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Datasheet for the decision of 21 June 2010

Case Number: T 1913/07 - 3.4.02

Application Number: 00112822.2

Publication Number: 1065550

IPC: G02F 1/035

Language of the proceedings: EN

Title of invention:
Electro-optic modulators with integrated impedance matching

Applicant:
Oclaro (North America), Inc.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step: yes"

Decisions cited:
-

Catchword:
-

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Case Number: T 1913/07 - 3.4.02

D E C I S I O N
of the Technical Board of Appeal 3.4.02
of 21 June 2010

Appellant: Oclaro (North America), Inc.
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Representative: McGowan, Cathrine
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 5 July 2007 refusing European patent application No. 00112822.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: A. G. Klein
Members: M. Stock
D. S. Rogers

Summary of Facts and Submissions

I. The appellant has appealed against the decision of the examining division refusing European patent application number 00 112 822.2 on the ground that the claimed subject-matter lacked an inventive step within the meaning of Article 56 EPC 1973, respectively, in view of the following documents:

D1: WO 99/09451 A (PIRELLI ET AL) 25 February 1999 (1999-02-25)

D2: IZUTSU M ET AL: "On the Design of Resonant Electrodes for Efficient Guided-Wave Light Modulators", The Transactions of the Institute of Electronics and Communication Engineers OF Japan, Section E, vol. E71, no. 4, April 1988, pages 342-344, XP000071412, ISSN: 0387-236X

D3: JP 09230296 A (FUJITSU LTD) 5 September 1997 (1997-09-05)

II. The appellant has requested that a patent be granted on the basis of claims according to the main request as amended during the oral proceedings before the examining division. This set of claims was also filed with the appellant's statement of grounds of appeal.

The appellant's arguments can be summarised as follows:

Considering D2 as the closest prior art, claim 1 differed from D2 in that according to claim 1, the electrical structure used for impedance matching includes a second electrical element extending from the

interface port to ground (stub 6). In contrast, in D2, the matching stub extended from the midpoint of the resonant electrode arms (resonant line) to ground, on the opposite side of the resonant line to the feeder line.

A technical effect of this difference was to provide an alternative arrangement for impedance matching, thereby allowing increased flexibility in the design of the optical modulator, for example for changing the modulating frequency. The solution according to claim 1 was to provide a matching stub (second electrical element) that extends from the interface port to ground. This solution was not obvious having regard to D2, D3 and Smith charts. D2 clearly taught the skilled person how to modify the electrode structure in D2 for use at other frequencies and for other impedance levels. In D2, a first modulator for use at a centre modulation frequency of 11.1 GHz was described with a second modulator for use at a frequency of 16 GHz being described later. To effect the change from 11.1 GHz to 16 GHz, it was first mentioned that the length of the stub is adjusted or tuned. Then was described how to optimise operation for 16 GHz by altering various parameters, in particular the separation **"s"** of the resonant electrode relative to the waveguide dimensions.

Hence, in D2, the skilled person was taught how to achieve impedance matching and good modulator performance for different modulator frequencies and impedance levels. He was taught to do this by, among other things, changing the length of the matching stub and varying the width and separation of the electrode. He received adequate instruction about how to modify

the modulator for operation at different frequencies, and would not be motivated to seek alternative designs beyond those suggested by D2. In particular, D2 made no mention of moving the matching stub from the described position in which it extends from the resonator line.

Therefore, the skilled person would not be prompted by D2 to move the matching stub to the position specified in claim 1 (extending from the interface port to ground). He was taught how to modify the modulators described in D2 for operation at other frequencies, and would not seek further alternatives. Hence, claim 1 was inventive over D2.

Similarly, the solution was not found in D3. This document described an optical modulator having an electrode structure similar to that of D2, in that a matching stub is provided which extends from the resonant electrode to ground on the opposite side of the resonant electrode to the input feeder line. However, D3 considered that a symmetrical structure such as that of D2 in which the resonant electrode has two equal arms, with the feeder line and the matching stub joined to the midpoint of the resonant electrode is deficient, and proposed that such a structure can be improved by making the two arms of the resonant electrode of unequal length. This was to reduce the driving voltage. This modification was the only change in the electrode structure described in D3. D3 was silent on the general subject of modifying a modulator for use at other frequencies. In particular, D3 did not propose any position for the matching stub other than that of a stub extending from the resonant electrode to ground.

Hence, if the skilled person considering the modulator of D2 were to consult D3, he would have only learned that the required driving voltage could be reduced by making the arms of the resonant electrode to have different lengths. Regarding changes required for operation at different frequencies, he would learn nothing from D3, and would still rely on the information in D2. There was nothing in D3 which would prompt him to move the matching stub in such a way as to arrive at the invention according to claim 1. Therefore, claim 1 was inventive over D2 combined with D3.

Furthermore, contrary to the opinion of the Examining Division, it was submitted that the skilled person would not consult a Smith chart when considering the modulator described in D2. As discussed above, D2 taught how to modify an optical modulator for use at different frequencies. Given this teaching, there would have been no incentive for the skilled person to look elsewhere for information about how to make a modulator operate for at different modulation frequencies. All the information he required could be found in D2. Moreover, the above-mentioned technical problem of how to realise an optical modulator for use at a particular modulation frequency related to the technical field of modulating optical signals. The only reason for contemplating changing the modulation frequency of an optical modulator was, if it were desired to modulate an optical signal at a different frequency. This would be of interest to the skilled person working with modulated optical signals, in other words, one skilled in the art of optical signal modulation. However, the

solution according to claim 1, that of repositioning the matching stub, laid in the technical field of impedance matching, and the configuration of circuits therefor. This was a radio frequency speciality, unrelated to optical frequency technology, and the person skilled in the art of optical signal modulation was not a radio frequency engineer. Thus, the person skilled in the art of optical signal modulation who considered the modulators described in D2 would not turn to the area of radio frequency engineering if seeking to operate the modulators at different modulation frequencies, and would not therefore consult a Smith chart.

In this regard, reference was made to T 422/93, which indicated that when examining for inventive step using the problem and solution approach, the appropriate skilled person should be defined according to the technical field of the problem to be solved, and could be an expert in the technical field to which the solution belongs if this technical field is different from the technical field considered when formulating the problem. Thus, in the present case, the skilled person was not skilled in the technical field of impedance matching, radio frequency engineering and the like, and hence Smith charts would not form part of his common general knowledge.

Therefore, claim 1 was considered to be inventive over D2 combined with a Smith chart and the use thereof.

Enclosed in appellant's letter dated 1 June 2010 were new description pages 5, 5a, 6 and 8. Page 7 was deleted.

III. Claims 1 and 2 of the Main Request filed with the written statement of grounds of appeal that underlies this decision read as follows:

1. A resonant optical modulator (10), for use with a signal source, comprising:
an electro-optical substrate (2);
an optical waveguide (1) formed in the substrate and having a variable index of refraction;
an active modulator electrode (3) formed on the substrate in relation to the waveguide to effect electro-optical variation of the index of refraction upon application to the electrode of a modulating signal at a frequency around a resonant frequency, the active modulator electrode having a termination to ground (4);
an interface port (5) formed on the substrate and providing the modulating signal to the electrode from the signal source, the signal source having an impedance; and
an electrical structure formed on the substrate and coupled to the interface port and the electrode, and comprising a first electrical element (7) formed on the substrate and extending from the interface port to the electrode; and
a second electrical element (6) formed on the substrate and extending from the interface port to ground, an impedance of the optical modulator including the interface port and the electrical structure being substantially equal to the impedance of the signal source for a modulating signal at a frequency around the resonant frequency.

2. An optical transmission system, comprising:
an optical source (200) for generating an optical signal;
an RF signal source for generating an RF signal (285) at a predetermined frequency, the RF signal source having an impedance;
a resonant optical modulator (10) as recited in claim 1 for modulating the phase of the optical signal according to the RF signal, the impedance of the optical modulator being substantially equal to the impedance of the RF signal source;
an optical amplifier (205,210) for amplifying the optical signal to a power greater than 6 dBm; and
an optical fiber line (220,230) for transmitting the amplified and phase modulated optical signal.

Reasons for the Decision

1. *Clarity and original disclosure*

The Board is satisfied that the requirements of Articles 84 and 123(2) EPC are met, these requirements having not given rise to objections by the examining division.

2. *Novelty*

2.1 Employing the terminology used in claim 1, document D3 discloses (corresponding reference numerals or designations used in D1 are appended to the features) a resonant optical modulator (optical control element), for use with a signal source (7), comprising an

electro-optical substrate (optical base plate), an optical waveguide (1) formed in the substrate and having a variable index of refraction; an active modulator electrode (3) formed on the substrate in relation to the waveguide to effect electro-optical variation of the index of refraction upon application to the electrode of a modulating signal at a frequency around a resonant frequency, the active modulator electrode having a termination to ground (implicit); an interface port (connection point 8) formed on the substrate and providing the modulating signal to the electrode from the signal source, the signal source having an impedance; and an electrical structure formed on the substrate and coupled to the interface port and ground, and comprising a first electrical element (2) formed on the substrate electrode; and a second electrical element (5) formed on the substrate and extending from the interface port to ground, an impedance of the optical modulator including the interface port and the electrical structure being substantially equal to the impedance of the signal source for a modulating signal at a frequency around the resonant frequency.

2.2 The electrical structure of claim 1 differs from that described in D3, in that the first electrical element extends from the interface port to the (modulator) electrode. In D3 the control electrode 2, if identified with the first electrical element, does not extend from the interface port (connection point 8) to the modulator electrode (3). Presumably it extends to ground as the modulator electrode (3) does. Therefore the subject-matter of claim 1 is new over D3.

2.3 Document D1, see Figures 6 to 8 with the connected description, discloses a modulator in which the electrodes include a portion 92 that has a first part which acts as an interface port, and a further part joining the interface port to the modulating electrode. However, D1 lacks any second electrical element connected between the interface port and ground. Therefore, the subject-matter of claim 1 is new over D1.

2.4 The subject-matter of claim 1 is also new with respect to D2, which has an electrode structure whose electrodes cannot unambiguously be identified with the electrode structure defined in present claim 1 as will become apparent from the following discussion of inventive step.

2.5 There is no document in the file which comes closer to the claimed subject-matter. Therefore the subject-matter of claim 1 is novel.

3. *Inventive step*

3.1 The Board agrees to the examining division's view that document D3 represents the closest prior art. The first electrical element (delay line 7) defined in claim 1 cooperates with the second electrical element (stub 6) to form an impedance matching network. Therefore the function of this network is purely electrical ensuring impedance matching of the signal source with the modulator. In D3, see Figures 1 to 3 and 5 with the associated description (see e.g. machine translation of D3), only the stub 5 has a purely electrical effect whereas the control electrode 2 influences the refractive index of the optical waveguide 1 at the

light input side as the other control electrode acts on the waveguide at the light output side. It should be noted in this context that the first electrical element is not designated as an electrode contrary to the active modulator electrode also specified in claim 1 and in contrast to the control electrodes 2 and 3 described in D3.

3.2 The problem solved by the present invention over D3 is thus related to the provision of at least an alternative, if not an improved, impedance matching network. The solution indeed provides increased flexibility in the design of the optical modulator, e.g. for changing the modulation frequency.

3.3 D3 is apparently limited to a design where the control electrode is split into two control electrodes acting on the waveguide in an asymmetric or symmetric manner in agreement with what is described in document D2 for the symmetric arrangement, see Figure 1. The stub (D3: 5, D2: "matching stub") is in both documents, D3 and D2, the only element apart from the feeder line and feeder electrode corresponding to the interface port of the present invention, which provides no optical effect. Therefore there is nothing in the two documents D2 and D3 which gives a hint towards a purely electrical network consisting of an electrical structure comprising a first element (delay line) and a second element (stub).

3.4 In its decision the examining division argued that the claimed arrangement would result in an obvious way from impedance matching by using the well-known Smith charts. The Board can in this respect accept the appellant's

argument that "the skilled person would not be prompted to look further afield for an alternative solution, and in particular would not look to a different field by consulting a Smith chart". The Board has doubts as to whether the Smith charts are so well-known in the field of electro-optic modulators that it was straightforward to use them as a basis for designing networks. In fact, none of documents D1 to D3 or of the six documents cited in the description of the present patent application including one document cited also in the European search report mention Smith charts. It is also not evident how merely using Smith charts would automatically lead to the claimed structure.

3.5 Therefore the Board concludes that it was not obvious for the skilled person starting from D3 as the closest prior art to arrive at the invention as defined in present claim 1. Starting from D2 as closest prior art would not lead to a different result. In addition, considering D1 cited in the European search report and the present application in combination with D2 or D3 would not lead to a different result.

4. *Conclusion*

4.1 It follows that the subject-matter of claim 1 involves an inventive step within the meaning of Article 56 EPC.

4.2 The dependent claims 3 to 13 are related to embodiments of the invention as defined in claim 1 and as such also meet the requirements of EPC. Moreover, this applies to claim 2 directed to an optical transmission system comprising a modulator as defined in claim 1.

4.3 The description has been adapted to the claims as amended in terms of the presentation of the prior art, the problem underlying the invention and its solution.

4.4 For these reasons the request of the appellant is allowable and there is no need to conduct the oral proceedings requested.

Order

For these reasons it is decided that:

1. The decision of the examining division is set aside.

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

Description:

Pages 1 to 4 and 9 to 20 as originally filed.
pages 5, 5a, 6, 8 filed with letter of 1 June 2010.

Claims:

Nos.: 1 to 13 filed with letter of 1 November 2007.

Drawings:

6 Sheets (Figures 1 to 10) as published.

The Registrar: The Chairman:

M. Kiehl A. G. Klein