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A New Demodulation Method of Air-ground Data Link Communication Based on MSK

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Abstract. With the development of civil aircraft, the ACARS (Aircraft Communications Addressing and Report System) is playing a more and more important role. This system uses the modulation of MSK, and has a special mapping relation between the waveform and code element. This paper analyzed the characteristic of the waveform, and presented a new demodulation method based on the characteristic. This method demodulates the signal by accumulating the second half of the sampling points of each element wave. This method has a simple structure compared to the traditional method. A simulation made by computer proved its feasibility and pretty performance.

Keywords: ACARS; modulation; demodulation; MSK;

1 Introduction

With the development of air transport, the safety and efficiency requirements of aircraft is increasing day by day, and the role played by modern electronic information technology is more and more prominent. Aircraft Communications Addressing and Report System (ACARS) put forward in 1988 by international civil aviation organization (ICAO), is a ground-to-air data communication system with functions of communication, navigation, monitoring [1].

The system includes the subsystems of airborne equipment, data link service providers and ground application subsystem [2]. It uses the signal of VHF with the frequency between 118MHz to 137MHz. It works in an automated manner, which can reduce crew workload and improve data trustiness. The modulation used is minimum shift keying (MSK) which has the advantages of constant amplitude and continuous phase. The symbol rate is 2400Hz, the signal has two frequency wave 2400Hz and 1200Hz [3]. The ARINC-618 protocol is the basic protocol of the ACARS system.

The demodulation of the MSK signal is one of the key technologies of ACARS system. This paper mainly studied the characteristic of the MSK waveform of ACARS, and proposed a more efficiency demodulation method for the signal of ACARS.

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2 A New Demodulation Method of MSK

The demodulation method of the MSK signal is important for the ACARS system. The structure of Fig.1 is one of traditional demodulation methods of MSK, called delay judgment of coherent demodulation. This method is nearly suitable for all kinds of MSK waveform [4]. However from the Fig.1 we know there is a special mapping relation between the element and waveform of ACARS, so we guess there would be a special demodulation method for ACARS. Now we will further analyze the feature of MSK waveform of ACARS, and get a more efficiency demodulation method for the signal of ACARS.

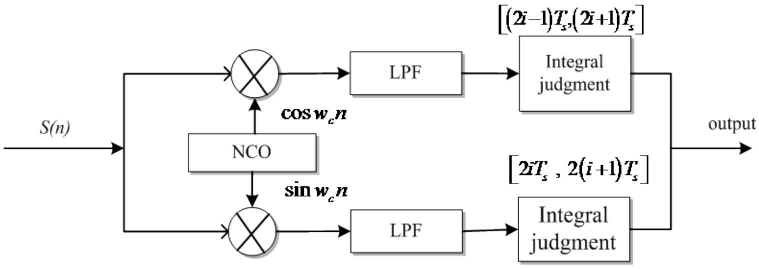

Fig. 1. The traditional demodulation method of MSK

The MSK waveform of ACARS can be expressed as the mathematical formula (1).

$$s_k(t) = \begin{cases} \sin(2\pi f_2 t), -\sin(2\pi f_1 t) & \text{when the } a_k = +1 \\ -\sin(2\pi f_2 t), \sin(2\pi f_1 t) & \text{when the } a_k = +0 \end{cases} \quad kT_s < t \le (k+1)\,T_s \tag{1}$$

$s_k(t)$ is the waveform of MSK, $f_1 = 1200Hz$, $f_2 = 2400Hz$,the a_k is the code element, k is the order of message sequence, $T_s = (1/2400)s$ is period of the code element.

When the signal is transported in the channel, it will be affected by the noise $n(t)$. So the signal we receive is the sum of signal and noise, it can be expressed as following.

$$s'_k(t) = s_k(t) + n(t) \tag{2}$$

From the figure.1, we divide the wave of each element into two half from the center. We can get the conclusion that when the code element is “1”, the second half the waveform is below the zero; while when the element is “0”, the second half the wave is above the zero. This conclusion can be expressed as following formula.

$$\begin{cases} \frac{1}{T_s/2}\sum_{kT_s+T_s/2}^{(k+1)T_s} s_k(t) < 0 \text{ when } a_k = 1 \\ \frac{1}{T_s/2}\sum_{kT_s+T_s/2}^{(k+1)T_s} s_k(t) > 0 \text{ when } a_k = 0 \end{cases} \quad kT_s < t \le (k+1)T_s \tag{3}$$

Usually $n(t)$ is a Gaussian random process with a mean equal to zero. So

$$\frac{1}{T_s/2}\sum_{kT_s+T_s/2}^{(k+1)T_s} n(t) \approx 0 \tag{4}$$

$$\begin{cases} \frac{1}{T_s/2}\sum_{kT_s+T_s/2}^{(k+1)T_s} \left(s_k(t)+n(t)\right) < 0 \text{ when } a_k = 1 \\ \frac{1}{T_s/2}\sum_{kT_s+T_s/2}^{(k+1)T_s} \left(s_k(t)+n(t)\right) > 0 \text{ when } a_k = 0 \end{cases} \quad kT_s < t \le (k+1)T_s \tag{5}$$

So we only need to accumulate the second half sampling points of every element waveform. If the sum is above the zero, the waveform will be demodulated to code element “0”; if the sum is below the zero, the waveform will be demodulated to code element “1”. The process of this method could be showed by the Fig.2.

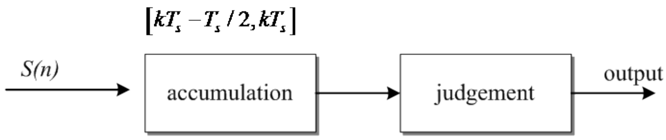

Fig. 2. The process of new demodulation method

3 Simulation Experiment

From the Fig.1 and Fig.2, we could see the new demodulation method can save many source, such as the local oscillator, low pass filters, multiplying unit and so on. However because we only accumulate the second half of the wave sampling points, the accumulator must be a flexible one. So this method is more suitable to a software radio receiver with a core processor like FPGA or DSP. In order to prove the validity of the method, we did a simulation, using the computer. The process are shown by the Fig.3, first we generate eleven random code elements, then we modulated them into MSK waveform, then we accumulate the second half of sampling points, finally we got the demodulated elements after judging, the result is correct.

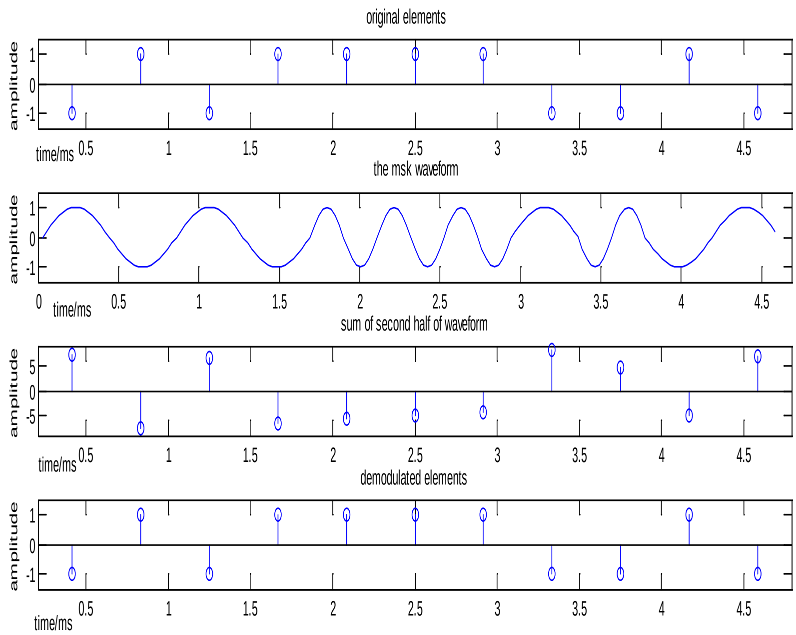

Fig. 3. The simulation of this demodulation method

4 Conclusion

In this paper, we introduced the Aircraft Communications Addressing and Report System, the modulation waveform is analyzed intensively. Base on the characteristic, we proposed a new demodulation method. This method demodulates the signal by accumulating the second half of every element wave sampling points. Through the simulation of computer, we proved the validity of the method.

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Meantime, all the authors declare that there is no conflict of interests regarding the publication of this article.

References

1. Curtis, Risly., James McMath.: Experimental Encryption of Aircraft Communications Addressing and Reporting System(ACARS) Aeronautical Operational Control (AOC) Messages. Digital Avionics Systems, vol. 2, pp. 7D4/1 – 7D4/8 (2001)
2. Shuguang, Sun.: ACARS Data Identification and Application in Aircraft Maintenance. Database Technology and Applications, pp. 255 – 258 (2009)
3. Air/Ground Character-oriented Protocol Specification, VHF ACARS ARINC Specification 618-5, Chapter 4.0(2000)
4. Ryu, SM., Un, C.K.: A Simple Method for MSK Modulation and Demodulation. Proceedings of the IEEE Volume:73, pp. 1690 – 1691(1985)

