 7.)

3) Both Low Distortion and Low Noise Achieved

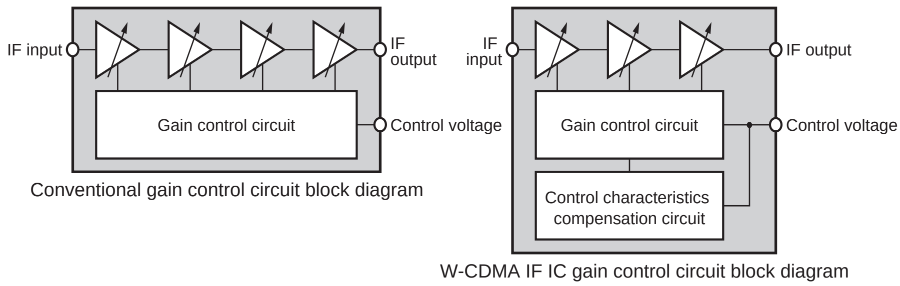
The W-CDMA reception gain amplifier must meet the conflicting requirements of low noise at high gains and low distortion at low gains. To achieve these required specifications, the IF input stage includes both a low-noise gain control cell and a low-distortion gain control cell connected in parallel. It then switches between these two circuits according to the voltage gain, and thus achieves both low distortion and low noise. (See figures 8 and 9.)

4) High Transmission Signal-to-Noise Ratio Achieved

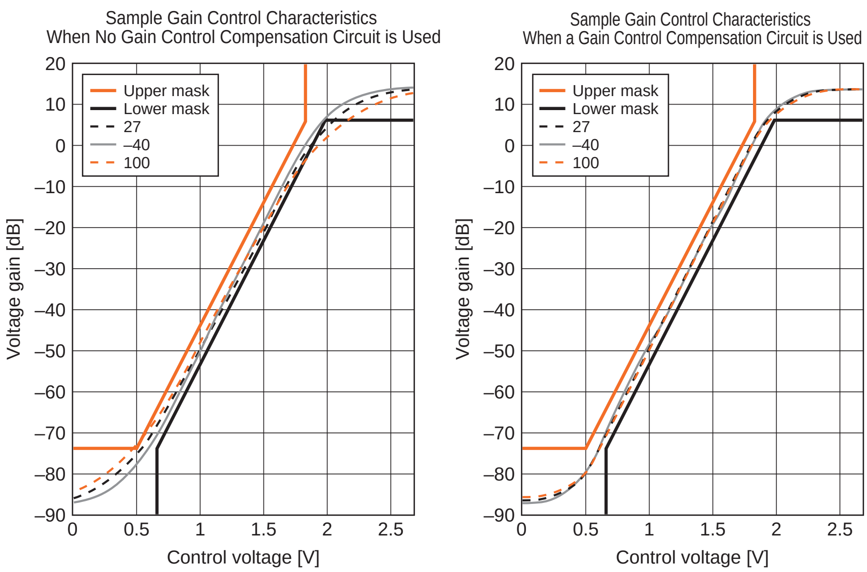
W-CDMA has extremely strict requirements for adjacent channel interference specifications, and requires a higher signal-to-noise ratio than the cdmaOne cellular phones. In Japan, interference with the PHS cellular phone system is seen as a problem. (See figure 3.) However, optimized design of the gain control and quadrature modulator circuits in these transmission IF ICs allows them to achieve the required high signal-to-noise ratio. (See figure 10.)

Low-noise Amplifier/ Downconversion Mixer (CXG1110EN)

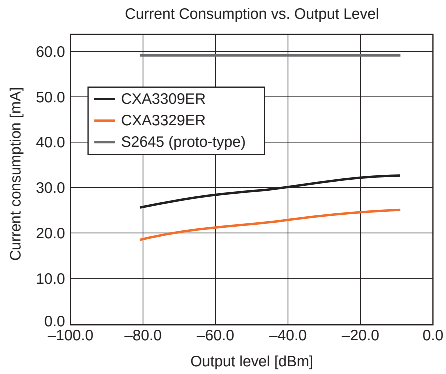
The CXG1110EN is a low-noise amplifier/downconversion mixer fabri-



■ **Figure 5** **Gain Control Circuit Adopted in this W-CDMA IF IC Compared to Conventional Gain Control Circuit**



■ **Figure 6 Effect of the Gain Control Compensation Circuit**



■ **Figure 7** **W-CDMA Transmission IF IC Current Consumption Comparison**

■ **Table 1** **Representative CXG1104EN/TN Characteristics**

(Ta = 25°C)

	Symbol	Condition	Typ.	Unit
Insertion loss	IL	900 MHz	0.30	dB
		1.9 GHz	0.40	dB
Isolation	ISO	900 MHz	23	dB
		1.9 GHz	16.5	dB
Harmonic distortion	2fo	*1	–75	dBc
	3fo	*1	–75	dBc
Input IP3	IIP3	*2	64	dBm

*1 : Pin = 29 dBm, 900 MHz, V_{DD} = 3.0 V, 0/3 V control
*2 : Pin = 24 dBm (900 MHz) + 24 dBm (901 MHz), V_{DD} = 3.0 V, 0/3 V control

cated in Sony's GaAs J-FET process. It features an optimized circuit design and layout that allow it to achieve adequate noise figure, conversion gain, and equivalent input third intercept point characteristics in the W-CDMA reception band. (See figure 11.)

SPDT Switch (CXG1104EN/TN)

The CXG1104EN/TN is an SPDT* antenna switch fabricated in Sony's GaAs J-FET process. It features single positive voltage power supply operation and provides adequate low loss, low distortion (high IIP3), and high isolation characteristics in the W-CDMA transmission and reception bands. (See table 1.)

* SPDT: Single Pole Dual Throw

Ultrasmall Package Product Line

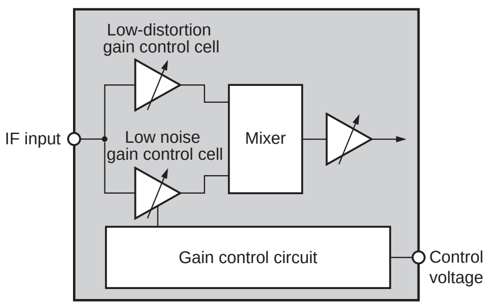
The four chips in these W-CDMA RF chip sets,

- Reception IF (CXA3328EN)
- Transmission IF (CXA3309ER/CXA3329ER)
- LNA downconverter (CXG1110EN)
- SPDT switch (CXG1104EN)

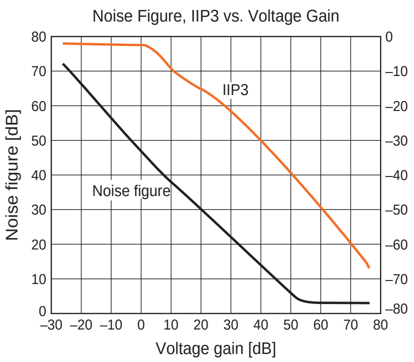
are all provided in ultrasmall leadless packages. The adoption of these packages allows significant reductions in the mounting area.

Future Developments

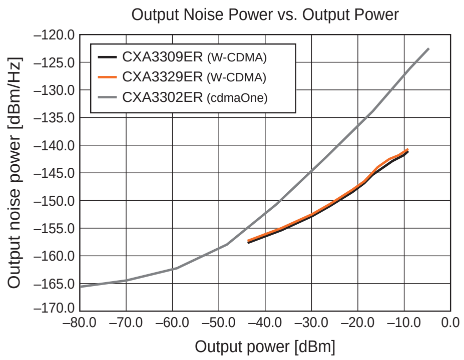
To complement the current RF chip sets, Sony is now developing the CXG1103K low-distortion high-efficiency W-CDMA power amplifier module that can operate from a single positive 3.5 V power supply and that uses P+-AlGaAs gate HFET devices. Furthermore, Sony is aiming to create a well-balanced line of easy-to-use products. In particular, Sony plans to expand their product line, striving for increased performance with reduced spurious emissions and wider dynamic ranges by adopting differential downconverter technologies, and also striving for increased integration levels with compound modules that combine transmission and reception IF ICs, RF/IF synthesizers, switches, and other function blocks.
Keep an eye out for Sony RF chip sets.



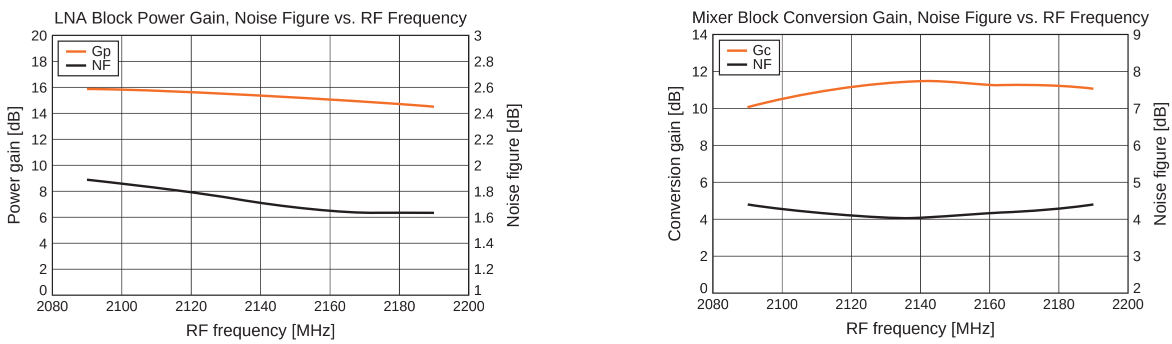
■ **Figure 8　Achieving both Low Distortion and Low Noise**



■ **Figure 9　Reception IF IC CXA3328TN/EN NF/IIP3 Representative Characteristics**



■ **Figure 10　Transmission IF Output Noise Power Comparison**



■ **Figure 11　CXG1110EN Gp/Gc/NF Representative Characteristics**