THE COMPUTER ANALYSIS OF THE WEIGHTING METHOD OF RADIOLOCATION SIGNAL TYPE CHIRP

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Article in short form shows simulation researches which apply Doppler distortion on the weighting chirp signal with linear frequency modulation on main lobe duration and distance between main lobe and side lobes. Provide researches include two cases of putting windows coefficient into matched filtering coefficient.

INTRODUCTION

There are two targets in research of weight function: the first one is the most distance between main lobe and side lobes and second is the smallest width of main lobe. Getting distance 70-85dB main lobe and side lobes permits decrease the mask of effect object which poorly reflect radar signal if they are nearly one witch reflect well.

1. SOFTWARE AND SIMULATION CONDITIONS

Simulation was made on software was written by author on Linux system with used fftw, Qt and qwt library. Result of simulation was storage on PostresQL data base for easier management.

In research as criterious of detection main lobe assumed: sample of signal after compression which have maximum amplitude is rating among main lobe, from this maximum sample next samples are compared one by one as long as next sample is larger then previous in range of time from maximum sample to the end of signal, and all this samples are rating to main lobe. Comparison from maximum sample when previous sample is bigger then compared sample in time range from start signal to maximum sample and all of this samples are rating to main lobe.(Fig 1.)

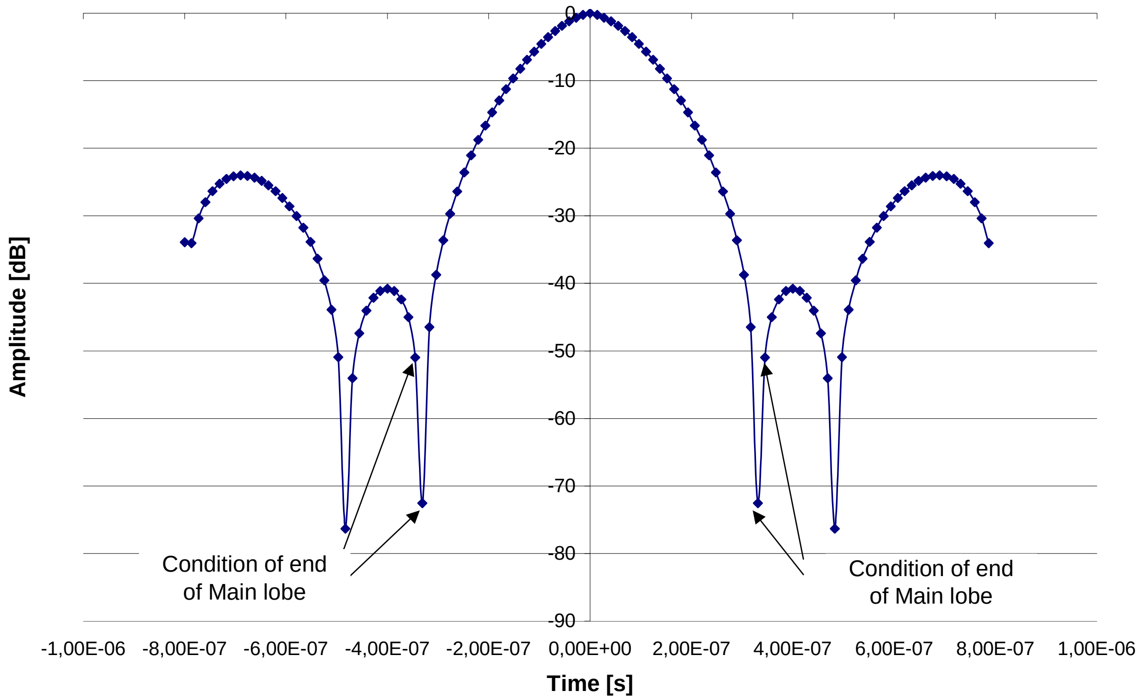

Fig.1 Condition of end of main lobe in compressed signal

Simulation was made for two ways of providing coefficient of window function into compression process. In the first case windows coefficients in frequency domain are multiplied by coefficient of matched filtering and next provide to frequency domain (Fig 2).

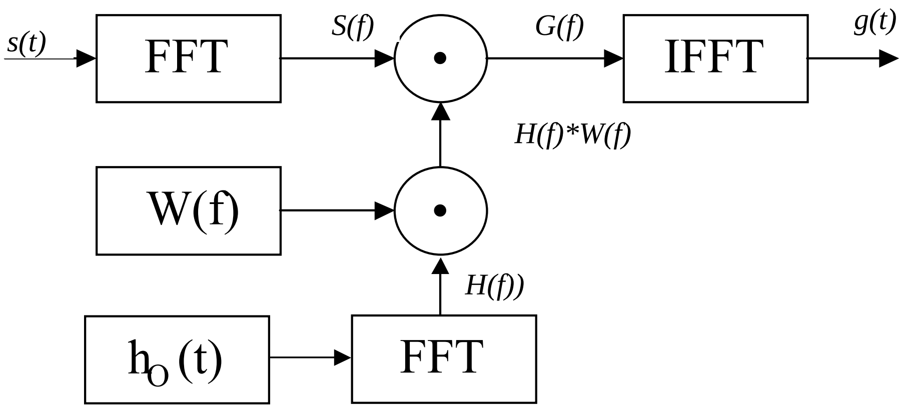

Fig.2 Schema of operations which are done for compression with added window in frequency domain (type compression 2.)

In second case windows coefficients in frequency domain are multiplied by pseudo-signal, from them one gets coefficient of matched filtering after provide to frequency domain by putting to the Fourier transforms (Fig. 3)

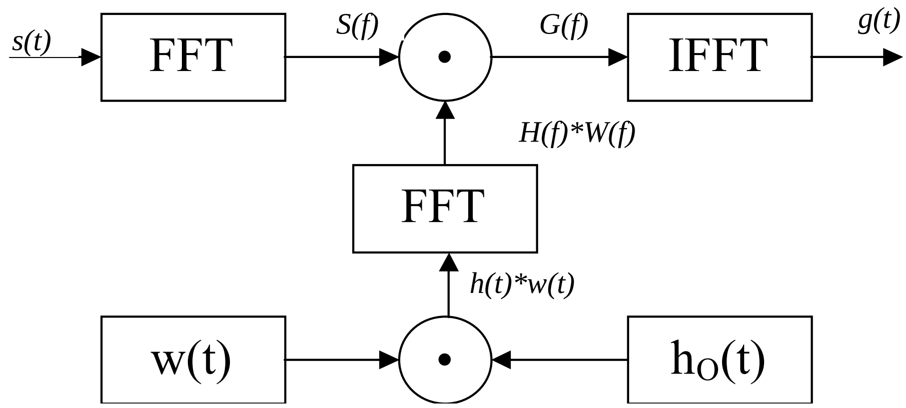

Fig.3 Schema of operations which are done for compression with added window in time domain (type compression 1.)

Simulation's condition:
- sampling frequency f_S – 74MHz
- carrier frequency f_C – 70MHz
- signal band B – 5MHz
- signal duration - 2μs ÷ 998μs with step 2μs

Weighting function are made on the basis of formulas:

- rectangle:

$$w(n) = 1, \forall n \in \left[-\frac{n}{2}, \frac{n}{2} \right] \tag{1}$$

- Hamminga:

$$w(n) = 0.54 + 0.46 \cos \frac{2\pi n}{N}, \forall n \in \left[-\frac{n}{2}, \frac{n}{2} \right] \tag{2}$$

- Blackmana:

$$w(n) = 0.42 + 0.5 \cos \frac{2\pi n}{N} + 0.08 \cos \frac{4\pi n}{N}, \forall n \in \left[-\frac{n}{2}, \frac{n}{2} \right] \tag{3}$$

- Weierstrassa:

$$w(n) = \exp\left[-\frac{1}{2} \left(\alpha \frac{|n|}{N/2} \right)^2 \right], \forall n \in \left[-\frac{n}{2}, \frac{n}{2} \right] \tag{4}$$

Window's domain is depended on weighting type. If computations are made for compression with weighting in time domain (type compression 1), then domain of window is in time and range is $\left[-\frac{n}{2}, \frac{n}{2} \right]$ and it's adjust to non zero's samples of signal. If computations are made for compression with weighting in frequency domain (type compression 2), then domain of window is in frequency domain and range $\left[-\frac{n}{2}, \frac{n}{2} \right]$ is adjust in this way to the first sample of signal fall on the window's sample as well as for last one samples.

2. RESULTS OF SIMULATION

In provided simulation researches author gets result 78dB distance between main lobe and side lobes for Blackman function for use compression type 1 and for BT=1500. Distance between main lobe and side lobes is increase linear with increase BT from value 25dB.

For Weierstrass weighting function distance between main lobe and side lobes is biggest in this research and it equals 83dB for BT=5000.(fig 4)

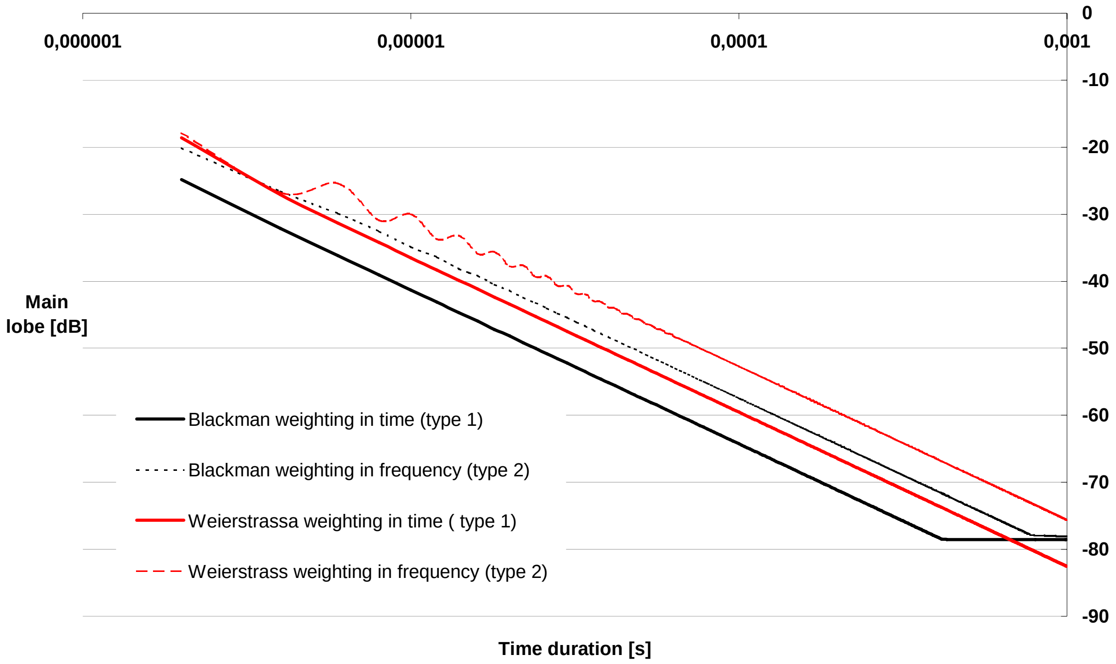

Fig.4 Distance between main lobe and side lobes for function with big distance

As you can see on figure 5 duration of main lobe varies between 0.8μs for Blackman function with BT=10 and 3.2μs for Weierstrass function with BT=5000.

Function with short duration of main lobe are Hamming and rectangle weight function. Because of using these functions duration of main lobe equals from 0.51μs for BT=10 to 0.405μs for BT=5000 for rectangle weighting function (fig. 6)

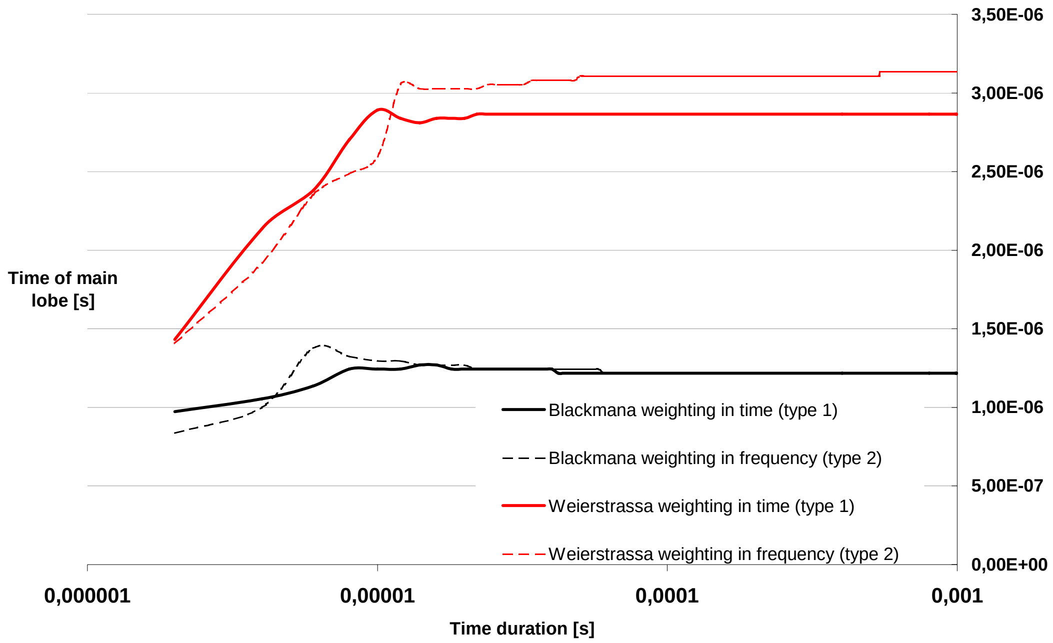

Fig.5 Duration of main lobe for function with big distance

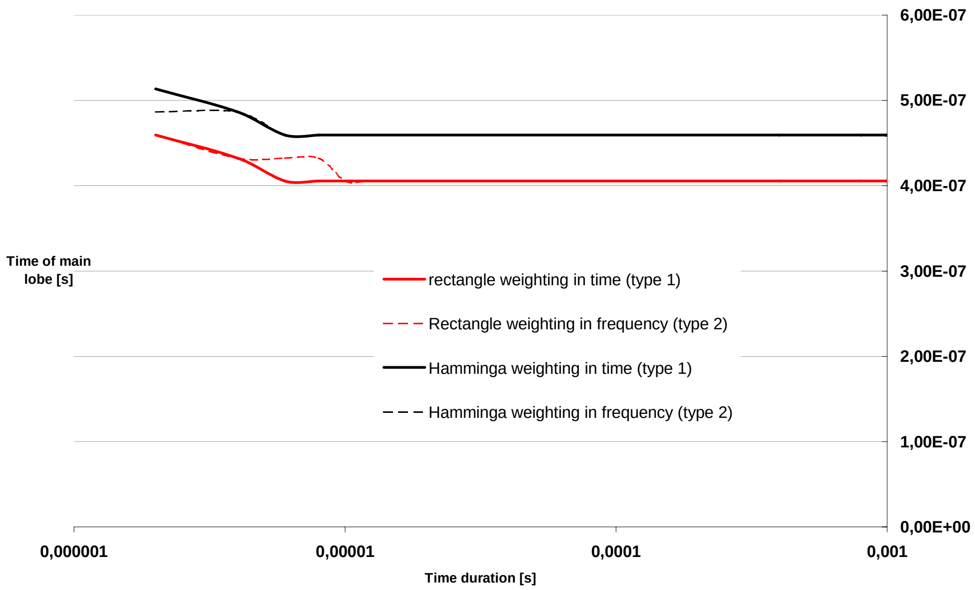

Fig.6 Duration of main lobe for function with small distance

Weighting function Hamming and rectangle, in comparison with Weierstrass and Blackman waighting function , gives duration of main lobe shorter then half of order. Rectangle and Hamming weighting functions give smaller distance between main lobe and side lobes. For Hamming function and uses type 1 of weighting this distance almost don’t change for BT from 10 to 5000 and its about 19.8dB (fig. 7).

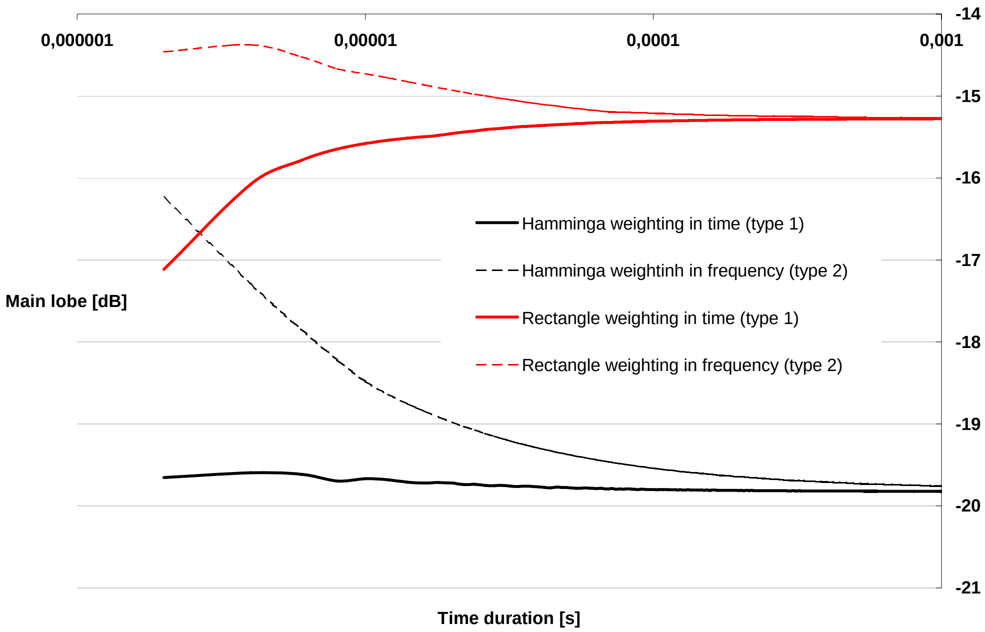

Fig.7 Distance between main lobe and side lobes for function with small distance

For rectangle weighting function main lobe is 17dB for type 1 of weighting and for BT near 10. It means when we wide main lobe about 600ns we increase about 3dB for BT=50 to 5000 when we use Hamming weighting function.

3. SIMULATION'S CONDITION WITH DOPPLER DISTORTION

Besides the biggest distance main lobe from side lobe and width of main lobe important is the weight functions resistance to the Doppler distortion.

For easer comparison author proposed a new coefficient "**l**" with Doppler distortion witch express by formula:

$$\mathrm{l} = \frac{\Delta A}{A} \tag{5}$$

l – coefficient that present changing main lobe with Doppler distortion

$\Delta A = A_{1.00} - A_{1.006144}$ - coefficient that provide what is different between main lobe with Doppler distortion and without,

$A_{1.000}$ - distance between main lobe and side lobes for signal without Doppler distortion,

$A_{1.006144}$ - distance between main lobe and side lobs with displacement carrier frequency of signal to 1.006144.

When we provide this new coefficient we can show figure with Doppler distortion and without it.

Figure 4 shows result of simulation of distance between main lobe and side lobs for 1.006144 Doppler coefficient.

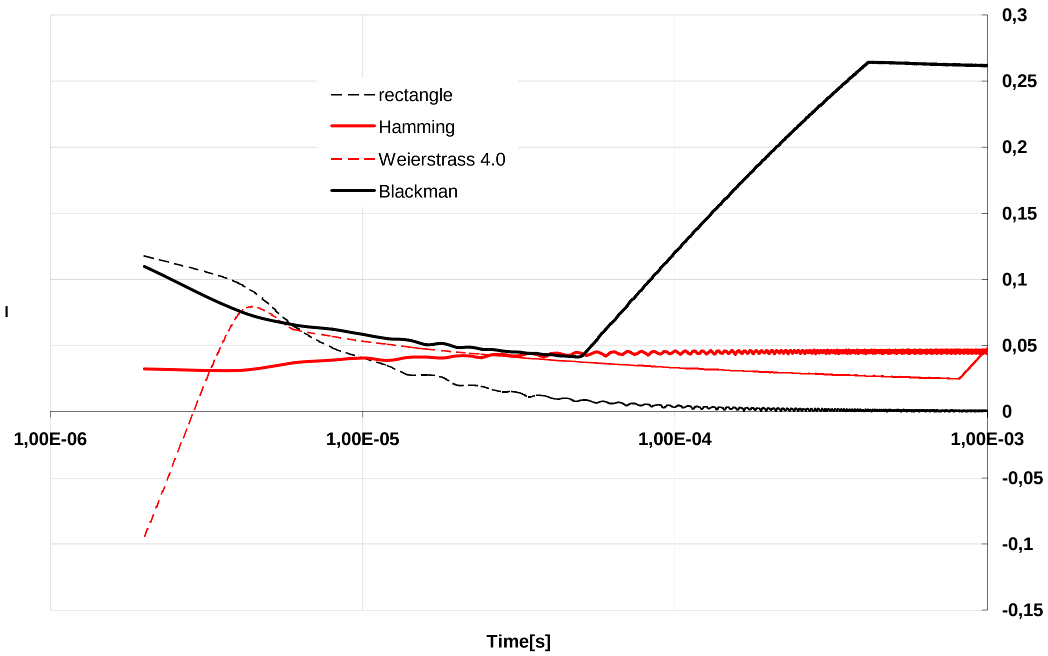

Fig.8 Figure shows “l” coefficient for weighting function.

Rectangle weighting function has a big sensitivity to Doppler distortion for BT coefficient in BT=10÷40, in this BT range “l” coefficient is about 0.1. Rectangular weighting function, for range of coefficient BT=10, has the biggest distance between main lobe and lide lobs, it means this distance is near 17dB. Rectangular weighting function has, between values from BT=50 to BT=5000, the smallest sensitivity to Doppler distortion among functions, witch were showed. But for this function distance main lobe from side lobes amounts to 15.5dB only.

Hamming weighting function has parameter “l” witch is changing from 0.03 to 0.045 in wide BT limit between 10÷5000. For Hamming weight function distance main lobe from side lobes in range BT from 10 to 5000 changes a little, how it’s showing on fig. 8.

Second group of weighting function with main lobe 70÷85dB is various sensitivity for Doppler distortion. For Weierstrass weighting function in BT range 10÷40 has a negative “l” coefficient that means Doppler distortions are increase main lobe. That phenomenon shows strong dependence of distance main lobe from side lobe on phase of signal.

Weierstrass weighting function in showed rang BT (10÷30) has main lobe about 30dB. In range BT 200÷4800 Weierstrass weighting function is characterized by smaller sensitivity to Doppler distortion then Hamming function and has **l**=0.045 for BT=200 and additionally “l” decreases with increasing BT. For BT=4800 Weierstrass has a minimum of coefficient “l” which equal 0.03.

4. CONCLUSION

Because reason simulation research is narrow main lobe, presented simulation suggest rectangle weighting function. For this function width of main lobe is smaller than 0.46μs for BT=10÷5000. But rectangle function has small distance between main lobe and side lobes.

It is possible to increase the width of main lobe of main lobe of 600 ns it will better use Hamming weight function type 1. For this case we have almost constant distance between main lobe and side lobes and it equal 19.8dB in range BT=10÷5000.

If we want to have the biggest distance main lobe from side lobs more correct to use are Blackman or Weierstrass weighting functions. For them we get distance from 70 to 85 dB, but cost of that is wider main lobe. The most width of main lobe in this simulation researche has Weierstrass function and this width equals 3μs for BT=50 to 5000. Blackman weight function has about half narrow main lobe in similar BT range (50÷5000) and has smaller main lobe about 78dB, but is very sensitive for Doppler distortion. That means it is possible to use Blackman weight function to detection of slowly moving objects.

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