Techno World

A Compendium of Bipolar and GaAs Technologies

CDMA LSI Chip Set

- Wide dynamic range, low noise
- Single-chip CDMA*1 analog baseband ICs incorporating various analog technologies
- On-chip automatic control filter with excellent temperature characteristics
- Low-distortion, low-insertion loss antenna switch
- Low-distortion, high-output power amplifier

With the recent remarkable advances in mobile communications technology, typified by digital cellular and cordless phones, the number of mobile communication subscribers is growing year by year.

Special modulation techniques are used in digital communications to take full advantage of the excellent characteristics of digital signals. Frequency division and time division techniques are used in the familiar PHS and PDC systems, but many different digital systems are being established on a worldwide scale.

In America, a growing movement emerged in 1989 in favor of general use of CDMA (code division multiple access)—one kind of spread spectrum communication system—with the aim of making efficient use of the frequency spectrum, one of man's most important natural resources. Today, CDMA is in use as one standard for car and portable phone systems.

Although CDMA offers a number of excellent features, it requires much more complex signal processing than other systems, and this has kept it out of the consumer field so far. Behind the process of bringing CDMA to the consumer market lie the remarkable advances made in digital modulation, semiconductor process, and circuit technologies.

In the digital communications field, Sony has already released a number of functional ICs such as PLLs, modulators, and mixers. Now, we are enhancing our CDMA IC lineup, employing a combination of bipolar and GaAs technologies.

What is CDMA?

CDMA is one kind of spread spectrum modulation system. The desired signal is modulated and transmitted by means of a key signal with a wider bandwidth than that required to transmit the desired signal. The features of this system are as follows:

1) As long as the key signals are different, demodulation can still be performed even if signals overlap, providing good "multiplicity" characteristics, unlike FDMA (frequency division multiple access) and TDMA (time division multiple access) in which demodulation is not possible if signals overlap.
2) "Call security" is protected, since the transmission can only be received if the key signal is known.
3) Since the spectrum is spread over a wide band, "confidentiality" is excellent, and there is no need for concern about communication to other parties.
4) "Time resolution" is high, since transmission is performed in a wider frequency band than the desired wave.
5) "Interference resistance" is good, since any interference is diffused in the demodulation process, giving a low noise level.

With such outstanding characteristics, CDMA could well be called an ideal communication system.

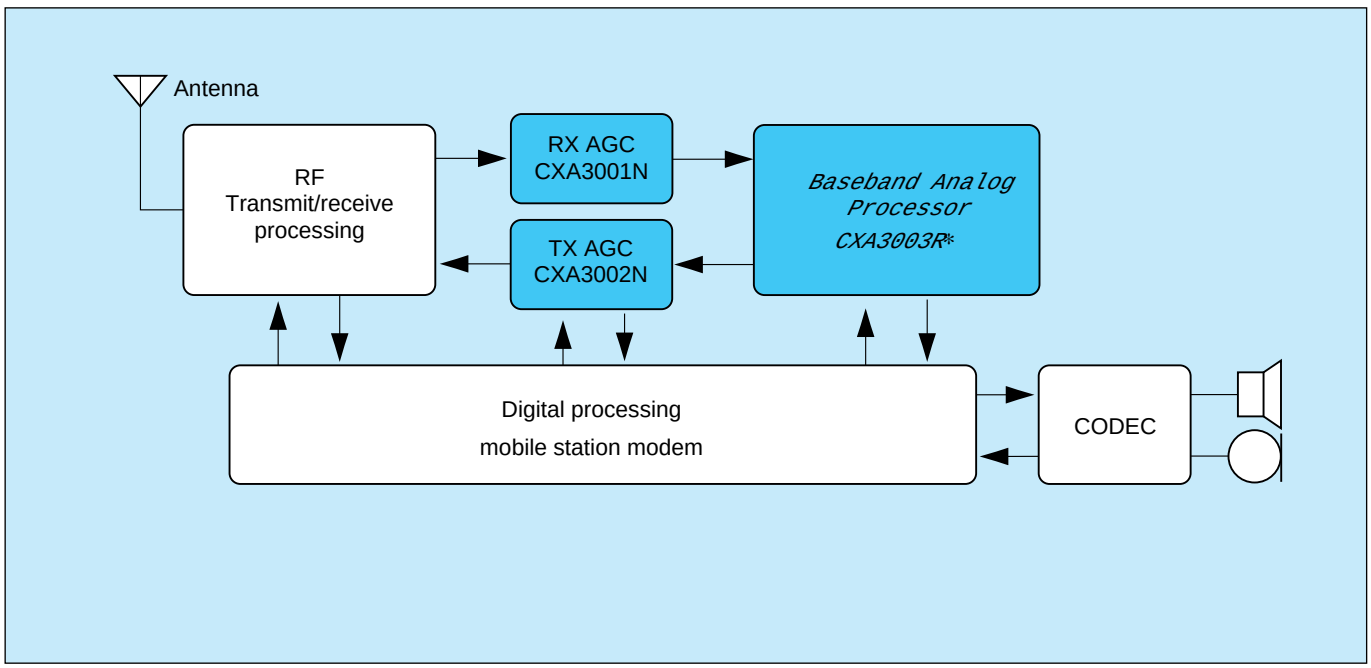
CDMA Portable/Mobile Phone Systems

First, consider the signal flow during reception. Figure 1 shows a block diagram of a CDMA portable phone.
The very weak receive signal from a base station is down-converted to the IF frequency band by the RF receiver, and amplified by the RX AGC unit. The IF signal is down-converted to an analog baseband signal by the analog baseband processor, and then the analog signal is converted to a digital signal. This digital signal is input to the mobile station modem where it undergoes CDMA demodulation, and is then output to the speaker via the CODEC.
In transmission, an audio signal input from the microphone is converted to a digital signal by the CODEC, then undergoes CDMA modulation in the mobile station modem. The resulting modulated digital baseband signal is converted to an analog baseband signal by the analog baseband processor, then up-converted to an IF signal before being output. This signal is input to the TX AGC unit where it undergoes output power control, and is then up-converted to the channel frequency in the RF transmitter before being output from the antenna.
The next section describes in detail the light-blue ICs in figure 1 (the analog baseband processor and the RX AGC and TX AGC units), developed using a bipolar process.

Single-Chip CDMA Analog Baseband IC with 17,000 Elements CXA3003R *

The CXA3003R is an analog baseband processor that interfaces between the digital processor and the RF front-end block. It supports dual-mode CDMA/FM cellular phone systems. The CXA3003R includes a variety of functional modules—modulator, demodulator, filters, A/D converters, D/A converters, PLL, VCO, etc.—in a single chip, and might be described as a compendium of analog technologies. This IC uses a 0.8 µ ultrafine bipolar process (ECL4) to accommodate more than 17,000 elements, while achieving a low power consumption of only 132 mW in CDMA RXTX mode.
The CDMA/FM signal flow is described in detail below.

*The detailed information is opened only to the CDMA licensees.



■ Figure 1 Block Diagram of CDMA Portable Phone

1) CDMA Signal Processing

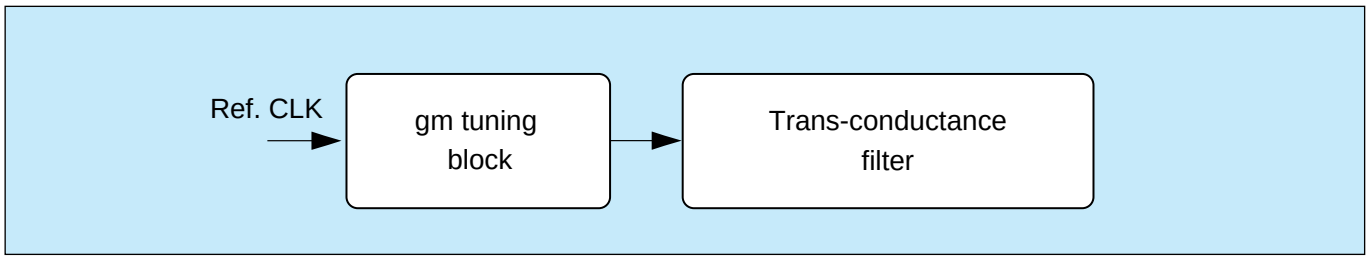
In the receiver, the CDMA spread spectrum modulated IF signal input to the CXA3003R via the RF front-end block is multiplied in the mixer block by an orthogonal local oscillator signal generated inside the CXA3003R. The signals pass through the CDMA low-pass filters and are converted to analog baseband signals, and are then converted into two 4-bit digital signals, I and Q, in the respective A/D converters, before being output.

In the transmitter, the CDMA I and Q digital baseband signals input to the CXA3003R from the digital processor pass through separate I and Q D/A converters and CDMA low-pass filters for the elimination of high-frequency components, and are converted to analog baseband signals. These signals are multiplied by an orthogonal local oscillator signal generated inside the IC, then added, and output as an I-plus-Q mixed CDMA spectrum modulated IF signal.

2) FM Signal Processing

In the receiver, the signal path is the same as for CDMA as far as the mixer block. After this, the signals pass through the FM low-pass filters and are converted to FM baseband signals, and are then converted into serial 8-bit digital signals before being output.

In the FM transmitter, the FM digital baseband input signal input from the digital processor passes through the D/A converter and FM low-pass filter, and is converted to an FM analog baseband signal. This signal modulates the transmit VCO frequency (130.38 MHz) and the result is output as an FM modulated signal.



■ Figure 3 Filter Block Configuration Diagram

Excellent Analog Filter Technology

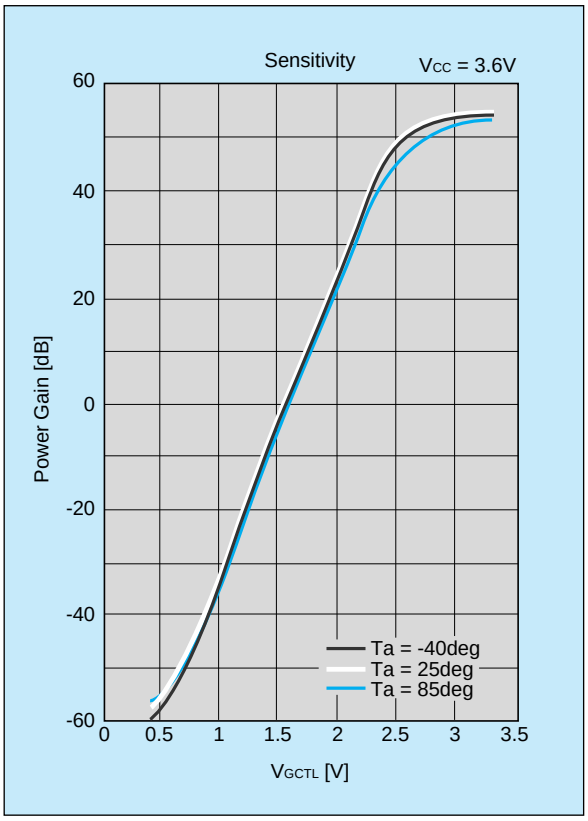
The current service frequency band for CDMA is 800 MHz. Since this frequency band contains powerful waves generated by the AMPS analog FM mobile phone system, very stringent filter characteristic specifications are used to prevent interference from these waves. The provision of an on-chip automatic control filter configuration which determines the gm of the filters in the IC according to the input reference frequency, as shown in figure 3, results in a good frequency characteristic which is unaffected by either temperature fluctuations or element variations .

Wide Dynamic Range and Low Noise

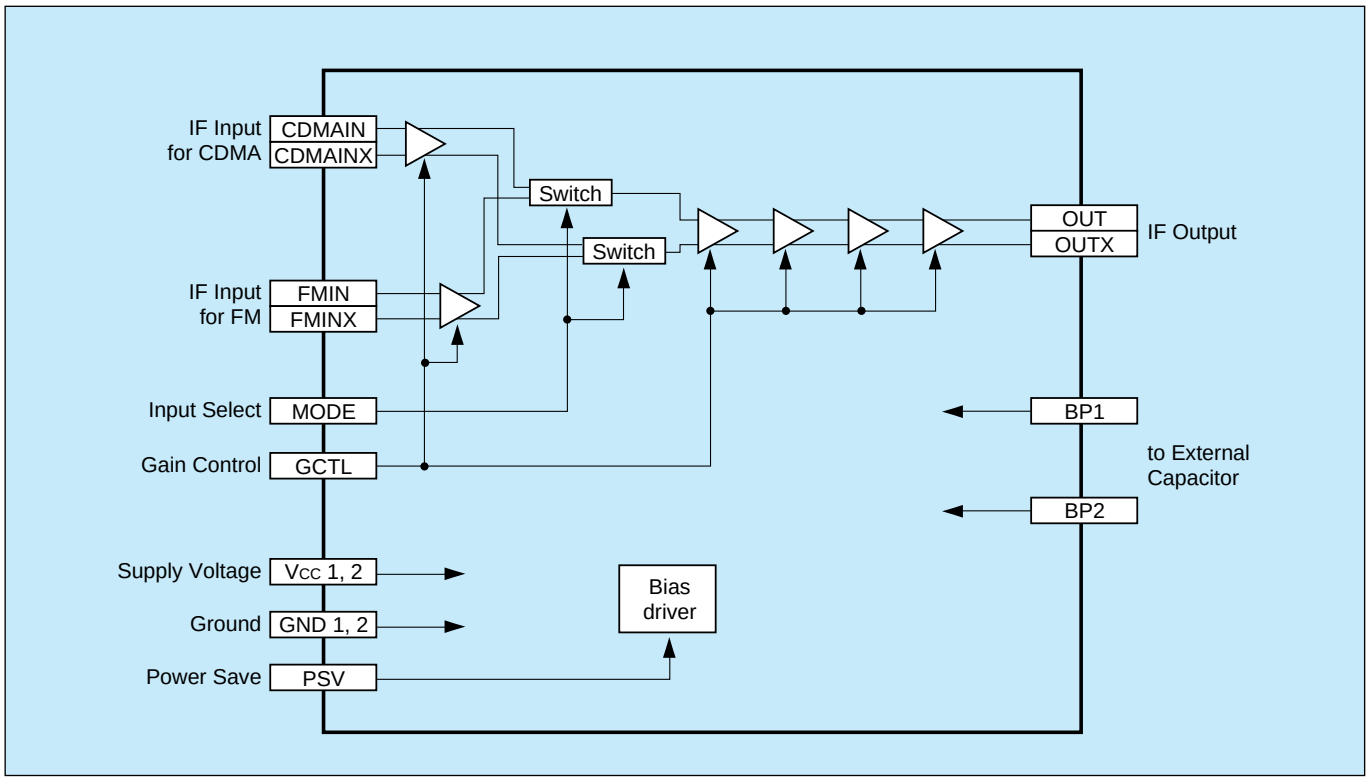
As a basic principle, CDMA communication requires level adjustment of both receive and transmit signals using AGC. Reception AGC requires a wide input dynamic range, and transmission AGC, a wide output dynamic range. The gain control range in both cases is 80 dB or more, and this must also be achieved with a low noise level.

The CXA3001N and CXA3002N are already on the market as CDMA cellular phone reception/transmission gain control amplifiers, offering performance on a par with the best in the industry, including a wide gain control range, excellent gain slope linearity, and dynamic characteristics unaffected by temperature fluctuations. Figure 5 shows the CXA3001N's gain control characteristic as an example of representative characteristic, and figure 7 shows the IIP3 of the CXA3001N.

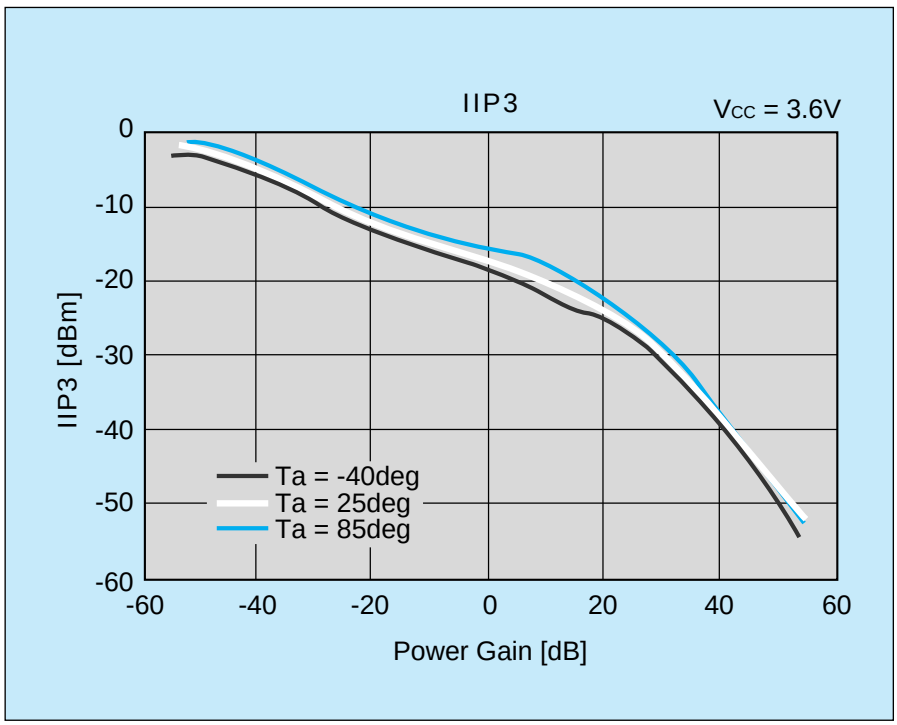
This concludes a summary of the relevant bipolar technology. The following description covers GaAs devices used in PCS (personal communication services), which is attracting attention as a next-generation mobile communication system. The GaAs devices are of low noise, low current, high gain and low parasitic capacitance. These features are suitable for the RF block of PCS as it uses extremely high frequencies in the semi-microwave band of 1.9GHz. An antenna switch is described here, as one example.



■ Figure 5 CXA3001N Gain Control Characteristic



■ Figure 6 CXA3001N Block Diagram

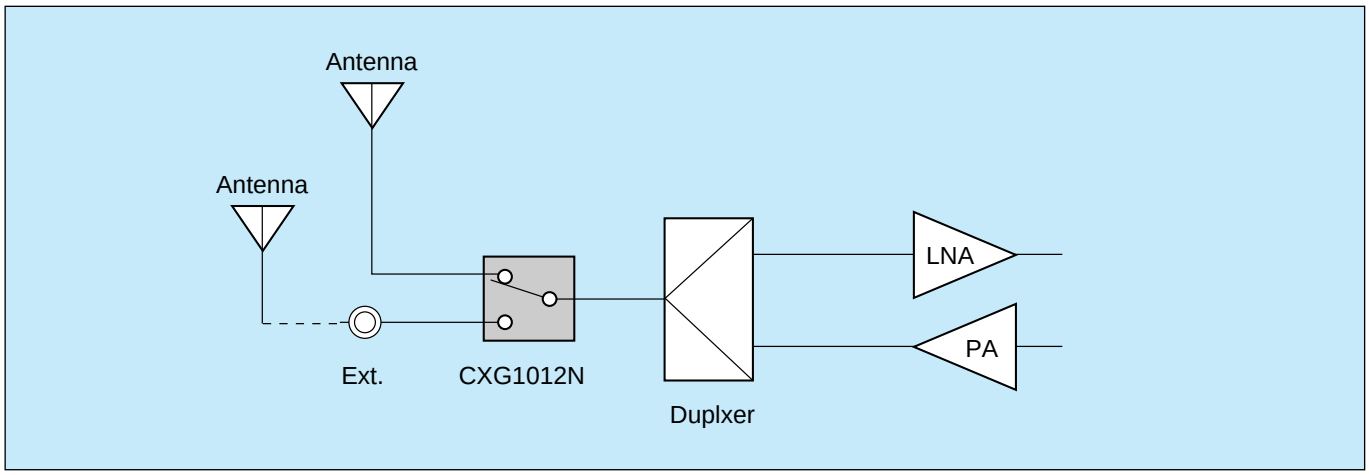


■ Figure 7 CXA3001N IIP3

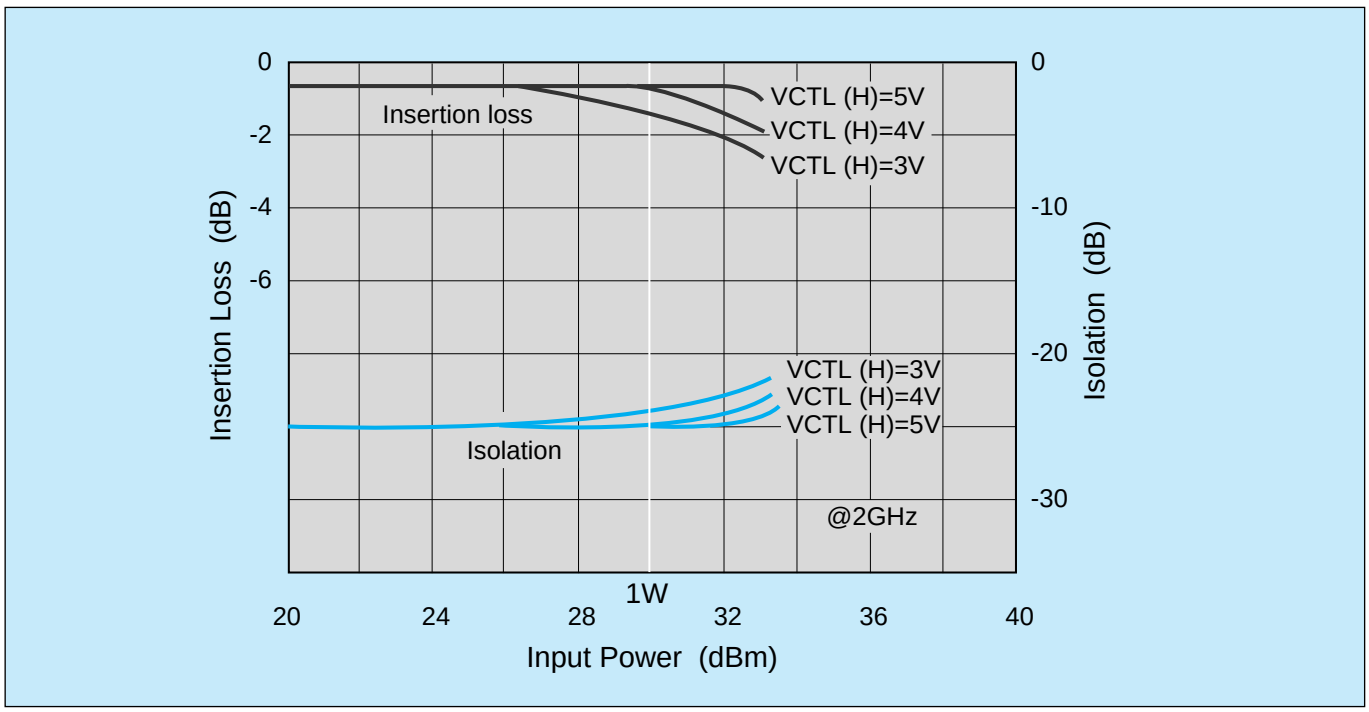
Low-Insertion Loss Antenna Switch CXG1012N

An antenna switch is used to switch between the internal antenna and a vehicle antenna or other external antenna (figure 8). Achieving low switching loss is an important consideration, since switching loss generally leads to a drop in reception sensitivity and increased power amplifier transmission output. Sony has solved these problems through the use of its proprietary low-distortion, low-insertion loss circuit technology and low-on-resistance GaAs JFET technology, in the shape of the CXG1012N.

As shown in figure 9, the CXG1012N achieves a low-insertion loss figure of 0.5 dB or less with positive power supply control, and in terms of power characteristics, is capable of switching a signal of



■ Figure 8 Example of External Antenna System Configuration



■ Figure 9 Input Power Dependency of Insertion Loss and Isolation in CXG1012N

1 W or less using 4 V control without loss of quality—a performance that places it in the top rank within the industry.

In addition to this antenna switch, Sony is currently developing low-noise amplifiers, mixers, power amplifiers, and other products, which make full use of the single positive power supply operation which is a feature of Sony's proprietary GaAs JFET technology.

Future Developments

A wide variety of digital communications systems are coming into use around the world—PDC in Japan, CDMA in America, GSM in Europe. This article has described ICs for use in CDMA systems; in the future, Sony also plans to develop and release devices for other standard systems used in various parts of the world.