



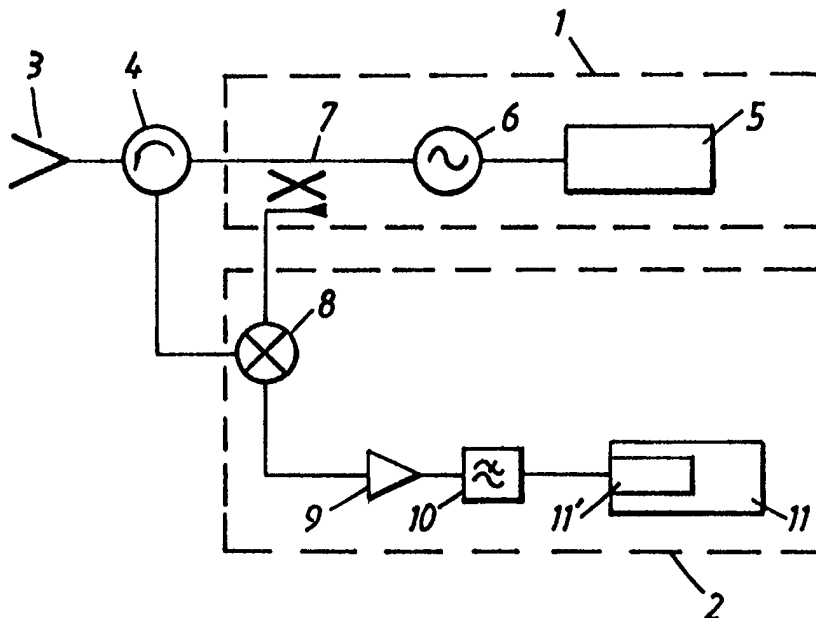
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(54) Title: PROCEDURE FOR THE ELIMINATION OF INTERFERENCE IN A RADAR UNIT OF THE FMCW TYPE

(57) Abstract

This invention concerns a procedure for the elimination of interferences, such as pulses and linear chirps, in a radar unit of the FMCW type. According to the procedure, the useable signal in the form of a beat signal, is subjected to time-frequency division of the type STFT for division of the signal into narrow-band frequency bands. Interference is detected and eliminated in each frequency band, after which the time signal freed from interference and its Discrete Fourier Transform, DFT, are calculated from the time-frequency division in narrow-band frequency bands.



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**PROCEDURE FOR THE ELIMINATION OF INTERFERENCE IN A RADAR UNIT OF THE FMCW TYPE**

This invention concerns a procedure for the elimination of interference, such as  
5 pulses and linear chirps, in a radar unit of the FMCW type with linear frequency  
sweep, where the transmitted and received signals are combined to form a  
useable signal in the form of a difference signal, the beat signal, with a wave for  
each target, where the frequency, amplitude and phase of the wave contain the  
information about the target. The procedure can be used within the field of  
10 mobile radar, but can also be used for other FMCW radar applications.

The principle for linear FMCW radar is well-known, see for example Skolnik,  
Introduction to Radar Systems, 2nd Ed., McGraw-Hill 1980, chapter 3. Technical  
advances have in recent years resulted in an increased use of FMCW radar units,  
15 which will not be considered further here. A linear FMCW (Frequency Modulated  
Continuous Wave) radar unit works in principle as follows:

A frequency sweep controls an oscillator with a variable frequency so that the  
transmitted frequency varies periodically. Each period has principally three parts,  
20 namely a constant base frequency, a linear frequency sweep and a rapid return  
to base frequency. The linear frequency sweep is the time when the radar unit is  
"carrying out useful work" and often constitutes 70 - 80% of the total time  
(work factor 0.7 - 0.8).

25 For the sake of simplicity in the discourse below the radar unit and its target are  
stationary. In the case of moving targets or moving radar units the Doppler  
effect also comes into play. For most actual FMCW systems, however, the  
Doppler effect only involves a minor correction to the following.

30 The propagation time from the radar unit to a target and back again is typically a  
few microseconds. A signal received from a target has therefore the frequency  
that was transmitted a certain time previously. As the frequency is swept this is

not the same frequency that is being transmitted. The received frequency also has a linear frequency sweep. As the received frequency sweep and the transmitted frequency sweep are parallel with a time-displacement equal to the propagation time, as a result for a fixed target the difference in frequency  
5 between the transmitted and received signal will be constant. This constant frequency difference is given by the product between the propagation time to the target and the gradient of the frequency sweep expressed as frequency per unit of time.

10 The signal processing in a linear FMCW radar unit consists principally of the transmitted and received signals being combined, so that the difference signal (the beat signal) is generated. This signal is the sum of a number of sine waves, where each sine wave represents a radar target. The sine waves have different frequencies, amplitudes and phase positions in accordance with the principle  
15 that large amplitude corresponds to large target, high frequency corresponds to target at a great distance. The Doppler effect (due to the relative speed) mainly affects the phase positions.

In order to determine what targets are being observed and their sizes and relative  
20 speeds, the difference signal is frequency-analysed. The frequency analysis is best carried out digitally by means of the difference signal being passed through an anti-alias filter and sampled at a constant sampling rate, after which the sampled signal is multiplied by a window function to reduce the amplitude of the signal at the start and end of the sampling period and is sent to a signal  
25 processor that carries out a Discrete Fourier Transform, DFT, usually with a fast algorithm, known as an FFT, Fast Fourier Transform. The Fourier Transform is generally complex but for a real time signal (difference signal) it has a certain degree of symmetry. In order to be able to use FFT algorithms the number of samples is usually selected as a power of two (256, 512, 1024, ...). 256  
30 samples give 256 FFT coefficients, but if the signal is real the symmetry means that of these 256 values only 128 (actually 129) are independent.

By Fourier Transform, for example by FFT, the signal is divided up into a number of discrete frequency components, sines. Each frequency corresponds as above to a distance. The amount of a complex FFT coefficient is a measurement of the radar target area (the received power) for the target in the corresponding

5 frequency window (distance window). The FFT performs what is known as a coherent integration of the target signal, which is advantageous. The subsequent signal processing in the system is carried out digitally on the calculated FFT coefficients.

10 It can be shown that the nominal width of a distance window is inversely proportional to the change in frequency of the linear FMCW sweep during the sampling period. For a distance resolution of 1 m a change in frequency of 150 MHz is required. In order to change the distance resolution, the gradient of the frequency sweep can, for example, be changed while retaining the same

15 constant sampling time.

The sampling rate limits the frequencies of the beat signal that can be studied and thereby the total observed distance area. The width of this "useable band" that lies parallel to the linear FMCW sweep is often less than 1 MHz.

20

A linear FMCW radar unit can be subject to interference if it receives signals other than its own transmitted signals reflected from various targets. The radar unit can be subject to interference from other radar units, including pulse radar units, pulse compression radar units and other FMCW radar units that are

25 operating at the same time and causing interference.

A pulse during the sampling period has a very short extent in the time domain and is very broad-band in the frequency domain. A strong pulse of interference only affects a few samples of the beat signal but can affect all the frequency

30 windows in the Fourier Transform. The "noise level" in the Fourier Transform appears to be increased, so that small targets can be masked by the interference.

A very common form of interference is what is known as a chirp, where the wave form causing interference moves with linear frequency through the useable band of the FMCW radar unit. Such chirps are generated by a pulse compression radar unit, and also by another FMCW radar unit if that unit's transmitted wave form during the base phase and return phase enters the first unit's useable band during its sampling period. The third phase, the linear frequency sweep, can also generate a chirp if the frequency sweep of the radar unit causing the interference has a different gradient to the frequency sweep of the first radar unit, e.g. because the radar unit causing the interference has a different distance resolution.

Interference in the form of a linear chirp is always broad-band in frequency, but can also have a considerable extent in time and cause interference to the whole FFT and affect a very large part of the sampled time signal.

There are also short chirps that can hardly be distinguished from pulses. The chirps that are caused by the base phase or return phase of an FMCW radar unit causing interference are of this type.

Interference of short duration such as short pulses or rapid chirps can in general be detected and eliminated in the sampled time signal and an FFT without interference can then in general be reconstructed. A chirp interference with a large extent in both the time domain and in the Fourier domain can, however, not be eliminated by any simple manipulation of the time signal without this having negative consequences for the FFT.

According to this invention a procedure is proposed for eliminating interference in radar units of the FMCW type that also allows interference with a large extent in both the time domain and Fourier domain to be eliminated. The method according to the invention is characterised by the beat signal being subjected to time-frequency division for time-local frequency division of the signal, by the

interference being detected and by the interference being eliminated separately in each frequency band individually, after which the time signal free of the interference and its Discrete Fourier Transform, DFT, are calculated from the time-frequency division free of the interference.

5

The sampled beat signal, the time signal, lies completely in the time domain. The samples give a resolution in time but no resolution at all in frequency. The FFT is a description of the same signal in the Fourier domain. The FFT gives a good resolution in frequency, but no resolution at all in time. An interference, e.g. a chirp, during part of the time signal is poorly visible in the Fourier domain. Information about the position of the interference is to be found mainly in the phases of the complex FFT values and not in the amounts.

What is known as a time-frequency division makes it possible to have certain (coarse) resolution of the signal in the time domain and in the Fourier domain. A known time-frequency division is the Wigner-Ville Transform, that is what is known as a quadratic transform and thereby creates false cross-modulation products, see Mayer, *Wavelets, Algorithms & Applications*, SIAM, Philadelphia, 1993. Another known time-frequency division is what is known as the wavelet transform, see the above book by Mayer, or Rioul/Vetterli, *Wavelets and Signal Processing*, IEEE Signal Processing Magazine, October 1991, that makes a "musical" frequency division. The frequency division is into different scales, "octaves". For high frequencies the frequency resolution (expressed in Hz) is coarser but the time resolution is finer.

25

For the application of interference attenuation in FMCW radar units there is proposed, however, mainly the simplest time/frequency division, Short Time Fourier Transform, STFT, described in the Rioul/Vetterli reference above. The time signal is divided into short sections that can overlap. Each section of signal is multiplied by a window function and a Discrete Fourier Transform is calculated. After the elimination of interference in each frequency band

30

individually, the original time signal is calculated from the STFT. The STFT can therefore usefully contain redundant (overlapping) information.

In this connection it is useful to point out that an FMCW radar unit is the only  
5 common type of radar unit where a target corresponds to a standing wave with a certain frequency and that thereby fulfils the conditions for being able to apply the normal Fourier analysis with band-pass filter or DFT (FFT).

One form of signal processing in the time-frequency plane suitable for e.g. active  
10 sensors is known through EP 0 557 660, A2. In this case an incoming broad-band signal is separated by a bank of band-pass filters into a number of signals that are each allocated a separate channel. After gain control and half-wave rectification coherent components of the signals are integrated. In this way a target can be detected simultaneously in several different frequencies and the  
15 best from each frequency can be utilised. In accordance with the above EP document, utilisation of parts with interference is thereby avoided. However, in contrast to the invention in this patent application, there is no elimination of interference so that parts of the signal with interference can be used.

20 Detection of interference in each frequency band can advantageously be carried out by methods suitable for the detection of interference of short duration.

In one suitable version of the method, the detection of linear chirps and pulses is carried out by methods for detecting straight lines in images, for example so that  
25 interference patterns in the form of straight lines deviating from lines parallel with the time axis are identified, the identified lines are related to the frequency band affected and the interference is eliminated separately in each affected frequency band. Such methods are known from image processing, see for example Gonzalez/Woods, Digital Image Processing, Addison-Wesley, 1992. A  
30 Hough Transform can be used for the detection of the straight lines.

In another suitable version of the method in accordance with the invention, the beat signal is filtered in association with the time-frequency division in narrow frequency bands of the signal in order to increase the sensitivity of the detection. The filter can be determined using adaptive methods. In one  
5 favourable version, the filter is applied on one or more of the narrow-band frequency windows in the narrow-band frequency bands of the time-frequency division.

In yet another suitable version of the method in accordance with the invention,  
10 the beat signal or useable signal is reconstructed after the elimination of interference by extrapolation from samples without interference, in one or more of the narrow-band frequency windows in the narrow-band frequency bands of the time-frequency division.

15 STFT-time-frequency division for the detection of interference, the elimination of interference and synthesis of the useable signal has many advantages, particularly for chirps. The advantages consist in general of two characteristics. The first is that a chirp in each frequency window in the STFT is of short duration and can therefore be detected/eliminated by the same methods as, for  
20 example, pulses. The second is that chirps are narrow-band in each frequency window in the STFT and can therefore be described (reduced to zero/extrapolated) using simple polynomials of already known structure.

The method according to the invention will be described below in greater detail  
25 with reference to the enclosed figures, where:

Figure 1 shows diagrammatically the principle for how a linear FMCW radar unit works.

Figure 2 shows examples of suitable frequency sweeps in a time-frequency diagram.

30 Figure 3 shows samples of a simulated FMCW beat signal with Gaussean noise and an interference.

Figure 4 shows the absolute amount of the FFT for the beat signal in figure 3.

Figure 5 shows the result of a time-frequency analysis of the beat signal in figure 3.

Figure 6 shows the absolute amount of the FFT for a beat signal in figure 3 without interference.

5

The radar unit shown in figure 1 includes a transmitter [1] and a receiver [2]. An aerial [3] is connected to the transmitter and the receiver via a circulator [4]. In the transmitter there is an oscillator control device [5] connected to an oscillator [6] with variable frequency. The frequency sweep from the oscillator control  
10 device [5] controls the oscillator [6] so that a signal is generated with periodically varying frequency, which signal is transmitted by the aerial [3] via a direction coupler [7] and the circulator [4]. The period of a frequency sweep, see figure 2, has principally three parts in the form of a constant base frequency [30], a linear frequency sweep [31] and a quick return [32] to the base  
15 frequency. The oscillator [6] can work within the Gigahertz range, e.g. 77 GHz. The reflected signal received by the aerial [3] is taken via the circulator to a mixer [8], where the reflected signal is combined with the transmitted signal. After amplification in the amplifier [9] and filtering in the filter [10] a difference signal or beat signal is obtained that is used as the basis for the subsequent  
20 signal processing for detecting and eliminating interference and synthesis of the useable signal without interference in a processor block [11] that can also contain what is known as an FFT processor [11'].

An example of how the time-frequency division can make possible the analysis  
25 of a difference signal with interference is shown in figures 3 - 6.

Figure 3 shows 1024 samples of an FMCW beat signal (time signal) that is simulated as a number of sine/cosine signals + Gaussean noise + an interference. It is difficult by eye to locate and characterise accurately the  
30 interference.

Figure 4, which shows the absolute amount of the FFT for the beat signal in figure 3, shows four distinct peaks [12], [13], [14] and [15] above a high noise base. Each peak [12] - [15] corresponds to a target. Nor in figure 4 is it possible to characterise the interference.

5

Figure 5 shows the result of a time-frequency analysis of the beat signal in figure 3. STFT on 64 samples one at a time with overlaps has been used. From figure 5 it appears directly from the V [16] that can be seen in the centre of the signal that the interference is a linear chirp. The explanation for the chirp being a V and not just a line is that the FFT analysis used cannot distinguish between positive and negative frequencies. The dominant peaks in the spectrum appear as horizontal bands [17] - [21] corresponding to standing sine waves with constant frequency. In figure 5 the frequency resolution is quite coarse and the two peaks [14], [15] in figure 4 move partly together into a single broad band [19], [20]. A horizontal band [21] at approximately  $0.8 \cdot \text{Nyquist}$  frequency does not correspond to any peak in figure 4.

By studying the simulated signal without interference and without chirps, shown in figure 6 as the absolute amount of the FFT, a fifth peak [22] appears associated with the band [21] corresponding to a fifth target. In figure 4 this peak is completely submerged by the interference.

One of the great advantages of time-frequency division (STFT) for the elimination of interference in FMCW signals can be seen by comparison between figure 5 and figure 3. In figure 3 the interference is long. The length of the interference corresponds to the projection of the V on the horizontal time axis in figure 5. In each frequency window in figure 5 the interference is, on the other hand, relatively short.

By processing each frequency window individually in an STFT, chirps can be detected and eliminated using the same methods that are used for interference of short duration, pulses. The V [16] in figure 5 can be detected and eliminated

and the horizontal bands, the useable signals, can be reconstructed, after which the reconstructed time signal without interference and FFT without interference can be calculated from the STFT. This is the principle behind the method according to the invention.

5

Figure 5 shows as stated previously that a chirp appears as a V, labelled [16], in an STFT division. In the same way a pulse appears as a vertical line localised in time but broad-band. The useable signals are, however, horizontal lines. It is therefore possible to detect interference of the pulse or linear chirp type by  
10 looking in an STFT image for lines that are not parallel with the time axis. Such methods are known from image processing, see for example the Gonzalez/Woods reference mentioned above. A suitable method in this connection is described in chapter 7 in this reference and is based on what is known as Hough Transform.

15

In the following we discuss in greater detail the principles for filtering the useable signal.

The useable signal in an FMCW radar unit, i.e. the signal that corresponds to the  
20 actual target, is a sum of sine waves. A signal consisting of a single sine wave, sampled with constant frequency, has a simple linear relationship between the samples. Assume that the signal can be written as  $\sin(\omega * t + \varphi)$ .

Between two samples the phase angle of the sine wave thus changes by the angle  $\omega T = \theta$ , where T is the sampling interval. In accordance with the  
25 trigonometric identity

$$\sin(\alpha + \theta) + \sin(\alpha - \theta) = 2 * \cos(\theta) * \sin(\alpha)$$

it is then the case for three successive samples of the signal that:

30

$$x(n + 1) + x(n - 1) = 2 * \cos(\theta) * x(n)$$

Note that this is applicable regardless of the amplitude of the signal. This linear relationship can be interpreted in various ways:

- 5 a) If the signal is passed through an FIR filter (Finite Impulse Response) with the coefficients [ 1 -2\*cos(θ) 1 ], the output signal y from the filter will be identical to 0:

$$y(n) = x(n) - 2 * \cos(\theta) * x(n-1) + x(n-2)$$

- 10 It is possible therefore to strongly attenuate the signal with a single FIR filter with constant coefficients.

b) If the relationship is instead written:

15 
$$x(n+1) = 2 * \cos(\theta) * x(n) - x(n-1)$$

it can be seen that the next sample can be predicted by a linear combination from the immediately preceding sample.

- 20 For a signal that consists of several sine waves with distinct frequencies corresponding filters can be created by multiplication of second order FIR filters. A signal that is the sum of four different sine waves, i.e. an FMCW signal with four strong targets, can thus be reduced to zero by an FIR filter of order 8 and a
- sample can be predicted linearly from the 8 preceding ones.

25

For a general FMCW signal these relationships are approximate, but the following can be said in general to apply:

1. It is possible to strongly attenuate an FMCW signal by means of a suitable
- 30 linear FIR filter of a suitable order.

2. It is possible to predict linearly an FMCW signal using a suitable linear relationship of a suitable order.

The application of point 1 is that the sensitivity of the detection of an interference is greatly increased if the useable signal is pre-filtered in a suitable way. In figure 5 this corresponds to the horizontal bands being filtered away. Only the interference then remains against a weak background. This permits the detection of interference with an amplitude that is much lower than that of the useable signal, e.g. a signal that is completely invisible by analysis of the amplitudes in figure 3 but that still increases the noise base in the FFT in figure 6.

Point 2 makes it possible to interpolate the useable signal past a short section with interference, which will be described in greater detail later on.

A "suitable" filter can be calculated in various ways, or calculated as an adaptive filter. Both problems according to point 1 and point 2 above are known from adaptive signal treatment, see for example Haykin, Adaptive Filter Theory, 2nd Ed., Prentice-Hall 1991. The coefficients can be determined by the usual algorithms, e.g. LMS, standardised LMS, RLS, etc, see in particular chapters 9 and 13 in the above reference.

By adaptive determination of a filter it is often possible to utilise the fact that the radar aerial has turned, although only a fraction of a beam width, since the previous FMCW frequency sweep. The dominant sine waves in the signals from two subsequent FMCW sweeps have as a result almost the same frequency and almost the same amplitude. The start values of the adaptation can therefore be selected as the end values from the adaptation during the previous FMCW sweep.

It is also an important observation that in each frequency window in an STFT division of the signal the filters are very simple. In each frequency window the

signal is narrow-band and the middle frequency of the window is known. This means that the phase shift between two successive samples is known and just a second order filter has a very good effect.

5 In the following the synthesising of the useable signal is discussed.

A usual method of attenuating interference is to detect interference, e.g. a pulse, by the signal amplitude being unusually large and then to carry out clipping of the signal, preferably to the level 0. This can in itself eliminate the  
10 interference, but affects the FFT adversely by also affecting the useable signal.

The precondition for an FFT is that the sample is sampled equidistantly over a suitable period. Clipping of the signal removes samples. It can be said that the time base of the useable signal is affected. A consequence is that distinct  
15 targets are widened in the Fourier domain, which among other things can result in a reduction in the resolution.

A very useful method is to follow up the interference elimination by a synthesis of the useable signal. Here point 2 above can be used. The synthesis can consist  
20 of an extrapolation (one-ended) or interpolation (two-ended) of the signal based on values without interference. Such a synthesis can result in a dramatic improvement in the reconstruction of the FMCW signal without interference and its FFT.

25 The polynomial of the interpolation/extrapolation can as mentioned above be determined adaptively or in another way. The interpolation is particularly simple if the signal is narrow-band, as an interpolation polynomial of low order is usually sufficient.

30 The interpolation/extrapolation is numerically sensitive, among other things on account of the fact that the roots of the polynomial of the extrapolation lie on or near the unit circle and numerical interference therefore does not die out, and

can also for other reasons only be carried out over short sections of time. It is therefore not possible simply to interpolate/extrapolate past a chirp of a certain length.

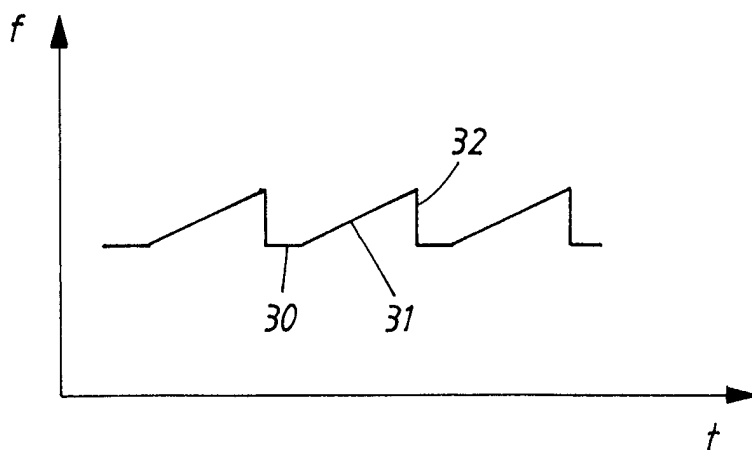
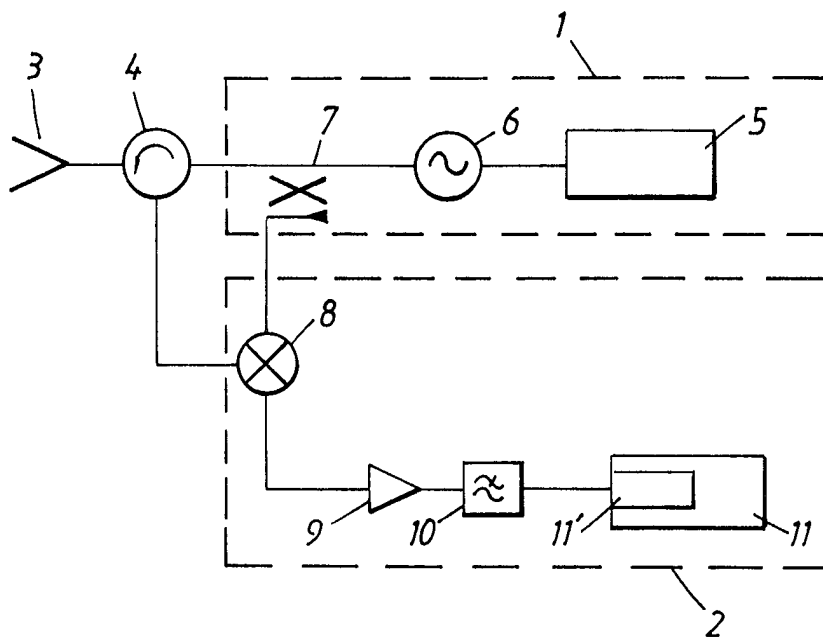
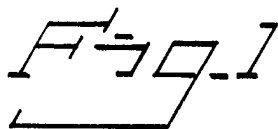
- 5 This problem can be solved by carrying out an STFT on the signal with interference in accordance with this invention. In each frequency window there will then be a chirp of only a short duration. In addition the signal components in each frequency window are narrow-band, which in accordance with the above makes the interpolation/extrapolation much simpler.

### Patent claims

1. A procedure for the elimination of interferences, such as pulses and linear chirps, in a radar unit of the FMCW type with linear frequency sweep, where the transmitted and received signals are combined to form a useable signal in the form of a difference signal, the beat signal, with a wave for each target, where the frequency, amplitude and phase of the wave contain the information about the target, **characterised by** the beat signal being subjected to time-frequency division for time-local frequency division of the signal, by the interference being detected and eliminated separately in each frequency band individually, after which the time signal freed from the interference and its Discrete Fourier Transform, DFT, are calculated from the time-frequency division freed from interference.
2. A procedure according to patent claim 1, **characterised by** the time-frequency division being carried out by what is known as STFT (Short Time Fourier Transform).
3. A procedure according to any of the preceding patent claims, **characterised by** the Discrete Fourier Transform, the DFT, being carried out by a fast algorithm, what is known as FFT.
4. A procedure according to any of the preceding patent claims, **characterised by** the detection of interference being carried out in each frequency band by methods suitable for the detection of interference of short duration.
5. A procedure according to any of the preceding patent claims, **characterised by** the detection of linear chirps and pulses being carried out by methods for detecting straight lines in images.
6. A procedure according to patent claim 5, **characterised by** the interference patterns in the form of straight lines deviating from lines parallel with the time

axis being identified, by the identified lines being related to the frequency band concerned and by the interference being eliminated separately in each frequency band concerned.

- 5 7. A procedure according to patent claim 5 or 6, **characterised by** a Hough Transform being used to detect the straight lines.
8. A procedure according to any of the preceding patent claims, **characterised by** the beat signal in connection with the time-frequency division in narrow  
10 frequency bands of the signal being filtered to increase the sensitivity of the detection.
9. A procedure according to patent claim 8, **characterised by** the filter being determined by adaptive methods.
- 15 10. A procedure according to any of patent claims 8 or 9, **characterised by** the filter being applied to one or more of the narrow-band frequency windows in the narrow-band frequency bands of the time-frequency division.
- 20 11. A procedure according to any of the preceding patent claims, **characterised by** the beat signal or useable signal after the elimination of interference being reconstructed by extrapolation from samples without interference, in one or more of the narrow-band frequency windows in the narrow-band frequency bands of the time-frequency division.



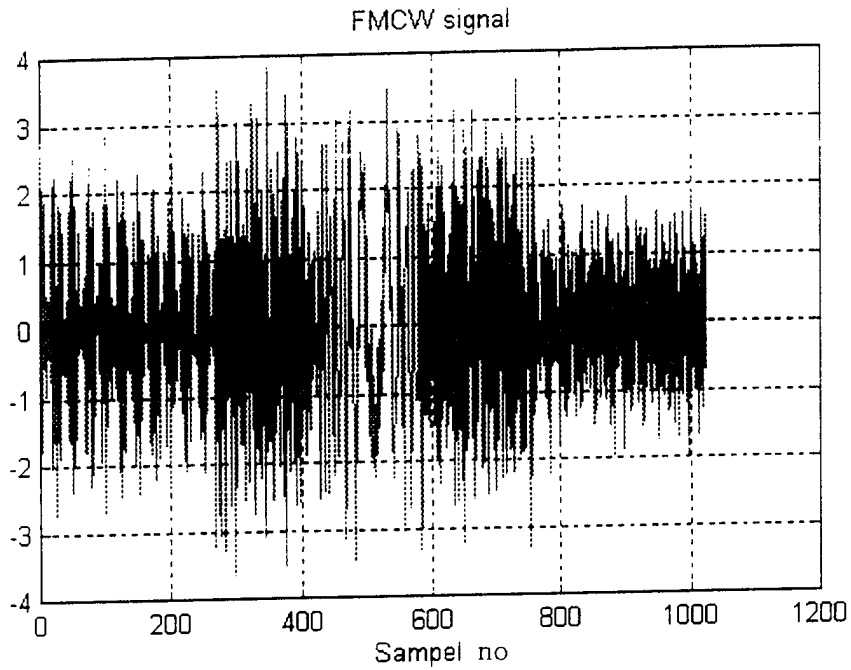


Fig. 3

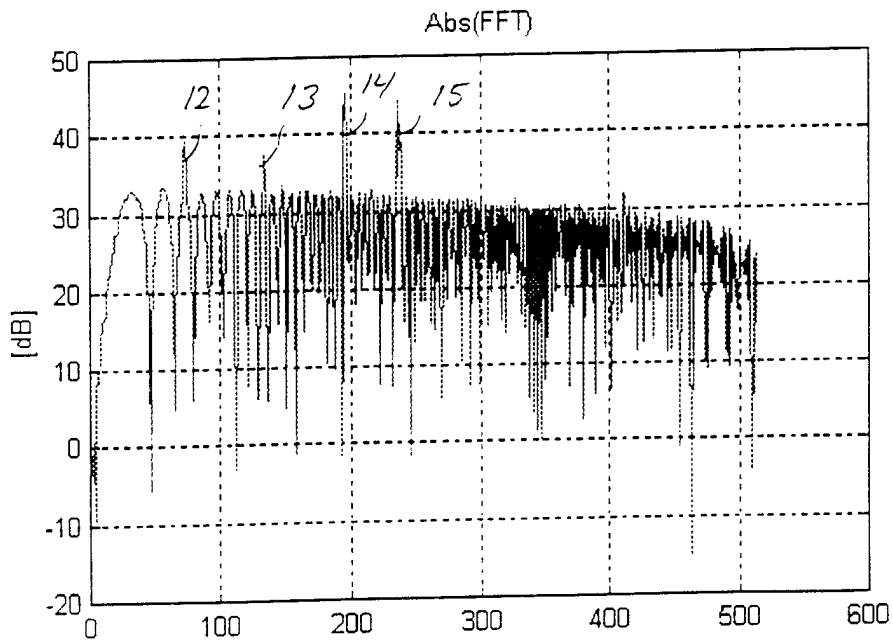


Fig. 4

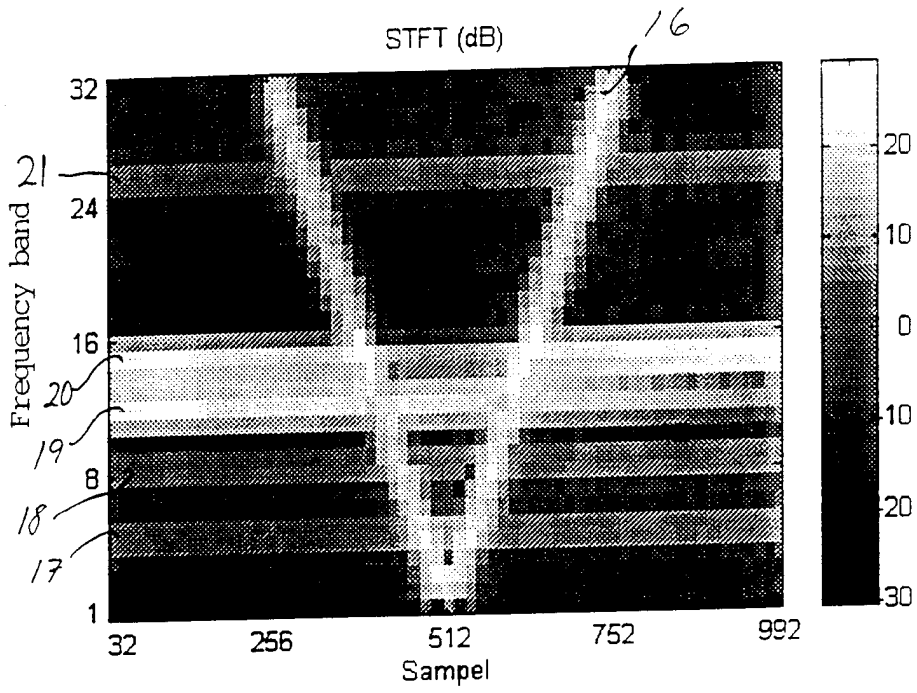


Fig. 5

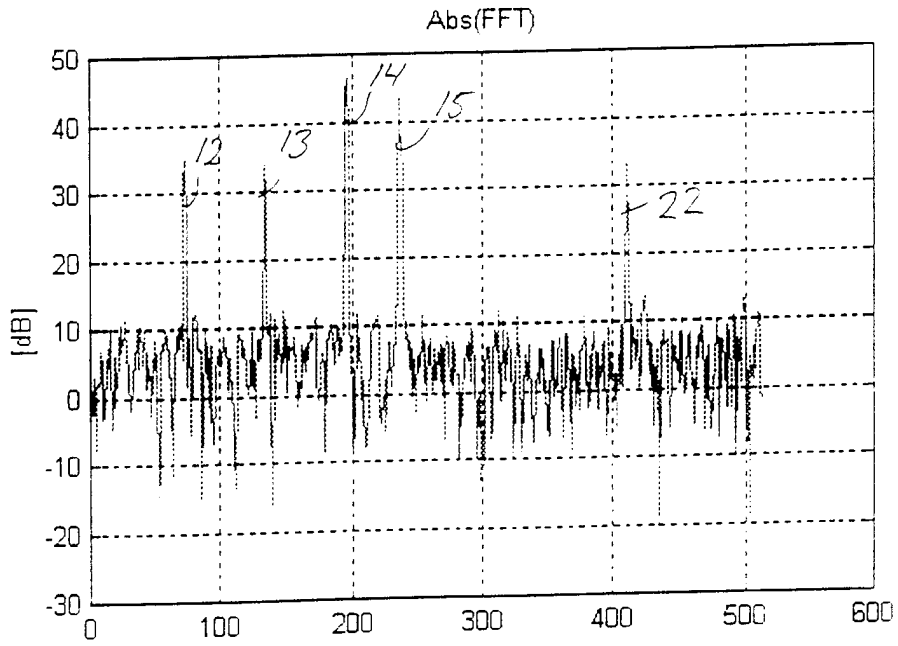


Fig.6

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01732

A. CLASSIFICATION OF SUBJECT MATTER		
<b>IPC6: G01S 13/34</b> According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: G01S, G06T		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EDOC, WPIL, INSPEC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0557660 A2 (RAYTHEON COMPANY), 1 Sept 1993 (01.09.93), page 3, line 39 - page 4, line 27, abstract ---	1-11
A	Proceedings of the SPIE, Volume 2027, 1993, (USA), M.P. Fargues et al, "Applications of Time-Frequency and Time-Scale Transforms to Ultra-Wideband Radar Transient Signal Detection", page 180 - page 193, see especially page 180 - 181 and page 184 - 185 --	1-11
A	GB 2248359 A (PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED), 1 April 1992 (01.04.92), abstract ---	1-11
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
9 March 1998		10.03.98
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer  Göran Magnusson Telephone No. +46 8 782 25 00

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01732

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2380557 A (INTERNATIONAL STANDARD ELECTRIC CORPORATION), 8 Sept 1978 (08.09.78), page 1, line 1 - page 3, line 9 <p style="text-align: center;">---</p>	1-11
A	R.C. Gonzales et al, "Digital Image Processing", 1987, Addison-Wesley Publishing Company Inc., (USA), page 344 - page 349 <p style="text-align: center;">-- -----</p>	7

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

03/02/98

International application No.  
PCT/SE 97/01732

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0557660 A2	01/09/93	US 5179542 A	12/01/93
GB 2248359 A	01/04/92	NONE	
FR 2380557 A	08/09/78	NONE	