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Datasheet for the decision of 3 December 2019

Case Number: T 2624/17 - 3.4.02

Application Number: 08794636.4

Publication Number: 2171528

IPC: G02F1/01

Language of the proceedings: EN

Title of invention:
METHOD OF CONTROLLING THE DC BIAS OF AN ELECTRO-OPTIC SWITCH DRIVEN WITH POSITIVE AND NEGATIVE RF VOLTAGES

Applicant:
Northrop Grumman Guidance
And Electronic Company, Inc.

Headword:

Relevant legal provisions:
EPC Art. 83, 54(1), 56

Keyword:
Sufficiency of disclosure - (yes)
Novelty - (yes)
Inventive step - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
European Patent Office
Office européen des brevets

Beschwerdekammern

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Case Number: T 2624/17 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 3 December 2019

Appellant: (Applicant)	Northrop Grumman Guidance And Electronic Company, Inc. 21240 Burbank Boulevard Woodland Hills, CA 91367 (US)
Representative:	Round, Edward Mark Marks & Clerk LLP 15 Fetter Lane London EC4A 1BW (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 5 July 2017 refusing European patent application No. 08794636.4 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	R. Bekkering
Members:	H. von Gronau
	B. Müller

Summary of Facts and Submissions

I. The appeal of the applicant is directed against the decision of the examining division to refuse European patent application No. 08794636.4. The examining division refused the application because it was of the opinion that the application did not disclose the claimed invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art, contrary to Article 83 EPC.

II. The following documents were cited in the examination proceedings:

D1: WO 89/11675 A
D2: US 2003/095262 A1
D3: Wichers M. et al.: "Optical duobinary modulation schemes using a Mach-Zehnder transmitter for lightwave systems", International Conference in Kielce, Poland 9-11 June 1999, Transparent Optical Networks, 1999, pages 15-18
D4: US 2002/0061034 A1 .

III. With the statement setting out the grounds of appeal, the appellant requested that the decision under appeal be set aside, and that a patent be granted on the basis of the claims pending at the time of refusal, i.e. claims according to a main request or an auxiliary request both filed again with the grounds of appeal, that the appeal fee be refunded on the basis of a substantial procedural violation, and
that the examining division be mandated to consider all provisions of the EPC in reaching a comprehensive position on patentability.
It also requested that oral proceedings be held "in lieu of any adverse decision and in the event that the

Board of Appeal is minded to refuse the main request or the auxiliary request".

IV. In a communication pursuant to Article 15(1) RPBA annexed to a summons to oral proceedings the board expressed its provisional opinion that the first-instance proceedings were not affected by a substantial procedural violation. Furthermore, the board noted that, with respect to the analysis of the sufficiency of disclosure, it was essential to take into account the whole originally filed application as it can be understood by the person skilled in the art and that the appellant so far did not make reference to Figure 4 and the related description in paragraph 24. The board also expressed its provisional opinion that none of the documents cited in the examination proceedings suggested the claimed method.

With a letter dated 18 October 2019 the appellant withdrew the request that the appeal fee be refunded on the basis of a substantial procedural violation and informed the board that its sole request was the main request, with the following documents intended for grant:
- the claims entitled "Main Request" as filed with the grounds of appeal dated 15.11.2017;
- the description pages 1 to 9 as originally published with replacement pages 1, 2, 8 and 9 enclosed with the same letter dated 18 October 2019; and
- the figures on pages 1/8 to 8/8 as originally published.

V. In a further communication pursuant to Article 15(1) RPBA the board stated that the general purpose mentioned in claim 4 was not consistent with that

defined in claim 1 and could give rise to doubts as to how the initial DC voltage should be selected.

VI. With a letter dated 11 November 2019 the appellant filed amended claims 1-6 of a main request replacing the claims of the previous main request. The documents intended for grant according to the main request were:
- claims 1-6 of the main request filed with the letter dated 11 November 2019,
- description pages 1-9 as originally published, with replacement pages 1, 2, 8 and 9 as filed on 18 October 2019, and
- figures on pages 1/8-8/8 as originally published.

VII. With a communication dated 18 November 2019 the board informed the appellant that the oral proceedings had been cancelled.

VIII. Claim 1 as filed with the letter dated 11 November 2019 reads as follows:

"A method for utilizing optical feedback to maintain minimum optical transmission in an OFF state of a Mach-Zehnder electro-optic switch (706) having an RF input port (704) and a DC port (708), which exhibits first and second ON states upon respective application of positive and negative RF voltage pulses of substantially equal magnitude, by adjusting a DC bias voltage of the electro-optic switch, the method comprising the steps of:

selecting an initial DC voltage level and an initial RF port voltage by measuring visibility over a range of predetermined DC voltages and a range of predetermined RF port voltages, then selecting the initial DC voltage associated with minimum measured visibility;

determining visibility over a range of DC voltages proximate the initial DC voltage level in accordance with the relation:

$$VIS(V,V_P) = \frac{I_1(V,V_P) - I_2(V,V_P)}{I_1(V,V_P) + I_2(V,V_P)}$$

where:
V is applied DC voltage;
VP is applied RF voltage pulse magnitude;
I_1 is the normalized output of the electro-optic switch (706)corresponding to its first ON state; and I_2 is the normalized output of the electro-optic switch (706)corresponding to its second ON state;

computing visibility slope in accordance with the relation:

$$SLOPE = \Delta VIS / \Delta V,$$

where:
ΔVIS is change in visibility value; and
ΔV is change in applied DC voltage; and

applying a correction voltage to the initial DC voltage level, where the correction voltage is

$$\Delta V_{CORR} = \frac{-VIS_M}{SLOPE}$$

where:
ΔV_{CORR} is the correction voltage;
VIS_M is the measured visibility; and
SLOPE is the visibility slope."

Independent claim 4 as filed with the letter dated 11 November 2019 reads as follows:

"A Mach-Zehnder electro-optic switch (706) which exhibits first and second ON states upon respective application of positive and negative RF voltage pulses of substantially equal magnitude, having an RF input port (704) and a DC port (708)
and further comprising:

means for utilizing optical feedback to maintain minimum optical transmission in an OFF state of the Mach-Zehnder electro-optic switch (706) including:

means for selecting an initial DC voltage level and an initial RF port voltage by measuring visibility over a range of predetermined DC voltages and a range of predetermined RF port voltages, then selecting the initial DC voltage associated with minimum measured visibility;

means for determining visibility over a range of DC voltages proximate the initial DC voltage level in accordance with the relation:

$$VIS(V,V_P) := \frac{I_1(V,V_P) - I_2(V,V_P)}{I_1(V,V_P) + I_2(V,V_P)}$$

where:

V is the applied DC voltage;

V_P is the applied RF voltage pulse magnitude;

I_1 is the normalized output of the electro-optic switch (706) corresponding to the first ON state; and

I_2 is the normalized output of the electro-optic switch (706) corresponding to the second ON state;

means for computing visibility slope in accordance with the relation:

$$SLOPE = \Delta VIS / \Delta V,$$

where:

ΔVIS is change in the visibility value; and

ΔV is change in the applied DC voltage; and

means for applying a correction voltage to the initial DC voltage level, where the correction voltage is

$$\Delta V_{CORR} = \frac{-VIS_M}{SLOPE}$$

where:
ΔV_{CORR} is the correction voltage;
VIS_M is the measured visibility; and
SLOPE is the visibility slope."

Reasons for the Decision

1. The appeal is admissible.

2. Main request - subject-matter of claim 1 - sufficiency of disclosure (Article 83 EPC)

2.1 The examining division was of the opinion that claim 1 of the main request did not teach how to select the initial RF port voltage. Neither the description nor the figures provided any help as regards the selection of the initial RF port voltage (see reasons for the contested decision, 2).

The claim provided no guidance on the choice of the predetermined ranges of DC and RF voltages required to carry out the measurements of visibility. Thus the person skilled in the art was not in a position to determine the initial DC and RF voltages (see reasons for the contested decision, 3).

In the last step the claim did not indicate which specific value of the visibility was meant by the expression "the measured visibility". It was not clear which specific values of DC voltage and RF voltage should be applied to the electro-optic switch in order to determine the value of the measured visibility. Paragraph 22 of the description did not provide information about how the measured visibility value was arrived at (see reasons for the contested decision, 4 and 5).

The effect to maintain minimum optical transmission in an OFF state of a Mach-Zehnder electro-optic switch could not be reproduced because it could not be established from the whole application documents which value should be used for the initial DC and RF voltages in the last step (see reasons for the contested decision, 7).

Any statement made in paragraph 29 of the description with regard to the cascaded configuration could not be applied to a method of maintaining minimum optical transmission in an OFF state of a single switch (see reasons for the contested decision, 8.1.1).

Under the assumption that paragraph 29 could be regarded as being applicable to a single switch, an initial RF port voltage V_P equal to zero would entail that the optical powers I_1 and I_2 would always be identical regardless of the applied DC voltage, and the person skilled in the art could not select the initial DC voltage level, because there would be no minimum measured visibility (see reasons for the contested decision, 8.1.2).

Paragraph 19 did not provide insight into the range of predetermined RF port voltages to be used in the first step, either. It disclosed only a single value of RF voltage (see reasons for the contested decision, 8.2).

Even if the person skilled in the art selected a range of DC voltages on the basis of paragraph 29 it would still find no guidance in the whole application as to the appropriate extent of the range of DC voltages. The application also did not discuss how to select the "range of predetermined RF port voltages" to be used in the first step. In paragraph 29 only a null RF port voltage was mentioned and under these circumstances the person skilled in the art could not select the initial DC voltage associated with minimum measured visibility, since there would be a plurality of DC voltages satisfying this condition (see reasons for the contested decision, 8.3).

2.2 In its grounds of appeal the appellant argued:

The range of predetermined voltages was "the proper operating voltage based upon characterising data supplied by the manufacturer" as described in paragraph 29 of the specification.

Figure 1 showed the result of "measuring visibility over a range of predetermined DC voltages and a range of predetermined RF port voltages". This was also shown in Figure 2. Paragraph 29 explained that there were "many iterative processes readily adaptable for finding suitable voltages for properly balanced optical transmission". This paragraph was not limited to the embodiment of figure 8, since it mentioned "the RF port" and "the switch".

The step of "selecting the initial DC voltage associated with minimum measured visibility" corresponded to conditions resulting in the switch outputting the least optical power, as shown in figure 1.

The last step was described in paragraph 22.

2.3 In the letter of 18 October 2019 the appellant explained that Figure 4 showed four fixed DC voltages and a plot of the visibility vs RF pulse voltage for these. However the claims were required to find a suitable DC bias voltage. To produce the graph of Figure 4, a number of measurements of visibility at predetermined voltages and a range of pulses was required. Figure 4, therefore, showed the results of these measurements and the associated description was concerned with optimisation of the RF pulse magnitude. Therefore, whilst the graph of Figure 4 was useful for understanding the invention, the use of interpolation to refine an RF voltage was more suited to the iterative process described in paragraph 31 in relation to the two modulators. Figure 4 therefore provided additional understanding for the invention.

2.4 The board takes note of the appellant's arguments in view of the reasons for the contested decision. For the analysis of the sufficiency of disclosure the board regards it as essential to take into account the whole originally filed application as it can be understood by the person skilled in the art. The board considers that the application as originally filed defines the initial DC and RF voltages in a sufficiently clear and complete manner. The purpose of the claimed method is to maintain minimum optical transmission in the OFF state of a Mach-Zehnder electro-optic switch by adjusting the

DC bias voltage. This implies that for a given Mach-Zehnder electro-optic switch a suitable DC bias voltage is already known at which the optical transmission in the OFF state is minimal. It is evident that the initial DC voltage is selected close to the known DC bias voltage to determine an actual DC bias voltage that drifts over time and temperature (see application, paragraph 02).

With respect to the initial RF port voltage, Figures 2 and 4 and the related portions of the description, in particular paragraph 19, provide sufficient guidance. This paragraph discloses that an RF pulse voltage V_P equal to $V_{P\Pi}$ is not suitable, but that an RF pulse voltage of 5/6 $V_{P\Pi}$ is a good starting point. This paragraph also explains how the RF pulse voltage can be varied and the advantages and disadvantages thereof. The board is therefore of the opinion that the application gives the person skilled in the art enough guidance to select a suitable initial RF pulse voltage.

Contrary to the opinion of the examining division, the initial DC voltage level, in paragraph 29, is not selected by measuring the visibility, but by not applying an RF pulse voltage and measuring the transmitted optical power over a range of DC voltages. How the suitable DC voltage is selected by measuring the visibility is sufficiently disclosed in Figure 2 and the corresponding description in paragraph 18.

In the last step of the claimed method it is defined that a correction voltage is applied to the initial DC voltage level. The board does not see a lack of disclosure in this step because it is clear that the measured visibility VIS_M is the visibility at the initial DC voltage to which the correction voltage

should be applied. Even if no particular values for the initial values are defined in the last step of the claimed method it is sufficiently clearly disclosed in the application as originally filed how to select the initial RF and DC voltages, as explained above.

2.5 The board therefore comes to the conclusion that the claimed invention is disclosed in a manner sufficiently clear and complete (Article 83 EPC).

3. Main request - claim 1 - novelty (Article 54(1) EPC)

None of the cited prior art documents discloses all the features of claim 1.

Document D1 discloses a Mach-Zehnder interferometer. It deals with the problem of voltage-induced drift and it discloses a method controlling the electrical potentials applied to the first and second electrodes of the Mach-Zehnder interferometer such that, in use, the average potential difference between the first and second electrodes is substantially zero (see e.g. page 2, third paragraph). This is achieved by using either positive voltage pulses or negative voltage pulses that are summed until a certain threshold is exceeded and then using the other type of voltage pulse until the summed pulses reach an opposite threshold (see page 9, last paragraph to page 10, first paragraph). Document D1 does not disclose using the optical output power of the two ON states to adjust the DC bias voltage.

Document D2 discloses an interferometer employed as optical sensor for measuring a selected parameter quantity. In particular a phase shift is induced between the pair of optical beams in response to, for example, an electrical current. An electro-optical

switch having two ON states that are compared in order to apply a correction to the DC voltage level is not disclosed.

Document D3 discloses a Mach-Zehnder modulator driven in different modulation schemes to generate a duobinary signal. It does not disclose using the optical output power of the two ON states to adjust the DC bias voltage.

Document D4 discloses a Mach-Zehnder optical modulator that contains respective bias and gain control subroutines that are executed in a time-interleaved manner, using feedback current extracted at the output of the Mach-Zehnder waveguide. Once initial values for bias and gain have been set to 'best guess' parameters the bias control subroutine derives the peak of the sinusoidal Mach-Zehnder function, where the derivative is zero and the slope of an induced error signal has the correct sign. A difference between the normalized output corresponding to a first ON state and a second ON state is not determined.

4. Main request - claim 1 - inventive step (Article 56 EPC)

4.1 Independent claim 1 largely corresponds to the wording of originally filed independent claim 7 comprising similar (clarified) method steps. The examining division was of the opinion that the subject-matter of originally filed claim 7 involved an inventive step (see communication of 11 June 2010 which refers to the International Preliminary Report on Patentability of the International Searching Authority of 26 January 2010).

4.2 The board agrees with the opinion of the examining division that none of the cited documents suggests using a method maintaining minimum optical transmission in the OFF state of a Mach-Zehnder electro-optic switch by adjusting the DC bias voltage based on the determined optical output power difference at the first ON state and the second ON state upon respective application of positive and negative RF voltage pulses.

4.3 The board therefore concludes that the subject-matter of claim 1 involves an inventive step in accordance with Article 56 EPC.

5. The corresponding independent apparatus claim 4 comprises means for performing the method steps of claim 1. Therefore, its subject-matter likewise meets the requirements of the EPC.

6. Claims 2 and 3, and 5 and 6, are dependent from claims 1 and 4, repectively. These claims therefore also meet the novelty and inventive step requirements of the EPC. The description fulfills the requirements of Rule 42 EPC.

7. For the sake of completeness it is noted that the appellant in its statement of grounds of appeal requested oral proceedings "in lieu of any adverse decision and in the event that the Board of Appeal is minded to refuse the main request or the auxiliary request". This not being the case, there was no need for oral proceedings.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division with the order to grant a patent in the following version:

Description:
Pages 3-7 as published.
Pages 1, 2, 8 and 9 filed with the letter dated 18 October 2019.

Claims:
Nos. 1-6 according to the main request filed with the letter dated 11 November 2019.

Drawings:
Sheets 1/8 to 8/8 as published.

The Registrar: The Chairman:

M. Kiehl R. Bekkering

Decision electronically authenticated