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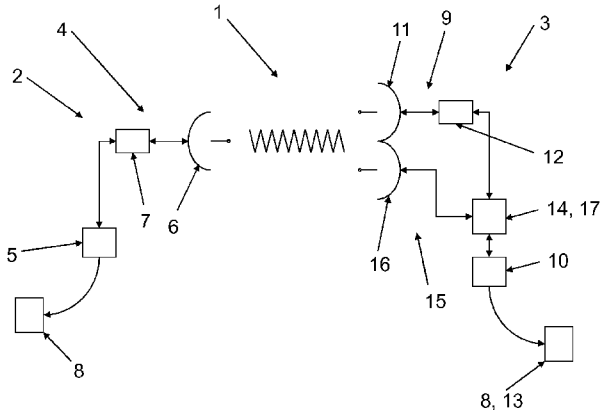

Fig. 2

(57) Abstract: The invention relates to a wireless communication system, comprising a point-to-point radio link, the point-to-point radio link comprising a receiving unit with a split configuration and a transmitting unit with a split configuration. The transmitting unit comprises a first modem unit connected to a first network where the first modem unit unit is capable of supporting a baudrate larger than the width of the licensed communication channel. A first transmitting antenna unit is connected to the first modem unit, the first transmitting unit transmitting signals in a predetermined frequency band. The receiving unit comprises a second modem unit connected to said first network or a second network and also capable of supporting a baudrate larger than the width of the licensed communication channel, a first receiving antenna unit connected to the second modem unit, the first receiving antenna unit receiving the signals from the first transmitting radio antenna. Said receiving unit further comprises a second receiving antenna unit and a first upgrade device connected to the first receiving antenna unit, the second receiving antenna unit and the second modem unit. The second receiving antenna unit receives signals from the first transmitting antenna unit and the first upgrade device comprises means for signal processing improving the signal quality of the system and/or allowing for an increased data throughput in the wireless communication system.

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TITLE

Improved wireless communication system

TECHNICAL FIELD

The present invention relates to a wireless communication system comprising a point-to-point radio link in split configuration. The point-to-point radio link in split configuration comprises a receiving unit and a transmitting unit. The transmitting unit comprises a first modem unit connected to a first network, the first modem unit being capable of supporting a baudrate larger than the width of the licensed communication channel.

The wireless communication system further comprises a first transmitting antenna unit connected to the first modem unit, the first transmitting unit transmitting signals in the licensed frequency band, the receiving unit comprises a second modem unit also capable of supporting a baudrate larger than the width of a licensed communication channel and connected to said first network or a second network, a first receiving antenna unit connected to the second modem unit, the first receiving antenna unit receiving the signals from the first transmitting radio antenna. A method for improving the throughput of a wireless communication system is also provided.

BACKGROUND ART

Today the entire modem unit of a point-to-point wireless communication system with a split configuration is replaced when upgrading to a multi-antenna system. This is done even though the actual capacity (in bps processing speed) of the modem unit may be sufficient also for the new capacity. Hereinafter, “Split configuration” means that the radio unit and antennae are spatially separated from the modem unit and traffic handling units and connected by means of some type of analog or digital interface, often but not always cable-based.

As an example, a state-of-the-art indoor modem unit designed for operation in a single antenna system with channel bandwidths up to 112 MHz (approximately 100 Mbaud symbolrate), and a maximum modulation order of 10 bits/symbol (e.g. 1024-QAM) may handle a throughput of up to 1Gbps of traffic including overhead. However, if the spectrum license only permits the use of a 7MHz wide channel the actual throughput will only be about 50 Mbps of traffic (including overhead).

Due to increased user traffic in cellular networks, there is a need for increased capacity in already deployed split configuration wireless communication networks. Since spectrum is scarce, and its use strictly regulated by government bodies; this implies a need for improved spectral efficiency (more bits/sec/Hz).

SUMMARY OF THE INVENTION

The present invention provides a wireless communication system and a method for improving the throughput of a wireless communication system as described in the accompanying claims.

It is an object of the invention to remedy at least some of the problems mentioned above and this is provided through the following aspects of the invention.

The present invention is based on upgrading an existing wireless communication system where the spectrum license limits the data throughput of the system without having to replace the existing hardware of the wireless communication system. This removes the need for replacing existing hardware when an increased data throughput, or additional interfaces towards transmitting units, are needed.

In order to save installation cost and time, the upgrade to multi-antenna systems can be done transparently to the indoor unit in cases where the

indoor unit is run below capacity. Thus, the existing hardware is re-configured and re-used. This is achieved by connecting an upgrade device between the old outdoor hardware and the indoor hardware. The upgrade device increases the spectral efficiency of the system by more advanced digital signal processing than present in the previously installed hardware. The baudrate of the indoor unit can therefore be increased without violating the spectrum license, since the air interface is run at the old baudrate, but at a higher spectral efficiency.

Improved spectral efficiency can be obtained using well-known multi-antenna solutions. Examples include; space diversity combining (SDC) that enables the use of higher order modulations (e.g. 1024-QAM). Cross-polar interference cancellation (XPIC) that exploits both horizontally and vertically polarized signaling to increase throughput, and multiple-input multiple-output (MIMO) systems, that exploit the spatial diversity of the radio channel in order to increase throughput.

The present invention describes a wireless communication system comprising a point-to-point radio link in split configuration. The point-to-point radio link in split configuration comprises a receiving unit and a transmitting unit. The transmitting unit comprises a first modem unit connected to a first network, the first modem unit being capable of supporting a baudrate larger than the width of the licensed communication channel.

The wireless communication system further comprises a first transmitting antenna unit connected to the first modem unit, the first transmitting unit transmitting signals in the licensed frequency band. The receiving unit comprises a second modem unit also capable of supporting a baudrate larger than the width of a licensed communication channel and connected to said first network or a second network, and a first receiving antenna unit connected to the second modem unit The first receiving antenna unit receivs the signals from the first transmitting radio antenna. Said receiving unit

further comprises a second receiving antenna unit and a first upgrade device connected to the first receiving antenna unit, the second receiving antenna unit and the second modem unit, the second receiving antenna unit receiving signals from the first transmitting radio antenna. The first upgrade device comprises means for signal processing improving the signal quality of the system and/or allowing for an increased data throughput of the wireless communication system.

The advantage of the invention is to allow for a better use of the first modem unit which is capable of supporting a baudrate larger than the width of the licensed communication channel. The invention thus allows for a baudrate in the modem unit higher than the limited spectrum license allowed for the prior art case when using only one transmitting antenna and one receiving antenna.

The networks to which the first and second modem units may be connected to may be a computer network such as the Internet or a local area network or an analogue telephone network. Other kinds of networks where modem units are suitable means for communication are also possible.

The transmitting unit of the wireless communication system may further comprise a second transmitting antenna unit and a second upgrade device connected to the first transmitting antenna unit, the second transmitting antenna unit and the first modem unit where the second transmitting antenna unit is transmitting signals in the predetermined frequency band. The second receiving antenna unit may receive signals from the first and second transmitting antenna units and the first upgrade device and the second upgrade device may comprise means for signal processing for increasing the spectral efficiency and/or improving the signal quality of the system allowing increased data throughput of the wireless communication system.

The first modem unit and the first and/or second transmitting antenna units are designed to communicate at a first intermediate frequency modulated at a first modulation baudrate and the second modem unit and the first and/or second receiving antenna unit are designed to communicate at a second intermediate frequency modulated at a second modulation baudrate

The baseband signal may undergo signal processing by the second upgrade device to produce a signal processed baseband signal.

The signal processed baseband signal may be modulated at a third modulation baudrate different from or the same as the second modulation baudrate to produce a modulated signal processed base band signal.

The modulated signal processed base band signal may be up-converted by the second upgrade device to the second intermediate frequency.

The first and second upgrade devices may comprise means for analogue-to-digital conversion and means for digital-to-analogue conversion.

The present invention also describes a method for improving the throughput of a wireless communication system, the wireless communication system comprising a point-to-point radio link with a split configuration, the point-to-point radio link with a split configuration comprising a receiving unit and a transmitting unit; the transmitting unit comprising a first modem unit connected to a first network, the first modem unit being capable of supporting a baudrate larger than the width of the licensed communication channel, a first transmitting antenna unit connected to the first modem unit, the first transmitting unit transmitting signals in a predetermined frequency band where the first modem unit and the first transmitting antenna unit are designed to communicate at a first intermediate frequency modulated at a first modulation baudrate; the receiving unit comprises a second modem unit connected to said first network or a second network, a first receiving antenna

unit connected to the second modem unit, the first receiving antenna unit receiving the signals from the first transmitting radio antenna where the second modem unit and the first receiving antenna unit are designed to communicate at a second intermediate frequency modulated at a second modulation baudrate. Said receiving unit further comprises a second receiving antenna unit and a first upgrade device connected to the first receiving antenna unit, the second receiving antenna unit and the second modem unit, the second receiving antenna unit receiving signals from the first transmitting radio antenna. The first upgrade device comprising means for signal processing improving the signal quality of the system allowing increased data throughput of the wireless communication system and in that the method comprises the steps of:

- down-converting the second intermediate frequency by the first upgrade device to produce a baseband signal;
- performing signal processing of the baseband signal by the first upgrade device to produce a signal processed baseband signal;
- modulating the signal processed baseband signal at a third modulation baudrate different from the second modulation baudrate to produce a modulated signal processed base band signal;
-up-converting the modulated signal processed base band signal by the first upgrade device to the second intermediate frequency.

The method may further be adapted for that said transmitting unit further comprises a second transmitting antenna unit and a second upgrade device connected to the first transmitting antenna unit, the second transmitting antenna unit and the first modem unit, the second transmitting antenna unit transmitting signals in the predetermined frequency band. The second receiving antenna unit may receive signals from the first and second transmitting radio antenna and the first upgrade device and the second upgrade device may comprise means for signal processing for increasing the spectral efficiency and/or improving the signal quality of the system allowing increased data throughput of the wireless communication system.

Of course, the method may be further adapted for that said transmitting unit comprises more than two transmitting antenna units. Also, the method may be further adapted for that said receiving unit comprises more than two receiving units.

The method may further be adapted for that the first and second upgrade devices comprise means for analogue-to-digital conversion and means for digital-to-analogue conversion.

Further details, aspects and embodiments of the invention will be described, by way of example only, with reference to the drawings. Elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 schematically illustrates a wireless system according to prior art;

Figure 2 schematically illustrates the invention according to a general configuration;

Figure 3 schematically illustrates the architecture of the upgrade device of the invention;

Figure 4 schematically illustrates the invention according to a first aspect of the invention;

Figure 5 schematically illustrates the invention according to a second aspect of the invention;

Figure 6 schematically illustrates the invention according to a third aspect of the invention;

Figure 7 schematically illustrates the invention according to a fourth aspect of the invention;

DETAILED DESCRIPTION

In figures 1-7 the same reference numbers are used for like features.

The invention relates to a wireless communication system comprising a point-to-point radio link. A point-to-point radio link refers to a radio connection restricted to two endpoints, i.e. with one transmitting unit and one receiving unit.

The point-to-point radio link comprises a receiving unit in a split configuration and a transmitting unit in a split configuration. Split configuration means that the transmitting unit and the receiving unit each are divided into separate components such as an antenna, a unit for modulating/demodulating an RF signal to/from an IF signal and a modem unit for analogue-to-digital/digital-to-analogue conversion of the IF signal. The separate components are often spatially separated, i.e. the antenna is located on for instance a mast outdoors while the modem unit is located at or around ground level and indoors.

The modem unit is capable of a predetermined data throughput, for instance 1 Gbps of traffic including overhead. Limitations of the available spectrum due to limited spectrum licenses reduce the baudrate of the entire wireless system to for instance 50 Mbps of traffic including overhead. The modem unit is thus capable of a higher throughput than the data throughput of the wireless communication system.

Figure 1 schematically illustrates a wireless communication system according to prior art. The wireless communication system 1 is a point-to point radio link comprising a transmitting unit 2 and a receiving unit 3. The transmitting unit 2

comprises a first transmitting antenna unit 4 and a first modem unit 5. The first transmitting antenna unit 4 is connected to the first modem unit 5 and comprises a first transmitting antenna 6 and first transmitting means 7 for modulating an IF signal from the first modem unit 5 to an RF signal to be used by the first transmitting antenna 6. The first modem unit 5 is connected to a first network 8. The network may be a computer network such as the Internet or a local area network or an analogue telephone network. The first transmitting unit 2 is transmitting signals in a predetermined frequency band. The first modem unit 5 and the first transmitting antenna unit 4 are designed to communicate at a first intermediate frequency modulated at a first modulation baudrate.

The receiving unit 3 comprises a first receiving antenna unit 9 and a second modem unit 10. The first receiving antenna unit 9 comprises a first receiving antenna 11 and first receiving means 12 for demodulating an RF signal from the first receiving antenna 11 to an IF signal to be used by the second modem unit 10. The first receiving antenna unit 9 is connected to the second modem unit 10. The second modem unit 10 is connected to said first network 8 or a second network 13 similar or different from the first network 8. The first receiving antenna unit 9 is receiving the signals from the first transmitting antenna 6. The second modem unit 10 and the first receiving antenna unit 9 are designed to communicate at a second intermediate frequency modulated at a second modulation baudrate.

The first transmitting antenna unit 4 comprises a first transmitting antenna 6 adapted to transmit an RF signal at least in a predetermined frequency band and first transmitting means 7 for modulating an IF signal from the first modem unit 5 to said RF signal. The first receiving antenna unit 9 comprises a first receiving antenna 11 adapted to receive RF signals in a frequency range at least corresponding to the frequency range of the first transmitting antenna 6 and first receiving means 12 for demodulating an RF signal to an IF signal to be used by the first modem unit 5. The above is valid for all

transmitting units and receiving units referred to below. The transmitting antenna units and the receiving antenna units may comprise additional features necessary for operating.

It is understood in the description below that the transmitting unit is connected to a first network and that the receiving unit is connected to a first and/or second network as described above.

This system is limited by the limitations in the available spectrum as only a small part of the first and second modem unit's capacities are used as described above.

Figure 2 schematically illustrates the invention according to a general configuration. The wireless communication system 1 as described in figure 1 comprises a first upgrade device 14 connected to the first receiving antenna unit 9 and the second modem unit 10 in the receiving unit 3. A second receiving antenna unit 15 is connected to the first upgrade device 14. The second receiving antenna unit 15 comprises a second receiving antenna 16 and second receiving means 17 for demodulating the RF signal to an IF signal. The second receiving means 17 may be separate from the first upgrade device 14 or an integrated part of the first upgrade device 14. In figure 2 the second receiving means 17 are integrated in the first upgrade device 14. The first upgrade device 14 is designed to communicate at the second intermediate frequency modulated at the second modulation baudrate. The first upgrade device 14 is adapted for different kinds of signal processing in order to increase the spectral efficiency and/or improving the signal quality of the system allowing increased data throughput of the wireless communication system 1 depending on the configuration of the wireless communication system 1. The addition of the first upgrade device 14 and the second receiving antenna unit 15 allows for the wireless communication system 1 to transmit data using the limited spectrum license and still increase the data throughput of the wireless communication system

1 without having to replace the entire existing wireless communication system 1.

It is understood that what is described above may be valid for a transmitting unit with an additional transmitting antenna unit and an upgrade device on the transmitting unit instead of an additional receiving antenna unit and an upgrade device on the receiving unit. Of course both sides may be equipped with additional antenna units and upgrade devices.

Figure 3 schematically illustrates the architecture of the first upgrade device 14 of the invention. Here the different steps for increasing the throughput of the receiving unit 3 of the wireless communication system 1 are schematically shown. The same steps apply for all upgrade devices described herein with the order of the steps reversed and the functionality if the components reversed for the upgrade devices of the transmitting unit 2.

First an RF signal is received in the first receiving antenna unit 9 and the second receiving antenna unit 15. Thereafter the RF signal is demodulated to the second IF signal by the first receiving means 12 and the second receiving means. In figure 3 the first receiving means 12 and second receiving means 17 are shown to be separate from the first upgrade device 14. It is possible to integrate the first receiving means 12 and second receiving means 17 in the first upgrade device 14. The second intermediate frequency is down-converted by the first upgrade device 14 to baseband of all input signals to produce a baseband signal in down-conversion means 18 which may be made up of one single means or several means, one for each receiving antenna unit. The down-conversion is made by any suitable method known in the art. The baseband signal then undergoes signal processing by the first upgrade device 14 to produce a signal processed baseband signal in signal processing means 19. The signal processed baseband signal is then modulated at a third modulation baudrate that may be the same or different from the second modulation baudrate to produce a modulated signal

processed base band signal. The modulated signal processed base band signal is then up-converted by the first upgrade device 14 to the second intermediate frequency by up-conversion means 20. The up-conversion is made by any suitable method known in the art. The second intermediate frequency may be modulated to an RF signal by other equipment (not shown).

In figure 3 an upgrade device with two interfaces for connecting with the receiving/transmitting antenna units are shown. There may be more than two interfaces in an upgrade device to allow for connection of more than two receiving/transmitting antenna units to an upgrade device. There may also be more than one connection on the other side of the upgrade device for connection to more than one modem unit. Further a modem unit may have more than one interface allowing for connection of multiple upgrade devices.

Figure 4 schematically shows a wireless communication system 1 according to a first aspect of the invention where the receiving unit 3 comprises a second receiving antenna unit 15 in addition to an existing first receiving antenna unit 9. The second receiving antenna unit 15 comprises a second receiving antenna 16 and second receiving means 17 for demodulating the RF signal to an IF signal. The second receiving means 17 may be separate from the first upgrade device 14 or an integrated part of the first upgrade device 14. In figure 4 the second receiving means 17 are integrated in the first upgrade device 14. Both the first receiving antenna unit 9 and the second receiving antenna unit 15 are connected to the first upgrade device 14 and to the second modem unit 10. The first upgrade device 14 comprises signal processing means 19 adapted to use SDC for improving the signal-to-noise (SNR) ratio. A better SNR ratio enables higher order modulation of the signal thereby increasing the spectral efficiency and improving the data throughput of the wireless communication system 1.

Figure 5 schematically shows a wireless communication system 1 according to a second aspect of the invention where the wireless communication system 1 comprises a transmitting unit 2 with a second transmitting antenna unit 21 in addition to the first transmitting antenna unit 4. The second transmitting antenna unit 21 comprises a second transmitting antenna 22 and second transmitting means 23 similar to the first transmitting means 7. In figure 5 the second transmitting means are integrated in the second upgrade device 24. The first transmitting antenna unit 4 and second transmitting antenna unit 21 are capable of transmitting with different degrees of polarization, the first transmitting antenna unit 4 for instance transmitting a signal with horizontal polarization and the second transmitting antenna unit 21 for instance transmitting a signal with vertical polarization. The first transmitting antenna unit 4 and the second transmitting antenna unit 21 are connected to a second upgrade device 24 and the first modem unit 5. The second upgrade device 24 has similar characteristics and functionality as the first upgrade device 14. The wireless communication system 1 further comprises a receiving unit 3 with a second receiving antenna unit 15 in addition to the first receiving antenna unit 9 connected to a first upgrade device 14 and the second modem unit 10. The second receiving antenna unit 15 comprises a second receiving antenna 16 and second receiving means 17 for demodulating the RF signal to an IF signal. The second receiving means 17 may be separate from the first upgrade device 14 or an integrated part of the first upgrade device 14. In figure 5 the second receiving means 17 are integrated in the first upgrade device 14. The first receiving antenna unit 9 and second receiving antenna unit 15 are capable of receiving the signals with different degrees of polarization from the first transmitting antenna unit 4 and the second transmitting antenna unit 21. The receiving unit 3 further comprises a first upgrade device 14 connected to the first receiving antenna unit 9 and the second modem unit 10. The first upgrade device 14 comprises signal processing means to remove the cross-polar interference caused by the second transmitting antenna unit 21 and hence

the second modem unit 10 is unaware and not affected by the increased interference caused by the differently polarized interfering signal. Thus the signal processing means 19 in the first upgrade device 14 feeds a clean signal to the second modem unit 10 modulated at a higher baudrate. This improves the data throughput of the wireless communication system 1 by around a factor of two.

Figure 6 schematically shows a wireless communication system 1 according to a third aspect of the invention where the transmitting unit 2 comprises a second transmitting antenna unit 21 in addition to the first transmitting antenna unit 4. The second transmitting antenna unit 21 comprises a second transmitting antenna 22 and second transmitting means 23 similar to the first transmitting means 7. In figure 6 the second transmitting means are integrated in the second upgrade device 24. The first transmitting antenna unit 4 and the second transmitting antenna unit 21 are connected to a second upgrade device 24 and the first modem unit 5. The second upgrade device 24 has similar characteristics and functionality as the first upgrade device 14. The wireless communication system 1 further comprises a receiving unit 3 with a second receiving antenna unit 15 in addition to the first receiving antenna unit 9 connected to the first upgrade device 14 and the second modem unit 10. The second receiving antenna unit 15 comprises a second receiving antenna 16 and second receiving means 17 for demodulating the RF signal to an IF signal. The second receiving means 17 may be separate from the first upgrade device 14 or an integrated part of the first upgrade device 14. In figure 6 the second receiving means 17 are integrated in the first upgrade device 14. The receiving unit 3 further comprises a first upgrade device 14 connected to the first receiving antenna unit 9 and the second modem unit 10. The first upgrade device 14 comprises signal processing means 19 adapted to use 2x2 MIMO signalling, thus enabling the wireless communication system 1 to run at around double capacity thereby improving the data throughput of the wireless communication system 1.

Figure 7 schematically shows a wireless communication system 1 according to a fourth aspect of the invention where the transmitting unit 2 comprises a second transmitting antenna unit 21, a third transmitting antenna unit 25 and a fourth transmitting antenna unit 26 connected to the second upgrade device and the first modem unit. The second transmitting antenna unit 21 comprises a second transmitting antenna 22 and second transmitting means 23 similar to the first transmitting means 7. The third transmitting antenna unit 25 comprises a third transmitting antenna 27 and third transmitting means 28 similar to the first transmitting means 7. The fourth transmitting antenna unit 26 comprises a fourth transmitting antenna 29 and fourth transmitting means 30 similar to the first transmitting means 7. In figure 7 the second transmitting means 23, the third transmitting means 28 and the fourth transmitting means 30 are all integrated in the second upgrade device 24. The transmitting antenna units 4, 21, 25, 26 all transmit signals with different polarizations. For instance the first transmitting antenna unit 4 and second transmitting antenna unit 21 may transmit with horizontal polarization and the third transmitting antenna unit 25 and fourth transmitting antenna unit 26 may transmit with vertical polarization. The transmitting unit 2 further comprises a second upgrade device 24 connected to the transmitting antenna units 4, 21, 25, 26 and the first modem unit 5. The receiving unit 3 further comprises a second receiving antenna unit 15, a third receiving antenna unit 31 and a fourth receiving antenna unit 32 in addition to the first receiving antenna unit all connected to the first upgrade device 14 and the second modem unit 10. The second receiving antenna unit 15 comprises a second receiving antenna 16 and second receiving means 17 similar to the first receiving means 12. The third receiving antenna unit 31 comprises a third receiving antenna 33 and third receiving means 34 similar to the first receiving means 12. The fourth receiving antenna unit 32 comprises a fourth receiving antenna 35 and fourth receiving means 36 similar to the first receiving means 12. In figure 7 the second receiving means 17, the third receiving means 34 and the fourth receiving means 36 are all integrated in the first upgrade device 14. The receiving antenna units 9, 15, 31, 32 are capable of receiving the signals with

different degrees of polarization from the transmitting antenna units 4, 21, 25, 26. The receiving unit 3 further comprises a first upgrade device 14 connected to the receiving antenna units 9, 15, 31, 32 and the second modem unit 10. The first upgrade device 14 comprises signal processing means 19 adapted to use 4x4 MIMO without the second modem unit 10 being aware of the increased interference caused by the additional transmitted signals. The signal processing means 19 in the first upgrade device 14 removes the interference and feeds a clean signal to the second modem unit 10. This improves the data throughput of the wireless communication system 1 by around four times.

Further antennas may be added in a similar way to further increase the data throughput of the wireless communication system.

The existing hardware in the transmitting unit 2 may be capable of a higher baud-rate, but may not necessarily support a higher order modulation. If for instance, the second transmitting antenna 22 is a multi-TX antenna system a second upgrade device 24 may be needed in order to separate and modulate each data stream going to each of the first and second receiving antenna units 9, 15. The same argumentation applies to systems with more than two transmitting antenna units and receiving antenna units.

The first upgrade device 14 and the second upgrade 24 device may comprise one or more of the above described signal processing means 19.

Although the above invention is described in terms of receiving and transmitting units it is understood that this is merely for descriptive purposes. A transmitting unit may function as a receiving unit and vice versa depending on the situation. All of the above aspects of the invention may therefore co-exist in one wireless communication system. The upgrade devices described herein may be locally or remotely set to use one or more of the above described signal processing means. Further, it is understood that the signals

coming from the transmitting antenna unit or transmitting antenna units depending on the aspect of the invention reaches all of the receiving antenna units.

CLAIMS

1. A wireless communication system (1) comprising a point-to-point radio link in split configuration, the point-to-point radio link in split configuration comprising a receiving unit (3) and a transmitting unit (2), the transmitting unit (2) comprising a first modem unit (5) connected to a first network (8), the first modem unit (5) being capable of supporting a baudrate larger than the width of a licensed communication channel, the wireless communication system (1) further comprising a first transmitting antenna unit (4) connected to the first modem unit (5), the first transmitting unit (2) transmitting signals in the licensed frequency band, the receiving unit (3) comprising a second modem unit (10) also capable of supporting a baudrate larger than the width of the licensed communication channel and connected to said first network or a second network, a first receiving antenna unit (9) connected to the second modem unit (10), the first receiving antenna unit (9) receiving the signals from the first transmitting radio antenna unit (4), the invention is characterized in that said receiving unit (3) further comprises a second receiving antenna unit (15) and a first upgrade device (14) connected to the first receiving antenna unit (9), the second receiving antenna unit (15) and the second modem unit (10), the second receiving antenna unit receiving signals from the first transmitting radio antenna unit (4), the first upgrade device (14) comprising means for signal processing improving the signal quality of the system allowing for an increased data throughput of the wireless communication system.

2. Wireless communication system (1) according to claim 1, **characterized in that** said transmitting unit (2) further comprises a second transmitting antenna unit (21) and a second upgrade device (24) connected to the first transmitting antenna unit (4), the second transmitting antenna unit (21) and the first modem unit (5), the second transmitting antenna unit (21) transmitting signals in the predetermined frequency band, and **in that** the second receiving antenna unit (15) receiving signals from the first

transmitting antenna unit (4) and/or the second transmitting antenna unit (21) and **in that** the first upgrade device (14) and the second upgrade device (24) comprising signal processing means (19) for increasing the spectral efficiency and/or improving the signal quality of the wireless communication system (1) allowing increased data throughput of the wireless communication system (1).

3. Wireless communication system (1) according to claim 1 or 2, **characterized in that** the first modem unit (5) and the first transmitting antenna unit (4) and/or the second transmitting antenna unit (21) are designed to communicate at a first intermediate frequency modulated at a first modulation baudrate and where the second modem (10) and the first receiving antenna unit (9) and/or the second receiving antenna unit (15) are designed to communicate at a second intermediate frequency modulated at a second modulation baudrate

4. Wireless communication system (1) according to any one of claims 1-3, **characterized in that** the second intermediate frequency is down-converted by the second upgrade device (24) to a baseband of all input signals to produce a baseband signal.

5. Wireless communication system (1) according to claim 4, **characterized in** that the baseband signal undergoes signal processing by the second upgrade device (24) to produce a signal processed baseband signal.

6. Wireless communication system (1) according to claim 5, **characterized in** that the signal processed baseband signal is modulated at a third modulation baudrate different from the second modulation baudrate to produce a modulated signal processed base band signal.

7. Wireless communication system (1) according to claim 6, **characterized in** that the modulated signal processed base band signal is up-converted by the second upgrade device (24) to the second intermediate frequency.

8. Wireless communication system (1) according to any of the previous claims, **characterized in** that the first upgrade device (14) and/or the second upgrade devices (14, 24) comprises means for analogue-to-digital conversion and means for digital-to-analogue conversion.

9. Wireless communication system (1) according to any of the previous claims, **characterized in** that the first upgrade device (14) and/or the second upgrade device (24) comprises multiple interfaces for connecting to a plurality of transmitting antenna units and/or receiving antenna units.

10. Wireless communication system (1) according to any of the previous claims, **characterized in** that the first modem unit (5) and/or second modem unit (10) comprises multiple interfaces for connecting to a plurality of upgrade devices.

11. Method for improving the throughput of a wireless communication system (1), the wireless communication system (1) comprising a point-to-point radio link, the point-to-point radio link comprising a receiving unit (3) with a split configuration and a transmitting unit (2) with a split configuration; the transmitting unit (2) comprising a first modem unit (5) connected to a first network (8), the first modem unit (5) being capable of supporting a baudrate larger than the width of a licensed communication channel, a first transmitting antenna unit (4) connected to the first modem unit (5), the first transmitting unit (2) transmitting signals in a predetermined frequency band where the first modem unit (5) and the first transmitting antenna unit (4) are designed to communicate at a first intermediate frequency modulated at a first modulation baudrate; the receiving unit (3) comprising a second modem unit (10) connected to said first network (8) or a second network (13), a first receiving

antenna unit (9) connected to the second modem unit (10), the first receiving antenna unit (9) receiving the signals from the first transmitting antenna unit (4) where the second modem unit (10) and the first receiving antenna unit (9) are designed to communicate at a second intermediate frequency modulated at a second modulation baudrate, **characterized in that** said receiving unit (3) further comprises a second receiving antenna unit (15) and a first upgrade device (14) connected to the first receiving antenna unit (9), the second receiving antenna unit (15) and the second modem unit (10), the second receiving antenna unit (15) receiving signals from the first transmitting antenna unit (4) and **in that** the first upgrade device (14) comprising signal processing means (19) improving the signal quality of the system allowing increased data throughput of the wireless communication system (1) and in that the method comprises the steps of:

- down-converting the second intermediate frequency by the first upgrade device (14) to produce a baseband signal;
- performing signal processing of the baseband signal by the first upgrade device (14) to produce a signal processed baseband signal;
- modulating the signal processed baseband signal at a third modulation baudrate different from the second modulation baudrate to produce a modulated signal processed base band signal;
-up-converting the modulated signal processed base band signal by the first upgrade device (14) to the second intermediate frequency.

12. Method according to claim 11, **characterized in that** the method further comprises the step of:

- modulating the second intermediate frequency signal to an RF signal.

13. Method according to claim 11 or 12, **characterized in that** said transmitting unit (2) further comprises a second transmitting antenna unit (21) and a second upgrade device (24) connected to the first transmitting antenna unit (4), the second transmitting antenna unit (21) and the first modem unit (5), the second transmitting antenna unit (21) transmitting signals in the

predetermined frequency band, and **in that** the second receiving antenna unit (15) receiving signals from the first transmitting antenna unit and/or the second transmitting antenna unit (21) and **in that** the first upgrade device (14) and the second upgrade device (24) comprising signal processing means (19) for increasing the spectral efficiency and/or improving the signal quality of the wireless communication system (1) allowing increased data throughput of the wireless communication system (1).

14. Method according to any one of claims 11-13, **characterized in** that the first upgrade device (14) and/or the second upgrade device (24) comprises means for analogue-to-digital conversion and means for digital-to-analogue conversion.

15. Method according to any one of claims 11-14, **characterized in** that the first upgrade device (14) and/or the second upgrade device (24) comprises multiple interfaces for connecting to a plurality of transmitting antenna units and/or receiving antenna units.

16. Method according to any one of claims 11-15, **characterized in** that the first modem unit (5) and/or second modem unit (10) comprises multiple interfaces for connecting to a plurality of upgrade devices.

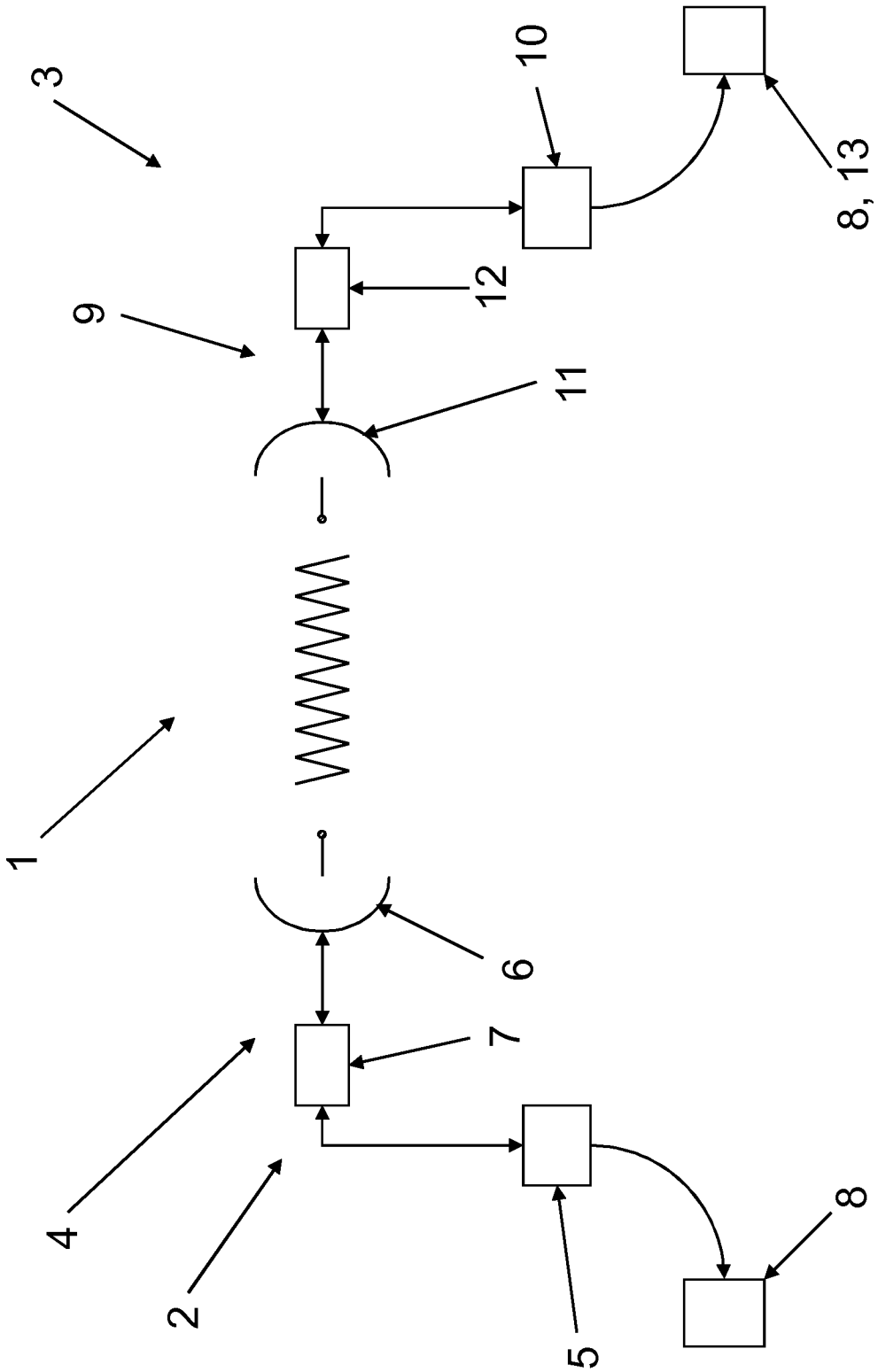

Fig. 1

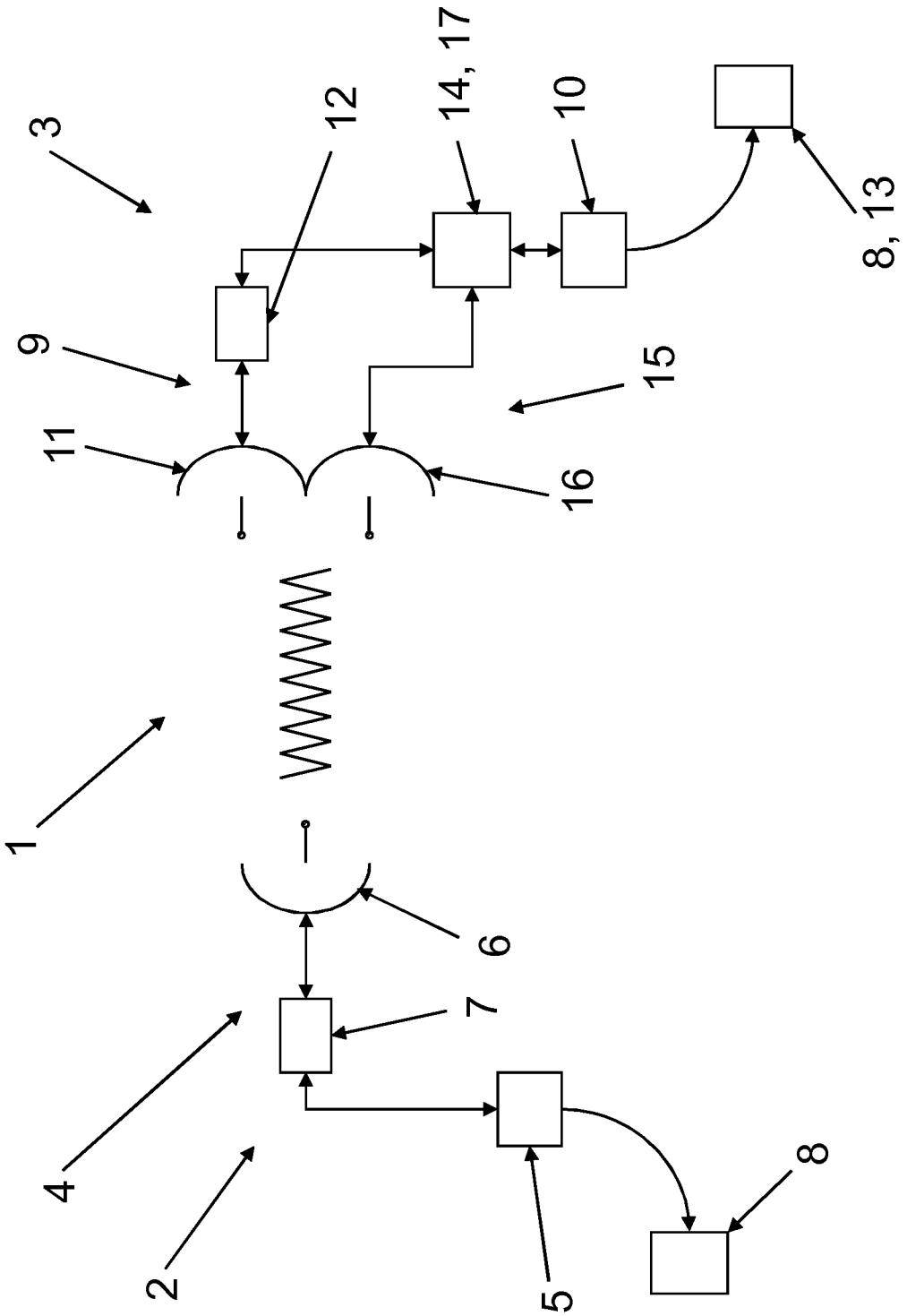

Fig. 2

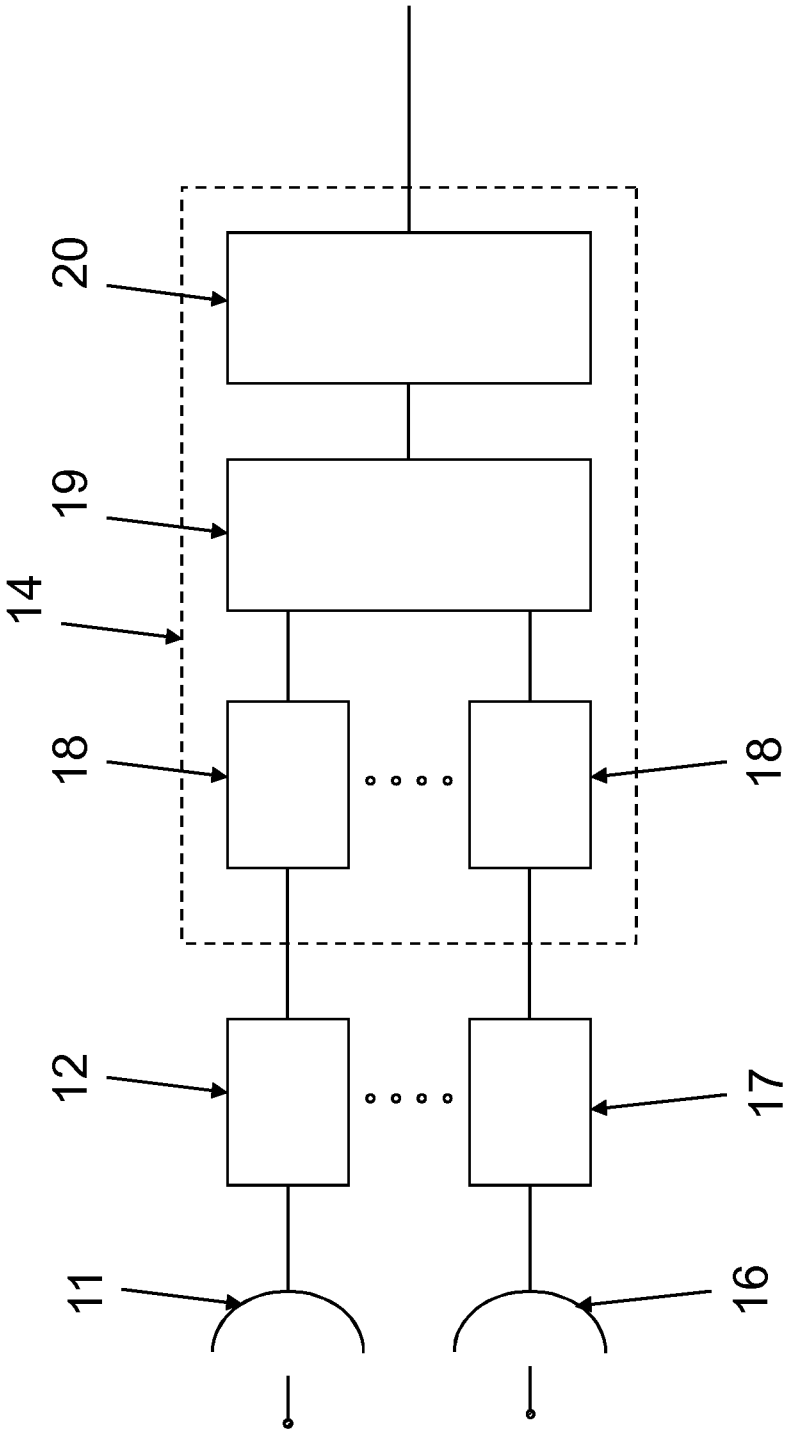

Fig. 3

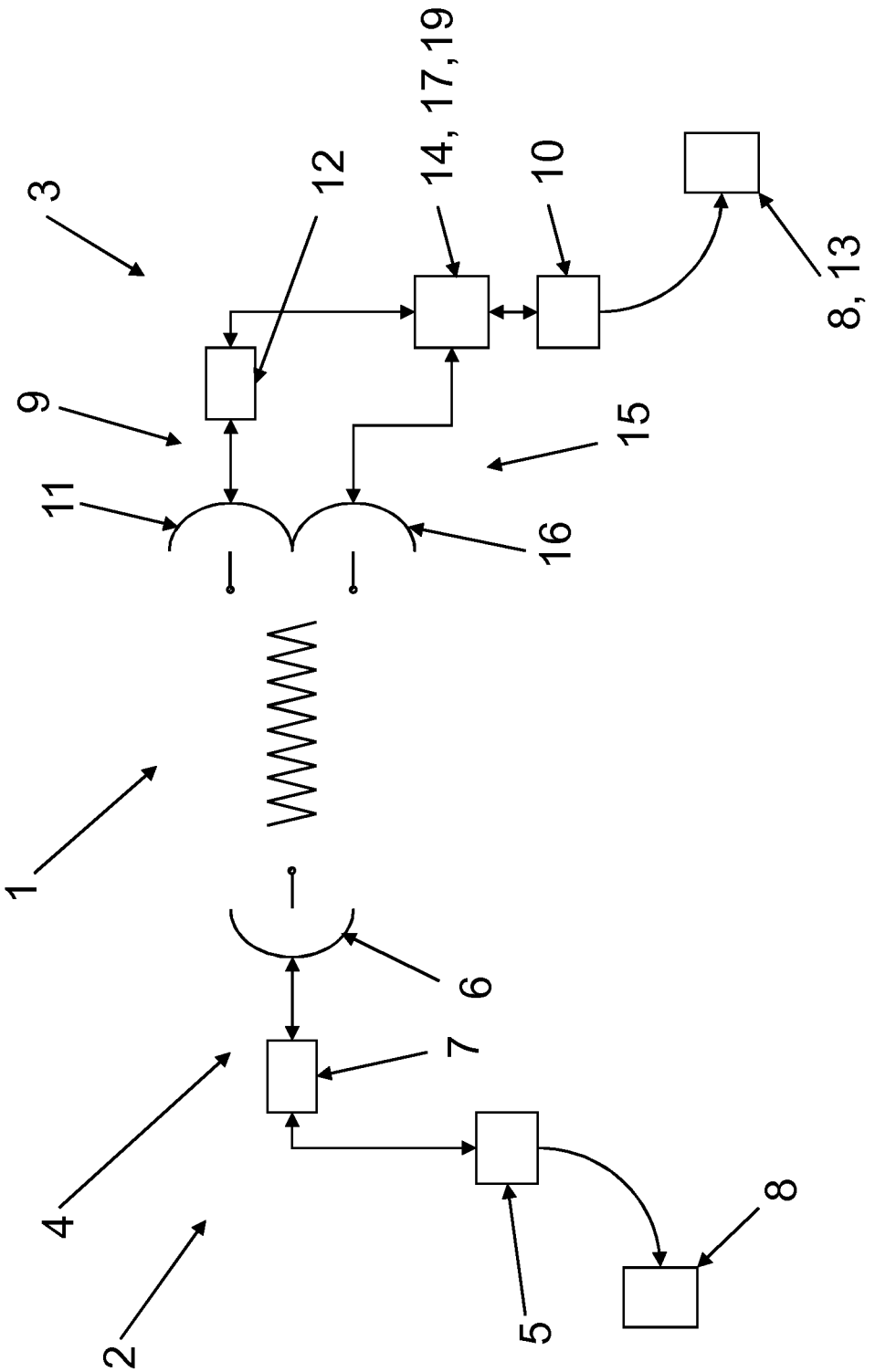

Fig. 4

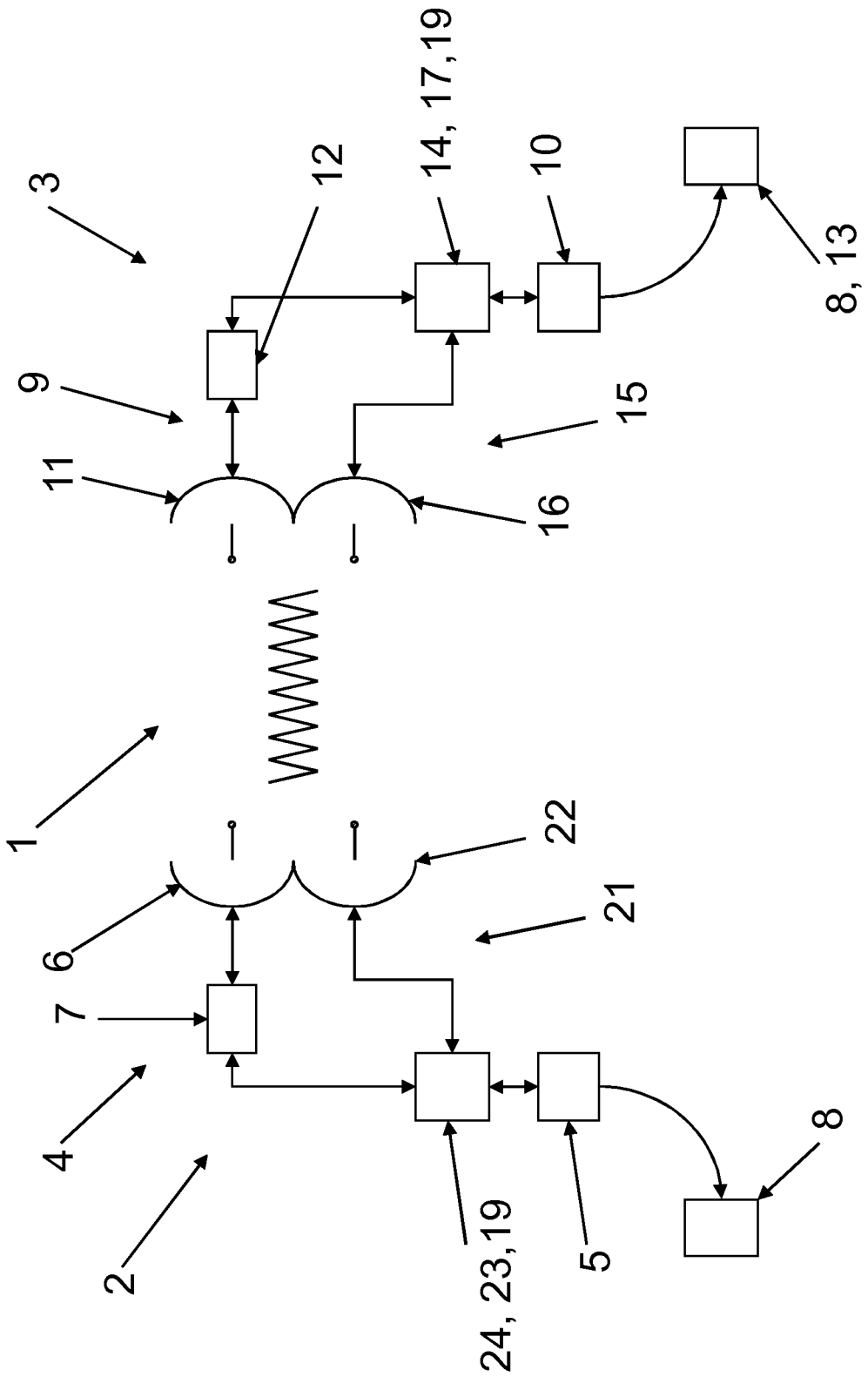

Fig. 5

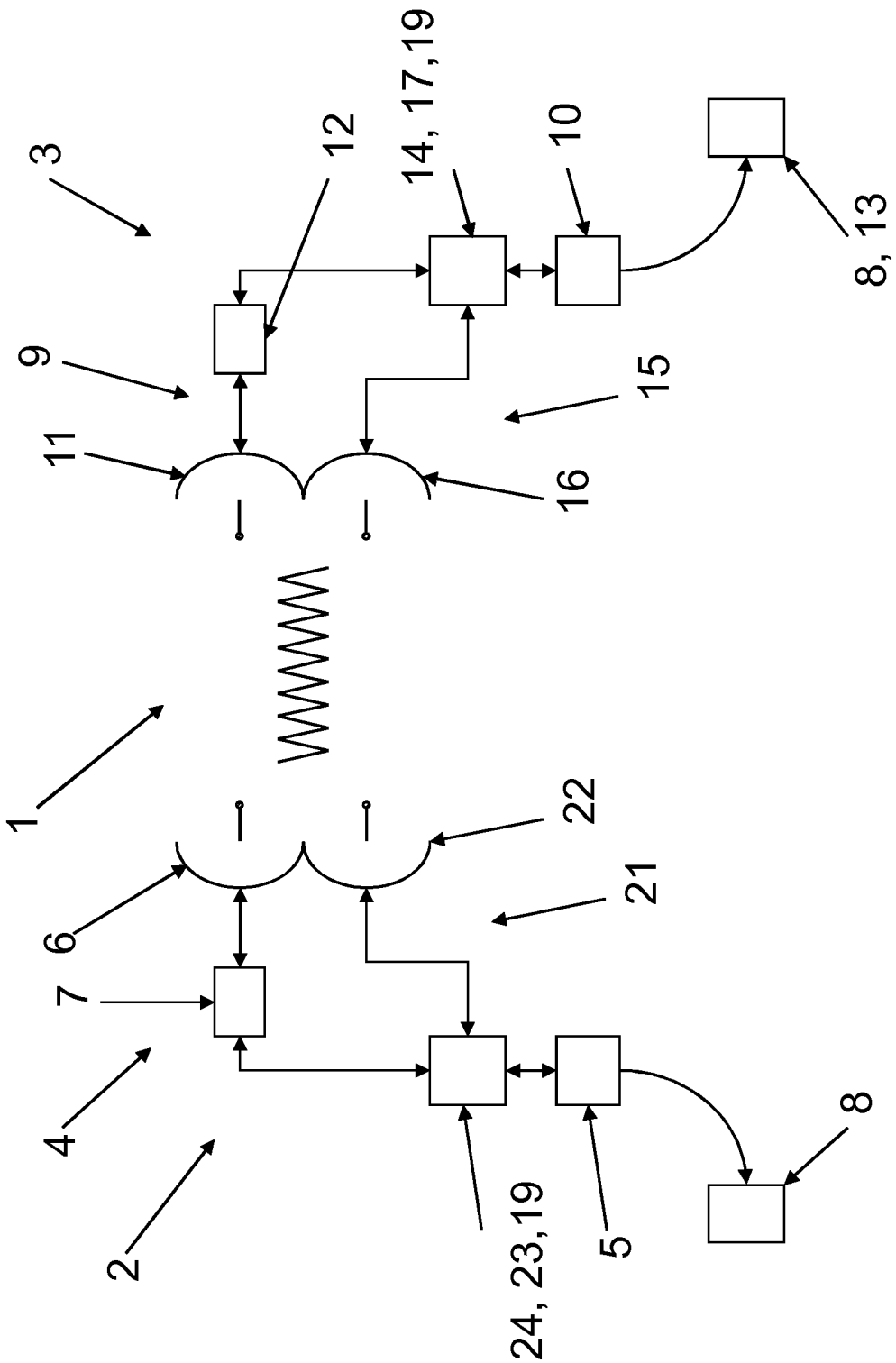

Fig. 6

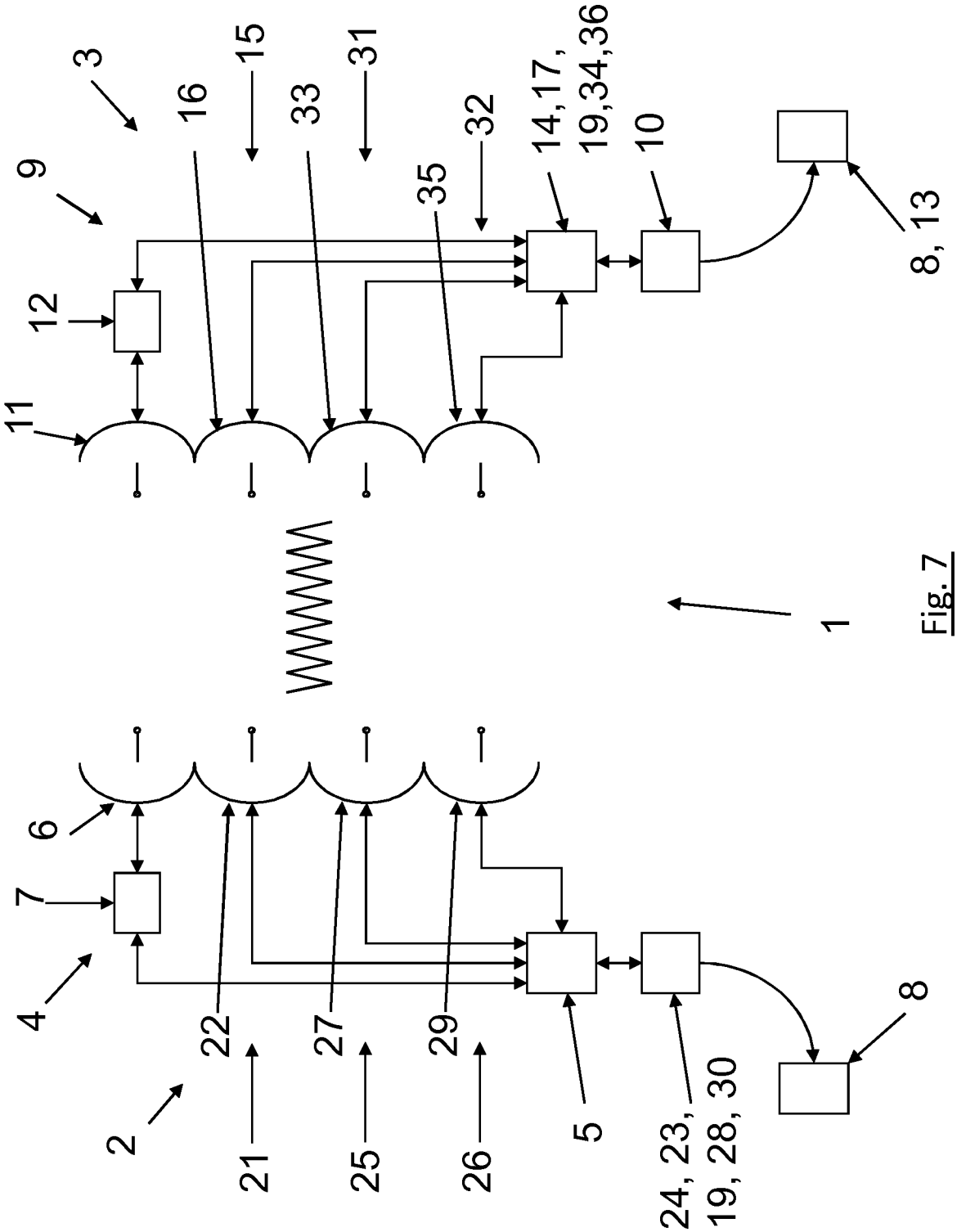
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Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/070792

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/06 H04B7/08 H04B7/04
ADD.

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)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2010/092166 A2 (SOCOWAVE TECHNOLOGIES LTD [IE]) 19 August 2010 (2010-08-19) abstract figures 4-6 page 15, lines 1-3 page 15, line 1 - page 20, line 30	1 2-16
A	US 2009/186585 A1 (AHRONY AHIKAM [IL] ET AL) 23 July 2009 (2009-07-23) paragraph [0045] paragraph [0054]	1-16
A	EP 1 160 997 A2 (LUCENT TECHNOLOGIES INC [US]) 5 December 2001 (2001-12-05) paragraph [0015] paragraph [0035]	1-16

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 September 2011	09/09/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Losada Corderí, Iker

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/260002 A1 (ZHANG HONGYUAN [US] ET AL) 23 October 2008 (2008-10-23) abstract page 1 paragraph [0008] paragraph [0017] paragraph [0021] - paragraph [0023] paragraph [0024] paragraph [0025] paragraph [0026] - paragraph [0027] -----	2-16
Y	US 2003/210750 A1 (ONGGOSANUSI EKO N [US] ET AL) 13 November 2003 (2003-11-13) abstract; figures 2a-2g paragraph [0002] paragraph [0018] paragraph [0108] paragraph [0107] paragraph [0109] - paragraph [0110] paragraph [0111] - paragraph [0123] paragraph [0124] - paragraph [0127] -----	2-16
Y	WO 2004/073249 A1 (DOCOMO COMM LAB EUROPE GMBH [DE]; BAUCH GERHARD [DE]) 26 August 2004 (2004-08-26) abstract -----	2-16
Y	EP 1 845 634 A1 (BROADCOM CORP [US]) 17 October 2007 (2007-10-17) abstract paragraph [0009] paragraph [0010] paragraph [0015] paragraph [0064] -----	2-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/070792

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010092166 A2	19-08-2010	GB 2467771 A	18-08-2010
US 2009186585 A1	23-07-2009	CN 101999209 A	30-03-2011
		EP 2245762 A2	03-11-2010
		WO 2009093232 A2	30-07-2009
		JP 2011510554 A	31-03-2011
EP 1160997 A2	05-12-2001	AU 4622201 A	06-12-2001
		BR 0102055 A	23-04-2002
		CA 2342533 A1	30-11-2001
		CN 1327319 A	19-12-2001
		JP 3902920 B2	11-04-2007
		JP 2002026781 A	25-01-2002
		US 6539209 B1	25-03-2003
US 2008260002 A1	23-10-2008	CN 101663838 A	03-03-2010
		EP 2140574 A2	06-01-2010
		JP 2010525683 A	22-07-2010
		WO 2009009199 A2	15-01-2009
US 2003210750 A1	13-11-2003	NONE	
WO 2004073249 A1	26-08-2004	AU 2003258636 A1	06-09-2004
		AU 2003303913 A1	06-09-2004
		CN 1742455 A	01-03-2006
		CN 1742456 A	01-03-2006
		DE 60313505 T2	27-12-2007
		WO 2004073247 A1	26-08-2004
		EP 1593225 A1	09-11-2005
		EP 1593226 A1	09-11-2005
		JP 4317139 B2	19-08-2009
		JP 2006515479 A	25-05-2006
		JP 4319626 B2	26-08-2009
		JP 2006517750 A	27-07-2006
		US 2006232416 A1	19-10-2006
		US 2006274846 A1	07-12-2006
EP 1845634 A1	17-10-2007	CN 101056130 A	17-10-2007