(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
29 January 2009 (29.01.2009)

PCT

(10) **International Publication Number**
WO 2009/014281 A1

(51) **International Patent Classification:**
H04B 7/14 (2006.01)

(21) **International Application Number:** PCT/KR2007/005650

(22) **International Filing Date:** 9 November 2007 (09.11.2007)

(25) **Filing Language:** Korean

(26) **Publication Language:** English

(30) **Priority Data:**
10-2007-0072636 20 July 2007 (20.07.2007) KR

(71) **Applicant** *(for all designated States except US)*: **ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE** [KR/KR]; 161, Gajeong-dong, Yuseong-gu, Daejon 305-350 (KR).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **PARK, Sung-Ik** [KR/KR]; #401 Venture Villa, 146-14, Sinseong-dong, Yuseong-gu, Daejon 305-804 (KR). **KIM, Heung-Mook** [KR/KR]; #503-202 Banseok Maeul 5 Danji, Banseok-dong, Yuseong-gu, Daejon 305-150 (KR). **EUM, Ho-Min** [KR/KR]; #201, 145-13, Sinseong-dong, Yuseong-gu, Daejon 305-804 (KR). **SEO, Jae-Hyun** [KR/KR]; #102-1102 Hanul Apt., Sinseong-dong, Yuseong-gu, Daejon 305-707 (KR). **LEE, Jae-Young** [KR/KR]; #111-612 Hanshin 2 Cha Apt., Jamwon-dong, Seocho-gu, Seoul 137-030 (KR). **LEE, Yong-Tae** [KR/KR]; #203-1307 Mokryeon Apt., Dunsan-dong, Seo-gu, Daejon 302-120 (KR). **LIM, Jong-Soo** [KR/KR]; 31-18, Yongdu-dong, Jung-gu, Daejon 301-110 (KR). **LEE, Soo-In** [KR/KR]; #106-606 Clover Apt., Dunsan-dong, Seo-gu, Daejon 302-120 (KR).

(74) **Agent: SHINSUNG PATENT FIRM**; ID Tower #601, Jungdaero 105 (99-7, Garak-dong), Songpa-gu, Seoul 138-805 (KR).

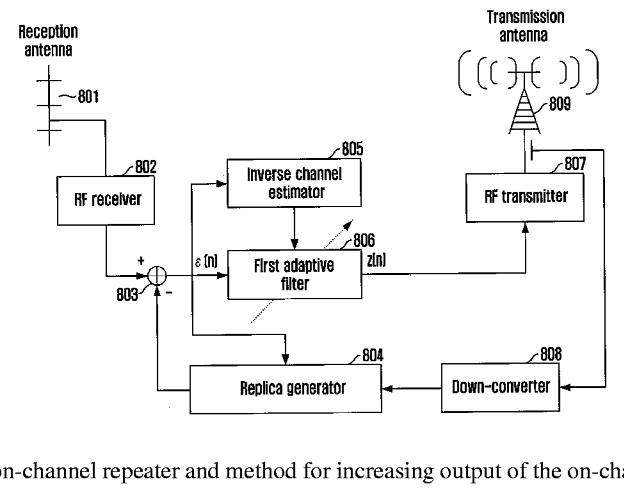
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

[Continued on next page]

(54) **Title:** ON-CHANNEL REPEATER AND ON-CHANNEL REPEATING METHOD

FIG. 8



(57) **Abstract:** Provided are an on-channel repeater and method for increasing output of the on-channel repeater by removing feedback signals caused by low isolation of transmission/reception antennas. The on-channel repeater includes: a receiver for receiving RF signals and converting the RF signals into baseband signals; a subtractor for subtracting replicas of feedback signals from the received signal; an inverse channel estimator for estimating inverse of a reception channel and generating a filter tab coefficients; a first adaptive filter for compensating for channel distortion of the subtracted signal; a transmitter for converting the signals whose channel distortion is compensated into an RF signal and performing radio transmission; a down- converter for down- convert ing the RF signal converted by the transmitter into the baseband signal; and a replica generator for calculating replicas and feeding back the replicas to the subtractor. The present invention is applied to the on-channel repeater.

WO 2009/014281 A1

ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

DESCRIPTION

ON-CHANNEL REPEATER AND ON-CHANNEL REPEATING METHOD

TECHNICAL FIELD

The present invention relates to an on-channel repeater and an on-channel repeating method; and, more particularly, to a repeater for repeating an output signal the same as an input signal on channel by removing feedback signals caused by low isolation of a transmission/reception antenna by converting a transmitted Radio Frequency (RF) signal into a signal of a predetermined band and subtracting a replica of the feedback signal from the converted signal, and by compensating for channel distortion of a reception signal by estimating an inverse of reception channel from a signal acquired by removing the feedback signal, and an on-channel repeating method.

This work was supported by the IT R&D program for MIC/IITA [2007-S-006-01, "Development of On-Channel RF repeating technology based on OFDM modulation"].

BACKGROUND ART

Repeaters are set up in an area where signals are weakly received from a main transmitter to resolve a problem of instable signal reception and widen signal transmission coverage of the main transmitter.

Fig. 1 shows a conventional repeating system where different frequencies are used among the repeaters.

Referring to Fig. 1, a main transmitter 101 transmits a signal of a frequency A and each of repeaters 102 to 105 repeats a signal of frequencies B, C, D and E, respectively, which are different from the frequency A. The conventional repeating system uses signals of the frequencies B, C, D and E, which are different for the repeater 102 to 105 respectively. Since a plurality of frequency bands are used, many frequency resources are required and it is inefficient in the respect of using the frequency.

Fig. 2 shows another conventional repeating system where the same frequency is used among repeaters.

A main transmitter 201 transmits a signal of a frequency A and on-channel repeaters 202 to 205 repeat the signal in the same frequency A. The signals of the same frequency transmitted from the main transmitter 201 and the on-channel repeaters 202 to 205 should be individually identified for on-channel repeating.

However, when the signals of the same frequency band outputted from the main transmitter and the repeaters are different, the signals are not removed as on-channel interference signals by an equalizer or other devices in each repeater.

Also, when the signals transmitted from the main transmitter and the on-channel repeaters have a time delay longer than a predetermined level, the equalizer cannot remove the delayed signal. Therefore, the output signals of the on-channel repeater should be the same as the output signals of the main transmitter for on-channel repeating, and the time delay of two output signals should be short.

Problems of the conventional on-channel repeaters will be described with reference to Figs. 3 to 7.

Fig. 3 is a block diagram showing a conventional RF amplification on-channel repeater.

Referring to Fig. 3, a reception antenna 301 and an RF receiver 302 receive RF signals transmitted from the main transmitter. An RF band-pass filter 303 passes only signals of a predetermined signal band in the received RF signals and a high-power amplifier 304 amplifies the band-passed RF signals. The amplified RF signal is transmitted through on-channel through a transmission antenna 305.

Fig. 4 is a block diagram showing a conventional Intermediate Frequency (IF) conversion on-channel repeater.

Referring to Fig. 4, a reception antenna 401 and an RF receiver 402 receive RF signals transmitted from the main transmitter. An IF down-converter 403 converts the received RF signals into IF signals based on a reference frequency provided by a local oscillator (LO) 408. An IF band-pass filter 404 passes the IF signals of a predetermined band. An RF up-converter 405 converts the band-passed IF signals into n RF signals based on the reference frequency provided by the local oscillator 408. A high-power amplifier 406 amplifies the RF signals and the amplified RF signals are transmitted through a transmission antenna 407.

Fig. 5 is a block diagram showing a conventional on-channel repeater employing surface acoustic wave (SAW) filter.

Referring to Fig. 5, a reception antenna 501 and an RF receiver 502 receive RF signals transmitted from the main transmitter and an IF down-converter 503 converts the received RF signals into IF signal based on a reference frequency provided by a local oscillator 508.

A SAW filter 504 passes IF signals of a predetermined band. An RF up-converter 505 converts the band-passed IF signals into RF signals based on the reference frequency provided by the local oscillator 508. A high-power amplifier 506 amplifies the RF signals and the amplified RF signals are transmitted through a transmission antenna 507.

Since the on-channel repeater of Figs. 3 to 5 cannot remove noise and multi-path signals caused in a channel between the main transmitter and the on-channel repeater, feedback signals caused by low isolation of a transmission/reception antenna, and system noise added in an on-channel repeater system, it has a characteristic that an output signal is inferior than an input signal. Also, there is another problem in that the feedback signals generated due to the low isolation of the transmission and reception antennas restrict the transmission output power of the on-channel repeaters.

Fig. 6 is a block diagram showing a conventional on-channel repeater performing a modulating/demodulating procedure.

Referring to Fig. 6, a reception antenna 601 and an RF receiver 602 receive RF signals transmitted from the main transmitter. An IF down-converter 603 converts the received RF signals into IF signals based on a reference frequency provided by a local oscillator 611. A demodulator 604 demodulates the IF signals into baseband signals. An equalizing and forward error correction (FEC) decoding unit 605 remove noise and multi-path signals caused in a channel between the main transmitter and the on-channel repeater from the demodulated baseband signal, and feedback signals caused by low isolation of a transmission/reception antenna. A FEC decoder 606 performs coding for error correction of output signals of the equalizing and FEC decoding unit 605. A modulator 607 converts the FEC encoded signals into signals of an IF band. An RF up-converter 608 converts the IF signals into an RF signal based on a reference frequency provided by a local oscillator 611. A high-power amplifier 609 amplifies the RF signals and the amplified RF signals are transmitted through a transmission antenna 610.

Through the equalizing and FEC decoding unit, the on-channel repeater of Fig. 6 improves the multi-path and noise removing capability which is the problem of the repeater shown in Figs. 3 to 5. However, since the on-channel repeater includes the equalizing and FEC decoding unit, it increases time delay from a microsecond unit to a millisecond unit. In addition, the transmission output power is limited when the feedback signals generated by ambiguity of a standard Trellis encoder of the FEC encoder is not removed in the repeater.

Fig. 7 is a block diagram showing a conventional on-channel repeater capable of compensating for distortion of a reception channel.

Referring to Fig. 7, an RF receiver 701 receives RF signals transmitted from the main transmitter and a down-converter 702 converts the received RF signals into signals of a desired band.

An inverse channel estimator 703 estimates an inverse of the reception channel including noise and multi-path signals caused in a channel between the main transmitter and the repeater from the converted signal, and feedback signals caused by low isolation of a transmission/reception antenna.

An adaptive filter 704 compensates for channel distortion based on inverse information of the estimated reception channel.

An up-converter 705 converts the compensated signals into RF signal and an RF transmitter 706 transmits the converted RF signals.

When the electric field strength of feedback signals (which are caused by low isolation of the transmission and reception antennas) is higher than the electric field strength of the input signal transmitted from main transmitter, the on-channel repeater of Fig. 7 does not remove distortion signals in the adaptive filter and does not estimate an inverse of the reception channel in the inverse channel estimator, thereby causing malfunction of the repeater.

Since the conventional technologies have a limitation in their removing capability of feedback signals, the conventional on-channel repeating systems have a low applicability in using a typical repeating facility and require a great deal of investment.

Therefore, it is required to develop an on-channel repeater having characteristics that the output signals of the on-channel repeater is the same as the output signals of the main transmitter, that the time delay between two output signals is small, that a characteristic of the on-channel repeater output signal becomes superior to that of the on-channel repeater input signal by removing the noise and multi-path signals caused in the channel between the main transmitter and the on-channel repeater, and that the applicability is raised and the small amount of investment is required by increasing transmission output power of the on-channel repeater by removing the feedback signals caused by the low isolation of transmission and reception antennas in the on-channel repeater.

DISCLOSURE

TECHNICAL PROBLEM

An embodiment of the present invention is directed to providing a repeater for repeating an output signal the same as an input signal on channel by removing feedback signals caused by low isolation of a transmission/reception antenna from a transmitted Radio Frequency (RF) signal and compensating for channel distortion of a reception signal by estimating an inverse of a reception channel from a signal acquired by removing the feedback signal, and an on-channel repeating method.

TECHNICAL SOLUTION

In accordance with an aspect of the present invention, there is provided an on-channel repeater, including: a receiver for receiving a Radio Frequency (RF) signal and converting the RF signal into a baseband signal; a subtractor for subtracting a replica of feedback signals from the signal received in the receiver; an inverse channel estimator for estimating an inverse of a reception channel based on the signal acquired from the subtraction in the subtractor and generating filter tab coefficients; a first adaptive filter for compensating for channel distortion of the signal acquired from the subtraction in the subtractor based on the filter tab coefficients generated by the inverse channel estimator; a transmitter for converting the signal whose channel distortion is compensated by the first adaptive filter into an RF signal and performing radio transmission; a down-converter for down-converting the RF signal acquired in the transmitting means into a baseband signal; and a replica generator for calculating a replica based on the baseband signal acquired from the conversion in the down-converting means and the signal acquired from the subtraction in the subtractor, and feeding back the replica to the subtractor.

In accordance with another aspect of the present invention, there is provided an on-channel repeating method, including: receiving an RF signal and converting the RF signal into a baseband signal; subtracting a replica of feedback signals from the received signal; estimating an inverse of a reception channel based on the signal acquired from the subtraction, and generating filter tab coefficients; compensating for channel distortion of the signal acquired from the subtraction based on the generated filter tab coefficients; performing radio transmission by converting the signal whose channel distortion is compensated into an RF signal; and down-converting the RF signal acquired in the transmitting means into a baseband signal, where the replica is calculated based on the baseband signal acquired from the down-conversion and the signal acquired from the subtraction, and is fed back to said subtracting the replica of the feedback signal.

In accordance with another aspect of the present invention, there is provided an on-channel repeater, including: a receiver for receiving an RF signal and converting the RF signal into a predetermined band signal; a subtractor for subtracting a replica of feedback signals from the signal received in the receiver; an inverse channel estimator for estimating an inverse of a reception channel based on the signal acquired from the subtraction in the subtractor and generating filter tab coefficients; a first adaptive filter for compensating for channel distortion of the signal acquired from the subtraction based on the filter tab coefficients generated by the inverse channel estimator; a transmitter for converting the signal whose channel distortion is compensated by the first adaptive filter into an RF signal and performing radio transmission; a down-converter for down-converting the RF signal acquired in the transmitting means into a predetermined band signal; and a replica generator for calculating a replica based on the predetermined band signal acquired from the conversion in the down-converter and the signal acquired from the subtraction in the subtractor, and feeding back the replica to the subtractor.

In accordance with another aspect of the present invention, there is provided an on-channel repeating method, including: receiving an RF signal and converting the RF signal into a predetermined band signal; subtracting a replica of feedback signals from the received RF signal; estimating an inverse of a reception channel based on the signal acquired from the subtraction in said subtracting the replica of the feedback signals, and generating filter tab coefficients; compensating for channel distortion of the signal acquired from the subtraction based on the generated filter tab coefficients; performing radio transmission by converting the signal whose channel distortion is compensated into an RF signal; and down-converting the RF signal acquired in the transmitting means into the predetermined band signal, wherein the replica is calculated based on the predetermined band signal converted in the step of down-converting the RF signal and the signal acquired from the subtraction in the step of subtracting the replica of the feedback signal, and is fed back to said subtracting the replica of the feedback signal.

ADVANTAGEOUS EFFECTS

As described above, the present invention can increase efficiency of limited frequency resources by repeating a signal that is the same as output signal of a main transmitter, has a short time delay between the output signals of the on-channel repeater and the main transmitter, and has its distortion caused in a transmission channel compensated.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a conventional repeating system using different frequencies.

Fig. 2 shows a conventional repeating system using the same frequency.

Fig. 3 is a block diagram showing a conventional Radio Frequency (RF) amplification on-channel repeater.

Fig. 4 is a block diagram showing a conventional Intermediate Frequency (IF) conversion on-channel repeater.

Fig. 5 is a block diagram showing a conventional on-channel repeater employing a surface acoustic wave (SAW) filter.

Fig. 6 shows a conventional on-channel repeater performing a modulating/demodulating procedure.

Fig. 7 is a block diagram showing a conventional on-channel repeater capable of compensating for distortion of a reception channel.

Fig. 8 is a block diagram showing an on-channel repeater in accordance with an embodiment of the present invention.

Fig. 9 is a flowchart describing a repeating method in the on-channel repeater of Fig. 8.

Fig. 10 is a block diagram illustrating the on-channel repeater of Fig. 8.

Fig. 11 is a flowchart illustrating the repeating method in the on-channel repeater of Fig. 8

Fig. 12 is a block diagram illustrating an inverse channel estimator of Fig. 8.

Fig. 13 is a block diagram showing a demodulating unit of Fig. 12 and it may be applied to the DVB-T DTV standard.

Fig. 14 is a block diagram showing a channel estimating unit of Fig. 12 and it may be applied to the DVB-T DTV standard.

Fig. 15 is a block diagram showing a converting unit 1203 of Fig. 12 and it may be applied to the DVB-T DTV standard.

Fig. 16 is a block diagram showing the on-channel repeater in accordance with another embodiment of the present invention.

BEST MODE FOR THE INVENTION

The advantages, features and aspects of the invention will become apparent from the following description of the embodiments with reference to the accompanying drawings, which is set forth hereinafter. The preferred embodiments of the present invention will be described in detail hereinafter with reference to the attached drawings.

Fig. 8 is a block diagram showing an on-channel repeater in accordance with an embodiment of the present invention.

Referring to Fig. 8, the on-channel repeater in accordance with the present invention includes a reception antenna 801, a Radio Frequency (RF) receiver 802, a subtractor 803, a replica generator 804, an inverse channel estimator 805, a first adaptive filter 806, an RF transmitter 807, a down-converter 808, and an RF transmission antenna 809.

The RF receiver 802 down-converts RF signals transmitted from a main transmitter or another repeater through the reception antenna 801 into signals of a desired band.

The subtractor 803 removes feedback signals by subtracting a replica of feedback signals from the predetermined band signal down-converted by the RF receiver 802.

The replica generator 804 generates a replica of the feedback signals based on signal acquired from the down-conversion into signal of a predetermined band by the down-converter 808 and a signal outputted from the subtractor 803, i.e., a signal acquired by removing the feedback signals, and feeds back the replica to the subtractor 803.

The inverse channel estimator 805 generates filter tab coefficients by estimating an inverse of a reception channel including noise, multi-path signals and remaining feedback signals based on the signal outputted from the subtractor 803. Herein, the remaining feedback signals mean feedback signals which is not removed through subtraction in the subtractor 803.

In accordance with the present invention, the subtractor 803 and the replica generator 804 only remove the feedback signals but do not affect the time delay of the repeater system.

The first adaptive filter 806 compensates for the channel distortion of the signal outputted from the subtractor 803 by performing filtering according to Equation 1 based on the filter tab coefficients generated by the inverse channel estimator 805.

$$z(n) = \sum_{i=0}^{N-1} c_i \cdot \varepsilon(n-1) \quad \text{Eq. 1}$$

where, $\varepsilon(n)$ is an output signal of the subtractor 803, $z(n)$ is an output signal of the first adaptive filter 806, c_i is a tab coefficient $\overline{c} = (c_0, c_1, \ldots, c_{N-1})$ estimated by the inverse channel estimator 805, and N is the number of tabs.

The RF transmitter 807 converts the signal outputted from the first adaptive filter 806 into RF signal and performs radio transmission through the RF transmission antenna 809.

The down-converter 808 down-converts the RF signal converted by the RF transmitter 807 into signal of a predetermined band.

Fig. 9 is a flowchart describing a repeating method in the on-channel repeater of Fig. 8.

Referring to Fig. 9, RF signal transmitted from the main transmitter or another repeater is received through the reception antenna 801 and is down-converted into signal of a desired band in the RF receiver 802 at step S901.

The subtractor 803 removes feedback signals from the output signal of the RF receiver 802 at step S902 by subtracting a replica of the feedback signals generated in the replica generator 804 from the signal outputted from the RF receiver 802.

The replica generator 804 generates replica of the feedback signals based on a signal down-converted into signal of a predetermined band by the down-converter 808 and a signal outputted from the subtractor 803, i.e., signal whose feedback signals are first removed, and feeds back the replica to the subtractor 803 at step S903.

The inverse channel estimator 805 generates filter tab coefficients by estimating an inverse of the reception channel including noise, multi-path signals and remaining feedback signals based on the signal outputted from the subtractor 803 at step S904.

The first adaptive filter 806 compensates for the channel distortion of the signal outputted from the subtractor 803 based on the filter tab coefficients generated by the inverse channel estimator 805 at step S905.

The RF transmitter 807 converts the signal outputted from the first adaptive filter 806 into RF signal and wirelessly transmits the signal through the RF transmission antenna 809 at step S906.

The down-converter 808 down-converts the RF signal converted by RF transmitter 807 into signal of a predetermined band at step S907.

Fig. 10 is a block diagram illustrating the on-channel repeater of Fig. 8.

Therefore, a reception antenna 1001, an RF receiver 1002, an inverse channel estimator 1005, a first adaptive filter 1006, an RF transmitter 1007, and a transmission antenna 1009 correspond to the reception antenna 801, the RF receiver 802, the inverse channel estimator 805, the first adaptive filter 806, the RF transmitter 807, and the RF transmission antenna 809.

Meanwhile, a replica generator 1004 includes a filter coefficient generator 1010 and a second adaptive filter 1011. The filter coefficient generator 1010 generates filter tab coefficients used in the second adaptive filter 1011 based on the signal acquired from the down-conversion into signal of a predetermined band by the down-converter 1008 and signal outputted from a subtractor 1003. The second adaptive filter 1011 generates replica of feedback signals based on filter tab coefficients generated in the filter coefficient generator 1010 and the signal acquired from the down-conversion into signal of a predetermined band by the down-converter 1008. The second adaptive filter 1011 feeds back the replica to the subtractor 1003.

The filter coefficient generator 1010 calculates filter tab coefficients $\overline{h_n}$ in a time index n according to Equation 2 based on a Least Mean Square (LMS) algorithm.

$$\overline{h_n} = \overline{h_{n-1}} + \lambda \cdot \varepsilon(n) \cdot \overline{s_n}^*$$

$$\overline{h_n} = [h_0(n)\, h_1(n) \ldots h_{M-1}(n)]^T$$

$$\overline{h_{n-1}} = [h_0(n-1)\, h_1(n-1) \ldots h_{M-1}(n-1)]^T$$

$$\overline{s_n} = [s(n)\, s(n-1) \ldots s(n-M+1)]^T$$

Eq.2

where $\overline{s_n}$ is a signal vector acquired from the down-conversion into signal of a predetermined band by the down-converter 1008 in a time index n; $\varepsilon(n)$ is an output signal of the subtractor 803 in the time index n; $\overline{h_{n-1}}$ is filter tab coefficients in a time index (n-1); λ is a constant for determining a convergence speed; M is a transpose; and * is a complex conjugate.

The second adaptive filter 1011 calculates a replica $fb(n)$ of the feedback signal according to Equation 3 by filtering the down-converted signal vector $\overline{s_n}$ outputted from the down-converter 1008 based on filter tab coefficients $\overline{h_n}$ generated in the filter coefficient generator 1010.

$$fb(n) = \overline{h_n}^T \cdot \overline{s_n} \qquad \text{Eq.3}$$

According to Equation 4, the subtractor 1003 removes the feedback signals caused by low isolation of the transmission/reception antenna by subtracting replica $fb(n)$ of feedback signals calculated in the second adaptive filter 1011 in an output signal $r(n)$ of the RF receiver 1002.

$$\varepsilon(n+1) = r(n) - fb(n) \qquad \text{Eq.4}$$

Fig. 11 is a flowchart illustrating the repeating method in the on-channel repeater of Fig. 8.

Referring to Fig. 11, RF signal transmitted from the main transmitter or another repeater is received through the reception antenna 1001, and down-converted into signal of a desired band in the RF receiver 1002 at step S1101.

The subtractor 1003 removes feedback signals from the output signal of the RF receiver 1002 by subtracting a replica of feedback signals generated in the second adaptive filter 1006 from the signal outputted from the RF receiver 1002 at step S1102.

The filter coefficient generator 1010 of the replica generator 1004 generates filter tab coefficients in the second adaptive filter 1011 based on signal acquired from the down-conversion into signal of a predetermined band by the down-converter 1008 and signal outputted from the subtractor 1003 acquired by removing the feedback signals at step S1103. The second adaptive filter 1011 generates a replica of feedback signals by filtering the output signal of the down-converter 1008 based on the filter tab coefficients generated in filter coefficient generator 1010, and feeds back the a replica to the subtractor 1003 at step S1104.

The inverse channel estimator 1005 generates filter tab coefficients by estimating an inverse of the reception channel including noise, multi-path signals and remaining feedback signals caused in the reception channel based on the signal outputted from the subtractor 1003 at step S1105.

The first adaptive filter 1006 compensates for channel distortion of the signal outputted from the subtractor 1003 based on the filter tab coefficients generated by the inverse channel estimator 1005 at step S1106.

The RF transmitter 1007 converts the signal outputted from the first adaptive filter 1006 into an RF signal and performs radio transmission through the transmission antenna 1009 at step S1107.

The down-converter 808 down-converts the RF signal converted by the RF transmitter 807 into signal of a predetermined band at step S1108.

Fig. 12 is a block diagram illustrating the inverse channel estimator 805 of Fig. 8.

Referring to Fig. 12, the inverse channel estimator 805 includes a demodulating unit 1201, a channel estimating unit 1202 and a converting unit 1203.

The demodulating unit 1201 demodulates the signal outputted from the subtractor 803 through a frequency and timing synchronizing procedure.

The channel estimating unit 1202 estimates channel distortion of the repeater reception channel including noise, multi-path signals and remaining feedback signals caused in a channel between the main transmitter and the on-channel repeater based on the signal demodulated by the demodulating unit 1201.

The converting unit 1203 generates filter tab coefficients used in the first adaptive filter 806 by estimating an inverse of the reception channel from the channel distortion information of the reception channel estimated by the channel estimating unit 1202.

The demodulating unit 1201, the channel estimating unit 1202, and the converting unit 1203 of Fig. 12 may be formed diversely according to system standards.

In Figs. 13 to 15, embodiments of the demodulating unit 1201, the channel estimating unit 1202, and the converting unit 1203 in a DVB-T DTV standard using an Orthogonal Frequency Division Multiplexing (OFDM) modulating technique will be described hereinafter.

Fig. 13 is a block diagram showing the demodulating unit 1201 of Fig. 12 and it may be applied to the DVB-T DTV standard.

The demodulating unit 1201 includes a guard interval remover 1301, a serial-to-parallel converter (SPC) 1302, and a Fast Fourier Transformer (FFT) 1303.

The guard interval remover 1301 removes a guard interval from a signal outputted from the subtractor 1003. The serial-to-parallel converter 1302 converts the signal whose guard interval is removed by the guard interval remover 1301 into a parallel signal. The Fast Fourier Transformer 1303 converts the parallel signal converted by the serial-to-parallel converter 1302 into a frequency domain.

Fig. 14 shows the channel estimating unit 1202 of Fig. 12 and it may be applied to the DVB-T DTV standard.

The channel estimating unit 1202 includes a pilot extractor 1401, a pilot storage 1402 and a channel distortion estimator 1403.

The pilot extractor 1401 extracts a pilot signal from an output signal of the demodulating unit 1201. The pilot storage 1402 stores a predetermined pilot signal. The channel distortion estimator 1403 estimates channel distortion by comparing the pilot signal extracted by the pilot extractor 1401 with the pilot signal stored in the pilot storage 1402.

Fig. 15 is a block diagram showing the converting unit 1203 of Fig. 12 and it may be applied to the DVB-T DTV standard.

The converting unit 1203 includes an inverse converter 1501 and a time-domain converter 1502.

The inverse converter 1501 generates inverse of channel distortion based on channel distortion information estimated by channel estimating unit 1202. The time-domain converter 1502 converts the inverse of the channel distortion generated in the inverse converter 1501 into filter tab coefficients of time domain.

Fig. 16 is a block diagram showing the on-channel repeater in accordance with another embodiment of the present invention.

Fig. 16 has the same format as Fig. 8 except that a signal is converted into a baseband signal in a transmitter/receiver.

Therefore, a subtractor 1606, a replica generator 1607, an inverse channel estimator 1608 and a first adaptive filter 1609 individually correspond to the subtractor 803, the replica generator 804, inverse channel estimator 805 and the first adaptive filter 806, respectively.

An RF receiver 1602 receives RF signal from the main transmitter or another repeater through the reception antenna 1601.

A first Intermediate Frequency (IF) down-converter 1603 down-converts the received RF signal into IF signal based on a reference frequency provided from a local oscillator 1617. A first analog-to-digital converter 1604 converts the analog IF signal outputted from the first IF down-converter 1603 into digital IF signal. The first baseband converter 1605 converts the output signal of the first analog-to-digital converter 1604 into baseband signal.

An IF up-converter 1610 converts the signal outputted from the first adaptive filter 1609 into IF signal. A digital-analog converter 1611 converts the digital IF signal outputted from the IF up-converter 1610 into analog IF signal. An RF up-converter 1612 up-converts the output signal of the digital-analog converter 1611 into RF signal based on a reference frequency provided from the local oscillator 1617.

The RF signal acquired from the up-conversion in the RF up-converter 1612 is amplified by the high-power amplifier 1613.

Through the second IF down-converter 1614, the RF signal amplified by the high-power amplifier 1613 is down-converted into signal of IF band which is the same as the band of analog IF signal acquired from the down-conversion in the first IF down-converter 1603 based on the reference frequency provided from the local oscillator 1617.

A second analog-to-digital converter 1615 converts the output signal of the second IF down-converter 1614 into digital IF signal. A second baseband converter 1616 converts the output signal of the second analog-to-digital converter 1615 into baseband signal. The replica generator 1607 generates a replica of the feedback signals based on the signal acquired from the down-conversion into the baseband signals in the second baseband converter 1616 and outputted signal from the subtractor 1606, i.e., signal acquired by removing the feedback signals, and feeds back the signal to the subtractor 1606.

That is, a filter coefficient generator 1618 of the replica generator 1607 generates filter tab coefficients of a second adaptive filter 1619 based on the signal acquired from the down-conversion into baseband signal by the second baseband converter 1616 and signal outputted from the subtractor 1606, i.e., signal acquired by removing the feedback signals. The second adaptive filter 1619 generates a replica of the feedback signals by filtering the signal acquired from the down-conversion into the baseband signal by the second baseband converter 1616 based on the filter tab coefficients generated in the filter coefficient generator 1618.

The local oscillator 1617 generates and provides a reference frequency to the first IF down-converter 1603, the second IF down-converter 1614, and the RF up-converter 1612.

Although the on-channel repeating method and the on-channel repeater which improve feedback signal removing capability in accordance with the present invention are proper to broadcastings such as Advanced Television Systems Committee (ATSC), Digital Video Broadcasting (DVB), Digital Multimedia Broadcasting (DMB) and Integrated Service Digital Broadcasting-Terrestrial (ISDB-T), and communications such as wireless broadband (Wibro) and Code Division Multiple Access (CDMA), they are not limited to these examples and can be applied anywhere in an environment which requires a repeater to configure a general single frequency network.

As described above, the technology of the present invention can be realized as a program and stored in a computer-readable recording medium, such as CD-ROM, RAM, ROM, floppy disk, hard disk and magneto-optical disk. Since the process can be easily implemented by those skilled in the art of the present invention, further description will not be provided herein.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

IDUSTRIAL APPLICABILITY

The present invention can increase efficiency of limited frequency resources by repeating a signal that is the same as output signal of a main transmitter, has a short time delay between the output signals of the repeater and the main transmitter, and has its distortion caused in a transmission channel compensated.

WHAT IS CLAIMED IS:

1. An on-channel repeater, comprising:

a receiving means for receiving a Radio Frequency (RF) signal and converting the RF signal into a baseband signal;

a subtracting means for subtracting a replica of feedback signals from the signal received in the receiving means;

an inverse channel estimating means for estimating an inverse of a reception channel based on the signal acquired from the subtraction in the subtracting means and generating a filter tab coefficients;

a first adaptive filtering means for compensating for channel distortion of the signal acquired from the subtraction in the subtracting means based on the filter tab coefficients generated by the inverse channel estimating means;

a transmitting means for converting the signal whose channel distortion is compensated by the first adaptive filtering means into an RF signal and performing radio transmission;

a down-converting means for down-converting the RF signal acquired in the transmitting means into a baseband signal; and

a replica generating means for calculating a replica based on the baseband signal acquired from the conversion in the down-converting means and the signal acquired from the subtraction in the subtracting means, and feeding back the replica to the subtracting means.

2. The on-channel repeater of claim 1, wherein the replica generating means includes:

a filter coefficient generating unit for calculating a filter tab coefficients in a time index n based on the baseband signal, the signal acquired from the subtraction in the subtracting means in the time index n, and the filter tab coefficients in a time index n-1; and

a second adaptive filtering unit for calculating the replica based on the filter tab coefficients in the time index n and the baseband signal acquired from the conversion in the up-converting means.

3. The on-channel repeater of claim 2, wherein the filter coefficient generating unit calculates a filter tab coefficients vector based on a Least Mean Square (LMS) algorithm.

4. The on-channel repeater of claim 3, wherein the filter coefficient generating unit calculates the filter tab coefficient vector $\overline{h_n}$ according to Equation 1:

$$\overline{h_n} = \overline{h_{n-1}} + \lambda \cdot \varepsilon(n) \cdot \overline{s_n}^*$$

$$\overline{h_n} = [h_0(n)\, h_1(n) \ldots h_{M-1}(n)]^T$$

$$\overline{h_{n-1}} = [h_0(n-1)\, h_1(n-1) \ldots h_{M-1}(n-1)]^T$$

$$\overline{s_n} = [s(n)\, s(n-1) \ldots s(n-M+1)]^T$$

Eq.1

where $\overline{s_n}$ is a signal vector acquired from the down-conversion into a baseband signal by the up-converting means in the time index n; $\varepsilon(n)$ is a signal acquired from the subtraction in the subtracting means in the time index n; λ is a constant for determining a convergence speed; M is the number of filter tabs; T is a transpose; and * is a complex conjugate.

5. The on-channel repeater of claim 4, wherein the second adaptive filtering unit calculates a replica $fb(n)$ according to Equation 2:

$$fb(n) = \overline{h_n}^T \cdot \overline{s_n} \qquad \text{Eq. 2}$$

6. The on-channel repeater of claim 5, wherein the subtracting means subtracts the replica from the baseband signal acquired from the conversion in the receiving means according to Equation 3:

$$\varepsilon(n+1) = r(n) - fb(n) \qquad \text{Eq. 3}$$

where $r(n)$ is a baseband signal converted by the receiving means in the time index n; and $\varepsilon(n+1)$ is a signal acquired from the subtraction in the subtracting means in a time index n+1.

7. The on-channel repeater of claim 1, wherein the inverse channel estimating means includes:

a demodulating unit for demodulating the signal acquired from the subtraction in the subtracting means;

a channel estimating unit for estimating channel distortion information of a repeater reception channel based on the signal acquired from the demodulation in the demodulating unit; and

a converting unit for calculating an inverse of the reception channel based on the channel information estimated by the channel estimating unit and generating a filter tab coefficients based on the calculated inverse of the reception channel.

8. The on-channel repeater of claim 7, wherein the demodulating unit includes:

a guard interval remover for removing a guard interval of the signal acquired from the subtraction in the subtracting means;

a serial-to-parallel converter for converting the signal whose guard interval is removed by the guard interval remover into a parallel signal; and

a Fast Fourier Transformer (FFT) for transforming the parallel signal acquired from the conversion in the serial-to-parallel converter to a frequency domain.

9. The on-channel repeater of claim 7, wherein the channel estimating unit includes:

a pilot extractor for extracting a pilot signal from the signal acquired from the demodulation in the demodulating unit;

a pilot storage for storing a predetermined pilot signal; and

a channel distortion estimator for estimating channel distortion by comparing the pilot signal extracted from the pilot extractor with the pilot signal stored in the pilot storage.

10. The on-channel repeater of claim 7, wherein the converting unit includes:

an inverse converter for generating an inverse of channel distortion based on the channel distortion information estimated by the channel estimating unit; and

a time-domain converter for converting the inverse of the channel distortion generated by the inverse converter into a filter tab coefficients of a time domain.

11. The on-channel repeater of claim 1, wherein the up-converting means includes:

an Intermediate Frequency (IF) down-converting unit for down-converting the RF signal acquired from the conversion in the transmitting means into an IF band signal;

a converting unit for converting the IF signal into a digital IF signal; and

a baseband converting unit for converting the digital IF signal into a baseband signal.

12. The on-channel repeater of claim 1, wherein the receiving means includes:

an RF receiving unit for receiving an RF signal;

an IF down-converting unit for down-converting the RF signal received in the RF receiving unit into an IF signal;

an analog-to-digital converting unit for converting the IF signal into a digital IF signal; and

a baseband converting unit for converting the digital IF signal into a baseband signal.

13. The on-channel repeater of claim 1, wherein the transmitting means includes:

an IF up-converting unit for converting the signal whose channel distortion is compensated by the first adaptive filtering means into a digital IF signal;

a digital-analog converting unit for converting the digital IF signal into an analog IF signal;

an RF up-converting unit for up-converting the analog IF signal into an RF signal; and

a high-power amplifying unit for amplifying the RF signal.

14. An on-channel repeating method, comprising:

receiving a Radio Frequency (RF) signal and converting the RF signal into a baseband signal;

subtracting a replica of feedback signals from the received signal;

estimating an inverse of a reception channel based on the signal acquired from the subtraction and generating a filter tab coefficients;

compensating for channel distortion of the signal acquired from the subtraction based on the generated filter tab coefficients;

performing radio transmission by converting the signal whose channel distortion is compensated into an RF signal; and

down-converting the RF signal acquired in the transmitting means into a baseband signal,

wherein the replica is calculated based on the baseband signal acquired from the down-conversion and the signal acquired from the subtraction and is fed back to said subtracting the replica of the feedback signal.

15. The on-channel repeating method of claim 14, wherein the replica includes:

calculating a filter tab coefficients in a time index n based on the baseband signal in a time index n, the signal acquired from the subtraction in the time index n, and the filter tab coefficients in a time index n-1; and

calculating a replica based on the filter tab coefficients in the time index n and the baseband signal.

16. The on-channel repeating method of claim 15, wherein in said calculating the filter tab coefficients, a filter tab coefficient vector is calculated based on a Least Mean Square (LMS) algorithm.

17. The on-channel repeating method of claim 16, wherein in said calculating the filter tab coefficients, the filter tab coefficient vector $\overline{h_n}$ is calculated according to Equation 1:

$$\overline{h_n} = \overline{h_{n-1}} + \lambda \cdot \varepsilon(n) \cdot \overline{s_n}^*$$

$$\overline{h_n} = [h_0(n)\, h_1(n) \ldots h_{M-1}(n)]^T$$

$$\overline{h_{n-1}} = [h_0(n-1)\, h_1(n-1) \ldots h_{M-1}(n-1)]^T$$

$$\overline{s_n} = [s(n)\, s(n-1) \ldots s(n-M+1)]^T \qquad \text{Eq.1}$$

where $\overline{s_n}$ is a signal vector acquired from the down-conversion into a baseband in the time index n; $\varepsilon(n)$ is a signal acquired from the subtraction in the time index n; λ is a constant for determining a convergence speed; M is the number of filter tabs; T is a transpose; and * is a complex conjugate.

18. The on-channel repeating method of claim 17, wherein in said calculating the replica,

the replica $fb(n)$ is calculated according to Equation 2:

$$fb(n) = \overline{h_n}^T \cdot \overline{s_n} \quad \text{Eq. 2}$$

19. The on-channel repeating method of claim 18, wherein in said subtracting the replica of the feedback signal,

the replica is subtracted from the baseband signal acquired from the said receiving RF signal and converting the RF signal according to Equation 3:

$$\varepsilon(n+1) = r(n) - fb(n) \quad \text{Eq. 3}$$

where $r(n)$ is a baseband signal acquired from the conversion in said receiving RF signal and converting the RF signal in the time index n; and $\varepsilon(n+1)$ is a signal acquired from the subtraction in said subtracting the replica of the feedback signal in the time index n+1.

20. The on-channel repeating method of claim 14, wherein said estimating the inverse of the reception channel includes:

demodulating the signal acquired from the subtraction in said subtracting the replica of the feedback signal;

estimating channel distortion information of a repeater reception channel based on the signal acquired from the demodulation in said demodulating the signal; and

calculating an inverse of the reception channel based on the estimated channel information and generating a filter tab coefficients based on the calculated inverse of the reception channel.

21. The on-channel repeating method of claim 20, wherein said demodulating the signal includes:

removing a guard interval of the signal acquired from the subtraction in said subtracting the replica of the feedback signal;

converting the signal without a guard interval into a parallel signal; and

transforming the parallel signal into a frequency domain.

22. The on-channel repeating method of claim 20, wherein said estimating channel distortion information of the repeater reception channel includes:

extracting a pilot signal from the demodulated signal;

storing a predetermined pilot signal; and

estimating channel distortion by comparing the extracted pilot signal with the stored pilot signal.

23. The on-channel repeating method of claim 20, wherein said calculating an inverse of the reception channel and generating the filter tab coefficients includes:

generating an inverse of channel distortion based on the estimated channel distortion information; and converting the inverse of the channel distortion into a filter tab coefficients of a time domain.

24. The on-channel repeating method of claim 14, wherein said down-converting the RF signal includes:

down-converting the RF signal acquired from the conversion in said performing radio transmission into an IF signal;

converting the IF signal into a digital IF signal; and

converting the digital IF signal into a baseband signal.

25. The on-channel repeating method of claim 14, wherein said receiving RF signal and converting the RF signal includes:

receiving an RF signal;

down-converting the RF signal into an IF signal:

converting the IF signal into a digital IF signal; and

converting the digital IF signal into a baseband signal.

26. The on-channel repeating method of claim 14, wherein said performing radio transmission includes:

converting the signal whose channel distortion is compensated in the step of compensating for channel distortion of the signal into a digital IF signal;

converting the digital IF signal converted in the step of converting the signal whose channel distortion is compensated into the digital IF signal into an analog IF signal;

up-converting the analog IF signal into an RF signal; and

amplifying the RF signal.

27. An on-channel repeater, comprising:

a receiving means for receiving a Radio Frequency (RF) signal and converting the RF signal into a predetermined band signal;

a subtracting means for subtracting a replica of feedback signals from the signal received in the receiving means;

an inverse channel estimating means for estimating an inverse of a reception channel based on the signal acquired from the subtraction in the subtracting means and generating a filter tab coefficients;

a first adaptive filtering means for compensating for channel distortion of the signal acquired from the subtraction based on the filter tab coefficients generated by the inverse channel estimating means;

a transmitting means for converting the signal whose channel distortion is compensated by the first adaptive filtering means into an RF signal and performing radio transmission;

a down-converting means for down-converting the RF signal acquired in the transmitting means into a predetermined band signal; and

a replica generating means for calculating a replica based on the predetermined band signal acquired from the conversion in the down-converting means and the signal acquired from the subtraction in the subtracting means, and feeding back the replica to the subtracting means.

28. The on-channel repeater of claim 27, wherein the replica generating means includes:

a filter coefficient generating unit for calculating a filter tab coefficients in a time index n based on the baseband signal acquired from the conversion in the down-converting means in the time index n, the signal acquired from the subtraction in the subtracting means in the time index n, and the filter tab coefficients in a time index n-1; and

a second adaptive filtering unit for calculating the replica based on the filter tab coefficients in the time index n and the baseband signal acquired from the conversion in the down-converting means.

29. The on-channel repeater of claim 28, wherein the filter coefficient generating unit calculates a filter tab coefficient vector based on a Least Mean Square (LMS) algorithm.

30. The on-channel repeater of claim 29, wherein the filter coefficient generating unit calculates the filter tab coefficient vector $\overline{h_n}$ according to Equation 1:

$$\overline{h_n} = \overline{h_{n-1}} + \lambda \cdot \varepsilon(n) \cdot \overline{s_n}^*$$

$$\overline{h_n} = [h_0(n)\, h_1(n) \ldots h_{M-1}(n)]^T$$

$$\overline{h_{n-1}} = [h_0(n-1)\, h_1(n-1) \ldots h_{M-1}(n-1)]^T$$

$$\overline{s_n} = [s(n)\, s(n-1) \ldots s(n-M+1)]^T \quad \text{Eq.1}$$

where $\overline{s_n}$ is a signal vector acquired from the down-conversion into a base band in the time index n; $\varepsilon(n)$ is a signal acquired from the subtraction in the time index n; λ is a constant for determining a convergence speed; M is the number of filter tabs; T is a transpose; and * is a complex conjugate.

31. The on-channel repeater of claim 30, wherein the second adaptive filtering unit calculates the replica $fb(n)$ according to Equation 2:

$$fb(n) = \overline{h_n}^T \cdot \overline{s_n} \qquad \text{Eq. 2}$$

32. The on-channel repeater of claim 31, wherein the subtracting means subtracts the replica from the baseband signal acquired from the conversion in the receiving means according to Equation 3:

$$\varepsilon(n+1) = r(n) - fb(n) \qquad \text{Eq. 3}$$

where $r(n)$ is a baseband signal acquired from the conversion in a time index n and $\varepsilon(n+1)$ is a signal acquired from the subtraction in the time index n+1.

33. The on-channel repeater of claim 27, wherein the inverse channel estimating means includes:

a demodulating unit for demodulating the signal acquired from the subtraction in the subtracting means;

a channel estimating unit for estimating channel distortion information of a repeater reception channel based on the demodulated signal; and

a converting unit for calculating an inverse of the reception channel based on the estimated channel information and generating a filter tab coefficients based on the calculated inverse of the reception channel.

34. The on-channel repeater of claim 33, wherein the demodulating unit includes:

a guard interval remover for removing a guard interval of the signal acquired from the subtraction in the subtracting means;

a serial-to-parallel converter for converting the signal without a guard interval into a parallel signal; and

a Fast Fourier Transformer (FFT) for transforming the parallel signal into a frequency domain.

35. The on-channel repeater of claim 33, wherein the channel estimating unit includes:

a pilot extractor for extracting a pilot signal from the demodulated signal;

a pilot storage for storing a predetermined pilot signal; and

a channel distortion estimator for estimating channel distortion by comparing the pilot signal extracted in the pilot extractor with the pilot signal stored in the pilot storage.

36. The on-channel repeater of claim 33, wherein the converting unit includes:

an inverse converter for generating an inverse of channel distortion based on the estimated channel distortion information; and

a time-domain converter for converting the inverse of the channel distortion generated by the inverse converter into a filter tab coefficients of a time domain.

37. An on-channel repeating method, comprising:

receiving a Radio Frequency (RF) signal and converting the RF signal into a predetermined band signal;

subtracting a replica of feedback signals from the received RF signal;

estimating an inverse of a reception channel based on the signal acquired from the subtraction in said subtracting the replica of the feedback signal, and generating a filter tab coefficients;

compensating for channel distortion of the signal acquired from the subtraction based on the generated filter tab coefficients;

performing radio transmission by converting the signal whose channel distortion is compensated into an RF signal; and

down-converting the RF signal acquired in the transmitting means into the predetermined band signal,

wherein the replica is calculated based on the predetermined band signal converted in the step of down-converting the RF signal and the signal acquired from the subtraction in the step of subtracting the replica of the feedback signal, and is fed back to said subtracting the replica of the feedback signal.

38. The on-channel repeating method of claim 37, wherein the replica includes:

calculating a filter tab coefficients in a time index n based on the baseband signal in a time index n, the signal acquired from the subtraction in the time index n, and the filter tab coefficients in a time index n-1; and

calculating a replica based on the filter tab coefficients in the time index n and the baseband signal.

39. The on-channel repeating method of claim 38, wherein said calculating the filter tab coefficients, a filter tab coefficient vector is calculated based on a Least Mean Square (LMS) algorithm.

40. The on-channel repeating method of claim 39, wherein in said calculating the filter tab coefficients, the filter tab coefficient vector $\overline{h_n}$ is calculated according to Equation 1:

$$\overline{h_n} = \overline{h_{n-1}} + \lambda \cdot \varepsilon(n) \cdot \overline{s_n}^{*}$$

$$\overline{h_n} = [h_0(n)\, h_1(n) \ldots h_{M-1}(n)]^T$$

$$\overline{h_{n-1}} = [h_0(n-1)\, h_1(n-1) \ldots h_{M-1}(n-1)]^T \qquad \text{Eq.1}$$

where $\overline{s_n}$ is a signal vector acquired from the down-conversion into a baseband signal in the time index n; $\varepsilon(n)$ is a signal acquired from the subtraction in the time index n; λ is a constant for determining a convergence speed; M is the number of filter tabs; T is a transpose; and * is a complex conjugate.

41. The on-channel repeating method of claim 40, wherein in said calculating the replica, the replica $fb(n)$ is calculated according to Equation 2:

$$fb(n) = \overline{h_n}^T \cdot \overline{s_n} \quad \text{Eq. 2}$$

42. The on-channel repeating method of claim 41, wherein in the step of subtracting the replica of the feedback signal, the replica is subtracted from the baseband signal converted in the step of receiving RF signal and converting the RF signal according to Equation 3;

$$\varepsilon(n+1) = r(n) - fb(n) \quad \text{Eq. 3}$$

where $r(n)$ is a baseband signal acquired from the conversion in said receiving RF signal and converting the RF signal in the time index n and $\varepsilon(n+1)$ is a signal acquired from the subtraction in said subtracting the replica of the feedback signal in the time index n+1.

43. The on-channel repeating method of claim 37, wherein said estimating the inverse of the reception channel includes:

demodulating the signal acquired from the subtraction in said subtracting the replica of the feedback signal;

estimating channel distortion information of a repeater reception channel based on the demodulated signal; and

calculating an inverse of the reception channel based on the estimated channel information and generating a filter tab coefficients based on the calculated inverse of the reception channel.

44. The on-channel repeating method of claim 43, wherein said demodulating the signal includes:

removing a guard interval of the signal acquired from the subtraction;

converting the signal without a guard interval into a parallel signal; and

transforming the parallel signal into a frequency domain.

45. The on-channel repeating method of claim 43, wherein said estimating channel distortion information of the repeater reception channel includes:

extracting a pilot signal from the demodulated signal in;

storing a predetermined pilot signal; and

estimating channel distortion by comparing the extracted pilot signal with the stored pilot signal.

46. The on-channel repeating method of claim 43, wherein said calculating an inverse of the reception channel and generating the filter tab coefficients includes:

generating an inverse of channel distortion based on the estimated channel distortion information; and

converting the generated inverse of the channel distortion into a filter tab coefficients of a time domain.

FIG. 1

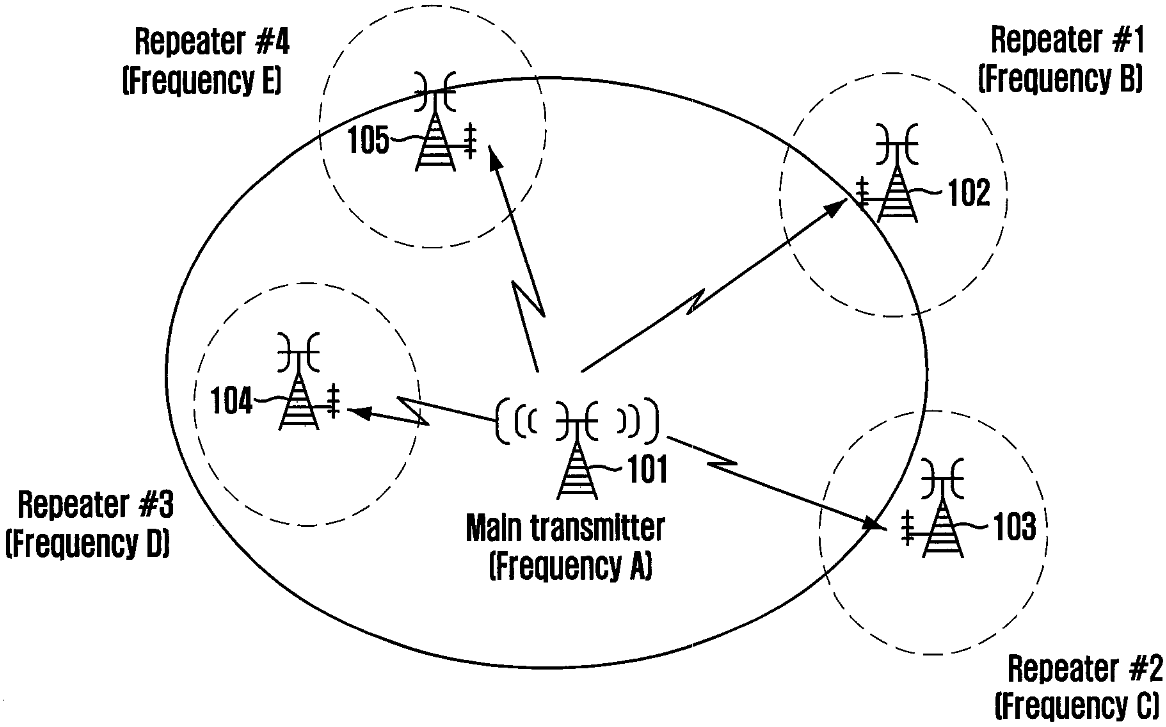

Repeater #4
(Frequency E)
105
Repeater #1
(Frequency B)
102
104
Repeater #3
(Frequency D)
101
Main transmitter
(Frequency A)
103
Repeater #2
(Frequency C)

FIG. 2

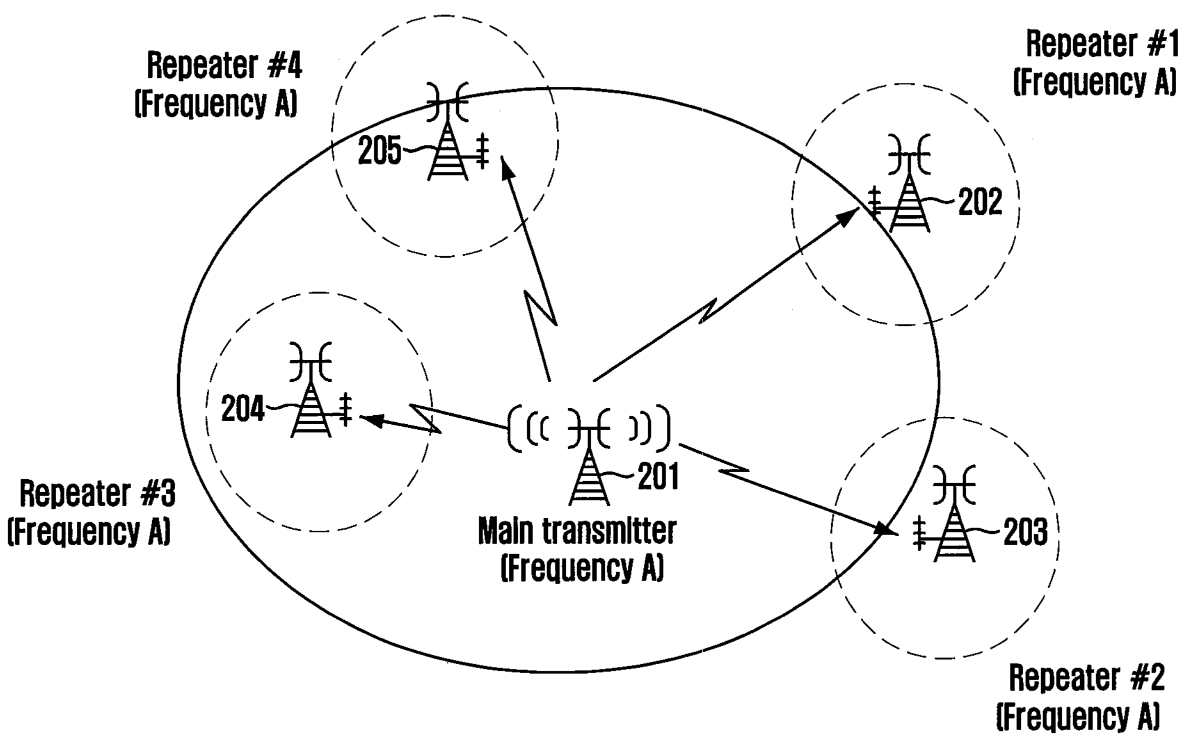

Repeater #4
(Frequency A)
205
Repeater #1
(Frequency A)
202
204
Repeater #3
(Frequency A)
201
Main transmitter
(Frequency A)
203
Repeater #2
(Frequency A)

FIG. 3

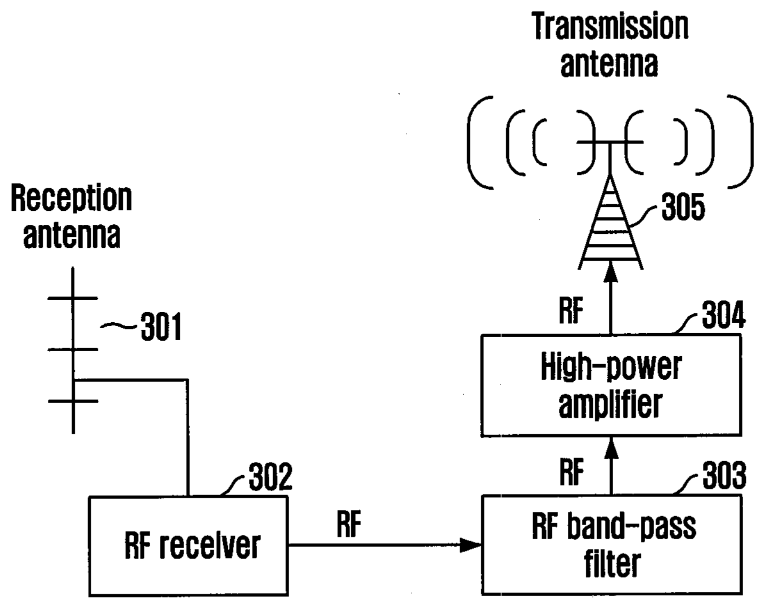

Transmission antenna
305
Reception antenna
301
RF
304
High-power amplifier
RF
302
303
RF receiver
RF
RF band-pass filter

FIG. 4

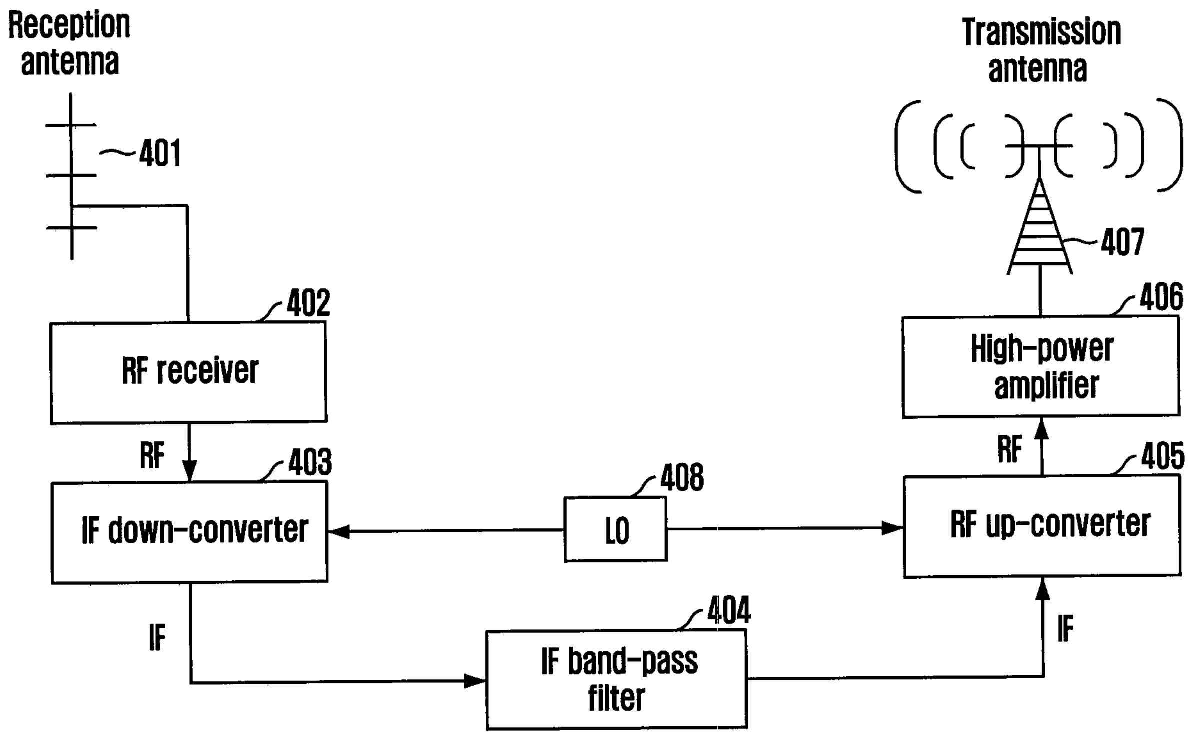

Reception antenna
401
402
RF receiver
RF
403
IF down-converter
IF
408
LO
404
IF band-pass filter
Transmission antenna
407
406
High-power amplifier
RF
405
RF up-converter
IF

FIG. 5

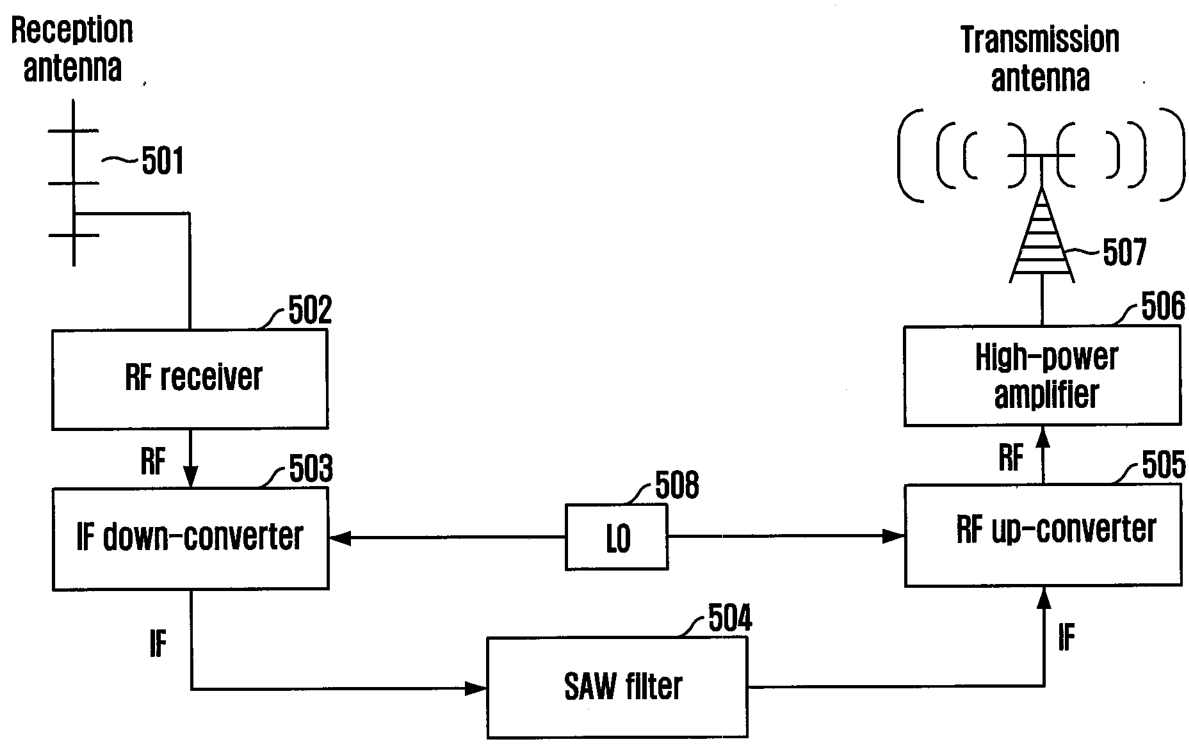
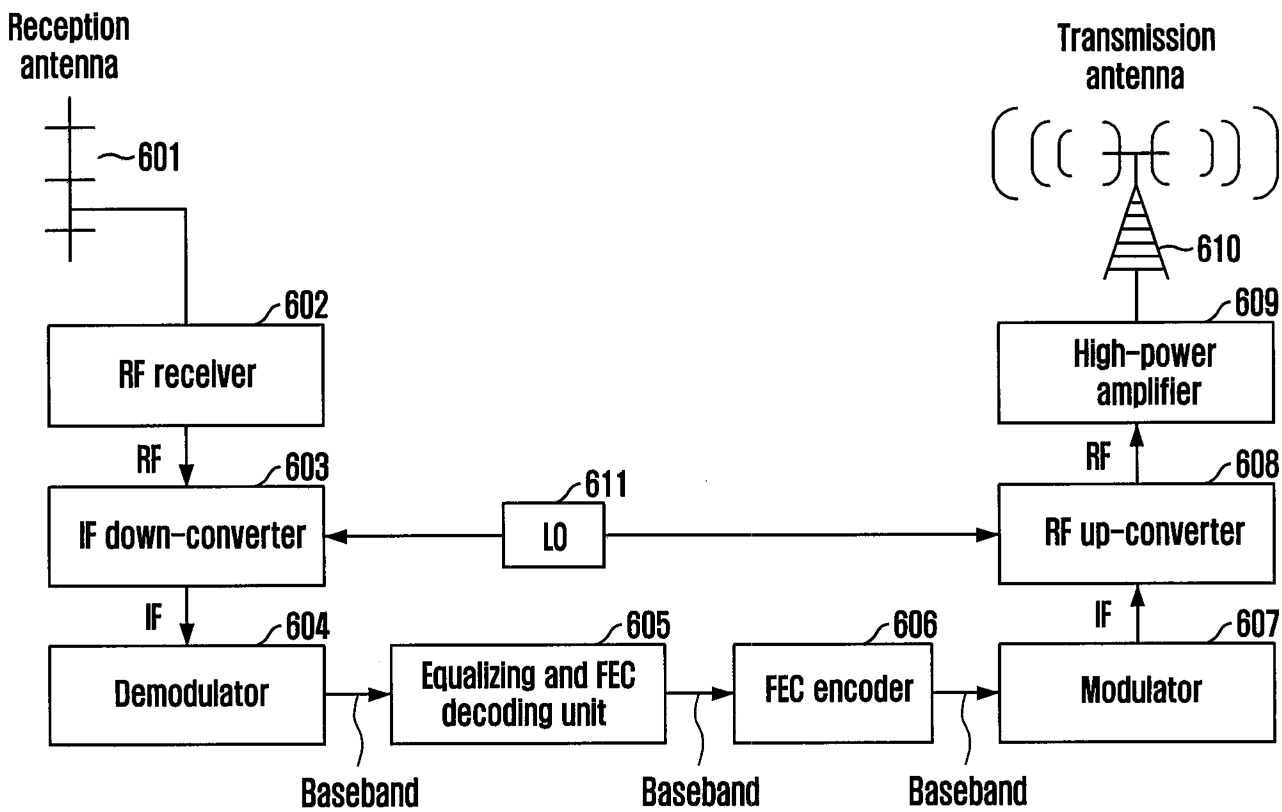

Reception antenna
501
502
RF receiver
RF
503
IF down-converter
IF
508
LO
504
SAW filter
Transmission antenna
507
506
High-power amplifier
RF
505
RF up-converter
IF

FIG. 6



Reception antenna
601
602
RF receiver
RF
603
IF down-converter
IF
604
Demodulator
611
LO
605
Equalizing and FEC decoding unit
606
FEC encoder
Baseband
Baseband
Baseband
Transmission antenna
610
609
High-power amplifier
RF
608
RF up-converter
IF
607
Modulator

FIG. 7

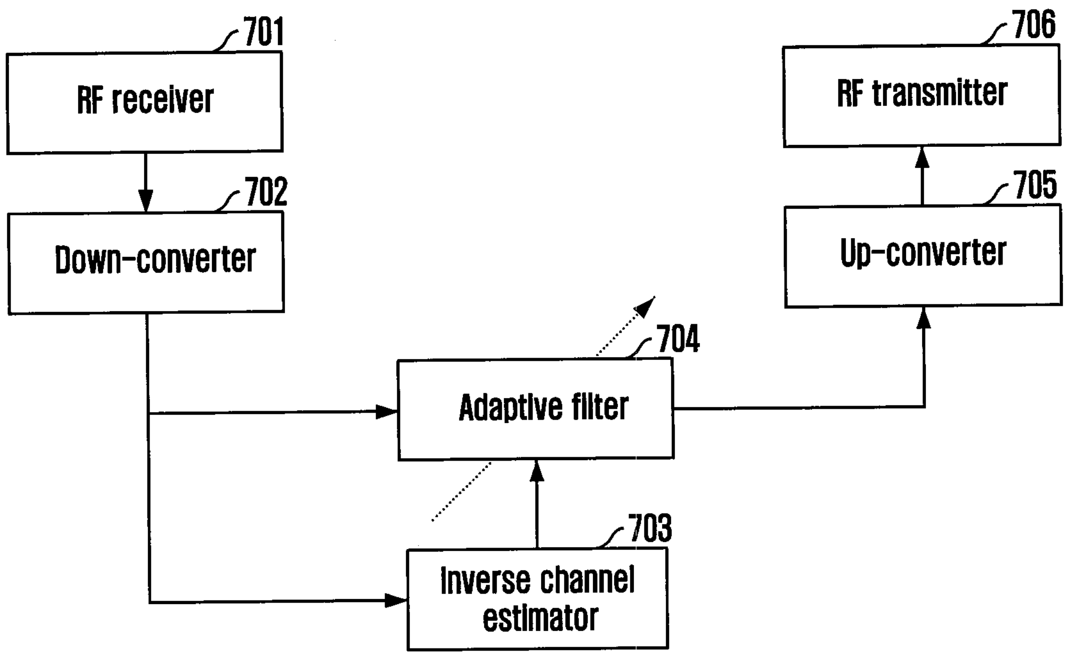

701
RF receiver
702
Down-converter
704
Adaptive filter
703
Inverse channel estimator
706
RF transmitter
705
Up-converter

FIG. 8

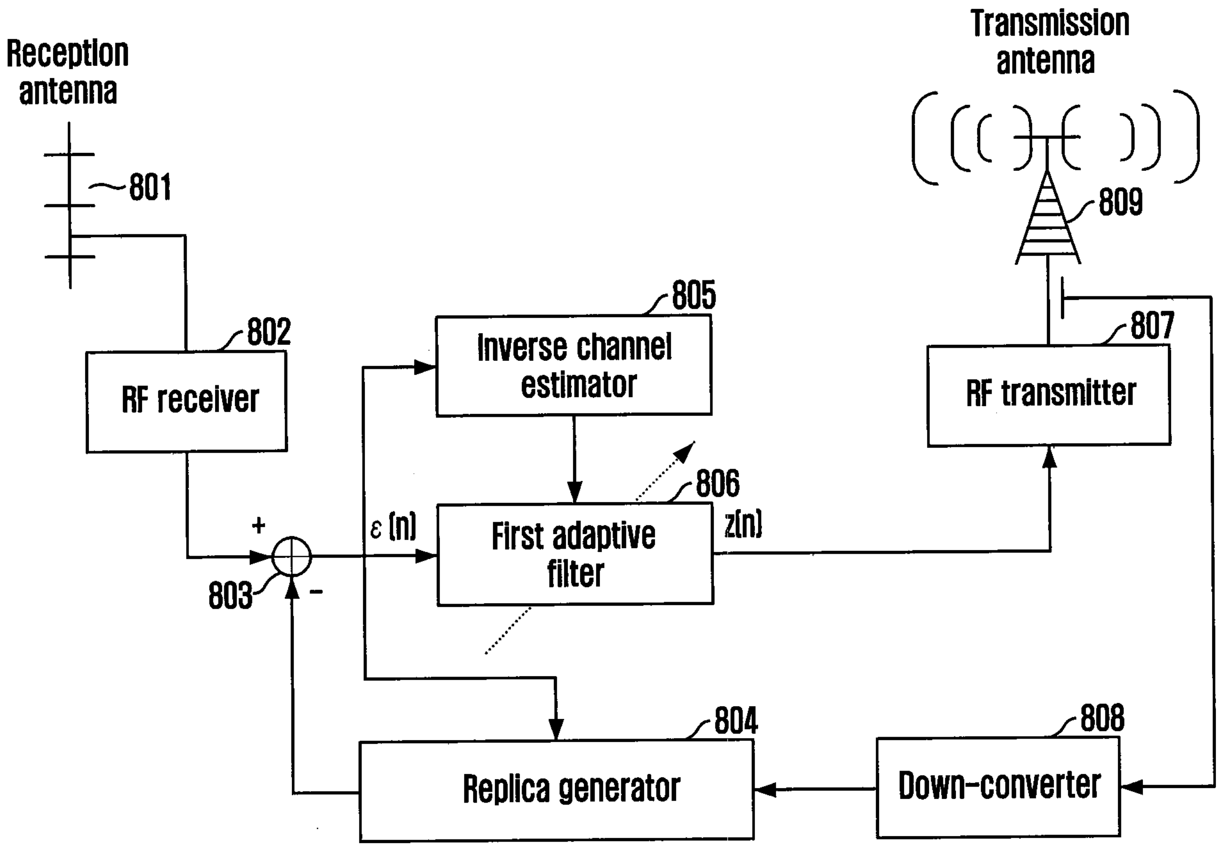

Reception antenna
801
Transmission antenna
809
802
RF receiver
805
Inverse channel estimator
807
RF transmitter
806
+
ε (n)
First adaptive filter
z(n)
803
-
804
Replica generator
808
Down-converter

FIG. 9

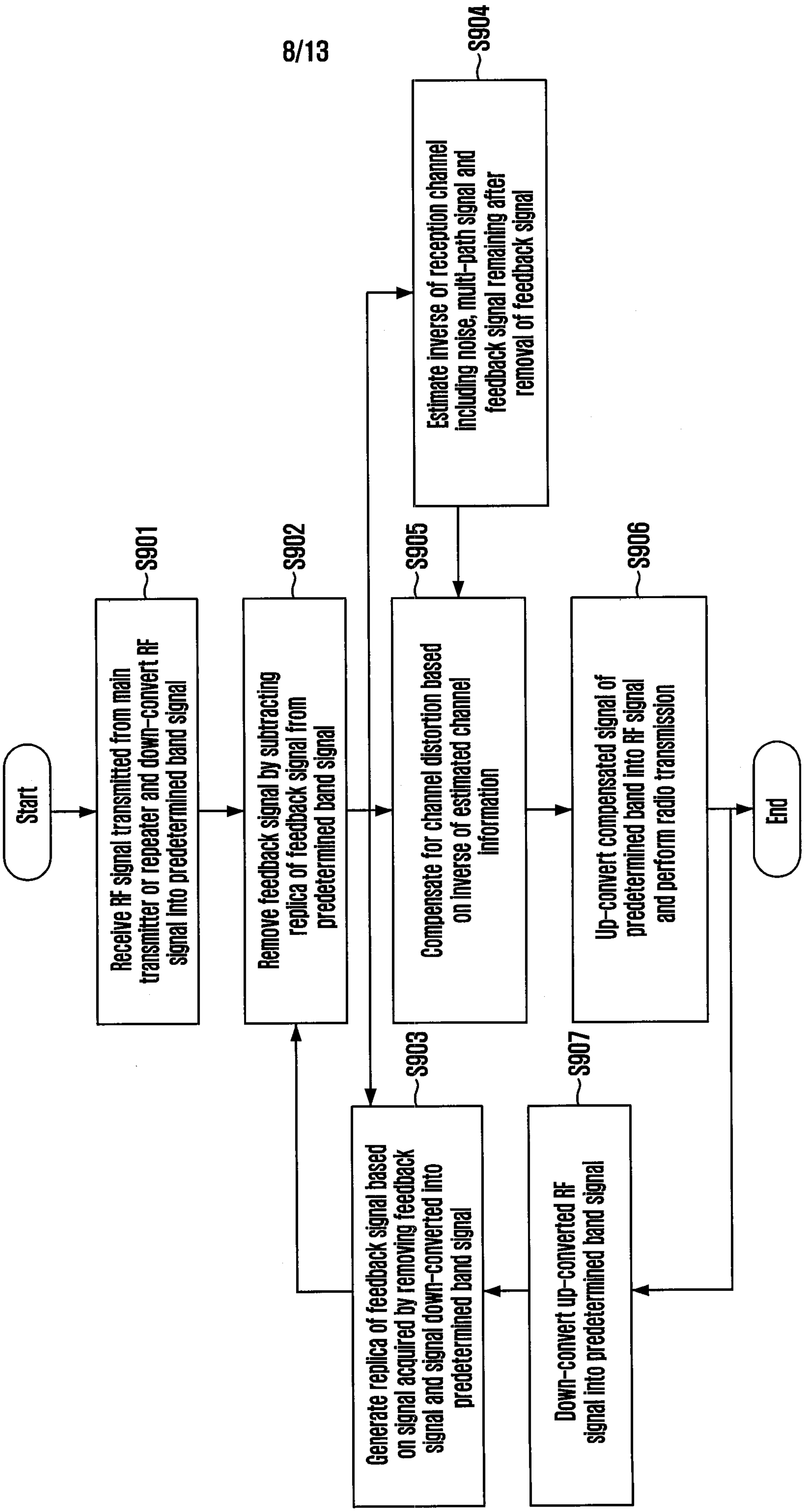

Start
S901
Receive RF signal transmitted from main transmitter or repeater and down-convert RF signal into predetermined band signal
S902
Remove feedback signal by subtracting replica of feedback signal from predetermined band signal
S903
Generate replica of feedback signal based on signal acquired by removing feedback signal and signal down-converted into predetermined band signal
S904
Estimate inverse of reception channel including noise, multi-path signal and feedback signal remaining after removal of feedback signal
S905
Compensate for channel distortion based on inverse of estimated channel information
S906
Up-convert compensated signal of predetermined band into RF signal and perform radio transmission
S907
Down-convert up-converted RF signal into predetermined band signal
End

FIG. 10

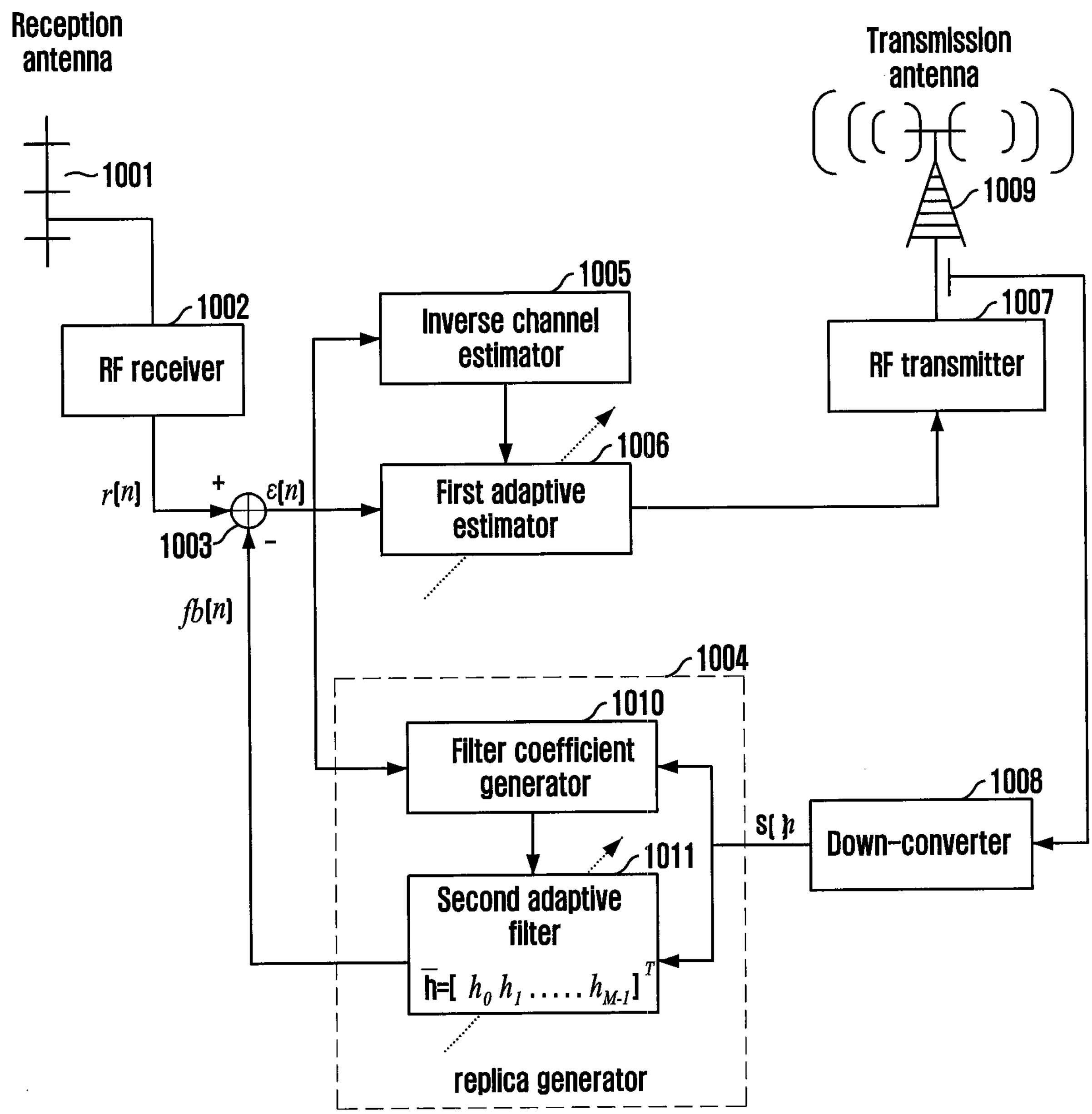

Reception antenna
1001
1002
RF receiver
r[n]
+
ε[n]
1003
-
fb[n]
1005
Inverse channel estimator
1006
First adaptive estimator
Transmission antenna
1009
1007
RF transmitter
1004
1010
Filter coefficient generator
1011
Second adaptive filter
h̄=[h0 h1 ..... hM-1]T
replica generator
S[ ]n
1008
Down-converter

FIG. 11

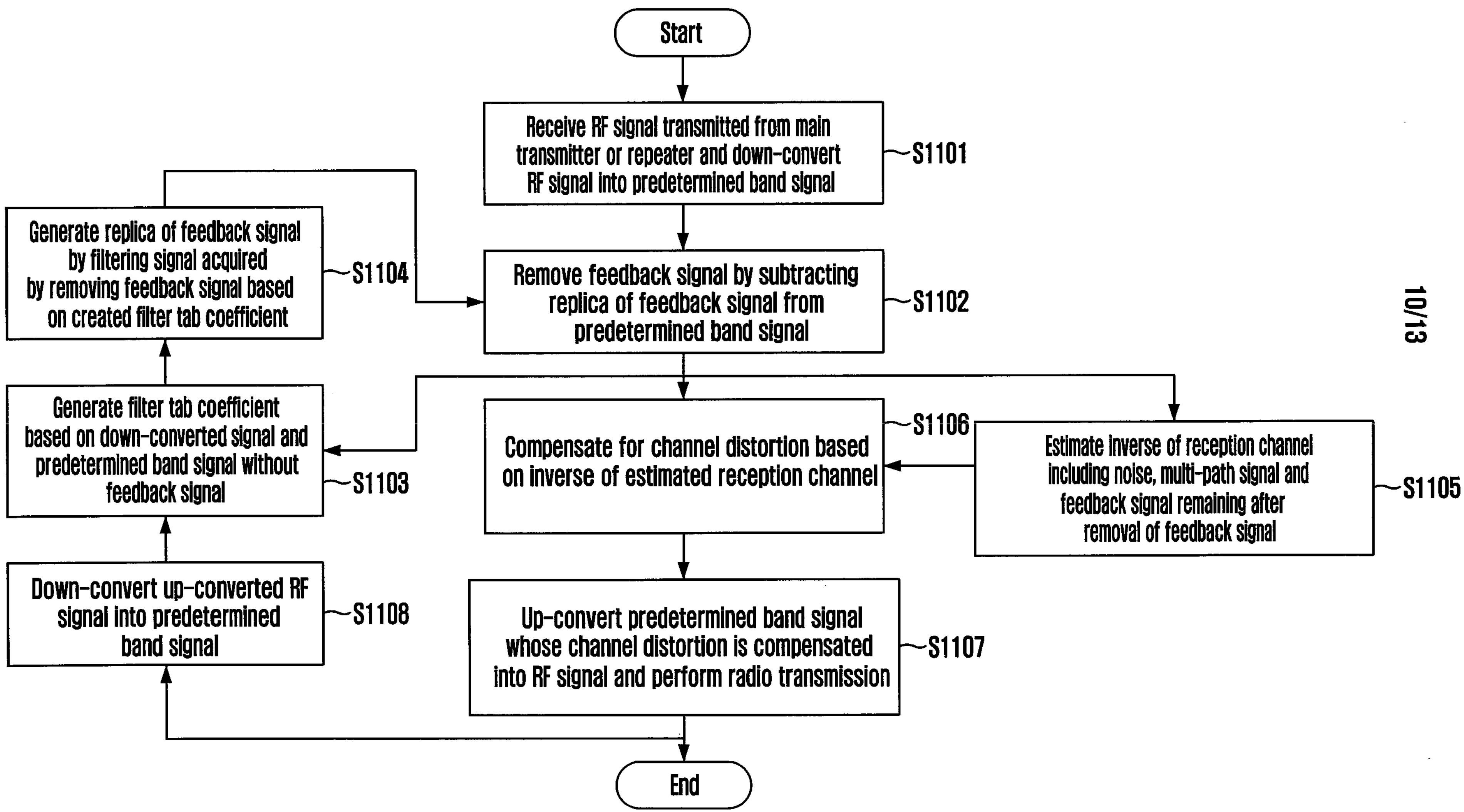

Start
Receive RF signal transmitted from main transmitter or repeater and down-convert RF signal into predetermined band signal
S1101
Remove feedback signal by subtracting replica of feedback signal from predetermined band signal
S1102
Generate filter tab coefficient based on down-converted signal and predetermined band signal without feedback signal
S1103
Generate replica of feedback signal by filtering signal acquired by removing feedback signal based on created filter tab coefficient
S1104
Estimate inverse of reception channel including noise, multi-path signal and feedback signal remaining after removal of feedback signal
S1105
Compensate for channel distortion based on inverse of estimated reception channel
S1106
Up-convert predetermined band signal whose channel distortion is compensated into RF signal and perform radio transmission
S1107
Down-convert up-converted RF signal into predetermined band signal
S1108
End

FIG. 12


1201
Demodulator
1202
Channel estimator
1203
Converter

FIG. 13

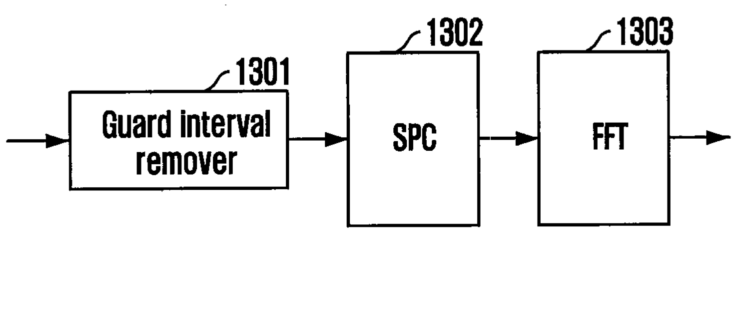

1301
Guard interval remover
1302
SPC
1303
FFT

FIG. 14

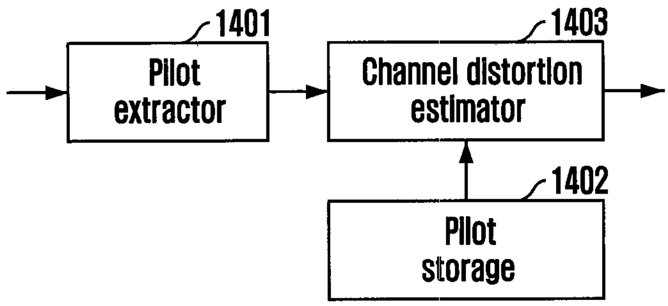

1401
Pilot extractor
1403
Channel distortion estimator
1402
Pilot storage

FIG. 15

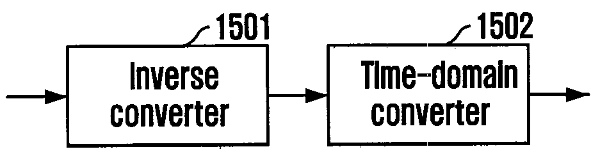
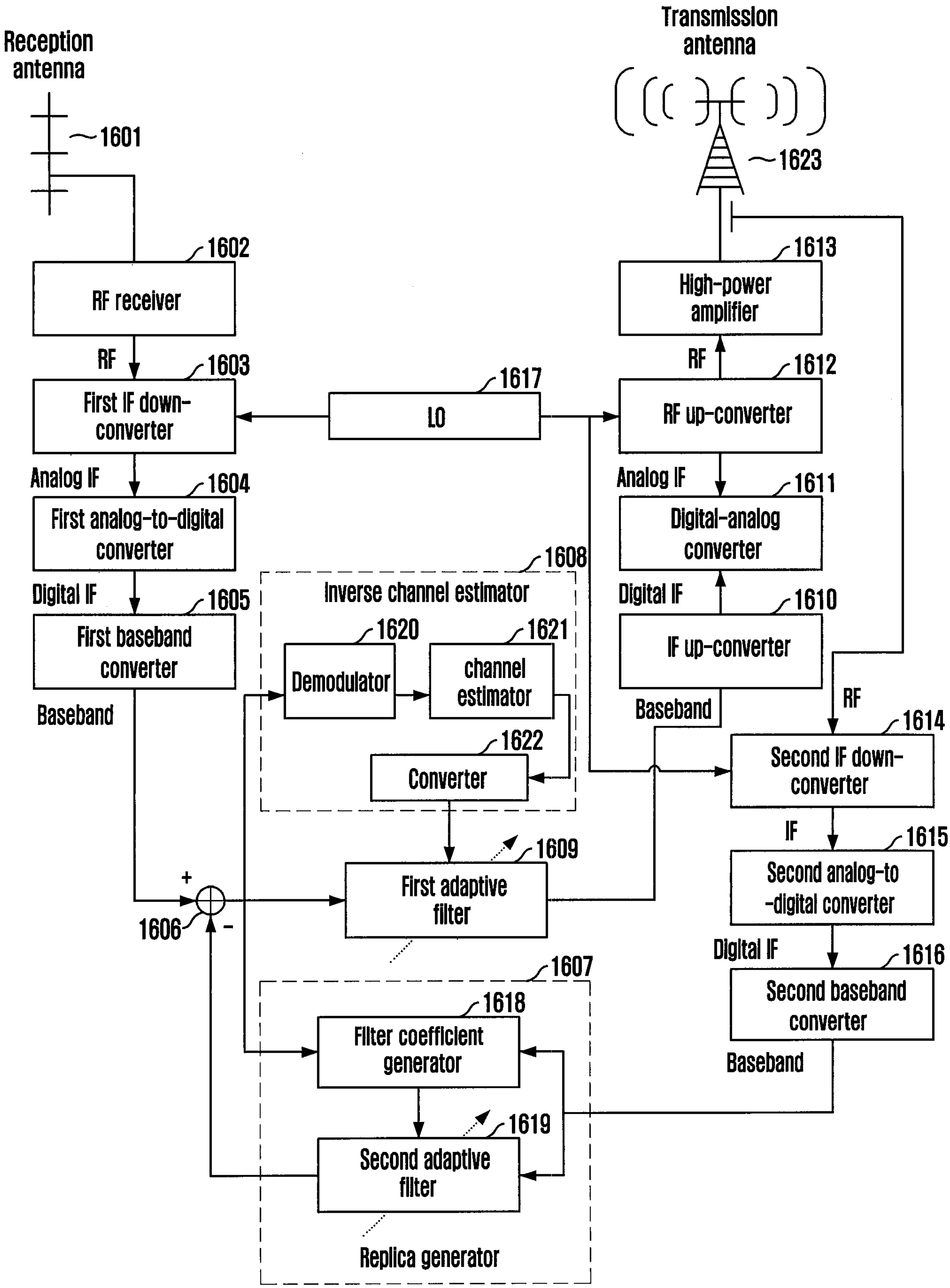

1501
Inverse converter
1502
Time-domain converter

FIG. 16


Reception antenna
1601
Transmission antenna
1623
1602
RF receiver
RF
1603
First IF down-converter
1617
LO
1613
High-power amplifier
RF
1612
RF up-converter
Analog IF
1604
First analog-to-digital converter
Analog IF
1611
Digital-analog converter
Digital IF
1605
First baseband converter
Baseband
1608
Inverse channel estimator
1620
Demodulator
1621
channel estimator
1622
Converter
Digital IF
1610
IF up-converter
Baseband
RF
1614
Second IF down-converter
IF
1615
Second analog-to -digital converter
Digital IF
1616
Second baseband converter
Baseband
+
1606
-
1609
First adaptive filter
1607
1618
Filter coefficient generator
1619
Second adaptive filter
Replica generator

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/005650

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/14(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 8 : H04B 7/14, H04N 7/015

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal) "co-channel repeater", "identical channel repeater"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006/115320 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 2 November 2006 See abstract, claims 1-22, and figs. 8 and 11.	1-46
A	WO 2005/109876 A1 (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 17 November 2005 See abstract, and fig. 6	1-46

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 APRIL 2008 (15.04.2008)	**15 APRIL 2008 (15.04.2008)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	LEE, JEONG SU
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5684

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/005650

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO2006115320A1	02.11.2006	CA2605834A1	02.11.2006
		KR1020060112586A	01.11.2006
WO2005109876A1	17.11.2005	CA2564236A1	17.11.2005
		CN1961577A	09.05.2007
		KR1020050109043A	17.11.2005
		MXPA06013060A	14.02.2007
		US20070224934A1	27.09.2007