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(54) **REPETEUR DE SIGNAUX RADIO**
(54) **REPEATER FOR RADIO SIGNALS**

(57) L'invention concerne un répéteur de signaux radio, utilisé de préférence sous forme d'un répéteur portatif dans des réseaux radio numériques cellulaires. Les signaux radio reçus par les liaisons descendante et/ou montante du répéteur sont démodulés et les flux de données numériques ainsi obtenus sont à nouveau modulés selon les normes appropriées, amplifiés et retransmis. Une unité intelligente de contrôle surveille les communications de signalisation dans le réseau radio et syntonise automatiquement les canaux de fréquence transmis par le répéteur avec les canaux utilisés dans une cellule radio avoisinante afin de transférer (hand-over) la liaison radio vers une nouvelle cellule radio.

(57) A repeater for radio signals is preferably designed for mobile use in digital cellular radio networks. The radio signals received in the down-link and/or up-link of the repeater are demodulated, and the thus obtained digital data flows are then remodulated in conformity with the prevailing norms, amplified and retransmitted. An intelligent control unit monitors the signalling traffic in the radio network and automatically tunes the frequency channels transmitted by the repeater with the channels used in the neighbouring radio cell, thus enabling a hand-over of the radio connection to a new radio cell.

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(54) Title: REPEATER FOR RADIO SIGNALS

(54) Bezeichnung: REPEATER FÜR FUNKSIGNALE

(57) Abstract

A repeater for radio signals is preferably designed for mobile use in digital cellular radio networks. The radio signals received in the down–link and/or up–link of the repeater are demodulated, and the thus obtained digital data flows are then remodulated in conformity with the prevailing norms, amplified and retransmitted. An intelligent control unit monitors the signalling traffic in the radio network and automatically tunes the frequency channels transmitted by the repeater with the channels used in the neighbouring radio cell, thus enabling a hand–over of the radio connection to a new radio cell.

(57) Zusammenfassung

Die Erfindung betrifft einen Repeater für Funksignale, vorzugsweise für den mobilen Einsatz in digitalen zellularen Funknetzen. Die im Downlink– und/oder Uplink–Zweig des Repeaters empfangenen Funksignale werden demoduliert, und anschließend die so gewonnenen digitalen Datenströme wieder normgerecht moduliert, verstärkt und ausgesendet. Es ist eine intelligente Steuereinheit vorgesehen, die durch Überwachung des Signalisierungsverkehrs im Funknetz und selbständige Abstimmung der vom Repeater übertragenen Frequenzkanäle auf die von der Nachbarfunkzelle verwendeten Kanäle einen Wechsel der Funkverbindung (Handover) in eine neue Funkzelle unterstützt.

Repeater for Radio Signals

The invention concerns a repeater for radio signals, primarily for mobile application in digital cellular radio networks.

A repeater is a type of relay station that receives the radio signals transmitted by a base station of a radio network, amplifies them, and sends them out again, so that these signals can be received by mobile stations of the radio network. Obviously, a repeater also works in the opposite direction, i.e. the radio signals transmitted by a mobile station are passed on by the repeater to a base station. In cellular radio networks, repeaters are frequently used for the purpose of extending a radio service region, e.g. for the servicing of tunnels, large buildings, mountain valleys, or the like. The use of repeaters is of particular advantage when, due to a lack of infrastructure, the line connection of a conventional base station is either impossible or possible only at a disproportionately large expense. There are also repeaters designed for mobile application, in particular for use on trains.

The principle upon which conventional repeaters are based is the bidirectional amplification of the radio signals in the uplink and downlink directions, in which process the radio signals are transmitted at the same frequency at which they were received. The downlink signal originating at the base station is received by means of a linking antenna, amplified and filtered in the downlink branch of the repeater, and sent out via a servicing antenna in the direction of the mobile station. At the same time, the uplink signal originating at the mobile station is received by the servicing antenna, amplified and filtered in the uplink branch of the repeater, and sent out via the linking antenna towards the base station. In applications on vehicles, as for example on high-speed trains, one must resort to using broadband repeaters, which transmit a large region of the frequencies used in the radio network, in order to ensure proper functioning in each of the cells traveled through by the vehicle. As a result of the broadband operation of the repeater, distortions of the signal naturally occur here (phase and amplitude errors, intermodulation, noise, and the like), which have a very disadvantageous effect on the quality of the radio contact.

Known from WO-A-95/24783 is a repeater for TDMA radio systems that demodulates the radio signals received in the downlink and/or uplink branches, and then remodulates according to norms, amplifies, and sends out the digital data streams so obtained. The repeater contains a control unit, which undertakes the communication among the relevant base sta-

tion, the repeater, and the mobile station to be serviced, as well an appropriate frequency assignment for the mobile station.

US-A-5 548 803 discloses a repeater that amplifies a signal received in the downlink or uplink and sends it out again on the same or another frequency. The repeater contains for this purpose a control unit that undertakes the communication among the relevant base station, the repeater, and the mobile station to be serviced, as well as an appropriate frequency assignment for the mobile station.

The task of the invention is thus to further develop a repeater of the type specified in the introduction, in such a manner that the processed radio signals undergo the least possible loss of quality and a noise-free mobile application of the repeater is ensured.

This task is accomplished through the features of Patent Claim 1.

The object of the invention is a repeater that demodulates the received signals and then newly modulates them, as well as makes a selection of the frequencies to be repeated.

The advantage of the invention consists in the fact that, during analog repeatings, unavoidable, high-level noise does not appear and thus the quality of the radio contact is considerably improved. A further and essential advantage is that fact that, by means of the intelligent control unit according to the invention, a switching of the channel necessitated by a cell change is recognized, which considerably facilitates the handover procedure and makes the repeater especially suitable for application in vehicles.

The repeater according to the invention works in accordance with the following operating principle:

The received signal is filtered, amplified, and demodulated in a radio station of the radio network in question (mobile station or base station). Preferably, the received field strength is here measured and used as a control signal for the control of the output power of the transmitter amplifier. In the case of radio networks that operate with TDMA (Time Division Multiple Access), the measurement of the received field strength takes place on a time slot basis. The demodulated digital data stream is fed to a modulator, amplified and again sent out.

Beyond that, with TDMA systems a system-appropriate forming of the burst edges (power ramping) is undertaken, in order to obtain the narrowest possible switching spectrum. The burst amplitude is controlled by the measured received field strength. For stabilizing the amplitude control with respect to disturbances through fading, an averaging of the received signal over several time periods can here be carried out.

Since the repeater can only operate in a channel-selective manner, in the case of application in vehicles an adaptation to the prevailing cell situation, i.e. to the frequency channels used in the cell, is required. This is achieved by the monitoring of the downlink signaling, i.e. of the signaling from the base station to the mobile station.

Achieved by means of the intelligent control unit in the repeater is the fact that the repeater must only process (receive, demodulate, and modulate) the frequencies of the strongest-received base station (radio cell) of the radio network in question, plus the frequency of the organization channel of the next-strongest neighboring cell (which must be determined by the logic of the repeater). For this purpose the intelligent control unit of the repeater must monitor the signaling traffic and extract the following information from it:

1. the list of the frequencies used in the strongest cell (serving cell),

2. the list of the organization channels of the neighboring cells,

3. according to the radio system, also information concerning the sequence of frequency-hop processes (frequency hopping) as well as their concrete course.

If the repeater is moved through a cell, then its control unit itself must be able to make the decision concerning the imminent switching into a new radio cell and to select the most suitable cell. If a cell switch (handover) is required, the repeater lowers the level of the strongest cell (serving cell) on the supplying side and raises the level of the target cell for the switch, so that the control of the radio system automatically brings about the switching of the radio contacts of the mobile stations to the new cell. As soon as the first mobile station that is serviced by the repeater has switched into the new cell, the repeater must also be able to service the frequencies of the new, stronger cell. The information concerning whether a mobile station of the repeated cell is serviced via the repeater or via direct radio contact with the base station can be determined through the temporal relationship of both

directions of the radio traffic and through the power of the signal of the mobile station received by the repeater.

To each repeater branch, functional units such as channel filter, demodulator, modulator, and transmitter amplifier are, if need be, connected in parallel multiple times according to the number of the high frequency channels.

The repeater contains a frequency standard, which is appropriately synchronized by means of the synchronization channel of the downlink channel coming from the base station. This frequency standard serves as a central clock generator for generating the carrier frequency, the modulation, if need be the burst formation, etc.

By means of a data connection in the form of a radio channel between repeater and base station, which radio channel is a component of the channel used by the repeater, a remote control and monitoring of the repeater can be realized. The realization of this data connection is undertaken by a structural group that has the functionality of a data-capable mobile station and is part of the intelligent control unit. This can be either directly coupled to the linking antenna or be coupled via a multiplexer/demultiplexer to the digital data streams of the two repeater branches so as to access these streams.

In the following, the invention is explained in more detail with the aid of drawings that represent merely one manner of implementation. In the course of this, further features essential to the invention and advantages of the invention will become evident.

The drawings show:

Figure 1: a schematic representation of functional units of a classic repeater according to the prior art

Figure 2: a schematic representation of the functional units of the repeater according to the invention

A classic repeater according to Figure 1 carries out in essence a bidirectional amplification of a radio signal coming from a base station BTS or a mobile station MS in the uplink and downlink directions; the radio signals coming from the direction of the base station BTS are received by means of a linking antenna 1 and a duplex filter 3 connected downstream from

this, and in the downlink repeater branch RZ 1 are amplified, possibly selected, and again sent out in the direction of the mobile station MS via an additional duplex filter 3 and a service antenna 2. The uplink repeater branch RZ 2 operates in the same way and transmits the signals coming from the mobile station MS to the base station BTS.

The repeater according to the invention according to Figure 2, on the other hand, works in a different manner. In the following, only the course of a downlink signal from the base station BTS to the mobile station MS is described, which signal passes through a first repeater branch RZ 1. The processing of the uplink signals takes place in the same manner.

The radio signal coming from the mobile station BTS is fed via a duplex filter 3 to a preamplifier 4 and via a mixer 5 is reduced to its base frequency band or to an intermediate frequency. The mixing frequency is generated by a local oscillator 6. The base-band signal is conducted via a channel filter 7 to a demodulator 8. After the demodulator the demodulated, digital data stream is present. This is then appropriately processed by a modulator 9 and modulated to a carrier frequency, amplified by a transmitter amplifier 10, and, via an additional duplex filter 3, is radiated by the service antenna 2 towards the mobile station.

The repeater is equipped with an intelligent control unit 12, which monitors and appropriately analyses the signaling traffic between the base stations and the mobile stations, as well as the prevailing received field strengths. Thus, it is possible to assign the radio contact of the mobile station with a base station to the most favorable base station in each case and to support a cell switch (handover). This capability predestines the repeater according to the invention for mobile applications.

The control unit 12 is appropriately equipped with a remote-control and remote-monitoring unit, which is controlled through a channel used by the repeater. The digital data stream present after the demodulator 8 is branched off, the signals relevant to the control unit being filtered out by a multiplexer/demultiplexer 13.

The control unit 12 supplies a synchronization signal generated from the data stream to the frequency standard 11, which serves as a central clock generator for all of the local oscillators 6. The synchronization signal is generated from the synchronization channel of the demodulated signal.

The control unit 12 is connected via a control lead at least to the transmitter amplifier 10 of the downlink branch and controls by this means the output power of the transmitter amplifier 10.

Legend for Drawings

1	linking antenna
2	service antenna
3	duplex filter
4	preamplifier
5	mixer
6	local oscillator
7	channel filter
8	demodulator
9	modulator
10	transmitting amplifier
11	frequency standard
12	intelligent control unit
13	multiplexer/demultiplexer
BTS	base station
MS	mobile station

Patent Claims

1. Repeater for radio signals, primarily for mobile application in digital cellular radio networks, in which repeater the radio signals received in the downlink (RZ1) and/or uplink (RZ2) branch of the repeater are demodulated, and the digital data stream so obtained is then remodulated according to standards, amplified, and sent out, **characterized by the fact** that provision is made for an intelligent control unit (12) that upon movement of the repeater through a cell itself makes the decision concerning the imminent switching to a new radio cell and supports, through the monitoring of the signaling traffic in the radio network and the self-supporting matching of the frequency channels transmitted by the repeater to the channels used by the neighboring radio cell, a switching of the radio contact (handover) to a new radio cell.

2. Repeater according to Claim 1, **characterized by the fact that** the radio signals received in a repeater branch (RZ2 or RZ1 respectively) are demodulated, and following this the digital data streams so obtained are remodulated according to norms, amplified, and sent out, while the other repeater branch (RZ1 or RZ2) operates in an analog manner.

3. Repeater according to one of the Claims 1 or 2, **characterized by the fact that** the intelligent control unit (12) forces the switching of the radio contact to a new cell through a specific influencing of the signal level of the radiated radio signals.

4. Repeater according to one of the Claims 1 through 3, **characterized by the fact that** a controlling of the power of the signal sent out and the determination of the parameters for this controlling of the power take place through the monitoring of the signaling traffic in the radio network.

5. Repeater according to one of the Claims 1 through 4, **characterized by the fact that** the received field strength of the radio signals received from the base station (BTS) is measured and used as a control signal for the regulation of the power of the transmitting amplifier (10).

6. Repeater according to one of the Claims 1 through 5, **characterized by the fact that** provision is made for a frequency standard (11) that, through synchronization with the syn-

chronization signal radiated by the base station of the radio network, obtains the standard frequency necessary for the modulation of the digital data stream.

7. Repeater according to one of the Claims 1 through 6, **characterized by the fact that** the intelligent control unit (12) includes a remote-monitoring and/or remote-control unit that, utilizing the transmission and reception groups (3-10) of the repeater, communicates with the base station of the radio network via the digital data streams accompanied by interposition of multiplexers/demultiplexers (13).

WO 98/25421

PCT/DE97/02807

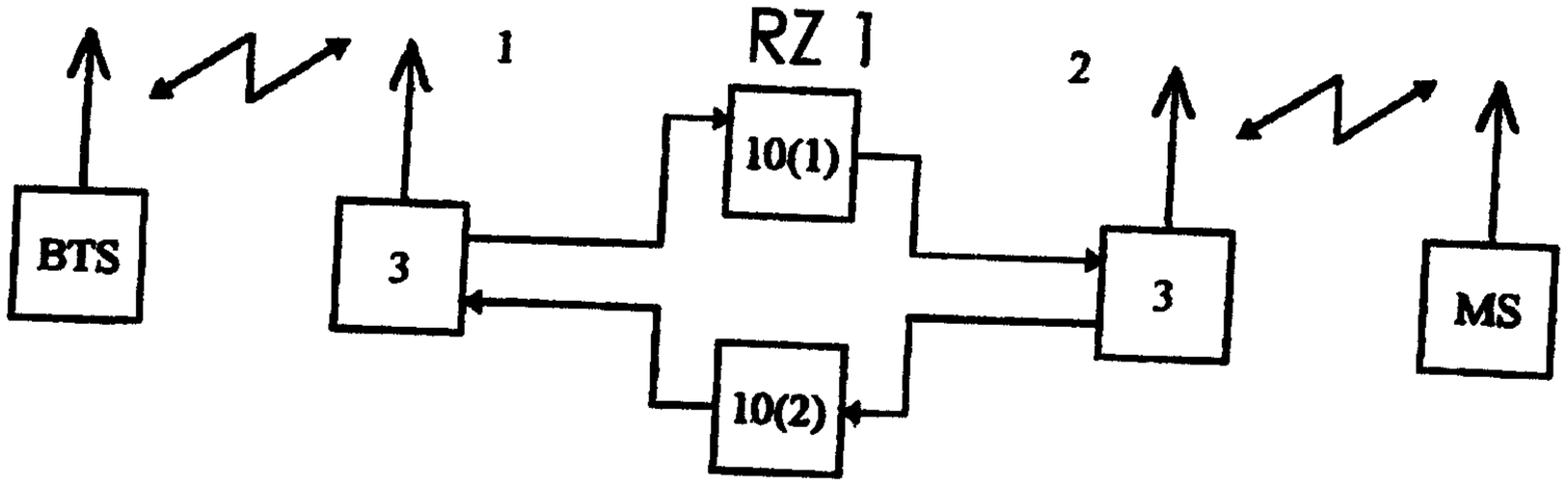

Fig. 1

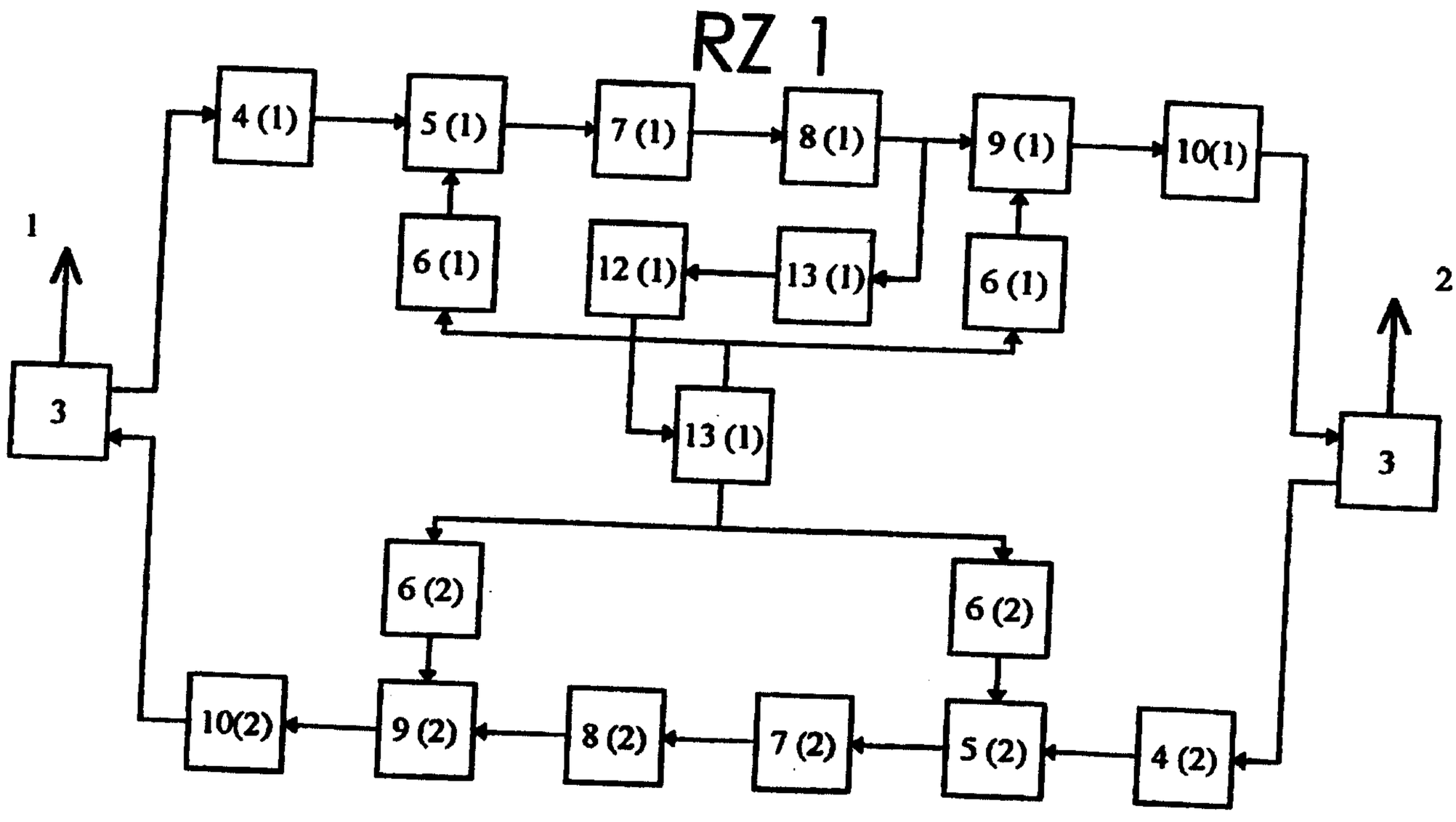

Fig. 2