FACTA UNIVERSITATIS
Series: **Economics and Organization** Vol. 11, N^{o} 4, 2014, pp. 367 - 379

ECONOMIC ASPECT OF ELECTRONIC CIRCUIT DESIGN AND MANUFACTURING IN REPUBLIC OF SERBIA

UDC 621.38(497.11)

Miljana Lj. Milić[1], Ivan B. Marković[2], Jelena B. Milojković[3]

[1]Faculty of Electronic Engineering, University of Niš, Serbia
[2]University of Niš, Faculty of Economics, Niš, Serbia
[3]ICNT – Innovation Center of Advanced Technologies, Niš, Serbia

Abstract. *Almost every activity of an electronic system design is closely related to technical as well as to other fields of science. The most important aspect for the future "life in the market" of the electronic product is the economic aspect. Foreign direct investment can greatly affect the R & D in the field of electronic industry. The fact that the electronic circuits' industry affected and affects all areas of social development, requires the establishment of the correlation between electronic circuit design and manufacturing, and economics in general. In this paper, we will try to analyze the position of Serbia's electronic industry perspectives on the global electronic circuit market, considering costs of their development and manufacturing.*

Key Words: *effects of FDI, electronic circuits, IC design, electronic circuit testing, IT*

INTRODUCTION

The historical moment that we live in today, represents a turning point between machines and the information society. Observed from the production point of view, we are witnessing the transition from the era of raw material processing to the era of information and energy (Litovski, 2000). Describing the period of machine era, we could say that the value of a product and a profit it was bringing, came from raw material i.e. its mass. In that way, a classification of the branches of industry was made: chemical, metal, plastic, food and other industries. Industrial products nowadays, on the other hand, are examples of multitechnological complexity. Such products are airplanes, computers, cars, telecommunication systems, consumer electronics etc.

The profit now mostly comes from software, built-in electronics, and special high-tech materials. According to some studies, the information caries two- thirds of the new products' value (Litovski, 2000; Ungson, Trudel, 1999: 60-65). Advances in technology,

Received October 24, 2014 / Accepted March 25, 2015
Corresponding author: Miljana Lj. Milić
Faculty of Electronic Engineering, Aleksandra Medvedeva 14, 18000 Niš, Serbia
Tel: +381 18 529 105 • E-mail: miljana.milic@elfak.ni.ac.rs

especially in computer-aided logistics, computer-aided product design, and modern communications enable large companies to overcome classic factory work. There are many cases of companies where profit coming from new technologies reached almost 100% of the global profit.

The profit from electronic devices industry grows every year. Technologies supporting this industry are developing rapidly. This is particularly noticeable in the mobile devices industry. In (Osborne, 2014.) according to the worldwide mobile electronic devices' shipments' statistics from 2013 and 2014, an estimate was made that in 2015 a 2.592.000 thousands of units would be sold. This is shown in Table 1. It gives a detailed view of the worldwide demand for most popular mobile electronic devices.

Table 1 Worldwide device shipments by segment (thousands of units)

Device type	2013.	2014.	2015.
Traditional PCs (Desk-Based and Notebook)	296 131	276 221	261 657
Ultramobiles, Premium	21 517	32 251	55 032
PC Market Total	317 648	308 472	316 689
Tablets	206 807	256 308	320 964
Mobile Phones	1 806 964	1 862 766	1 946 456
Other Ultramobiles (Hybrid and Clamshell)	2 981	5 381	7 645
Total	2 334 400	2 432 927	2 591 753

(Source: Gartner, June 2014)

Having this in mind, one can conclude that the key issue in today's economy development lies in following new trends of electronic devices as well as software that they require. Achieved and expected profit depending on device Operating systems for the period 2013-2015 is presented in Table 2.

Table 2 Worldwide device shipments by operating system (thousands of units);

Operating system	2013.	2014.	2015.
Android	898 944	1 168 282	1 370 893
Windows	326 060	333 419	373 694
iOS/Mac OS	236 200	271 115	301 349
Others	873 195	660 112	545 817
Total	2 334 400	2 432 927	2 591 753

(Source: Gartner, June 2014)

Computer aided design (CAD) becomes a key industrial and economic activity, no mater of the product type. There are several reasons for such a trend. First, the complexity of new technologies is becoming so high, that nothing could be designed without a computer. Computer designing becomes the most important activity that consolidates the development, production and product placement at the market. On the other hand, the most significant factor for the competitiveness of a product is its quality. When high quality of the product is easily achievable, companies that still want to be competitive now have to offer newly designed products that no one else offers. As stated back in 1983 [Re83], the delay of just six month in putting a new product to the market, reduces the profit of the product for additional 50%. There are plenty of modern industrial products (mostly electronic), whose time for development lasts longer than the product itself. The key activity to overcome such a scenario is the efficient design. In this way CAD becomes one of the main drivers of the industrial development.

1. ECONOMIC STATE AND THE FUTURE OF SERBIA'S ELECTRONIC INDUSTRY

The importance of FDI for economic growth in the modern economy is becoming increasingly evident on two grounds (Damijan et al, 2003). Quantitative growing importance of FDI, measured by total FDI flows or state, beyond the absolute values of key economic indicators such as GDP, exports and domestic capital investment (Marković 2010). Qualitatively, TNK, as the main SDI agents become dominant participants in the world economic space by integrating themselves into the basic methods of economic activity and investment, trade in goods and services, transfer of technology and financial flows. To the potential host country, FDI brings an integrated package of tangible and intangible resources (capital, technology, management, marketing, organizational knowledge, training, workforce, etc.) that serve as an alternative to labor migration and as a stimulus to economic development (Marković, Janković-Milić, 2013). Investment package, on the one hand, supplemented by available domestic factors of production both creates the conditions for new employment and work, and encourage, on the other hand, the growth of the host country through technology transfer, training, workforce, establishing a connection with the rest of the local economy and creates local roads producers to the world market. Serbia has indeed become an attractive location for foreign direct investment and now that foreign investors are finally beginning to invest in it and its capital, it is necessary to do a lot of things (Mencinger, 2003). This primarily refers to the continued political and economic stability, the adoption of the new system of laws with European standards (including the adoption of the Law on Foreign Investment, which would guarantee the rights of foreign investors), rescheduling and partial write-off of foreign debt, as well as the implementation of more aggressive promotional policies and strategies. It also requires faster and further implementation of initiated economic reforms, addressing legal and regulatory issues related to foreign investments, the use of the tried and tested but also finding new incentives to attract FDI, the inclusion of Serbia in international financial and political organizations, and the like. Otherwise, foreign investors would still continue to be treated as a high risk area, extremely unattractive for investment, which in our economy due to the lack of domestic capital and modest inflows of FDI, may have devastating consequences (Hausmann, Pritchett, Dani, 2005).

While investment in all sectors of the economy is needed and welcomed, the following sectors have been identified as those who could contribute most to considering the competitive advantage you have or may have in Serbia:

- Agriculture and food processing industries: food and non-food agricultural products, with an emphasis on organic products,
- Car Parts: Focus on companies-suppliers of new factory car and truck manufacturers / heavy vehicles,
- Banking and financial services
- Engineering: specialized services, designing, building on a "turnkey", and so on.
- Wood industry: first, the production of wood furniture, which is based on craft skills,

- Information and communication technology (ICT): products and services with the possibility of software, administrative and business services, call centers, initiatives that are based on the ability of universities / research centers,
- Pharmaceutical / healthcare / clinical research and the chemical industry,
- Public-Private Partnerships: Energy / Telecommunications / Infrastructure / metallurgy, mining and exploration / traffic checkpoints and distribution centers,
- Textile industry: short-term production branded clothing and orientation specific markets,
- Tourism.

The above sectors are distinguished for the following reasons:

- They have the potential to create a significant number of new, permanent jobs.
- Projects SDI many of these sectors can enable progress in certain areas in Serbia.
- Projects in these sectors may increase exports.
- It is possible to connect local companies and attract foreign companies-suppliers and service industries.
- Provide sectors to develop globally.
- The new foreign direct investment in these sectors is in southeastern Europe.

Serbia is becoming interesting for the investment. According to the data of National bank of Serbia, since 2005 Serbia has received about 13 billion of Euros in direct investments. This is shown in Table 3. As seen from Figure 1, due to different, mostly political impacts, the investment trend was not always increasing.

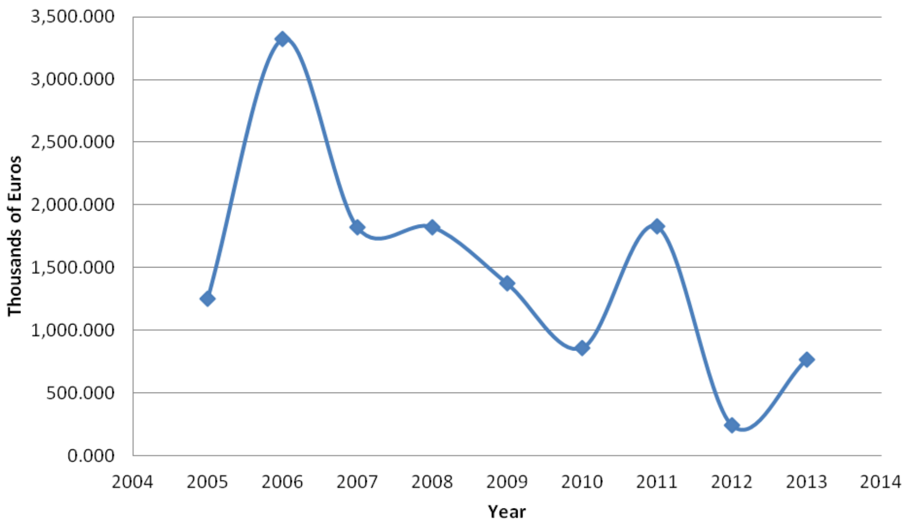

Fig. 1 Trend of direct foreign investments in Serbia for the period 2005-2013

Table 3 Serbia, Foreign direct investment, net in the period 2005-2013, by country (in thousands of Euros),

Country	2005.	2006.	2007.	2008.	2009.	2010.	2011.	2012.	2013.
Austria	168 864	409 815	848 627	330.567	234 149	145 850	154 693	55 275	40 646
Norway	24	1 296 061	2 326	4 025	-526	1 567	953	3 451	3 535
Greece	183 137	672 010	237 108	33 338	46 724	24 450	9 958	-296 053	29 057
Germany	154 868	645 370	50 516	59 572	40 101	32 921	76 591	43 444	48 391
Italy	14 759	49 087	111 504	333 665	167 386	42 296	128 068	81 709	43 912
The Netherlands	80 387	-176 560	-24 199	336 711	172 267	200 100	240 840	1 386	131 094
Slovenia	149 854	154 529	64 033	70 659	34 290	80 859	-108 387	52 560	24 480
The Russian Federation	11 722	12 713	1 700	7 903	419 751	6 993	74 187	18 503	45 295
Luxembourg	88 331	4 839	185 226	48 576	6 002	6 739	812 829	64 435	22 604
Switzerland	45 922	-4 223	70 458	82 319	62 883	50 643	47 742	78 389	49 012
Hungary	24 613	179 260	22 901	21 891	17 787	15 488	67 591	504	45 686
France	34 816	79 087	61 458	53 810	7 150	17 089	113 652	14 304	-1 080
Croatia	30 356	17 446	26 802	100 428	19 938	37 928	4 918	118 959	-5 548
United Kingdom	51 444	77 977	-21 054	10 122	51 842	53 344	-6 174	39 541	32 848
Montenegro	0	10 466	152 631	54 078	-3 608	-64 947	5 621	-8 747	102
USA	16 067	-20 593	23 536	35 624	12 583	54 779	25 633	28 051	16 759
Bulgaria	0 651	42 034	34 350	14 605	1 291	9 745	793	29 654	7 587
Slovakia	21 578	15 959	2 320	935	24 512	32 531	-4 830	-13 449	2 661
Belgium	10 306	4 160	17 276	12 000	2 366	3 536	5 .006	1 672	43 659
Israel	11 588	3 681	19 397	- 494	52	1 703	223	1 042	2 041
Latvia	5 208	8 178	2 645	482	1 065	80	1 715	3 093	7 396
Liechtenstein	-32 839	-14 595	-1 916	3 375	174	814	9 867	- 429	854
Cyprus	56 697	-300 383	99 901	1 795	26 348	44 953	42 581	39 776	8 682
Bosnia and Herzegovina	3 599	-13 582	-622 496	-47 327	340	-22 000	-9 800	143	5 559
others	118 317	169 871	455 780	255 755	27 605	82 665	132 637	-115 344	163 304
Total	1 250 268	3 322 606	1 820 831	1 824 413	1 372 473	860 125	1 826 908	241 869	768 534

(Source: National Bank of Serbia 2014)

Nevertheless, one should have in mind that foreign companies that are mostly oriented in electrical and electronic devices manufacturing and Information technologies (IT), such as: Bosch, Yura, Panasonic, Siemens, Intel, Telenor, Cisco, SAP, Mobilcom Austria, Leoni, Oracle, Seavus, Schneider electric, invested in Serbia (SIEPA, 2014). This may sound promising for the future of this branch of industry. The drop of the direct investment does not have to appear worrying. It is reasonable to conclude that after establishing the productivity and quality, those companies in Serbia could earn for themselves.

Considering global Serbian industry, electronic industry holds a good, second position, being one of the largest exporters with 844.7 mil. Euros in 2013. (Electronic machines, systems and devices). On the other hand, import of the same goods in 2013. was about 654.8 mil. Euros, putting this sector at the fourth place of import significance (SIEPA, 2014).

To design and produce an integrated electronic circuit (IC), that is a chip, many steps must be followed. They are shown in Figure 2 (Ernst, 2009). Each one of these steps can be quite difficult.

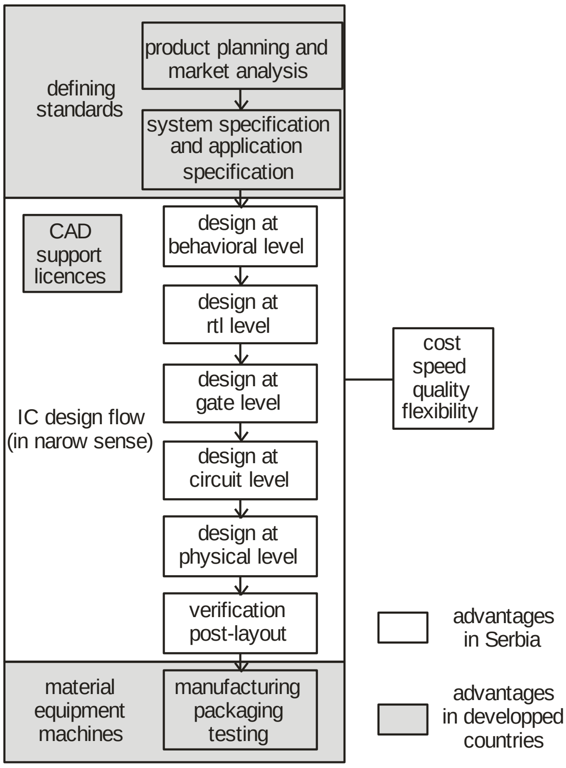

Fig. 2 IC design flow

Serbia is still not ready to start a project that can perform the entire flow. We simply are still not ready for it. It requires huge investments in infrastructure for material preparation facilities, for manufacturing and for testing floor facilities. On the other hand, a relatively cheap workforce, in the neighborhood of highly developed European countries, can be a plus. In comparison to other neighboring countries, Serbia has favorable geographic position, stimulates the creation of new jobs, and tax rate on profit is among the lowest in Europe (Serbian Chamber of Commerce, 2009). According to the data obtained by the Institute of Economics (Economics Institute, Belgrade), Serbia is ranked third in terms of favorable conditions for production and seventh in terms of service. Also, political risk is less than it had been in the first half of the decade and investments and financial capital are far safer in Serbia now.

The key problem in those investments is that we do not have a long-term vision for the development. Also such sophisticated industry requires enough qualified experts. Our chance in this design flow can be found in those phases that do not require production facilities. Development of such activities is a good start. For that, one will need an expert, a computer and a place to work.

Stages of the design where we can find our place are marked yellow in Figure 4. They include mostly brainwork, experts' engagement, computers and software. Our advantage here is speed, quality, flexibility and costs. All those steps essentially represent the design in its narrow sense.

As a logical continuation of this, a good idea would be the investment in knowledge, not in facilities. Our country has several education centers that are capable of producing suchpersonnel . Most of them are university centers (Belgrade, Novi Sad, Niš), and they have a long history of educating similar experts. Most of them are working for large international companies in electronics and IT sector.

Historically, there is a good correlation between the investments in IT and electronic sector, and a progress of the society. According to the EU, only during the ten-year investment in the IT and electronic sector in certain countries, the competitiveness and productivity of their companies raised as much as 50 percent. Being at 15 percent would be a drastic increase in our case. The country has the capacity and potential of this industry and should wisely exploit that.

We cannot ignore the growth in the electronic and IT industry each year. Such trend will surely continue, because this technology penetrated every pore of social life and work. This increases the need for IT and electronic solutions. Because of such estimates, Serbia has to popularize this sector among young people in the sense of applicable knowledge. They have to be assured that those professions are not meant for some geniuses, but are like any other studies. One has to work and learn just a little bit harder than others.

2. Costs of Electronic Circuit Design and Manufacturing

The cost of product and its design are not correlated just during the product development. We can observe life cycle of an electronic product, like it is shown in Figure 3. (Litovski, 2000). It begins with the extraction of raw materials (minerals, fossil fuels, air, chemicals). These materials are processed and prepared for further application. After this step, one can plan design technology, design constraints, design process and the manufacturing of the IC. Further activities entail shipment of product to the customer or to the market. Tasks to be solved here involve time and manner of transportation, or the storage. Delivered products should now be installed and used. During its operating cycle, the device requires energy and maintenance, and also involves cleaning, and spare parts replacements.

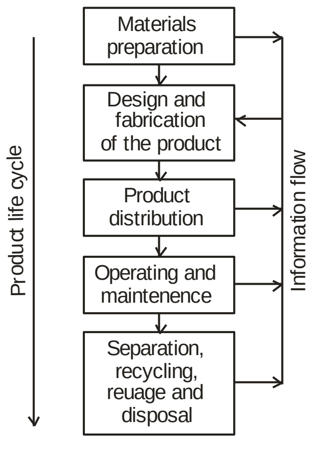

Fig. 3 Product life cycle and the information flow

The last phase of product life cycle could also be very interesting. It can end for two reasons: because the product is not needed any more (where we expect that new product with improved features will appear in the market), or because its repair costs are so high that repairing does not pay off. It is usual that the largest part of such a system can operate well and be reusable, at least like a spare parts source for the reparation of similar system. To enable this, a proper separation of the system parts should be conducted.

One should also have in mind that many electronic systems that have no faults, can be resold. In such a way older technologies are shipped to undeveloped parts and countries. This activity is particularly common in car and computer industry, and telecommunications.

The reuse of components can be very significant in estimating the life cycle of the electronic component. It is usually said that such a component can have one or more incarnations. The reused component is recycled. Material can also be a result of recycling. It is worth to recycle materials only if it is cheaper than buying new, raw materials. Based on these facts, we can conclude that the life cycle of a single product is very complex, and that the job of a designer or a manufacturer does not end the moment when the product leaves the production plant. The designer has to consider all the phases of product life cycle. This is particularly important, since most developed countries nowadays, have low obligations for the manufacturers that require separation, re-use, recycling and disposal of their old devices. The designer has to solve those problems and implement them in the most efficient way possible.

To have a better clue about the costs of IC design, its flow will be described first. We will here discus about one special type of integrated circuits i.e. chips, which are called ASICs (Application Specific Integrated Circuits). The cost-effective mass-production is achievable only for this type of electronic circuits. Every ASIC-based product realization procedure begins with a specification phase (Lee, 2005). Market and/or technology requirements determine these specifications. Almost every ASIC contains several major blocks. Sometimes it is cheaper to buy a design for a certain block than to design in from scratch. Next phase requires analysis of tradeoff and make-versus-buy decisions for each major design block. Purchasing blocks from an intellectual-property (IP) provider, usually involves some additional costs: for purchasing the IP, the per-chip/per-design royalties, and the cost of verifying the IP (Lee, 2005).

Now the design of the ASIC in the narrow sense can begin. During this, new parts of the design are developed. Every block needs verification. It is reasonable to use only the correctly designed parts. All these blocks are now integrated, that is placed and connected together on the same piece of silicon. The global verification repeats again at this stage. After being verified, the design is now used to create GDSII files (Graphic Database System), that can be used for ASIC's manufacturing machines.

The Manufacturing Phase follows. Using the designer's GDSII files special software generates masks and the actual manufacturing of the chip can begin. During this phase the obtained silicon dies are packed into packages and then tested. Chips are now prepared for assembling into corresponding devices or packed for market.

Creating a cost list is a very complex task, since each step in the process can impose costs in other design or manufacturing phases. For example, a simple concept like low number of pins or low-power design (everything has to be paid) affects final product cost in several ways. To place silicon die in the package does not cost much. Nevertheless, if the chip has too many pins, then connecting them to the package can be a problem. Machines that do that will have more problems due to the smaller connection points (bonds) on the package and on the die. This will affect yield (and costs), since more defective devices will appear. Further problems may appear because more pins require more power. Consuming more power causes more heat. The increased chip temperature requires proper cooling with a heat-sink or a fan, and this increases the total cost of the system.

All expenses of the IC design and manufacturing could be classified into two groups: Fixed expenses, and proportional expenses. Fixed expensesentail : time and costs of the design, costs of masks production, other fixed expenses such as rent and others. Proportional expenses, on the other hand,entail : costs of the required materials (silicon, cooper, acids …), packaging, testing, and they are proportional to the size of the chip series, as well as to the size of the chip. The increase of the fixed expenses is affected by the increase of the design expenses. Designers are becoming mre expensive because they require appropriate education, and working and living environment. Also during the design, certain investments must be made in new hardware and software.

If we consider proportional expenses, we can notice that technology development enables smaller electronic devices. Figure 4, shows how the cost of a single integrated transistor (which is the essential part of every modern electronic device), is falling during years (Electronics we Srch, 2014; Moore, 1998).

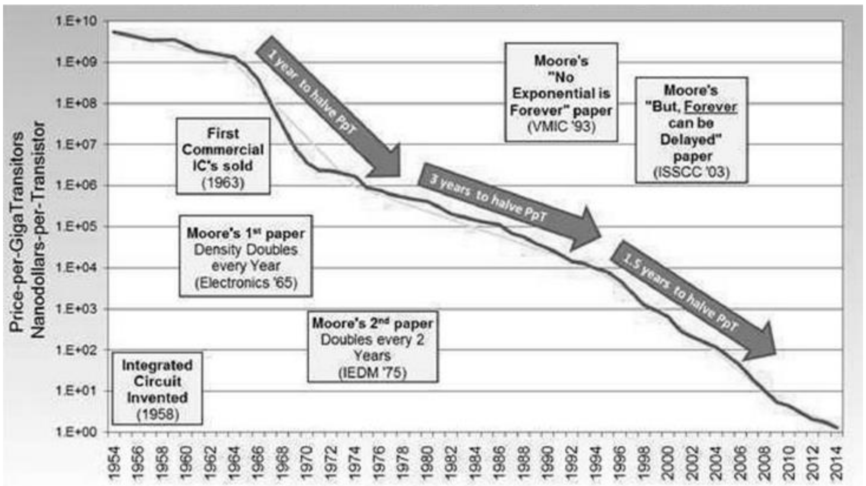

Fig. 4 Transistor pricing history by Moor's law

Nevertheless, this drop did not reflect on the reduction of proportional chip costs, since modern devices are much more complex, and require much more transistors. Those systems require more sophisticated and more expensive methods, tools and instruments for validation and testing.

List of items that contribute to cost so far can also be classified as follows:

Costs inside the die:

- One-time or fixed charges
- IP-procurement costs
- Engineering-design costs

- Verification costs
- Mask charges
- Other NREs. Non-recurring engineering (NRE) refers to the one-time cost to research, develop, design and test a new product.
- Per-chip costs
- IP royalties
- Die cost
- Bad-die cost (defects)

Outside the die:

- One-time or fixed charges
- CAD-tool licensing
- Generation and setup of test programs
- Load boards, probe cards, and other test NREs
- Generation of documentation
- Market timing costs
- Per-chip costs
- Package cost
- Assembly cost
- Test cost

One more topic that arises from the experience in ASIC design is unsuccessful project. During the late 1990s, the main aim was to create a correct chip without the need for redesign and re-fabrication – i.e. no spin. This used to be accomplished quite often. Chips nowadays are far more complex. Consequently the spin rate is higher. The expenses for one spin may vary drastically. They can be minimal requiring only small changes, or may involve a complete redesign. Many companies even plan a certain number of spins in their overall costs and schedules (Lee, 2005).

Besides the engineering, verification, manufacturing, packaging and testing costs for the new spin, additional factor to consider include the market timing costs because of a product delay.

One of the most important designers' ways to avoid or reduce number of spins is the project verification. Verification should be performed frequently during each phase of the design. If everything is correct, we can go further with the project development. Doing so may appear like prolonging the design, but generally, can save a lot of money. Verification can be performed using large collection of tools and teams of experts. In case of a spin, a trade off analysis must be conducted between the cost and time of additional verification (tools, people, and time needs), and the cost of additional spins.

One of the most important phases of the circuit design is its testing. The aim of electronic circuit design is to give a fault free product. The absence of faults is determined by testing. If we find products i.e. electronic devices, produced by different manufacturers that perform the same function and cost drastically differently, we can be sure that the costlier product underwent a very serious testing procedure. Cheaper product did not go through that activity and the manufacturer would probably not guarantee about its long-lasting functionality.

This means that testing is a very expensive activity. It does not add any new functionality to the electronic circuit, device or system, but it shows a value that is already in the product. Industrial testing of large scale chip series represents go/no-go test. The result of testing a circuit is one small piece of information: Yes, it works, or No, it doesn't work. It is just enough to make sure that the circuit operates well. If not, it is discarded. In the laboratory environment, when prototypes are checked, testing requires very sophisticated tools and electronic instruments. Nowadays chips work at speed of little GHz. Testing equipment for them should be more advanced with much better features than the device to be tested. It means that we would need spectrum analyzers that can work on few tens of GHz. This fact is quite enough for one to conclude how expensive those testers are.

On the other hand, testing systems must be so fine and tiny and precise to explore the insight of all chips where parts are small as molecules. The probers should be made of very expensive, high conductive materials that could ensure very strong and at the same time easily separable connection to the chip internal testing points.

Testing requires engineers, time for conducting and special equipment. Engineers have to make the fastest and the most efficient testing method and procedure possible. It means that in the mass production, if the defect exists, it should be detected in the fastest way. The most possible defects must be detected first. Without any further observation, such faulty chips are discarded. Testing a device with few millions of transistors in it for a very short time is an important requirement. For example, if we want to test one digital device, there are many combinations of input signals that should be applied at its inputs. After stimulating the device, we are expecting to obtain response. This response is compared with the fault free one, and the device is classified as the faulty or faults free. For the circuit that has 10 inputs, number of possible input combinations is 2^{10}. If one combination testing last 1ms, the time to check all combinations is 1.024 seconds. For the circuit with 15 inputs, this would last almost 33 seconds. For a series of million devices, this would last about a year. Let us just mention that today's chips contain a few tens or hundreds of inputs. The calculation or the conclusion about the size and complexity of one classic test engineer's problem is left to the reader.

One more aspect of testing economics represents the cancelation of test. How large can its cost be ? There is one rule for test engineers that describes canceling the test. It is called 10x1 (Litovski, 2000). This is shown in Figure 5. The Figure describes cost of the test at different levels of design abstraction. There are three levels of abstraction displayed. The lowest one is the level of component. Testing the component costs a certain amount of money. If we skip testing the component and build it into the printed board, then testing the board to find the defective component would cost approximately 10 times more than testing a single component. Similar story stands for placing a printed circuit board with a defective component into the system. Cost to test such a system and detect a faulty device cost 100 more than the initial cost. In the end we can conclude that giving up testing does not pay off, in any case.

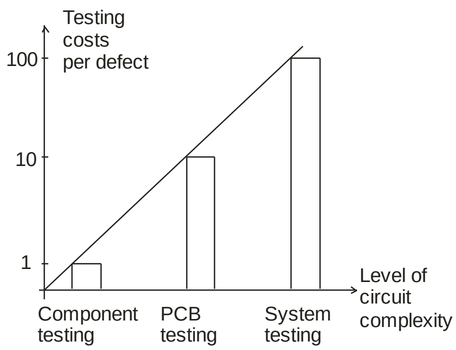

Fig. 5 Rule 10 x 1

At the end of the IC design cost discussion, we should analyze the costs of the electronic circuit design itself. When analyzing the expenses, one should have in mind the entire life cycle of the product.

Modern designers are highly educated and highly responsible persons. Independently from the cost of their work, the cost of their education is extremely high. The work on the design and the product preparation, represent the largest part of the design cost.

Although the price of hardware resources is dropping every day, the expenses for computer equipment required for IC design, do not decrease so fast. Namely, the complexity of the project raises every day, and also the demand for the improved hardware. Constant investment in a new hardware represents a significant part of the design cost. On the other hand, software design tools' cost also grows. New technology requires new hardware and new software, while new hardware and software require new training and education for the designers. Everything costs a lot. Modern and professional working place for IC's design can cost hundreds of dollars. To justify those costs, very specific and efficient designers are required. Taking into account testing (that is prepared during the circuit design), and other aspect related to the life cycle of the product, the software that can support such a complexity is very demanding and requires experts from different fields. The design team is then created from a group of experts, and it increases the price of the design.

The largest design cost, as well as the cost of a product corresponds to unsuccessful project. A mistake in the design can have very bad consequences on the development of the company or can, in the end, financially destroy it.

CONCLUSION

In this paper we have tried to analyze all economic aspects of electronic design and manufacturing. In the period since 2000 in Serbia quite a lot has been achieved in the field of establishing macroeconomic stability, trade liberalization and the creation of some stimulative legislation of interest to foreign investors. However, the initiatedeconomic reforms adopting new legislation and efforts to segment the promotion of investment potentials are just the first step in creating an overall environment necessary for intensive FDI. In addition, one should have in mind that political risks are still very high.

The obvious lack of local entrepreneurial knowledge (international marketing, quality and standards), economically and politically responsive orientation in the direction of encouraging FDI inflows may be a significant factor in the export recovery. Generally speaking, the key interest is that the Serbian economy enter those foreign investors who intend to serve with our sites and third markets, and to purchase inputs in the domestic market to encourage the modernization of local productive capacity and competition among domestic producers. All this together should result in an increase in efficiency and overall global competitiveness of the Serbian economy. We can conclude that electronic technologies are, in fact, high technologies for poor nations. To encourage IC design in Serbia investments in knowledge are required. Afterwards, we only need a computer and space and everything else is in our heads. This sector of economy is what we can and need to cultivate, promote and use for the benefit of us all. The job of IC designer is a great opportunity after graduation, while salary is far above the average in Serbia. It is the opportunity to earn much more if young people are diligent and willing to learn constantly. At the end, generally speaking, this sector may be an efficient shortcut for faster development of underdeveloped countries like ours.

REFERENCES

1. Litovski, V. (2000), "Projektovanje elektronskih kola", - Niš, DGIP: Nova Jugoslavija – Vranje
2. Marković, I. (2010), „Improvement of Serbian Export Competitiveness"- Facta Universitatis, Series: Economics and Organization Vol. 7, No 3, pp.271-278.
3. Marković, I., Janković-Milić, V., (2013), „Konkurentnost u novim uslovima poslovanja", XVIII Internacionalni naučni skup SM 2013, Strategijski menadžment i sistemi podrške odlučivanju u strategijskom menadžmentu, tema skupa: Korporativno upravljanje u funkciji održivog razvoja, Palić. UDC 339.137.2 ; 005.51, str. 684-689.
4. Hausmann, R., Pritchett,L., and Dani R., (2005), „Growth Accelerations," Journal of Economic Growth, Vol. 10.
5. Mencinger, J., (2003), „Does Foreign Direct Investment Always enhance economic growth?", KYKLOS Vol. 56-2003-fasc.4, 491-508.
6. Damijan et al (2003), „The role of FDI, R&D accumulation and trade in transferring technology to transition countries: evidence from firm panel data for eight transition countries", Economic Systems 27.
7. Ungson, G.R., and Trudel, J.D. (1999), "The emerging knowledge-based economy", IEEE Spectrum, Vol. 36, No, 5, pp. 60-65.
8. Osborne, C. (2014.), Gartner: Worldwide PC, mobile device market to grow in 2014. (online at www.zdnet.com)
9. Serbia Investment and Export Promotion Agency – SIEPA (2014.) "Investirajte u Srbiji", (online at http://siepa.gov.rs/sr/files)
10. Ernst, D., (2009.), A New Geography of Knowledge in the Electronics Industry – Asia's role in Glebal Innovation Networks", East-West Center, Honolulu, Hawai.
11. Serbian Chamber of Commerce (2009.), Serbia Attracts Foreign Investments (online at http://promoney.rs/maj2009/privredna_komora_srbije.pdf)
12. Economics Institute, Belgrade, (online at www.ecinst.org.rs)
13. Lee, J.M. (Aug/Sept 2005.), "IC Economics 101", Chip design magazine (online: www.chipdesignmag.com).
14. Electronics.wesrch.com
15. Moore, G. E. (1998.)," Cramming More Components onto Integrated Circuits", Proceedings of the IEEE, Vol. 86, No. 1, pp: 82-55.

EKONOMSKI ASPEKT PROJEKTOVANJA I PROIZVODNJE ELEKTRONSKIH KOLA U SRBIJI

Gotovo svaka aktivnost u procesu projektovanja elektronskog sistema je usko povezana sa tehničkim, ali i drugim naučnim oblastima. Najvažniji aspekt projektovanja elektronskih proizvoda za njihov budući opstanak na tržištu jeste svakako ekonomski. Strane direktne investicije u velikoj meri mogu uticati na R&D u oblasti elektronske industrije. Činjenica da industrija elektronskih kola utiče na sve oblasti društvenog razvoja, zahteva uspostavljanje korelacije između projektovanja i proizvodnje elektronskih kola i ekonomije uopšte. U ovom radu biće učinjen pokušaj analize perspektive srpske elektronske industrije na globalnom tržištu elektronskih kola uzimajući u obzir troškove njihovog razvoja i proizvodnje.

Ključne reči: *efekti SDI, elektronska kola, IC dizajn, testiranje elektonskih kola, IT*.