GaAs Switch ICs for Wireless Broadband Applications

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Abstract

Compact and slim packaged switch ICs are required for use in switching the antennas and signals of wireless broadband applications such as WiMAX, wireless LAN, Bluetooth and cellular phones. This paper is intended to introduce the GaAs switch IC technologies that match these requirements as well as some of the characteristic products based on the technologies.

Keywords

GaAs, switch IC, wireless broadband, cellular phone, low loss, low distortion

1. Introduction

The recent popularity of a variety of wireless applications such as wireless LAN and Bluetooth has been expanding the related markets. The wireless LAN used to be mainly mounted on PCs but it is being increasingly used in game machines, digital cameras, music players and various home electric appliances. Cellular phones are also incorporating various wireless applications to support the accelerated adoption of a range of functions including multimode and multiband compatibilities. Recently, new wireless broadband network technologies such as the mobile WiMAX and the wireless USB technologies are starting up. These are expected to grow rapidly as a next-generation wireless broadband network and will be on top of the existing applications.

The switch IC is a device for use in switching the paths of the high-frequency signals of wireless applications as a transmission/reception switch or an antenna switch. It is required to offer characteristics and specifications matching the requisite usages, for example the switching of high-power transmitting signals with low loss, high isolation and wide bandwidth. It must also feature compact and slim packaging.

This paper describes the technologies for creating a switch IC suitable for wireless broadband applications including WiMAX, wireless LAN, Bluetooth and cellular phones and some of the characteristic products based on these technologies.

2. Outline of the High–Frequency Switch IC

High-frequency switches for switching the paths of multiple high-frequency signals include a combination of several PIN diodes and ICs using FETs that are employed according to their individual purposes. Although PIN diodes are used widely, they are sometimes, because of their low prices not considered to be suitable for circuit size reduction or composite circuit creation. This is because, when for example organizing a single pole double throw (SPDT) switch for switching the signal from a single port into two ports, two diodes and a 1/4-wavelength strip line are required. Also, when switching the high-power transmission signal of a cellular phone, the flow of a few milliamperes of consumption current shortens the standby period of the handset.

On the other hand, the switch ICs using FETs do not need a 1/4-wavelength strip line as do the PIN diodes and the package size can be reduced by adopting a device in the form of an IC. The current flowing through the control terminals ranges from a few to tens of microamperes, which is much lower than for the PIN diodes, so the overall power consumption can be reduced. Therefore, the replacement of PIN-diode switches by high-frequency switch ICs based on FETs is increasingly being adopted to support the purposes for which compact, slim size and low power consumption are essential, such as for cellular phones.

The mainstream device process used in the fabrication of high-frequency switch ICs is the GaAs process. Some recent switch ICs use the CMOS process of Si, but the GaAs ICs feature superior high-frequency characteristics including low insertion loss. The GaAs devices are often thought to be expensive, but their prices have dropped relatively due to the beneficial effects of the mass-production process. As this has increased inquiries and orders from the fields that previously tended to avoid them due to their high price, the fields of applications of GaAs switches are currently expanding.

3. Technologies Applied to GaAs Switch IC

In addition to the need for low cost products that are slim and compact, recent requirements for the characteristics of multimode/multifunction switches are as follows.

- Low signal loss of the selected circuit path (Low loss characteristic).
- Prevention of mixing of signals across different paths (High isolation characteristic).
- Capability of handling high-power transmitting signals (High power compatibility).
- Prevention of distortion of transmitting signals (Low distortion characteristic).
- Operation at low voltage and low power consumption.

These requirements were met by applying our originally developed HJFETs (Hetero-Junction Field Effect Transistors) [1]. We provided the epitaxial wafer with a double-doped, double-heterojunction structure, in which an additive-free InGaAs channel layer mounted on GaAs substrate is sandwiched between donor-added AlGaAs layers. The device characteristics obtained are as follows:

- Low ON resistance and high current linearity.
- High current density and high breakdown voltage.

We applied the HJFET in the switch IC to make it a compact chip switch IC with low loss, low distortion and high isolation characteristics up to high transmitting power.

In parallel with the chip size reduction, we also developed a compact and slim package by adopting a thin, fine lead frame and a gold wire bonding technology with low height. As a result, we succeeded in the commercialization of a switch IC featuring the smallest package size among the switch ICs of similar function and transmitting power.

4. Switch IC Products

The applications of switch products are roughly determined according to the function, or how many circuits they can switch over, as well as by the transmitting power level, or how high a signal power they can handle. In addition, every switch product must also have the requisite specifications and characteristics such as having compactness, slim size, low-voltage operation, low loss and wide bandwidth.

First and foremost, the µPG2176T5N is an IC for use in the data transmission/reception switching and/or antenna selection switching that is required in the construction of a mobile WiMAX system complying with the radio communication standards [2]. The WiMAX system is controlled by a strict distortion standard, and should be capable of switching a five times larger transmitting signal power than that of the wireless LAN systems and of handling high-frequency signals in a wide bandwidth from 2.3 to 5.85GHz. **Fig. 1** shows the developed SPDT switch IC, that uses the HJFET technology described in Section 3 and switches a high 37dBm signal with a low loss of 0.45dB at 2.7GHz or 0.7dB at 5.85GHz.

Table 1 shows the main characteristics of the IC, and **Photo 1** shows the appearance. Due to the compact, slim package of the industry's smallest class of 1.5mm × 1.5mm × 0.37mm thickness, and the mounting area has been reduced by 25% and the slimness improved by 50% compared to our previous products.

The second product, µPG2401T6A is an antenna switch IC for use with multimode/multiband compatible cellular phones.

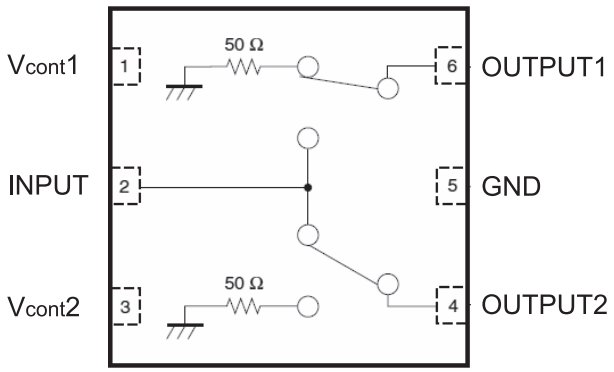

Fig. 1 µPG2176T5N block diagram.

Table 1 Outline of µPG2176T5N (SPDT switch).

Item	Specifications
Control voltage	+2.5 - +5.0 V
Insertion loss	0.45dB typ. @ f = 2.7GHz
Isolation	0.55dB typ. @ f = 3.8GHz
(INPUT-OFF port)	0.7dB typ. @ f = 5.85GHz 27dB typ. @ f = 2.7GHz 24dB typ. @ f = 3.8GHz 21dB typ. @ f = 5.85GHz
Transmitting power	Pin (1dB) = 5W (+37dBm) typ. @ f = 2.7GHz, Vcont = 3.0V/0V Pin (1dB) = 5W (+37dBm) typ. @ f = 3.8GHz, Vcont = 3.0V/0V Pin (1dB) = 5W (+37dBm) typ. @ f = 5.85GHz, Vcont = 3.0V/0V
Consumption current	16µA
Package	6-pin TSON (1.5 × 1.5 × 0.37 mm³)

Control voltage: 3.0V/0V. Temperature: +25°C.

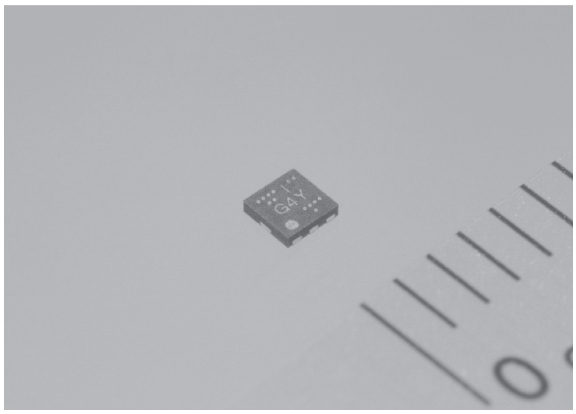

Photo 1 External view of µPG2176T5N.

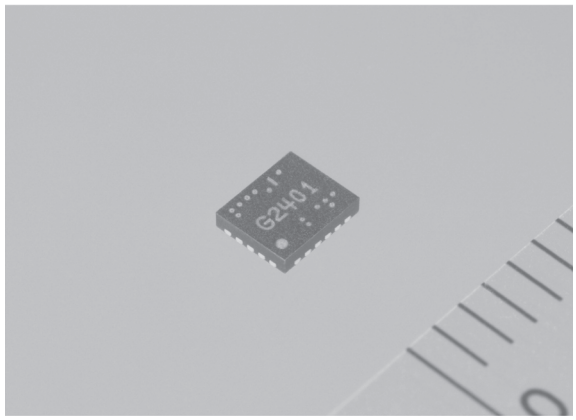

Photo 2 External view of µPG2401T6A.

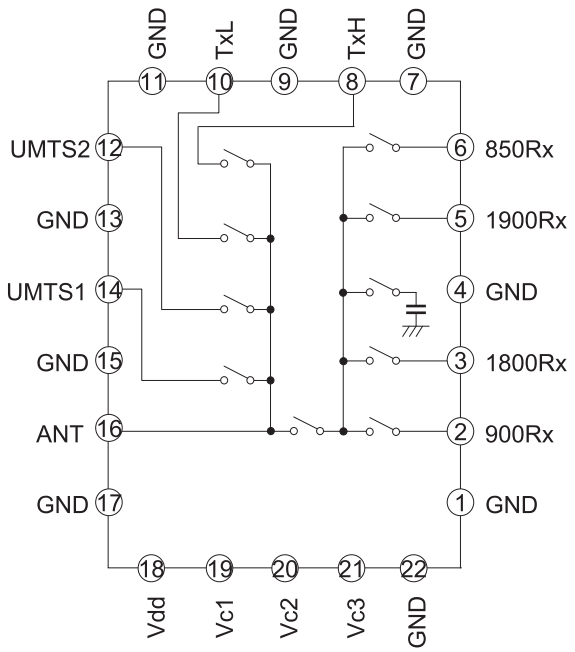

Fig. 2 µPG2401T6A block diagram.

This switch IC is for use with a cellular phone equipped with both the GSM and UMTS communication functions and has an SP8T function as shown in **Fig. 2** . Namely, it switches the 6 bands of the GSM transmission/reception signals and the 2 bands of the UMTS signals for the antenna. The port switching is controlled by a logic signal, and all of the functions are accommodated in a compact and slim package of 3.0 × 2.5 × 0.55mm. The appearance of this IC is shown in **Photo 2.**

As shown in **Table 2** , this IC features excellent primary characteristics such as 0.3dB loss at 0.9GHz, 0.5dB loss at 1.9GHz and -80dBc of third harmonic distortion. These characteristics are much lower than those of the switch ICs fabricated with the Si device process. This switch IC is expected to contribute to support an extension of talk time for cellular phones.

Table 2 Outline of µPG2401T6A (SP8T switch).

Item	Specifications
Supply voltage	+2.8V
Control voltage	+1.8V
Insertion loss	0.3dB typ. @ f = 0.9GHz 0.5dB typ. @ f = 1.9GHz
Second harmonic	-78dBc min. @ f = 0.9GHz, 1.9GHz
Third harmonic	-80dBc min. @ f = 0.9GHz, 1.9GHz
Consumption current	800µA typ.
Package	22-pin RQFN (3.0 × 2.5 × 0.55 mm³)

Control voltage: 1.8V/0V. Temperature: +25°C.

5. Future Development, Conclusion

Following the recent reductions of voltages in baseband/control systems, switch ICs are also required to reduce their control voltages. Our HJFET technology has already made it possible to set the operating voltage specification at 1.8V and has gained high reputation among users. We intend to increase the 1.8V operation products among the single-control type products that can be switched with a single control terminal, and we will also pursue the possibility of operations at even lower voltages.

With regard to the need for compact and slim packages, we will expand the multiport switch IC products including the

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SP3T, SP4T and DPDT as well as SPDT switches. We will thus provide products that match user needs by contributing to size reductions and improving the compactness of wireless communication equipment.

*The Bluetooth word mark and logo are owned by Bluetooth SIG. Inc., and any use of such marks by NEC is under license.

References

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