

## ISSCC Over the Decades – A Brief Statistical Overview of 40 Years

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As part of a retrospective on the occasion of the 40th International Solid-State Circuits Conference, a set of statistical studies has been undertaken on a variety of aspects of the historical paper presentations. The overall goal of this effort was to capture and encapsulate information reflecting upon the historical importance of the papers presented, together with facts concerning their subject emphasis and authorship. Of necessity, the result you will see before you is quite limited. There is much more work to be done!

While ideally informative in and of itself, this presentation will be a measurable success if it serves to tantalize the interest of its readers in the wealth of historical technical information which the Conference Digest embodies. As such, the study summarized here can be seen merely as a prototype of further studies to follow. After all, our 50th year is not far away!

The primary study was directed at uncovering some quantitative measures of aspects of the importance of ISSCC papers to the technical readership. One measure of the utility of a technical idea is the degree to which it is referenced later by others. A convenient source of such information is available in citation-listings, those compendia of subsequent publications which cite a particular original work as relevant to the subsequent one. Note, however, that the use of such data is not entirely straightforward; There are several issues involving peculiarities of authors which must be accommodated:

The first is the obvious fact that the archival record provided in the ISSCC Digest is a summary, rather than a full paper. Typically, but certainly not always, a more complete paper, called here the *successor paper*, will appear as well. As this label indicates, this appears almost always after the Conference, typically within one year, but with timing that varies historically. Generally speaking, the timing has tended to cycle as the ongoing growth in desire to publish is compensated by the successive emergence of new publication vehicles, of which the special issues of the Journal of Solid-State Circuits (JSSC) are a relatively recent example. Thus, the present study attempts to identify the "successor paper" through analysis of titles (and some actual paper perusal), and uses both Digest and successor citation counts in the statistical analysis.

As well, there are other factors of which to be aware: For example, academic and industrial authors have markedly different attitudes to publication, particularly of successor-papers. While this has the obvious immediate impact, there is a more subtle effect as well: It is simply that there is an overall dominance of academic authorship of papers in general and, correspondingly, also of citations. Accordingly, citations are unlikely to represent a true measure of importance of an idea to industry, since its members, who display a pronounced tendency not to write, lack both time to write and any incentive to reveal their sources. As well, to confuse the issue further, at the referencing end of the process, is the tendency

for some ideas to be picked up in what later becomes a very important seminal paper, which then behaves as the de facto surrogate of the original. That is not to say that the second paper always replaces and obviates the first (which may on occasion also be the case), but rather it highlights, compares, and/or employs the first idea in such an effective way that to refer to it, the second, is to capture the essence of both. Thus, publication patterns are far from uniform, and citation lists are far from ideal. As well, the scope of journal coverage and completeness are other problematic issues. Regrettably, these are realities about which there is little that can be done, beyond extending future studies to quantify their underlying conjectures.

Now, let us return to the results of the actual citation study: Note that the study conducted was far from exhaustive, being based on a selection of the papers chosen by the authors of topic overviews in the 40th-Anniversary Commemorative issue. A particularly interesting subset of these nearly fifty papers, ones actually referred to in the exemplary figures, are listed by year and author code in Figure 1. As noted there, the analysis segregates the papers into major topic areas: Analog (4/30), Digital (4/25), DSP (2/10), Memory (4/20), Microwave (2/10), and Other (4/30), where the parenthetical ratio is that of the number of papers characterized over the number selected in the topic overview. Note, as well, in Figures 2 through 8 to follow that: (a) Citation counts are presented in relative terms rather than as absolute values for the reasons of the imperfections suggested above; (b) Time is presented as years following the original ISSCC presentation, the associated graphical ribbon terminating in 1992; (c) The year of initial presentation and the initials of the lead author are used (at the right) to identify each paper (as listed in Figure 1).

Finally, note a variety of interesting features of the data presented: (a) Clearly, the graphs show that some ideas are more exciting than others on the short term, while yet others provoke a more sustained interest. For example, of the four analog papers whose data is presented in Figure 2, 77-IAY was recognized quickly as important, while 74-RES attracted a delayed but more-sustained interest. Note as well in Figure 2, that 69-ABG, while less dramatically utilized, has sustained a quite noteworthy continuing interest.

Generally speaking, similar attributes can be identified in the other interest areas, but there are also more specifics to be seen: For example, in Figure 3, the digital paper 70-HKG illustrates the potential longevity of interest in an obviously seminal paper on device modelling. Yet other examples of a sustained interest in a quite fundamental idea is illustrated in Figure 5, by the continuing citation of 71-DFB, a basic paper on EPROM, and in Figure 7, by the recurring reference to 72-RMS on low-voltage CMOS.

Finally, as far as citation counting goes, Figure 8 provides an overall comparison of citation frequency over all technical areas, with the ordering of the 6 top-cited papers being Digital, Memory, Analog, Other, Microwave, and DSP. Of these, the top four (70-HKG, 71-DFB, 74-RES, 72-RMS) have clearly attracted a sustained long-term interest.

To place the previous citation data in a broader context, Figure 9 shows the relative occurrence of a variety of historically important topics at ISSCC. While the relative impor-

tance of Memory is likely to have been obvious to the average attendee at the Conference, other facts may be less so. That Microwave papers have been so important is quite interesting, for example. That DSP has reached the level indicated in such a short time is also worthy of note.

Finally, Figures 10 and 11 present some important data concerning the nature of paper authorship: Here, Figure 10 on author multiplicity shows a dramatic shift in numbers of authors over the history of the Conference. It is immediately apparent that the situation has changed in 40 years from one in which single authors initially dominated to one in which more than 3 authors barely exceeds the norm. Perhaps more interesting is the relative stability of the rate of occurrence of either 2 or 3 authors over the 40-year interval. Of possible interest as well is the trend toward marked growth in double authorship seen since the late 80's. Perhaps this is indicative of a trend to the recognition of the importance of problems of sufficient complexity to need a team, but for which 3 (or more) members is recognized as a crowd!

Finally, Figure 11 is provided to illustrate the trends in international authorship. An unexpected property of the distribution data is the singular importance of the Netherlands

which Figure 11 highlights. Interesting as well is the relative consistency of the level of non-USA, non-Japanese contributions. Of significance also is the relative exchange of roles of the USA and Japan in providing the majority of the papers.

Perhaps, in regard to a consideration of Figures 10 and 11 together, it may be of interest as well to reflect on the cultural significance of the apparent correlation of the reduction of single-author papers with the increasing growth of non-USA authorship!

In conclusion, we wish to emphasize the extent of the wealth of technological-trend data which the history of ISSCC embodies. All we have done here is to provide a glimpse of its possibilities, in the hope that others may continue the digging process.

#### Acknowledgements

The authors wish to acknowledge the contributions of Dr. Alberto Yi for his work in accessing basic citation data, and of Trieu Chau for his work in software design, data reduction, and graph production.

**Figure 1: The Selection of Exemplary Papers Whose Data is Depicted in the Following Graphs (using the year-author code).**

Code	Number	Title	Principal Author
<b>Analog...</b>			
74-RES	74.16.04	An All-MOS Charge-Redistribution A/D Conversion Technique	R.E. Suarez
77-JAY	77.13.05	Analog NMOS Sample-Data Recursive Filter	I.A. Young
85-MWH	85.07.05	MOS ADC-Filter Combination That Does Not Require Precision	M.W. Hauser
69-ABG	69.08.05	Phase Locking as a New Approach for Tuned Integrated Circuits	A.B. Grebene
<b>Digital...</b>			
70-HKG	70.07.01	A Compact Bipolar Transistor Model	H.K. Gummel
72-HHB	72.08.02	Merged Transistor Logic — A Low-Cost Bipolar Logic Concept	H.H. Berger
72-CMH	72.08.03	Integrated Injection Logic — A New Approach to LSI	C.M. Hart
63-FMW	63.03.05	Nanowatt Logic Using Field-Effect Metal-Oxide Semiconductor Triodes	F.M. Wanlass
<b>DSP...</b>			
80-JRB	80.03.04	A Digital Signal Processor for Telecommunications Applications	J.R. Boddie
83-TF	83.18.04	An Image Signal Processor	T. Fukushima
<b>Memory...</b>			
71-DFB	71.07.03	A Fully-Decoded 2048-Bit Electrically Programmable MOS ROM	D. Frohmann-Bentchkowsky
79-RPC	79.12.06	A Fault-Tolerant 64K Dynamic RAM	R.P. Cenker
70-WMR	70.04.02	A Three-Transistor-Cell, 1024-Bit, 500ns MOS RAM	W.M. Regitz
69-JKA	69.04.01	A High-Performance Monolithic Store	J.K. Ayling
<b>Microwave...</b>			
72-WB	72.14.01	X- and Ku-Band Amplifiers with GaAs Schottky-Barrier FETs	W. Baechtold
62-MU	62.06.03	An Extremely Low-Noise 6-Gc Nondegenerate Parametric Amplifier	M. Uenohara
<b>Other...</b>			
72-RMS	72.16.05	Ion-Implanted Complementary MOS Transistors in Low-Voltage Circuits	R.M. Swanson
64-KMJ	64.07.04	Photodiode Signal Enhancement Effect at Avalanche Breakdown Voltage	K.M. Johnson
71-RGD	71.06.02	The Electronic Wristwatch: An Application for Si-Gate CMOS ICs	R.G. Daniels
62-HR	62.09.02	Development of an Implantable Cardiac Pacemaker	H. Raillard

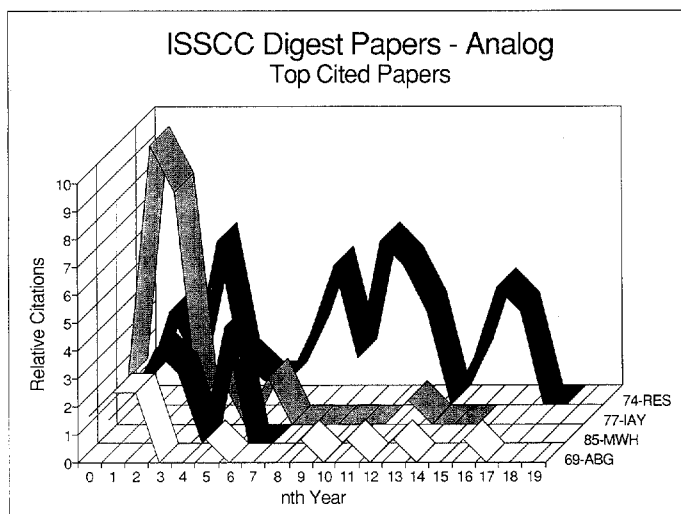


Figure 2

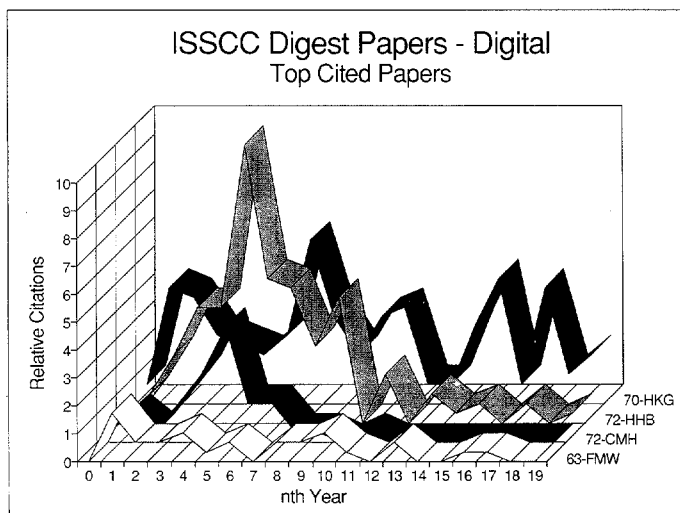


Figure 3

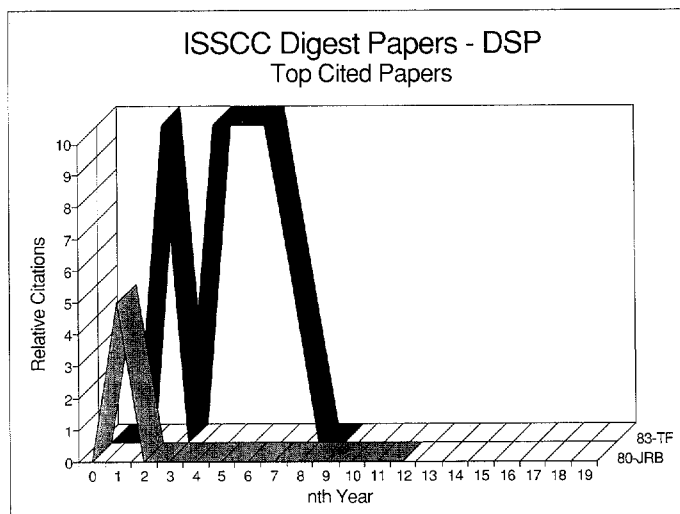


Figure 4

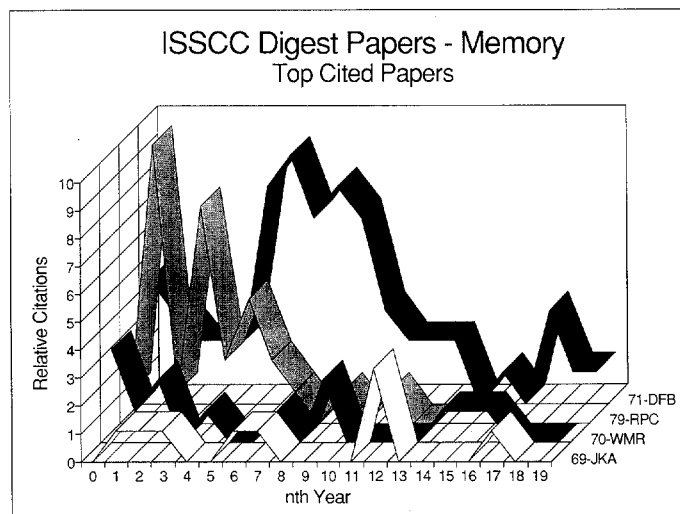


Figure 5

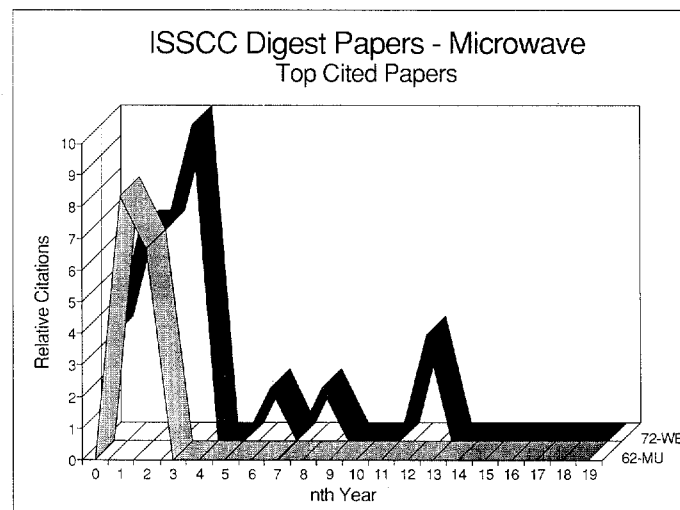


Figure 6

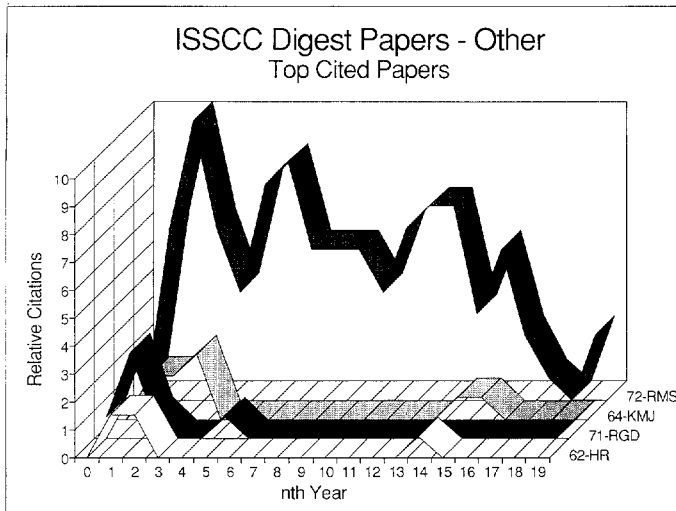


Figure 7

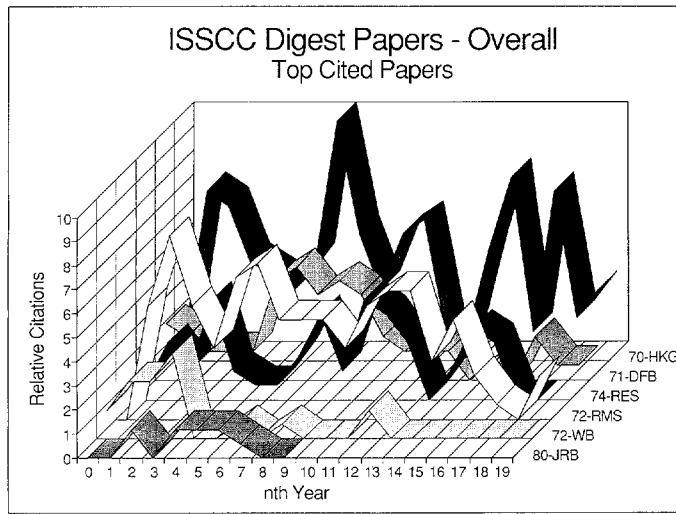


Figure 8

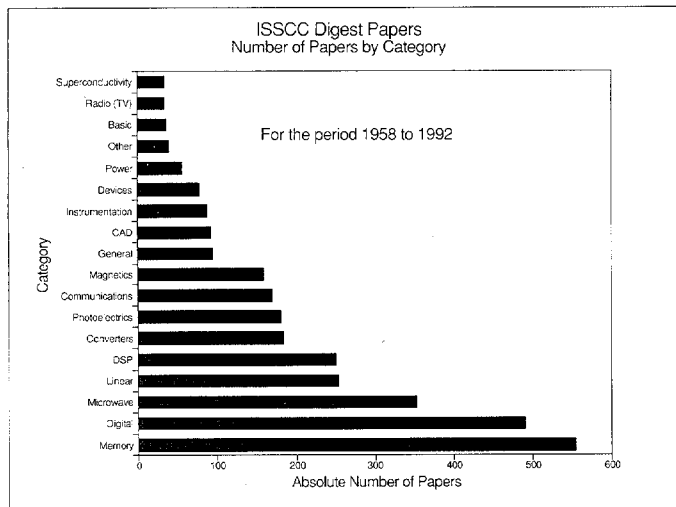


Figure 9

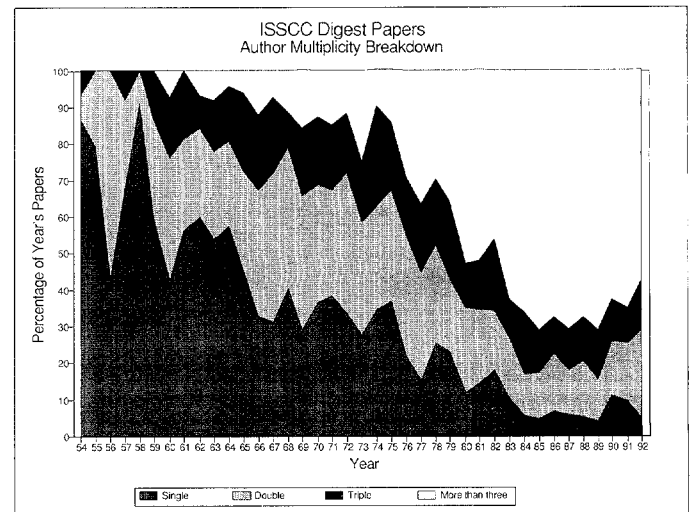


Figure 10

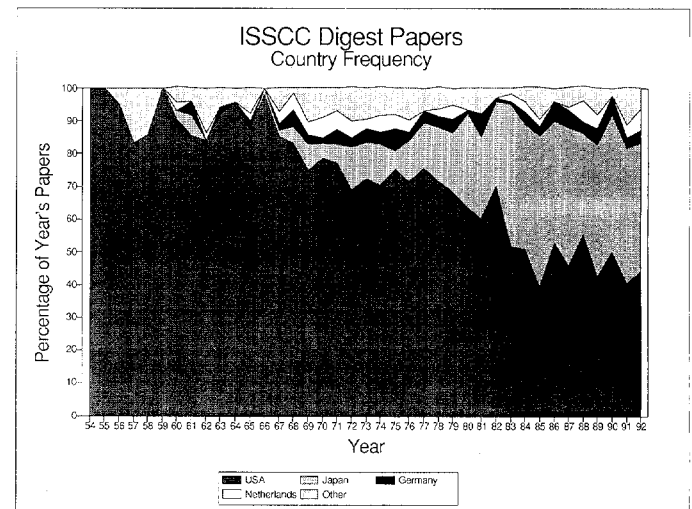


Figure 11



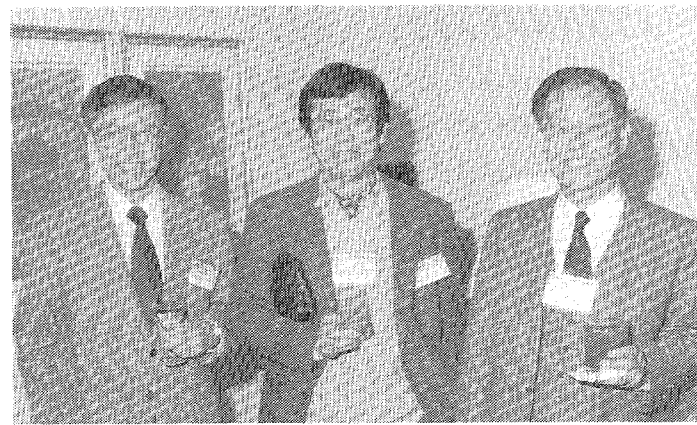
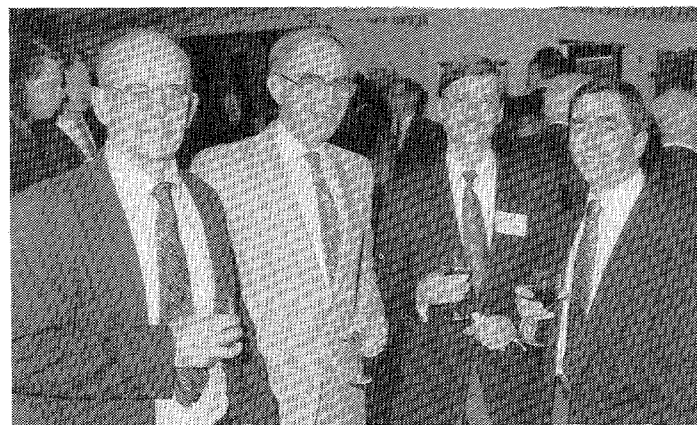
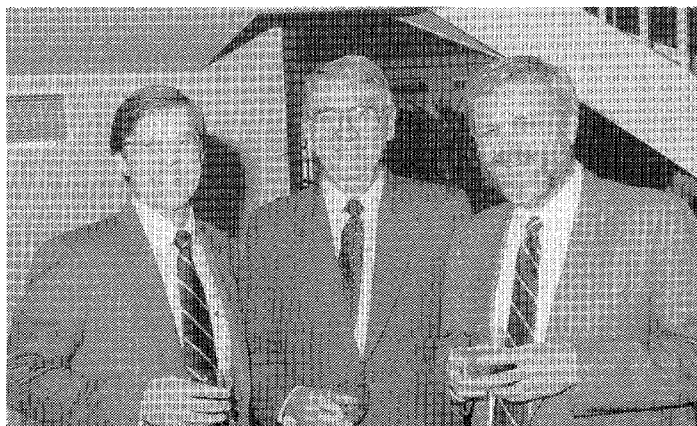


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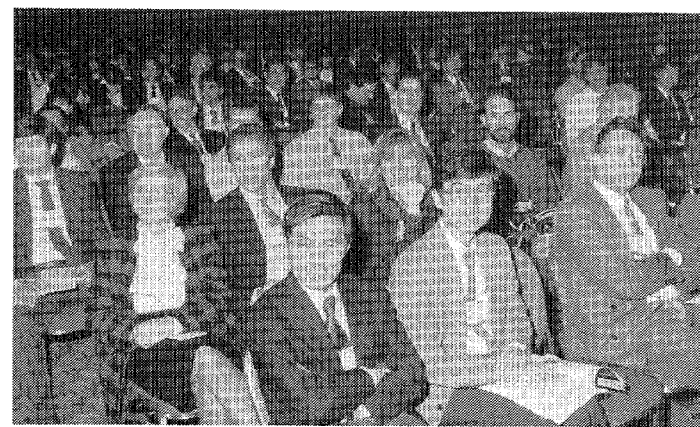
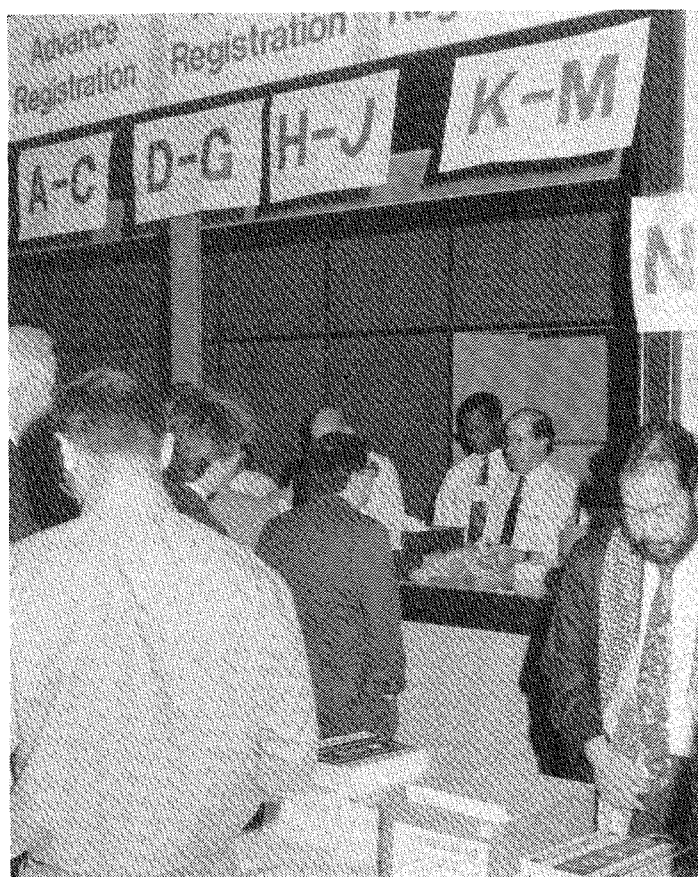
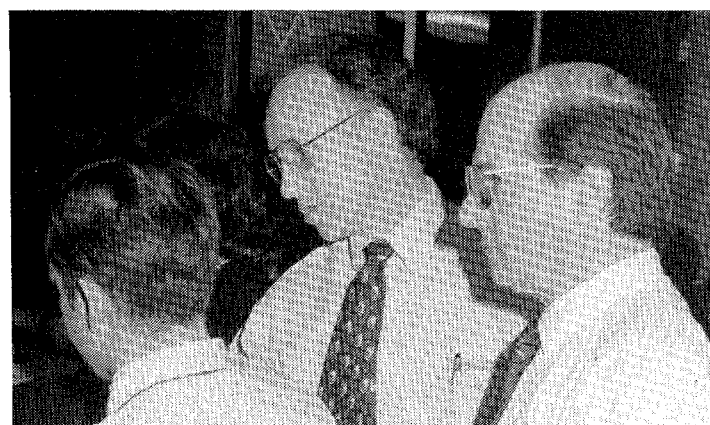


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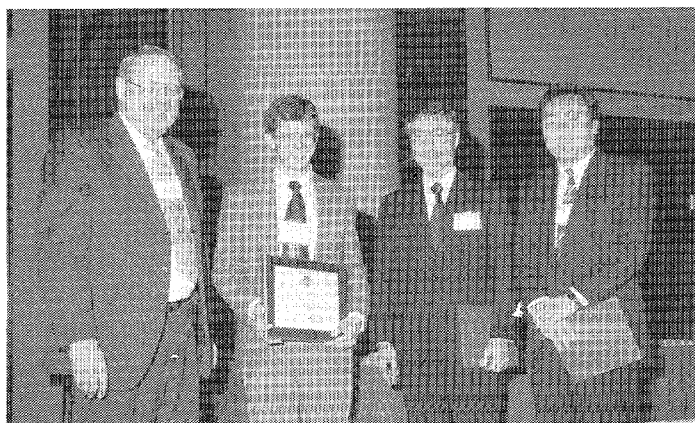




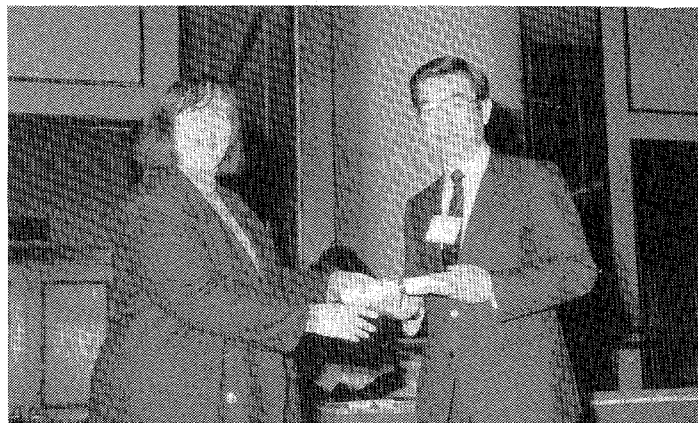
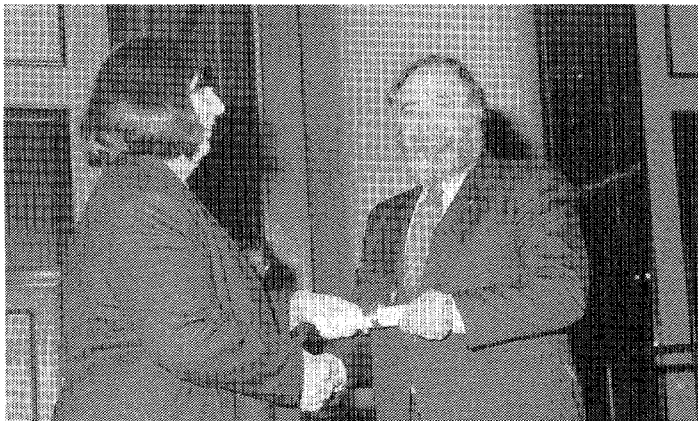
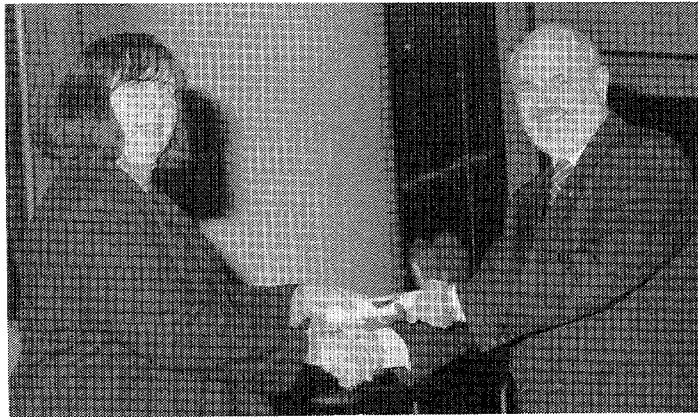
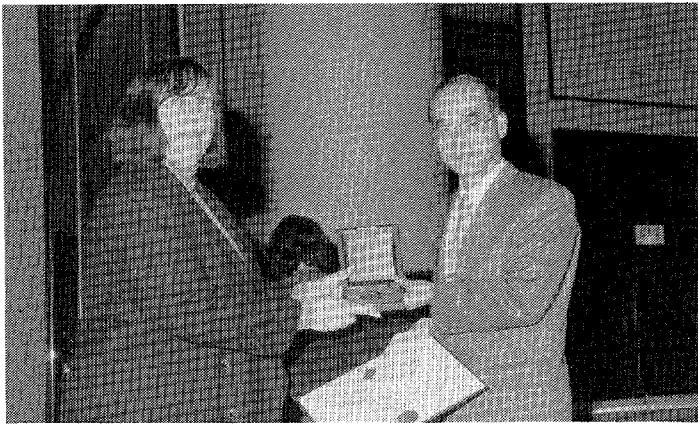












# ISSCC 94 CALL FOR PAPERS

## *Original Papers in the Following Subject Areas are Solicited*

- DIGITAL:** design, fabrication, and test of digital LSI and VLSI systems; fixed and reconfigurable logic arrays; clocking; microprocessors and coprocessors.
- ANALOG:** amplifiers; filters; comparators; multipliers; voltage reference circuits; phase-locked loops; sample-and-hold circuits; A/D and D/A converters; power control circuits; consumer electronics, optical data links.
- MEMORY:** design, fabrication, and test of static and dynamic memories; memory architecture; redundancy and self-test techniques; non-volatile and read-only memory; special-purpose memories; embedded memories.
- SIGNAL PROCESSING and COMMUNICATIONS:** digital and analog signal processors; graphic processors; modems and telecommunication circuits; magnetic-media interfaces; HDTV and ISDN processing.
- GENERAL:** image sensors; displays; transducers; CAD, simulation, verification, modelling; neural network circuits; interconnect & packaging; speech-synthesis circuits; medical sensors & circuits; design for harsh environments; solid-state technology applications.
- EMERGING TECHNOLOGIES:** fuzzy logic; AI; real-time reconfigurable systems; micromachining; vacuum microelectronics; circuit advances using compound semiconductor devices.

## *Preparation of Summary and Abstract*

A summary, with text with no more than 120 lines of 65-character length, is required for review. This summary must state clearly what new results have been obtained and what techniques have been used to obtain these results. Additional pertinent illustrations such as circuit diagrams and graphs of data should be included. The summary must also state clearly what, if anything, will have been published prior to the conference. Please include data sheets, press releases, and other forms of publication. The most competitive papers have specific new results, sufficient detail and data for the contribution to be understood, and diagrams and behavior of key circuits.

Please indicate in which subject area (listed above) your paper should be considered.

Additionally, an abstract, 5 lines of 65 character length, is required for publication in the advance program, if the paper is accepted. The abstract must be factual and provide as complete a description as possible, including specific performance data. Marketing claims, such as "new", "advanced", "novel", "high performance", "high-speed", and "optimized" should be avoided. Abstracts may be edited without consultation to accommodate program format.

Summaries and abstracts are to be prepared in single-sided, double-spaced form, with full name(s) of author(s), affiliation, complete return address, FAX, and telephone contact on the first page, and the author(s) name(s) on subsequent pages. The author(s) of accepted papers will submit on disk a final, illustrated, exclusive version for publication in the ISSCC Digest of Technical Papers by November 17, 1993.

Each paper will be allowed 23 minutes for presentation and 7 minutes for questions.

The paper will be rejected or withdrawn if the contents have appeared or been disclosed prior to the conference. Data sheets distributed under non-disclosure agreements, press announcements which do not release technical information beyond that printed in the ISSCC Advance Program, and presentations at workshops with limited attendance and no published proceedings are not considered prepublication.

***Receipt Deadline: Wednesday, September 15, 1993***

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