2014

ISSN : 0974 - 7435 Volume 10 Issue 18

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(18), 2014 [10776-10781]

Research on radio signal reconnaissance based on if digital channel reconnaissance receiver

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ABSTRACT

Modern electronic communications are heading a way of compact, complex, and widened occupying electromagnetic spectrum. The higher signal density is, the more signal reconnaissance receiver gets. The increasing complexity in signal forms and the widening electromagnetic spectrum require the receiver improved and achieve ultra-wideband intercept. And channelized technology is said to be the best method for ultra-wideband communication reconnaissance. This study explains the necessity of using ultra-wideband radio in receivers based on the current developing trend of reconnaissance receiver, describes its characters and advantages over conventional one. Then this study gives an overview on channelized technology mainly about its three basic structures and compares advantages and disadvantages of each structure. Later, it analyzes on the use of IF channel technology in reconnaissance receiver, mapping out the composition of the receiver, which is strong in acquisition probability, sensibility and resolution ratio, optimizes the search mode of the system, and analyzes the figure of relationship between IF channel reconnaissance receiver and the system, pointing out that the rough workmanship and the operating temperature explain the low center frequency.

KEYWORDS

Compact; Complex; UWB; Channelized technology.

INTRODUCTION

With the development of society, science and technology is undergoing rapid changes, communication and information processing technology are in constant progress, and informatization level of the society is gradually improving, thus there is increasing demand for satellite communication link[1]. Satellite communication, as an important means of military communication, has a wide application in the field of military communications. This increasing demand for it as well as constant application of new communication satellites, bring the related organizations the importance of satellite signal analysis and processing. Along with the increase in the use of satellite communication, new situations in satellite link are emerging, so study on radio signal reconnaissance is particularly important. To make up for the lack of efficiency and leaky alarm of the current reconnaissance technology, introduction of advanced computer technology and radio technology into the field of reconnaissance is now becoming the new study trend. So as the most representative of the development of radio technology, wideband radio is introduced to the modern reconnaissance means, which is applied widely in areas such as wireless communications, radar tracking, and precise positioning and so on. Early in 1990s, the United States began to take advantage of wideband wireless radio technology to develop a variety of wideband radio communication, radar, precision positioning systems, and ultra-wideband systems with multifunction such as integrated communication and positioning, communications and radar, which have been actually used in the military field and Government departments in US. At present, various electronic warfare receivers together can realize ultra-wideband communication reconnaissance. And channelized technology is the best way. Therefore, this study aims to improve the current using reconnaissance technology by suggesting radio signal reconnaissance be under the guide of IF digital channel reconnaissance receiver.

CHARACTERISTICS OF ULTRA-WIDEBAND RADIO

Up to now, there is still no standard definition for ultra-wideband reconnaissance for different applications having different meanings. In field of communication reconnaissance, it means the frequency range is over 1 GHz. Ultra-wideband radio has features of good invisibility, high processing gain, strong multipath resolution, high transmit speed, large capacity, strong penetrability, low energy consumption and so on. Here is a detail description on these mentioned features.

(1) Good invisibility: Compared to wired communication, radio communication is generally lack of invisibility, for radio waves are open to the public in the process of communication on the external space. While ultra-wideband radio has a frequency bandwidth above 1GHz, when used, has relatively small average power consumption, so it is hard to be detected in the environmental noise and other signal.

(2) High processing gain: The duty cycle of both ultra-wideband radio pulse and the sent pulse, during the process, gains better than that of wireless amplifier system. So it has a feature of high process gaining[2].

(3) Strong multipath resolution: RF signal of conventional wireless communication is usually continuous and needs much longer time than that of multipath transmission, with the latter having certain restriction on the communication quality and speed of data transmission. Since the ultra wideband radio has a low duty cycle, in the short duration of a single cycle pulse, multi-path signals can achieve separation, when the multipath pulse overlaps in time during transmission, their multi signals won't overlap, and this makes multi-path components can be well separated, so that the transmission signal energy is fully utilized in order to ensure the high multi-path resolution ability[3-4].

(4) High transmit speed: Only when the information rate reaches to 50Mbps or above can the wireless networks are within high quality standard[5]. With the development trend of digital, intelligent and broadband of communication technologies, so many researchers, money and resources have been devoted into the improvement of channel capacity of the conventional radio, but the result is still far from satisfactory. However, ultra-wideband can eliminate the effects of multipath transmission, and its data transfer rate is much higher than the conventional one.

(5) Large capacity: Ultra-wideband impulse radio has a low duty cycle sending impact pulse, using time-hopping multiple-access, thus composing a network system similar with the DS-CDMA system. Besides, the features of high processing gain and multipath resolution all enable a limitless number of system users.

(6) Strong penetrability: Ultra-wideband radio has a strong penetrating ability for the leaves and certain obstacles, which makes up for the disadvantages of FM signals in travelling through a jungle, and UWB technology also has a function of through-the-wall imaging.

(7) Low energy consumption: Ultra-wideband radio communication is very low in power consumption, only 1-4mW, which can greatly extend the power supply time of the receiver.

INTRODUCTIONS ON CHANNELIZED TECHNOLOGY

Conception of channelized technology

Channelized technology is being used to obtain every independent standard signal contained in intermediate frequency receiving bandwidth for the next ports' baseband processing[6]. Channel processing consumes large amounts of computation and hardware resources, thus how to enable channel process to achieve the highest efficiency is the focus of

current research. Depending on the difference in bandwidth of each subband signal as well as the distribution of band positions of intermediate frequency broadband signals obtained by channelized technology, different channelized technologies are used in the course of study for intermediate frequency signal processing.

Currently the homogenizing channel treatment is used for intermediate frequency broadband signals with same subband signal bandwidth having equal intervals in bandwidth distribution, and it is based on polyphase filter banks[7], which solves the shortcomings of large amount of computation of previous channel processing, and has a relatively simple structure. But for intermediate frequency broadband signals with same subband signal bandwidth but unequal intervals in bandwidth distribution, Goertzel method is applied[8]. This channelization method can use the Goertzel filter to lift the constraints on the equal intervals in distribution of subband signals. In real application situation, however, due to each subband burdens different duties, there are difference in communication system and standard, and the distribution of bandwidth is casual. Therefore, parallel digital down-conversion is applied for intermediate frequency broadband signals with different subband signal bandwidth having unequal intervals in bandwidth distribution; this method can process each subband signal separately, but has a large computation and occupation of resources.

Basic structure of channelized technology

Channel receiver has three basic structure forms: pure information channel structure, folded-frequencies information channel structure, and time-division information channel structure. Pure information channel structure means information channel is divided into adjacent multiple channels by bank of filters according to the range of reconnaissance frequencies, so that the channel bandwidth can meet the required frequency resolution, this division can be completed in multiple levels. Figure 1 shows the schematic diagram of secondary pure channelized receiver. In the diagram, signals are divided into N adjacent equal bandwidth frequencies based on the range of reconnaissance frequencies, then each frequency will divided into adjacent subbands with equal bandwidth. In this way, secondary pure channel structure has N by M channels.

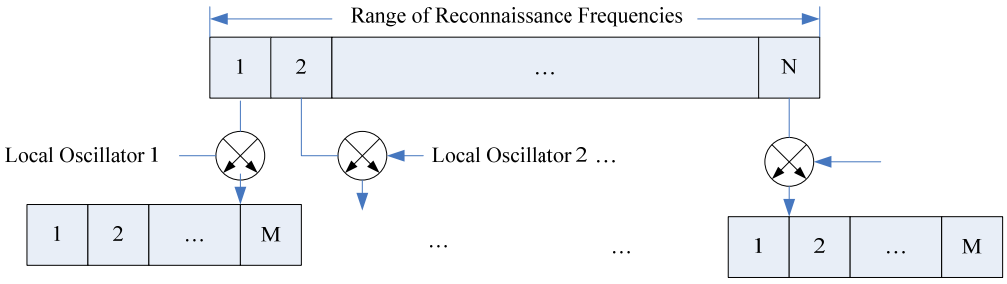

Figure 1 : Schematic diagram of secondary pure channelized receiver

According to Figure 1, in pure channelized structure, each frequency has a corresponding intermediate frequency band, and the bandwidth of these N intermediate frequency bands are the same. N intermediate frequency bands folded together, with other parts of the structure changeless, N frequencies using the same one intermediate frequency band will form another structure named folded-frequencies information channel structure, whose schematic diagram is showed in Figure 2. This structure uses less equipment but can get the same resolution compared with pure channelized structure. However, folding makes noise power of the public intermediate frequency bands N times bigger than before, thus the signal-noise ratio also dropped to N times lower than before. Besides, the resolution reduces when two signals reach to receiver at the same time.

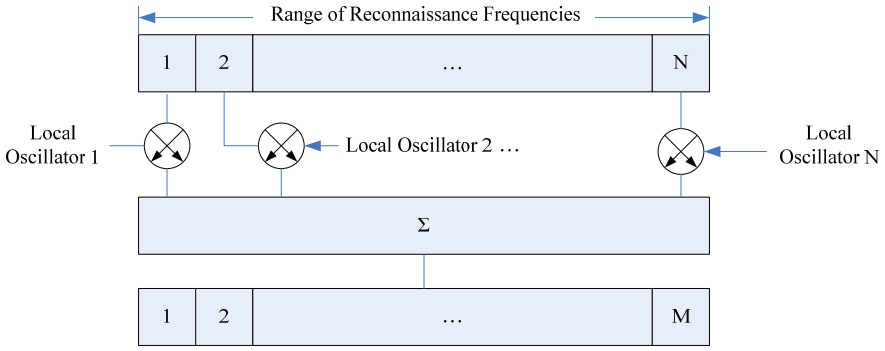

Figure 2 : Schematic diagram of folded-frequencies information channelized receiver

By accessing only a single one of N frequency bands to public intermediate frequency a time in the pure channel structure, rather than folding them together, this will form time-division channelized receiver. Figure 3 is its schematic diagram. There is a switch in it which can control the program. The switch can either be a high bandwidth call switching or a network which is controlled by the activity of the band or a controller or digital technology in a programmed way. This receiver has the same resolution with pure channelized receiver, and uses same quantity in equipment with folded-frequency channelized receiver. The problem with this receiver is that its interception probability will decline apparently.

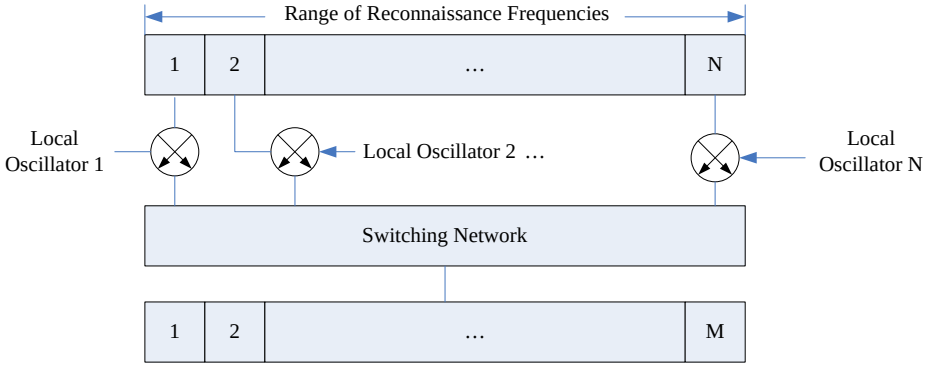

Figure 3 : Schematic diagram of time-division channelized receiver

DESIGN OF RECONNAISSANCE RECEIVER BASED ON INTERMEDIATE FREQUENCY CHANNEL

Frame of the receiver

Wideband receiver is the main type of receiver while ultra-wideband generally refers to whose frequency range is over 1GHz. Ultra-wideband receivers mainly are: crystal video receiver, superheterodyne receiver, instantaneous frequency measurement receiver, composite receiver, channelized receiver and so on. In this study, composite receiver is analyzed. Because it utilizes technologies of SHR, channelization and digital processing, it is fast in signal capture, high in probability of intercept, sensitivity and resolution. This owes to the advantages of channelized receiver which are instantaneous broadband, high interception rate, high-speed signal capture capability. The studied composite receiver's composition is showed as Figure 4.

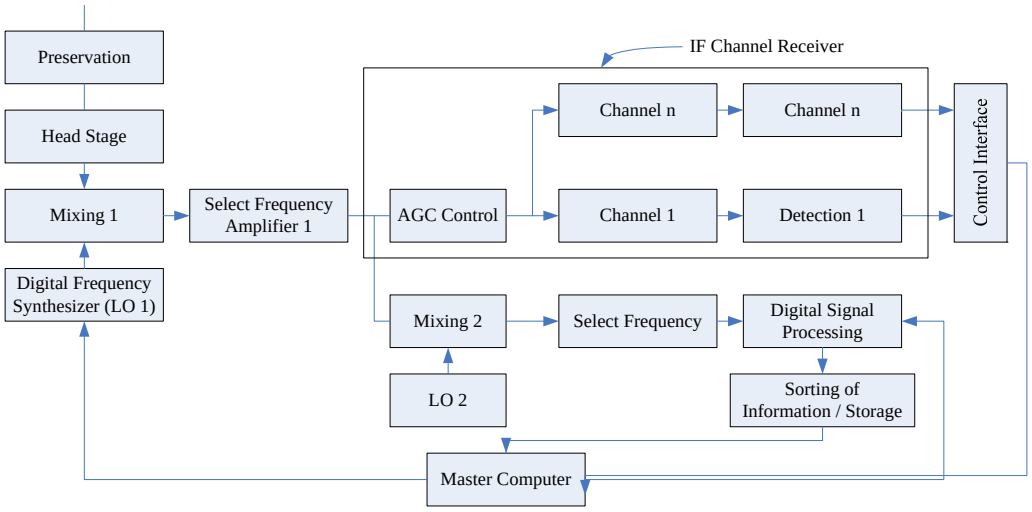

Figure 4 : Composition diagram of composite receiver

Main search mode of the system

The search mode of the studied system mainly is using scanning of local oscillator 1 and IF channel identification technology to initiate local oscillator 2. First, local oscillator 1 completes the scan job, when a band is identified, the signal recognition will completed by the IF channel receiver, once radio signal is recognized, it will be digitally encoded and transmitted to the controlling computer. Then the controlling computer will measure the signal frequency range of the radio signal and the control coding of local oscillator 2 based on the principle of the IF channel coding. Finally, local oscillator 2 is modulated to corresponding point, thus radio signals are directly output through IF channel 2 and at last digital signal processors are motivated by computer and get a very high frequency resolution. The process is mapped out in Figure 5.

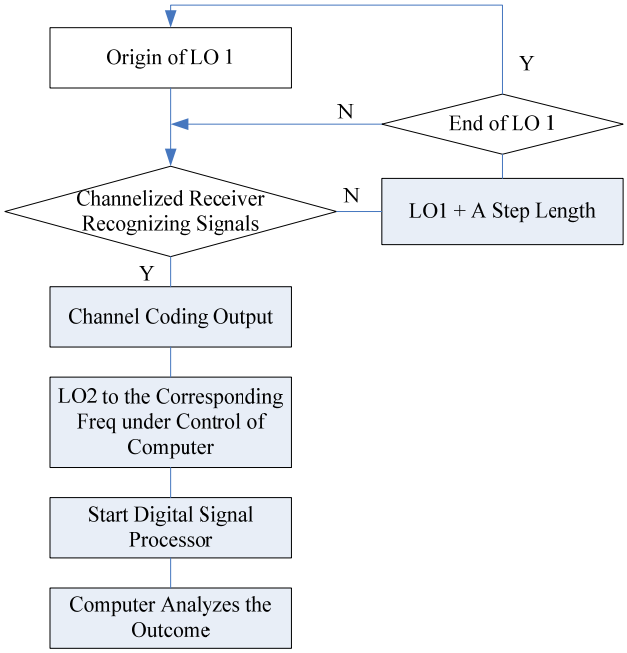

Figure 5 : Flow chart of the main search mode

Design of IF channel receiver

A IF channel receiver is mainly composed by channel filter banks. Figure 6 shows the former relation of the system and channel receiver. The key of channel receiver is mainly about squareness factor of channel filter, a better squareness factor is more favorable for the recognition of signal position. SAW filters can be said to be the best way to achieve a number of filter banks, and its band attenuation characteristic is excellent, it also enjoys advantages in very small volume, very close to the ideal characteristics, and very high side lobe suppression ratio. So it is applied in IF channel receiver in overlapping distribution. In spite of this, due to the rough workmanship and the operating temperature affection, the receiver has a low center frequency.

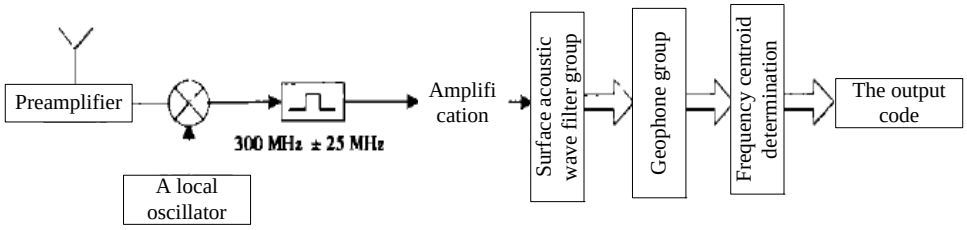

Figure 6 : Relation of IF channel receiver and the system

According to Formula (1), if the center frequency is very high, and the operating temperature range is very wide, it will lead to mutation of the channel filter in frequency variation during operation.

$$\Delta F = \Delta T K_T f_0 \quad \textbf{(1)}$$

In the above formula, ΔF represents the frequency variation; ΔT represents the temperature change; K_T represents temperature coefficient; f_0 represents the center frequency.

CONCLUSION

Reconnaissance receiver is an important device in the military field, for its role in enemy's radio signals intercept, as well as distinguish of the nature of the intercepted radio signals. With the development of modern information technology, radio signal faces a situation of wide in information technology and electromagnetic spectrum occupation. To solve this problem, it is necessary to introduce a broadband reconnaissance receiver, thereby enhancing the separation rate and capture capability of the receiver. This study analyzes the characteristics of ultra-wideband radio, explains the need for ultra-wideband radio receiver, and then overviews on channelized technology, at last, designs a reconnaissance receiver based on

IF channel by mapping its structure, describing the system's search mode, and designing the IF channel receiver. Through this study, it is expected to provide some reference for the development of UWB radio IF channel reconnaissance.

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