GaAs MMIC Devices that Support Digital Personal Communication

GaAs MMIC Product Line for PDC and PHS Applications

- Low-loss switches, high-efficiency low-distortion power amplifiers, and high gain low-noise amplifier/ mixers achieved by adopting high-performance JFET (junction FET) devices
- Ultraminiature 10-pin TSSOP package developed to respond to needs for set miniaturization

*A full-fledged personal digital communication network is now taking shape in Japan. This network consists of two Japanese-developed standards, the PHS (Personal Handyphone System), which first entered service in July 1995, and the earlier portable telephone system (PDC, Personal Digital Cellular), which continues to grow explosively. Furthermore, a PHS-based high-speed data communication service *1 is scheduled to become available this year (1997). Thus it can be said that 1997 marks the start of a multimedia age in which high-quality information can be handled easily even in mobile communication.*

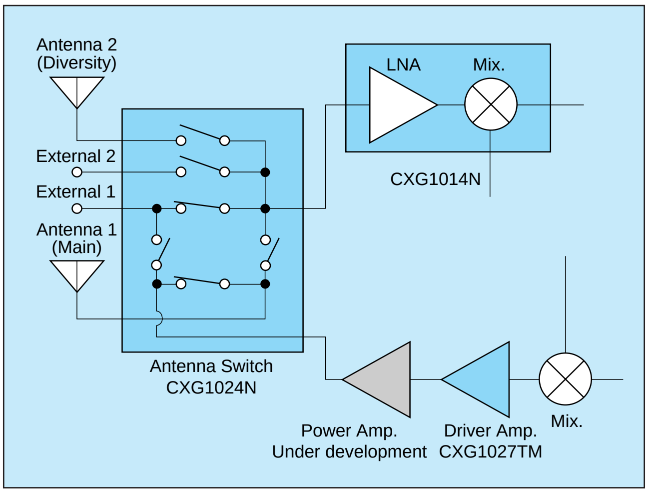
Sony provides GaAs MMIC technology, which can be said to be the crystallization of Sony's high-frequency circuit technology and JFET process technology developed over many years, to the personal digital communication market, which has been exhibiting this rapid growth. We believe that the newly-developed PHS/PDC GaAs MMIC products introduced here will contribute to improved performance and further miniaturization in cellular telephone products, and that they can be seen as "GaAs MMIC devices that support digital personal communication."

Note:*1 The PHS 32-kbps high-speed data communication service will first become available in April 1997. Portable information terminals that provide electronic mail and facsimile functions will be introduced at the same time.

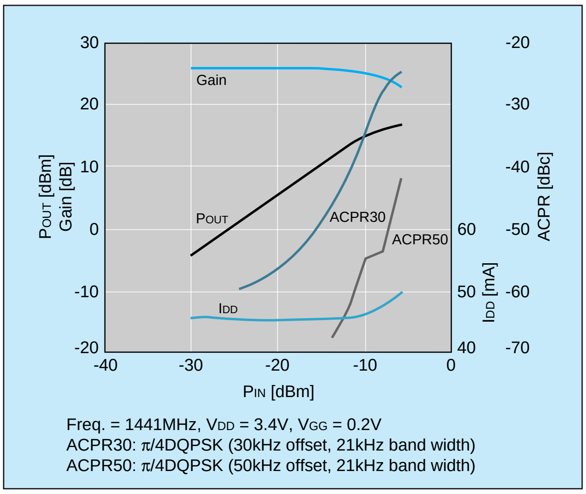
PDC MMIC Product Line

High-Performance PDC Solutions from Sony

Although GaAs MMIC devices are highly regarded for their performance, they have long been limited to military, measuring equipment, and other special-purpose applications due to their high cost and the lack of applications where they could fully exhibit their abilities. However, many new applications, such as satellite broadcasting and personal communication, that use the quasi-microwave and higher frequency bands have appeared recently, and the wide-spread use of GaAs semiconductor devices in consumer electronics, which has long been the dream of researchers and developers in this area, is finally becoming a reality. Meanwhile, the frequency characteristics of silicon devices have improved in recent years and they can now be used in applications handling frequencies of 1 GHz and higher. Leveraged by their low cost, silicon semiconductors are expanding their range of application into the quasi-microwave frequency band used for personal communication and other applications, a band that was previously considered the exclusive domain of GaAs semiconductors.



■ Figure 1 Block Diagram of the PDC Terminal RF block



■ Figure 2 Characteristics of the CXG1027TM Driver Amplifier MMIC

Within this technological background, by achieving significant cost reductions while retaining the superlative characteristics of the GaAs JFET device, Sony can now provide GaAs products that will prove attractive to our users, even for end products for frequencies of 1 GHz and below, such as the PDC 800-MHz band, which until now have been mainly implemented with silicon semiconductors.
We have already released three products as RF block MMIC devices for the PDC 1.5-GHz and 800-MHz bands, which are relatively low-frequency digital communication bands: the CXG1024N antenna switch that significantly reduces the required mounting area and thus supports terminal miniaturization, the CXG1027TM driver amplifier that features low current consumption characteristics, and the CXG1014N that integrates a front-end low-noise amplifier and mixer in a single compact device. We are also currently developing a power amplifier MMIC for use in cellular telephones that will allow, for the first time in the industry, positive power supply drive. (See figure 1.)

1) Key device for portable terminal miniaturization: the CXG1024N antenna switch MMIC

As shown in figure 1, PDC terminals require switching between as many as four antenna circuits; first the transmission and reception blocks must be switched between the terminal's built-in antennas and the external connectors used when external antennas are used, for example in a car, and then each of those cases requires switching between the main and diversity antennas. Previously, this switching structure was implemented by a combination of duplexers, mechanical switches, and PIN diode switches. However, since this is a combination of discrete components, it limited the ability to reduce the required mounting area, and thus was a major obstacle to achieving miniaturization of the terminal as a whole. To overcome this problem we developed and are now releasing the CXG1024N, which takes advantage of the low ON resistance of Sony's GaAs JFET MMIC process devices and integrates the switching blocks in a single miniature 16-pin SSOP package. As a result, this product can contribute significantly to end product miniaturization. Furthermore, although operating from a low-voltage drive, the CXG1024N achieves a significantly lower loss than the discrete component structure used previously and can contribute to extended battery life. Note that since loss in the antenna switching block leads directly to an attenuation of the power amplifier output signal, which accounts for the majority of the power dissipation during transmission, this reduction in loss can contribute significantly to reducing the total power consumption of portable telephones.

2) Optimal for implementing miniature, low-voltage, low-distortion RF transmission blocks: The CXG1027TM driver amplifier MMIC

The CXG1027TM is a two-stage driver amplifier MMIC that can be used for both the PDC 800-MHz band and the 1.5-GHz band by changing an external matching circuit. It is provided in an ultraminiature 10-pin TSSOP package and can contribute to reduced mounting areas. It features low current consumption and high gain despite its low distortion, and can improve the total performance of the RF transmission block. Furthermore, designing end products is easier with this device since it operates at the low voltage of 2.9 V on a positive power supply and can be used to implement adjustment-free circuits. (See table 2 and figure 2.) Thus the CXG1027TM is an IC that combines superlative performance and total balance. We are sure our customers will be more than satisfied with this product.
Note that the CXG1014N combines a front-end low-noise amplifier and a mixer in a compact 16-pin SSOP package. (See table 3.)

The Industry's First Positive Power Supply Drive PDC Power Amplifier MMIC

Sony is now developing PDC power amplifiers (for both 800-MHz and 1.5-GHz products) that take full advantage of the superlative performance of GaAs JFET MMICs. The first point that must be mentioned is that these will be the industry's first PDC power amplifiers that achieve positive power supply drive. These products will provide high performance with 3.5-V low-voltage drive, an efficiency of 50% or better, and a gain adjustment of at least 35 dB. Furthermore, the use of a newly-developed low thermal resistance package will enable these products to achieve both small mounting areas and low cost. We are convinced that these will be the ICs that our customers' set designers have been waiting for. These products are expected to be released shortly.

■ Table 1 Main Characteristics of the CXG1024N Antenna Switch MMIC

Insertion loss	0.4dB @1GHz (Tx POUT)
Isolation	21dB @1GHz (Tx POUT)
P1dB	32dBm VCTL (H) = 3V 35dBm VCTL (H) = 4V
Package	16-pin SSOP

■ Table 2 Main Characteristics of the CXG1027TM Driver Amplifier MMIC

Gain	27.5dB
Adjacent channel leak power ratio 30-kHz offset	-50dBc
Adjacent channel leak power ratio 50-kHz offset	-69dBc
Current consumption	45mA
Package	10-pin TSSOP

(f = 1.441GHz, POUT = 10dBm, VDD = 3.4V)

■ Table 3 Main Characteristics of the CXG1014N Low-Noise Amplifier + Mixer MMIC

Low-noise amplifier block	Current consumption	2.2mA
	Power gain	16dB
	Noise figure	1.85dB
Mixer block	Current consumption	3.8mA
	Conversion gain	8dB
	Input IP3	2.0dBm
Package	16-pin SSOP	

(VDD = 3.0V, fRF = 1.49GHz, fLO = 1.62GHz, PLO = –15dBm)

■ Table 4 Target Specifications for Power Amplifier MMIC Products

Item	Target value
Frequency	925 to 960 MHz (800-MHZ band) 1429 to 1453 MHz (1.5-GHz band)
Output	30dBm
Current consumption	570mA
Adjacent channel leak power ratio For 50-kHz offset	–50dBc
Package	Newly-developed low thermal resistance plastic package

An Overview of the PHS System and the Challenges of Using MMICs in PHS Products

"Whenever, wherever, and conveniently." This is the desire that has been realized by the various systems in the personal communication age. Of these systems, it is PHS that is, by combining the most advanced radio technologies with a highly information-oriented digital network, expanding the possibilities of the current personal communication age even further and at the same time pushing forward towards the achievement of the future multimedia age.

Since PHS terminals use high-frequency quasi-microwave band signals (1.9 GHz) for transmission and reception, the design of the high-frequency blocks is extremely important for achieving improvements in miniaturization, performance, and functionality. Given this background, Sony is developing commercial MMIC chip sets that can provide optimal solutions for PHS terminal high-frequency design by taking maximum advantage of Sony's unique GaAs JFET technology. Also, Sony is constantly striving to improve integration levels in PHS MMICs to contribute to further telephone miniaturization.

MMIC Chip Sets for PHS Communication Terminals

1) Power amplifier MMICs : CXG1020AN and CXG1030N

The transmitter stage power amplifier in a PHS terminal is the key device for increasing the length of the time which the telephone can use for conversation and for achieving further miniaturization in the terminal high-frequency circuit. Thus, while it goes without saying that increased efficiency is strongly desired, there are also a wide range of other requirements on the structure of this circuit. To respond to these demands, Sony has developed and is now releasing two ICs, the CXG1020AN and CXG1030N, for use as PHS transmitter stage power amplifiers. Table 5 lists the features of these MMICs.

The CXG1020AN uses two FET stages and achieves a significant reduction in current consumption by using external input and output matching circuits and holding the high-frequency signal loss in the matching circuits to an absolute minimum. The CXG1030N uses three FET stages to achieve high gain, and has absolutely no need for a driver amplifier due to the adoption of a gain control function using a dual-gate FET. Furthermore, this IC integrates the input and output matching circuits on chip to provide a significant reduction in the mounting area required in the end product.

The CXG1020AN and CXG1030N both use Sony's GaAs JFET process and achieve full single-voltage positive power supply operation, which was extremely difficult with earlier GaAs MESFET processes. Furthermore, additional improvements in the circuit structure have held the DC voltage loss to an absolute minimum to allow these ICs to operate at the low drive voltage of 3.0 V.

2) Antenna switch MMIC: CXG1022TM

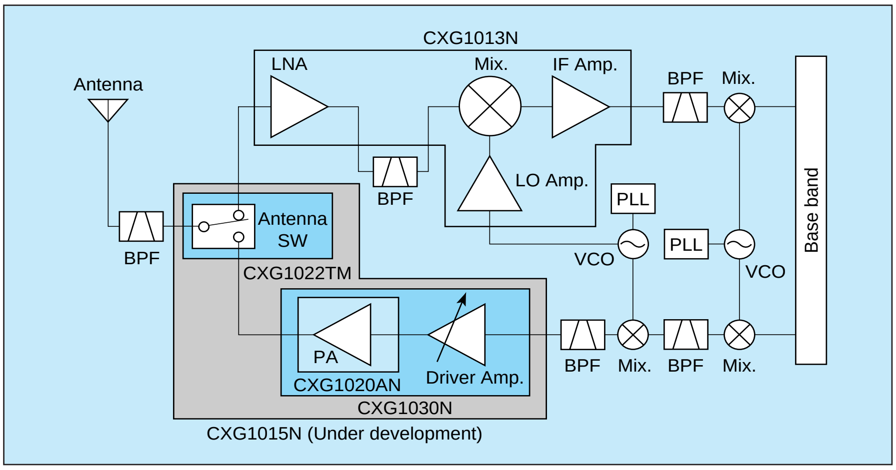
Since high-frequency signals with the same frequency are used in both transmission and reception in PHS terminals, an antenna switch that can handle high frequencies must be used for switching between transmission and reception. There are two requirements placed on this antenna switch. The first is that it should contribute to increasing the length of the time which a cellular telephone can use for conversation by reducing the required power amplifier output power by achieving lower loss in the transmission port. The second is that it should contribute to telephone miniaturization by reducing the mounting area required for circuits and components.

Figure 4 shows the CXG1022TM insertion loss and isolation characteristics. The CXG1022TM takes maximum advantage of the low ON resistance characteristics of the GaAs JFET and achieves the ultralow ON resistance of 0.4 dB (typical at 2.0 GHz). Not only was the mounting area reduced by developing a 10-pin TSSOP miniature package, but the pin count was reduced by taking the FET drive power supply from the switch control pin using an on-chip bias circuit to provide further reduction in the mounting area.

■ Table 5 Features of the CXG1020AN and CXG1030N Power Amplifier MMICs

Item	CXG1020AN	CXG1030N
Supply voltage	3.0V	3.0V
Current consumption	140mA	170mA
Output power	21dBm	21dBm
Power gain	30dB	39dB
Adjacent leak Channel Power Ratio 600-kHz offset	–59dBc	–59dBc
Package	8pin SSOP	16pin SSOP
Gain control function	No	Yes
Input and output matching circuits	External	Built-in

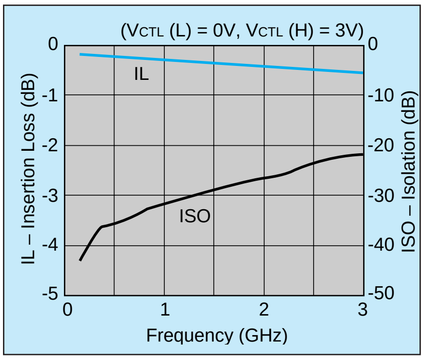
(These values are typical values.)



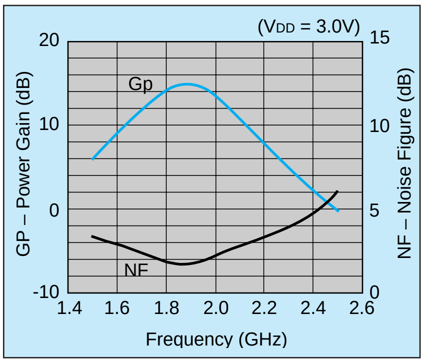
■ Figure 3 PHS Communication Terminal High-Frequency System Block Diagram

3) Low noise amplifier + mixer MMIC: CXG1013N

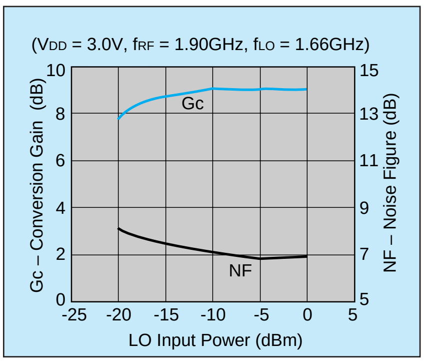
The CXG1013N integrates two of the main functions used in the PHS terminal reception block: a low-noise amplifier and a frequency conversion mixer for the first IF stage, and achieves, with good balance, the performance required in a telephone reception block. Of these performance characteristics, it is extremely important to make the NF characteristic as small as possible to increase the reception sensitivity of the telephone. In the CXG1013N, the current consumption in the low-noise amplifier block and the mixer block were held to 2.5 mA (typ.) and 5.5 mA (typ.), respectively, and figures 5 and 6 show the superlative NF characteristics of this device. Also, since this IC integrates both a LO amplifier and an IF amplifier, it is possible to form a receiver circuit by directly connecting the CXG1013N to the LO signal oscillator or the frequency conversion mixer for the second IF.



■ Figure 4 CXG1022TM Antenna Switch MMIC Characteristics



■ Figure 5 CXG1013N Low-Noise Amplifier + Mixer MMIC Characteristics: LNA Block



■ Figure 6 CXG1013N Low-Noise Amplifier + Mixer MMIC Characteristics: Mixer Block

Single-Chip MMIC Integration of PHS Power Amplifier + Antenna Switch

Development of the CXG1015N

Since PHS service was started in July 1995, PHS telephone development efforts have focussed on miniaturization, weight reduction, and increased functionality. Now, since the PHS 32-kbps high-speed data communication service will become available in the spring of 1997, these PHS terminals are no longer merely telephones, but can be seen as developing into full-fledge communication terminals that function as tools for increasing the use of information in our daily lives. As a result of this development, we expect that there will be even stronger demand for further miniaturization in the existing basic communication functions of these devices.

Sony is striving to develop IC integration technologies to support even further miniaturization of these communication terminals. We have already developed the CXG1030N and CXG1022TN as high-performance ICs. Now we are pushing forward with the development of the CXG1015N MMIC that integrates a high-gain power amplifier and a low-loss antenna switch on a single chip. By releasing the CXG1015N as a commercial product, it will become possible to implement the high-frequency blocks of a PHS communications terminal with just two main ICs, one for transmission and one for reception and thus form a highly miniaturized multi-function device. Sony is committed to the continued development of PHS MMIC products that meet system requirements and respond to the needs and hopes of you, our customers.

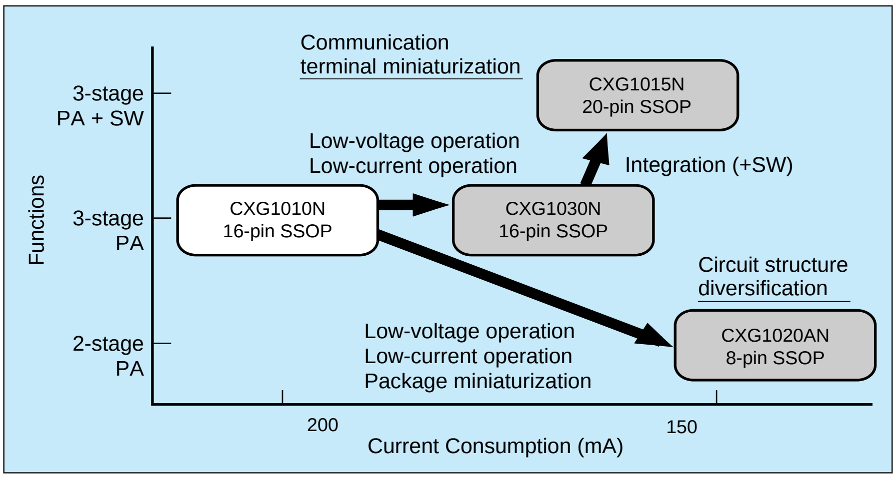
Future Developments

Future developments in Sony MMIC products will include:

1) The development of new standard miniature packages to achieve both improved high-frequency characteristics and smaller mounting areas.
2) Expansion of the range of ICs that use those packages.
3) The development of low-voltage, low-current drive ICs.

Sony will respond to needs for reduced power consumption and further miniaturization in end products by proceeding energetically with these development efforts. While a wide range of other standards, such as GSM and PCS, are in use in countries other than Japan, Sony has already provided MMIC products, mainly switching ICs, for a wide range of communication standards. Sony will continue to expand its product line in this area focussing on the creation of charismatic products.

You can expect great things from Sony in future JFET MMIC products!



■ Figure 7 Development Directions in Sony PHS Power Amplifier MMIC Products