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Datasheet for the decision of 18 January 2007

Case Number: T 0396/05 - 3.4.01

Application Number: 02011841.0

Publication Number: 1262793

IPC: G01S 13/34

Language of the proceedings: EN

Title of invention:
Method and apparatus for removing a DC-offset in the frequency spectrum before performing Fourier transform in a radar

Applicant:
MURATA MANUFACTURING CO., LTD.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54(1)(2), 56

Keyword:
"Novelty (no; main request)"
"Inventive step (no; first to fourth auxiliary request)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0396/05 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 18 January 2007

Appellant: MURATA MANUFACTURING CO., LTD.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 5 November 2004 refusing European application No. 02011841.0 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: B. Schachenmann
Members: H. Wolfrum
G. Assi

Summary of Facts and Submissions

I. European patent application 02 011 841.0 (publication No. EP 1 262 793 was refused by a decision of the examining division dispatched on 5 November 2004, for the reasons of lack of novelty and inventive step (Articles 52(1), 54(1) and (2) and 56 EPC) of the subject-matter of the requests then on file.

II. The applicant lodged an appeal against the decision and paid the prescribed fee on 17 January 2005. On 15 March 2005 a statement of grounds of appeal was filed by which the main request on which the contested decision had been based was maintained and three auxiliary requests were filed.

III. On 9 June 2006 the appellant was summoned to oral proceedings which were initially arranged for 11 January 2007 and subsequently postponed to 18 January 2007.

IV. In a communication dated 16 November 2006 the Board gave a preliminary view as to the issues of novelty and inventive step.

In response, the appellant filed by letter of 7 December 2006 four sets of claims as first to fourth auxiliary requests, respectively, replacing the former auxiliary requests.

V. In the appeal, reference was made *inter alia* to documents:

D2: WO-A-98 19177;

D3: US-A-5 625 362; and

D9: S. Salous, "On the potential applicability of auto-regressive spectral estimation to HF chirp sounders", Journal of Atmospheric and Solar-Terrestrial Physics, vol. 59, no. 15, 1997, pages 1961 to 1972.

Document D9 was cited from the board's own knowledge.

VI. Oral proceedings were held on 18 January 2007.

After discussion, the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of
claims 1 to 11, filed on 24 October 2003 according to a **main request**;
claims 1 to 11, filed by letter of 7 December 2006 according to a **first auxiliary request**;
claims 1 to 10, filed by letter of 7 December 2006 according to a **second auxiliary request**;
claims 1 to 7, filed by letter of 7 December 2006 according to a **third auxiliary request**; or
claims 1 to 5, filed by letter of 7 December 2006 according to a **fourth auxiliary request**.

VII. Claim 1 of the appellant's main request reads as follows :

"*1. A radar comprising:*

a transmitter (5) transmitting a transmission signal as a detecting radio wave and a receiver (5)

receiving a reception signal including a reflection signal from a target which reflects the transmission signal as the reception signal;

an A/D converter (8) that samples a beat signal comprising a signal related to the frequency difference between the transmission signal and the reception signal and AD-converting [sic!] *(8) the beat signal so as to obtain a sampling data-sequence having a predetermined number of data items;*

a DC removal unit (9) generating data to be frequency-analyzed by subtracting an average of data in a predetermined sampling interval of the sampling data-sequence from each of the data items in the sampling interval; and

a frequency-analyzer (12, 13) analyzing the data to be frequency-analyzed by a Fourier transform to obtain a frequency component of the beat signal and detecting the target based on the frequency component."

Independent claim 8 is directed to a corresponding method of detecting a target.

Claims 2 to 7 and 9 to 11 are dependent claims.

Claim 1 of the appellant's **first auxiliary request** differs from claim 1 of the main request in that the DC removal unit is specified to generate "*data to be frequency-analyzed by subtracting an average of all data items within a predetermined sampling interval to be frequency-analyzed of the sampling data-sequence from each of the data items in the sampling interval, all data items subtracted by the average representing the data to be frequency analyzed*", and in that the frequency analyser is defined as "*performing a Fourier*

transform processing on all data to be frequency analyzed". Corresponding amendments are made to method claim 8.

Claim 1 of the **second auxiliary request** is based on claim 1 of the first auxiliary request and adds to the definition of the DC removal unit the feature "*thereby removing a DC component of the beat signal, which occurs due to asynchronism between a sampling interval and a period of the beat signal or when the beat signal is less than one period in a sampling interval for FFT*". A corresponding amendment is made to method claim 7.

Claim 1 of the **third auxiliary request** is also based on claim 1 of the first auxiliary request and specifically defines the DC removal unit as comprising "*an average value data calculator that calculates an average of all data items within a predetermined sampling interval to be frequency-analyzed of the sampling data-sequence; and a subtraction stage that subtracts the average from each of the data items in the sampling interval, all data items subtracted by the average representing an output of the DC removal unit (9)*". Additionally, the claimed radar comprises "*a window function process [sic!] for performing window function processing on the output from the subtraction stage, to obtain data to be frequency-analyzed*". Again, corresponding amendments are made to method claim 6.

Independent claims 1 and 5 of the **fourth auxiliary request** are based on claims 1 and 6, respectively, of the third auxiliary request, at the end of which the following feature is added: "*wherein the detecting*

radio wave is a frequency-modulated wave including an up-modulation interval in which the frequency increases and a down-modulation interval in which the frequency decreases, the up-modulation interval and the down-modulation interval being repeated over time so as to form a triangular waveform of frequency versus time, and wherein a relative distance and a relative velocity between the radar and the target are detected based on the beat signal in the up-modulation interval and the beat signal in the down-modulation interval."

VIII. In support of novelty and inventive step for the subject-matter of its main request, the appellant argued in essence that the phrase "an average of data in a predetermined sampling interval" in independent claims 1 and 8 had to be understood as referring to an average of all data in said sampling interval. In distinction thereto, document D2 formed the average merely from the" high and low amplitude values", *ie* from only selected values, and thus failed to teach a satisfactory removal of DC components before Fourier transformation of the data. Consequently, operating the radar of D2 entailed the risk that close-range targets, which induced only small frequency shifts in the reflected signal, might go undetected in a strong DC background signal. None of the other documents of the cited prior art which related to radar systems taught the claimed solution, either. In particular, document D9 was silent as to a determination of a DC component by averaging of data items. Moreover, DC removal was considered necessary only for methods of frequency analysis which did not apply a Fourier transform, and, as far as the possible alternative of a Fourier

transform was discussed, this was performed on a limited set of data items of a sampling interval only.

These considerations applied all the more to claims 1 and 8 of the first auxiliary request, the wordings of which were amended so as to remove any doubt that the average was formed of all data items in the predetermined sampling interval and that a Fourier transform was made on all DC-corrected data of a sampling interval.

Independent claims 1 and 7 of the second auxiliary request further specified the origin of the DC components appearing in a Fast Fourier Transform (FFT), namely that the DC components arose from an inevitable asynchrony between the division of sampling data into assembling intervals for FFT and the period of the beat signal. None of the prior art documents even mentioned this problem, nor did any of them teach the claimed solution.

In addition, the third auxiliary request added a stage of window processing on the DC-corrected data items so as to suppress truncation errors caused by an FFT on a limited sampling interval. The application of this technique was particularly beneficial for an FMCW radar of the present invention for detecting close range distances to targets in the absence of Doppler shifts. Window processing, although known as such and mentioned in document D9, was not applicable to the radar known from document D2. The sole embodiment described in D2 made use of an FSK radar technique which relied on the evaluation of a phase difference of the reflected signal in order to determine the distance to a target.

Window processing, however, destroyed any phase information so that the skilled person would have been dissuaded to contemplate this technique for the radar known from document D2. As far as document D2 referred in passing to the possibility of employing an FMCW radar technique, it relied on the evaluation of phase differences of signals obtained in two parallel data channels by means of two separate transmitters/receivers. Neither was any DC removal foreseen in this case nor did D2 mention a window processing to be performed on the data items before performing the FFT.

The subject-matter of the independent claims of the fourth auxiliary request further emphasised the present invention, which was to be seen in the combination of an efficient removal of DC-components and the application of window processing to the data items obtained by a FMCW radar technique so as to reliably detect targets at close distances.

Reasons for the Decision

1. The appeal complies with the requirements of Articles 106 to 108 and Rule 64 EPC and is, therefore, admissible.

A. *Main request*

2. *Novelty (Articles 52(1) and 54(1) and (2) EPC)*

2.1 Document D2 refers to a method and apparatus for detection of objects proximate to an automotive vehicle

(see in particular Figures 2 and 3 and the corresponding description). In this context, document D2 discloses a radar comprising a transmitter (items 201 and 207 in Fig. 2) transmitting a transmission signal as a detecting radio wave, a receiver (item 213 in Fig. 2) receiving a reception signal including a reflection signal from a target which reflects the transmission signal as the reception signal, an A/D converter (item 218 in Fig. 2) that samples a beat signal (produced by a coupler 203 and a mixer 209) comprising a signal related to the frequency difference between the transmission signal and the reception signal and AD-converts the beat signal so as to obtain a sampling data-sequence having a predetermined number of data items, and a frequency-analyzer/microprocessor (item 220 in Fig. 2; item 301 in Fig. 3) analyzing the data to be frequency-analyzed by a Fourier transform to obtain a frequency component of the beat signal and detecting the target based on the frequency component in accordance with the respective features of claim 1 under consideration.

The microprocessor of the known radar also functions as a DC removal unit which generates the data to be frequency analyzed. More specifically, this is done on a block of data consisting of 512 sampled digital values which undergoes, prior to performing the FFT, a DC removal algorithm in which "*the average of the high and low amplitude values from within the block of data is subtracted from each amplitude value*" (page 23, lines 24 to 28).

2.2 In the appellant's view, the radar known from document D2 differed from the method according to claim 1 in that it merely averaged "the high and low amplitude values" in order to yield the average to be subtracted from each amplitude value and thus failed to disclose a DC removal unit generating data to be frequency-analyzed by subtracting an average of "all" data in a predetermined sampling interval of the sampling data-sequence from each of the data items in the sampling interval.

2.3 However, this argument is not convincing because the phrase "an average of data in a predetermined sampling interval" in claim 1 under consideration is not specific as to the extent of data items taken from a sampling interval to calculate the average and cannot therefore delimit the claimed method from the disclosure of document D2.

2.4 With the subject-matter of claim 1 lacking novelty, the main request is not allowable.

B. *First auxiliary request*

3. *Inventive step*

3.1 Claim 1 specifies that the DC removal unit subtracts an average of "all" data items within a predetermined sampling interval to be frequency-analyzed, and that all these data items are subject to the Fourier transform.

3.2 Indeed, the respective disclosure in the cited passage from page 23 of document D2 ("Prior to performing the FFT, each block of data undergoes a D.C. removal algorithm in which the average of the high and low amplitude values from within the block of data is subtracted from each amplitude value.") is ambiguous as to whether in fact all data items of the block of data or only certain data items are used for calculating the average. Because of this ambiguity in the teaching of the prior art, the provision of a DC removal unit which subtracts an average determined from "all" data items of a sampling interval is considered to constitute a distinguishing feature with respect to the radar known from document D2, so that the claimed subject-matter is regarded novel.

3.3 At any rate, forming the average of an ensemble of data items by taking all data items into consideration is considered to constitute a conventional measure as it is the standard procedure for calculating the (arithmetic) mean. Hence, it would have been obvious for the skilled person that DC removal in the radar known from D2 might be based on the subtraction from each data item of an average calculated from all data items of the block of data.

For this reason, the subject-matter of claim 1 of the first auxiliary request does not involve an inventive step. Consequently, the first auxiliary request is also not allowable.

C. *Second auxiliary request*

4. *Inventive step*

4.1 With respect to claim 1 of the first auxiliary request, claim 1 of the second auxiliary request further specifies the possible origin of the DC component to be removed, in that the DC component is specified to occur "*due to asynchronism between a sampling interval and a period of the beat signal or when the beat signal is less than one period in a sampling interval for FFT*".

4.2 This statement is merely an explanation of the cause of the DC component to be removed and does therefore not have any limiting effect on the claimed subject-matter in terms of structure or function.

Thus, the considerations given above for the subject-matter of claim 1 of the first auxiliary request apply with equal force to claim 1 of the second auxiliary request.

Therefore, the second auxiliary request is not allowable, either.

D. *Third auxiliary request*

5. *Inventive step*

5.1 In addition to claim 1 of the first auxiliary request, claim 1 of the third auxiliary request defines the DC removal unit to comprise an average value data calculator and a subtraction stage and the radar to further comprise a window function processor for

performing window function processing on the output from the subtraction stage, to obtain data to be frequency-analyzed.

5.2 In view of the fact that, in order to execute the DC removal, the microprocessor employed in the radar known from document D2 necessarily operates as an average value data calculator and a subtraction stage, the first amendment does not define a feature which would distinguish the claimed subject-matter from the known radar.

5.3 Document D2 does not mention window function processing on the data items prior to the Fourier transform.

Window function processing is however conventionally performed on a sequence of data items as a preparatory step to a digital Fourier transform in order to compensate for the effect of "frequency leakage" due to the fact that the Fourier transform assumes a periodic signal of infinite duration but is performed in practice on a limited set of data (and thus on data sampled in a limited time interval). Evidence for the respective common knowledge of the skilled person applied to the evaluation of radar data is given by document D9 (see in particular Figure 2 and the corresponding description which expressly teach that the window function processing is performed subsequent to a step of DC removal and prior to a Fast Fourier Transform (FFT)).

5.4 Appellant's argument that the application of window function processing was particularly beneficial for a frequency modulated continuous wave (FMCW) radar of the

present invention for detecting close range distances to targets in the absence of Doppler shifts is irrelevant because of the fact that the subject-matter of claim 1 of the third auxiliary request is neither limited to an FMCW radar nor is it specific as to the detection of target distances.

The further argument that window processing was not applicable to the radar known from document D2 because the frequency shift key (FSK) modulation employed according to the sole embodiment determined distances by detecting phase differences whereas window function processing destroyed phase information is not convincing.

Indeed, document D2 describes in detail how the known radar operates with an FSK modulation and, in that case, determines target distances by evaluating relative phase information in the frequency domain after Fourier transformation (see for instance page 5, lines 11 to 26; page 14, line 13 to page 15, line 2; and page 26, lines 6 to 25). However, the appellant has not proven to the satisfaction of the Board that conventional window function processing would destroy phase information, and in particular that relative phase information would indeed be affected by window processing. On the contrary, document D2 expressly refers to an FFT to be performed on the data obtained with FSK modulation, and an FFT is generally accompanied by a window function processing.

Besides, the appellant's argumentation disregards the fact that the teaching provided by document D2 is by no means limited to a radar operating with FSK modulation

and evaluating phase shifts. In fact, D2 repeatedly refers to the alternative of using a modulation based on a ramped frequency transmission signal, which is synonymous to an FMCW technique, for the determination of target distances and velocities (see page 5, lines 3 to 5; page 14, lines 4 to 12; and page 17, lines 28 to 30).

Finally, appellant's assertion that document D2 did not foresee DC removal in case of an FMCW radar ignores the fact that the respective information concerning DC removal is given in document D2 in a chapter "Processing of Digital Values" in the context of signal processing and thus is manifestly independent from any specific type of modulation.

5.5 For the above reasons, also the subject-matter of claim 1 of the third auxiliary request does not involve an inventive step so that the third auxiliary request is not allowable.

E. *Third auxiliary request*

6. *Inventive step (Articles 52(1) and 56 EPC)*

6.1 Based on the amendments made to the third auxiliary request claim 1 of the fourth auxiliary request additionally specifies the frequency modulation to be of the FMCW type for which beat signals are sampled and evaluated in an up-modulation interval and a down-modulation interval.

6.2 As already indicated in paragraph 5.4 above, document D2 contemplates an FMCW technique as an alternative to

FSK modulation. Although document D2 is silent as to details of the FMCW radar, *eg* such as the claimed separate sampling and evaluation of data in an up-modulation interval and a down-modulation interval, such details are commonplace and for instance described in the specific context of a radar system in document D3 (see in particular Figure 2 with the corresponding description). Therefore, the further amendments made to claim 1 do not add inventive subject-matter.

6.3 Contrary to the appellant's submission, the subject-matter of claim 1 of the fourth auxiliary request does not constitute an inventive selection of features which as such may have been known but, in combination, entailed synergistic effects.

As a matter of fact, each of the claimed features, *ie* the transmitter and receiver operating on the basis of an FMCW type modulation, the DC removal unit calculating the average of the data of a sampling interval and subtracting the average from each data items to be Fourier transformed, and the window function processor processing the date to be Fourier transformed, serves its own specific purpose. Since each of said features is known with the associated effect in the field of radar technology, and since no further technical effect is obtained by their common assembly in a radar, no exercise of inventive skill would have been required for the skilled person to devise a radar as claimed by claim 1 of the fourth auxiliary request.

6.4 For the above reasons, the fourth auxiliary request is not allowable, either.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

R. Schumacher B. Schachenmann