FEATURING

TMS2: 0.25 µm SiGe BiCMOS Process Technology

Mixed-Signal Process Achieves Higher Speeds and Lower Power

- **SiGe HBT for low-noise, high-performance analog circuits**
- **CMOS transistors for low power and seamless analog/digital integration**
- **Wide range of passive RF devices allows RF functions to be implemented on a single chip**
- **Trimming technologies for adjustment-free manufacturing**

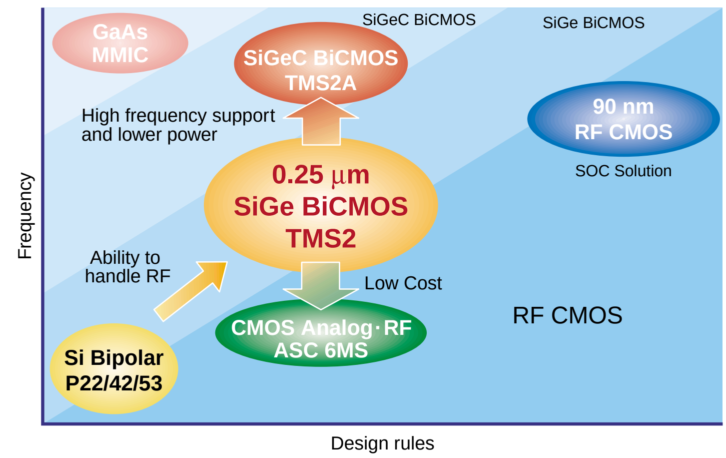
SiGe BiCMOS Mixed-Signal Process Supports RF

Over the years, Sony has been developing device and circuit technologies for analog signal processing.

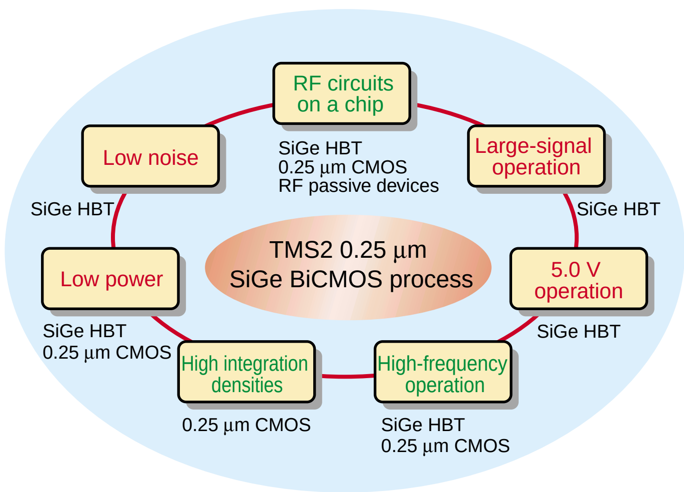
Now, Sony provides a 0.25 µm SiGe BiCMOS process technology that includes SiGe HBT (silicon-germanium heterojunction bipolar transistor) devices and that achieves superlative performance in the RF region as a new solution for mixed-signal applications. (See figure 1.)

Adoption of this new process technology allows Sony to provide products that support high-frequency systems and that achieve not only low noise and low power, but low cost as well.

TMS2 is based on the “ASC-6” 0.25 µm CMOS logic process, and can be used to fabricate ICs that integrate SiGe HBT devices, CMOS devices that can be used in both RF and analog designs, and a rich set of options that realize RF circuits on a chip. (See figure 2.)



■ **Figure 1 Sony RF Device Process Portfolio**



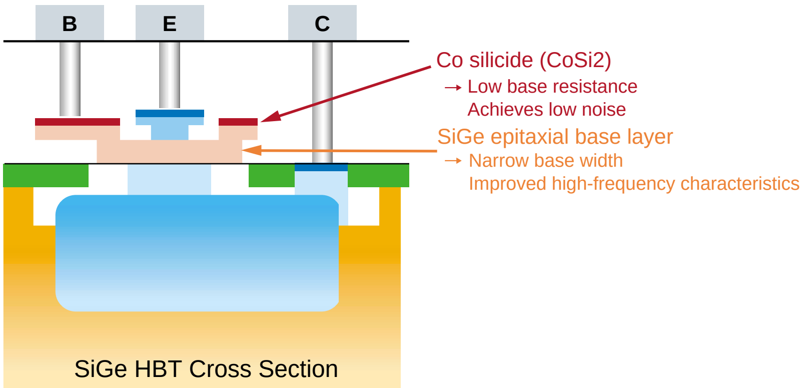
■ **Figure 2 TMS2 Main Features**

SiGe HBT Technology Features High Speed, Low Noise, and Low Power

The SiGe HBT is a bipolar transistor that adopts a thin SiGe epitaxial layer that provides a heterojunction effect in the base region of the device. This technology can implement transistors that feature a higher cutoff frequency, f_T, and a higher maximum operating frequency, fmax, than conventional Si bipolar technologies. The base resistance is reduced, thus lowering noise, by adopting a cobalt silicide layer (an alloy of cobalt (Co) and silicon (Si)) in the transistor's base electrode. Furthermore, since excellent high-frequency characteristics can be obtained at low supply voltages and low current densities, these devices can contribute to lower power as well. (See figure 3.)

Extensive Analog Options for RF Products with Superb Performance

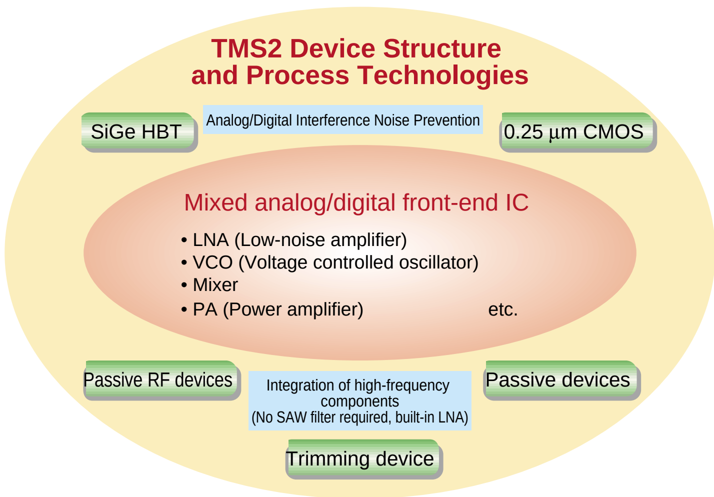
The TMS2 process allows an extensive set of optional devices to be integrated on the same chip, including high quality factor (Q) passive devices with excellent reliability at high frequencies. This allows the TMS2 process to implement high-functionality analog/digital mixed-signal front end SOC (System on a Chip) products. In particular, high-frequency circuits such as low-noise amplifiers (LNA), voltage-controlled oscillators (VCO), frequency mixers, and power amplifiers (PA) can be integrated together on the same chip. This allows parts counts to be reduced and flexible and revolutionary architectures to be adopted. (See table 1 and figure 4.)



■ **Figure 3 SiGe HBT Key Technologies**

■ **Table 1 TMS2 Device Product Lineup**

Device	Included devices
SiGe HBT NPN	Em length: 0.3, 0.8 µm Beta 130 $f_T$max 48 GHz, fmax 87 GHz Vceo > 3.6 V
MOS FETs	NMOS FET 2.5, 3.3 V PMOS FET 2.5, 3.3 V
Capacitors	MIS capacitor 2.0 fF/µm^2 MIM capacitor (SiON) 0.6 fF/µm^2 MIM capacitor (Ta2O5) 6.0 fF/µm^2
Resistors	High resistor 2000 Ω/□ Medium resistor 500 Ω/□ Low resistor 7.9 Ω/□
Varactors Spiral inductors Trimming device	PN junction varactors Metal thickness: 3 µm Polysilicon fuse



■ **Figure 4 TMS2 Device Structure and Circuits**

TMS2 Application Products

Sony is now taking advantage of the high frequency, low noise, and low power features of the TMS2 process by developing products using this process. These products include Global Positioning System (GPS), cellular phone transceiver, wireless LAN (W-LAN), and TV tuner devices. Of these products, this article introduces the CXA3355ER GPS RF IC.

CXA3355ER GPS RF IC Achieves High Sensitivity and Low Power

Sony has already developed the industry's first single-chip CMOS GPS device*, and that product is now being mass produced. However, Sony has now developed a GPS RF IC that uses the TMS2 technology. This article presents this new device.

As shown in figure 5, GPS applications are not limited to automotive products, rather, the areas where GPS is being adopted are expanding continually and now include notebook personal computers, digital cameras, and cellular phones. This growth is leading to changes in the characteristics required of GPS devices. For example, higher sensitivity and lower power are not required in automotive applications, but are strongly desired in portable equipment.
The CXA3355ER GPS RF IC combines bipolar technologies, an area where Sony is particularly strong, with the analog CMOS design technology nurtured during the development of Sony's CMOS GPS SoC products. This combination allows the CXA3355ER to achieve at the same time both the ultralow power optimal for portable equipment and higher sensitivity due to integrating an LNA on the same chip.

*: See CX-News Volume 33 for details.

LNA and Mixer Circuits

The TMS2 SiGe HBT allows products fabricated in this process to include a low-noise amplifier (LNA) circuit. In conventional bipolar processes, an LNA would draw several tens of mA, but the LNA circuit integrated in the CXA3355ER only requires a mere 2 mA. Furthermore, the noise figure (NF) is the extremely low 2.0 dB (typical) at 50 Ω matching.
The newly developed image rejection mixer circuit allows the CXA3355ER to achieve an image rejection ratio of 40 dB over a wide bandwidth.
The CXA3355ER adopts single conversion, a simple circuit structure. Until now, the degree of image rejection has been a serious issue for single conversion circuits. However, by combining the small relative variations of the TMS2 process with Sony's advanced circuit design technologies, Sony was able to integrate image rejection functionality with a high rejection ratio on the same chip.

**: E911: Enhanced 911 Emergency Calling System. The US Federal Communications Commission (FCC) created laws requiring communications providers to be able to determine the location of transmission when an emergency is reported from a cell phone. This law was enacted October 5, 2001.
E112: A European Union law equivalent to the E911 law.

■ **Figure 5 GPS Applications**

VCO and PLL Circuits

The VCO is implemented using on-chip inductors and varactors. The high quality factor (Q) of the inductors fabricated in the TMS2 process minimizes current consumption. Sony's circuit design know-how developed over the years provided workarounds for sample-to-sample variations, which are often a problem in VCO circuits. The effectiveness of these workarounds has already been proven.

A pulse swallow integer-divisor type PLL circuit was adopted. Conventional GPS RF circuits use 16.368 and 18.414 MHz TCXO frequencies, and the PLL divisor is fixed. While the comparison frequency must be reduced to handle the 13 MHz or 19.8 MHz TCXO frequencies used in cellular phone applications, the VCO current increases if attempts are made to suppress phase noise. Current increases are minimized by using high-performance RF passive devices in the tank circuit. Furthermore, high-speed bipolar and CMOS devices are used where appropriate in the pulse swallow frequency divider to further reduce current consumption. The adoption of the TMS2 process has thus made lower power and further miniaturization possible.

Interface and Control

This device supports a 1-bit digital output, making connection with the baseband system easier and at the same time obviates the need for a buffer amplifier at the DSP input.

Furthermore, the CXA3355ER includes a control block fabricated in CMOS that not only controls the PLL and filter settings, but also can set up tests. Fabricating this block in CMOS minimizes the increase in chip area required for these functions. All the blocks in the IC can be controlled from this tiny control circuit. TMS2 is also a superlative process for analog CMOS. Fully half of this IC's analog block is implemented using CMOS circuits.

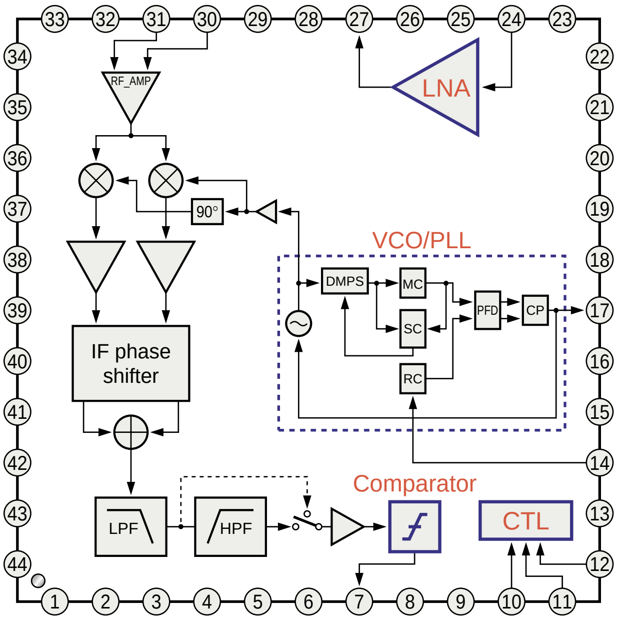
The CXA3355ER GPS RF IC combines both SiGe HBT and CMOS devices on the same chip and takes maximum advantage of both the high potential of the TMS2 process technology and Sony's superlative circuit technologies, making it a highly competitive product.

Future Developments

Sony is now working on developing a 0.25 µm SiGeC BiCMOS technology that adds carbon (C) to the TMS2 base layer. Sony is also developing, among other processes, a 0.25 µm RF CMOS technology that includes both 6 V breakdown voltage CMOS and MONOS trimming technologies while removing SiGe HBT fabrication from the TMS2 process. All these efforts are aimed at expanding the range of process technologies Sony has available and to allow Sony to provide a wide range of device solutions for the RF area. Keep your eye on Sony's mixed-signal device technologies for even more exciting developments.

■ Table 2 Main Specifications

	CXA3355ER (SiGe-BiCMOS)	CXA3336ER (Bipolar)
Operating voltage	1.8 ± 0.2 V	3.0 ± 0.3 V
Current consumption (operating)	11 mA	25 mA
Low-power mode current	1 µA	100 µA
LNA NF	2.0 dB	–
Image rejection ratio	40 dB	0 dB
TCXO frequency	10 to 26 MHz	16, 18 MHz (Fixed)
Output format	Digital 1 bit	Analog 0.6 V_{PP}



■ Figure 6 Block Diagram