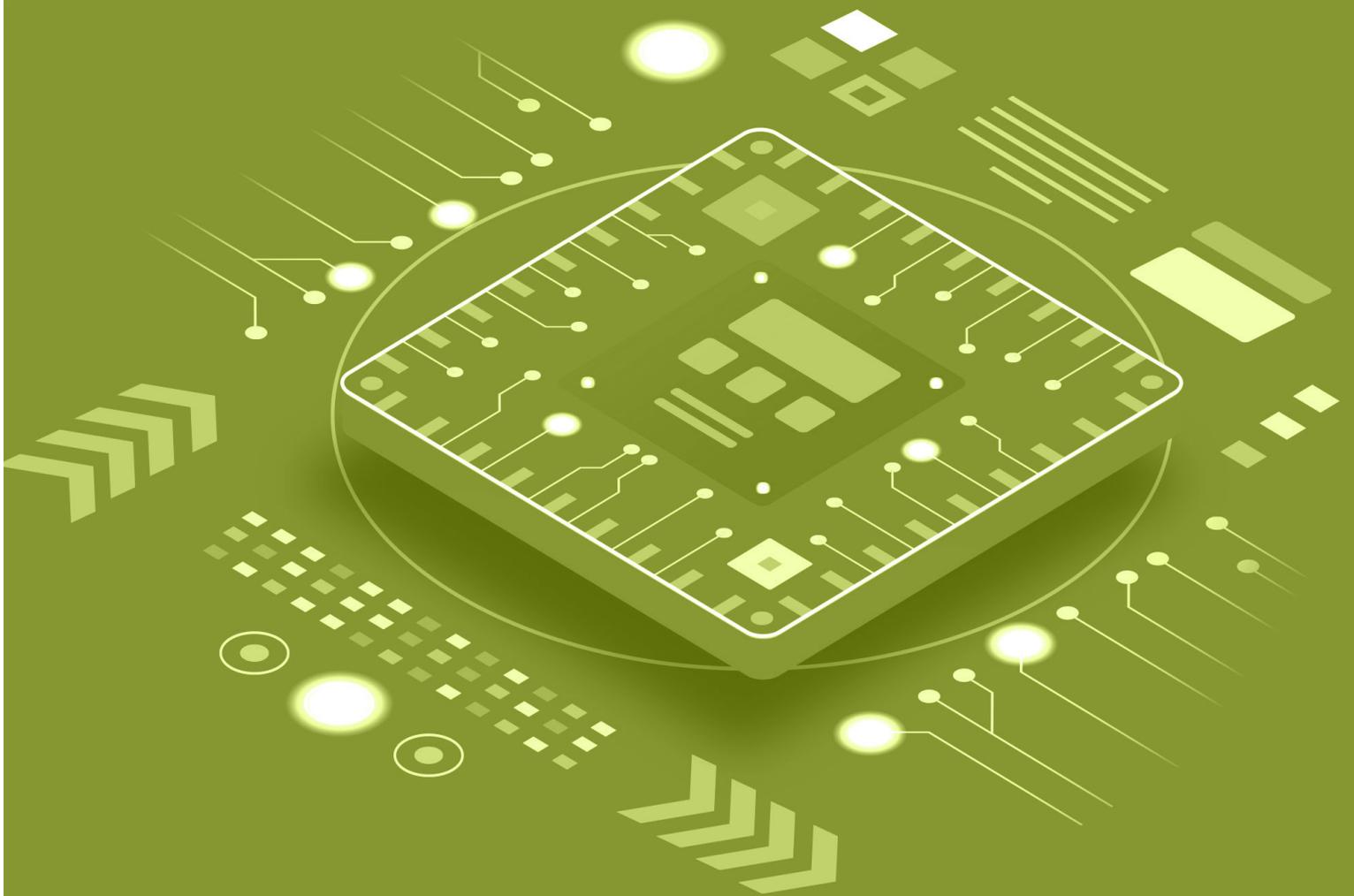
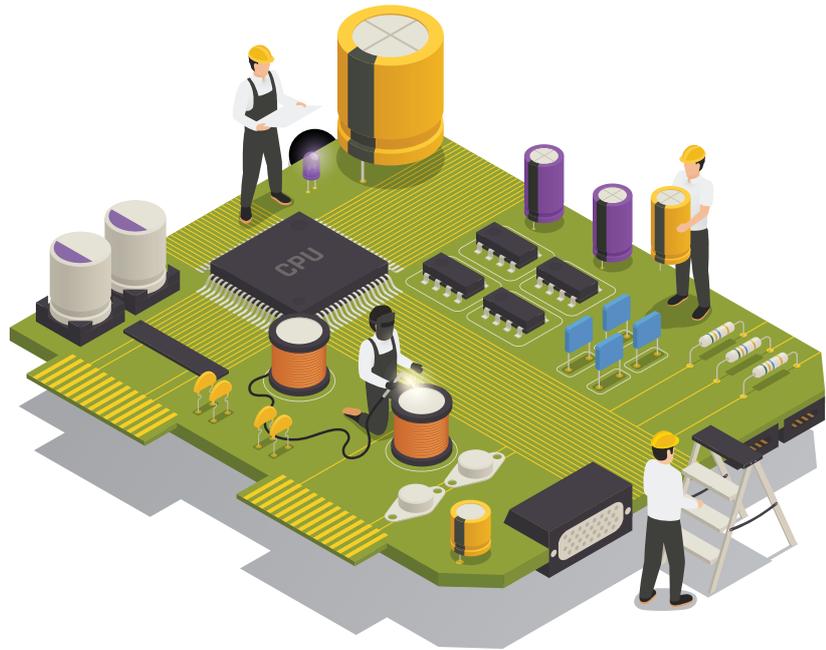


CHIP DESIGN AND EMBEDDED SYSTEMS

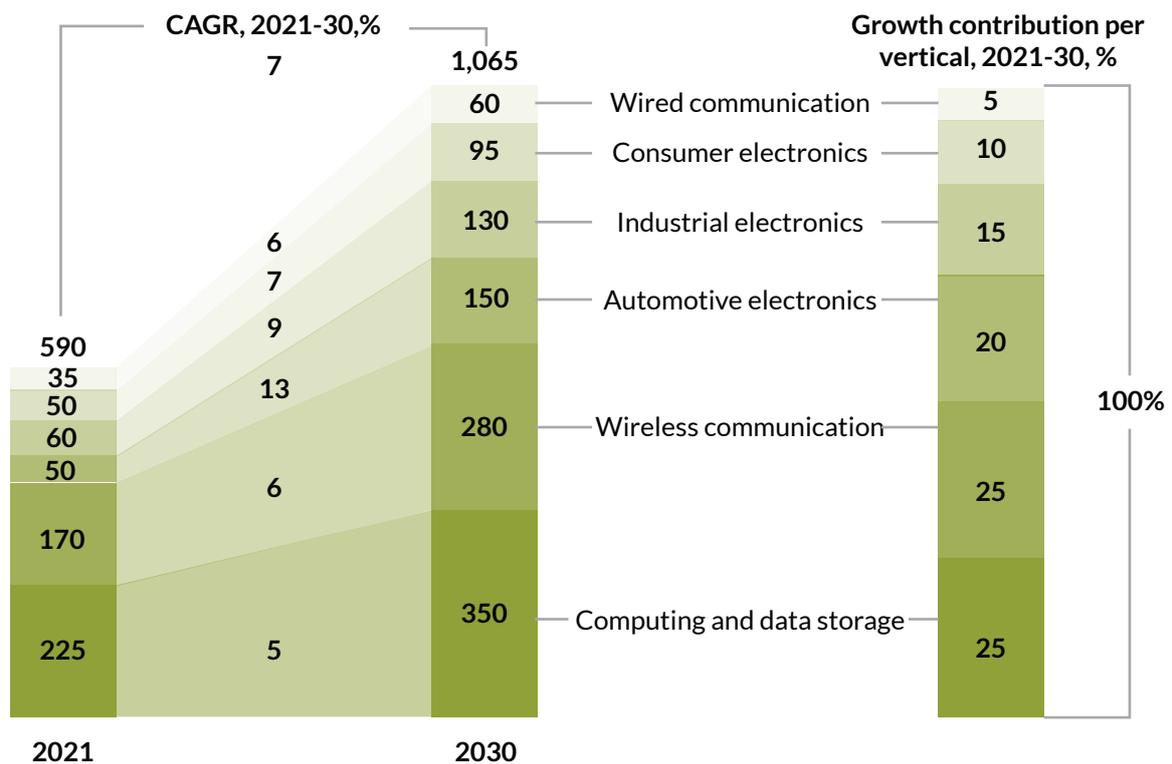


Chip Design and Hardware Industry

Embedded systems and smart systems on chip are present everywhere in our lives from food processors in our kitchen to automobiles, airplanes, spacecrafts and industrial automation systems. They are shaping almost every aspect of modern-day life. Most of these systems may seem invisible to the user but play a significant role in many modern systems.



Global Semiconductor Market Value by Vertical, Indicative, \$ Billion¹



We can hardly find any area of scientific and technological advancement that has made progress with the same pace as that of chip design and embedded systems. Since the invention of the electronic transistor, systems on chips have remarkably improved in performance, smaller footprint and low power consumption.

¹<https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry>

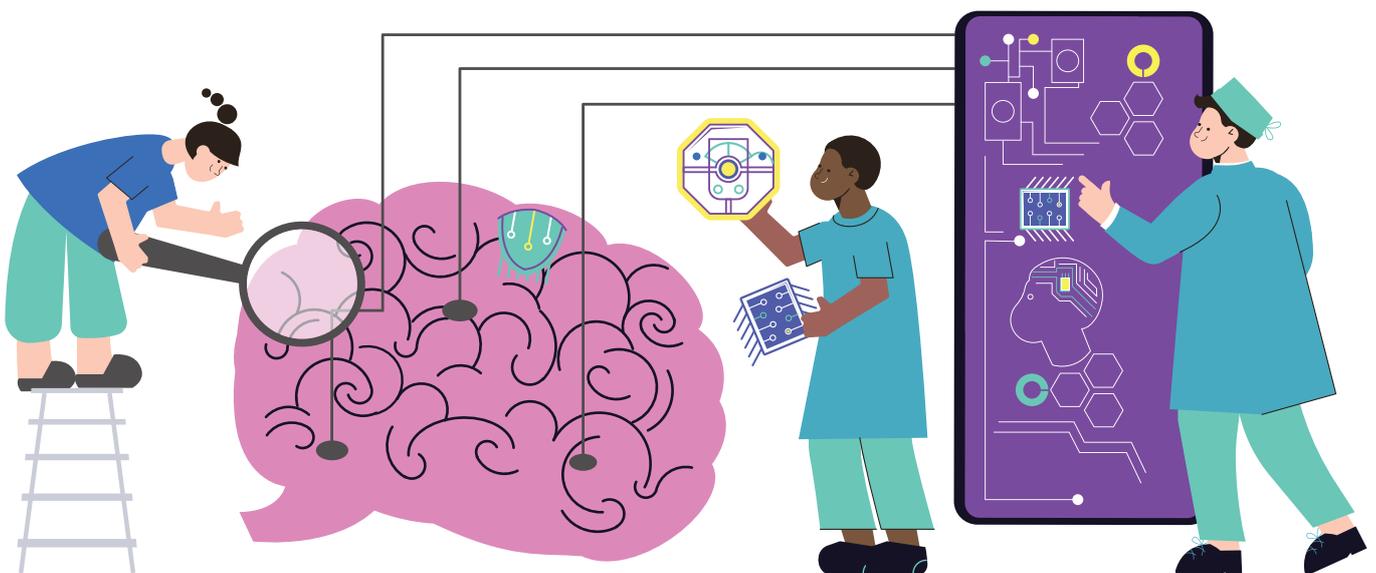
Global Outlook for the Semiconductor Industry

The global semiconductor chip industry is expected to reach about \$600 billion in 2022 with 80% of the products coming from a handful of manufacturers in select countries, according to a Deloitte report.² The same report showed that the past two years have seen a critical chip shortage which has resulted in a loss of more than \$500 billion. The shortage, which was brought on by the pandemic was so dire in 2021, that it shut down automotive production lines.³ However it was the same shortage that brought the importance of chips into the limelight with a stress on how everything from the seat control option in a car to mobile phones needs semiconductor chips to function.

The 10% growth expected in 2022 is being driven by the use of semiconductor chips in everything from computers and phones to appliances and factories. As for the shortages that plagued 2020 and 2021, they are expected to ease in the second half of the year along with supply chain issues.

The chip industry is looking to increase its overall output on a global scale so that the supply and demand disparity does not get as dire as it did in 2020. Governments have already committed billions of dollars to increase output with some 50% higher outputs expected from traditional manufacturing clusters in places like Taiwan and Korea. The rest of the output is expected from the United States, China, Japan, Singapore, Israel, and Europe. Since a traditional factory that makes these chips costs around \$15 billion, there are not many who are willing to get into this production line. Currently, three companies account for most of the sales of semiconductor chips - Intel, Samsung, and TSMC.

Since typical lead times for such products usually exceed four months, the chip shortage is unlikely to be completely resolved anytime soon. As a result, companies that require semiconductors are revamping their procurement strategies.

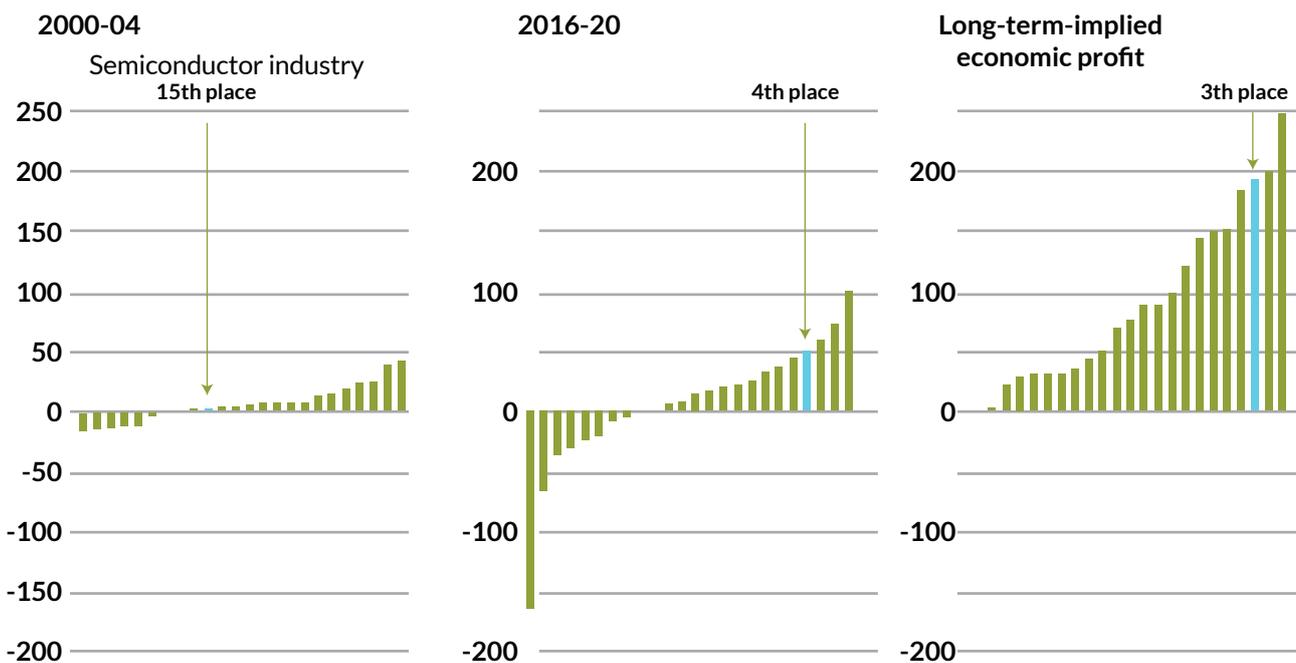


²<https://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/articles/semiconductor-industry-outlook.html>
³<https://www.weforum.org/agenda/2022/02/semiconductor-chip-shortage-supply-chain/>

Many are shifting from ordering semiconductors when they need them to order them in advance to cut down on lead times. Why the four-month wait time though? It is because creating a semiconductor chip is a task that needs to be done very meticulously. The room in which the chip needs to be created has to have zero dust and while most of the process needs to be done with robots, when humans are involved, they need to be covered in head-to-toe protective equipment. Moreover, 57 different types of specialized equipment are required.⁴

While the 2000s saw profit margins remain considerably low at semiconductor companies, profitability improved during the last decade. The improvement came as a result of the soaring demand for microchips which in itself was a result of the rapid growth witnessed by the technology sector. An increase in the usage of cloud technology also amped up the demand for chips.

Average Economic Profit (EP), by Industry, \$ Billion (n =2,644 Companies in 24 Industries)⁵



A McKinsey report assumes that as per the current rate, the industry’s average growth could average from 6-8% a year up to 2030. Such a rate would result in the semiconductor chip industry growing into a trillion-dollar industry by the end of the decade.⁶

⁴<https://profit.pakistantoday.com.pk/2021/07/04/semiconductor-chip-shortage-to-impact-pakistan/>

⁵<https://www.weforum.org/agenda/2022/02/semiconductor-chip-shortage-supply-chain/>

⁶<https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry>

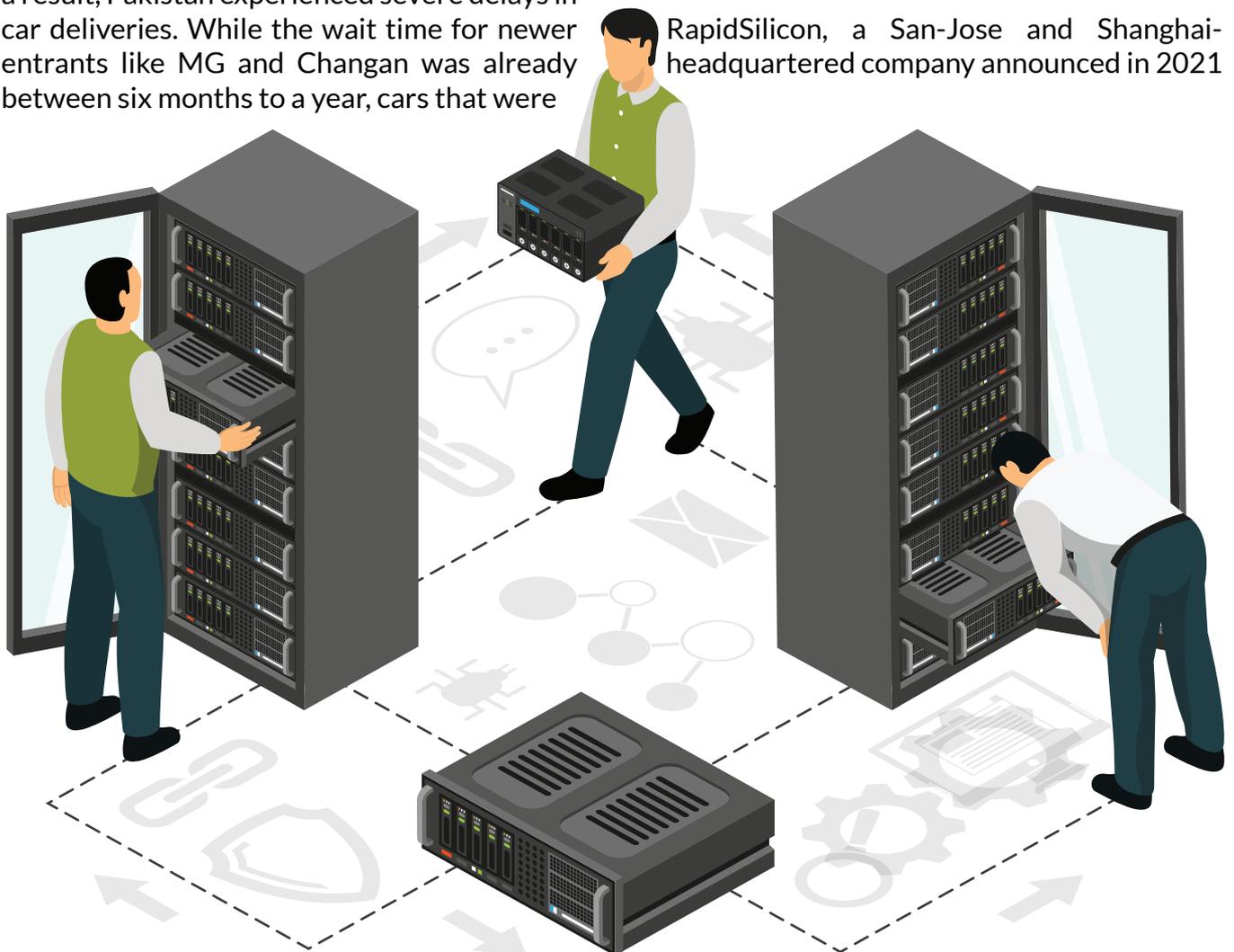
Growth Potential for the Semiconductor Industry in Pakistan

As for Pakistan, while the semiconductor industry is considered to be at a nascent stage, developing semiconductors is an “existential” matter because the sector can serve as an economic and sovereign lifeline.⁷ Since Pakistan imports most of the semiconductor chips used in local manufacturing, the global shortage brought on by the pandemic had ramifications for the country too. Since vehicles cannot function without chips, the shortage in chips led to leading car manufacturers, scaling back on production. As a result, Pakistan experienced severe delays in car deliveries. While the wait time for newer entrants like MG and Changan was already between six months to a year, cars that were

usually available on a much lesser wait period like Honda and Toyota experienced delays too.⁸

The good news is that initiatives are underway to push this sector to the fore. Funding amounting to PKR 41.75 million was approved by the provincial government for establishing chip design centers in eight universities in Punjab. The initiative was pushed forward seeing how other countries are leaps and bounds ahead of Pakistan in this area.⁹

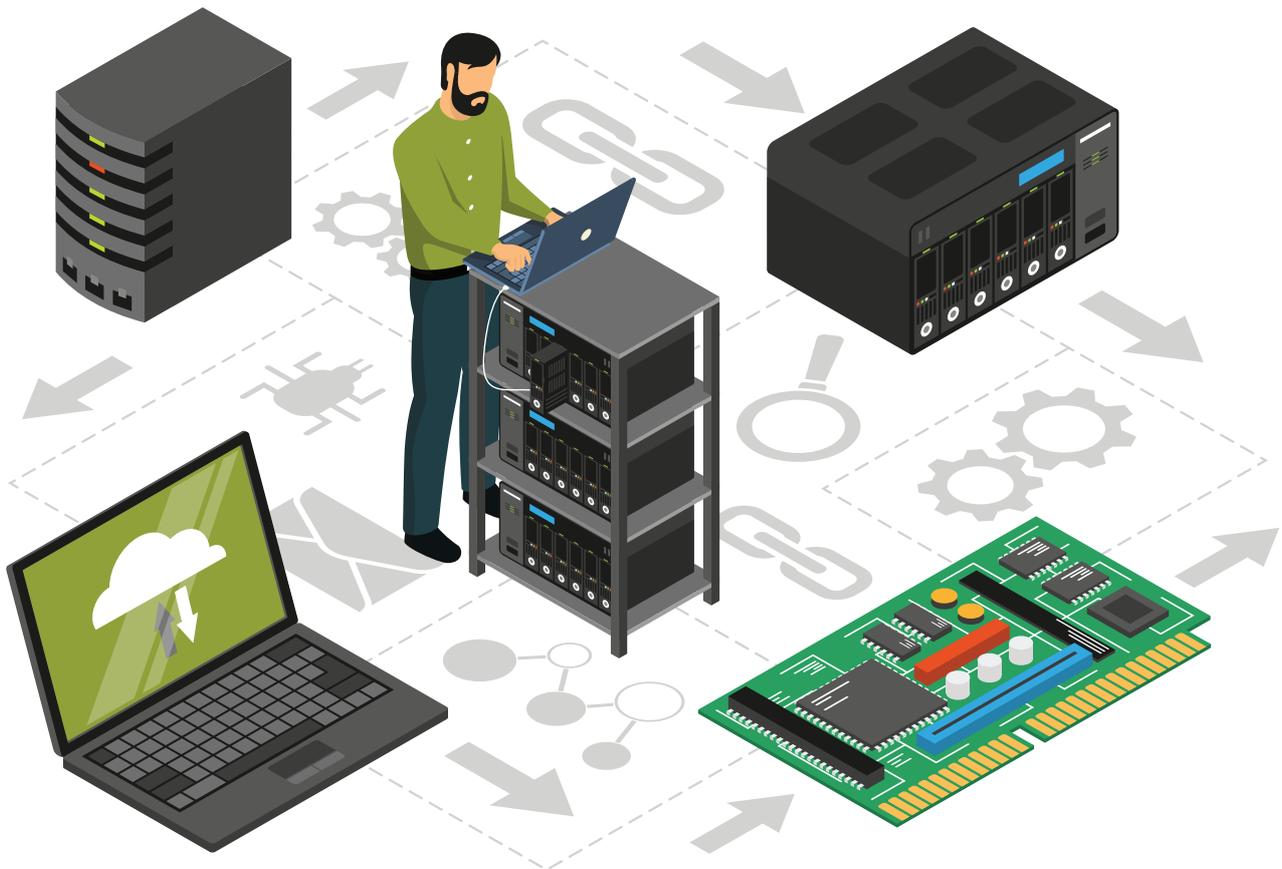
RapidSilicon, a San-Jose and Shanghai-headquartered company announced in 2021



⁷<https://internationalpakistan.com/semiconductor-industry-can-bring-4b-annually/>

⁸<https://propakistani.pk/2021/10/09/this-is-how-global-chip-shortage-will-affect-the-pakistani-market/>

⁹<https://www.dawn.com/news/1629534/punjab-to-invest-in-chip-design-centres>



that they aimed to become the first chip design company in Pakistan. After acquiring \$15 million in seed funding, the company opened up a local office and began operations by hiring 60+ engineers in Lahore.¹⁰

Moreover, in February 2022, it was announced that the country would partner up with China in order to build a semiconductor zone in Pakistan. The initiative was discussed with China during former Prime Minister Imran Khan's visit to the country.¹¹ 2022 also saw the development of Pakistan's first open-source microprocessor by the Usman Institute of Technology, sponsored by Google, where the microprocessor was created in the University's Micro Electronics Research Lab.¹²

Furthermore in July 2022, NUST researchers successfully completed full functional testing

of the country's first truly indigenously designed microprocessor. Called NTiny-E, NUST partnered with the world's leading commercial foundry, Taiwan Semiconductor Manufacturing Company Ltd, for chip fabrication.¹³

Besides NUST, other universities like the University of Engineering Technology Taxila are also investing heavily in the acquisition of IC technology. UET's Chip Design Center is focused on helping Pakistan achieve self-reliance in the field of electronics and is currently working on three projects. The first is Defender, a trojan-aware processor design that will help protect hardware from side-channel attacks. The second is a tracking algorithm for moving objects, while the third is FPGA-based real-time video tracking for surveillance purposes.¹⁴

¹⁰ <https://blogpakistan.pk/rapid-silicon-is-coming-to-pakistan-as-chip-design-company/>

¹¹ <https://tribune.com.pk/story/2343187/pakistan-desires-to-build-semiconductor-manufacturing-with-chinese-help-fawad>

¹² <https://www.thenews.com.pk/print/939004-40-computer-chip-and-design-labs-to-be-set-up-in-pakistan-says-dr-arif-alvi>

¹³ <https://nust.edu.pk/news/nustdevelopspakistansfirstmicroprocessor/>

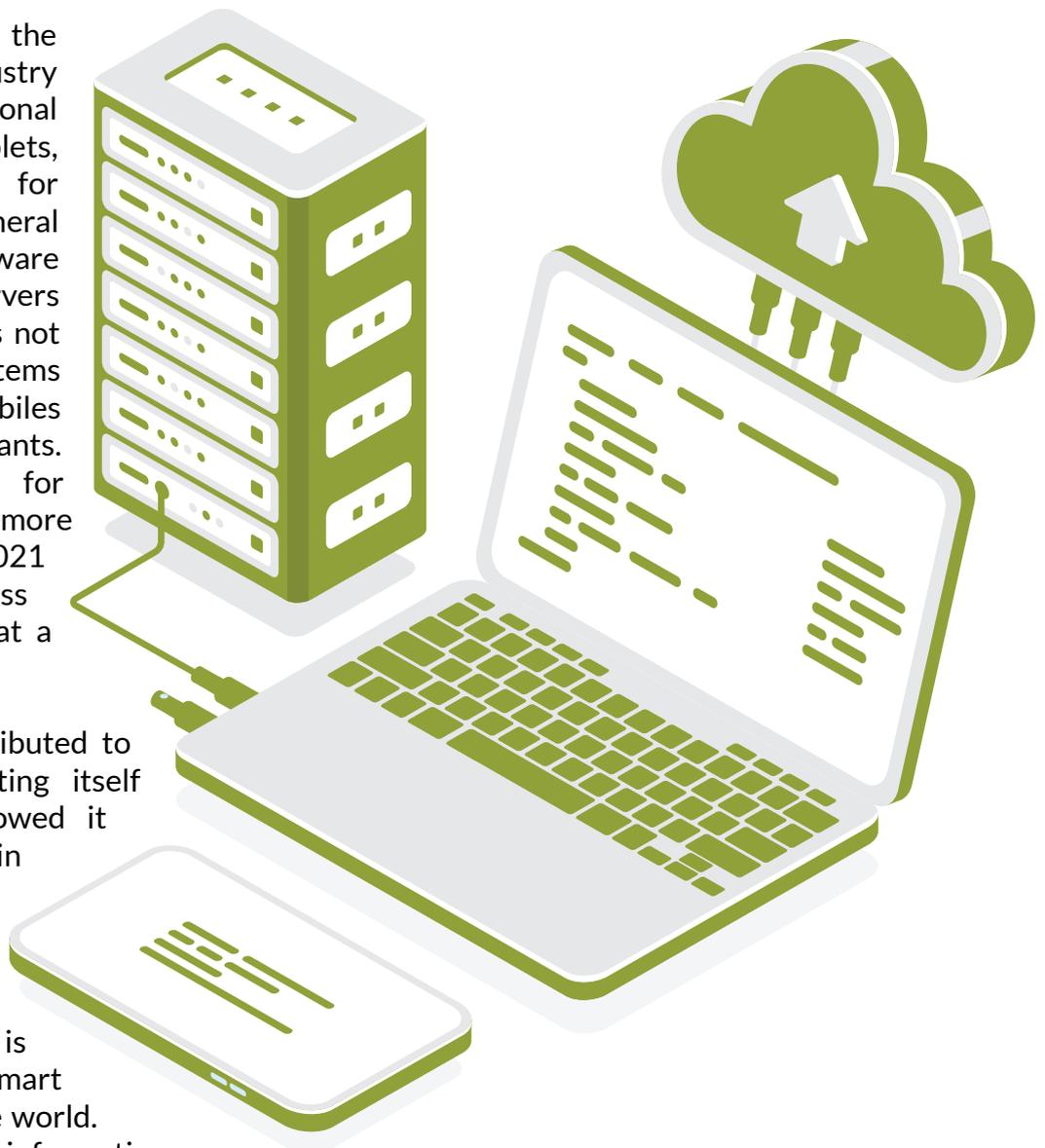
¹⁴ <https://web.uettaxila.edu.pk/cped/StudyArea.asp?Id=cdc>

Embedded Systems Industry

A similar industry is the computer hardware industry which includes personal computers, laptops, tablets, storage devices for computers, and peripheral equipment. The hardware market also includes servers and processors but does not include embedded systems that are used in automobiles and manufacturing plants. The global market for computer hardware was more than \$1,129 billion in 2021 and is expected to cross \$1,215 billion in 2022 at a CAGR of 7.6%.¹⁵

The growth can be attributed to the market self-correcting itself after the pandemic slowed it down which resulted in operational challenges for manufacturing.

Another factor attributing to its growth is the high investment in Smart City projects all over the world. Smart City projects use information technology to manage and operate urban services like water supply, transportation, etc amongst other things. Computers and related hardware are needed for such projects. More than 1000 smart city projects have been deployed globally with many underway and all of them contributing to the growth of the hardware market.



Major companies in this market include Dell Technologies Inc, Hewlett Packard, Apple, Lenovo Group Limited, and Samsung Electronics amongst others. When it comes to region-wise distribution, North America takes the lead with the Asia Pacific following in as a close second.¹⁶

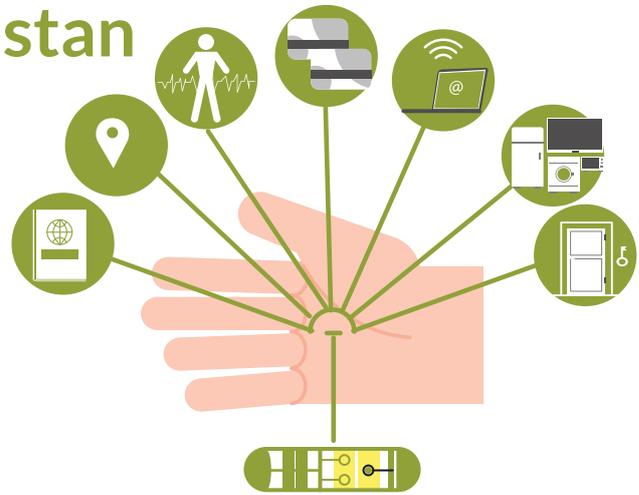
¹⁵<https://www.thebusinessresearchcompany.com/report/computer-hardware-global-market-report>

¹⁶<https://www.thebusinessresearchcompany.com/report/computer-hardware-global-market-report>

How is the Embedded Systems Industry Faring in Pakistan

As for Pakistan, the country saw the first instance of computerization in 1957 after 'Packages Ltd' started using computers for work. While this opened up a new avenue for growth in the country, adoption was still slow owing to numerous issues including import licenses taking two years on average to process and high customs duties. The market was initially dominated by IBM, ICL, and National Cash Register which sold data entry machines.¹⁷ Since computer hardware manufacturing is an extremely capital-intensive industry, it faces considerable challenges in the country. China has positioned itself as a hub for manufacturing and supplying hardware components which makes the supply of such products always in abundance and at affordable prices. As such instead of producing parts on their own, local vendors are assembling imported parts and components to produce local computers.

Despite the challenges caused by the pandemic, the market for computers and peripherals saw an uptake in 2021. Since there is no domestic production to date, the country relies on imports to fulfill the country's growing computer hardware needs. In 2018, only 0.2 million desktop computers were being locally produced in the country.¹⁸ While in 2005, there were around 20 local companies that assembled PCs locally including Viper Technologies, Inbox, and Optimum Technology amongst others, almost all were forced out of business or pivoted to another offer. The only brand company from that era still offering services includes Viper Technology which launched Pakistan's first



local brand of PC in 2018. Viper was also the first channel partner for Intel.¹⁹

Through its National IT Policy, the Government of Pakistan has been pushing for the widespread availability of computers and the skills development needed to use them. Several projects have been launched in that regard including the development of software technology parks. Currently, there are 22 software technology parks operating in the country while in Jan 2022, the Ministry of Information Technology promised the development of 18 more parks by the end of 2022.²⁰ Other incentives include the increase in internet penetration through different mediums, more money being poured into research and development, development of technology incubation centers, etc.

The primary users of computers and peripherals in Pakistan include private businesses, software development houses, call centers, IT service companies, Business Process Outsourcers, internet service providers, education institutions, incubation centers, and private users.²¹

¹⁷<https://pide.org.pk/pdfpideresearch/wp-0168-competitiveness-in-Pakistan-a-case-study-of-the-ict-industry.pdf>

¹⁸<https://www.thenews.com.pk/print/298677-pakistan-produces-0-2mln-computers-annually>

¹⁹<https://tribune.com.pk/story/557163/viper-a-local-pc-brand-undaunted-by-flood-of-used-computers>

²⁰<https://www.thenews.com.pk/print/927664-it-ministry-to-set-up-18-more-software-technology-parks>

²¹<https://www.trade.gov/country-commercial-guides/pakistan-computers-and-peripherals>

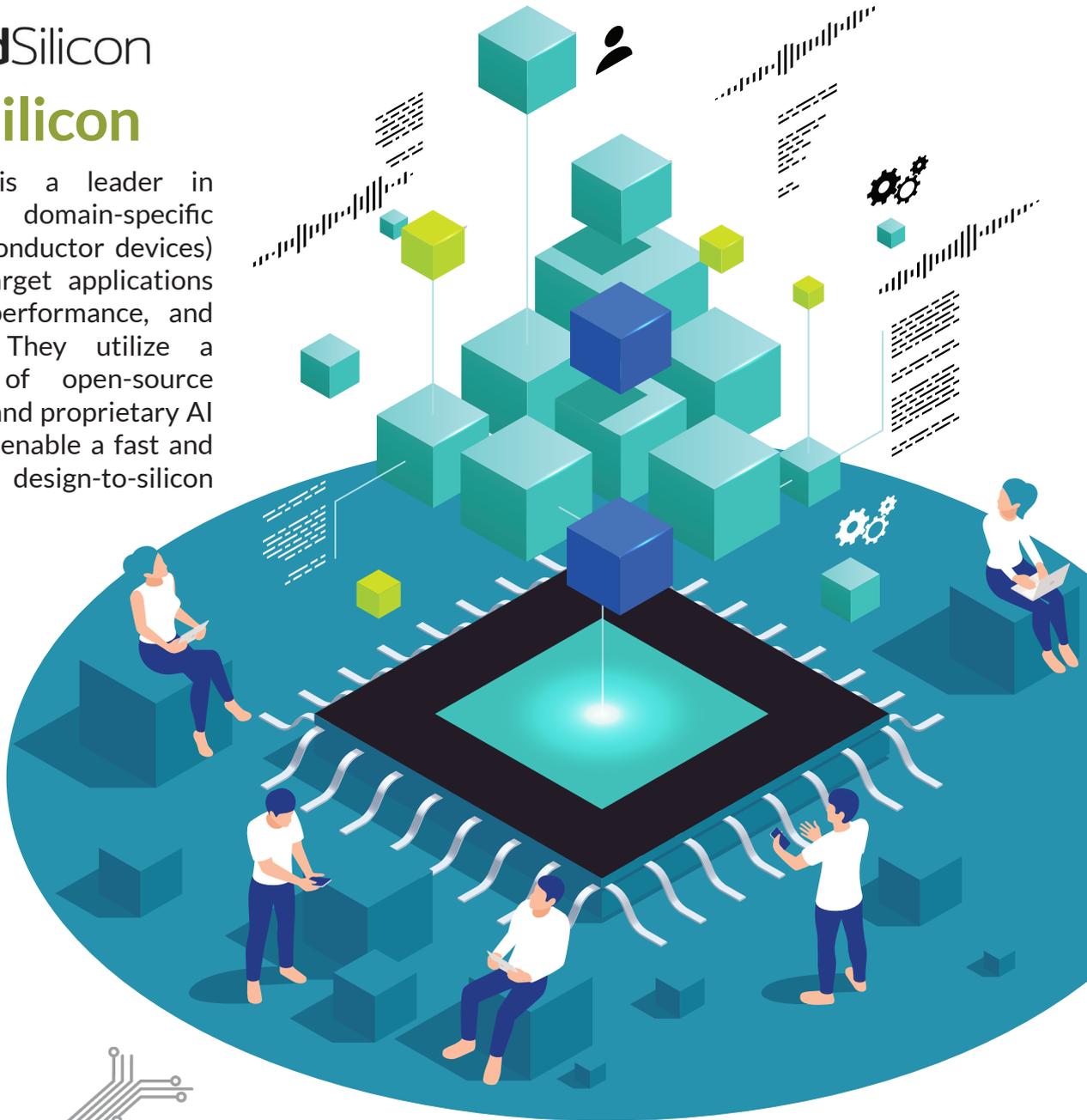
| Industry | Companies |
|-----------------------|---|
| Semiconductor Devices | Rapid Silicon, Innoventors Semiconductors, Centre for Advanced Research in Engineering, MicroTech Industries |
| Embedded Systems | Swift Biz Solutions Ltd, Mikrostar Tech, Digitek Engineering, Creative Embedded Systems and Robotics Pakistan, Enumba, Status 200, B-Tek Weighing Technologies, Embedded System Technologies, Hydropak International, ETechPk, IC Store, AB Enterprises, Spectrum Biz |





RapidSilicon

RapidSilicon is a leader in providing domain-specific FPGAs (semiconductor devices) for diverse target applications and power, performance, and area (PPA). They utilize a combination of open-source methodology and proprietary AI technology to enable a fast and seamless design-to-silicon experience.²²



Innovation Semiconductor

Innovators Semiconductors

INNOVENTORS semiconductors is a full-service electronic design firm established in 2017. They have a team of industry experts with 70+ years of collective experience with an attractive track record of successfully delivering complex ASICs and SoCs design, FPGA design, RTL design and verification, Embedded System Design, Circuit & PCB Design, and Firmware development. Their clients cut across various industries including IoT, automotive, agriculture, and others.²³

²³<https://rapidsilicon.com/>

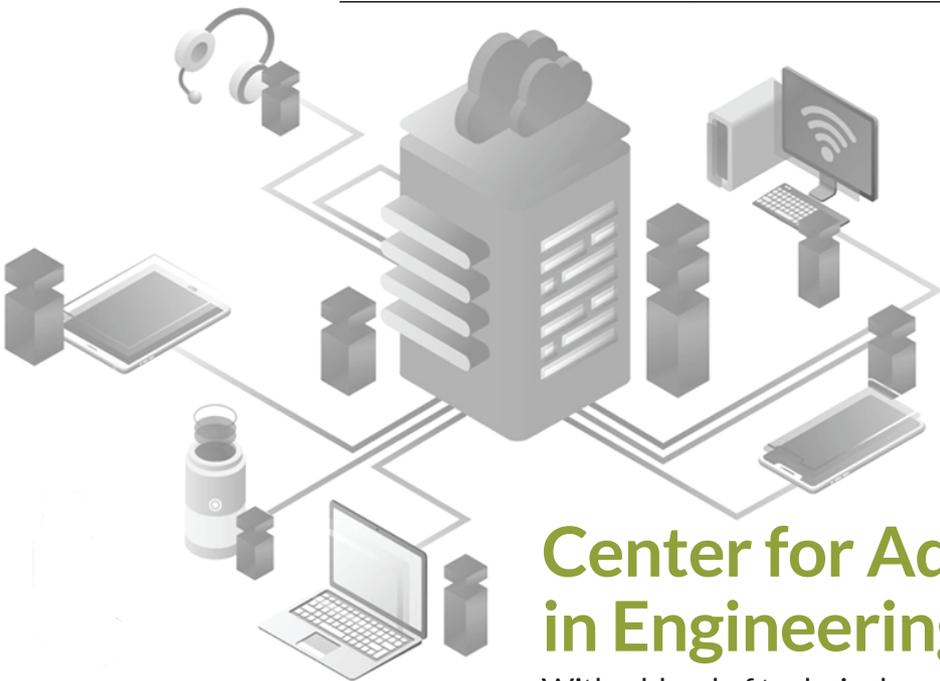
²⁴<https://www.mustakbil.com/companies/company/78616>



Swift Biz Solutions

Swift Biz Solutions Pvt LTD

Swift Biz Solution is a services company actively involved in the IT, telecom, banking, education, and energy sectors offering the best products of renowned brands from around the world. They are actively engaged in introducing new products and technologies to enhance our product range. Their IT products include Android and Windows tablets and hybrids, rugged laptops/tablets, web services, and solutions as well as customized products.²⁴



Center for Advanced Research in Engineering

Center for Advanced Research in Engineering (CARE)

With a blend of technical expertise and creativity, CARE provides state-of-the-art embedded solutions to the industry. They specialize in FPGA and ASIC technologies, and their team of highly skilled design engineers can provide a range of electronic design services and consultancy. Their range of services includes Software Design, Embedded Systems, Cyber Security, the Internet of Things, and ASIC Design.²⁵

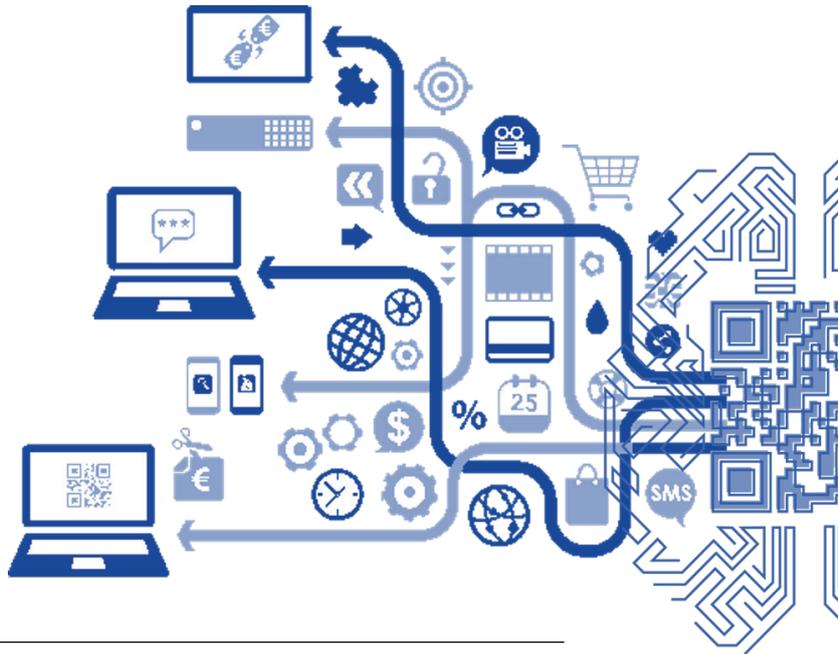
²⁴<https://www.swiftbsol.com/>

²⁵<https://carepvtltd.com/home.html>



MikroStarTech

MikroStarTech is a custom software services firm based in Lahore, Pakistan. Their range of services includes embedded designs, 3D modeling, wireless systems, research and development, PCB layout design, electronics design, application development and web development.²⁶



Digitek Engineering

DIGITEK Engineering is a well-established electronic design company in Karachi, Pakistan. They are an export-oriented company committing well-reputed USA-based communication companies as its clients, through its USA Intermediaries.

Their products include full turnkey hardware board design services, IP (Intellectual Property) core design and development, and fully customizable embedded firmware solutions. With capable and experienced professionals at work, they strive to do highly advanced and sophisticated levels of design work in Pakistan.



Creative Embedded Systems and Robotics Pakistan

Creative Embedded Systems and Robotics Pakistan (C.E.S.R Pak) is an electronics engineering firm and training institute, providing exceptional services, including academic, research, and industrial projects consultation, Internet of Things (IoT) development, ASIC embedded systems development, electronics system design and software integration, domestic and industrial automation, security systems development, hybrid application/software development, network design and support solutions and IT solutions.²⁷

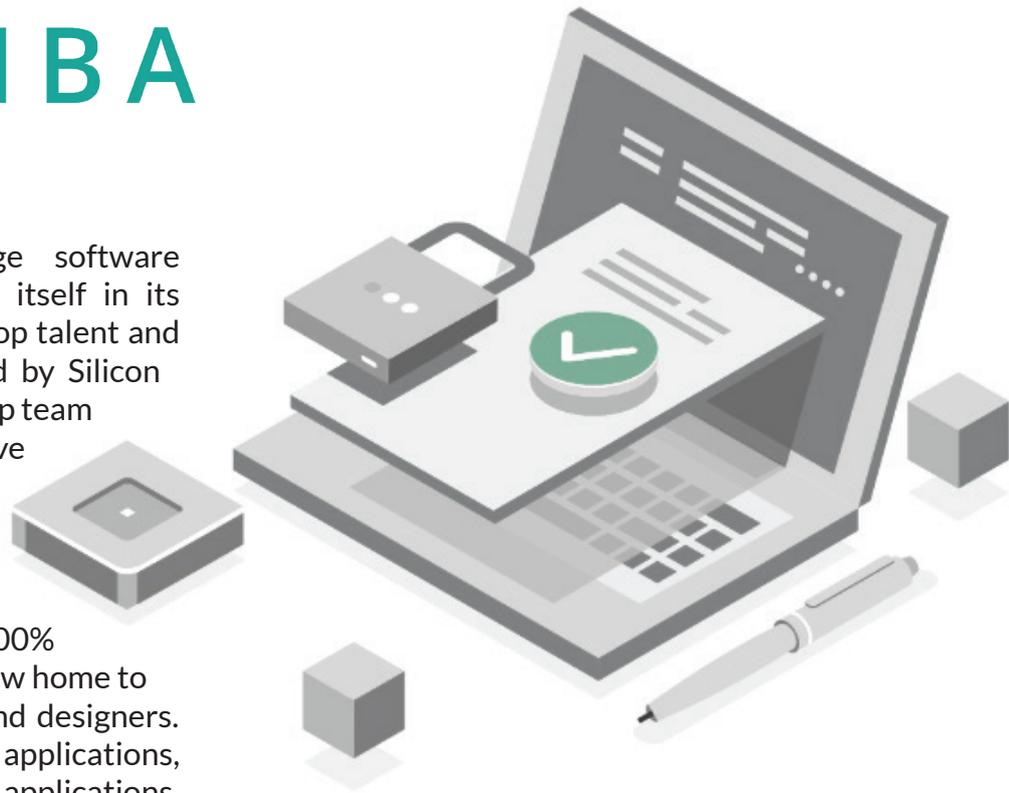
²⁶<http://mikrostartech.com/>

²⁷<https://www.cesrpak.com/>

EMUMBA

ENUMBA

Emumba is a cutting-edge software technology firm that prides itself in its ability to attract and retain top talent and solve complex problems. Led by Silicon Valley veterans, the leadership team has 75+ years of cumulative global experience in technology development, product design and leadership. Founded in 2011, the company has realized 100% year on year growth and is now home to 150 world-class engineers and designers. Their services include web applications, cloud and DevOps, network applications, design/UX and quality assurance tools.²⁸



Status200

Based in Lahore, Status200 provides its clients with a plethora of services including app development, development and maintenance of embedded systems, game development, web development and AI/ML services. They have a multidisciplinary engineering team that designs and develops innovative solutions in embedded system development.²⁹



Lampro Mellon

Lampro Mellon is a global system-on-a-chip (SoC) design and verification services company with a rich history of satisfied customers and successful projects. Their engineering pedigree is impeccable, with leadership from top semiconductor design, service, and IP companies in North America, Europe, and Asia. They have delivered turn-key SoC and systems design solutions in avionics, telecommunications, and imaging; and delivered board support packages for ARM and RISC-V-based systems. They work with a variety of industry standard tools and design flows, have developed innovative verification methodologies to meet unique client needs, and have set up multiple verification and test environments.³⁰

²⁸<https://www.emumba.com/>

²⁹<https://status200.net/>

³⁰<https://lampromellon.com/>



B-Tek Weighing Technologies

B-Tek Weighing Technologies has sixteen years of experience in providing weighing technology and weighing automation tools. Headquartered in Karachi, they supply weighing balances, table scales, platform scales, weighbridges and also develop embedded weighing systems for tanks etc. They have hundreds of clients both in Pakistan and the Middle East.³¹



Embedded Systems Technologies

Embedded System Technologies (EST) is an organization focused on providing a broad range of embedded solutions. It offers design services including hardware and software development customized product design system engineering etc. They have a group of hi-tech experts that are determined to provide a cost-effective indigenous solution to the hi-tech industry in Pakistan, with a special focus on defense-related problems.³²



ETechPk

ETechpk is an online webstore that deals in a vast variety of electronics equipment and components. Whether it is a robot that can cook breakfast or a GPS cat tracking device, their products and resources are designed to make the world of electronics more accessible. In addition to products, ETech also offers classes and online tutorials to help educate individuals in the wonderful world of embedded electronics.³³



IC Store

The IC store is a digital store that specializes in providing electronics and electro-mechanical components, robotic parts, Arduino, Raspberry PI, Arduino Shields, STM discovery kits, Microcontrollers and their programmers, electronic tools and much more. They sell their items to engineers, professionals and hobbyist project makers, colleges, students and manufacturers.³⁴

³¹<https://www.btekw.com/>

³²<http://www.estlimited.com/>

³³<https://etechpk.net/>

³⁴<https://theicshop.pk/>

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ABOUT THIS INDUSTRY ROUNDUP

Pakistan Software Export Board developed this paper by hiring services of independent consulting firms to prepare this roundup on Pakistan's Chip Design and Embedded Systems sector. The paper focuses on Pakistan-based companies in this vertical and appraises the reader of the expertise available in Pakistan in the Chip Design and Embedded Systems domain.

DISCLAIMER

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