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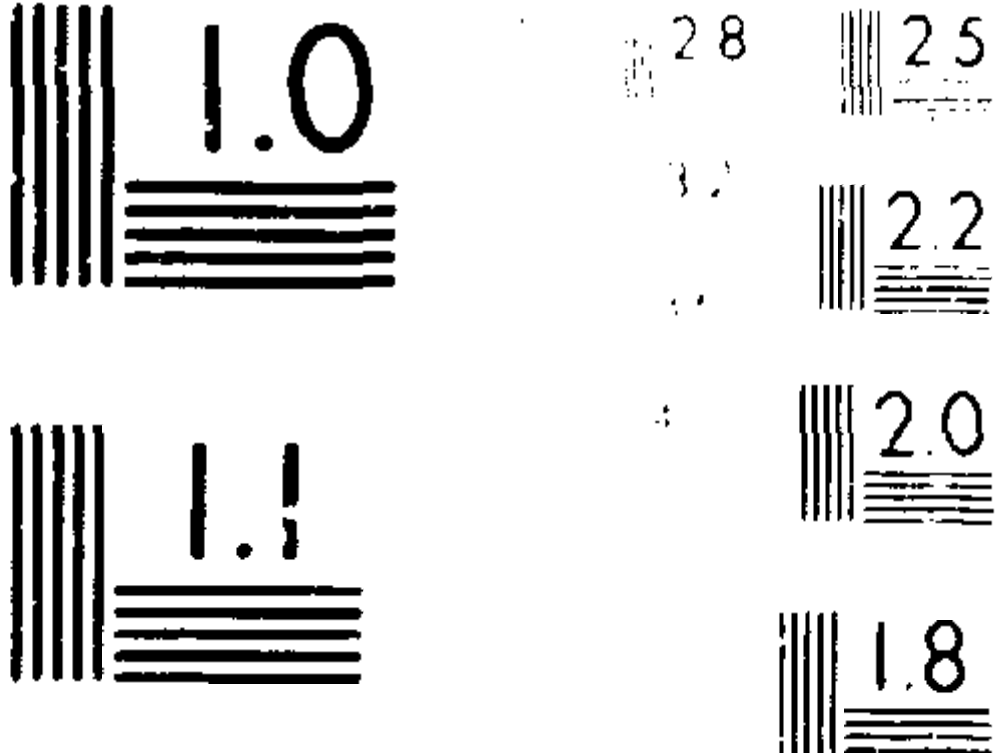
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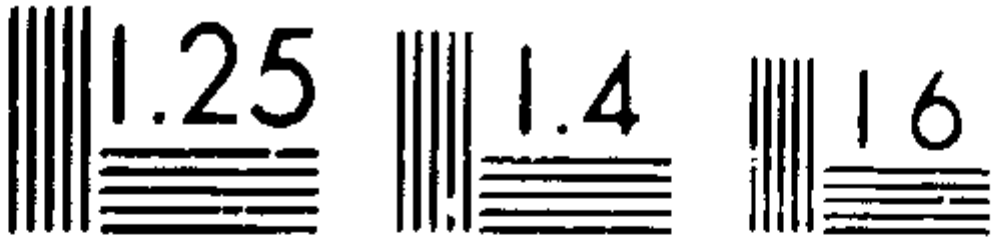
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SOME CONSIDERATIONS ABOUT A PRACTICAL APPROACH TO THE DEVELOPMENT OF TECHNICAL INFRASTRUCTURE FOR MICROELECTRONICS*

prepared by

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INTRODUCTION

Microelectronics is causing a tremendous revolution in industry, in services and in the way of life of hundreds of millions of people all over the world.

Developing countries find in microelectronics a great opportunity but also a force that tends to open the technological and economical gap that separates them from the more industrialized countries.

The technological change in this field is happening so quickly, and the research and development infrastructure of more advanced countries is so large, that any effort undertaken in microelectronics by the less industrialized countries appears much like a race to catch-up with a far away train that moves faster.

Reality shows that in fact, microelectronics is accelerating the development of more advanced countries but also offers great opportunities to those countries that, having a lesser scientific and technological capacity, establish intelligent strategies that are carried out with a strong governmental support.

In this short document, I will analyze some strategies followed by several countries to improve their development with

the help of microelectronics. Some conclusions have been drawn and it is suggested that in general terms the strategy to be followed could include the following stages:

1. Development of microelectronics applications, giving the necessary priority to those that are more relevant in each case; i.e. industry, education, services, etc. For that, it is a requisite to have specialized engineering capacity in the applications themselves and adequately combine it with electronic and computing engineering in the development of specific applications and with the necessary industrial engineering, in order to attain a degree of quality and efficiency required for industrial production.

2. Development of custom or semi-custom microcircuits based on applications that represent a great demand and characteristics that make design and development of those microcircuits advantageous. Manufacture of these microcircuits can initially be made in association with enterprises that have reached a high degree of maturity and efficiency in the more industrialized countries.

3. Local manufacture of microcircuits based on the demand already developed for specialized microcircuits that may

also have a wide international demand if it is adequately selected. This stage requires a previous development of substructure, research and engineering necessary to master the process technology involved and the capacity to properly select and negotiate the technological support needed from foreign countries.

I. THE DEVELOPMENT OF APPLICATIONS OF MICROELECTRONICS

The development of applications of microelectronics must take into account several factors, among which the following stand out:

1. Specialized engineering capacity in the applications themselves. The development of a good product is based on a thorough knowledge of the conditions under which it must work. It is thus therefore inevitable to know precisely those systems into which the product shall be integrated, conditions under which it will operate, changes it will have to undergo in the future and, of course, characteristics of equipment that may constitute its competition or that can substitute it for the same application. It is precisely this factor that suggests that application development groups in microelectronics should be localized, or at least initiated, in research or engineering institutions that are associated with specific sectors, such as: electricity, communications, bio-engineering, machinery, etc.

By belonging to institutions that respond to the technological needs of specific sectors, the application development groups in microelectronics should benefit from the substructure of specialized information systems, laboratories and collaboration mechanisms with the users of the equipment, as well as the communications that those institutes frequently have with similar organizations in other countries. An interdisciplinary activity is thus obtained, which allows the development of equipment adequate to the country's specific needs and that many times result in innovations that may have a great value for countries that suffer similar problems which, because they are foreign to engineers of big multinational firms, they are not solved with commercial equipment. Besides, this situation generates a market niche, where a small or medium company might find great opportunities for competition.

2. Capacity in mechanical and manufacturing design engineering. Possibilities of a good electronic design are often limited because the characteristics of a good mechanical design could not be properly integrated to the equipment. Cabinet quality, contacts, access to parts and components must be assured and, in general, resistance, durability and easy of operation and maintenance for equipments that ought to function in difficult conditions quite often, must be optimized.

It is therefore, necessary that the electronic group be backed by mechanical engineers and industrial designers specialized in the solution of specific problems that arise in the development of electronic equipment, including those due to the standards and specifications that must be compiled.

An important function of mechanical engineers and industrial designers is to maintain a close contact with potential manufacturers in order to develop the design in such a way that it will possess the adequate quality with a realistic knowledge of their manufacturing capabilities and any extra capacity that can be developed within companies that receive the technology of a product.

A fundamental aspect of electronic equipment is their fast innovation rate, necessary to maintain a competitive edge in a highly dynamic market. Therefore, designs should be flexible to adjust with minimum changes to different applications. To reach this goal, careful attention must be given to mechanical design and manufacturing engineering, beginning with the first version of the product.

On the other hand, new companies starting operations in manufacturing electronic equipment, lack the technical capability to incorporate aspects such as quality assurance and quality control on their manufacturing lines. Development groups

should take this into account, and put themselves into the position of giving the necessary technical support. This is particularly important for countries that have an incipient degree of industrialization and have not yet developed an experienced electronic production infrastructure.

5. Capacity of software development. To a great extent, the capability and versatility of most electronic equipment depends on the capacity for developing software associated with either the functional characteristics of the equipment or with the application.

This capacity is embedded into the electronic group. Software is an indispensable component in many electronic equipments and in systems into which they are to be integrated. For this reason, special attention must be given to the capacity for developing software within the electronics groups themselves and also in those groups responsible for system integration.

Software development can be made very efficiently with adequate methodology and the availability of development systems. The technical capacity necessary to obtain this methodology can be attained by giving proper attention to personnel training with adequate professional help.

Training of engineers and specialists that will participate in software development, and should have a working knowledge of computer architecture, is one of the most important factors to be considered. It is of course important that engineers acquire the know-how to develop programs but it is more important that they be able to integrate into software development groups, where analysis, pre-coding, coding, standardization, tests and documentation functions are separated. Only in this manner it is reasonable to expect that software will be of uniform quality, be structured in accordance with a general logic and be amenable to modifications and updating.

It is necessary that universities and technical schools' programs, and also actualization courses, be designed, taking into account the new demands posed by the "industrial" software development, formerly referred to.

4. Development of a supporting industry and standardization programs. One of the worst problems faced by the electronics equipment manufacturer is the availability of components and intermediate products.

References are made to components and intermediate products such as: printed circuits, connectors, button stations, microcontacts, relays, power sources, transformers, screens, plastic parts, cabinets, metal-mechanical parts, etc.

Industries producing these components are generally small-or medium-sized and may require specialized technolcgical support and also a reasonably wide and growing market. This can be pursued through standardization programs that would include collaboration from the government, designers and manufacturers, and may be highly successful.

5. Close collaboration of electronic industries and technological research institutions in which applications can be developed. This aspect has special importance when industries are small-or medium-sized and do not have the minimum technological capacity to take advantage of existing developments, without proper support.

Nearness is a factor that can be important to facilitate communication, including the sharing of facilities such as information systems, testing grounds and services, support for solving urgent technological problems and even facilitating recruiting and contracting specialized personnel. It is not uncommon to find in developed countries that the physical location of electronic industries is generally associated to universities, research institutes or large enterprises, that act as a supporting nucleus for the development of many electronic firms.

It ought not to be forgotten that to secure specialized per-

sonnel is particularly critical in the electronic industry, which as characteristic has very high mobility rate among its technical staff. Adequate location of technological research institutes and related industries in attractive places, where facilities for professional development, culture and sports are available, can substantially contribute towards personnel stability and improve possibilities of collaboration among institutes and industry.

6. Managerial capacity of executives and technical managers. Another factor that bears substantial influence on the development of industries that use microelectronic applications and on those that use advanced technology, is the managerial ability of executives and technical managers.

Electronic firms require a managerial capacity sensitive to identifying opportunities in product and process innovation and in the organization of its technical groups, to insure an adequate collaboration among them and with users, and with research institutions, without neglecting financial, commercial and planning aspects that are indispensable for the good operation of any enterprise.

Innovation is the key to success for these companies and to reach it, it is required that in every level of the organization, but very particularly in those of management, the importance and the mechanics of this process be understood and properly implemented.

II. MICROCIRCUIT DESIGN AND PRODUCTION

A microcircuit design is based upon a good electronic design that corresponds to a marketable circuit that has good competitive possibilities.

The design itself must be made with due consideration of the manufacturing technology and to the manufacturer's process specific adjustments. The only way to obtain an economically acceptable design is through the use of CAD (computer assistance design) system that allows for the implementation of the design, operation with moduli and enormously simplyfying the - work required for the mask design

It is thus required that technological capacity be developed in CAD systems, in order to reach an economical design of microcircuits. Development of these systems is a long and costly process, and it is more convenient to start form systems already in operation in this type of applications and to form groups of specialists capable of applying them efficiently, in order to continue their development.

The next step is the manufacture of wafers with microcircuits. It can be taken up at a more advanced stage of develcpment of this industry, although initial sub-contracting with one of the many firms that presently offer this kind of services will be preferred. This is in order to avoid the large investments in equipment and development that are required for this stage.

However, the next phase of the process, which is cutting and packing of microcircuits and the final test, is something fairly available as far as investment and technological capacity are concerned, specially if it would be possible that this phase could be supported by an adequate assistance from a proper research and technical infrastructure.

If the premise is given that there is an industrial sector in electronics (industrial electronics, communications, computers, etc.) this can be the pivot upon which a microelectronics industry would be developed.

The manufacturer of electronic equipment has at his disposal three alternatives to choose for designing and manufacturing its products:

- Standard components, microprocessors, discreet logic, etc.
- Semi-custom components; programmable arrangements
- Custom components: functions defined by the users

In the first stage (applications to microelectronics), the obvious option would be the use of standard components. However, the use of "custom" or "semi-custom" comp nents is to be encouraged, based on the numerous advantages that these alternatives can incorporate to the products that have a large production volume.

To make this transition possible, there must be groups of specialists capable of transcribing electronic systems based on standard components to "customized" microcircuits. Generally speaking. The designers of electronic equipment have a somewhat different orientation, compared to specialized personnel in microcircuit designs; the former orientation leans markedly toward applications, while the latter group does - toward microcomponent integration (basic design cells) in basic functions. It is therefore very important to stablish proper training facilities for the designers of microcircuits.

III. REGIONAL CENTER FOR MICROELECTRONIC DEVELOPMENT

As a support to a long-term program for development of microelectronics in the stages formerly described, a profile is - proposed of what would be a regional center for microelectronics development.

OBJECTIVES OF THE CENTER:

- To lend support to the industrial activity in the professional electronics sector.
- To induce, in the electronic industry, the development and use of specialized capacity in design and testing.
- To lend support to pioneer activities in microelectronics and lead these activities among manufacturers of electronic equipment.

In order to comply with these basic objectives, the center must

have specialists in the following areas:

- Evaluation, characteristics, and test of passive, active and integrated components.
- Design and manufacture of printed circuits.
- Electronics subsystem moduli tests
- Test and evaluation of equipment (Final products).
- Microcircuit design.
- Mask generation for microcricuits.
- Microcircuits testing and characterization.

CHARACTERISTICS OF THE CENTER :

The Center ought to offer the following areas of development:

A) DESIGN

- Capacity to interpret the necessities of the manufacturer of an equipment (system)
- Capacity to offer the best alternative to this manufacturer in terms of a solution based on :
  . Standard circuits- microprocessors of semi-discreet logic
  . Semi-custom circuits, plas, etc.
  . Custom circuits.

- Capacity for transferring from a system to the specifications of a custom, or semi-custom, integrated circuit.
- Capacity for the design of integrated microcircuits (via CAD) based on design specifications compatible with - foreign manufacture that will be contracted to produce the wafers themselves.
- Capacity for prototype testing.
- Capacity for prototype adjustment. (according to test results or user's evaluation), until a final form is obtained.

B) MASK DESIGN .

- Capacity for transferring a circuit design to a mask set to build a prototype and mass production.

The foregoing covers a fundamental part of the needs that an equipment manufacturer should have if he is interested in going into microcircuit.

In order to enlarge the service to a larger group of industrial list, it would be usefull to explore the following items :

C) TECHNICAL SUPPORT SERVICE ORIENTED BASICALLY TO COMPONENTS.

- Capacity for evaluation and characterization (tests according to standards) of passive and active components and integrated subassemblies that could encompass the following activities:

. Qualifying suppliers.

. Support to manufacturers of components.

. Establishing standards for acceptance of components.

. Establishing testing criteria for quality control.

- Capacity to supply specialized information support - (standards, etc.) to local manufacturers.
- Capacity to support manufacturers to qualify suppliers.
- Others, that have to be defined, depending on each case.

D) TESTING SERVICES .

- Universal testing capacity applied to intelligent moduli based on microprocessors or less complex moduli.
- Capacity to advise manufacturers on design criteria that contain testing aspects.
- Testing capacity for final products including :

. Verifying compliance with national or international standards.

. Supporting national or international homologation of equipments.