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Development of low-cost low-power-consumption transceiver circuit technology for quasi-millimeter-wave-band wireless-communication systems

Experimental production of 24-GHz-band single-chip MMIC and confirmation of its operation with low-power consumption of 100 mW

Tokyo, September 13, 2010 --- Hitachi, Ltd. (NYSE : HIT/TSE : 6501, hereafter Hitachi) today announced the development of a high-frequency transceiver circuit for quasi-millimeter-wave-band (frequency band from 10 to 30 gigahertz (GHz)) wireless communication systems and the successful prototyping of a 24-GHz band single-chip monolithic microwave integrated circuit (MMIC)^{*1}. The high-frequency transceiver circuit developed was fabricated with low-cost silicon technology, and the prototype 24-GHz-band single-chip MMIC achieves outstanding low power-consumption of 100 mW, one third that of a conventional 24-GHz-band single-chip MMIC. This work was supported by “The Research and Development Project for Expansion of Radio Spectrum Resources” of the Ministry of Internal Affairs and Communications, Japan.

Recently, with the rapid spread of mobile phones and wireless LANs, the frequency band used by such equipment for wireless communication (6 GHz and below) is becoming crowded, and alleviating this overcrowding has become one of the key issues for the further expansion of wireless communications. Accordingly, to effectively use the limited radio spectrum resources, fundamental technology to make the transition to other frequency bands with a relatively wider bandwidth is being developed. Further, the quasi-millimeter-wave band (namely, from 10 to 30 GHz) is expected to become the next-generation wireless-communication frequency band. Compared to a frequency range of 6 GHz and below, the quasi-millimeter-wave band is wide and is capable of handling higher speed larger capacity data communication than current wireless LAN. It is expected therefore to be used for high-speed wireless access systems in the home and office, network-type video-monitoring systems, and data communication between base stations in mobile-phone networks. For widespread use of the quasi-millimeter-wave band communication systems, the systems need to be low-cost and of a compact size. Further, from an environmental viewpoint, they also need to be low power-consuming.

In response to this expectation, Hitachi has developed low-cost, compact and low-power-consuming high-frequency transceiver circuit technology. This technology uses a silicon (Si) IC which is cheaper than the conventionally used compound semiconductor IC, and by integrating the functions achieved previously by several chips into the circuit of one chip, achieves higher integration. Moreover, the circuit technology developed allows high-frequency coupling circuits composed of passive components for connecting circuit blocks in a single-chip IC, to be introduced. As the passive-component coupling circuits do not require a power supply for operation, power consumption of the high-frequency transceiver circuit is reduced.

In the past, active devices were used in the coupling circuit however at a high operating frequency in the quasi-millimeter-wave band, “impedance^{*2} matching” degradation between the circuit block and the coupling circuit occurs, resulting in decreased signal-transmission efficiency. To overcome this, a large operating current is required, resulting in increased power consumption. The coupling circuit developed utilizes spiral-shaped passive components which resolves the impedance mismatch and realizes increased signal transmission efficiency. In addition, as the coupling circuit developed with the passive components only uses alternating current signals in signal transmission, it is possible to reduce the power-supply voltage compared to the conventional active components which used both direct-current and an alternating-current signal.

To verify the high-frequency transceiver circuit technology developed, Hitachi fabricated a prototype 24-GHz-band single-chip transceiver circuit based on 0.18- μm silicon-germanium (SiGe) bipolar complementary metal-oxide semiconductor (BiCMOS)^{*3} technology. Operating at a power consumption of 100 mW (which is one third of that of a conventional chip-set of a transceiver operating in the quasi-millimeter-wave-band), the developed transceiver circuit attains a maximum gain of 60 dB and a noise figure^{*4} of 5.8 dB in the receiver mode, and a gain of 38 dB and transmitter linear output^{*5} of 4.3 dBm in the transmitter mode.

This high-frequency transceiver circuit technology is fundamental technology which will contribute to the achievement of future low-cost, low-energy, quasi-millimeter-wave-band wireless communication systems. Hitachi intends to continue actively working on the

development of various technologies which will contribute to the effective use of radio spectrum resources.

These results will be presented on 14th September at the European Solid-State Circuits Conference, which will be held from 13th to 17th September 2010 in Seville, Spain.

Note:*1 MMIC (monolithic microwave integrated circuit): a type of integrated circuit that operates at microwave frequencies. It integrates active components and passive components on a semiconductor substrate.

*2 Impedance: the voltage–current ratio at a particular frequency. It is a complex number. When the impedances of signal source and load are conjugate-matched, maximum power transfer can be achieved.

*3 SiGe BiCMOS: a technology that fabricates a single integrated circuit with both silicon-germanium hetero-bipolar transistors and complementary metal–oxide–semiconductor (CMOS) transistors.

*4 Noise figure: an indicator of analog circuit performance, It represents degradation of the signal-to-noise ratio caused by components in a signal chain.

*5 Transmitter linear output: maximum output power at which a transmitter can transmit the signal with low distortion.

About Hitachi, Ltd.

Hitachi, Ltd., (NYSE:HIT / TSE:6501), headquartered in Tokyo, Japan, is a leading global electronics company with approximately 360,000 employees worldwide. Fiscal 2009 (ended March 31, 2010) consolidated revenues totaled 8,968 billion yen (\$96.4 billion). Hitachi will focus more than ever on the Social Innovation Business, which includes information and telecommunication systems, power systems, environmental, industrial and transportation systems, and social and urban systems, as well as the sophisticated materials and key devices that support them. For more information on Hitachi, please visit the company's website at <http://www.hitachi.com>.

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