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Radio Relay Communication Method for Single Frequency Simplex Radio System Using by ROIP Technology

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Article Info
Volume 81
Page Number: 2234 - 2238
Publication Issue:
November-December 2019

Article History
Article Received: *5 March 2019*
Revised: *18 May 2019*
Accepted: *24 September 2019*
Publication: *12 December 2019*

Abstract
In order to realize the radio relay device for single frequency simplex radio system, RoIP technology which is interoperability technology of digital communication was utilized. By implementing software algorithm through combination of DTMF signal of voice signal processing module of RoIP gateway equipment, half-duplex communication through transmission / reception mute function is realized and controlled to be suitable for wireless repeater for single frequency single communication, A high-quality wireless relay system can be constructed. It is also possible to construct a unified communication network with the new digital wireless network.

Keywords*: Radio Repeater, Single frequency radio, DTMF Signal, RoIP*

1. INTRODUCTION

Generally, in a radio operating system, a radio repeater is used to extend communication coverage. However, a repeater cannot be used in a single frequency radio communication because the repeater uses two different frequencies for transmission and reception. In order to solve this problem, there is a method of introducing a separate transponder or introducing a radio relay device utilizing LCX Cable (leakage coaxial cable), but it is not only insufficient in functional requirements, but also difficult to install and maintain, and high construction cost is required.

In the single frequency radio communication system, since the transmission frequency and the reception frequency are the same, a self-oscillation phenomenon occurs in which the output signal returns to the input. Accordingly, it is difficult to develop a radio relay system because a signal output from the transmitter is fed back to the receiver, the receiver amplifies the received signal back fed back, and the transmitter transmits an amplified signal again.[1]

In order to solve this problem, a radio relay device for single frequency radio communication providing a two - way single - channel communication service using one frequency is implemented by software using RoIP technology which is a digital communication interworking technology.

2. PROBLEM OF RADIO REPEATER IN SINGLE FREQUENCY RADIO SYSTEM

2.1 Simplex Communication in Single Frequency Radio System

Simplex means the radio stations are communicating with each other directly on the

same frequency. When transmitting, it is not received. When the transmission is completed, it is automatically switched to the reception standby state.

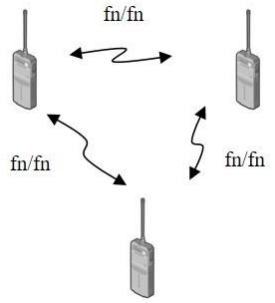

Figure 1: Conceptual Diagram of Simplex Communication

2.2 Radio Relay Communication

The radio relay communication is a method used to expand the service area when the call service cannot be provided in a single section. The repeater uses two frequencies and relays signals in the baseband.

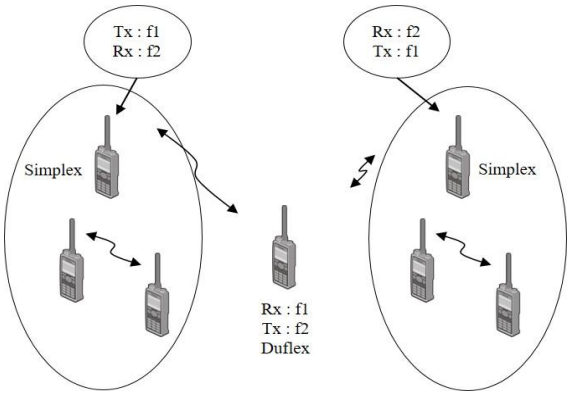

Figure 2: Conceptual Diagram of Radio Relay Communication

2.3 Self-oscillation in Relay System of Single Frequency Communication System

In the single frequency communication system, since the transmission frequency and the reception frequency are the same, a self-oscillation phenomenon occurs in which the output signal is returned to the input. Accordingly, the signal output from the transmitter is fed back to the receiver, and the receiver amplifies the received and returned feedback signal, and the transmitter generates an infinite feedback loop for transmitting the amplified signal again. Due to this phenomenon, it is difficult to develop a relay system.

In order to solve this problem, it is possible to consider the isolation system of the transmitting antenna and the receiving antenna, that is, a relay system having a physical distance. In such a relay system, the gain of the repeater is determined by the isolation between the transmitting antenna and the receiving antenna.

Therefore, it is difficult to secure a high repeater gain, and a repeater self-oscillation may occur due to a change in environment and position. In addition, since the installation possibility of the equipment is determined according to the installation site, there is a limit in installation and operation.

To overcome this limitation, one may consider using a plurality of low-gain repeaters. This method uses the isolation of the transmitting driver and the receiving driver. However, if you want to get high gains or have a large service area, you need to install a large number of repeaters. In addition, the isolation inside the repeater is low, causing the communication quality to be degraded due to the self-feedback signal, thereby degrading service quality.

3. CONVENTIONAL TECHNOLOGY FOR SINGLE FREQUENCY REPEATER

3.1 Single Frequency Bidirectional Repeater

Single frequency bidirectional repeater with very high gain by eliminating self-oscillation which may occur between transmission and reception in single frequency wireless communication by using electronic circuit, and having high gain amplifier in only one path specially.[3]

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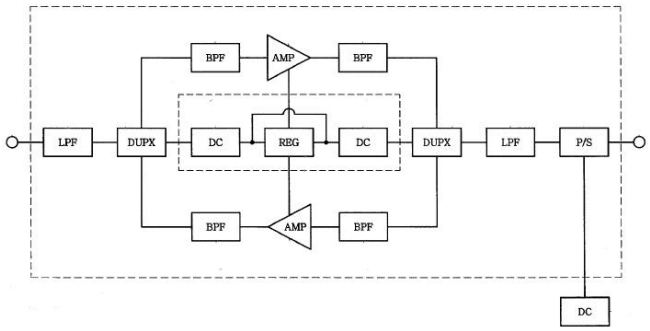

Figure 3: Diagram of Korean Patent 20-0291022

3.2 Bidirectional repeater using single frequency

Single frequency wireless communication repeater applying a method of eliminating the self-oscillation phenomenon in which the signal frequency transmitted through the transmitting circuit is amplified and fed back to the receiving circuit.

It is composed of a low noise amplifier, a frequency converter, a band pass filter, a path change switch, a signal remover, a transmit/receive signal detector, and a microprocessor for automatic operation control.[4]

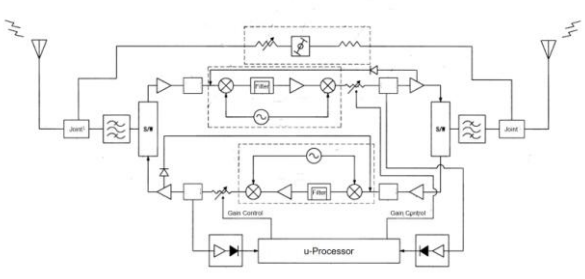

Figure 4: Diagram of Korean Patent 10-0399485

3.3 Wireless relay device and method for single frequency simplex communication

A wireless relay apparatus and method for a single frequency communication including a donor to turn on the transmission path and turn off the reception path when the transmission synchronization signal is detected, and to turn on the reception path and turn off the transmission path when the reception synchronization signal is detected.[5]

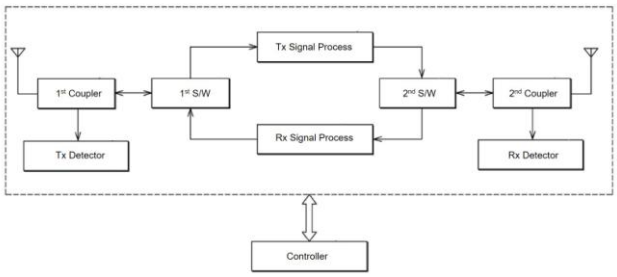

Figure 5: Diagram of Korean Patent 10-1097406

3.4 Problem of Conventional Technology

Conventional technology uses an electronic device to remove resonance caused in a transmission / reception wireless relay using a single frequency, but has the following problems.

- Difficult to adjust according to various radio characteristics
- Operation is inconvenient.
- The structure of the device is very complicated.
- The price of the device is expensive.

4. SOFTWARE PROCESS FOR SEMI-DUFLEX RELAY COMMUNICATION

This method is to apply a semi-duplex communication through a transmit/receive mute function by applying Software Algorithm through DTMF frequency combination of voice signal processing module of RoIP gateway equipment. In the radio relay method for the single frequency radio communication, when the voice signal processing module of the RoIP gateway connects with the IP-PBX, a single-wire cable of the conventional full duplex communication method (see Figure 6) The algorithm that sends the DTMF signal is processed by software and the signal is modulated to convert it into a signal with different frequency components (see Figure 7, ∮ A + #, ∮ B + *) do. By doing so, it is possible to transmit the transmission / reception signals with

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a single cable.

In this case, the path of the data is two transmission / reception bands obtained by frequency-division by modulation rather than a pair of conductors, so that the signal output from the transmitting terminal is fed back to the receiving terminal. And the transmission terminal can block the infinite feedback loop phenomenon in which the amplified signal is transmitted again, so that the voice signal can be processed by the single frequency band.

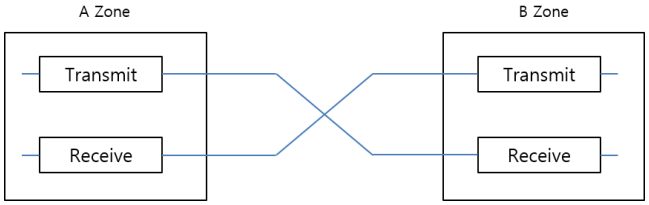

Figure 6: Full Duplex Communication Method

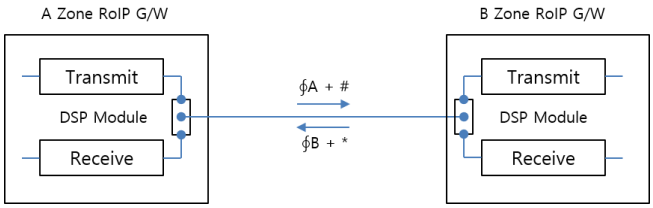

Figure 7: Semi-duplex Relay Communication by RoIP G/W

4.1 DTMF(Dual Tone Multi Frequency) Algorithm of RoIP G/W voice signal processing module

The RoIP G/W voice signal processing module is dedicated to voice processing tasks such as high-performance digital ↔ analog voice conversion of 400 MHz clock, codec encoding / decoding, VAD, COR, echo cancellation and the like. By applying these DTMF principles to the part that plays a key role in the processing part, it is possible to apply the DTMF principle as follows, by using different specific frequencies to generate sounds of two different frequencies corresponding to signals generated by Dual Tone Multi Frequency, The principle is applied that the sound corresponding to each button is generated by the operation to prevent the device from operating as if it is a normal signal and to prevent the high frequency and to eliminate the interference by other frequencies. For example, if you press button 1 on your phone, you hear 697Hz and 1209Hz mixed sounds of two frequencies.[2]

Table 1: DTMF Signal Tone Frequency

Frequency	1209Hz	1336Hz	1477Hz	1633Hz
697Hz	1	2	3	A
770Hz	4	5	6	B
852Hz	7	8	9	C
941Hz	*	0	#	D

4.2 Example of DTMF signal Processing

1) Radio A: PTT- ON (Transmit)→ DTMF: ∮ A + # (697Hz + 1633Hz) +(941Hz + 1477Hz) = DTMF CODE: # (Transmit MUTE) → Radio B: PTT OFF (Receive)

2) Radio B: PTT- ON (Transmit)→ DTMF: ∮ B + * (770Hz + 1633Hz) +(941Hz + 1209Hz)= DTMF CODE: * (Transmit MUTE) → Radio A: PTT OFF (Receive)

3) Overlap Zone Radio C: PTT- ON (Transmit)→ DTMF: ∮ A + ∮ B = DTMF CODE: # (Transmit MUTE) → Radio B: PTT OFF (Receive) & DTMF CODE: * (Transmit MUTE)→ Radio A: PTT OFF (Receive)

4.3 Description of DTMF signal processing

First, in DTMF signal processing on the calling side, the DTMF ∮ A + # is transmitted after the push-to-talk (PTT) activation, and then the call setup is started, voice can be transmitted by applying a transmission Mute processing algorithm. Next, in DTMF tone processing on the receiving side, DTMF ∮ B + * is transmitted. Then, the DTMF tone, which is fed back to the receiving side, is recognized as speech and the

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priority is transmitted to the transceiver. The transmitting side can ignore the PTT and receive it with the ignoring algorithm. (Reception start) [7-9].

5. CONCLUSION

In this paper, we designed a software algorithm for communication control of RoIP gateways in order to solve the situation that radio communication is impossible in the wireless shaded area in a zone using single frequency radio communication - Further, RoIP Gateway enables complete interoperability between various radio types

By implementing the proposed system design, it is possible to solve the technical difficulties of the single frequency radio communication repeater device and realize the radio relay device which can be constructed at a low cost, so that the utilization of the infrastructure due to the expansion of the radio coverage will be increased, Interoperability between digital radios and existing radios will also increase.

ACKNOWLEDGEMENT

The research was supported by the BB21+ project in 2019.

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