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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Technological Trends in Custom and
Semi-Custom Integrated Circuits

by Stephen L.Gilbert
UNIDO Consultant

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In the early seventies certain developing countries began efforts to accelerate the acquisition of microelectronic technologies. These efforts took the direction of purchasing a current production semiconductor fabrication facility ('foundry'). Bipolar technology prevailed at that time which was used primarily to produce Linear circuits used in TV and analogue device areas. It is informative to observe the effect these relatively expensive efforts have had in achieving their desired affect, namely assisting and accelerating microelectronic technology transfer. In general these efforts have not achieved their desired goals. The acquired technology has stagnated and programs built around these fabrication facilities have not successfully followed the rapid introduction of new technologies.

The failure of these large investments to generate a viable local microelectronics industry directly results from a lack of stimulation of design functions.

The Bipolar technology transferred at the beginning of the seventies was progressively displaced by newer MOS technologies, PMOS, NMOS, and CMOS, as the seventies ended. As the newer MOS technologies competed successfully with established Bipolar technology and progressively displaced it, the marketplace accepted the newer technology as superior and more desirable. The determining element in incorporating MOS technology into new products was not a local production capacity however, but rather the engineering ability to DESIGN and effectively utilize the new capabilities of the technology... in short, the capability to use the new MOS abilities in new products - a design capability.

Unfortunately, the outright purchase of a production facility did not include the necessary design experience and expertise required to develop new products nor the expertise to adapt to new device characteristics, such as the transition from Bipolar to MOS design methodology. Such design expertise must be developed engineer by engineer, with experience the most valuable instructor. Design experience remained the sole province of the company supplying the fabrication facility and was closely guarded as a valuable asset or trade secret. Most contracts detailing purchased technology covered only the products of the design experience, not the expertise itself. This design expertise will be increasingly valuable as long as the semiconductor industry is, and will continue to be, one of the most rapidly changing modern industries. What remains uncertain is the problem of how to adapt the new technologies to current needs without creating a stagnate environment.

A question to consider is, "How serious is the need to be in the forefront of technology?" Sales of current consumer products such as TV's, VCR's, Personal Computers, etc. are technology driven, i.e. noone wants last years' models. The sales advantage lies almost entirely with the most current technology products. This creates a market where the manufacturer who falls behind in including whatever is new in his products will shortly have no sales. While this is especially true on the international market it is also valid in the local market as long as a competitive market exists for the particular goods. Even a supermarket chain that does not have the latest "talking terminals" at the checkout counter will find competition based not only on the quality of their products but also strongly influenced by their customers perception of technological superiority. Brand Names carefully cultivate this particular perception and carefully emphasize it with aggressive advertising programs.

Many companies and countries are finding that the process of identifying the specific product to produce, i.e. selecting the proper marketing nich, is much harder to accomplish successfully than the mastery of the hardware aspects of microelectonics. A possible reason for this problem lies in the extremely rapid change in products, both in their capabilities and scope as the technology matures. Each company, country, or region must successfully identify those products which are not offered on the open market that will find maximum utilization within the local market.

TECHNICAL APPROACHES

Off-the-Shelf Components

Using off-the-shelf components, memories, and microprocessors allows the manufacturer to reap the benefits of low manufacturing costs because these components are manufactured in very high volumes by offshore international vendors. The technical level is only slightly below the highest technology available (only military products have more stringent specifications at much higher per item costs, typically 10 to 1000x). A superior design implement with off-the-shelf components that fully utilizes the performance of such devices could be marketed successfully either locally or internationally. There are no sales barriers or limitations for exceptionally designed products.

Off-the-shelf components are suitable for design intensive SYSTEMS. The component costs themselves are minimal and the majority of the value added elements lie in the overall system integration and software controls. A prime example of this system approach is the IBM Personal Computer. All of the individual components are available from independent vendors, (and in most cases from several vendors) while not a single component was supplied by IBM. The value added lay entirely in the organization and assembly of the complete system (which of course included the operating system and relevant applications software) This approach, that of system integration, is the most fruitful area for developing countries to concentrate their efforts. A quick survey of the vast numbers of IBM PC 'clones' from various corners of the world indicates the potential impact of successful system integration.

Semicustom

Semicustom chips are expensive. They essentially perform the function of several discrete chips that are generally available off-the-shelf. The prime advantage of using the semicustom approach is one of speed and size. If sufficient volume of product is required, more than 100,000 units, some economy of scale will help in reducing the costs of tooling. The up-front costs of semicustom designs while significantly less that full custom are still significant and generally do not justify the added expense.

Full Custom

The very few designs requiring full custom design are very specialized applications requiring high density, very high speed, and cost is not a consideration. Some examples are missile guidance systems, and automatic telephone switching stations. The first example is self-explanatory while the second is produced in such large quantities that the small savings in time using the higher speed circuit saves over the large volume of devices used. The large number of devices used in the telephony systems further dilutes the costs of the full custom design process.

These key elements should be considered when enbarking on a national or regional program of assistance in microelectronics:

It is necessary to stay abreast of emerging technologies, i.e. the shift from Bipolar to MOS device technology.

It is not a requirement to manufacture IC's but it is a requirement to use IC's in products to be competitive locally and internationally.

It is most important to identify what your particular industrial needs are.

Demonstration projects that exercise the capability of the engineering staff but fail to develop a product that has a potential market are doomed to failure.

Multiproject chip approach to education of cadre of trained designers, not just for manufacturing chips, but also with the understanding of the relevant technology details to design new products and incorporate technological advances into the marketplace.

Off-the-Shelf components should be considered for the great variety of systems

SEMICUSTOM gate array approach could be considered for teaching design engineers, developing and introducing specialized products

Full Custom circuits should be considered only when a oroduct is fully found, designed, and market demand justifies intensive investment in volume production.