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Application FFT-Based Algorithm Pseudo-Code Serial in Measurement and Control of the Spread

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Abstract. For low SNR actual spread spectrum telemetry applications, large Doppler shift characteristics studied in low SNR, FFT-based fast acquisition of pseudo-code methods, theoretical analysis and simulation results show that the method can significantly reduce acquisition time and improve acquisition performance.

1. Introduction

Monitoring and control systems for aerospace spread, the impact have not only captured the Doppler shift a big problem, a very low signal to noise ratio is also an important feature. Low SNR requirement must improve the implementation of the correct capture processing gain, and high processing gain corresponding to the processing bandwidth is small, the accumulation time is longer; and the Doppler shift is large due to the pseudo-code Doppler large, this limits the accumulation of pseudo-code time. Therefore, we must consider the code and Doppler processing bandwidth for high dynamic, low SNR signal capture.

2. Construction Capture System

In the pseudo-code capture process, it is generally believed that the signal to noise ratio of 13dB can achieve the correct detection. For the spread spectrum measurement and control signals, the signal to noise ratio is even when the lowest only about 30dB. When the carrier noise power spectral density ratio of 37dB-Hz, the pseudo-code rate 5.115Mchip / s when the signal bandwidth of 10.23MHz, equivalent to the received signal to noise ratio of -33dB ($37-10\lg(10.23M)=-33dB$).

The pseudo-code Doppler frequency is calculated as follows:

$$\Delta R_{PN} = R_{PN} \times \frac{f_d}{f_{RF}} \quad (chips/s) \tag{1}$$

Where: f_{RF} for the RF signal carrier frequency, generally 2.2GHz;

f_d for the carrier Doppler frequency, the maximum can reach 150kHz;

R_{PN} is the transmission pseudo code rate, the value is 5.115Mchip / s;

So, set a single residence time is T, then there should be $\Delta R_{PN}T \le 1/2chip$, brought into the formula: the maximum pseudo-code Doppler frequency of 348.75chips / s, and then can calculate the single residence time should be less than $\frac{1}{2\times\Delta R_{PN}}=\frac{1}{2\times 348.75}\approx 1.4(ms)$.

The accumulated 7.8ms data contains the number of pseudo code codes $5.115\times10^6\times7.8\times10^{-3}=39897(chip)$, and the 150 kHz Doppler frequency offset causes the chip offset to $\Delta R_{PN}\times T=5.115\times10^6\times\frac{150\times10^3}{2.2\times10^9}\times7.8\times10^{-3}=2.72(chip)$, between 2.5chip and 3chip. And because 2.5chip and 3chip corresponding offset pseudo bit code rates were 0.32kHz and 0.38kHz, so select the median 0.36kHz, consider the Doppler frequency offset can be negative, the code rate offset in the -0.36kHz and 0.36kHz between the election 6-way parallel, then each generated PN code rate difference of 0.12kHz, the equivalent of $0.12\times10^3\times7.8\times10^{-3}=0.936(chip)$. This 6-way and local real-time code was different: -2.808chip, -1.872chip, -0.936chip, 0.936chip, 1.872chip and 2.808chip. 6-way parallel capture, the maximum pseudo-code Doppler frequency of each road is 58.125chips / s, the single-stay integration time should be less than 8.6ms.

Figure 1 for the choice of 6 to achieve the capture of the block diagram.

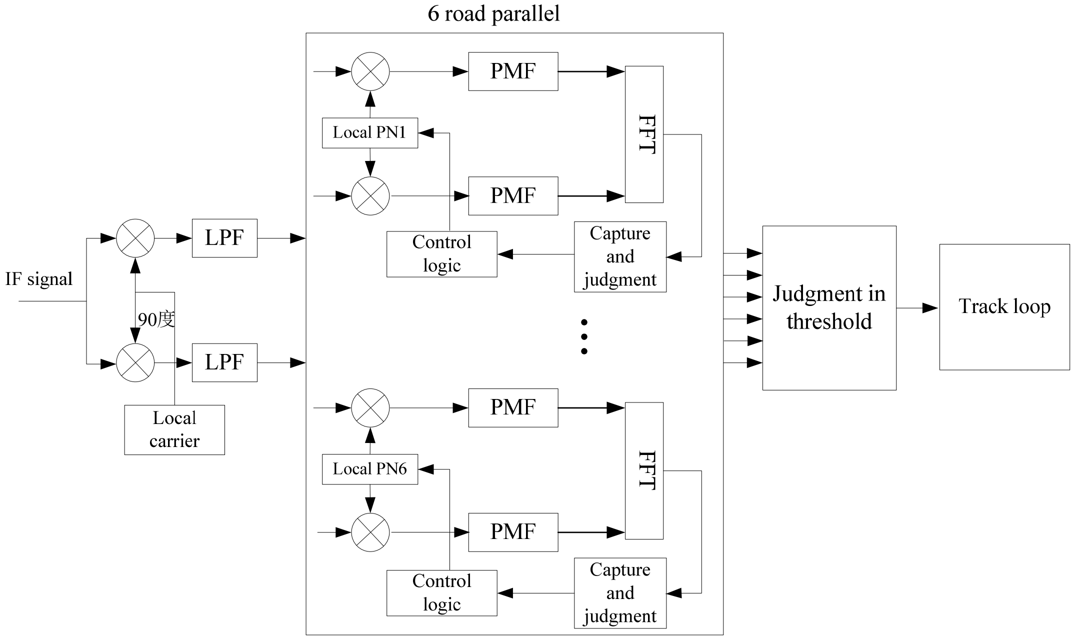


Figure 1. Capture the structure of the system

The concrete realization process is: first to receive the digital IF signal mixing, low-pass filter processing, into the baseband signal, and then sent into the parallel 6-way capture system to capture the decision. From the above analysis, we can see that the 6-bit local pseudo-code bit rate difference of 0.12 kHz, respectively, and the incoming baseband signal were partially matched filter, the FFT operation of the spectrum analysis, and the results for the capture decision, All the way to extract the carrier Doppler and pseudo-code phase information, the tracking loop to initialize.

3. Simulation Verification

The simulation conditions in Figure 2 are:

A). The maximum carrier Doppler shift is 80 kHz;

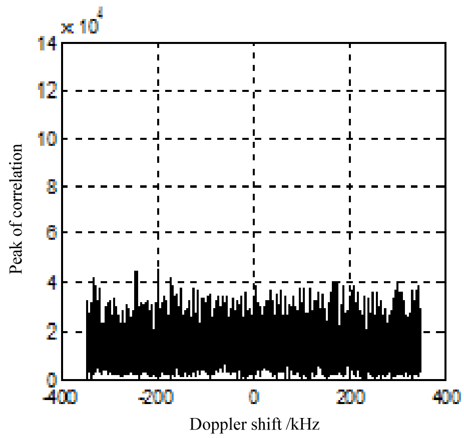
B). Carrier to noise ratio 37dB-Hz;

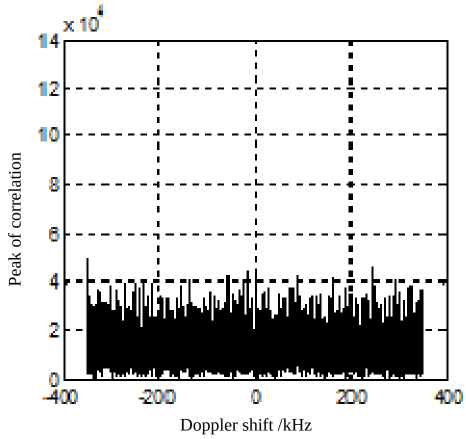
C). The local pseudo-code rate of the 6-channel signals is 0.12kHz respectively;

D). Take 80 points;

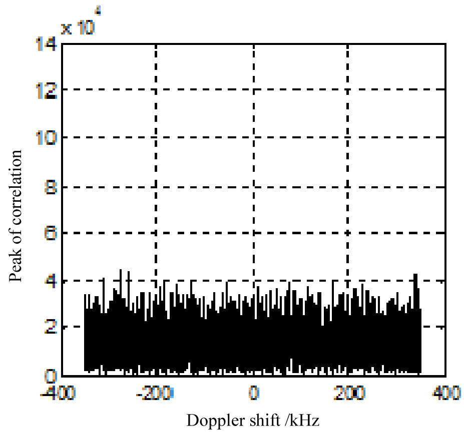
E). Single integration time 7.8ms (regardless of the effect of data hopping).

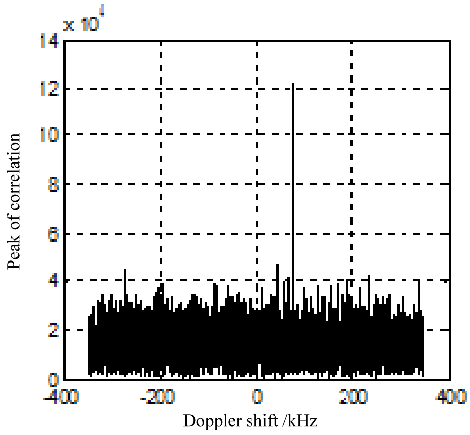
From the above analysis, 80kHz Doppler frequency offset caused by the offset bit rate of 0.192kHz, calculated by the frequency offset caused by the chip offset 1.5chip, and the fourth road 0.936chip and 5 Road 1.872 Chip difference between the number of chips are less than 1chip, so these two can achieve the correct capture.



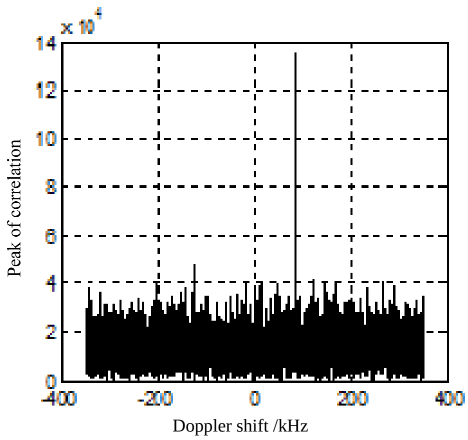


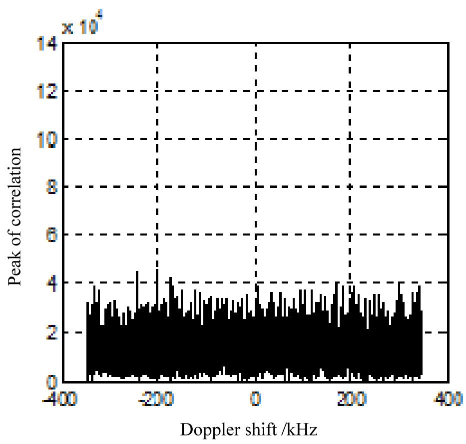
(a) Road 1 (b) Road 2





(c) Road 3 (d) Road 4

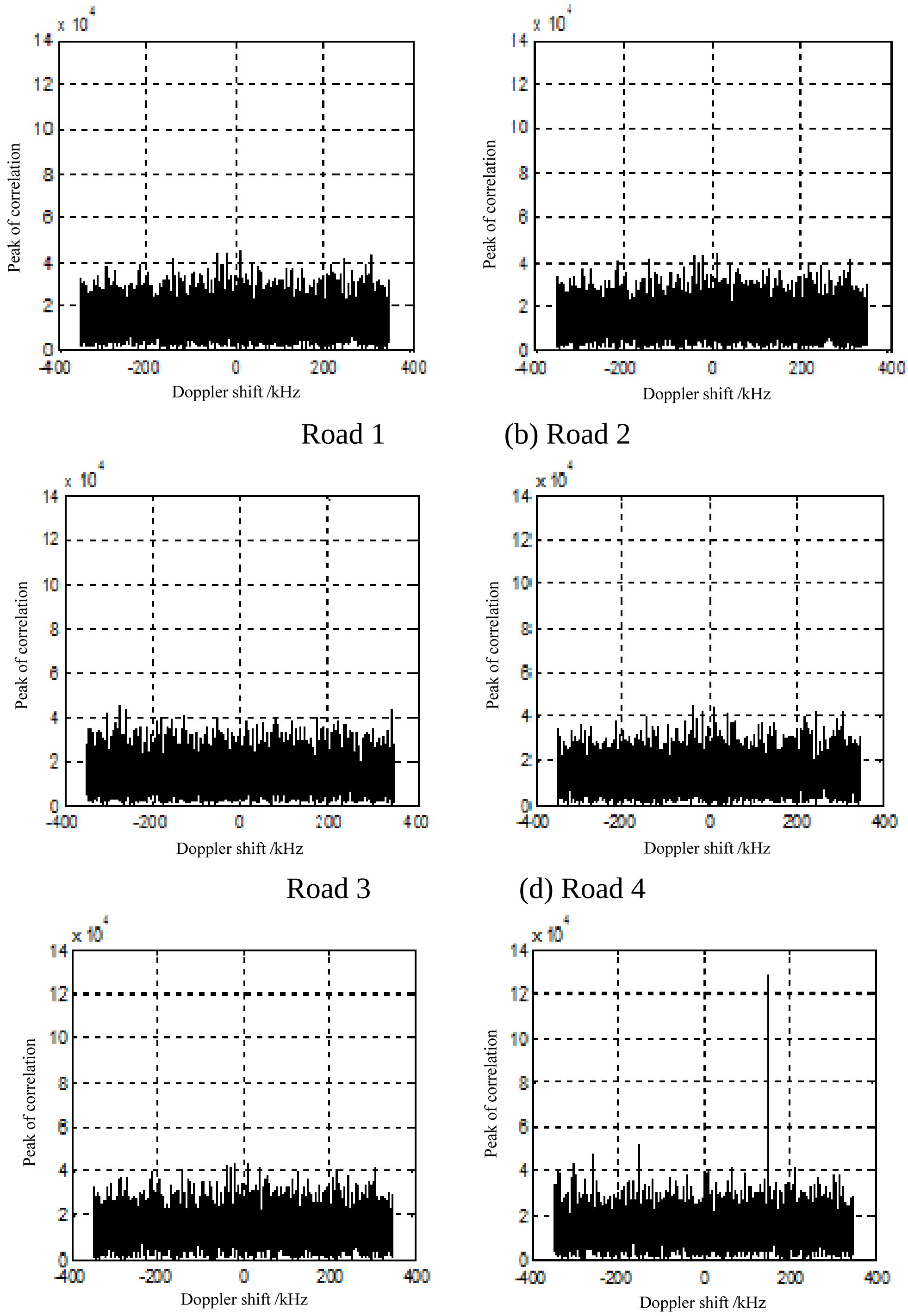




(e) Road 5 (f) Road 6

Figure 2. Doppler frequency offset is the parallel capture peak of 80 kHz

Figure 2 shows the use of MATLAB simulation of the six parallel results, it is clear that the fourth and fifth road peak is much higher than the other few, and the fourth road code is 0.936chip, and 1.5chip difference of 0.564 Chip 5 and 1.5chip difference of 0.372chip, so the fifth road to capture the peak to be higher than the fourth road.



Road 1 (b) Road 2

Road 3 (d) Road 4

Road 5 (f) Road 6

Figure 3. Doppler frequency offset is a parallel capture peak of 150 kHz

Figure 3 shows the capture simulations when the carrier Doppler frequency is 150 kHz under the same conditions. Similarly, from the above analysis we can see that 150 kHz offset rate of 0.34 kHz, so only the last way to capture success.

4. Summary

In this paper, we study the pseudo-code fast capture method based on FFT in the case of low signal-to-noise ratio (SNR) in the case of low SNR and Doppler shift in practical spread spectrum measurement and control. The results of theoretical analysis and simulation show that this method can greatly shorten the acquisition time and improve the capture performance.

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