

APPARATUS FOR PROCESSING A RADIO FREQUENCY SIGNAL FOR AN AUTOMOBILE BASED TERMINAL

Technical Field

5 The present invention relates to a radio frequency (RF) signal processing apparatus having an RF communication function, and more particularly, to an RF signal processing apparatus for an onboard terminal which can be used in a construction of a system, e.g. an electronic toll collection system (ETCS), and also can achieve miniaturization, lightness and inexpensiveness of a terminal by integrating an RF signal
10 transceiver module into a Monolithic Microwave Integrated Circuit (MMIC) chip.

Background Art

 While an increase in vehicles makes traffic more congested, an Intelligent Transport System (ITS) was suggested to innovatively improve mobility, stability,
15 efficiency, and traffic conditions by integrating an existing traffic system with high technologies, such as information & communications, electronics, control, computers, and the like.

 As an example of an ITS, an electronic toll collection system (ETCS) was suggested to automatically collect tolls on toll roads, such as a highway, and congestion
20 fees in the downtown areas. In the ETCS, tolls are automatically collected by wireless communications between a roadside base station device which is installed on a way to a toll gate and a terminal mounted on each vehicle which passes through the toll gate.

 The conventional ETCS constructed as above has a frequency band of about 300 MHz. Namely, a frequency utilization ratio is comparatively low. To solve this
25 problem, a method of increasing a frequency utilization ratio using a short range wireless communication network is being pursued.

 Also, there is a growing need for reducing size, weight, and production costs of electrical and electronic equipment in a large number of technical fields. A representative example is System-on-a-Chip (SoC) in which a system is integrated into
30 one semiconductor chip. With developments in semiconductor processing technologies, SoC is being applied to a larger number of areas.

 In the case of a wireless communication system, which is a technical field of

the present invention, semiconductor processing parameters needs to be very precisely adjusted so as to design an apparatus for processing high frequency signals. Accordingly, in comparison with normal apparatuses, it may be technically very difficult to integrate a system into a single chip.

5 A steady attempt to integrate a system into a single chip has been made even in the aforementioned ETCS utilizing a short range wireless communication network. However, as described above, such an effort to integrate an RF signal processing apparatus into a single chip has been only partially successful due to technical difficulties.

10 An RF signal processing apparatus, which is utilized in any type of communication system as well as an ETCS, generally includes a receiving unit, a transmission unit and a controller. However, in a conventional art, each of the receiving unit, the transmission unit, and the controller was integrated into a single chip while the apparatus was embodied by a plurality of chips. In this case, each unit of the
15 RF signal processing apparatus may be easily embodied. However, the RF signal processing apparatus may have difficulties in expanding its application fields, as well as in expanding its consumer markets, due to limitations in reducing its size, weight, and production costs.

 Accordingly, the present invention suggests a new technology which can
20 achieve miniaturization, lightness, and inexpensiveness by more effectively constructing an RF signal processing apparatus and integrating the principal configuration elements into a single chip.

Disclosure of Invention

25 Technical Goals

 The present invention is conceived to solve the aforementioned problems in the conventional art. Thus, the present invention provides an RF signal processing apparatus which can accomplish its miniaturization and lightness by integrating an RF signal receiving unit, an RF signal transmitting unit, and a frequency generation unit
30 into a Monolithic Microwave Integrated Circuit (MMIC) chip. In this instance, the units are principal configuration elements of the RF signal processing apparatus.

 The present invention also provides an RF signal processing apparatus which

can include a transmit/receive signal separator as its principal configuration element, thereby having a function of transmitting/receiving signals via one antenna.

The present invention also provides an RF signal processing apparatus which can duplex a transmit/receive signal in a Frequency Division Duplexing (FDD) scheme or a Time Division Duplexing (TDD) scheme by constructing a transmit/receive signal separator utilizing a duplexer or an RF switch.

The present invention also provides an RF signal processing apparatus which can embody a superheterodyne receiver having high receiving efficiency by converting an RF reception signal into an intermediate frequency signal and outputting the intermediate frequency signal to a demodulator.

The present invention also provides an RF signal processing apparatus which can embody an inexpensive direction conversion receiver by directly converting an amplitude shift keying (ASK) modulated RF signal into a baseband signal and extracting a digital value of a reception signal via a limiting amplifier and a comparator.

The present invention also provides an RF signal processing apparatus which can be easily embodied and shorten a development period by integrating only a voltage controlled oscillator (VCO) and a prescaler for devices necessary for synthesizing frequencies, into an MMIC chip. In this instance, a temperature compensation crystal oscillator (TCXO) and a phase locked loop (PLL) are excluded.

The present invention also provides an RF signal processing apparatus which can be widely utilized and also satisfy various demands from consumers through inexpensiveness, high effectiveness, miniaturization and lightness of the RF signal processing apparatus, particularly, an onboard terminal of an ETCS.

Technical solutions

To achieve the above objectives and solve the aforementioned problems in the conventional art, according to an aspect of the present invention, there is provided an RF signal processing apparatus including: a transmit/receive signal separator separating a signal path of an RF transmission signal and that of an RF reception signal, an RF signal transceiver module down-converting the RF reception signal into a baseband signal or up-converting a baseband signal to the RF transmission signal, and a frequency controller connected to the RF signal transceiver module, and generating an

up-conversion signal or a down-conversion signal to be inputted into the RF signal transceiver module for frequency conversion, wherein the RF signal transceiver module includes: an RF signal receiving unit mixing the RF reception signal with down-conversion signal to convert the RF reception signal into a baseband reception signal; an
5 RF signal transmitting unit mixing the second baseband signal with the up-conversion signal to convert the second baseband signal into the RF transmission signal; and a frequency generation unit including a VCO and a prescaler.

Also, the RF signal transceiver module constructed as above may be integrated into an MMIC.

10 Also, an RF signal transceiver module, which is a principal configuration element of an RF signal processing apparatus according to an aspect of the present invention, needs an up-conversion signal and a down-conversion signal generated by a VCO for up-conversion mixing and down-conversion mixing. In this instance, the VCO is controlled by a PLL which is connected to the RF signal transceiver module.
15 The PLL is driven by a reference frequency signal and the reference frequency signal is generated by a TCXO.

Brief Description of Drawings

FIG. 1 is a diagram illustrating a schematic configuration of a communication
20 terminal having an RF signal processing function;

FIG. 2 is a diagram illustrating a configuration of an RF processor processing an RF signal in FIG. 1;

FIG. 3 is a diagram illustrating an internal configuration of an RF signal processing apparatus according to an embodiment of the present invention; and

25 FIG. 4 is a diagram illustrating an internal configuration of an RF signal processing apparatus according to another embodiment of the present invention.

Best Mode for Carrying Out the Invention

Hereinafter, an RF signal processing apparatus according to the present
30 invention will be described with reference to the accompanying drawings.

An RF signal processing apparatus according to the present invention may be constructed to communicate with a roadside base station which is installed by a road, in

an ETCS utilizing an active Dedicated Short Range Communication (DSRC) system. In this instance, the DSRC system applied by the present invention may utilize a 5.8 GHz frequency band to transmit/receive signals. Namely, a large number of channels may be secured by transmitting/receiving a signal utilizing a higher frequency band. Also, frequency utilization ratio may be increased.

According to the present invention, an RF signal transceiver module which is a principal configuration element of the RF signal processing unit may be integrated into an MMIC chip which can be manufactured in one process on a semiconductor substrate. FIG. 1 illustrates a configuration of a general onboard terminal.

As illustrated in FIG. 1, the onboard terminal in the ETCS includes an RF processor 101, a power processor 102, a memory 103, a display 104 and a speaker 105, a user information interface 106, and a main controller 107. In this instance, the RF processor 101 transmits/receives an RF signal which includes necessary information to automatically collect tolls by communicating with a roadside base station via an antenna ANT. The power processor 102 supplies power and the memory 103 stores detailed card transactions, vehicle information, etc. The display 104 displays menus, detailed card transactions, etc. The speaker 105 vocally guides procedures associated with automatic toll collection and results thereof. The user information interface 106 receives a user's selection or provides the user with an interface for collecting tolls utilizing a smart card. The main controller 107 manages an overall operation of the onboard terminal and transmits/receives an RF signal with the roadside base station via the RF processor 101, to control an operation of automatically collecting tolls.

The RF processor 101 of FIG. 1 will be described further in detail with reference to FIG. 2. Referring to FIG. 2, the RF processor includes a transmit/receive signal separator 200, an RF signal transceiver module 201, 202 and 205 and a frequency controller 210. In this instance, the transmit/receive signal separator 200 separates a signal path of an RF reception signal and a signal path of an RF transmission signal

The RF signal transmitting/receiving module 201, 202 and 205 down-converts the RF reception signal into a baseband signal or up-converts a baseband signal into the RF transmission signal. The frequency controller 210 is connected to the RF signal transceiver module 201, 202 and 205 and generates an up-conversion signal or a down-conversion signal to be inputted into the RF signal transceiver module.

Also, the RF signal transceiver module includes an RF signal receiving unit 201, an RF signal transmitting unit 202, and a frequency generation unit 205. In this instance, the RF signal receiving unit 201 converts the RF reception signal into a baseband signal by mixing the RF reception signal with a down-conversion signal.

5 The RF signal transmitting unit 202 converts the baseband signal into an RF transmission signal by mixing a baseband signal with the up-conversion signal. The frequency generation unit 205 includes a VCO for generating the up-conversion signal or the down-conversion signal, and a prescaler scaling a period of a waveform, which is generated by the VCO, by an integer number of times, to feedback the prescaled

10 waveform to a phase locked loop (PLL) 206. Herein the prescaler may be a divider.

The signal which is received and converted into a baseband signal by the RF signal receiving unit 201 is inputted into a demodulator 204 and restored to an original signal. Also, a baseband signal inputted into the RF signal transmitting unit 202 may be amplified via a baseband amplifier 203 and then converted into a high frequency

15 signal.

The frequency generation unit 205 is a principal configuration element of the RF signal transceiver module and is controlled by the PLL 206 which is externally connected. In this instance, the PLL 206 operates according to a reference frequency signal which is outputted from a TCXO 207. A feedback control signal for operating

20 the PLL 206 is obtained from the frequency generation unit 205, which will be described in detail later.

The technical characteristic of the present invention is to integrate the RF signal transceiver module, which is a principal configuration element of the RF signal processing apparatus according to the present invention, into an MMIC chip. Namely,

25 in comparison with the conventional art where the RF signal receiving unit 201, the RF signal transmitting unit 202, and elements associated with frequency synthesis are embodied into separate chips, the present invention may achieve a higher level of miniaturization and lightness by integrating the RF signal receiving unit 201, the RF signal transmitting unit 202, and the frequency generation unit 205 into one chip.

30 Namely, according to the present invention, by integrating configuration elements embodied into a plurality of chips in the conventional art into one chip, space utilization ratio may be improved and a manufacturing cost may be reduced. Also, a number of

consumers may be increased.

FIG. 3 illustrates an example of an RF signal processing apparatus including an RF signal transceiver module which is integrated into an MMIC chip.

As illustrated in FIG. 3, the RF signal processing apparatus according to an embodiment of the present invention is configured to integrate functions of a power amplifier 301, an up-conversion mixer (UMIX) 302, a low noise amplifier 303, a down-conversion mixer (DMIX) 304, and an intermediate frequency amplifier 305 and functions of a VCO 306 for providing a necessary reference frequency to the UMIC 302 and the DMIX 304, into one RF signal transceiver module 310. Also, the RF signal processing apparatus interoperates with a PLL 308 and a TCXO 309. In this instance, the PLL 308 enables a frequency outputted from the VCO 306 included in the RF signal transceiver module 310 to have a certain precision without being affected by any change in an external environment. Also, the TCXO 309 oscillates at a low frequency, below 1 MHz, that is utilized as a clock or a basic reference that enables the PLL 308 to determine a frequency.

The power amplifier 301 and the UMIC 302 are configuration elements of the RF signal transmitting unit 202 of FIG. 2. Also, the low noise amplifier 303, the DMIX 304, and the intermediate frequency amplifier 305 constitute the RF signal receiving unit 201 of FIG. 2. Also, the VCO 306 and the prescaler 307 correspond to the frequency generation unit 205 of FIG. 2. The PLL 308 and the TCXO 309 are included in the frequency controller 210 as described above.

According to an embodiment of the present invention, the prescaler 307 may scale a period of a waveform, which is generated by the VCO 306, by four times. Performance of a prescaler using the four times, was confirmed by an experiment. Currently, a prescaler constructed as described above is widely utilized in a general RF communication system.

The RF signal processing apparatus according to the present embodiment includes the transmit/receive signal separator 200 connected to the antenna ANT and separating a signal path of an RF reception signal and that of an RF transmission signal; the RF signal transceiver module 310 transmitting/receiving an RF signal; band pass filters 311 and 312 respectively band pass filtering the RF transmission signal and the RF reception signal which were processed in the RF signal transceiver module 310; the

PLL 308 controlling a reference frequency to be outputted in a certain frequency; and the TCXO 309 oscillating a low frequency signal and outputting to the PLL 308, in which the reference frequency is provided for up/down-conversion mixing of the RF signal transceiver module 310.

5 In this instance, the RF signal transceiver module 310 includes an RF signal receiving unit and an RF signal transmitting unit. The RF signal receiving unit amplifies an RF reception signal via the antenna ANT with low noise and the transmit/receive signal separator 200, and filters the amplified signal via the band pass filter 312. After this, the RF signal receiving unit converts the band pass filtered
10 RF reception signal to an intermediate frequency by down-conversion mixing, amplifies and transmits the intermediate frequency to the demodulator 209. Also, the RF signal transmitting unit converts an intermediate frequency signal to be transmitted which is outputted from a main controller 107 via a baseband amplifier 208, to an RF transmission signal through up-conversion mixing, and band pass filters the
15 intermediate frequency signal to be transmitted via the band pass filter 311. After this, the RF signal transmitting unit amplifies the filtered RF transmission signal and outputs the amplified RF transmission signal to the transmit/receive signal separator 200.

Also, the PLL 308 controls a reference frequency, according to a control of the main controller 107, to maintain a constant frequency without being affected by any
20 change in an external environment. In this instance, the reference frequency is utilized in up-conversion mixing and down-conversion mixing for frequency conversion of the RF signal transceiver module 310 with respect to an RF signal and an intermediate frequency signal. The TCXO 309 is an oscillator in which a unique oscillation frequency does not be significantly changed by a temperature variation. The TCXO
25 309 oscillates a low frequency, below 1 MHz, and is utilized as a clock or a basic reference that enables the PLL 308 to determine a frequency.

Also, the RF signal transceiver module 310 includes the power amplifier 301 and the UMIX 302 for processing an RF transmission signal, the low noise amplifier 303 and the DMIX 304 for processing an RF reception signal, and the intermediate
30 frequency amplifier 305. Also, the RF signal transceiver module 310 includes functions of the VCO 306 and the prescaler 307. In this instance, the VCO 306 generates a reference frequency which is utilized in up-conversion mixing and down-

conversion mixing for frequency conversion of an RF signal and an intermediate frequency signal according to a control of the PLL 308. Also, the prescaler 307 scales an output frequency of the VCO 306 by an integer number of times, to output a low frequency signal which is necessary for high frequency stability of the PLL 308.

5 In the present embodiment, a structure of a receiver which initially converts an RF reception signal to an intermediate frequency and subsequently performs amplifying, demodulating, etc., a structure of a superheterodyne receiver is, basically described. A superheterodyne receiver is widely utilized to solve an oscillation problem and the like which may occur when directly amplifying a carrier frequency signal. In this instance,
10 since amplification is performed in a comparatively lower intermediate frequency, carrier frequency signals may be easily amplified and very efficiently received. In the present embodiment, the widely utilized superheterodyne receiver is adopted for embodiment of an MMIC. Accordingly, an RF signal processing apparatus may be miniaturized while achieving an excellent receiving performance.

15 Hereinafter, an operation of processing an RF signal when an RF signal processing apparatus is constructed as an RF signal transceiver module will be described.

When an onboard terminal receives information from a roadside base station, an RF reception signal is selected out of an RF signal received via the antenna ANT, by the
20 transmit/receive signal separator 200, and inputted into the RF signal transceiver module 310. When the RF reception signal is inputted into the RF signal transceiver module 310 that is integrated into an MMIC chip, the low noise amplifier 303 included therein amplifies and transmits the RF reception signal to the band pass filter 312 to be filtered therein. After this, the filtered RF reception signal is transferred to the DMIX
25 304 which is included in the RF signal transceiver module 310.

The DMIX 304 of the RF signal transceiver module 310 converts the RF reception signal to an intermediate frequency signal based on a frequency which is provided from the VCO 306. After this, the DMIX 304 amplifies the intermediate frequency signal with a certain signal level, i.e. an intermediate frequency via the
30 intermediate frequency amplifier 305 and transmits the amplified intermediate frequency signal to the demodulator 209 so that the demodulator 209 converts the amplified intermediate frequency signal to a digital signal and transfers the digital

signal to the main controller 107. Through this, an operation of receiving an RF signal may be embodied.

Next, when the onboard terminal transmits information to the roadside base station, an RF transmission signal which is outputted in the main controller 107 is amplified in the baseband amplifier 208 to transfer an intermediate frequency signal to be transmitted to the RF signal transceiver module 310. In this case, the UMIX 302 included in the RF signal transceiver module 310 converts the intermediate frequency signal to be transmitted into an RF transmission signal based on a frequency which is provided from the VCO 306, to be transmitted to the band pass filter 311. After filtering the RF transmission signal, the band pass filtered RF signal is transmitted to the power amplifier 301 included in the RF signal transceiver module 310.

In this case, the power amplifier 301 of the RF signal transceiver module 310 which is integrated into an MMIC chip amplifies the RF transmission signal and transmits the amplified RF transmission signal to the transmit/receive signal separator 200. The RF transmission signal is transmitted to the roadside base station device via the antenna ANT. Through this, an operation of transmitting an RF signal may be embodied.

The transmit/receive signal separator 200 is required to simultaneously transmit and receive RF signals via one antenna. In this instance, the transmit/receive signal separator 200 may be variously constructed according to a method of duplexing an RF reception signal and an RF transmission signal. In case of adopting an FDD scheme of allocating a carrier having a different frequency with respect to an RF reception signal and an RF transmission signal, the transmit/receive signal separator 200 may be implemented utilizing a duplexer. In this instance, when frequencies between an RF reception signal and an RF transmission signal are different, two neighboring frequencies with respect to one central frequency are utilized. Accordingly, an RF reception signal and an RF transmission signal may be separated utilizing one antenna.

Also, in case of adopting a TDD scheme of making an RF signal appear to be simultaneously received and transmitted by allocating different time slots with respect to operations of transmitting/receiving an RF signal, the transmit/receive signal separator 200 may be implemented in a form of an RF switch. Namely, an RF reception signal and an RF transmission signal may be separated by switching the RF

switch so that a transmitted circuit and a received circuit may be respectively connected to the antenna for a relatively short period of time.

In an active DSRC(Dedicated Short Range Communication) technique ,a bidirectional communication function is needed since a road base station does not unidirectionally transmit signals to an onboard terminal and the onboard terminal also has to transmit information to the road base station. Accordingly, the transmit/receive signal separator 200 is required and it is a necessary configuration element so that an RF signal processing apparatus according to an embodiment of the present invention operates in the active DSRC.

FIG. 4 illustrates a configuration of an RF signal processing apparatus according to another embodiment of the present invention. Similar to the above-described embodiment in FIG. 3, the RF signal processing apparatus according to the present embodiment also includes a transmit/receive signal separator 200. Also, an RF signal transmitting unit 202 includes a power amplifier 401, an up-conversion mixer 402 and a band pass filter 413. Also, an RF receiving unit 201 includes a low noise amplifier 403, a DMIX 404, a band pass filter 408, a limiting amplifier 409 and a comparator 410.

Similar to the above-described embodiment in FIG. 3, the frequency generation unit 205 of FIG. 2 includes a VCO 406 and a prescaler 407. A frequency controller 210 is connected to the VCO for supplying a reference frequency and may include a PLL 411 and a TCXO 412.

A configuration and function of the RF signal processing apparatus according to the present embodiment will be described with reference to FIG. 4. The RF signal processing apparatus according to the present embodiment may collectively process an operation of receiving and an operation of modulating an RF signal when an RF reception signal is modulated by an amplitude shift keying (ASK) scheme. Hereinafter, a process of receiving an RF signal will be described.

The RF signal processing apparatus according to the present embodiment receives an RF signal via an antenna ANT. The transmit/receive signal separator 200 separates a signal path of an RF reception signal and a signal path of an RF transmission signal. The RF reception signal is inputted into the low noise amplifier 403 of an RF signal transceiver module 420 which is integrated into an MMIC chip. The low noise

amplified signal is inputted into the DMIX 404. The RF reception signal is mixed with a down-conversion signal via the DMIX 404, band pass filtered via the band pass filter 408 and converted into a baseband reception signal. Also, the limiting amplifier 409 converts the converted baseband signal into a certain amplitude of a signal and
5 outputs the converted signal. The comparator 410 is connected to an output terminal of the limiting amplifier 409, and compares an outputted signal from the limiting amplifier 409 with a reference voltage. According to the result of comparison, the comparator 410 determines and outputs a value which is any one of '1' and '0'.

In the case of ASK modulation, a transmission signal is modulated so that a
10 carrier has a different amplitude with respect to a value of transmission data. Accordingly, a receiver which receives the ASK modulated signal extracts a digital value of the transmission data by utilizing amplitude of the reception signal. Namely, as illustrated in FIG. 4, a demodulation function may be easily embodied by utilizing the band pass filter 408, the limiting amplifier 409, and the comparator 410. Also,
15 according to the present embodiment, since the embodied demodulation function is included in the RF signal transceiver module 420, a demodulator may not be additionally needed. Accordingly, a physical space and cost may be reduced.

The RF signal transmitting unit 202 of the RF signal processing apparatus according to the present embodiment may include the power amplifier 401, the UMIX
20 402, and a variable gain amplifier 405. A main controller 107 inputs a baseband signal into the variable gain amplifier 405 of the RF signal transceiver module 420 via a baseband filter 414. In this instance, the RF signal transceiver module 420 is integrated into an MMIC chip. The variable gain amplifier 405 amplifies a signal with variable gain value according to a control voltage from an outside. In the present
25 embodiment, the variable gain amplifier 405 is only an example for explaining a configuration of the present invention, and may be replaced with any type of amplifier which can perform the same or analogous functions and be integrated into an MMIC chip.

A transmission signal, which is amplified in a baseband via the variable gain
30 amplifier 405, is mixed with an up-conversion signal in the UMIX 402 and converted to an RF transmission signal. The band pass filter 413 filters out an unnecessary signal component from the converted RF signal to be transmitted, before finally being

amplified for RF transmission. The filtered RF signal to be transmitted is amplified in the power amplifier 401 and transmitted to a roadside base station via the transmit/receive signal separator 200.

The band pass filter 413 is connected to the transmit/receive signal transmitting unit and is also a filter for a transmission signal which is converted to a high frequency. As an example, the band pass filter 413 has a pass band of about 5.8 GHz. The band pass filter 408 included in the RF signal transmitting unit is a filter for a baseband signal having a pass band of, for example, about 1 MHz. Accordingly, the band pass filter 408, rather than the band pass filter 413, may be comparatively easier to be integrated into an MMIC chip.

Also, the VCO 406 and the prescaler 407 which are configuration elements for frequency synthesis may be integrated into an MMIC chip, to make an external connection for a PLL 411 and a TCXO 412 of the MMIC chip. In this instance, a first part including the VCO 406 and the prescaler 407 which is integrated into an MMIC chip is called a frequency generation unit 205, and a second part including the PLL 411 and the TCXO 412 which is not integrated into an MMIC chip is called a frequency controller 210. A more realistic configuration of an apparatus which can be applied to a current level of semiconductor process technologies may be constructed by integrating only configuration elements corresponding to the frequency generation unit 205 among configuration elements which are utilized for frequency synthesis, just like selectively integrating band pass filters into an MMIC.

The RF signal processing apparatus according to the present embodiment directly converts an RF reception signal to a baseband signal and amplifies and demodulates the baseband signal. A receiver structure as described above is referred to as a direct down-conversion system. While the superheterodyne receiver described in FIG. 3 has a guaranteed excellent performance, its configuration is comparatively complicated and its cost is also expensive. Accordingly, when adopting the direct down-conversion system, a cost according to an MMIC may be significantly reduced.

Also, as illustrated in FIG. 3, the RF signal transmitting unit 202 directly converts transmission data without an intermediate frequency, utilizing a direct up-conversion system, whereas the RF signal receiving unit 201 configured to operate as a superheterodyne receiver, has an intermediate frequency of about 50 to about 70 MHz.

In this case, a frequency difference of about 50 to about 70 MHz occurs in a local oscillator (LO) frequency for a transmit/receive signal. Accordingly, when changing between transmitting and receiving mode, the LO frequency also has to be changed. In this instance, in comparison with a frequency locking time of a PLL, a masking time for
5 LO frequency conversion is very short. Accordingly, stability of the PLL is affected. However, the present embodiment based on the direct down-conversion scheme which does not require conversion of an LO frequency, may guarantee a stable PLL performance.

Although a few embodiments of the present invention have been shown and
10 described, the present invention is not limited to the described embodiments. Instead, it would be appreciated by those skilled in the art that changes may be made to these embodiments without departing from the principles and spirit of the invention, the scope of which is defined by the claims and their equivalents.

15 Industrial Applicability

An RF signal processing apparatus according to the present invention can achieve a higher level of miniaturization and lightness than a conventional art by integrating an RF signal receiving unit, an RF signal transmitting unit, and a frequency generation unit, which are principal configuration elements of the RF signal processing
20 apparatus, into an MMIC chip.

Also, an RF signal processing apparatus according to the present invention can process an RF transmission signal and an RF reception signal via one antenna utilizing any one of a TDD scheme and an FDD scheme via a transmit/receive signal separator.

Also, an RF signal processing apparatus according to the present invention can
25 have high receiving efficiency and also can be miniaturized and light by adopting a superheterodyne receiver which converts an RF reception signal into an intermediate frequency signal and amplifies and demodulates the same in an intermediate frequency.

Also, an RF signal processing apparatus according to the present invention can embody a simple and inexpensive direct conversion receiver by converting an RF
30 reception signal into a baseband signal and amplifying and demodulating the baseband signal in one MMIC chip.

Also, an RF signal processing apparatus according to the present invention can

be easily embodied, and can shorten a development period by selectively integrating band pass filters and configuration elements associated with frequency synthesis into an MMIC chip. Namely, according to the present invention, an RF signal processing apparatus may be more efficiently constructed by selecting configuration elements
5 which can be embodied with a reasonable cost by current semiconductor technologies.

CLAIMS

1. An apparatus of processing a radio frequency (RF) signal, the apparatus comprising:

5 a transmit/receive signal separator separating an RF signal which is received via an antenna and a second RF signal which is to be transmitted via the antenna;

an RF signal transceiver module down-converting the first RF signal into a first baseband signal or up-converting a second baseband signal into the second RF signal; and

10 a frequency controller connected to the RF signal transceiver module, and generating an up-conversion signal or a down-conversion signal to be inputted into the RF signal transceiver module for frequency conversion,

wherein the RF signal transceiver module comprises:

an RF signal receiving unit mixing the first RF signal with the down-conversion signal to convert the first RF signal into the first baseband signal;

15 an RF signal transmitting unit mixing the second baseband signal with the up-conversion signal to convert the second baseband signal into the second RF signal; and

a frequency generation unit comprising a voltage controlled oscillator for generating the up-conversion signal or the down-conversion signal, and a prescaler scaling a period of an up-conversion signal or a down-conversion signal, which is
20 generated by the voltage controlled oscillator, by an integer number of times and inputting the prescaled waveform into the frequency controller, and

the RF signal transceiver module is integrated into a Monolithic Microwave Integrated Circuit (MMIC).

25 2. The apparatus of claim 1, wherein the frequency controller comprises a temperature compensation crystal oscillator (TCXO), and the frequency controller generates the up-conversion signal or the down-conversion signal using a reference frequency signal that is generated by the TCXO.

30 3. The apparatus of claim 1, wherein:

the RF signal receiving unit comprises:

a low noise amplifier amplifying the first RF signal to generate an amplified

signal;

a down-conversion mixer mixing the down-conversion signal with a first filtered signal which is obtained by band pass filtering the amplified signal, to generate an intermediate frequency signal; and

5 an intermediate frequency amplifier amplifying the intermediate frequency signal, and

the RF signal transmitting unit comprises:

an up-conversion mixer converting the second baseband signal into an RF signal by amplifying the second baseband signal and mixing the amplified second baseband signal with the up-conversion signal; and

10 a power amplifier amplifying a second filtered signal which is obtained by band pass filtering the RF signal, to generate a second RF signal.

4. The apparatus of claim 1, wherein the transmit/receive signal separator utilizes a Frequency Division Duplexing (FDD) scheme with respect to the first RF signal and the second RF signal.

5. The apparatus of claim 1, wherein the first RF signal is a modulated signal by an amplitude shift keying (ASK) scheme.

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6. The apparatus of claim 5, wherein:

the RF signal receiving unit comprises:

a low noise amplifier amplifying the first RF signal to generate an amplified signal;

25 a down-conversion mixer mixing the amplified signal with the down-conversion signal to generate a down-conversion mixed signal;

a band pass filter extracting a baseband signal from the down-conversion mixed signal;

30 a limiting amplifier converting the extracted baseband signal into a certain amplitude of a signal and outputting the converted signal; and

a comparator comparing an converted signal from the limiting amplifier with a reference voltage to determine a digital signal value, and

the RF signal transmitting unit comprises:

a variable gain amplifier amplifying the second baseband signal with an variable gain value;

an up-conversion mixer mixing an amplified signal from the variable gain
5 amplifier with the up-conversion signal to convert the amplified signal into an RF
signal; and

a band pass filter filtering the RF signal

a power amplifier amplifying the band pass filtered RF signal to generate the
second RF signal.

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7. The apparatus of claim 1, wherein the transmit/receive signal separator utilizes
Time Division Duplexing (TDD) scheme with respect to the first RF signal and the
second RF signal.

15 8. The apparatus of claim 1, wherein the first RF signal and the second RF signal
are signals in a 5.8 GHz frequency band.

9. The apparatus of claim 1, wherein the prescaler scales a period of an input
waveform by four times and outputs the scaled period.