Decision of Technical Board of Appeal 3.5.01 dated 13 December 2006

T 1227/05 - 3.5.01

(Translation)

Composition of the board:

Chairman: S. Steinbrener

Members: K. Bumes

G. Weiss

Applicant: Infineon Technologies AG

Headword: Circuit simulation I/Infineon Technologies

Article: 52(1), (2), (3), 56, 84 EPC

Keyword: "Computer-implemented method with mathematical steps for simulating the performance of a circuit subject to 1/f noise - technical character (yes)" "Undefined technical purpose - adequate for clarity (no)"

Headnote:

I. Simulation of a circuit subject to 1/f noise constitutes an adequately defined technical purpose for a computer-implemented method functionally limited to that purpose (point 3.1).

II. Specific technical applications of computer-implemented simulation methods are themselves to be regarded as modern technical methods which form an essential part of the fabrication process and precede actual production, mostly as an intermediate step. In that light, such simulation methods cannot be denied a technical effect merely on the ground that they do not yet incorporate the physical end product (point 3.4.2).

Summary of facts and submissions

I. The appeal lies from the examining division's decision to refuse application No. 01964907.8 on the grounds that the simulation method according to claim 1 as it then stood constituted a mental act or mathematical method as such and was therefore excluded from patentability under Article 52(2) EPC as a non-invention.

II. In an annex to summons, the board remarked that a computer-implemented embodiment of the method would overcome the non-invention objection. Inventive step assessment though could only consider features which contributed to the technical character of the simulation method. So what particularly needed to be examined was whether the mathematical formulae in the independent claims could contribute to technical character.

III. The appellant requests that the decision to refuse his application be set aside and that a patent be granted on the basis of claims 1 to 6 as filed at oral proceedings before the board of appeal. With an obvious correction ("t_i") of an obvious typing error ("t") in the formula for e(i,j) in claim 2 (compare with description page 5, line 10, and page 11, line 26), the claims read:

"1. Computer-implemented method for the numerical simulation of a circuit with a step size δ which is subject to 1/f noise, wherein:

- the circuit is described by a model (1) featuring input channels (2), noise input channels (4) and output channels (3);

- the performance of the input channels (2) and the output channels (3) is described by a system of differential equations or algebroid differential equations;

- an output vector (**OUTPUT**) is calculated for an input vector (**INPUT**) present on the input channels (2) and for a noise vector (**NOISE**) y of 1/f-distributed random numbers present on the noise input channels (4); and

- the noise vector **y** is generated by the following steps:

- determining a desired spectral value β of the 1/f noise,

- determining a value n for the number of random numbers to be generated for a 1/f noise,

- determining an intensity constant const,

- forming a covariance matrix C of dimension (n x n), each element e(i,j) of covariance matrix C being determined by the following equation:

$e(i,j)= const\cdot|\delta|^{\beta+1}(|i-j+1|^{\beta+1}-2|i-j|^{\beta+1}+|i-j-1|^{\beta+1})$

where i,j = 1, ..., n

- forming the Cholesky decomposition L of covariance matrix C,

the following steps being performed for each sequence of random numbers to be generated for a 1/f noise:

- forming a vector x of length n from random numbers having a Gaussian (0,1) distribution,

- generating the vector y of length n of the desired 1/f-distributed random numbers by multiplying the Cholesky decomposition L by the vector x.

2. Computer-implemented method for the numerical simulation of a circuit subject to 1/f noise at observation instants t_0 to t_n, wherein:

- the circuit is described by a model (1) featuring input channels (2), noise input channels (4) and output channels (3);

- the performance of the input channels (2) and the output channels (3) is described by a system of differential equations or algebroid differential equations;

- an output vector (**OUTPUT**) is calculated for an input vector (**INPUT**) present on the input channels (2) and for a noise vector (**NOISE**) y of 1/f-distributed random numbers present on the noise input channels (4); and

- the noise vector **y** is generated by the following steps:

- determining a value n for the number of random numbers to be generated for a 1/f noise,

- determining an intensity constant const,

- determining a desired spectral value β of the 1/f noise,

- forming a covariance matrix C of dimension (n x n), each element e(i,j) of covariance matrix C being determined by the following equation:

$e(i,j)= const\cdot(-|t_j-t_i|^{\beta+1}+|t_{j-1}-t_i|^{\beta+1}+|t_j -t_{i-1}|^{\beta+1}-|t_{j-1} -t_{i-1}|^{\beta+1})$

where i,j = 1, ..., n

- forming the Cholesky decomposition L of covariance matrix C,

the following steps being performed for each sequence of random numbers to be generated for a 1/f noise:

- forming a vector x of length n from random numbers having a Gaussian (0,1) distribution,

- generating the vector y of length n of the desired 1/f-distributed random numbers by multiplying the Cholesky decomposition L by the vector x.

3. Method according to claim 1 or 2 wherein not all elements of the covariance matrix C are determined, the uncalculated elements being given a value of 0.

4. Computer program for executing a method according to any of claims 1 to 3.

5. Data medium holding a computer program according to claim 4.

6. Computer system on which a computer program according to claim 4 is loaded."

IV. The appellant sees a technical contribution not only in the computer-implemented embodiment but in the following aspects of the claimed simulation method:

(a) In numerical circuit simulation, technical considerations are required to solve problems in the engineering sciences, in particular electrical engineering, i.e. to predict the performance of a circuit whose variables are technical parameters (e.g. voltages).

Using the simulation method, noise influences can be factored in, and flaws and weaknesses in circuit design can be identified at an early stage, i.e. before the start of circuit fabrication. That means considerable savings in outlay and time in the development of electronic circuits, e.g. a considerable reduction in the number of test chips needed until the product is mature. Chip production time can be considerably reduced with the claimed method.

(b) Specifically, the simulation of 1/f noise by generating random numbers that can be built into the time step sequence of a technical application - circuit simulation - constitutes a technical process in itself, especially as the claimed series of random numbers for the first time produces an exact 1/f noise, which earlier technical literature holds to be difficult if not impossible (see e.g. US-A-5 719 784, column 6, lines 55-65). The present application, in addition to using a formula to generate the required random numbers, does also supply mathematical proof that the generated numbers actually introduce an exact 1/f noise into the simulation; but this supplementary mathematical disclosure does not make the claimed teaching non-technical.

(c) An instruction to populate computer storage with formula-generated random numbers of a 1/f noise is addressed to the technical engineer, not the mathematician, and thus in itself constitutes technical teaching. It makes it possible, for example, to build a special random number generator which like any other modern signal generator (e.g. one based on direct digital synthesis) constitutes a commercially tradable technical product.

(d) Compared with other conceivable approaches to simulating noise-affected circuits, the claimed method requires shorter computing times and less storage space because the random numbers can be generated separately before they are integrated into the circuit simulation and because the prior art uses equation systems whose dimensions greatly increase with the number of noise sources. The claimed method makes it possible to simulate noisy circuits on small computer systems which were previously not powerful enough for the purpose, or to simulate large circuits which previously could not have been simulated on any computer system. Resource efficiency thus constitutes a technical effect which goes beyond the normal physical interaction between a computer program and a data processing system.

V. The board pronounced its decision at the end of the oral proceedings.

Reasons for the decision

1. Teaching of the application

1.1 The purpose of the application (see introduction to description) is to simulate or model the performance of a circuit under the influence of a 1/f noise, i.e. a stochastic process with a frequency spectrum whose intensity is inversely proportional to a power β of the frequency. (In the claims, β is referred to as a "spectral value".) The process describes the time dynamics of a physical variable, e.g. electric voltage.

1.2 The solution is based on the notion that 1/f noise can be simulated by feeding suitable random numbers into the circuit model. The application derives the numbers from a Gaussian stochastic process B_{FBM} (fractional Brownian motion as a function of time) whose derivative is known to have a 1/f spectrum. The B_{FBM} process and its derivative are characterised in particular by a covariance function (equation 1.4) and a covariance matrix (equation 2.7).

The invention generates a covariance matrix (equation 2.8) which features the same simple elements as the covariance matrix (equation 2.7) of the derivative of the fractional Brownian motion. A triangular (Cholesky) decomposition of the generated covariance matrix is multiplied by a vector x of random numbers having a Gaussian distribution. Due to the design of the covariance matrix, the resultant random number sequence y forms a 1/f noise source.

1.3 The design of the random number sequence also allows any desired time intervals in the circuit simulation to be taken into account: the interval may be of constant length (step size δ; claim 1) or variable (observation instants t_0, t_1, ... t_n; claim 2) in order to adapt to a dynamic circuit simulation. In both cases the random numbers merge seamlessly into the time step sequence of the numerical circuit simulation.

In addition, the random numbers can be calculated separately, before circuit simulation starts, and then built into the simulation.

This and the simple generation of random numbers provide for resource-efficient computer simulation of a circuit under the influence of 1/f noise.

2. Article 123(2) EPC - original disclosure

2.1 The board is in no doubt that a computer-implemented simulation method with the features of claims 1 and 2 is derivable from the application as originally filed and published as A2: WO-A2-02/19089.

The following passages disclose a circuit which is simulated with allowance for 1/f noise: A2, page 1, lines 9-11; page 5, lines 13-26. The circuit may for example be a p-n diode or a MOSFET (page 1, lines 21-23).

The following passages show that the simulation is computer-implemented: A2, page 1, line 34, to page 2, line 13; page 12, lines 15-23; original claims 5 to 7.

The following passages disclose that simulation is performed numerically (i.e. digitally): A2, page 2, lines 19-23; page 2, line 36, to page 3, line 11; page 5, lines 16-19.

The following passages among others show that an exact 1/f noise is simulated by generating and feeding in random numbers: A2, page 2, lines 19-25; page 3, lines 29-34; page 4, lines 22-24; page 12, paragraph 2; original claim 4.

The following typical passages show that the same step size is used to generate the desired covariance matrix of random numbers as to simulate the circuit, and they also demonstrate that the step size may be constant (claim 1) or dynamically adaptable (claim 2): A2, page 4, lines 8-16 (constant step size δ) and page 4, line 35, to page 5, line 11 (adaptive step size = interval between successive observation instants t_j).

It is evident e.g. from Fig. 1 and the associated description that the circuit being simulated is modelled by means of input channels (2), noise input channels (4) and output channels (3) and that their performance is described by a system of (algebroid) differential equations.

The steps for computing the random numbers which form a noise vector (y) for simulating 1/f noise are evident in particular from original claims 1 and 2.

2.2 Claims 3, 4 and 5 are based on original claims 3, 5 and 6. The use of the method on a computer system (claim 6) underlies the whole application, see e.g. page 1, line 34, to page 2, line 13.

3. Article 52(1), (2), (3) EPC - technical character

To be eligible for patent protection it is necessary and sufficient for the claimed method to have technical character (see e.g. T 930/05 - *Modellieren eines Prozessnetzwerks*/ XPERT, not published in OJ EPO). As the method according to independent claim 1 or 2 is computer-implemented, it uses technical means and by that very token has technical character, see in particular T 258/03 - Auction method/HITACHI (OJ EPO 2004, 575, Reasons 4.1 to 4.7) and T 914/02 - Core loading arrangement/GENERAL ELECTRIC (not published in OJ EPO, Reasons 2.3.4 to 2.3.6).

Below the board discusses which other features in its view contribute to the technical character of the method, as only such features may and must be considered for the purpose of assessing inventive step, see T 641/00 - Two identities/COMVIK (OJ EPO 2003, 352, Reasons 6).

3.1 Beyond its implementation, a procedural step may contribute to the technical character of a method only to the extent that it serves a technical purpose of the method.

The board is persuaded that simulation of a circuit subject to 1/f noise constitutes an adequately defined technical purpose for a computer-implemented method, provided that the method is functionally limited to that technical purpose.

3.1.1 The metaspecification of an (undefined) technical purpose (simulation of a "technical system", see original claim 4), on the other hand, could not be considered adequate, as the purpose of a claim in this context is not to quote the technical character requirement, but to identify clear features supported by the description which meet that requirement (Article 84 EPC).

However, a circuit with input channels, noise input channels and output channels whose performance is described by differential equations does indeed constitute an adequately defined class of technical items, the simulation of which may be a functional technical feature.

3.1.2 In the present case the stated purpose - simulation of a circuit subject to 1/f noise - is established in the further steps of the claimed method. On the basis of the physical and mathematical derivation specified in the description, it is verifiable that the random numbers generated according to the claims actually introduce 1/f noise into the circuit simulation. The board is therefore persuaded that the independent method claims are functionally limited to the simulation of a noise-affected circuit.

3.2 The board is further persuaded that the claimed simulation of a circuit constitutes neither a mathematical method as such nor a computer program as such, even if mathematical formulae and computer instructions are used to perform the simulation.

3.2.1 While the invention may be preceded by a mental or mathematical act, the claimed result must not be equated with this act. The present claims relate to a simulation method that cannot be performed by purely mental or mathematical means, not to the thought process that led to that simulation method.

3.2.2 Simulation performs technical functions typical of modern engineering work. It provides for realistic prediction of the performance of a designed circuit and thereby ideally allows it to be developed so accurately that a prototype's chances of success can be assessed before it is built. The technical significance of this result increases with the speed of the simulation method, as this enables a wide range of designs to be virtually tested and examined for suitability before the expensive circuit fabrication process starts.

Without technical support, advance testing of a complex circuit and/or qualified selection from many designs would not be possible, or at least not in reasonable time. Thus computer-implemented simulation methods for virtual trials are a practical and practice-oriented part of the electrical engineer's toolkit. What makes them so important is that as a rule there is no purely mathematical, theoretical or mental method that would provide complete and/or fast prediction of circuit performance under noise influences.

3.2.3 As regards the potential exclusion of computer programs, the board stands by its earlier ruling that this exclusion does not apply to computer-implemented methods (claims 1 to 3), see T 424/03 - Clipboard formats I/MICROSOFT (not published in OJ EPO, Reasons 5.1).

3.2.4 For the above reasons, in the board's view, all steps relevant to circuit simulation - and that includes the mathematically expressed claim features - contribute to the technical character of the simulation method according to claim 1 or 2.

3.2.5 In this context the board notes that the above conclusion cannot be drawn from the mere observation that a claimed method runs faster than a "conceivable" reference method (see point IV(d) above). As it is always possible to conceive of a slower reference method, a mere speed comparison is not a suitable criterion for distinguishing between technical and non-technical procedural steps. If, for example, a sequence of auction steps leads to price determination more quickly than some other auction method, that does not necessarily imply that the auction steps contribute to the technical character of the method (see T 258/03).

3.3 The computer program according to claim 4 has the potential for a technical effect going beyond basic hardware/software interaction in a standard computer. Loaded onto a computer it provides for automatic simulation and evaluation of noise-affected circuits. The computer program thus does not come under the program exclusion, see T 1173/97 - Computer program product/IBM (OJ EPO 1999, 609, Reasons 6.5).

The potential exclusion of computer programs is likewise not applicable to data medium claim 5, see the above-mentioned T 424/03 (Reasons 5.3).

Lastly, claim 6 too relates to patentable subject-matter, as a computer system must be considered technical *per se*, see T 931/95 - Pension benefits system/PBS (OJ EPO 2001, 441, Reasons 5) or the above-mentioned T 258/03 (Reasons 3.8).

3.4 Distinction from earlier T 453/91

3.4.1 In T 453/91 - Method for physical VLSI-chip design/IBM of 31 May 1994 (not published in OJ EPO), the board (in a different composition) held a semiconductor chip design method to be a non-invention because the design delivered a mere image of something which did not and possibly never would exist in the real world; thus the result of the claimed method was not necessarily a physical entity. The only contributions the design steps made were in excluded fields, such as mental acts and their implementation by computer programs (Reasons 5.2). Only methods involving an extra step for actually manufacturing the designed semiconductor chips were to be regarded as technical overall (Reasons 5.3).

3.4.2 The board in its present composition is persuaded that a circuit design method is not necessarily to be equated with a simulation method for testing a designed circuit under noise influences. Be that as it may, with regard to the general statements in T 453/91, and especially its demand for the inclusion of a manufacturing step, it must be noted that the importance and assessment of industrial simulation methods are changing. For the reasons discussed in point 3.2 above, for an increasing number of fields in the engineering sciences "the application of numerical simulation is becoming a cost-effective alternative to expensive, experimental investigations consuming significant time and personnel resources. In many industrial branches numerical simulation has already evolved to a key technology" (to quote for example from the website of the Computational Engineering faculty of Darmstadt Technical University, http://www.ce.tu-darmstadt.de/res/gk-mso.en.php?language=en). Even today, in some situations, technological progress demands developments whose performance and reliable operation can only be tested by simulation, where the real application environment is not directly available to the tester, as is the case for example with space travel.

To that extent, specific technical applications of computer-implemented simulation methods are themselves to be regarded as modern technical methods which form an essential part of the fabrication process and precede actual production, mostly as an intermediate step. In view of this development it must be assumed that the outlay for implementing a technical product will increasingly shift to the numerical simulation phase, while final implementation of the simulation result in the actual manufacture of the product will entail no or only comparatively little extra innovation effort. In that light, such simulation methods cannot be denied a technical effect merely on the ground that they do not yet incorporate the physical end product (in effect the German Federal Court of Justice ruled in the same way in its decision of 13 December 1999, X ZB 11/98 - *Logikverifikation*; Reasons II.4(h)).

A further fundamental change is to be found in the fact that development and production are increasingly separated, materially and geographically, in a globally distributed industry. In that light, too, the board considers specific patent protection to be appropriate for numerical development tools designed for a technical purpose.

3.5 Distinction from T 49/99

3.5.1 In T 49/99 - Information modelling/INTERNATIONAL COMPUTERS of 5 March 2002 (not published in OJ EPO), the board held steps of abstract information modelling for an undefined physical system in a computer to be an intellectual activity which had all the traits typical of non-technical branches of knowledge and was therefore analogous to the non-inventions listed under Article 52(2)(a) and (c) EPC. Information modelling was a first stage of software development for systematically gathering data about the physical system to be modelled or simulated and providing as it were a real-world model of the system on paper (Reasons 7).

3.5.2 The board's rejection was based on claim elements whose subject-matter was more like a metalanguage for describing an abstract model than a description of technical features which implemented the model.

That is not the situation here. The independent method claims both entail the specific modelling of an adequately defined class of technical systems (circuits) and define specific measures, not just mental constructs, for targeted implementation and application of the circuit model under the technically relevant conditions of 1/f noise. In keeping with a further finding of T 49/99 (Reasons 7, last sentence), that means a purposive use of information modelling in the context of a solution to a technical problem and hence a contribution to the technical character of the method according to claim 1 or 2.

4. Article 56 EPC - inventive step

Features which contribute to the technical character of the simulation method according to claim 1 or 2 are to be taken into account in assessing inventive step (T 641/00). The board is persuaded that all features relevant to circuit simulation, including the steps expressed by formulae, contribute to the technical character of the simulation method. While the idea and practice of computer implementation for the general purpose of automating a numerical simulation method and making it faster are *prima facie* obvious, the question that now arises is whether the claimed simulation methods, given their mathematically defined steps, involve an inventive step.

This question was not discussed before the examining division. The state of the art was not searched in either the international or the European phase. Only the applicant himself has mentioned a number of publications, during the proceedings before the examining division.

Hence a prior art search will now be necessary so that the features contributing to technical character can then be assessed for inventive step.

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 for further examination.