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D E C I S I O N
of 12 March 1999

Case Number: T 0516/97 - 3.5.2

Application Number: 94913704.6

Publication Number: 0648386

IPC: H03K 3/03

Language of the proceedings: EN

Title of invention:
Ring Oscillator

Applicant:
STMicroelectronics Limited

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes"

Decisions cited:
-

Catchword:
-

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Case Number: T 0516/97 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 12 March 1999

Appellant: STMicroelectronics Limited
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 21 November 1996 refusing European patent application No. 94 913 704.6 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: R. G. O'Connell
J. H. P. Willems

Summary of Facts and Submissions

I. The appellant contests the decision of the examining division to refuse European patent application No. 94 913 704.6 on the ground that the subject-matters of the respective claims 1 of the main and auxiliary requests filed with the letter dated 5 September 1996 did not involve an inventive step having regard to the following document:

D4: IBM Technical Disclosure Bulletin, volume 31, No. 2, July 1988, pages 154 to 156, New York, US; "CMOS ring oscillator with controlled frequency".

II. Following a telephone interview with the rapporteur, the appellant's representative requested the board to amend the statement of invention at page 2 of the description to bring it into line with claim 1, and to make a minor typographical amendment of claim 1. The application as presently amended consists of the following documents:

Claims: 1 to 4 as amended by telephone on 9 March 1999;

Description: pages 4 to 6 as published in WO 94/26025, pages 1 and 3 as filed with the letter dated 13 March 1996, page 2 as amended by telephone on 9 March 1999;

Drawings: sheets 1 to 3 as published.

In addition the applicant filed with the letter dated 5 September 1996 an acknowledgement of prior art EP-A-0 187 572 (D2) (in the form of a proposed insert) in case the examining division or board of appeal should regard it as necessary that D2 be so acknowledged.

III. Claim 1 is worded as follows:

"A ring oscillator comprising a plurality of oscillator stages (S1,S2,S3), each stage comprising first (T1) and second (T2) transistors, wherein the first transistor (T1) has a controllable path connected between an output node (SOUT) and a reference voltage and a control node acting as an input node to the stage and wherein the second transistor (T2) has a controllable path connected between the output node (SOUT) and the reference voltage and a control node connected to the output node, each stage further comprising a respective current source (2) comprising a transistor gated by a control voltage (V) which controls the speed of the stage and which is connected to said output node (SOUT), wherein the input node of one stage is connected to the output node of a preceding stage to form said ring and wherein the number of stages (S1,S2,S3) is selected so that there is a total phase shift of 360° around the ring at the frequency of operation, characterised in that the gain of each stage (S1,S2,S3) is selectively determined by the ratio m of the widths of the first (T1) and second (T2) transistors to produce an output signal having a sawtooth or trapezoidal waveform where $m \geq 2.5$."

Claims 2 to 4 are dependent on claim 1.

IV. The appellant argued in effect that D4 did not address the problem underlying the present invention, viz to construct an oscillator capable of operating at low voltage and having good noise immunity providing a stable amplitude over a wide frequency range with a view to its application in a phase locked loop (PLL). Instead D4 set out to provide a ring oscillator generating a stable sinusoidal waveform which could be expected to find application in a frequency synthesiser for r.f. applications. The aim of providing a good sinusoidal output was explicitly mentioned in D4:

"The variations in current caused by this factor cause undesirable distortion of the output waveform away from the ideal of a sinusoid" (page 155, bottom paragraph)

"By this means, the PFETS 1a to 3a are kept operating in their current saturation regions, providing almost constant current, and the distortion of the output waveform is substantially reduced" (page 156, final sentence).

There was no suggestion of an application in a PLL. The D4 oscillator operated specifically at 5V and there was no reference to the problem of operating with a lower supply voltage. Since D4 did not address the problem underlying the present invention it could not lead the person skilled in the art to a solution to that problem.

The solution offered by the present invention was to set the operating conditions for a ring oscillator as specified in the characterising portion of the claim so as to give the waveform a better defined edge for switching purposes, thus giving an improved noise margin at lower supply voltages.

The reasoning in the decision under appeal, in particular at point 4, which concluded that the D4 circuit had a value for m > 2.0 was based on a hindsight analysis. D4 did not discuss the ratio m at all and there was no reason for the person skilled in the art to analyse the D4 circuit in terms of this parameter.

V. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of the documents specified at point II above. The appellant also filed an auxiliary request corresponding to the first instance auxiliary request.

Reasons for the Decision

1. The appeal is admissible.

2. The main issue to be decided in this appeal is whether the ring oscillator according to claim 1 involves an inventive step, having regard to the prior art known from D4.

3.1 It is not disputed by the appellant, and it is confirmed by the board, that the ring oscillator disclosed in Figure 2 of D4 has all the features of the prior art portion of claim 1. In the judgement of the board, it is appropriate to regard D4 as the closest prior art since it addresses the same general problem of providing a ring oscillator of controllable frequency and was acknowledged as such from the outset at page 1 of the description of the present application. Indeed, despite the appellant's assertion to the contrary, D4 envisages the application of the ring oscillator disclosed therein in a PLL; cf D4, page 155, third paragraph, last sentence. The specific

problem solved by the ring oscillator of claim 1 is to increase frequency stability and range while providing increased noise immunity to enable the circuit to operate with a low voltage power supply (loc.cit.). This is achieved by modifying the known oscillator in accordance with the measures specified in the characterising portion of the claim which, in the judgement of the board, are best analysed as three distinct features which the board labels A to C:

(A) the gain of each stage (S1, S2, S3) is selectively determined by the ratio m of the widths of the first (T1) and second (T2) transistors

(B) to produce an output signal having a sawtooth or trapezoidal waveform

(C) where $m \geq 2.5$.

3.2.1 In considering the question whether it would be obvious for the person skilled in the art to solve the problem referred to above by modifying the D4 oscillator as specified in the characterising portion of claim 1, it is important to note that NFET '11b' in Figure 2 of D4, although the formal counterpart of the "second (T2) transistor" in reading the prior art portion of the claim onto D4 does not have the function specified in characterising feature (A) of codetermining the stage gain by virtue of the (inverse) ratio of its width to that of the first transistor. As noted at point 5 of the decision under appeal, the aim of D4 is primarily to prevent the voltage across the transistors (1a, 2a, 3a) from decreasing to a value for which they would not any more operate as ideal current sources, which would lead to frequency inaccuracies (D4, page 155, third

paragraph). To solve this problem, D4 teaches the addition of second transistors acting as **clamps** in the stages, yielding an output voltage swing of 4 volts, with a power supply voltage of 5 volts; see D4, page 155, last three lines.

3.2.2 In D4 there is no mention of transistor widths or even of stage gain. According to the present application at page 3, lines 12 to 22 it was "well known in the design of ring oscillators" that for a 3-stage ring the gain should be > 2 for oscillation. The board regards this statement as a valid acknowledgement of common general knowledge in the art before the priority date of the application and it does not interpret the appellant's statement in the statement of grounds of appeal, criticising the use the examining division made of this passage as resiling from this acknowledgement of common general knowledge in the art. The board judges it plausible therefore, as the examining division did in the decision under appeal, that the person skilled in the art would interpret D4 as relating to a 3-ring oscillator having a stage gain marginally > 2 since it is designed to produce an ideal sinusoid waveform (D4, page 155, middle of fourth paragraph). On the other hand, the board is not at all persuaded that the person skilled in the art would derive any inspiration from D4 to determine the stage gain selectively by means of the ratio 'm' of the widths of the first and second transistors as specified in feature (A) of claim 1. Such an idea would be incompatible with the voltage clamping function of the second transistor (NFET '11b') in D4.

3.2.3 Even if, for the sake of argument, it is assumed that the person skilled in the art would somehow be motivated to modify D4 to replace the clamping transistor '11b' by a 'second transistor' functioning in accordance with feature (A) of claim 1, it is not

plausible, in the judgement of the board, to argue that the person skilled in the art would be led by the teaching of D4 to take the further step of varying the aim clearly and explicitly expressed there of generating an ideal sinusoidal waveform, to modify D4 to generate instead a trapezoidal or sawtooth waveform as specified in feature (B) of claim 1. The examining division's finding that the advantage of providing a steep edge for improving noise immunity would be obvious to the person skilled in the art is not supported by any evidence and has therefore to be regarded as not well founded.

3.2.4 In view of the above conclusions, it is unnecessary for the board to decide whether the person skilled in the art, having arrived at features (A) and (B) would find it obvious to choose a value of 'm' ≥ 2,5 as specified in feature (c) to generate a trapezoidal or sawtooth waveform.

3.2.5 In the judgement of the board therefore, it would not be obvious for the person skilled in the art, starting from the closest prior art D4, and addressing the problem specified at point 3.1 above, to modify the known ring oscillator by means of the features specified in the characterising portion of claim 1.

3.3 The board concludes therefore that the subject-matter of claim 1 involves an inventive step within the meaning of Article 56 EPC, having regard to the prior art according to D4.

4. The board agrees with the appellant that D2 is not sufficiently relevant to the problem solved by the ring oscillator of claim 1 of the present application as to require acknowledgement in the description.

5. In the judgement of the board, the application in accordance with the main request (as amended by telephone on 9 March 1999) meets the requirements of the EPC. The auxiliary request need not be considered.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

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

Claims: 1 to 4 as amended by telephone on 9 March 1999;

Description: pages 4 to 6 as published in WO 94/26025,
pages 1 and 3 as filed with the letter dated 13 March 1996,
page 2 as amended by telephone on 9 March 1999;

Drawings: sheets 1 to 3 as published in WO 94/26025.

The Registrar: The Chairman:

M. Kiehl W. J. L. Wheeler